AIRBORNE HYPERSPECTRAL IMAGING

DO'S and DON'TS

Herbert Ripley, FRSPSoc

Hyperspectral Imaging Limited

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Canada, B2S 2L2

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HYPERSPECTRAL IMAGING LIMITED CONDUCTS CONTRACT AERIAL HYPERSPECTRAL SURVEYS AROUND THE WORLD. OUR SERVICES INCLUDE DATA COLLECTION, DATA ANALYSIS AND DATA MAPPING. COMPANY PRINCIPALS HAVE EXTENSIVE PROJECT EXPERIENCE. THE PRINCIPAL COMPANY FOCUS IS IN THE COASTAL MARINE SECTOR.

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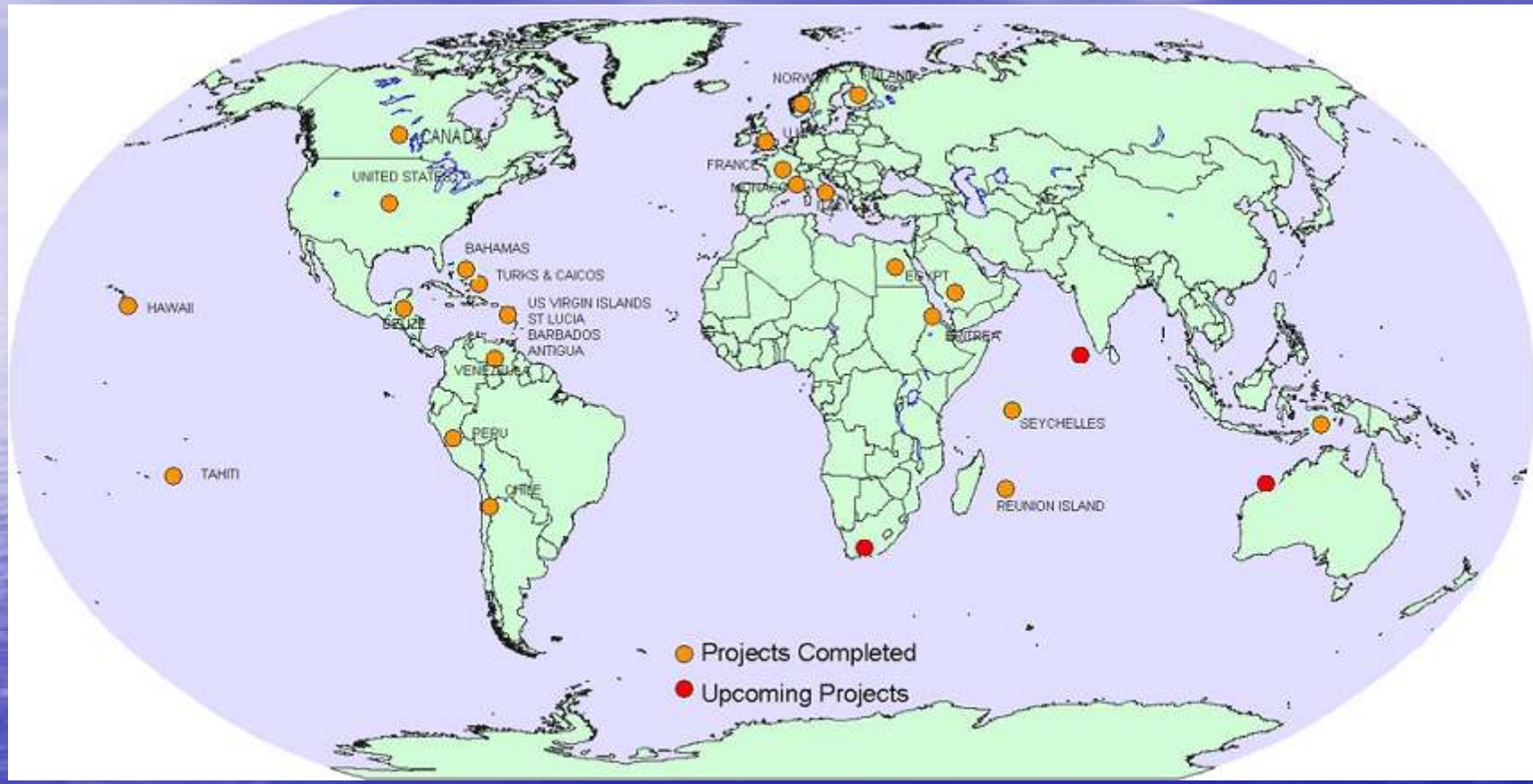

PROJECT ACTIVITY

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TODAY'S SESSION

- the technology
- planning an airborne survey (design and layout of flight lines, things to avoid)
- execution of the survey (type of aircraft to use, when to fly)
- data pre-processing (geocorrection, atmospheric correction)
- brief overview of data analysis

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THE BASIC TECHNOLOGY

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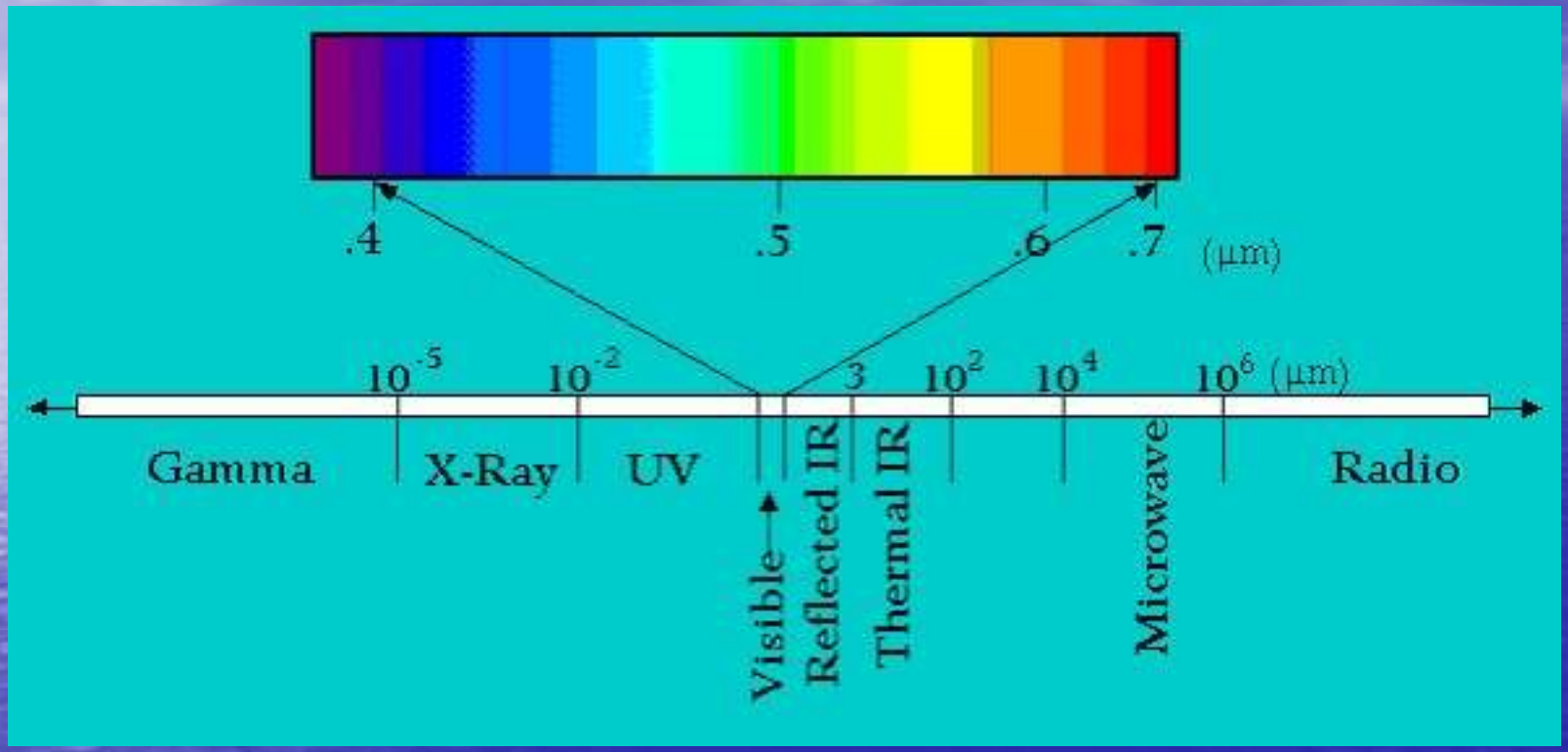

THE SPECTRUM

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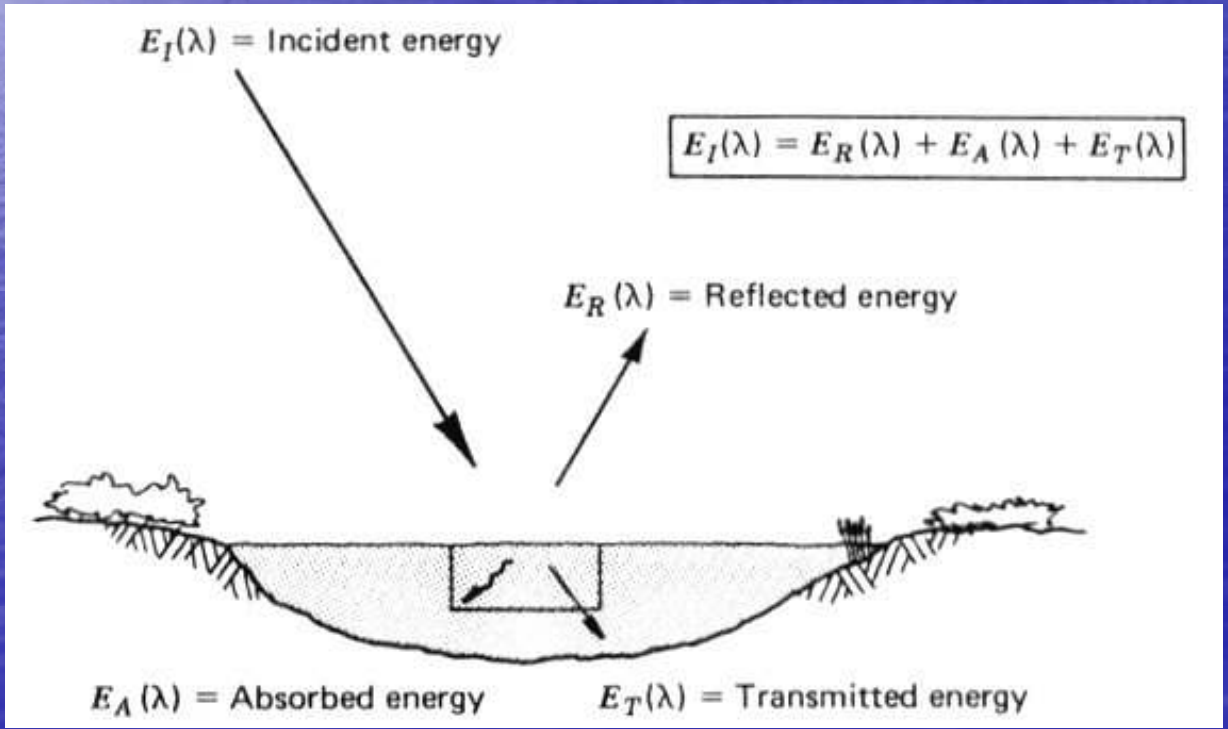
ENERGY INTERACTION - EARTH

Energy incident on a surface will be:

- Reflected, transmitted, absorbed



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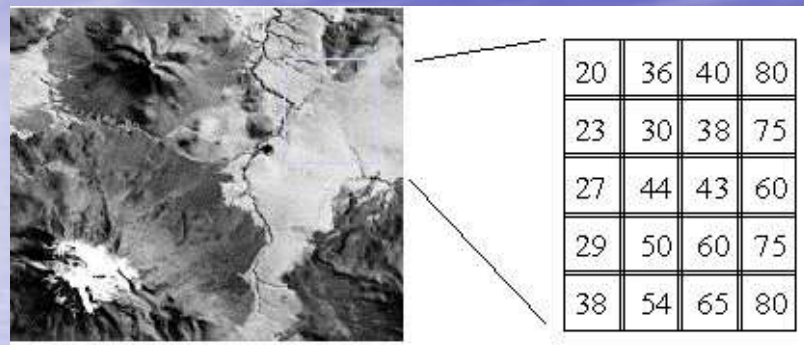
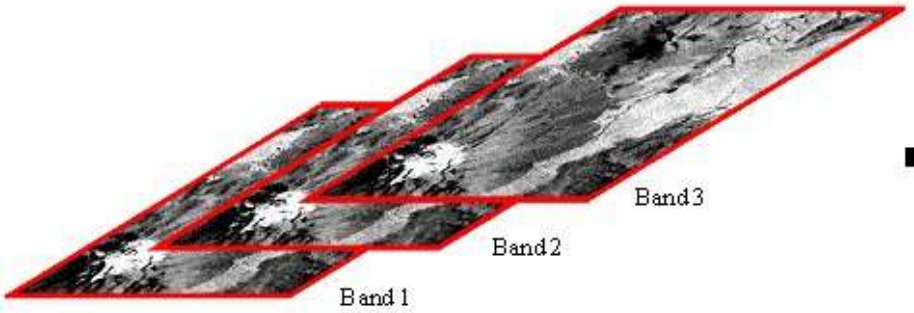
DIGITAL IMAGES

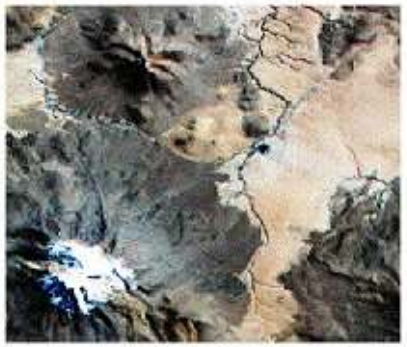


20	36	40	80
23	30	38	75
27	44	43	60
29	50	60	75
38	54	65	80

A digital image is a two dimensional array of elements where each element represents some measure or characteristic of the feature of interest

Elements are assigned a digital number which is converted to a grey shade for visual representation





A colour image is formed by the display of images through colour filters

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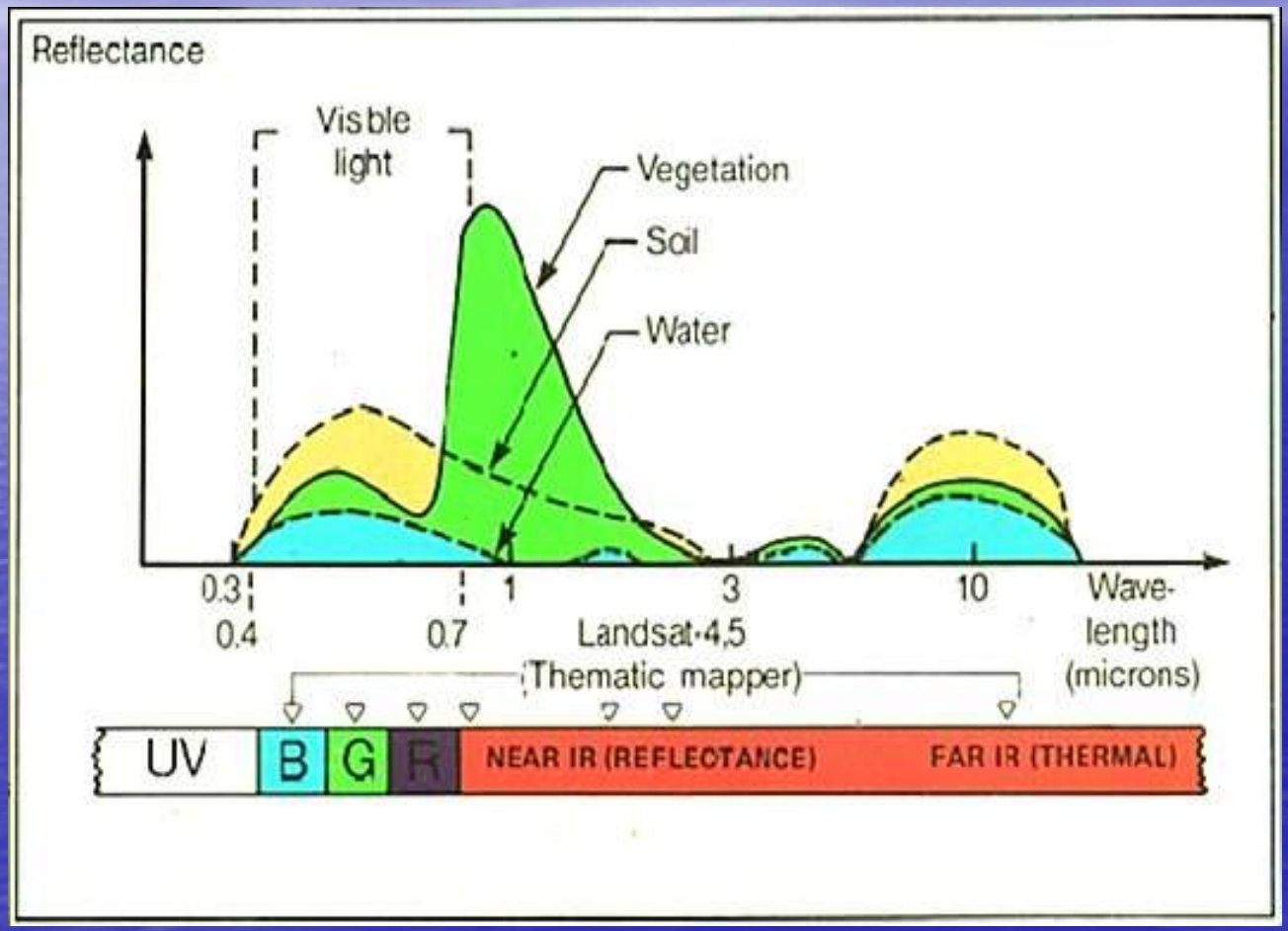
SPECTRAL REFLECTANCES



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Remote Sensing – need to think of resolution in 3 ways

Spatial Resolution - ability to detect ground features (size)

Spectral Resolution - ability to subdivide EM spectrum

Radiometric Resolution - sensitivity of measurement

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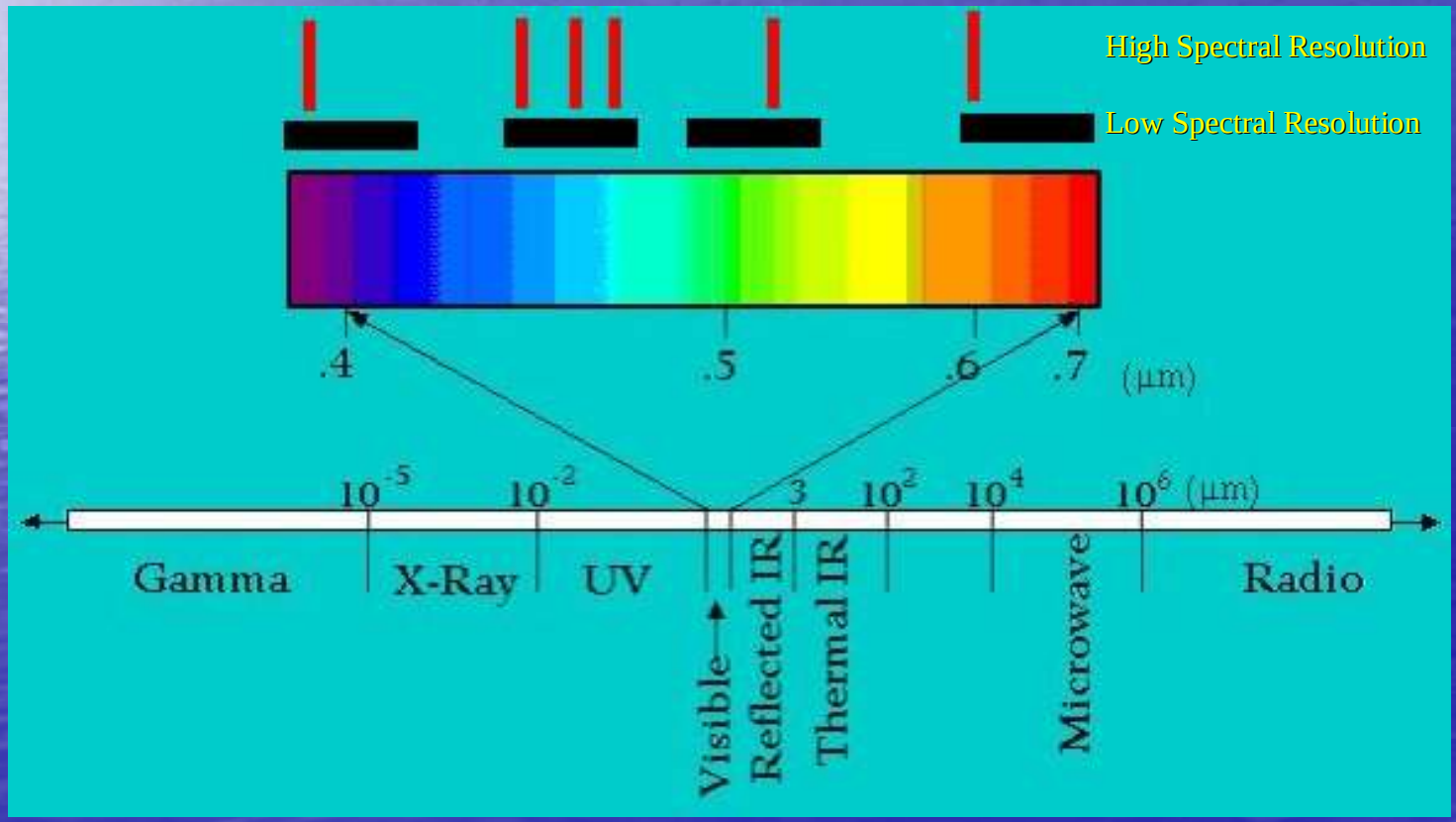
Spectral resolution describes the ability of a sensor to define wavelength intervals

Finer the spectral resolution, the narrower the wavelength range for a particular channel or band



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Radiometric resolution describes ability to discriminate very slight differences in energy

Finer the radiometric resolution, the more sensitive to detecting small differences in energy

4 bits to record the data

2^4 = 16 digital values

8 bits to record the data

2^8 = 256 digital values

casi550 is now a 14 bit sensor!

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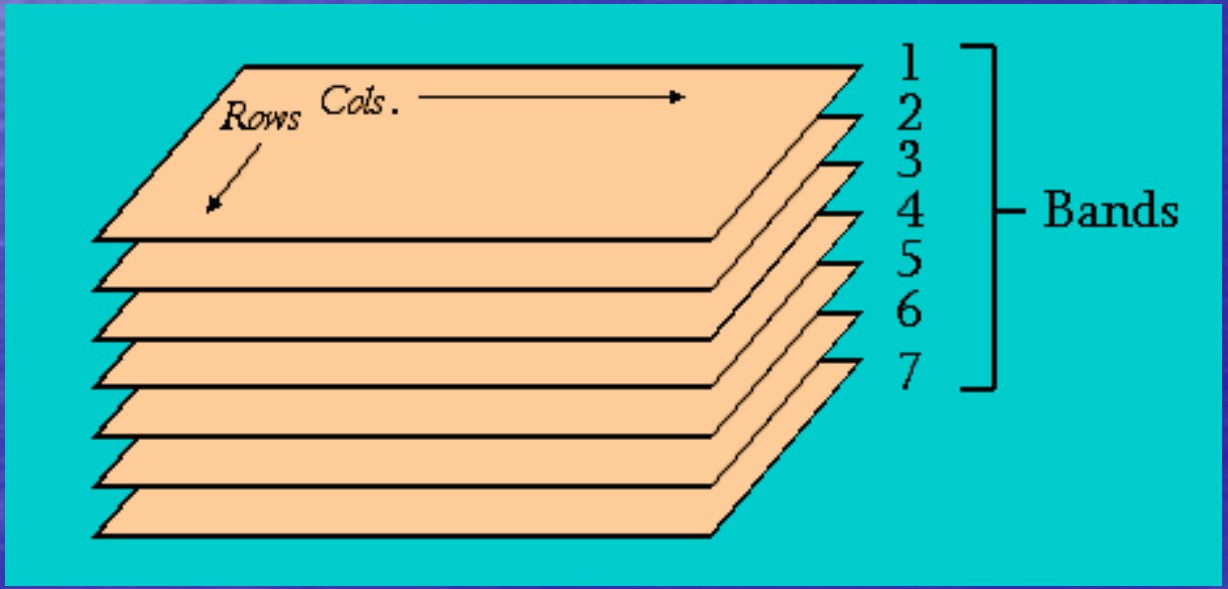
DATA CONCEPT

- Conceptually, hyperspectral or multispectral images comprise "layers" or bands of 2 dimensional arrays
- Bands represent discrete wavelength intervals

Major difference is the number of bands



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Multispectral versus Hyperspectral

- so what really is the difference?

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What spectral range do hyperspectral sensors cover?

. . . Is it 400 – 1000 nm

or

. . . Is it 400 – 2500 nm

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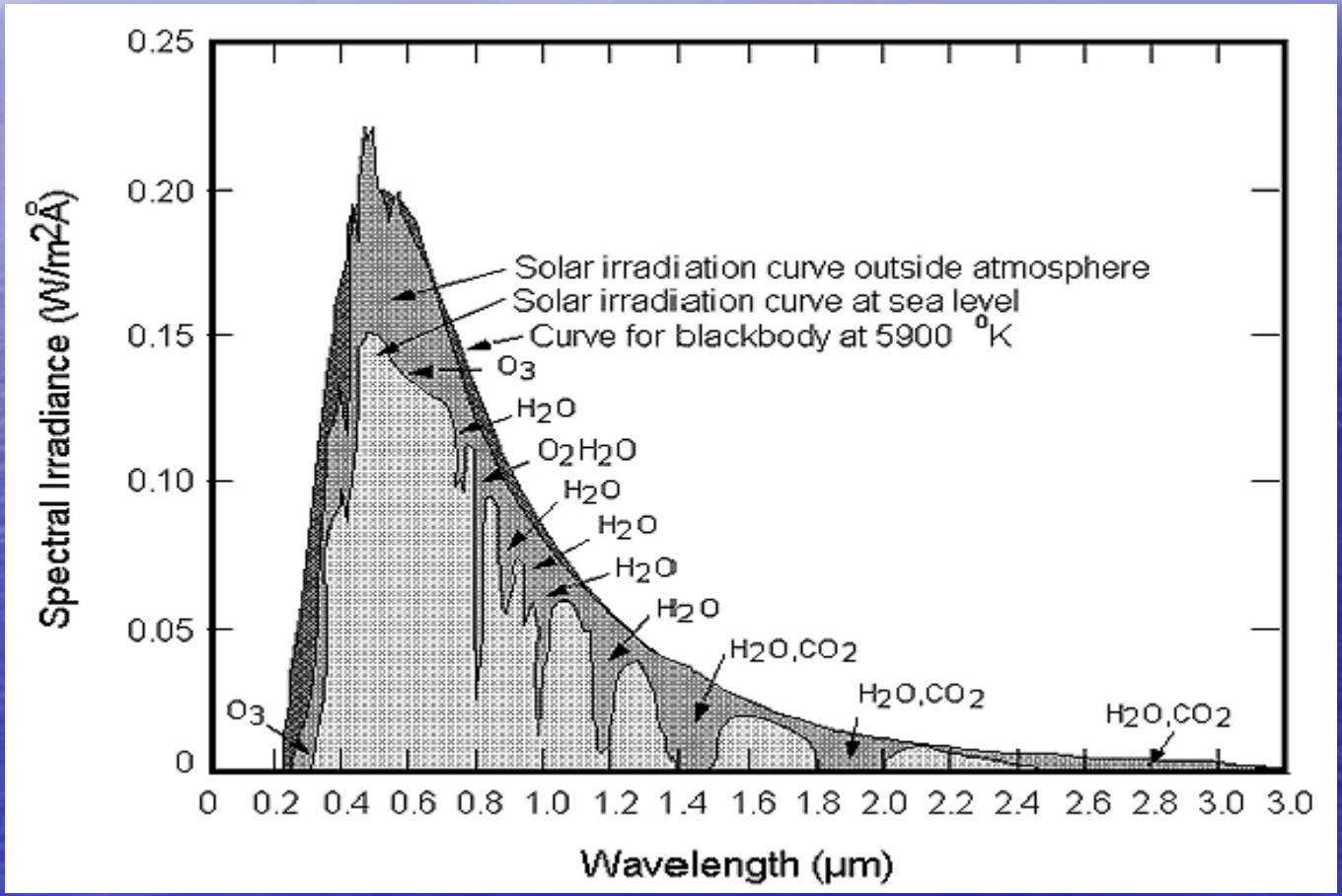
ATMOSPHERIC WINDOWS



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What does this tell us??

- all sensors have to deal with the same issues

- signal to noise is a critical issue, especially as you get further out in the spectrum

- significant issues caused by atmosphere must be dealt with

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AIRBORNE SYSTEMS

- *casi* (casi,casi2,casi550..,SASI)
- AVIRIS
- AISA (plus, Eagle, Birdie)
- PROBE1
- HyMAP
- MASTER

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SATELLITE SYSTEMS

- HYPERION
- MERIS
- MODIS
- CMODIS
- ASTER
- GLI

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PROJECT PLANNING

Or perhaps better stated

PAY ME NOW OR PAY ME LATER

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MANY FACTORS HAVE TO BE CONSIDERED AT THIS STAGE.....

- WHEN TO FLY
- WHAT BANDSET
- WHAT RESOLUTION
- SIZE OF AREA
- SPATIAL ACCURACY
- GROUND DATA COLLECTION
- HOW TO FLY (direction, flight line order)

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POSSIBLE CHOICES

- Time of day
- High tide – low tide
- Time of year

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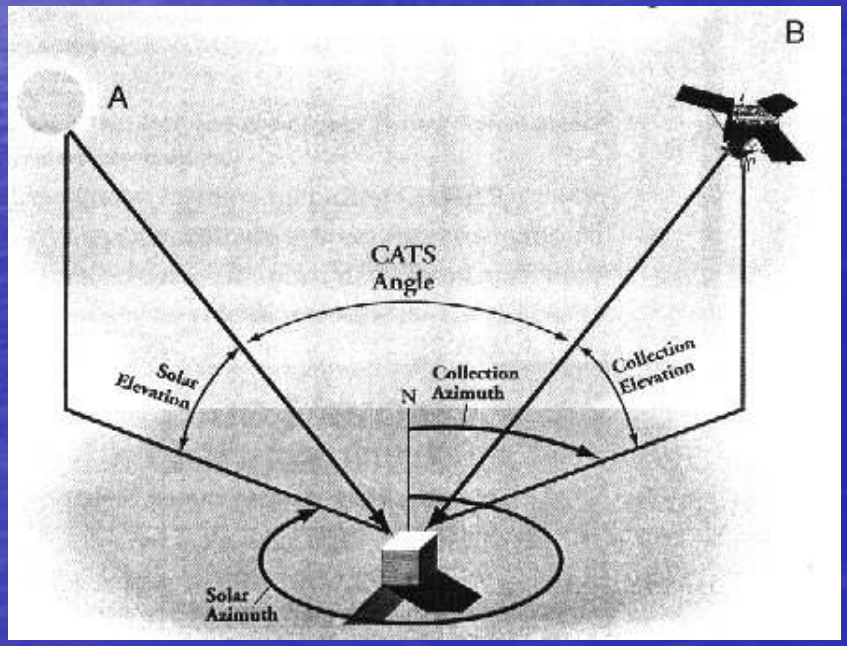
CATS – Camera Target Sensor Geometry

- Solar elevation differences have significant effect
- At 40 degree latitude, given an identical imaging time, brightness values can change by a factor of 40% between summer and fall



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PICKING A BANDSET

- How many bands
- what spectral resolution
- what specific wavelengths

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WHAT SPATIAL RESOLUTION TO PICK

- low res means fewer flight lines
- higher res means more lines, more detail
- pixel size is influenced by aircraft speed

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STUDY AREA SIZE

- relative to pixel resolution
- relative to constraints (low or high tide)
- time of year
- ground data collection

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SPATIAL ACCURACY

- what is the intended use of the data
- is very accurate x,y important
- what are technical implications
- what are cost implications

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INERTIAL MEASUREMENT UNITS

- bring high accuracy
- have implications on data collection
- more time needed to data process
- generally mean higher costs

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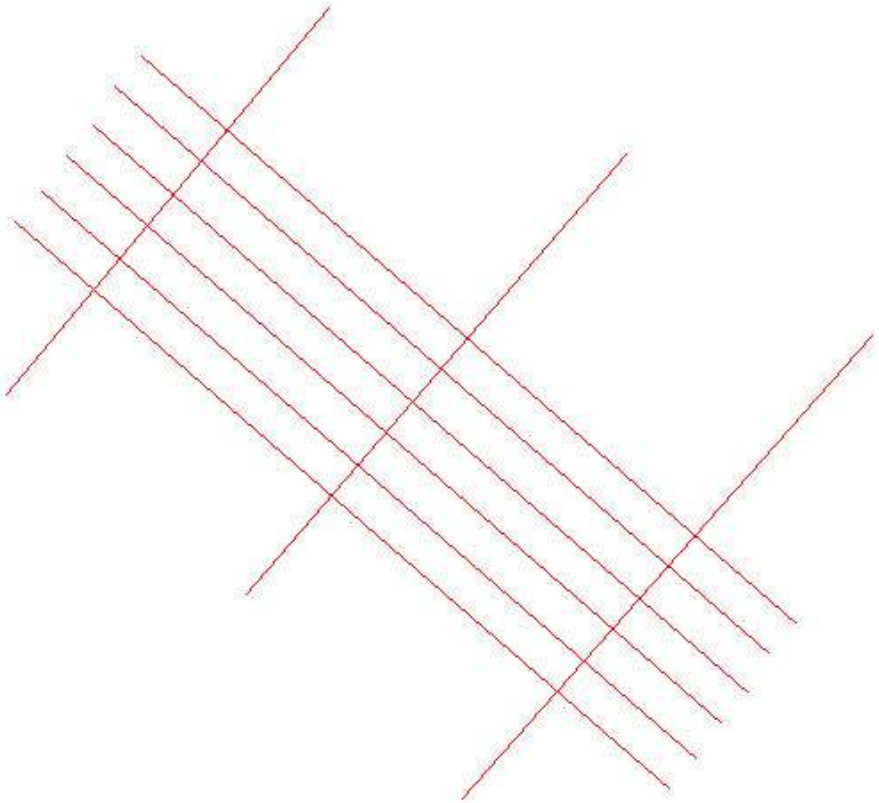

- Increased sidelap
- Flown over area with prominent features
- Must be flown with same configuration

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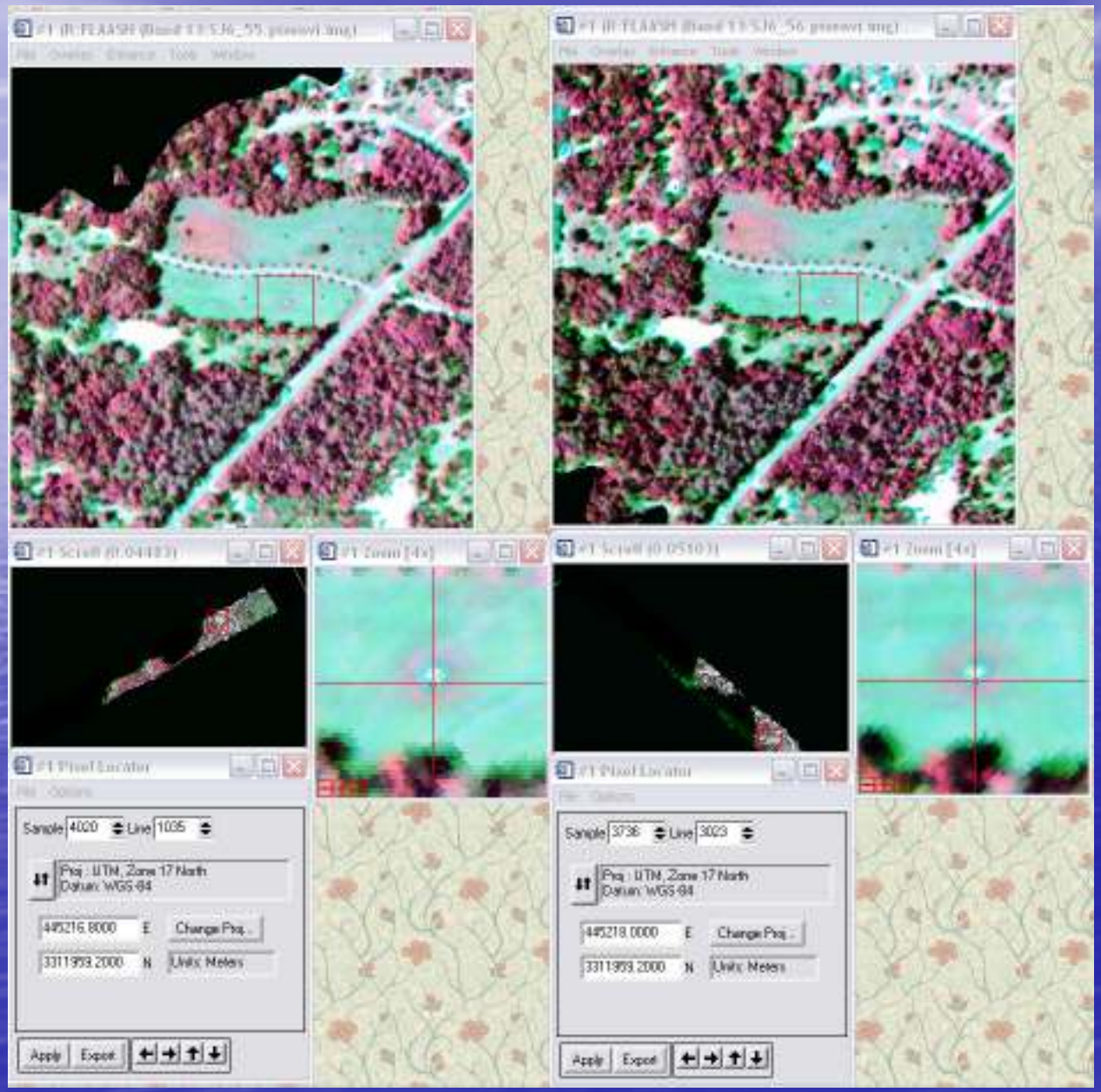

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GROUND DATA COLLECTION

- does the aircraft have to be over the area at the same time

- will the ground team have spectral targets that need to be flown

- time implication, cost implication

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PLANNING YOUR FLIGHT LINES

- what orientation?
  - east/west
  - other
- overlap
- effect on flying

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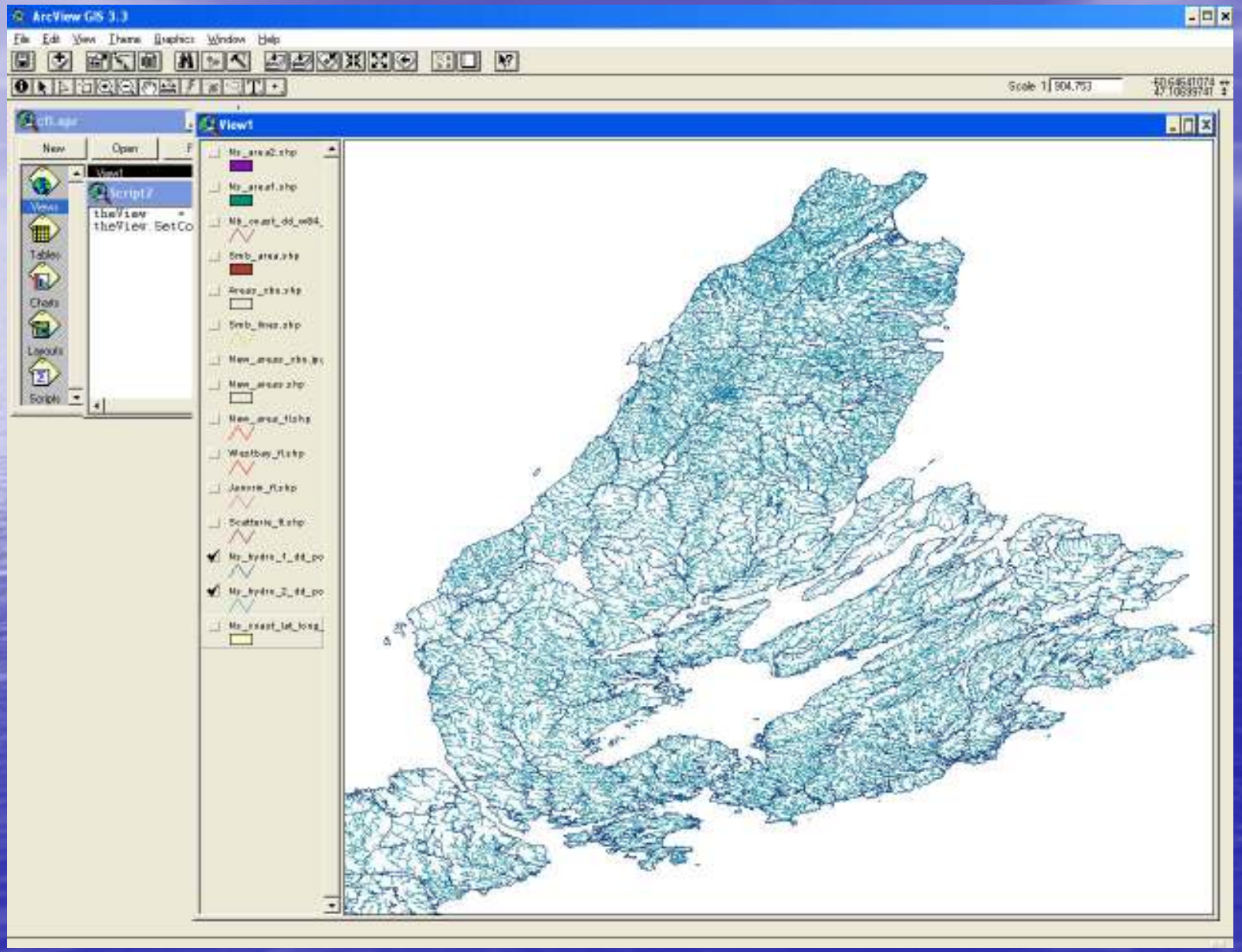

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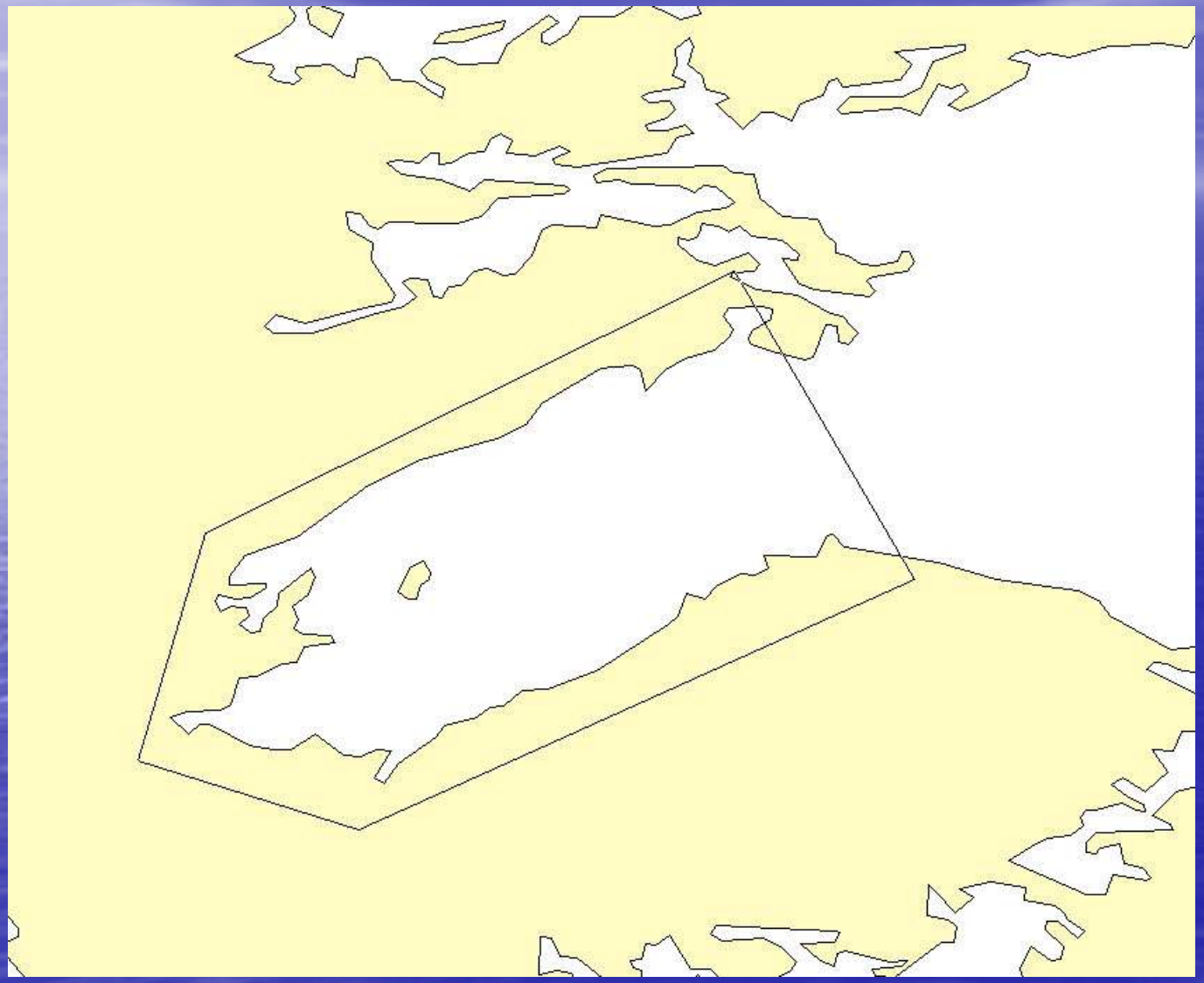

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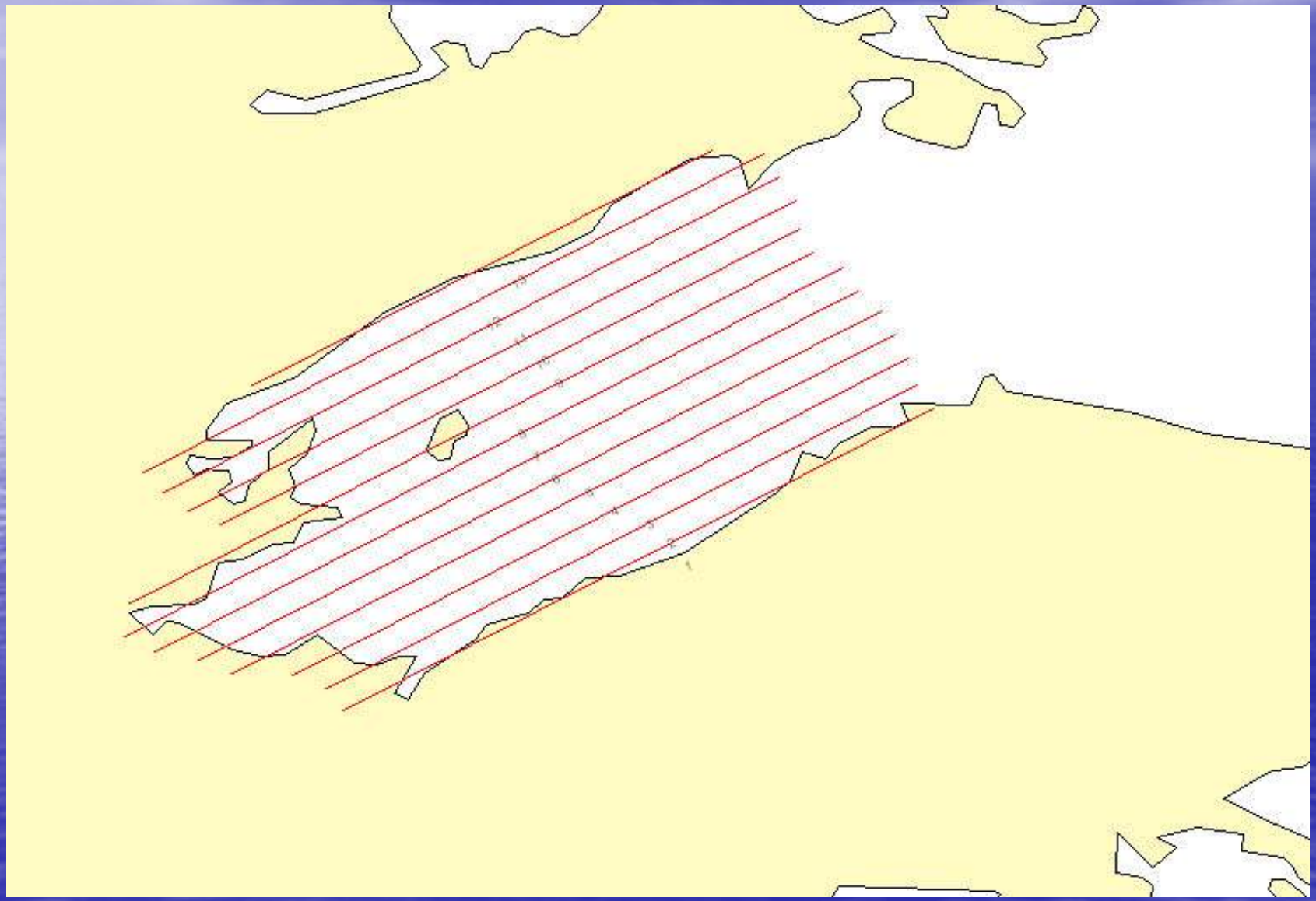

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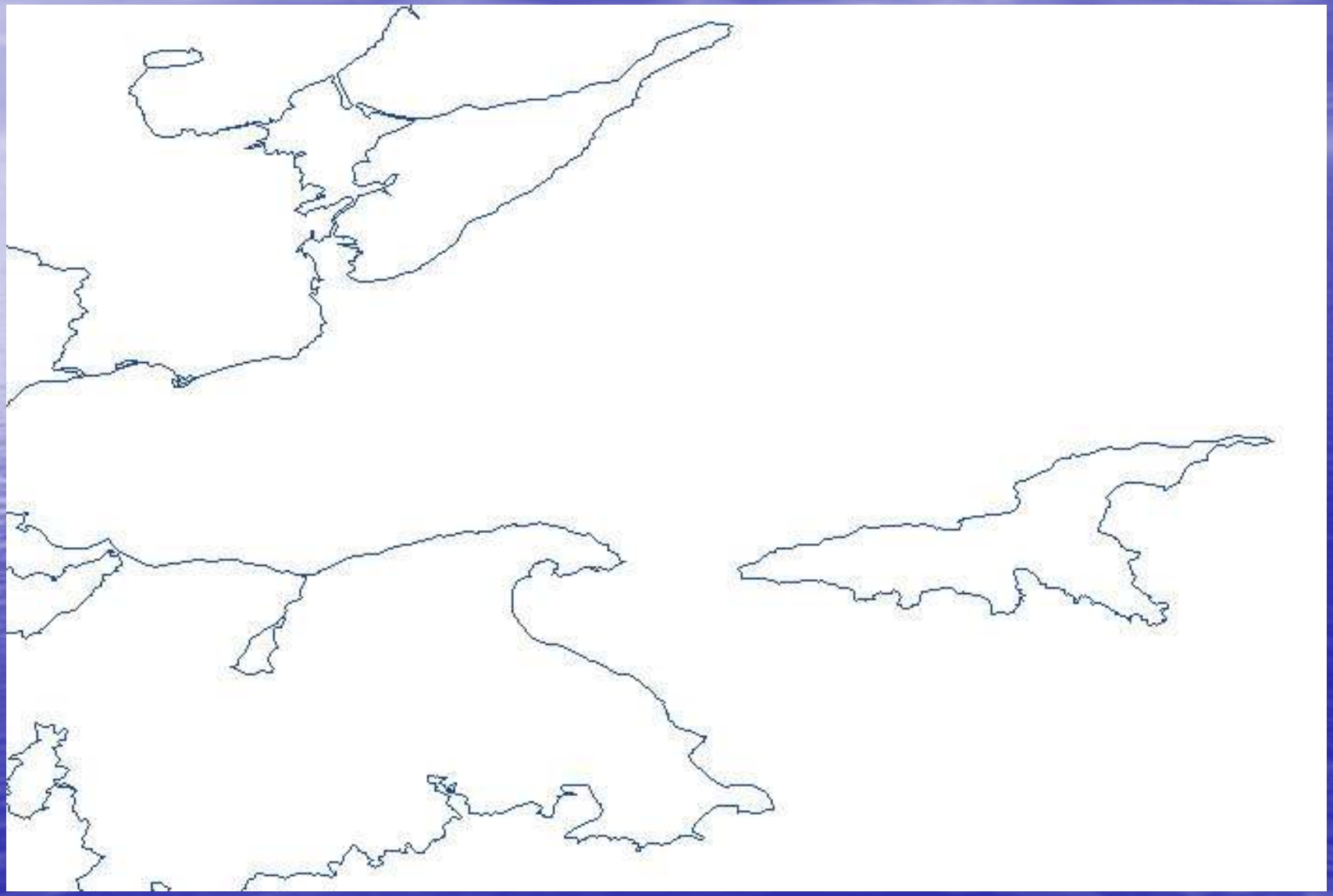

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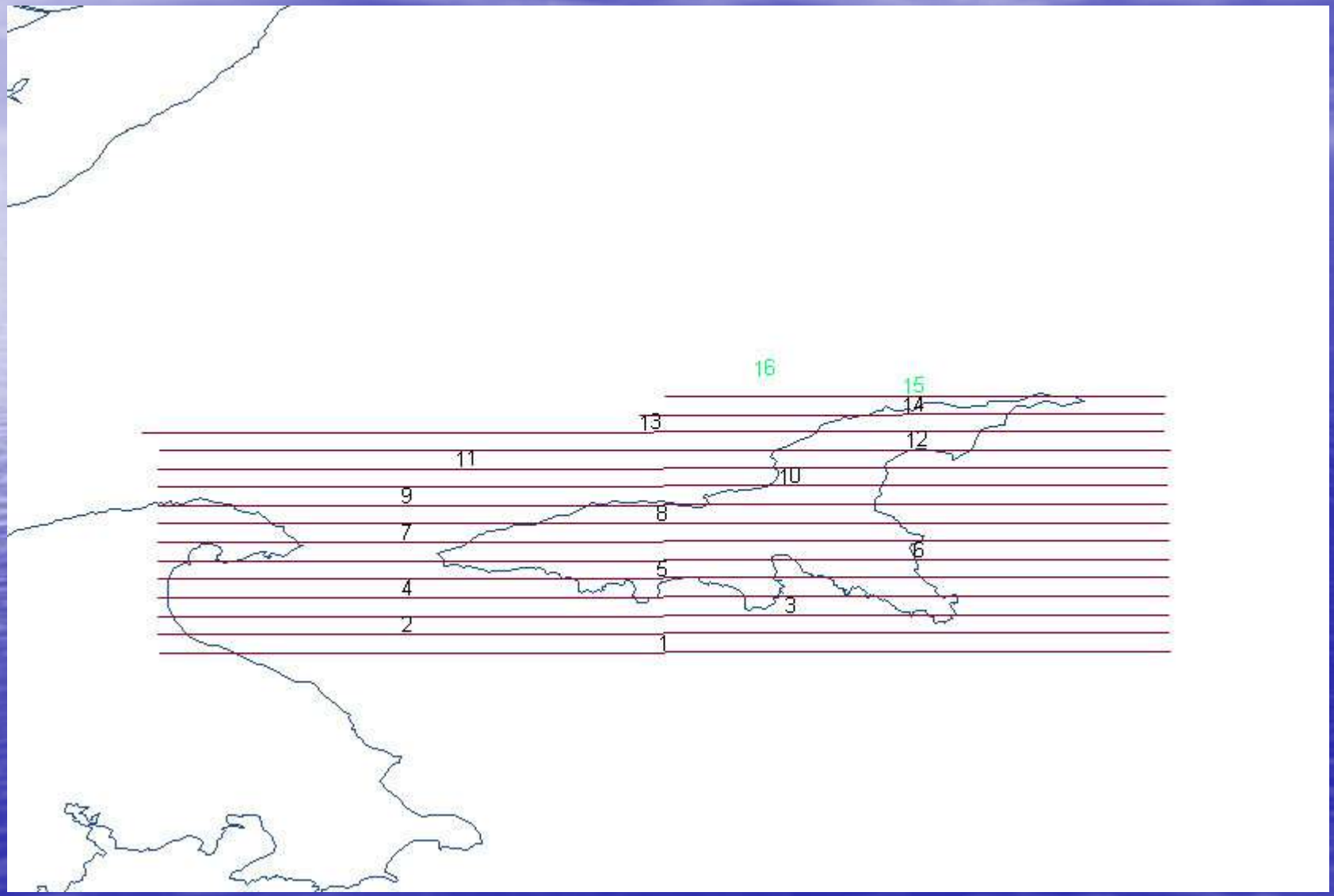

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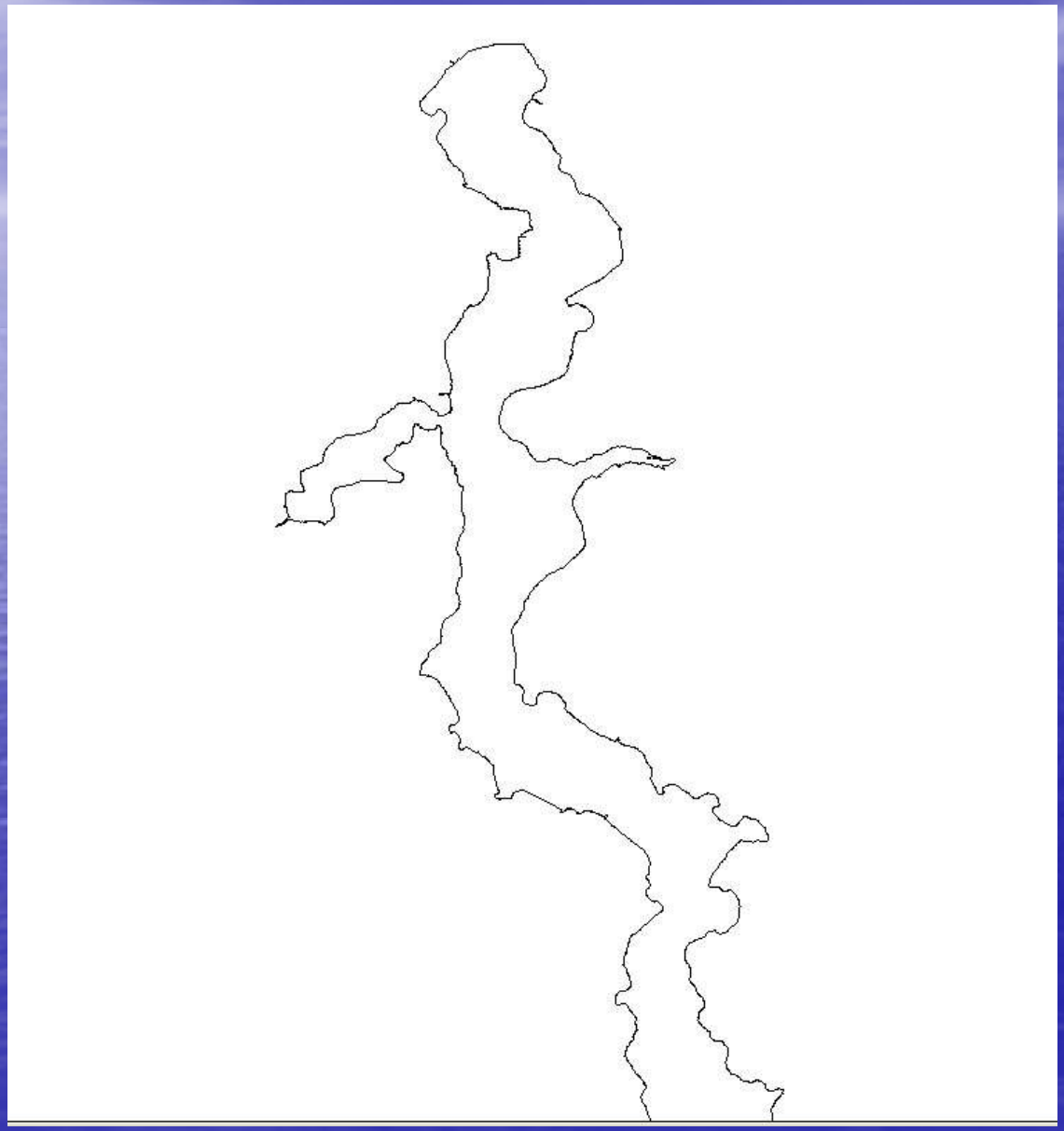

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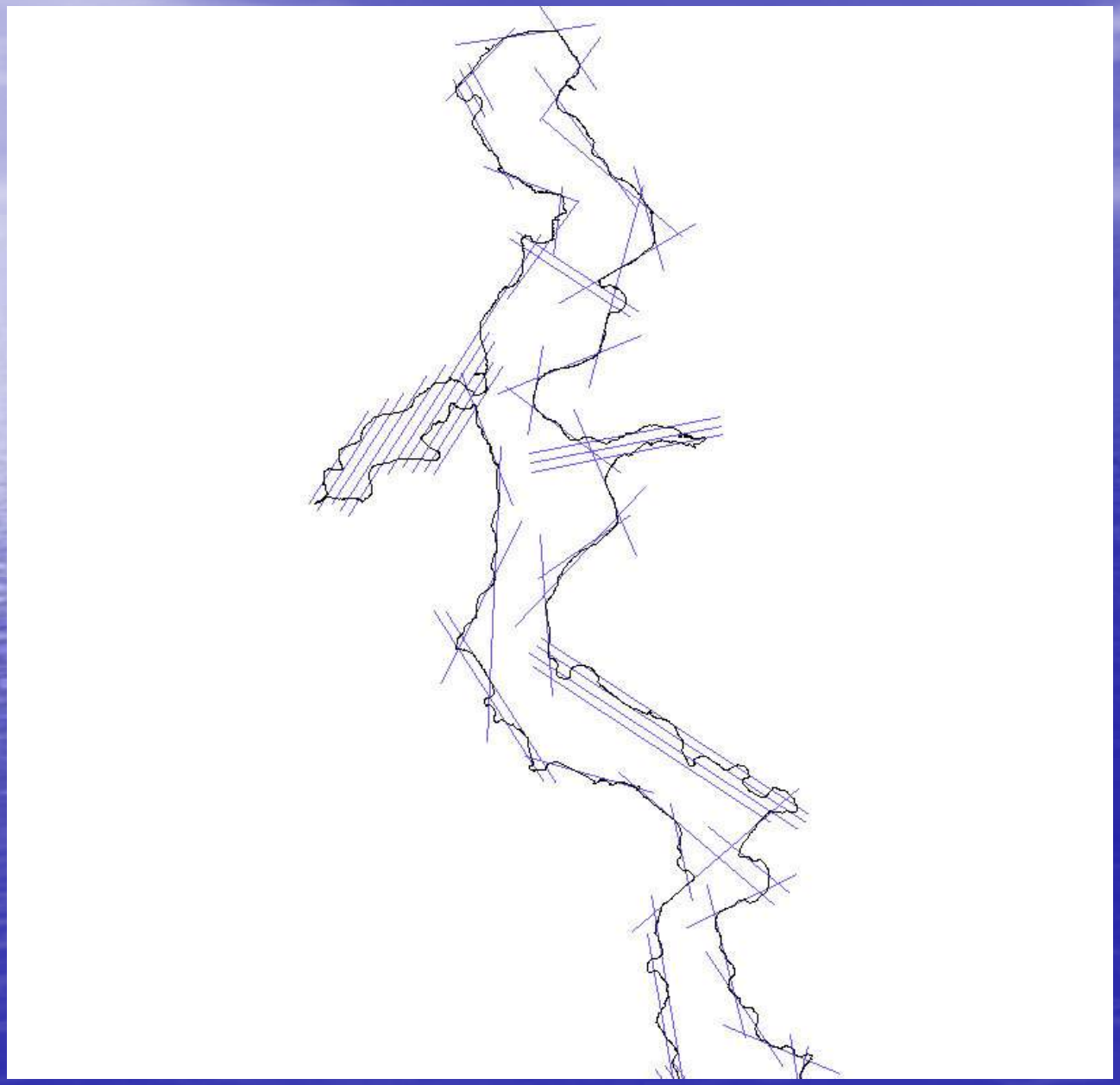

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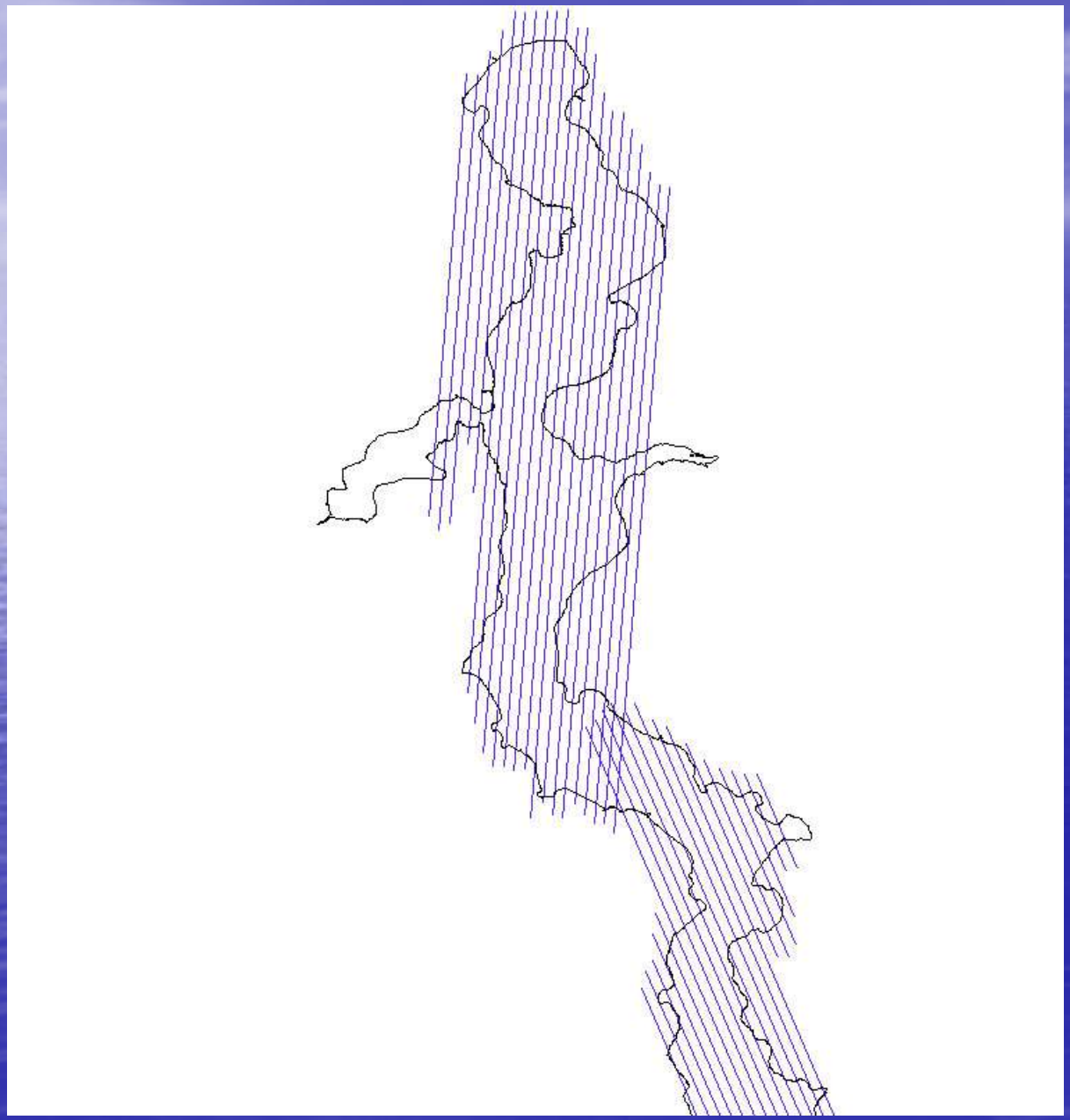

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TECHNICAL ISSUES

(Things that jump up and bite you if you are not careful)

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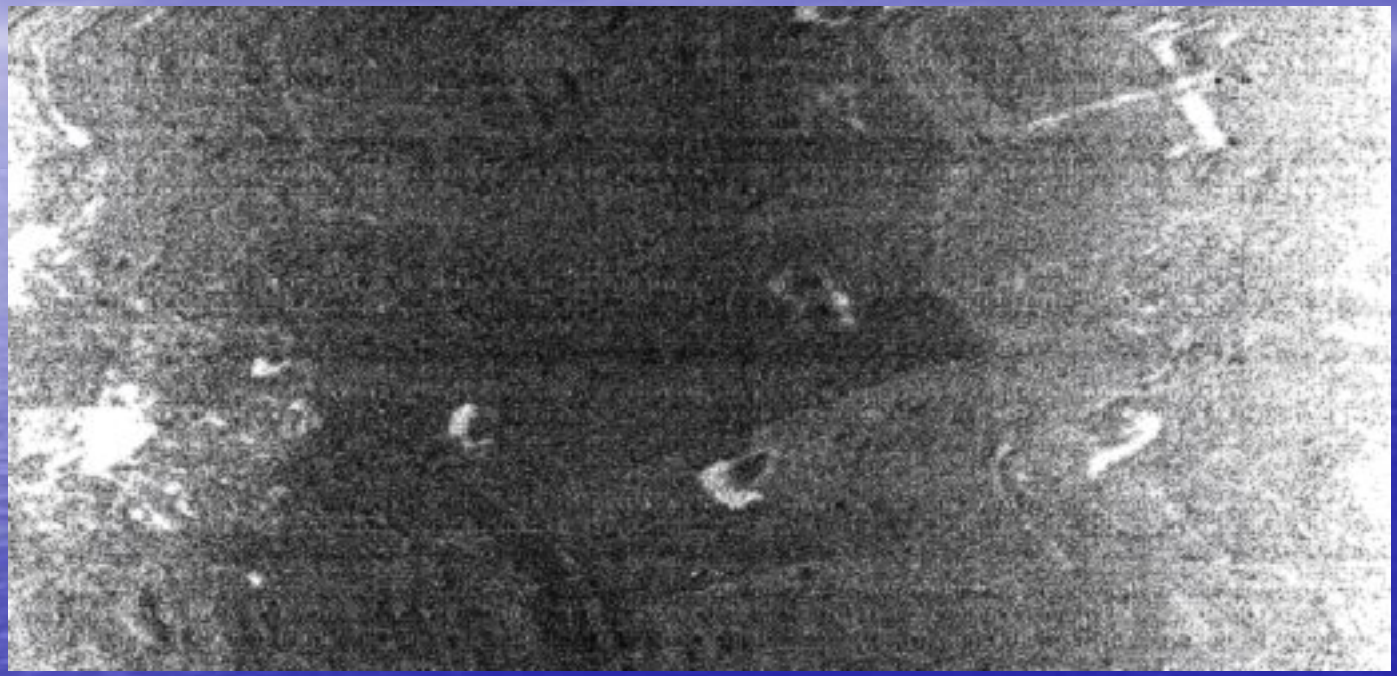
SMILE . . .



Uneven illumination across an image caused by a number of factors

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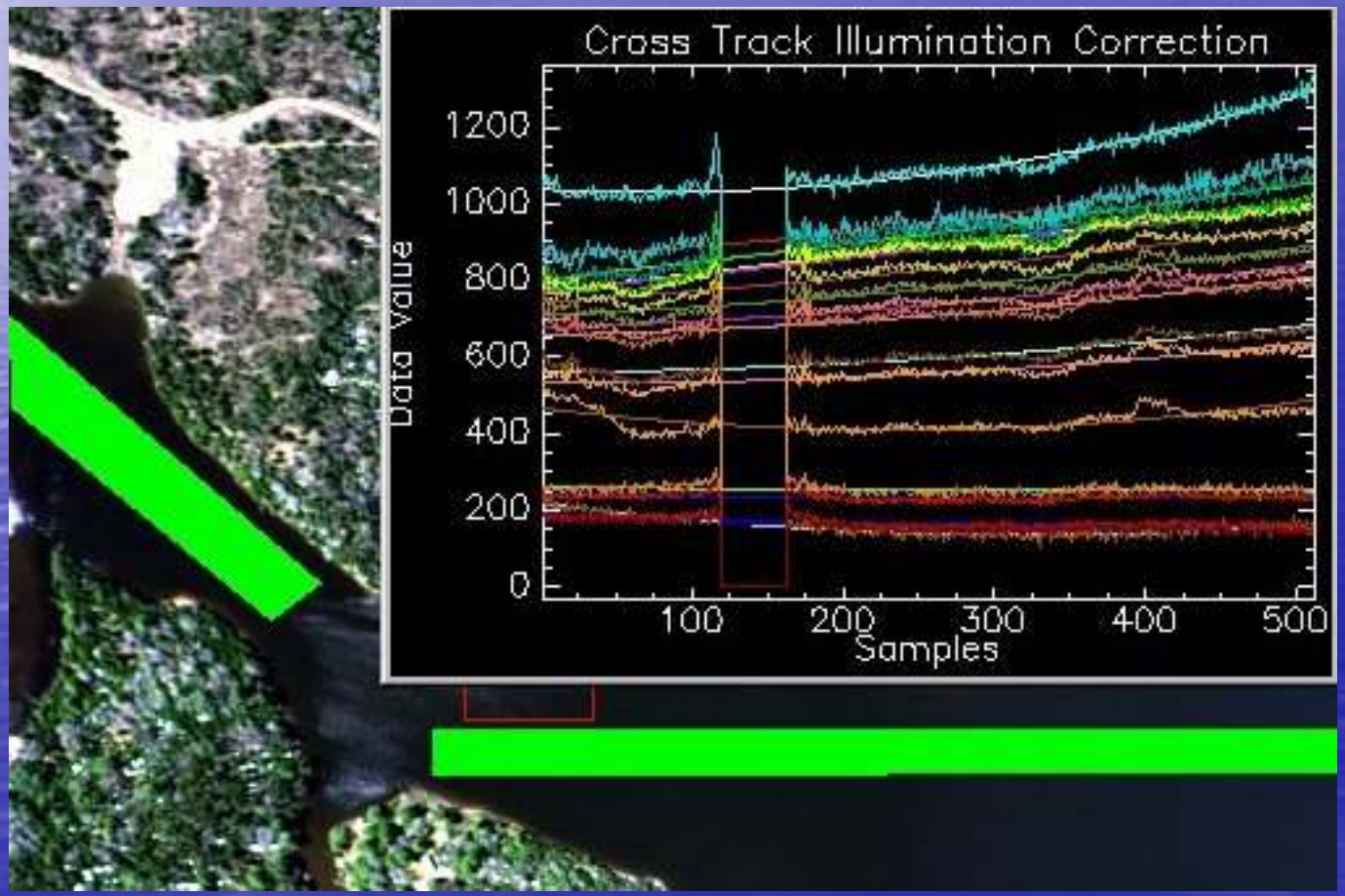
Cross Track Illumination

- Another manifestation of this effect occurs in airborne digital image data



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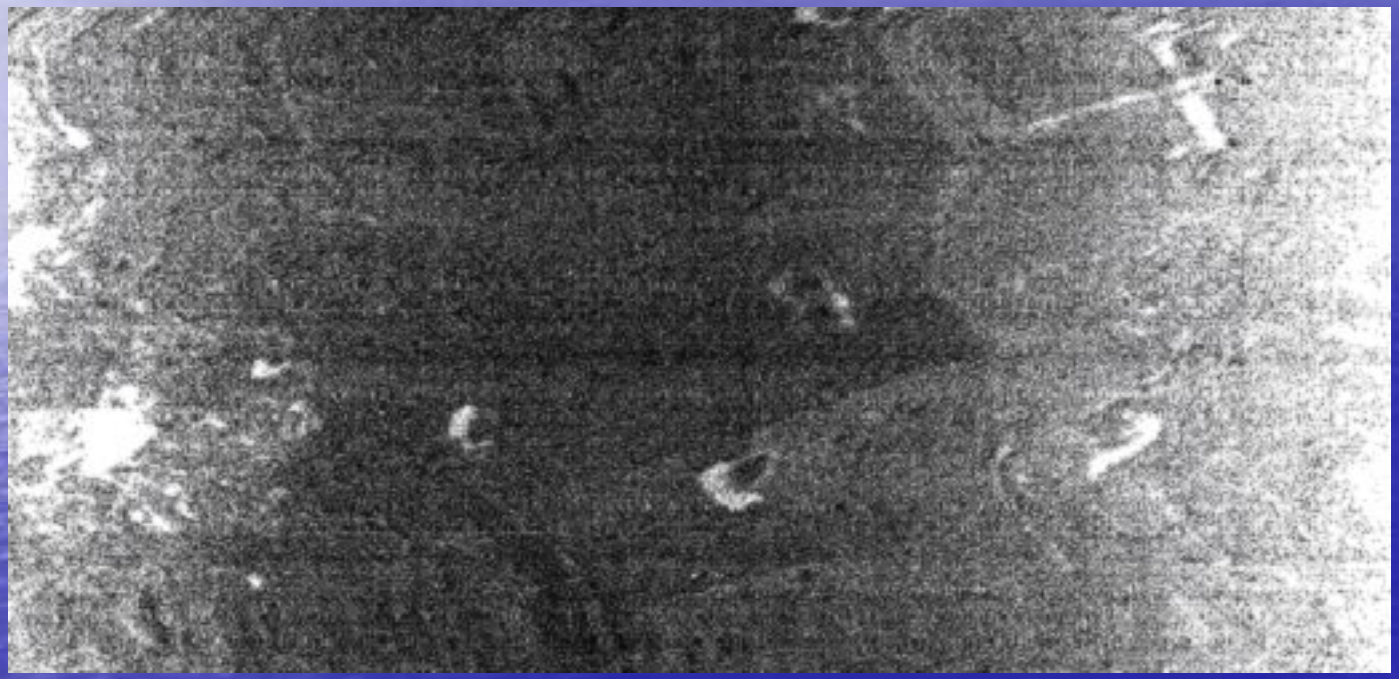
Horizontal Banding

- Occurs in low lighting conditions



- Noise dominates – low S/N level
- correction difficult – sufficient redundancy in other bands of hyperspectral set

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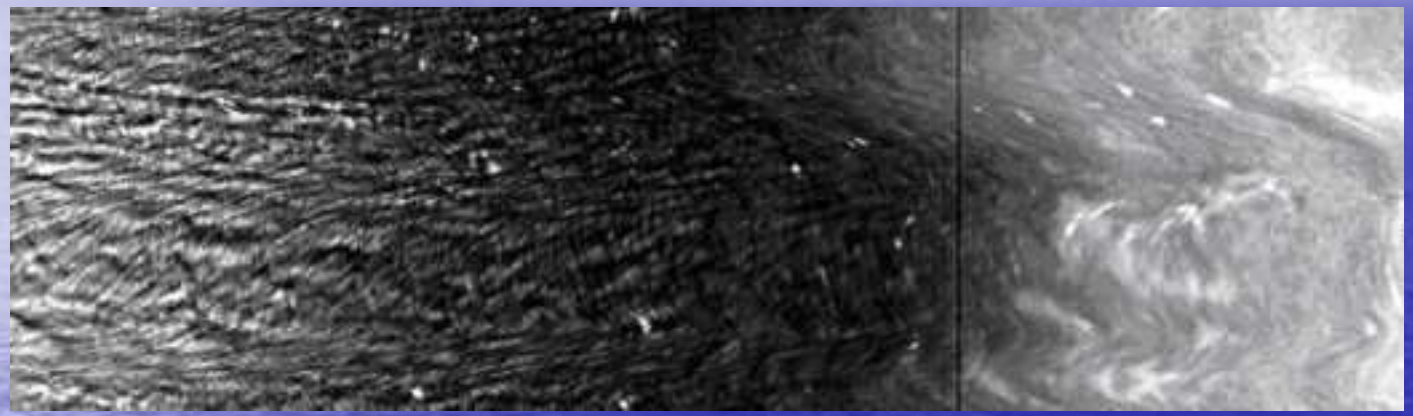
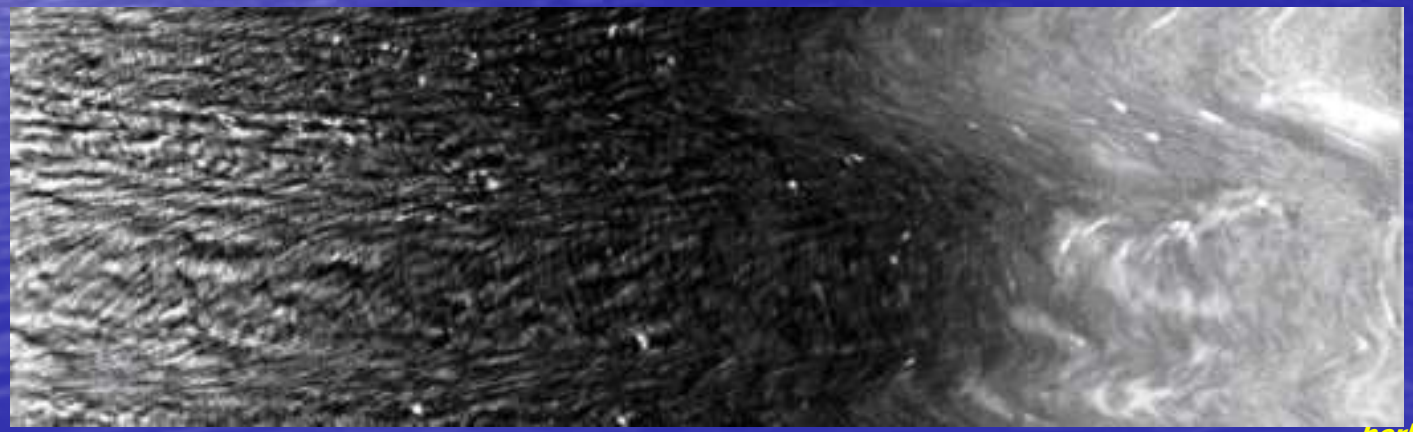
Vertical Striping

Original image



Corrected image



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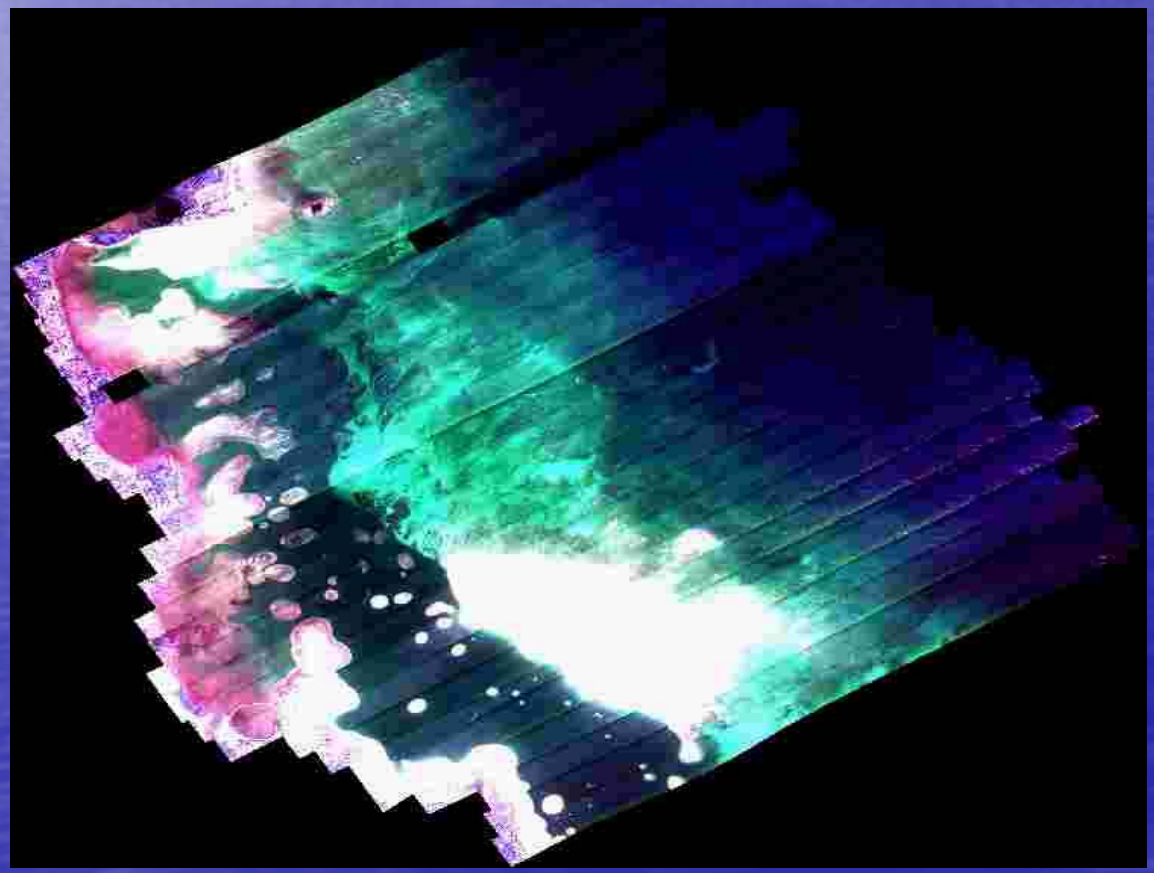
Flightline Radiance Variations

- Differences in the overall brightness of flightlines
- Differing illumination conditions



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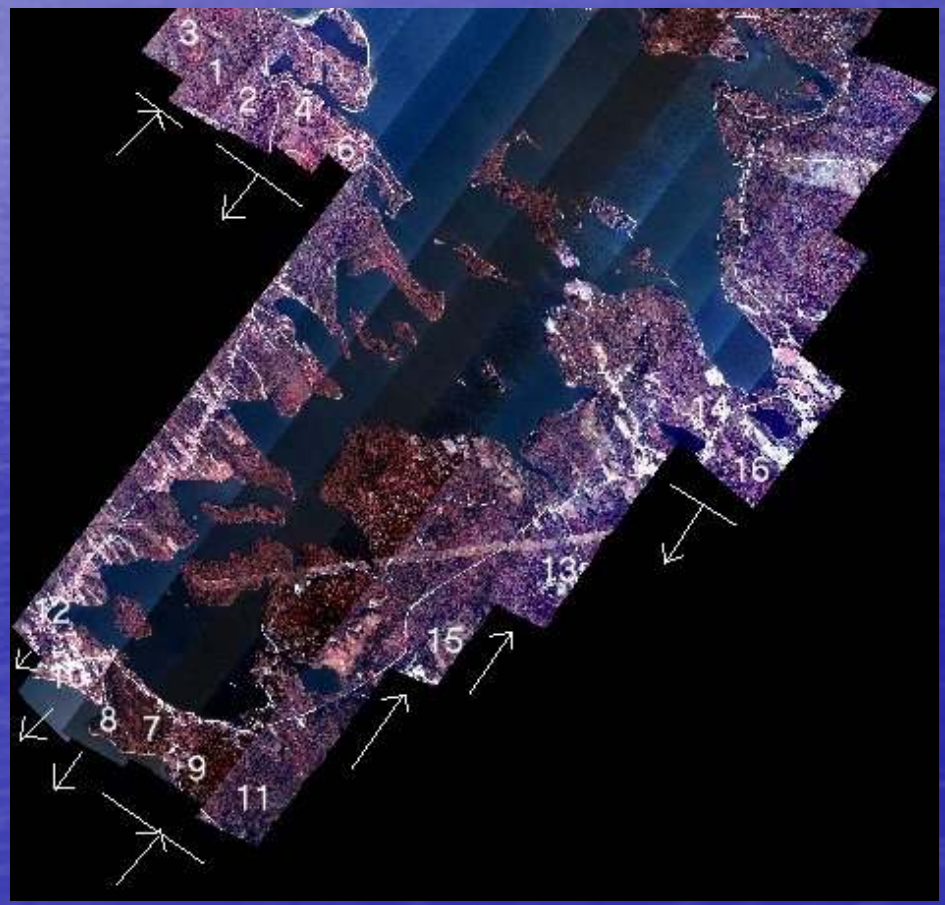
Flightline Radiance Variations

- Example of CASI data
- Interesting to note the frequency of variability



Visible change - minutes

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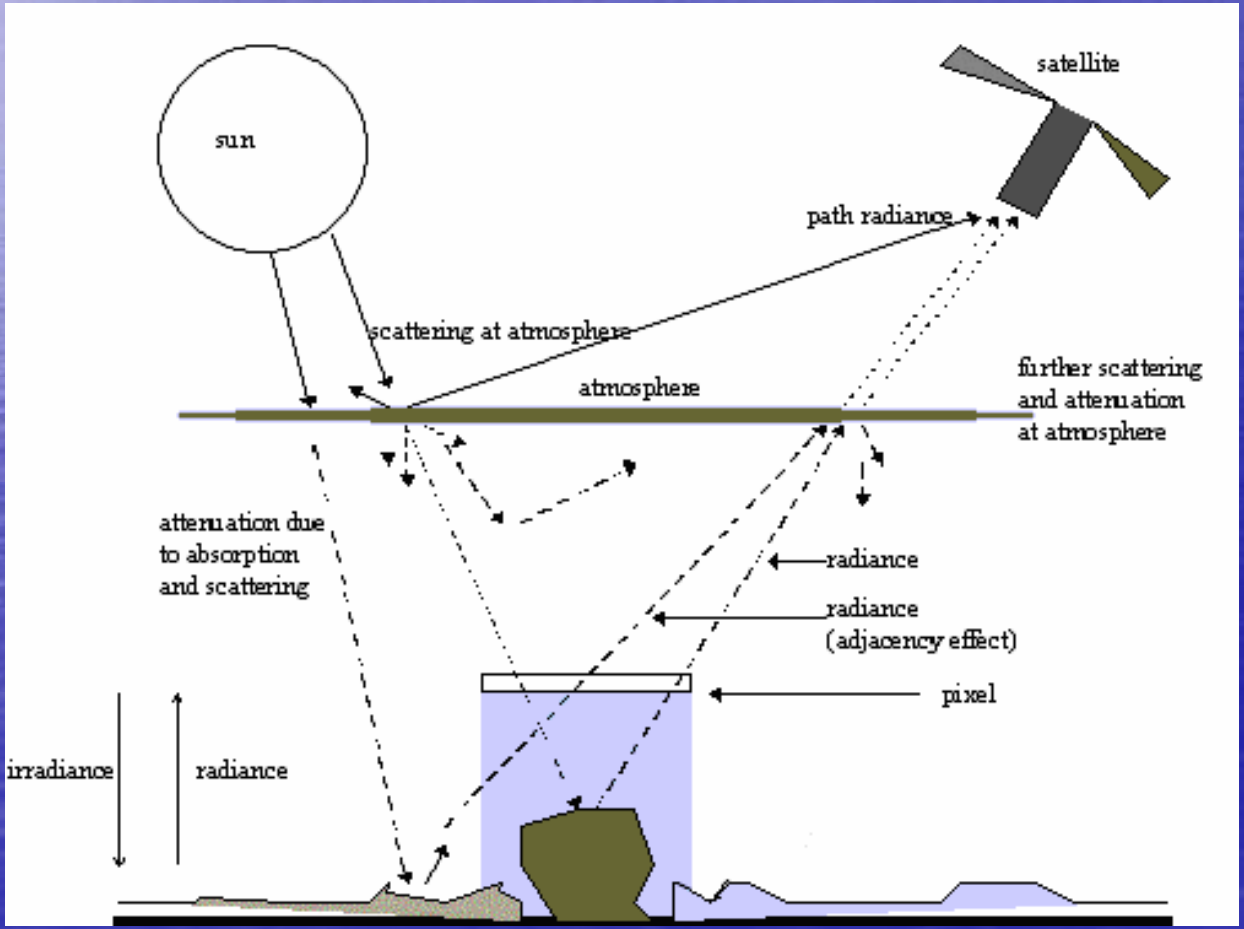
Atmospheric Interaction

- The next step - atmosphere



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BUT WHEN IT WORKS…WOW THE DATA CAN BE GOOD!!

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DATA COLLECTION SEPT 2005

MOSAIC OF 12 casi FLIGHT LINES

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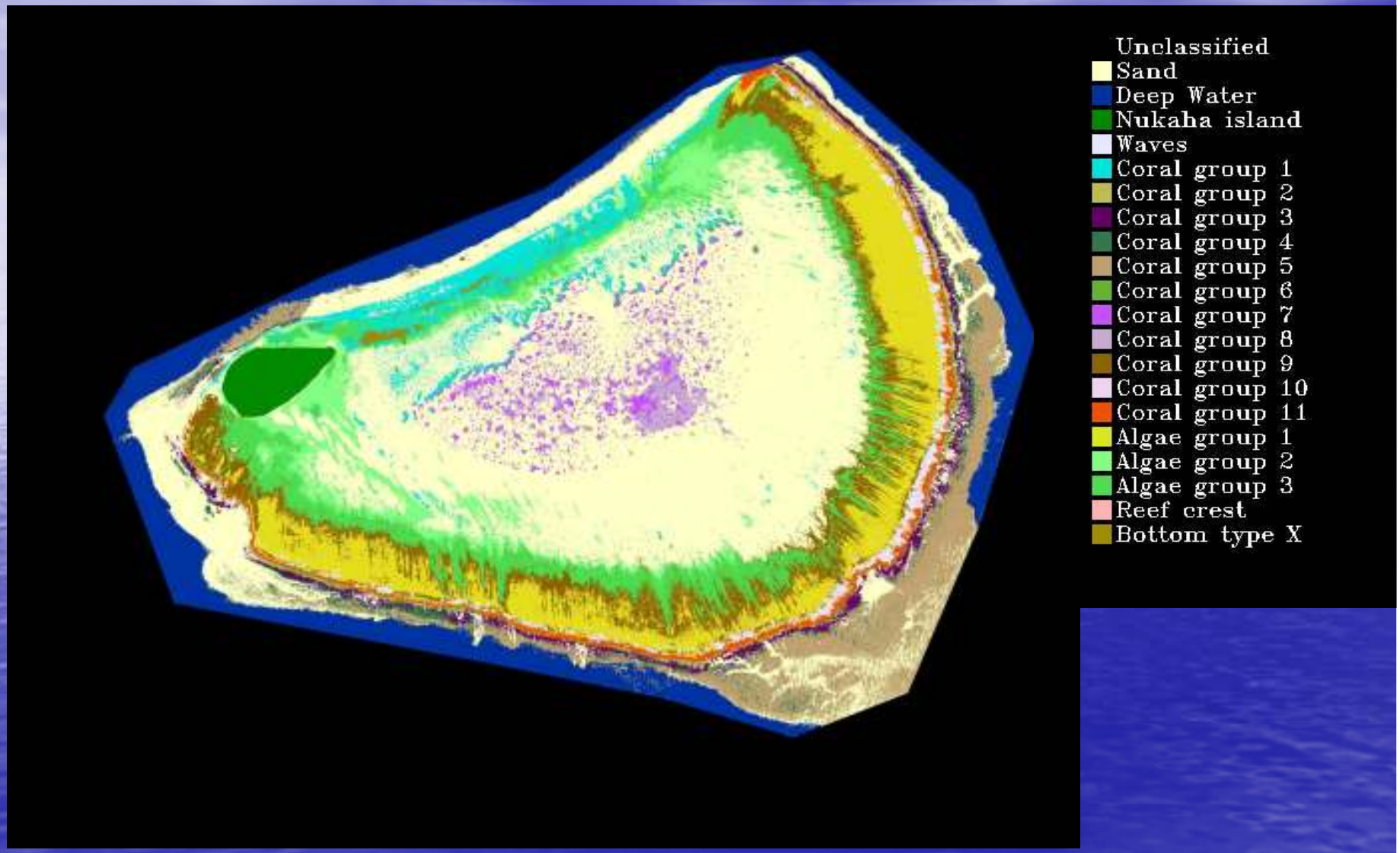

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LETS LOOK AT SOME ACTUAL PROJECTS AND DISCUSS SOME SPECIFIC USE OF WHAT WE HAVE BEEN TALKING ABOUT

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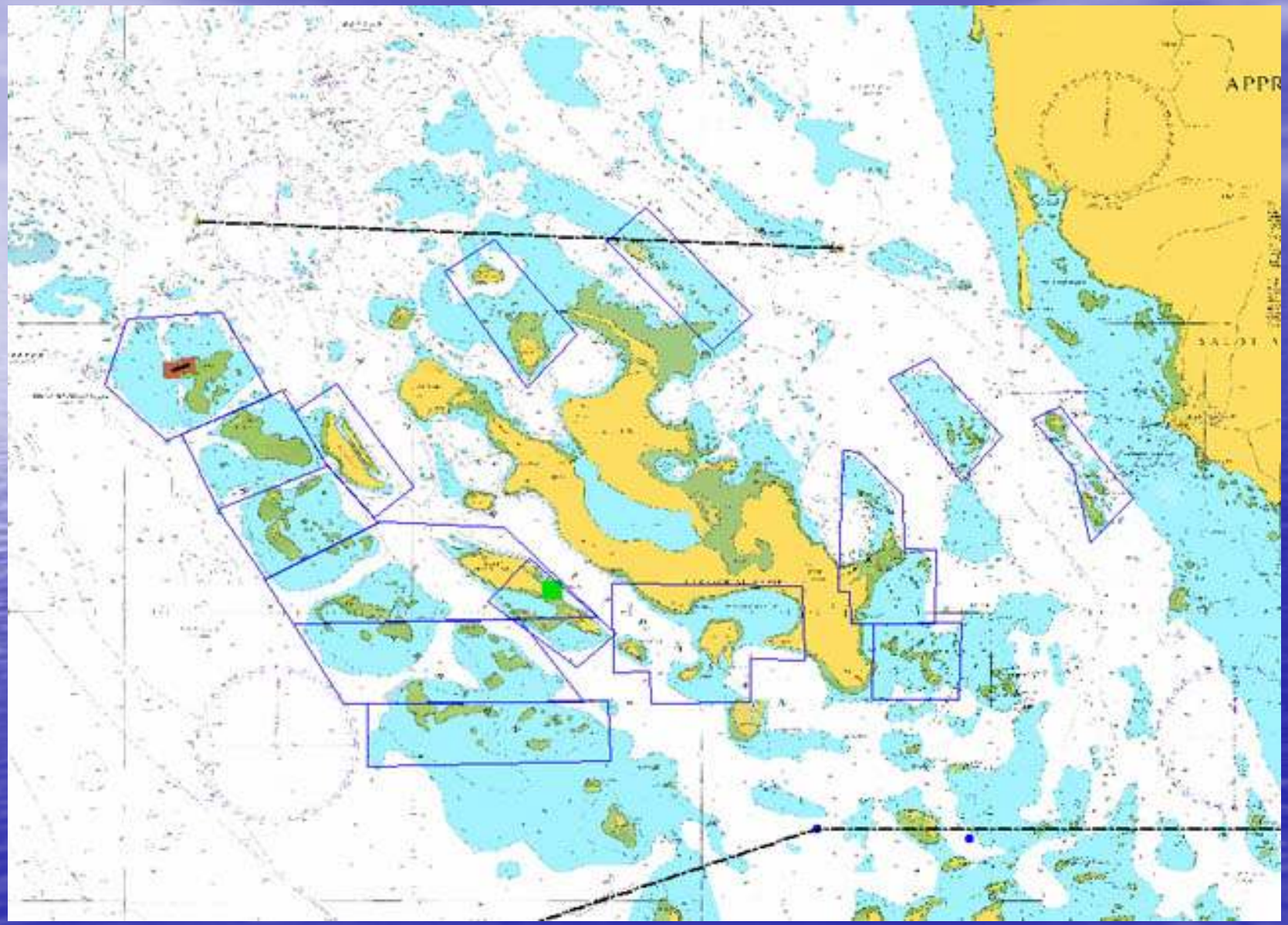

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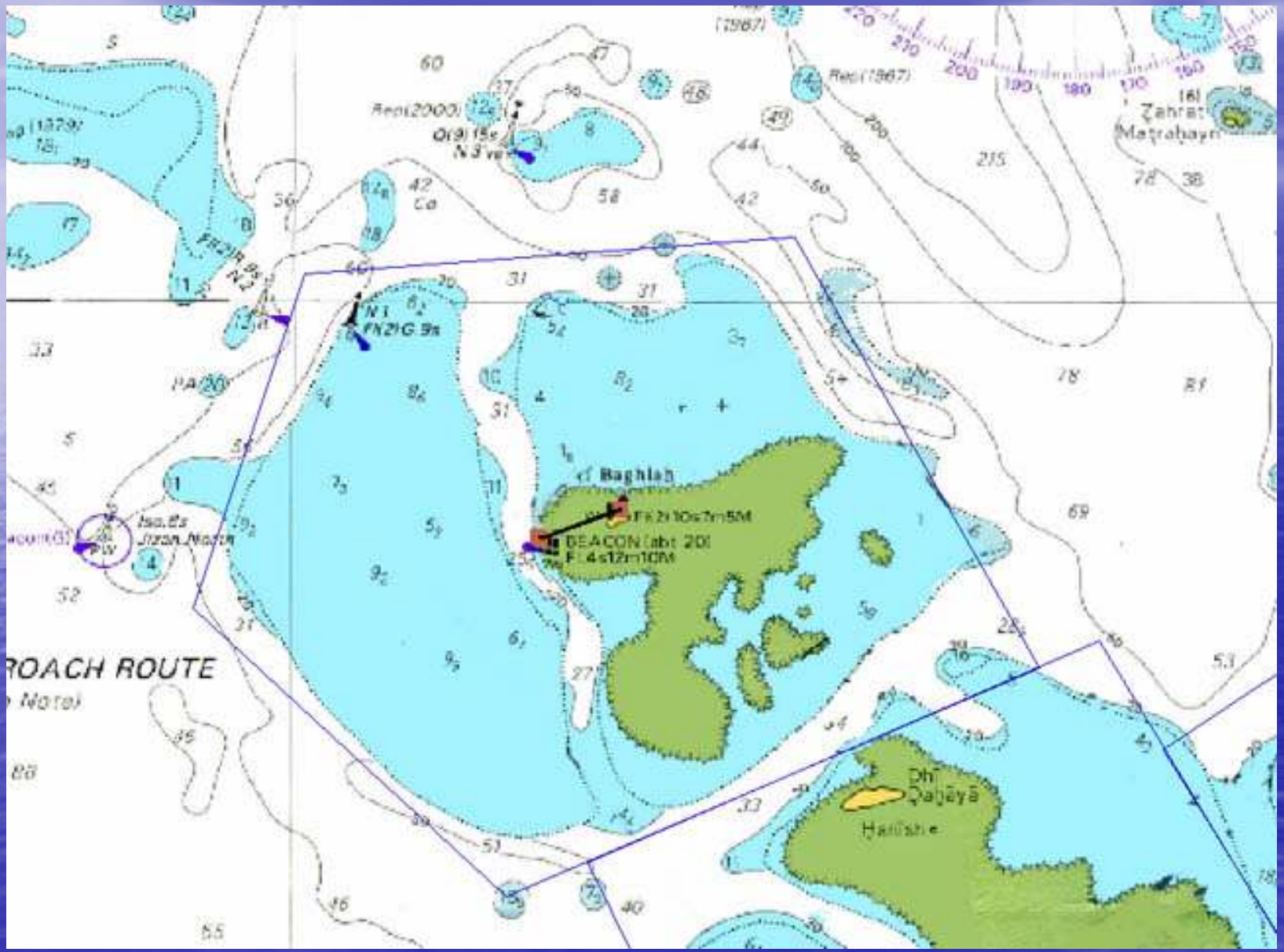

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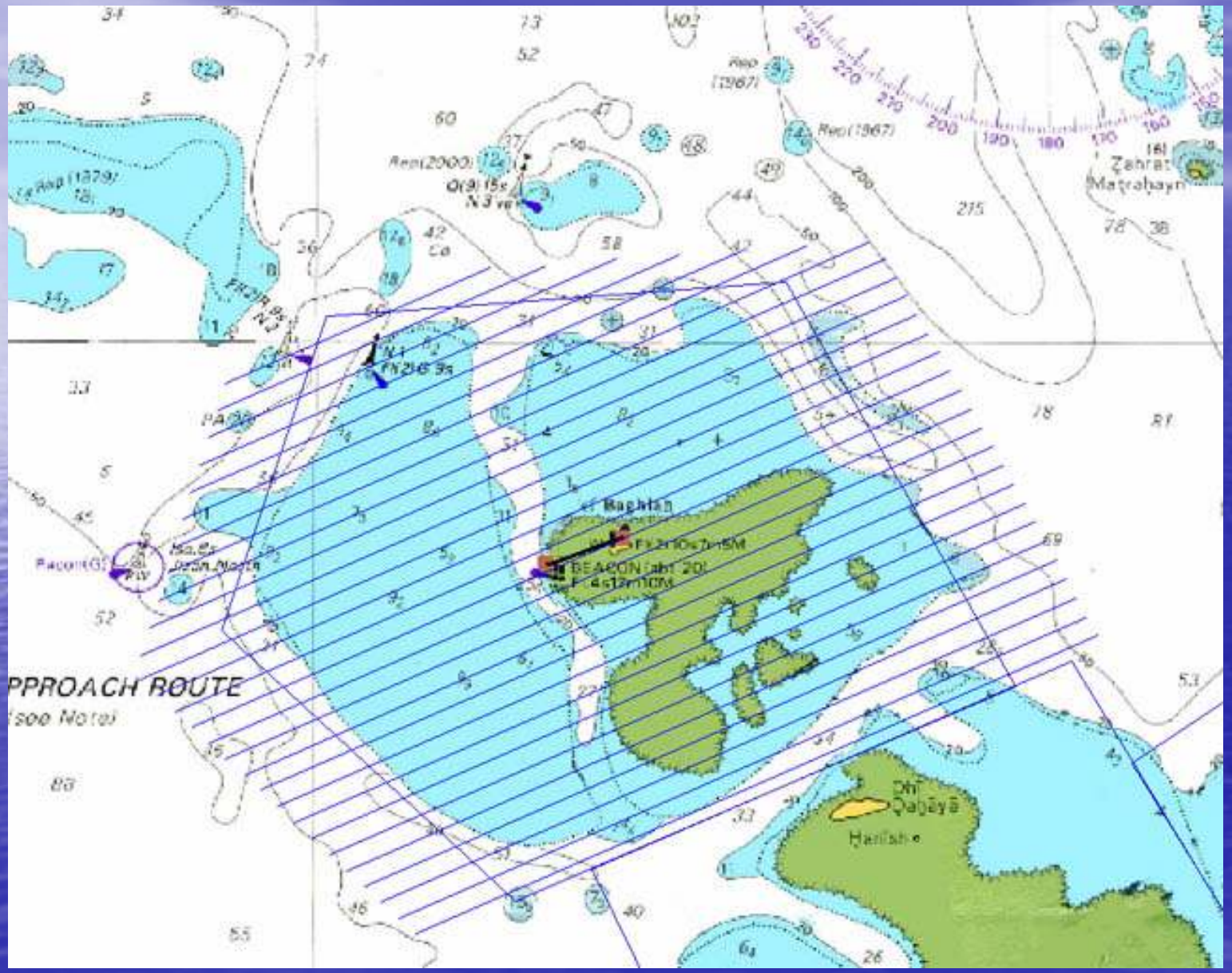

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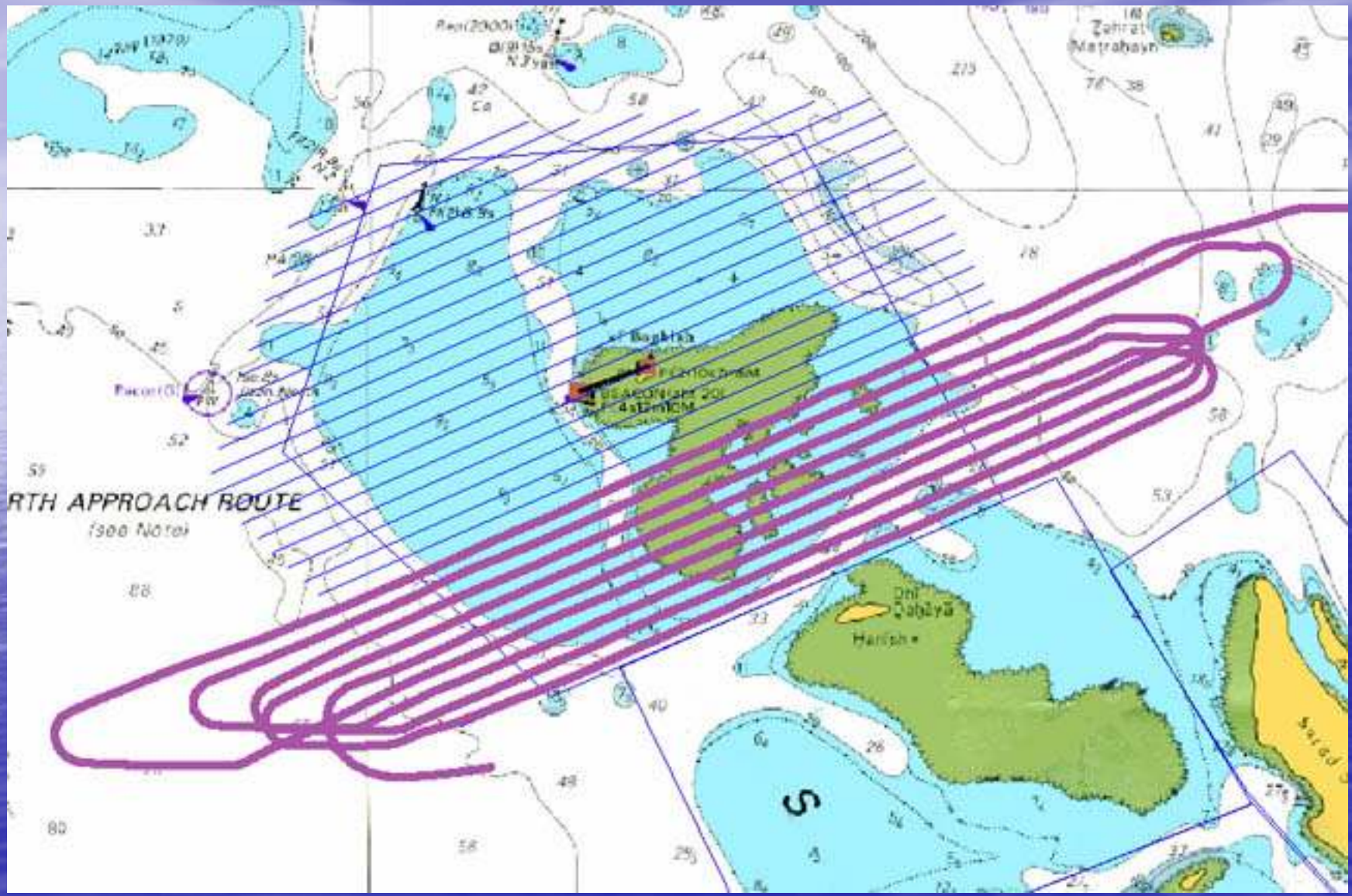

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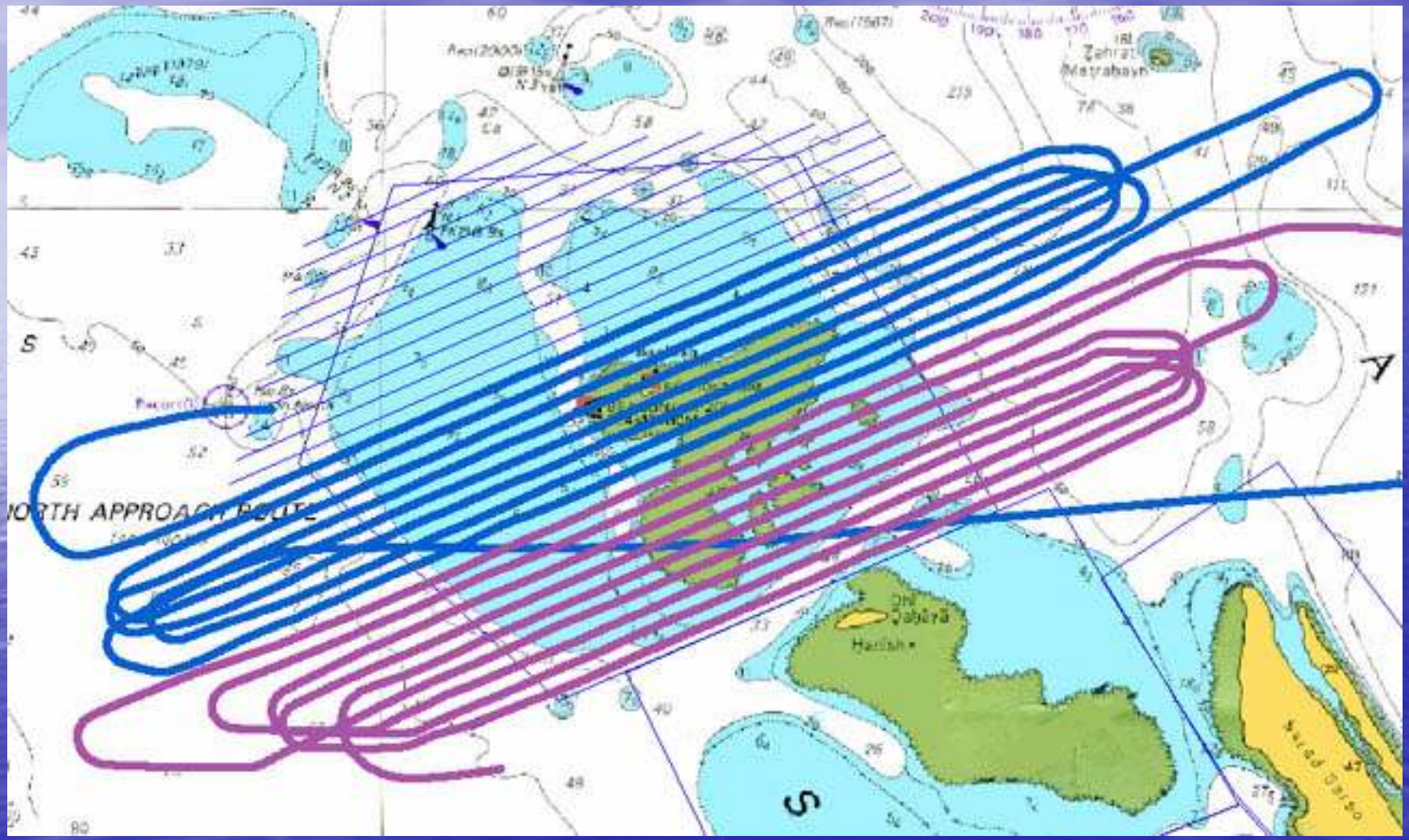

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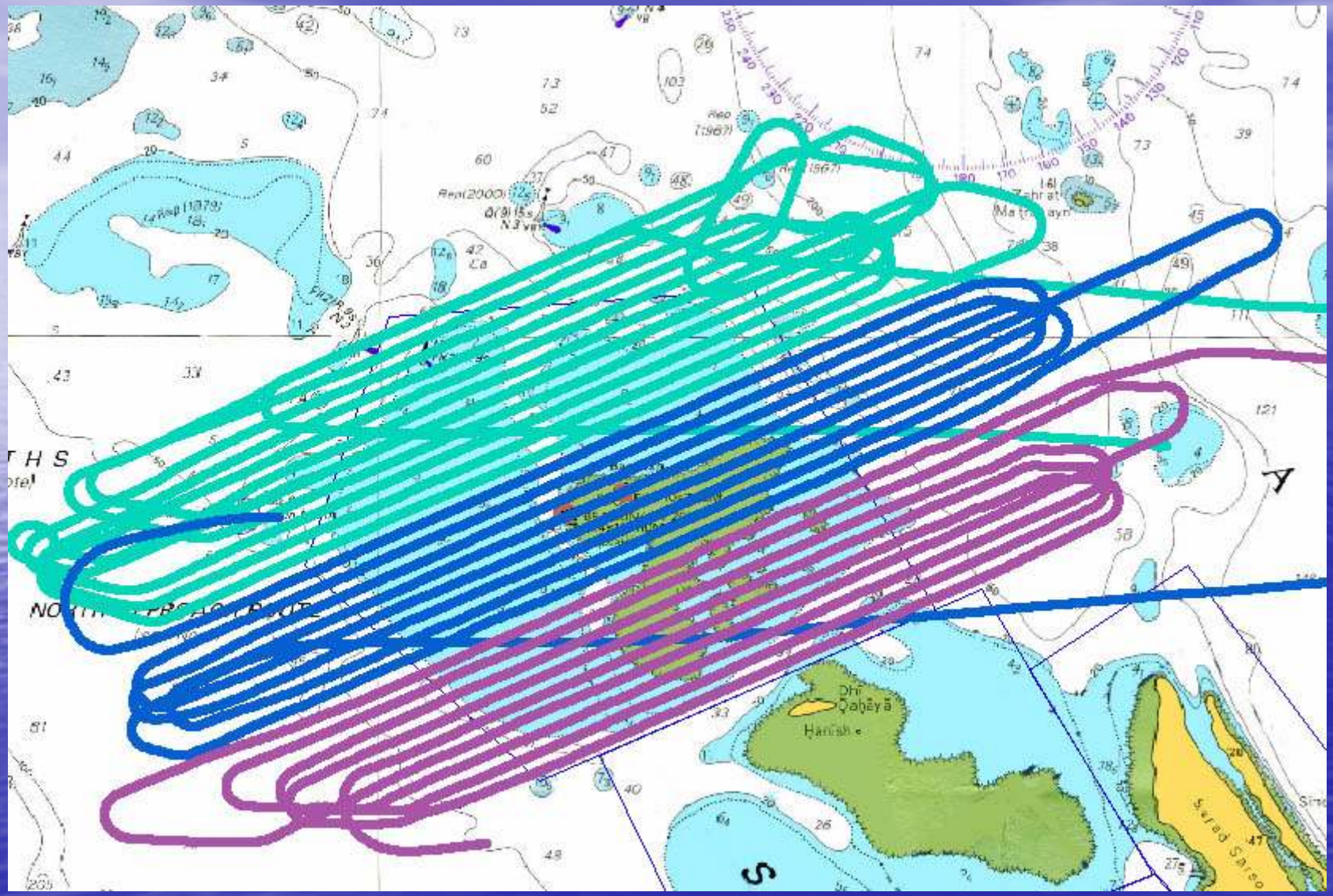

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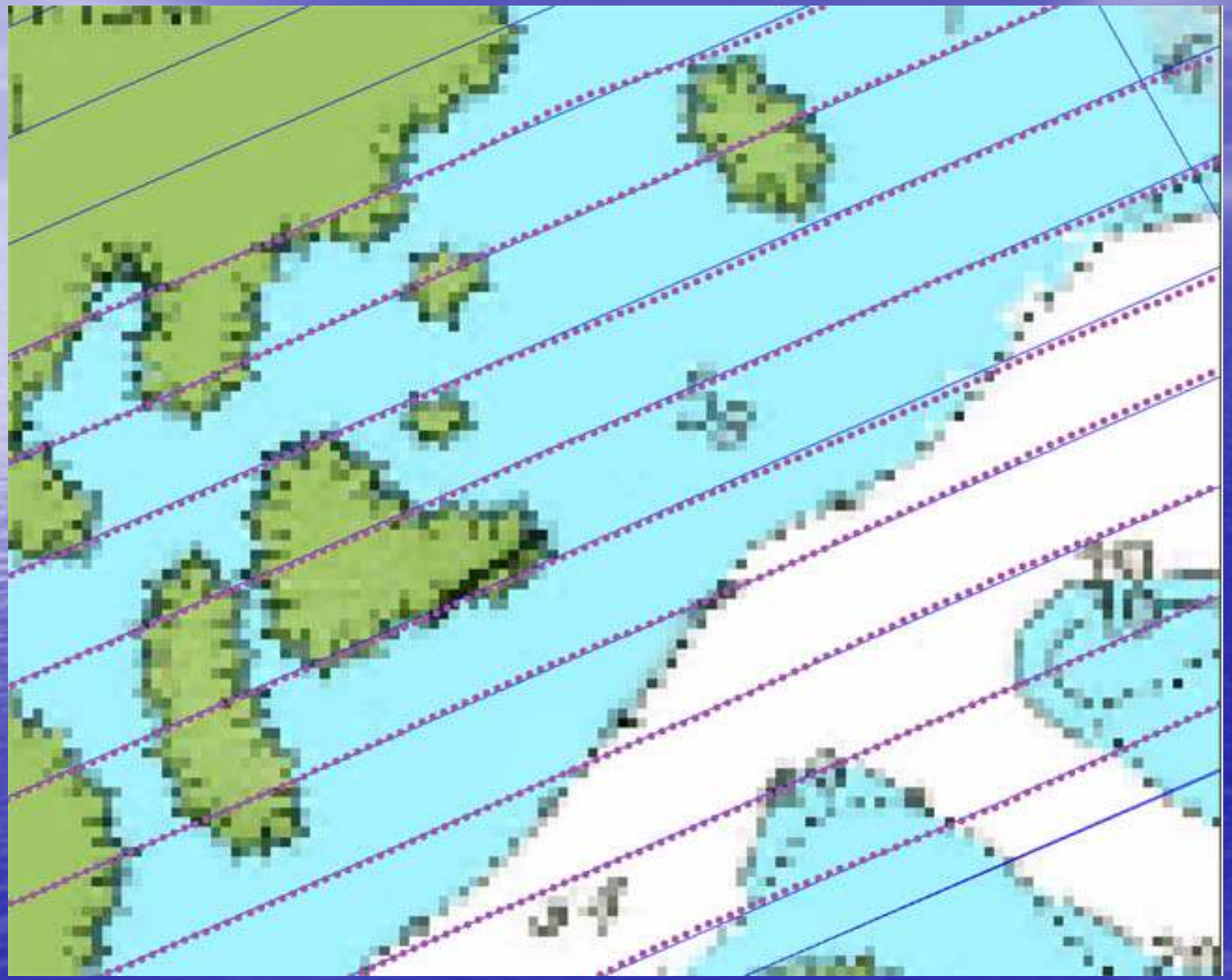

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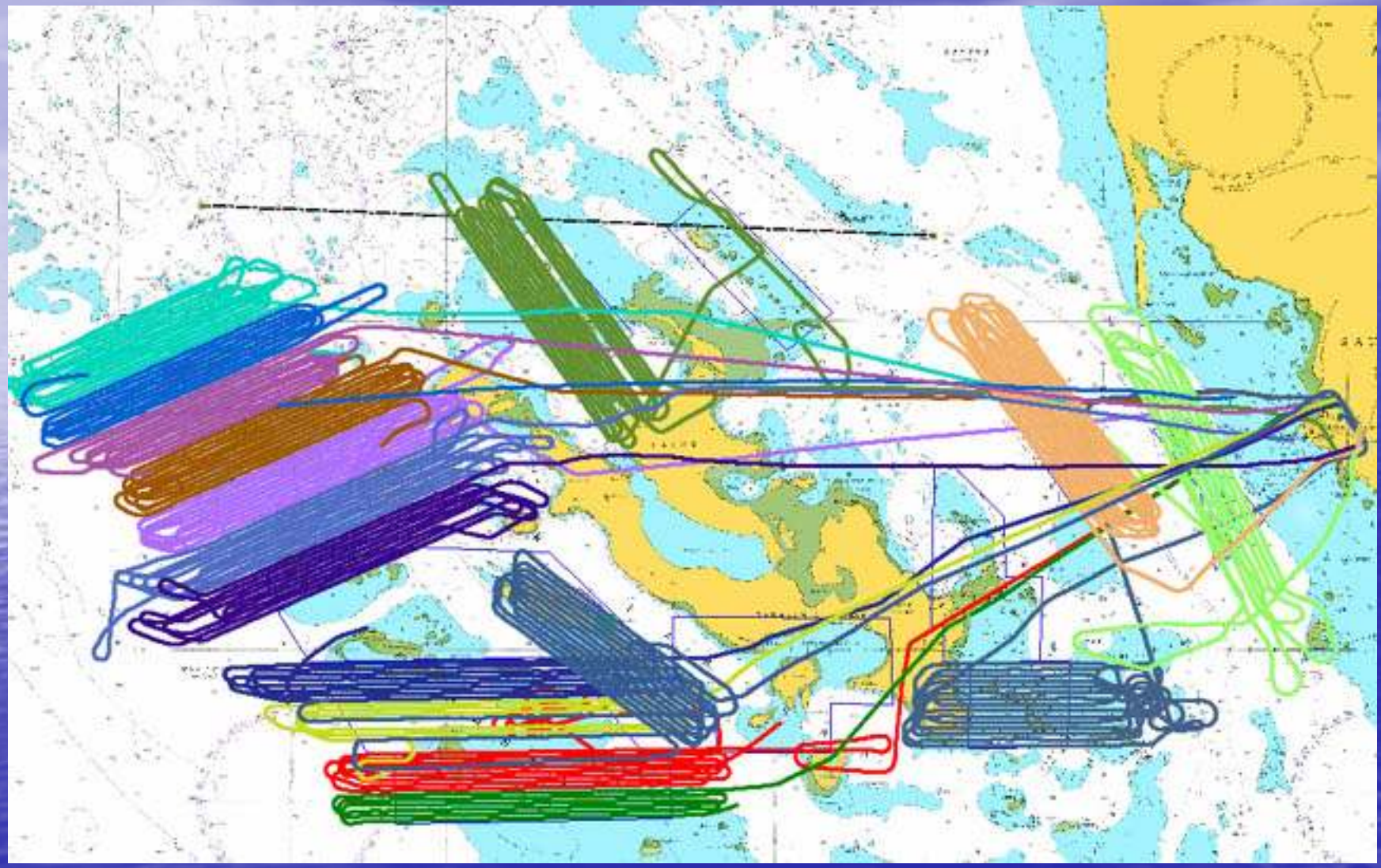

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PROJECT STATS:

- TWO WEEK DATA COLLECTION PERIOD
- 250+ FLIGHT LINES FLOWN
- 14 SPECIFIC AREAS COVERED
- 150 GIGABYTES OF RAW DATA COLLECTED

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DATA COLLECTION SEPT 2005

MOSAIC OF 12 casi FLIGHT LINES

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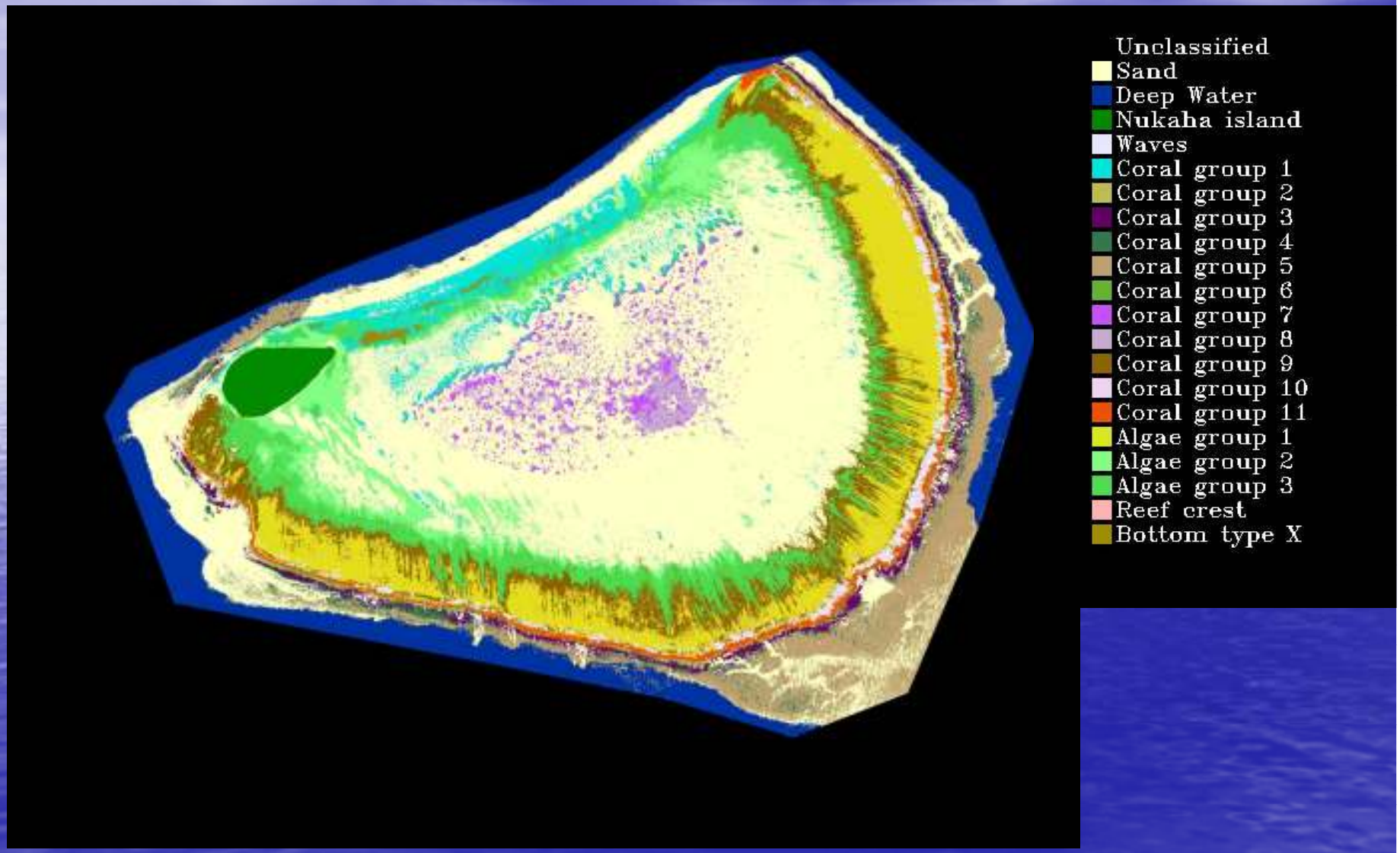

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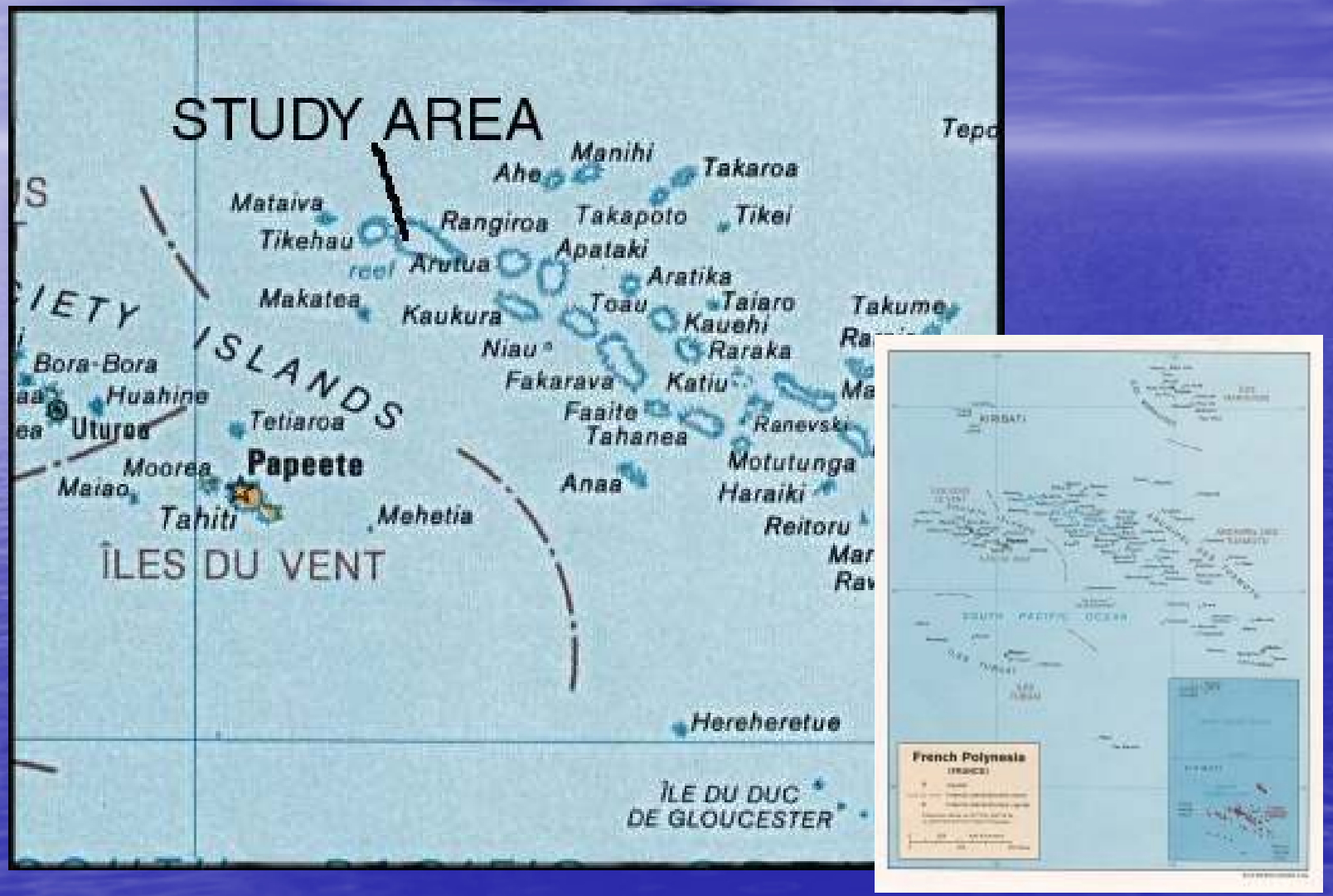

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GOLDEN ODESSEY

GOLDEN SHADOW

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MOVING AIRCRAFT ON DECK

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CESSNA 206 BEING LOWERED INTO WATER

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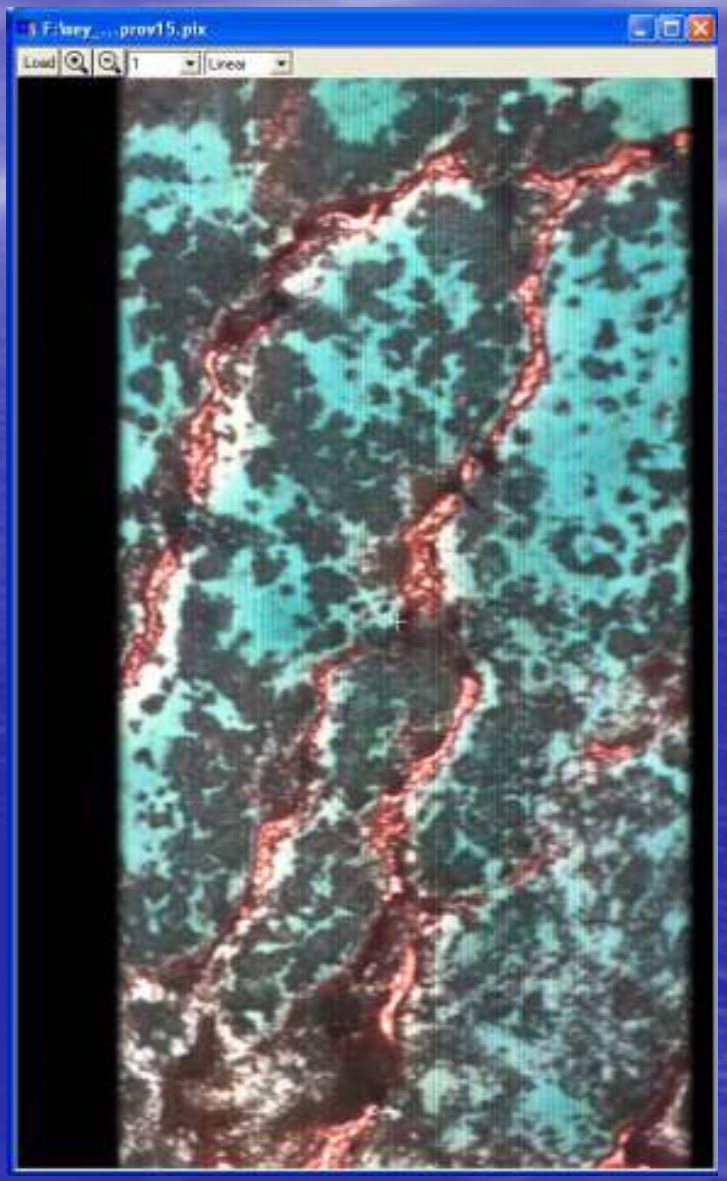

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Summary of CASI Dataset

- Amount of CASI data collected

ISLANDS PLANNED/FLOWN	15
AREA PLANNED	850 SQ KMS
AREA FLOWN	815 SQ KMS (96%)
FLIGHT LINES PLANNED	139 LINES
FLIGHT LINES FLOWN	133 LINES (96%)
DATA VOLUME (RAW)	65 gbytes
DATA VOLUME PROCESSED (est)	150 – 175 gbytes

CESSNA 210 – TYPICAL AIRCRAFT USED TO FLY *casi*

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***casi* SENSOR AS INSTALLED IN AIRCRAFT**

(note presenters foot in lower right corner)

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