Value Engineering Takes Its Place in the Transportation Industry
The Romans were the greatest road builders of the ancient world. Given the tools and materials they had at their disposal, they were probably the greatest road builders of all time. It is instructive to compare some aspects of the U.S. Interstate Highway System with those of the Roman road system.

The Roman road system provided all-weather access to the most distant provinces. The most well-known, the Via Appia (or Appian Way), joined Rome with the city of Capua and extended to the heel of Italy. The Via Flaminia connected Rome with the Roman colony in former Celtic territory. In Britain and North Africa, as well as in Italy, we can trace the path of Roman conquest by the growth of the Roman road system.

All told, the Romans built 50,000 miles of roadways through territory that today covers more than 30 countries. In truth, one could say that "All roads lead to Rome." In fact, the access that this network of roads provided facilitated the spread of Christianity. The roads were remarkably durable and remained in use during the Middle Ages. Parts of the roads are still in use today.

The U.S. Interstate Highway System has yet to match the number of miles of the Roman road system. The system was instituted by the Federal Aid Highway Act of 1944 as the National System of Interstate and Defense Highways. The act authorized a system of limited-access highways not to exceed 40,000 miles. Subsequent legislation increased the limit to 42,795 miles.

The U.S. Interstate Highway System is essentially completed. The implementation has almost met the design criteria of carrying 20% of the nation's motor traffic, connecting all of the continental United States, and reaching 90% of all the U.S. cities with populations of 50,000 or more.

As in the United States, road building was an important function of Roman rulers, whose functionaries awarded contracts and supervised construction. As the roads were extended into the provinces, responsibility for funding and work was assigned to the provincial governors. These governors received subsidies from Rome and frequently imposed toll collection.

In the case of the U.S. Interstate Highway System, the federal government paid 90% of the cost and the states paid 10%. Several states have converted portions of the interstate highways within their boundaries into toll roads.

The reigning Roman emperor used inscriptions on milestones along the provincial roads as a means of asserting his authority and advertising his benevolence. Here is a small sample of what I found while probing the U.S. Department of Transportation’s Public Affairs Office on the Internet.

- Secretary Peña Announces Grant of $79 Million for Secaucus Commuter
- Secretary Peña’s Remarks at New York Waterway Loan Guarantee Announcement
- DOT Announces $12.4 Million Grant to New Jersey Transit Corporation
- Transportation Secretary Peña Signs Agreement for Light Rail Funding in Northeast New Jersey
- Secretary Peña Announces Airport Improvement Grants for New Mexico
- DOT Gives $125 Million in Federal Transit Funds to New York’s Queens Connector Project

The more things change, the more they remain the same. By the way, only about half of the roads in the United States are paved. All roads still lead to Rome.

We are devoting an entire issue of Value World to transportation because of the problems we face in the third millennium. I thank SAVE International for inviting me to participate in this issue and for the chance to talk again to the readers.

Goodnight and 30.
Critical Technology in Transportation Staff Report

Jack V. Michaels, Ph.D., P.E., CVS

INTRODUCTION

Advanced technology remains a driving force in U.S. economic prosperity and national security. Maintaining the strength and competitiveness of U.S. technological enterprises is vital to the nation's interest. In the current climate of intensifying global competition, rapid technological change, geopolitical uncertainties and limited resources, the need for identifying critical technologies for concentration of effort has intensified.

Value World’s staff adapted this article from the “Report on the Third Biennial National Technologies Review,” which was obtained via the Internet from the U.S. Department of Transportation’s Bureau of Transportation Statistics. The report covers the state of the art from 1990 through 1994, and designates the technology areas and specific technologies that constitute priorities for federal and industry-cooperative R & D efforts. For transportation, the areas that need attention are aerodynamics, avionics and controls, propulsion and power, systems integration, and human interface.

AERODYNAMICS

Aircraft Aerodynamics

Aerodynamic efficiency is one of the key parameters that determines the weight and cost of an aircraft. Roughly speaking, an aircraft's range is directly proportional to its aerodynamic efficiency without any increase in fuel usage. Such fairly recent aerodynamic technologies as supercritical airfoils and winglets have already provided substantial increases in aerodynamic efficiency over first-generation jet transports, and there are many emerging aerodynamics technologies worthy of development and implementation. One of the most promising, especially for improving efficiency in jet transports, is laminar flow control.

For commercial aircraft, improved aerodynamics reduces operating costs, thereby making the aircraft more competitive on international markets. It also significantly contributes to the national security by improving efficiency and performance of military aircraft.

Surface Vehicle Aerodynamics

Surface vehicle aerodynamics provide the scientific foundations for developing lower drag shapes for automobiles, buses, trucks, and trains. As vehicle speed increases, aerodynamic drag becomes a major contributor to vehicle inefficiency and increased fuel consumption, higher levels of noise, and control problems.

Aerodynamically designed vehicles can be both quiet and more efficient than existing vehicles, although current vehicles already incorporate efficient aerodynamic shapes. Drag reduction translates into reduced energy consumption and more efficient vehicles, and ultimately lowers demand for foreign oil.

AVIONICS AND CONTROLS

The United States leads in most avionics and controls technology, and is likely to maintain — but not increase — its edge over the next several years. Two European firms, France's Sextant Avionique and the United Kingdom's General Electric Company, are challenging the leadership across a wide range of avionics products; but, with the current downturn in military budgets and commercial developments, few companies will be willing to risk large investments solely for the commercial market.

Aircraft and Spacecraft Avionics

Several goals drive development of fly-by-light control systems: increased resistance to electromagnetic interference and increased bandwidth for data and weight reduction. Fly-by-light systems also provide better protection against lightning strikes. Moreover, fiber-optic cables can carry vast amounts of data and offer potential weight advantages. The technology will probably not be used in commercial transports until the 21st century.

U.S. firms, led by McDonnell Douglas, appear to have the lead in fly-by-light development. Much of the impetus for the U.S. developments comes from the Advance Research Projects Agency's technology reinvestment program. The United States also is the leader in ring laser gyro technology and has a slight lead in fiber-optic gyroscopes, an alternative technology for aircraft inertial-grade accuracy. U.S. manufacturers retain a lead in global positioning systems receivers and processing equipment, largely because of experience developing the satellite system.

Spacecraft avionics currently involves issues of reliability, space certification, miniaturization, reduced power consumption, and "black box" modularity. Spacecraft control systems, on-board navigation systems, and precise engine throttling would all benefit from further improvements in this area. There is a growing trend toward the standardization and assembly of building block components to achieve a number of different functions and, in this way, avoid a requirement to develop a large quantity of special purpose systems.

Surface Transportation Controls

Surface transportation controls span applications, from microprocessor-based emissions-control systems for monitoring
and controlling engine performance to reduce emissions and optimize engine performance, to the myriad components that would be essential to attain an intelligent vehicle highway system. A critical examination of the emissions control application suggests that these systems may operate effectively for much of a vehicle’s useful life; but, ultimately, many of these systems may degrade and exhibit highly variable behavior that is accompanied by gross emissions of hydrocarbons.

Thus, the issue is not to develop systems whose performance when new is exemplary. Rather, it is to develop reliable maintenance-free emission control systems that will operate at close to new-car levels when a vehicle is well past 100,000 miles and into its third, fourth, or fifth level of ownership. This remains a major challenge, particularly if years of neglect and poor maintenance are considered. In general, it seems plausible to think that reliable emission control systems for exhaust and evaporative emissions hold the key to reducing urban emissions and ozone formation in many areas, particularly in California, where 40% of vehicles have more than 100,000 miles on their odometers. The United States is preeminent in this technology area, driven by our commitment to clean air.

PROPULSION AND POWER

Propulsion technologies are important to both national security and economic prosperity because better engines improve fuel economy, reduce maintenance costs, and allow designing a smaller, cheaper aircraft to perform some required mission. The interaction of propulsion and aerodynamics is essential for developing powered lift vehicles.

Aircraft Turbines
In the turbojet engine, a key objective of the last 40 years has been to increase combustion temperatures for better efficiency and reduce fuel consumption without burning up the turbine blades. This is done by using better materials such as the ceramics mentioned elsewhere, better cooling approaches, and better computational analysis methods. Reduced emissions and noise are also becoming extremely important for the civil sector. Performance improvements in engine technology historically have been driven by military programs, and commercial engine development will continue to benefit from military research efforts. The United States leads in aircraft turbine engine technology, based on its superior military technology, but shares the lead in commercial propulsion systems technology with the United Kingdom’s Rolls Royce.

Because of the trend toward higher-thrust engines, in concert with the trend toward larger aircraft, by the year 2000 deliveries of engines with greater than 45,000 lb. thrust are forecasted to become more than 50% of the market by value. The trend toward higher-thrust engines has two general consequences for the development of smaller engines. Second-tier manufacturers are increasing their roles in the development of smaller engines.

Spacecraft Power Systems
Spacecraft power systems provide power for spacecraft missions, communications, and housekeeping functions. In the case of lunar or planetary missions that involve instrumented or human landings, surface power systems also must be provided. Efficiency, power density, reliability, environmental risk, safety, and shielding must all be considered in any power system.

Space power systems are relevant to both economic progress and national security. They contribute to sustainable economic growth through promoting efficient energy production and utilization technology, and help the environmental monitoring and assessment function through their ability to provide long-term power for environmental monitoring satellites. They contribute to national security through their ability to provide energy sources for military surveillance systems.

The United States is preeminent in spacecraft power systems, based largely on the relative scale and sophistication of its space effort. Only the United States and Russia are manufacturing radioisotope thermal generators essential for the space mission to the planets, but there is a possibility that the United States will abandon research in this technology.

SYSTEMS INTEGRATION

Systems integration refers to the ability to design, produce, test, and implement large-scale complex systems that have individual elements that often use advanced technology components. The most widely cited example is manned space flight.

Intelligent Transportation Systems
Intelligent transportation systems use advanced computers, sensors, electronics, communications, and other technologies to improve the safety and efficiency of all modes of surface transportation for people and goods, including intermodal transfers. Areas currently being emphasized are: travel and transportation management, travel demand management, public transportation operations, commercial vehicle operations, emergency management, and vehicle control and safety systems.

The latter technology would culminate in an automated highway system and include different types of collision avoidance systems, vision enhancement, improved safety readiness, and pre-crash restraint deployment. On some stretches of highway, automatic platooning of vehicles that are electronically controlled could increase lane capacity by three or four factors. In addition to the above major areas, electronic payment services would improve convenience and efficiency for toll collection, personal vehicle use, interstate tracking, and public-transit users.

There seems to be no clear leader in intelligent transportation systems technologies. The United States, western Europe, and Japan are pursuing active programs involving both private and public resources.
Spacecraft and Aircraft Integration

Complete integration of an aircraft or spacecraft, as opposed to mere component design, requires broad experience, a complete understanding of all component technologies, and a design infrastructure including methods, tools, and people. The added complexity of making many subsystems operate simultaneously, without interference with each other, requires a special set of skills that are different from skills required to design and build an individual component.

Multidisciplinary optimization hopes to allow complex system optimization of hundreds or thousands of variables resulting in lower aircraft weight and cost. Lower weight and cost will, in turn, improve the competitiveness of U.S. aircraft on world markets and will result in aircraft that are more friendly to the environment because they will use less fuel and produce fewer emissions. In addition, multidisciplinary aircraft design will allow designers to produce better military aircraft, contributing to national security.

Europe is slightly behind the United States in overall systems integration capability for civil and military aerospace systems. With the development of the Boeing 777, the United States took the lead in the design and manufacture of commercial aircraft. Boeing used an integrated approach through fully digital product definition, with all parts created by computer systems. Airbus has not yet used this approach and may not for the next several years. However, Europe does have the capability to integrate increasingly complex aircraft systems, as demonstrated in a host of commercial and military aircraft. Japan, on the other hand, has not yet led a major commercial development and has had difficulty with systems integration of its military programs.

HUMAN INTERFACE

A human interface is an essential element in the successful design and safe, reliable operation of any transportation system. The field of study that leads to proper design focuses on human capabilities, limitations, behavior, and performance while interacting with complex engineered systems and environments. The role of the human operator in the control loop has changed greatly— from driving, navigation, and piloting as traditionally conceived to the control of complex systems in relatively infrequent off-nominal, potentially high-risk situations.

The willingness to use and perhaps depend on technology, as opposed to human operators, is a cultural phenomenon not simply bound by the basic technology. A primary case in point is the degree of automation entailed in the Airbus flight control systems. As automation becomes more capable, the degree of keeping humans in the control loop and the ability to override the control system will become more of an issue. In the case of highly unstable nonlinear control regimens where computer control is the only option, operator training and operator acceptance pose difficult problems, in particular the judgment of when and how to override the automation.

Human Factors Engineering

The United States has a clear-cut lead in antigravity countermeasures in high performance aircraft, and even cockpit display and instrumentation. As the pressure suits universally worn by fighter pilots are capable of being pressurized, it is more of a deployment decision rather than one of underlying technology. The ultrasonic Doppler flow techniques for assessing individual pilot status during high “g” loads have been more fully evaluated, and control algorithms have been refined and reduced to practice in the United States.

The limit of human capability, however, is becoming an important factor in safe and effective operation of transportation systems. High gravity loads experienced by military pilots reduce the availability of well-oxygenated blood to the retina, which causes “gray out,” a tunneling of vision, and eventually a loss of blood flow to the brain that results in loss of consciousness. Countermeasures using small ultrasonic transducers are able to sense the reversal of blood flow at high “g” and are used to control the pressure in a lower body garment intended to restrict the pooling of blood in the lower abdomen and legs. Lessons learned from the deterioration of the visual field under high “g” loads have also been applied to instrument design, head-up displays, and alarm systems intended to catch a pilot’s attention even in a high-noise, high-stimulus environment.

Spacecraft Life Support

Spacecraft life support involves issues of reliable, closed, physical-chemical, or bioregenerative systems. The goal is an integrated, stable ecosystem with greater simplification, minimal resupply, and greater degrees of closure. Current baseline designs for the space station depend entirely on reliable resupply of air and water consumables from the ground. The Russian “Mir,” the only permanently manned platform currently in space, provides an example of the capabilities of water recycling and CO₂ removal with total dependency on ground-based resupply of oxygen.

The mass costs are unacceptable for any extended-duration manned missions, either on the lunar surface or for Mars transit and exploration. While the Russians believe they can simply stock supplies for a two-year mission, serious long-term exploration requires a commitment to bioregenerative, closed, ecological life-support systems. These systems must be capable of recycling and providing air, water, and food, while controlling toxics and bacterial or viral contamination. Stable, robust life-support systems are essential to reducing remote outpost dependencies on resupply missions. In order of complexity, partially closed physical-chemical systems would be first, followed by closed physical-chemical systems.

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TRANSPORTATION FOR A GROWING REGION

Patrick O'Neill, P.E., and Eric Meng, CVS, AIA

The Pacific Northwest portion of the United States is experiencing unparalleled growth, with predictions for 20% population increases within the next five years. Transportation has become the primary issue affecting both budgets and quality of life throughout the region. Yet even with transportation budgets at their highest, the transportation systems are able to grow at only a 5% rate and taxpayers are resisting even higher taxes.

A good part of this disparity must be overcome by increasing the efficiency of all funded transportation projects. Fortunately, in Washington state, those responsible for transportation planning and funding have recognized the important role value engineering can play in defining creative, efficient systems.

For more than a decade, the Washington State Department of Transportation, the Port of Seattle (Seattle/Tacoma), and the Sound transit agencies have maintained active, mandatory value engineering programs. The WAMIHT program, using in-house trained staff with both independent facilitators, has applied VE to all major projects, and has diligently tracked the results.

A recently passed initiative is now in design for a multibillion-dollar regional commuter transit system that encompasses light rail, commuter rail and regional bus. This voter initiative failed on its first attempt, but, with the assistance of formal value analysis was reconfigured and succeeded at the polls a year later.

One of the more effective VE programs is managed by the Transportation Improvement Board (TIB), which administers funding for local transportation improvement projects. Although also a member of several transportation VE programs, it is coordinated with the other programs to increase the availability of experienced facilitators and team members. Patrick O'Neill coordinates the TIB program, selecting appropriate projects, team members, and facilitators.

VALUE ENGINEERING AND THE TIB

The TIB is a Washington state agency directed by a 21-member board. The primary purpose of the TIB is to administer state funds for local government transportation projects through municipal accounts. Revenues for these projects come from the state vehicle license tax and the motor vehicle excise tax. Projects are funded by state TIB revenue in combination with local matching funds and private sector contributions.

Legislation passed by the Washington Legislature in 1988 required the TIB to develop rules and procedures requiring VE studies to be performed by an interagency team for certain projects. The legislature also required the TIB to consider project cost, length, and complexity in determining the need for VE studies.

The TIB initially required all funds projects exceeding $1 million in total costs or $3.5 million per mile to undergo VE studies. Staff members also had authority to require studies for projects that were considered to be complex, if it involved major structures, extensive right of way, complicated traffic control or detours, or expensive construction methods. The agency director had authority to waive these requirements if it was determined that significant savings could not be gained from a study. The threshold was recently raised to $2 million in total project costs.

Initially, facilitators were used from the ranks of the Washington State Department of Transportation (WSDOT). While that worked for a while, the board found it took too many WSDOT staff members from their duties and tied up TIB staff in trying to fill teams. In late 1991, the TIB advertised for certified value engineers (CVSSs) to facilitate VE studies on a consulting basis. Six consultants were chosen in the initial round and a seventh was added a year later. Consultants are assigned projects by the TIB staff on a rotating basis.

The average length of a noncertified, facilitator-led VE study was three days, and the average certified facilitator-led VE study was four days. Costs of the studies have not been tracked on a regular basis, but a 1993 survey of 26 studies done by CVSs showed total VE costs ranged from $6,100 to $24,900 per study. These costs included the facilitator, team members, agency support costs, and additional consultants, when required.

The TIB funds projects but does not have responsibility for design or construction of those projects. The local agencies are responsible for design and construction, and have been given responsibility for forming a VE team and contracting directly with an assigned VE consultant.

The facilitator is involved in determining the expertise needed for the team and can be enlisted to form the team. The TIB has no rigid process for the studies themselves but believes implementation is critical. To that end, the local agency decision makers are encouraged to be in attendance at the end of the study for a VE team presentation of findings. The TIB also requires the local agency to address all VE recommendations before funding the construction phase of a project. Recommendations do not have to be accepted by the agency, but rejections must be explained.

The TIB has been involved in doing VE studies since 1985 and has overseen the completion of almost 100 VE studies to date (see Figure 1). Until 1992, studies were conducted by the agencies
Figure 1

Value Engineering Studies
Certified Facilitators vs. Non-certified Facilitators

Figure 2

Value Engineering Studies
Recommended Savings vs. Accepted Savings
receiving volunteer help from other organizations. Since then, the TIB requires certified value specialists be assigned as facilitators.

Of the 22 studies done prior to using certified facilitators, $9.7 million in savings were recommended for an average of $440,000 per study, and $1.6 million in savings were accepted by the agencies. Since then, 70 studies have been led by certified facilitators recommending a total of $105.7 million in savings for an average of $1.51 million in savings per study, while $35.5 million in recommendations were accepted by the agencies (see Figure 2).

One goal of the TIB as a state agency is the completion of quality projects that meet the needs of the local agency. The TIB is not after cheap projects. VE studies are one means being used to accomplish that goal. A major and welcome byproduct of VE has been the dollar savings as noted above. The $37 million savings have been made available to be used by the local agencies for more projects. The return has been well worth the investment of $6,000 to $24,000 per study. 1996 numbers are incomplete as of this writing.

Much of the credit should be given to the local agencies for their cooperation and acceptance of the value engineering process.

Eric Meng, CVS, AIA, leads the architecture, engineering, and research firm MENG. The firm specializes in the design of complex public facilities including education, transportation, and technology. Meng has led more than 350 value analysis studies for buildings, transportation, utilities, ports, construction products, management systems, and environmental remediation. He teaches and facilitates creative value-engineering techniques nationally and internationally. He is particularly interested in the application of VA as a design tool. Eric is active as past president of the Seattle Chapter of SAVE and serves on the board of SAVE International as Vice President–Marketing.

Patrick O’Neill, P.E., has 25 years of engineering experience in the public-works field, the last five with the Washington State Department of Transportation. O’Neill holds primary responsibility for the Urban Arterial Trust Account (UATA) program. He earned his bachelor of science degree in civil engineering at St. Martin’s College in Lacy, Washington, and has been a registered professional engineer since 1976. O’Neill first trained in value engineering in a management training course at Clark County in 1977.

Value Engineering and Partnering in Highway Construction

Kirk Juranas, P.E.

The Missouri Department of Transportation (MoDOT) introduced partnering into the state’s highway construction program in 1991. Since that time, value engineering has been a major area of emphasis that adds value and extends limited resources to accomplish the same function.

The partnering process uses many VE principles. The project teams are brought together representing designers, construction managers, and field personnel from contractors, subcontractors, utilities, local municipalities, and the state. The key concept is working together toward a common goal that is established by the partners. This requires communication of each member’s priorities and the priorities of the public to draw up a partnering agreement that all members support. The use of VE is a key tool for making improvements to the project and is included in the partnering agreement.

VE provides opportunities for the state to control costs and allows the contractor to increase profit. Since the savings benefit all parties, the partnering team can work together to generate and refine cost-saving methods. The diversity of the group provides much of the expertise needed to develop proposals into working alternatives for proposed construction.

This year, the 1996 Marvin M. Black Excellence in Partnering Award from the Association of General Contractors was presented to MoDOT and Fred Weber Inc. for joint achievements on the construction of a new single-point urban interchange at Route 67 and I-55 in Saint Louis County. The project was completed six weeks ahead of schedule, with no fatalities and no unresolved disputes. As a result, MoDOT and the contractor were able to split $600,000 in VE savings. The VE proposals involved changes in the construction staging and traffic control, changes in temporary pavements, and rock-fill base in lieu of stabilizing permeable base.

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Value Engineering in the Transportation Sector

Harlen E. Smith, P.E., CVS

INTRODUCTION

This article will examine the transportation sector with respect to value engineering during 1997 to determine the prospects for VE in this sector.

I will first look at the volume of work expected in the transportation sector by looking at federal appropriations, which give us a yardstick to measure the work expected in this sector in 1997. I also will take a cursory look at the legislation that is intended to advance the requirements for value engineering. In both areas, I will show examples of what we are seeing in our efforts to provide value engineering services concentrated in the transportation sector.

BUDGETS

One encouraging yardstick for measuring the potential for value engineering in the transportation sector in fiscal-year 1997 (FY '97) is the federal budget. In an effort to avoid a government shutdown and demonstrate legislative accomplishments to voters, both Democrats and Republicans put aside their differences and agreed to funding increases for many federal programs, particularly in the area of infrastructure. Congress completed seven of the 13 federal agency funding bills as stand-alone bills, and the remaining bills were rolled into a large omnibus continuing resolution (CR), which Congress approved just hours before the October 1, 1996, deadline.

A summary of FY '97 federal agency appropriations is shown in Table 1.

DOT programs did very well, receiving $1 billion more than FY '96 in total funding ($37.9 billion vs. $36.67 billion). Most major programs did better than last year, and highway and transit programs actually ended up with more money in the final bill than they had in either of the individual House or Senate bills.

- Federal Highway Administration (FHWA). The final obligation ceiling is $18 billion, which is higher than either the House or Senate numbers and $450 million more than the FY '96 level. The total available funding for the highway program is approximately $20 billion, which is also higher than FY '96 figures by $86 million.

The final bill also included $150 million in federal funds for the 10 states selected to participate in the State Infrastructure Bank program. Additional states have six months to apply to participate in this demonstration program.

- Federal Transit Administration (FTA). Total FTA funding of $4.382 billion is also higher than that in the House or Senate bills and $331 million higher than FY '96 funding.

- Federal Railway Administration (FRA). The original House bill made severe cuts in funding for Amtrak and the Northeast Corridor Improvement Program (NECIP). However, in the end, NECIP is budgeted to receive $175 million, $60 million more than FY '96 and considerably better than the zero funding in the House. Amtrak received a total of $223 million for its capital program.

Transportation appropriations on the local level include:

- California. Santa Clara County passed a sales-tax measure to fund a combined highway/transit program that will include funding for light-rail extensions. Measures A and B will impose a nine-year half-cent sales tax. Measure A lists 16 specific projects to be funded. Measure B mandates a half-cent hike in sales tax, from 7.75% to 8.25%. Projects encompass highway improvements, traffic management, and transit.

- Georgia. Gwynett and DeKalb counties passed a sales tax for infrastructure improvements.

- Missouri. A retail sales tax of $0.00125 was passed in Kansas and Missouri counties to repair and restore the Kansas City Union Station, including parking facilities. This tax will raise approximately $18 million.

- North Carolina. A $950 million bond referendum for statewide highway improvements passed in this state. In this package, $500 million will be used to accelerate the construction of outer loops around seven of North Carolina's major metropolitan areas; $300 million will fund improvements to the primary highway system (increasing it to four lanes); and $150 million will be used to pave rural roads.

- Washington. The Seattle Regional Transit Authority (RTA) ballot approved a sales-tax measure to fund a redefined regional transit plan.

- Intermodal Surface Transportation Efficiency Act (ISTEA) II
Table 1 — Federal agency appropriations (capital improvements and infrastructure)

<table>
<thead>
<tr>
<th>FY '96</th>
<th>Agency Request</th>
<th>House Bill</th>
<th>Senate Bill</th>
<th>Final FY '97</th>
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<tr>
<td><strong>Department of Transportation/Federal Highway Administration</strong></td>
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<tr>
<td>Total</td>
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<tr>
<td>ITS</td>
<td>$218 million</td>
<td>$250 million</td>
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<td>State Infrastructure Bank</td>
<td>0</td>
<td>$336 million</td>
<td>0</td>
<td>$250 million</td>
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<tr>
<td>Total</td>
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<td>Plan &amp; research</td>
<td>$85.5 million</td>
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<td><strong>Federal Railway Administration</strong></td>
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<td>Amtrak capital</td>
<td>$230 million</td>
<td>$296 million</td>
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<td>High-speed rail</td>
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<td>Northeast Corridor Improvement Program</td>
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<td>$200 million</td>
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<td><strong>Federal Aviation Administration</strong></td>
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<td>AIP</td>
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<td>Water loan fund/grants</td>
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<td>Construction</td>
<td>$326 million</td>
<td>$439 million</td>
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<td><strong>Federal Emergency Management Administration Disaster Relief</strong></td>
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<td>$320 million</td>
<td>$1.12 billion</td>
<td>$1.32 billion</td>
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<tr>
<td><strong>General Services Administration</strong></td>
<td></td>
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<tr>
<td>Federal Construction</td>
<td>$545 million</td>
<td>$715 million</td>
<td>$540 million</td>
<td>$657 million</td>
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<tr>
<td>Corps Construction</td>
<td>$804 million</td>
<td>$914 million</td>
<td>$1.03 billion</td>
<td>$1.04 billion</td>
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<td><strong>Department of Energy</strong></td>
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<tr>
<td>Environmental restoration</td>
<td>$5.55 billion</td>
<td>$5.40 billion</td>
<td>$5.40 billion</td>
<td>$5.60 billion</td>
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<td><strong>National Park Service</strong></td>
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<tr>
<td>Construction</td>
<td>$192 million</td>
<td>$143 million</td>
<td>$119 million</td>
<td>$165 million</td>
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<td><strong>Military Construction</strong></td>
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<tr>
<td>Trade &amp; Development</td>
<td>$2.72 billion</td>
<td>$2.76 billion</td>
<td>$3.24 billion</td>
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<tr>
<td>World Bank &amp; various development banks</td>
<td>$40 million</td>
<td>$40 million</td>
<td>$38 million</td>
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Value World Volume 20, Number 1, March 1997
Status and Update. The ISTEA of 1991 expires on September 30, 1997. Congress must pass — and the president must sign — reauthorization legislation by that date, or funding for federally aided highway and transit programs will end. The discussion to date on ISTEA II has been general in nature, focusing on broad program structure rather than on specific items.

LEGISLATION

The Office of Management and Budget’s Circular A-131 was revised in 1993. This circular requires federal departments and agencies to use value engineering as a management tool to reduce program and acquisition costs. It also requires the inspector general to perform random audits of federal agencies to determine the level of value-engineering activity. This circular is scheduled for another sunset review in 1998.

The following value engineering bills have been introduced, but not passed:

- H.R. 133, introduced by Representatives Cardiss Collins of Illinois and John Conyers of Michigan
- H.R. 2014, introduced by Representative Leslie Byrne of Virginia
- H.R. 719, introduced by Representative Cardiss Collins of Illinois

As of February 10, 1996, we have Public Law 104-106, the Defense Authorization Act, Section 4306. The newly added Section 36, titled Value Engineering, states that each executive agency shall establish and maintain cost-effective value engineering procedures and processes.

Legislative efforts pertaining to value engineering have definitely affected the transportation sector, not so much because of the legislative mandate to perform value engineering, but because most major transportation sector projects are at least partially financed by government agencies. To qualify for funds, projects will have to comply with the mandates. Legislation by itself will not move people to change but might cause them to begin to take notice. Whatever the case, people are human, and we should not think that they will make changes in the way they work just because of some piece of legislation or because we, as value engineering practitioners, want to help them and their projects become more cost-efficient.

I have recently worked with a number of state Department of Transportation agencies seeking to perform value engineering on their projects and have found that these agencies vary widely in their use of value engineering. Some have embraced it and are using it widely. One agency is planning to increase its annual value engineering studies from approximately 20 to 100 or more. Other agencies either do not use value engineering to a great extent or do not fully understand what they can do, and do not — at least openly — show any signs of changing the way they do business. Some of these agencies say that they have been performing transportation projects in their states for many years without using value engineering and do not see the need to change. Others have had differing experiences with value engineering and are taking somewhat of a cautious wait-and-see posture before committing their projects to this tool.

In the June 1996 issue of Interactions, John Hoving wrote an article titled “The Defense Authorization Act — It’s in Our Hands.” In that article, John writes, “If a Democratic president and a Republican Congress can agree that value engineering is good for American taxpayers, then it’s time for all members of SAVE to vigorously and creatively let government decision makers, businesses and the media know of the importance of value engineering.”

John makes a point here that is very important to us as value engineering practitioners. We seem to be very prolific in our writings and speeches about value engineering. It is time for us to take it to the next level. We need to let the rest of the world know about value engineering and what it can do to help make their programs more cost-efficient and successful.

We must continuously communicate value engineering capabilities and success stories to those decision makers who can do something about it. We need to submit articles about value engineering to industry and professional publications that our clients and government agencies subscribe to and read, as well as to call on them to discuss where they are with respect to value engineering in their programs.

We should not expect to see a tremendous growth in the use of value engineering if we do not actively promote it to those decision makers who have the ability to insist that this set of techniques be used. John concludes this article by writing, “Now is the time you can make a difference. Be proud and vocal about what value engineering can do.”

Now that we have discussed the budget appropriations for FY '97 in the transportation sector and the legislative mandates for value engineering, how does this relate to the prospects for value engineering services in FY '97?

In the article referenced above, John includes the following table, released annually by the Office of Management and Budget and depicting the dollars saved by value engineering in FY '95.

I expect that the same data for FY '96 will be available in April.

Table 2 — Dollars saved through value engineering

<table>
<thead>
<tr>
<th>Federal department/agency</th>
<th>Dollars saved – FY '95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>$734,385,000</td>
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<tr>
<td>Department of Transportation</td>
<td>686,373,874</td>
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<tr>
<td>General Services Administration</td>
<td>109,608,453</td>
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<td>Army Corps of Engineers</td>
<td>59,554,000</td>
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<td>Department of the Interior</td>
<td>22,427,840</td>
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<td>Department of Agriculture</td>
<td>8,764,155</td>
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<td>Department of Justice</td>
<td>5,990,387</td>
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<tr>
<td>Department of Veterans Affairs</td>
<td>2,270,800</td>
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<td>Department of Health and Human Services</td>
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<td>Agency for International Development</td>
<td>800,000</td>
</tr>
<tr>
<td>State Department</td>
<td>91,721</td>
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</table>


or May, and that we will see an increase across the board in the dollars saved by VE. With the FY '97 increases in federal budgets in the transportation sector over the FY '96 budgets previously discussed, and the increased emphasis by legislation to utilize value engineering more widely by federal agencies, I believe this produces an atmosphere that will provide the opportunity and requirement for value engineering to expand its use in FY '97 in all federal agencies, including the transportation sector. Coupled with a perceived interest by most advertisements for major projects to include value engineering, we can be optimistic about the prospects for growth in the foreseeable future.

**FORECAST**

I am not suggesting that all this VE work is going to just fall into our laps. There is much work to be done to help clients wrestle with their many concerns about how to get their projects completed. Value engineering is just one of the tools available to them to help meet their goals.

_We, the practitioners of value engineering, must become more active in helping our prospective clients understand what value engineering can and cannot do for them._

We, the practitioners of value engineering, must become more active in helping our prospective clients understand what value engineering can and cannot do for them. They have questions and concerns that require careful consideration in order to meet all their needs. Recently, we talked to a state transportation agency that does approximately 20 in-house value engineering studies per year. It wants to expand the number of studies to more than 100 per year — not a trivial task. In discussions, the agency seemed reluctant to use outside consultants and has already come to recognize that it has not done more because of its workload. The staff is there to design and manage transportation projects; performing value-engineering studies is not their highest priority. They have streamlined the process so that most studies are completed in less than 40 hours.

Another state transportation agency recently conducted a VE study for the first time in about 10 years. For reasons beyond the scope of this article, the agency took more than a year to decide what to do about the alternatives proposed. In the end, it rejected them all.

As in these examples, there is more involved than just deciding to perform VE studies. Agencies are sometimes wrestling with circumstances on the periphery that affect their entire programs. We need to be prepared to consult with them on some of these situations.

**SUMMARY**

I have tried to give you reasons for optimism about the prospects for value engineering in the transportation sector in FY '97. You have seen FY '97 federal agency budgets compared with FY '96 budgets to show the relative increases in budget appropriations and give some indication as to the legislative thrust for value engineering usage by federal agencies. There are no guarantees; however, we do believe that prospects for VE in the transportation sector are going to be healthy in FY '97.

**REFERENCE**


Harlen E. Smith, P.E., CVS, is the immediate past president of the Dallas/Fort Worth Chapter of SAVE International. He is now serving as Vice President—Administration of SAVE International and has served the society in other positions. Smith is employed by Parsons Brinckerhoff Construction Services Inc., where he is an assistant vice president and manager of Value Engineering Services. Parsons Brinckerhoff has been chosen by Engineering News-Record (ENR) for eight consecutive years as the number one engineering design firm in transportation.
Value Engineering on Commuter Rail: An Owner’s Story

Ginger R. Adams, CVS

In 1995, the firm I work for — VEI, Inc. — was one of several considered to perform a series of value engineering studies for the Fort Worth (Texas) Transportation Authority, also known as “The T,” on the RAILTRAN Commuter Rail project. VEI was fortunate to be selected for the work and conducted three VE team studies over a period of approximately three months. Rather than tell our own story, I am pleased to offer the following, which was published on the Internet in February 1996 by the Federal Transit Administration (FTA). On the FTA Web site, there is a category called “Lessons Learned,” which covers a wide variety of topics related to FTA activities. The ninth lesson is repeated below exactly as it appears on the Web page (except for formatting, which has been modified to fit this article).


LESSONS LEARNED NO. 9 — FEBRUARY 5, 1996

Value Engineering (VE) on Transit Projects

Background

The RAILTRAN Commuter Rail Project extends between Fort Worth and Dallas [Texas] along an existing 34-mile corridor which was acquired jointly by the cities in 1983 from the trustee of the former Chicago Rock Island and Pacific Railroad. The Federal Transit Administration also participated in the acquisition of this real estate. The cities have designated their local transit agencies, The Fort Worth Transportation Authority (The T) and Dallas Area Rapid Transit (DART), to develop the commuter rail services for the cities.

Services are being implemented in several phases. Phase 1, being implemented by DART, extends 10 miles from Dallas to South Irving. Phase 2, being implemented by The T, extends from South Irving to Fort Worth. Phase 2 is comprised of a series of elements:

- An Intermodal Transportation Center (ITC) located at the site of the Texas and Pacific Railway Terminal Building (listed in the National Register of Historic Buildings).
- A 1.5 mile “downtown” connection between the ITC building and the existing RAILTRAN corridor.
- Improvements and additions to the existing rail facilities within the existing RAILTRAN corridor to allow joint use of operations with freight trains and passenger service. This work includes passing sidings, signals, upgraded track, etc.
- Five new passenger stations between the ITC and South Irving.
- Expansion of the Equipment Maintenance Facility developed by DART.
- Acquisition of diesel locomotives and passenger coaches.

At the concept phase, the project had an estimated cost of $101 million (1992 dollars) at completion. Based on a more detailed preliminary engineering work, the estimated project cost increased to $140 million, significantly above what was considered feasible. At this point the planned Value Engineering program was initiated.

Overview

Value engineering is defined as an organized effort to analyze the function of systems, equipment, facilities, procedures and supplies by a multidisciplined group for the purpose of achieving the required function at the lowest total cost. Considerations are given to effective ownership consistent with requirements for performance, reliability, quality, maintainability and safety. FTA guidelines endorse the use of value engineering in analyzing the design and cost effectiveness of federally funded projects.

In keeping with the FTA guidelines, The T, through its standard consultant selection process, solicited proposals for value engineering services to be performed on three of its major design components of the Commuter Rail Project. These components included the Intermodal Transportation Center in downtown Fort Worth, the Downtown Rail Corridor, and the RAILTRAN Corridor.

Following selection of the VE consultant, The T collaborated with the consultant in the development of a customized work program which was tailored to the specific issues and needs of the RAILTRAN/Commuter Rail Project. The five-phase VE process (Information, Speculation, Analysis, Development and Presentation) was followed; however, additional program features were introduced to maximize the VE results.

A Preparation phase was added to familiarize the design consultants and the owner with the VE process and to establish a “team” concept among the design consultants and the owner. A Decision phase was also added following the VE Presentation phase during which the team members discussed each proposal prior to the owner’s decision on acceptance, acceptance with modification or rejection. This was followed by an Implementation phase during which the design consultants confirmed the cost savings of each VE proposal through more detailed estimates. The VE manager then monitors the implementation of the proposals through final design.

Also, each VE team was staffed to ensure that the necessary
specialized expertise was represented. This was considered especially important on this project which included many diverse and specialized components.

**The Lesson**
The Fort Worth Transportation Authority recognized early in their preliminary engineering design that the available budget could not support the escalating costs of the Project and remain debt free. Prudent management decisions lead to the use of value engineering as one means to bring the costs back in line with available funding. An important part of the VE studies included the direct involvement of The T's management staff and design consultants. The design consultants presented the design concepts to the VE team as well as provided them with preliminary design, documents, preliminary estimates and schedules. The VE team made a site visit to each of the project components and was accompanied by the project management staff and consultants who pointed out various aspects of the existing conditions and proposed plans. The VE team then began to develop proposals for presentation to The T and its project management staff.

*Prudent management decisions lead to the use of value engineering as one means to bring the costs back in line with available funding.*

The VE process was successful in identifying cost savings proposals. Proposals that were not accepted, were rejected primarily because they did not maintain The T's program requirements. Many proposals were not accepted as presented but were noted as warranted for further study. All accepted proposals will be incorporated into the project during final design.

There were 87 VE proposals offered for consideration, of which 38 were accepted. The total estimated savings identified by the VE proposals was approximately $11 million. The estimated project cost that the VE team analyzed was approximately $78 million. The percentage of savings equates to approximately 14%. The cost to perform the VE study was $129,000, resulting in a return of $85 for every $1 invested in the studies.

**Summary**
The T's success in achieving a significant reduction in the project cost is attributable to a number of factors:
- A prudent management decision to utilize the VE process was fundamental.
- The timing of the VE studies at the conclusion of preliminary engineering and before final design provided the VE team with the necessary level of design development information and, at the same time, allowed adoption of the proposals without causing serious delays due to lost design effort.
- The establishment of a team concept involving the collaboration of the owner, VE consultant and the design consultant resulted in a cooperative productive effort.
- The addition of formal preparatory and follow-up phases to the basic five step VE process resulted in a complete program designed to deliver the maximum VE results.

**Applicability**
The application of value engineering can be applied to most major Transit Capital projects across the nation. It has proven to be a successful method for reducing project costs while maintaining a project's functional objectives. The success of VE can be maximized by tailoring the basic VE process to the specific needs of each project and by integrating the VE effort into the overall project design development process.

**Reference**
The Fort Worth Transportation Authority Intermodal Project Office, Paul Byrne, Intermodal Project Manager, 817/871-8858.

Ginger Adams is immediate past president of SAVE International — "The Value Society" (formerly the Society of American Value Engineers). Adams has more than 25 years' experience in business operations and management, including 17 years in the field of value analysis/value engineering. A certified value specialist since 1990, Adams is vice president of VEI, Inc., a Dallas, Texas-based value engineering consulting firm, where she participates in corporate financial and management planning.
Can Value Analysis Play a Part in Transportation Research?

Rod Curtis, P.E.

Research is a major component of the transportation industry. One marvels at the efforts expended toward developing new methods and materials, and at the success of those efforts. Those not familiar with the transportation industry might think of it as somewhat staid when compared with the electronics world. Nothing could be farther from the truth!

The transportation industry is constantly changing and needs to keep doing so to have any chance of meeting the challenges we face. This is especially true given the growing difficulty of obtaining resources for the design and construction of transportation infrastructure. The need for infrastructure continues to increase, but the resources available do not keep pace — a familiar theme in the public sector.

The purpose of this article is not to take the reader through a review course of the world of transportation research. Rather, I would like to suggest some opportunities for the use of value methodology in the research field. As is always the case with value work, I am not offering or touting a panacea. Wonderful things are happening in transportation research, and this will continue to be the case with or without the use of value analysis. Responsible value practitioners are not trying to fix a problem, and must constantly struggle to avoid the perception of the know-it-all “efficiency expert,” riding in on a white horse to solve all the world’s problems. Value analysis is, however, a tool well-suited to helping those involved in research get the most for their expended resources and for the taxpayers, who are usually footing the bill. As practitioners, our goal must be to increase the knowledge and usage of this powerful tool. Those of us in the public sector, or working for the public sector, have the added mission of maximizing the value of the taxpayer dollar. I hope that this article encourages experimentation in this area.

A major premise of this concept is that a disconnect is likely to occur between research engineers and their customers in the design, construction, and maintenance sections of state departments of transportation (DOTs). The two groups are likely to work in separate physical environments, and the nature of their work differs significantly. By design, a research environment is somewhat more cloistered and may be closely related to a university. Engineers responsible for design, construction, and maintenance tend to have much more frenetic styles of work, trying their best to do more with less. Some time ago, I conducted an informal survey of research directors for state DOTs around the country. While not all of the respondents perceived that there was a significant problem in this regard, all agreed that value analysis (based on my brief description in the survey) could be helpful in improving their connections to their customers.

There are two aspects of research work that are candidates for the use of value analysis.

The first involves deciding what subjects should be researched. Resources are limited, and ideas must compete for selection for research. At the Arizona Department of Transportation (ADOT), where I work, the research group sends annual requests asking engineers in the design, construction, and maintenance groups to suggest subjects for study. This is a well-intentioned gesture. But, from conversations within the design community, the decisions about what will actually be researched are not necessarily connected in a formal way to the input received from these surveys. Even if the decisions are responsive to this input, how do we, as an agency, know that we are expending our resources on the most important topics and not on the personal agendas of a small number of well-placed people?

... we don’t yet have complete knowledge of how value analysis can function as a part of the agency culture, not just as a separate unit conducting value engineering studies. If we would learn how to do this, connections ... could greatly increase our efficiency, to say nothing of building consensus and teamwork across functional boundaries.

We could use the value methodology, practiced by multidiscipline teams, to surface and prioritize research needs. ADOT recently conducted a survey of more than 30 technical standards to ascertain the opinions of its staff about the potential for value improvement. Now ADOT is following up on the information it received and will soon generate a list of standards on which to conduct value studies. During this process, I became aware that the research group was procuring a consultant to study bridge approach and anchor slabs, which happened to be one of the highest scoring standards on our survey. Checking for overlap, I discovered that the research effort was to be directed only to the joints in these devices, not the overall item. This may or may not be a worthy expenditure, but if the “left hand” knew about the interest in value improvement evidenced by our survey, and the
considerable amount of their time. The latter approach has the consensus among the smaller number of players but may require a has the advantage of developing a stronger expertise and groups, probably with some overlap in membership. The former those functions and other cost data. Or we could use three separate functions to be analyzed, and determining the existing costs of identifying the items to be researched, identifying the specific functions exactly are to be examined, and why? Although proactively searching for new ways to achieve needed functions is a worthy activity, in a world of scarce resources it makes sense to scratch where it itches. To return to the previous example, if we decided to research bridge approach and anchor slabs, we could answer the “what” and “why” questions with a brief value-analysis session conducted by a multidiscipline team of the appropriate players. Are we going to analyze only the joints in these structures? Or perhaps we should critically examine the entire concept. The skills needed to conduct the research may vary greatly, depending on which functions we feel need to be looked at.

Once we know the precise functions that concern us, how much is it costing us today to provide those functions? Again, even though pure research is desirable, we are most of the time seeking lower-cost methods of achieving needed functions. Another possibility, of course, is that we have identified a function we need but is not being delivered today. Precisely what is that function? How much are we willing and able to pay for that function? The no-nonsense rigor of a properly executed function analysis can help the “more with less” folks communicate with the researchers so that both can win.

When thinking about a possible model by which this concept could be built into the research efforts of a public works organization, one key decision clearly needs to be made. We could involve essentially the same people in all three activities, namely: identifying the items to be researched, identifying the specific functions to be analyzed, and determining the existing costs of those functions and other cost data. Or we could use three separate groups, probably with some overlap in membership. The former has the advantage of developing a stronger expertise and consensus among the smaller number of players but may require a considerable amount of their time. The latter approach has the advantage of involving more people in the value-analysis process and may help with the larger goal of including the methodology in the organization’s culture. Either way, the value practitioner should be clear about how the process will work and communicate it to all involved. I have learned the hard way that aspects of value analysis that seem clear and simple can nevertheless fail to be absorbed by key personnel. It may not be rocket science, but it is different than the concepts and approaches that most public works professionals are used to working with. And, for overworked public servants, “different” sometimes means “now not, I’m too busy.”

A very brief model for the incorporation of this concept might be as follows:

1. **Identify research items** — Using surveys, customer feedback, cost models, matrices, and multidiscipline team(s), create a consensus as to what items are worthy of research effort and in what priority.
2. **Identify functions for analysis** — Using function brainstorming and FAST diagramming, determine which functions are in question. Check back with survey respondents and others as needed to ensure that the work is on track.
3. **Determine function/cost/value relationships** — Using available cost model information, assign cost to function and create consensus on targets for research, such as: find a way to provide Functions X, Y, and Z reliably, at a present worth (life-cycle) cost equal or less than $C.
4. **Research effort** — Complete the research work, and check back against the targets and logic developed in earlier steps. Have we really unearthed something of superior value or just something different?

In summary, it is my belief that value analysis methodology uses just the right combination of rigor, logic, creativity, team building, and consensus building to make it an ideal tool for bringing together the disparate worlds of research, design, operations, and maintenance in a transportation/public works agency. I intend to use this brief article as the guide for an experiment in my agency, and I encourage other practitioners to do the same.

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Rod Curtis, P.E., is the value engineer for the Arizona Department of Transportation, a position he has held for more than eight years. He earned degrees in civil engineering and public administration, and has nearly 30 years’ experience in public works engineering and management. Curtis currently serves as president of the Arizona Chapter of SAVE International and as chairman of the AASHTO Value Engineering Task Force. He is currently completing the requirements for his CVS certification.
The following briefs are excerpts from the recently held 1996 Discover Awards to innovators around the world. In the automotive and transportation fields, inventions include a spin-control mechanism, a side-impact airbag, catalytic converters, drowsiness monitors, and Volkswagen's quiet diesel engine. The following text from the July 1996 issue of Discover magazine is copyrighted 1996 by The Walt Disney Co. and is reprinted with permission of Discover magazine.*

**WINNER**

**Spin Control**

**Mercedes-Benz's Electronic Stability Program**

**Innovator: Armin Mueller**

You're driving down the highway and a box falls off the truck in front of you. As you swerve to avoid it, your car might fishtail — what engineers call yaw — and even go into an uncontrollable spin. If this happens, your antilock brakes won't do much good, because they act with equal force to slow each wheel. What's needed are brakes that can be applied to each wheel independently. Engineer Armin Mueller and his team at Mercedes-Benz have devised a braking system, called the Electronic Stability Program, that can be used exactly that way. Its eight sensors, at various positions in the car, keep track of what the driver is doing and how the car is moving, and a watchful central computer looks for the precise set of conditions that indicate yaw.

Once the computer decides the car is sliding or spinning, it automates the brakes to stabilize it. For instance, if the car's rear is sliding to the left, it applies the brake to the left front wheel. On a mixed surface — when one wheel is on, say, asphalt and another is on dirt — the system varies the braking pressure applied to each wheel, bringing the car to a smooth, stable halt. As a last resort, the system slows the car by throttling back or shifting gears.

The Electronic Stability Program is now available as standard equipment in Mercedes' S600 and SL600 V-12 models and can be installed on V-8 models for an additional $1,870.

**FINALISTS**

**Saved by the Sausage: BMW/Simula Government Products' Side-Impact Air Bag**

**Innovators: Klaus Kompass and Gershon Yaniv**

Air bags have succeeded in reducing injuries from frontal collisions, but many head injuries still occur because of inadequate protection from side impacts. In 1993, when BMW Safety Engineering Director Klaus Kompass and his colleagues considered protecting passengers' heads with side air bags, they found that conventional air bags would not do the trick; they were too slow to deploy, the explosives needed to unfurl them were themselves dangerous, and the bags tended to get pinned to the side in a collision, rendering them useless. A radical new design was called for.

Fortunately, Gershon Yaniv, research director at Simula Government Products in Phoenix, had already begun developing a side-impact air bag, which he and Kompass adapted for BMW's cars.

Leave it to a bunch of Bavarian engineers to name the five-foot-long hot-dog-shaped air bag the weisswurst, after their favorite local sausage. Officially known as the Inflatable Tubular Structure, it is pinned on one end to the top side corner of the dashboard and, on the other end, to the ceiling above the door catch. The whole thing tucks up behind the interior door trim.

"Much of the inflation time of frontal air bags is the time they need to unfold," says Kompass. "Our bag inflates in just 20 milliseconds." A small explosion fills the bag with superheated gas, which keeps it inflated for several seconds — long enough to protect the head in cases in which the car rolls.

To make the concept work, Kompass and Yaniv had to develop a balloon that could expand instantly, accept the hot gas without bursting, and be easy to stow in narrow spaces. They also came up with a thin sleeve strong enough to hold the balloon in its wiener shape. "The hardest thing was to make the components reliable and still thin enough," Kompass says.
BMW engineers have put the finishing touches on the Inflatable Tubular Structure in time for the company’s 1997 models.

Body Heat: Ergenics’s and National Renewable Energy Laboratory’s Cold-Start Catalytic Converters
Innovators: Mark Golben, David Benson and Tom Potter
Catalytic converters are good at removing most of the noxious gases from car exhaust, but they have a big drawback: they work only when the car is warm. Consequently, automobiles emit as much as 70% of their pollutants in the first two minutes after starting up. Two engineering companies have independently come up with different ways of solving this cool-start problem and making converters more efficient.

Mark Golben got his inspiration from a newspaper article about a researcher who used an electric heater to warm a catalytic converter to working temperature in a few seconds. Rather than using costly electricity, however, Golben thought of heating the converter with the alloy metal hydride. “When a hydride absorbs or releases hydrogen, the reaction creates instant temperature swings — often dramatic — that are very predictable,” he says.

Golben and his research team at Ergenics in Ringwood, New Jersey, designed a heater to be mounted in the exhaust system just upstream of the catalytic converter. The heater includes two containers of metal hydrides — one at a higher pressure than the other — separated by a valve wired to the vehicle’s ignition key. When the engine starts and the valve opens, the hydride in the pressurized container releases hydrogen, which flows to the low-pressure container and is absorbed. This reaction releases sufficient heat to warm the car’s exhaust to 750° F, enough for the converter to begin working. As the engine warms up and the exhaust temperature rises to 1000° F or higher, the low-pressure alloy heats up and pushes the hydrogen back through the valve to its original container, resetting the mechanism for the next trip.

Golben finished the heating system last summer, and Ergenics is looking for partners to help commercialize it. Expected to cost no more than $100, the heater could be retrofitted to an old car. “Right now our heater assists a vehicle’s catalytic converter,” Golben says. “Eventually, it could become the converter.”

David Benson and Tom Potter at National Renewable Energy Laboratory in Golden, Colorado, took a different approach. They developed a catalytic converter so well insulated that it stays warm almost indefinitely. To trap heat, the converter is surrounded by “vacuum insulation” — two sheets of metal with a vacuum between them — “which works like a thermos bottle,” Benson explains. The half-inch space between the insulation and the converter is filled with an aluminum magnesium alloy, which melts and absorbs heat when the converter gets hot. Later, when the converter cools, the alloy solidifies, giving up heat to the converter.

To keep this well-bundled converter from overheating, Benson’s group also adds a bit of metal hydride to the vacuum layer to help regulate the temperature. As the converter’s temperature rises above 1100° F, the hydride begins to release hydrogen into the vacuum. The hydrogen conducts the excess warmth away. When the engine is turned off and the converter begins to cool, the hydride reabsorbs the hydrogen and restores the vacuum layer’s effectiveness.

In tests, the National Renewable Energy Laboratory’s converter was found to stay warm for 61 hours after the engine was turned off. Since 98% of all car trips occur within 24 hours of each other, that amounts to a possible reduction of more than 70% in auto emissions. “We’re being encouraged by the Big Three automakers,” Benson says. “We’re on a fast track with this.”

Awake at the Wheel: Nissan’s Drowsiness Monitor
Innovator: Hideo Obara
To keep drivers from nodding off, Nissan developed a device back in 1983 that triggered an alarm when the steering wheel moved erratically. But the auto company found that by the time the driver begins moving the wheel, it is sometimes too late to prevent an accident.

In 1990, Nissan Engineer Hideo Obara and his team came up with a way of catching drowsy drivers earlier. They mounted a camera on the dashboard to peer into the driver’s eyes and make sure they were open and alert.

When the driver starts the car, the camera takes a snapshot of his face and records an image of his eyes. Throughout the trip, the camera continuously scans the driver’s face while an onboard computer compares the pictures with the original image to make sure the eyes are still open and that they aren’t drooping or being diverted for too long from the road. The computer uses all this information to generate an alertness rating, and if it falls too low, a loud buzzer startles the driver back to full consciousness. At night an infrared lamp illuminates the driver’s face.

Although the system is still stumped by drivers who wear sunglasses, “the most difficult problem in creating it was helping the computer locate the driver’s eyes and do it within a set period of time,” recalls Obara. “Our technique begins by measuring the driver’s facial outline and then defining the possible areas where the eyes might be.”

Obara and his team completed tests of the drowsiness monitor in 1995, but until there is consumer demand for what would be a pricey system, Nissan has no plans to build the monitor into any of its cars.

Nissan developed the monitor as part of a demonstration of several new safety technologies, including a device that releases a bracing fragrance when the driver dozes, and another that brakes the vehicle and flashes its warning lights if the driver can’t be roused.

Diesel Delight: Volkswagen’s Quiet Diesel Engine
Innovator: Karl-Heinz Neumann
Because diesel fuel is cheaper than gasoline and burns more efficiently, with less carbon monoxide in its exhaust, diesel-powered cars are, in principle, a good idea. The problem is noise. Instead of using spark plugs to ignite their fuel, diesel engines rely on pistons to compress the fuel-air mixture, creating enough heat to set off a loud explosion. A diesel engine would roar like a tank without modifications that end up sacrificing its wonderful fuel
efficiency.

Ever since the U.S. auto industry's brief infatuation with diesel cars in the 1970s, their waning popularity has bothered Karl-Heinz Neumann, the director of diesel engineering at Volkswagen. After studying the problem for 15 years, Neumann and his team of engineers came up with a quieter way to ignite the fuel. Instead of dumping fuel into the cylinder and exploding it in one big bang, Neumann’s method is to squirt in the same amount of fuel but slowly, over a longer period of time. As a result, the fuel burns in a series of small, quiet explosions. Called turbo direct injection, or TDI, this engine ensures more thorough burning of fuel.

To make the process work, Neumann had to devise an elaborate electronic circuit that translates the pressure of the driver’s foot on the gas pedal, and dozens of other factors, into perfectly timed explosions of fuel in the cylinders. A particularly delicate challenge was to design the engine geometry to ensure optimum efficiency — each piston ends in a bowl shape, for instance, to promote better mixing of the fuel. "The amount of fuel the TDI injects is calculated against the precise diameter of the injection holes and also the shape of the hole," Neumann says. "This is the basis of the TDI system."

Volkswagen introduced Neumann’s turbo direct injection engine in its 1996 Passat, which gets 45 miles to the gallon on a highway and 37 miles to the gallon in city traffic — all the while puffing out 20% less carbon dioxide than today’s typical gasoline engine.

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Value Engineering and Product Design

By Paul N. Romani

Recent legislation mandating the inclusion of value engineering provisions in government contracts has opened a new domain. However, the degree of control being applied is already stifling the technique's full potential. It is unfortunate that, many in the value engineering profession are overlooking this fact in their rush to celebrate a legislative victory.

This article has two purposes: to reject the pigeonholing of value engineering solely as a "procurement" technique, and to point out the absence of definitive accountability for value engineering's success in the public law containing provisions for the method.

In a memorandum to executive department and agency heads dated October 15, 1996, Franklin D. Raines, director, Office of Management and Budget, wrote, "the Federal Acquisition Reform Act, Public Law 104-106, section 4306, (which amends the Office of Federal Procurement Policy Act), requires that each executive agency must establish and maintain cost effective value engineering procedures and processes." The term "value engineering" is defined in Public Law 104-106 as: "An analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply of an executive agency, performed by qualified agency or contractor personnel, directed at improving performance, reliability, quality, safety, and life cycle costs." The emphasis on procurement reform is clear.

Nowhere in the act or the definition is there an emphasis on applying the methodology in the design phase of product development. Design is the area where return on investment will be greatest. The value engineering community must reject the time-honored purchasing theory in favor of another that is broader and compatible, but not congruent. To paraphrase Thomas S. Kuhn in The Structure of Scientific Revolutions: "Persons who share the same paradigms are committed to the same rules and standards."

For the value engineering methodology to mature and reach its potential, the purchasing paradigm must be abandoned, and its supporters — both theorists and practitioners — must convert or maintain an open mind when it comes to considering a paradigm with design at its core. Why design? Because it:

- Enhances the utilization of feedback data from usage tests or trial runs;
- Increases the possibility of product or equipment revisions due to changes in the user's needs;
- Allows integration of technological innovation not apparent at the time of the original design;
- May improve product functionality and lower costs in spite of time and money restrictions imposed on the initial design.

Consider the words of Takeomi Nagafuchi, general manager of quality control at Ricoh: "Seventy percent of quality control is determined at the design stage. So, naturally, the biggest effort is made at that stage. If you improve manufacturing only, you won't get much improvement." Nagafuchi knows what he is talking about. He was the project manager who helped win the Deming Prize for Quality Control for Ricoh, the first photocopier company ever to win the coveted award.

John Mayo, vice president of AT&T's Bell Laboratories, sees American industry stranded in what he calls an "inspect and fix" mode. This means that components that fail during tests are simply replaced by better quality (and more expensive) parts. Few attempts are made to redesign products around less expensive components. Thus, final designs released for manufacture commonly exceed budgeted cost. The Japanese redesign for quality. "One Japanese watchmaker found that it isn't necessary to use an expensive quartz crystal to achieve high accuracy in a wristwatch. An inexpensive capacitor could compensate for cheaper crystals without sacrificing overall accuracy," says Mayo.

The messages of both Nagafuchi and Mayo are clear: You can’t inspect quality into a product. The earlier you value engineer a product, the greater are your prospects for an enhanced return on investment.

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How do the Japanese capitalize on design savings? The answer is simpler than one would expect. Product designers tear apart existing equipment (of any type) and thoroughly test every part. A copier with 3,000 parts would require every nut, bolt, and screw to be examined. They believe this is the best way to determine which parts are necessary and which parts can be replaced. For example, Canon replaced the dry toner in its early copiers with an energy-efficient liquid that reduced power consumption from 250 to 110 volts. Minolta retaliated by replacing 27 microswitches with a simpler electronic part. Why? Products with fewer parts are more reliable and cost less to build and operate.

Contrast Minolta's design changes with a design flaw that Xerox faced. In 1960, Fortune magazine named Xerox's model
914 photocopier “the most successful product ever marketed in America.” Two years later, the company made the Fortune 500 for the first time, coming in at 423. Unfortunately, Xerox management made two costly mistakes: It rested on its laurels rather than seeking ways to improve, upgrade, and lower the cost of its product; and it ignored the Japanese and concentrated on besting IBM and Kodak. Humiliation followed, and the Cinderella growth story that accompanied the machine’s popularity ended abruptly.

The 914’s fuser paper had a tendency to catch fire when it came into contact with hot fuser rollers. Since Xerox was the only company in the marketplace with technology to produce images on ordinary paper, continuous design improvement was seen as superfluous. Developmental stagnation proliferated. In case of fire, Xerox urged operators to do nothing and let the fire burn out. Instead of redesigning the fuser rollers, Xerox equipped each machine with a fire extinguisher, which it euphemistically labeled a “scorch eliminator.” The precaution did not placate many customers. To publicize this design defect, Ralph Nader, author of Unsafe at Any Speed, traveled to Rochester, New York, and publicly assailed the Xerox 914, claiming its design was shoddy. He said the 914 in his Washington office caught fire three times during a four-month period.

**With the institutionalization of value engineering, excuses are no longer acceptable. To borrow a word from the Japanese, we should desire to be “dantotsu” — the best of the best — in every business venture.**

In the meantime, the Japanese had captured the low end of the copier market in less than ten years. Executives at Xerox were shocked to find that the Japanese could sell a copier (Canon) at a profit for less than it cost Xerox to make one. Underestimating the Japanese cost Xerox dearly. Its piece of the $25 billion copier market dropped from 82% to 41% between 1976 and 1982. It has since rebounded, but not to previous market-share levels and only after intensive redesign efforts.

Wake-up calls such as this have made American management more sensitive about the distinction between new product research and process research. (Some managers use the terms “pioneering research” and “sustaining research.”) Combined traditional R & D budgets help to obscure these fundamental differences in emphasis. No matter. The important point is that organizations are becoming more aware of the need to link process R & D with new-product R & D, and value engineering can be the key to the link. University of Pennsylvania economist Edwin Mansfield found that “Japanese firms spend fully two-thirds of their R & D budgets on process R & D” — significantly more, he claims, than their American counterparts.

Japan Steel’s Oita Works has as its slogan “001” — for zero accidents, zero pollution, and number one performance. At Toyota Motor Company last year, a half-million suggestions were received from employees about materials savings, general quality, and labor saving. And this was without the monetary incentives such as value engineering change proposals. If the Japanese can do it, we can too. With the institutionalization of value engineering, excuses are no longer acceptable. To borrow a word from the Japanese, we should desire to be “dantotsu” — the best of the best — in every business venture.

Half a century of sporadic use of value engineering methodology in government agencies proves it has merits too valuable to be ignored; however, the management backing needed to support full-fledged value engineering programs has not been present. One reason is the failure of subordinates to follow through on suggestions from busy executives. The illustration that follows is from Jonathan Daniels’ book about Franklin Roosevelt and his cabinet, titled *Frontier on the Potomac*:

> “Half of a President’s suggestions, which theoretically carry the weight of orders, can be safely forgotten by a Cabinet member. And if the President asks about a suggestion a second time, he can be told it is being investigated. If he asks a third time, a wise Cabinet officer will give him at least half of what he suggests. But only occasionally, except about the most important matters, do Presidents ever get around to asking three times.”

Through their actions, managers need to convince staff members of the organization’s seriousness in making value engineering methodology an integral part of the work process. Management also needs to ensure adequate funding. Richard M. Cyert and James G. March theorize in *A Behavioral Theory of the Firm* that most government entities use more resources than actually are required to meet their assigned functions. They term these excess resources “organizational slack.” Most agencies have sufficient resources to divert some of them to the value engineering effort without adversely affecting the accomplishment of their duties.

Value engineering can save a company money. In May 1996, the Hoving Group reported General Accounting Office estimated savings in the 3% to 5% range when value-engineering techniques were used in government programs. These funds alone, if reprogrammed, are more than sufficient to sustain first-rate governmentwide value-engineering initiatives.

In the Fall 1968 issue of *The Defense Management Journal*, George R. Allen and Paul N. Romani wrote, “Management must do more than endorse value engineering and place it in an appropriate organizational unit. Top company officials have the responsibility for establishing and vigorously pursuing definite cost-reduction goals. They also should provide value engineers with access to all company specialists to assure the utilization of the widest possible pool of knowledge in the cost-reduction effort.” Later they say, “Insufficient support by top management, or delays in action on value engineering [change] proposals, will severely reduce the possibility for expanding effective value engineering programs.” What was true then, is true now: Public
Law 104-106 notwithstanding. Spirited support at the top of the organization is central to value engineering’s success. Now, the development and delivery of consumer-oriented quality products may be crucial to the prosperity and economic health of the American economy.

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Paul N. Romani is president of R3, a firm specializing in cost containment, proposal development, and network selection and configuration. Earlier in his career, he served for nine years at the White House — three as deputy director of the computer center and six as director of administrative operations for the White House and the 17 agencies of the Executive Office of the President. He holds a doctorate in public administration and an M.B.A. in information sciences.

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