

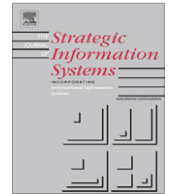


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Ubiquitous IT: The case of the Boeing 787 and implications for strategic IT research

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ABSTRACT

Case-based research was conducted on strategy and IT evolution in the Boeing Company. Results showed IT investment in the 20th century supported an increasingly decentralized hierarchical functional corporate organization structure, and shifted during the early decades of the 21st century toward an IT-enabled global network organization structure. IT investment context changed from an inward focus to an outward, IT-ecosystem focus. IT had penetrated every facet of the corporation creating IT ubiquity. But while IT was everywhere, IT strategic leadership remained fragmented and nowhere. Further research is required to define strategic IT leadership and its locus in the modern corporation.

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1. Introduction

IT is now everywhere, critically essential and plays multiple roles in the strategies and operations of every successful company. Global IT has enabled information on most everything to flow most everywhere at stealth speeds. Simply stated, IT is ubiquitous, does matter; and matters a lot.

Boeing's bold 21st century strategy (i.e., 2016) has put the company back on the road to reasserting its 20th century aerospace industry leader status recently lost to competitor Airbus. But partially due to diffused strategic IT leadership, Boeing's road back has been plagued with long and expensive new commercial airplane delivery delays challenging Boeing's healthy balance sheet, and moving the 787 new airplane program profitability out more than a decade from plan. The case of the Boeing 787 is important to CEO's, CIO's, and IT academics alike.

Ubiquitous IT begs a key research question: Has IT reached a point whereby its role in the corporation is clarified, and can be effectively organized for and managed? If in fact so, I argue that relevant research on strategic IT must be broadened to a more gestaltism approach similar to the Boeing 787 case. A corollary research question then is: What is effective IT leadership for 21st century corporations?

As the Boeing 787 case study illustrates, strategic IT has shifted from IT systems to an IT ordering and integration – that is, an IT architecture, of ubiquitous IT enabling and facilitating the creation of bold corporate strategies and operations. Examples of strategic IT architectures include smart phones (Apple's closed IT architecture for its iPhone, Goggle's open IT architecture for Droid phones, and Microsoft's IT architecture for its Mango phone); salesforce.com Internet-based IT architecture

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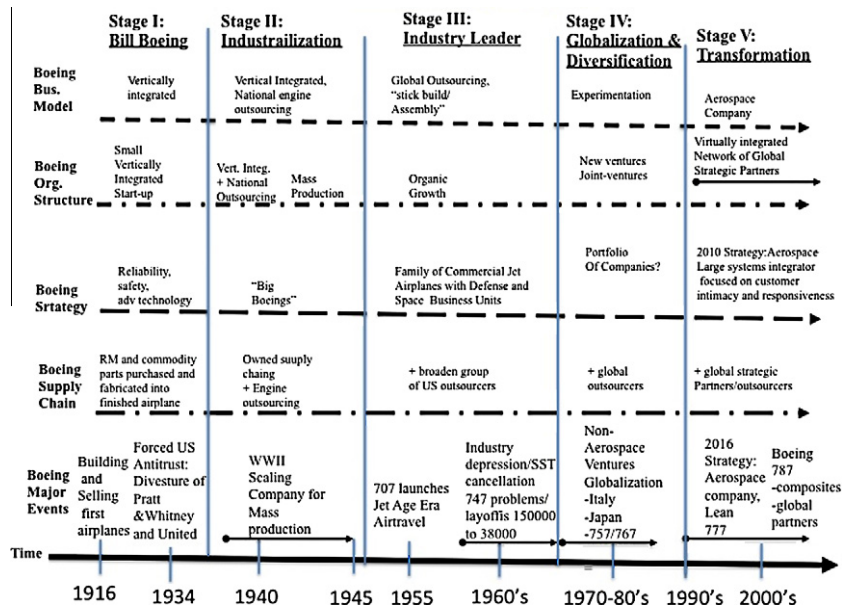


Fig. 1. Evolution of the Boeing Company.

for customer management; Amazon's IT infrastructure IT architecture for online retail sales, customer service, and product delivery; and the Boeing 787 IT architecture for global design, manufacture, and operation of its Boeing 787 commercial airplane.¹

The strategic IT architecture is a part of a broader IT ecosystem. Our terms and taxonomies to describe strategic IT are at an early stage of development and include such terms as cloud computing, and taxonomies like Software as a Service like salesforce.com services (SaaS), Platform as a Service like Google's Droid smart phones (PaaS), and Infrastructure as a Service like Amazon's cloud computing service (IaaS). All this is improving as both academics and the IT industry further develop the concepts, products, and case studies for strategic IT architectures. The Boeing 787 case study helps us to gain a better understanding of the nature and development of strategic IT architectures. The case also highlights the costly consequences of a lagging and fragmented understanding of the strategic role of IT among the senior corporate leadership team – including the board of directors.

2. The Boeing Company

The Boeing Company has been a high tech company pioneer. The company is somewhat unique in that it is a high tech company that has created and mass-produced a high tech artifact with unmatched reliability. The failure rate of a Boeing commercial airplane on any individual commercial flight is about one in a billion.² As can be occasionally heard among Boeing engineers: "Think of it, millions of parts flying in close formation more than 5 miles high, at close to the speed of sound!"

And as most of us know from our first-hand experience in flying, Boeing commercial airplanes fly within an ecosystem of deeply embedded IT systems that include not only the millions of parts of the airplane itself, but also include the air control system, airline reservations systems, the weather reporting system, airplane maintenance systems, and many other related IT systems. Failure in any one brings flying to a halt.

To fully understand the Boeing 787 case and its IT architecture, it is important to understand the context of the Boeing Company in creating the capabilities that the Boeing 787 came out of. We can gain an appreciation of the context by breaking up the evolution into time-based stages from the founding of the company to the present day capabilities. Notably, we can track the growth and complexity as Boeing grew from a start-up in 1916 to a \$36 million revenue company in 1934, a billion dollar company in 1954, and over a \$50 billion company during the turn of the century. During the stages, the business model changed from small company oriented to global; the organization structure changed from vertically integrated to

¹ Jonathan Zittrain in his book, *The Future of the Internet and How to Stop It*, 2008, Yale University Press, describes the Internet as a "generative" platform or technology contrasted with a "sterile" platform or technology like Apple's iPhone. The generative technology is open like the Internet that allows anyone to interface with it, or build on it, compared to the "sterile" platform, which is tightly controlled by a company. There are many variants inbetween.

² In commenting in a *US Today* news article about zero deaths from commercial airline flights in 2007 and 2008, MIT Professor Arnold Barrett reported that he calculated "that its more likely for a young child to be elected president in his or her lifetime than die on a single jet flight in the USA, or similar industrial nation in Europe, Canada, or Japan." Accessed on November 2, 2011, "Airlines go two years with no fatalities," http://www.usatoday.com/travel/flights/2009-01-11-airlinesafety_N.htm.

horizontally virtually integrated; and Boeing's corporate strategy was refined and honed to focus on a small set of core capabilities. Somewhat transparent, but critically important, Boeing's IT investments maintained pace to enable its strategies. Fig. 1 summarizes these processes into stages through time as Boeing became a major corporation and sustained its industry leadership.

The first stage started when Bill Boeing recognized the commercial potential of flight and set up shop on the shores of Seattle's Lake Union in 1916. In an expanding country still not fully developed at the frontier, airplanes could bypass primitive roads and costly railroad tracks, making air travel faster and more efficient than any other means of transportation. Bodies of water like Lake Washington provided natural airports.

Boeing's heady early days came to an abrupt end when the company became a bit too successful and the US government brought an antitrust lawsuit in 1934, forcing the divestiture of Boeing's United Airlines and Pratt-Whitney business units. The government settlement also triggered the ouster of Boeing's protégé and president, P.G. Johnson.³ Dejected at this outcome, Bill Boeing sold his Boeing stock and left the company.

The Boeing Company after divesting its Pratt-Whitney and United Airlines business units, had to learn to operate with these important business units now as independent corporations. Organizationally, Boeing began developing extended capabilities to effectively work with outsourcers by building a cadre of airplane propulsion engineer "auditors" that enhanced airplane propulsion systems beyond what Boeing had achieved with their sole in-house engineers. These were Boeing's first steps in forging its ever expanding network organization and network relationships.

Another Boeing protégé, Clairmont Egtvedt, became president, and aggressively pursued his "big Boeings" strategy: producing big military bombers and a derivative big commercial airplane. This strategy leveraged early adoption of advanced technologies of military airplanes in commercial airplanes. Although the initial strategy almost bankrupted Boeing, the company was saved when the United States was drawn into World War II, and Boeing was awarded the B-17 bomber contract.

The production demands of WW II forced the Boeing Company to figure out how to mass-produce B-17's. The board⁴ asked P.G. Johnson to return, and he and his team turned Seattle Plant 2 factory into one of the most successful mass production facilities in the world. Toward the end of WW II, the factory produced 16 B-17's in one 24-hour period – a rate of large airplane production that has not since been matched. Efficient mass production became the hallmark of successful 20th century corporations.

During WW II, Boeing along with other companies in the Aircraft Industry became early adopters of automatic data processing (ADP) equipment to support the requirements of mass production and engineering calculations. During these early years, data centers were built with ADP machines from IBM and Remington Rand which included large "tub files" containing data coded on 80 column punched cards for manipulation, analysis and printed reports.⁵ Boeing engineers and the University of Washington engineers collaborated extensively in using ADP and early analog computers to analyze wind tunnel data on airframe performance.

After the war, Boeing resumed its big-Boeing strategy and built the Dash-80 prototype (to become the Boeing 707), which propelled Boeing into Stage III and its industry-leading position in commercial airliners. And in 1954, Boeing joined a relatively small group of corporations numbering 23 that had become very big for the times – those exceeding \$1 billion in annual revenue.

Boeing had established an early Scientific Computing organization with the latest UNIVAC (Univac 1108) and Control Data Corporation (CDC 6600) computers, and later established a Commercial Data Processing organization with early IBM computers (IBM 650 and IBM 7080).⁶

Peacetime prosperity in the US economy and affordable intercontinental jet-age travel gave more and more of the US population the opportunity to visit foreign countries. Understanding other cultures and values became a challenge for companies as well as individual Americans during the Cold War, as US corporations started working with outsourcing partners and selling American products like airplanes in other countries. Boeing went onto dominate the commercial airplane market by building a family of jet aircraft for worldwide sales. Its revenue growth was organically fueled, and the company entered Stage IV: globalization and diversification.

Large multi-product, multi-billion dollar revenue corporations were becoming commonplace during the 1960's and 1970's. To cope with the complexity, these growing corporations typically decentralized operations by product or geography, and assigned planning and management control to a small centralized corporate headquarters. At the same time, the "big-eight" professional accounting firms (e.g., PriceWaterhouse, Peat Marwick and Arthur Anderson) and large management consulting firms (e.g., McKinsey and Boston Consulting Group) grew rapidly to assist corporations in establishing decentralized

³ P.G. Johnson was one of the first engineering graduates of the Boeing/University of Washington relationship that Bill Boeing established soon after founding the Boeing Company.

⁴ Bill Boeing also pioneered in establishing an outside board of directors. Bill Allen, Boeing's lawyer, was recruited as one of the Boeing Company's first outside directors, and went onto become CEO and leading the company into the development of the first successful commercial jet airplane: the Boeing 707.

⁵ Chandler and Cortada, 2000, *A Nation Transformed by Information*, 2000, Oxford University Press, p. 190.

⁶ During this period Boeing was a leader in the use of IT, and one of its first IT leaders, Dr. Robert A. Worsing, Boeing Director of Systems Administration and Computer Department, delivered a now classic speech to IBM Field Engineering Branch Managers on July 31, 1967: "On Reliability and Service," reference, accessed November 17, 2011: <http://www.cs.brandeis.edu/~dkw/Worsing.txt>. ID is 118.

structures and systems. These professional accounting and consulting companies played an important part in assisting companies in building their IT organizations and management systems.⁷

Responding to the troublesome commercial airplane boom-and-bust selling cycle, Boeing experimented with diversification and globalization in Italy and Japan. Still a newcomer to Boeing at the time, future CEO Phil Condit worked with Italian companies on the joint development and manufacture of a small, 100-passenger commercial airplane. Boeing also worked with the Japanese on a joint commercial airplane design and manufacturing venture. Neither venture resulted in a jointly built airplane, but both engendered long-term outsourcing partnerships with companies in Italy and Japan, as well as closer relationships between Boeing and the respective governments – a number of which operated state-owned airlines.⁸

Boeing's diversification initiatives extended to related as well as unrelated business ventures. In 1970, Boeing consolidated its 13 internal computing organizations into a wholly owned subsidiary called Boeing Computer Services. BCS served Boeing's internal operations, and also sold computing services to outside customers, including the US government.

Unrelated diversification ventures included hydrofoil boats for both military and private use, mass transit light train equipment and systems, and windmills for power generation. All in all, Boeing entered into 33 diversification ventures, and eventually exited all of them. Boeing learned to do many things, but its cost structure, workforce, and culture were designed for competitive advantage in the aerospace industry, not appropriate for a profitable conglomerate company.

Boeing entered Stage V during the last years of the 20th century continuing to enjoy industry leadership and its strongest financial position with its stock peaking at \$106 a share. Legendary Boeing engineer Phil Condit⁹ was made president in 1996. Condit and his team developed Boeing's 20-year vision and strategy, called the 2016 strategy. The 2016 strategy focused the company on maintaining its industry leadership into the 21st century.

When Phil Condit became CEO, the IT industry had passed its 40 years of corporate organizational learning and IT industry infrastructure building. At Boeing, Condit had led two major new airplane programs, the Boeing 757 and the Boeing 777. The Boeing 777 was the first commercial airplane fully designed with modern CAD/CAM systems.¹⁰ The Condit lead Boeing 2016 20-year strategy focused Boeing on becoming the premier aerospace "large-system integrator." And importantly, Boeing along with other corporations had "discovered" and internalized the importance of the Internet and IT to their business strategies. In my 2003 discussions with Phil Condit about becoming the first recipient of the Boeing endowed professorship at the University of Washington, it was clear to me that Condit had not only internalized the strategic role of IT, but was down the road in implementing the strategy. I accepted the opportunity to follow first-hand one of the most successful corporations execute its 21st century strategy.¹¹

3. Boeing's 21st century strategy

Condit unveiled the ideas of the 2016 strategy to Boeing managers in the 1996 spring managers meeting in Seattle: "That Boeing must become a knowledge and resource-sharing company that excels in the design, manufacture and support of commercial aircraft, defense and space systems. That it would continue its global leadership in core competencies such as the integration of large, complex¹² systems, with detailed customer knowledge and focus on operating lean and efficient systems."¹³

Condit aimed to transform the Boeing Company from a predominately commercial airplane manufacturer to a balanced aerospace industry leader. At the time, Condit became CEO, commercial airplanes produced 80% of Boeing's revenue. He and

⁷ I directly participated in this stage of IT development through co-founding the Nolan, Norton and Company (a strategic IT consulting company), where from 1977 to 1991, NNC provided consulting services to assist large global corporations in managing their IT resources. For interested researchers, upon becoming a HBS emeritus professor, the Harvard Business School Baker Library has a program to collect the work (journal articles, books, cases, videos and other materials) of a business professor in their respective area, and catalog the materials in the Baker Library making them accessible for interested researchers. My IT work/research materials including my time at HBS from 1969 to 1977, NNC from 1977 to 1991, and HBS 1991–2003 are accessible at the Baker Library. In my chapter, "Information Technology Management from 1960," (Chandler and Cortada, 2000, pp. 217–256), I trace the influence of scientific computing on business computing, and the merger of the two with the advent of IBM's 360 computer series. As the late eminent business historian observed, a major technology such as IT requires about 40 years for organizational learning and infrastructure building to lay the foundation for the next 40 years when the technology application significantly impact value creation in the economic system.

⁸ This experience is important to understand that Boeing early on developed outsourcing capabilities. Hence, 787 global outsourcing was undertaken with a relatively long history of working with global outsourcers.

⁹ An important element of Boeing's company culture was the early recognition and celebration of their accomplished aerospace engineers, whereby the accomplished aerospace engineer came to be called a "legendary engineer." The legendary engineer was informally permitted to drop in on designated chief engineers of airplane programs unannounced for "a chat." For example, Phil Condit described a drop in by legendary engineer, George Schairer, when he was Chief engineer for the 757 airplane, and suggest that Phil consider extending the range of the 757, which Phil and his team did. Implementation of this suggestion is a factor for keeping the 757 in airline fleets today. Other high tech companies like Microsoft, Google and IBM have also incorporated the concept of "Distinguished Engineers" in a like manner.

¹⁰ Early Boeing commercial airplanes were designed with the aid of physical prototypes to assist in coping with complex airfoil curves and wind tunnel tests. Today computer generated physical mock-ups are typically generated along with IT-enabled virtual walk-throughs of the various components of the airplane.

¹¹ I accepted the offer in 2003 after talking with Phil Condit, the president of the University of Washington and the dean of the business school. Wife, dog and I moved to Seattle. Ironically, in 2004, Phil Condit, the UW president, and business school dean all left their positions and were replaced. With support from the new UW leadership team, I persisted in studying the Boeing Corporation.

¹² Subsequently, the term "complex" was eliminated. While the systems were complex, Condit said, there was no inherent objective to make them complex. In fact, the emphasis was more on simplification.

¹³ Nolan/Condit video interview, March 1, 2010.

his team concluded that they could not effectively move to a more balanced aerospace company through its traditional approach of organic growth. Thus, they included aerospace acquisitions in their 2016 strategy. In addition, the team concluded that their traditional vertical organization (which had been evolving to include more global outsourcers) had to be transformed from vertical to virtual, including a major shift to global outsourcing. The relationship with outsourcers had to change from impersonal, third-party contractual-based to close, strategic-oriented partnership-based.

4. Execution of the 2016 strategy

Condit and his team got off to an aggressive start with execution of the 2016 strategy. Boeing acquired the Rockwell Aerospace Company. Then in 1997, Boeing acquired McDonnell Douglas – a \$17 billion company that had a troubled commercial airplane business but a viable Defense business. The McDonnell-Douglas acquisition increased Boeing's revenue to \$52 billion, making Boeing a more balanced aerospace company in revenues, as well as the world's largest manufacturer of commercial and military airplanes. McDonnell-Douglas board member John F. McDonnell, CEO Harry Stonecipher and CFO Michael Sears were integrated into the Boeing board and executive management team.

That same year, Condit restructured the Boeing organization into three divisions: commercial, defense and space. For each of the divisions, Condit appointed a CEO. Condit remained Boeing Corporate CEO and chairman of the board. The previous CEO of McDonnell Douglas, Harry Stonecipher, became Boeing Corporate president and chief operating officer. These moves further decentralized the company. In 2001, Condit moved Boeing headquarters from Seattle to Chicago claiming that Boeing's corporate headquarters needed to be in a neutral place, which would not be a place of one of its major business units.

These transformational decisions were made at stealth speed, and hailed by the business press. *Fortune* magazine called Boeing's acquisition of McDonnell Douglas the "sale of the century."¹⁴ The 2016 vision and strategy focused Boeing growth on a core competency: large-scale systems integration. Greater emphasis on outsourcing commodity-like manufacturing was designed to improve asset management and profitability.

In the meantime, Boeing like other modern corporations had reached a point of near IT ubiquity, and further IT value realization slowed due to maintaining and building on an IT foundation of "legacy systems."¹⁵ Then, almost overnight, the IT management environment changed from a highly controlled centralized environment to a highly decentralized environment. The fragmented, decentralized environment has continued to evolve with persistent fast changing technologies like smart phones substituting and extending many PC functions.

Leading the corporation out of this IT quagmire is a top agenda item of today's CIO's. And, as in the Boeing case, the business does not slow down to make the legacy issue any easier to resolve. Airbus had closed the gap between it and Boeing in manufacturing "very good" commercial airplanes, and had aggressively priced their airplanes. Previous CEO, Bill Allen's strategy "of build the best airplane, and the airlines will buy it" had run its course. Boeing factories had gradually lost their cost advantage. Airbus began outselling Boeing.

At the time, Boeing's lean manufacturing program had not closed the gap of Airbus' lower cost per commercial airplane. Nevertheless, Condit and his senior management team responded by dropping the price of their airplanes to be competitive with Airbus. Boeing's order book rebounded. But in October 1997 the increased production was too much for the traditional factories, causing control and supply chain problems. Boeing shutdown two major assembly lines. The shutdown caused one factory manager to be replaced and cost Boeing \$2.6 billion to recover. For 1997, the year Condit was elected chairman, Boeing reported its first lost in 50 years: \$178 million. Wall Street analysts turned from praising Condit to severe criticism. Boeing's share price topped from \$106 to \$49.

Airbus kept the pressure on Boeing by bring out their Very Large Airplane (VLA) the Airbus 380 – a giant 2-decker, state-of-the-art airplane that seemingly dwarfed Boeing's aging giant 747's. Boeing was feeling the Airbus competition, and had decided to boldly take a different course to retaining commercial airplane leadership in the 21st century. Instead of challenging Airbus in a VLA commercial airplane dependent on the continuation of the hub-and-spoke commercial airplane industry model, Condit and his senior management team decided to build a light, fuel efficient composite, mid-sized, long-range airplane that would take a smaller number of passengers than a VLA directly where they wanted to go, in contrast to taking passengers to the few congested large airport hubs, where passengers would then have to take smaller airplanes or other means of transportation to get to their ultimate destinations. Some industry observers called the proposed new Boeing airplane an "industry game changer."

This new Boeing airplane was first designated the Dreamliner, and later formally named the Boeing 787. The Dreamliner also embraced a bold global manufacturing scenario that would allow it to be priced similar to the price of a Boeing 767 – Boeing's earlier generation of commercial airplanes. The aggressive pricing appealed to the airlines, many of which were continuing to experience hard times from overcapacity in the industry and fierce price competition in airfares.

But even the most well thought out business plans often incur events that require corrections along the way. The year 2003 was not kind to Phil Condit and Boeing. At an all-hands management meeting at Plant 2, Alan Mulally, then Boeing Commercial Airplane CEO announced to a silent room that Airbus had surpassed Boeing in the number of commercial airplanes delivered, and worst for Boeing, had a bigger backlog of orders for commercial airplanes than Boeing. Airbus would

¹⁴ David Whitford, "Sale of the Century," *Fortune*, February 17, 1996, pp. 92–100.

¹⁵ Legacy systems is a term that developed to describe IT systems and infrastructure that had become obsolete in respect to useful life and maintenance expenses.

not only build and sell more commercial airlines than Boeing in 2003, but would also have the largest and most advanced commercial airplane flying – the Airbus 380. Boeing had lost its industry leadership position to Airbus.

Further bad news was in the making, when it was revealed that Boeing's newly reorganized Integrated Defense Systems Division had made an inappropriate hiring of an Air Force director in the Pentagon. The Air Force director had been influential in awarding Boeing a multi-billion dollar contract to build a fleet of new tanker Air Force airplanes. Congress immediately canceled the Boeing tanker contract, and both the Boeing CFO and the tanker contract Air Force director were tried in US federal court, and given prison sentences for their transgressions. The board asked for, and received Phil Condit's resignation.

In early 2004, the board approved the launching of the Dreamliner program, even though some reluctance was expressed by board members concerning the risk of simultaneously building a leading-edge new commercial airplane together with building it with a global set of outsourcing partners. Some board members wanted to first manufacture in-house, certify and successfully integrate the plane into airline fleets. Then afterwards, they suggested that Boeing could focus on managing the process of outsourcing the manufacture to a set of global strategic partners.

This position was argued from the basis of Boeing's "tribal" knowledge that no more than four major changes/technologies should be tackled in a new airplane program. Experience had shown that any more than four would not leave enough organizational slack to effectively cope with the inevitable unknown major change(s) that would be discovered during execution of the new airplane program. The Boeing board voted to overrule this approach approving the Dreamliner new commercial airplane program in April of 2004.

Once the Dreamliner program obtained board approval, more than 800 airline orders flooded in, making the Dreamliner the fastest selling commercial airplane ever. With the Boeing 787 on the horizon, further orders for the Airbus 380 were slowed to a crawl.

Bad news, however, was not over. Harry Stonecipher CEO reign lasted only 15 months. He was fired by the Boeing board for company ethics violations. And, Boeing board director and CEO of the 3-M Corporation, Jim McNerney replaced Stonecipher as Boeing CEO.¹⁶ It was during McNerney's CEO reign that the Boeing 787 announced successive airplane delivery delays incurring more than \$20 billion of penalty costs.¹⁷

5. The Boeing 787: Industry "Game Changer," breakthrough product, breakthrough global manufacturing, breakthrough global supply chain management, and product-driven corporate transformation

While the 787 airplane was not specifically conceived in the Boeing 2016 strategy, its concepts were: to be an industry game changing product designed and built with global outsourcing partners enabling Boeing to focus on large-scale systems integration. All of this was seen as enabling Boeing to create the most advanced commercial airplane ever with a breakthrough low cost and price.¹⁸

5.1. Breakthrough product

The 787 would involve extensive use of composites rather than aluminum for structural components and the skin of the fuselage, wings, and empennage. It made history with the majority of its primary structure (wings and fuselage) built from advanced composites. Aggressive use of composites not only would make the airplane significantly lighter, but would also allow complex molding to sculpt more efficient aerodynamics. The choice of composites for the primary structure was a bold and risky move, compared by some to the reinvention of the commercial airplane with jet propulsion.¹⁹

The 787 would also involve a bold decision to extensively use electrical systems to replace many hydraulic systems, making the airplane lighter and consuming less energy.

Fig. 2 summarizes the overall customer value-proposition for both airlines and airline customers of the 787.

5.2. Breakthrough global manufacturing

The 787 business processes were extremely different from Boeing's 20th-century processes. The conventional business processes began with a relatively small team of 100–200 to participate in conceptual design. This team would then convene Boeing contractors and suppliers for further conceptual design of the new airplane. Once the conceptual design of the airplane was agreed upon, the design-engineering group exploded to thousands, who would engage in detailed design, and

¹⁶ Alan Mulally worked up the Boeing aeronautical engineering ranks and was groomed to be in contention for CEO. After not being chosen by the Boeing board in 2005, Mulally accepted the CEO position at Ford Motor Company, and has been credited with a major role in leading Ford's business transformation.

¹⁷ Corporate business transformations from successful twentieth century organizational structures to successful IT-enabled 21st century organizational structures is risky and the lessons are costly. Our IBM case shows that IBM incurred \$16 billion of losses before getting on the right track: "IBM Corporation Turnaround" by Professors Robert D. Austin and Richard L. Nolan, HBS Case #9-600-098, Revised November 14, 2000.

¹⁸ For further description of the Boeing 787 new airplane program, see "Boeing 787: The Dreamliner," by Professors Suresh Kotha and Richard L. Nolan, HBS Case #9-305-101 Revised June 21, 2005.

¹⁹ Serling, *Legend and Legacy*, 457. Boeing had considered building the 777 as an all-composite airplane but then abandoned the idea to the disappointment of many of the company's admirers.

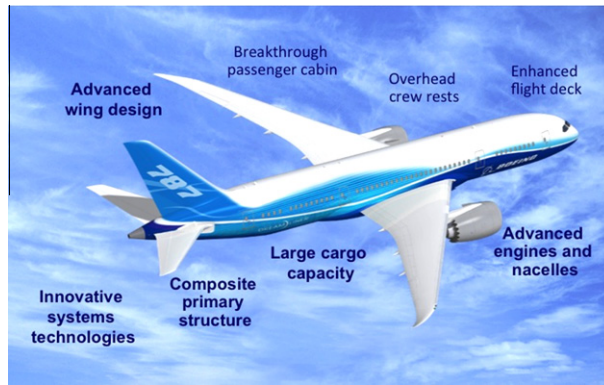


Fig. 2. 787 Value proposition.

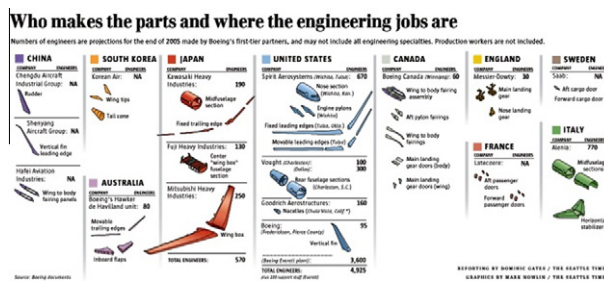


Fig. 3. Boeing 787: Global partners.

development of detailed engineering drawings, which eventually would be fanned out to Boeing manufacturing facilities and contract suppliers. The process was called “build to print.” If a supplier subsequently ran into problems, Boeing sent out teams to assist the supplier to get back on track, working from the detailed engineering drawings.

The 787 new airplane deviated from this process. Instead of “build to print”, a group of Tier 1 partners would be chosen to “build to performance” – that is, performance specifications would be supplied by Boeing to Tier 1 partners, and Tier 1 partners would develop detailed drawings from which to build the major components of the airplane. Global partners would create their own tooling to build the major components (Tier 1 components) to become finished components – that is, a Tier 1 component would be fully completed including electrical systems, fuel tanks and the like, so final assembly could be simplified and shortened to mere days. An extremely sophisticated IT-based CAD/CAM system would be used by all and coordinated by Boeing to ensure that all the Tier 1 parts came together into “fully stuffed” major components ready to be “clicked” together during final assembly.

Boeing selected thirty Tier 1 global strategic partners, and their engineering teams came to Seattle to do preliminary engineering design. These partners represented the most diverse global talent pool ever assembled to create a Boeing new commercial airplane. They were assigned to eight teams: (1) fuselage, (2) propulsion, (3) services, (4) interiors, (5) systems, (6) production, (7) integration, and (8) wing, empennage (i.e., an aviation term for the airplane tail section), and landing gear.²⁰ Fig. 3 shows the Tier 1 787 components and the 787 global partners.

5.3. Breakthrough global supply chain management

Specially fitted-out Boeing 747’s would then fly around to each Tier 1 outsourcer, pick up a full set of 787 components, land at Boeing’s Everett final assembly facility, and be “clicked” together like big lego parts into a finished 787 airplane in a 3-day period – an unheard of short period of time for final assembly of a large commercial airplane.

To facilitate coordination among Boeing and its 30 Tier 1 outsourcing partners, Boeing contracted with IBM and Dassault Systemes S.A. to develop one of the most sophisticated Project Lifecycle Management Systems (PLMs)/CAD/CAM systems. Boeing also built a state of the art command and control center (equipped with video conferencing and high data transmission speeds that allowed all partners to share and coordinate using the same CAD/CAM drawings of the 787 airplane). This Puget Sound center would operate 24/7 366 days a year to work and coordinate with Boeing’s global outsourcing partners. In

²⁰ Norris, G., Wagner, M., 2009. Boeing 787 Dreamliner. Zenith Press, Minneapolis, p. 76. This well-illustrated book is accessible and comprehensive on background and development of the Dreamliner.

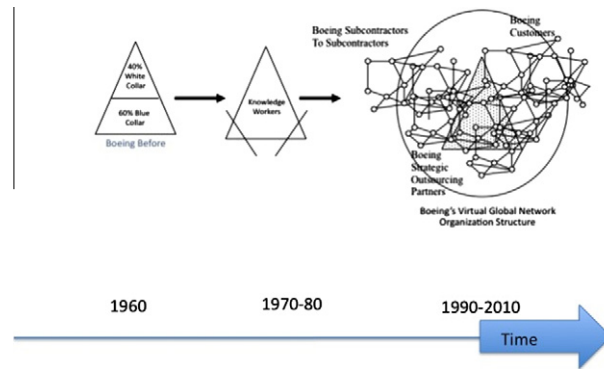


Fig. 4. Creative destruction of vertically integrated corporate organization structures to IT-enabled virtually integrated organization structures.

addition, Boeing deployed Boeing engineers to each of their Tier 1 sites to facilitate on-site communications and coordination.

5.4. Product-driven corporate transformation

Another important element not directly expressed in the 2016 strategy was product-driven transformation. By focusing Boeing's transformation on a new airplane program, Boeing buffered its other airplane programs and its Integrated Defense Systems business unit from transformational risks. Indeed, this approach turned out well for Boeing, sustaining the company's revenue stream during trouble with the 787 program.

The bold 787 new commercial airplane program sustained a continuous stream of trouble starting with lost of CEO continuity and associated problems, continuing with global supply chain problems, manufacturing problems, resulting in unprecedented delivery delays of more than 3½ years, costing Boeing more than \$20 million of late delivery penalty costs. Pundits were all over the problems, many predicting that the financial costs would cripple and likely bankrupt the Boeing Corporation.

The pundits were proved wrong. The maiden flight took place on December 15, 2009, and All Nippon Airlines first 787 commercial flight took place on September 29, 2011. Boeing began ratcheting up manufacturing. New company estimates predicted that Boeing would breakeven on the airplane in about 10 years, and sales were predicted to exceed 1200 787's.

Relatively few of the airlines canceled their orders during the 3½ years of delays. Airbus responded to the 787 with their Airbus 350, but this airplane will not be in service for several years providing Boeing with a first-mover advantage, and an uncontested field if their industry game changing strategy of long haul point-to-point strategy proves successful. Although the Boeing 787 program is not yet a proven success, it is shaping up to be one.

The Boeing 2016 strategy is proving out to be a good strategy, but its execution has been plagued by extremely expensive missteps along the way. Extraordinary credit must be attributed to Boeing's company culture and its people that the Boeing 787 new airplane program has been brought to a successful conclusion in delivering a breakthrough, certified commercial airplane to Boeing's customers. We will have to wait to see if the Boeing 787 becomes a game changer like the Boeing 707.

6. Discussion and implications

The Boeing Corporation is an important case for both academics and corporate leaders. The case helps to clarify the role of IT during most of the 20th century and into the 21st century – both the good and the bad. The 787 chapter of the case has brought a number of the effects of IT to conclusion, but many are still being played out. Seeing the final effects is messy in that they occur in intense, and many times confusing, periods of business transformation and organizational learning.²¹

First, the good: the effects of IT facilitate breakthrough products, breakthrough manufacturing, and breakthrough supply chain management, essential to strategic corporate success in the 21st century global marketplace. Second, IT is everywhere (mostly good) and nowhere (the bad). IT is everywhere in that it is deeply intertwined in just about everything Boeing does. IT is nowhere in that IT leadership is dissipated and fragmented throughout the Boeing Corporation, similar to other global corporations.

IT at Boeing extends beyond its traditional organization boundaries to include not only Boeing's strategic outsourcers, but also throughout the global IT ecosystem for building and flying commercial airplanes. This is a particularly difficult issue for

²¹ I believe that it is important for academic IT researchers to conduct more case studies like the Boeing 787 case to provide a deeper understanding of the complex contextual factors influencing the role of IT in both business strategies and operational execution of the strategies.

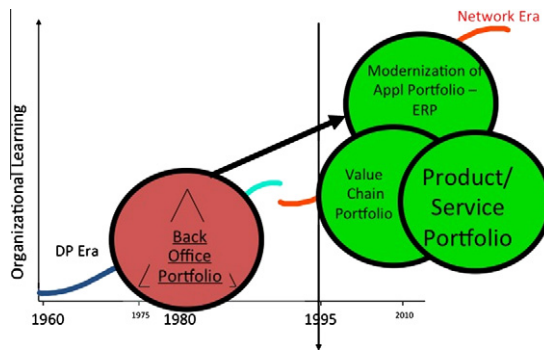


Fig. 5. Boeing 787 initiative involves modernizing the legacy backoffice portfolio and the building the value chain portfolio and the product/service portfolio.

current corporate CIO's whose direct responsibility for IT leadership has shifted from a direct responsibility to a fiduciary responsibility similar to CFO leadership. While neither the CFO or CIO has direct control over the corporation's money assets or information assets, both are responsible for the overall effective management of the respective assets.

6.1. Creating the IT-enabled virtually integrated global network

The familiar multi-divisional functional hierarchical organizational structure of corporations in the 20th century enabled efficient mass production, and had taken a mature form before the advent of IT. During the last half of the 20th century, IT was applied to mostly improve the efficiency of the functional hierarchy with an occasional strategic information system appearing to provide a competitive advantage.

But more importantly during this period, IT began being everywhere through a process of creative construction. Gradually, a shadow IT-enabled, real time network was replacing the slower functional hierarchy. Simultaneously a process of creative destruction of the functional hierarchy and creative construction was going on as graphically illustrated in Fig. 4.²²

As part of this evolution from functional hierarchy to a virtual network structure, formerly internal activities migrate across the boundary of the firm to external suppliers. The superior coordinative capabilities made possible by maturing IT systems created the possibility for such outsourcing.

Digitization of the physical artifacts that compose the 787, and the overall plane itself, enabled a degree of outsourcing that allowed the company to access unique capabilities wherever they resided in the world; and these unique capabilities enabled aggressive product design choices that generated competitive advantage for the company.

Boeing's 2016 strategy of becoming a "large systems integrator" implied a global IT-enabled network organizational structure, and my interviews with Phil Condit certainly reflected Condit's understanding of this emerging structure for Boeing. However, I did not detect a common understanding from my other management interviews of what the new structure was, or would be.

With the sudden departure of Condit, Boeing lost a unique IT strategy savvy CEO, and at the inception of the 787 program execution, Boeing had not filled the lost knowledge gap with successive appointments of new CEO's. Fragmented IT leadership was further accentuated by the new CEO's re-organizations resulting in the corporate CIO reporting to the corporate CTO, with remaining dual reporting lines of business unit CIO's reporting into the divisional line organizations including "thin-dotted lines" for coordination with the corporate CIO. The board of directors had no explicit IT strategy oversight mechanism in place such as a board-level IT sub-committee to weigh in on IT leadership.

Management actions in executing the 787 program applied IT technologies and capabilities evolving towards the network structure, but without a shared vision of what it would be. As a result, there appeared to be frequent confusion on 787 program execution and control activities. For example, communications between Boeing and its outsourcers continuously broke down on tracking manufacturing performance and quality problems. Better understanding this process and its management is an urgent need and opportunity for further academic research.²³ Key research issues include mapping the extended global network organization structures, and defining coordination mechanisms including IT-enabled mechanisms like CAD/CAM 3-D drawings, virtual reality walkthroughs of the airplane, videoconferencing, and the more intangible coordination techniques involved in creating trust among strategic partners.

²² I observed and participated in this process first-hand through our IT strategy consulting company, Nolan and Norton, Inc. Upon returning to the HBS faculty in 1991, I co-authored with David Croson *Creative Destruction, 1995*, Boston, Harvard Business School Press, describing the process and emerging new principles of management of network organization structures.

²³ Earlier, Professor F. Warren McFarlan and I addressed the issue of board-level IT oversight: Nolan, Richard L., McFarlan, F. Warren, October 2005, "Information Technology and the Board of Directors," *Harvard Business Review*, 99–106.

6.2. Managing IT infrastructure and applications portfolios

Creating new capabilities and value creation possibilities required that Boeing modernize its almost 60 year-old IT infrastructure. Some of this work had been done in the 1980s, which consisted of standardization, database integration, and real-time infrastructure development. However, the IT integrations problem was magnified many times over by Boeing's major acquisition of the McDonnell-Douglas Corporation, and the integration is still far from complete.²⁴

Fig. 5 conceptually shows the traditional legacy IT applications portfolio evolving to a modernized IT applications portfolio and operating within the context of an integrated set of portfolios including a supply chain portfolio with strategic virtually integrated partners, and a product artifact applications portfolio integrated with the 787 product itself connecting the product with its customers and their associated systems.

Also, illustrated in the figure are the three organizational learning curves that have evolved over decades, labeled the Mainframe era, the Microcomputer era, and the Network era.²⁵ It was not until the Network era that companies could build the IT architectures enabling the real time integration of global supply chains and real time global collaboration among strategic partners in designing and manufacturing a complex product like the Boeing 787. While applications like CAD/CAM were developed during the first two IT eras, their overall management was not rationalized until they were pulled out of the legacy applications portfolio, and managed as separate portfolios in the Network era. This is what began to ultimately evolve during the 787 product-driven transformation at Boeing.

It was not that the Boeing management team did not conceptually understand the need to create integrated applications portfolios; Boeing had started addressing the challenge in the mid-1980s through a corporate-wide ERP initiative in partnership with the BAAN Company and adapting the BAAN ERP software product. After more than two decades and an informal estimate of more than \$1 billion investment, integration is far from complete.

Herein lies one of the biggest challenges facing CIO's and corporate leaders. This challenge and the root of the problems in addressing are found in the way IT and its management evolved in the 20th century combined with the evolution of the corporate form to its current size and complexity. Referring to Fig. 4 (creative destruction/construction of the corporate form of organization), and Fig. 5 (the eras of IT technology evolution), we can summarize: (1) during the first 20 years, the divisionalized functional hierarchical organization structure remained largely intact, and centralized IT leadership supported the organization – some say “IT paved the cow path”, (2) during the following 20 years, PC's poured into the corporation beginning the march towards IT-enabled networks, but fragmenting IT leadership, and (3) at the turn of the century, the organization operated as a shadow-network with strategic IT leadership “everywhere and nowhere.”

The 787 project made clear that the design and operations of such a complex IT enabled virtual organization involves significant organizational change and organizational learning. Boeing could not simply rely upon strategic partners shipping completed Tier 1 components for the 787 ready to be “clicked” together in 3-days time in final assembly. Rather, Boeing needed to extend its IT through Tier 1 partners down through Tier 2, 3, and 4 suppliers in order to effectively manage the virtual global supply chain for the 787.²⁶ The magnitude and complexity of this task is huge and largely eluded Boeing in its execution of its 787 program.

6.3. Re-conceptualizing the product

Boeing's 2016 strategy of being a “large scale system integrator” changed the focus from the finite physical airplane product to the product being viewed as an organic set of integrated systems, providing a product life-time stream of value to the customer, and derived revenue streams to Boeing. When IT integration is fully unfolded, it results increasingly in new revenue sources, in addition to, and in contrast with, the cost-saving value creation realized on the way to a more revenue-orientated perspective.

Enabled by IT integration, the view of the physical product itself – the airplane – shifts, and, perhaps is the most mature of the IT value creation capabilities, based on the generation of complementary revenues not necessarily related to sale of a physical product.²⁷

²⁴ Perspective on the magnitude of the problem and difficulty of executive leadership in creating and commercially executing an integrated strategic IT architecture can be gleaned from the reporting of Walter Isaacson in his book *Steve Jobs, 2011*, New York: Simon & Schuster. Isaacson's reports on Job's leadership in creating the strategic IT architecture of making Apple computers (iMac's) as the hub of a set of smart IT components and systems including the iPod, iPhone, and iPad.

²⁵ Nolan, R.L. 2000, “Information Technology Management Since 1960,” in Chandler, A., Cortada, J., *A Nation Transformed by Information: How Information Has Shaped the United States from Colonial Times to the Present*, Oxford University Press, pp. 217–256.

²⁶ The HBS Cisco Systems case focused on the process of implementation IT integration in an extended network, but in a less complex environment than the Boeing environment. See the Harvard Business School Case #9-699-022, “Cisco Systems, Inc.: Implementing ERP” by Robert D. Austin, Richard L. Nolan and Mark J. Cotteleer as an example of integrating the supply chain applications to Cisco's “extended organization,” enabling the “sensing and responding” to customer demand all the way through the ordering of raw materials by Cisco suppliers. The information transparency of materials and sub-assemblies among Cisco suppliers that Cisco Systems developed was missing in management of the Boeing 787 integrated supply chain.

²⁷ For the last 10 years or so my colleague and co-chair of the HBS CEO ExecEd program has asked participants to write down the five most important IT projects conducted at their companies over the last 5 years. After listing the projects, Professor Austin then asks the participants to place a C (Cost-saving) or R (Revenue generation) next to each to designate the major benefits envisioned for each project. Inevitably, 80–100% would be C rather than R, reinforcing the general bias towards cost-saving projects and missed for strategic opportunities.

7. Lessons and Implications for IT strategy researchers

Long ago the role of IT in corporations has shifted from supporting and being aligned with business strategies to being an integral part of business strategies. As shown in the Boeing case, strategic IT cannot be simply functionalized and positioned into the traditional 20th century organization structures to enjoy the full strategic benefits of IT investments.

A key research issue is resolving “IT being everywhere”, and “IT leadership being nowhere” – that is, IT leadership and decision-making have become so fragmented and dissipated in 21st century global networks that formulating coherent corporate IT strategies have become exceedingly illusive. This illusiveness contributed to the unprecedented three and a half year delivery delay and \$20 billion penalty costs of Boeing’s 787 airplane – an extremely expensive lesson to be learned.

While the CIO is often viewed to be similar to the CFO position and seems to be moving in the right direction, the CIO position is comparatively immature in most corporations in respect to having a voice at the senior management table and included in strategic conversations. Similar to the CFO stereotyping as the “numbers guy” before the Enron fiasco and bankruptcy, CIO’s have been too often dismissed and stereotyped as the “IT geeks.”²⁸

In the Boeing 787 case, the strategic IT issue was subtle. Boeing was a leader in many aspects of IT, but overall strategic thinking about the role of IT and its opportunities went missing upon the departure of Phil Condit as CEO. And there was no board oversight to call attention to this omission.

The “elephant” in the Boeing board room, as well in the board rooms of many modern corporations, is ubiquitous IT spread throughout the corporation, but no IT strategic focus and leadership.

An overarching academic research question is confirmation or rejection of my hypothesis of existence of ubiquitous IT. If confirmed, important research questions must be addressed. First, what is the gestalt of a corporation’s IT.²⁹ Second, what should be the IT strategic focus? Third, what strategic IT leadership is required? Fourth, what action plan is required to execute the IT strategy?

A number of corollary IT strategic leadership questions provide further opportunities for academic research, including:

1. What are the strategic consequences of fragmented strategic IT leadership?
2. What are frameworks to access the costs of omissions, and the benefits of effective strategic IT leadership?
3. What are ways to assess fragmented IT leadership in the modern corporation, and create action oriented agendas to provide sustained inclusion of strategic IT opportunities and thinking in both the strategy and execution of the strategy of the corporation?
4. What should a sitting CIO do to become an integral participant in the corporation’s strategic discussions?

8. Conclusion

Like most case studies, real life events intervened in the Boeing 787 program causing the 787 program to not turn out as planned. With the sudden departure of CEO Phil Condit, the top down vision of the 787 program being a manageable product-driven transformation of the Boeing Corporation was lost by the Boeing senior management team, while the team turned to coping with their Defense business problems and the 787 problems. It seemed that the senior management team became overwhelmed and fatigued by organizational changes. The original transformation vision of propagating the learnings and new organizational structures of the 787 program in spearheading the transformation of the rest of the company was pushed into the background, and then faded away.

The Boeing 787 case can be compared and contrasted with another major business transformation case, the IBM case³⁰, which had a similar IT leadership fragmentation as did Boeing. Upon becoming IBM’s first outside CEO, Lou Gerstner and his senior management team concluded that IT was key to regaining cost control and creating an integrated “one IBM” in serving customers. An early step was to eliminate the 101 CIO’s operating in the various IBM business units and establish one corporate CIO. Next each of IBM’s senior executives was assigned responsibility to consolidate IBM’s key business processes such as financial accounting, order entry, and inventory control into one shared process implemented with one integrated common IT system. An Internet-based system was also developed allowing Gerstner to directly communicate in real time with his global management team and all IBM employees. In contrast to the Boeing 787 product-driven transformation case, the IBM transformation case describes the CEO beginning at the outset to address IT leadership fragmentation, and following through by replacing inefficient and ineffective legacy systems.

²⁸ IT leadership continues to be unsettled and an important area for academic research. See Nolan, R.L. “Plight of the EDP Manager.” *Harvard Business Review* 51(3) (May–June 1973), pp. 143–152; Nolan, R.L. “Business Needs a New Breed of EDP Manager.” *Harvard Business Review* (March–April 1976), pp. 123–133, and Austin, R.D., Nolan, R.L., O’Donnell, S., 2009, *Adventures of an IT Leader*, Boston: Harvard Business Press.

²⁹ The concept of the “gestalt of a corporation’s IT” is similar to the Gestalt approach of the 1920’s Berlin School of Psychology by studying a person’s form by focusing on the brain as a holistic, parallel and analog with self-organizing characteristics.

³⁰ Austin, R.D., Nolan, R.L., “IBM Turnaround,” HBS Case #9-800-098, Revised November 14, 2000.

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