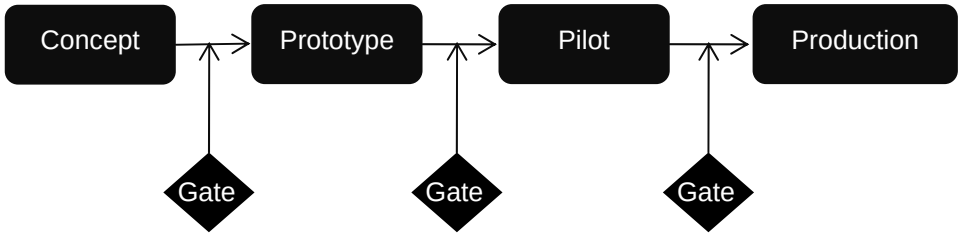
Blog - MEMS New Product Development, The Technology Development Process and Design Review Checklist, *David DiPaola, DiPaola Consulting, LLC, www.dceams.com*

After a functional A-sample prototype is built, it doesn't take long for a project to gain traction that has market pull. This is usually the point that a project becomes highly visible within a company and it enters the Technology Development Process (TDP). The TDP is made up of multiple phases including concept, prototype, pilot and production with gates at the end of each phase. Design and process reviews are required at each gate but may also occur within a phase. These reviews are an open forum for communication of project progress and gaps towards technological, business and schedule milestones. Furthermore the product is constantly evaluated against the market need and potential changes in market that may have occurred. The audience for the reviews at a gate include peers and management who provide feedback on the project to date and collectively decide whether additional work is needed to complete the current phase or the completed work is sufficient to allow the project to proceed to the next phase with additional funding. In certain instances, a project that has not met all of the deliverables may be allowed to proceed to the next phase but under strict conditions that must be fulfilled within a given timeline. The goal of the TDP is to focus the team on high quality execution, effectively screen projects allowing only the best to proceed and hence accelerate successful innovation and profitability.

The MEMS Industry Group (MIG) Technology Development Process Template is an excellent tool for companies to use to implement the TDP within their organization (Marty et al. 2013). The goal of the TDP was to create a simplified frame work that could be easily customized to fit a company's needs. The TDP structure shown below is a slightly modified version of the TDP developed by MIG. In this version there are four major phases including concept, prototype, pilot and production with three major gates.

Figure 1
TDP Structure



The concept phase is where ideas are generated and the initial A-samples are developed. It is also where the business case is first generated and the market need is defined. It is highly desirable to have market pull at this point. The prototype phase is where the design is developed in detail and B-samples are fabricated to support various levels of validation. The outcome of the prototype phase is to have design that can be manufactured in volume production. Towards the end of the prototype phase, production tooling is often released. The pilot phase is where production tooling is built and qualified. In addition, the product is made on production tooling (C-samples) and revalidated. It is important to note that there should be no change in the product design between the last revision in prototype and the first samples off the production tooling. The production phase is low to high volume production ramp. Often customers will require revalidation of products in production once a year for the life of the product.

At each gate, there is a design and process review for the project. In order for the team to be focused and efficient, there needs to be a clear set of deliverables defined for completion of each phase. These deliverables range from business and market definition to project technical details to production launch. The following checklist provides an in-depth set of deliverables for the design reviews at each gate that can be tailored to the specific needs of an organization. It is

noted that a fourth gate is common 3-6 months after production launch to review project status but is not depicted in Figure 1.

Figure 2
Design Review Checklist

Design Review Gating Requirements					
Responsibilitiy	**Category**	**Concept**	**Prototype**	**Pilot**	**Production**
Engineer	Application Review	Preliminary	Finalized	Review	Review
Engineer / Marketing	Review of competitive landscape and is it favorable?	Finalized			
Engineer	Product History (new product, derivative, cost reduction, change)	Finalized			
Eng / Sales / Marketing / Purchasing	Design to Cost Goals	Preliminary	Finalized	Adjust / Revise	Adjust / Revise
Sales / PM / Marketing	General Business Case - volumes, cash flow, return on investment	Preliminary	Finalized	Adjust / Revise	Adjust / Revise
Engineer	Intellectual Property / Patent Review	Finalized	Review	Review	Review
Engineer / Patent Attorney	Intellectual Property Creation, Patent Disclosure Submitted	Review	Finalized	Review	Review
Sales / PM / Engineer	Customer Schedule / Milestones Defined	Preliminary	Finalized	Review	Review
Engineer	Detailed Review of Product Design and Function	Preliminary	Finalized	Review	Review
Engineer	- Review Critical Characteristics (details of each component, how they function, physics on why it works)	Preliminary	Finalized	Review	
Engineer	- System Approach (system on chip, system in package, discrete chips (sensor / signal conditioning), CMOS processes / compatible, wafer size, etc.)	Preliminary	Finalized	Review	
Engineer	- Material Selections (silicon, graphene, etc.)	Preliminary	Finalized	Review	
Engineer	- Wafer Approach (SOI, monocrystalline, polycrystalline, etc)	Preliminary	Finalized	Review	
Engineer	- Orientation of Silicon	Preliminary	Finalized	Review	
Engineer	- Doping Strategy (type, quantity, ion implanation, diffusion, etc.)	Preliminary	Finalized	Review	
Engineer	- Sensing / Actuation Technology (piezoresistive, capacitive, etc.)	Preliminary	Finalized	Review	
Engineer	- Micromachining Technology (bulk, surface, wet or dry etch, etc.)	Preliminary	Finalized	Review	
Engineer	- MEMS Features (undercuts, membranes, channels, etc.)	Preliminary	Finalized	Review	
Engineer	- CMOS Features (if required)	Preliminary	Finalized	Review	
Engineer	- Nanofabrication Feature Integration (if required)	Preliminary	Finalized	Review	
Engineer	- Metalizations (traces, wirebond pads, etc.)	Preliminary	Finalized	Review	
Engineer	- Oxide layers	Preliminary	Finalized	Review	
Engineer	- Through Silicon Vias	Preliminary	Finalized	Review	
Engineer	- Does the design require energy harvesting? If so, what approach?	Preliminary	Finalized	Review	
Engineer	- Process Steps and Order	Preliminary	Finalized	Review	Review
Engineer	- Explain features resulting from concurrent development of design, process, tooling and equipment for high yield and cost optimization. Does the design require new processes not currently deployed? If so, how is risk mitigated?	Preliminary	Finalized	Review	Review
Engineer	- Concurrent Design of MEMS Integration Strategy with Subsystem (i.e. solder bumps, hermiticity, packaging, sensor) and End System (final product - brake system, IED detection system, etc.)	Preliminary	Finalized	Review	Review
Engineer	- Completion of Models and Detailed Drawings	Preliminary	Finalized	Review	Review
Engineer	- Design feedback from foundry, equipment vendors and customer (MEMS integrator)	Preliminary	Finalized	Review	Review
Engineer	Review of analysis completed to validate design (Pspice simulations, tolerance stacks, doping simulations, FEA, matlab simulations, etc.)	Preliminary	Finalized	Review	
Engineer	Review for compliance to existing engineering specifications (JEDEC, ASTM, SAE, JIS, etc.)	Preliminary	Finalized	Review	Review
Engineer	DFMEA Completion and Review	Preliminary	Finalized	Review	Review
Sales / PM / Engineer	Customer Specification Review	Preliminary	Finalized	Review / Adjust	Review
Sales / PM / Engineer	- Gaps to specification that cannot be met, reasoning and mitigation plan	Preliminary	Finalized	Review / Adjust	Review
Sales / PM / Engineer	- Documentation of verbal communications of critical information not contained in spec.	Preliminary	Finalized	Review / Adjust	Review
Engineer	- Review of System FMEA	Preliminary	Finalized	Review / Adjust	Review
Sales / PM / Engineer	- Changes in Specifications During Development	Preliminary	Finalized	Review / Adjust	Review
Sales / PM / Engineer	- New Area of Concern Based on New Information from Development	Preliminary	Finalized	Review / Adjust	Review
Engineer	Design and Production Validation Test Plans	Preliminary	Finalized	Review	
Engineer	Review of Design and Production Validations Completed	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Measurement system analysis (Gage R&R, accuracy analysis, etc.)	Preliminary	Finalized		
Engineer	- Controls used	Preliminary	Finalized	Review	
Engineer	- Design of experiements review	Preliminary	Finalized	Review / adjust	
Engineer	- Highlights from Critical Tests	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- History of design issues, root causes and resolutions	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Comparison of results from concept, prototype, pilot and production samples when meaningful trends present	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Results from competitive benchmarking	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Review of results from testing at customer facility	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Visual inspection and tear down analysis of parts processed through validation showing robustness or potential issues	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	Strategic Testing to Failure (or 3 - 5X specification)	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Review of design weaknesses	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineer	- Design robustness (margin compared to spec)	Preliminary	Design Finalized	Pilot Finalized	Prod. Finalized
Engineers (design, process, equip)	Prototype and Production Tooling / Equipment Strategies	Preliminary	Design Finalized	Prod. Finalized	
Purchasing / Engineer	Supplier Reviews	Preliminary	Finalized	Review	Review
Purchasing / Engineer	- New or existing supplier	Preliminary	Finalized		
Purchasing / Engineer	- Supplier audit - knowledge, capability, quality and financial stability	Preliminary	Finalized	Review	
Purchasing / Engineer	- Component specifications accurate and complete	Preliminary	Finalized	Review	Review
Purchasing / Engineer	- Compliance and resolution to meet defined component specifications	Preliminary	Finalized	Review	Review
PM / Engineer	Risk Assessment	Preliminary	Finalized	Review	Review
PM / Engineer	Lessons Learned	Prev. Products	Review	Review	Finalized

PM - Program Manager

*Note all of this information cannot be displayed in one review. This document highlights critical areas and its up to the engineers/managers to decide the most meaningful information to include. However, all of this information should be completed and available to address potential concerns.

This table can be downloaded from the following link in PDF format (http://www.dceams.com/Assets/Design%20Requirements%20for%20Product%20to%20Pass%20a%20Phase.pdf). Many of the items listed above are self explanatory. Others are explained in more detail in previous blogs posts such as DFMEA and tolerance stacks.

The Technology Development Process is an essential element of successful MEMS new product launches. The Design Review Checklist can also provide a frame work for discussion between management and engineers on required deliverables to pass a particle gate. With improved communication and efficient execution of technology development, the TDP is a great tool for accelerating innovation and profitable MEMS products. In next month's blog, the necessary attributes of a MEMS engineer for new product development will be discussed.

Works Cited:

Marty, Valerie, Dirk Ortloff, and David DiPaola. "The MIG Technology Development Process Template." MEMS Industry Group, Mar. 2013. Web. 28 Apr. 2013.

Updated Bio:

David DiPaola is Managing Director for DiPaola Consulting a company focused on engineering and management solutions for electromechanical systems, sensors and MEMS products. A 17 year veteran of the field, he has brought many products from concept to production in high volume with outstanding quality. His work in design and process development spans multiple industries including automotive, medical, industrial and consumer electronics. He employs a problem solving based approach working side by side with customers from startups to multi-billion dollar companies. David also serves as Senior Technical Staff to The Richard Desich SMART Commercialization Center for Microsystems, is an authorized external researcher at The Center for Nanoscale Science and Technology at NIST and is a Senior Member of IEEE. Previously he has held engineering management and technical staff positions at Texas Instruments and Sensata Technologies, authored numerous technical papers, is a respected lecturer and holds 5 patents. To learn more, please visit www.dceams.com.