



**Pipeline and Hazardous Materials Safety Administration**  
**Office of Pipeline Safety**

**PHMSA's Research and Development Forum 2023 – CO<sub>2</sub> Working Group**

*Ashley Kroon – General Engineer*

*Engineering and Research Division*

October 31, 2023



# Working Group Leaders



Ashley Kroon  
PHMSA – General Engineer



Gary Choquette  
PRCI – Executive Director  
of Research & IT



# Outline of Agenda – Day 1

- 2:30 p.m. – 2:35 p.m. – Transition Time
- 2:35 p.m.– 2:45 p.m. – Introduction
- 2:45 p.m. – 4:15 p.m. – Presentations
  1. *Exxon Mobil – Rick Noecker*
  2. *DNV – Ramgopal Thodla*
  3. *Health and Safety Executive (HSE) – Simon Gant*
  4. *DOE/FECM – Kevin Dooley*
  5. *ECA Solutions Engineering – Aquiles Perez, PhD*
  6. *NIST – Dash Weeks*
- 4:15 p.m. – 4:30 p.m. Wrap up, submit initial gap ideas



# Outline of Agenda – Day 2

- 8:00 a.m. – 9:00 a.m. – Questions on presentations, brainstorming, and regrouping gaps
- 9:00 a.m.– Noon – Voting and road mapping
- Noon – 1:00 p.m. – Lunch
- 1:00 p.m. – 2:30 p.m. Wrap up and prepare report out presentation.
- 2:30 p.m. – 2:45 p.m. – Break
- 2:45 p.m. – 4:00 p.m. – Reconvene for Working Groups 1-5 Report Out Session



# PHMSA's Mission

To protect people and the environment by **advancing the safe transportation of energy and other hazardous materials** that are essential to our daily lives. To do this, the agency establishes national policy, sets and enforces standards, educates, and conducts research to prevent incidents. We also prepare the public and first responders to reduce consequences if an incident does occur.

## PHMSA By the Numbers

**3.3 Million**

Miles of Regulated  
Pipelines

**1.2 Million**

Daily Shipments of  
Hazardous Materials

**16,700**

Underground Natural Gas  
Storage  
Wells

**1.6 Billion**

Tons of Hazardous  
Materials Shipped  
Annually by All Modes

**64%**

Of U.S. Energy  
Commodities  
Transported by Pipeline



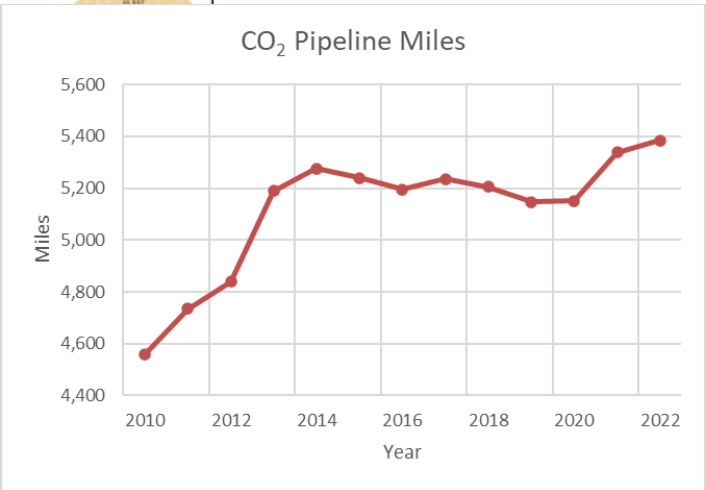
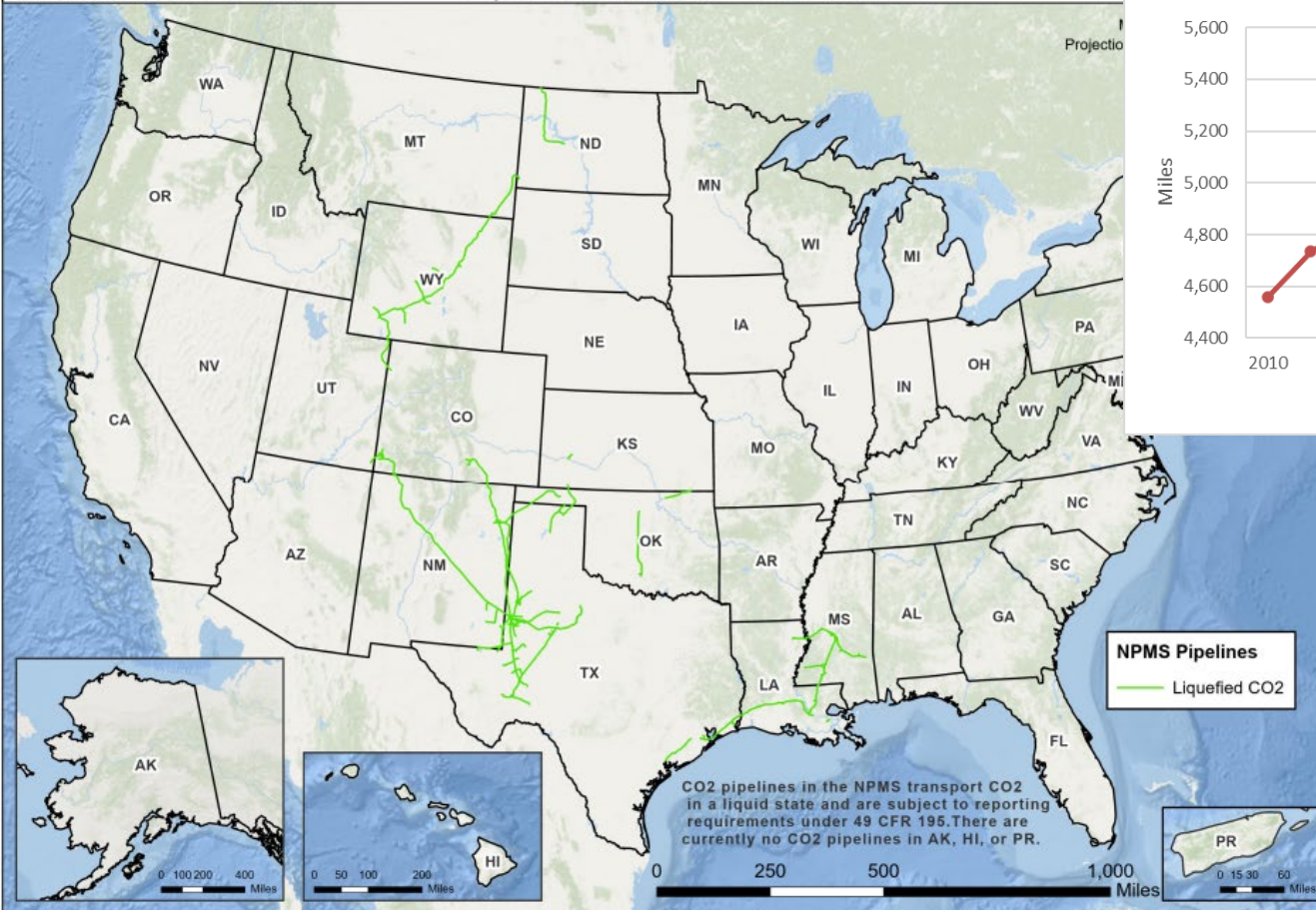
# Carbon Dioxide Pipelines

# Carbon Dioxide Pipelines (CO<sub>2</sub>)



# CO<sub>2</sub> Pipeline Network

## Active CO<sub>2</sub> Pipelines in the NPMS Pipeline data as of 9/15/2023



**5,385 Miles**

**All Pipelines:  
PHMSA  
Regulates 3.3 M  
Miles Total**



# Developing Design and Welding Requirements Including Material Testing and Qualification of New and Existing Pipelines for Transporting CO<sub>2</sub>

**Researcher:** BMT Commercial USA

**Project Cost:** \$1,500,000 (\$1,200,000 PHMSA + \$300,000 cost sharing)

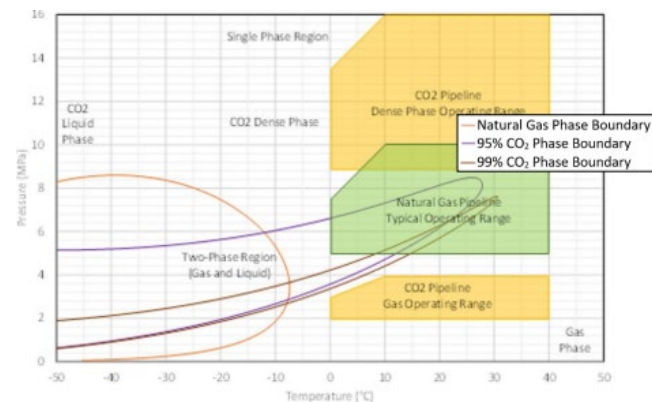
**Public Page:** <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=996>

## Project Objective:

- Identify unique aspects of CO<sub>2</sub> pipeline design, integrity, and operational considerations currently not well supported by existing knowledge.
- Define processes and procedures to fill these safety gaps.
- Identify performance-based safety targets for CO<sub>2</sub> pipelines.

**Project End Date:** 9/29/2024

**Potential Impact on Safety:** Will advance the safe transportation of impure CO<sub>2</sub> at both low pressure (gas phase) and high pressure (supercritical and dense phase), by defining the state of knowledge and how it can be applied in CO<sub>2</sub> pipeline design, operation, and maintenance.



Pictures courtesy BMT





# Determination of Potential Impact Radius (PIR) for CO<sub>2</sub> Pipelines Using Machine Learning Approach

**Researcher:** Texas A&M Engineering Experiment Station

**Project Cost:** \$359,560 (\$279,754 PHMSA + \$79,806 cost sharing)

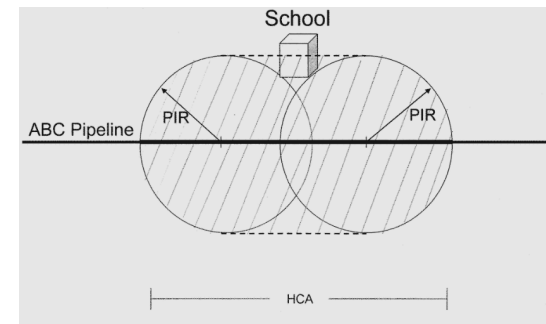
**Public Page:** <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=987>

## Project Objective:

- Establish a computational fluid dynamics model to simulate the release and dispersion of supercritical CO<sub>2</sub> from full pipeline ruptures.
- Use the simulation results to construct a database comprising CO<sub>2</sub> dispersion data under different scenarios.
- Use the resulting scenario data in a machine learning analysis for predicting dispersion ranges and health consequences.
- Develop a rapid, universally applicable tool to assess the consequences of accidental CO<sub>2</sub> dispersion from high-pressure pipelines.

**Project End Date:** 9/29/2025

**Potential Impact on Safety:** A tool to measure the impact radius will aid in the development of effective response planning.



# Past CO<sub>2</sub> Projects

## Design, Development, and Testing of Optimized Composite Crack Arrestors – Two Phase Project

**Researcher:** Engineering Mechanics Corporation of Columbus

**Project Objective:** The development of the "Soft Crack Arrestor" validated design procedure will allow this device to be used for a wide variety of natural gas and liquid CO<sub>2</sub>, pipeline projects. This device will reduce the risk associated with catastrophic fracture of large-diameter natural gas or liquid CO<sub>2</sub>, pipelines.

### Phase 1

**Project Cost:** \$100,000

**Public Page:** <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=228>

**Phase 1 End Date:** 2008

### Phase 2

**Project Cost:** \$750,000

**Public Page:** <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=290>

**Phase 2 End Date:** 2013



# Tell us where you're from!



# Working Group Objectives

To advance the safe transportation of CO<sub>2</sub>, this working group will take into consideration all public interest, including what was learned during the Pipeline and Hazardous Materials Safety Administration's (PHMSA's) May 2023 public meeting held in Des Moines, Iowa. This working group will seek solutions to address the following research topics:

- Criteria for engineering assessments on existing infrastructure to be converted to CO<sub>2</sub> service;
- Leak detection;
- Odorization for both gaseous and supercritical CO<sub>2</sub> pipelines;
- Dispersion modeling, including validation of existing models;
- Fracture propagation of CO<sub>2</sub>, including potential for crack arrestors; and
- Compatibility of gaseous and supercritical CO<sub>2</sub> with, and the effects of impurities on, pipeline systems, including inspection tools.

This working group also will consider incorporation of machine learning and artificial intelligence (AI) into these research areas. PHMSA envisions that the workgroup will develop four or five research topics that focus on advancing knowledge and technology related to CO<sub>2</sub> transportation and storage.



# Expectations

**Ultimate Goal** is to develop **3 to 5** research topics that PHMSA can use in upcoming research solicitations:

- Develop a consensus agenda of technical gaps and challenges for future R&D that does not duplicate existing efforts.
- Produce output that identifies both short-term and long-term research objectives, where possible, for a diversity of pipeline commodity, transportation, or facility types.
- Tailor the research gaps to assist with data or solutions for challenges identified in rulemaking, congressional mandates, or National Transportation Safety Board (NTSB) recommendations.
- Consider how AI and Machine Learning can be incorporated into research topics.



# CO<sub>2</sub> Working Group Participants

Ramadan Ahmed  
Basim Bacenty  
Melissa Batum  
Joshua Bruce-Black  
W. R. Bill Byrd  
Jean-Benoit Cazaux  
Lawrence Cho  
Gary Choquette  
Pamela Chu  
Emma Coatney  
Seth Dickson  
Omer Dogan  
Kevin Dooley  
Atul Ganpatye  
Simon Gant  
Karen Gentile  
Sarah Gilliland

Jenna Graham  
Richard Hill  
Joshua James  
Jon Jennings  
Dan Jia  
Takayuki Kagaya  
Ryan Kammer  
Max Kieba  
Ramanan Krishnamoorti  
Ashley Kroon  
Banglin Liu  
Lauren Lopez  
Juan Mendoza  
Rick Noecker  
Hong Pan  
Bjorn N.P. Paulsson  
Aquiles Perez

Justin Poepsel  
Tyler Rippel  
Lindsay Sander  
Amy Seminsky  
Eric Sherrock  
Gabe Sierra  
Robert Smith  
Ramgopal Thodla  
Sam Wang  
Dash Weeks  
Matthew White  
Jeff Whitworth  
Nicholas Wiewiorowski  
Jason Wolf  
Xuanyu Zhou



# S&K Mission Support



Amy Seminsky  
S&K Mission Support



# R&D Links

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## About Pipeline Research & Development

The mission of PHMSA's Pipeline Safety Research & Development Program is to sponsor projects focused on providing technical solutions that will improve pipeline safety, reduce the environmental impact of failures, and enhance the reliability of the Nation's pipeline transportation system.

## The research program has the following objectives:

- Employ a coordinated and collaborative approach to address mutual pipeline challenges with a wide set of pipeline stakeholders
- Help remove technical and sometimes regulatory barriers on a given challenge
- Tell the research story by measuring our research results, outputs, and impacts
- Promote transparency by posting online R&D program/project actions and products.

**R&D Program Website:** <https://www.phmsa.dot.gov/research-and-development/pipeline/about-pipeline-research-development>

**R&D Program Awards:** <https://primis.phmsa.dot.gov/matrix/>

**Submit a research gap suggestion:** <https://primis.phmsa.dot.gov/rd/gapsuggestions.htm>

**Join the R&D Program Alerts Distribution List:** <https://service.govdelivery.com/accounts/USDOTPHMSA/subscriber/new>

**R&D Program Email:** [R&Dteam@dot.gov](mailto:R&Dteam@dot.gov)

