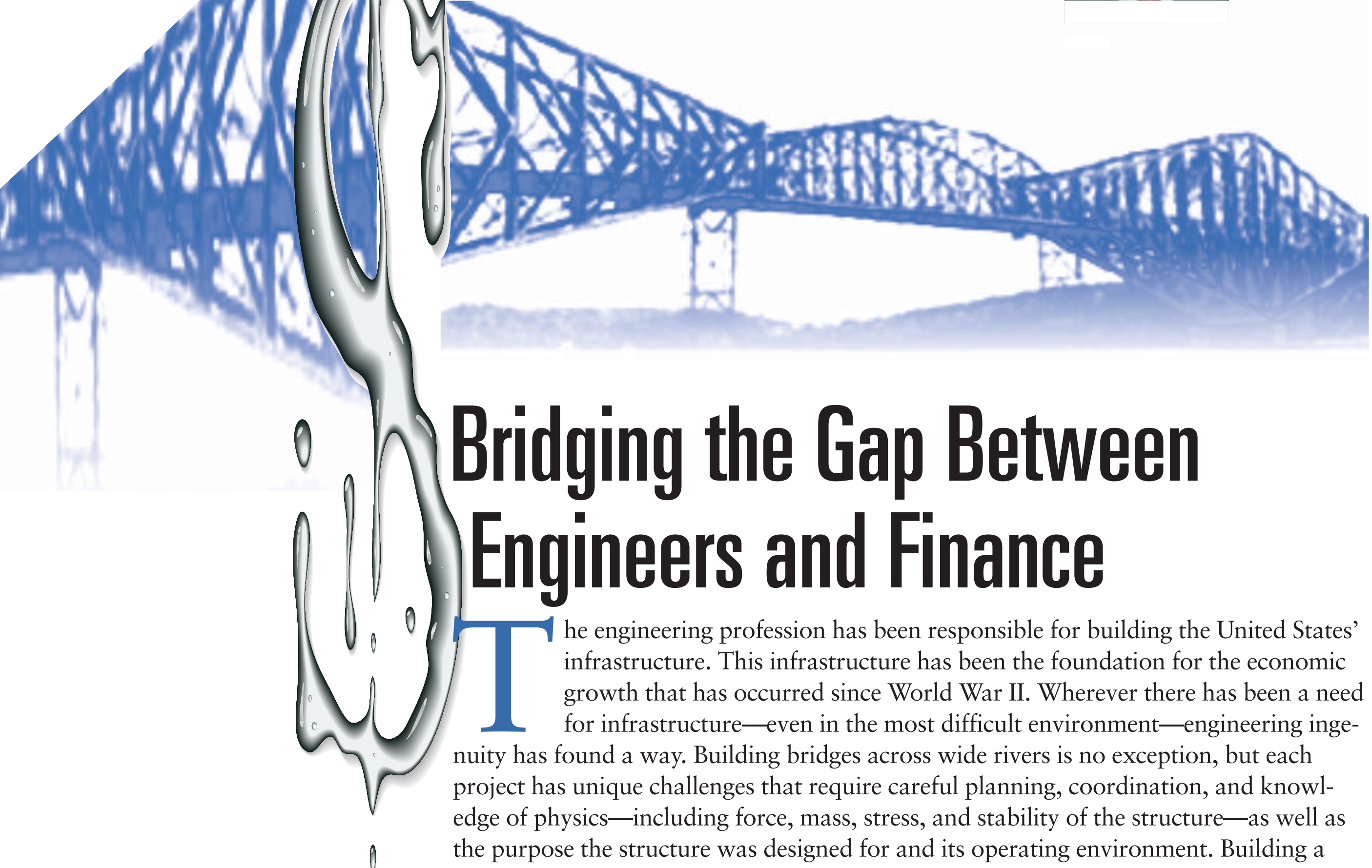
GREGORY M. BAIRD



Bridging the Gap Between Engineers and Finance

The engineering profession has been responsible for building the United States' infrastructure. This infrastructure has been the foundation for the economic growth that has occurred since World War II. Wherever there has been a need for infrastructure—even in the most difficult environment—engineering ingenuity has found a way. Building bridges across wide rivers is no exception, but each project has unique challenges that require careful planning, coordination, and knowledge of physics—including force, mass, stress, and stability of the structure—as well as the purpose the structure was designed for and its operating environment. Building a bridge across the disciplines of engineering and finance is in some ways like building a suspended-span cantilever bridge.

There are five basic types of bridges: cantilever, arch, beam, cable-stayed, and suspension. The advantage of the cantilever bridge is that it does not need a temporary structure to hold the bridge in place. The suspended span bridge has two cantilever arms that do not meet but instead support a truss bridge located in the center (Wallulis, 2010). Each cantilever needs to be built correctly, use the proper resources, and be strong enough to stand on its own, independent of the other. The weight and span of the central truss are critical to the overall design calculations.

For the purpose of this article, the two cantilevers could be considered as representations for engineering and finance, whereas the gap could represent the aging water infrastructure crisis. The entire bridge structure includes representations for all of the practices and joint efforts between these two disciplines to span the distance between the two symbolic cantilevers.

The Québec Bridge over the St. Lawrence River in Québec, Canada, is the longest suspended-span cantilever bridge, and an examination of the history of its construction may offer some insight into the risks, challenges, and rewards of such an undertaking. "The peculiarities of the site made the design of the bridge a most difficult one in 1897. Because the St. Lawrence River was a shipping lane, the 2,800-foot bridge must have an 1,800-foot single span, almost 150 feet above the water, to allow the ocean-going vessels to pass. Further, the bridge was to be multifunctional to accommodate two railway tracks, two streetcar tracks, and two roadways" (Ricketts, 1998).

HOW TO BUILD A SUSPENDED-SPAN CANTILEVER BRIDGE

The bridge must be large enough to support two-way communication, data-sharing, policy development, and both short- and long-term decision-making. In essence, the effort required evaluating and balancing the probability and consequence of various risks with the projected costs both monetary and societal. This effort should be supported and managed at an executive/corporate level and applied to the entire enterprise.

Step One: Measure the distance to be spanned and determine the design of the central truss. The distance between engineering and finance can be assessed by conducting a needs analysis or gap assessment before engaging in an asset-management plan. This assessment will help highlight possible strengths and weaknesses internal to the organization. An understanding of the functions of each organization including the background of the key stakeholders is also an important criterion for selection of the best project team.

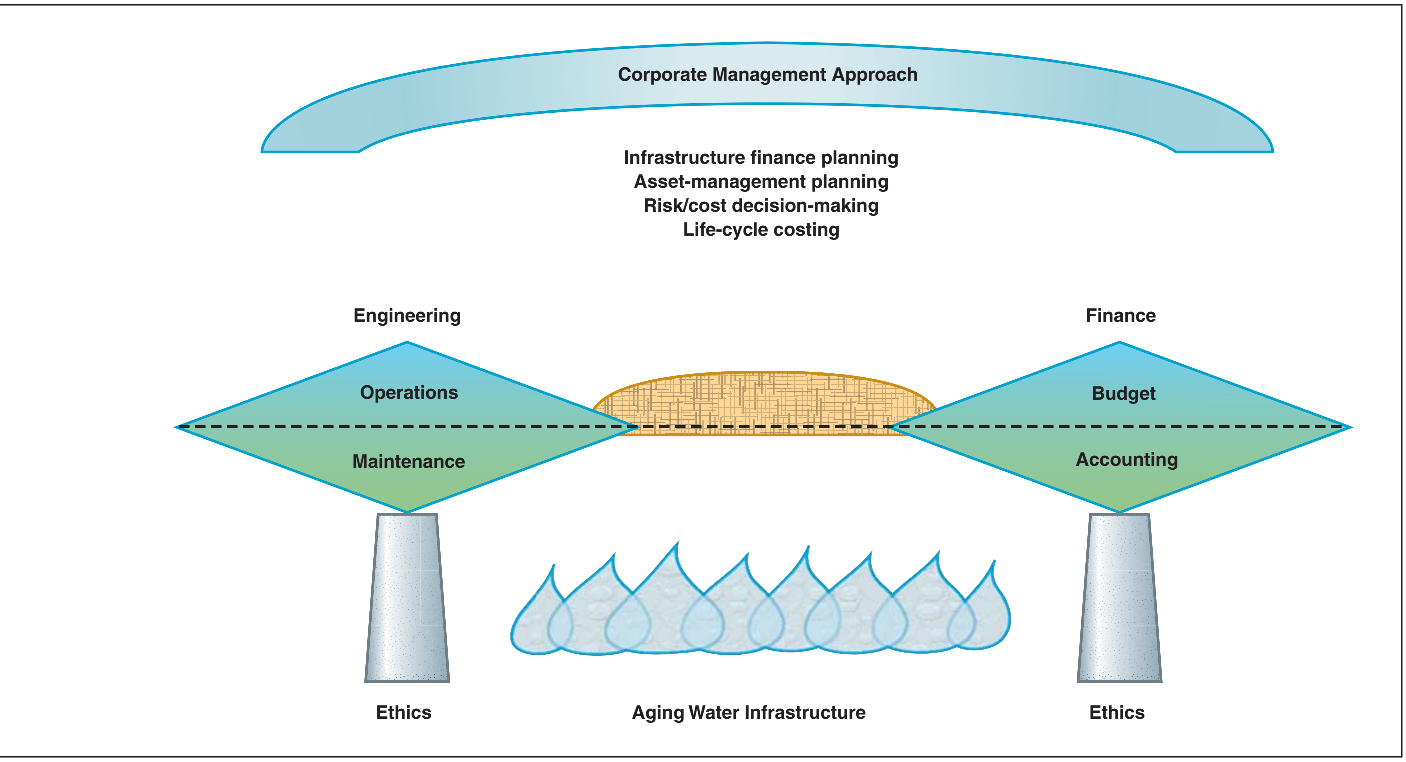
Step Two: Install foundation piers so they provide vertical support for the overall span. At the base of each "cantilever," a solid foundation is required to maintain the force of the load. The commonality for both disciplines lies in their individual strengths related to the practice of ethics as a solid foundation (see illustration below). "The Ritual of the Calling of an Engineer," a practice started in Canada in 1922 (Iron Ring, 2011), and the iron ring worn by many engineers today, stand as symbols and reminders of the obligations and ethics associated with the profession. One rumor about the source of the ring points to the engineering failure of the Québec Bridge in 1907 from poor planning and design, which resulted in the deaths of 75 construction workers (Wikipedia, 2011).

Likewise, the finance profession taking up the ethical and fiduciary duties in its role is best captured by the Government Finance Officers Association (GFOA), which states that the public official members are organized to ". . . enhance and promote the professional management of governmental financial resources by identifying, developing and advancing fiscal strategies, policies and practices for the public benefit. To further these objectives, all government finance officers are enjoined to adhere to legal, moral and professional standards of conduct in the fulfillment of their professional responsibilities. . . " (GFOA, 2011). When each discipline has a foundation of ethical and moral behavior on which the pillars of its organization rests, then the challenge of bridging the gap narrows significantly.

Step Three: Build cantilever arms toward the center of the span and also toward the supporting foundations at the ends of the bridge and attach them to the support piers. The arms that extend toward the supporting foundations are called anchor arms and counterbalance the arms that extend to span the obstacle (eHow, 2011).

The engineering cantilever. Other critical functions and activities exist within each of the overall descriptions of the disciplines of both engineering and finance. Engineering as a symbolic cantilever requires balance and anchoring with maintenance and operations.

Maintenance. In a water utility, the maintenance activities and records that are part of a computerized



maintenance management system (CMMS) and work order system are the most basic components of a maintenance program. Not only should work histories contain important details on the actual activity and asset condition, they should also consider costs and performance data such as planned and unplanned events. The data contained in the CMMS facilitate the prioritizing of asset maintenance based on poor current performance. As cost and work history data are attached to individual asset records, a financial metric and benchmarks can be established to make better resource allocation and replacement decisions. The common benchmarks include

- high unplanned maintenance costs (exceeding 15% of replacement costs),
- high consequence of failure (consequence costs exceed replacement costs),
- high ratio of unplanned-to-planned maintenance (unplanned activities exceed 50% of planned activities), and
- high total maintenance cost (exceeding 20% of replacement value).

Other critical operational metrics include maintaining an 85–95% level of planned work. This is the portion of corrective maintenance work hours that is scheduled in advance by the CMMS, allocating human capital effectively for greater cost savings. The total cost is the planned and unplanned maintenance for each asset. Overtime is another cost factor that must be managed. As a target, only 5–8% of the maintenance work hours should be performed at an overtime rate. Maintenance workers should spend 70–85% of their working hours on productive activities versus rework or waiting for parts. The annual maintenance spending as a percentage of asset replacement value of the plant being maintained should be 1.5–2.5%. The percentage of rework (poor installation and workmanship or incorrectly prescribing a fix) should only range between 2 and 5% (USEPA, 2010). An asset registry is also central to any asset management program or strategy. In the US Environmental Protection Agency (USEPA) workshops on the fundamentals of asset management, the first step is development of an asset registry. An asset registry is a "systematic recording of all assets an organization owns or for which it has responsibility. A registry uses asset identification numbers to which attribute information can be linked" (USEPA, 2010). As a best practice, a geographic information system (GIS)-centric asset registry uses the GIS geodatabase as the centralized location for all asset attributes and condition assessments (Baird, 2010).

Operations. Condition assessment as defined by the Water Environment Research Foundation (WERF) states that condition assessment establishes the current condition of assets as a means of prioritizing and forecasting maintenance and rehabilitation efforts. Condition assessment can also help operators understand the level of asset deterioration and its effect on the probability and consequence of failure (WERF, 2010). Just as maintenance relies on a CMMS, operators rely on supervisory control and data acquisition (SCADA) systems to monitor and control the operations.

Engineering. The success of the engineering cantilever is based on the organizational integrity and coordination within the engineering (capital planning), operations, and maintenance divisions. Asset and infrastructure rehabilitation and replacement planning should include the input of both operations and maintenance to improve design and selection of assets that best perform in the environment while also considering life-cycle costs, energy demands, new regulatory requirements, and community needs. A determining factor in the gap that resides on the engineering side may include the accurate knowledge of the description, location, and condition of the current assets.

The financial cantilever. The actual span of the gap between the engineering cantilever and the finance cantilever many times may also rest with the background of the finance officer and the balancing and coordination within individual finance-related divisions. The financial cantilever is made of accounting, budget, revenue and billing, investments, debt management, and finance (capital funding). Utility finance officers are mobilizing to increase their awareness of asset-management practices and the knowledge required to do their part to address the aging infrastructure dilemma (Baird, 2011). These efforts will strengthen the financial cantilever and improve its alignment with the engineering cantilever.

Accounting. Modern accounting is based in a legacy computer system and hierarchy of codes (similar to an asset registry hierarchy), but is called the chart of accounts. The financial system is the "system of record" and strict guidelines and rules, as well as time-consuming audits, are followed to ensure both the accuracy and completeness of the data. The accounting function focuses on what has happened in the past in order to complete timely financial reporting requirements. These critical accounting data are revered by accountants just as work history is by maintenance personnel. Accounting also has a fixed-asset database to meet reporting requirements of the Governmental Accounting Standards Board. This financial fixed-asset database is not the same as the asset registry or asset inventory, nor should they be (Gauthier, 2011). Accounting, however, only holds one part of the financial process.

Balanced Disciplines

Engineering specific	Finance specific
Civil, managing, environmental, design, capital planning project management, construction	Rates, investment, debt, bonds, reserves, capital funding, cash flow
Operations/supervisory control and data acquisition	Budget control
Maintenance: Geographic information systems, global positioning system, asset registry, work history, inventory	Accounting: Fund types, fixed assets, capitalization, depreciation
Procurement selection	Procurement approvals
Long-term sustainability	Long-term affordability

Budgeting. The budget division primarily deals with the preparation, authorization, and control and monitoring of an annual budget. Budgeters are not accountants, just like operators are not maintenance staff. But, just as operators use SCADA, budget staff apply budgetary controls to funds, departments, programs, and projects to track and report current activities. Although the legal appropriated budget is at the fund level, it is by policy that lower levels of budgetary control exist.

Finance. For a static organization, budget and accounting functions alone may suffice to make a complete department, but most utilities are dynamic in nature and require additional financial services such as investments, debt issuance and management, rate and fee setting, financial and billing systems, and purchasing (engineering can be just as diverse with civil, mechanical, electrical, and chemical specializations). Investment portfolio management requires a completely different background and base of experience than do revenue requirements, cost of service calculations, and rate design. Most finance directors or chief financial officers come from an accounting background, especially for smaller to mid-size organizations. Although this basic training supports good financial reporting and annual debt disclosure, the knowledge of capital planning and funding is still paramount to bridging the infrastructure investment gap. Project planning and funding do not have a past-oriented perspective like accounting data, but rather a prospective view of balancing financing with various kinds of risk. Government accountants and investment managers are, for the most part, risk-challenged and are not rewarded for taking risks. Seasoned financial officers (planners) are comfortable with making a decision after an evaluation of risk and cost. Long-term infrastructure financial planning is more of an art than a science because rate and fee increases, rate stabilization reserves, repair and replacement reserves, credit agency financial metrics, demographic affordability, growth projections, election processes, fiscal policies, project delivery, weather, conservation, low-income programs, cash flow, legal considerations, and debt issuance (timing and sizing) all are orchestrated in a way to achieve relative fiscal and political balance.

Step Four: Insert a central truss bridge between projecting cantilever supports. The truss bridge may be constructed offsite and dropped in place, raised into place, or built onsite. As each cantilever is strengthened to effectively perform its various critical functions, the central truss bridge—designed by the executive asset-management team—can be constructed and carefully set in place. The actual design is defined by the organization's asset-management goals and policies. These policies (while taking into account the capabilities and capacity of each division) should consider open selection and procurement practices for all rehabilitation and replacement materials on the basis of life-cycle costs, finance participation in capital planning, a review of asset capitalization practices, asset valuations and replacement costs, and stakeholder and public communications. These efforts will develop the scope of the asset management plan and the integrated infrastructure financial plan.

Step Five: Attach the projecting cantilever arms to the ends of the central truss bridge with connecting pins. The capital asset-management practices and business processes that are fully supported by executive staff and understood and followed by all parties (maintenance, operations, engineering, accounting, budget, and finance) will create the strength required to balance the load across the entire organization. This process may need to be supported with an upgrade in GIS software, a CMMS with improved asset inspection and condition assessment forms, a benchmark and validation of system operability and control, and a combined hydraulic model/asset criticality analysis software for distribution and transmission systems as well as a total asset-management decision support or infrastructure-optimization analytical software for all assets. Because of the complexity of most water utility systems and their number of assets, technology investments are critical to the success of ongoing asset-management improvement processes.

Step Six: Install the roadway or railway decking, then the roadway or railway itself. The last step ensures that the process is continually being updated, communicated, and improved. Cracks or signs of stress in the decking may be an early sign that a cantilever is weakening or the alignment is shifting. The reality of the nation's aging infrastructure dilemma is that we are only beginning to ramp up our efforts to address the planning and costs. The fact remains that the aging water infrastructure issue will never go away, so our industry must incorporate all of its best practices and available technologies to consistently meet these demands in the most cost-effective manner considering both long- and short-term needs while balancing sustainability with affordability. To do this, the respected and balanced disciplines of both engineering and finance must continually work together to promote asset management as the bridge over troubled waters.

—Gregory M. Baird (greg.m.baird@agingwaterinfrastructure.org) is managing director and chief financial officer (CFO) of AWI Consulting. He served as the CFO of Colorado's third-largest utility with financial oversight on the Prairie Waters Project and as a California municipal finance officer. Baird is a graduate of Brigham Young University's Marriott School of Management with a master's degree in Public Administration. An active member of AWWA, Baird also serves on the Economic Development and Capital Planning Committee with the Government Finance Officers Association for the United States and Canada.

REFERENCES

Baird, G., 2010. Leveraging Your GIS, Part 1: Achieving a Low-cost Enterprise Asset Management System. *Jour. AWWA,* 102:10:16.

Baird, G., 2011. A Finance Officers' Guide to Utility Management. Government Finance Officers Association Ann. Conf. San Antonio, Texas.

eHow, 2011. www.ehow.com/how_2108024_build-cantilever-bridge.html (accessed May 20, 2011).

Gauthier, S.J., 2011. Personal communication.

GFOA (Government Finanace Officers Association), 2011. www.gfoa.org/index.php?option=com_content&task=view&id=98&Itemid=108 (accessed May 24, 2011).

Iron Ring, 2011. The Calling of an Engineer. www.ironring.ca/ (accessed May 26, 2011).

Ricketts, B., 1998. www.mysteriesofcanada.com/Quebec/quebec_bridge_collapse.htm (accessed May 26, 2011).

USEPA (US Environmental Protection Agency), 2010. USEPA Asset Management Workshops. www.epa.gov/owm/assetmanage/assets_training.htm (accessed July 6, 2010).

Wallulis, K., 2010. Types of Cantilever Bridges. www.ehow.com/list_7478681_types-cantilever-bridges.html (accessed May 27, 2011).

WERF (Water Environment Research Foundation), 2010. www.werf.org/AM/CustomSource/Downloads/uGetExecutivesummary.cfm?File=ES-03-CTS-20CO.pdf&contentFileID=15706 (accessed Sept. 24, 2010).

Wikipedia, 2011. http://en.wikipedia.org/wiki/Iron_Ring (accessed May 20, 2011).