Commercial Remote Sensing (CRS) for Bridge Monitoring – NCRST-Bridge Project

Shen-En Chen, Edd Hauser, Wanqiu Liu, Corey Rice-UNC Charlotte

Ron Eguchi, Zhenghui Hu - ImageCat

Chuck Boyle - Boyle Consulting Engineering

Howard Chung - Acellent Technology

Need for Research

- US bridge infrastructure is in a critical state of repair due to aging and other structural and environmental factors.
- Potential of Commercial Remote Sensing and Spatial Information (CRS-SI) as supplements to inspection practices and bridge management systems.
- Need to promote an understanding of these technologies to bridge engineers.

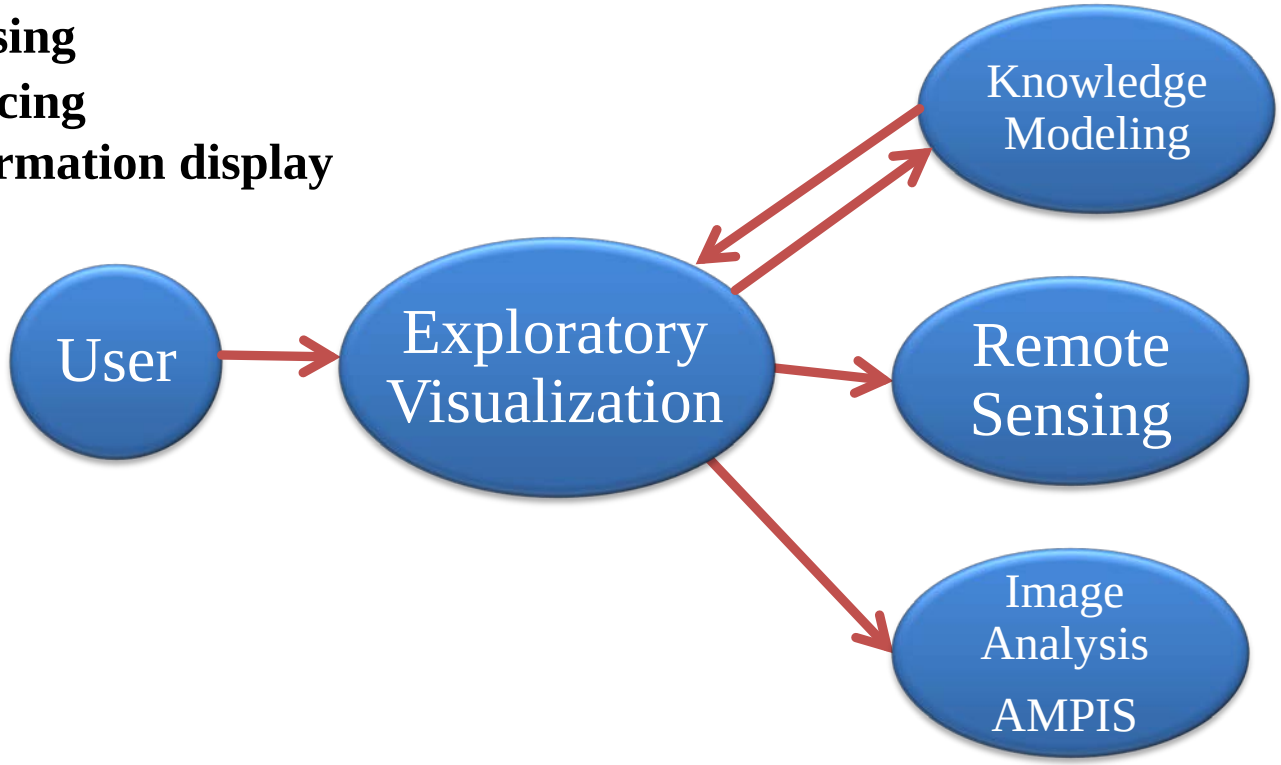
Phase 1 Project Overview

- Research Goal:
  - Encourage high-level remote sensing and visualization technologies' applications to bridge condition monitoring; and
  - Demonstrate such applications to a nation-wide audience through outreach to other highway agencies.
- Phase I research objective: to develop an **integrated Remote Sensing and Visualization (IRSV) system** that integrates CRS for bridge monitoring and maintenance.
- Target population: **Charlotte and Mecklenburg County, NC.**

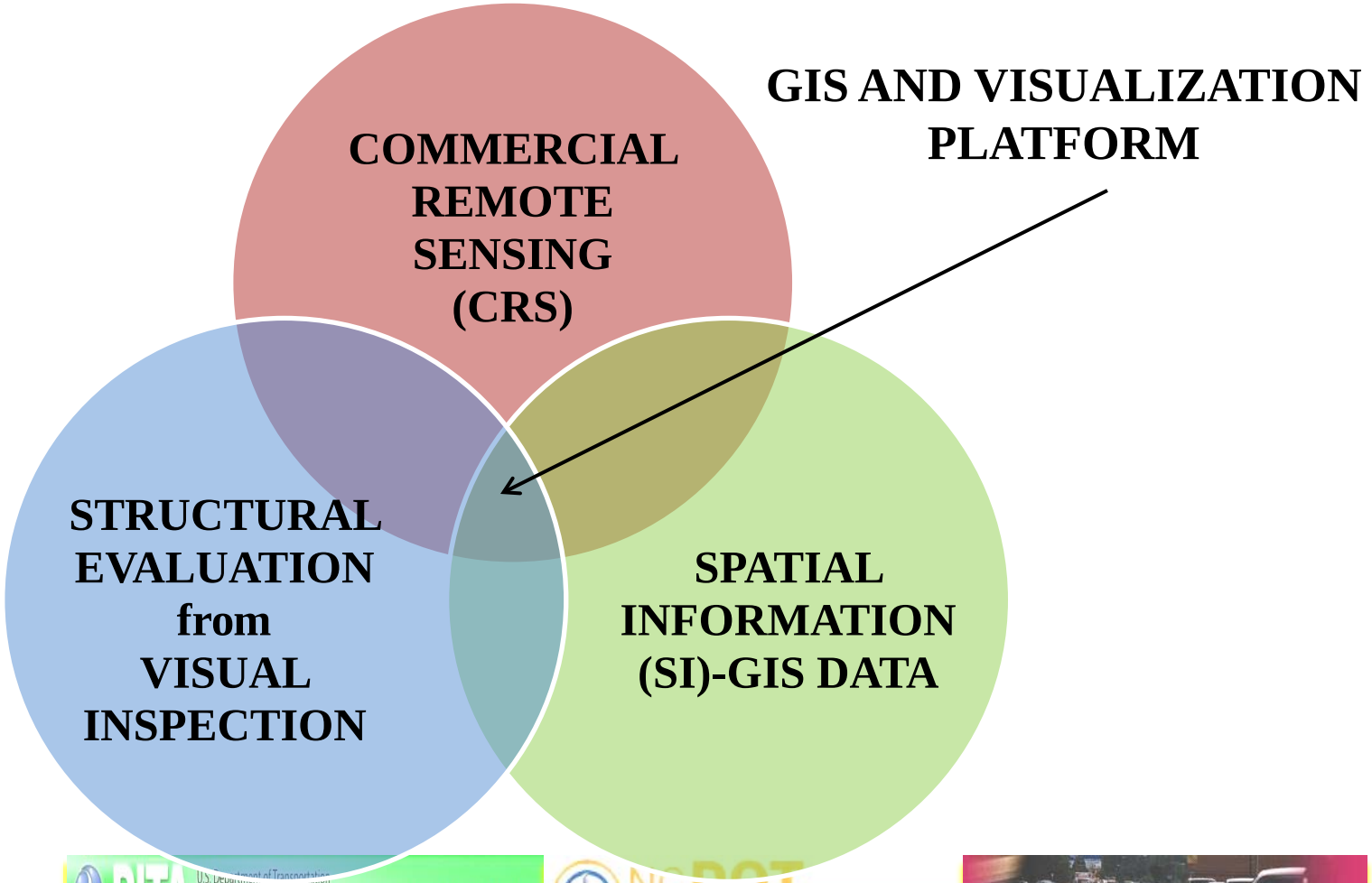
  (over 200 bridges represented – 20 bridges studied in detail)

IRSV System – software + remote sensing data

- IRSV: a high-tech bridge data visualization and management system that can be utilized by bridge engineers to better manage their assets via a total viewpoint that includes:
  - **remote sensing**
  - **geo-referencing**
  - **spatial information display**



Merging of Technologies



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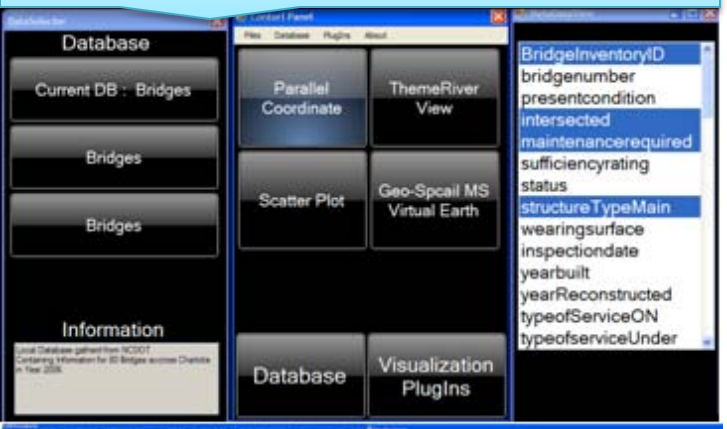
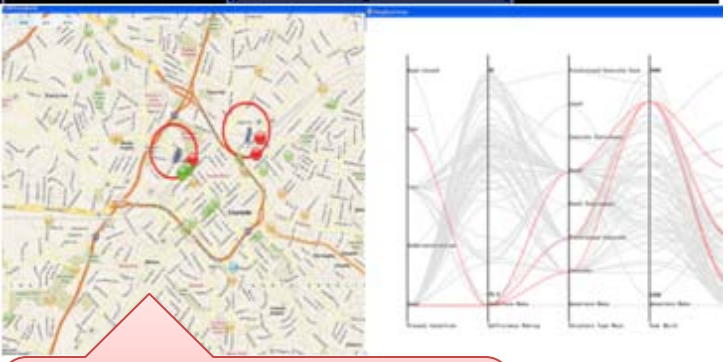
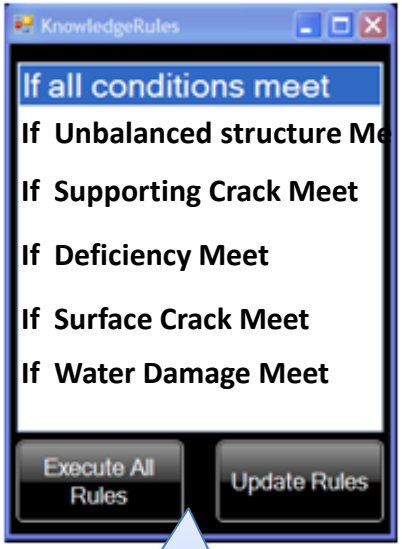
IRSV System Overview

Interactive Visualizations





Coordinated Visual Representations

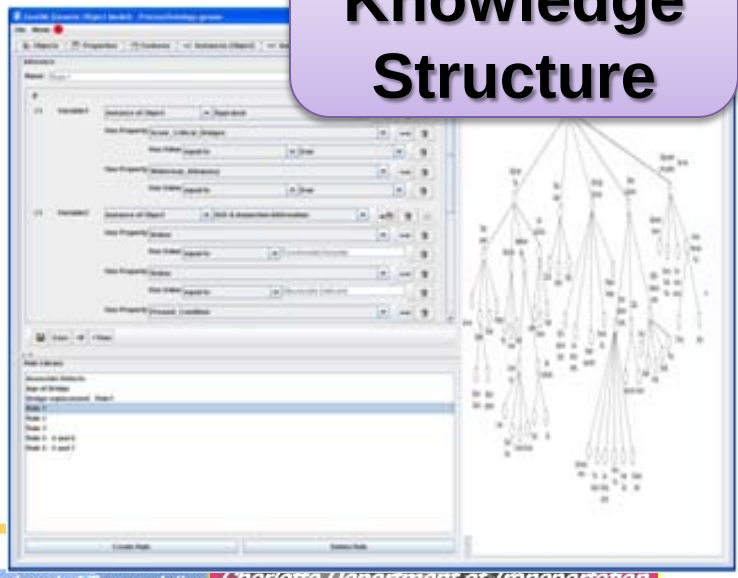


Know. Comm.

Peripheral Data

Remote Sensing Data

Ontological Knowledge Structure



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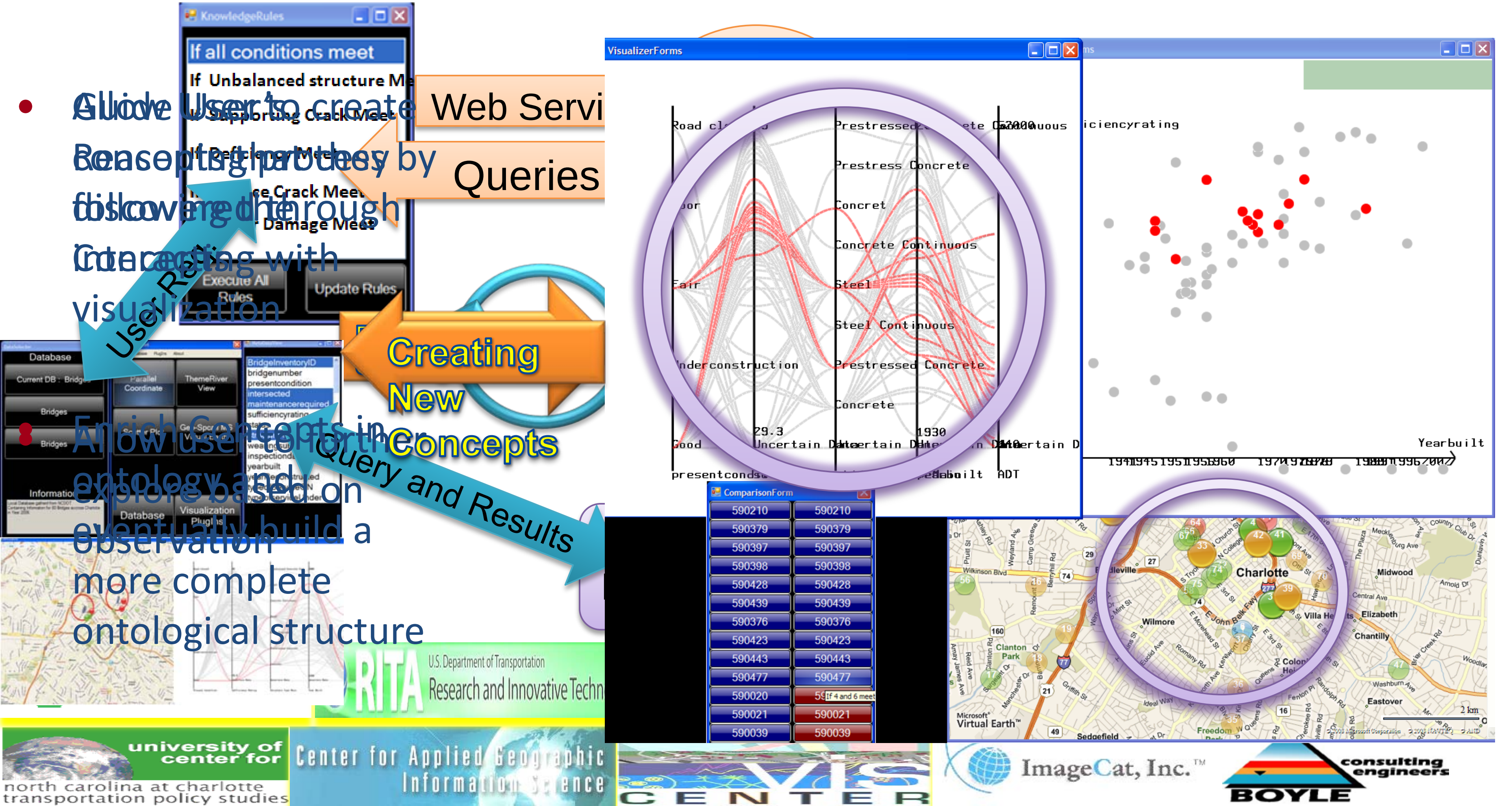
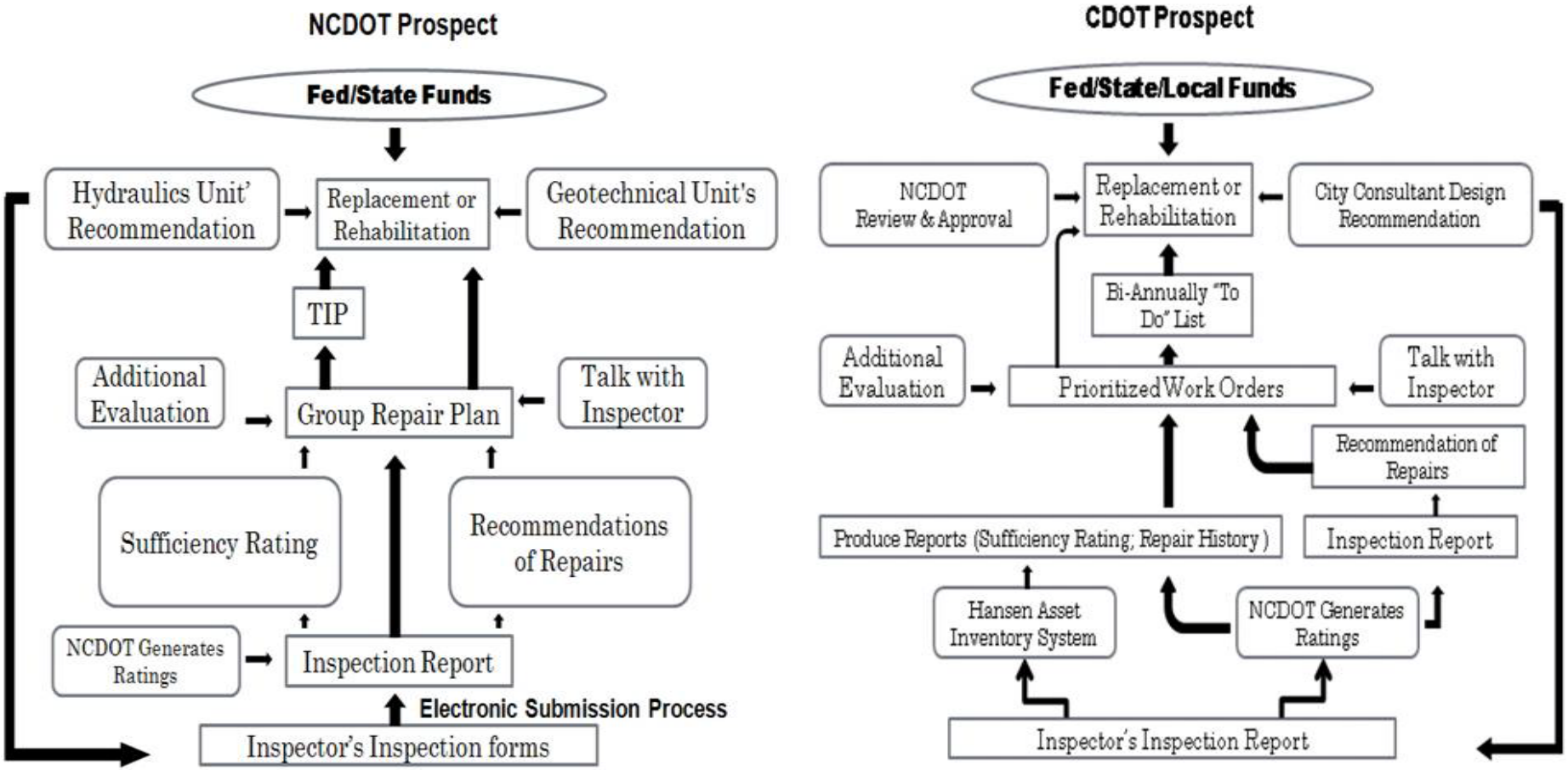
Bridge Management Engineer Interface

Ontology Visualization (OV Process)
User through Visualization to Ontology (VUO Process)

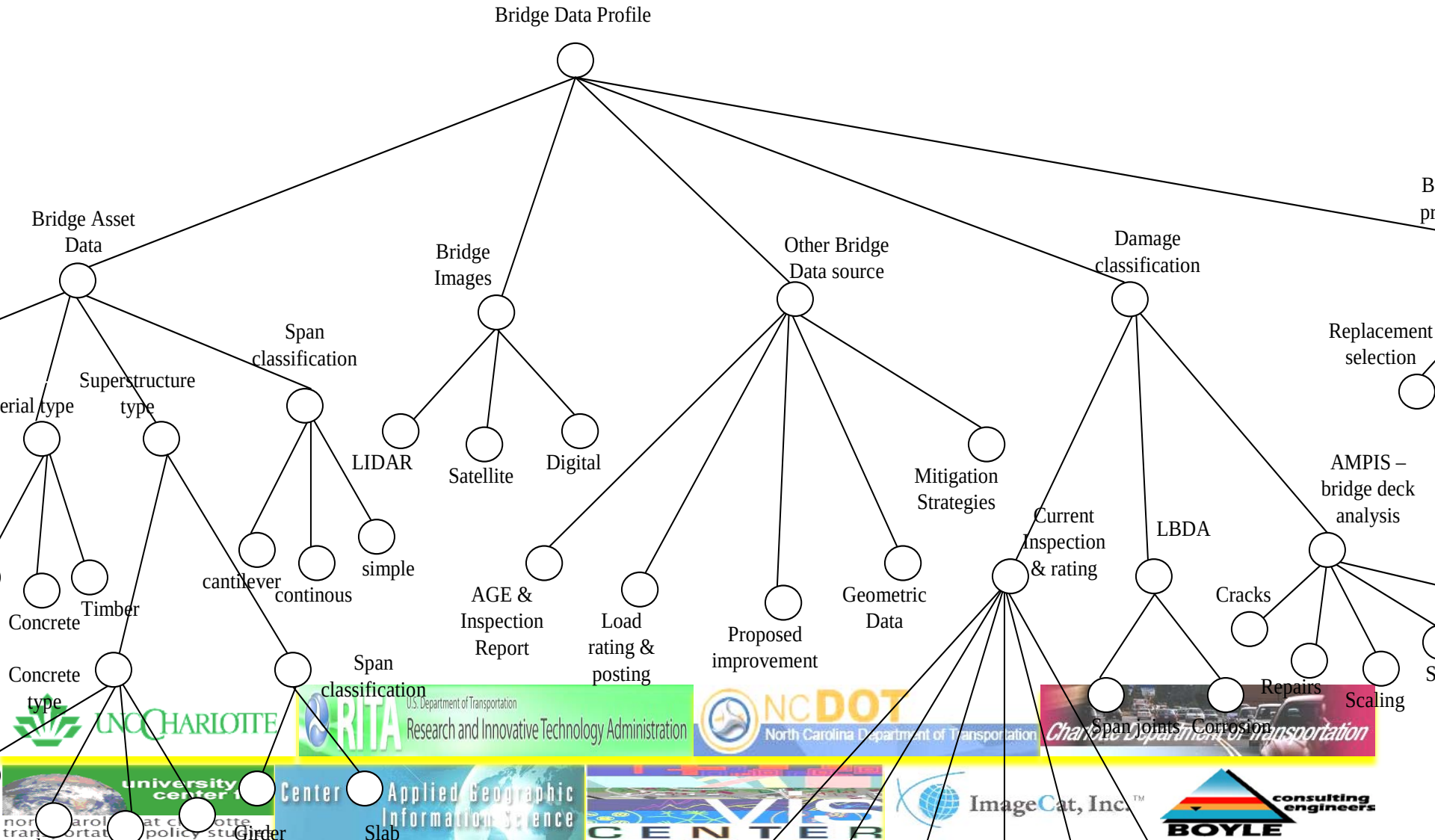
- Allow User to create Concepts/Properties by Browsing through/Interacting with visualization
- Guide User's reasoning process following the ontology concepts
- Enrich Concepts in ontology and eventually build a more complete ontological structure
- Allow user to further explore based on observation



Decision Making Comparison



IRSV Knowledge Structure

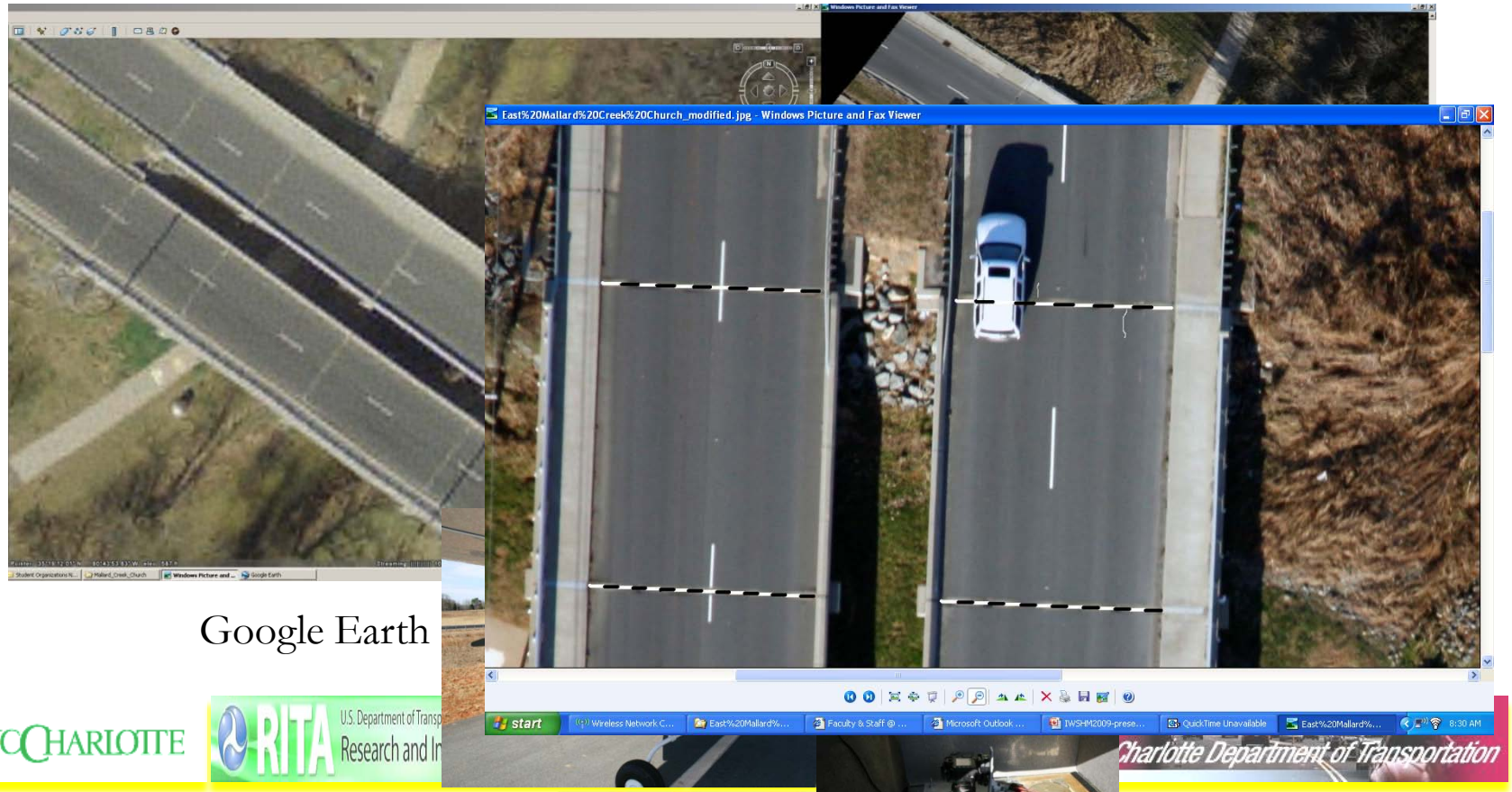


New Technologies: LiDAR and High Resolution Small Format Aerial Photography (SFAP)

Specific bridge problems that are addressed using CRS include:

- Bridge clearance (LiDAR)
- Concrete loss, steel beam bending and corrosion (LiDAR)
- Bridge deck cracking vs. bridge movement (SFAP)
- Possible substructure problems including pier movements (LiDAR)
- New bridge construction documentation (LiDAR + SFAP)
- Channel width/environmental effects (SFAP)

New Technology: Integrated Sub-Inch SFAP and AMBIS Imaging



Google Earth

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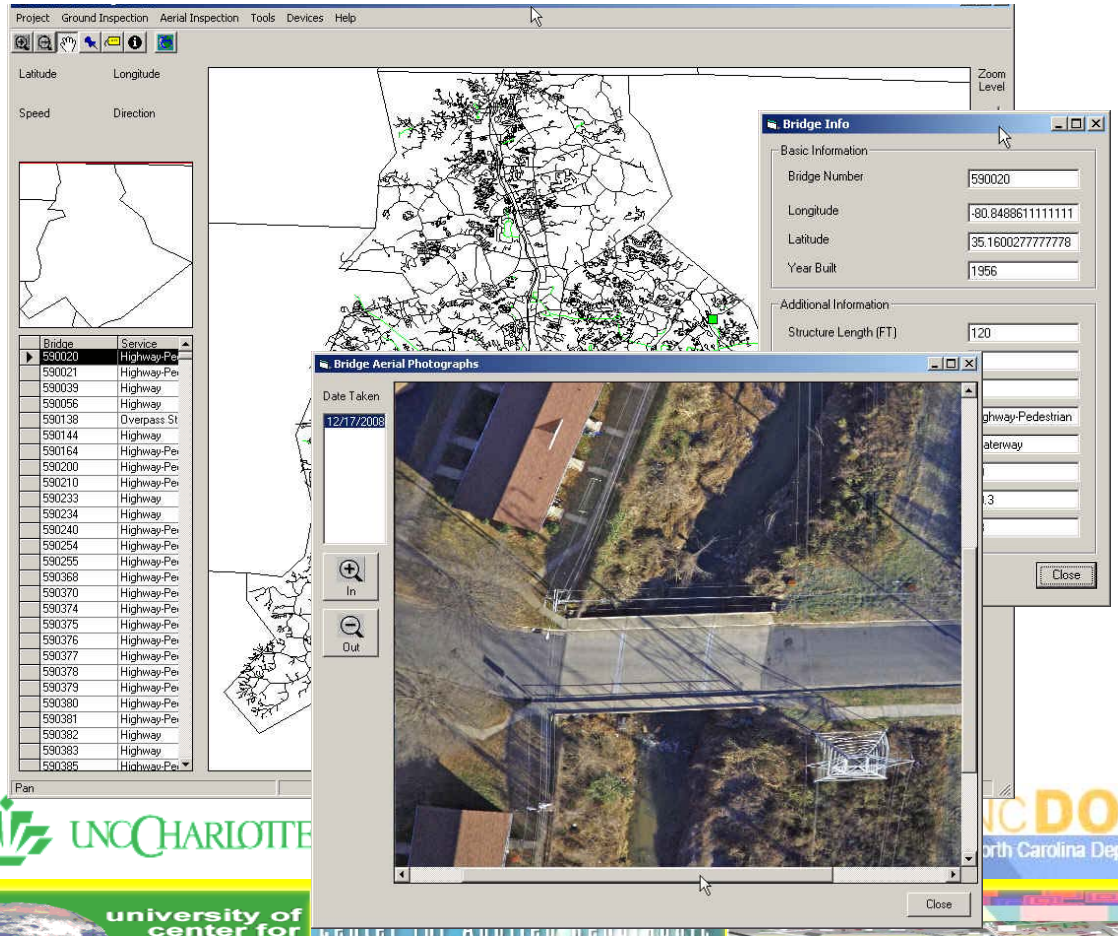
Organizing Bridge Management Information



- Geographically locate bridges
- Display high- resolution aerial photography
- Integrate with GIS platform

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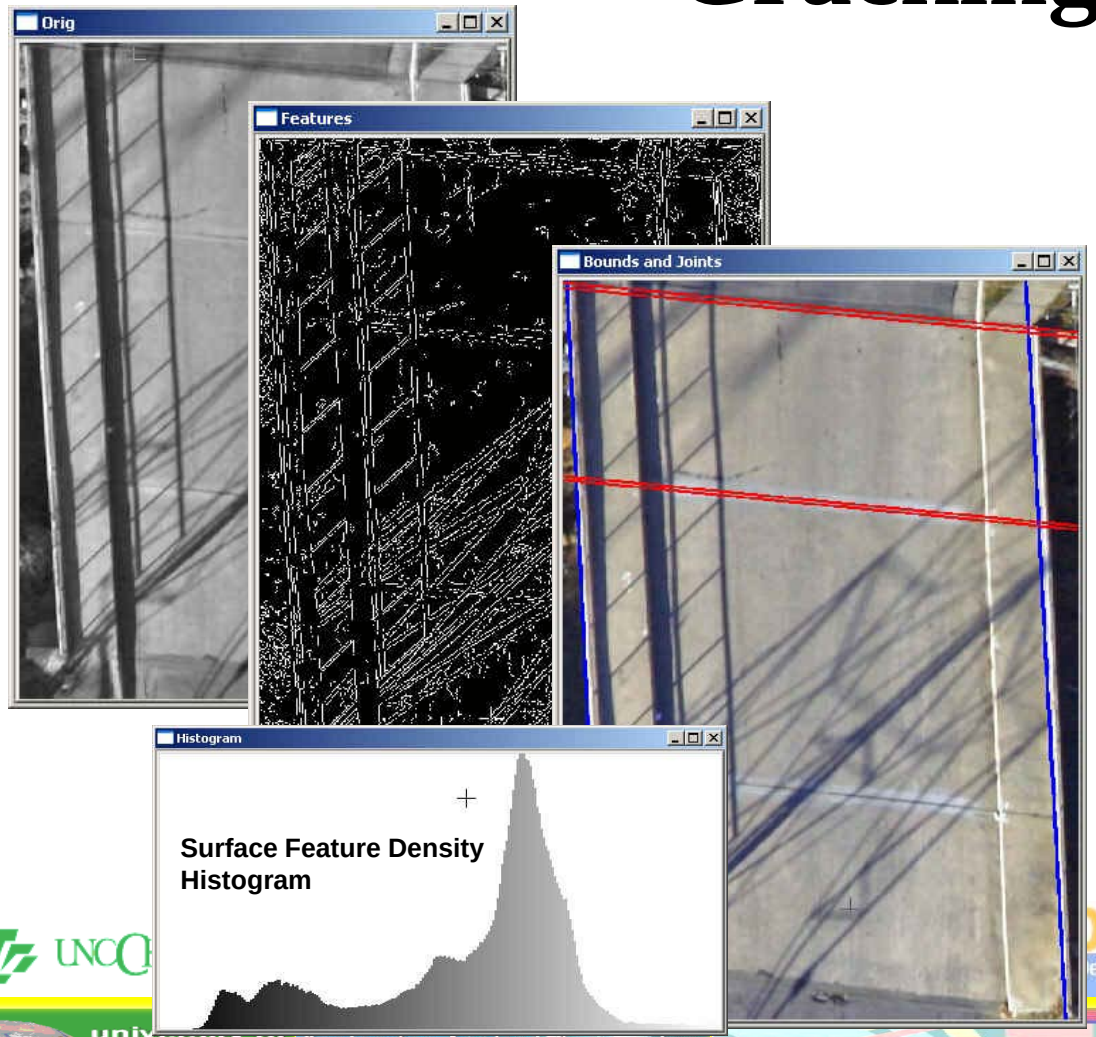
Quantifying Joint Separations and Cracking



- Delineate deck boundaries (i.e., sides)
- Filter noise (e.g., shadows, cars)
- Detect bridge deck joints
- Compile bridge distress statistics (e.g., extent of joint separation)

New Technology: LiDAR Damage Detection

- Construction delivery
- Image Documentation
- Geometry Estimation
- Bridge Clearance Determination
- Structural Damage Measurement (impact)
- Structure Defect Quantification (mass loss)
- Bridge Displacement Measurement During Static Load Tests

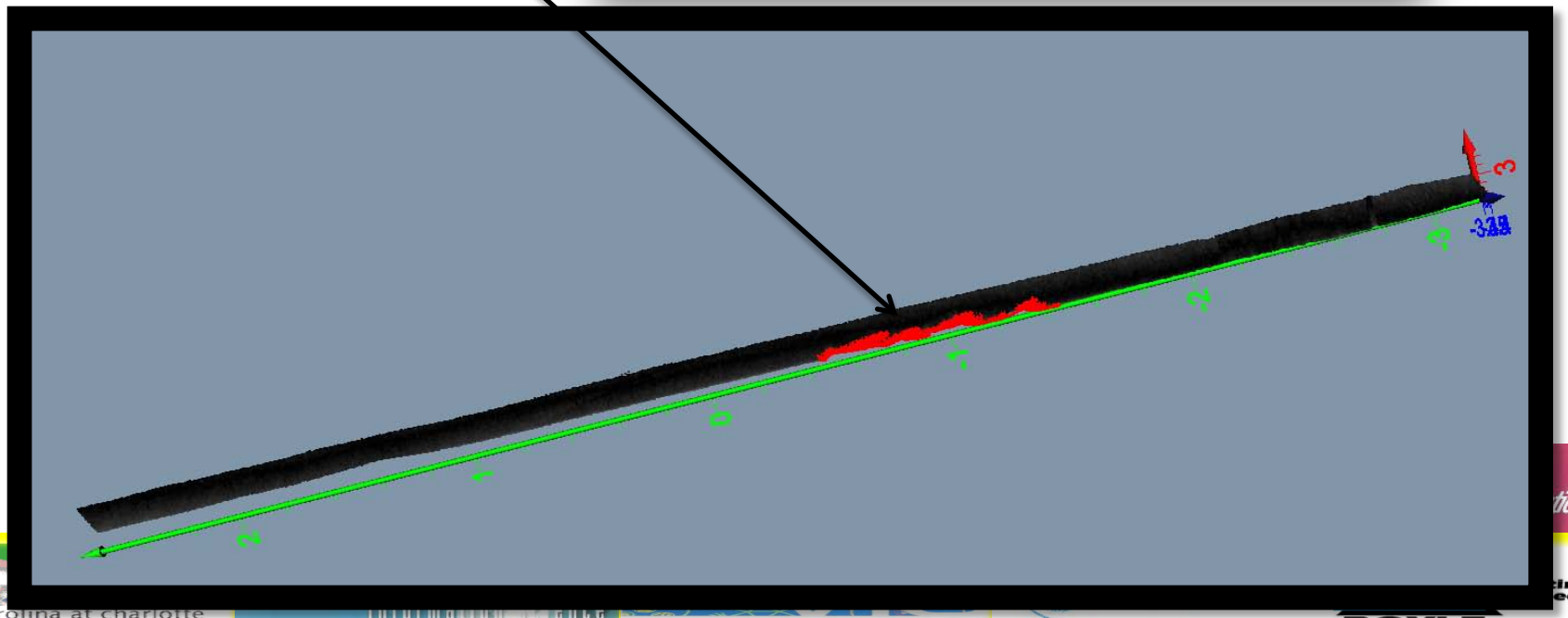
Defect Detection

Defective Area:

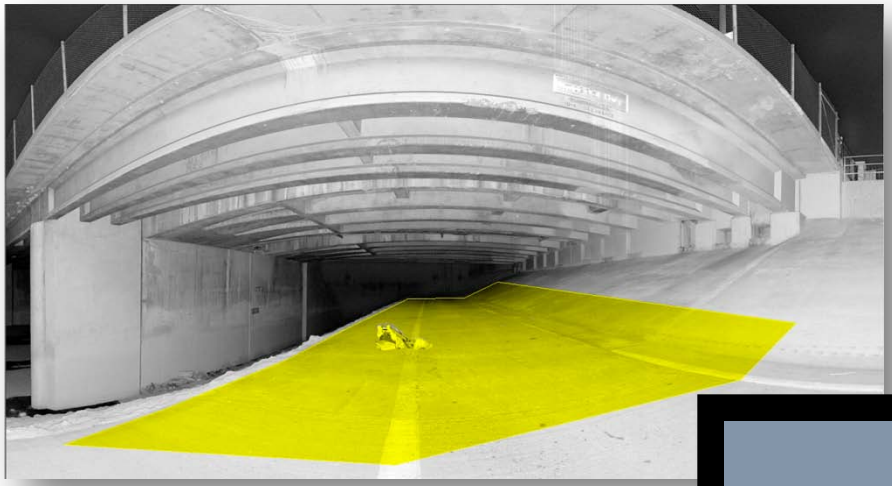
1.375E-002m^2

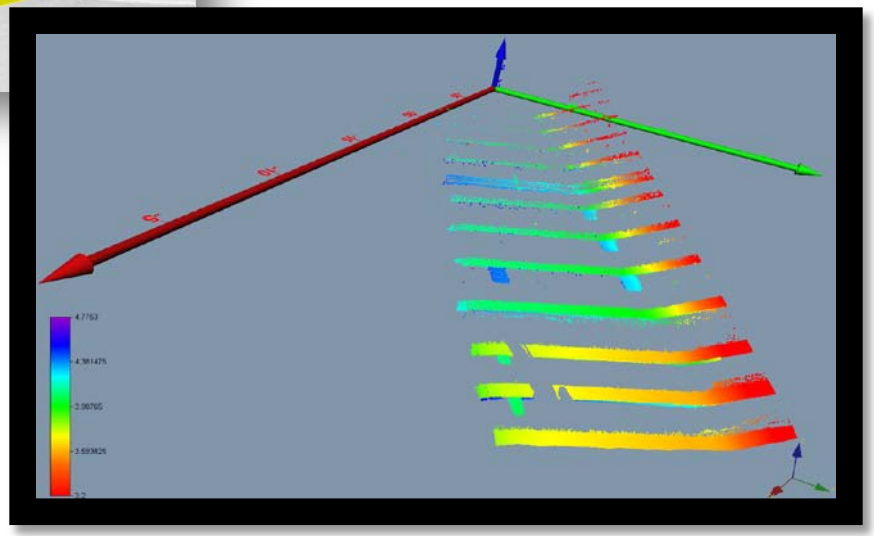
Defective Volume:

3.136E-004m^3



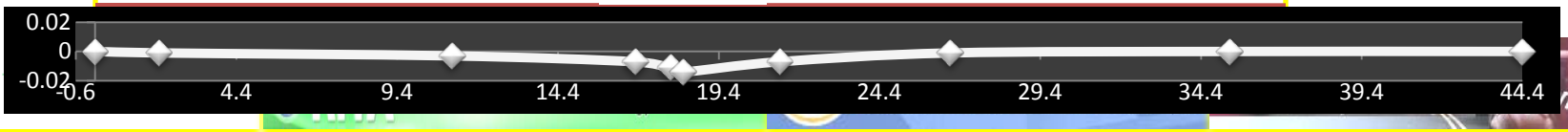
Clearance Measurement





Measured clearance at the damage location is around 12 feet

New Construction Load Test Deflection Measurement



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“Market Research” Results

- National survey conducted by AASHTO and our joint efforts indicate:
  - More than 40 states use PONTIS – database structure, but not the BMS component.
  - PONTIS does not include CRS data.
  - There is a strong push to integrate our technologies with PONTIS – may dictate commercialization approach.
- No direct applications of CRS on any bridge regular inspections.
- There is limited understanding about CRS among bridge engineers.

Testimonials from Partners (over 10 divisions)

- **Recognition of new information**: Bridge managers considered IRSV useful in depicting bridge temporal trends and patterns as well as revealing structural attribute correlations.
- **Effective data study**: “much easier than making similar observations from Excel or other database.”
- **Balancing inspection subjectivity**: Multiple coordinate views in IRSV can help reduce influences from individual differences.

Phase 1 Self-Evaluation

- System design based only on two regional DoTs – need more DoTs – clustered modeling.
- Is Ontology the best approach to knowledge modeling? – need to explore other knowledge modeling techniques – advanced knowledge modeling.
- Potential of Visual Analytic applications – what can we learn from visualization.
- Bridge joint movement evaluation (temporal effects) not included – need multiple year remote sensing data.

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