Eco & PLM Project for Environmental Traceability of EEE

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OVERVIEW: Previously, manufacturers of EEE (electrical and electronic equipment) have not been held accountable for the traceability of their products in the way food and vehicle manufacturers have, because these products do not have the same direct impact on human life. In recent days, however, environmental laws with strict regulations and accountability about included substances and restrictions on hazardous substances are being introduced worldwide. These regulations impose additional expenses on producers for the recycling and collection of EEE. Hitachi has some previously introduced traceability systems limited to its own products, and only a partial traceability systems for individual objects. Taking into consideration recent environmental laws, we have started to construct an integrated traceability system for EEE as an Eco & PLM (product lifecycle management) project. This term refers to not only ecology but also product lifecycle management. Thus the Eco & PLM project has two missions: to observe environmental laws and to manage all records of product lifecycle.

INTRODUCTION

IN light of the need for environmental conservation, regulations affecting the manufacturing industry have grown from day to day. Environmental laws require manufacturing industries to operate ecological factories that regulate environmental contamination and waste materials generated by production activity at the plant. New environmental laws also require the regulation of hazardous substances in EEE (electrical and electronic equipment) and recycling or disposal
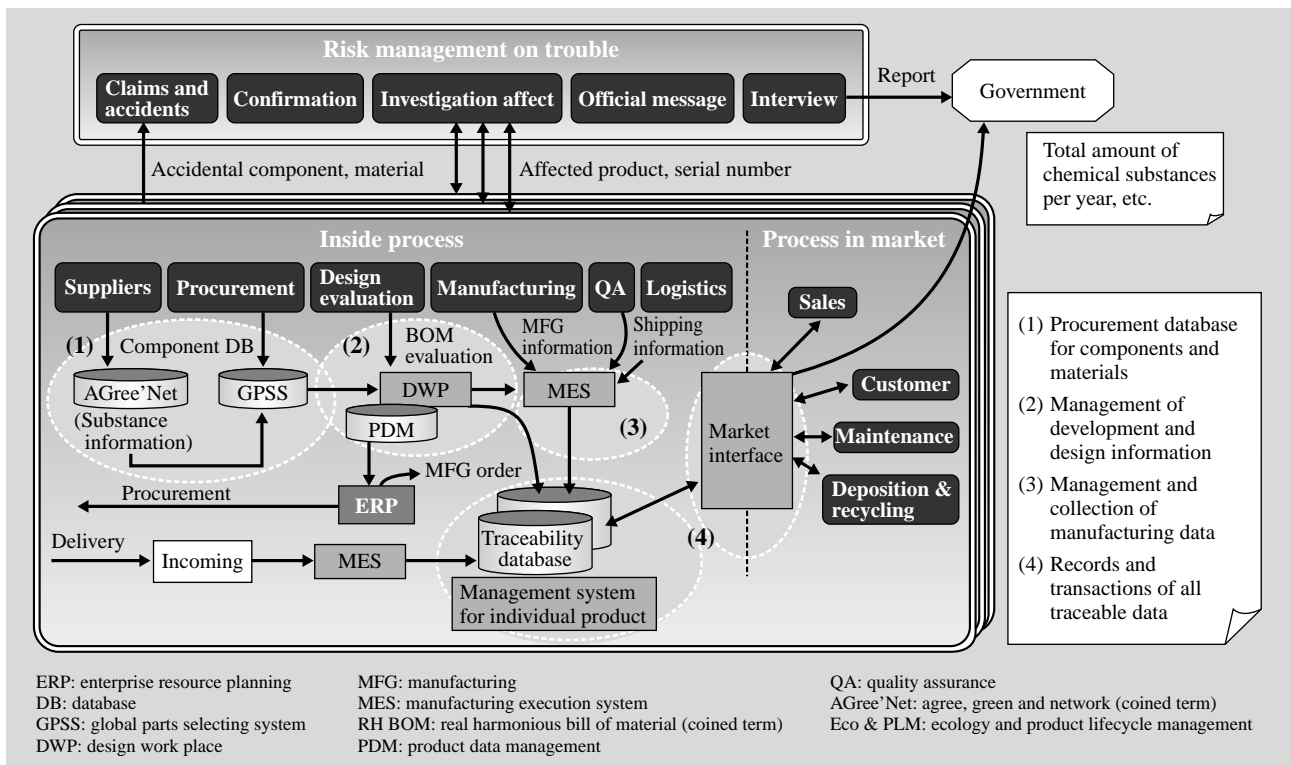

Fig. 1—Conceptual Chart for the Eco & PLM.
The Eco & PLM database manages information about all stages of the product lifecycle from procurement to disposal
or recycling. This enables the evaluation of whether the product complies with the environmental laws. It also
facilitates the recording of environmental data and makes quick product recall possible when a problem arises.

at the end of product life. The intention is that ecological-products are produced. Hence, manufacturers are required to keep manufacturing records as an evidence of their observance of those laws. In other words, ultimately, the necessity for the management of individual products is clear. The management of individual products means going from the raw material stage to the production stage and continuing until the recycle or disposal stage at the end of the lifecycle. This management of product lifecycle can be seen in diagram form (see Fig. 1).

ELV: end-of-life vehicle
PRTR: pollutant release and transfer register
WEEE: waste electrical and electronic equipment
RoHS: restriction of hazardous substances
EUP: energy using product
REACH: registration, evaluation, and authorization of chemicals

Fig. 2—Trends in Legal Restrictions and ResponsibilitIes of Manufacturing Companies.
The eco-factory has its origin the ISO14000 enacted in 1996. In addition, regulations have been tightened to include all substances in a product, i.e. that they conform to eco-product requirements.

ENVIRONMENTAL REGULATIONS AND ACTIONS IN MANUFACTURING

Major recently introduced regulations are RoHS (restriction of hazardous substances) and WEEE (waste
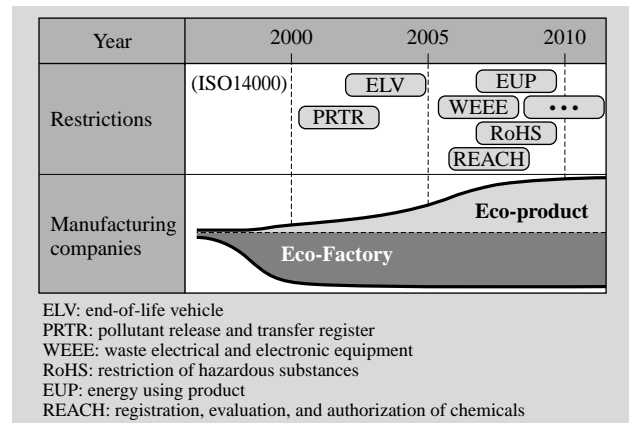
TABLE 1. Relation between Law Restrictions and Production Process
In "related process," upper case letters indicate existing regulation; lower case letters indicate desired regulation. The letters A through E indicate the flow process.

A Development and design	B Procurement	C Manufacturing	D Sales and maintenance	E Recall/recycling

Region	Name of regulation	Item of regulation	Object products	Object region	Effect date	Related process
Europe	**RoHS**	• **6 restricted substances (Mercury, cadmium, lead, etc.)**	**EEE 100 items**	**Member countries of EU**	**Jul. 2006**	**A, B, c, d**
	WEEE	• **Recycling of EEE products** • **Recycling ratio**	**EEE 120 items**	**Member countries of EU**	**Aug. 2005**	**A,E**
	REACH	• Registration, evaluation, and authorization of chemicals	1t per year or more (each company and product)	Member countries of EU	2006	A
	EUP	• Environmental requirement for product a) Lifecycle assessment b) Energy saving c) Labeling	EEE	Member countries of EU	2006	A
Japan	Home Appliance Recycling Law	• Recall and recycling of used product • Recycling ratio	4 products (TVs, refrigerators, etc.)	Japan	Apr. 2000	A, E
	Law for chemical substances	• Specific chemicals prohibited in products	Specific products	Japan	1990	A, B, c, d
	Japan RoHS	• Under study of Japanese restrictions based on EU restrictions				
	PRTR	• Registration of pollutants in production	354 kinds of substances	Japan	2001	B, C
Asia	Chinese RoHS Chinese WEEE	• 6 restricted substances • Recycling of EEE	EEE	China	Jan. 2006	A, B, c, d, E
	Korean RoHS	• 6 restricted substances	EEE	Korea	2006	A, B, c, d
USA	Proposition 65	• Warning and announcement to customer for 800 kinds of chemical substances	Included products	California	1988	A, B, c, d
	Mercury legislation	• Labeling on products using mercury	Lamps, batteries, etc.	6 states in USA	2000	A, B, c, d
	SB20	• Recall and recycling of used products • 6 restriction substances	Flat panels, CRTs, etc.	California	Jul. 2004	A, B, c, d, E

of electrical and electronic equipment) in the EU (European Union). RoHS prohibits the use of six hazardous substances in EEE. The WEEE directive puts producers to the expense of recycling and disposal of EEE. This trend has been spreading from the EU to Asia, US and other countries. In addition, other environmental regulations are increasing and appear set to tighten up in the future. ISO14000 which was enacted in 1996, has the target of reducing the emissions generated by a plant, i.e. it aims for an eco-factory. Recent regulations have tightened to include substances in a product and treatment at the end of product life, i.e. it aims for an eco-product. Both eco-factories and eco-products go together (see Fig. 2).

As a result of these regulations, manufacturers are required to manage all stages of development/design, procurement of materials/components, production, sales, customers, maintenance and recycling/disposal (see Table 1).

GREEN PROCUREMENT AND MAKING TRACEABLE SUPPLIER CHAINS WITH GREEN PROCUREMENT SUPPLIERS

To remove prohibited substances and ensure they are below threshold values, Hitachi makes binding contracts with suppliers of materials, components and sub materials (solder, flux, glue, and etc.) to register the measured values of hazardous substances in their supplies before delivery. When suppliers make a change in a manufacturing process, manufacturing line or make any other major change, Hitachi asks them to inform them properly. Even minute quantities of additional substances may affect overall makeup. Therefore, it is important to correlate the measurement methods[1].

Keeping Traceable Supplier Chain

The importance of sharing and revealing information about included substances, quality, etc. with suppliers, has increased. In particular, it is necessary to include the following items in the purchase contract. These are a record of included substances for each production lot and the availability of that record. In other words, it is very important for total traceability to make traceable chains with all suppliers. It is also necessary to take into consideration the ability to trace the supplier's supplier when raw materials are purchased.

IT System for Green Procurement

Hitachi has a portal web-site for suppliers to register components and materials information. Suppliers can upload their technical information and included substances using a standard format. We named it AGree'Net (agree, green and network)[2].

Each division in Hitachi that intends to use those components or materials has to evaluate whether to use those components and materials based on uploaded information. Eligible components and materials are registered in the Hitachi internal component database, which includes drawing numbers, evaluation test data for eligibility, past track record, price, and uploaded information from suppliers. This database, a global parts selection system, is also used for the confirmation database to satisfy internal standard of green design (see Fig. 3).
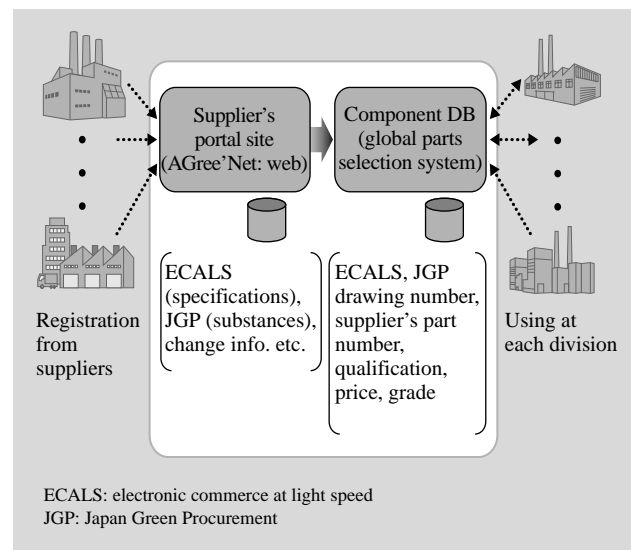

ECALS: electronic commerce at light speed
JGP: Japan Green Procurement

Fig. 3—Green Procurement System.
This system consists of supplier's portal website through which information about components and materials can be registered and a component database system for internal use.

GREEN DESIGN PROCEDURES
Evaluation of Included Substances in Components or Materials

Information about included substances in the components or materials is in the above component database. Before the component or material is used for the first time, information from the supplier needs to be uploaded, then the prescribed procedure as qualification needs to be followed. With regard to the

contents of regulated substances, in principal, uploaded information from suppliers is used, but we also provide measuring equipment for coping with contingent events.

Evaluation of Total Amount of Included Substances for Components Used and Materials in Products

The total amount of included substances is basically the added values of all the components and materials used in the product. However, we have to consider substances added during manufacture at our factories as well as those from EMSs (electronic manufacturing services) and OEMs (original equipment manufacturers) suppliers. These substances include lead in solder, fire retardant in wire covering, couplers, adhesive glues, paint and varnish, and screws. We need to take into account a wide range of materials such as the above. In the past, we have not included those sub materials in the E-BOM (engineering bill of materials). But, those should be included in the E-BOM as components or materials in our products. It is very important to include comprehensively using IT support.

Listing of Total Amount of Included Substances for Each Individual Product

With computer systems, there are a range of configurations, depending on the wishes of the customer. It is necessary to create a hierarchical BOM (bill of materials) tree diagram that breaks up each element in a product to enable ready calculation of included substances no matter what the system configuration is.

In addition, the replacement of out of orders FRU (field replaceable unit) is common, and it is usual to handle FRUs when configurations change at a customer site. Therefore, it has become very important to trace FRUs in the management of individual products (see Fig. 4).

Listing of Total Amount of Included Substances for Packing, Logistics, Sales and Installation

EEE producers have to consider not only substances included in their product but also packing materials such as cardboard boxes, accessories, back-up supplies, and instruction manuals. Lock-in screw bolts, earth wires, etc. at customer sites also need to be taken into consideration. Special components procured and appended to goods for the overseas market, such as
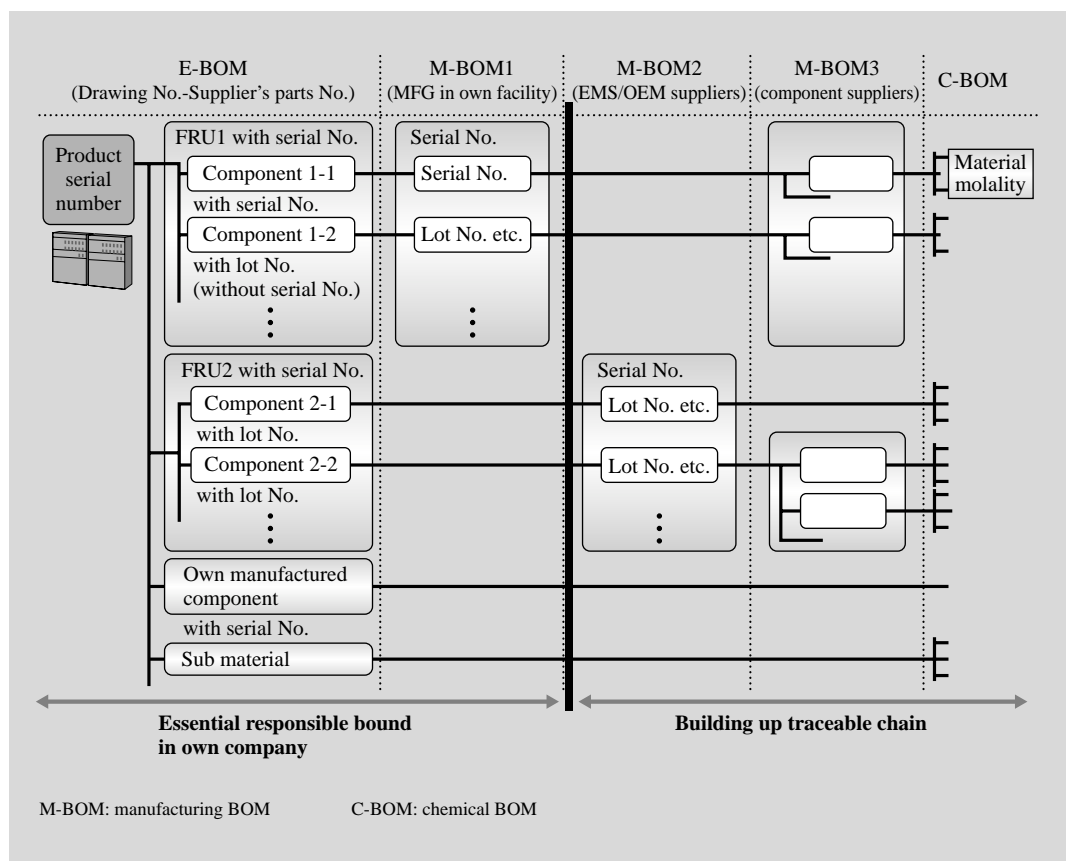

Fig. 4—Example of Layer Structured Traceability DB. It shows a four layer structured database in which own manufactured parts are separate from suppliers' parts. Records can be traced forward from product serial numbers and traced back from lot numbers of components.

special power plugs and cables also need to be considered.

GREEN MANUFACTURING AND QUALITY ASSURANCE

Incoming Inspection of Components and Materials

The incoming inspection process involves collecting information about manufacturing from the factory. It is necessary to make a record corresponding to the supplier's record that lists manufacturing lot and serial number. Systems and workings are needed to tie the component supplier to our own manufacturing process. Specifically, when we close a contract with a supplier to get a record of the included substances in their product. Then in our own facility, we record the serial number of the product which was built into those component or material. If occasion arises, we can then work out details of all included substances in an individual product using the supplier's records.

Compiling Track Record on Manufacturing/ Quality Assurance/Shipping Process

It is important that a record of what lot number was built into what serial number of product. We record all components and materials not only by serial numbered component but also date coded component, no marked small size component, liquids, powders, wires, screws, nuts, and washers using most proper method which makes easy to specify the range to be targeted per each. Then, it is a key point to make the record corresponded to supplier's record.

It is important to record that sub material is used in the manufacturing process such as solder, flux, solvent, and adhesive glue. The details that should be recorded for the manufacturing track record are the usual data such as yield ratios, factures, record of rejig, manufacturing personnel, major tools, measurements, test records including the measured value, etc.

When a product is shipped, we need to verify the correspondence between both the product and the packing box which show product serial number from outside of packing box. This provides an important manufacturing track record that includes packing materials and quantities used (see Fig. 5)[3].

Manufacture Tracking and EMS/OEM Suppliers

Basically complete manufacturing records need to be kept when a product or part of a product is manufactured on commission by an EMS and OEM supplier. It is necessary to maintain close contract with an EMS or OEM supplier just same as with components or materials supplier to ensure that manufacturing records are kept and that this record can be accessed as needed.

We believe traceability data records should be kept for FRUs and products assembled at their own facilities. That way they have a record of their own assembly work. When we give EMS/OEM suppliers a commission, we ask them to keep records of manufacture at their facility. When to occasion requires it, we ask them to conduct discovery the record to ingest given layer of the applicable product in own database. This philosophy of database layering is used
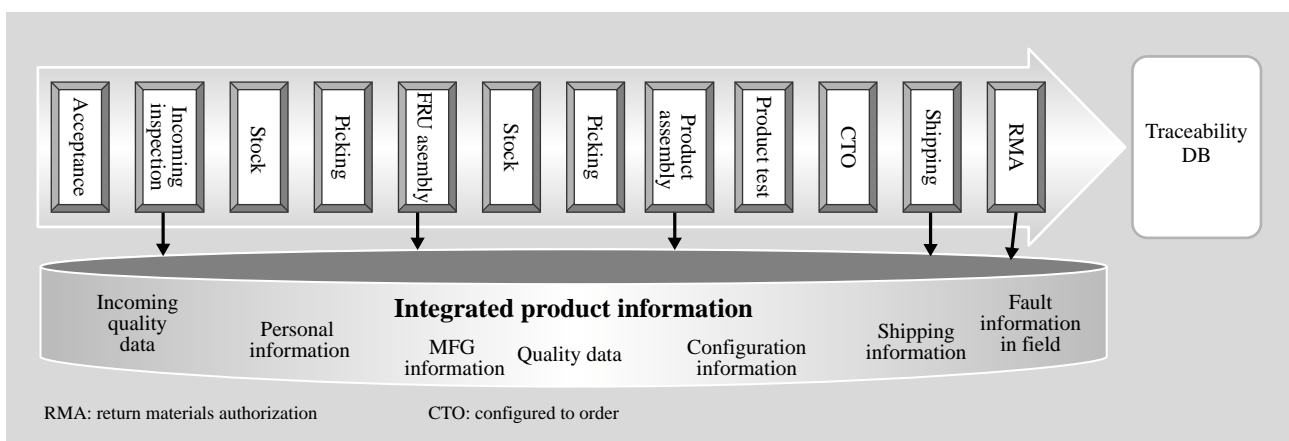

Fig. 5—Manufacturing Data Collection with MES.
The MES is expected to integrate all manufacturing equipment in the manufacturing line, then to collect accurate data in a timely fashion. It is also expected to coordinate other production systems such as SCM (supply chain management) and PDM (product data management), etc. In addition, it is expected that charges in manufacturing will be easy to follow to support multi-plant global production.

in the same way as for suppliers of components and materials. We provide a multi-layered database for product traceability. Then it locate layer of C (chemical)-BOM which includes a list of chemical substances at the deepest layer. The C-BOM is essential data for the management of environmental substances. Thus, an important aim of this project is to keep reliable systems and workings to make and keep up a traceable chain (see Fig. 4).

INTERFACE BETWEEN MARKET AND TRACEABILITY
Liaison with Sales and Maintenance Companies

Our consumer products are usually sold to customers through supermarkets, volume retailers, and distribution outlets. It is important to maintain channels of communication with them to obtain end user information for traceability. However in recent times they have each installed individual IT systems, making it difficult to connect to their system. However, we have to find a solution to this for the sake of customers and the state of the global environment.

There are various ways to install products at customer sites and to carry out maintenance: by ourselves, by subsidiaries, by sales companies, by repair specialists and by consumer product distribution outlets. For this reason, there are many instances when we are not in a position to collect all the information ourselves. With this in mind we have to provide a means of coordinating all the information.

It is important to develop an accurate traceability system that enables all parties to feed back information about installation location and date as well as

information about any FRU replacements, date of breakdown and other related information.

Relationship between Customers, NPOs, Government Agencies and Traceability

We need to make product information such as specifications, product grade, and included substances available for customers at all times via the Internet. In addition, we need to provide information about how to dispose of the product when the customer have done with it.

We need to provide report and data regarding keeping global environment immediately when requested from NPOs (non-profit organizations) or government agencies. If a product should have to be recalled, our goal is to ensure that the number on the product corresponds to the recorded serial number.
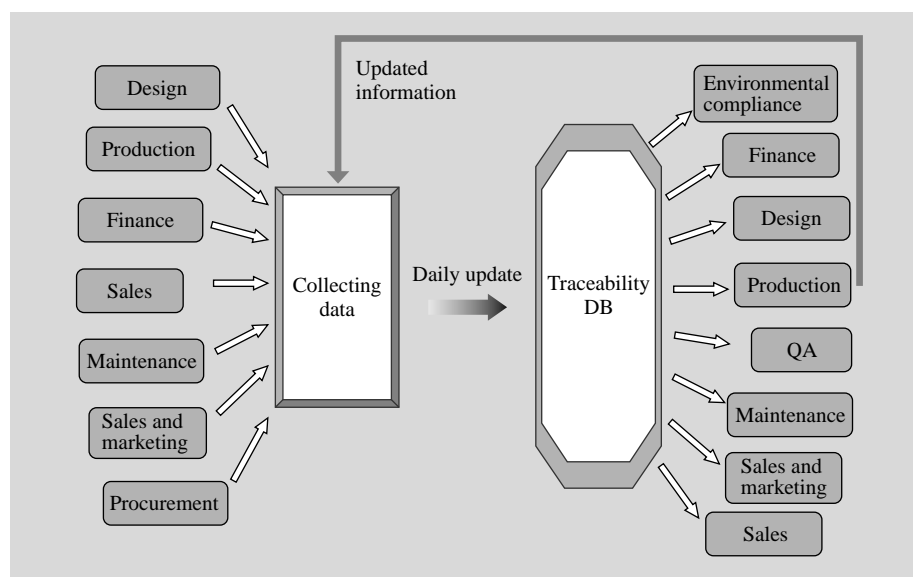
Recall, Disposal and Recycling

When customers have a used product and deconstruct it, we need to provide information about which FRU or components should be recalled, and whether the components are recyclable or reusable, through a website. When a product does not comply with regulations, we have to provide detailed information about components and handling. Finally, we need to record the end of life of the serial numbered product.

ADDITIONAL APPLICATIONS FOR DATABASE

We expect to be able to apply this traceability DB, which has been constructed as part of the Eco & PLM project, to other areas. For instance, having an

Fig. 6—Progressed Traceability DB. All the information about an individual product through its lifecycle can be registered in a traceability DB. The DB offers high-speed processing technology enabling wider application in daily business administration.

integrated database of information such as prime cost and sales price, assists daily business administration, because the BOM database is updated every day for an individual product through its lifecycle. If finance, sales volume, and sales forecast information is added to previous input on design, procurement, and manufacturing, then the company will be able to make good use of this to carry out at wide range of analysis and evaluation tasks (see Fig. 6).

CONCLUSIONS

Hitachi Group makes harmony with the environment a top management priority. We take cognizance that stewardship of the environment plays a key role in business enterprise, and strive to reduce the load on the environment through management of the production process and green procurement. Furthermore, in response to the recent introduction of the environmental laws in EU, we have moved forward to develop process management that takes into account the chemical substances in products. This process of Eco & PLM project provides an immediate solution to meet recent environmental laws. We also plan to implement a more advanced management process for environmental hazardous substances. We also intend to maintain this an ongoing process and maintain leadership in this field.

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