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# PRODUCT INFORMATION MANAGEMENT IN CONCURRENT DESIGN SYSTEMS

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A THESIS SUBMITTED  
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## *Abstract*

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In this thesis, the management of product information in concurrent design systems has been investigated with particular reference to product development in small and medium enterprise (SME) industry and design education at polytechnic level in Singapore. From a critical review of the relevant literature on product design and development processes, concurrent engineering, concurrent design systems, product data management and related methods, it is found that there is a clear need for a new design of a system for organizing and managing product information in a concurrent design environment in the above contexts. This finding has led to the development of a conceptual rationale, termed the Design Tensor Method, and the design and development of an innovative product information management system called PRIMAS. PRIMAS is a systematic methodology for the classification, organization, integration, communication, storage and management of product information in the product development process. A software prototype based on PRIMAS has been subsequently developed. PRIMAS along with its conceptual principles have been applied and tested in a product design project in a tertiary educational institution and in two significant industrial product development projects based respectively in two SMEs. Positive evaluation feedback on PRIMAS has been obtained in these studies. The product development projects investigated with PRIMAS have also produced outcomes that meet the original specified design requirements. The findings from this research have led to the conclusion that PRIMAS is a viable product information management system that can be used effectively for managing product information in concurrent design projects in SME industry and design education. Substantial PRIMAS databases of useful product information have been compiled for the product development projects investigated with PRIMAS. Finally, recommendations are made for future research.

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## *Glossary of Terms*

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*ANSI* -- American National Standard Institute.

*Collaborative Product Commerce (CPC) or Virtual Enterprise* - A business model used by some companies which retain only strategic functions while outsourcing tactical functions to suppliers and contractors, including design and production operations, and collaborate with them using Internet and related tools.

*Computer Aided Design (CAD)* - The use of computer systems (hardware and software) to assist in the creation, modification, analysis, or optimization of a design.

*Computer Aided Manufacturing (CAM)* - The use of computer systems (hardware and software) to plan, manage, and control the operations of a manufacturing plant through either direct or indirect computer interface with the plant's production resources.

*Computer Aided Engineering (CAE)* - A common term used to represent the use of computer systems (hardware and software) in engineering analyses and applications, including design and process simulation and optimization, mathematical analyses such as the Finite Element Analysis, and so on.

*Computer-Integrated Manufacturing System* - Often used interchangeably with the term *Flexible Manufacturing System*, this is a production system that normally consists of a group of numerically controlled machines connected together by an automated materials handling system and operating under computer control.

*Concurrent Design* - See *Concurrent Engineering*.

*Concurrent Engineering (CE)* - A systematic approach, also called *Simultaneous Engineering*, *Concurrent Design*, *Concurrent Team Design* or *Concurrent Product and Process Design*, that facilitates the coordination of tasks in product development, enabling them to be carried out in a concurrent (or simultaneous) and collaborative manner, instead of in a sequential or serial way. The main purpose is to achieve shorter time-to-market, lower manufacturing costs and higher product quality. CE requires that all parameters or factors that affect the success of a product be considered early in the product design stage.

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*Concurrent Product and Process Design* – See *Concurrent Engineering*.

*Concurrent Team Design* – See *Concurrent Engineering*.

*Configuration Management* – A disciplined approach, commonly part of the functions of PDM and EDM systems, to define elements of product engineering data, to control its change, and to track the changes made.

*CQTF strategies* – Proposed by the author in the thesis, these consist of four strategies closely related to *Concurrent Engineering*, which are used in companies to achieve competitive advantages. These strategies are: (1) Reduce total manufacturing Costs, (2) Improve Quality of products and services, (3) Shorten Time-to-market of products, and (4) Increase Flexibility of products and processes.

*DBMS* – Database management system, e.g. MS Access, Oracle, and so on.

*Design for Manufacture and Assembly (DFMA)* – A method, also called *Design for Manufacturability*, or *Design for Manufacture (DFM)*, where the manufacturing and assembly factors in the design of a product and its parts are considered early in the product design and development process, for the purposes of minimizing time-to-market, maximizing product quality and minimizing total manufacturing costs.

*Design Tensor Method (DTM)* – Proposed and developed by the author in this research program, using the analogy of the tensors from mathematics, this is a conceptual rationale in which: (a) the sharing of vision and design objectives in the design team is stressed, (b) information generated and used in the product development process can be grouped according to different design parameters (or specifications), and (c) design parameters can be organized and communicated in the design team in an integrated manner, so that their essence is maintained throughout the entire product development process.

*Engineering Data Management (EDM)* – A software system or a set of functions built into CAD/CAM software, used for managing engineering data in product design and development.

*Evolutionary product development* -- Design and development of new version or new model of an existing product.

*Failure Mode and Effects Analysis (FMEA)*: A design procedure in which the consequences of the potential failure modes of a component or subsystem are investigated.

*Finite Element Method (FEM) or Finite Element Analysis (FEA)* – A technique in which an object is divided into a large number of finite elements (usually

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rectangular or triangular shapes) which form an interconnecting network of concentrated nodes; and by using a computer of significant computational capabilities, the entire object can be analysed for stress-strain, heat transfer, and other characteristics by calculating the behaviour of each node.

*Flexible Manufacturing System (FMS)* - See *Computer-Integrated Manufacturing System*.

*Group Technology (GT)* - A manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in manufacturing and design, in order to achieve efficiencies in the form of reduced setup times, lower in-process inventories, better scheduling, improved tool control, and the use of standardized process plan.

*House of Quality* - See *Quality Function Deployment*.

*HPV* - Human Powered Vehicle, the title of final-year project in the design education project experimental investigation of this research project.

*HTML* - Hypertext Markup Language, or HTML, is a system of marking up, or tagging, that describes the contents and appearance of pages on the World Wide Web.

*Initial Geometric Exchange Specification (IGES)* -- A file format used in the transfer and interchange of design data in CAD/CAM systems, developed by the American National Standard Institute.

*Information Fields* - The standardized fields or generic domains of product information, for classifying and organizing product information corresponding to the Product Constituents in PRIMAS-DB; the four Information Fields which are located in one of the two axes of PRIMAS-DB, are Parameters, Process, Knowledge and History.

*ISO* - International Organization for Standardization.

*Legacy system* - A system used to store information residing in the company including in-house intellectual property data (*legacy data*).

*PRIMAS (Product Information Management System)* - Designed and developed by the author in this research program, this is a novel systematic methodology used for the classification, organization, integration, communication, storage and management of product information in the product development process.

*PRIMAS-DB (Product Information Management System Database)* - Designed and developed by the author in this research program, this is a

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standardized, practical and reasonably scalable (i.e. can be increased or reduced in size to suit different applications) database structure, which is made up of a matrix of two main categories of factors, namely, the Information Fields and the Product Constituents.

*Product Constituents* - Forming one of the two axes of PRIMAS-DB, these represent the activities, tasks, phases, or sets activities and tasks in the product design and development process.

*Product Data Management (PDM)* - Software system used to manage product data, including design and manufacturing information and so on, in product development; PDM systems are generally concerned with information about product structure, discrete parts, and source files and their derivatives. PDM may therefore be defined as a system used within an enterprise to: organize, access, and control data related to its products, and to manage the life cycle as those products.

*Product Design Process* - Commonly regarded as the most important phase in the Product Development Process, this is the activity for converting requirements or specifications to design descriptions ready for implementation and manufacturing.

*Product Development Cycle Time* - See *Time-to-market*.

*Product Development Process* - Equivalent to *Product Design and Development Process*, or *Product Delivery Process*, it consists of the phases that define the entire life cycle of a product from the very first idea of its conception to the retirement of the product. This is the systematic activity necessary, from the identification of the market/user need, to the selling of a successful product to satisfy that need - an activity that encompasses product, process, people and organization.

*Product Lifecycle Management (PLM)* - A recently used new term which is equivalent to Product Data Management.

*Quality Function Deployment (QFD)* - A method, also called *House of Quality*, where matrices are used to translate the wants, needs, and desires of customers into quality characteristics, technical requirements, and engineering characteristics of a product and subsequently into its parts' characteristics, process plans, and production requirements by integrating information from marketing, engineering, research and development, manufacturing and management.

*Rapid Prototyping (RP)* - A technique for making physical three-dimensional prototypes rapidly (as compared to the traditional prototype making by machining and craftwork) using the concept of slicing the object from a 3D

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CAD file into very fine layers, and then constructing the object layer-by-layer with a RP machine.

SME -- Small and medium enterprise.

*Standard for the Exchange of Product Model Data (STEP)* - An international file format used in the transfer and interchange of design data in CAD/CAM systems, developed by the International Organization for Standardization.

*Time-to-market* - A term, equivalent *product development cycle time*, used to represent the total time needed or taken in product development, i.e. the total time from the conception of a product idea to the launch and delivery of the product to the customer.

*Total Quality Management (TQM)* - A philosophy advocating that all aspects of the company must be well managed and all employees well trained with adequate authority to perform their jobs effectively, emphasizing on principles including continuous improvement, defect prevention, good feedback system, the Plan-Do-Check-Act process and management review and audit.

*Value Analysis (VA) or Value Engineering (VE)* - A systematic method used in design analysis, with the aims of either: (1) increase the value to the customer for the same, or lower, cost; or (2) produce the same, or greater, value for the customer at a lower cost.