



Mistakes People Make Developing MEMS Products *And What You Can Do To Avoid Them*

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Scope of the Practice

This BKP (Best Known Practice) describes seven of the common MEMS product development mistakes and what you can do to avoid them. MEMS product development is easy to visualize but difficult to do well. While primarily based on common sense, we hope this document will help you in your product developments.

Stage/Timeframe for the Practice

Properly screening projects is important to investors, product developers, MEMS suppliers, and the industry as a whole. Failure is incredibly expensive; it is a waste of investor resources, skills, supplier resources, and time. It's also a waste of vision and personal capability of development teams. Nobody, whether an investor, a team member, a customer, or a supplier, wants to spend several years of his or her life on a product development that fails.

A typical successful 'greenfield' development will take in the range of three years (yes, three years!), to get a product from concept to volume production. Since there is rarely, if ever, a typical development, actual timing is frequently longer.

Actual steps in a development can vary; we are using the following steps because they are common to most developments. The elapsed time is shorter than the individual step times because many of the steps happen in parallel.

Pre-Development Timing

Step	Ideal Time (months)	Elapsed
Vision	1	1
Team Formulation	2	3
Strong Lead Customers	2	5
IP Management	2	5
Budget Formulation	2	7
Executive Sponsorship and/or Financing	3	9

Development Timing

Step	Ideal Time (months)	Elapsed
Requirements	2	11
Modeling	2	12
Supplier Selection	3	13
DFM – Product Quality Planning, Process Capability Planning	4	16
Process Development	6	22
Prototypes, Pilots	9	25
Packaging, Integration and Validation	9	28

Production Timing

Step	Ideal Time (months)	Elapsed
Transfer to Manufacturing	1	29
Ramp to Volume	6	35
Supply Chain Management	6	35
Yield and Cost Improvement	Ongoing	
Pricing, esp. avoiding price erosion	--	
Next Generation Planning and Implementation	--	

Problem Statement and Goals of the Best Practice

Micralyne is one of the world's largest and most profitable independent MEMS developers and manufacturers. We have a twenty plus-year track record of MEMS development, during which we have served hundreds of customers; both in developing next generation MEMS products with and for them, and in manufacturing the resulting products after development is complete. This document outlines many of the common product development mistakes we have experienced during this time.

We have seen enough product development to know the ingredients for both success and failure. We screen new projects using these criteria, and we suggest you should too.

General Description of Approach/Strategy

While mistakes can happen anywhere, we at Micralyne repeatedly see the following seven most common areas where developers make mistakes. Let's look at each in turn.

(1) Team Formation

Developers may consider that a good semiconductor development team can develop MEMS: it can do a partial but not a complete job. They may consider that any patent attorney can understand the uniqueness of their own Intellectual Property (IP): this is not true because application and technology area knowledge is also important. They may consider that design can be independent of a foundry: it can't. They may consider that project management can be done by a good technical person: it usually cannot. While not unique to MEMS, team formulation is vital, and is often not done well.

(2) Lead Customers

In our opinion, this is the most egregious of errors, not having a lead customer in place. We hear developers say they do not want to engage customers because they are "flying under the radar". Or that they don't need to engage customers because their new product will be disruptive so customers will not understand it until they see it. Or that it's not important to engage customers yet because a demonstration of the basic architecture, not compliance with the detailed requirements, will be enough to stimulate customer interest. Or that competitors won't respond to their offering. Or that they need only a small fraction of worldwide market to be successful. There are all major warning signs that a new product development will fail. Customers are the heart of new products: let them in, get their input and commitment, make them need your success as much as you do. And if you have to give up something to a strong lead customer, it may well be worth doing so in order to ensure early success of your new product.

(3) Financing and Cost

We have yet to see an inexpensive new MEMS product development. An ideal development takes three years and many millions of dollars. And yet, we do see developers making

unrealistic budgets about development, and relying on optimism that somehow costs will be lower than they would like. This results in compromises on the major project steps, including requirements not being fully identified, feasibility budgets being tight, and validation procedures not being properly developed.

(4) Requirements

Requirements are easy to specify in general, but frequently very difficult to specify in detail. Starting development with a less than complete set of requirements is common. Sometimes a developer may 'get away with this'. However, a missed requirement can require a full product redesign, adding even more to cost and timeline. We suggest that having good lead customers is the best way to get your requirements known fully in advance.

(5) Product Quality Planning

This refers to design for manufacturing and other DfX activities, including Failure Mode and Effect Analysis, gauge R&R studies, control plans, product development gates, and other activities that result in products that meet their cost and performance goals. These are often overlooked, or done incompletely: developers frequently expect that these activities will be done 'later, after feasibility is complete'. However, we believe that these should be part of feasibility. At the least, if they are delayed in the interest of developing an early prototype to show customers, the development team should recognize that these are essential design steps that will have to be done eventually.

(6) Packaging, Integration, and Validation, and Verification

Validation, developing the right product, means the product meets the external requirements if users have. Verification, developing the product right, refers to compliance with the developer's or manufacturer's specifications. Both are critical, and unfortunately a common mistake in product development is that these important steps are not defined up front. In addition, MEMS products usually require custom packaging, which itself is a significant portion of the total product cost. Finally, because MEMS have physical performance specifications, interactions between the MEMS device and its package can cause performance problems.

(7) Ramp to Volume

Finally, manufacturing in volume requires effective manufacturing information systems, and defect reduction and product engineering strategies. In many cases a new product requires new processes, and these may not have been properly characterized before volume production starts. Processes developed in a lab may not be amenable to volume manufacturing without re-engineering. These issues may not be serious if volumes remain low, but rarely do developers intend that their product remain low volume forever. If you're serious about selling in volume, it's important to have an effective ramp strategy.

When we boil this all down to the most important success factors, we at Micralyne believe that having strong lead customers, and having the right team, are the most important criteria.

Customer driven product development, done by wise developers, is the most likely way to achieve success in MEMS product development.

Detailed Steps/Activities for Practice Implementation – Illustrated with examples or a case study if possible (Optional)

Conclusion and Recommendations

*Comments on the effectiveness of results, challenges and lessons learned.
What recommendations do you have others to address a similar issue?*

In reality there are an almost infinite number of things that can cause product development failure: the above are our observations of the most common ones. On the other hand, successful product development requires that everything is done right. This is no small feat, and it's no surprise that product development is so difficult. But we suggest that if you are going to spend several years of your life and several million dollars developing a new product, it's worth learning from the mistakes of other's efforts in the industry.

Reviewers Comments

When this white paper was reviewed by ACAMP, they suggested two preliminary steps to the approach/strategy listed above.

(-1) Planning

Because the cost of development is so high in terms of both cash and organizational resources thorough planning is essential prior to execution in order to avoid costly mistakes and reduce the risk of failure. Thorough planning should be carried out prior to execution to identify the product requirements, major milestones, key activities, resource requirements, cost, timelines, risks, risk mitigation strategies etc.

(0) Control

The MEMS marketplace is high dynamic, conditions can change rapidly and the requirements for a product can change significantly during the product development cycle. The development process is often littered with technical challenges which pose significant risk to project success and successful execution of the steps. Progress of the project should be reviewed regularly by a team external to the project team. Ideally the review team will include key stakeholders in the

success of the project such as marketing, engineering, operations and finance. Such reviews are typically embodied in a stage gate methodology where the decision to continue, modify or kill the project is made at key milestones in the development process. Typical metrics applied to the project include project ROI, Risk, Alignment with the overall business strategy in the early phases and 'harder' metrics such as yield, reliability, product performance vs requirement specification and customer feedback in later stages of the product development.

ACAMP also suggested additional steps in the *pre-development* and *development timing*.

Pre-Development Timing

Step	Ideal Time (months)	Elapsed
Vision	1	1
Market research	3	3
Team Formulation	2	3
Project planning	2	5
Engage Strong Lead Customers	2	5
IP Management	2	5
Budget Formulation	2	7
Executive Sponsorship and/or Financing	3	9
Requirements specification	3	9
Stage gate review	1	9

Development Timing

Step	Ideal Time (months)	Elapsed
Simulation and Design, short loop tests	3	12
Supplier Selection	3	13
DFM – Product Quality Planning, Process Capability Planning	4	16
Stage gate review	1	16
Process Development	6	22
Prototypes, Pilots	9	25
Product testing with lead customers	6	25
Packaging, Integration and Validation	9	28
Reliability and performance characterization	6	28
Stage gate review	1	28