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Remote Sensing and Geospatial Technologies in Transportation: Examples from the Infrastructure Lifecycle

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University of California, Santa Barbara
standing in for K Thirumalai, RSPA, USDOT

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NCRST Background

- 1998: Transportation Equity Act for the 21st Century
  - remote sensing and spatial information technologies
  - university research
  - private sector commercialization

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NCRST Structure

U.S. DOT (RSPA) — NASA
Partnership
Transportation Legislation "TEA-21"

Environment | Infrastructure | Flows | Hazards

4 universities
4 TAPs

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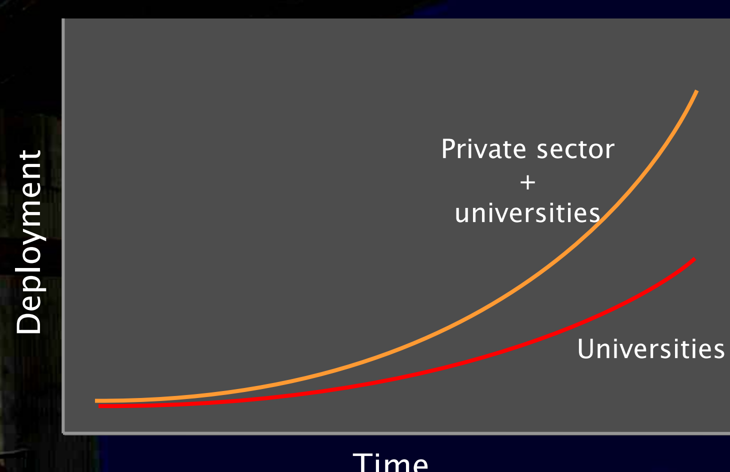
The Goal is Deployment



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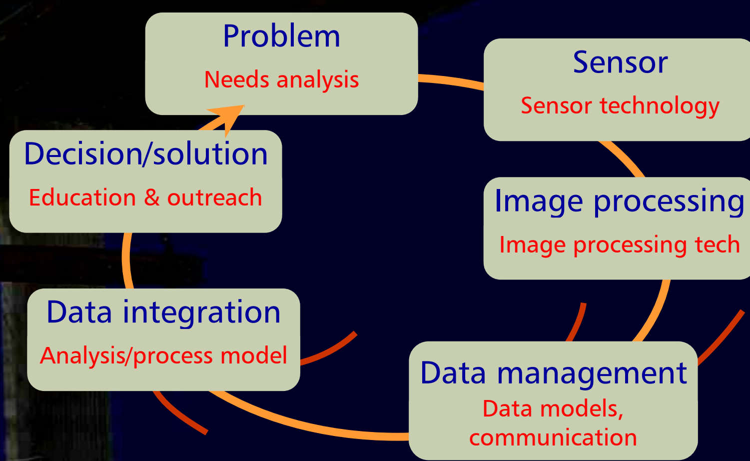
Research Production Line



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Infrastructure Management

Management of infrastructure involves systematic
planning, design, construction, maintenance, operation, and renewal
of assets such as
pavement, bridges, pipelines, rail lines, harbors and airports.
Information on the
location and condition
of these is critical to effective decision making.

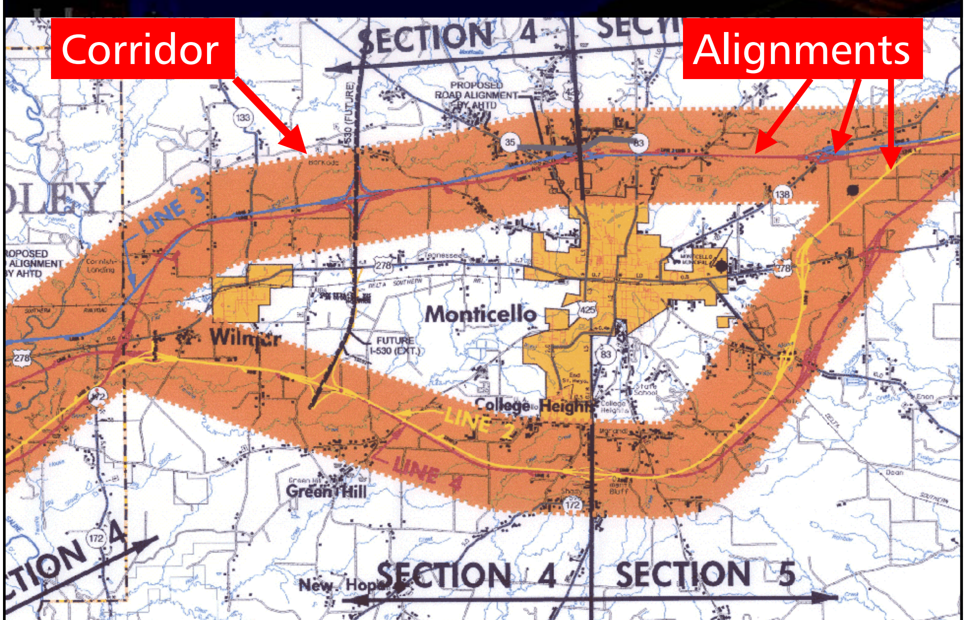
GeoSpatial Technologies

- Remote Sensing
  - high resolution photo/video
  - multi-spectral, hyper-spectral
  - RADAR, LIDAR
  - ground sensors
- GIS, incl spatial modeling
- GPS

Some Infrastructure Projects

- Corridor development
  - alignment
  - redevelopment
- Inventory and condition assessment
- Network rationalization
  - developing/decommissioning
  - resilience and fortification

CORRIDOR DEVELOPMENT



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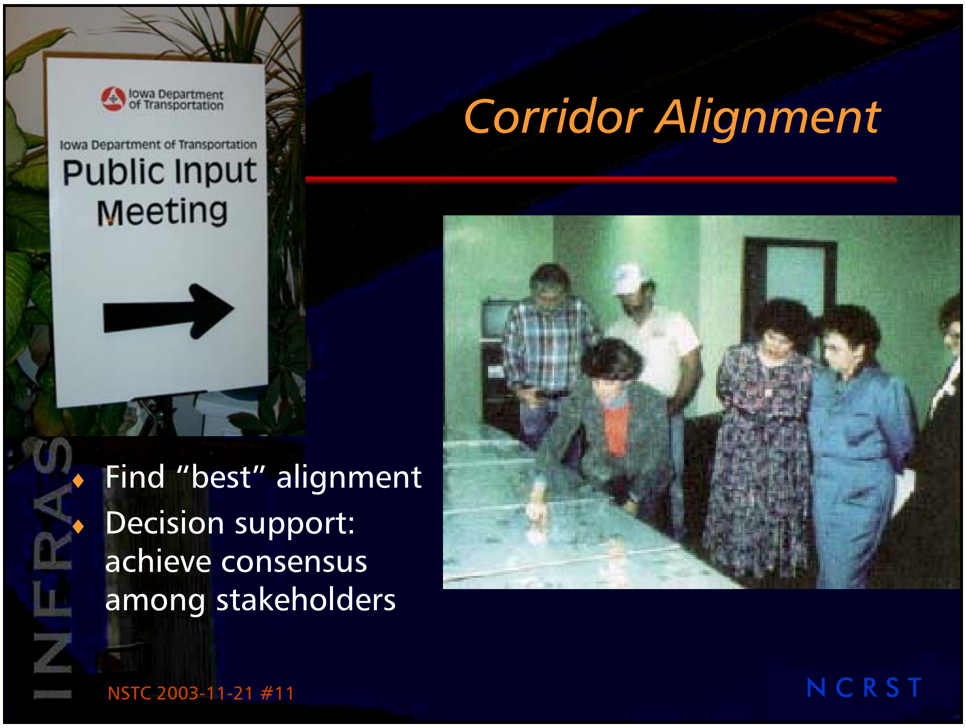
Iowa Department of Transportation
Iowa Department of Transportation
Public Input Meeting
Corridor Alignment
INFRAS
Find "best" alignment
Decision support: achieve consensus among stakeholders
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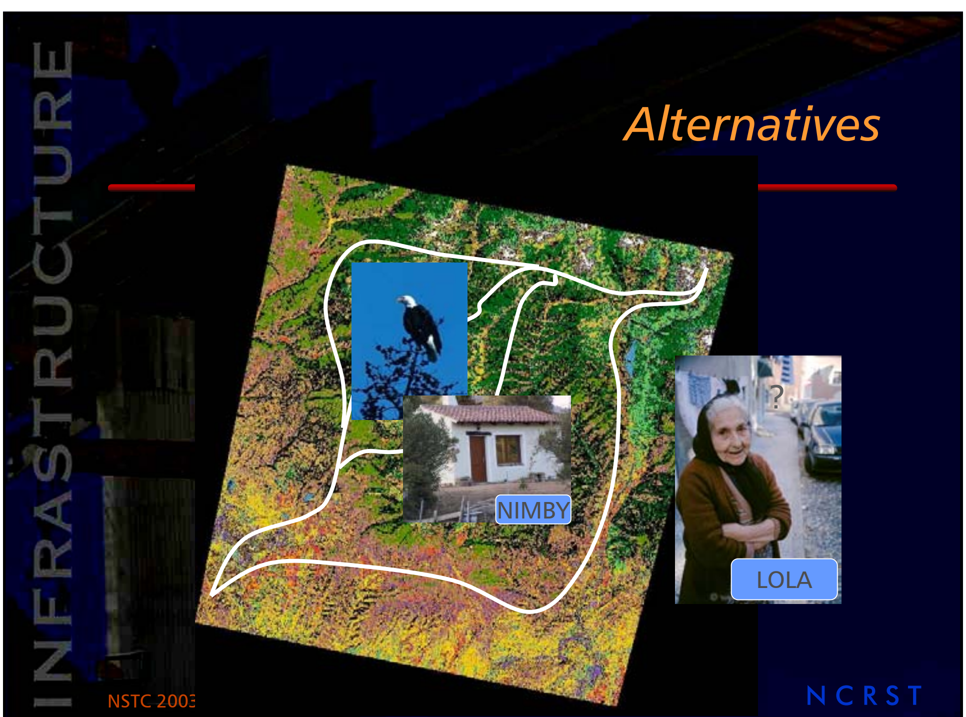
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Alternatives
NIMBY
LOLA
NSTC 2003
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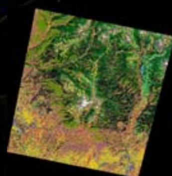
Scope of this Solution



Data gathering (1:5,000) → Data scoring

↓

Consultation
Consensus

Detailed data (1:500) → Final design

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Cell Suitability (much idealized)

2	3	4			
1	2	3			
3	3	3	4		
	3	2	3	4	
		1	2	3	1
			3	2	1

Environment (wetlands, etc)

x 0.6

+

8	5				
4	3	4			
6	4	6	2		
	8	3	9	10	
		2	8	10	5
			8	4	1

Culture (burial grounds, etc)

x 0.4

+

4	5	4			
3	3	3			
4	4	3	3		
	4	2	1	1	
		3	2	1	1
			2	2	1

Terrain

x 0.8

=

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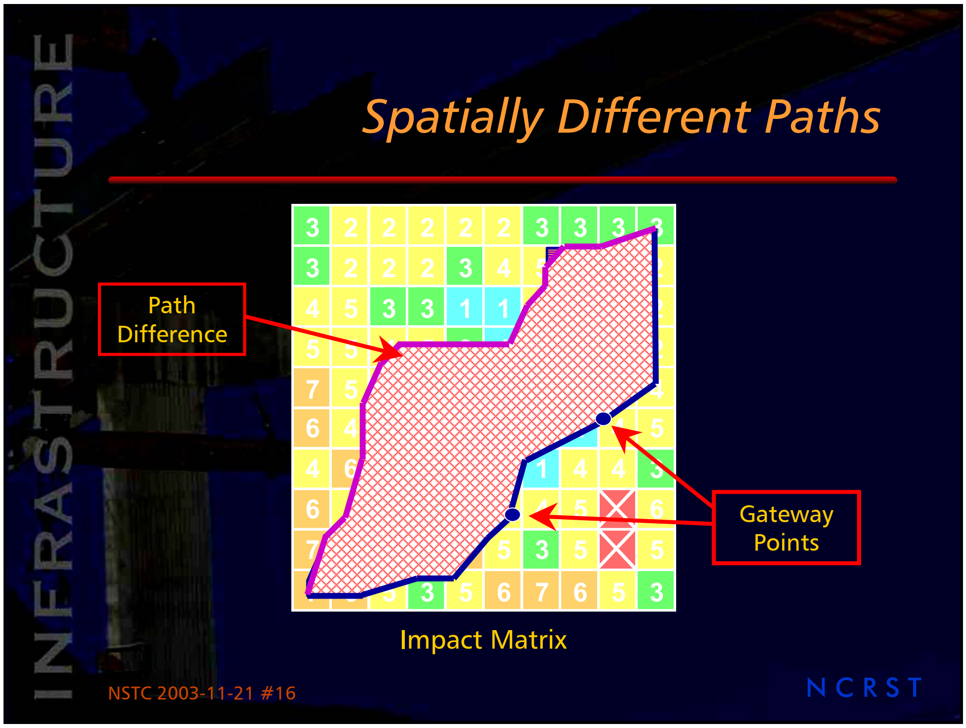
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Spatially Different Paths
Path Difference
Gateway Points
Impact Matrix
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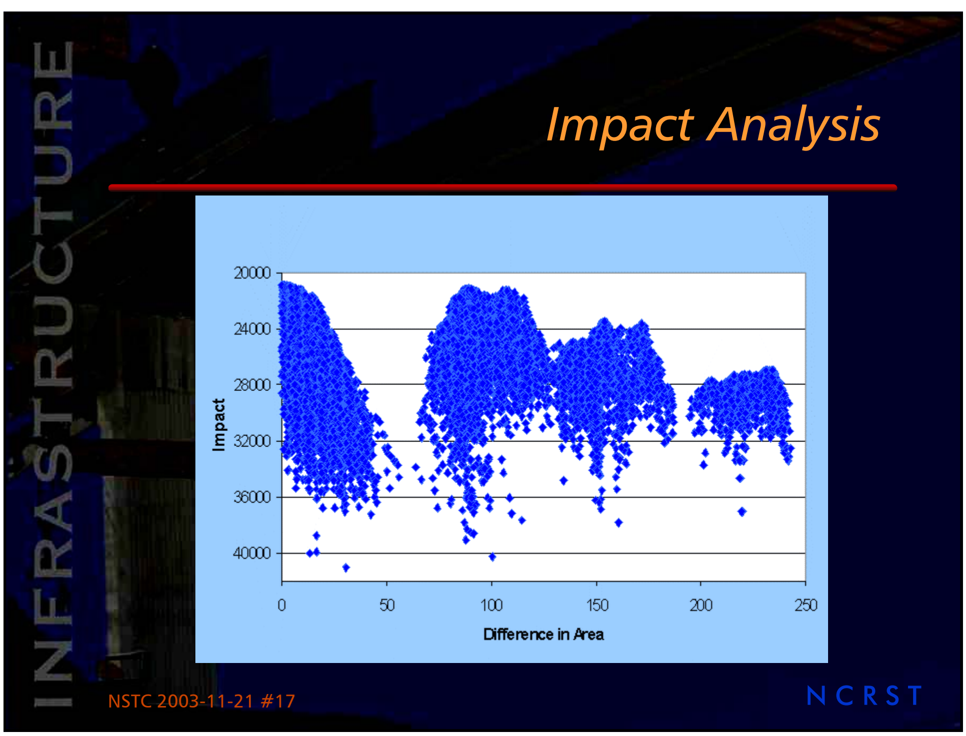
INFRASTRUCTURE
Impact Analysis
Impact
20000
24000
28000
32000
36000
40000
0
50
100
150
200
250
Difference in Area
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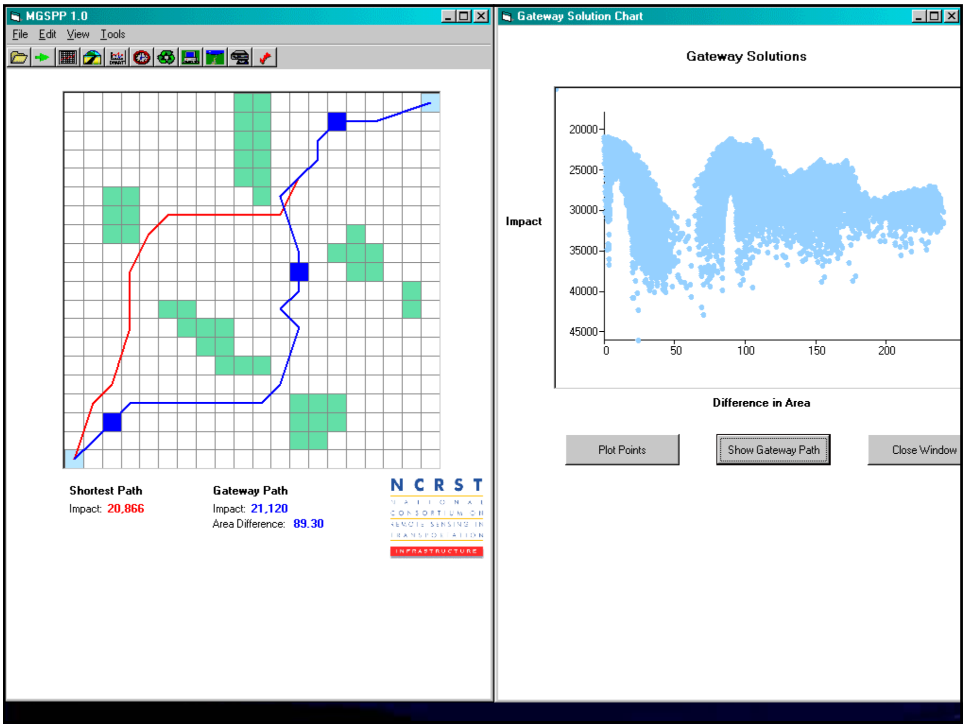

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Redevelopment: the case of I-710

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T

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5 accidents/day

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INTERFLOW
RAILROAD CROSSING
NRS

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FHWA Intermodal Connector Program

- Evaluate the condition of National Highway System connector highway infrastructure to major intermodal freight terminals
- Review improvements and investments made or programmed for these connectors
- Identify impediments and options to making improvements to the intermodal freight connectors.

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Washington Blvd Terminal

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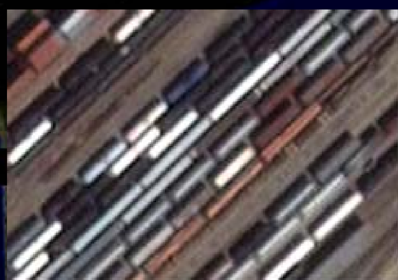
Container Counts



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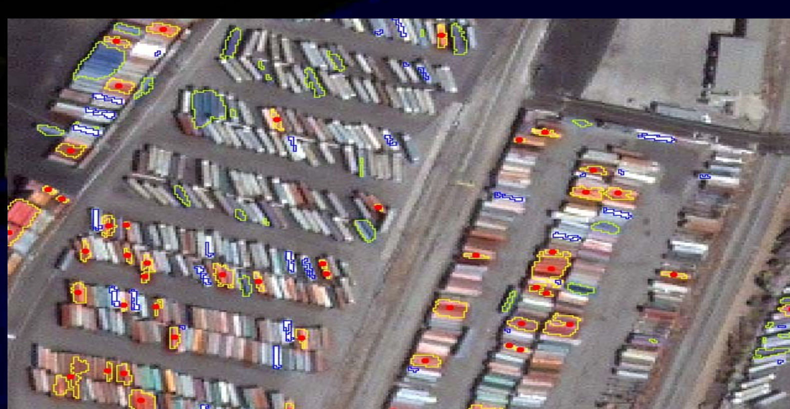
Container Classification



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RS/GIS: Comprehensive Solution

- Integrated
  - from data acquisition to inventory and decision support
- Multiple cutting-edge technologies for
  - data acquisition
  - data handling, storage, dissemination
  - decision support
- Integrating GIS, remote sensing
  - satellite, airborne, ground-based

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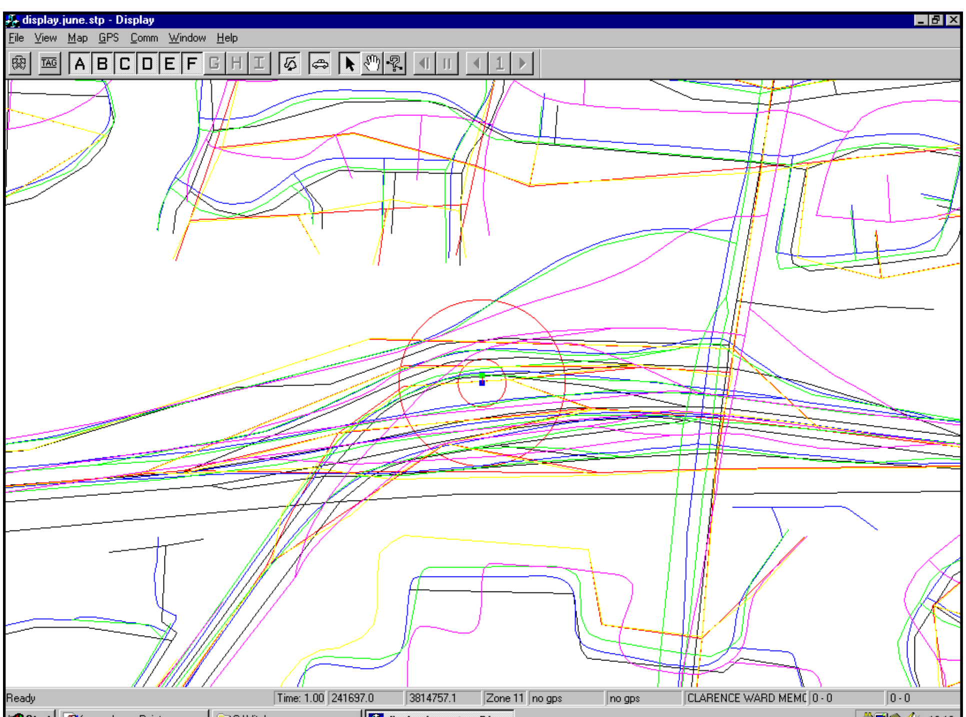
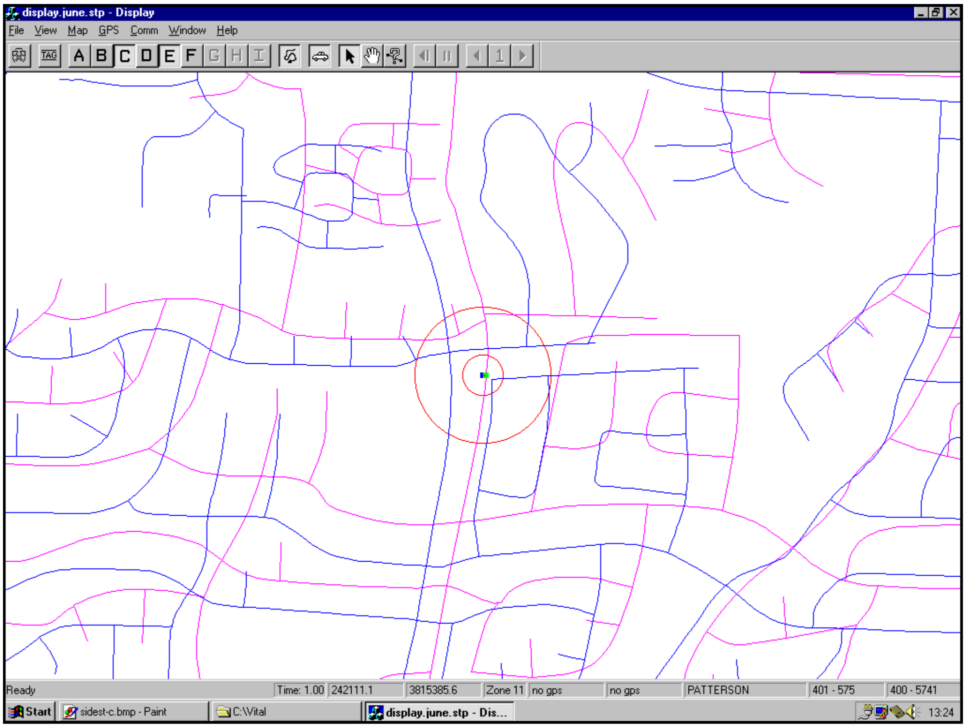
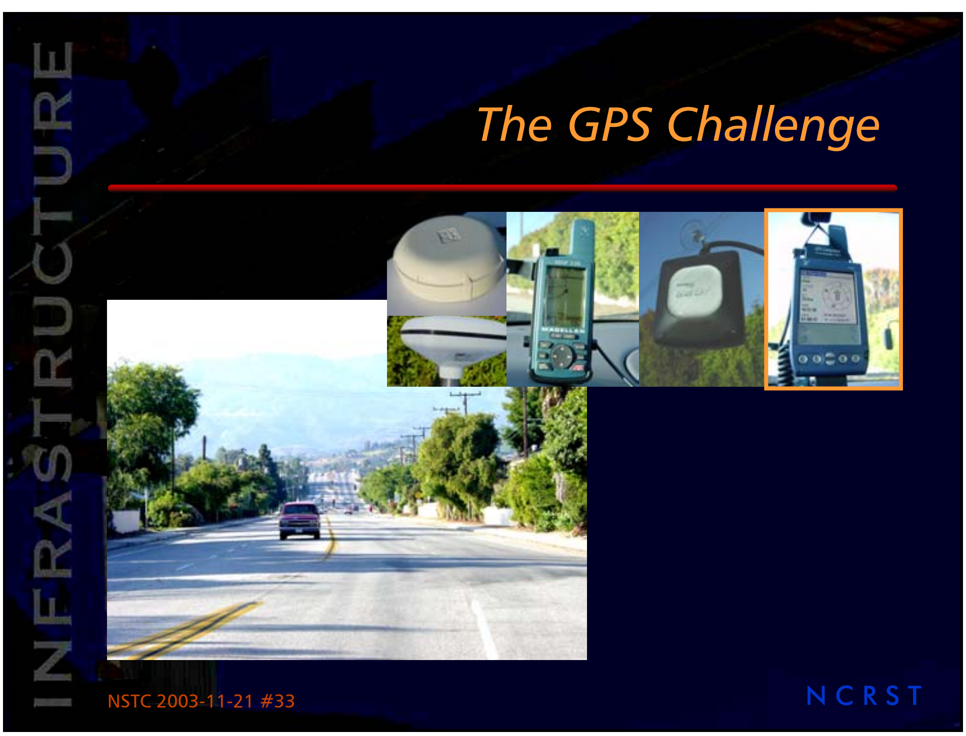
RS/GIS Specifics

- I-710 asset inventory: geometry, lanes
- Wide area traffic microsimulation
  - handling construction closures
  - diversion: upgrade of alternate routes
  - reduced accessibility, social issues
  - port incident/evacuation management

INVENTORY AND CONDITION ASSESSMENT




display.june.stp - Display
File View Map GPS Comm Window Help
Ready
Time: 1.00
242111.1
3815385.6
Zone 11
no gps
no gps
PATTERSON
401 - 575
400 - 5741
Start
sidest-c.bmp - Paint
C:\Vital
display.june.stp - Dis...
13:24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The GPS Challenge
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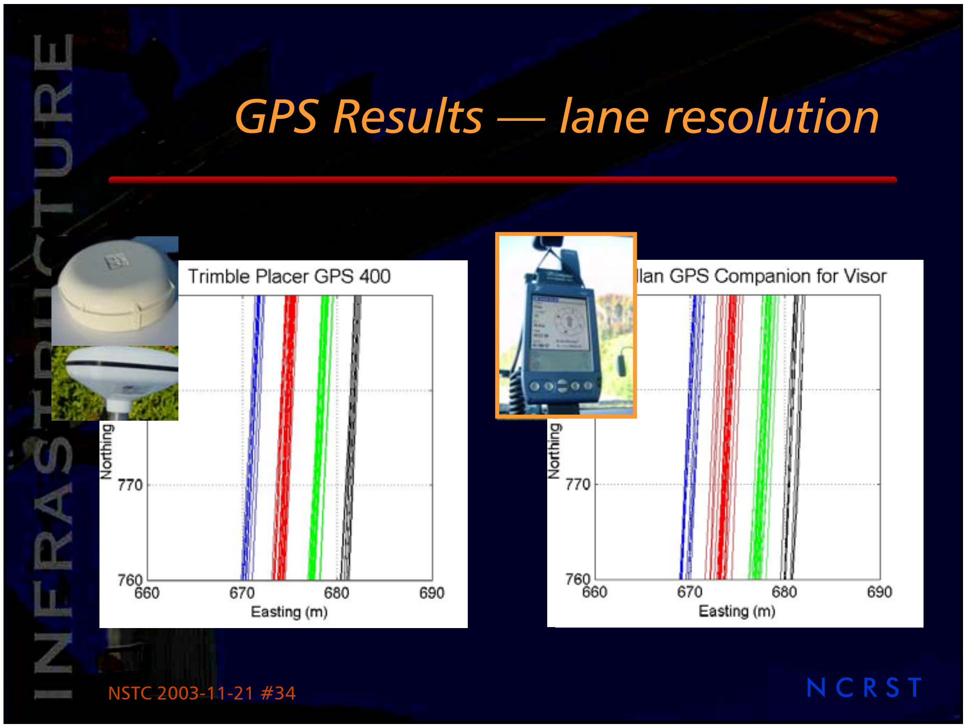
INFRASTRUCTURE
GPS Results — lane resolution
Trimble Placer GPS 400
llan GPS Companion for Visor
Northing
770
760
660
670
680
690
Easting (m)
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BridgeView
BridgeView
Version 1.0
Requires ArcView 3.2 by ESRI®
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WISCONSIN
Copy BridgeView.zip to hard drive. Unzip and read BridgeView_Manual.doc for installation instructions
BridgeView
Updating Bridge Location for NBI Compliance
U.S. DEPARTMENT OF TRANSPORTATION
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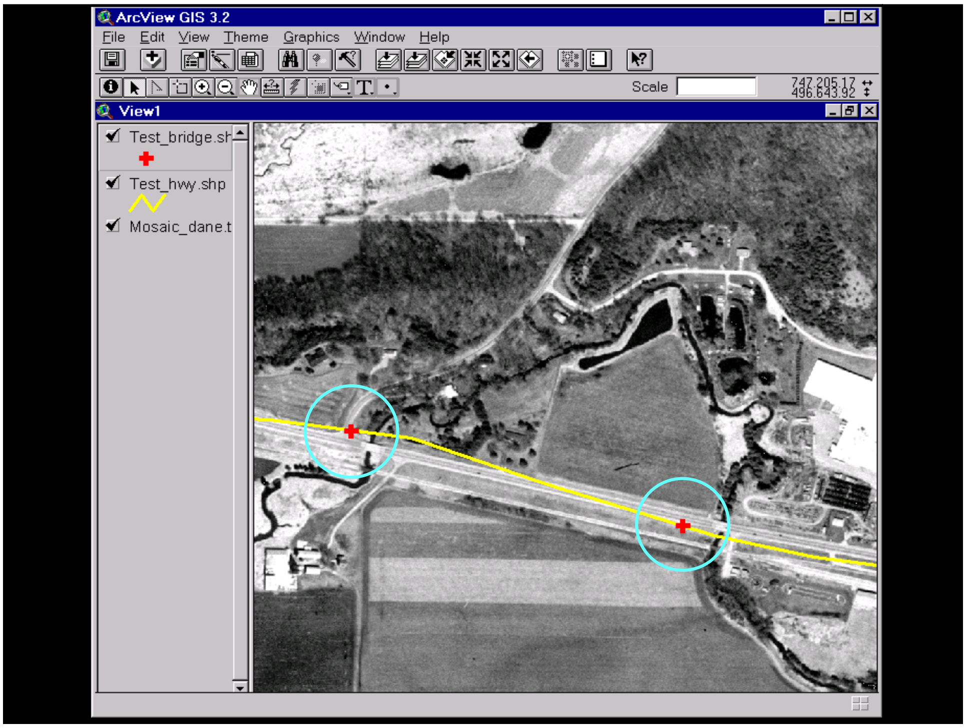
ArcView GIS 3.2
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Scale
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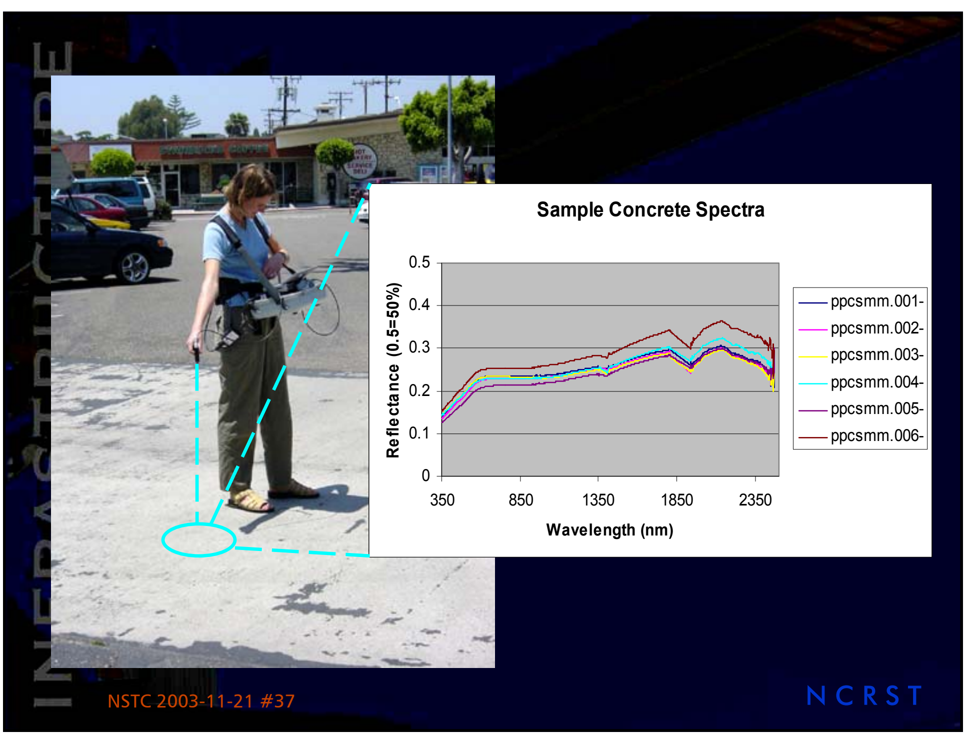
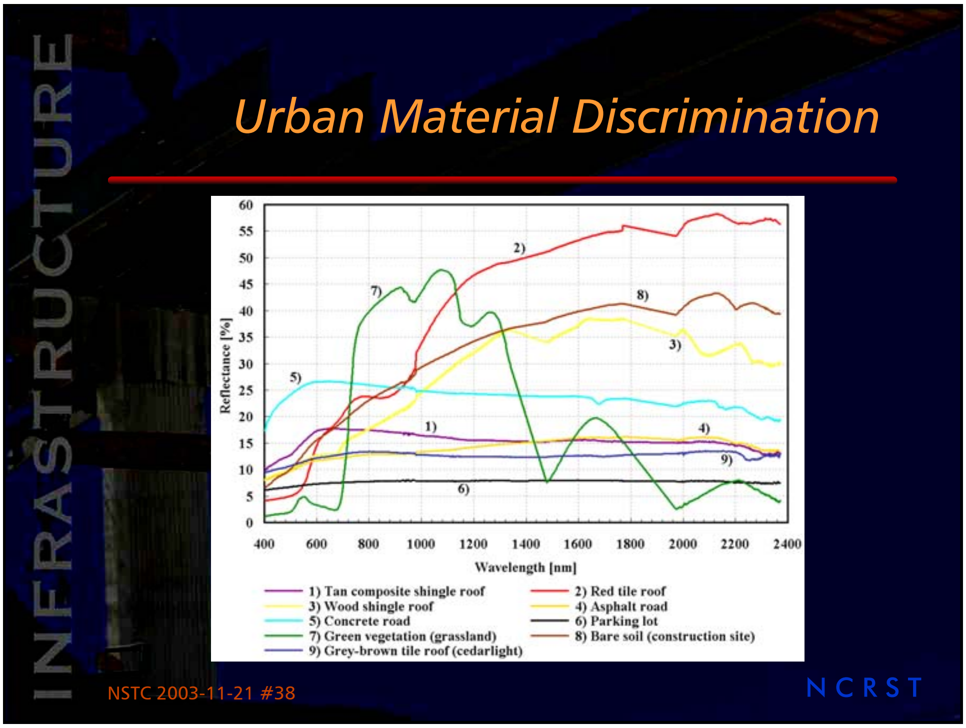
496,643.92
View1
Test_bridge.sh
Test_hwy.shp
Mosaic_dane.t


Sample Concrete Spectra
Reflectance (0.5=50%)
0.5
0.4
0.3
0.2
0.1
0
350
850
1350
1850
2350
Wavelength (nm)
ppcsmm.001-
ppcsmm.002-
ppcsmm.003-
ppcsmm.004-
ppcsmm.005-
ppcsmm.006-
NSTC 2003-11-21 #37
NCRST


INFRASTRUCTURE
Urban Material Discrimination
Reflectance [%]
Wavelength [nm]
1) Tan composite shingle roof
2) Red tile roof
3) Wood shingle roof
4) Asphalt road
5) Concrete road
6) Parking lot
7) Green vegetation (grassland)
8) Bare soil (construction site)
9) Grey-brown tile roof (cedarlight)
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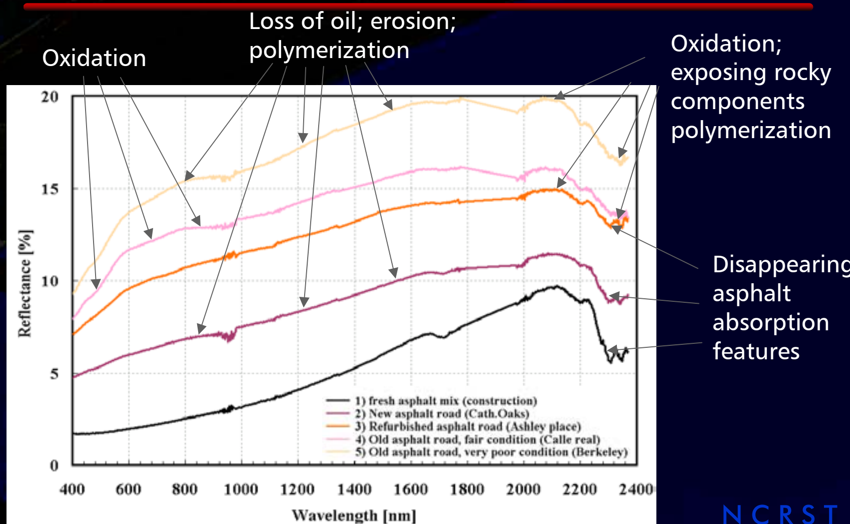
Pavement Surface Evolution



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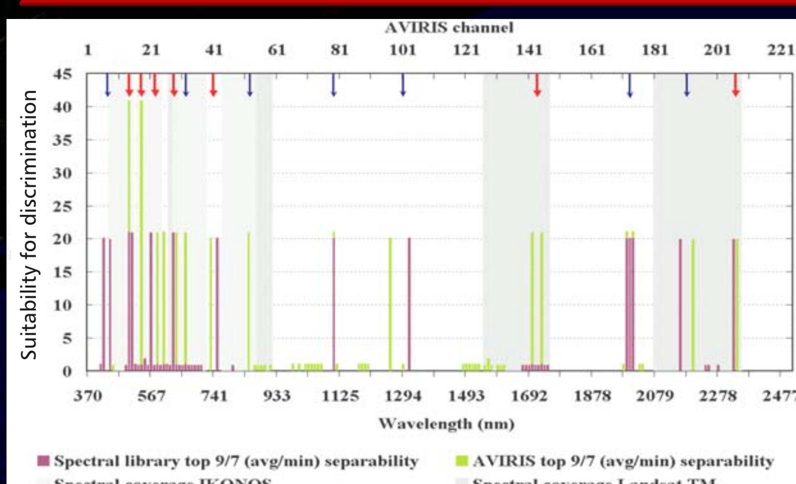
Optimized Urban Sensor: 224→14



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Can RS see Pavement Condition?

- Working on it
  - Pavement experts
  - Roadware survey
  - <1m hyperspectral flight
- So far, aging chemistry, not physical condition

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LIDAR

- Laser scanning
  - X-Y: 1 m
  - Z: ± 30 cm

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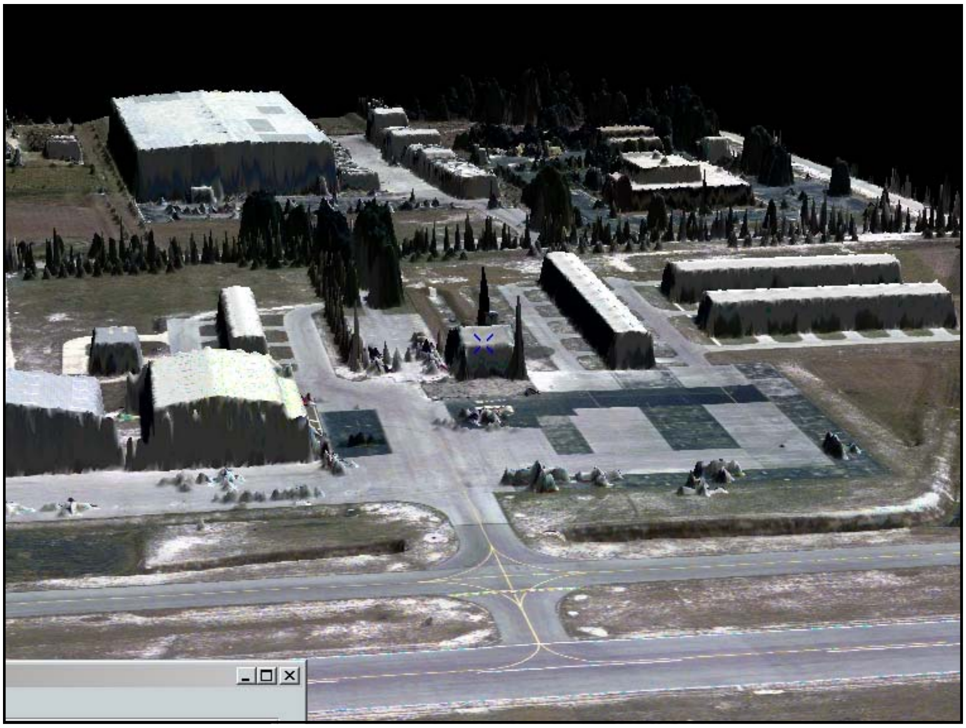
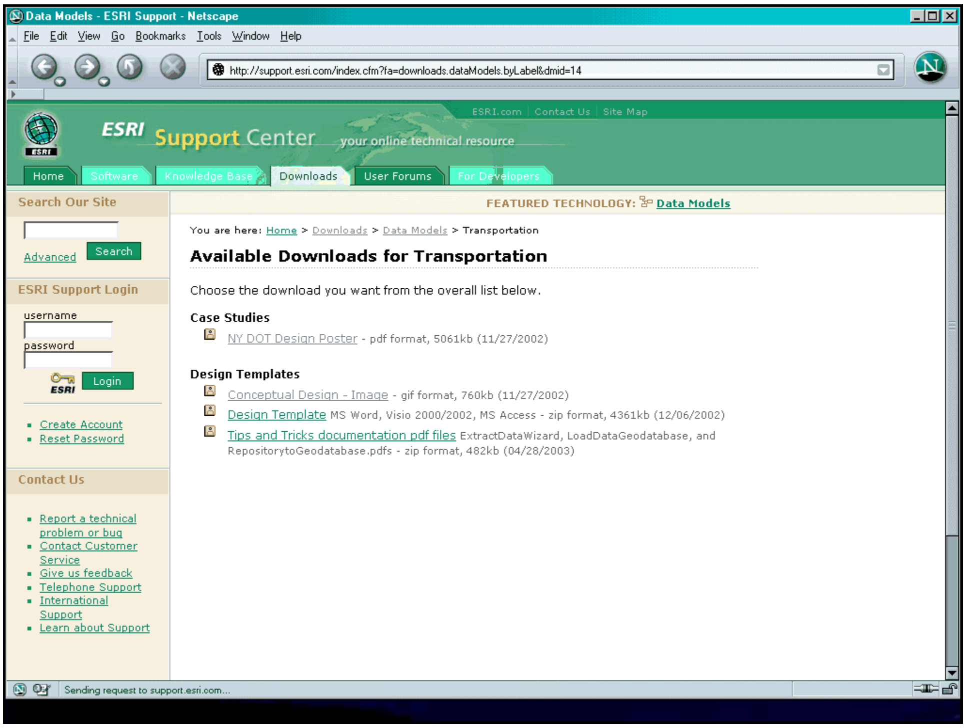


INFRASTRUCTURE


Data Models - ESRI Support - Netscape
File Edit View Go Bookmarks Tools Window Help
http://support.esri.com/index.cfm?fa=downloads.dataModels.byLabel&dmid=14
ESRI.com | Contact Us | Site Map
ESRI Support Center
your online technical resource
Home
Software
Knowledge Base
Downloads
User Forums
For Developers
Search Our Site
Advanced
Search
ESRI Support Login
username
password
Login
Create Account
Reset Password
Contact Us
Report a technical problem or bug
Contact Customer Service
Give us feedback
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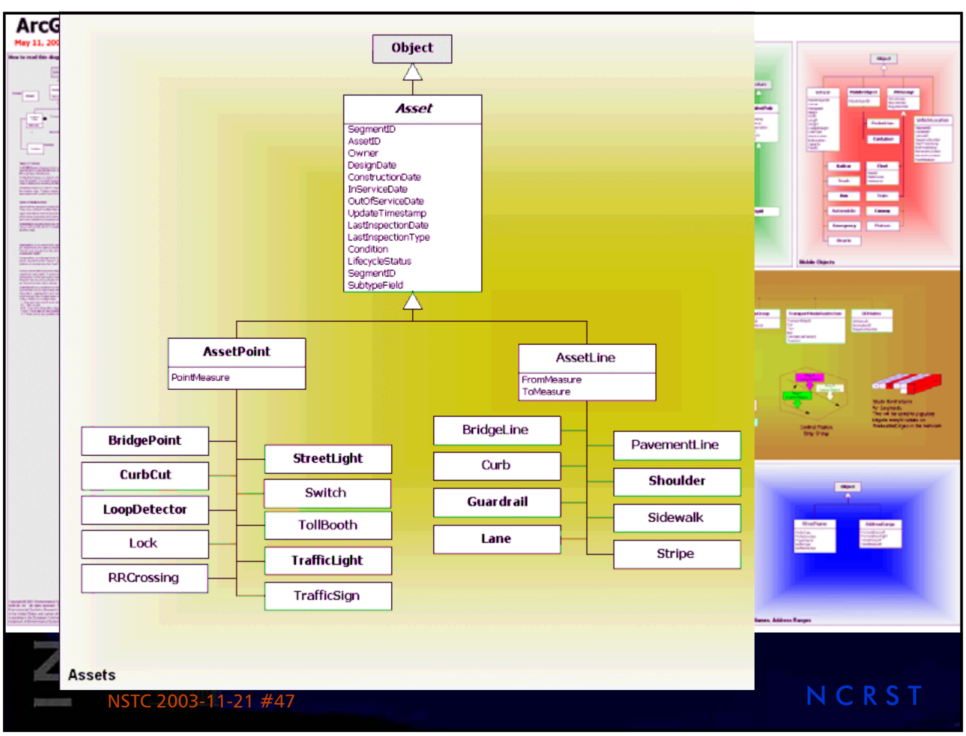
Design Templates
Conceptual Design - Image - gif format, 760kb (11/27/2002)
Design Template MS Word, Visio 2000/2002, MS Access - zip format, 4361kb (12/06/2002)
Tips and Tricks documentation pdf files ExtractDataWizard, LoadDataGeodatabase, and RepositorytoGeodatabase.pdfs - zip format, 482kb (04/28/2003)
Sending request to support.esri.com...


Object
Asset
SegmentID
AssetID
Owner
DesignDate
ConstructionDate
InServiceDate
OutOfServiceDate
UpdateTimestamp
LastInspectionDate
LastInspectionType
Condition
LifecycleStatus
SegmentID
SubtypeField
AssetPoint
PointMeasure
AssetLine
FromMeasure
ToMeasure
BridgePoint
CurbCut
LoopDetector
Lock
RRCrossing
StreetLight
Switch
TollBooth
TrafficLight
TrafficSign
BridgeLine
Curb
Guardrail
Lane
PavementLine
Shoulder
Sidewalk
Stripe
Assets
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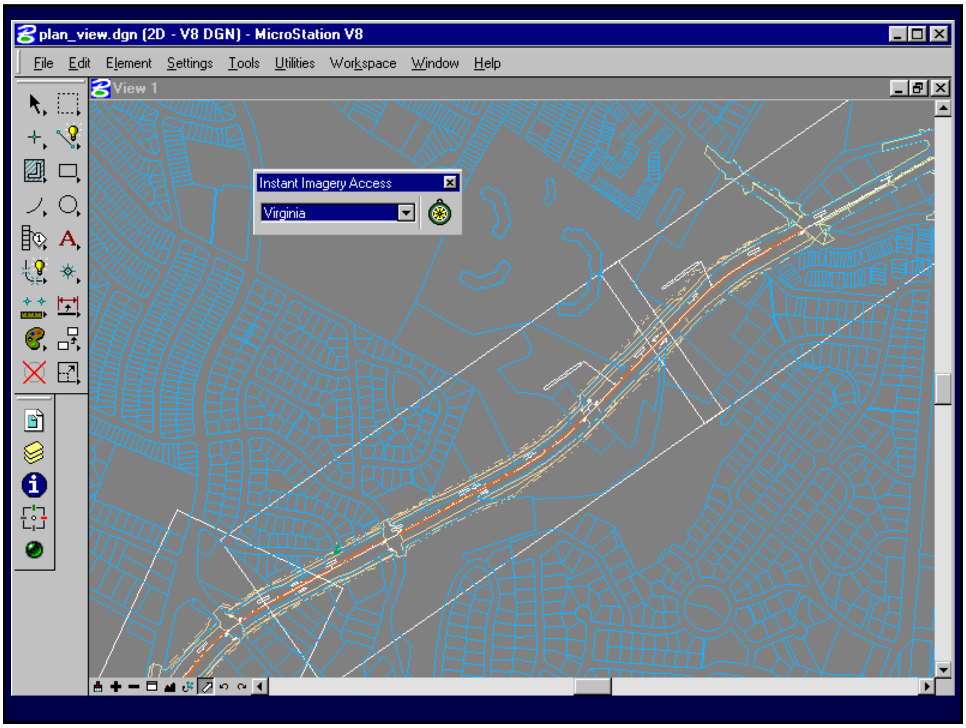
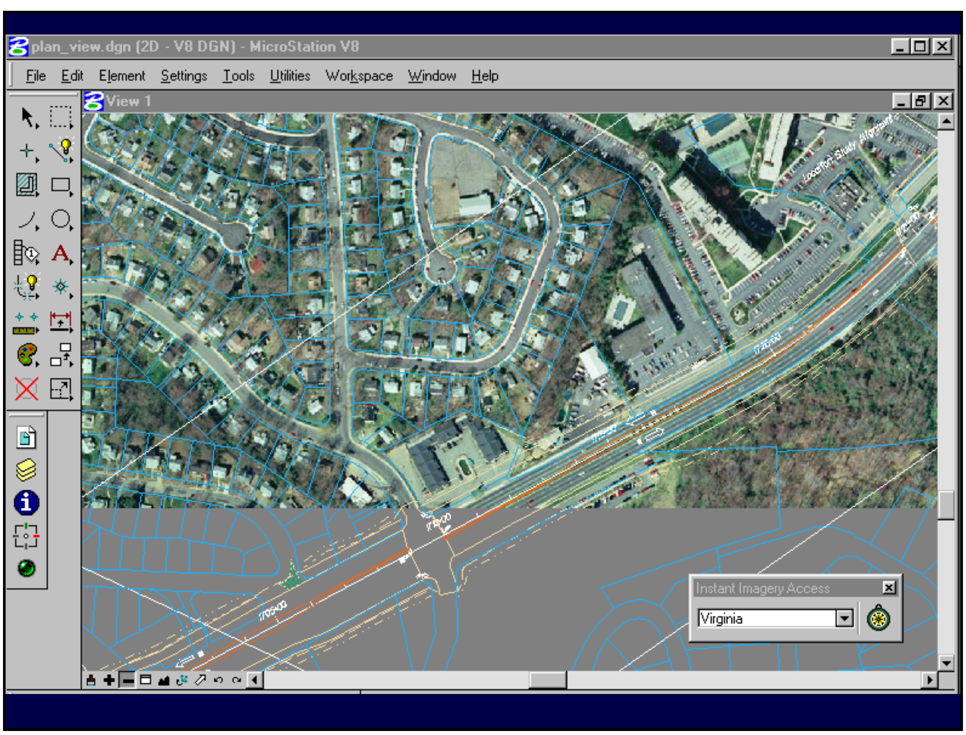
NCRST


plan_view.dgn (2D - V8 DGN) - MicroStation V8
File Edit Element Settings Tools Utilities Workspace Window Help
View 1
Instant Imagery Access
Virginia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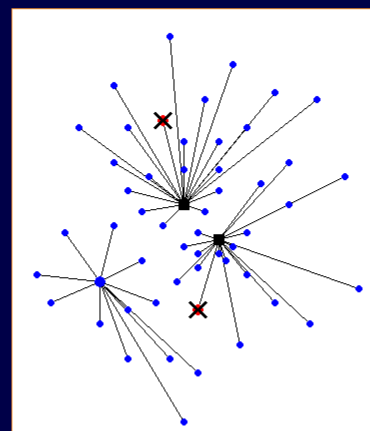
File Edit Element Settings Tools Utilities Workspace Window Help
View 1
Instant Imagery Access
Virginia

NETWORK RATIONALIZATION



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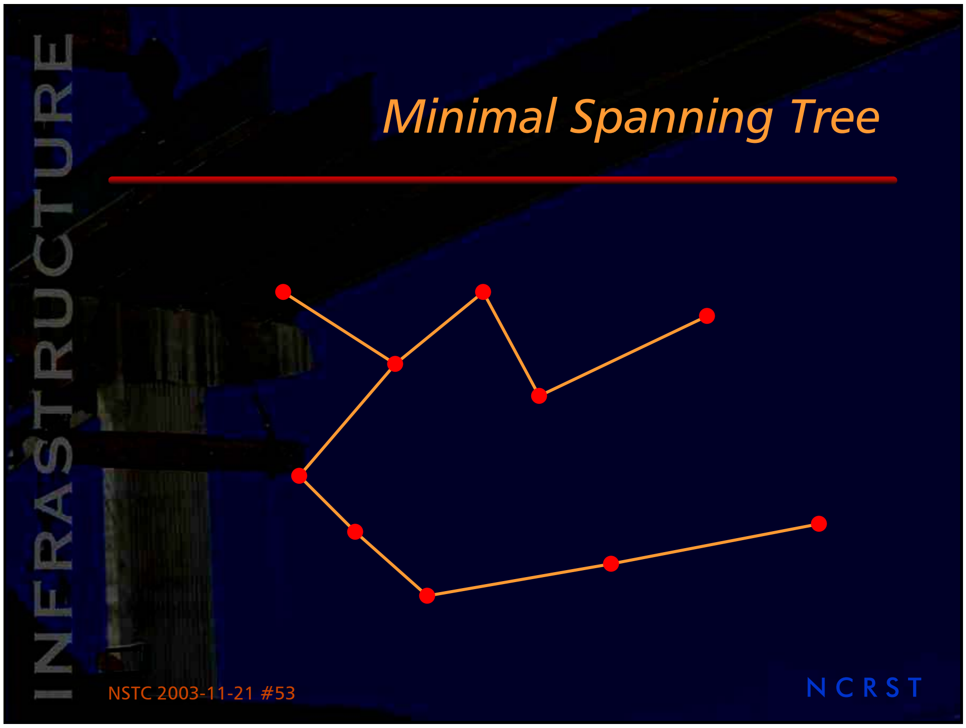
Developing a Network

- Villages isolated
- Poor/seasonal roads
- Development inhibited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Minimal Spanning Tree
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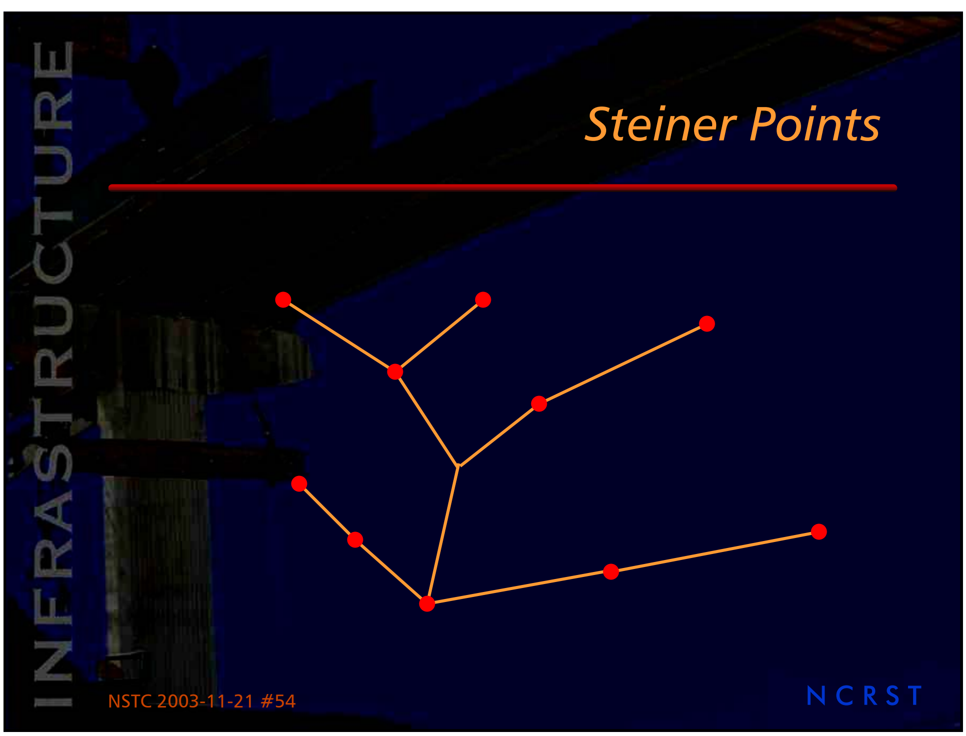
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Steiner Points
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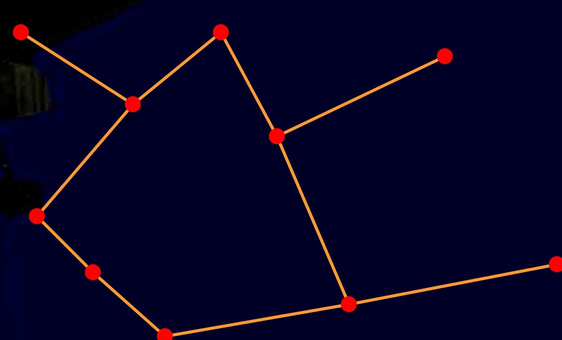
Our Challenge

- To meet incremental development targets, e.g.
  - 50% within 4 years
  - 75% within 6 years
  - 90% within 8 years

Our (Incremental) Approach



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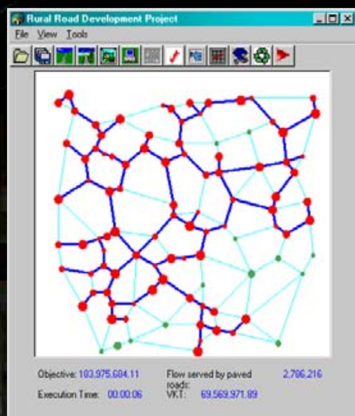
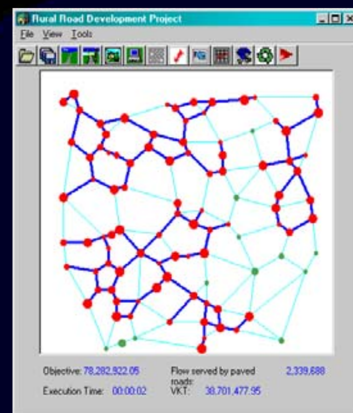
Connectivity vs Distance Traveled



(a)
96% of total traffic flow



(b)
80% of total traffic flow
improves VKT by almost 50%

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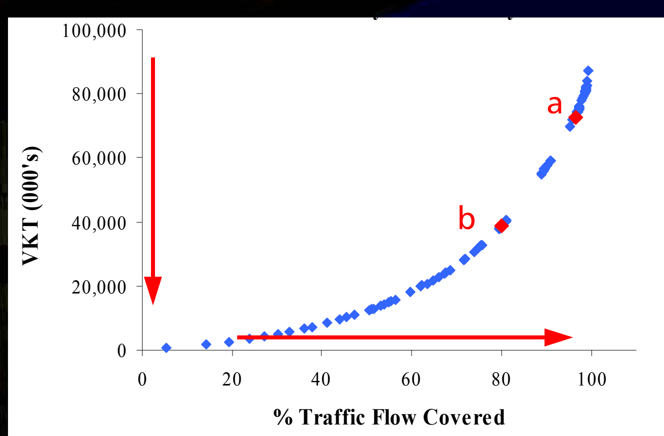
Trade-off curve



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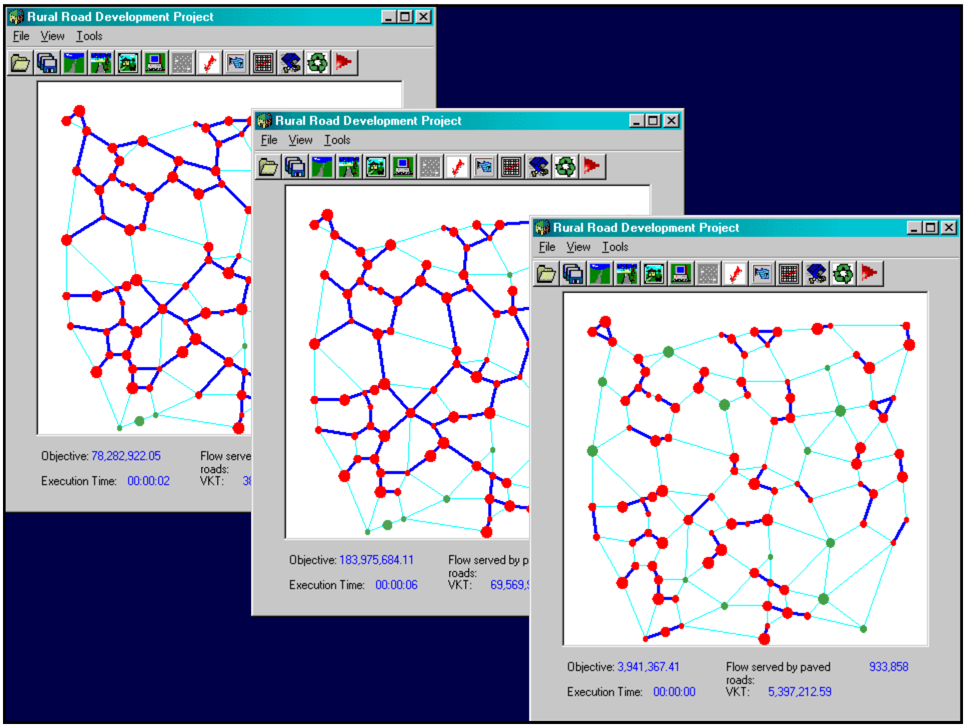

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Challenges

- Multiple criteria
  - Local: accessibility
  - Regional: connectivity
  - National: mobility
- Dual applications
  - India: network growth
  - USA: decommissioning

Degrading a Network

Defining "Critical" Infrastructure: Resilience & Fortification

Is the Golden Gate Bridge a "critical" facility?

Interdiction/Fortification

- Which facilities are critical?
  - Those which, if lost, have the greatest impact on the system
- Which should be fortified?
  - Not necessarily all the critical ones

Assumptions

- Underlying model: p-median
- Interdiction: seeks to maximize the weighted distance impact by interdicting *r* facilities
- Fortification: seeks to minimize the effects of the best interdiction by protecting *q* facilities
- Fortification of a facility completely prevents its interdiction
- The interdictor is smart ;) and always uses his resources to attack in the best possible way

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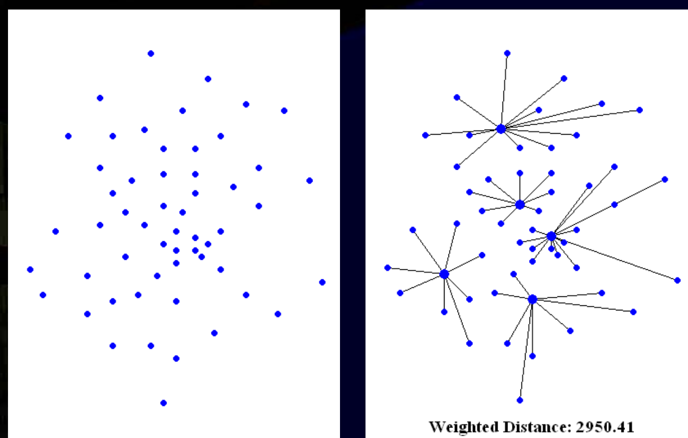
Initial system configuration



(a) (b)

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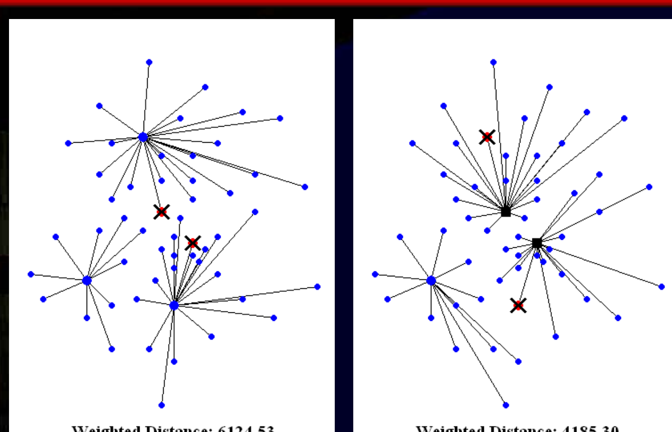
Fortification/Interdiction …



(a) (b)

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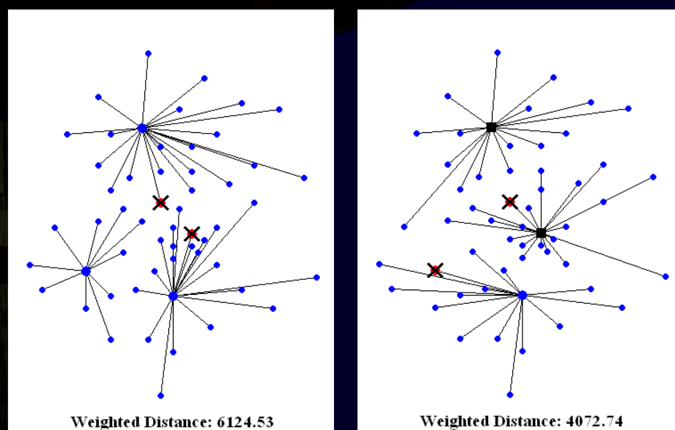
… Fortification/Interdiction



(a) (b)

Conclusions

- Protecting facilities in the optimal interdiction pattern is not necessarily the best fortification strategy
- At least one (but not all) of the facilities in the best interdiction pattern must be included in the fortification plan

Future research

- Consider fortification strategies against random interdiction patterns (average instead of worst case scenarios)
- Consider different fortification degrees
- Include probabilistic elements
- Study different service/supply systems

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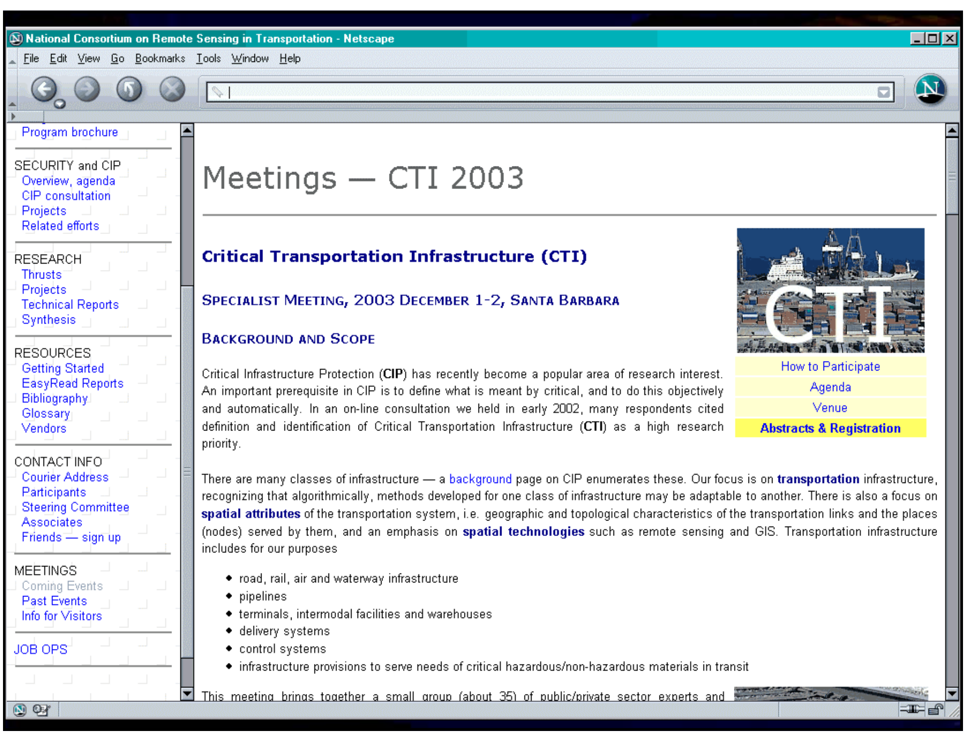


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CTI Research Agenda
N C R S T
Critical Infrastructure Protection
www.ncgia.ucsb.edu/ncrst/cip
NSTC 2003-11-21 #71
N C R S T


National Consortium on Remote Sensing in Transportation - Netscape
File Edit View Go Bookmarks Tools Window Help
N C R S T
INFRASTRUCTURE
Friends of NCRST: be on the front line of our events
HOME
BACKGROUND
Program origins
Program overview
Program brochure
SECURITY and CIP
Overview, agenda
CIP consultation
Projects
Related efforts
RESEARCH
Thrusts
Projects
Technical Reports
Synthesis
RESOURCES
Getting Started
EasyRead Reports
Bibliography
Glossary
Vendors
CONTACT INFO
Courier Address
Participants
Steering Committee
Associates
Meetings — UAV 2003
Roadmap for Deploying UAVs in Transportation
DEADLINES
Hotel: Nov 14
Register: Nov 25
BACKGROUND
AGENDA
VENUE
REGISTER
FOCUS MEETING, 2003 DECEMBER 2, SANTA BARBARA
BACKGROUND AND SCOPE
Unmanned Aerial Vehicles (UAVs) have aroused much interest recently, particularly following their highly publicized military deployments. This meeting focuses on their civilian uses in transportation, including emergency and incident management, traffic flow monitoring and congestion management, and infrastructure integrity assessment. The emphasis is on low cost, low weight, low altitude micro UAVs (MAVs).
UAV 2003 brings together a small group of federal and state professionals, academics, UAV manufacturers and service providers, (a) to summarize the present state of accomplishment, (b) to develop a vision for the future, (c) to identify research, technological, economic and institutional barriers, (d) to develop a consensus on steps to overcome these barriers. The motivation is eventually to develop simple guidelines or standard operations practices (SOP) for UAV deployment by states and local agencies.
Issues to be addressed
1. UAVs' unique technical capabilities and advantages (e.g. vantage point, deployment speed, cost, ease of use, number of operators and ground control, data links), and the spectrum of applications (object/incident monitoring; traffic counting, surveillance for anomaly identification or on-demand damage assessment)
2. Future technical developments needed for priority applications
3. Civilian applications other than transportation: synergistic capabilities and players

N C R S T

NATIONAL CONSORTIUM ON REMOTE SENSING IN TRANSPORTATION

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University of California, Santa Barbara
University of Wisconsin-Madison
Iowa State University
University of Florida

Credits, clockwise from top left: NASA, Terraserver, Phil Dennison, Space Imaging

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Keep in touch!

Infrastructure:
www.ncgia.ucsb.edu/ncrst

All NCRST (Environment, Infrastructure, Flow, Hazards): *www.ncrst.org*