High Resolution Satellite Imagery Applied to Oil and Gas Projects

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Content

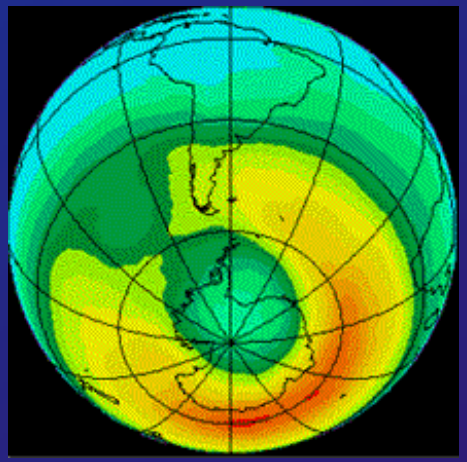
- History
- Science
- Image Resolution and Coverage
- From Raw to Useful Data
- General Applications in Oil and Gas
- Four Case Studies
- Conclusions

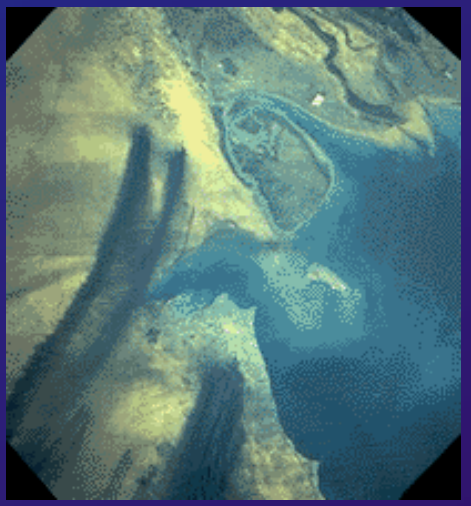
History

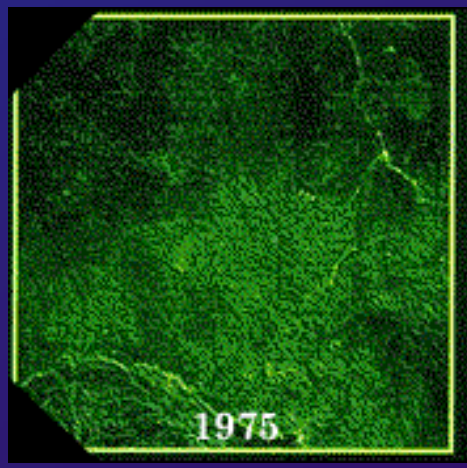
- 1859 First use of photograph from balloon
- 1903-1909 Pigeons and Aeroplane carry cameras
- WW1 and WW2 gave great technical advances
- U2 planes gather images during Cuba Crisis in 1962
- 1968 Apollo 8 maps potential landing sites on the Moon

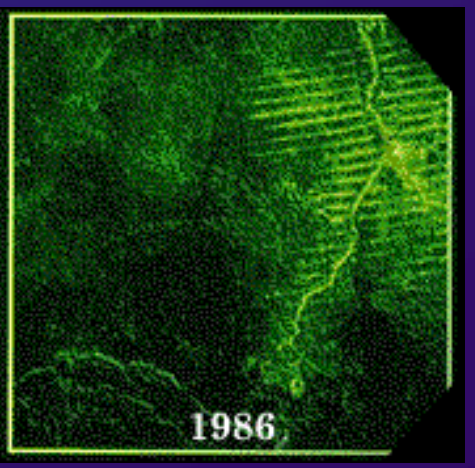
History

- 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

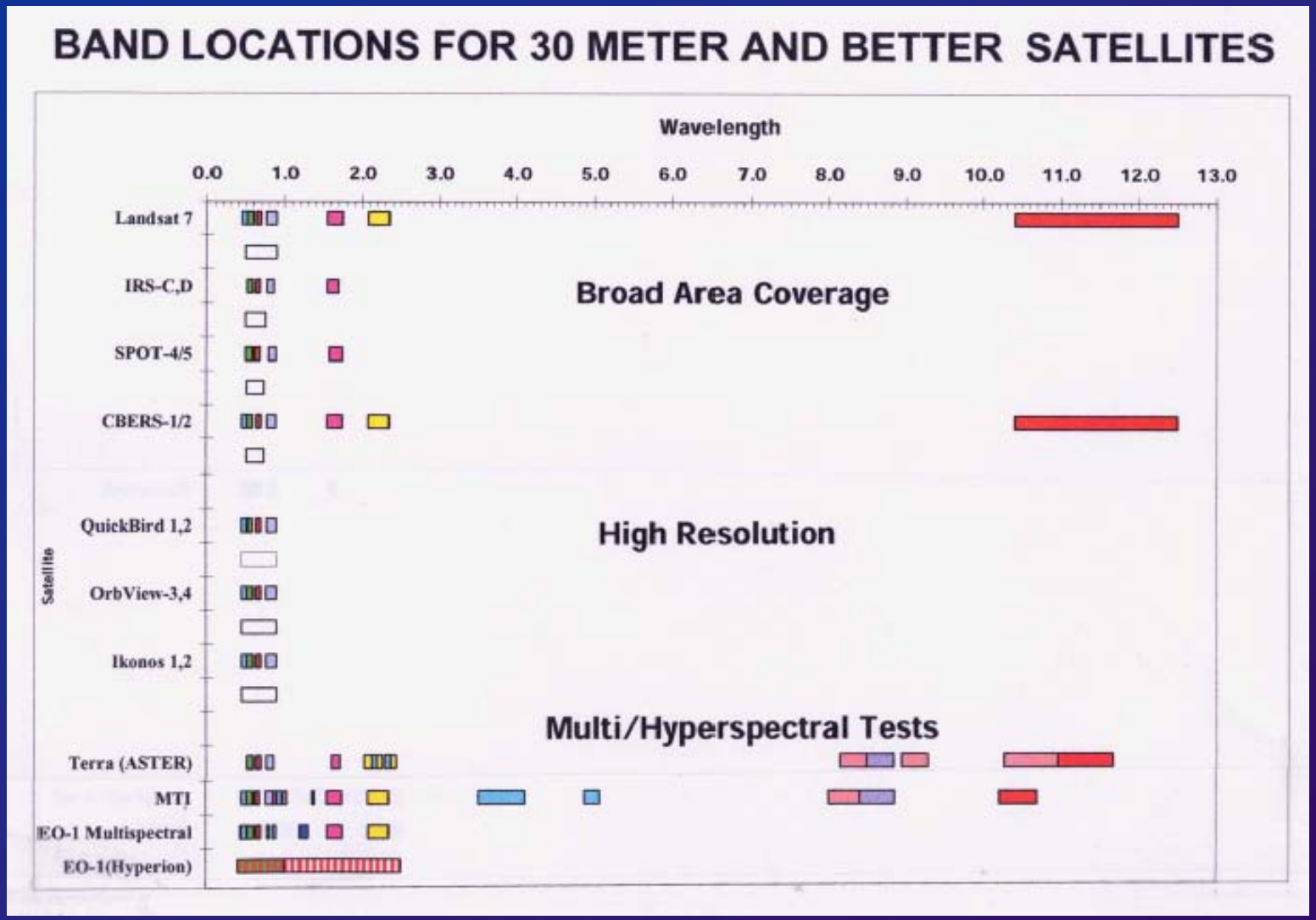








Science

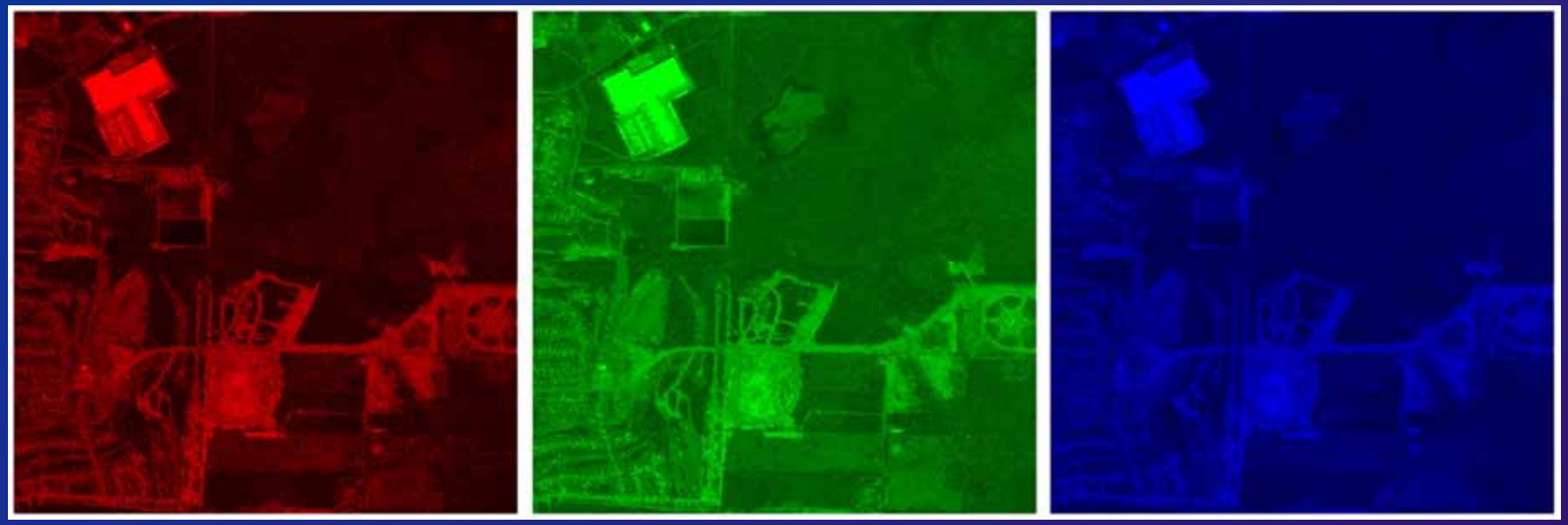

BAND LOCATIONS FOR 30 METER AND BETTER SATELLITES
Wavelength
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
Satellite
Landsat 7
IRS-C,D
SPOT-4/5
CBERS-1/2
QuickBird 1,2
OrbView-3,4
Ikonos 1,2
Terra (ASTER)
MTI
EO-1 Multispectral
EO-1(Hyperion)
Broad Area Coverage
High Resolution
Multi/Hyperspectral Tests

QuickBird Sensor Bands

Band 3	Band 2	Band 1
0.63-0.69 µm	0.52-0.60 µm	0.40-0.52 µm

Wave Lengths in Micrometers

Sensor Bands in RGB Slots

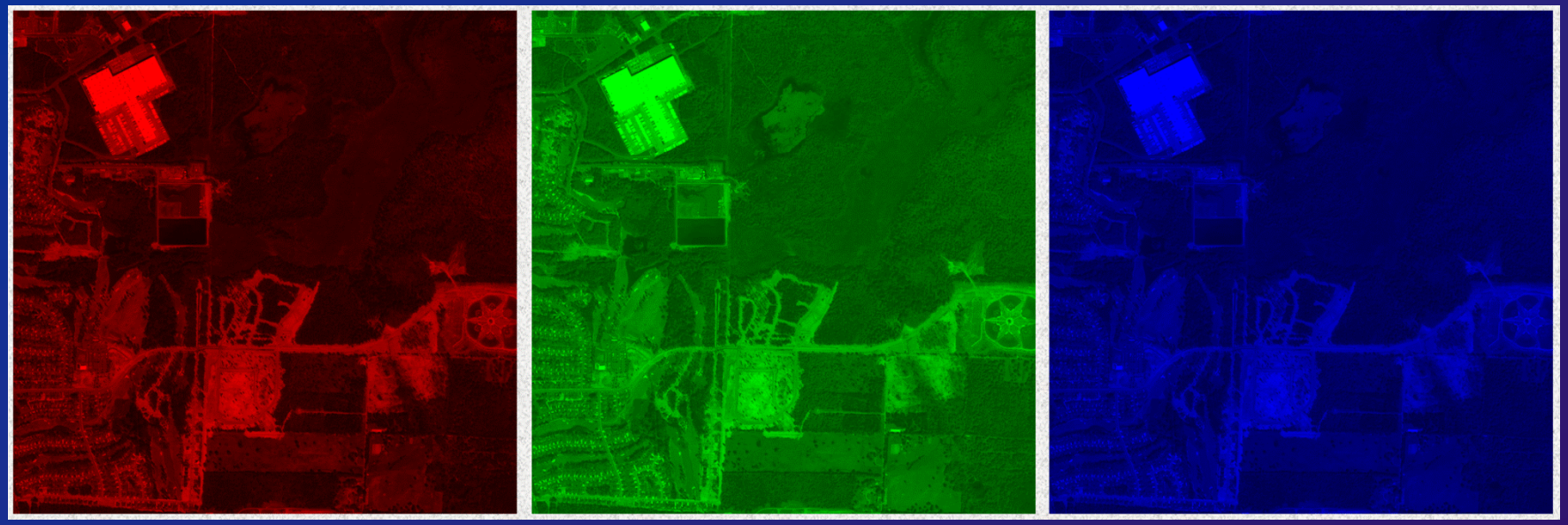


Band 3
Red

Band 2
Green

Band 1
Blue

Merge Animation



Final Natural Color Composite

www.satimagingcorp.com

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

Unadjusted

Adjusted

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

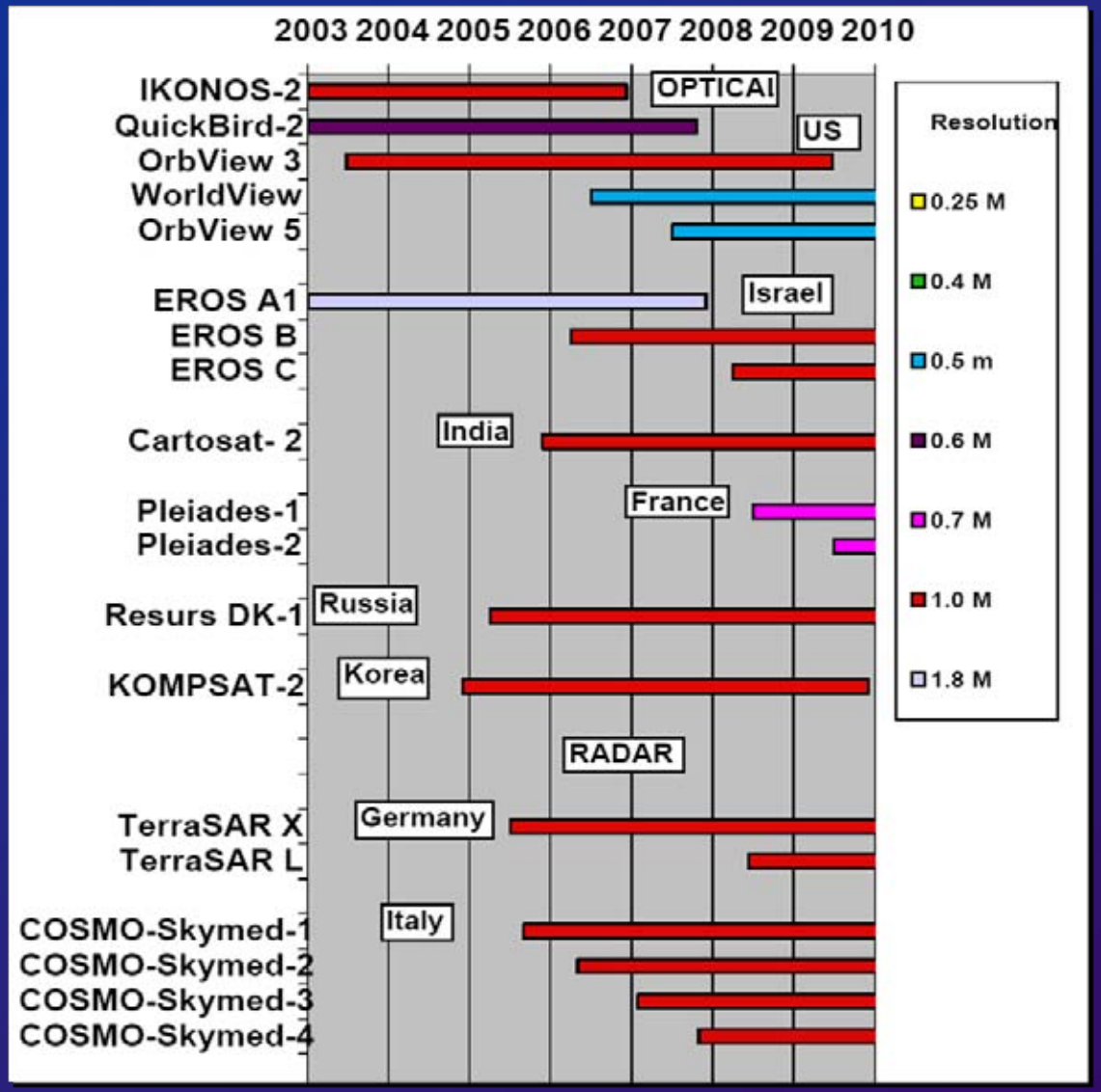


Image Resolution

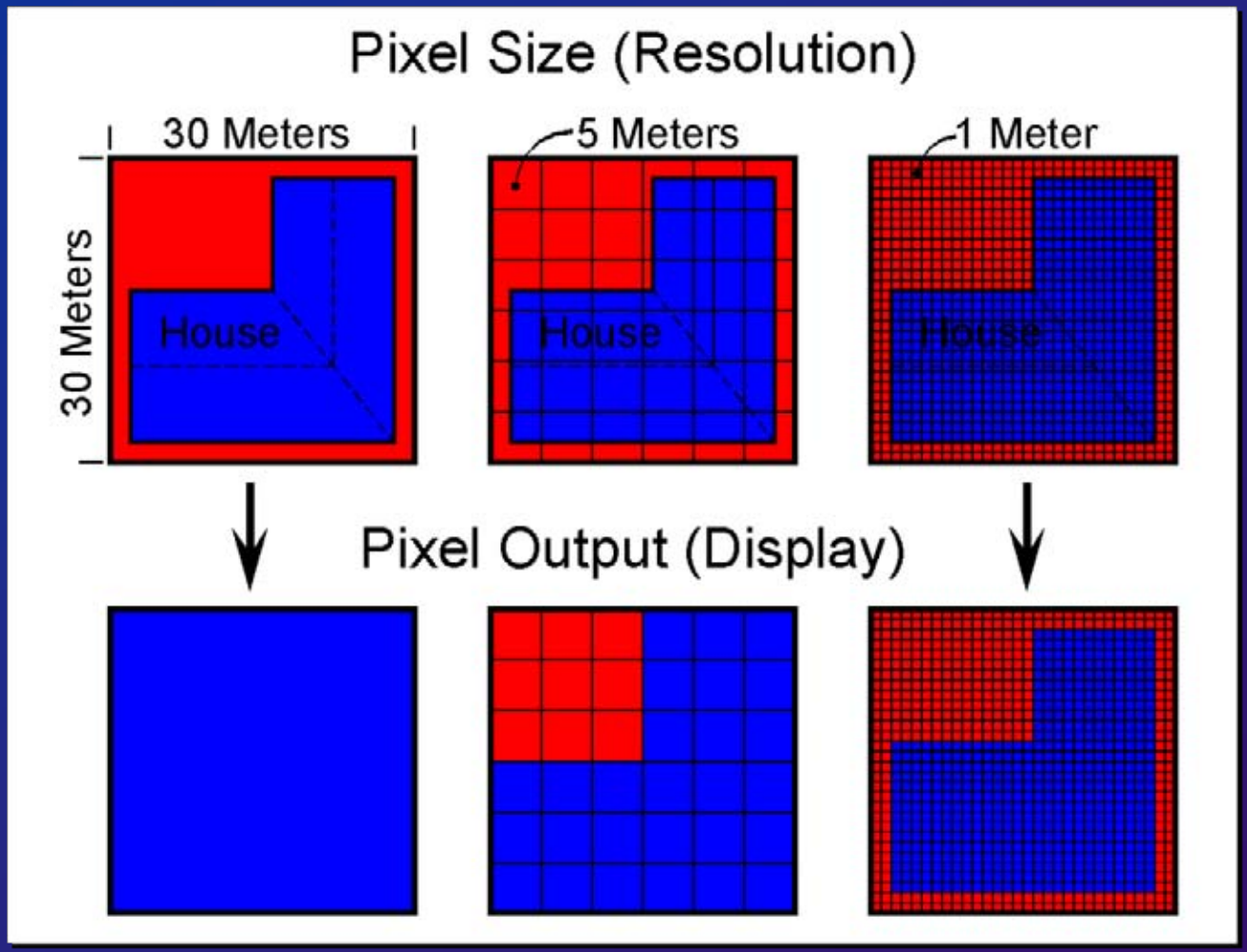


Image Resolution

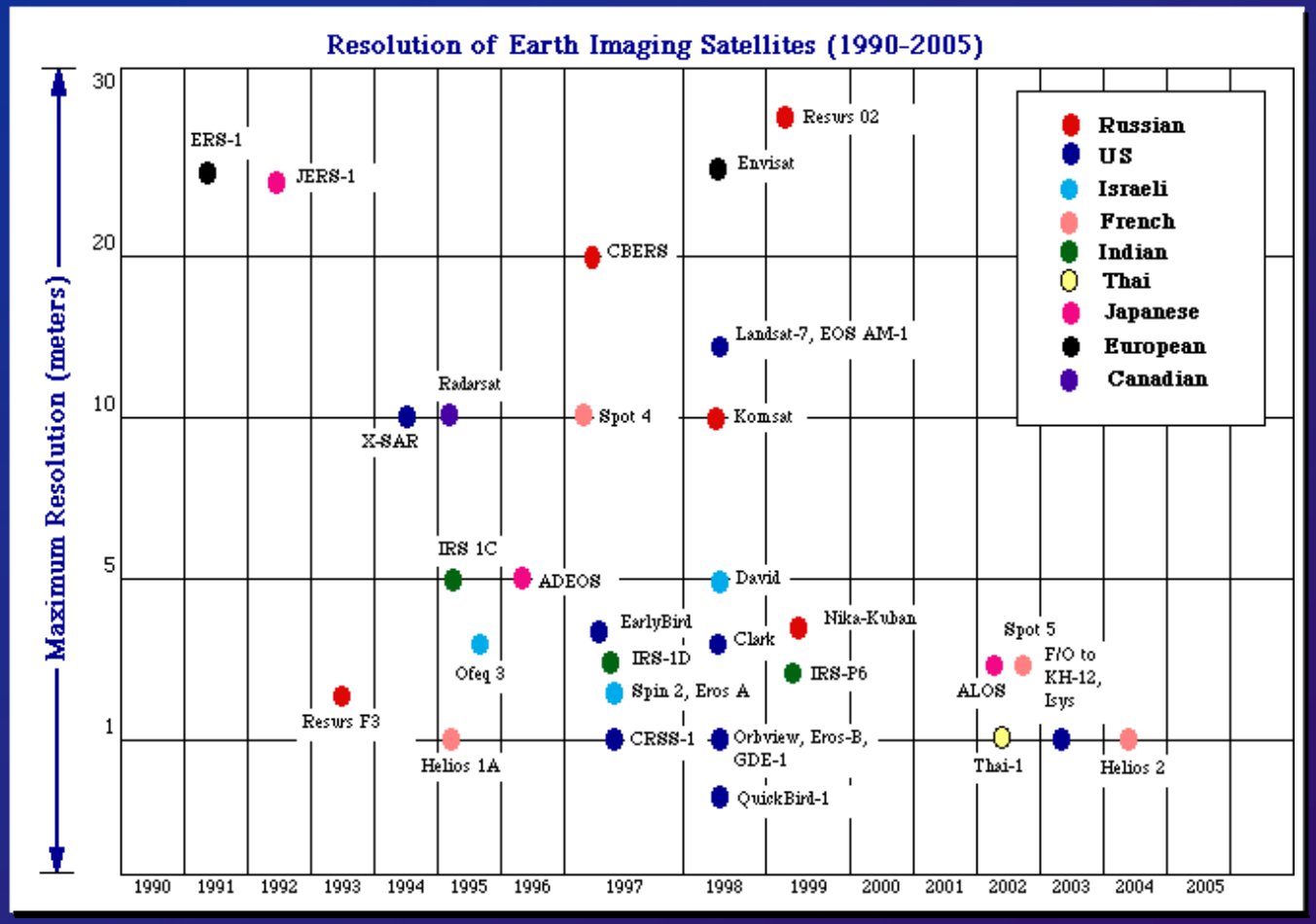
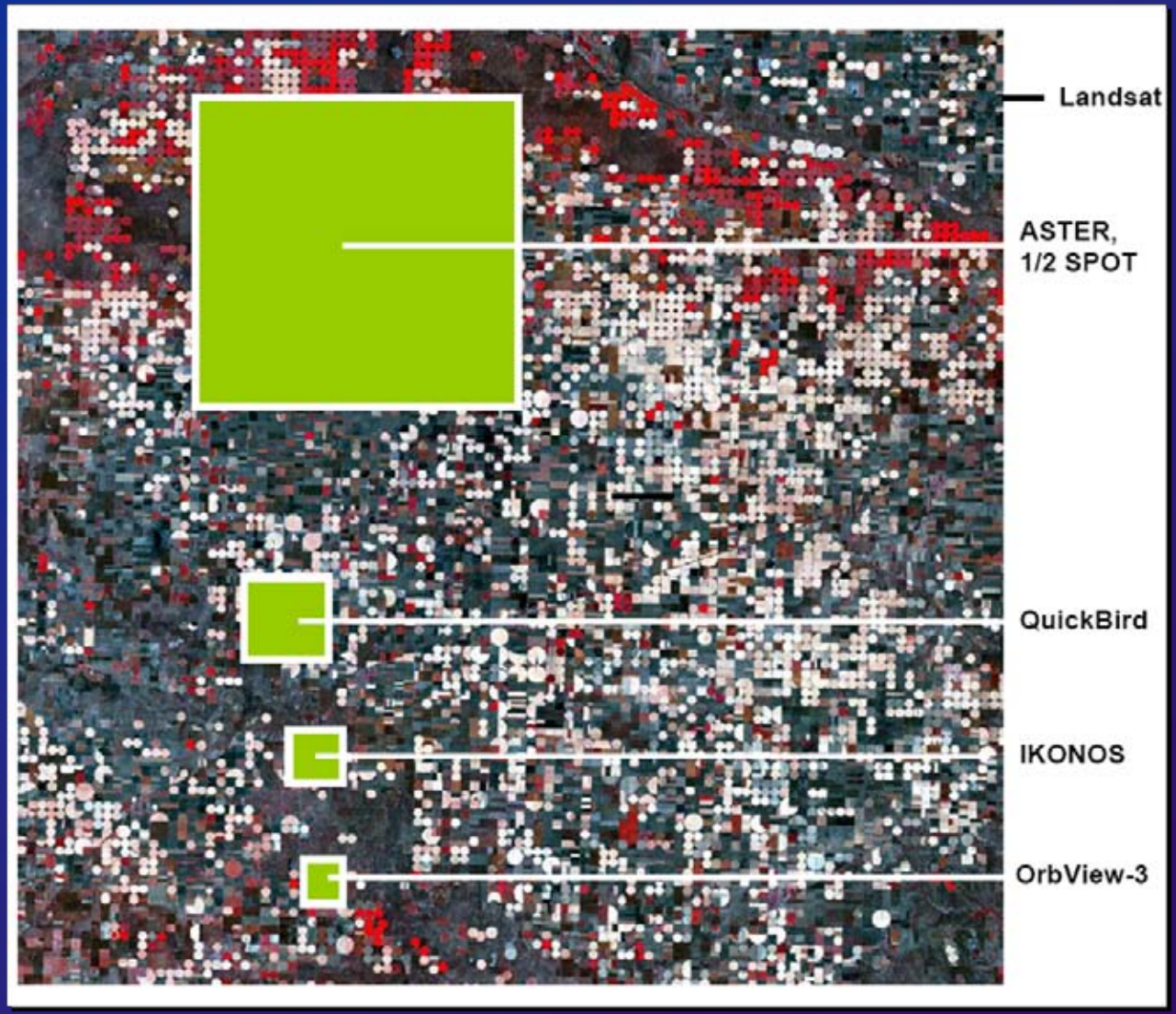
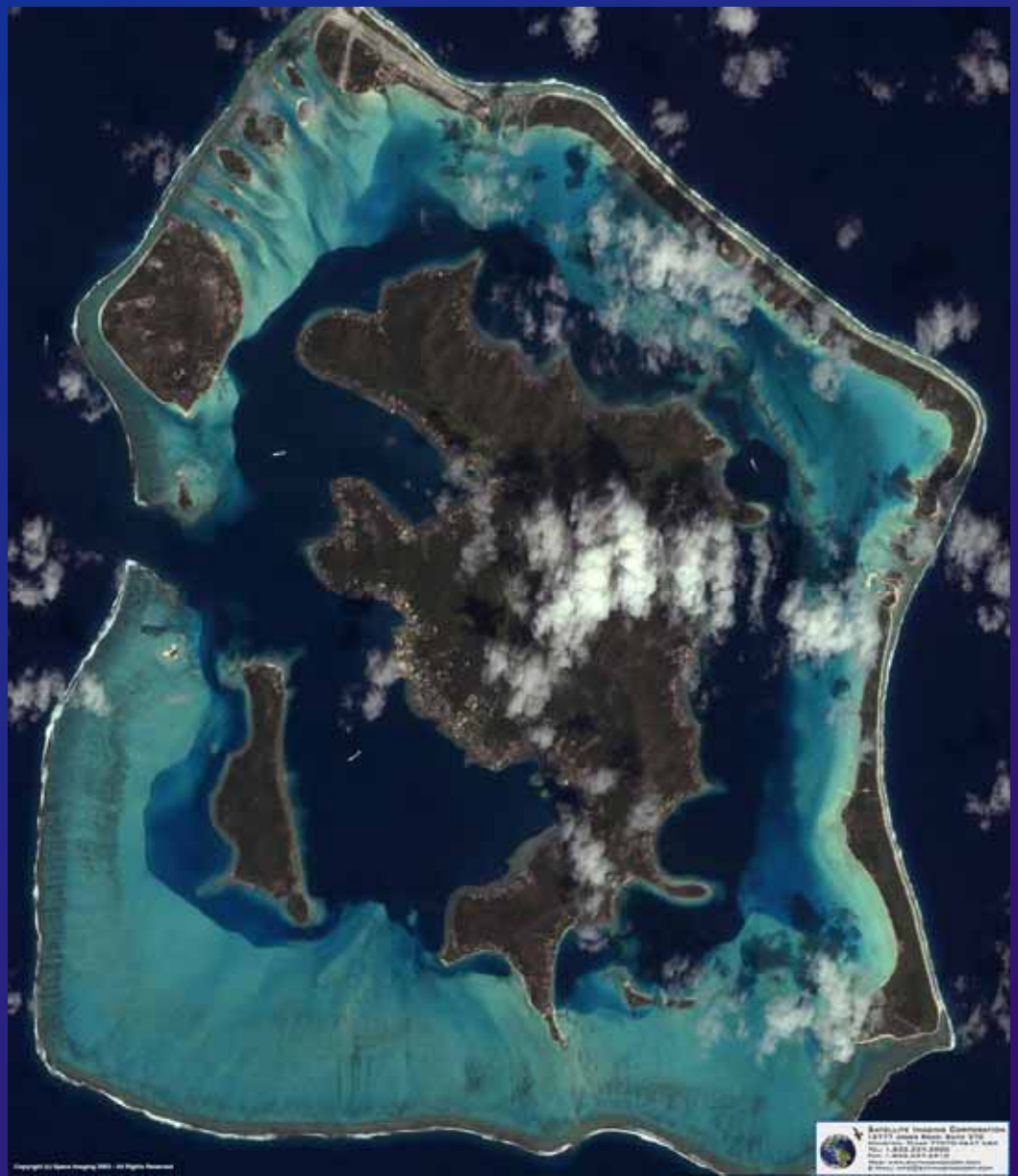


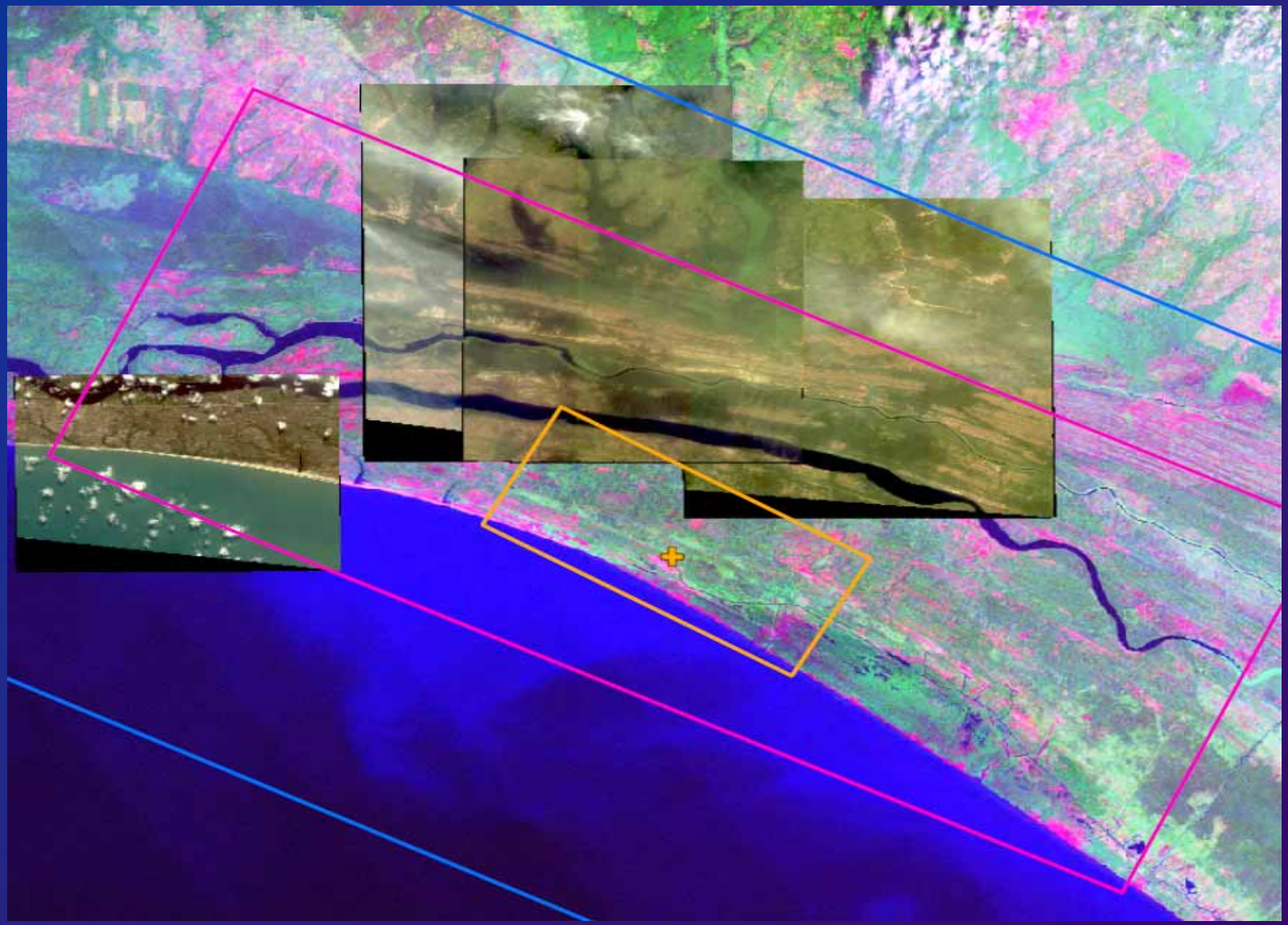
Image Coverage



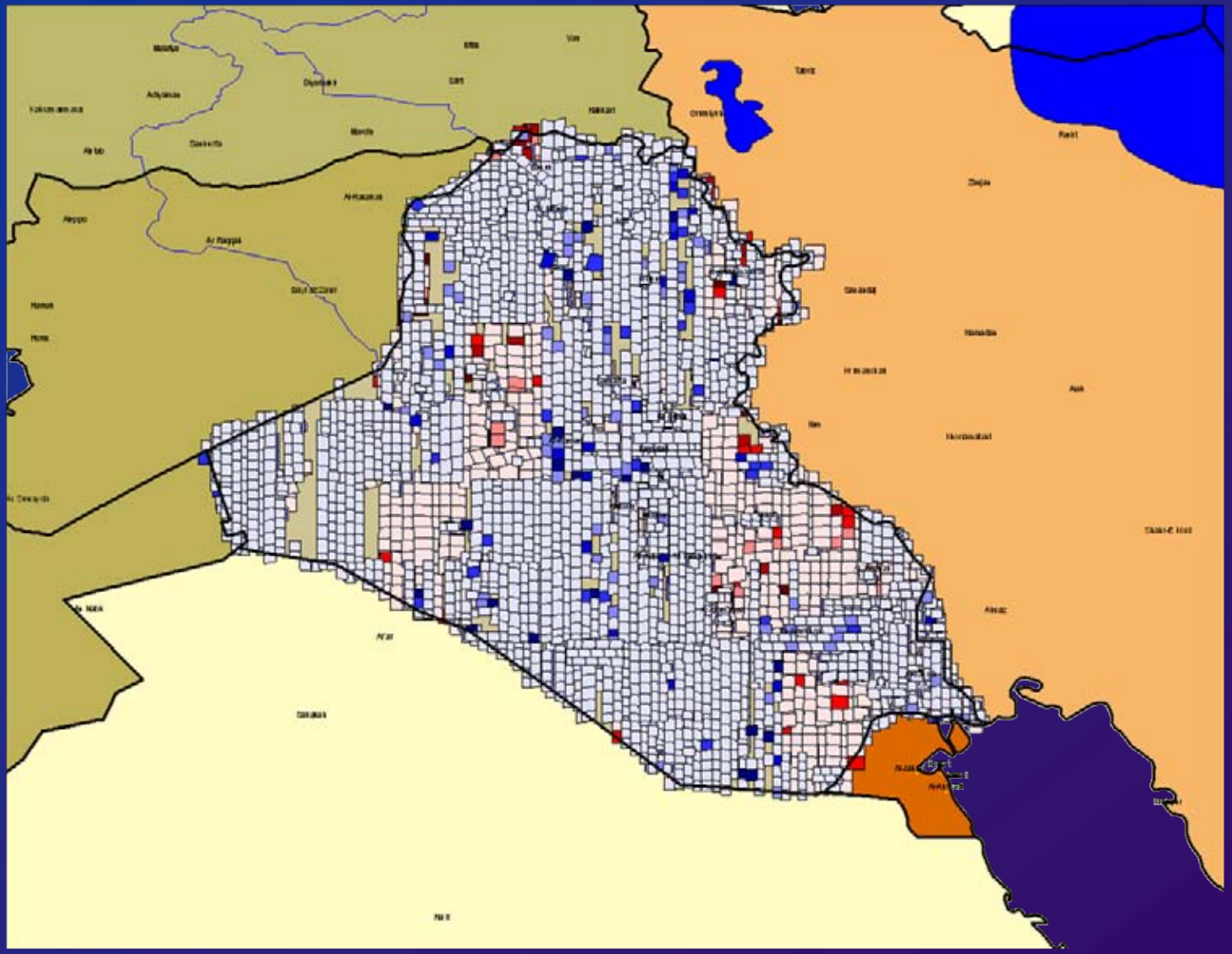
Perennial cloud cover ~ Bora-Bora



Area of Interest ~ Nigeria



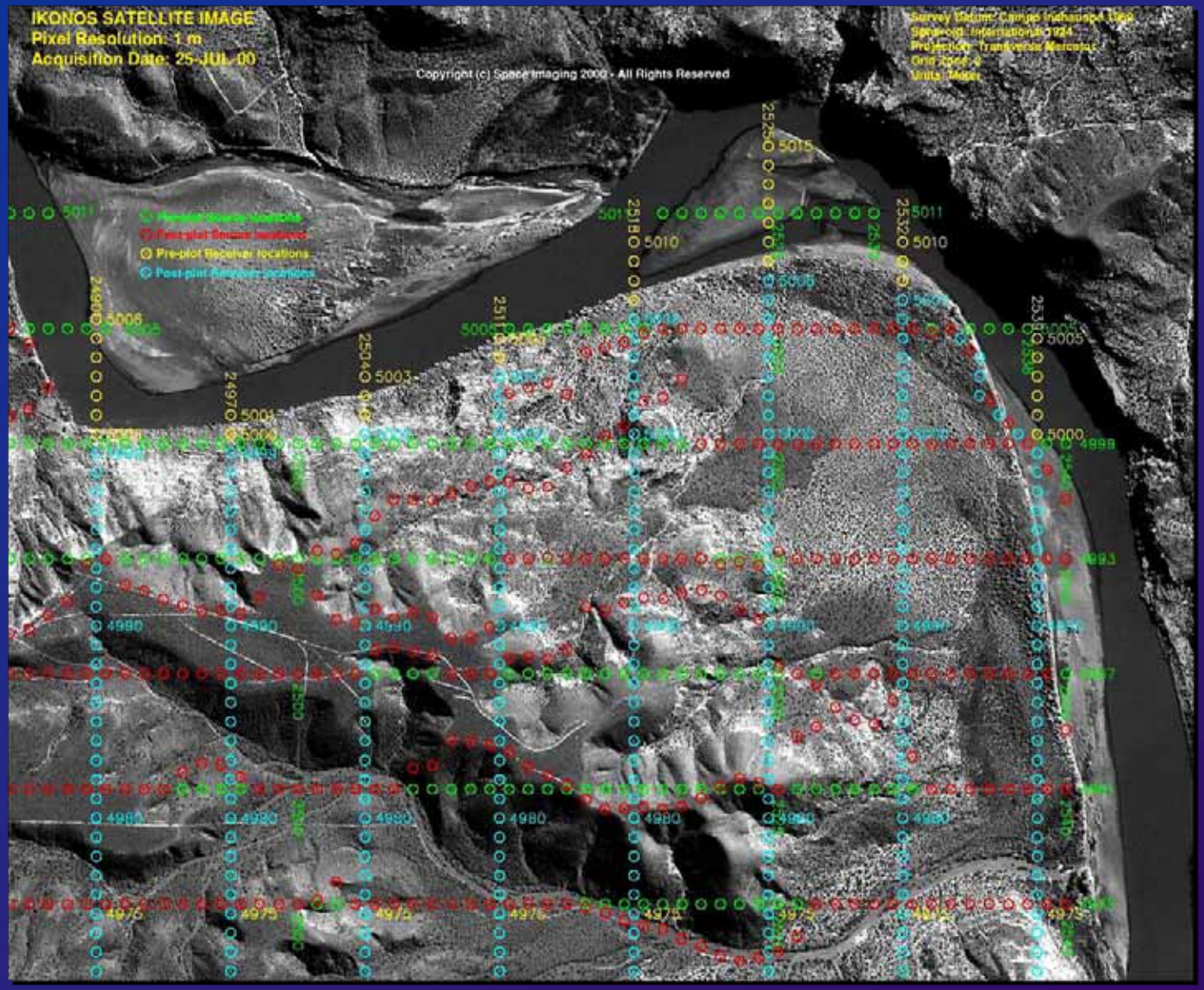
National Coverage ~ Iraq



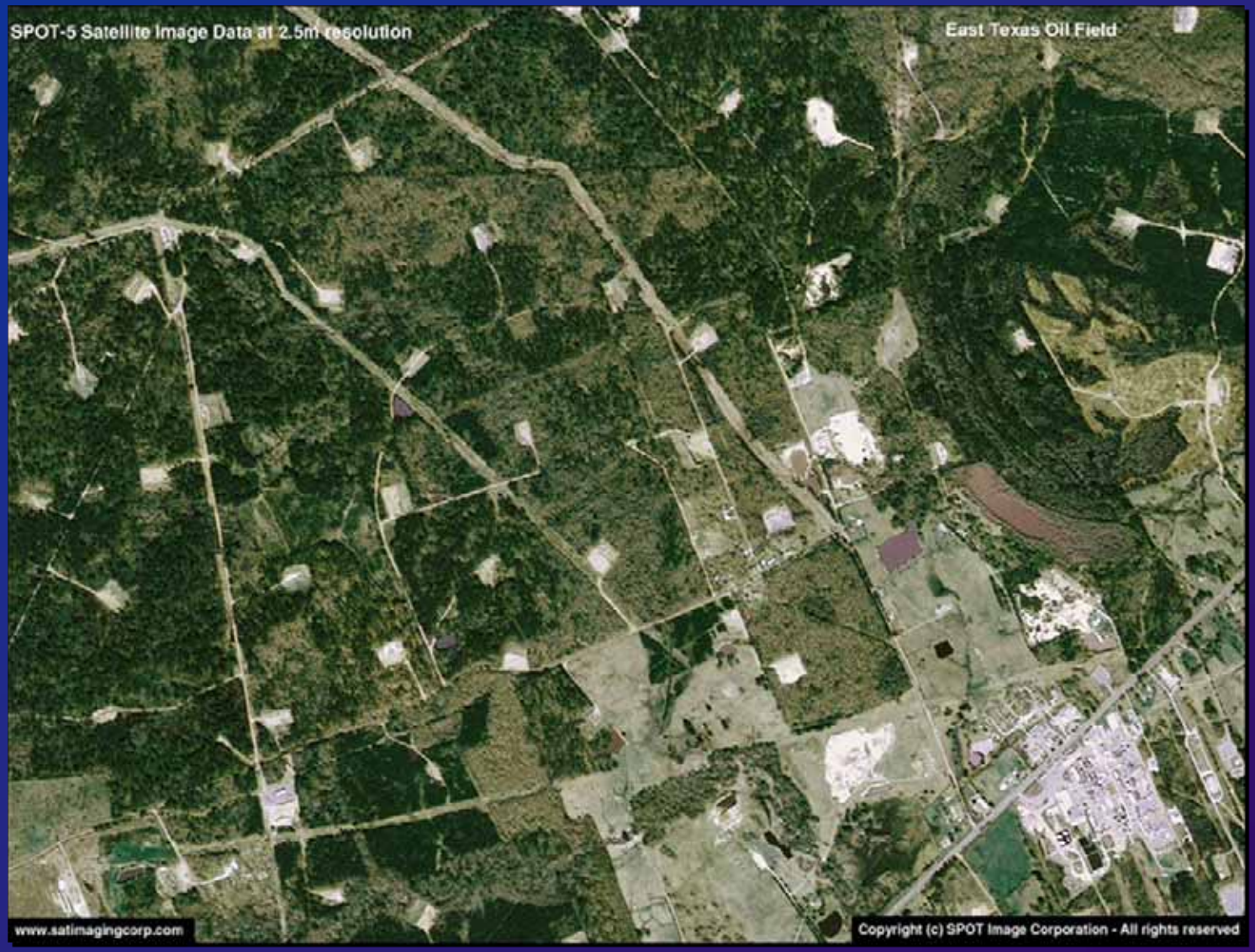
Oil and Gas Applications

- 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

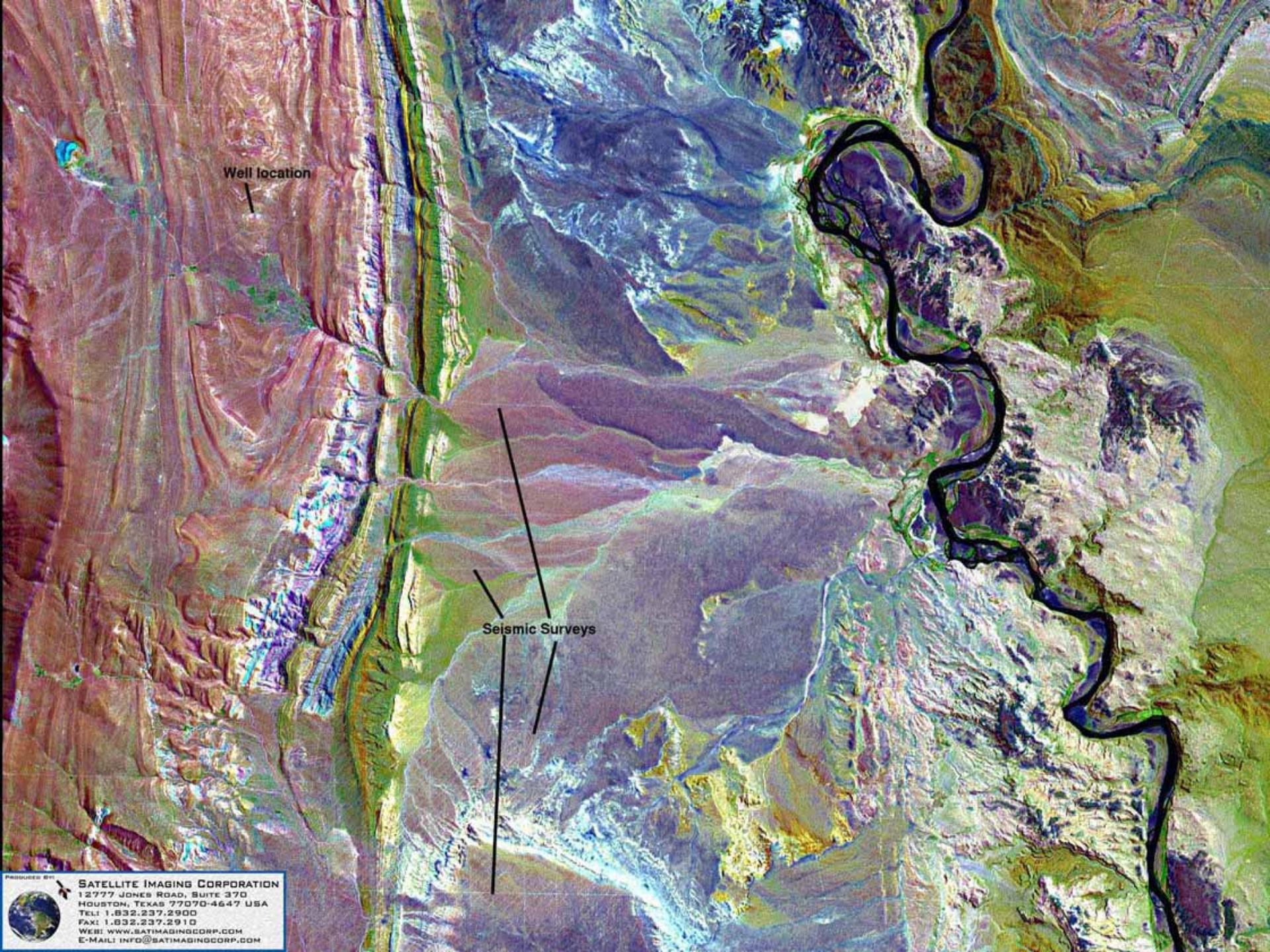


Example: Well Locations



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**



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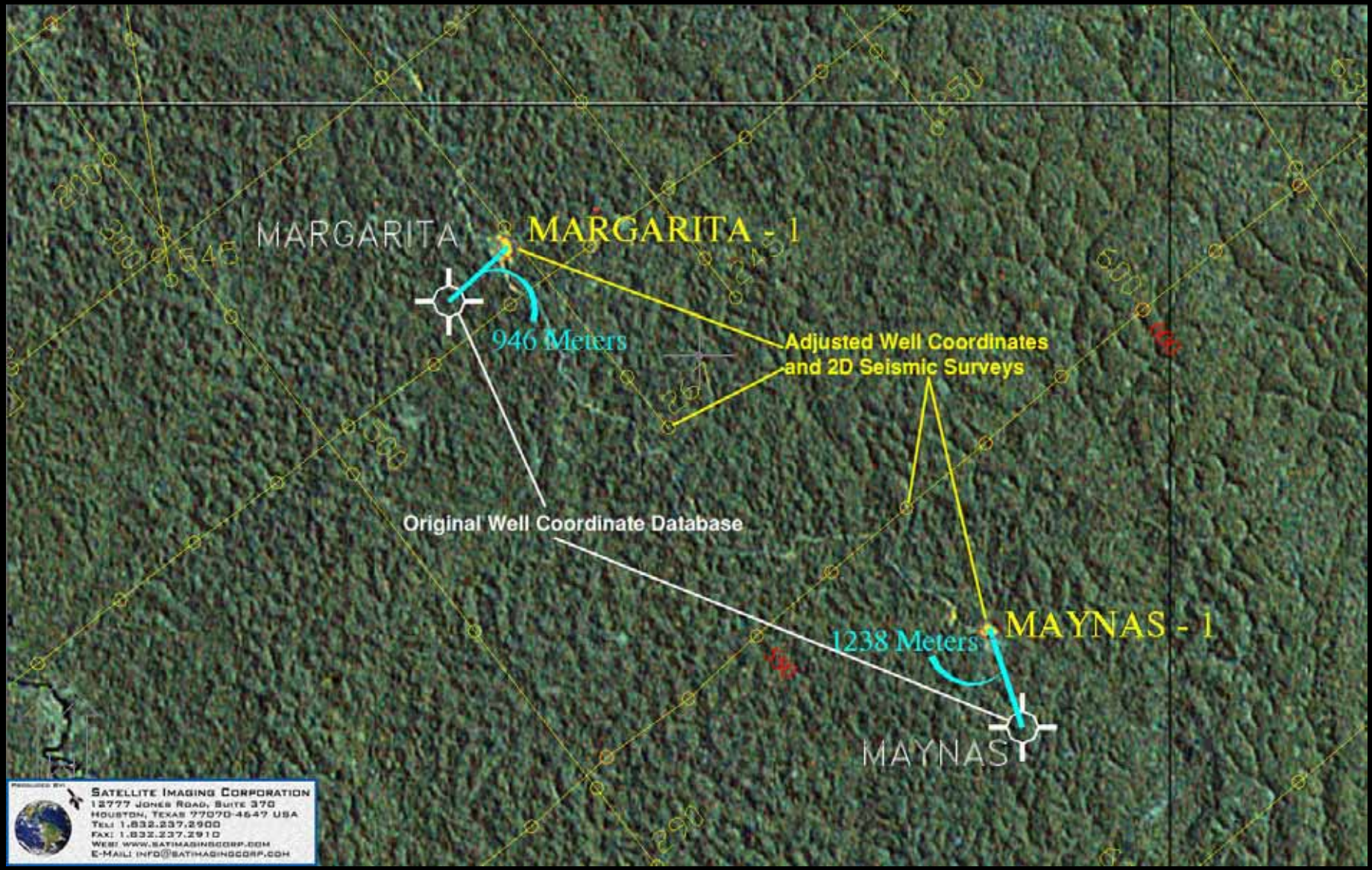

MARGARITA
MARGARITA - 1
946 Meters
Adjusted Well Coordinates
and 2D Seismic Surveys
Original Well Coordinate Database
MAYNAS - 1
1238 Meters
MAYNAS
SATELLITE IMAGING CORPORATION
13777 JONES ROAD, SUITE 370
HOUSTON, TEXAS 77070-4647 USA
TEL: 1.832.237.2900
FAX: 1.832.237.2910
WEB: WWW.SATIMAGINGCORP.COM
E-MAIL: INFO@SATIMAGINGCORP.COM

Example: Transition Zone operations

Case Studies

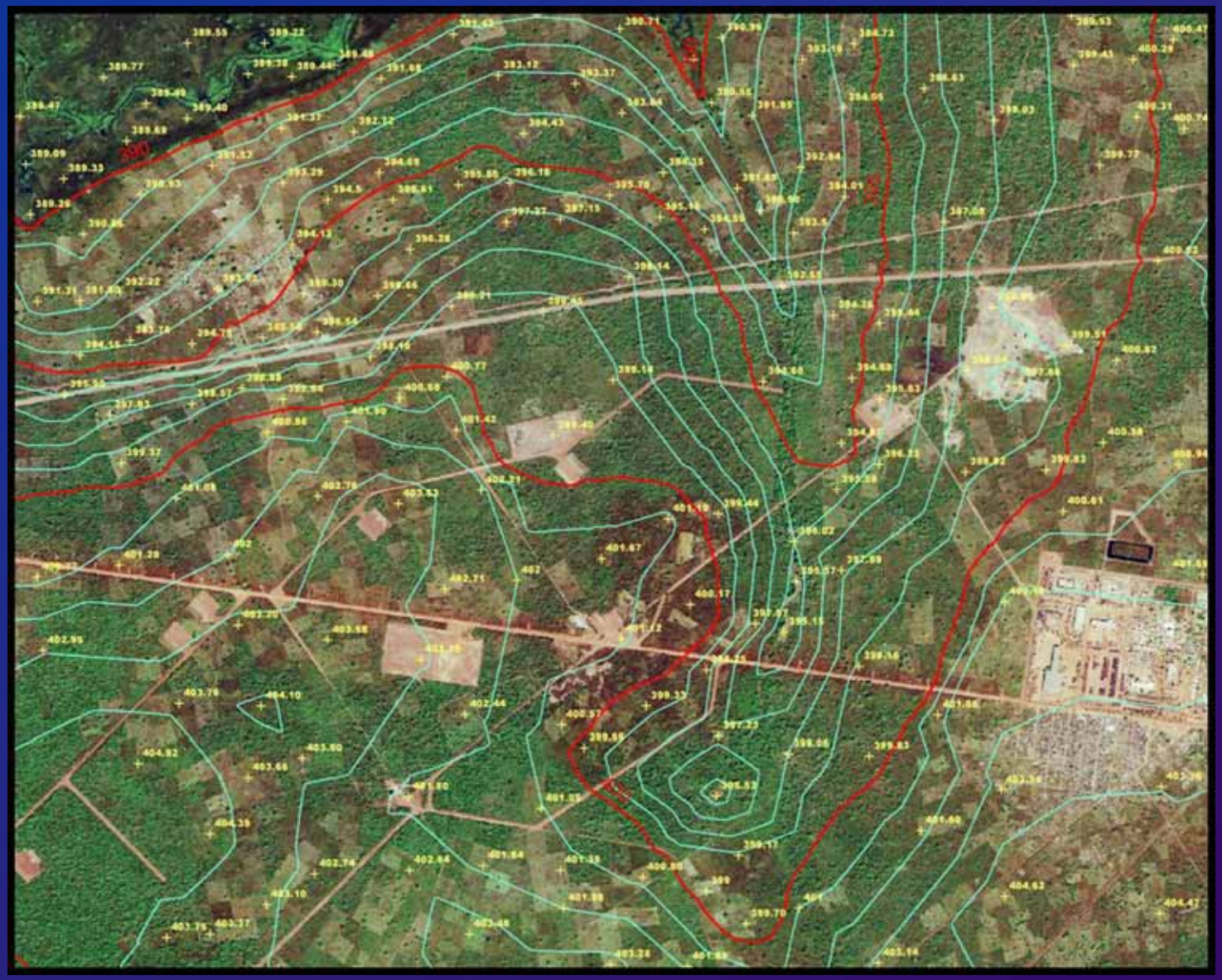
- **Extracted culture: Chad, USA, Nigeria**
- **Regional geologic classification: Yemen**
- **Change monitoring by time lapse: USA, China**
- **3D digital elevation modeling: Tunisia**


IKONOS Satellite Image at 0.8m resolution - Chad
Acquired on: 20-NOV-2003
www.satimagingcorp.com
Powerlines
Wellhead
Copyright (c) Space Imaging - All rights reserved

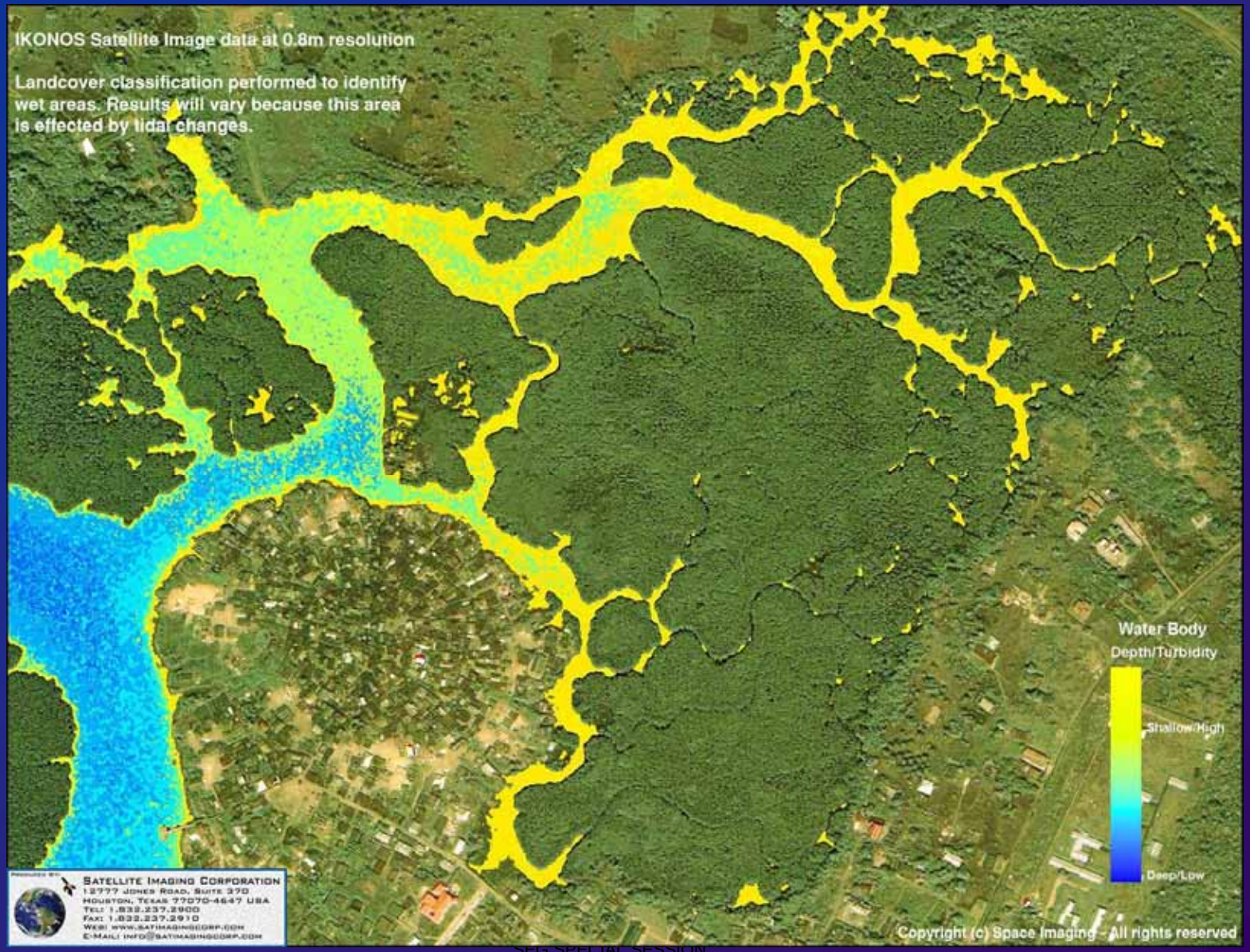
Extracted Culture Data from Orthorectified 0.8m IKONOS Image

www.satimagingcorp.com

Extracted culture: Topography, Chad



Extracted culture: Tidal Wetlands, Nigeria

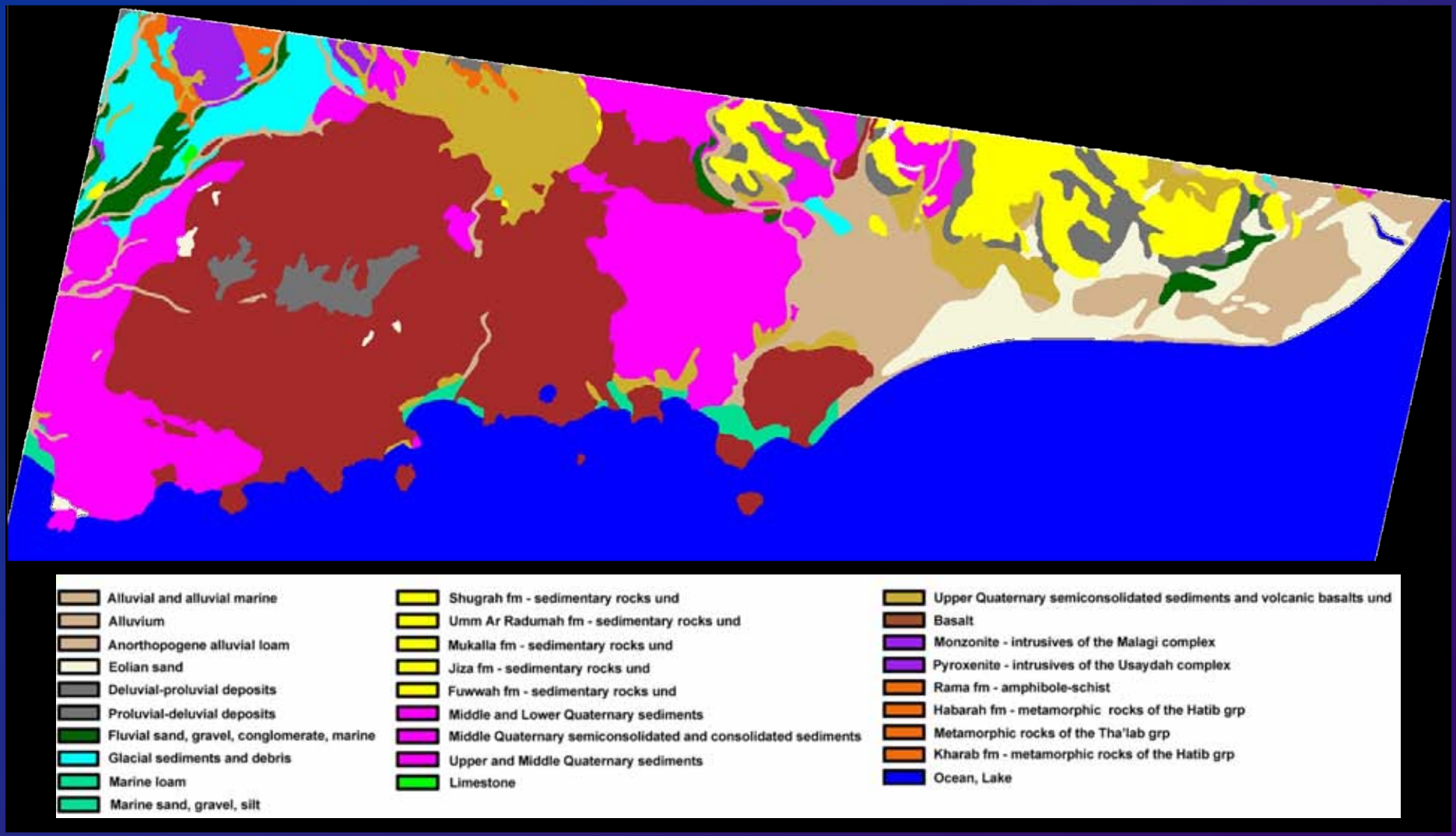


Regional Use of Imagery

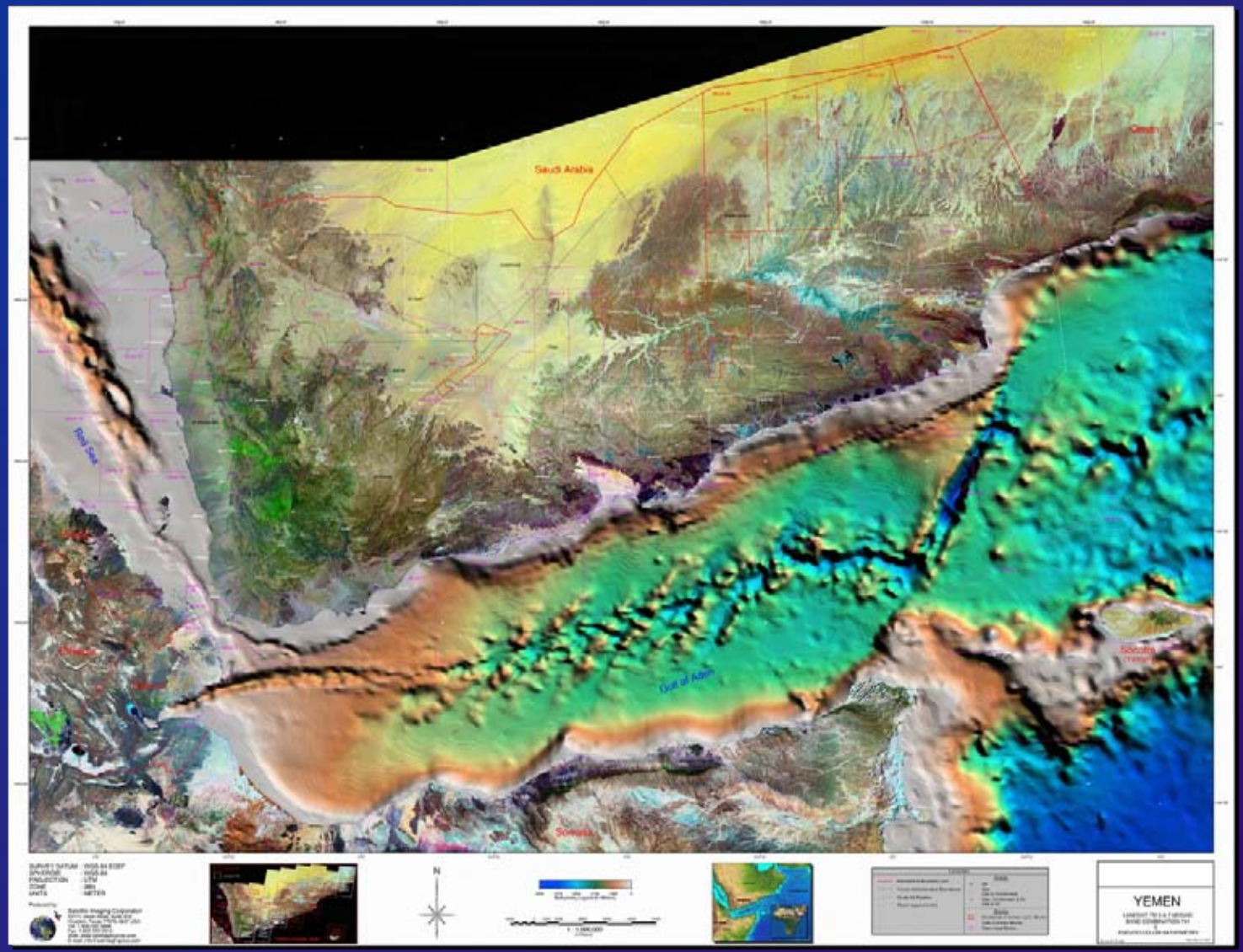
Aster 15m Natural Color Composite

Aster 15m Geological Processing Composite

15m Geological Processing Final Classification

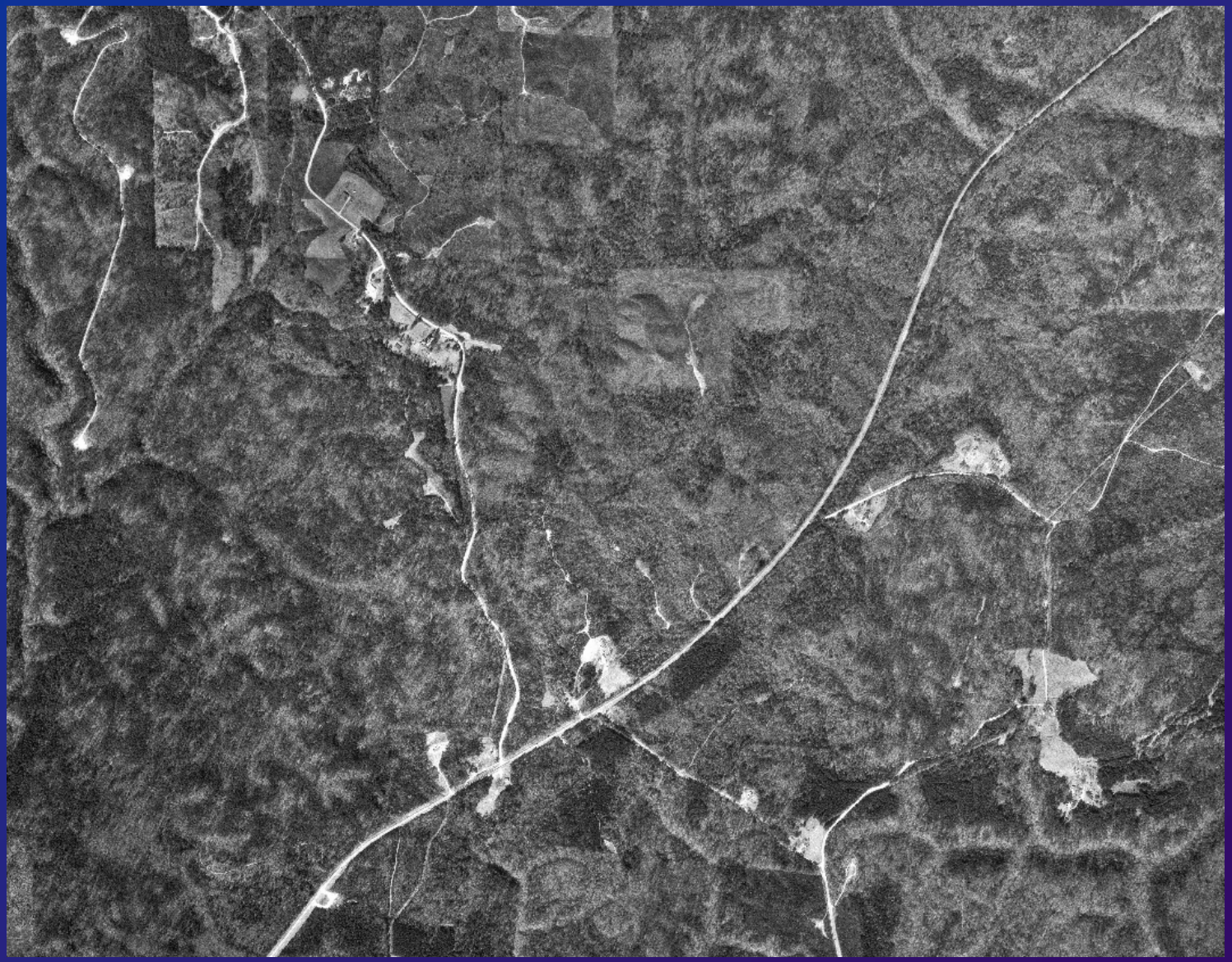


Landsat 30m mosaic with bathymetry



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

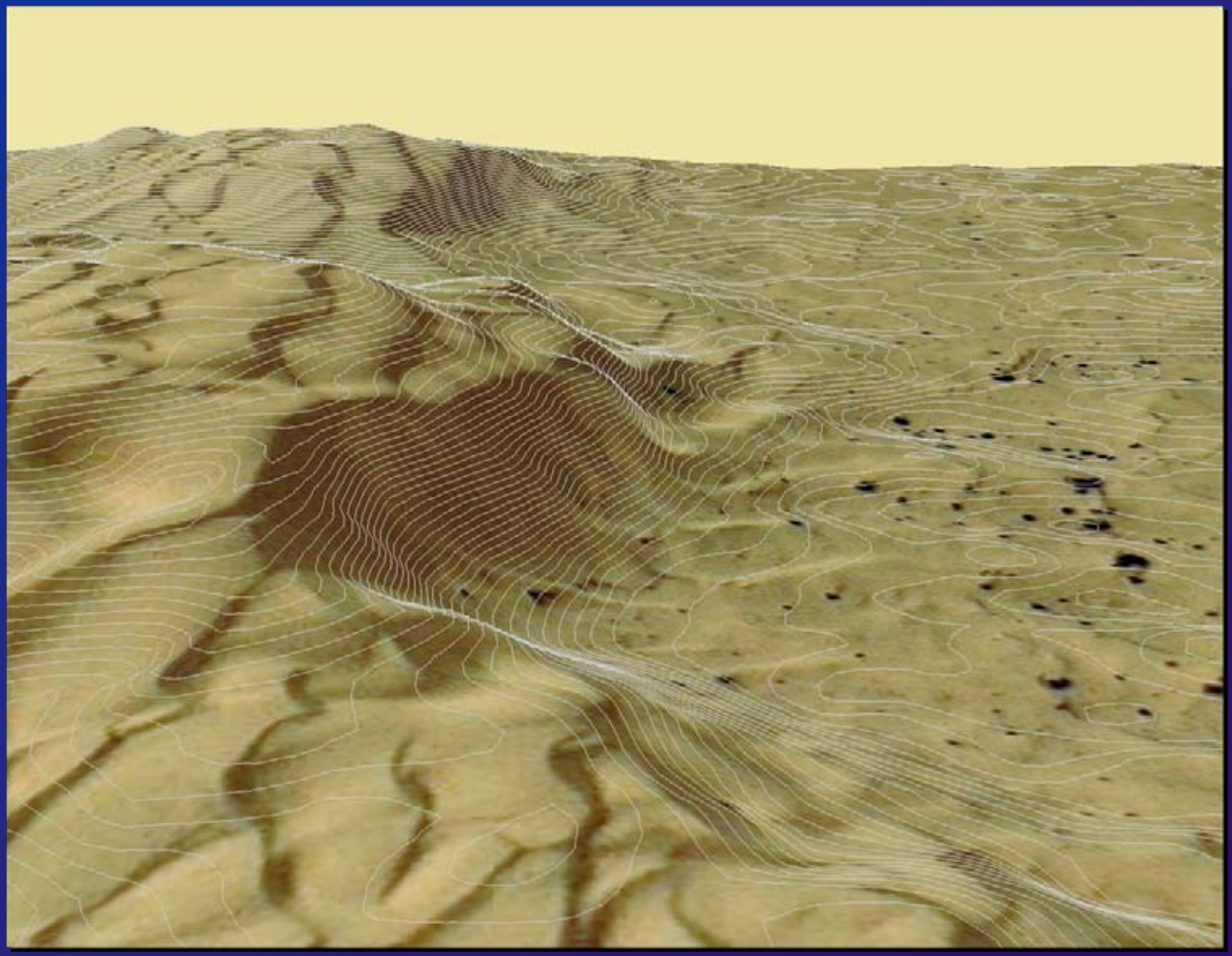
July 18, 2004

Construction Progress Animation (7 Months)
QuickBird 0.6m Satellite Image ~ CSPC Petrochemicals – Huizhou, P.R. China

Three Dimensional Use of Imagery

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

References

- **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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