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MONITORING/MAPPING OF TRANSPORT NETWORK

RGB image including roads, vegetation and buildings.

PRODUCT DESCRIPTION

Category

☐ Topographic information	☐ Surface deformation
☐ Impact assessment	☐ Precision ortho-images
☐ Change detection / continuous monitoring	☐ Terrain information
☒ Land cover / use	☐ Water quantity & quality
☐ Near surface geology	

Uses

Exploration – Infrastructural mapping

Environmental Assessment & Permitting – Access to sites

Design, Construction & Operations - site design and layout of infrastructure, baseline mapping of terrain and infrastructure

Challenges addressed

Exploration – Mapping Infrastructure

Development and Operations – Existing Infrastructure

Geo-information needs

E-4 Infrastructural mapping including information on terrain and access/roadways

DO-1 Access to site – national roads/rail etc.

Description

Transport network and road status are essential datasets for logistics planning. As narrow linear features, the detection and extraction of roads and their attributes is a challenging task. The base imagery required is typically high to very high-resolution optical data since such sensors provide the spatial resolution required to detect road features.

Baseline transport network information includes roads and road types (single track, multi-track), railways or railroads including track gauge, ferries as well as airports.

Baseline road status information includes the road surface (e.g. sealed or un-sealed, gravel, dirt) and road size (single-track or multi-track). Other information could include the road elevation gradient (for which elevation data are needed) and/or nature of turns along the road.

Information on transport network and road condition is important during the wet season in tropical countries, where seasonal rains can prevent travel along certain routes. There is a need to identify what natural hazards are in the area that might impact transport infrastructure. In mountainous regions, roads may regularly become impassable due to landslides, especially in areas where roads are former logging roads. River crossings may also be affected. The degree of deterioration of a road surface (pot holes, rutting, etc.) is difficult to detect with current spatial resolution of satellite sensors.

Road condition and status is typically assessed using very high to high resolution optical data. Radar data can be used to detect subsidence and monitor changes over time.

Known restrictions / limitations

Limitations for use of optical and radar sensors include the extraction of road baseline information and status in forested areas where the canopy can prevent visibility of the road surface. In mountainous areas, radar sensors are not likely to perform well because of sensor geometry.

Manual extraction of baseline road geometries may be required to provide accurate results, but is more time consuming and expensive than automatic methods. Management of conflation issues can be time-consuming where multiple data sources result in conflicting road information.

Monitoring roads requires frequent data acquisitions at high spatial resolution and image segmentation algorithms. Along with the linear nature of roads, this can result in high acquisition costs. Cloud cover could also affect optical datasets.

Recent developments use satellite-based observations with information based on open street mapping or machine learning to detect which pixels are road/railway and which are not.

Lifecycle stage and demand

Exploration	Environmental Assessment & Permitting	Design, Construction & Operations	Mine Closure & Aftercare
■■■■	■■	■■■■	

Exploration: Exploration companies need to know how they will access a prospective area. For example, what tracks are there to allow Geologists access, what roads are there to bring in drill rigs. There is a need to identify what natural hazards are in the area that might impact on Health and Safety.

Environmental Assessment & Permitting: It is necessary to understand land usage to understand the baseline condition of the land where mining is planned and to assess what the impact of mining might be and what the rehabilitation criteria might be.

Design, Construction & Operations: In order to develop a mine, it is necessary to access the mine site location with construction equipment, building materials and both mobile and fixed plant components. Assessment of infrastructure that is required to access the site is a critical aspect of planning and executing a mine development. Additional roads as well as modification to existing structures (low bridges etc.) may all need to be completed to allow a mine to be developed.

Infrastructural projects take time to develop and any changes to infrastructure that impact on the development or operation of the mine will therefore take time to be realised. As such, an annual update would be sufficient to detect change and mobilisation works associated with upcoming change.

Geographic coverage

Global coverage

EARSC Thematic Domain

Domain	Built environment
Sub-domain	Infrastructure
Product description	Monitor transport networks

PRODUCT SPECIFICATIONS

Input data sources

Satellite	*SkySat –1/2 Planet Labs*	*WorldDem TerraSAR X*	*Landsat 8*	*Sentinel 2*
Status	In operation	In operation	In operation	In operation
Operator	Planet	Airbus	NASA	EUMETSAT/ ESA
Data availability	Commercial	Commercial	Public	Public
Resolution (m)	0.5 m	12 m	30 m	Depending on sepctral band (10 m-60 m)
Coverage	Global	Global	Global	Global
Frequency (days)	Sub-daily possible		6 days	5 days
Launch year	2013	2010	2013	2015
Website	link	link	link	link

There is not ready-to-use satellite-based product. However it can be made using the different sensors listed before. SkySat-1/2 and TerraSar X may provide the required combination of spatial resolution and temporal frequency. Landsat 8 and Sentinel 2 can possibly be used to detect major roads.

Obligatory supporting data:

- Spatial thematic data (use information)

Supporting data:

- Digital elevation models depending on the need to understand topography in relation the road network. Meaningful elevation and slope data could be extracted from WorldDEM (12 m) and any local high resolution DEMs
- Existing GIS data such as topographic maps, infrastructure, and assets
- Existing land cover information
- Local knowledge

Minimum Mapping Unit (MMU)

The MMU is based on the expected minimum size of the road features to detect. Four meters is a typical single-track road width, although the contribution of road reflectance in coarser imagery usually allows for estimation of the road centerline.

The minimum feature width (MFW) could be as fine as a single-track road with a width less than two meters.

Accuracy / constraints

Thematic accuracy: It is necessary to understand land usage (e.g. livestock, arable crops, forestry etc.) to understand the baseline condition of the land where mining is planned and to assess what the impact of mining might be and what the rehabilitation criteria might be.

Spatial accuracy: The goal would be 1 pixel, but this depends on reference data.

Accuracy assessment approach & quality control measures

Automatic transport network and road status detection and classification should be checked against ground validation data (e.g. GPS data from vehicle or foot travel) and visual interpretation of road surfaces. Ancillary vector data from local or regional government or industrial operations (forestry etc.) are sometimes available.

Stratified random points sampling approach can be performed.

Frequency / timeliness

Observation frequency:

The frequency is constrained by satellite revisit and acquisition timeframes, but also processing requirements. While the minimum frequency is technically driven by the revisit cycle of the satellite, the maximum frequency is defined by the customer. Depending on the requirements of the customer the most suitable satellite sensor has to be selected, considering spatial / spectral resolution as well as revisit frequency. Most of the time, long-term changes are detected in 2 years or longer intervals (frequency can be lower depending on demand). Baseline road mapping is a one-time process. Monitoring of changes in road status is typically performed on an annual basis. Daily change detection may be required during seasonal flooding or in emergency situations, if possible.

Timeliness of delivery:

Baseline data will depend on the availability of recently archived imagery or new image tasking. Processing is not challenging and products can be available in 1 week to 1 month depending on project size. Manual road extraction can be more time consuming and depends of many factors (area, designed accuracy and level of detail). Change detection and updates to validated road networks can be performed quickly.

Emergency assessment of road conditions can be completed in near real time (< 24 hours) depending on the established processing chain for the project and availability of base images.

Availability

On-demand availability from commercial suppliers.

New acquisitions can be requested globally.

Archived products availability may be limited for specific dates and locations.

Delivery / output format

Data type:

- Vector formats
- Raster formats (depending on customer needs)

File format:

- Geotiff or shapefile (standard - any other OGC standard file formats)

USE CASE

Detection of road infrastructure using remote sensing images is possible using several methods and is a research topic. Several methodologies have been compared and concluded was that there was not a single method most suitable and that several methods should be combined according to real applications (Wang, 2016).