Use of QuickBird satellite data for natural, semi-natural and urban environments

Livio Rossi & Fabio Volpe  
Eurimage S.p.A., via D’Onofrio 212, 00155 Roma, Italy  
volpe@eurimage.com, rossi@eurimage.com, www.eurimage.com

ABSTRACT: With very high resolution satellites, it is now possible to carry out, using collected data from space, many applications that in the recent past were exclusive to airborne and on site surveys. Due to the high geometrical resolution, the multi-spectrality, the high radiometric sensitivity, the revisit capabilities, the wide area imaged by a single frame and to the accurate geometrical processing that can be targeted, QuickBird imagery is a key source of information for a wide range of applications related to natural, semi-natural and urban areas.

For example, a possible range of QuickBird applications in urban environment are: map generation and updating, road network extraction and updating, three dimensional vision, illegal building detection, real estate, utilities management.

In agricultural business, European decisions encouraging the use of remotely-sensed data for over a decade have been crowned with the mandatory inclusion of GIS techniques based on at least 1 metre ortho-photos or better. Very high Resolution satellite data (VHR) appears in this context as a valuable tool, besides cadastral maps or digital Land Parcels System.

Quickbird data if used in agriculture, forestry and environment projects, allow detection and growing monitoring, permanent and renewable resources identification. Moreover, updated VHR images permit an easier and more feasible cadastral overlapping.

New activities, such as archaeological research and coastal sea investigation can now be carried out at larger scale with VHR and Quickbird, adding new capabilities to the traditional territorial problems solving. It can be said that these data do not replace airborne, which remain an important tool for large/national areas and background preparation.

1 QUICKBIRD SATELLITE

The original digital data and the radiometric amplitude is one of the main sensor features, while resolution, multi-spectrality, swath, revisit time and products & services are the others differences in VHR imagery competition.

Very high resolution data is therefore changing the field of large-scale applications and local, national and international Agencies/Organizations can plan ahead to include this new tool to provide the best solutions to the user community.

Quickbird with its digital sensor can improve both the reference scale of applications and thematic results through:

- Up to 0.61 m resolution in panchromatic mode at nadir
- Up to 2.44 m resolution in multi-spectral mode at nadir
- simultaneous acquisition of pan and multi-spectral (ranging from 272 to 300 kmq)
• radiometric range of 11 bit (2048 levels of grey) instead of the usual 8 (256)
• wider panchromatic band towards infrared (ranging from blue up to 1 micron).

The last 2 improvements in particular allow a better spectral and radiometric analysis, cleaner visibility of the images and therefore better discrimination, reducing mistakes and project costs.

We can now apply the most important classic parameters of target analysis and interpretation to the Earth Observation sector, such as:
• tone and texture of objects rather than pixels
• shape (e.g. for trees, crown and pruning)
• object distances, position and geometry
• context analysis (e.g. different human activities)
• multi-spectral analysis of objects rather than pixels or pixel groups.

In addition, it is possible to:
• always have updated information
• select the best acquisition date (e.g. for phenological seasons in agro-forestry environment) for different areas and different purposes.
• Get cartographic accuracy up to 1:4/5.000 scale and thematic identification up to 1:1.000 scale.

2 INFORMATION EXTRACTION

The following list gives just some examples of the most important application opportunities, using Quickbird:

Agriculture
• Production status and trend (inventory and yield estimation)
• Production process management (field variability and crop vigour)
• Subsidy area control (field measurement and single crop identification), even to the point of almost avoiding ground surveys.
• Agricultural cadastral parcel updating (local taxes and subsidies)

Figure 1. Comparison, at the same high enlargement, between traditional analogue remote sensing data (left) and digital Quickbird imagery (right).
• Updating of permanent crop registers (olives, vineyards and citrus)
• Vineyard trend analysis and harvest management
• Crop damage assessment and mapping at parcel level, coming from hail, rain, pests, drought, wind storms
• Irrigation efficiency

The most important European Union budget is related to Agriculture. Arable land Subsidies Controls are mandatory for each country and are based on single farmer declaration. Subsidies are supplied for managing crop distribution and agribusiness market with the following aim:

• To avoid high crop stocking in EU
• To support market needs and requirements
• To decrease pollution derived by agriculture practises (by decreasing fertilizers use) paying subsidies for crop acreage and environmental conditions maintenance and not for production
• To promote set-aside practises in not suitable areas (marginal or not vocate) also avoiding soil erosion and soil overload.

Forestry

• Structure/typology maps
• Illegal logging (forest losses due to illegal harvesting)
• Local health analysis (up to single crown)
• Fragmentation index and mapping
• Contribution to fuel maps at large scale
• Health evaluation of surviving trees (post crisis/fire)

Forest mapping and inventory analysis appear the basic products for the correct management. Forest map gives information about the distribution of the wooded areas; forest inventory gives information about the quantity and quality of wood available for the market.

The information can be produced using remote sensing data such as satellite images at different resolution (up to larger scale using Quickbird), allowing the possibility to produce maps, such as:

• Area of forest and other land use and changes
• Area of afforestation, reforestation and deforestation

Figure 2. Quickbird in archaeology. All over the world, detection and measurements of buried finds show the useful capability of the sensor.
• Forest structure and changes
• Above ground biomass/carbon stock and changes
• Forest environmental indicators

**Cartography/cadastre**

• DEMs and city models (3D)
• Updating topographic maps (object positioning up to 1:4,000; thematic polygons up 1:1,000)
• Identifying cadastral parcels to be updated by traditional means (if the scale is larger than 1:4,000)
• Illegal building detection (not accessible or hidden zones)
• Infrastructure detection and monitoring (down to telephone/lighting poles)

Cadastral data provide largest scale information about the boundaries and details about the ownership, geographic extension and assessed value of each land unit.

Knowledge of rural territorial distribution, related ownerships, and the real value of land parcels is of paramount importance to support both the economic development of rural areas through private financing mechanisms and public subsidies.

The units are commonly referred to as land register parcels, cadastral parcels or as plots.

The plot/parcel relationship can best be depicted on the basis of high-resolution remote sensing data, such as ortho-photos.

**Environment/water**

• Fire impact evaluation for sensitive habitats and species
• Local wildlife habitat maps
• Freshwater and pollution in coastal ecosystems (11 bit permits penetration of shallow water)
• Coastline condition and changes (beaches, submerged vegetation, urbanization, oil on the shore, etc.)
• Coastal sediment transportation analysis
• Aquaculture and shallow water monitoring
• Inland water/wetland monitoring
• Waste deposit and quarry detection and monitoring
• Chemical holding tank failure monitoring
• Identification and quantification of air (sometimes water) pollution sources

Figure 3. Quickbird in forestry. The higher resolution, including the higher radiometric range are the strengthen points, beside the multi-spectral bands, for forestry large scale detection and monitoring.
Only sensors which acquire with native blue band and higher radiometric resolution can provide the user with the above information list.

**Land/urban management**

- Land use mapping at regional/local scale (thematic identification up to 1:800/1000 scale)
- Thematic and geometric support to Corine LC 4° level
- Soil composition and structural morphology (small areas)
- City parks management and monitoring (at single tree level)
- Contribution to design (and check) telecommunication networks (antenna positioning, wireless and cellular networks)
- Contribution to public service inventories

Managing a correct urban planning and rural development, taking into account the environmental sustainability, is a priority task of Public Administration at national and local level. All modern techniques for territorial marketing for local development are based on specialized land cover and land use maps.

These data-bases have to be always updated and at adequate legend and scale.

Existing European Corine land cover (all Europe, 1:100.000 scale, a same legend) makes a homogeneous natural and human resources distribution map available to all the EU Countries, but the Corine legend and scale are not appropriate for addressing operational plans. Larger scale and accurate classifications of land cover, or better land use maps are therefore needed. Land cover describes the territory, without entering into human activities, while land use gives information about the real “use” of the land portion by the inhabitants (e.g. water body is a land cover class, while fishing lake or hydroelectric basin are land use outputs). Using existing and new remote Sensing data and tailored ground surveys, land use mapping at regional/local scale is duly achievable and ready for development policy.

![Figure 4. The higher level of detail provided by Quickbird data allows urban environment mapping and monitoring, up to single tree, parkings or pedestrian crossing analysis.](image-url)
International treaties, public safety and health

- Clear picture of the situation for areas of limited media access (or denied areas)
- Compliance verification for international agreements (site inspection, etc.)
- Contribution to de-mines projects
- Information for humanitarian emergencies, tracking refugee movements
- Resource availability information for humanitarian response teams
- Management of industrial disasters

The above listed information, readily available and on GIS based, can become the main input of a lightened international/policy.

Risk management

- Flood boundary definition at large scale, for flood damage assessment
- Assessment of single landslides (without stereoscopic view) and natural damage (earthquakes, storms, floods, etc.): monitoring down to single building level
- Disasters management preparedness and mitigation efforts

The improvement of geo-morphological analysis, without stereoscopy, in addition to the steering acquisition of the sensor for catching all the scattered phenomena, make Quickbird and VHR powerful instruments for Geologic Departments and Civil Protections.

Transportation and services

- Transportation plan preparation (corridor studies: highways, railways, pipelines, etc.), road networks assessment and monitoring
- Electricity, telecom, water, oil & gas transmission and distribution corridors assessment and monitoring
- Road network extraction and evaluation (status, changes, markers, etc.)
- Digital database (e.g. TeleAtlas, Navtech) overlap for completing information

Archaeology

- Buried structures, excavation updating
- New archaeological plan, tourist parks

The 11 bit of Quickbird allow good investigation under the surface soil, also if crops are present, due to the possible detection of water stagnation and/or of the lack of water capillarity when a buried structure is present. The possible planning and acquisition of the data without censure or other limitation improves the value of such application.

Advertising and media

- Education & web
- Tourist maps and facilities; posters and background images

The satellite data finally go towards the single customer detail requirement.

3 CONCLUSION

QuickBird appears as the satellite that better fits these application requirements and, due to its geometrical resolution, is the best choice when a high detail is required. In order to allow the extraction of layers for a GIS, the ortho-correction of the imagery is to be obviously performed. By using commercial software, it is possible, with QuickBird, to reach accuracy even in the order of less of 1-meter RMSE. This way, the use of satellite for topographic mapping goes to the real detailed scale (up to 1:5,000/4,000). It must be considered, anyway, that more detailed scales can
be reached for thematic mapping. After the ortho-rectification, a quick image enhancement session, carried out with entry-level image processing software, enables the use of the satellite data within a GIS environment for the needed information extraction.

In general, the best situation for a complete detection of the above described targets, is to start from pansharpened images (natural or false colour data fusion at the pan resolution of 0.6 m) collected from March to November with a collection angle below 20°. The reachable thematic scale is depending on the requested specifications and geometric accuracy, but anyway it must be considered that QuickBird images can be used even with enlargements up to 1:1,000.

REFERENCES

Rossi, L. and Volpe, F. QuickBird, the application of very high satellite resolution for natural and semi-natural environments (in Italian) – VI ASITA Conference, Perugia 2002, pp. 1817-1822.