Evaluating the Use of Information Technology in Inter-Organizational Relationships

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Abstract

In inter-organizational settings the use of information systems and networks is often not evaluated in a very formal way and decisions are made "by gut feeling" rather than based on rational evidence. Since benefits depend not only on internal contingencies but also on the decisions and the loyalty of business partner, issues of trust and the risk of becoming locked in with a disloyal partner become crucial. The Internet and Web-based technologies facilitate system development and the deployment of inter-organizational systems and may thus help change this picture. In times where IT use is becoming more and more important to stay competitive and efficient, system costs and benefits have to be balanced very carefully in order to build systems that are perceived as being beneficial even in cases where risk-aversion makes this a difficult task.

In this paper the issue is addressed with a focus on applications which link a buying organization with its suppliers. We introduce a generic framework for the evaluation of IT systems and networks that might help mitigate the lack of success measures. The framework is applied to a procurement support system that was developed by Lawrence Livermore National Laboratory (LLNL) and that is currently used to link the Lab with its suppliers. The case also provides an example for a system that balances costs and benefits in a way that makes the system advantageous "even" in an inter-organizational setting.

1. Introduction

The use of information technology (IT) across organizational boundaries such as EDI has some tradition but to date never really caught on at a large scale, despite frequent claims that it is at the verge of a major breakthrough [17]. One of the reasons could be that systems which basically "electrify" existing means of communication usually only pay off for large players where transaction volumes outweigh the high setup cost. More sophisticated applications like just-in-time systems promise major benefits, but are usually also more risky because they require major investments in technology and systems as well as for organizational changes and adaptations of business processes [2], [12].

If measured at all, system benefits are usually assessed in terms of cost or time savings to be achieved in the short term (e.g., by comparing surface mail expenses and time requirements to the fees and speed of electronic connections), but not in terms of more strategic and long-term benefits [9]. As a result, above all, systems with very obvious and "low-hanging" benefits tend to be implemented and many opportunities to streamline business processes across organizational borders and to gain competitive advantages are not realized [8].

With the advent of worldwide information networks, especially the Internet, this picture could be changing. Inter-organizational systems are now easier to set up and open standards help avoid getting locked into partners. However, in the face of tightening competition and increasingly open and fast paced markets, the use of new technologies is becoming a key success factor for businesses, as is the ability to quickly adapt to changing market requirements. Careful up-front evaluation and a strategic view are becoming more important than ever.

With this paper, we provide an economic framework for assessing the economic value of business-to-business applications based on new information technologies with a specific look at procurement. We derive the framework parameters that are relevant for an economic evaluation, and demonstrate the usage of the framework by looking at a project, conducted by Lawrence Livermore National Laboratory (LLNL) in order to improve its procurement processes.

In section 2 we discuss procurement processes and the use of information technology to support them. This provides the basis to introduce an economic framework for the evaluation of procurement processes in section 3.
framework draws especially on new developments in information and network technologies. In section 4 we present a case study conducted by Lawrence Livermore. The goal is to apply the general framework and to derive some insights on the future use of information networks. Finally, we discuss generalizations of the framework and show how these generalizations reflect the findings of the case study.

2. The use of IT in procurement processes

Procurement is the process of obtaining material and services and managing their inflow into the organization [21]. It is important because it usually accounts for at least one third of an organization’s revenues or budget [7]. Organizations are experiencing competitive pressures from increasingly open and global markets and are recognizing the benefits that are to be gained by improving and streamlining procurement processes.

According to an empirical survey conducted in the U.S., the four most important measures for procurement’s success are cost, time, satisfaction (of internal customers with the service of procurement office), and quality [15] (Figure 1). Other research reports similar results [3], [11], [21].

![Figure 1. Measures of procurement success][15]

Procurement is well suited for the use of information technology for several reasons. The exchange of goods and services between organizations, commonly referred to as business transactions [20], evolves to a large part around communication and information processing between organizations (buyers, suppliers, and third parties) as well as within organizations, e.g., between the procurement group, end users, and accounting [10]. In addition, procurement processes are often highly repetitive and standardized, and in many cases involve items that are relatively easy to describe [21].

On the other hand, the workflow routines that a company installs to handle procurement processes must account for the diversity of items purchased and for a variety of situational requirements. They usually involve a large number of participants, such as end users, the purchasing department, an approval manager, the receiving dock, and accounts payable. As a result, purchasing processes are frequently very complex, time consuming, error-prone and expensive.

Although there is some tradition in the use of IT systems to support or even automate purchasing activities (CD-ROM based catalogs, EDI systems), most of today’s procurement-related communication processes and most of the information exchanged between business partners as well as within organizations occurs on paper. IT applications that reach beyond organizational boundaries often require significant investments, implementation efforts, and coordination between all participants. Examples are

- Systems for online ordering and order tracking
- Systems which allow suppliers or customers to access internal business partners’ data
- Systems integrating external data with in-house systems, data, and workflow routines
- Systems supporting and automating negotiations

In return, they promise process streamlining and improvements, not often otherwise available. Traditionally, such systems are often built on proprietary technology and, as a result, pose some risk of becoming locked-in, especially for smaller players.

With increasing mutual engagement, trust in the ongoing nature of business relationships and the loyalty of the partner(s) are gaining in importance when decisions about investments in organization spanning IT systems have to be made. Decisions to install an inter-organizational system and use it in radical ways might be hindered because such a system has to show somewhat higher benefits than an internal system in order to compensate for the trust issue. In the case of EDI, this could well be one of the reasons why this technology has never reached really widespread diffusion.

New technologies such as the Internet and World Wide Web are currently raising big hopes of changing the picture of complex, costly and error-prone business processes. Based on features like immediacy and interactivity, multimedia support, and the Web browser’s universal interface and ease of use, users are now able to access, compile and process dispersed information from virtually every desk in ways that were not possible before [19].

Being based on open standards these technologies also offer a way to link up with business partners without becoming locked into a proprietary system. As a result, trust could become somewhat less important and the setup of electronic connections is generally facilitated. Early applications include search engines, Web catalogs, Internet EDI links, online auctions and bidding systems, as well as an ambitious new generation of Internet-based procurement systems trying to combine boundary-crossing transactions with internal workflow processes in the area of indirect procurement [4], [16]. While new technologies show the potential to improve procurement, the majority

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[15]: Figure 1. Measures of procurement success

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[21]: Time, Accuracy, Stock, Find

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[10]: Find

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[20]: Find

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[11]: Find
of currently available off-the-shelf system is in a very early stage. Most search engines are not yet sophisticated enough to help locate information in an efficient way. A lack of common standards prevents the easy integration of electronic catalogs from different suppliers [1]. Weaknesses regarding security and reliability as well as a lack of adequate systems, e.g., to support payment, hinder the widespread use of Internet-based EDI systems. “New generation” procurement systems have yet to prove their viability beyond pilot stage.

3. Evaluating the use of IT to support procurement processes

Considering the costs that IT projects generally involve, especially in inter-organizational contexts, it is surprising how little up-front evaluation is usually conducted in order to assess the bottom-line benefits. Evaluations are often done in an informal way and decisions are made “by gut feeling” rather than based on rational evidence. An important reason might be that organizations often find it difficult to measure the return on investments of IT projects. Traditionally, the evaluation of IT systems revolved around variables that were easy to quantify such as cost and benefits directly related to the implementation and use of the systems [13], [14]. Often, the success of the systems was also rated in pure technical terms, such as Mips installed, response times, and systems availability. Such perspective, however, risks falling short of the core needs of the business [18].

From our point of view, a framework to analyze IT systems to support procurement processes has to meet three basic requirements.

- It is necessary to capture the most important parameters, i.e. the advantages and disadvantages of using IT to support procurement processes.
- The framework should take into account that business-to-business relations can last for many years. To do so, they have to be evaluated from as long-term a perspective as possible.
- In inter-organizational settings, benefits depend not only on internal contingencies but also on decisions and the loyalty of business partners. As a result, issues of trust and the risk of becoming locked into with a disloyal partner become crucial. Therefore, an appropriate framework has to capture uncertainty that arises from the decisions of business partners.

In the following, we outline a framework that meets these requirements by taking a long-term and relatively comprehensive perspective for the evaluation of an IT system. Our approach allows us to analyze explicitly the uncertainty that arises from the behavior of the suppliers.

Below, we first discuss different cost types that the buyer encounters to install and maintain a network solution. The second step provides a classification of benefits. Finally, we examine opportunities for an economic evaluation of the framework.

3.1. Cost Types

Establishing business relations on the basis of information networks leads to expenses for all business partners involved. We categorize these expenses by using two dimensions: time and specificity. The first dimension refers to the time and frequency at which the costs occur: one time setup costs involve all expenses that are necessary to install the technical and organizational solution (infrastructure). Current costs occur subsequently on a day-to-day basis and relate to the use and maintenance of the system (operations). We assume that one time costs occur only once in the beginning of the planning period, \( t_0 \). Current costs occur in each period from \( t=1 \) until \( t=T \). These costs must be discounted by using the internal interest rate \( i \). The second dimension refers to the specificity of the costs: they can be general system related and business partner related. By combining the two dimensions we obtain a four-quadrant matrix. Taking into account that each of the four categories occurs at the buying company as well as at the supplier side, we end up with eight categories in total. In this paper we are focusing on the buying company, but we will also have to include a look at the supplying company's situation, as we will explain below: Examples for the different cost types are given in table 1.

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We denote the one-time setup costs occurring for the buying company \( i \) to implement a network solution by \( a_{ij} \), which includes both general costs and partner-related costs. We summarize these two cost types into one because partner-related setup costs are usually very low compared to the general costs. In addition to the setup costs, the buyer has to bear current costs. Here, we can make a distinction between general costs and partner-related costs and denote the general current cost in period \( t \) plus the supplier-related current costs in period \( t \) as \( a_{ij} \).

3.2. Benefits

We concentrate our analysis of the benefits on two factors, cost and time, which we basically address in terms of improvements (savings) between the old and new systems. This assumption can be justified by the importance that these two issues have today (see section 2). We further base our framework on the assumption that the outcome of the business process itself remains unchanged, i.e., we assume that the use of IT will not have an impact on the quality of purchased goods.

We use the concept of information costs in a very general way, including not only the expenses for receiving, processing, or communicating information, but also factors such as the staffing costs for the employees who are entrusted with these tasks. Let \( c_{ij}^{old} \) denote the information costs that buyer \( i \) faces for conducting business with supplier \( j \) in period \( t \) before implementing the network solution and \( c_{ij}^{new} \) represent the information costs the buyer has to bear in \( t \) after implementation. This allows us to write the cost savings resulting from the use of information networks as

\[
c_{ij} = c_{ij}^{old} - c_{ij}^{new}
\]

Reductions in process lead times denote the second major benefit that we consider as a result of the use of the information network. Using the same formal language, we can write the time savings as

\[
t_{ij} = t_{ij}^{old} - t_{ij}^{new}
\]

To make the economic evaluation feasible it is convenient to consider only monetary terms. To do so, it is necessary to express time savings in monetary units. While it is often possible to determine time savings induced by the use of information networks, it might be problematic to transform these effects into monetary units, e.g., monetary benefits that arise from increased customer satisfaction due to time savings. In some cases it is however possible to estimate the monetary value of such time savings. One example is the case where a shorter delay between ordering and receiving of goods helps to lower the costs for storage. In the following we will assume that it is possible to capture the interrelation between the time delay and the opportunity costs that a buyer has to bear for one time unit by a parameter \( \gamma \). Therefore, we can express the advantages by time savings in monetary units by \( \gamma t_{ij} \).

3.3. Framework and Evaluation

The framework, presented in this section, addresses a two-fold decision problem. First, it will help to answer the question whether the implementation of a system makes sense at all, i.e., whether an organization will find it beneficial to join an inter-organizational network. Second, it will give us some hints on the kind of system that is appropriate for a certain kind of situation, i.e., tells us how much effort should ideally be put into setting up an infrastructure.

We will especially consider whether it is worthwhile for a buyer \( i \) to invest into an IT-solution. Our framework is based on the following assumptions:

1. We consider a time horizon of \( T \) periods \((t=0,1,...,T)\).
2. Disadvantages consist of the one-time setup costs for the implementation of the IT solution \( a_{ij} \) and the current costs \( a_{ij} \). The one-time setup costs occur in the beginning of the planning period \( t=0 \). The current costs occur from \( t=1 \) until \( t=T \).
3. The advantages of buyer \( i \) conducting business with supplier \( j \) in period \( t \) are savings of information costs \( c_{ij} \) and time savings expressed in monetary terms \((\gamma t_{ij})\). These advantages occur from \( t=1 \) through \( t=T \).
4. Buyer \( i \) can only take advantage of the solution to the extent that its suppliers also decide to participate in the system. \( p_{j} \) denotes the given probability with which a vendor \( j \) will choose the solution.
5. We assume that the buying company \( i \) conducts business with a given number of suppliers. We will denote the set of suppliers as \( M_{i} \subseteq M \). Both, the buyer and the suppliers make their decisions concerning the implementation of the networks solutions in \( t_{0} \). Under these assumptions the value of the usage of the IT solution \( V_{i} \) for the buying organization \( i \) is given by (1).

\[
(1) \quad V_{i} = -a_{ij} - \sum_{t=1}^{T} a_{ij}(1+i)^{t} + \sum_{j \in M_{i}} \sum_{t=1}^{T} p_{j}(c_{ij} + \gamma t_{ij} - a_{ij})(1+i)^{t}
\]

The (discounted) net revenue \( e_{ij} \) buyer \( i \) receives from the IT solution in the periods from \( t=1 \) to \( t=T \) from each of the suppliers is given by (2).


\[ e_{ij} = \sum_{i=1}^{T} (c_{ij} + \gamma_{ij} \cdot t_{ij} - a_{ij}) \cdot (1 + i)^{t} \forall j \in M_{i} \]

Summarizing the first two terms of (1) into $a_{i}$ we can express the value of the solution as:

\[ V_{i} = -a_{i} + \sum_{j \in M_{i}} p_{j} \cdot e_{ij} \]

Using (3) we can apply decision theory to analyze the framework. We assume buyer $i$ has two alternatives:

1. investment in the IT-solution
2. no investment

The value of the solution then depends on both the decision of the buyer and the state of the environment, which depend on the decisions of the suppliers. In the case of $m$ suppliers, all of which must decide whether or not to use a given technical solution, we have to consider $2^{m}$ environmental states. For example, let us assume there are two suppliers, S1 and S2. The probability that S1 will adopt the solution is given by $p_{1}=0.6$, and the probability that S2 will use the solution is $p_{2}=0.3$. Therefore, we have to deal with four states:

- Z1: none of the suppliers adopts the network solution ($p(Z1)=0.28$)
- Z2: only supplier 1 adopts the network solution ($p(Z2)=0.42$)
- Z3: only supplier 2 adopts the network solution ($p(Z3)=0.12$)
- Z4: both suppliers adopt the network solution. ($p(Z4)=0.18$)

It is obvious that the value of the investment into the network solution increases

- with increasing probabilities $p_{j}$
- with increasing net revenues $e_{ij}$
- and with decreasing costs $a_{i}$

If we assume that the decision-maker is risk-neutral, he will base his decision on the mere comparison of the cost $a_{i}$ with the expected returns \[ \sum_{j \in M_{i}} p_{j} \cdot e_{ij} \]. However, usually we can observe that decision-makers behave rather in a risk-averse manner. In decision theory we capture this phenomenon by assuming a concave utility function. This shape of a utility function makes the adoption of a network solution less likely. The reason is that risk-averse behavior weighs a possible loss higher than a possible gain. Losses occur especially, when none or fewer of the partners decide to select the given solution.

Moreover, a low-cost-solution will increase the probability that suppliers will adopt this solution. This result is especially important in the context of emerging technologies, such as the Internet and the Web. To the extent that these technologies reduce setup and operation costs ($a_{i}$, $a_{ii}$, $a_{ij}$), they allow buyers to accommodate even small suppliers in their electronic procurement networks. IOS implementations become economically worthwhile that could not be justified in traditional EDI-based settings.

Our results are becoming even more evident, if we assume that a supplier will conduct an analysis that is symmetrical to the one the buyer does. We will further outline the concept introduced in this section by using a case study.

One opportunity to reduce the uncertainty is a cooperation strategy with the supplier. Such a strategy can significantly increase the probabilities that the partners will adapt the IT-solution. Of course, such a strategy also leads to costs for negotiations. One possibility might be to negotiate only with a couple of selected suppliers. Another measure might be to launch a competence center or a hotline in order to support the suppliers and partners with possible problems.

Lawrence Livermore National Laboratory's Zephyr system is an example of an inter-organizational procurement application based on the Internet and the World Wide Web. Although structured in a relatively simple way, it provides high value to the organization and proves to be successful even in a risk-averse world and across organizational boundaries, i.e. involving external partners.

4. Lawrence Livermore National Laboratory's Zephyr Project

Lawrence Livermore National Laboratory (LLNL) is a research & development facility, located in Livermore, California, and operated by the University of California under a contract with the U.S. Department of Energy. Research includes, among others, projects in the areas of defense and nuclear technology, laser systems, energy, biology, and biotechnology. The research programs are sharing Lab internal support from more general disciplines such as chemistry and materials science, physics and space technology, computation, and engineering.

4.1. The Challenge

Our case study focuses on the Engineering Directorate, which involves about 2,100 technical and administrative employees and which is divided into two organizations, mechanical and electronics engineering (for more details see [6], [5]). The outcome of engineering processes, i.e., the design and manufacturing of complex systems, is usually based on tight collaboration among engineering specialists, not only within LLNL but also with partners of other research institutions, contractors, and suppliers. In some cases it even stretches beyond national and continental borders.

Collaboration and the exchange of information between the participants of an engineering process is crucial for its success, yet often difficult, especially when different steps such as design, procurement, payment, fabrica-
tion, testing, and evaluation are conducted in isolation from each other and when information is stored and exchanged on paper. At LLNL, complex administrative processes aggravated the problem. Apart from the exchange of engineering and administrative documents between project participants, the purchasing of parts for prototyping was considered a major bottleneck. Together, these flaws resulted in slow, error-prone, and expensive procedures and inhibited efficient, high-quality engineering activities.

For years, LLNL's purchasing department has been using Electronic Data Interchange (EDI) systems to process transactions in a cost and time efficient way. Restrictions inherent in the structure of EDI messages as well as the high setup and operations cost, however, called for large volume transactions of standardized, commodity goods to make the overhead feasible and worthwhile. Most of the parts involved with prototyping do not fit well with the economics to set up and use EDI systems since they are non-standard and complex to describe and specify. The procurement process around these items requires close interaction between the end user engineer and the vendor. While transaction volumes and order frequencies are low, demands are usually unpredictable and often come on short notice. Nevertheless, the capability to build prototypes within a short time frame is a major strategic issue in a research environment where success cannot always be measured in hard dollar figures.

The length and the quality of the process were considered as to be problematic because:

- Procurement was involved in most of the purchasing acts, and again
- Communication between engineering, procurement, and the vendors was mostly paper-based.

4.2. The Solution

With Zephyr, the Internet- and Web-technology based system for the procurement of prototype-related items, LLNL aimed at reducing both, process lead time and cost, as well as ultimately improving the quality of its outcome. The system, which was initiated by the Engineering Directorate and developed in collaboration with Procurement, Administrative Information Systems, and Computations, enables the paperless, distributed workflow and is the outcome of the initial idea to improve collaboration among engineers by making engineering documents centrally accessible. While complex data such as job descriptions and blueprints are stored in a central database, the workflow around them is steered and monitored via Web forms and e-mail.

Since March 1995, the Zephyr pilot has covered the purchase of printed circuit boards. The system links engineering and procurement throughout all major process steps and connects LLNL's employees internally and with suppliers and partners across the nation and internationally. So far, LLNL has signed up about 30 external partners for participation. To avoid the time-intensive process of setting up new relationships, the project team targeted only vendors LLNL was already doing business with. In line with the Lab's general policies, these vendors were pre-qualified, i.e., had already met LLNL's standards in terms of product quality and reliability. Out of this group of 30, currently 12 partners are actively involved in the use of the pilot system; all small or medium sized enterprises (SME's) with up to several hundred employees. According to the project leader they were much easier to win than large companies and showed more flexibility in deciding about the changes that the participation in Zephyr would require. In order to participate in the system a vendor needs to establish access to the World Wide Web and e-mail as well as corporate credit card capabilities.

The workflow process is initiated upon a user request to purchase engineering items. Fabrication data files describing the specification of the required item are generated, transferred into the Zephyr database, and stored there in a commonly downloadable format. While the files stay on the server, the workflow process around them is monitored via e-mail and Web based forms. This includes internal approval depending on the size and other details of the job, and notification of the vendors who are selected to participate in the Request for Quotation bidding process. Informed by the "trigger" email, vendors access LLNL's Web site where they find the specifications necessary to submit their bids, again, via email and Web-based forms. After reviewing the incoming bids online, LLNL chooses the winning bid and then notifies all participants about the result electronically. The winning bid is given access to more detailed information on LLNL's Web server, necessary to actually execute the job. Finally, shipment and payment are supported by the system, too. After completing the job and upon shipping the item, the vendor notifies LLNL via email. While the system allows tracking the shipment from LLNL's side, the shipment notice itself immediately triggers payment: via the corporate credit card mechanism, the vendor gets payment usually within 48 hours.

Compared to the old system, communication around the procurement process is now entirely supported by the electronic Zephyr system. The system also allowed some additional administrative changes which made it possible for the end user community (Engineering) to be basically responsible for the process operations. While the procurement department used to be involved in most of the purchasing activities, it now becomes involved only in cases of exceptions, such as for the approval of purchases over $5,000, or to take actions in cases of unsatisfactory supplier performances. As a result, central Procurement now has more time for strategic and long-term oriented
tasks such as defining the process infrastructure, e.g., by setting up contracts and monitoring vendor performance.

### 4.3 Economic Evaluation

To determine the success of the project, we now apply the framework that we introduced in Section 3 to the data that we collected. As we pointed out, we compare the costs for setting up and running the system (set up costs and current costs) with time and cost savings resulting from its use.

#### 4.3.1. Setup Costs

The one-time setup costs of the Zephyr system include:

- **Human Resources**
  - programmer(s) (almost a full time task)
  - project engineer (full time task)
  - system analyst (part time task)
  - system administrator (part time task)
- **Technology**
  - HP Unix host machine
  - Netscape Commerce Server Software
  - Oracle Database

Security turned out to be a very important issue. Zephyr provides secure electronic forms for all process steps, e.g., for vendors to submit their bids. Bidders can only see the public quote sheet and their own bid, but not the bids from their competitors, and not even quote sheets for offers that do not apply to them. Only authorized staff inside LLNL can place quote sheets, or follow up on the shipping or receiving status. The setting up of secure areas inside the Netscape browser system was very important for the success of the project and required significant time and effort.

All these setup costs $a_{00}$ sum up to a total amount of $250,000.

#### 4.3.2. Current Costs

Most of the current (operating) costs for running the system are considered general costs. Therefore, no distinction was made between general costs and partner-related costs. They can be divided into costs for system administration and costs for application development. Tasks that belong to the area of system administration include:

- Data backup
- Remounting discs
- Password and privilege management
- Database management
- Security monitoring

According to LLNL’s estimates these costs sum up to about 10 man-days per year. Using a rate of $500 per man-day, labor expenses for system administration result in $5,000 per year. If we assume a planning horizon of 3 years and an interest rate of 5%, this leads to a discounted value for the current costs of $13,616.

On the other hand, the department spends approximately $30,000 for application development. These costs involve the following tasks:

- Systems analysis
- Code development
- Code walkthroughs
- Production release
- Developed code configuration management

In sum, the total current costs are $43,616.

LLNL leveraged its collaboration utility by exploiting every possible aspect of its electronic procurement system. Therefore, both systems are hosted on the same server (multi-processor) machine and are using the same Netscape Commerce Server Software and the same backup hardware and software. They have a separate Oracle database, different application software, but utilize the same Systems Administration.

#### 4.3.3. Time Savings

One of the major project goals was to reduce process lead time. With time savings ranging from 60% to 90%, this objective was achieved impressively. For example, the procurement of printed circuit boards, which used to take 20-25 days, can now be done in less than 2 days.

The time savings not only result from the substitution of paper-based communication by the electronic Zephyr system, but also from administrative changes. In the case of the printed circuit boards, those changes alone reduced the purchasing process from weeks to days. The use of Zephyr then further squeezed the process into what is sometimes just a matter of hours. Additionally, LLNL receives the incoming bids now in a standardized format.

This reduces potential errors and makes bids easier to compare, which again speeds up the decision process from the Laboratory’s side.

Fast delivery of research results and prototypes is very important to LLNL. It enables the Lab to acquire funding for additional projects and helps to improve the overall research quality.

In Section 3 we pointed out difficulties of translating time savings into quantitative (dollar) measures. In one case this is relatively easy. The fact that payment is now initiated much faster than in the past (using the corporate purchasing card) actually allowed LLNL’s procurement officer to renegotiate contract conditions. For “high expense” items like custom optical components these negotiations resulted in 3-5% "same as cash" discounts worth $120,000 in just two months. For orders costing $80,000, LLNL now expects to save about $2,000-4,000, depending on how negotiations with individual vendors develop in the future.

#### 4.3.4. Cost Savings and Improved Product Quality

Besides time reductions, significant cost savings occurred. In some cases both types of savings are directly linked,
e.g., when a system allows LLNL to reduce the level of staff necessary to perform a given task. In the case of Zephyr, administrative and IT related changes together actually allowed to reduce a group of 18 people being involved in the procurement process of printed circuit boards to just one person.

In the past some vendors, especially smaller ones, were not able to do business with LLNL at all because of its slow payment cycle, which could easily take more than 180 days. With the new system LLNL can in principle choose from a larger number of vendors. This increases competition and opens new opportunities for cost savings and improved product quality.

Additional cost (as well as time) savings are gained from the improved communication between the end user engineer and the suppliers. Misunderstandings and the costs related to them are now avoided because the "experts" communicate directly with each other and the former additional administrative information filter is bypassed. Moreover, IT-based communication is often more precise and the data transmitted more detailed than in the case of paper or fax. Also, by the use of forms, the Lab as well as the vendors are forced to submit all the information that is necessary to complete the job.

In line with its general orientation, LLNL's goal behind utilizing a bid quote (Request for Quote "RFQ") process is not necessarily to minimize cost but rather to get a number of bids and award on "best value." This means that in some cases time might actually play a more important role than cost. As the project leader puts it, "if we're not time limited for our manufactured items, we'll award on lowest cost if all else is equal. Otherwise, we are willing to pay a higher cost if there are potential schedule impacts." Interestingly enough, there can be a 50-300% difference in vendors' quotes. Zephyr allows LLNL to discover these differences very efficiently and to single out the vendor that best matches LLNL's requirements for a given project.

4.4. Lessons Learned and Success Factors

The benefits that LLNL's Zephyr system provides to its users come about at a remarkably low cost. As mentioned above (Section 3), this point is especially important for the diffusion of organization-spanning systems. More generally, it is crucial in cases where immediate benefits and costs do not concern the same organizational group. In the case of Zephyr, it is the engineering department that reaps the biggest benefits from using the system in terms of process lead time, cost, and quality. Procurement, however, was actively involved in the decision process, contributed to its development in financial terms, and also had to cope with the fact that it lost some administrative control over the process by the organizational changes that came along with it. The same is true for the suppliers. Their acceptance of the system and participation was crucial for its overall success. LLNL's Zephyr team managed to build a system that provides significant benefits at reasonably little cost requirements for the stakeholders of its success (engineering, procurement, and suppliers).

At the same time, the system meets LLNL's basic requirements in terms of functionality, security, and reliability.

While the project team was less worried about general break-ins into the system, it was considered essential to ensure a variety of secure areas, granting different users access rights and data views according to their individual roles. For example, vendors should always only see their own bids, but not the bids of their competitors. The tasks of making the initial Zephyr compliant with LLNL's security requirements account for the biggest part of the project cost as of today. To determine the adequate level of security for different areas of the system in terms of feasibility and bottom-line value, LLNL performed cost-risk analyses. Time dependency of the data was eventually chosen to be the major determinant of security requirements - the longer a piece of information stays valid, the more strongly it needs to be protected.

Besides security, reliability of the Internet is sometimes considered problematic and might actually hinder its diffusion. While in traditional EDI-based settings, value added network (VAN) services offer reliable communication services and guarantee that electronic messages are not changed and delivered to the right person, these middleman services are missing in an Internet-based environment. In the case of LLNL, the reliability issue was solved in a very low-key manner. Compared to just-in-time production settings or financial transactions, prototype engineering processes are less time sensitive and therefore do not require guaranteed real-time links to begin with. Second, Zephyr did not result in the complete automation of the bidding and ordering processes for prototype related parts. In fact, one person continues to overview the process very closely and interacts with the vendors directly, e.g., in case they do not respond in time to an RFQ that has been sent out via email. Third, the system is designed in a way that most of the sensitive data remains on LLNL's central server the access to which is controlled by LLNL. Email is used, e.g., to notify vendors of an opportunity to bid or about the results of their bids, whereas payment information is not communicated over the Internet.

A main success factor for Zephyr was to sign up an acceptable number of suppliers. To avoid the time-intensive process of setting up new relationships, the project team targeted only vendors LLNL was already doing business with. In order to participate in the system, a vendor needs to establish access to the World Wide Web and e-mail and corporate credit card capabilities. Both can be obtained at
Obtaining credit card capability costs about $500. In exchange, LLNL offers their vendors extremely fast payment compared to the traditional weeks, and a sound basis for regular future business. Additionally, vendors are given the opportunity to access technical specifications in electronic form which greatly facilitates their handling, and reduces the possibility of errors.

Initially, the internal financial department raised some objections in the administrative departments because payment upon receipt was preferred rather than on announced shipment. The system development team, however, could explain convincingly that the Lab has been maintaining relationships with the selected vendors over a long period of time, and that the vendors were very aware of the fact that if they did not meet the expectations they risked losing future business.

The full benefits of the new system (see Section 5) result as much from the implementation of the Zephyr pilot, i.e., the use of information technology, as from administrative changes of the underlying procurement process. Engineering, i.e., the end user of the requested parts, is now empowered to do most of the transactions within its own domain without having to use purchase orders and to go through Procurement.

Although the benefits are obvious today, the project which was initiated by Engineering and Computational services encountered resistance from Procurement, which was about to be circumvented by the new system. It was only after some reorganization that Central Procurement shared the vision with Engineering about the benefits of streamlining the process and relying on outsourcing as much as possible.

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The case of LLNL’s Zephyr project teaches us two important lessons. First, it demonstrates the importance of carefully balancing trade-offs, compared to aiming at the perfect solution. Second, it shows that it is never enough to view the IT solution on its own. A complex organizational environment requires a more comprehensive view and maybe most importantly, creativity and open-mindedness from all parties involved.

5. Conclusion and Discussion

In this paper we outlined a general framework for the economic evaluation of organization-spanning information systems, using the example of procurement processes. The framework considers set up costs, current costs, information cost savings, and time savings as the major framework parameters. Therefore, we focused on selected advantages and disadvantages of using information technology in inter-organizational relationships. For example, we did not take a closer look at strategic issues as well as organizational and social aspects. However, the application of the framework using the example of LLNL reveals that these framework parameters can be seen as the most important advantages and disadvantages.

Both, the framework and the case study show that low setup costs are critical success factor for the diffusion of organization-spanning IT solutions. Hence, the framework reveals that a simple network solution is more likely than a more sophisticated solution to be adapted. The main reason is the uncertainty that the business partners will adopt the IT solution in conjunction with the risk-averse behavior of the actors, a result our case study confirms. According to the project leaders it would have been very difficult if not impossible to convince the suppliers to adapt a solution with significant higher setup costs, even if there had been technical advantages. This is especially true for companies of small and medium sizes. Hence, we can learn from the framework and from the case study that is not always necessary to use the best technical solution available. In many cases it might in fact be the better decision to implement only an “80% solution.” This might increase the probability that business partners will adopt the solution. Moreover, easy solutions can be implemented fast, allowing both buyers and sellers to derive benefits from the solution within a short time frame. The ubiquity, openness, and cost advantages of the Internet will certainly help increase the number of IT supported business-to-business relationships in the future.

There are at least three important research questions in the context of support for procurement processes over information networks that we have not discussed. First, we did not explicitly analyze the opportunities of changing the business by the usage of IT, although the benefits of the Zephyr solution hinge heavily on some (administrative) process changes. However, there is no general theory available today that provides thorough decision support concerning the question of how processes should be changed due to the ubiquity of the Internet - and our framework does not provide a very explicit road map, either. Although we touch the issue of process reengineering, we do not address it at an explicit and formal level. In the case of LLNL, procurement processes become more and more intertwined with engineering processes, intensifying the collaboration between engineers, employees from procurement, and vendors. Second, our framework assumes a given set of suppliers. Even though this assumption was confirmed by the LLNL-case, of course, the ubiquity of the Internet might have an impact on the selection of business partners. For example, we expect a shift towards more international business-to-business relations, since the meaning of geographic boundaries is fading. The size of changes and their direction, however, is very much dependent on the individual business and industry. Moreover, we did not...
provide detailed data to compare the use of the Internet for procurement processes with traditional (EDI-based) inter-organizational systems. More research is necessary to determine how much a player like LLNL can use the Internet as a vehicle to expand its existing procurement network, e.g., to include small suppliers.

Third, we need to ask about the impact of IT, especially the Internet, on competition. For example, decreasing costs to search and locate new business partners may increase the number of global players, which might again lead to increased worldwide competition. In the Internet Age, competitive factors are not only products and services provided, but also the ability to network using information technology. Good networking competencies can therefore be seen as one of the key success factors for the business of tomorrow. Not only technical skills but also organizational abilities as well as trust are becoming more important. The development of a networking theory that captures these questions will be an important step in understanding and winning the global challenges on the business of tomorrow.

References