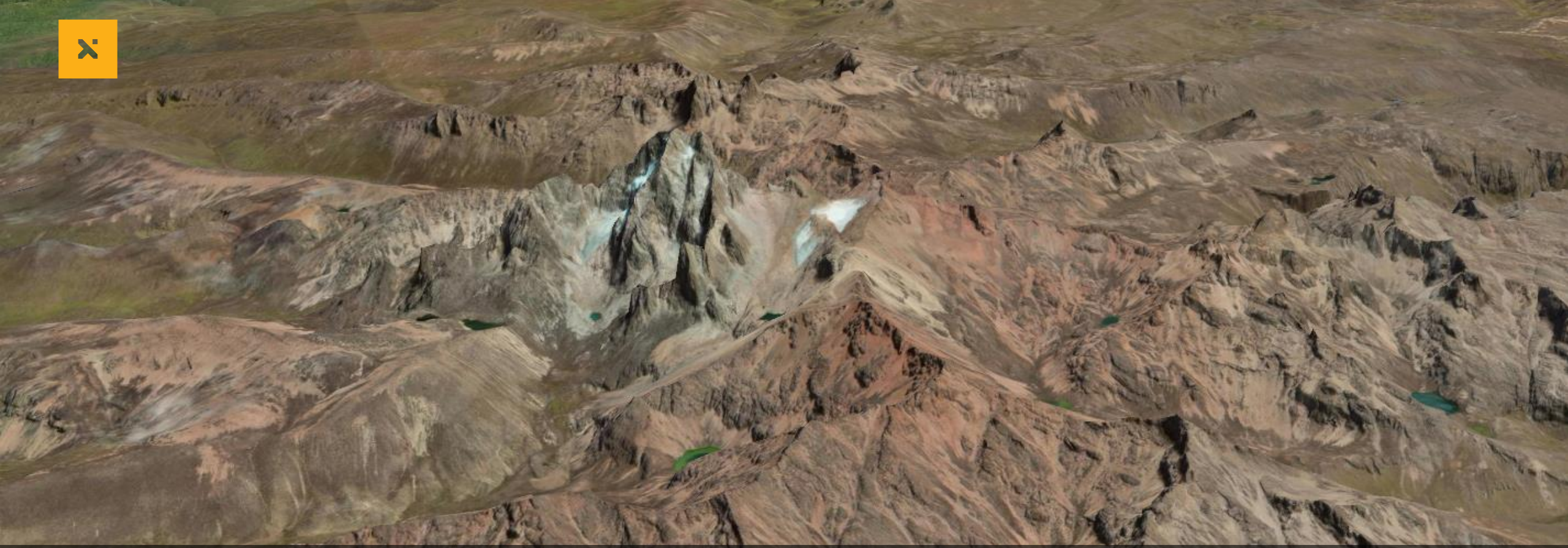


NASA Commercial Smallsat Data Acquisition (CSDA) Program

Vendor Focus – Maxar Intelligence

October 23, 2024

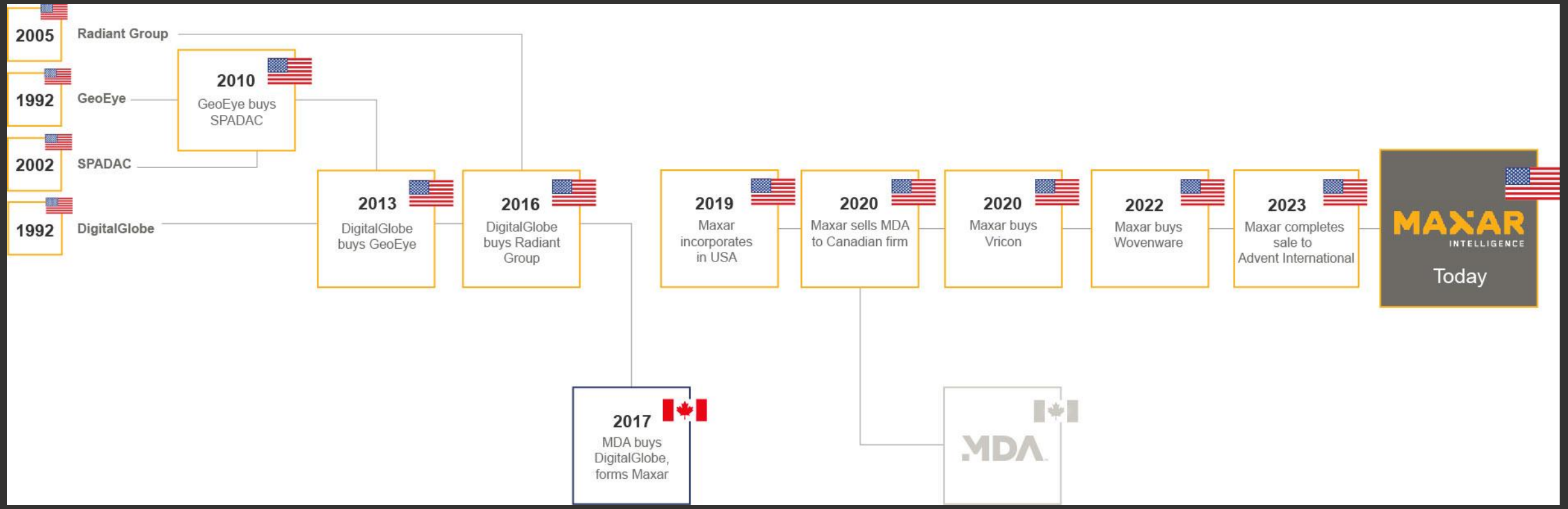
MAXAR INTELLIGENCE

Who we are

Maxar Intelligence is a leading provider of secure, precise geospatial insights.

- We use the power of very high-resolution satellite imagery and software technology to drive mission success on Earth and in space.
- Our secure, increasingly AI-powered products and services deliver ground truth in near real-time to advance earth science research, keep nations safe, improve navigation, speed up disaster response and more.

Maxar history



MAXAR INTELLIGENCE

Maxar is pushing forward the industry we helped create

Decades of deep mission expertise

- World's most capable commercial Earth imaging constellation
- World's most advanced, trusted geospatial foundation built on 125+ PB of data collected over 20 years
- Trusted provider of geospatial insights to the U.S. and allied governments for more than 20 years

Building an intelligent future

- Investing in advanced geospatial computation platform (AI/ML) and next-gen ground systems
- Expanding our constellation to include 3x more 30 cm capacity and synthetic aperture radar
- Competitive advantage in 2D/3D accuracy and quality, georegistration and security
- Best-in-class talent, including leaders with heritage from Palantir, Google, Meta

Our partners

U.S. Government

- Trusted provider of geospatial products and services to the U.S. government for 20+ years
- Provide 90% of the government's foundational intelligence
- 400,000 analysts, warfighters and first responders rely on Maxar data
- Support many of the most innovative geospatial programs, including EOCL, GEGD, OneWorld Terrain and Project Maven

International Government

- Serve dozens of U.S. allies across six continents
- Customers include federal, state and local agencies across the defense and civil sectors
- Provide multi-domain, multi-force operations to support defense and intelligence, maritime security, national mapping, census and environmental monitoring missions

Enterprise

- Leading provider of high-resolution data for the world's most popular navigation and location-based services
- Partner with major telecom companies to support infrastructure planning and 5G rollouts
- Enable infrastructure monitoring and planning to improve operations across the energy/utilities sectors

Maxar history supporting NASA research

Deciphering the Precision of Stereo IKONOS Canopy Height Models for US Forests with G-LiHT Airborne LiDAR

by **Christopher S. R. Neigh** [1,*], **Jeffrey G. Masek** [1], **Paul Bourget** [2], **Bruce Cook** [1], **Chengquan Huang** [3], **Khaldoun Rishmawi** [3] and **Feng Zhao** [3]

[1] Biospheric Sciences Laboratory, Code 618, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[2] Geography-Anthropology Program, Muskie School of Public Service, University of Southern Maine, P.O. Box 9300, Portland, ME 04104, USA
[3] Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA
* Author to whom correspondence should be addressed.

Remote Sens. **2014**, *6*(3), 1762-1782; **https://doi.org/10.3390/rs6031762**

ELSEVIER

Remote Sensing of Environment
Volume 191, 15 March 2017, Pages 95-109

Using high spatial resolution satellite imagery to map forest burn severity across spatial scales in a Pine Barrens ecosystem

Ran Meng [a], Jin Wu [a], Kathy L. Schwager [b], Feng Zhao [c], Philip E. Dennison [d], Bruce D. Cook [e], Kristen Brewster [a,f], Timothy M. Green [b], Shawn P. Serbin [a]

ELSEVIER

Remote Sensing of Environment
Volume 210, 1 June 2018, Pages 282-296

Measuring short-term post-fire forest recovery across a burn severity gradient in a mixed pine-oak forest using multi-sensor remote sensing techniques

ELSEVIER

Remote Sensing of Environment
Volume 284, January 2023, 113332

Optimizing WorldView-2, -3 cloud masking using machine learning approaches

J.A. Caraballo-Vega [a], M.L. Carroll [a], C.S.R. Neigh [b], M. Wooten [b], B. Lee [c], A. Weis [b], M. Aronne [a], W.G. Alemu [b], Z. Williams [a]

ELSEVIER

Science of Remote Sensing
Volume 7, June 2023, 100092

Detection and mapping of artillery craters with very high spatial resolution satellite imagery and deep learning

Erik C. Duncan [a,b,1], Sergii Skakun [a,c,1], Ankit Kariryaa [b,d], Alexander V. Prishchepov [b,1]

ELSEVIER

Remote Sensing of Environment
Volume 212, June 2018, Pages 8-20

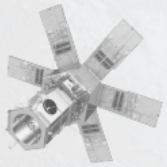
Smallholder crop area mapped with wall-to-wall WorldView sub-meter panchromatic image texture: A test case for Tigray, Ethiopia

We operate the world's most advanced Earth imaging constellation

RETIRED / IMAGERY AVAILABLE IN ARCHIVE

IKONOS
80 cm-class resolution

QUICKBIRD
60 cm-class resolution



WorldView-4
30 cm-class resolution

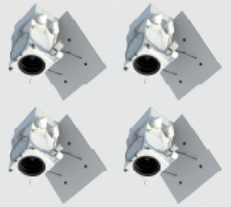
ON-ORBIT / NEW AND ARCHIVE IMAGERY AVAILABLE

WorldView-1
50 cm-class resolution

GeoEye-1
40 cm-class resolution

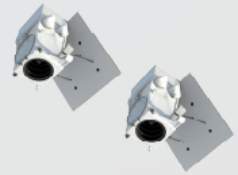
WorldView-2
40 cm-class resolution

WorldView-3
30 cm-class resolution



WorldView Legion
30 cm-class resolution

IN PRODUCTION



WorldView Legion
30 cm-class resolution

Maxar has more 30 cm-class collection capacity on orbit than any other commercial imagery provider.

3.8M+
Sq km of Earth imagery capacity each day

1.4B
Sq km of Earth imagery capacity each year

Today

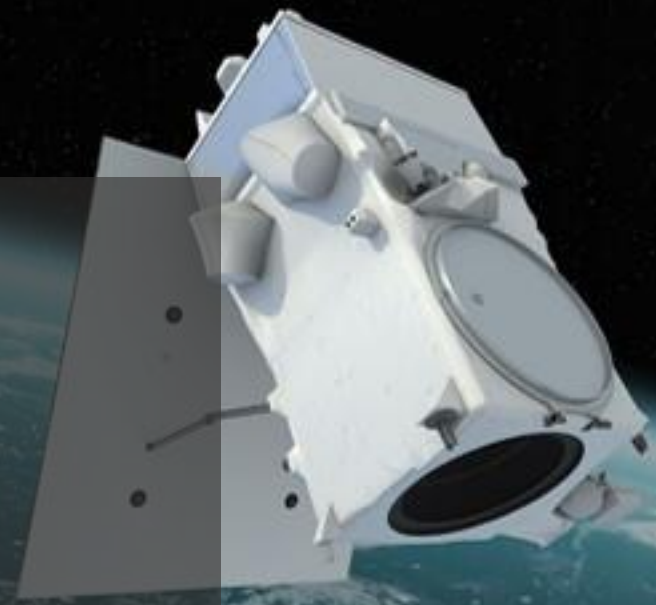
6M+
Sq km of Earth imagery capacity each day

Up to 12x
Revisits per day for some locations

Mid-2025

WorldView Legion further expands our industry-leading capabilities

WorldView Legion™ is a fleet of six high-performing satellites that dramatically expands our ability to revisit the most rapidly changing areas on Earth, enabling more near-time insights.



More high-resolution capacity

- Triples our 30 cm-class capacity
- Collecting 6M+ sq km per day by mid-2025
- Increased daily point target collection capacity

High revisit rates

- Will enable our constellation to revisit some areas up to 12x per day
- Mean-Time to Access will improve to less than 4 hours

"Dawn-to-dusk" collection

- Can collect imagery across more varied times of day

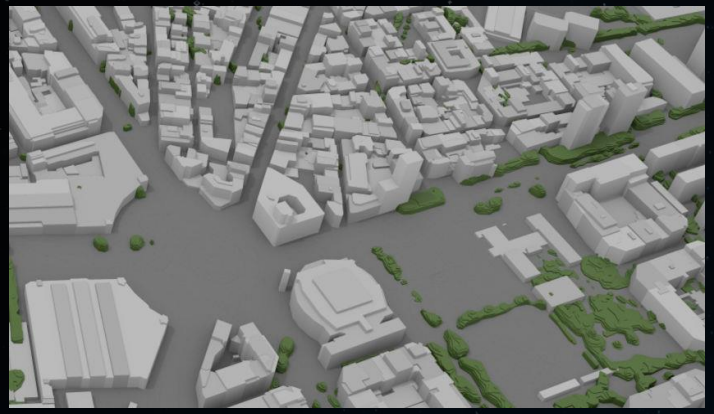
Highest geometric accuracy

- Maintains our ability to offer the highest accuracy available today

→ Future innovation considerations for WorldView Legions 7 & 8

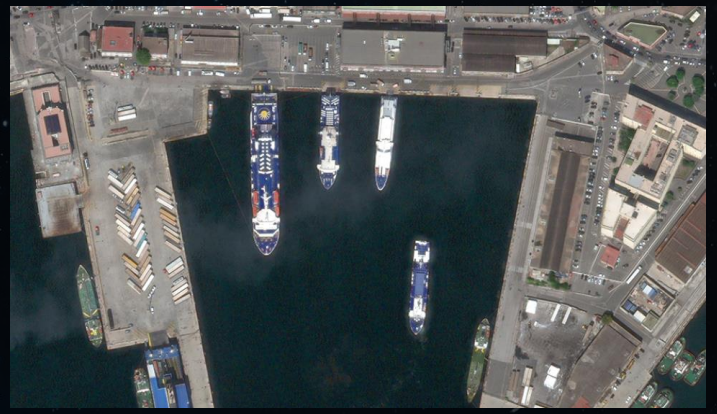
- **Capacity/capability:** CMGs, sensor line rate, focal plan width, on-board image processing and ATR
- **Comms:** WBTX Vendor Study, real-time TT&C, mesh network laser comms
- **Resilience and performance:** Power margin, optical filtering, GPSR updates, NEI tasking

Our core products and capabilities



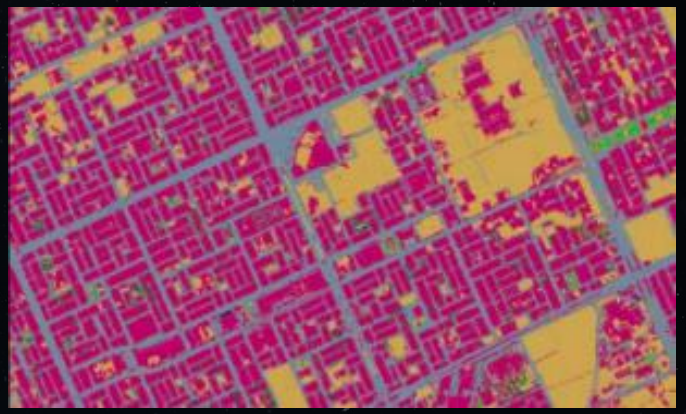
Information

- Best-in-class geospatial foundation and first-of-a-kind 2D + 3D products
- Space domain awareness products



Access

- Maxar Geospatial Platform Pro (MGP Pro)
- Tasking (RAP, DAP, SAR)



Analytics

- Change monitoring
- Thematic layers
- Crow's Nest maritime monitoring
- Automated imagery exploitation

Key Capabilities

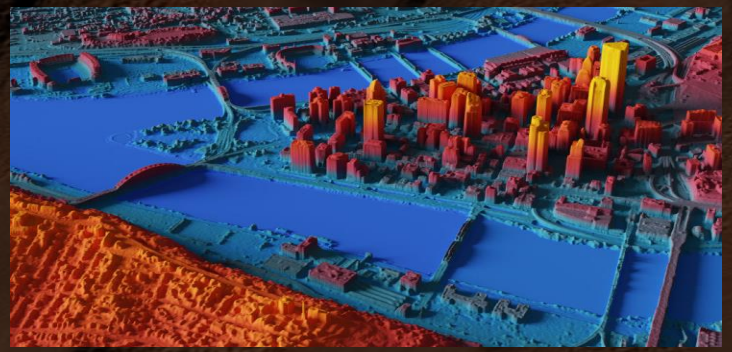
Virtual constellation | Secure and resilient systems | Geospatial computation platform | Artificial intelligence & machine learning

Deep dive: Information products

2D: Highest-quality satellite imagery

Optical imagery
- Native 30 cm resolution and derived 15 cm HD imagery
- < 5 m CE90 positional accuracy
- Multispectral diversity
- Analysis-ready data

Imagery basemaps
- Stunning, virtually seamless
- Accurate, consistent and actionable
- Local and global scale



3D: Most accurate representation of Earth

Precision3D™
- 50 cm resolution 3D TIN model with real textures and an absolute accuracy of 3 m in all dimensions
- Data layers include 3D vectors, 3D surface model, digital surface model and digital terrain model

Precision3D Registration (P3DR)
- Precision3D data layer automatically georegisters geospatial data—from drone FMV to satellite imagery

Non-Earth imaging: Enabling space domain awareness

- First company licensed to conduct non-Earth imaging (NEI)
- Can collect and distribute images of space objects across LEO, MEO, GEO
- Capable of imaging LEO objects at less than 6-inch resolution
- Can also support tracking of objects across a much wider volume of space

Maxar CSDA product catalog

Maxar Products

- Level 1B (NASA Level 1A equivalent)
- Level 2A Ortho-rectified w/o DEM (NASA Level 1C)
- Level 3X Ortho-rectified w/ DEM (NASA Level 1C)
- Analysis Ready Data (ARD) w/ Atmospheric and Terrain Corrections (NASA Level 1C)
- Vivid Imagery Basemaps 15cm – 4m GSD (NASA Level 1C)
- CAVIS and SWIR data (designed to image snow, ice, and clouds)
- Precision 3D Data
  - Digital Surface Model (DSM)
  - Digital Terrain Model (DTM)

Maxar Sensor and Date Range

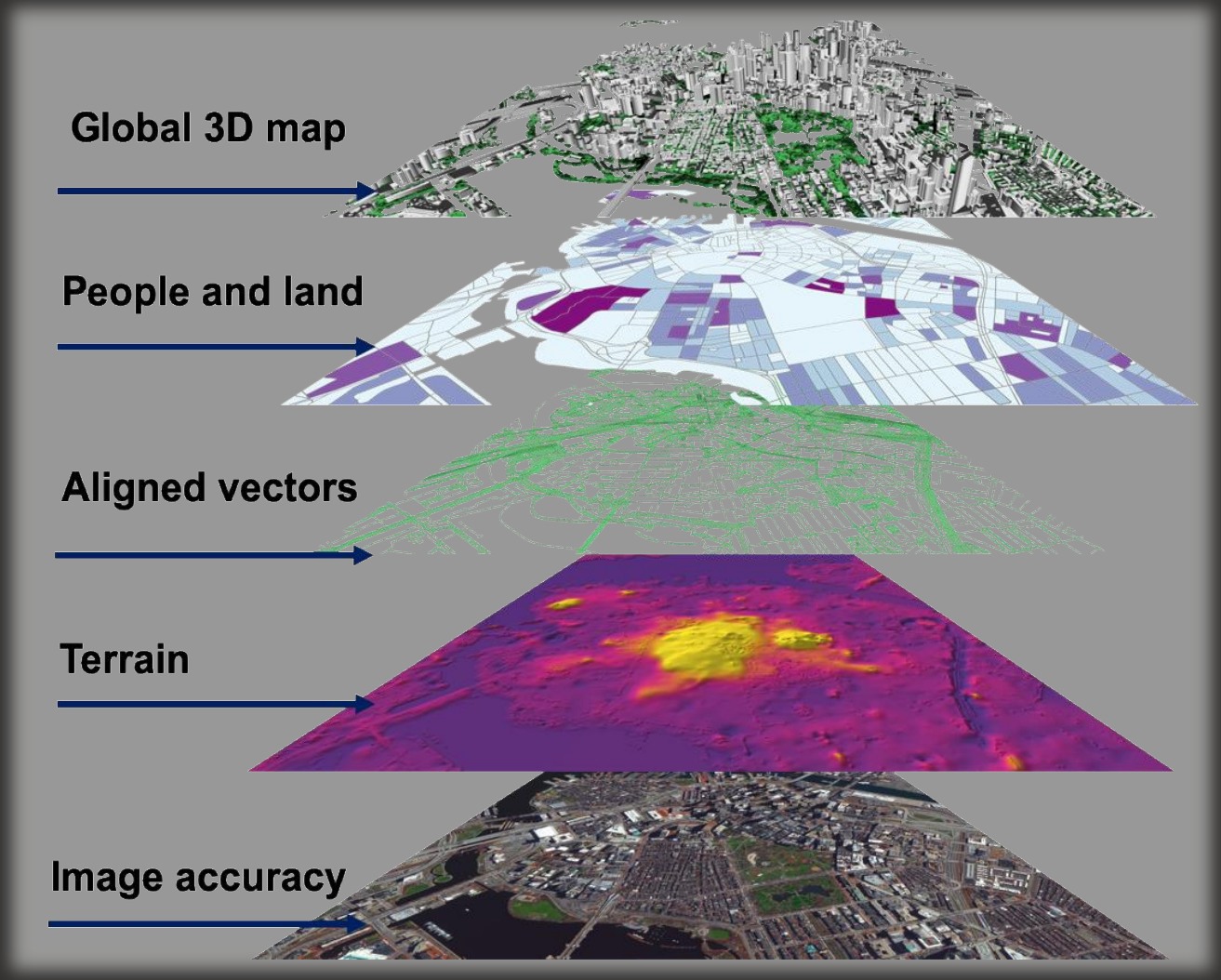
Maxar (formerly DigitalGlobe)	WorldView 1	09/18/2007-Present
	WorldView 2	10/8/2009-Present
	WorldView 3	8/13/2014-Present
	GeoEye-1	9/6/2008-Present
	QuickBird	10/18/2001-1/27/2015
	IKONOS	10/24/1999-3/31/2015
	WorldView 4	12/1/2016-1/7/2019

Maxar Products & Capabilities: CSDA

Maxar Products and Capabilities | Core Imagery

MAXAR INTELLIGENCE

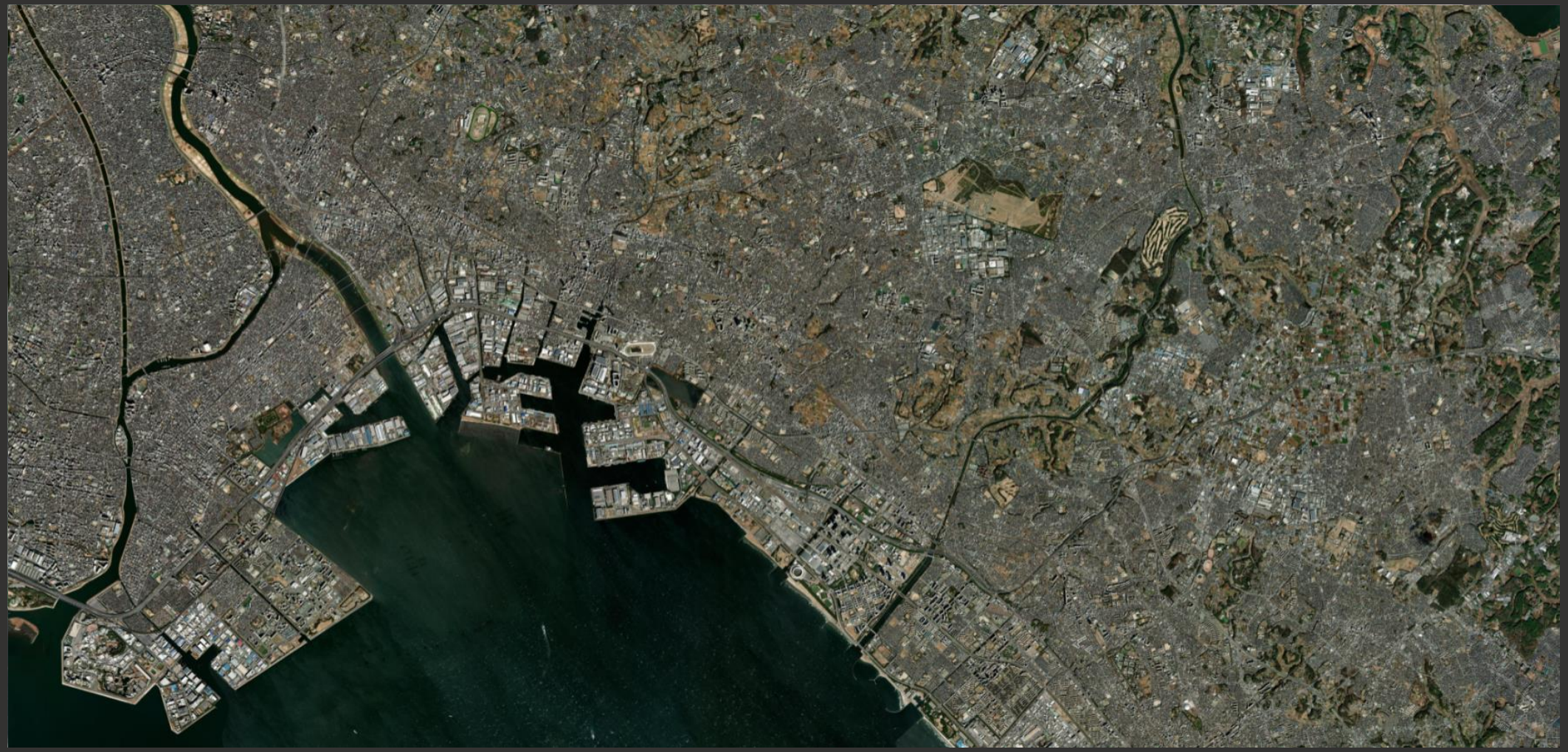
Imagery basemaps are the foundation for understanding our world



- ✓ **Global coverage**: work anywhere, at scale
- ✓ **Data consistency**: predictable data
- ✓ **High resolution**: precisely extract features
- ✓ **High accuracy**: accurate data layers plus consistency year to year
- ✓ **Stunning aesthetics**: visual context in maps and reference layers to vector data
- ✓ **Off the shelf**: available immediately to integrate into products and applications
- ✓ **Annual refresh**: monitor change and maintain maps

MAXAR

Vivid™ Standard Basemaps



The first commercially available, online global basemap with consistent 30cm GSD and 5m CE90 accuracy.

Vivid™ Advanced Basemaps

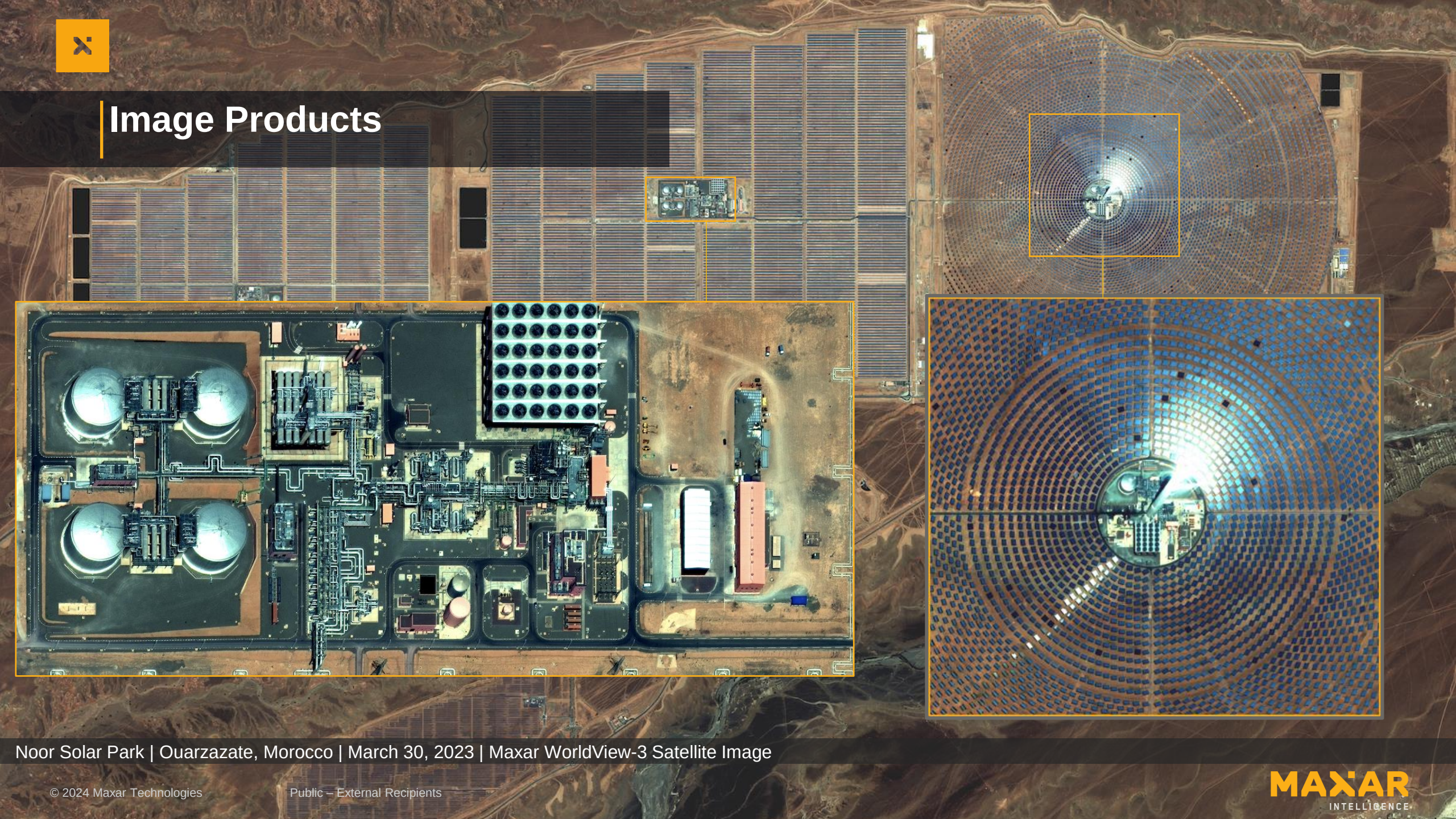
Predictable, high-quality coverage of global population and high interest areas at 15-centimeter resolution.

Dynamic Basemaps

Dynamic Basemaps Offer Flexibility for Unique Customer Needs

- Available in weeks, made to order
- AOI coverage, up to ~1M sq km
- Configurable basemap specs for flexibility in meeting unique project needs
- Ability to define source imagery start/end dates for specific image layer currency

Image Products



Noor Solar Park | Ouarzazate, Morocco | March 30, 2023 | Maxar WorldView-3 Satellite Image

MAXAR INTELLIGENCE

System-Ready (1B)	View-Ready (2A & OR2A)	Map-Ready (Ortho)	System-Ready & View-Ready Stereo Imagery
Sensor corrected, un-projected (raw) product	Projected and resampled, projected to a Digital Elevation Model (DEM)	High-quality, standardized, orthorectified imagery	Create your own DEMs for 3D feature extraction
Supports image manipulation and photogrammetric analysis by image processing systems	Ideal for image viewing, analysis and manipulation in geographic information systems	Ideal for image viewing and locational reference by users in any application	Supports 3D visualization and advanced analytics

MAXAR INTELLIGENCE

Dynamic Basemaps

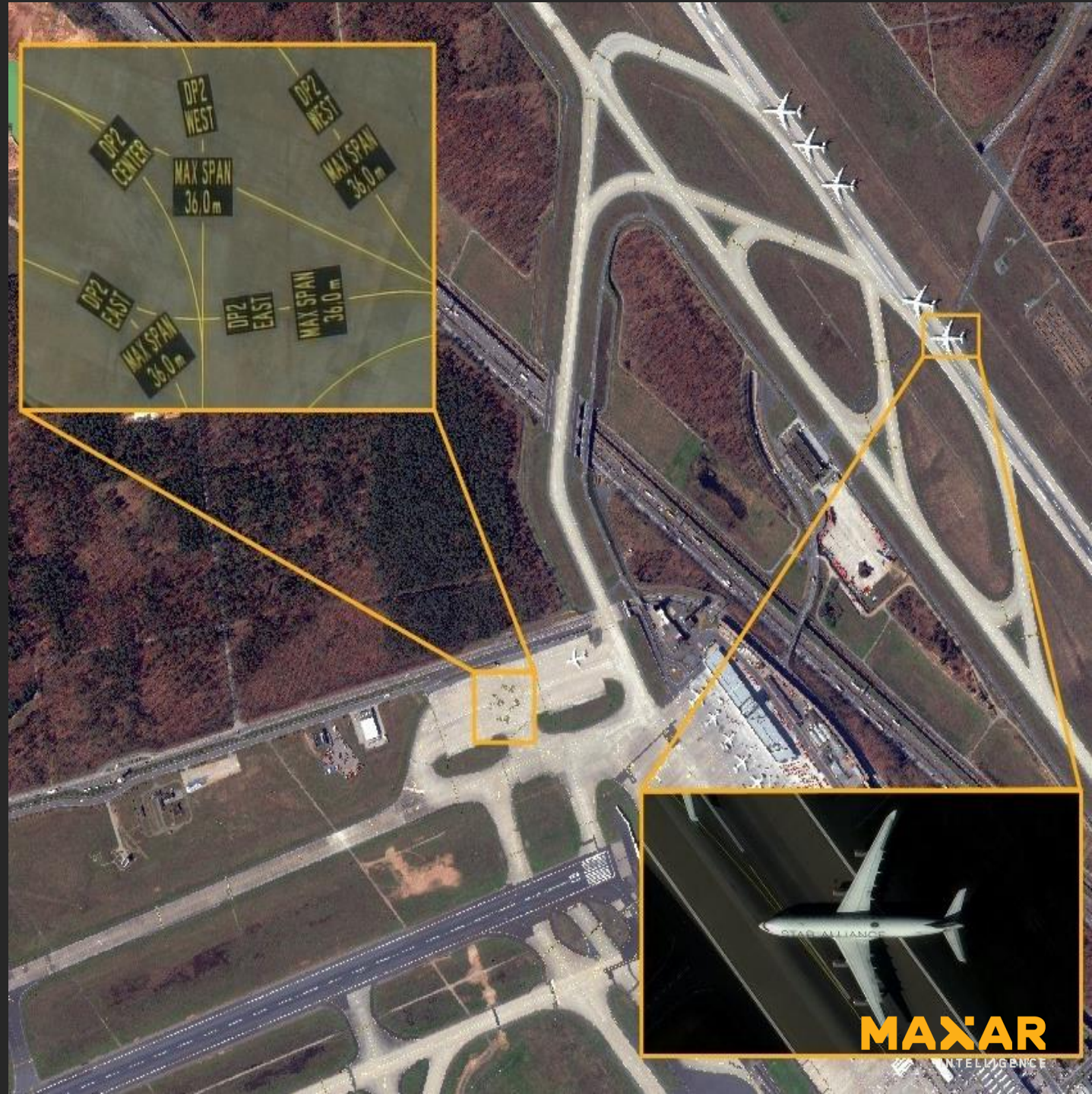
Dynamic Basemaps Offer Flexibility for Unique Customer Needs

- Available in weeks, made to order
- AOI coverage, up to ~1M sq km
- Configurable basemap specs for flexibility in meeting unique project needs
- Ability to define source imagery start/end dates for specific image layer currency

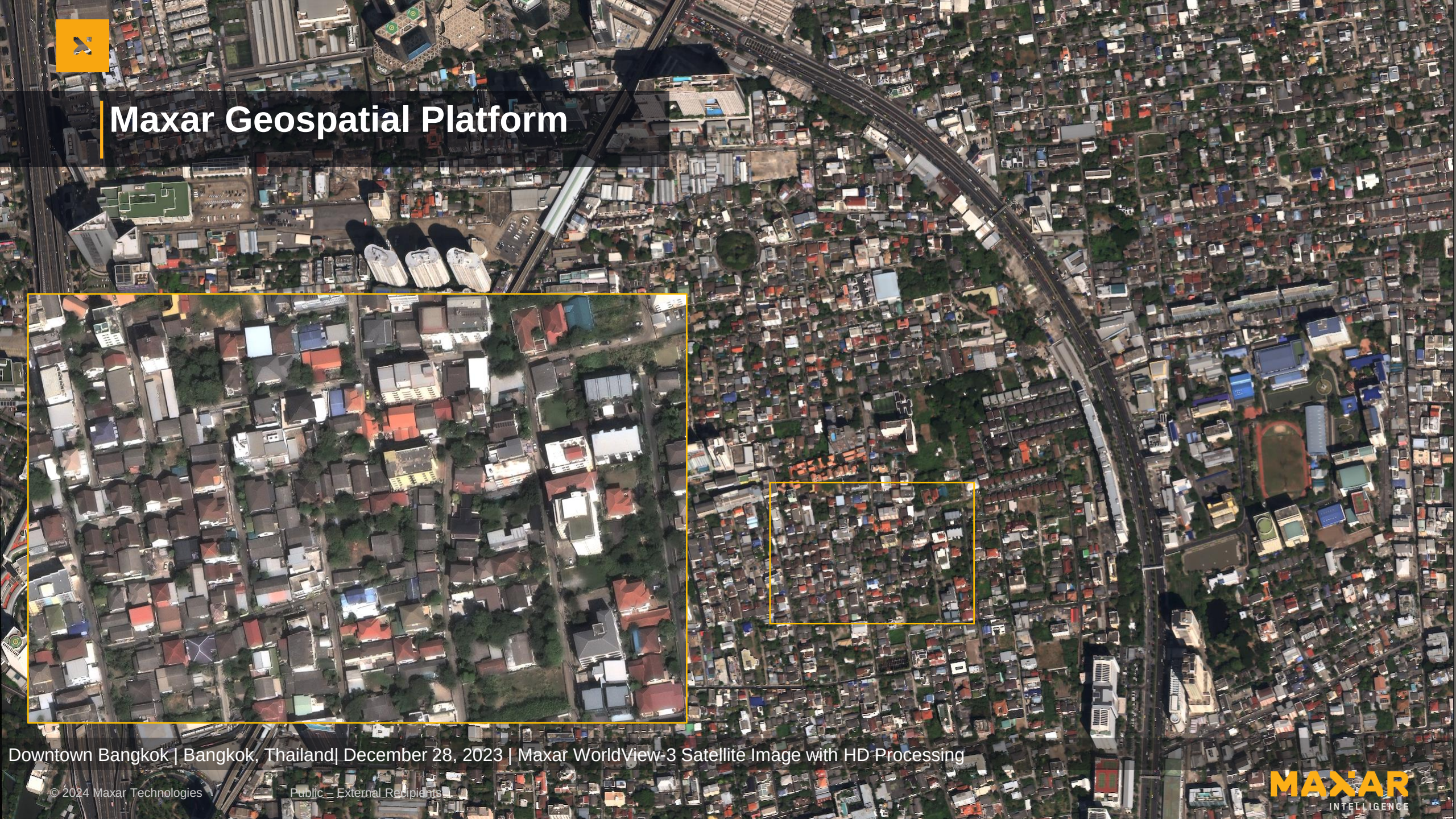
High-Definition (HD) Imagery

A Maxar proprietary technique that improves the image clarity

- Increases 30 cm inventory by processing a 1.6+ million sq km of 50 cm imagery with HD per day
- Enables up to 15 cm HD for 30 cm-class
- Reveals fine mapping details and features available with aerial imagery
- Improves visual clarity making it easier to detect features using AI/ML
- Available in View-Ready and Map-Ready Imagery



Maxar Geospatial Platform

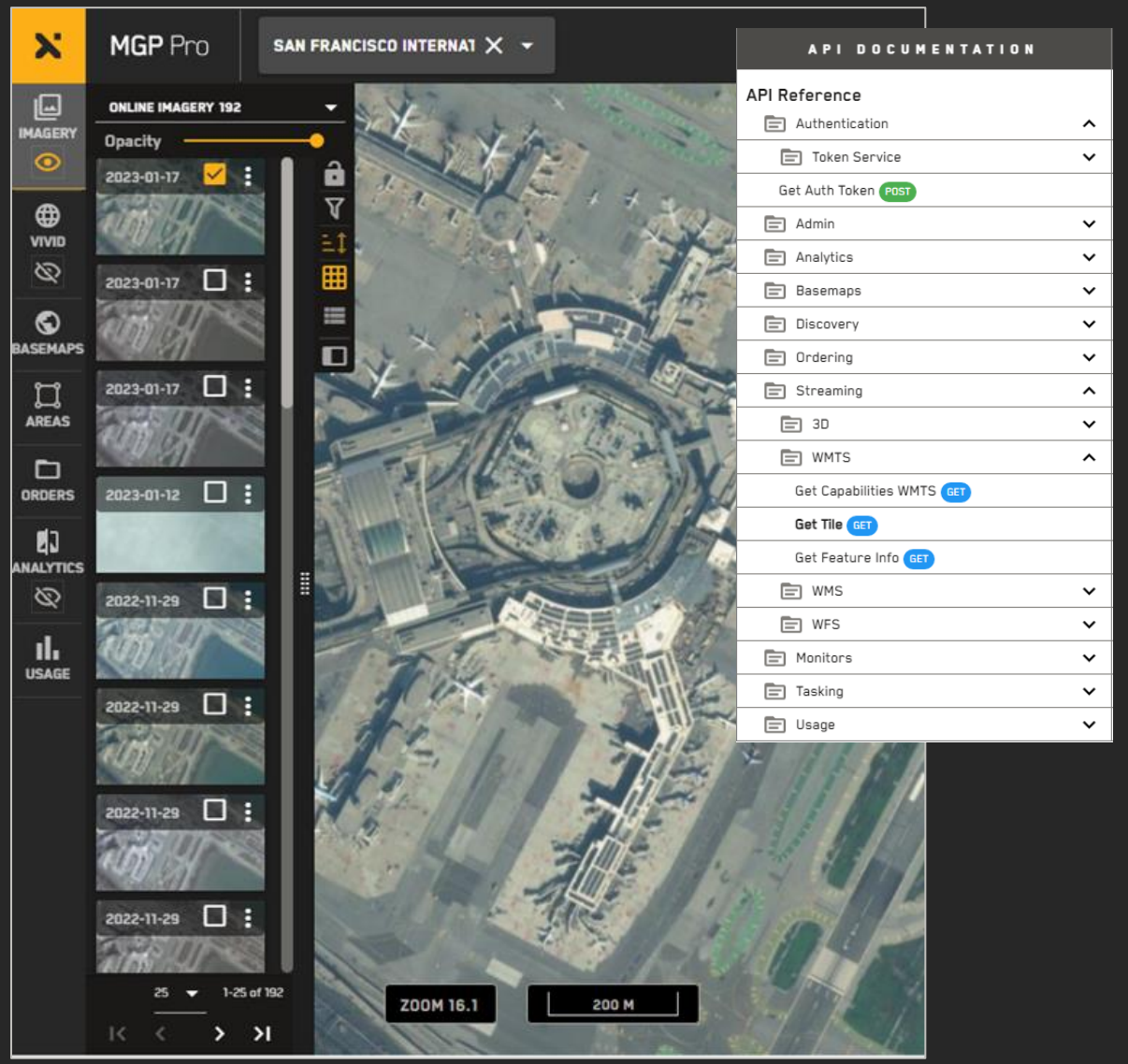


Downtown Bangkok | Bangkok, Thailand| December 28, 2023 | Maxar WorldView-3 Satellite Image with HD Processing

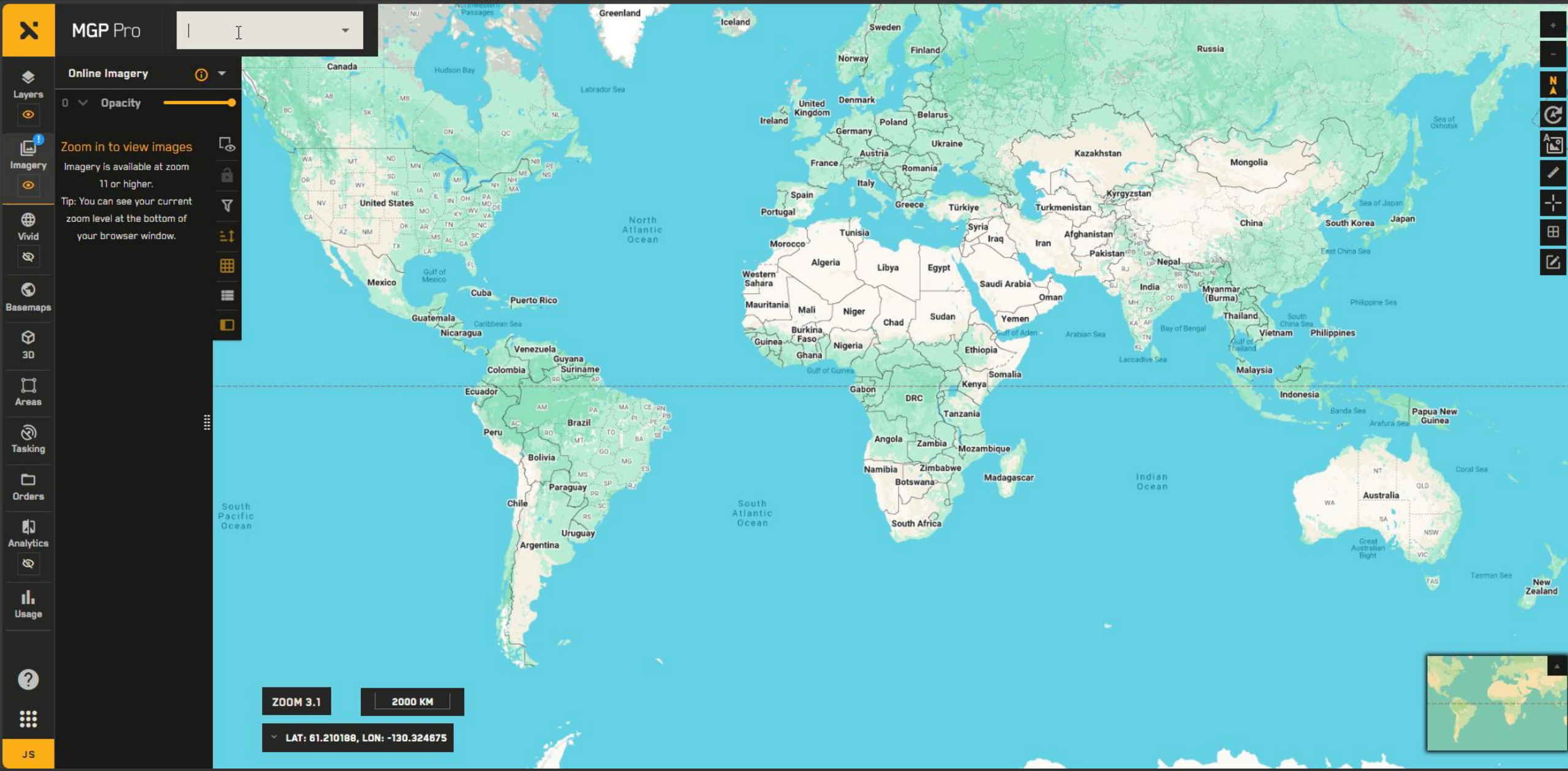
MAXAR INTELLIGENCE

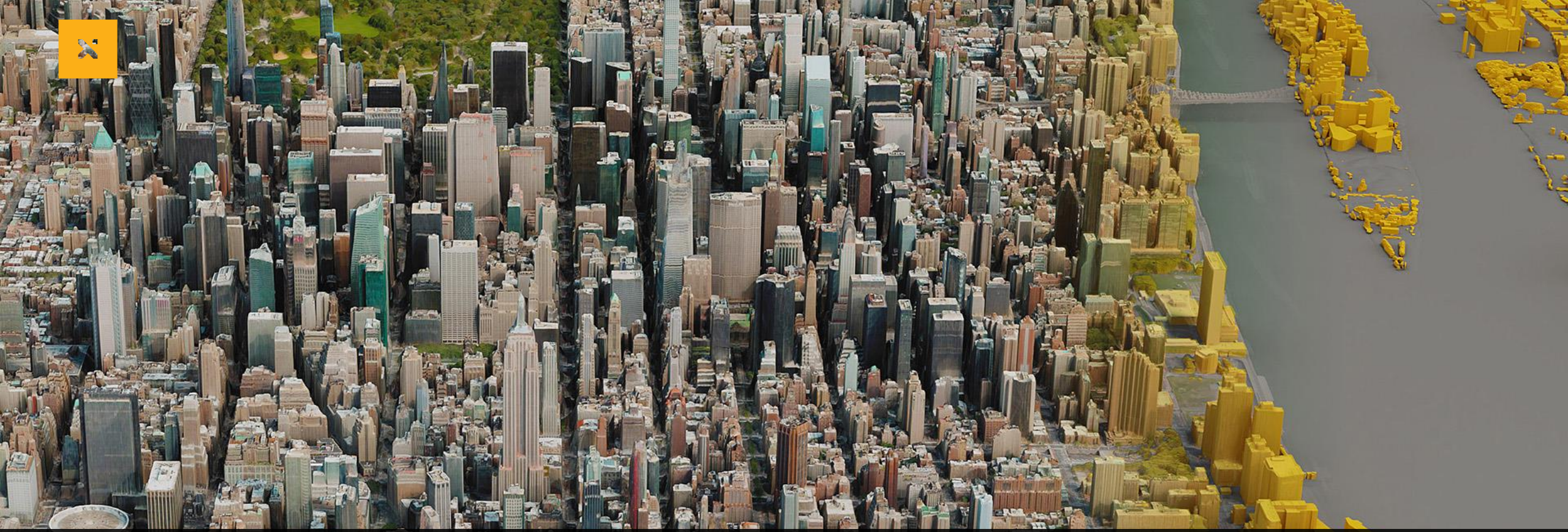
On-Demand Access To Earth Intelligence

- With a broad range of imagery and geospatial data products, MGP Pro provides unrivaled coverage, quality and flexibility.
- Stream or download imagery within hours of collection to monitor and communicate relevant activity in any location around the globe.
- Subscriptions include full access to the Maxar image library via web browser and MGP APIs.



Full access to MGP APIs, also powering MGP Pro UI


MGP Pro
Online Imagery
Opacity
Zoom in to view images
Imagery is available at zoom 11 or higher.
Tip: You can see your current zoom level at the bottom of your browser window.
Layers
Imagery
Vivid
Basemaps
3D
Areas
Tasking
Orders
Analytics
Usage
JS
ZOOM 3.1
2000 KM
LAT: 61.210188, LON: -130.324675
Greenland
Iceland
Canada
Hudson Bay
Labrador Sea
United States
Mexico
Gulf of Mexico
Cuba
Puerto Rico
Caribbean Sea
Guatemala
Nicaragua
Venezuela
Guyana
Suriname
Colombia
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
Uruguay
Argentina
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Sweden
Finland
Norway
Russia
United Kingdom
Ireland
Denmark
Poland
Belarus
Germany
Ukraine
France
Austria
Romania
Italy
Spain
Portugal
Greece
Türkiye
Kazakhstan
Mongolia
Kyrgyzstan
Turkmenistan
Syria
Iraq
Iran
Afghanistan
Pakistan
China
South Korea
Japan
Sea of Japan
East China Sea
Sea of Okhotsk
Nepal
India
Myanmar (Burma)
Thailand
Vietnam
Philippines
Philippine Sea
South China Sea
Malaysia
Indonesia
Papua New Guinea
Banda Sea
Arafura Sea
Australia
Coral Sea
New Zealand
Tasman Sea
Tunisia
Morocco
Algeria
Libya
Egypt
Western Sahara
Mauritania
Mali
Niger
Chad
Sudan
Burkina Faso
Guinea
Nigeria
Ghana
Gulf of Guinea
Saudi Arabia
Oman
Yemen
Gulf of Aden
Arabian Sea
Ethiopia
Somalia
Kenya
Gabon
DRC
Tanzania
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana
Madagascar
South Africa
Bay of Bengal
Laccadive Sea



Maxar Products and Capabilities | Precision3D

Digital Surface, Terrain, and Elevation Models

MAXAR INTELLIGENCE

Benefits of Maxar's patented multiview process

Complete surface measurements

- Multiple look angles from high resolution sensors nearly eliminate occlusion

Consistent high accuracy

- Deep stack image alignment on pixel-by-pixel basis averages out the pointing errors of individual images and enable 3m SE90 w/o ground control

High fidelity surface representation

- Hyper semi-global matching that leverages Maxar's unique 'global deep imagery stack' along with advanced AI produces native 50cm resolution 3D, the most detailed resolution ever available globally

The highest resolution, most accurate representation of the entire face of Earth, enabling customers to see the world at global scale in fully immersive 3D

3m Absolute Accuracy, 1m Relative Accuracy
50cm Resolution/Post Spacing

Precision3D core products

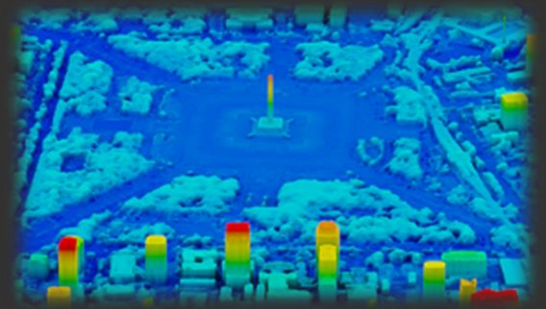
- **3D Products (Mesh)**
  - 3DSM
  - 3DTM
  - 3D Textured Objects

3DSM

3DTM

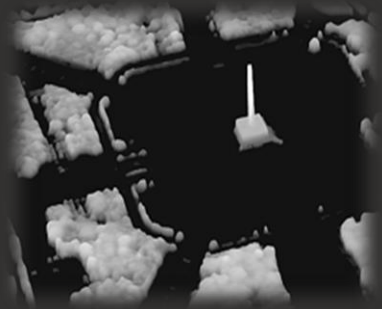
3D Textured Objects

- **Elevation Products (DEMs)**
  - DSM
  - DTM
  - DHM
  - Point Cloud



DSM

DTM

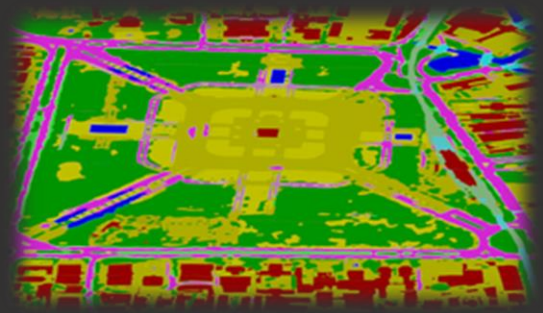


DHM

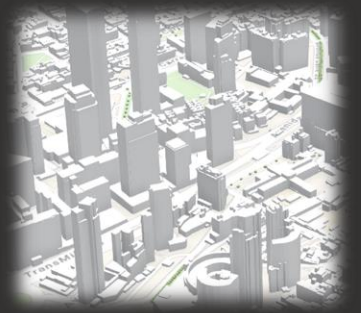
Point Cloud

- **Extracted Products**
  - True Ortho
  - Classification
  - Building/Veg (vectors)

True Ortho

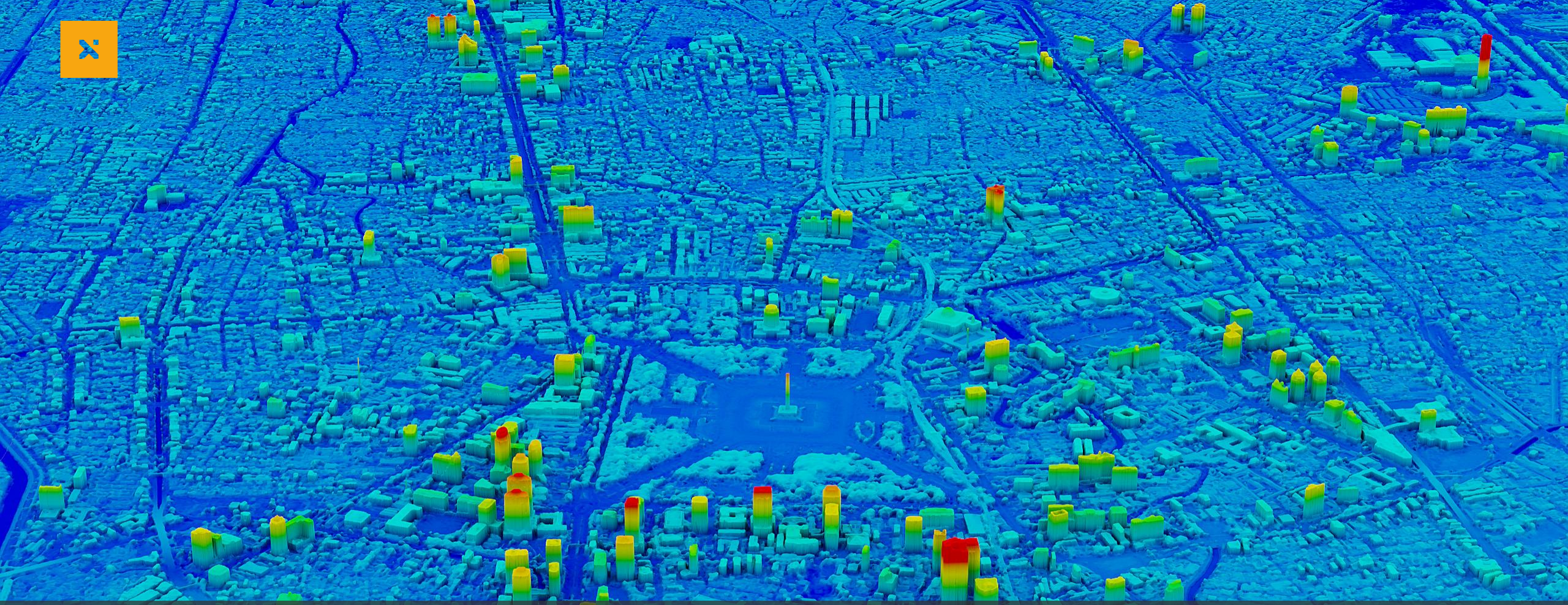


Classification



Building and/or
Veg Vectors

MAXAR INTELLIGENCE



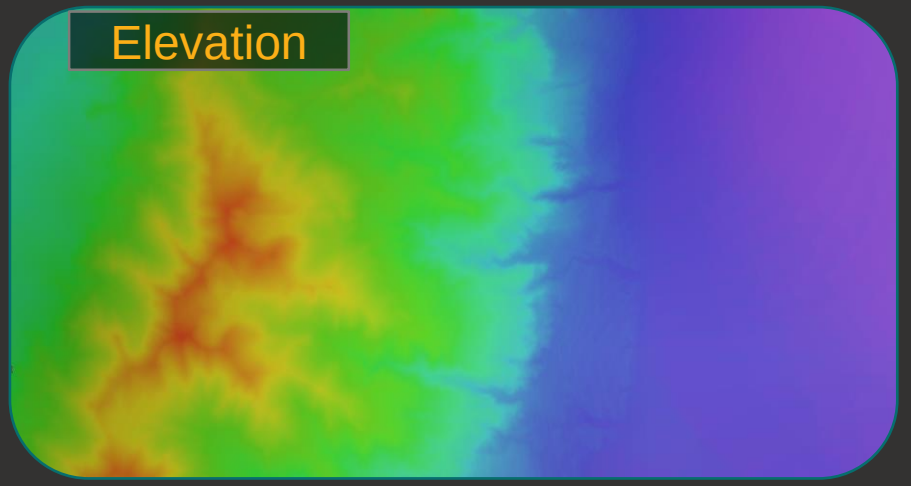
Digital Surface Model

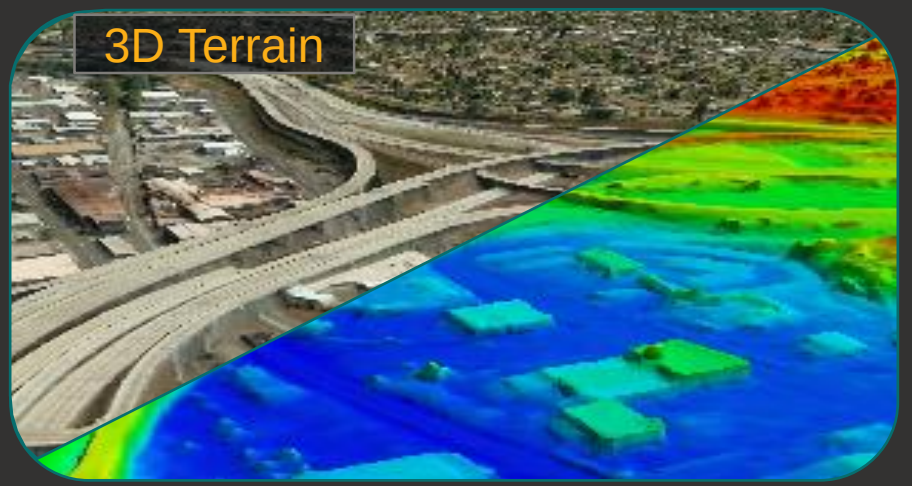
- Describes the elevation of the earth surface in a raster format. The data represents the average elevation in the post spacing area.
  - Type: First surface model
  - Format: GeoTIFF, Esri BIL, (others on request)
  - Resolution: 50 cm, 1m, 2m, 4m

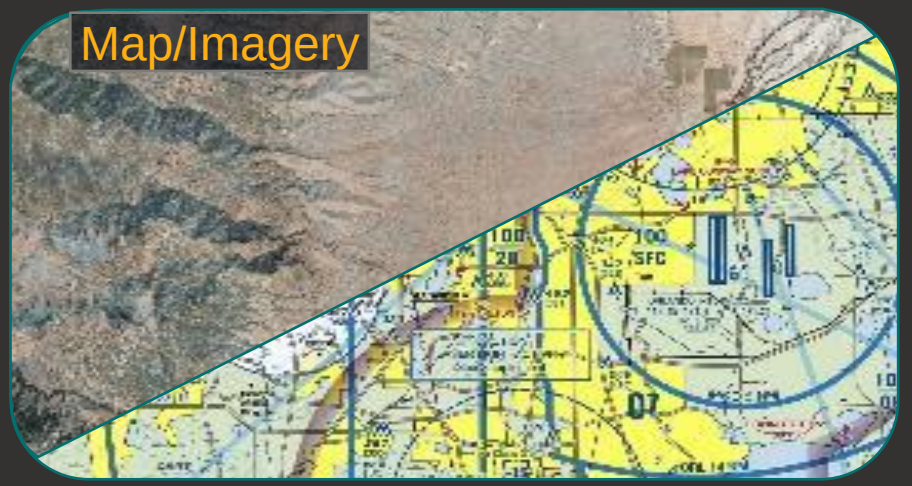
Digital Terrain Model

- The elevation of the bare earth in a raster format, based on the Precision3D DTM with trees and man-made objects removed by automated processing. The data represents the average elevation in the post spacing area.
  - Type: Bare Earth model
  - Format: GeoTIFF, Esri BIL, (others on request)
  - Resolution: 50 cm, 1m, 2m, 4m

Mapping and terrain evaluation







Risk Planning and Mitigation

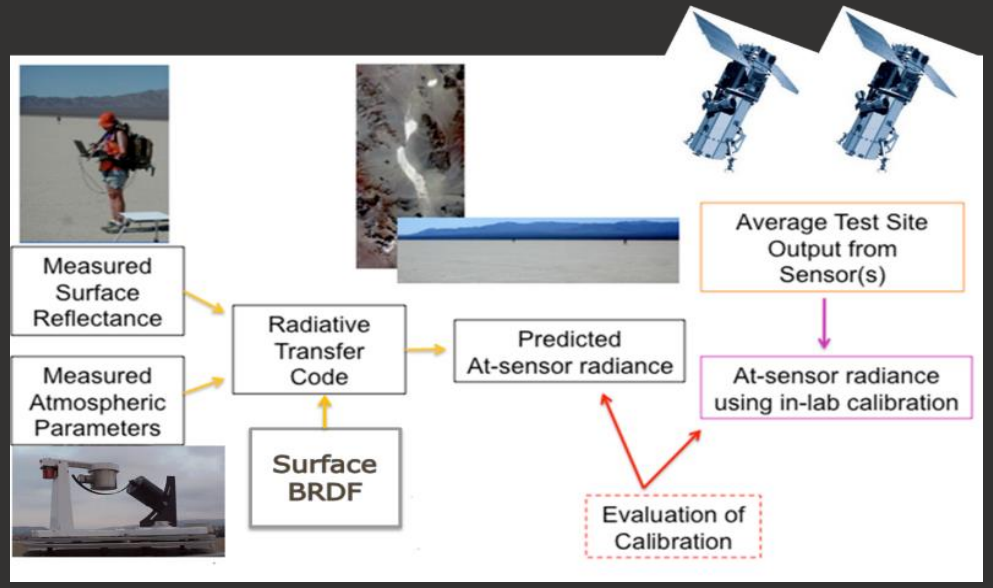
MAXAR INTELLIGENCE

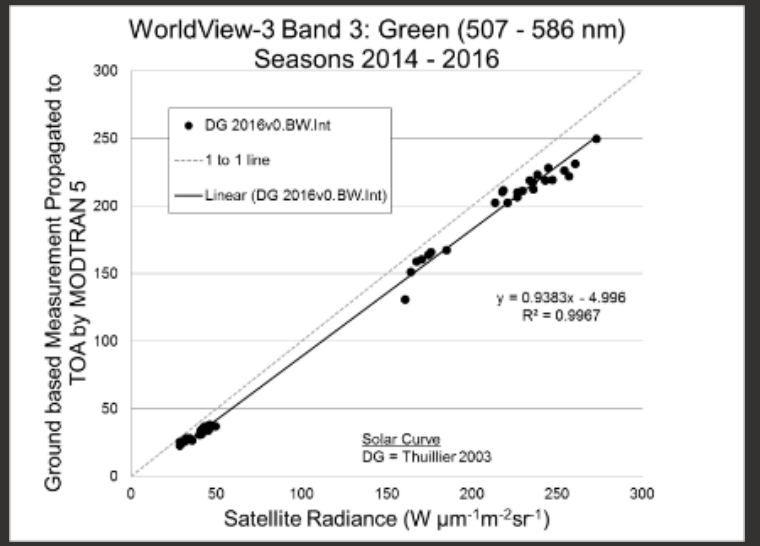
Bigach impact crater, Kazakhstan

Maxar Products & Capabilities | Processing

Absolute radiometric calibration

- We employ the reflectance-based vicarious calibration approach developed by the University of Arizona in the late 80's and employed by NASA and other international agencies
- This method uses in-situ measurements of surface reflectance (of spectrally and spatially homogenous targets) and atmospherics in a radiative transfer model to predict at-sensor radiance for validation and calibration efforts
- Many measurements/dates are used in a regression to determine required adjustments to the pre-launch calibration





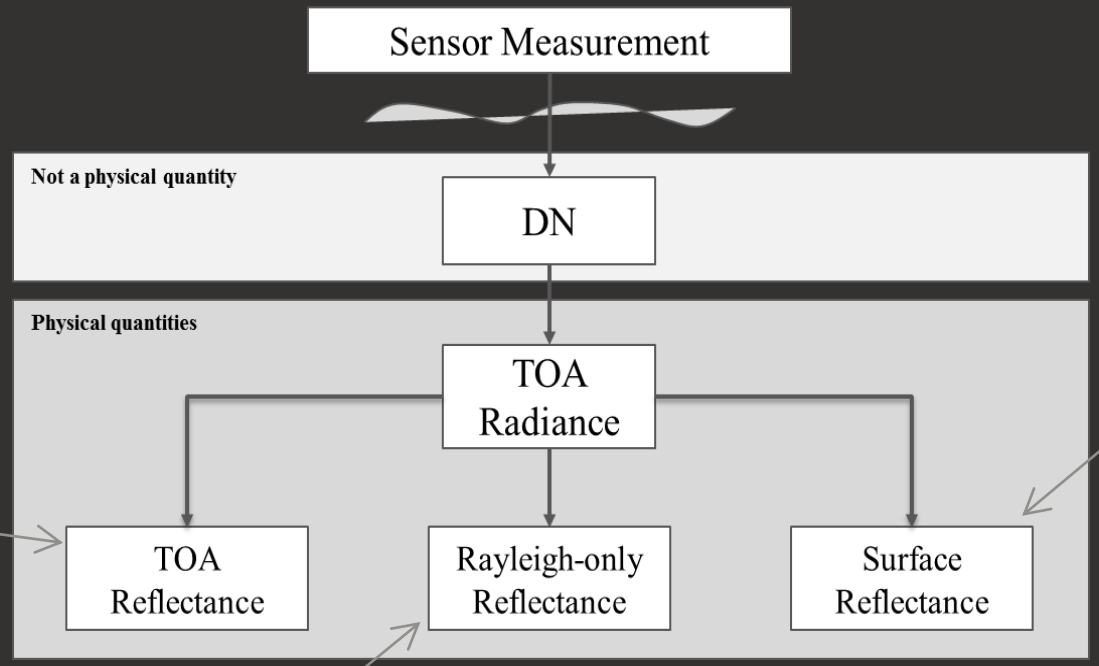
From sensor to surface reflectance

Surface reflectance is the physically-based normalization of the image values regardless of the different atmospheric and viewing conditions, i.e., it corrects the images to be consistent with viewing the area from the ground.

At-sensor radiance L to TOA reflectance ρ^{TOA} $[unitless]$:

$$\rho^{TOA} = \frac{L \cdot d_{ES}^2 \cdot \pi}{E_{sun} \cdot cos(\theta_S)}$$

where E_{sun} is the mean exoatmospheric solar irradiance $[Wm^{-2}\mu m^{-1}]$, θ_S is the solar zenith angle $[degrees]$, and d_{ES} is the Earth-Sun distance $[astronomical\ units]$.



Compensates for solar illumination

Compensates for solar illumination and Rayleigh scattering

Compensates for solar illumination, Rayleigh scattering, and atmosphere

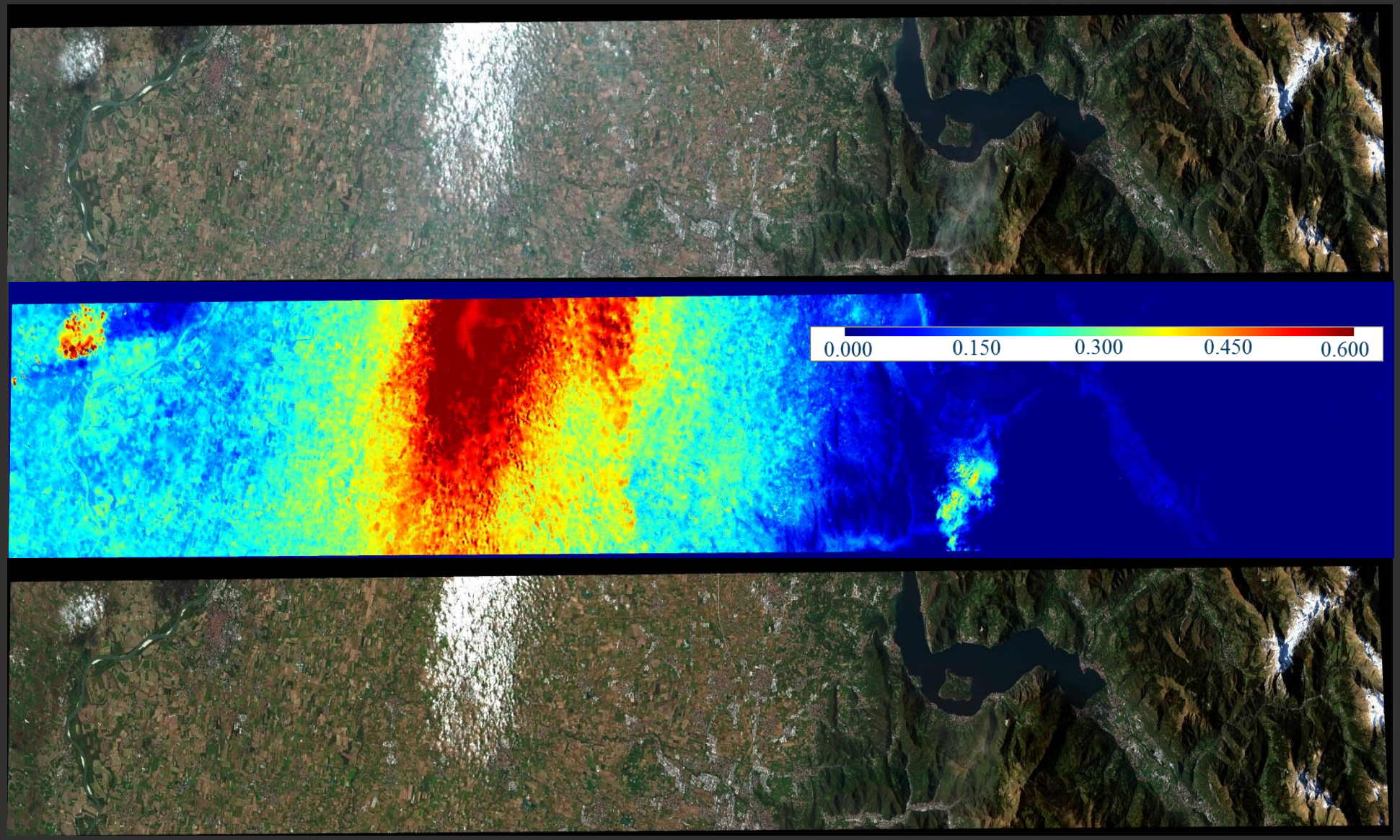
Surface reflectance can be derived as:

$$\rho = \frac{(L - L_{up}) \cdot d_{ES}^2 \cdot \pi}{\tau_{up} \cdot (E_{sun} \cdot cos(\theta_S) \cdot \tau_{down} + E_{down})}$$

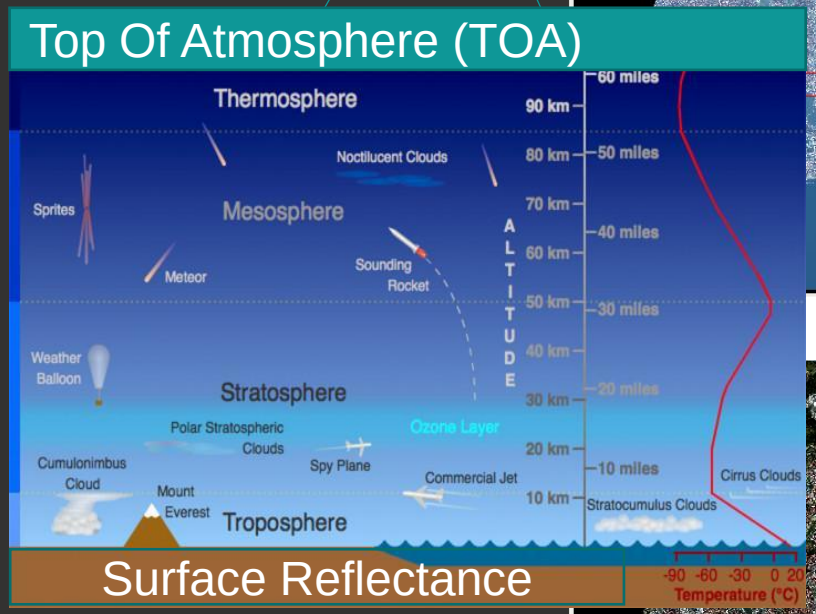
where L_{up} $[Wm^{-2}sr^{-1}\mu m^{-1}]$ is the upward radiance scattered by the atmosphere, τ_{up} $[unitless]$ is the atmospheric transmittance from the ground to the top of the atmosphere, τ_{down} $[unitless]$ is the atmospheric transmittance from the top of the atmosphere to the ground, and E_{down} $[Wm^{-2}\mu m^{-1}]$ is the diffuse irradiance at the surface.

AComp: Maxar's Atmospheric Compensation

- Derives aerosol optical depth (AOD) and water vapor from image
- Works on PAN, VNIR, and SWIR imagery
- Fully automated (no human in the loop)
- Suitable for large-scale production



TOA versus Surface Reflectance



https://scied.ucar.edu/learning-zone/atmosphere/layers-earths-atmosphere

Istanbul – WV02: Feb. 19, 2010 Top of Atmosphere (TOA) Reflectance

Istanbul – WV02: Feb. 19, 2010 (Surface Reflectance)

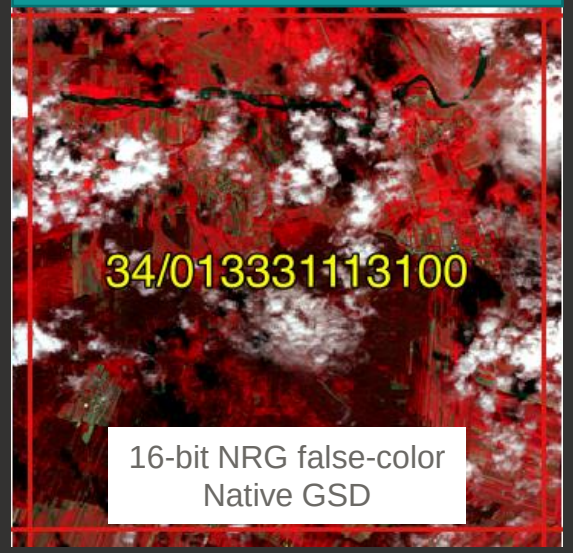
Credit: Fabio Pacifici

MAXAR INTELLIGENCE

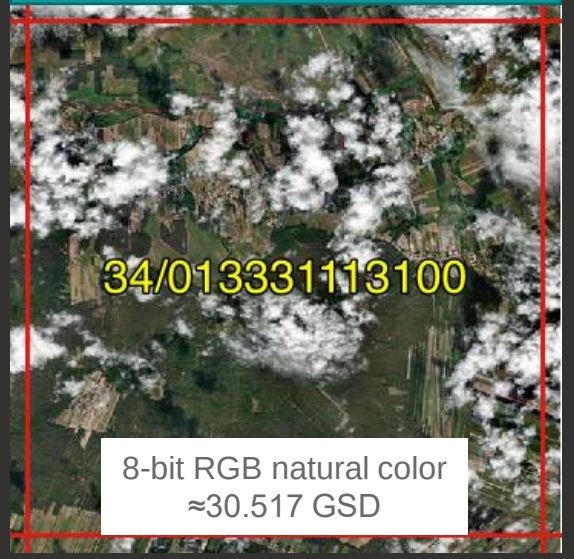
Analysis Ready Data (ARD)

Goal: Minimize the burden of repetitive and boilerplate tasks on the users of the data
Method: Generate a set of standard image products on a fixed global grid

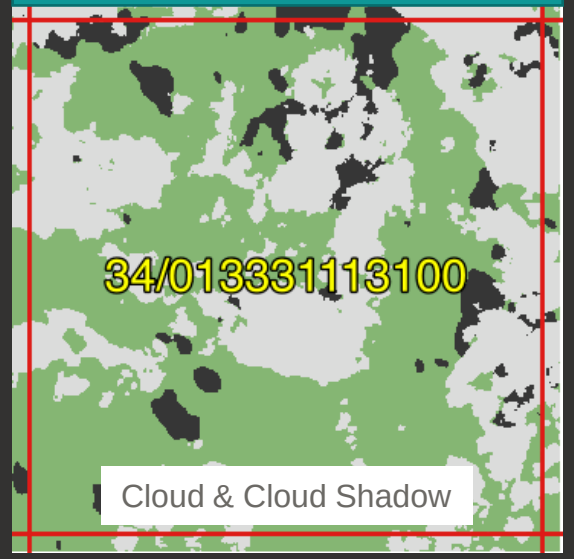
Surface Reflectance



RGB Visual



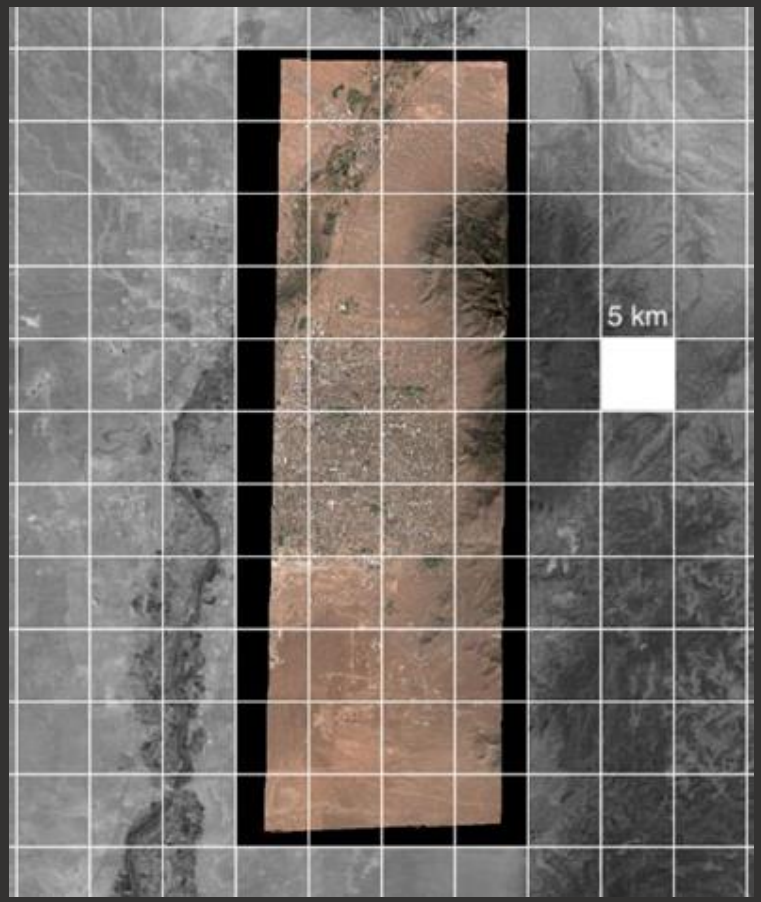
Data Masks



- Clear
- Cloud
- Cloud Shadow

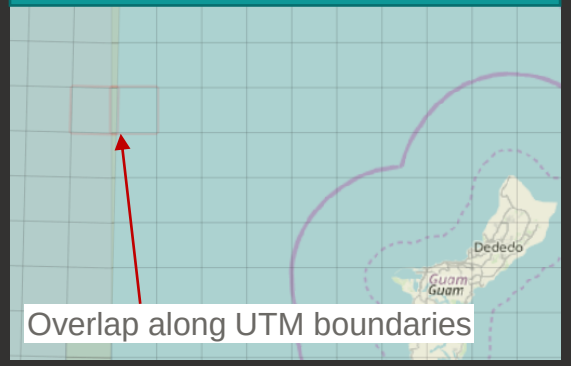
Additional Masks:

- Clouds
- Healthy Vegetation
- PAN & MS Saturation
- Terrain Shadows
- Water

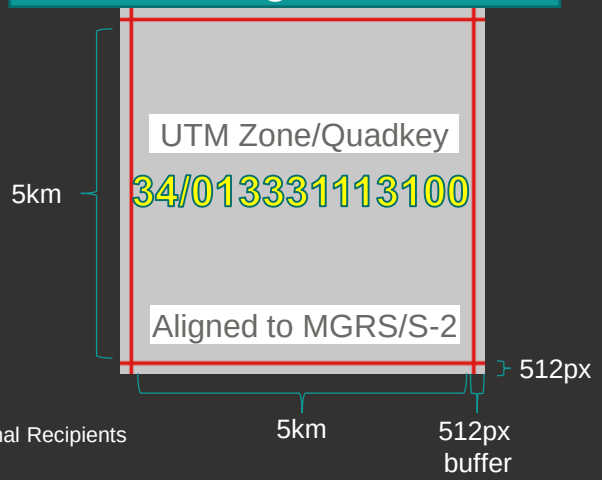


https://ard.maxar.com

60 UTM Grids



Pixel-aligned Grid



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