Project Description

Offshore Labrador Sea

Gravity Gradient Survey

2014 - 2018

ARKeX

and

TGS-NOPEC Geophysical Company ASA

Prepared by: RPS Energy Canada Ltd.
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1 INTRODUCTION

ARKeX Ltd. and TGS-NOPEC Geophysical Company ASA (TGS) in partnership are proposing to conduct a Non-Exclusive Geophysical program offshore Newfoundland and Labrador under the jurisdiction of the Canada - Newfoundland and Labrador Offshore Petroleum Board.

TGS is an independent international geophysical contractor that supplies first class geophysical products, services and solutions worldwide. TGS optimizes data in prospective regions through niche surveys at a low cost, utilizing the best and most appropriate acquisition and processing.

The primary tool used by ARKeX in surveying is the Gravity Gradiometer, which provides the highest possible resolution across the widest bandwidth of any gravity instrumentation. The application of Gravity Gradiometry has been shown to be very complementary to seismic data, especially as a way to quickly fill in information between 2D seismic lines in a very cost effective way. Whichever platform is used to acquire the data (aircraft or vessel), there are a number of other data sets that can also be acquired at the same time, namely conventional gravity and magnetic data. Our plan is to also acquire these data concurrently with the Gravity Gradiometry. The equipment needed to collect these data are described in Section 3.

Gravity Gradiometry has been used as an exploration technique since the 1920's in the form of the torsion balance. In 1938, the development of less sensitive but cheaper methods meant the torsion balance was superseded and the industry focused on utilizing ground gravity measurements for exploration at that time. Subsequent developments in dynamic gravity instrumentation focused on these less sensitive measurement techniques, which subsequently led to the development of the L & R type dynamic air/sea meter. Although more recently the development of accelerometer based systems has taken place (e.g. BGM-3, AirGrav system and GT-1A), their measurement resolution is fundamentally limited, particularly in high dynamic environments.

In 1973, the US navy developed the first Full Tensor Gradiometer (FTG). The subsequent de-classification of the system and adaptation of the technique for oil, gas, and mineral exploration now means that Gravity Gradiometry is once again a commercially viable technique. With greater resolution and accuracy, Gradiometry now offers the greater geologic resolving power, especially in high dynamic environments (e.g. airborne acquisition).

This document is a Project Description intended to allow the C-NLOPB to fulfill its responsibilities under the Canada--Newfoundland and Labrador Atlantic Accord Implementation Newfoundland & Labrador Act and the Canada Newfoundland Atlantic Accord Implementation Act. The project description is presented to allow C-NLOPB the opportunity to provide scoping advice to provide C-NLOPB with an Environmental Impact Assessment for the project.

1.1 RELEVENT LEGISLATION & REGULATORY APPROVAL

An authorization to conduct a Geophysical program will be required by the C-NLOPB. The C-NLOPB is mandated in this matter by the Canada Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act and the Canada Newfoundland Atlantic Accord

Implementation Act. Geophysical Surveys are no longer on the schedule of projects under the Canada Environmental Assessment Act 2012.

1.2 THE OPERATOR

The Operator will be ARKeX, a geophysical service company for the oil & gas exploration industry specializing in providing non-seismic solutions. ARKeX helps deliver an upgraded geologic insight to exploration companies seeking a deeper understanding of their geology, but lacking the specialist resources necessary to efficiently leverage all that non-seismic data can offer. ARKeX helps reduce the risk of exploration and increase the likelihood of success. ARKeX is the industry's most experienced and proven non-seismic specialists, the single most concentrated pool of Gravity Gradiometry processing, interpretation and integration expertise within the oil and gas sector, a unique team armed with unique tools and patented processes.

1.3 CANADA NEWFOUNDLAND & LABRADOR BENEFITS

ARKeX, and its partner TGS, are committed to providing maximum benefits associated with East Coast operations to Canadian, and in particular, Newfoundland and Labrador residents and companies where they are commercially acceptable in accordance with "The Operators" operating requirements and fair market value.

The Operator will manage the East Coast operation from Newfoundland & Labrador. The Operator will provide full and fair opportunity to Canadian individuals and organizations, in particular those from Newfoundland and Labrador, to participate in its activities wherever possible. The Operator will support the principle that first consideration will be given to personnel and support services that can be provided in Newfoundland & Labrador.

Contractors working with ARKeX must apply a high standard of Health, Safety & Environmental competency where such services can be delivered.

1.4 CONTACTS

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2 PROJECT DESCRIPTION

The official name of the proposed project is "**Labrador Sea Gravity Gradient Survey**". The Operator is proposing to conduct one or more Gravity Gradient surveys from the first of April through the end of October in 2014 through 2018 The survey may start as early as April 1st, 2013, within the proposed Project Area (Figure 1).

In Figure 1, the "Study Area" represents the entire area potentially affected by the project activities beyond the Project Area proposed for assessment from 2014 to 2018. The "Project Area" represents the whole of the area recommended to be surveyed. Five (5) initial Phases have been identified in the Project Area. Industry participation will dictate which of the five (5) Phases will be surveyed first and in subsequent seasons.

There are 2 options open to ARKeX to conduct this survey. The survey data will be either acquired from a Fixed Wing Aircraft flown at a constant altitude or sailed with a small dedicated Marine Vessel.

Option 1 – Fixed Wing Aircraft
Option 2 – Small Dedicated Marine Vessel

The Operator would like the flexibility to use either option in a given year (2014-2018). The decision on whether or not any given year will use Option 1 or Option 2 will be based on the availability of the Aircraft, Vessel and system. The "Geophysical Operations Authorization" (GOA) will be submitted in accordance with which acquisition mode has been determined.

All proposed program activity, used by either Option 1 or 2 above, will occur seaward of 12 miles from the shoreline. No geophysical data will be collected in "the zone".

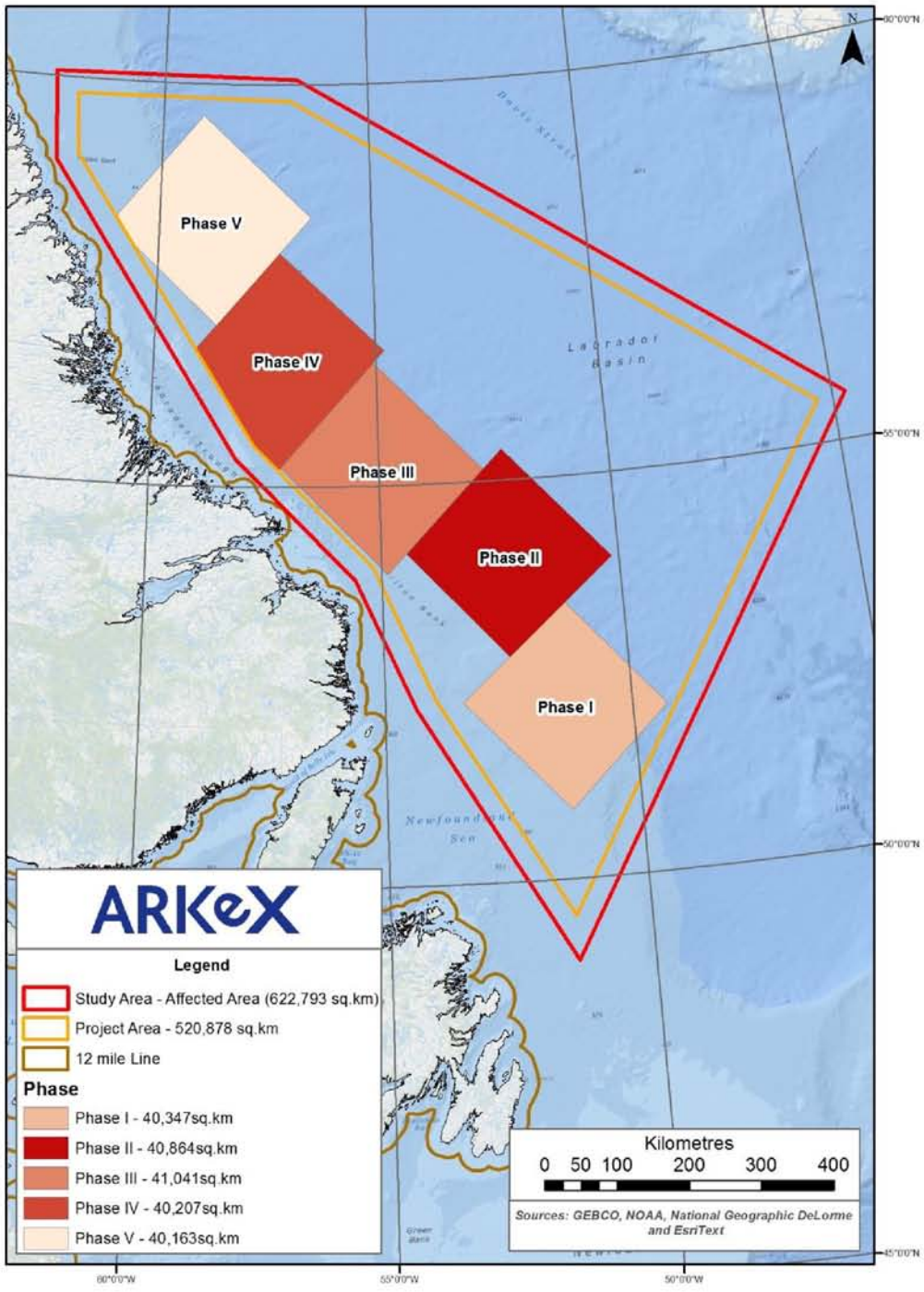

Figure 1. Study Area-Affected Area Location (red outline), Labrador Sea proposed Project Area (2014-2018) (yellow outline) and initial Phases shown as colored boxes

2.1 SPACIAL AND TEMPORAL BOUNDARIES

The Study Area (2014-2018) includes the five (5) Project Areas and these are within the Study Area, as shown. The coordinates and extents of the Study Area and Project Areas are the following:

Table 1. UTM Zone 21N WGS 1984 Coordinates for Study Area-Affected Area (Red Box) Clockwise from Top NW Corner

X	Y
182503.843	6672171.755
514004.118	6657690.22
1272608.654	6228203.344
906062.94	5440846.004
680631.146	5785437.669
595309.414	5965088.946
428904.071	6133988.3
181391.867	6549587.518
182503.843	6672171.755

Table 2. UTM Zone 21N WGS 1984 Coordinates of ARKeX Five Project Areas 2014-2018 (Shaded Boxes)

Phase 1

Area=40347km^2

Clockwise from 1 (East Corner)

Point	X	Y
1	1026712.2	5797034.538
2	896362.315	5649444.368
3	744620.824	5795812.16
4	884702.104	5935448.94

Phase II

Area=40864km^2

Clockwise from 1 (West Corner)

Point	X	Y
1	666166.046	6002176.412
2	796170.324	6148283.332
3	949410.927	6000493.773
4	808677.23	5859665.305

Phase III

Area=41041km^2

Clockwise from 1 (West Corner)

Point	X	Y
1	491101.248	6121073.358
2	619582.475	6266404.215
3	771248.283	6120129.651
4	640244.122	5973335.224

Phase IV

Area=40,207km^2

Clockwise from 1 (South Corner)

Point	X	Y
1	487944.055	6117149.059
2	452821.957	6152457.467
3	373103.103	6286313.87
4	490202.923	6417635.303
5	634418.194	6283679.146

Phase V

Area=40163km^2

Clockwise from 1 (East corner)

Point	X	Y
1	533899.762	6467113.534
2	402535.871	6318369.296
3	285472.449	6433455.025
4	263645.539	6470104.719
5	385865.09	6609195.068

The temporal boundaries of the survey are between April 1st and October 31st from 2014-2018. The duration of the program is estimated at not greater than 210 days in a given year.

2.2 PROJECT OVERVIEW

The proposed project is a Gravity Gradient Survey, consisting of five (5) Phases each approximately 40,000 km^2 in size with data collection in 2014-2018. (Survey lines yet to be determined).

The platform requirements for aircraft and marine vessel deployment are discussed below.

Option 1 – Fixed Wing Aircraft

When a new aircraft is used for the first time a number of modifications have to be made to facilitate the survey work. This makes the process of moving the instrumentation to a new aircraft for each job very expensive. It is normal that once an aircraft is set up and configured for gravity gradient survey work it is used for many years. The Gravity Gradiometer is deployed in a Fixed Wing Aircraft and flown in a grid pattern over the area of interest at a low altitude (typically 150-500m). A typical flight plan for a survey such the one being discussed over the Labrador Sea would employ a 1,000m or 2,000m flight line spacing with orthogonal tie lines flown at a much wider spacing (5-10 km). The base of operations (typically a regional airport with hanger access) for survey work could be 100s of km from the area to be surveyed. The aircraft makes repeated trips to the project area over a 3-5 month period, gradually building up the grid of measurements. Operations will be limited by weather, as the survey equipment requires less turbulence to record higher quality data. Good visibility is also required for safe operations at low altitude, so operations are also restricted by daylight hours and weather conditions.

Magnetic Data will also be acquired from the Aircraft in a remote module on the wingtips or nose/tail boom. Magnetic data will be very useful for understanding basement geology or the presence of igneous deposits.

Proposed aircraft for survey – De-Havilland Canada Twin Otter (DH-6)

Option 2 – Dedicated Marine Vessel

The choice of marine survey platform is more flexible than an aircraft in terms of system deployment. The Gravity Gradient survey equipment is containerized and can be fitted to the back deck of an appropriately sized vessel. This allows the use of a vessel that is available and best suited to a certain area. A Gravity Meter is also attached to the same platform as the Gravity Gradiometer. While this Gravity Meter generally lacks the resolution of the Gravity Gradiometer it is

able the boost the signal to noise ratio of the very long wavelengths. This is only useful on very large surveys, but the proposed Labrador Sea survey would be an example of this. Magnetic Data will also be easily acquired from a marine vessel via a towed sensor. Magnetic data will be very useful for understanding basement geology or the presence of igneous deposits as mentioned above. It is important to note that none of the gravity or gravity gradiometry equipment is even in the water and although the magnetic equipment is towed on a small cable all systems are complete passive. This means that no signal is emitted; they measure naturally occurring properties of the earth.

The Gravity Gradiometer system is regarded as the primary data output and will be maintained within specification throughout the survey duration. All other data systems deployed are deemed secondary systems. ARKeX will provide its best efforts to maintain secondary system specifications throughout the survey duration. But in the event of equipment failure, or degradation of system performance, the affected lines will not to re-flown/re-sailed.

2.2.1 Objectives and Rationale

The primary objective of the project is to determine the presence and likely locations of geological structures that might contain hydrocarbon deposits. The application of Gravity Gradiometry has been shown to be very complementary to seismic data, especially as a way to quickly fill in information between 2D seismic lines in a very cost effective way. Existing 2D / 3D data has been found to be insufficient to serve all the needs of energy companies in their exploration, development, and production activities.

The proposed Gradiometry Survey of data collection will be collected to compliment previous 2D data sets previously collected in the region, including that collected by TGS as outlined in Figure 2 below.

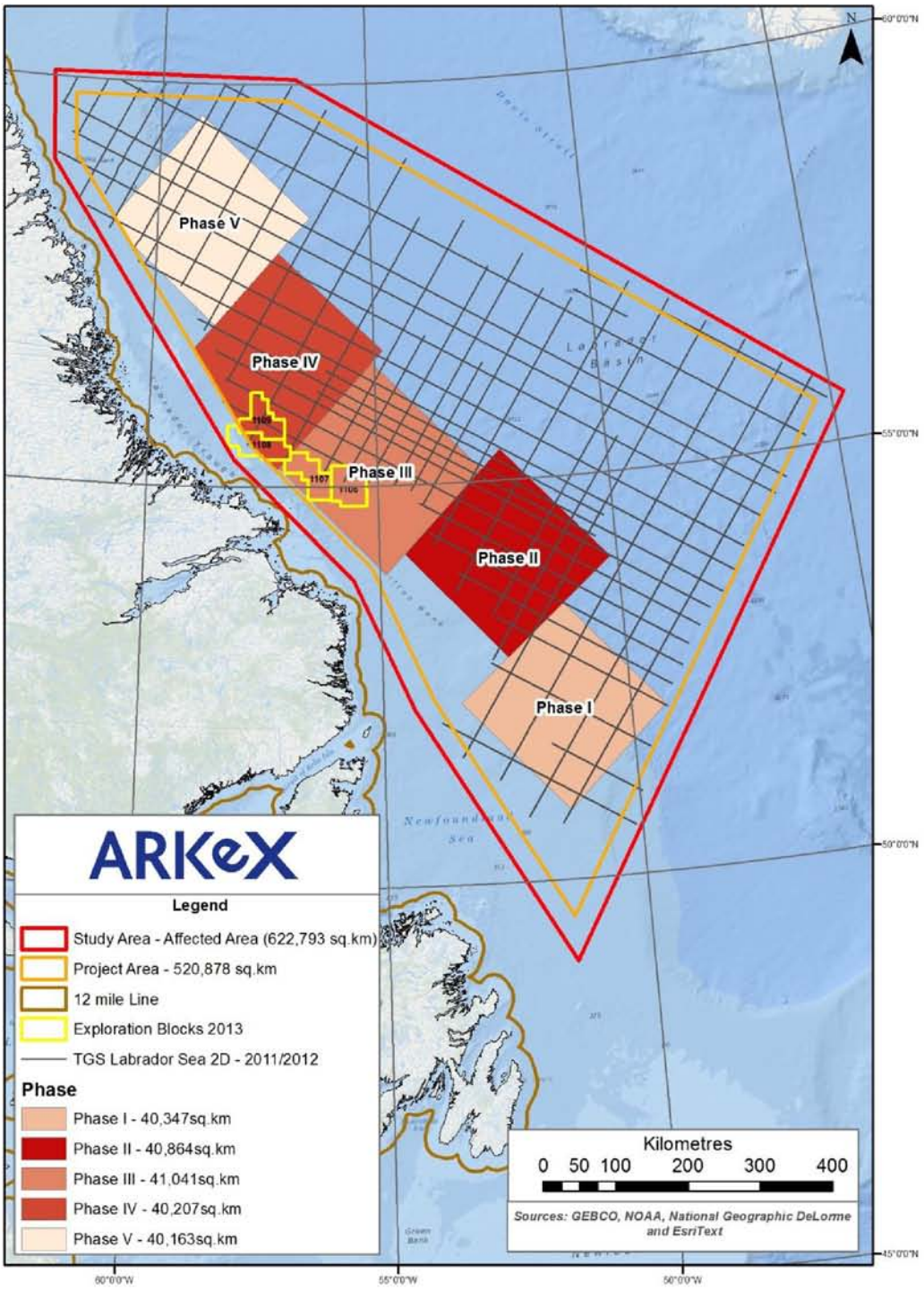

Figure 2. Distribution of TGS 2D data (black lines) and outline of proposed survey with C-NLOPB license blocks

2.2.2 Alternatives to the Project and Within the Project

The alternative to the project would be to forego exploration in the Labrador Sea and pursue opportunities elsewhere in the world, in order to assist market demand for data.

2.2.3 Phases

The project will be in two phases.

2.2.3.1 Phase 1

The initial phase will include Gradiometry data collection with auxiliary data, Gravity and Magnetic, in 2014. Final elevation models or ship tracks will be provided upon consideration of flight restrictions, infrastructure, or activity in the area upon filing for the GOA.

2.2.3.2 Phase 2

The remaining Phases will include Gravity, Magnetic, and Gradiometry data collected in 2015-2018 in areas within the Study Area based on the results of the 2014 analysis.

2.2.4 Project Scheduling Phase 1

Any survey will not exceed 210 days. However, logistics and weather will play an important role in scheduling; therefore, in order to allow flexibility in timing the proponent is proposing April 1st, 2014 – October 31st, 2014 window for data collection.

2.2.5 Project Scheduling Phase 2

The surveys can occur between April 1st through until October 31st in any given year 2015 - 2018. Maximum estimated duration of any of the proposed surveys is 210 days per year.

2.2.6 Site Plan

The Project Area proposed for 2014-2018 is shown in Figure 1. The proposed survey line orientation for Gradiometry data collection in 2014 will be provided upon application for the GOA.

Option 1 – Fixed Wing Aircraft

Altitude	150+ m above sea level
Survey Lines – Direction & Spacing	~045°/225° at 1,000m or 2,000m
Tie Lines - Direction & Spacing	~135°/315° at 5,000m or 10,000m

Option 2 – Maine Vessel

Altitude	sea level
Survey Lines – Direction & Spacing	~045°/225° at 1,000m or 2,000m

Tie Lines - Direction & Spacing	~135°/315° at 5,000m or 10,000m

3 EQUIPMENT

3.1 AIRCRAFT

Aircraft:	De Havilland Canada Twin Otter (DHC-6) or equivalent
Operator:	Rampart Aviation, LLC (FAA Certificate # 3RAA413M)
Speed:	132 mph typical (60 m/s)
Engine:	Pratt and Whitney PT6A-27 turboprop
Climb:	Climb Performance – 1000 fpm based on project altitude and temperature

3.2 MARINE VESSEL

Example Vessel:	M/V Aquarius
Length:	130ft (40m)
Width:	26ft (8m)
Draft:	11.5 ft (3.5m)
Bunkering:	3 weeks
Speed:	10 knots survey speed

3.3 GRAVITY GRADIOMETRY

Gravity Gradiometer	Full Tensor Gravity Gradiometry (FTG) system from Lockheed Martin incorporating latest LM and ARKeX proprietary technologies
Components:	Independent measurement of 6 components of the gravity gradient tensor
Bandwidth:	0.2 Hz (325 m recoverable wavelength)

3.4 GRAVITY GRAVIMETRY (GMA CHANNEL OF THE FTG SYSTEM)

System:	Lockheed Martin FTG - GMA channel
Static Noise:	0.1 mGal RMS per hour, 0.3 mGal RMS over 30 days

Static Drift:	<1 mGal per day
Stability of Drift Rate:	above rate stable to <1 mGal/month

3.5 MAGNETIC

Airborne specification:

System:	Bi-directional Horizontal Gradient System utilizing two wing tips sensors and one sensor in a nose or tail boom
Sensor type:	Geometrics G-822A Cesium Magnetometer
Range:	20,000 – 100,000nT
Sensitivity:	<0.0005 nT/sqrtHz rms, typically 0.003nT at sampling rate of 0.1s
Compensation:	Aircraft generated fields compensated using digital compensator operating on a measured set of defined maneuvers
Marine specification:	Similar level of quality system (or better) to airborne specification

3.6 SELF CONTAINED ARKEX INSTRUMENT CONTAINER

Container Weight:	5 tons
Container Size:	20ft x 8ft 6 x 8ft
Power Requirements:	400v AC 3 phase plus neutral 60 Hz
Positioning:	Back deck close to centre of gravity