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Janis L. Gogan
Bentley College, jgogan@lmnta.bentley.edu

Jane Fedorowicz
Bentley College, jfedorowicz@bentley.edu

Ashok Rao
Benley College, ARao@bentley.edu

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Janis L. Gogan
Jane Fedorowicz
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Ashok Rao
Babson College

JGogan@Bentley.edu

RISK ANALYSIS

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A Strategic Opportunity and a Necessary Evil

Janis L. Gogan,
Jane Fedorowicz,
Bentley College

Ashok Rao
Babson College

JGogan@Bentley.edu

ABSTRACT

McFarlan's IT Project Risk Assessment Framework (Applegate, et al., 1996), identifies three main areas of IT project risk: project size, project structure, and technology familiarity. According to this framework, if two IT projects are of similar size, a project which is designed primarily around emerging technologies will entail significantly higher risks than a project which is designed primarily around traditional technologies. This paper analyzes two comparably sized IT projects. One, a telemedicine initiative at Fletcher-Allen Health Care in Vermont, is designed primarily around emerging technologies. The other, the year 2000 compliance program at the New York Metropolitan Transportation Authority (MTA), is focused primarily on fixing and testing existing systems on traditional platforms. Our assessment identified two additional salient criteria which, when applied to the two projects revealed higher risks at the MTA. These criteria are time constraints (i.e., the immovable deadline of the year 2000) and system interdependence (i.e., the need for applications to share data with other applications, both within the MTA and with numerous external parties). When these two factors are taken into account, it becomes evident that Year 2000 initiatives represent far higher project risks than the emerging technology projects that are considered to be on the "bleeding edge."

KEYWORDS: Risk analysis, cases, strategic opportunity, McFarlan Risk Assessment Framework, Year 2000, telemedicine

I. INTRODUCTION

Many organizations, across a broad range of industries, currently face a dual challenge:

- With great fanfare, they enthusiastically launched strategic Internet initiatives (such as electronic commerce and telemedicine); and

- They reluctantly allocated significant resources to their Year 2000 (Y2K) compliance projects. This work is seen as a necessary condition for survival, but offers little, if any strategic advantage.

An AICPA survey of "Top 10 Technology Issues," released in January, 1999, listed Y2K and the Internet as the two top technology issues for 1999, based on their impact on revenue, organizational and personal productivity and efficiency, and exposure to risk (AICPA, 1999). The Internet represents a significant strategic opportunity to forge new relationships with customers and business partners as organizational and geographic boundaries dissolve (Applegate and Gogan, 1995; Rayport and Sviokla, 1994). In health care, Internet-based telemedicine is expected to transform how patient care is delivered (Gallegos, 1998). Meanwhile, successful resolution of the Y2K problem is critical to organizational survival, even though many senior executives believe that their compliance effort is unlikely to yield strategic advantages (Allen, 1998; Jenkins, 1997; Violino, 1997). Kappelman (1997) reported that Fortune 500 organizations are allocating, on average, 30 percent of their IS budget to Y2K compliance.

Thus, many organizations are simultaneously managing both "strategic opportunity" projects (such as telemedicine) and "necessary evil" projects (such as Y2K compliance). This dual challenge is not merely a matter of resource allocation. Since both kinds of initiatives may be large and complex (Applegate and Gogan, 1995; Freeman and Meador, 1997), each requires careful risk assessment and effective project planning and control. Further, a common framework for assessment would provide a tool for measuring and monitoring riskiness across projects. In this paper, we consider risk to be a function of the likelihood of failure and the consequences of failure; if likelihood and consequences are both high, the project is highly risky.

An IT project risk assessment framework first proposed by McFarlan and reported in Applegate, et al. (1996) notes that IT projects vary along three major risk dimensions: project size, project structure, and familiarity with the technology. Two categories representing the extremes of each dimension illustrate the range of projects the framework encompasses. Figure 1 summarizes the resulting eight risk categories based on the three dimensions (the cells in **bold** characterize the two projects discussed in this paper).

This paper compares two large IT projects to assess the face validity of this project risk assessment framework. One, aimed at a "strategic opportunity" (Fletcher-Allen Health Care telemedicine initiative), appears to fall in the Large/Unfamiliar Technology/Low Structure cell of Figure 1. The other, aimed at a "necessary evil" (New York Metropolitan Transportation Authority year 2000 project), appears to fall in the Large/Familiar Technology/High Structure cell. As we will discuss, the year 2000 project risks are far higher than those suggested by this risk assessment framework. Two new risk dimensions become evident in an analysis of this project. Each project is briefly described next, followed by an overview of the McFarlan Project Risk Assessment Framework.

	Project Size	High Structure	Low Structure
Familiar Technology	Small	lowest risk	very low risk (susceptible to mismanagement)
	Large	**low risk**	low risk (susceptible to mismanagement)
Unfamiliar Technology	Small	medium-low risk	high risk
	Large	medium risk	**highest risk**

Source: Applegate, McFarlan, McKenney, 1996, p. 627

Figure 1. McFarlan's Project Risk Assessment Framework

II. METHODOLOGY

We report on longitudinal, field-based case studies at two non-profit organizations: Fletcher-Allen Health Care in Burlington, Vermont and the New York Metropolitan Transportation Authority (with headquarters in New York City).

At Fletcher-Allen Health Care — Vermont's only tertiary-care teaching hospital -- 13 field interviews were conducted, as follows:

- In summer 1996, exploratory interviews were conducted with three individuals: the CIO, a physician who was participating in an early pilot test of a telemedicine system, and the technical coordinator of this telemedicine initiative. The purpose of these interviews was to discover the goals for the telemedicine initiative, project readiness, steps that had been taken thus far, and anticipated implementation challenges.

- In spring 1997, semi-structured interviews were conducted with the CIO, three physicians, two nurses, two technical specialists, and two patients. These interviews were directed at reviewing the steps that had been taken by that time to induce physicians at Fletcher Allen and at rural hospitals and clinics in its catchment area to try to use the technologies that had been made available to them. Interview questions were also directed at identifying technical, organizational and other challenges that had arisen in the early stages of this initiative.

At the New York Metropolitan Transportation Authority (MTA), the following interviews were conducted:

- Semi-structured interviews were conducted with five individuals from MTA headquarters in fall 1996 and winter 1997.

- Semi-structured interviews were conducted with nine individuals from MTA's two largest operating agencies (New York City Transit Authority and Long Island Rail Road) in fall 1996 and winter 1997.

- In addition, documents associated with MTA and agency year 2000 initiatives were examined (including memoranda, Y2K project plans, requests for proposals, and minutes of the MTA Inter-Agency Year 2000 Work Group from its inception in February 1995 through February 1997). Two meetings of the Inter-Agency Year 2000 Work Group were also observed.

Interview and meeting transcripts were produced from all of the data-gathering efforts at FAHC and MTA, and these were augmented by an extensive literature review on both organizations. Each case is briefly introduced below, before analyzing them within the structure of the McFarlan framework.

III. A STRATEGIC OPPORTUNITY: FLETCHER-ALLEN HEALTH CARE'S TELEMEDICINE INITIATIVE

Fletcher Allen Health Care (FAHC), Vermont's only tertiary-care teaching hospital, is promoting video-conferencing and other telemedicine technologies in its catchment area, consisting of Vermont and six New York counties. An ambitious $30 million technology initiative was funded in 1996, with $17 million allocated to enhancing Fletcher Allen's IT infrastructure and decision support capabilities, and $13 million allocated to development of a regional telemedicine network. In a case study about the initiative (Gogan and Guinan, 1997), the CIO states that telemedicine will be critical to FAHC's successful transition to a system of "capitation" (prepaid managed care) because it enables improved services at reduced costs. In fall, 1997, the telemedicine project was at the pilot stage, involving 15 remote sites. Usage statistics indicated that use of telemedicine systems for continuing medical education was increasing, but usage for medical consultations was declining slightly. In 1998, management planned an ambitious roll-out of telemedicine stations (personal computers equipped with video-conferencing cameras and software) to 600 physicians' offices and additional remote sites, as well as the development of numerous software applications.

IV. A NECESSARY EVIL: METROPOLITAN TRANSPORTATION AUTHORITY'S YEAR 2000 PROJECT

Another case study (Gogan and Fedorowicz, 1998) describes the New York Metropolitan Transportation Authority's (MTA) Y2K software compliance projects from 1995 to 1997. The case notes: "If not fixed, the Year 2000 software problem would give rise to a host of inaccuracies and various systems failures. For MTA and its five semi-independent operating agencies, the cost to repair systems was estimated at $25 to $30 million." The case describes how the five

agencies' IS departments worked with the MTA headquarters IS organization to coordinate their planning, assessment, coding, and testing efforts (hereafter, these four activities will be collectively referred to as “Y2K remediation”). The largest agency, New York City Transit Authority, with 38,000 employees, accounted for 65% of the total MTA budget. Its Y2K project was to involve conversion of at least 11 million lines of code in 73 applications. The year 2000 project proposal for this agency stated that, if not rectified, the Y2K problem could have serious impacts, including the following (a subset of their extensive list):

- *“Revenue*: Automated Fare Reporting and monthly posting process will be disabled.
- *MSA Payroll:* Inaccurate paychecks, due to incorrect age calculations, causing deduction calculation errors...This will be a total nightmare.
- *Suspension:* Inaccurate calculations of suspensions, with incorrect paychecks.
- *Subway Signals:* Automated scheduling of inspection and servicing for signals and relays will not function. Calculation of last maintenance and time between inspections will be inaccurate, as will maintenance history reports. This will result in a less safe subway system, with more delays, accidents, and lawsuits.
- *Track Walker Inspection:* Time intervals between track inspections will be calculated wrong. Management will have difficulty complying with biweekly inspection of track, and will be unable to track substandard conditions throughout the subway system. There will be a reduction in the level of safety and in the state of repair.”

Thus, while Fletcher-Allen management saw the telemedicine project as an important strategic opportunity to essentially invent new modes of quality

healthcare, MTA management viewed the year 2000 projects as imperative, but offering little value-added – i.e., a “necessary evil.”

The next section discusses the elements comprising McFarlan's IT Project Assessment Framework, and the uses to which it is typically put.

V. McFARLAN'S IT PROJECT RISK ASSESSMENT FRAMEWORK

IT projects (to modify, develop or acquire systems) range from small and simple to large and complex. As discussed above, Applegate, McFarlan and McKenney (1996) note that projects may be compared along three key dimensions: project size, project structure (or degree of definition), and experience with the necessary technologies. The questions in Figure 2 (below) help managers identify project risks and measures to control risks.

Risk Dimension	**Key Questions**
Project Size	How much will it cost? Expected work-hours? Number of departments involved? Estimated time to completion? Can it be carved into smaller, manageable sub-projects?
Project Structure	Are the project inputs, outputs and data requirements clear? What is the severity of expected user-department procedural changes? What is the degree of needed organization structural changes needed? How much do we have to build ourselves? Can we buy some components off-the-shelf? To what extent can structure be imposed on this project?
Experience with the Technology	Are the necessary hardware, software and network tools new to us? If so, can we hire people who have the necessary expertise? Do the vendor(s) involved have a track record with these technologies?

Figure 2. McFarlan's Risk Assessment Framework: Three Risk Dimensions

The above-stated questions can help managers identify risks associated with a particular project, and serve as a guide for the identification of possible measures to reduce or control those risks. Since most IS organizations simultaneously manage multiple initiatives, it is also considered prudent to achieve a "balanced portfolio" of projects (ranging from small, simple, low-technology projects to large, complex, high-technology projects).

Thus, there are two complementary uses of the McFarlan framework:

- An IS organization's "project portfolio" can be assessed according to dimension-specific and over-all risk, leading to resource-allocation decisions (including "pulling the plug" on projects if the over-all level of risk is deemed untenable).

- For each initiative, appropriate project management mechanisms can be identified to address the specific risks in each of the three categories.

"Strategic opportunity" projects (especially those involving emerging technologies) typically entail higher risks than projects of similar size that involve conventional technologies. The project team may not have experience working with the necessary technologies, and/or the applicable vendors are not well established and may not be viewed as reliable. In addition, the structure of strategic opportunity projects typically emerges from prototypes, whereas established projects have an existing structure to guide development efforts. These observations would lead us to infer that the FAHC initiative entails higher over-all risk than the MTA's year 2000 initiative. FAHC's telemedicine project relies on widespread use of Web-based video-conferencing, which is not yet in common use. In contrast, the MTA's systems are old, and many are being retrofitted using software and hardware that has been in place for years.

However, as we will explain, the MTA year 2000 project actually entails very high project risks, which come most sharply into focus when two additional risk dimensions are taken into consideration.

VI. RISK COMPARISONS

PROJECT SIZE

Each project has a budget of nearly $30 million, which would indicate that they are of similar size. Other aspects of project size are noted in this section.

The Fletcher-Allen telemedicine initiative is a complex set of projects involving numerous parties. The roll-out of video-conferencing stations is but an early step toward a form of data-rich telemedicine in which caregivers on either side of a medical consultation will have real-time access to a fully integrated patient medical record. In fall 1997, only a handful of physicians and nurses were involved with the telemedicine project. Half of eighteen clinical departments had utilized telemedicine for at least one medical consultation, but only three departments used it on a regular basis. In the 1998 rollout many more caregivers, in several more departments, were to be brought into active involvement, with an ultimate aim of involving the hospital's 250 resident physicians, 380 medical students, and 380 nursing students.

The MTA initiative is also a complex set of projects involving numerous parties (five agencies, software and hardware vendors, etc.). Thirty people regularly attend meetings of the inter-agency work group, and report back to teams in their agencies. The case suggests that this project is not unusually large, compared with other MTA projects. For example, some 40 project managers at New York City Transit Authority worked on 500 separate capital improvement projects involving 4,300 employees. Several IS development

initiatives had $15 million price tags. However, the case also reports that the MTA has been heavily criticized for ineffective project management in the recent past. Hence, this organization may not, as yet, have developed the capacity to learn from its extensive experience in managing large projects.

The FAHC and MTA projects both involve large numbers of target users. The FAHC project can be managed in small deliverables (such as utilizing it in a sub-set of medical specialties, or limiting the number of remote sites). MTA also can identify each system to be made Y2K compliant as a small sub-project. We will show in our later discussion that interdependence complicates dividing the Y2K projects in this fashion. But, we can say there are some limited opportunities to sub-divide.

Over-all, the two projects seem comparable when compared on the dimension of project size. The MTA project might be slightly more risky as there are fewer opportunities to sub-divide the project.

PROJECT STRUCTURE

The goal of the FAHC project was quite open-ended: "to return to the patient-centered, efficient values of the country doctor with the technology of the 21st century." The CIO envisioned giving caregivers and patients advanced video-conferencing capabilities for "any time, any place" interactions. Some project requirements were well-specified (e.g., FAHC campus network, video conferencing architecture, Internet information access). Other elements (e.g., enhanced e-mail applications and an expert system effort) were not well-specified. Once physicians are comfortable with video-conferencing, they will want to have access to a patient's complete medical record during a consultation. To that end, it was expected that an enterprise-wide Master Medical Index would eventually be integrated with an enterprise-wide Patient Data Repository, giving rise to an enormous data-integration challenge. The

CIO's expansive vision was far ahead of actual practice to date, creating the potential for unrealistic expectations to be created in the minds of physicians or administrators. This loosely defined project gives rise to a challenge to manage constituents' expectations realistically.

The MTA project appears to have a clear goal: find and fix date-sensitive code, using a systematic life-cycle approach consisting of the following steps: inventory, assessment, conversion, testing, and migration. This approach would suggest the project is highly structured. But a closer look reveals that in some respects the project also suffered from a lack of clarity. In February 1997 the MTA project scope was expanding significantly. Some systems replacement projects were behind schedule, forcing 5 million additional lines of code (in systems that were originally slated to be replaced or retired) to be included in the Y2K remediation effort. Management also began to recognize that end-user computing would have to be addressed, as would processors embedded in various devices (in elevators, climate-controls, and other equipment).

Both the FAHC and MTA projects suffer from a lack of clarity. At FAHC, lack of clear definition leads to a risk of unrealistic expectations, which could result in excessive project costs and delays in gaining the commitment of necessary stakeholders (especially physicians located at remote sites). At MTA, the risk was accentuated as management recognized the need to consider other systems and embedded processors. We would estimate the risk at the MTA due to project structure as being moderate while at FAHC the risk level would be very high (since the telemedicine project is very loosely defined and structured).

EXPERIENCE WITH THE TECHNOLOGY

At FAHC, many technologies must be harnessed for telemedicine to reach its potential, including wide- and local-area networking, video-conferencing equipment and software, expert systems, and data integration. Of these, data integration is seen to represent the greatest technical risk. The case states that FAHC's IT architecture was characterized by "incompatible administrative and clinical systems, many of which utilized outdated technologies." The hospital's clinical information systems are especially complex. The patient medical record will need to be integrated with dozens of organizational units and laboratories (e.g., radiology and pharmacy), to generate a correct bill, measure effectiveness of care, and answer medical research questions. Ideally, all images from radiology and elsewhere will be integrated with the patient record. Once physicians are comfortable with video-conferencing, they will want to have online access to the patient's complete medical record during telemedicine consultations. Yet, the "holy grail" of a completely integrated online patient medical record has yet to be fully achieved at any hospital, anywhere.

The telemedicine network itself represents a less complex challenge, thanks to improved technologies for routing data among varied networks and systems. FAHC's project has a movable target, from a platform perspective, in that the project specifications are fluid enough to accommodate innovation as new technologies are proven in and demanded by the marketplace. For example, the project is now moving to a Web-based video transmission platform. Once each party has access to a high-speed network, the installation of video-conferencing capabilities is fairly straightforward, due to widely accepted standard protocols for video communications and availability of relatively inexpensive equipment. Fine-tuning network performance under varying demand conditions will be a challenge, since physicians are not willing to use an unreliable system when patient outcomes are at stake. However, the line

capacity problem involves relatively simple issues in comparison with data integration. Short term, it is only necessary to capture still or video images at one site and transmit them without distortion to another. Long term, this capability is to be integrated with the patient medical record and with diagnostic expert systems.

Updating legacy systems at the MTA will not require the use of leading-edge technologies. However, many tools for identifying, converting, and testing date-sensitive code are new to both the MTA and the market in general. The All-Agency Work Group is a useful mechanism by which the agencies and headquarters shared information about these tools, and helped each other to quickly identify, evaluate, select and utilize appropriate tools.

Usually, consideration of technology familiarity helps focus attention on the challenge of utilizing leading-edge technologies in the face of a limited supply of personnel who have experience with them. But, for many Year 2000 initiatives, the key issue is finding people who are experienced with the *older* programming languages and operating systems that comprise many legacy systems. A scarcity of COBOL programmers is a major concern. Furthermore, in 1997, under time pressure, they started to consider the use of a software logic/windowing approach for date conversion[1]. The increased use of windowing amplifies concerns about technology familiarity, since programmers must both understand COBOL and have a relatively deep understanding of how an application works (Fedorowicz and Gogan, 1997). The MTA is also using the Year 2000 crisis as an opportunity to replace several older systems with new,

[1] In "fixed-pivot windowing," date-sensitive code is altered so that, when a call to a year field yields a number greater than a pre-defined "pivot year," the software returns a result preceded by "19;" if the number is less than the pivot-point, the software returns a result preceded by "20." Thus, if a pivot year of 30 is set, then numbers less than 30 will be read as occurring in the twenty-first century, and numbers 30 or greater will be interpreted as occurring in the twentieth century. "Sliding pivot windowing" applies a different pivot-point depending on the system date. For further explanation, see deJager and Bergeron, 1999; Fedorowicz and Gogan, 1997 and Frankel and Gehr, 1997.

state-of-the-art, client-server systems, for which they have no internal development expertise. Thus, although at its outset it appeared that the year 2000 project would entail largely familiar technologies, actual experience revealed several key areas of the project that involved unfamiliar technologies.

As summarized in Figure 3 (below), comparison of the two projects using the McFarlan framework leads to the conclusion that, over-all, the two projects entail rather similar risks, with Fletcher-Allen slightly higher over-all. Next, two additional risk factors are discussed, which lead to a different conclusion.

	Fletcher-Allen	**MTA**
Project Size	Large, but can be sub-divided into smaller deliverables. *Risk: Moderate*	Large but getting larger, with fewer opportunities to sub-divide. *Risk: Moderate - High*
Project Structure	CIO vision is very ambitious and open-ended, therefore loosely structured. Danger of constituent backlash due to unrealized expectations. *Risk: Very High*	Project involves converting existing systems, therefore a high degree of structure. But scope is expanding rapidly, and fundamental assumptions are challenged (e.g., expansion versus windowing, replace versus remediate). *Risk: Moderate*
Technology Familiarity	Although new to FAHC, the technologies required for the first phase are known and manageable. Subsequently, multimedia data integration technologies will represent very high risk. *Risk: In 1998 and 1999, Moderate; in 2000 and later, Very High*	Project primarily involves converting old systems, but a shortage of COBOL programmers raises risk. Automated Y2K tools, while not complex, are new. Project success also hinges on successful completion of replacement projects, which are based on new client/server technologies. *Risk: High*

Figure 3.Comparison of Project Risks based on the McFarlan Framework

TIME AND INTERDEPENDENCE

Two dimensions that significantly raise the level of project risk faced by the MTA are time and interdependence. These risks are not specifically considered in the McFarlan framework but they impact each dimension he outlined.

Time constraint: The MTA Y2K project is time dependent. Since all systems have to be compliant by 2000, the MTA has to inventory all of its existing systems and determine those that need to be made compliant. While they knew of problems with embedded processor chips, they couldn't determine the number that had to be fixed until they started to test. The result: a large project that is getting larger.

In addition to impacting the project size, the immovable deadline adds complexity to the project structure. Systems developers often try to avoid "scope creep" by deferring requests for added functionality. In Y2K projects, however, the scope must be allowed to expand in order to avoid date-related systems failures that might arise within the organization's own portfolio of systems, as well as within systems of other parties with whom data are exchanged (see “Interdependence,” below). The only other viable option is to discontinue the function or service that is supported by a non-compliant system.

The time constraint also forces the MTA to use subcontractors for some of the work. For an enterprise that relied primarily on internal systems development and maintenance resources, building the capability to manage an external workforce is a significant challenge.

Time constraints can also affect project structure because of the necessity to utilize a methodology different than what had been planned. In the case of

MTA this was evidenced as a change from the initial plan to use a “date field expansion” conversion methodology (expand date fields from two digits to four digits). As noted above, in 1997, under time pressure, they started to use “windowing” for date conversion.

One might argue that the severe time constraint gave the MTA organization a sharp focus on the Y2K project, and caused them to defer other, lower-priority projects. Although this did happen, the Y2K problem was also used as a rationale to accelerate work on several new systems development projects. The high estimated costs of fixing several large outdated systems led management to decide to replace them instead with new client-server systems that would already be Y2K-compliant. While it made sense to upgrade to newer technology, these client-server development projects were also large and complex, and (as could have been predicted by the McFarlan model) several of them fell behind schedule. Absent a time constraint, these replacement projects could have been allowed to continue. Instead, recognizing that the replacement projects might not be completed by the end of 1999, management had to "bite the bullet" and require that the existing systems undergo Y2K remediation as well, even though it was expected that some time in 2000 they would be replaced by the client-server systems.

At Fletcher-Allen Health Care, there was no particular time constraint on the telemedicine project, and this worked in their favor. Telemedicine consultations are not covered under current insurance reimbursement plans, so consulting physicians taking part in the prototyping phase are essentially volunteering their time where the patient is otherwise covered by today's insurance plans (the physician at the remote hospital, where the patient is, would be reimbursed. The physician at Fletcher-Allen, who provides the telemedicine consultation, would not be reimbursed.) Eventually, reimbursement is expected to move to a capitation-based scheme, under which the amount of

reimbursement will depend on the number of participating subscribers, not on the specific services provided. Telemedicine provides an inexpensive method of reaching remote areas, and thus is consistent with capitation economics. However, because the transition to capitation is taking place more slowly than originally expected, delays in system implementation may actually result in higher participation interest once the system is fully operational. Technology options also improve as the telemedicine project extends later into the future, and the costs of leading-edge technologies will decrease as well.

Thus, time delays may actually work to Fletcher-Allen's favor. The telemedicine initiative *as defined by the current project manager* will be "completed" once all designated remote sites are engaging in telemedicine-based applications with Fletcher-Allen physicians on a regular basis. It appears that this goal will be reached by the end of 1999 or early 2000. On the other hand, one can argue that the lack of a time constraint can also lead to a lack of management discipline regarding project focus. As was noted above, the CIO articulated quite an expansive vision for future applications of telemedicine. Over time, this vision can lead to extensive scope creep, which in turn can lead to excessive consumption of project resources, with few tangible benefits. Thus, subsequent telemedicine projects based on the CIO's vision of "any time, any place" medical care, supported by a fully integrated patient record and sophisticated knowledge-based software tools, stands a great risk of never being fully completed, if lax management discipline allows scope creep to accompany a flexible deadline.

Interdependence. As companies have developed systems and connected them to other systems within the company and outside there has been a growing interdependence. Interdependence greatly adds to the complexity of the Y2K project. An approach used to reduce project size is to

defer non-critical functions. As the MTA tried to identify systems that could be deferred, they found interdependencies that limited their options.

Interdependencies also make it more difficult to carve up projects into smaller sub-projects. Since the date-sensitive output of one MTA system had to feed another it became important to perform Y2K remediation in appropriate sequence and with consistent technology. In addition to testing each system by itself, extensive end-to-end testing had to be done across all interrelated systems.

Perhaps most risky to the MTA was the dependence on outside suppliers. After checking if outside suppliers of information, software, hardware, and services intended to become Y2K- compliant, the MTA would have to check if those systems were indeed compliant when connected to those of the MTA. Many suppliers claimed they would be compliant by mid to late 1999. This places tremendous stress on the project structure as end-to-end testing and debugging of these large interrelated systems will have to be done close to the deadline.

Interdependence also had a significant impact on the underlying technology. With no interdependence a system can be taken off line, fixed and tested, then synchronized to make its data base consistent with transactions that may have occurred during the time it was off line. Because of extensive interdependence, the MTA systems cannot be simply taken off line; they need to continue functioning with links to other systems. Therefore, software "bridges" had to be constructed and later dismantled.

Another example of interdependence affecting technology occurs when a system has been working for years on an old computer with its old operating system. The manufacturer of that hardware and software typically converts

systems to make its new equipment Y2K compliant but would decline to upgrade the old. The MTA then had to adopt the new version of the technology and rewrite their systems to be compliant with it. In several instances, the MTA had to undergo multiple upgrade installations to "catch up" to the Y2K-compliant version.

Altogether, this myriad collection of interdependencies increases the risk factor of completing the project successfully, completely, and on time.

Thus, two additional factors seem to amplify the risks of managing this very large project at the MTA: a severe time constraint and a high degree of systems interdependence. In contrast, these two factors are in far less evidence at FAHC, initially, although the risk of systems interdependence is likely to increase sharply at FAHC in later phases of the telemedicine project.

The early phase of the FAHC project (which was the subject of the current study) incorporates videoconferencing over the Internet. This phase of the project relies on existing open protocols that greatly simplify the interchange problem, so that interchange risk at this stage is low. A second phase of the project will entail adding images to the shared data. The imaging system employed for this level of sharing also involves a low level of risk, as a common imaging system will be adopted for use at the remote sites. The project received a grant that covers the cost of these systems, allowing image sending and receiving organizations to employ a common technology base. The only exception to the use of standardized imaging systems will be when specialized equipment may need to be added to the common configuration, which will be a rare accommodation.

A later phase of the FAHC telemedicine project (post-2000) will depend on implementing a common data structure that integrates medical and

administrative data. Integration will entail very high risk in the long term, both because no medical facility has ever succeeded in this, and because the FAHC data must match across all organizations involved in the telemedicine activities. This system cannot be rolled out as a prototype because a great deal of planning and data cleansing will be necessary before it can be adopted. This activity must succeed immediately upon implementation, and carries very risky consequences if it does not work.

VII. MANAGEMENT IMPLICATIONS

Managers are intimately familiar with the risk-vs.-return tradeoff on which feasibility studies depend. Many managers, and researchers alike, focus on the expected return of projects, ignoring or overlooking the importance of a significant risk assessment. Riskiness is less measurable than return, so that many project studies underplay this aspect of decision making. A risk assessment framework -- like the modified McFarlan framework which is proposed in Figure 4 -- would provide a valuable evaluative and comparative tool for examining individual and portfolios of projects.

TIME CONSTRAINT

By definition, all year 2000 projects are time-dependent (except in the very few organizations where the threat of Y2K failures was identified and resolved early). Although a tight deadline can have a positive effect (by forcing an organization-wide focus on priorities and by reallocating resources away from lower-priority projects to the Year 2000 project), this study demonstrates several ways in which the immovable deadline increased Y2K project risks. For the MTA, system performance and cost considerations were forced to take a back seat to scheduling, as the deadline drew near. Thus, MTA management had to decide to utilize a windowing approach for much of the date conversion, even though

	Fletcher-Allen	MTA
Project Size	Large, but can be sub-divided into smaller deliverables. *Risk: Moderate*	Large but getting larger, with fewer opportunities to sub-divide. *Risk: Moderate - High*
Project Structure	CIO vision is very ambitious and open-ended, therefore loosely structured. Danger of constituent backlash due to unrealized expectations. *Risk: Very High*	Project involves fixing existing systems, therefore high degree of structure. But scope is expanding rapidly, and fundamental assumptions are challenged (e.g., expansion vs. windowing, replace vs. remediate). *Risk: Moderate*
Technology Familiarity	Although new to FAHC, the technologies required for the first phase are known and manageable. Subsequently, multimedia data integration technologies will represent very high risk. *Risk: In 1998 and 1999, Moderate* *In 2000 and later, Very High*	Project primarily involves fixing old systems, but a shortage of COBOL programmers raises risk. Automated Y2K tools, while not complex, are new. Project success also hinges on successful completion of replacement projects, which are based on new client/server technologies. *Risk: High*
Time Constraint	Iterative prototype approach is flexible. Longer timeframe has financial benefits, although scope-creep could arise. *Risk: Low*	Immovable deadline vies with scope creep. Methodology and staffing changes result. *Risk: Very High*
Interdependence	Phase in of prototype does not need to be linked. However, the level of data integration that is planned for later phases (200x) has never been successfully achieved elsewhere. *Risk: In 1998 and 1999, Low* *In 2000 and later, Very High*	Delays in replacement project schedules increase scope of existing system remediation. Reliance on external links and embedded systems require software bridges and timetable adjustments. *Risk: Very High*

Figure 4. Proposed Five Factor Comparison of Project Risks

expansion would have been preferable had time pressure not been a factor. MTA management also had to make difficult choices to fix older systems that were scheduled to be replaced by client-server systems (strategic development projects that had fallen behind schedule). Euro conversion projects face a similar set of challenges, although the phase-in of the Euro provides for a somewhat more flexible deadline (electronic transactions began in 2000, but full cash currency conversion does not go into effect until 2002).

In contrast to the MTA, at FAHC scheduling was given a lower priority than achieving a high-performing, reliable system. While the use of telemedicine applications was seen as a desirable means to enhance patient care, a delay of six months, a year or more would not have serious consequences.

From this discussion, we observe that a time constraint can affect different types of project risk. An immovable deadline increases the risks of grave consequences to the organization if the project is not completed on time. However, a deadline can sometimes be used to good effect if management chooses to respond with discipline in resource allocation and focused attention.

Where there is no time constraint, by definition there is very little risk that the organization will face grave consequences if the project is delivered late. However, the lack of a time constraint can cause problems if management allows unnecessary scope creep, which increases the risk of poor project productivity (i.e., overspending, with few concrete deliverables, resulting in a poor ratio of project benefits to project costs).

Thus, we conclude that time constraint does increase project risk, yet (somewhat paradoxically), risk can be reduced by using the time constraint as a way to justify increased project management discipline and focus. Furthermore, the lack of a time constraint reduces the risk of adverse consequences due to

late project completion, yet (again paradoxically), if management allows a relaxed deadline to lead to scope creep, then having “too much time” can increase the risk of poor project productivity.

INTERDEPENDENCE

Adding to MTA project complexity was the extent to which date-sensitive data flowed to and from systems within the MTA, its five agencies, and a host of external parties (including banks, insurance companies, regulators, and various service providers). Indeed, all year 2000 compliance projects, Euro conversion programs, and other highly synchronized systems conversions efforts, entail similarly extensive interdependence, both among systems within an organization's application portfolio, and with third parties. Since other parties may have different priorities, it is difficult to coordinate the scheduling of conversion and testing activities across multiple activities. For example, if different parties make different choices about their specific Y2K conversion approach (e.g., expansion versus windowing; or windowing with a different pivot-point), then an extra layer of activities, coordination, and documentation must be imposed because "bridging" software must be written to convert output from one application into an input that can be interpreted by another.

At Fletcher-Allen Health Care, the specific telemedicine project studied in this report involved only moderate interdependence; however, future telemedicine-related projects will most likely involve extensive system interdependence (particularly in the full integration of a multimedia online patient record). Like the MTA, the data integration of future Fletcher-Allen projects mandates that all involved systems be fully synchronized and work correctly at the time they are released for use. Management will have to freeze changes to such a system for some months prior to the actual conversion to assure that all components are functioning properly as separate units and as a cohesive system. Supplier and customer (or at FAHC, physician offices') systems are also

important to these efforts, and all bridges or other connections must work correctly at the time of cut-over.

Interdependence also gives rise to a need to incorporate extensive contingency planning into time-constrained projects like year 2000 and Euro conversion projects. Given the project risks discussed above, it is prudent to prepare for various types of failure. *Programmatic* contingency planning addresses issues that need to be resolved when a project experiences schedule slippage, while *operational* contingency planning addresses various business process interruption scenarios which could occur if the root problem (such as the Y2K bug) is not completely eradicated. Well-designed and tested contingency plans represent a significant project management challenge on their own. With time-bound projects, especially those entailing high system interdependence, contingency planning must occur in parallel with the focal project activities. Parallel operation, in turn, exacerbates the already formidable challenges of resource-allocation and management attention. Projects that are less time-constrained and involve less interdependence benefit from both a lower need for contingency planning (especially programmatic contingency planning) and the luxury of doing operational contingency planning late in the project life cycle.

Most organizations do not have the luxury of focusing on a single system development project at a time. Instead, projects begin and end continually, and project assessments must take into account the likelihood of other projects competing for resources, including time and user expertise. A framework such as that provided in Figure 4 gives I/S managers a tool to examine a portfolio of projects collectively, to gauge the aggregated risks of an entire set of proposed and ongoing activities. This approach provides a means of justifying the occasional high risk project that has some expectation of high returns, but would not qualify for investment on its own. The framework, as it stands, must be

further refined to provide detailed guidance for its use as a measurement tool. Research to further this end is prescribed in the concluding section below.

VIII. CONCLUSION

Case studies are undertaken to illustrate the complexity of real situations studied within a theoretical framework. Multiple-case studies can serve the same purpose as multiple experiments. Yin (1989, p. 54) explains:

> "An important step is the development of a rich, theoretical framework. The framework needs to state the conditions under which a particular phenomenon is likely to be found (a literal replication) as well as the conditions where it is not likely to be found (a theoretical replication). The theoretical framework later becomes the vehicle for generalizing to new cases, again similar to the role played in cross-experiment designs. Furthermore, just as with experimental science, if some of the empirical cases do not work as predicted, modification must be made to the theory."

In this study, the McFarlan framework predicted that the FAHC "strategic opportunity" telemedicine initiative would entail higher project risk than the MTA "necessary evil" year 2000 compliance projects. Application of the McFarlan IT project risk assessment framework usually points to the conclusion that (when controlled for project size), emerging technologies projects entail the highest risks. However, comparative analysis of these two cases reveals that two heretofore-unacknowledged elements — time constraints and systems interdependence — appear to contribute to a higher degree of project risk at the MTA. The "necessary evil" of year 2000 compliance may well represent the highest-risk initiatives that IS organizations will manage as this century draws to a close, claiming the lion's share of IS resources and attention. In contrast, many

emerging technology projects do not suffer from an immovable deadline, and many do not depend heavily on coordination with external parties.

Thus, it appears that the McFarlan project risk framework can be enhanced through the addition of two new risk elements — time constraint and system interdependence. Further research is needed to validate these elements, as well as to more clearly identify the specific factor components defining both these new elements and the original three elements of size, structure, and technology familiarity. Further case-based research is needed to reveal measures that project managers have used to cope successfully with the risks posed by time constraints and interdependence in other year 2000 compliance projects as well as in other large IT initiatives.

Our assessment of the two new risk factors also helped to reveal a lack of clarity in the relationship between particular risk factors and the adverse outcomes that project managers are seeking to avoid. We observed that the Y2K time constraint raised the risks that the MTA project would not be completed on time, which could lead to severe consequences (in terms of public safety, employee morale and other outcomes). Yet, we also speculated that the lack of a time constraint at Fletcher-Allen could lead to scope creep (i.e., exacerbate the telemedicine project's loose structure), leading to excessive costs and disappointing returns. Further research is needed to address the relationships among specific project risk factors and with specific outcomes.

Survey-based research across a broad range of projects and contexts will be required in order to isolate the features comprising all five risk elements, with two aims:

1. development of a reliable and valid project risk diagnostic instrument and

2. investigation of the relative importance of each risk element in determining over-all project risk.

McFarlan (1982) proposed a set of 42 questions that could be evaluated and weighted to produce a numeric risk assessment. These questions need to be reexamined and analyzed statistically, to ascertain their grouping into the five elements discussed here. It is highly likely that some questions need to be updated or replaced due to technological advances. It is also probable that the questions will group across the five factors we propose instead of the three in the original framework, as questions pertaining to timing and interdependence link to these new factors.

Note that, in laying claim to these two new risk factors, we cannot propose that all existing sources of risk have now been identified. Further research is needed, across a broad range of organizational contexts and types of IT projects, to identify other measurable risk factors that cannot be accommodated under the five-factor umbrella. For example, one broad factor that comes readily to mind might be labeled “organizational readiness.” Weak senior management support, lack of prior experience in managing complex projects, and low employee morale may constitute elements of this risk factor.

Finally, similar in-depth case analysis should be undertaken to compare and contrast the application of the five-factor framework with other risk management approaches. Lyytinen et al. (1998) analyze the similarities and differences among four risk frameworks, but do not provide any empirical demonstration of their relative use. We have demonstrated the application of one framework, and suggest that a productive next step would be to conduct similar assessments across frameworks to test the Lyytinen et al. conclusions.

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ABOUT THE AUTHORS

Janis Gogan received her D.B.A., M.B.A., and Ed.M. degrees from Harvard University. At Bentley College she teaches courses in accounting information systems, electronic commerce, and year 2000 project management. She previously taught at Arthur D. Little Management Education Institute, Boston College, Boston University, Harvard, and various corporate executive education programs. Dr. Gogan has conducted extensive field research on emerging IT issues and applications, leading to more than 20 Harvard case studies and articles in *Journal of Management Information Systems*, *Journal of Information Systems Management*, *International Journal of Electronic Commerce*, *Review of Accounting Information Systems*, *Journal of Information Technology Cases and Applications*, and others. She currently conducts research in electronic commerce and Year 2000 compliance initiatives. She writes a column, titled "Benchmarks," for *Information Week*.

Jane Fedorowicz holds the Rae D. Anderson Chair in Accountancy and Information Systems at Bentley College where she teaches accounting and information systems courses. She holds M.S. and Ph.D. degrees in Systems Sciences from Carnegie-Mellon University and previously taught at Carnegie-Mellon University, Northwestern University, Boston University and the University of Massachusetts at Boston. She serves on the editorial boards of *Information Systems Research, Communications of the Association for Information Systems* and *Review of Accounting Information Systems.* She conducts research on organizational impacts of information technologies, especially enterprise information systems and object oriented technologies. She has published in *Decision Sciences, Journal of Management Information Systems, Information and Management, ACM Transactions on Database Systems, Communications of the ACM, International Journal of Technology Management, Decision Support Systems,* and other venues.

Ashok Rao, a Professor at Babson College, earned his Ph.D. in Industrial Engineering and M.S. in Electrical Engineering from the University of Iowa. He previously taught at Rensselaer Polytechnic Institute and Northeastern University, and served as Director of Business Systems at Northern Telecom, Canada. Decision Sciences Institute has twice recognized him for his teaching. His consulting experience includes implementation of Enterprise Resource Planning systems and management of new product development in the software industry. He has published in *Decision Sciences*, *European Journal of Management, Journal of Marketing*, *Operations Research*, *Production and Inventory Management*, and other outlets, and was the lead author of *Total Quality Management: A Crossfunctional Approach*. He is actively involved with APICS (Curriculum and Certification Council) and the Center for Quality of Management.

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