Engineering Aspects and the Transport and Fate of Spilled Oil

- Deepwater jet-oil properties and interactions with dispersants
- Fate and Transport / Modeling: Understand the Contaminant Geo-Spatial-Temporal Distributions
- Deployable Data Gathering Systems
- Remediation, Bioremediation

Engineering Aspects and the Transport and Fate of Spilled Oil

1. Deepwater jet-oil properties and interactions with dispersants

- **Research Objectives**:
- Analyze deepwater blowout, plume characteristics
- Model multi-phased system behavior
- Study the effects of dispersant against baseline model
- **Benefits**
- Describes characteristics of oil, water at subsea source
- Provides subsea trajectories to best place surface response assets and resources
- Provides subsea trajectories to develop toxicity, environmental health data sampling protocols during the event
- Provides baseline real time research that can be used for future studies

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Deepwater jet-oil properties and interactions with dispersants

- **Research Issues**
- **Oil-jet thermodynamic conditions**
- thermodynamic properties of oil in the presence of methane hydrate
- Determine the scaling parameters at the nano and macro scale that mimic deepsea horizon oil spill characteristics (sea water column: 117 atms, (3000 psi), 4C) or when the oil comes out (8000 psi, 300F??).
- At conditions of the jet, what is the P gradient, how does dispersants get sucked into the main stream? What are the flow dynamics, effects of mixing surfactants, shear forces, compositions, and surface properties?
- How to inject a dispersant to a deepsea oil torrent and determine what the best way to apply? How is the velocity being affected?
- What is the behavior of natural oil as a function of components such as Methane, hydrates, ionic strength of sea water, temperature, etc.?
- Are there any mechanisms that function as heavy weights that hold the dispersant/oil complex at the bottom of the sea (sediments???)or does it remain suspended in the water column?
- How does oil interact alone in sea water?
- How does oil interact with other compounds present naturally or with current or newly-developed surfactants?

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Deepwater jet-oil properties and interactions with dispersants

- **Research Issues**
- **Effective dispersants**:
- Are dispersants effective at extreme conditions?
- What dispersants are non toxic, how to determine toxicity? Determine if newly develop materials or techniques of implementation are sustainable.
- How to construct equilibrium data?
- How to test and synthesize biodegradable dispersants and non toxic?
- Development and test at the interfacial phenomena
- How do interfacial properties of dispersants change under extreme conditions of T and P?
- Study agitation and the functionality of injection
- Study fundamental problems such as dispersants at interfaces and understand the forces to which they undergo in deepsea conditions and at the air-sea water interface?

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Deepwater jet-oil properties and interactions with dispersants

- **Research Issues**
- **Oil – dispersant system**:
- What is optimal ratio of dispersion – oil mix?
- How do deepsea conditions affect dispersants?
- What is the polarity of dispersants alone and the oil/dispersant system?
- What is the drop behavior they exhibit?
- What are the oil decomposition mechanisms?
- Do dispersants make the oil more available to microbes or other organisms? Are drops biodegradable and are they going to be effective? How is biodegradation uptake being affected?
- What are the conditions for having micro emulsions?
- What are the parameters that will drive the design of effective dispersants?

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- **Research Issues**
- **Unique techniques and characterization for dispersion and oil/dispersion system**:
- Use special techniques such as small angle neutron scattering and x-ray diffraction to determine structure and nucleation or/and crystallization mechanisms under extreme conditions.
- Use of Electron microscopy – Cryo stage and other surface characterization techniques
- Use a step down approach from atmospheric conditions to high P and high T conditions.
- Model the experimental properties, activity coefficients, optimization parameters relevant to realistic processes.
- Use similar oil properties as the one in the deepsea oil spill ("sweet oil").
- Make sure the samples are preserved and oxidation is prevented by having a protocol with Ar storage, stable temperatures.

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- **Collaborative Research**:
- How to relate multidisciplinary research and incorporate th States in the GofM?
- Develop a catalog of expertise between the multidisciplinary team and the academic institutions related to the GofM phenomena

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2. Fate and Transport / Modeling: Understand the Contamin Geo-Spatial-Temporal Distributions

- **Research Objective**
- **Crude, Crude Compounds, and Dispersants in Water, Sediment and Shoreline**: Predict concentration of crude and crude compounds on geo-spatial and temporal scale which will include transport and fate phenomenon (water column, sediment, shoreline, and wetlands).
- **Air Quality Modeling**: Be able to model impact on air quality due to the spill and spill related emissions
- **Health Risk Modeling**: Be able to mode public health due to the spill and spill related emissions
  - Estimate emissions using inverse-dispersion modeling using the existing ambient air monitoring and/or other methods
  - Develop emission spectra for various air pollutants (on time scale)
  - Use emission spectra (emission rates) to model incremental air pollutants in the ambient air

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Fate and Transport / Modeling: Understand the Contaminan Geo-Spatial-Temporal Distributions

- **Benefits**:
- Useful in decision making in terms of response and response measures
- Analyzes impact on the environment, public, and worker health
- Analyzes impact on food chain
- Provides toxicologists with sampling protocols
- Research Issues
- **What exactly needs to be done**?
- Develop a fluid dynamic model to understand oil drift from the well-head to the surface. Model will estimate the volume change from the well-head to the surface
- Develop a multi-component supercritical high speed fluid mixing into stagnant waterbody (short-term). Will predict oil concentration at different locations and time periods
- Large-scale and long-term model to include weathering phenomenon, transport, and fate of crude oil.

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Fate and Transport / Modeling: Understand the Contaminan Geo-Spatial-Temporal Distributions

- **Research Issues**
- **What we need / Inputs**:
- Identify and collect existing data and measure as necessary to conduct your fate and transport models in order to predict geo-spatial and temporal pollutant distributions
- Crude/natural gas flow, composition etc. Output short-term model could be used in this.
- Experimental and field studies to support model development and logic
- Water, fluid interactions
- Shoreline impacts

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Fate and Transport / Modeling: Understand the Contaminant Geo-Spatial-Temporal Distributions

- **Need for multi-disciplinary involvement**: As the model to be developed will involve physical, chemical, and biological principles to accurately define, validate, and predict the model output. For example, if the model involves microbial degradation of certain compound in marine environment, this information has to be supplied by the microbiologists.
- **Collaborative Disciplines**: Computational fluid dynamics; Heat/mass transfer; Chemistry; Meteorology; Environmental science and engineering; Air quality modelers; Computer science; Mathematics; Physics; Physical oceanography; Microbiology;

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3. Deployable Data Gathering Systems

- **Research Objective**:
- Develop deployable real time data collection & analysis system that is responsive from swarms of collaborating sensing platforms to the individual sensing platforms at a specific location that minimizes potential negative environmental impacts of human data collection

3. Deployable Data Gathering Systems

- **Benefits:**
- Provides emergency responders, scientists, trustees and environmental managers with timely, accurate & valid data to make effective and safe plans and decisions during an emergency event
- Real time, online collaborative decision support system, integrated with other system behavior models and GIS that support technical, operational, political and socio-economic interests
- Enhances responder safety
- Enhances data collection techniques

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Deployable Data Gathering Systems

- **Four subareas defining our strand topic:**
- Sensors
- Platform development
- Data mining and decision and support systems
- Robotics and automation

Deployable Data Gathering Systems

- **Research Issues**
- Control theory, robotics, and automation are the glue that holds the entire data gathering systems together. We should help humans make decisions, but we should develop semiautonomous systems that get humans out of the platforms because of harsh environments
- Minimize worker risk
- Exploration scans an area and collects data, while exploitation zooms in closer to discover more detailed information on areas of interest

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Deployable Data Gathering Systems

- **Research Issues**
- Sensors must detect air chemistry, dispersant chemistry, meteorology, and oil chemistry
- Intelligent algorithms for sensor networks
- System must be adaptive to weather and other changing conditions
- Platforms must be able to operate at various scales to take samples
- Aerial and marine vehicles are needed, including vehicles that deploy other micro vehicles
- Abnormal event data management models are needed. We must detect when sensors are not functioning correctly or when they must be moved
- Data must be fused to produce useful information using data mining techniques
- Data must integrate with existing data streams

Deployable Data Gathering Systems

- **Multiple disciplines** including applied physics, atmospheric science, chemistry, computer science, engineering, mathematics, and oceanography

4. Remediation, Bioremediation

- **Research Objectives**
- Develop effective bioremediation process and techniques that meet government deployment standards during an oil spill
- **Benefits**
- Provides a reliable, less intrusive technique to effectively remove oil for various dynamic environments
- Provides remediation, bioremediation as a proactive response tool
- Develops an effective, pre-approval process for remediation, bioremediation

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Bioremediation

- **Issues**
- implications for implementation of remediation technologies
- Remediating historic structures (cannot make things worse)
- Access to materials and data is difficult
- Mapping and instrumentation
- Biological aspects and ecological aspects of the work are important.
- Oxygenate water in bioremediation environment
- Clean Water Act, legal implications
- Simulation in the lab of deep water situations (e.g. pressure, temperature, oxygen limitations, possibly separate but eventually together)
- Sampling techniques that will more clearly confirm and allow bioremediation in situ;
- Liability and legal issues and how engineers and scientists can still get good data (come up with techniques, legal, instrumentation, etc. to actually get good data to make things more rational).

Bioremediation

- **Collaborative Efforts**
- Multiple disciplines
- Data gathering
- System behavioral modeling

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