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NeuronicWorks Inc.

Design for eXcellence (DFX)

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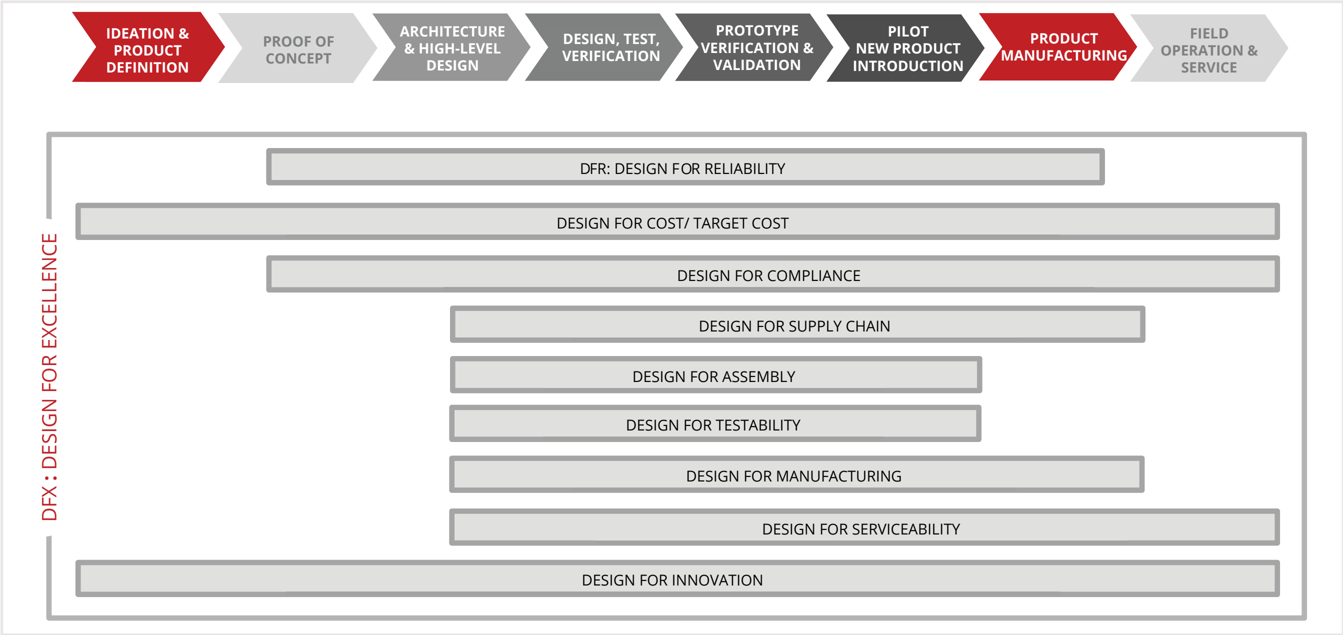
Design for eXcellence (DFX)

Designing for Excellence (DFX or DfX), as the name suggests, is a set of established practices and methodologies aimed to increase the product value by meeting its defined requirements simultaneously with optimizing the entire product development cycle.

The product value can be regarded as the benefit perceived by the customer (functionality, usability, robustness, reliability, maintainability, etc.) relative to the total cost of ownership for that product.



Design for eXcellence in NPI

> It is crucial to be armed with all the information, expertise, and experience right from the beginning of a project while being guided by the Design for Excellence methodology.

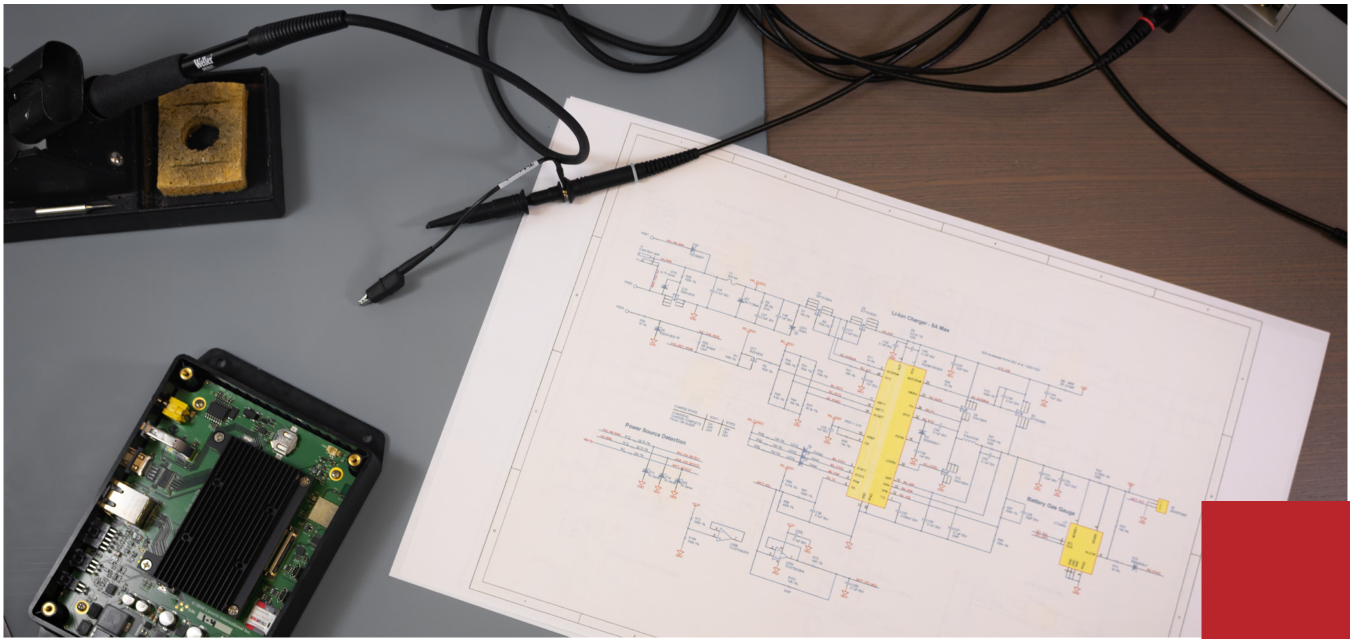
As covered in our previous blog on the electronic product development process, there are several learnings that can be extracted from the design journey of concept to manufacturing. Decisions that are made early in the design stage have cascading implications on the project in terms of cost, quality, and development time. If errors, omissions, or non-compliances are detected early in the design phase, it is much easier to accommodate changes then, rather than later in the prototype or manufacturing stage. Late changes can significantly drive-up development costs and project timeline.

To avoid such issues and oversights, it is crucial to be armed with all the information, expertise, and experience right from the beginning of a project while being guided by the Design for Excellence methodology. To understand the use of the Design for Excellence methodology in design engineering practice, let us discuss some of the key categories by the DFX umbrella:

DESIGN FOR RELIABILITY (DFR)

Designing for Reliability means designing a product that performs its required functions under stated conditions for a specified time-period. To build reliability into a product, considerations shall be made from the concept design phase, must continue throughout the full development cycle, and extend through manufacturing.

Designing for Reliability includes methodologies to identify, assess and reduce the risk of product failures, as well as approaches to predict product reliability. Product reliability can be expressed as MTBF (mean time between failures), MTTF (mean time to failure), failure rate during useful life, etc. Product MTBF is expected to be estimated and published as an important product characteristic.



DFR techniques that can and should be considered in product development:

Components selection with derating analysis

All components and materials shall be selected based on well understood environmental, operational, and stress conditions that they will function as part of the product.

Certified components with known reliability characteristic are preferable for critical functions. Parametric margins (i.e., do not design at functional limits) should be provided according to derating factors that follows company or industry guidelines and standards. Derating analysis shall be performed at every design iteration.

Design Failure Modes and Effect Analysis (DFMEA)

This analysis should be performed at different levels: subsystems, assemblies, and necessarily at system level, and should start with as soon as the high-level system design is available. The failure modes and their effects are identified from historical data (product variants), competitive research (similar products), or brainstorming sessions (for new products). For each failure mode, the design controls for failure prevention and detection are analysed, and then a final score RPN (Risk Priority Number) is calculated. The RPNs that exceeds a specific threshold triggers design improvement activities that aims to reduce the score to below an acceptable level. Obviously - the later DFMEA is performed, the more difficult it will be to reduce the RPNs. DFMEA is updated during the design process, to include all design changes implemented towards reliability improvement.

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Process Failure Modes and Effect Analysis (PFMEA)
While similar in principle to DFMEA, PFMEA focuses on analyzing the failures caused by product life cycle processes (supply chain, manufacturing, service, shipment, etc.) that can inadvertently impact the product reliability.

Highly Accelerated Life Testing (HALT)
A planned, structured, documented set of tests designed to bring the product to its destruct limits, by applying various types and levels of stress over the product under test, with the aim of identifying the "weakest reliability links" - i.e. the component(s) or the subsystem(s) that will fail first. Typical stresses are: temperature, vibration, humidity, voltage, electrical discharges, and they can be applied independently or combined, steady, incrementally increasing or cyclical. The failed components or failure modes identified through HALT are studied by the development teams and corrective actions are taken, as they are expected to have a major detrimental impact on product reliability. HALT is performed for subassemblies and systems, during the product development, ideally for the first lot of prototypes, sometimes even earlier.

Analytical Reliability Prediction
A broad range of analysis methodologies, supported by various guidelines, standards, papers, component databases, software tools that generate a reliability model of the designed subassembly or system, and which can predict its MTBF (and other reliability metrics). Predicting reliability using models is difficult, laborious, empirical, and rather inconsistent: various methods return different values; the modeling methodologies are rather simplistic and cannot comprehensively express the product functionality, the stress factors, the design robustness, etc. However, these methods are broadly used, as they can help compare design options, identify design weaknesses, assess whether some reliability goals are feasible, etc. The analysis is typically performed during prototype design and may initiate design changes.

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Reliability prediction models

- Parts Count (all parts are considered operating at reference conditions, and all have equal impact to system reliability),
- Parts Stress (components failure rates are weighted by factors modelling the actual component stress level).
- Commonly used reliability standards and handbooks: IEC 61709 guidance modeling the reliability prediction of electric components considering the stress factors; MIL-HDBK 217 military handbook for reliability prediction of electronic equipment, with widely used prediction data; Telcordia (Bellcore) SR-332 / TR-332 - similar reference, evolved from telecom industry experience; Siemens Standard SN 29500 - provides failure rate for major electrical components.

Accelerated Life Testing (ALT)

This is a test process using accelerated stress factors to generate failures in a shorter time than it would happen during the actual life of the product. The accelerated stresses emulate the time passing in the field.

ALT is complex and expensive, requiring technical equipment (similar to HALT), high effort, expertise, extensive analysis and modelling. ALT predicts product reliability (during useful life) and drives reliability improvement early in the development. Product reliability (MTBF) can be estimated by mapping ALT failure data (stress level) with field failure data using acceleration factors that depend on stress and system specifics.

It is worth mentioning that similar dependencies could be established for HALT, so in this respect both ALT and HALT data can be used for relative reliability prediction, and both are typically more accurate than analytical prediction.

Environment Stress Screening (ESS):

This is a test process used in manufacturing, for the final product, that applies stress conditions as temperature and vibration, to reveal latent product failures that went undetected during manufacturing assembly or test. ESS reduces early failures (i.e., infant mortality) and can identify weaknesses of the manufacturing process.

Highly Accelerated Stress Screening (HASS) is similar to ESS, the difference being higher level stress factors used to find potential failures faster. Like ESS, HASS is also part of the manufacturing processes.

DESIGN FOR SECURITY

Frequently, the security aspect of a device is an afterthought, added as a top layer to a finished design. The Design for Security principle dictates that security should instead be an integral part of a design from the beginning of the project, to ensure that proper security protocols are implemented. Improper or inadequate security leaves a product vulnerable to hacking, and if an attacker is successful, serious consequences can include:

- Unauthorized use – for example, with subscription-based products – leading to loss of revenue for the product manufacturer.
- Hijacked control of the product's behaviour, endangering the security of an entire facility, and possibly even the physical safety of its personnel.
- Manipulation of the product as a "back door" into the local network, breaching the data privacy of users.

The approaches which hackers commonly employ to achieve these exploits are well known, as are the practical steps which designers can take to deter them. But the steps must be taken proactively and not in the eleventh hour.

Often by a combination of techniques – such as dumping and rewriting flash or RAM memory, discovering and gaining access to a communication port that has not been disabled, or obtaining a firmware image from the vendor's server for analysis – the successful hacker is able to alter a device's running firmware code, or discover cryptographic keys and other secret materials.

And while one might point out that the countermeasure of enabling write- and read-protection does happen in the eleventh hour at production time, this is not the rule but an exception, which furthermore protects only code and data that resides in the device's internal memory, and only against the less hardcore casual attacker.

Unlike this exception, other countermeasures do not operate by the flip of a switch, but by carefully thought-out design, often on the part of multiple disciplines. To prevent unauthorized access to firmware images from the vendor's server, for instance, encryption and authentication should be implemented, which involves effort in both firmware and cloud software. A good method to prevent discovery of the cryptographic keys needed for defeating the encryption and authentication – as well as to avoid disclosure of secrets generally, for that matter, by dumping memory – can be to introduce a secure element IC, which entails work on both the firmware and the hardware side.

Security should therefore be treated as an important fundamental element of product development, and should be built into the product design process for all design disciplines – from hardware, to firmware, to software, including even mobile app as the case may be – natively from the beginning. Where it is most obvious that treating security as an incidental add-on is infeasible may be those cases in which deploying security measures in firmware would not be possible if the hardware did not already have necessary components in place to support them (having designed that secure element IC into the PCBA, for example).

Today with the rapid proliferation of IoT and IIoT devices, Designing for Security is no longer an optional feature, but a mandatory requirement. And although on the one hand their ever-growing numbers represent collectively a vast attack surface for hackers, on the other hand embedded systems can potentially be made more secure than a bank vault, since the latest cryptographic techniques can be deployed to them as soon as outdated weaker ones get defeated. (Whereas a bank needs years to change its security protocols). With technologies advancing quickly, products should be designed with an agile and scalable approach so that security updates can be launched faster and achieve global coverage more efficiently. These are features that can enhance a Design for Security approach, but that are not possible without one. The most responsive security updates are worthless against the competent hacker who has cracked the over-the-air (OTA) firmware update system that delivers them.

Deployed embedded devices face the perils of a harsh world, no less than human beings do. The dangers should not be taken lightly with one any more than the other. We should Design for Security to keep our devices safe, just as we educate our children to be street smart.

DESIGN FOR COMPLIANCE

Identifying the regulatory standards that the product and its life cycle processes shall comply with, must start early in the concept development phase. Designing a product to prototype level or even beyond and then discovering that the compliance requirements have not been applied and reviewed will result in costly re-design and re-test iterations.

Defining the compliance standards right at the product definition stage provides critical input for technology and components selection, dictates the design approach, design review and test requirements, and influences the entire product development process to be applied.

As mentioned in our previous blog on electronic product development, the product design can undergo few iterations with repeated pre-certification testing in between these iterations.

Developing and maintaining the design documentation required at the final certification stage is critically important.

Design for Compliance includes the inherent Design for Safety, Design for EMI/EMC for electrical - electronic products.

Design for compliance may also require that the product development house is capable and formally certified to operate under specific industry standards, for example medical device design and manufacturing.

> Developing and maintaining the design documentation required at the final certification stage is critically important.

DESIGN FOR SUPPLY CHAIN (DFSC)

Arguably one of the biggest challenges experienced today, the objective of this method is to design a product with high supply chain availability, efficiency, with lesser inventory cost, lesser lead time and ideally zero waste.

Many product innovators make the mistake of thinking about supply chain and logistics only after the product design is completed and is transferred to manufacturing.

The supply chain of a product needs to be established from the initial design phase. The selection of components, OEM devices, materials should consider life cycle maturity (active with at least 5 years longevity ahead), availability through major distributors, specifications clarity, compliance assessment, and availability of equivalents or alternative (substitute) components, choose common components wherever possible, BOMs review at every design stage and iteration.

In the context of current worldwide components shortage, it is important to verify and book stock, pre-order and place blanket orders, identify key distributors, discuss pre-production agreements and finalize product cost, quotations, delivery times, packaging and transportation, etc.

Besides individual components, the supply chain includes identifying, qualifying, and engaging vendors that manufacture electrical, mechanical, mechatronics, and other integrated subassemblies (e.g., cables, enclosures, panels, OEM devices, etc.) and those providing manufacturing and field services.

Design for Supply Chain is a synergy between design and systems engineering, regulatory, manufacturing and procurement, and it can be accomplished by design houses with mature and comprehensive multi-functional expertise.

DESIGN FOR COST

Design for Cost is a product development principle that aims to optimize the overall cost of product and its life cycle processes, including material costs, supply chain, manufacturing, field service, product sustaining and warranty, design and development cost and time to market. A true designing for cost approach is built in the organization structure and strategy, driving continuous advancement of technical capabilities and process optimization.

Design for Cost include techniques like developing alternative designs and choosing the winner trough comparative methods, reduce the number of sub-assemblies (simplification), modularization, re-using designs, using generic and efficient manufacturing processes, choosing among off-the-shelf, OEM, or custom designs, etc.

An important point to note is the consideration of the hidden costs associated with a project, such as re-design, re-build, re-test and management of obsolete components.

Related to Design for Cost, but somewhat different, is Target Costing, an approach where the business calculates the maximum cost expected for a product with a specified set of features required by the market, a cost that keeps the business profitable. The product development focuses on meeting the product cost by various techniques involving engineering design, procurement, and manufacturing.

DESIGN FOR ASSEMBLY (DFA)

Although Design for Assembly (or "Assembleability") is typically considered a subset of Design for Manufacturing, we can think of DFA as being a separate dimension, for two main reasons: to show distinctively what the techniques are, and to support the idea that DFA is also an integral part of Design for Service, and Design for Testability. Indeed, assembly - and disassembly operations - happen in manufacturing, test, and field service, and directly influence the efficiency of these life cycle processes. Moreover, DFA impacts reliability, PFMEA often reveals assembly errors.

The best DFA practices address the ability of a designed product to be put together fast, correctly (with minimum risk of errors), ergonomically (ensuring safety), and, when needed, to be easy to disassemble for rework or field service.

DFA techniques are discipline specific guidelines, they apply respectively for PCB design, mechanical design, cables and interconnect designs, mechatronics, electro-mechanical design, system design, etc. Regardless of discipline specificity, the DFA techniques focus on the following key objectives:

- Modular, easy to understand design, robust interfaces.
- Standardization of parts, sub-assemblies, assemblies, assembly operations and tools.
- Optimized assembly operations with minimized number and type of tools.
- Logic, intuitive flow of assembly, easy to understand instructions, no ambiguities.
- Reduced number of fastenings and fastening types, incorporate fasteners in the design.
- Mistake proofing design ("Poka-Yoke") - only one way to put the product together.
- Correct tolerance stack analysis; sufficient clearances between parts and subassemblies.
- Minimized (ideally none) operator-dependent adjustments and calibrations.
- Traceable assembly process, easy to inspect and correct.

The DFA objectives are followed by engineering disciplines and reviewed during the concept development stage and subsequently for every design iteration. Updating the design to improve DFA late in the product development cycle increases the development cost and the timeline.

Not doing it at all, leaving everything to be addressed post-design, typically compromises the product cost by increasing the manufacturing and service cost and complexity, and degrading the reliability of the product.

> Developing test systems for manufacturing should start right after the first design iteration is reviewed, to optimize the product introduction process.

DESIGN FOR TESTABILITY (DFT)

Test capabilities shall be included in each design - either assembly, subsystem, or system, with the objective that each assembly and the final product has maximum (ideally 100%) test coverage for all physical and functional characteristics. Care should be taken to make sure that each serviceable part or subassembly has full testability coverage.

Design for Testability begins with devising a test strategy by design engineers in collaboration with manufacturing test representatives, no later than the first design iteration for prototype.

Test coverage extends to design test and manufacturing test, so both should be included in the design review. Manufacturing vendor's test capabilities, preferences and limitations should be assessed at this stage. Developing test systems for manufacturing should start right after the first design iteration is reviewed, to optimize the product introduction process.

DFT is a broad discipline, applicable to all technologies: electronic assemblies, electrical systems, mechatronic systems, analytical instruments, mechanical designs, communication systems, software products, etc. - each has specific testability needs, guidelines, and approaches.

For electronic assemblies, at the schematic design stage, one should determine the signals that have to be probed and this can prove to be challenging. For PCB design, decide the placement of the test points to minimize test jig complexity (have all the test points on one size of the PCB and be aware of the proximity of tall components to the test points).

For complex products, it is not unusual to build a full "hidden" data acquisition system inside the actual product, relying on hardware, firmware, and software integrated capabilities, to ensure comprehensive test coverage.

Software testability is a very generous topic, and essentially requires that every software function or characteristics shall be tested by a built-in software capability. This design for test strategy ensures comprehensive regression testing at every iteration and release, driving inherent, verifiable, traceable product quality.

DESIGN FOR MANUFACTURING (DFM)

Design for Manufacturing (DFM or "Manufacturability") is a combination of product development methodologies, engineering practices, and life cycle processes that optimizes product manufacturing by increasing efficiency, minimizing the cost, ensuring required quality, while complying with regulatory specifications, safety, and ergonomics.

DFM can be thought as complementary to DFA, and for this reason the term Design for Manufacturing and Assembly (DFMA) has been frequently used to describe the tandem. However, a broader understanding of the manufacturing process reveals that DFM has many DFX dimensions: DFSC, DFR, DFA, DFT. Manufacturability means that all parts, subassemblies, subsystems, and complete systems must be feasible and efficient to procure, fabricate, build, assemble, test, and controlled for required quality and compliance.

Manufacturing can be done either by the company that owns the product, or by contract manufacturing parties. In any case, manufacturing is integrated with the vendor management process that handles the interface with all suppliers of parts, subassemblies, and services.

Beside the DFX dimensions already mentioned, DFM has specific, general objectives, considered from the start of the development phase, when technologies and architectural alternatives are explored:

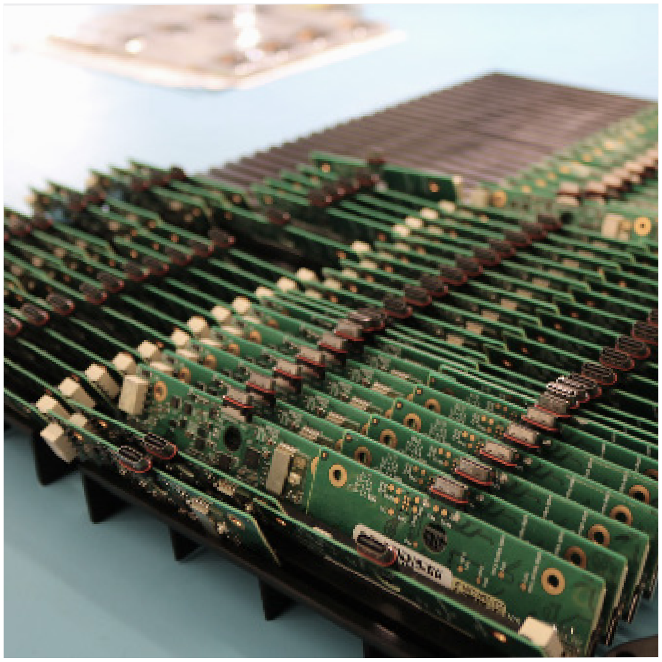
• System approach: clear definition of technologies and breakdown of system in subsystems, assemblies, and parts, easily to describe and specify to manufacturing vendors.

• Ease of fabrication: select parts, materials and processes that are readily available and can be met by many manufacturing suppliers.

• Stay generic as much as possible: avoid exotic parts, materials, or processes.

• Ergonomics: eliminate sharp edges; avoid heavy, oversized, awkward parts or sub-assemblies; provide handling capability for parts, subassemblies, and final product.

• Fluency: Integrate manufacturing in a logical flow, in one pass, eliminating redundant phases and minimizing the need to repeat operations or processes (sometimes this is inevitable).



• Design for automation: consider automating sub-processes for efficiency, robustness, consistency, and cost.

A key aspect of DFM is the collaborative relation between design teams and the manufacturing vendors that includes the following steps:

• Identify potential manufacturing vendors for the assemblies or subsystems of interest, and assess their capabilities, capacity, processes, and operational risks.

• Establish direct communication with selected vendors and ask them to provide their internal DFM guidelines and constraints; the design team should adapt the design to comply as much as possible to these vendor specific DFMs rules, the generic practices are not always sufficient.

• Review the design manufacturability throughout the development phases, with manufacturing vendors technical representatives, asking for input and confirmation.

• Develop the DFA, DFT, DFR strategies in collaboration with vendors, and validate all manufacturing fixtures, tools, procedures by end of pilot phase.

• Plan and implement the monitoring process of the manufacturing, to ensure compliance with specifications, track and improve product and manufacturing efficiency and reliability.

DFM should be factored early in the design process and should include all stakeholders - product owner, system architects, engineers, designers, quality assurance, regulatory houses, component manufacturers, testing partners, suppliers, contract manufacturers, through a holistic view of the product development.

DESIGN FOR SERVICEABILITY (DFS)

Serviceability measures the efficiency of maintaining the full functionality and integrity of a product in the field, considering the following capabilities:

• Ability to diagnose and clarify the reason for a service call. Remote diagnosis can be effective in identifying the cause and sometime resolving the field issue without the need for a site visit. On-site diagnosis supported by effective diagnostic capabilities built-in the product or service information tools ensuring simple, intuitive, controlled troubleshooting workflow.

• Ease of disassembly and correct assembly, by modular architecture, mistake-proofing design (parts cannot be assembled erratically), ergonomic sizing of parts, use of minimal number of tools, use of standardized tools, etc. (In one word: DFA).

• Minimal effort for calibration, setup, and re-validation, after servicing the product.

• Effective integration with supply chain (DFSC) such that the serviced parts are available timely.

Design for Serviceability requires participation of field service representatives early in the product development process, preferably in the concept development stage.

DESIGN FOR INNOVATION

Innovation may not be a formal DFX dimension, but innovative design is certainly reflected inherently in any successful product. New ideas driving solutions that add product value, or enhance business capabilities as knowledge, technology, and process competencies, are fundamental differentiators in product market and business landscape today.

Design for Innovation is a generous topic, rather difficult to define in terms of methodologies or guidelines; few possible directions in product development would be:

• Start with multiple options when exploring technologies and explore alternative ways to architect the product, although there might be an obvious solution available.

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• Compare and contrast legacy solutions with new, never explored approaches.
• Brainstorm in multi-disciplinary teams, especially at early stages of development, and when difficult problems occur, and no easy solution is foreseeable.
• If a chosen solution or feature implementation seems clumsy, or too common, or has low value (low ratio between functionality versus cost and complexity), consider the opportunity to innovate.
• Competitive research - understand how similar products are defined, designed, manufactured.
• Innovation opportunities are everywhere, technology and processes: look for alternatives to assembly, test, fabricate, service the product.

It is worth remarking that contract design and manufacturing houses are valuable contributors to innovation due to their diverse knowledge gained by developing products in multiple market segments, with ability to use and infer novel techniques and ideas, as they need to stay on the rising edge of the technology evolution by continuous learning.

DESIGN FOR ENVIRONMENT

Design for Environment (DfE) is a larger umbrella that covers the entire lifecycle of a product and focuses on sustainable development with minimal impact on the environment. The DfE approach covers five aspects through the products lifecycle:

1. Materials and extraction of primary materials

Vet suppliers based on their harvesting process and environmental policies to ensure recyclability.

2. Transportation of raw materials

Ensure minimal carbon footprint during transportation of parts, components, supplies and sub-assemblies.

3. Production

Identify the length, complexity, and energy intensiveness of manufacturing process. Ensure efficient manufacturing process with a capability to measure waste produced and comprehensive waste disposal plans.

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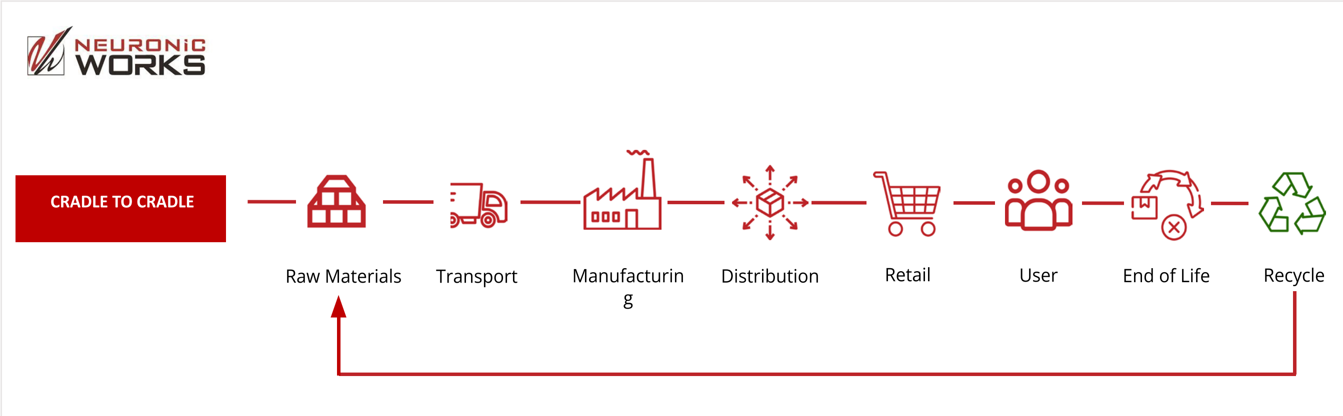
4. Transport, Distribution and Packaging

Aim to minimize offshore activities that will contribute to increased carbon footprint of transportation from manufacturer to retail stores. Identify storage and distribution plans for logistics.

5. Usage
6. End of Life (Design for Recyclability)

Aim to design a recyclable product (either whole or parts). Identify and be aware of how long unusable parts would take to breakdown in environment.



Cradle to Cradle Design

Design firms must employ DfE practices to improve the environmental performance of products by using environmentally friendly materials, using fewer materials and less packaging, reducing energy consumption, implementing low power designs, and implementing green supply chain management practices. Considering DfE early in the product development process can lock in benefits from the beginning instead of costly accommodation efforts in the later stages.

DESIGN FOR RECYCLABILITY

Design for Recyclability is a subset of Design for Environment (DfE). We believe it is deserving of a separate section on its own as it was the first initiative that gained prominence.

This is a circular design thinking strategy that aims to design products that have minimum impact to the environment. Most products that are available in the market today are not designed with the end-of-life recyclability in mind. In fact, today, electronic products typically have a lifespan of 1.5 to 13 years, with an average of 4.5 years.

To ensure a safer, green world, it is important to conceptualize designs while considering environmental impacts. Considerations must be made for the design, manufacturing and recycling stages. There are various strategies that can be adopted including choice of components and materials, quantity of materials, improved techniques, choosing local suppliers/manufacturers among others.

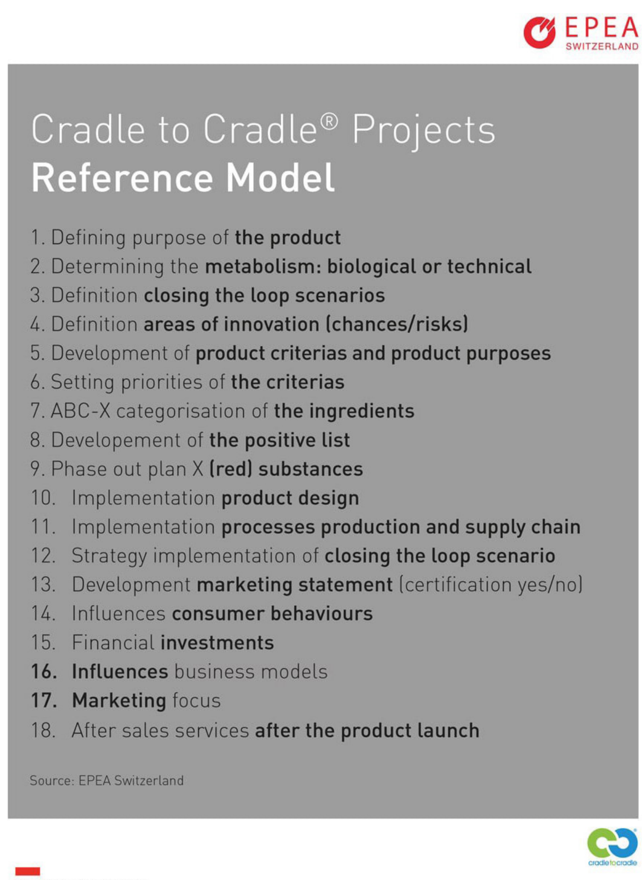
A framework for realizing Design for Recyclability is the cradle-to-cradle approach. A properly functioning cradle-to-cradle approach eliminates waste by creating products with materials that are safe and recyclable.

In contrast to the cradle to grave approach, which conveys a message of 'use it, lose it and bury it', the cradle-to-cradle approach is more long-term and is more infinite in nature.

EPEA Switzerland has created the Cradle-to-Cradle Innovation Reference Model, to make it easier to create products which can meet cradle-to-cradle principles. Design companies need to go beyond satisfying or fulfilling product requirements to also thinking about designing for recyclability that will contribute to success in recycling.

It cannot be just an afterthought, as when the product is manufactured, there is not much that can be done to change its destiny.

Come to think of it, designers can only do so much, it also takes a strong culture of recycling at a national and community level to adopt, implement and maintain a strong recycling program.



DESIGN FOR DISASSEMBLY AND SERVICEABILITY

Complementing both Design for Recyclability and Design for Environment is the design principle of Design for Disassembly. It involves planning for product, component, and material deconstruction, recovering materials and retaining value at the product end-of-life.

Designing with this principle in mind makes it easier for products to be upgraded, recycled, and repaired, thereby prolonging its life. Some of the strategies for designing with disassembly includes using fewer parts and fewer simple fasteners. To implement these strategies, designers need to discover waste, set goals, create solutions, and monitor results through production, release, use and end-of-life.

DESIGN FOR ENERGY EFFICIENCY

Energy efficiency involves the level/amount of energy used by a product/device/ appliance to execute its function. Electronic products in some countries sport energy labels or energy symbols that reflect energy efficiency (Energy Star, Class A – G scale), thereby promoting the adoption of energy-efficient appliances. It is important to design for energy efficiency right from the concept design and to consider energy saving methodologies through the product development lifecycle. In this case, designing for energy efficiency directly affects the end user as they pay for the energy consumed by the device for its entire life. A good example of energy efficiency design and use is incandescent bulbs vs LED bulbs.

In terms of design, designing for energy efficiency is a function of components that are used (especially in HW design) and the design techniques being employed (HW, SW, FW)

> Developing test systems for manufacturing should start right after the first design iteration is reviewed, to optimize the product introduction process.

WHY DFX?

Should DFX be listed as a formal product requirement, although it is so complex and extensive? Well, very few of its components usually appear as formal requirements, typically compliance standards, cost target, maybe the MTBF, but rarely more than these. DFX equates product value, through its entire life cycle. DFX cannot be precisely measured: as we could see through this paper it is a complex set of methods, rules, approaches, many in relative conflicting relationship, that should be applied holistically, through inter-disciplinary, diligent trade-off analysis. The DFX capability of a product development team is built through years of design and engineering experience, and by interdisciplinary expertise; nowadays DFX is perhaps the main differentiator when it comes to design quality and value. It is not enough just to design a product from a set of requirements, it must be designed for, and with, eXcellence.

"We do not inherit the earth from our ancestors; we borrow it from our children" is an old proverb that summarizes the need to adopt DFX principles that will result in green, clean, sustainable designs. At NeuronicWorks, our vision statement is "To design a sustainable, clean, and safe future!" and our mission statement is "To create great products that are human centric, functional, reliable, sustainable, energy efficient, and recyclable, while using minimal carbon footprint to produce and distribute." We believe the future is in our hands and we have the power to design to make a positive impact.

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