

Mobile Model-based Bridge Lifecycle Management Systems (*MMBLMSs*)

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Telegeoinformatics and Infrastructure Management Group

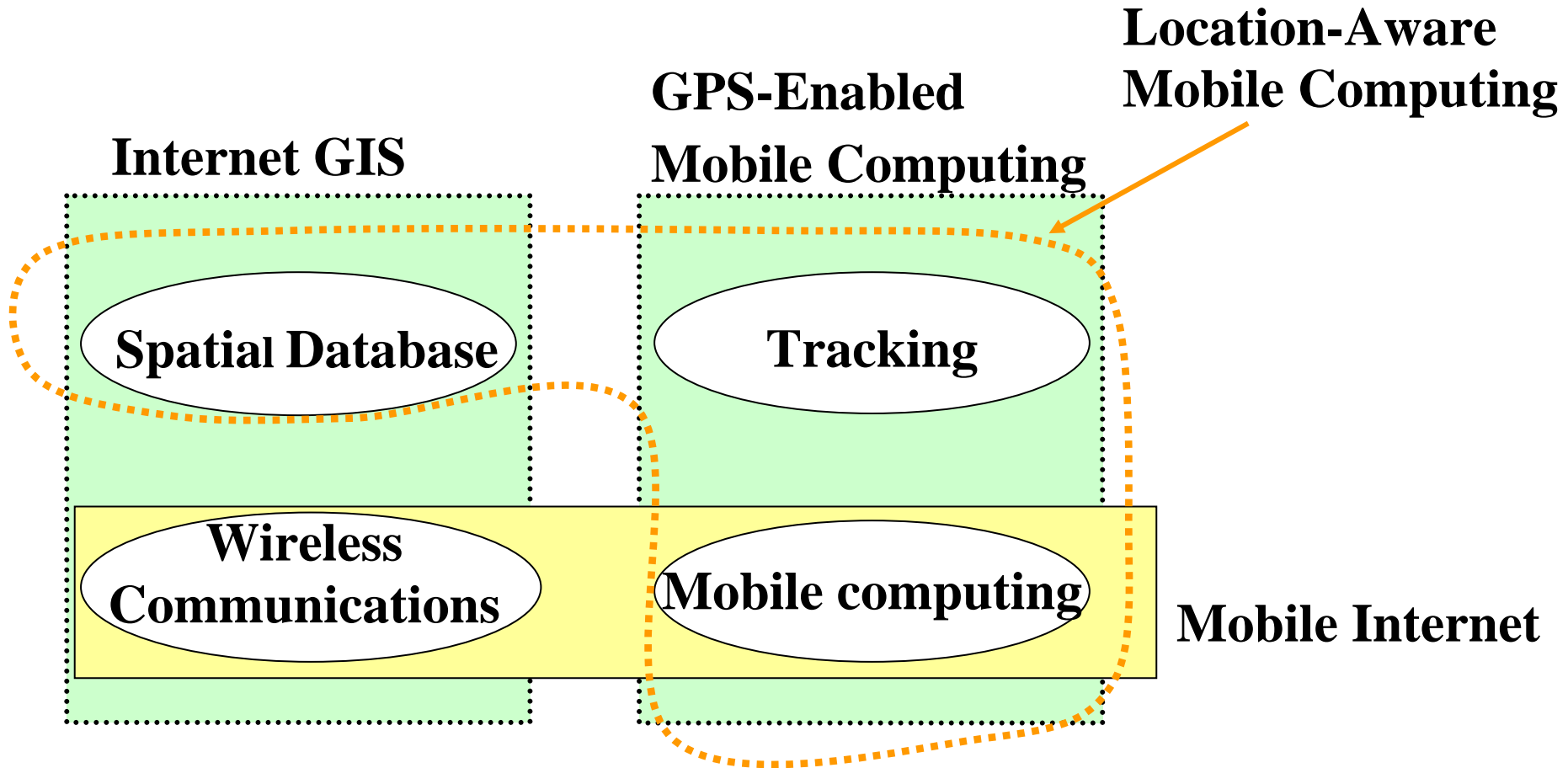
**Concordia Institute for Information Systems Engineering (CIISE)
Concordia University, Montreal**

Needs for Mobile Computing

- Field workers (e.g., inspectors, construction superintendents) need to read maps and drawings and access and update information
- Data from visual inspection, non-destructive testing, or health monitoring systems should be fused
- Location information is important

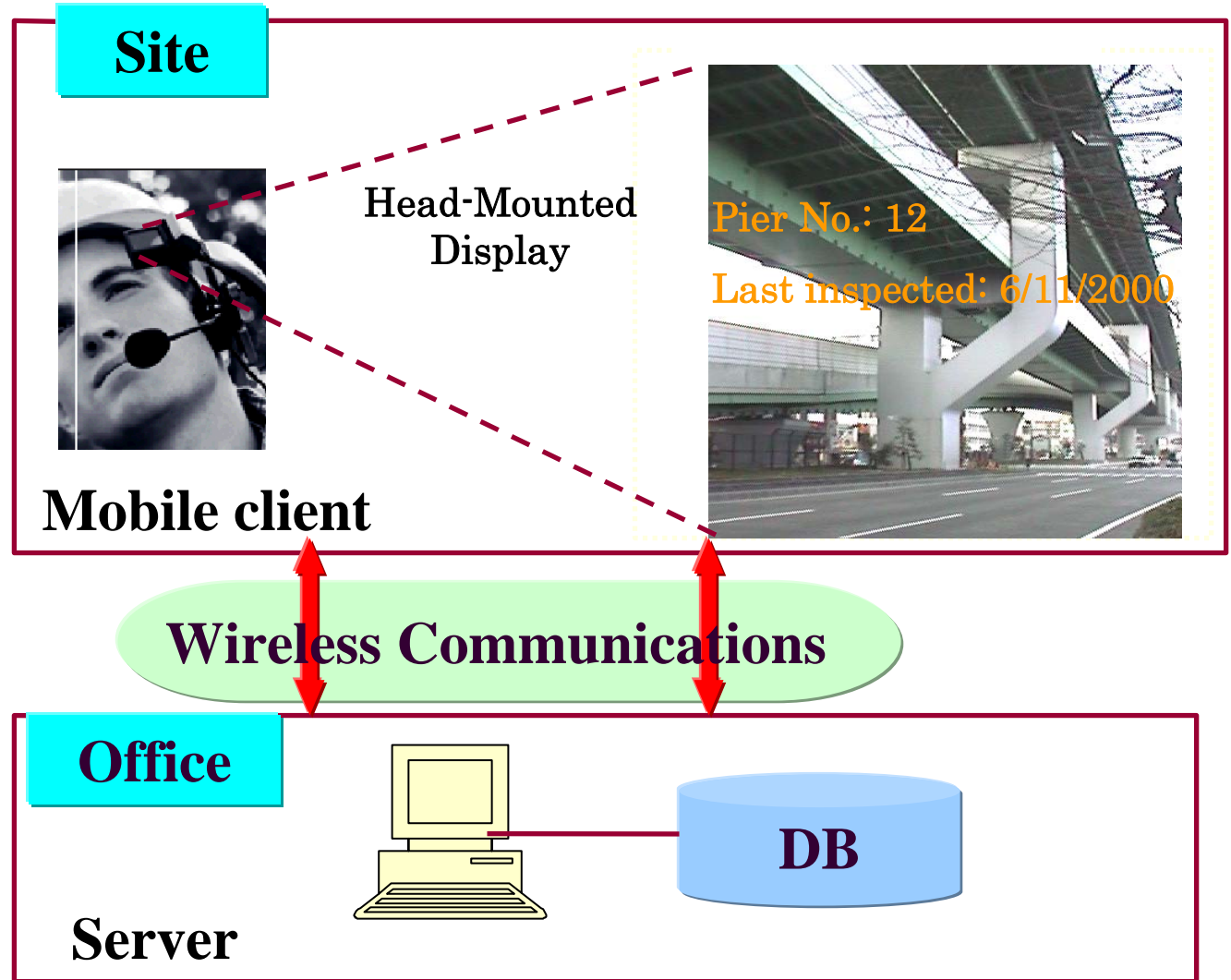


Telegeoinformatics Technologies



Vision: Augmented Reality Inspection System

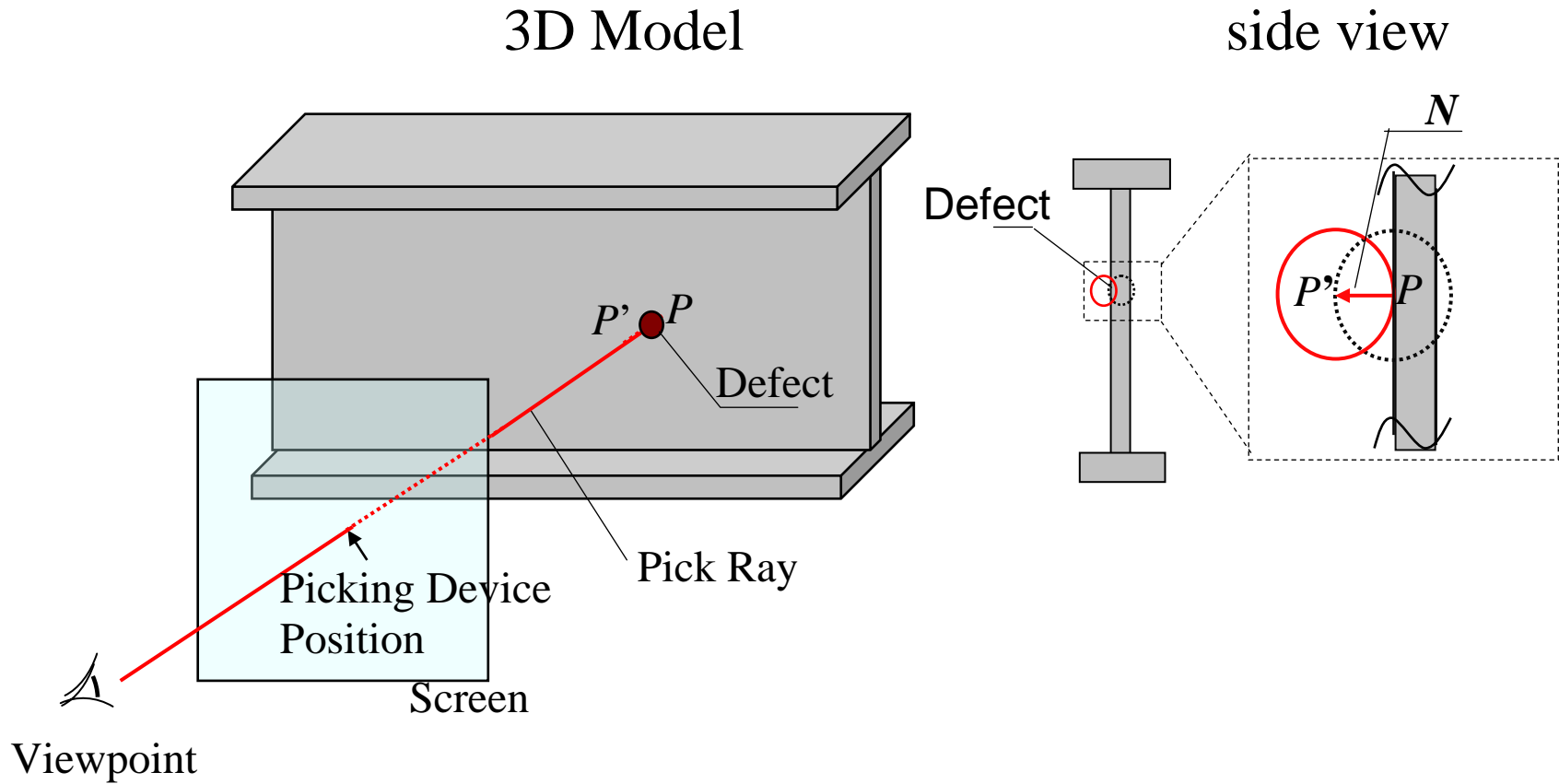
Tracking devices:
DGPS,
Gyroscope,
Digital compass,
Tilt sensors, etc.



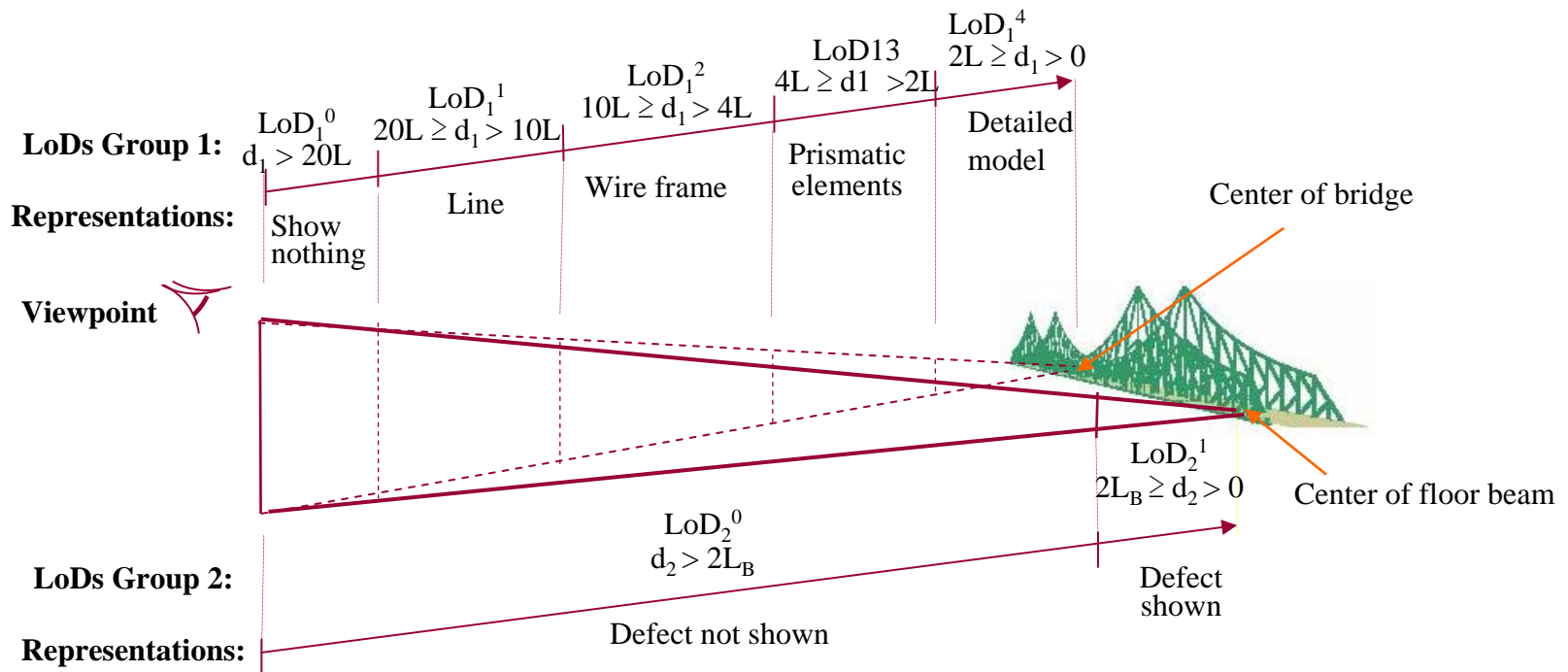
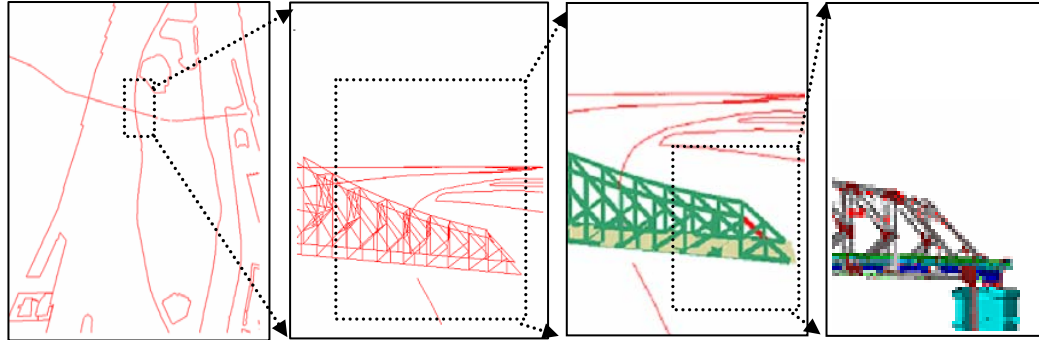
Requirements of MMBLMSs

- 4D modeling
 - Allowing for spatio-temporal visualization
- Lifecycle data integration
 - Design, construction, inspection, and maintenance
- Standardization Issues
 - Using de-facto and international standards (e.g., IFC)
- Databases Issues
 - Support distributed databases
- Mobile and location-based computing
 - Used on thin clients (e.g., PDA and tablet PC)
 - Tracking devices (e.g., GPS)
 - Wireless communications
- 3D user interfaces
 - Space and time Levels of Details (LoDs)
 - Navigation
 - Picking

Picking a 3D Model for Marking Defects



Relationship Between Distance and LoDs



d_1 : Distance between center of bridge and viewpoint

d_2 : Distance between center of beam and viewpoint

L : Length of bridge

L_B : Length of beam

Prototype System Development

- Development in Java and Java 3D
- Use MapObjects Java Edition to integrate GIS
- Present the 4D model of the bridge with LoDs
- Design a window-based GUI for Tablet PC
- Develop databases for construction, inspection and maintenance

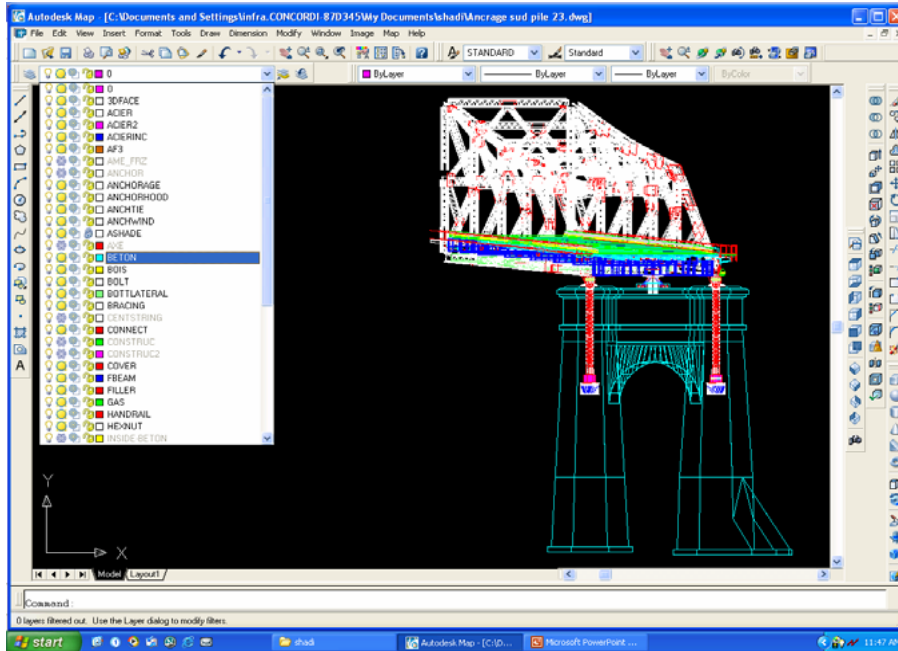
Case Study: Jacques Cartier Bridge



- Landmark of Montreal
- One of the busiest bridge in North America
- More than 70 years
- Re-decking in 2001 and 2002

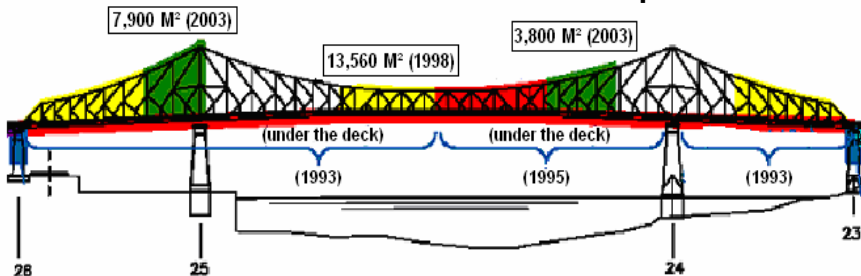
Sample Data of Jacques Cartier Bridge

AutoCAD Drawings

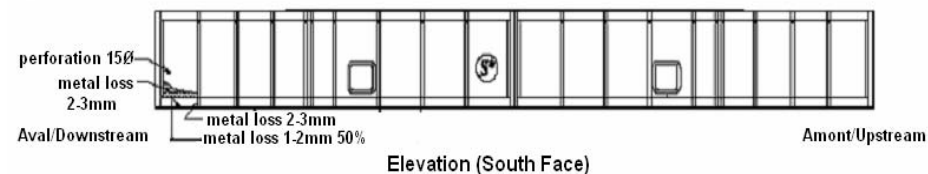


Schedule of Deck Rehabilitation

Maintenance Data: Main Span Painting



Floor-Beam Inspection Data



Mobile Computing Techniques



Digital camera

GPS and RF antennas

Tablet PC
with electronic stylus

- Tablet PC with electronic stylus
- RTK-GPS tracking
- Digital camera
- Microphone
- Wireless communications
- etc.

Model Interface

The screenshot shows the Bridge 3D Simulator interface. At the top left is a 'Calendar for date input' showing December 2004 with the date 11/30/28 selected. To its right is a 'GIS interface' window displaying a map of the bridge's location. The main 3D view shows a bridge model with 'Built elements' in blue and 'Not built elements' in yellow. A '4D browser' is visible in the background. At the bottom of the 3D view are 'Pre-defined cameras' labeled Camera1 through Camera5. On the right side, there is a 'Navigation tree' listing components like Foundation, SuperStructure, Deck, and SubStructure. Below it is a 'Color codes' legend for Corrosion, MetalLoss, Perforation, Undulation, Serious, and Very Serious. Further down is a 'Simulation' table with fields for Start time, End time, Start, Hide Model, Construction_Sim, Rehabilitation_Sim, Map, CPM Simulation, and Inspection. Below the simulation table is a 'Time slider' for Year, Month, and Date. At the bottom is an 'Element Detail' table with columns for ID, Element_ID, Type, Length, Width, Height, StartX, StartY, StartZ, EndX, EndY, EndZ, Material, Cross-section, and Notes. Buttons for 'Show All Records', 'Clear All Records', 'Clear Selection', and 'Go to Element' are located below the table.

Calendar for date input

GIS interface

Navigation tree

Color codes

Start time

End time

Workspaces generation and analysis

Time slider

Built elements

Not built elements

4D browser

Pre-defined cameras

ID	Element_ID	Type	Length	Width	Height	StartX	StartY	StartZ	EndX	EndY	EndZ	Material	Cross-section	Notes
Trying to locate element...														



- JCBridge
 - Foundation
 - SuperStructure
 - SubStructure

Legend for simulation parameters:

- Construction period:
- Input period:
- Corrosion:
- MetalLoss:
- Perforation:
- Undulation:
- Light:
- Moderate:
- Serious:
- Very Serious:

Simulation	
Start time	<input type="text"/>
End time	<input type="text"/>
Start	Maintenance
Inspection	Hide Model
Reset Model	Construction_Sim
Rehabilitation_Sim	Map
Hide >	Truss_Inspection

Year

Month

Date

Camera1 Camera2 Camera3 Camera4 Camera5

Element Detail														
ID	Element_ID	Type	Length	Width	Height	StartX	StartY	StartZ	EndX	EndY	EndZ	Material	Cross-section	Notes
<input type="button" value="Show All Records"/> <input type="button" value="Clear All Records"/> <input type="button" value="Clear Selection"/> <input type="button" value="Go to Element"/>														

Database jdbc:odbc:Bridge is connected.
Welcome YTT


Inspection Interface

The screenshot shows the 'Bridge Truss Inspection' software interface. On the left is a tree view of inspection categories. The main area contains a data entry form with fields for TaskID, InspectorName, InspectionDate, InspectionType, ElementType, InstrumentName, InspectionTechnology, DamageType, and Picture. A 'Report' section shows 'Query successful'. At the bottom are buttons for 'Find', 'Add', 'Update', and 'Clear'. A small photo of a crack is visible on the right side of the form.

Inspector	Schedule	Element	Instrument	Damage	Task
TaskID	8				
InspectorName	yongxin, hu				
InspectionDate	January 06, 2004				
InspectionType	Routine				
ElementType	UL-LDiangoloElement-202				
InstrumentName	Ultrasonic				
InspectionTechnology	Ultrasonic testing				
DamageType	Fatigue crack				
Picture	crack.jpg				

Report: Query successful

Buttons: Find, Add, Update, Clear



Inspection Interface

The image displays two software interfaces for bridge inspection. The top window, 'Bridge 3D Simulator', shows a 3D model of a bridge truss with a red rectangular area highlighted. A yellow callout box labeled 'Marking damage by picking' points to this area. Another yellow callout box labeled 'Navigation arrow' points to a small white arrow on the bridge deck. The bottom window, 'Bridge Visual Inspection', shows a detailed form for inspecting a 'Section-Loss' defect. A yellow callout box labeled 'Image capturing' points to the 'Image Capture' button. Another yellow callout box labeled 'Hyperlink function' points to a field containing the number '1949'. A final yellow callout box labeled 'Evaluation of a member's condition using expert system' points to the 'Evaluation' button at the bottom of the form.

Damage type

- Corrosion
- Metal-Loss
- Perforation
- Undulation

Damage level

- Light
- Moderate
- Serious
- Very Serious

Simulation

Start time	2/16/05
End time	5/25/05
Start	Maintenance
Inspection	Hide Model
Reset Model	Construction_Sim
Rehabilitation_Sim	Map
Hide >	CPM Simulation
WorkSpaceG	WorkSpaceA
DiscreteS	

Bridge Visual Inspection

Inspector | Schedule | Instrument | Process | Element | Damage | Task

Element ID: 973
Element Material: Steel
Image Capture

Section-Loss
Section-Loss Inspection Content

Dimension
Percentage(%) 12
Level severe
Depth(M) 0.03

Location
Side North Face South Face
Direction West East
Horizontal Distance(M) 3.50
Vertical Distance(M) 0.63

Description
Consider advanced inspection

Picture & Video

Picture Show Save Remove Clear Evaluation

Conclusions and Future Work

- A new type of **M**obile **M**odel-based **B**ridge **L**ifecycle **M**anagement **S**ystems (MMBLMSs) were investigated including creating an object-relational data model, technology integration and applications development.
- Several computational issues for realizing the framework were also investigated, such as navigation, picking and LODs.
- The developed prototype system integrates 3D graphics and a database to realize the 4D model of Jacques Cartier Bridge.
- The preliminary testing of the system and its user interface showed that it has good potential for realizing future MMBLMSs.
- Further development and testing of the system in practical situations are necessary to improve the functionalities and usability of the system.