High Resolution Satellite Imagery
Applied to Oil and Gas Projects

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Content

- History
- Science
- Image Resolution and Coverage
- From Raw to Useful Data
- General Applications in Oil and Gas
- Four Case Studies
- Conclusions
• 1859 First use of photograph from balloon
• 1903-1909 Pigeons and Aeroplane carry cameras
• WW1 and WW2 gave great technical advances
• U2 planes gather images during Cuba Crisis in 1962
• 1968 Apollo 8 maps potential landing sites on the Moon
July 1972 NASA launched the first Earth Resources Technology Satellite (ERTS-1), aka Landsat

1985 Nimbus 7 Total Ozone Mapping Spectrometer (TOMS) discovers Ozone Hole

1986 Brazilian massive deforestation detected by Landsat

1991 Seven hundred Oilfield Fires in Kuwait from shuttle
BAND LOCATIONS FOR 30 METER AND BETTER SATELLITES

Satellite

\begin{itemize}
\item Landsat 7
\item IRS-C,D
\item SPOT-4/5
\item CBERS-1/2
\item QuickBird 1,2
\item OrbView-3,4
\item Ikonos 1,2
\item Terra (ASTER)
\item MTI
\item EO-1 Multispectral
\item EO-1(Hyperion)
\end{itemize}

\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline
Wavelength & 0.0 & 1.0 & 2.0 & 3.0 & 4.0 & 5.0 & 6.0 & 7.0 & 8.0 & 9.0 & 10.0 & 11.0 & 12.0 & 13.0 \\
\hline
\end{tabular}

\begin{itemize}
\item Broad Area Coverage
\item High Resolution
\item Multi/Hyperspectral Tests
\end{itemize}
**QuickBird Sensor Bands**

Wave Lengths in Micrometers

<table>
<thead>
<tr>
<th>Band</th>
<th>Wave Lengths</th>
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</thead>
<tbody>
<tr>
<td>Band 1</td>
<td>0.40-0.52 μm</td>
</tr>
<tr>
<td>Band 2</td>
<td>0.52-0.60 μm</td>
</tr>
<tr>
<td>Band 3</td>
<td>0.63-0.69 μm</td>
</tr>
</tbody>
</table>
Sensor Bands in RGB Slots

Band 3  
Red

Band 2  
Green

Band 1  
Blue
Merge Animation
Final Natural Color Composite
Final Near Infrared (NIR) Composite
Orthorectification is fundamental

- Image data is geometrically distorted
- Error sources: sensor construction, platform-induced, earth rotation, topography etc
- Image sensor is rarely in the nadir position
- Terrain displacement can be hundreds of meters
  - for example, if the satellite sensor acquires image data over an area with a kilometer of vertical relief with the sensor having an elevation angle of 60° (30° from Nadir) the image product will have nearly 600 meters of terrain displacement
- Additional terrain displacement result from errors in
  - setting the reference elevation, low elevation angles of images, imperfect terrain models, and variability of sensor azimuth and elevation angles
Satellite Systems Overview

- Optical, 26 in orbit, 25 planned
- Radar, 3 in orbit, 9 planned
- Two major resolution groups
  - 18 high resolution (0.5 to 1.8 meters)
  - 44 mid resolution (2.0 to 36 meters)
- Swathe coverage varies
  - High resolution from 8 to 28 kilometers
  - Mid resolution from 70 to 185 kilometers
- Four privately funded systems in orbit
  (3 US and 1 Israeli)
High Resolution Satellites

Chart showing the timeline and resolution of various high resolution satellites from 2003 to 2010. The chart includes satellites from different countries and their respective resolutions.
Image Resolution

Pixel Size (Resolution)

30 Meters

5 Meters

1 Meter

Pixel Output (Display)
Perennial cloud cover ~ Bora-Bora
Area of Interest ~ Nigeria
National Coverage ~ Iraq
Oil and Gas Applications

- Pre and post 2D/3D seismic surveys
- Recovery of old well locations
- Corridor mapping
- Landcover and geologic classification
- Environmental Impact Studies and Monitoring
- Site selection, construction and monitoring
- Facilities mapping
- Base mapping for project GIS
Example: 3D seismic planning
Example: Well Locations
Reasons for Mislocation of Wells

- Accuracy and reliability of original measurement systems
- Miscalculations and poor QC
- Error in transformation of co-ordinate systems
- Transcription errors
- Data entered wrong
- Transposing legacy data to new technologies
- Inadequate documentation
Example: Transition Zone operations
• Extracted culture: Chad, USA, Nigeria
• Regional geologic classification: Yemen
• Change monitoring by time lapse: USA, China
• 3D digital elevation modeling: Tunisia
Extracted Culture Data from Orthorectified 0.8m IKONOS Image
Extracted culture: Topography, Chad
Extracted culture: Tidal Wetlands, Nigeria

IKONOS Satellite Image data at 0.8m resolution

Landcover classification performed to identify wet areas. Results will vary because this area is affected by tidal changes.
Aster 15m Natural Color Composite
Aster 15m Geological Processing Composite
15m Geological Processing Final Classification
Landsat 30m mosaic with bathymetry
Time Lapse Use of Imagery
NAPP DOQQ ~17-Feb-1997 to IKONOS ~ 26-Jan-2003
Timeline Transition
Construction Progress
QuickBird 0.6m Satellite Image ~ CSPC Petrochemicals – Huizhou, P.R. China

December 15, 2003

July 18, 2004
Construction Progress Animation (7 Months)
QuickBird 0.6m Satellite Image ~ CSPC Petrochemicals – Huizhou, P.R. China
IKONOS 0.8 m with stereo extracted 1 m contours ~ Tunisia
6m Stereo Extracted Elevation Model ~ Tunisia
Conclusions

- High resolution satellite imagery currently produces up to 0.8 meter of image resolution with promise of 0.25 meter resolution during this decade.
- Accuracy is dependant on correct application of geodetic survey and mapping principles.
- Imagery can support a broad range of applications for geoscience and engineering purposes.
- Desktop use of imagery effectively saves time and money in planning, preparation and operations of field and office based projects.
• **Websites:**
  - satimagingcorp.com
  - digitalglobe.com
  - spaceimaging.com
  - terraserver.com
  - keyhole.com
  - rst.gsfc.nasa.gov
  (Remote Sensing Tutorial from EOS Goddard)

• **Google these:**
  - ASPRS Guide to Land Imaging Satellites
  - Satellite imagery/ images/ imaging/ photos
  - Google Earth
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