



**Expert Contributors**

**MEMS Commercialization Report Card – Part 12: Summary, Conclusions & Wrap Up**

**By Roger H. Grace**

**INTRODUCTION**

**Welcome back again to the continuation of the MEMS Industry Commercialization Report Card Series. This will be the last in the series that started in mid-December 2019 and will be a summary of some of the key points that have been made in the previous 11 articles. It will also provide a wrap-up and some reportage and repartee on the topics not previously addressed. Last, it will provide my opinions on the impact of COVID-19 on the health of the MEMS and sensors industry as well as recommendations to move forward.**

## **Background**

The MEMS Industry Commercialization Report Card was introduced in 1998 and has the purpose of tracking and reporting on the progress (or lack thereof) of the MEMS industry. The impetus of the Report Card is based on the author's being invited to participate in a panel discussion at the seminal Hilton Head Conference. The topic of the panel discussion was, "Why weren't there more MEMS millionaires?"

Being a market research consultant, I decided to interview several of the approximately 300 attendees of the event to come up with some answers to that thorny question. I presented my results to the attendees with rave reviews and with lots of questions. As a result, I decided to continue the market research process by creating a report card of nine critical success factors that I considered vital to commercialization success. Five additional topics were soon added based on continuous reassessment of the ever-changing dynamics and resultant performance of the MEMS industry. It has remained at this level since 2003 ... and here we are 20 years later.

## **Research Method**

Questionnaires were emailed to 90 select individuals in the Roger Grace Associates database who have played and continue to play major roles in the MEMS commercialization process. These expert participants represented a broad range of MEMS manufacturers, users of MEMS, and individuals who represent companies engaged in MEMS infrastructure, i.e., foundries, design software, and equipment providers. Academics were not included in the research universe.

The participants represented a worldwide universe, with the majority of the respondents coming from the US and Europe. The members of the research universe were asked to rate the 14 critical success factors/topics using grades A through D, adding pluses and minuses where applicable. Additionally, they were asked to provide specific comments, a.k.a., verbatims, as to the rationale of their assigned grades.

The 35 respondents had a collective experience of over 750 years, averaging out to approximately 25 years per respondent. Follow-up interviews were also conducted to obtain specific information on the rationale for the submitted grades. Certainly, this was an exceptionally well-experienced and well-qualified group of expert participants.

This research approach, known as Delphi, provides the best possible insight into a research topic when a statistically significant and projectionable approach is not feasible. These statistically significant research projects are similar to those used during elections to help forecast outcomes.

The Report Card is unique in the technology commercialization strategy sector and to the MEMS industry. It has been widely published and presented worldwide since its introduction in 1998 and is widely accepted internationally as a valuable tool for MEMS industry participants to create winning business strategies for their organizations.

## **The Problem**

It is interesting to note that MEMS technology established the discovery of the piezoresistive effect at Bell Laboratories in 1955 by Charles Smith. The discovery is approximately the same age as integrated circuit (IC) technology that was discovered at the same laboratory by Bardeen, et al., only a few years earlier. More importantly, however, the total sales of MEMS as reported by numerous groups in 1998 was approximately 1/25th of the sales of ICs at the time the first Report Card was published.

The MEMS market for 2019 has been reported by several organizations to be approximately \$13 billion to \$15 billion, whereas the total semiconductor market for 2019 was reported to be in excess of \$419.18 billion. That's down from \$469.4 in 2018 and a loss of 12% from the previous year — approximately a 30:1 ratio. The positive news here is that the MEMS market has been reported to be growing over the past several years at a compounded annual growth rate (CAGR) of approximately 10. This growth rate is primarily fueled by mobile phones, tablets, automotive vehicles, and consumer products. However, the question still remains: Why is there still such a disparity in the market sizes? The Report Card's raison d'être is to help address this seemingly apparent paradox.

## RESULTS

Figure 1 provides the letter grade results of the 2018 MEMS Commercialization Report Card on a yearly basis from 1998 to 2018. It also provides the change in grade from the 2017 to 2018. Figure 2 provides a bar chart of the grades. The 2018 Report Card provided an overall grade of B- to the 14 critical success factors for MEMS commercialization. The overall grade had not changed since 2010. More importantly, however, was the change in the individual grades.

# MEMS 2018 COMMERCIALIZATION REPORT CARD

SUBJECT / YEAR	98	99	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
R&D	A	A	A	A	A	A-	A-	A-	A-	A-	B+	B	B	B+	B	B	B	B	B+	A-	A-
Marketing	C-	C	C+	C+	C+	C	C	C+	C+	C+	C+	C	C	C+	C+	B-	B-	B	B	B	B
Market Research	C	B-	B-	B-	B	B	B+	B-	B	B	B	B+	A-	B	B-	B-	B-	C+	C+	B-	B-
Design For Manufacturing	C+	B-	B	B	B	B	B	C+	B-	B	B+	A-	A-	B+	B-	B	B+	A-	A-	A-	B+
Established Infrastructure	C+	B	B+	A	A	A	A	A-	A-	A-	B+	B+	A-	A-	A-	A-	A-	A-	A-	A-	A-
Management Expertise	C	C	C+	C+	C+	C+	C+	B-	B-	B	B	B	B	B	B	B	B	B	B	B	B
Venture Capital Attraction	C	B-	B+	A	C	C-	C	C+	C+	C	C-	D	D+	D+	D+	D+	D+	D	D	D+	C-
Creation Of Wealth	C	B-	B+	A	C	C-	C-	C-	C-	C	C-	D+	C-	C+	C+	C+	B-	C+	C+	C+	C+
Profitability	C-	C-	C-	C-	C-	C-	C-	C	C+	C	C-	D+	D	C-	C	C+	C+	C	C-	C-	C-
Industry Roadmap	INC	B-	B	B+	A-	A	A	B	B-	C+	C-	C-	C	C	C	C+	B-	C+	C	C-	C-
Industry Association	INC	INC	INC	B	B+	B+	B+	B	B	B+	B	B	A-	B+	B+	B+	B+	B+	A-	B+	B-
Standards	INC	INC	INC	INC	C	B-	B-	B-	C+	C	C	C	C+	C	C	C+	B-	C+	C-	C-	C-
Employment	INC	INC	INC	INC	INC	C	C	C+	C+	C+	C	C-	C	C+	C+	C+	B-	B-	B	B	B
Cluster Development	INC	INC	INC	INC	INC	B	B+	B+	B	B-	C+	C+	C+	C	C+	C+	B-	C+	B-	C+	C+
Overall Grade	C+	B	B	B	B	B	B	B	B-	B	C+	C+	B	B	B	B	B	B	B	B	B

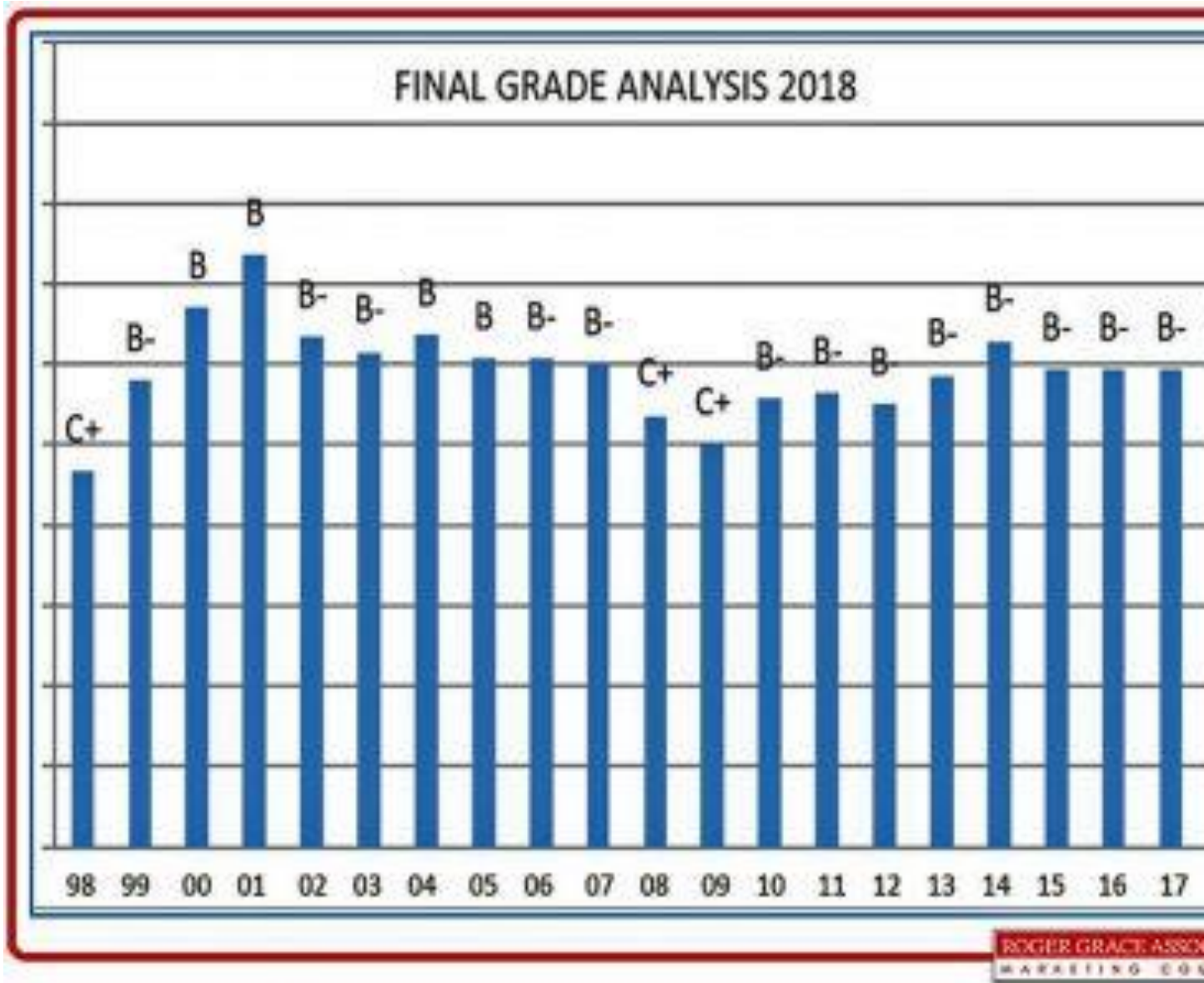
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**Fig. 1: The MEMS Industry Commercialization Report Card, established in 1998, annually provides objective and measurable details of the performance on a graded scale of the 14 critical success factors for the successful commercialization of MEMS. The overall 2018 grade was B- with changes in several of the topics from their 2017 level. Courtesy: Roger Grace Associates**

Out of the 14 topics, R&D and Established Infrastructure had the highest grade of A- and Venture Capital Attraction and Standards had the lowest grade of C-. Three topics increased one grade level — Venture Capital Attraction(C-), Profitability (C), and Industry Roadmap (C). One topic, Design for Manufacturing, decreased one grade level to B+, and Industry Association decreased two grade levels to C-. The remaining nine topics remained constant.

The lowest C- grades established that Venture Capital Attraction and Standards continue to need major improvement and may be critical items in restraining the industry from realizing its true potential. In 2018, Venture Capital Attraction finally emerged from its D level that it

held since 2009, when the worldwide crises hit our economy and, regrettably, venture capital monies began being targeted to software and social media startups.



**Fig. 2:** Since its inception in 1998, the MEMS Industry Commercialization Report Card has assessed the performance of the MEMS industry with letter grades from A to D. The overall performance grade began at C+, improved to the B/B- level, decreased to C+ during the worldwide financial crisis (2008/2009), and has maintained a B- grade since 2010. It is believed that the maturity of the MEMS industry has played a significant role in this process of grade enhancement over time. Courtesy: Roger Grace Associates

With a little help from my MANCEF co-director friends over the past 11 episodes, I have addressed the Report Card subjects of:

- Cluster Development
- Established infrastructure with Doug Sparks

- Design for Manufacturing and Test with David DiPaola: [Part One](#) & [Part Two](#)
- Marketing: [Part One](#), [Part Two](#), [Part Three](#), & [Part Four](#)
- Industry Association with Todd Christensen and Andy Oliver: [Part One](#) & [Part Two](#)

These represent only five of the 14 total number of subjects in the Report Card. The following paragraphs will provide commentary on several of the other subjects not previously addressed.

### Profitability, Venture Capital Attraction & Creation of Wealth

I refer to these as the economic triumvirate subjects, which have historically experienced fair to poor grades and, regrettably, the only subjects that have received grades of D over the 20-year history of the Report Card. In this Report Card, I am happy to report that the respondents gave an improved grade of C- from D+ for Venture Capital (VC) Attraction, C- to C for Profitability, and no change in the grade of C+ for Creation of Wealth.

All these fall below the overall grade of B- for the 14 subjects. I believe that there are several factors that have influenced these grades. First, the economy had been on a tear for several years, especially the stock market. This fuels VC activity.

I also believe that suppliers of MEMS are becoming more astute and judicious about manufacturing and sourcing and are able to make better products more effectively and with higher profit margins. In the Creation of Wealth category, while no MEMS companies went public, the popular exit strategy continued to be acquisitions, with numerous MEMS companies being acquired and their founders and stakeholders profiting from this activity<sup>[1]</sup>.

### Industry Roadmap

The Industry's Roadmap grade moved from C- to C, which I believe is attributed to the ongoing work of iNEMI volunteers. The Organic Electronics Association (OE-A) produces an annual roadmap for the organic electronics industry<sup>[2]</sup>. There appears to be no other MEMS-specific roadmap activity since the seminal work of MANCEF in their early 2000s — the International MEMS, Microsystems, Top Down Nano Roadmap<sup>[3]</sup>.

Please keep in mind that many things have changed since the early 2000's when this 614-page behemoth was published. Perhaps there's an opportunity for the MEMS industry to step up to the plate and update this work?

### Standards

Standards, with a non-moving grade of C-, continues its lackluster journey. The MEMS and Sensors Industry Group (MSIG) has taken up the challenge of supporting this activity in the past, and the author believes that MSIG's new affiliation with SEMI will be a major incentive for MSIG to continue this good work. Most recently, MSIG published a MEMS standard.

### Market Research

Market Research continued with its B- grade. Several market research firms worldwide continue to produce a plethora of reports to address market size and growth rates. Industry associations including IVAM also frequently conduct and provide market studies specific to the interests of their members<sup>[4]</sup>.

## R&D

Research & Development (R&D) expenditure continued with its A- grade. This topic has been the best performing subject over the 20-year history of the Report Card, attaining its lowest grade of B several times. I believe that this could be due to the continued support of various federal organizations including NSF, NIH, and DARPA, plus investments in the private sector and in the many universities that have developed stellar research faculties to support this topic.

## Employment

Employment has remained steady at its B grade. Once again, the continued growth of the MEMS industry and constantly evolving new applications for these devices necessitate the support of a well-trained workforce. Based on my informal research with my MEMS clients and colleagues, there was a pent-up demand for MEMS design engineers and fab engineers necessary to maintain the momentum of the industry.

## COVID-19's Impact on Future MEMS Commercialization

Below is my opinion on the current and anticipated impact of COVID-19 on several subjects involved in the commercialization of MEMS.

## R&D

A reduction in R&D spending results as sales volumes are negatively impacted. It is well known that R&D and marketing are the first two line-items on the budget to be slashed during economic downturns in order to maintain profitability.

## Marketing

Marketing is experiencing a reduction in budgets and supporting activities. This was addressed in my previous article, "Marketing in a Recession"<sup>[5]</sup>. The MEMS industry, as with most industries, is currently realigning its marketing tactics with the current COVID-19 situation.

Webinars are increasingly becoming the gold standard for delivering information to customers. Heightened interest in social media, YouTube, and automated marketing<sup>[6]</sup> are becoming quite popular. I personally receive between 10 to 15 invites weekly to attend webinars and have become a webinar junkie.

Also, the role of in-person trade shows and conferences is being seriously impacted. Zoom and other meeting vehicles are becoming most popular to provide information previously

provided in person at technical conferences. However, the role of a technical trade show and how it can be reimaged is still up for grabs.

### Infrastructure

Supply chain management has been challenged as a result of supplier layoffs and transportation issues. It appears that as of the writing of this article, the industry is experiencing a return to the office and factory. Many of the wafer fabs in Asia are now back at full strength.

### VC Funding

As MEMS serial entrepreneur Dr. Janusz Bryzek said during an interview for this article, “challenges create opportunities.” Certainly, necessity is the mother and father of invention. This is especially true in the sensors industry at this time since I believe that sensors currently play — and more so will play — a dominant role in the tracking, monitoring, distancing, and other functions that will enhance the safety of the population.

Many startups are being funded that have potential solutions to help reduce the impact of COVID-19. Existing suppliers are expanding their product lines and repositioning their existing products to make them more COVID-19-resistant. NSF and other federal agencies have made funds available for sensor-based solutions to support e-health and other implementations.

### Employment

Many organizations, including those in the B2B sector, have experienced a reduction in workforce. As of this writing, the US unemployment rate is approximately 13.3%. This is because many establishments that are not considered “essential businesses” cannot continue to keep their product development and manufacturing lines open, even with proper social distancing procedures.

However, this problem is currently on the decline, and the industry is expected to be back to normal within the next several months. Also, as a result of the lockdown, many products, like automobiles and consumer goods, have been losing ground. People have not rushed out to buy these, even on Amazon.

### Summary

The purpose of the Report Card has been to provide MEMS industry participants with an objective assessment of critical success factors over time and to act as a tool to help them better understand, respond to, and exploit the ever-changing dynamics and evolution of the MEMS industry. The Report Card has been developed not only to help assess the progress of the commercialization of this technology, but more importantly to serve as a vehicle to help guide industry participants to best overcome the barriers to the successful commercialization of MEMS and to achieve maximum commercialization success.

I believe that the objective of the 2018 annual MEMS Industry Commercialization Report Card of providing a valuable tool for MEMS industry participants to objectively monitor the health



of the MEMS industry has been realized once again. The results of the 2018 Report Card should provide industry participants with valuable information to effectively help craft their business strategies moving forward. As it has been for the past 20 years and will continue to be, my intention in the creation and publishing of the MEMS Commercialization Report Card is to provide the industry with an objective assessment of the state of the industry and to provide actionable recommendations to continue its improvement and ongoing success.

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