Recycling of Automobiles

• Current status of industry [US]
  – Market exists for used parts and scrap materials
  – Old regs permitted on-site landfilling for site improvement
  – New regs call for ‘offsite’ licensed landfilling [PA]

• Future of industry [US & Europe]
  – More regulation for handling and storage of wastes
  – More direct responsibility of OEMs because of ‘mandatory product takeback’ regulations [EU]
TPP 123 Objectives

• Understand the impact of EOL regulations on design of new vehicles
• Model [estimate] costs of EOLV part recovery, material recovery, and/or disposal of wastes
• Identify ways to improve the vehicle design or improve the regulations to reduce environmental impact

EOLV Regulations

• Choice of words …
  – “EOVLs should be 75% recycled”
  – “less than 25% of an EVOL may be landfilled or ...”
  – “a new vehicle should have a 75% content”
• Some US MSW regulations began with numerical targets for recycling, but evolved to become numerical measures of the amount of waste diverted from landfills.
Scale of US Industry

- OEMs - the “Big 3” plus …..
- Disassemblers in the US - order of 1000 to 10,000; does not include car theft specialists
- Shredders - order of 200 plus -many shred other products besides EOLVs
- Landfills - order of 5000 - none specialize in EOLVs

US VRP Materials Description

- Plastics
  - ABS, PA, PET, PC, PUR, PP, PE, PVC, TPO, TEO, and OP
- Ferrous
  - carbon steel, iron
- Non ferrous
  - Al, Cu, Zn, Mg, Pb, stainless steel, ONF
- Other materials
  - glass, tire rubber, other rubber, fluids, OM
US VRP List of Parts ..26

- base engine
- **body shell**
- cowl, wipers
- engine compartment
- fluids
- F/R bumper & grill
- F/R door & lift gate
- **front fenders**
- F/R seats
- front suspension
- fuel tank
- head/tail lights
- heater/ventilator
- hood
- instru.panel/center console
- int/ext trim & carpet floor mat
- rear suspension
- **roof**
- safety systems
- side glass
- transfer case
- transmission
- tires
- wheels
- windshield/rear window
- others

End-of-life Vehicles

- Vehicle [model] lifetime is nominally 10-12 years.
- Vehicle may have several owners.
- Last owner addresses EOLV issues.
- Maintenance and repair results in functional parts with different lifetimes.
- Are EOLV parts or materials worth more?
- What is a classic or antique vehicle?
EOL Vehicle Age Distribution

- Some EOLV are young [<5 years] and some are old.
- Models of birth-death processes apply to vehicles
- Demographics: retirement age is getting later; how much is EOLV ‘death weight?’
- Material composition of EOLV changes with time and there is a time lag before this affects disassemblers and shredders.

EOL Vehicle Processing

- This is a separate industry from the OEMs.
- Disassemblers may pay or charge [tipping fee] for receipt of an EOLV.
- Shredders may pay or charge for receipt of an EOLV, a flattened hulk, or a whole hulk.
- Used parts and scrap materials may be offered for sale by disassemblers and shredders.
EOLV Disassembly

- Disassemblers may specialize in brands, in younger models, or have no specialization.
- Some disassemblers handle other products in addition to motor vehicles.
- Some disassemblers are modern, high tech operations using electronic data bases.
- Some disassemblers handle ‘walk-in’ and ‘distant -meaning world wide’ customers

Hulk Shredding

- EOLVs are flattened to fit into feed opening of hammermills.
- Hammermills reduce large objects to ‘fist sized pieces.’ This is called ‘shredding.’
- In addition to EOLVs, used appliances [white goods] and other materials are processed in the same hammermills.
EOLV Outputs

- Parts and scrap materials are recovered to generate revenue.
- Waste products are regulated and typically generate costs to the disposer.
- Dissipative environmental releases from handling and processing have received less attention than “solid waste” products. Noise, truck traffic, and road litter are local concerns.

Shredder Industry Description

- In 1995, there were 211 ‘heavy duty’ shredders in US and 651 in world.
- Between 10 and 11 million scrap vehicles processed annually in the US.
- EOLVs represent between 45 and 80 wt% of shredder input.
Disassembly Unit Operations

- Labor intensive - skilled and semi-skilled labor
- Past practice - pour fuel over EOVL, ignite, burn off combustibles to facilitate identification and recovery of ‘assets’
- Current practice - plan ahead to remove ‘goods’ and ‘bads’; manage inventory

Shredding Operations

- Weigh inputs and outputs from site - scales at the gates
- Materials handling - cranes and conveyor belts
- Inventory of inputs and outputs - geometry of piles
- Size reduction - hammermills
- Magnets for ferrous separation
- ‘Eddy current magnets’ for non-ferrous separation
- Air cyclones for separation by density
- Labor to select materials by visual inspection - distinguish metal coins from metals - significant revenue stream
- Attend to security - ‘feed the dogs’
• Inputs
  – 5 materials: F, NF, Polymer, NHM, HM to describe composition of EOLV and hulk
  – 5 materials sum to curb weight of EOLV
  – 7 cost parameters for unit operations and EOLV and hulk purchase
  – 9 revenue parameters

• Technology Description - 11 parameters input as fractions
  – 6 parameters: fraction of F, NF, and P and fraction of curb weight removed as parts by disassembler [a4,a5,a6,a11]; fraction of P removed by disassembler as NH [a7]; fraction of total NH removed by disassembler [a10]
  – 2 parameters: extraction efficiency of shredder for F and NF [a2,a3]
  – [a1] fraction of NH disposed; [a8] fraction of NH polymer disposed; [a9] fraction of H polymer disposed
J.A. Isaacs and S.M. Gupta
“Economic Consequences of Increasing Polymer Content for the US Automobile Recycling Infrastructure”

- Outputs from model
  -Weights of materials and parts removed or disposed by disassembler
  -Costs and revenues for disassemblers
  -Weights of materials separated by shredder
  -Costs and revenues for shredders
- Goal to maximize net revenues

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**Isaacs Inventory List**

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<thead>
<tr>
<th>Materials</th>
<th>Mass</th>
<th>Steel Unibody</th>
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<tr>
<td>Ferrous</td>
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<td>Nonferrous</td>
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### Isaacs Cost Parameters

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<tr>
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<th>Cost ($/kg)</th>
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<td>Disassembling EOVL</td>
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<td>Shred &amp; separate hulk</td>
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<td>Disposing ASR</td>
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### Isaacs Revenue Parameters

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## Isaacs Technology Parameters

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