IVEY | Publishing

W13513

CATERPILLAR TUNNELING: REVITALIZING USER ADOPTION OF BUSINESS INTELLIGENCE

Caterpillar Tunneling Canada Corporation (CTCC), a subsidiary of the U.S. company Caterpillar Inc., had been experiencing a host of problems — e.g., data inconsistency, uneven reporting and poorly defined processes — with its outdated enterprise resource planning (ERP) system. Between 2011 and 2012, it planned to upgrade to its parent company's SAP but had to cancel due to resource allocation issues. A business intelligence (BI) platform had been deployed locally as an intermediary solution to facilitate business decision making; after the cancellation, it became an even more critical tool to complement the troubled ERP system in transforming raw and disparate business data into actionable business insights. Faced with limited information technology (IT) resources, an inflexible ERP infrastructure, imbalanced user adoption of BI, and under pressure to generate timely financial and performance reporting to the corporate office, Jon McEwan, the CTCC's business resource manager and head of the finance department, struggled to turn the existing BI solution into the platform of choice for trusted information distribution throughout the company.

The BI platform allowed users to link disparate data sources successfully, but not all business units within the company were ready to adopt the software. As a result, the different levels of participation, technical aptitude and personal motivation created an imbalanced reporting landscape characterized by two types of users. On one hand, the analytics junkies who favoured slicing and dicing interactive datasets on their own and getting hands-on with the latest data visualization utilities. On the other, the canned report users who were passive in performing their own analyses or looking beyond the static results generated, and preferred receiving information from the traditional channels with which they were most familiar. Thus, the BI platform had become both the go-to platform for effective decision making for some and a source of multiple versions of the truth for others.

This great divide fostered the emergence of "information insiders" who were more proficient in extracting business insights for decision making than those who were less technology-savvy or less adaptive to new tools and processes. To release the full potential of the existing BI platform, McEwan had to focus his energy on user needs and the flaws of the initial BI platform implementation.

SAP BUSINESS TRANSFORMATION AT CATERPILLAR

From 2005 to 2006, Caterpillar embarked on a business transformation project to implement SAP across its machine and engine businesses to replace a host of legacy systems and to standardize an enterprise-wide ERP platform.[1] To facilitate the transformation, Caterpillar established a special taskforce called MACH 1 that would work with new target deployment sites to localize the Caterpillar SAP template to the site's business and legal requirements, support transformation to the enterprise business processes, map and load legacy system data into SAP, participate in system user acceptance testing and train local users.[2]

In 2010, CTCC was selected as one of the sites to undergo SAP implementation. A team of key employees was selected to act as subject matter experts and collaborate with the corporate team and external consultants to assess CTCC's business processes and determine the gaps that the corporate SAP template would need to overcome. After more than a year of localization sessions and data cleansing efforts by the local, corporate and external teams, the project was put on hold indefinitely, mostly because the implementation was demanding more local resources from CTCC than previously expected. The discontinuation of the project allowed corporate resources to be offloaded to other sites with higher priorities for SAP transformation. Furthermore, the gap analysis revealed that CTCC's unique concurrent engineering and project-based business model would require a SAP template to be designed from scratch to facilitate the management of the end-to-end cycle from design to delivery for tunnel boring machine (TBM) projects, an endeavour unfamiliar to the corporate and external teams. CTCC was left with no choice but to operate under its original ERP system with no plan to invest further in ERP development.

CATERPILLAR TUNNELING OVERVIEW

Founded in 1972 as Lovat Inc., CTCC was a leading tunneling technologies provider for soft ground to hard rock geological conditions, specializing in the custom design and manufacture of tunnel boring machines (TBMs) used in the construction of transportation and utility tunnels ranging from two to 12 metres in diameter. The company also offered refurbishments and reselling of TBMs, technical and field services support, product support and spare parts fulfillment.

CTCC was headquartered in Toronto, Canada and employed a staff of 330 people, with sales agents stationed in worldwide locations including Russia, the United Kingdom and China. It provided management on transit projects globally and contributed to infrastructure building such as sewers and underground cables in places as diverse as China, Egypt and Colombia.[3] Mining companies also use TBMs to create mine access. Some of the high profile TBM contracts that have been awarded to CTCC include the provision of four TBMs for mining an 8.6-kilometre extension of the Toronto Transit Commission's (TTC) Yonge-University-Spadina subway from the Downsview Station terminal to the Vaughan Metropolitan Centre at Highway 7 and the provision of a TBM to Thiess Tunneling for mining a 3.2-kilometre cable tunnel under the heart of the central business district in the city of Sydney for Ausgrid, the largest electricity distributor in Australia.

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[1] Vertex, "Caterpillar's Strategy for World-Class Value Added Tax Management," May 2012, www.vertexinc.com/ResourceCenter/WhitePapers/PDFs/vertex-vat-caterpillar-white-paper-dsb-review-v2.pdf, accessed May 8, 2013.
[2] Caterpillar, "Information Technology," www.caterpillar.com/cda/layout?m=629355&x=7&id=2492888, accessed May 8, 2013.
[3] Kim Laudrum, "Lovat Has Tunnel Vision," Plant, February 18, 2008: pp. 17—19.

In 2008, Caterpillar Inc. announced the entry into the tunnel boring business through the acquisition of Lovat Inc. At the time of acquisition, Caterpillar intended to leverage its global purchasing organization, its global reach and its experience in large-scale manufacturing processes to support and invest in Lovat's product line and in the tunnel boring business. Lovat was later renamed the Caterpillar Tunneling Canada Corporation and became a part of Caterpillar's Diversified Products Division, alongside forestry, paving, work tools, original equipment manufacturer (OEM) solutions and defense, and related federal products.

As a privately owned company for more than 34 years, Lovat operated as a family business and lacked the organizational governance characterized by a multinational corporation like Caterpillar. Many activities were carried out in a reactive manner. Some decision making was also dominated by undocumented tribal knowledge. As CTCC integrated more closely into its parent company with operations that were highly methodical and procedural, the need to streamline and standardize some of the existing processes grew. At the same time, the parent company realized that CTCC's concurrent engineering and project-based model was vastly different from Caterpillar's repetitive manufacturing model. Therefore, not all established manufacturing protocols could be directly applied to CTCC.

One of the biggest reforms was in how project management was facilitated. The core of CTCC's business was to deliver custom tunnel boring solutions to its clients. Every TBM was unique and had varying project requirements including the geological condition of the ground, the size of the tunnel, restrictions to site access, sensitivity of the buyer to the overall cost, etc.[4] All these factors could affect the type of machine selected and its configuration. Prior to the acquisition, the project management process was rather lax and lacked the consistency and rigour of regular status reporting. It could be months after the project was completed before the project management team realized that the project was significantly over budget.

To ensure that the different projects with varying scopes that were running in parallel were all delivered on time, with the highest quality and on budget, a standard project management methodology needed to be established for tighter control on project scheduling, assignments of tasks, reporting of statuses and identification of bottlenecks. An external consultant was brought in to assess CTCC's project management needs and facilitate a series of training programs on project duration planning and control, resource and cost management, team communications and dynamics, as well as project risk management. A proprietary web update system from the consultant was implemented to enable fast and reliable updates from employees on their assigned tasks. Marked improvement was observed on delivery times and team communications.

BUSINESS SYSTEMS LANDSCAPE

A number of companywide information systems had been implemented over the years to meet the expanding needs of business users. There were two predecessors to the existing integrated ERP system. The earliest was a homegrown Microsoft Access database that managed engineering parts creation and basic work order processing. It was followed by a custom business system with additional functionalities designed by a contracted software company. Since not all historical data was migrated to the latest ERP system, the predecessors remained accessible to selected users for the sole purpose of information retrieval. Aside from the ERP system, there was also a custom quality assurance (QA) system for keeping track of nonconformance records (NCRs). The QA system had very basic functionalities for the creation of NCRs and the assignment of advocates for resolving them. It did not provide reporting functionalities.

[4] *Rick P. Lovat, "TBM Design Considerations: Selection of Earth Pressure Balance or Slurry Pressure Balance Tunnel Boring Machines," International Symposium on Utilization of Underground Space in Urban Areas, Sharm El Sheikh, 2006.*

The data captured by the QA database was virtually untapped in spotting trends of the origins of nonconformance incidents.

The latest ERP system consisted of modules including project management, sales order processing, item master data, finance, material purchasing, production planning, inventory management, shipping and receiving and time and administration. All transactional business data were captured by this system.

The implementation of the ERP system was completed in 2005 and was carried out by an ad hoc team of handpicked employees who were knowledgeable about the company's operations. The specific ERP package was selected by the executive members of the company, primarily due to the attractive offer from the software company that was at the time expanding its business in North America. While the original ERP package was designed for the European market, the software company wanted to partner with Lovat to launch a pilot program that aimed at customizing the ERP package to suit the needs of Canadian companies. For example, the taxation configuration had to be tailored for the Canadian market. Lovat also requested other parts of the ERP system to be customized to conform to its business processes. The result of the extensive customization was unpredictable system behaviours that the end users and the local ERP support team had to bear, resulting in prolonged dissatisfaction and complaints. ERP implementation had since been a touchy subject in the company. The cancellation of the SAP implementation further intensified employees' dismay.

There were other silo applications or utilities developed and used by departments for their own internal processes that the ERP system was not adequate to support. For example, the TBM sales department established its own quotation tools for TBM contracts, and the power and controls systems engineering unit created its own electronics and hydraulics parts database for facilitating the design process of electrical and hydraulic assemblies. Both utilized data feeds from the ERP system (see Exhibit 1).

INFORMATION TECHNOLOGY DEPARTMENT

IT was not regarded as a strategic business unit but merely a supportive function at CTCC. Prior to the acquisition, the IT department reported to the operations manager, who was responsible for operations in all production facilities and for maintenance and capital expenditure for buildings and equipment. Typical IT activities included setup and maintenance of computer hardware and peripherals, web and network administration, software installations and upgrades, phone system management, systems security management, IT asset management and helpdesk support, etc. After the acquisition, the IT department temporarily reported to the business resource manager who led the finance department. It was later reorganized and became part of the parent company's Global Information Services (GIS) unit. While it remained in Toronto, it was under the supervision of Simon Swiss, an IT manager from GIS located in Peoria, Illinois. Its responsibilities also expanded to support a number of Caterpillar facilities outside of Toronto.

The reorganization provided an opportunity for CTCC's IT department to gain a wider exposure to the vast IT resources of the parent company and learn to adopt the standard operating procedures established by GIS. Swiss also became the key contact to help CTCC navigate the corporate IT landscape that was confusing to the local members due to the large number of subdivisions. The most prominent change was on network and web security. By bringing CTCC's network behind Caterpillar's corporate firewall, the flow of incoming and outgoing network traffic was secured.

Aside from an IT audit performed on CTCC's computer network, there was no formal assessment performed on the company's overall information management needs to determine how the subsidiary could better leverage corporate's IT resources. It remained challenging for the rest of CTCC to identify the proper individuals from GIS to engage on specific IT-related matters. Since GIS was a shared service organization that supported all Caterpillar facilities, its response was often not prompt, a situation to which local users needed to adjust to as they were used to the fast turnaround of the local IT team.

ERP DEPARTMENT

The ERP department was relatively small and consisted of two ERP analysts who managed all facets of the system and the financial application that worked in conjunction with it. This was the only department that had sufficient knowledge on the ERP database structure to perform structured queries for custom information retrieval. Prior to the acquisition, the ERP department was under the same roof as the IT department. After the acquisition, it was put under the supervision of McEwan. Due to the parent company's unfamiliarity with the local business systems and its inability to advise the ERP team on the future management of these systems, ERP did not become a part of GIS like its IT counterpart despite the fact that many activities that ERP carried out had close ties with the databases and servers that the IT team helped manage. The ERP team was left with managing the ERP and BI systems independently. The separation of the two departments resulted in communication problems. Since they were under the supervision of different authorities, it was sometimes not clear to them in what direction each was heading.

Faith Lang was the ERP analyst who not only proposed and oversaw the implementation of the BI platform but also managed the administration and development of the platform. When she first started with the company, it had relatively few reporting capabilities. Canned reports that were supplied as a standard to the ERP system were the only reporting service available to the majority of users. Most of these canned reports were static and not formatted to make the information displayed immediately useful to users.

Lang and her colleague were constantly bombarded by requests to create custom queries about the business systems and generate aggregated results. Without a mechanism to store or enable secure sharing of these queries, the same ones were often redundantly created. While in the past the results were delivered to each requestor as embedded queries in Excel files, the future usage and access to these queries that ended up on the users' machines were out of the staff's control. The introduction of the BI platform was successful in eliminating most of these problems related to data security, content management, version control and information sharing and somewhat reduced the number of one-off requests. However, the adoption of the technology remained sparse. Lang felt that she was largely accountable for maximizing the benefits that the BI platform could bring to all employees who had the needs to derive insights from raw business data. See Exhibit 2 for CTCC's organization chart. See Exhibits 3 to 8 for an overview of business intelligence.

ORGANIZATIONAL BUSINESS ANALYTICS NEEDS AT CTCC

Spare Parts Sales and Field Services

As the director of marketing and product support, Norman Neves's role at CTCC demanded him to grow spare parts sales, oversee field services dispatch and establish the Caterpillar brand in the tunneling segment. When he first started at CTCC, he struggled with getting the data that he needed to make sales projections due to the lack of reporting in the ERP system. Before he came aboard, the finance department reviewed the financials of the spare parts but there was no market segmentation analysis performed by the sales team to help drive sales. Although raw data could be manually exported from the ERP system for such an analysis, it was deemed too time consuming. The ERP system did not offer the utilities for the sales team to effectively monitor sales performance by customers, geography and spot trends through time. Neves needed a tool that would allow him to slice and dice the data multi-dimensionally.

Neves heard of the BI platform at CTCC, but as a relatively new member to the organization, he was not yet formally introduced to it. He was hopeful that the ERP team would be able to assist him in setting up a reporting solution for market segmentation. With permission from McEwan, Neves and his lead spare parts sales advisor, Stacey Martin, began working with Lang from ERP on requirements. In a few weeks, Lang designed a set of reports and dashboards that allowed Neves's team to forecast future sales targets and provide feedback to the global sales representatives on what to expect in terms of field services needs. By segmenting historical spare parts sales data by customers, geographical locations, product categories, etc., the department was able to gain insights that no one ever had access to before. They were able to determine the customers that drove sales regions that had the highest demand, during what times of the year sales would likely spike, the types of components with the highest demand, the probability of a quotation turning into sales and more. Neves was able to better communicate with the supply chain team to ensure that inventory was available for the long lead time items and advise the inventory management team on the most optimum stock quantity for specific spare parts. With a good grasp of the types of components that were in demand, he was also able to identify the inactive spare parts in the inventory and devise a disposition strategy. See Exhibit 9 for the interactive report template developed for analyzing spare parts sales performance by geography.

Project Management Office (PMO)

PMO was the first department to be introduced to the BI platform due to its pressing demand for a better project reporting solution. Before this, project cost reporting was deemed a very challenging task by many. Retrieving the latest project costs from the ERP system could take hours due to the massive bill of materials (BOM) of a TBM. The standard reporting interface from the ERP system could only provide the bulk cost for each project phase, not the details at the task or component level. Visibility to the overall TBM production status was poor considering that each phase could take weeks if not months from design to completion. Although production status for a particular part could be looked up on the ERP system, it did not provide the big picture on where the project was at and what was left to complete. Without a good grasp of what was on the critical path, if ordering a long lead time item was missed and no one caught it, the overall project status could be affected.

Lang knew that she had to be proactive to show that she could help. She contacted Nathan Zachery, the PMO supervisor, to get an understanding of what his team needed to monitor projects on a regular basis. Through many iterations of redesign, a project cost template was standardized and used in all control meetings. An interactive report allowed users to retrieve the latest costs accrued for a given project. They could narrow the costs at different levels of a machine down to the nuts and bolts, compare the budgeted versus actual costs, analyze the number of labour hours consumed for designing and manufacturing different parts of a machine, analyze resource loading by reviewing the labour hours each work centre had accumulated, etc.

Bound by tight deadlines and high volume workload, not all PMO members were eager to spend time on learning a new set of analytics tools. At the same time, the ERP team needed the project managers' engagement and feedback to continuously improve and maintain the reporting solution that would work for them. Prior to becoming the PMO supervisor, Zachery had been a project manager himself. He understood the benefits that the BI platform could bring, if all members of PMO could explore the capabilities of the BI platform at the same pace and suggest to ERP the areas that the reporting was not yet able to accommodate. For example, it would be helpful for PMO to see the cash flows of the projects when clients made payments. Since the finance department handled payments in a separate financial system, this information was not visible to PMO unless someone asked for it. As all projects were billed by progress, it would also be helpful for PMO to gain visibility to profit margins for different parts of a machine.

Engineering

The engineering department at CTCC was made up of a large team of multidisciplinary engineers divided into three units: mechanical design, backup system design and power and controls systems design. To balance resource loading, supervisors needed to monitor the workload of each engineer to maximize resource utilization. All engineers were required to clock their working hours throughout the day based on the tasks they performed. This allowed their supervisors and the engineering manager to determine the number of hours spent on different types of engineering activities such as component design, component testing, research and development (R&D), training and onsite support. The time and administration module of the ERP system was capable of generating reports on the total number of hours committed during a specified period by a particular engineer or by the work breakdown structure of a TBM project. It however could not offer insights on the resource loading by a combination of those dimensions.

The BI platform overcame the shortcoming of the ERP system by providing the engineering supervisors with an interactive dashboard that reported on a multidimensional dataset of engineering hours. Users were able to identify the engineers who were working on the same project; the daily, weekly and monthly engineering resource loading patterns by activity types; over- and underutilized resources; the most and least demanding engineering tasks, etc. (see Exhibit 9 and 10). However, user adoption of BI for engineering was slow since it was not a project mandated by management but more of a push by the ERP team to get the supervisors interested in using the tool rather than them actively providing feedback on what would be useful features to embed in the reporting.

Quality Assurance

Manufacturing a TBM is a complex, concurrent engineering process. Most TBMs were built as one-off units, often hand-built in segments with minimal fixturing by a highly talented workforce.[5] Design and planning were critical stages since they had to be done right the first time. Quality was built by experience. It was important for the workforce to learn from past mistakes to continuously improve the design and manufacture process. The premise of the QA system, which was implemented long before the deployment of the latest ERP, was to capture information on all nonconformance incidents for analysis and control. It was a silo system that was managed independently. Its serious flaw was that it did not come with an automated notification feature for driving the workflow. Employees relied on each other's due diligence to ensure that the NCRs were attended to and resolved in an efficient manner. The QA system also did not have reporting capabilities so it was difficult for the QA team to monitor the overall state of the NCRs.

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[5] *Robert B. Aronson, "Making the Monsters," Manufacturing Engineering, November 2004, pp. 67—76.*

Stanley Malcolm, the QA manager, had to report on NCR statuses as well as the material and labour costs in TBM projects that were attributed to quality issues. The visibility simply was not there for anyone to easily evaluate quality performance. Malcolm's superior referred him to the ERP department for help.

While NCR data was on the QA system, project details such as costs and labour were captured by the ERP system. To report on the QA performance by projects, the two disparate data sources needed to be linked. The BI platform offered the utility to do this. Malcolm worked closely with Lang to establish a number of metrics to quantify quality performance by monitoring the number of NCRs in the queue or past due, the most frequently occurring quality issues, the average amount of time that each advocate took to resolve the issues, etc. Since scheduled report distribution was a feature offered by the BI platform, Lang was also able to solve the QA workflow problem by configuring automatic email notifications that sent out details of the NCRs to the respective advocates whenever the NCRs changed status.

Operations Management and Production

As operations manager, Roy Young's role encompassed the management of all production facilities, manufacturing staff, equipment maintenance, health and safety and capital expenditures. A critical need for data analytics for Young was in analyzing the resource loading of manufacturing staff, tradespeople with expertise in machining, welding, electrical and hydraulic machine assembly, painting, etc. Due to the concurrent engineering and one-off nature of TBM projects, the production workflow could be sporadic and it was difficult to gauge the number required for each production work centre throughout the different production stages. As a result, some production staff members on duty could be idle.

Young came up with the idea to analyze production labour hours accumulated for past TBM projects and superimpose the results to predict resource loading requirements for ongoing and future TBM projects with similar technical specifications. Together with the ERP department, an interactive dashboard was designed to display production labour hours by project numbers, production work centres and TBM components over the duration of TBM projects. By creating multidimensional time series of production labour, he was able to transform the raw data into actionable insights to minimize the idling of resources on the shop floor. The dashboard also revealed spikes of welding labour at particular times and this led Young to develop a cross-training program to allow a more balanced distribution of tasks.

Finance

The finance department generated supporting financial analyses to assess the company's operational and financial performance on a regular basis. Constant information flow between the finance department and other business units was critical in communicating the latest operational and financial statuses.

Kelly Kennedy, senior staff accountant at CTCC, was responsible for analyzing TBM project costing, labour efficiency, inventory valuation, etc. There was some duplication in the review of records between the finance and other departments. In the analysis of labour efficiency, for example, billable engineering and production labour hours were compared to the total hours worked to determine the utilization rate and for assessing how effectively the managers were utilizing their resources. Since the initial reporting requirements for labour were requested at different times, each department had its own version of reports related to labour. As a result, the engineering, operations management and finance departments analyzed labour hours independently, differently and at varying degrees. This illustrates the lack of communication among departments on how data should be analyzed and the lack of stewardship in detecting conflicts that some reports could bring. If report users were to indicate to the ERP staff the interdependencies of labour analysis among the three departments, the reporting could be consolidated to prevent misinterpretation of data and the need for reconciliation.

BI PLATFORM DEVELOPMENT AT CTCC

The BI platform was not implemented as a company-wide system. It was, rather, an initiative proposed by Lang from ERP that aimed at addressing the reporting shortcomings of the ERP system and inducing a better practice of information distribution. When the business proposal was prepared to acquire funding for the project, it was viewed as an interim solution to equip CTCC with the ability to generate ad hoc reporting locally before its migration to the parent company's integrated ERP system with analytics capabilities. However, when the decision to put SAP implementation at CTCC on hold indefinitely became official, the BI platform was no longer an interim solution but a critical piece of software that enabled users to make informed and data-driven decisions. The daily operations of some departments, including spare parts sales, PMO and quality assurance, had become dependent on the BI platform.

The business needs for data analytics was mostly driven by users. In some cases, the ERP team would recommend reporting solutions that it determined would be in the best interest of users. They provided services to scope, develop and launch reporting solutions based on the requirements provided by users. During the first year of deployment, the project management staff used the BI platform only for project costs monitoring. As more and more users approached the ERP team for new reports to be developed, the user base grew from five users during the first year to 50 in the second year.

Expertise on databases and data analytics was very scarce at CTCC. There were only two employees who could support data querying and reporting. As the demand on reporting continued to increase, the ERP team began to feel some strain in keeping up with the demand.

Interfaces

The BI platform implemented at CTCC had two components: a web-based interface that allowed users to retrieve reports or dashboards to which they were granted access and a client tool that allowed the user to build or customize interactive reports with the available datasets built by the ERP team. The report folder structure was designed to be intuitive, classifying reports by the types of information that they conveyed, such as inventory management, purchasing, project management, resource loading, quality assurance, etc.

Data Security

Data storage and availability had always been issues at CTCC. Prior to the introduction of the BI platform, employees used a variety of methods to distribute reports, which could be queries or data embedded in spreadsheets, Word documents, Microsoft Access Databases or other applications. Thus, data resided in multiple locations, and inconsistency was inevitable. The BI platform resolved these problems by providing a single platform for information sharing and distribution. Since most of the information was sensitive, access to BI reports was granted after consultation with the department managers.

Training and Social Media

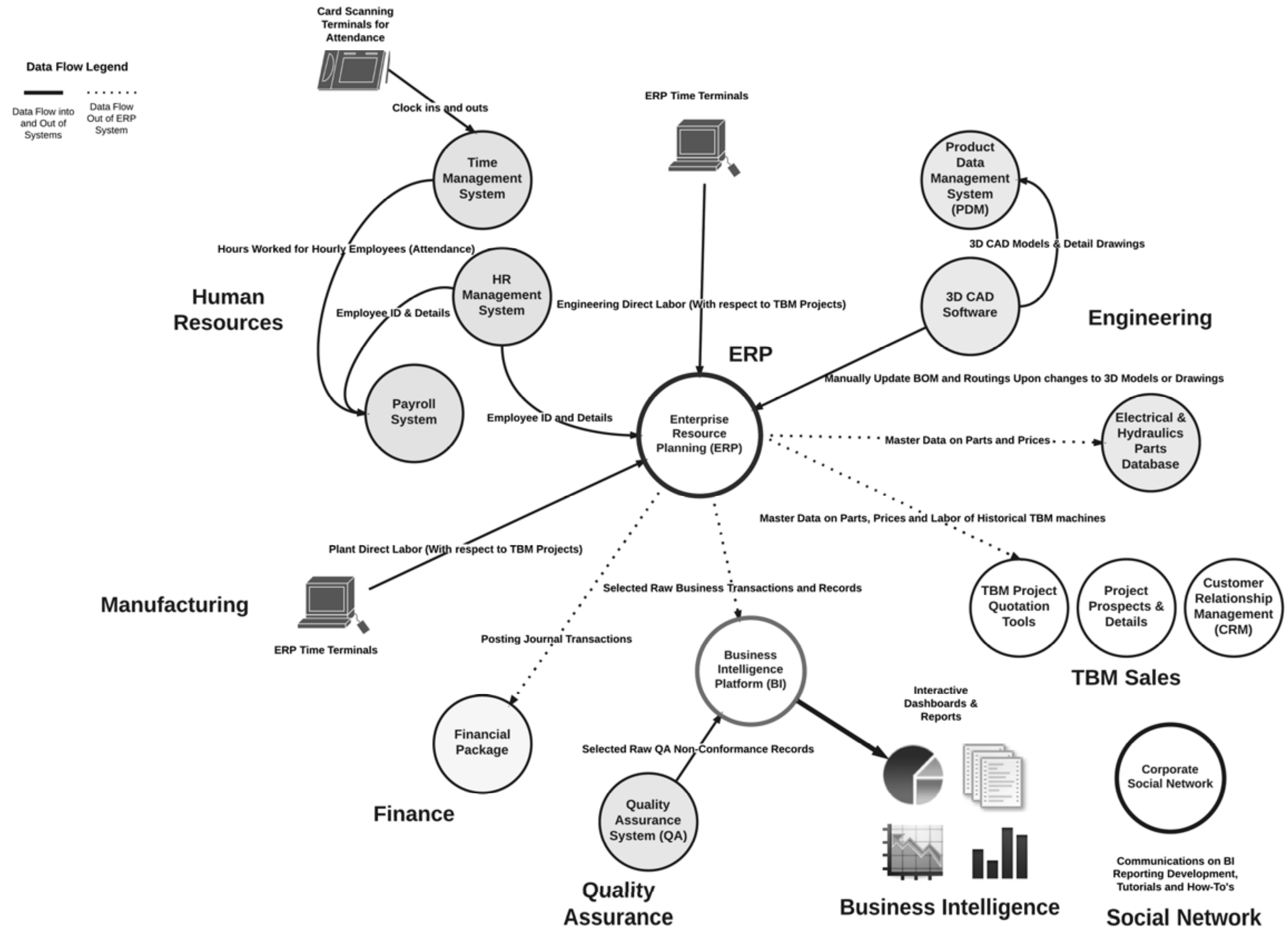
The demand for training increased with the growing number of users. With only two staff members managing the BI platform, there was limited resource to provide training to everyone. When there were fewer than 20 users, one-on-one training sessions were conducted, but as the user base continued to grow, the ERP team needed to develop a wider method of distribution. To communicate the latest news on BI platform development, a closed group called the Caterpillar Tunneling Business Intelligence Group was established on the corporate social network. All users of the BI platform were added to the group to receive newsfeeds, view report tutorials, share documents and participate in online discussion boards. However, the participation rate on the social network group was poor due to varying user preferences. Some found social media in the workplace to be a distraction. Others were comfortable with receiving instant updates from the community.

PROBLEMS WITH SILO REPORTING DEVELOPMENT AT CTCC

While reports on the BI platform were built as requested, each report had a very specific purpose that perhaps only the requestor and the report designer could fully comprehend. Over time, a large number of these custom reports had accumulated. Some built for different departments showed overlapping features. Since there was no direction from a single authority on the overall development of enterprise reporting, development continued to diverge to meet each requestor's needs as they arose. No one had taken the step to review all reports collectively to determine if conflicts existed. Some found it an effective tool for decision making, others found it confusing and stopped using it altogether.

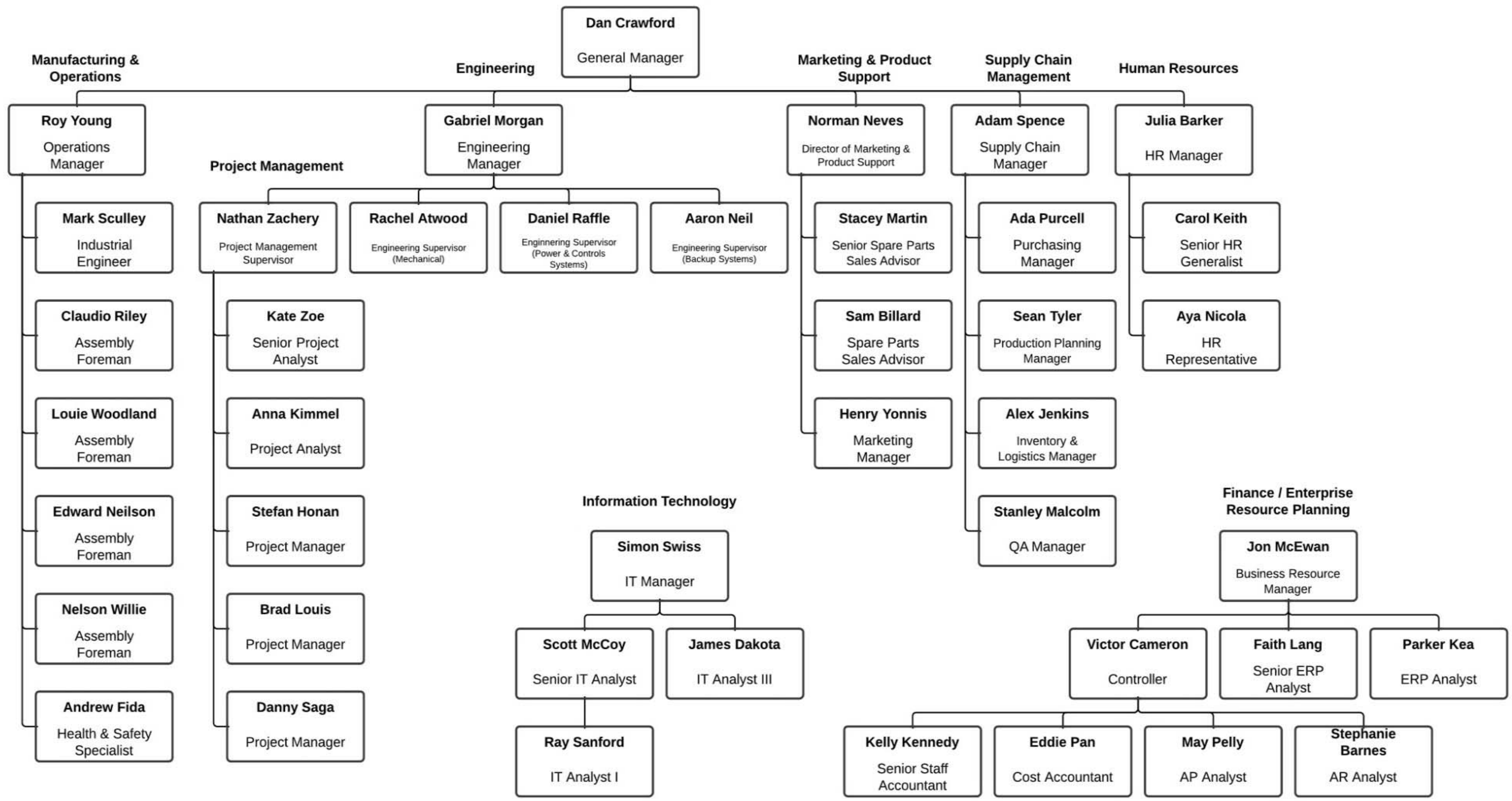
How could the BI reporting development be mandated differently to avoid having to reconcile the large number of reports that were being created? Could more training help to communicate the uses of the reports? How could users be motivated to use the new analytics tools? Was it a proper use of the BI platform to overcome some of the functionalities that the ERP and QA systems ought to provide?

EXHIBIT 1: CTCC BUSINESS SYSTEM



Source: Created by author.

EXHIBIT 2: CTCC ORGANIZATION CHART



Source: Created by author.

EXHIBIT 3: WHAT IS BUSINESS INTELLIGENCE?

The term business intelligence system was first used by computer scientist Hans Peter Luhn in a 1958 IBM journal article titled "A Business Intelligence System."[6] Luhn was at the time envisioning a system that could automate the process of channeling particular information to those who need to know it. A business intelligence system was defined as a mechanism to provide selective dissemination of information according to the requirements and desires of the users. Such a system was to overcome the barriers to effective information flow brought upon by increased specialization and divisionalization in industrial, scientific or government organizations.

In 1988, Howard Dresner, then a lead analyst at the technology research firm Gartner, provided an updated and more technologically oriented definition of the BI concept[7] as an umbrella term for the applications, infrastructure, tools and best practices that enable access to and analysis of information to improve and optimize decisions and performance.[8] Many variations of definitions have proliferated as the BI market matured and product and service providers continued to reinvent their offerings.

BI Process

The derivation of insights from raw data is an iterative and user-oriented process that forms a feedback loop as the end users gather, explore, interpret and analyze the available data to learn, generate knowledge and come up with new requirements to drill deeper into the data. The BI process can be divided into five stages: data, information, knowledge, actions and outcomes. The corresponding steps are to integrate, access, report, analyze, understand, decide, act, produce and measure. The ultimate goal of this process is the creation of economic value and growth for an organization as a better understanding of the operations is obtained and actions are taken accordingly (see Exhibits 4 and 5).

BI Platform

BI solutions are generally offered in the form of a platform. Gartner defines this as a software platform that has 15 capabilities across three categories: integration, information delivery and analysis as shown in Exhibit 6. These capabilities enable organizations to transform raw business data from disparate sources into distributable and customizable formats for the extraction of insights to support decision making.

Business Analytics

The deployment model of BI has traditionally been IT-centric due to the end users' lack of knowledge of data structure and the technical know of how to implement a solution for secure access to the data. Once the integration of and access to data is overcome, the focus shifts to analysis. Business analytics is a phase that follows reporting (which may be in the form of dashboards and scorecards or other types of data visualization) and precedes understanding (which is done by people).[9] This is a critical phase when information is transformed into knowledge for it to be made useful (see Exhibits 4 and 5 for the placement of business analytics in the BI process).

Trends in BI Product Offerings: BI for the Masses, Data Discovery, Workflow Collaboration

2007 marked the year of BI consolidation frenzy when three of the leading ERP and software integration providers acquired independent BI companies to strengthen their business analytics offerings and complement their ERP and database management solutions. Oracle began the race with the acquisition of Hyperion, followed by SAP's

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[6] *Hans Peter Luhn, "A Business Intelligence System."* *IBM Journal of Research and Development**, October 1958: pp. 314—319.*

[7] *Jerzy Surma, Magdalene Górniakowska and Peter Gee,* *Business Intelligence: Making Decisions through Data Analytics**, Business Expert Press, New York, 2011.*

[8] *Gartner. "IT Glossary — Business Intelligence," www.gartner.com/it-glossary/business-intelligence-bi/, accessed May 22, 2013.*

[9] *Dave Wells, "The Changing Faces of Business Intelligence," BeyeNetwork, November 18, 2008, http://www.b-eye-network.com/view/9007, accessed May 22, 2013.*

EXHIBIT 3 (CONTINUED)

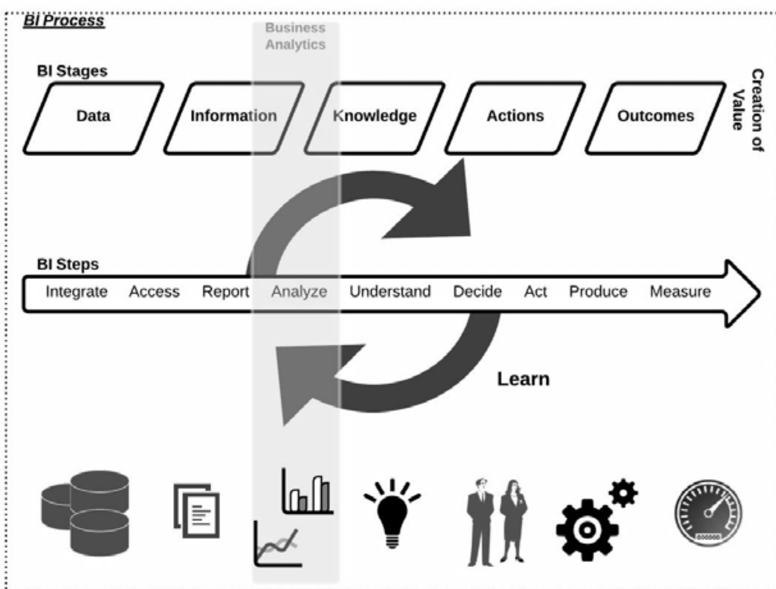
acquisition of Business Objects and finally IBM's acquisition of Cognos.[10] These acquisitions signified the interests of the major business system and database vendors in gaining a foothold in the BI marketplace.

While the majority of business vendors has consistently displayed greater customer satisfaction in information delivery capabilities including reporting, ad-hoc query and dashboards, search-based BI and predictive analytics are functionalities that have received double digit increase in usage between 2011 and 2012 according to a user survey on BI platform functionality conducted by Gartner.[11] These increases were countered by decreased usage in metadata management, Microsoft Office integration, BI infrastructure and BI development tools. See Exhibit 7 for the customer rating of BI platform capabilities in meeting needs. The changes in user behaviour can be attributed to a new breed of BI vendors that strive to offer BI solutions for the masses to allow inexperienced individuals and small-sized companies to take advantage of BI. BI vendors with a focus on data visualization and presentation, such as Tableau, QlikTech and Tibco Spotfire, have been driving data discovery to the mainstream by providing tools that allow users to quickly and effectively turn data into interactive visualizations without the traditional support from an IT department. The free service called Tableau Public from Tableau, for example, has been popular with journalists and bloggers in creating interactive data visualizations on publicly available data such as economic indicators. IBM Research and the IBM Cognos software group also offer a free service called Many Eyes as an experiment to allow users to create visualizations from existing datasets.

As new forms of BI platforms emerge, there appears to be a shift from IT-intensive BI that is centralized and controlled to office productivity BI that is decentralized and autonomous. While the two models are at the two extremes, organizations looking into starting or improving BI look to find a happy medium that will work in their environments. See Exhibit 8 for the ease of use versus composite product rating for 34 BI product lines across 14 different BI platform capabilities, resulting from Gartner's 2012 BI platform user survey.

Source: Created by author.

EXHIBIT 4: THE BUSINESS INTELLIGENCE PROCESS



Source: Adapted from Dave Wells, "The Changing Faces of Business Intelligence," BeyeNetwork, November 18, 2008, www.b-eye-network.com/view/9007, accessed May 22, 2013.

[10] *Christian Fuchs, "Business Intelligence Mergers and Acquisitions," The BI Verdict, Business Application Research Center, www.bi-verdict.com/fileadmin/FreeAnalyses/consolidations.htm, accessed May 22, 2013.*
[11] *John Hagerty, "User Survey: Customers Rate their BI Platform Functionality, 2012," Gartner, August 15, 2012.*

EXHIBIT 5: BI PLATFORM CAPABILITIES

Integration	Information Delivery	Analysis
1. BI Infrastructure	5. Reporting	11. Online Analytical Processing (OLAP)
2. Metadata Management	6. Dashboards	12. Interactive Visualization
3. Development Tools	7. Ad-hoc Query	13. Predictive Modeling and Data Mining
4. Collaboration	8. Microsoft Office Integration	14. Scorecards
	9. Search-based BI	15. Prescriptive Modeling, Simulation and Optimization
	10. Mobile BI	

Source: Gartner, Magic Quadrant for Business Intelligence and Analytics Platforms, February 5, 2013. www.gartner.com/id=2326815, accessed May 29, 2013

EXHIBIT 6: THE 15 CAPABILITIES OF A BI PLATFORM

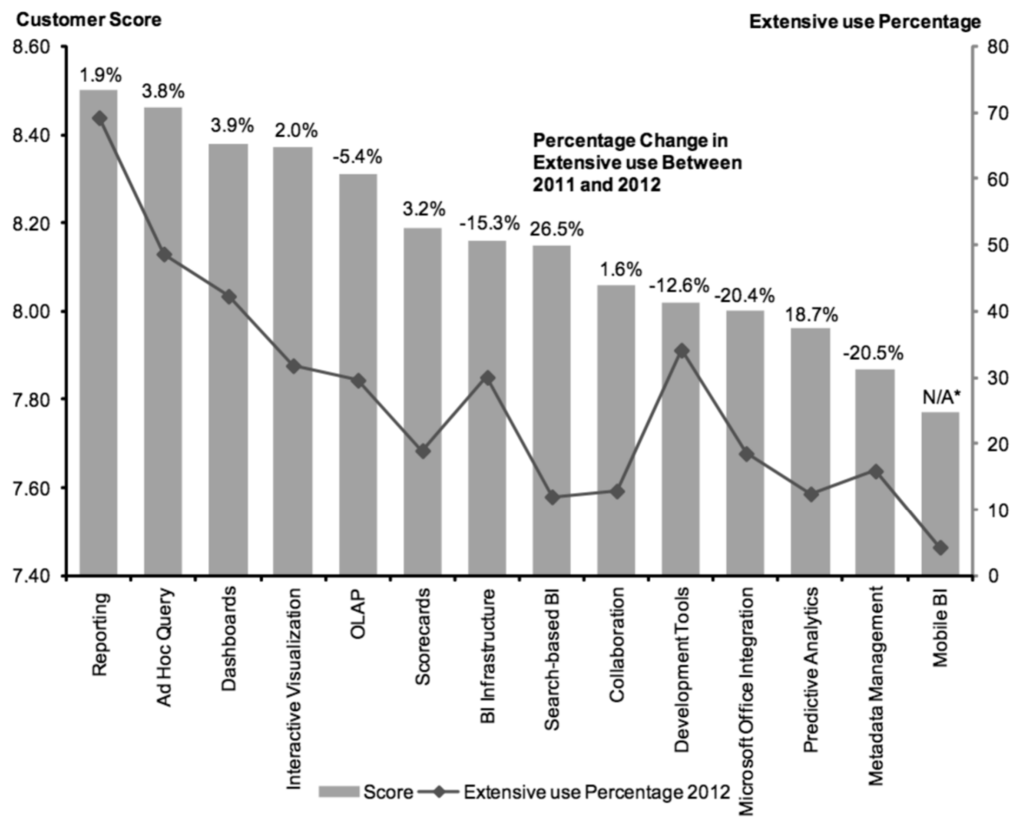
	Capabilities	Description
Integration	BI Infrastructure	All tools in the platform use the same security, metadata, administration, portal integration, object model and query engine, and should share the same look and feel.
	Metadata Management	Tools should leverage the same metadata and the tools should provide a robust way to search, capture, store, reuse and publish metadata objects, such as dimensions, hierarchies, measures, performance metrics and report layout objects.
	Development Tools	The platform should provide a set of programmatic and visual tools, coupled with a software developer's kit for creating analytic applications, integrating them into a business process and/or embedding them in another application.
	Collaboration	Enables users to share and discuss information and analytic content and/or to manage hierarchies and metrics via discussion threads, chat and annotations.
Information Delivery	Reporting	Provides the ability to create formatted and interactive reports, with or without parameters, with highly scalable distribution and scheduling capabilities.
	Dashboards	Includes the ability to publish Web-based or mobile reports with intuitive interactive displays that indicate the state of a performance metric compared with a goal or target value. Increasingly, dashboards are used to disseminate real-time data from operational applications or in conjunction with a complex-event processing engine.
	Ad-hoc Query	Enables users to ask their own questions of the data, without relying on IT to create a report. In particular, the tools must have a robust semantic layer to enable users to navigate available data sources.
	Microsoft Office Integration	Sometimes, Microsoft Office (particularly Excel) acts as the reporting or analytics client. In these cases, it is vital that the tool provides integration with Microsoft Office, including support for document and presentation formats, formulas, data "refreshes" and pivot tables. Advanced integration includes cell locking and write-back.
	Search-based BI	Applies a search index to structured and unstructured data sources and maps them into a classification structure of dimensions and measures that users can easily navigate and explore using a search interface.
	Mobile BI	Enables organizations to deliver analytic content to mobile devices in a publishing and/or interactive mode and takes advantage of the mobile client's location awareness.
Analysis	Online Analytical Processing (OLAP)	Enables users to analyze data with fast query and calculation performance, enabling a style of analysis known as "slicing and dicing." Users are able to navigate multidimensional drill paths. They also have the ability to write back values to a proprietary database for planning and "what if" modeling purposes. This capability could span a variety of data architectures (such as relational or multidimensional) and storage architectures (such as disk-based or in-memory).
	Interactive Visualization	Gives users the ability to display numerous aspects of the data more efficiently by using interactive pictures and charts, instead of rows and columns.
	Predictive Modeling and Data Mining	Enables organizations to classify categorical variables and to estimate continuous variables using mathematical algorithms.
	Scorecards	These take the metrics displayed in a dashboard a step further by applying them to a strategy map that aligns key performance indicators with a strategic objective.
	Prescriptive Modeling, Simulation and Optimization	Supports decision-making by enabling organizations to select the correct value of a variable based on a set of constraints for deterministic processes, and by modeling outcomes for stochastic processes.

Source: Gartner, Magic Quadrant for Business Intelligence and Analytics Platforms, February 5, 2013. www.gartner.com/id=2326815, accessed May 29, 2013

EXHIBIT 7: 2012 OVERALL CUSTOMER RATING OF BI PLATFORM CAPABILITIES IN MEETING NEEDS

Each year Gartner evaluates the BI platforms market with the ultimate goal of creating its "Magic Quadrant for Business Intelligence Platforms," which was last published on February 6, 2012. Part of that process is a large user survey of vendor-supplied references. Organization leaders — including many from IT, business or hybrid IT-business backgrounds — disclose their experiences with vendors' BI and analytics products and explain how those products and their capabilities contributed to their overall business success.

Disclaimer: Gartner publishes raw survey data solely as supporting evidence for its written analysis and prohibits all use or excerpting of such raw survey data in isolation from the research document from which it was taken.



Rating is equal to the mean of means score across vendors for each capability. The percentage axis reflects the mean percentage of respondents claiming extensive use across vendors. The percentage change number at the top of each capability score bar represents the percentage change in extensive use of the functionality in 2012 over 2011.
Chart represents customer perception and not Gartner's opinion.
The chart may feature vendors that (in Gartner's opinion) do not deliver the functional capability described.
BI = business intelligence; N/A = not available; OLAP = online analytical processing
*Mobile BI added in 2012
N = 1,364

Source: Gartner, "User Survey: Customers Rate their BI Platform Functionality, 2012," August 15, 2012. www.gartner.com/id=2122916, accessed May 29, 2013.

EXHIBIT 8: 2012 BI PLATFORM EASE OF USE VERSUS COMPOSITE PRODUCT RATING

The top two reasons indicated for choosing a particular BI platform provider were functionality (45.5 per cent) and ease of use for end users (42.6 per cent). There is a difference in attitude between IT and business users — users significantly weighted ease of use higher than functionality, with IT the opposite — but both are closely evaluated. Gartner hears this every day in inquiry; self-service BI is the goal for many organizations and ease of use is a strong criterion to make that goal a reality.

When you plot ease of use ratings against functionality ratings by vendor, you can easily see which vendors/products are rated "above average" on both vectors.

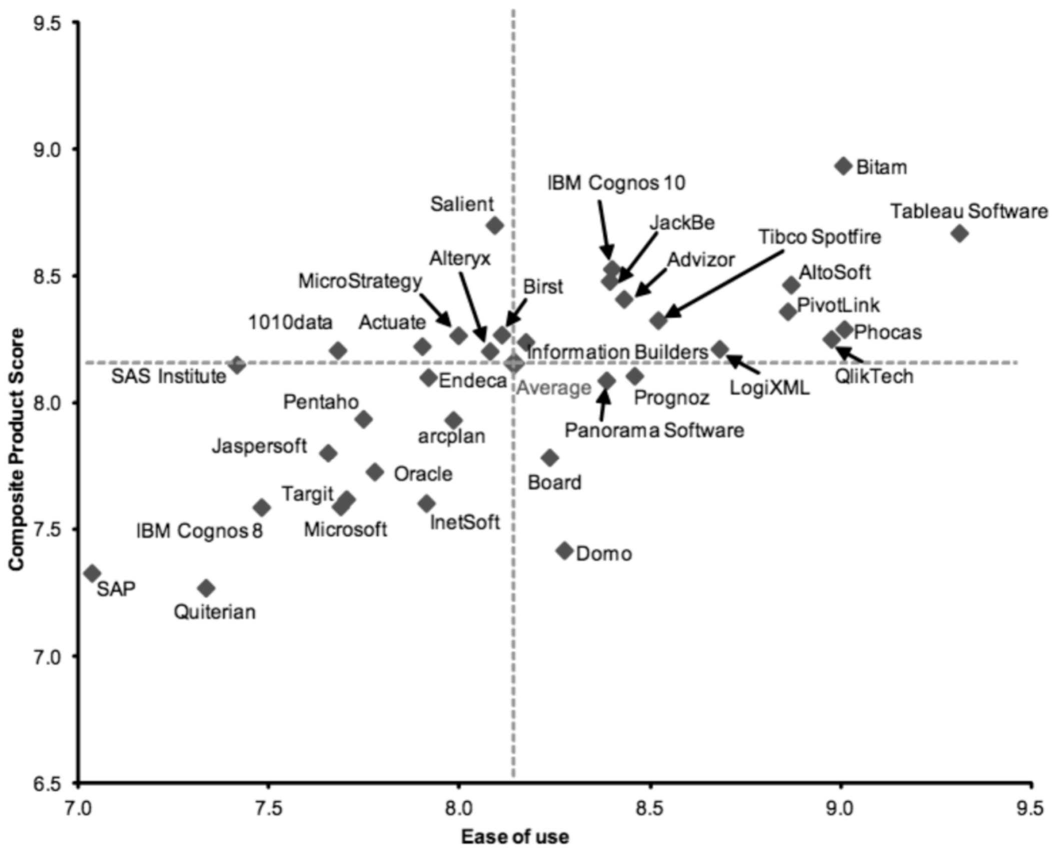
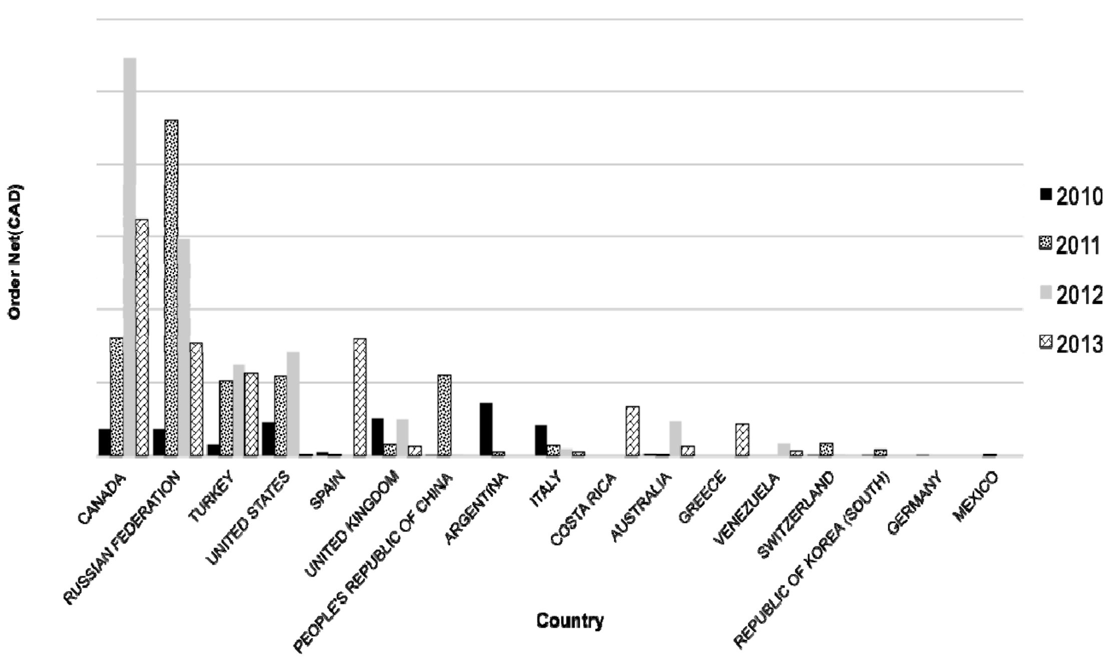


Chart represents customer perception and not Gartner's opinion.
N = 1,321

Source: Gartner, "User Survey: Customers Rate their BI Platform Functionality, 2012," August 15, 2012. www.gartner.com/id=2122916, accessed May 29, 2013.

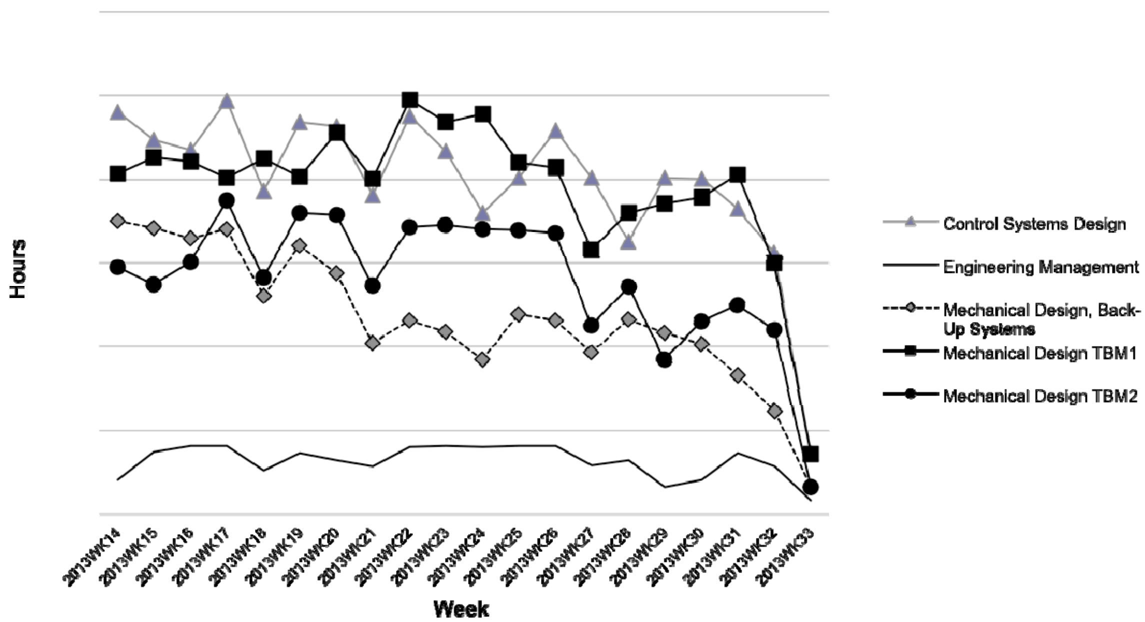
EXHIBIT 9: SPARE PARTS SALES PERFORMANCE BY GEOGRAPHY REPORT TEMPLATE

	2010			2011			2012		
	Order Net (CAD)	Invoice Net (CAD)	Outstanding (CAD)	Order Net (CAD)	Invoice Net (CAD)	Outstanding (CAD)	Order Net (CAD)	Invoice Net (CAD)	Outstanding (CAD)
ARGENTINA	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
AUSTRALIA	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
CANADA	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
COSTA RICA	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
GERMANY	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
GREECE	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
ITALY	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
MEXICO	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
PEOPLE'S REPUBLIC OF CHINA	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
REPUBLIC OF KOREA (SOUTH)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
RUSSIAN FEDERATION	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
SPAIN	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
SWITZERLAND	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
TURKEY	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
UNITED KINGDOM	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
UNITED STATES	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
VENEZUELA	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Sum:	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx



** Financial figures are masked due to confidentiality. Report users could drill down into the spare parts sales performance details by time to see the breakdown by years, quarters, months and weeks. The drill down action could also be performed to the countries to display the sales details by states or cities.*
Source: CTCC.

EXHIBIT 10: ENGINEERING RESOURCE LOADING REPORT TEMPLATE



Engineering Work Centers	2013M04	2013M05	2013M06	2013M07	2013M08	Sum:
Control Systems Design	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Mechanical Design TBM1	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Mechanical Design TBM2	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Mechanical Design, Back-Up Systems	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Engineering Management	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Sum:	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx

** Hour figures are masked due to confidentiality. Report users could drill down into the resource loading details by time to see the breakdown by years, quarters, months and weeks. The drill down action could also be performed to the work centres to display the resource loading details by project numbers, employees or tasks.*

Source: CTCC.