TUTORIAL

Extraction of Geospatial Information from High Spatial Resolution Optical Satellite Sensors

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7. Land use and land cover mapping
8. Use of HR for mapping, landscape change detection and map update, and comparison to alternative information sources
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Cartosat Mission Objectives

The main objectives of CARTOSAT-1 mission are

- To design and develop an advanced 3-axis body stabilized remote sensing satellite for providing the enhanced spatial resolution (better than 2.5 m) with stereo imaging capability for cartographic applications.

- To further stimulate new areas of user applications in the areas of cartographic applications, urban management, disaster assessment and relief planning and management, environmental assessment and other GIS applications.

Unique Characteristics of CARTOSAT-1 mission pertaining to Data Products

- Stereo imaging of terrain with fixed b/h in alongtrack direction at < 2.5 m resolution
- One near nadir viewing payload
- Spacecraft tilt for faster coverage of gaps
- Pitch bias to acquire occluded areas in regions with large slope
- Possibility of wide swath mono imaging
- 10 bits/pixel
- Staggered CCD array
- Stable platform
- Statistically lossless data compression

NOMINAL ORBIT

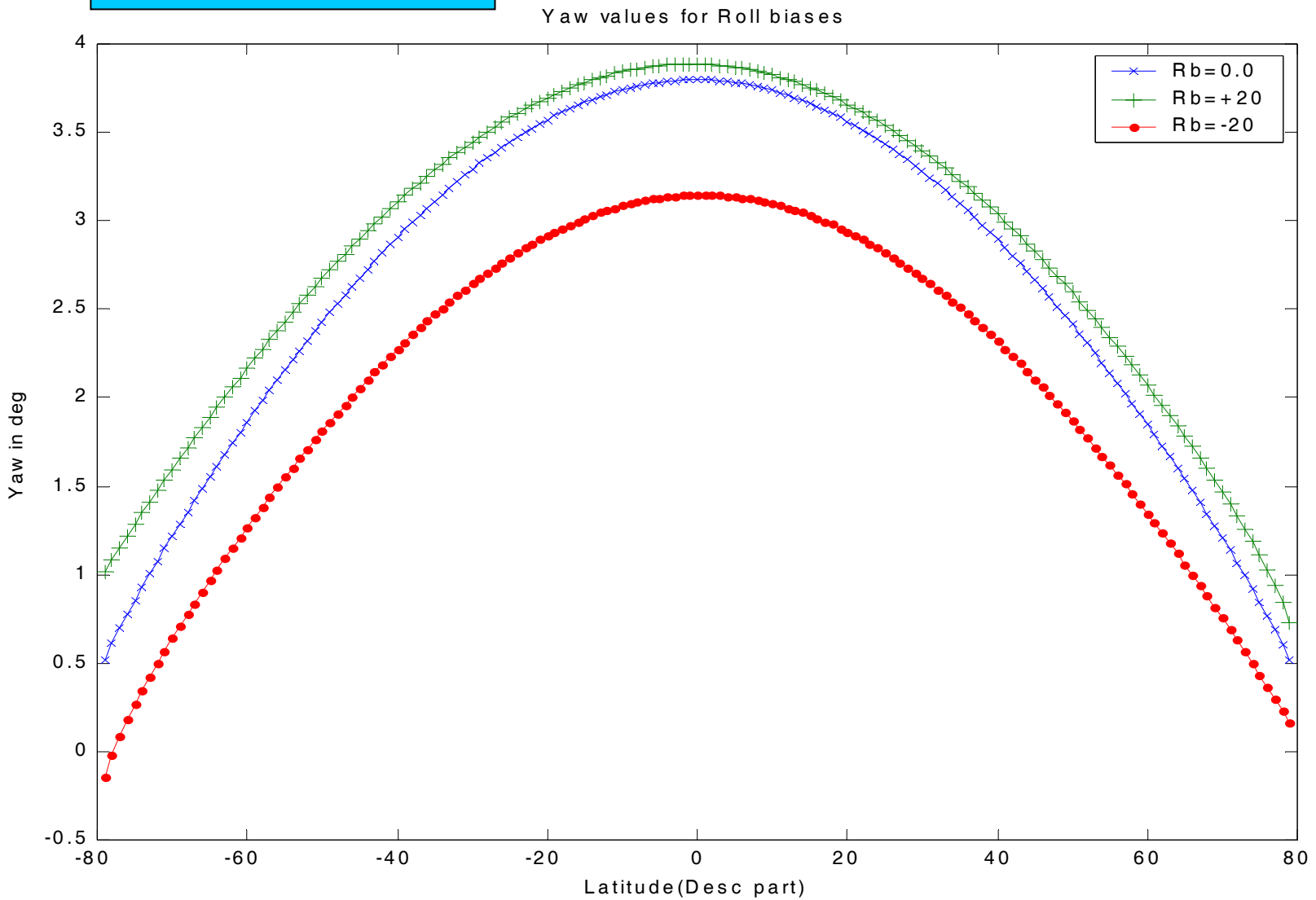
- Nominal altitude: 618 km
- Repeat Cycle: 1867 revolutions in 126 days
- Orbits per day: $14^{103}/_{126}$
- Nominal paths identified as per zero-roll bias yaw steering

Referencing Scheme

Proposed Scheme:

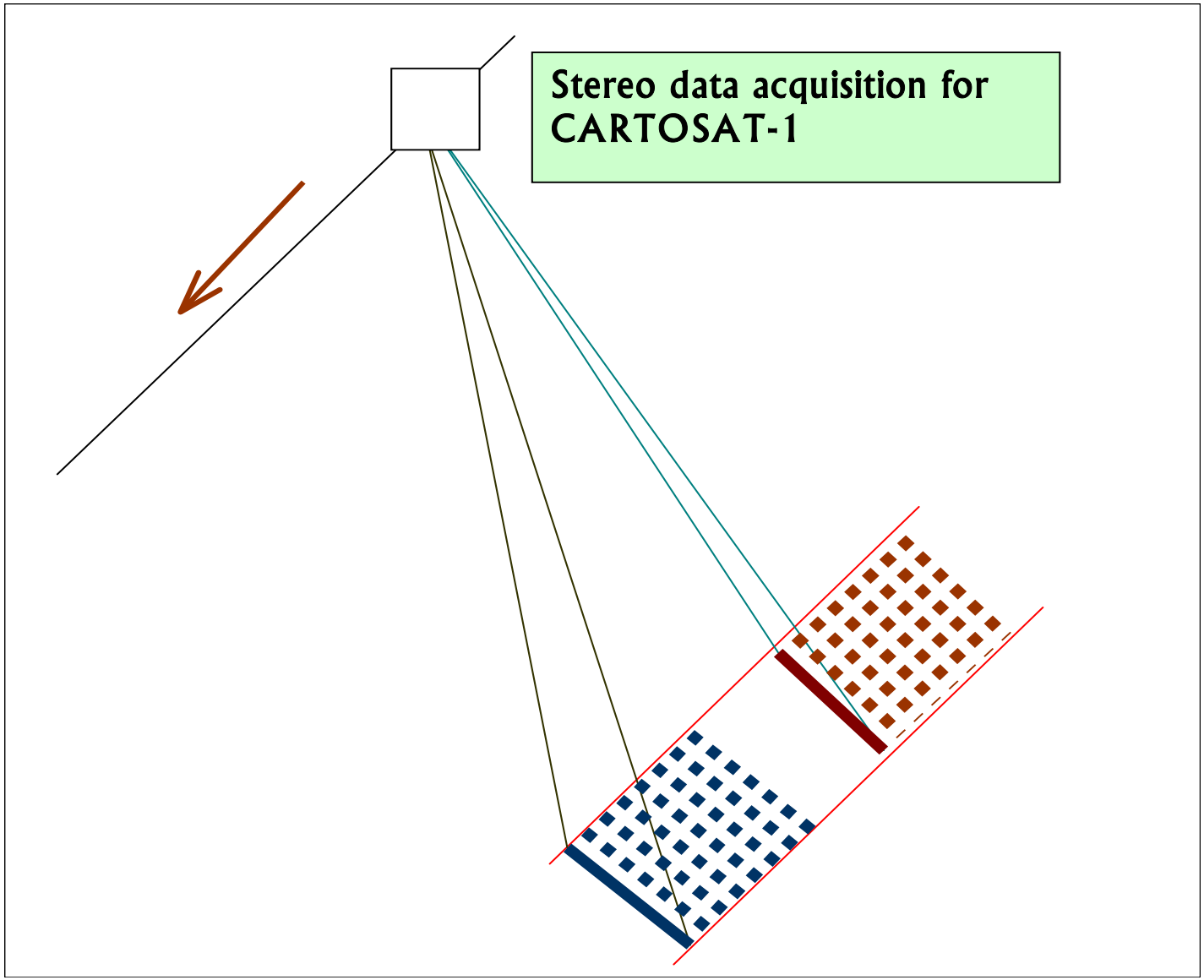
- 1867 paths
- Scene Size: 26kmX26km(Square)
- Rows identified in terms of number of lines
- Alternate rows(all odd numbered rows) for wide-mono
- Both Path, Row and Scene-id(I,J,M,N) are provided in ADIF
- Scheme Applicable to both Stereo and Wide-mono.

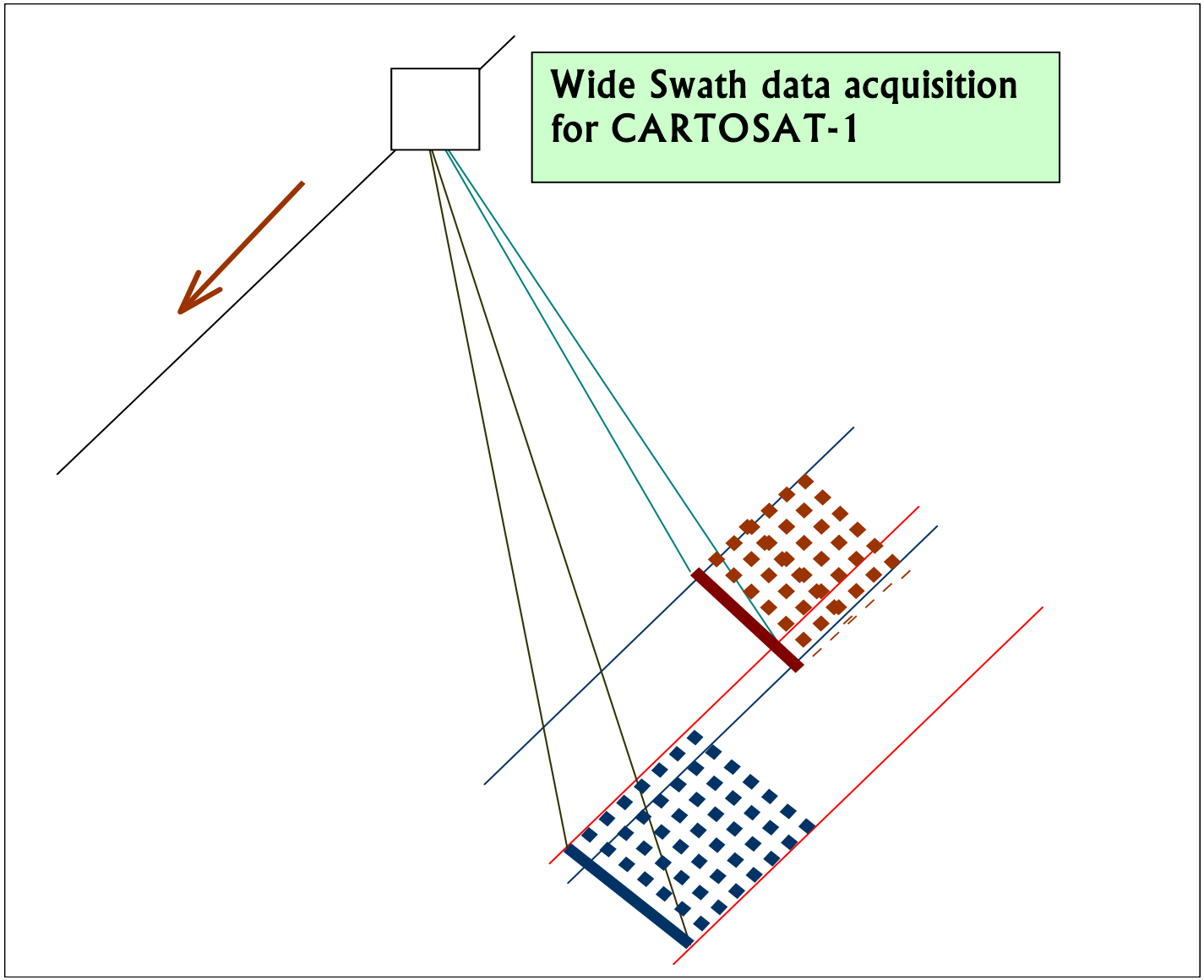
Yaw Steering



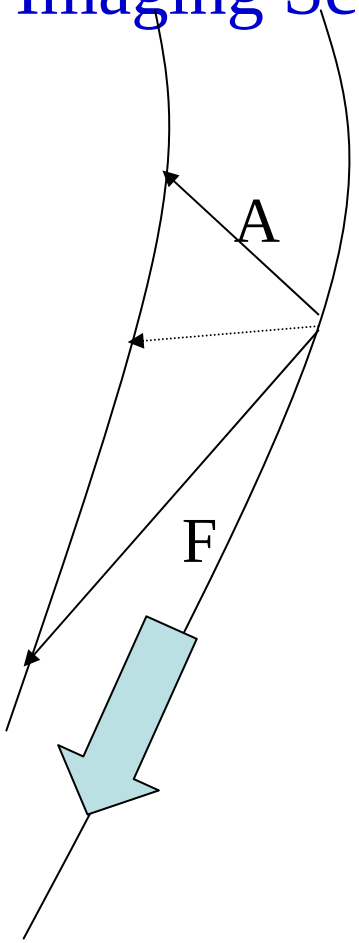
Payload details

- PAN-A & PAN-F cameras
- No. of detectors = 12000 in each camera
- Quantisation (No. of bits) = 10
- No. of ports = 8
- Data rate = 338 Mbps for each camera
- Data rate after compression = 105 Mbps (in two channels I & Q each 52.5 Mbps) for each camera
- Compression ratio = 3.22:1
- Onboard recording(OBSSR) = 120Gb


Stereo data acquisition for CARTOSAT-1


Wide Swath data acquisition
for CARTOSAT-1

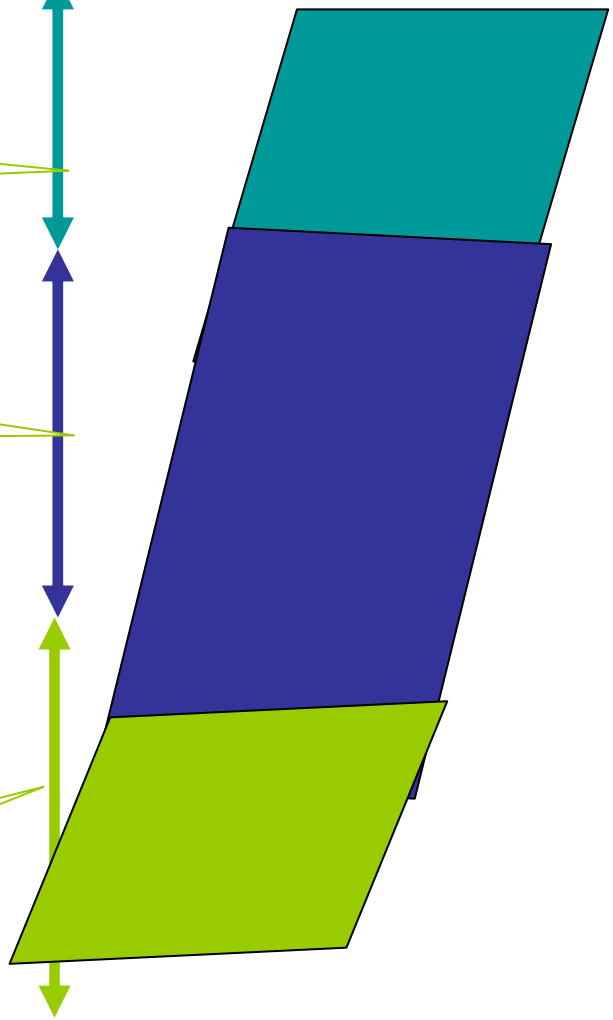
Imaging Scenario for basic stereo



Aft alone

Fore+Aft

Fore Alone



Scene Details

Standard scene size = 12000 x 12000

$\sim$ 30km x 30km

Fore camera: 0 deg roll bias: 2.45m, 29.42 km swath

25 deg roll bias: 2.9m , 34.9 km swath

AFT camera : 0 deg roll bias: 2.18m, 26.2 km swath

25 deg roll bias: 2.7m , 33.4 km swath

Path to Path separation : 21.5 km at equator

System Level Location accuracy: 250m 3 sigma (design)

150 m 3 sigma(achieved)

Data Products types, formats and accuracies

Product type: Stereo Pair, North Oriented, Geocoded

Extents:	30 km * 30 km, 57 km * 57 km, 7.5′*7.5′, 5′*5′, 2.5′*2.5′
Processing level:	Radiometric, Systematic geometric, GCP based geometric, Orthorectified
Formats:	Superstructure, Geotiff, Orthokit
Media:	CD ROM, DVD

Levels of correction

- Standard(1) - Radiometrically corrected and geometrically corrected with system know.
- Precision (2) Radiometrically corrected and
  - geometrically corrected with GCPs and no DEM
- Ortho (3A) – Radiometrically Corrected and
  - geometric correction with GCPs/TCPs &
  - external DEM
- Ortho (3B) – Radiometrically Corrected and geometric correction with GCPs/TCPs & internal DEM

Data Product Types

Sr.No.	Product Type	Area (km)	Level	Format (on DAT/CD/DVD)
1.	RAD (Mono/Stereo)	-do-	0B	LGSOWG
2.	Standard	-do-	1	LGSOWG/GeoTiff
3.	Orthokit (Rad – Mono/Stereo + RPC)	-do-	0B	GeoTiff + RPC file
4.	Orthokit (Standard + RPC)	-do-	1	-do- L (Max) = 4 Scenes

Data Product Types

Sr.No.	Product Type	Approx. Area (km)	Level	Format (on CD)	NRSA Requirement
1.	7.5' x 7.5'	14 x 14	3A or 3B	GeoTiff	Precision Geocoded
2.	5' x 5'	9 x 9	-do-	-do-	-do-
3.	4.4' x 4.4'	8 x 8	-do-	-do-	-do-
4.	2.25' x 2.25'	4 x 4	-do-	-do-	-do-

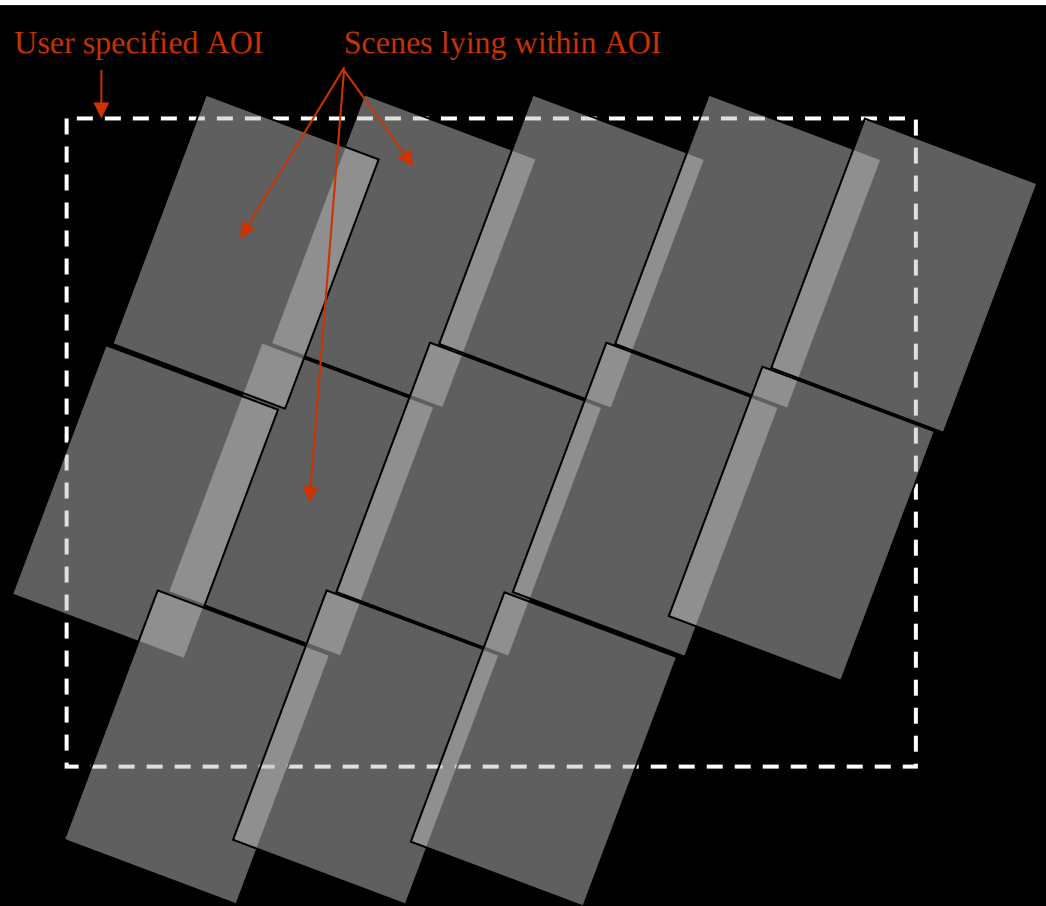
Output Formats/Media

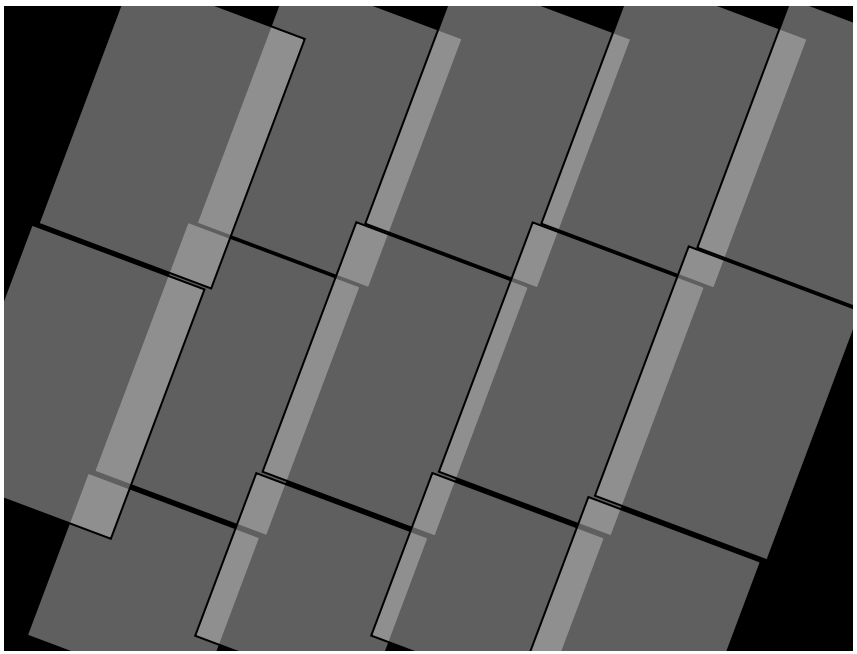
- Formats
  - Super Structure
  - GeoTiff
- Media
  - CD
  - Disk

AOI Product and packaging

- Area of Interest(AOI) product for any user desired area
- Generation of multiple standard scene products
- Using corner coordinates
- Using shape file/vector polygon
- Masking required to be done for areas outside user region
- Single work order request with multiple entries
- Packaging logically into a multi-volume set

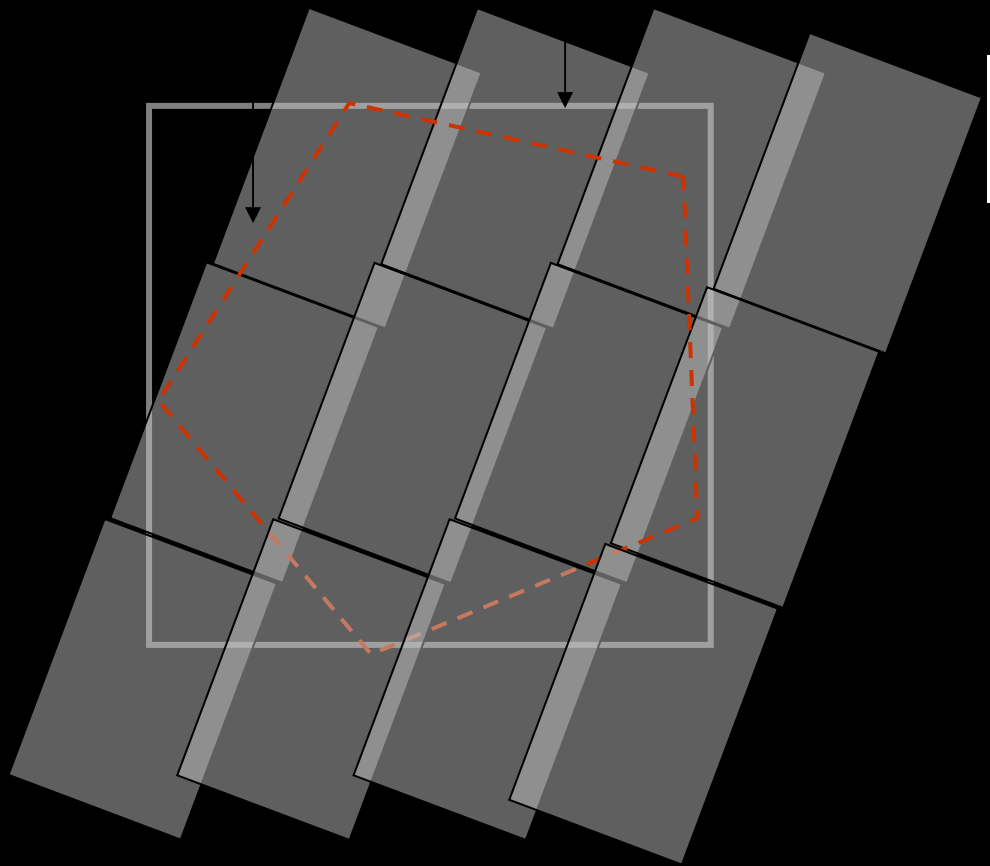
Area Of Interest
Corner coordinates

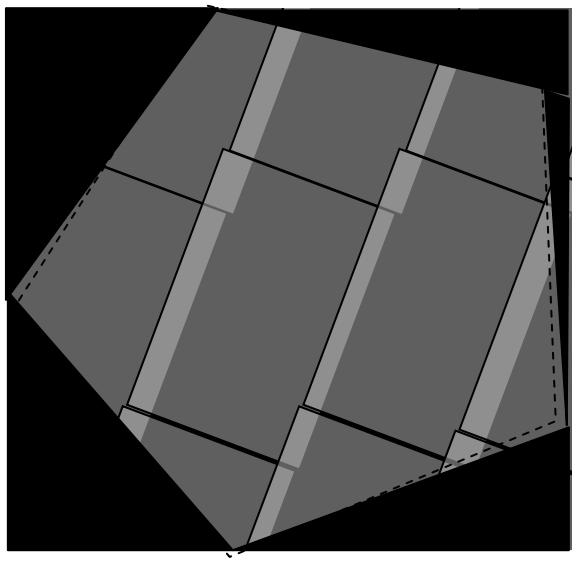




Area Of Interest Shape File

User specified AOI Bounding rectangle





Rational Polynomial Coefficients

- Relation between image and ground in terms of Ratio of Polynomials
- Generally 3rd degree
- The formulae for rational function give an image co-ordinate as a ratio of two polynomial functions in the ground co-ordinate:

$$xn = \frac{p1(Xn, Yn, Zn)}{p3(Xn, Yn, Zn)}$$

$$yn = \frac{p2(Xn, Yn, Zn)}{p4(Xn, Yn, Zn)}$$

The polynomials Pi have the form

$$p(X,Y,Z) = \sum_{i=0}^{m1} \sum_{j=0}^{m2} \sum_{k=0}^{m3} a_{ijk} X_i Y_j Z_k$$

a_{ijk} = Rational Polynomial Coefficients (RPCs)

- 78 Coefficients
- Scanline number, Pixel number, Latitude, Longitude and Height are normalised to lie between -1 and 1 to overcome computational problems

Orthokit

- Geometrically system corrected products of fixed scenes or
- Radiometrically corrected products (varying length) as input data sets for orthoimage generation
- Users are provided with 3 degree Rational Polynomial Model coefficients
- in line with similar products from IKONOS and Quickbird satellites

Product accuracy

System Level accuracy : 150 m

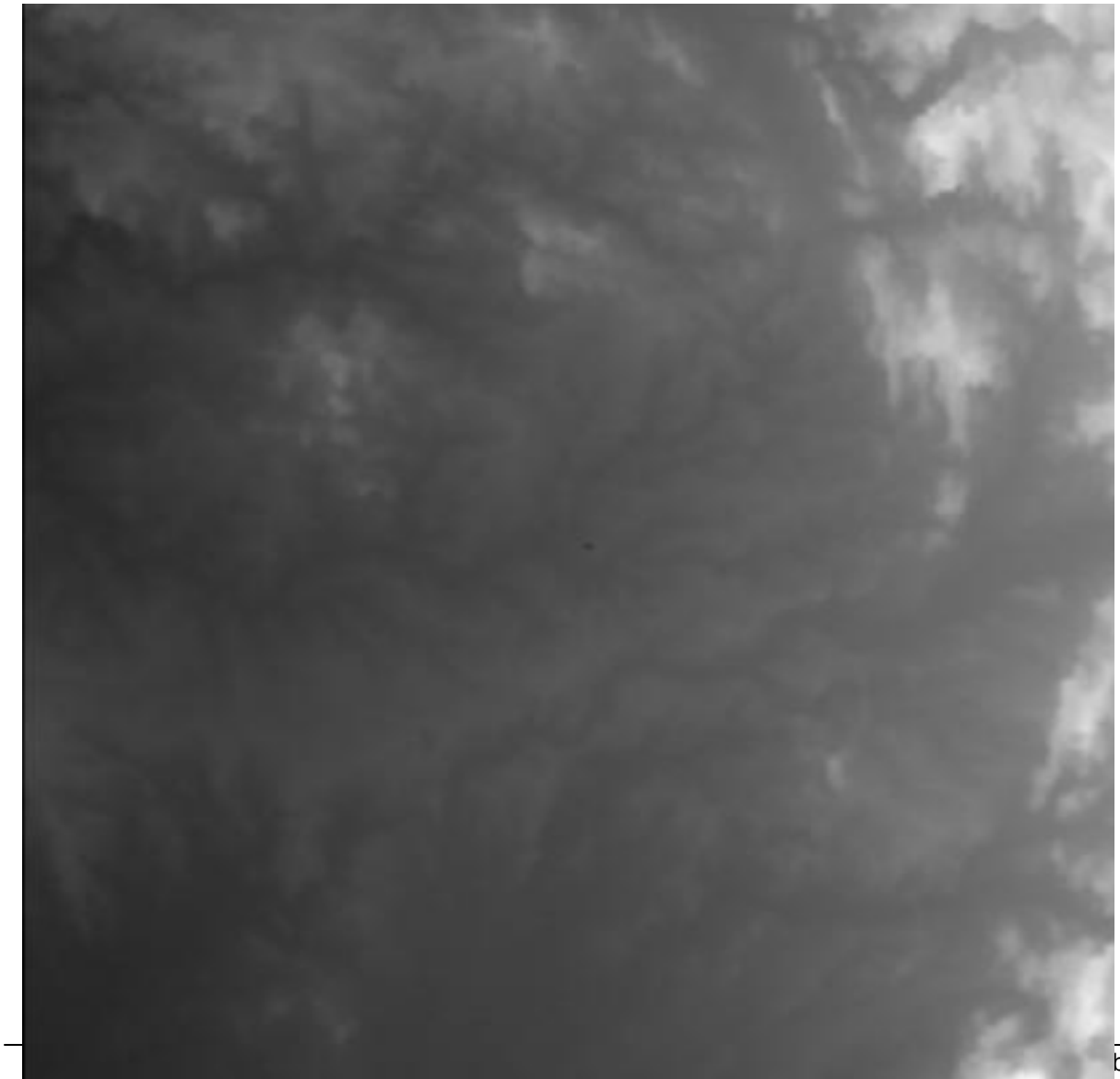
With GCP level (level 2) : 15 m (LA)

With terrain(Coarse DEM) corrected Level-3A : 15 m (LA and ID)

With finer DEM (Level 3B) : 5-7 m (LA and ID)

Digital Elevation Model Generated From Cartosat-I Stereo pair

Khedbrahma, Gujarat



Min. Height = 168 m

Max. Height = 503 m

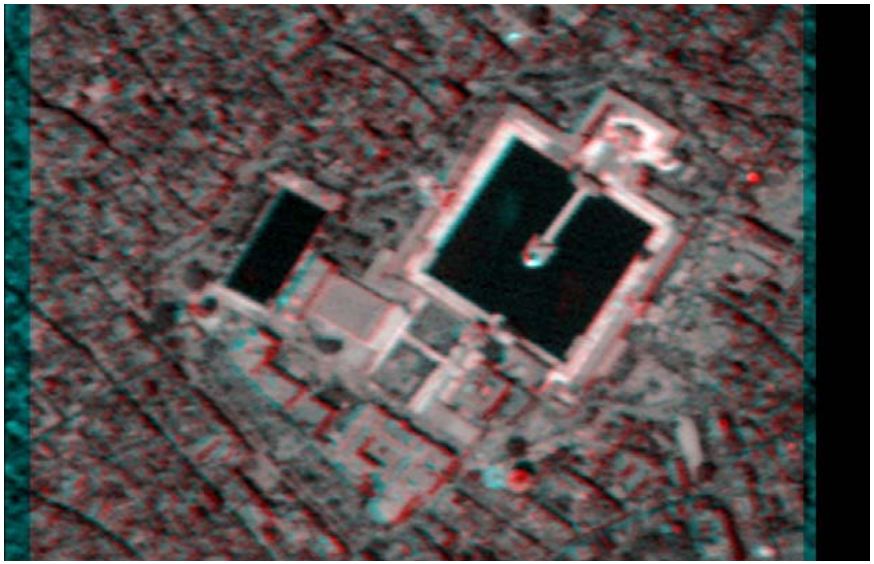
Date of Pass : 08-05-2005

Darker → Brighter

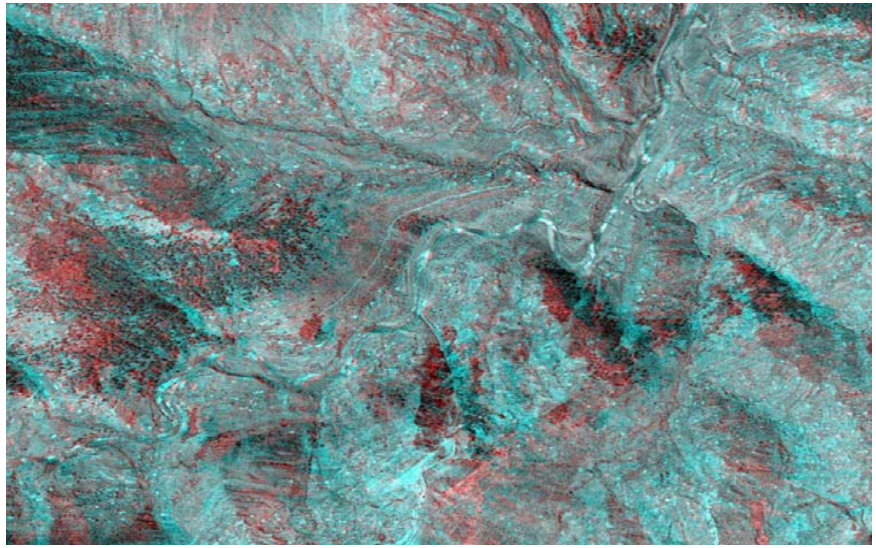
Low Elevation → High Elevation

Anaglyph From Cartosat-I Fore and AFT Images

Golden Temple, Amritsar



Anantnag, J.K.



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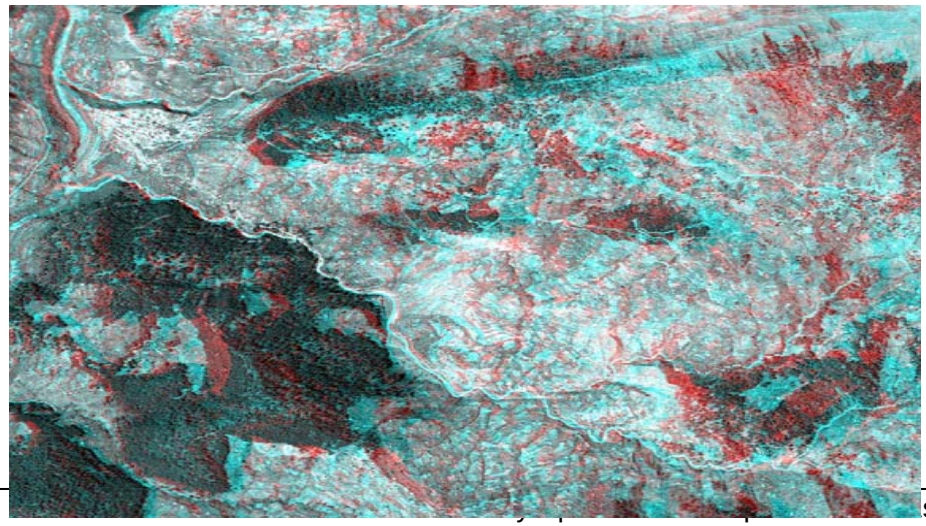
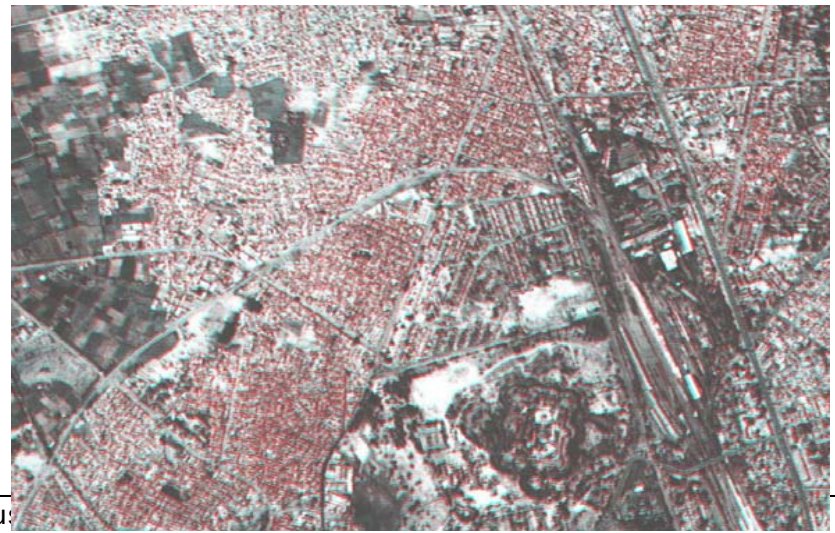
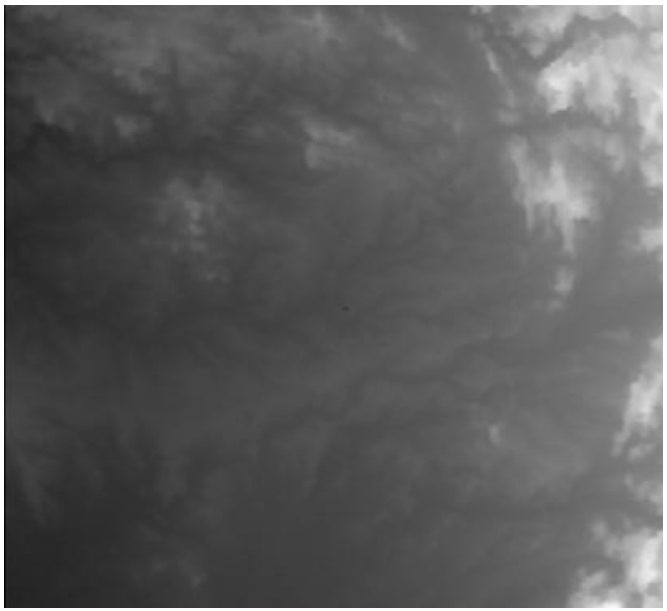


Amritsar Railway Station

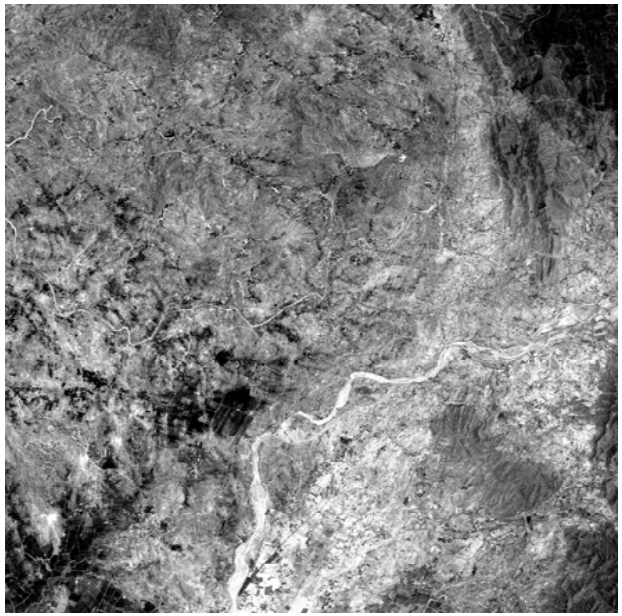


DEM and Perspective Views

DEM

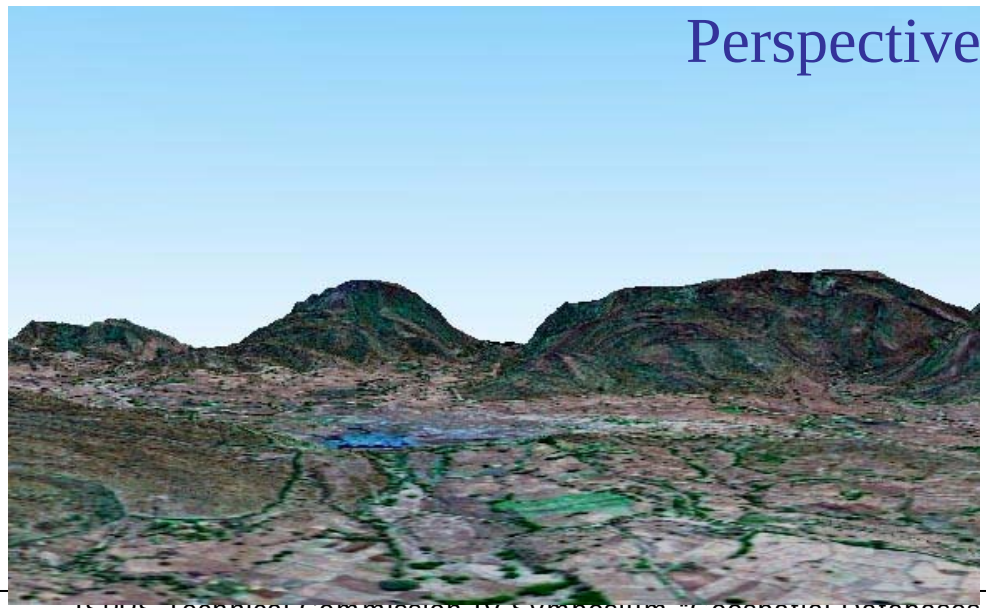


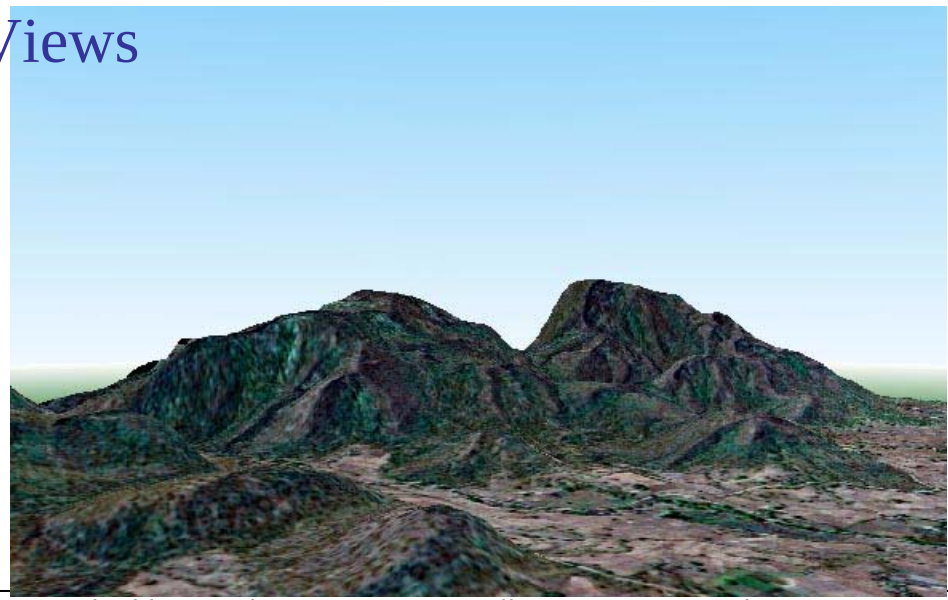
Ortho Image

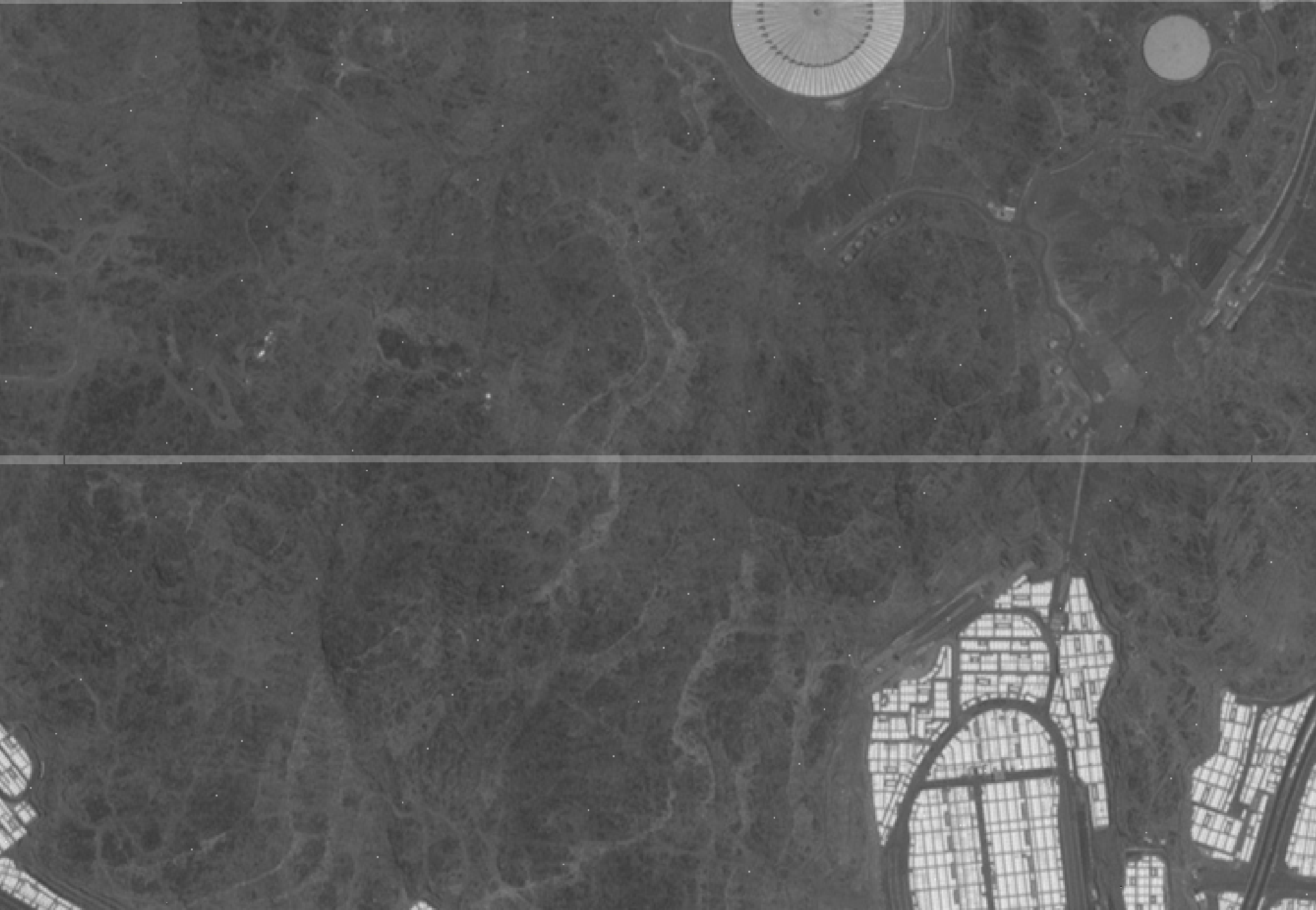


NCC Merged

Perspective Views







Commercial Software Interface

- Agreement achieved with four vendors viz. Leica Geosystems, ZI imaging, Sierra Atlantic and PCI Geomatica.
- Interface at Geotiff, Orthokit and AOI products
- A certification of these COTS s/w packages for Image Processing, Scene level triangulation, Block Triangulation and Digital mapping being carried out at SAC.

Stereo Visualization

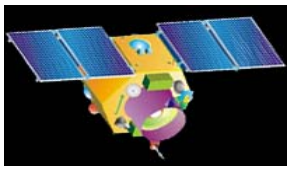
- As anaglyph image pairs
- On stereo ready monitors with active/passive glasses,
- Static or dynamic views
- Using Stereo Projectors on wide screens
- 2.5 D flythrough on imagery draped over DEM

Cartographic Potential

- DEM at 1/3" ground posting with an accuracy of 2-3 m
- Preparation of 1:25,000 scale topo Maps
- Updating of 1:10,000 scale thematic maps

Digital Maps

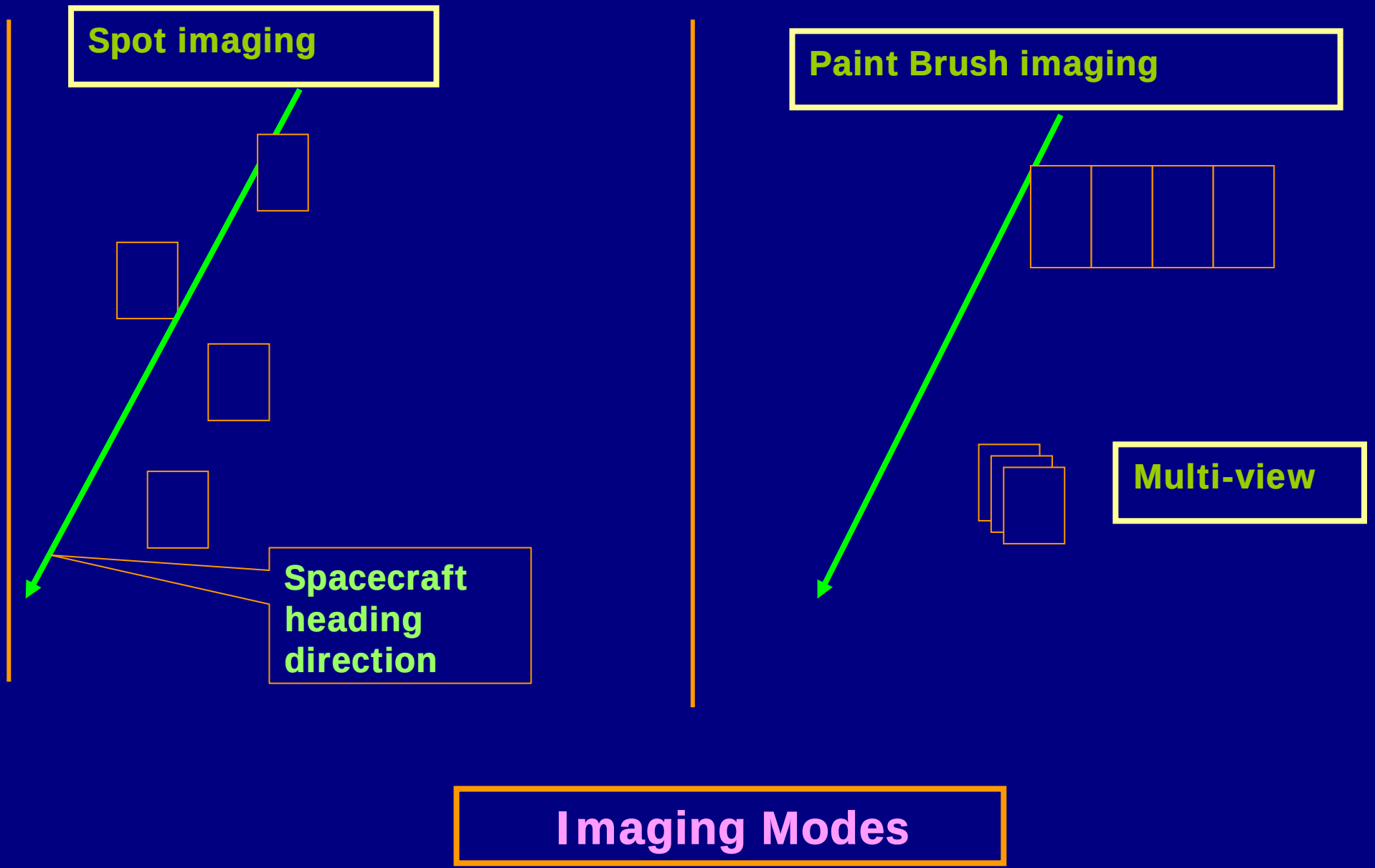
- Consists of
  Orthoimage Pyramid +
  DEM +
  Derived Vector Layers +
  Annotation Layers +
  An interactive visualization / analysis software



An introduction
CARTOSAT-2 Data Products

Mission Modes

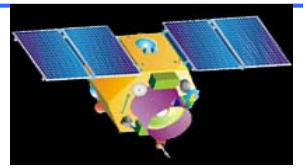
- Spot scene imaging with a capability of paint brush mode
- Multi-view acquisition within a pass



Imaging Modes

Number of Strips that can be imaged in a pass of duration 12 min is tabulated below for different types of imaging

Type of Imaging	Number of Strips with Strip length = 9.6 km	Number of Strips with Strip length = 28 km	Number of strips with Strip length = 50 km	Number of strips with Strip length = 290 km
Spot	14	12 (N-S Imaging) 10 (S-N Imaging)	10	2
Paint- Brush	5*6	4*4	4*3	-----
Multi-View	6*3	4*3	3*3	-----



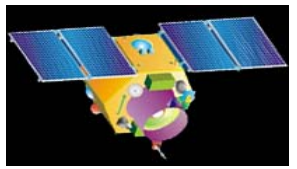
Type of Products and Correction Levels

Level of products	Product Type	Remarks
Level-0	Raw	Only stagger correction
Level-1	Radiometrically corrected	Stagger correction and radiometric correction
Level-2 Standard AOI	(a) Standard (SCENE BASED) Single scene or multiple scenes max. 3 scenes without shape file (b) Standard (AOI Based) (c) Orthokit (RAD data with RPC)	Radiometric & geometric corrections at system level (only for DQE) As above 'Rad' image data along with RPC generated using system knowledge
Level-3A (Precision)	Orthocorrected AOI	Support for Photographic products. With TCP/DEM from Cartosat-1 SSTS. No mosaicing at DP
Level-3B (High Precision)	Orthocorrected AOI	Support for Photographic products. No mosaicing at DP

Imaging Modes vs Data Products

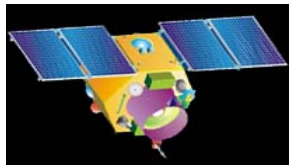
S.No.	Satellite Image Mode	Data Product
1.	SPOT/STRIP	All (Levels 0,1,2,3)
2.	Multiview	All levels, for only individual views
3.	Paintbrush	All levels without mosaic
4.	Inertial	Level 0 & 1 only (RAW and RAD)

Type of Value Added Products & Services



Level of products	Product Type	Remarks
Level-3A	OFF the shelf city based precision products	Mosaiced city product from a standalone database prepared offline
Level-3A/3B	Merged (Precision corrected) IRS-P6 (L-IV (MX)) + PAN of Cartosat-2	AOI R&D product for DP
	Visualisation tools/products for static drapes, fly throughs	Definition of products and formats are yet to be decided by NDC

Product Accuracy Specifications (CE90)



S.No.	Type of product	Accuracy (CE90)	Remarks
1.	Level 1&2	136 m	Using System Knowledge
2.	Level-3A	<10 m	Using TCPs/GCPs & internal DEM
3.	Level-3B	<5 m	Using user provided information like GCPs &DEM Accuracy may vary depending upon user inputs
4.	City based products	<5 m	Using GCP library GCPs and SSTS DEM/optionally user provided GCPs/DEM

Thank You