MIS QUARTERLY EXECUTIVE

CONTINENTAL AIRLINES FLIES HIGH WITH REAL-TIME BUSINESS INTELLIGENCE[1,2]

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Executive Summary

Real-time data warehousing and business intelligence (BI), supporting an aggressive Go Forward business plan, have helped Continental Airlines transform its industry position from "worst to first" and then from "first to favorite." With a $30M investment in hardware and software over six years, Continental has realized conservatively over $500M in increased revenues and cost savings in areas such as marketing, fraud detection, demand forecasting and tracking, and improved data center management.

Continental is now recognized as a leader in real-time business intelligence based upon its scalable and extensible architecture, prudent decisions on what data are captured in real-time, strong relationships with end users, a small and highly-competent data warehouse staff, a careful balance of strategic and tactical decision-support requirements, its understanding of the synergies between decision support and operations, and changed business processes that utilize real-time data.

CONTINENTAL TRANSFORMS ITSELF

Real-time business intelligence (BI) is taking Continental Airlines to new heights. Powered by a real-time data warehouse, the company has dramatically changed all aspects of its business. Continental's president and COO, Larry Kellner, describes the impact of real-time BI in the following way: "Real-time BI is critical to the accomplishment of our business strategy and has created significant business benefits." In fact, Continental has realized more than $500 million in cost savings and revenue generation over the past six years from its BI initiatives, producing an ROI of more than 1,000 percent.

Continental's current position is dramatically different from only ten years ago. The story begins with the arrival of Gordon Bethune as CEO, who led Continental from its "worst to first" position in the airline industry. A key to this turnaround was the Go Forward Plan, which continues to be Continental's blueprint for success and is increasingly supported by real-time BI and data warehousing.[3] Currently, the use of real-time technologies has been critical for Continental in moving from "first to favorite" among its customers, especially among its best customers.

Continental's real-time warehouse provides a powerful platform for quickly developing and deploying applications in revenue management, customer relationship management, flight and ground operations, fraud detection, security, and others. Some of these applications, the quantifiable benefits they are generating, and the technology in place that supports them are described. Continental's experiences with real-time BI and data warehousing have resulted in insights

[1] The senior accepting editor is Jack Rockart.

[2] We thank Anne Marie Reynolds, Luisa Chong, Saleem Hussaini, Carlos Ibarra, and the rest of the data warehousing team at Continental Airlines for their contributions to this article. Teradata, a division of NCR, provided funding for this case study.

[3] Some people prefer the term "right-time" over real-time in order to emphasize that data only needs to be as fresh as the decisions or business processes require. Depending on the business need, data can be hourly, daily, and even weekly or monthly and still be real-time. We use the terms real-time and right-time synonymously.

and practices from which other companies can benefit, and these lessons learned are discussed.

Decision support has evolved over the years, and the work at Continental exemplifies current practices. The article concludes by putting Continental's real-time BI and data warehousing initiatives into a larger decision-support context.

CONTINENTAL'S HISTORY

Continental Airlines was founded in 1934 with a single-engine Lockheed aircraft on dusty runways in the American Southwest. [4] Over the years, Continental has grown and successfully weathered the storms associated with the highly volatile, competitive airline industry. With headquarters in Houston, Texas, Continental is currently the USA's fifth largest airline and the seventh largest in the world. It carries approximately 50 million passengers a year to five continents (North and South America, Europe, Asia, and Australia), with over 2,300 daily departures to more than 227 destinations. Continental, along with Continental Express and Continental Connection, now serves more destinations than any other airline in the world. Numerous awards attest to its success as an airline and as a company (see Appendix A).

An Airline in Trouble

Only ten years ago, Continental was in trouble. There were ten major US airlines, and Continental ranked tenth in on-time performance, mishandled baggage, customer complaints, and denied boardings because of overbooking. Not surprisingly, with this kind of service, Continental was in financial trouble. It had filed for Chapter 11 bankruptcy protection twice in the previous ten years and was heading for a third, and likely final, bankruptcy. It had also gone through ten CEOs in ten years. People joked that Continental was a "Perfect 10." [5]

Enter Gordon Bethune and the Go Forward Plan

The rebirth of Continental began in 1994 when Gordon Bethune took the controls as CEO. He and Greg Brenneman, who was a Continental consultant at the time, conceived and sold to the Board of Directors the Go Forward Plan. It had four interrelated parts that had to be executed simultaneously.

- *Fly to Win.* Continental needed to better understand what products customers wanted and were willing to pay for.
- *Fund the Future.* It needed to change its costs and cash flow so that the airline could continue to operate.
- *Make Reliability a Reality.* It had to be an airline that got its customers to their destinations safely, on time, and with their luggage.
- *Working Together.* Continental needed to create a culture where people wanted to come to work.

Most employees supported the plan; those who did not left the company. Under Bethune's leadership, the Go Forward Plan, and a re-energized workforce, Continental made rapid strides. Within two years, it moved from "worst to first" in many airline performance metrics.

Information Wasn't Available

The movement from "worst to first" was, at first, only minimally supported by information technology. Historically, Continental had outsourced its operational systems to EDS, including the mainframe systems that provided a limited set of scheduled reports. There was no support for ad hoc queries. Each department had its own approach to data management and reporting.

The airline lacked the corporate data infrastructure for employees to quickly access the information they needed to gain key insights about the business. However, senior management's vision was to merge data into a single source, with information scattered across the organization so that employees in all departments could conduct their own business analyses to execute better and run a better and more profitable airline.

Enter Data Warehousing

This vision led to the development of an enterprise data warehouse. Janet Wejman, CIO at the time, recognized that the warehouse was a strategic project and brought the development, subsequent maintenance, and support all in-house. She believed the warehouse was core to Continental's business strategy, so it should not be outsourced. Work on the warehouse began, and after six months of development, it went into production in June 1998.

The initial focus was to provide accurate, integrated data for revenue management. Prior to the warehouse, only leg-based (a direct flight from one airport to another) data was available. Continental could therefore not track a customer's itinerary from origin to destination through several stops. Thus, Continental could

[4] The company history is available at www.continental/company.

[5] The story of Continental's problems and the actions that turned the company around can be read in Bethune, G. with Huler, S. *From Worst to First: Behind the Scenes of Continental's Remarkable Comeback*, Wiley, New York, 1998.

Figure 1: Three Initial Data Warehouse Applications

Demand-driven Dispatch

Prior to the warehouse, flight schedules and plane assignments were seldom changed once set, regardless of changes in markets and passenger levels. Continental operated flights without a detailed, complete understanding of each flight's contribution to profitability. After the data warehouse, Continental created a Demand-driven Dispatch application that combines forecast information from the revenue management data mart (which is integrated with the enterprise data warehouse) with flight schedule data from the data warehouse, to identify opportunities for maximizing aircraft usage. For example, the system might recommend assigning a larger plane to a flight with unusually high demand. Continental uses this application to "cherry pick" schedule changes that increase revenue. Demand-driven Dispatch has lead to an estimated $5 million dollars a year in incremental revenue.

Goodwill Letters

An eight-month test of the airline making goodwill gestures to customers showed that even small gestures can be very important to building loyalty. To make these gestures, marketing analysts used the data warehouse to marry profitability data and algorithms with customer records to identify Continental's high-value customers. The marketing department then divided these high-value customers into three groups. When any of these individuals was delayed more than 90 minutes, one group received a form letter apologizing, the second group received the letter and a free trial membership to the President's Club (a fee-based airport lounge) or some other form of compensation, and the third group received no letter at all.

Customers who received regular written communication spent 8 percent more with the airline in the next 12 months. In addition, nearly 30 percent of those receiving the President's Club trial membership joined the club following the trial, resulting in an additional $6 million in revenues. The concept of goodwill letters was expanded across the company to include the top 10 percent of Continental's customers.

Group Snoop

Group Snoop refers to a fare rule and contract compliance application that attempts to reduce the risk and financial impact of "no show" customers for any given flight. Because of the impact that groups can have on the final number of passengers boarded on a flight, advanced deposits and other contractual obligations are required for bookings of groups of 10 or more people who are traveling together.

However, travel agents can bypass this requirement and book a group of 16 by making two bookings of seven and nine without deposits or contracts. The fare rule has therefore created an incentive for agencies to block space in smaller groups to avoid making a deposit. Should the group not materialize, the financial impact to the airline can be significant. Sometimes agents convert smaller bookings to a group, but sometimes the bookings merely hold inventory space.

Using the booking and agency data from the warehouse, this Group Snoop application sorts reservations by booking agent and travel agent and then queries all groups of less than ten to identify the same travel agent ID and itinerary. Continental can then assess seat inventory more accurately and get travel agents to comply with the group booking requirements. Group Snoop has provided Continental an annualized savings of $2 million.

not study market and customer behavior, nor optimize its entire network of flights. The warehouse integrated multiple data sources – flight schedule data, customer data, inventory data, and more – to support pricing and revenue management decision-making based on journey information.

The data warehouse provided a variety of early, big "wins" for the business. The initial applications were soon followed by applications that required integrating customer information, finance, flight information, and security. These applications created significant financial lift in all areas of the Go Forward Plan. Figure 1 gives three examples of how the new integrated enterprise data was initially used at Continental.

Raising the Bar to "First to Favorite"

Once Continental achieved its goals of returning to profitability and ranking first in the airline industry in many performance metrics, Gordon Bethune and his management team raised the bar by expanding the vision. Instead of merely performing best, they wanted Continental to be their customers' favorite airline.

The First to Favorite strategy builds on Continental's operational success and focuses on creating customer loyalty by treating customers extremely well, especially the high-value customers (who are called CoStars). Figure 2 shows a poster in Continental's headquarters that reminds employees of the First to Favorite initiative

Figure 2: Continental Airline Internal Communications Poster

The Go Forward Plan identified more actionable ways the company could move from first to favorite. Technology became increasingly critical for supporting these new initiatives. At first, having access to historical, integrated information was sufficient for the Go Forward Plan, and it generated considerable strategic value for the company. However, as Continental moved ahead with the First to Favorite strategy, it became increasingly important for the data warehouse to provide real-time, actionable information to support enterprise-wide tactical decision-making and business processes.

Fortunately, the warehouse team had anticipated and prepared for the ultimate move to real-time.[6] From the outset of the warehouse project, they built an architecture able to handle real-time data feeds into the warehouse, extracts of data from the warehouse into legacy systems, and tactical queries to the warehouse that required sub-second response times.[7] In 2001, real-time data became available in the warehouse.

REAL-TIME BI APPLICATIONS

The amount of real-time data in the warehouse grew quickly. Continental moves real-time data (ranging from to-the-minute to hourly) about customers, reservations, check-ins, operations, and flights from its main operational systems to the warehouse. The following sections illustrate the variety of key applications that rely on real-time data. Many of the applications also use historical data from the warehouse.

Fare Design

To offer competitive prices for flights to desired places at convenient times, Continental uses real-time data to optimize airfares (using mathematical programming models). Once a change is made in price, revenue management immediately begins tracking the impact of that price on future bookings. Knowing immediately how a fare is selling allows the group to adjust how many seats should be sold at each given price. Last-minute customized discounts can be offered to the most profitable customers to bring in new revenue, as well as to increase customer satisfaction. Continental has earned an estimated $10 million annually through fare design activities.

Recovering Lost Airline Reservations

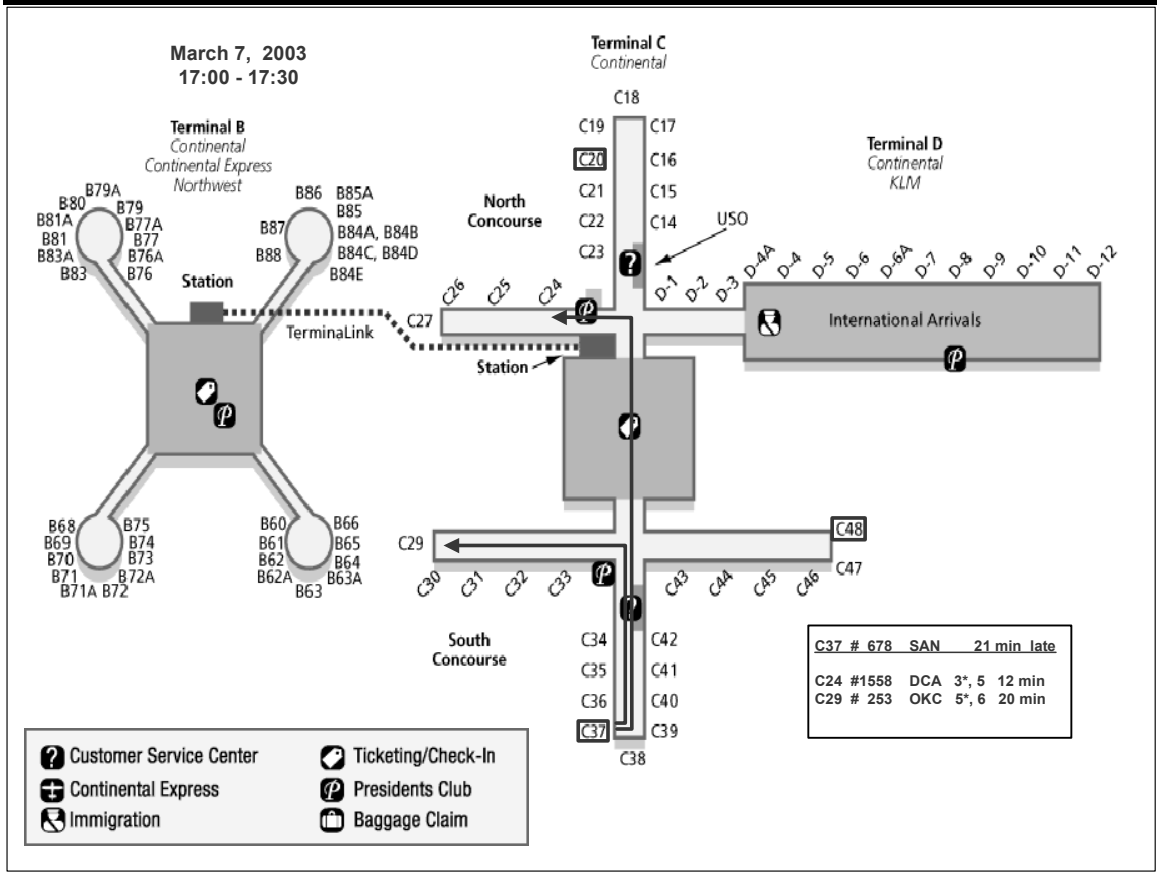
In 2002, an error in Continental's reservation system resulted in a loss of 60,000 reservations. Within a matter of hours, the warehouse team developed an application whereby agents could obtain a customer's itinerary and confirm whether the passenger was booked on flights.

Another similar situation happened in 2004 when the reservation system had problems communicating with other airlines' reservation systems. In certain circumstances, the system was not sending reservation information to other airlines, and, consequently, other airlines weren't reserving seats for Continental's passengers. As a result, Continental customers would arrive for a flight and not have a seat. Once the problem was discovered, the data warehouse team was able to run a query to get the information on passengers who were affected but who had not yet flown.

[6] An excellent research report on real-time BI is White, C. *Building the Real-Time Enterprise*," The Data Warehousing Institute, Seattle, WA, 2003.

[7] Insights about the methods and challenges of providing real-time data feeds is provided in Brobst, S. "Delivery of Extreme Data Freshness with Active Data Warehousing," *Journal of Data Warehousing* (7:2), Spring 2002, pp.4-9.

Figure 3: Concourse Display of High-Value Customer Activity



This information was fed back into the reservation system so that seats could be assigned, thus avoiding a serious customer relations problem.

Customer Value Analysis

A customer value model using frequency, recency, and monetary value gives Continental an understanding of its most profitable customers. Every month, the customer value analysis is performed using data in the data warehouse, and the value is fed to Continental's customer-facing systems so that employees across the airline, regardless of department, can recognize their best customers when interacting with them.

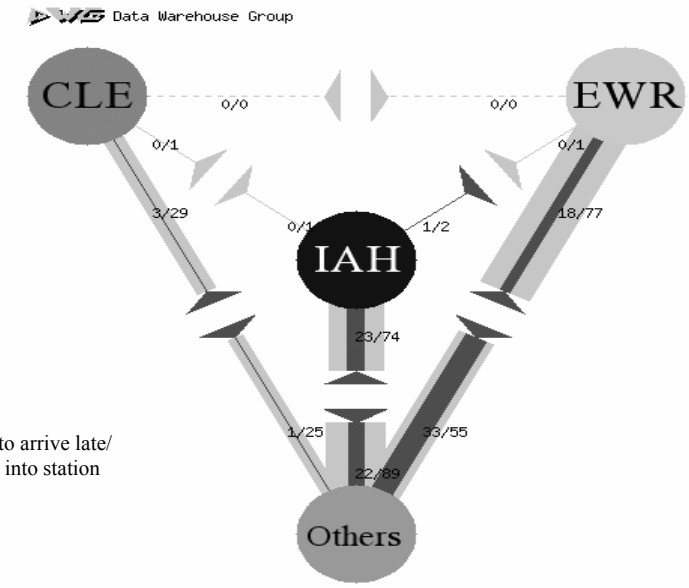
This knowledge helps Continental react quickly, effectively, and intelligently in tough situations. For example, just after 9/11, Continental used customer value information to understand where its best customers were stranded around the world. Continental applied this information to its flight scheduling priorities, and, while the schedules were being revised, the company worked with its lodging and rental car partners to make arrangements for its stranded customers. The highest value customer was in Zurich, and he used Continental's offices to conduct business until he was able to fly home.

Marketing Insight

Marketing Insight was developed to provide sales personnel, marketing managers, and flight personnel (e.g., ticket agents, gate agents, flight attendants, and international concierges) with customer profiles. This information, which includes seating preferences, recent flight disruptions, service history, and customer value, is used to personalize interactions with customers.

Gate agents, for instance, can pull up customer information on their screen and drill into flight history to see which high-value customers have had flight disruptions. Flight attendants receive this information on their "final report," which lists the passengers on their flights, including customer value information. A commonly told story is about a flight attendant who learned from the final report that one of the high-value customers on board recently experienced a serious delay. She apologized to the customer and thanked him for his continuing business. The passenger was very suprised that she knew about the incident and cared enough to apologize.

Figure 4: Display of Flight Lateness From/To Hubs



Flight Management Dashboard

The Flight Management Dashboard is an innovative set of interactive graphical displays developed by the data warehouse group. The displays help the operations staff quickly identify issues in the Continental flight network and then manage flights in ways to improve customer satisfaction and airline profitability.

Some of the dashboard's displays help Operations better serve Continental's high-value customers. For example, one display, a graphical depiction of a concourse, is used to assess where Continental's high-value customers with potential service issues are located or will be in a particular airport hub (see Figure 3). The display shows where these customers have potential gate-connection problems so that gate agents, baggage supervisors, and other operations managers can provide ground transportation assistance and other services so that these customers and their luggage do not miss flights.

Figure 3 shows that Flight 678 is arriving 21 minutes late to Gate C37 and eight high-value customers need assistance in making their connections to Gates C24 (three passengers) and C29 (five passangers), and they have 12 minutes and 20 minutes, respectively, to catch their flights.

On-time arrival is an important operational measure at Continental. The Federal Aviation Administration requires airlines to report arrival times and provide the summary statistics to the flying public. Therefore, another critical set of dashboard displays helps Operations keep arrivals and departures on time. One display shows the traffic volume between the three Continental hub stations and the rest of their network (see Figure 4). The line thickness between hub locations is used to indicate relative flight volumes and the number of late flights so that the Operations staff can anticipate where services need to be expedited. The ratio of the number of late flights to the total number of flights between the hubs also is shown. The Operations staff can drill down to see individual flight information by clicking on the lines between the hub locations.

Another line graph summarizes flight lateness. Users can drill down to detailed pie charts that show degrees of lateness, and within each pie, to the individual flights in that category. Still another chart concentrates on flights between the US and Europe and the Caribbean. It can show similar critical flight statistics.

In all of these elements of the dashboard, high-level views can be broken down to show the details on customers or flights that compose different statistics or categories.

Fraud Investigations

In the wake of 9/11, Continental realized that it had the technology and data to monitor passenger reservation and flight manifests in real-time. A "prowler application" was built so that corporate security could search for names or patterns. More than 100 "profiles" are run regularly against the data to proactively find fraudulent activity. When matches are found, e-mail and a message page are sent immediately to corporate security. Not only does this application allow corpo-

rate security to prevent fraud, but it also enhances their ability to gather critical intelligence through more timely interviews with suspects, victims, and witnesses.

One profile, for example, looks for reservations agents who make an extraordinary number of first-class bookings. Last year, Continental was able to convict an agent who was manufacturing false tickets and then exchanging them for real first-class tickets that she sold to her friends. Continental received over $200,000 in restitution from that one case. In total, Continental was able to identify and prevent more than $15 million in fraud in 2003 alone.

Is it Safe to Fly

Immediately after the terrorist attacks of 9/11, planes were ordered to land at the nearest airport. Continental had 95 planes that did not reach their planned destination. Sometimes there were three or four planes at a little airport in a town with no hotels, and passengers had to move in with the local people. At Continental's headquarters, FBI agents moved into a conference room with a list of people they had authority to check. Queries were run against flight manifest data to see if potential terrorists were on flights, and it was only after a flight was deemed safe that it was allowed to fly. Continental Airlines was recognized by the FBI for its assistance in the investigations in connection with 9/11.

SUPPORTING FIRST TO FAVORITE WITH TECHNOLOGY

Real-time BI requires appropriate technologies that is, those that extend traditional BI and data warehousing. At Continental, real-time technologies, and the associated processes, are critical for supporting the First to Favorite strategy.

The Data Warehouse

Continental's real-time BI initiative is built on the foundation of an 8-terabyte enterprise Teradata Warehouse running on a 3 GHz, 10-node NCR 5380 server. [8] The data warehouse supports 1,292 users who access 42 subject areas, 35 data marts, and 29 applications. Figure 5 shows the growth of the data warehouse over time.

The basic architecture of the data warehouse is shown in Figure 6. Data from 25 internal operational systems (e.g., the reservations system) and two external data sources (e.g., standard airport codes) are loaded into the data warehouse. Some of these sources are loaded in real-time and others in batch, based on the capabilities of the source and the business need. Critical information determined from analyses in the data warehouse (e.g., customer value) is fed from the data warehouse back into the operational systems.

Figure 5: Warehouse Growth Over Time

	1998	2001	Current
Users	45	968	1292
Tables	754	5851	16226
Subject Areas	11	33	42
Data Marts	2	23	35
Applications	0	12	29
DW Personnel	9	15	15

Data Access

Users access the warehouse data in various ways (see Figure 7). Some use standard query interfaces and analysis tools, such as Teradata's QueryMan, Microsoft Excel, and Microsoft Access. Others use custom-built applications. Still others use either the desktop (i.e., "fat client") or Web versions of Hyperion Intelligence. An estimated 500 reports have been created in Hyperion Intelligence, and many of these reports are pushed to users at scheduled intervals (e.g., at the first of the month, after the general ledger is closed). Other products include SAS' Clementine for data mining and Teradata CRM for campaign management.

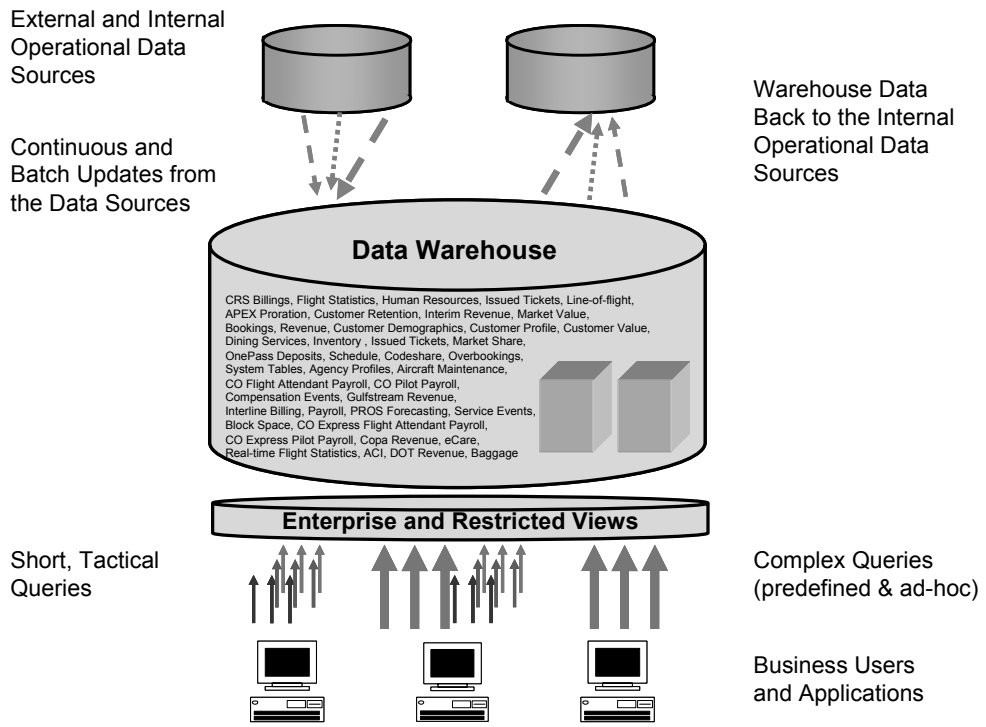
Real-time Data Sources

The data warehouse's real-time data sources range from the mainframe reservation system to satellite feeds transmitted from airplanes to a central customer database. Some data feeds are pulled from the sources in batch mode. For example, files of reservation data are extracted and sent using FTP (file transport protocol) from a mainframe application on an hourly basis. An application converts the data into 3rd normal form and writes the updated records to queues for immediate loading into the data warehouse.

Other data feeds are loaded to the warehouse within seconds. Flight data (called FSIR, or flight system information record) is sent real-time from airplanes

[8] Teradata uses the "active" data warehousing term to describe real-time data warehousing.

Figure 6: The Data Warehouse Architecture



via satellite to an operations control center system. FSIR data may include time estimates for arrival, the exact time of lift-off, aircraft speed, etc. This data is captured by a special computer and placed in a data warehouse queue, which is then immediately loaded into the warehouse.

Other data sources are pushed real-time by the sources themselves, triggered by events. For example, Continental's reservations system, OnePass frequent flier program, Continental.com, and customer service applications all directly update a central customer database. Every change made to a customer record in the customer database activates a trigger that pushes the update as XML encoded data to a queue for immediate loading into the data warehouse.

The Data Warehouse Team

The data warehouse team has 15 people who are responsible for managing the warehouse; developing and maintaining the infrastructure; data modeling; developing and maintaining data extraction, transformation and loading processes; and working with the business units. The organization chart for the data warehouse staff is shown in Figure 8.

Data Warehouse Governance

The Data Warehouse Steering Committee provides direction and guidance for the data warehouse. This large, senior-level committee has 30 members, most at the Director level and above. They come from the business areas supported by the data warehouse and are the spokespersons for their areas. Business areas that intend to participate in the warehouse are invited to join the committee. The warehouse staff meets with the committee to inform and educate the members about warehouse-related issues. In turn, the members identify business-area opportunities for the warehouse staff. They also help the warehouse team justify and write requests for additional funding. Another responsibility is to help set priorities for future directions for the data warehouse.

Securing Funding

The business areas drive the funding for the data warehouse. There has always been one area that has helped either justify the initial development of the warehouse or encourage its later expansion. Revenue Management supported the original development. The second and third expansions were justified by Marketing to support the Worst to First, and then First to Favorite strategies. Corporate Security championed the fourth, and most recent, expansion. This approach to funding helps ensure that the data warehouse supports the needs of the business.

Figure 7: Data Warehouse Access

Application or Tool	Types of Users	Number of Users
Hyperion Intelligence – Quickview (web)	Enterprise	300
Hyperion Intelligence – Explorer (desktop)	Enterprise	114
Access	Enterprise	200
Custom Applications	Enterprise	700
Teradata CRM	Marketing	20
Clementine Data Mining	Revenue Management	10
Teradata QueryMan	Enterprise	150
Excel	Enterprise	Many

The funding does not come directly from the business areas (i.e., their budgets). Rather, the funding process treats proposals as a separate capital expense. However, the business areas must supply the anticipated benefits for the proposals. Therefore, any proposal must have a business partner who identifies and stands behind the benefits.

THE BENEFITS OF BUSINESS INTELLIGENCE

Continental has invested approximately $30 million into real-time warehousing over the past six years. Of this amount, $20 million was for hardware and software, and $10 million for personnel. Although this investment is significant, the quantifiable benefits are magnitudes larger. Specifically, over the past six years, Continental has realized over $500 million in increased revenues and cost savings, resulting in a ROI of over 1,000 percent.

The benefits range from better pricing of tickets to increased travel to fraud detection. Figure 9 identifies some realized benefits. Because almost 1,300 users have warehouse access, it is impossible to know all the benefits. However, when big "wins" are achieved, the benefits are recorded and communicated throughout the company. This internal publicity helps preserve the excitement around warehouse use, and encourages business users to support warehouse expansion efforts.

LESSONS LEARNED

The experiences at Continental confirm the commonly known keys to success for any enterprise-wide IT initiative: the need for senior management sponsorship and involvement, close alignment between business and IT strategies, a careful selection of technologies, ongoing communication, a clear vision and roadmap, and letting the business drive the technology. More interesting, though, are the following seven insights

Figure 8: The Data Warehouse Organization Chart

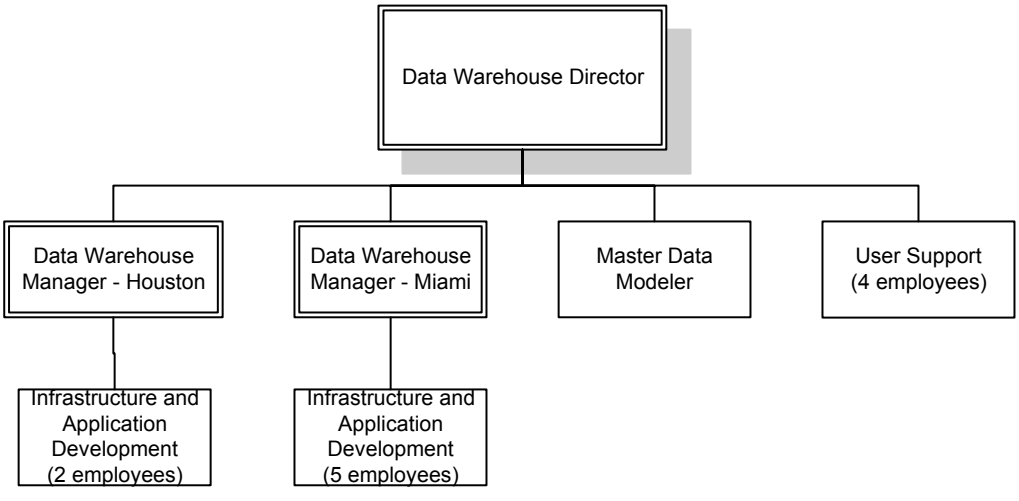


Figure 9: Sample Benefits from Real-time BI and Data Warehousing

Marketing	• Continental performs customer segmentation, target marketing, loyalty/retention management, customer acquisition, channel optimization, and campaign management using the data warehouse. Targeted promotions have produced cost savings and incremental revenue of $15 to $18 million per year. • A targeted CRM program resulted in $150 million in additional revenues in one year, while the rest of the airline industry declined 5 percent. • Over the past year, a goal was to increase the amount of travel by Continental's most valuable customers. There has been an average increase in travel of $800 for each of the top 35,000 customers.
Corporate Security	• Continental was able to identify and prevent over $30 million in fraud over the past three years. This prevention resulted in more than $7 million in cash collected.
IT	• The warehouse technology has significantly improved data center management, leading to cost savings of $20 million in capital and $15 million in recurring data center costs.
Revenue Management	• Tracking and forecasting demand has resulted in $5 million in incremental revenue. • Fare design and analysis improves the ability to gauge the impact of fare sales, and these activities have been estimated to earn $10 million annually. • Full reservation analysis has realized $20 million in savings through alliances, overbooking systems, and demand-based scheduling.

learned especially about the development and implementation of real-time BI.

Lesson #1: Prepare Early On for Real-time BI

Experienced BI professionals know there are continual demands for ever-fresher data. This demand is especially true for applications that are customer-facing or monitoring critical business processes. Even with traditional data warehousing, the trend is always for more frequent warehouse updates.

Continental was able to move into real-time quickly because the architecture had been designed with real-time in mind. When the business needed real-time information, the warehouse team was prepared to deliver it.

Lesson #2: Recognize That Some Data Cannot and Should not Be Real-time

The decision to move additional data to real-time should be made with care; data should be only as fresh as its cost and intended use justify. One reason for taking care is that real-time data feeds are more difficult to manage. The real-time processes, such as the flow of transaction data into queues, must be monitored constantly because problems can occur throughout the day (rather than just when a batch update is run). And, when problems with data occur, they must be addressed immediately, putting pressure on staffing requirements. Also, additional hardware may be needed to run loads and back up the data. Finally, obtaining real-time data feeds from some source systems can be prohibitively expensive (or even impossible) to implement. Because of these factors, data should only be as fresh as its cost and intended use justify.

Lesson #3: Show Users What Is Possible with Real-time BI

It is often difficult to get users to initially "think outside the box." They typically want new systems to give them exactly what the old ones did. They need help visualizing what real-time information can do for them. Once they appreciate what is possible, they are more likely to say: "Help me change the way we do business."

Continental's data warehousing staff addresses this problem by developing "cool" prototypes to show what is possible. One example is the Concourse Map

application described earlier. When the users saw how data could be depicted in graphical ways (e.g., as an actual concourse with colors and lines with special meaning), they came up with their own ideas for how real-time data could help them operate the hubs better. At Continental, the current challenge is to find the time to support the many new ideas the users have.

Lesson #4: Adjust the Skill Mix on Both the Warehouse and Business Sides

In many companies, the data warehousing staff generally has strong technical skills but limited business knowledge, while the business side has limited technical skills but good business knowledge. At the intersection of the warehousing and business organizations, there is a dramatic change in the technical/business skills and knowledge mix.

At Continental, this change is very gradual across the warehouse/ business intersection. Those warehouse personnel who work closest with the business users have considerable business knowledge. On the other hand, many business users have developed excellent technical skills – in fact, enough knowledge to build their own warehouse applications. The gradual shift in skills has reduced what can be a significant "divide," and helps ensure that Continental's warehouse is used to support the business.

Lesson #5: Manage Strategic and Tactical Decision Support to Co-exist

Strategic and tactical decision support have different characteristics, yet they must co-exist in the same warehouse environment. Strategic decision support typically involves the analysis of large amounts of data that must be "sliced and diced" in various ways. Tactical (sometimes called "operational") decision support often requires repeatedly accessing and analyzing only a limited amount of data with a sub-second response time.

Successful support for both requires both business and technical solutions. On the business side, priorities must be set for the processing of queries from users and applications. For example, a tactical query should have a higher priority than a strategic data-mining application. On the technical side, a query manager must recognize priorities, monitor queries, defer long-running queries for later execution, and dynamically allocate query resources.

At Continental, tactical queries that access single records are set to high priority. These queries usually come from applications, such as continental.com, that require instantaneous response time. All daytime batch data loads are set to low priority, and all daytime trickle feed loads are set to medium priority. And, users who perform ad-hoc queries are given medium priority access.

Lesson #6: Real-time BI Blurs the Line Between Decision Support and Operational Systems

For one thing, the performance requirements for real-time BI (e.g., response time, downtime) are similar to those of operational systems. In fact, the same personnel (or ones with similar skills) may be used for both. Whereas decision support and operational systems may previously have had their own standards, because of the need for closer system integration, common standards become more important. In nearly all instances, the warehouse needs to be compatible with overall IT standards. Furthermore, the data warehouse team must be made aware of any upcoming changes to any operational system that provides real-time data because these changes could have immediate and potentially disruptive impacts.

Lesson #7: Real-time BI Doesn't Deliver Value Unless Downstream Decision-making and Business Processes Are Changed

There are three sources of latency in real-time BI: the time to extract data from source systems, the time to analyze the data, and the time to act upon the data. The first two can be minimized using real-time technologies. The third requires getting people and processes to change. Unless downstream decision-making and business processes are changed to utilize real-time data, the value of the data decreases exponentially with the passage of time.

PUTTING THE WORK AT CONTINENTAL IN A DECISION SUPPORT PERSPECTIVE

The initial thinking, research, and practice of computer-based decision support started in the late 1960s. Prior to then, computers were used almost exclusively for transaction processing (with the exception of scientific applications). Books by Scott Morton and Keen and Scott Morton helped to create awareness of the potential of computer-based decision support.[9] Decision support systems (DSS) was the name given to

[9] Scott Morton, M. *Management Decision Systems: Computer-Based Support for Decision Making*, Division of Research, Harvard, Cambridge, MA, 1971. Keen, P.G.W. and Scott Morton, M. *Decision Support Systems: An Organizational Perspective*, Addison-Wesley, Reading, MA, 1978.

this type of application, and it continues in academia to be both the name of a discipline and a specific type of application. Throughout the 1970s and into the 1980s, DSS was the "hot topic" in both academia and practice. The Sprague and Carlson book (published in 1982) codified much of what had been learned about DSS, including the need for a dedicated decision-support database.[10]

In the early 1980s, the decision support focus turned to executive information systems (EIS). Rockart and Treacy's article, "The CEO Goes Online" published in the *Harvard Business Review*, and Rockart and DeLong's book, *Executive Support Systems: The Emergence of Top Management Computer Use*, did much to publicize and create interest in EIS.[11] The research and work on EIS provided many insights that have influenced current practice. For example, many EIS failures were related to an inadequate data infrastructure, which supported the emergence of data warehouses.[12] The use of critical success factors is now seen in business performance management (BPM), digital dashboards, and balanced scorecards, all popular today.[13] In successful decision-support applications, there are continuing pressures to provide users with ever-fresher data.[14]

In the late 1980s, data warehousing emerged to provide the data infrastructure needed for decision-support applications. The writings of Inmon (who is widely recognized as "the father of data warehousing") and Kimball helped many organizations think about and develop data warehouses.[15] Among the first warehouse adopters were firms in telecommunications, retail, and financial services, which are highly competitive and need to understand and use customer data to be competitive.

Initially, data warehouses were perceived as a repository of historical data and were used primarily to support strategic decision making. As companies recognized the need and potential to support tactical and operational decisions, they developed operational data stores (ODS) to meet the need for very fresh data.[16] For the warehouse itself, extraction-transformation-loading (ETL) processes became more frequent, once again to provide more current data for decision support. Recognizing the need for real-time data, in the past couple of years, vendors have introduced products that allow companies to move to real-time warehousing. As companies make this move, the distinctions between operational and decision-support systems blur.[17]

Data warehouses differ in the ways companies use them. In some cases, warehouses primarily support reporting and queries, while in others they provide critical support for applications that are aligned with a company's business strategy.[18] When companies move to real-time warehousing and BI, they are better able to support tactical and operational decisions. This is both a natural evolution and a dramatic shift. It is natural in terms of the movement to providing ever-fresher data, but is a significant change in how the data can be used. With current data, it is possible to support many additional kinds of decisions and use the data to support internal operations and interactions with customers. For example, business activity monitoring (BAM) is dependent on the availability of up-to-date data.[19]

As decision support has evolved over the years, a new term emerged in the industry for analytical applications. In the early 1990s, the influential Gartner Group began to use the term business intelligence (BI), and it is now well entrenched. BI applications include DSS, on-line analytical processing (OLAP), EIS, and data mining. The BI term is only now beginning to find its way into academia's vocabulary.

Continental Airlines provides an outstanding example of how decision support is changing in many leading companies. Real-time data warehousing and BI allow Continental to use extremely fresh data to support current decision making and business processes to affect the organization's fate. Continental has put in place a decision-support infrastructure that is able to evolve with the needs of the business. Organizations must understand the natural evolution of decision support –

[10] Sprague, R.H., Jr. and Carlson, E.D. *Building Effective Decision Support Systems*, Prentice-Hall, Englewood Cliffs, NJ, 1982, pp. 221-255.
[11] Rockart, J.F. and Treacy, M.E. "The CEO Goes On-Line," *Harvard Business Review* (60:1), January-February 1982, pp. 81-93. Rockart, J.F. and DeLong, D.W. *Executive Support Systems: The Emergence of Top Management Computer Use*, Dow Jones-Irwin, Homewood, IL, 1988.
[12] Gray, P. and Watson, H.J. *Decision Support in the Data Warehouse*, Prentice-Hall, Upper Saddle River, NJ, 1998, pp. 4-6.
[13] Gregory, M.A. "Keys to Successful Performance Management," *Business Intelligence Journal* (9:1), Winter 2004, pp. 41-48.
[14] Paller, A. with Laska, R. *The EIS Book*, Dow Jones-Irwin, Homewood, IL, 1990, pp. 50-51.
[15] Inmon, W.H. *Building the Data Warehouse*, Wiley, New York, 1992. Kimball, R. *The Data Warehouse Toolkit: Practical Techniques for Building Dimensional Data Warehouses*, Wiley, New York, 1992.
[16] Gray and Watson, op. cit.
[17] Atre, S. and Malhotra, D. "Real-Time Analysis and Data Integration for BI," *DM Review* (14:2), February 2004, pp.18-20.
[18] For examples of the different ways that data warehouses are used, see Watson, H.J., Goodhue, D.L. and Wixom, B.J. "The Benefits of Data Warehousing: Why Some Companies Realize Exceptional Payoffs," *Information and Management* (39:6), May 2002, pp. 491-502. Goodhue, D.L., Wixom, B., and Watson, H.J., "Realizing Business Benefits Through CRM: Hitting the Right Target in the Right Way" *MISQE*, June 2002, pp.79-94
[19] White, C. "Now Is the Right Time for Real Time BI," *DM Review*, (14:9) September 2004, pp. 47, 50, 52, 54.

how far the field has come and its future possibilities – so that they, too, can be prepared to harness the power of real-time BI to make the right decisions at the right time.

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Dr. Hugh Watson

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Hugh is a Fellow of The Data Warehousing Institute and the Association for Information Systems and is the senior editor of the *Business Intelligence Journal*. He is also senior director of the Teradata University Network, a free portal for faculty who teach and research data warehousing, BI/DSS, and database. For the past 17 years, Watson has been the consulting editor for John Wiley & Sons' MIS series.

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APPENDIX A: HONORS AND AWARDS

Best Customer Service	J.D. Power, *SmartMoney*, Ziff Davis *Smart Business*
Best International or Premium Class Service	OAG, National Airline Quality Rating, *Nikkei Business Magazine*, *Travel Trade Gazette Europa*, Inflight Research Services, *Condé Nast Traveler*, *Smart Money*, *Wall Street Journal*
Best Airline	*Fortune*, *Air Transport World*, *Investor's Business Daily*, *Hispanic Magazine*, *Aviation Week*, OAG
Best Technology	#1 Airline, #2 of 500 Companies – *InformationWeek*, #1 Web, by Forrester, Gomez Advisors, NPD New Media Services and InsideFlyer, TDWI 2003 Best Practice Award – Enterprise Data Warehouse, TDWI 2003 Leadership Award, CIO Enterprise Value Award

