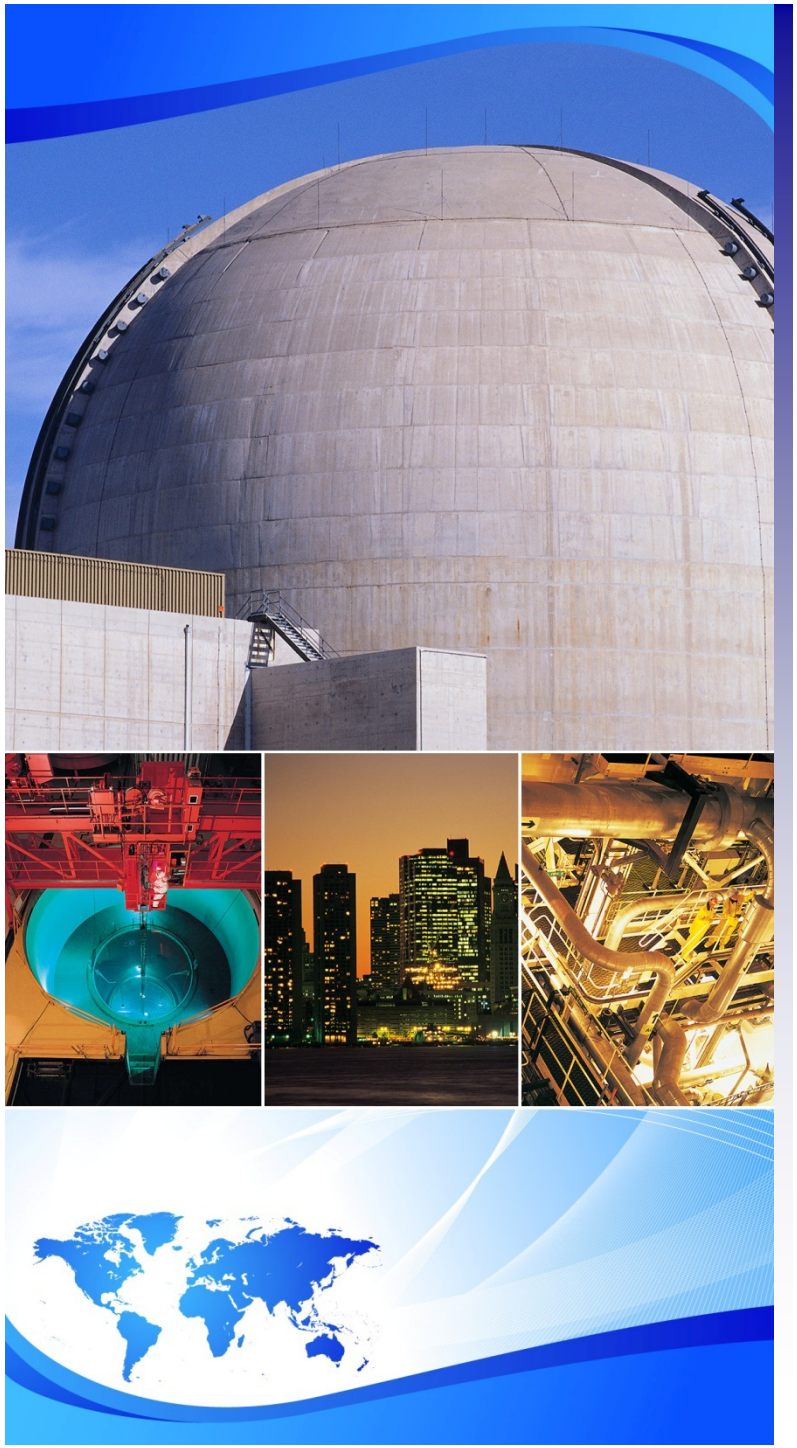


EPRI | ELECTRIC POWER RESEARCH INSTITUTE

EPRI's Buried Pipe Initiative

Industry/NRC Meeting on Buried Pipe

October 22, 2009

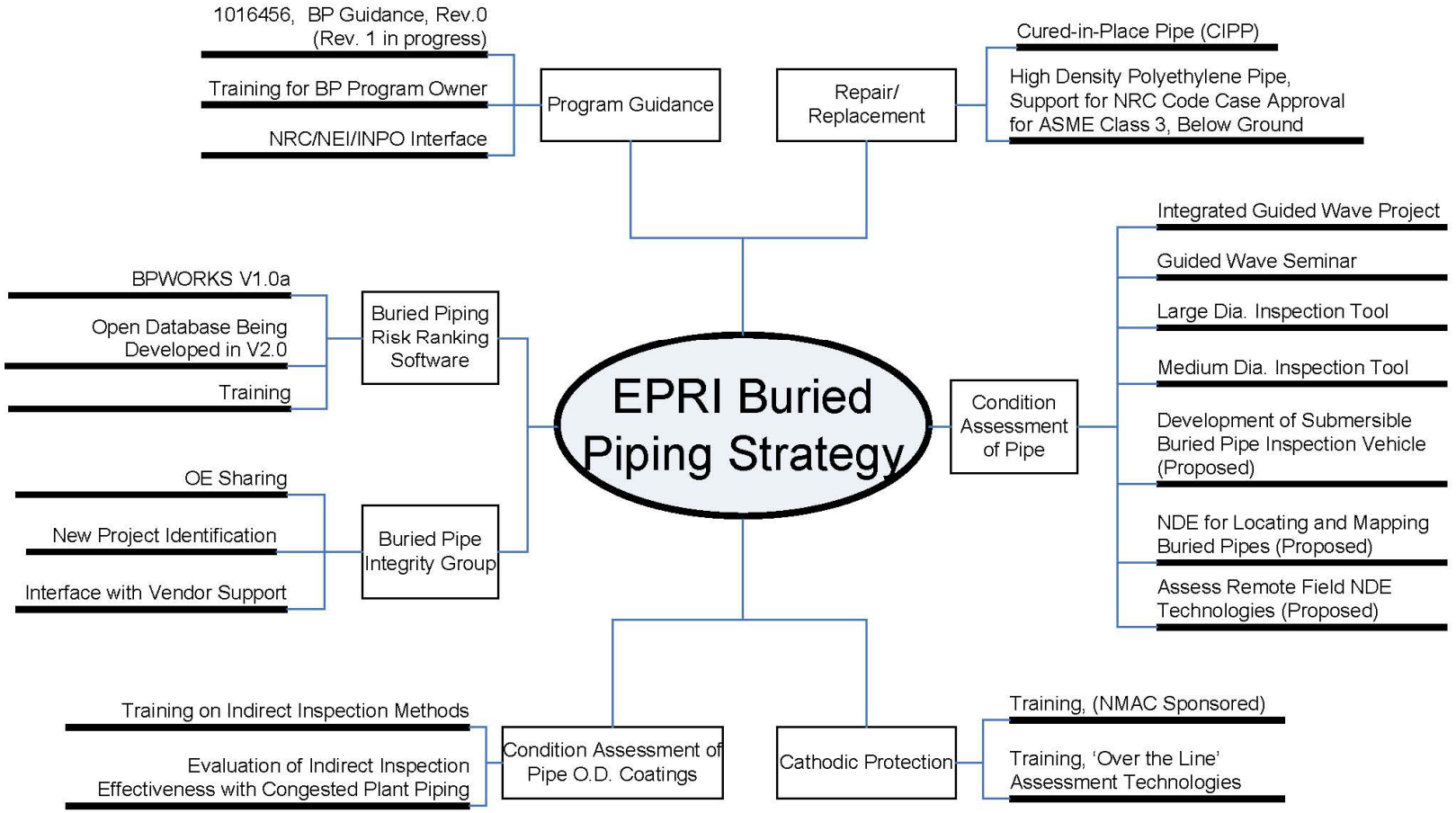
Bo Clark

EPRI, BOP Corrosion Program Manager

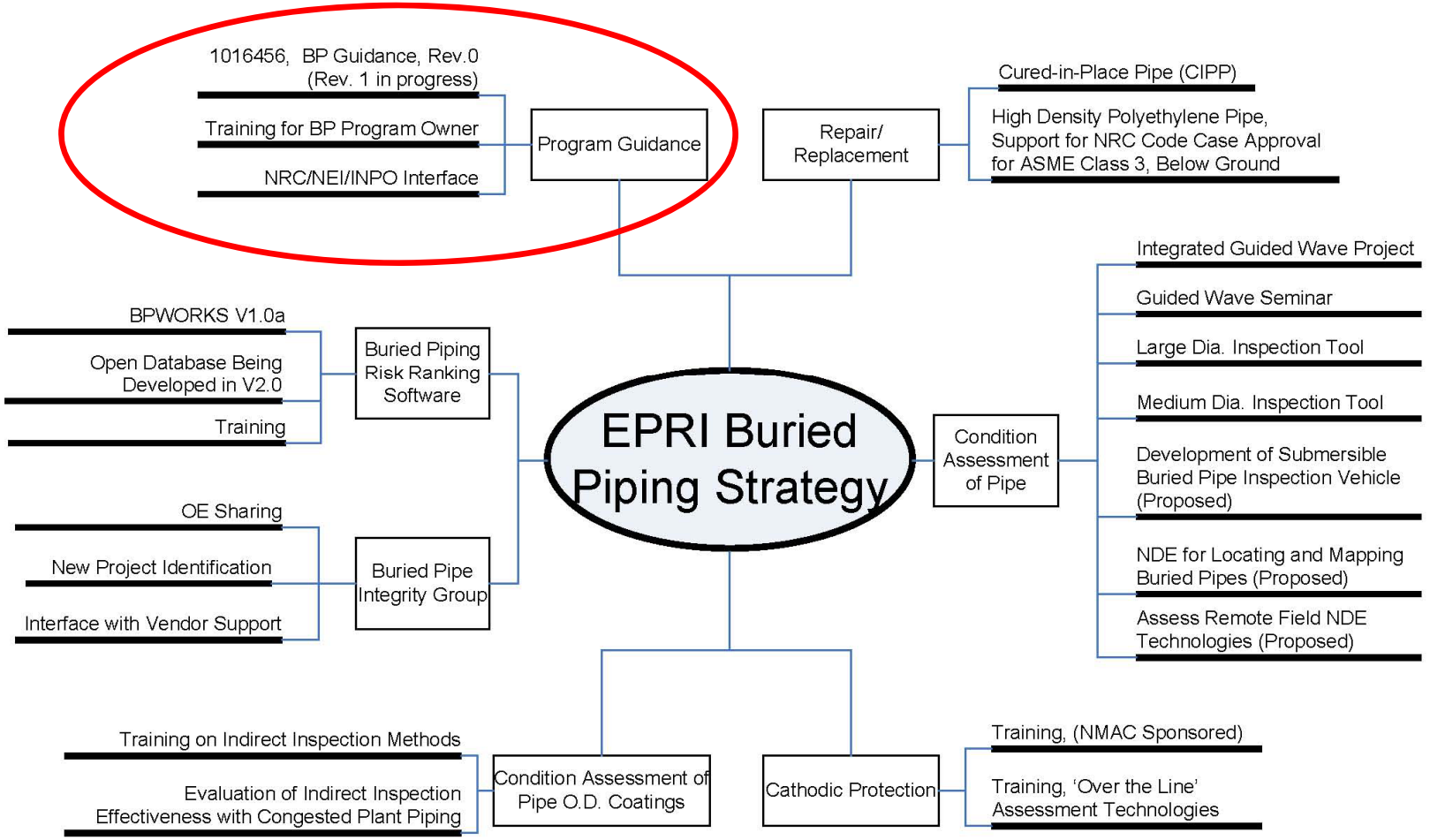
EPRI's Buried Pipe Initiative

- 2007 – Nuclear Power Council expresses concern
- March 2008 - 1016276, "An Assessment of Industry Needs for Control of Degradation in Buried Pipe"
  - Gap Analysis Identified needs for:
    - 1) Guidelines to Control Degradation
    - 2) Risk Ranking Method for buried pipe
    - 3) Technical Resources document for buried pipe
    - 4) Dedicated test facility
    - 5) Experience sharing
    - 6) Assess and Develop Inspection Tools
    - 7) Training

EPRI's Buried Pipe Strategic Activities



Program Guidance



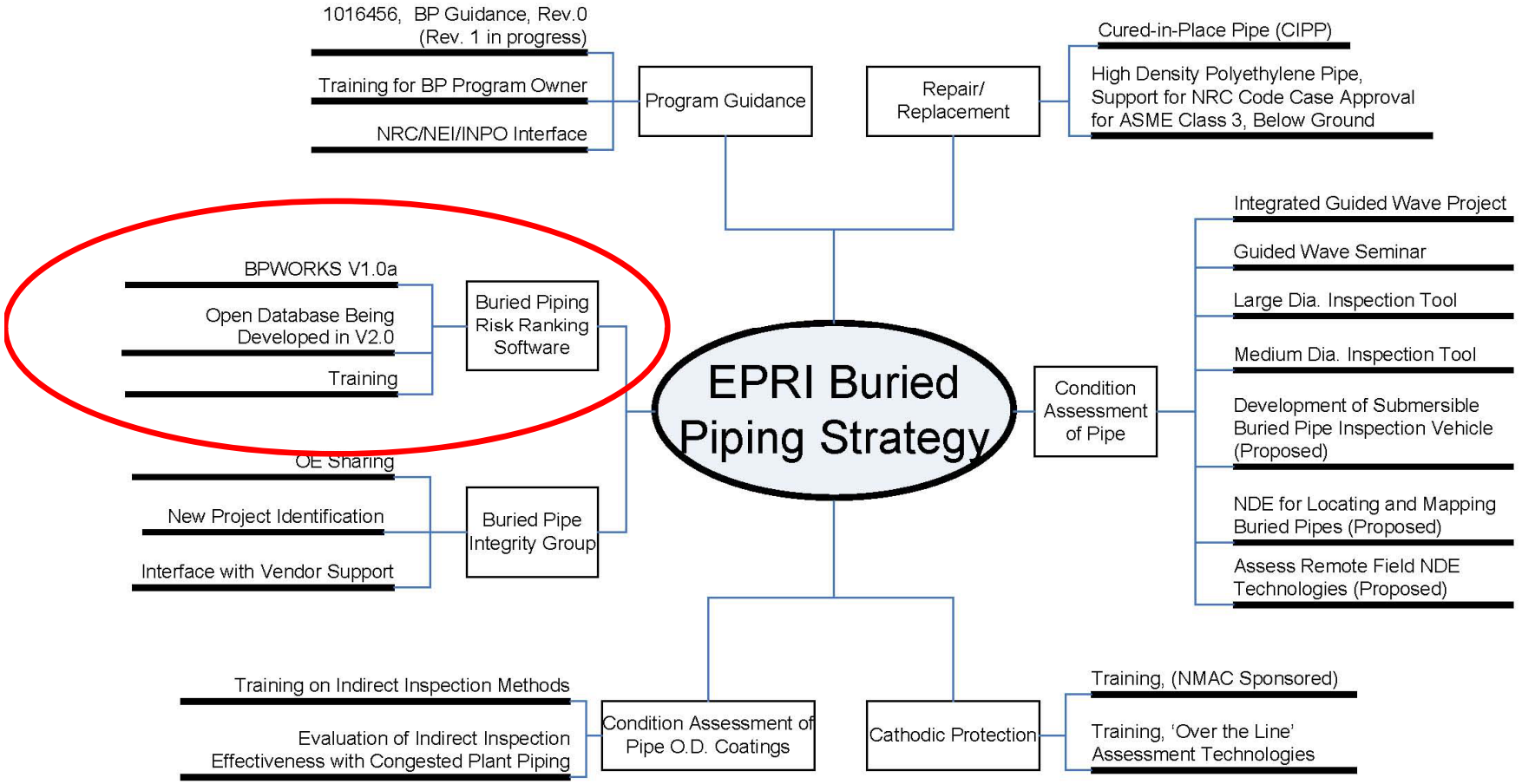
Program Guidance

- 1016456, Recommendations for an Effective Program to Control the Degradation of Buried Pipe
  - Rev. 1 in progress
  - Discussed in depth later
- Training for Buried Pipe Program Owners
  - June 2-4, 2009
  - Sept 9-11, 2009
  - November 10-12, 2009, Dallas

Program Guidance (continued)

- NRC/NEI/INPO Interface
  - INPO uses “Recommendations” document as a basis for BP program evaluation
    - Program feedback
  - Met with NEI/NRC on Aug 19-20, 2009 on Buried Pipe and ASME Code Case N-755 on HDPE

Risk Ranking Software



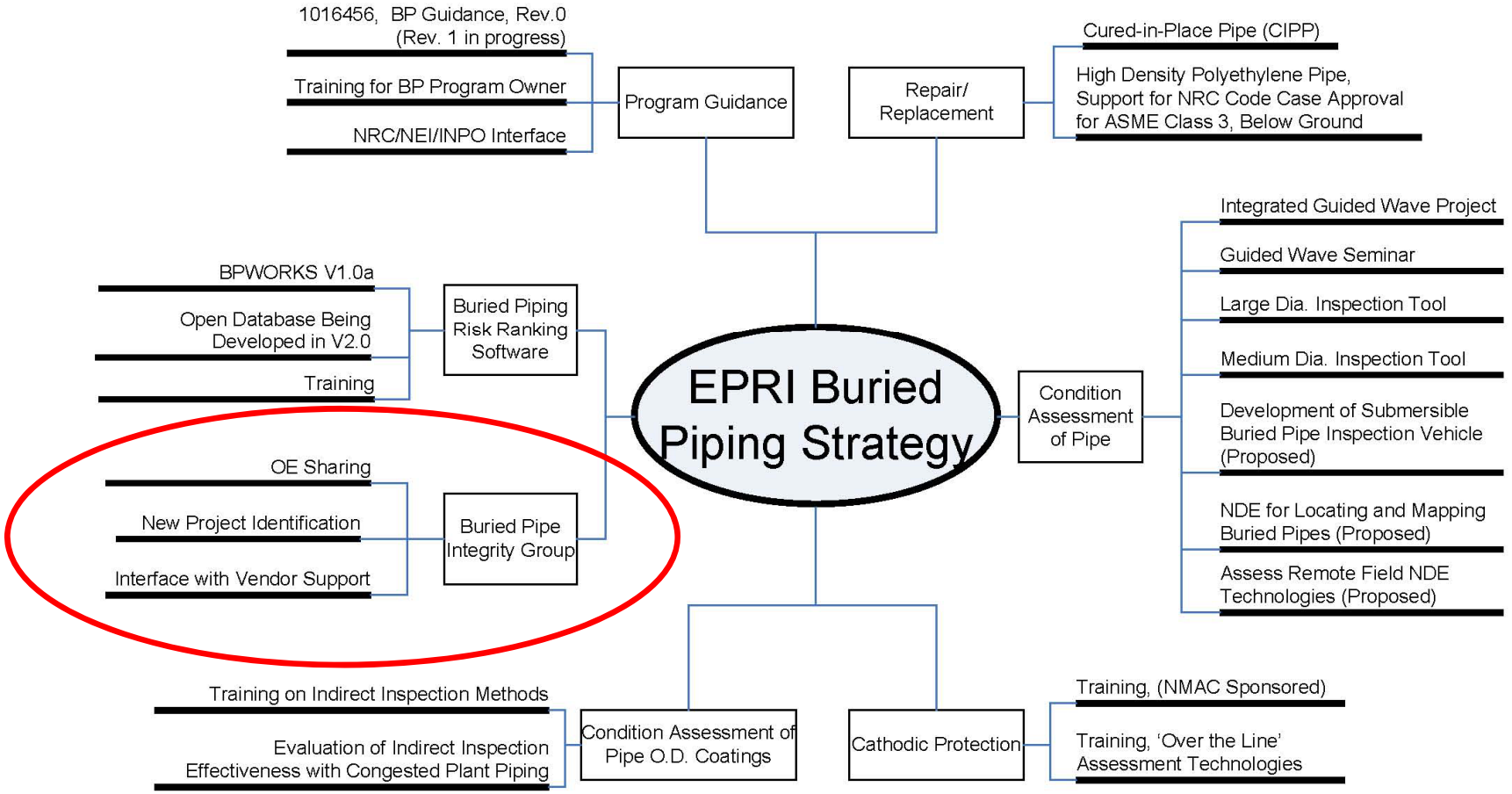
Risk Ranking Software

- **Risk Ranking - used to prioritize the selection of inspection locations.**
  - **Correlates the likelihood of failure against the consequences of failure.**

Risk = Likelihood X Consequences

- **BPWORKS V1.0a**
  - **Open Database being developed in V2.0**
  - **Other commercially available tools also exist**
  - **Training - BPWORKS Software**

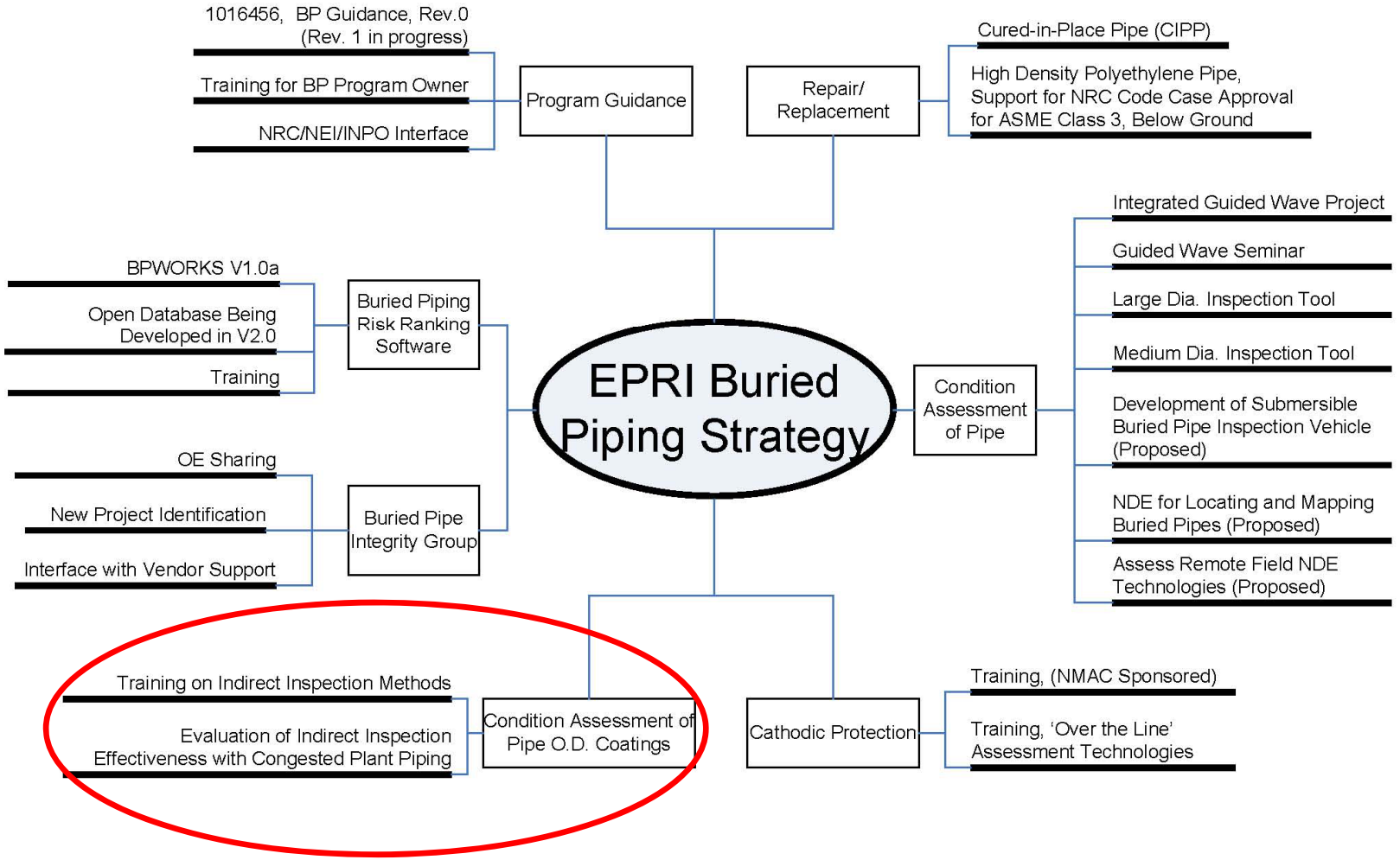
Buried Pipe Integrity Group (BPIG)



Buried Pipe Integrity Group (BPIG)

- Buried Pipe Integrity Group (BPIG) formed in 2008
  - In 2010, all US Utilities will be members
  - Meets two times/year
- Provides:
  - Forum for plant owners to discuss buried pipe issues and exchange experiences (OE Sharing)
  - Forum to obtain a consensus on industry issues
  - Technical support on buried pipe issues, as well as support for related products
  - Related training
  - Interface with Vendor Support
- Sponsor related R&D

Condition Assessment of Pipe O.D. Coatings



Condition Assessment of Pipe O.D. Coatings

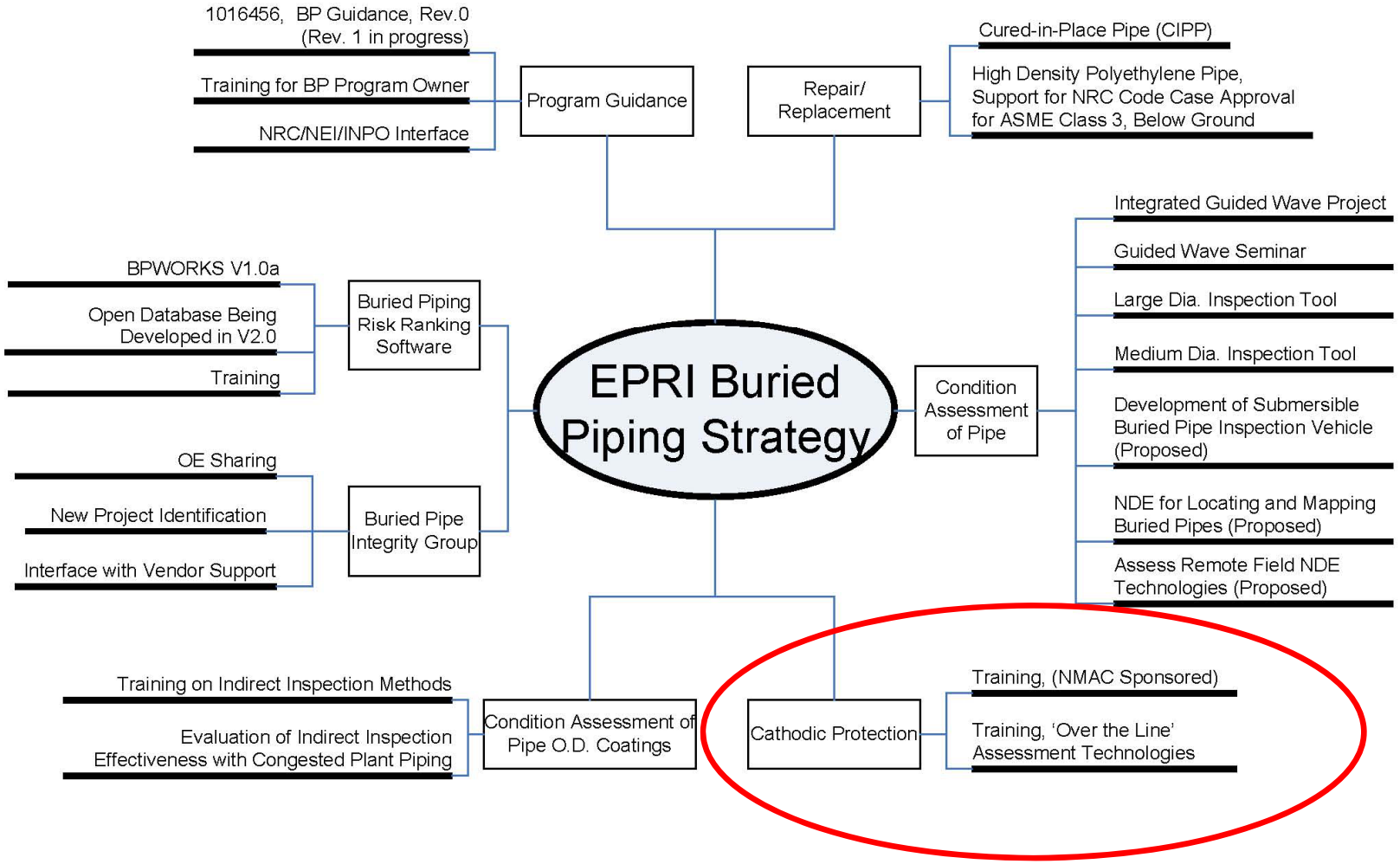
- Indirect Inspection Methods Used in Pipeline Industry
  - Pipe-to-Soil potential
  - Direct Current Voltage Gradient (DCVG)
  - Pearson survey
  - AC Current Attenuation
  - Close Interval Potential Survey
  - Area Potential Earth Current (APEC)

- Application challenges
  - Congested Plant Piping

Condition Assessment of Pipe O.D. Coatings

- Briefly Covered in Training for Buried Pipe Program Owners
- Discussed in depth in Cathodic Protection / Indirect Inspection Training

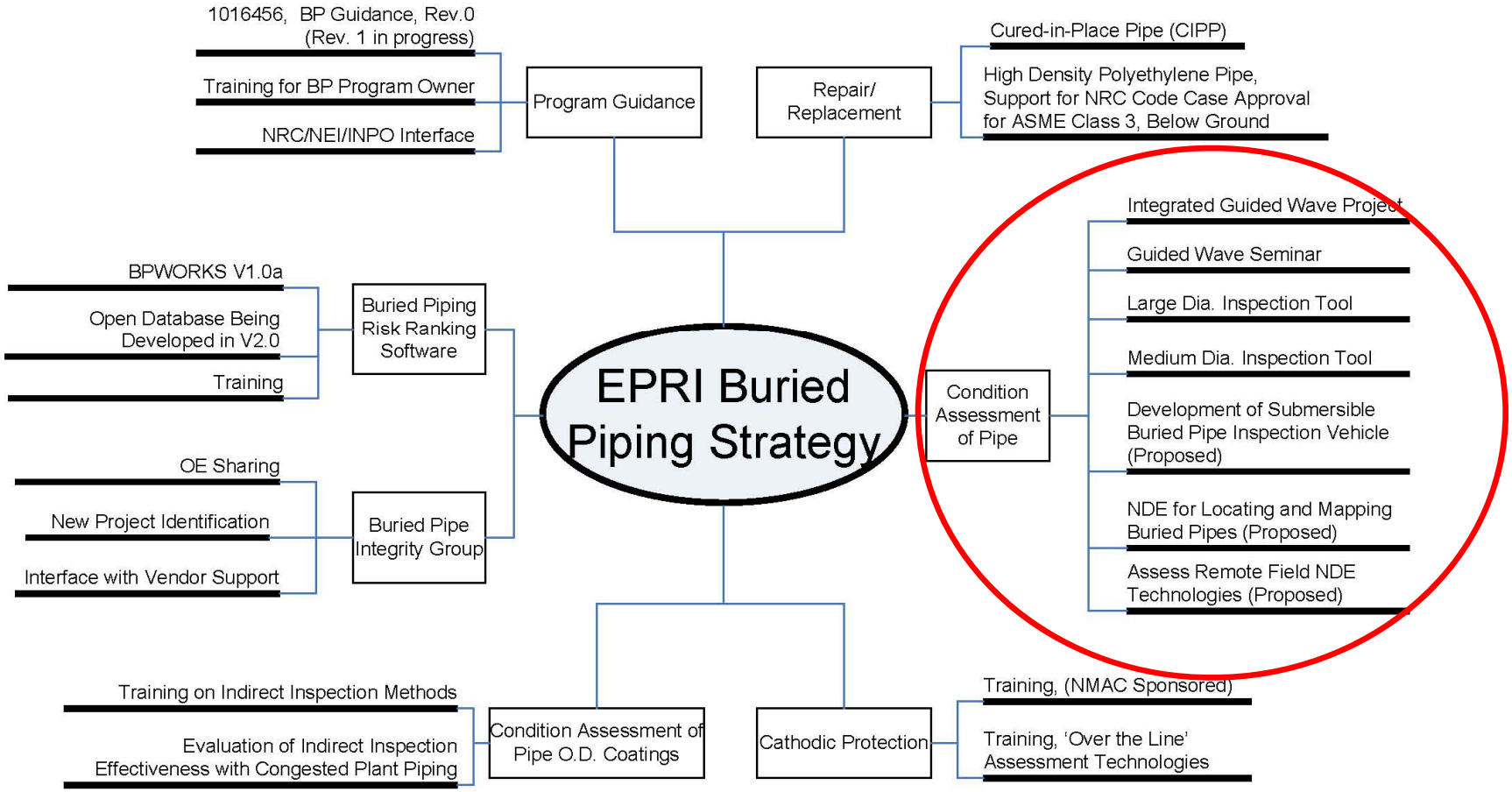
Cathodic Protection



Cathodic Protection (CP)

- O.D. Coating - First Line of Defense against external corrosion
  - Cathodic Protection - Backup Defense for areas of damaged coating
- CP Training
  - NMAC's CP Workshop
  - BP Program Owners' Training
  - CP Field Training Covered in Cathodic Protection / Indirect Inspection Course

Condition Assessment of Pipe



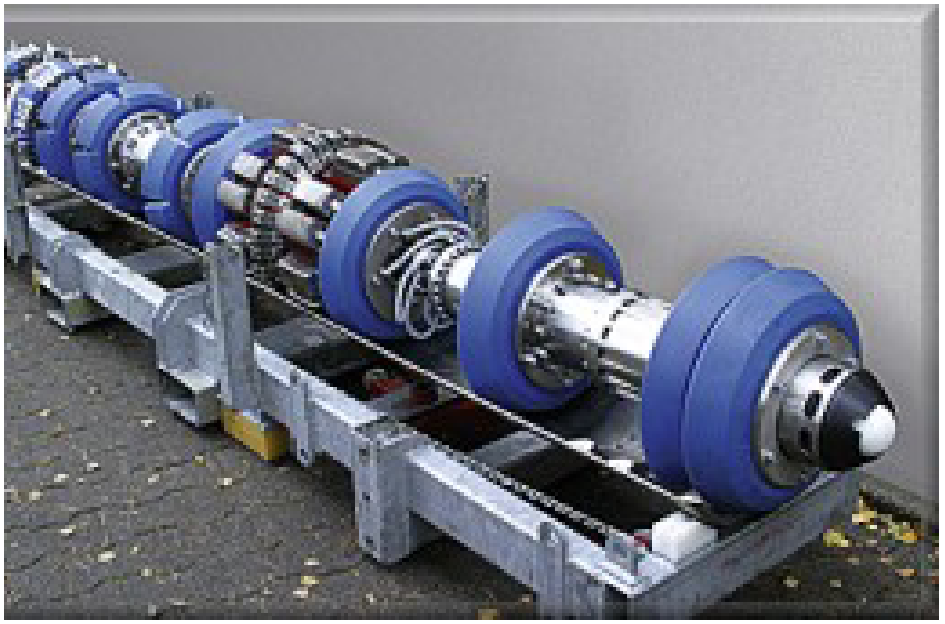
Condition Assessment of Buried Pipe

- Ongoing Research
  - Internal Pipe NDE Inspection Vehicles
  - Guided Wave NDE
  - Buried Pipe Mockups

- Proposed/Planned Research
  - 10” & smaller internal vehicles
  - Buried pipe location & mapping

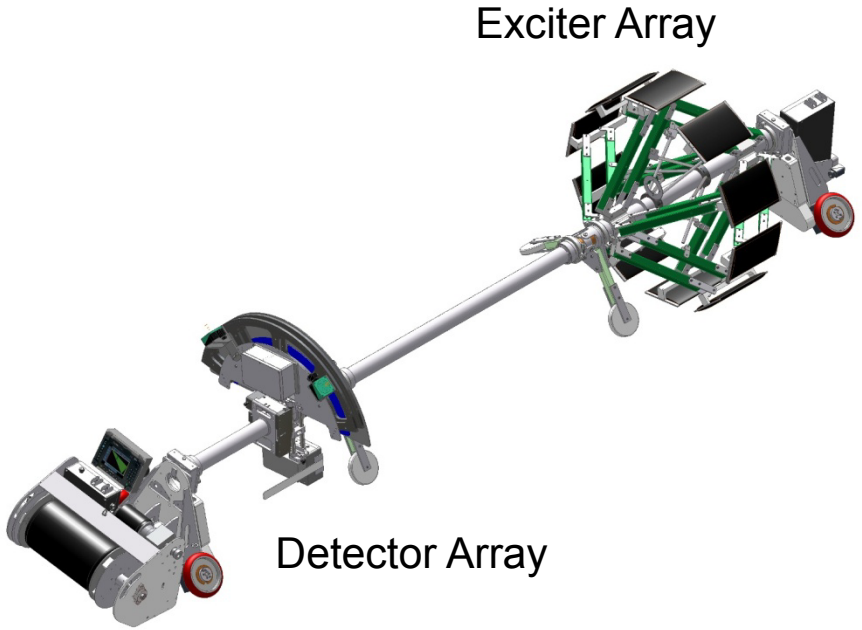
In-Line Instrumented Vehicles

- There are commercial offerings that offer in-line inspections of pipe wall thickness (pigs)
- Limitations:
  - In-ability to go through elbows, tees, valves, elevation changes
  - Require dedicated launch and retrieval stations
  - Require 1/8” liftoff for accurate detection & sizing of pits
- Since 2004 EPRI has been developing vehicles and sensors suited for power plant piping (1” liftoff to accommodate pipe crud)



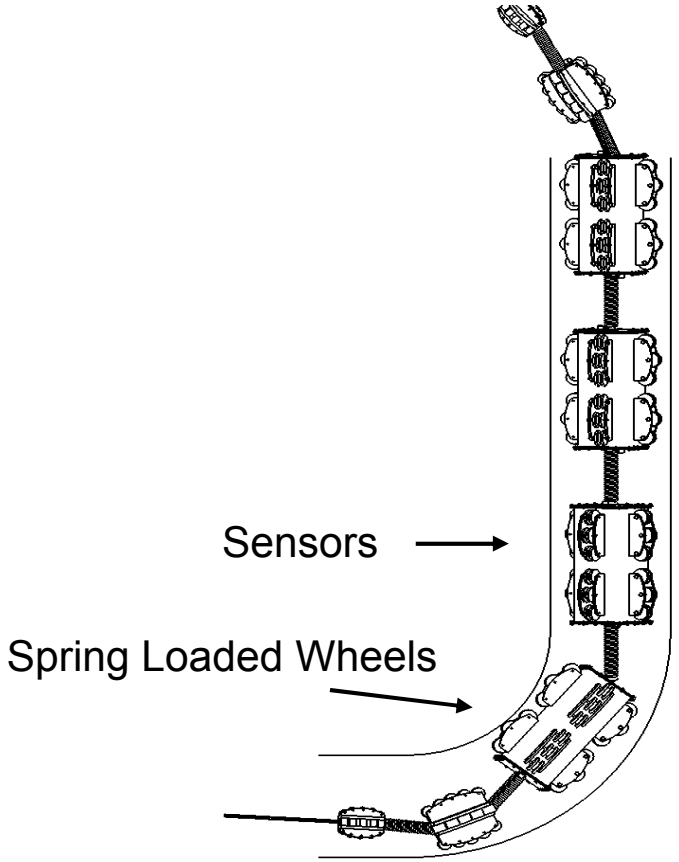
Vehicle for Large Diameter Pipe Inspection

- 'Proof of Concept' of EPRI vehicle for very large diameter buried pipe (36" ≤ D ≤ 12') completed in 2008
- Detect
  - Internal and external pits
  - Circumferential weld degradation
  - Longitudinal weld degradation
- Install through 24" diameter man way
- Can disassemble to pass through elbows



Vehicle for Intermediate Diameter Pipe

- "Proof of Concept" -facilitate pipe inspection (12" to 30" diameter)
- Pulls itself along a guide wire
- 1" of radial clearance to allow for mud, tubercles, coatings, etc
- Can traverse
  - Change of elevations
  - Branches, tees
  - Multiple elbows (at least 6)
- Field testing in 2010

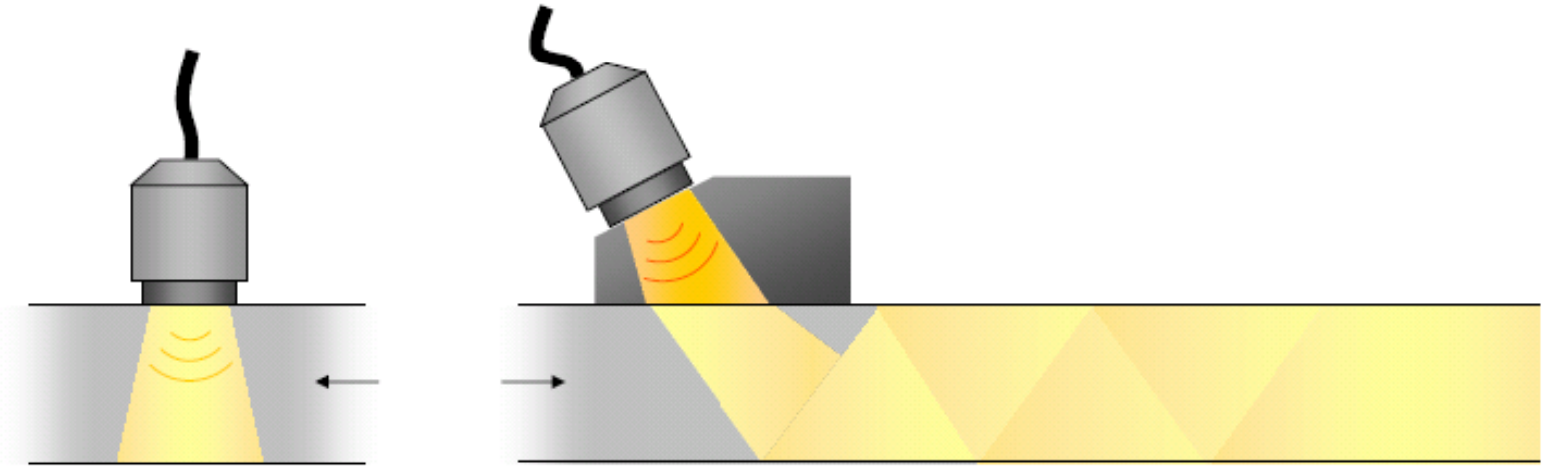


Project Timeline

Deliverable Title	Scheduled Date
Condition Assessment of buried Piping of Intermediate diameter	12/31/2009
Condition Assessment of Buried Piping of Intermediate Diameter-Field Trial	12/31/2010
Condition Assessment of Buried Piping that Cannot be Drained-Engineering Design	12/31/2011
Condition Assessment of Buried Piping that cannot be drained-Manufacturing and Lab evaluation	12/30/2012
Condition Assessment of Buried Piping that cannot be drained-Field Trial	12/30/2013

Guided Wave Ultrasonics

- Guided Wave ultrasonics is an existing technology that is being extended to inspect buried pipe

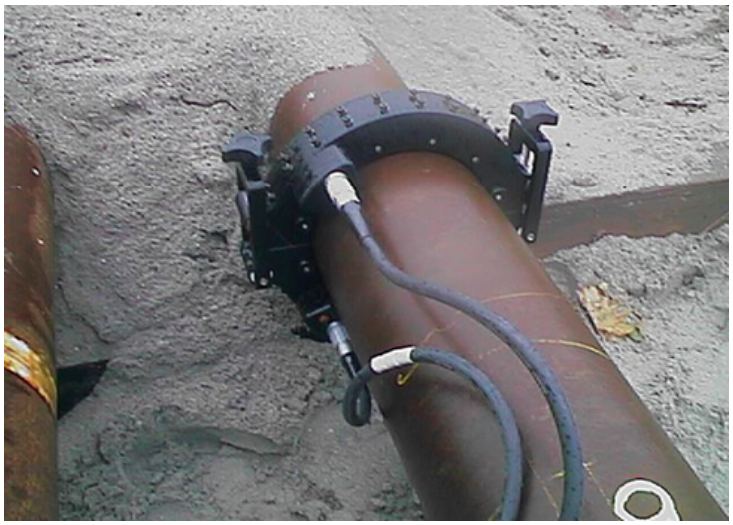


Bulk Wave

Guided Wave

Guided Wave Ultrasonics

- Multiple sensors are wrapped around pipe and send signals both directions. Provides
  - 100% volumetric coverage over length of exam
  - Screens for change in cross section area; can be focused on a specific area
  - Ability to inspect under coatings, in inaccessible areas, and without complete excavation
  - Length of exam limited by coatings, ground compaction, elbows



Piezoelectric Sensors

Guided Wave Variables

Guided wave technology for buried pipe examination is:

- Relatively new and is **emerging**
  - Capabilities and limitations are not well known/documented

Flaw characterization is currently limited

Several complex factors affect successful application

- Piping geometry
- Coating type and thickness
- Flaw shape and depth
- Surface conditions
- Multiple flaws
- Inspection distance

Guided Wave Pipe Mock-ups

EPRI is building two piping mock-ups

- 24” diameter 0.375” thick carbon steel
  - Most common based on industry survey
- Un-coated Mock-up status
  - Welded together
  - Flaw implant scheduled to start in October
- Coated mock-up status
  - Piping has been coated and ready to ship
  - Construction scheduled for 4th quarter
  - Flaw implant to begin after studies on un-coated mock-up are complete

Un-coated Mock-up

Purpose

- Study guided wave
  - Interaction on multiple flaw shapes independent of coating variables
  - Response through elbow
- Process and technology development
- Develop training and test specimen
- Validation of computer modeling
- Identify appropriate flaw characteristics for buried mock-up

Un-coated Mock-up

- Guide wave collar

Coated Mock-up

Purpose

- Identify Gaps
- Develop advanced GW techniques
  - Improve detection (including around elbows)
  - Improve flaw characterization
  - Focusing
  - Signal processing
- Benchmark technologies
- Study effects of coating on GW (attenuation)
- Develop/validate modeling
- Not intended as a qualification mock-up

Coated Mock-up (continued)

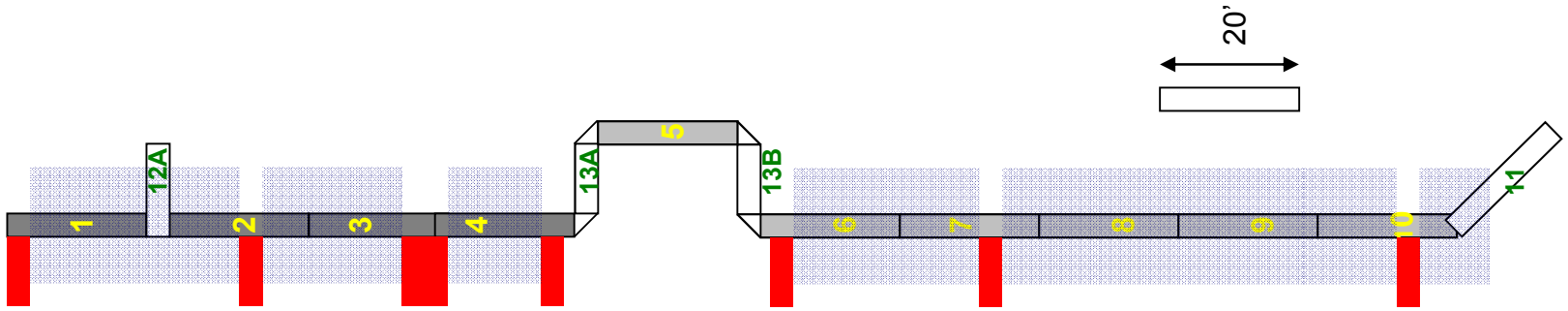
Variables within mockup

- Multiple coatings – coal tar enamel and coal tar epoxy
- Multiple flaw shapes and sizes
- Multiple data acquisition locations

Vendor Capability Demonstrations

- Invite NDE Services vendors to perform blind demonstrations; publish the results

EPRI Buried Pipe Mockup Layout



Coal Tar Enamel

Coal Tar Epoxy

Access Point

Backfill

QUANTITIES

10 – 20' 24" OD .375" Wall CS Pipe Sections

5 – CT Enamel A106B

5 – CT Epoxy A106B

3 – 10' 24" OD .375" Wall CS Pipe Sections A106B

3 - No coating

4 – 90 elbows

1 – 45 bend

1 - Tee

Schedule

Uncoated Mock-up

- Fabrication complete
  - Flaws to be inserted 4th quarter of 2009

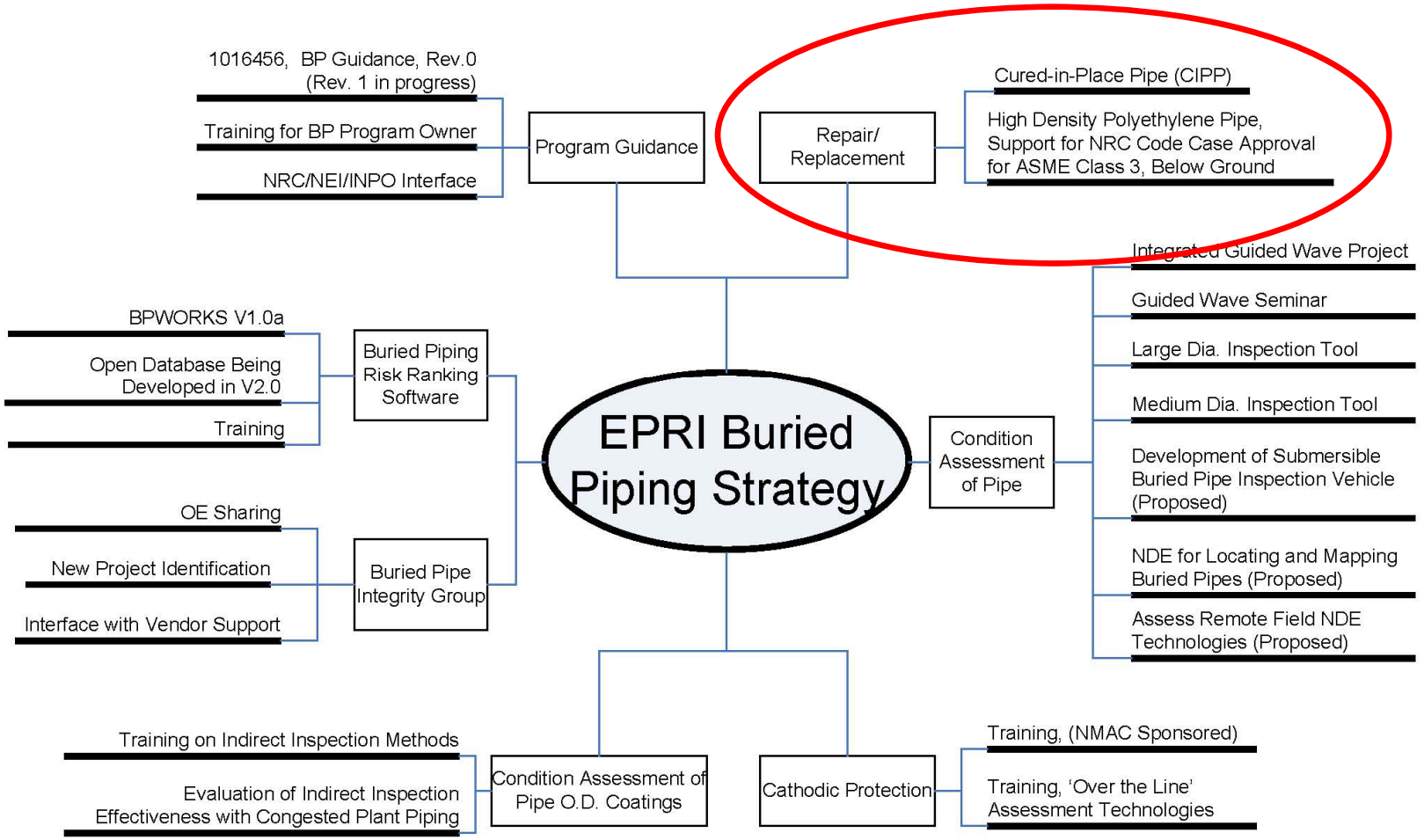
Coated Mock-up

- Coating complete
- Fabrication to be completed during 4th quarter of 2009
- Flaws to be inserted 1st quarter of 2010
- Backfill to occur after initial R&D and evaluation of inserted flaws

Future Vision

- Potential use for demonstration or qualification of vendor capabilities
  - Use of NDE data to produce Virtual Pipe Specimens
    - Two possibilities
      - Embed recorded flaw data into data files obtained from clean pipes
      - Use models to develop NDE responses to known flaws, embed into clean pipe data
  - Enables preparation of unlimited varieties of specimens for blind demonstrations or qualifications
    - Varied flaw types, locations, configurations (elbows, for example), test conditions (soils, coatings, temperature, …)

Repair / Replacement



Repair / Replacement

Cured-in-Place Pipe (CIPP)

- ASME Code Case N589-1 provides rules for cured-in-place pipe (CIPP) to be used to repair Class 3 piping
  - However, R.G. 1.193 did not approve its use
- Although the CIPP products have many limitations, there are many applications where they are useful

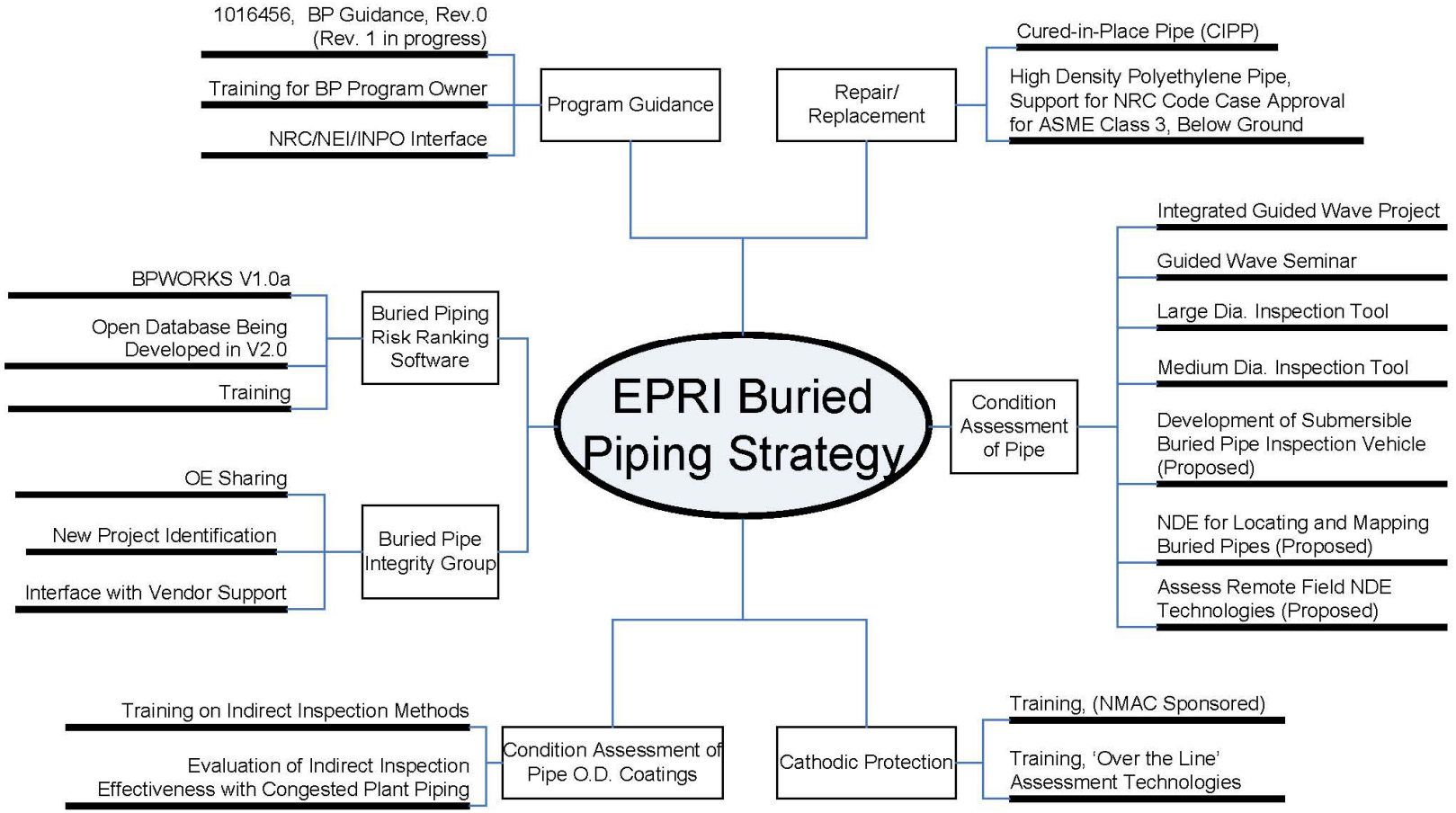
Insertion of an Inverted Liner

Repair / Replacement

High Density Polyethylene (HDPE)

- Considered to be an attractive option for replacements of degraded pipe
- Extensive effort underway to support ASME to revise and obtain approval for Code Case N-755
- Details of R&D activities on HDPE were discussed with NRR during public meeting on August 20, 2009

Buried Pipe Strategic Activities



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