An Overview of Astronaut Photography

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Overview

❖ The Data

Basic Remote Sensing Theory

International Space Station Platform

Astronaut Photography Data Characteristics

❖ Astronaut Training and Operations

Crew Earth Observations Group

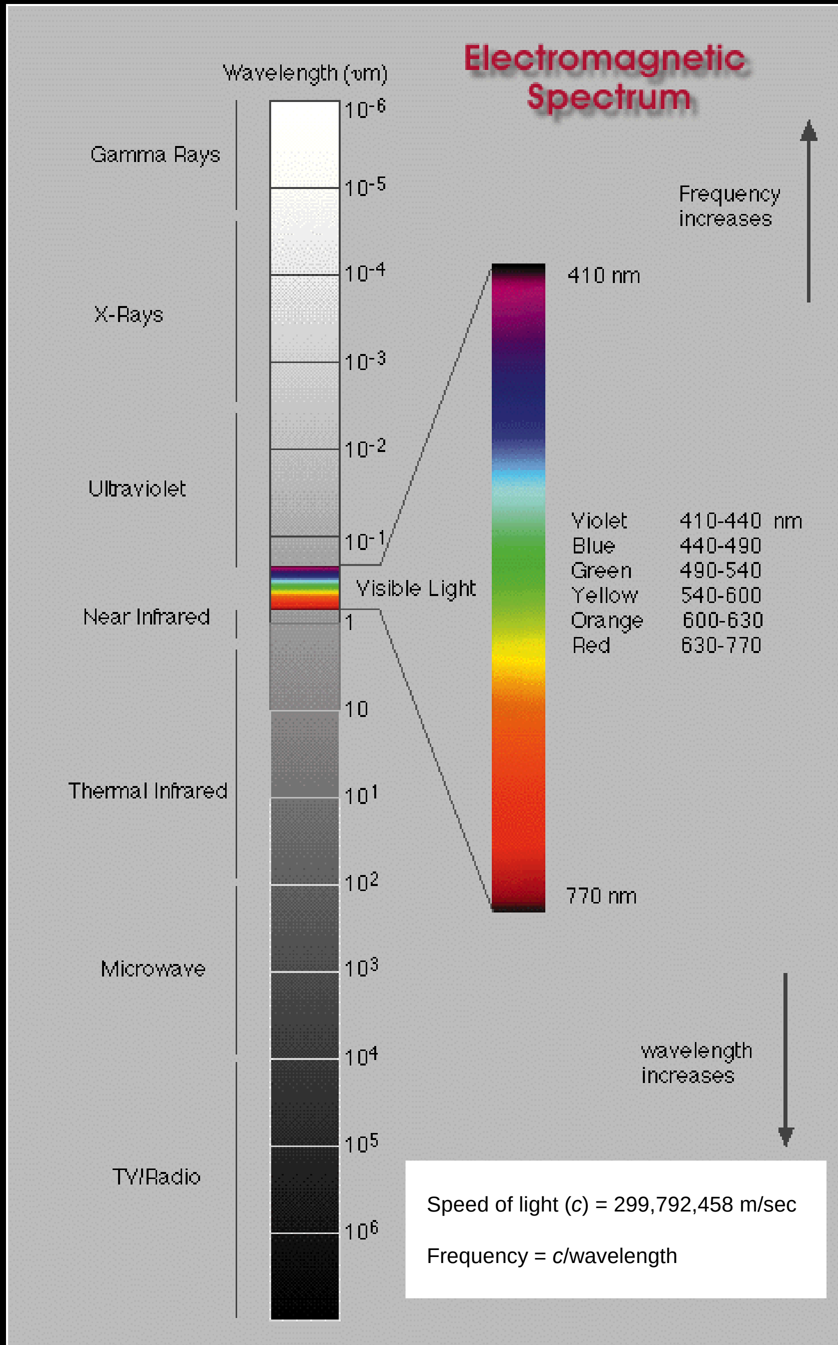
Targeting Sites and Acquisition

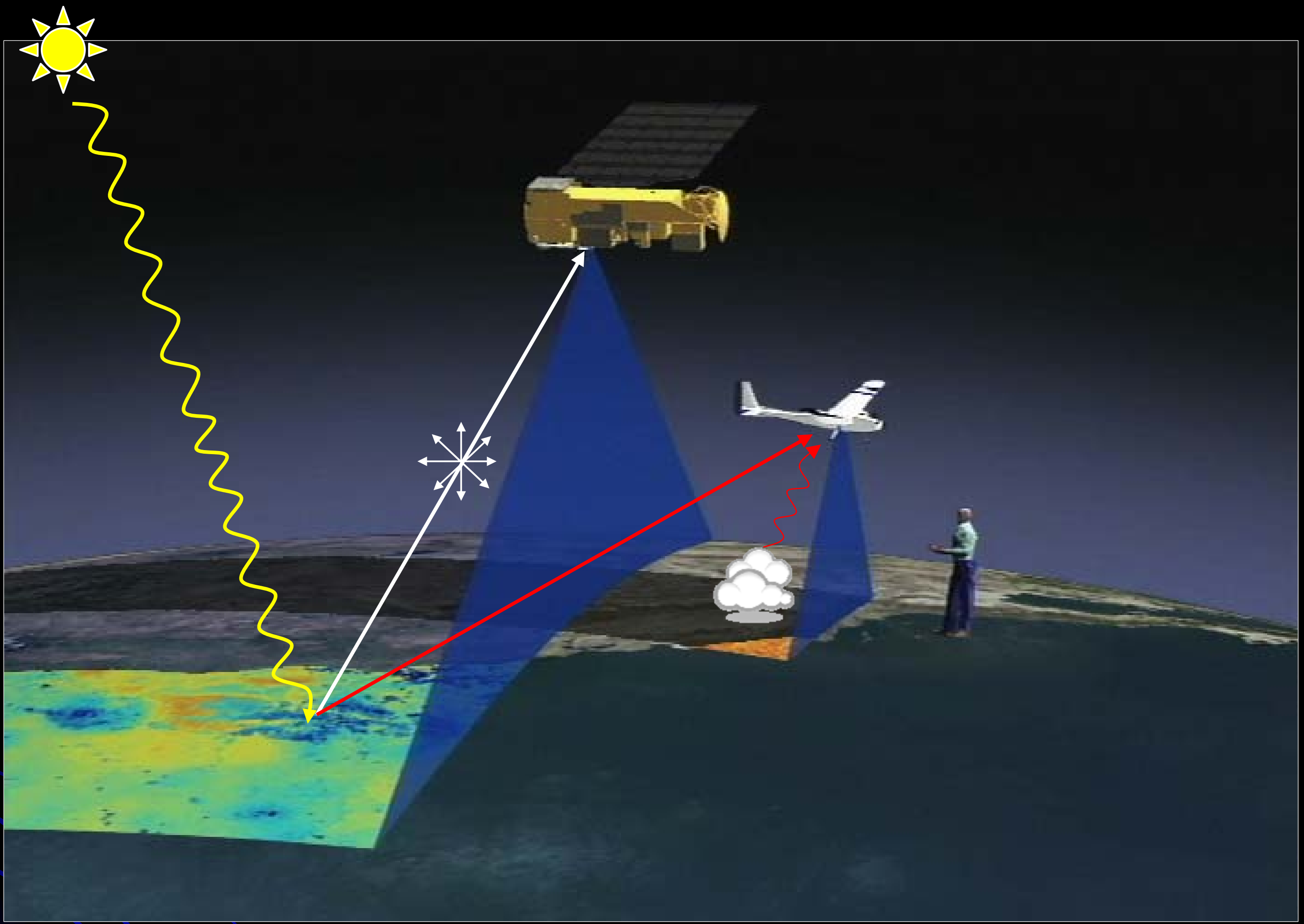
Cataloging and Database

* all images in this presentation courtesy of NASA unless otherwise noted*

Basic Theory

- Earth's atmosphere defines "windows" useable for remote sensing
- Different information is obtained using different wavelengths
- Most sensors are passive (radar and LIDAR are active)
- Information obtained is directly related to material chemistry and physics



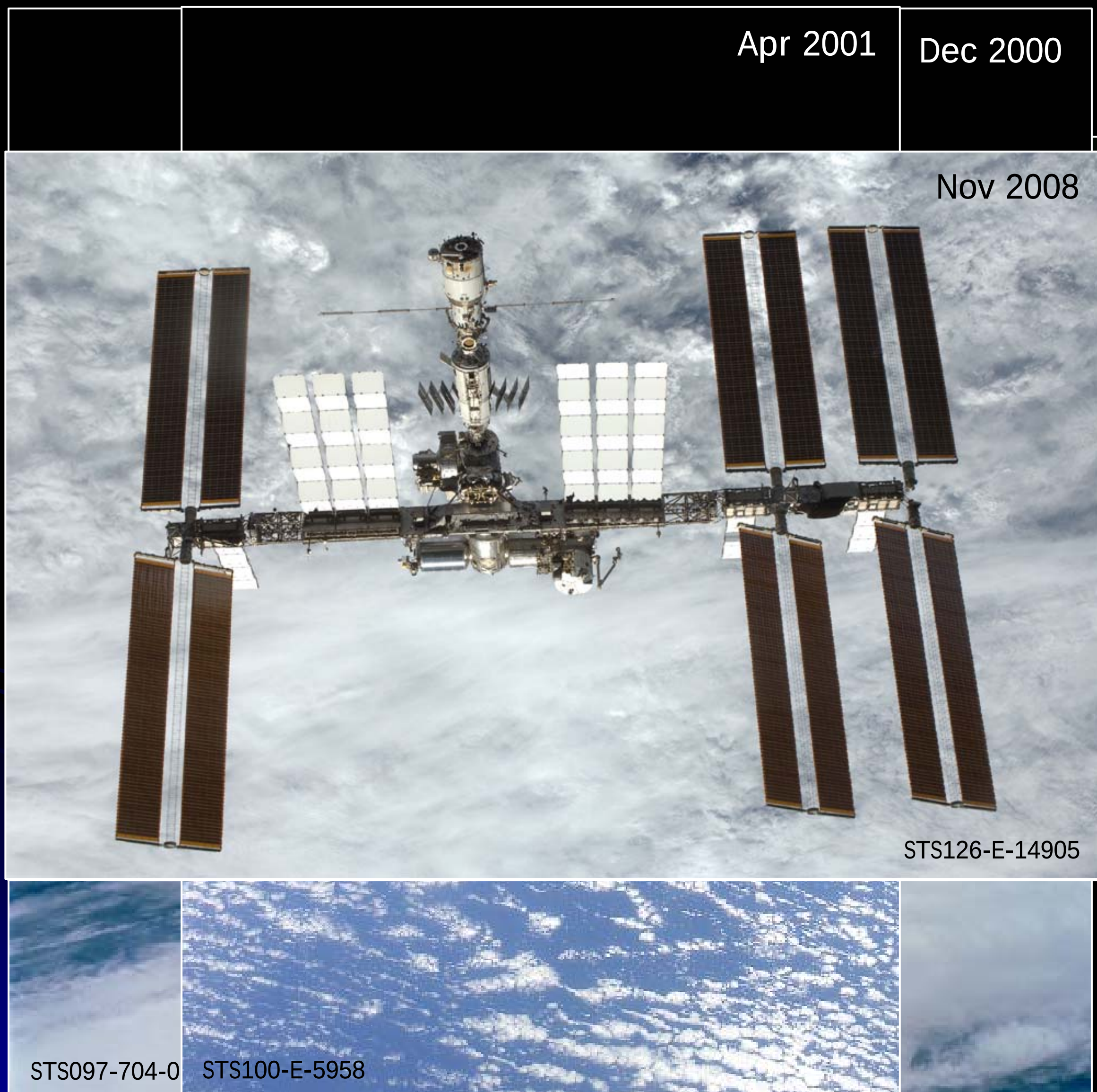


Base image source: NASA/Goddard Space Flight Center, Scientific Visualization Studio

Incident energy is reflected, transmitted, or emitted from surficial materials; sensor sees mixture of energy from multiple surface materials and atmosphere

For passive systems, information is obtained from only the uppermost surface (~130 microns); no depth profiles!

International Space Station



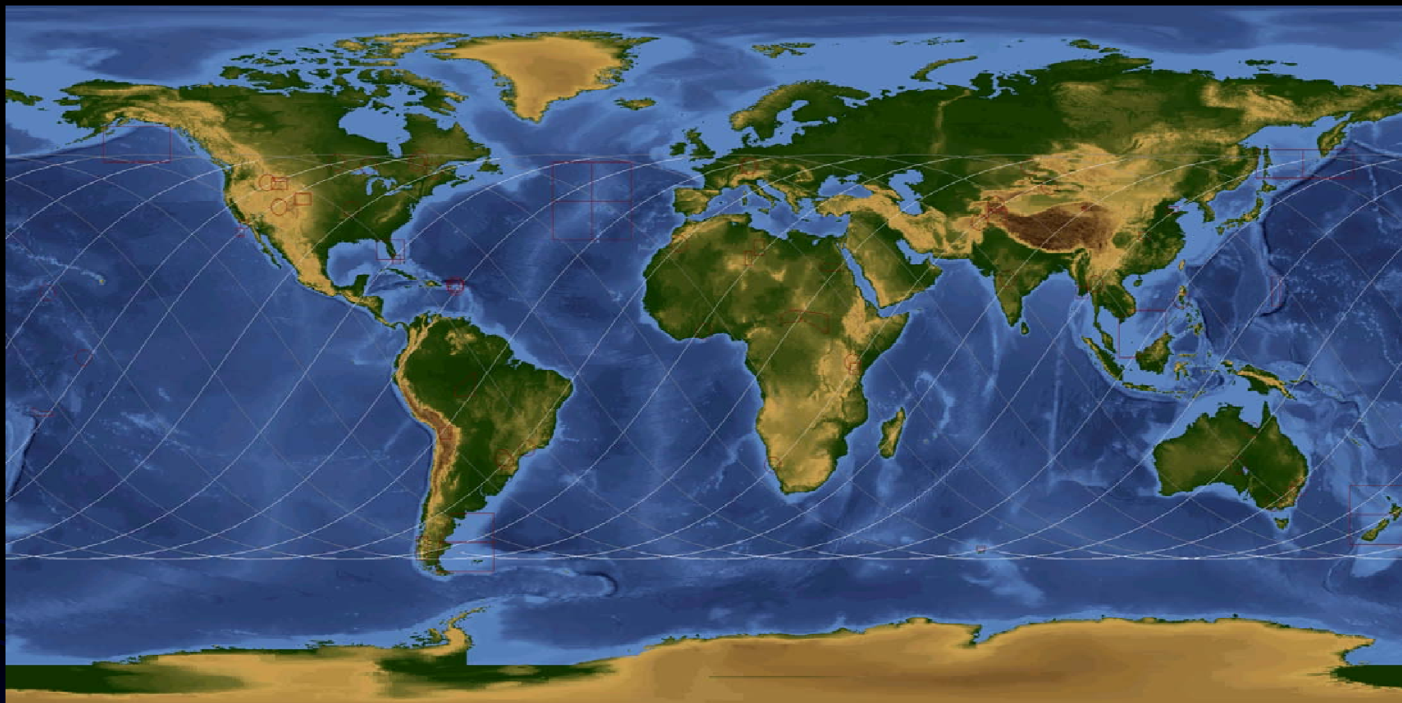
- Multinational space effort including Canada, Japan, Russia, Brazil, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, UK, USA

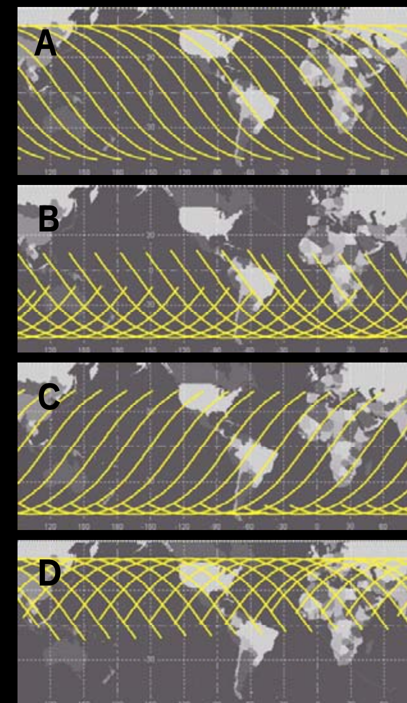
- Crews have included astronauts from NASA, ESA, JAXA, CSA, BSA; Russian cosmonauts; and “space tourists” over 18 Expeditions

- Crew rotation is typically six months; 6-person crews slated to begin 2009

- Station provides zero-g facility for science, engineering, and biomedical experiments vital for future long-duration missions to the Moon and Mars

ISS Orbital Parameters



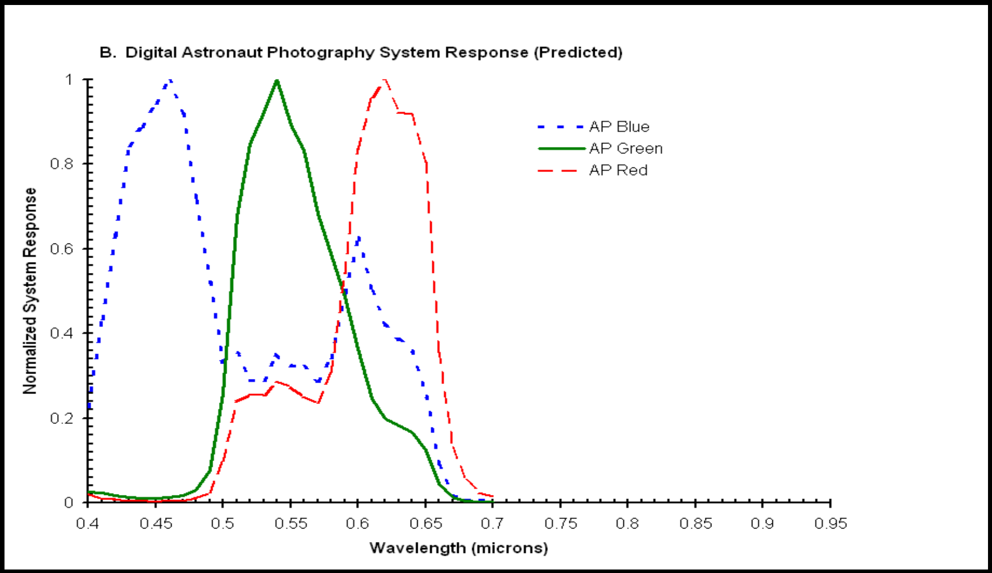


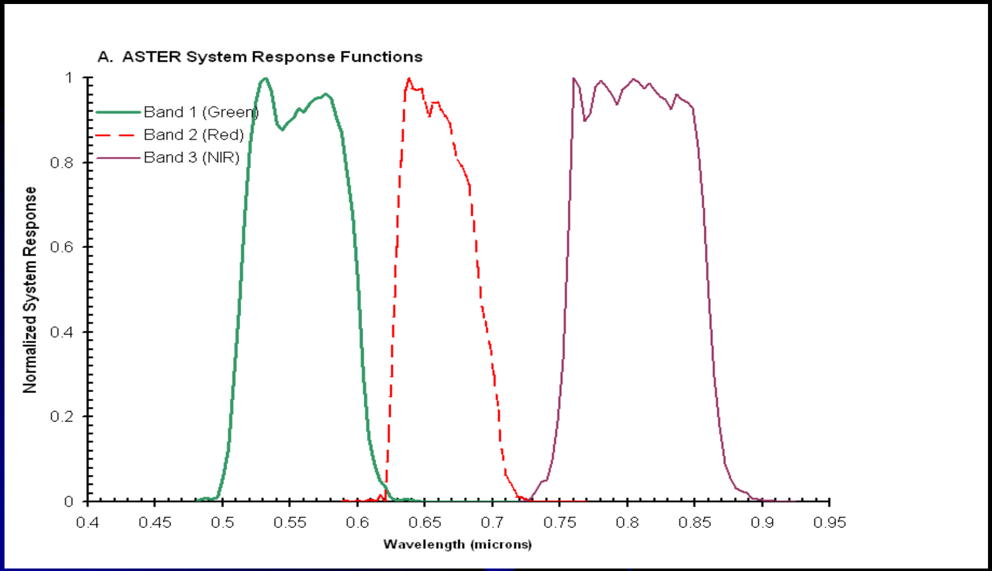
Unlike polar-orbiting satellites such as Landsat or Terra, the International Space Station (ISS) has an inclined equatorial orbit that is not sun-synchronous.

This type of orbit limits nadir viewing opportunities to approximately 52N and 52S latitudes, and results in variable ground illumination.

A – Successive orbit paths, descending ISS passes.
B – Daylight illumination in Southern Hemisphere only.
C – Successive orbit paths, ascending ISS passes.
D – Daylight illumination in Northern Hemisphere only.

Data Characteristics





- AP acquired since 1960s as part of crewed missions
- System response for digital cameras is comprised of CCD response, optical filters (NIR) and transmissivity of ISS window.
- Response curves typically exhibit significant overlap below the 60 % incident energy level
- Theoretical maximum resolution approaching 4 m/pixel confirmed in ISS digital imagery

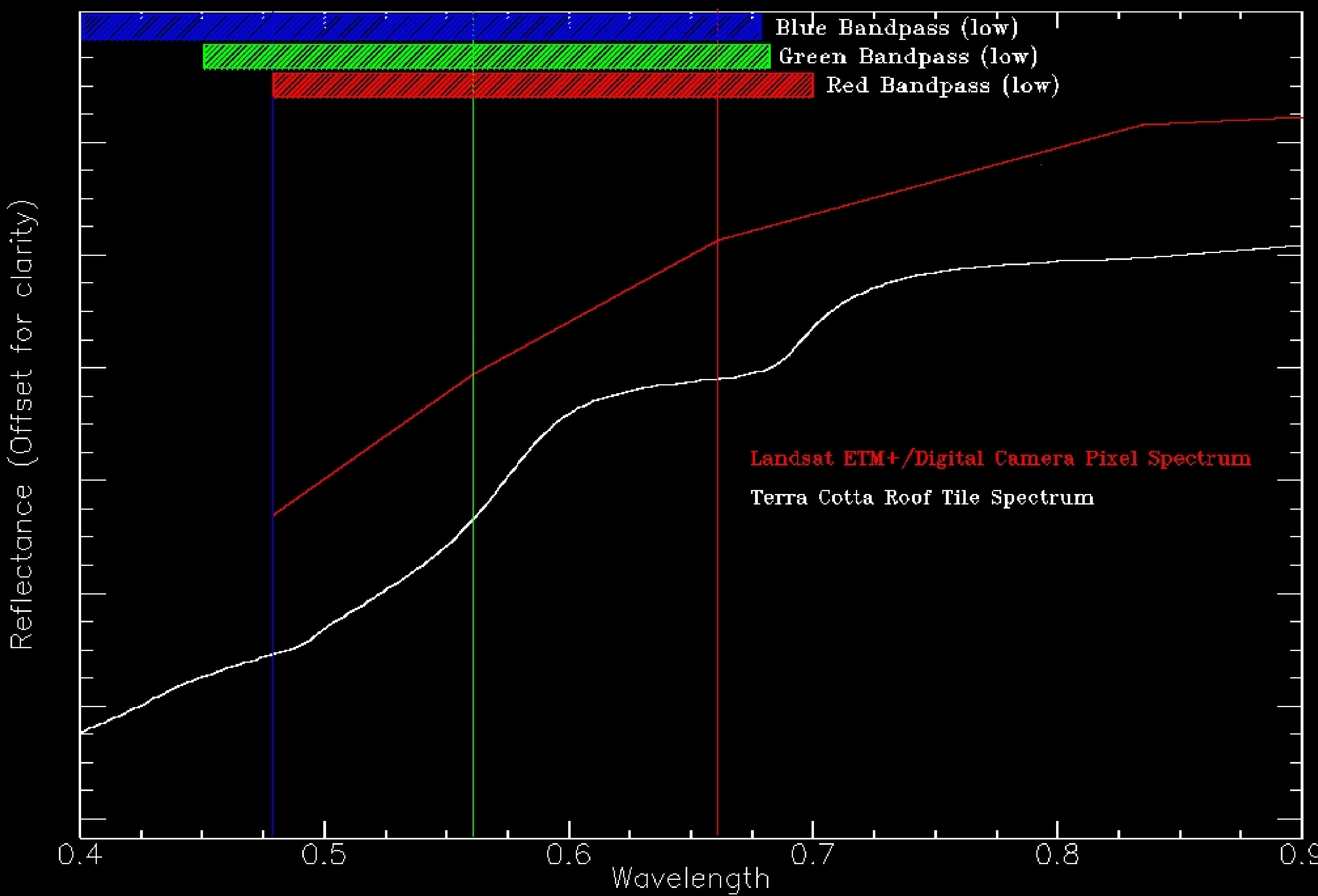
		Station Altitude	
		Minimum	Maximum
Camera	Lens	368 km	386 km
Hasselblad	110 mm	35.4	37.1
	250 mm	15.6	16.3
	350 mm	11.1	11.6
Nikon	300 mm	13.0	13.6
	400 mm	9.7	10.2
DSC	300 mm	11.0	11.6
	400 mm	8.3	8.7
	800 mm	4.2	4.4

Nikon D2Xs Camera

Image source: Nikon

Effective pixels	12.4 million
Image sensor	CMOS sensor, 23.7 x 15.7mm size, 12.84 million total pixels
Image size	Full Image: [L] 4,288 x 2,848-pixel / [M] 3,216 x 2,136-pixel / [S] 2,144 x 1,424-pixel

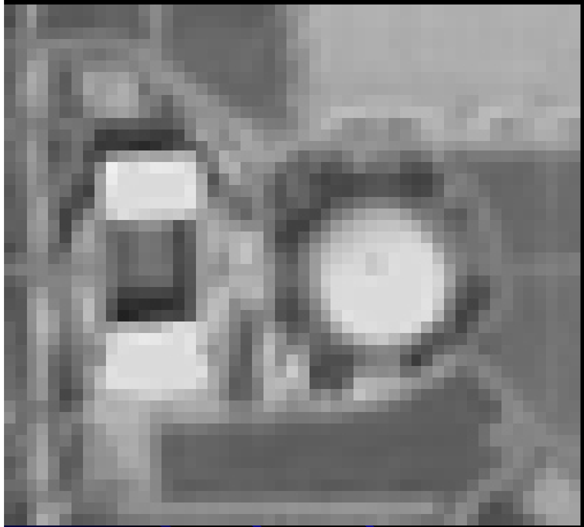
Spectral Resolution



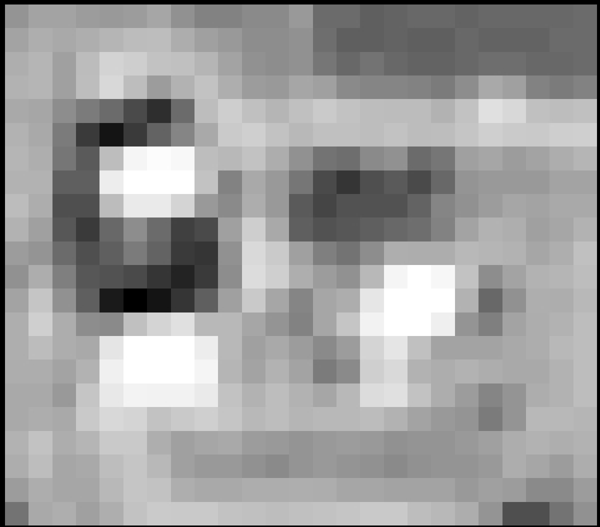
Spatial Resolution

Reliant Stadium, Houston, TX

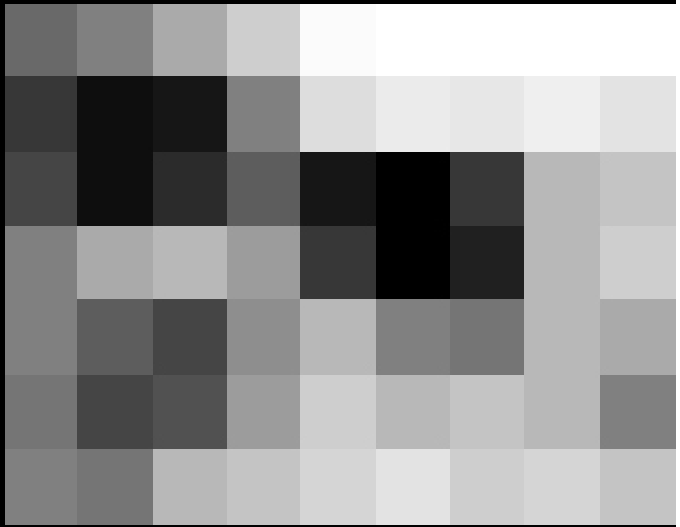
0 200 m



ASTER Band 2 – visible green
15 meters/pixel

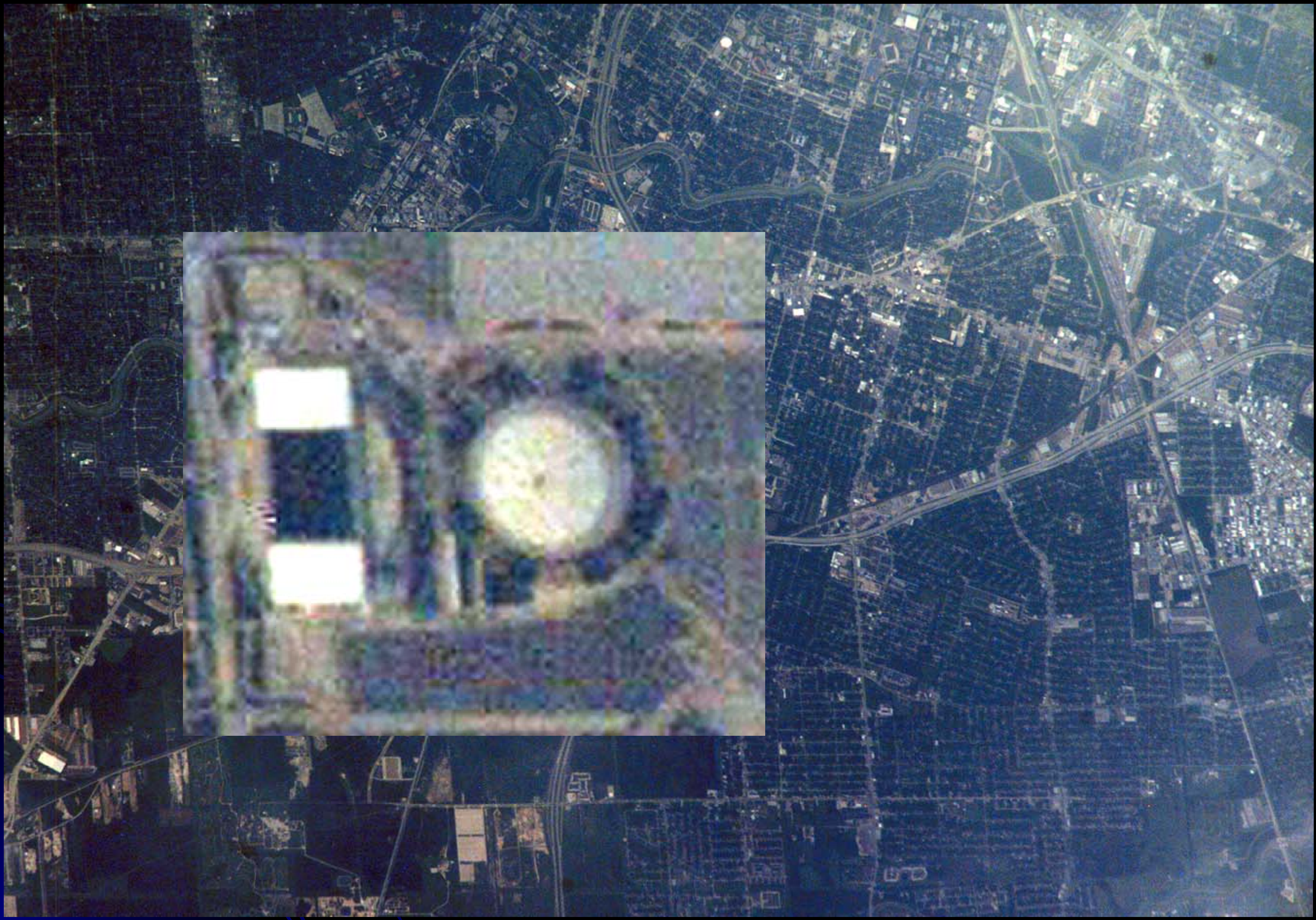


ASTER Band 6 – shortwave IR
30 meters/pixel



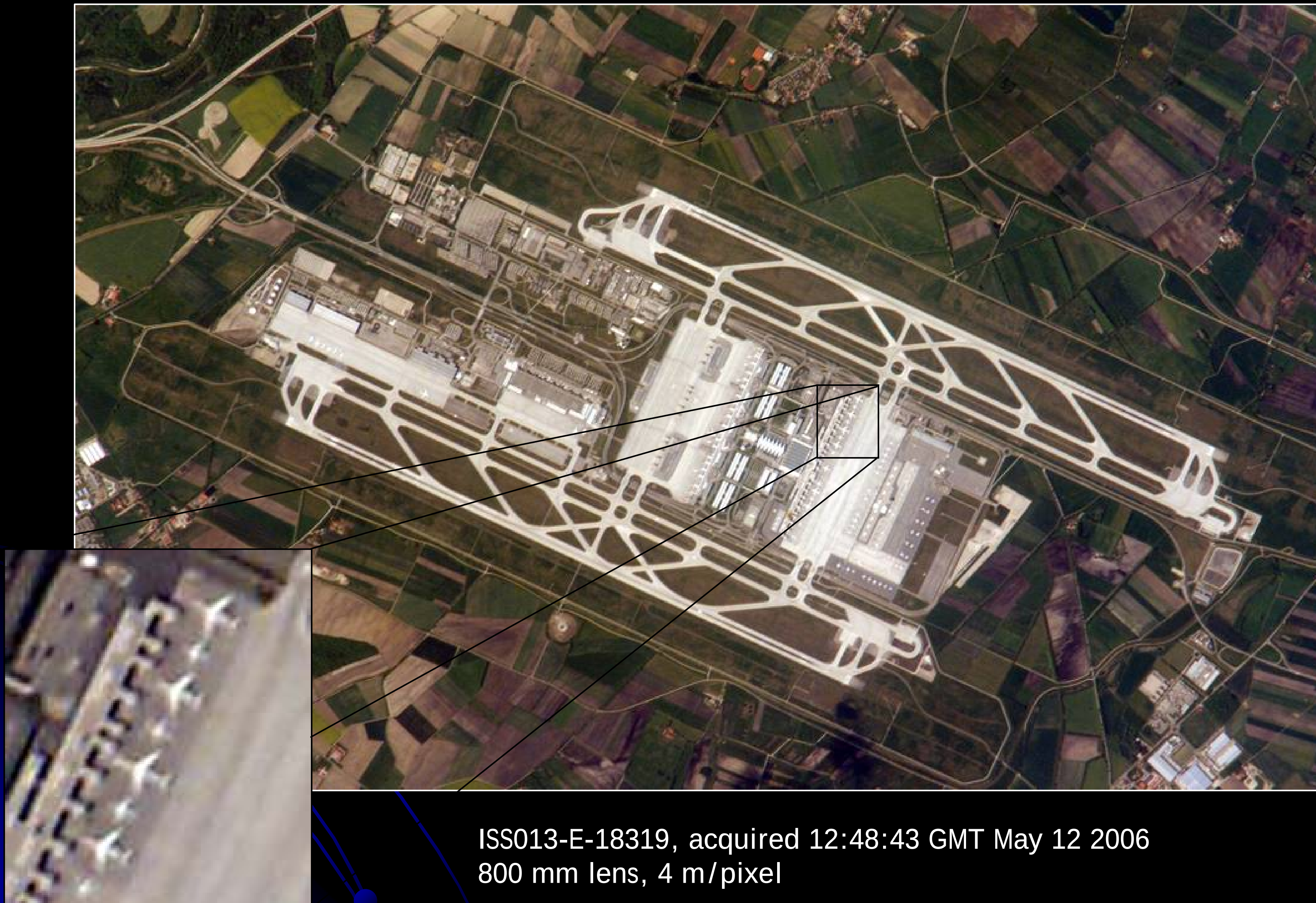
ASTER Band 11 – thermal IR
90 meters/pixel

ASTER data acquired 15-October-2003



Astronaut photograph ISS007-E-13075
Acquired 20-August-2003, ~ 7 meters/pixel

High-resolution astronaut photography – Munich Airport, Germany



ISS013-E-18319, acquired 12:48:43 GMT May 12 2006
800 mm lens, 4 m/pixel

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- Astronaut Training and Operations
  - Crew Earth Observations Group
  - Targeting Sites and Acquisition
  - Cataloging and Database

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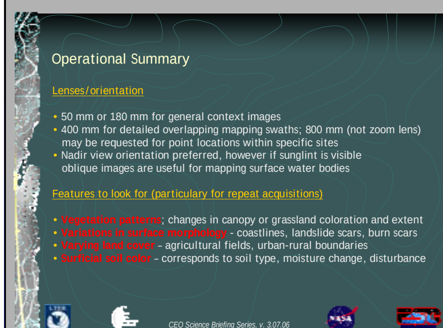
Crew Earth Observations (CEO)

- Science team based at NASA Johnson Space Center
- Currently tasked with performance of Crew Earth Observations experiment payload aboard the ISS
- Astronaut training for specific science objectives (includes urban areas, ecological monitoring sites, glaciers, deltas, megafans, volcanoes, impact craters)
- Download and cataloging of images for entry into database, curation of astronaut photography database
- Distribution of data to collaborating scientists and performance of research
- Educational outreach (NASA Earth Observatory, Public Affairs Office, NASA Hurricane Resource web site)

Payload Workflow

Crew Training

- Astronauts and cosmonauts are given briefing on science objectives and photographic technique by CEO scientist prior to Expeditions



Slide excerpts from CEO "Long Term Ecological Research" crew briefing.

Mission Operations

Daily determination of potential CEO LTER target visibility using ISS orbit ephemeris data

Screening of potential target list by crew activity schedule, sun elevation, ISS orientation (determines nadir versus oblique imagery)

Predicted cloud cover (24 hrs. out) favorable?

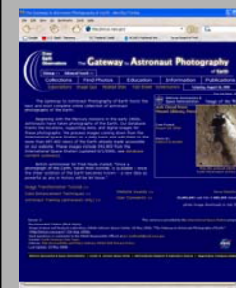
NO

YES

ISS/site area of interest intersection time and coordinates; descriptive text and specific photographic instructions; and supporting data formatted into CEO Target List message

CEO Target List message reviewed by Operations Controller and Payload Operations Director; uploaded to crew prior to waking

Image Database



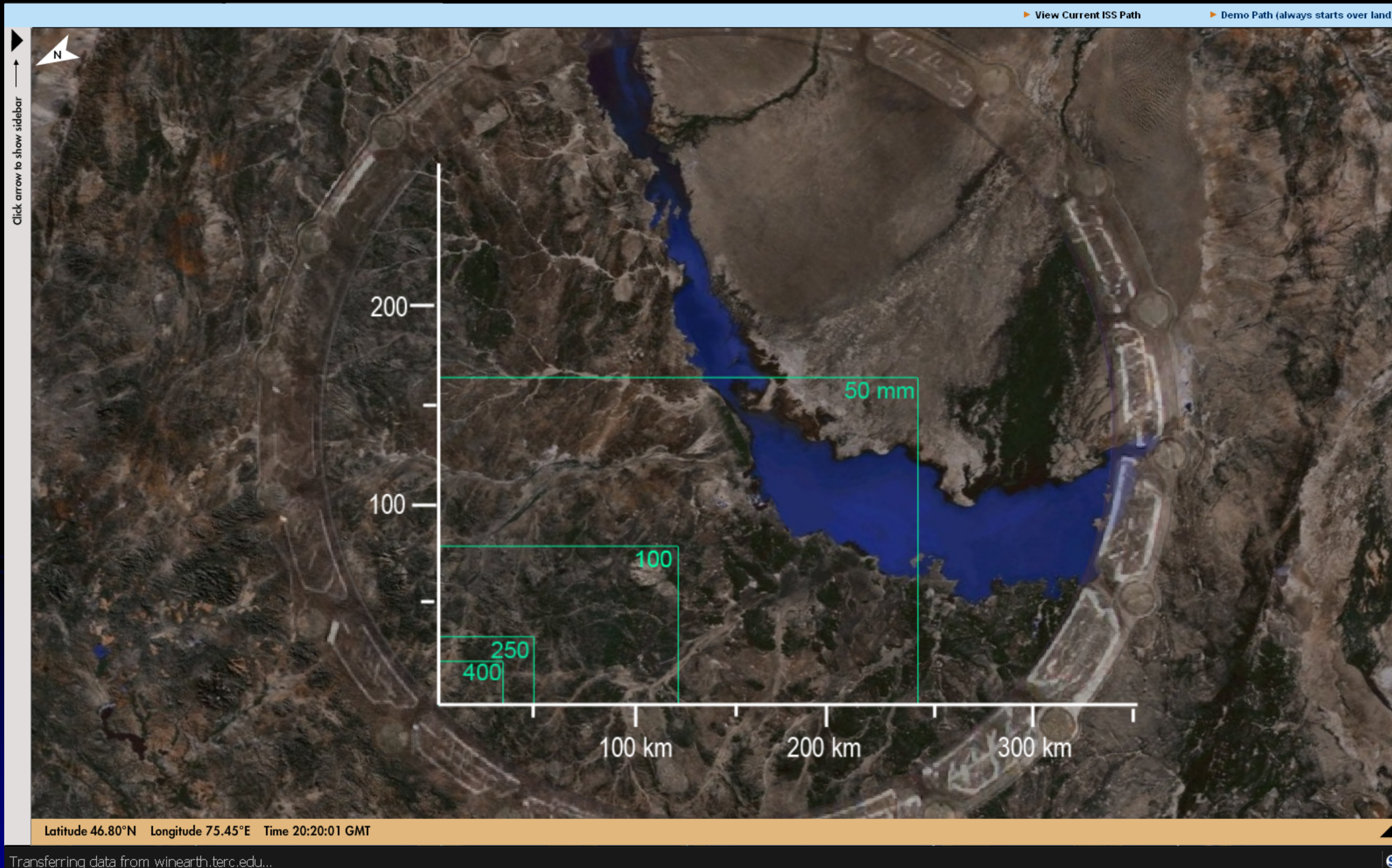
Geographic center coordinates and descriptive metadata are determined for each image by CEO staff using georeferenced remotely sensed data and maps.

Images are then added to the online searchable astronaut photography database "Gateway to Astronaut Photography of Earth": **http://eol.jsc.nasa.gov**.

Online database can be searched by geographic coordinates, date/time, mission, keyword, illumination and look angle parameters, lenses, etc. using Technical Search tools (left) @ **http://eol.jsc.nasa.gov/sseop/sql.htm**.

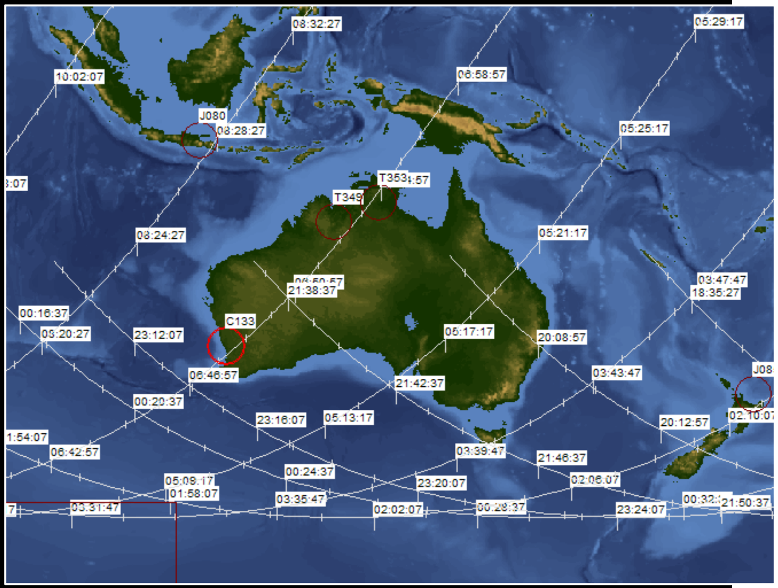
Query results include links to full metadata for each image (right). Images can be downloaded at full resolution free of charge.

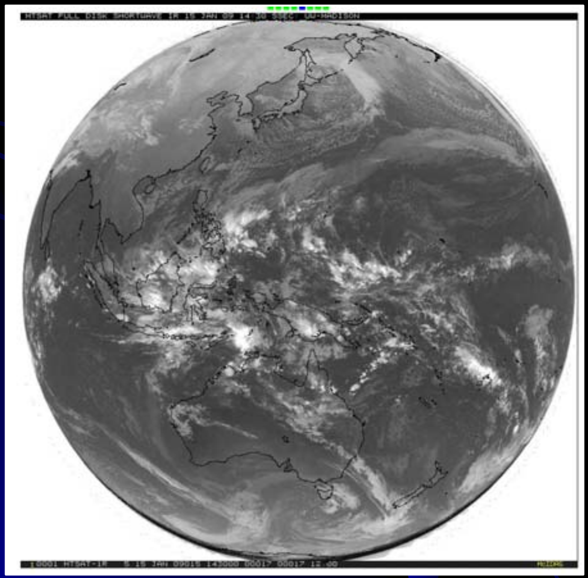
The View From Above



Windows on Earth software – http://winearth.terc.edu/appISSFlight

CEO operations





Earth Observations Station Message for 16-JAN-2009/GMT Day 016
Message Generated: 15-JAN-2009

16-JAN-2009/GMT Day 016

GMT	Site	Lat	Lon	Lens
06:47:56	Perth, Australia	33.7S	115.0E	800

Weather is predicted to be clear over the capital city of Western Australia. Look slightly to the left of track for the city (Fig. 1) located along the Swan River. We request overlapping mapping frames, taken along track, of the southeastern urban-rural fringe of the metropolitan area to track land use and land cover change.

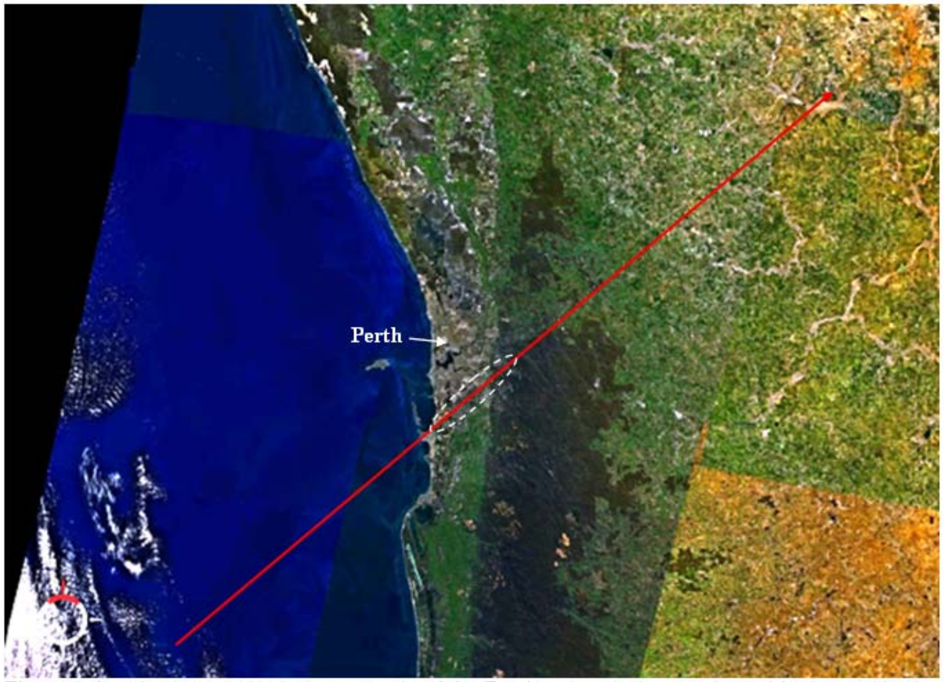


Figure 1. Landsat true-color image mosaic of the Perth target region as viewed from an altitude of 356 km. The red arrow indicates your approximate orbit track, and the dashed ellipse indicates the area of interest for photography.

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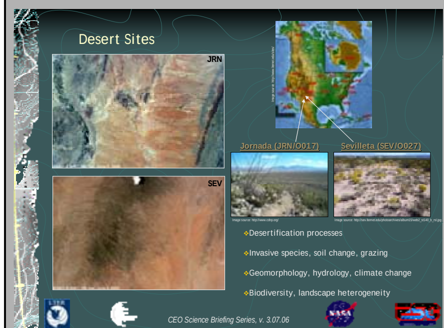

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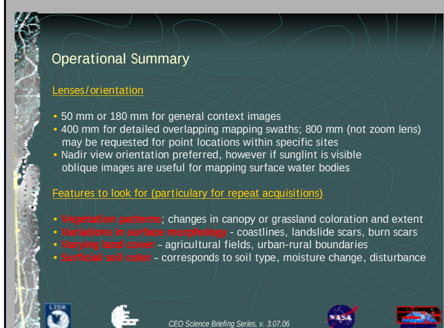

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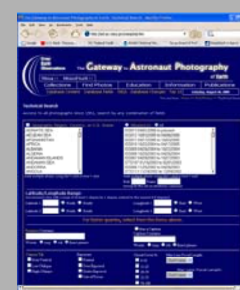

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So Why Use Astronaut Photographs?

Advantages	Disadvantages
Variable look angles, sun illumination, and acquisition time can provide new information on surface reflectance processes	Variability of human-acquired data makes direct comparison difficult, both within time series of photographs and with other datasets
Extensive database represents longest image record for many portions of the globe	Repeat acquisition cycle typically not regular
Spatial resolutions as high as 4 m/pixel can be acquired under ideal conditions	Bandpasses of cameras are broad and overlap at low intensity levels – makes spectral analysis of data difficult
Ability to acquire high oblique imagery allows for photography of surface and atmospheric features (hurricanes, aurora)	Several outside factors can contribute to nonacquisition of data (weather, lighting, operational constraints)
Data are easily interpreted without need for sophisticated software	Data require preprocessing (georeferencing) for quantitative analysis
Data are freely available to user community	

Astronaut photography could be used for…

Geologic Mapping
- bedrock, structure

Economic Resource Assessment
- structure, vegetation

Hazard Assessment
- volcanoes, earthquakes, floods,

Land Cover Mapping/Change
- patch dynamics, urbanization, vegetation

Geomorphology/Landscape Characterization
- topography, visualization

Soil Mapping
- agriculture, soil moisture

Hydrology
- drainage networks, vegetation, land cover, floods

Climatology/Surface Fluxes
- albedo

Environmental Monitoring
- anthropogenic contaminants, air quality

Selected References

Gebelein, J., and Eppler, D. (2006) How Earth remote sensing from the International Space Station complements current satellite-based sensors. International Journal of Remote Sensing 27 (13):2613-2629.

Robinson, J.A., Liddle, D., Evans, C., and Amsbury, D. (2002) Astronaut-acquired orbital photographs as digital data for remote sensing: spatial resolution. International Journal of Remote Sensing 23:4403-4438.

Stefanov, W.L. (2008) Astronaut photography: "Hands-on" remote sensing of the Earth. Phi Kappa Phi Forum 88 (1):2-7.