From **URBAN** To **RURAL**

Enabling Sustainable Urban Planning and Development Using Satellite Imagery

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AN OVERVIEW

It is estimated that 55% of the world's population lives in urban areas. This number is expected to increase to 68% by 2050. Studies have shown that urbanisation combined with the overall growth of the world's population could add another 2.5 billion people to urban areas. This proposes a challenge for today's urban planners that can be aided by incorporating Very High Resolution (VHR) optical satellite imagery into their planning.

This rapid rate of change challenges urban planners to ensure efficient city infrastructure management whilst minimising the impact on the surrounding environment. Satellite imagery provides urban intelligence to support urban, city and land planners in making the right decisions for sustainable urban development. It allows detailed analysis for creating or updating Geographic Information Systems (GIS), as well as detecting and monitoring changes in urban / rural land use and land cover mapping.

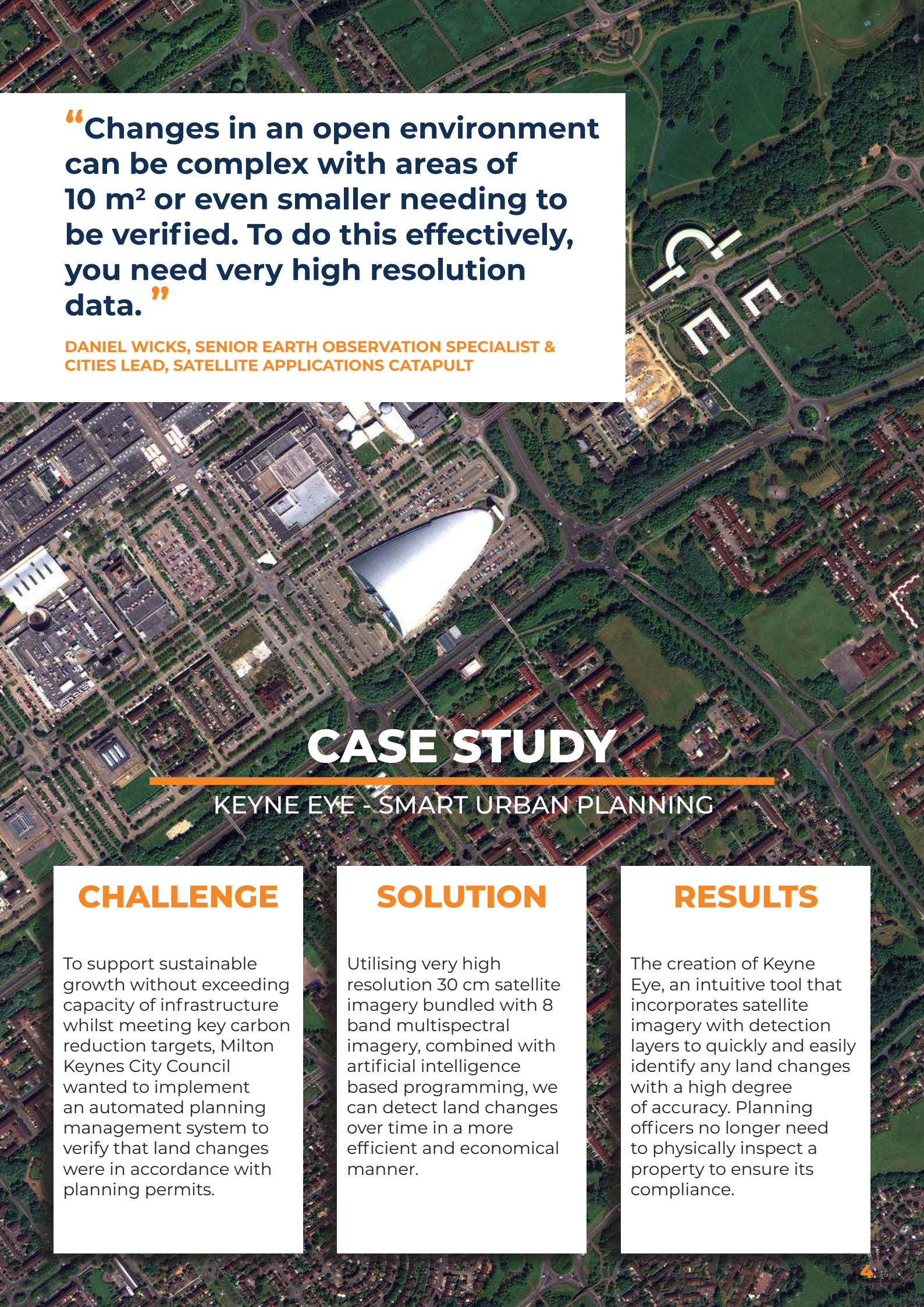
The use of remote sensing and GIS technology in urban planning applications gives enormous benefits over traditional in situ data collection methods. The data is obtained in a timelier manner, is highly accurate and reliable and can be combined with GIS to extract and classify features. Furthermore, the combination of data from optical satellites with other socio-economic data provides a crucial link in the total planning process imparting the necessary insights to make effective planning decisions.

What is Feature Extraction and Classification?

One of the most basic tasks within remote sensing is the mapping of urban and rural settlements. This provides the foundation for further analyses including feature extraction and classification, a powerful resource for urban planning. Utilising artificial intelligence, combined with the power of geospatial data, feature extraction systems can automatically identify and classify building typologies, building heights, sidewalks, forest, grass, water, roads, vegetation and more. From this, spatial urban landscape models (ULM) can be developed.

VHR optical satellite imagery can be an essential tool to monitor urban sprawl and map population growth and density. It offers a non-destructive means of providing recurrent information from both a local and global scale. By combining data sources with artificial intelligence and machine learning, further insights can be gained autonomously and in a timelier manner. Advances in these technologies is increasing the affordability for most users, making the exploitation of remotes sensing reliable and profitable.

Other areas whereupon VHR optical satellite imagery can provide benefits include land use & land cover classification, impervious surfaces detection, infrastructure modelling, environmental impact monitoring, archaeological exploration, urbanisation morphology and 3D modelling.



> **"Changes in an open environment can be complex with areas of 10 m² or even smaller needing to be verified. To do this effectively, you need very high resolution data."**

DANIEL WICKS, SENIOR EARTH OBSERVATION SPECIALIST & CITIES LEAD, SATELLITE APPLICATIONS CATAPULT

CASE STUDY

KEYNE EYE - SMART URBAN PLANNING

CHALLENGE

To support sustainable growth without exceeding capacity of infrastructure whilst meeting key carbon reduction targets, Milton Keynes City Council wanted to implement an automated planning management system to verify that land changes were in accordance with planning permits.

SOLUTION

Utilising very high resolution 30 cm satellite imagery bundled with 8 band multispectral imagery, combined with artificial intelligence based programming, we can detect land changes over time in a more efficient and economical manner.

RESULTS

The creation of Keyne Eye, an intuitive tool that incorporates satellite imagery with detection layers to quickly and easily identify any land changes with a high degree of accuracy. Planning officers no longer need to physically inspect a property to ensure its compliance.

WHAT IS VHR SATELLITE IMAGERY?

Very High Resolution (VHR) satellite imagery are images of Earth taken from space in sub-meter resolution – that is every pixel of the image is under one metre in width and height. VHR imagery can be delivered in different combinations of multispectral bands allowing the user to see more detail than possible with the human eye.

EUSI utilises the Maxar WorldView Constellation from their ground station in Munich, Germany to acquire imagery at 30 – 50 cm resolution with rapid revisit. Rapid revisit refers to the ability of the satellites to collect imagery over the same area within a short time frame.

10 M

Suitable for large land area coverage but will not provide any detailed area – for example identifying surface types

1 M

Provides some level of detail but will hinder detection and identification objectives – markings such as property boundaries or road lines will not be clear

30 CM

The highest amount of detail commercially available and necessary for projects relating to object identification

What can multispectral bands do for me?

The WorldView satellite constellation has 16 multispectral spectral bands that are focused on a part of the light spectrum and sensitive to a particular feature on the ground. By arranging these multispectral bands in various combinations, additional information can be extracted that is invisible to the human eye, such as the condition and age of surfaces, vegetation health and roof types.

WHAT SOLUTIONS CAN SATELLITE IMAGERY PROVIDE?

The power of 30 cm resolution imagery in combination with frequent revisits and rapid delivery can be critical for making strategic decisions that decrease inputs while increasing profitability within urban planning. Urban and rural settlements are widespread with buildings being an integral feature and as such, local authorities require area-wide and up-to-date inventories of buildings in order to monitor urbanisation.

VHR imagery allows urban and city planners to monitor changes in the number, size and area, density, layout, height and volume of buildings. Additional features such as pipelines, road networks, water and waste sources, green spaces and more can also be determined.

Additionally, due to the rapid revisit rates of many satellites and their frequency to image an area, time sequences can be created to classify environmentally safe and sustainable areas for proposed development sites. This enables the use of empty space within the city to avoid expanding the city limits.

Land Use & Land Cover Classification

Large-scale monitoring to review change detection over time. Provides reliable data on urban growth as well as updated information on road networks and urban infrastructure to assist urban sprawl identification

Enforcement Methodologies

Provides information to support decision makers from local and national government in regards to traffic management, zoning, property planning permissions and tax

Environmental Impact & Planning

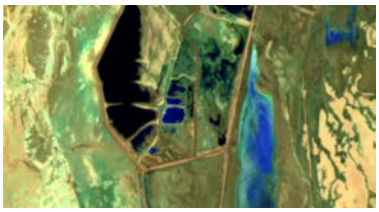
Enables mapping and analysis of environmental parameters such as green cover, leaf area index, normalised difference vegetation index, water and waste, impervious surfaces and drainage networks

Building Footprints

Structured georeferenced interpretation of the geometric footprint of each building can be extracted from VHR satellite data to verify address and POI points.

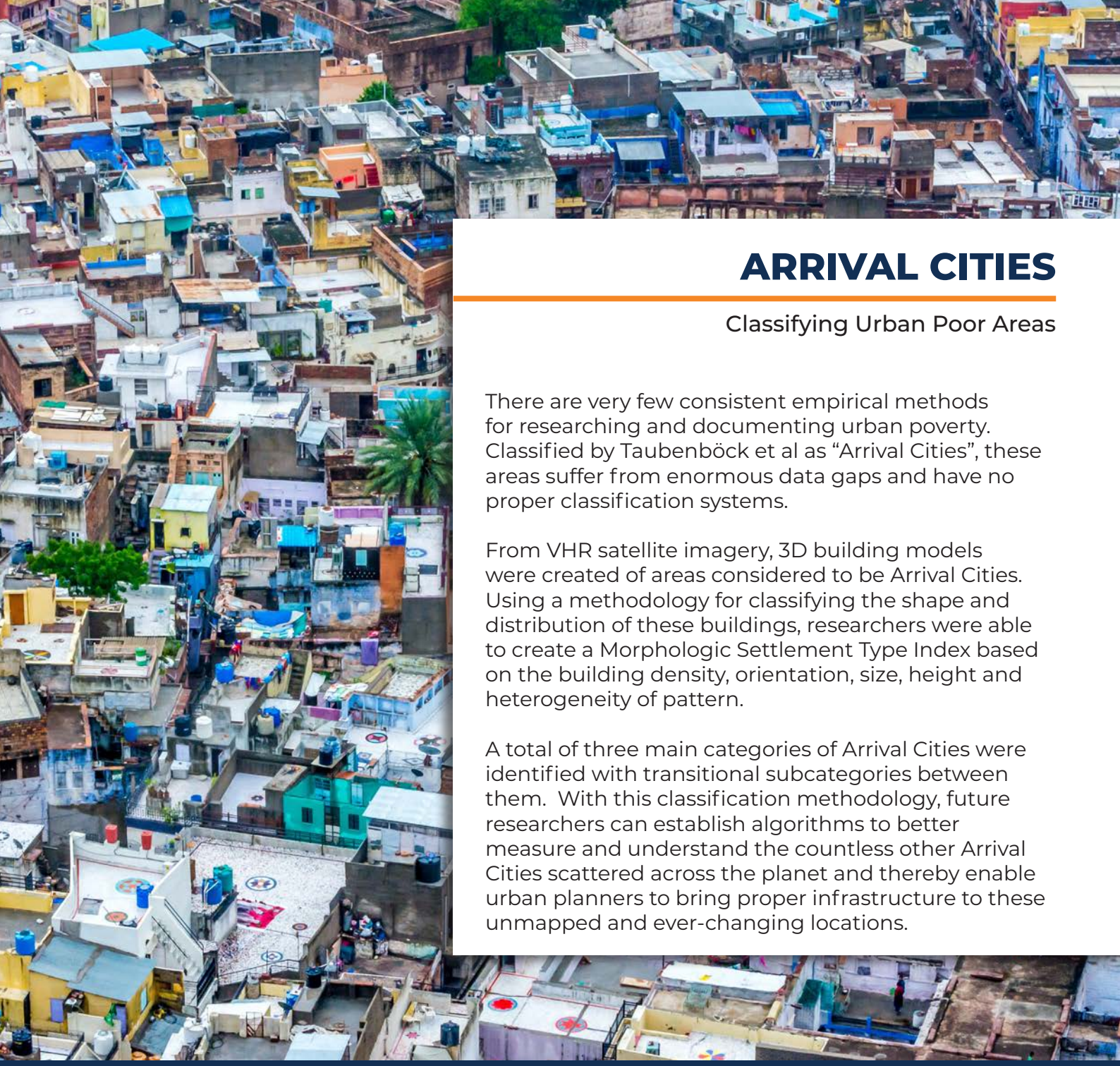
3D Modelling

Stereo VHR satellite imagery is used to make 3D models of terrain, vegetation and existing infrastructure. This provides crucial insights to aid development planning.



Soil Moisture Estimates

Archaeological structures and human activity alter the soil surface - making it dry, bright, humid or dark. This can be measured with satellite imagery to identify potential archaeological sites.



ARRIVAL CITIES

Classifying Urban Poor Areas

There are very few consistent empirical methods for researching and documenting urban poverty. Classified by Taubenböck et al as “Arrival Cities”, these areas suffer from enormous data gaps and have no proper classification systems.

From VHR satellite imagery, 3D building models were created of areas considered to be Arrival Cities. Using a methodology for classifying the shape and distribution of these buildings, researchers were able to create a Morphologic Settlement Type Index based on the building density, orientation, size, height and heterogeneity of pattern.

A total of three main categories of Arrival Cities were identified with transitional subcategories between them. With this classification methodology, future researchers can establish algorithms to better measure and understand the countless other Arrival Cities scattered across the planet and thereby enable urban planners to bring proper infrastructure to these unmapped and ever-changing locations.

Why not just use Google?

Google Maps is one of the most widely used services on the internet and allows high quality data free of charge. Google Earth has significantly lowered the barriers to accessing high resolution satellite images, however it does come with limitations.

- Data is not current and Google has no publicly available schedule of updates
- Populated areas are imaged more frequently than rural or coastal areas
- It is not possible to download geo-referenced images from Google
- Multispectral band combinations cannot be changed to reveal additional insights

HOW DO I GET VHR IMAGERY?

Traditionally VHR satellite imagery could be obtained via an order processing system whereby a user contacts an Earth Observation company. The user either requests a specific area of interest and date from the catalogue or order satellite tasking for a future image to be collected.

This method of obtaining data is useful for users who require infrequent data or who need new collections. For more demanding users who need continuous access to the whole archive catalog, SecureWatch is the smarter and more cost-effective option.

EUSI offers both traditional and cloud-based imagery delivery options combined with personal customer support to guide users to the perfect image.

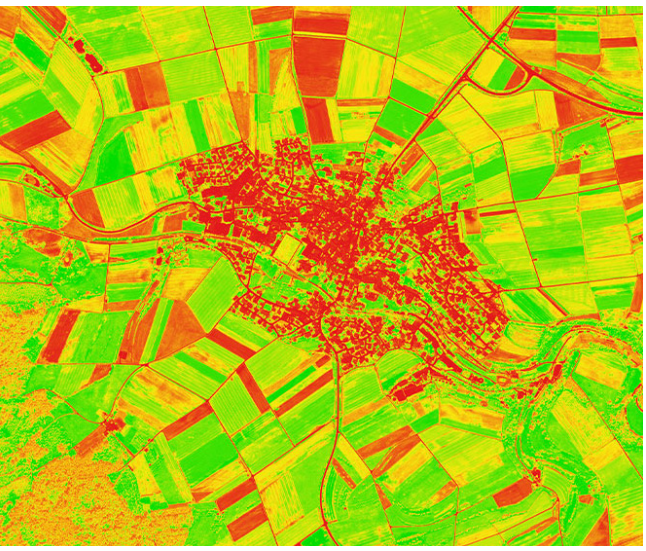
Traditional Order Processing

- Search the catalogue dating back to 1999 or request a new image collection
- Pay for each image upon delivery
- Global coverage – no geographical restrictions, simply define area of interest from available global coverage
- Average delivery in less than 48 hours
- Ability to order imagery with different processing methods (band combinations, pan-sharpening and atmospheric compensation)
- Satellite Tasking – the ability to request a new image collection at specific location
- Smarter model for tailored projects or if new collections are needed

SecureWatch: Cloud-based

- Stream full resolution imagery dating back to the year 1999
- Subscription based service – a yearly price to view, stream and download
- Global coverage – no geographical restrictions, simply define area of interest from available global coverage
- Instant access to imagery via a user friendly web interface or API
- Ability to enhance imagery on screen (band combinations, atmospheric compensation, adding layers and making annotations)
- Set alerts that notify you when new data is collected in your area of interest
- Perfect for customers who need a regular access to archive imagery or integration into software solutions

APPLICATIONS

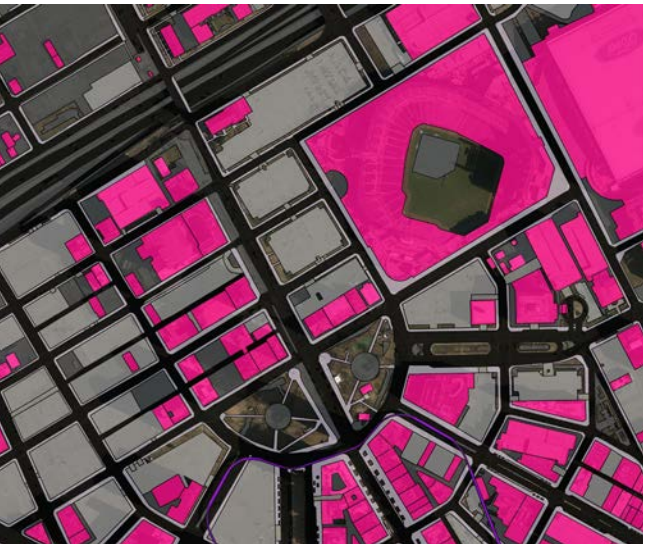


Green Space

Green area monitoring is a key component in urban planning around the world. The use of Normalised Difference Vegetation Index (NDVI) from satellite imagery aids urban planners in quantifying green spaces. Monitoring these areas is important for change detection to ensure that landscape ecology principles are upheld. For the city of Madrid, VHR satellite imagery derived from WorldView-2 enabled a methodology to be established that takes into account NDVI as well as Fractional Vegetation Cover (FVC). These indices are used to cost effectively measure and monitor plant growth, vegetation cover and biomass production to provide ongoing information for both protecting existing green space and identifying new opportunities.

Population Dynamics

Uncontrolled urbanisation leads to a multitude of problems within cities. This results in poor living conditions, severe issues with drinking water, noise, air pollution, waste disposal and traffic congestion. In limited resource environments, it is necessary to rapidly estimate population growth and density. Surface reflectance data can be extracted from satellite imagery providing data on vegetation, urban residential areas and non-residential areas. From this, pixel-based regression models can be created to predict land cover and determine the average dwelling size. Combined with census data, population growth and density can be estimated with high accuracy.



Road Networks & Infrastructure

Transportation systems are pivotal in rapid modernisation, particularly in developing countries. It is necessary to implement a strategic plan to avoid traffic congestion and pollution whilst ensuring interconnectivity of the population and ease of access to freight carriers. Insights into road patterns, width and alignment in addition to items such as dividers, sidewalks and gutters can be obtained from satellite imagery. When combined with land and parcel information, potential sites for new roads and rail infrastructure with the least environmental impact, can be determined.

IMPERVIOUS SURFACE ESTIMATION

Classification and identification with VHR Satellite Imagery

Written by Tobias Leichtle, German Aerospace Center (DLR)

The exponential increase of impervious surfaces for the establishment of settlements and transport infrastructure yields negative consequences in many domains, such as increased surface runoff and flood risk, decreasing groundwater recharge, or intensification of the urban heat island effect. Thus, exact and area-wide estimation of impervious surfaces is of high value and must be repeated regularly in order to provide up-to-date information.

In urban environments, image analysis is challenging since different surface materials are concentrated in a heterogeneous and highly complex manner. In this context, VHR imagery with 50 centimeters, or better, spatial resolution enables proper recognition and identification of individual objects. This allows the classification of pure pixels with regard to imperviousness, which is realized in an object-based image analysis (OBIA) approach. Subsequent to geo-referencing, atmospheric correction as well as radiometric enhancement, spectral, textural and contextual features are calculated based on a multi-resolution segmentation via eCognition software.

These features are fed into a transferable knowledge-based classification tree in order to identify land cover with respect to different surface materials and subsequent binary classification of pervious and impervious surfaces.

Pervious Surface Impervious Surface

CONCLUSION

Seeing The Big Picture From Space

By remotely sensing from their orbits high above the Earth, satellites provide us with much more information than would be possible to obtain solely from the ground.

In particular, Very High Resolution satellite images offer a unique view of what lays in, on and around urban and rural settlements. It provides a cost-effective and simple method of monitoring wide areas both locally and globally, as opposed to using in situ data, and is an indispensable tool for managing the actions and events that impact urbanisation leading to urban sprawl.

From this data you can gain insights into population growth and density, building typologies, slum detection, development site suitability and so much more. The data extracted from satellite imagery is integral to the creation and updating of urban maps to detect major changes in urban land cover and land use and ensures accuracy of cities for key decision makers.

The Future of Satellite Imagery

In recent years there has been a surplus of satellite imagery available. Advances in technology have seen data analytics leverage the power of Artificial Intelligence (AI), cloud computing and machine learning.

These advances have a huge potential to disrupt traditional business and provide enormous benefits in the long term. Ultimately the future lies in cloud based multi-source data platforms that have high powered analytics integrated within. SecureWatch is an example of a satellite imagery platform incorporating features pertinent to Earth Observation and providing the user with a tremendous array of analytical tools at their fingertips.

In the past we only had traditional methods of ordering imagery from Earth Observation companies, however the future of satellite imagery lies in the cloud – that is delivery of images via web browser or API.

This interface provides the user with instant access to satellite imagery that can be immediately analysed and manipulated. This is especially important for time sensitive projects. Of course, there will always be a need for traditional data ordering whereupon a project has specific needs and requires direct satellite tasking.

Arming yourself with the right tools is the first step for any urban, city or land planner and one of those tools should be VHR satellite imagery.

About European Space Imaging (EUSI)

Since the launch of the first commercial VHR satellite, we at EUSI have committed ourselves to providing much more than the world's highest quality satellite imagery.

We provide solutions. Utilising our multi-mission ground station at the German Aerospace Center, the team of geospatial experts at EUSI are able to bring together unique partnerships, innovative techniques and tailored services to achieve results for any project.

European Space Imaging GmbH
Arnulfstrasse 199
80634 Munich
Germany

+ 49 089 130 1420
info@euspaceimaging.com
www.euspaceimaging.com