



Case study

Managing large-scale global enterprise resource planning systems: a case study at Texas Instruments[☆]

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Abstract

At a time when many companies are embarking on enterprise resource planning (ERP) implementations, despite the belief among CEOs that approximately two-thirds of such systems are said to be failures, Texas Instruments' (TI) multi-stakeholder ERP system offers many lessons for future adopters. A constancy of vision, providing visibility of the ERP system to external constituents via Web linkages, and standardization of internal processes and important information technology systems to support market needs, were the foundation for the success of this implementation. In this paper, we detail the management of this implementation from a process-oriented perspective. The lessons learned from this effort help to support and further the academic and practitioner literature especially in the area of large-scale information systems management.

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1. Introduction

The jury is still out on the efficacy of enterprise resource planning (ERP) systems. On the one hand, surveys (e.g., Cliffe, 1999) reveal that a remarkable 65% of executives believe that ERP systems could be harmful, this perception being buttressed by specific examples of how poorly implemented ERP systems have contributed to the bankruptcy of companies (e.g., Appleton, 1997). On the other, there is also evidence indicating the numerous tangible and intangible benefits of ERPs. The purpose of this paper is to detail Texas Instruments's (TI's) large-scale global

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Web-enabled ERP implementation that entailed a three-and-half-year effort and a \$250 million budget. The motivation for this implementation is aptly expressed by Pallab Chatterjee, TI's Senior Vice President and Chief Information Officer:

In today's fast-paced, ever-changing Internet era, TI could no longer afford to have information technology systems that could not be easily changed to meet customer and business needs. The transition to open systems allows us the flexibility to respond to changing needs, capture new market opportunities, and realize our global processes and worldwide integrated systems vision.

The goals of the effort are to:

- evolve standardized processes that support market trends;
- leverage e-commerce to link customers and suppliers to TI's system; and
- base the implementation on open hardware and software systems.

The ERP system is used by 10,000 TI employees, and handles over 45,000 products and 120,000 orders per month. Information for this case study was collected using: (i) a number of structured interviews (including a face-to-face informal interview, a written interview, and an open-ended interview); (ii) several telephone and email communications; (iii) "snowballing" sessions with additional interviews with Andersen Consulting (now Accenture) personnel based on the recommendation of the senior level executive; and (iv) archival information supplied by TI and other, secondary, sources. We describe this implementation by utilizing the following process-oriented framework adapted from the advanced manufacturing technologies literature (Meredith, 1987; Sarkis & Lin, 1994; Small & Yasin, 1997). Details are available in Sarkis and Sundarraj (2001).

- Strategy formulation, in which the visions, goals and objectives of the organization are defined and a technology strategy is adopted to fit these goals.
- Process Planning and Systems Design, in which processes are reengineered to meet business objectives.
- System evaluation and justification, in which actual IT systems must be evaluated and justified.
- System configuration, in which the system or the organizational process is configured to produce an alignment between each other.
- System implementation, in which actual implementation of the system takes place.
- Post-implementation audit, in which we measure whether the goals set for the system have been accomplished.

2. Process-oriented analysis of the TI case study

An overview of the implementation is given in Fig. 1. In this section, we describe the activities that were undertaken by TI during each stage of the framework described in Section 1.

2.1. Strategy formulation

As discussed in Section 1, there were three elements to strategy formulation:

- Identify and support market trends;

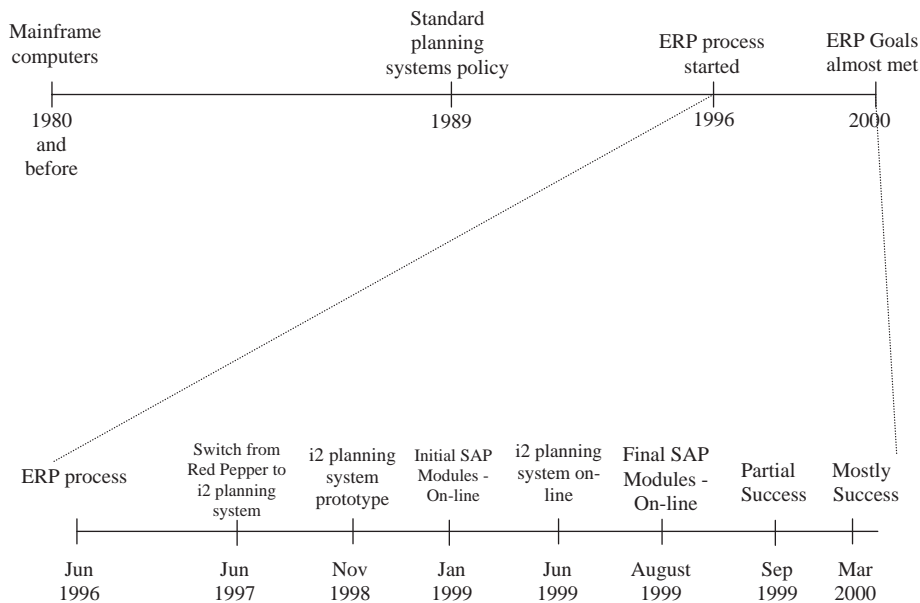


Fig. 1. Timeline of TI's ERP implementation.

- Leverage the Web for external partners; and
- Standardize information systems.

Market trends. TI began as a leader in the design and production of standardized digital TTL (transistor-transistor logic) “commodity” products. However, this focus was challenged by the evolution from a one-size-fits-all market to one in which mass customization was being demanded (Sinwell, 1997; Lavidge, 1999). TI re-focused the organization on the digital signal processing (DSP) business, which called for the design and production of custom chips using application specific integrated circuit (ASIC) methodology.

Further, TI had a number of customer needs that could not be met easily, because of disparate systems. For example, a customer in Taiwan wanted to place all orders in California and would allocate a worldwide destination for the ordered products only at the time of shipping. Other customers wanted to place orders for complete sets of devices that all worked together. To fit such requests within the existing system, TI had to enter the order for each device separately, and then use manual workarounds and interventions to synchronize the delivery of the complete system. According to Phil Coup¹:

“we had customers tell us that if we couldn't improve, then they were going to do business with other suppliers. In some cases we were taking as long as 6 months to deliver products that our best competitor can do in less than 30 days.”

¹TI Vice President and Open Systems transition manager.

Thus, the goal was to determine the appropriate processes and information systems that needed to be operational in order to support such agile design and manufacturing strategies (Peters & Saidin, 2000).

Move toward supplier-managed inventory and customer-managed orders. Prior to 1996, TI worked with its customers/suppliers using manual processes, or non-open systems such as EDI. As a way to launch itself into the budding e-commerce era, a goal of the ERP system was to leverage the capabilities of the Internet to provide visibility of its systems to its customers and suppliers so that the management of such external organizations can be done inexpensively.

Standardize systems. Unlike a number of organizations whose business units could be on incompatible systems, TI's strategy was to ensure standardization of its systems as much as possible. Specific areas such as factory automation were, of course, left to use custom solutions, but other areas such as planning were required to be on standardized open systems in order to support the two goals identified above.

Part of TI's strategic management and development process was to make sure that metrics were used to manage the project. TI is a metrics-driven organization, where strategic goals and objectives are translated into tactical and operational metrics, and such a fact-based management approach kept clarity in the direction and managed the scope of the project.

2.2. *Process planning and systems engineering*

By using its key business managers as well as noted outside consultants, TI conducted a massive reengineering effort for the whole organization with the goal of setting standard processes globally. The major result was to prescribe global management of inventory and manufacturing processes, and thereby discontinue the practice of earmarking a production lot for specific customers (e.g., orders could be received in US, replenished from Europe and shipped to Asia). Such a process change would save on capacity, reduce inventory and would turn more output into revenue, since it would not require a separate lot to be started in the US. In addition to process issues, there were problems with the information systems arising from the thousands of programs in use at that time and from the proliferation of stand-alone systems. Thus a proposal for an ERP system was made to the president and other key managers.

Unlike most organizations, TI decided to implement a single-instance ERP system to fully leverage the system's capabilities to support the flexibility and standardization demanded by global processes. After site visits by major ERP vendors, TI selected SAP primarily because of its scalability to handle voluminous amounts of data. Yet, questionnaires with hundreds of questions were given to the vendors and evaluated by the implementation team before final selection was made.

2.3. *System justification*

A budget of approximately \$250 million was set for the implementation. The justification of the system was completed using a combination of tangible and intangible factors at both the enterprise and business-unit levels. Standard hard-justification measures such as ROI and IRR were used to ensure the financial viability of the project. Global capacity utilization as a result of

the ERP system was also projected, keeping in mind that such projections were only guidelines and could get offset or boosted as a result of other continuous-improvement activities that were ongoing in the company. These estimates ranged from 3–5% output improvements based on current assets, which although seemingly small, amounted to increased profit of several hundred million dollars. Additional tangible and intangible reasons were:

- TI's proprietary-mainframe-based ordering was incompatible with the goal of moving toward a web-based model;
- TI had thousands of programs that incurred huge maintenance costs;
- Accurate global inventory was not possible without a "single-instance" ERP system; and
- An ERP system would facilitate in cycle-time reduction, which would help TI compete effectively in the custom DSP market.

In summary, according to Phil Coup:

At the enterprise level it is more like 'you have obsolete plumbing and wiring in your house, and you are going to have to replace it. And, therefore, you need to do something new.' From a business perspective, it boils down to having key business managers say: 'it is obvious we need to do this, we are going to get benefits and we are going to have huge risks if we don't fix the plumbing and wiring in our house. So, whether you think that these benefit numbers are right or not, whether you think it is a bit more or a bit less, it is still a good decision.' A lot of the intangibles came into play.

2.4. System configuration

The goals and processes outlined above are fairly easy to state, but they entailed a number of difficult changes at the detailed level. A few examples now follow.

Business process examples. First, the number of levels of approval on a purchase order was standardized at four (there were some countries which had fifteen levels). Second, authorization amounts were standardized according to the level of the concerned person in the organization. These two examples are a direct result of TI wanting to limit the amount of customization of the software package to a minimum, realizing the cost of customization and the chain reaction that could get set off by business units following one another in demanding customization. As Mitch Cline, the Andersen Consulting management partner in this project stated:

...if at any point the planned change in the business process (due to software requirements) was to have a negative impact on a process, it had to be significant for the software to be customized. It could not be "we don't like" it... the justification had to be significant, it would have to degrade service to the customer or increase cost to the business, not a slight productivity dip... a good example of one such justification, if we can't do supplier managed inventory like the automotive guys like to do it and it's going to cause a burden on these customers... it had to had to impact the customer or it had to take away capability that would drive up cost...

Technical example. One of the consequences of global inventory was that the number of a given part must be the same in all the regions of the world. An 18-character part number became an

agreed upon standard. This standardization involved a huge IS and business effort because changes had to be made to the databases, programs supported by them, and some manufacturing procedures in addition to having to communicate the changes to the customers.

Cultural example. All systems were mandated to be in English, except for customer-specific information such as addresses used for external communication with them. That is, if some element of the system is meant for global usage, then it shall be communicated in English.

2.5. Implementation

In this phase, concepts and goals must be translated into tangible action, and as a result, it is perhaps one of most difficult phases of the project. We describe three subphases of the implementation: startup, project management, and going live.

Start up. Unlike many organizations in which the IT departments have to “sell” the implementation of new technologies to business managers, IT projects at TI are initiated and driven by the business units. Given this corporate culture, it is imperative to have the concurrence of business managers on the design and implementation of the ERP system. Thus, a number of key personnel, along with their families, were expatriated to the US and stationed in Dallas for a few years.

Second, about 250 people were transitioned from TI to Andersen Consulting (i.e., put on Andersen’s payroll), which became the main provisioner of services with respect to the ERP system. This transition was completed after numerous discussions with business leaders and business teams. IT outsourcing in this case involved Andersen Consulting taking over the employment and management of former TI people.

Project management. TI adopted a number of different approaches to handle change management. First, CEO’s of the solution providers (Sun, SAP, etc.) met with TI’s IT and business leaders, and sometimes with the president on a quarterly basis. Second, people from other companies that have been through ERP implementation were brought in to relate their experiences. Third, leadership teams were defined for people who were leading key implementation areas for their business units, and executive teams oversaw the performance of the leadership teams with respect to change management. Finally, a process was established to handle problems that arose.

- On-site experts were made available to new users of the system;
- A help desk was set up to handle problems that could not be addressed by these experts; and
- A ticketing system for managing and prioritizing problems was also established (e.g., a system stop was a high-priority ticket that would get round-the-clock attention).

In summary, the goal was to handle a problem at the lowest possible level, without magnifying it and “sending it up the management chain”.

As stated earlier, in addition to SAP, TI used another package for performing advanced planning. Initially, a package named Red Pepper was selected for this purpose. However, after the implementation began Red Pepper was purchased by PeopleSoft a company that specializes in human-resources software. Its capabilities leveled off, whereas those of another package called i2 kept increasing and became dominant in the marketplace. Thus, TI did a major and

critical mid-course change of switching from Red Pepper to i2 advanced planning system software application.

Handling go-live. To get prepared for “go-live”, the key managers who were stationed in Dallas were sent back to their territories for educating the next level of users. Using selected experts, user-acceptance scripts were defined and tested, with problems, if any, being resolved as per one of the schemes outlined above. Daily conference calls were set up for 30 days prior to go-live to obtain status checks on progress and on the tickets.

Based on the results of these checks, a risk analysis was conducted weekly to determine the effects of various potential failures. The implementation plan was to have a few go-live dates one after another, but in relatively quick succession. For each of these events, a “war room” was formed and it had up to 500 people that included TI’s employees in addition to consultants from Andersen, Sun, SAP, i2, Oracle and other suppliers. The first stage of going live was a prototype of the planning system, the second stage involved the first major modules of SAP (finance and procurement), the third stage was to switch over to the global planning system with i2 (TI still had the legacy systems in operation), and the final stage was to implement sales, logistics and marketing systems. Except for the planning system, all other stages were implemented using a direct conversion². That is, with a downtime of about 2–3 h during a weekend, the old system was turned off and the new one turned on.

2.6. *Post-audit implementation*

The assessment of the implementation is discussed in detail in the next section.

3. Results of implementation

The system met most of its goals 9 months after the complete implementation, although there were some problems immediately after the implementation. Response time for the system exceeded expectations, with 90% of the transactions worldwide getting a response within 3 s. There are around 13,000 users (10,000 TI+3000 outside) on the system, with concurrent users ranging from 300 to 1700. The integrated system allowed TI to better manufacture and deliver its 120,000 orders per month involving 45,000 devices. Some key occurrences are as follows.

Productivity dip. Because of learning-curve effects, there was an initial period of reduced productivity. TI anticipated and planned for such an occurrence and discussed with Andersen methods to ameliorate this problem.

On-time delivery. TI was not hitting its goal of on-time delivery. However, this problem could not all be attributed to the systems alone. Because of market conditions, businesses were able to book more orders than they can deliver, and were as a result, falling short of capacity.

Single-instance, global system. The success of the single-instance, integrated, global model has fundamentally transformed how business is conducted at TI. It has allowed the company to have actions taken in, say, the US and determine impact on other parts of the world.

²Since planning was critical, the old and new systems ran in parallel for some time to provide the needed confidence.

Better response. Because of its web capability of the system, over 70% of TI's external transactions were conducted electronically. TI's worldwide external constituents include distributors, customers, suppliers, and field-sales people. This faster, easier-to-use process reduced order-management costs for customers by allowing access to all orders, and providing access to real-time global information using open and non-TI-specific systems.

Inventory reduction. Although it is still fairly early in the process of such a sweeping institutional change, it is not too soon to state that the project is helping those it was designed to help. For example, a few months after startup, some TI factories reported output increases of 5–10%, and up to 15% reduction in work-in-process inventory.

According to Phil Coup,

“We are now truly operating as a global company. We now have one customer backlog, one global planning system optimizing how global capacity is used and daily access to global business information via our Intranet Web portal.”

4. Managerial implications

The case study described in Section 3 offers a number of lessons for managing ERP systems. In this section, we examine the extent to which these lessons are grounded to the research literature.

4.1. Lessons

Conduct a thorough strategic plan. This case illustrates how market forces compelled TI to make radical shifts to its business. TI's strategic response to these changes identified flexibility and time (speed) as the key strategic performance metrics that had to be stressed in order to be competitive in the DSP business.

Align IT plans with business'. TI found that to support its global inventory model it needed to have an integrated information system (i.e., ERP). Further, to best align IT with the business, the ERP system would have to be a single-instance one. Multi-instance systems that require batching or other forms of integration mechanisms would be insufficient for TI's purpose.

Get top management support. TI's President Rich Templeton and the Chairman of TI's Board communicated the importance and status in their quarterly satellite broadcasts to the company. The president considered a successful ERP implementation to be one of five strategic goals for the organization, and followed through with the goal by sitting in on quarterly meetings. He explicitly lent his support to the standardization of the business processes, stating:

if somebody does not want to use [the] standard and wants to customize it, [he/she] needs to see me personally and explain to me why they were going to make more profit by doing that.

Change management. Researchers have often attributed many implementation problems to users' resistance to change. They need to address issues related to:

- *User expectation*—TI illustrated how, instead of increased efficiency, there was a productivity dip for an initial time period as a result of time lost in learning the new system. TI anticipated it and planned for it by setting expectations accordingly;

- *User involvement*—with TI, to provide a chance for greater involvement during difficult periods, TI provided an increased frequency of such communications as the project approached its final stages;
- *User satisfaction*—TI established a ticketing system and web-based user groups to help support users' problems.

Champion characteristics. In TI's situation, the manager of the ERP project had over two decades of experience at various levels of the organization. As manager of several businesses (product families) within TI, he had broad process knowledge as well as technical knowledge related to enterprise-wide open systems. He had both the credibility and expertise to lead the project.

Rationalize business models and processes. Since time and flexibility were the strategic goals of TI, a global inventory system along with its accompanying models and process was the rational choice.

Consider intangible benefits. An example of intangible leveraged by TI is the linking of the ERP system to web. This enabled 3000 customers and suppliers to connect to the system.

Build budgetary slack. In TI's case, the switch-over from Red Pepper and the temporary hold-off on i2's implementation are examples that highlight the importance of budgetary slacks. Contingency budgetary planning may reduce the political issues relating to increased financial expenses that may label the project as a "black hole" or failure.

Make mid-course changes when needed. As exemplified by the i2 implementation in this case, parallel piloting was not central to the full ERP system, but was deemed necessary for that risky module.











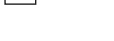

Manage external enterprises. Appropriate and well-planned involvement of consultants is important for keeping the project on a tight schedule. Further, with the advent of e-commerce, companies are more likely to ship and order goods on the basis of web-based inputs.

Manage using metrics. TI and Andersen Consulting have a corporate culture and policy that requires the stringent and formal use of metrics in the management and evaluation of projects. They attribute this policy adherence as one of the key reasons for success of the ERP implementation.

4.2. Summary

Fig. 2 categorizes the lessons learned into two dimensions, and it can serve as a guideline that future implementers can adapt to their situation. First, we separate lessons with strong literature support from those with partial support. It is noteworthy to mention that even those with strong support tend to get ignored during the "rush" of the implementation process. A classic case is the involvement of top management (Jarvenpaa & Ives, 1991).

A notable lesson with limited literature support concerns the leveraging of the system to utilize emerging e-commerce technologies, thereby providing better management of customers and suppliers. Other such lessons include the need to make modification to plans, as needed, to ensure project success. This lesson is especially important, because of the numerous business and technological changes that can likely occur during the inordinately long life-cycle of an ERP project.

Planning Stage Literature Support	Continuum of Strategy to Implementation 	Lesson Learned [Bracketed Numbers are example references of issue]	Key Supporting instance from TI
PARTIAL		Champion Characteristics [9]	IT and business experience of champion
		Make Mid-Course Changes when Needed	Changed from Red Pepper to i2
		Budget appropriately	Budgeted for delays and changes
		Manage External Enterprises [18]	70% of external transaction are electronic
STRONG		Conduct a Thorough Strategic Plan	Moved from "commodity" to DSP business
		Align IT Plans with Business [8,25]	Single-instance ERP to support global inventory
		Get Top Management Support [16,22]	President regularly sat in meetings
		Change Management [4,5,11,13, 14, 17,20]	Transported key "process owners" (users)
		Rationalize Business Models and Processes [2,28,30]	Decided on global inventory model
		Consider Intangible Benefits [6]	E-commerce links to customers and suppliers
		Manage Using Metrics [1,10,12]	Used productivity and utilization metric

LEGEND:




-  -- Critical
-  -- Very Important
-  -- Important

Fig. 2. Summary of lessons learned (Adams, Sarkis, & Liles, 1995; Aharoni & Burton, 1994; Baronas & Louis, 1988; Baroudi, Olson, & Ives, 1986; Beatty & Gordon, 1988; Davenport, 1998; Dean, 1987; Deming, 1986; Davis & Bostrom, 1993; Dixon, Nanni, & Vollman, 1990; Ginzburg, 1981; Goodman & Griffith, 1991; Joshi, 1991; Kalakota & Whinston, 1996; Lucas, 1978; Reich & Benbasat, 2000; Selig, 1982; Stevens, 1997).

Further, as the project progresses along its life-cycle, different lessons have differing degrees of impact and would involve different levels of personnel. Thus, in our second dimension, we classify lessons according to the process-oriented framework used in Section 1. For example, TI's experience suggests that to align an IT plan with that of the business plan, the guidance and support of senior management is critical and that too in the early stages of the project.

5. Conclusions

In this paper, we have utilized a process-oriented framework to describe the implementation of TI's single-instance, global ERP system that sought to: (i) standardize processes and information systems; (ii) integrate manufacturing, procurement and logistics to support market trends; and

(iii) provide visibility to suppliers and customers via the web. Despite numerous challenges (e.g., national and cultural differences, reconciliation of business processes and unanticipated mid-course changes), TI went through its implementation that lasted over 3 years and received a nomination for the ComputerWorld Smithsonian Award for its efforts. The response time of the system is under 3 s 90% of the time, and with 10,000 registered internal users, 3000 registered external users, 120,000 orders and 45,000 devices, although it should be pointed out that there were some initial dips in productivity and on-time delivery. The lessons learned include those that are suggested in the research literature but often ignored in practice, as well as new ones (see Fig. 2).

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