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# *Maintaining Reason in Product Modeling with an Open Source CAD System*

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***Abstract***

*For a new product modelling decision process, the current and future problems of a new product design, forecasting, and risk management launch strategy The purpose of this study is to propose and investigate the creation of a low-cost integrated CAD-CAPP-CAD/CAM product modelling system for the design and production of a suggested product. It's a connection between numerous design phases, such as functional, technological, and physical design. The drafting of a product to be maintained with the drafting software package is the first step in the modelling data generating process. The data is transmitted from the CAD drawing to be utilised as product models, and a CAPP software programme will then produce the operational parameters for the product's manufacture. These process data are sent to a CAM software programme, which generates the automated data processing processes. The function's last stage is to assist design and production activities, which may have garnered significant cost savings in terms of basic equipment and software.*

***Keywords:*** *product modelling; open sources CAD, Computer Numerical Control (CNC), modular design;, reason maintenance*

## INTRODUCTION

Manufacturing firms have been searching for more efficient procedures to make items with Computer Numerical Control (CNC) equipment for more than five decades. Since then, CNC production has depended heavily on data and product modelling, thus technologies such as Computer Aided


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Design (CAD), Computer Aided Engineering (CAE), Computer Aided Process Planning (CAPP), and Computer Aided Manufacturing (CAM) have become crucial. The development of a product model consists of three elements: first, a problem definition; second, product modelling, which includes synthesis, a rough physical implementation of the product model, and evaluation of the model's functional behaviour; and third, the selection of the best product model.

Product and process data may be separated from the information, database, and data model that CNC manufacturing operations contain. In today's global economy, these data are often transferred across diverse production facilities. Because of increased consumer wants and reduced product life-cycle and time-to-market, the sector is characterised by an increasing need for diversity and increasing demands on product development time. These developments encourage manufacturers to concentrate on long-term product development planning in order to adapt to different market structures and short product life cycles.

The suggested product development is based on an overall approach for client product structure, assembly, and maintenance. A mapping between many design phases, such as functional design, technical design, and physical design, may be stated as a product model. The product modelling process, in particular, begins with the identification of client demands and their articulation as functional requirements. The design parameters are then used to transfer these criteria onto the physical domain.

As illustrated in Fig. 1, a mapping approach between different design stages such as functional design, technical design, and physical design is used in the product modelling system for the design and production of any proposed product. The key objectives, as well as all of the project research activities or tasks, are displayed throughout the design phase. It also explains and displays each variety's key actions for each period. The product, customer, functional, and structural variety must all be defined by the system. Product variety is described as the range of items available, with three forms of variation

customer, functional, and structural . The capacity to differentiate client requirements is provided by a customer variety. A structural variety has a common link to part and sub-assembly variation,


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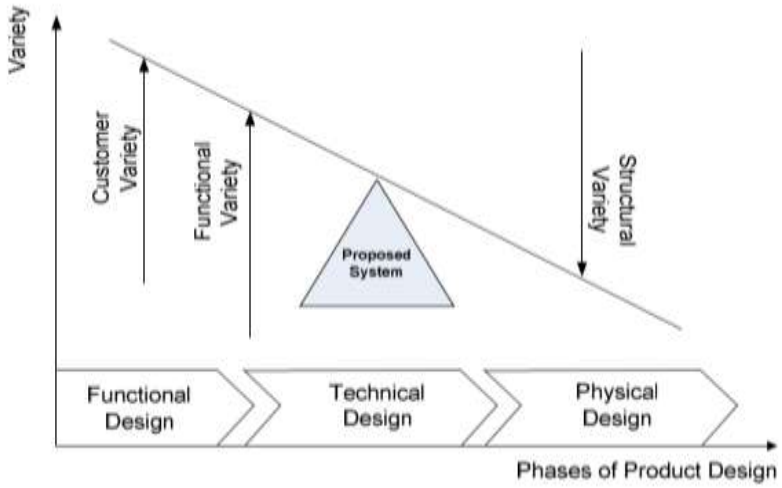


***Fig. 1: The design phases***

Where as a functional variety refers to any diversity in product functionality qualities.

There are a number of drawbacks to utilising CAD software, which may be broken down into two categories: expense and error. Costs are always a consideration in any firm. CNC machines are far more expensive than traditional technology, and they do not eliminate the necessity for expensive tools. Furthermore, items like as tools and equipment are expensive, and their procurement need substantial justification. They are also costly to maintain. CNC machines do not completely remove mistakes when it comes to faults. Operators can still click the wrong buttons if they make erroneous alignments or fail to properly position items on a jig.

Virtual CAD simulators have been offered as a solution to this problem since they are software that illustrates, verifies, and simulates the functioning of a CNC machine tool's PC. The task's operation is to present a picture of the machine's three-dimensional model via animation from a simulation device that had received historical data in the form of lapsing time information and positional information connected with the lapsing time information of the operation [7]. A virtual CAD simulator aids in the detection of errors so that improvements may be made

The usage of this simulation has the benefit of increasing user preparation, reducing programming mistakes and machine failures, and increasing the efficiency of time spent in the laboratory. Not just for the educational benefit of students, but also to assist enterprises better manage their


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resources, simulation techniques are becoming increasingly valuable. Virtual machining is described as a strategy for allocating mistakes in machine tool design and production, diagnosing the cause of machine tool faults, and predicting the precision of components to be created on machine tools. The machining process and workpiece forming process can be observed directly in the virtual environment, allowing the correctness of the CAD/CAM code to be checked in advance to avoid interference, collisions, and other problems during actual lathe processing, as well as reduce the scrap rate of the work piece and tool during actual machining.

The primary goal of this study is to provide a systems technique for maintaining product modelling for the line-up alternatives. Despite the existing hardware approaches, the project research output goals of the software. The project research's particular goal may be met by creating a prototype product model, which is the optimal choice for model selection owing to the reasoning process.

It will be necessary to employ a new set of product model requirements, standards, suitable charts, user interfaces, and languages. The programme will be utilised to provide distributed, simulation, and real-time product model selection capabilities to the algorithm. The scope of this research project is defined in accordance with the prototype's integrated CAD-CAPP-CAD/CAM product modelling system, that is, the modelling selection operations, by agreeing that product modelling is at the heart of modern design tools and that it is traditionally done in an interactive vendor-specific proprietorship, manually or by software. Supporting interactive and interoperable multi modular product modelling has been a constraint. Traditional product models are also rigid and closed in nature. As a result, research into combining traditional product modelling with the creation of an interactive open source CAD system is continuing.

## MATERIAL AND METHOD

### A. Project Tasks Product Modelling

The goal of this study is to keep the product model while looking for the optimal product model that can meet the original functional criteria. A design solution must fulfil a variety of restrictions, including cost, weight, features, and forms, but the most crucial is the product's capacity to execute the job for which it was created. In most cases, a number of product models meet functional requirements and should be examined as design candidates.


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Starting with product design and utilising CAD tools to generate machining instructions that direct a CNC machine to make the end product, CAD systems sit at the start of the process. Production planning and machining are also part of this process chain. Traditional product modelling, in conjunction with CAD technology, has enabled the industry to make items of uniform quality while also increasing efficiency through a high degree of production system flexibility. Traditional product modelling, on the other hand, provides an open source CAD system architecture for industrial and system integration. Despite the fact that traditional product modelling and open source CAD systems have only been around for a short time, extensive study has already been done both worldwide and inside countries/organizations. This has necessitated the involvement of universities, companies, and CAD system makers in a number of initiatives, particularly in the development of a new system foundation for open source CAD systems.

The challenge is to provide an efficient search technique for identifying all feasible product models, that is, product models that fulfil the overall design function by accurately describing connections among design sub-functions. Nobody knows which functionally valid model will lead to the optimal design solution given other design needs and objectives; hence no possible model should be neglected.

The project research activity begins with significant product modelling efforts. The project study will be divided into three phases, as shown in Fig. 2. The first is the construction of a model basis of abstract components that correspond to design functions.

Second, the abstract product models are now being synthesised. Finally, using abstract models, an investigation of the functional behaviour of product conceptions will be carried out. It corresponds to the creation of a conceptual framework on which the system's test bed will be built. Working with a generic and native programme as part of the project research allows the system to achieve the needed intelligence and operability.


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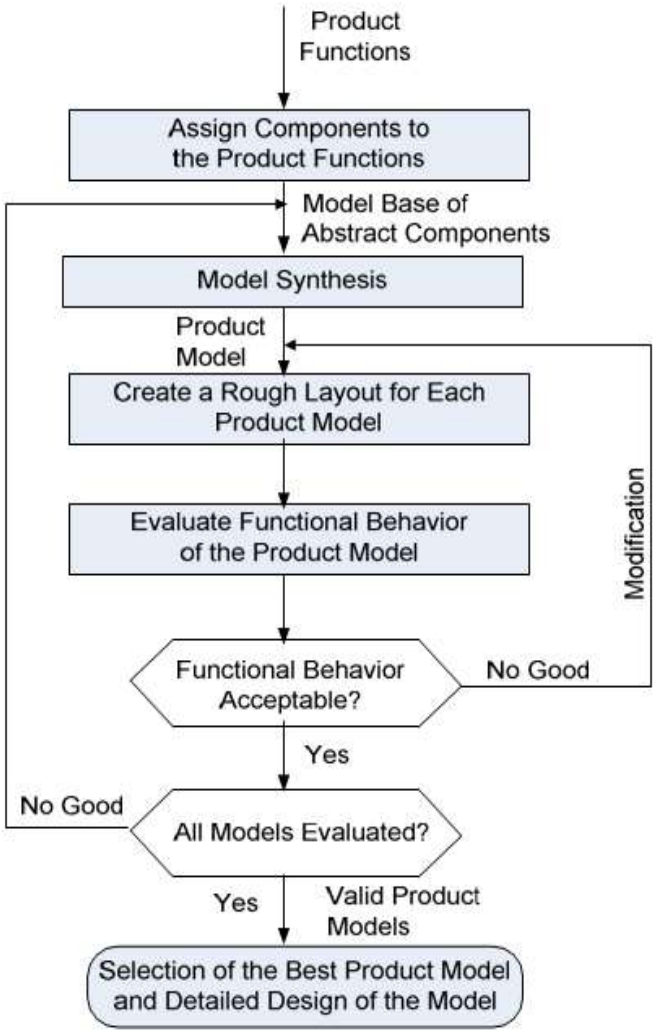


***Fig. 2 Activities in product modelling***

**B. Modules in the Systems**

As previously stated, a product model must meet both structural and functional criteria by going through stages of abstract component synthesis and functional behaviour analysis. The detailed design of the product will be based on the best overall product model.

In the future, while modelling a new product, it will take into account technological advancements and cycle times, as well as engineering to production and marketing connections. Globalization, the internet, and the World Wide Web have recently become factors for future innovative product models. In terms of technical change and cycle time, the requirement to get to market quickly will become increasingly more critical as technology development and competition


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intensify. The typical sequential process will become more ad hoc and iterative, and industries will use more overlap in their operations.

Initial techniques to integrating engineering design to market reactions will be practised by engineering, manufacturing, and marketing ties using a conjoint analysis and quality functional deployment. It's become a matter of taking another step ahead. Micro design/manufacturing specs must be used to connect comprehensive engineering design operations to markets.

The globe and the marketplace are both affected by globalisation. Rather than geographically defined country market groups, companies are increasingly contemplating global goods that target economically and psychologically defined sectors. The firm evaluates a worldwide market that spans 50 nations, including China, Poland, France, Canada, Kenya, Chile, and Japan [12]. The internet is a significant advancement in marketing technology. For new product development, this paradigm change will bring both possibilities and problems. Web shopping for consumer and industrial items and services will become more popular in our marketplaces in the future.

Recently, the CAD system with an open source solid modelling computer-aided design system with a full Integrated Development Environment (IDE) has gained popularity for producing interactive 3D visuals and a suite of editing tools. It is the first IDE to provide a comprehensive set of tools in a single package. Researchers should take the effort to learn about the design model, which is a critical artefact of the suitable applications that isn't included in an IDE. Operators and supervisors must review the source code for conformity with established CAD standards while aiding with computerised design.

Computer programmes for product modelling were created for the purpose of making product design and manufacture more efficient. Early programmes quickly evolved into complicated systems, with capability extending to all stages of the product life cycle. The essential qualities of a subset of those toolkits, integrated development environments, are reviewed in this project research: intuitive programming language, isolation from mainstream system changes, lower maintenance costs, and quick reaction to changing requirements.

The name of the IDE idea is "integrate," and it is a component of a system with which it


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interacts and shares resources. The purpose of development is to generate new applications, increasing the mainstream system's capabilities or potential to a more effective state in which the environment is a well-configured, complete set of tools and resources designed to construct professional extensions of the system.

**C. Component-Products Function**

The initial step is to determine the Product-Process Model and Parameters in order to construct the Component-Products Function MODULE. The product model will be utilised in the same way as it was in the idea approval stage. A model foundation comprising abstract components that correspond to design functions is the core module to be constructed.

Because of the fast advancement of technology in the manufacturing business, a big number of highly competent draughtsmen are necessary to design a product. Because the feature of design procedures is highly demanded expertise and difficult to programme and operate, the most competent technician must be enhanced based on applied knowledge.

It also need regular setup for product modifications and setup conducted in-line with the tool to live by running product, which takes time away from production and might be considered as waste. The product modelling step, which necessitates a skilled designer and proper design modelling medium, is an important part of executing a design activity.

**D. Model Synthesizer**

The Model Synthesizer MODULE is responsible for the establishment of research technique as well as the synthesis of abstract product models in the following step. The generic data model programme is another name for this programme. Responding to the needs of customers has resulted in recent breakthroughs in product modelling. The new conventional techniques, software, and hardware on the market enable visually simulating part feature modelling and the usage of an open source component to optimise manufacturing processes further.

The knowledge and content structuring via collaborative ontology design project, which attempts to build a unique paradigm for knowledge structuring based on the interaction between cognitive psychology and ontology engineering, is presented in this module. In the form of a graph, map, or diagram, the conceptual model outlines the major domain ideas and their relationships. Individual cognitive styles are taken into


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account, and contemporary breakthroughs in knowledge engineering and conceptual structure are used. Its goal is to develop new, consistent, and architecturally comprehensive knowledge bases in a variety of scientific and technological fields.

**E. Model Layout**

The Model Layout MODULE is the next phase, which will take several months to complete. The module creates a conceptual foundation on which a testbed may be built. The importance of software quality in software engineering is stressed throughout this subject. The goal of software architecture evaluation is to produce quality scenarios that save money on development and maintenance. This paper proposes a discrete event simulation environment for evaluating software design from both a functional and quality standpoint. The simulation elements are specified using the Discrete Event System Specification (DEVS) language and the underlying framework.

The simplification of discrete event simulation models is the focus of this module. The required concepts and methods for the automated development of simpler variants of a discrete event model are specifically examined. Observations of model behaviour were used to build the simplification technique. As a result, the simplified models that are constructed follow all of the formalism's canons. DEVS- Scheme, a hierarchical modular discrete event modelling and simulation framework, is used to create the implementation. It has two layers: a lower layer that observes model behaviour and a higher layer that creates code based on the observation data collected by the lower layer. The system that results enables for the creation of simpler models at any level of the model structure hierarchy. The validity and complexity reduction of the reduced models relative to the models from which they are taken are demonstrated using a local area network model base.

**F. Standard for Product Modelling Protocol**

Product modelling is at the heart of a slew of new product development paradigms aimed at addressing this problem. As a result, the application and research communities have given it a lot of attention. The engineering professional's job is to create innovative goods with the shortest lead time, greatest quality, and lowest cost while taking into account the whole life cycle. In recent years, the breadth and techniques to product modelling have significantly changed. In this approach, the


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computer directs the model's design and production. CAD software often has a broad scope, and product modelling methodologies have grown fast in recent years.

In today's environment, product modelling data is maintained across several systems, with minimal integration and a high level of data redundancy. The new product model (ISO10303) addresses the data flow issue by providing a uniform standard for describing all features of a product throughout its life cycle. This effort resulted in the development of the STEP product model [ISO 10303-1, 1994]. The model's distinguishing characteristic is that it unifies product data by establishing a single product data standard. The protocol does this by developing a number of Application Protocols (APs) aimed at specific application domains, such as design, production, and maintenance. It includes both general-purpose data modelling methodologies and data models tailored to particular industrial applications. Product modelling technique, research tools for IDE-compliant CAD choices, and the optimal system fit are all important components of a CAD system. It is also vital to improve the interface and any icon toolbar involved in order to boost CAD system validity. The link between the data model and the features is discovered during the component design stage, and by simulating, a solid theoretical foundation for upgrading and boosting CAD system performance may be established.

Apart from that, another reason for doing this study is to give an option to local institutions, who have always had to pay for CAD systems, despite the fact that open source CAD systems are freely accessible and can be downloaded from any network. When compared to commercial CAD system packages, several of those open source CAD systems have comparable performance and quality, as well as knowledge-based functionality. The goal of this study is to use the finest open source CAD system that has been made available to enterprises and higher education institutions over the internet.

An IDE is a software application that offers complete software development features to computer programmers. A source code editor, build automation tools, and a debugger are often included in an IDE. Intelligent code completion is available in most current IDEs.

When developing on a console or terminal, IDEs become available. Because programmes are created using flowcharts


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and entered using punched cards (or paper tape, etc.) before being submitted to a compiler, early systems cannot handle one.

## RESULTS AND DISCUSSION

### A. Application Protocol

A specific application domain is the emphasis of an application protocol. This project proposes a framework, or tool, that can be used to assist every stage of the life cycle of a security protocol. Its integrated development environment (IDE) makes protocol creation, debugging, and simulation easier.

Security protocols define a method for two or more parties to exchange messages via an untrusted medium in order to get specific assurances about each other.

Parties may, for example, want to verify each other's identities, share confidential information, or even interact without disclosing their true identities.

The design and execution of security protocols is a complicated and error-prone undertaking, according to experience. Programming languages and environments for general use aren't very helpful.

In languages like Java and C++, a protocol stated in a few lines might result in millions of lines of code. Debugging may become a lengthy and tedious process when the protocol's semantics become obscure.

### B. Open Sources CAD Systems

The term "open-source" refers to software whose source code has been made publicly accessible and may be shared and updated. Some individuals use the phrase "open source" software to refer to software that is similar to free software.

It is not the same type of software that accepts certain licences that are seen to be too restrictive, and there are free software licences that are not accepted. However, the distinctions in the category's scope are minor: almost all free software is open source, and almost all open source software is free.

Open source is a term that refers to software whose source code is freely accessible to the general public for usage and/or modification from its original design. Typically, open source code is generated as a collaborative effort in which programmers enhance the code and share the results with the rest of the community. As a reaction to proprietary software held by businesses, open source arose in the technology world.


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The Open Source Initiative (OSI) has created a certification standard that certifies that a computer program's source code is freely accessible to the general public. This movement is based on the idea that a wider number of programmers who aren't concerned with private ownership or financial gain would generate a more usable and bug-free product for everyone to use. The notion depends on peer review to detect and fix defects in computer code, a procedure that isn't used in commercially built or packaged software. On the Internet, programmers read, redistribute, and edit the source code, driving the product to evolve quickly.

Because information is shared across the open source community, the process of removing defects and enhancing the programme moves considerably faster than it does in standard commercial software development channels. It does not begin in a corporation's research and development cogs and then pass through them.




***Fig. 3 Differences between closed source software and open source software***

According to the title of the project study, the best way to identify open source CAD systems is to use open source software. It's software for which the source code has been made publicly accessible and may be updated and redistributed. Most open source software is also released as free software with few limitations on how it may be used; hence, the word "free" when used to open source software has two


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meanings: free of charge and free to do anything you want with it. The contrasts between closed source and open source software are shown in Figure 3.

**C. Open Cascade**

Open Cascade Technology (OCCT), originally known as CAS.CADE, is an open source software development platform created and maintained by Open Cascade SAS for 3D CAD, CAM, CAE, and other applications. CASCADE (Computer Aided Program for Computer Aided Design and Engineering) was created in the early 1990s by Matra Datavision, the creator of the Euclid CAD software, as the foundation for its future version, Euclid Quantum. In 1998, the firm decided to focus on services rather than software development, and most of the software development facilities were sold to Dassault Systems, the maker of the competitive CATIA programme.

Open CASCADE is an open source software development kit (SDK) for developing apps that deal with 3D CAD data. It comes with a collection of C++ class libraries that help with 3D surface and data interchange, solid modelling, quick application development, and visualisation.

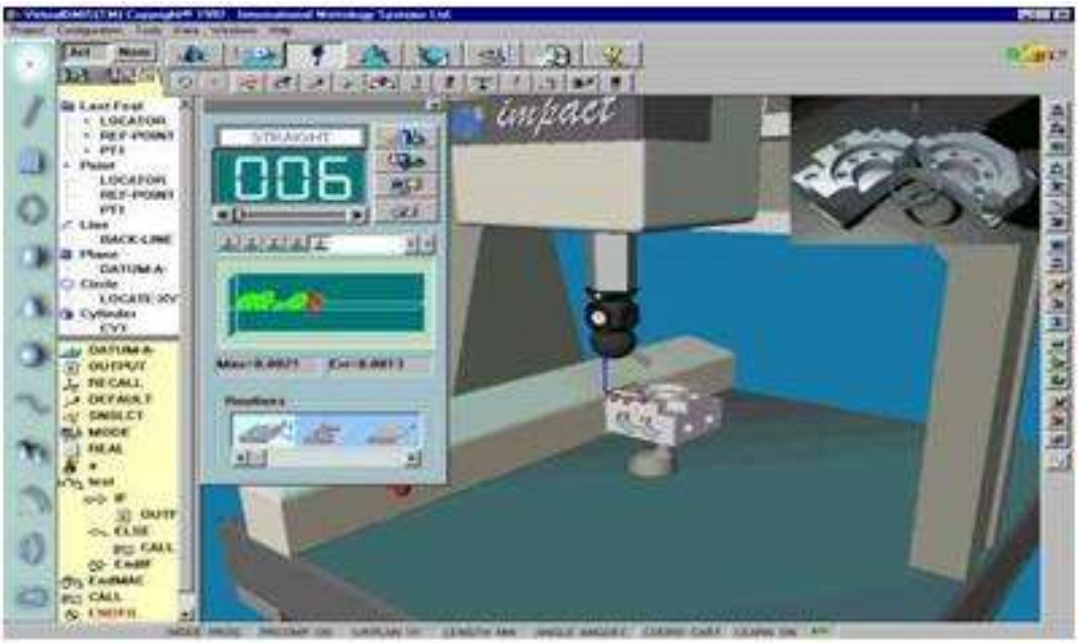


***Fig. 4 Open CASCADE software***

It's best used in the creation of specialist CAD/CAM/CAE software. Typical Open CASCADE Technology applications include pre- and post-processors for finite


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element analysis tools, numerical simulation programmes, and CNC/CAM route generators. Figure 4 depicts the Open CASCADE software's process, which includes a 3D visual and detailed information on the icon.

## CONCLUSIONS

The researcher must key in input data for the models and apply the procedure in the suggested system when using the software implementation approach to model products. Based on the theory function, all models must meet the needs requirements. The researcher is able to do programmatic project research using the power of existing empirical data, and the user of the system may have great designers or co-authors to go through the generalizability process, in which a statistical framework is used to conceptualise, investigate, and design any reliable observations, and finally a solution. Product modelling, design maintenance systems and technologies, as well as appropriate system software tools, must all be done as part of the project review. The literature should also be checked for any standard documents linked to the proposed system. Early study findings suggest that one of them should take a holistic perspective of these new product modelling technologies and try systems to arrive at comprehensive definitions of these technologies. Implementations will be examined in order to highlight some of these technologies.

The proposed system and reason maintenance in product modelling are two emerging requirements that may hold the key to developing a new generation of product modelling system that is reconfigurable and modular in structure, adaptable and interoperable in functions, according to the findings of the project research. The current functional design, technological design, and physical design are provided in three primary components. It's also included in this document, where the system will highlight some of the most important concerns and provide pertinent data.

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