Changes in IT and Strategies for Civil Engineering

How Big Data is Affecting Your Life and Civil Engineering

Geo3T2 Conference
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NC State University

2012 Horizon Report – Technologies to Watch

- Within next 12 months:
    - Mobile Apps
    - Tablet Computing
- Within 2~3 years:
    - Game based learning
    - Learning analytics
- Within 4~5 years:
    - Gesture based computing
    - The Internet of Things

http://www.nmc.org/pdf/2010-Horizon-Report.pdf

Top Issues Affecting University IT

- Big Data
- Research Funding
- Online Education
- Mobility
- Cloud
- Globalization

Focus on Big Data

THE **MOBILE WEB** RECEIVES **217** NEW USERS.

YOUTUBE USERS UPLOAD **48** HOURS OF NEW VIDEO.

EMAIL USERS SEND 204,166,667 MESSAGES.

GOOGLE RECEIVES **OVER** 2,000,000 SEARCH QUERIES.

WORDPRESS USERS PUBLISH **347** NEW BLOG POSTS.

571 NEW WEBSITES ARE CREATED.

FACEBOOK USERS SHARE **684,478** PIECES OF CONTENT.

CONSUMERS **SPEND** $272,070 ON WEB SHOPPING.

EVERY MINUTE of the **DAY**

FOURSQUARE USERS **PERFORM** **2,083** CHECK-INS.

FLICKR USERS ADD **3,125** NEW PHOTOS.

INSTAGRAM USERS SHARE **3,600** NEW PHOTOS.

TUMBLR BLOG OWNERS PUBLISH **27,778** NEW POSTS.

BRANDS & **ORGANIZATIONS** ON FACEBOOK **RECEIVE** **34,722** "LIKES."

TWITTER USERS SEND OVER **100,000** TWEETS.

APPLE RECEIVES ABOUT **47,000** **APP** DOWNLOADS.

Value to Industries Impacted by Civil

Who Will Benefit Most From Big Data

Sequence of Alerts

Advanced Analytics with multiple data sets had alert 60 days earlier

GI Distress by Date

NC EMS Data

University Data Mart – Vision

NC STATE UNIVERSITY

Existing NC State Databases

- Student data (courses, demographics, grades, etc)
- Faculty and Staff (demographics and employment information)
- Door and gate security (approved locations you can enter (if electronic))
- Library access (books, reservations, etc)
- Room reservations (both classes and ad-hoc)
- Fiscal (budgets and expenditures for units)
- Facilities
- Motorpool info (fleet inventory, reservations, etc.)
- Property insurance
- Bookstores
- Hazardous materials tracking
- Surplus and inventory management
- Asset management (capital and non-capital)

- Maxient (Office of Student Conduct)
- Student Health system
- All Campus Card
- Ticket Central (Ticketing systems for ArtsNCState)
- MySoft in ComTech (Phone & Network)
- Remedy (Help Desk requests and IT service)
- Transportation Ticketing system
- Research Grant Proposal system - PINS
- Software Licensing Access
- Anti-Virus Information
- Advancement data (donor profiles, giving records, etc.)
- Conference services
- Research (grants and effort reporting in addition to proposals)
- Teaching licensure tracking
- Athletics Data

NC-NGN - Joint RFP for 1 Gig bandwidth

Chapel Hill, Carrboro, Cary, Durham, Raleigh, Winston/Salem &

Duke, NC-State, UNC-CH & Wake Forest

- Facilitate Industry to build 1-Gb fiber to business, homes & MDUs

Hunt Library – High Tech Collaboration

Hunt Library

Collaboration is Key

Hunt Library – Collaboration is Key

Hunt Library

Research Focus

So How Does This Relate to Civil Engineer?

- Civil Engineering is highly data intensive
- Big Data is found in two forms:
  - Structured (we are most used to this)
  - Unstructured (Text, video, pictures, twitter, comments, observations, …
- We need to be part of the revolution

Barge Impact Tests at St George Island Bridge

Barge Impact Tests were conducted at St. George Island Bridge during March / April 2004. A total of 15 impact tests were conducted

Courtesy of UF Structure Research Group, Gary Consolazio et al.

Validation of Coupled Vessel Impact Analysis (CVIA) Models of FB-Multipier

Impact force time history

Courtesy of UF Structure Research Group, Gary Consolazio et al.

Data management

Upload of soil boring data

Sustainability (performance monitoring)

- Imote 2 + SHM-A smart sensors >> real-time data collection >> database >> structural performance analysis upon extreme event

Tanker strikes San Francisco-Oakland Bay Bridge

By By GARANCE BURKE and PAUL ELIAS | Associated Press – Tue, Jan 8, 2013

Associated Press/Jeff Chiu – The tanker Overseas Reymar travels in the San Francisco bay from Yerba Buena Island, Calif., Monday, Jan. 7, 2013. The empty oil tanker ship struck the San Francisco-Oakland Bay ...more ▼

RELATED CONTENT

SAN FRANCISCO (AP) — Coast Guard investigators on Tuesday plan to interview the pilot of an empty tanker that struck a tower in the middle of the San Francisco-Oakland Bay Bridge while navigating beneath the hulking span.

The 752-foot Overseas Reymar rammed the tower on Monday afternoon as it headed out to sea, according to the Coast Guard and state transportation officials.

Geostatistical analysis

Probabilistic analysis
(a heterogeneous soil condition
out of 9,000 geostatistical realizations)

Geostatisical prediction of
bearing stiffness

Old Way of Handling Big Data - Caltrans Experience

- ☐ 30,000 project files
- ☐ 2 million documents
- ☐ 300 projects/year
- ☐ 80 years of data
- ☐ Difficult to access information

Real World

Data Construction

Linkages

Sample collected from exploratory hole

Three sub-samples created in laboratory

Sub-samples tested in triaxial compression

Project

locations

Hole — ID = ABCD-1

samples

Sample — ID = ABCD-12 / Source = ABCD-1

Sample — ID = ABCD-20 / Source = ABCD-12

Sample — ID = ABCD-123 / Source = ABCD-20

Sample — ID = ABCD-124 / Source = ABCD-20

Sample — ID = ABCD-125 / Source = ABCD-20

laboratoryTesting

CompressiveStrength — ID = ABCD-1234 / Source = ABCD-20

CompressiveStrengthDetail — ID = ABCD-12345 / Source = ABCD-123

CompressiveStrengthDetail — ID = ABCD-23456 / Source = ABCD-124

CompressiveStrengthDetail — ID = ABCD-34567 / Source = ABCD-125

Hole — ID = ABCD-1

Sample from Hole — ID = ABCD-12 / Source = ABCD-1

Sample from Sample — ID = ABCD-20 / Source = ABCD-12

CompressiveStrength — ID = ABCD-1234 / Source = ABCD-20

Sample from sample — ID = ABCD-123 / Source = ABCD-20

CompressiveStrengthDetail — ID = ABCD-12345 / Source = ABCD-123

Sample from sample — ID = ABCD-124 / Source = ABCD-20

CompressiveStrengthDetail — ID = ABCD-23456 / Source = ABCD-124

Sample from sample — ID = ABCD-125 / Source = ABCD-20

CompressiveStrengthDetail — ID = ABCD-34567 / Source = ABCD-125

Real World

Borehole with well installed

water level

groundwater samples

duplicate groundwater samples

trip blank sample

Data Construction

Project

Hole — ID = DMDC-BH1

Sensors

Installation — ID = DMDC-BH1W

Samples

standard sample — **Sample** — ID = DMDC-BH1W_20070613
Source = DMDC-BH1W

duplicate sample — **Sample** — ID = DMDC-BH1W_20070613b
Source = DMDC-BH1W

trip blank sample — **Sample** — ID = DMDC-TB1_20070613

Groupings

Group — ID = DMDC-GROUP_1
ID = DMDC-BH1W_20070613
ID = DMDC-BH1W_20070613b

duplicate group

Group — ID = DMDC-GROUP_2
ID = DMDC-TB1_20070613
ID = DMDC-BH1W_20070613
ID = DMDC-BH1W_20070613b

trip blank group

This is one example of a considerable number of complex examples that have been considered

What is happening here in North Carolina?

NC STATE CIVIL ENGINEERING

Smart Grid Management: A Big Data Problem

Real-time big data processing and control

1   2   3   ... N

Communication Network

Smart Grid Power System Layer

Time-sensitive big data
- Sensor measurements
- Storage gauge
- Utility price
- Fault event

- Over 963 million distributed sensors and controllable devices by 2020
- Penetration of 68.4 million PHEVs/PEVs to the market by 2023
- Over 76 million MWh energy storage capacity

- **Trade-Off** : Real time Implementation vs. Accuracy

Incorporating Sensors in Undergraduate Education: Remote Monitoring of Geostructural Health

Post-construction monitoring of large geo-structures is increasingly frequent.

- Two earth dams and a large load frame on the NCSU Centennial Campus have been instrumented for monitoring

- Pore water pressures, dam movement, and strains in the steel superstructure are monitored

- Data are transmitted wirelessly, uploaded to a database and posted to the project website

Virtual Project Management

- TEAM (Tele-Engineering and Management) Laboratory
  - "Project Command Center"

Project A: Site Management Team (includes **Information Engineer**)	Project B: Site Management Team (includes **Information Engineer**)

Information Engineer: collects cost, schedule, quality, and safety data to populate the dashboard, conduct virtual tours

Clients

Knowledge experts

Project Command Center

Purpose: Oversees project operations (cost, schedule, safety, quality monitoring) and monitors high risk activities

Specific Tasks: performs virtual inspections in areas of safety and quality; monitors large, heavy lifts; tracks performance metrics; serves as knowledge expert hub; sets up virtual meetings with clients, banks, insurance companies, and designers

Technologies Used for Virtual Construction Management

iPhones, Androids, or

MiFi

Video/Audio Capture

Signal Transmission

Reception/Real time Interaction

Lean Construction:
A Production Management Based Approach to Project Delivery

Delay

- Cause of delay in construction activity?
- Frequency and severity of those causes?
- How does my delay impact my neighbors and who should be responsible for what?

Causes of variation that pose greatest risk

Trade Social Network

- Identified the frequency and severity of causes for delay

- Investigated how the trades are connected and affected by delay in the trade social network

- Help contractors increase *value* and *reduce waste* in project delivery process

Structural Health Monitoring and Prognostics: Technologies for Nondestructive Evaluation

Application of vibration based damage detection for rapid assessment of scour in coastal bridges.

Detecting cracks to prevent leakage. Electrically based sensor systems for inspecting concrete pipes

Traffic Operations

- Developing methods for monitoring system mobility and reliability

- Preparing a national guidebook for travel time reliability monitoring

- New methods are being developed for both freeways and signalized arterials

Segment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Stitched Route	Instant Route	Straight Average	Weighted Average
Free Flow TT	0.61	0.3	0.29	0.5	0.69	0.91	1.08	0.61	1.5	0.68	0.46	0.49	0.44	0.92	0.26	0.27	0.21	0.22	0.42	0.21	0.46	0.91	12.462	12.462	12.462	12.462
Length	0.66	0.33	0.31	0.54	0.75	0.99	1.17	0.66	1.63	0.74	0.5	0.53	0.48	1	0.28	0.29	0.23	0.24	0.45	0.23	0.5	0.99	13.500	13.5	13.5	13.5
08:00	5.43	4.17	3.26	3	2.03	1.62	1.42	1.18	1.09	1.05	1.07	1.07	1.1	1.06	1.14	1.15	1.09	1.08	1.06	1.06	1.07	1.04	1.702731	1.675752	1.692	1.617
08:15	5.43	4.17	3.26	3.66	2.41	1.86	1.63	1.16	1.09	1.07	1.09	1.07	1.11	1.09	1.18	1.15	1.13	1.1	1.08	1.08	1.08	1.05	1.770576	1.815667	1.770	1.709
08:30	5.01	3.71	3.26	3.3	2.41	1.91	1.45	1.14	1.1	1.08	1.11	1.09	1.14	1.11	1.2	1.19	1.13	1.12	1.1	1.08	1.08	1.05	1.673806	1.692572	1.717	1.659
08:45	5.01	4.17	3.43	3.66	2.41	1.88	1.45	1.16	1.1	1.08	1.11	1.09	1.14	1.12	1.25	1.19	1.13	1.12	1.08	1.09	1.08	1.05	1.680695	1.744953	1.764	1.689
09:00	4.34	3.03	2.83	2.64	1.86	1.71	1.36	1.16	1.12	1.08	1.11	1.09	1.14	1.1	1.2	1.17	1.13	1.12	1.1	1.09	1.08	1.07	1.458588	1.56991	1.570	1.525
09:15	3.42	2.38	2.04	2.2	1.71	1.48	1.23	1.12	1.07	1.07	1.07	1.09	1.14	1.08	1.14	1.12	1.11	1.1	1.08	1.08	1.07	1.05	1.32665	1.366067	1.402	1.373
09:30	2.96	2.22	1.92	1.83	1.51	1.25	1.14	1.12	1.05	1.05	1.07	1.07	1.11	1.09	1.12	1.12	1.09	1.1	1.1	1.08	1.08	1.05	1.313863	1.324122	1.325	1.290
09:45	2.47	1.8	1.55	1.57	1.33	1.23	1.1	1.12	1.05	1.05	1.07	1.07	1.1	1.07	1.11	1.11	1.09	1.1	1.1	1.08	1.08	1.07	1.23102	1.252293	1.242	1.220
12:00	1.12	1.17	1.11	1.12	1.07	1.1	1.07	1.07	1.03	1.03	1.06	1.06	1.08	1.05	1.06	1.09	1.08	1.08	1.08	1.08	1.08	1.05	1.048606	1.046596	1.079	1.071
12:15	1.12	1.17	1.13	1.12	1.07	1.08	1.07	1.07	1.03	1.03	1.06	1.06	1.08	1.03	1.06	1.07	1.06	1.07	1.06	1.06	1.05	1.05	1.052494	1.046901	1.072	1.066
12:30	1.14	1.17	1.14	1.12	1.08	1.1	1.05	1.07	1.03	1.03	1.04	1.06	1.08	1.03	1.08	1.07	1.06	1.07	1.06	1.06	1.07	1.05	1.043186	1.038395	1.076	1.068
12:45	1.19	1.21	1.13	1.16	1.1	1.1	1.05	1.07	1.03	1.03	1.06	1.06	1.08	1.03	1.08	1.09	1.06	1.07	1.06	1.08	1.07	1.05	1.086415	1.075971	1.084	1.075
13:00	1.18	1.21	1.16	1.22	1.14	1.12	1.05	1.07	1.03	1.03	1.06	1.06	1.08	1.03	1.08	1.09	1.08	1.08	1.06	1.08	1.07	1.05	1.05369	1.068343	1.093	1.083
13:15	1.16	1.21	1.18	1.2	1.12	1.12	1.07	1.07	1.03	1.03	1.06	1.06	1.1	1.03	1.06	1.07	1.06	1.07	1.06	1.08	1.08	1.05	1.069591	1.062533	1.090	1.081
13:30	1.16	1.21	1.18	1.27	1.1	1.12	1.07	1.07	1.03	1.03	1.06	1.06	1.08	1.05	1.08	1.07	1.06	1.07	1.06	1.06	1.07	1.05	1.056106	1.055568	1.091	1.083
13:45	1.21	1.21	1.16	1.18	1.1	1.12	1.05	1.07	1.03	1.03	1.06	1.06	1.1	1.05	1.06	1.07	1.08	1.07	1.06	1.06	1.07	1.05	1.056655	1.055167	1.088	1.080
17:00	1.49	1.39	1.28	1.29	1.18	1.2	1.12	1.14	1.09	1.07	1.06	1.07	1.11	1.08	1.12	1.12	1.13	1.12	1.17	1.19	1.2	1.52	1.487192	1.423853	1.189	1.188
17:15	1.45	1.33	1.23	1.27	1.23	1.18	1.14	1.16	1.1	1.07	1.07	1.07	1.11	1.09	1.2	1.19	1.17	1.27	1.5	1.67	1.86	2.51	1.66414	1.494679	1.313	1.312
17:30	1.39	1.33	1.25	1.37	1.25	1.3	1.28	1.14	1.1	1.1	1.13	1.19	1.24	1.41	1.94	1.92	1.93	2.36	2.74	3.04	2.75	3.11	1.662475	1.766475	1.695	1.576
17:45	1.39	1.33	1.23	1.35	1.25	1.23	1.19	1.14	1.09	1.12	1.19	1.39	1.5	1.81	2.2	2.18	2.12	2.28	2.63	3.04	2.75	3.11	1.785109	1.765031	1.750	1.617
18:00	1.25	1.31	1.23	1.27	1.16	1.24	1.16	1.12	1.09	1.12	1.17	1.24	1.27	1.69	1.88	1.86	1.93	2.05	2.44	2.78	2.75	2.84	1.675295	1.763667	1.630	1.525
18:15	1.16	1.23	1.21	1.24	1.16	1.16	1.14	1.1	1.07	1.1	1.09	1.13	1.15	1.2	1.53	1.63	1.53	1.95	2.35	2.78	2.64	2.97	1.487649	1.595148	1.525	1.440
18:30	1.23	1.28	1.21	1.27	1.14	1.16	1.1	1.1	1.07	1.08	1.09	1.13	1.15	1.18	1.47	1.31	1.46	1.65	1.95	2.38	2.36	2.51	1.28712	1.429679	1.423	1.360
18:45	1.23	1.26	1.23	1.35	1.18	1.14	1.1	1.1	1.07	1.08	1.09	1.11	1.14	1.14	1.14	1.19	1.2	1.2	1.26	1.52	1.44	1.63	1.209843	1.295667	1.218	1.201

Coastal Engineering

Goal: Generate knowledge on coastal processes, hazard identification and response strategies

Approach: Develop and utilize 1) geospatial techniques for 3-D time dependent, remotely sensed data, 2) numerical models to better understand and visualize solutions to coastal problems

Impact: Long (decadal) and short (storm) term hazard identification and enhance the resilience of coastal environments

Methods: Coastal hydrodynamics, sediment transport, numerical models, high performance computing.

Water and Wastewater Treatment

Goal: Optimize the efficiency of water and wastewater treatment processes

Approach: Use validated Computational Fluid Dynamics model coupled with global search optimization algorithms

Impact: UV disinfection systems that enhance microbial inactivation using less electrical power

Methods: CFD, Optimization, laboratory analytical measurements

Sewer Collection System Sustainability

Goal: Understand and eliminate fat, oil, and grease (FOG) related sanitary sewer overflows

Approach: Biological and analytical techniques. Consider interactions of wastewater and concrete

Impact: Enhanced grease interceptor designs that remove more FOG from restaurant discharges

Methods: CFD, microbiological molecular techniques, FTIR