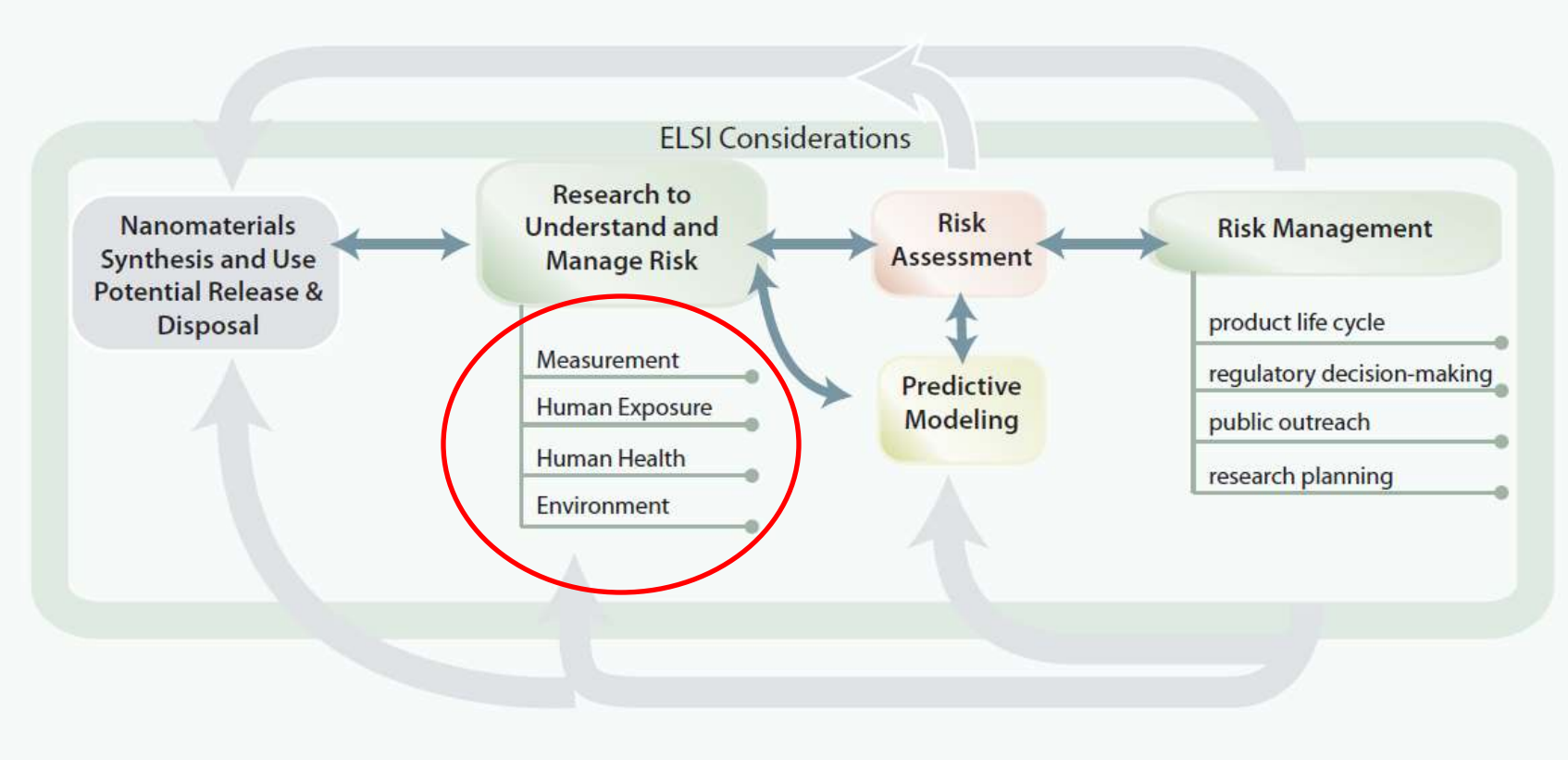
Exposure Assessments and Risk Management Guidance – Update on Strategic Approaches

Kenneth Martinez, CIH, MSEE

Field Studies Team Leader
Nanotechnology Research Center
Education and Information Division
National Institute for Occupational Safety and Health

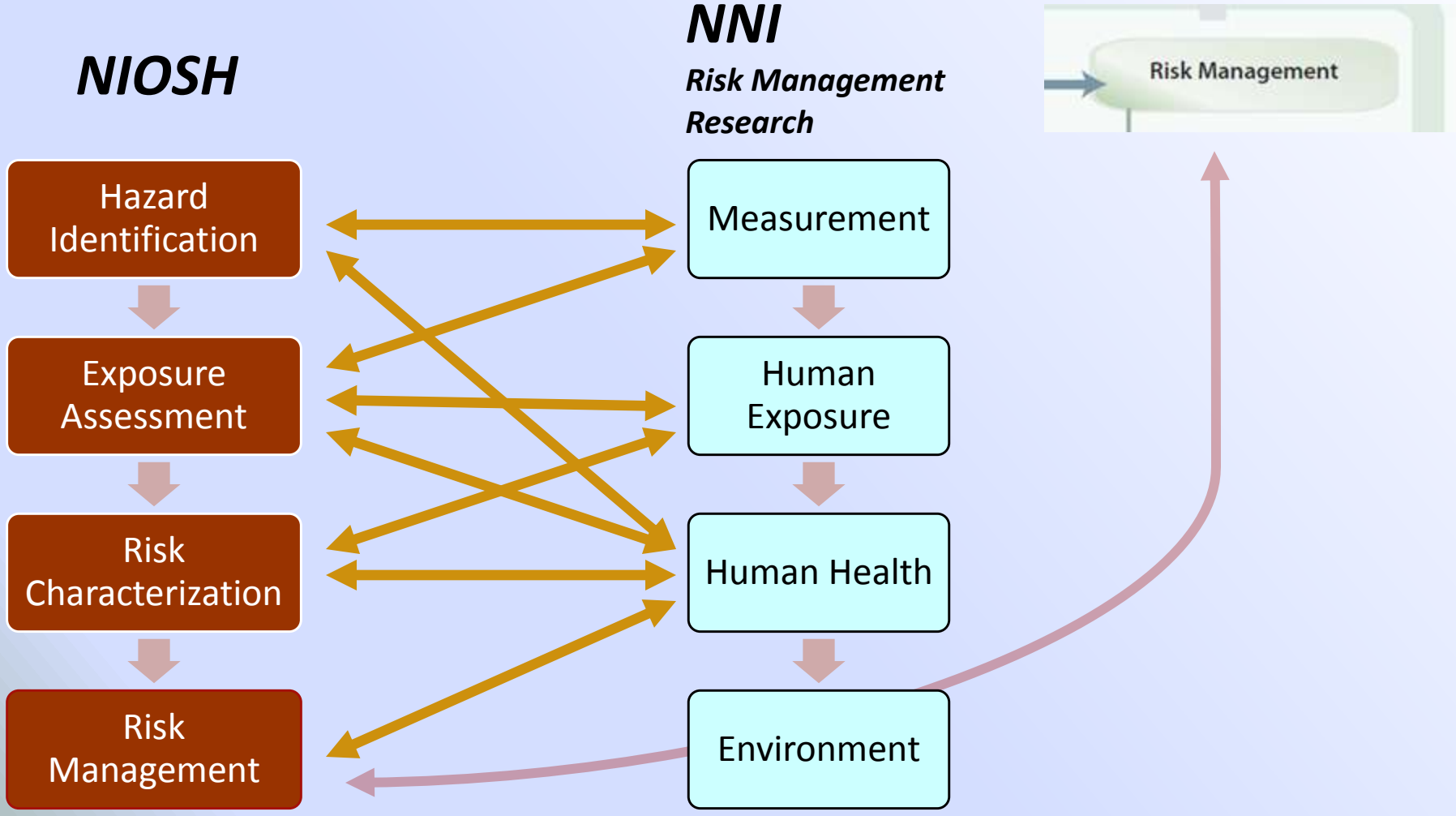
The findings and conclusions in this presentation have not been formally reviewed by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

NNI EHS Risk Management Research Framework



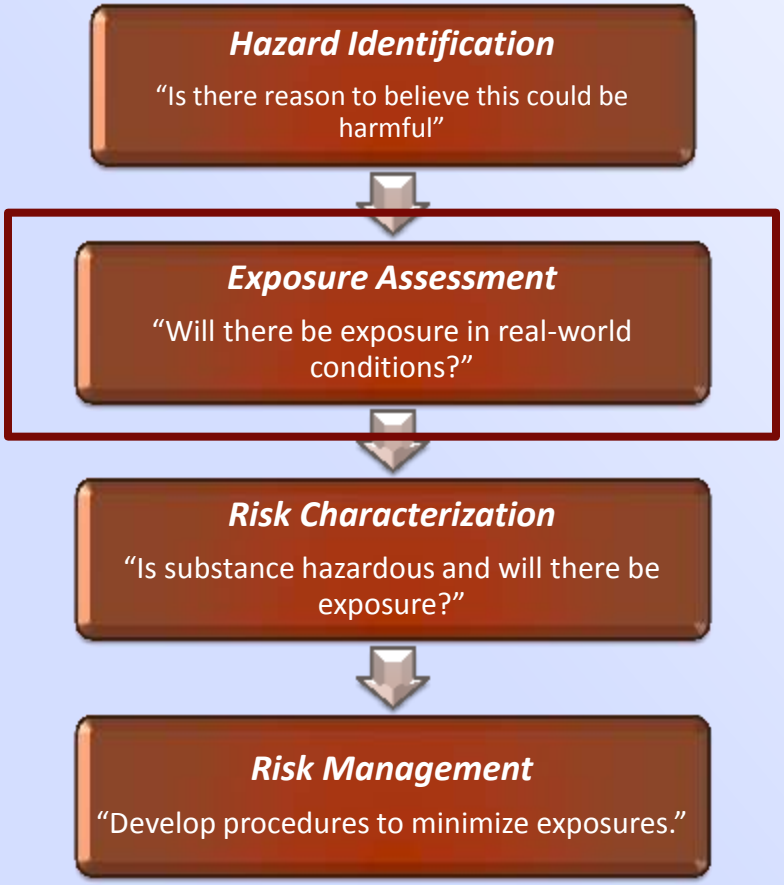
Key Elements of Risk Management

Research Strategy Correlation



Key Elements of Risk Management

Focus for today



NTRC Field Studies Team Background

- Formally organized in 2006 as a component of the NIOSH Nanotechnology Research Center
- Conducted 20 site visits in a variety of work places
- Tasked with “learning nanomaterial processes”…
- Attempting to fill an important knowledge gap regarding nanomaterial creation and use:
  - ***Is there a release?***
  - ***To what extent?***
  - ***Is there potential worker exposure?***

NFST – 2011 to Present

Goals

- Evaluates the entire material flow of a process and identifies points of potential material emission that can result in worker ***exposure***
- Uses an array of instruments and conventional air sampling methods to characterize exposures
  - Available to the practicing industrial hygienist
- Evaluates ***engineering controls*** and their effectiveness in reducing emissions and exposures
- Evaluates ***work practices*** used during the production or use of nanomaterials
- Evaluates the use of Personal Protective Equipment in use, if any, including respiratory protection

NFST – 2011 to Present

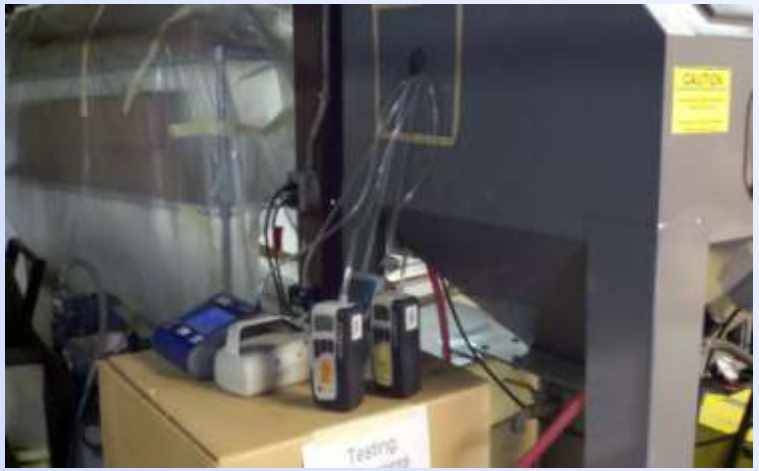
Methods

- Preassessment
  - Occupational exposure limits and health effects
    - Review pertinent literature
      - Toxicology
      - Epidemiology
    - Provides context of interpretation of data
  - Develop sampling strategy
    - Integrated samples
    - Real-time instrumentation (RTI)
    - Wipe sampling

NFST – 2011 to Present

Methods

- Sampling Strategy
  - Integrated samples
    - *Core component of exposure assessment*
    - Filter-cassette based
      - Elements
      - Electron Microscopy
    - Area and personal breathing zone
    - Full-shift and task-based

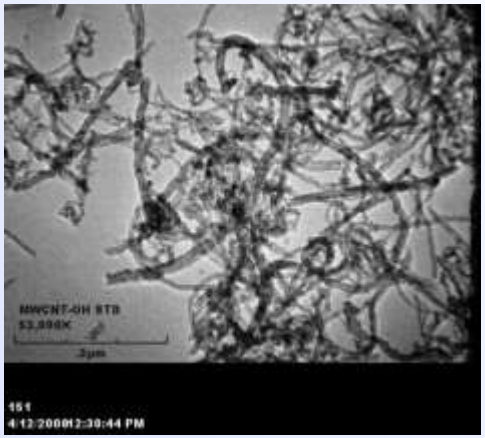


Integrated Sampling

- Elemental mass
  - Sampling and analytical methods not designed for nanomaterials
    - Specificity

      NMAM 5040 (elemental carbon) versus NMAM 7300 (cadmium)
    - Sensitivity

      10 µm particle weighs the same as 10^9 (1 billion) 10 nm particles
- Electron microscopy
  - TEM versus SEM
  - Morphology
  - EDS for chemical composition
  - Particle count
  - No counting convention exists
- Respirable fraction



Inhalable	• 100 µm diameter
Thoracic	• 10 µm diameter
Respirable	• 4 µm diameter

Integrated Sampling

- Personal breathing zone
  - "True" indicator of worker's exposure
  - Determines levels of exposure throughout workday
  - Can be compared to OELs
- Area
  - Survey sources of contaminant
  - Evaluate engineering controls
- Background
  - Other contributions not related to the process

Integrated Sampling

- Full-Shift versus Task-Based
  - Most OELs are based on TWA
    - + Full-shift
    - - No OELs exist for nanoparticles
      - Except NIOSH (CNT and TiO_2)
  - Identify level of source contribution
    - + Task-based
    - - Activities may be of short duration
      - Analytical sensitivity ↓

Direct Reading Instruments

- TSI CPC 3007 (TSI Inc., Shoreview, MN)
- ARTI HHPC-6 (Hach Company, Grants Pass, OR)
- TSI DustTrak DRX (TSI Inc., Shoreview, MN)

Appropriate Use of DRIs

- Assess efficacy of engineering controls
- Assess potential for emission of specific processes/tasks
- Identify general increases or decreases in total particle concentration
- Provide supporting evidence for integrated samples

Limitations of DRIs

- ***No*** material identification
- Condensation Particle Counter
  - Engineered to measure 'particle' concentrations – not fibers
  - Upper dynamic range in the order of 10^5 pt/cc
- Small inlet can become clogged with larger particles
- Optical Particle Counter (DustTrak)
  - Unable to accurately assign 'size bin' to fibrous materials
- Optical Particle Counter (ARTI)
  - Unable to accurately assign 'size bin' to fibrous materials
  - Only total count is useful data
    - Only 50% collection efficiency for the smallest size bin (0.3-0.5 µm)
    - Unable to correct accurately due to inaccurate size designations
  - Clean room instrument
    - Inlet easily clogged in dusty environment

Wipe Sampling

- Surface contamination
- No correlation with worker inhalation exposures
- Assess worker hygiene practice
- NMAM 9102
  - Elements
  - Wash ‘n Dry or ASTM equivalent

    Pre-packaged moist disposable towelette
  - Analysis by inductively coupled argon plasma atomic emission spectroscopy

Vacuum Sampling

- Surface contamination
  - Filter sock
    - More mass
    - Less time
    - Use of a template
    - Analysis requires resuspension
  - 37-mm filter cassette
    - Good for hard to reach areas
    - Less mass
    - Labor intensive
    - Amenable to standard sample analysis and EM

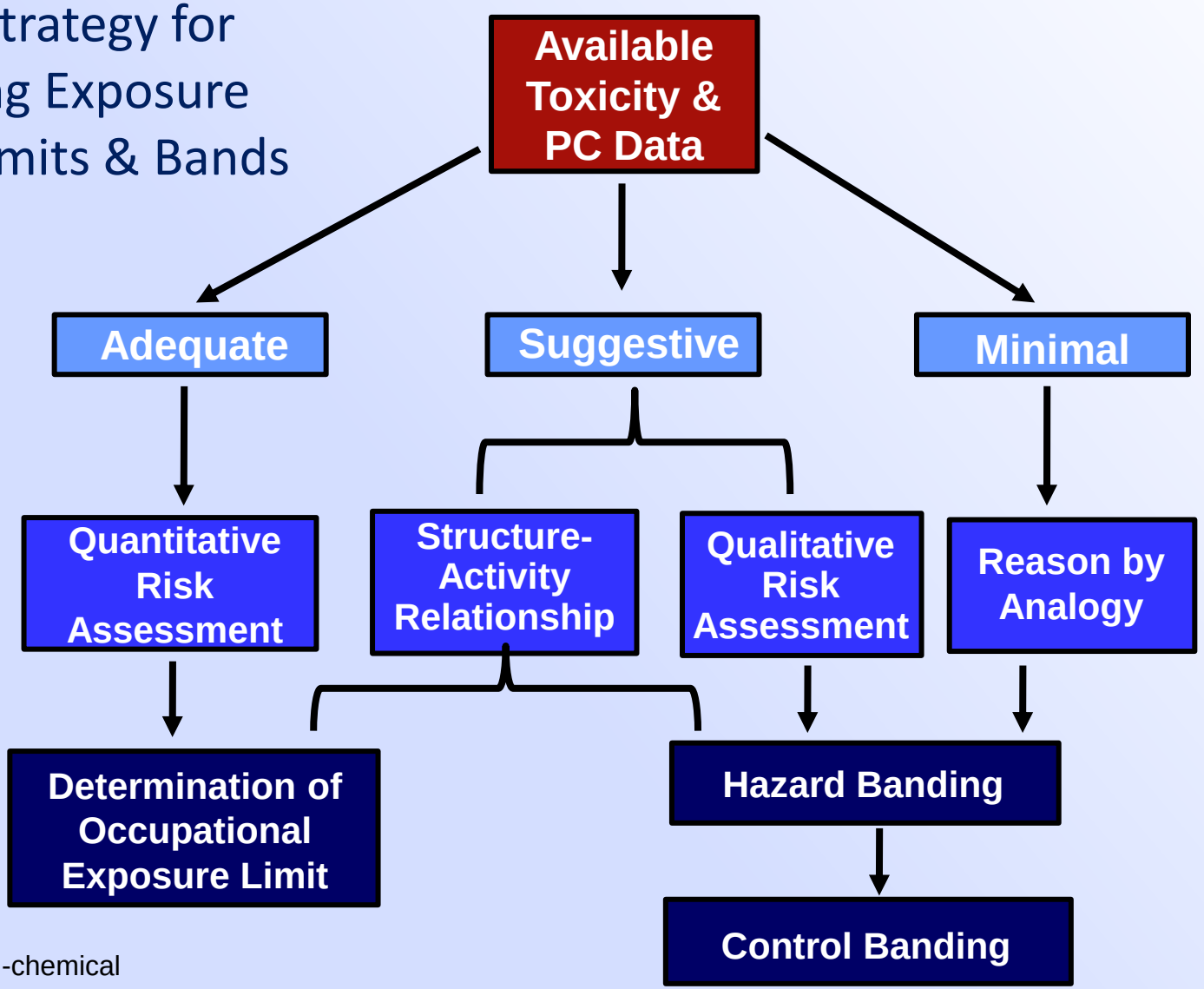
NFST – 2010 to present

12 Field Studies

Types of facilities	Number of sites
Primary producer of nanomaterials	9
Secondary user of nanomaterials (manufacturer)	1

- Agents
  - Carbon nanotubes, aluminum oxide, amorphous silica, cerium oxide, quantum dots, silver nanowires, zirconium oxide, hafnium oxide, catalytic nanoparticles (iron, nickel, silver-palladium, and magnesium) and nickel-titanium alloy

Possible Strategy for Developing Exposure Control Limits & Bands



PC: physical-chemical

[Adapted from Schulte et al. 2010, J Nanopart Res]

Output to Participating Companies

- Report
  - Introduction
  - Background
  - ***Evaluation Criteria***
  - Methods
  - Results
  - Discussion
  - Conclusions and Recommendations