PHILIPS ORAL HEALTHCARE (B): THE SUNSHINE PROJECT

Professor Ron Sanchez prepared this case as a basis for class discussion rather than to illustrate either effective or ineffective handling of a business situation.

The cooperation of Mr. Maarten Barmentlo, Dr. Max Pachel, and Dr. Erwin Hochreiter of Philips Domestic and Personal Appliance division and of Mr. Paul Hissel of Philips Center for Industrial Technology in the preparation of this case is hereby gratefully acknowledged.

In early 1999, managers of the electric toothbrush business within Philips Oral Healthcare made a strategic decision which they summed up succinctly in the phrase, "We stay fighting." But the decision to stay and fight in the increasingly difficult electric toothbrush market meant that Philips Oral Healthcare would need to develop vastly improved capabilities if the business unit were to succeed in the competitive struggle ahead. The Oral Healthcare management team knew that those new capabilities would have to come from a very different kind of foundation for the electric toothbrush business.

Success--indeed, survival--in the future would depend on rapidly building up the installed base of Philips electric toothbrushes to assure growing sales of replacement brushes, which were the main source of profits in the electric toothbrush business. On the demand side, Philips would have to "grow the market" for its electric toothbrushes by investing heavily in advertising and promotions to stimulate consumer "demand pull" for its products, while also continuing to invest in developing both existing and new distribution channels. On the supply side, building up the installed base would require creating radically improved capabilities to significantly lower production and supply chain costs, expand product variety, provide faster supply chain response, *and* support rapid product upgrading, featuring, and special packaging of products. Moreover, there was not a lot of time left for Oral Healthcare's managers to launch this new marketing approach and to create a new production and supply chain foundation for the business.

The Launch of the Sunshine Project: Defining New Strategic Business Objectives

In May 1999, Mr. Maarten Barmentlo, head of the electric toothbrush business unit, asked Dr. Max Pachel, head of research and development for DAP Klagenfurt, and Dr. Erwin Hochreiter, head of production in Klagenfurt, to lead a top priority project to create a new generation of product designs and supply chain processes capable of supporting the business unit in its increasingly competitive environment. Within a few weeks, Dr. Pachel and Dr. Hochreiter launched the "Sunshine Project" to create a new "platform" of carefully integrated *product and process architectures*[1] that would be the foundation for Oral Healthcare's strategy in the increasingly competitive electric toothbrush market.

The first step in this process was a detailed analysis of the current and expected competitive environment in the electric toothbrush market. Philips Oral Healthcare managers defined in precise terms the cost reductions, expansions of product diversity, intended technical improvements in products, improved supply chain performance, and production capacity expansions that the Oral Healthcare business unit would have to achieve to compete profitably in the electric toothbrush market over a five to six-year planning horizon. The set of new performance targets and their implications for development of new capabilities was challenging, to say the least:

<u>Cost Reductions</u>

To support Oral Healthcare's need for rapid expansion of its market share, especially in the rapidly growing market for inexpensive brushes, average unit product costs ex factory would have to be reduced by *at least 45%.* In addition to this challenging target for reducing production costs, analysis established that in 1999 about 70% of total logistics costs in Oral Healthcare were being generated by 30% of product units shipped, primarily in the form of costs for air freighting components and products for packaging special models in Philips' Regional Distribution Centers (RDCs) or National Distribution Centers (NDCs) to supply special deals for large retailers. Such high marginal costs of fulfilling special orders for these increasingly important customers would have to be eliminated.

Moreover, a future requirements analysis undertaken with consultants from Philips Center for Industrial Technology (known within Philips as "CFT") in Eindhoven, The Netherlands, established that even though product diversity

[1] The term *platform* is used with a variety of meanings both in the product development literature and in product development practice. In this case, the term *platform* refers to *coordinated product and process architectures intended to support a defined set of strategic business objectives.* The terms *product architecture* and *process architecture* refer to (i) the technical decomposition of a product or process design into functional components (or "building blocks"), and (ii) the specification of the interfaces that define how the functional components of a product or process design will interact in the functioning of the design as a system [see Ron Sanchez (1999), "Modular Architectures in the Marketing Process," *Journal of Marketing,* **63** (special issue), 92-111.] Analogously, the term *platform* is now used by Philips CFT (Center for Industrial Technology) in referring to "integrated solutions for product, production-system, and supply-chain architectures."

would be increasing significantly in the future, both carrying costs and obsolescence costs of finished goods inventories would have to be substantially reduced.

These imperatives for cost reductions implied the need for fundamentally new designs for the product, production system, and supply chain in the electric toothbrush business. The current highly variable mix of make-to-inventory and make-to-order production resulted in a production planning system with poor predictability and often necessitated cost-ineffective responses to order consolidations. This approach would have to be replaced by new, strategically coordinated product and process architectures that would make possible much reduced production and supply chain costs and much more predictable, manageable, and cost-effective make-to-plan (MTP) and make-to-order (MTO) production and supply chain processes.

Greater Product Diversity

To support continued customization of products for large customers and for new distribution channel initiatives, product diversity would have to expand significantly beyond the current 105 models (including packaging variations). *At least 200 different product models* would have to be available for the five-year planning period beginning in 2001, largely to provide a stream of new product variations for the increasingly important special channels for fast-moving consumer goods (FMCG). To achieve adequate levels of differentiation, each new product variation would have to offer a unique combination of features, styling, accessories (e.g., travel pouches), promotional gifts (e.g., toy teddy bears for children), special warranties, and/or promotional printed matter.

Featuring and styling would have to be expanded to offer new plastic handle shapes, switch designs, colors, electronic features like brushing time indicators, containers for holding brushes, and various accessory materials (e.g., travel kits). Packaging variations to support sales development internationally would add further diversity. These would include “fancy boxes” with full-color graphics, standard blister packs with a variety of size and labeling options, and special printed boxes that allow a second printing of promotional labels (e.g., “Special Summer Offer!” or “A Carrefour Exclusive!”)

At the same time, to expand market share in the face of ongoing price erosion, the new range of brushes would have to be sold profitably at much lower price points than currently possible and in volumes much larger than currently realized. Increased product variety would have to be carefully leveraged from the new product and process architectures without imposing significant costs of product diversity on development processes or on the supply chain, and without impeding the fast response capability needed from the supply chain.

Continual Technical Upgrading

To remain competitive, Oral Healthcare would have to continue to develop and introduce new electric toothbrushes with improved dental cleaning benefits. To heighten consumer perceptions of new benefits, technical improvements should wherever possible produce a *visible benefit* that can be directly felt or observed by the consumer. This would require introducing new models with new brushing motions and/or new bristle materials and configurations at the top end of the product range, while maintaining current brushing motions in mid-range and moderately priced models. In addition, a line of non-rechargeable battery-operated toothbrushes would have to be added to answer expected introductions of such models by major competitors.

Improved Supply Chain Performance

To support development of collaborative marketing with major retailers as well as sales initiatives launched by Philips' own national sales organizations (NSOs), Oral Healthcare would essentially have to develop *a rapid mass-customization capability.* Production lead times for orders from NSOs for standard models would have to be reduced from the current two weeks to one week or less. Production lead times for special deals for large retailers or for orders from FMCG channels would have to be reduced from two or more weeks to no more than five working days. (Lead times for very large special deals--e.g., orders for 200,000 units or more--could remain at six to eight weeks.)

These improvements in supply chain response would require a new approach to structuring and coordinating the supply chain for the electric toothbrush business. All elements--Oral Healthcare's suppliers, its own production processes, and its logistics for deliveries to its internal and external customers--would have to work together in one integrated, closely synchronized, fast, and highly reliable supply chain process. To remain a preferred supplier to large retailers, order fulfillment rates (the percentage of customer orders actually accepted, produced, and delivered as promised) at the Klagenfurt supply chain center would have to increase from 72% (the target for 1999) to at least 95%--and preferably to 98%.

To respond effectively to growing demands by large retailers for new OEM or exclusive Philips-branded models, the time to develop and produce custom designs would have to be reduced from a few months to a few weeks. Finally, lead times for small lots of products required to support new direct-sales marketing initiatives would have to be reduced to five days.

Capacity Expansion

To meet production cost reduction targets, production levels would have to increase from the 1.5 million units produced in 1999 to at least 2.3 million units per year capacity by 2002, with an eventual goal of 3.5 million units annually. However, since it was not possible to make major capital investments in new buildings, this expansion capacity would have to be realized within the existing factory space allocated to electric toothbrush production in the Klagenfurt facility.

The Need for Modular Product and Process Architectures

Based on their own recent development experiences within Philips DAP, on what they had learned about breakthrough development efforts in other Philips business units, and on discussions with consultants from Philips CFT, Dr. Pachel and Dr. Hochreiter concluded that only the systematic application of modular design concepts[2] could lead to new product and process architectures capable of providing the unprecedented product configuration flexibilities, cost efficiencies, and supply chain speed and reliability levels required to achieve these strategic business objectives. Several special characteristics of modular architectures would play essential roles in creating the capabilities needed to support the electric toothbrush business unit's new strategy:

- Modular product architectures are designed to allow a range of component variations to be substituted directly into a product design to create product variations. This ability to configure product variations by "plugging and playing" a range of component variations would be the key to achieving the product configuration flexibility needed to meet demands for considerably greater product diversity.

- Modular architectures can be "strategically partitioned" to "contain" variety and technological change in certain components that are the sources of perceived product variety and performance improvements, while creating "islands of stability" in other common components that are used in common across product models or in re-usable components that can be used through successive generations of products. To achieve the ambitious 45% cost reductions required by the new strategy, the most cost-intensive components in the new modular product architecture for Philips electric toothbrushes would have to be used in common in all product models to increase economies of scale and reduce parts variety. In addition, wherever possible, common components would be industry standard components already available "off the shelf" at low cost from reliable, large-scale suppliers. In most cases, these industry-standard common components would then be re-used in future generations of Philips electric toothbrush designs to reduce development costs and further improve sourcing economies.

- When modular architectures are strategically partitioned into a set of common "core components" that are invariant across product models and a second set of "differentiating components" that are the sources of perceived product variety and change, production process may be designed to produce a standard assembly of common components, and then to add differentiating components in the last step(s) in the production process. The use of modular designs to enable such *late-point differentiation* of product models in the production process would make it possible for Philips to use automated, high-speed, mass-production technologies to achieve low costs in the manufacture and assembly of the electric toothbrush's common components. These assemblies of common components used in all product models could then be mass-produced in a stable, make-to-inventory production process that would be unaffected by the unpredictable fluctuations in demand for specific product models. At the same time, the differentiating components that are the sources of perceived product variety

[2] A *modular architecture* is one in which the interfaces between functional components have been specified to allow the substitution of a range of component variations into the product design without having to make compensating design changes in other functional components. [See Ron Sanchez (1999), "Modular Architectures in the Marketing Process," *Journal of Marketing,* 63 (special issue), 92-111.]

could be added by less capital-intensive means (including human labor) in smaller lots at the end of the production process, thereby both increasing speed and reducing the minimum lot size in fulfilling orders.

In addition, the use of a single set of high-speed, mass-production equipment for producing and assembling common core components could give Philips a significant increase in production capacity within the existing spatial limitations of the Klagenfurt facility.

A New Development Process for the Sunshine Project

After extensive discussions with product architecture and supply chain consultants from Philips CFT, Drs. Pachel and Hochreiter concluded that only an integrated product and process architecture approach could achieve the challenging strategic goals set for the Sunshine Project. This integrated architectural approach would involve creating a new modular product architecture that was conceived to achieve both much lower product costs and much higher levels of configurability. The new modular product architecture would have to be developed simultaneously with a new process architecture designed to support significantly improved production and supply chain flexibilities, reliabilities, efficiencies, and speed. Drs. Pachel and Hochreiter realized that the creation of strategically focused and integrated product and process architectures would require a new model for product creation that was fundamentally different from the traditional product development model that had been used to launch the original Sensiflex electric toothbrush line.

The product-creation process (PCP) model used to launch the original Sensiflex product line was essentially the traditional sequential development model shown in ***Exhibit 1***. Initial estimates of market requirements for product diversity, volumes, price points, and product performance levels defined the parameters to be met in developing the new product designs. After new product designs were developed, operations managers were given responsibility for creating the production and supply chain designs needed to realize the new product designs.

Philips Oral Healthcare's managers had come to understand, however, that there are at least two significant shortcomings in this traditional sequential approach to product creation and realization. First, significant opportunities to reduce production and supply chain costs were missed, because opportunities for improved "design for manufacturing" and improved supply chain performance were not systematically included in product design decisions. The second shortcoming was even more serious. Given the rapid growth and competitive evolution of the electric toothbrush market, original estimates of required product diversity and of rates of price erosion fell short of eventual demands. The supply chain for the Sensiflex product line, however, had been designed and optimized to support the original estimates for diversity and cost made in the mid 1990s. This production and supply chain design was eventually nearly overwhelmed by the demands placed on as competitive conditions intensified in the electric toothbrush business.

Drs. Pachel and Hochreiter realized that design of the process architecture for production and supply chain would have to be carried out in close coordination with design of the new product architecture in a simultaneous development process. They envisioned a more integrative development process like that shown in ***Exhibit 2***. The simultaneous development project for new product and process architectures would have to remain clearly focused on finding an integrated solution to the strategic business objectives for reducing cost, increasing product diversity, and improving production and supply chain speed and reliability. On the recommendation of Philips CFT staff, the Sunshine Project team adopted the process model for integrated architecture development shown in ***Exhibit 3***. Moreover, to help the Sunshine team evaluate the ability of alternative product and process architectures to achieve the project's strategic business objectives, key performance indicators (KPIs) were defined for each stage of the overall production and supply chain.[3]

The Sunshine Project team also adopted some *new rules* to guide their simultaneous development processes. For example, product architecture decisions would in all respects be made jointly and simultaneously with process architecture decisions, and these joint architectural decisions would always be made with specific reference to the defined strategic business objectives for the project. Costs would not be defined solely by bills of materials (BoMs) for specific product models, but would always be evaluated "system-wide" with reference to all costs that would be incurred for development and realization over the lifetime of the product line. Further, key components would be standardized (using industry standard components, if possible) and used in common across all planned product models unless a clear strategic need and convincing business case could be established for investing in developing and supporting component variations. Most important, the interface specifications for the new product and process architecture would be managed strategically during development through a carefully controlled architecture management process. Uncoordinated changes to interfaces in either product or process architectures would not be permitted.[4]

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[3] Like most businesses, over the years DAP Klagenfurt had developed a set of KPIs for managing its production and supply chain operations. Since implementing measuring systems to generate the data needed to calculate KPIs takes considerable effort and cost, the Sunshine Project team first evaluated existing KPIs to determine which previously implemented measures were relevant to and could therefore be used in monitoring the new performance requirements for the supply chain. Some existing measures were judged to be relevant to the performance objectives for the new supply chain and therefore could be used, but in other cases old measures were judged not to be relevant indicators of the new supply chain performance objectives and had to be replaced by more appropriate KPIs. Some key supply chain performance indicators used in the Sunshine Project are:
LAP = Line Acceptance Performance = line orders accepted / line orders requested.
SR = Supply Reliability = Orders delivered as agreed / Orders accepted
RLIP = Realized Line Item Performance = LAP x SR.
LT = Lead Time = Time from consolidation of NSO order to delivery to NSO

[4] Control and coordination of interface specifications during development is necessary to maintain the ability to "plug and play" component variations in a modular product architecture and to assure that the outputs of each activity in a process architecture are compatible with the input requirements for each downstream stage in the process architecture.

To carry out a simultaneous product and process architecture development process, the Sunshine Project team would also have to include participants from all areas of the electric toothbrush business that would be affected by or could provide useful inputs to the next generation product and process architectures. Accordingly, Drs. Pachel and Hochreiter recruited key staff members from product management, product design, industrial design, production design, supply chain management, marketing, purchasing, and finance to join the Sunshine project team. In addition, staff from DAP product line management, Philips CFT, and Philips Design (Philips' in-house product design consultants) also participated in the project. To establish a shared understanding of architecture and modularity concepts, strategies, and vocabulary, the project team members closely read and discussed several external and internal publications on product and process architectures.

The Sunshine Project team also defined some important *new roles* for managing its architecture development process. A new and especially critical role is that of architectural coordination. A product architect was selected to be responsible for defining the range of component variations needed to configure the range of product variations required to support the new business strategy. The product architect also had to check and document all relevant component interface specifications to assure that the anticipated range of component variations could be freely combined to configure the required range of new product variations. Analogously, production and supply chain architects were appointed to assure that each stage in production and the supply chain had the flexibility needed to process the range of variations in parts, components, and products required to support the business strategy. The product and process architects were also to work closely with the electric toothbrush product line and marketing managers to assure that the new product and process architectures could deliver the greatest attainable combination of cost efficiency and speed in supplying the required range of product variations in any mix and volume level demanded.

Defining the Sunshine Product Architecture

After adopting the new organizational approach to carrying out their project, the Sunshine Project team identified a sequence of steps they would follow in creating the new product and process architectures that would serve as the new platform for Philips' electric toothbrush business. The team's first concern was to determine the most advantageous *strategic partitioning* of the Sunshine product architecture into functional and physical components. The next step was to define *interfaces* between components in the Sunshine product architecture that could provide the "plug and play" component configurability needed to leverage the high levels of product diversity required from the new modular product architecture. Both of these essential steps in defining a product architecture had to be carried out in close coordination with the definition of new production and supply chain architectures to assure that the new product and process architectures jointly would have the flexibility needed to support the strategic business objectives to be served by the new platform.

The three key steps in the architecture definition process were as follows, in order of execution:

1. Analysis of strategically required product diversity

The "acid test" of a new platform is its ability to efficiently bring to market the range of product diversity and technical evolution needed to effectively carry out a defined business strategy. Thus, the first steps in creating a new platform are to determine:

- the range of product variations required (both the range of basic *models* based on differences in functions, features, and performance levels and the range of *versions* based primarily on differences in styling and packaging must be defined)
- anticipated volumes and price points for each product variation required to serve targeted market segments and distribution channels,
- the timing of new product introductions needed to fully support the defined business objectives over the strategic planning horizon.

Using these criteria, the Sunshine Project team defined an initial product range specification consisting of seven major product models needed to cover major retail price points from 15 to 79 Euros over the three-year planning horizon 2001-2003, as shown in ***Exhibit 4***. This analysis suggested that the Sunshine Project development process could be largely focused on five product models that would generate nearly all the sales volume in Philips' electric toothbrush business.[5] These models were subsequently called "Basic" models because (i) they offered the proven cleaning action of Philips' standard combination of rotary brush motion and an oscillating small brush at the tip of the rotary brush unit, and (ii) they would be positioned at the critical lower-price end of the market needed to build market share and installed base.

Each of the five Basic models differed from other models in its specific combination of features, handle designs, and packaging. The two lowest priced Basic models were intended to be standard, high-volume models targeted for special deals with large retailers and the Fast-Moving Consumer Goods channels. These models would allow a limited range of featuring variations, as well as variations in colors, printing, and packaging. The three other Basic models would be offered through traditional distribution channels with a range of variations in plastic handle shapes, switch designs, charge indicators, and other electronic features, as well as color and printing variations, accessories, and packaging variations. (*Features noted by "?" in* ***Exhibit 4*** *were identified as possible options for future development if needed to serve market demands*.)

Estimates of total volumes for each of the defined models for the 2001-2003 planning horizon were made. The estimated volumes for this initial three-year period ranged from 800,000 units for mid-priced models to nearly 5 million units of lower priced models.

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[5] Two "Trident 2" models at the top end of the price range were to offer a new cleaning motion called "reflex action" based on a new brush design with two counter-rotating brushes and an second high-speed reciprocating brushing motion. These models were included in the Sunshine project as a potential evolution within the product architecture, but ultimately were not developed.

2. Strategic partitioning of the Sunshine product architecture

The first step in strategically partitioning a new product architecture is the technical decomposition of the overall functionalities to be provided to the user by a product into a set of functional components that, when working together as a technical system, will deliver the overall "bundle" of desired functionalities. For example, to deliver the functionality of "brushing action" to a user of an electric toothbrush requires a set of functional components such as electric power source (usually a battery), power converter to convert electric power into mechanical power (usually a small motor), a motion converter (usually a drive assembly that converts the motor's motion into the kind of motion desired at the brush), and a brush (usually attached to a drive assembly). The basic functionalities to be offered by the Sunshine product architecture did not differ significantly from the functionalities provided by Philips' prior electric toothbrushes. Thus, the basic set of technically necessary functional components required in the Sunshine product architecture were not significantly different from the functional components used in prior products.

The next step in the strategic partitioning of functional components within a product architecture is grouping all the technically necessary functional components in a product architecture into the most *strategically* advantageous set of individual physical components or assemblies of components (*refer to* ***Exhibit 5***). The Sunshine Project team continuously considered their fundamental strategic business objectives--always including production and supply chain cost and performance goals--when evaluating alternative approaches to grouping technically necessary functional components into sets of physical components in the Sunshine product architecture.

Strategic Objective to Provide Required Product Diversity

In any product, some components will be more important sources of perceived differentiation than other components. The Sunshine Project team determined that their strategic objectives for product diversity could be met by differentiating product models on the basis of styling variations, specific combinations of features, accessories that could be included with certain models, and packaging variations.

The waterproof housing unit that serves as the handle of the electric toothbrush is the most visible component in the product. The Sunshine Project team therefore targeted variations in shapes and colors of the housing unit as key sources of differentiation among product models. The color and content of printing on the housing and the color and shape of the rubber cover for the power switch would also be varied to visibly differentiate models.[6]

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[6] Note that the electrical switch mounted under the rubber cover is placed in a standard location on the power unit itself (which is inside the handle unit), and that the switch and switch cover are intentionally separated from each other so that the switch cover color and shape could easily be varied while maintaining use of the standard electrical switch in a standard location within the product architecture.

Two combinations of existing electronic features would also be used to differentiate mid-range models: (i) a brushing time indicator plus a charging indicator, and (ii) a low-charge indicator plus a charging indicator. In addition, the team also identified additional electronic indicators that could be developed to further differentiate top-end models, including an "intelligent timer" to indicate when an adequate amount of brushing time has transpired, a fast-charge system, and a charge management system for prolonging battery life.

Further product models or versions could be differentiated by the number of extra brush tips provided with a model and by the design of a stand unit consisting of a charger and container unit. The container unit would be offered in several designs to support product variations for different market segments and distribution channels. However, all container design variations would be constrained to fit over a standardized charger unit which would be a common component used in all models and thus purchased in large volumes to reduce costs.

In addition, a number of packaging variations were envisioned to differentiate product versions, ranging from "self-selling" plastic blister packs to multicolor printed boxes.[7]

Strategic Objective to Achieve Substantial Cost Reductions

In any product, costs of some components have a major impact on total product costs. The Sunshine Project team paid special attention to the design of those components in order to reduce component costs and overall production cost savings. In addition, the team consistently applied "design for manufacturing" (DFM) concepts to reduce costs for assembling components. For example, use of simple "snap together" connections rather than mechanical fasteners to attach components together reduced both parts costs and assembly costs.

The team also systematically evaluated the potential for common components used across product variations to create economies of scale in component manufacture or to lower prices for outsourced components by increasing volumes purchased. The Sunshine Project team determined that the main source of cost in the overall product would be the power unit (which includes the functional components of an internal charging system, rechargeable battery, switch, and drive system) and the mechanism for the controlled pressure system (CPS) for "clicking-back" the brush tip when the user applies excessive brushing pressure. As a result, the team decided to create standard designs for these components to

[7] The Sunshine Project team also considered including a low-priced replaceable battery-electric toothbrush in the development of the Sunshine architecture. This differentiation would have to be accomplished technically through a significant change in the design of the power unit to accommodate two disposable batteries and a special plastic housing with an access door for replacing batteries. In addition, both internal and external battery charger systems would be deleted for the replaceable battery-electric toothbrushes. Given the scope of these technical changes, the Sunshine team decided not to pursue development of a replaceable-battery model during the project. This decision was revisited after completion of the Sunshine project, and a replaceable-battery model was subsequently developed in Klagenfurt under the code name "Rabbit." This model requires its own power unit, housings, and packaging, but shares a number of other common components within the Sunshine architecture.

be used in common across all Basic product models. Use of standard designs for these cost-intensive components in all Basic models would enable steady, large-scale mass-production of those components, which would both reduce product costs and stabilize production and upstream supply chain flows.

The team also considered ways in which adoption of standard common components could simplify supply chain logistics and lower supply chain costs. For example, the charger unit (transformer and inductance coil unit within the stand unit) had previously been used as a source of product differentiation for Philips electric toothbrushes and had been offered with many variations in shapes, colors, printing, and even electronic features. In addition, a number of country-specific versions had been used to meet local market requirements for voltage, mains plugs, and safety and environmental regulations. However, the large number of different charger units used and the need to source such charger units from low-cost suppliers in China had created recurring logistics problems and associated costs, such as late shipments that had to be air freighted to meet production schedules. By foregoing the use of charger units as a source of differentiation and by adopting a single standard charger design (one shape, one color, no printing, but retaining 120-volt and 240-volt versions), the team achieved significant cost reductions and supply chain simplification. At the same time, by creating different container designs that can be added to the standard charger unit in the last step of the assembly and packaging process in Klagenfurt, variations in the overall stand unit could still be used as a source of product differentiation.

In some cases, to increase standardization of common components, the team made use of component designs with "redundant" capabilities--i.e., capabilities that are selectively activated in some product models, but not for others--to enable a single standard component to be used across a range of product models with varying functions and features.[8] For example, power units for low-priced models could use a simple diode (rectifier) in recharging the battery, while higher-priced models would include a small printed circuit board (PCB unit) for electronic monitoring of battery charge levels, managing battery charge rates, and indicating battery charging. The solution to meeting these two requirements adopted by the Sunshine Project team was to include electrical connections for both a diode and a PCB in the standard power unit. In power units for low-priced models, the diode would be snapped in place in the last step of assembly of the power unit, while in power units for higher-priced models, the PCB would be snapped in place. This redundant design approach allowed a single standard design for the power unit to be produced in large volume for all Basic product models.

The team also systematically investigated possibilities for using industry standard components that are already produced at large scale and available at low costs and could therefore lead to further reductions in both development and production costs. In some cases, the cost savings available through use of industry standard components were dramatic. For example, the team found that the small constant-

[8] Component designs with redundant capabilities may lower overall product costs when the cost savings realized through economies of scale in producing a single redundant component are greater than the "extra" costs of materials and labor used in the parts of the component that remain unused (i.e., are redundant) in some products.

speed motor they would need to use in electric toothbrushes was available from a very large-volume, high-quality Japanese producer. A cost analysis by the Sunshine Project team determined that when purchased in the quantities required for Philips electric toothbrush business, the *delivered cost* of such motors from this supplier would less than the *cost of the raw materials* Philips would have to purchase to make the motors internally.[9]

The team also considered the interrelated financial and operational risks involved in deciding whether to develop and make a component internally *or* to outsource the component. Sourcing a component internally incurs financial risk in the form of sunk costs for component development and production tooling. However, insourcing may bring certain advantages in improved control and predictability of the supply chain for that component. By contrast, outsourcing a component may require additional logistics management in the supply chain, but outsourcing makes the cost of the component a variable cost rather than a sunk cost, and thereby lowers the financial risk of creating a new product. In deciding whether to insource or outsource a given component, the Sunshine Project team realized the need for systematic financial risk and return evaluations of the interdependencies between alternative approaches to defining the component structure (i.e., strategic partitioning) of a new product architecture and the performance and cost reduction objectives for the production and supply chain architectures intended to support the new product architecture.

Strategic Objective for Improved Product Performance

Some components importantly affect users' perceptions of the performance levels of a product. When this is the case, product and process architectures may be defined to accommodate the planned introduction of higher performing versions of those components to create consumer perceptions of higher performance in some important functionality of the product.

The Sunshine Project team identified one potential performance improvement for the Sunshine product line during the 2001-2003 planning horizon--the introduction of a "reflex-action" two-way brushing motion in the two Trident models (*refer to* ***Exhibit 4***). Reflex-action brushing motion could be created technically by a motion design variation within the motion converter functional component. To allow this performance improvement (when technically developed) to be introduced directly into the existing Sunshine product architecture and quickly brought to market, the Sunshine Project team decided that the motion converter functional component should be "contained" within a single physical component (the brush tip in ***Exhibit 5***) so that the future addition of a reflex-action motion converter design would not require compensating design changes in the other physical components of the product architecture. In this way, all anticipated technical development and change within the planned commercial lifetime of the Sunshine product line could be contained within a single physical component of the Sunshine product architecture.

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[9] Although Philips' electric toothbrush business would require several million such motors a year, the Japanese supplier typically produces more than *one billion* motors of that type per year.

During the strategic partitioning of the Sunshine product architecture, the Sunshine Project team came to understand clearly that the functional decomposition of a product architecture into a set of physical components should never be treated as a purely technical or "engineering" task. Rather, decisions about the component structure of a new product architecture must always consider the full range of product, production, and supply chain strategic implications of alternative approaches to partitioning a new product architecture.

Exhibit 6 shows schematically the results of the Sunshine Project team's strategic partitioning of the new product architecture for Philips electric toothbrush business into six physical components--bristle unit, housing unit (plastic handle plus bottom cap), power unit, PCB unit, charger unit, and container unit. The resulting six main components of the Sunshine product architecture shown schematically in ***Exhibit 6*** are also shown in their physical realizations in ***Exhibit*** *7*.[10]

3. Strategically motivated specification of component interfaces

Component interfaces refer to the ways in which the components in a product architecture interact with each other, with product packaging, with production and supply chain processes, and with users. (*Refer to* ***Appendix 1*** *for a summary of eight types of component interfaces*.)

A central concern of the Sunshine Project team in specifying component interfaces was to create a strategically required level of "loose coupling" of component designs in the Sunshine product architecture. An interface specification creates a loose coupling between component designs when the interface specification allows design variations in a component that is a source of perceived differentiation or that is evolving technically to be "plugged and played" (i.e., substituted) in a product architecture without having to make compensating design changes in other components (i.e., in standard common components or other variable or evolving components). When component interfaces are specified to create this strategically motivated loose coupling between components, component design variations can be freely substituted into a product architecture and combined with other component design variations to configure desired product variations.[11]

After strategically partitioning the Sunshine product architecture, the Sunshine Project team defined the specifications for the interfaces between the six physical components[12] in the Sunshine product architecture, as shown in ***Exhibit 8***. Each of

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[10] In ***Exhibit*** *7*, the bristle unit is shown above the handle unit, and the container unit is shown above the charger unit.

[11] Component interfaces that are specified to create the technical loose coupling that enables component variations to be "plugged and played" within a product architecture are the defining characteristic of a *modular* product architecture.

[12] For the purposes of establishing standardized component interface specifications, the housing component was decomposed into its two component parts, the (power unit) housing itself and the bottom assembly. Thus the seven components of the Sunshine product architecture during the component interface specifications process were the bristle unit, housing unit, bottom assembly, power unit, PCB unit, external charger unit, and stand/container unit (which includes the external charging system).

these interfaces was specified to create the required extent of loose coupling of component designs needed to support the product diversity, evolution, and cost performance objectives for the product architecture. Following are several of the strategically important interfaces that the Sunshine Project team specified and standardized in the Sunshine product architecture, as well as the strategic motivations behind these specifications (*refer to **Exhibit 8** for interface numbers*).

Interface #1: Power unit <--> Housing unit. Styling variations in the plastic housing unit would be a main source of product differentiation, so the spatial interface between the power unit and the housing (i.e., the physical space that the power unit can occupy inside the housing unit) would be specified as compactly as possible to allow the greatest possible freedom in creating new housing styling variations. In addition, to further increase design freedom in styling the plastic housing, the power unit shape was made as "neutral" as possible--a compact cylindrical shape with no unusual angles or extensions that would significantly limit possible shapes for the plastic housing unit enclosing the power unit.

Since use of a standard, mass-produced power unit in all Basic models was essential in achieving overall cost reduction objectives, the interfaces of the power unit with the housing unit and all other components with which it interacts would be standardized to enable the use of the standard power unit in any product configuration. For example, both the location of the switch within the power unit and the location of the rubber switch cover in the housing unit were standardized to overlap exactly in all housing designs.

Since inductance charging is used for charging the power unit within the housing unit in all product models, a standard spatial configuration for the inductance charging interface between the housing unit and the power unit was also adopted. The inductance coil probe of the charger unit would have to extend into the housing just the right distance and in the right location to generate the inductance field needed to activate the internal charging system in the power unit. Since a standard inductance charger unit would be used to charge all power units, both the location of the recess in the bottom of the housing for accepting the inductance probe and to the location of the internal charging system within the power unit had to be standardized.

Further, product safety requires protecting the power unit from intrusions of water, which in turn requires maintaining watertight seals on both ends of the housing unit. Given the importance of maintaining highly reliable watertight seals, and given the significant cost and time requirements for developing and testing new kinds of watertight interface designs, the interfaces between the housing unit and the power unit and between the housing unit and its bottom cap were standardized to a circular shape[13] and a standard o-ring sealing method. Adopting this standardized interface clearly imposed a constraint on the freedom of designers to develop new shapes for the housing unit--for example, non-cylindrical housing designs could not be used--but that trade-off was judged necessary to adequately address the overriding concern of assuring the overall safety and reliability of Philips' electric toothbrushes.

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[13] A circular shape generally allows a more robust sealing against water penetration than non-circular shapes.

Interface #2: Power unit <--> PCB unit. As previously noted, the Sunshine Project team decided that the power unit would be equipped with redundant electrical connections so that either a diode or a PCB unit could be snapped into the power units to provide different sets of features for different models. Designing these minimal-cost redundant interfaces into the power unit allowed a standard power unit to be used in common across the full range of Sunshine models.

Interface #3: PCB unit <--> Housing unit. The interfaces for switches and indicator lights on the PCB unit were standardized to be located under certain designated surface areas of the housing unit. Constraining these interfaces to specific areas on the housing unit allowed the same injection moulds for making a given type of housing to use different inserts to create a variety of switch cover shapes, thereby enabling the same injection moulds for the plastic handles to be used in producing the full range of Basic product models.

Interface #4: Power unit <--> Bristle unit. The attachment interface for attaching the bristle unit (brush tip) to the power unit was standardized to assure backward and forward compatibility between all Philips power units and prior and future brush tips sold by Philips. Standardizing the interface between the power and bristle units assured that consumers could continue to use any Philips brush tip with any Philips electric toothbrush. Maintaining this standardized interface through successive generations of product architectures also meant that Philips could sell future versions of upgraded, higher performing brush tips to the entire installed base of Philips electric toothbrushes, including early product models--an essential strategic issue, since the majority of profits in the electric toothbrush business come from sales of replacement brush tips. The use of a standardized interface to assure compatibility of all Philips brush tips with all Philips power units also greatly simplified the processes of inventorying and shipping brush tips in the supply chain.

In addition, much of the message communicated by Philips to consumers about the benefits of the Philips electric toothbrush concerned the distinctive action of the Philips brush tip and the superior cleaning power of its bristle design. In this sense, maintaining compatibility of all Philips brush tips with all Philips power units was essential to sustaining the marketing message about the benefits of relying on Philips electric toothbrushes for maintaining oral health. A standardized interface to assure backward and forward compatibility between brush and power units was thus a key to maintaining Philips' market positioning as well as achieving the Sunshine Project's cost reduction and profit improvement goals.

Interface #5: Housing unit <--> Charger unit. Since the Sunshine Project team decided to use a standard component design for the charger unit so that it could be bought in large quantities to reduce costs, the interface between the inductance probe of the charger unit and the bottom of the housing unit was made a standard (invariant) interface. Maintaining this standardized interface enables any Philips Sunshine (or earlier Sensiflex model) electric toothbrush to be used with any Philips Sunshine (or earlier Sensiflex) charger unit for recharging and storage.

Interface #6: Charger unit <--> Container unit. All electric toothbrushes with rechargeable batteries require a charger unit. Top end models, however, are differentiated in part by being sold with a container unit for holding a tube of toothpaste and spare brush tips or brush tips for different family members. To support the use of a standard charger unit, while also providing some degree of design freedom in creating container unit designs for top-end models, standardized interfaces between the charger unit and the container were designed to allow the container unit to slip over and rest on top of the standard charger unit (*refer to* ***Exhibits 6*** *& 7*). Thus, a variety of inexpensive container designs could be created to differentiate product versions, and these could be added at a late point in the supply chain (for example, during packaging). For low-end models, the standard charger unit was designed to charge and store a single electric toothbrush without the container unit.

Compared to using a range of integrated charger and container designs to differentiate product models, this component and interface design solution offered significant overall cost savings and supply chain simplifications for the toothbrush business, even though some individual integrated charger and container designs might have appeared to be less costly when evaluated solely on the basis of a bill-of-material ("BOM") for an individual product model.

Strategic Coordination of Product and Process Architectures

Given the difficulties of the previous supply chain in supporting the Sensiflex product line, the Sunshine Project team understood from first-hand experience that developing a strategically effective platform requires coordinated co-development of integrated product and process architectures that work together well to achieve the desired performance of the overall supply chain.

One of the ways in which the Sunshine Project team sought to maintain an effective integration of the new Sunshine product and process architectures was aligning the component structure of a product architecture with the most strategically advantageous *point of product differentiation* in its supporting production and supply chain process architecture. The Sunshine Project team then used their analysis of the optimal point of product differentiation in the production process to define a new "NSO (National Sales Organization) order decoupling point," or "NODP," that would be critical to achieving the supply chain performance improvement objectives for the Sunshine Project. We next consider each of these two key aspects of coordinating product and process architectures in more detail.

Defining the Point of Product Differentiation in a Supply Chain

The point of product differentiation in a process architecture (production and supply chain architecture) is the point at which the parts and components flowing through the process are combined in ways that determine a specific product model. In effect, the point of product differentiation is the first point in an assembly process in which a component (or set of components) that is uniquely used in only one product model is incorporated into the assembly. The point of product differentiation will generally occur in the early stages of an assembly process when the various product models being assembled consist largely of unique sets of component variations used only in specific product models. By contrast, when product models share significant numbers of common components and specific product models are differentiated through use of relatively few unique components, the assembly process can often be designed so that differentiating components can be added in the last steps of an assembly process.

The point of product differentiation in an assembly process is indicative of the intrinsic costs of the production and supply chain processes supporting a product architecture. Intrinsic production and supply chain costs increase substantially when an assembly process has to maintain extensive work-in-process inventories of unique component sets and component subassemblies to be used or generated early in an assembly process and intended only for specific product models. When product differentiation is achieved through addition of a few differentiating components in the last steps of an assembly process, however, these intrinsic production and supply chain costs can be greatly reduced.

Thus, an important principle in designing cost-effective supply chains to meet diversity requirements is to coordinate the strategic partitioning of a modular product architecture with the design of its supporting assembly process so that the point of product differentiation (i.e., of configuring a specific product variation) is as late as possible in the assembly process. Effective coordination of product and process architectures in this way lowers intrinsic production and supply chain costs by reducing the diversity of component and subassembly variations an upstream supply chain must bring to an assembly process, by making possible large-scale production of assemblies of common components, and by reducing the diversity of subassemblies that have to be inventoried as work-in-process. In this regard, development of configurable modular product architectures supported by a production and supply chain processes designed for "late point differentiation" becomes the key to meeting demands for product diversity in the most cost-effective way.[14]

Defining the New "NSO Order Decoupling Point" (NODP)

Given their strategic targets of achieving at least a 45% reduction in unit costs, greater product diversity, and improved supply chain performance in speed and reliability, it was clear to the Sunshine Project team that the Sunshine product architecture would have to make much greater use of both common components in the new product architecture and late point product differentiation in the process architecture than was the case in Philips' prior product and process architectures for electric toothbrushes.[15]

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[14] In an ideal sense, the desired outcome of effective coordination of product and process architectures would be (i) an integrated set of standard common components that is used in all product variations and that can therefore be mass-produced to plan, and (ii) the minimum necessary number of components (available on short notice either internally or from suppliers) needed to configure required product variations in the last step of a production process.

[15] Prior Philips electric toothbrushes had included many components that were unique to one product model or to a limited range of product models. Moreover, these unique components were brought together in an assembly process that essentially determined product differentiation at a very early stage of assembly.

To achieve this critical coordination of its new product and process architectures, the Sunshine team defined a new "NSO order decoupling point" (NODP) for the Sunshine platform. The NODP is the point in the assembly process at which assembly of specific models begins for specific orders from individual NSOs (National Sales Organizations). In the previous Sensiflex supply chain, the NODP was at the beginning of the manufacturing process, and components unique to specific product models were thus introduced at the beginning of the assembly process, as shown in ***Exhibit 9a.*** In the new Sunshine supply chain architecture, however, the NODP would be at a very late point in the Sunshine assembly process, only standard subassemblies of common components (power units, PCBs, brush tips, and charger units) would be produced up to the NODP, and production volumes for these standard components used in all product models would be driven by production planning based on aggregated orders for all models from all NSOs. Assembly after the NODP would only add the housing, container, and packaging that would differentiate specific product models in the last steps of the assembly process. This key new point for coordinating product and process architectures is shown in ***Exhibit 9b***. In effect, upstream supply chain operations and production up to the NODP would be driven by "make to plan," would be focused on achieving maximum efficiency, and would be a relatively stable, predictable, large-scale production process. Production and supply chain operations after the NODP would be driven by "make to order" and would be focused on providing maximum flexibility in fulfilling current orders. Orders for the Basic models in greatest demand would be served through semi-automated assembly operations that would run more or less continuously. Orders for Basic models and packaging variations demanded in smaller volumes would be served by flexible, low-cost, hand-labor methods of configuring and packaging products.[16]

Under this coordinated approach, standard common components can now be produced in large volumes, more or less continuously, at low unit costs on high-speed automated production equipment. Alternatively, because demand for standard components used in all models is relatively stable and predictable, large orders for common components can also be outsourced from low production-cost countries without creating logistics complexity, unpredictability, and their associated costs (e.g., air freighting late shipments of unique components for specific product models). In either case, the use of standard common components across all product variations helps to minimize work-in-process diversity and inventory levels for these types of components and essentially eliminates the risk of obsolescence in holding inventories of such components.

At the same time, unpredictable downstream demand for specific product models could be served through flexible human assembly or semi-automated assembly operations. Because human assembly workers (often called "flex workers") can be hired or contracted for in response to total volume fluctuations, labor costs can

[16] The clear identification of these different objectives on the two sides of the NODP makes it possible to define performance indicators and standards that are appropriate to the two architecturally linked--but strategically and operationally distinct--supply chain processes on either side of the NODP. These performance indicators focus on measuring cost efficiency in the operations upstream from the NODP and on supply chain flexibility and reliability in operations downstream from the NODP.

now be quickly and closely aligned with varying demand levels. In essence, the new Sunshine process architecture uses variable labor costs for assembling specific models as a source of flexibility in responding to unpredictable demand for specific models. This flexible, variable-cost, make-to-order assembly capability is used in combination with a relatively inflexible, fixed-cost, make-to-plan automated assembly technology for the high-volume production of common components for which demand is relatively stable and predictable.

The Sunshine Project team's approach strongly contrasts with Philips' previous increasingly costly supply chain strategy of carrying growing inventories of product-specific components and finished goods to meet rapidly changing and expanding market demands for product diversity. Instead, the Sunshine Project team adopted a new strategy based on achieving supply-chain flexibility, speed, and overall cost effectiveness through better strategic partitioning of the Sunshine product architecture and the close strategic coordination of the Sunshine product architecture with its supporting production and supply chain process architectures.

Appendix 1

Component interfaces within a product architecture are of six basic types:[17]

(i) *Attachment interfaces* define the way that one component physically attaches to another.

(ii) *Spatial interfaces* define the space a physical component may occupy within a product.

(iii) All components perform a primary task of transforming some kind of input into another kind of output (otherwise there would be no need for the component!). *Transfer interfaces* define the inputs that each component transforms and the outputs of that transformation process.

(iv) *Control and communication interfaces* define the ways in which one component signals another component what state it is in, and how the second component signals back to the first component whether to stay in that state or change to some other state. Control and communication interfaces are used to maintain stability in dynamic systems.

(v) *User interfaces* define the important ways in which the user of a product interacts directly with specific components of the product.

(vi) *Environmental interfaces* define how each component interacts with other components in unintended ways within the environment of the product as a system.

Components of a product and the assembled product itself usually interact with some kind of packaging design. Thus, a seventh kind of interface may be defined as follows:

(vii) *Product/packaging interfaces* define how an assembled product and/or specific components in the assembled product will physically interact and interconnect with the packaging for the product. In this sense, packaging may be considered a component of a product architecture itself.

In addition, because a product architecture should always be developed jointly with the process architecture for realizing the product architecture, the interactions between product components and the processes for realizing (producing, shipping, and supporting) those components also constitute a critical eighth kind of interface:

(viii) *Product component/process interfaces.* Examples of product component/process interfaces include the bar-coding of parts and components for identification during production or support, specific aspects of components for orienting the component during production processes (e.g., for gripping during pick up and transfer and for placement in jigs and fixtures), and for testing and adjusting components during assembly.[18]

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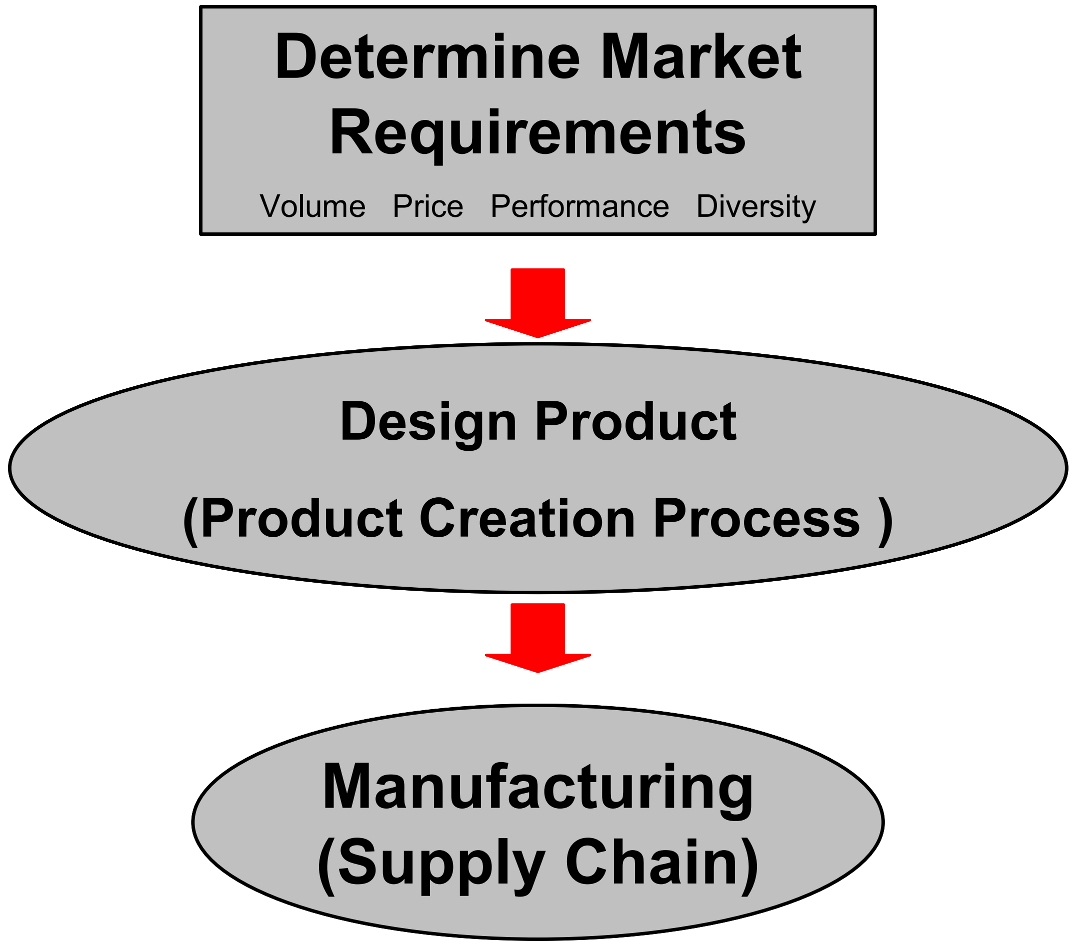
[17] See Ron Sanchez (1999), "Modular Architectures in the Marketing Process," *Journal of Marketing,* **63** (special issue), 92-111.

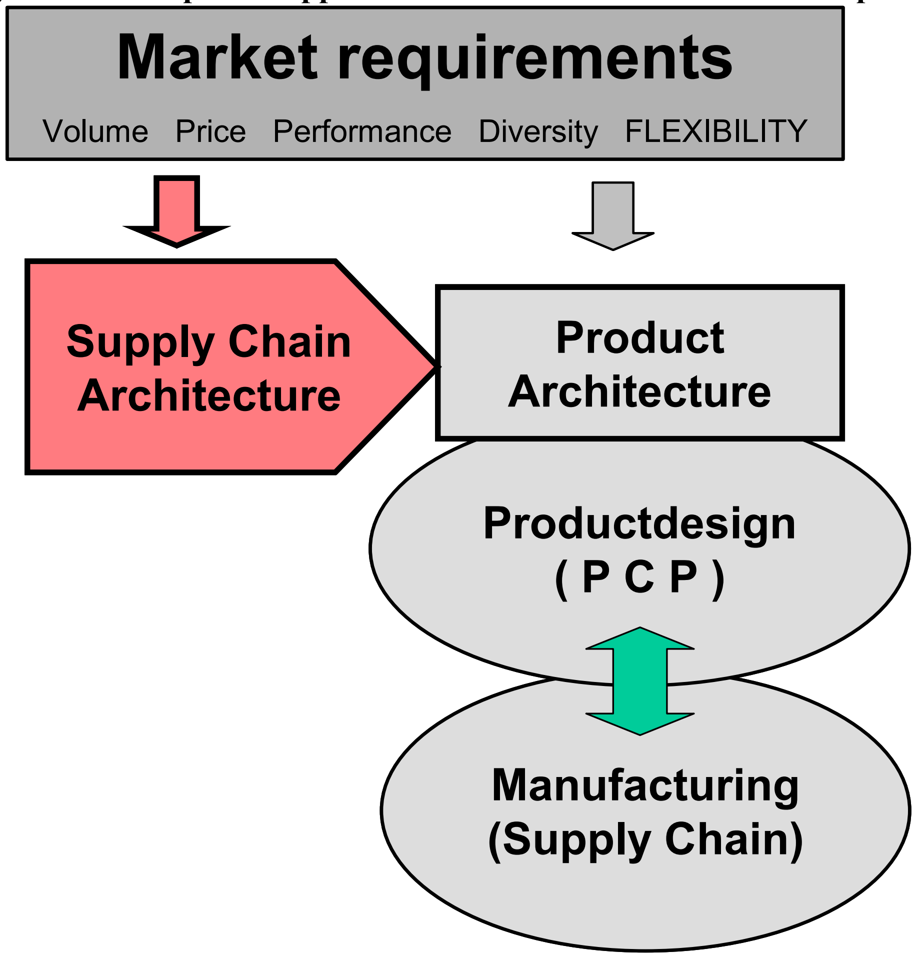
[18] The author wishes to thank Mr. Paul Hissel of Philips CFT for providing these examples of product component/process interfaces.

Exhibit 1
Traditional Development Model Used to Launch Original Sensiflex Product Line



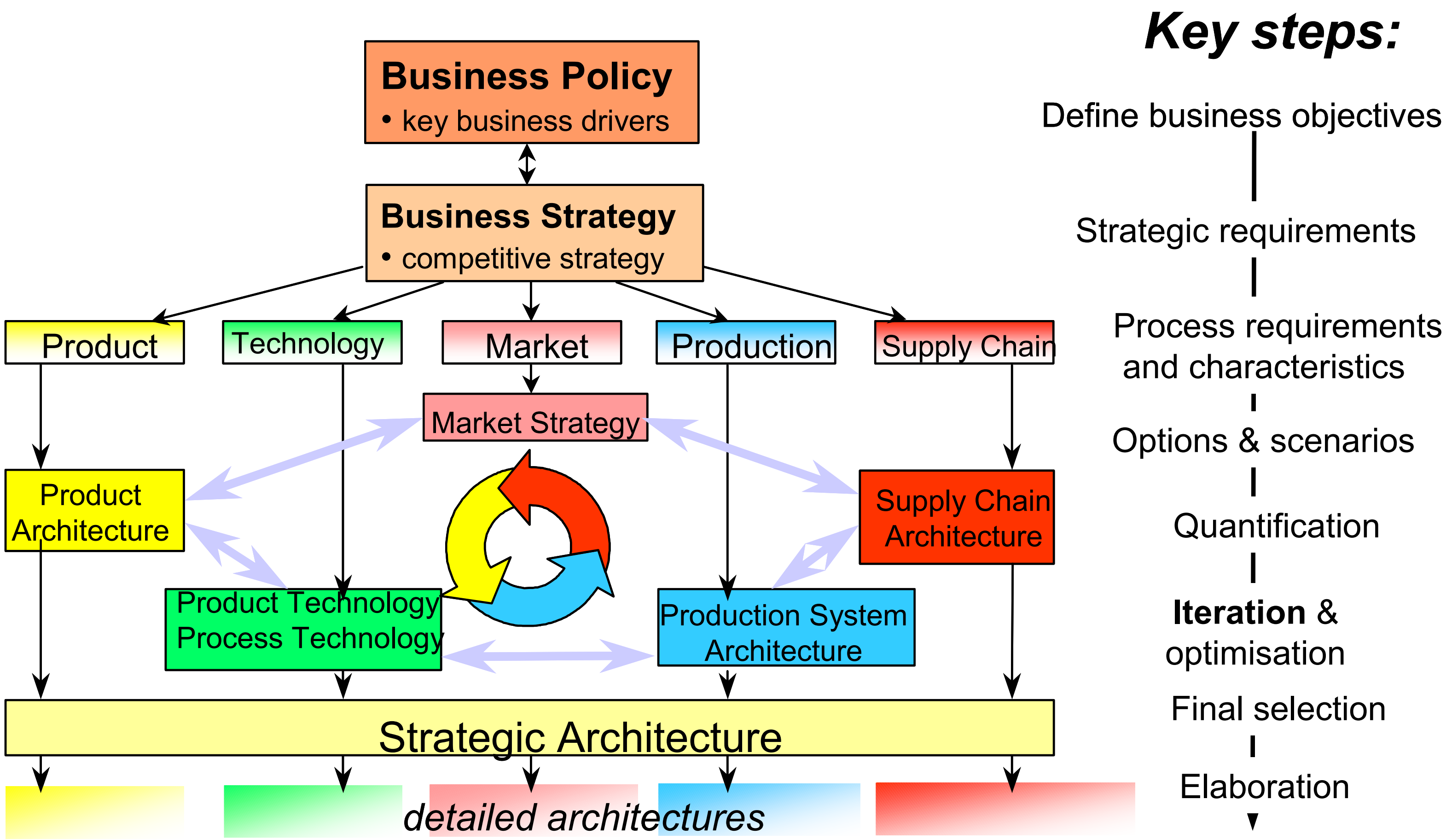
Source: Company information

Exhibit 2
More Integrative Development Approach Envisioned for Sunshine Development Project



Source: Company information

Exhibit 3
Philips CFT Framework Adopted for Analysis and Integration of Sunshine Platform Product and Process Architectures



Source: Company information

Exhibit 4
Product Diversity Analysis for 2001-2003 Planning Horizon

Diversity Survey - - Basic Brush (incl. Trident 2)

range 2001	Basic					Trident 2		
type	A	B	C	D	E	F	G	Remarks:
price points (Euro)	15,--	19,--	29,--	39,--	49,--	59,--	79,--	
distribution channels	FMCG	FMCG	Trad. Dis.	Trad. Dis.	Trad. Dis.	Trad. Dis.	Trad. Dis.	Fast Moving Cons. Goods / Traditional
purchasing process	low	low	mid	mid	mid	high	high	level of involvement
marketing strategy	pen.	pen./sat.	pen.	pen.	sat.	rep./pen.	rep./pen.	penetration, saturation, replacement
consumer profile	basic	basic	basic	extra	extra	clinical	clinical	function
packaging	blister	F-box	blister	F-box	F-box	F-box	F-box	self selling F-box
inside architecture	Basic	Basic	Basic	Basic	Basic	Trident 2	Trident2	
design	basic	basic	mid end	mid end	mid end	Trident 2	Trident 2	
brushing concept	Active tip	Active tip	Active tip	Active tip	Active tip	Reflex act.	Reflex act.	
controlled pressure	CP-	CP-	CP+	CP+	CP+	Adaptive	Adaptive	
battery management	adapter	adapter	stand	stand	stand	new	new	
featuring	-	travel kit	-	batt. mgt.	batt. mgt. travel kit	display	display +	>display with more functions
housing unit diversity								
design / styling	1	1	2	2	2	3	3	
indicators (LED windows)	-	-	?	?	X	X	X	t.b.d.
extra switches	-	-	-	-	-	?	?	e.g. 2-speed, el. switch
display	-	-	-	-	-	?	?	e.g. LCD
color / texture variants	X	X	X	X	X	X	X	e.g. elastomer colors
printing variants	X	X	X	X	X	X	X	corona treatment for PP
drive unit diversity								
CPS	1	1	1	1	1	2	2	2 > extra spring in CPS
motor	1,2V	1,2V	1,2V	1,2V	1,2V	2,4V	2,4V	
brush sensor	-	-	-	-	-	?	?	additional contact in CPS
battery unit diversity								
charging interface:								
inductive	?	?	X	X	X	X	X	
pin / contact	?	?	-	-	-	-	-	
plug	?	?	-	-	-	-	-	
electr. feature PCB	-	-	-	X	X	X	X	t.b.confirmed

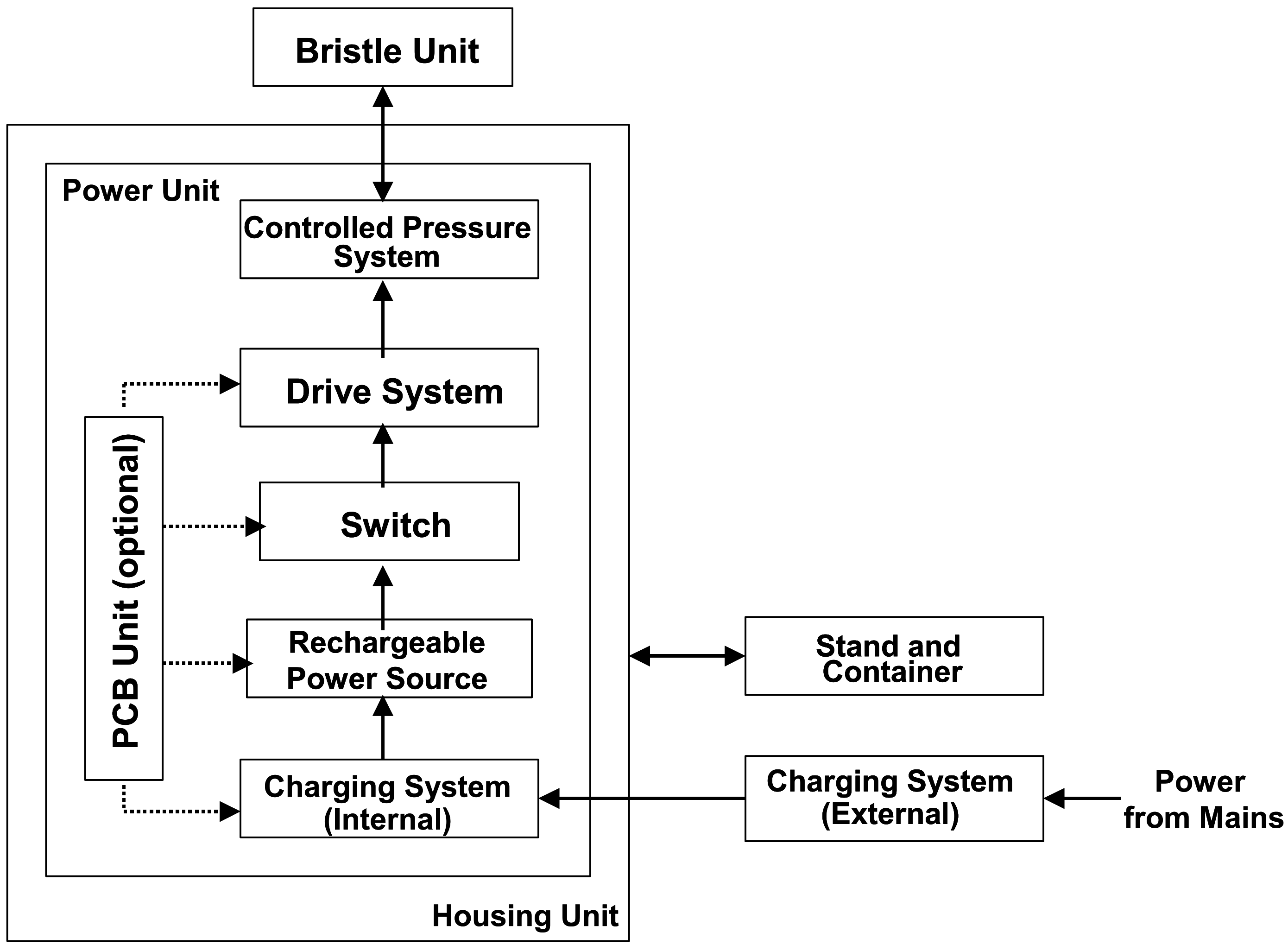
Source: Company information

Exhibit 5
Basic Partitioning of Functional and Physical Components in Sunshine Product Architecture

Basic Partitioning	Functional Components	Physical Components
Brush Tip	Bristle Unit	Bristle Unit
Handle Unit	Power Unit:	
	• Charging System (Internal)	• Charging System (Internal)
	• Rechargeable Power Source	• Rechargeable Battery and Connectors
	• Drive System	• Motor, Motion Converter, and Shaft Assembly
	• Switch	• Switch and connectors
	• Controlled Pressure System	• "Click-back" Hinge
	Housing Unit:	
	• Power Unit Housing	• Plastic Housing
	• Bottom Assembly	• Plastic Bottom Seal and Switch Cover
Stand/Charger Unit	Charging System (External)	Transformer/Inductance Coil
	Stand	Plastic enclosure
	Container	Container Unit (optional)
Electronic Indicators (optional)	PCB unit (optional)	PCB unit (Optional)

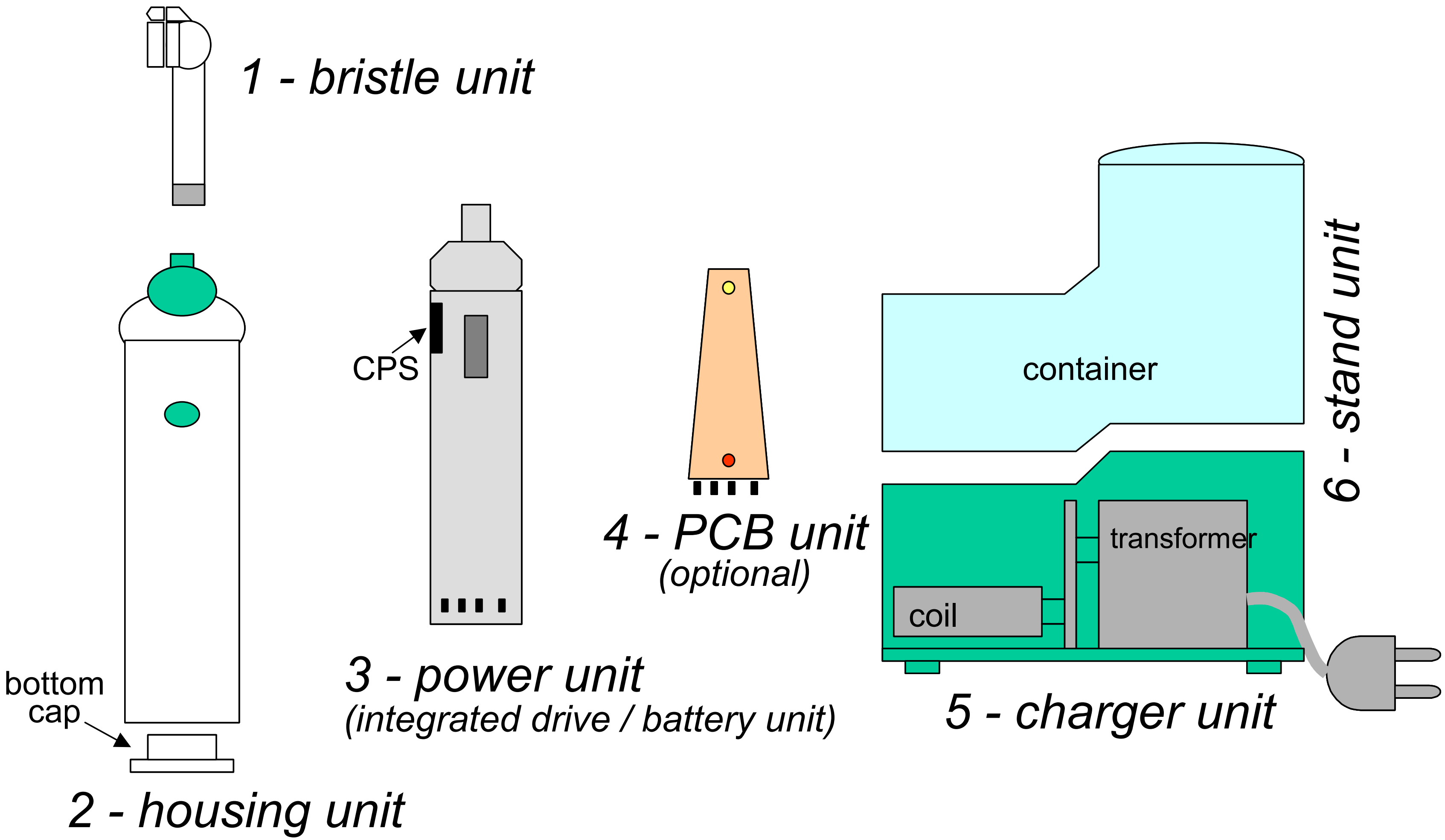
Source: Company information

Exhibit 6
Basic Arrangement of Functional Components in Sunshine Product Architecture



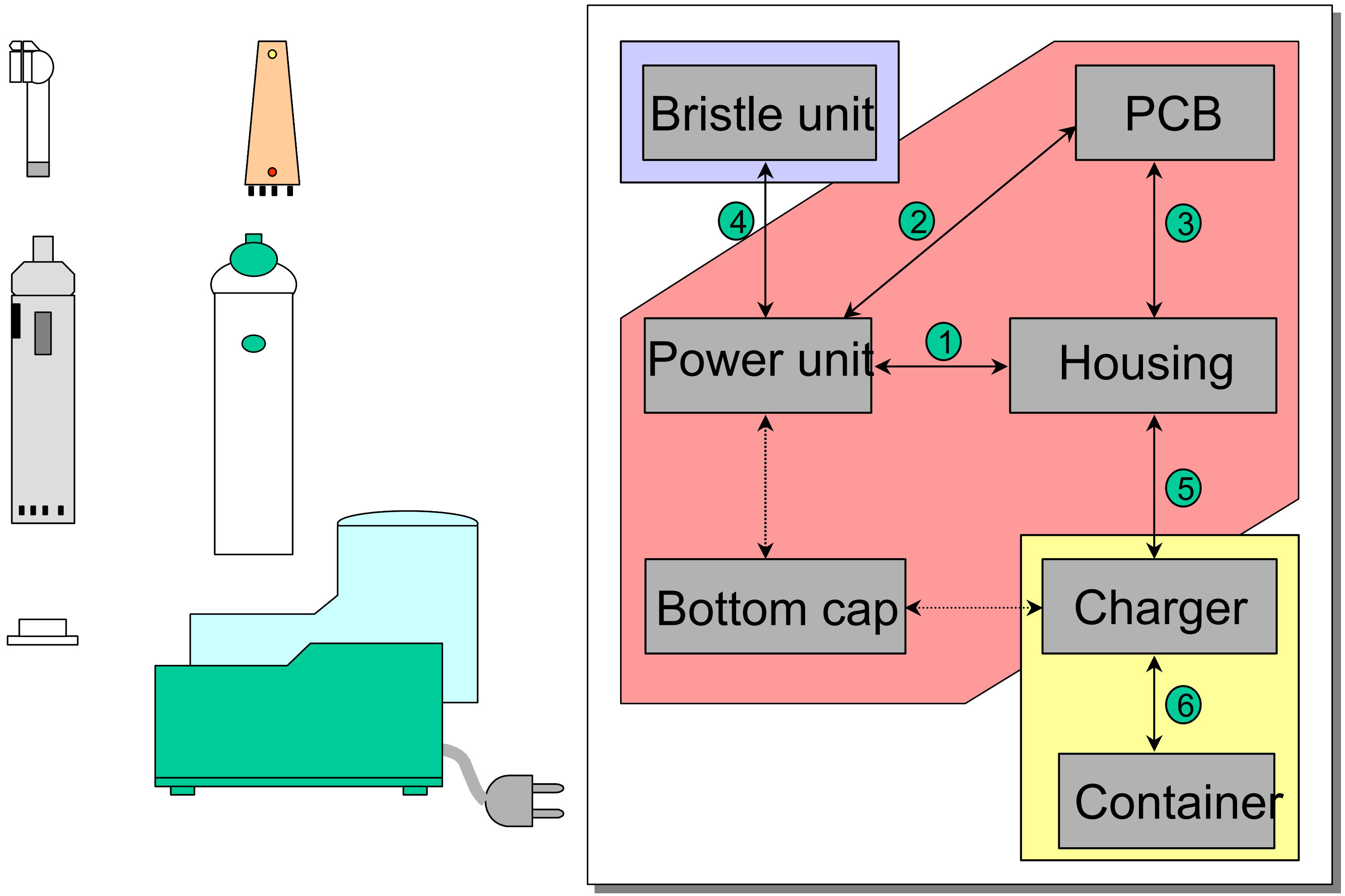
Source: Company information

Exhibit 7
Physical Components in Sunshine Product Architecture



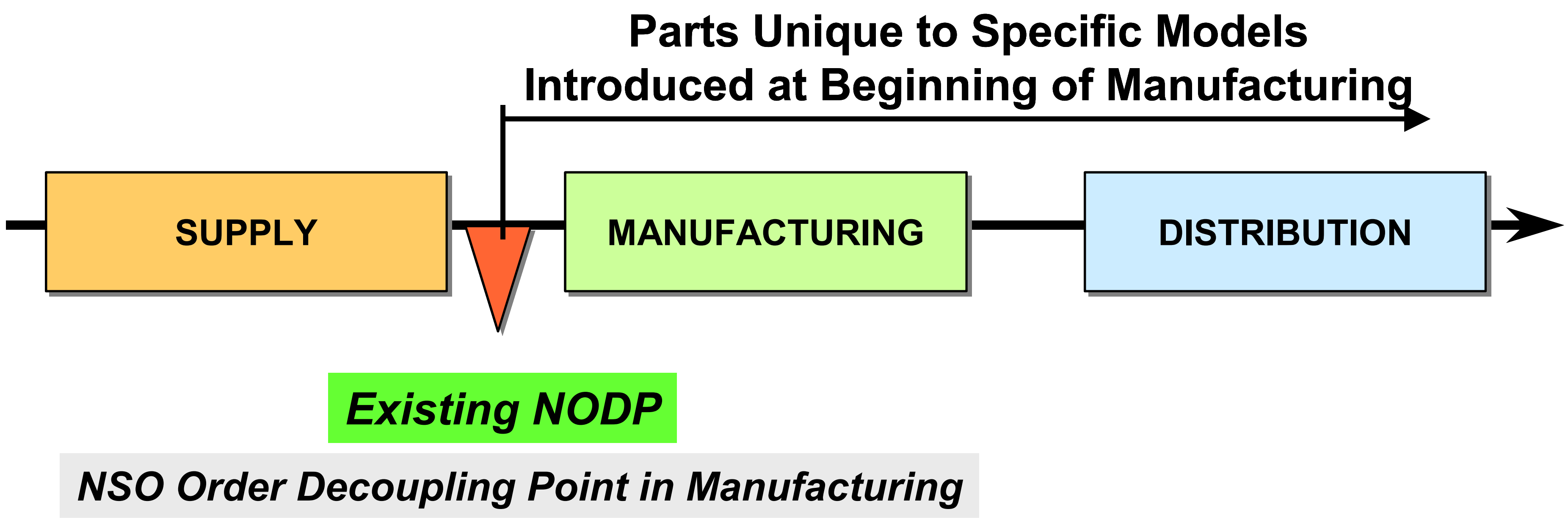
Source: Company information

Exhibit 8
Interfaces Between Physical Components in Sunshine Product Architecture



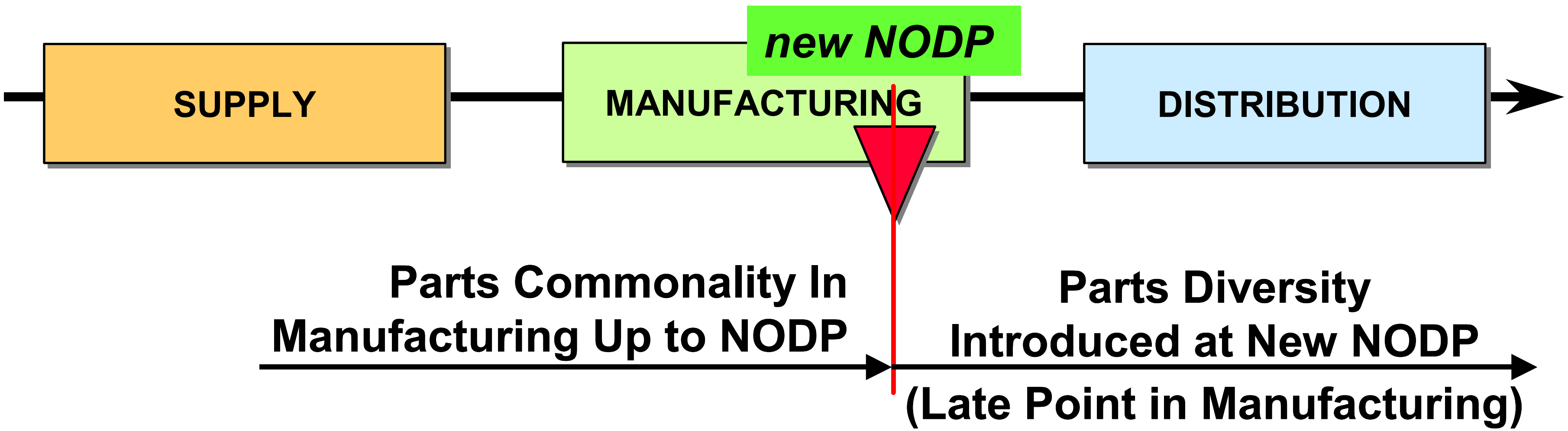
Source: Company information

Exhibit 9a
NODP and High Parts Diversity in Original Sensiflex Supply Chain Architecture



Source: Company information

Exhibit 9b
New NODP and High Parts Commonality in Sunshine Supply Chain Architecture



Source: Company information