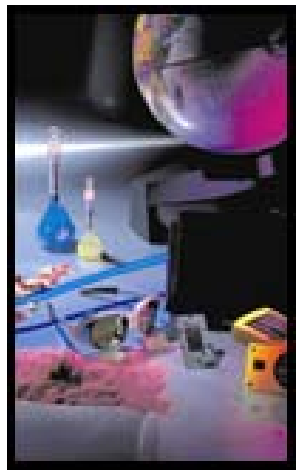
Battelle
The Business of Innovation

New Products from Biomass

BIOP 2008



Rich Chapas, PhD,
Rick Heggs
Battelle

Battelle's purposes stem from the 1925 will of Gordon Battelle

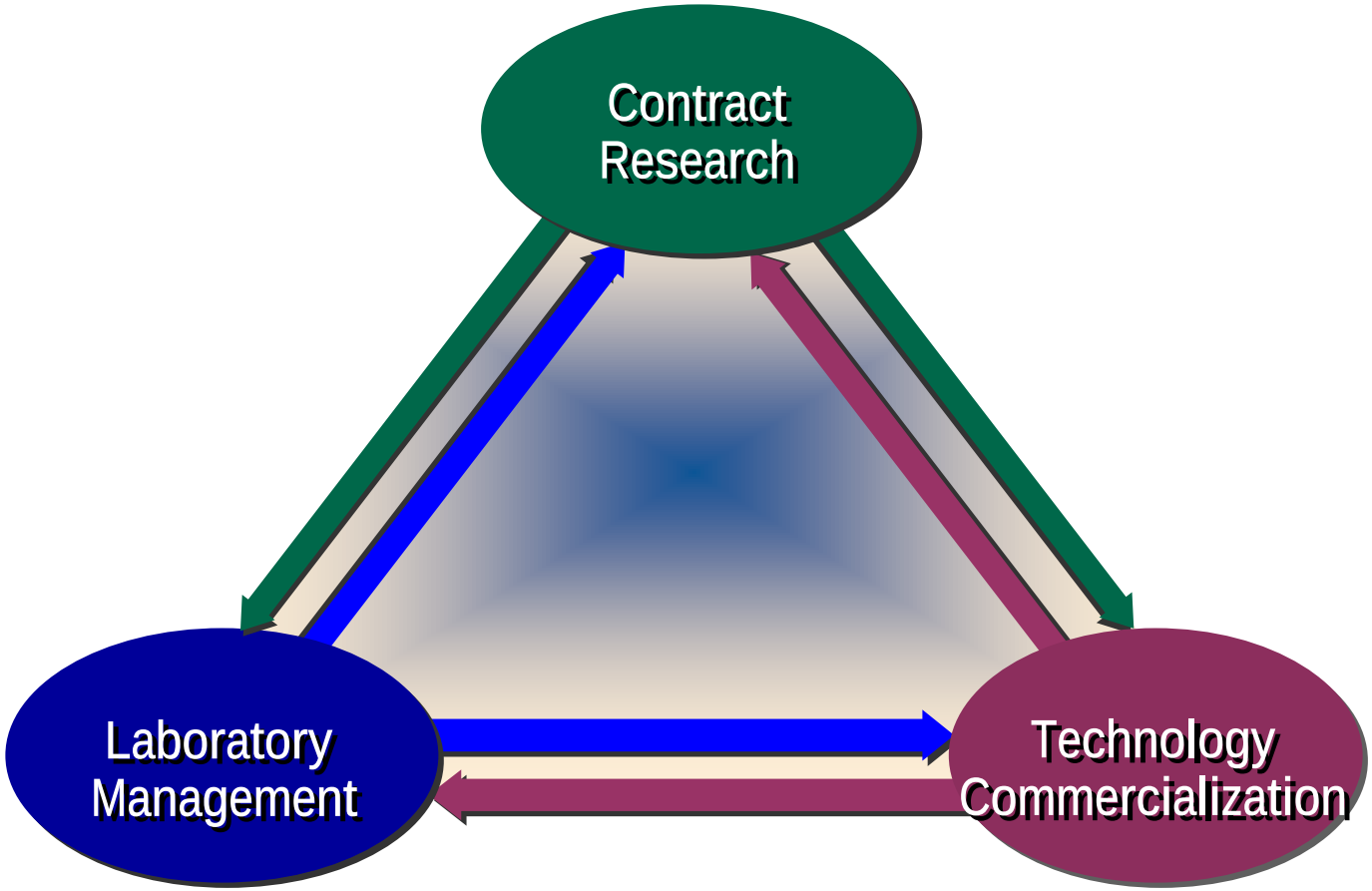
- Charitable trust
- Scientific research and development
- Creative activities of a scientific nature

- Reduction to practice and licensing of inventions, discoveries, and developments
- Advancement of learning and better education of men and women for employment (Refueling the education pipeline)

Key Battelle Features

- Non-profit charitable trust – began operations in 1929
- 78 years of research and development leadership
- Major businesses are contract R&D, laboratory operations, and commercialization/commercial ventures
- Conduct $4.0 billion in annual R&D
- 22,000 employees worldwide (including labs we co-manage)

Battelle Three-Part Business Model



Each part supports and reinforces the other two.

Major Technology Centers

Corporate Headquarters
Columbus, Ohio

Battelle West Jefferson
West Jefferson, Ohio

Battelle Eastern Science and Technology Center
Aberdeen, Maryland

Battelle Europe
Geneva, Switzerland

Battelle Marine Sciences
Sequim, Washington

Battelle Ocean Sciences
Duxbury, Massachusetts

Major Technology Centers (Cont.)
DOE Labs Managed/Co-managed

Brookhaven National Laboratory
Upton, New York

Pacific Northwest National Laboratory
Richland, Washington

Oak Ridge National Laboratory
Oak Ridge, Tennessee

National Renewable Energy Laboratory
Golden, Colorado

Idaho National Laboratory
Idaho Falls, Idaho

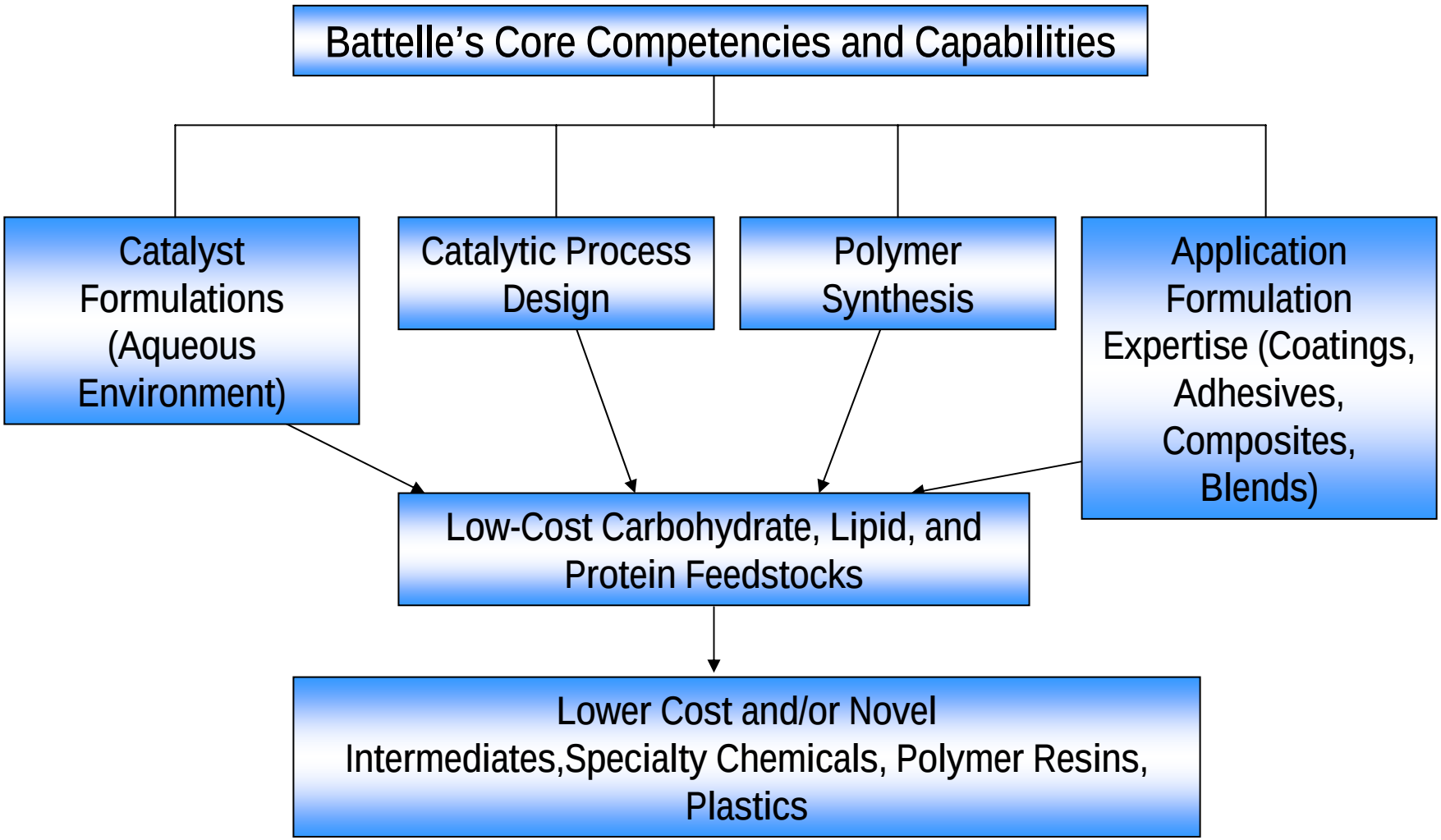
Advanced Materials Applications at Battelle

- ~ 110 Staff
- ~ 200 projects Annually
- Equipment and Laboratory Intensive
- Government and Commercial Markets
- Highly Creative - Applied Technology/Patents
- One of the largest applied polymer groups outside captive industrial laboratories
- Highly innovative, very strong capability for “inventing to need”
- Works with other Battelle groups in conducting multidisciplinary programs

Biobased Products Background

- A long and sustained activity in biomass
  - Lactide and PLA in late 80's
  - Steam explosion of cellulosics and lignin in 70's
  - Interactions with PNNL and NREL
- Over the last 10 years focus on
  - Soybeans and to a limited extent on corn and wheat
  - Oil and protein based feedstock
  - Established strong relationships with farmer-based organizations at the State and National level
  - Gained recognition in the field
- Successful commercialization model with industry partners

Biobased Technology Platforms



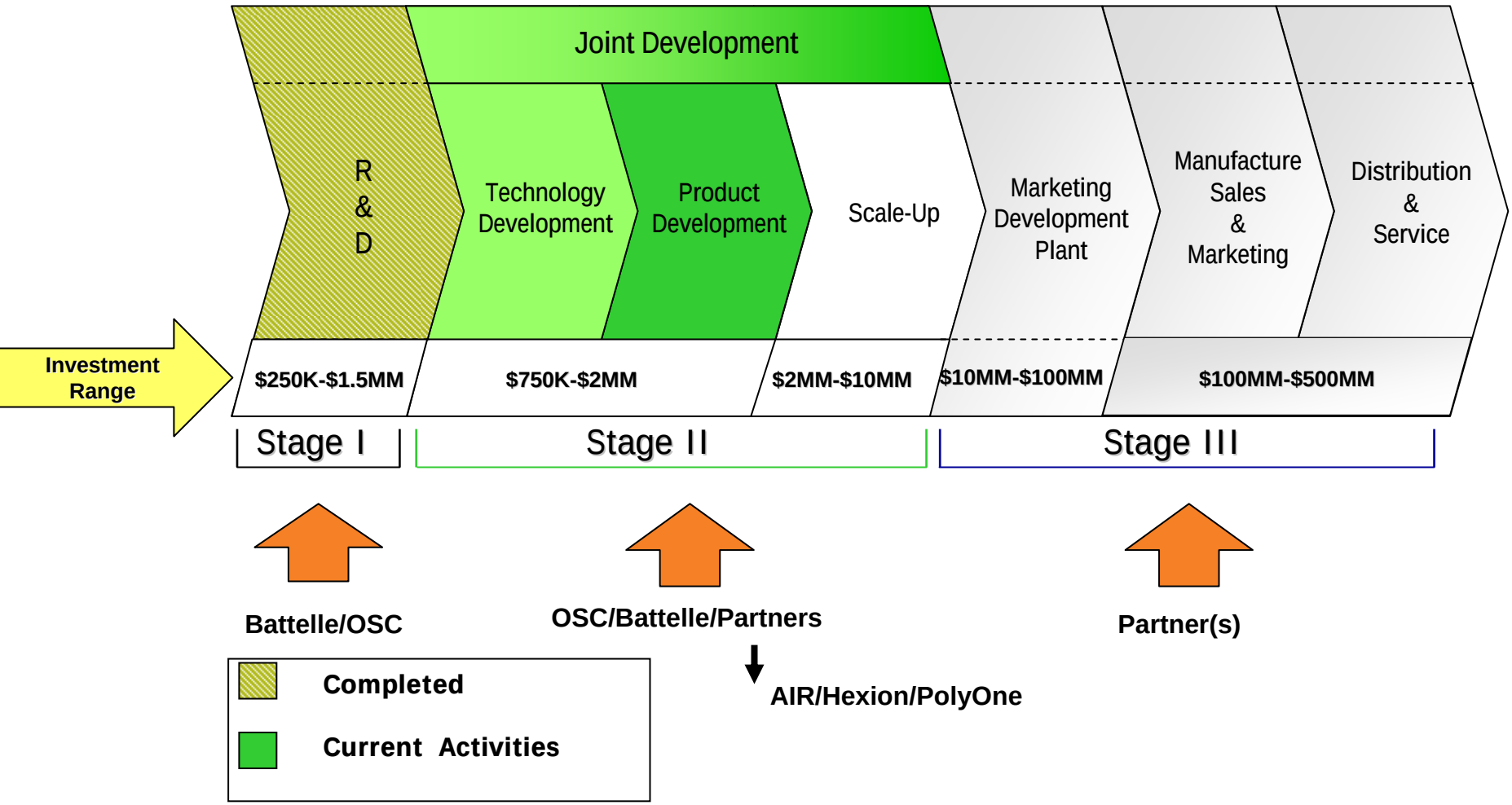
Products

- Bio-products serving many markets: plastics, coatings, adhesives, packaging, ink/toner.
  - PVC plasticizer
  - Soy toner
  - Structural biocomposites
  - Wood adhesives and laminates
  - **Powder coatings**
  - Biolubricants
  - Urethane top coats/foams
  - **Polyols**
  - **Deicer**

Biodegradable Polymers

Battelle developed the technology to convert lactic acid into totally degradable polymers, such as those used in disposable salad containers.

Commercialization Model: Toner, Plasticizer and Powder Coatings



Biobased Powder Coating

- Pioneering technology enabling use of renewable resources. (R&D 100 Award 2008)
- Key differentiating factor:

Agriculture, Furniture, Toys for Sustainability

- Resins fit with existing manufacturing plants
- Performance in line with current technology
- Very good wetting properties
- Additional advantages in low temperature cure: high reactivity & no “blooming”

For Hexion, it is a unique, bio-based solution

Design Example of New Product and Application of Life Cycle Engineering

Production of a Chemical Intermediate from Petroleum Feedstock Versus Bio-Derived Feedstock

Product	1,4-Butanediol (BDO)	Biopolyols
Use	manufacture of several commercial chemical and polymeric compounds	Coatings, Foams, Adhesives
Conventional Technology	Petroleum feedstock	Petroleum feedstock
Alternative Technology	agricultural feedstock – Corn	Vegetable oil & glycerin

New Technology. Could be of Potential interest.

R&D 100 Award

2006

R&D
Research & Development

Ohio Soybean Council
United Soybean Board

Clear, low odor bio-polyols

Battelle Low Cost Raw Materials

Status of Polyols

- A novel approach bio-derived polyols from low cost feedstocks including crude-2 glycerin has been developed.
- Preliminary economics are promising.
- The structures resulting from the ozonolysis/ transesterification process gives representative coating and foam properties.
- 2-part urethane, zero VOC (volatile organic compound) polyurethane coatings have been prepared that have reasonable properties.
- 100% replacement of petroleum polyols in typical coating and foam formulations has been demonstrated.
- Adhesive and sealant applications are being tested.
- A comprehensive patent application has been filed.
- Several scale-up issues are being addressed.
- Several potential industrial partners have expressed interest.

Patented Biobased Aircraft (ADF) and Runway (RDF) Deicing Fluids

- Developed ADF: concept through proof of principal testing, scale up, demonstration, and licensing
- Developing RDF: invented process, completed small test, scaled up, and now planning demonstration tests

Challenges and Success

- ADF
  - Conventional fluid
    - Prepared from propylene glycol
    - High biological oxygen demand
    - High cost
    - Modestly toxicity
  - Battelle Solution
    - Prepared from biobased materials and other additives
    - Reduced oxygen demand, lower toxicity, lower corrosivity
    - Lower fluid cost and life cycle costs

- RDF
  - Conventional fluids
    - Prepared from potassium acetate
    - Low oxygen demand
    - Corrosive
    - High cost
    - Modest toxicity
  - Battelle Solution
    - Biobased materials and other additives
    - Lower toxicity, lower corrosivity, reduced brake-pad attack
    - Lower fluid cost and life cycle costs

Battelle Offers...

- A wide range of scientific and engineering talent for identifying, analyzing, and solving product/process development/improvement problems
- Deep understanding of Sustainability and LCA
- Expertise in new materials, processes, and testing protocols
- Experience based on solving tough problems
- Facilities for preparing models and testing
- Protection of proprietary and business sensitive information

Thank You

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