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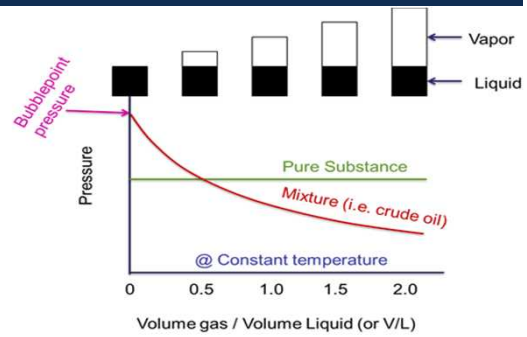

Crude Oil Characterization Research Study Update

Presentation to

US DOT Office of Hazardous Materials Safety

Research & Development Forum
March 23-24, 2016
Washington, DC

Presented by
David L. Lord, Ph.D.
Geotechnology & Engineering Department
Sandia National Laboratories
Albuquerque, NM 87185

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Technical Team

- David Lord (Ph.D., Env E.), Project technical lead
  - Geotechnology & Engineering Department, Sandia National Laboratories
- Anay Luketa (Ph.D., Mech E.), Combustion/fluids modeling lead
  - Fire Science & Technology Department, Sandia National Laboratories
- Tom Blanchat (Ph.D., Nuclear Engr), Combustion testing lead
  - Fire Science & Technology Department, Sandia National Laboratories
- Chad Wocken (B.S., Chem E.), Hydrocarbon supply chain specialist
  - University of North Dakota Energy & Environmental Research Center
- Ted Aulich (B.S., Chemistry), Hydrocarbon supply chain specialist
  - University of North Dakota Energy & Environmental Research Center
- Ray Allen (B.S. Chem E.), PE (TX), HC sampling and testing specialist
  - President of Allen Energy Services engineering consulting firm
- David Rudeen (B.S., Mathematics), Data analyst and EOS modeler
  - GRAM, Inc. technical consulting

Outline

- Problem Statement and Objectives
- Project Governance and Workflow
- Overview of Task 2 – Task 3 Testing
- Project Management Contacts
- Project Publications

Technical Objectives

PROBLEM STATEMENT

Problem Statement

- Crude transport by rail poses risks recognized by US and Canadian regulators
- Hazards have been realized in a number of high-profile train derailments leading to oil spills, environmental contamination, fire, property damage, and fatalities
- Open debate on whether the types of crude (tight oil vs. conventional production) have significant bearing on severity of transportation accidents

NTSB (2014). "Preliminary Report Railroad DCA14MR004." National Transportation Safety Board, Washington, DC 20594.

TSBC (2014). "Runaway and Main-Track Derailment Montreal, Maine & Atlantic Railway Freight Train Lac-Megantic, Quebec 06 July 2013." ***R13D0054***. Transportation Safety Board of Canada, Gatineau QC K1A 1K8. Railway Investigation Report.

DOE/DOT Project Objectives

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- Determine what combinations of sample capture and analysis methods are suitable for characterizing selected physical properties of volatile crudes
- Evaluate selected physical properties of crude oils (tight vs. conventional production) that are moved within rail transport environment that may have some bearing on flammability risks
- Measure combustion properties (flame dimensions, surface emissive power) of selected crude oils (tight vs. conventional) in controlled burn scenarios that have bearing on hazard determination
- Compare combustion properties to existing published data on other flammable liquids, including methanol, ethanol, jet fuel, hexane
- Evaluate if selected tight oils exhibit measurably different combustion properties from conventional crudes and the reference fluids tested previously

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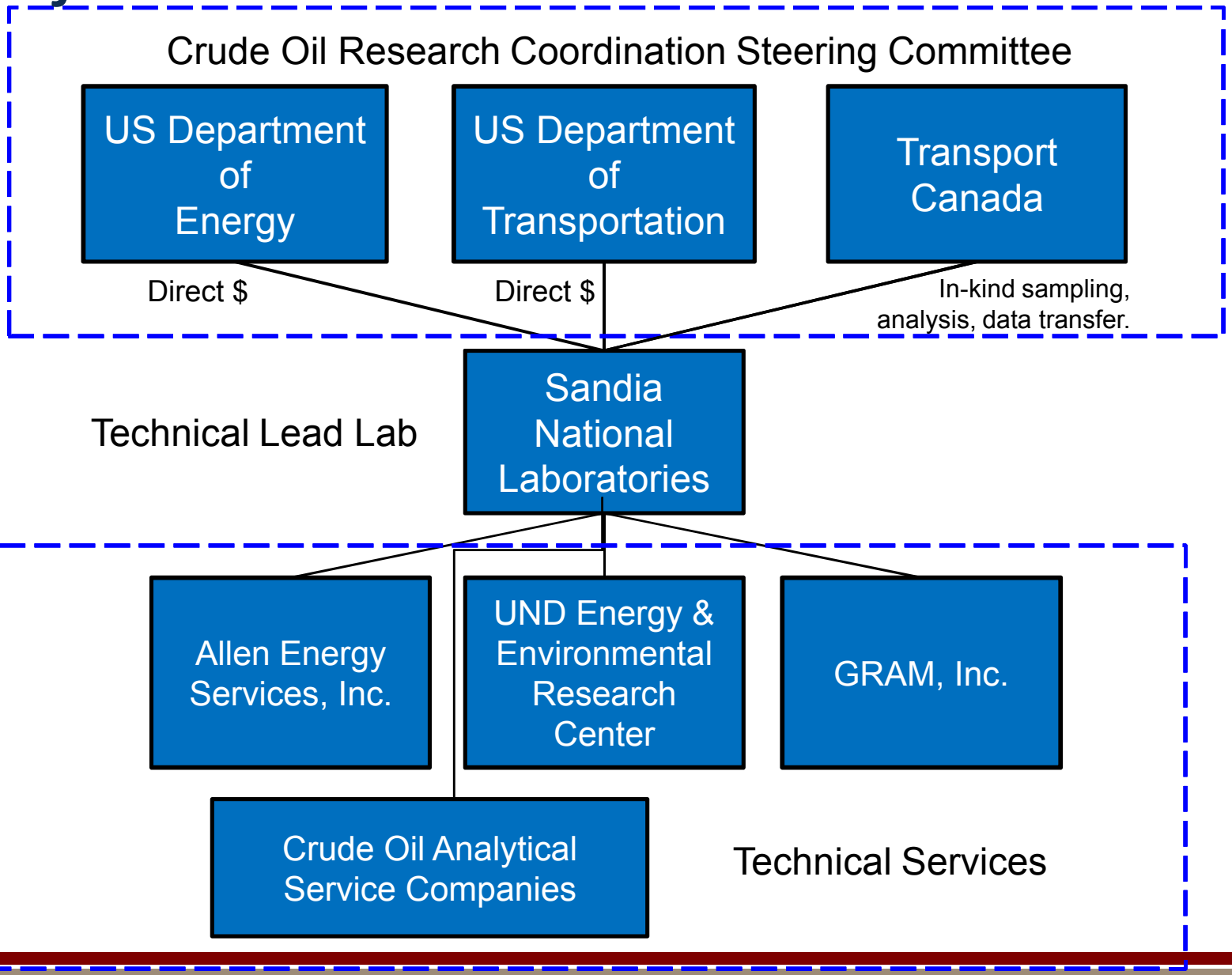
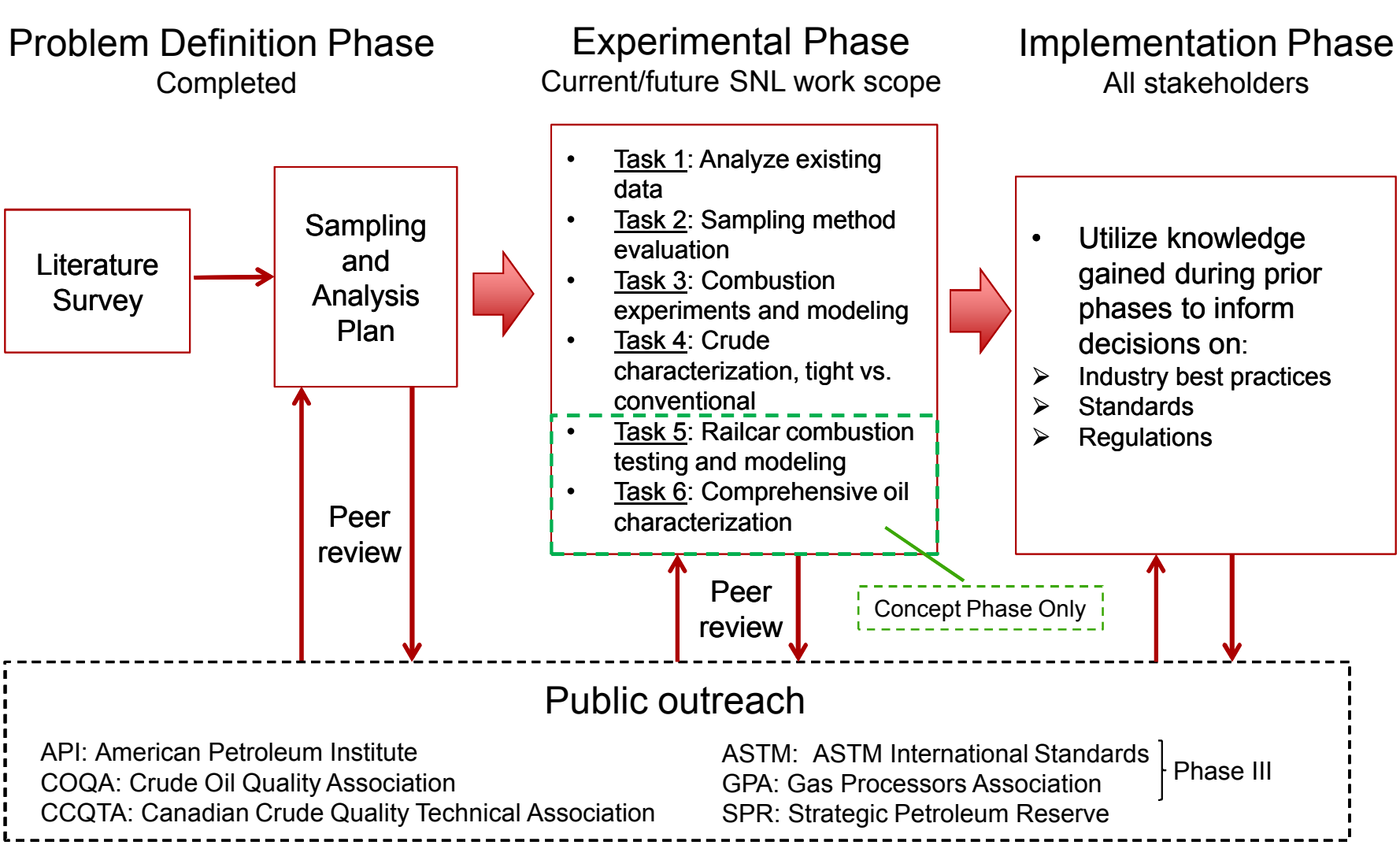
PROJECT GOVERNANCE

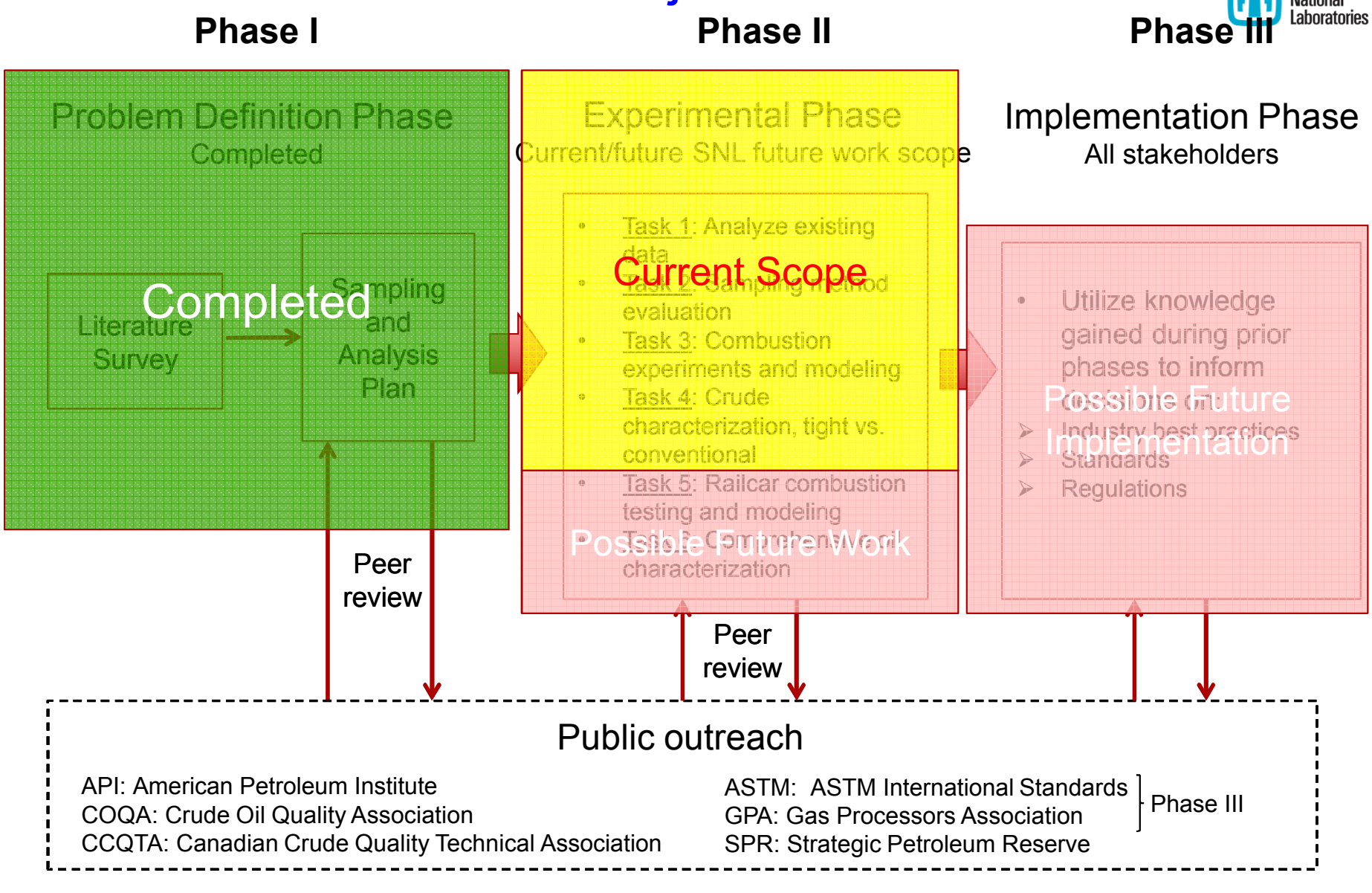
Project Governance



Overall Project Workflow



Overall Project Workflow



High-Level Project Schedule, Phase II

		Year 1				Year 2			
Task	Description	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Review new & emerging data								
2	Evaluate sampling and analysis methods								
3	Large sample acquisition, combustion tests, modeling								
4	Tight vs. conventional crude characterization								

Crude Oil Property and Combustion Tests

TESTING OVERVIEW

Task 2 Overview

- Compare sample capture and analysis methods for two selected North American crude oils
  - Prefer upstream production or tank terminals handling tight oils
- Sandia National Laboratories and Transport Canada will administer parallel tests using a variety of sample capture and analysis methods
- Critical review of open vs. closed capture and applicability for use on minimally stabilized oils for measuring:
  - Crude vapor pressure VPCRx(T) at selected V/L and temperature
  - Pressurized GC light ends concentration
  - Unpressurized GC DHA and simulated distillation
  - Unpressurized physical property measurements MW, SG, viscosity
  - IBP based on 0.5 wt% determination

Task 2 Test Matrix

		Property Measurement								
Sample Technique	**Standard**	TVP	Composition 1	Composition 2	Composition 3	Avg MW	Relative Density	Viscosity	Flashpoint	IBP (0.5 wt%)
SPR Tight Line		ASTM D6377 & Separator shut-in	BPP flash gas GC analysis	GOR flash gas GC analysis	Separator liquid C30+	frz pt dep	ASTM D5002	N/A	N/A	EOS with flash gas
Floating Piston Cylinder	ASTM D3700-14	ASTM D6377-M	GPA2103 M	GPA2177 + ASTM D7900 + ASTM D7169	ASTM D8003 + ASTM D7169 + GOR flash gas	frz pt dep	ASTM D5002	ASTM D7042	ASTM D93 or D56	GPA 2103/2177
H_2O displacement	GPA 2174-14	ASTM D6377-M	GPA2103 M	GPA2177 + ASTM D7900 + ASTM D7169	ASTM D8003 + ASTM D7169 + GOR flash gas	frz pt dep	ASTM D5002	ASTM D7042	ASTM D93 or D56	GPA 2103/2177
Manual Syringe	ASTM D8009-15	ASTM D6377-M	GPA2103 M	GPA2177 + ASTM D7900 + ASTM D7169	ASTM D8003 + ASTM D7169 + GOR flash gas	frz pt dep	ASTM D5002	ASTM D7042	ASTM D93 or D56	GPA 2103/2177
Boston Round	ASTM D4057-12	ASTM D6377-M	GPA2103 M	GPA2177 + ASTM D7900 + ASTM D7169	ASTM D8003 + ASTM D7169 + GOR flash gas	frz pt dep	ASTM D5002	ASTM D7042	ASTM D93 or D56	GPA 2103/2177
Manual Syringe	ASTM D7975-14	ASTM D7975-14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Color coding	Test Administrator
White	SNL
Red	TC
Blue	Both

- Test matrix will be run on two minimally stabilized North American crudes
- Objective is to compare multiple methods on a homogeneous sample
- Note: Oil variability across production regions or supply chain is addressed in Task 4, not Task 2

Task 3 Overview

- Subject four selected North American crudes to basic property and controlled burn testing
- Span a range from tight oils (Bakken, Eagle Ford) with high visibility, to baseline light sweet (WTI, LLS), to specially-stabilized crude from the Strategic Petroleum Reserve
- Compare results against existing hydrocarbon liquid combustion test data

Burn Test Configurations

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Pool fire

- Surface emissive power (SEP)
- Heat flux to engulfed objects
- Flame height
- Fuel consumption rate

Fireball

- Surface emissive power (SEP)
- Heat flux to nearby objects
- Fireball diameter
- Fireball duration

Project Sponsor Contacts

- U.S. Department of Energy
  - Evan Frye
    - U.S. Department of Energy, Office of Fossil Energy, Office of Oil & Natural Gas
    - *evan.frye@hq.doe.gov*
    - 202-586-3827
- U.S. Department of Transportation
  - Joseph Nicklous
    - U.S. Department of Transportation, Office of Hazardous Materials Safety
    - Pipeline and Hazardous Materials Safety Administration
    - *joseph.nicklous@dot.gov*
    - 202-366-4545
- Transport Canada
  - Barbara Di Bacco
    - Transport Canada, Transport Dangerous Goods Directorate
    - *barbara.dibacco@tc.gc.ca*
    - 613-990-5883

Sandia Project Contacts

- Sandia technical lead
  - David Lord
    - Sandia National Laboratories, Geotechnology & Engineering Department
    - *dllord@sandia.gov*
    - *505-284-2712*
- Sandia geosciences program manager
  - Erik Webb, Senior Manager
    - Sandia National Laboratories, Geoscience Research & Applications
    - *ekwebb@sandia.gov*
    - *505-844-9179*

Project Publications

- Lord, D., A. Luketa, C. Wocken, S. Schlasner, R. Allen and D. Rudeen (2015). "Literature Survey of Crude Properties Relevant to Handling and Fire Safety in Transport." *Unlimited Release* ***SAND2015-1823***. Sandia National Laboratories, Albuquerque, NM 87185.
- SNL (2015). "Crude Oil Characteristics Sampling, Analysis and Experiment (SAE) Plan." Office of Fossil Energy. U.S. Department of Energy, http://energy.gov/fe/articles/crude-oil-characteristics-research. 9-Jul-2015.

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END OF PREPARED SLIDES