

Continental Airlines

I. Executive Summary

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This case study would not have been possible without the great work of a team from Continental Airlines and the academic community in collaboration with Teradata. So many Continental staff gave generously of their time to speak about their experiences and successes, in particular Ron Anderson-Lehman, Anne Marie Reynolds, and Luisa Chong. Assisting with interviews, research and writing were Hugh Watson/Terry College of Business, University of Georgia, Barbara Wixom/McIntire School of Commerce, University of Virginia, and Jeffrey Hoffer/School of Business Administration, University of Dayton.

Continental's comeback from "Worst to First" is an airline industry legend. Now the company is engaged in a new initiative to move from "First to Favorite." To support this ambitious initiative, Continental tapped into its Enterprise Data Warehouse and expanded it to enable a real-time business intelligence capability.

In the first five years of operations, the EDW achieved an ROI of more than 1000% on a \$25 million investment. To do this, Continental has changed the way it does business, transforming its decision-making process to include multidimensional views of the business. A company that once knew little about its important customers, set fares and schedules using only the limited conventional industry assumptions, conducted contract negotiations blind, and fought fraud only after the damage was done, Continental today is one of the best managed airlines in the world. Its strategic and tactical decision-making analytics are on the cutting edge of the airline industry.

- > **Customer Relationship Marketing** provides customer service finely tuned by segmentation. At any time, Continental can see a single, real-time profile of any of its customers and act accordingly.
- > **Employees** are empowered with access to the information they need, when they need it, to get answers and implement solutions. The result is employees who do a great job and a spot on the *Fortune 100 Best Companies to Work For* list for five consecutive years.

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- > **Revenue Management** maximizes revenue for each flight by projecting demand by true origin and destination, allocating seat inventory by fare class, reducing overbooking and dynamically matching aircraft capacity.
 - > **Operations** acts on real-time information to manage issues as they arise in the flight network, including delays, cancellations, equipment changes and last-minute staffing changes.
 - > **Crew Systems** optimizes crew schedules to reduce unnecessary pay costs and provides critical information to reduce contention during contract negotiations.
 - > **Security** takes proactive steps to prevent credit card, frequent flyer, and internal and external fraud. They analyze bookings and create profiles to identify and target suspicious behavior before significant damage is done.

In just ten years, Continental has gone from being the worst U.S. airline to being one of the best, and it has the awards and accolades to prove it – Best Customer Service, Best International or Premium Class Service, Best Airline, Best Technology – the airline has been recognized around the world by analysts, industry experts, and customers. And what the public knows of its success is just the tip of the iceberg. Beneath the surface are hundreds of other initiatives and successes the company cannot divulge for critical competitive reasons.

Continental's story is one of inspired leadership, a bold vision for the technology to support its goals, and a strong cooperative work ethic from the top to the front line.

The Catalysts for Change

In 1994 Continental was a perfect 10. It ranked 10th of 10 in every key Department of Transportation metric. Out of the 10 major U.S. airlines, Continental ranked 10th in on-time performance, baggage handling, customer satisfaction, and overbooking accommodation. Its last profitable year had been 1984. The company had filed twice for Chapter 11 bankruptcy protection and was headed for a third bankruptcy. Ten CEOs had come and gone in ten years.

If Continental was going to compete and stay in business, change was needed. The story of the airline's transformation "From Worst to First," under the leadership of CEO Gordon Bethune is a lesson for every struggling business.

Today Continental has won accolades and awards for all aspects of its business performance. Headquartered in Houston, Texas, Continental is the fifth largest airline in the U.S. and sixth largest in the world, employing about 49,000 people. It carries more than 50 million passengers a year to five continents (North and South America, Europe, Asia and Australia), with over 3,045 daily departures to more than 271 destinations, serving more destinations than any other airline in the world.

II. The Decision to Invest

From 1994 through the end of 1997, Bethune's "Worst to First" business strategy relied little on technology. Bethune began by reshaping the company with his "Go Forward Plan," which still guides the business today. The Go Forward Plan has four interrelated parts, dealing with the airline's product, finances, market and people:

- > **Fly to Win.** Understand what products customers want and what they are willing to pay for.
- > **Fund the Future.** Manage costs and cash flow so the airline can continue to operate.
- > **Make Reliability a Reality.** Get customers to their destination safely, on time and with their luggage.
- > **Work Together.** Create a culture where people want to come to work.

Under Bethune's leadership, guided by the Go Forward Plan, Continental was re-energized. But succeeding in today's business environment takes speed, efficiency and flexibility. Companies must continually transform to adapt to fast-changing market forces. There was only so far the airline could go forward without the support of its information technology.

From Outsourcing to In-house

In 1995 Continental had one daily performance report, with no financial data, and historical data was inaccessible for detailed analysis. The airline outsourced its operational systems to EDS and there were

The Go Forward Plan

Fly to Win

Understand what products customers want and what they are willing to pay for.

Fund the Future

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Make Reliability a Reality

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Work Together

Create a culture where people want to come to work.

few proprietary applications. Mainframe systems provided a limited set of scheduled reports and there was no support for ad hoc queries. Each operational area had its own approach to data management and reporting. There was no corporate infrastructure that would enable a broad range of employees to get quick access to key insights about the business. In fact, information was inconsistent across the different areas and there was no detailed information to explain the differences.

Bethune and current President Larry Kellner had a vision of a company that put all the information its people needed at their fingertips. They believed that with the right information, people would not only make the right decisions when decisions needed to be made, but would also spot new opportunities.

A well-informed management team can make precise and timely decisions, creating an environment of cooperation and contribution that impacts the bottom line. As Kellner says, "Real-time BI is critical to the accomplishment of our business strategy and has created significant business benefits."

Janet Wejman, Continental's CIO at the time, was charged with developing an Enterprise Data Warehouse (EDW). Wejman recognized the strategic importance of the project and knew that it needed to be brought in-house for Continental to meet its goals. She understood from the beginning that the scope of the project should not be limited to the specific business problem, but rather that each new development of business functionality would set the stage for another

valuable strategic use. To accommodate the required flexibility and responsiveness, the project needed to be implemented in-house and could not rely on the limitations of outsourcing.

The initial impetus for the implementation of an EDW project came from the Revenue Management team. Revenue analysis was restricted to a leg-based demand forecast, meaning Continental could not track a customer's itinerary from origin to destination (O&D) if it involved more than one stop. Revenue Management could see only each "leg" of the customer's travel, because there was no access to integrated detailed information

such as schedule, booking, customer data, inventory, market value tables and other data. Historical data was limited to less than one year, so trending analysis was ineffective at best. A system was needed to provide Revenue Management with the capability to do O&D tracking and forecasting and fare design and analysis, and to integrate customer information with revenue and agency information. Better optimizing revenue was critical to Continental's sustainable success.

The second important driver for continued expansion of the EDW was Continental's Customer Relationship Marketing team. Until the EDW, it was not possible to

determine whom the actual high value customers were or how to predict and influence their behavior. When a customer called the customer care center, unless he gave his One Pass number, agents might not know if he was a frequent flyer, nor could they see baggage history, future bookings, service disruptions or the fare basis of the ticket. The information any Continental employee might have regarding a customer was so limited that it might even be misleading. The airline's customer information was simply not accessible to facilitate customer interactions – to the detriment of its bottom line.

As Revenue Management and Customer Relationship Marketing began to demonstrate the value of the EDW, the implementation project spread throughout the company. And as each new functional team saw the value it could extract from additional information resources, the project grew.

“Real-time BI is critical to the accomplishment of our business strategy and has created significant business benefits.”

– Larry Kellner, President, Continental Airlines

III. Implementation

At the end of 1997, Continental began development work on its EDW and the first iteration of the warehouse was rolled out in June 1998.

In the early stages of the EDW implementation, Continental held dozens of employee and customer focus groups worldwide to gain insights into the needs of each operational area. Hundreds of ideas were generated. The ideas were then evaluated and prioritized by teams from each operational division. After this initial idea blitz, a longer-term structure was put in place for optimal growth of the EDW.

A Data Warehouse group was established to manage the ongoing maintenance and continuous improvement of the EDW capability. An Application for Expenditure (AFE) process was established, under which departments looking to fund new warehouse functionality make a formal business case, showing the costs and anticipated ROI of the proposed project. In most cases when a business unit presents an AFE, it understands that the new functionality will benefit other end users around the company. In this way, when a substantial capital project is funded, it has a ripple effect around the company as it enables other smaller data warehousing projects to piggyback their needs on the new data and applications, increasing the ultimate ROI of the original AFE.

The Data Warehouse Steering Committee is composed of 30 high-level managers, most at the Director level and above, from

each operational function of the company. It reviews EDW use and new AFEs and makes decisions on future directions and priorities. Each committee member acts as a spokesperson for his or her business area. The data warehouse staff meets with the committee to inform and educate the members about warehouse-related issues. In turn, the members identify opportunities for the warehouse staff to become involved with business areas. This give-and-take is often the impetus for new AFEs.

With the solid executive support of Bethune and Kellner's visionary leadership, new ways of working together were devised to enable good employees to use the technology to do an even better job. Strong divisional relationships and divisional ambassadors ensured that cooperation around the company was maximized. A key innovation of the project is that the users are empowered to find the data they need themselves so that, unlike many companies, the Data Warehouse group produces few reports. It is the business users who "own" the EDW, not IT, as has traditionally been the case at many companies. The Data Warehouse group manages the system and their Service Bureau is responsible for maintenance and upgrades.

Data Warehouse Director Anne Marie Reynolds says, "Our philosophy of letting users have free reign on the data allows the cream to rise to the top." The people who are capable of hard analysis are using

the data in innovative ways. In Revenue Management, for example, Managing Director Greg Lough often creates new reports as he needs them, enabling him to immediately take advantage of opportunities he spots for deeper analysis and understanding of the business.

On the flip side, IT monitors for users who bog down the system with unproductive queries and will, if necessary, lower a query's prioritization where excess resources are being used. IT conducts user group seminars every two months, providing training on new software and a forum to answer user questions. The key for IT is to stay in touch with the user group and understand their business needs.

Continental's Data Warehouse group is uniquely business savvy. The delineation between business users and IT is less distinct than at other companies, leading to a close and fruitful cooperation. IT-savvy business users on the data warehouse team act as business liaisons and have a high level of understanding of the needs of the business unit they serve. On the other side, power users on the business team with a high level of technological understanding may develop their own reports independent of IT assistance.

Brief descriptions of the architecture of the EDW and the active data warehouse (ADW) capability follow. More detailed information on the technology can be found in Technical Appendix A.

The Enterprise Data Warehouse

The 8TB warehouse runs on a 10-node 5380 server. The warehouse supports 1,292 users who access 42 subject areas and 29 applications.

Data from 25 internal operational systems and two external data sources are loaded into the warehouse. Some sources are loaded in real-time and others in batch, based on capabilities of the source and the business need for timelines.

Source systems include:

- > Schedules
- > Inventory
- > Reservations
- > Airline tickets
- > Airline revenue flown information
- > SOCC (Systems Operation Coordination Center)
- > One Pass (frequent flyer program)
- > Customer profiles and demographics
- > Aircraft maintenance
- > Alliance data
- > Employee and crew payroll
- > Customer care

Application areas include:

- > **Revenue Management.** Providing real-time revenue projections for any flight based on detailed data so appropriate pricing and booking decisions can be made and aircraft assignment is optimized.
- > **Customer Relationship Management.** Providing a single, integrated view of each customer so a customer value model can give accurate, up-to-date profitability pictures.
- > **Flight Management Dashboard.** Tracking all flights and monitoring late flights, the basis for decisions affecting customer satisfaction and airline profitability.
- > **Fraud Detection.** Identifying reservations that are not in fare and contract compliance, and profiling suspicious booking and ticketing transactions.

Active Data Warehousing

Making real-time data available was a critical piece in the business strategy of capitalizing on information resources. An ADW is a timely, integrated, logically consistent store of detailed data available for strategic, tactical and event-driven

business decision-making. Continental realized that if operational data was even one day old, critical situations could not be analyzed and addressed as they occurred throughout the day. High-value customers could not be identified on the spot and treated accordingly to ensure their continued loyalty and business. Responding to flight delays and re-booking connecting flights could not be done quickly enough. Half-full planes might take off; while on a nearby flight, passengers were denied boarding due to overbooking. Switching aircraft could have solved both problems. With up-to-the-minute information, many of these logistical and operational issues can be solved on the spot.

Thanks to a long-range vision for the EDW, the architecture of the demanding ADW environment was planned from the earliest design phase at the system's inception. Continental developed data transformation and loading processes, including trickle feeds, which are fully automated and monitored. In fact, the EDW is essentially "watched" by a group of networked PCs, allowing IT developers to work on new projects and respond to problems only when the automated system cannot resolve an issue. As a result, with an EDW team of only 15 people, new projects are constantly under way and the ADW environment is provided with scalability, high availability and support.

Warehouse Growth Over Time			
	1998	2001	Current
Users	45	968	1,292
Tables	754	5,851	16,226
Subject Areas	11	33	42
Applications	0	12	29
DW Personnel	9	15	15

Table 1

The Teradata System Architecture

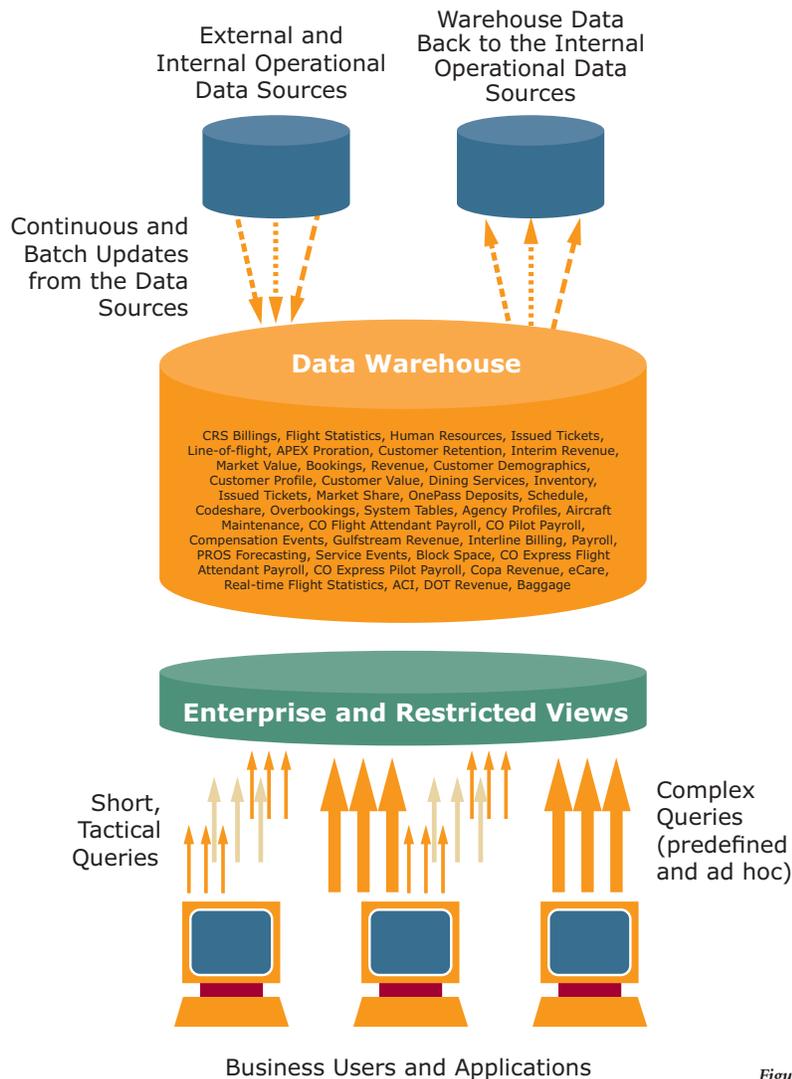


Figure 1

In 2001, real-time data became available in the warehouse and is now used for tactical decision-making or on-the-spot decisions, in Customer Management, Revenue Management, Flight Information, Revenue Accounting and Fraud Detection.

While tactical decision-making requires the real-time capabilities of the ADW, strategic decision-making and planning also need time-stamped data “as it was” at any point. The real-time warehouse ensures detailed long-term memory to the enterprise in addition to up-to-the-day data freshness. Referring to this important feature, Continental calls its warehouse the Time Machine.

Continental is moving toward a fully 24x7 environment, in which all hardware is mirrored in a redundant system, so that as servers are taken down for repairs or upgrades, users will experience a seamless transition from one server to another. As users find more ways to capitalize on the information at their disposal, the uninterrupted availability of the EDW becomes ever more essential.

The implementation of the EDW is an ongoing project. As more sources are added and people become more attuned to the availability of rich data sources, new and better business methods are developed. Real-time data enables tactical decision-making and flexible engagement of opportunities at the highest available level.

IV. New Business Strategies

Action can be taken immediately when an issue is spotted, not later when the window of opportunity for effective action has passed.

Every corporate plan is founded on one of the four objectives of the original Go Forward Plan and leadership has disseminated its vision at every level of the company, so that every decision is informed by at least one of these four goals:

- > Fly to Win
- > Fund the Future
- > Make Reliability a Reality
- > Work Together

This unity of purpose is made possible by an extraordinarily high level of constant communication with employees and by committing to one complete, consistent source of information so that everyone is on the same page. Daily news e-mails and messaging posters in common office spaces are just two of the ways that Continental achieves its communication goals.

Continental constantly relies on its information resource to alter its models and analyze ways its business might change to be better positioned in both the volatile economic climate and in its competitive industry. Every day, Bethune and Kellner set the standard, their eyes on thousands of seemingly small things, asking where costs can be cut without diminishing service and what revenue

opportunities exist that have not been fully captured. Continental uses its information to question everything about how people fly, prompting scrutiny of even the hub and spokes model the carrier's route system is based on. The only thing that won't change is the basic vision of the company – what products do people value, what will they pay for and how can they be delivered profitably?

The oft-quoted corporate mantra is “You can't manage what you don't measure.”

Management has an array of financial, operational and other information at their fingertips, on their desktop computers, every day. They can dig into regional numbers, country numbers and individual flights to pinpoint successes and, more importantly, problem areas. Consequently, action can be taken immediately when an issue is spotted, not later when the window of opportunity for effective action has passed.

Of course it took time for this new way of thinking to catch on. People needed to learn new habits, as more powerful information-driven tools became available. Now, as more information becomes available, the demand keeps increasing.

For example, real-time flight statistics (RTF) mean that upper management can see real-time revenue projections for any flight, where the most valuable customers are while in flight and which ones are affected by delays and cancellations. With this information, better, faster decisions can be made on things such as which customers should receive priority in booking on other flights if their original one is delayed or cancelled. Using real-time information, what-if scenarios can be run to determine the impact of events and the best course of action, as the events are happening. The result – Continental has enhanced its service recovery response times, and all around the company, people are using information to improve the way they do business.

“First to Favorite”

Continental is famous for its turnaround from “Worst to First,” a phrase embedded in the public consciousness by Gordon Bethune in his bestselling book. The company now has a new goal, which it embodies in the phrase “First to Favorite.” This new branding initiative recognizes the need to be not just the #1 airline, but to be each customer's favorite airline. “Go big or stay home,” is how Kelly Cook, Director of Customer Relationship Management Marketing, describes Continental's philosophy of how it intends to pursue First to Favorite. The initiative is simply good basic CRM. However, CRM is not solely the responsibility of a Customer Relationship Marketing group. Building a customer-centric culture needs to be

instilled into business strategies and practices in every operational aspect. Customer focus becomes the mindset of the whole company.

The leadership at Continental works hard to build employee trust, because becoming customer-centric begins with each and every employee. The focus of what employees do every day in their jobs needs to be, “What impact does this have on the customer’s experience?” Ultimately, building employee trust will lead to building the customer’s trust. Continental wants to continue to be the best place to work and the best airline to fly. Continental understands that these goals are interconnected. Employee attitude is reflected in the customer experience.

This commitment to the customer required a deep financial commitment in an industry plagued by a weak economy and under significant profit pressures. Even with a strong business case, because First to Favorite demanded an overhaul of everyone’s approach to strategy, and because the project was to be ongoing, quantifiable value needed to be demonstrated all along the way. Hard numbers at every stage, showing the measurable value of the stated goals, was a requirement.

The Customer Relationship Marketing group’s expansion of the EDW to accommodate the First to Favorite goals was

driven through Continental’s AFE process. Implementing initiatives through a phased approach enabled the group to find the quick hits and show the immediate benefits of the data warehouse project. At every stage, the actual ROI exceeded the projected ROI.

In the first phase, the off-site marketing data mart was eliminated. At a cost of \$1 million per year, the outsourced data mart took weeks to set up a marketing promotion based on only 12 months of data. Now, marketing initiatives can be implemented within days. The marketing group recalculates ROI every six months, to ensure its initiatives are on target.

In another First to Favorite initiative powered by the EDW capability, one of the Go Forward goals for 2004 included increasing on-line check-in from 5% to 25%. The goal is ambitious, but Continental is committed to streamlining the check-in process. Continental’s self-service model envisions customers moving through the airport with as little need for lines and agent contact as possible. The role of ticket and gate agents, and all other airport employees, will transition from managing passenger processing to servicing the customers. Agents will be more focused on providing quality service to each customer. Increasing on-line check-in moves Continental closer to the customers, where they can best serve them.

Customers

Customer segmentation is an essential tool in any customer-focused enterprise. But segmentation is only as effective as the information on which it’s based. Complete, consistent information is critical and the EDW is an essential foundation of Continental’s sophisticated segmentation. A customer value model uses frequency, recency, and monetary value to identify the airline’s most profitable customers.

After extensive research into the information available through the EDW, Continental has established three primary customer categories, each of which receives a different focus. Within each category, of course, are many more segments.

- > “High Value” customers number only in the tens of thousands. These frequent travelers use high fares and are willing to pay more for personalized service. This top 1% of flyers represents \$1 billion of the \$8.5 billion annual revenue. What they look for is a “relationship,” and what Continental focuses on is giving them an extraordinary level of personal service. These customers fly Continental for the employees, not the product. Personalized, handwritten notes every quarter are just one of the myriad points of contact with these customers. The marketing group is also studying whether to segment Continental.com, so that High Value customers will see a different version of the website or have access to extra features.

At every stage the actual ROI exceeded the projected ROI.

- > “Elites” number in the hundreds of thousands. These travelers, who are members of the One Pass frequent flyer program, use a mix of high and low fares and make some price-driven decisions. What they look for is “Visible Product Differentiation” (VPD). For these customers, attentive customer service can be the difference between flying Continental or its competitors. Continental gives them elite access at airports, priority check-in, priority security, priority boarding, bonus miles if they are seated in a center seat and automatic upgrades, among other things.
- > “Others” are the millions of infrequent travelers using low fare tickets. These customers are price driven and look for a routine, smooth and consistent experience – what Continental calls “Clean, Safe and Reliable” (CSR). To maintain CSR standards, Continental measures on-time departures and arrivals, baggage handling, complaints, involuntary denial of boarding as a result of overbooking and other essentials of its product, constantly watching for opportunities to improve.

The EDW has enabled Continental to test the concept that building relationships with its High Value customers and treating them well will increase loyalty. An eight-month goodwill letter test showed that even small gestures can be critical to building loyalty. A sampling of High Value

customers was divided into three groups. When individuals were delayed by more than 90 minutes, one group received an automated form letter apologizing; a second group received a letter and a trial membership to Continental’s President’s Club (or some other form of compensation); and the third group received no letter. Customers who received the written communication spent 8% more in the next 12 months, the equivalent of \$6 million in extra revenue. And, 30% of those who received the President’s Club trial membership joined the Club, an additional revenue bonus. This high yield program has since been expanded to include the top 10% of Continental’s customers.

The ADW environment enables Continental to see time a single, real-time profile of any of its customers at any time. Not only is the history of the customers’ experiences accessible, but also near real-time information on reservations, operations, service events and compensation.

The customer experience is divided into three phases: pre-travel, the travel experience, and post-travel. At each stage, different divisions of the company affect the customer: Revenue Management determines optimal seat allocations by fare basis; Sales and Marketing targets prospective and returning customers with offers; Reservations and Ticketing issues travel documents; airport personnel interact

directly with the customer, at the gate and in the President’s Club; pilots and flight attendants are responsible for customers in the air; baggage handlers close the travel experience; customer loyalty and service recovery responses round out the picture. At each of these phases, the ADW environment enables Continental to see a single, real-time profile of its customers and helps employees to focus on the customer’s experience. With such detailed information available, the customer’s profile guides the treatment appropriate to that particular customer’s value.

Although Continental calls on its information to provide an extraordinary level of personal service at each phase of the customer experience, the company takes customer privacy very seriously. Not only does Continental comply with all applicable data privacy laws and regulations in the U.S., it is the only U.S. airline to be registered with the Department of Commerce as a safe harbor company. This designation certifies Continental’s compliance with the stricter European Union data directives on individual privacy.

While customers value their privacy, Continental knows that its “high value” customers expect and deserve upgraded service and personal recognition. Continental continues to work to find the balance between providing superior personalized service, without invading the privacy of customers.

Empowered Employees

Employees are one of the key resources at Continental, and more productive employees mean better margins. Kellner believes that employees rarely make mistakes on purpose. Before the EDW, without relevant data, the thousands of decisions that Continental made about its 2,300 flights a day were based on guesses and assumptions. In an environment without reliable information, it is difficult for any employee to succeed.

But with Continental's commitment to information resources, the EDW has created an environment in which employees are given the opportunity to flourish. With easy access to the wealth of information at their fingertips, employees are empowered, which means better business. The ability to get answers to ad hoc queries and analyze new issues as they arise means employees can be more creative and forward-looking in their thinking. Problem solving is that much easier when the tools for getting answers and implementing solutions are readily available. The ability to deal with issues efficiently, in turn, creates job satisfaction, as employees see their efforts yield results. Motivated employees are happier, and happy employees are more motivated. Bethune and Kellner lead by example. They set a high standard of curiosity into the information available and are accessible and communicative as corporate leaders.

Russell Rego, Hub Operations Coordinator at Newark Airport, is just one example of an employee motivated by the problem-solving capability at his fingertips. Rego started in 1993 as a baggage handler working on the ramps loading aircraft. He was frequently frustrated by the lack of coordination and communication about gate changes, meaning ramp workers were rarely able to plan the workflow of their days effectively, and instead wasted significant time chasing planes from gate to gate. Rego, hoping to improve the planning, moved into operations in 1996 and has since been instrumental in coordinating all the new technologies in the new operations tower in Newark. Now a range of employees from vice president to gate agents to anyone who needs the data, can access a website for up-to-the-minute information on flight delays and cancellations, so decisions can be made about gate changes, airport staffing and other front line tactical decisions.

For example, during a major winter storm, up to 200 of the 400 daily departures from Newark might be cancelled or delayed. Getting this information out to people early means that operations can plan appropriately and hold airport personnel to staff the extra flights arriving after normal work hours.

In another example, Rego describes how some flights used to "get lost" between touchdown and gate arrival because no gates were available due to other delays and the arriving aircraft was held in a waiting area on the runway known as "the ballpark." Now, using up-to-the-minute Web reports, Continental tracks all arrivals closely and keeps tabs on flights waiting more than 30 minutes in the ballpark for a gate assignment to ensure nothing slips through the cracks.

On the strategic side, Rego helped create a daily report to help understand the no-show factor and plan the future accordingly.

Rego is constantly thinking of new ways to use information. A top priority on his current wish list is access to accurate information on the exact arrival and departure runways used by Continental flights. Some runways are shorter and closer to Continental's gates and thus have shorter taxi times than others. With rising fuel costs, an average taxi minute costs \$33. Rego hopes that with timely access to runway information, Continental can reduce taxi costs by using runways more efficiently.

Rego's motivation to succeed is a win-win situation for Continental. The airline has a happy and loyal employee who feels challenged in his job. Rego, in turn, works together with his colleagues, finding ways to improve the way Continental does business.

Communication with employees is a hallmark of the Continental work environment – from weekly voicemails from the CEO, to a detailed “First to Favorite” Website for employees, to posters encapsulating corporate philosophy and goals in elevator banks, kitchens and copy rooms. Here’s just one example of an internal communication poster:



Continental is constantly communicating with its employees, reinforcing the positive work environment and the vision of leadership, as expressed in one of the four pillars of the Go Forward Plan – Work Together.

The norms and attitudes when management is not present, for example, at the ticketing desk, at the gate, or on the plane, are directly impacted by the positive employee culture. Employees “know it,” “believe it” and “live it.” Providing the personalized touches that distinguish Continental from its competitors is part

of the employee experience as well as the customer experience. The employees understand that they are walking billboards for the company. They are the front line of customer loyalty. Continental knows its empowered-employee, customer-focused culture is working, because even the baggage handler is motivated to achieve the levels of customer service the airline is committed to give. Every employee has internalized the First to Favorite mentality, and everyone understands that the philosophy is “win together or lose together.” This is a long way from the de-motivated, unhappy and sometimes hostile work environment of the company prior to 1994.

Through its communications process, Continental highlights “heroes” and rewards them with recognition. In a recent instance, the agent at an airport President’s Club saw a customer bend over to pick up his briefcase and split his pants. Because the customer had swiped his One Pass card coming in, the agent knew that he was one of Continental’s top customers. She immediately took him to the President’s Club conference room, where he waited in privacy while she mended his pants. This kind of customer-oriented, pitch-in behavior is common among Continental employees. The EDW makes it possible by putting the essential information where it’s needed, when it’s needed.

Continental earns accolades for every aspect of its operations and in 2003 the company ranked on the *Fortune 100 Best Companies to Work For* list for the fifth consecutive year – an accomplishment that only about 20 companies have ever achieved.

Revenue Management

Revenue Management used to be handicapped in its analysis by incomplete data and an inability to see anything beyond the leg-based data relating to a customer.

The EDW has enabled Revenue Management to correlate a customer’s complete itinerary, from Origin to Destination (O&D), and integrate related important data like ticket revenue, travel agency information, four years of historical information on every passenger and every flight, and future information on schedules and bookings out 340 days.

With this information available for analysis, Revenue Management is able to maximize the revenue for each flight in innovative ways. Some of the analytical functions the group performs include:

- > Projecting demand by O&D to get a true view of the airline product
- > Allocating seat inventory by fare class based on anticipated demand for high yield travel
- > Reducing overbooking
- > Tactically matching asset capacity (aircraft configuration and type) with customer demand forecasts on a dynamic basis, which includes switching aircraft day-of, if revenue projections dictate and schedules allow
- > Designing and tracking fare sales to analyze the impact of discounts and competitors’ pricing actions on revenues

Airline seats are perishable goods. Once a plane takes off, an unfilled seat has no potential value. Forecasting demand and determining the optimum allocation of this perishable inventory (seats) is a key airline function. Based on a theory built in collaboration with MIT, marginal seat revenue and the probability of assigning seats at particular fare rates can be calculated on a rolling basis for each flight. Pricing then uses the information to determine the best schedule for fare discounts and other special fares.

From the up-to-the-day demand forecast, other opportunities to optimize business functions also flow. Continental's proprietary application, Demand-driven Dispatch, identifies opportunities for maximizing aircraft use. Based on forecast information and flight schedule data, aircraft are dynamically swapped to accommodate more or less demand. For example, on the weekend of the New Orleans Jazz Festival, swaps occur to accommodate the increased demand for seats to New Orleans. This application alone saves Continental \$5 million a year while also increasing revenue.

Access to real-time information means Revenue Management can spot problems sooner. Overbooking data from the night before, for example, can result in an investigation into why the overbooking happened. Did agents have access to inventory they shouldn't have? Did a

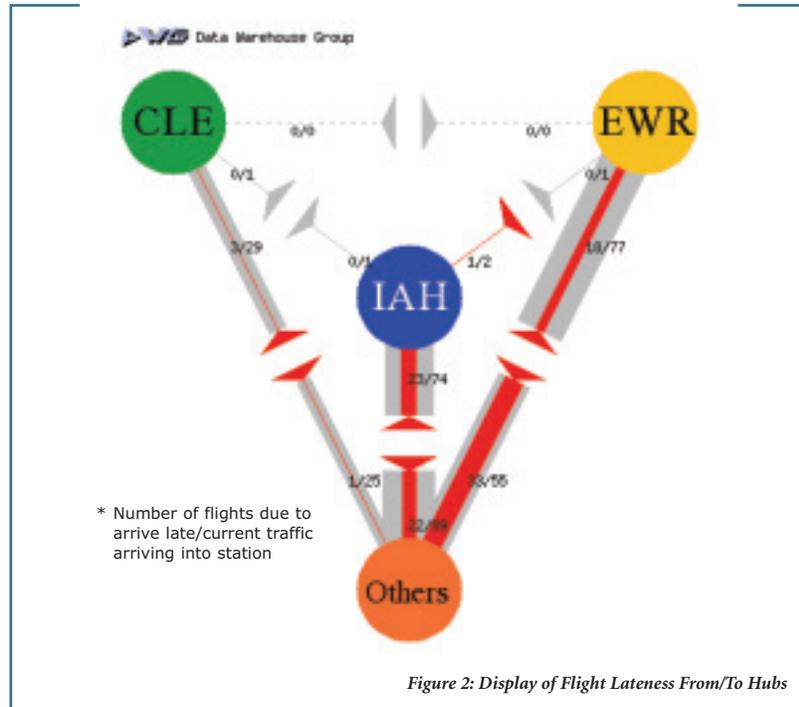


Figure 2: Display of Flight Lateness From/To Hubs

flight cancel? How were customers re-accommodated? The information allows Continental to see the things that need to be fixed and fix them.

Operations

Operations successes at the Newark hub were highlighted earlier, but Russell Rego's work at Newark is just one area in which Operations has been improved.

The proprietary Flight Management Dashboard application developed by the data warehouse group is an innovative set of interactive graphical displays that help Operations staff quickly identify and deal with issues in the Continental flight

network. One set of dashboard displays shows traffic between the three hubs and the rest of the airline's network (see Figure 2). The visual display of flight volumes and delays enables staff to react immediately to situations requiring expedited services.

Another dashboard display (see Figure 3) shows gates where high value customers have potential gate connection problems so that gate agents, baggage supervisors, and other operations managers can assess what assistance is needed to ensure those important customers don't miss their flights.

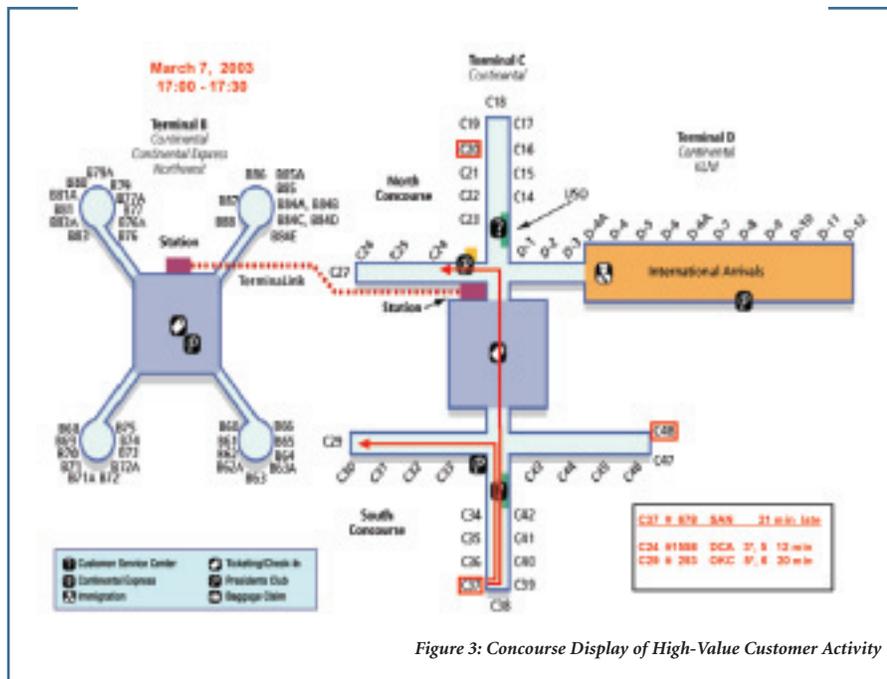


Figure 3: Concourse Display of High-Value Customer Activity

Crew Payroll

In 2001 the crew management statistical reporting system moved from an unwieldy mainframe, with independent FOCUS databases for particular reporting, to managing information from the EDW. Where the mainframe and FOCUS database set up meant much of the information was inaccessible except to a few and updating a reporting function could take hundreds of hours, the breadth, depth, and timeliness of information available through the EDW enables sophisticated management of one of the highest costs of flights – pilot and flight attendant pay. The following is a sample of what the Flight Operations group can do with access to the EDW:

- > Manage the cost of non-flying hours paid out to pilots

- > Understand the impact of contract negotiations prior to commitment and create a stronger working relationship with the unions

Each of these new capabilities meant substantial cost savings and more efficient use of crew and pilot resources.

“Other” Pilot Pay

Over the years, prior to the implementation of the EDW, Flight Operations was aware that 5-10 hours per pilot/per month went unaccounted. Although Payroll knew that the hours were legitimate, they fell into an “other” bucket; that is, other than hard flying hours, company business, vacation, training and other hours accounted for precisely in the payroll records. There was simply not enough detail in the information to drill down into the “other” bucket.

Once detailed information was made available through the EDW, Continental discovered that a large proportion of the “other” hours were attributable to dead-head – hours when a pilot was on duty, but flying as a passenger on a flight to catch up to the next flight they were booked to pilot – and pay protection. By focusing on these areas, Continental was able to pair scheduling for pilots with greater efficiency. As a result of the EDW detail, 80% of the “other” hours are now explained, and the “other” bucket has been reduced to less than 1 hour per pilot/per month.

Contract Negotiations

There are two broad categories of pilot, line holders and reserves. Line holders are the more senior pilots who have fixed monthly schedules, usually established by a combination of request and airline need. Reserves are the junior pilots, and are called upon as needed when line holders are not available.

During a recent round of contract discussions, the union’s position was that too many pilots were being placed on furlough, and they held the perception that Continental was using the reserves to fill the schedule during normal operations to such an extent that if an irregular operation (such as due to weather) were to occur, Continental would find itself without enough pilots to operate all the flights. Using the data warehouse, Continental was able to show that this was not, in fact, the case and that the usage of reserves tracked historical values. Further,

Continental was able to show that occasional increases in reserve usage correlated to times when line holders were calling in sick at above normal rates, and when there had been an above normal number of bad weather days. The negotiations could then deal with the true issues, rather than the false perceptions. As Anna White, Director of Crew Technology, says, “We now have the ability to tell a story with the data warehouse.” And the stories provide invaluable insight into the operation of the business, enabling the company to establish appropriate controls and monitoring procedures. The more information at its disposal, the more insight Continental has during contract negotiations.

Security

Although Revenue Management and Customer Relationship Marketing were the first two drivers for the EDW implementation, in an unanticipated benefit, Security quickly realized the power of the EDW to assist with identifying and preventing the costly fraud that employees, customers, and travel agents commit against the company. Some examples of the kinds of abuse first identified include:

- > Blocking of seat inventory
- > Stored Fare abuse (employees bypassing auto-pricing and providing discounted fares)
- > Fictitious booking records
- > Fraudulent lost baggage claims
- > One Pass account redemption abuse
- > Passive records and Global Distribution System (GDS) billing errors

The data available enabled Security to develop rules and flags to find behavior that follows a common fraud pattern. For example:

- > An application called Group Snoop monitors non-compliance with certain fare rules related to block bookings by travel agents. Advanced deposits are required for groups of 10 or more booked by agencies, as a group cancellation poses a greater risk for Continental than an individual cancellation. Agents, however, would book large groups in the guise of several smaller groups to circumvent the advance deposit rule, causing distortions in demand forecasts and pricing. Group Snoop automatically sorts by booking agent and travel agent and then finds all groups of fewer than ten with the same IATA# and itinerary.
- > An application called Dupe Snoop identifies when the same passenger is booked on simultaneous flights, to find wasted inventory.

Security is constantly developing profiles to target suspicious booking and ticketing transactions. To date, they have more than 100 profiles of suspicious behavior. Craig Cunningham, Director of Security Automation, calls it the “big sky” theory of fraud detection. It’s a big sky, so the likelihood of two planes colliding is virtually zero. The likelihood of certain coincidences occurring in ticketing transactions is equally unlikely, and therefore suspicious on its face. The technical investigations group was created to track and investigate profile anomalies.

A “proowler application” was built so that Corporate Security can search for names or patterns. More than 100 “profiles” are run regularly against the data to search proactively for fraudulent activity. When matches are found, an e-mail and page message is sent immediately to a contact at Corporate Security. This capability helps Corporate Security identify fraudulent activity as it occurs. Not only does this feature allow Corporate Security to prevent fraud that is occurring, but it also enhances the ability to gather critical intelligence through more timely interviews with suspects, victims, and witnesses.

Security recently put together an AFE requesting more information be standardized and integrated into the EDW. Security wants to be able to see the ticketing server, so investigators can look up the history of an electronic ticket to watch for illogical locations on ticket sales and track the agents related to tickets. The group also wants access to the electronic certificate database, which tracks compensation certificates given for flight cancellations and other service recovery. Security expects that this information will turn up illegal issuances and be another fruitful avenue for fraud prevention.

This proactive approach to corporate fraud is an innovative departure from the usual responsive nature, where investigations begin based on tips from concerned sources – telephone tips, complaints, stolen laptops, thefts and customer disturbances. Those traditional security

issues are dealt with by the assets protection side of security and are far less data intensive. Continental is using its information resources to find fraud long before it is reported.

For example, a ticketing agent was recently convicted for a scheme under which fake exchange documents, unused tickets for exchange, were used to “pay” for new first class tickets, where the upgrade or change fee was paid in cash. The purchasers only knew they were paying a relatively low cash fare for a first class ticket. Because there was no system by which the exchange documents were verified during the transaction itself, there was no red flag raised about this activity. However, a security profile picked out the unusually high number of first class ticket sales for cash as a suspicious behavior and was then able to link back the fake exchange documents and make the case. The agent is facing jail time and has been ordered to make restitution of the nearly \$200,000 stolen. Security’s success sent a warning to would-be embezzlers that they are watching closely.

In another instance, the sudden appearance of a new customer who ranked as the most profitable Continental customer that month was a red flag for Stacey Warren, Manager in Customer Relationship Marketing. She looks at customer profitability data regularly and recognizes most of the names. The new name tipped her curiosity. She passed the information on to Security and they followed up. It turned out that the apparently new, highly profitable customer, who had never

In its first three years of operation, the technical investigation group eliminated \$30 million worth of fraud and recovered \$7 million reimbursement in cash. In 2002 alone, Security identified and prevented more than \$15 million in fraud.

appeared on any customer profitability list before, had dummied up counterfeit boarding passes and tickets and deposited them all in one day to his new One Pass account. Access to his frequent flyer account was shut down immediately, preventing any fraudulent redemption of miles for real tickets.

In its first three years of operation, the Technical Investigation group eliminated \$30 million worth of fraud and recovered \$7 million reimbursement in cash. In 2002 alone, Security identified and prevented more than \$15 million in fraud. The amount of fraud eliminated is calculated by annualizing losses for frauds lasting more than 30 days and assuming a one-year duration. For fraud under 30 days, the actual loss to date is used, without any assumption of future loss. No account is taken for the amount of fraud prevented by tightened security, nor are fraudulent schemes that would have lasted more than a year accounted for. As a result, it is likely that the already enormous benefits of technical investigations are undervalued. The more information resources the group has access to, the harder it will be for long-term fraud to occur.

Alliances

Alliances have always presented a level of complexity requiring extensive data resources. For example, for four years, Continental had code share agreements with airlines A and B, involving complex contract structures under which diversion penalties were to be paid for instances where code share A took business away from code share B as a result of the cooperation agreement with Continental. Unfortunately, the data required to perform the calculation of diversion penalties was not available in usable form – until the EDW. Now Continental has the data resources and processing power to calculate the diversion penalties accurately and fulfill the contractual obligations undertaken four years ago.

As information has become more available, Continental realized that it could extend its flight network through more alliances and optimize revenue. From 230 destinations, the network is extended to 650 destinations with alliance partners. To tap the revenue potential of alliances, it is necessary to track not just the O&D information, but also to understand the ultimate destination of every passenger.

A booking on a Continental flight from Houston to Paris may not reveal the ultimate destination of Moscow.

“The goal,” as Derek Adair, Senior Manager in Corporate Development and Alliances, says, “is to form new alliances so as to create a presence where Continental has a small market share, and to achieve market share shifts where Continental already has a presence.” To analyze alliance potential, Continental draws on internal and external information, using data available on worldwide booking to assess the total demand for any given O&D and the fare classes paid. Information still needs to be standardized and integrated to enable Continental to see origin and ultimate destination easily in cases where a passenger travels some legs outside Continental and its code share flights. The EDW will be used to tie data from disparate sources together to transform the leg-based information that looks like this,

San Diego-----Houston

Houston-----Amsterdam

Amsterdam---Moscow

into information that is joined in a string.

San Diego--Houston--Amsterdam--Moscow

This will enable Continental to see true O&D and all the stops in between to determine which hubs are pushing traffic to which destinations, for a fuller understanding of the way people travel.

Disaster Response

In a world of heightened security and greater perceived threats, airlines need to be prepared. In the immediate aftermath

Constant innovation, employee creativity and leadership vision will ensure that Continental builds on this foundation for the future.

of the events of September 11, 2001, Continental had 95 planes that did not reach their planned destination. 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.

Using the flight manifests, the airline was also able to determine where its high value customers were stranded and treat them with extra care, coordinating with lodging and rental car partners to make arrangements and ensuring they were prioritized for the first re-scheduled flights. In one case, the airline identified that its highest value customer was in Zurich and provided him with Continental offices to conduct business until the customer was able to get home.

From an operational perspective, the first week after 9/11 was expended on triage to save the airline from going out of business. Then came the quick and critical decision about resource allocation. The schedule and costs needed to be cut by 20%. On September 15, 2001, Continental Airlines

knew that it would also need to cut at least 20% of its workforce to reduce costs sooner in order to deal most effectively with the crisis in the airline industry precipitated by the events of September 11.

Because the EDW provided mastery of its information resources, Continental was able to absorb the impact of the tragedy immediately into its business planning. The airline differentiated bookings made prior to September 11 and those made after, and applied metrics to each that calculated the possibility of a no-show. Continental management was able to integrate this data with information about where planes were scheduled to be and where they might be more valuable. They were able to combine booking information with logistics information to gain a more complete picture of the airline’s situation during the crisis. Continental leveraged its information capital to make decisions about where to reroute planes, cancel flights and reassign employees.

The airline suffered economically, of course. But Continental’s losses were a fraction of the losses suffered by its competitors.

V. ROI

In a time when the airline business has been besieged by bad news (the September 11 effect on travel, SARS, corporations cutting costs and high fare travel, high fuel prices and strong competition from low cost carriers), Continental has stayed ahead of the game.

- > \$250 million total cost savings and incremental revenue over first five years of operations, equivalent to an ROI of more than 1000% on a \$25 million investment in hardware, software and development resources
- > Cost savings of \$20 million in capital and \$15 million in recurring data center costs as a result of the EDW investment
- > Annual cost savings of \$31 million for business operations as a result of the EDW
- > Estimated revenue increase of \$40 million in 2002 from Revenue Management, Fraud Detection, Crew Payroll and CRM applications
- > \$5 million in incremental revenue as a result of tracking and forecasting demand by Origin and Destination
- > Annual savings of \$10 million as a result of the improved ability to gauge the impact of fare sales
- > \$20 million saved through code share decision enhancements, overbooking systems and demand-based scheduling because full Passenger Name Record (PNR) was available for analysis
- > \$15 million of identified and prevented fraud in 2002. \$30 million of identified and prevented fraud over three years and \$7 million reimbursement

- > \$15-18 million annual cost savings and incremental revenue as a result of better targeted promotions

Not only has Continental enjoyed a substantial, directly quantifiable return on its investment, the list of awards and accolades the airline is collecting continues to grow.

The Future

Continental Airline's EDW project is not finished, nor will it ever be static if it is to continue to fulfill its promise to constantly provide the adaptability and flexibility

essential to succeeding in today's market. The EDW has already achieved extraordinary ROI and changed the way Continental does business. The airline industry is changing. Financial pressures, security pressures and competitive pressures are all taking their toll. Continental has established the strong technical foundation it needs to stay ahead of the curve. Constant innovation, employee creativity and leadership vision will ensure that Continental builds on this foundation for the future.

Awards and Accolades

Best Customer Service

- > J.D. Power
- > SmartMoney
- > Ziff Davis Smart Business

Best International or Premium Class Service

- > OAG
- > National Airline Quality Rating
- > Nikkei Business
- > Travel Trade Gazette Europa
- > Conde Naste Traveler
- > SmartMoney
- > Wall Street Journal

Best Airline

- > Fortune
- > Air Transport World
- > Investors Business Daily
- > Hispanic Magazine
- > Aviation Week
- > OAG

Best Technology

- > #1 Airline
- > #2 of 500 companies – Information Week
- > #1 Web by Forrester
- > Gomez Advisors
- > NPD New Media Services and Inside Flyer
- > TDWI 2003 Best Practice Award – Enterprise Data Warehouse
- > TDWI 2003 Leadership Award
- > CIO Enterprise Value Award

Technical Appendix A

At Continental, real-time technologies and the associated processes are critical for supporting the Go Forward Plan and the First to Favorite strategy. The following is a description of the Enterprise Data Warehouse functionality implemented by the airline.

The Teradata System

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

The basic architecture of the data warehouse is shown in Figure 1. 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 that is determined from analysis within the data warehouse (e.g., customer value) is fed from the data warehouse back into the operational systems.

All of the data are stored at the lowest level of detail in the Teradata Database. The same database also contains a work area for each department so that they can store specialized data, such as summary tables with department-specific calculations and aggregations. Departments can work with the data warehouse team to create logical dependent data marts within the Teradata system.

Warehouse Growth Over Time			
	1998	2001	Current
Users	45	968	1,292
Tables	754	5,851	16,226
Subject Areas	11	33	42
Applications	0	12	29
DW Personnel	9	15	15

Table 1

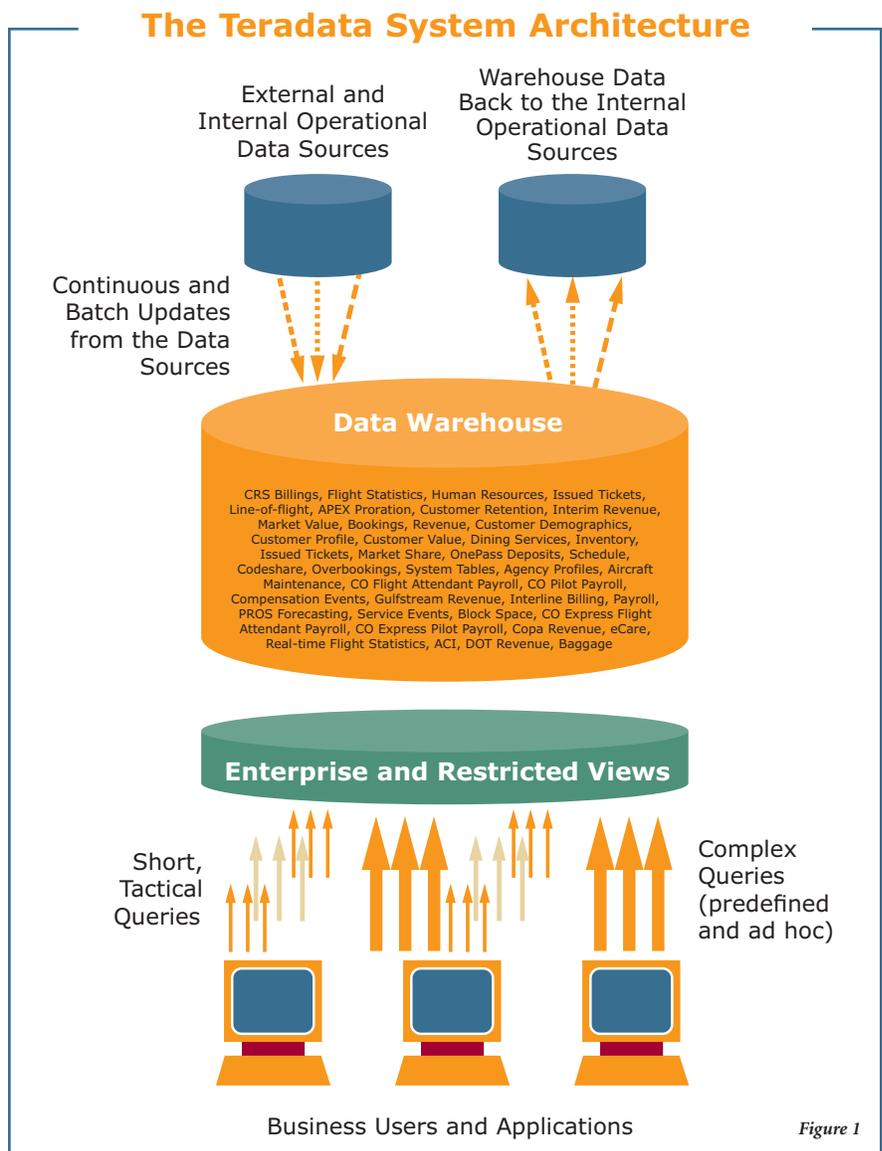


Figure 1

When users send queries to the data warehouse, the queries do not “hit” the actual tables in the database. Instead, they hit one of the hundreds of views that were set up for users and applications to access. These views simplify and standardize table joins and business logic. It is much simpler and more consistent for users to query views as opposed to the base warehouse tables. Additionally, real-time loads can lock up base tables; whereas, views remain unaffected by the continuous changes to the warehouse.

Some views are created for security purposes. When data is too sensitive to be placed in the enterprise views for all to see, it is placed in views with restricted access. The Data Warehouse Director explains, “Our policy is that every piece of data in a subject area should exist in the enterprise view layer unless there is a strong reason to not include it. We default on giving as much access to data as possible to our users. But, a subject area like ticket sales might include credit card number, which we want to restrict. In this case, you must have access to the restricted view for ticket sales to see that information.”

The Enterprise Data Model

Data in the warehouse are completely integrated into a physical enterprise data model. The warehouse team started with a data model for the revenue management subject area, which was the initial subject area for the data warehouse. From the start, the team’s vision was to have an enterprise-wide view of the data;

therefore, the initial modeling efforts modeled revenue management with the entire company in mind.

As new subject areas are added, the data model evolves. A subject area expert works with a user group to create a proposed model. Then, after extensive data analysis and discussion, the new subject area is integrated into the enterprise data model. Although most people on the warehouse team are database administrators and are capable of developing data models, the modeling efforts are funneled through the Master Data Modeler. This person is responsible for updating the enterprise data model and ensuring consistency across all subject areas. She makes sure that all modeling efforts follow standards and naming conventions.

The data in the enterprise data model is in strict 3rd normal form. The Master Data Modeler believes that 3rd normal form makes the data warehouse much easier to administer. In her words, “Our discipline

in sticking to 3rd normal form means that our data are not duplicated throughout our data model. In terms of size, Continental is not one of the biggest databases, but I believe that we have more actual information than most companies.”

Data Access

A Data Warehouse Steering Committee member/representative oversees access to the basic enterprise views of the data warehouse, and management controls access to the restricted views. For example, a manager from Human Resources controls who can see compensation data.

The users access warehouse data in various ways (see Table 2). Some use standard query interfaces and analysis tools, such as Teradata’s QueryMan, Microsoft Excel, and Microsoft Access. Others access data using custom-built applications. Still others use either the desktop (i.e., “fat client”) or Web versions of Hyperion Intelligence to access data. An estimated 500 reports have been created in Hyperion Intelligence, and

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

Table 2

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's 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 loading into the data warehouse.

Other data feeds are streams of data that are loaded to the warehouse in seconds. The flight data (called FSIR, or flight system information record) is sent real-time from the airplanes via satellite to an operations control center system, which supports the command center for Continental where the actual flights are coordinated throughout the flight network. The data warehouse team took advantage of the command center infrastructure already in place and set up a Windows NT machine that "listens" to the FSIR data and feeds the appropriate data (as they occur real-time) into 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 that is made to a customer record in the customer database activates a trigger in the customer database, which pushes the update as XML encoded data to a queue for loading into the data warehouse. The data is immediately loaded into the warehouse.

Although the data sources each have different characteristics (making the loading process potentially complex), Continental has created an infrastructure called the Service Bureau (see next section) that allows the various sources to be loaded using a single, reusable infrastructure.

The Service Bureau – Teradata System Loading and Management

Continental's vision from the start was for the Teradata system to be highly automated. To achieve this, the warehouse team built a set of shared services that run on 10 Windows-based servers called the Continental Service Bureau. The Service Bureau was built using object-oriented design techniques, and it automatically loads and manages the data warehouse. Its object orientation facilitates efficient, parallel, scalable, and restartable transformation processes. The Service Bureau contains a number of components, which are listed in Table 3.

The Service Bureau's scheduler has about 50 tasks that run at intervals from minutes to hours, and others that run at specified times. Many of these tasks check whether a load is ready to run and, if so, start it. Most of the loads depend on either a file becoming available through the network or the completion of another load. The dependencies are quite complex.

The Service Bureau manages a series of automated alerts that page the on-call warehouse staff member when some process needs human intervention. If the on-call person fails to respond and fix the problem, another page is sent to a secondary support person.

The Service Bureau monitors the number of items in the various work queues for the real-time loads, and if the queues fill up beyond certain preset thresholds, it issues an alert, paging the on-call staff. The Service Bureau also notifies the on-call staff member when any data warehouse load fails, or a data feed is not available in time, or a batch load process is taking too long and is projected to finish beyond its allotted time. It also monitors the latency of the data in the warehouse and issues an alert if it gets beyond a predefined value. For batch loads, the Service Bureau notifies the users of the data when their data has been loaded and is ready for the day.

A Standard Data Loading Process

A key benefit of the Service Bureau is that its objects were created for reusability. Therefore, it takes the warehouse staff a minimal amount of time to introduce a new data source into the warehouse process. A standard data loading process also helps to reduce the time to add new data sources. As feeds evolve from batch to real-time, there are minimal changes to the loading process. Regardless of latency, data feeds are transformed and sent to queues, which then are loaded immediately using TPump, the real-time loading utility provided by Teradata. Table 4 provides an overview of the data loading process.

Because the standard loading process is generic and reusable, as users demand more and more real-time data, and as real-time feeds become available, incorporating real-time data into the warehouse is relatively simple.

Managing Mixed Queries

Traditional warehouses are optimized to support strategic queries that require many table joins and aggregations; however, as warehouses become more real-time and support tactical queries, the prior optimization strategies no longer work. The challenge is to optimize real-time warehouses so that all queries can co-exist. Continental's optimization strategy aligns with the overall vision to "keep things simple," and this approach has worked well.

Components of the Service Bureau
A set of components and libraries that implement the common services
Scheduler, file transfer, and data conversion programs
A watchdog service to ensure other services are up
A system for paging on-call personnel through the Skytel service
An e-mail queuing service that connects to the corporate e-mail system
COM + components that provide a uniform Data Access Layer for Web and other clients for logging and connection pooling to minimize database connection usage
A set of services that transform and load reservations and operational data into the Teradata system in real-time
A process that monitors the performance of the data warehouse, keeps history, and alerts the warehouse staff to exceptionally long-running queries
Automatically generated meta data that is refreshed and published on the Intranet
An SQL Server operational database that stores configuration and status data
Control of Teradata load utilities, and monitoring of MVS jobs through 3270 emulators and
Real-time display of what each service is doing in each transformation server machine.

Table 3

The data warehouse team takes advantage of the data warehouse's existing Teradata Priority Scheduler application to help manage the mixed query loads. The Teradata Priority Scheduler utility allows for concrete rules that determine the priority settings for users and applications. The tactical queries that access single records are set to *high* priority. These queries usually come from applications, such as the continental.com Web site 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.

The Service Bureau continuously monitors all of the queries to identify those that are using too much of the system's resources. For example, when queries run longer than one hour, they are allowed to run while the monitor service alerts someone

on the data warehouse team. A team member investigates the query, and the query responses that are not needed immediately are set to the lowest priority. The warehouse team works with users to help them understand how to optimize inefficient queries.

Creating a “Time Machine”

Within Continental’s warehouse, data about customers, flights, locations, etc. change due to normal business environment activities. Some groups at Continental, such as Revenue Management, need to understand data as “it was” at any point in time. The Warehouse Director explains how the “time machine” can be used by the Revenue Management group: “With the ‘time machine,’ Revenue Management can go back and see how last year’s bookings looked 50 days before Thanksgiving and see how they eventually came out. Then, they can extrapolate that to [the flight and booking activity of] this year and make pricing recommendations. The reservations group can look at bookings as they occur throughout the day to determine peak times and change staffing practices.”

To do this, the warehouse team saves every change that is made to a record and uses a combination of timestamp fields and flag fields to keep track of which record is current. For example, a reservation record that changes 100 times would have 100 associated records in the data warehouse, but only one record (i.e., the latest one) would have a flag field set to “active.” When queries run, the WHERE clause

The Real-time Data Loading Process
1. Continuous data loads use software, such as CDC (Change Data Capture), or special hooks or triggers on the operational systems to capture events of interest.
2. Special queue middleware, such as MQ Series, Oracle AQ, and MSMQ move the data to dedicated transformation servers.
3. Each update to the operational systems “triggers” a record to the queue.
4. Service processes continuously monitor these queues and transform each piece of data that gets loaded into the Teradata system using the Teradata continuous load TPump facility.
5. Strategic and tactical queries can run at the same time that data is being loaded.
In the case of batch updates, the operational systems create nightly files that are FTP’d to the transformation servers where they create an event that causes the transformation programs to run. These programs transform the data and push the transformed data through the Teradata Fastload and Multiload utilities to load the data into the Teradata system.

Table 4

must contain a date range or a flag field to keep the answer from including all of the changes to a record over time. The warehouse team creates views of “active” records that users can query, thus shielding them from query mistakes.

Continental refers to this capability as the “time machine,” and members actively market the warehouse’s ability to view data as they change over time. In doing so, the warehouse team creates awareness within the user groups about how the warehouse stores data and how users need to access it. The warehouse team notes that users have a very difficult time understanding how to access data at “a point in time.” By keeping a potentially technical topic at a level that

is interesting and catchy to users, the users are better able to understand and take advantage of the “time machine” capability.

The Data Warehouse Team

Continental has 15 people on its data warehouse team. They are responsible for managing the warehouse, developing and maintaining the infrastructure, data modeling, developing and maintaining ETL processes, and working with the business units. The organization chart for the data warehouse staff is shown in Figure 4.

The Data Warehouse Director reports to the Chief Information Officer. The warehouse staff is located in Miami and

The Data Warehouse Organization Chart

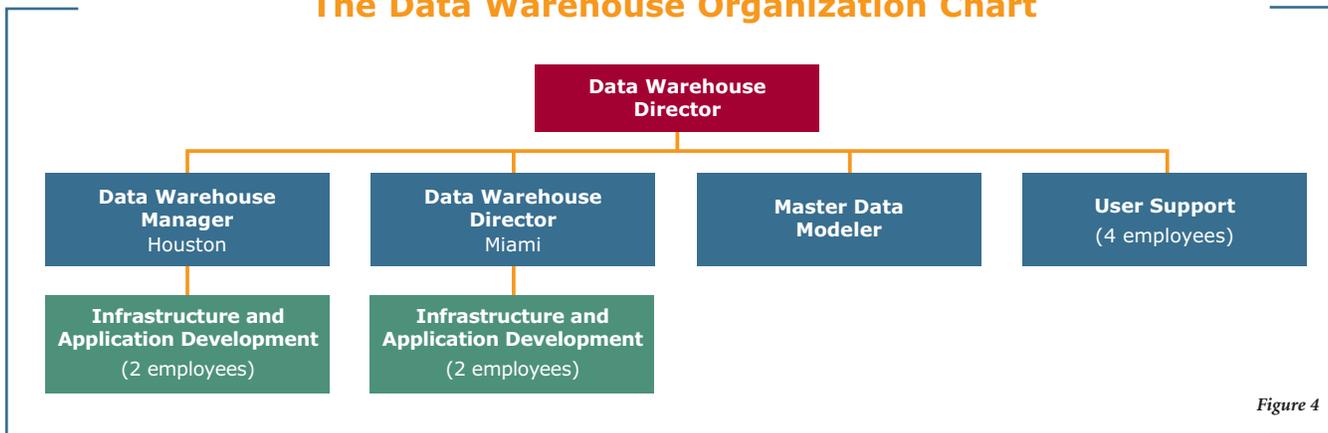


Figure 4

Houston. When the data warehouse initiative began, Continental filled the Director position with a highly experienced woman from Miami who had previously worked with excellent data warehouse professionals in the area, and she was able to hire them if they could continue to live in Miami. The Houston and Miami groups work as a team and share the infrastructure development and maintenance work, including building the processes that source data for the warehouse. The most technical people on the team have degrees in computer science. Everyone on the data warehouse team wears many hats, including providing operational support for the data warehouse. However, they also have specialized roles, such as the Master Data Modeler.

Four team members have specific support roles. Three work with the revenue

management, marketing, and crew operations areas. The fourth is responsible for supporting Hyperion Intelligence and miscellaneous tasks. All of the support people originally worked in the user areas they now support and, therefore, are experts on the data for those areas. They assist rather than build applications for the business areas. As one explains, "I am the technical expert for the revenue management subject area. The warehouse team believes that the users own their data. We understand the data, but the user areas write the applications. Revenue Management has a programming staff that writes the applications that they use. They come to me for assistance when they have a problem." Several team members have extensive work experience with operational systems, which has helped them in implementing real-time data warehousing.

Data Warehouse Governance

The Data Warehouse Steering Committee provides direction and guidance for the data warehouse. It is a large, senior-level committee with 30 members, most at the Director level and above. The members 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 also 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 opportunities for the warehouse staff to become involved with the business areas. 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.

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