CHAPTER III

3 PROFILE OF THE CAD/CAM INDUSTRY

3.1 Origin and Background of CAD/CAM Industry

The first ever designs can date back to the days when cave-men drew pictures on the walls of cave. Engineering design evolved over a period since the days of industrial revolution. Design with the Aid of Computers started in the 50s at various universities of the US. As stated by Weisberg “In 1947, the group within the Servomechanism Laboratory working on Project Whirlwind became the Lab’s Electronic Computer Division and in 1951 it became the MIT Digital Computer Laboratory, independent of the Servo Lab” (Weisberg, 2014). This MIT Digital Computer Lab is one of the first CAD/CAM systems in the academia and the entire World. The commercial CAD/CAM systems were developed and sold around early 60s. They were deployed on large computers (Minicomputers or Super minicomputers, main-frame computers). In the early 80s IBM introduced PC- Personal Computer and then onwards, CAD/CAM systems got implemented on them.

Early days, good display devices (monitors) were not advanced; hence they were purchased only with CAD/CAM systems. Typically CAD/CAM system’s configuration those days, needed to specify monitor, digitizers/ tablets- light pens, plotters, memory and storage space. Today PC with higher specifications can meet the hardware requirements of CAD/CAM system. Thus CAD/CAM today refers to the software applications rather than any hardware.

As seen in the initial paragraph of this chapter first developmental efforts for CAD/CAM systems took place in the various US academic institutes including

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universities of Syracuse, Rochester, Cornell, Utah, & Rensselaer Polytechnic Institute, and Massachusetts Institute of Technology- MIT, etc. Students or associates of these educational institutes did the pioneering work for CAD/CAM. Ken Olsen of Digital Equipment Corporation developed the PDP I and was associated with MIT. Ivan Sutherland’s PhD thesis at MIT was on SKETCHPAD- first interactive graphics system. Apart for academia, there are some industries that sponsored the development of CAD/CAM system. Lockheed has supported development of CADAM (Computer-graphics Augmented Design And Manufacturing) McDonnell Automation supported McAuto which is famous as UGS (Unigraphics), Dassault Aviation promoted CATI that was renamed CATIA later.

Several CAD/CAM products existed since 60s; but a few have survived till date. The industry has seen several mergers and acquisitions. Products have been purchased by competitors and merged to offer a better product; or some products vanished from the market for ever. A few of the famous names were Alibre- Design, Aries- ConceptStation, Ashlar- Vellum, Micro Control System- Cadkey, CalComp System25, Cadvance, IronCAD, Think3, Euclid, IntelliCAD etc.

3.2 Current Scenario and CAD/CAM Market

CAD/CAM today is also referred to as 3D Product Lifecycle Management that takes care of multiple stages involved in a product development (CAx) that include design (CAD), engineering analysis (CAE), and manufacturing (CAM). CAD/CAM market is a very specialized market. Development of any CAD/CAM software requires expertise in sophisticated mathematical techniques, and handling very complex algorithms. Thus developers have not traditionally concentrated on entire CAD/CAM market. Some of them have developed one market say CAD and then expand to CAE and later to CAM. Thus the strategy they adopt is to build functionalities over a period and then expand to another market and then to next. Till such a time, they keep their data compatible to the remaining functionalities so as to facilitate transfer of data to that functional software. Thus in above example the organization will concentrate on CAD development and will keep data compatibility with CAE and CAM software.
All these products are software products and are subject to quick development of their releases, revisions and versions. When one buys a product, some version and enhancements to the software products are offered free of cost to the end-customer. These enhancements are referred to as updates. But when larger enhancements are incorporated in the software functionalities, it is made available at some incremental cost to the end-customer. These are called upgrades. The end-customer is given free service for a period of one year from the date of purchase of the software. Later the end-customer has to get covered under one year subscription which is called as annual maintenance contract (AMC). Once end-customer is under AMC, he/she is liable to get updates/upgrades free of cost during that period.

There are some additional services provided to the end-customers by all these CAD/CAM vendors. They are:

- Orientation training on how to use the product
- Online help for problem solving
- Download of some add-on utilities, or Hot-fix (a routine to solve some software problems found after release of the version/revision)
- Download upgrades or updates (both discussed in later paragraph)
- Online forums where exchange and sharing between end-customers can take place
- Blogs to discuss some issues quickly and find answers to some issues
- Articles and white papers to explain certain features, concepts in CAD/CAM with how to perform a certain task
- Consulting services

Most of these services are offered free of cost, where as the consultancy services are offered on chargeable basis. In short all possible ways are used by vendors to lure the end-customers and to see that they are served properly to use their respective product. The aim is to get the customers under AMC after one year of initial purchase or expiry of previous AMC. This is a constant source of assured revenue from the customer.
In the current CAD/CAM market, there are major players like Autodesk’s Inventor, Siemens’ NX-UG & Solid Edge, Dassault Systems’ Catia & Solid Works, and PTC’s Pro/E-Creo. Most of them are US based brands except for Dassault which is French organization. All these brands support majority of CAD/CAM functionalities directly or by add-on programmes. So functionally they represent CAD/CAM market. Their individual company revenue figures cross one billion US dollar. Thus they are the organizations that constitute for major market share in CAD/CAM market. In conclusion, these brands and their respective organizations are representative of the CAD/CAM industry as a whole. These organizations have more than one popular brand which have been discussed in the study during the field survey with interviewees. Some of these other brands are Autodesk’s AutoCAD, Alias, Moldflow; PTC’s Windchill, Mathcad; Siemens’ Teamcenter; Dassault’s Enovia etc.

There are a few companies that are popular in CAD/CAM market like Ansys, MasterCAM, Graebert, NISA, COSMOS etc. They have not been considered in this study for two reasons. One reason is that their individual organization sales revenue is below one billion US dollar. They do not constitute the major share of the CAD/CAM market. The other reason is that they operate in one CDA/CAM sub-market; either CAD or CAE or CAM. They lack the functional representation of entire CAD/CAM market. Thus their impact on the entire market is not very significant, though they may have great functionalities and may impact one of the CAD/CAM sub-markets.

3.3 Profile of Individual CAD/CAM Brands

As discussed earlier in this chapter, some CAD/CAM products got merged, bought-over by competitors or just died with time. But the ones that survived the global competition became Brands. Following sub-sections describe the individual brands and their organizations in detail.
3.3.1 Inventor

Autodesk Inc is a US based multinational organization that is promoted by John Walker, Mike Riddle and Dan Drake in 1982. AutoCAD is the flagship product of Autodesk and clearly dominated the 2D drafting market of CAD/CAM. Inventor is its major CAD/CAM product which is bundled in various packaged products viz. Inventor Suit, Product Design Suit, & Factory Design Suit. The products are further divided as standard, premium, and ultimate suits that contain functionalities in the increasing order as stated here. The basic Inventor module is a powerful solid and surface modeling tool, which constitute towards CAD functionalities. It has in built CAE functionalities that are based on the acquired CAE brand- Algor. It has various third party software routines to create the CNC codes providing the CAM functionalities. Autodesk has recently acquired DelCAM- a powerful CAM product and soon will include full CAM functionalities in the suit. Autodesk states: ‘On February 6, 2014, Autodesk acquired the entire issued and to be issued share capital of Delcam plc (“Delcam”), for £20.75 per share, or approximately £174.6 million or $284.6 million. Delcam was previously listed as a public company (LON: DLC) and is a leading supplier of advanced CADCAM and industrial measurement solutions for the manufacturing industry. With this transaction Autodesk gains Delcam’s range of design, manufacturing and inspection software that provide automated CADCAM solutions for a variety of industries, ranging from aerospace to toys and sports equipment.’ (Page 168) (Autodesk Annual Report, 2014)24.

These products constitute Autodesk’s Digital Prototyping tools that allow the manufacturing industry users to create, visualize, simulate and analyze real world products. Two other acquisitions have given Autodesk competitive advantages. Alias is market leader in Automotive Styling and converting this data into digital content. MoldFlow has given Autodesk leadership position in injection molding simulation market.

Autodesk is headquartered at San Rafael, CA, US and has revenue of over 2.27 Billion USD in fiscal year 2014 (page 106) (Autodesk Annual Report, 2014). Inventor suits form Autodesk’s first vertical that is manufacturing vertical. Autodesk’s second vertical is AEC & Infrastructure vertical which has market leader brands like Revit, Autodesk Civil 3D, Autodesk Map 3D. The Building Information Modeling (BIM) concept is a breakthrough technology in AEC market, and is instrumental in NASA’s Ames building, Shanghai Tower, New York Freedom Tower, and San Francisco Bay Bridge. Third vertical of Autodesk is Media & Entertainment vertical. Autodesk enjoys market leadership position in this vertical also with brands like Maya, & 3D Studio Max. Many Bollywood, Hollywood movies including Avatar, are outcome of these software products that have won the Academy Awards for Best Visual Effects for more than 15 years.

Autodesk has promoted ATC- Authorized Training Centers globally, and has made available third party books available on its products. Autodesk users had two magazines named CADalyst and Cadence earlier but now both are merged to retain CADalyst. It also supports external programming routines to customize products, and has a huge network of ADN- Autodesk Developer Network members. Autodesk has around 4000 Third-Party (AND) software developed around its products- Autodesk Annual report-page 84 (Autodesk Annual Report, 2014). Thus Autodesk has a unique position in the CAD/CAM market though it lacks straight application handling manufacturing.

Autodesk’s strength over decades is its globally present, unmatched channel structure. It consists of regional headquarters, supporting national distributors that control local dealers. Autodesk in its Annual Report, page 83 reasserts its distribution channel policy as: ‘Our indirect channel model includes both a two-tiered distribution structure, where distributors sell to resellers, and a one-tiered structure, where Autodesk sells directly to resellers. We have a network of approximately 2,500 resellers and distributors worldwide. For fiscal 2014, approximately 84% of our revenue was derived from

indirect channel sales through distributors and resellers, and we expect that the majority of our revenue will continue to be derived from indirect channel sales in the future’.
(Autodesk Annual Report, 2014)  

Throughout its history, Autodesk products have been running on microcomputers like PC or Mac with MS Windows and MAC OS. A small exception took place when products were available on of UNIX before Release 13, which was later discontinued. Currently Autodesk works on Wintel that refers to Windows and Intel platform for all its products.

Official Web site for Inventor is:
http://www.autodesk.com/products/inventor/overview

3.3.2 CATIA

CATIA stands for Computer Aided Three- dimensional Interactive Application. The software is product of Dassault Systèmes, S. A. (Vélizy, France) which is promoted by an aircraft manufacturer- Dassault Aviation. Dassault Aviation has purchased CADAM (Computer-graphics Augmented Design and Manufacturing) software from Lockheed in 1960s. A team of graphics and aircraft engineers was given task to augment the CADAM software with computer programs, for development of Mirage fighter jet. Team has created substantially good programs and the product was called CATI. It was renamed as CATIA since 1981 and it could replace CADAM in Dassault.

As stated in Wikipedia: ‘At the end of 1980, the rumours surrounding CATIA reached the very top of the company and Marcel Dassault aged 88, asked for a demonstration of the software capabilities. The company management understood the engineers' vision and started to discuss how to leverage their innovation. They quickly realised they could not afford to keep and develop this invention internally and decided to create a new


Thus the first shipments of Catia were in the year 1981. Though the software was developed internally for jet, it was later developed to handle aeroplane, automobile, marine and similar industries. In 1992, Dassault acquired CADAM and integrated with CATIA. It was ported successfully from mainframe to UNIX based machines (Catia V4) to today’s Windows based PC (Catia V5). Today, Catia on the Cloud is cloud compatible version of Catia along with Catia V5 and V6 as current versions. Catia calls its product suit as 3D PLM referring to Product Lifecycle Management. Added to Catia are DELMIA to support manufacturing, SIMULIA to support engineering analysis, and ENOVIA to supported product data management tools.

DELMIA is developed by Dassault after acquisition of Deneb as a digital manufacturing simulation and covers all areas of production process. Creation, planning, control and monitoring of production processes is possible with DELMIA. DELMIA’s applications for manufacturing communities drive manufacturing innovation by planning, simulating and executing global production processes. DELMIA allows all stakeholders in manufacturing, no matter their level of expertise, to be part of a single community that has all of its members working toward the same shared objectives of production performance (page 18) (CATIA Annual Report, 2014)29.

ENOVIA is an outcome of acquisition of SmartTeam and MatrixOne. It provides collaboration toll across all products. ENOVIA offers a rich portfolio of collaborative enterprise business process applications that complete the 3DEXPERIENCE Platform and facilitate business processes interoperability in context of various information and

data authoring applications, such as CATIA, DELMIA, SIMULIA and other Dassault Systèmes’ solutions (page 19) (CATIA Annual Report, 2014)\(^\text{30}\).

Acquisition of Abacus helped Dassault to promote SIMULIA which takes care of testing and simulation as described below (page 18) (CATIA Annual Report, 2014)\(^\text{31}\):

**Finite Element Analysis:** Allows companies to create and test virtual prototypes of products and processes;

**Multiphysics Solutions:** Enables companies to reach beyond the boundaries of a single domain to simulate two or more interacting physical phenomena;

**Design Optimization:** Empowers designers and engineers to perform rapid trade-off studies of real-world behavior using a full range of tools for advanced optimization applications and workflows;

**Simulation Lifecycle Management:** Simplifies the capture and deployment of approved simulation methods and best practices, providing guidance and improved confidence in the use of simulation results for collaborative decision making.

Thus it is an all comprehensive CAD/CAM product. It is available on UNIX, MS Windows platform. Well accepted by Automobile, Aerospace, Ship Building, Industrial Equipment industries worldwide.

Dassault Systems SA is headquartered at Paris Campus, Paris France. Total sales revenue of Dassault for fiscal year ended December 2013 is €2.066 Billion of which €818.9 million is pure CATIA revenue which is equivalent to US $1.015 billion (page 59 of annual report) (CATIA Annual Report, 2014)\(^\text{32}\).

**CATIA Mechanical Engineering:** Optimizing Design to Manufacturing Digital prototyping, analysis, and simulation enable developers to virtually create mechanical


products in their operating environment and give Mechanical Engineers key insights into quality and performance early in development. CATIA applications create 3D assemblies for a wide range of mechanical engineering processes, including cast and forged parts, plastic injection and other moulding operations, composite part design and manufacturing, machined and sheet metal part design, advanced welding and fastening. Engineers can rely on CATIA to define the complete mechanical product, including functional tolerances and 3D annotations (page 17) (CATIA Annual Report, 2014).33

Official Web site for CATIA is: http://www.3ds.com/products-services/catia/welcome/

3.3.3 UG- NX

Unigraphics NX is today called as NX, is still famous for its earlier name UG. Currently the software is a product of Siemens PLM Software which is headquartered in Plano Texas, USA. Siemens PLM Software is a subsidiary of Automation & Drives division of Siemens AG, Germany.

As stated by Weisberg, the history of NX dates back in 50s when McDonnell Aircraft Corporation formed McAuto (McDonnell Automation Company) for its computer services. In 1967 McDonnell Aircraft and Douglas Aircraft merged to form McDonnell Douglas Corporation (MDC). The developed CAD/CAM system was called CADD (Computer Aided Design & Drafting). This software was made available to public unlike Lockheed’s CADAM. Meanwhile in 1973, UNI-GRAPHICS was developed by United Computing in USA. In 1976, Unigraphics was taken over by McAuto. McAuto was renamed as McDonnell Douglas Manufacturing And Engineering Company in 1987. In General Motors (GM) acquired Electronic Data Systems (EDS) which is largest computer service organization. EDS selected Unigraphics with CADAM to be purchased for GM. More UG seats were installed at GM and thus it became popular. In 1991, EDS acquired Unigraphics. In 1998 separate Unigraphics Solutions (UGS) was

floated as a listed company in the USA. In 2001, EDS announced acquisition of major competitor SDRC - Structural Dynamics Research Corporation (creator of I-DEAS software) and formation of new company - EDS PLM Software, which later became UGS PLM Software. In 2002 UniGraphics NeXt (generation) software or UG- NX was offered in the market. Since 2007, Unigraphics NX is the product of Siemens (Chapter 19) (Weisberg, 2014).\(^{34}\)

NX offered today in the market is a very powerful solution. As per the technical brochure (Siemens PLM-NX Web Site, 2014)\(^{35}\) NX delivers:

- Advanced solutions for conceptual design, 3D modeling and documentation
- Multidiscipline simulation for structural, motion, thermal, flow, multiphysics and optimization applications
- Complete part manufacturing solutions for tooling, machining and quality inspection

NX leverages Teamcenter® software, a collaborative product development management (cPDM) solution from Siemens PLM Software, to establish a single source of product and process knowledge that coordinates all phases of development, standardizes your processes and accelerates decision making. (Page 3) (Siemens PLM-NX Web Site, 2014).\(^{36}\)

NX for Design:

NX can help you deliver greater innovation at higher quality and lower cost with comprehensive 3D product design.

With unmatched power, versatility and flexibility, NX gives your design teams the freedom to use the most productive approach for the task at hand. Designers can select wireframe, surface, solid parametric or direct modeling techniques with seamless interchange.

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NX includes powerful assembly design tools with performance and capacity that enable you to work interactively in the full assembly context, even with the most complex models. Assembly navigation, multi-CAD mock-up, interference analysis, path planning and other engineering tools accelerate assembly design and improve quality. (Page 4) (Siemens PLM-NX Web Site, 2014)  

NX for Simulation:  
A modern CAE environment  
NX CAE is a modern, multi-discipline environment for advanced analysts, workgroups and designers who need to deliver high quality performance insights in a timely fashion to drive smarter product decisions. Unlike disconnected, single-discipline CAE tools, NX CAE integrates best-in-class analysis modeling with simulation solutions for structural, thermal, flow, motion, multiphysics and optimization into a single environment. It also seamlessly integrates simulation data management into an analyst’s workflow so that information is no longer lost within some obscure hard drive. Finally, NX CAE enables simulation-driven design by giving companies the ability to expand simulation to the design community and increase collaboration between analysts and designers. (Page 8) (Siemens PLM-NX Web Site, 2014)  

NX for Manufacturing:  
NX provides a complete set of numerical control (NC) programming capabilities in a single CAM system as well as an integrated set of manufacturing software applications. These powerful applications facilitate part modeling, tool design and inspection programming – all based on the proven, future-proof architecture of NX. NX allows the use of a common 3D model from part design to production. Advanced model editing, tool and fixture design, part and inspection programming are all associative, enabling fast, easy changes. (Page 12) (Siemens PLM-NX Web Site, 2014)  

NX today runs MS Windows, Mac OS and Linux. The products are well accepted by Automobile, Aerospace, Forgings, Industrial Equipment, and heavy engineering industries.

Official Web Site of Unigraphics NX is:

3.3.4 Pro/ENGINEER

Dr Samuel P Geisberg is the founder of Parametric Technology Corporation, but the earlier name was SPG Consulting Corporation formed in 1985. Dr Samuel had earlier worked in Prime Computers, Computervision and Applicon. The first version of Pro/ENGINEER was commercially sold in 1988 as the first parametric modelling software. After that the company has never looked back. From 2000 onwards the company is referred as PTC but still it is legally Parametric Technology Corporation. The software products of the company were the first to the market and fully developed to serve the end-customer. In 2010 Pro/ENGINEER was renamed as PTC- Creo. (Chapter 16) (Weisberg, 2014)

PTC is headquartered at Massachusetts USA. PTC sales revenue for 2013 is US $1.29 Billion (Page 15) (PTC Annual Report 2013, 2014)

The product line of PTC as described in the annual report consists of following:

CAD

Our CAD products enable users to create conceptual and detailed designs, analyze designs, perform engineering calculations and leverage the information created downstream. Our principal CAD products are described below.


PTC Creo® is an interoperable suite of product design software that provides a scalable set of packages for design engineers and that are optimized to meet a variety of specialized needs. PTC Creo provides capabilities for design flexibility, advanced assembly design, piping and cabling design, advanced surfacing, comprehensive virtual prototyping and other essential design functions.

PTC Mathcad® is industry-leading software for solving, analyzing and sharing vital engineering calculations. PTC Mathcad combines the ease and familiarity of an engineering notebook with the powerful features of a dedicated engineering calculations application. (Page 4) (PTC Annual Report 2013, 2014)\(^42\)

Extended PLM
Extended PLM includes our PLM, ALM and SCM products.

PLM: Our PLM products address common challenges that companies, particularly manufacturing companies, face over the life of the product, from concept to retirement. These software products help customers manage product configuration information through each stage of the product lifecycle, communicate and collaborate with the extended enterprise, and manage change. Our principal PLM products are described below.

PTC Windchill® is production-proven PLM software that offers complete lifecycle intelligence - from design to service. PTC Windchill offers a single source of truth for all phases of the product lifecycle to help companies streamline enterprise-wide communication and make informed decisions.

PTC Creo® View™ enables enterprise-wide visualization, verification, annotation and automated comparison of a wide variety of product development data formats, including CAD (2D and 3D), ECAD, and documents. PTC Creo View provides lightweight access to designs and related data without requiring the original authoring tool. (Page 4) (PTC Annual Report 2013, 2014)\(^43\)

ALM: Our ALM products are designed for discrete manufacturers where coordination and collaboration between software and hardware teams is critical to understand product


release readiness, support variant complexity, automate development processes, ensure complete lifecycle traceability and manage change. Our ALM products enable companies to accelerate innovation of software intensive products. Our principal ALM product is PTC Integrity™.

**PTC Integrity™** enables users to manage system models, software configurations, test plans and defects. With PTC Integrity, engineering teams can improve productivity and quality, streamline compliance, and gain complete product visibility, and ultimately drive more innovative products into the market. (Page 4) (PTC Annual Report 2013, 2014)

**SCM:** Our SCM products allow manufacturers to collaborate across product development, the supply chain, sourcing and procurement, so they can identify an optimal set of parts, materials and suppliers. SCM accelerates the sourcing process through an automated process with detailed cost modeling and provides visibility into supply chain risk information to balance cost, quality and compliance. Our principal SCM products are described below.

**PTC Windchill® FlexPLM®** is designed specifically for manufacturers in the Consumer Products and Retail, Footwear and Apparel industries. PTC Windchill FlexPLM addresses both industry-specific challenges and everyday business pressures. It offers a high-performance, internet-based platform to bring together globally distributed teams. Plus, it provides line planning, specification management, merchandizing, and other essential PLM capabilities for managing a company’s complete assortment of products.

**PTC Windchill Product Analytics** is a suite of products that enable manufacturers to assess product compliance, performance and risk early in the innovation process and throughout the product lifecycle. It helps engineers ensure that products meet performance targets at launch, including cost, weight, compliance, and more. (Page 4) (PTC Annual Report 2013, 2014)

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With these products PTC has a strong CAD/CAM product line which is available on Windows & UNIX platform. PTC has gone strong with various acquisitions like Rasna Corporation (in 1995), Computervision (in 1998), Arbortext (in 2005), MathSoft (in 2006), CoCreate (in 2007).

Official Web site of PTC is: www.ptc.com

3.3.5 SolidWorks

SolidWorks a company headed John Hirschtick, first delivered SolidWorks 95 in 1995. The work on SolidWorks was started in 1994 in Winchester Design Systems based in Massachusetts, US by Hirschtick and Michael Payne - an ex- PTC employee. SolidWorks was a success from the start of its first deliveries.

Weisberg writes in his chapter on SolidWorks that: ‘…SolidWorks 95 took off with a bang. Most initial releases of new software products have severe functional shortcomings and far too many bugs that prevent productive work from getting done. Not so with SolidWorks 95’. (Weisberg, 2014)\(^{46}\)

From the very beginning SolidWorks made it clear to that it would not develop a direct sales channel to compete with its resellers’ channel. This resulted in a highly committed group of distributors & dealers. This resulted in great amount of sales and revenues in early years. The second important point was that the company indicated that it planned to focus on the core software development of CAD, and not on developing peripheral application software. This strategy fostered rampant growth of independent software developers and soon they were offering applications that worked with SolidWorks. In some cases, SolidWorks bundled these application with its own software and offered to the rest of CAD/CAM industry as a better solution.

Structural Research & Analysis Corporation (SRAC), Founded by Dr. Victor Weingarten had developed COSMOS/M which is a comprehensive, engineering analysis software. SRAC developed COSMOS/Works within the environment of SolidWorks to provide Finite Elements Modelling capabilities. This is one such example of how seamless collaboration of two software products can help end-customers.

In June 1997 Dassault Systems acquired SolidWorks. In practice they never competed against each other. Actual competition was between Autodesk, SolidWorks, and PTC. Till date SolidWorks continues to sell and there is no mixing of two technologies between CATIA and SolidWorks. CATIA continues with its acquire ACIS geometric modelling kernel while SolidWorks still uses Parasolid geometric modelling kernel. (A geometric modelling kernel is set of basic software utilities defining geometries in 3D; CAD/CAM software uses these utilities and builds CAD or CAM application.) Thus the Dassault acquisition has not affected SolidWorks’ channel strategy and 3rd party developer’s strategy.

Dassault Systèmes SolidWorks Corp., a subsidiary of Dassault Systèmes, S. A. (Vélizy, France) is Headquartered in Waltham, Massachusetts, USA. Total sales revenue of Dassault for fiscal year ended December 2013 is €2.066 Billion of which €409.5 million is pure SolidWorks revenue which is equivalent to US $507.8 million (page 59) (CATIA Annual Report, 2014)47

As stated in the Dassault System’s Annual Report: SOLIDWORKS applications cover all aspects of the product development process with a seamless, integrated workflow for design, simulation, technical communication and data management. Designers and engineers can span multiple disciplines with ease, shortening the design cycle, increasing productivity and delivering innovative products to market faster. SOLIDWORKS applications include 3D tools to design, manage, simulate and communicate.

3D Design: 3D design application for rapid creation of parts, assemblies, and 2D drawings with minimal training. Application-specific tools for sheet metal, weldings, surfacing, and mould tool and die make it easy to deliver best-in-class designs. SOLIDWORKS 3D applications also include photo realistic rendering, a sophisticated components and parts library, design validation, as well as advanced wire and pipe routing functionality;

Data Management: SOLIDWORKS product data management (‘‘PDM’’) applications help professionals to get design data under control and substantially improve the way teams manage and collaborate on product development;

Simulation: SOLIDWORKS offers a comprehensive suite of simulation applications to set up virtual real-world environments to test product designs before manufacture. Tests can be conducted against a broad range of parameters during the design process – like durability, static and dynamic response, motion of assembly, heat transfer, fluid dynamics, and plastics injection moulding – to evaluate design performance and improve quality and safety;

Technical documentation: SOLIDWORKS Composer allows users to easily repurpose existing 3D design data to more rapidly create and update high quality graphical assets for product deliverables, including documentation, technical illustrations, animations, and interactive 3D experiences;

Electrical Design: SOLIDWORKS Electrical applications provide a Digital prototyping range of electrical system design functionality to meet the needs of design professionals. All project design data is synchronized with real-time, bi-directional updates between schematics and the 3D model. Powerful schematic design tools quickly develop embedded electrical systems for machines or products, with built-in symbol libraries, manufacturer part data, and 3D component models (pages 16, 17) (CATIA Annual Report, 2014) 48.

SolidWorks operates on Windows and in PC environment.

Official Web Site of SolidWorks is: http://www.solidworks.com/

3.3.6 Solid Edge

Solid Edge is originally developed by Intergraph in 1996. Intergraph is one of the old players from CAD/CAM industry having hardware as also the main business line. Intergraph stood for Interactive Graphics. It was formed in 1969 as M&S Computing under leadership of Jim Meadlock and went public as Intergraph in 1980. In 1998 EDS acquired Solid Edge and merged it with Unigraphics Solutions (UGS). Later in 2007, UGS was taken over by Siemens and a new organization named Siemens PLM Software came into existence. (Chapter 14) (Weisberg, 2014)

Currently the software is a product of Siemens PLM Software which is headquartered in Plano Texas, USA. Siemens PLM Software is a subsidiary of Automation & Drives division of Siemens AG, Germany. The company offers NX and Solid Edge as two main CAD/CAM product lines to the market.

Solid Edge® ST7 software features as explained in the brochure include:

- Faster and more flexible 3D part and assembly modeling, photorealistic renderings and improved 2D drawing production capabilities that enable you to improve product design and get products to market ahead of your competitors
- Expanded visual design management capabilities enable you to complete projects faster and more efficiently
- Wider capabilities for design, manufacturing and collaboration through powerful new and expanded Solid Edge Apps that speed design through manufacturing
- Significant user interface enhancements and easier access to leading design technology speed time-to-value for product development for all types of organizations, from startups to established manufacturers (Page 1) (Solid Edge ST7, 2014)

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The product is a full suite of CAD/CAM functionalities. These functionalities are described in the brochure as follows:

**Accelerate your 3D modelling:**
Faster and more flexible 3D part and assembly modeling, expanded use of synchronous technology, photorealistic rendering and enhanced 2D drawing production capabilities enable you to design better products and get those products to market ahead of their competition. (Page 1) (Solid Edge ST7, 2014)\(^5\)

**Faster processing and improved preference handling using Solid Edge Simulation:**
Solid Edge Simulation, a built-in finite element analysis (FEA) tool that enables design engineers to digitally validate part and assembly designs within the Solid Edge environment, now gives you the ability to specify multiple processor use and the number of processors to be used. A new capability to specify and store global preferences has also been added, enabling you to apply preferences immediately across multiple analyses. (Page 5) (Solid Edge ST7, 2014)\(^5\)

**Embedded CAM capabilities with CAMWorks for Solid Edge:**
The embedded CAMWorks for Solid Edge solution from Geometric has been expanded to include multi-axis milling, wire EDM, and mill-turn capabilities. Support for Solid Edge assemblies allows the NC programmer to see his or her entire setup (including fixtures) while creating tool paths. (Page 6) (Solid Edge ST7, 2014)\(^5\)

Some of the key characteristics of Solid Edge are:

- Solid Edge is oriented towards the design of assemblies rather than just individual parts. More than a million parts can be handled very effectively within Solid Edge.
- The software is Windows compatible and PC based, greatly reducing learning time.
- Solid Edge with synchronous technology supports accelerated design, faster changes, and improved re-use of imported data. Thus chamfers recognition,
offset parts, and a pattern within patterns is recognized giving flexibility in handling imported parts

Official site of Solid Edge is:

3.4 CAD/CAM Product Overview

As discussed in the earlier sections of Chapter 3, we are considering six CAD/CAM products out of tens of available product companies in the global market. The point remains here is to check whether we are doing justice to the study or we are taking only peripheral overview. A report from Bill Martin-Otto, CAD/CAM Evangelist from Lenovo was studied to get an answer to this question.

The report is titled “2012 CAD/CAM Performance Market Report” (Martin-Otto, 2014)\(^54\). The study covered respondents from US and 38 other countries are also represented, including Canada, India, the UK and American Samoa. The respondents included Engineers, Designers, Engineering Managers, IT Specialists, IT Manager/Executives. Thus the study was quite exhaustive. The study was done by unbiased organizations Lenovo and NVIDIA. They supply computer hardware and are preferred hardware partners for most of the CAD/CAM vendors. Thus the author is from the CAD/CAM industry.

Under the study % of respondents were using following CAD/CAM products:
- AutoCAD (from Autodesk): 45.9%
- SolidWorks: 18.3%
- CATIA: 9.8%
- Creo or Pro/Engineer: 8.4%
- Siemens NX: 4.7%
- Others: 12.9%

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The above report proves that when it comes to any CAD/CAM research the industry experts consider the above 5 products predominantly. The above five CAD/CAM products are the same products that are the studied in this study, with an exception of Solid Edge. Solid Edge is been considered in this study as it is another Siemens PLM software product in addition to UG-NX (Unigraphics- NX). This global report shows that Research Student's approach to study six CAD/CAM products is in-line with what is happening in the global market. Thus conclusion can be drawn for the entire CAD/CAM market from actual field study of six CAD/CAM products.