Space and Air-based Remote Sensing of Transportation Flows: Promising Applications

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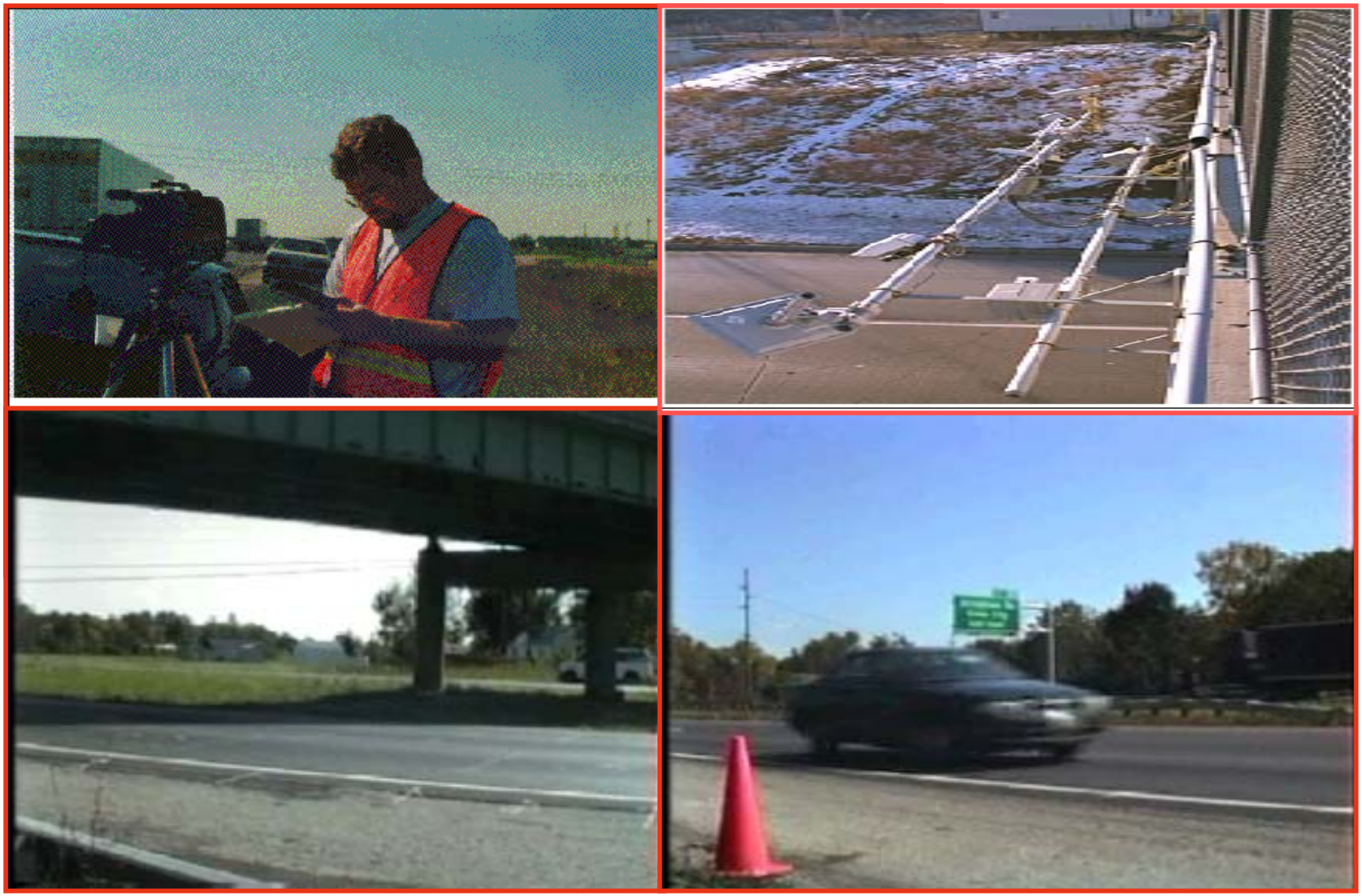
The National Consortium on Remote Sensing of Transportation – Flows

NATMEC 2002 - Orlando, FL

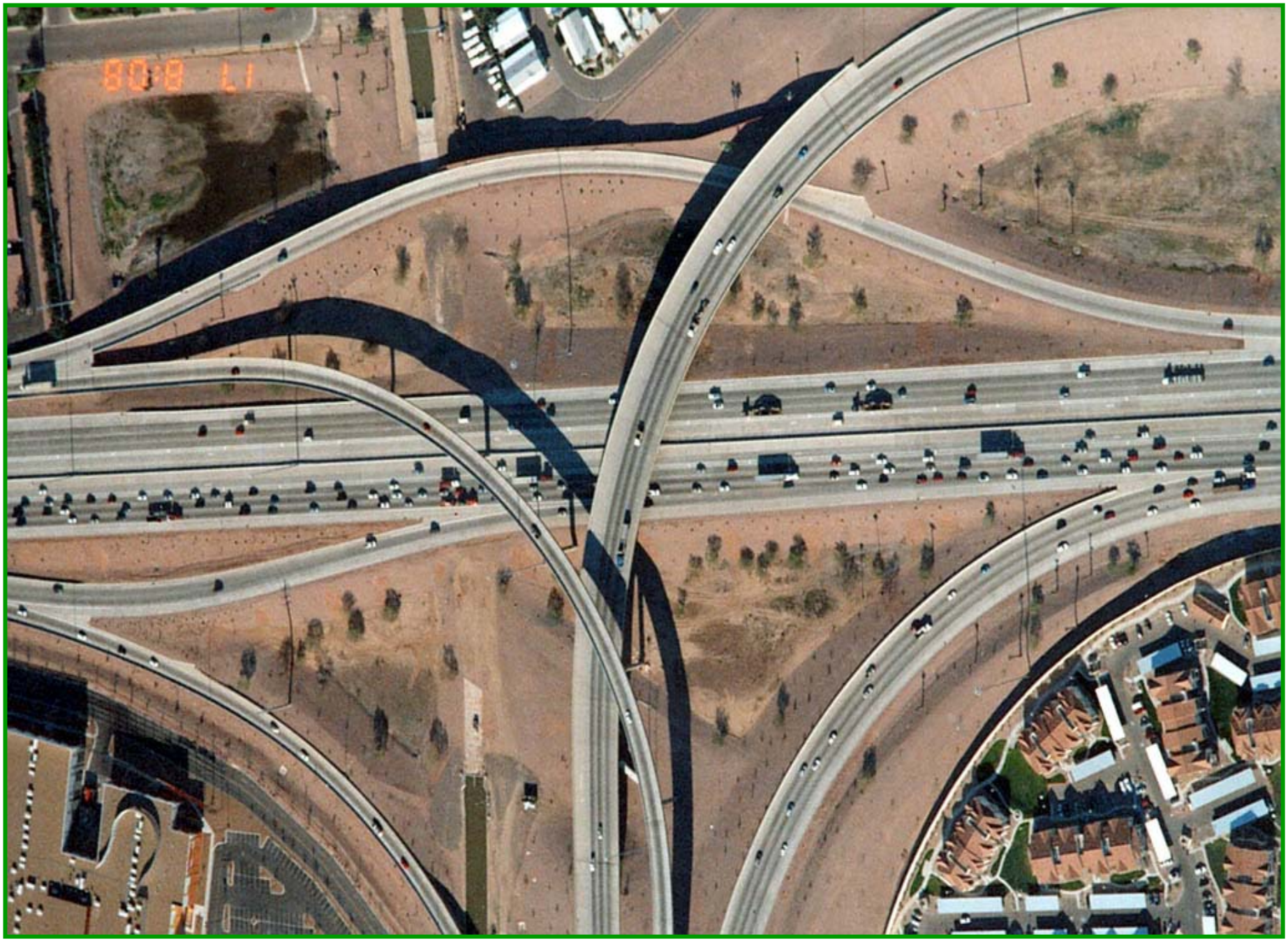
14 May 2002

Ground-Based Traffic Observations



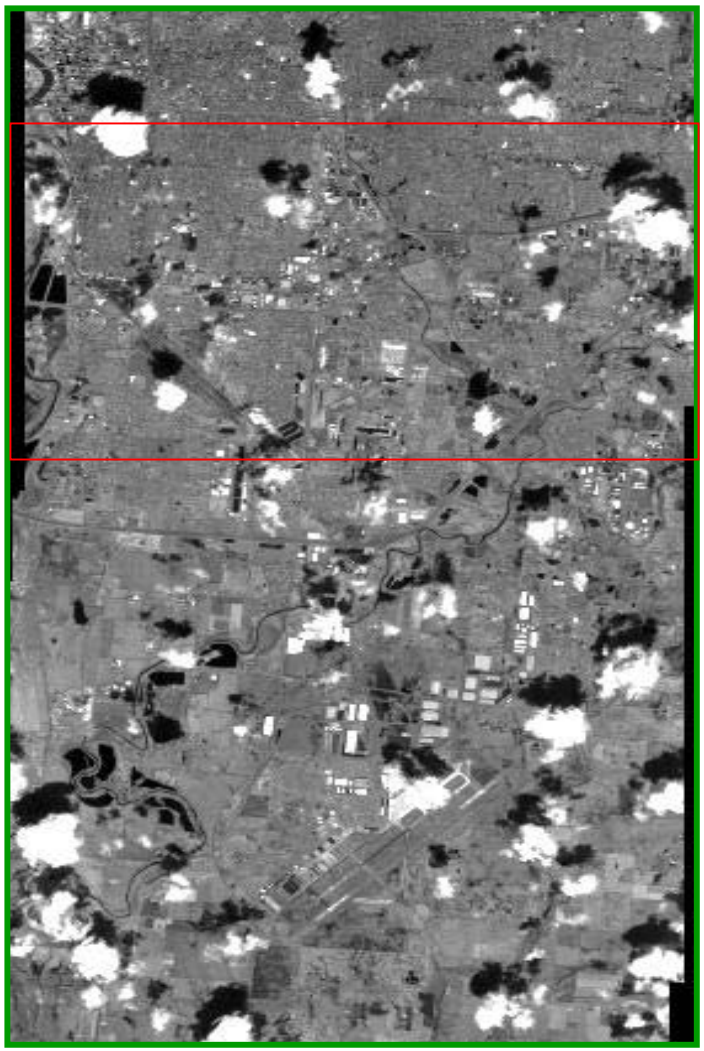
Aerial Views

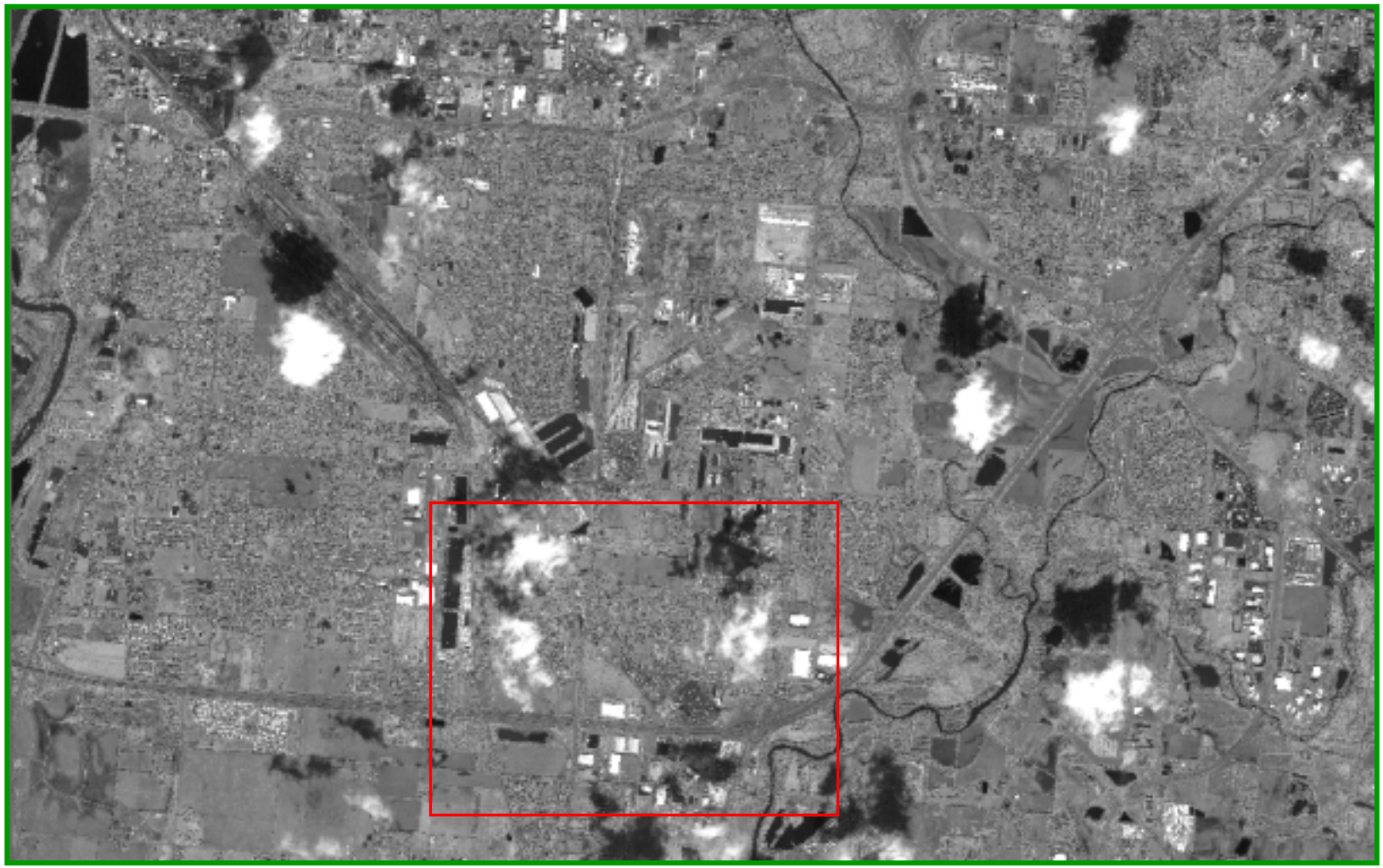
Skycomp, Inc.



Space-based Views

IKONOS 20 km x 11 km Image
Southeast Franklin County, Ohio





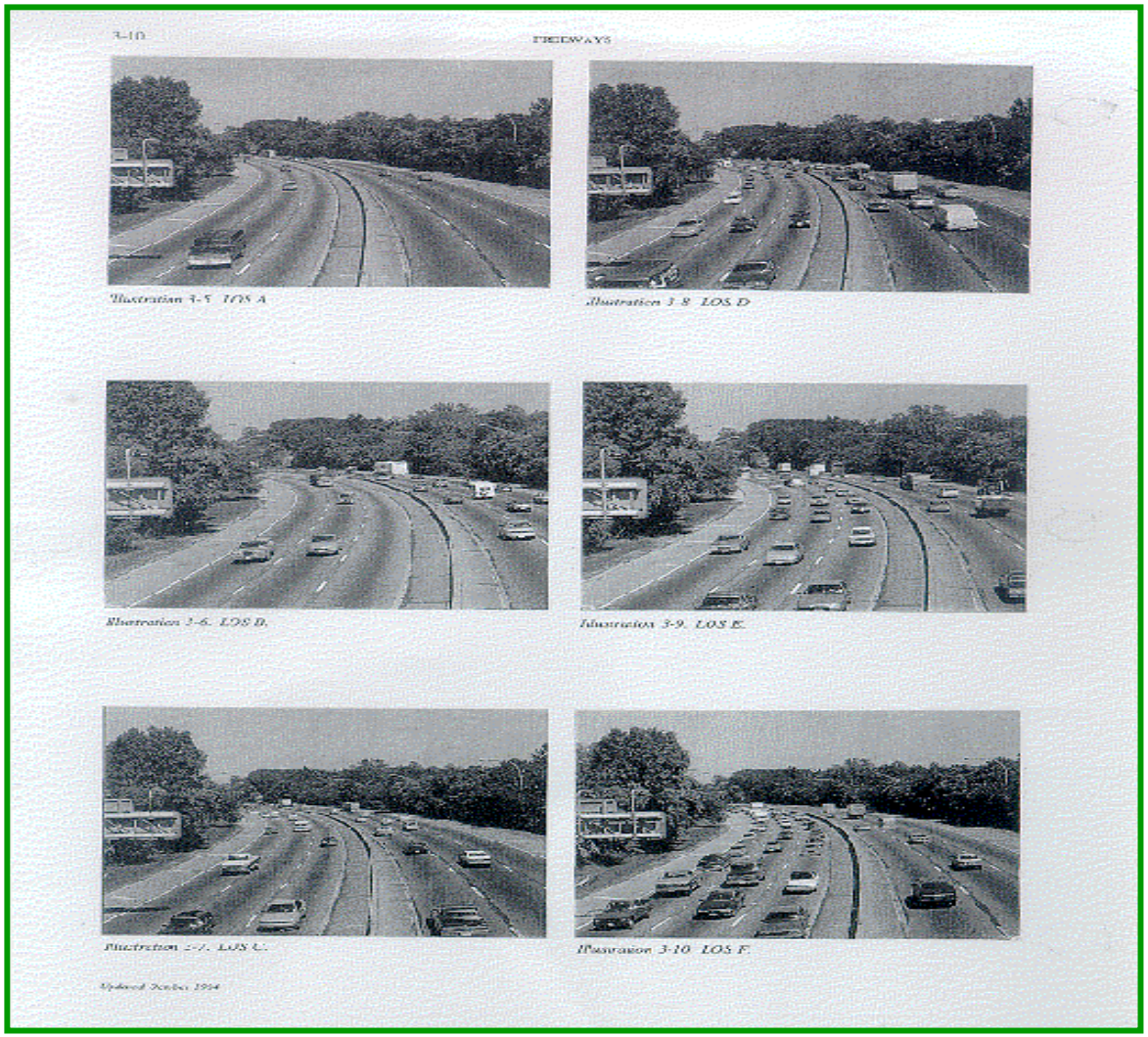
After application of one of the algorithms (gradient based method)

PROMISING APPLICATIONS

– Level-of-Service from the air

- Automatic flow extraction from georeferenced imagery
- Improved AADT and VMT
- Image backdrops for real-time bus locations
- Improved OD Estimation
- Remote Sensing and ITS

Highway Capacity Manual



3-10 FREEWAYS

Illustration 3-5. LOS A

Illustration 3-8. LOS D

Illustration 3-6. LOS B

Illustration 3-9. LOS E

Illustration 3-7. LOS C

Illustration 3-10. LOS F

Updated October 1994

Highway Capacity Manual

Table 3-1. LEVEL OF SERVICE CRITERIA FOR BASIC FREEWAY SECTIONS

LEVEL OF SERVICE	MAXIMUM DENSITY (PC/MI/LN)	MINIMUM SPEED (MPH)	MAX SERVICE FLOW RATE (PCPHPL)	MAXIMUM *v/c* RATIO
FREE-FLOW SPEED=70 MPH				
A	10.0	70.0	700	0.318/0.304
B	16.0	70.0	1,120	0.509/0.487
C	24.0	68.5	1,644	0.747/0.715
D	32.0	63.0	2,015	0.916/0.876
E	36.7/39.7	60.0/58.0	2,200/2,300	1.000
F	var	var	var	var

Freeway LOS Analysis

Arterial LOS Analysis

Estimating highway level of service using airborne imagery

alejandro angel and mark hickman

april 2002

NCRST-F cookbook report # 1

N C R S T - F
National Consortium
on Remote Sensing
in Transportation
F l o w s

Other Guidebooks

- Hyperspectral imaging
- Air-based traffic services
- Detecting vehicles in high-resolution imagery
- LIDAR
- Traffic parameters from airborne radar
- Georeferencing

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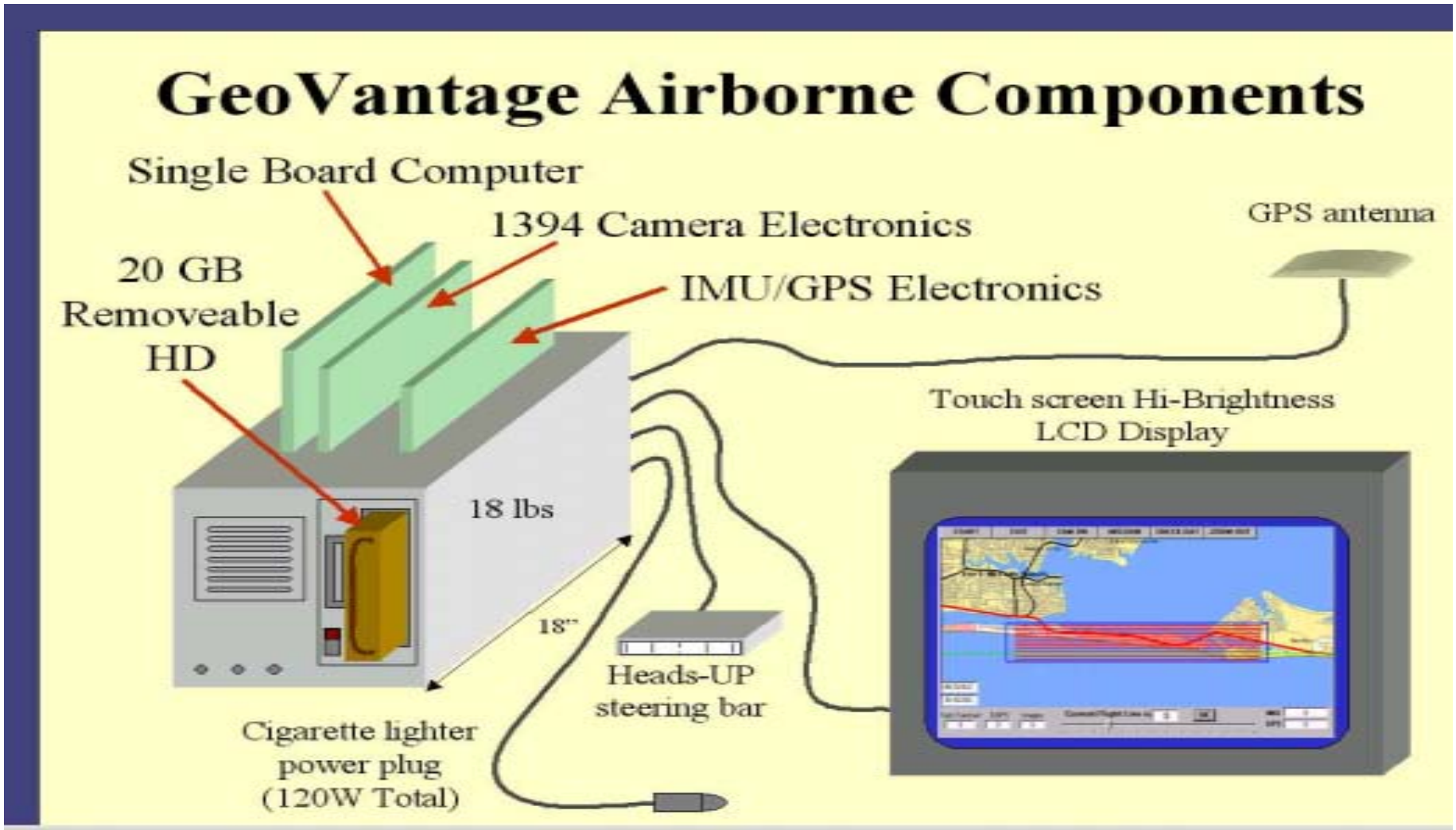
Skycomp's Georeferencing Camera




Cessna 182 Tail No. 1847168
Computer Chassis
with Cargo Net

Overlapping Georeferenced Images

Travel Speeds:
63 mph

Air- vs. Ground-based Velocities
Empirical Study

Figure 4. Time = 1 second. The field of view is approximately 190 feet

Figure 5. Time = 15 seconds. Platoon is moving on Speedway from bottom-right to top-left. Field of view is 950 feet.

Air-based Velocities Outperform Floating Car Velocities

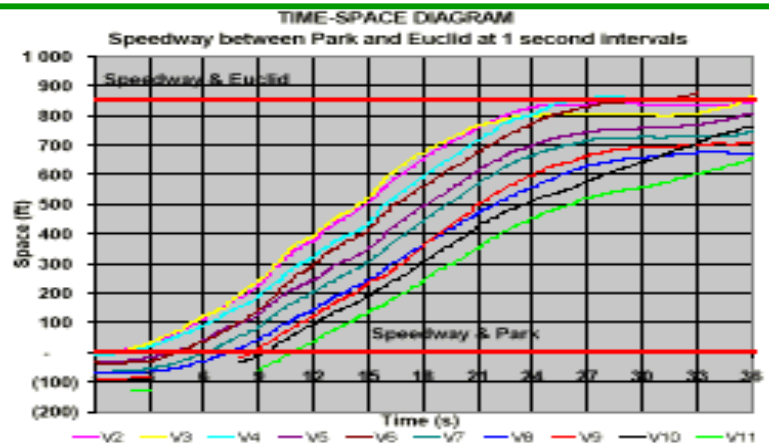


Figure ES-2. Vehicle trajectories with 1s intervals

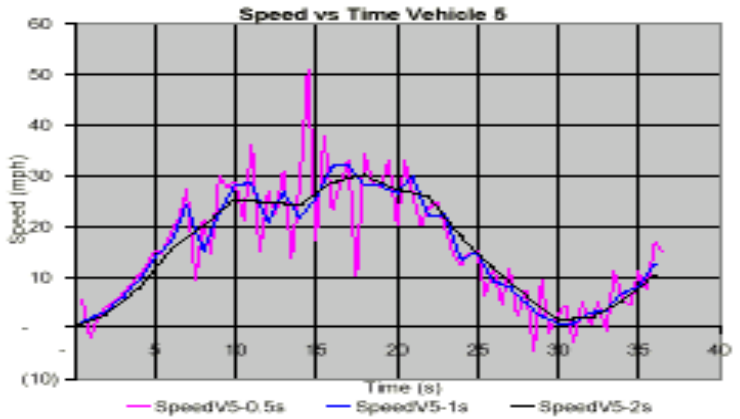


Figure ES-3. Speed profile 0.5, 1 and 2s intervals

Technique	Sample Size	Mean Travel Time with 95% Confidence	Sample Standard Deviation (sec)	Space Mean Speed (Km/h)	Space Mean Speed (mi/h)
Floating Car	1	0:07:45		36.4	22.6
Platoon from aerial video	9	0:07:36 ± 8 sec	0:00:11	37.1	23.1
Platoon from ground video	5	0:07:38 ± 6 sec	0:00:05	36.9	23.0

Table ES-1. Eastbound Travel Times by Technique

Present Efforts

- **Efficient traffic data extraction**: vehicle counts and classifications, velocities, Level-of-Service, …
- **Cost-effective hardware-software** for traffic flow determination

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Statewide Network Coverage:
Large Labor and Equipment Expenses

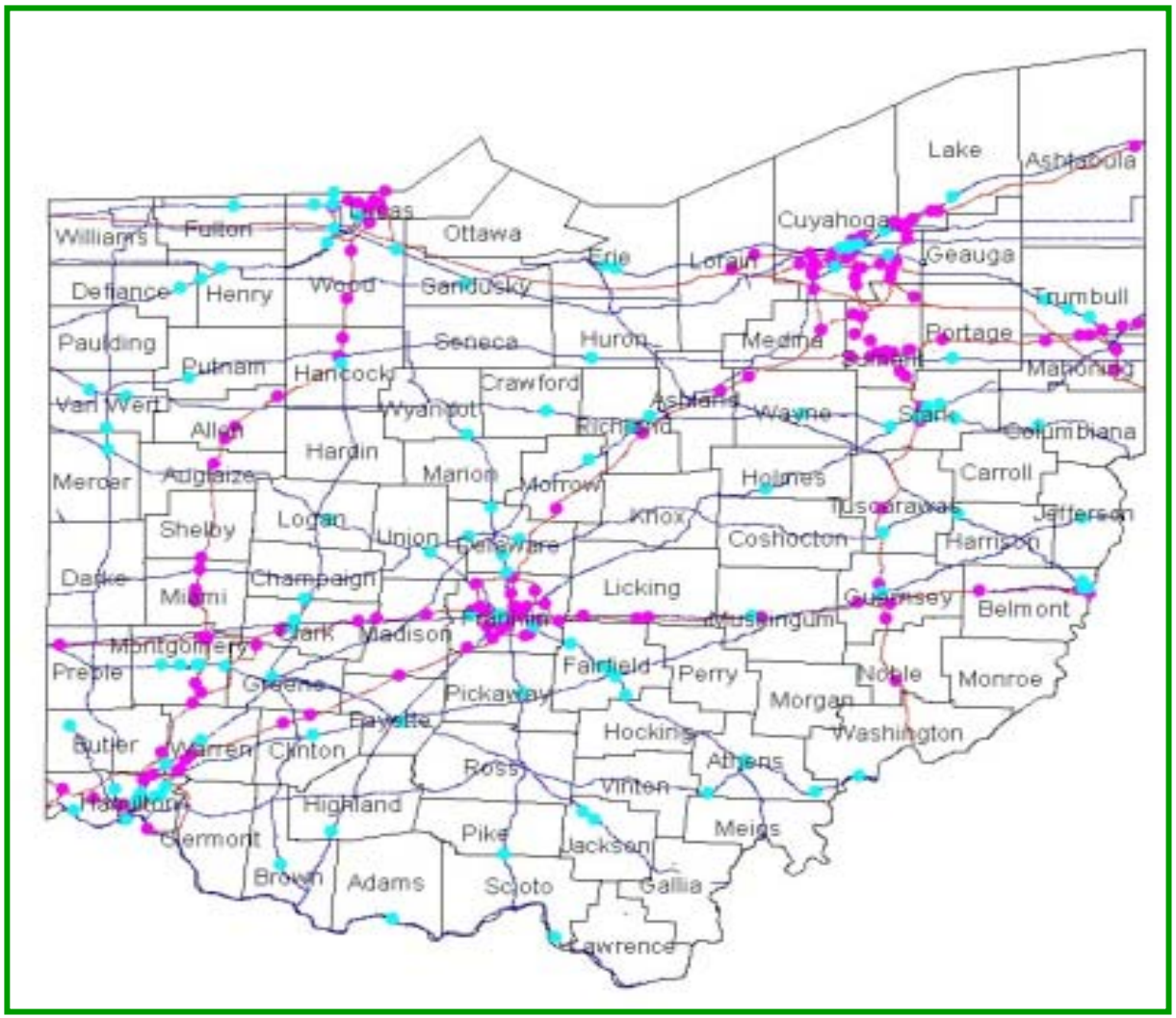
Atr_at_ushighway_dd.shp

Atr_at_uinterstate_dd.shp

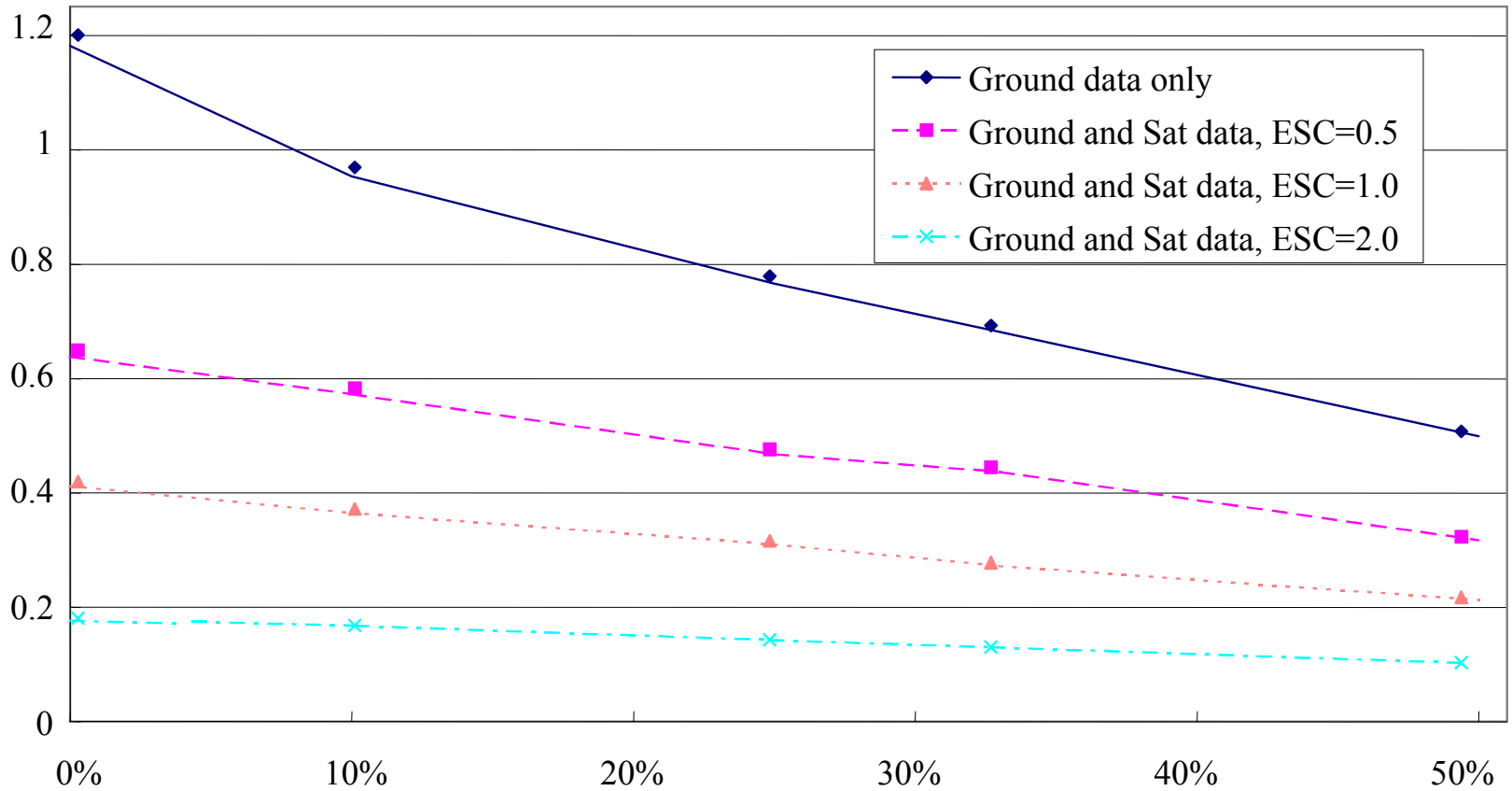
Ushighway_dd.shp

Interstate_dd.shp

Oh_county.shp



Reduced Ground-based Sampling and Error from Satellite Data



AADT from IKONOS Image:

I-270 near Columbus, OH

49,560 vehicles/day

Segment (platform, date)	Density (veh/mi)	Segment length(mi)	Estimated flow(vph) *	Image based AADT **	Conventional AADT ***	% Error Image based vs. Conventional AADT
I270 @ US23						
(IKONOS,05/29/01)	46.17	8.08	3102	49560	50562	-1.98%
I71 @ US62						
(airplane,11/30/95)	24.90	7.47	1625	32742	31611	3.58%
I71 @ US62						
(airplane,10/29/96)	24.64	15.06	1649	30661	32970	-7.00%

Based on: *speed limit, **hourly and ODOT seasonal factors, ***publised AADT and growth factors.

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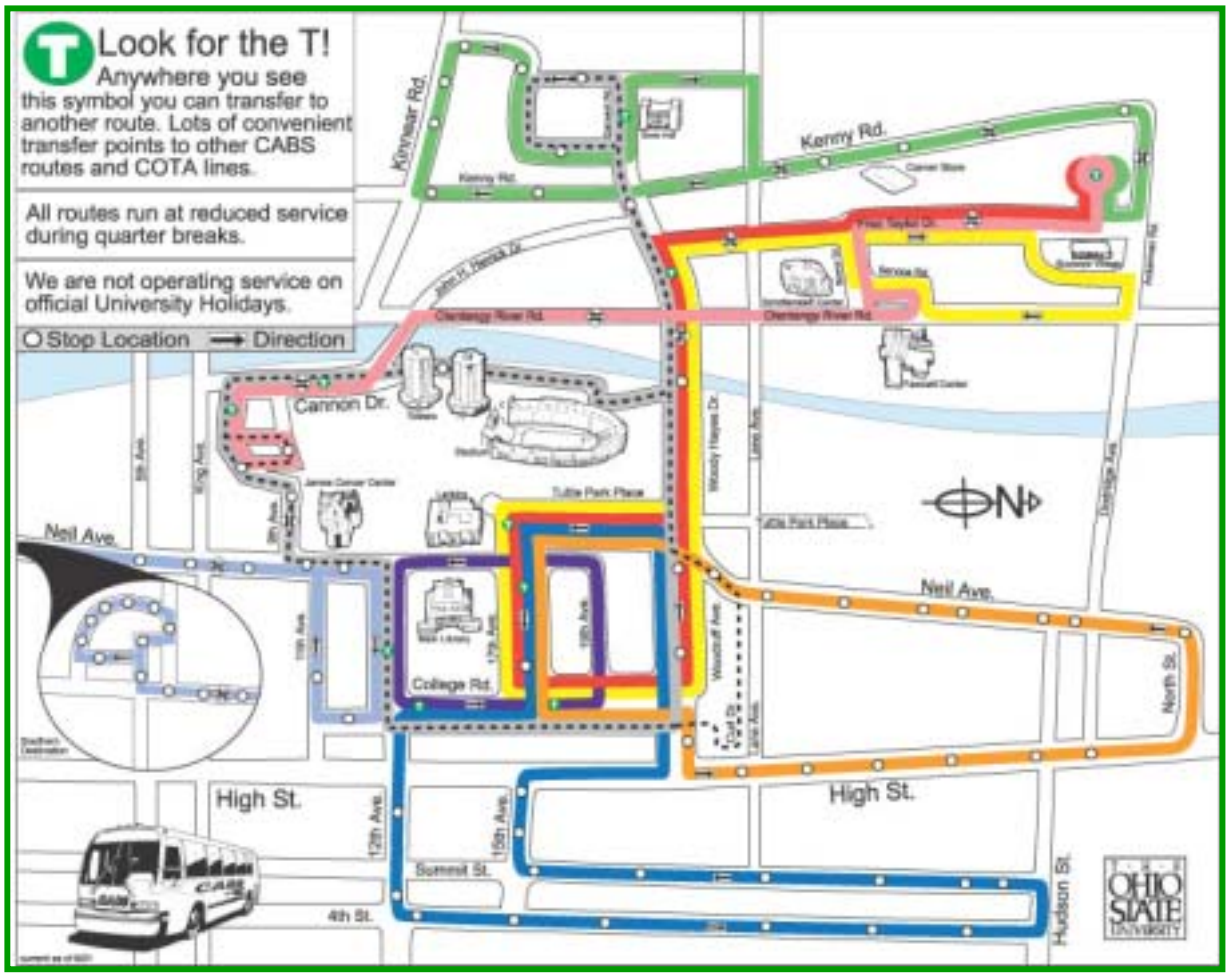
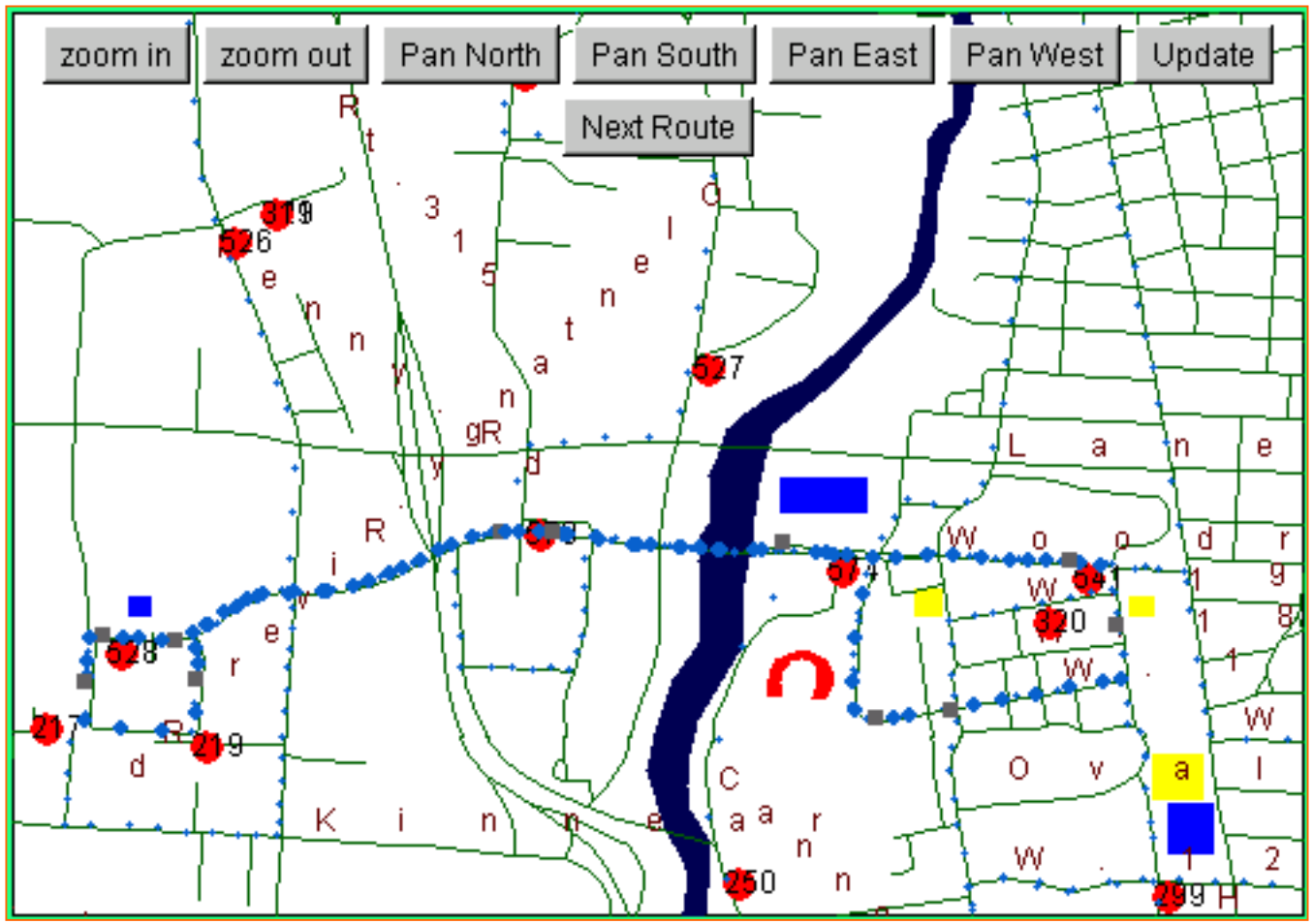
OSU Campus Area Bus System

~30 buses, 11 scheduled service routes



http://blis.units.ohio-state.edu



http://blis.units.ohio-state.edu/aerial

North

West

East

South

North

West

East

South

North

West

East

South

PROMISING APPLICATIONS

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Static and Dynamic OD Flows

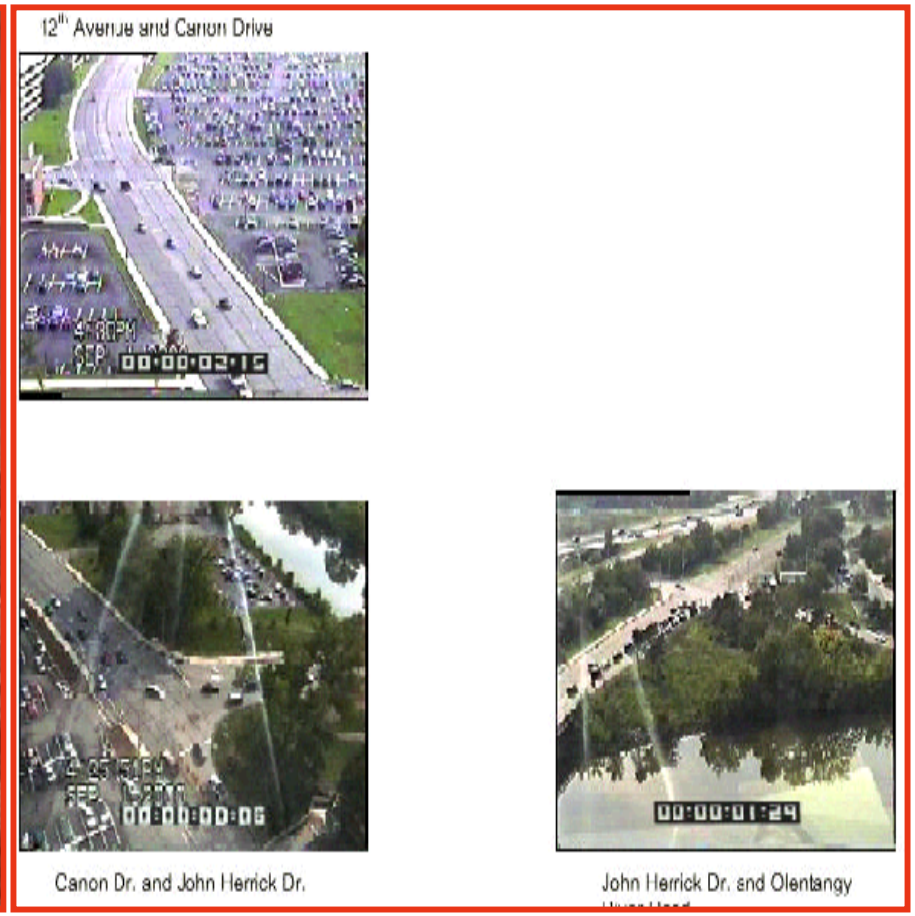
- Fundamental for Planning and Management
- OD-from-Ground-Count Estimation

  Presently based on **Link Volumes**

  Potential for R.S.-based Partial **Path Observations**

OSU Campus


Intersection 1
Intersection 2
Observation Point
Intersection 3


12th Avenue and Canon Drive
Canon Dr. and John Herrick Dr.
John Herrick Dr. and Olentangy

Data Collection and Processing

3 hours of video

Manual Processing

Digitized Data Set

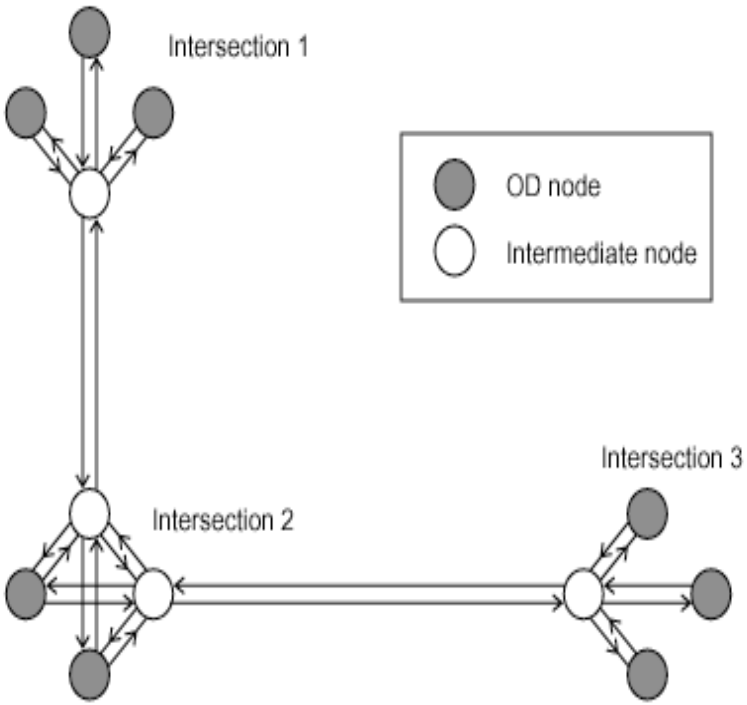
Truth and Samples

- OD flows
- Link volumes
- Turning movements
- Link Travel Times

Canon Dr. and John Herrick Dr.

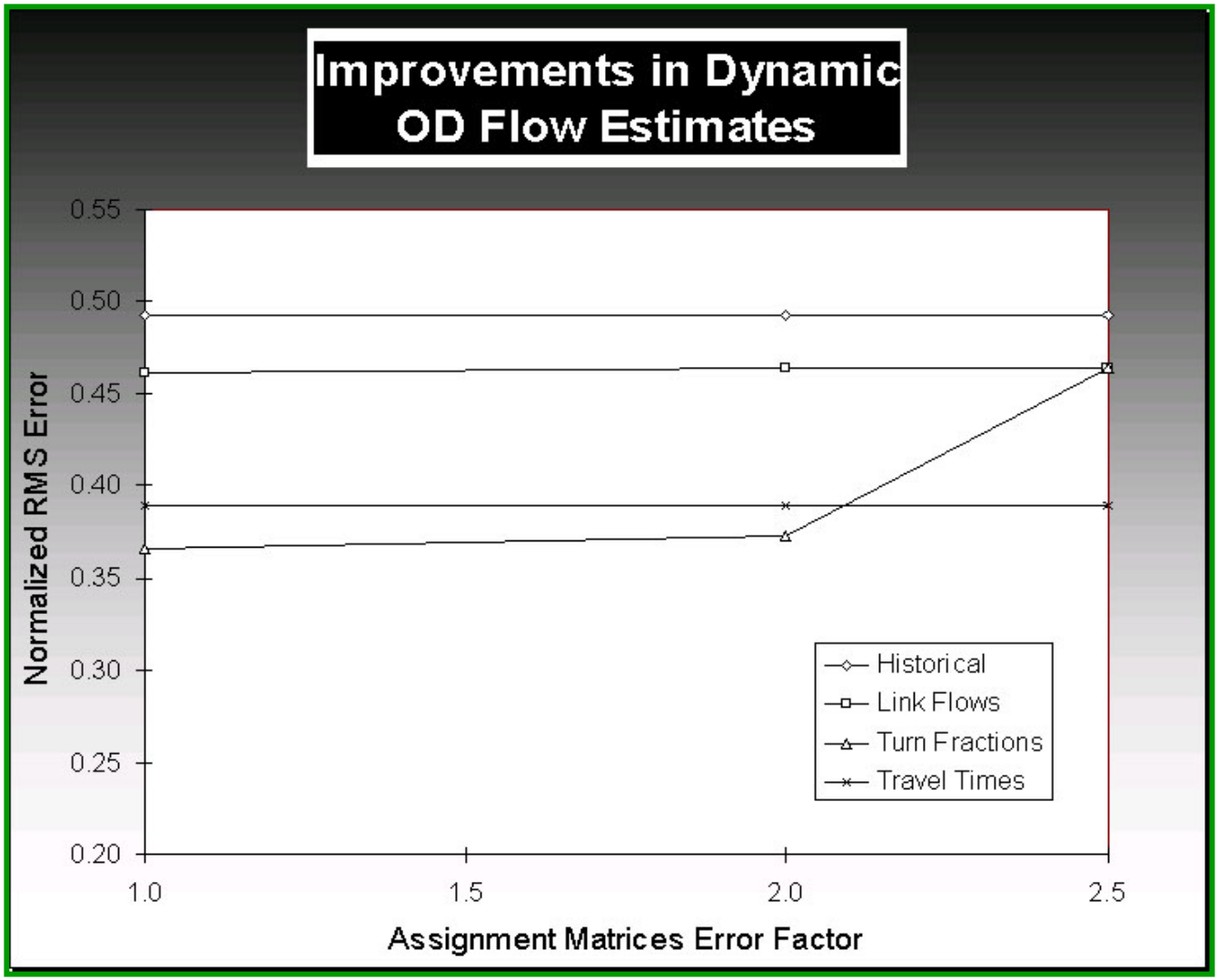
John Herrick Dr. and Olentangy

Analysis



- Data Set
- Surveillance Scenarios
- Kalman Filtering
- Sensitivity Analysis

Improved Dynamic and Static OD Flows from Remotely Sensed Turning Movements



GeoDATA Systems, Inc.: Advanced Data Acquisition System

Figure 1. ADAS.


Dec. 4, 01


Dec. 4, 01


Dec. 4, 01

Upcoming

- Central Ohio ADAS and Helikite Demonstration (June 2002)
- Monitoring of OSU Campus (2002-2003)

PROMISING APPLICATIONS

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ITS – NCRST-F Workshop

George Mason University, July 9-11 or 23-25

Integration of Remote Sensing of Traffic with Intelligent Transportation Systems

- Incident management and UAV's
- Complementing ground-based with airborne traffic surveillance
- Freight, Heavy Vehicles, Border Crossings

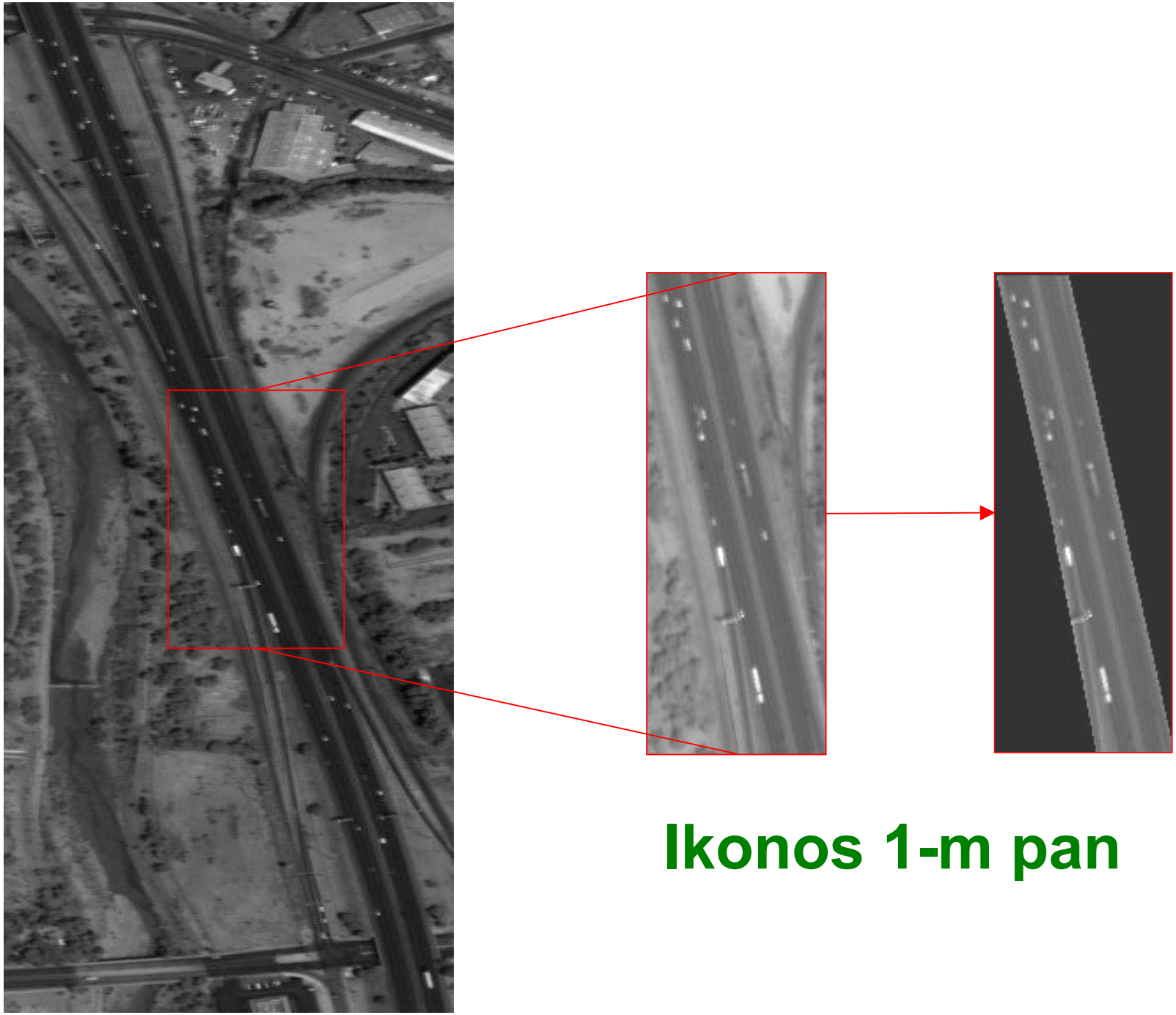
SUMMARY

- **Level-of-Service from the air**
- **Automatic flow extraction from georeferenced imagery**
- **Improved AADT and VMT**
- **Image backdrops for real-time bus locations**
- **Improved OD Estimation**
- **Remote Sensing and ITS**

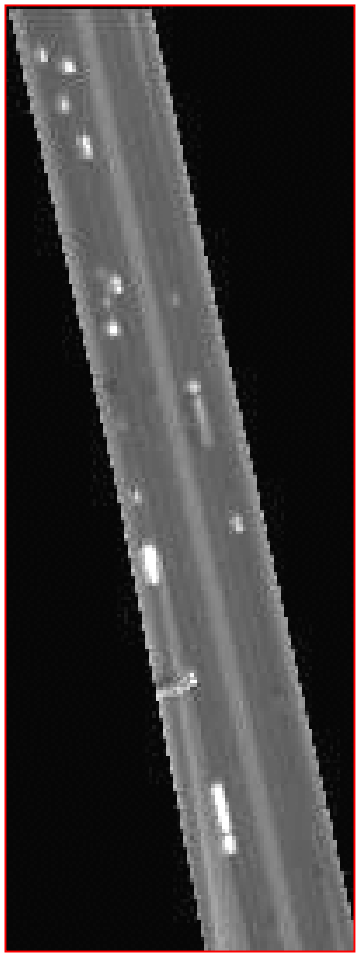
Repeatable Applications

Sensor and Image Processing Developments

High-Resolution Satellite Imagery



Ikonos 1-m pan



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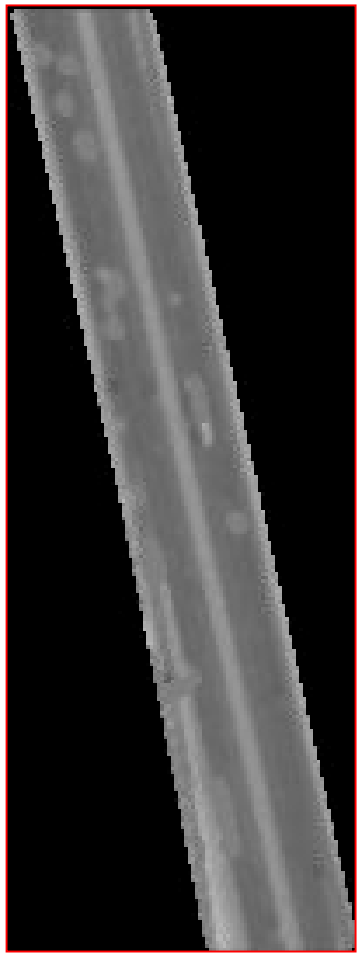
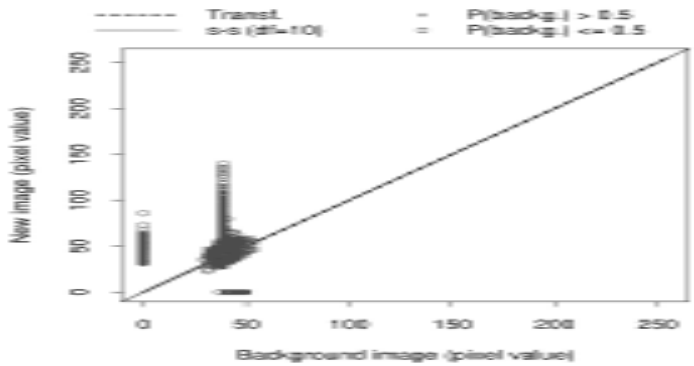
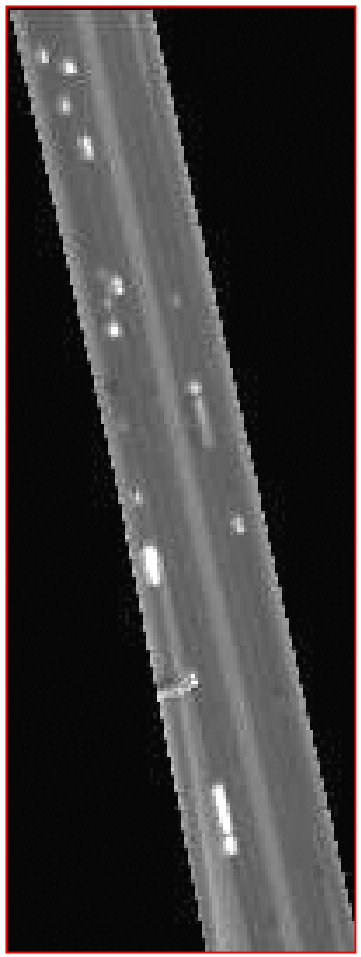


Background Image

Methodology

- Simultaneous Transformation & Differencing
- Iterative Process
- Natural Splines
- Expectation-Maximization





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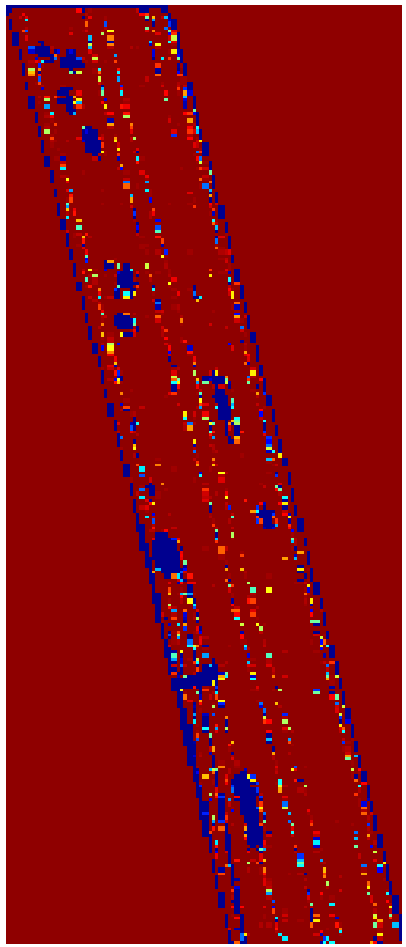
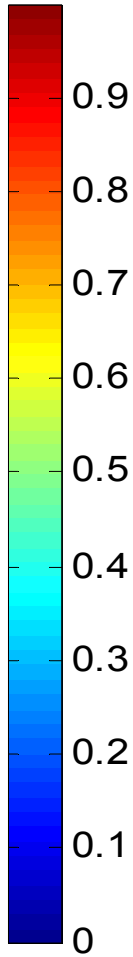
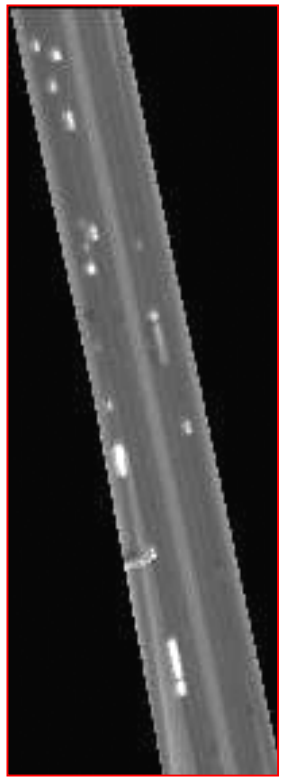




Probability Image Map

Thresholding



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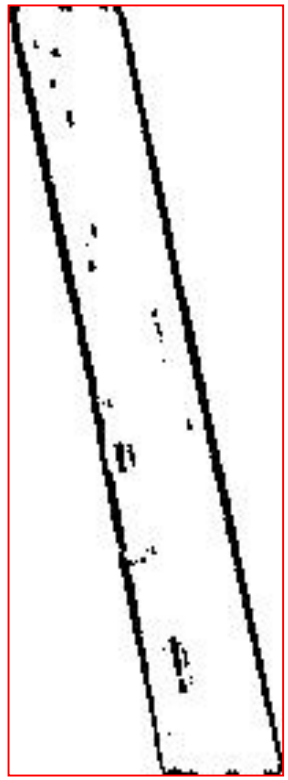
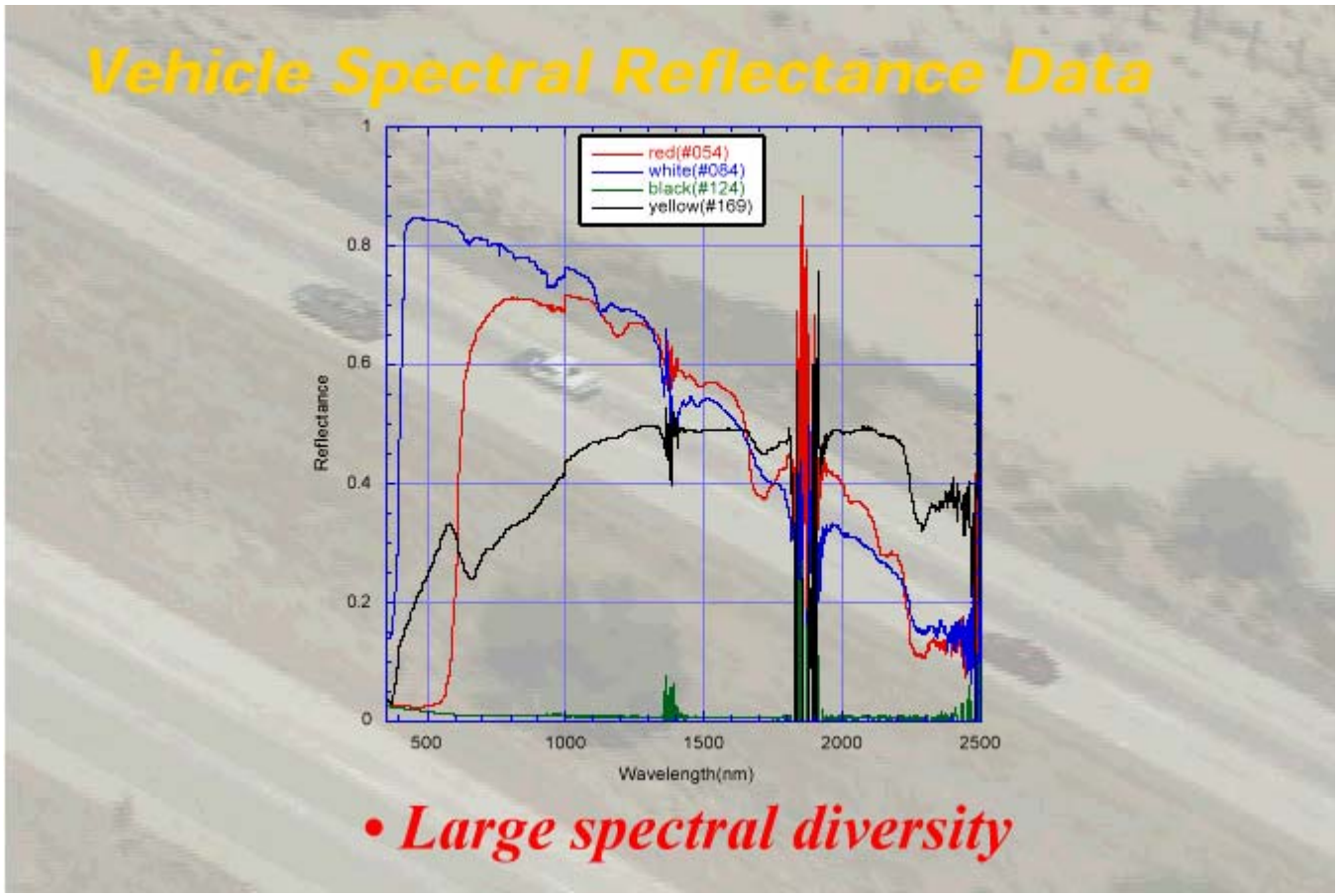


Binary Image

Multi/Hyperspectal
Vehicle and Pavement Signatures

Selected Vehicle Spectral Signatures



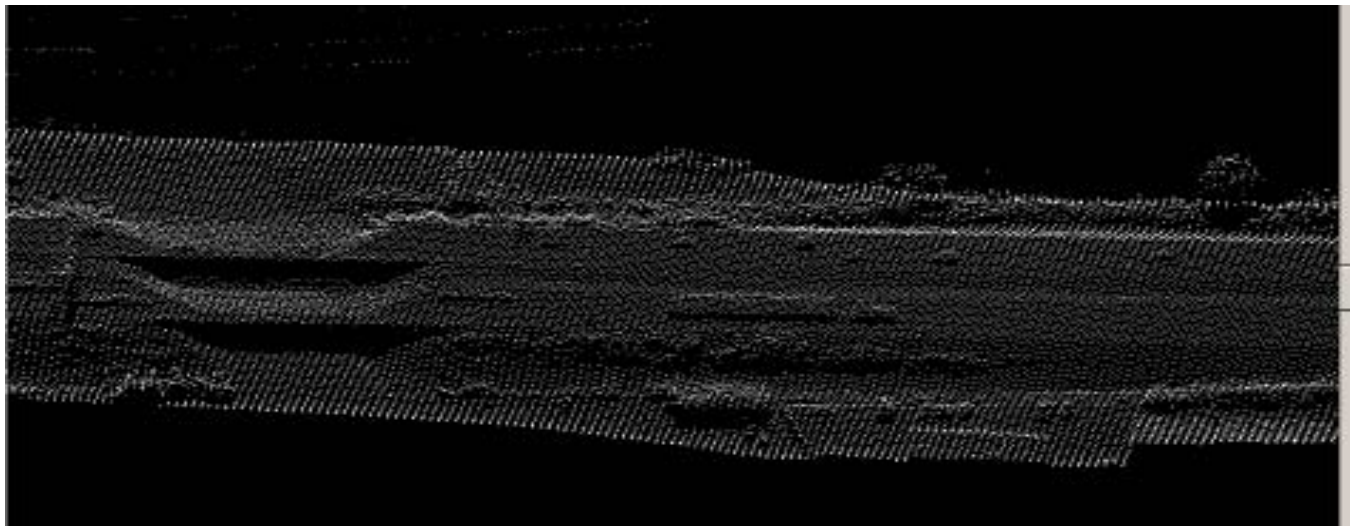
Light Detection and Ranging
LIDAR

Acknowledgment:

Woolpert, LLP

Vehicle Detection

US 35 Dayton, OH



Velocity Estimation

Inputs

- Aircraft speed
- LIDAR scan rate
- Vehicle length

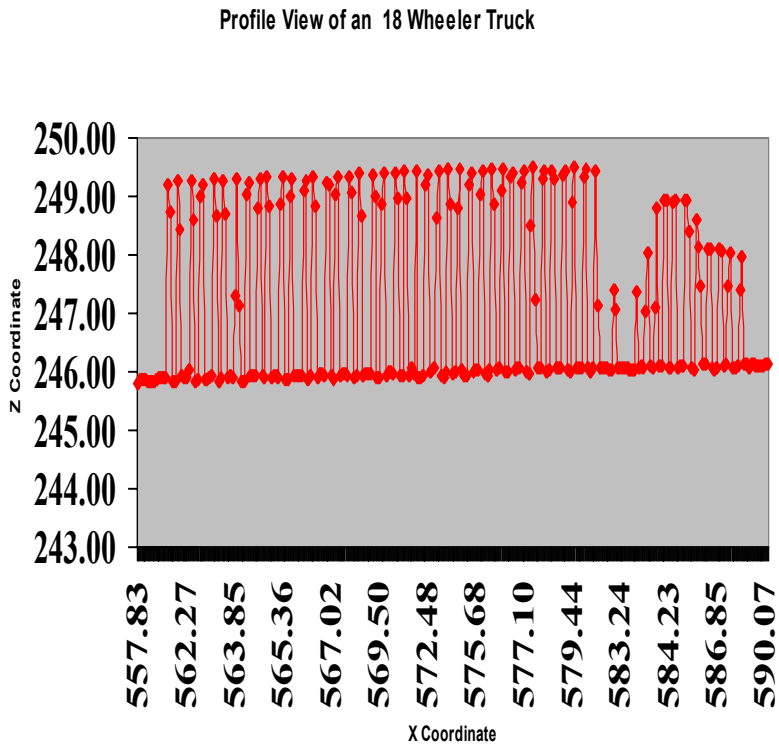
Data

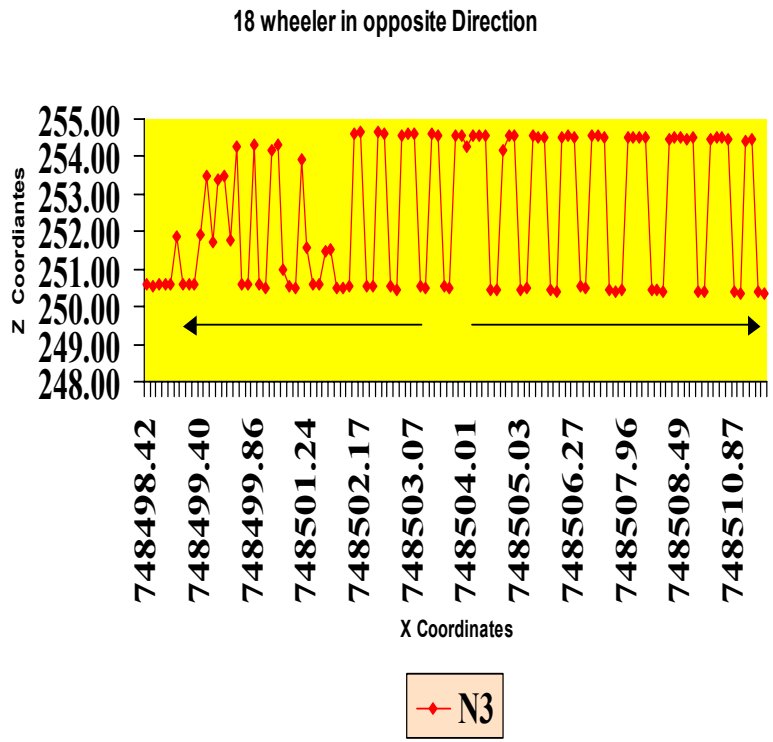
- LIDAR returns

Output

- Vehicle Velocity

Profile of 18-wheeler in opposite directions





Air- and Space-Based Remote Sensing of Transportation Flows

- Promising, Repeatable Applications
- Technology Needs Development
- Implementation Issues: New Ways of Doing Business