NEW AIRBORNE THERMAL IMAGING SYSTEM FOR MAPPING AND MONITORING PIPELINES

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ABSTRACT

The TABI-1800 is a new high-performance airborne thermal imaging/mapping system designed and manufactured by ITRES Research Limited. This commercial-off-the-shelf imager uses patented optics to produce a diffraction-limited 1800 across-track pixel swath. And, it has a temperature finesse of less than 30mK at 12C.

In Fall 2013, the TABI-1800 was used in a proof-of-concept trail to map the faint thermal emissions from the ground heated by buried liquefied natural gas pipelines in southern Alberta. The TABI-1800 was mobilized in a Piper Navajo and flown, at night, at an altitude of 1,250m and a speed of 175knot; this resulted in a 0.5m/pixel spatial resolution and a 900m swath. Approximately, 100 line-kilometers of pipelines were flown; this produced more than 20 gigabytes of raw data. The raw data were subsequently radiometrically calibrated, ortho-rectified, mosaiced and analyzed to produce traceable apparent temperature maps highlighting the location of the active pipelines and the detection of the right-of-ways.

The proof-of-concept's successful detection and delineation of active buried liquefied natural gas pipelines and their right-of-ways may be applicable to the operational use of the TABI-1800 in very large-scale pipeline mapping and monitoring programmes.

Key words: thermal remote sensing, pipelines, MWIR, airborne, TABI-1800

BACKGROUND

Airborne and spaceborne thermal remote sensing is a mature and well-established field. Many commercial companies and government agencies provide high quality thermal imagers and/or thermal mapping services.

However, a few applications, including some in the energy sector, require ITAR-free (legally operable throughout most of the world) thermal mapping systems capable of efficiently and cost effectively mapping very large areas at very high spatial resolution with superb temperature finesse.

ITRES addressed this requirement by embarking on a program in 2010 to develop such a system – the TABI-1800, an 1800-pixel **T**hermal **A**irborne **B**roadband **I**mager.

The TABI-1800 incorporates a cryo-cooled MCT FPA. The FPA has been spectrally-filtered to be sensitive in only the longwave portion of the mid-wave infrared (3.7 to 4.8 microns). This minimizes the overestimation of surface temperatures from reflected sunlight; a problematic phenomenon encountered by full range mid-wave infrared (3.0 to 5.0 micron) systems. The TABI-1800 also incorporates very fast diffraction-limited optics (true single pixel focus) and a patented optical system. These features combine to make an industry-leading 1800-pixel swath in a single instrument with superb temperature finesse (<30mK at 12C) – with no moving parts. In addition, the TABI-1800 is ITAR-free.

During TABI-1800's first flight, on March 23rd 2011, the city of Calgary (40km by 27km) was thermally mapped in just five hours at 0.5m/pixel (three hours after sunset). An image of the mosaiced ortho-rectified temperature map is shown in Figure 1. In the figure, Calgary's downtown core's heat-island effect is easily seen. Also, topographical cooling can be seen in Calgary's NW quadrant (N is up) due to its higher elevation.

Since its successful first flight, the TABI-1800 has become commercially successful and it's routinely used in ambitious projects to thermally map very large areas at high spatial resolution. These projects include large-scale forest fires (Figure 2), sea surface temperature anomalies (Figure 3) and urban and industrial heat loss (Figure 4). Also, when coupled with ITRES' real-time processing systems, it becomes a powerful search-and-rescue platform. And, 18 months ago, it was used on a trial basis to map pipelines.

BURIED PIPELINE TRIALS

In October 2013, ITRES, on prompting from Spatial Energy, acquired TABI-1800 data over approximately 100 line-kilometers of active buried liquefied natural gas pipelines in southern Alberta. A TABI-1800 was mounted in a Cessna Stationair 206. The system was flown two hours after sunset and at speed of 175knots and an altitude of 2025ft AGL.

The active buried pipelines were easily detected and delineated through several types of vegetative cover and soil types. Figures 5, 6 and 7 show typical TABI-1800 temperature map examples highlighting the subtle localized ground heating by the buried pipelines. Each map is contrasted against a corresponding Google Earth image. The heated ground temperatures ranged from 0.02C (barely discernable) to 2.00C (extremely discernable) from background.

CONCLUDING REMARKS

The buried pipeline trials successfully demonstrated that the TABI-1800 could efficiently detect, map and monitor active buried pipelines in southern Albertan-type environments. In fact, the aircraft could be pushed to its maximum speed, to increase data collection efficiency, without impairing the TABI-1800's ability to collect 0.5m/pixel data.

Figure 1: TABI-1800 temperature map of Calgary. (N is up, 40km X 27km, 0.5m/pixel)

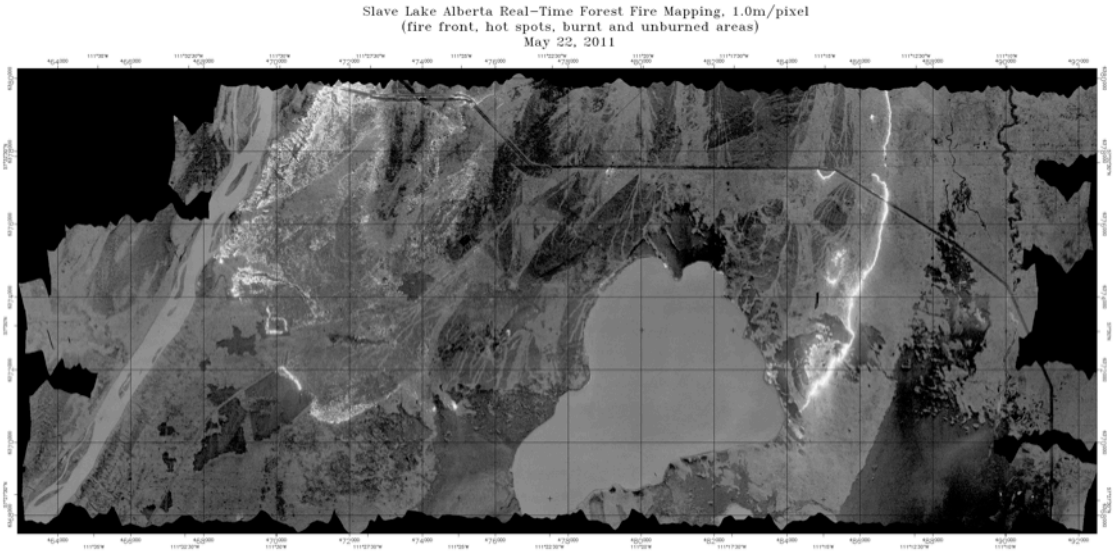

Figure 2: Forest fire mosaic. The fire fronts and hot spots behind the fire fronts are easily delineated and isolated. (30km by 13km, north is up, 1.0m/pixel)

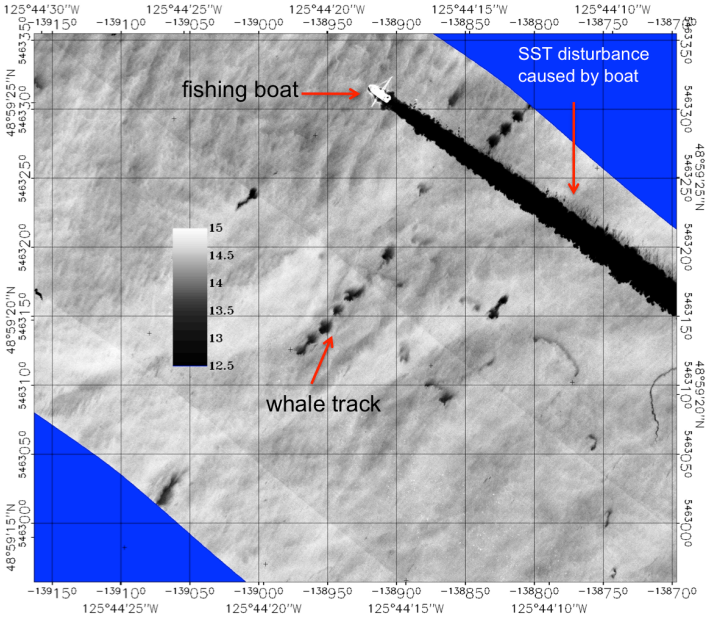

Figure 3: TABI-1800 temperature map of sea surface temperature disturbances caused by the passage of a fishing boat, a whale and other animals.

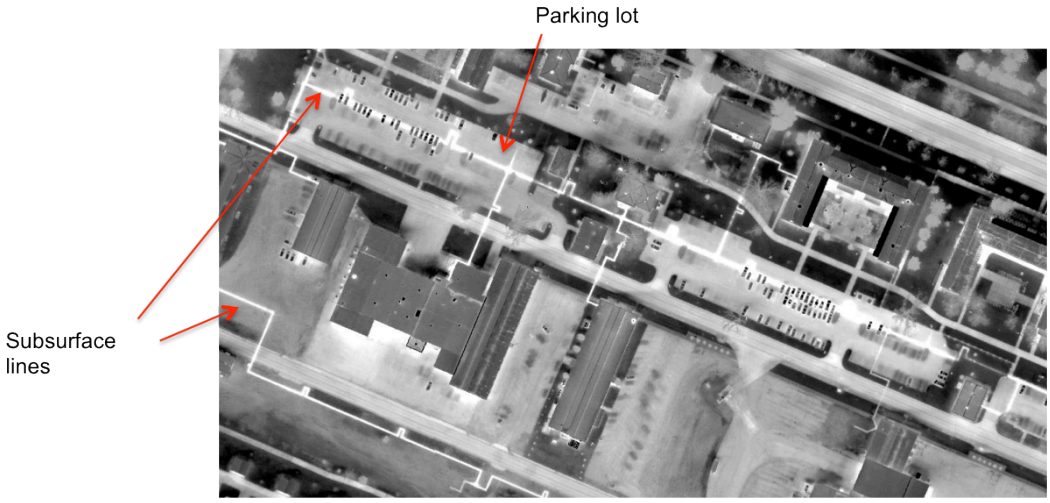

Figure 4: Monitoring of warm subsurface lines in an industrial site

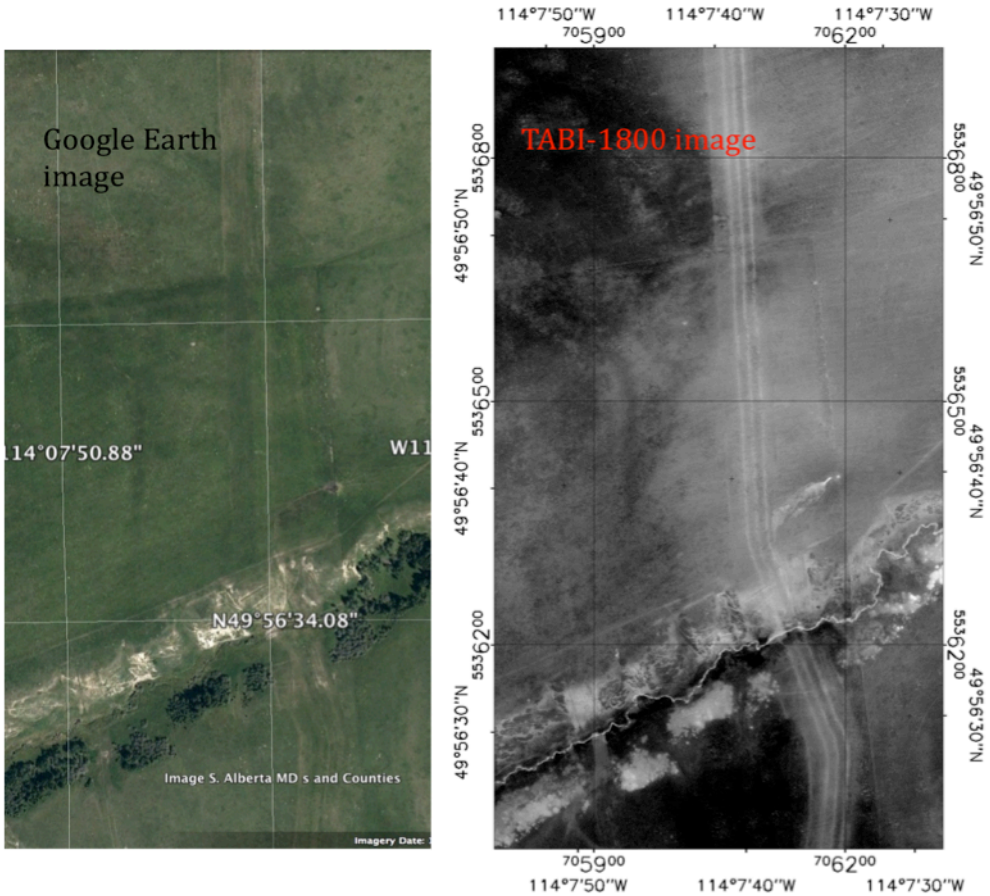

Figure 5: TABI-1800 example 1 of buried pipeline detection - triplet of parallel white lines.

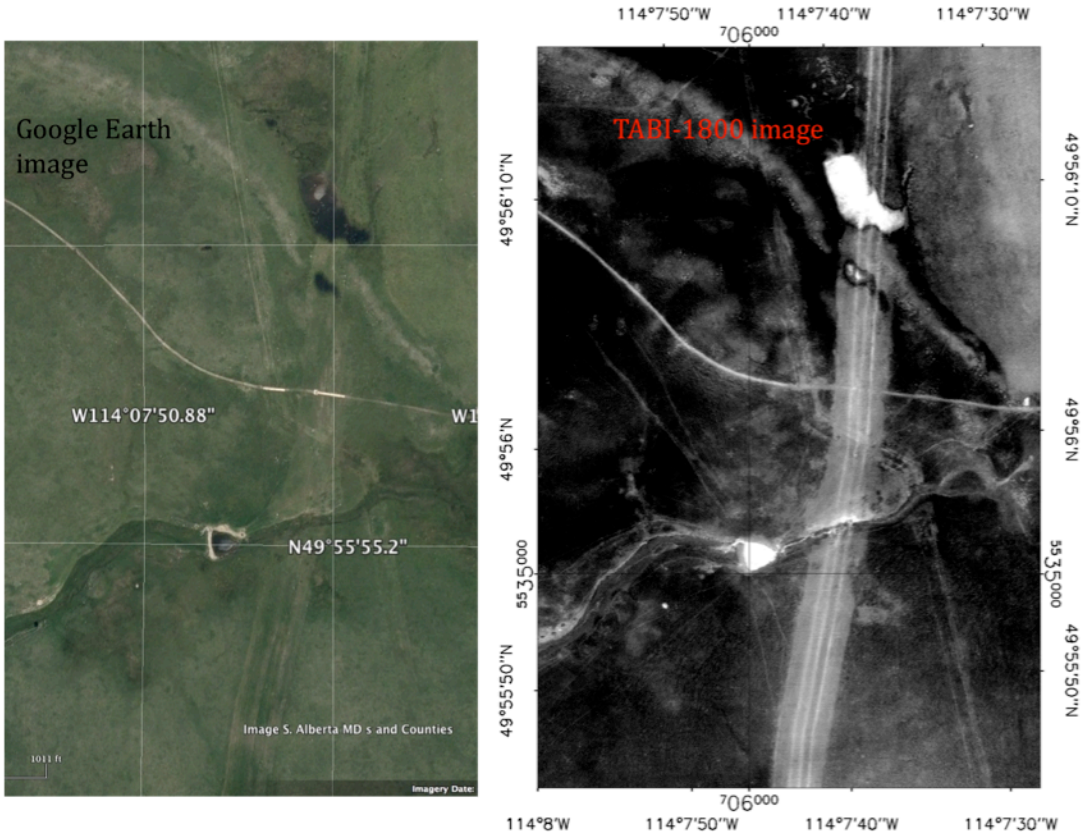

Figure 6: TABI-1800 example 2 of buried pipeline detection - triplet of parallel white lines.

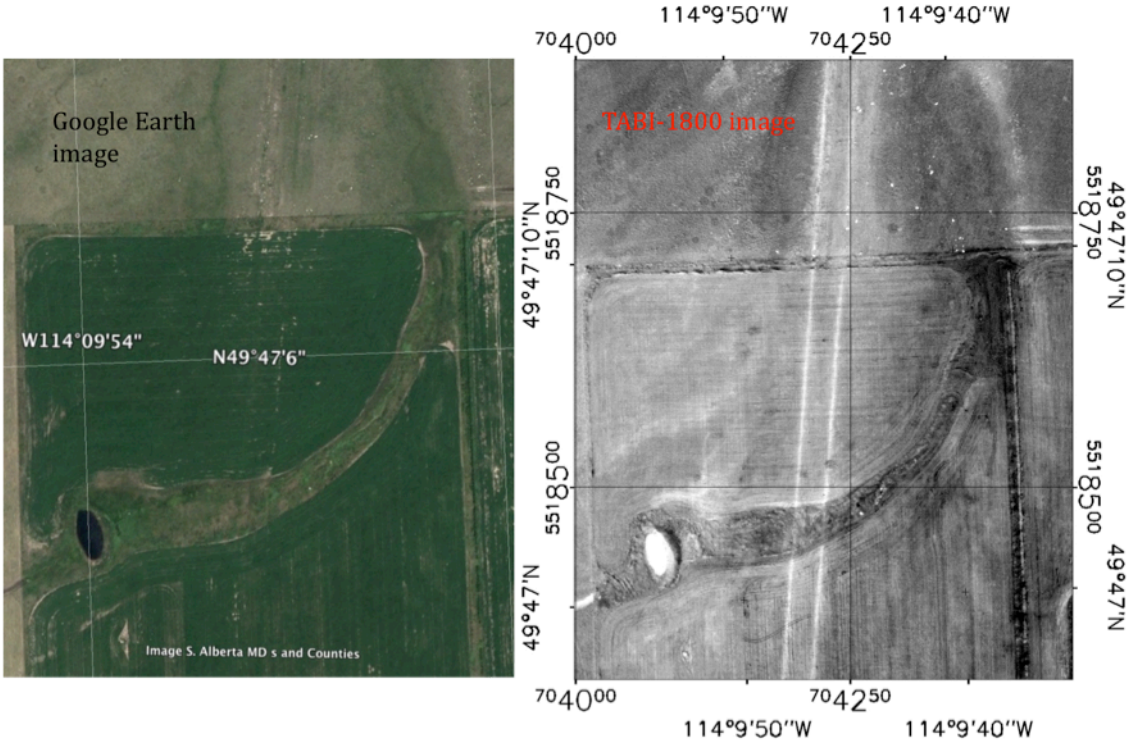

Figure 7: TABI-1800 example 3 of buried pipeline detection - doublet of parallel white lines.