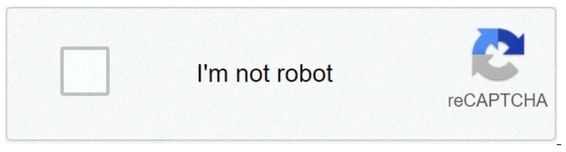

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What is six sigma green belt training

Not to be confused with Sigma 6 (disambiguation) or 5S (methodology). Part of a series of articles onMachine industry Manufacturing methods Batch production Job production Flow production Lean manufacturing Agile manufacturing Industrial technologies PLM RCM TPM VDM QRM TOC Six Sigma TQM ZD Information and communication ISA-88 ISA-95 ERP IEC 62264 B2MML Process control PLC DCS SCADA vte Six Sigma (6σ) is a set of techniques and tools for process improvement. It was introduced by American engineer Bill Smith while working at Motorola in 1986.[1][2] A six sigma process is one in which 99.99966% of all opportunities to produce some feature of a part are statistically expected to be free of defects. Six Sigma strategies seek to improve manufacturing quality by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. It does this by using empirical and statistical quality management methods and by hiring people who serve as Six Sigma experts. Each Six Sigma project follows a defined methodology and has specific value targets, such as reducing pollution or increasing customer satisfaction. The term Six Sigma originates from statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a sigma rating indicating its yield or the percentage of defect-free products it creates—specifically, to within how many standard deviations of a normal distribution the fraction of defect-free outcomes corresponds. History Motorola pioneered Six Sigma, setting a "six sigma" goal for its manufacturing business. It registered Six Sigma as a service mark on June 11, 1991 U.S. Service Mark 1,647,704; on December 28, 1993, it registered Six Sigma as a trademark. In 2005 Motorola attributed over $17 billion in savings to Six Sigma.[3] Honeywell and General Electric were also early adopters of Six Sigma. As GE's CEO, in 1995 Jack Welch made it central to his business strategy,[4] and in 1998 it announced $350 million in cost savings thanks to Six Sigma, which was an important factor in the spread of Six Sigma (this figure later grew to more than $1 billion).[5] By the late 1990s, about two-thirds of the Fortune 500 organizations had begun Six Sigma initiatives with the aim of reducing costs and improving quality.[6] In recent years[update], some practitioners have combined Six Sigma ideas with lean manufacturing to create a methodology named Lean Six Sigma.[7] The Lean Six Sigma methodology views lean manufacturing, which addresses process flow and waste issues, and Six Sigma, with its focus on variation and design, as complementary disciplines aimed at promoting "business and operational excellence".[7] In 2011, the International Organization for Standardization (ISO) has published the first standard "ISO 13053:2011" defining a Six Sigma process.[8] Other standards have been created mostly by universities or companies with Six Sigma first-party certification programs. Etymology Normal distribution underlies the statistical assumptions of Six Sigma. At 0, μ (mu) marks the mean, with the horizontal axis showing distance from the mean, denoted in units of standard deviation (represented as σ or sigma). The greater the standard deviation, the larger the spread of values; for the green curve, μ = 0 and σ = 1. The upper and lower specification limits (USL and LSL) are at a distance of 6σ from the mean. Normal distribution means that values far away from the mean are extremely unlikely—approximately 1 in a billion too low, and the same too high. Even if the mean were to move right or left by 1.5 standard deviations (also known as a 1.5 sigma shift, colored red and blue), there is still a safety cushion. The term Six Sigma comes from statistics, specifically from the field of statistical quality control, which evaluates process capability. Originally, it referred to the ability of manufacturing processes to produce a very high proportion of output within specification. Processes that operate with "six sigma quality" over the short term are assumed to produce long-term defect levels below 3.4 defects per million opportunities (DPMO). The 3.4 dpmo is based on a "shift" of ± 1.5 sigma explained by Mikel Harry. This figure is based on the tolerance in the height of a stack of discs.[9][10] Specifically, say that there are six standard deviations—represented by the Greek letter σ (sigma)—between the mean—represented by μ (mu)—and the nearest specification limit. As process standard deviation goes up, or the mean of the process moves away from the center of the tolerance, fewer standard deviations will fit between the mean and the nearest specification limit, decreasing the sigma number and increasing the likelihood of items outside specification. According to a calculation method employed in process capability studies, this means that practically no[failed verification] items will fail to meet specifications.[9] One should also note that the calculation of Sigma levels for a process data is independent of the data being normally distributed. In one of the criticisms of Six Sigma, practitioners using this approach spend a lot of time transforming data from non-normal to normal using transformation techniques. It must be said that Sigma levels can be determined for process data that has evidence of non-normality.[9] Doctrine Six Sigma symbol Six Sigma asserts that: Continuous efforts to achieve stable and predictable process results (e.g., by reducing process variation) are of vital importance to business success. Manufacturing and business processes have characteristics that can be defined, measured, analyzed, improved, and controlled. Achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management. Features that set Six Sigma apart from previous quality-improvement initiatives include: Focus on achieving measurable and quantifiable financial returns Emphasis on management leadership and support Commitment to making decisions on the basis of verifiable data and statistical methods rather than assumptions and guesswork In fact, lean management and Six Sigma share similar methodologies and tools, including the fact that both were influenced by Japanese business culture. However, lean management primarily focuses on eliminating waste through tools that target organizational efficiencies while integrating a performance improvement system, while Six Sigma focuses on eliminating defects and reducing variation. Both systems are driven by data, though Six Sigma is much more dependent on accurate data.[citation needed] Six Sigma's implicit goal is to improve all processes but not necessarily to the 3.4 DPMO level. Organizations need to determine an appropriate sigma level for each of their most important processes and strive to achieve these. As a result of this goal, it is incumbent on management of the organization to prioritize areas of improvement. Methodologies Six Sigma projects follow two project methodologies, inspired by W. Edwards Deming's Plan–Do–Study–Act Cycle, each with five phases.[6] DMAIC ("duh-may-ick", /də.ˈmeɪ.ɪk/) is used for projects aimed at improving an existing business process DMADV ("duh-mad-vee", /də.ˈmæd.vi/) is used for projects aimed at creating new product or process designs DMAIC DMAIC's five steps Main article: DMAIC The DMAIC project methodology has five phases: Define the system, the voice of the customer and their requirements, and the project goals, specifically. Measure key aspects of the current process and collect relevant data; calculate the "as-is" process capability Analyze the data to investigate and verify cause and effect. Determine what the relationships are, and attempt to ensure that all factors have been considered. Seek out the root cause of the defect under investigation. Improve or optimize the current process based upon data analysis using techniques such as design of experiments, poka yoke or mistake proofing, and standard work to create a new, future state process. Set up pilot runs to establish process capability. Control the future state process to ensure that any deviations from the target are corrected before they result in defects. Implement control systems such as statistical process control, production boards, visual workplaces, and continuously monitor the process. This process is repeated until the desired quality level is obtained. Some organizations add a Recognize step at the beginning, which is to recognize the right problem to work on, thus yielding an RDMAIC methodology.[11] DMADV DMADV's five steps Main article: DFSS Also known as DFSS ("Design For Six Sigma"), the DMADV methodology's five phases are:[6] Define design goals that are consistent with customer demands and the enterprise strategy. Measure and identify CTQs (characteristics that are Critical To Quality), measure product capabilities, production process capability, and measure risks. Analyze to develop and design alternatives Design an improved alternative, best suited per analysis in the previous step Verify the design, set up pilot runs, implement the production process and hand it over to the process owner(s). Professionalization One key innovation of Six Sigma involves professionalizing quality management. Prior to Six Sigma, quality management was largely relegated to the production floor and to statisticians in a separate quality department. Formal Six Sigma programs adopt an elite ranking terminology similar to martial arts systems like judo to define a hierarchy (and career path) that spans business functions and levels. Six Sigma identifies several roles for successful implementation:[12] Executive Leadership includes the CEO and other members of top management. They are responsible for setting up a vision for Six Sigma implementation. They also empower other stakeholders with the freedom and resources to transcend departmental barriers and overcome resistance to change.[13] Champions take responsibility for Six Sigma implementation across the organization. The Executive Leadership draws them from upper management. Champions also act as mentors to Black Belts. Master Black Belts, identified by Champions, act as in-house coaches on Six Sigma. They devote all of their time to Six Sigma, assisting Champions and guiding Black Belts and Green Belts. In addition to statistical tasks, they ensure that Six Sigma is applied consistently across departments and job functions. Black Belts operate under Master Black Belts to apply Six Sigma to specific projects. They also devote all of their time to Six Sigma. They primarily focus on Six Sigma project execution and special leadership with special tasks, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma. Green Belts are the employees who take up Six Sigma implementation along with their other job responsibilities, operating under the guidance of Black Belts. According to proponents, special training is needed for all of these practitioners to ensure that they follow the methodology and use the data-driven approach correctly.[14] Some organizations use additional belt colors, such as "yellow belts", for employees that have basic training in Six Sigma tools and generally participate in projects, and "white belts" for those locally trained in the concepts but do not participate in the project team. "Orange belts" are also mentioned to be used for special cases.[15] Certification Main article: List of Six Sigma certification organizations General Electric and Motorola developed certification programs as part of their Six Sigma implementation. Following this approach, many organizations in the 1990s started offering Six Sigma certifications to their employees. In 2008 Motorola University later co-developed with Vative and the Lean Six Sigma Society of Professionals a set of comparable certification standards for Lean Certification.[6][16] Criteria for Green Belt and Black Belt certification vary; some companies simply require participation in a course and a Six Sigma project.[16] There is no standard certification body, and different certifications are offered by various quality associations for a fee.[17][18][self-published source] The American Society for Quality, for example, requires Black Belt applicants to pass a written exam and to provide a signed affidavit stating that they have completed two projects or one project combined with three years' practical experience in the body of knowledge.[16][19] Tools and methods Within the individual phases of a DMAIC or DMADV project, Six Sigma uses many established quality-management tools that are also used outside Six Sigma. The following table shows an overview of the main methods used. 5 Whys Statistical and fitting tools Analysis of variance General linear model ANOVA Gauge R&R Regression analysis Correlation Scatter diagram Chi-squared test Axiomatic design Business Process Mapping/Check sheet Cause & effects diagram (also known as fishbone or Ishikawa diagram) Control chart/Control plan (also known as a swimlane map)/Run charts Cost–benefit analysis CTQ tree Design of experiments/Stratification Histograms/Pareto analysis/Pareto chart Pick chart/Process capability/Rolled throughput yield Quality Function Deployment (QFD) Quantitative marketing research through use of Enterprise Feedback Management (EFM) systems Root cause analysis SIPOC analysis (Suppliers, Inputs, Process, Outputs, Customers) COPIS analysis (Customer centric version/perspective of SIPOC) Taguchi methods/Taguchi Loss Function Value stream mapping Software Main article: List of Six Sigma software packages Role of the 1.5 sigma shift Experience has shown that processes usually do not perform as well in the long term as they do in the short term.[9] As a result, the number of sigmas that will fit between the process mean and the nearest specification limit may well drop over time, compared to an initial short-term study.[9] To account for this real-life increase in process variation over time, an empirically based 1.5 sigma shift is introduced into the calculation.[9][20] According to this idea, a process that fits 6 sigma between the process mean and the nearest specification limit in a short-term study will in the long term fit only 4.5 sigma – either because the process mean will move over time, or because the long-term standard deviation of the process will be greater than that observed in the short term, or both.[9] Hence the widely accepted definition of a six sigma process is a process that produces 3.4 defective parts per million opportunities (DPMO). This is based on the fact that a process that is normally distributed will have 3.4 parts per million outside the limits, when the limits are six sigma from the "original" mean of zero and the process mean is then shifted by 1.5 sigma (and therefore, the six sigma limits are no longer symmetrical about the mean).[9] The former six sigma distribution, when under the effect of the 1.5 sigma shift, is commonly referred to as a 4.5 sigma process. The failure rate of a six sigma distribution with the mean shifted 1.5 sigma is not equivalent to the failure rate of a 4.5 sigma process with the mean-centered on zero.[9] This allows for the fact that special causes may result in a deterioration in process performance over time and is designed to prevent underestimation of the defect levels likely to be encountered in real-life operation.[9] The role of the sigma shift is mainly academic. The purpose of six sigma is to generate organizational performance improvement. It is up to the organization to determine, based on customer expectations, what the appropriate sigma level of a process is. The purpose of the sigma value is as a comparative figure to determine whether a process is improving, deteriorating, stagnant or non-competitive with others in the same business. Six Sigma (3.4 DPMO) is not the goal of all processes. Sigma levels A control chart showing a process that experienced a 1.5 sigma drift in the process mean toward the upper specification limit starting at midnight. Control charts help identify when a process should be investigated in order to find and eliminate special-cause variation. See also: Three sigma rule The table below gives long-term DPMO values corresponding to various short-term sigma levels.[21][22] These figures assume that the process mean will shift by 1.5 sigma toward the side with the critical specification limit. In other words, they assume that after the initial study determining the short-term sigma level, the long-term Cpk value will turn out to be 0.5 less than the short-term Cpk value. So, now for example, the DPMO figure given for 1 sigma assumes that the long-term process mean will be 0.5 sigma beyond the specification limit (Cpk = –0.17), rather than 1 sigma within it, as it was in the short-term study (Cpk = 0.33). Note that the defect percentages indicate only defects exceeding the specification limit to which the process mean is nearest. Defects beyond the far specification limit are not included in the percentages. The formula used here to calculate the DPMO is thus D P M O = 1 , 000 , 000 ⋅ (1 − ϕ (l e v e l − 1.5)) {\displaystyle DPMO=1,000,000\centerdot (1-\phi (level-1.5))} Sigma level Sigma (with 1.5σ shift) DPMO Percent defective Percentage yield Short-term Cpk Long-term Cpk 1 −0.5 691,462 69% 31% 0.33 −0.17 2 0.5 308,538 31% 69% 0.67 0.17 3 1.5 66,807 6.7% 93.3% 1.00 0.5 4 2.5 6,210 0.62% 99.38% 1.33 0.83 5 3.5 233 0.023% 99.977% 1.67 1.17 6 4.5 3.4 0.00034% 99.99966% 2.00 1.5 7 5.5 0.019 0.0000019% 99.9999981% 2.33 1.83 Six Sigma in practice Main article: List of Six Sigma companies Six Sigma mostly finds application in large organizations.[5] According to industry consultants like Thomas Pyzdek and John Kullmann, companies with fewer than 500 employees are less suited to Six Sigma or need to adapt the standard approach to making it work for them.[5] Six Sigma, however, contains a large number of tools and techniques that work well in small to mid-size organizations. The fact that an organization is not big enough to be able to afford black belts does not diminish its ability to make improvements using this set of tools and techniques. The infrastructure described as necessary to support Six Sigma is a result of the size of the organization rather than a requirement of Six Sigma itself.[5] Manufacturing After its first application at Motorola in the late 1980s, other internationally recognized firms currently recorded high number of savings after applying Six Sigma. Examples include Johnson & Johnson, with $600 million of reported savings, Texas Instruments, which saved over $500 million as well as Telefónica, which reported €30 million in savings in the first 10 months; Sony and Boeing also reported successfully reducing waste.[23] Engineering and construction Although companies have considered common quality control and process improvement strategies, there's still a need for more reasonable and effective methods as all the desired standards and client satisfaction have not always been reached. There is still a need for an essential analysis that can control the factors affecting concrete cracks and slippage between concrete and steel. After conducting a case study on Tinjin Xianyi Construction Technology, it was found that construction time and construction waste were reduced by 26.2% and 67% accordingly after adopting Six Sigma. Similarly, Six Sigma implementation was studied at one of the largest engineering and construction companies in the world: Bechtel Corporation, where after an initial investment of $30 million in a Six Sigma program that included identifying and preventing rework and defects, over $200 million were saved.[23] Finance Six Sigma has played an important role by improving the accuracy of allocation of cash to reduce bank charges, automatic payments, improving the accuracy of reporting, reducing documentary credit defects, reducing check collection defects, and reducing variation in collector performance. For example, Bank of America announced in 2004 that Six Sigma had helped it increase customer satisfaction by 10.4% and decrease customer issues by 24%; similarly, American Express eliminated non-received renewal credit cards. Other financial institutions that have adopted Six Sigma include GE Capital and JPMorgan Chase, where customer satisfaction was the main objective.[23] Supply chain In the supply-chain field, it is important to ensure that products are delivered to clients at the right time while preserving high-quality standards. By changing the schematic diagram for the supply chain, Six Sigma can ensure quality control on products (defect-free) and guarantee delivery deadlines, the two main issues in the supply chain.[24] Healthcare This is a sector that has been highly matched with this doctrine for many years because of the nature of zero tolerance for mistakes and potential for reducing medical errors involved in healthcare.[25][26] The goal of Six Sigma in healthcare is broad and includes reducing the inventory of equipment that brings extra costs, altering the process of healthcare delivery in order to make it more efficient and refining reimbursements. A study at the MD Anderson Cancer Center, which recorded an increase in examinations with no additional machines of 45% and a reduction in patients' preparation time of 40 minutes; from 45 minutes to 5 minutes in multiple cases.[23] Lean Six Sigma was adopted in 2003 at Stanford hospitals and was introduced at Red Cross hospitals in 2002.[27] Criticism While there are many advocates for a Six Sigma approach for the reasons stated above, not all projects are successful: in 2010, the Wall Street Journal reported that more than 60% of projects fail.[28] A review of academic literature [29] found 34 common failure factors in 56 papers on Lean, Six Sigma, and LSS from 1995-2013. Among them are (summarized): Lack of top management attitude, commitment, and involvement; lack of leadership and vision Lack of training and education; lack of resources (financial, technical, human, etc.) Poor project selection and prioritization; weak link to strategic objectives of the organization Resistance to culture change; Poor communication; Lack of consideration of the human factors Lack of awareness of the benefits of Lean/Six Sigma; Lack of technical understanding of tools, techniques, and practices Others have provided other criticisms. Lack of originality Quality expert Joseph M. Juran described Six Sigma as "a basic version of quality improvement", stating that "there is nothing new there. It includes what we used to call facilitators. They've adopted more flamboyant terms, like belts with different colors. I think that concept has merit to set apart, to create specialists who can be very helpful. Again, that's not a new idea. The American Society for Quality long ago established certificates, such as for reliability engineers."[30] Inadequate for complex manufacturing Quality expert Philip B. Crosby pointed out that the Six Sigma standard does not go far enough—customers deserve defect-free products every time.[31] For example, under the Six Sigma standard, semiconductors, which require the flawless etching of millions of tiny circuits onto a single chip are all defective.[32] Role of consultants The use of "Black Belts" as itinerant change agents has fostered an industry of training and certification. Critics have argued there is overselling of Six Sigma by too great a number of consulting firms, many of which claim expertise in Six Sigma when they have only a rudimentary understanding of the tools and techniques involved or the markets or industries in which they are acting.[33] Potential negative effects A Fortune article stated that "of 58 large companies that have announced Six Sigma programs, 91% have trailed the S&P 500 since". The statement was attributed to "an analysis by Charles Holland of consulting firm Qualpro (which espouses a competing quality-improvement process)".[34] The summary of the article is that Six Sigma is effective at what it is intended to do, but that it is "narrowly designed to fix an existing process" and does not help in "coming up with new products or disruptive technologies."[35][36] Over-reliance on statistics More direct criticism is the "rigid" nature of Six Sigma with its over-reliance on methods and tools. In most cases, more attention is paid to reducing variation and searching for any significant factors, and less attention is paid to developing robustness in the first place (which can altogether eliminate the need for reducing variation).[37] The extensive reliance on significance testing and use of multiple regression techniques increase the risk of making commonly unknown types of statistical errors or mistakes. A possible consequence of Six Sigma's array of p-value misconceptions is the false belief that the probability of a conclusion being in error can be calculated from the data in a single experiment without reference to external evidence or the plausibility of the underlying mechanism.[38] One of the most serious but all-too-common misuses of inferential statistics is to take a model that was developed through exploratory model building and subject it to the same sorts of statistical tests that are used to validate a model that was specified in advance.[39] Another comment refers to the oft-mentioned Transfer Function, which seems to be a flawed theory if looked at in detail.[40] Since significance tests were first popularized many objections have been voiced by prominent and respected statisticians. The volume of criticism and rebuttal has filled books with language seldom used in the scholarly debate of a dry subject.[41][42][43][44] Much of the first criticism was already published more than 40 years ago (see Statistical hypothesis testing § Criticism). In a 2006 issue USA Army Logistician an article critical of Six Sigma noted: "The dangers of a single paradigmatic orientation (in this case, that of technical rationality) can blind us to values associated with double-loop learning and the learning organization, organization adaptability, workforce creativity and development, humanizing the workplace, cultural awareness, and strategy making."[45] Nassim Nicholas Taleb considers risk managers little more than "blind users" of statistical tools and methods.[46] He states that statistics is fundamentally incomplete as a field as it cannot predict the risk of rare events—something Six Sigma is especially concerned with. Furthermore, errors in prediction are likely to occur as a result of ignorance of or distinction between epistemic and other uncertainties. These errors are the biggest in time variant (reliability) related failures.[47] 1.5 sigma shift The statistician Donald J. Wheeler has dismissed the 1.5 sigma shift as "goofy" because of its arbitrary nature.[48] Its universal applicability is seen as doubtful. The 1.5 sigma shift has also become contentious because it results in stated "sigma levels" that reflect short-term rather than long-term performance: a process that has long-term defect levels corresponding to 4.5 sigma performance is, by Six Sigma convention, described as a "six sigma process".[9][49] The accepted Six Sigma scoring system thus cannot be equated to actual normal distribution probabilities for the stated number of standard deviations, and this has been a key bone of contention over how Six Sigma measures are defined.[49] The fact that it is rarely explained that a "6 sigma" process will have long-term defect rates corresponding to 4.5 sigma performance rather than actual 6 sigma performance has led several commentators to express the opinion that Six Sigma is a confidence trick.[9] Stifling creativity in research According to John Dodge, editor in chief of Design News, the use of Six Sigma is inappropriate in a research environment. Dodge states[50] "excessive metrics, steps, measurements and Six Sigma's intense focus on reducing variability water down the discovery process. Under Six Sigma, the free-wheeling nature of brainstorming and the serendipitous side of discovery is stifled." He concludes "there's general agreement that freedom in basic or pure research is preferable while Six Sigma works best in incremental innovation when there's an expressed commercial goal." A BusinessWeek article says that James McNerney's introduction of Six Sigma at 3M had the effect of stifling creativity and reports its removal from the research function. It cites two Wharton School professors who say that Six Sigma leads to incremental innovation at the expense of blue skies research.[51] This phenomenon is further explored in the book Going Lean, which describes a related approach known as lean dynamics and provides data to show that Ford's 6 Sigma program did little to change its fortunes.[52] Lack of documentation One criticism voiced by Yasar Jarrar and Andy Neely from the Cranfield School of Management's Centre for Business Performance is that while Six Sigma is a powerful approach, it can also unduly dominate an organization's culture; and they add that much of the Six Sigma literature – in a remarkable way (six-sigma claims to be evidence, scientifically based) – lacks academic rigor: One final criticism, probably more to the Six Sigma literature than concepts, relates to the evidence for Six Sigma's success. So far, documented case studies using the Six Sigma methods are presented as the strongest evidence for its success. However, looking at these documented cases, and apart from a few that are detailed from the experience of leading organizations like GE and Motorola, most cases are not documented in a systemic or academic manner. In fact, the majority are case studies illustrated on websites, and are, at best, sketchy. They provide no mention of any specific Six Sigma methods that were used to resolve the problems. It has been argued that by relying on the Six Sigma criteria, management is lulled into the idea that something is being done about quality, whereas any resulting improvement is accidental (Latzko 1995). Thus, when looking at the evidence put forward for Six Sigma's success, mostly by consultants and people with vested interests, the question that begs to be asked is: are we making a true improvement with Six Sigma methods or just getting skilled at telling stories? Everyone seems to believe that we are making true improvements, but there is some way to go to document these empirically and clarify the causal relations. — [37] See also Design for Six Sigma DMAIC Kaizen – Japanese concept referring to continuous improvement – a philosophical focus on continuous improvement of processes Lean Six Sigma – Methodology of systematically removing waste Lean manufacturing – Production methodology in which time is reduced as much as possible Management fad Quality management – Process to provide consistent fitness for use of product or service Total productive maintenance – Maintenance management methodology Total quality management – Approach to business improvement. W. Edwards Deming – American professor, singer and consultant References ^ "The Inventors of Six Sigma". Archived from the original on 2005-11-06. Retrieved 2006-01-29. ^ Tennant, Geoff (2001). SIX SIGMA: SPC and TQM in Manufacturing and Services. Gower Publishing, Ltd. p. 6. 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This article is missing information about traffic signals produced by 3M. Please expand the article to include this information. Further details may exist on the talk page. (September 2020) 3M Company3M headquarters in Maplewood, MinnesotaFormerlyMinnesota Mining and Manufacturing Company (1902–2002)TypePublicTraded asNYSE: MMMDJIA ComponentS&P 100 ComponentS&P 500 ComponentIndustryConglomerateFoundedJune 13, 1902; 119 years ago (1902-06-13) (as Minnesota Mining and Manufacturing Company)Two Harbors, Minnesota, U.S.[1]Founders Dr. J. Danley Budd Henry. S. Bryan William A. McGonagle John Dwan Hermon W. Cable[2] HeadquartersMaplewood, Minnesota, U.S.Area servedWorldwideKey peopleMike Roman(Chairman, President, & CEO)[3]Revenue US$32.18 billion (2020)[4]Operating income US$7.161 billion (2020)[4]Net income US$5.38 billion (2020)[4]Total assets US$47.3 billion (2020)[4]Total equity US$12.931 billion (2020)[4]Number of employees 94,987 (2020)[4]Websitewww.3m.com The 3M Company is an American multinational conglomerate corporation operating in the fields of industry, worker safety, US health care, and consumer goods.[5] The company produces over 60,000 products under several brands,[6] including adhesives, abrasives, laminates, passive fire protection, personal protective equipment, window films, paint protection films, dental and orthodontic products, electrical and electronic connecting and insulating materials, medical products, car-care products,[7] electronic circuits, healthcare software and optical films.[8] It is based in Maplewood, a suburb of Saint Paul, Minnesota.[9] 3M made $32.8 billion in total sales in 2018, and ranked number 95 in the Fortune 500 list of the largest United States corporations by total revenue.[10] As of 2018[update], the company had approximately 93,500 employees, and had operations in more than 70 countries.[11] History Five businessmen founded the Minnesota Mining and Manufacturing Company as a mining venture in Two Harbors, Minnesota, making their first sale on June 13, 1902.[1][12] The goal was to mine corundum, but this failed because the mine's mineral holdings were anorthosite, which had no commercial value.[12] Co-founder John Dwan solicited funds in exchange for stock and Edgar Ober and Lucius Ordway took over the company in 1905.[12] The company moved to Duluth and began researching and producing sandpaper products.[12] William L. McKnight, later a key executive, joined the company in 1907, and A. G. Bush joined in 1909.[12] 3M finally became financially stable in 1916 and was able to pay dividends.[12] The company moved to St. Paul in 1910, where it remained for 52 years before outgrowing the campus and moving to its current headquarters at 3M Center in Maplewood, Minnesota in 1962.[13] The John Dwan Office Building, where 3M was founded, now a museum Expansion and modern history In 1947, 3M began producing perfluorooctanoic acid (PFOA) by electrochemical fluorination.[14] In 1951, DuPont purchased PFOA from then-Minnesota Mining and Manufacturing Company for use in the manufacturing of teflon, a product that brought DuPont a billion-dollar-a-year profit by the 1990s.[15] DuPont referred to PFOA as C8.[16] The original formula for Scotchgard, a water repellent applied to fabrics, was discovered accidentally in 1952 by 3M chemists Patsy Sherman and Samuel Smith. Sales began in 1956, and in 1973 the two chemists received a patent for the formula.[17][18] In the late 1950s, 3M produced the first asthma inhaler,[19] but the company did not enter the pharmaceutical industry until the mid-1960s with the acquisition of Riker Laboratories, moving it from California to Minnesota.[20] 3M retained the Riker Laboratories name for the subsidiary until at least 1985.[21] In the mid-1990s, 3M Pharmaceuticals, as the division came to be called, produced the first CFC-free asthma inhaler in response to adoption of the Montreal Protocol by the United States.[22][23] In the 1980s and 1990s, the company spent fifteen years developing a topical cream delivery technology which led in 1997 to health authority approval and marketing of a symptomatic treatment for genital warts, Aldara.[24][25] 3M divested its pharmaceutical unit through three deals in 2006, netting more than US$2 billion.[26][27] At the time, 3M Pharmaceuticals comprised about 20% of 3M's health care business and employed just over a thousand people.[26] 3M traffic signals installed in Shelton, Washington. Standing off-axis from the intended viewing area, these signals are invisible to adjacent lanes of traffic in daylight. (A faint glow is visible at night.) The same two signals above, taken in the signal's intended viewing area (a single lane of northbound traffic). Special light-diffusing optics and a colored fresnel lens create the indication. By the 1970s, 3M developed a theatrical blood formula based on red colorfast microbeads suspended in a carrier liquid.[28] This stage blood was sold as Nextel Simulated Blood,[28][29] and was used during the production of the 1978 film Dawn of the Dead.[30] It has since been discontinued.[29] 3M Mincom was involved in some of the first digital audio recordings of the late 1970s to see commercial release when a prototype machine was brought to the Sound 80 studios in Minneapolis. In 1979 3M introduced a digital audio recording system called "3M Digital Audio Mastering System".[31] 3M launched "Press 'n Peel" in stores in four cities in 1977, but results were disappointing.[32][33] A year later 3M instead issued free samples directly to consumers in Boise, Idaho, with 95% of those who tried them indicating they would buy the product.[32] The product was sold as "Post-its" in 1979 when the rollout introduction began,[34] and was sold across the United States[34] from April 6, 1980.[35] The following year they were launched in Canada and Europe.[36] On its 100th anniversary, 3M changed its legal name to "3M Company" on April 8, 2002.[37][38] On September 8, 2008, 3M announced an agreement to acquire Meguiar's, a car-care products company that was family-owned for over a century.[39] In August 2010, 3M acquired Cogent Systems for $943 million[40] and on October 13, 2010, 3M completed acquisition of Arizant Inc.[41] In December 2011, 3M completed the acquisition of the Winterthur Technology Group, a bonded abrasives company. As of 2012, 3M was one of the 30 companies included in the Dow Jones Industrial Average, added on August 9, 1976, and was 97 on the 2011 Fortune 500 list.[42] On January 3, 2012, it was announced that the Office and Consumer Products Division of Avery Dennison was being bought by 3M for $550 million.[43] The transaction was canceled by 3M in September 2012 amid antitrust concerns.[44] In May 2013, 3M sold Scientific Anglers and Ross Reels to Orvis. Ross Reels had been acquired by 3M in 2010.[45] In March 2017, 3M purchased Johnson Control International Plc's safety gear business, Scott Safety, for $2 billion.[46] In 2017, 3M had net sales for the year of $31.657 billion, up from $30.109 billion the year before.[47] In 2018, it was reported that the company would pay $850 million to end the Minnesota water pollution case concerning perfluorochemicals.[48] On May 25, 2018, Michael F. Roman was appointed CEO by the board of directors.[49] There are a few international subsidiaries such as 3M India, 3M Japan, & 3M Canada.[50] On December 19, 2018, 3M announced it had entered into a definitive agreement to acquire the technology business of M*Modal, for a total enterprise value of $1.0 billion.[51] In October 2019, 3M purchased Acelity and its KCI subsidiaries for $6.7 billion, including assumption of debt and other adjustments.[52] Products and patents 3M produces approximately 60,000 products, as of 2019,[53] and has four business groups focused on safety and industrial, transportation and electronics, health care, and consumer products.[54] 3M obtained its first patent in 1924, and acquires approximately 3,000 new patents annually. The company surpassed the 100,000-patent threshold in 2014.[55] Environmental record The Target Light System, built by 3M at Target headquarters in Minneapolis.[56] 3M's Pollution Prevention Pays (3P) program was established in 1975. The program initially focused on pollution reduction at the plant level and was expanded to promote recycling and reduce waste across all divisions in 1989. By the early 1990s, approximately 2,500 3P projects decreased the company's total global pollutant generation by 50 percent and saved 3M $500–600 million by eliminating the production of waste requiring subsequent treatment.[57][58] In 1983, the Oakdale Dump in Oakdale, Minnesota, was listed as an EPA Superfund site after significant groundwater and soil contamination by VOCs and heavy metals was uncovered.[59] The Oakdale Dump was a 3M dumping site utilized through the 1940s and 1950s. During the 1990s and 2000s, 3M reduced releases of toxic pollutants by 99 percent and greenhouse gas emissions by 72 percent. The company earned the United States Environmental Protection Agency's Energy Star Award each year the honor was presented, as of 2012.[60] In 1999, the U.S. Environmental Protection Agency began investigating perfluorinated chemicals after receiving data on the global distribution and toxicity of perfluorooctanesulfonic acid (PFOS).[61] These materials are part of a broad group of perfluoroalkyl and polyfluoroalkyl substances often referred to as PFAS, each of which has different chemical properties.[62] 3M, the former primary producer of PFOS from the U.S., announced the phase-out of PFOS, perfluorooctanoic acid, and PFOS-related product production in May 2000.[63][64] Perfluorinated compounds produced by 3M have been used in non-stick cookware, stain-resistant fabrics, and other products. The Cottage Grove facility manufactured PFAS from the 1940s to 2002.[65] In response to PFAS contamination of the Mississippi River and surrounding area, 3M stated the area will be "cleaned through a combination of groundwater pump-out wells and soil sediment excavation". The restoration plan was based on an analysis of the company property and surrounding lands.[66] The on-site water treatment facility that handled the plant's post-production water was not capable of removing PFAS, which were released into the nearby Mississippi River.[65] The clean-up cost estimate, which included a granular activated carbon system to remove PFAS from the ground water was $50 to $56 million,[67] funded from a $147 million environmental reserve set aside in 2006.[68] In 2008, 3M created the Renewable Energy Division within 3M's Industrial and Transportation Business to focus on Energy Generation and Energy Management.[69][70] In late 2010, the state of Minnesota sued 3M for $5 billion in punitive damages, claiming they released PFCs—classified a toxic chemical by the EPA—into local waterways.[71] A settlement for $850 million was reached in February 2018,[72][64][73] although in 2019, 3M, along with the Chemours Company and DuPont, appeared before lawmakers to deny responsibility, with company Senior VP of Corporate Affairs Denise Rutherford arguing that the chemicals pose no human health threats at current levels and have no victims.[74] 3M's Zwijndrecht (Belgium) factory caused PFOS pollution that may be contaminating agricultural products within a 15 kilometer radius of the plant which includes Antwerp.[75][76] The Flemish Government has paid 63 million euros for cleanup costs so far with 3M contributing 75,000 euros.[77] Earplug controversy The Combat Arms Earplugs, Version 2 (CAE v2), was developed by Aearo Technologies for U.S. military and civilian use. The CAE v2 was a double ended earplug that 3M claimed would offer users different levels of protection.[78] Between 2003 and 2015, these earplugs were standard issue to members of the U.S. military.[79] 3M acquired Aearo Technologies in 2008.[80] In May 2016, Moldex-Metric, Inc., a 3M competitor, filed a whistleblower complaint against 3M under the False Claims Act. Moldex-Metric claimed that 3M made false claims to the U.S. government about the safety of its earplugs, and that it knew the earplugs had an inherently defective design.[81] In 2018, 3M agreed to pay $9.1 million to the U.S government to resolve the allegations, without admitting liability.[82] Since 2018, more than 140,000 former users of the earplugs—primarily U.S. military veterans—have filed suit against 3M claiming they suffer from hearing loss, tinnitus, and other damage as a consequence of the defective design.[83] Internal emails showed that 3M officials boasted about charging $7.63 per piece for the earplugs which cost 85 cents to produce. The company's official response indicated that the cost to the government includes R&D costs.[84] N95 respirators and the COVID-19 pandemic The N95 respirator mask was developed by 3M and approved in 1972.[85] Being able to filter viral particulates, its use was recommended during the COVID-19 pandemic but supply soon became short.[85] Much of the company's supply had already been sold prior to the outbreak.[86] The shortages led to the US government asking 3M to stop exporting US-made N95 respirator masks to Canada and to Latin American countries,[87] and President Donald Trump invoked the Defense Production Act to require 3M to prioritize orders from the federal government.[88] The dispute was resolved when 3M agreed to import more respirators, mostly from its factories in China.[88] 3M later struck a $70MCAD deal with the federal government of Canada and the Ontario provincial government to produce N95 masks at their plant in Brockville, Ontario.[89] Operating facilities 3M facility in St. Paul, Minnesota 3M's general offices, corporate research laboratories, and some division laboratories in the US are in St. Paul, Minnesota. In the United States, 3M operates 80 manufacturing facilities in 29 states, and 125 manufacturing and converting facilities in 37 countries outside the US (in 2017).[90] In March 2016, 3M completed a 400,000-square-foot (37,000 m2) research-and-development building that cost $150 million on its Maplewood campus. Seven hundred scientists from various divisions occupy the building. They were previously scattered across the campus. 3M hopes concentrating its research and development in this manner will improve collaboration. 3M received $9.6 million in local tax increment financing and relief from state sales taxes in order to assist with development of the building.[91] Selected factory detail information: Cynthiana, Kentucky, US factory producing Post-it Notes (672 SKU) and Scotch Tape (147 SKU). It has 539 employees and was established in 1969.[92] Newton Aycliffe, County Durham, UK factory producing respirators for workers safety, using laser technology. It has 370 employees and recently there was an investment of £4.5 million ($7 million).[93][94] In Minnesota, 3M's Hutchinson facility produces products for more than half of the company's 23 divisions, as of 2019.[95] The "super hub" has manufactured adhesive bandages for Nexcare, furnace filters, and Scotch Tape, among other products.[96][97] The Cottage Grove plant is one of three operated by 3M for the production of pad conditioners, as of 2011.[98] 3M has operated a manufacturing plant in Columbia, Missouri since 1970. The plant has been used for the production of products including electronic components,[99][100] solar and touchscreen films, and stethoscopes. The facility received a $20 million expansion in 2012 and has approximately 400 employees.[101][102] 3M opened the Brookings, South Dakota plant in 1971,[103] and announced a $70 million expansion in 2014.[104] The facility manufactures more than 1,700 health care products and employs 1,100 people, as of 2018, making the plant 3M's largest focused on health care.[105] Mask production at the site increased during the 2009 swine flu pandemic, 2002–2004 SARS outbreak, 2018 California wildfires, 2019–20 Australian bushfire season, and COVID-19 pandemic.[106] 3M's Springfield, Missouri plant opened in 1967 and makes industrial adhesives and tapes for aerospace manufacturers. In 2017, 3M had approximately 330 employees in the metropolitan area, and announced a $40 million expansion project to upgrade the facility and redevelop another building.[107] In Iowa, the Ames plant makes sandpaper products and received funding from the Iowa Economic Development Authority (IEDA) for expansions in 2013 and 2018.[108][109] The Knoxville plant is among 3M's largest and produces approximately 12,000 different products, including adhesives and tapes.[110] 3M's Southeast Asian operations are based in Singapore, where the company has invested $1 billion over 50 years. 3M has a facility in Tuas, a manufacturing plant and Smart Urban Solutions lab in Woodlands, and a customer technical center in Yishun.[111] 3M expanded a factory in Woodlands in 2011,[98] announced a major expansion of the Tuas plant in 2016,[111] and opened new headquarters in Singapore featuring a Customer Technical Centre in 2018.[112] The company has operated in China since 1984,[113] and was Shanghai's first Wholly Foreign-Owned Enterprise.[114] 3M's seventh plant, and the first dedicated to health care product production, opened in Shanghai in 2007.[115] By October 2007, the company had opened an eighth manufacturing plant and technology center in Guangzhou.[113][116] 3M broke ground on its ninth manufacturing facility, for the production of photovoltaics and other renewable energy products, in Hefei in 2011.[117] 3M announced plans to construct a technology innovation center in Chengdu in 2015,[118] and opened a fifth design center in Shanghai in 2019.[119] Leadership Board chairs have included: William L. McKnight (1949–1966),[120][121] Bert S. Cross (1966–1970),[122][123] Harry Heltzer (1970–1975),[124] Raymond H. Herzog (1975–1980),[125] Lewis W. Lehr (1980–1986), Allen F. Jacobson (1986–1991),[126] Livio DeSimone (1991–2001),[127] James McNerney (2001–2005),[128] George W. Buckley (2005–2012),[129][130] and Inge Thulin (2012–2018).[131] Thulin continued to serve as executive chairman until current chair Michael F. Roman was appointed in 2019.[132] 3M's CEOs have included: Cross (1966–1970),[133] Heltzer (1970–1975),[124] Herzog (1975–1979),[133][134] Lehr (1979–1986),[135] Jacobson (1986–1991),[126] DeSimone (1991–2001),[127] McNerney (2001–2005),[128] Robert S. Morrison (2005, interim),[136] Buckley (2005–2012),[129][130] Thulin (2012–2018), and Roman (2018–present).[131] 3M's presidents have included: Edgar B. Ober (1905–1929),[137] McKnight (1929–1949),[121][138] Richard P. Carlton (1949–1953),[139] Herbert P. Buetow (1953–1963),[140] Cross (1963–1966),[141] Heltzer (1966–1970),[122] and Herzog (1970–1975).[142] In the late 1970s, the position was separated into roles for U.S. and international operations. The position overseeing domestic operations was first held by Lehr,[134] followed by John Pitblado from 1979 to 1981,[143] then Jacobson from 1984 to 1991.[144] James A. Thwaits led international operations starting in 1979.[143] Buckley and Thulin were president during 2005–2012,[145] and 2012–2018, respectively.[131] See also Oakdale Dump Further reading V. Huck, Brand of the tartan: the 3M story, Appleton-Century-Crofts, 1955. Early history of 3M and challenges, includes employee profiles. C. Rimington, From Minnesota mining and manufacturing to 3M Australia Pty Ltd (3M Australia: the Story of an Innovative Company), Sid Harta Publishers, 2013. Recollections from 3M Australia employees in context of broader organisational history. 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