

# **Anthropometric Survey of Respirator Users**

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# Goals

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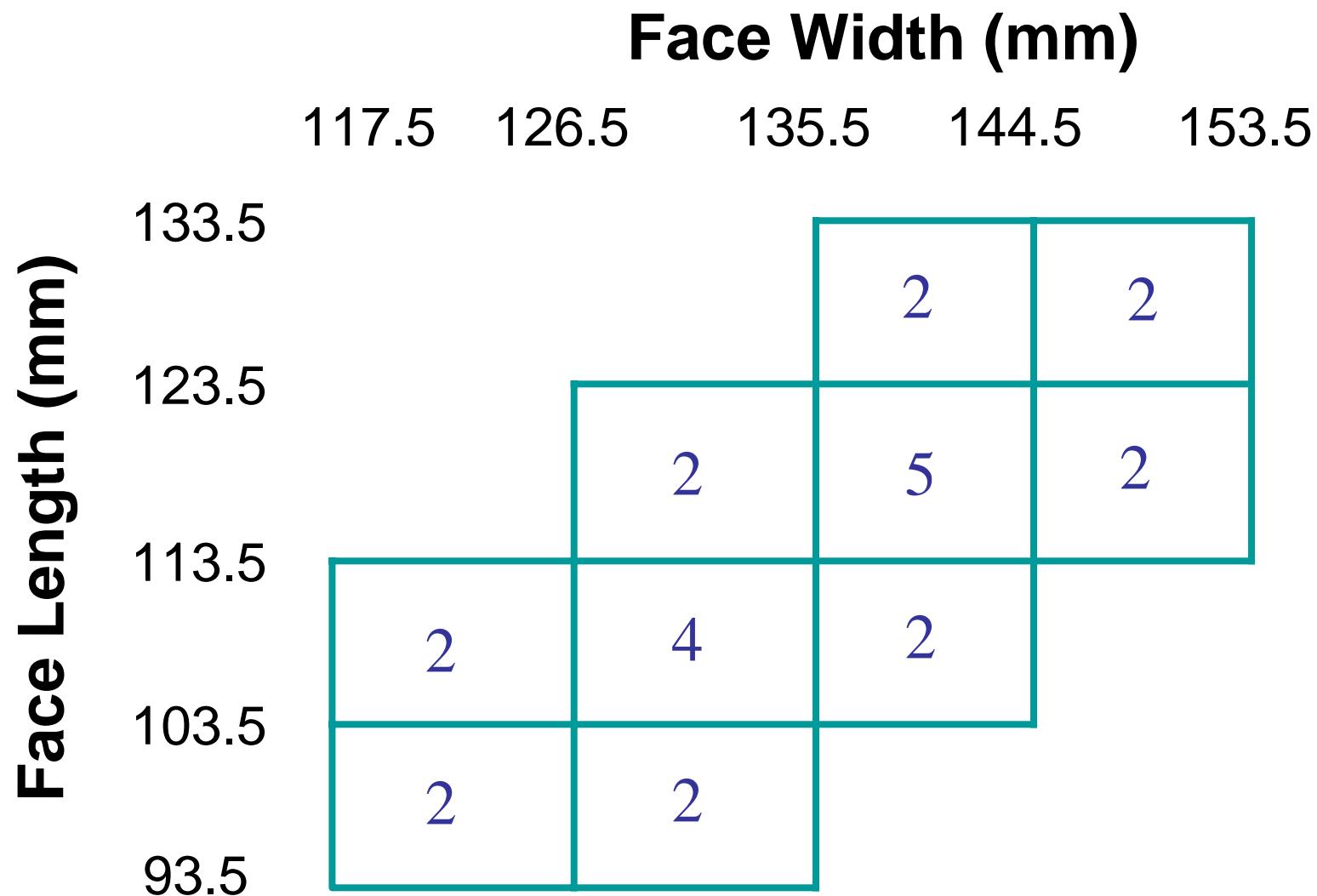
- Conduct a large-scale anthropometric survey of respirator users
- Upgrade the LANL respirator fit test panels

# Background

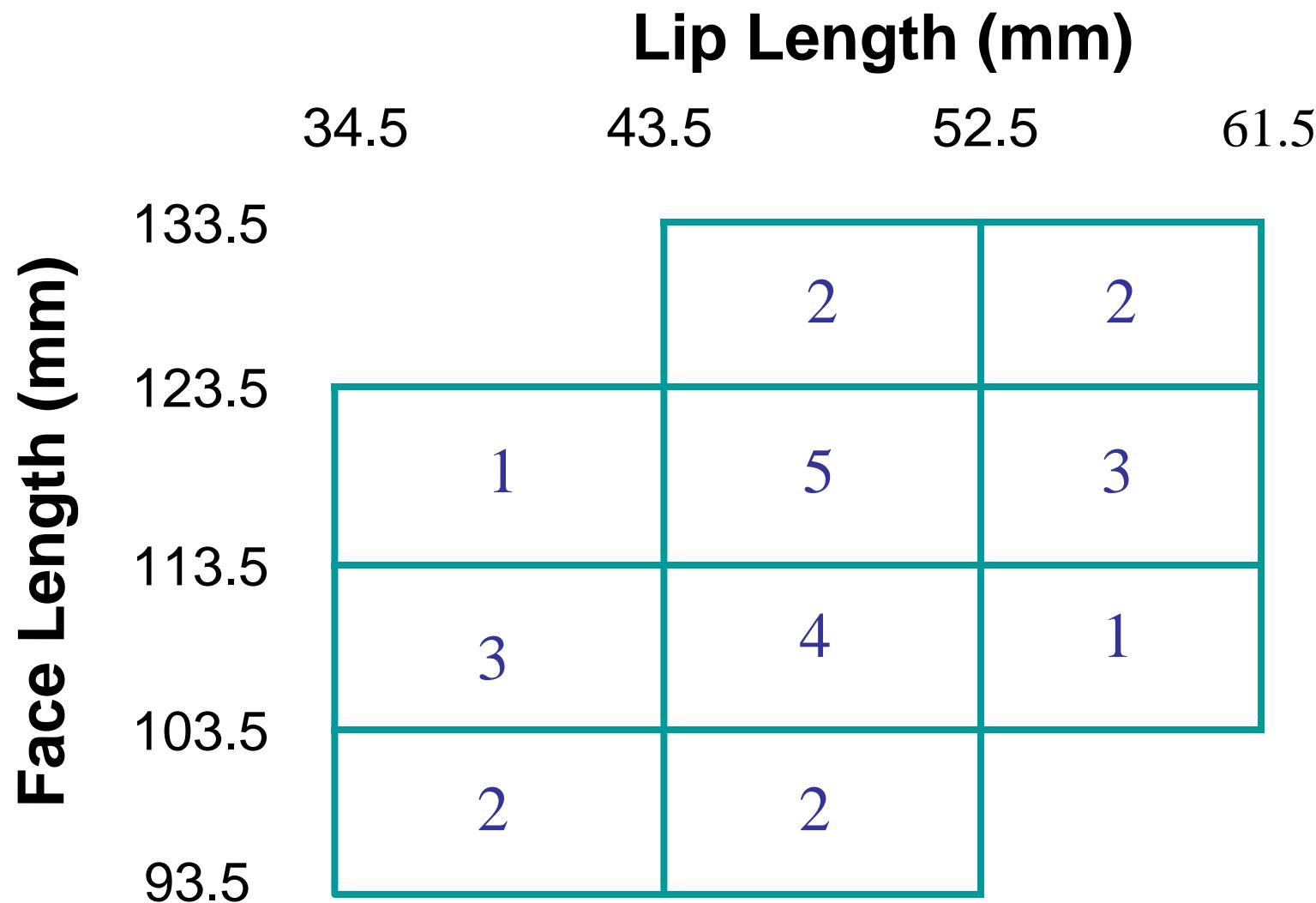
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- **Military data has been the normative basis for commercial respirator sizing**
- **Anthropometric panels of facial dimensions are often relied upon to provide sizing reference**
- **The current panels were developed based on 1967-68 US Air Force surveys**

# LANL 25-Member Panel for Full-Facepiece Respirators



# LANL 25-Member Panel for Half-Facepiece Respirators



# Background (Continued)

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- These panels have played a prominent role in respirator fit test
- The facial anthropometry is assumed to be representative of U.S. adults
- Respirators designed to fit these panels are expected to accommodate 90-95% of the population

# Background (Continued)

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- Concern was raised about compatibility
- Los Alamos surveyed 200 males (1973)
- Bureau of Mines surveyed 48 male mine rescue workers (1978)
- NIOSH found that 16% of CAESAR subjects were rejected by LANL panel for full-facepiece respirators (2002)

# Background (Continued)

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- **Military data may not represent the great diversity in face size in civilian population**
- **The demographics of the U.S. population have changed over the last 30 years**

# Race Distribution of 1967-1968 Air Force Survey Subjects and 2000 U.S. Population

| <b>Race</b>             | <b>Air Force</b>          |                             | <b>2000 Census</b>        |                             |
|-------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|
|                         | <b>Male</b><br><b>(%)</b> | <b>Female</b><br><b>(%)</b> | <b>Male</b><br><b>(%)</b> | <b>Female</b><br><b>(%)</b> |
| <b>White</b>            | <b>98</b>                 | <b>91</b>                   | <b>71.6</b>               | <b>71.4</b>                 |
| <b>African American</b> | <b>1</b>                  | <b>8</b>                    | <b>11.8</b>               | <b>12.5</b>                 |
| <b>Hispanic</b>         | <b>1</b>                  | <b>1</b>                    | <b>12.1</b>               | <b>11.5</b>                 |
| <b>Asian/Pacific</b>    | <b>-</b>                  | <b>-</b>                    | <b>3.7</b>                | <b>3.9</b>                  |
| <b>American Indian</b>  | <b>-</b>                  | <b>-</b>                    | <b>0.8</b>                | <b>0.7</b>                  |

# Objectives

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- Develop an anthropometric database detailing the face-size distributions of respirator users
- Compare the distributions of respirator users with those of Air Force pilots
- Determine if the LANL respirator fit test panels need to be revised

# Methods

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- A stratified sampling plan was used
  - 2 gender strata: male and female
  - 3 age groups: 18-29, 30-44, and 45-66
  - 4 race/ethnic groups:
    - White, African American, Hispanics, and Others
- Sample size was determined using the procedures outlined in ISO 15535
$$\begin{aligned} n &= (1.96 \times CV / a)^2 \times 1.534 \\ &= (1.96 \times 5.3 / 1)^2 \times 1.534 = 166 \end{aligned}$$

# Targeted Sample Size by Sampling Cell

|                  | Male       |            |            |             | Female     |            |            |             |
|------------------|------------|------------|------------|-------------|------------|------------|------------|-------------|
|                  | Age Group  |            |            |             | Age Group  |            |            |             |
| Race             | 18-29      | 30-44      | 45-65      | Sum         | 18-29      | 30-44      | 45-65      | Sum         |
| White            | 166        | 166        | 166        | 498         | 166        | 166        | 166        | 498         |
| African American | 166        | 166        | 166        | 498         | 166        | 166        | 166        | 498         |
| Hispanic         | 166        | 166        | 166        | 498         | 166        | 166        | 166        | 498         |
| Others           | 166        | 166        | 166        | 498         | 166        | 166        | 166        | 498         |
| <b>Sum</b>       | <b>664</b> | <b>664</b> | <b>664</b> | <b>1992</b> | <b>664</b> | <b>664</b> | <b>664</b> | <b>1992</b> |

# Methods (Continued)

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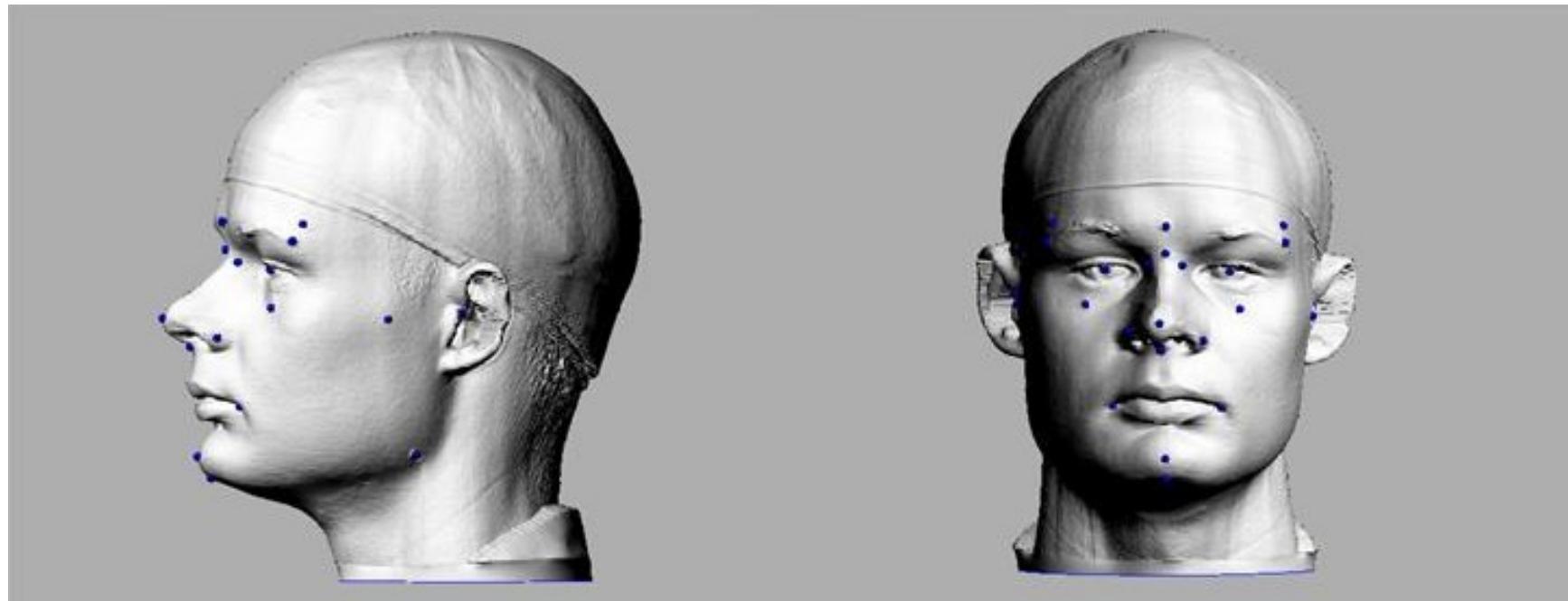
- Traditional measurement methods
- 3D laser scanner

# Measurement List

|                           |                         |
|---------------------------|-------------------------|
| Maximum Frontal Breadth   | Bigonial Breadth        |
| Menton Selliion Length    | Bitragion Coronal Arc   |
| Minimum Frontal Breadth   | Bitragion Frontal Arc   |
| Nasal Root Breadth        | Bitragion Subnasale Arc |
| Neck Circumference        | Bitragion Chin Arc      |
| Nose Breadth              | Bizygomatic Breadth     |
| Nose Protrusion           | Head Breadth            |
| Stature                   | Head Length             |
| Subnasale Selliion Length | Head Circumference      |
| Weight                    | Interpupillary Breadth  |
|                           | Lip Length              |

# 3D Scan with Landmarks

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# Methods (Continued)

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- Nationwide data collection
- Manufacturing
- Construction
- Healthcare
- Fire department
- Law enforcement

# Results

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- A total of 4026 subjects were measured using the traditional methods
- 1043 of them were scanned into the computer using a 3D head scanner
- Subjects aged 18-66 were included in the final sample (n=3998)

# Final Sample by Sampling Cell

| Race             | Male      |       |       |       | Female    |       |       |       | Total |  |
|------------------|-----------|-------|-------|-------|-----------|-------|-------|-------|-------|--|
|                  | Age Group |       |       | Total | Age Group |       |       | Total |       |  |
|                  | 18-29     | 30-44 | 45-65 |       | 18-29     | 30-44 | 45-66 |       |       |  |
| White            | 271       | 611   | 485   | 1367  | 151       | 194   | 174   | 519   |       |  |
| African American | 101       | 255   | 278   | 634   | 51        | 213   | 325   | 589   |       |  |
| Hispanic         | 155       | 182   | 75    | 412   | 53        | 36    | 37    | 126   |       |  |
| Other            | 24        | 47    | 59    | 130   | 52        | 65    | 103   | 220   |       |  |
| Total            | 551       | 1095  | 897   | 2543  | 307       | 508   | 639   | 1454  |       |  |

# Final Sample (Scanned) by Sampling Cell

| Race             | Male       |            |            |            | Female     |           |           |            | Total |  |
|------------------|------------|------------|------------|------------|------------|-----------|-----------|------------|-------|--|
|                  | Age Group  |            |            | Total      | Age Group  |           |           | Total      |       |  |
|                  | 18-29      | 30-44      | 45-65      |            | 18-29      | 30-44     | 45-66     |            |       |  |
| White            | 77         | 169        | 128        | 374        | 97         | 52        | 14        | 163        |       |  |
| African American | 29         | 78         | 62         | 169        | 16         | 32        | 35        | 83         |       |  |
| Hispanic         | 41         | 69         | 33         | 143        | 18         | 10        | 11        | 39         |       |  |
| Other            | 6          | 21         | 11         | 38         | 12         | 4         | 14        | 30         |       |  |
| <b>Total</b>     | <b>153</b> | <b>337</b> | <b>234</b> | <b>724</b> | <b>143</b> | <b>98</b> | <b>74</b> | <b>315</b> |       |  |

# Final Sample by Geographic Region

| State        | N           | %            |
|--------------|-------------|--------------|
| California   | 229         | 5.7          |
| Illinois     | 1564        | 39.1         |
| Kentucky     | 93          | 2.3          |
| New York     | 120         | 3.0          |
| Ohio         | 751         | 18.8         |
| Pennsylvania | 29          | 0.7          |
| Texas        | 857         | 21.4         |
| Virginia     | 355         | 8.9          |
| <b>Total</b> | <b>3998</b> | <b>100.0</b> |

# Final Sample by Occupation

| Occupation      | Male        |              | Female      |              | Total       |              |
|-----------------|-------------|--------------|-------------|--------------|-------------|--------------|
|                 | N           | %            | N           | %            | N           | %            |
| Construction    | 594         | 23.4         | 47          | 3.2          | 641         | 16.0         |
| Fire Fighting   | 775         | 30.5         | 74          | 5.1          | 849         | 21.2         |
| Health Care     | 381         | 15.0         | 1100        | 75.7         | 1481        | 37.0         |
| Law Enforcement | 121         | 4.8          | 7           | 0.5          | 128         | 3.2          |
| Manufacturing   | 429         | 16.9         | 60          | 4.1          | 489         | 12.2         |
| Others          | 244         | 9.6          | 166         | 11.4         | 410         | 10.3         |
| <b>Total</b>    | <b>2544</b> | <b>100.0</b> | <b>1474</b> | <b>100.0</b> | <b>3998</b> | <b>100.0</b> |

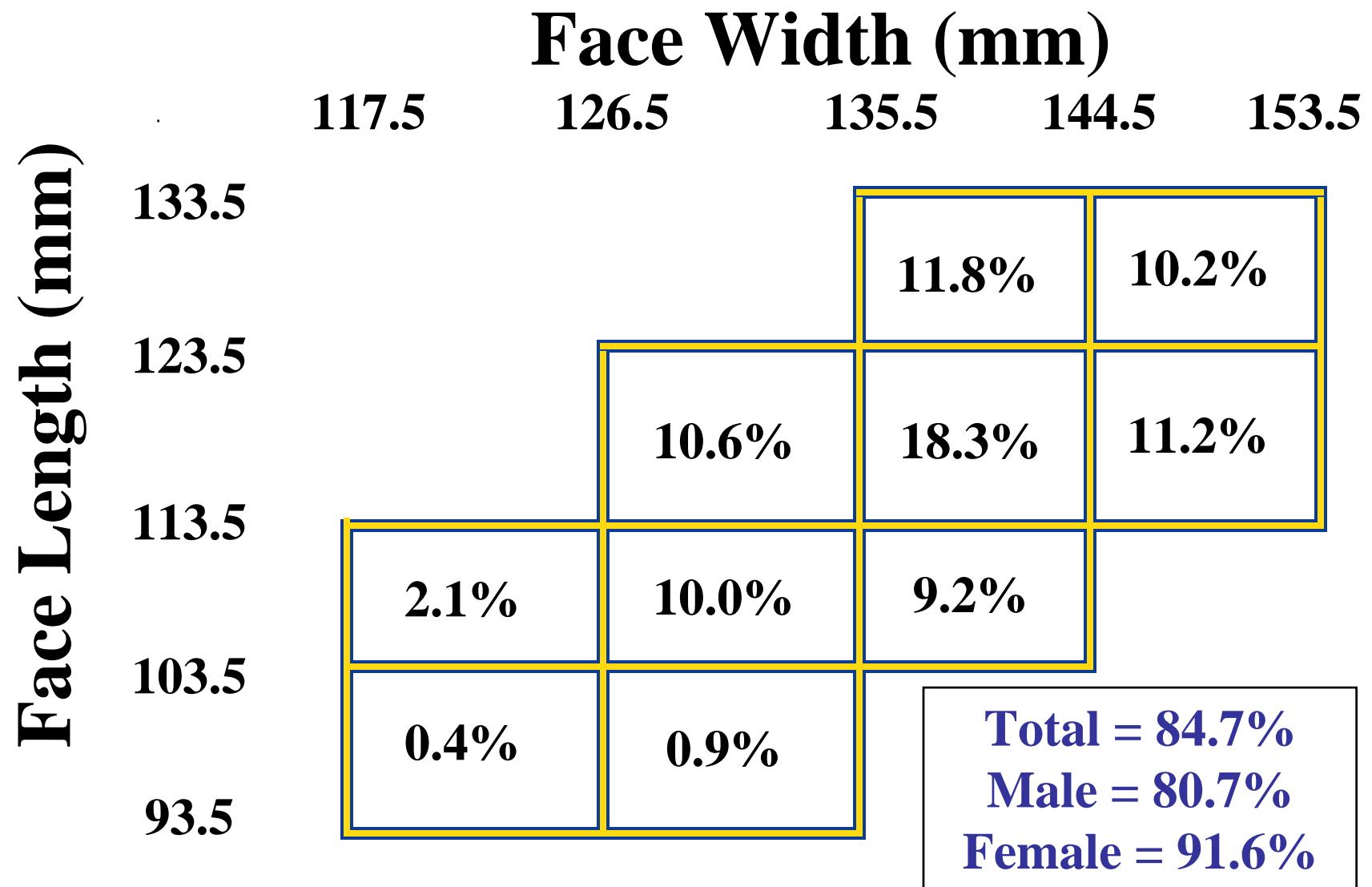
# Weighting Factors (Fraction of a Race/Age Group in U.S. Population Divided by the Fraction of the Same Group in the Sample)

| Race             | Male      |       |       | Female    |       |       |
|------------------|-----------|-------|-------|-----------|-------|-------|
|                  | Age Group |       |       | Age Group |       |       |
|                  | 18-29     | 30-44 | 45-65 | 18-29     | 30-44 | 45-65 |
| White            | 1.517     | 1.069 | 1.474 | 1.502     | 1.890 | 2.406 |
| African American | 0.836     | 0.425 | 0.312 | 1.000     | 0.324 | 0.162 |
| Hispanic         | 0.809     | 0.691 | 0.934 | 1.124     | 1.822 | 1.150 |
| Other            | 2.333     | 1.339 | 0.742 | 0.597     | 0.566 | 0.265 |

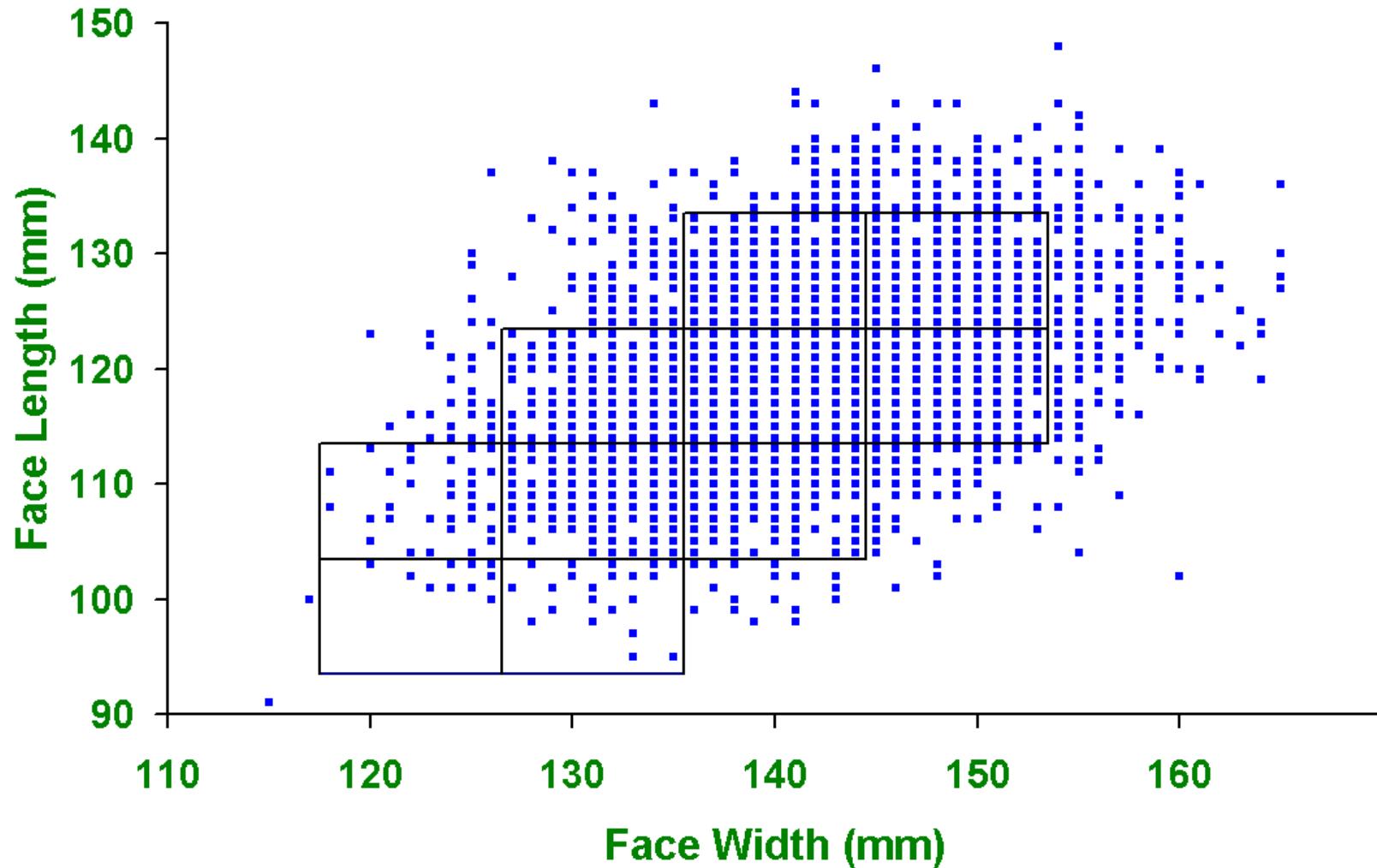
# Summary Statistics for Key Dimensions

| Facial Dimensions | Survey | Male      |     | Female    |     |
|-------------------|--------|-----------|-----|-----------|-----|
|                   |        | Mean (mm) | SD  | Mean (mm) | SD  |
| Face Length       | USAF   | 120.3     | 6.1 | 106.3     | 6.1 |
|                   | NPPTL  | 122.7     | 7.1 | 113.4     | 6.1 |
| Face Width        | USAF   | 142.3     | 5.2 | 129.0     | 5.8 |
|                   | NPPTL  | 143.5     | 6.9 | 135.0     | 6.5 |
| Lip Length        | USAF   | 52.3      | 3.8 | 43.8      | 4.2 |
|                   | NPPTL  | 51.1      | 4.2 | 48.0      | 4.0 |

# Fitting the NPPTL Data into the LANL Panel



## Bivariate Distribution against the LANL Panel



# Conclusions

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- An anthropometric database detailing the face-size distributions of the current U.S. workers was created
- The 1967-68 Air Force survey data is not reflective of the anthropometric distribution of the current U.S. workers
- New respirator fit test panels need to be developed

# Acknowledgement

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- **Anthrotech Staff**

# Thank You

## Any questions?