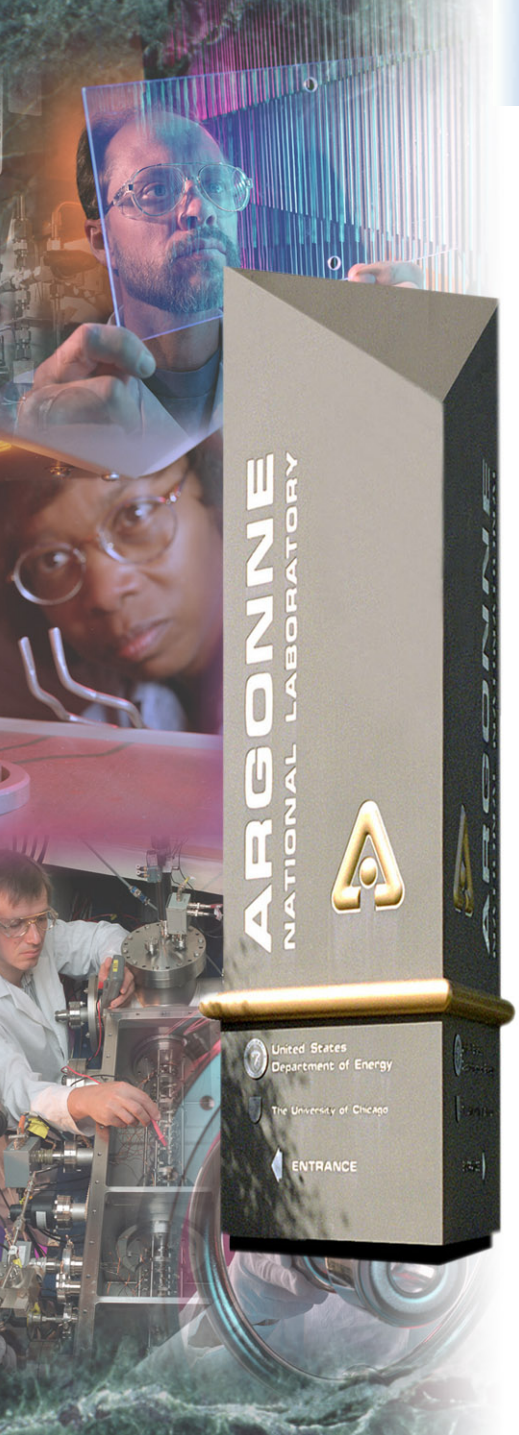

Industry and Government Collaboration to Facilitate Sustainable End-of-Life Vehicle Recycling

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Energy Systems Division

November 10, 2005

Argonne National Laboratory is managed by The University of Chicago for the U.S. Department of Energy

Recycling End-of-Life Vehicles (ELV) of the Future Cooperative Research and Development Agreement (CRADA)---Public/Private R&D Partnership

- *CRADA*
  - *Cooperative research and development agreement (contract) to do cost-shared R&D*

- *ELV CRADA Partners (US ELV CRADA Team)*
  - *Argonne National Laboratory/ U.S. Dept. of Energy*
  - *American Plastics Council*
  - *USCAR's Vehicle Recycling Partnership (DaimlerChrysler, Ford, GM)*

- *Organizing Theme*
  - *To achieve greater fuel-efficiency and safety, today's cars incorporate an increasing share of innovative lightweighting materials. While these materials greatly enhance efficiency during vehicle use, they can present special challenges to recycling.*

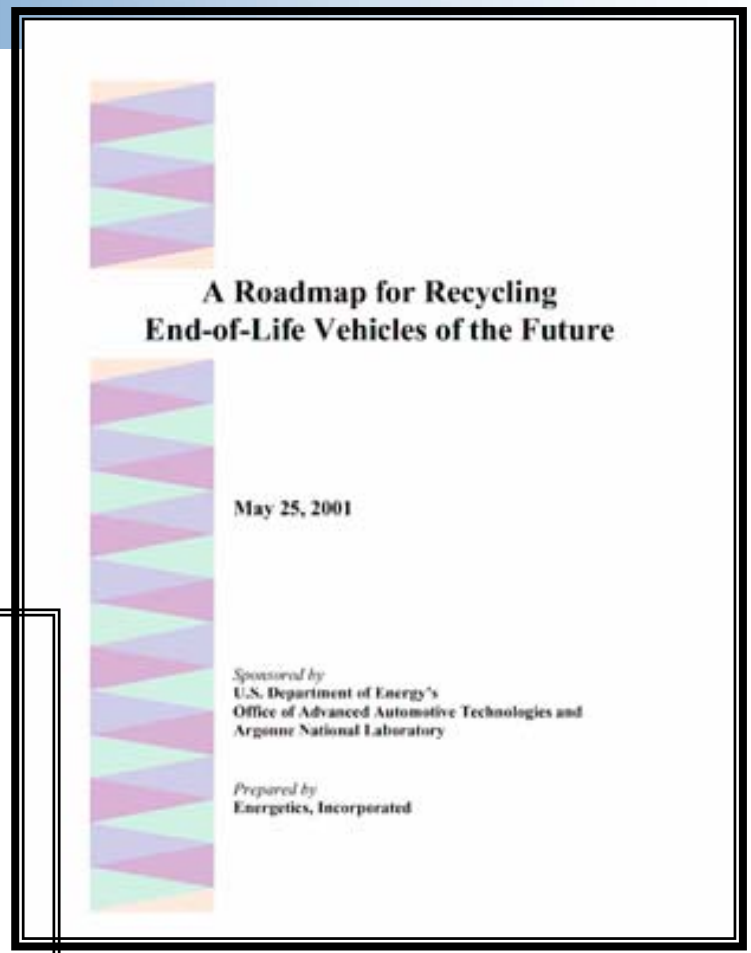
CRADA Background

- *Current CRADA initiated in August 2003*
  - *5 Years*

- *Scope of the CRADA*
  - *a) examination of issues that prevent recycling*
  - *b) identification of technology to enable recycling*
  - *c) development and demonstration of technologies to recover resources and materials*
  - *d) examination of options for design modifications to provide for more effective recycling*
  - *e) examination of alternative materials to increase recycling*

Current R&D Portfolio Evolved from Roadmap

- *Roadmap Issued May 25, 2001*
  - *Information*
  - *Technology*
  - *Markets*



Albany Research Center
The Aluminum Association
American Plastics Council
Argonne National Laboratory
Automotive Parts Rebuilders Assoc.
DaimlerChrysler Corp.
Department of Natural Resources, Canada
Ford Motor Co.
General Motors Corp.
Institute of Scrap Recycling Industries
Massachusetts Institute of Technology
Oak Ridge National Laboratory
Rochester Institute of Technology
Steel Recycling Institute
Sandia National Laboratory
US DOE

The Roadmap recommended---

- *The recyclability of ELVs is presently limited and several technical and economic barriers need to be overcome to increase recovery and recycling*
  - *Lack of commercially proven technical capabilities to cost-effectively separate, identify and sort materials*
  - *Lack of profitable post-use markets*
- *Development of technology to recycle today's materials will provide the basis for recycling of future materials*
- *Focus should be on post-shred technology demonstration*
- *Industry-wide collaboration is needed*
- *Worldwide technology needs to be tracked and information disseminated to users*

Projects Initiated Include:

- *Baseline Assessment of Recycling Systems and Technology*
  - *Literature review, bibliography, technology assessment*
  - *Life-cycle studies of "post-shred" technologies*
  - *Vehicle recyclability studies*

- *Post-shred Materials Recovery Technology Development and Demonstration*
  - *Technology Development and Benchmarking*
    - Mechanical Separation Technology
    - Thermo-chemical Conversion

- *Development of Technology for Removal of PCBs and Other Substances of Concern*

- *Compatibilization/compounding Evaluation of Recovered Polymers*
  - *Physical properties testing*
  - *Mold trials*

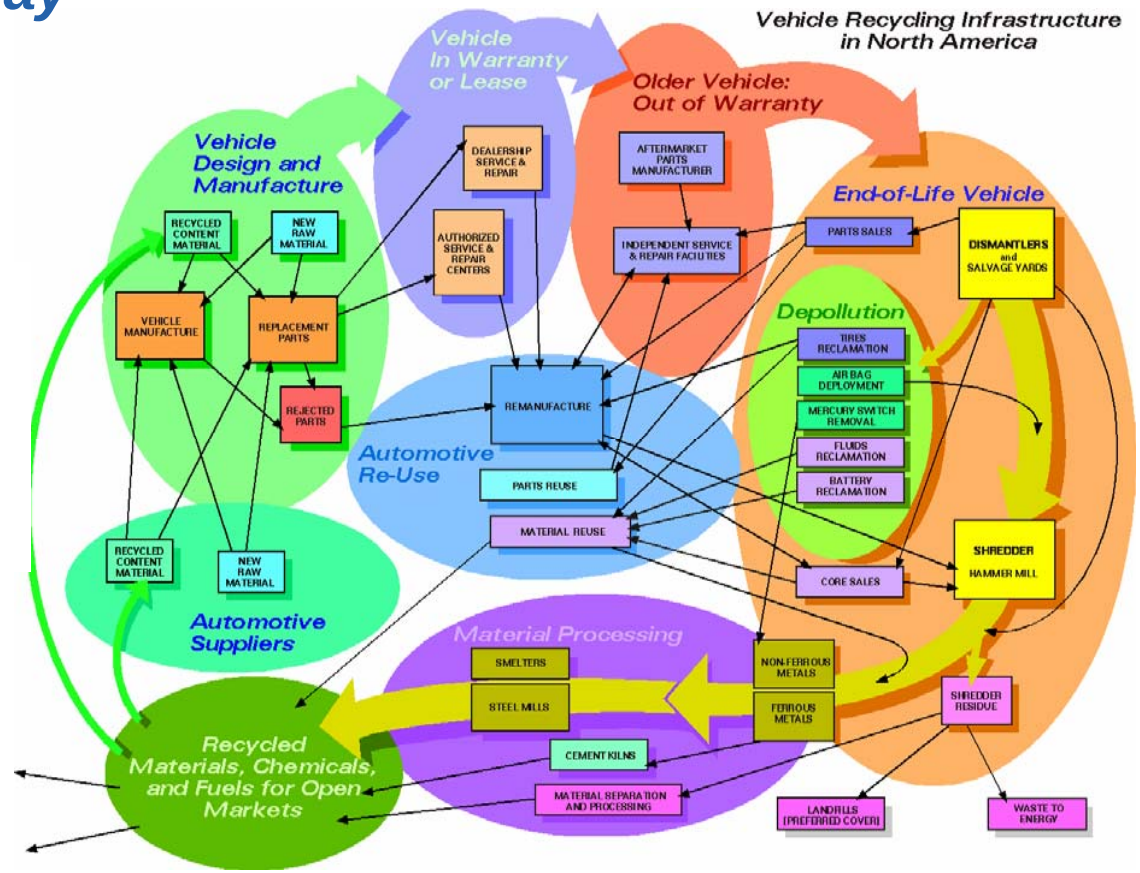
ELV Recycling is a Market Driven Success Today

75% of automotive materials are recycled

More than 12000 dismantlers

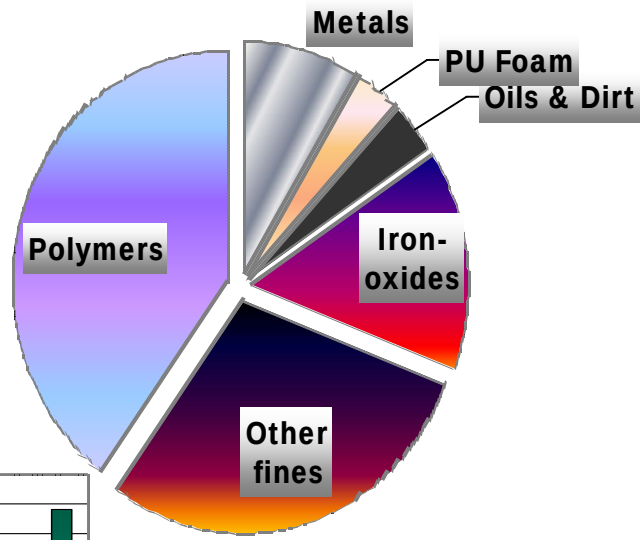
About 20000 remanufacturers

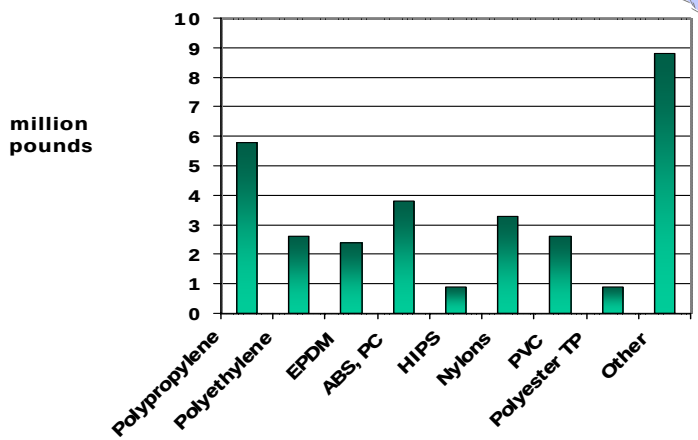
About 200 shredders



Options for Recycling the Balance of Automotive Materials

- *Separate and recover materials*
- *Convert to fuels and chemicals*
  - *Gasification*
  - *Pyrolysis*
  - *Glycolysis*
- *Energy Recovery*





The CRADA team is pursuing a comprehensive R&D portfolio to identify sustainable options for North America

- *Benchmarking of emerging European ELV processes*
  - *Salyp*
  - *VW-Sicon*
- *Demonstrating and developing advanced separation processes*
  - *Argonne mechanical separation/ froth flotation technology*
  - *MBA Polymers wet separation technology*
- *Evaluating novel separation technologies*
  - *Mineral jigs*
  - *Kinetic density separators*
- *Demonstrating and developing novel thermo-chemical conversion processes*
  - *Changing World Technologies hydrolysis process*
  - *Troy Polymers foam glycolysis process*

Argonne's Mechanical Separation Pilot-plant Provides a Focal Point

- *Physical separation produces material concentrates from bulk shredder residue*
  - *Foam*
  - *Ferrous and Non-ferrous*
  - *Polymer Concentrate*
- *Plastics recovery process is a 6-stage wet (froth flotation) system for recovery of plastics from the polymer concentrate*
  - *Polyolefins*
  - *ABS*
  - *Nylons*
  - *Other*

Physical Separation Pilot-Plant

Plastics Recovery Facility

Mold Trials Confirm the Technical Feasibility of Re-use of Recovered Polymers

- *Steering column cover*
- *Battery tray*
- *Knee bolster*

Some of Our Accomplishments to Date---

- *Developed a modular LCA for evaluation of alternative "post-shred" recycle technologies to serve as a guide for our research*
- *Designed, built and installed 1/10 scale mechanical separation and froth flotation pilot-plant at Argonne*
- *Confirmed the technical feasibility of recovering and reusing polyolefins from shredder residue (research is ongoing to recover additional plastics)*
- *Changing World Technologies confirmed the technical feasibility of converting shredder residue to liquid hydrocarbon fuels*
- *Troy Polymers confirmed the technical feasibility of converting polyurethane foam from shredder residue to polyol initiators*
- *Process economics appear favorable, but need confirmation*

Conclusion: The changing automotive material mix over the past fifteen years and evolutionary technology trends relative to automobile architecture for improved safety and environmental performance increase the recycling technical challenge

- *A joint U.S. government-industry CRADA was established in 2003 to lead the development of improved recovery and recycling methods for current and future ELVs*
- *The vision leading to this effort is one of sustainability and reduced environmental impact over the lifecycle of the automobile*
- *Ultimately, any new technology developed in response to these changes must have minimal risk--*
  - *Proven cost-effective at full-scale*
  - *Proven markets for products*
  - *Regulatory barriers removed/transactions costs minimized*

The CRADA Team actively seeks opportunities to work in collaboration with other major stakeholders…Sustainable ELV recycling is a global issue…

This research is funded by the American Plastics Council, USCAR's Vehicle Recycling Partnership and the U.S. Department of Energy Office of FreedomCAR and Vehicle Technologies.

A Brief History of Collaboration

- *1991 Vehicle Recycling Partnership formed*
- *1994 **First** CRADA (among VRP, Argonne and APC)*
  - *Dismantling*
  - *Seat foam recycling*
- *1997 **Second** CRADA among VRP, Argonne and APC Demonstration of Argonne froth flotation technology (post-consumer appliance plastics)*
- *1999 DOE PNGV (now FreedomCAR) funds*
  - *Argonne --- polymer matrix composite recycle*
  - *Aluminum Alliance --- LIBS alloy sorting*
- *2001 ELV Recycle Roadmap released*
- *2003 **Third** CRADA among VRP, Argonne and APC*
  - *Sustainable recycling*