

TMRC 2020 conference Technology Survey



Survey this year 1/2

Survey of opinions on technology intercepts for HDD and MRAM industry.

1. Describe your affiliation ?

- HDD Industry Member
- MRAM Industry Member
- Academia
- Vendor
- Other

Typically Survey issued in 2 waves:

•However the response rate was lower this year, so we consolidated the pre and post conference survey into one.

2. What is the Maximum Areal Density Capability expected for Perpendicular/Shingled/Two dimensional - magnetic recording extensions?

3. What is the expected Year of Technology introduction to HDD Products ?

	2020	2021	2022	2023	2024	2026	2028	2030	Never
BPM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
HAMR	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
MAMR	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
HDMR(BPM+HAMR)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Survey this year 2/2

MRAM questions....

3. What is the expected Year of Technology introduction to HDD Products ?

	2020	2021	2022	2023	2024	2026	2028	2030	Never
BPM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
HAMR	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
MAMR	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
HDMMR(BPM+HAMR)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. What is the expected STAND_ALONE MRAM capacity (Megabits) per chip in 2021?

256 Mb	512Mb	1 Gb	2 Gb	4 Gb	N/A
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. What is the expected EMBEDDED MRAM capacity (Megabits) per chip in 2021

256 Mb	512Mb	1 Gb	2 Gb	4 Gb	N/A
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. What is the expected NAND capacity (Gigabits) per chip in 2021?

1000 Gb	2000 Gb	3000 Gb	5000 Gb	10,000 Gb	N/A
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

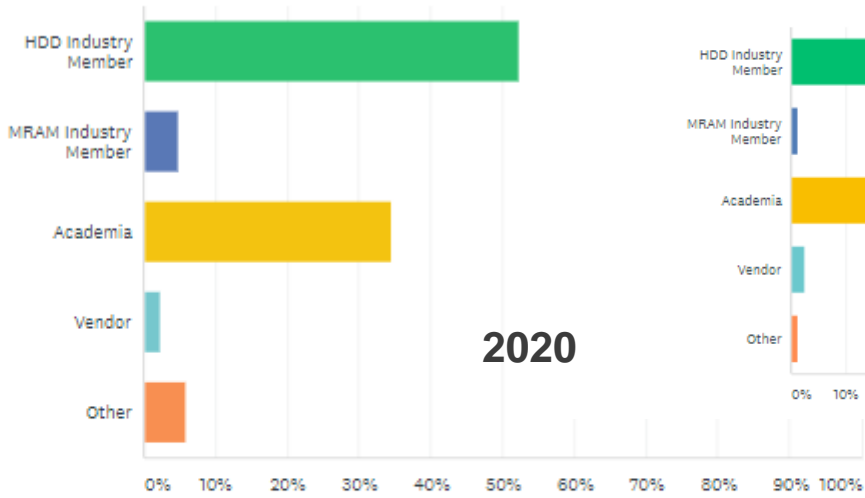
Population of respondents up to 08/26/20 (post conference)

As with 2015-19.

Dominant responses from HDD members.

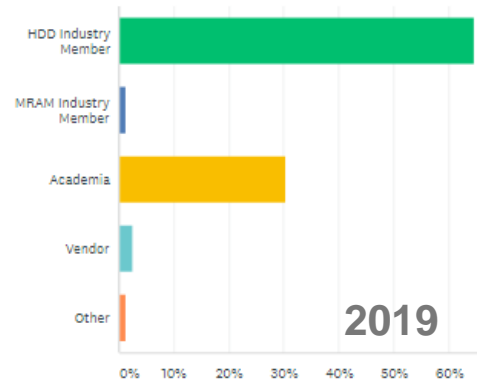
Describe your affiliation ?

Answered: 84 Skipped: 0



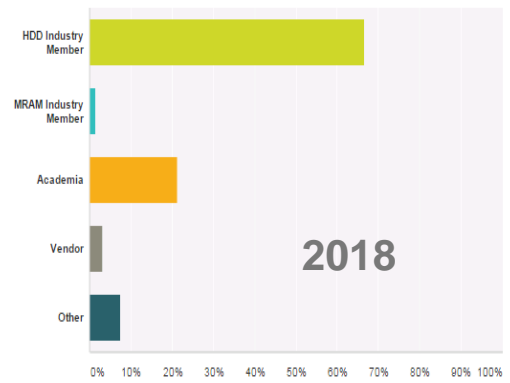
Describe your affiliation ?

Answered: 79 Skipped: 0



Describe your affiliation ?

Answered: 66 Skipped: 0



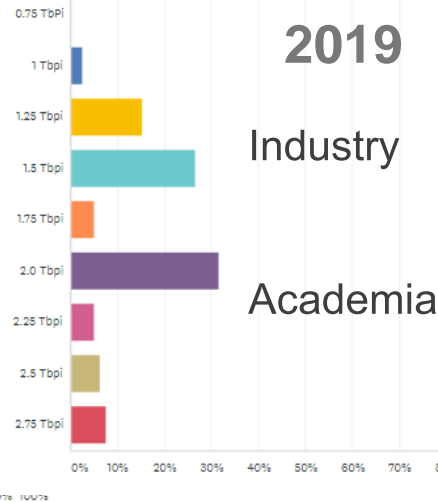
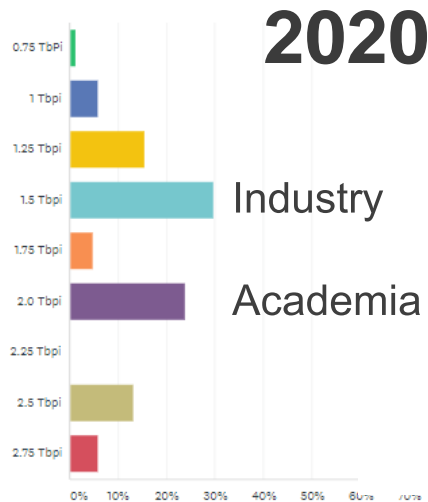
ANSWER CHOICES	RESPONSES	
▼ HDD Industry Member	52.38%	44
▼ MRAM Industry Member	4.76%	4
▼ Academia	34.52%	29
▼ Vendor	2.38%	2
▼ Other	5.95%	5
TOTAL		84

Maximum ADC, for conventional technology

- Median of 1.5Tb/inch² +/-0.25, mean of 1.75 Tb/inch²
- A few optimistic voters for 2.5 Tb/inch², and above.
- Bimodality between Academia and Industry (lower mode for industry)
- Pattern very similar to 2019/2018

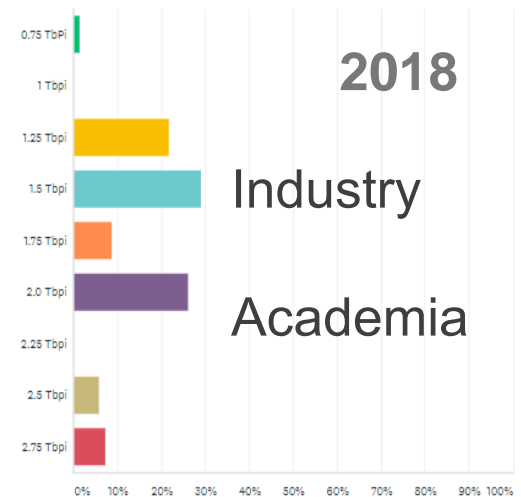
What is the Maximum Areal Density Capability expected for Perpendicular/Shingled/Two dimensional - magnetic recording extensions? Answered: 79 Skipped: 0

Answered: 84 Skipped: 0



What is the Maximum Areal Density Capability expected for Perpendicular/Shingled/Two dimensional - magnetic recording extensions? Answered: 69 Skipped: 0

Answered: 69 Skipped: 0



Expected introduction year

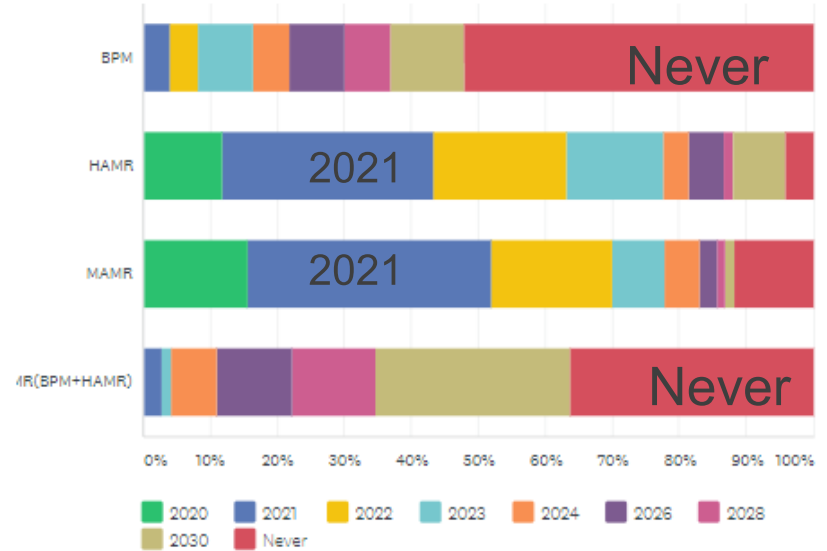
Answered: 80 Skipped: 4

Pessimism for MAMR reduced in 2017, and improved 2018- drift back up 2019+ stayed.

BPM/Heated Dot remains pessimistic

Focus in next slide on specific fraction of people that think a technology will not work

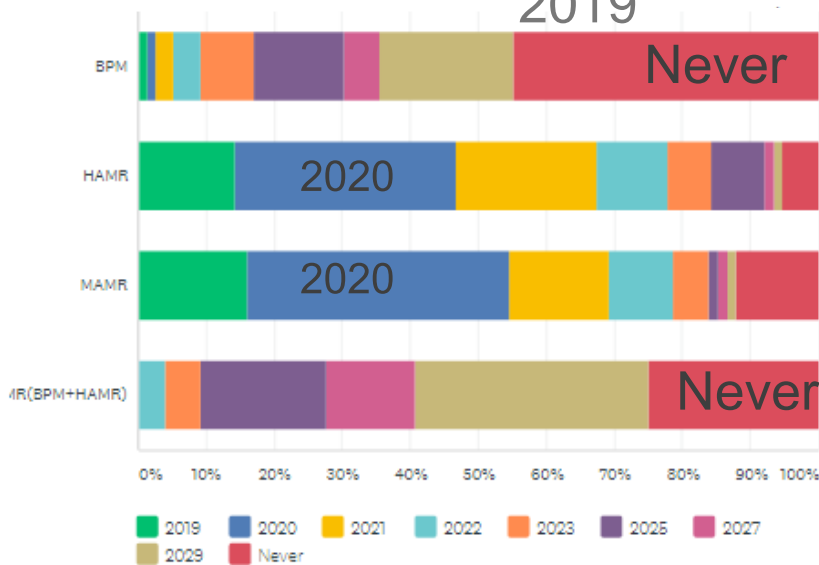
2020



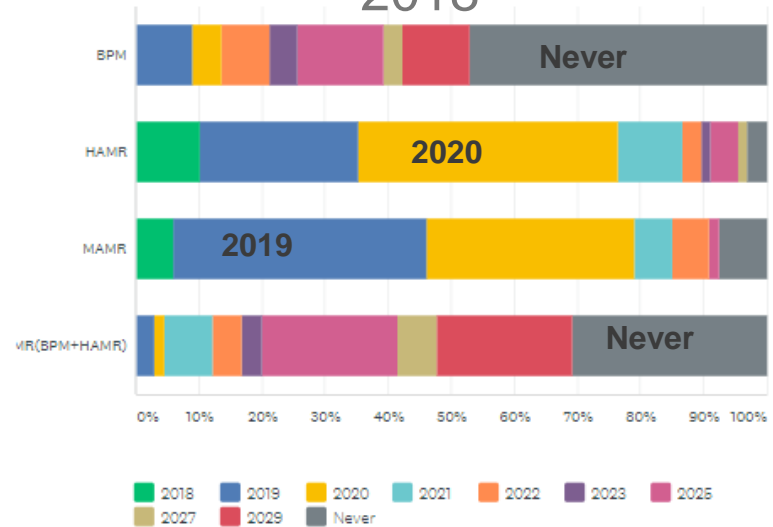
2019

What is the expected Year of Technology introduction to HDD Products ?

Answered: 68 Skipped: 1

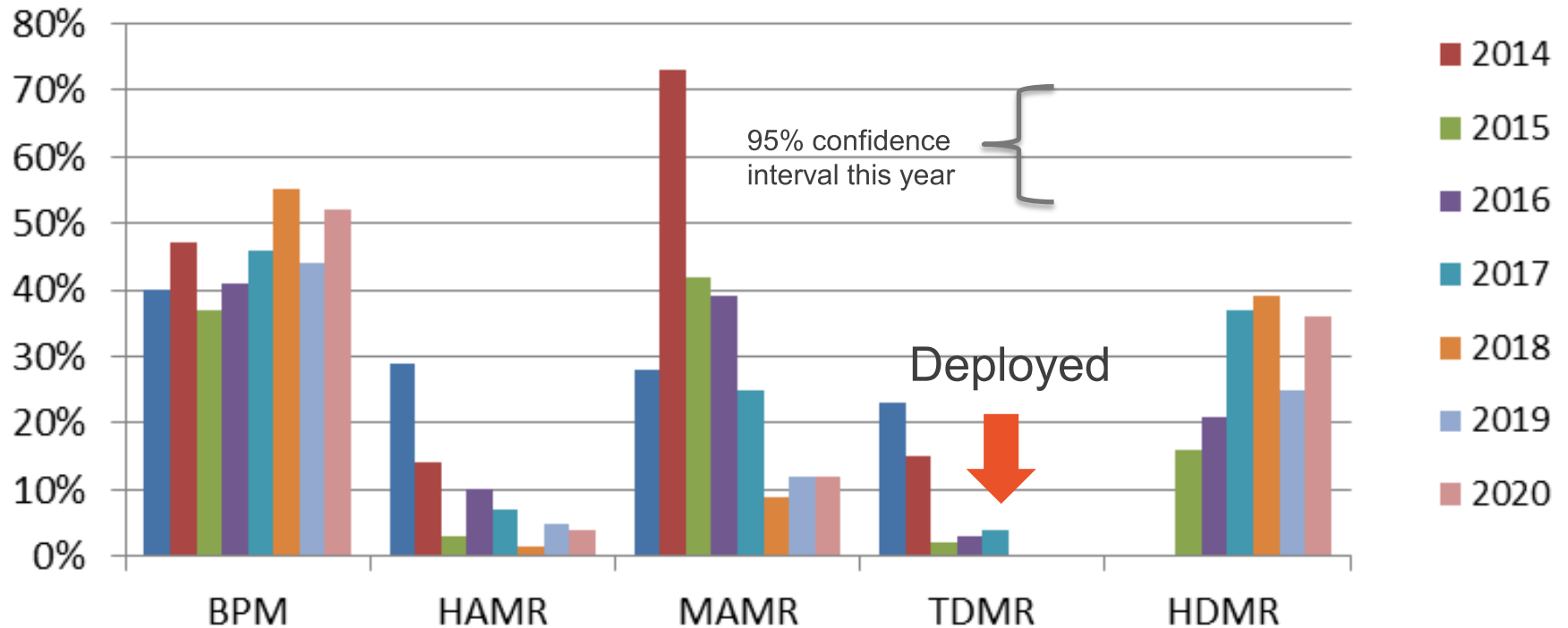


2018



Technology pessimism(Never): Compare 2020 with 2019-2013

Technology Pessimism - by survey year



From left to right..

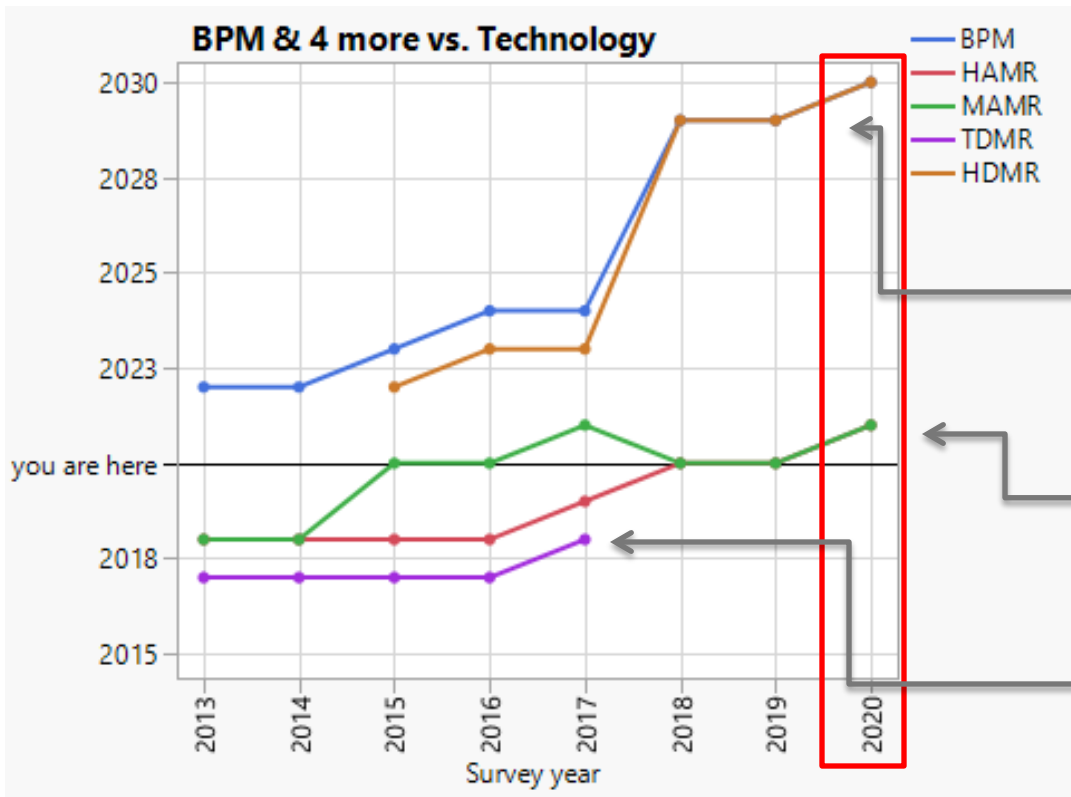
- BPM appears stable and poor.
- HAMR confidence steady improved.
- MAMR hit a bad patch 2014, started recovery in 2016-2017, and significantly improved 2018.
- TDMR Launched 2017 into product – so removed 2018.
- HDMR confidence – higher than BPM but still poor, may have improved?

Technology	BPM	HAMR	MAMR	TDMR	HDMR
2013	40%	29%	28%	23%	
2014	47%	14%	73%	15%	
2015	37%	3%	42%	2%	16%
2016	41%	10%	39%	3%	21%
2017	46%	7%	25%	4%	37%
2018	55%	2%	9%		39%
2019	44%	5%	12%		25%
2020	52%	4%	12%		36%

Technology Introduction year

Technology	BPM	HAMR	MAMR	TDMR	HDMR
2013	2022	2018	2018	2017	N/A
2014	2022	2018	2018	2017	N/A
2015	2023*	2018	2020*	2017	2022
2016	2024*	2018	2020*	2017	2023
2017	2024*	2019	2021*	2018	2023*
2018	2029*	2020	2020	-	2029*
2019	2029*	2020	2020	-	2029*
2020	2030*	2021	2021	-	2030*

*Pessimism is high
So confidence on introduction year is poor.



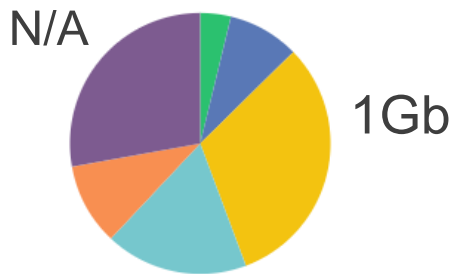
- BPM and HDMR continues to drift out.
- MAMR and HAMR both moved to 2021.
- TDMR Launched 2017

MRAM questions- Stand Alone Memory

What is the expected STAND_ALONE MRAM capacity (Megabits) per chip in 2021?

Answered: 79 Skipped: 5

2020



256 Mb 512Mb 1Gb 2 Gb 4 Gb N/A

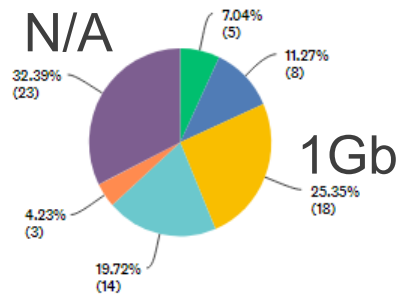
	256 MB	512MB	1 GB	2 GB	4 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	3.80% 3	8.86% 7	31.65% 26	17.72% 14	10.13% 8	27.85% 22	79	4.30

1 or 2 GB per chip remains most popular choice, and stable.

What is the expected STAND_ALONE MRAM capacity (Megabits) per chip in 2020?

Answered: 71 Skipped: 8

2019



256 Mb 512Mb 1 Gb 2 Gb 4 Gb N/A

	256 MB	512MB	1 GB	2 GB	4 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	7.04% 5	11.27% 8	25.35% 18	19.72% 14	4.23% 3	32.39% 23	71	4.04

the expected STAND_ALONE MRAM capacity (Megabits) per chip in

Skipped: 11

2018

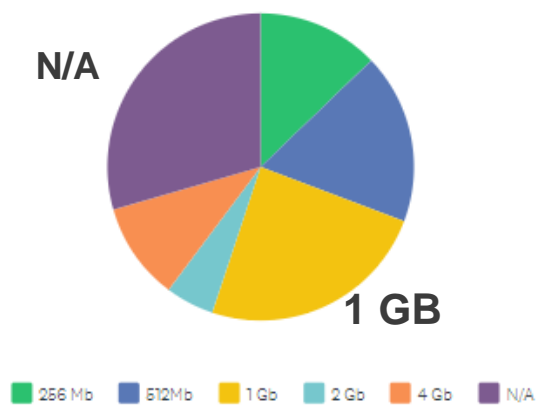


256 Mb 512Mb 1 Gb 2 Gb 4 Gb N/A

	256 MB	512MB	1 GB	2 GB	4 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	0.00% 0	8.62% 5	25.86% 16	20.69% 12	8.62% 5	36.21% 21	68	4.46

What is the expected EMBEDDED MRAM capacity (Megabits) per chip in 2021

Answered: 78 Skipped: 6



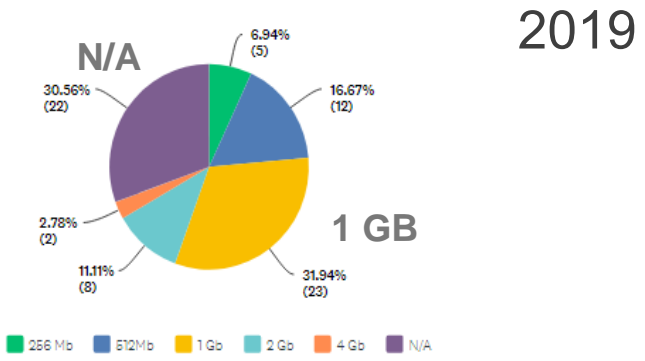
	256 MB	512MB	1 GB	2 GB	4 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	12.82% 10	17.95% 14	24.36% 19	5.13% 4	10.26% 8	29.49% 23	78	3.71

Embedded MRAM

Similar to 2018
512 and 1 Gb most popular
Moving more into 1Gb node.

What is the expected EMBEDDED MRAM capacity (Megabits) per chip in 2020

Answered: 72 Skipped: 7



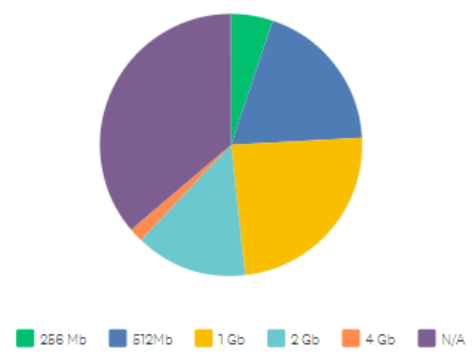
	256 MB	512MB	1 GB	2 GB	4 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	6.94% 5	16.67% 12	31.94% 23	11.11% 8	2.78% 2	30.56% 22	72	3.78

2019

What is the expected EMBEDDED MRAM capacity (Megabits) per chip in 2020

Answered: 58 Skipped: 11

N/A



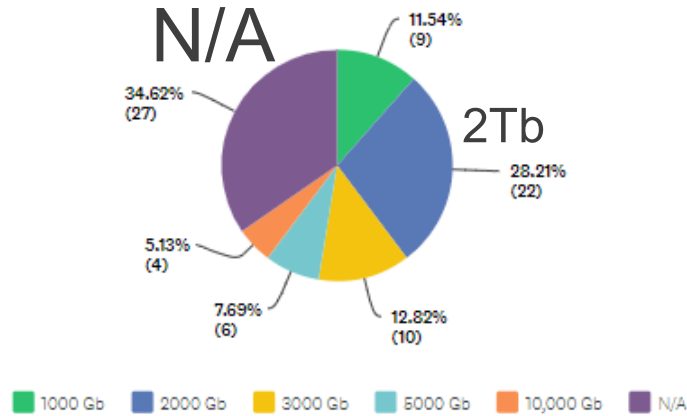
	256 MB	512MB	1 GB	2 GB	4 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	5.17% 3	18.97% 11	24.14% 14	13.79% 8	1.72% 1	36.21% 21	68	3.97

2018

NAND Question

What is the expected NAND capacity (Gigabits) per chip in 2021?

Answered: 78 Skipped: 6



2020

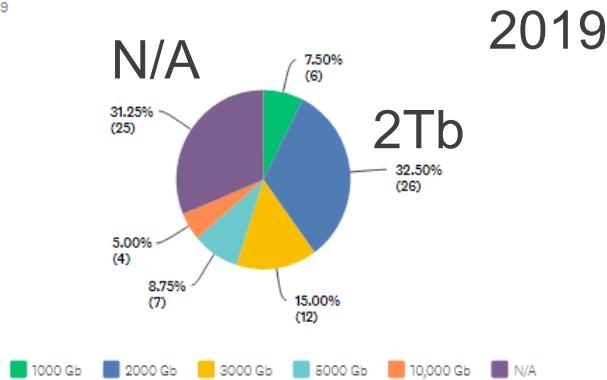
2Tb is most popular node. Which is a significant change in votes from 2018.

But stabilized since 2019

	1000 GB	2000 GB	3000 GB	5000 GB	10,000 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	11.54% 9	28.21% 22	12.82% 10	7.69% 6	5.13% 4	34.62% 27	78	2.49

What is the expected NAND capacity (Gigabits) per chip in 2020?

Answered: 80 Skipped: 9

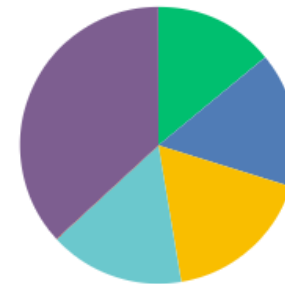


2019

What is the expected NAND capacity (Gigabits) per chip in 2020?

Answered: 57 Skipped: 12

2018



	1000 GB	2000 GB	3000 GB	5000 GB	10,000 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	7.50% 6	32.50% 26	15.00% 12	8.75% 7	5.00% 4	31.25% 25	80	2.68

	1000 GB	2000 GB	3000 GB	5000 GB	10,000 GB	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	14.04% 8	15.79% 9	17.54% 10	15.79% 9	0.00% 0	36.84% 21	57	2.66

THANK YOU

The 31st Magnetic Recording Conference
Virtual Conference Hosted by University
of California, Berkeley, Berkeley, CA

August 17-20, 2020

