

Same 10 Mask Makers in 2017, 2018 Surveys



- **Thank you to the participating Mask Makers:**
 - AMTC, DNP, GLOBALFOUNDRIES, Intel, PDMC, Photronics, Samsung, SMIC, TMC and Toppan
 - Independently collected by David Powell, Inc.
- **Collected data are “for the last 12 months (July 2017 to June 2018)”**
- **Mask Maker survey slides available at www.ebeam.org by Sept 18 7:30pm**

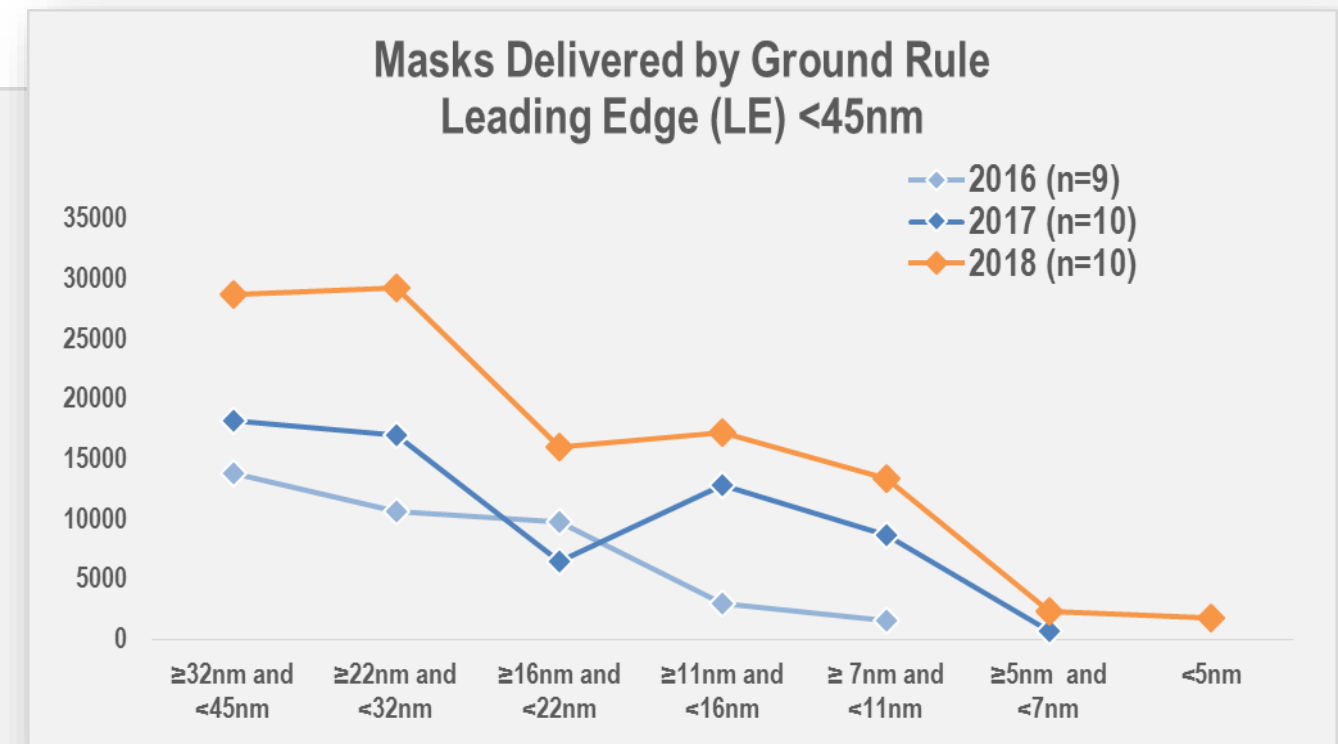
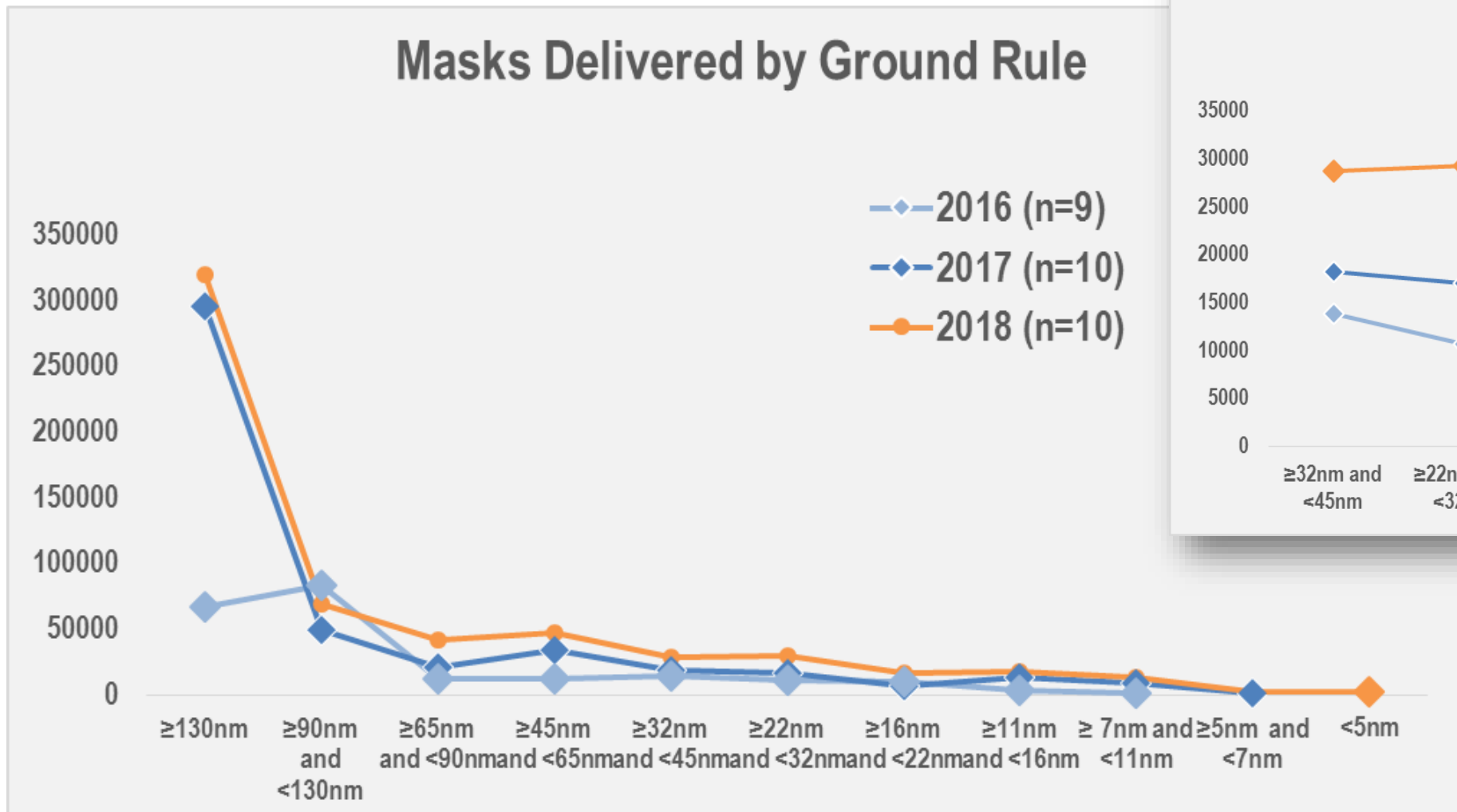
Mask Output Grew 27% Over Previous Year



- **Same 10 mask makers delivered 27% more masks in 2018**
 - Overall yield remained steady at 93.8%
- **EUV masks reported increased 2X from 1041 in 2017 to 2185 this year**
 - Yield improved to 72.2%
- **No progress in mask turnaround time for leading edge nodes**

587,233 Masks Delivered by 10 Companies

27% increase over 2017 (463,792)

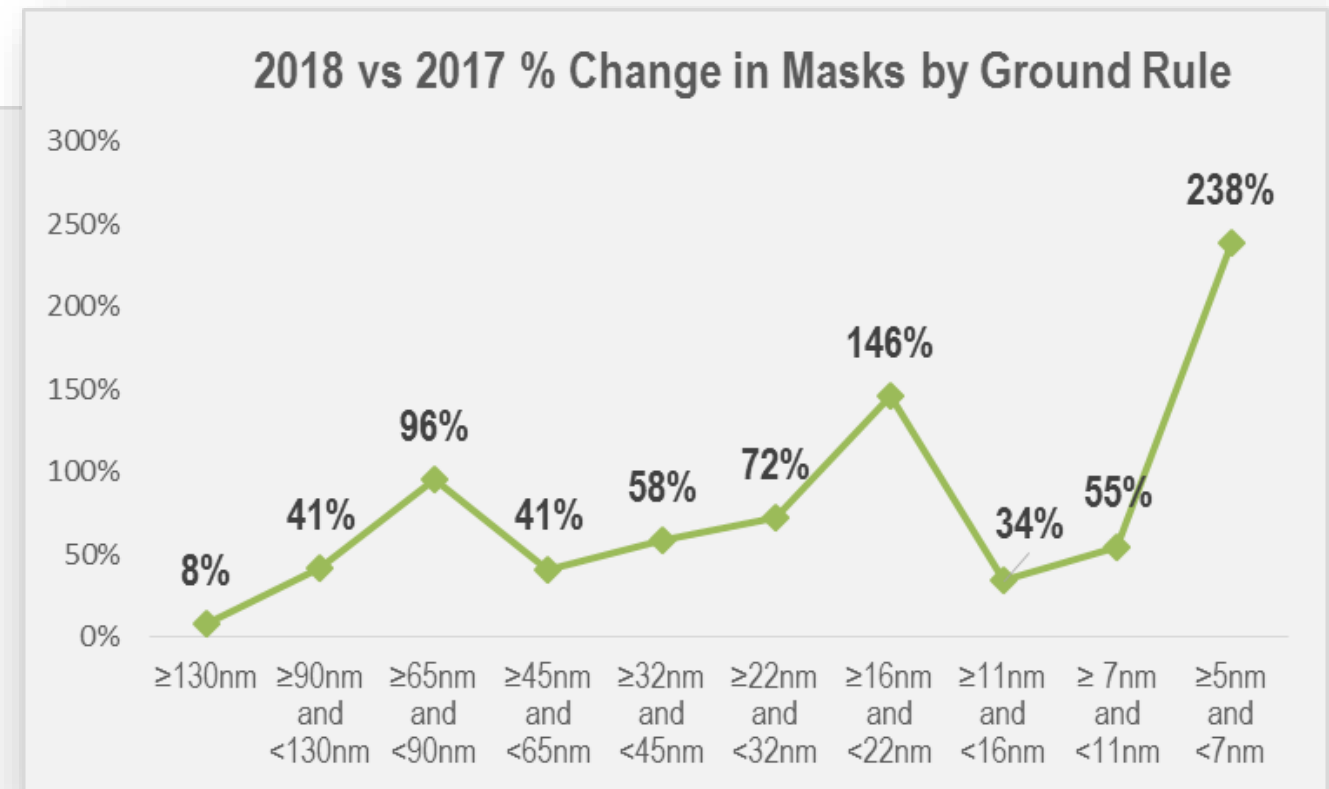
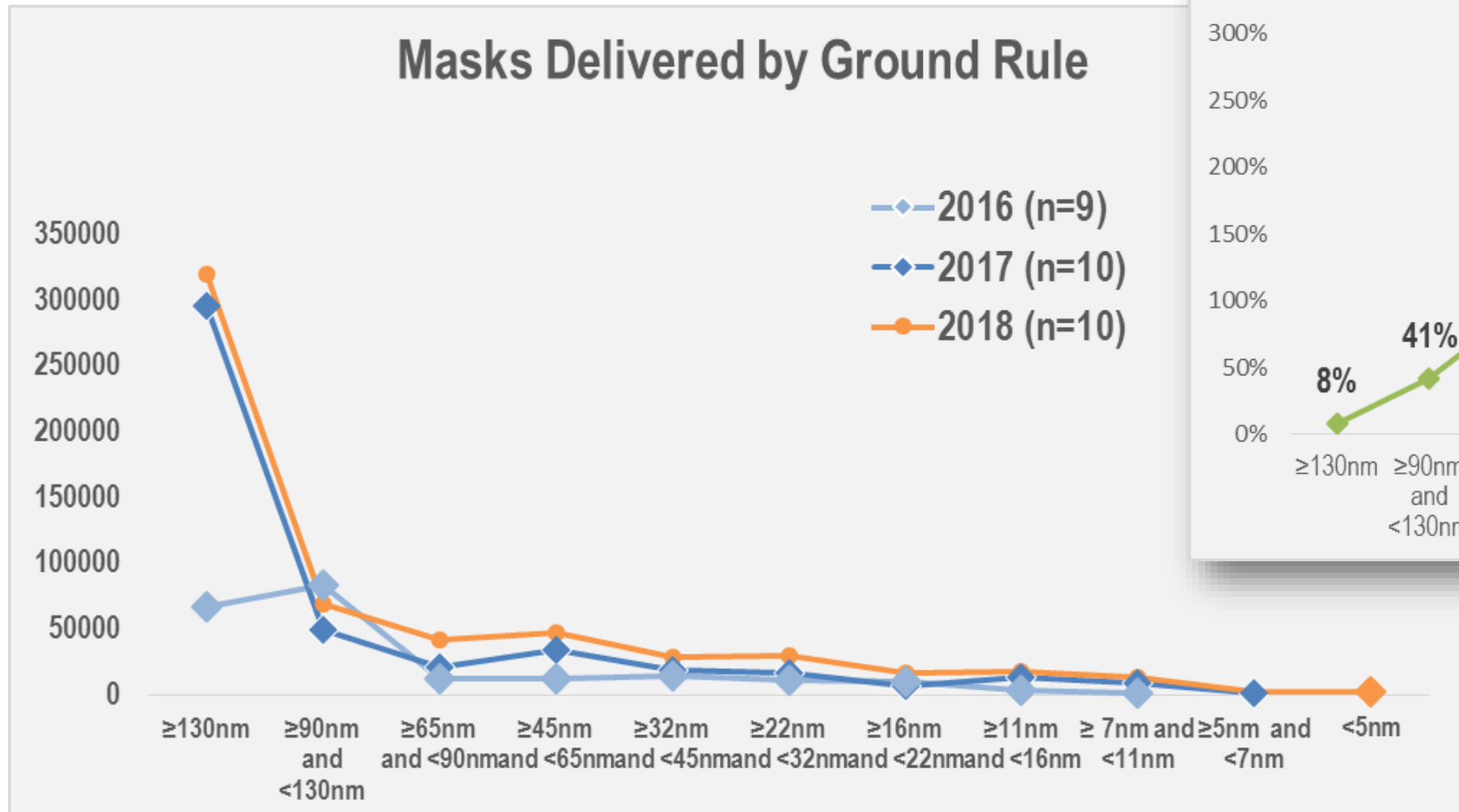


Q: What was the number of masks delivered?

Q: Percent of the total number of masks in the preceding question by Ground Rules?

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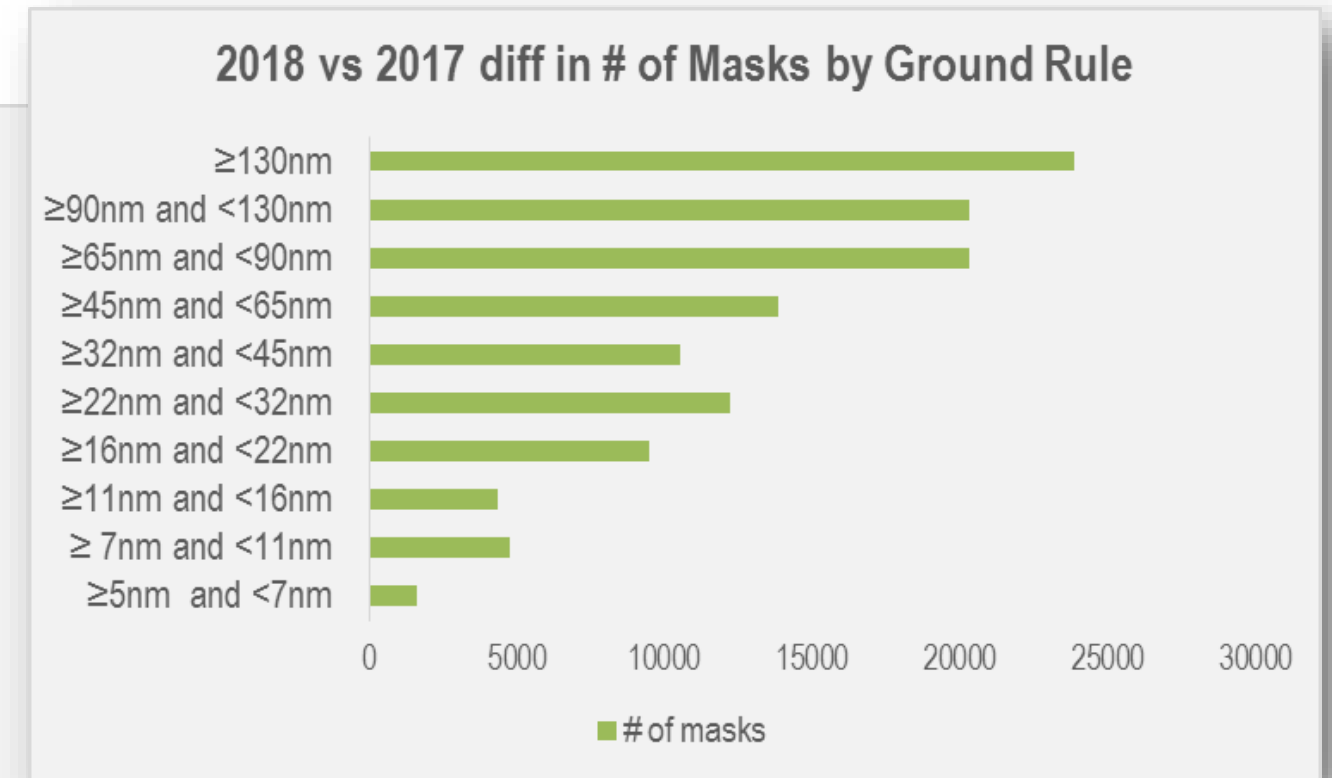
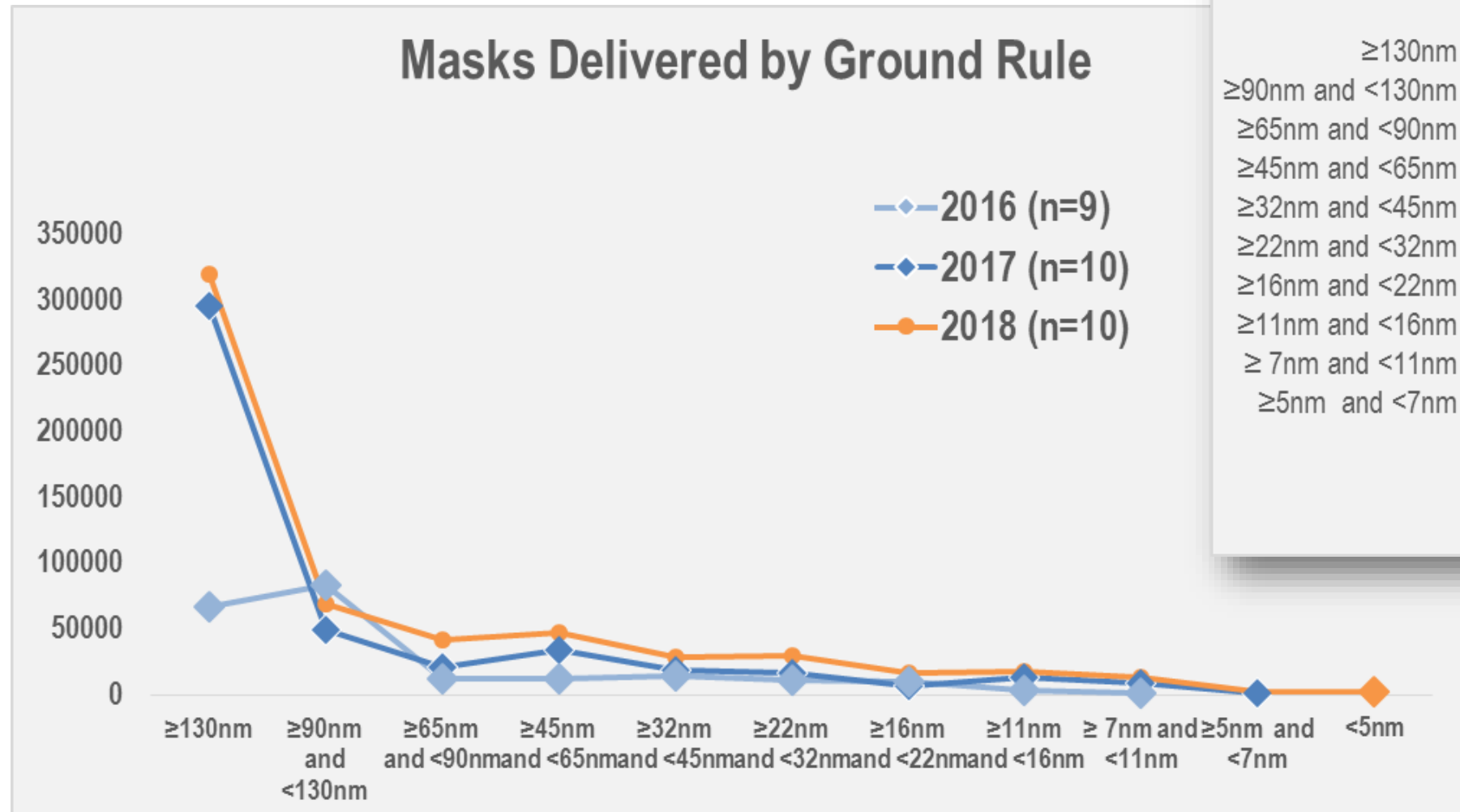


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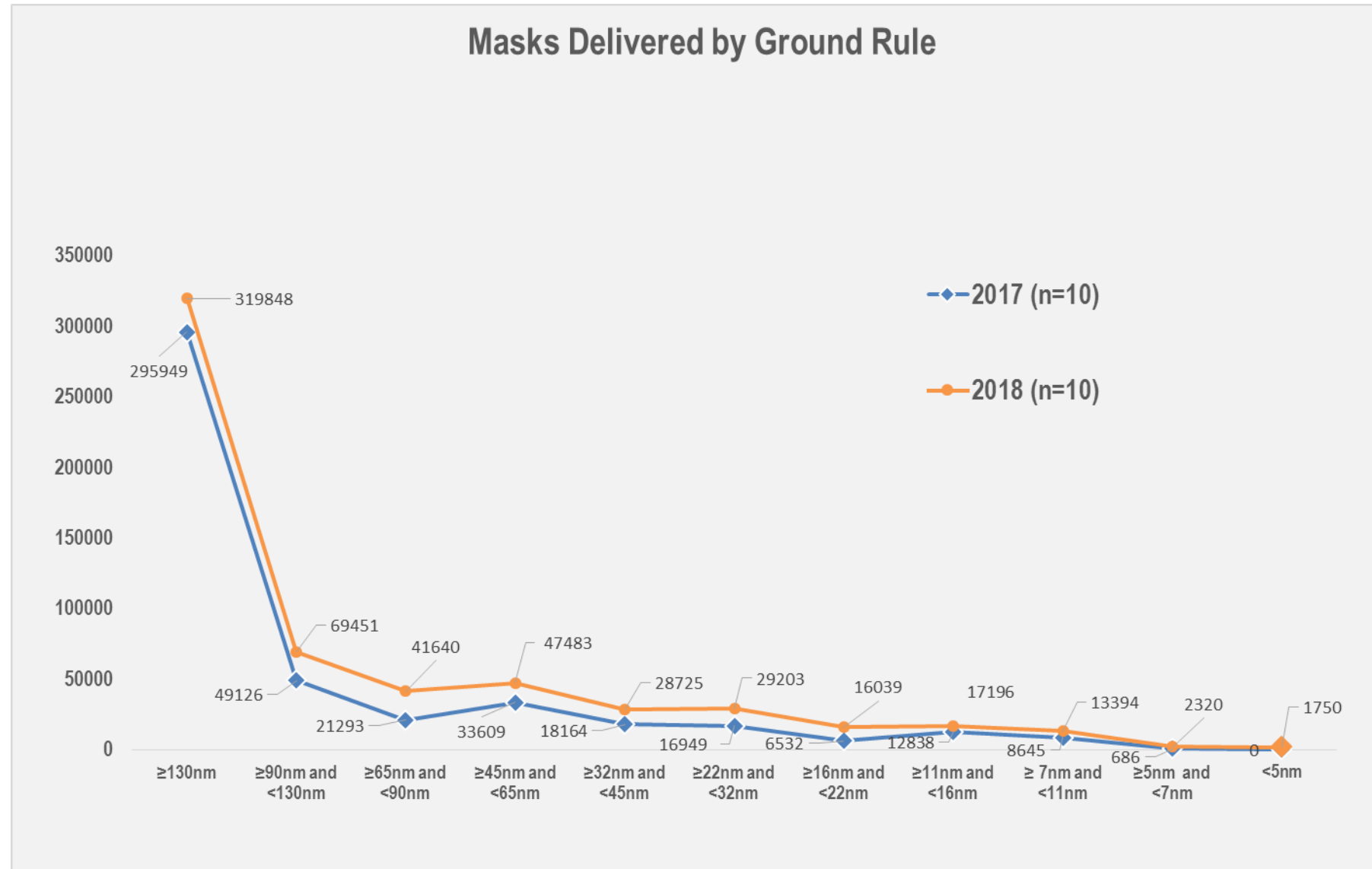
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2018 vs 2017 Masks Delivered by Ground Rule

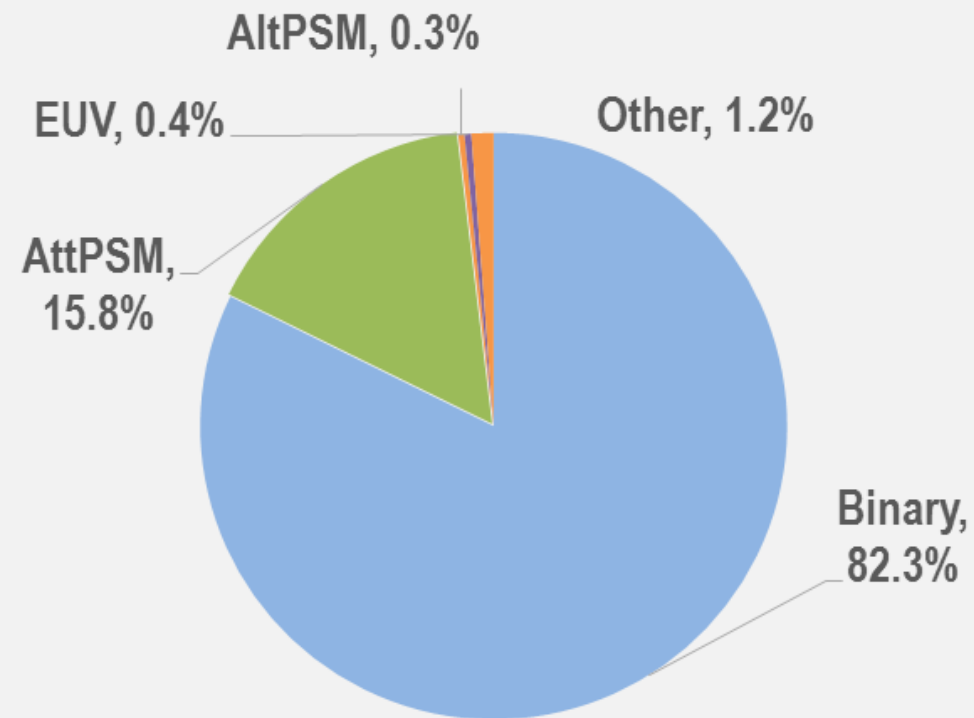


2185 EUV Masks Reported in 2018 Survey

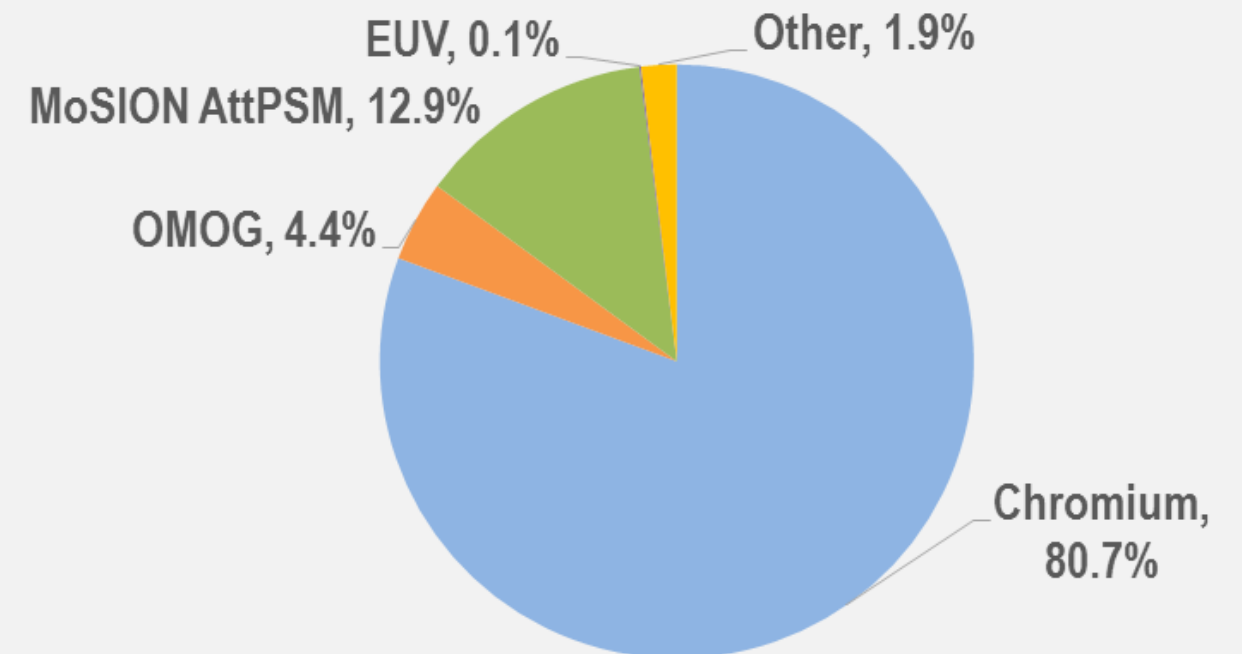
1041 EUV masks in 2017; OMOG was 2.6% in 2017



Masks Delivered by Type
2018 (n=10)



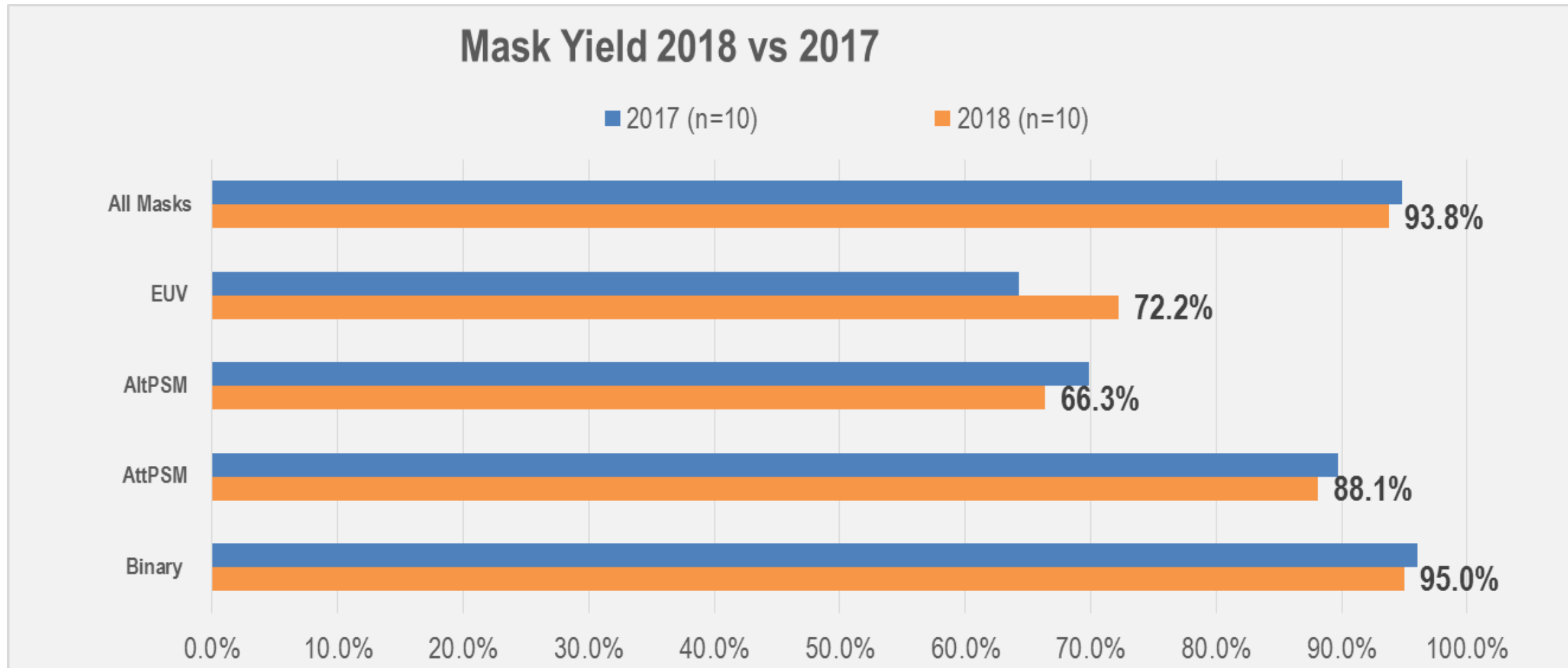
Masks Delivered by Substrate
2018 (n=10)



Q: What was the % by...?
Binary, AttPSM, AltPSM, EUV, Other

Q: What was the % by substrate type?
Chromium, OMOG, MoSION AttPSM, EUV, Other

Mask Yield Was 93.8%; EUV Yield Improved

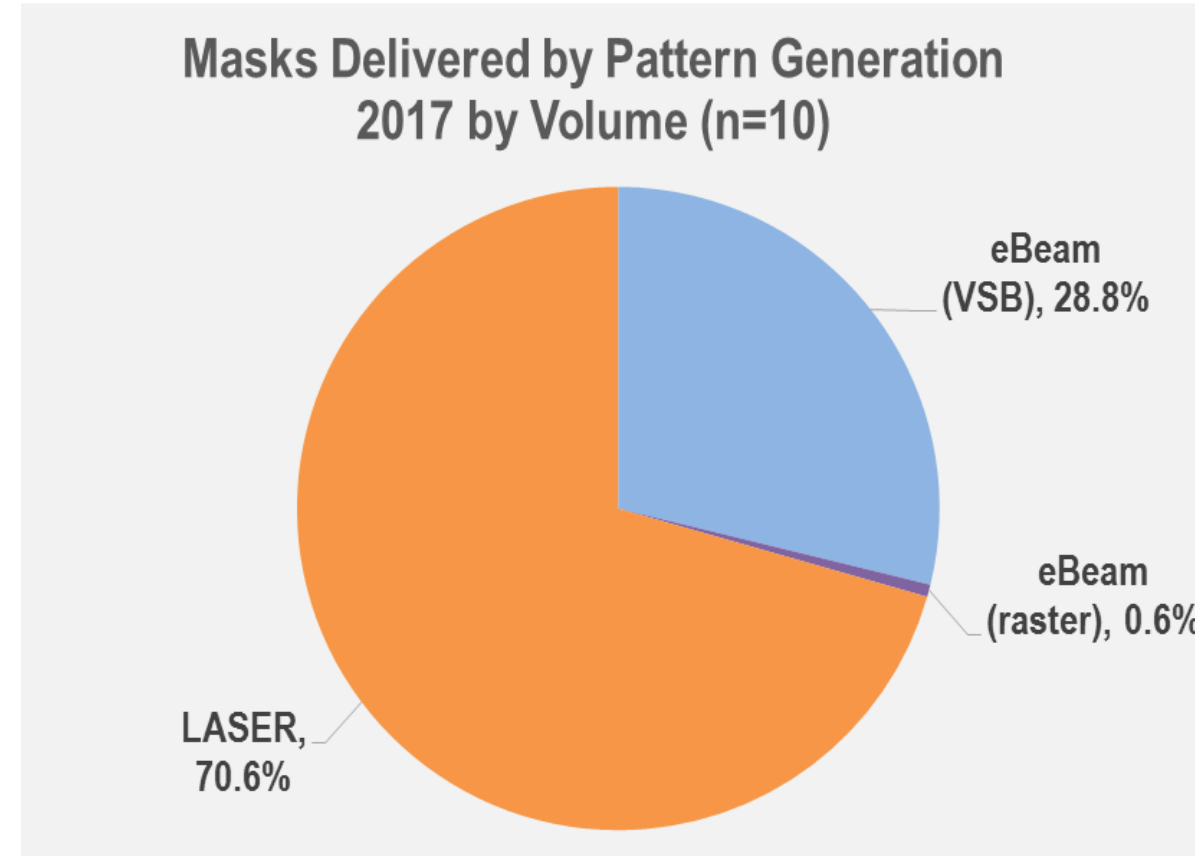
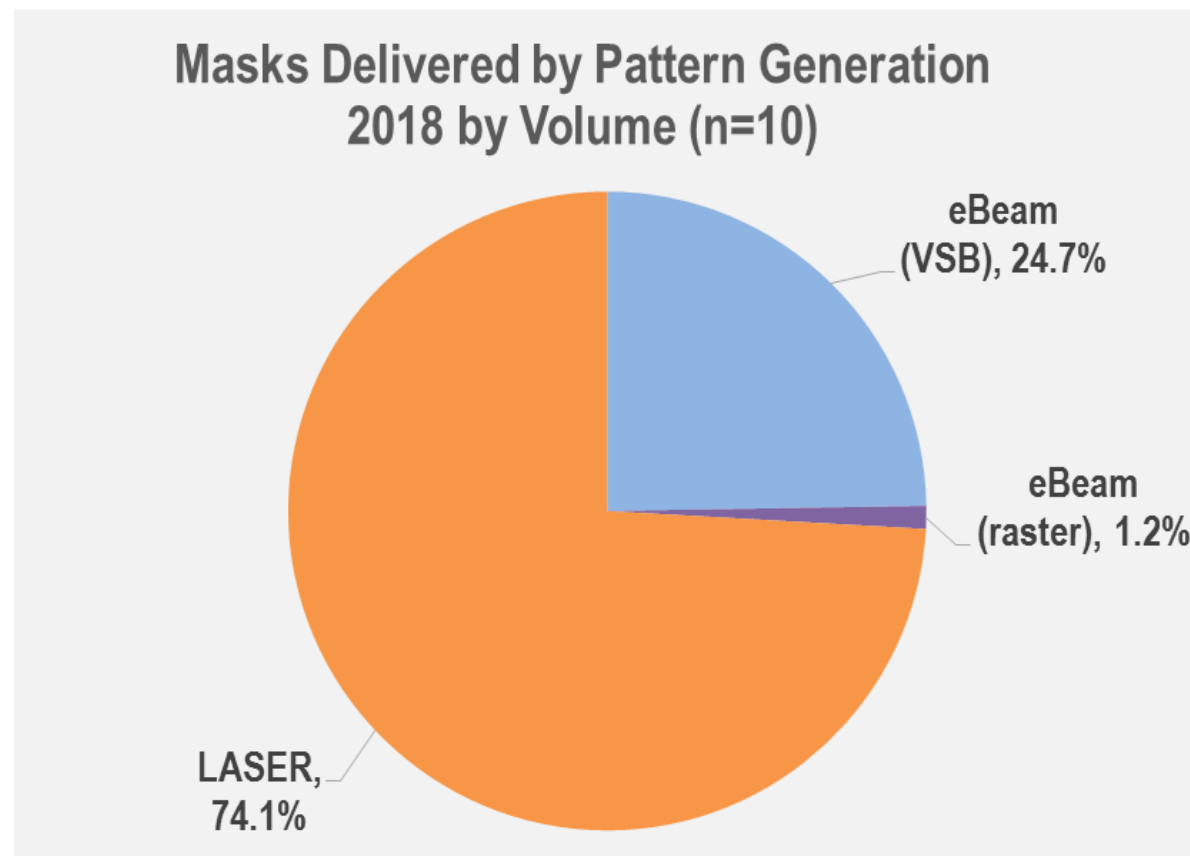


Q: What was your overall mask yield?

Q: What was your percent mask yield by category?

Pattern Generation Relatively Unchanged

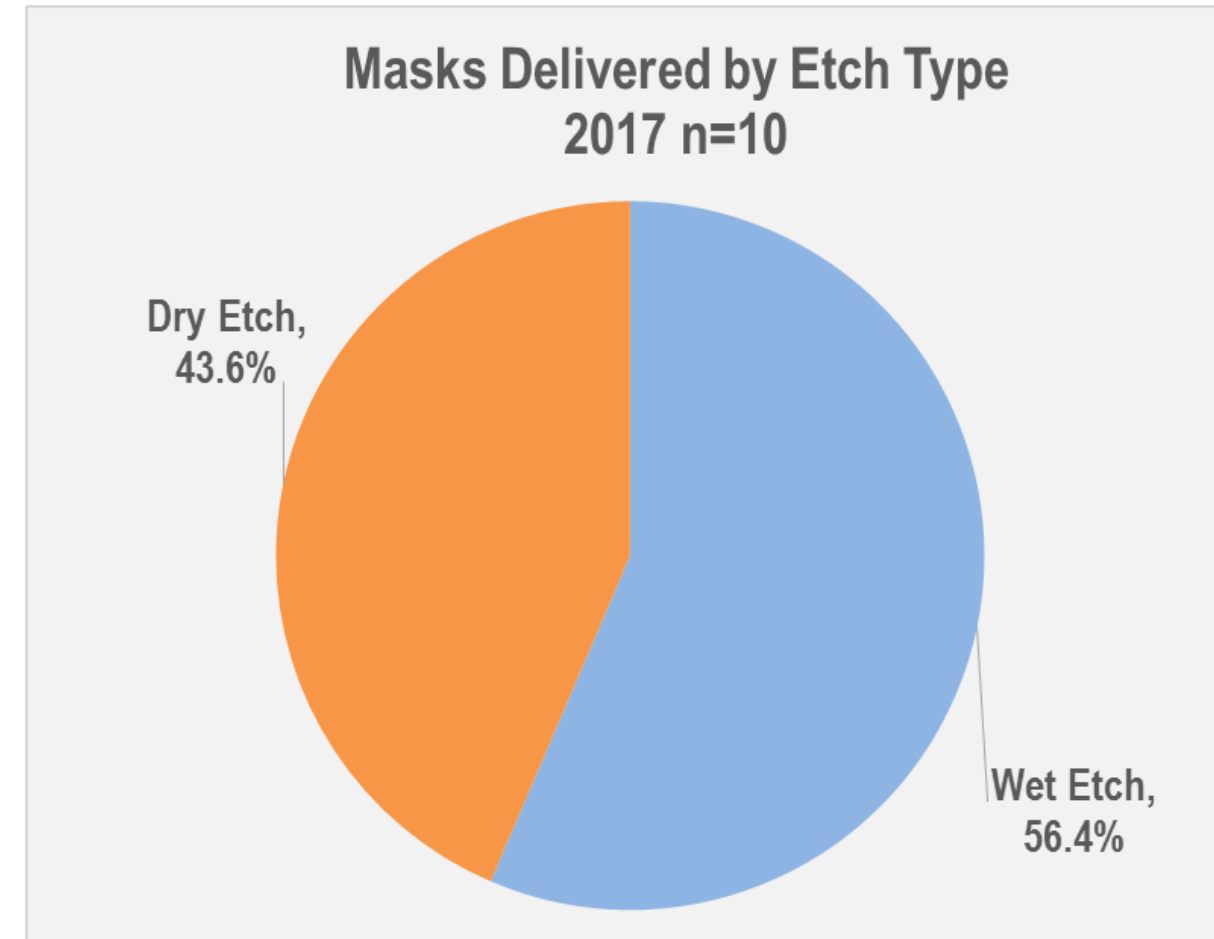
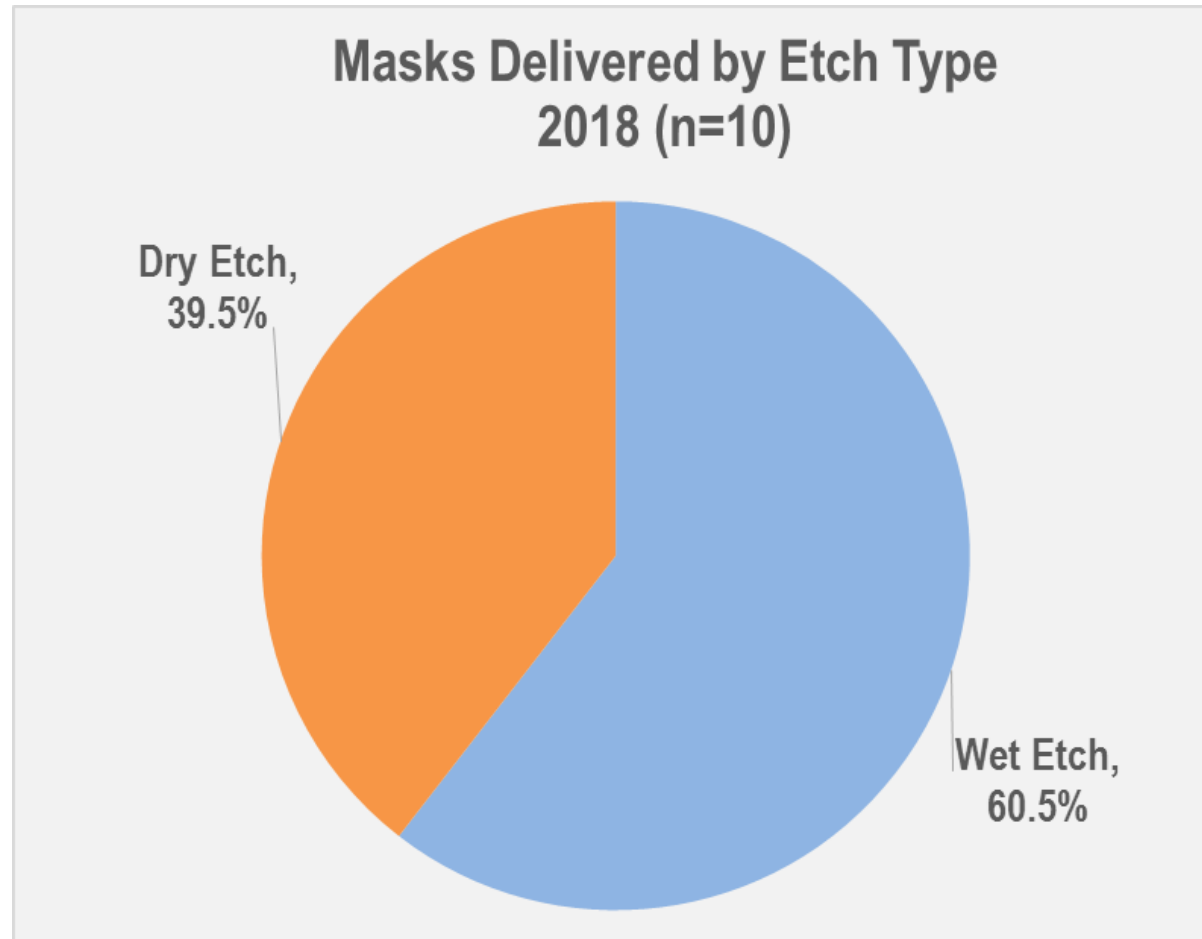
Not enough data to report Multi-beam



Q: What was the % written by the following pattern generation?

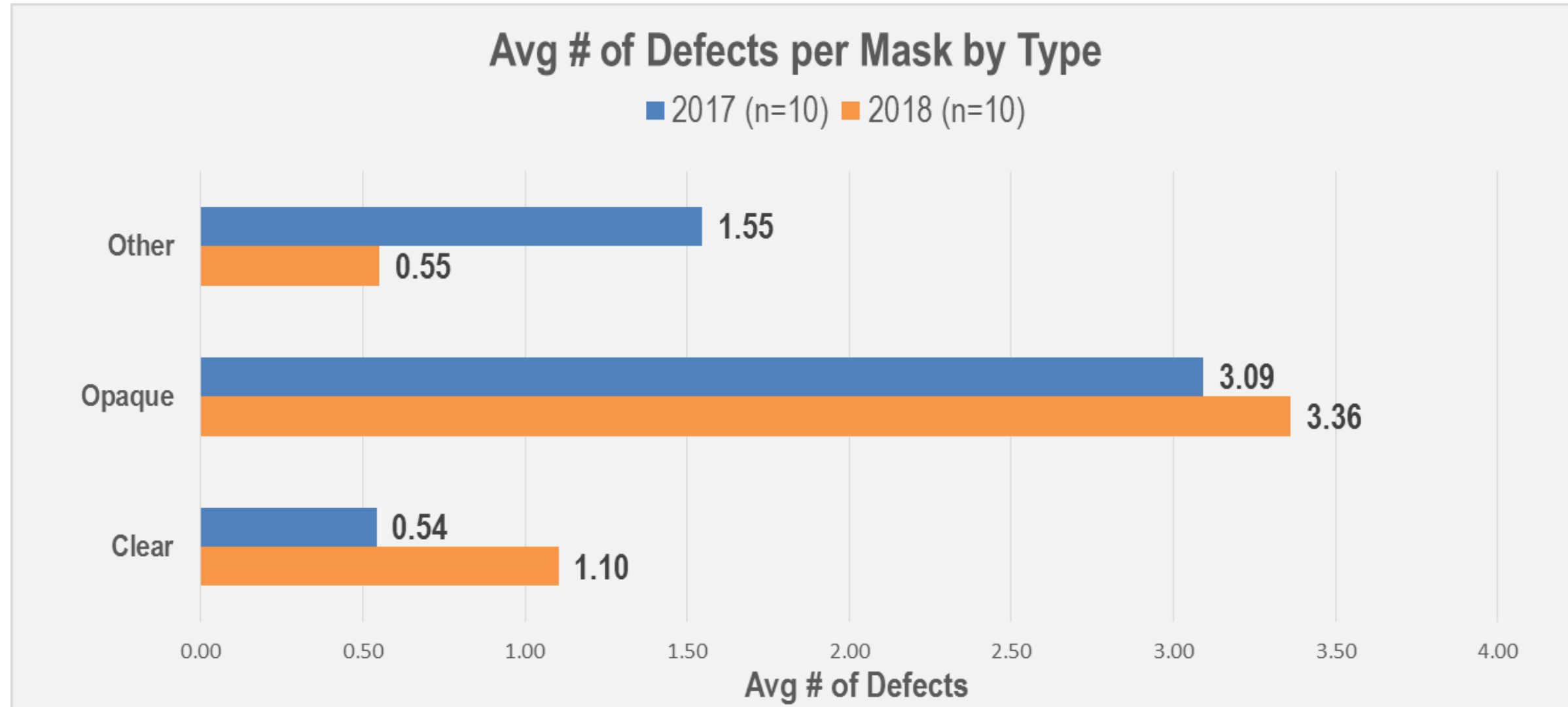
eBeam (VSB), eBeam (multi-beam)*, eBeam (raster), LASER, Other*

Wet Etch Usage Increased Slightly



Q: What was the percentage by...? Wet Etch, Dry Etch

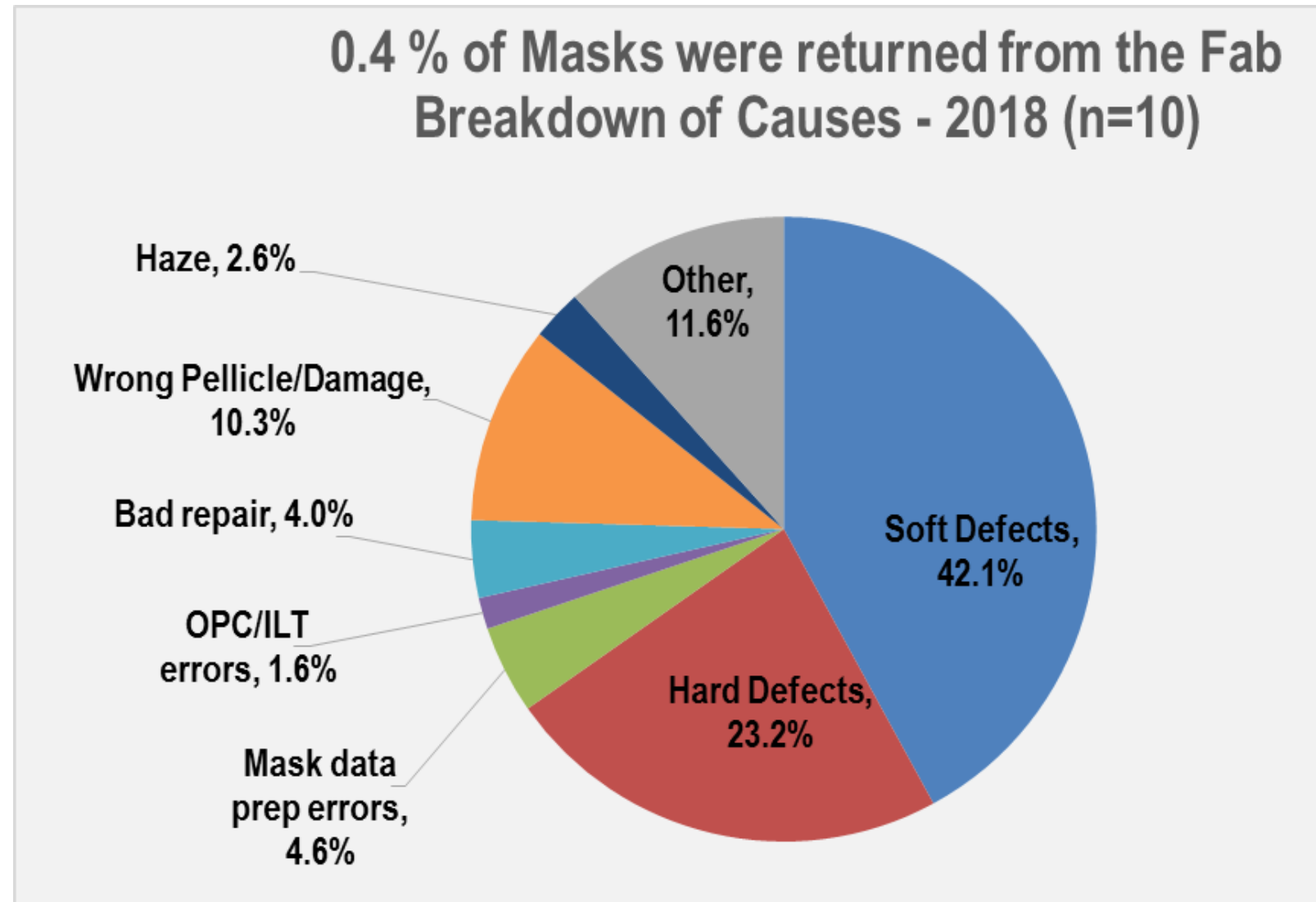
Avg # of Defects Up for Clear and Opaque



Q: What was the average number of defects per mask?

Soft and Hard Defects Dominate Returns – 2018

Choices changed: Data Prep Errors replaced by Mask Data Prep, OPC/ILT Errors

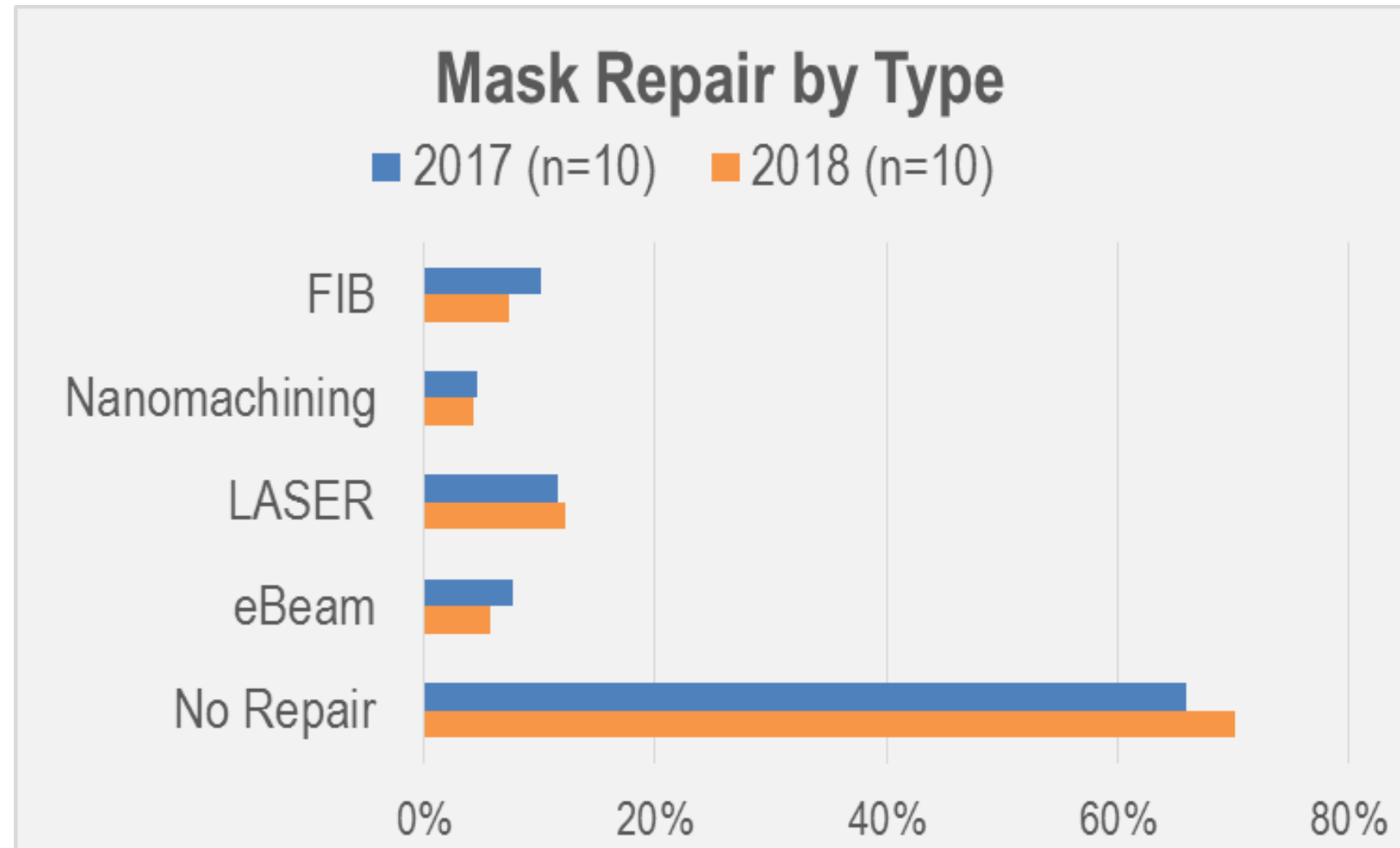


Q: What percentage of masks were returned from the fab?

Q: Of the masks returned from the fab, what percentage were attributed to the following causes?

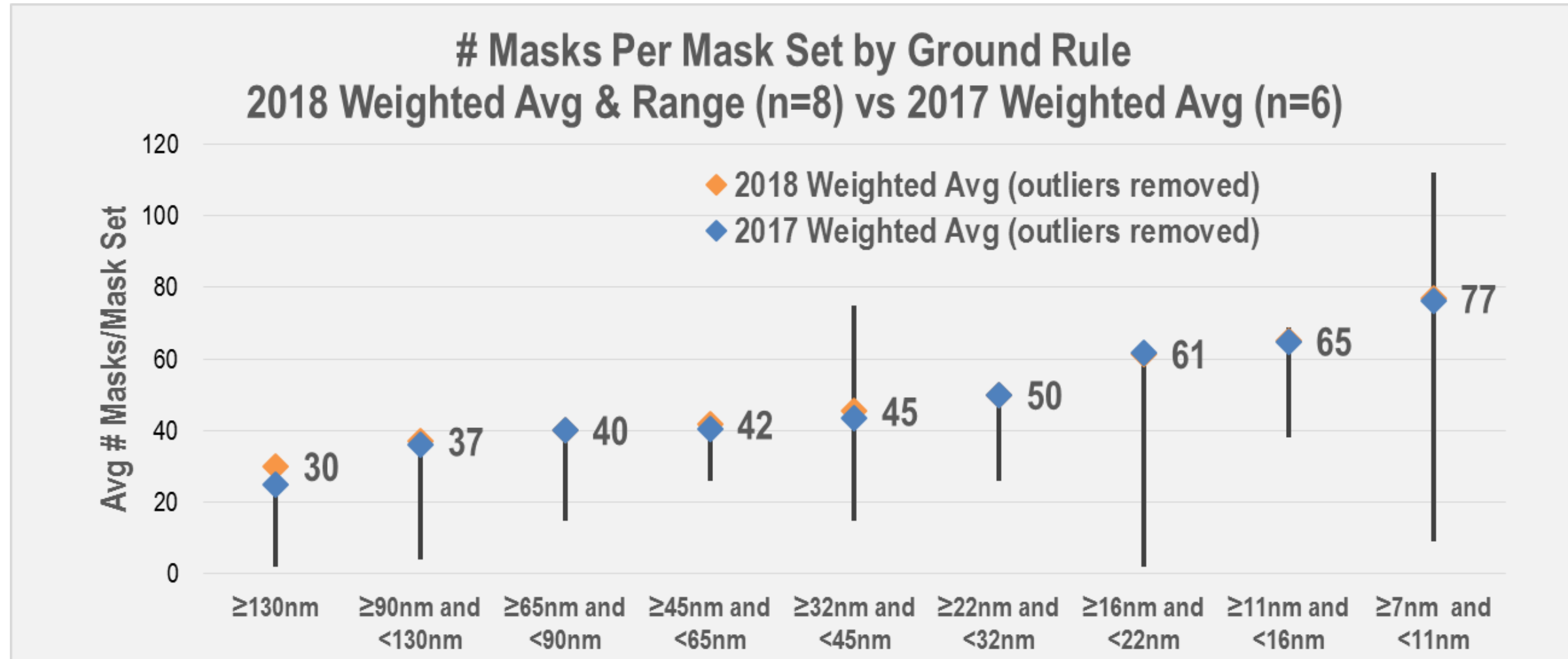
Data plotted was changed from 2017 survey, so year to year comparisons are not valid.

“No Repair” Rate Increased



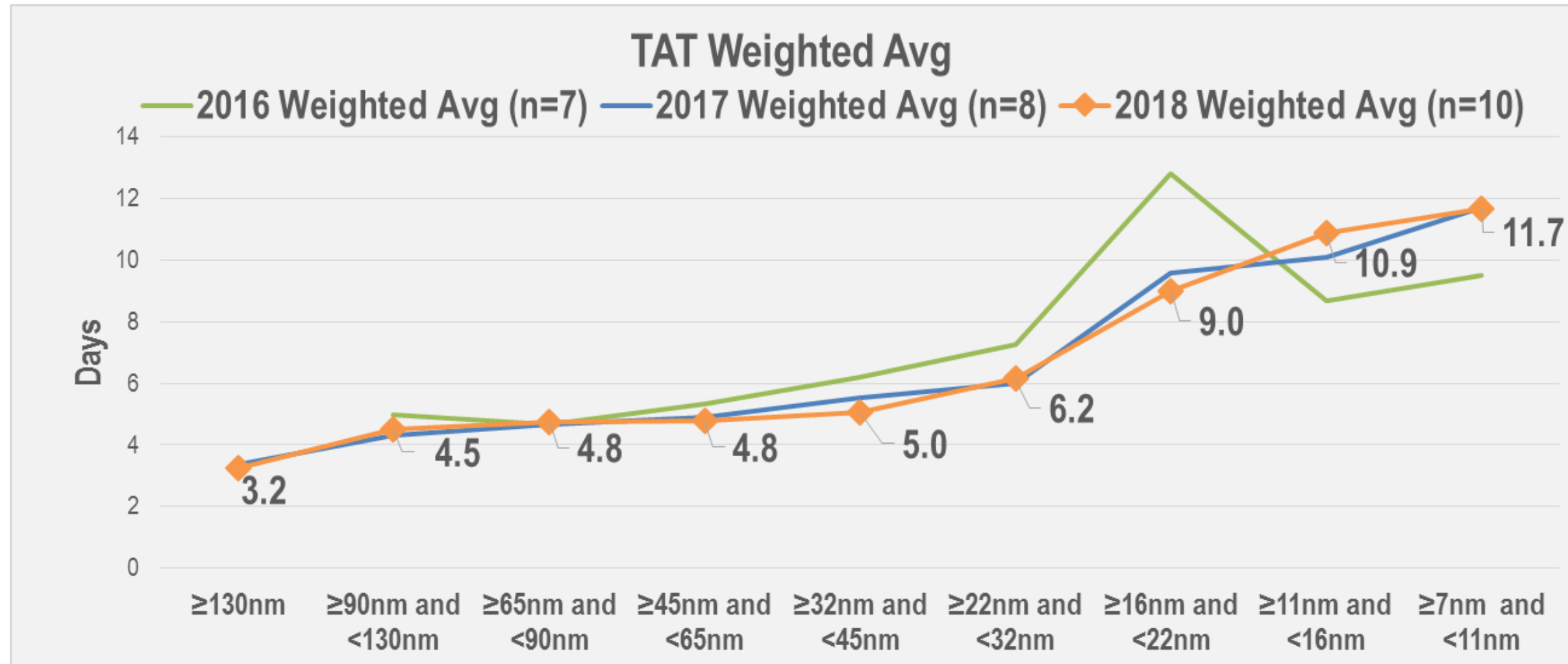
Q: What was the percentage of masks repaired by...No Repair, eBeam, LASER, Nanomachining, FIB

112 Masks per Mask Set was the High Again



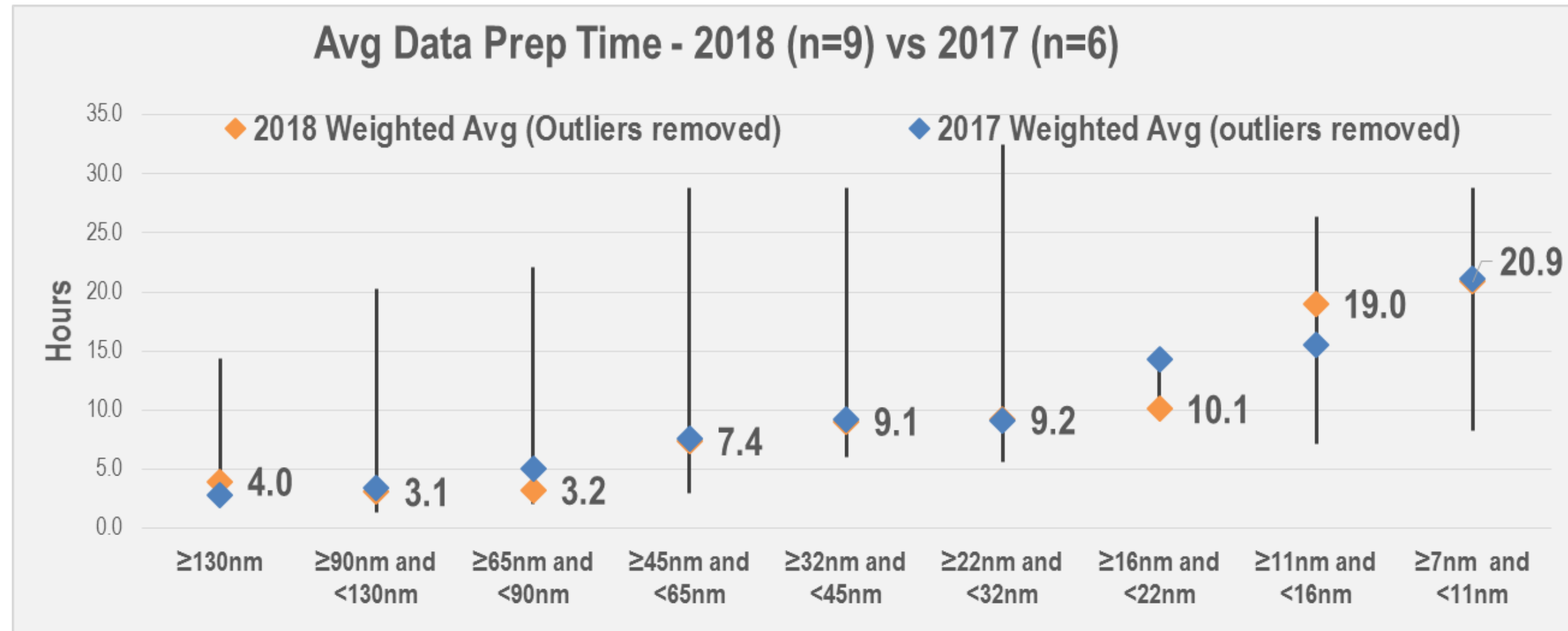
Q: What was the average # of masks per mask set by Ground Rules?

No Progress in TAT at Leading Edge Nodes



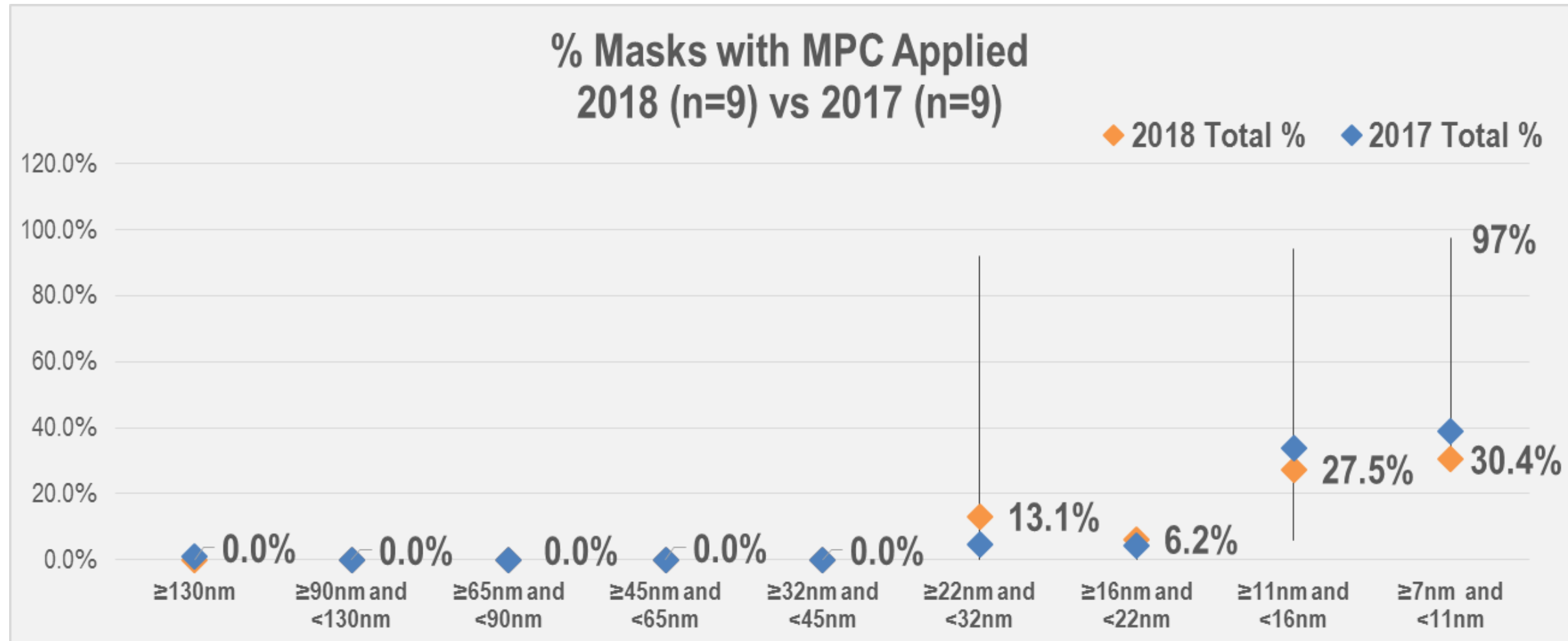
Q: What was your average Turn-Around-Time (TAT) per mask for critical layer masks by Ground Rules in the past year?

Data Prep Time Increases at Leading Edge Again



Q: What was the average data prep time (starting point defined as RET output) by Ground Rules?

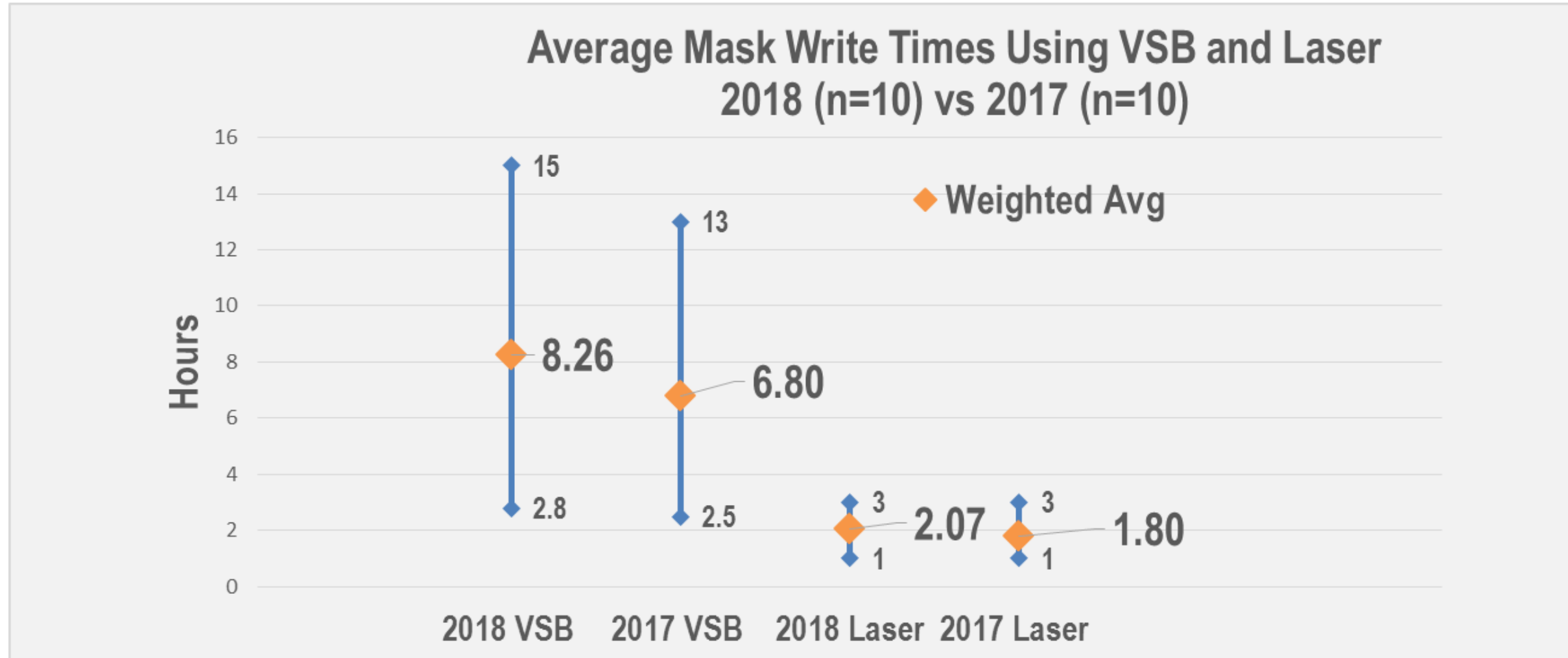
MPC Introduced at <16nm Confirmed Again



Q: What % of masks by ground rules had Mask Process Correction (MPC) applied?

Mask Write Times Increased >20% for eBeam VSB

8.26 hours in 2018 vs 6.8 hours in 2017

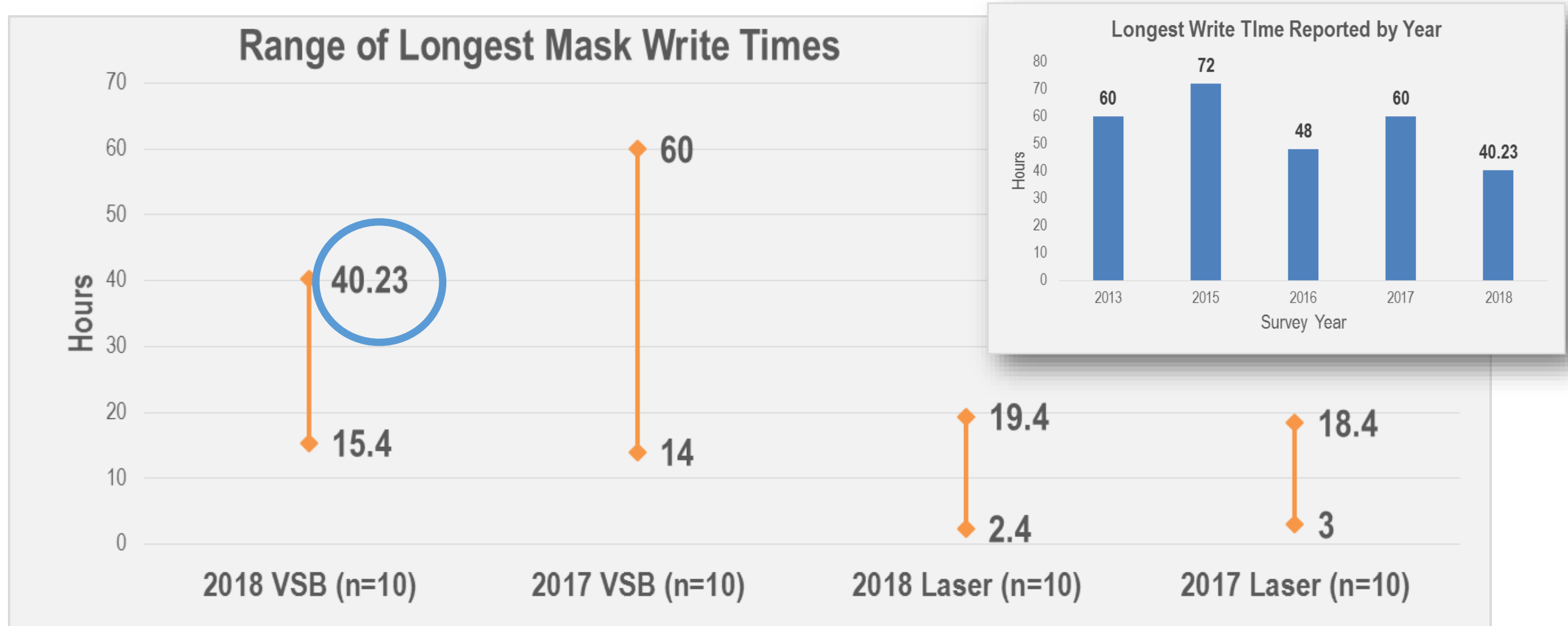


Q: What was the average write time for each type of pattern generation*?

For VSB and Laser Weighted Avg, each response of each writer type is weighted by percentage share of that company of total reported masks of that type.

Longest Write Times Contained

40.23 Hrs VSB, 19.4 Hrs Laser

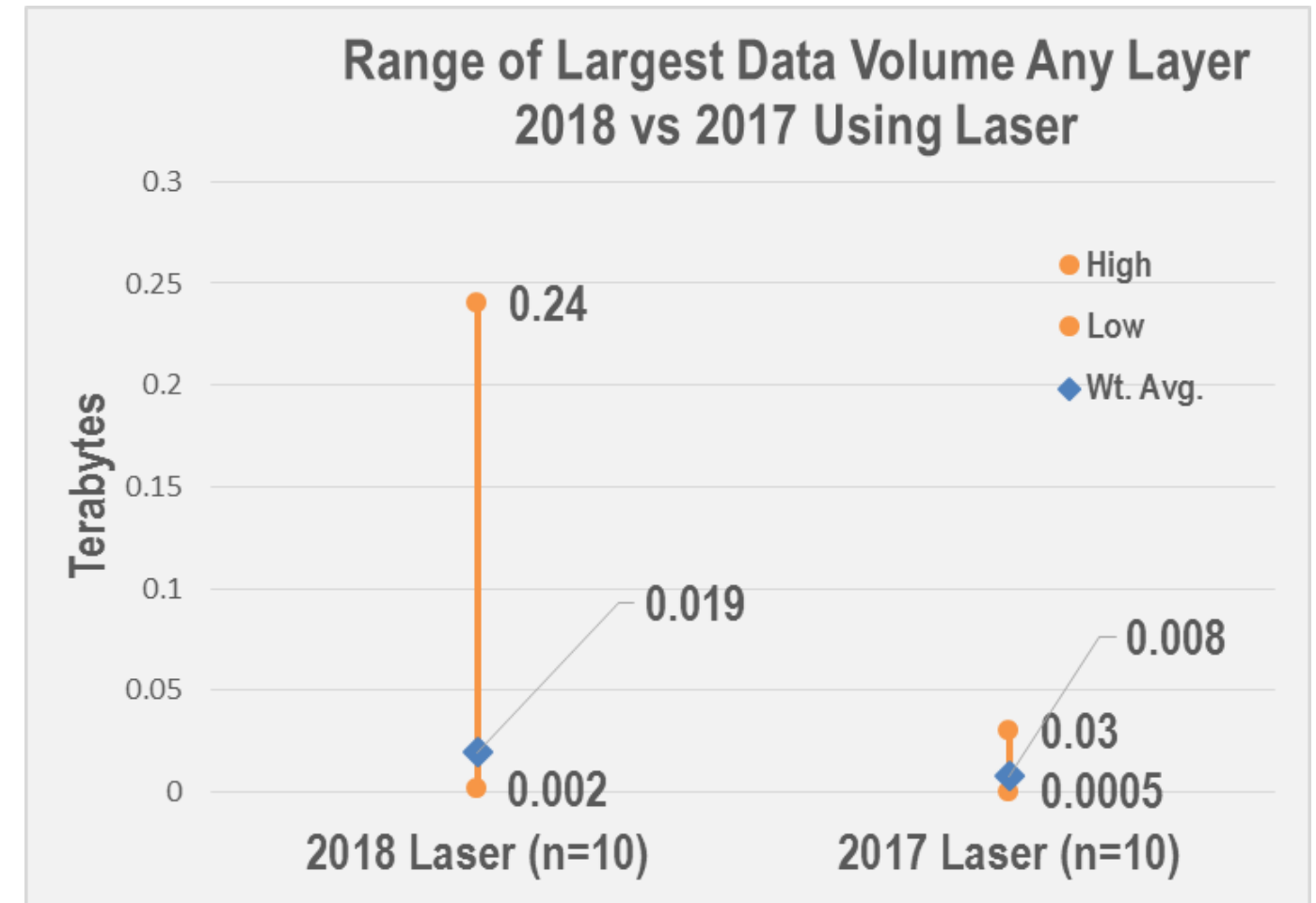
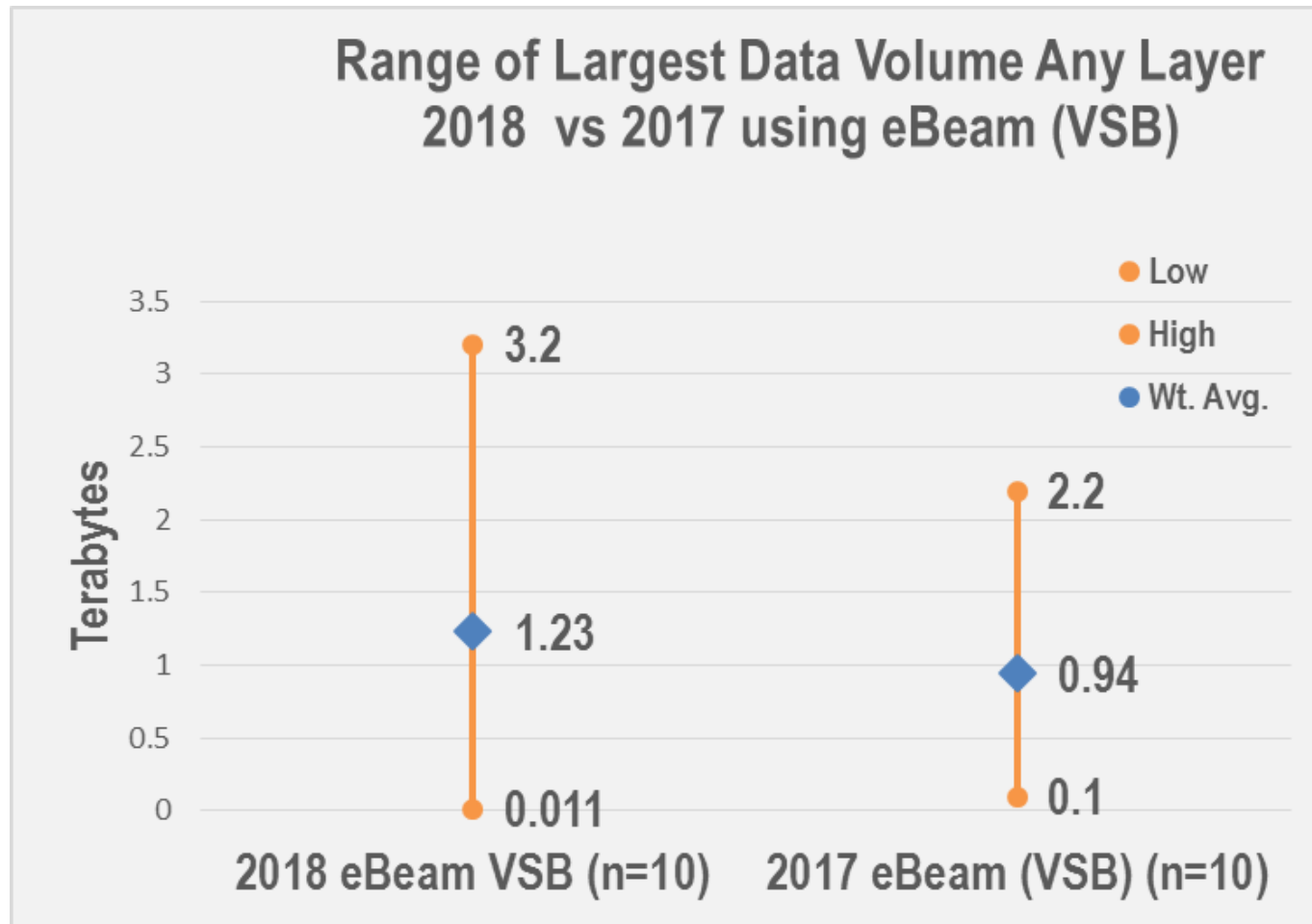


Q: What was the longest write time for each type of pattern generation?

Data Volume Range Increased for eBeam & Laser



2.2 -> 3.2 TBytes eBeam; 30 -> 240 GBytes Laser



Q: What was the largest data volume for any mask level for each type of pattern generation?

Mask Output Grew 27% Over Previous Year



- **More than half of growth attributed to 65nm ground rules and above**
- **Laser writers wrote 74% of the masks in 2018**
- **No progress in mask turnaround time for leading edge nodes**