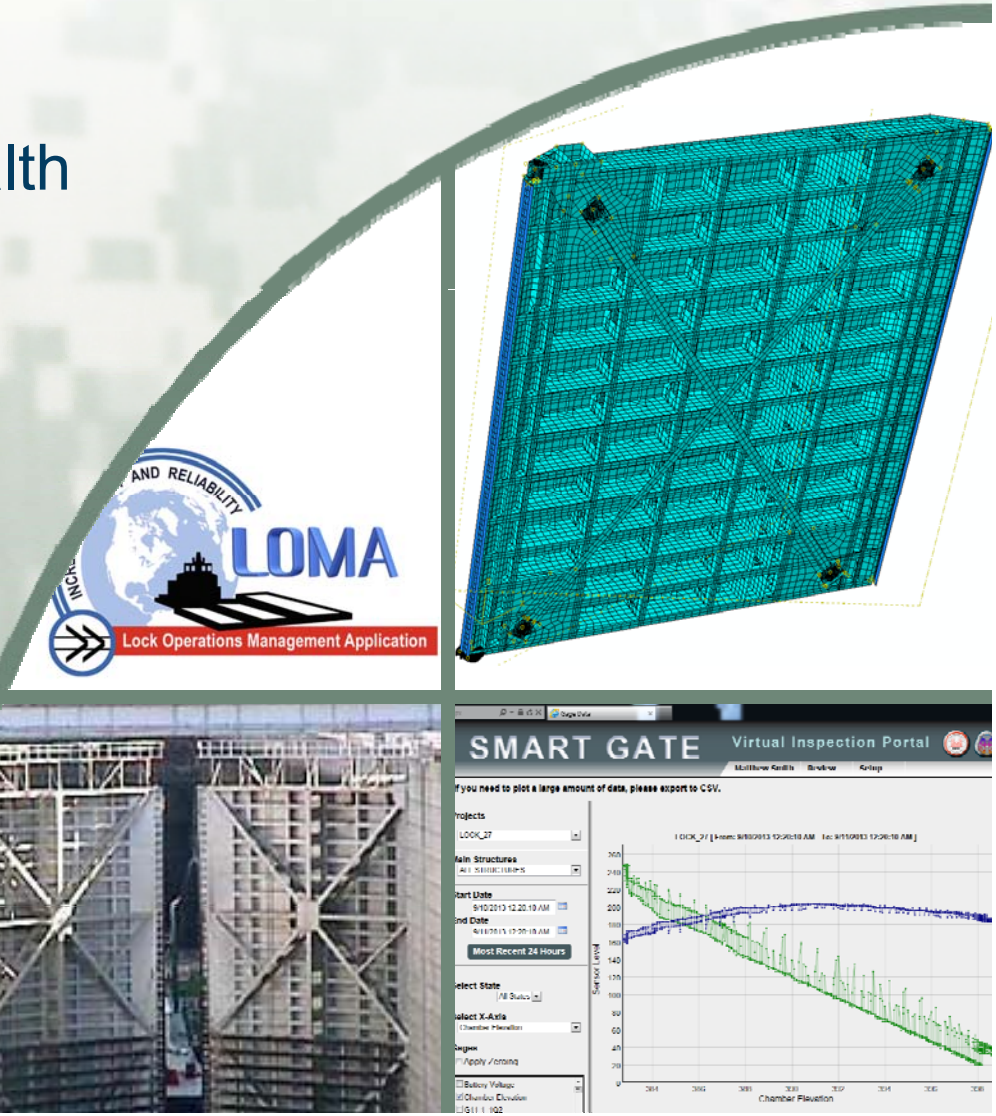
Automated Data-to-Decision Support Research

ERDC
Engineer Research and Development Center

Applications for Structural Health



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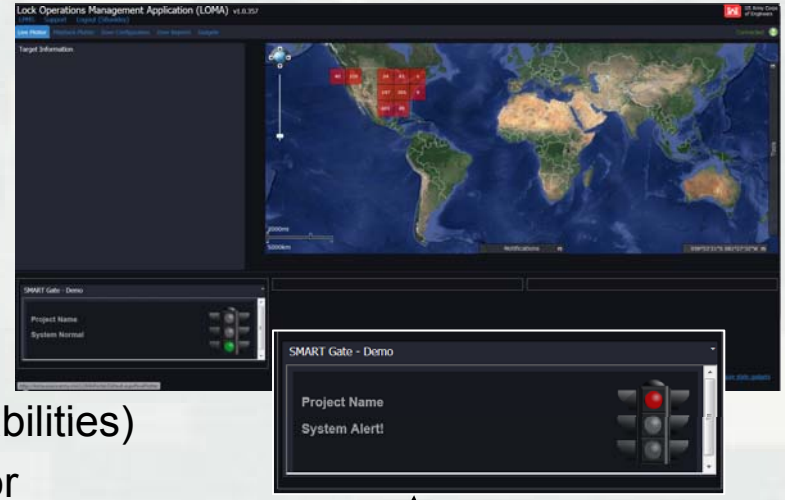
ERDC-ITL

28 October 2014

US Army Corps of Engineers®

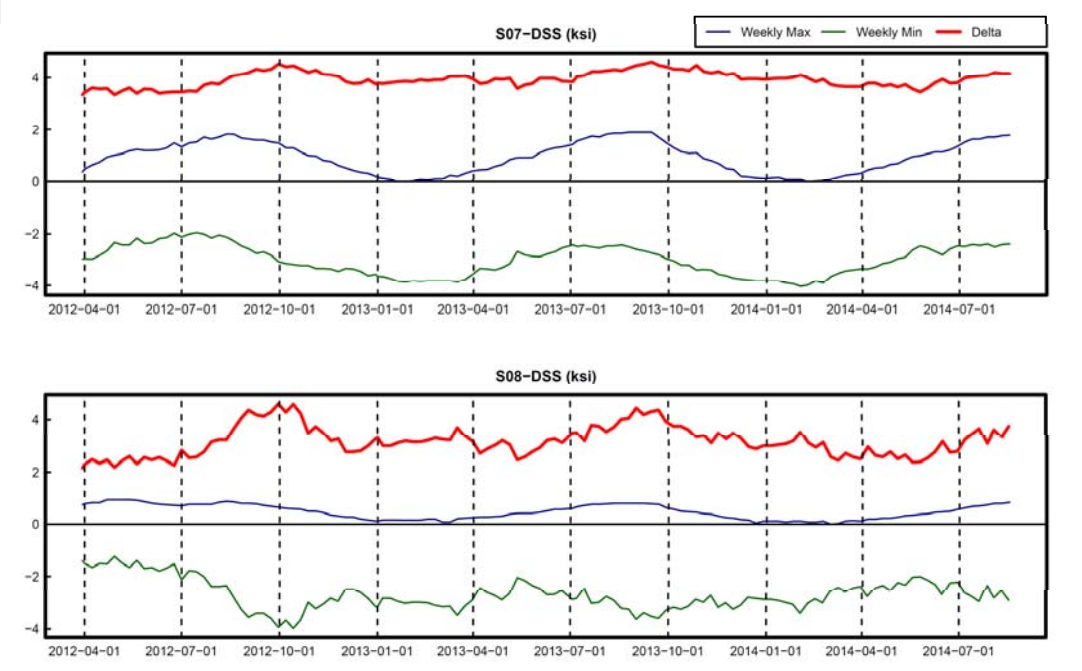
SMART Gate 2.0



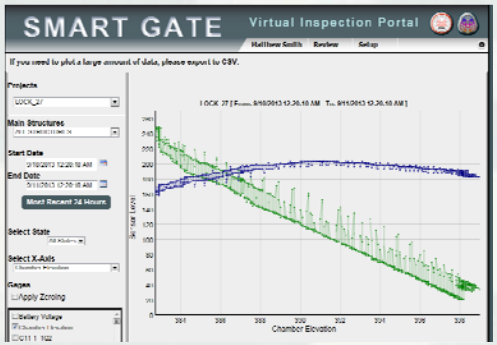
- Early warning system
  - Automated detection
    - Leading to catastrophic conditions
    - Useful to field
    - Quick to implement (within current capabilities)
    - Traffic light type signals for lock operator
    - LOMA implementation
  - Data-portal for post-warning decision support
  - Affordable
  - Incorporate structural and mechanical systems
  - Design guidance and specifications for existing and new gates

Early SMART Gate 1.0

- 5 Lock Projects
  - Greenup
  - The Dalles
  - Bonneville
  - Meldahl
  - Lock 27 (St. Louis)



- Engineering Focus
- Instrumentation Monitoring
- Manual Alarms
- Web-Portal: http://smartgate.erdc.dren.mil



- NWP using this to help save ~$400K / year

Lessons Learned

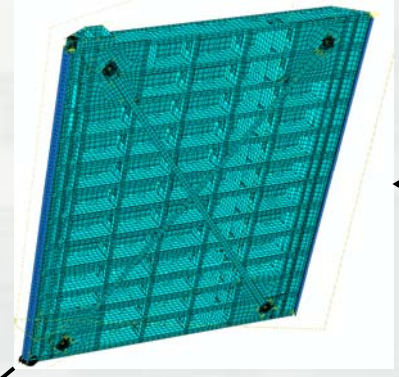
Structural Monitoring and Analysis in Real-Time (SMART)

Version 1.0	Version 2.0
Many Sensors	Few Sensors
No Detection Targets	Carefully Selected Targets
$600k+ per Chamber	Goal of <$250k per Chamber
No Automated Decision Support	Automated Event Detection using FEM
Easy Data Access and Plots via Website https://smartgatedev.usace.army.mil	Same Web Access with Plotting + LOMA Warning Traffic Lights
Manual Alarms (email & text)	Auto and Manual Alarms (email & text)
No Elec/Mechancial Sensors	Incorporated Elec/Mech. Sensors

SMART Gate 2.0

Validation Data

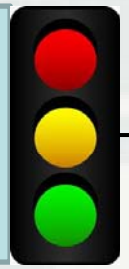
Sensors at Lock



High-Fidelity FEM

Surrogate Model

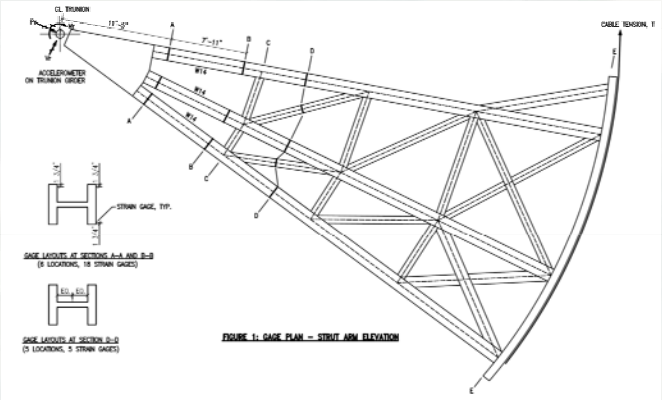
Decision Support
-Warning Lights
-Data Archival/Retrieval
-Email/Text Alerting

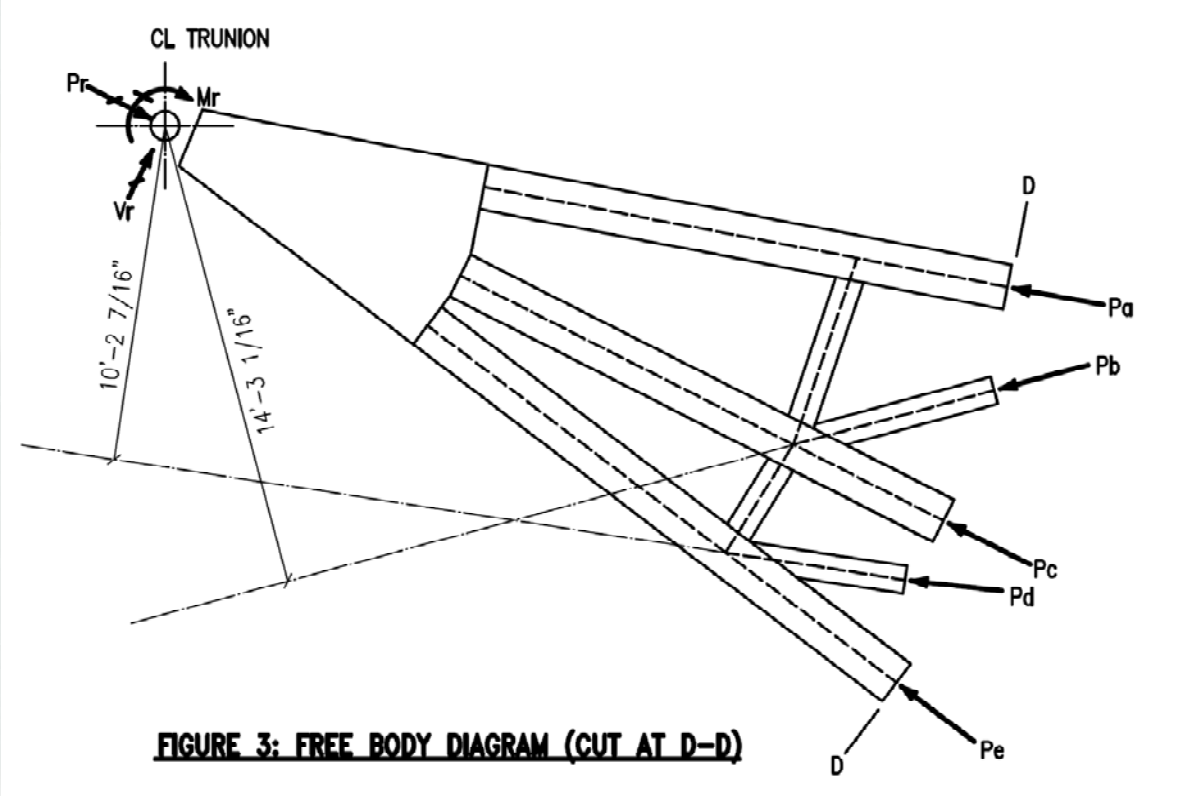


Reachback Capability

Detection Targets
(Verified with Field Needs)
- Barge Impact
- Quoin/Wall Degradation
- Dragging Debris

Trunnion Friction Monitoring



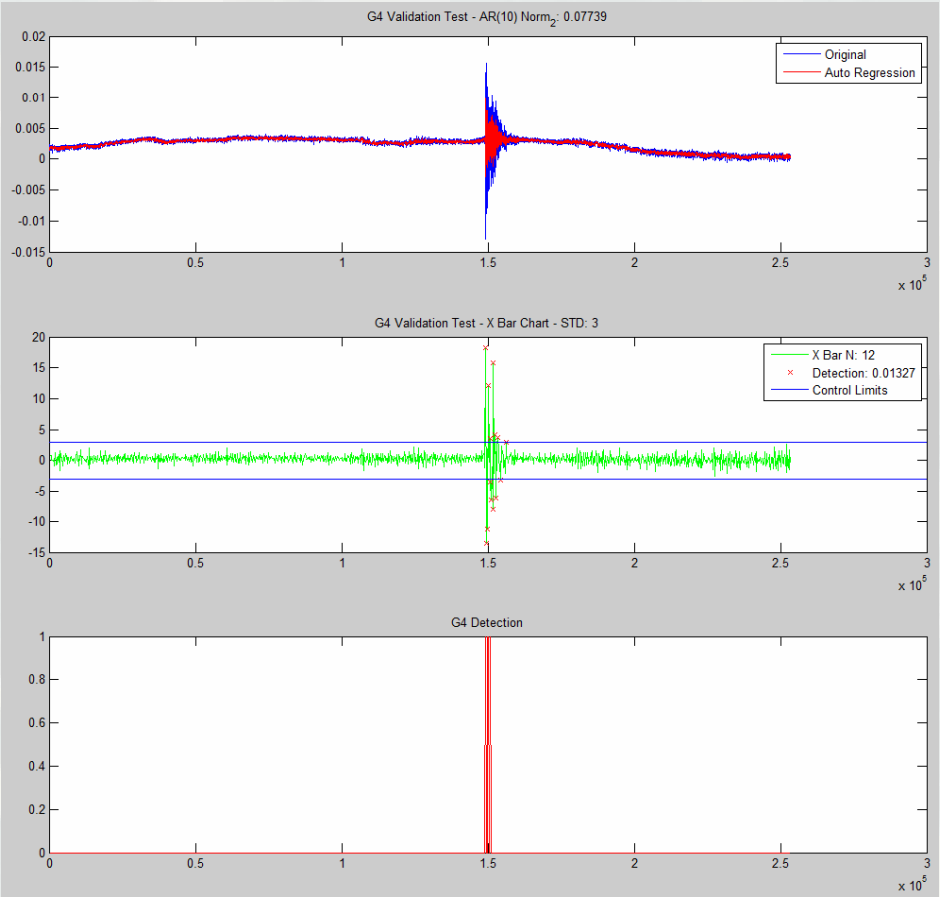


- Minimal sensors to detect trunnion friction
- Threshold alerts to inform for lubrication
- Vibration
- Strength

Condition Monitoring Targets

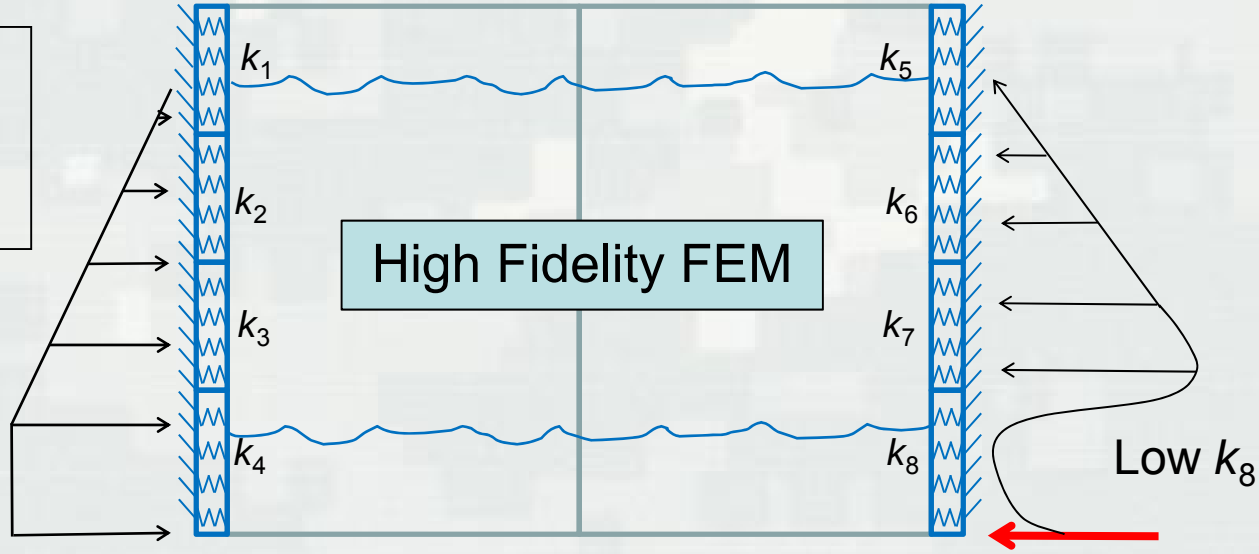
- Three Initial Targets Developed with Field (District Ops and Eng) PDT
  - Lock Gate Barge Impact
  - Degrading Quoin-to-Wall Contact
  - Dragging/Trapped Debris

- Barge impact
  - Test acceleration vs. learned thresholds
  - Combined with LOMA can determine parties responsible for repairs
  - Algorithms developed with actual barge impact data



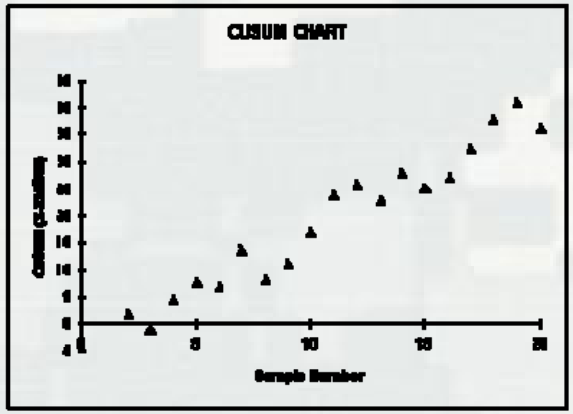
Condition Monitoring Targets

Degrading Quoin-to-Wall Contact



Elevation of Gate

Force on Pintle!!!



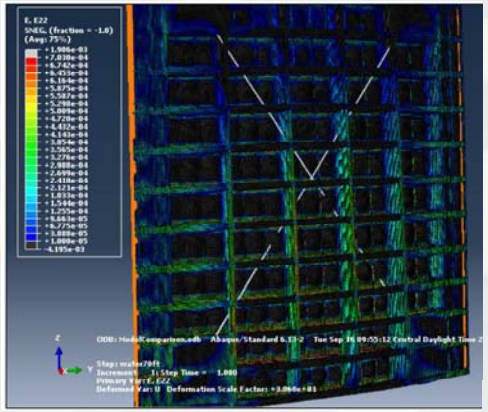
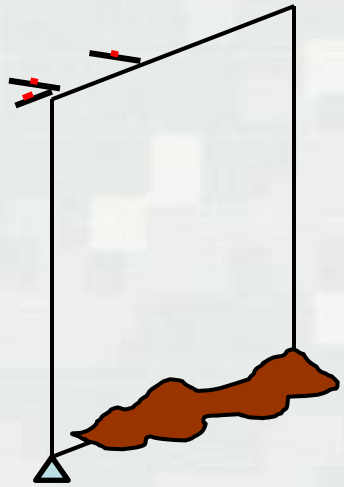
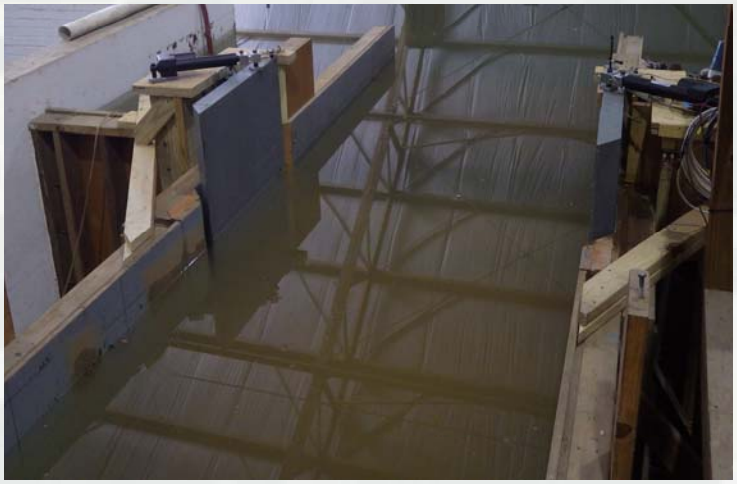


Image Ref: http://lorien.ncl.ac.uk/ming/spc/spc8.htm

Condition Monitoring Targets

- Dragging/Trapped Debris
  - Forces in anchors and struts indicate dragging
  - Auto-regressive time-series techniques
  - Statistical process control
  - Scale Model V&V





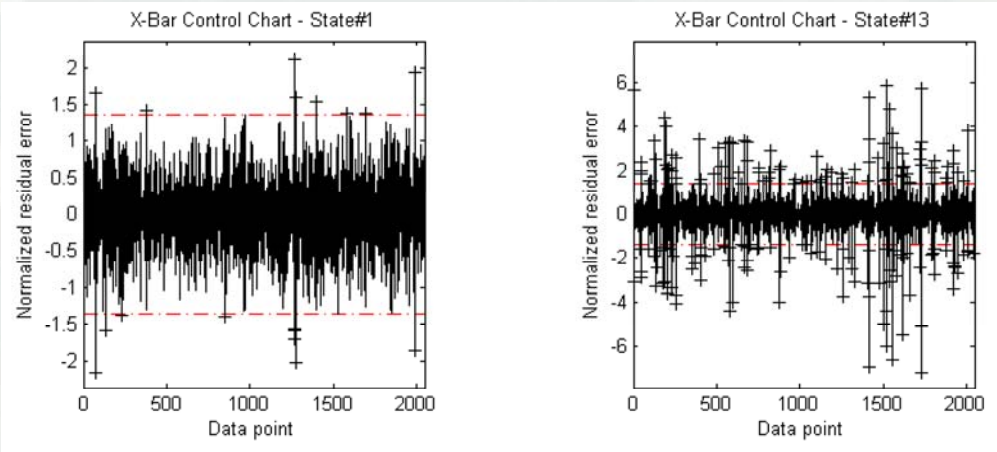


Image Ref: SHM Course Notes, Los Alamos Dynamics, http://www.la-dynamics.com/