

# Overview of NIOSH Research for Improving and Understanding Respirator Fit: Past, Present, and Future

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No Fit Test Respirator Research Workshop  
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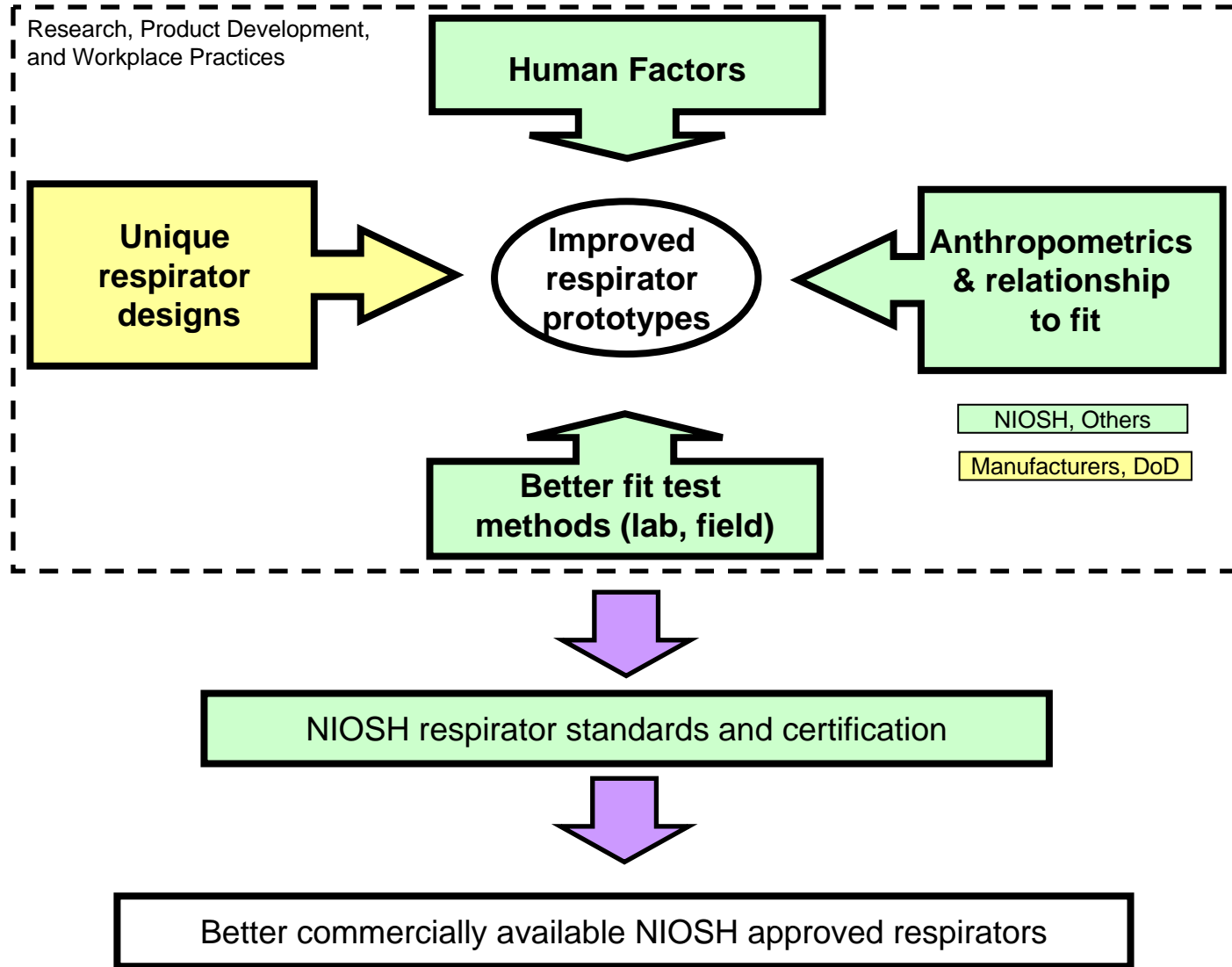
# Improving Respirator Fit Supports NIOSH PPT Program Objectives

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## Program Objectives for NIOSH PPT Strategic Goal #1:

1. **Ensure the integrity of the national inventory of respirators through the implementation of a just-in-time certification process**
2. **Develop CBRN Respirator Standards to reduce exposure to CBRN Threats**
3. **Ensure the Availability of Mine Escape Respirators for escape from mines**
4. **Improve reliability and level of protection by developing criteria that influence PPE designs to better fit the range of facial dimensions of respirator users in the U.S. workforce**
5. **Quantify the impacts of various PPE on viral transmission**
6. **Evaluate the nanofiber-based fabrics and NIOSH-certified respirators for respiratory protection against nanoparticles**
7. **Develop and make available end-of service life indicator (ESLI) technologies that reliably sense or model performance to ensure respirator users receive effective respiratory protection**
8. **Gather information on the use of respirators in the workplace to identify research, intervention, and outreach needs**

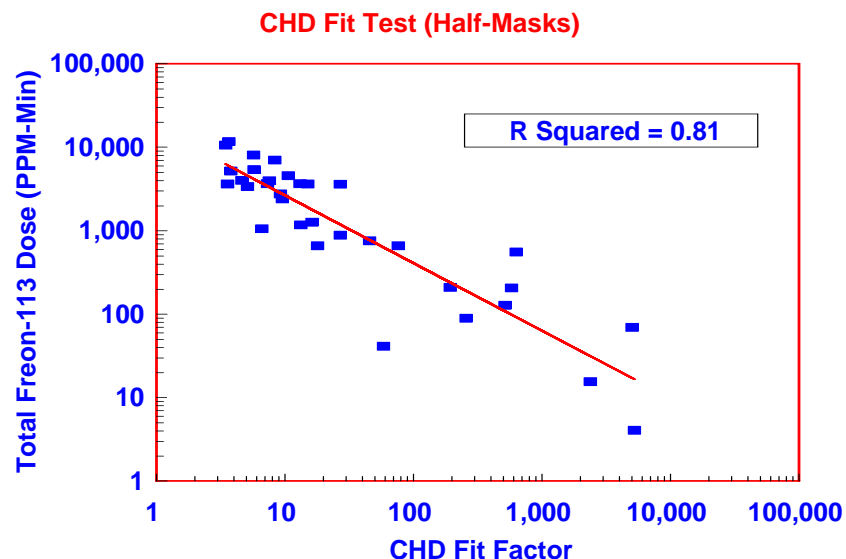
# NIOSH Strategies for Improving Respirator Fit



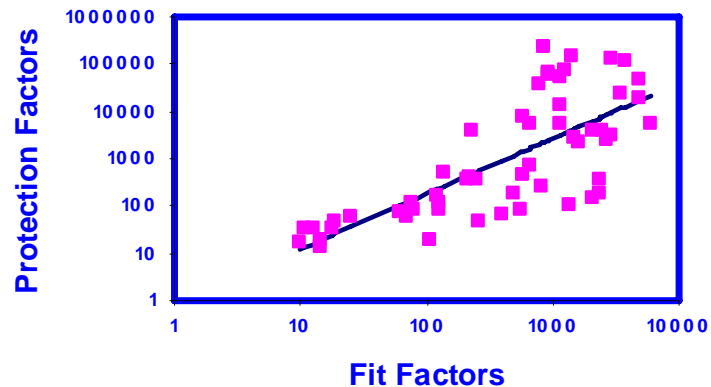
# Better Fit Test Methods (lab/field)

# Validation / Evaluation of Fit Test Methods

- **Multiple research projects conducted between ~1995 – 2005**
  - Validate quantitative & qualitative fit test methods
  - Simulated workplace protection factor studies
  - Workplace protection factor studies
  - New fit testing concepts
- **>10 manuscripts published**
- **Key findings**
  - Fit testing reduces worker exposure
  - Quantified fit test error rates



**Correlation between Fit Factors and Protection Factors Measured at a Steel Foundry (Half-Masks)**



# LRPL Test Chamber

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- **Background** – Laboratory Respiratory Protection Level (LRPL) testing is a multiple exercise fit test protocol to assure good self-donning face fitting characteristics across a wide range of faces. Currently used in all CBRN certification approvals and can easily be used for future requirements
- **Current Status** – operational

## Subjects in LRPL Chamber



# P100 vs. N95 Protection

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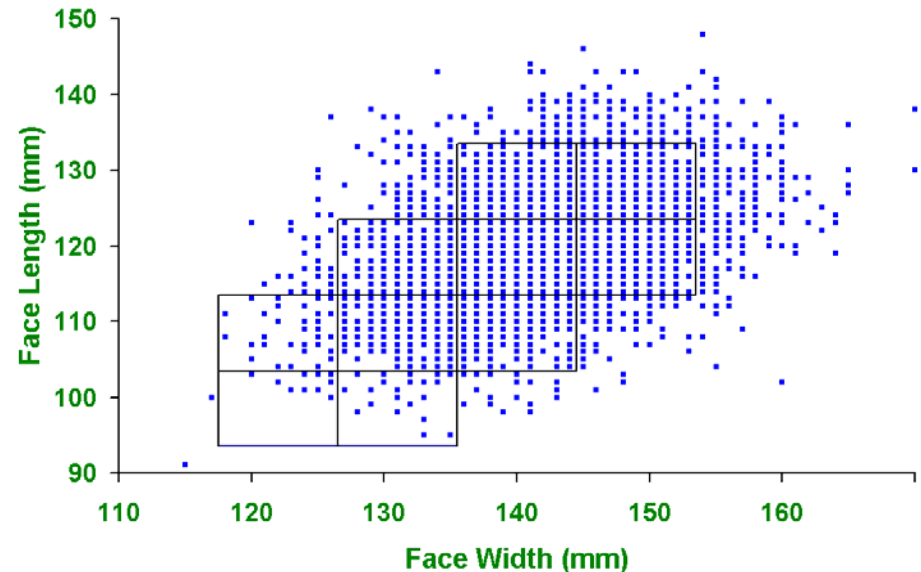
- **Background** – significant interest in assessing the differences in protection provided by an N95 versus P100
- **Concept**
  - N95 and P100 FFRs, elastomeric half-masks
  - The test panel consists of 10 individuals who were representative of the LANL Panel for half-mask respirators.
  - Using new NPPTL fit test facility
- **Status**
  - Data is currently being reviewed and will be shared with stakeholders upon completion of the analysis

# Anthropometrics & Relationship to Fit

# 2003 Head and Face Anthropometric Survey

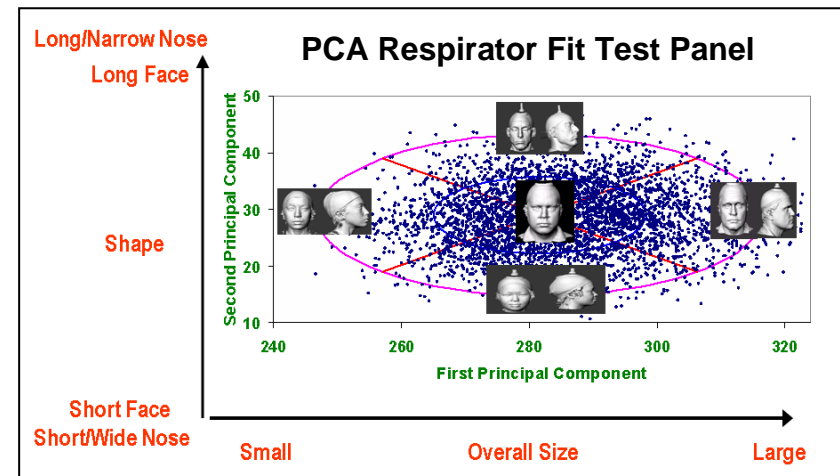
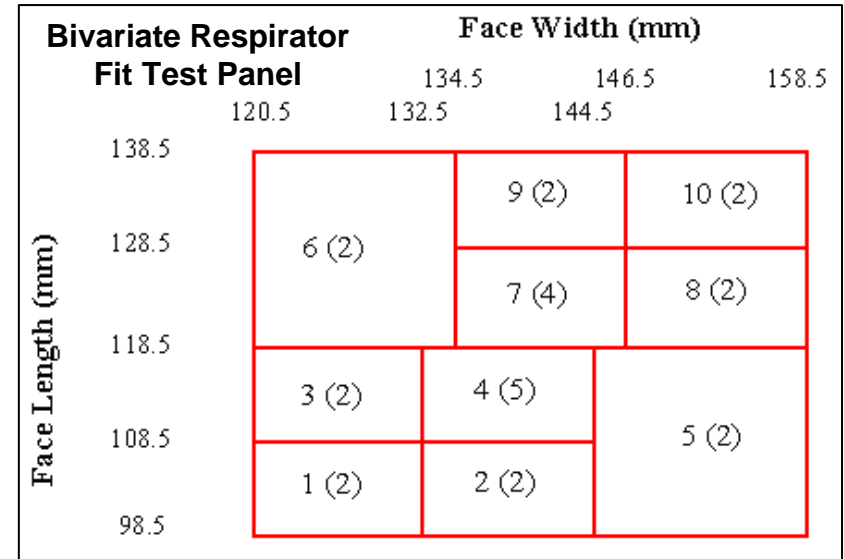
- **Goal** – better understanding the sizes and shapes of the heads and faces of the U.S. work force
- **Approach** – 3997 subjects (traditional measurements), 1039 subjects (3-D scan data)
- **Key findings**
  - Los Alamos National Laboratory (LANL) full-facepiece panel excludes > 15% of the current US work force
  - Current U.S. work force has larger heads and faces and is more diverse than 1967 military personnel

Overlay of NIOSH Survey Data vs. LANL Panel



# Respirator Fit Test Panels

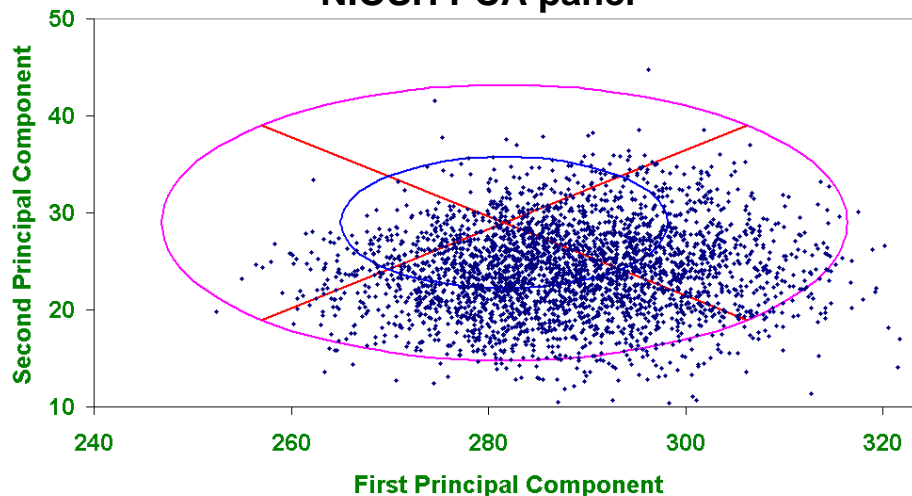
- **Goal** – Develop new respirator fit test panels & sizing systems
- **Background** - respirator fit test panels provide an objective tool for selecting test subjects based upon their facial characteristics for use in research, product development, testing, and certification
- **Key findings** - NIOSH bivariate and the PCA fit test panels are more representative than the LANL panel and cover > 95% of the current U.S. work force
- **Current applications** – used in draft NIOSH total inward leakage test and ISO technical specifications & test methods, cited by FDA as an example test panel, by manufacturers for product design



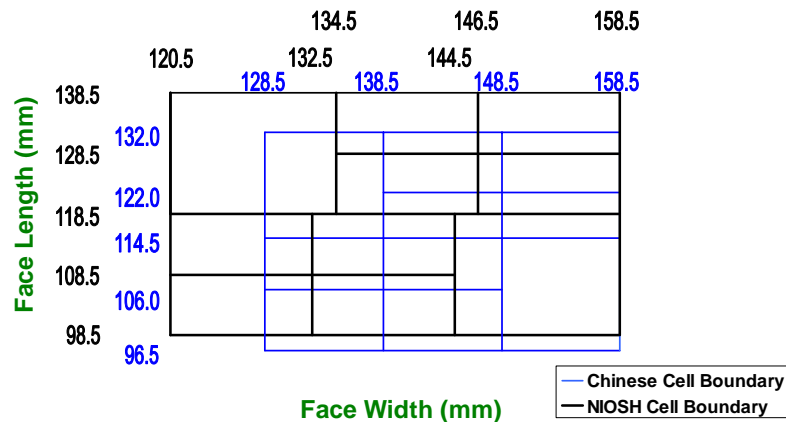
# Appropriateness of NIOSH Survey for ISO standards

- **Goal** – Determine how well NIOSH data represent global workforce
- **Approach** – collaborated with Tongji Medical College to (1) create an anthropometric database of 3000 Chinese workers, (2), evaluate applicability of NIOSH respirator fit test panels, and (3) if needed, develop new panels using Chinese survey data
- **Key findings** –
  - 95% of the Chinese survey within limits of the NIOSH panels
  - Distribution across panels was uneven (shorter face length, smaller nose protrusion, larger face width)
  - Fit test panels specific for the Chinese work force may be beneficial for some applications

Distribution of the Chinese subjects in NIOSH PCA panel



Comparison of NIOSH and Chinese bivariate panels



# Representative Headforms for Respirator Testing

- **Goal** – characterize new approaches for developing respirator test headforms
- **Approach** –
  - Used 3-D head scan data from the 2003 NIOSH anthropometric survey
  - Averaged five 3-D head scans from the survey that were representative of each of the 5 “sizes” from the NIOSH PCA respirator fit test panel
- **Current status** –
  - 5 digital 3-D headforms created
  - Comparison with other headforms still in progress



Large, medium, and small test headforms

# Respirator Fit Research

- **Goal** – investigate the relationships between half-facepiece respirator fit data and facial anthropometry
- **Approach** – obtained respirator fit (4 models) and anthropometric data for 30 human test subjects
- **Key finding** – correlation found between respirator size and face size category based upon the NIOSH respirator fit test panels



NIOSH face size category	Respirator size with highest passing rate	Fit Test Passing Rate		
		Respirator Size		
		Small	Medium	Large
Small (NIOSH Cells 1-3)	Small	$\frac{22}{27} = 81\%$	$\frac{18}{27} = 67\%$	$\frac{7}{27} = 26\%$
Medium (NIOSH Cells 4-7)	Medium	$\frac{32}{48} = 67\%$	$\frac{40}{48} = 83\%$	$\frac{32}{48} = 67\%$
Large (NIOSH Cells 8-10)	Large	$\frac{12}{43} = 28\%$	$\frac{33}{44} = 75\%$	$\frac{36}{42} = 86\%$

# Frequency of Fit Testing

- **Background**

- OSHA regulations (29CFR 1910.134) require respirator users to pass a fit test before using a respirator. Fit testing and training should be conducted annually
- Factors causing changes in respirator fit are not well quantified



- **Approach** – Multi-year laboratory study to investigate how changes in weight and facial shape/size affect changes in fit over time
- **Status** – Peer-review completed and is currently under review by NIOSH's human subject review board
- **Goal** – initiate data collection in 2009



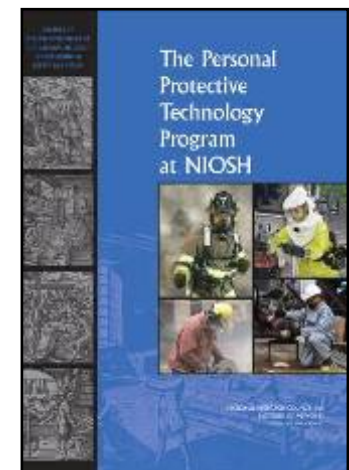
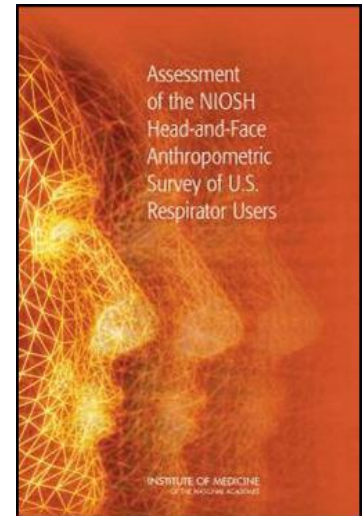
# Overview - Action Plan for Facial Anthropometrics and Respirator Fit Research

- **Background** – In 2006, IOM conducted an evaluation of the NIOSH anthropometric survey

## Approach

- Analyzed IOM recommendations and reviewed ongoing research in NIOSH, academia, government, and industry
- Developed a NIOSH strategy (“Action Plan”) for facial anthropometrics and respirator fit research resulting in a prioritized 10 year plan for the sequence of research projects to address information gaps
- Solicited public comments (9/2007 – 5/ 2008)

- **Current status** – Analyzing comments and incorporating into broader NIOSH PPT program action plan



# Human Factors

# Respirator Use and Practice

- **Objective** – identify well-developed practices to improve respirator use
- **Methods**
  - 2001 BLS survey
  - Focus groups & worksite observations
  - Questionnaire & donning evaluation in post-hurricane New Orleans
- **> 10 manuscripts published**
- **Some key findings relevant to fit**
  - BLS survey: fit testing is not done in ~50% of the establishments where tight fitting respirators are used
  - Among participants in New Orleans survey <25% demonstrated proper donning technique; factors reflecting respirator training and experience associated with proper donning



*Water-damaged New Orleans home with extensive mold growth, March 2006.*

# Quality Partnerships Enhance Worker Safety & Health



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***Disclaimer: The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.***

## Thank you

# Contact Information

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