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Parasolid

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The world's leading production-proven 3D modeling kernel

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3D design modeling business challenges



The commercial and technical benefits of 3D digital models have never been use 3D digital models to develop, validate and manufacture products – spanning the entire product lifecycle with 3D product definitions. With the advent of 3D geometric component modeling demand for 3D digital representation by integrating modeling kernels into product lifecycle applications.As 3D modeling kernels are incorporated into must be able to handle larger, more complex models, support higher levels of modeling automation and provide the versatility needed to support broad-based important, modeling kernels must reliably manage data accuracy and consistency while providing the openness and interoperability needed to facilitate the seamless exchange of 3D product data.

Interoperability is crucial in product development and manufacturing, where product makers use different applications for product design, design validation and manufacturing engineering – but require these systems to interoperate across a variety of upstream processes.To address these needs and provide software developers with world-class modeling technology that is easy to integrate and supports the diverse requirements of 3D digital representation, Siemens PLM Software offers Parasolid[®] software – the world's leading productionproven 3D modeling kernel.

Introducing Parasolid



"Parasolid is the world's most advanced modeling kernel and its continuing industry-wide expansion has opened up new markets for our VISI-Series software."

Don Babbs CEO Vero International Software

A true foundation for digital 3D representation

Parasolid is the world's leading production-proven 3D geometric modeling component software or "kernel" modeler, providing core functionality that enables users to rapidly and robustly model the industry's most complex products. Based on high-precision boundary-representation technology, Parasolid supports solid modeling, generalized cellular modeling and freeform surface/sheet modeling within an integrated framework.

Developed and supported by Siemens PLM Software in Cambridge, England, Parasolid is a key offering in the company's PLM Components suite of solutions and is marketed, distributed and supported through the company's playing field business model. Parasolid provides the comprehensive modeling foundation for hundreds of the world's leading computer-aided design, manufacturing and engineering analysis (CAD/CAM/CAE) applications and serves as the corporate standard for Siemens PLM Software's own market-leading portfolio of product lifecycle applications, providing 3D digital representation capabilities for the company's NX[™] software, Solid Edge[®] software, Femap[™] software and Teamcenter® software solutions. Industrially proven in high-end mechanical CAD applications, the power of Parasolid is also deployed in many leading mid-range systems and enjoys widespread use in the independent CAD, CAM, CAE and visualization markets. Parasolid is also leveraged in numerous specialized application domains, including machine tools, coordinate measuring, fluid dynamics and architectural CAD.

The global reach of Parasolid-enabled applications spans multiple industries and has grown beyond three and a half million end users – all of whom benefit from the ability to seamlessly share geometric models through Parasolid native XT file format. Parasolid users also benefit from intrinsic, tolerant geometry processing that combines with Parasolid translation and healing technologies to facilitate the most robust interoperability platform available today.

By coupling unsurpassed 3D modeling functionality with industrial-strength interoperability and a proven record of customer support, Parasolid continues to rapidly expand its market share and enhance its position as the kernel- ofchoice for powering the world's premier product development applications.

"Broad acceptance of Parasolid throughout the CAD market as well as its adoption by the number one, two and three suppliers of digital prototyping and simulation software have led Parasolid to become a de facto standard for open, commercially available geometric modeling kernels."

Charles Foundyller CEO Daratech, Inc

Parasolid benefits

Benefit	Business advantage
Facilitates open innovation for application developers	Parasolid low-maintenance open integration architecture enables software developers to easily incorporate Parasolid in their applications, allowing them to focus resources on developing value-added innovations while using the industry's state-of-the-art 3D modeling technology for their foundation.
Reduces development costs and risks	Vendors who license Parasolid avoid the prohibitive cost of developing a 3D modeling platform from scratch, while eliminating quality and delivery risks associated with building applications on an unproven modeling foundation.
Delivers proven results	Siemens PLM Software develops Parasolid in conjunction with the world's most demanding base of 3D geometry users. Because Parasolid demonstrates its credentials daily in the most stringent production settings, application developers and users are assured that their kernel-of-choice is capable of meeting the world's most complex modeling challenges.
Delivers unsurpassed modeling functionality	Parasolid combination of modeling power, versatility and applicability constitutes the most modeling functionality compelling functionality of any solid modeling kernel on the market today. Parasolid comprehensive features provide the modeling foundation for hundreds of commercial 3D applications, including solutions for product design, visualization, design analysis and manufacturing engineering. The breadth and depth of Parasolid modeling capabilities have also made Parasolid the popular choice among academic and research organizations.
Ensures state-of-the-art quality and robustness	Due to the widespread usage of Parasolid throughout the world, vendors and users are assured that Parasolid is continually enhanced to meet the ever-growing quality expectations of today'suser community. Comprehensive and rigorous testing across a spectrum of application scenarios enables Parasolid to be maintained at production quality levels throughout the development cycle. Parasolid plug-and-play updates assure users that new releases are seamlessly integrated with current mission-critical capabilities.
Facilitates supply chain collaboration	Parasolid marketplace success makes it highly likely that the vendors and allied partners in many supply chains will be using CAD/CAM/CAE tools powered by Parasolid. As a result, participants in these supply chains find it much easier to collaborate with one another by sharing and seamlessly exchanging native geometry data.
Delivers superior third-party interoperability	Parasolid provides a wide range of proven interoperability tools and methods that can handle complex third party data migration and data exchange tasks, enabling Parasolid-based applications to perform high quality, highly successful data exchange with any modeling application.
Provides world-class support to faster rapid time-to- market	Siemens PLM Software supports Parasolid with a world class team of dedicated subject matter experts, coupled with tools for automated fault reporting, focused training and consulting and rapid implementation that help software developers quickly bring Parasolid-based applications to market.

Established market leader



Real-world credentials

Over three and a half million users are leveraging Parasolid- based systems for product development and research.

Parasolid is industrially proven in high-end MCAD systems.

Parasolid-based systems lead the mid-range CAD market.

The largest, most successful and fastest growing CAM and CAE applications use Parasolid.

Widespread availability of data in Parasolid XT format is driving new Parasolid adopters.

Parasolid production-proven capabilities are leveraged by the corporate IT departments of leading global manufacturers.

Parasolid is the world's premier 3D modeling component technology with well over a million end users now creating, analyzing, manufacturing and visualizing definitive 3D models using Parasolid-based applications.

Indeed, many of today's most successful and fastest growing application vendors have established Parasolid as the standard for meeting their core 3D modeling and interoperability requirements.

Parasolid is distinguished by five key attributes:

- Widespread industry acceptance
- Superior modeling and innovation
- Unsurpassed interoperability
- Support for the product lifecycle
- Ease of implementation

This level of market leadership translates into a wide variety of benefits for both application vendors and application users. For example, vendors who need to quickly bring their applications to market can avoid the significant technology, delivery and scheduling risks associated with implementing unproven 3D modeling technology.

Equally important, the prevalence of Parasolid-based applications enables end users who participate in global enterprises to exchange geometric models across product lifecycle processes as seamlessly as possible while retaining the accuracy of their product definitions. Siemens PLM Software works with its user community to enable Parasolid to handle the world's most complex and demanding modeling problems. Consequently, Parasoliddriven applications have been adopted and validated for use by a diverse set of industries, including the automotive, aerospace and defense, high tech electronics and consumer products markets that require high-end modeling capabilities.

Parasolid market success enables Siemens PLM Software to support its customer base with a world-class services organization that includes consulting, training and subject matter experts who have proven their credentials working with the world's most demanding base of 3D modeling users. Siemens PLM Software also employs rigorous feedback methodologies to incorporate the voice of the user into its ongoing enhancements. Plug-and-play updates provide users with new features that are seamlessly integrated with Parasolid current modeling capabilities. These regular enhancements enable Parasolid to maintain its competitive advantage, sustain its quality, expand its capabilities and extend its usability.

"By leveraging the Parasolid standard, we gain its industry-proven functionality and establish a seamless geometry interchange with other Parasolid-based CAD/CAM/CAE products worldwide."

James E. Cashman III President and CEO ANSYS, Inc

Superior functionality and sustained innovation



Siemens PLM Software works closely with the world's largest base of modeling kernel users to meet today's real-world 3D modeling requirements. This relationship drives Parasolid to excel in important areas such as blending, surfacing, hollowing, editing and sewing. It plays a major role in shaping the extremely powerful modeling automation capabilities of Parasolid, as well as validating the comprehensive application support and graphical output functions that enable customers to quickly and easily integrate Parasolid into their software solutions.

Parasolid robust capabilities extend to more than 800 object-based functions that include a wealth of model creation, editing and querying utilities, as well as high-level, application-oriented functions packaged to maximize modeling automation. The breadth and depth of these capabilities combine to enable users of Parasolidbased applications to design, analyze, manufacture and visualize the most complex products found in today's highly sophisticated industrial, commercial and consumer markets. Parasolid continual commitment to excellence draws its strength from more than 850 developer years of R&D investment and is reflected in the Parasolid record of sustained innovation – which has resulted in the following industry firsts.

- Tolerant modeling for seamless handling of model data consistency
- Intrinsic symmetric multi-processing for optimized processing algorithms
- Partitioned rollback for complex undo and recovery strategies
- Two-way data compatibility for eliminating application versioning issues
- Direct modeling for complex, history-independent model editing

Functionality	Parasolid advantage
Modeling operators	 Powerful hybrid modeling operators enable users to create and edit new models by uniting, subtracting or intersecting any combination of wire, sheet and solid bodies. The suite of Boolean-based operations includes: Versatile region selection and matching options for optimized feature attachment Instancing for fast replication of features Generalized Booleans for operations involving disjoint, non-manifold or mixed-dimensional models
Feature support	 Parasolid offers several powerful modeling techniques to support advanced feature creation, including comprehensive extrude, emboss and patterning capabilities. Extrusion allows profiles to be swept linearly into solid models with a range of termination conditions Embossing enables profiles to be mapped onto models to create complex pads and pockets Patterning quickly creates a repeating pattern of existing features across multiple faces of a model
Advanced surfacing	 Parasolid provides a broad range of generalized surfacing functionality for generating sculptured shapes from profiles and boundaries. Sweeping allows profiles to be swept along an arbitrary path to generate complex shapes Lofting creates a surface that fits a series of sectional profiles, using powerful shape controls that can accommodate guide curves, tangencies, degeneracies and curvature continuity Automatic hole-filling includes the capability to patch open regions of a model smoothly with freeform surfaces Parasolid fully integrates these functions at the topological level, which results in industry-leading functionality, reliability and performance.
Thickening, hollowing and offsetting	Parasolid delivers a range of methods that enable CAD users to create thin-walled parts using simple inputs, including: • Thickening of sheet models • Hollowing of solid models • General offsetting Each of these methods provides powerful functionality, including automatic self-intersection removal and together form a comprehensive suite of tools that accelerate the design of plastic moldings, castings, pressings and panels.
Tapering and drafting	Parasolid includes an extensive range of tapering and drafting functionality to support auto- mated mold and die-making. Parasolid accommodates complex tapering strategies, including both single and double-sided tapering, mitering, undercuts and flexible definition of parting surfaces to support diverse mold-making and casting techniques.
Direct modeling	Direct modeling is an extremely powerful editing capability that allows regions of a model to be manipulated and/or replaced; it is particularly useful when applications need to make complex model adjustments independent of any model history. Parasolid provides high-level functions that users leverage to perform multiple model edits including offsets, tapers, geometry replacements and transformations in a single step while automatically regenerating surrounding data to ensure the resulting model's integrity.
Blending and filleting	Parasolid provides a comprehensive suite of functionality for blending and filleting edges and faces of complex geometry with unmatched reliability and ease-of-use. Parasolid supports rolling ball, variable-radius, face-face, 3-face, cliff-edge, curvature continuous, tangent hold line, disc, conic section and conic hold line blend types. Parasolid also provides automatic overflow, propagation and self-intersection repair controls, which combine with blend preview capability and general ease of use to allow applications to make sensible decisions in ambiguous cases and further automate this critical area of modeling functionality

Functionality	Parasolid advantage
Sheet modeling	 Parasolid sheet modeling functionality complements the system's core modeling capabilities by enabling applications to seamlessly integrate the strengths of the two paradigms for hybrid modeling environments. For example, for parts containing freeform geometry, NURBS of any shape can be arbitrarily trimmed to meet designer concepts and can be sewn together to construct solid or sheet models. Parasolid sheet modeling functionality includes: Extending, trimming and untrimming Replacing the surface of a sheet body Deleting holes from a sheet body
Graphics and rendering	Parasolid supports wide-ranging graphical output capabilities including wire frame, drafting and precise hidden line removal with comprehensive controls and rapid performance. Parasolid supports high performance requirements by enabling users to accurately render very large models; it minimizes memory usage and enhances performance by providing convenient mechanisms for rendering selectively and incrementally.
Tesselation	Extensive model faceting and tessellation capabilities are provided to support visualization, CAM, CAE, surface analysis and simplification applications. Parasolid faceting includes a wide range of visibility, shape, tolerance and connectivity controls to enable flexible and adaptive tessellation of a model, and further optimizes performance with the ability to filter out insignificant levels of detail.
Model simplification	Parasolid can be used to identify and remove model details, including holes, blends and arbitrary faces to support downstream operations – such as finite element analysis and CAM – where certain model details can be safely ignored
Model enquiries	Parasolid models can be used across the manufacturing process as definitive 3D representations.Parasolid provides a comprehensive suite of functions that enable applications to query information abouta given model, including:• Mass properties• Model validity• Data structure• Entity selection• Geometric evaluations• Min/max distance calculation, clashing and containment
Modeling support	 Parasolid includes a range of advanced functions to create profile and curve information that can beused as the basis for further modeling or analysis. These include: Spun silhouette for computing the outline of a rotated model Swept outline for computing the outline or shadow of a swept model Nondestructive section for computing sectional outlines without altering the model
Integration and application support	 Parasolid provides a wealth of tools that help integrate Parasolid tightly and efficiently to support complex application-specific functionality, including: Ability to store attribute information on any model entity, with behavior that is customizable via callbacks Intrinsic entity-tracking mechanisms to support diverse feature-based modeling strategies Comprehensive rollback and partitioning capabilities for unlimited undo/redo and history management Advanced debugging facilities for efficient application development Enhanced performance for multi-processor machines
Interoperability support	 Parasolid provides core functionality to support interoperability between Parasolid-based applications and with other sources of 3D model data. Features include: Two-way XT data compatibility – enabling Parasolid-based applications to share models seamlessly from both later and earlier versions of Parasolid Interoperability tools – including functions for importing trimmed surfaces and boundary-representation solid models Sewing and checking – including tools for stitching trimmed surfaces together into composite sheet or solid models, and for checking the geometric and topological validity of models

Unsurpassed interoperability



Parasolid is the technology foundation for a community of product development applications that span multiple industries and provide digital 3D representation functionality for well over a million end users. To provide this community with unparalleled interoperability, Parasolid leverages an open, flexible architecture and wide range of data import, export and optimization tools to ensure high-quality, highsuccess data exchange between Parasolid-based applications and non-Parasolid-based applications.

Parasolid native XT file format has become a widespread and reliable means for representing, storing and exchanging geometric and solid model data. It is estimated that approximately 45 percent of today's 3D product models are stored in XT format. This open and published format facilitates translation-free model exchange between all Parasolidbased applications.

The XT format ensures two-way version compatibility that enables bi-directional exchange of XT data between Parasolid-based applications that utilize different versions of Parasolid. This innovation eliminates versioning issues when multiple Parasolid-based applications interact, thereby enabling enterprises to maintain a free flow of XT data across their supply chain.

To support the exchange of models with non-Parasolidbased applications in heterogeneous computing environments, Parasolid supports several methods of data exchange.

Trimmed surface import/export enables Parasolid to accept and export geometric data in trimmed B-spline form. This methodology is typically used when third party representation is surface-based rather than solids-based. **Topology and geometry creation** allows Parasolid-based applications to directly create, populate and query the boundary-representation model data structure for applications that have access to full topological and geometric data.Parasolid Translators are add-on components that enable Parasolid-based applications to exchange data with third-party applications that require either standard or proprietary modeling formats.

Once data is imported, Parasolid intrinsic tolerant modeling approach allows users to work transparently and securely with model data created under less stringent tolerance criteria. Pioneered by Parasolid, this robust methodology manages local tolerances adaptively so that users can model seamlessly with imported data of variable accuracy.

Parasolid Bodyshop is an add-on component for problematic data that provides tools for rectifying a wide range of quality and consistency problems that can materialize when importing geometry data from third-party applications. These tools include data preprocessing, model healing and postprocessing optimizations that combine to enable translator writers to easily manage issues that overwhelm the capabilities of less robust modelers.

XML pipeline is an open strategy that also plays a complementary role in fostering Parasolid-based interoperability. PLM XML is Siemens PLM Software's broad-based data transport protocol that enables both geometric and nongeometric product model information to be shared between multiple applications that play a role in today's product lifecycles. Parasolid XT format is the geometric core of the PLM XML pipeline, and Parasolid-based applications can use the PLM XML pipeline for broader product data exchange.

Supporting the product lifecycle

"The decision to base GibbsCAM's full range of solids-based applications on Parasolid was an easy one. Our development time was shorter because so much of the functionality our clients need has already been developed and tested in Parasolid, allowing us to add value by focusing on what we do best."

Bill Gibbs Founder and President Gibbs and Associates



Parasolid is distinguished by its ability to support multiple phases of the product lifecycle, including design automation, design validation and manufacturing processes. In addition, Parasolid is the solid modeling kernel-of-choice for academic and research institutions, as well as for enterprises that want to develop their own value-added applications in-house.

Design automation. During the development phase of the product lifecycle, designers use applications that leverage Parasolid unparalleled robustness and CAD modeling functionality. Parasolid capabilities support a diverse range of advanced modeling and history-based systems. Parasolid integrated sheet/ surface/solid representation enables application developers to implement hybrid-modeling strategies, while its high-level modeling functions facilitate the implementation of highly sophisticated macros or "wizards" for greater automation of end-user process-specific tasks.

Design validation. Parasolid provides an ideal platform for standardizing the geometry preprocessing required in today's analysis applications. It delivers flexible tessellation, identification and simplification capabilities that enable engineers to optimize models for validation. In addition, Parasolid comprehensive querying capabilities excel at supporting evaluation, validation and analysis processes.

Manufacturing. Parasolid delivers comprehensive modeling capabilities for tapering, blending, thickening, outlining and identification that support a wide range of manufacturing processes, including 3D machining, molding, casting, turning and numerical control (NC) toolpath generation. Parasolid also is an ideal platform for exchanging solid models across manufacturing supply chains, including sharing models with bundled CNC and inspection/metrology applications. **Visualization.** Parasolid provides a wealth of model rendering functionality that can support diverse visualization applications across the product lifecycle. Parasolid also provides a broad spectrum of model measurement and interrogation functionality that can be leveraged in a digital mockup environment.

In-house enterprise applications.

Parasolid is an ideal platform for enterprises wanting to develop internal value-added applications that implement industry-specific knowledge and/or company-specific projects. In addition to the benefits of being able to focus development resources on core capabilities, using Parasolid enables in-house applications to share data natively with hundreds of commercial Parasolid-based applications with which they might need to interact.

Academic and research institutions.

Parasolid easy-to-integrate standard interfaces are especially well suited for academic institutions and research facilities that want to prototype innovative applications in a state-of-the-art modeling framework. Native data compatibility across many commercial and academic adopters makes Parasolid an attractive choice for research institutions that work with commercial and industrial partners on today's highly collaborative development projects.



Quality and ease of implementation



Parasolid is committed to delivering quality products to its customers by facilitating ease of implementation and low cost of ownership. The easier it is for software vendors and enterprises to integrate Parasolid into their applications:

- The faster they can bring these improvements to market in their own product offerings
- The more they can minimize cost of ownership
- The better able they are to ensure their quality objectives
- The more they can maximize their applications' added value

Siemens PLM Software has spent many years understanding and anticipating customer expectations, translating these requirements into improved Parasolid capabilities and developing patent-pending quality processes that deliver these benefits to a worldwide customer base through consistent and reliable software releases. The Parasolid global support team is available to provide customers with functional knowledge and application development expertise gained servicing the world's leading product lifecycle vendors. Parasolid customers acknowledge this advantage by consistently reporting positive experiences during all phases of Parasolid implementation, including evaluation, integration and ongoing maintenance and enhancement.

Getting started with Parasolid. Integrating Parasolid into end-user applications is a straightforward one-time task that application developers can quickly plan and execute using Parasolid implementation support tools.



The Parasolid toolset includes a comprehensive Jumpstart Kit, which provides a Getting Started guide, sample code and implementations that illustrate best practices, as well as the Parasolid Workshop testbed for prototyping functionality. By using these tools in conjunction with comprehensive, accurate and easy-to-use documentation, developers are able to rapidly and effectively integrate Parasolid functionality into their applications.

Parasolid ease of integration

- Delivers standardized and consistent API
- Provides comprehensive Jumpstart Kit to accelerate developer productivity
- Supports all major operating systems including Windows, Unix, Linux and Mac OS X
- Includes full reference documentation
- Provides targeted training and consultancy resources
- Enables upgrades to seamlessly integrate with existing application code

Quality is a key enabler. Parasolid delivers proven product quality by focusing on functional reliability and performance, as well as ease-of-use and ease-ofenhancement. Parasolid embraces a holistic process of testing, monitoring and correction as part of its continuous improvement program. All levels in the Parasolid system architecture are comprehensively tested on a daily basis, including evaluating Parasolid in application environments and checking all functionality, performance and platform variants. In all, more than one million tests are executed daily to optimize Parasolid quality and robustness.

Parasolid testing strategy

- Covers all Parasolid functionality and interfaces
- Targets every level of system architecture
- Tests relevant customer scenarios
- Monitors application performance
- Over one million tests every 24 hours

Quality and ease of implementation

'In developing STAR-Design, we addressed the need to add state-of-the-art solid modeling capability and enhance value for engineers needing a dedicated CAD capability. Parasolid not only enabled us to meet this objective, but also allowed us to bring an easy-to-use product to market in record time."

Steve MacDonald President CD Adapco



Siemens PLM Software's attention to quality-related detail enables Parasolid customers to quickly take advantage of frequent online releases. Parasolid plugand-play update strategy lets customers take the latest update releases and drop them into their applications without changing source code, recompiling or rework.

Release-at-any-time culture

- Meticulous software engineering
- Zero-regression policy
- Production quality at all times
- Patent-pending processes

Plug-and-play updates

- Integrate enhancements immediately
- Seamlessly deliver end-user improvements
- Enable application providers to maintain schedule control

Maximum responsiveness. Parasolid is developed in a release-at-any-time culture that is based on meticulous software engineering principles, embracing a zero regression policy that enables production quality levels to be maintained throughout development. As a result, customers are assured that they will receive every update in a timely fashion – without



"At Bentley, we know we can trust Parasolid releases to be frequent and high quality, slotting easily into our development process and delivering continual enhancements that we can deploy rapidly and confidently."

Brad Workman Vice-President Bentley Software Bentley Systems

incurring any degradation in quality. This approach maximizes the ability of Parasolid customers to respond to user requirements while protecting their software and data investments.

Minimized cost of ownership. The proven benefits of Parasolid low-maintenance integration architecture combine with a seamless plug-and-play update strategy to minimize the ongoing cost of ownership for Parasolid adopters.

When these advantages are joined with Parasolid world-class customer support and robust functionality, today's application developers are positioned to leverage a modeling platform they can trust to drive innovation in today's highly competitive product lifecycle market.



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About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with nearly 6.7 million licensed seats and 69,500 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with companies to deliver open solutions that help them turn more ideas into successful products. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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