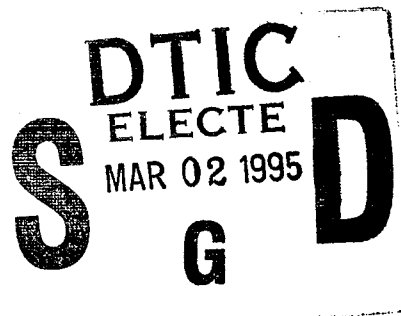


253850-5-0

Final Briefing
RETRIEVAL, DISPLAY, AND ANALYSIS SUPPORT
TOOL FOR EARTH IMAGERY (RDAST)

R. C. Anderson
C. C. Chiesa
W. A. Tyler

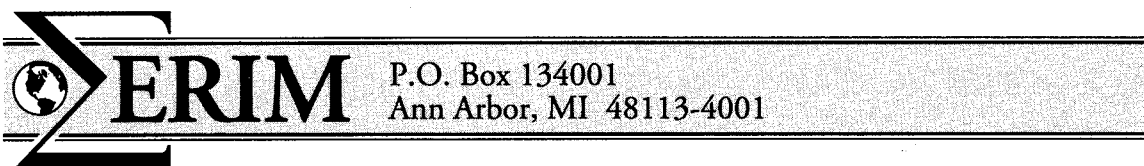
September 1994



Submitted to:
Defense Technical Information Center
Cameron Station, Room 5B205
Alexandria, VA 22304-6145

Attn: Dr. Forrest R. Frank

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13. ABSTRACT (Maximum 200 words) The Retrieval, Display, and Analysis Support Tool (RDAST) is a system designed to facilitate access to the wide variety of available earth imagery. Using the ARC/INFO geographic information system, RDAST converts user requirements into specific sensor parameters and searches internal and external databases for the availability of suitable imagery. Sample imagery are displayed. The current implementation is based on public systems (LANDSAT, SPOT, and several airborne collections, but is not limited to this. This document contains viewgraphs from the final briefing for this program. DTIC QUALITY INSPECTED 4				
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**Retrieval, Display, and Analysis Support
Tool for Earth Imagery (RDAST)**



RDAST Final Briefing

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**13 September 1994
Environmental Research Institute of Michigan
Arlington, VA**

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DTIC	<input type="checkbox"/> TAB
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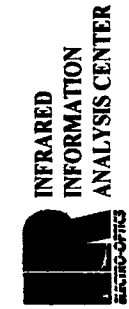


**Retrieval, Display, and Analysis Support
Tool for Earth Imagery (RDAST)**



Agenda

Project Overview	Rod Anderson	1000
Sensor Data Comparison	Bill Tyler	1015
RDAST System System overview Demonstration	Chris Chiesa	1100 1130
Discussion	All	1145
Adjorn		1200



**Retrieval, Display, and Analysis Support
Tool for Earth Imagery (RDAST)**



Program Overview

Contract number: DLA 900-88-D0392 DO 052

Program Objectives: Develop tools to index, search and compile available imagery of the earth's surface for military and dual use purposes.

Period of Performance: 9/28/93 -8/27/93 (with extension)

Milestones:

- Planning meeting: 19 Jan 1994
- Interim briefing: 31 Mar 1994
- Final briefing: 13 Sep 1994



Retrieval, Display, and Analysis Support Tool for Earth Imagery (RDAST)



Obstacles to Efficient Use of Available Datasets

- Sheer numbers of satellites, sensors, and observations have hampered a systematic assessment of the utility of various combinations.
- Data and sensor fusion techniques have been insufficiently mature to extract useful information from disparate data sets.
- Fusion techniques require extensive knowledge of sensor parameters and ground truth.
- National security considerations limit access to certain data sets.
- Requirements on information content and data extraction methods differ greatly with user needs.



Retrieval, Display, and Analysis Support Tool for Earth Imagery (RDAST)



RDAST Approach

- **Task 1: Image Identification and Compilation**
Identify sources of earth imagery from airborne and space-based sensors
Develop indexing schemes that identify imagery available of earth scenes
Compile "Metadata" each included sensor mode
- **Task 2: Image Evaluation**
Develop measures of image goodness, based on user requirements
Characterize the quality of image sets using ground truth and other measures
Develop a system for consistent annotation of selected images
- **Task 3. Coordination and Requirements Development**
Identify specific user groups to use as benchmarks in requirements development
Assess group needs and derive requirements
Review and assess features of existing data archiving and retrieval systems.
- **Task 4. Sensor Data Comparison**
Select two space-based or airborne sensors
Display the extraction of information using data and sensor fusion techniques
illustrate multiple phenomenology representations

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*Data Base Development and
Demonstration*



13 September 1994

Retrieval, Display and Analysis Support Tool

**Christopher C. Chiesa
Environmental Research Institute of Michigan
Ann Arbor, MI 48105
(313) 994-1200 ext. 3791
chiesa@erim.org**

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*Data Base Development and
Demonstration*



Presentation Overview

- **Task Background & Overview**
- **RDAST Data Base Description**
- **RDAST Prototype System Demonstration**

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*Data Base Development and
Demonstration*



Task Objectives:

Design and Implement Electronic Data Base for Storage, Retrieval and Display of Primary and Metadata for Airborne and Spaceborne Remote Sensing Systems.

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*Data Base Development and
Demonstration*



Data Base Requirements

- **Provide Local Data Management Capabilities including Storage, Query, Retrieval and Display of Remotely-Sensed Imagery**
- **Store/Query/Retrieve Sensor Metadata**
- **Link to External Archives/Catalog Systems**

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*Data Base Development and
Demonstration*



Data Base Design

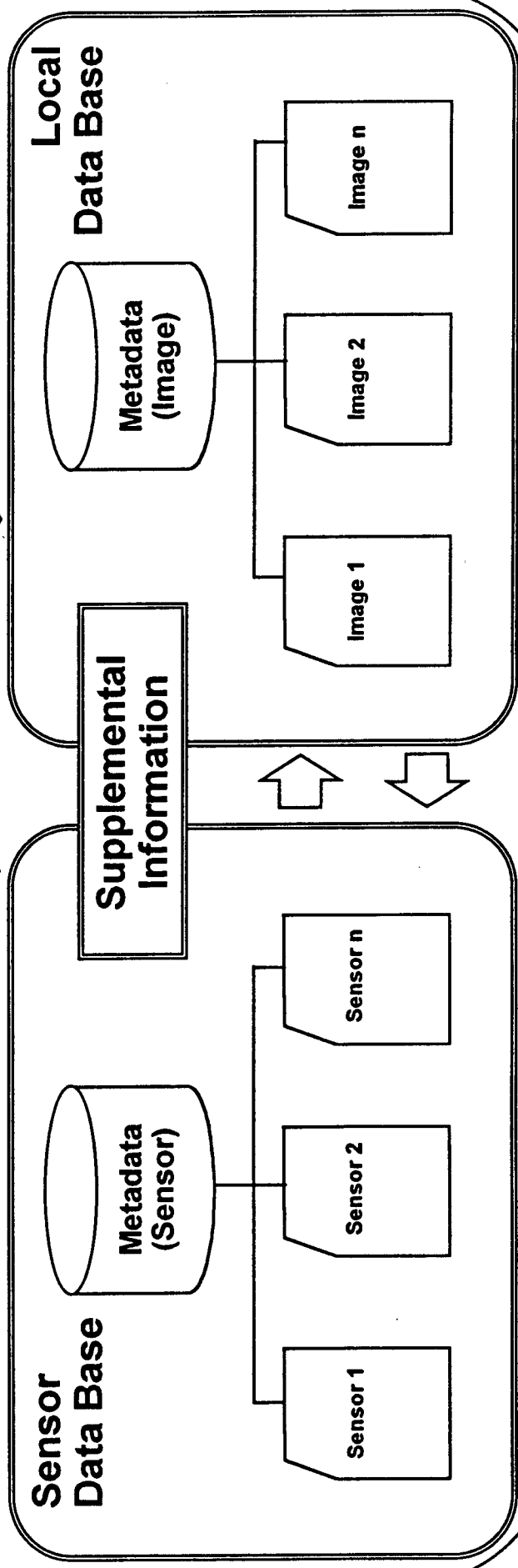
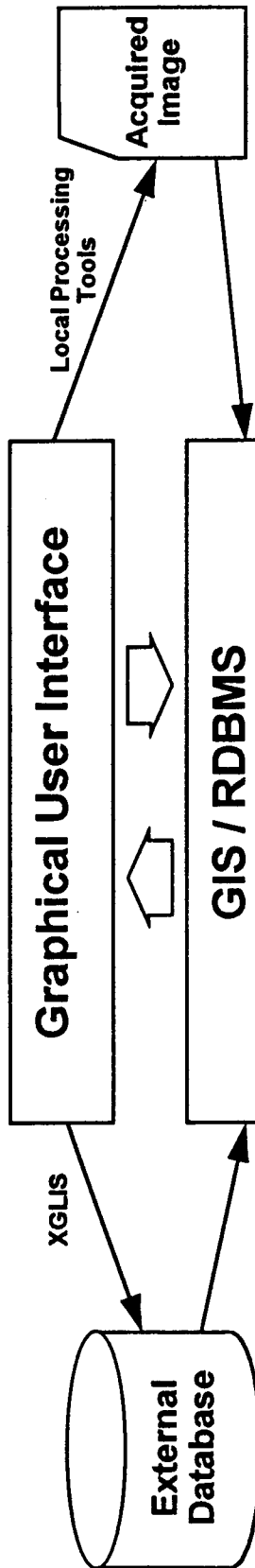
- **GIS/RDBMS-Based**
- **Sensor Data Base**
 - **Metadata**
 - **Sample Data Sets**
 - **Supplementary Information**
- **Local Data Base**
 - **Metadata**
 - **Inventory (Images)**
- **External Archive Search Linkage**
 - **XGLIS (EDC)**



Data Base Development and Demonstration

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Data Base Design





Data Base Description

- **Sensor Database Tables**
 - **SENSORBANDS:** Describes RDAST sensors/platform/band info
 - **BANDSTYPS:** Lists valid band types
 - **PLATFORMS:** Lists valid image platforms
 - **PLATFORMTYPES:** Lists platform types (e.g. SAT/ACFT)
 - **SENSORTYPS:** Lists valid sensor types
 - **SENSORS:** Lists RDAST sensors
 - **SENSORSAMPLES:** Lists sample image for each sensor
- **Image Database Tables**
 - **IMAGEDEFS:** Describes local and sample images
 - **IMAGEBANDS:** Lists bands processed for each local/sample image
 - **IMAGEDOCS:** Lists Hypertext documents related to lcl./smpl. imgs.
 - **IMAGEPROJCPARAMS:** Lists projection params. for l/s imgs.
- **Support Database Tables**



Data Base Description - IMAGEDEF Table

4.0 IMAGEDEF

This table is used to describe the local/sample images. Certain fields in this table are platform specific and may be left blank.

Database Table: IMAGEDEF

Table Field Name	Format	Use	Description	Validation	Cross-Reference Tables
IMAGEID	Char 30	Primary Key	The image identification name.	Uppercase. Not Null. Unique ID/SHELF key.	IMAGEBANDS IMAGEDOCS IMAGEPROJ- PARAMS SENSORSAMPLES
IMAGESHELF	Char 11	Primary Key	The unique shelf location for the image (or image name).	Uppercase. Not Null. Unique ID/SHELF key.	IMAGEBANDS IMAGEDOCS IMAGEPROJ PARAMS SENSORSAMPLES
IMAGEDATE	Date		The date of image acquisition. In the case of a mosaic image, choose a date that most fits the image.	Format DD/MM/YY.	
SEASON	Char 6		The season that this image was acquired. (automatically calculated from imagedate when the record is added or updated from Iupdate).	Must be one of: SPRING SUMMER, AUTUMN, WINTER	
TITLE	Char 50		A descriptive title for the image.		
SECURITY_CLASS	Char 1	Foreign Key	The security classification of the image. Must be a valid classification as defined in the validclass table.	Uppercase. Not Null.	VALIDCLASS



Data Base Development and Demonstration

RDAST

Data Base Description - IMAGEDEF Table

Table Field Name	Format	Use	Description	Validation	Cross-Reference Tables
SENSOR	Char 10	Foreign Key	The sensor from which the image originated.	Not Null. Must be a valid sensor from the SENSORS table.	SENSORS SENSORBANDS SENSORSAMPLES
PLATFORM	Char 10	Foreign Key	The platform from which the image originated.	Not Null. Must be a valid sensor from the PLATFORMS table.	PLATFORMS SENSORBANDS
SENSORTYP	Char 10	Foreign Key	The sensor type from which the image originated.	Not Null. Must be a valid type for the sensor - from the SENSORTYPES table.	SENSORS SENSORTYPES SENSORBANDS SENSORSAMPLES
PLATFORMTYP	Char 10	Foreign Key	The platform type from which the image originated.	Not Null. Must be a valid type for the platform - from the PLATFORMTYPES table.	PLATFORMS PLATFORMTYPES SENSORBANDS
ARCHIVETYP	Char 20	Foreign Key	The type of media of the image (e.g. 9-TRACK, CD-ROM). Must be a valid type as defined in the validarchivetypes table.	Must be validated against the VALIDARCHIVETYPES table.	VALIDARCHIVETYPES
GEOCODE_LEVEL	Number 1	Foreign Key	The geocode/reference level of the image. Must be a valid level as defined in the validgeocode_levels table.	Must be validated against the VALIDGEOCODE_LEVELS table.	VAKIDGEOCODE_LEVELS
CELLSIZE_X	Number 5		The cell size in the X direction (DX).		



Data Base Entity Relationship

Sensor Database Tables

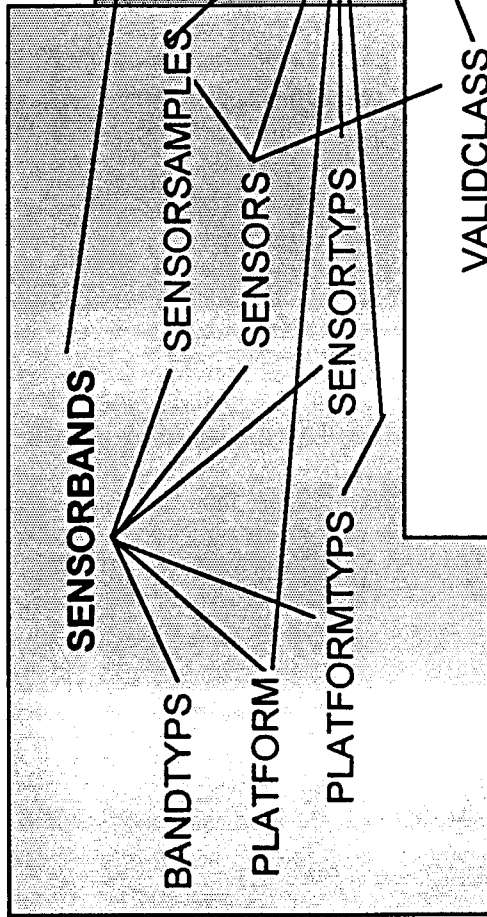
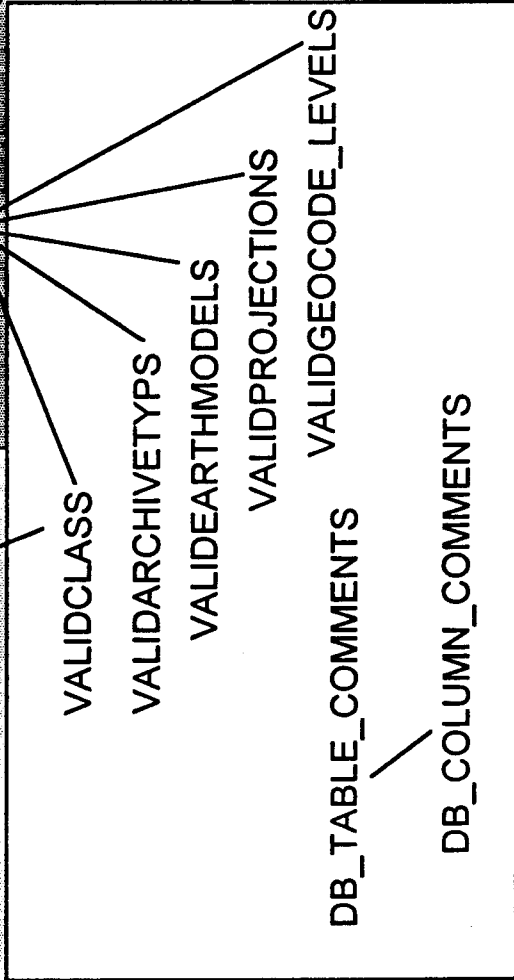
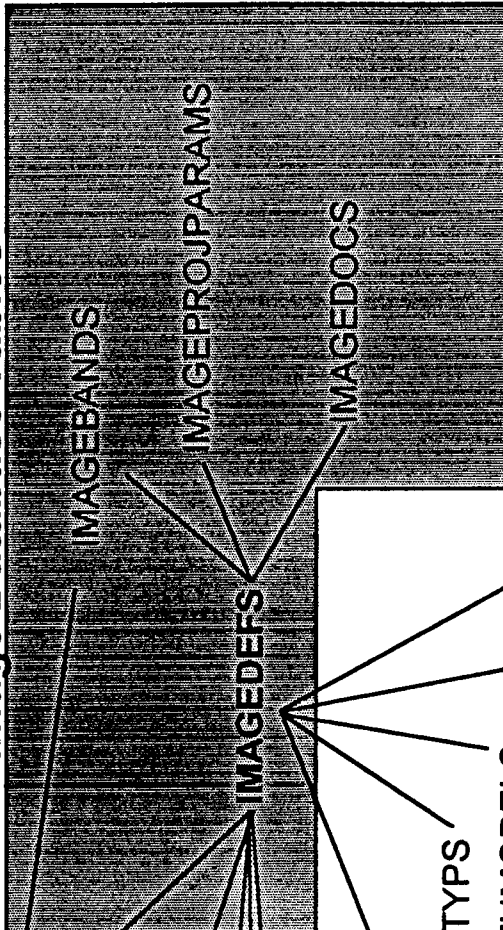


Image Database Tables



Support Database Tables

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*Data Base Development and
Demonstration*



Data Base Implementation

- **ARC/INFO Geographic Information System (GIS)**
- **ARC Macro Language (AML) Graphical User Interface (GUI)**
- **ARC/INFO Data Structures**
 - **INFO Tables Metadata**
 - **Raster Images**
 - **Topological Vector ... Boundary/Reference**
- **Supplemental (Guide) Sensor Information**
 - **Frame View Hypertext**

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*Data Base Development and
Demonstration*



Operational Scenario (Sample)

- **Situation Requiring Remotely Sensed Data Arises**
- **Query RDAST to Determine Necessary and Suitable Image Sources**
- **Local Data Base Searched for Availability of Imagery**
- **External Archive Searched for Availability of Imagery**
- **Data Acquired, Processed and Archived (Local DB)**



*Data Base Development and
Demonstration*

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RDAST Demonstration

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***Task 4 - Sensor Data Comparison
Image Examples***



13 September 1994

RETRIEVAL, DISPLAY, AND ANALYSIS TOOL FOR EARTH IMAGERY

Task 4: Sensor Data Comparison

**William A. Tyler
Environmental Research Institute of Michigan
Ann Arbor, MI 48113
tyler@vaxa.erim.org**

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Task 4 - Sensor Data Comparison
Image Examples



TASK OBJECTIVE: To Demonstrate the Utility of Using Commercial Space-Based and Airborne Sensors to Exploit Image data Using Information Extraction and Sensor Fusion Techniques

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***Task 4 - Sensor Data Comparison
Image Examples***



Commercially Available Satellite Data

- SPOT (XS and Pan) ✓✓
- Landsat (MSS and TM) ✓✓
- AVHRR (LAC and GAC)
- JERS-1 (Optical and Microwave)
- ERS-1
- CZCS
- KFA (image or digital)

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***Task 4 - Sensor Data Comparison
Image Examples***



Other Sources of Image Data

- Airborne Multispectral Scanners (M7) ✓
- Airborne Imaging RADAR Sensors (IFSARE)
- Aerial Photography

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***Task 4 - Sensor Data Comparison
Image Examples***



Obtainable Ancillary Data

- Large Scale Topographic Maps
- Digital Elevation Models (for some parts of the World)
- Digital Chart of the World (DCW)
- Scanned Navigational Charts

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***Task 4 - Sensor Data Comparison
Image Examples***



**By Combining Commercial Remote
Sensing Images With Available
Ancillary Data, Information Products
May Be Generated**

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***Task 4 - Sensor Data Comparison
Image Examples***



Examples of Satellite-Derived Information Products

- Cartographically Accurate Image Maps
- Derived Images such as Categorized Images, Bathymetric Images, Enhanced Images
- Fused Image Products such as Perspective Views, Pan-Sharpener Multispectral Data, Change Images

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***Task 4 - Sensor Data Comparison
Image Examples***



Information Products Generated

During Task 4 Activities

- Portions of the RDAST Data Base Were Populated With Examples of Commercially Available Data
- Examples of Landsat MSS, TM, SPOT and SPOT-Sharpened Image Data Were Generated For a Variety of Geographic Areas
- A Perspective View Flythrough Loop was Produced for the RDAST Data Base
- Examples of Other Image-Derived Products were Generated: Data Fusion Examples, Change Detection, Terrain Categorization, and Spot-Sharpened TM

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***Task 4 - Sensor Data Comparison
Image Examples***



Digital Files Generated for RDAST Data Base

- Ann Arbor Data (M7, TM, MSS, AVHRR)
- Chambery Data (TM, MSS, DTED, Fly-Through)
- Baghdad Data (2 TM)
- St. Charles Flood (2 TM, Spectral Features)
- Washington, D.C. (SPOT, TM, Sharpened)

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**Task 4 - Sensor Data Comparison
Image Examples**



Important Dates in Commercial Remote Sensing

- July 1972 - October 1992, Landsat
MSS Data Available
- July 1982 - Present, Landsat TM Data
Available
- February 1986 - Present, Spot Data
Available
- October 1979 - Present, AVHRR Data
Available

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**Task 4 - Sensor Data Comparison
Image Examples**



Pixels per Millimeter at Various Scales and Spatial Resolution

<u>Sensor</u>	<u>1:250,000</u>	<u>1:100,000</u>	<u>1:50,000</u>	<u>1:25,000</u>
AVHRR	0.25	0.1	0.05	0.025
MSS	5.0	2.0	1.0	0.5
TM	10.0	4.0	2.0	1.0
SPOT-XS (20m)	12.5	5.0	2.5	1.25
SPOT-Pan (10m)	25.0	10.0	5.0	2.5

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**Task 4 - Sensor Data Comparison
Image Examples**



Pixels per Square Kilometer for Various Satellite Sensors

<u>Sensor</u>	<u>Resolution</u>	<u>Pixels/sq.km</u>	<u>Bands</u>	<u>Total Pixels/sq km</u>
AVHRR	1,100 m (nadir)	0.9	5	4.5
MSS	80 meters	226	4	904
TM	30 meters	1,231	7	8,617
SPOT-XS (20m)	20 meters	2,500	3	7,500
SPOT-Pan (10m)	10 meters	10,000	1	10,000

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**Task 4 - Sensor Data Comparison
Image Examples**



The SPOT Satellite System (SPOT 1 - 3)

- SPOT Acronym: *Système Pour l'Observation de la Terre*
- Development of the SPOT System
 - launch facility in South America
 - CNES: *Centre National d'Etudes Spatiales* (like NASA in the U.S.)
 - Toulouse: SPOT Image Headquarters
- SICORP
 - U.S. Distributor of SPOT Data

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**Task 4 - Sensor Data Comparison
Image Examples**



The HRV (*Haut Resolution, Visible*) Sensor

- Pushbroom Design: No Moving Parts
- Spectral Resolution
 - panchromatic mode 0.51-0.73 μm
 - XS mode, 3 bands 0.50-0.89 μm
- Spatial Resolution
 - panchromatic mode 10 m
 - XS mode 20 m

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**Task 4 - Sensor Data Comparison
Image Examples**



SPOT Satellite Orbit

- Sun Synchronous
- Near Polar
- Overpass Time: 10:30 AM at Equator
- Off-Nadir Viewing
 - Advantages: Rapid Revisit (2.5 days on average), Stereo Coverage Possible
 - Disadvantages: More Complex Geometric Correction Algorithms

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***Task 4 - Sensor Data Comparison
Image Examples***



SPOT Scene Geometry

- Nominal SPOT Frame Size 60 x 60 km
- Off-Nadir: up to 80 x 60 km
- Number of Pixels
 - panchromatic mode: 6,000 x 6,000
 - XS mode: 3,000 x 3,000 x 3 bands

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**Task 4 - Sensor Data Comparison
Image Examples**



Memory Requirements

- SPOT Pan scene: $6,000 \times 6,000 = 36$ Mbytes per scene
- SPOT XS scene: $3,000 \times 3,000 \times 3 = 27$ Mbytes per scene
- One degree x One degree Area: 6 - 8 SPOT scenes required

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**Task 4 - Sensor Data Comparison
Image Examples**



Satellite Locator Map

- GRS sheets: (*Grille de Reference*
SPOT) map series @ 1:5,000,000
scale showing scene center locations
- K/J Coordinates
 - "K" coordinates along track of
satellite
 - "J" coordinates analogous to lines
of latitude (equator J>350)

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***Task 4 - Sensor Data Comparison
Image Examples***



The Landsat Satellite System

- Landsat 1 Launched in July 1972
 - carried Return Beam Vidicon (RBV) and Multispectral Scanner (MSS)
 - Landsats 2 & 3 carried same two sensors
- Landsat 4 Launched in July 1982
 - carried Thematic Mapper (TM) and Multispectral Scanner (MSS)
 - Landsat 5, launched in March 1984, carried same two sensors

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***Task 4 - Sensor Data Comparison
Image Examples***



The Multispectral Scanner

- **Spatial Resolution** Approximately 80 meters
- **Spectral Resolution:** 4 Broad Spectral Bands
from 0.5 - 1.1 μ m
- **Radiometric Resolution:** 6-bits/pixel/band

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***Task 4 - Sensor Data Comparison
Image Examples***



The Thematic Mapper

- **Spatial Resolution 30 meters**
- **Spectral Resolution: 6 Spectral Bands from 0.45 - 2.35 μ m, plus one thermal band**
- **Radiometric Resolution: 8-bits/pixel/band**

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***Task 4 - Sensor Data Comparison
Image Examples***



Landsat Satellite Orbit

- Sun Synchronous
- Near Polar
- Overpass Time: 9:30 AM at Equator
- Revisit Every 16 Days (18 days for Landsat 1-3)

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***Task 4 - Sensor Data Comparison
Image Examples***



Landsat Scene Geometry

- Landsat Scene 185 x 185 km
- Amount of Sidelap Varies with
Latitude
- Number of Pixels
 - nominal size 5965 rows x 6967
columns (41.56 Mbytes/band)

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***Task 4 - Sensor Data Comparison
Image Examples***



Landsat Scene Storage Requirements

- Landsat TM scene: $5,965 \times 6,967 = 41.56$ Mbytes per band
- Full Frame: $5,965 \times 6,967 \times 7 = 291$ Mbytes
- MSS data: $2300 \times 3264 \times 4 = 30$ Mbytes
- One degree x One degree Area: 1 - 4 Landsat scenes required

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***Task 4 - Sensor Data Comparison
Image Examples***



Ann Arbor, Michigan

- M7 Data for Willow Run Airport (geocoded)
- Landsat MSS Data From August 1990
(geocoded)
- Landsat TM Data From May 1992 (geocoded)

RDAST

***Task 4 - Sensor Data Comparison
Image Examples***



Chambery, France

- Landsat MSS Data From May 1976 (geocoded)
- Landsat TM Data From July 1984 (geocoded)
- Digital Elevation Model Generated from 3 Arc-Second DTED Data
- Animated Fly-Through Sequence Produced

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***Task 4 - Sensor Data Comparison
Image Examples***



Baghdad, Iraq

- Landsat TM Data From January 1990
(geocoded using satellite ephemeris)
- Landsat TM Data From January 1991
(geocoded using satellite ephemeris)

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***Task 4 - Sensor Data Comparison
Image Examples***



St. Charles, Missouri

- Landsat TM Data From 15 July 1986,
Geocoded, Pre-Flood Data
- Landsat TM Data From 18 July 1993,
Geocoded, Flood Near Peak
- Various Derived Images (Flood
Extent, Flooded Agricultural Land,
etc.)

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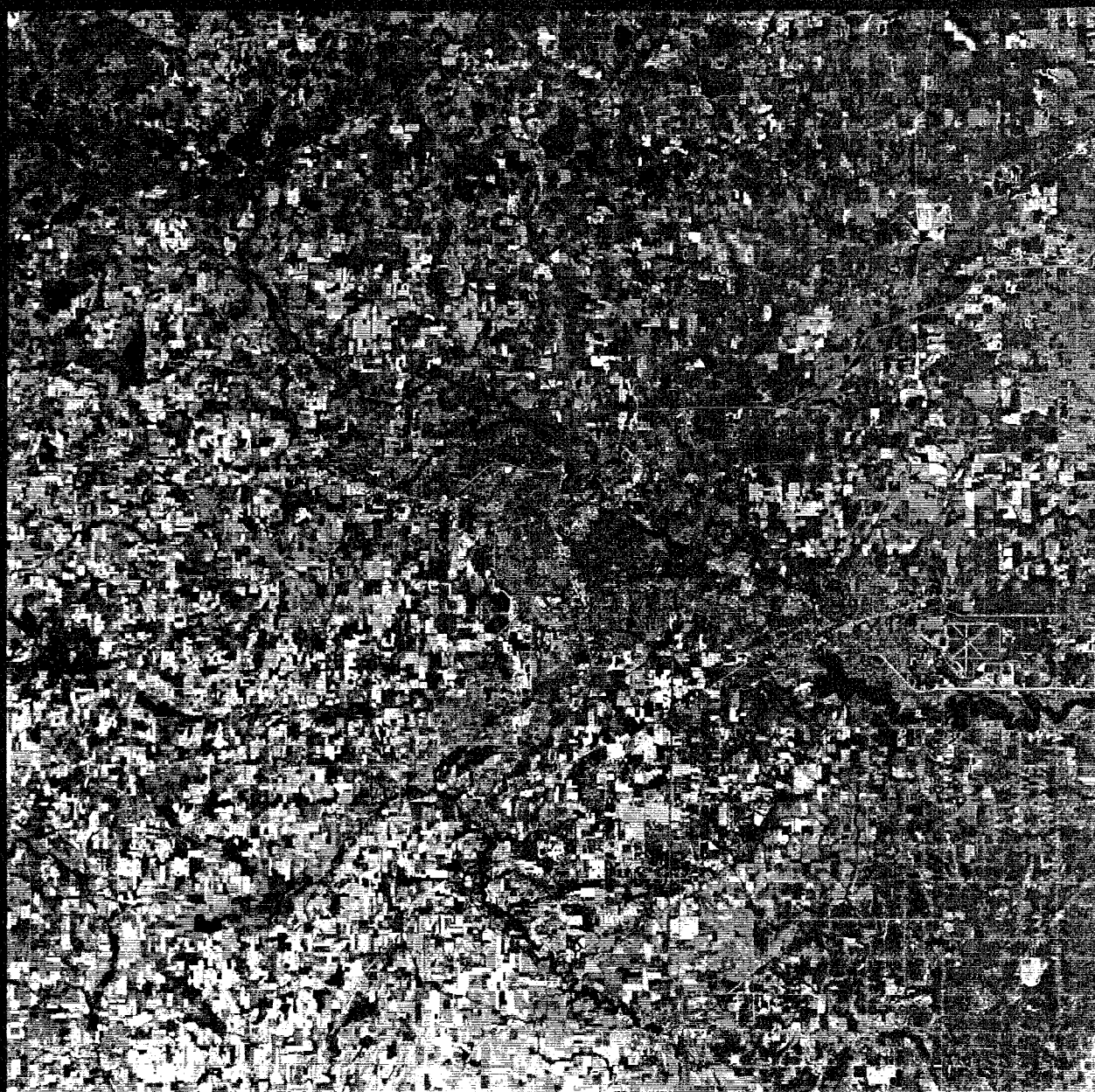
***Task 4 - Sensor Data Comparison
Image Examples***



Summary

- Commercial Satellite are Data Available For Most of the World at a Variety of Resolutions
- SPOT Data (10m spatial resolution) Useful at Scales as Large as 1:20,000
- Landsat TM Data (30m) Useful at Scales as Large as 1:50,000
- Commercial Data May Be Used To Derive a Variety of Information Products

Ann Arbor, Michigan



Landsat Thematic Mapper (TM) Data, Partial Scene

False Color Composite

Bands 4 3 2 / R G B

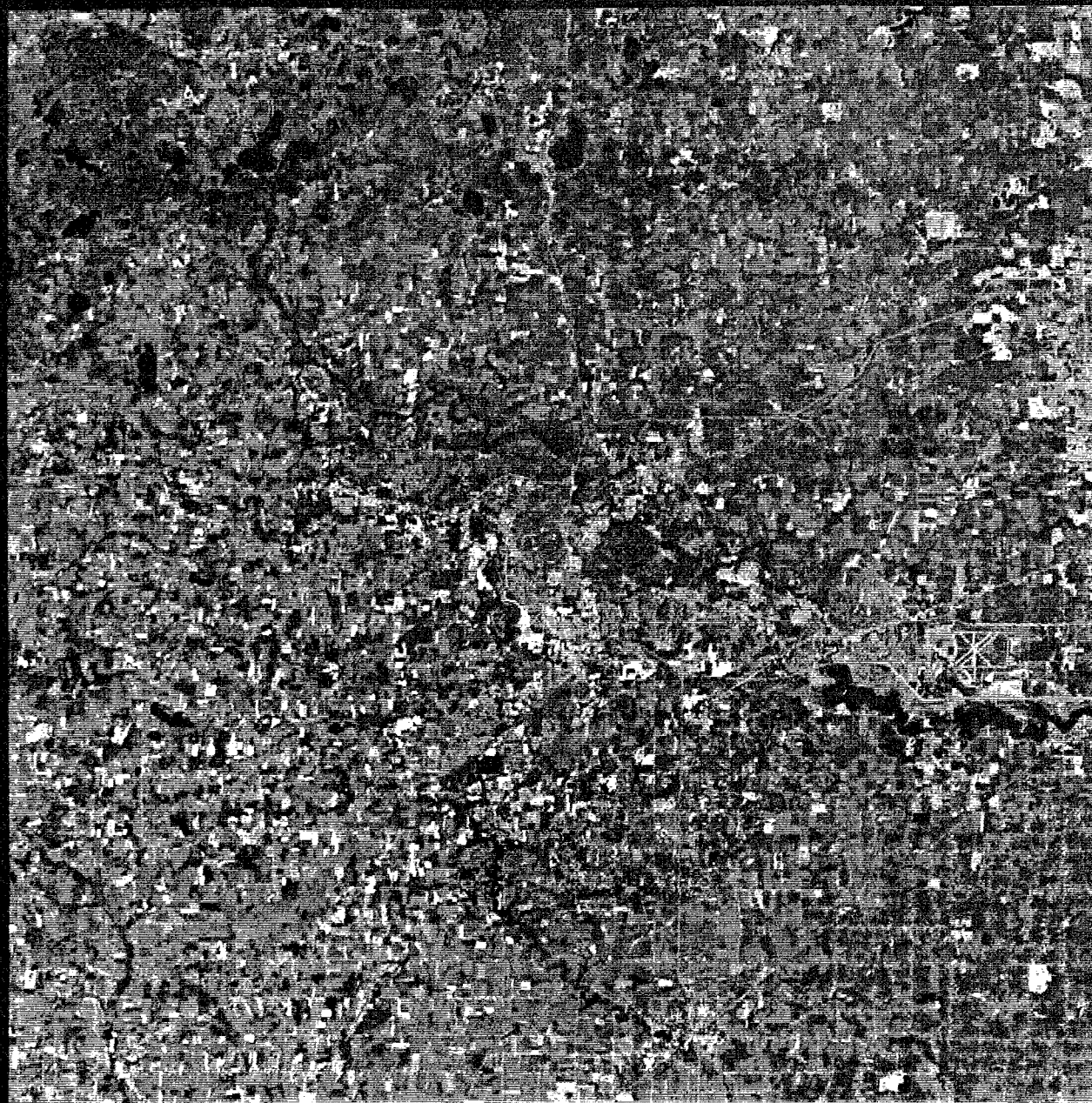
Path 20 Row 30

Scene Date: 16 May 1992

0 5 10 Kilometers



Ann Arbor, Michigan



Landsat Multispectral Scanner (MSS) Data, Partial Scene

False Color Composite

Bands 4 2 1 / R G B

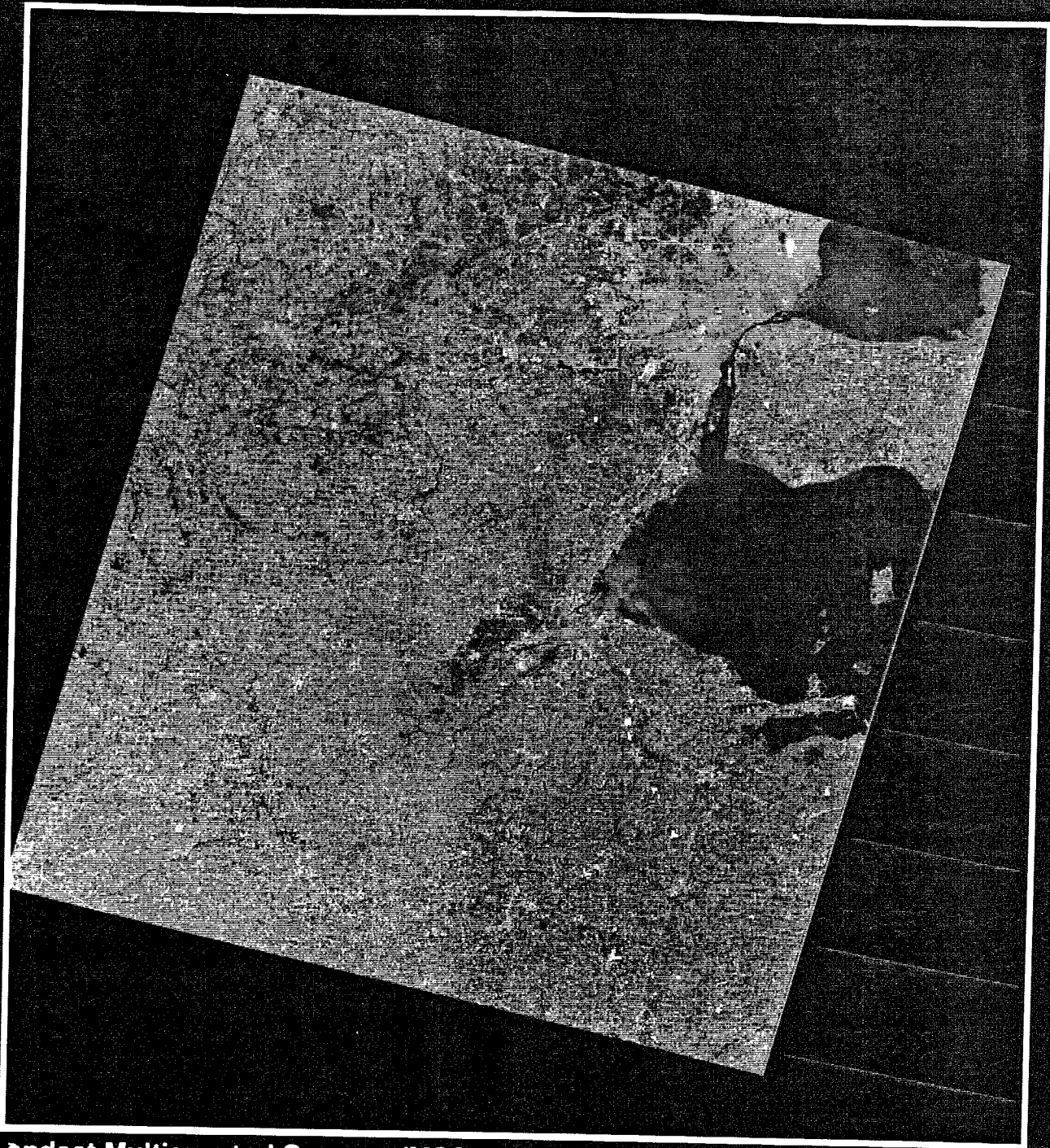
Path 20 Row 31

Scene Date: 31 August 1990

0 5 10 Kilometers



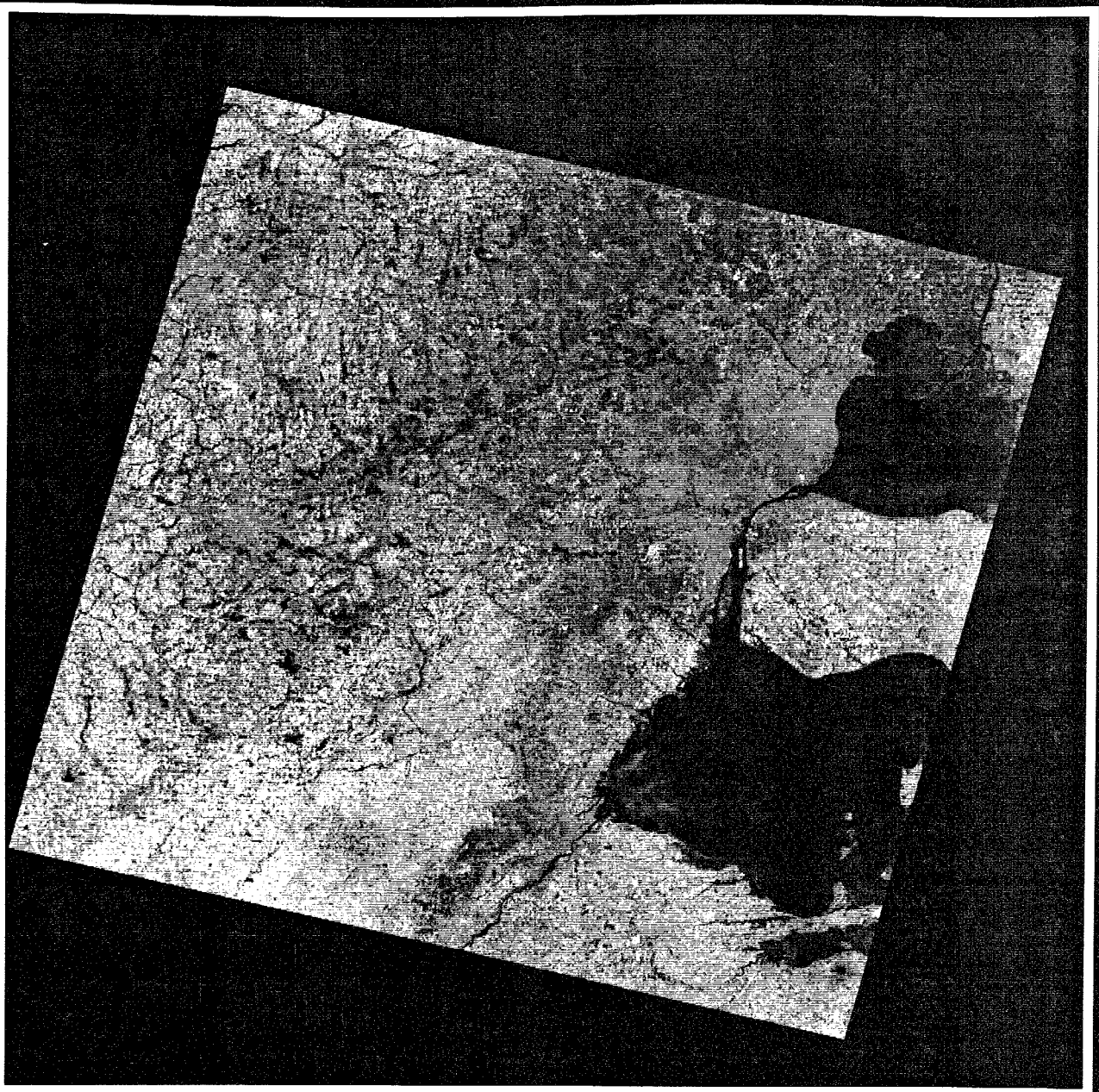
Ann Arbor, Michigan



Landsat Multispectral Scanner (MSS) Data, Full Scene
False Color Composite
Bands 4 2 1 / R G B
Path 20 Row 31
Scene Date: 31 August 1990



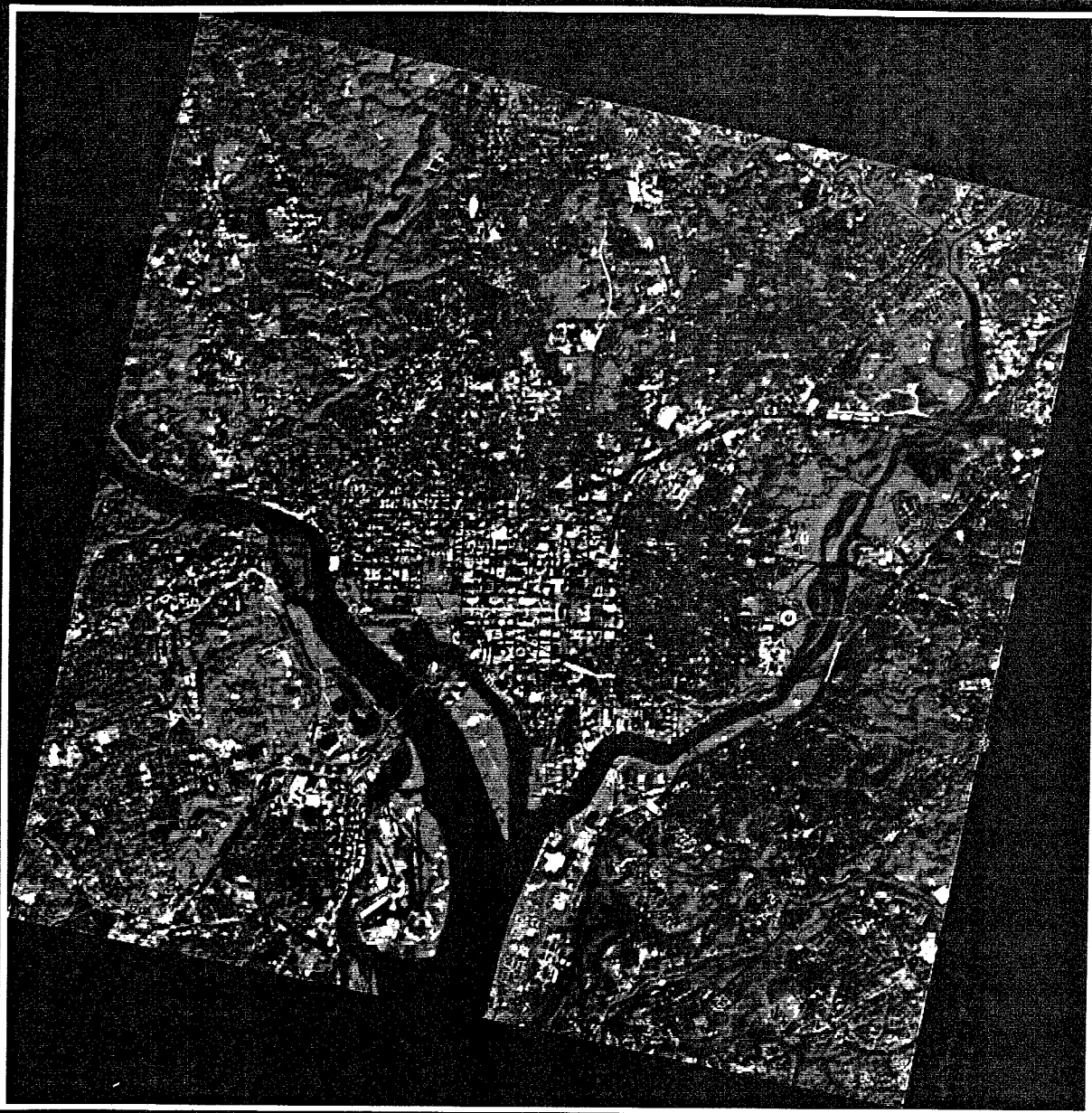
Ann Arbor, Michigan



Landsat Thematic Mapper (TM) Data, Full Scene
False Color Composite
Bands 4 3 2 / R G B
Path 20 Row 30
Scene Date: 16 May 1992



Washington, D.C.



Landsat Thematic Mapper (TM) Data
False Color Composite
Bands 4 3 2 / R G B
Scene Date: 23 October 1993
Resampled to 20 m cells, UTM Projection

0 2 4 Kilometers



Washington, D.C.



SPOT Data © 1993 CNES

SPOT Panchromatic Data

K 623 J 272

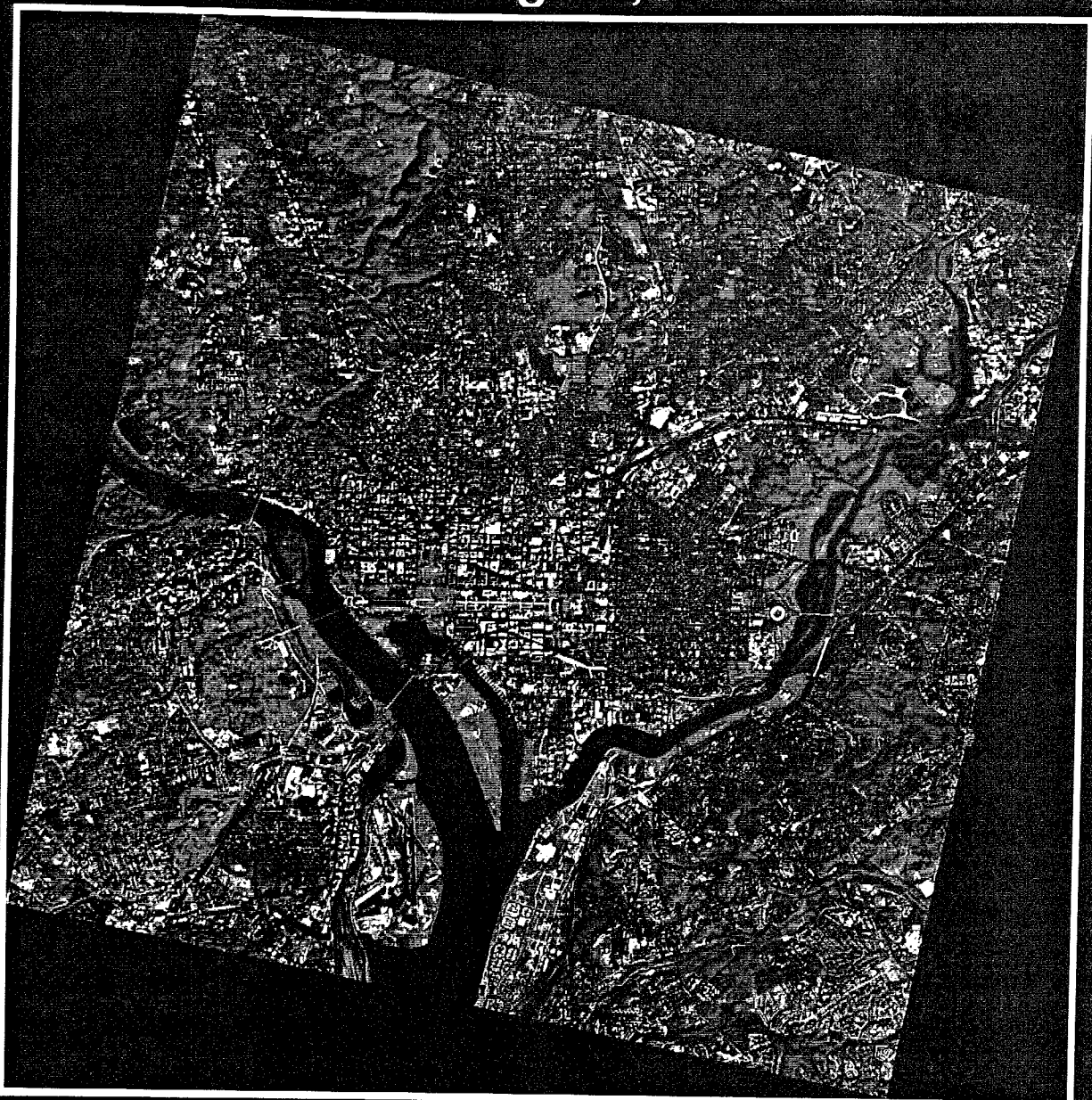
Scene Date: 28 September 1993

Resampled to 10 m cells, UTM Projection

0 2 4 Kilometers

ERIM

Washington, D.C.



SPOT Data © 1993 CNES

SPOT-Sharpened TM Data
SPOT Pan Data and TM Bands 432/RGB
SPOT Scene Date: 28 September 1993
TM Scene Date: 23 October 1993
Resampled to 10 m cells, UTM Projection
Sharpening Algorithm: SPARKLE

0 2 4 Kilometers



St. Charles, Missouri Flood Extent, 18 July 1993



Flood Mask (Red) Overlaid on Natural Color Image

0 2 4 Kilometers

Scene Date: 18 July 1993



St. Charles, Missouri Flooded Cultural Features



Water Feature 1986: Blue
Water Feature 1993: Green
Built-Up Land: Red

0 2 4 Kilometers

Interpretation Key:

Dark Blue = Flooded Areas
Magenta = Flooded Roads/ Parking Lots
White = Flooded Buildings
(if Surrounded by Blue)



St. Charles, Missouri Flooded Agriculture



Flooded Agricultural Land (Green) Overlaid on
Tasseled Cap Brightness Spectral Feature

0 2 4 Kilometers

Scene Date: 18 July 1993



St. Charles, Missouri



15 July 1986
Landsat TM Bands 321/RGB
(Natural Color Composite)



18 July 1993
Landsat TM Bands 321/RGB
(Natural Color Composite)

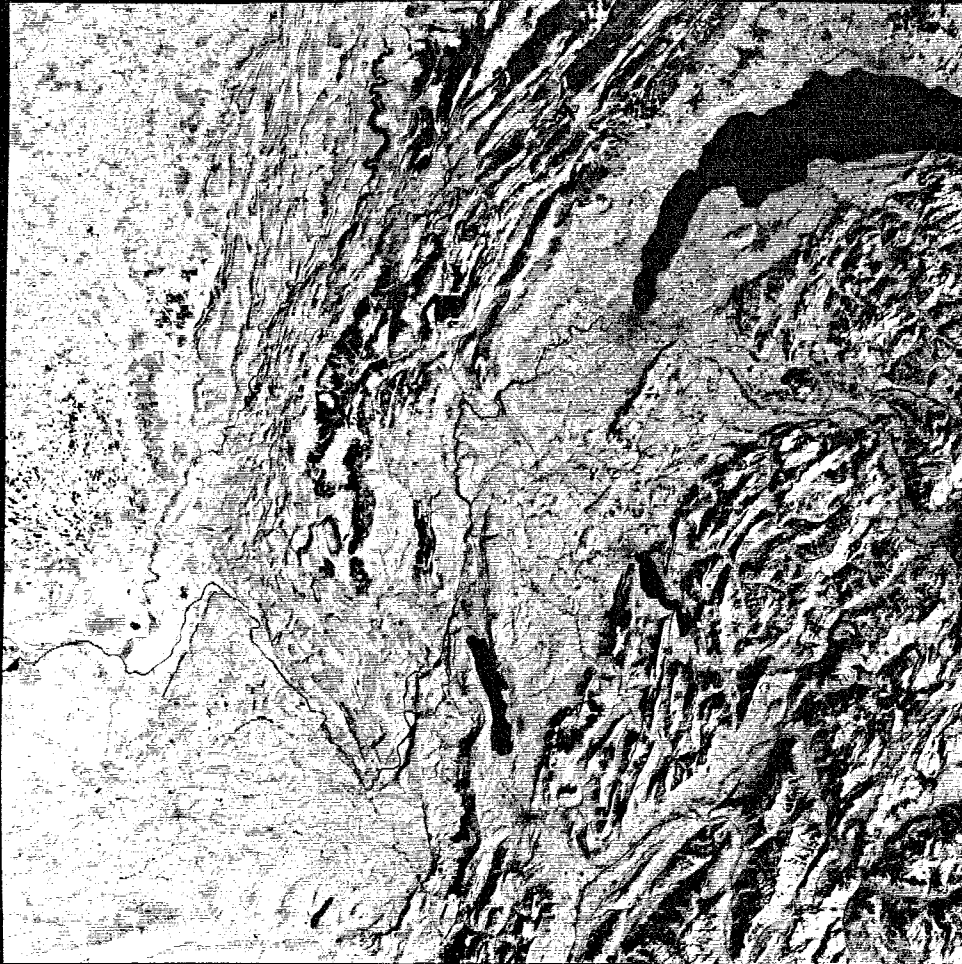


Water Feature



Water Feature

Chambery, France



0 20 40 Kilometers

Landsat Thematic Mapper (TM) Data
False Color Composite
Bands 7 4 2 / R G B
Path 196 Row 28
Scene Date: 30 July 1984
Resampled to 25 m cells, Lambert Projection



Chambery, France



Landsat Thematic Mapper (TM) Data, Partial Scene

Natural Color Composite

Bands 3 2 1 / R G B

Path 196 Row 28

Scene Date: 30 July 1984

Resampled to 25 m cells, Lambert Projection

0 10 20 Kilometers



Perspective View Fly - Through



Frame 47



Frame 60



Frame 117



Frame 130



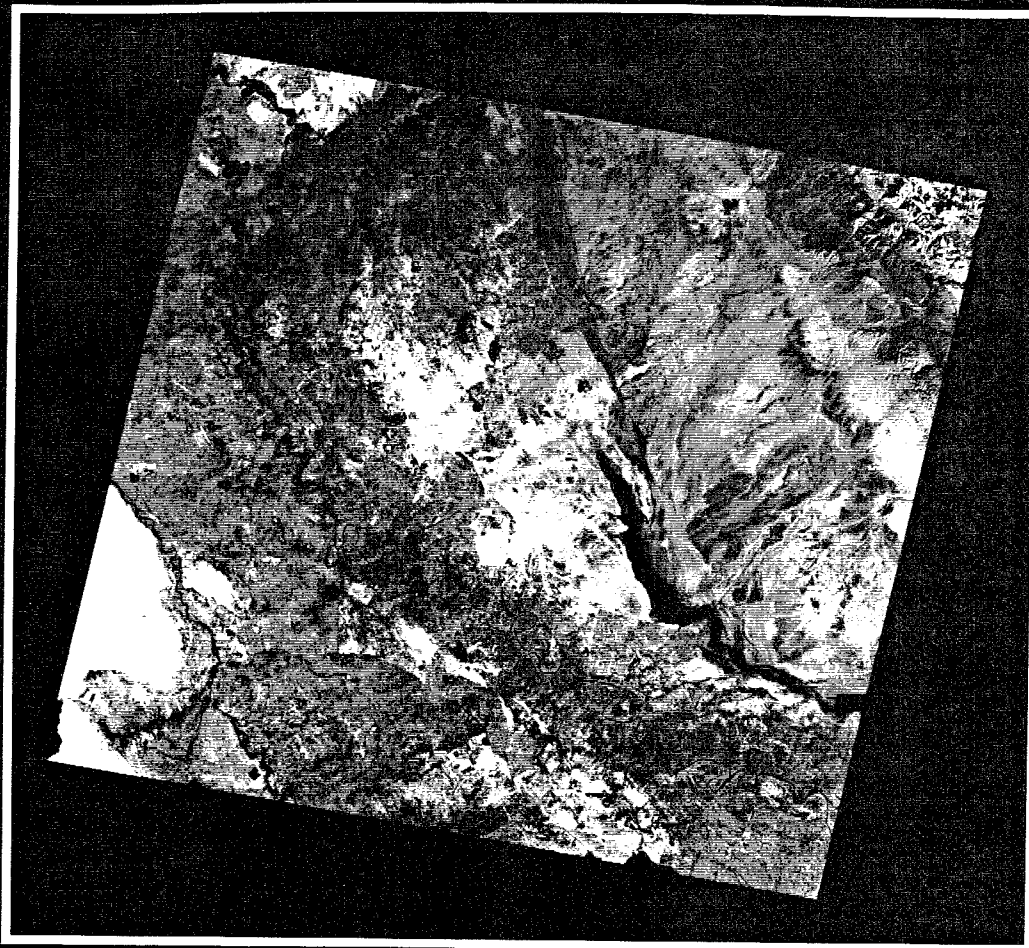
Landsat TM
Natural Color
Scene Date: 30 July 1984
Path/ Row: 196-28



3 Arc - Second DTED



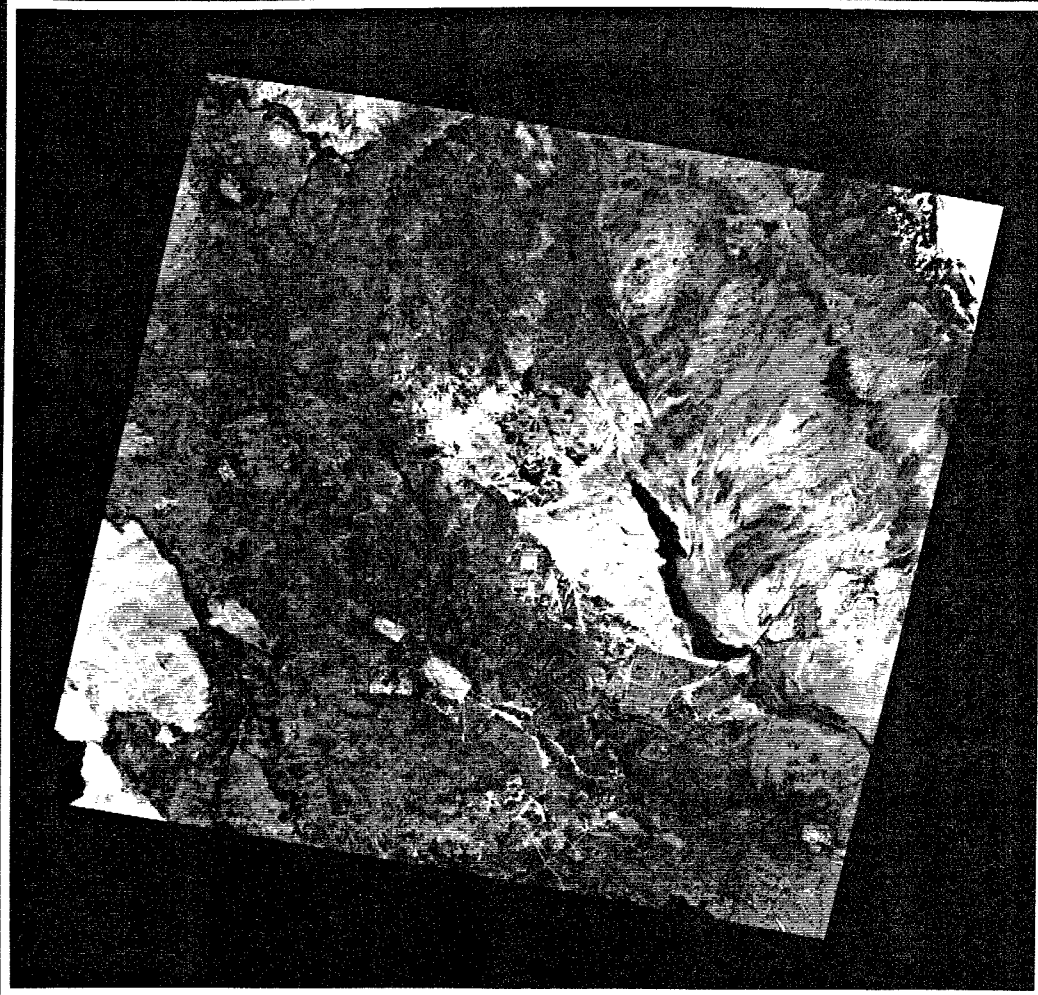
Baghdad, Iraq



Landsat Thematic Mapper (TM) Data, Full Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 8 January 1990
Resampled to 25 m cells, UTM Projection

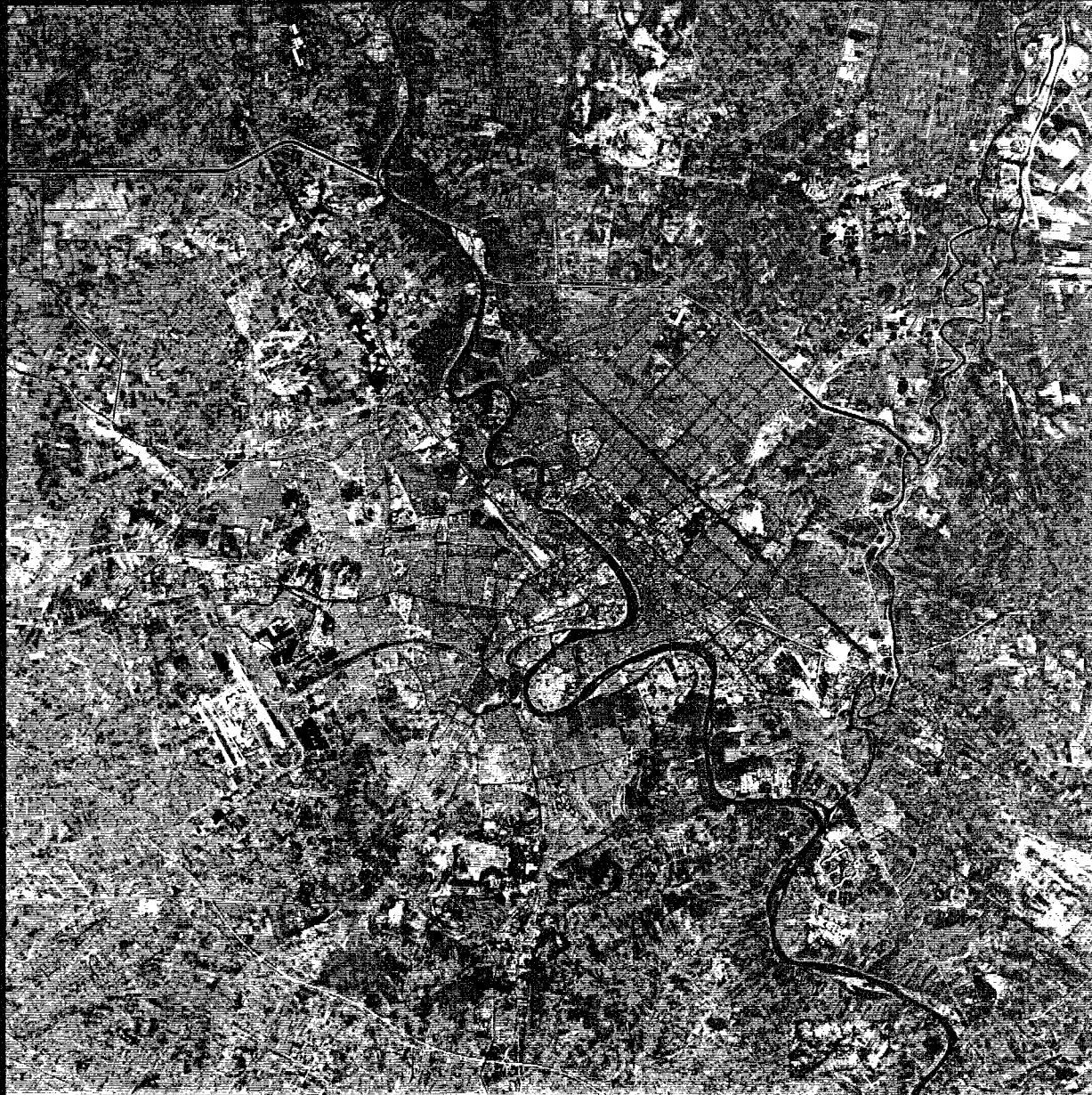


Baghdad, Iraq



Landsat Thematic Mapper (TM) Data, Full Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 27 January 1991
Resampled to 25 m cells, UTM Projection

Baghdad and Environs



Landsat Thematic Mapper (TM) Data, Partial Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 8 January 1990
Resampled to 25 m cells, UTM Projection

0 5 10 Kilometers



Baghdad and Environs



Landsat Thematic Mapper (TM) Data, Partial Scene
False Color Composite
Bands 7 4 2 / R G B
Path 168 Row 37
Scene Date: 27 January 1991
Resampled to 25 m cells, UTM Projection

0 5 10 Kilometers



Spatial Filters Baghdad, Iraq



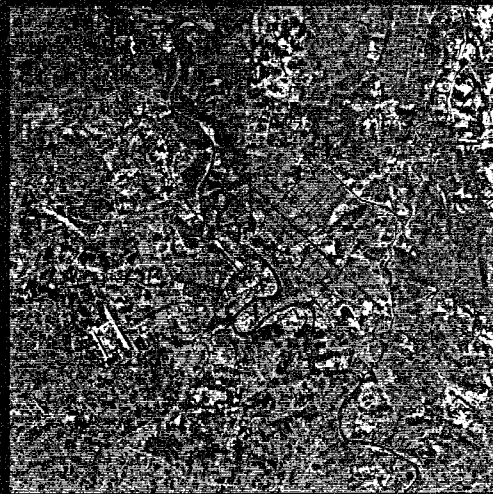
Raw Data TM 742/RGB



Laplacian



11 x 11 Boxcar



51 x 51 Boxcar

Landsat TM Data
Scene Date: 8 Jan 1990
Path 168 Row 37

