

United Technologies Corporation
Achieving Competitive Excellence (ACE)
Operating System Case Study



Achieving Competitive Excellence

The United Technologies Operating System

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Lean Enterprise Change Research Case Study Series

This case study provides an example of managerial and organizational changes that have accumulated into significant performance improvements. It is one of a series of case studies undertaken by researchers at the Lean Advancement Initiative (LAI) at the Massachusetts Institute of Technology. LAI focuses on developing, testing and studying the application of lean and other management principles in the aerospace industry. LAI's sponsors, and their improvement initiatives, have created a natural laboratory for studying lean enterprise efforts. The case studies in this series report on effective, interesting and novel applications of lean methodologies at enterprise levels in LAI-sponsoring and other organizations.

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UTC ACE Operating System Case Study

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Introduction

When I grew up in business, it was all about the financial system, we had financial planning and analysis... you performed against the financial plan quarterly and that was the way the world worked. People didn't pay attention to how do you run a good plant or how do you run a good engineering program? We have invested lots of money, effort and care in [ACE] in the last years. It is repetitive, formal, disciplined, taught, and it doesn't change. It is the basis of more than half the shareholder value increase in UTC. We went from a market capitalization of six billion dollars in the early 1990s to seventy billion dollars today... and we did it on the back of this [ACE] operating system... There is no force more powerful in modern business than productivity. You do it or die. It is what gives goodness to life... make no mistake, it is productivity underneath everything. There is no limit. It will go on forever and ever and ever.¹

George David,² UTC's former Chairman & CEO, credits ACE (Achieving Competitive Excellence) with having had a significant role in United Technologies Corporation's dramatically improved performance. This case study describes UTC's ACE operating system, both what it is today, and how it developed over two decades. As an "operating system," ACE defines the management system used by individuals and organizations across UTC to delight its customers, provide returns to its shareholders, and satisfy its employees. ACE guides the setting of strategic priorities, establishes processes for translating strategies into actions, and sets up feedback mechanisms for assessing improvement and performance. It uses tools and methods adapted from lean, quality, and statistical process control practices. ACE's benefits are achieved when empowered employees use it as the operating system that guides what they do, including the further development of ACE itself. ACE should be of interest to both new and experienced managers everywhere because, as UTC's executives claim, it is the basis for UTC's industry leading results.

United Technologies Corporation (abbreviated UTC, NYSE ticker symbol UTX) is a large, industrial conglomerate that designs, manufactures and services a broad range of products, ranging from air conditioners and elevators to jet engines and helicopters. At the end of 2008, UTC's sales were \$58.7 billion, its market capitalization over \$50 billion, making it the 39th company on the Fortune 500 list. UTC is one of the world's top performing large corporations (see Table 1). David's assertion that ACE is behind UTC's performance has unique credibility coming from the CEO. His position as a top executive provides greater credibility than if the claim came from the operations manager or improvement expert who typically advocates continuous improvement programs. What is ACE, how did it develop, and how is it evolving? What lessons might other corporations, leaders and managers draw from ACE for improving their businesses? These questions are investigated and reported in this case study.

¹ Comments made by George David, Dean's Innovative Leader Series, MIT Sloan School of Management, February 22, 2007.

² George David was UTC's Chairman & CEO at the time he made the above remarks. Mr. David had retired after 34 years with UTC and no longer held an official corporate or board position. I generally refer to George David in this case study as "former Chairman & CEO." David was Otis' President in 1986, UTC's President in 1992, UTC President & CEO in 1994, and UTC Chairman & CEO in 1997. Louis Chênevert succeeded George David in UTC's top leadership roles, first as UTC President & COO in March 2006, then as UTC President & CEO in April 2008, and finally as UTC Chairman & CEO in January 2010. I generally refer to Louis Chênevert in the case study as "UTC Chairman & CEO." Given the involvement and support of both these top leaders for ACE through their careers, to be accurate I indicate their position at the time they made quoted comments in the footnotes.

- Organic revenue growth of 8% in 2004, 7% in 2005, 9% in 2006, 9% in 2007, and 5% in 2008
- Compound average revenue growth rate of 10% in last eight years, comparing favorably to industry peer compound average revenue growth rate of 6.3%
- Compound average earnings per share growth rate of 14% in last eight years, comparing favorably to industry peer compound average earnings growth rate of 7.9%
- Revenues more than doubled and operating profit increased 2.6 times while manufacturing square feet declined 18% (2000 to 2008).³
- Cumulative shareholder returns over the last 15 years that are over 3 times that of UTC's industry peers.

Table 1 United Technologies Corporation Results Summary

United Technologies Corporation

People are more likely to recognize the well-known divisions of United Technologies Corporation than they are the corporate parent (see Table 2). The conglomerate's backstage identity reflects management's view that its divisions should be prominent. UTC's divisions are valued brands and, in many cases, companies that invented their industries. UTC is a corporation that adds value to its divisions through having developed methods that enable it to learn in one setting and then adopt its proven experience across multiple divisions.

UTC Division	Employees	Revenue (\$ billions)	Operating Profit (\$ millions)	Primary businesses
Pratt & Whitney	37,987	13.0	2,122	Jet engines for commercial and military industry, turbines for auxiliary power
Sikorsky	16,937	5.4	478	Military and commercial helicopters
Hamilton Sundstrand	18,311	6.2	1,099	Electrical power generation and distribution systems, engine and flight controls, propulsion systems and other industrial products
Otis Elevator	64,324	12.9	2,477	Design, manufacture, installation, service and upgrade of elevators, escalators and moving walkways
Carrier	40,651	14.9	1,316	Heating, ventilation, air conditioning and refrigeration systems, components, controls and services
Fire & Security	42,523	6.5	542	Electronic security and fire safety systems, software and services
Power	893	Not reported	Not reported	Fuel cell systems for on-site, transportation, space and defense applications
UTC TOTAL*	<u>Employees</u> 223,100	<u>Revenues</u> \$ 58.7	<u>Net profit</u> \$ 4,689	

Table 2 UTC Divisions in 2008 (based on 2008 UTC annual report)

(*note: UTC total from corporate 10-K, exhibit 13, filed 2/11/09)

³ Figures based on adjusted segment revenues and operating profit, where operating profit are adjusted for restructuring and one-time items.

Corporate history

United Technologies Corporation was created in 1975 when CEO Harry Gray changed its name from United Aircraft Corporation. United Aircraft was formed in 1934 when the United States government declared United Aircraft and Transport Corporation, founded in 1929, as anti-competitive. A government ruling separated airframe and engine manufacturers from airlines. The manufacturing companies east of the Mississippi River became United Aircraft, which included Hamilton Standard, Pratt & Whitney, and Sikorsky. Those to the west of the Mississippi River became Boeing Aircraft, and United Airlines became an independent corporation. United Aircraft focused on aerospace and defense industries until the mid-1970s. Since its formation, United Technologies Corporation has bought and sold many businesses. The large acquisitions include UT Automotive (1973).⁴ Otis Elevator (1976), Carrier Refrigeration (1979), Sundstrand Corporation (1999), Chubb Security (2003), Kidde (2005), Rocketdyne (2005). In 1999, United Technologies sold UT Automotive, using the proceeds to purchase Sundstrand Corporation. UTC's subsidiaries, their employees, revenues, and operating profit are shown in Table 2.

UTC's on-going improvement efforts are evident in its performance. Using the year 2000 as a baseline, revenue has more than doubled as manufacturing square footage has declined.⁵ UTC's abilities to grow revenue while managing costs has been made possible through significant productivity gains (see Figure 1, which shows revenue, manufacturing space, employment levels, free cash flow, and operating profits).

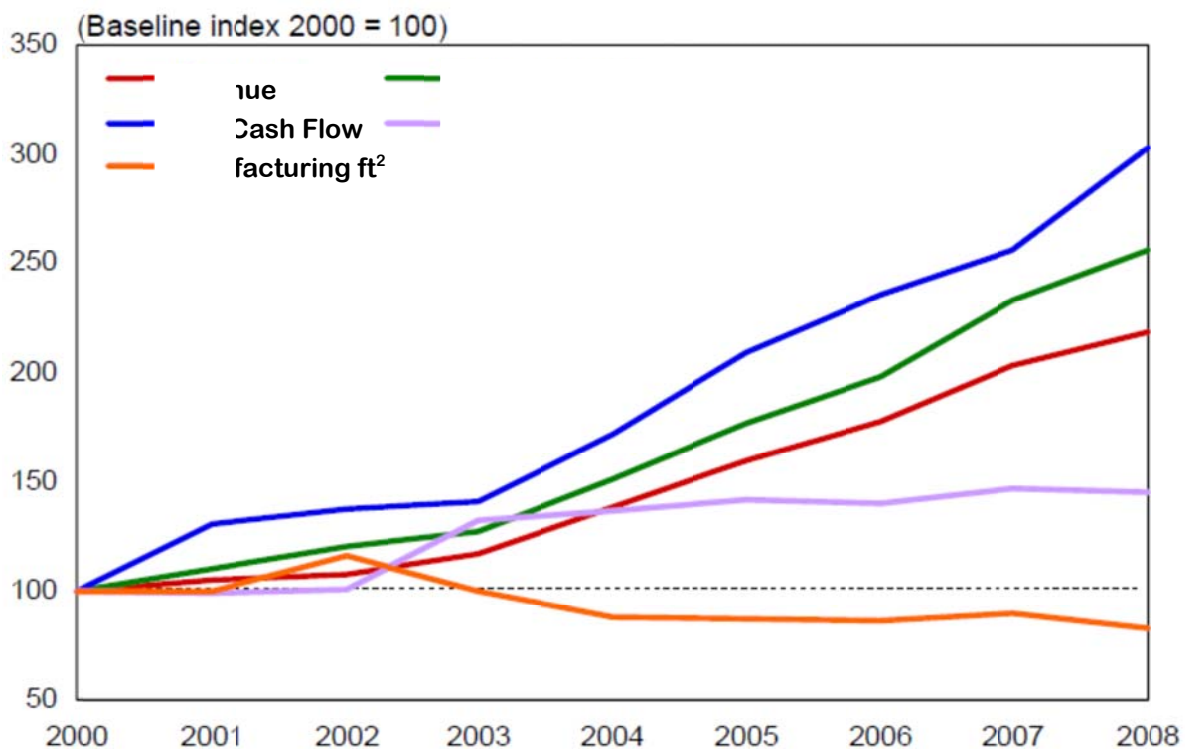


Figure 1 UTC Productivity Gains, 2000 to 2008⁶

⁴ UT Automotive was a division based on Essex Wire & Cable, acquired in 1973, and followed by other automotive component company acquisitions

⁵ Manufacturing floor space decreased approximately 9M square feet over the 2000 to 2008 period.

⁶ Source: slide 14 of Greg Hayes, CFO, March 12, 2009 presentation to Analyst and Portfolio Managers, downloaded from UTC web site on April 7, 2009; revenue and segment operating profit are adjusted for restructuring and one-time items; data exclude the impact of Accounting for Engine Collaboration Agreements..

Despite the economic downturn of 2008 - 2009, UTC's market valuation provides positive and greater returns than Standard & Poor's 500 Index or Dow Jones Industrial averages.⁷ The Motley Fool's lists UTC among its "Best Companies on Earth" as an illustration of "operating efficiently" because it "is continuously looking to reduce costs by redesigning factory floors, workflow processes, and products" in products and services ranging from aircraft engines to elevators and air conditioning systems.⁸

UTC has not always performed as well as it does currently. What has produced the gains of the last 20 years has been a relentless focus on processes in manufacturing, engineering and research and development. George David commented on the conditions at an earlier time as follows.

These huge opportunities to improve processes resulted from the American preoccupation in the post-war period with product development and invention to the exclusion of process. When Japanese companies making productivity improvements invaded American markets in the 1980s because of an overvalued United States dollar during the Regan presidency, many of the best American companies woke up and responded with their own process revolutions.⁹ American companies in the whole post war period, certainly through the late 1980s, have focused on products rather than processes... we have invented enormous amounts of intellectual property: semiconductors; digital communications; digital control; materials of all kinds, whether plastics or composites or the exotic metals found in jet engines... and, any one of us could continue this list almost without limitation. But, American companies focused on products to the exclusion of process. Our prevailing production mentality was economies of scale and standardized products. But, we failed to see how subtle changes in these processes could have truly dramatic results.¹⁰

The result of a focus on process improvement, David commented in 2007, is that "operating margins for UTC's businesses were 5% in the early 1990s, [in 2007] they're 14%, and headed to 17 or 18%..."¹¹ These margin increases came from many incremental and continuous improvements in all aspects of its business. Continuous improvement, David goes on to comment, has important benefits for corporate capital and cash flow requirements.

Every time we do a lean event in a plant, and this is broadly true, we double capacity and halve cost. That is why we built the last bricks and mortar in UTC years ago. This is true for companies throughout. I think it has implications for capital markets. We can talk about low savings rates in America. Maybe we don't need the savings rates that we used back when we built the capital intensive sectors, like process industries, railroads, highways and things like that. You don't need [high investment rates] in a knowledge based company like ours, where manufacturing productivity is at super high levels.¹²

⁷ Cumulative five-year return is \$123.35 for UTC stock verse \$89.53 for S & P 500 and \$93.93 for Dow Jones Industrial averages. See 2008 UTC 10-K, Exhibit 13, page 52.

⁸ "The Best Companies on Earth," by Andrew Sullivan, March 1, 2009, <http://www.fool.com/investing/value/2009/03/01/the-best-companies-on-earth.aspx>

⁹ Remarks added by George David, former UTC Chairman & CEO, in reviewing this case in August 2010.

¹⁰ Remarks of George David, then UTC Chairman & CEO, Japan Management Association Consultants, February 18, 1999, downloaded from http://www.utc.com/press/speeches/printable/print_1999-02-18_david.htm on 11/7/07

¹¹ Comments made by George David, then UTC Chairman & CEO, Dean's Innovative Leader Series, MIT Sloan School of Management, February 22, 2007.

¹² Comments made by George David, then UTC Chairman & CEO, Dean's Innovative Leader Series, MIT Sloan School of Management, February 22, 2007.

ACE and productivity gains are the basis for UTC's sustained growth and performance. ACE enabled UTC's organic growth of 7 to 9 % from 2004 to 2007 (about twice US GDP growth), 5% in 2008, and a free cash flow that equaled or exceeded net income attributable to common shareowners.¹³ Other benefits of productivity gains are illustrated in Figure 2. In the fifteen years from 1992 to 2007, UTC's annual capital expenditures averaged 112% of its annual depreciation (in Figure 2 the green line is the percentage of annual capital expenditures to annual depreciation; red bars are operational capital expenditures, blue additions are restructuring expenditures). These capital investments did not constrain growth as UTC's revenues tripled during this period. UTC's improved asset utilization enables it to draw down invested capital as it grows revenues. Jothi Purushotaman, then UTC's VP, Operations, noted, "The proof of ACE is in the performance of UTC."

UTC's results derive from improvements it has made at over approximately 900 Pratt & Whitney, Sikorsky, Hamilton Sundstrand, Otis, Carrier, Fire & Security, and Power division sites, all of which use its ACE operating system. During the last two decades, many corporations have restructured and adopted continuous improvement methods, but few have attained and sustained UTC's performance. Its leaders have taken an unequivocal stance that development and implementation of ACE has produced these results, and the continued use of ACE will sustain them.

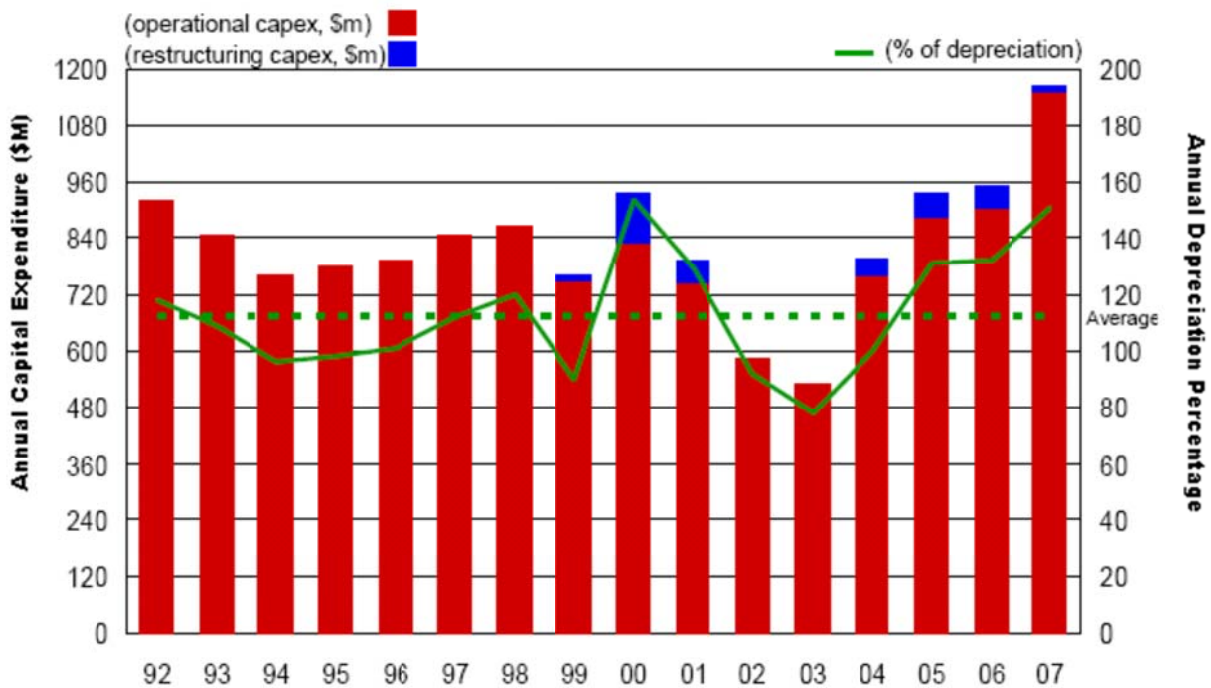


Figure 2 UTC Annual Capital Expenditures and Depreciation, 1992 -2007¹⁴

¹³ Free cash flow (FCF), which represents cash flow from operations less capital expenditures, is the principal cash performance measure used by UTC. Management believes free cash flow provides a relevant measure of liquidity and a useful basis for assessing the Corporation's ability to fund its activities, including the financing of acquisitions, debt service, repurchases of the Corporation's Common Stock and distribution of earnings to shareholders.

¹⁴ Presentation by George David, then UTC Chairman & CEO, "United Technologies," at John Hopkins University, January 24, 2008. Downloaded from <http://www.utc.com/press/speeches> on 2/5/2008.

Case Study Organization and Methods

The ACE operating system has evolved through several distinct stages. Its development traces back to experiences in UTC companies in the 1980s. What was learned in one location became part of a “program” that addressed the local needs and was later re-used in other settings. ACE is no longer a program, but a “business operating system.” An operating system is a concept that specifies a way of managing. It is based on a broad approach and philosophy, using specific tools and methods, supported by dedicated people, departments and training that are tied to overall measurement, reporting, and reward systems. ACE is used as UTC’s operating system because managers at multiple levels have confidence in it, confidence that they have gained from their experience using ACE. ACE is best explained in the context of UTC’s history. Many leaders at corporate, division, and plant levels participated in the evolution of ACE. These leaders created environments that adapted, developed, and integrated improvement methods to achieve better results and shared what they achieved to help others.

The ACE history is presented in three sections: 1) leadership and followership for improvement, 2) the progression of events that created ACE and 3) comments on future opportunities and challenges. Three appendices provide additional information: Appendix A answers the questions, “What is the ACE operating system?” Appendix B answers the question, “What are the ACE tools and methods, and how did they develop?” These details are described in appendices to focus the case study on what UTC and its leaders did to develop ACE. Appendix C provides two mini-cases based on visits to two international ACE sites – “Industrial Pumps” company in Germany and Chengdu Aerotech in China. These cases illustrate ACE working across different languages and national cultures.

This case study draws upon more than 40 in-depth interviews with UTC people, ranging from individual experts that helped develop ACE to senior leaders, including UTC’s current Chairman & CEO, Louis Chênevert. I also used secondary sources such as publicly available articles, annual reports, SEC filings, archived speeches, internal documents, briefings, and training materials. Data collection primarily took place between June 2007 and April 2008, with updates between January and May of 2009. Writing, editing, reviews, and approval took place from June 2009 through to February 2010. UTC managers and lawyers reviewed these materials for accuracy and proprietary information. I have reported descriptively, tried to do my best to present representative assessments and overall views accurately. ACE has been very successful, both in its outcomes for all UTC’s stakeholders and in UTC’s ability to continue to develop ACE as the basis for continued improvement. I am grateful for the open and welcome reception I have received, for unprecedented access to materials, and for the support and candor that many UTC executives, managers, and associates have provided.

As with any improvement initiative, there are limitations to understanding the corporate efforts without examining local organizational changes. Four additional case studies examine ACE applications in manufacturing, engineering, office, and cross-organizational settings. These studies, at Homogenous Metals Incorporated (HMI), the Turbine Module Center (TMC) engineering site, the Internal Audit Division (IAD), and the Military Engines Deficiency Reporting (DR) process, are written as separate research cases. UTC uses ACE across all aspects of its business operations, and these additional cases illustrate successful applications in specific locations. The case study that follows is of the development of the UTC ACE operating system, which begins by describing the direction and support that successive UTC leaders have provided.

1) Leadership and Followership for Continuous Improvement

Statements from its leaders might make it seem that they drove ACE from the top of UTC's organization. A closer review of interviews reveals leaders such as former UTC Chairman & CEO George David and current UTC Chairman & CEO Louis Chênevert were not simply a driving force, but rather leaders who listened and encouraged people to propose and act on their ideas. As David led changes, he learned by asking people questions. Observations that UTC's executives both led and followed are the basis for this section's title, "Leadership and followership for continuous improvement." At times leaders led, and at times they followed directions set by others. When these behaviors were modeled at the top of the corporation, they were examples that managers followed at all levels within UTC.

As CEO of a large, multinational conglomerate, David was concerned with financial results. His speeches and comments give voice to his confidence that financial results follow from continuous improvement efforts. David began learning about quality methods and their linkage to business results as a manager at Otis Elevator. He became Otis' President in 1986, UTC's President in 1992, CEO in 1994, and Chairman in 1997. He took the time to learn ACE's tools and methods, and was such a proponent that several times people mentioned that he would go to a flipchart and give lectures at plants on the use of these methods. David's leadership is an endorsement for the use and development of ACE. The support that he provided at the top of the corporation for 16 years enabled the use and development of ACE throughout UTC. The selection of Louis Chênevert as his successor in the Chairman & CEO role provides UTC with another top leader who strongly supports ACE. In writing about leadership, Warren Bennis notes that effective leaders create good followers and good followers create great leaders.¹⁵

During the period in which ACE developed, it was used and promoted by many leaders. Most notably, the current UTC Chairman & CEO, Louis Chênevert, is a strong advocate that has personal experience and has made important corporate commitments based on ACE. He became President of Pratt & Whitney in 1999, UTC's President & COO in 2006, UTC President & CEO in April 2008 and UTC Chairman & CEO in January 2010. The sections that follow chronicle the experience, involvement, and leadership for continuous improvement. David set conditions that enabled other leaders to create change in what are, in retrospect, notable incidents. These incidents include the following:

- Matsushita's quality confrontation,
- Nippon Otis' partnering with Matsushita's Ito,
- Ito becoming David's quality consultant,
- David and Cosentino engaging Shingijutsu Consulting,
- Ponchak making changes that prevented the North Berwick plant's closure,
- Coran asking manufacturing experts to develop ACE for Pratt & Whitney,
- Aklilu persisting through three Presidents Council meetings to pitch ACE across UTC,
- David committing a week to Ito University training,
- ACE Council acknowledging efforts were falling short of expectations,
- Aklilu and Brittan persisting through seven Presidents Council meetings to launch Operations Transformation,
- Chênevert's publicly committing to 70% ACE Silver and Gold sites by 2009, and
- Chênevert's publicly committing to 70% of UTC key supplier certifications by 2011.

¹⁵ Warren Bennis, *An Invented Life: Reflections on Leadership and Change*, (1993), Addison-Wesley Publishing Co.

These notable incidents are part of a complex interplay of leadership and followership in achieving results while developing ACE. Figure 3 illustrates these developments on a time line that includes ACE milestones, UTC's corporate leaders, and important business events. This timeline shows how successive efforts responded to changing needs. These efforts created the ACE operating system. The cumulative actions of UTC's leaders in proposing ideas, using tools, implementing improvements, and getting feedback refined ACE.

From responsive subsidiary President to proactive corporate CEO

David's enthusiasm for ACE came from his experience. He began his UTC career in 1976. After earning his undergraduate degree in physical sciences at Harvard University, he went to the University of Virginia's graduate business school. From business school he worked as a management consultant for seven years in the Boston Consulting Group before joining one of his clients, Otis Elevator, in 1975. Within a few months, Otis was acquired by UTC. David later said that he had expected to lose his position, but he stayed on, working for Otis' corporate staff. He eventually moved to leadership roles for Otis in South America, then North America, and, in 1986, to Otis' President. In 1992, he became UTC's President, and in 1994 its Chief Executive Officer (CEO).

David's exposure to quality efforts began at Otis Elevator. Like many managers, he attended quality training. A critical incident changed what had been his initially negative attitude toward quality efforts.

My first exposure to quality education was in the mid-1980s at Otis Elevator Company with Phil Crosby and his four absolutes... I hated Crosby... because it was theology rather than methodology and you didn't know precisely what to do when you wanted to go at quality improvements. I couldn't stand it. In 1986...we installed Otis Elevonic 401 elevators in a pair of Matsushita Electric's office buildings in Osaka, Japan. ...the elevators did not perform to Japanese market standards... we had call back rates as high as 40 calls per elevator per annum... compared to a Japanese market standard of four-tenths of a call per elevator per annum... one hundred times out of sync with market standards. We did the usual thing, dispatch our North American field engineers to Japan. What happened next... was to me amazingly revealing... Nippon Otis Elevator Company took the field engineers... not to the motor room... they took them to the conference room...and demanded root cause analysis right then and there, even while elevators were shut down and while the place was literally on fire... I learned right then and there that the American character has in it the propensity to fix, to temporize, and to get by. We do it with a smile; with the best of intentions... it is Yankee ingenuity in the latter years of the 20th century. The Japanese character instead is to search for bedrock. And, those cultures came together in 1986 in that pair of buildings, and the Japanese won, and it was correct that they won. We got the elevators fixed, in that pair of buildings and also for the Elevonic 401 population worldwide.¹⁶

Otis' quality problems were apparent to its Japanese partner. Working through these problems created a relationship between David and Matsushita Electric's Quality Vice President, Yuzuru Ito. Several years later, after he retired from Matsushita, Ito moved to Connecticut on the invitation of David and became UTC's quality consultant.

¹⁶ Remarks of George David, then UTC Chairman & CEO, "Ito University – Opening Remarks," Cromwell, CT, July 13, 1998; downloaded from <http://www.utc.com/press/speeches> on 5/3/2007.

Leadership for Improvement

Ito was influential in developing ACE. David's behaviors showed his complete receptivity to an expert's input. Ito reported directly to David, and David followed his advice, which gave Ito great influence in UTC. David later said that Ito "was like a father to him," and when Ito died in 2000, it was like "he lost his father." In his consultant role, Ito visited many UTC facilities. He met people, walked through production areas, and left people with assignments. He would later return to see what progress they had made. One manager interviewed said, "The worst thing you could ever do was to ignore Mr. Ito's homework assignment or not take his advice. That would occasion a letter from Ito to the CEO, which would go to the division president and then come down on you. If you looked like you were against Mr. Ito, it was a fatal career move."

Ito influenced David's support for quality. Ito convinced David to create a corporate quality position. David appointed Tesfaye Aklilu, a former Xerox executive working at Pratt & Whitney, to the position of UTC Quality Vice President. Aklilu, despite initial reluctance to become a corporate staff person, stayed in that position for more than ten years. He influenced the development of ACE, including the discussions at UTC's Presidents Council in 1998 to use ACE across UTC and in 2003 to re-launch ACE with Operations Transformation. Aklilu also influenced David, coaching him, among other things, to "always talk about ACE." In addition to listening to his people, David's action aligned what he did to what he said. A 2004 Business Week article illustrates his actions in visiting Carrier's Tyler, Texas plant.

What he [David] encountered was a cluttered and somewhat dingy operation almost choking on its own dust. With the exception of a possible takeout menu or two, there were few signs of Japanese-inspired innovation in evidence. Forget about comforting the stricken. David was livid. When he discovered that senior management at the operation – and their superiors back at headquarters – had essentially pooh-pooed ACE in favor of just churning out more air conditioners and heating units, he fired the plant managers. Heck, he even sent the head of Carrier packing, though he prefers to couch that as an amicable parting. In a visit more than two years later, it was clear that the message was starting to sink in. Dusty air and chaotic interiors were vanishing in favor of compact U-shaped assembly lines and brightly lit open spaces.¹⁷

When launching Operations Transformation in 2003, David asked the consultant presenting value stream concepts, Kevin Duggan, to spend a day teaching him these concepts. What David learned from this day, he subsequently applied wherever he went. On plant visits, David was known for asking to see value stream charts, posing questions, making technical suggestions, and occasionally even giving a tutorial on value stream mapping methods.

One executive noted that since ACE was introduced in 1998, all of the UTC division presidents had been replaced. David selected these subsequent leaders based on his confidence that the leader would embrace ACE. In the re-launch of ACE in 2003, the leaders of each division, including Otis President Ari Bousbib, Carrier President Geraud Darnis, Pratt & Whitney President Louis Chênevert, Sikorsky President Steve Finger, and Hamilton Sundstrand President Ron McKenna, each spoke about specific ACE applications in his organization.

¹⁷ "The Unsung CEO," Business Week, October 25, 2004, reprint, page 9.

Listening to Other Leaders

UTC's improvement emerged from experiences in its divisions. Learning from divisions' experiences happened with quality, as well as lean production methods, which David recounted as follows:

It began for us with Shingijutsu at Otis in Bloomington, Indiana, in 1991... We moved to Pratt with Shingijutsu the following year, 1992. Sikorsky did agile manufacturing first in 1992...and together all of these things implemented fundamentally classic lean manufacturing techniques, and they are at the heart of most of the cost and profit improvement at UTC.¹⁸

Otis and Pratt & Whitney were among the first American companies to contract the former Toyota consultants when they formed the Shingijutsu Consulting in 1987. Taiichi Ohno, who developed the Toyota Production System, had taught these consultants.¹⁹ Danaher Corporation hired Shingijutsu Consulting following a 1988 *kaizen* seminar in Connecticut. One of Danaher's former managers, John Cosentino, was President of Otis North America when he hired Shingijutsu Consulting in 1991. In 1992, Shingijutsu was discussing consulting with General Electric Aircraft Engines. Since Shingijutsu would not consult with a client's competitors, Cosentino arranged an "emergency meeting" between George David and Shingijutsu's principal Iwata. Cosentino and David convinced Iwata to work with Pratt & Whitney.²⁰

Although David was outspoken in his ideas, he did not force them onto others, and promoted a consensus decision-making style. The Presidents Council decision-making process illustrates this style. The Presidents Council consists of division presidents, and corporate chief executive, chief operating, and chief financial officers. It meets monthly to review performance and make corporate-level decisions. When ACE was first proposed as a corporate-wide program, most division presidents were against it. Without a decision, David kept ACE as an agenda topic the next month, which continued for the next three consecutive meetings. When division presidents all agreed upon ACE across UTC, these months of discussions produced an alignment across divisions that improved implementation. The process illustrated David's leadership – not imposing a decision but instead continuing discussions until there is sufficient alignment to move collectively forward.

Taking three months to decide to implement ACE across UTC illustrates UTC's consensus decision-making process. The presidents are accountable for their divisions' performance, and corporate initiatives are seen with suspicion. Deciding to adopt an improvement program across all divisions runs counter to a minimal corporate involvement philosophy. Louis Chênevert, current UTC Chairman & CEO, and then member of the Presidents Council as Pratt & Whitney President, described David's leadership style as follows:

George David drove consensus around ACE. It was important that everyone saw the benefits and understood how ACE could improve performance across very different and independent business units. The data and results allowed this to happen. Examples of ACE leading to margin expansion, customer satisfaction and employee engagement were

¹⁸ Remarks of George David, then UTC Chairman & CEO "Ito University – Opening Remarks," Cromwell, CT, July 13, 1998; downloaded from <http://www.utc.com/press/speeches> on 5/3/2007.

¹⁹ See Ohno, T. 1988 Toyota production system: beyond large-scale production Cambridge, Mass.: Productivity Press.

²⁰ Emiliani, R. (2006) "The Origins of Lean Management in America," Journal of Management History, Vol. 12 No. 2, 2006, page 174.

compelling, allowing us to overcome the initial inertia and doubts around this “corporate” initiative.²¹

Discussion forums across divisions are replicated at multiple levels. The councils associated with UTC’s improvement efforts include the ACE Council, Operations Council (Operations VPs), Quality Council (Quality VPs), and Supplier Management Council (Supply Chain).²² These councils operate outside the division decision-making process, although individuals on these councils have responsibility for decisions in their divisions. Each council has representatives from every division. They meet monthly for a half or whole day to review each other’s progress and recommend future courses of action. In addition to promoting alignment, the councils provide means for comparing and learning from experience. They are also used to provide rapid feedback on new ideas and leverage cross-division business opportunities and efficiencies.

Leading from Experience

David’s quality and lean experience gave him confidence that using these methods would invariably produce desired results. Louis Chênevert, David’s successor as UTC’s Chairman & CEO, has experience leading improvement efforts. Chênevert worked at General Motors for 14 years before joining Pratt & Whitney Canada. His first experience at General Motors provides insight into his confidence in people leading improvement efforts.

I joined GM because it had a structured training program for college graduates. I began my career as first-line supervisor on the night-shift of the frame line producing Oldsmobile Cutlass Supremes and Pontiac Grand Prix. On my first night of work, I’m paired-up with the production line supervisor, just shadowing him to see what he does. When the line starts, it is chaos. It’s not what I’m expecting, not what I learned in school. As the line moves, the inspector is finding issues with nearly every frame, and the repairman is barely keeping up fixing all the issues. I’m the new guy watching this and wondering how we could have so many issues with the frame assembly, which is so fundamental to the automobile.

My second night on the job was a defining event in my 30-year career. I went home after the first-night and was woken up by a call from the general supervisor. He told me, “I have some bad news.” The bad news was that the production line supervisor I was shadowing my first night needed an emergency operation for appendicitis, and the general supervisor wanted me to start the line.

So I get to the line, get everyone assigned, and the line starts. Immediately, I notice our repair guy is working like crazy to fix a cross-threaded fitting bolted to the rear axle on almost every second car. He explains that it has been like this for several weeks.

Trying to get to the source of the problem, I go see the guy on the axle line, a big burly biker named John. John is working with a big fixture, loading every axle onto the frame and securing it with two big nuts. At first, he’s really unfriendly. He is barking at me more than talking. Then I see his toolbox, where he has a picture of his family. I talk to

²¹ Interview with Louis Chênevert, then UTC President & CEO, May 6, 2009.

²² The councils were not all created at the same time and have evolved over time. The Operations Council was formed in 2003 to support Operations Transformation. Later, under Jothi Purushotaman, the Operations Council subsumed Manufacturing, Quality, and Supplier Management Councils. The ACE Council was formed in 2004 and reported to the Quality Council. Some UTC people might argue that ALL councils undertake improvement efforts.

him about his kids, and he starts to mellow. Soon I am talking to him about his job and all the repairs needed for the cross-threaded bolts. He explains that we wouldn't have problems if we could just shim the fixture. He tells me that the maintenance guys won't help, they don't care; they only want to work overtime after shift. So I ask, "what if we can get a maintenance guy to shim your fixture on break?" John's response, "Good luck!"

I go see the maintenance guy and tell him that John is upset with his fixture. His reaction, "John's always complaining; he doesn't know what he's talking about." But I keep at it, and he finally agrees to come out and shim the fixture during break. After break, instances of cross-threaded bolts go from one in two to one in ten. Within an hour the repairman says, "Good job. Are you looking for more stuff to fix?" My response: "before we fix anything else, we need to get John's fixture perfect." So I ask the maintenance guy, to stay after shift to get the fixture to 100%" His response, "Are you going to pay me overtime?" I said, "if you fix it, I'll pay you." That's all that he wanted to hear. So the John and maintenance guy stayed after shift. The first 15 minutes is disaster as they yell at each other. After a while, they start working together to make the necessary adjustments to the fixture. The next night there wasn't a single cross-threaded axle on the line.

I share that story to highlight an important lesson I was lucky to learn very early in my career, a lesson that is still with me. That lesson is that employees know how to fix most problems around them. Given the right support, resources and opportunity, employees can fix most problems.²³

Chênevert's early work experience provides a basis for his historical support and current confidence in ACE. He has confidence that people solve problems when given the opportunity, and he creates an environment that supports these efforts. Chênevert left GM in 1993 to become Pratt & Whitney Canada's operations vice president. In 1998, he moved to Connecticut to become Pratt & Whitney executive vice president for operations, and in 1999, he became Pratt & Whitney's president. In 2006, UTC's board of directors named him as its President and Chief Operating Officer. After working closely with CEO David, in April 2008, Chênevert succeeded him as UTC's President & CEO, and in January 2010, he became UTC's Chairman & CEO. In all his positions, Chênevert had a substantial role in developing and supporting ACE.

²³ Interview with Louis Chênevert, then UTC President & CEO, May 6, 2009.

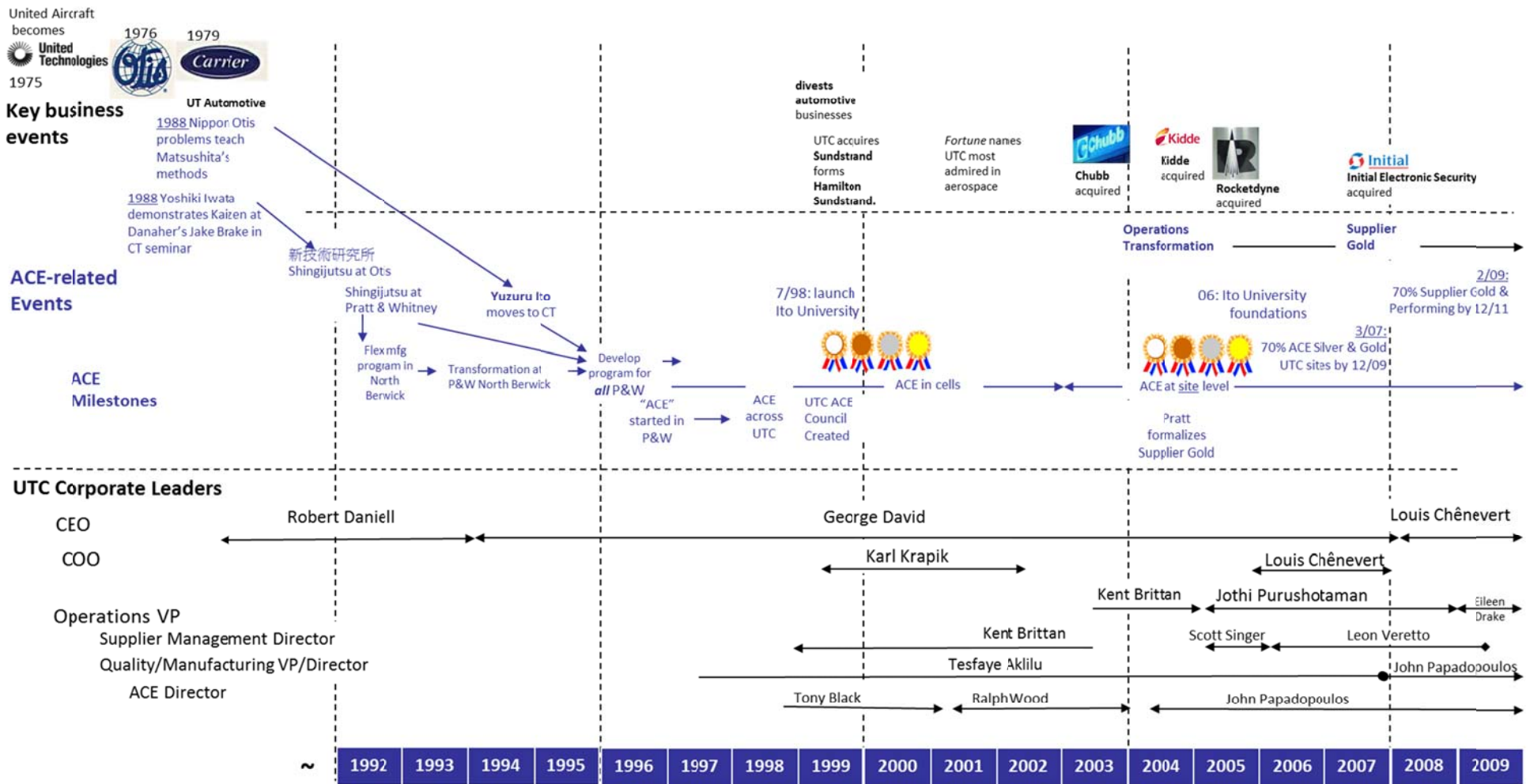


Figure 3 Time Line of Business Events, Corporate Leaders, and Development of UTC ACE

Name	Position / Role	Summary
Harry Gray	UTC CEO, 1972 to 1985	Hired from Litton Industries in 1971 as Pratt & Whitney President, became CEO of United Aircraft one year later. In 1975, he changed name of corporation to United Technologies. Gray presided over many acquisitions that grew UTC, both friendly and hostile. The acquisitions included Essex International (wire and cables, in 1974), Otis Elevator (in 1975), Dynell Electronics (radar systems, in 1978), Ambec Industries (diesel power systems and fuel injection devices in 1978), Mostek (semiconductors, in 1977, sold in 1985), Carrier Corporation (heating and air conditioning, in 1979). Under Gray's leadership, UTC operated four divisions: Power Products, Flight Systems, Building Systems, and Industrial Products.
Robert Daniell	UTC CEO, 1985 to 1994	Succeeded Gray as UTC CEO in 1985 from previous position as Sikorsky President. Provide focus on stability and operations from previous period of acquisitions.
George David	UTC CEO from 1994 to 2008	Former Otis Elevator President, which he had joined in 1975, David presided over UTC during a period of decentralization and globalization. Under his leadership, UTC sold its automotive businesses, and acquired Sundstrand Corporation, Chubb Security, Kidde, and Rocketdyne. David led in the development of quality and continuous improvement methods, supporting the ACE operating system that UTC developed and adopted during his CEO tenure.
Louis Chênevert	UTC CEO starting in 2008	Chênevert became UTC President & CEO in 2008, and in January 2010 UTC Chairman & CEO. He had been UTC President & COO from 2006. In 1999, he succeeds Krapek as President Pratt & Whitney. Chênevert joined Pratt & Whitney Canada in 1993 as its Operations VP after 14 years with General Motors Canada. In 1996, he became Executive VP Operations for Pratt & Whitney. He supported ACE in all his positions, including developing innovations at Pratt & Whitney Canada that UTC later adopted.
Yuzuru Ito	UTC quality consultant, 1994-2000	As Matsushita Electric Corporation Quality VP, Mr. Ito helped guide the joint venture between Matsushita and Otis, Nippon Otis, with quality improvements in 1989. When Ito retired from Matsushita in 1991, he consulted with UTC, and in 1994, he moved to United States to work with UTC, reporting to George David. His contributions are acknowledged by UTC naming its quality and ACE education program Ito University.
Tesfaye Aklilu	UTV VP, Quality & Manufacturing, 1997-2007	David named Aklilu UTC Vice President, Quality in 1997 to focus on improving quality across divisions. Quality efforts, working with Ito's methods, led to developing ACE. Along with Brittain, Aklilu led Operations Transformation, which re-launched ACE in 2004. He joined Pratt & Whitney from Xerox in 1995, and retired from UTC in 2007.
Kent Brittain	UTC VP Supply Management, 1998-2005	Brittain led UTC's supplier improvements efforts starting in 1997, first as UTC Vice President, Purchasing and then, in 1998, as UTC's Vice President, Supply Management. In 2004, he led Operations Transformation efforts, which included strategic sourcing and supplier improvement activities. In 2005, he became Chairman, UTC International Operations.
Tony Black	UTC ACE Director, 1998-2000	Black was picked by Aklilu from his position in Otis' field operations to be the first director of UTC's ACE program. He had previously worked as a test engineer at Pratt & Whitney, and subsequently continued in other management positions at Otis. Black helped to establish ACE as a program across all UTC companies.
Ralph Wood	UTC ACE Director, 2001-2003	Wood became UTC's ACE Director after Black. His previous position had been as a manager in UTC Research. He led efforts to further diffuse ACE, and its investigation and re-launch with a focus on sites and value streams and as an operating system that used balanced performance criteria.
John Papadopoulos	UTC ACE Director, starting in 2004	Papadopoulos is the third UTC ACE Director. He followed Wood, having been an ACE Council member as Pratt & Whitney's ACE Director. He held prior engineering and management positions in Pratt & Whitney. Papadopoulos has led the broad diffusion of ACE across UTC, improvements in site assessment, training, and education, enabling the 70% ACE Silver and Gold sites goal by the end of 2009.

Table 3 Glossary of UTC Leaders in ACE Case Study

ACE over time

ACE evolved from many activities over time. Figure 3 provides a time line that shows the sequence of events, UTC's leaders, and ACE milestones described in this case study report.²⁴ The time line's period is from 1992 to 2009. Before 1992, there were several important business events. Those events were the 1975 name change from United Aircraft Corporation to United Technologies Corporation (UTC), beginning a broadening of the conglomerate's identity shift from aerospace to a broader industrial concern. In 1976, UTC acquired Otis Elevator Corporation and in 1979, UTC acquired Carrier Corporation. Also in 1979, UTC formed UTC Automotive by merging several automotive manufacturing companies it had acquired. Each of these companies were divisions, and they joined UTC's other divisions, which were Pratt & Whitney, Sikorsky, and Hamilton Standard. There were no major acquisitions or divestitures for twenty years, until in 1999 UTC sold its automotive business, and used the proceeds to purchase Sundstrand Corporation, merging it with Hamilton Standard to form Hamilton-Sundstrand. Other major acquisitions took place in 2003 and 2005, with the purchase of Chubb and Kidde, and the formation of UTC Fire & Security. In 2005, UTC also purchased Rocketdyne, which it has retained as an autonomous company under Pratt & Whitney.²⁵ In 2007, UTC acquired Initial, which it added to UTC Fire & Security.

Looking across the time line of events and milestones, a pattern emerges. What were local lean or quality events in Nippon Otis, then Otis and Pratt & Whitney in the US, continue as other initiatives in other parts of these companies. When Yuzuru Ito moves from Japan to Connecticut to become the CEO's consultant and North Berwick develops its flexible manufacturing program and survives a possible closure, the roots of ACE appear. The name ACE is given to a set of tools that will help make changes. The successes that were local are replicated across Pratt & Whitney, and later UTC. That replication, however, is limited in its benefits to customers, and a group collects data, rethinks, and re-launches ACE as UTC's business operating system. As this history will show, it was not a carefully designed, precise, or predetermined approach that was used to develop ACE. ACE emerged and developed through feedback and improvisation. The history of ACE is a series of decisions that continue to be made based on directions gained from experience.

²⁴ Figure 3 is a simplified version of a time line that was used in interviews. It shows three levels – key UTC business events, development of ACE through relevant events and milestones, and the leadership at corporate levels. The time line used in interviews also included corporate performance measures – revenue, income, earnings per share, stock price, employment, and market capitalization. These corporate metrics were included to ask respondents how corporate results related to the development of the ACE, a connection former UTC Chairman & CEO George David made in his speeches.

²⁵ A conglomerate that owned, managed, purchased, and sold various businesses was a popular corporate form in the 1970s and '80s. Harry Gray, UTC's CEO from 1972 to 1986, architected many acquisitions, in a style exemplified by Harold Geneen at ITT Corporation that was a strategic approach and corporate form popular in the 1970s and 1980s. Owning diverse businesses as a conglomerate created economic diversity, which could cancel out individual industries' business cycles, provide financial stability for corporate investments, and give shareholders regular returns. The conglomerate strategy has since fallen out of favor as corporate leaders found themselves responsible for managing diverse businesses with insufficient industry expertise. This case study does not cover this broader trend in corporate strategy, except to note that it provides a context and background for UTC's development of ACE. In the period covered, UTC is very careful to hold division presidents responsible for their specific industry knowledge and performance, yet also develop common capabilities that cut across divisions improve and sustain corporate results. As UTC's financial summary shows [see graph in Figure 1], it has achieved and sustained superior performance, results that its leaders attribute to ACE. ACE could be seen as an alternative strategy for managing diverse companies, creating capabilities for continuous improvement and ongoing management.

The bottom section of the timeline provides names of UTC's corporate leaders. These leaders are important to the development of ACE because they created conditions that enabled and sustained tests, feedback, consolidation, and diffusion of effective practices. UTC's leaders supported and promoted ACE. ACE developed in the middle of these organizations, with individual contributors providing expertise while local proponents, plant managers, and division executives provided leadership and support. What emerged from the middle and front lines of UTC's companies was integrated and codified by the ACE Council at corporate levels. That integration was in the standards, resources, and training that the ACE Council created. Other UTC councils, including the Presidents Council, Operations Council, and Supply Chain Council, provide venues for leaders from different UTC division to exchange ideas and learn from each other's experience in adopting ACE across UTC.

Finally, the pattern across the time line is a series of punctuated efforts. The experience with Flexible Manufacturing and need for change led to ACE for all of Pratt & Whitney in 1996. That need for change and application of ACE, along with Ito University, was applied across UTC in 1998. In 2001 ACE efforts to date are studied, ACE is redesigned, and at the start of 2004 ACE is re-launched with a site level focus in combination with Operations Transformation. In 2007, then UTC President & COO, Chênevert commits to analysts that 70% of UTC's sites will be at ACE Silver and Gold levels, implying results for customer, investors and employees, by the end of 2009. At the start of 2009, then as UTC President & CEO, Chênevert commits to Supplier Gold & Performing performance across 70% of UTC's key supplier spend by the end of 2011. UTC corporate leaders' strong direction to division executives, made at the times that they were, show their commitment to ACE and Supplier Gold achievements. That commitment comes from UTC leaders' confidence that their ACE business operating system will help achieve desired enterprise results for customers, employees, and shareholders. The basis for leaders' direction, commitment, and confidence can be seen in examining their involvement as ACE was developed.



Figure 4 ACE Boards - Hamilton Sundstrand, Windsor Lock, CT (7/20/05)
 (Source – internal UTC ACE web site)

2) Emergence of ACE Operating System

When you walk into almost any UTC facility today, you will encounter its ACE boards. An ACE board is a display with information regarding that facility, how it is organized, its recent improvement projects' actions and results, and its current performance status. These boards are updated regularly, visually attractive, and self-explanatory in communicating this status information. Figure 4 shows ACE boards as they might be seen at UTC facilities.

ACE boards and the information on them are a part of a system that provides transparency for the performance and status of work. Visual displays are an element of lean production, which are practices associated with Japanese automotive companies.²⁶ UTC's development and use of lean, quality and other improvement practices are linked with specific events, often challenges that have been overcome, in its corporate history. In overcoming particular challenges, UTC has developed ACE as an approach that develops and maintains its capabilities to solve future problems. The sections that follow describe important events for ACE's history, including Nippon Otis' quality problems, Shingijutsu's lean consulting, North Berwick's Flex Manufacturing, Pratt & Whitney's ACE program, adoption of ACE across UTC, Operations Transformation and second generation ACE, developing ACE assessors, and top leaders' public ACE commitments. These events involved leaders who took actions using new methods, and where successful, these methods evolved and were integrated into ACE. As ACE methods and the organizational context that supported them were used, they changed how people responded to new problems. Two decades of events and responses have accumulated into UTC's ACE operating system today. [See Appendix B for details on the development and integration of the tools and methods used in ACE.]

Nippon Otis – finding new direction from past failure

In 1973, Otis formed a partnership with Matsushita Electric (known in the United States by its Panasonic, Quasar, and Technics brands), creating Nippon Otis Elevator Company. As part of the Matsushita *keiretsu*, this partnership provided Otis with the association and credibility needed to sell its products in the Japanese marketplace. In 1986, when there were problems with new elevators installed in Matsushita's Osaka headquarter buildings, Otis sent two of its best North American field engineers. Field engineers, who go out and fix problems, are the "heroes" in Otis' culture. When confronted by Nippon Otis' people, the field engineers called back to

²⁶ Womack, J. and D. Jones, 1996 Lean thinking: banish waste and create wealth in your corporation, New York: Free Press.

Otis President David, saying that they could not apply the known TIPs (Technical Information Publications). In fixing elevator problems, engineers documented solutions as TIPs. Field engineers then reference TIPS for fixing problems. Matsushita did not just want their problems fixed, they insisted on knowing the root causes.

Otis' problems went beyond what Matsushita experienced with its two new Osaka elevators. Nippon Otis' products had hurt the reputation of Matsushita and other companies in its *keiretsu*. Otis President David had received a letter from Matsushita Electric's President Tanii, where he wrote, "It has become clear that the inferior quality of your elevators is about to affect the quality image of not only Nippon Otis, but Matsushita products other than elevators. This situation cannot be left unattended."²⁷ A year earlier, David had heard a similar message when Mr. Ito, Vice President of Quality, and Mr. Takahata, a board member of Matsushita Electric, visited him in Connecticut. Mr. Ito had visited Otis' manufacturing facilities in Shibayama, Japan and reported a lack of attention to quality.

Matsushita would help Nippon Otis improve its quality. Its Quality VP Ito was personally involved, and through his efforts developed a relationship with Otis President George David. When Ito retired from Matsushita in 1991, he became a quality consultant to Otis, making frequent trips to the United States. In July 1994, David convinced Ito, then at the age of 66, to move with his wife to Connecticut. "Ito-san," as he was called in UTC, reported directly to David, who was then UTC's CEO. UTC's internal web site recognizes Ito as follows:

*This [move] began Mr. Ito's tireless journey to visit all UTC facilities and to teach his simple yet powerful message of "quality first," backed up by a few simple tools that he wanted everyone, from top leadership to production and office associates, to learn and practice daily. By the time of his death in 2000, Mr. Ito had left an indelible legacy for UTC that includes a common language and culture, a quality university named in his honor to carry on his teaching, and a spiral-bound notebook, called simply "Ito Quality Philosophy," in which he amplified his beliefs and operating principles to secure the highest quality of goods and services. Mr. Ito... was literally the father of quality at UTC.*²⁸

Ito's influence – a welcomed prophet in a new land

With his move to Connecticut and through his relationship with George David, Yuzuru Ito's influence went across UTC. David said that Ito was "his teacher" and influenced him in profound ways. Ito applied quality methods he had used in producing consumer electronic products. He introduced six key techniques across UTC [see Appendix B for detailed description of these quality methods]:²⁹

1. QCPC (Quality Control Process Charting): team-based approach to identify process problems, prioritize relentless root causes analyses, and mistake-proof solutions to eliminate problems' sources.

²⁷ Remarks of George David, then UTC Chairman & CEO, at Japan Management Association Consultants, February 18, 1999, downloaded from <http://www.utc.com/press/speeches> on 11/9/2007.

²⁸ History of Achieving Competitive Excellence, UTC internal web site 10/4/2006.

²⁹ April 18, 1997 remarks of George David, then UTC Chairman & CEO, NASA Quality Conference, Alexandria, Virginia; downloaded from <http://www.utc.com/press/speeches> on 5/3/2007.

2. 5S: visually laid out plant work flow that is apparent to even casual observers; empowered associates to make their work places highly productive.
3. Rejection tags: when deficiencies are discovered parts are tagged and trigger a relentless root causes investigation.
4. Defect Concentration diagrams: simple, visual depictions of defect concentrations on parts or other work products to facilitate diagnosis.
5. Returning failed parts: getting failed parts back quickly for analysis and viewing defects as gems to be treasured for the learning experience represented.
6. TPM (Total Productive Maintenance): collecting machine data and performing routine maintenance by operators to maintain machine availability, accuracy and throughput.

Ito's approach, learned from three decades at Matsushita, was based on several key premises: take quick action to eliminate defective processes at their sources, never build bad products, make quality methods sufficiently simple to involve *every* employee, interest every employee in doing his job right the first time, treasure defects as gems for understanding, and use that understanding to eliminate defects forever.³⁰ These principles became the basis for UTC's improvement efforts.

Ito documented his thinking on quality tools, methods, and organizational practices in writing to help him teach them to UTC's people. His quality philosophy used simple tools and emphasized the importance of people's active participation: Quality methods should never confuse people with abstract methods or too many tools. His "two pillars to quality" were QCPC and Clinic activity. QCPC Activity places people on teams that develop quality process charts, and use those charts to develop insights and take action. Clinic Activity, based on hospital clinic techniques for diagnosing and treating illnesses, applies this method to manufacturing. Clinic Activity was developed in the early 1980's at Panasonic, and applied at Nippon Otis' Shibayama factory in 1989.

Ito complemented QCPC Activity and Clinic Activity with supplemental tools, such as Passport, 5S, and TPM (see Appendix B for detailed description of methods). Figure 5 is Ito's diagram of his quality methods. This diagram links the goal of a healthy corporate body and quality products to diagnostic activities where quality tools are to correct errors and monitor performance. Ito pushed every UTC division to use QCPC and Clinic Activities. He emphasized the importance of managerial relationships and employee engagement, what he called a "quality first" approach, which he described as follows:

*The human heart is considered to be the most important thing in any management method. Learning a management tool is easy in some sense. However, people use the tool. If activities of the human hearts are neglected, any tool can be no longer effective. Managers need to spend more efforts to study human hearts frankly than to study management tools... If somebody visits a Pratt & Whitney factory, the person should witness the shiny and vivid eyes of machine operators in the shop and high spirits of the group of people. A management tool could not achieve such an excellent situation.*³¹

³⁰ February 18, 1999 Remarks of George David, then UTC Chairman & CEO, Japan Management Association Consultants

³¹ Ito Quality Philosophy, from UTC internal web site, dated as written by Y. Ito in September 1998.

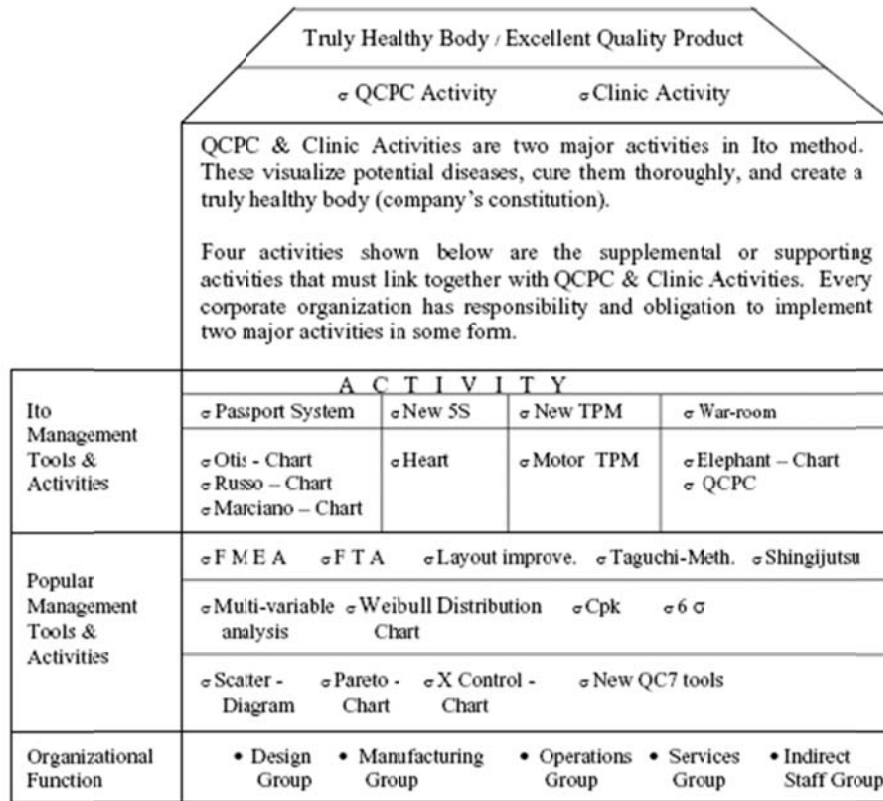


Figure 5 Diagram of Ito's Quality and Management Tools
 (Source – Internal UTC document; see Appendix B for quality tool descriptions)

Ito promoted what he called “New 5S” to improve workplace organization. The term “5S” comes from five Japanese words – *Seiri, Seiton, Seisou, Seiketsu,* and *Shitsuke* – which is alliteratively translated to Sort, Straighten, Shine, Standardize, and Sustain. Ito’s “new” in 5S goes beyond physical improvement to emphasize heart or human spirit. When 5S focused on physical aspects of a plant, Ito found that it would often “become a mannerism, stagnated, and nothing but framework.” Making and sustaining physical changes, he said, was only possible through engaging human psyches. A quality approach would lead to business results, and efforts to improve productivity or reduce costs should follow quality improvements. He was adamant about leaders actively engaging their people to improve working conditions.

Lean Production – learning Toyota’s methods from Shingijutsu Consulting

An important influence in ACE is the methods developed by Toyota. In the early 1990’s, Shingijutsu consultants were contracted to conducted *kaizen* events at different UTC facilities. A *kaizen* event is an intense, short-term project accomplished by rapidly implementing changes such new work cell organization, improved machine setup, or streamlined processes. The Shingijutsu consultants led work area groups in eliciting information about their current operations, brainstormed improvements ideas, selected among options, and made immediate changes.

These *kaizen* events led to numerous and significant improvements. For example, Pratt & Whitney’s Middletown, Connecticut plant had consolidated space, and tooling 75% by

May, 1992. Pratt & Whitney's North Haven, Connecticut turbine blade manufacturing plant made similar gains, decreasing its throughput time, inventory, and work-in-process by 70%. Pratt & Whitney's President Karl Krapek (whom CEO David had moved from Carrier) and Pratt & Whitney's Operations VP Mark Coran actively led these changes. In addition to deploying lean methods, they negotiated with unions, replaced reluctant managers, focused on value streams, replaced monument machines with flexible equipment and restructured business units. These leaders' involvement combined with *kaizen* to achieve extraordinary gains.³²

While *kaizen* often produced dramatic improvements, some people reported that the technique alienated workers. One shop floor worker recalled the following:

The Japanese trainers had special techniques for initiating rapid change... their goal is to brainstorm and get radical ideas. It is human nature to give reasons why certain things aren't possible. When that happened, the Japanese trainers put him in his place by humiliating him for his resistance, and asked him to leave. Once that happened, the atmosphere changed. Everyone is knocked back, possibilities are back on the table, and we spend the week actually doing things.

While some complained, others said *kaizen* events were refreshing. There was little bureaucracy, documentation, or analysis, but an effort focused on making changes. As Pratt & Whitney people became *kaizen* facilitators, they adopted a more "culturally sensitive" approach, their sensitivity helped the acceptance of *kaizen*.

North Berwick – "flexible manufacturing" staves off closure

Continuing economic declines in the early 1990s created financial stress for Pratt & Whitney. While improvements increased capacity and reduced costs, demand declined. Sales fell from their peak of 1,162 engines in 1989 to an eventual low of 364 engines in 1994.³³ In December 1991, Pratt & Whitney announced that it would close 2.8 of its 11 million square feet of manufacturing space.

Pratt & Whitney had opened its North Berwick, Maine plant in 1979 to produce turbine blades and vanes. It was an offshoot of Pratt & Whitney's North Haven plant, but built on innovative work system concepts. Pratt & Whitney rented space in a former textile mill, which at 877,000 square feet was the largest facility in the state of Maine. Operations began in half of the building and by 1981 expanded into the entire plant. Some production equipment was moved from North Haven and some was newly purchased. Agreements with the state government and a local university were used to train the 900 welders, grinders, and machinists that Pratt & Whitney hired.

North Berwick became a mass production paragon. The two-thousand-person workforce efficiently operated lines of machines in tightly organized manufacturing villages. Production costs were \$50 to \$100 less per hour than the North Haven plant. The facility employed several innovative social practices, including quality circles. Using statistical quality control methods to

³² See Womack, J. and D. Jones (1996) "The Acid Test," chapter 8 in Lean Thinking, New York: Simon & Schuster, pages 151 to 188, for a description of the many changes at Pratt & Whitney's plants between 1992 to 1995.

³³ Page 152, Womack, J. and D. Jones (1996) Lean Thinking, New York: Simon & Schuster

manage large 2,500-unit batch runs, the plant achieved high quality standards, standards that had eluded North Haven's production.

In early 1992, Pratt & Whitney Operations VP Mark Coran called North Berwick plant manager Robert Ponchak to a meeting at Connecticut headquarters. Coran told Ponchak that he was to close the North Berwick plant in six months. Pratt & Whitney's strategy accepted that it was not cost competitive, and so it would outsource more of its production, reduce in manufacturing facilities, and focus on technology innovations. Management's task was to downsize or close production facilities.

When Ponchak returned to North Berwick, he broke the news, and asked his staff, "Did they want to go quietly?" They had some experience with production innovation. A year earlier, their engineers developed a novel application of brush seal technology to jet engines. They set up a new production area to make these seals for the PW4000 engine. Using *kaizen* methods, production experts and engineers worked with machine operators to move 101 pieces of equipment between plant shut down Friday night and plant startup Monday morning. Over that weekend, they created the "brush seal production cell." The cell, designed around flexible manufacturing and lean flow concepts, was very effective. Cell concepts, however, did not spread to other parts of the factory.

Ponchak suggested they extend cell concepts. He assigned fifteen people to lead plant-wide changes and challenged them to produce results in six months. The change team set up a conference room as their operations center. They benchmarked Toyota, John Deere, and Harley Davidson, worked with Shingijutsu consultants, and used Ito's quality principles to develop a "flexible manufacturing" approach. Ponchak wrote a compelling "Maine vision" that they communicated to employees across all three shifts. With the vision and detailed plans, they restructured the plant into twenty-four cells. Each cell was based on simple concepts: putting everything needed to produce parts together, focusing material flow, and teaching operators the skills to maintain their equipment. They started at one end of the plant, moved equipment to form cells, and applied what they learned to the next cell.

One lesson from reorganizing equipment villages into production cells is the importance of having workforce leaders to make and sustain changes. The change team selected eight production people that were identified as natural leaders. They held daily session with these leaders where they taught them "flexible manufacturing" concepts, which included workplace organization (5S), operator maintenance (TPM), mistake-proofing, process certification, set-up reduction, and standard work methods. What these leaders learned in their daily 20 to 45 minute conference room sessions they then applied, first in the 8743 cell where they worked together with their teachers, and then in their own cells. The cell where the leaders and teachers worked together was the plant's poorest performing cell, the 8743 cell. This cell produced 45 different bearing housing parts. All these parts were about the same size and were produced using a similar process, but otherwise they varied greatly. The 8743 cell employed twenty-one people across three shifts. When it was redesigned, it required nine people working across two shifts to produce the same volume at higher quality. Each day, with what they learned in the conference room and in the 8743 cell, the leaders returned to their work cells, and tried implementing similar improvements using the same methods. These changes were not always smooth or easy; several reported that they "ended up almost having fistfights with operators." The leaders needed more than improvement method education and skill; they needed to learn skills to help others change.

In East Hartford, Pratt & Whitney Operations VP Mark Coran noticed North Berwick's production improvements. He extended the plant's closure deadline by six months. In 1993, as performance continued to improve, he cancelled closure plans. These efforts continued with ongoing reorganizations and improvements to achieve greater efficiency and quality. The plant's 980 production machines were moved an average of four times each over a four-year period. The workforce decreased to 1,500 people, while delivered work hours remained relatively constant, varying between 750,000 and 1,100,000 hours. The plant increased its revenues by a factor of five from a combination of productivity gains and producing higher value parts. Overall Equipment Effectiveness (OEE), which measures a machine's productive work time, was a key improvement metric. Toyota was the benchmark, with a 94% OEE. North Berwick's OEE was 1.4% in 1992. In 1996, OEE reached 86%, which is a world-class performance level. People came from other UTC facilities, other companies, and industries across the world to visit and benchmark North Berwick. In 1998, the plant averaged 5 tours per week and 1,600 annual visitors.

Designing ACE – Pratt & Whitney recreates flexible manufacturing

The results achieved in North Berwick were what Pratt & Whitney's leaders, Mark Coran and later Louis Chênevert, who succeeded him as Operations VP, wanted across the company. Coran asked Ponchak to loan him several of his experts. Stacy Hall and Jim Moore from North Berwick joined a team with Dave Haddock, Rob Rourke, and Joe Dawson from East Hartford. Pratt & Whitney's Vice President of Quality, Roger Chereconi, was the senior executive who guided and supported their efforts. The team's task was to design and implement an improvement program for all of Pratt & Whitney. Starting at the end of 1995, over a six-month period, they reflected on the North Berwick experience, talked to other experts, and benchmarked other companies before proposing a new program. They added two methods – QCPC (Quality Control Process Charting, one of Ito's quality pillars) and mistake proofing – to the five methods North Berwick used. These seven methods were the basis for their new program (see Appendix B for detailed method descriptions). Their program got its name as they tested it. In the North Haven plant in May of 1996, the team presented its program to operators and discussed whether they should name it. Instead of identifying it based on the methods, like "flex manufacturing," operators asked what they were trying to accomplish. Their goal was to be competitive. Mike Rusate proposed a name: they were trying to help Pratt & Whitney *achieve competitive excellence*, which, when spelled out, was A – C – E. ACE was easy to remember; it had a positive meaning and related to Pratt & Whitney's business as a term for an expert aircraft pilot.

An additional element of ACE included assessment and feedback on achievement levels. In designing the program, the team wanted to engage people and acknowledge achievements. It was the spring of 1996, and there was a great deal of attention on the upcoming Atlanta Olympics. The Olympics inspired the idea for defining bronze, silver, and gold achievement levels. To assess a cell, they used an activity checklist. ACE achievements required establishing production cells, and if a cell was doing 9 out of 12 activities, it achieved bronze status. If the cell had 12 out of 16 activities, it achieved a silver status. When first introduced, they had not yet specified the gold criteria. The initial level, originally called prerequisite and later called ACE qualifying, required a cell's people to have basic level of awareness and training. People quickly became engaged in the recognition of ACE accomplishments. When launched in June of

1996, ACE had an appealing name, provided a focus on establishing and improving cells, specified improvement methods, included training and support, and had a structure to assess progress and provide feedback.

The ACE launch was not the end, but the beginning of the team’s efforts. The five members worked together over the next year and a half to enhance ACE as they trained people and helped implement improvements. The elements that made up ACE and their origins are shown in Figure 6.³⁴ ACE integrated multiple methods, and resolved tensions that had developed among competing philosophies. Ito promoted a quality-first mindset, teaching that paying attention to quality first unlocked other results to follow (not sure this sentence makes sense). Shingijutsu consultants taught organizing production for flow first and then resolving the quality issues that surfaced. In Pratt & Whitney, these differences created improvement factions – a quality and a continuous improvement group. Tesfaye (“Tes”) Aklilu, who later became UTC’s Quality VP, commented on what he saw as follows.

There were two factions that were separate and competing with each other. There were stories that when Ito comes, here is what you do, and when Shingijutsu comes, here is what you do differently. When I came in, both started reporting to me. I could see them fighting and competing with each other. We got them together, saying, ‘Hey, guys, we’re trying to skin the cat in different ways. They are one in the same, but we’re confusing people.’

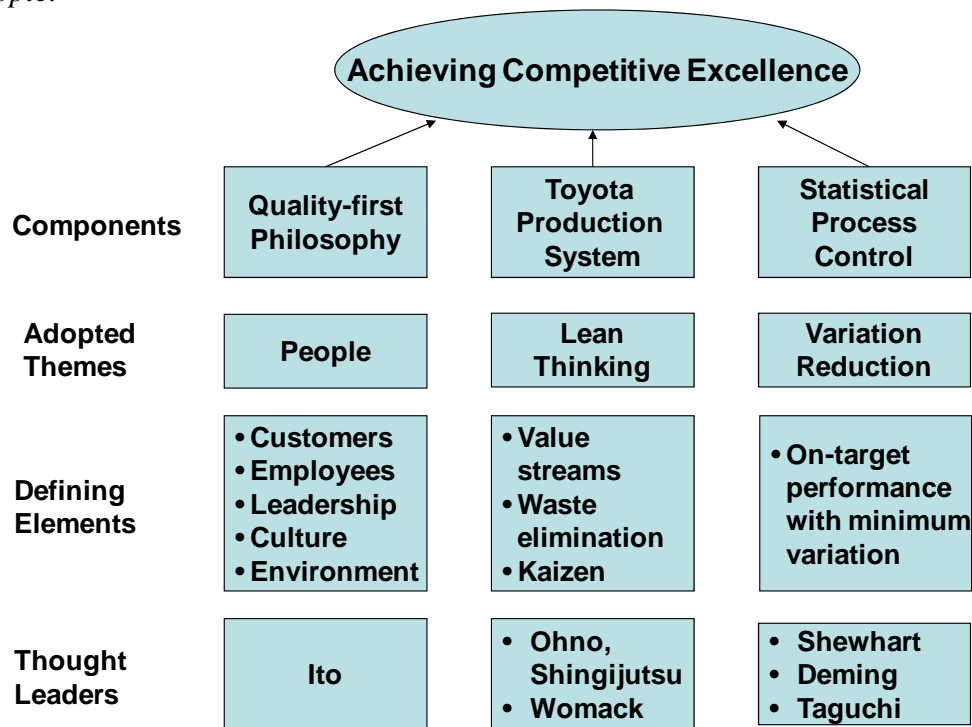


Figure 6 Contributing Components to ACE Program³⁵

³⁴ This diagram was created several years later, in 2006, as part of Ito University Foundations, to explain these origins of ACE.

³⁵ Source: Presentation to Ito University Foundations Facilitators’ Training, 2006

For Pratt & Whitney, it was important to create a program that its people owned. People questioned why they needed to create a unique program, rather than buying a proven program, as they had done in the past. Stacy Hall commented on these issues:

We had noticed, myself and others who were in this business for some time, that if we didn't foster it internally, or we didn't utilize our own talent and transfer knowledge to that talent, it would not hold. We had bought Q-Plus from Amoco and it never was ours. We knew that we could not just unplug Toyota's TPS method and put it in. That was Toyota's and it had to be Toyota's. We had to utilize best practices but make them ours. My exposure to other companies confirmed my suspicions. My hypothesis was that if it's not something we develop, design, foster, nurture, and care for along the way, we are not going to be successful.

Creating local ownership was important in implementing ACE; it guided the selection and training of local specialists. From North Berwick's experience, they had learned the importance of selecting, training, and equipping leaders from work groups to make and sustain changes. The term for the work area leaders that would be trained was "ACE Pilot." Pratt & Whitney's managers identified ACE Pilots for their facilities. The training took place in plants, where people who had used the methods taught them and showed how they were used. When ACE Pilots returned to their workplaces, they led improvement efforts by "educating others up, down, left, right within their organizations in those seven best-practices."

ACE across UTC – making efforts to institutionalize quality

In 1997, George David invited the divisions' Quality VPs to attend a Presidents Council meeting. David stated, "Ito is getting old, one of these days he is going to leave us. How are we going to institutionalize his teachings and make sure that it is never dropped?" He asked division presidents to work with their Quality VPs and propose their ideas at the next council session. Before that next meeting, the Quality VPs met together four times to develop ideas. They presented these ideas at the next Presidents Council, each VP describing a program he proposed for his division. When they had finished David's reaction was that UTC had nothing, saying, "If he [Ito] goes tomorrow, this thing will die."

At a Presidents Council meeting in 1997, David announced that he would create a UTC Quality VP position. In that discussion, Pratt & Whitney President Karl Krapek recommended Tes Aklilu, who had been championing Pratt & Whitney's ACE efforts. Aklilu, who had joined Pratt & Whitney two years earlier from Xerox, and was involved in implementing ACE, made the following comment about that moment:

My agreement with Karl Krapek was to help him with quality and reorganizing Pratt & Whitney. Then I was supposed to take a line position. I never had quality in Xerox, I was a line manager. I said, 'Karl, I don't want to do that. You promised me a line function.' His advice was when the CEO asks you to do something, if you want a career at UTC, you better accept it. But, tell him what you want... So, I sat down with George David and that is what I asked him. He was very gracious and said, 'Okay, help me establish quality and I'll take care of that. Don't worry.'

In becoming UTC's Quality VP, Aklilu reported directly to David. Aklilu was to "institutionalize" quality across all UTC and drive UTC to a process centric organization. One element was company-wide quality training. Aklilu proposed adopting Pratt & Whitney's ACE. He scheduled a discussion to make that decision at the Presidents Council meeting. It was a one-hour topic on the agenda. While some of the division presidents agreed to the concept of one program across UTC, each had different priorities and his own approach. Division presidents perceived ACE as a directive that told them what to do. David's style was not to impose decisions. After more than two hours of discussion, the decision on ACE was carried over to the next meeting. Aklilu followed up with each division President and his Quality VP. The finance organization also had requirements; it wanted a cost-benefit analysis on training and implementing improvements relative to expected results. The scheduled one hour to discuss ACE, similar to the first month, lasted more than two-and-a-half hours, and the ACE topic was again carried over. This pattern continued for three months, at which point there was an agreement. With the understanding developed in deliberations, ACE was implemented quickly across UTC. At its 1998 inception, ACE across UTC did start with manufacturing. ACE would be the one program adopted by every UTC division.

Ito University – establishing management commitment for ACE

Engaging leaders would spread ACE across UTC. Leaders were to attend a class called "Ito University." The class promoted ACE, and its name honored Yuzuru Ito and his legacy. The presidents agreed on the content and length. It was a one-week, five-day, session. However, none of the presidents had the time for a week of training; they wanted a shorter one or two-day session for themselves. Aklilu described Xerox's Leadership for Quality program: it was mandatory for everyone from the top to the bottom of the organization, starting with the CEO, President, and senior executives attending as a group. The program then cascaded through Xerox as each executive led a second weeklong session with his organization's top leaders, these leaders then held sessions with their organizations, and so on. Aklilu described his appeal to division presidents:

If it is good for the masses, it is good for you. You are going to send a message. Is this something very critical, very important? If you all tell me it is good and very important then you have to put in the time. Slowly George David just came up and said, "Okay. I'll be in the first one."

When David committed to attend sessions, the presidents' attitudes shifted. They would each lead a class with attendees from all divisions. The first Ito University was in July 1998 in Connecticut. CEO David and twenty-five senior managers selected from all divisions attended the five-day Ito University ACE course. The sessions were taught by engineers, team leaders, supervisors, and hourly workers who had used ACE methods, rather than dedicated professional instructors. UTC selected people with ACE experience and hired consultants to develop their teaching skills. These teachers could share their actual experience, demonstrate the use of tools, and show how they lived the philosophy. David's remarks to being the first session were recorded as follows:

This is a very special moment for UTC, and I really mean that quite sincerely. I'm delighted to be here with you this morning and also for virtually the entire week to share the experience with you and to learn as well. It is a special moment because for the first

*time in many, many years, and it is at least a half a dozen, we are going after UTC-wide education in a formal and focused manner. We really haven't had any since the early 1990s. It is an even more special moment because we begin this effort with Ito-san and with Ito University, and we signal in doing so without qualification our commitment to quality and to reliability of performance of our products and service as our first and most important priority as a company.*³⁶

To reinforce ACE's broad application, Ito University sessions took place in Asia and Europe. Division presidents attended all these sessions. The presidents' attendance and Ito University's extensiveness created a "big splash" across UTC. David asked that a special Ito University session be created for UTC's board members. In that session, an hourly worker taught ACE to UTC's board members.

Ito was involved in the development of Ito University. He made clear and adamant statements about the orientation and priority he expected from managers. Without it, he recommended that they not participate in ACE training or Ito University. ACE extended Ito's quality concepts and Ito University delivered that training.

*Quality management never talks about productivity or cost down. Quality always comes first as a policy. This is a belief that productivity improves and production costs will be reduced if the quality is improved... If either productivity or production costs are not improved, it is proof of not providing 'quality-first' management. If you cannot understand this matter, it is useless that you attend Ito University.*³⁷



Figure 7 Yuzuru Ito and Ito University Pictures

(Source: UTC internal web site)

Ito University has evolved considerably since its 1998 inception. More than 20,000 managers have completed what is the original or an equivalent Ito University course. That Ito Foundations ACE course is now a three-day program that uses computer-based case study simulations. It uses a structured curriculum, involves both classroom and in-field work, and is offered around the world. A one-day "ACE at Work" course, a revision of what was formerly called "ACE Basics," is required for all new UTC employees. ACE at Work can be taken in English, French, Chinese, Spanish, Polish, German, Korean, Portuguese, Japanese, or Hindi versions, in either on-line, DVD, or instructor-led versions. UTC's people can achieve ACE specialist certification at the three levels: associate, practitioner, and master. At the end of 2009, over 30,000 UTC employees

³⁶ Remarks of George David, then UTC Chairman & CEO, "Ito University – Opening Remarks," Cromwell, CT, July 13, 1998; downloaded from <http://www.utc.com/press/speeches> on 5/3/2007.

³⁷ "Ito Quality Philosophy" document, UTC ACE internal web site, by Yuzuru Ito, September 1998, pg. 11.

were taking courses toward one of these ACE certifications.³⁸ Ito University offers more than 120 unique courses in 22 different countries. ACE courses are also offered to UTC's suppliers.

ACE Council – broadening decision-making and feedback

The agreement to adopt ACE across UTC required repeated discussions over three months. In addition to the discussions at the Presidents Council, conversations also took place at UTC's Quality Council. The Quality Council is a full day, monthly meeting of division Quality VPs. UTC has multiple councils, such as the Operations, Supply Management, and Technical Councils, in addition to those already mentioned. These councils hold monthly meetings of senior people with similar responsibilities from each division. The councils provide mechanisms for sharing experience, gaining feedback, testing new ideas and aligning activities across divisions.

To guide ACE across UTC, Aklilu appointed a UTC ACE Director. The first ACE Director, Tony Black, came from Otis Elevator's field operations. Black's thirteen years at UTC included five years at Pratt & Whitney as an F100 test engineer, and after earning an MBA degree, management positions in Otis' sales and field operations. He had led the implementation of a new sales and service program in over 200 Otis locations in North America and Europe when approached by Aklilu. At the time, Black recalled, "ACE was not yet defined in a way that the divisions would accept, it was still Pratt & Whitney's program." Aklilu chose Black to give ACE credibility with line managers. Black was from one of UTC's commercial companies, and he would help "sanitize" ACE to go beyond its aerospace roots. Black had demonstrated his skills in implementing global programs, which was what ACE needed.

Aklilu established the ACE Council as reporting to the Quality Council. Each Quality Council member appointed an ACE manager for his division. Black chaired that ACE Council. Black's goal was to involve each division in the development and deployment of a UTC-wide ACE program. The ACE Council would specify and oversee the development of ACE materials and training curriculum, as well as define UTC's standards for certifying Qualifying, Bronze, Silver, and Gold cells. Developing common criteria across divisions was neither simple nor easy. Black recalled, "To get consensus from the ACE Council and then the Quality Council was difficult. We spent a lot of time, like a bunch of lawyers, arguing every word. It was constructive, and in the end we had a real deliverable." Ito himself remained active in deploying the quality elements of ACE across UTC, which Black commented on as follows:

Ito-san was a legend. Everyone knew who he was. I got to meet him, visit factories with him, and hear his views. He was strong in his views, very focused on quality. In discussions on productivity and efficiency, there was tension on the right balance, and he questioned if there was enough focus on quality. It was a constructive tension and forced good discussions. He was very involved in how ACE was used, how we deployed it, and how we evaluated cells.

The assessment process is an important ACE element. Not only does it certify achievements, it also provides immediate and specific feedback. When ACE was launched across UTC, Otis was using an assessment process for selling, installing, and handing over elevators to customers in its North American sales and service field operations. Using a well defined Otis Sales and

³⁸ The courses and enrollment in ACE certification are as of November 2008.

Installation Process, a Bloomington-based group assessed and scored each elevator installation step. That group then immediately debriefed management, explaining what they observed that was done well and where improvement was needed. In addition to verbal feedback, the assessors later issued a written report. Aklilu liked Otis' approach, and suggested it be adopted for ACE.

The ACE Council specified the training needed to deploy ACE. They defined two roles: the specialist, who learned and taught tools, and the ACE coordinator, who scheduled and managed a facility's improvement activities. Other divisions modified the terms that Pratt & Whitney had used, such as "ACE Pilot" for their specialist or "Control Tower" for their metric scorecard. Carrier, for example, correspondingly used "ACE Specialist" and "Thermostat." While the terms were different, the philosophy, approach, standards, and training were common across UTC. To promote ACE globally, the first UTC ACE Specialist training programs were held at Carrier in Syracuse and at Otis in China.

After two years as UTC ACE Director, Black moved to Otis as VP of Quality. In those initial years, ACE activities began across all UTC divisions, multiple Ito University courses were added, and each division appointed an ACE manager to develop its ACE specialists and guide its activities.³⁹ Aklilu searched for a new UTC ACE Director, he was looking for someone to continue changes. That person needed to be credible across a wide range of organizations, be hands on, work from a small office with only a lean staff, be open, practical, willing to take feedback and push change across division complexities, as Aklilu said, "with a velvet hammer." Ralph Wood, a manager in United Technologies Research Center who had been leading a group that developed engineering productivity improvements, was that person.

Wood began in his new role at a time when ACE had been widely adopted across UTC. However, these efforts also seemed to be reaching their limits. Divisions' benefits were slowing with their continued efforts, and some customers were still experiencing quality and delivery problems. ACE was across UTC, and all managers attended Ito University, but ACE applications were largely focused on operations and manufacturing. UTC's corporate performance had improved since the mid-1990s; it went from 7th in 1994 to 1st in 2006, 2007, 2009 and 2010 on Fortune Magazine's most admired aerospace companies list.⁴⁰ Shareholder returns were steadily rising, outpacing peers and the Standard & Poor 500 index. Market conditions, particularly in the aerospace industry, were already not good, would soon change dramatically. Wood's first ACE Council meeting was memorable; it occurred on September 11, 2001.

Restructuring – using ACE in its own redesign

Managers that embrace ACE – supporting training, coordinating improvement projects, coaching ACE specialists, and leading change efforts – achieved organizational results. Those results, however, did not always extend beyond local settings. Several UTC customers talked to Aklilu, saying they had heard a lot about ACE, but they had not yet seen any benefits. When one

³⁹ Within UTC, the title "Director" is an executive level position, implying a level of responsibility and corresponding stock incentive compensation. Not all positions that directed ACE activities across UTC's division are at the UTC Director level, although each division has an individual that manages and directs ACE activities for his or her division and is a member of the ACE Council. The responsibility and authority for the leadership of ACE in the divisions was recognized by making these positions all UTC-level directors.

⁴⁰ See <http://money.cnn.com/magazines/fortune/mostadmired/> for industry rankings from 2006 to 2010 (note Textron as rated 1st in Aerospace and Defense industry in 2009), and "How companies rank in 41 Industries," by McGowan, Joe, Fortune Magazine, March 6, 1995, Vol. 131, Issue 4.

customer blankly told him, “You talk about ACE, but we don’t see any difference,” Aklilu brought this feedback to the ACE Council. In that council meeting, several division ACE managers shared their experience. Implementing ACE had become an uphill battle; their division leaders were “not fully on board.” Aklilu and the ACE Council agreed to collect data and look for root causes.

ACE Council members themselves conducted one-on-one interviews and commissioned an employee survey. In the analysis of these data, they determined that UTC’s performance improved through ACE. ACE had helped identify unnecessary operations and eliminate waste. Those changes provided internal benefits, but these gains were not evident to UTC’s customers. While ACE achieved local gains within cells, these gains did not accumulate across cells.⁴¹ Stacy Hall, who had helped develop North Berwick’s, then Pratt & Whitney’s, and also UTC’s ACE programs, commented on their findings as follows:

Our naïveté was that we thought that if we identified everything in a cell, and every cell achieves ACE Gold, the organization would run well. We missed the fact that not every cell contributes to the value stream, and there are factors in the value stream not captured by cell processes.

Other factors for results falling short of expectations were that divisions made extensive modifications to ACE. In efforts to promote ACE ownership, each division developed its own implementation approach and unique communication materials. Another critique was managers’ complaints that ACE was too prescriptive. Managers did not want to do nine of twelve practices to attain ACE levels; they wanted ACE to help them achieve business results. They found that business leaders had delegated ACE responsibilities by appointing ACE managers to lead their efforts.

In the 4,000 survey responses the ACE Council received, they found that many ACE practices had changed. Some ACE elements were common across UTC divisions: they all used Ito University to educate managers, the same tools training for ACE specialists, and the same standards for cell certification. However, since they had launched ACE, one-third of the divisions’ leaders had changed. Using these data, the ACE Council identified and put its focus on two issues: implementation problems and low commitment levels.

ACE implementation problems stemmed from its focus on cells. To measure progress, managers counted the number of silver and gold cells in their organizations. It had taken twenty months to make process management a part of Ito University (which taught how to identify and prioritize process improvements). The ACE examples used in the training were in manufacturing applications, requiring people to translate the methods to apply them in business processes. Most importantly, the reason customers did not experience benefits was that improvements in one cell were not always utilized downstream. Figure 8 is a diagram used to illustrate the delivery of a product using cells at different ACE levels. If some cells improve while others do not, in the end,

⁴¹ A person interview that was involved in the development of ACE noted that focus on cells was intentional and the limitations were known from the start. By getting people involved and excited about results in cells, it would create stickiness and learning, which was to be the basis for the planned, future evolution of ACE. While results did not accumulate across cells, the enthusiasm for using ACE tools to make improvements spread quickly.

the customer, Figure 8 shows, was still unhappy. This realization led to the adoption of value stream thinking and management practices within ACE.

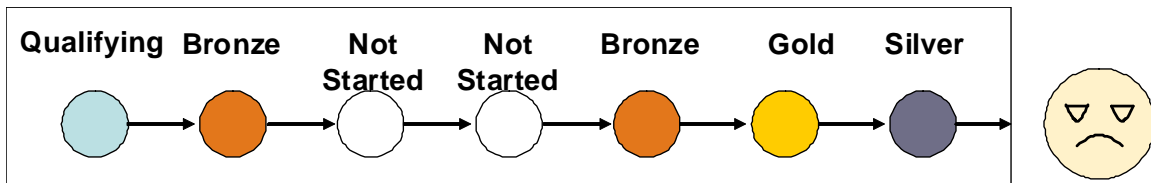


Figure 8 Impact on customer of cells at different ACE-levels
(Source: internal UTC “What’s wrong with ACE?” presentation)

The ACE Council identified causes for low commitment levels. They took responsibility, stating, “We failed to educate our senior managers in how to lead the change to a process-focused culture.” Many managers perceived ACE as tactical and not strategic. ACE was for “manufacturing,” and manufacturing examples did not translate easily into business processes. ACE training emphasized tools, with little emphasis on desired cultural changes. When ACE successes occurred, they were not widely communicated, and those that they publicized were seen with suspicion. Many managers thought of ACE as a “tax,” suggesting that it was an expense and not an investment. They sent people to training and appointed an ACE specialist to satisfy a corporate requirement. Managers were accountable for results, not the means to achieve results, so many had delegated ACE leadership. A general manager’s comment captured the widespread sentiment: “I won’t get fired for not doing ACE; I will get fired for missing a delivery.”

These two main realizations drove the ACE Council’s next steps. Attaining an increased number of Gold cells was misguided; a more impactful approach was getting all of a facility’s cells Bronze, and then all Silver, and eventually all Gold. The second insight questioned UTC’s functional priorities, which UTC ACE Director Ralph Wood explained as follows:

In developing the business case, we realized that we made most of our money in operations. Operations were strategic, and business functions were tactical units supporting operations. That was a big comeuppance to everybody. The business case for focusing ACE on operations was absolutely enormous. Our rationale was that we start on the delivery end with the customer. The operations people felt the pull from the customer. That pull was then felt by the whole supply chain. Supply chain pulls on the support organizations. If we have problems in operations, it is often because we have designs that cannot be produced easily, so we pulled engineering in. We could have a better supply chain if we had better contracts, so we pulled in Legal. We started to think about how we rationalize the metrics by which we are measured. These corporate metrics are owned by finance, so we pulled finance in. Pull is felt by everybody who supports operations.

The ACE Council accepted its role in what one person called “an initial misstep” in ACE. They worked to develop appropriate training and communication messages. These efforts, which took

place over time, included developing more business process examples and promoting process analysis methods. The next UTC ACE Director, John Papadopoulos, promoted the use of SIPOCs.⁴² SIPOC became a key ACE method, and essential to the application of ACE to business processes improvements across UTC.

Operations Transformation – emanating from the business case

Aklilu and the Quality VPs worked with UTC’s Vice President of Supply Chain, Kent Brittan, to develop a business case for Operations Transformation. ACE was the method by which UTC improved its processes, and there were needs, not just for UTC’s processes to improve, for improvements in suppliers’ processes. UTC’s purchases from suppliers account for more of its cost of goods sold than its internal operations expenditures. An opportunity for UTC to improve profitability and capital utilization, identified by its financial models, required supplier changes. To identify and execute these changes, UTC hired several outside experts, including business consultant Ram Charan and lean consultant Kevin Duggan. Aklilu advocated an overall operations-focused UTC strategy:

One of my objectives is to make UTC a manufacturing centric organization. UTC is an engineering and finance-driven organization. Manufacturing is seen as a necessary evil. I had these discussions with George David in 2000, and again in 2002. Revenue was \$27 billion, and if you look at the cost of goods sold, it was about \$13 billion out of the \$27 billion. But, who manages the cost of goods sold? Gross inventory at a UTC level is huge, but who manages it? Operations are not managed at a UTC level.

In its decentralized management approach, the manufacturing, operations, and supplier decisions are in the domain of UTC’s divisions. Aklilu and Brittan presented a business case to the Presidents Council that showed significant corporate returns, estimated at over five billion dollars, from better quality, improved processes, and inventory reductions from UTC-wide process and supplier improvements.⁴³ Division presidents, Aklilu recalled, “were highly against” these operation decisions being made at UTC levels. Each division was in different markets – aerospace and industrial products, vertical flight, turbine engines, power generation, heating, ventilation, and air conditioning, fire and security alarms, and building management – and would not benefit from a common operations strategy. They had already agreed to ACE, which provided divisions with specific methods and training from corporate, and they did not all like it. A UTC-level focus on operations would essentially create a new strategy that required managing across UTC companies.

There was no consensus; the discussion on supplier and lean manufacturing process was tabled until the next month. Aklilu and Brittan led Presidents Council discussions for six consecutive

⁴² SIPOC is an acronym for supplier, input, process, output, and customer. SIPOC methods involve creating a diagram for each key process, each of its inputs and from whom they come (suppliers), and each of its outputs and to whom they go (customers). A template is often used, and this template includes detailed information on the metrics for the performance of the process and measures for the process’ inputs and outputs.

⁴³ This analysis is in the UTC ACE Criteria, 11.4 V8 document, “UTC’s business case for ACE,” downloaded from UTC internal web site. The analysis summed division estimates. Quality costs include warranty, post release engineering, and scrap, rework, and repair. Process improvements were estimated by comparing research, engineering, and development spending on new products, services, processes, and technology to industry benchmarks. Inventory gains were estimated using best-in-class companies in similar industrial areas and calculating the additional required working capital.

months before, in October 2002, division presidents reluctantly agreed to move forward together. They would call the new strategy “Operations Transformation.” ACE was their business operating system, or “how” they did things, and Operations Transformation was “what” they were doing. Operations Transformation set in place four elements for UTC’s strategic direction – 1) lean flow, 2) design for manufacturability, 3) strategic sourcing, and 4) talent development. Lean flow included improvement methods to eliminate waste, better processes, reduce inventory, improve quality, and deliver greater customer value. Design for manufacturability involved making engineering design choices tied to production capabilities. Strategic sourcing defined what was unique and core to a product’s value, focused on that value, and developed low cost suppliers for everything else. Talent development grew people to be leaders that executed changes and transformed the end-to-end value chains.

To get their message out they held a two-day conference on January 16 and 17, 2003 (subsequent conferences were held in Europe and Asia). Three-hundred-and-fifty executives from manufacturing, engineering, finance, legal, and human resource functions from all UTC companies attended the meeting, which was held in a large hangar on Pratt & Whitney’s East Hartford campus. the impacts of George David, UTC CEO at that time, kicked off the meeting with remarks on UTC’s accomplishments and opportunity:

ACE, Ito, and supply management are the reason why the operating margin is 14%, up from 4%. It is also why the operating income is going to keep on going. 14% is by no means the top; I would say that it could be 20% at UTC easily.⁴⁴

Division presidents and Operations VPs talked about the importance of ACE, lean manufacturing, and value streams. They described specific projects and tangible gains made from strategic sourcing, developing low cost suppliers, and design for manufacturability. On the morning of the first day, consultant Kevin Duggan gave the audience a primer on value stream management. When he was done, each executive had a checklist of what to look for in factory operations. They formed teams, boarded busses, and visited area UTC and supplier factories.

On the bus ride back, each team created a report, which it presented at the conference the next morning. Ron McKenna, at the time Hamilton Sundstrand’s President, responded to these team reports by describing what he learned. After him, other division presidents, Wood recalled, “spontaneously stood up and gave extemporaneous testimonials about how ACE worked in their organizations... they each gave really great talks.” In closing the meeting, David asked each executive to thoughtfully commit to doing something different in the future as a result of the conference. Setting an example, David committed himself to learning more about value stream mapping. He subsequently spent a day with consultant Duggan at Sikorsky to learn value stream mapping and visited more UTC factories. David closed the meeting by setting UTC’s objectives going forward:

Six more points of operating income margin, in six years, and double the gross inventory turns. We have to do it, we have the intellectual property [ACE], we have the will, we have the record, we have the people, and I believe that we will do it. I certainly hope and anticipate that I want to be fully standing with each one of you, shoulder to shoulder, side

⁴⁴ Comments of George David, then UTC Chairman & CEO, transcribed from “Operations Transformation Leadership” videotape, January 16 & 17, 2003.

*by side. My goal is to look back on this day, three years from now, and conclude that this day, this instance, was a defining moment for UTC.*⁴⁵

David asked each leader to send him a short, no-more-than-one-page email with his or her three commitments for the next year. Two months later, when 40% had not yet responded, many said they thought David's request applied only to operations, he sent each delinquent manager a personal reminder note. His message was clear: Operations Transformation and ACE are for everyone.

Operations Transformation – a strategy that required ACE

To achieve the goals set out for Operations Transformation required more communications and greater transparency on improvement progress and current performance. Some ACE methods, specifically one and five year roadmaps, were used in developing, aligning, and communicating business-specific strategies.⁴⁶ Other ACE tools were used to deliver that strategy. At monthly Presidents Council meetings, the CEO and division presidents now reviewed operations data – ACE maturity, quality, on-time delivery, and escapes to customers – in addition to rolled up financial data.

Strategic sourcing focused on leveraging supplier relationships across UTC's divisions.. UTC would manufacture core component (those whose design or production process used unique intellectual property), and source all non-core components from suppliers. Each division was to develop low cost sources. UTC-level people worked with divisions and their suppliers to create an overall corporate sourcing strategy. In the traditional as well as low cost suppliers, divisions were to help suppliers establish and develop improvement initiatives. The model for supplier improvements was UTC's own ACE experience.

Supply Chain VP Brittan estimated a need for 250 to 300 specialists across UTC to work with suppliers. These specialists would be trained in lean and other related methods. Brittan established an Operations Transformation Leadership (OTL) program to teach these skills and certify people to work with suppliers. Initially, OTL included Ito University courses, but because of the timing and number of people involved, it was separate from UTC's internal ACE training. In OTL, people taught, and applied improvement methods – value stream mapping, production preparation, and *kaizen* – at UTC's suppliers. OTL defined three levels – associate, practitioner, and master levels – to certify its people in leading supplier improvements initiatives. The skills and methods for OTL and ACE were similar, and the two efforts later merged into one common ACE certification. ACE adopted the terminology OTL developed for skill certification.

UTC's top leadership, as illustrated by David's letter to shareholders in the 2003 UTC Annual Report, endorsed and emphasized gains from ACE.

Achieving Competitive Excellence (ACE) is UTC's mature discipline for productivity and quality assurance. Without qualification, ACE is the reason for our operating income margin expansion from 6 percent to 14 percent over the last decade and the

⁴⁵ Source: George David, then UTC Chairman & CEO, quote transcribed by case study author from statements recorded on videotape of Operations Transformation Leadership Conference, January 16 & 17, 2003.

⁴⁶ A description of roadmaps and their use in aligning business sites is described in the sections on "alignment" and "roadmaps" as a part of the ACE Operating System.

*Corporation's total shareholder return performance. We see the evidence in statistics like the doubling of Otis' and Carrier's physical production rates over the last decade with workforces only a quarter larger. Comparable gains have been achieved throughout UTC, and we see lots more ahead.*⁴⁷

Second Generation ACE

UTC top leaders reinforced the messages from the January 2003 Operations Transformation launch with conferences in Milan in 2004 and Shanghai in 2005. Managers in those geography attended each of these events. The goals of Operations Transformation increased the need for ACE, and defined it as an “operating system.” In the ACE pocket guide, UTC Operations VP Jothi Purushotaman describes ACE as follows:

*ACE is our strategic, competitive weapon and is our operating system. The key aspect of ACE is that it engages and empowers all of our employees to achieve world-class products and processes to delight our customers, shareholders, and associates.*⁴⁸

Operations Transformation created “a manufacturing centric approach” that Aklilu had spoken about. The strategy required the application of ACE to achieve improvement goals, but to achieve these goals, ACE itself needed to go to the next phase of its evolution – from cells to a site view. Ralph Wood recalled that insight as follow:

We came to the system view. What we had done by focusing on individual cells is gotten parts of the value streams Gold, and maybe a smattering of them Silver. But, the rest of them had not started, and so it didn't matter that we had a Gold element. We are not going to see improvements until we get everyone to the same level; we have to coordinate and synchronize activities. That was another 'a-ha' moment for us.

For a site to improve, all its cells had to achieve the same process maturity level. This maturity level went beyond physical attributes and included employees' attitudes and organizational culture, or what was called the “spirit of ACE.” Ito was interested in more than quality or business improvement; he wanted to improve the “health” of the business through the development of its people. “Shiny eyes” was the term for his assessment of people's liveliness and engagement. People's liveliness went beyond what many ACE specialists had been teaching; it required managers' full support to involve everyone in site improvement activities.

The ACE council revamped ACE criteria for site levels. These criteria included employee satisfaction and other balanced scorecard concepts. A balanced scorecard approach utilizes multiple measures – financial results, process measures, customer satisfaction, and employee survey questions – with an emphasis on measuring means as well as results.⁴⁹ Figure 9 shows the diagram used to illustrate the concepts that became a part of ACE site metrics.

⁴⁷ Quote from CEO George David, then UTC Chairman & CEO, in “Letter to Shareholders,” 2003 UTC Annual Report, page 2.

⁴⁸ Quote attributed to Jothi Purushotaman, then UTC Operations VP, ACE Handbook (internal UTC publication), version 5 (not dated).

⁴⁹ See Kaplan, R. and D. Norton “The Balance Scorecard: Measures that Drive Performance,” Harvard Business Review, 1992. Pages 71-79.

ACE changes required greater leadership involvement. Aklilu made numerous briefings about these changes to executives. Each division president reviewed his ACE progress at Presidents Council meetings. UTC created an executive information system to show divisions' ACE status and progress. Incentive compensation and advancement criteria for managers included achieving ACE goals. Its University courses included more examples of overall operation improvements, including improvements in the business functions supporting operations. The combination of efforts created a transition in the use and scope of ACE. Jothi Purushotaman, at the time UTC Operations VP (currently President UTC India), noted that ACE became a “fact based, data driven approach that applies enterprise wide and links operations to their customers using market feedback analysis.” David, then CEO, publicly promoted ACE, particularly its benefits in what customers and market analysts could expect as performance gains from UTC’s ACE progress.

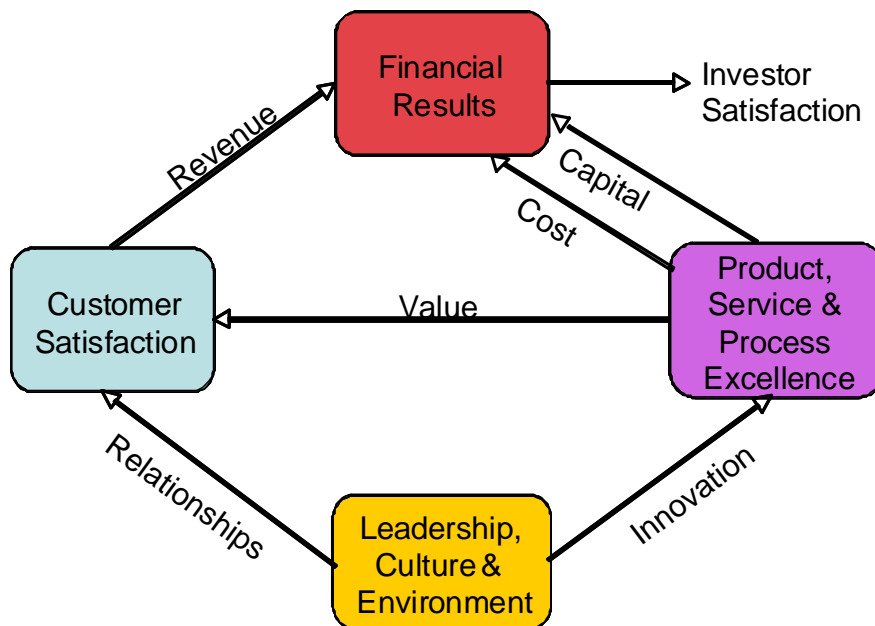


Figure 9 Balanced scorecard concepts in second generation ACE
(Source: Internal UTC presentation)

UTC Commitments

Leaders’ discussions on Operations Transformation and ACE raised questions of what needed to change and what needed to be preserved. Many organizations address these issues by defining their “core values.”⁵⁰ David, then CEO, disliked the term and concept of “values,” and instead put UTC’s focus on clarifying its “commitments.” Commitments are what UTC promises to its customers, employees, shareholders, and local communities. These commitments are shared across UTC. They were first defined in 2000, and then updated as part of relaunching ACE. They are 1) Performance – customers have a choice so set ambitious goals and use customer feedback to reset direction, 2) Innovation – commitment to research and development, sharing

⁵⁰ For example, see “Building Your Company’s Vision,” (*Harvard Business Review*, September-October 1996, pages 65-77), co-author Collins and Porras recommend companies define their “core values.”

ideas, and encouraging diversity of experience and opinion, 3) Opportunity – inspiration creates opportunities, strive to continuously improve, pursue lifelong learning, take risks, cooperate, and learn, 4) Responsibility – maintain highest ethical, environmental, and safety standards everywhere, and 5) Results – meet aggressive targets whatever the economic environment, communicate honestly, and deliver what is promised.⁵¹ UTC’s commitments create a set of goals that all leaders and their organizations are expected to achieve. They are integral to the fabric of the ACE culture.

Ongoing ACE – staying on course

The January 2003 Operations Transformation conference required more than a year’s preparation by ACE, Quality, and Supplier Management Council members for data gathering, analysis, presentations, and planning. Their efforts and that focus would need to persist over the next six years to meet the CEO’s challenges for operating margin and inventory improvements. Guiding ongoing activities required considerable time, coordination, and communication from ACE Council members. Each ACE Council member headed his division’s ACE office, which was made up of a small staff of ACE consultants supporting efforts across sites in the division. The sites selected people as ACE specialists and coordinators who led and supported improvement efforts.⁵² The ACE Council worked to improve ACE criteria, upgrade Ito University courses, develop new training, a curriculum for Associate, Practitioner, and Master proficiency levels, and improve the site assessment process.

More effort was made to standardize ACE. While ACE concepts and methods had been common, ACE was implemented in different ways by each division. Many sites embraced ACE, with locations in different countries translated materials and created unique, local logos. As with other UTC councils, the ACE Council provided a forum to discuss whether creating greater commonality was a worthwhile endeavor. Ideas are proposed and discussed at councils, and if these proposals gain sufficient support, they are carried out. If an idea is not supported or ignored, it usually dies a quiet death. These councils enable UTC leaders to consider and make decisions that are implemented across divisions without relying on top-down authority, and instead seek consensus through discussions and tests for collective agreement. For example, in 2005, in seeking commonality for representing ACE with a corporate logo and a more centralized approach, had there not been ACE Council support, the idea would not have gone forward. Through its discussions, the ACE Council developed a common ACE logo and used the communication of that new logo to get out its message of one common operating system across all of UTC.⁵³

Another function of the ACE Council’s regular, one-day, monthly meetings were as a forum to discuss progress, issues, and test new ideas or practices. The council drew upon on experiences in different divisions to assess ideas that, if successful, would be promoted across all of UTC. The sections that follow – collecting data and assessing progress, developing assessor standard work, and addressing barriers to progress – describe activities guided by the ACE Council that improved ACE implementation across UTC.

⁵¹ See http://utc.com/utc/About_UTC/UTC_Commitments.html for more detailed description.

⁵² See “Organizational Proficiencies – staffing appropriately” section in Appendix A.

⁵³ See Appendix A, Figure 17 for UTC ACE logo.

Collecting data and assessing progress

In 2003, the ACE Council recognized that some of the variations that they had once promoted to help divisions adopt ACE were now dividing their efforts and impeding its wider impact. The council commissioned a survey to understand this variation. In the data collected, they examined methodologies used, their appropriateness, and sequencing relative to improvement progress and business results. Their insights and directions addressed a long-standing debate among different divisions regarding lean or quality methods.

Experience with Operations Transformation has confirmed Mr. Ito's wisdom: productivity (flow) can't happen until quality is in place first. UTC's essential learning is that quality and productivity reinforce one another. We have also learned that, from a teaching point of view, employees grasp the significance of quality much faster when asked to try to create flow first, than when asked to learn quality principles for the sake of quality.⁵⁴

The ACE Council used its own methods – collecting data, conducting analysis, and making decisions based on empirical evidence – in making changes. In examining the impact of what was then the new ACE site focus, they examined the first Gold sites in September 2004. To be an ACE Gold site required all gold cells in addition to achieving site performance requirements. They found several common factors across the first ACE Gold sites (Pratt & Whitney's Turbine Overhaul Services in Singapore; Otis's Manufacturing Facility in Nogales, Mexico; Pratt & Whitney's Homogeneous Metals Incorporated in Clayville, New York; Otis's SSI-Electronics Operation in Berlin, Germany; Pratt & Whitney's Eagle Services Asia in Singapore; and Carrier's United Technologies Electronic Controls in Huntington, Indiana). All these sites had leaders who possessed similar characteristics: these leaders "lived" ACE; they motivated people, were fully engaged, balanced improving processes with achieving results, and focused on employees' well-being.⁵⁵ ACE Gold sites had a high percentage of their employees using ACE in their daily work, including senior leaders, and applying ACE across the organization. Several sites also received best-in-class recognition from other organizations, such as OSHA (as VPP Star sites), Malcolm Baldrige, Global Excellence in Operations (GEO), and local Chambers of Commerce. The ACE Council called what they found the "Spirit of ACE." The "Spirit of ACE" consists of the leadership behaviors that produce improvements across a broad set of business and employee measures; it enabled these organizations to achieve ACE Gold site certification.⁵⁶ The "Spirit of ACE" was a demonstration of UTC's five commitments.

UTC reviewed ACE achievements at the highest corporate levels, including its Board of Directors. UTC's executives reported ACE results in the corporation's annual report and

⁵⁴ Quote from "History of ACE" article, internal UTC ACE web site

⁵⁵ The specific assessments factors for these sites included personal development (rates of participation in education and training), employee satisfaction (empowerment teams, acted-upon feedback, and recognition programs), customer satisfaction (survey scores, and quality escapes, lead time, on-time delivery and communications), financial performance (market share, growth, budgets, and return on invested capital), product and service quality (reliability, performance, absence of defects, and warranty claims), process efficiency (process yields, standard work, flow, certification, poor quality costs, and continuous improvements), supply chain competence (rationalized suppliers, high incoming quality, on-time delivery), and improvement priorities (customer and market feedback, root cause analysis and mistake proofing). Each site had these factors in its use of ACE methods.

⁵⁶ These details were reported in a "Spirit of ACE, Characteristics of Gold Organizations" internal UTC presentation, September 2004.

forecasts to Wall Street analysts. To help senior executives assess its progress, Jothi Purushotaman, then UTC Operations VP, led the development of an Operations Dashboard. The dashboard, shown in Figure 10, displays the division-level information for Operations Transformation and ACE. Each division's top-level data are displayed using colored icons for favorable, progressing, unfavorable, or no data. These data are by division for quality (which includes ACE, cost of poor quality, and quality escapes), on-time delivery, suppliers (suppliers' delivery and quality), cost, and asset utilization. Beneath the dashboard display is an executive information system that enables UTC's leaders to investigate these status data by clicking on items to see detailed reports on the performance and progress by specific sites, locations, geographies, or divisions.

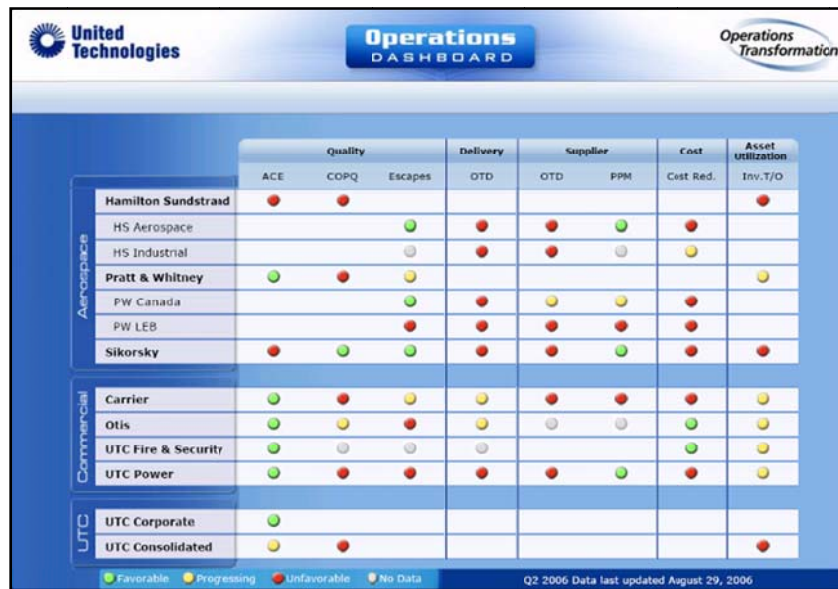


Figure 10 UTC Operations Dashboard
(Illustrative example –not based on actual company data)

Developing assessor standard work

Achieving ACE certification is key goal for every site, its managers, and employees. ACE achievements are a part of everyone's bonus. To certify sites, UTC has specific criteria for ACE assessors and their certification. Initially, the ACE Council members themselves assessed the sites in their division, except for ACE Gold site certification. For ACE Gold, an assessor from outside the division provides an external review. The ACE Council develops and updates the certification criteria and standards for each ACE certification level. The certification criteria have been carefully documented so that everyone knows what is required at each level.

A 36-page document describes the ACE criteria, which is at version 11.4 in 2008. The ACE Council initially issued the version 11.4 criteria in February 2005. Before 2005, the ACE criteria had changed numerous times as the ACE Council revised these criteria to improve their clarity and link to desired outcomes. Some site managers complained that these changes were the ACE Council "raising the bar." The ACE Council, responding in part because they did not want complaints to undermine implementation, committed to the 11.4 criteria. Written criteria, however, still left some site managers uncertain about what to expect in an assessment. There

was an additional challenge of how to develop the assessors needed to certify UTC's nearly 960 sites.

These concerns were addressed when the ACE Council created an assessor training program and defined assessor standard work. Standard work for assessors consists of documented processes and standards for conducting assessments. John Papadopoulos, who succeeded Ralph Wood as UTC's ACE Director in early 2005, led these efforts. Once the ACE Council defined the standards, Papadopoulos taught many of the assessor training sessions. To be certified, assessors first observe, then participate in, and later lead site assessments. The context matters, as certification takes place within divisions and in production or business process settings. As part of their development, the assessors-in-training receive on-the-job training, coaching, and feedback from senior, certified assessors, such as division ACE directors.

Before becoming UTC's ACE Director, Papadopoulos had been Pratt & Whitney's ACE Director. His range of experience – as an engineer, engineering manager, sales and marketing manager, program manager, P&L (profit and loss) owner, and operations manager – helped him understand the range of ACE applications. In his position as Pratt & Whitney's ACE Director, which he took in 2002, he shifted the focus of the ACE consultants in Pratt & Whitney's core ACE office. The ACE consultants were experts that helped client organizations. Papadopoulos redefined their roles as “client managers.” An ACE client manager, like a consultant, provides help and resources when called upon. As client managers, they are also responsible for the progress of the sites that they support. A client manager, as opposed to a consultant, has, as was said, “skin in the game.” Client managers' goals align with those of site managers, and being accountable for a site's progress gave Client Managers a directive to work proactively with the site managers he or she supported. Papadopoulos brought the client manager concept to the UTC level. These and other changes moved site improvement efforts forward across UTC.

Overcoming barriers to progress

In May 2006, ten years after Pratt & Whitney first launched ACE, there were only twenty-six UTC ACE Gold sites. When the ACE Council examined ACE progress, it found dramatic changes at a few exceptional sites, what it called “pockets of excellence.” To create the desired impact across UTC, ACE had to achieve “excellence across the board” and create consistent value to customers. In examining why sites languished, the ACE Council identified their top five ACE barriers. These were 1) the lack of management priority and commitment, 2) an unclear understanding of the relationship between ACE and business results, 3) failure to provide recognition for ACE implementation, 4) a perception that ACE is only for the factory, and 5) an allocation of insufficient time and resources. To help sites progress their improvement more rapidly, the ACE Council created presentations illustrating what some sites had done and the significant and consistent results they had achieved. The improvements from when sites first measured their processes, at the Qualifying or Bronze level, to their achieving ACE Gold certification included improvements in sales, return on investment, inventory turnover, lead time, on time delivery, and customer satisfaction. In September 2006, from their analysis of the twenty-seven sites that had achieved ACE Gold, the ACE Council found the following improvements:

- 35% increase in sales,
- significant percentage point return on sales increase,
- 60% inventory turnover improvement,

- 24% on-time delivery improvement, and
- 35% customer satisfaction score increase.⁵⁷

These ACE Gold sites, however, represented less than 3% of UTC’s total sites. The message from executives to its managers, customers, and shareholders was that there were considerable opportunities, or “runway,” for ACE progress.⁵⁸ Their analysis created confidence that when a site focused on ACE it delivered better results. The commitment to ACE progress came from the top of UTC. As CEO, George David had been a visible and ardent spokesperson for ACE, quality, lean, and continuous improvement. His successor, Louis Chênevert, spent 18 months as President & COO, working closely with David before taking over as UTC President & CEO in April 2008.

Chênevert had extensive operations experience, fifteen years at Pratt & Whitney and before that fourteen years at General Motors. He had been taught quality methods by Edward Deming and Joseph Juran. Chênevert applied what he learned, and spoke from experience about leading improvement and change.⁵⁹ He was an advocate for ACE in its early incarnation at Pratt & Whitney. Chênevert described his confidence in ACE from his position as UTC President & COO as follows:

During my first year as COO, I visited over 60 factories and met with over 100 customers around the world. What I observed was truly amazing. Wherever ACE principles had been applied, the results were remarkable. I saw this at our facilities in China, Singapore, Europe and North America. The geographic location, the native language employees spoke, and local culture didn’t matter. What did matter was embracing the ACE principles, beginning with a real focus on customer feedback. If you think about a business like UTC where we have strong competitors across our portfolio, our results only improve when customers see the value we can provide.⁶⁰

Chênevert’s support and promotion of ACE, along with his rise through the organization to become UTC’s top executive, had one insider who was interviewed speculate that ACE would be Chênevert’s legacy.

70% ACE Silver and Gold sites by 2009

In providing corporate financial guidance to investment analysts in a February 2007 meeting, Louis Chênevert, then UTC President & COO, accompanied by David, then UTC Chairman & CEO, made a bold commitment. Chênevert told investors and analysts that UTC’s leaders had agreed to a goal of 70% ACE Silver or Gold sites by the end of 2009. In February 2007, 18% of

⁵⁷ Improvement statistics are based on changes from earlier ACE Bronze site measurements. The source of these ACE Bronze to Gold improvements is from “ACE and Operations,” internal presentation made to UTC Board of Directors, September 13, 2006. ACE Gold certification requires achieving monthly goals for 12 straight months and these goals includes operational and financial measures (along with safety, process, and employee measures). Business measures are a part of ACE Gold criteria; therefore, a correlation between business results and ACE certification levels is expected.

⁵⁸ From UTC presentation “Road to Gold, Big Results through Accelerating ACE” May 10, 2006.

⁵⁹ See quote from Louis Chênevert on his early experience with quality and change at General Motors Canada in earlier section of this case titled “Leading from Experience.”

⁶⁰ From interview with Louis Chênevert, then UTC President & CEO, May 6, 2009, Hartford, CT.

UTC sites were at that ACE level. UTC ACE Director Papadopoulos commented on the significance of this commitment:

It was a game changer when our President & COO, Louis Chênevert, went public, and made a commitment to a time frame for our sites to achieve silver and gold. The pull, commitment, and desire to get to ACE Gold increased dramatically. It has been a game changer from my perspective. There are people at leadership levels 100% engaged in learning more about ACE today.

When Chênevert set these goals and made them public, he set expectations for improvements in UTC's margins, profitability, and cash flow. In past meetings with analysts, David presented business results that accompanied ACE progress. Chênevert set UTC's goal after talking with division presidents, seeking to unite and leverage improvements across UTC. His comments about the goal were:

I was looking at the 2007 guidance we had given Wall Street in December, and as the new President & COO, I wanted to focus on a single area that would significantly impact all our businesses. In a meeting with the division presidents in January, I proposed a big goal of 70% ACE Silver and Gold for all divisions by the end of 2009. Pratt & Whitney, Sikorsky, and Otis accepted the challenge as "the right thing to do." Fire & Security pushed back. As the newest company in our portfolio, their ACE deployment was less mature, and they understood they could not achieve 70% as quickly as the other divisions. Overall, we agreed on an aggregate goal of 70% across all of UTC, up from 17% at the end of 2006.⁶¹

With Chênevert's public commitment, more than half its business, some 52% of UTC's sites, would have to make significant changes.⁶² Even UTC's ACE proponents, some of whom wondered if Chênevert had misspoken, saw the goal with uncertainty. It had taken years to achieve 17% ACE Silver and Gold. 70% ACE Silver or Gold was a stretch, and many people wondered how they could accomplish it. But the message was certain: UTC's executives were behind ACE, and all UTC's managers were going to be behind it too.

Accelerating ACE

As part of its annual planning cycle, the corporate ACE office asked each division for its ACE commitment. Division ACE directors forecast their numbers based on expectations for sites achieving ACE Silver and Gold. ACE Council members aggregated these numbers, and in the past, they challenged divisions to be more aggressive, and generally negotiated a goal somewhat higher than what divisions originally proposed. That overall ACE goal then became the basis for ACE Council plans. Essentially, Papadopoulos noted, planning was done with a "check the box mentality," and ACE achievements were "voluntary." When Chênevert made his UTC ACE commitment, division presidents made ACE achievements a priority. Before 2006, anything more than local leaders' pull for ACE would probably have derailed it. Before that time, there was insufficient infrastructure – skilled experts, ample training, case study exemplars, and certified assessors – to support the scale of activities that came from a corporate directive. The

⁶¹ From interview with Louis Chênevert, then UTC President & CEO, May 6, 2009, Hartford, CT.

⁶² To get from the current 18% of sites ACE Silver and Gold to the 70% goal required 52% of the remaining UTC sites to make these improvements.

70% goal required, for example, the capacity to conduct more than one thousand site assessments.⁶³ ACE support activities were already ramped up and, for example, the UTC ACE office had scheduled 190 site assessments in the last three months of 2007. ACE was ready, as Papadopoulos, commented:

The timing was right for Louis Chênevert to go out, issue the operational challenge, and allow people to move forward. Had he made that statement five years ago, ACE may not have been here today. We would have rushed, and we would not have had the infrastructure and experience to support the demand. We have accelerated ACE tremendously.

Between 2003 and 2006, the individual ACE certification training typically had between 50 to 100 people across UTC enrolled at any one time. In 2006, as the ACE curriculum was revamped, 1,000 people were enrolled in these courses. When Chênevert told Wall Street analysts that 70% of UTC sites would be ACE Silver or Gold, many people signed up for ACE certification. By the end of 2008, there were 20,000 people enrolled in ACE certification training. The foundation that UTC had from its past efforts, including Operations Transformation and ACE certification training, and the materials developed to teach these skills, allowed a rapid expansion in this training.

An accelerated ACE deployment was possible not only because of the training that was in place, but also because of the stability in ACE criteria achieved in earlier years. ACE had evolved from the original manufacturing oriented program deployed at Pratt & Whitney in 1996 to UTC's business operating system. A business operating system generates information and provides performance feedback, specifying and assessing improvement capabilities, and helps align individual, site, and organizational activities in making and sustaining organizational improvements that are aligned to strategic objectives.

Supplier Gold – extending improvements beyond UTC's boundaries

UTC formalized its efforts with suppliers, an important part of the Operations Transformation strategy launched in 2003, with the launch of its Supplier Gold program in mid-2007. The tools and methods to make supplier improvements are those of the ACE operating system. Supplier Gold includes measuring, assessing, certifying, and monitoring suppliers' performance and improvements. UTC uses criteria similar to ACE in Supplier Gold, but they are described generically (for example, internally certification criteria require competency in specific ACE tools; in Supplier Gold, the criteria are based on generic lean and quality methods).

Supplier Gold is a voluntary program available to all UTC's suppliers. However, UTC identified 1,500 key and critical suppliers, representing approximately half of its annual product supplier spending and proactively approached these companies.⁶⁴ It provided these suppliers with its information on their performance, including process maturity data that comes from internal ACE

⁶³ For example, a quick calculation reveals that for only the 58% of UTC 965 sites to become ACE Silver and Gold, at over 1,100 (2 x .58 x 965) would need to be done by the UTC ACE office (all site silver and gold assessments required UTC-level assessors). Of course, more than 58% of sites would be striving in their ACE efforts, and have assessment requirements. To achieve these goals, the sites needed skilled ACE people to lead the efforts, and training and events for their whole employee population.

⁶⁴ UTC companies purchase \$ 30 billion annually from suppliers. Statistic is reported on page 64 in "Purchasing salutes suppliers" *Purchasing*, November 2008, Vol. 137, No. 11.

efforts. There are four areas – quality, delivery, lean maturity, and customer satisfaction – that are assessed for Supplier Gold performance. Supplier Gold, the highest level, like ACE Gold, requires achieving twelve consecutive months without quality escapes (zero parts per million produced), meeting all customer’s requirements (100% quality and deliver requirements or best in class performance), and achieving scores of 6 or above (on a 7 point scale) in customer survey feedback. These data are used in a scorecard to categorize suppliers into four tiers - Gold, Performing, Progressing, or Underperforming. Sharing its data and working with suppliers, UTC people use these categories to define and prioritize improvement efforts.

The Supplier Management Council (Supplier or Purchasing Vice Presidents from each division) developed this scorecard. In responding to Carrier’s request for help measuring its suppliers, the Supplier Management Council assessed best practices and selected the format and process used by Pratt & Whitney Canada. Suppliers access these data by logging onto a UTC server, where they see their scores and can query data to the part-level quality and deliver information used to assessing them.⁶⁵ When a supplier organization achieves Supplier Gold goals, its UTC contact visits their facilities and confirms self-assessment scores. After maintaining that performance for twelve months, the UTC contacts submits and presents a Supplier Gold application at UTC’s Supplier Management Council.⁶⁶ The council members review and vote on the application. If approved, the Gold Supplier accomplishment is communicated to all UTC divisions. Achieving Supplier Gold gives that supplier instant credibility and can help it gain more UTC business. UTC recognizes these suppliers by publishing their names on its web site and often in a full-page trade magazine advertisement.⁶⁷

The extension of ACE-like efforts to UTC’s suppliers provides operational performance and stability required for UTC to achieve its own improvement goals. UTC is not able to achieve its 70% ACE Silver and Gold site goal without changes at its suppliers. Supplier improvement is crucial, as UTC Operations Director Leon Veretto states, “with more than 75% of UTC’s product cost based in the then supply base, it is critical to have world-class performance from our suppliers to drive overall company results.”⁶⁸ The magnitude of the improvement attained by suppliers is similar to improvement achieved by ACE progress in UTC sites.⁶⁹

To achieve these gains, UTC recommends suppliers begin by measuring their performance (particularly quality and delivery), conducting a lean self-assessment, and obtaining customer feedback. This information creates the basis for an analysis of current and desired performance gaps. Action plans are created to close those gaps, resources are allocated, and repeated measurements provide feedback on progress. UTC’s Supplier Management Council recommends and provides training in its process improvement methods (5S, set up reduction, TPM, standard work, process certification, value stream mapping, and production preparation) and problem

⁶⁵ The supplier’s lean score is calculated using an on-line self-assessment survey developed and administered by Dunn and Bradstreet. On this survey, a score of 350 or above for manufacturing suppliers or 260 or above for service and distribution businesses is required to achieve Supplier Performing.

⁶⁶ The UTC Supplier Management Council, like the Quality Council and Operations Council, meets once a month for a half day. It is headed up by the UTC Operations VP and includes supply chain VPs from each UTC division.

⁶⁷ For example, see advertisement in Purchasing magazine acknowledging 15 UTC suppliers that achieved Supplier Gold, page 69, November 2008.

⁶⁸ Quote from “Purchasing salutes suppliers” Purchasing, November 2008, Vol. 137, No. 11. Page 64.

⁶⁹ See figures calculated in September 2006 analysis of 27 sites ACE Bronze to Gold performance gains, in “Overcoming Barriers to Progress,” pg. 40.

solving methods (QCPC, root cause, mistake proofing, and market feedback). Whereas UTC's internal efforts specify the ACE tools and methods that must be used, with suppliers UTC only recommends its methods and offers its training, and accepts other methods that suppliers prefer to use in producing desired outcomes. UTC does not conduct supplier assessment with the same rigor that it does for its own sites.

70% Supplier Gold and Performing by 2011

UTC CEO Louis Chênevert explained how important its suppliers are to UTC's efforts to achieve 70% ACE Silver and Gold site goals.

*Achieving 70% percent ACE Silver and Gold was a challenging task. Ideally, you'd like to sustain 100% ACE gold performance, but this is almost impossible when you're competing against very strong competitors in very complex, technology-driven markets. Technology improvements constantly redefine world-class performance and customer expectations. Even our best performing units need to guard against becoming complacent, both with their internal operations and with the performance of their suppliers. As ACE was deployed internally at UTC, it became clear to me that our ACE journey would not stop at our own facility walls, but rather needed to include our supply base. We needed to leverage every opportunity available across the UTC value chain to optimize performance and ensure customer loyalty. It is hard to overemphasize just how important suppliers are to a company like UTC that builds for itself only a fraction of the components that become part of our final products. If UTC is to meet its goals and deliver value to customers, we must have suppliers who excel at delivering on time with perfect quality.*⁷⁰

In a meeting with his executives at the end of 2008, Chênevert discussed the implications of setting a goal for UTC suppliers. With agreement from division Presidents, Chênevert announced in an analysts meeting at the start of 2009 that 70% of UTC key supplier spend would come from Gold or Performing suppliers by the end of 2011.⁷¹ His comments positioned the importance of this goal for UTC's continued financial and operational improvement.

*The performance data we assembled on our top suppliers across the UTC business units revealed a tremendous improvement opportunity. Few suppliers were meeting delivery and quality expectations. Clearly, this was unacceptable. In response, we launched a new supplier-focused effort, with a big goal of getting 70% of our key supplier spend to the Performing or Supplier Gold level by 2011. This effort represented a significant opportunity for margin expansion as we synchronize the supply chain with our own factories.*⁷²

The supplier goals are a stretch. The key suppliers assessed as Gold or Performing in January increased to 22% by the end of 2007. Suppliers have been responsive to improvement efforts. The economic downturn that started in 2008 helped focus suppliers on improvements, with hopes for additional UTC business. In mid-2009, CEO Chênevert has spoken of his confidence that the

⁷⁰ From interview with Louis Chênevert, then UTC President & CEO, May 6, 2009, Hartford, CT.

⁷¹ See "Analysts and Portfolio Managers" meeting slides, presented by Louis Chênevert, then UTC President & CEO, December 11, 2008, download from UTC web site on April 7, 2009.

⁷² From interview with Louis Chênevert, then UTC President & CEO, May 6, 2009, Hartford, CT.

70% goal for key supplier spend will be met in 2011. He noted the importance of ACE as the enabling framework to connect passionate UTC employees with suppliers to deliver value to customers.

You need people to be passionate about what they do and to know that the framework is there to support them. This is the environment we created as we expanded ACE into our supply base. It is essential to engage suppliers in the design process, well ahead of product launch. Designing a product without regard to our suppliers' capabilities can lead to unanticipated costs and production delays, as well as field maintenance and quality issues. All of these issues can prevent us from satisfying our customers. In our business, customers have choices and if we don't deliver, they will choose somebody else.⁷³

3) Future Challenges for UTC and ACE

This case study of ACE began by describing UTC's recent accomplishments, particularly its operational, financial, and stock market performance. UTC's leaders attribute these results to UTC's development and use of ACE. Current CEO Chênevert has echoed his predecessor David's confidence in ACE by committing to future gains. UTC's top leaders have promised significant benefits for all stakeholders, including Wall Street analysts, based on 70% of UTC's roughly 900 sites attaining ACE Silver or Gold levels by the end of 2009 and 70% of UTC's top 1500 suppliers attaining Supplier Performing or Gold levels by the end of 2011. This final section shifts from description to analysis to examine these ACE expectations and their implications.

As the basis for how it operates, UTC has developed the ACE Operating System to achieve desired performance outcomes, maintain continuity, and build confidence for further improvements. ACE developed during George David's tenure, from 1994 to 2008, as UTC's CEO. David provided continuous stewardship for quality, lean, and other compatible improvement practices. He listened to people and acted on their advice, and selected future leaders based on their orientation, efforts, and support of ACE. All of UTC's division presidents actively support ACE. This support developed without a corporate mandate, but through the alignment of top-level leaders, some of which occurred through discussion in Presidents Council meetings.

As this case study has shown, ACE is dynamic, evolving in response to UTC's needs, and through that experience, becoming its "operating system." Feedback guided that evolution, as the ACE Council collected data and held discussions to adjust, adapt, and extend ACE. Confidence developed throughout UTC as the use of ACE created a context for learning, improvement, and change. ACE training and certification for individuals, along with site certification for organizations, touches every entity at every level in UTC. The more recent emphasis on supplier improvement efforts extends ACE-like concepts across UTC's enterprises. This venerable history invites reflection on what helped ACE succeed in the past, and whether what helped in the past will sustain ACE into the future.

⁷³ Comments from interview with Louis Chênevert, then UTC President & CEO, May 6, 2009, Hartford, CT.

Achieving results

A corporate performance commitment to Wall Street analysts based on process improvement illustrates UTC leaders' confidence in ACE. Historically, from 1998 to 2002, UTC focused ACE on improvements in cells. Without integrating across cells, however, the local gains from improvement efforts did not readily transfer to organizational results or customers. In 2003, the focus for ACE shifted to sites. When the same tools and methods used in cell were used at site levels they created improvements that translated to the bottom line and customers. One new method, value stream mapping, played a crucial role. Value stream mapping allowed people to integrate improvement efforts across cells. Many organizations fail to achieve benefits from new methods because they do not stay with them long enough to yield results commensurate with their investment and efforts. In efforts to get results, organizations adopt new methods before current methods yield expected benefits. Often the new approaches conflict with the old ways and undermine gains. Stay with, testing, and adding only appropriate and compatible methods to ACE contributed to its success and improved results for UTC and its customers.

Collecting data that links their ACE efforts to results has been a factor in UTC's improvement. The ACE Council tracked ACE Bronze to Gold site performance changes and found consistent results: 35% sales increase, significant return on sales increase, 60% reduction in inventory levels, and 35% customer satisfaction improvement.⁷⁴ These averages enabled executives to project the impact on UTC's results when 70% of its sites are certified ACE Silver or Gold. When former CEO David states, "Every time we do a lean event in a plant, and it is broadly true, we double capacity and halve cost,"⁷⁵ he asserts outcomes that have been measured and tracked in UTC. These results are consistent with the findings of the researchers that identified "lean" for performance differences between American and Japanese automotive companies.⁷⁶ The magnitude of gains and their ability to sustain these improvements show that UTC has created a system comparable to that of high-performing Japanese automotive companies. This accomplishment is noteworthy as, despite much study and effort, this result eluded most large American manufacturing companies.

Supporting Learning

A challenge in describing ACE is that "it" is not *one* immutable system. In addition to being dynamic, ACE embodies multiple organizational concepts. ACE has is not only tools, but has created a culture that evolves through experiences and utilizes was learned at one point in time to influence what is done later. As ACE tools and methods evolve,⁷⁷ the updates to ACE capture and apply cumulative experience. ACE allows for variation based on what is appropriate in different contexts, extending improvements to international sites (see Appendix C) and suppliers. Although ACE assessment criteria are similar, people tailor the mix of tools and methods they use to achieve results to their context. This flexibility in the application of ACE is important given that UTC's divisions, such as Pratt & Whitney's military engines and Carrier's air conditioners, are so different.

⁷⁴ Source: ACE and Operations Presentation, UTC Board of Directors, September 13, 2006, downloaded from UTC ACE Internal website.

⁷⁵ Source: Quote from George David, then UTC Chairman & CEO, Dean's Innovative Leader Series, MIT Sloan School of Management, February 22, 2007.

⁷⁶ See Womack, Jones, and Roos (1991) *The Machine that Changed the World*, page 48.

⁷⁷ see Appendix B for evolution of ACE methods; particularly the ACE tools time line in Figure 29

UTC's ACE operating system has all the elements of a learning architecture. The three elements of an organizational learning architecture are: 1) guiding ideas, 2) theory, tools and methods, and 3) innovations in infrastructure.⁷⁸ ACE tools and methods build upon lean production and quality management theories and practices. ACE is an expression of UTC's Commitments, which then CEO David articulated in response to concerns for what endures in the midst of continuous change. Ideals were important to Ito, who wrote out a philosophy that informed the training of UTC's people and development of ACE. Ito stipulated that anyone who did not care about people should bother to attend ACE training. UTC's innovations in learning infrastructure include Ito University, its Employee Scholar's program, and its councils. The councils connect people in similar roles across multiple divisions, such as the Presidents Council, Quality Council, Operations Council, and ACE Councils. An organizational architecture is not static; by examining and improving itself, it changes as it guides the firm's learning and performance. ACE provides the organizational learning architecture for UTC. It has helped UTC's companies and suppliers continue to improve, and the ACE operating system itself has continued to evolve to enable future improvements.

Importance of Growth

What are limitations in the development and use of ACE? Successful continuous improvement, lean, and quality efforts enable organizations to produce higher quality products and services with less space, in a shorter time, and with fewer man-hours.⁷⁹ Organizations and their people sustain these efforts by continuing to use tools to make additional improvements. People will not, however, sustain these efforts if their own livelihood, security, or safety are threatened. Their jobs may change, and the advice proponents of these methods give is that organizations commit to never releasing people due to their productivity or quality gains. People will continue to strive and improve if they can trust their leadership to protect their livelihood. Some of that protection comes from producing more competitive products and services, which enables leaders to secure new business.

Achieving ACE Gold signifies that a site has satisfied customers, and satisfied customers will purchase more products and services. There is, however, a gap in time between when a site achieves internal gains and when it grows its business. In that gap, there is unused capacity, and this is when workforce concerns develop. An alternative to the improvement-followed-by-growth scenario is that leaders seek and secure new business based on expected results. This scenario requires leaders to be confident that deploying ACE will produce gains, and use those expected gains as a basis for winning new business. This proactive growth differs from a reactive growth. Proactive growth requires leaders to take risks to win business their site would otherwise not handle or would be unprofitable without improvements. The philosophy, tools, and methods for seeking and developing business growth are not yet a formal element in ACE. ACE will need to complement the certainly with which it produces quality, delivery and productivity gains with approaches that develop the aspirations and ideas of across managers and workers in setting proactive targets. Those targets will in turn support the continued development of ACE, which is then needed to achieve these growth goals.

⁷⁸ See "The Architecture of Learning Organizations" in Senge, P. M., A. Kleiner, et al. (1994). The Fifth Discipline Fieldbook: Strategies and tools for building a learning organization. New York, Doubleday Currency. Pages 21 to 41.

⁷⁹ These results have been found across industries, and documented in many books on lean methods. George David specifically notes these results in UTC when he said, "Every time we do a lean event in a plant, and it is broadly true, we double capacity and halve cost." (see earlier use full quote, from George David, then UTC Chairman & CEO, Dean's Innovative Leader Series, MIT Sloan School of Management, February 22, 2007)

Final Evidence

The study of any company and its change efforts is problematic when that company has been chosen for its success. What contributed to success historically, does not necessarily apply in the future. Often, as is the case with companies that win awards, such as the Malcolm Baldrige quality award or Shingo Prize for lean manufacturing, leaders focus so strongly on the award criteria that subsequent to their winning, the companies goes into decline. I chose to study UTC and its ACE program because of its success, and at this time there are no indicators that ACE or UTC has reached a plateau or started to decline.

The evidence is that UTC can be expected to continue to improve and perform well. It has steadily increased the involvement of people with ACE, and by setting performance goals and allocating resources to help its sites and suppliers, improved its own and its suppliers capabilities to continue to improve into the future. The indications that UTC will not only sustain its performance but make further improvements are in the trajectories that can be heard and seen from people's words and actions regarding their efforts to capture, develop and diffuse these capabilities through their ACE operating system.

There is also important quantitative information that confirms what is heard and seen in UTC companies. 2000 to 2009 decade has been one of the worst in stock market history, with the valuation of companies in Standard & Poor's 500 down ten percent over that time. This decline, even when accounting for dividends reinvested, is the first ever decade in the history of the stock market with negative returns, even worse for stocks than the Great Depression in the 1930s. In an analysis done by Reuters, the industrial company during that decade with the best performance is UTC. UTC is the number one company, providing an increase in its valuation of 155.49%.⁸⁰ UTC was closely followed by only Caterpillar and 3M with triple-digit percentage gains. Companies that respected champions of market returns, notably General Electric, Merck, DuPont, Alcoa, and Coca Cola, show up on this Reuter's analysis as the worst performers, providing their investors with double-digit percentage losses for the decade. Ask nearly anyone at UTC what has contributed to this long-term historic performance and the answer that you will get is ACE.

Finally, ACE also is a major driver of innovation. Game-changing new products – such as Pratt & Whitney's new Geared Turbofan jet engine that is setting new standards for fuel efficiency, or Sikorsky's new X2 high-speed helicopter – have their roots in the ACE culture that fosters relentless customer focus. Sweeping improvements in supply chain management and engineering performance are directly traceable to the ACE objectives. Together, such technological innovations and performance improvements are the ultimate source of sustainable business advantage and customer satisfaction.

⁸⁰ Mnyandu, E. "Wall Street's lost decade eclipses an upbeat 2009" Reuters, December 23, 2009. Downloaded from www.reuters.com on January 4, 2010.

Appendix A: ACE Operating System

The ACE operating system has evolved over more than a decade. What Pratt & Whitney employees first created and designated as ACE in 1996 is considerably different from what UTC calls ACE today. Given UTC's approach to ACE, it is likely that ACE will continue to evolve and change in the future. Not only has ACE changed in the last decade, but so has the business and managerial context in which UTC operates. What gives ACE longevity is that the meaning of the terms has evolved with the needs and maturity of UTC's divisions. ACE has an evocative name that executives continue to promote as symbol and substance for the way they want to manage and improve their business operations.

ACE has a logo across UTC, shown in Figure 12. In the information on the use of the logo, it is described as "the one operating system for all of UTC," that should be part of "one brand identity" across the corporation. In its logo, the ACE graphic cube "represents unity and consistency of the ACE system throughout all UTC businesses, as well as a mark of unsurpassed excellence and credibility. The logo includes two sets of diagonal stripes that enhance the multi-perspective solutions of ACE and reminds people that not all problems can be detected from a single perspective."⁸¹



Figure 12 UTC ACE logo and text

(Source: internal UTC web site)

This appendix describes the ACE operating system. It is described as the system it has become, including the ongoing benchmarking to compare, contrast, and continue to enhance it. The elements that make up the operating system include organizational infrastructure, alignment processes, individual and organizational proficiencies, education and training, and assessment approaches. Specific improvement tools and methods of the operating system, and their evolution, are described in Appendix B.

⁸¹ Source: UTC ACE web site, ACE logo graphic guideline, letter from Tes Aklilu, downloaded from <http://www.utc.com/corpid/ace/index.html>, June 20, 2008.

ACE Operating System

In 2003, ACE became UTC's "business operating system." As a "business operating system," it defines a basis for operations in all of UTC's operations. The ACE operating system defines "our individual and collective daily management system to maximize the flow of value to our customers, employees, and investors." The operating system elements are culture (focus on customer, valuing people, and common language), tools (defined methods for process improvement, problem solving, and decision-making), and the competency in the culture to implement the tools (through education, sharing best practices, and quality clinics).

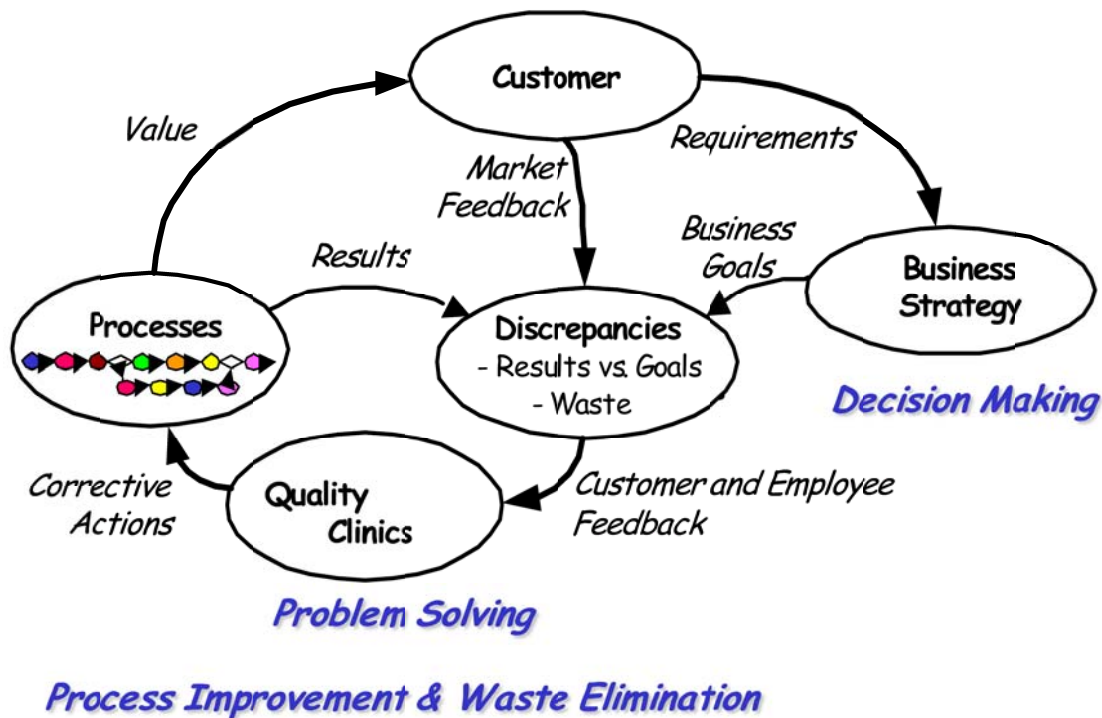


Figure 13 Diagram of UTC ACE Operating System

Figure 13 shows an ACE operating system illustration found in numerous UTC documents and presentations.⁸² The diagram provides a structure for explaining the relationship of elements in ACE. By linking elements using a causal loop notation, the diagram illustrates a feedback-based, systemic approach to continuous improvement and business management. The diagram shows the goal—that customers, at the top, derive value from UTC's business processes. Customers, in turn, provide market feedback and their requirements are inputs into business strategy. UTC's business processes are designed and improved in Quality Clinics based on that customer feedback and inputs from employees. The only colored section in the diagram is processes, which is done to indicate the importance of process management and process improvement. Processes produce results, which are analyzed along with market feedback from customers and business goals from strategies for possible discrepancies. These discrepancies, along with the customer and employee feedback are inputs to the Quality Clinics.

⁸² There are several similar versions of this diagram, what varies are the graphics, as all of these use the same nomenclature and show the same relationships.

The content of the ACE operating system are its tools and methods. These ACE tools are grouped into three sets – 1) Decision Making, 2) Problem Solving, and 3) Process Improvement & Waste Elimination (noted in the relationship of ACE elements shown in Figure 13). These ACE tools and methods are based on quality improvement, lean production, and statistical control methods. Many of the methods UTC uses are similar to those that are widely taught and written; they are not all unique nor proprietary to UTC. What UTC has done is developed and standardized ways to teach and use these methods. People across UTC are trained in and use the common ACE tools to manage and improve businesses across UTC (see subsections that follow and Appendix B for ACE tool summaries). What is important about UTC’s improvement methods is that people from the very top of the corporation through to front line workers use common tools, each selecting what is appropriate in their given situation.

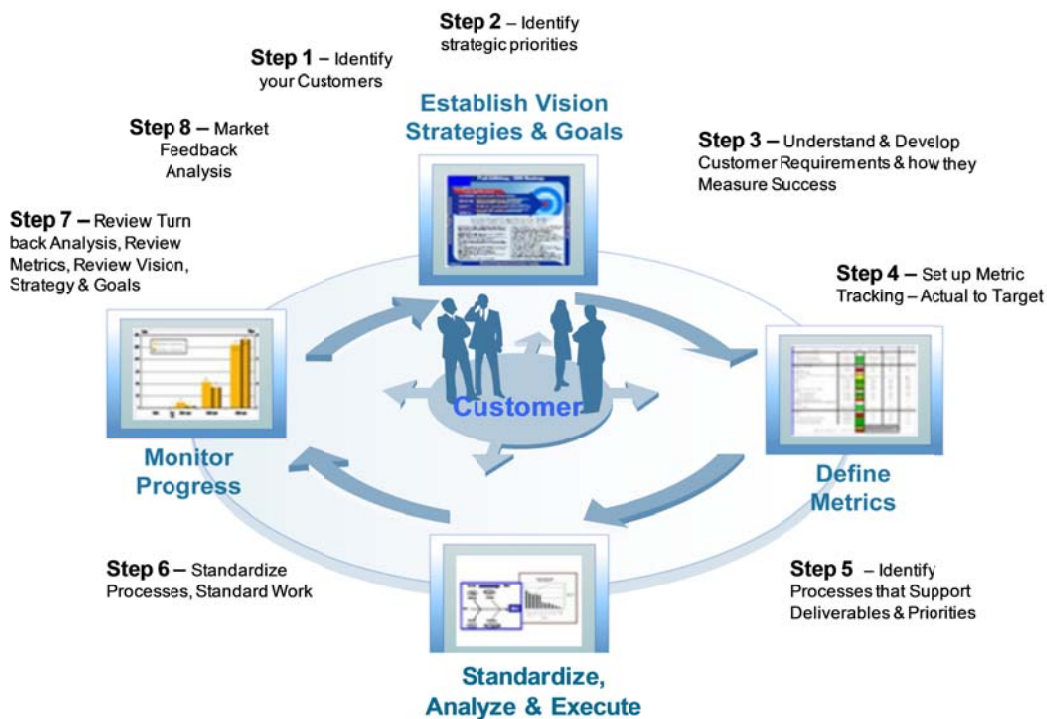


Figure 14 UTC ACE Operating System
 (Source: diagram from UTC ACE Council presentation)

Figure 14 provides an alternative, more recent, depiction of the ACE operating system. It illustrates an organization’s learning cycle, building upon Shewhart’s Plan-Do-Check-Act (PDCA) cycle for individuals.⁸³ The important elements of the cycle – establishing vision, defining metrics, executing projects, and monitoring progress – are a closed loop that connects each element to the next. The eight specific steps provide details for carrying out ACE, which uses tools and methods people have been taught to facilitate and close their individual and organizational learning cycle. The ACE tools associated with these six steps are described in Appendix B.

⁸³ Deming, W. Edwards (1986) *Out of the Crisis*, MIT Center for Advanced Engineering Study.

Benchmarking

The learning process embedded in UTC's ACE operating system practices includes benchmarking at site and cell levels. Benchmarking is a continuous, focused process of measuring and comparing products and services against industry leaders as well as identifying and integrating best in class practices. UTC's descriptions for implementing and assessing the ACE operating system propose, "benchmarking be used throughout" the company. Implementing ACE, described as "the ACE journey," and what an ACE assessor looks for in assessing a site's benchmarking, is shown in Figure 15. As is shown at the top of this figure, the orientation to "benchmarking through" is to always seek out, compare, and learn from others. The benchmarking process should begin early in a site's ACE improvement efforts and be maintained as an ongoing and continuous process through that ACE journey.

The detailed steps in benchmarking efforts begin with identifying customers, and other people, departments, suppliers, and partners that influence value delivery to customers (see Figure 15). Once customers are identified, clarify their expectations, and then define metrics that measure that performance, how help a site know whether it is meeting or exceeding customer needs. Benchmarking includes balancing customer needs with business requirements such as personnel headcounts, make-or-buy decisions, financial returns, and budgets.

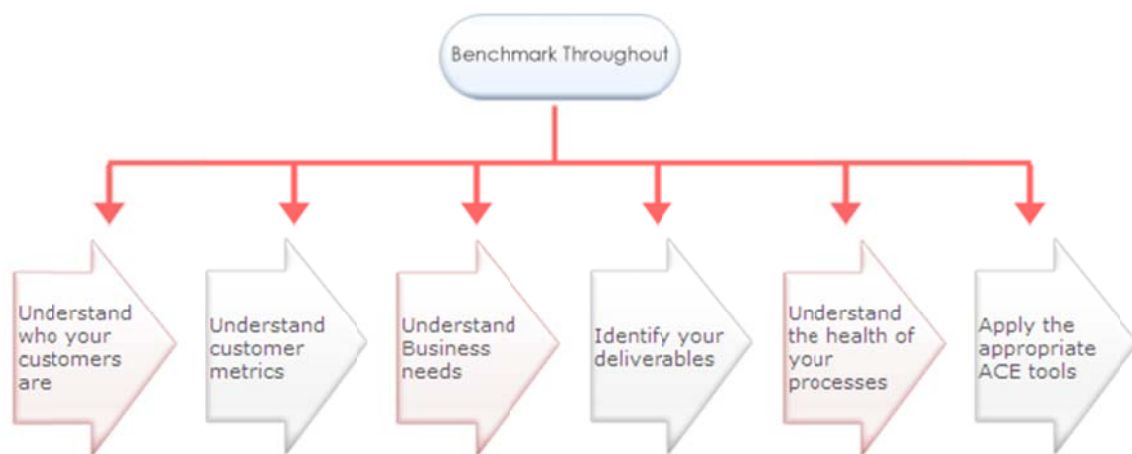


Figure 15 ACE Implementation and Benchmarking

(Source: diagram from UTC ACE Council presentation)

Benchmarking depends upon identifying the essential processes and deliverables to meet customer goals, focus on critical areas, and eliminate non-essential items. ACE methods are to be used to first identify and measure key process, and then improve and monitor these processes by closing any gaps in delivering what customers need. Once improvements have been made, the question is how good those processes are at delivering customer value. The comparison, and determination, of best practice or world-class performance, is what benchmarking determines. As indicated in Figure 15, this is not a one time or one step effort, as these steps are to be performed while "benchmarking throughout." The ACE operating system specifies benchmarking as a continuous loop learning process that starts and ends with value to the customer. What is learned in any one effort informs and provides input to subsequent efforts. The benchmarking orientation promotes visits and learning others inside and outside of UTC. A site must demonstrate that it operates at world-class levels relative to comparable processes outside UTC to be certified as ACE Gold.

The benchmarking and ACE operating system diagrams depict overarching visions that use tools and methods to connect continuous improvement practices into processes and activities for managing its businesses. UTC's states its confidence in ACE in its presentation materials, which concludes with, "If you follow this process you will have a Roadmap to Gold that delights your customers and is an effective way to guide you to the optimal and effective use of the appropriate ACE Tools." In addition to benchmarking and designating twelve tools as part of ACE, other practices supporting UTC's ACE operating system include establishing an infrastructure, aligning improvement activities to strategic priorities, defining individual and organizational proficiencies, reporting and managing overall performance and improvement progress, specifying and providing required training, and giving feedback through site assessments. The six sections that follow, on infrastructure, alignment, proficiency, reporting, training, and assessment, describe these ACE elements.

Infrastructure

ACE infrastructure consists of UTC's resources and support for implementing improvement and change. There are several types of infrastructure at different UTC levels for ACE. Guiding efforts is an ACE corporate office and several UTC councils with senior representatives from each division. These are the ACE Council, the Quality Council that it reports to, and the Operations Council to which the Quality Council reports. These councils facilitate learning from one another's experience, provide rapid feedback on new ideas, and, by identifying factors associated with efforts progressing as expected or needing corrective action, help to steer changes.

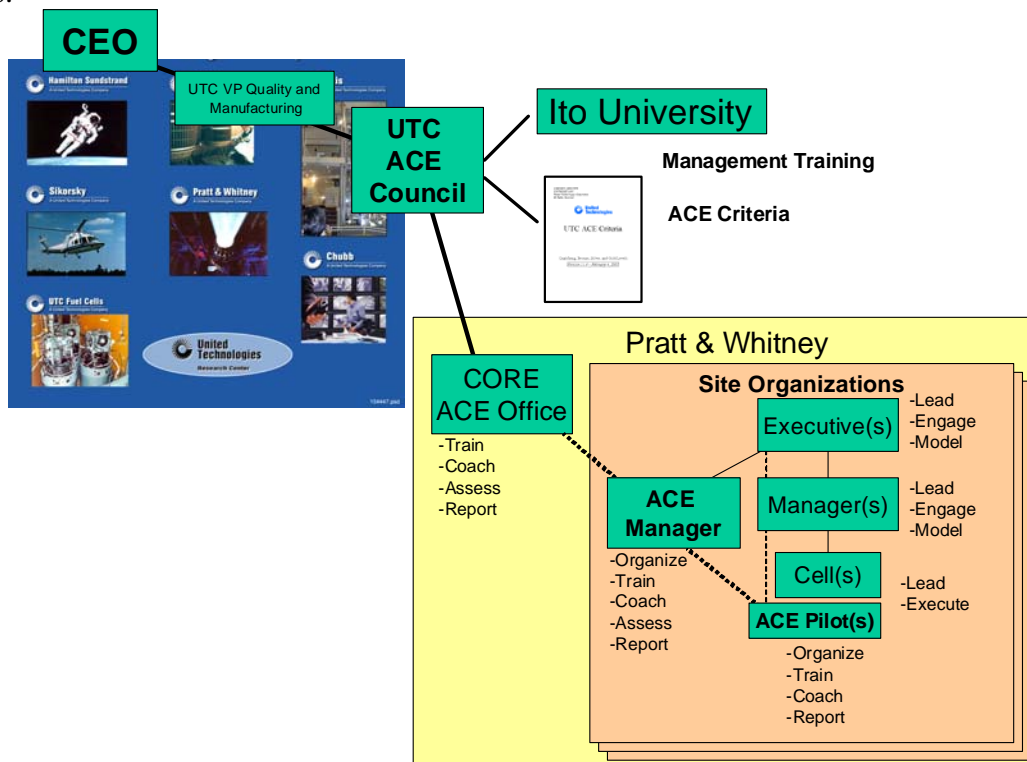


Figure 16 UTC ACE Infrastructure (2005)⁸⁴

⁸⁴ Presentation on "Infrastructure for Transformation," by John Kirkgasser, ACE Manager, Pratt & Whitney Military Engines, March 22, 2005.

The ACE Council is responsible for Ito University and its content, the ACE Criteria that guide progress and specify assessment standards, and the development and deployment of ACE tools and methods across UTC. Figure 16 illustrates UTC's ACE organizational infrastructure. Note that there are few corporate resources, and more resources at division levels, such as what is shown for Pratt & Whitney. Other UTC divisions also have Core ACE offices and report to the UTC ACE Council.

ACE Council

The UTC ACE Director chairs UTC's ACE Council. His staff, in 2008, is an administrative assistant and four ACE experts. This small headquarters group coordinates UTC's corporate ACE efforts and support ACE efforts for corporate sites. This small, centralized approach is consistent with other aspects of UTC's operations, where the goal is to have resources and expertise in divisions. For example, Pratt & Whitney, like other UTC divisions, has an ACE Director, reporting to Pratt & Whitney's Quality VP, responsible for overall improvement progress. The ACE Director manages Pratt & Whitney's ACE office, which, in 2006, consisted of three ACE managers and fourteen ACE client managers. The ACE client managers support and consult with Pratt & Whitney sites. Each site has at least one ACE Pilot (pilot is the designation for the ACE specialist in Pratt & Whitney), but as is often the case, large sites have an ACE manager and several ACE specialists.

The ACE Council consists of the UTC ACE Director and ACE directors from each division. It meets monthly, typically the first Friday of each month. The ACE Council makes policy decisions, updates and changes ACE criteria, monitors ACE assessments, and reviews Ito University training programs for managers, basic ACE training for all employees, and specialized tool training for ACE specialists, coordinators, consultants and assessors (for more details, see subsections that follow on Assessment and Training).

Reporting and Monitoring Progress

The ACE Council reports on and creates tools for reviewing ACE deployment. The UTC Presidents Council reviews ACE results on a quarterly basis. Since setting the goal of 70% Silver and Gold sites across UTC by 2009, a summary of ACE progress for UTC and by division is reported by the CEO or CFO in their presentations to market and investment analysts (see Figure 17). These charts illustrate the maturity of ACE in Pratt & Whitney and then Sikorsky over other UTC divisions.

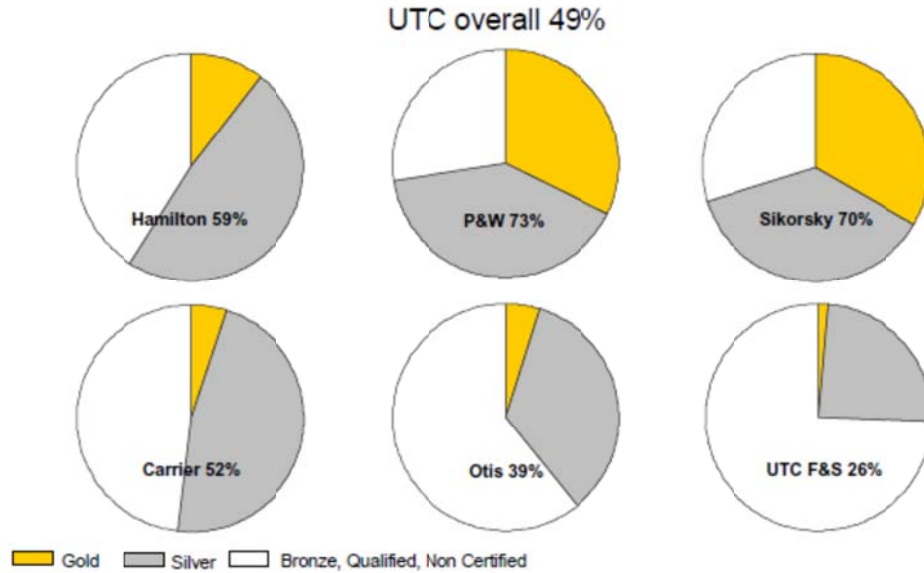


Figure 17 UTC ACE Status (as of 12/31/08)⁸⁵

Responsibility for UTC’s corporate performance is through its divisions, from the CEO through division presidents to line managers. ACE managers support line managers at site levels, where ACE specialists, who are trained and experienced in ACE tools, carry out improvement activities, often with help or coaching by division ACE client managers.

To enable regular reporting and review of progress, the ACE Council commissioned a web-based system that allows sites to update their progress. This ACE Management System allows ACE Council members or UTC executives to view ACE status by divisions, applications area, or geography, find information specific sites and their status, and view trends by these categories (see Figure 18). The ACE Council uses the information from this system to focus its efforts in advancing ACE.

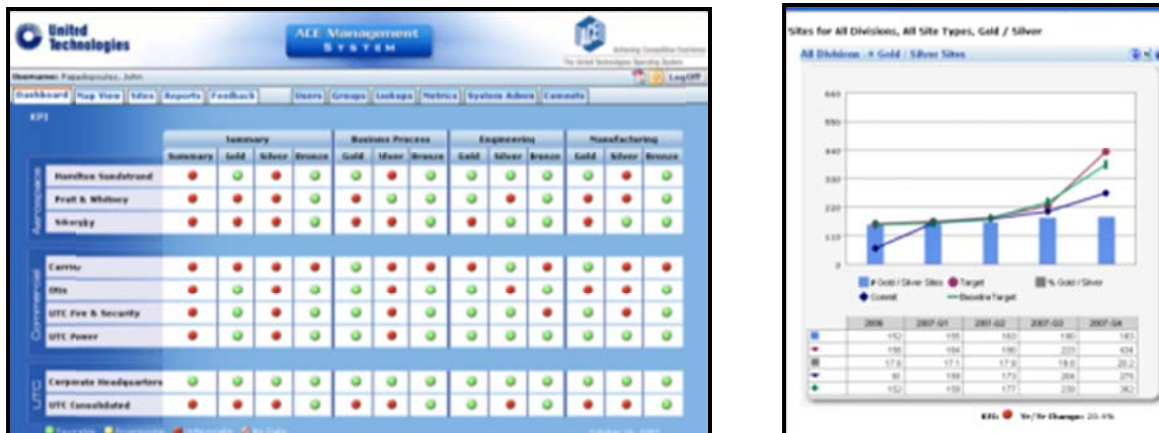


Figure 18 Screenshots of ACE Management System and Graphic Display
(Illustrative example – does not use actual data)

⁸⁵ Source: Slide 17 of presentation by Greg Hayes, UTC CFO, to Analysts and Portfolio Managers on March 12, 2009; downloaded from UTC web site on April 7, 2009

Employees

While effort has gone into capturing and reporting ACE status and progress, ACE is to engage all of UTC's more than 200,000 people in transforming its culture. As in other elements of the ACE operating system, the focus on employees and their engagement includes specifying goals, providing resources, and gathering feedback to guide activities. Within ACE certification, employee involvement is a key criterion. In addition to employee surveys, assessors visit sites and talk to people, examining their responses to see if their involvement and attitude meet Ito's concept of "shiny eyes," or engaged employees (see ACE assessment section that follow for more details).

UTC uses annual surveys for employee feedback, and includes specific questions regarding their involvement and attitude toward ACE. Survey information, as the quote from Chairman & CEO Chênevert illustrates, provides not just feedback on the ACE tools and methods, but on the environment that UTC's leaders have created for it to be successful.

We know that our success depends upon the individual contributions of our more than 200,000 employees around the world. One way we gauge whether we've created an environment that optimizes employee contributions is through our employee survey process. For me, the ultimate question is, "would you recommend UTC to your family and friends as a place to work?" If the majority of the employees at a particular site would not recommend UTC to their family and friends, we know the employees at that site aren't engaged and the facility is not operating at its highest potential. Not surprisingly, wherever we've implemented ACE, we see better survey results as well as better financial performance.⁸⁶

The ACE council has segmented and targeted the people it wants to reach with specific messages, training, and improvement experiences to bring about desired cultural change. Their analysis resulted in several focused efforts: all of UTC's senior executives had to be actively engaged, as did cell and site leaders. Managers are to initiate, support, and lead improvement efforts, and have people proficient in ACE to support them.

There are three ACE proficiency levels: Associate, Practitioner, and Masters (see ACE proficiency section that follows for ACE level details). Through their training, employees become proficient as they learn, participate in, and lead improvement projects. The ACE Council targeted 16% of UTC's employees, which is a percentage they chose because it creates a tipping point, which, once attained, becomes self-sustaining.⁸⁷ When these numbers of people are regularly involved in ACE, it is expected to become a permanent part of UTC's culture. To achieve that level of involvement, the ACE Council developed specific courses and training for executives, managers, and ACE specialists. These courses include relevant examples for operations, business processes, and engineering contexts, and are offered in multiple languages (see Figure 19).

⁸⁶ Comments from interview with Louis Chênevert, May 6, 2009, Hartford, CT.

⁸⁷ See Malcolm Gladwell (2000) *The Tipping Point: How Little Things Can Make a Big Difference*, Little, Brown and Company: Boston, Ma.

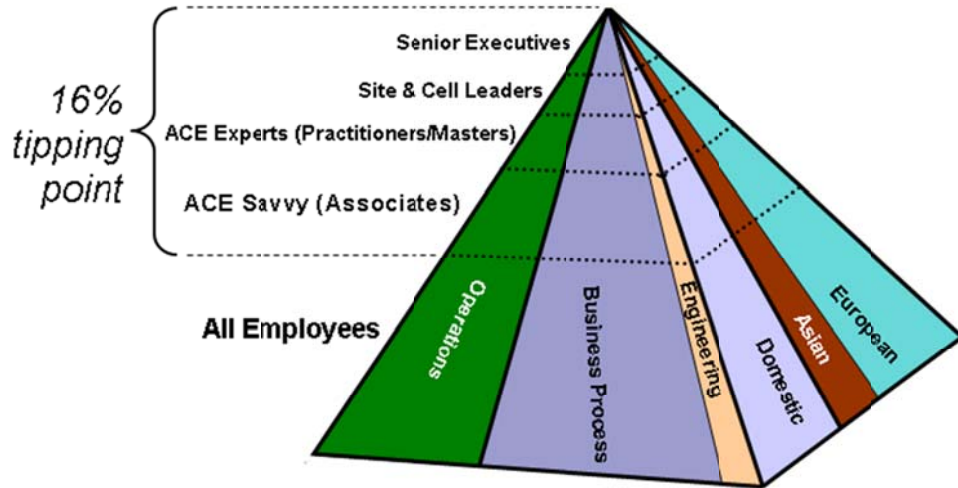


Figure 19 Targeting ACE training and expertise for culture change

Alignment

ACE provides tools and methods for process improvement, problem-solving, and decision-making.⁸⁸ ACE provided guidance and focus for line businesses from a road mapping process, development of metric scoreboards, and use of ACE Criteria. These roadmaps, control towers, and ACE criteria have common categories and use consistent language. Together the roadmaps, metric scoreboard, and ACE criteria provide guidance and processes that span from organizational vision to individual objectives. This subsection describes these multiple mechanisms and the organizational alignment that they help create.

Roadmaps

UTC's ACE operating system diagram (shown in Figures 13 and 14) includes the establishment of a business vision. Vision is expressed through setting top-level goals for the organization or site. This goal setting takes place at least annually, as organizations, or sites, develop their one and five year Roadmaps. UTC's roadmap process is a part of its ACE operating system. What has been adopted as part of ACE across UTC is based on the planning process that was developed and used by Pratt & Whitney Canada.

A focus for all UTC organizations is to "delight" its customers. The target in Figure 20 visually signifies that customer orientation. Customer focus applies internally as well as to external customers; for sites that produce products for other UTC sites, those internal sites are its customers. As illustrated in the Internal Audit Department 2010 Roadmap in Figure 20, UTC Roadmaps focus on four key areas: customer focus, employee fulfillment, quality processes, and business results. The efforts across these focus areas are aligned to achieve "delight customers" goals. The short statements and details that follow in each focus area provide the details and measures for achieving that goal (these details are UTC confidential and not readable in Figure 20). An overall strategic statement, which for Internal Audit Division is "developing strong business leaders while providing quality audit and consulting services," provides a purpose statement, with details for carrying out that purpose listed beneath as topic areas and bullet

⁸⁸ See Appendix B: ACE tools and methods for details.

summaries. The words written along the borders of the Roadmap emphasize the organization or site's core values.

The development of Roadmaps takes place within the context of an organization's reporting relationships. For example, the IAD Roadmap follows from the Roadmap of the UTC Corporate Finance organization, to which IAD reports. Organizations embedded in complex reporting relationships, such as Pratt & Whitney's Turbine Module Center (TMC) Engineering group, develop their Roadmaps based on goals and strategies that flow down from the Roadmaps of other organizations. The relationships across organizations are illustrated in Figure 21. The Pratt & Whitney Roadmap flows down into goals and strategies for the Module Center and Operations, Engineering, and Program organizations. These organizations develop their Roadmaps with that guidance, and their Roadmaps influence other organizations, as shown using arrows in Figure 21 going to the Turbine Module Center (TMC) and TMC Engineering Roadmaps. In Figure 21, there are also numerous links among functions in Pratt & Whitney's value stream, and the TMC Engineering value stream. These linkages, through a flow down of goals or roll up of metrics, provide strategic direction for continuous improvement guidance. Conversely, the continuous improvement results provide feedback that influences strategic directions. This flow down and feedback of information through multiple linkages help to minimize conflict and align strategic and continuous change. Creating alignment and avoiding conflict across organizational units is aided by the discussions that take place in meetings where roadmaps are presented and reviewed.

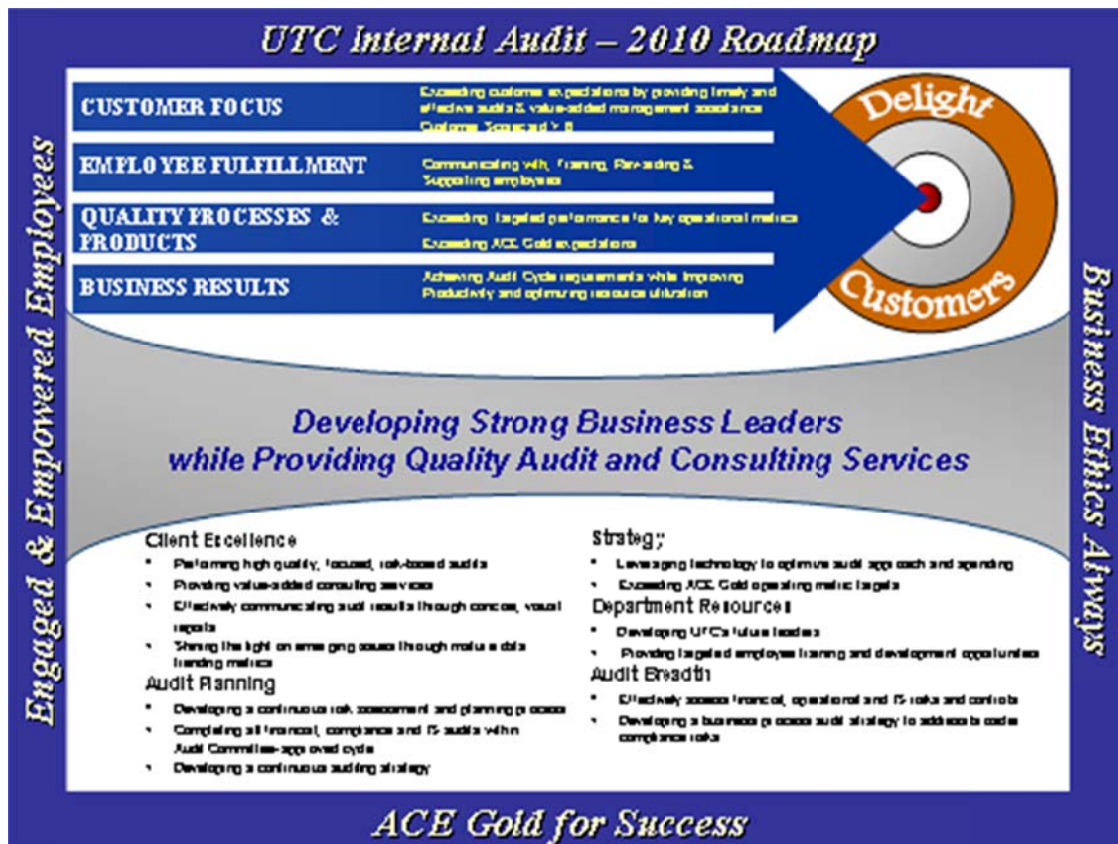


Figure 20 UTC Internal Audit Roadmap⁸⁹

⁸⁹ From Internal Audit Department ACE Gold Assessment Presentation, March 27, 2007

UTC’s managers update and review their Roadmaps at least annually, but managers may change their Roadmap more frequently. Each site has a one-year and a five-year Roadmap, where the five-year Roadmap sets long-term direction and the one-year Roadmap flows directly into the site’s activity plans and metric scorecard. The Roadmap goals determine the metrics that the organization uses to guide and track its performance. There are metrics that cover the four key roadmap areas: customer focus, employee fulfillment, quality processes, and business results. The organizational Roadmaps and Scorecards also flow into individuals’ goals and objectives.

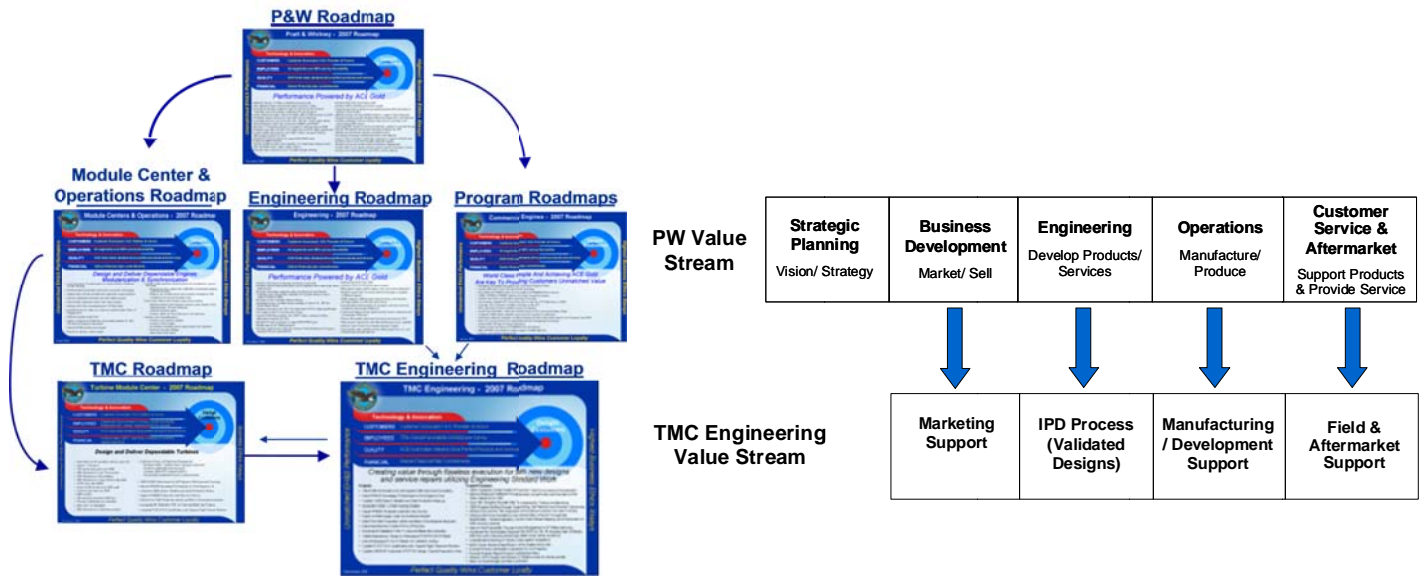


Figure 21 Flow Down and Linkages among Roadmaps⁹⁰

Metric Scorecards

An important element in using and updating the Roadmap is the discussion that follows from the Roadmap for developing the metrics to measure improvement and assess performance. All UTC organizations use a metric scorecard. This form has different names. Pratt & Whitney uses the term “control tower,” which relates to its aviation heritage, and Carrier uses the term “thermostat,” which relates to its heating and air conditioning business. These metric scorecards, much like an airport control tower, provide a visual display of important business information.

Metric scorecards report information related to Roadmaps, which are generally in six key areas: customer, employee, EH&S (employee, health, and safety), quality, delivery, and financial metrics. In general, the scorecards also include the current year’s planned and actual metrics on a monthly basis, along with prior year-end actual results. This metrics time series provides an overview of plans, progress to date, and variance from plans. The boxes in which metrics are reported in most scorecards are shaded, using background colors of green, yellow, and red or bronze, silver, and gold, to provide a visual reference for whether those measures meet or fall short of what was expected. Figure 22 shows two metric scorecards, both control towers from Pratt & Whitney sites, taken from ACE presentations. Each illustrates the display of 12 months’ time series information with metrics across the six focus areas and color shading indicating

⁹⁰ Source: TMC Engineering ACE Gold presentation, August 1, 2007

variations from expectations (the detailed numbers are UTC confidential and not readable in these figures).

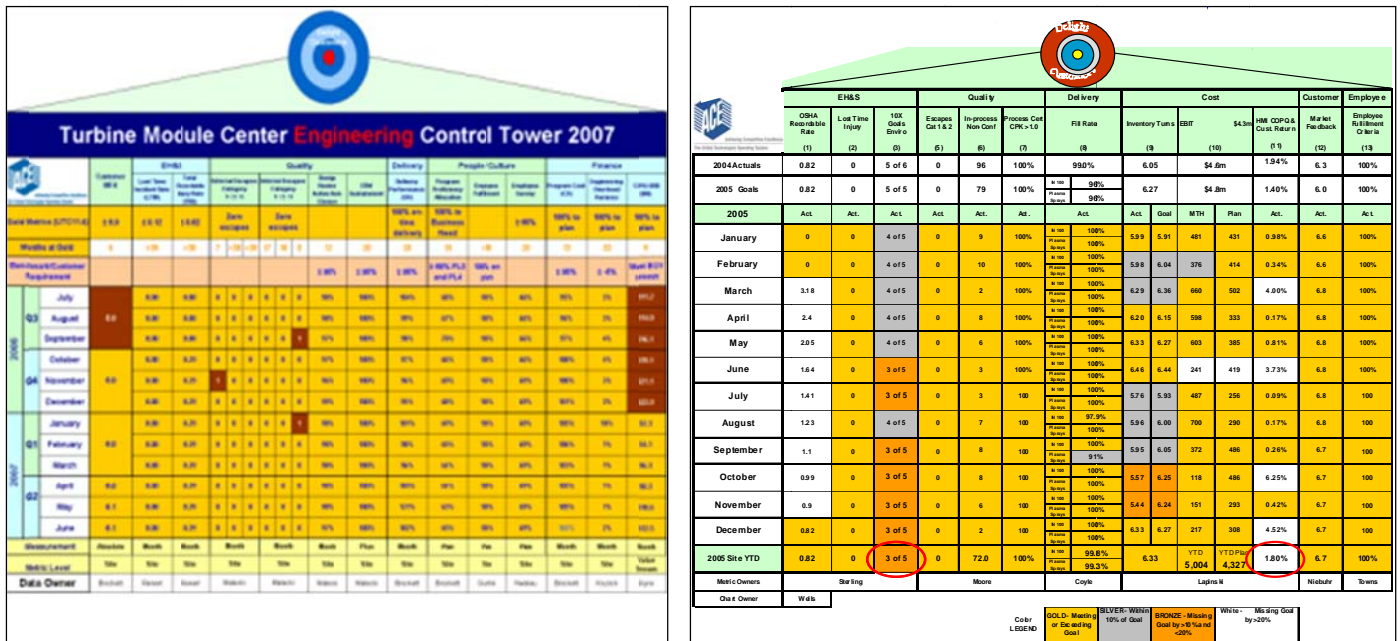


Figure 22 TMC Engineering and HMI Metric Scorecards (Control Towers)⁹¹
(Illustrative example – does not use actual data)

Sites prominently display their metric scorecards, along with one and five-year Roadmaps in public spaces. The display of organizational goals enables everyone at the site to see goals and expectations as well as track current performance. Color-coding cells makes it quickly apparent if there are performance variations. Visual displays in departments or cells provide information for how these units are performing against their goals.

ACE Boards

Metric scorecards and Roadmaps are some of the information displayed on ACE boards. They are regularly updated so that employees, or visitors, can see plans and performance. On the operations floor, daily cell meetings occur with the use of ACE boards to address issues or anticipate changes. ACE boards include other information beyond strategic goals and business results, such as the overall organization and responsibilities at the site, identity statements (vision, mission and team logos), improvement initiative outcomes, and general company and events information (examples of ACE boards are shown below in Figure 23 and earlier in Figure 4). The people in the area, usually as part of their ACE responsibilities, develop and maintain their site’s ACE boards.

Each cell is encouraged to use ACE boards, and to and tailor them to their business needs. The ACE Council provides some minimum guidelines for ACE Boards, in the form of standard work. The standard work for developing these boards recommends that they be constructed so that they can easily be updated. Neat, hand-written information updates are preferred over computer

⁹¹ TMC Engineering Control Tower from ACE Gold Site Assessment, August 1, 2007; HMI Control Tower from ACE Gold Site Assessment, May 16, 2006.

printer generated information. The ACE boards should also allow for written comments with status updates and issues. The people whose performance and accomplishments are represented on the ACE Board should have a sense of ownership for that information and how it is displayed. The development and use of ACE boards helps to in alignment efforts. People at the site regularly see organization's goals, any changes to these goals, and the status of current improvement efforts and results from previous initiatives. Displaying performance information informs people about their organization's progress and its needs.



Figure 23 Examples of ACE boards
(from Carrier in Montluel, France and Pratt & Whitney in Connecticut)⁹²

Councils

Councils are another mechanism UTC uses to achieve alignment within and across its divisions. Councils are cross-organizational groups made up of individuals from different UTC divisions or companies that come together regularly for consultation, deliberation, or discussion. Most councils meet for a day or half day on a monthly basis. In those meetings, members discuss topics of common interest and report on the progress of their activities. Each of the individuals on a council, such as the ACE Council or Quality Council, has direct line reporting relationships to division executives. The councils themselves do not have line authority; they work by communicating information and using their experience to influence corporate direction. For example, although the ACE Council is responsible for establishing UTC's ACE Criteria and deploying ACE across UTC, the management of each division has some latitude. For example, when ACE was implemented across UTC in 1998, the Otis ACE director decided not to assess cells in Otis, but to focus on sites and only do ACE assessments for sets of cells. As all UTC's division fully embraced ACE, the ACE Council sought more standardization and saw benefits from their efforts.

Councils provide its members opportunities to discuss activities and experiences with colleagues that have comparable responsibilities in the other divisions. Examples of other UTC councils include an Operations Council for operations issues across UTC, Technology Council for research, development, engineering and new technology issues, and Supplier Management Council for supplier and supply chain management. These councils create influence mechanism across UTC's divisions while allowing each company autonomy and accountability for results.

⁹² From UTC ACE web site, Good Practice Reference Information

The model for how councils function across UTC comes from the top, or UTC's Presidents Council. The Presidents Council consists of UTC's Chairman, President & CEO, the COO, the Finance, Operations, Human Resources, and Science and Technology Vice Presidents, General Counsel, and the presidents of each division. How the Presidents Council functions is described in its decisions to adopt ACE across UTC, or to move forward with Operations Transformation.⁹³ Council decisions, because councils do not have line authority, require consensus. When an item on a council's agenda does not result in an agreement, it either returns to be discussed again or goes without resolution. Black, UTC's first ACE Director, commented on the role of councils and efforts to achieve consensus for implementing ideas across UTC.

The role of councils and consensus is important in a global company because of the need to weigh flexibility versus standardization. Councils help develop the right balance. If you have one person making decisions, you can get lopsided. There are pros and cons to councils. The con is that it takes longer. But, if you have a good leader, then he or she can force a decision when the time is right. Without a good leader, it can drag on and no decision is made. Things move pretty quickly once a decision is made. It takes longer to make a decision and people are buying into the decision, but the implementation is faster.

Managerial Orientation

UTC's Roadmaps, metric scorecards, ACE boards, and councils are mechanisms for creating alignment within and across its divisions. All these alignment mechanisms are visible artifacts or defined routines that come from an overall, underlying managerial orientation that pervades UTC. That managerial orientation has developed through ACE, and has created a consistency in people's thinking and behaviors. The Roadmap or strategy, metric scorecard or control tower, and ACE Criteria flow down into what become people's individual goals and objectives. Alignment takes place when people adjust their local actions to operate in ways that are consistent with overall directions. It is difficult for managers to script the behaviors across organizations that create alignment, and alignment often emerges from people's understanding and willingness to strive towards desired outcomes. UTC's efforts to create organizational alignment came through ACE efforts to ensure consistent messages for individual's objectives from strategy (roadmaps), metrics (organizational scorecards), and assessments (ACE criteria).

⁹³ The processes by which decisions are made at the Presidents Council were described in earlier sections of this case study on these topics; see, respectively, pages 25 and following and 31 and following.

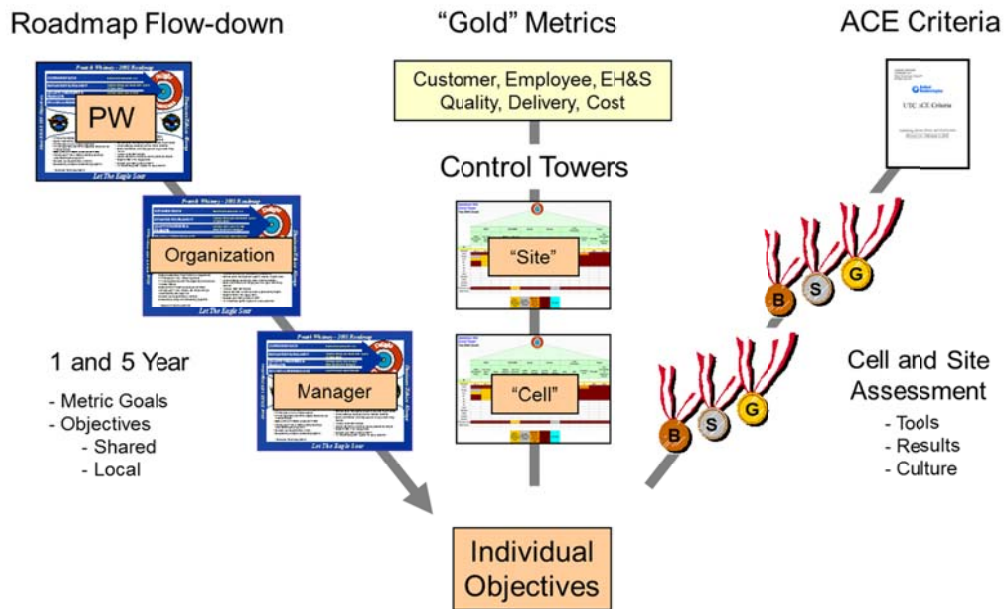


Figure 23 Individual Objectives to Roadmap, Control Tower & ACE Criteria Alignment⁹⁴

Proficiency

UTC’s ACE operating system facilitates learning and development, leading to improved individual and organizational proficiencies. Proficiencies range from demonstrating some ability to perform to a complete mastery of a specific skill or activity. At both individual and organizational levels, UTC has prescribed standards and provided avenues for achieving ACE proficiencies.

Individual Proficiencies – ACE Associate, Practitioner, and Master

People develop their individual ACE proficiencies through training courses, applying what they learn in training, and continuing to apply that knowledge to ongoing projects that seek to achieve desired organizational outcomes. To develop ACE skills, the ACE Council defined three proficiency levels: Associate, Practitioner, and Master. These levels relate to skills in using tools and leading improvement events. People achieve these proficiency levels by enrolling and completing a curriculum and through successful performance assessments. These curriculums include on-line, classroom, and applied, on-the-job, training. The applied training, depending upon the level, requires either participating in or leading improvement events and demonstrating abilities to use ACE tools and organizing, lead, and complete ACE improvement events. More advance proficiencies require more effort in carrying out improvement projects and less time in on-line or classroom training. Figure 24 shows estimated curriculum hours of formal education (classroom or on-line training) and events-based (participating in or leading projects and learning on-the-job) for the three ACE proficiency levels. The emphasis on learning by doing is seen at higher ACE proficiency levels.

⁹⁴ Presentation on “Infrastructure for Transformation,” by John Kirkgasser, ACE Manager, Pratt & Whitney Military Engines, at LAI Plenary meeting, March 22, 2005.

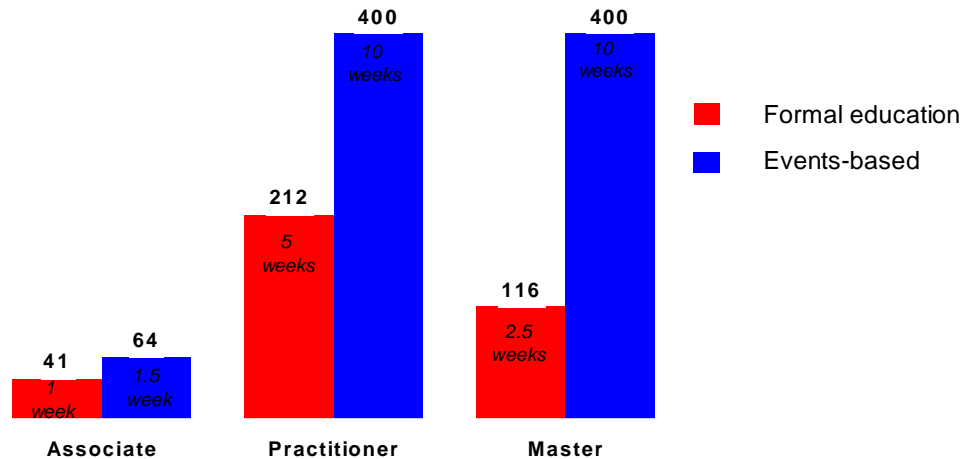


Figure 24 Training and Event Time Requirements for ACE proficiency levels (hours)⁹⁵

Managers select candidates for ACE training based on employees’ characteristics and their organization’s requirements. Employees are expected to promote ACE, find and communicate improvement opportunities, and use their skills to implement changes. An ACE Associate has taken courses, including operations transformation leadership, project management, operations transformation, ACE basics, quality systems, and value stream mapping, and participated in a four-day value stream mapping event. Following their value stream mapping event participation, they are required to take additional courses in such areas as *kaizen* principles, Toyota production system, and production preparation process (3P) in either classroom or on-line formats. They then participate in another four-day rapid improvement, or *kaizen*-type, event. Finally, to be certified as an ACE Associate, a person takes additional courses, such as managing change, total cost calculation, financial literacy, process certification, or supply chain management,. Certification as an ACE Practitioner requires five weeks of in-depth training on ACE tools and ten weeks as a participant and then leader of improvement projects. ACE Master’s proficiencies are focused on improvement activity leadership. The formal, classroom training, requires two-and-a-half weeks of courses. The other requirement is for ten weeks of supervised learning while leading improvement projects. Many ACE courses are available as either web-based or instructor-led modules. These training materials have been developed to be content-specific, with tracks that teach and apply ACE methods in manufacturing, operations, and engineering settings. Much of the content and many of the examples used in these courses is based on actual UTC’s ACE projects experiences.

Organizational Proficiencies – Staffing Appropriately

UTC plans for organizational proficiency by ensuring its units have sufficient numbers of appropriately skilled people undertaking improvement initiatives. Each organization’s supervisors assess employee skill levels. One element of this assessment is people’s ACE awareness, working knowledge, leadership, and mentoring skills. Supervisors create a skill matrix that maps employees to their skill levels and calculates the percentage of the organization’s people at each level. This information determines the training that takes the site to its desired organizational skill levels. In its recommendations, the ACE Council proposes that every organization plan on a critical number of people with particular skills be active to move

⁹⁵ ACE Benchmarking Presentation, provided to UTC visitors, obtained September 25, 2007.

forward and sustain ACE activities. These employees are to be the “influencers” that actively transform sites. These influencers are the sum of all senior leaders, all the site and cell managers, and the people with ACE training (Master, Practitioner, and Associate proficiency levels) actively making improvements.

The ACE Council has defined expectations and responsibilities for employees at different management and expertise levels. Based on those expectations, it developed a targeted training curriculum for each employee level (see Table 4). Leaders are expected to develop their employees’ proficiencies to have sufficient numbers of appropriately skilled people to lead their ACE efforts. In its initial efforts, the ACE Council estimated overall UTC training needs for its roughly 250 manufacturing and 650 engineering or business process sites.

These initial estimates were one Master and five Practitioners per manufacturing site and one-half Master and two Practitioners per engineering or business site. Using these ratios, the ACE Council estimated an overall UTC requirement of approximately 650 Masters and 3,000 Practitioners. Requirements for ACE Associates were estimated based on one ACE Associate per ten employees. Combining these requirements with cell and site leaders resulted in estimates of approximately 15% of UTC employees actively involved in ACE. This total percentage of people involved in ACE yielded results that attained what the ACE Council’s targeted as the needed critical number of people involved to ensure UTC’s cultural transformation (see Figure 19).

<u>Level or Expertise</u>	<u>ACE Responsibilities and Expectations</u>	<u>ACE targeted training</u>
Senior Leaders	<ul style="list-style-type: none"> Set direction, targets, and culture Champion ACE to achieve business goals Provide resources Review progress/ask right questions 	ACE Leadership Training (subset of Manager/Supervisor training)
Cell and Site Leaders	<ul style="list-style-type: none"> Lead & program manage ACE to achieve business goals Align metrics to established targets Translate organization strategy/direction into actions Fully engaged with ACE activities Engage senior leaders on ACE progress Ensure appropriate ACE competency exists 	ACE Leadership Training <ul style="list-style-type: none"> DIVE 101 QCPC ITO Foundations Assessment ACE At Work
ACE Experts (Practitioners/Masters)	<ul style="list-style-type: none"> Coach, train, mentor and facilitate ACE activities Guidance on ACE site progression requirements to achieve business results Expert application of ACE to achieve business results 	ACE Certification Program Curriculum
ACE Savvy (Associates)	<ul style="list-style-type: none"> Identify and communicate opportunities for ACE applications Promote and support the benefits of ACE Use ACE daily for individual processes Engage management on ACE progress General application of ACE to achieve business results 	ACE Certification Program Curriculum
All Employees	<ul style="list-style-type: none"> Use ACE daily for individual processes 	One or more of the following: <ul style="list-style-type: none"> ACE Overview ACE at Work ITO Foundations (2 day) specific tool training as needed

Table 4 Targeting of ACE training to Employee’s Responsibilities and Expectations

The ACE Council later delegated the decisions on what numbers of people to prepare at specific ACE proficiency levels to the divisions. Depending upon their business needs and ACE maturity, divisions have set different goals. While some divisions are still experimenting with their ACE proficiency needs, other divisions have set five to ten year goals to have all of their employees be certified at ACE Associate levels. From its experience, the estimate for the number of ACE Master needed on a worldwide basis has dropped to approximately 100 people, while the estimates for the needed number of ACE Practitioners has remained at about 3000.

The sum of individual proficiencies provides a basis for organizational proficiency. Organizational proficiency can also be diagnosed by assessing sites using ACE criteria. These criteria, or what makes a site ACE Bronze, Silver, or Gold, are described after the next section, which provides details on ACE education and training.

Education and Training

An organization’s ability to improve performance and demonstrate increasing collective competence depends upon individual and collective learning, as well as the conditions it creates that enable people to put their new learning into practice. This section has focused on these latter conditions, where ACE initially as a program, and later as an operating system, has promoted and enabled change. UTC, from the inception of ACE, developed and deployed traditional education and training programs as a part of its ACE efforts. These included Ito University, Organizational Transformation Leadership (OTL) program, and the use of outside consultants and education programs. Short descriptions of each of these programs follow.

Ito University

Ito University provides instruction for ACE awareness, develops skills for leading improvement efforts, and offers in-depth courses on lean, process improvement, and statistical quality control methods. As described in the history of ACE section, UTC named its corporate university to honor Yuzuru Ito, the former Matsushita quality expert. Ito had first worked with the Japanese Nippon Otis company, an Otis Elevator and Matsushita Electronics joint venture, and following his retirement from Matsushita, moved to the United States to work as CEO David’s quality consultant.

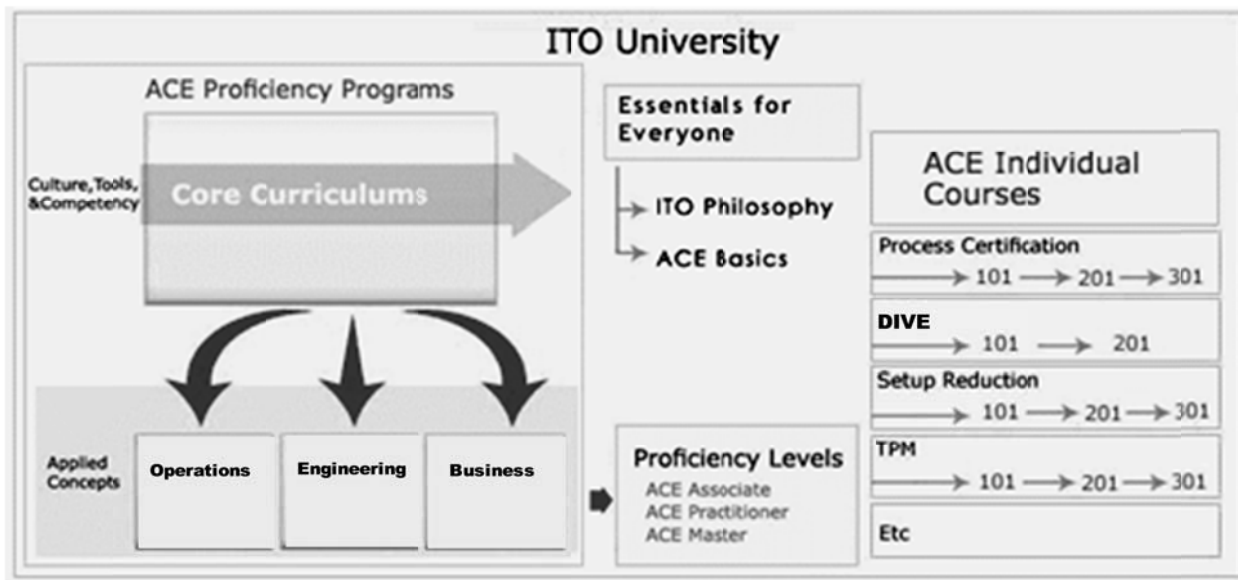


Figure 25 Ito University’s ACE Offerings Organization

(Source: UTC internal web site)

When Ito University was launched in 1998, it offered a five-day course on ACE concepts and tools for UTC executives. The UTC CEO and division presidents attended the initial sessions. The ACE course cascaded down through executive and into UTC's managerial ranks. Instructors who had used ACE methods and implemented improvements taught Ito University (initial, introductory ACE course for UTC leaders) in locations across the world. Rather than use professional trainers, these instructors were coached by outside consultants to develop their teaching skills. The program provided a hands-on learning experience, with instructors facilitating exercises that used ACE methods to make improvements, much like what they had done before in their organizations.

ACE Courses

Ito University has expanded its offerings to teach a variety of ACE principles and methods courses that are available to UTC and its suppliers' employees. Figure 25 provides a diagram of its programs. There are courses teaching specific methods, curriculums of multiple courses for developing ACE proficiencies in operations, engineering, and business process contexts leading to ACE Associate, Practitioner, and Master proficiency levels, and basic introductory and overview courses. The ACE Council specifies the curriculum requirements and training available through Ito University. To achieve desired proficiencies, Ito University courses are targeted for different responsibilities (see Table 4). There are basic and "as needed" courses for all UTC employees and specific courses for executives, manager, supervisors, and ACE experts. All UTC employees are asked to take two to four hours in ACE courses, essentially providing awareness and basic understanding. Given its global operations, ACE Basics is available in 10 different languages (i.e. English, French, Simple Chinese, Spanish, Polish, German, Korean, Portuguese, Japanese, and Hindi) in the classroom or as an on-line course.

The Ito Foundations course continues to focus on engaging participants through hands on examples, and teaches, now in three days, about overall ACE operating system applications. The curriculum includes instructor-led training through classroom and WebEx delivery, with video and on-line materials, tests, and participative event-based modules. In-depth courses on specific ACE methods, such as value stream mapping, process certification, QCPC, and so on, are also a part of what Ito Foundations offers. An internal web site makes it easy for individuals to find course offerings and locations. Ito University and its courses have reached a large proportion of UTC's employee population. Enrollment in ACE certification programs increased dramatically between 2006, when there were several hundred employees enrolled, and 2008, when there were 20,000 employees enrolled. This large enrollment increase is attributed local organizations enrolling their people so that they can achieve CEO Chênevert's goal of 70% ACE Silver and Gold sites across UTC by the end of 2009.

Employee Scholars

In addition to its internal Ito University offerings, UTC sends people to courses offered by consultants, industry associations, and universities. For example, one of the Pratt & Whitney repair organizations sent its ACE expert to a two-week *kaizen* course offered by Shingijutsu Consulting in Japan. The site leader sent this individual to the Shingijutsu course because he was concerned that their improvement events were extending too far over time, and wanted a better understanding of the nuances in Toyota's original methods.

UTC promotes employees' learning and education in all areas. The United Technologies Corporation Employee Scholar Program is UTC's commitment to "developing skills and

engaging in lifelong learning.” UTC pays tuitions and fees for university courses, and does not limit these benefits to specific degree programs or require courses related to work responsibilities. Many of the people interviewed for these case studies earned degrees as part of the Employee Scholar Program. Through 2009, the Employee Scholar Program had supported UTC employees in earning over 29,000 degrees, and over 15,000 employees were enrolled in degree programs.

By the end of 2009, UTC had spent \$878M on the program. . With such a substantial price tag, then CEO David, when interviewed by a financial newspaper, was asked, “Is it worth it?” He responded, “Categorically. Flatly. No argument. I think that's the best thing we ever did for employee benefits... I go back to my basic principle, which is education is definitely the most powerful force in life. Educated people are more thoughtful. They're more widely read. They're more alert to change.”⁹⁶

In addition to encouraging individuals to take universities courses, UTC partners with a select group of universities to offer customized degree programs in key disciplines tied to the talent strategy. UTC’s divisions also recruit other graduates from these programs.

Organizational Assessment

An organization that learns has feedback mechanisms that allow it to make appropriate adjustments when efforts fall short of its goals. A key to guiding people’s collective activities are mechanisms that assess performance, and where needed, implement improvements. UTC’s ACE operating system provides the structure of this organization-level learning, combining, among other things, continuous improvement efforts with criteria and processes for assessing capabilities and performance. This section describes the ACE criteria, assessors, and assessment processes. Each of these concepts represents an important element in a learning and improvement system. ACE Criteria are the standards, the assessment process collects information, and assessors compare that information against the standards.

ACE Criteria and Certification Levels

ACE criteria are used to measure an organization’s improvement capabilities and performance. These criteria also provide standards for certifying sites at Qualifying, Bronze, Silver, and Gold levels. The ACE criteria developed and evolved as the ACE Council gained experience in articulating desired standards, making assessments, and determining whether achieving ACE criteria produced desired results. The ACE Council is responsible for updating and providing needed clarifications to ACE Criteria. The intent in having ACE Criteria is to have global standards that guide UTC’s organizations in focusing improvement resources and activities. The ACE criteria have evolved over time in both their focus and content. The focus shifted from evaluating cells to sites in 2003.

Cells are a basic work unit, but improving cells does not always correlate with improvement in customer benefits. An analysis by the ACE Council found that improvements in cells sometimes did little, and at other times even reduced the value delivered to customers. This unexpected result occurred because workgroups and cells made improvements and progress based on their internal focus, and in their ongoing zeal to improve even further, they did what was best for them and did not think about or understand the impact on the site or value stream. A larger entity, such as a site, encompasses of what is needed to deliver customer value. UTC defines a site as an

⁹⁶ Interview with George David, “Transformer in Transition” [Wall Street Journal](#), May 17, 2007.

organizational unit, made up of working groups or cells, that together delivers value to internal or external customers. A site can control its processes, is accountable for working with its suppliers, and for delivering value to its customers. The ideal scope for improvement is the value stream, but because value streams cut across multiple organizations and locations, making improvements is difficult.

The ACE criteria are developmental standards, meaning that Qualifying, Bronze, Silver, and Gold criteria changes at these achievement levels. From its inception, the developers of ACE conceived of utilizing standards that changed depending upon an organization’s achievement or maturity. This approach encourages developing an experience base, which comes from using tools in basic applications before trying to apply these tools and other more sophisticated methods in increasingly complex situations.

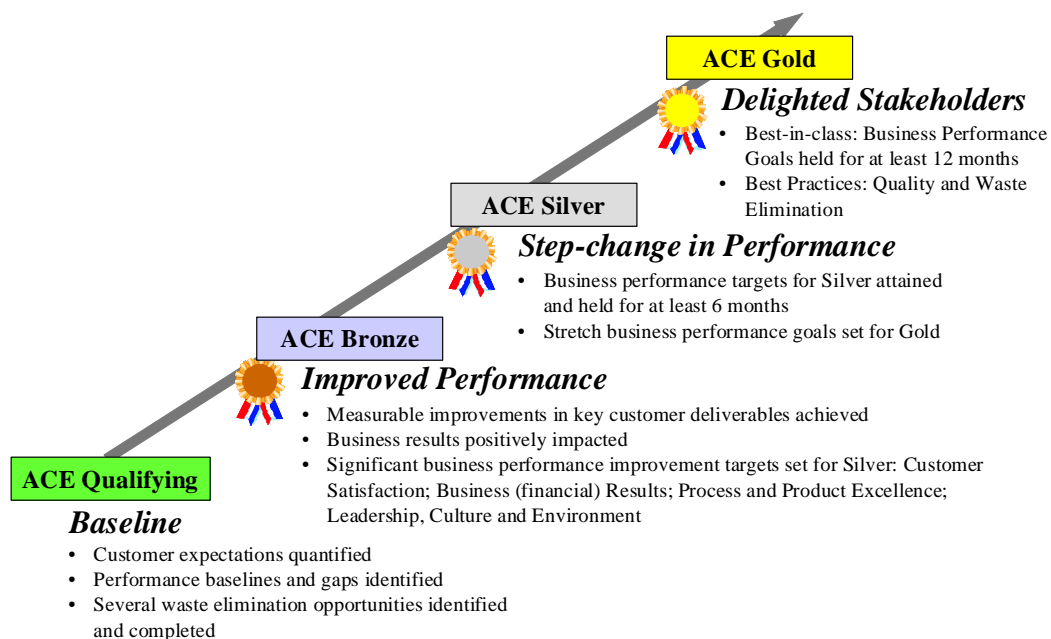


Figure 26 ACE Maturity Levels
(Source: UTC ACE Assessors presentation)

What follows is a description of ACE criteria based on version 11.4. This version became the ACE criteria in February 2005. The ACE Council has held to this standard through 2008, or for over three years, because it did not want to undermine progress. In the past, people complained that criteria changes continually “raised the bar.” The four ACE levels are shown in Figure 26. Progressing from Qualifying to Bronze, Silver, and Gold levels requires learning and demonstrating the appropriate use of ACE tools, establishing cells, defining and measuring processes, and improving process maturity while making and sustaining performance improvements. At Qualifying, the focus is on an awareness, education, and learning of ACE methods, in essence demonstrating both commitment and involvement of leaders and employees in site improvement efforts. Based on its learning efforts and organizational commitment, the site is “qualified” to move forward with ACE. The initial use of ACE methods helps managers identify, define, and develop measures of its key processes, which forms the basis for prioritizing improvement efforts and measuring results. For each ACE proficiency level, there are standards in three broad categories: business performance, proficiency with tools, and organizational

factors. Higher ACE proficiency levels have increasing business, organization, and performance expectations. Business performance includes results (such as financial results and performance to plan) but also direct customer feedback. Proficiency with ACE tools involves defining, measuring and delivering product, process and service excellence. Organizational factors are based on collective concepts, such as cultural alignment, individual employee and overall workforce competencies, and environment, health and safety (EHS) performance. The ACE Criteria listed in Table 5 show an increase in the specificity of standards, moving to quantitative measures with more stringent expectations at higher achievement levels. The initial assessments of improvement efforts and process specification are intended to encourage a spectrum of improvement activities that develops skills and creates a basis for change.

At the Bronze level, the focus is developing competency with ACE tools and methods, and demonstrating knowledge for their appropriate application by implementing improvements. In earlier versions of the ACE criteria, Bronze certification required demonstrating the use of a certain number, such as 6 out of 10, ACE tools. There are expectations at each level that people have learned ACE tools, and where applicable, and demonstrate that they use these tools appropriately.

When a site progresses to ACE Silver, all its processes have been defined, measured, and improved using appropriate ACE tools. ACE Silver requires the evidence of these improvements, demonstration of using ACE tools appropriately, and a six-month track record where those improvements have been sustained. For ACE Gold, what has been improved has to be shown as stable, requiring 12 consecutive months of consistent, high performance according to plan. In the 12 months that it takes to demonstrate sustained performance, sites often develop additional applications of ACE tools to make additional improvements. While ACE Silver required some benchmarking to establish performance goals, ACE Gold is based on going beyond internal and historical standards to achieving performance levels based on outside benchmarks of “competitive excellence.” Competitive excellence requires operating at a world-class performance level. Excellent performance often requires improving inputs or changing outputs to internal processes. Internal process improvements are often constrained by the timeliness, quality, and cost of inputs from or outputs to partners in the value stream, which requires working with suppliers and customers to improve overall performance. ACE Gold requires sites to demonstrate that they can develop new, innovative applications of product and process technologies that achieve and sustain high, best-in-class, performance levels.

Category	ACE Achievement Level			
	Qualifying	Bronze	Silver	Gold
Business Performance (Customer Value & Satisfaction and Financial Results)				
Customer scorecard	• Customers identified and expectations defined.	• Measurable improvements based on key customer deliverables.	Improvement efforts continue to achieve customer satisfaction (average survey scores ≥ 5)	≥ 6 (on 1 to 7 scale)
Performance to financial plan	• Performance measures established and baseline recorded	• Business results being positively impacted by ACE activities.	100% Business goals achieved and evidence that they are sustained. Savings recorded in QSTARS.	100%
ACE & Process Proficiency (Process, Product and Service Excellence)				
Customer-defined quality	• Process outputs assessed against customer expectations. • Process measurements defined.	• Measurable improvement in process performance. • Identification of best-in-class practices started. • Cross-functional process improvement opportunities identified and being worked with customers and suppliers.	Zero repeat escapes	Zero escapes
Customer-defined delivery			$\geq 90\%$ to requirements	100% to requirements
Productivity/efficiency			100% critical-to-quality characteristics under control with Cpk ≥ 1.0	100% critical-to-quality characteristics certified
Organizational factors (Leadership, Culture and Environment)				
Cultural alignment	• ACE implementation plan defined • Value stream owners and accountability identified and advanced training provided. • Site-level training plan in place; value stream awareness training completed by all.	• Value stream objectives allocated • Active leadership involvement • ACE proficiency training completed	100% alignment	100% alignment
Employee competency			$\geq 90\%$ to business need	100% to business need
EH&S			100% to 10X plan	100% to 10X plan

C o m p e t i t i v e E x c e l l e n c e

Table 5 Summary of Performance Expectations by Category for ACE Achievement Levels
(Source: table developed from UTC ACE Criteria 11.4 Version 8)

Assessors

In February 2007, when Louis Chênevert set the goal to that 70% of UTC's roughly 900 sites be ACE Silver and Gold before the end of 2009, the ACE Council realized that it needed to ramp up the number of people qualified to perform these assessments. When ACE started in 1996, the people that developed the program conducted assessments. As individuals train and become ACE Pilots, they develop some of the skills needed for becoming assessors. Assessors are qualified at different ACE levels (Bronze, Silver, and Gold) and application areas (Business Processes, Operations, and Engineering). To become an assessor requires ACE experience and completing assessment courses, both classroom-based and on-the-job training, which is given by currently qualified assessors. The UTC ACE Director approves assessors at the gold level, and gold assessors, once qualified, teach and qualify assessors in their application areas at Silver and lower levels. All assessors are qualified based on their performance in actual ACE assessments. In order to remain qualified, assessors must be part of at least one assessment annually.

The goal to advance so many sites to ACE Silver and Gold levels required greater transparency and explicit standards for assessment processes and assessor qualification. The responsibility for the efforts rests with the corporate ACE office and UTC ACE Council. These ACE organizations use the ACE tools, such as customer feedback, process standardization and certification, standard work, 5S, Quality Clinic Process Charting (QCPC) clinics, and Relentless Root Causes Analysis (RRCA) processes, to perform, monitor and improve its work. These activities have resulted in creating such materials as standard processes and templates, checklists, and standard work for assessment and assessor training and qualification. The Assessor Standard Work has been noted as particularly helpful, not just in the education and qualification of assessors, but also in communicating expectations for Silver and Gold assessments to sites and their managers. Before Assessor Standard Work materials were available, the site assessment process was unclear, which created anxiety among site managers and other personnel before assessments.

Assessment Process

Assessment is the act or process of making an appraisal and collecting data to compare what is observed to a standard. The standard for UTC's process improvement and performance is specified in the ACE Criteria, and the check on the administration of those criteria comes through the ACE assessment process. The ACE site assessment process has progressed in much the same way as ACE Criteria; it has become more explicit as UTC has gained experience in performing and getting feedback on ACE assessments. The need to teach and qualify a cadre of assessors has also contributed to standardizing and making the assessment process explicit.

Managers in all UTC companies have goals to achieve and progress along ACE levels. The ACE specialist, and in larger sites this includes an ACE Manager or ACE Coordinator, are responsible for specific events and progression in ACE levels. These two efforts are interrelated. Improvement progress is made teaching and using ACE tools to identify processes, collect performance data, analyze that data, develop improvement alternatives, implement changes, and monitor process performance and variation data to guide further improvements and document achievements. ACE achievement levels are attained by assessing the awareness and engagement

of the workforce in improvement, skills in the use of tools and methods, and improvements in process capabilities and business performance.

Any two qualified assessors can perform both Qualifying and Bronze site assessments. Like all ACE assessments, it is preceded by a conversation between the ACE specialist and division ACE consultant or client manager responsible for that site. The ACE consultant or client manager that supports a site is not making the site assessment, but does help guide efforts and communicate expectations, works on specific projects as needed, helps in the efforts to get progress in ACE levels, including pre-assessment walkthroughs with the ACE specialist and site managers. Although it is the responsibility of the general manager, it is considered a process defect for the ACE office if an ACE consultant recommends and supports a site going forward with an assessment and the intended ACE certification is not achieved.

The UTC ACE office has developed checklists and presentation templates that are recommended for Bronze, Silver and Gold site assessments. Three of the checklists are pre-assessment, assessment, and follow-up items. The presentation template includes a proposed table of content for areas that should be covered, and within each of those areas, information on what assessors would expect to see, and what questions they are likely to ask. Although assessment presentation materials are prepared by the ACE Pilot who is often aided by the ACE Consultant, the site leadership team is expected to make the presentation. It is common that employees who were part of ACE projects attend these sessions and present their specific projects and applications of ACE tools.

Site Assessment	A group of UTC-designated Assessors visits the site, and, after detailed inquiry, votes on the appropriate ACE status.
Three months before assessment	The ACE Office, through the site’s client manager, conducts an on-site pre-assessment.
Two months before assessment	The site submits a preliminary assessment package, which makes the case for ACE gold, to the ACE client manager. Over the next few weeks, the client manager will ask for clarification and provide feedback on the package.
Two weeks before assessment	Site submits the final assessment package.
~ Site assessment ~	
Two weeks after assessment	The ACE Office gives the site a summary of the assessment, including several “homework” items to be completed, if necessary.
Three months after assessment	The site reviews its completed homework with the ACE Office.

Table 6 ACE Assessment Timetable
(Source: UTC Internal Presentation)

An ACE assessment is more than a decision on whether a site has met a set of criteria. The assessors are different from auditors, where auditors are generally third parties that have no stake in the outcomes of their audits. UTC's ACE assessors want the sites they assess to progress, are performing the assessment to help the site improve, and do this by comparing the site's performance, what its people have done, and its demonstrated competencies against ACE criteria. A site assessment is intended to be a learning process, reviewing the use of ACE tools and methods for identifying and improving the delivery of customer value. The standards for ACE certification are clearly spelled out, and there is an overarching orientation to "do what is smart and appropriate" to meet customer and business goals. If there are standards that do not make sense for a site's customers and business, its leaders may raise those standards as issues with ACE assessors and discuss what might be appropriate standards in their context.

The assessment goes beyond the event itself. One assessor commented that what is seen by those participating on the day of the assessment is only one tenth of what the assessors do. There are activities that take place before the ACE assessment occurs. The assessment is itself a time and resource intensive process, requiring clear expectations, including a well-communicated timeline of expectations, to proceed effectively. These expectations are communicated in the assessors training (see Table 6). Company ACE experts should visit the site leadership team three to six months before an assessment is scheduled to review and agree on the site's status. The purpose of that meeting is for people to become acquainted, review ACE Criteria and other expectations, share assessment checklists and timelines, and identify any exceptions or gaps and discuss actions to address them before the assessment. The follow up from that meeting is for the site, which includes its leaders, ACE Pilot and Consultant, to prepare and submit a pre-assessment package.

For a Gold Assessment, the UTC ACE council assigns the lead and co-lead assessors. Both Silver and Gold Assessments require two appropriately qualified assessors, with at least one coming from another UTC company to provide an external perspective. Forty-five days before its assessment date, the site submits its assessment package. The package is essentially a Microsoft PowerPoint presentation file, with data tables and other quantitative information, including customer survey results. The package contains a nomination form (see Figure 27) signed by the site executive and an executive council member, after it was signed for specific categories by site managers, providing their support for the ACE assessment.

ACE Gold Site - Executive Nomination Form

Site/Value Stream Name _____

Category	Requirement	Role	Signed
ACE Assessment Package	All requirements met	ACE Manager	
Customer Feedback	6> in all four categories	Site Mgr	
5S	V11.4 requirements met	Site Mgr	
Employee Satisfaction	Employee satisfaction	HR Mgr	
EH&S	EHS requirements met	EH&S Mgr	
Internal Quality Audit	No significant failed audits or issues	Quality Mgr	
QCPC	Actively used and visible	Site Mgr	
Critical Checklist Items **	Passed Pre-assessment	Certified ACE assessor	
Legal	No significant legal issues	Legal	

12 Months Sustained Gold Level Performance

Site Executive: _____

Executive buy in from Executive Council

Quality VP _____

Figure 27 ACE Gold Site Nomination Form
(Source: UTC ACE Benchmarking Presentation)

After a review of the assessment package materials, the assessors note any items that do not meet ACE Criteria, such as quality defects or metrics that do not meet plan, and request exception packages for those items (there are defined contents for exception packages). A month before the scheduled assessment date, the lead and co-lead assessors should have conducted their own independent contact to customers and, if they were required, reviewed any exception packages. About 15 days before the assessment date, a final decision to go forward with the assessment is made and the agenda is finalized.

ACE Certification

An ACE certification for Silver or Gold takes between one-half and two days, depending upon the site, its business, and what is in its assessment package. This assessment package is submitted in advance, leaving time for review, questions, and follow-up by the assessors. The follow up includes an independent MFA (assessors send messages or make calls to solicit feedback from the site's customers). Assessors have commented that ninety percent of the work of an assessment takes place outside the meeting, and that people should relax, present their materials, and learn from the proceedings.

The flow of activities for the on-site assessment is shown in Figure 28. The meeting generally starts with comments from the site leader, which include a welcome to the assessment team and any guests. Guests include ACE specialist and managers from other organizations, executives to whom the site reports, internal customers, and other UTC observers.⁹⁷ Following introductions, there is an overview of the agenda for the day, setting of expectations for what will follow. The lead ACE assessor frames the day and sets expectations. His or her comments generally are that the focus of assessment is learning, that assessors' see site management team as their customer, and issues uncovered during the presentation and discussions should be seen as opportunities for deeper understandings of ACE tools and methods. The site and its managers will receive the assessors' decisions at the end of their scheduled time.

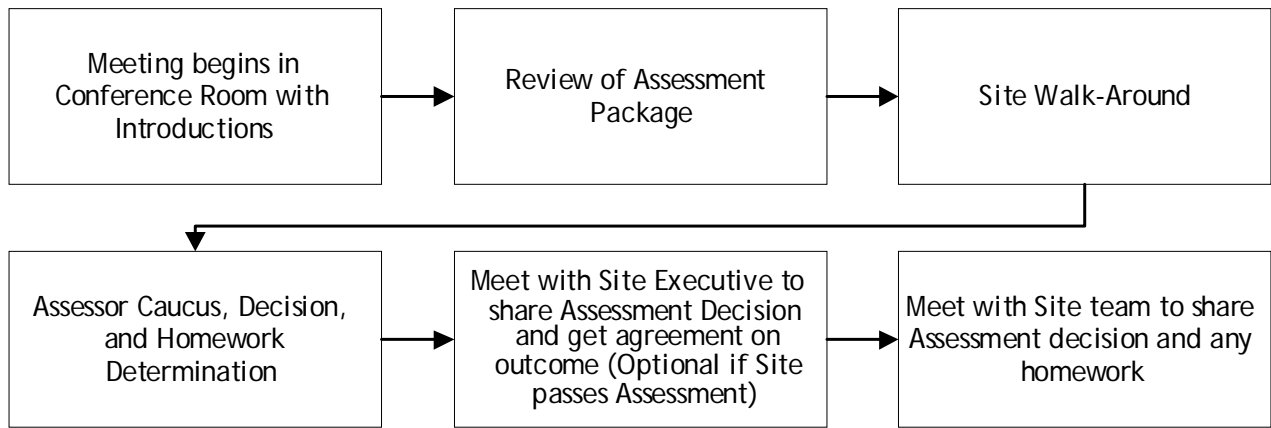


Figure 28 ACE Assessment Day Process
 (Source: UTC ACE Assessment Templates Presentation)

A senior manager presents and emcees the site's presentation. The presentation includes an overview of products, services and customers, and the site's improvements and performance status. Performance is summarized using a metric scorecard, which includes one or more metrics in six categories: customer satisfaction, safety, quality, delivery, employees/culture, and finances. The background on the metrics scorecards are color-coded, making it easy to see figures that deviate from expectations. Any deviation is reviewed and discussed (for ACE Gold certification, exception packages are submitted with the application explaining the deviation).

The discussion of overall performance is generally followed by presentation of specific improvement projects or issues that the site has encountered. These presentations are an opportunity to demonstrate employees' ACE knowledge, and their use of ACE tools, and their problem-solving skills. There are often questions in these presentations, which assessors use to clarify and teach nuances of ACE tools and their use. Assessors often describe other sites and their practices, suggesting locations where people from the site might go to continue their learning. The presentations and discussions often continue through lunch and into the afternoon.

⁹⁷ With some exceptions, such as members of this MIT case study team, ACE assessments are closed to people from outside of UTC.

A site walk-around takes place after the presentations. The site visit provides an opportunity to get out of the conference room and go beyond claims made in presentations. This includes seeing the physical infrastructure and talking to employees. The assessment team breaks into smaller groups to visit different areas and not overwhelm employees with a large group. Assessors talk with employees, ask them about their ACE experiences, how they use ACE in their work, and, for example, when was the latest time that the employee submitted a turnback. The site visit lasts at least an hour, and can take several hours. Assessment team members complete a checklist as they see equipment and facilities and talk with employees. The checklist has descriptions of ACE Criteria 11.4 and specific questions that prompt assessors, depending on the level and whether it is applicable, to indicate, using green, yellow or red scale, if the site meets, is on, or is behind plan in meeting requirements. Many topics on the checklist relate to topics covered in the site presentations.

Following the site visit, assessors meet in a closed session. The lead assessor begins by asking if everyone has the information needed to make his or her decision. There are four possible decisions: pass, pass with homework, postpone decision pending additional information, or failure to achieve the next level. The standard for achieving ACE Silver or Gold certification is that “all criteria must be reasonably met, not just the specific items in this checklist.” A vote is taken by anonymous written ballot to determine whether assessors agree on the outcome. A discussion follows, where any differences are discussed, and an outcome is set. The lead assessor then facilitates a conversation that gathers comments on the ACE criteria checklist (customer value, business results, value streams, leadership, culture, environment, health and safety practices, use of tools – market feedback analysis, process certification, standard work, quality clinics, root cause analysis, set up reduction, mistake proofing, and preventative maintenance and 5S practices). The team develops three lists: the “well done areas,” “areas of opportunity,” homework, and “recommendations for next steps.”

The final step in the assessment meeting depends upon the decision. If the decision were to postpone the decision or fail, the assessors first would meet privately with the site’s leaders. In this private meeting, there is a review and discussion of the findings, with efforts made to get leaders to agree with their decision. Should a site have failed, there is a commitment of time and resources from the ACE office to provide additional help that will help the site progress and succeed. Often a failure leads to renewed and appropriately focused efforts that result in recovery and faster progress by the site. If the decision is to pass, there is no private meeting with leadership. The assessment team invites the site leaders, managers, and employees that have been participating in the assessment back into the meeting room. The lead assessor announces the decision. A discussion follows, where insights, findings, suggestions, and homework are reviewed. The assessment team will provide written feedback within 14 days, and if there is homework, the site has 90 days to address them. The written follow up is reviewed by the lead assessor, and, if needed, he or she will visit to review homework items and close out the assessment. Division executives usually acknowledge, in written form or through personal visits, sites when they achieve Silver and Gold certifications. Many sites mark their ACE accomplishment with a celebration that involves all its employees.

Once a site is ACE Gold, its leaders and personnel are expected to help other UTC sites. The sites it helps can be others with similar contexts, or they could be supplier or customer sites. The

expectations of its customers are higher once a site is designated ACE Gold. Although customers provided good feedback scores and are receiving on-time deliveries with near perfect quality, they often want further improvements. The customer's increasing expectations require additional and continued improvement efforts. ACE Gold status is renewed annually. In the first year, renewal is accomplished by submitting an update showing sustained performance. In the second year, recertification involves a process identical to the original ACE Gold assessment, following all the requirements and timelines for submittal of information and the assessors' visit. If sites have problems or encounter hardship, such as the financial impact of economic downturns, safety issues, or customer problems, they will de-certify themselves from ACE Gold to ACE Silver. The ACE Gold renewal requires the twelve consecutive months of consistent high performance, which determines the timeframe in which the site applies for its ACE Gold certification.

Appendix B: ACE Tools and Methods

The ACE operating system, as described in this case study, includes developing an infrastructure, fostering alignment, developing proficiency, and using assessment for feedback. This appendix describes the specific tools and methods used in the ACE operating system. The tools and methods that UTC has included in its ACE Operating System are largely similar to what is written about in books and articles, and taught by industry consultants and at colleges and universities. For ACE, UTC has developed and standardized on specific terms, and developed ways in which it consistently teaches and practices these methods not just in the United States, but throughout its global operations. More recently, UTC has provided consulting and training using its ACE tools and methods to its suppliers. As its basis for the ACE operating system, UTC has adapted generic tools for its specific purposes, developed its own training curriculum and materials, and taught these methods in a consistent way across the globe in different languages.

<p><i>Process Improvement and Waste Elimination</i></p> <ol style="list-style-type: none">1. 5S - visual workplace2. Value Stream Management3. Process Control & Certification4. Standard Work5. Production Preparation Process (3P)6. Total Productive Maintenance7. Set-up Reduction <p><i>Problem Solving</i></p> <ol style="list-style-type: none">8. Market Feedback Analysis9. QCPC (Quality Clinic Process Charting)10. Relentless Root Cause Analysis11. Mistake Proofing <p><i>Decision Making</i></p> <ol style="list-style-type: none">12. Passport Process

Table 6 The Twelve Tools of UTC's ACE Operating System

The description of ACE tools and methods has been relegated to an appendix for an important reason. A common pitfall in many improvement initiatives, and a consistent factor in managers' failure to copy Toyota methods, is that people "confuse the tools and practices... with the system itself."⁹⁸ While individual tools and methods, such as these ACE tools, are easily grasped, learned, and applied, it is the development of an appropriate context in which the tools are used that is paramount to the organization's success. An organization's leaders create, through their ongoing support and consistent involvement, this context. Leadership creates a culture that embraces learning and continuous improvement. The focus of this case study is UTC's leadership, learning, and change process. At one level leadership has embraced and supported the selection, development, and codification of an ACE tool set that is taught and applied in improvement initiatives. But only one element of those improvement initiatives is to use the

⁹⁸ See Spear, S. and H. K. Bowen (1999) "Decoding the DNA of the Toyota production system." Harvard Business Review 77: 96-108.

tools. In many cases, people have to modify tools to better fit specific needs, and through those modifications or a search for better tools, feed their innovations back into UTC to improve ACE and the use of its tools at other sites.

The ACE operating system creates a disciplined approach to measure results, compare them to expectations, and use tools to close gaps between expectations and results. Some aspects of the ACE operating system and tools, for example, Market Feedback Analysis, QCPC and 5S, help prioritize improvement areas. The tools that are part of ACE fall into three broad areas: process improvement and waste elimination, problem solving, and decision-making (see Table 6). Based on experience and formal feedback, the suite of ACE tools has changed, as have the detailed descriptions, instructions, and training associated with them.

Addition of Tools to ACE

In 2008, the ACE Operating System consists of 12 tools or methods. In 1996, when Pratt & Whitney coined the term “ACE” and adopted this improvement program, it designated 7 Tools as part of ACE (along with assessing and certifying cells and training ACE Pilots). These tools and methods, many of which were originally developed by American pioneers of quality and continuous improvement methods, such as Edward Deming, and Henry Ford, had been adopted and developed as tools and integrated into an overall production system by Japanese manufacturers, such as Toyota, Honda, and Matsushita Electronic. Experiences with improvement initiatives in UTC companies guided choices of tools, their integration into ACE, and the evolution and focus of ACE from a program to an operating system. The History of ACE Theme describes the activities and events in and across companies that evolved into the current UTC ACE Operating System. These activities included using, gaining experience and seeing results, from using specific tools and methods. Figure 29 shows the evolution of the ACE Operating System in terms of these tools.

Each of the current twelve ACE tools can be traced back in time, either as one of the five tools originally used in North Berwick’s 1992 Flexible Manufacturing Program, one of the seven tools that were part of Pratt & Whitney’s 1996 ACE Program, or a specific, later addition. With its additional two years of experience, when UTC launched ACE across UTC and Ito University, ACE included ten tools. Tools have been added and changed and some UTC companies use different versions of these tools. UTC’s approach to these twelve ACE tools is flexible in their use, not based on rigid adherence to a single method, but rather appropriate use of a tool for problems being addressed. This flexible approach enables variation in experience in one local setting that then informs other’s efforts, use, or adaptation of ACE tools.

UTC’s improvement activities and experiences triggered changes in tools, additions of new tools, or improvement in the integration of tools into the ACE Operating System (see Figure 29 for diagram of triggers and evolution of ACE tools). The arrows and dates in Figure 29 show the directions of influence and approximate dates when UTC people described formal efforts to adopt specific tools. When tools are associated with companies, such as Toyota, Shingijutsu, or Matsushita, UTC people described the influence of those companies in their use of specific tools. While it is easy to identify specific tools and their development, they should not be separated from the overall set of tools used in combination that constitutes the system for improvement and change. What is glaringly absent in describing tools is the overall integration and philosophical approach with which these tools are used in UTC.

For example, *kaizen*, which in some translations means, “change for the better,” assumes a particular approach to improvement activities. The term, like other Japanese methods, have various translations, depending upon whom you read. In general, the *kaizen* approach organizes people into teams that use lean tools collect data, conduct analysis, and carry out improvements. The teams collect data, consider alternatives, and make changes in short, one or two days to a week, periods. *Kaizen*, often called “rapid improvement events,” seeks a quick tempo to make 80% of improvements immediately rather than a more analytic, get-everything-just-right-before-you-implement-change approach.

Kaizen is a part of ACE, as a philosophy, but it is not included in UTC’s list of ACE tools. UTC’s ACE philosophy and integrated framework is taught as part of the Ito University Foundations course and ACE Associates training. The philosophies, taught in these training courses, were written out by Yuzuro Ito. The facilitator’s wrap-up to interactive case studies and simulations in Ito University Foundations walk students through this framework. What follows are short descriptions for each of these individual tools.

Process Improvement and Waste Elimination

The grouping of these seven tools into this heading reflects the legacy of methods that Toyota has integrated into what is called “lean production.” Womack and Jones’ 1996 book, *Lean Thinking*, proposes five principles guiding lean techniques, what they called “lean thinking” (Womack and Jones 1996). The following principles direct the use of these tools: specify *value* by specific product, identify the *value stream* for each product, make *value flow* without interruptions, let the customer *pull* value from the producer, and pursue *perfection*.

New 5S - visual workplace⁹⁹

A visual workplace is organized so that anyone can *visually see* and understand the organization’s flow of work or material, schedule, and current operating conditions. The organization of a visual workplace is such that abnormalities are immediately noticed. Shingijutsu consultants taught people to use all of their five senses, and to even develop a sixth sense that determined if something was not right. Adhering to visual practices creates a workplace in which people attain high levels of product and service quality and efficiency.

When an area has been improved by 5S methods in a production environments by the cleanliness, organization, and visible order in what are otherwise often a chaotic manufacturing environment is clear. In business, engineering and office environment, 5S methods are applied to both the physical and electronic workplaces. In the physical workplace, 5S applies to clearly marking file cabinets and drawers and items within them with labels, creating visual cues where equipment belongs, an making an office both visitor and employee-friendly. In the electronic workplace, the principles of 5S to keep their electronic files organized and in compliance with policy. When properly applied, 5S methods increase employee engagement and customer satisfaction levels in all work environments.

⁹⁹ A reference for 5S – visual workplace methods is Hiroyuki Hirano’s 5 Pillars of the Visual Workplace by Productivity Press (1990, Portland, OR).

1988 Nippon Otis
problems lead to
learning Matsushita's
quality methods

1980's

Toyota (Lean) Production System

- set up reduction
- one piece flow
- standard work
- TPM

Shingijutsu 1991
- Kaizen

Statistical Process Control
-ProCert Council

1992 Ito's
quality
philosophy

North Haven 1994
- QCPC

**North Berwick
Flex Mfg 1992**

**P&W ACE
June 1996**

**UTC VP Quality
& Quality Council**

5 Tools:

- 5S - visual workplace
- Process Certification
- Standard Work
- TPM
- Set-up Reduction

7 Tools:

- new 5S - visual workplace
- Process Certification
- Standard Work
- Total Productive Maintenance
- Set-up Reduction

• QCPC/RRCA

• Mistake Proofing

PTRM

MFA

QCPC

RRCA

Passp

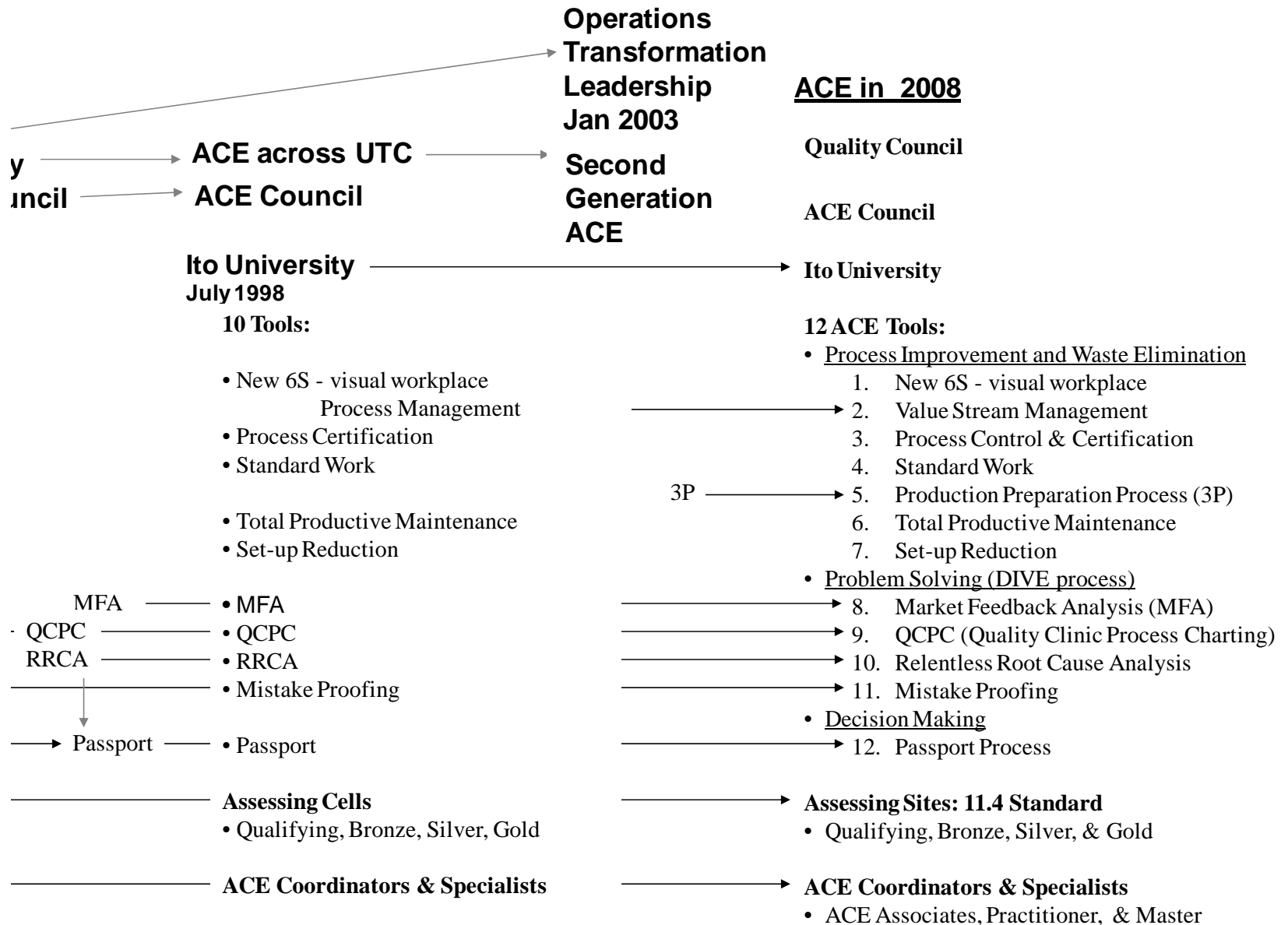
Assessing Cells

- Qualifying, Bronze, Silver, Gold

ACE Pilots

continued on next page...

Figure 29 ACE Tools Evolution (part 1 of 2)



...cont'd from previous page

Figure 29 ACE Tools Evolution (part 2 of 2)

The methods for achieving facilities where materials are properly arranged, in order, clean and continuously cleaned up and maintained are known as “5S,” pronounced five “es.” The five letters are the first letters of five Japanese words: *seiri* (separate and remove unneeded items), *seiton* (neatly arrange and identify items), *seiso* (conduct cleanup efforts), *seiketsu* (repeat *seiri*, *seiton*, and *seiso* at frequent intervals), and *shitsuke* (make these practices a habit). In English, the terms associated with 5S by UTC are sort, straighten, shine, standardize, and sustain, which are equivalent in substance and sequence to the Japanese words. The results of 5S efforts instantiate the adage, “a place for everything and everything is in its place.” The goal for these methods, in addition to creating settings that support productivity improvements, is to make the workplace appealing, or “refreshing,” to employees and visitors.

5S methods are often a first step in initiating changes. Improvements are immediately visible to anyone coming into the work area. The method gets people involved in improving their own working environment, and introduces the concept of removing items that frustrate or inhibit the efficient conduct of work. Changes are made quickly, which produces a sense of achievement and pride. In UTC’s training materials, there are six characteristics of a good 5S effort: the workplace **explains itself** (makes information available with pictures, symbols, color codes, lights or signals using minimal words), **organizes itself** (labeling, standard structures, dedicated or point-of-use tools and material packaging, and shadow boarding), **controls itself** (visual status, visual instructions, *kanban* or signals to downstream process, and *poka yoke* or mistake proofing), it improves itself (displays goals, metrics, trends, status, and improvement actions), **refreshes itself** (good first impressions, provides open views, and is orderly, well lit and maintained), **is safe** (no hazards, signs for safe exit and protective equipment, no floor or heavy storage, and oil leaks), and **welcomes** employees and visitors (signs, no clutter, and inviting product displays).

The term “6S” comes from adding an additional letter S (es) for “safety to the visual workplace concept.” Included in 6S workplace practices are safety improvement and accident prevention practices, items that are visual, such as good markings and items that are preventative, such as a different layout or not placing heavy items on high shelves. As with visual workplace practices, the goal is to motivate and engage employees in assessing their work environment, make changes, continually look out for possible issues and maintain the improvements, and regularly assess one another.



Figure 30 UTC ACE New 5S – visual workplace
 (Source: UTC internal ACE web site)

UTC ACE uses the “new” in 5S to include a value promoted by Yuzuro Ito. He was adamant that people and their engagement were the basis for all improvement and quality efforts, and that new 5S place its greatest emphasis on human spirit. Ito noted that traditional 5S activities focused exclusively on physical phenomena. By including human spirit, new 5S methods would help to cultivate unparalleled morale, and on that foundation realize manufacturing and productivity improvements. To keep people engaged, improvement methods should be straightforward and simple so that they could be quickly grasped and used by everyone. The means by which improvement activities would succeed was by leaders nurturing good hearts, good minds and employee engagement. Engaged employees respond well to simple, visual approaches to process improvement. They seek to generate information on how they are doing, and use that feedback to discover problems, guide solutions, and validate improvements. When someone enters a workplace that is improved with new 5S, they should experience a feeling of “refreshment.” That impression of refreshment is “the human feeling is the basis for producing good quality products.”

Ito used the term “shiny eyes” as a litmus test for an engaged workforce. The shiny eyes are “hard to define, but easy to see,” meaning that they are produced by creating an appropriate dynamic for change in the organization’s culture that involves people, rather than a dynamic for change that is imposed upon people. Conditions that are noted in UTC training that produce shiny eyes are as follows: engaged leader, available resources, training that results in understanding, involvement beyond Pilots and managers, facing challenges and change with excitement, positive orientations to suggestions and change, and employee engagement and satisfaction that is measured and taken seriously. The terms that Ito used for these conditions,

shown in the circle around 5S in Figure 30, is spirit and respect for workplace and employees. These concepts are easy to talk about, but much harder to do in practice.

Value Stream Management (VSM)¹⁰⁰

A key, central concept in lean is the creation and improvement of customer value. Products and services are produced through a sequence of activities where each of the steps in that sequence “adds value.” What is significant in any activity sequence depends solely upon producing customer benefits. The term is based on these two components, what has “value” to the customer and the “stream” of activities or processes that creates it. Value stream management requires a focus on customer value and an effort to organize activity sequences and improve these processes to reliably deliver it. In reality, focusing on value entails paying attention to those things that distract from contributing value. People and resources that do not add value are considered wasteful, and must be addressed by active efforts to “eliminate waste” in the value stream. Customer benefits are not derived because of internal organizational preferences for how a department or firm is organized, unless that organizing produces greater or more reliable benefits to customers. Given historical priorities for how managers organize firms, value stream management can be unlike or possibly even in conflict with existing functional, departmental, and corporate structures.

Consistent with the broader value stream context, UTC uses tools that it calls Value Stream Management to achieve process effectiveness, efficiency and agility through waste elimination and the standardization of work. The goal is to identify and focus on improvements to the group of processes that delivers value to customers by taking a system-level view and focus on creating lean processes by eliminating waste. As shown in Figure 29, Value Stream Management was only recently identified as an ACE tool. In part, this recent addition is because Value Stream Management is a set of tools and methods guided by lean precepts. These methods identify and improve value to customers as they identify and improve the processes that deliver value. The methods for identifying and improving value include interviews and customer survey data to understand, measure, and assess customer value and satisfaction. This market feedback data analysis is done using Russo charts (method for gathering and analyzing customer data on product or service reliability and escapes), Elephant charts (large, multi-year table used to capture and track historical performance and failure modes of those product and service elements that stand out as major problems on Russo charts; provides a balanced view of the whole that is not possible from a small part of that whole, and so named from the ancient tale that one cannot imagine an elephant just by touching its tail) or other similar methods.

Specific methods for identifying and improving processes include impact maturity charts (see explanation that follows), value stream and process mapping, and *kaizen* events or bursts. In turn, other tools of the ACE operating system may be brought into play during *kaizen* events. These are all methods that are written up in a variety of books, many of which base their origins on methods used by Toyota and other Japanese automotive manufacturers. Ito University, as well as numerous consultants and training organizations, provide courses that include these methods.

¹⁰⁰ Value Stream Management references include [Lean Thinking](#) (Womack and Jones 1996), [Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA](#) (Rother and Shook 1999), and [Creating Mixed Model Value Streams: Practical Lean Techniques for Building to Demand](#) (Duggan 2002) and [The Complete Lean Enterprise: Value Stream Mapping for Administrative and Office Processes](#) (Keyte and Locher 2004).

The improvement cycle starts with collecting data on the sequence of activities, drawing diagrams that show these process steps, adding information about those steps (time, resources, delays, inventory, quality), and assessing the overall end-to-end performance of the process. From that depiction of the process and information on its steps, changes are considered. These changes improve end-to-end performance by eliminating wasteful or non-value adding activities and connecting activities in different and better ways. Approaches to connecting activities such as single piece flow, downstream pull, just-in-time inventory, error proofing, and point-of-use tooling are techniques used to consider changes. The improvements are made by proposing and planning projects, which when implemented create change and achieve a new future state.

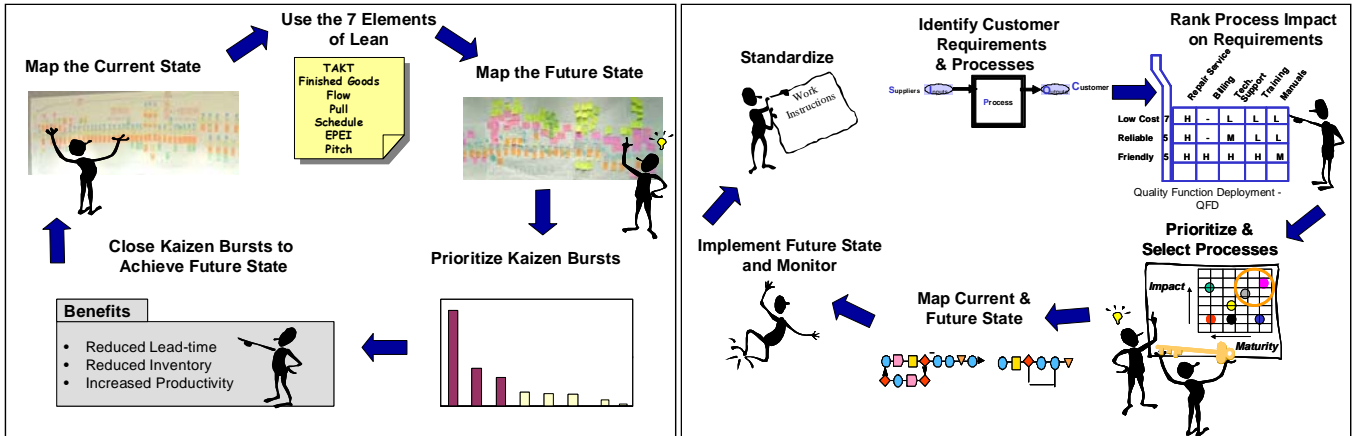


Figure 31 Value Stream Mapping & Process Management elements of ACE Value Stream Management
(Source: UTC ACE internal web site)

Process Control & Certification

Improvements beyond data collection, identification, mapping, implementing changes in processes are made by certifying and developing the maturity of processes in terms of their reliability to deliver what is expected when it is expected. UTC defines process certification as Level 6, which is the highest level of maturity. This signifies that a process is in control (stable, predictable, repeatable) and that it is capable of producing products or services that meet customers' expectations (based on measured numerical targets) 100% of the time. The inputs to key processes that are controllable factors affecting results are identified, studied, and controlled. A certified process also has minimal variation.

The six steps to process certification are to 1) form teams; 2) define the process; 3) review and assess the process; 4) establish statistical control and capability; 5) document a control plan; and lastly, 6) certify the process. The first step in forming a team requires users of the process and experts in that process or methods. Their efforts are to identify issues that are customer related, such as quality and delivery, or in the process itself, such as variation, quality, or performance. The team is expected to formalize its efforts to address these by completing an improvement mandate. This document requires a signoff as part of clarifying the team's efforts and management's support. The second step involves methods similar to process and value stream mapping in defining the process. Additional attention is placed on identifying and linking

customer requirements to key product or service characteristics. This link is made by finding the relationships between characteristics that are critical to product or service quality and key process inputs and outputs. Quality Function Deployment or Tree Diagrams are methods used to identify key characteristics of processes. A SIPOC (Supplier, Input, Process, Output, Customer, see explanation that follows) template is used to capture and measure process characteristics.

The third step involves reviewing and assessing process data, comparing key process input and key process output data with process characteristics. This review is done using control charts which display process information over time in graphic form. These time series plots help to assess variation and its sources, such as what is random variation (common cause) and what is non-random variation (specific sources). Specific sources are identified with assignable causes, and these causes are the focus for statistical control methods, which are step 4. Statistical control and process capability methods are used to establish upper and lower control limits. A variety of approaches developed by statisticians, including histogram displays and using a capability index, design of experiments, and robust design methods, are used to determine process potential and performance, reduce variation, and improve performance. The fifth step involves the team's creating a plan to maintain the control and capability of the process. This plan should include who is responsible, what is measured, when and where measurements are taken, how the results will be interpreted, and what controlling actions to take in response to possible problems to maintain process capabilities. The sixth and final step documents steps one to five, verifies process performance at appropriate levels, and provides standard work for process operations.

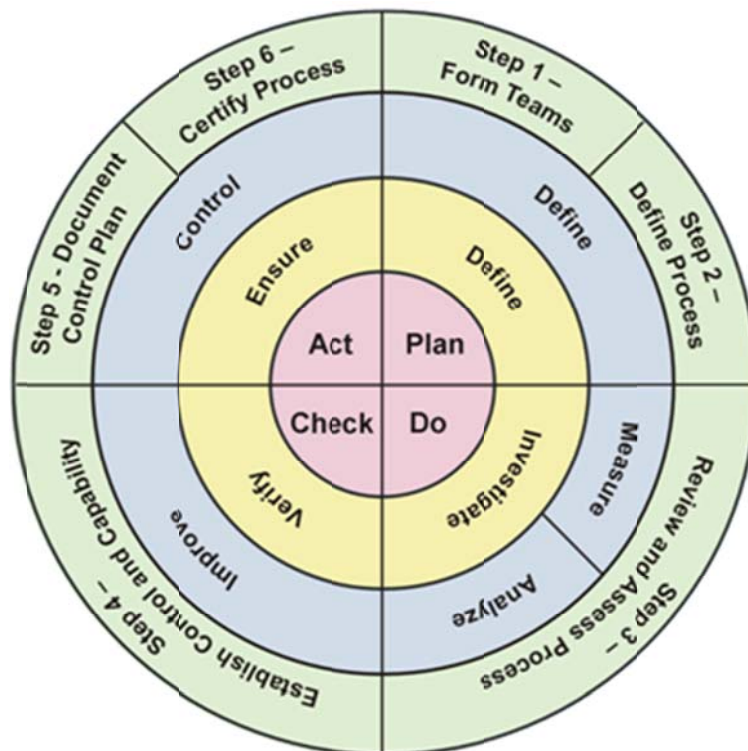


Figure 32 UTC ACE Process Certification and other methods
(Source: UTC ACE web site)

Statements on UTC internal web site note that Process Certification is “often viewed as the most complex of the ACE Operating System tools because of its statistical nature.” Suggestions are made that the complexity of statistics are addressed by using computer programs such as Minitab or DOE Wisdom. The Process Certification six steps are mapped onto other quality (Shewhart’s plan, do, check, act cycle), problem solving (DIVE: Define, Investigate, Verify and Ensure), and Six Sigma (Define, Measure, Analyze, Improve, and Control, or DMAIC) steps, as shown in Figure 32. Each of these methods invokes a learning cycle by establishing goals, making measures, planning and taking action, and using feedback; they are appreciably equivalent.

SIPOC

A focus on processes is easy to understand when following the flow of material and sequence of task in production settings. A process perspective is not as clear in business and engineering processes. A key tool that has seen extensive use in process identification, certification and improvement is the SIPOC. As with other ACE tools, the SIPOC is a method intended for team use. The name is an acronym for process elements: “S” for suppliers of the process, “I” for the supplier’s and other inputs to the process, “P” for the process or tasks that are performed, “O” for the outputs of the process, and “C” for the customers that who receive these outputs. Collecting this information requires people to think of what they do in their process, and how the linkage from suppliers and inputs to their process affects the outputs and customers. Although it is a tool to improve processes, UTC recommends starting the SIPOC with customers, and working through SIPOC steps from right to left. When organizations start with suppliers, they tend to create internally focused improvement efforts. Once customers have been identified, what are the outputs that they expect? Then, what processes produce those outputs? Once outputs have been identified, additional information is added to the SIPOC. Generally this information includes quality, cost, and delivery metrics for these process outputs.

The other important task in a SIPOC is examining what is needed to perform a process. This analysis requires listing all the inputs to the process, and then who the suppliers (internal or external) that provide each of those inputs. Again, an evaluation and quantitative metrics are helpful assessing supplier performance and input quality. An important consideration in conducting SIPOC analysis is that the better and more predictable the inputs to a process, the better the performance of that process. For example, if inputs do not arrive as or when required, then the process cannot be executed, and expected results achieved. These can be derived by sharing SIPOC information with customers, and determining what is important to the customer, or the “critical to quality” characteristics. These key outputs are traced back by through the process and used to identify key process inputs.

An organization, site, or cell will have a number of processes, and therefore a number of rows completed in its SIPOC table. Although the same supplier or customer may be involved in different processes, the SIPOC focuses on examining what happens before, through and as a result of each process. In a production example, a value stream can be constructed by linking the SIPOCs of multiple organizational units, going from the source of raw materials, equipment, labor, and capital through the multiple processes that in the end deliver finished products and services to customers. In an engineering example, where the output is a completed design for the customer, the SIPOC would include analysis steps, and suppliers, such an analysis, programs, sources of data, and test results, used in the analysis process to deliver the finished design. In its

training materials, UTC notes that the SIPOC “is the backbone of key ACE tools.” A SIPOC table can be seen as this backbone because process certification is used on SIPOC inputs, the processes are analyzed using Impact Maturity Analysis, process input and output metrics are reported on metric scorecards, and customer deliverables are assessed using MFA (Market Feedback Analysis), and process robustness.

Impact Maturity Analysis and Charts

Impact maturity analysis and charts are team-based methods for assessing, displaying, and targeting process health. These methods are often used after SIPOCs have been created to analyze processes, or some of these data are included in the development of the SIPOC. For example, after the customers have been identified, and the outputs and actions that customers value and expect are listed, it is important to assess the relative impact of those processes on customers. The impact can be put forward by grouping members and tested with customers, or assessed by asking customers, and then rated by group members assigning a group. In either method, the goal is to accurately estimate the impact of processes on customers using a 1 to 10 scale, where 1 is low and 10 is high.

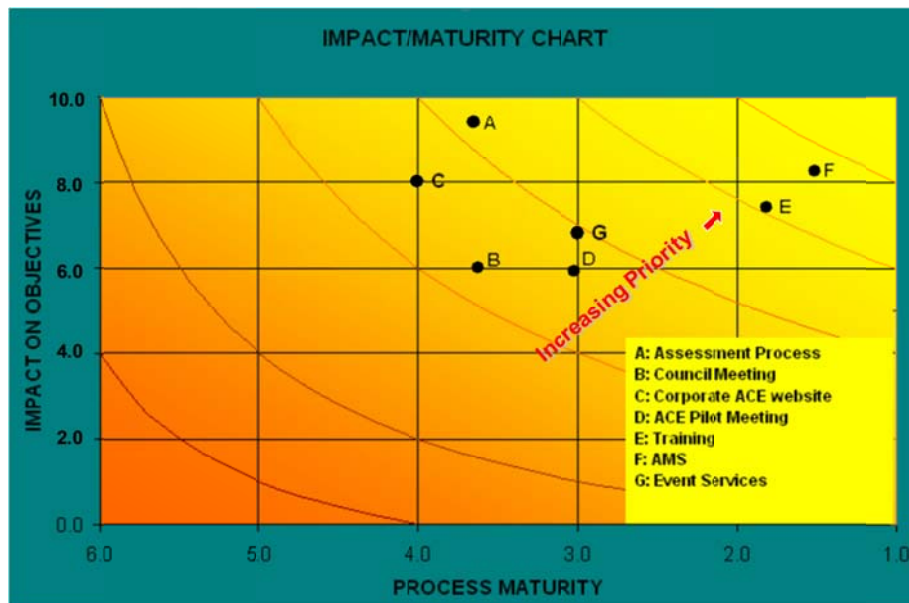


Figure 33 Impact Maturity Chart Example
(Source: UTC presentation for UTC ACE Office)

The maturity of a process, in terms of delivering results to customers, is assessed. The data to determine process maturity includes performance metrics, delivery performance results, customer MFA, process turnbacks, and quality escapes. The maturity scale starts at 1 (defined process – process has been identified, but performance is not predictable), and proceeds through to 6 (robust process – reliable delivery performance at world-class levels that are fully integrated with customer expectations). Other steps include 2 (baseline process – owner, waste elimination opportunities, inputs, outputs, and metrics have been identified), 3 (defined process – process has been mapped, standard work is being developed, customer agreed to quality and metric outcomes, and MFA is being collected), 4 (managed process – QCPC process in place, improvements are

being carried out, and desired future state has been defined), and 5 (optimized process - delivery aligned to most important customer expectations, metrics are in place and monitored, and standard work has been developed and improved). UTC has also developed automated tools that collect process information and provide process maturity scores.

Once both the impact and maturity of all processes have been assessed they are charted using an impact maturity chart. This chart, as shown in Figure 33, has an impact scale from 1 to 10 on the Y axis, and a maturity scale from 6 to 1 on the X axis. All of an organization's, site's or value stream's processes are plotted on this chart. This then allows the group to determine its priorities, based on resources and expected improvement, for which processes improvement to undertake first. The lower maturity, higher impact processes are the priorities for improvement efforts.

Standard Work

Standard work is the method by which work, its tasks, and their sequence are documented and used to guide activities (for example, the "P," or process in a SIPOC should be documented with standard work). In the documenting the ways in which work should be done, it is helpful to carefully understand how it is currently done, consider ways to do it better, and document and then follow the improved tasks details and their sequence. This seemingly meticulous and bureaucratic approach – documenting work details and adhering to them – is an element in explaining Toyota's continually improving operational performance. Documentation and regularly reviewing and improving standard work is what enables both the flexibility that leads to continuous improvement and the rigid scripting that leads to efficient operations.

Harvard Business School professors studying Toyota wrote that, "Activities, connections, and production flows in a Toyota factory are rigidly scripted, yet at the same time Toyota's operations are enormously flexible and adaptable. Activities and processes are constantly being challenged and pushed to a higher level of performance enabling the company to continually innovate and improve."¹⁰¹ The basis for the principles guiding Toyota is a "system of nested experiments through which operations are constantly improved."¹⁰² As these authors write, it is not the activities, which many companies have copied, that explain Toyota's performance. The basis for this performance it is the orientation to people, their work, its organization, and improvement that has developed in Toyota's culture. These concepts build upon but go beyond the technical details of standard work. It is the technical details for UTC's ACE approach to standard work that are described in this section, and these other concepts are part of the description of the ACE Operating System.

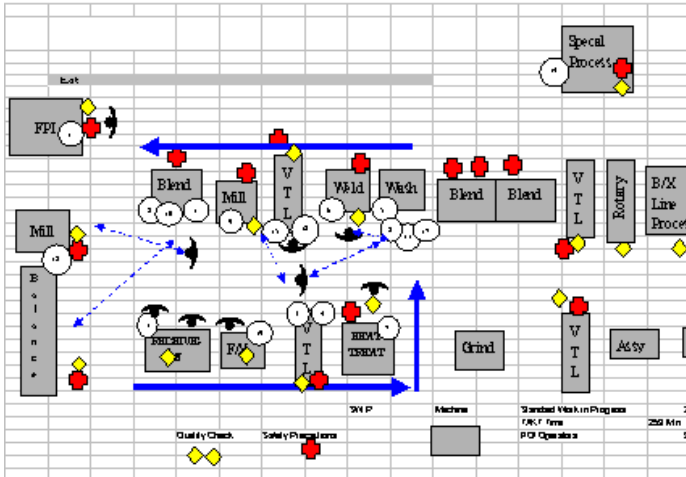
UTC's ACE standard work tool is described as "the method by which work is simplified and structured to ensure maximum quality, productivity and repeatability over time." Standard work includes the following components: defined standards, defined processes and systems, visual controls and work instructions, current sound practices, and documented lessons learned. Standard work, with variation in what and how it is documented, applies to operations, business processes and engineering. For example, Figure 33 shows that operations standard work

¹⁰¹ Spear, S. and K. Bowen (1997) "The DNA of the Toyota Production System," *Harvard Business Review*, Sept-Oct. Page 97.

¹⁰² Spear, S. (2004) "Learning to Lead at Toyota" *Harvard Business Review*, May, Page 80.

includes flow diagrams for the sequence of tasks in a manufacturing cell, while business process standard work includes task descriptions and flow charts of their sequence.

Operations



Business Process

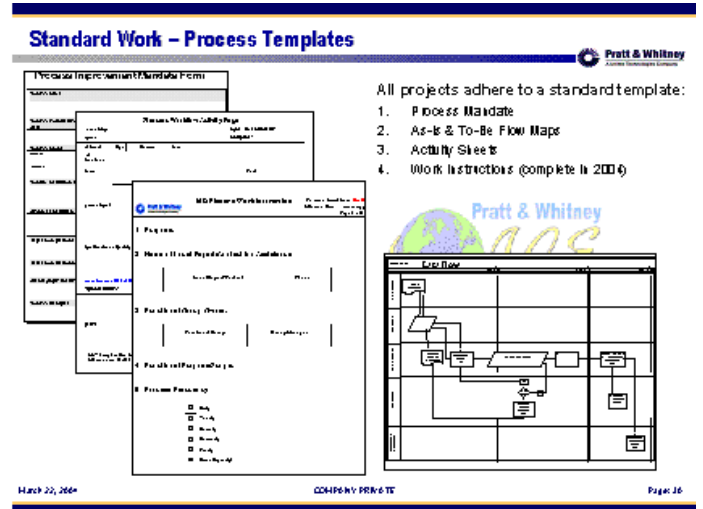


Figure 33 Operations and Business Process Standard Work Examples

(Source: UTC ACE Internal web site)

A goal in documenting steps in work is to guide efficient operations and avoid errors, rework, and loss of time. For example, manufacturing standard work details the motion of the operator and the sequence of the movement of material through the work area. In business processes, steps and sequences for activities and services performed are detailed. In engineering, there are often detailed descriptions of analytic procedures using software programs, such as finite elements, stress, or heat transfer analysis. The process of developing standard work uses improvement methods in identifying processes, collecting information on how it is done, and developing better ways to perform the work. While the use of standard work is associated with lean production methods, other lean methods, such as the calculation of takt time, flow charting work sequence, and a use of minimum or no work-in-process inventory, guide changes in standard work (and metrics and diagrams produced in these improvement efforts are often used in the resulting standard work documentation). To keep standard work “fresh,” people are asked to perform audits on another, paying attention to the accuracy and appropriateness of these instructions. People also keep their standard work fresh by benchmarking other locations doing similar work. If the instructions are not accurate, or better ways are devised to to perform that work, then a change is made to either the work or its documentation.

A part of UTC’s ACE efforts includes the concepts of “turnbacks” and process improvements. A turnback is any process step or occurring event that hinders the correct and timely completion of a required task (see QCPC description for more information on turnbacks). Process improvements are slightly different. Rather than errors or hindrances, process improvements are possibly better ways to complete tasks that workers see as they carry out tasks. In doing their work, people are asked to report turnbacks on any obstacles that they encounter. Turnbacks could be based on the standard work not being clear, accurate, possible or appropriate. This feedback is important in

the use and validity of standard work. The ACE operating system requires efforts to be made in all UTC sites to create systems and processes that simplify people's reporting, tracking, and resolution of turnbacks (and process improvement suggestions). The regular and timely reporting of turnbacks provides data that teams use to make changes in standard work and other process documentation and procedures.

Most organizations have developed templates for standard work, which require people developing standard work to include the what (task being described), who (person responsible for the work), when (sequence and frequency), the where (at what location), the how (methods to be used in their descriptions), and why (reasons work is performed as it is. Standard work descriptions are kept close to where that work takes place. In manufacturing cell, binders with the relevant standard work descriptions are kept in the work areas. In business process and engineering, there are binders, or computer accessible files with standard work descriptions. The goal is to produce work instructions that are simple and visual.

A special case of standard work is Pratt & Whitney's development of Engineering Standard Work (ESW). While the concept is similar to what is described above, ESW is based on six elements of engineering work that are documented – workflow maps, tools and methods, design criteria, design standards, lessons learned, and practioner proficiency assessments – each of which has assigned owners to review and make ESW changes. The detail, focus, and magnitude of Pratt & Whitney's ESW efforts are noteworthy. The company faced engineering knowledge shortages as mergers and market conditions caused the company to close its military engine operations in Florida and move them to Connecticut in 2000. Many engineers did not make this move, and Pratt & Whitney found that they could not rely on engineers passing experience on as they normally had done. They had to capture and document the knowledge and develop a process focus in engineering, which their ESW efforts addressed.

Difficulties in meeting developing schedules for the Joint Strike Fighter F135 engine caused them to stop all engineering development activities for two months in 2001 to write engineering standard work documentation. From the F135 and GP7000 programs, they created 450 workflow maps, 9,000 activity pages, and 17,000 documents overall for their engineering processes. Pratt & Whitney recovered time lost and executed the F135 program within budget and schedule targets. An assessment in 2002 found that every \$1 spent on ESW paid back \$4 in cost savings. Engineering change orders decreased by 50% from 2001 to 2002 (and continued to drop in 2003), and for all design-quality escapes, estimated as having cost \$46 million, 70% were attributed to ESW execution failures.¹⁰³

Production Preparation Process (3P)

Production Preparation Process, contracted into 3P and said as “three pee,” methods as the most recent addition to the ACE tools. 3P became part of the ACE operating system tool kit during 2004. As part of the operations transformation, UTC people benchmarked other companies. Several companies, including Lantech and Freudenberg-NOK,¹⁰⁴ used these methods as part of

¹⁰³ See HBS Case Study #9-604-084, “Pratt & Whitney: Engineering Standard Work” by Kent Bowen and Courtney Purrington, Harvard Business School, March 27, 2006

¹⁰⁴ Description of lean methods implemented at Lantech and Freudenberg-NOK can be found in Womack and Jones, 1996 book Lean Thinking.

their lean efforts. With the help of Shingijutsu Consulting, the ACE Council adopted 3P as the twelfth UTC ACE tool.

	Monday	Tuesday	Wednesday	Thursday	Friday
	Date	Date	Date	Date	Date
Morning	Brief Sponsors Review and adjust goals and team structure	Create seven concepts (per process or process step)	Prepare full-scale 3D mockup Start Simulation	Simulate + Kaizen + Simulate Choose final set of options	Prepare Presentation to Sponsors Brief sponsors
Afternoon	Create seven concepts (per process or process step)	Evaluate seven options Choose best three options	Simulate + Kaizen + Simulate	Prepare Documents: <ul style="list-style-type: none"> • Process at a Glance • Cycle times • Process capacity • Standard Work layout • Material Flow 	Agree on execution plan, resources, and next-phase contract
1600 Hr	Team Leaders Meeting	Team Leaders Meeting	Team Leaders Meeting	Team Walk-Through	

Figure 35 Block schedule for 3P event
 (Source: UTC ACE web site, standard work for 3P document)

One of the basic tenants of lean is to eliminate waste in the tasks and processes where work is done and value is added in creating a product or service. In this context, waste is any activity, physical material or resource used in a process that does not contribute value to the product or service produced by that process. One goal for *kaizen* and other lean methods in a production process is to make improvements and eliminate waste. 3P has a similar goal, which seeks to eliminate waste and make improvements by rapidly creating and testing new product and process designs. Although most of what is described in ACE materials is for process designs, 3P has also been called “pre-production planning” and similar techniques are used in establishing production methods in design manufacturing cells making new products. 3P follows a *kaizen* event type schedule – led by a *sensei*, preparation prior to the event, initial briefing to management, daily summaries and schedules for next day’s activities, final briefing at end of

week, implementation of changes during week, and creating a plan for unfinished activities.¹⁰⁵ A block schedule for the timing and sequence of activities involved in a 3P effort is shown in Figure 35.

Safety
1. No operations require more than one person
2. No forklifts, cranes, hoists, pits or platforms
3. Nothing in the work area is higher than 1.5 m (5 ft.)
Material
4. No materials of concern used in any process
5. Part orders are dispatched from the shop floor with a simple replenishment system: “I’m out, I need more” (no MRP)
6. No trash containers in production areas
Design
7. Reduced part count
Flow
8. Produce to customer rate of demand (Takt time)
9. Flow, FIFO, Pull (supermarket) is the right sequence
10. Have a pacemaker
11. Make final test a part of the flow
12. Do as much modular assembly as possible
13. Have a visual signal (<i>Andon</i> trigger) when something is wrong, and have standard work for responding rapidly to an <i>Andon</i> trigger
Continuous Improvement
14. Market feedback, QCPC, clinics and process/value stream management are routinely used to improve quality and productivity
15. Last non-negotiable: Leaders and associates abide by these principles

Table 7 Fifteen 3P Non-negotiable Rules
(Source: UTC ACE internal web site)

The prototype process designs are developed by cross-functional teams that participate in events. People create product, process, and tooling mockups made from inexpensive wood, cardboard or Styrofoam materials in these events to simulate alternative process and improvement ideas on a proposed production line. As part of developing a new design, Shingijutsu Consulting developed for UTC a set of fifteen non-negotiable rules that are to be met as the result of a 3P event (see Table 7). These rules implement lean, visual workplace, and safety practices in the process mock ups, where it is easy to simulate changes and observe their impact, that are created in 3P events.

The goal of 3P events is to learn as much as possible about a potential new product or process design before physically implementing and being committed to it. 3P is a shift from other ACE methods, methods that seek to make changes to existing processes through continuous,

¹⁰⁵ Although *kaizen*, the Japanese word for ongoing improvement, is not specified as an ACE method, these techniques – customer orientation, quality control, team effort, small group activities, everyone involved, making and maintaining changes – inform the team and event-based methods in which most ACE tools are used. For more information on *kaizen*, see M. Imai’s book, *Kaizen: The Key to Japan’s Competitive Success*, McGraw Hill, 1986.

incremental improvement. 3P can apply to non-manufacturing situations, such as service delivery. Techniques used in communicating and simulating new designs in these applications include role playing, operation scripts, live storyboards, process models, and pilots.

Total Productive Maintenance

Total productive maintenance, or TPM, focuses on the reliable, safe, and efficient operation of machines, which makes that equipment available for productive work the maximum amount of time possible. TPM does not leave machine maintenance solely to specialists, but involves the people using machines, often referred to as operators, expanding their role from just using the machine, to basic cleaning and maintenance functions. Operators collect and examine data on machines' functioning to schedule preventative maintenance. Maintenance personnel teach operators approaches to cleaning their machines and some aspects of routine maintenance. Engaging operators to maintain their own equipment is a positive and energetic way to increase machine up time and thus overall facility productivity gains.

TPM methods are appropriate beyond the material handling and computer numeric control grinding, drilling, milling or other material operations machines found on factory floors. It can be applied to a broad range of machines found in other settings, such as offices, where it includes computers, copiers, plotters, and printers. TPM is associated with other lean methods, such as 5S and visual workplace. Machine operations, cleaning, and maintenance tasks are visibly displayed near the machine, making it easy for someone to diagnose the current status, spot an abnormality, or carry out needed tasks.

UTC experience with TPM goes back to its early efforts with Shingijutsu Consulting, who taught this approach based on their Toyota experience. Pratt & Whitney's production relies on many specialized milling and grinding machines for making precision parts for jet engines. The basic steps for TPM (see Figure 36) involve monitoring machine performance to take preventative action before breakdowns or malfunctions occur. These methods involve listing quality, maintenance and safety issues, developing ways to visually gauge the functioning and status of the machine, creating checklists for these functions, schedule preventative maintenance, and maintaining spare parts and tools near the machine to expedite possible repairs. TPM methods also include making improvements in the equipment and its environment to improve machine operations and availability. Examples of improvements include air filters on motor housings, pans or painting the floor under machines so that oil leaks are noticed, gauges with acceptable ranges clearly marked, fluid level indicators on sight glasses, and use of lockout/tagout procedures to prevent unsafe use of machines.

Pratt & Whitney adopted an overall metric called Overall Equipment Effectiveness (OEE) that is associated with TPM results at its facilities. OEE combines measures of availability, performance efficiency and quality yields of machine functioning to provide an overall measure of the net time that machines are available for production. Machines lose availability because of breakdowns and the time needed to set-up and make adjustments, lose performance because of stoppages and reductions in speed and feeding materials, and lose quality because of startup, rework, defects and wear. Percentages from each of these three domains are multiplied together to get an overall OEE percentage (for example, 60% availability, 70% performance efficiency

and 80% quality yield give an OEE of 34%). Toyota factories operating at world class levels have 85% OEE scores, typical US factories have OEE scores in the range of 40%.

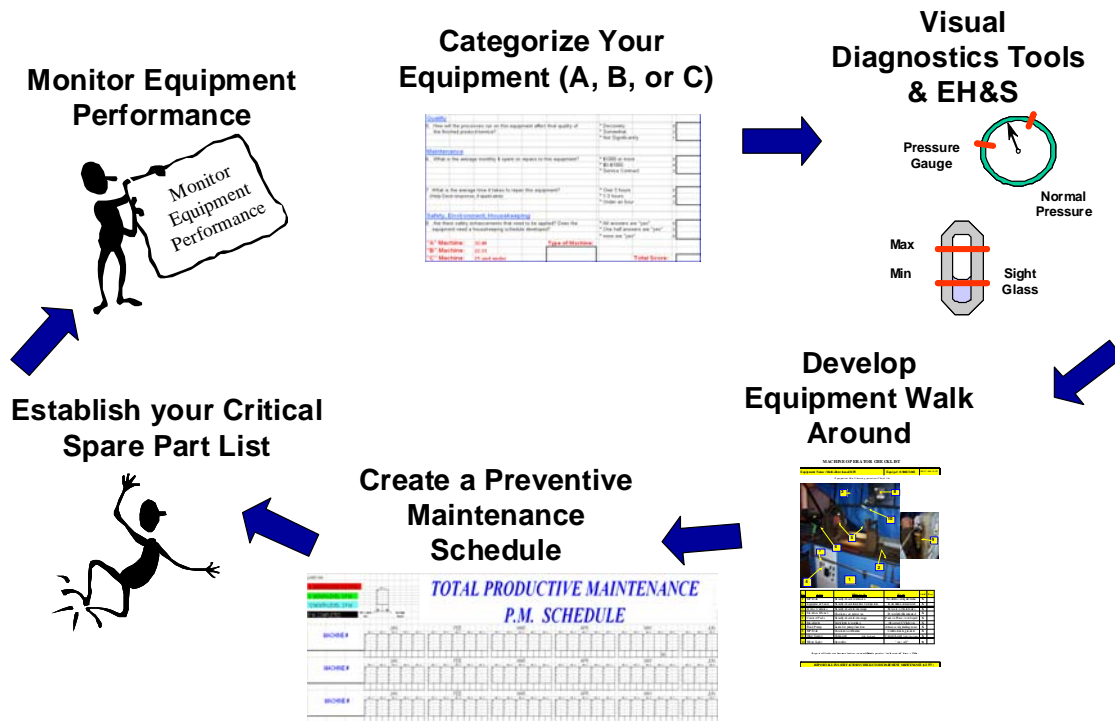


Figure 36 Basic TPM Steps
(Source: UTC ACE web site)

Set-up Reduction

Set-up reduction is a methodology that improves the availability of machines and processes for production. The methods aim to reduce the time it takes to setup a machine for the next operation or restart a process for subsequent operation. The time is measured from the completion of the last good part to when the machine or process are ready to produce the next good part. Set up reduction methods often identify and eliminate tasks that delay the next operation. A basic approach to these improvements involves converting internal setup activities (things done when the machine is stopped) to external setup activities (activities accomplished while the machine is running and adding value). Set up reduction is employed to approach or achieve single piece flow.

A technique associated with set-up reduction is single minute exchange of dies (SMED). SMED is a technique developed by Toyota for the rapid change over of machines for running the current product to running the next product. The term “single minute” does not mean that all changeovers and startups take only one minute, but that they should take less than ten minutes, or be completed in the “single digit” of minutes. An illustration from the UTC ACE web site stated, “changing the die on certain presses used to be a manual process requiring the use of a hoist and several hours of the machine being stopped. A roller system has been adapted so that all dies are easily available and changing dies is just a matter of rolling it into the machine, all in less than nine minutes.” The improvements in productivity from set-up reductions can be dramatic.

Shigeo Shingo noted that between 1975 and 1985 that average setup times at Toyota were reduced to 2.5% of the time originally required, or a 97% improvement.¹⁰⁶

Problem Solving

The ACE Council has defined the organization of ACE tools into a set used for problem solving. This tool set includes four phases, all of which use quality and documented process control methods. These four phases make up D.I.V.E., which are the initials for the Define, Investigate, Verify, and Ensure phases of UTC's overarching problem solving process. These problem solving phases proceed as follows: 1) **D**efine the problem, 2) **I**nvestigate probable root causes, 3) **V**erify that what you have identified are the actual root causes of the problem, and 4) **E**nsure that you have correctly implemented mistake-proof solutions and that they are working effectively. Defining the problem includes gathering customer data (using market feedback analysis tool or customer surveys) or process data (using information generated by employees through Quality Clinic Process Charts). This definition also involves analysis of that data, using such methods as Pareto charts or Russo charts and Elephant charts (all of these charts are ways of collecting, categorizing, displaying and analyzing data), and process mapping. The defining activities end with the establishment of a team and a team mandate.

The second step, investigation and analysis, uses that feedback data or process information in a "Relentless Root Causes Analysis (RRCA)" that will invoke Fishbone (cause-and-effect) Diagrams, Five Why's techniques, and Quality Clinics. When needed, UTC has experts in advanced, industry-taught, root causes techniques such as Red X, Fault Tree Analysis, Design of Experiments, and Kepner-Tregoe methods.

The verify step involves testing for root causes and testing potential solutions developed using brainstorming or nominal group techniques to solicit and prioritize ideas by engaging a group of people. For difficult cases, UTC experts have learned the Theory of Inventive Problem Solving (TRIZ). Verify includes applying mistake proofing concepts, which involve moving from inspecting for errors after they have occurred to analysis and control of the processes that cause errors, to finding and eliminating errors at their sources. Verify activities end with the development of an implementation plan for mistake-proof solutions and a control plan for monitoring subsequent performance. Finally, the ensure step includes implementing solutions and tracking product and process performance to monitor improvements and identify new opportunities. Ensure also involves documenting and sharing the solution in the form of standard work, along with acknowledging, rewarding, or publicly celebrating the team's success.

The goal of the DIVE framework and its problem solving tools is to provide a reliable and robust method that has people analyze problems in a structured and consistent manner, identify causes, or what UTC calls "true root causes," and develop and implement preventative actions that can be sustained over time to keep the problem from recurring. The UTC literature references and notes that the DIVE process is conceptually similar to the Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control). These methods have been broadly used in General Electric and Motorola, and there are many books, handbooks, and consulting organizations offering training

¹⁰⁶ See *A Revolution in Manufacturing: The SMED System*, Productivity Press, 1985, page 113. For a more recent reference, see *Kaizen for quick changeover: Going beyond SMED* by K. Sekine and K. Arai, 1992, Productivity Press.

and services associated with them. Another example is Ford Motor Company's Eight Discipline (8D) problem-solving method.¹⁰⁷

DMAIC and 8D methods are similar to UTC's DIVE; all are examples of team-based problem solving methods. These methods define a cycle of detective and corrective actions in solving manifest problems. In that sense, they are somewhat different in their focus from other quality methods, which are based on continuous improvement rather than reactive problem solving. However, many of these overall methods use similar tools, such as root causes analysis with fishbone diagrams and five why's, and so on. All these methods are documented and taught so that they become a common method used by a group of people that enables everyone on that team to contribute to improvement or problem-solving activities. As such, an important condition, or change that needs to take place, is the orientation of the people in the organization to use and participate in problem-solving and improvement activities.

Market Feedback Analysis (MFA)

Market feedback analysis is a disciplined approach to collecting and analyzing customer feedback. It involves collecting quantitative data from customers regarding their experiences with product or service quality and delivery, and with relationships, responsiveness and overall satisfaction with the UTC organization.

A prevalent use of MFA in UTC companies is as a methodology for collecting customer feedback as part of monitoring and reporting customer satisfaction. Generally, a seven-point scale is used for customer survey questions. These customer data include both internal and external customers, and involve their making assessments of the organization's product and service performance (and its improvement or decline). These customer feedback scores can be reported on a monthly basis on a cell's or site's metric scorecard.

An example of MFA in a business process is its use in responding to increases in customer complaints. In one setting, for example, customer complaints rose unexpectedly. A team gathered data using a customer survey. The survey information showed decreased customer satisfaction due to an increase in "temporary" resolutions by service technicians. Data collected from service technicians found that they had become less committed to routine maintenance jobs and were often unfamiliar with site conditions. These data helped steer efforts to restructuring service teams by giving them dedicated administrators, which improved service monitoring and the customer relationship.

When customer data reveal issues, such as a loss of satisfaction, a drop in product reliability, poor on-time delivery, long lead times for delivery, incorrect orders, or handling damage, MFA tools are applied in the "Define" step of UTC's DIVE problem-solving process. Russo and Elephant Charts are used in the capture and analysis of product, component and part related problems to help translate them to the appropriate underlying causes and processes. QCPC and

¹⁰⁷ This method was originally developed by the US Government after World War II and later popularized, because of Ford's own internal use and use with its suppliers. The process is made up of eight steps to 1) assemble a cross-functional team, 2) define the problem, 3) implement and verify temporary fixes, 4) identify and verify root cause, 5) choose and verify permanent corrective actions, 6) implement and validate corrective actions, 7) prevent recurrence of the problem, 8) recognize the team's efforts.

process mapping are usually the analysis tools of choice for obvious process problems surfaced by customers; most frequently, these problems would include delivery-related issues.

The data from customers can be used for a variety of improvement processes. As shown in Figure 37, different analytic techniques are associated with different uses of customer and market data. All are structured or disciplined methods for collecting and analyzing data from customers to create new products, services and processes to improve the delivery of what customer's value. In Figure 37, the Russo Chart is used to initially capture and track historical data and gain guidance from experts to identify improvement priorities, which then feeds Elephant Charts to capture patterns over time and identify recurrent problems or feeds the design of components in new designs based on data and failure modes of components in existing designs.

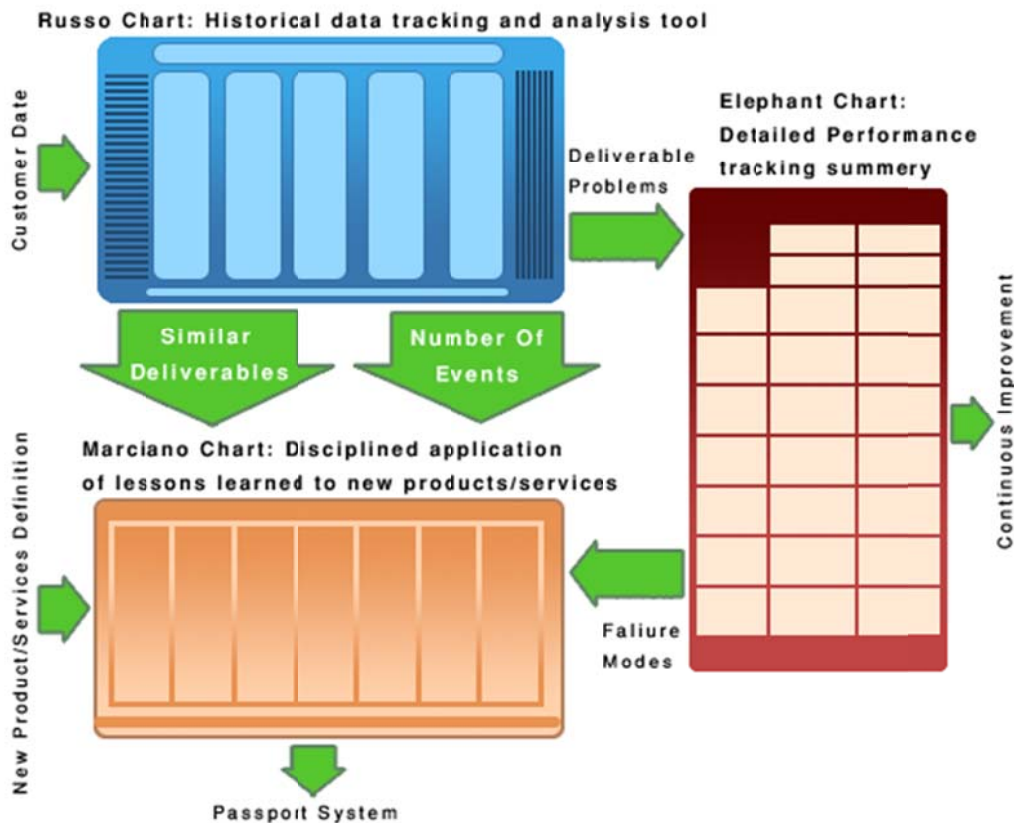


Figure 37 Market Feedback Analysis Tools
(Source: UTC ACE internal web site)

Quality Clinic Process Charting (QCPC)

Quality Clinic Process Charting, or QCPC, is another team-based problem-solving method. Yuzuro Ito brought the method to UTC based on his experiences in Matsushita. Ito's philosophy was to keep improvement methods and processes as straight forward as possible so that they would engage and be used by workers. He found that many managers created a sense of their own superiority in their use of quality terms. He advocated, "simple is best," so that anyone can understand, and execute simply and easily what needs to be done.

Ito disagreed with the ways that many statistical control and lean methods were implemented because they were led by experts and not easily used by workers. Ito's close relationship to George David let him speak his mind and encouraged people developing the UTC ACE program and its tools to come to agreement with him.

Ito stressed a focus on the QCPC method and teaching its clinic activities through case studies. Clinic methods and process charting were highlighted in Ito University since other methods, what Ito called "widely known quality management theories and statistical quality control methods," such as TPM, FMEA, QC 7 tools or Taguchi Methods, could be learned from books. In addition to having developed QCPC at Matsushita in the 1980's, Ito had taught and used these methods at many UTC facilities, starting with Nippon Otis in Japan in the early 1990s, and starting with Pratt & Whitney's North Haven plant in the United States in 1994.

QCPC integrates clinic methods with process charting (see Figure 38 where QCPC steps are identified as charting or clinic activities). The process charting involves capturing process data, recording and displaying it, and observing its changes over time. The data that is captured includes a concept called a "turnback." A turnback is anything that impedes the smooth flow of work. Turnbacks are synonymous with the various forms of waste in the Toyota Production System.

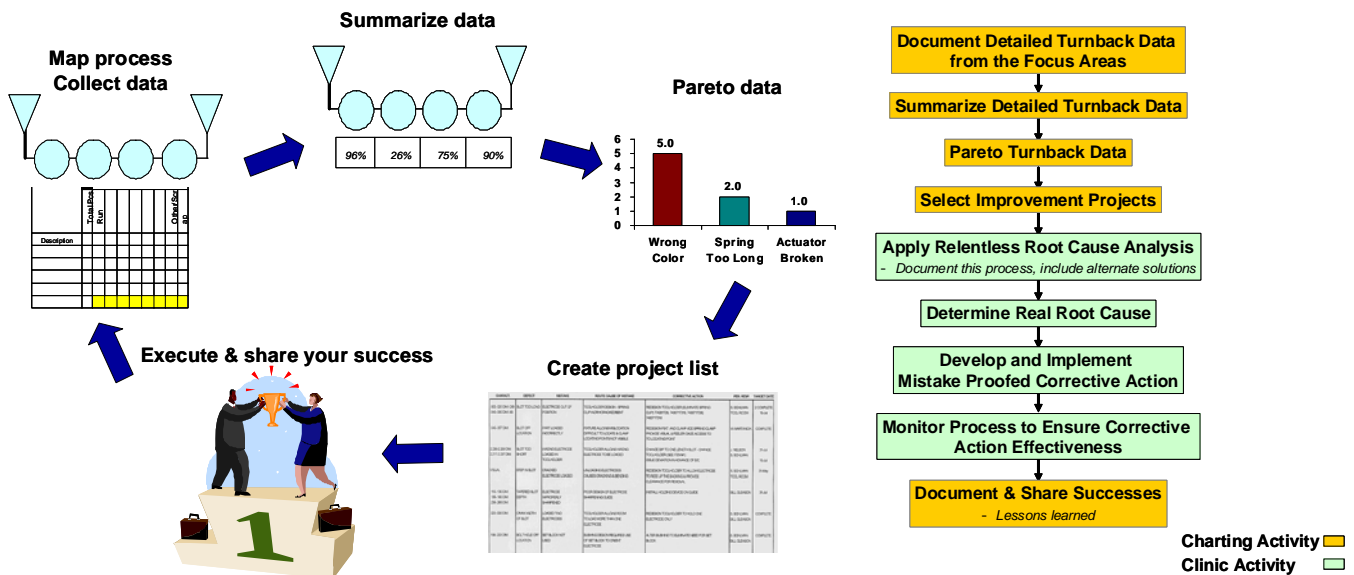


Figure 38 Summary of QCPC
(Source: UTC ACE internal web site)

The organization seeks to ensure that everyone working in a process understands what a turnback is, and then makes it easy to report any impediment, or turnback. The reported turnbacks are the data that are analyzed in developing and prioritizing product and process improvement efforts. As the description of this method implies, a team of people are to be continuously involved in generating, collecting, analyzing, and using data to direct improvement efforts. The data that are collected and analyzed are diagnosed in a "clinic" type activity and setting. Similar to a medical

clinic, where patients present their ailments for diagnosis and treatment, the turnback data are sorted, grouped and analyzed to propose problems to be subjected to UTC's DIVE problem solving methodology. In the medical setting, the goal of a clinic is to eliminate diseases; in a business setting, the goal of a clinic is to eliminate problems and create perfect processes that yield first time and every time 100% quality and timely results.

Some UTC manufacturing organizations have physical quality clinics as part of their ACE efforts. The clinic is a physical space dedicated to taking in, analyzing and improving non-conforming processes or products as part of a QCPC process. That space is typically a room or area on the manufacturing floor. This space allows for defective or questionable parts or tooling to be brought to the area. There, open communications about quality issues can be encouraged, measurement instruments and problem-solving methods are used, and changes to standard work, processes and product designs are developed. These clinics are expected to have a triage capability, which requires assessing scope and impact of potential problems, considering containment, determining priority and assigning ownership, and providing some feedback within 24 hours. UTC focuses on seven elements of successful clinics: people, physical location, layout, equipment, visual management, metrics and performance reviews. Physical elements of a quality clinic, i.e., layout, equipment, and visual management are shown in Figure 39.

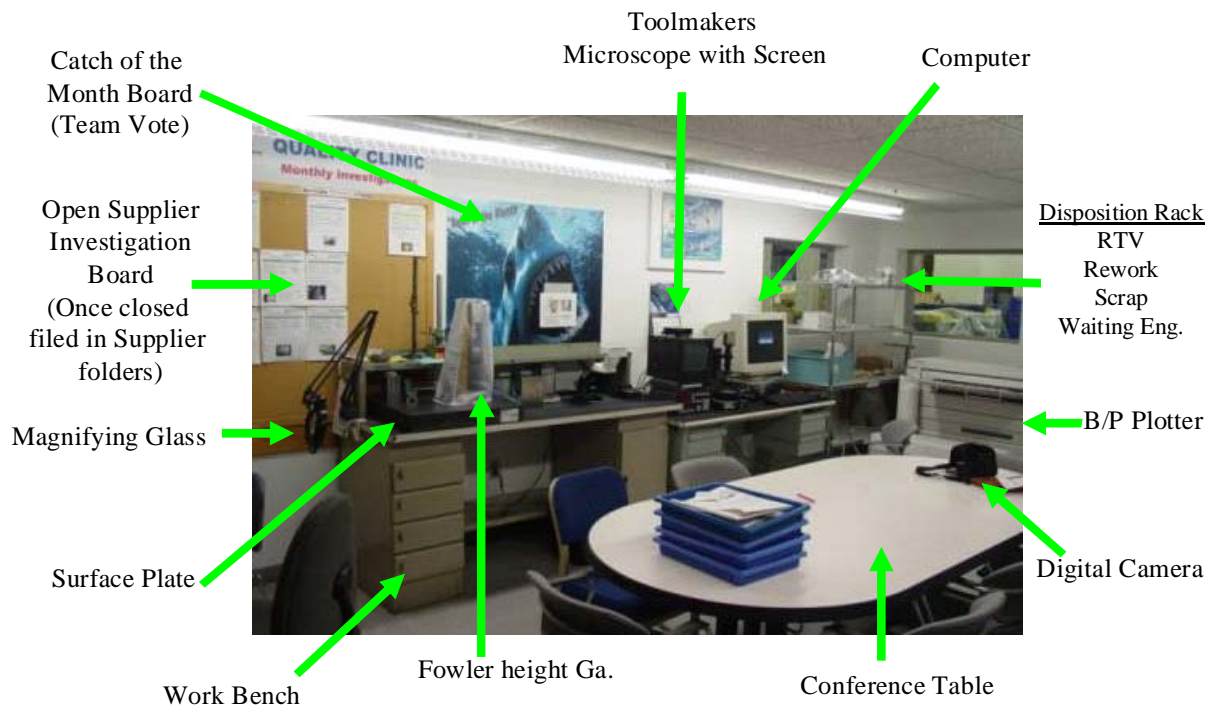


Figure 39 AMS Quality Clinic, Windsor Lock, CT. (circa 2004)
 (Source: Hamilton Sundstrand ACE Training Materials)

QCPC is commonly described as a five-step process. It begins by assembling a team of knowledgeable and involved people, who decide on specific elements of the process to be examined, map that process, from a framework for data collection, and establish criteria for how the process should be executed. The people on the team should include those working in the

process, and they are asked to generate turnbacks in the future, as they continue to do their work and perform the process.

The second step is to use either historical data, or collect new data, to analyze turnbacks. Summaries of turnback data can be made using various charting methods. The suggested preference is a hand-drawn, manually calculated defect concentration diagram to which all team members contribute. In the third step, from the overall historical data, the team should choose a focus area (component or process subsection) for Pareto charting and analysis of related turnbacks or quality problems. The focus on specific components and subsections of a process suggest improvement projects, which are then carried out. In the control plan, results continue to be monitored, by collecting turnback data and continuing charting activities, to determine if expected results are achieved. The recommended goal for QCPC activities is to set aggressive goals. The common expectation is to get an accurate baseline and then reduce turnbacks to one-half in three months and to one-tenth in nine months. A challenge in achieving these goals is recognizing that it takes time for people working in the process to develop trust in how their turnbacks are handled and confidence that they are responded to, in reporting all turnbacks that occur. Figure 40 illustrates this challenge, showing that there is a time period in which trust is built that worsens the reported turnback ratio before employees' engagement and process improvements take hold and reduce turnbacks.

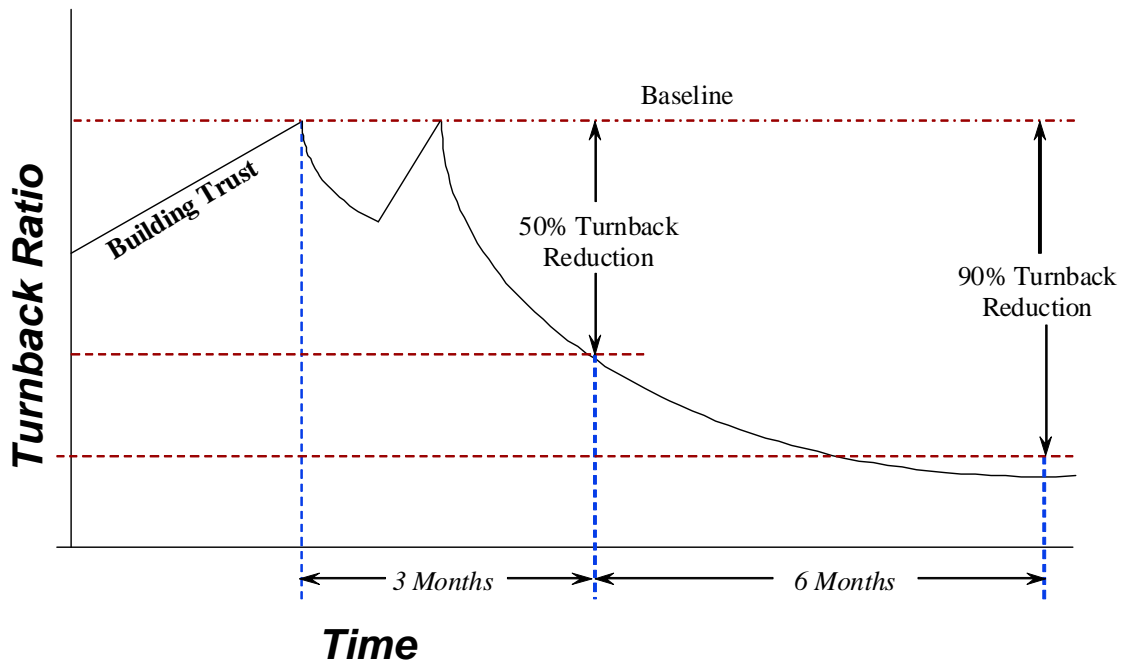


Figure 40 Expectations for QCPC improvements over time
(Source: QCPC training materials, UTC ACE internal web site)

Ito's QCPC training stresses a transition from the collection and charting of turnbacks to the brainstorming, diagnosis, and root cause analysis of problems and planning of corrective actions. That transition is in the clinic activities, which include specific requirements for managers. Ito wrote, "I wish to sound the alarm vigorously... the methods of managers... are dangerous cancer

cells in the structure of UTC's clinic activities."¹⁰⁸ In writing training materials in 1998, Ito noted that it often took a team weeks or months to examine defective parts, managers showed no concern for clinic activities and shirked their responsibilities, they were reluctant to make necessary capital investments, and clinics focused on manufacturing lines or field defects (not including parts, materials and whole product lifecycle). His suggestion was that the UTC division presidents and executive managers occasionally visit and offer encouraging words to clinic personnel.

The fourth step of the QCPC process involves implementing improvement projects. The QCPC clinic process and charting processes help identify problems, and as such is part of D (define) in the DIVE problem solving framework. A meeting involving QCPC teams, support, and staff management is recommended to identify and examine baseline process data and improvement goals, and develop, prioritize, and monitor a set of improvement projects. A regular review of these efforts helps to share trends, project status, and successful efforts. It is important to make and maintain a list of improvement projects (see Figure 41) available to everyone in the work area so that they know and can follow their progress.

CHARACT.	DEFECT	MISTAKE	ROUTE CAUSE OF MISTAKE	CORRECTIVE ACTION	PER. RESP.	TARGET DATE
032-030 DIM 08 040-030 DIM 18	SLOT TOO LONG	ELECTRODE OUT OF POSITION	TOOLHOLDER DESIGN - SPRING CLIP WORN/CRACKED/BENT	REDESIGN TOOLHOLDER (ELIMINATE SPRING CLIP) 74081T25, 74007T315, 74007T330, 74007T316	S BOHMAN TOOL ROOM	2 COMPLETE 15-JJ
045-057 DIM	SLOT OFF LOCATION	PART LOADED INCORRECTLY	FIXTURE ALLOWS MISLOCATION DIFFICULT TO LOCATE & CLAMP LOCATING POINTS NOT VISIBLE	REDESIGN FIXT. AND CLAMP ADD SPRING CLAMP PROVIDE VISUAL & FEELER GAGE ACCESS TO TO LOCATING POINT	W MARTINCK	COMPLETE
2.226-2.226 DIM 2.217-2.237 DIM	SLOT TOO SHORT	WRONG ELECTRODE LOADED IN TOOLHOLDER	TOOLHOLDER ALLOWS WRONG ELECTRODE TO BE LOADED	CHANGE BP TO ONE LENGTH SLOT - CHANGE TOOLHOLDER (SEE ITEM #1) ISSUE DEVIATION IN ADVANCE OF EC	J NELSON S BOHMAN	31-JJ 15-JJ
VISUAL	STEP IN SLOT	CRACKED ELECTRODE LOADED	UNLOADING ELECTRODES CAUSES CRACKING & BENDING	REDESIGN TOOLHOLDER TO ALLOW ELECTRODE TO RIDE UP THE BACKING & PROVIDE CLEARANCE FOR REMOVAL	S BOHMAN TOOL ROOM	31-May
110-130 DIM 130-100 DIM 235-265 DIM	TAPERED SLOT DEPTH	ELECTRODE IMPROPERLY SHARPENED	POOR DESIGN OF ELECTRODE SHARPENING GUIDE	INSTALL HOLDING DEVICE ON GUIDE	BILL GLEASON	31-JJ
030-030 DIM	MAX WIDTH OF SLOT	LOADED TWO ELECTRODES	TOOLHOLDER ALLOWS ROOM TO LOAD MORE THAN ONE ELECTRODE	REDESIGN TOOLHOLDER TO HOLD ONE ELECTRODE ONLY	S BOHMAN BILL GLEASON	COMPLETE

Figure 41 Example QCPC Project List
(Source: QCPC training materials, UTC ACE internal web site)

The fifth and final step of the QCPC method is to document improvement project outcomes, celebrate and share success, and update process standard work. Criteria for success are that problems have been mistake proofed, evidence for adverse effects on other parts or processes has been looked for but not found, a design or process change has been implemented, and the QCPC charts show trends that indicate improvement and no recurrences. The recommendation is to storyboard the improvement project so that others can reference and learn from it. As shown in

¹⁰⁸ "Ito Quality Philosophy" document, UTC ACE internal web site, by Yuzuru Ito, September 1998, pg. 54.

Figure 42, the preferred method of documenting success is a simple, visual one-page summary that identifies people involved, describes the problem, what actions were taken, results achieved, and changes to the standard process.

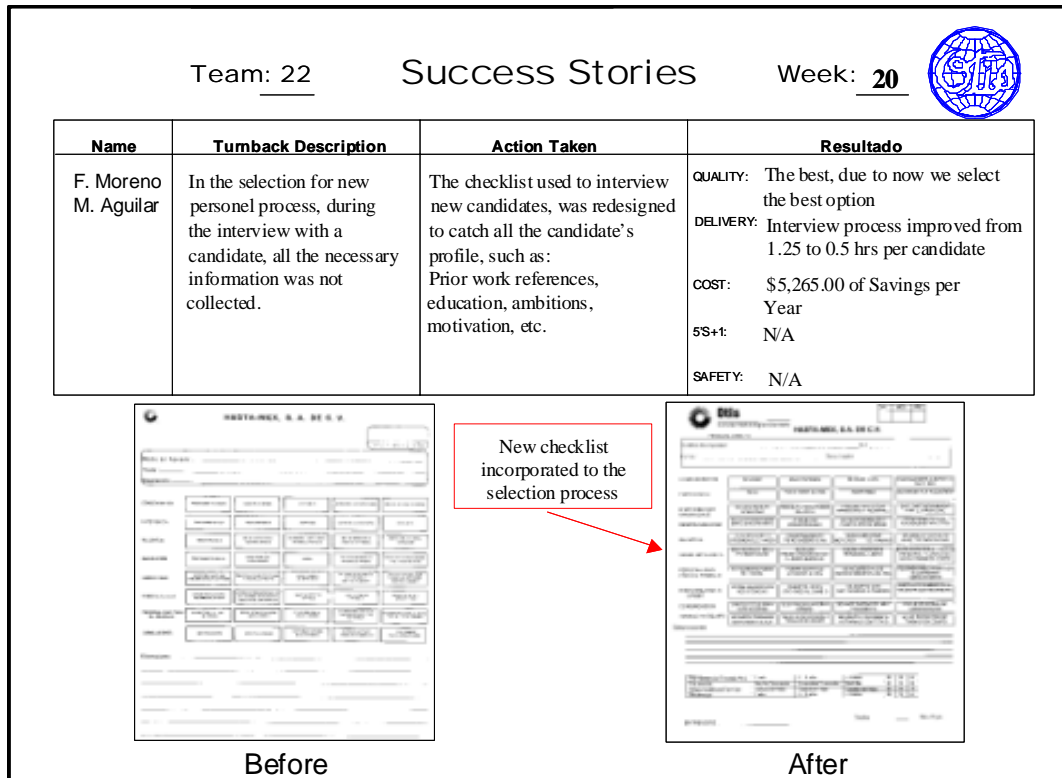


Figure 42 Example Success Storyboard from Otis improvement project

(Source: QCPC training materials, UTC ACE internal web site)

While the physical aspects of manufacturing make QCPC and turnbacks easily to see and understand, the QCPC is equally important in business processes. It might be even more important, as the following example illustrates, because in the absence of turnbacks and a QCPC process, improvements based on error-symptoms in business processes are harder to see and make. The UTC Internal Audit Department, responsible for conducting financial, information systems, and government compliance audits, created an application in its auditing software to collect turnbacks. The auditing group consisted of nearly one hundred people from of twenty-one different nationalities working across three continents. Whenever an auditor encounters something that is not as planned, he or she can quickly and easily enter a turnback. The turnbacks are collected and based on the content dispersed to one of the fifteen ACE teams. Each auditor is on at least one ACE team, and these teams use QCPC to diagnose turnbacks, take action, and follow up with submitters. Creating and using a universal turnback collection tool along with QCPC was a key factor that enabled the department's many continuous improvement achievements.

Depictions of UTC's quality model show QCPC to be central approach around which other aspects of continuous improvement. The overarching goal is to create and manage processes that produce highest quality, zero defect products and services, 100% of the time, with no delays or need for rework. Although turnbacks are not quality escapes, errors, or defects, they are impediments and indicators of future, more serious problems. As such, turnbacks are "golden nuggets or treasures," since if captured, tracked and investigated, can lead to eliminating process errors and product defects before they occur.

Relentless Root Cause Analysis (RRCA)

The third UTC ACE problem-solving tool is called Relentless Root Causes Analysis (RRCA). Root cause analysis is a class of problem solving methods that seek to identify root causes of problems or events. The basic belief, which is logically easy to understand, underlying this method is that problems are best solved by preventing or eliminating root causes, as opposed to addressing and eradicating only the obvious symptoms. RRCA is a part of the DIVE framework; it is focused on the "I" (investigate) step.

All of these provided structured methods for broadening individual thinking or engaging groups of people to develop alternative and increasingly fundamental views of problems and their source conditions. Root cause methods seek to distinguish problem symptoms from their root causes so that attention and effort are focused on what are expected to be enduring solutions. Root causes analysis is often considered to be iterative, and part of continuous improvement methods, because some problem are not solved by single solutions, or other problems may surface once one problem has been eliminated. UTC adds the adjective "relentless" to root cause to indicate the desire for a continuous, persistent, and unyielding focus on eliminating problems.

The importance of root causes analysis, identifying and correcting problems at their source, is essential to quality management. If the causes of a problem or defect are not eliminated, defects will flow out into the market even with rigorous inspections. RRCA is a method associated with Quality Clinics, and the QCPC tool. However, RRCA can be broadly applied, and is listed as an ACE tool independent of QCPC. The introduction of RRCA to UTC was as part of QCPC in the 1996 Pratt & Whitney ACE program, but was designated as a distinct method in 1998 when ACE was adopted across UTC (see Figure 29 ACE Tools Evolution).

While RRCA is a general problem-solving method, there are specific practices associated with it. Teaching on these practices, provided in UTC's ACE training, includes the use of Nominal Group Techniques, fishbone (cause-and-effect) diagrams, and the Five Why's method. Nominal Group Techniques are facilitated group methods for encouraging people's thinking about new ideas, sharing their thoughts, discussing them, and voting and ranking to come to group consensus and action.¹⁰⁹ Fishbone diagrams, also called cause-and-effect diagrams, are a structured technique to consider a broad range of possible causes of problems. The problem or effect is listed on the right side of the diagram, and symptoms related to these areas are listed on

¹⁰⁹ Many books include descriptions of Nominal Group Techniques; academic references on this topic include A. Van de Ven and A. Delbecq (1974). "The Effectiveness of Nominal, Delphi, and Interacting Group Decision Making Processes," *Academy of Management Journal*, Vol. 17, No. 4 (Dec., 1974), pp. 605-621 and J. Bartunek, and J. Murnighan (1984). "The nominal group technique: Expanding the basic procedure and underlying assumptions," *Group and Organization Studies*, Vol. 9, pp. 417-432.

the diagram's branches: people, methods, measurement, machines/equipment/systems, materials/information, and environment.

A simple fishbone diagram for causes of poor gas mileage is shown Figure 43. This diagram lets a group develop and discuss alternatives, and determine possible root symptoms. Five Why's analyses helps the group delve more deeply into symptoms. A Five Why's should be conducted on key symptoms to determine possible root causes. In the diagram (Figure 43) the team has circled "Poor Maintenance" for further investigation. Most problems, however, have multiple root causes and do not happen in isolation.

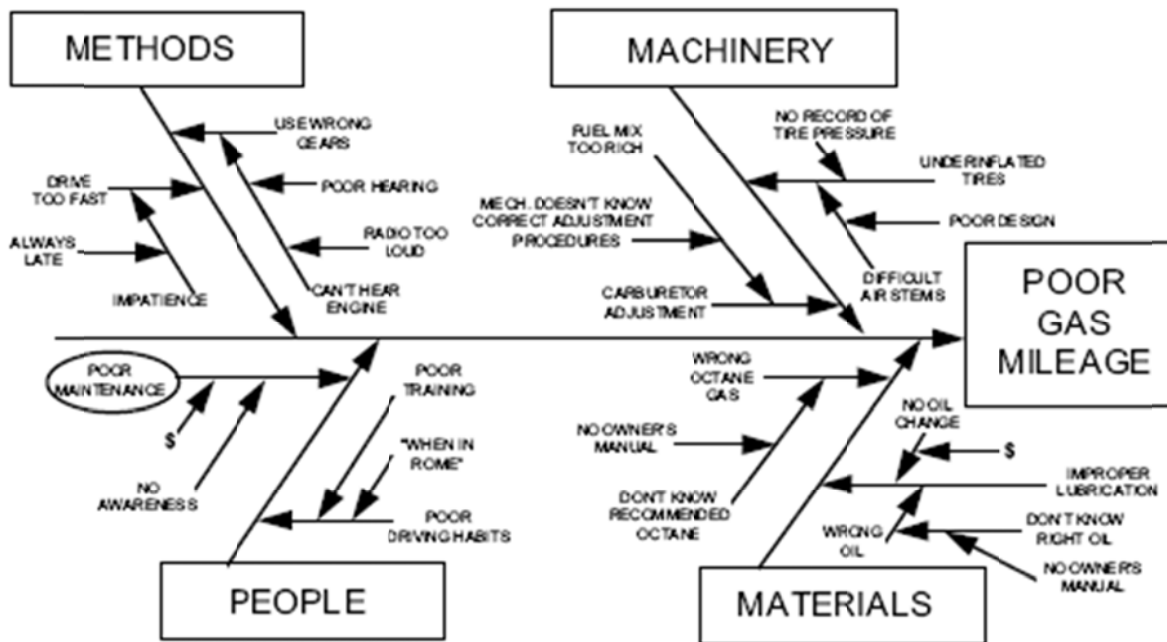


Figure 43. Sample Fishbone (cause-and-effect) Diagram
 (Source: RRCA Training Materials, UTC ACE web site)

Five Why's Analysis involves a team investigating problems and identifying root causes. It uses a visual method for structuring and considering alternative problem sources (see Figure 4). The basic method involves asking, "Why did this occur?" That question is repeated, "Why did that occur?" for the explanation. The general rule is that there are three to five levels of "why's" need to get from the original symptom experienced from the problem to an underlying root cause that can be controlled or eradicated. The "why" question can be modified to "what proof do you have," or "is there any other explanation" to surface alternative causes. The number of "why's" depends upon the problem, but the process is the same, i.e., to keep asking "why" until a fundamental problem is identified against which to take corrective action.

All of the root-cause analysis and corrective action techniques are intended to stimulate thinking and investigation of possible causes of problems as a prerequisite to developing and choosing preventative ("mistake-proofed") actions.

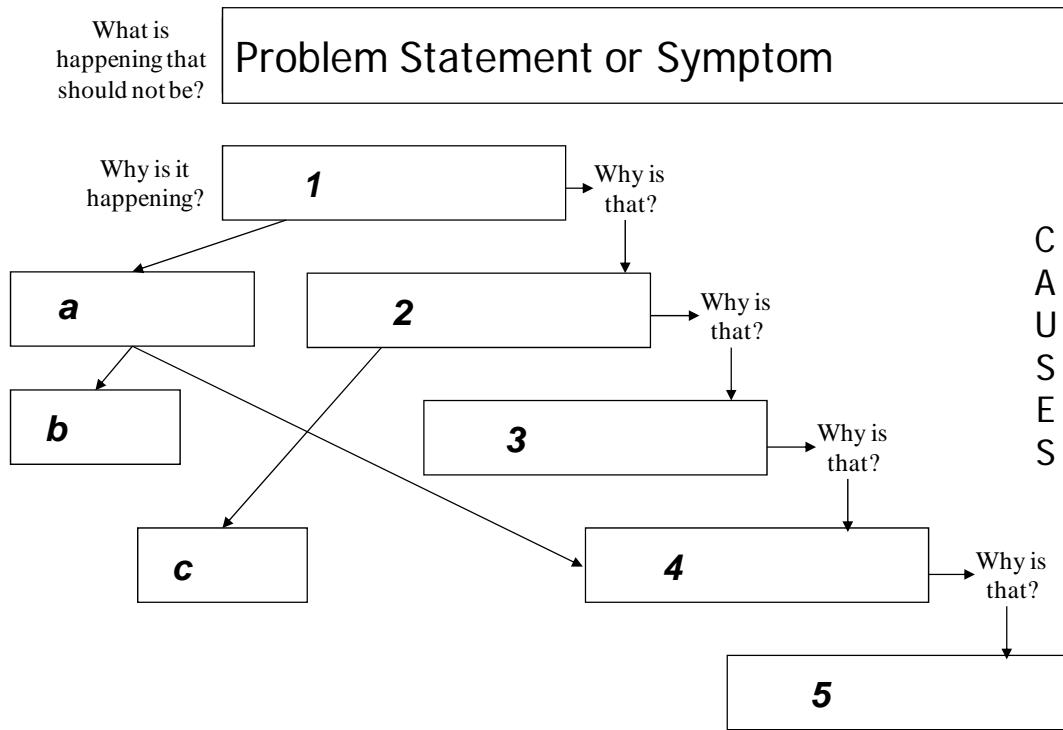


Figure 4 Sample Diagram for Five Why's Analysis
 (Source: modified from RRCA Training Materials, UTC ACE web site)

Mistake Proofing

The outcome of problem-solving methods are identifying and taking preventative actions to create a defect-free process. Within UTC's ACE operating system and framing problem-solving in the DIVE approach, MFA, QCPC and RRCA methods focus on Define and Investigate. The Mistaking Proofing (MP) methods focus on Verify and Ensure. The philosophy of Mistake Proofing is that errors will occur, but it is possible to design tasks, processes, products and people's attitudes to prevent errors. The goal of Mistake Proofing, as stated in its ACE tools documentation, is to use "wisdom and ingenuity to create devices which allow people to do their jobs 100% defect free, 100% of the time."¹¹⁰ Like other ACE methods, this improvement effort is made involving people doing related work, in groups, brainstorming ideas, choosing a preferred preventative action, and carrying out an improvement project to implement changes and monitor results. The basic process and steps in Mistaking Proofing are shown in Figure 45.

UTC defines three levels of mistake proofing. The first level is to find and stop the error after a process has been completed, and keep the defect from reaching the customer or affecting the products and processes that follow it. The second level is to detect and correct the problem during the process, thus producing products or services without errors. The third level, and most desirable mistake proofing action, is to prevent the error at its source. This solution creates physical or logical changes in processes so that identified errors can not be made. An example of mistake proofing at the source is to design components so that they can only fit together in one

¹¹⁰ "Mistake Proofing" description document, ACE problem-solving tool descriptions, UTC ACE internal web site.

way, eliminating assembly errors. Another example is automatically calculating fields in a spread sheet to avoid manual input errors.

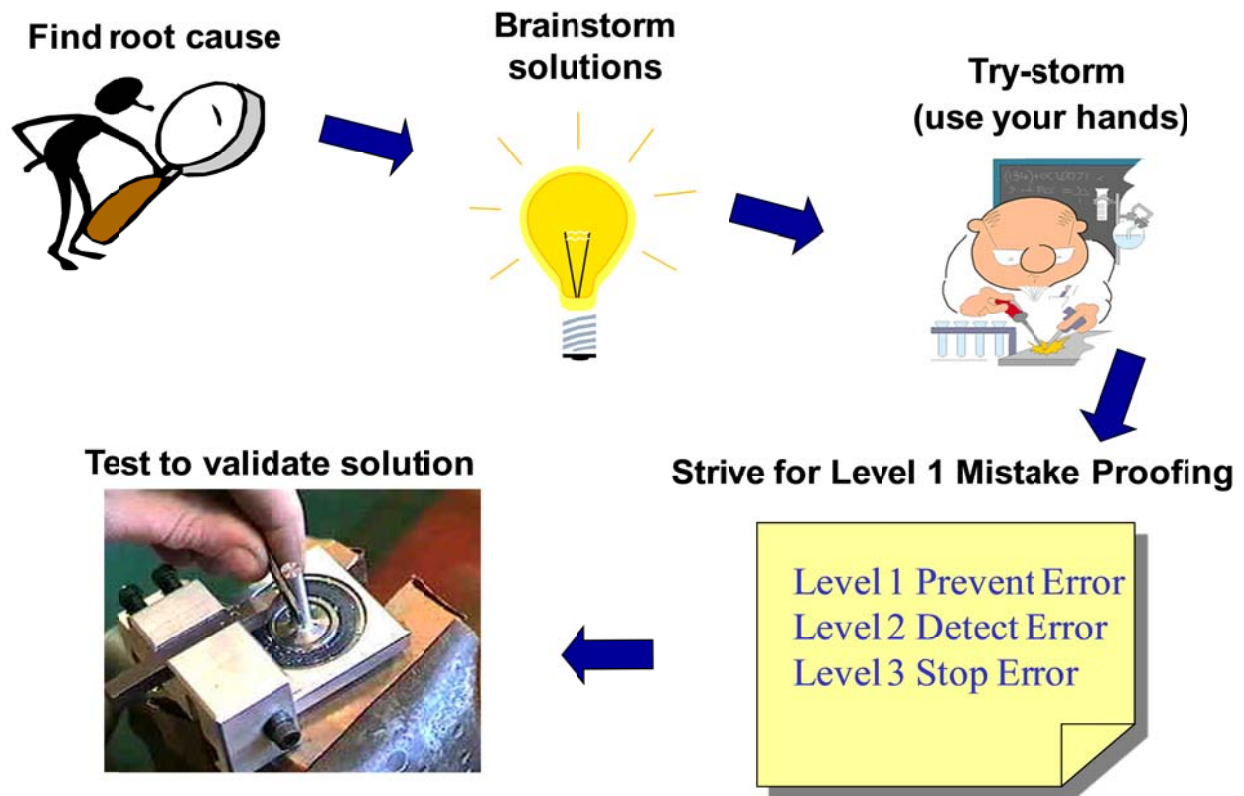


Figure 45 Overview of Mistake Proofing Method

(Source: Mistaking Proofing description, UTC ACE web site; figure was modified to remove confidential pictures)

The mistake proofing method begins by categorizing defect causes, such as mistakes from omissions, processing, tool and fixture set up, missing items, and wrong parts. These defect categories are critically assessed by team members, alternative mistake proofing options are physically tested and evaluated using prototypes, and a solution is chosen, implemented and validated. Mistake Proofing is a method UTC adopted from benchmarking quality practices, and was one of the seven tools when Pratt & Whitney first launched ACE. It is very similar to a method developed by Japanese companies called “poka-yoke,” which is a Japanese term for mistake proofing. A poka-yoke device is any mechanism that either prevents a mistake from being made or makes the mistake obvious at a glance.¹¹¹

The ACE guidelines for implementing a mistake proofing device conform to all of the following seven attributes: does not hinder the operator, makes corrective action irreversible, is simple to use, easy to install, easy to maintain, durable, and done at minimal, usually less than \$500 in cost. As

¹¹¹ References for this method include Shigeo Shingo (1986) Zero quality control: source inspection and the poka-yoke system. Portland, Oregon: Productivity Press, and Nikkan Kogyo Shimbum (1989) Poka-Yoke: Improving Product Quality by Preventing Defects, Portland, Oregon: Productivity Press.

with other corrective actions, Mistake Proofing methods should conclude with documenting the new process, updating standard work to include best practices and lessons learned, documenting the success story, and recognizing and rewarding contributors.

Decision Making

The third of the three categories of ACE tools is methods that support group decision-making. An element of the ACE operating system is to ensure smart and timely decisions. There is one ACE tool, the Passport review process, which is used to facilitate an organization's strategic decision-making. Passport is explained in the section that follows.

The ACE web site describes three categories of tools and methods that are appropriate for facilitating organization decision-making, and the implementation of decisions. All of these methods help develop the thinking and commitment that come from a planning process, and help in the execution or deployment of those plans. These methods are common industry practices that are available in books, courses, and from consulting organizations. The three subcategories of decision-making tools noted are policy deployment, program management, and portfolio management.

Policy deployment is a terminology and planning methodology associated with lean production methods. *Hoshin kanri*, the Japanese words for policy deployment, starts with high-level objectives and cascades these objectives to every function in the organization. It involves a give and take communication process between high and middle level management in the process of translating executive level, strategic objectives into specific actions tied to quantifiable metrics at operator levels. *Hoshin kanri*, as practiced at Toyota, empowers workers in the context of an organization's strategic direction; it is "a system that encourages employees to analyze situations, create plans for improvement, conduct performance checks, and take appropriate actions."¹¹² A common tool associated with policy deployment is the "X-matrix." The X-matrix is a large sheet on which explicit linkages are made among strategies, tactics, processes, and results (the measure of strategies is in financial targets or results, and results are produced by improving processes, and tactics, or improvement projects, that link to strategies improve processes). This matrix helps executives communicate, test, and clarify its thinking for the linkage between performance targets and improvement projects. Other methods for policy deployment include tree diagrams (diagram with probability of getting specific results based on set of activities), quality function deployment (method for identifying and translating customer wants and needs into the technical characteristics of a product or service), and roadmaps (method for developing and communicating strategic direction, see roadmap description in ACE operating system alignment section).

Program management involves methodologies to make and execute decisions in the context of managing a development or production program. It often involves methods and tools for managing multiple ongoing inter-dependent projects and activities, and is a layer above project management by defining constituent projects and providing an infrastructure through which projects are run by project manager and project management methods. In government contracts, Earned Value Management is a form of program management used to measure and reward

¹¹² Jeff Liker (2004) [The Toyota Way](#), page 219.

progress by combining technical, schedule, and cost performance measurements into an integrated methodology. Critical path management, Program Evaluation and Review Technique (PERT), resource management, time estimation, scope management, and program reviews are other methods associated with program management. UTC has developed, through a Program Management Steering Committee working as an offshoot of the UTC Technical Council, a program management book to provide guidelines and standards to which each division should add its own specifications and needed details. In view of the importance of program management, UTC has formed a Program Management Council.

Portfolio management is related to program management in that sets of activities are considered in combination, particularly with respect to the availability of critical resources. Impact Maturity Analysis (linking an organization's key objectives and critical-to-quality objectives to assessments of its processes and their maturity) and Pareto Charts are examples of portfolio management tools for the "portfolio" or set of process improvement opportunities. Most organizations will identify more opportunities for improvement projects, and hence need to use methods to prioritize their efforts based on the expected outcomes of improvement activities, the resources that can be delegated to improvement efforts while maintaining business performance, and the sequencing of activities so that they build upon one another and yield cumulative results.

Passport Process

The Passport Process is UTC's name for its phase-gate review process. Phase-gate, or stage-gate, review processes are disciplined activities that are part of developing a project, process, or service. At each stage in a development there are checkpoints, or gates, that are defined in terms of what information is needed and reviewed to make decisions to continue, stop, or redirect (obtain additional information and repeat the review). These reviews are generally meetings that involve people from all phases of a product's life cycle – from research and development, marketing, sales, product development, manufacturing, quality, distribution and logistics, and customer support – as well as from corporate functions – executive and general management, engineering and finance. Passport was first introduced and used in UTC by Ito at Nippon Otis. The process was detailed and lengthy, and received only sporadic use. This Passport process was extensively redesigned with the help of the PRTM consultants working with Pratt & Whitney in 1999 and 2000.

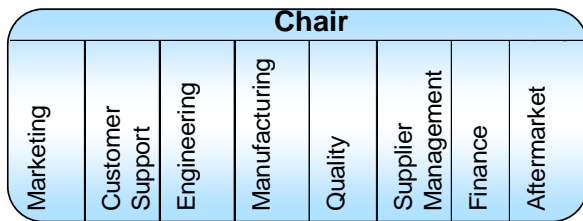
A stage-gated approach used by many organizations to create a structured and disciplined process for developing new products and services that allows them to allocate resources and manage risk. One of the benefits of the review at each phase is that it provides opportunities for people and groups that are not involved in the day-to-day development activities to provide input and give feedback to development plans. Also, by establishing what information is needed at each phase review, the company manages its risk in terms of moving forward and expending resources to develop a product or service without all needed information relative to product, technology, market, or customer risks.

The importance of a good phase review decision-making process is illustrated in Pratt & Whitney's Airbus A318 engine development. Pratt & Whitney experienced significant market share and financial losses with its PW6000 turbofan jet engine as airlines ordered the alternative CFM56 engine (made by CFM International, a joint venture between the French Snecma and US General Electric companies). In 1999, well into its development and test of the PW6000 engine,

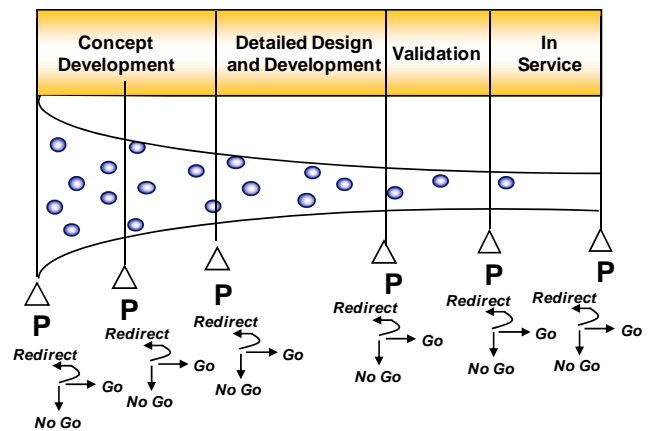
Pratt & Whitney's five-stage compressor design failed to meet fuel burn expectations. A key attribute of jet engines for commercial airlines is fuel efficiency; producing an engine that did not meet fuel economy would have meant paying penalties to airlines. To recover, Pratt & Whitney bought a six-stage compressor from MTU Aero Engines and recertified the new design. This process cost hundreds of millions of dollars and four years in time to market for PW6000 engines. The compressor design failure so late in the development process was attributed to a lack of discipline in decision-making in the product development process. This situation led to changes in Pratt & Whitney's engineering management, and an emphasis on their Passport process.

The Passport process provides a governance function, defining who is empowered to make what decisions and what information is needed at each development stage. Clarity for what decisions are made at each stage enables development teams to move forward confidently and gives executives and functional managers opportunities to monitor progress and the overall resources and risk in an organization's product portfolio. These four main phases of the ACE Passport Process are shown in Figure 46.

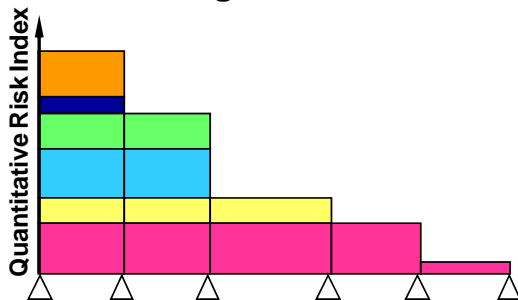
1. Governance structure (Passport Review Board)



2. Disciplined phase review process



3. Risk-management focus



4. Phase-by-phase empowerment of Program Team

- Allocation of funds for next phase only
- Clear contract (win-win agreement for next phase)

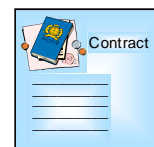


Figure 46 Overview of Passport Decision-Making Process
 (Source: Passport Process, Version 5.3, circa 2003, UTC ACE web site)

The Passport Process involves senior leaders throughout the lifecycle of a program and is intended to be a source of help to program managers. At each review, senior leaders and program manager focus on progress, or how well they are executing their plan, and whether they are working on the right plan or program given the market, environment and customer conditions. For product and program development, reviews are mandated at key life cycle phases: market opportunity analysis, concept development, detailed design and development, production validation, and in service. Each UTC division has discretion to add additional review phases. As each review phase is completed, there is more information and greater certainty about the product or program. Quantitative calculations of risk are made for projects, and reduction is expected with each review phase, and is shown as a waterfall chart (“Risk-management focus”) in Figure 46.

Each Passport phase is to have well-defined inputs, decision criteria, and outputs. The outputs are the decisions, and any follow up action. A Passport review phase is concluded with the Passport Review Board choosing one of three options: Go (continue to the next phase of development); Redirect (obtain additional information that the Passport Review Board needs to see before it can make a decision); or No-Go (stop the program because it is no longer viable or a better opportunity has surfaced). The Passport Review Board consists of a management chair and representatives from marketing, finance, engineering, manufacturing, aftermarket, quality and service organizations at local, regional, or corporate levels, depending on the complexity and scope of the product or program. Organizations that use Passport reviews extensively, schedule review days as standing meetings for its review board members.

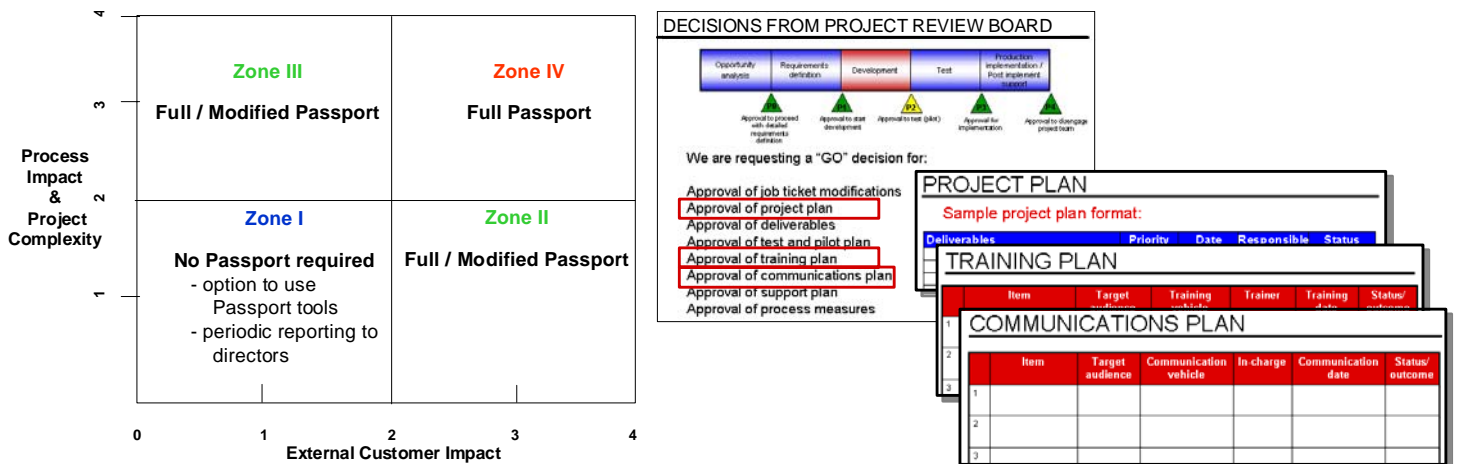


Figure 47 Internal Audit Department Passport Process
(Source: IAD 2005 Passport Process Presentation)

With these general guidelines, the Passport Process, including the people on the review board, review phases, and information required at each phase, is adjusted and scaled to the program or product being considered. For example, the Passport Process detail is different for a five year, multi-billion dollar jet engine development program at Pratt & Whitney than a several month long team improvement project for the annual planning process at the Internal Audit Department. The Internal Audit Department modified the Passport Process defined by Pratt & Whitney to use for its management of ACE projects, making explicit who is on the review board, which projects

required Passport reviews based on impact and complexity, and what decisions are made at each phase (see Figure 47). While the details and complexity vary, in each case the overall Passport Process includes the basic elements – a review board, defined information requirements, and go/no-go decisions.

UTC’s Passport process and reviews follow from the development of a concept into a product or service. There are also defined processes and approaches for business and technology planning that examines and develops new product and service opportunities. As UTC’s business planning processes develop concepts for future products and services, the Passport planning and review process coordinates the development, production, delivery, and servicing of those products and services (see Figure 48).

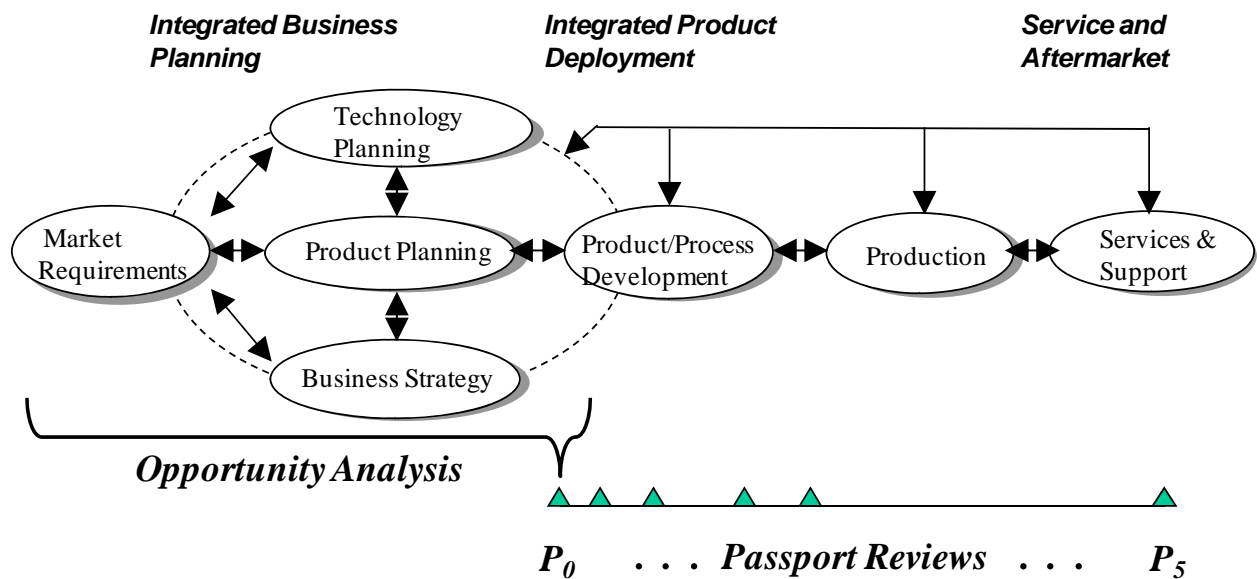


Figure 48 UTC Business Planning linked to Passport Process

Appendix C Enabling Global Value Creation

Global businesses gain advantages by using unique resources in foreign locations – access to raw materials, low labor rates, and specialized skills – and integrate them into their operations. A challenge for a global business is managing entities in different countries, particularly when trying to optimize ongoing improvement and change across many organizations. UTC ACE Director John Papadopoulos repeatedly emphasized the importance of ACE as the enabling framework for a global business, providing common operating methods, essentially a common language, for all UTC sites in all countries across the world. Visiting any UTC facility would reveal common methods, and along with those methods, sites that achieved and sustained superior results. Short visits to two foreign sites provided an opportunity see ACE in its international application.

Industrial Pumps¹¹³

Located in a small town in Germany, Industrial Pumps is a maker of specialized sanitary process pumps for food, beverage, and cosmetic industries. Whole strawberries can be moved through its positive displacement pumps with little or no damage to the fruit. Industrial Pumps manufactures pumps at this factory and distributes them from this location throughout the world. Industrial Pumps achieved ACE Gold site certification in July 2007. In the process of stepping through ACE Bronze, Silver and then Gold certifications, Industrial Pumps changed its business model and transformed itself. These business model changes were neither intended nor foreseen when Industrial Pumps' leaders adopted ACE. Rather, they had set out to ensure their own survival by embracing a corporate program, ACE, promoted by their American parent. This case describes the significant changes that took place at Industrial Pumps.

Industrial Pumps was founded in the 1960s based on the development of a new pump technology for processing crushed grapes, including stems and branches, for winemaking industries. In the next several decades, the company created other specialized pumps capable of moving fragile solids and liquids for the food, beverage, cosmetic, pharmaceutical and chemical industries. Industrial Pumps uses sinusoidal or planetary rotor technologies enabling them to be easily flushed, cleaned and sterilized. Its product offering consists of four lines pumps, based on different technologies, each offered in several size variations. If the adapter options to fit the pumps into their processing lines are included, there are 71,000 variations in Industrial Pumps' products. The company has about 150 employees. It shipped thousands of products in 2006 to more than 700 customer locations. Industrial Pumps' products are more expensive those of its competitors, but they are higher quality and have greater reliability.

In 1998, Sundstrand Corporation acquired Industrial Pumps. Sundstrand Corporation designs, manufactures and supports industrial pumps and compressors. The new parent gave Industrial Pumps worldwide distribution for its products. In 1999, Industrial Pumps became a UTC company when Sundstrand Corporation was acquired and merged into UTC to create Hamilton Sundstrand. Although UTC provided Industrial Pumps with access to global distribution and service, it also presented a new challenge for its management. Becoming part of a large

¹¹³ The identity of the company visited has been changed to the pseudonym "Industrial Pumps." All of the materials provided in this sort summary are slightly disguised as this company has since been sold by UTC, and the identity of the company is not as important as the details of their ACE efforts.

industrial conglomerate brought new requirements for how Industrial Pumps operated and improved. Industrial Pumps is not a supplier to other UTC operations, and its managers are concerned that they are remote, and neither significant in their size or strategy for their corporate parent. It is important that Industrial Pumps perform well to maintain its corporate affiliation.

To demonstrate Industrial Pumps' abilities, and establish its reputation as a well-performing, desirable subsidiary, General Manager determined that it would excel in the application of ACE. He based his approach on a concern that Industrial Pumps was in a tenuous position as a subsidiary in UTC, being remote and unrelated to aerospace. He wanted to be consistent with UTC executives' requirement that every site implement ACE. As a small company "you could find a thousand excuses why a corporate program would not fit your business," said the General Manager, but you could also take the approach to be determined to make it work. He was determined to make it work, personally embracing ACE and setting an example to his managers that adopting ACE would benefit and improve Industrial Pumps' operations. It was initially difficult, in part because they had to get over their initial negative reaction to being told that they "had to do ACE," and shift their mind-sets to "showing that we could do this well."

Their strong operational performance results lead to a change in their business model. Industrial Pumps began learning ACE in October 2001, met ACE qualifying criteria in October 2002, and were certified ACE Bronze in October 2003, ACE Silver in June 2005, and ACE Gold in July 2007. When I visited Industrial Pumps in May 2007, their inventory turnover ratio was the highest of all companies in Hamilton Sundstrand's industrial products group. The annual cost of poor quality was less than 0.05% of sales, and their return on sales almost three times greater their industry's average.¹¹⁴ Most importantly, their delivery time has gone from 38 days to 1 day. This change in delivery time is what has transformed their business.

As part of its ACE activities, Industrial Pumps conducted a value stream mapping of its pump production processes. These value stream improvement projects started in July 2003 with a mapping exercise that reduced delivery lead times to 30 days from what had been 38 days. That 2003 mapping project identified a future state with 10 days lead-time. As a part of on-going improvement projects, in September 2004, Industrial Pumps purchased a new flexible machine that enabled it to achieve a 20-day delivery lead-time reduction. They then introduced flow assembly techniques to replace bench assembly methods to reduce lead-time to five days in December 2005. By developing a parts supermarket and maintaining a stock of subassemblies for each of the four pump lines, Industrial Pumps was able to assemble and ship standard pumps in one day from receipt of order. Industrial Pumps is continuing its improvement efforts by undertaking value stream mapping and improvement efforts with its suppliers and subcontractors. A unique capability that Industrial Pumps has is its application expertise and tailoring pumps to customers' specifications, which takes place in assembly operations. To focus on its uniqueness, Industrial Pumps shifted who does what work. Industrial Pumps no longer does machining of stainless steel stock, but has its suppliers do that basic machining. In the process of moving work to subcontractors, they have transferred people that worked for Industrial Pumps to those suppliers. Industrial Pumps also integrated work that other

¹¹⁴ Industrial Pumps operational and financial information are not publicly reported and specific figures, while made available and reviewed for this study, are UTC proprietary.

subcontractors previously did into their processes, focusing on final preparation and assembly of electrical and agitator pump parts.

The ability to ship pumps quickly transformed its business, because it can now provide for factories whose pumps failed and need replacing. A factory could not wait for the higher reliability Industrial Pumps when a production pump failed, and hence Industrial Pumps was only able to sell pumps for planned upgrades and changes, or new production lines. It was easy to make a business case for a higher priced, higher reliability pump when a lower quality pump had failed and stopped production. With its access to quick replacement industrial pump applications, Industrial Pumps began growing its volume at double-digit rates.

Business changes resulted from efforts to achieve ACE certification, sending people to Ito University, and using ACE tools in improvement projects – using value stream analysis, market feedback analysis, process certification, 5S visual workplace, standard work, set up reduction, production preparation process, QCPC, TPM, root cause analysis, and mistake proofing. In addition to its business performance, other measures associated with ACE certification improved. Industrial Pumps' customer satisfaction scores were high (6.38 on a scale of 1 to 7), they had no lost-time injuries in the last seven years, and their employee satisfaction scores were good (3.2 on a scale of 1 to 4).

Chengdu Aerotech

Does ACE translate into Chinese? ACE can be literally translated, as the Chinese characters in Figure 49 shows. Chengdu Aerotech is the first joint venture with majority ownership by a western corporation in China. The company was registered in 1996. It completed its new facility construction and began operations in 1998. The initial multi-million dollar investment was made by Pratt & Whitney (50.5%), Chengdu Engine Group (39.5%), and Aviation Industries of China (10%). These three companies established a new 9,000 square meter air-conditioned manufacturing facility that could employ over 300 people. The manufacturing equipment includes computer controlled machining devices, forming and welding machines, vacuum furnaces, plasma spray furnace, and non-destructive test and inspection equipment. The products are complex, precision metal parts, such as jet engines combustors, compressor disks, and stator, bearing, and shroud assemblies. The customers are Pratt & Whitney Aircraft, Pratt & Whitney Canada, and Hamilton Sundstrand. Production is organized by cells that are dedicated to specific product sets, specialized operations, or customers. Chengdu Aerotech's ongoing improvement efforts started with cells certified as ACE Qualifying in May 1999, with some ACE Bronze cells in June 2001, and some ACE Silver cells in December 2002. The general manager and his management team were Pratt & Whitney American expatriates, and the workforce was made up of local Chinese people.



Figure 49 ACE at Chengdu Aerotech¹¹⁵

Chengdu Aerotech's sales grew by a factor of ten from 1998 to 2001. While revenues increased, instead of losses declining, they continued to rise. In 2003, Pratt & Whitney faced a difficult situation. Continued and increasing losses made Chengdu Aerotech a questionable operation. All its customers had voiced significant concerns: for Pratt & Whitney it was quality problems, for Pratt & Whitney Canada it was delivery issues, and for Hamilton Sundstrand it was delivery and development time performance. Chengdu Aerotech's cost of poor quality was very high (the cost of its scrap was a significant percent of its sales volume). There were balance sheet problems for the joint venture partners; Chengdu Aerotech's liabilities exceeded its assets and it had accumulated significant debt. To stay in business, the company had to mortgage all its remaining assets.

Powerful political partners had stakes in this joint venture company. Chengdu Aerotech was founded after the 1995 visit by George David, who was the UTC CEO at that time, to Chengdu, China. The Chinese government had organized children waving American flags along the route that David traveled from the airport to the city. The government had plans to expand its Russian joint venture aerospace business in Shenyang, and planned to develop airframe and jet engine industries in Chengdu. Chengdu is a city of approximately 11 million people, and the capital of the Sichuan province in western China. Closing Chengdu Aerotech would create political implications its owners.

In 2003, the business crisis was addressed by restructuring Chengdu Aerotech. UTC injected additional cash, increased its ownership stake, and sent in a new general manager. That general manager was Lien Jing Chen, called "LJ," a Chinese American from Pratt & Whitney. Chen was born in China and came to the United States as a graduate student to earn a PhD degree. Since graduating, he had worked in UTC for 17 years. He began his career in UTC's research labs, and then became a business unit manager for the F119 JSF engine. He later became the operations manager for UTC's fuel cell business, where he transferred a research technology to commercial applications. The promotion to Chengdu Aerotech's general manager gave Chen full business responsibility. His first task was to determine whether this joint venture could become profitable; if not, it was his responsibility to close it.

¹¹⁵ source: Chengdu Aerotech web site, www.aerotechjv.com

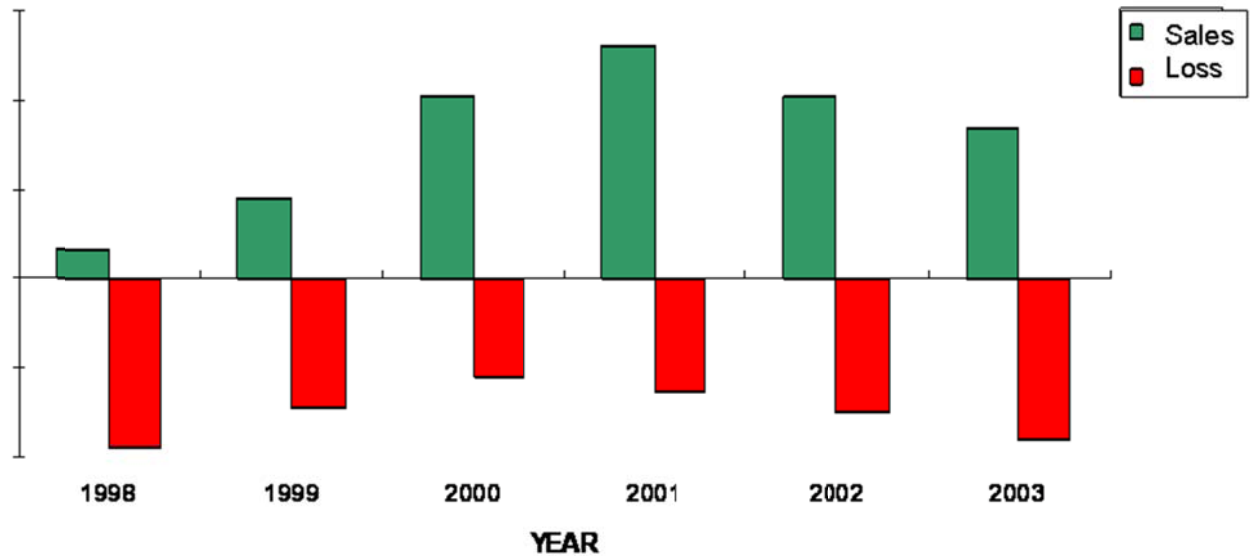


Figure 50 Chengdu Aerotech Financial Summary, 1998 to 2003
 (Source: Chengdu Aerotech Presentation, September 12, 2007)

To address customers' complaints, Chen put together strategies and action plans to improve delivery (using master schedule, daily production meetings, and addressing late parts), create perfect quality (address top issues, reduce scrap, and certify processes), lessen development time (using project management planning and value stream mapping), and reduce costs (involve workers, reduce consumables, energy usage, materials costs). These goals were not new to Chengdu Aerotech's workforce; each of the previous general managers had proposed similar efforts. The workforce was skeptical of Chen's efforts when he started. Chen's strategy was to use ACE, and build from the successes he had seen in Pratt & Whitney's North Berwick plant. Chengdu Aerotech employees began using ACE methods in 1999, improving cells, and had certified all cells as either ACE Bronze or Silver in December 2002. Employees, however, had concluded that ACE created busy work.

Initially Chen did not use the term ACE, but he did use its tools. Root causes analysis was used to identify what could be done to improve delivery and quality performance. Improvement projects, using Passport as a decision-making method for prioritizing improvement efforts, focused on identify and certifying key production processes so that they produced perfect quality. Quality standards and the frequency for product inspection were clearly specified. An owner, who would develop and follow up on a maintenance schedule, was assigned to every piece of equipment in the plant. Many of the production machines were from UTC's United States factories and efforts were organized to consistently paint, clean, and maintain them. Upgrades were also made - one *kaizen* and follow on project modified a 4-axis milling machine into a 5-axis machine. Safety improvements, and engaging workers to identify hazards, were made priorities. Everyone was involved in some improvement activity: making toolboxes, painting, or improving the workplace and machines, or internal benchmarking. The result was a visible change in the physical appearance and lay out of the factory, as can be seen in Figure 51.



Before



After

Figure 51 Visual Changes in Chengdu Aerotech Production Facility

Chen adopted an organizational philosophy and slogan to think of the “company as my home.” This concept asked workers to consider a “my home” attitude in their decisions, asking them to think and act as if they were the owners. The goal was mutual respect and support between the organization and its workers, striving for win-win outcomes for company and employees. Often missing in this approach, Chen noted, is what the company does for its employees. His approach was simple and straightforward; if an employee had difficulties, the company would help him or her. Examples of company help included medical, financial, or housing issues.

A challenge to create improvement at Chengdu was, as Chen said, “a cultural issue.” Workers expected centralized management and direction, and were not accustomed to a Western style “take the ball and run with it” management approach. From its inception, the general manager and his staff were all expatriates, who struggled in directing and motivating the local Chinese workforce. Chen deployed standard work, which specified what was expected of each person in each role in order to engage and empower workers. His goals were that every employee knows at the start of every day what his or her job is, that there is a clear standard for performing that job, and that each employee gets regular feedback on his or her performance. Chen required managers and supervisors to provide greater feedback to each employee on at least a monthly basis, and tied that feedback requirement to his or her performance bonus. He gradually replaced all but one of the expatriate managers with Chinese managers. Performance expectations based on standard hours for each part were established, and goals were set that each employee average seven of their eight shift hours on production tasks. This clarification of goals, work, and performance expectations helped guide employees in performing multiple jobs simultaneously and with assisting one another when there were problems or slowdowns.

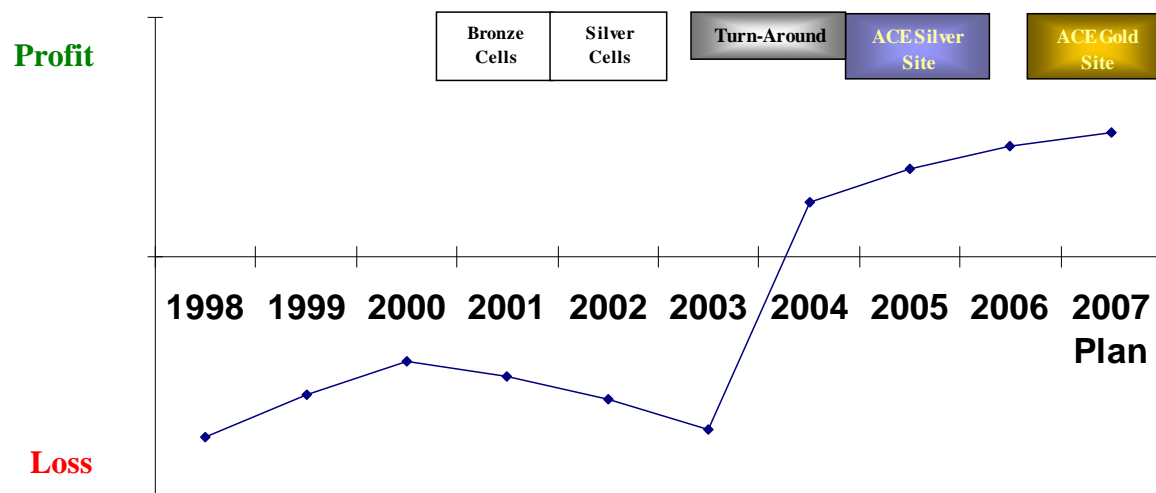


Figure 52 Timeline of Chengdu Aerotech’s Profit and ACE Achievements
 (Source: Chengdu Aerotech Presentation)

Chen began leading improvement efforts in November 2003, and in March 2004 Chengdu Aerotech had its first profitable month. The company has remained profitable, month after month, since then. With financial and operational viability, efforts focused on achieving better performance standards. ACE Gold provided a process and criteria for achieving world-class levels. Employees did not initially understand what was meant by ACE Gold performance levels. Chen sent groups, first managers, then supervisors, and later operators to visit ACE Gold site in Singapore. What they saw inspired Chengdu Aerotech’s efforts, and provided an understanding of what achieving ACE Gold would provide. As Figure 52 shows, the turnaround effort, achievement of ACE Silver and later ACE Gold correlated with Chengdu Aerotech moving its financial performance from a net loss to profitability.

Metric	Date	Nov. 2003 (ACE Bronze)	July 2007 (ACE Gold)
Revenue		~	388% increase
Financial Results (Return on Sales)		(negative)	double-digit return
Customer Satisfaction (7pt scale)		4.4	6.2
On-time Delivery		~	34% improvement to 98% on time
Quality (Scrap/Sale (%))		~	1600% decrease ? HAVE SUPPORT for 92% decrease
Employee Favorability Rating		52%	73%
EH&S (Total Recordable Incident Rate)		1.23	0

Table 8 Chengdu Aerotech Improvement Measures, 2003 to 2007 ¹¹⁶
 (Source: Aug. 26, 2008 Chengdu Aerotech Presentation)

Chengdu Aerotech achieved ACE Silver site certification in December 2005 and ACE Gold site certification in July 2007. In May 2007, it was recognized as one of three UTC sites with over 1,000,000 man-hours without a lost time injury. Changes from a 2003 baseline, when ACE Bronze measures were taken, show improvements across multiple dimensions that are all of significant magnitude (see Table 8). The results provide the credibility needed to support Chengdu Aerotech’s future growth plans. They expected to grow sales 800% by 2012, with a tripling of employees and the building of a new facility that more than doubles their manufacturing space. The ACE Gold site certification gives other UTC businesses confidence in Chengdu Aerotech’s cost, quality and delivery, which will help it to achieve its growth plans.

ACE in the international realm

The visits to Industrial Pumps and Chengdu Aerotech confirmed an applicability and usefulness of ACE tools and methods in foreign sites. Similarly, case studies conducted with MIT colleagues at the Homogeneous Metals Incorporated production facility in Clayville, New York; Internal Audit Division in Farmington, Connecticut; Military Engines Customer Services Group in East Hartford, Connecticut; and Turbine Module Center Engineering in East Hartford find consistent improvement from adopting, using, and developing ACE methods. It is, however, inappropriate to draw the conclusion from only these studies that ACE always works, or works as well as it seems. These sites were selected based on their accomplishments, and MIT researchers were given opportunities to observe and document how ACE works. These cases, and there are undoubtedly many other UTC examples, illustrate that ACE has and is producing many of the desired outcomes across business, operational, employee, and customer measures.

¹¹⁶ Where the specific numbers are UTC proprietary, the changes have been expressed as a percentage change from the November 2003 baseline.

