

THE 2020 MEMS INDUSTRY COMMERCIALIZATION REPORT CARD: IMPLICATIONS OF COVID

FINAL REPORT

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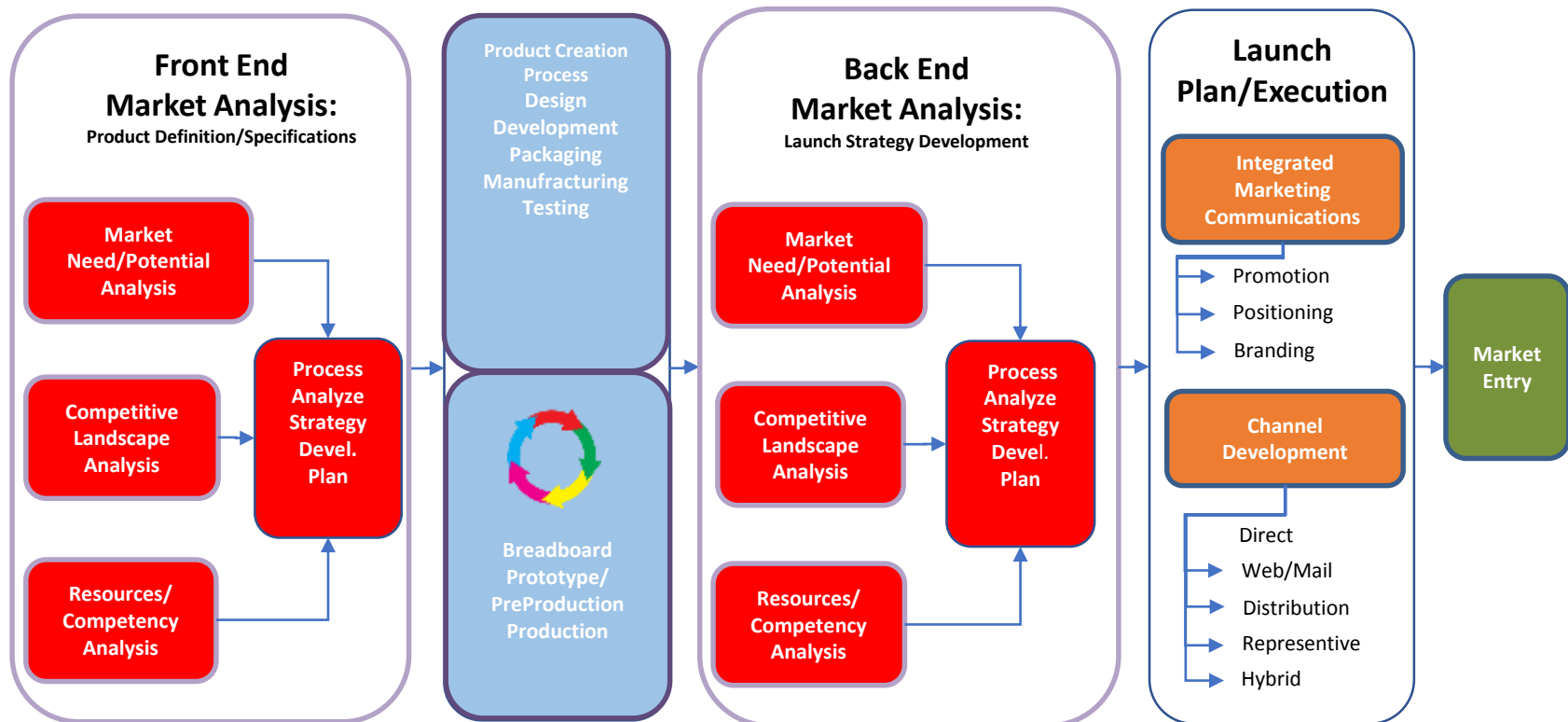
ROGER GRACE ASSOCIATES

- Founded in 1982
- Offices in Naples, Florida and San Francisco, California
- Over 30 Years of experience in the MEMS/Nano industry...an industry pioneer
- International clientele of companies, laboratories and governments
- Specializing in sensors, semiconductors, MEMS/MST, Nanotechnology, capital equipment
- Focus on:
 - custom market research
 - strategic marketing
 - due diligence analysis / merger and acquisition support
 - strategic marketing communications
 - company and product positioning
 - new product introduction
 - Branding
 - promotion
 - business development
 - distribution channel development
- For more information...www.rgrace.com; rgrace@rgrace.com

ROGER GRACE BACKGROUND

- Education: BSEE, MSEE (Raytheon Graduate Fellow) Northeastern University, Boston, MA; MBA Program, University of California Berkeley
- Design Engineer with specialty in microwave and RF, 13 years...Raytheon, Avco, Ford Aerospace
- Applications Engineer, RF semiconductors, 3 years, Avantek/HP
- Marketing Manager, MEMS, 3 years ,Foxboro ICT
- Marketing Consultant, MEMS, Sensors and Semiconductors, 32 years
- Guest Lecturer, University of California Berkeley, 1990-2003
- Alumni Engineer of the Year, 2004, Northeastern University
- Co-Founder, Past President and VP Americas of Micro and Nanotechnology Commercialization Education Foundation (MANCEF)
- Published over 50 papers and articles on MEMS/Sensors
- Organized and Chaired over 40 technical sessions worldwide on MEMS/Sensors
- Board membership...Florida MEP, University of Michigan WIMSS, Northeastern University High Rate Nanomanufacturing Center
- Organizing committee includes Transducers 2009,COMS, Smart Systems Integration (EU), Advanced Microsystems for Automotive Applications (EU), IRISS(EU), IWLPAC
- Citizenship...US / Portugal

TECHNOLOGY COMMERCIALIZATION* PROCESS MODEL



*Def: Process or cycle of introducing a new product or production method to the market

Roger Grace Associates supports its clients in front and back-end market analysis as well as in the product launch plan and execution

OUTLINE

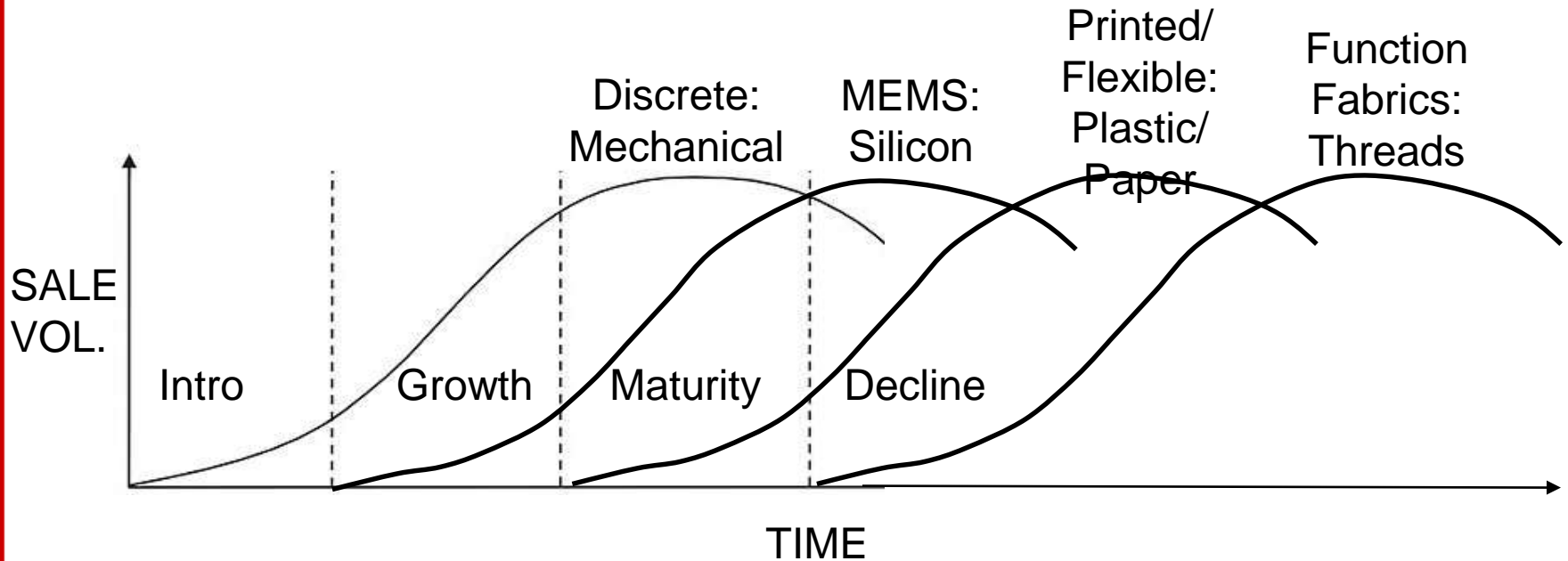
- Situational Analysis
- Market Research Background
- Market Research Mythology
- Results
- Implications of COVID on Grades
- Summary/Call to Action/Recommendations
- References
- For more information

BARRIERS TO COMMERCIALIZATION

SITUATIONAL ANALYSIS

- Lack of well defined direction from roadmaps, industry standards, industry associations
- Multidisciplinary knowledge is required...materials, electronic design, mechanical design
- Packaging and testing costs typically at 70% of total value...however focus has been (and continues to be) on devices not systems solutions
- Lack of focus on customer needs...technology-centric suppliers...technology push versus market / applications pull strategy
- Lack of capital formation opportunities, risk averse investors; low IPO opportunity because of small sales volume levels of companies
- Successive “bubble busts” i.e. biomems, optical telecom...wary investors
- Very fragmented market, many small companies, few large players
- Limited “success stories” of MEMS/MST companies e.g. Invensense, SiTime (IPOs)
- However...new market opportunities for large volume applications have emerged in Automotive; Consumer e.g. mobile phones; Point-of-Care Diagnostics; Wearables; Environmental/Infrastructure Monitoring; Internet of Things (IoT)

SENSOR PRODUCT LIFE CYCLES



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MARKET RESEARCH BACKGROUND

- Initiated in 1998 during Hilton Head Conference
- Determination of 14 critical success factors established after investigation of various other industries (9 initial and 5 added over time)
- Everyone likes grades...people can easily relate...e.g. NY Department of Health grades restaurants regarding their cleanliness, Zagat Restaurant Guides, Michelin Restaurant Stars, AAA Diamonds
- Objective is to monitor and report on the “health” of the MEMS industry in hopes of creating and influencing positive change...not only by conducting the research but by “evangelizing” via presentations and articles
- Added motivation was to determine the effects of COVID on the grades

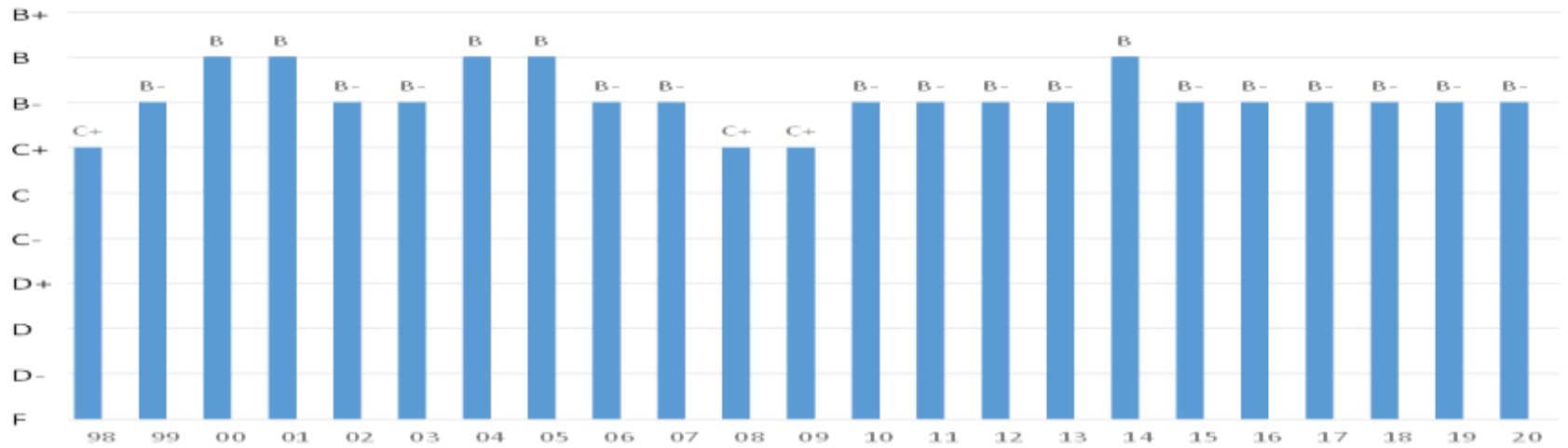
MARKET RESEARCH METHODOLOGY

- “Delphi” approach used...not statistically significant i.e. non-projectable...however constitutes the opinions and rationale (via verbatim comments) of MEMS industry thought leaders (average experience 25 plus years) amounting to over 1000 person-years of experience
- Personal Emails sent to over 300 personally known and highly respected MEMS industry leaders
- Two follow up mailings. (I did not vote)
- 41 completed questionnaires received with many verbatims
- Follow up telecons with numerous respondents
- International in scope with majority of respondents from US and Europe
- Broad selection of interviewees...suppliers, users, infrastructure providers (little-to-no academics)
- Incentive of \$100 Amazon gift card (random drawing from submissions)

STUDY RESULTS

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2020 MEMS COMMERCIALIZATION REPORT CARD



ANALYSIS / COMMENTS

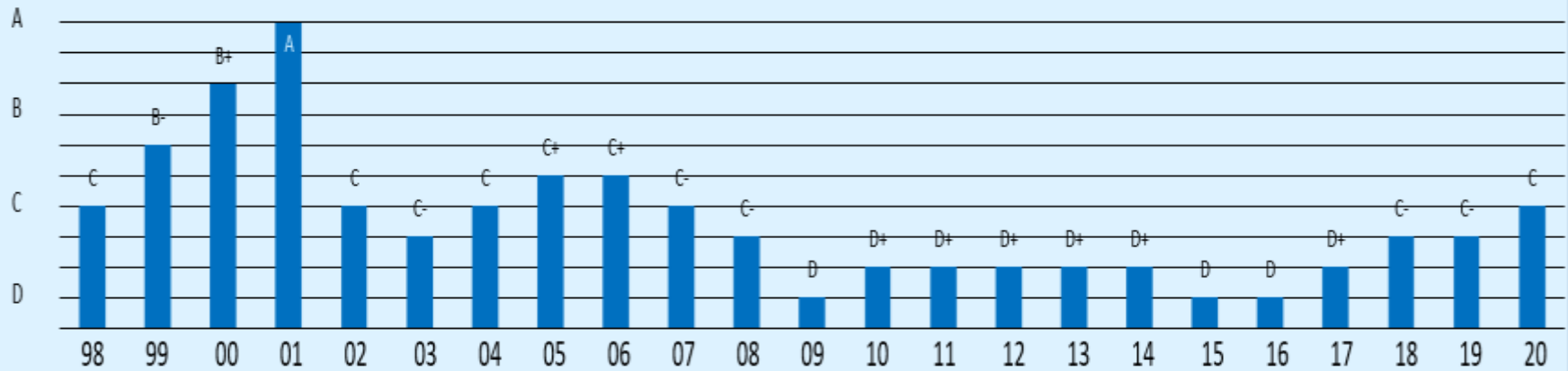
- 2020 grade remained at B- and consistently since 2014 which demonstrates the continuing maturity of the MEMS industry
- Significant level of verbatims provided especially in VC attraction and Infrastructure
- Standard deviation of 0.54
- Lowest overall grade was C+ in 1998, 2008, 2009, 2010 and 2012
- Highest overall grade was B in 2001
- Changes from 2019 to 2020:
 - R and D decreased from B+ to B
 - Marketing Research decreased from B- to C+
 - Infrastructure decreased from A- to B+
 - Profitability increased from C to C+
 - Venture Capital Creation increased from C- to C

2020 MEMS 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	19	20	Δ
R&D	A	A	A	A	A	A-	A-	A-	A-	A-	B+	B	B	B+	B	B	B	B	B+	A-	A-	B+	B	-1
Marketing	C-	C	C+	C+	C+	C	C	C+	C+	C+	C+	C	C	C+	C+	B-	B-	B	B	B	B	B-	B-	0
Market Research	C	B-	B-	B-	B	B	B+	B-	B	B	B	B+	A-	B	B-	B-	B-	C+	C+	B-	B-	B-	C+	-1
Design For Manufacturing	C+	B-	B	B	B	B	B	C+	B-	B	B+	A-	A-	B+	B-	B	B+	A-	A-	A-	B+	B	B	0
Established Infrastructure	C+	B	B+	A	A	A	A	A-	A-	A-	B+	B+	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B+	-1
Management Expertise	C	C	C+	C+	C+	C+	C+	B-	B-	B	B	B	B	B	B	B	B	B	B	B	B	B	B	0
Venture Capital Attraction	C	B-	B+	A	C	C-	C	C+	C+	C	C-	D	D+	D+	D+	D+	D+	D	D	D+	C-	C-	C	1
Creation Of Wealth	C	B-	B+	A	C	C-	C-	C-	C-	C	C-	D+	C-	C+	C+	C+	B-	C+	C+	C+	C+	C+	C+	0
Profitability	C-	C-	C-	C-	C-	C-	C-	C	C+	C	C-	D+	D	C-	C	C+	C+	C	C-	C-	C	C	C+	1
Industry Roadmap	INC	B-	B	B+	A-	A	A	B	B-	C+	C-	C-	C	C	C	C+	B-	C+	C	C-	C	C	C	0
Industry Association	INC	INC	INC	B	B+	B+	B+	B	B	B+	B	B	A-	B+	B+	B+	B+	B+	A-	B+	B-	B-	B-	0
Standards	INC	INC	INC	INC	C	B-	B-	B-	C+	C	C	C	C+	C	C	C+	B-	C+	C-	C-	C-	C	C	0
Employment	INC	INC	INC	INC	INC	C	C	C+	C+	C+	C	C-	C	C+	C+	C+	B-	B-	B	B	B	B	B	0
Cluster Development	INC	INC	INC	INC	INC	B	B+	B+	B	B-	C+	C+	C+	C	C+	C+	B-	C+	B-	C+	C+	C+	C+	0
Overall Grade	C+	B-	B	B	B-	B-	B	B	B-	B-	C+	C+	B-	B-	B-	B-	B	B-	B-	B-	B-	B-	B-	0

2020 VENTURE CAPITAL ATTRACTION

$\Delta = 2.21$



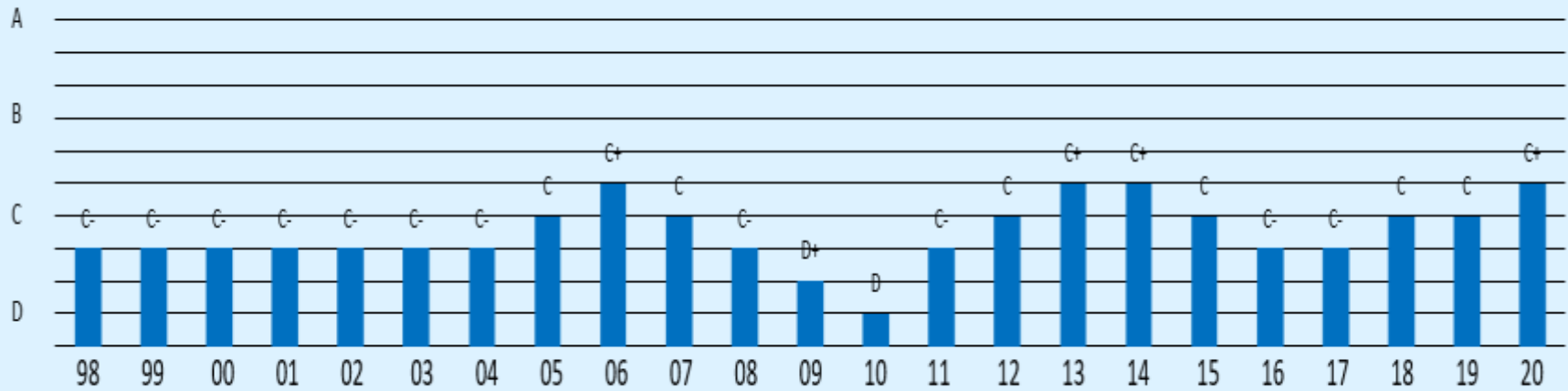
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ANALYSIS / COMMENTS

- 2020 GRADE C- 2020 GRADE C STANDARD DEVIATION=2.21
- VCs got interested in MEMS again and fueled in-part by COVID diagnostics
- SPAC/IPOs enabled several LIDAR technology companies to move forward
- There has been a growing interest in seed-level investing
- Government funding of medical devices surged as SPAC/IPOs
- Large advanced round funding events occurred with Exo Imaging, Butterfly, Vesper (\$8M), Innovusion (\$60M), and Barga (\$40M).
- Multiple startups were funded included Hinge Health (\$300M) and Oura (\$100m)
- It continues to be a challenge to compete with software innovation which have faster time to market as well as higher profitability
- Successes occur in bringing solutions/products to the market and not just components e.g. Exo Imaging ultrasonic imagers
- Much interest from mainland China VCs especially for China-based manufacturing

2020 PROFITABILITY

$\Delta = .99$



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ANALYSIS / COMMENTS

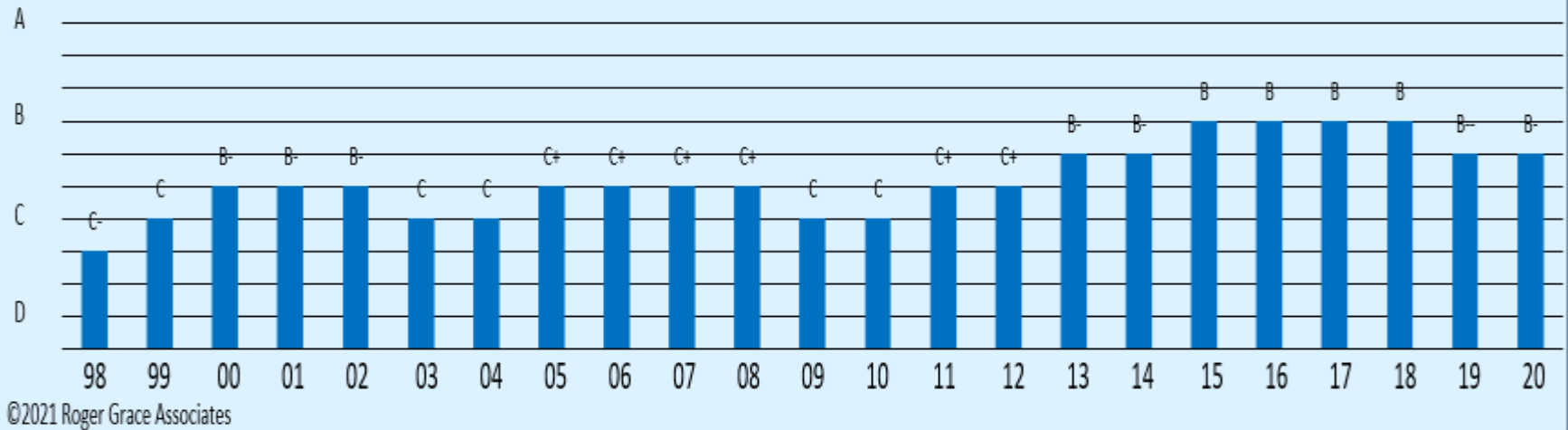
- 2019 Grade=C 2020 Grade= C+ Standard Deviation=0.99
- Many MEMS organizations have gone to professional management and were focused on cost reduction over the last few years
- Big company R &D investments were significantly reduced or eliminated in the short term...and this directly affected the bottom line in a positive sense...the question is...will this affect their long-term success?
- COVID has generated several new product application business opportunities for us
- As a result of the reduction in work force and work-in-place practices, overhead has been reduced thus increasing profitability
- Covid gave us an opportunity to eliminate our less-productive workforce
- The reduction of travel related business, marketing and market research activities and their associated expenses enhanced our profitability(Ref. 1)
- Profitability remains elusive due to continuous commoditization

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ROGER GRACE ASSOCIATES
MARKETING COUNSEL

2020 MARKETING

$\Delta=1.13$

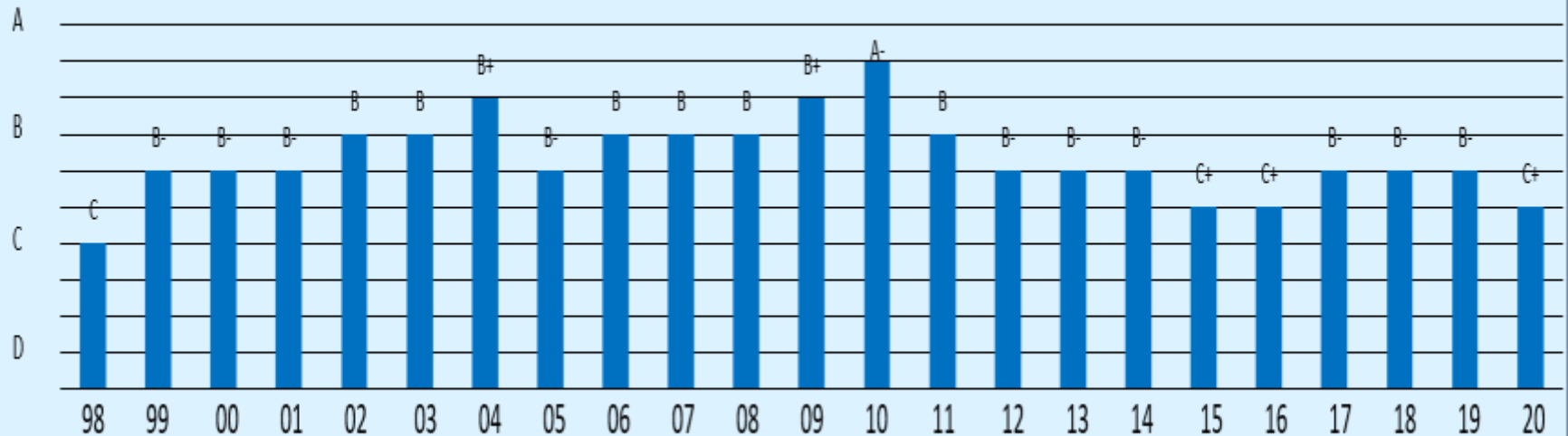


ANALYSIS / COMMENTS

- **2019 Grade=B-...2020 Grade=B- Standard Deviation=1.13**
- **MEMS has the same old problem which is that no one knows what MEMS are or what they can do... and therefore they do not care**
- **We as a MEMS community need to educate and sell MEMS as the most sexy technology in existence and if we do not...we will be ignored by the public and suffer the consequences**
- **The restrictions on in-person meetings, travel and attendance at trade shows/conferences has led to an embracing of social media and other communications vehicles to support organizations' marketing efforts**
- **Direct mail e.g. Constant Contact and webinars have come into play as valuable and cost effective promotional vehicles (Ref. 1)**
- **What will be the "new normal" when it comes to MEMS marketing?**

2020 MARKETING RESEARCH

$\Delta = 1.11$



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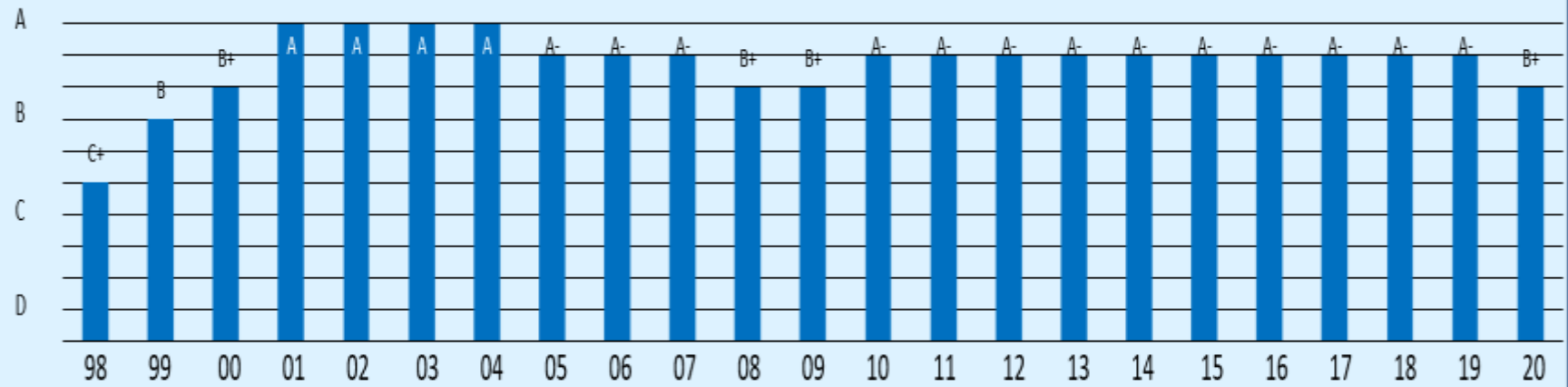
ANALYSIS/ COMMENTS

- **2019 Grade =B- 2020 Grade C+...Standard Deviation=1.11**
- **Not much change**
- **I still see too many startups with unrealistic business plans from a time-to-market and sales volume perspective based on their lack of support for smart market research**
- **Reduction in sales and corresponding marketing budgets including market research eliminated or reduced many programs previously funded**
- **Companies were trying to survive and R and D and marketing/market research budgets were considered unnecessary and the first to go**
- **MEMS industry management has historically not placed much value on marketing and market research...and it continues to be so.**

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2020 ESTABLISHED INFRASTRUCTURE

$\Delta = 1.10$



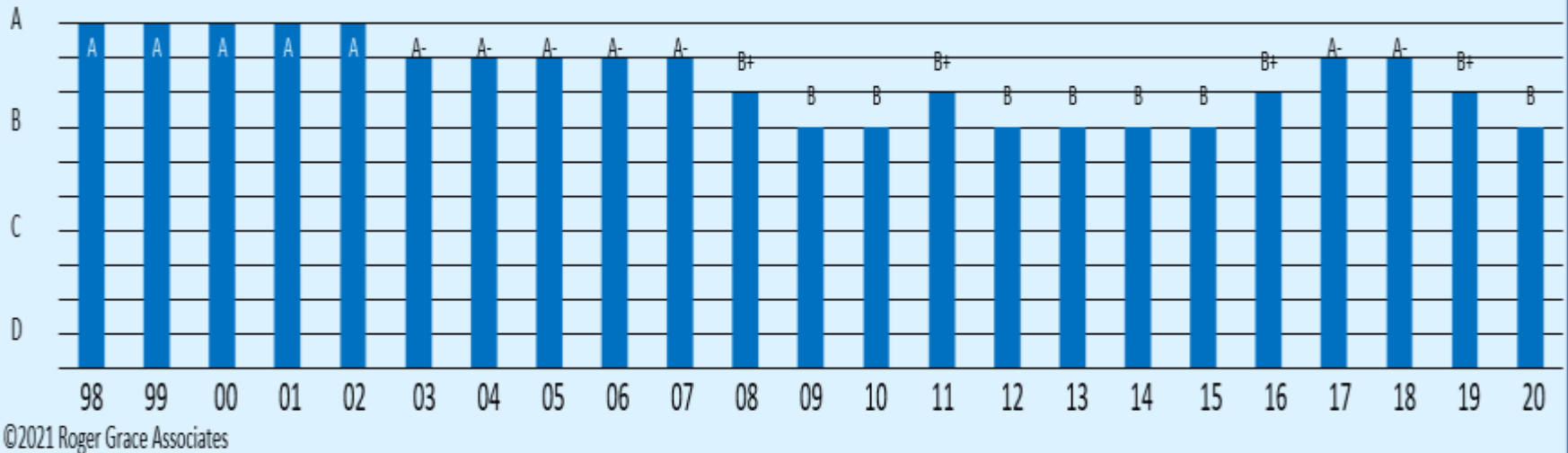
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ANALYSIS / COMMENTS

- **2019 Grade=A- 2020 Grade=B+ Standard Deviation=1.10**
- **We have foundries...yes. Are they state of the art? Increasingly the answer is no.**
- **US government has not supported MEMS infrastructure for many years.**
- **No coordinated effort amongst foundries.**
- **The MEMS industry did not respond to COVID well. Supply chains were horrible.**
- **While it is widely publicized that companies are investing, they are investing in uniquely 300 mm. Thus, significant gaps in capacity exist for 200 mm. MEMS product manufacturing infrastructure**
- **We have developed our own internally and try to leverage it as much as possible within our semiconductor business**
- **MEMS manufacturing increased last year in ASIA with the opening of several large foundries**
- **The digitization of products and production plays an important role for all companies...good MEMS products are no longer enough**

2020 RESEARCH AND DEVELOPMENT

$\Delta = 1.16$



ANALYSIS / COMMENTS

- 2019 Grade=B+ 2020 Grade=B Standard Deviation=1.16
- DARPA lost interest in MEMS several years ago which set the standard for several other agencies to follow
- US needs huge government funding to create a major breakthrough and enable revolutionary research to be performed
- Perhaps the new administration's apparent interest in funding semiconductors will have a halo effect on MEMS
- Pandemic was in full force and disruption at universities has seriously affected faculty and student research activities
- Many foreign students were not able to return to campus and thus negating their efforts
- Shifting to working at home/shelter in place negatively activities at universities and corporate labs
- Converting university activities continue to be a challenge for bringing products to market
- Young new professors supplementing experienced ones who helped create this field

IMPLICATIONS OF COVID ON GRADES

- INTRODUCTION

- As seen in the previous slides, several of the grades have been affected by COVID demonstrated by grade changes both positive and negative
- The many insightful verbatims provided by the respondents addressed several of these issues from their personal perspectives
- Especially affected negatively were R & D, Infrastructure and marketing/marketing research
- In addition to the subjects addressed in detail earlier, other subjects affected by COVID included employment

- GRADE SUMMARY EFFECTS

- R & D...work at home negatively affected progress
- Marketing/Market Research...elimination of travel affected in-person meetings and conferences...however compensated for by virtual events
- Infrastructure...supply chains were severely challenged and under-performed
- VC Attraction...COVID accelerated new investments in biomed and supported later stage commitments
- Profitability...reduction of work force, overhead and reduced R & D and marketing budgets increased profitability
- With the recent surge in COVID cases in Q-3, 2021, we believe that the Report Card for 2021 will be similarly affected

SUMMARY / CALL TO ACTION / RECOMMENDATIONS

- Continue to create significant awareness as to the unique solution benefits of MEMS based system solutions (MBSS)...add value
- Understand customer / market needs vis-à-vis rigorous market research
- Define and establish defensible product differentiation
- Adoption of a marketing / applications pull vs. technology push strategy
- Adopt new media strategies including social media, webinars, email to keep/develop new customers...lessons learned from COVID
- Continue to develop manufacturing / packaging solutions that can help differentiate the product from a price/feature/performance perspective...packaging and testing will continue to be “king”
- Embrace system solutions/integrated products vs. component approach to maximize value and encourage investments e.g.ExoSystems
- Accept the fact that obtaining VC funding for MEMS will continue to be a big struggle / a better route are angels / industrial partnering / buy- outs
- “Those who forget the past are condemned to relive it”...George Santayana...Reason in the Common Sense, 1905

REFERENCES

- [1] R. Grace; Marketing in a Recession: How to Survive; Sensors Daily; April 8, 2020; www.rgrace.com.
- [2] R. Grace; 2020 MEMS Industry Commercialization Report Card; Fierce Electronics; July 25,2021; www.rgrace.com.

FOR MORE INFORMATION

- A copy of the article on the 2020 MEMS Industry Commercialization Report Card which was published in the July 25 issue of Fierce Sensors/Fierce Electronics appears on the Roger Grace Associates website www.rgrace.com Ref. 2.