

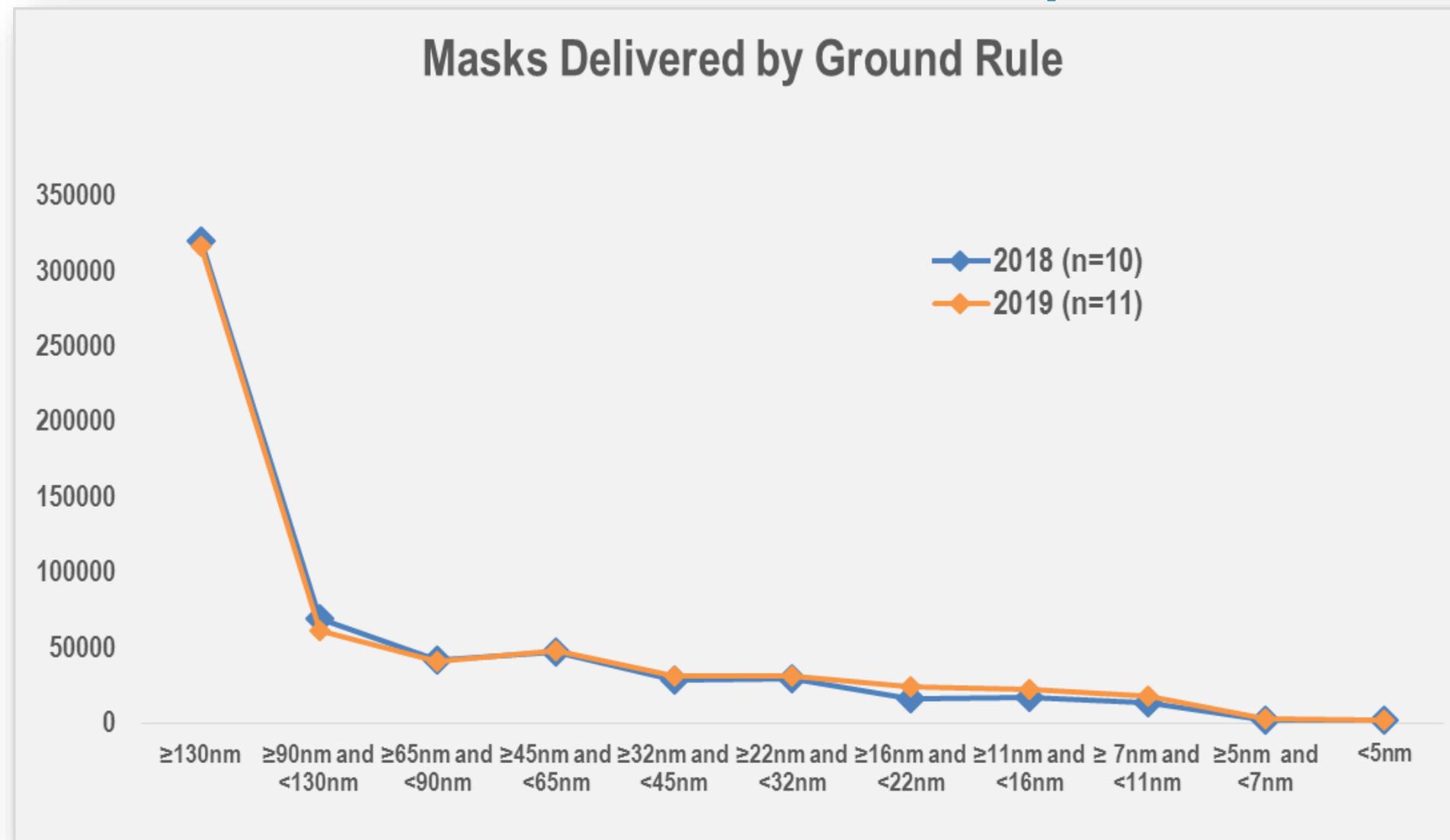
# Different Participants in 2019 vs 2018 Surveys



- **Thank you to 11 participating companies in 2019 Mask Makers' Survey:**
  - Thank you to Micron and SK Hynix for joining this year
  - AMTC, DNP, Intel, Micron, PDMC, Photronics, Samsung, SK Hynix, SMIC, TMC, Toppan
  - Independently collected by David Powell, Inc.
- **Collected data “for the last 12 months (July 2018 to June 2019)”**
- **Mask Makers' survey slides available at [www.ebeam.org](http://www.ebeam.org) by Sept 16 noon**

# 599,536 Masks Delivered by 11 Companies

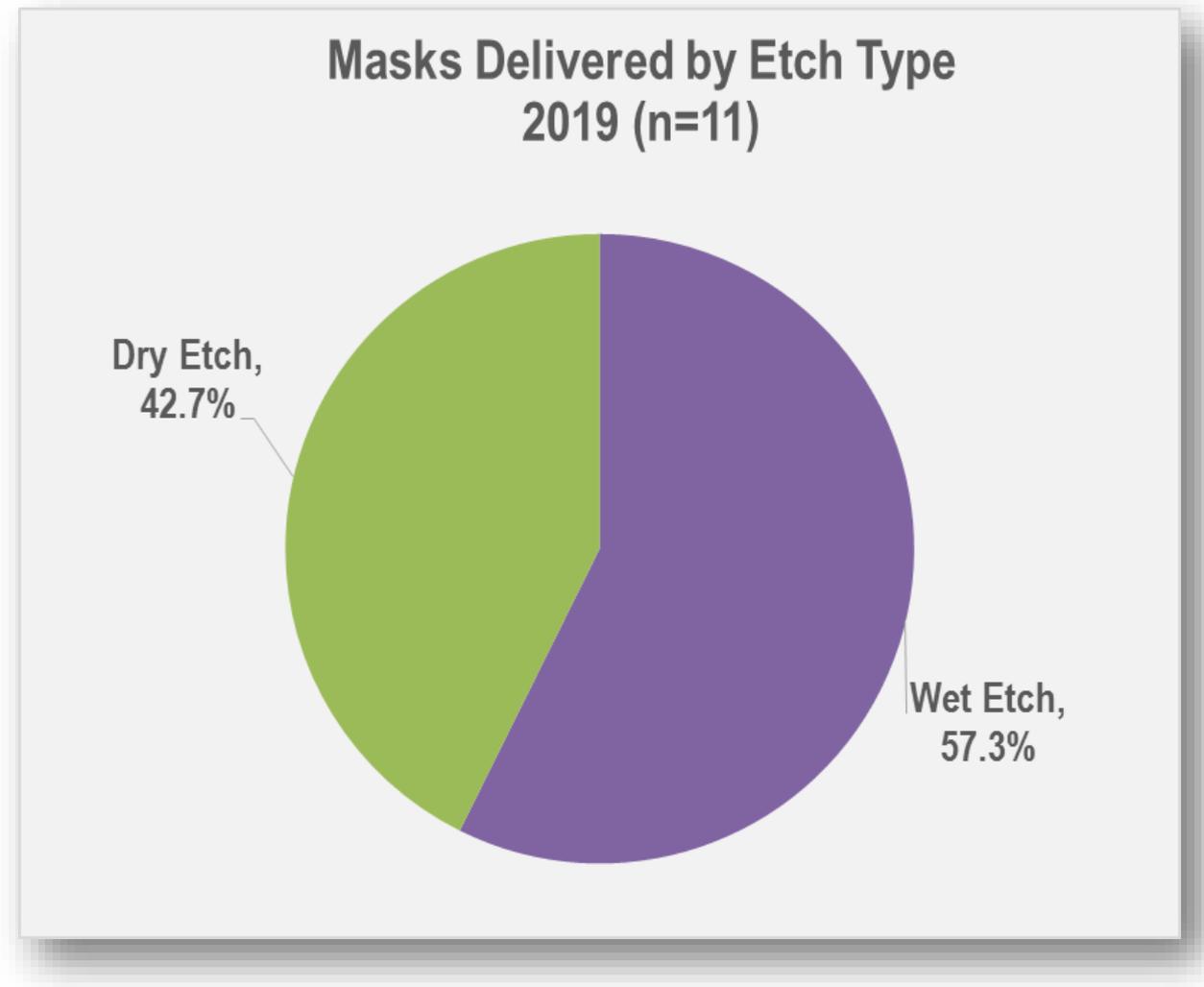
587,233 in 2018 from a different set of companies



Q: What was the number of masks delivered?

Q: Percentage of the total number of masks in the preceding question by Ground Rules of the critical layers?

# 43% of the Reported Masks used Dry Etch



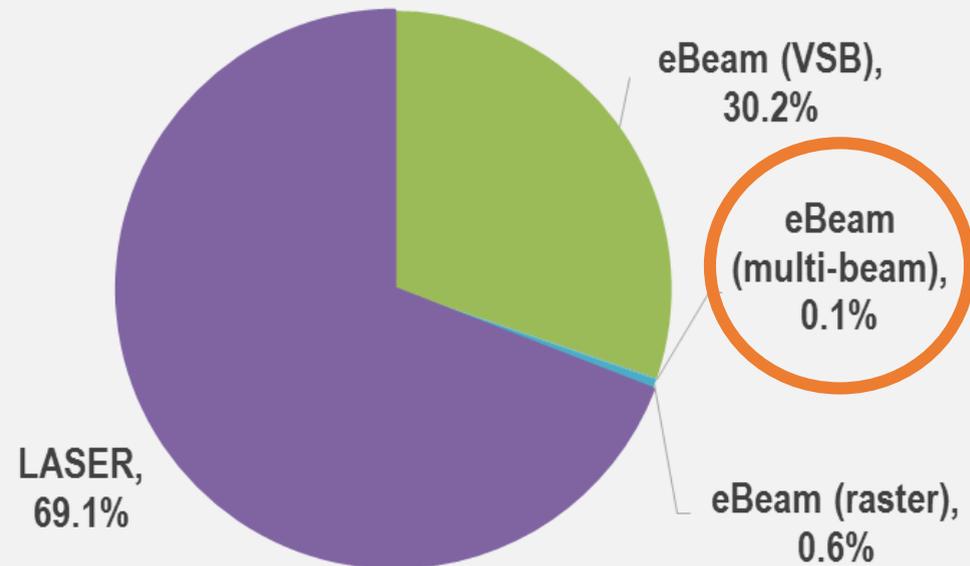
Q: What was the percentage by...? Wet Etch, Dry Etch

# First Time Multi-beam Masks Reported

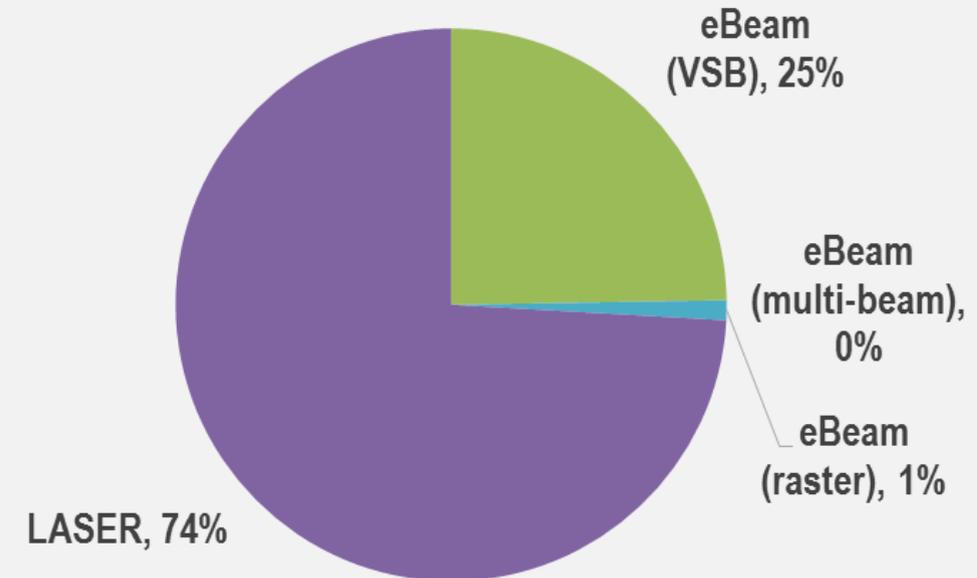
30% written by VSB



Masks Delivered by Pattern Generation  
2019 (n=11)



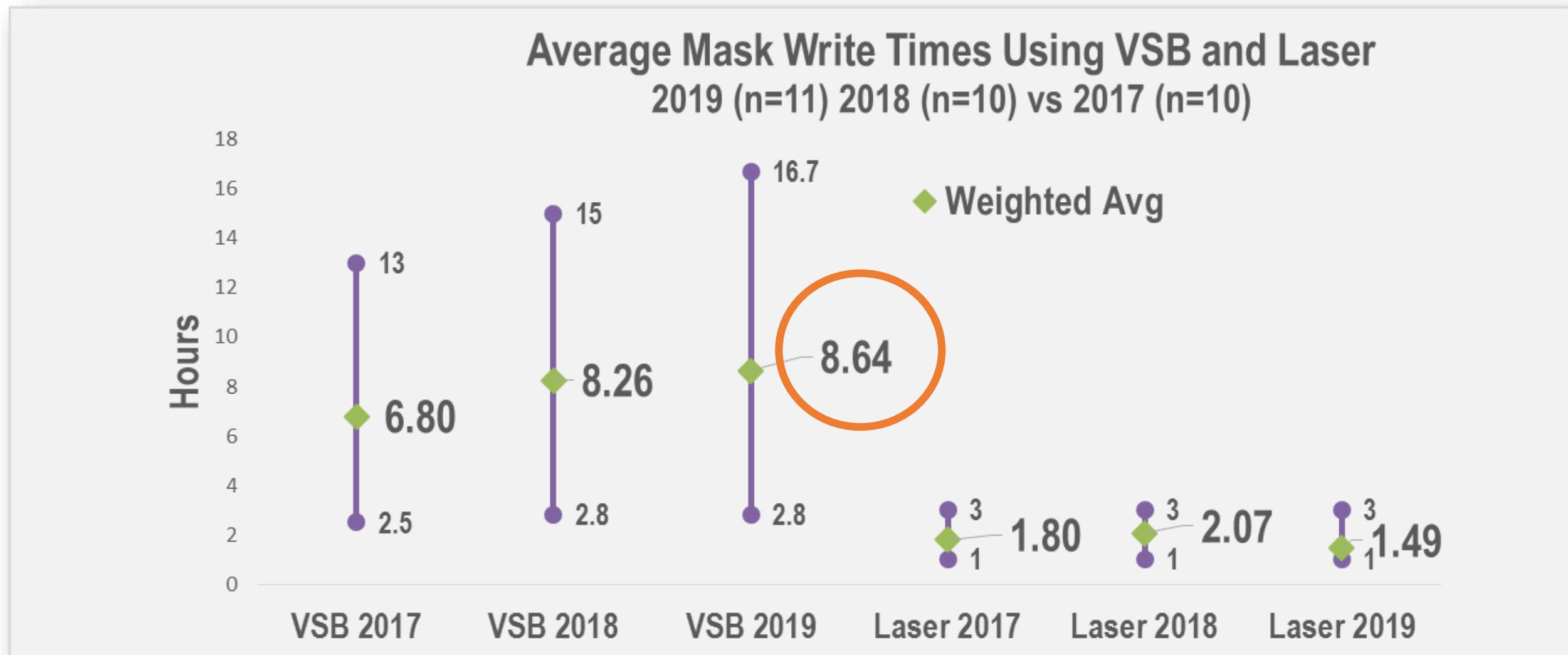
Masks Delivered by Pattern Generation  
2018 by Volume (n=10)



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

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

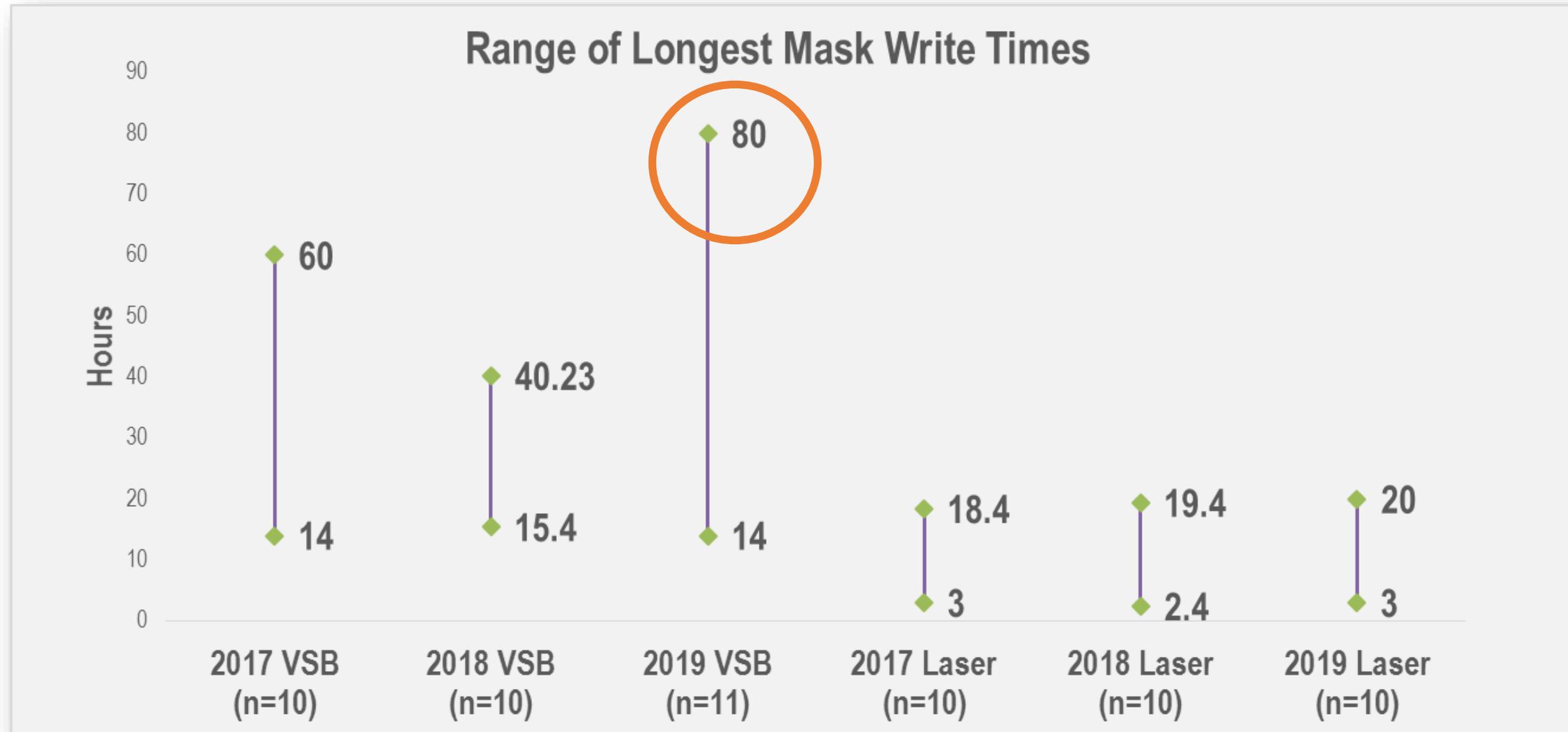
# Avg Mask Write Time for VSB was 8.64 Hours



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

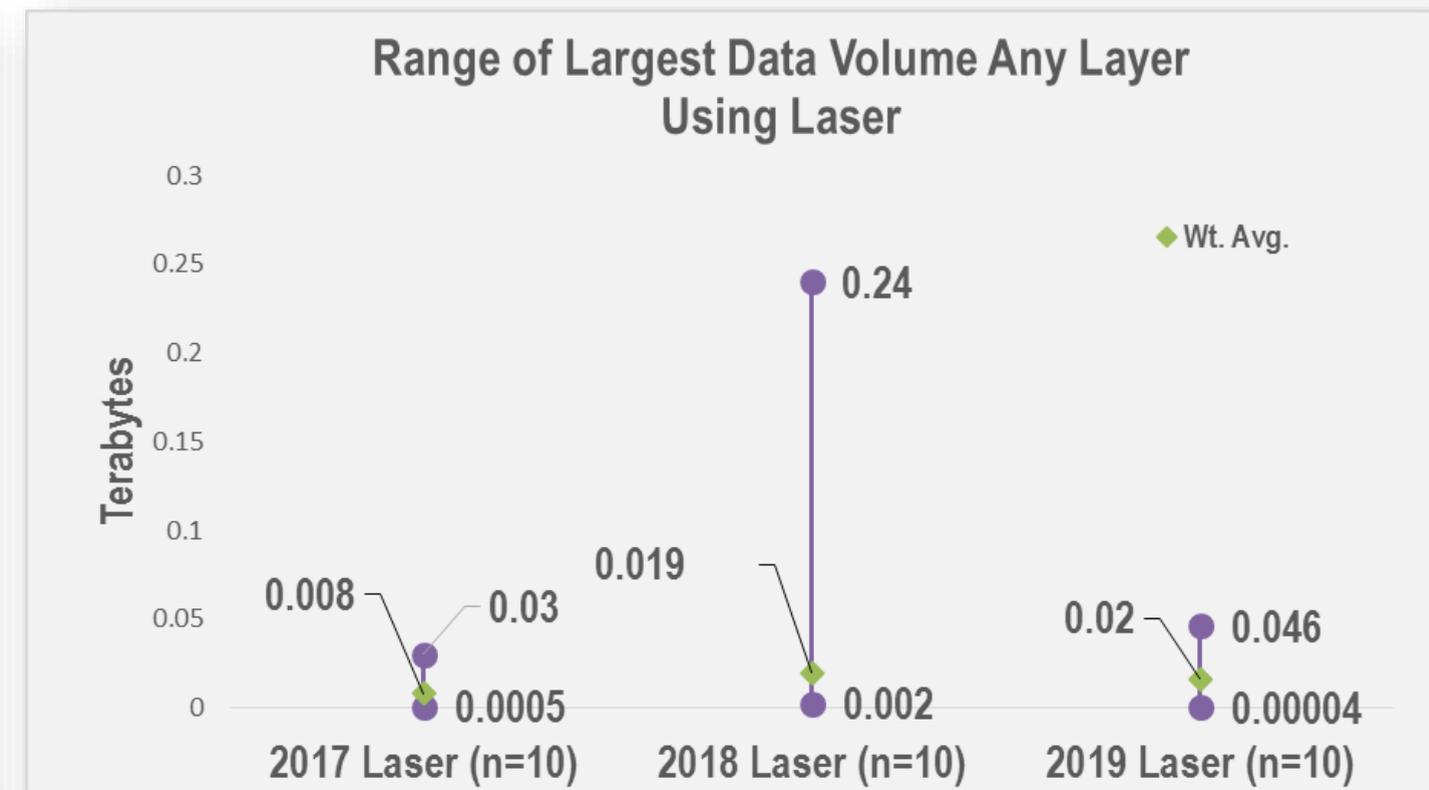
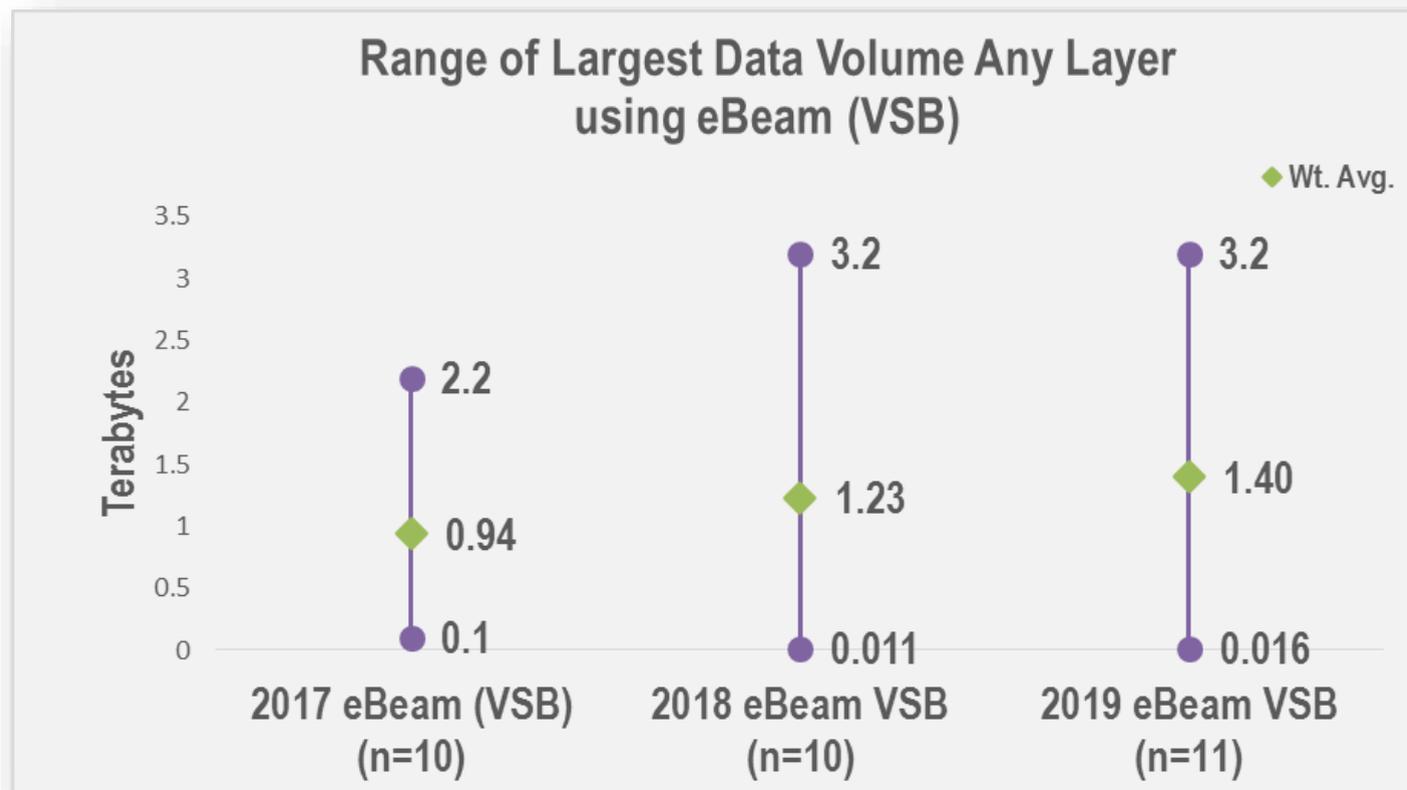
For VSB and Laser Weighted Avg, each response of each writer type is weighted by percentage share of that company of total reported masks of that type.

# 80 Hour VSB Write Time Reported



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

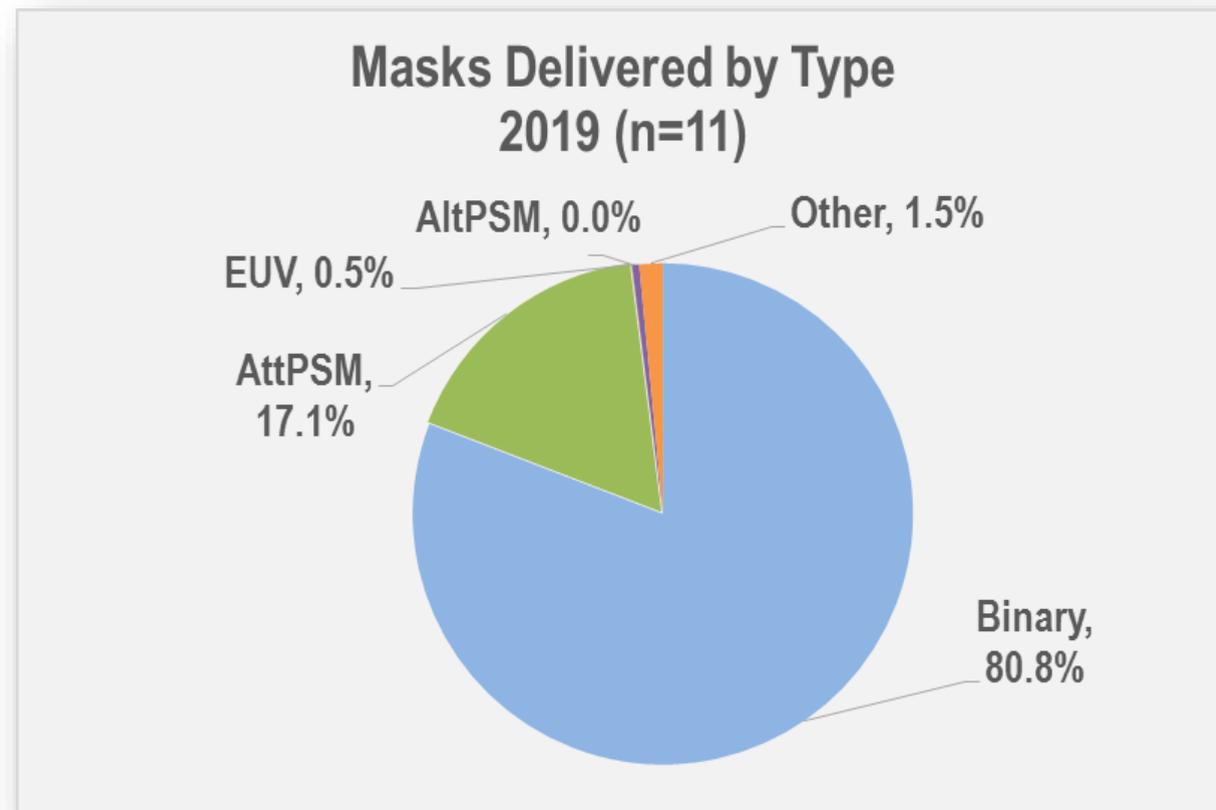
# Data Volume Range Unchanged for VSB Laser Range Reported Much Smaller for 2019



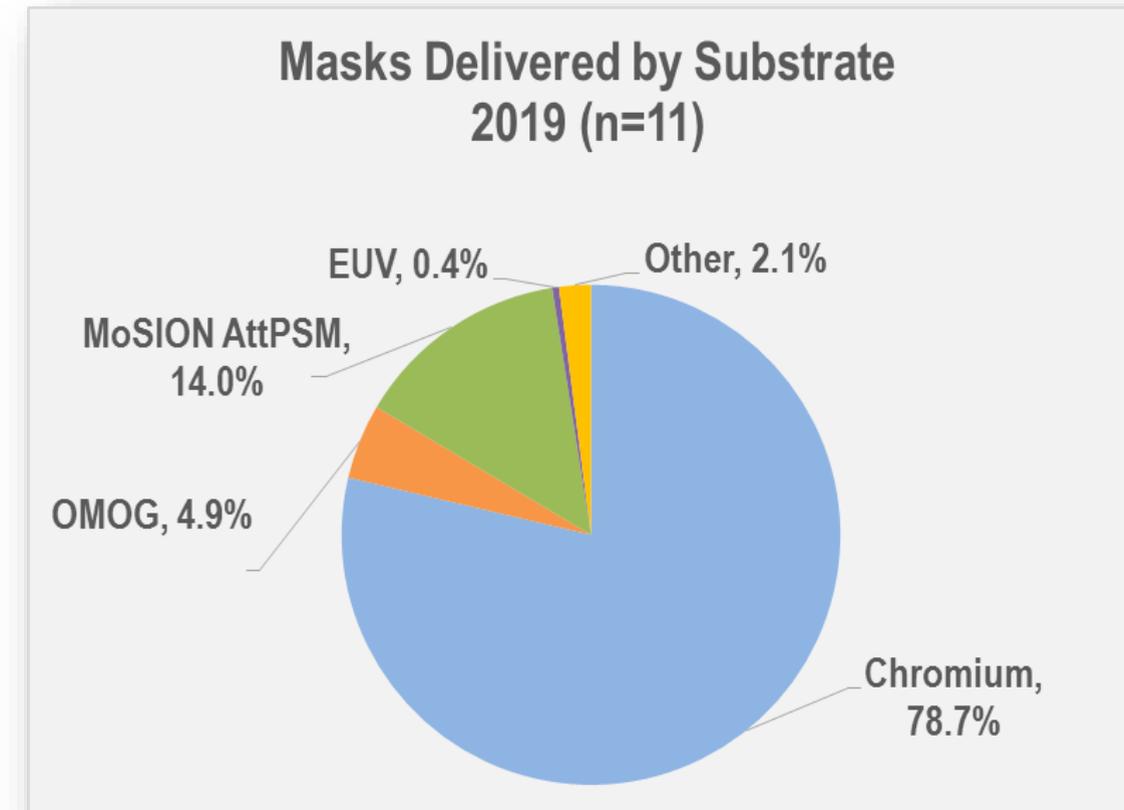
Q: What was the largest data volume for any mask level for each type of pattern generation?

Weighted Average is computed by averaging each company response multiplied by that company's percentage share of all reported masks of the writer type.

# 2789 EUV Masks Reported in 2019 Survey



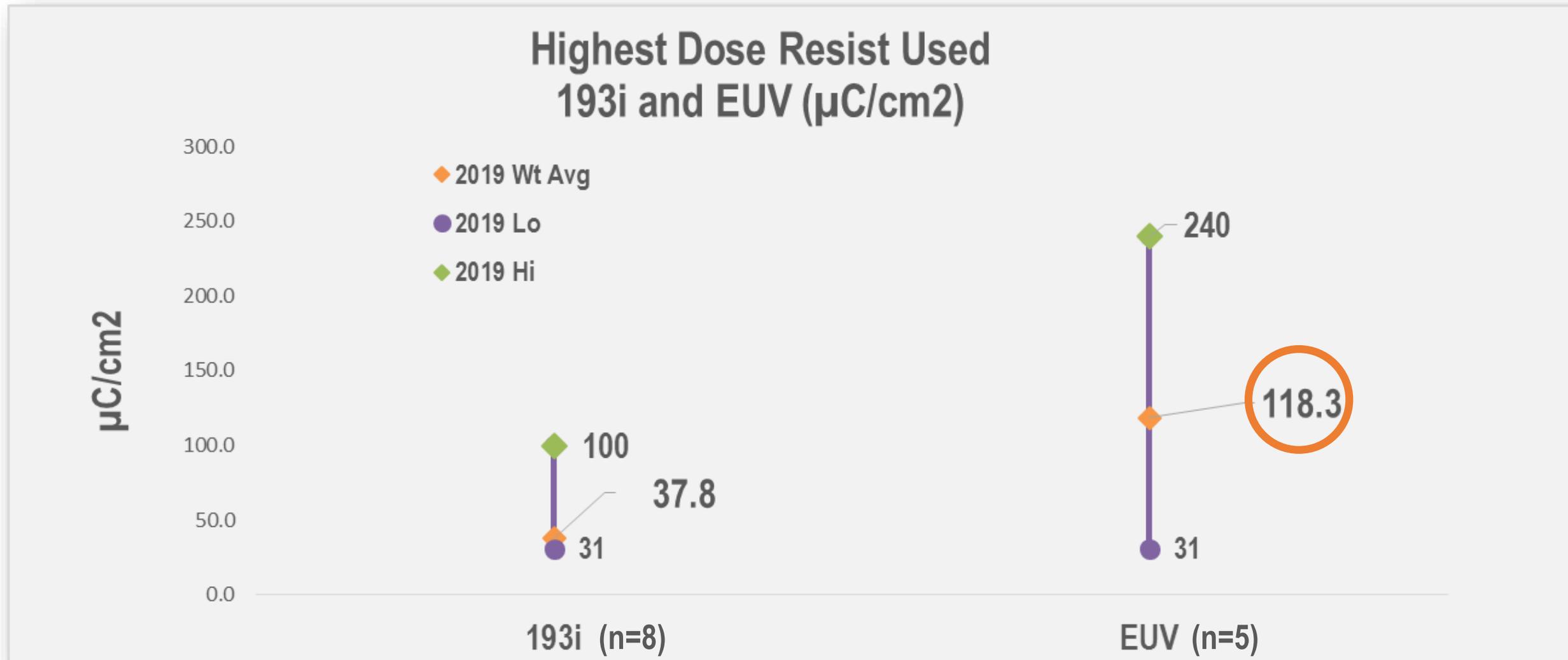
Q: What was the % by...?  
Binary, AttPSM, AltPSM, EUV, Other



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

# Highest Dose Resist Used is More for EUV

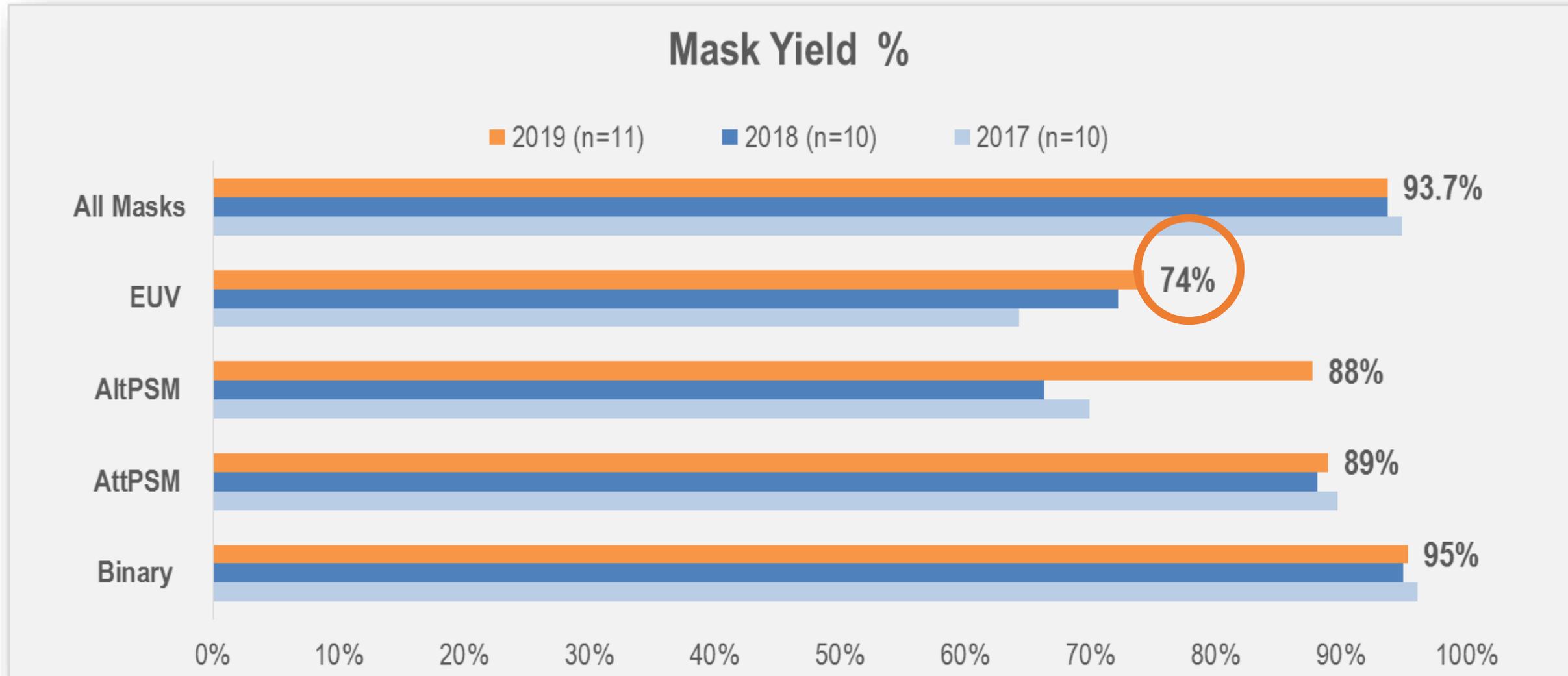
## EUV Wt Avg of 118.3 $\mu\text{C}/\text{cm}^2$



Revised Q so year to year comparisons are not valid: In the past year, what was the highest dose resist used in production for each category?

# Mask Yield Reported Was 93.7%

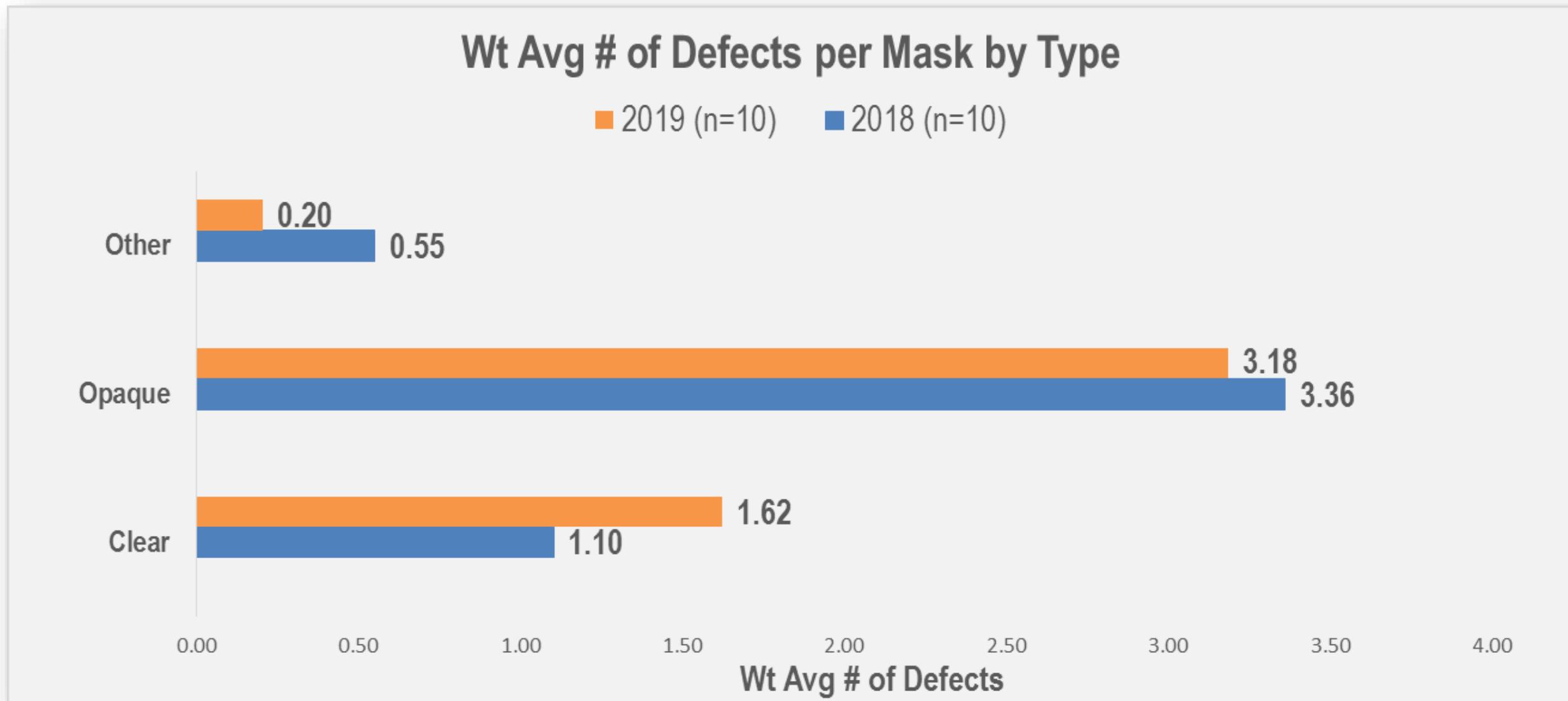
## EUV Yield Reported Improved to 74%



Q: What was your overall mask yield?

Q: What was your percent mask yield by category?

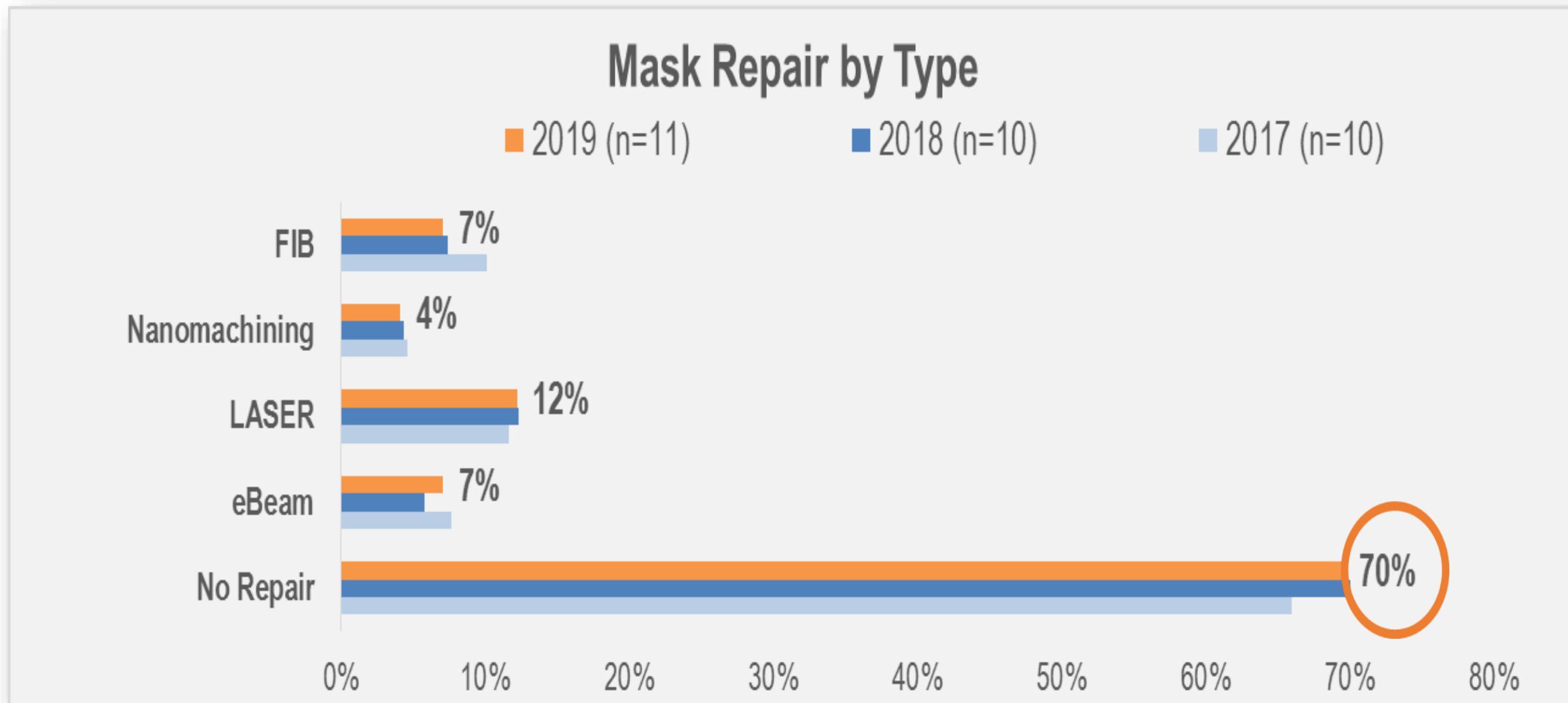
# More Opaque than Clear Defects Reported



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

Weighted Average is computed by averaging each company response of each category multiplied by that company's percentage share of reported masks of that category.

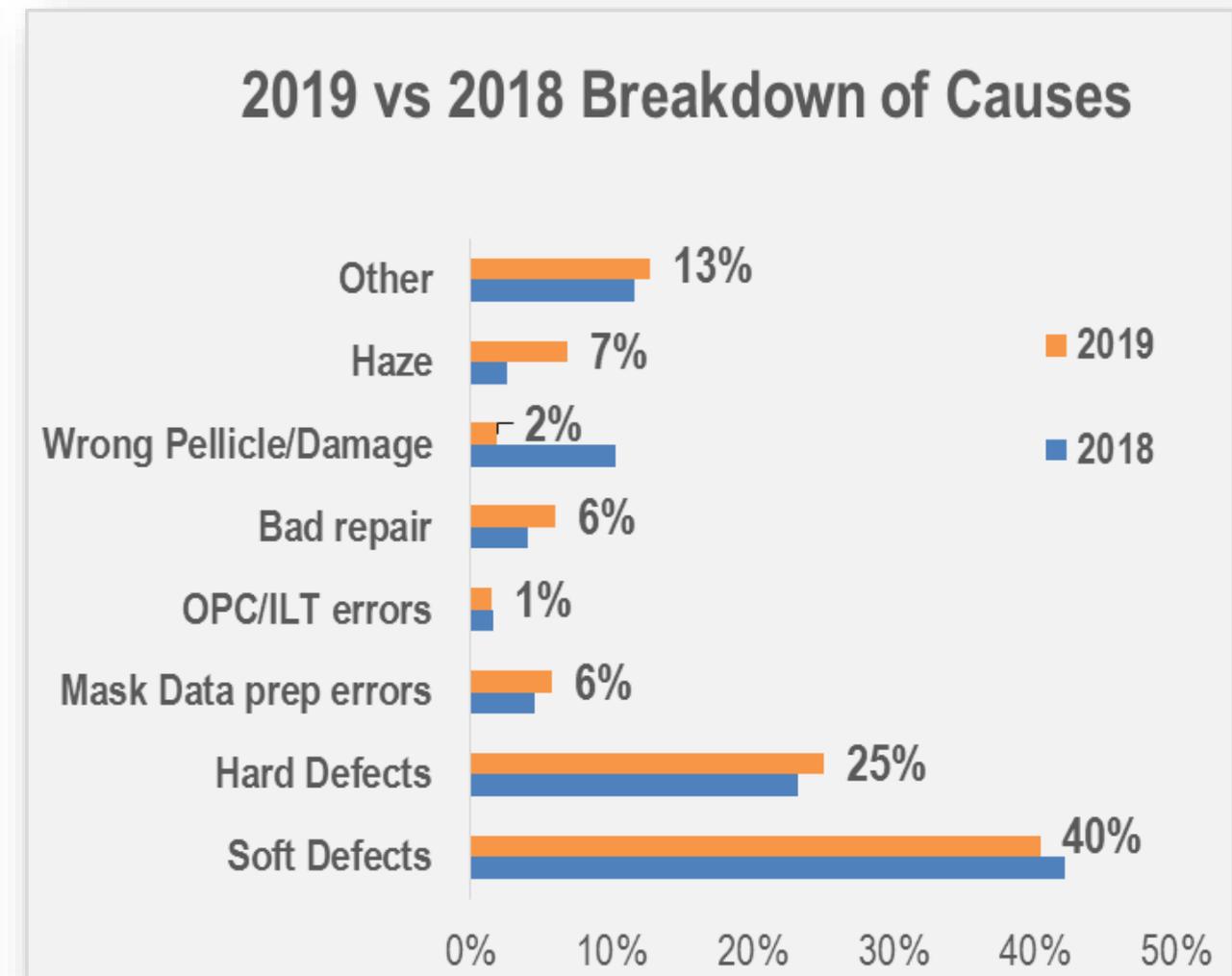
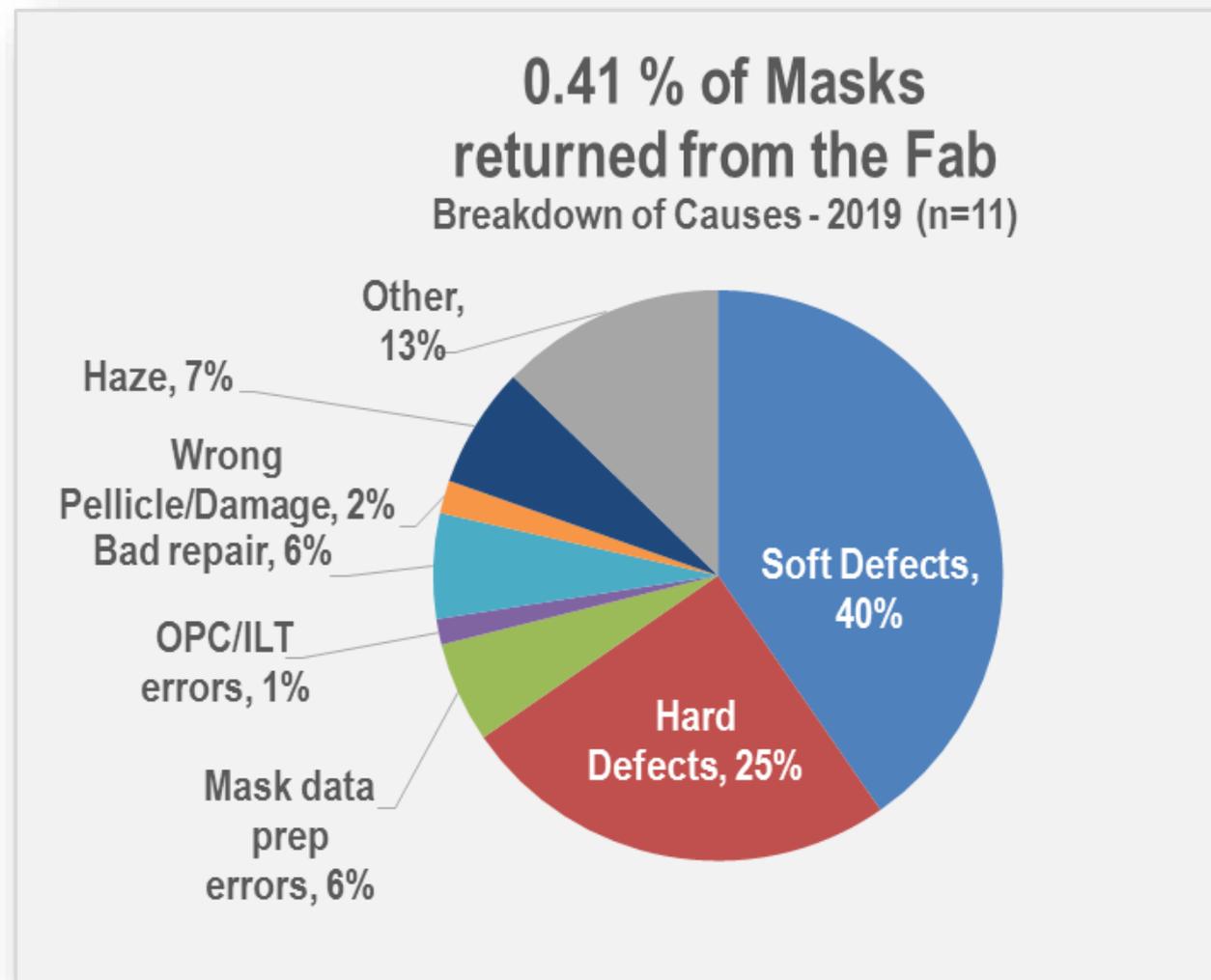
# “No Repair” Reported for 70% of Masks



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

# Soft and Hard Defects Dominate Returns

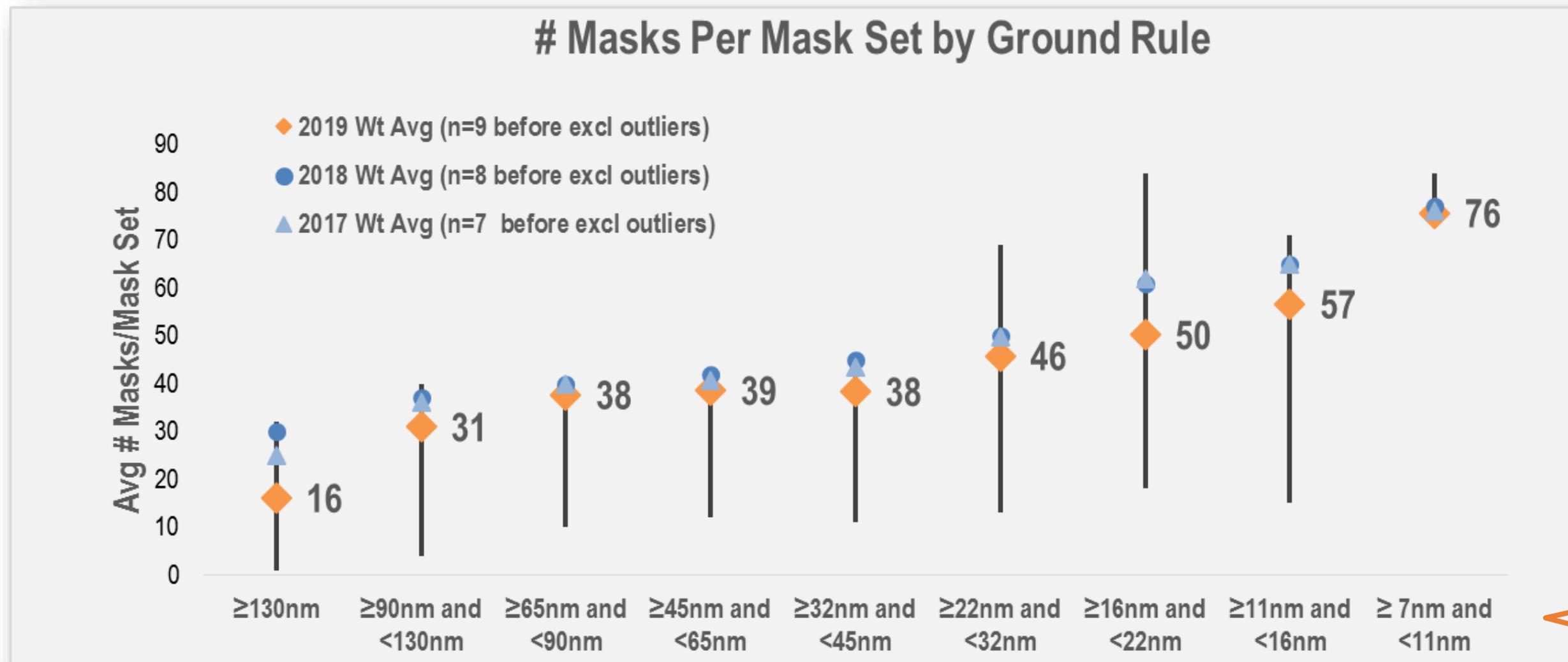
## Haze Increased While Pellicle (wrong or damaged) Decreased



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?

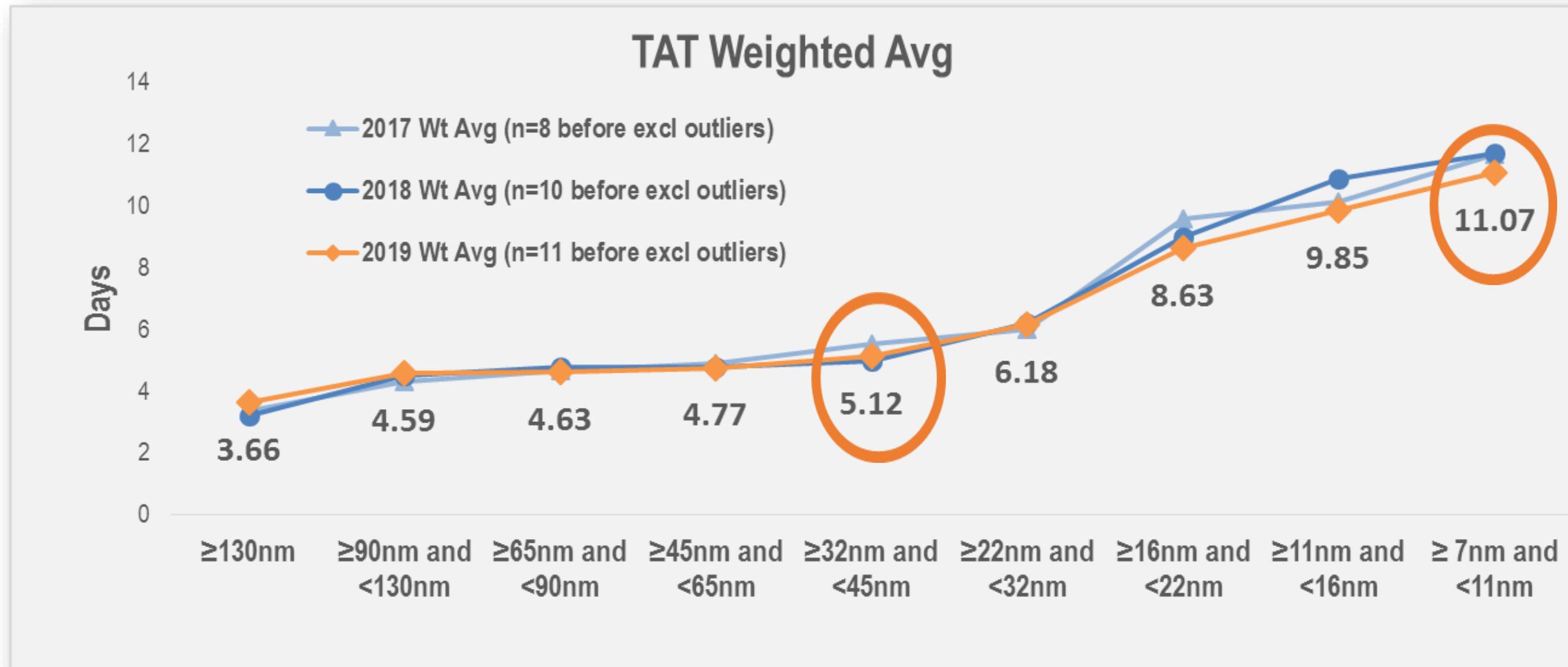
# 2019 Survey Says Fewer Masks per Mask Set



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

Weighted Average is computed by averaging each company response of each category multiplied by that company's percentage share of reported masks of that category. <sup>14</sup>

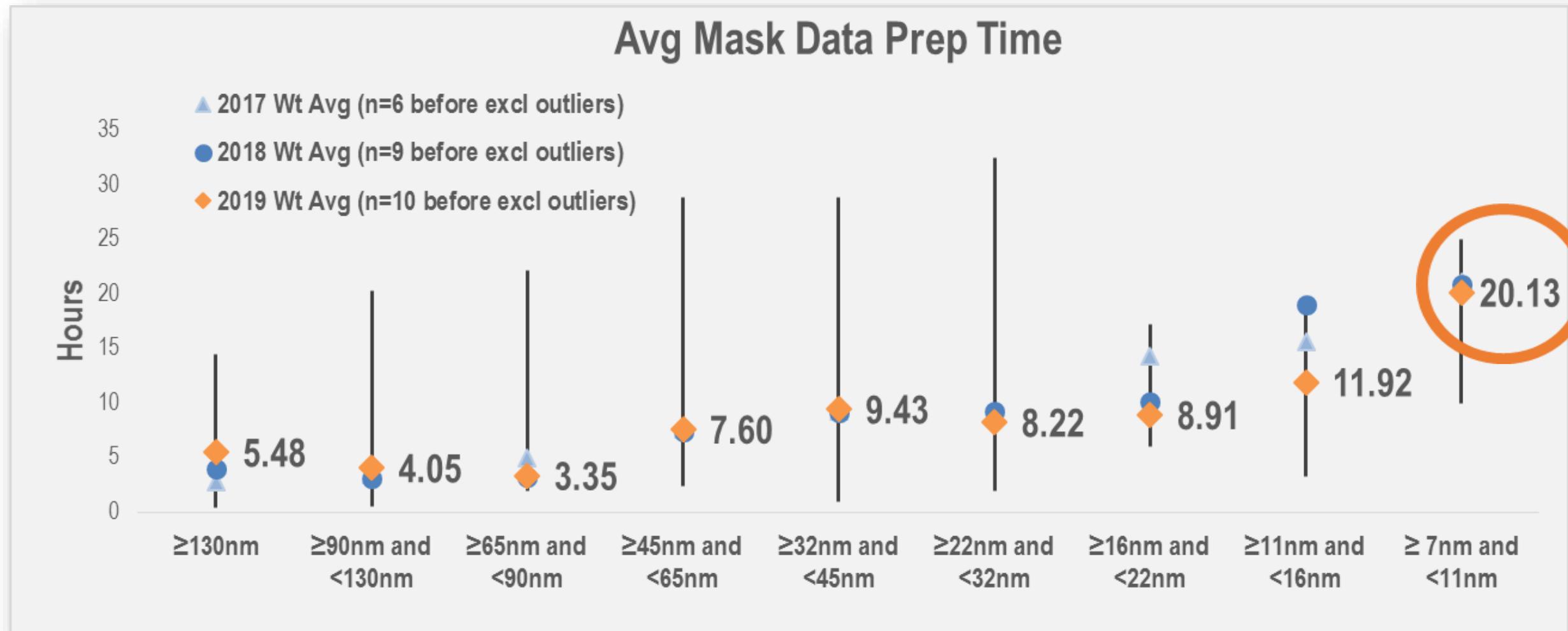
# TAT at 7nm More than 2X at 32nm



# responses insufficient (<3) for <7nm

Q: What was your average Turn-Around-Time (TAT) per mask for critical layer masks by Ground Rules in the past year? (Please note, this question is only asking about critical layer masks, not the average of all masks.)

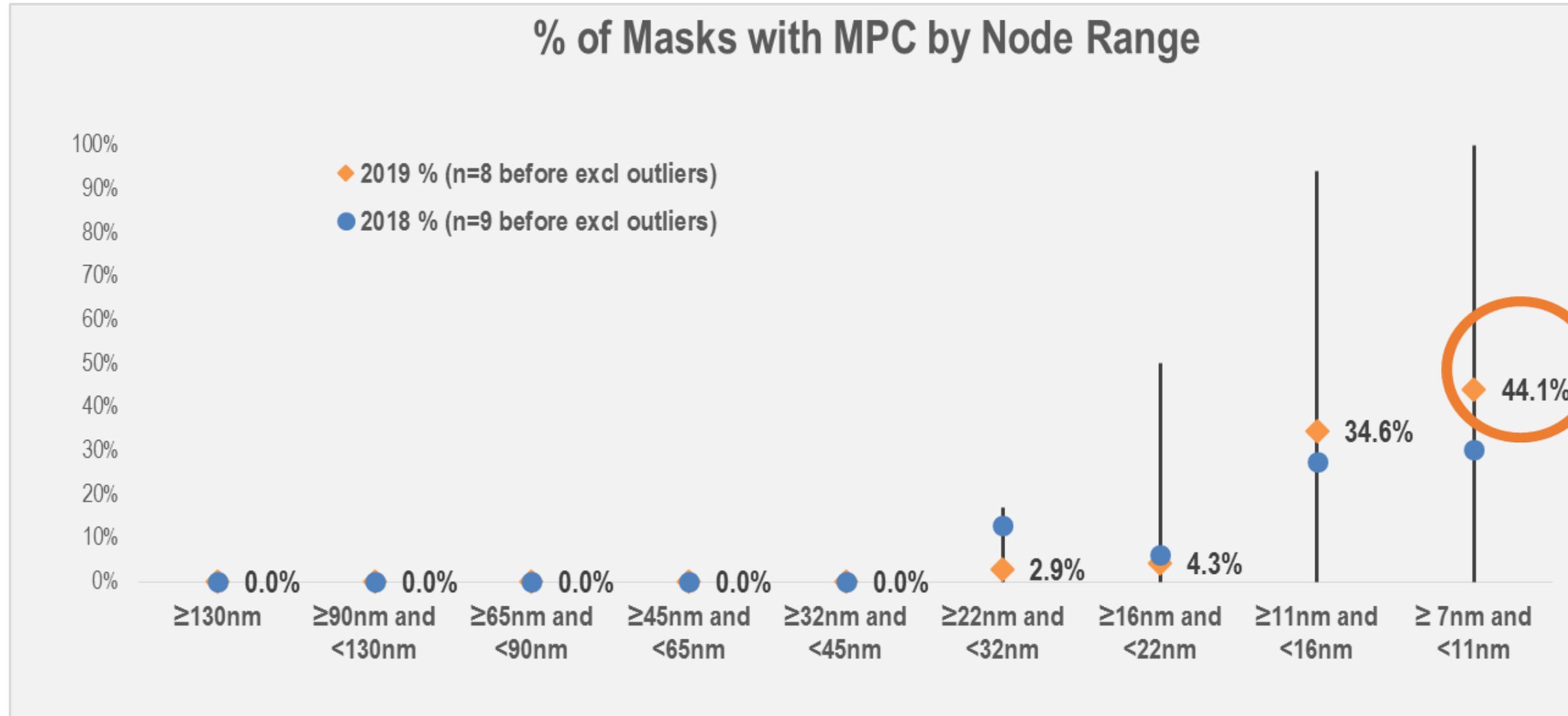
# Mask Data Prep Remains High at Advanced Nodes



# responses insufficient (<3) for <7nm

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

# 44% of Masks Below 11nm Used MPC



# responses insufficient (<3) for <7nm

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

# Multi-beam Masks Reported for the First Time



- **599,536 masks reported by 11 companies**
- **2789 were EUV masks**
- **Avg mask turnaround time (TAT) for  $<11\text{nm}$  and  $\geq 7\text{nm}$  was 11 days**