# I C E Y E

## DARK VESSEL DETECTION

PRODUCT SPECIFICATION

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www.ICEYE.com

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### 1. INTRODUCTION

#### INTRODUCTION

ICEYE SAR Satellite Constellation provides commercial access to timely and reliable Earth observation data. This document is intended to describe the specification for our Dark Vessel Detection product. With its increase of operational satellites, ICEYE is actively working on refining our solution offerings. This Early Data Access document contains parameters that will be updated as our products evolve, and we receive valuable customer feedback. Questions and/or comments on this documentation or how to order an ICEYE product should be directed to our Customer Success or Sales team.

#### 1.1 SCOPE

This document defines the service and format specifications of the Dark Vessel Detection product which is part of a set of derived products generated from the ICEYE SAR constellation. The output is delivered in a vector format which guarantees better accessibility and easy manipulation for the end-user.

#### 1.2 DISCLAIMER

The materials presented in this document are for informational use purposes only. The products and services it describes are subject to change without prior notice. ICEYE makes no representations or warranties with respect to this product specification or with respect to the products or services described herein. ICEYE shall not be liable for any damages, losses, costs or expenses, whether direct, indirect or incidental, consequential or special, arising out of, or related to the use of this material or the products or services described herein.

#### 1.3 ACRONYM LIST

#### INTRODUCTION

AIS Automatic Identification System AOI Area of Interest Constant False Alarm Rate CFAR EGM Earth Gravitational Model GRD Ground Range Detected IMO International Maritime Organisation MMSI Maritime Mobile Service Identity SAR Synthetic-Aperture Radar SLC Single Look Complex Vessel Monitoring System VMS

## 2. DARK VESSEL DETECTION PRODUCT RATIONALE

#### DARK VESSEL DETECTION PRODUCT RATIONALE

Detect vessels invisible to AIS for prevention of illegal fishing, controlling drug and arms, security control, monitoring trafficking, and embargo monitoring.

The ICEYE Dark Vessel Detection product uses high-resolution X-band microsatellite SAR data and Satellite/Terrestrial AIS to identify non-collaborative targets at sea. The product integrates AIS messages from both Spire and Orbcomm satellite constellations to increase the chance of message reception. Vessels are detected in a SAR acquisition and correlated against AIS data to identify Verified Targets (Correlated) and Dark Targets (Not-Correlated).

Target locations are geocoded using a reference Earth Gravitational Model (EGM) which approximates the altitude of the sea-surface. A buffered land mask is used to prevent false detections near the coastline.

#### VESSEL TYPES IN ICEYE SAR DATA

**Fishing vessel** 

Tanker

Cargo, Bulk Carrier

Platform





DARK VESSEL DETECTION PRODUCT RATIONALE

#### DELIVERED INFORMATION

The delivery is comprised of two files, in Google Earth KMZ format: 1) SAR acquisition Extent and 2) information about the Targets detected within the SAR acquisition and correlated with AIS. The image below gives an overview of the standard product delivery package.





- Verified AIS Matched Target
- SAR Acquisition Extent

#### DETECTED VESSEL INFORMATION



## 3. PRODUCT SPECIFICATION

#### PRODUCT SPECIFICATION

#### VESSEL DETECTION ALGORITHM

Vessels have a high radar reflectivity and appear as bright targets in SAR imagery. Smooth seas cause specular reflection, so most of the energy from the radar is reflected directly away from the sensor. The resulting effect is that the difference in brightness between vessels and the sea surface is usually extremely large. The effect of wind and other phenomena on the sea surface causes variations in brightness which is referred to as sea clutter.

The vessel detection is based on an adaptive threshold algorithm - CFAR (Constant False Alarm Rate). The CFAR vessel detection involves estimating the distribution of the local background sea clutter to calculate a local threshold. A set of pixels which are brighter than the local threshold are marked as a target.

#### VALIDATION BY AN ANALYST

During the process of validation, a trained Analyst reviews the output of the automatic Vessel Detection algorithm. The Analyst inspects each target at the resolution of the original product and removes false positives detections which have arisen from ambiguities or other phenomena such as unmasked islands, coastlines or metocean features.

All ICEYE SAR images undergo a Quality Control process (QC) prior to Vessel Detection.

#### DETECTION ACCURACY

The vessel detection algorithm is tuned to have a high Recall (Detection Rate). A buffered land mask is used to mask out coastlines to reduce false alarms. Each product is validated by an Analyst before delivery which includes a process to remove False Positives. PRODUCT SPECIFICATION

#### GEOLOCATION ACCURACY

Each target is geocoded using a range-doppler algorithm under the assumption that the sea surface follows the EGM96 Geoid. This gives a high geolocation accuracy with typical geolocation errors within 20 meters. This assumption ignores tides and other causes of sea surface topography.

#### SATELLITE AND TERRESTRIAL AIS DATA SOURCE

Spire and Luxspace provide Satellite and Terrestrial AIS to ICEYE for this service. Data from two satellite AIS constellations is used to provide exceptional coverage and the highest chance of AIS message reception. AIS data is fetched from 2 hours before and after acquisition before being interpolated to estimate the position of each vessel at time of imaging. Each detected target is subsequently matched against these interpolated positions to identify whether it is dark or collaborative.

#### SMALL TARGETS

The ICEYE Dark Vessel Detection product has successfully detected vessels confirmed by AIS as small as 9x20m and targets as small as 3m. An algorithm is under development to be able to locate small fast-moving vessels through detection of wakes visible on the sea surface.

#### IMAGING MODES

Dark Vessel Detection currently supports Stripmap imaging mode and ScanSAR imaging mode is under development. Currently the max length of images for Dark Vessel Detection is 200km.

<sup>&</sup>lt;sup>1)</sup> The NASA GSFC and NIMA Joint Geopotential Model https://cddis.nasa.gov/926/egm96/egm96.html

## 4. FORMAT SPECIFICATION

FORMAT SPECIFICATION

#### 4.1 PRODUCT DELIVERY PACKAGE

Two derived KMZ (Keyhole Markup Language Zipped) files will be delivered for the Dark Vessel Detection Product. The SAR Data Package is an addon. Custom delivery formats and custom integrations are possible through separate projects.

#### SAR Targets KMZ

- Contents: Location of each Target with associated AIS fields when available.
- Each Verified Target (where there is an AIS match) is identified using its Maritime Mobile Service Identity (MMSI) and typically includes information like name of vessel, IMO number, country, type of vessel, length, speed, heading
- Each dark target is located using latitude, longtitude, and a timestamp
- Image chip (PNG) for every vessel for visual analysis 500x500px
- Naming convention: <Date of acquisition YYYYMMDD>\_<Acquisition ID>\_targets\_correlated.kmz
- Filename example: 20190816\_7981\_targets\_correlated.kmz
- File structure: The KMZ zip file is formed of two components: 1) A Targets KML and 2) an "image\_chips" folder. Each Target in the KML is associated with a PNG chip for visual analysis

#### SAR Extent KMZ

- **Contents:** Polygon of SAR acquisition extent.
- Naming convention: <Date of acquisition YYYYMMDD>\_<Acquisition ID>\_extents.kmz
- Filename example: 20190816\_7981\_extents.kmz
- File structure: The KMZ zip file contains a KML with the extent polygon that indicates the area of the SAR image

## 4.2 KMZ PRODUCT ANNOTATION - VERIFIED TARGET (CORRELATED)

#### FORMAT SPECIFICATION

| FIELD<br>NAME | ТҮРЕ                       | UNIT               | DESCRIPTION  | VALUE EXAMPLE       |
|---------------|----------------------------|--------------------|--|---------------------|
| Point_ID      | Int                        | -                  | Unique Identifier  | 1                   |
| UTC           | String UTC                 | -                  | Time of Acquisition, Mid point                                 | 2019-01-21T18:28:00 |
| DetectConf    | -                          | -                  | Currently Unavailable  | -                   |
| Latitude      | Float, 6 decimal<br>places | Decimal<br>Degrees | Target geographic location                                     | 52.000000           |
| Longitude     | Float, 6 decimal<br>places | Decimal<br>Degrees | Target geographic location                                     | 1.000000            |
| Length        | Float                      | Metres             | Length of target estimated from<br>SAR                         | 90.0                |
| Width         | Float                      | Metres             | Width of target estimated from SAR                             | 30.0                |
| Heading       | Float                      | Metres             | Heading of target estimated from<br>SAR with ambiguity of 180° | 179.0               |
| Pol           | String                     | -                  | Polarisation of SAR sensor                                     | VV                  |
| Beam          | String                     | Degrees            | Incident Angle range, Near to Far                              | 26.0-28.0           |
| MMSI          | Int                        | -                  | Maritime Mobile Service Identity                               | 235017045           |
| IMO           | Int                        | -                  | International Maritime<br>Organisation number                  | 9160592             |
| ShipName      | String                     | -                  | Vessel Name from AIS   | HMS ALBION          |
| CallSign      | String                     | -                  | Vessel Call Sign from AIS                                      | GDIU                |

#### FORMAT SPECIFICATION

| SoG         | Float      | Knots   | Speed over Ground from AIS             | 4.1                       |
|-------------|------------|---------|--|---------------------------|
| CoG         | Float      | Degrees | Course over Ground from AIS            | 320.1                     |
| LengthAIS   | Float      | Metres  | Vessel Length from AIS                 | 120.1                     |
| WidthAIS    | Float      | Metres  | Vessel Width from AIS                  | 32.3                      |
| HeadingAIS  | Float      | Degrees | Vessel Heading from AIS                | 340.0                     |
| Туре        | String     | -       | Ship/vessel Type from AIS              | Cargo                     |
| Status      | String     | -       | Navigational Status from AIS           | Under way using<br>engine |
| ETA         | String UTC | -       | Estimated Time of Arrival from AIS     | 2019-01-21T18:28:00       |
| Destination | String     | -       | Destination from AIS                   | HELSINKI                  |
| Confidence  | String     | -       | Confidence of AIS match with<br>Target | HIGH, MEDIUM or<br>LOW    |

#### 4.2 KMZ PRODUCT ANNOTATION - DARK TARGET (NOT CORRELATED)

#### FORMAT SPECIFICATION

| FIELD<br>NAME | ТҮРЕ                       | UNIT               | DESCRIPTION  | VALUE EXAMPLE       |
|---------------|----------------------------|--------------------|--|---------------------|
| Point_ID      | Int                        | -                  | Unique Identifier  | 1                   |
| UTC           | String UTC                 | -                  | Time of Acquisition, Mid point                                 | 2019-01-21T18:28:00 |
| DetectConf    | -                          | -                  | Currently Unavailable  | -                   |
| Latitude      | Float, 6 decimal<br>places | Decimal<br>Degrees | Target geographic location                                     | 52.000000           |
| Longitude     | Float, 6 decimal<br>places | Decimal<br>Degrees | Target geographic location                                     | 1.000000            |
| Length        | Float                      | Metres             | Length of target estimated from<br>SAR                         | 90.0                |
| Width         | Float                      | Metres             | Width of target estimated from SAR                             | 30.0                |
| Heading       | Float                      | Metres             | Heading of target estimated from<br>SAR with ambiguity of 180° | 179.0               |
| Pol           | String                     | -                  | Polarisation of SAR sensor                                     | VV                  |
| Beam          | String                     | Degrees            | Incidence Angle range, Near to Far                             | 26.0-28.0           |

## 5. ORDER PROCESS

ORDER PROCESS

Dark vessel detection service can be ordered in two different ways:

- 1. As an **Add-on Service** to SAR imagery previously bought by the customer
- 2. As a Persistent Monitoring Service where a specific monitoring area and monitoring frequency is agreed upon

The Add-on service can be selected during the process of ordering the SAR product, as specified in the ICEYE SAR Product Guide. Orders should be placed by contacting the Customer Success team.

The order process for the Persistent Monitoring Service is defined during setup of the service. Typically one or several areas (AOIs) that should be monitored are agreed upon, as well as the monitoring frequency. E.g. Monitor Area 1 (100x300km) on a daily basis, or Area 2 (30x50 km) weekly.

ICEYE plans the monitoring scheme on a weekly basis and communicates monitoring time and areas the week beforehand, e.g. on Friday, the next week's monitoring plan is communicated to the customer. Changes to the overall monitoring scheme can be requested by the customer 2 weeks in advance.

For more information about the Order Process, please download the SAR Product Guide at <u>www.ICEYE.com</u>.



## 6. CUSTOMER SUCCESS TEAM

CUSTOMER SUCCESS TEAM Customer Success (CS) team is a department of ICEYE in charge of the order processing and support of the Customer Organizations. Customer Success staff who interacts directly with the customer are called Customer Success Specialists. The scope of responsibilities of the CS Specialist are:

- 1. Customer onboarding and training
- 2. Customer order management
- Receiving order
- Confirming order
- Processing order
- Running products through the Quality Control Process
- Order delivery
- 3. Customer Communications regarding any issues within the framework of the current contract
- 4. Customer Feedback management
- 5. Improvement of the existing processes in order to improve overall customer experience

#### Working hours

The Customer Success team is available from 7.30 am to 8.00 pm CET on Polish workdays. The availability of the Customer Success team may change in the future according to the customers needs. Additionally, there is a 24/7 on-call support.

#### **Contact information**

The customer can reach out to the Customer Success team via email <u>customer@iceye.com</u>.

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