



# *Nanotechnologies for Future Armament Systems*

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# What are Nanotechnologies

- ✱ *Technology based on the characteristics of small atomic clusters (1 to 100nm) have very different properties than the same materials in bulk and that the physical properties are size dependant*
- ✱ *Materials display new chemistry and physics when their size falls below the critical lengths that characterize a particular property such as scattering length, diffusion length, etc.*
- ✱ *Properties can be engineered by altering cluster size*
- ✱ *Materials can be any type; metals, ceramics, polymers, glasses, or composites synthesized from bottom up from individual atoms and molecules*



# TACOM-ARDEC Needs Nanotechnologies

- ✱ **Electronics/Optics/Sensors**
  - ✱ Smart Munitions
  - ✱ IR Sensors
- ✱ **High performance light weight structural materials:**
  - ✱ Warhead and Gun components
  - ✱ Penetrators
  - ✱ Armors
- ✱ **Functional Gradient coatings**
  - ✱ Corrosion prevention
  - ✱ Lubricants
- ✱ **More Powerful Energetics**
  - ✱ Multi-role functionality
  - ✱ Enhanced Blast
  - ✱ Non lethal effects

# Why develop this technology for weapons?

## • Nanoparticles

### • Energetic Materials

- C-H-N-O formulations may have reached a viable energy limit
- Nanoparticle metals may react in a detonation zone.
- Nanoparticle metals may enable the energy release process to be engineered for detonations.

## • Carbon Nanotubes (CNT)

### • Strength of Materials

- Carbon nanotubes (CNT) have a yield strength that is 100 times larger than the yield strength for steel.
- CNT will enable the mechanical properties of materials to be engineered

*Grand challenge is to render small munitions effective against FCS Target spectrum*

Material	DH <sub>f</sub>
CL-20	393 kJ/mol
AlF <sub>3</sub>	1510 kJ/mol
Al <sub>2</sub> O <sub>3</sub>	1675 kJ/mol

## • Why Now?

- Starting in FY01 there is a massive National Nanotechnology initiative that can be leveraged (\$412M)
- This effort is anticipating (\$528M) in FY02
- National Advanced Energetics program being initiated by OSD (\$30M/yr for the next 3 to 5 years)
- Affords the opportunity to mature these technologies in time to impact FCS EMD.

# Nanopowder Programs for Munitions Applications

	Army	Navy	AF	DOE
<b>Nanomaterial Synthesis and Characterization</b>				X
<b>Reactive Structural Components for Warheads</b>	X		X	
<b>Reactive Fragments</b>		X		
<b>Micro Energetic Initiators for MeMs S&amp;A Designs</b>	X	X		X
<b>High Energy Explosives Formulations and Processing</b>	X		X	
<b>Metastable Intermolecular Compounds (MIC) materials</b>	X	X		
<b>Structural Materials</b>	X			

# What are the technical barriers?

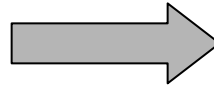
## ✱ Barriers to implementation:

- ✱ No established quantitative weapons effectiveness study to verify claims of nano enhanced energetics/warheads
- ✱ Surface area affects and reactivity make processing these materials difficult and hazardous.
- ✱ Nanoparticle metals or Carbon Nanotubes cannot be readily produced economically
- ✱ Methodologies and standards for characterizing these materials do not exist

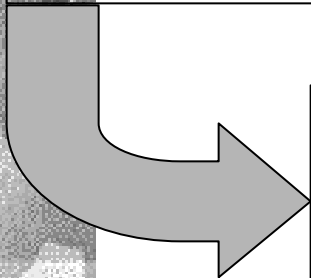


# Approach

- Identify optimal nanopowder characteristics by:
  - Screening different materials (ie compound species)
  - Varying particle size and size distributions
  - Varying the passivation



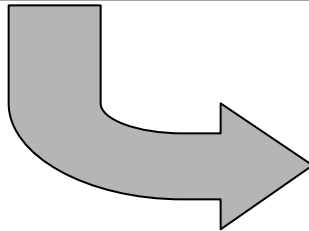
- Develop nanopowder fabrication alternatives
  - Evaluating different processes
  - Assess producibility
  - Scale-up



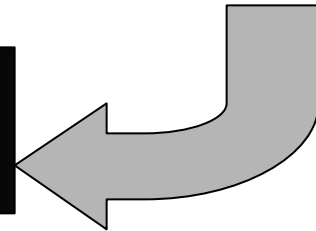
- Develop highly filled material processes
  - Rheological characterization of constituents
  - Model and simulate process flows
  - Conduct process runs & Characterize
  - Assess producibility and scale-up



- Develop a process for consolidation of metal powders
  - Model and Simulate
  - Conduct process runs & Characterize
  - Assess producibility and Scale up



- Design and LAP Test Vehicle
  - Model & Assess performance
  - LAP hardware & Test



# Initial Team Members

## • TACOM-ARDEC

- Chemical and Vapor phase condensation nanopowder production
- Materials characterization
- Project coordination

## • Stevens Institute of Technology/MPRI

- Process Modeling and Simulation
  - Nanopowder process development and scale up
  - Nanopowder composite processing
- Material characterization

## • ATK (Thiokol Division)

- Energetic material fabrication and testing
- Energetics production processes

## • Rutgers.

- Nanopowder process development
- Nanopowder production

## • General Dynamics(OTI Division)

- Effectiveness determination
- Device design and prototype demonstrations

## • SAA International

- Device demonstrations
- Warhead testing and manufacturing technology implementation



# Manufacturing Research, Development, & Education Center for Nanotechnologies

Industry/Academe/Government Affiliated

## NanoValley



# Purpose:

- ✱ Establish a regional coalition of universities and educational institutions to conduct research in Nanotechnologies
- ✱ Generate an environment that is conducive to business growth
  - ✱ Small innovative start-up initiatives
  - ✱ New ventures for large organizations
- ✱ To optimize the utilization of existing facilities and resources at Picatinny Arsenal.



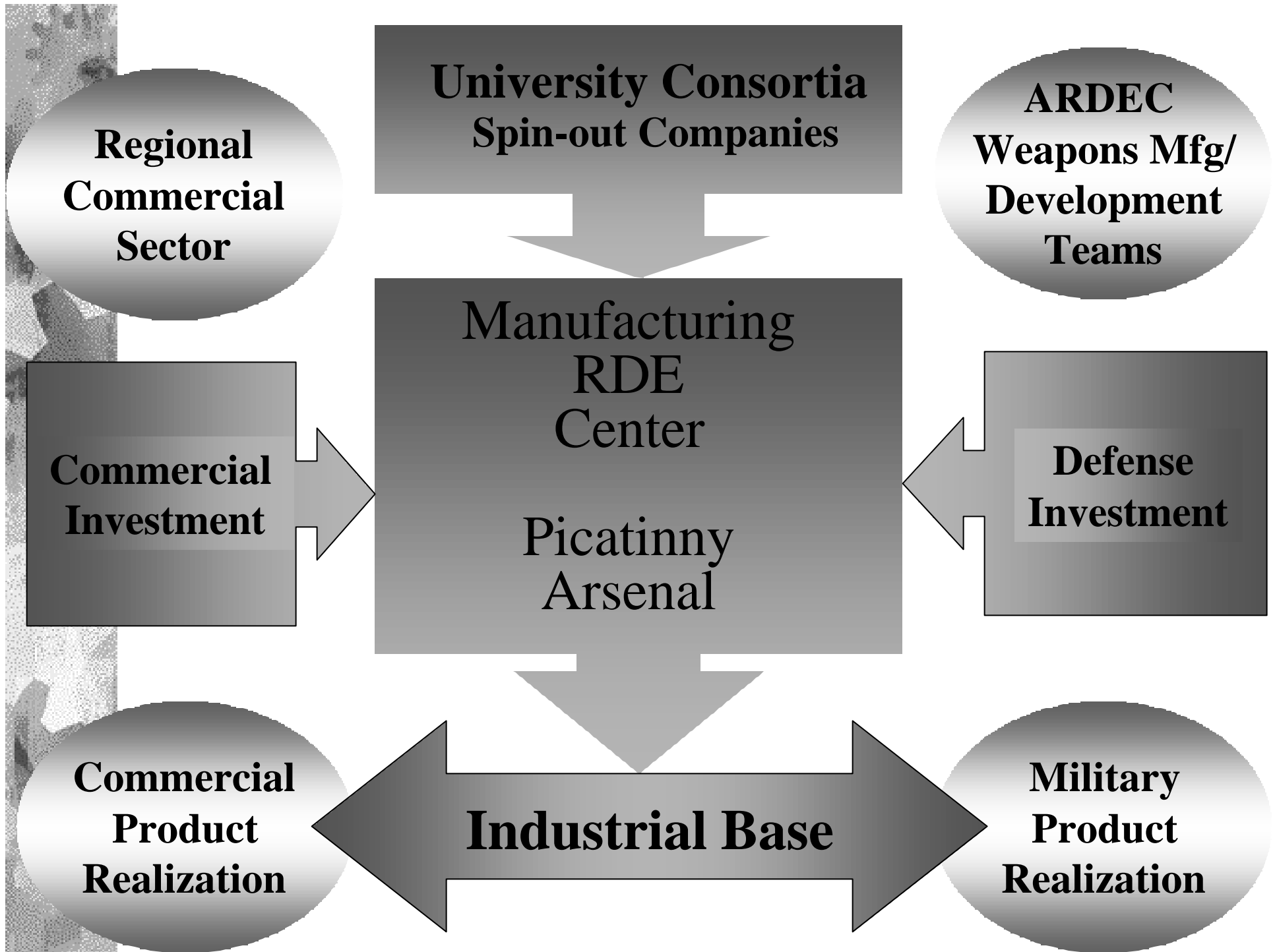
# The Mission:

- ✱ To facilitate the development of future manufacturing technologies and to train a competent workforce.
  - ✱ To promote research collaboration among regional Academic institutions
  - ✱ To accelerate the growth of small “High Tech” businesses
  - ✱ To enable new growth areas for large companies
  - ✱ To streamline the technology transfer process
    - ✱ Establish a manufacturing knowledge base for both the defense and commercial industrial communities
    - ✱ Establish new educational opportunities



# Initial Start-up FY02

- ✱ To exploit regional expertise in Nanotechnologies
  - ✱ The Center for Nanomaterials Research(CNR) at Rutgers University has become a focal point for nanomaterials research and collaboration
    - ✱ Has a proven track record for building successful businesses
  - ✱ The Highly Filled Materials Institute HfMI at Stevens Institute of Technology is a focal point for materials processing and technology transfer to industry
    - ✱ Has a long established relationship with many manufacturing organizations in major industrial areas.
- ✱ To exploit existing facilities at Picatinny Arsenal
  - ✱ The US Army TACOM-ARDEC is the Army's lead laboratory for energetic materials life cycle issues.
    - ✱ Has an established link between weapon developers and the defense industrial base
    - ✱ Existing facilities include:
      - Laboratories for hazardous operations
      - Prototype pilot facilities



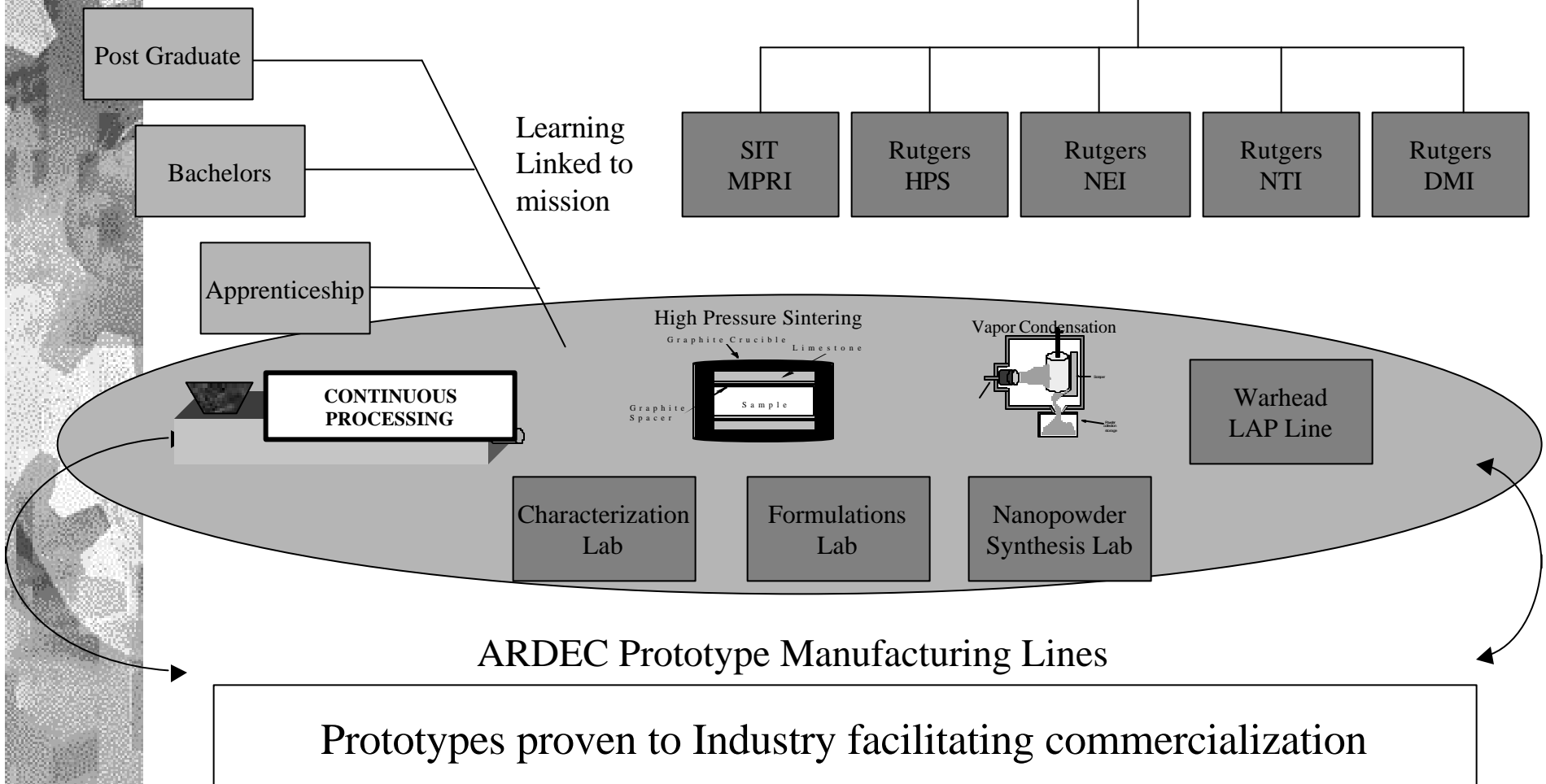
# Manufacturing R&D Center Initial Ventures for FY02

## Picatinny of the Future

### Training Center

Skilled Labor Development

### University Intellectual Property





# Major Technology Areas

- ✱ Technology areas:
  - ✱ Energetics
  - ✱ Pharmaceuticals and Biological Materials
  - ✱ Chemical Processes
  - ✱ Advanced Composite Materials
  - ✱ Functionally Gradient Materials
  - ✱ Special Coatings
  - ✱ Electronics, Sensors, and Micromachines
  - ✱ Miniature Power Sources and Fuel Cells
  - ✱ Metastable Ceramics



# Future Growth Beyond FY02

## ✱ University Coalition

- ✱ As research from the national initiative matures it is anticipated in FY03
  - ✱ Additional NJ Institutions
    - NJIT
    - Princeton
  - ✱ Pennsylvania Institutions
    - Drexel University
    - University of Pennsylvania
    - Penn State University
    - Ben Franklin Institute
    - Nanotechnology Institute of Pennsylvania

## ✱ New business spinouts

- ✱ Rutgers anticipates adding 1 new organization every 6 months
- ✱ As the weaponization efforts mature processing information may lead to alliances with several major companies in different industries
  - ✱ May also enable spinouts
- ✱ SIT/Rutgers/ARDEC collaboration may produce patentable technologies for future ventures

# Summary

- ★ **An enormous effort to develop nanotechnologies is underway within and outside of DoD**
- ★ **The Army needs to identify which nanotechnologies can be rapidly developed for high payoff**
- ★ **ARDEC has positioned itself to efficiently develop and transition new technology and maximize resource Several key technology insertion windows exist**
- ★ **The Army must exploit this technology**

