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# High Resolution Stereo Satellite Elevation Mapping Service
# Confirmed Proof of Accuracy
# Case History, Cartosat-1 Stereo Photos, Asmara, Eritrea

## A five-metre square grid of elevations was produced by geophysical processing of Cartosat-1 stereo satellite photos over an area of 1,428 square kilometres.

## The elevation accuracy is better than 1.2m RMSE as determined by 6,768 conventionally established elevation checkpoints.

Gerry Mitchell, P. Geo, Geophysicist, President PhotoSat Information Ltd;

A 5m square grid of elevation values was produced for an area of 1,428 km$^2$ in Asmara Eritrea. The elevation grid was constructed using geophysical processing of 2.5m ground resolution stereo satellite photos taken by the Cartosat-1 satellite on April 18, 2011. The stereo satellite elevations were referenced to the same benchmark as 6,768 previously established accurately surveyed gravity survey stations. The survey check points cover 692 km$^2$ of the 1,428 km$^2$ mapping area.

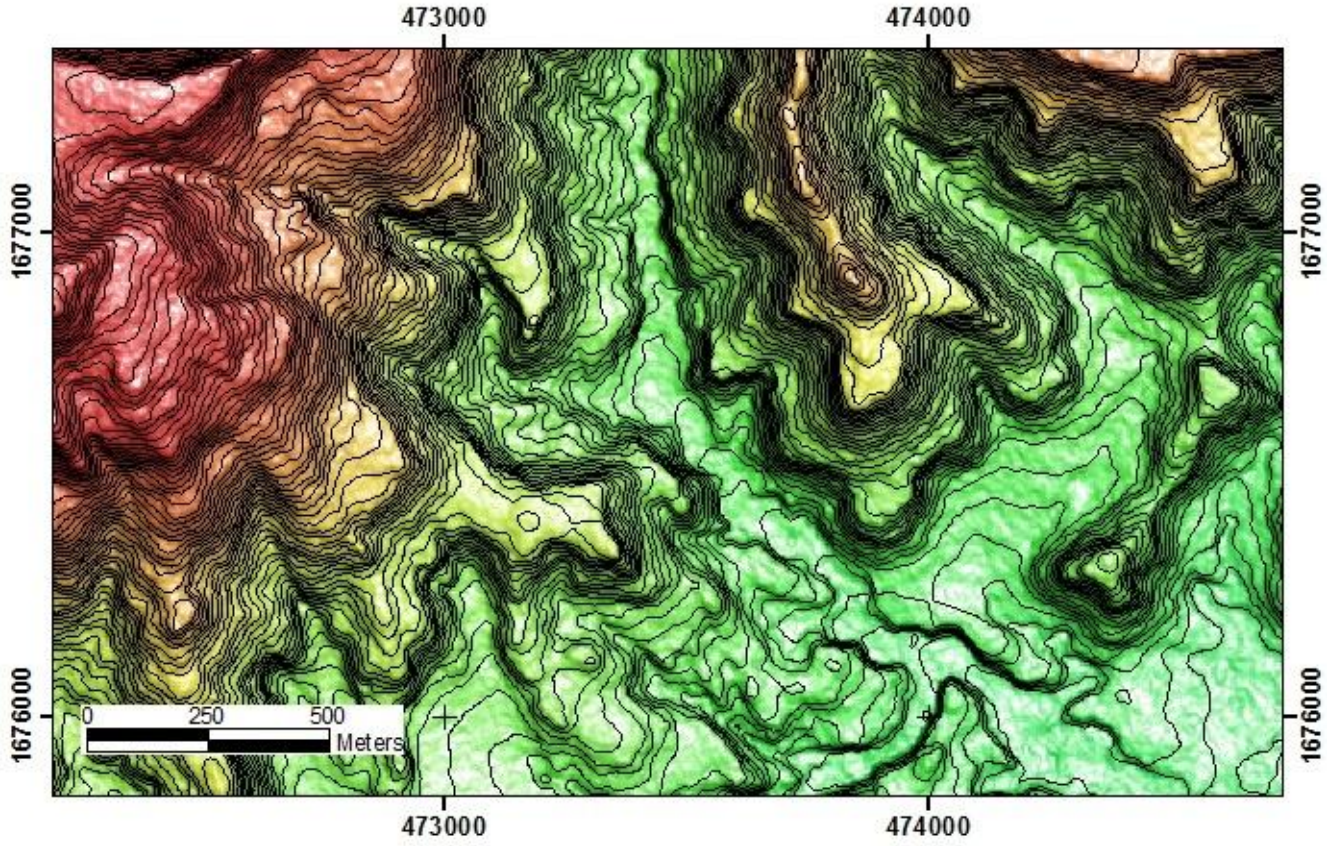


**Figure 1.** Cartosat-1 elevation image with 5m contours from the stereo Cartosat-1 elevation mapping for Asmara Eritrea.

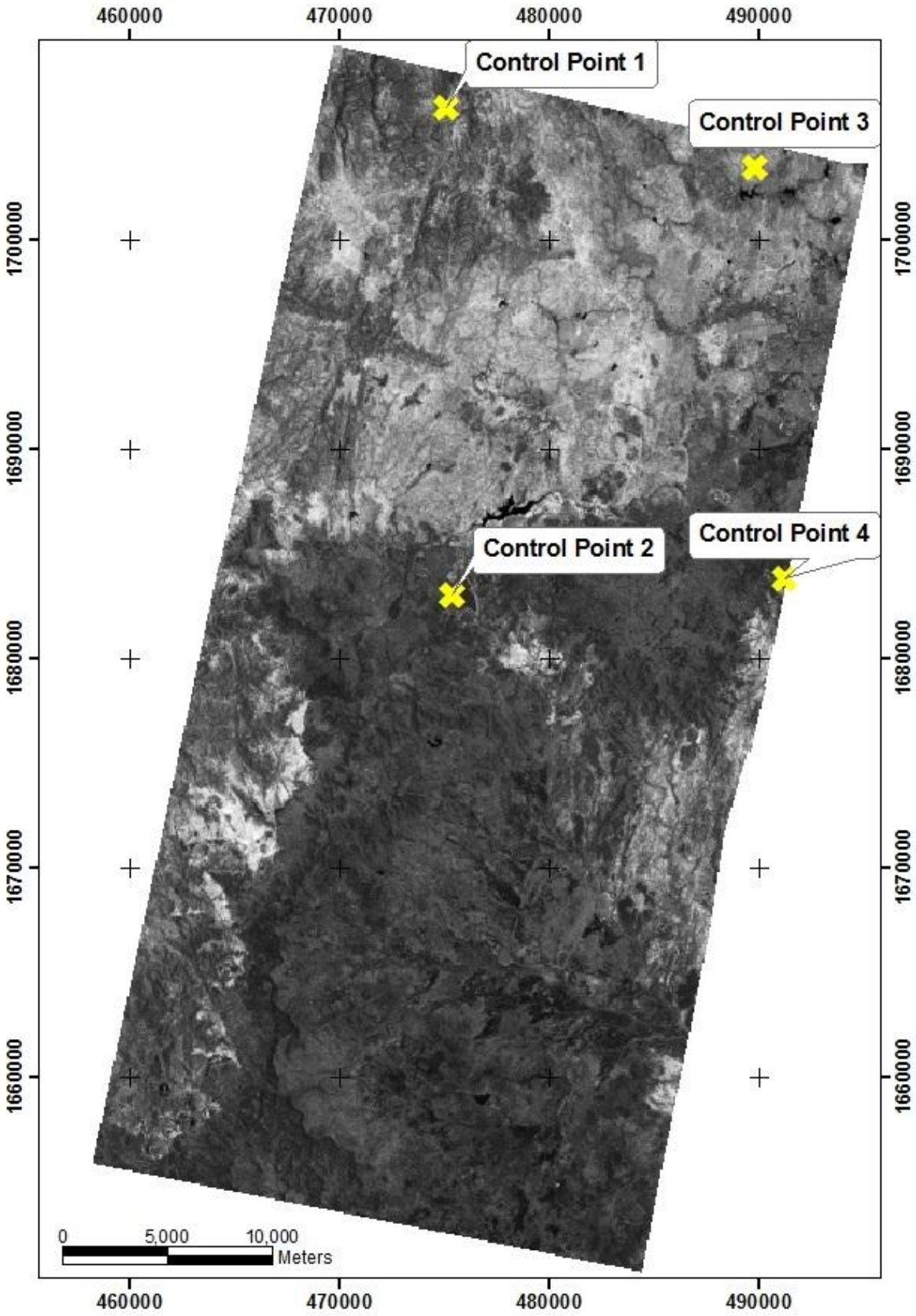


**Figure 2.** 1,428 km$^2$ Cartosat-1, 2.5m stereo satellite photo, Asmara, Eritrea, April 18, 2011, showing the locations of the four ground control points used to reference the elevation mapping.

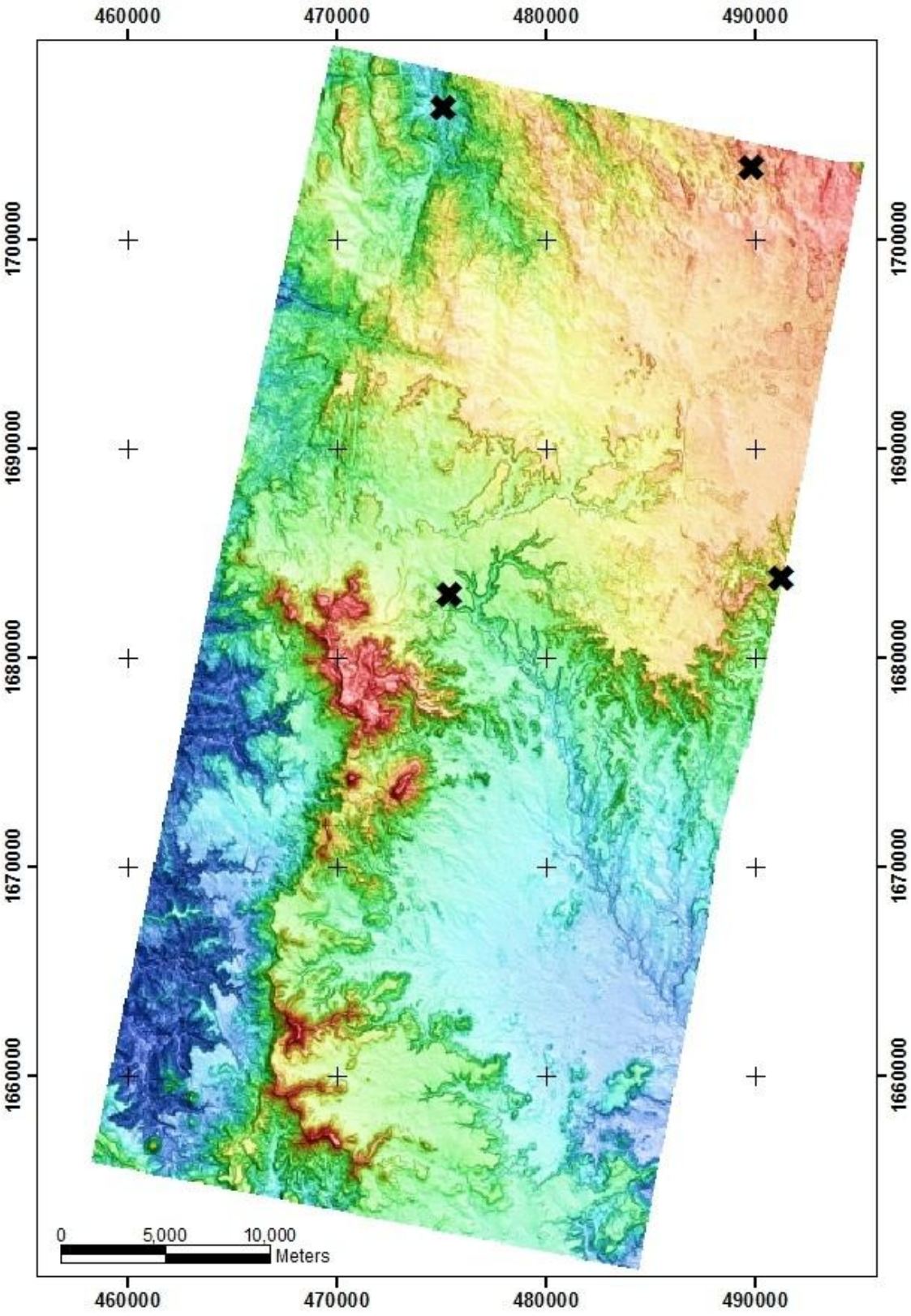


**Figure 3.** 1,428 km$^2$ stereo Cartosat-1 elevation image, Asmara, Eritrea, created from a 5m posted elevation data set. The image shows the four ground control points used to reference the elevation mapping. The elevations range from 1495 m to 2595m.

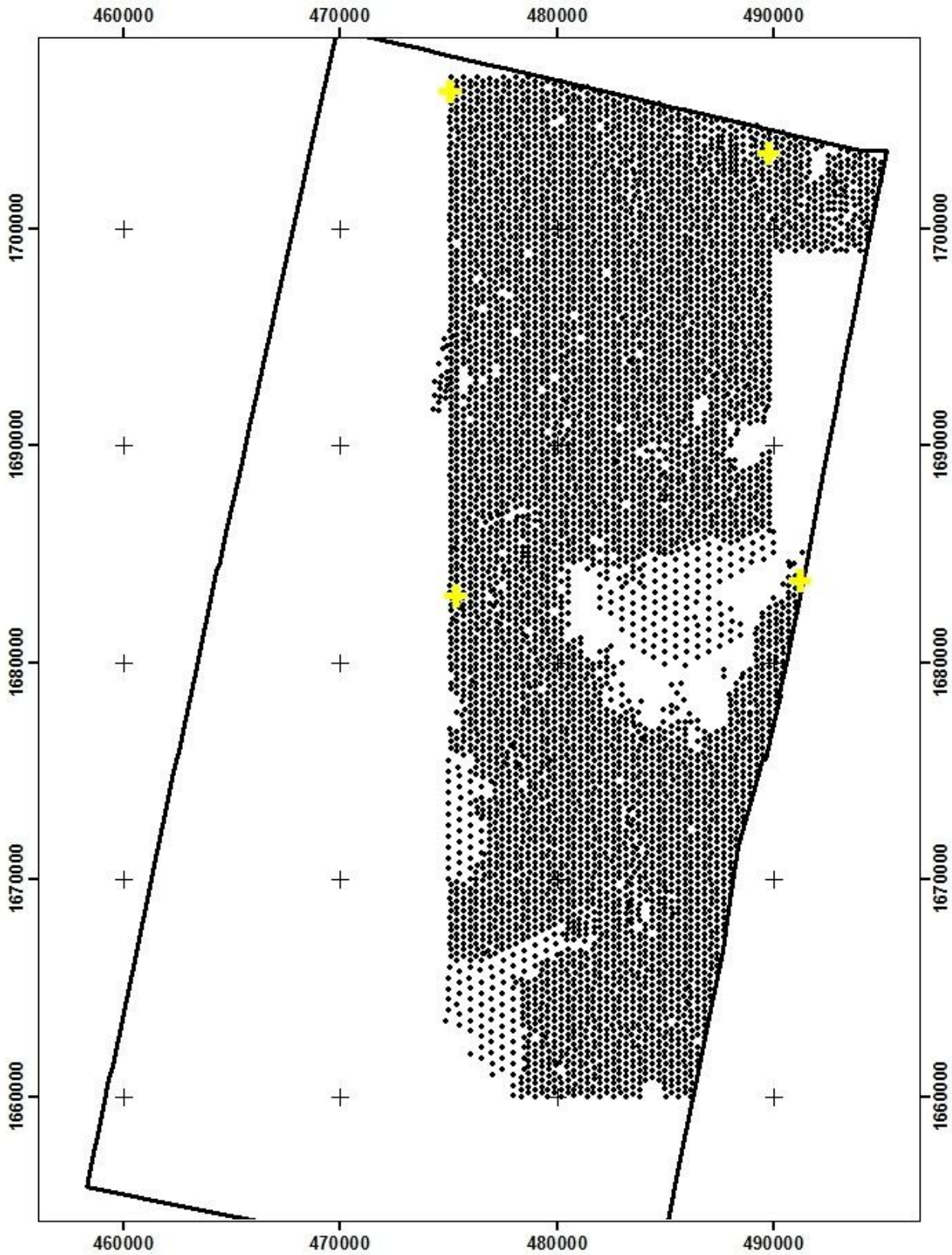


**Figure 4.** Area of the 1,428 km$^2$ area of Eritrea stereo Cartosat-1 5m elevation mapping showing the four ground control points and the 6,768 gravity survey stations used as elevation checkpoints to determine the accuracy of the elevation mapping. The elevation check points cover 692 km$^2$ of the 1,428 km$^2$ mapping area. The survey point elevations range from 1856m to 2448m

**Figure 5**. Asmara Eritrea. MWH Geo-Surveys differential GPS survey crew and equipment. Over 45,000 gravity stations were surveyed from 2004 through 2008 using differential GPS instruments from Magellan. All of the GPS positions were surveyed in Real Time Kinematic (RTK) mode with accuracies of 2 cm or better. 6,768 of these gravity survey stations were used as elevation checkpoints for the Cartosat-1 stereo satellite elevation mapping accuracy assessment. The Magellan RTK base with a ProMark$^{TM}$ 500 GPS rover are shown in this photo.

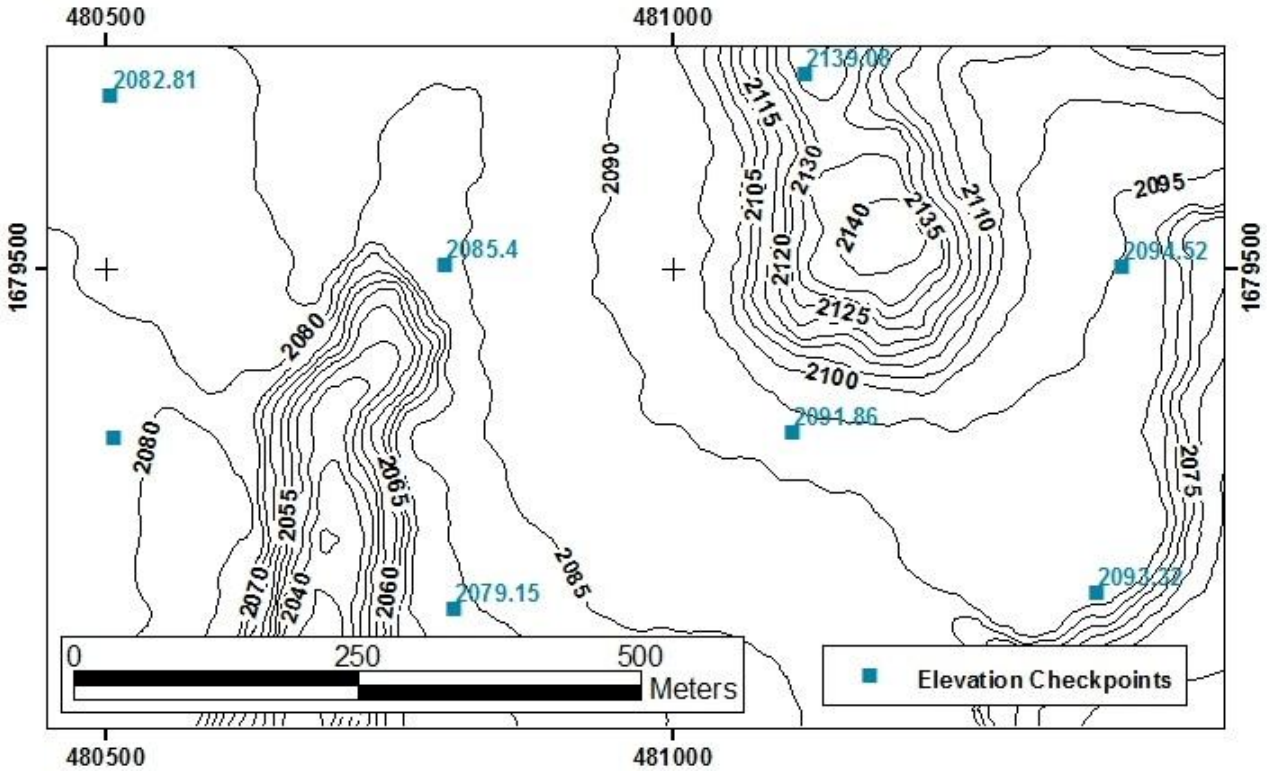


**Figure 6.** 5m contours from the stereo Cartosat-1 elevation mapping showing the elevations of some of the 6,768 elevation checkpoints used to determine the stereo satellite elevation mapping accuracy of better than 1.2m RMSE

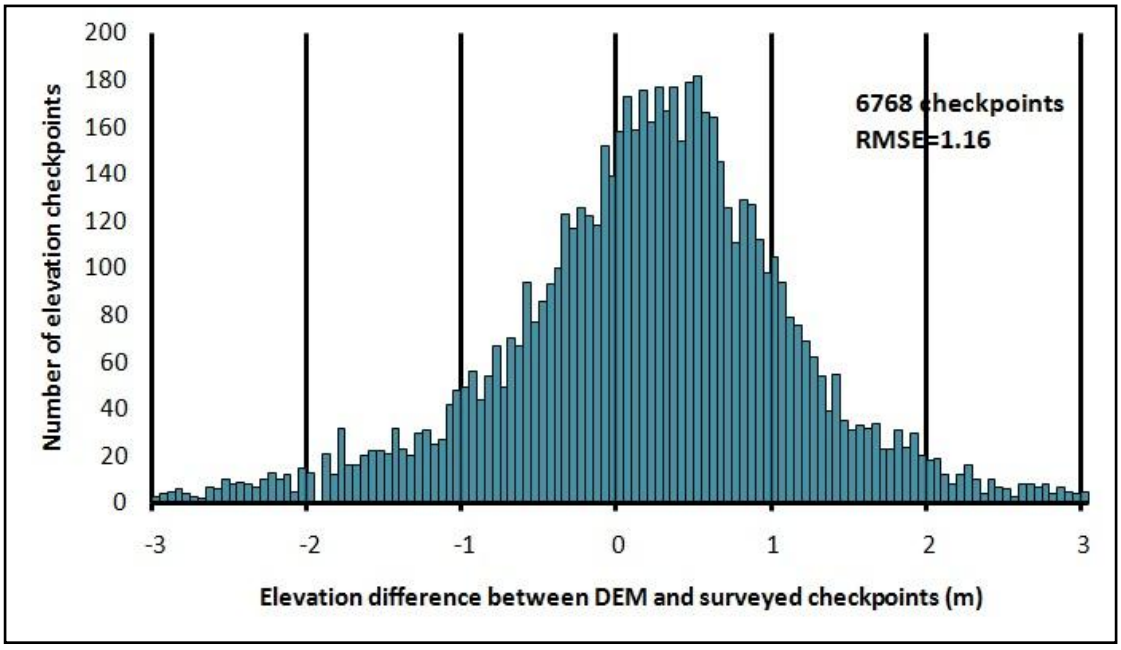


**Figure 7.** Histogram of the elevation differences between the Cartosat-1 stereo satellite elevations (DEM) for the 692km$^2$ surveyed area and the 6,768 elevation checkpoints. RMSE 1.16m

**Ground Control Points:**
We registered the stereo Cartosat-1 ortho photo and elevation data to the four ground survey points shown in figures 2. These four control points have horizontal accuracies of better than 50cm and elevation accuracies of better than 10cm. After registering the stereo Cartosat-1 ortho photo and elevation data to the four ground control points, the elevation differences between the 6,768 independent survey checkpoints and the elevation data has an RMSE of 1.16m. We initially tested the registration of the stereo Cartosat-1 to a single ground reference point. When registered to only a single ground reference points the Cartosat-1 ortho photo had horizontal errors of over 10m and the elevation data had errors of over 5m.

**Cautionary Statement:**
This is an accuracy assessment for elevation mapping using two stereo pairs of Cartosat-1 satellite photos. While we expect that these results will be typical for most Cartosat-1 stereo photos, we cannot yet confirm that these results apply to more than these pairs of stereo photos.

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