Applications of Earth Observation

Data | Information | Knowledge

SURREY
SATELLITE TECHNOLOGY LTD

Table of contents

▸ *Satellite derived data is becoming critical in many modern and emerging economies. It assists in developing robust policies and then evaluating their effects compared with the cost benefits.*

▸ *Satellite ownership is important for economic growth and national security. Ownership ensures operational independence, privacy and priority in the security of the country.*

▸ *Develop space technology and derived products for export by either owning an imaging spacecraft or owning the imaging capacity.*

South Aral Sea.

Introduction

It is accepted and proven that Earth observation information gathered from spacecraft provides substantial benefits supporting economic development and supports informed policy and decision making.

Earth imaging satellite owners are afforded a unique capability for underpinning national technical developments and capacity building in many different areas. This capacity building may exist across the spectrum of activities from operating a satellite through to providing information products that are used by policy and decision makers for economic growth, environmental management, emergency management and security applications. Satellite ownership allows for full visibility and control of the system in support of specific organisational priorities.

Spatial resolution describes the level of information in an image and a higher resolution means increased image detail. Resolution can be measured in various ways and there are some basic differences between aerial photography and observations collected from space. These differences help illustrate the value of satellite imagery.

In contrast to aerial photography, satellite images typically have a lower spatial resolution that is accompanied by vast area coverage. This large area coverage can allow for hundreds of thousands of square kilometres to be captured in a single image. These large images can be put together so that an image map of an entire continent can be regularly updated and recent changes in land cover automatically highlighted using computer software.

Satellites have a far wider range of resolutions than aerial imagery, from tens of centimetres up to kilometres, depending on the applications. As a general guide, very high detail images (1m resolution or less) can cover areas of 20km east to west and thousands of kilometres north to south. Medium detail images (15m resolution or more) can have a width of 600km east to west and thousands of kilometres north to south.

Standard spatial resolution for Earth observation satellites are:

▸ medium-resolution visible imagery
(10m to 100m resolution)
▸ high-resolution visible imagery
(2m to 5m resolution)
▸ very-high visible imagery
(sub 1m to 1.5m resolution)

▸ *38% of the world's land is used for agriculture.[1]*

▸ *1 in 3 people work in agriculture worldwide.[1]*

▸ *70% of world water withdrawal is used for agriculture.[1]*

▸ *World production value US$3.269.477 million.[1]*

Agriculture

Satellite imagery is regularly used for agriculture and is growing in popularity, providing data to enable economic and environmental benefits to farm management processes. Satellite imagery can improve revenue generation for agricultural applications by providing information related to:

▸ Crop health monitoring and management
▸ Crop type
▸ Crop insurance damage assessment
▸ Production management practices
▸ Fertiliser application requirements
▸ Yield estimates
▸ Re-growth monitoring
▸ Illicit crop monitoring

▸ Pest and invasive species monitoring
▸ Irrigation requirements and application
▸ Field boundary management
▸ Field scale mapping
▸ Monitoring agri-environmental measures (e.g., acreage) to inform subsidy allocations
▸ Assessing storm damage

Precision farming

Precision farming combines GPS technology with satellite imagery to enable farmers to apply fertiliser more efficiently and reduce overheads. Farmers can target resources to where they are needed and reduce excess resources being expended on healthy field areas. The reduction in fertilisers and pesticides results in both economic and environmental benefits.

Rapid revisit imagery acquired over agricultural areas during variable crop growth cycles is analysed and delivered to farmers online, providing field level services such as leaf area index (LAI) and nitrogen application maps.

▸ *Increases crop yields and reduce farming costs.*

▸ *In the UK there is an average £27 cost reduction per hectare and a 3% to 8% increase in crop yield when imagery is used to guide fertiliser applications.[2]*

▸ *The Allen study estimates that Australia could see a national benefit of A$ 152-206 million ($155-210 million) for agriculture, which could rise to A$1005-1357 million ($1-1.3 billion) by 2030 if a nationwide Global Navigation Satellite System (GNSS) network is established.*
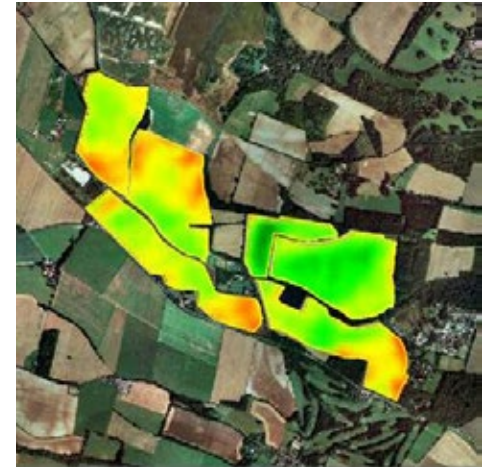
Crop health mapping

Nearly all crops can be assessed for their health using satellite data. The images here show an area on the outskirts of Bangkok that is largely covered in small rice paddies at various different growth stages. The Normalised Differential Vegetation Index (NDVI) classification can be used to monitor the growth stages.

NDVI has been shown to be proportional to the amount of chlorophyll that is found in vegetation. The volume of chlorophyll changes as the crop grows and as the crop health changes. By using a simple NDVI to monitor the chlorophyll content through the growth cycle, the producer can pinpoint areas of concern and apply fertiliser and water appropriately. The biggest cost savings are found when fertiliser application is targeted to areas that show a need.

The first analysis is to take a normalised ratio of the Red and Near Infrared bands to give the NDVI values. The healthy areas are then mapped according to their relative NDVI values, which gives a crop health map.

Many other uses of this data exist, including building water consumption models and mapping and monitoring pest hazards and crop blight.

▶ *Rice is the world's most important staple food crop and demand is due to more than double during the next two decades.*
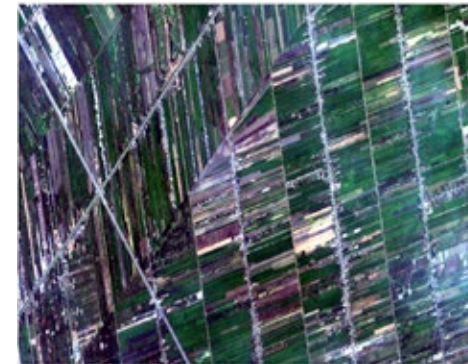
▶ *More than 1 billion people depend on rice production for their livelihoods.[9]*

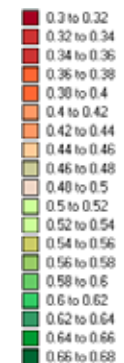▶ *By not fertilising areas that are growing well, money is saved on fertiliser.*

▶ *Increase crop yield and quality by better managing problem areas.*

▶ *Health mapping can warn about food shortages.*

▶ *Health mapping can estimate crop yields and anticipate crop sales prices.*

2.5m pan sharpened RGB and NIR image of an area in the outskirts of Bangkok. RGB bands displayed.

0.3 to 0.32
0.32 to 0.34
0.34 to 0.36
0.36 to 0.38
0.38 to 0.4
0.4 to 0.42
0.42 to 0.44
0.44 to 0.46
0.46 to 0.48
0.48 to 0.5
0.5 to 0.52
0.52 to 0.54
0.54 to 0.56
0.56 to 0.58
0.58 to 0.6
0.6 to 0.62
0.62 to 0.64
0.64 to 0.66
0.66 to 0.68
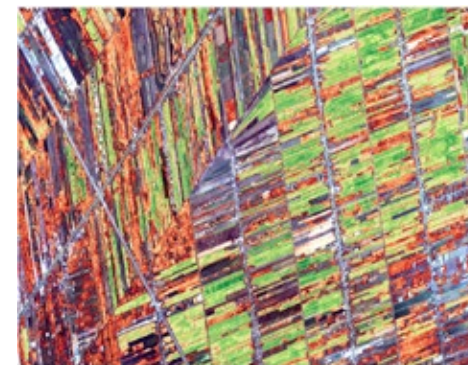
Vegetated areas categorised according to NDVI.

Crop pests

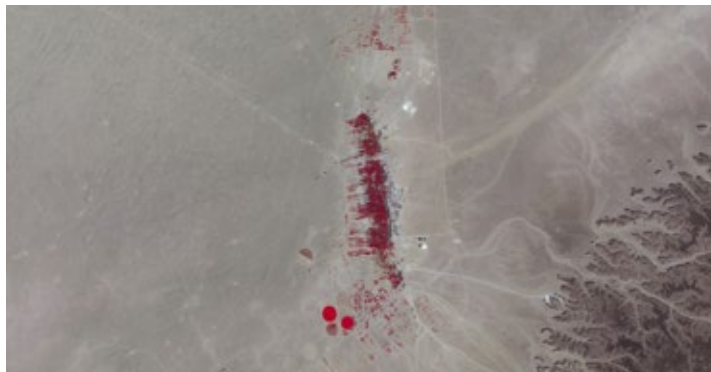Plagues of locusts that destroy crop yields cause stark devastation and threaten food security across North Africa every year.

Multispectral satellite images can help to predict the location of the locusts' breeding grounds accurately, where the swarms have been and where they are most likely to go. For example, the red areas in the images here indicate healthy vegetated areas that are potential targets for locust feeding.

Each swarm can contain billions of locusts, and each one can eat its weight in food every day. This makes for a devastating effect on crops, as they can strip whole fields in minutes.

Algeria.
Copyright: UK-DMC2 satellite image© [2013]
SSTL, all rights reserved, supplied by DMCii.

▶ *Creates pest forecasts.*

▶ *Focus the application of pesticides to reduce pest impact and stop swarms.*

Illicit crop monitoring

High-resolution satellite imagery is used for the survey and identification of illegal crops such as opium poppy cultivation. Opium production is an increasing problem for law enforcement agencies due to expanding crops and increasing yields.

Imagery acquisition is programmed to coincide with forecast harvest and crop cycle events to reveal areas of cultivation. Satellite imagery enables accurate information to be determined concerning crop yield and annual change. This information is used to support enforcement, social measures and policy changes to help understand and control the production and distribution of illicit crops. The composite image of Afghanistan shown here illustrates how wide area images can be combined to monitor large areas. Information derived from these images can be used to inform national and international drug trafficking agencies.
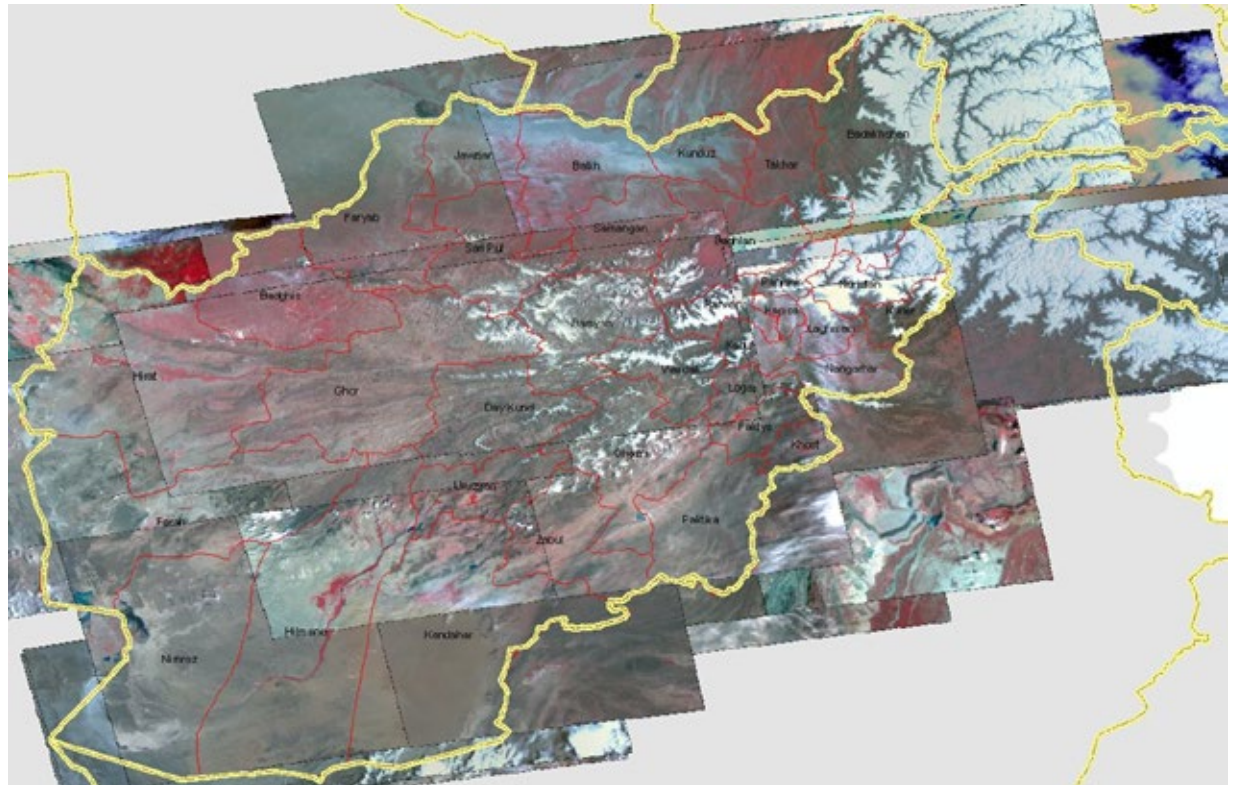
Composite image of Afghanistan used to reveal areas of poppy cultivation.

Forestry

High resolution imagery can complement wide area lower resolution imagery by providing more detailed information for:

- Obtaining information on forest acreage, stand density (the quantity of trees per unit area) and monitoring stand development (Stand - a group of forest trees of relatively uniform species composition, age, and condition to be considered as a single unit for management purposes)
- Surveying, evaluating and monitoring forest health
- Updating forest management plans: tree felling, delimitation and monitoring of parcels, biomass estimation, plant health and plantation monitoring
- Estimating fire, storm and other extreme weather damage
- Planning and protecting conservation areas
- Performing fuel analysis and identification of areas where the danger of fire is high
- Mapping of deforestation
- Monitoring of forest regrowth and conservation activities

- *In 2009 the formal forest's contribution to global GDP was estimated to be nearly US $468 billion.[14]*

- *Between 65-80% of the global population rely on medicines derived from forests.[14]*

- *More than 1.6 billion people worldwide depend on forests for food, medicine and fuel as well as for their livelihoods.[14]*

- *31% of land area is covered by forests.[1]*

- *Forests absorb greenhouse gas emissions, helping to mitigate climate change impacts.*

Forest stock mapping

Large area imaging enables the management of vast areas of forestry, building valuable historical data to monitor quality of stock, mitigate potential problems and plan future management programmes.

▸ **Reforestation, afforestation and deforestation**
▸ **Forestry management**
▸ **Degradation**
▸ **Logging road and logging concession**
▸ **Natural, artificial, illegal practises**
▸ **Species and growth stage monitoring**
▸ **Land tenure related to forestry concessions**

Wide area imagery from satellites is the best and most efficient way to accurately and regularly monitor vast areas of forest which cannot be surveyed from the ground - the tropics alone make up half of the Earth's land area.

Burn scar mapping

Fire damage estimation and the monitoring of fires is critical world-wide in providing:

▸ A detailed and up to date land cover map

▸ Risk maps which can be created based on the vegetation index

▸ Accurate mapping of burn scar extent

▸ Automatic evaluation of burn scar extents

▸ Detailed analysis using a land cover map to assess areas damaged

▸ Remediation effort which can be directed to prevent problems due to later erosion

California wildfires.
Copyright: UK-DMC2 satellite image © [2013] SSTL, all rights reserved, supplied by DMCii.

Illegal deforestation

Data can be successfully used for tropical forest monitoring and deforestation assessment. Wide area coverage drastically reduces the impact of cloud cover while radar satellites remove the issue of cloud cover common to tropical rainforest regions.
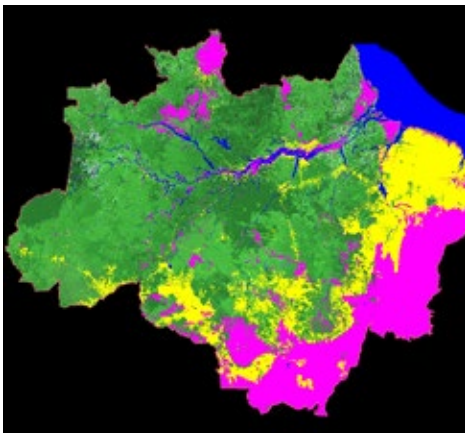
A summary plot of the Brazilian Amazon basin (Green = rainforest, Purple = old deforestation, Yellow = new deforestation).

▸ *The illegal logging trade is estimated to be worth between US $30 billion and $100 billion annually, with governments losing $10 billion each year in tax income.[4]*

▸ *Deforestation affected an estimated 13 million hectares per year between 2000 and 2010; net profit loss was 5.2 million hectares per year, due to afforestation and natural expansion.[1]*
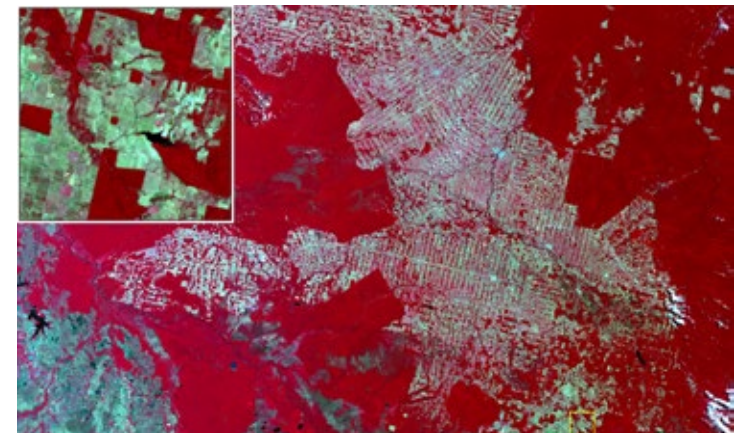
False colour image of typical herringbone pattern deforestation, the image depicts a subject in colours that differ from those a full-colour photograph would show. The picture highlights the difference between green tree cover (shown in red) and forest floor (turquoise).

Risk management

Continental scale mapping

Management and conservation of the countryside, the environment and in particular land ownership, is a key component of government policies. Regularly updated comparison maps supporting land use and environmental monitoring are integral tools in this process. Example applications include:

▸ General land use monitoring
▸ Urban growth evaluation
▸ Telecoms clutter analysis
▸ Change detection
▸ Infrastructure planning

Sub-Saharan Africa is a vast and diverse landscape with climatic extremes ranging from arid Ethiopian desert to the Congo rainforest. Satellite imagery is an invaluable tool for monitoring region-wide changes in land use and the environment.

Tropical forests present specific challenges as they are frequently obscured by cloud, which a single satellite may take many years to map. Solutions to this issue can be provided with a constellation of optical Earth observation satellites, or by the use of a Synthetic Aperture Radar (SAR) satellite, which will image through cloud and at night, providing 24 hour coverage. For the first time, annual and seasonal tropical forest maps are available, providing vital information for monitoring of forest carbon resources for the United Nations collaborative programme on Reducing Emissions from Deforestation and forest Degradation (REDD).

Panchromatic image of the Dubai skyline including the Burj Khalifa, which is currently the world's tallest building.
Copyright: NigeriaSat-2 Image © 2012 [NASRDA] all rights reserved.

Urban growth

Urban growth can create problems that include flooding, increased demand on public services and pressures on emergency services for disaster planning.

Satellite imagery provides valuable data to monitor urban growth through the use of regular snapshots. The imagery is combined with flood models in catchments prone to flooding, along with soil models, digital elevation model and precipitation data. This data can be used with census information for population growth models.

▶ **Rainwater runoff and flood risk**
▶ **Demands on public services**
▶ **Planning control**
▶ **Monitoring urban growth**
▶ **Monitoring population via census**
▶ **Estimating population growth**
▶ **Monitoring unplanned developments**
▶ **Providing rapid casualty estimates after disaster**

Soil sealing

Soil sealing is the covering of the soil surface with impermeable layers of materials such as stone and concrete used for increasing housing and infrastructure. This causes irreversible loss of the soils natural functions which can lead to floods as water can no longer drain away and cities are increasingly affected by heat waves due to lack of evaporation in the summer.

▸ *By 2050, 70 per cent of the world's population is expected to live in urban areas, two thirds of this in low and middle income nations.[6]*

▸ *An area the size of Cyprus is paved over every 10 years.[15]*

▸ *Each year an estimated 24 billion tonnes of fertile soil are lost due to erosion in the world's croplands.[8]*

▸ *The European Commission's Joint Research Centre estimates that four million tonnes of wheat are potentially lost every year to soil sealing.*

Area of Adelaide with various land cover types, 2.5m RGB image.

1: Salt Pan
2: Forest
3: Wetlands
4: Urban/Infrastructure
5: Parks
6: Soil
7: Water

Land classified using image processing software.

Land cover classification

Land can be classified into categories which enable us to learn about its relative uses and monitor its changes over time. This is useful for many different applications, for example mining and resource extraction monitoring, measuring deforestation, land cadastre and planning regulations.

The analysis revolves around a characterisation of the land in all available spectral bands, in this case Red, Green, Blue and Near Infrared and arranging them into groups to give clear identifiers.

▶ *The global community is losing up to 5% of total agricultural gross domestic product (GDP) due to land degradation, costing some USD $490 billion per year – according to a recent study titled The Economics of Desertification, Land Degradation and Drought: Methodologies and Analysis for Decision-Making.*

Disaster monitoring

Timeliness of data and the ability to task satellites quickly is critical for disaster relief efforts, meaning priority imaging to allow rapid response. Having nationally owned assets allows priority to be given to imaging requests which allow a much faster revisit time for affected areas.

Coastal flooding in Thailand.
Copyright: UK-DMC2 satellite image© [2012] SSTL, all rights reserved, supplied by DMCii.

▸ *More than 226 million people globally are affected by disasters associated with natural hazards every year.[6]*

▸ *Economic losses regularly exceed $100 billion annually and are projected to double by 2030.[6]*

▸ *Weather related disasters comprise about 81% of all events, causing 72% of all economic losses and 23% of fatalities.[6]*

▸ *By 2050, 70% of the world's population is expected to live in urban areas, two thirds of this in low and middle income nations. Much of this growth is taking place in locations already prone to earthquakes, cyclones, floods and droughts.[6]*

Flooding

Being able to monitor soil moisture, water levels and changes to these over time gives a good indication of how likely flood and drought risks are. This can be done through a combination of Digital Elevation Modelling from high fidelity interferometric Synthetic Aperture Radar (SAR) measurements and also utilising S-band SAR, medium resolution optical imagery and ground truth measurements to identify changes in levels. Being able to combine this with detailed weather predictions to understand the likelihood and expected level of rain allows identification of potential threats from flooding and also drought.

The ability to provide rapid mapping of areas affected by disasters is also critical for safety of life and rescue operations. It allows relief efforts on the ground to be targeted, routes through affected areas to be identified and help to be directed to areas which most need it.

SAR data is very useful for flood management due to its ability to image through cloud, a common occurrence in flood risk areas. The main information required includes flood extent, to allow immediate assessments of the areas at risk and aid decision-making for relief and cleanup operations. Flood risk maps may also be produced, showing potential economic losses and the spatial distribution of damage potential, and historical mapping of flood events can be provided using an archive of SAR data.

Water covered areas are detected in SAR imagery due to their darker appearance hence change detection techniques can be used to detect flooded areas.

Maritime
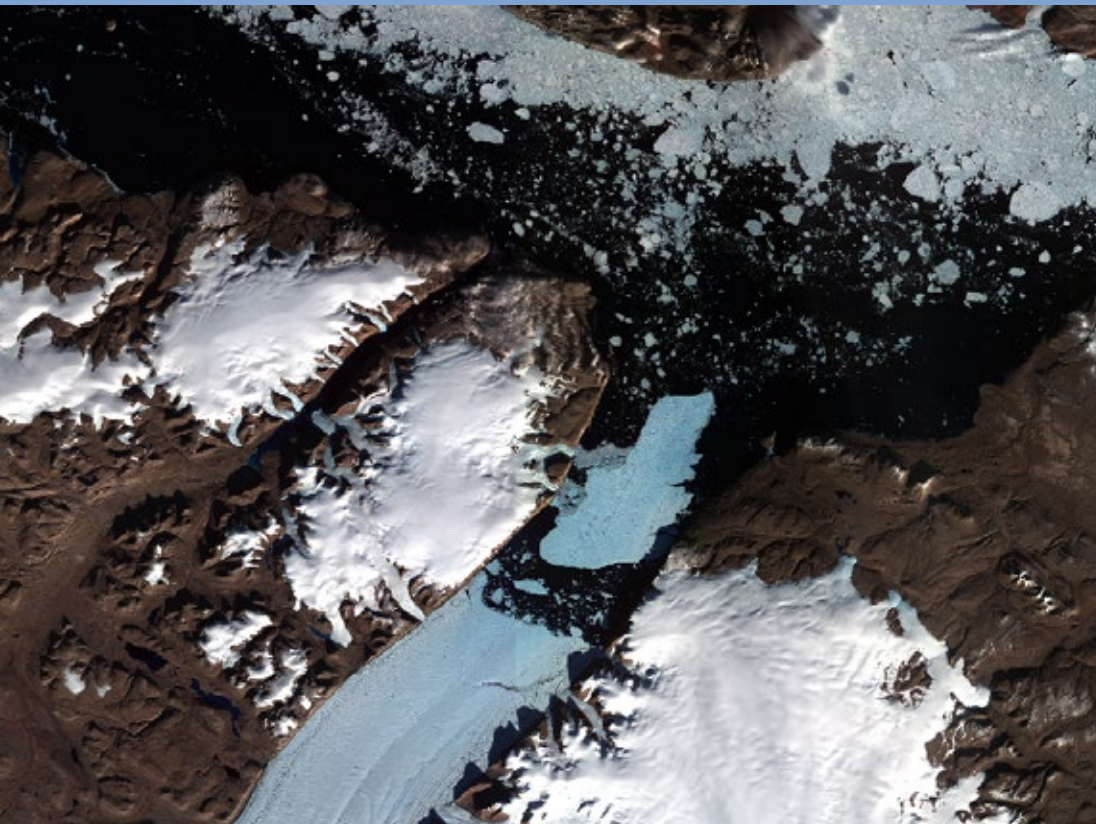
Satellites help keep our seas safe

▸ Ship tracking

▸ Bathymetic data - used for measuring beach erosion, subsidence, sea levels, construction of harbours and for creating nautical charts

▸ Detection of iceberg threats on shipping routes

▸ Marine environmental protection

▸ Oil spill monitoring

▸ Illegal oil discharge detection

▸ Detection of unlicensed fishing vessels

▸ Port monitoring

▸ Maritime piracy - detection of incoming inhospitable objects

▸ *Oceans cover 70% of the Earth's surface and contains 96.5% of its water.*

▸ *The Arctic Ocean produces up to 50,000 icebergs a year.[13]*

▸ *95% of oceans are unexplored.*

▸ *The total length of the world's coastlines is about 315,000 miles which is enough to circle the Equator 12 times.*

Ship detection

Both radar and optical imagery are helpful for monitoring maritime activity and ship detection. Using Automatic Identification System (AIS) signals and tracking applications, the flexibility of these Earth observation systems will allow ships, boats and other vessels to be detected, classified by type and their movements monitored. Specific capabilities include:

▸ Detection of ships involved in oil product spills and violation of environmental law including tank flushing at sea

▸ Detection of illegal ships (not sending AIS signals) including those engaged in illegal fishing, transportation of illegal immigrants, drug trafficking or piracy

▸ Detection and monitoring of vessels in distress and those with malfunctioning navigation equipment

▸ Monitoring of maritime traffic in ports and high traffic regions to support shipping traffic management and defence applications

▸ Fisheries monitoring

▸ Monitoring shipping traffic around offshore oil operations

Spaceborne Synthetic Aperture Radar (SAR) is an invaluable tool for detecting and monitoring maritime traffic particularly as it can image at any time of the day or night and through cloud cover. As well as detecting ships it is also possible to derive additional information such as speed and heading and, depending on resolution, broad class of ship. Uses for ship detection information include law enforcement, including enforcing legislation regarding fishing activities, environmental protection, search and rescue, ship traffic monitoring as well as customs and excise activities such as stopping illegal smuggling activities.

The optical image above shows high maritime traffic in Singapore's harbour.

▸ *At least 90% of the volume of global trade is seaborne.[5]*

▸ *There are 4.4 million fishing vessels in the world.[1]*

▸ *60% of fish trade originates from developing countries.[1]*

Oil slick from a grounded boat.   *Example of oils slicks in Synthetic Aperture Radar (SAR) imagery.*
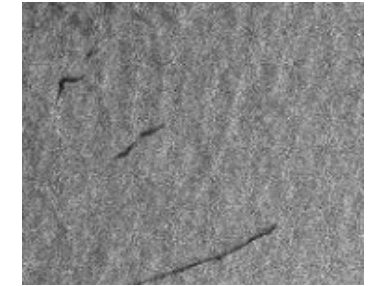
Oil spill monitoring

Several million tonnes of oil are spilled into the world's oceans each year. The detection and monitoring of oil slicks on the sea surface is a capability needed by most sea faring and coastal nations for enforcement of maritime pollution laws and identification of offenders, support to clean-up and control activities, oil spill detection from remote pipelines and the detection of oil seepage from ocean floors indicating possible new oil fields. Oil slicks are detected in Synthetic Aperture Radar (SAR) images as they appear darker than oil-free areas.
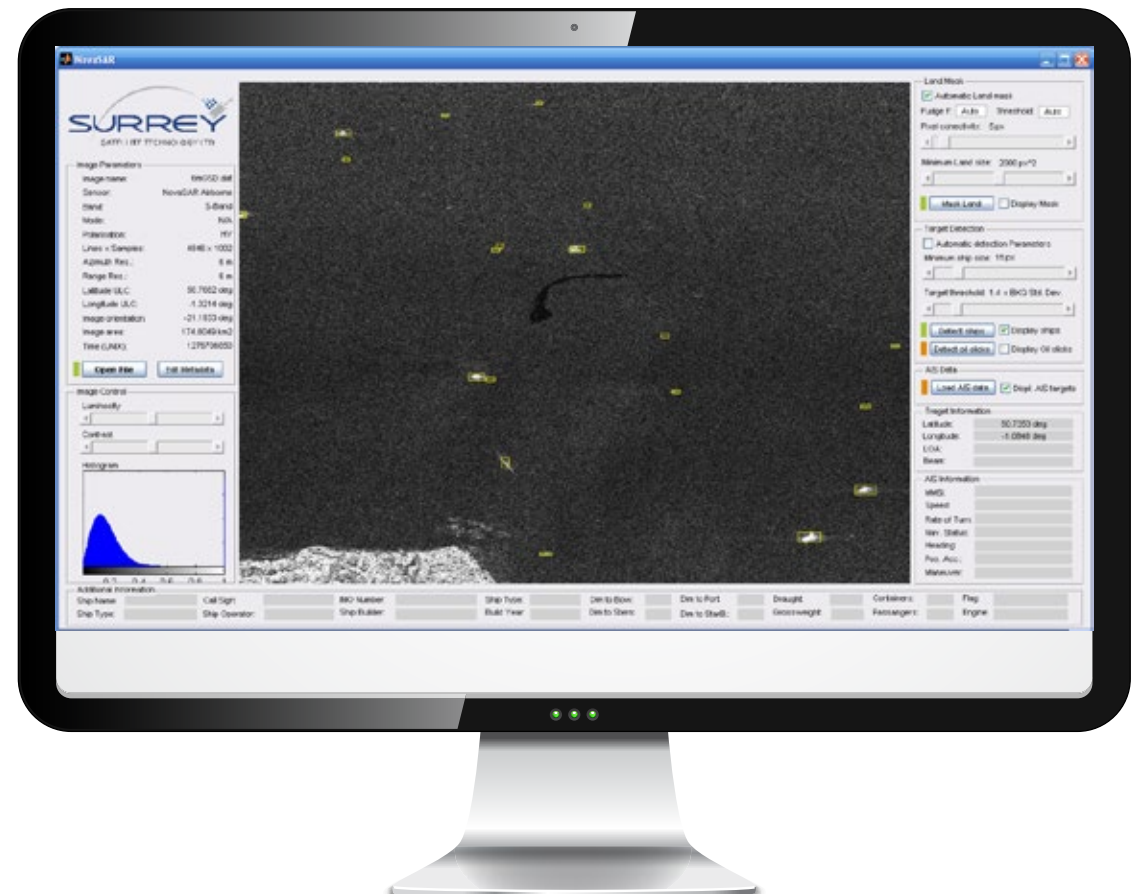
The image to the right shows the detection of a simulated oil spill using SAR data combined with Automatic Identification System (AIS) data. The ship tracks derived from the AIS data have been displayed to assess which ship may have been the cause of the incident.

Hydrology

Hydrological survey is critical to the understanding of a territory's coastal zones and inland waterways. The use, consumption and distribution of water resources can be monitored through the use of imagery. Manual surveys are labour intensive and rarely offer a complete overview of the resource in question. Automated sensors are important to monitor single points in waterways, levels at gauges and points of critical concern. However, they don't provide data elsewhere and can suffer in remote areas from a lack of connectivity and power. There is therefore a role for Earth observation from space. Additionally, it is possible to monitor agricultural water use and wastage and take accurate measurements of soil moisture from space.

Satellites offer a method to routinely and regularly survey water resources for operational or research projects. Cross-border issues are often of key concern to policy makers. The use of satellite imagery provides an impartial and comprehensive surveying method.

Some satellites measure the precise height of the water level, others measure the soil moisture level directly. By looking at the water use of farms and the amount of crops grown, it can be seen how much water is wasted. The fertiliser that runs off these farms can be monitored as it causes algal blooms in inland waterways, starving fish and other inhabitants of oxygen.

Coastal and tidal zones subject to regular changes due to meteorological influences can be of concern. Utilising the technical capabilities of satellites, information may be derived such as shallow water depths, topology of mudflats or presence or absence of outflow or sediments. In coastal zones, satellite imagery provides information on the changing bathymetry, which can be particularly useful around ports and busy shipping areas. The surveys that can be undertaken from space give a regular accurate overview.

▶ Flood extent
▶ Inland waterways
▶ Coastal zone
▶ Shallow water bathymetry
▶ Tidal plain
▶ Water levels
▶ Ice floe
▶ Iceberg movements
▶ Glacier and lake monitoring

Defence and security

Imaging capability supports nations wishing to better understand and police their borders, coastlines and assets. From tracking illegal shipping to identifying illegal immigration routes, being able to monitor the flow of people and goods into and out of a country supports good policy making.

▶ Mission planning and situational awareness through up to date mapping of sites of interest and surrounding environment

▶ Analysis and monitoring of key sites and installations of interest e.g. weapon storage, airfields and hangers, ports

▶ Detection, recognition and identification of military vehicles, particularly aircraft and naval vessels including
  - identification of aircraft
  - detection of radar and surface to air missile emplacements
  - differentiation of tracked and wheeled vehicle types
  - identification and analysis of maritime vehicles

▶ Identification of specific infrastructure, such as railways and control towers.

Space based imaging allows the collection of information during day or night, and in all weather. This allows the steady collection of information to understand short, medium and long term behaviour of the subject of surveillance. For rapid information collection, time critical images can be acquired, using the spacecraft agility to image as quickly as possible.

Once imagery is acquired, automated image processing is carried out. This can, for example, pick out all the aircraft in an image with great speed, or analyse imagery to spot targets with unexpected spectral signatures. When a time series of imagery is combined, the changes between images are quickly identified to focus the attention. When combined with the existing information sources, such as human intelligence, this offers a powerful information tool.

Satellites provide a force multiplier to defence and security operations. The data derived enables governments to focus efforts where they are most needed. Earth image data from satellites allows operators to pinpoint the most likely targets of interest and to deploy land, marine and air forces to the right places instead of searching vast areas using aircraft or land vehicles with their significant associated human resources.

London Heathrow Airport.
Copyright: NigeriaSat-2 satellite image© [2013] NASRDA,
all rights reserved, supplied by DMCii.

Natural resource management

Water resource management

Efficient resource management of water is essential to ensure that an adequate supply of freshwater is available for all users in the future. Earth observation satellites provide the benefit of improving the knowledge of freshwater supply and assist in the management of the distribution of water to users. One particular common use is to determine the rate of evapotranspiration in irrigated agriculture. This increases the efficiency and productivity in agricultural usage of water, which frees up availability of water for other sectors such as municipal and industrial uses. Satellite imagery can effectively be utilised to detect groundwater regions.

It is very apparent that both satellite derived data and geographic information systems are ideal tools for aiding authorities with the resource management of water. Satellite imagery should range from high to medium resolution within the visible and near infrared bands with regular revisits to be of use for water resource management.

▶ *By 2030, the demand for food, energy and water is expected to increase by at least 50%, 45% and 30%, respectively.[8]*

▶ *The World Health Organization estimates that if half of the global households that still use traditional fuels and stoves switched to cleaner cooking sources, over a ten year period families would save $34 billion per year and generate an economic return of $105 billion per year.[11]*

▶ *The International Energy Agency (IEA) estimates that if countries focused on boosting energy efficiency, they could not only provide a 10% reduction in global energy demand by 2030 but also save $560 billion.[12]*

Energy infrastructure optimisation

Efficiency gains that can result from information provided by advanced imagers and sounders can result in savings that can be passed to the consumers or used to improve infrastructure.

The efficiency gains are made by being able to provide the required resource that is demanded and ensuring that excess is not wasted. Energy providers rely on demand models to forecast electricity production and natural gas requirements. These demand forecasts are heavily driven by temperature forecasts. Earth observation data have the capability to improve temperature forecasts which in turn improve demand forecasts leading to energy industry savings. More accurate forecasts lead to improvements in production and distribution of energy and require less product to "be available", thereby lowering costs.

Similar to the electricity companies, the gas transmission companies rely on accurate demand forecasts, based largely on temperature forecasts. By looking at the annual natural gas volume used, estimates can be made regarding the extent to which more accurate forecasts can reduce unnecessary movements, and hence cost, of natural gas transmissions.

> ▸ *Satellite imagery is valuable in providing detailed maps of areas of interest including land cover classification, vegetation type and soil utilisation but also for planning of infrastructure such as roads, workers accommodation and access to refineries, ports and pipelines.*

> ▸ *Monitor assets such as pipe lines and platforms that would be expensive if a ground crew was sent, especially useful in remote areas.*

Oil and gas

▸ Broad area mapping

▸ Infrastructure management

▸ Environmental monitoring and safety

▸ Disaster response

▸ Visualisation and simulation modelling

▸ Seismic layouts

▸ Pipeline routing

▸ Locating assets

▸ Change detection

▸ Facility security

Some of the most popular applications for oil and gas include iceberg monitoring, which improves shipping safety. There is also a need to spot leaks and spills of oil in the maritime domain. Slicks and spills are monitored over huge areas of ocean using radar satellites. The oil flattens out the surface of the ocean, which can be seen in satellite imagery.

The requirements of oil and gas operations also share some similarities with security requirements. When working in remote, unforgiving areas, services from satellites can help improve safety.

South Wales oil refinery - Airborne SAR image – 3m resolution.

Mining

Mining is a high investment, high risk and usually strictly regulated industry that requires timely and accurate geospatial data. Imagery, used in mining to plan exploration, perform daily operations, ensure environmental compliance and complete land reclamation, clearly reveals extraordinary detail about the true landscape of the Earth.

▶ **Exploration and mapping mineral deposits**
▶ **Environmental survey of surrounding area**
▶ **Planning for mining sites and associated communications infrastructure**
▶ **Planning for rehabilitation of area for public use**

Imagery helps mining professionals identify, analyse and act on geological data, and reduces the time and resources required to find, mine and recover the resource site. Existing vegetation, hydrology, population centres, soils and infrastructure are easily mapped using satellite and aerial imagery; and evaluating before and after images show progress, boundary compliance and restoration needed to return the site to pre-mine health. Because imagery eliminates much of the onsite field study previously required for day to day and follow up operations, the industry gains valuable insight and efficiencies about investments and operational impact, while enjoying significant cost savings.

Satellites can image anywhere in the world, even in remote, mountainous and hostile areas that would otherwise be costly to research. With high resolution satellite imagery, geologists can detect and study multispectral images to analyse topographic surface features along with geological data to predict subsurface geology and understand where to mine.

Hibbing, Minnesota, USA.
*Copyright: NigeriaSat-2 satellite image© [2013] NASRDA, all rights reserved, supplied by DMCii.*

The city was built on the rich iron ore of the Mesabi Iron Range. At the edge of town is the largest open-pit iron mine in the world. The bright colours are the result of the concentrations of different ores found in the mine bottoms. Mines in this area were so large that entire villages were relocated to accommodate them.

Bisbee, Arizona, USA.
USA NigeriaSat-2 satellite image© [2013] NASRDA, all rights reserved, supplied by DMCii.

Surrounding Bisbee are the Mule Mountains, Sulphur Springs Valley, San Pedro River and Valley. The upper ridges of the mountains consist primarily of a very hard brecciate limestone. To the left of the Mule Mountains are Copper Queen Mine and the Lavender Pit, a large and very deep copper mine. There are currently no organised mining operations in the Mule Mountains.
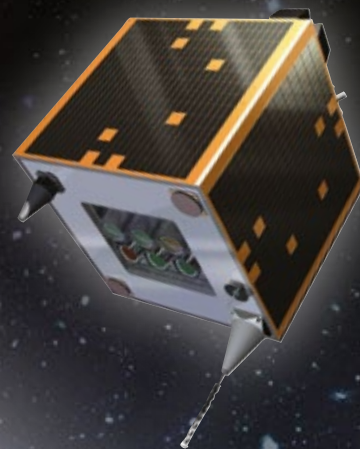
Medium resolution optical
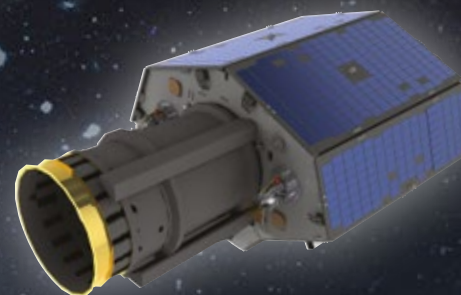
High resolution optical

Synthetic aperture radar

Example satellite solutions

Medium resolution (wide area) optical

Applications with short revisit times and medium spatial resolution requirements are efficiently serviced by wide area systems. These types of satellites combine wide area sensors (up to ~660km image width) with medium resolution (~20m) and long duty cycles to image the entire world every week. In areas with high presence of clouds the high imagery throughput allows composite cloud free images to be produced in shorter timescales.

The applications which wide area optical systems can address include mapping, urban growth monitoring, land cover management, land cover classification, monitoring of agriculture and forestry, monitoring ocean colour and disaster monitoring.

In particular wide area optical satellites could bring the benefits associated with improved urban and Infrastructure planning, desertification monitoring and water resource management.

High resolution optical

High resolution optical systems (<= 1m) can effectively service a wide range of civil applications whilst also supporting national security interests. Satellites providing high resolution imagery offer high data throughput, highly accurate image geolocation and the ability to manoeuvre the satellite to enable both faster revisits and the ability to image several different scenes within a single area of interest during the same pass.

Typical applications addressed by high resolution optical satellites include, but are not limited to, precision agriculture, forestry monitoring, urban and regional land planning, maritime security, infrastructure development and mapping, and disaster mitigation and monitoring.

In particular high resolution optical satellites bring benefits associated with border security and urban planning.

Synthetic aperture radar

The advantage of Synthetic Aperture Radar (SAR) satellites is their unique capability of imaging during day-and-night and through clouds. SAR imagery is suitable for a large and varied range of applications from wide area environmental monitoring to detailed assessment of specific target areas.

Development and implementation costs of traditional SAR technology can be prohibitive, which has restricted the number of nations who have developed such a capability in the past. Recently, however, advances in electronics technology have enabled a new generation of satellite SAR systems to be designed for a fraction of the traditional cost.

Typical applications for which SAR imagery is well suited include maritime applications, such as ship detection and oil slick monitoring, forestry applications (including deforestation monitoring), natural disaster management (such as flood monitoring and pest damage assessment), and agriculture and land use mapping and monitoring.

Sources:

[1] Food and Agriculture Organization of the United Nations, 2013

[2] SOYLsense

[3] Food and Agriculture Organization of the United Nations, 2009

[4] Space Technology and climate Change (OECD)

[5] IMO [2012] International Shipping Facts and Figures: Information
Resources on Trade, Safety, Security and the Environment

[6] TST Issues Brief: Climate Change and Disaster Risk Reduction

[7] European Commission

[8] TST Issues Brief: Desertification, Land Degradation and Drought.
The Technical Support Team (TST) is co-chaired by the
Department of Economic and Social Affairs and the United
nations Development Programme.

[9] Food and Agriculture Organization of the United Nations, 2014

[10] International Food Policy Research Institute, 2012. 2011 Global Food
Policy Report.

[11] UNDP, Achieving Sustainable Energy for All in the Asia-Pacific, 2013

[12] TST Issue Brief: Sustained and Inclusive Economic Growth,
Infrastructure Development, and Industrialization

[13] National Geographic

[14] TST Issues Brief: Forests

[15] Global Monitoring for Environment and Security: Satellites pinpoint
the loss of natural soil
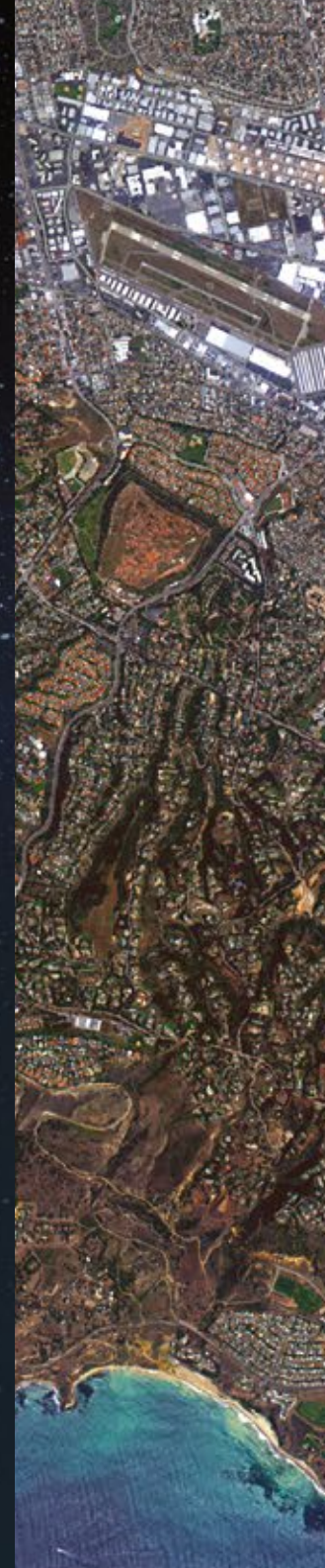
Richat Structure, Mauritania.

Applications | Innovation | Value

SURREY
SATELLITE TECHNOLOGY LTD

Changing the economics of space

Surrey Satellite Technology Ltd Tycho House, 20 Stephenson Road, Surrey Research Park, Guildford GU2 7YE, United Kingdom

Tel: +44 (0)1483 803803 | Fax: +44 (0)1483 803804 | Email: info@sstl.co.uk | www.sstl.co.uk