Description of Services and Deliverables

Background: Contractor will write software that runs on Google Earth Engine (GEE) that processes Sentinel 1 data and performs change-detection using statistical approaches. Change detection will be validated against independent datasets.

Note: Change-detection refers to the process of identifying differences in the state of physical features of interest by observing them at different times using remote-sensing satellite data.

4.1 Services

The Contractor will provide the services described below together with any additional services requested by Google in writing (including by email) during the SOW Term in order to meet Google's objectives for the Project and to fulfill the Purpose (together the "**Services**").

Software Development.

- The Contractor will produce change-detection software using Sentinel 1 data. This will enable Google to identify areas of the world that have physically changed. ('The **Software**')
- The core functionality of this software will be structured in such a way that for a bounding-box (defined with latitude and longitude) and two time periods (a start time-period and end time-period) change can be detected for a defined location over a defined time-period.

  More technically, this can be structured as a function (See Figure 1 in Attachment A) that takes the parameters *bounding_box*, *start_time*, *end_time* and returns a multiband raster with change-detection information encoded.This function should flexibly handle bounding-boxes that cover combinations of Sentinel-1 tiles (partial tiles, overlapping tiles, tile seams etc). This bounding-box could cover an area as small as 100m x 100m or as large as 100K x 100K.
- This function should provide an indication of the confidence in the change detection and allow the overall sensitivity of the change-detection algorithm to be fine-tuned against validation datasets
- This function should be able to indicate the time-intervals when the change occurred
- The output of this code will be validated against internal Google Maps datasets that may contain proprietary information. These validation datasets will be shared with the contractor but should not be shared externally.
- This code will be documented extensively using Python best-practices.
- The Contractor shall produce a weekly update in the collaboration document outlining progress (doc) and meet with the team at least once a week (or as needed)

4.2 Deliverables

Contractor is responsible for obtaining all necessary permissions, clearances and authorisations in connection with the Services and Deliverables for Google's unrestricted use, including and without limitation, material licenses for all individuals and third party materials incorporated into the Services and Deliverables.

Summary and scope of deliverables. Contractor will provide the deliverables described below together with any additional deliverables requested by Google in writing (including by email) during the SOW Term in order to meet Google's objectives for the Project and to fulfil the Purpose (together the "**Deliverables**").

- The Software - A Custom software code that will enable change detection to be identified using Sentinel-1 data. This statistical approach will run on GEE using libraries that are compatible with the GEE platform and allow commercial use.This code will be written in the Python programming language and can be run on any location throughout the world to detect change.

  This code will be a functional software that meets the criteria outlined above. This will run on test locations of Google's choosing on GEE, meet appropriate benchmarks and will be transferred to Google at the end of this contract.

- Weekly video-conference/meeting with Google to provide an update on the progress of the project with details tracked in a collaboration document (template)
- Weekly updates

4.3 Deliverable Criteria. All materials, images, or other created content (whether in digital form or otherwise) created as part of the Services (excluding Contractor Background IP) will be construed as Deliverables for the purpose of the Agreement.

4. Payment

5.1. Fees	After Google accepts the completed Services and Deliverables, Google will pay Contractor a flat fee of ____
5.2. Maximum Total Cost	Under this SOW, the total aggregate invoiced amount for the Services and Deliverables (including expenses but excluding Taxes) will not exceed the following Maximum Total Cost: XXXX. The parties agree that the Maximum Total Cost does not constitute a minimum volume commitment or spend commitment.
5.3. Expenses	Contractor's expenses are included in the fees in SOW Section 5.1 (Fees). No other expenses will be reimbursed.
5.4. Invoicing	Contractor will invoice Google for Services and Deliverables after Google's acceptance of the Services and Deliverables

5. Resources

Resources	Google will provide the following resources under this SOW, which will remain Google's property (including Intellectual Property): • Access to Google Earth Engine (platform and data), potentially with additional compute and data storage quota • Validation data-sets to measure accuracy of change-detection using publicly available data.

ATTACHMENT A: Pseudocode Illustration

Figure 1: Proposed pseudocode illustrating functionality needed. This code can be viewed as a black-box where we send a set of values and it returns some new values telling us the information that we care about. An example response from this black-box would be "Change has occurred in this lat/lon on X data with Y% confidence.

```
def change_detection(bounding_box, start_time, end_time, {...}):
 """Identify all pixels that have changed within this bounding box during the specified time period

 Args:
  bounding_box: Tuple with lon,lat values
  start_time: time-period in yyyy-mm-dd
  end_time: time-period in yyyy-mm-dd

 Returns:
   Change_dection_raster with an estimate of a time when the change occurred

 """

   // code and associated modules to be provided by contractor

   return change_dection_raster
```