Urbanisation and the convergence of BIM, GIS and 3D

Geoff Zeiss
Director Utility Industry Program
Autodesk
The world economy is expanding at an unprecedented rate
The world economy is expanding at an unprecedented rate.
Worldwide Infrastructure Expenditure
2005-2030

Exhibit 1: The Infrastructure Challenge
Percentages of total projected cumulative infrastructure investment needed during the next 25 years to modernize obsolescent systems and meet expanding demand, broken down by region (rows) and sector (columns).

Middle East
$0.9T

Africa $1.1T

U.S./Canada $6.5T

South America/Latin America $7.4T

Europe $9.1T

Asia/Oceania $15.8T

Water $22.6T

Power $9.0T

Road and rail $7.8T

Air/seaports $1.6T

Source: Booz Allen Hamilton, Global Infrastructure Partners, World Energy Outlook; Organisation for Economic Co-operation and Development (OECD),
Boeing, Drewry Shipping Consultants, U.S. Department of Transportation.

http://www.strategy-business.com/article/07104?pg=all

$24 trillion to $53 trillion
Intelligent infrastructure networks

SMART GRID
A vision for the future — a network of integrated microgrids that can monitor and heal itself.


Massoud Amin, Univ Minnesota
Annual construction spending breakdown

<table>
<thead>
<tr>
<th>Asset classes</th>
<th>Average annual Infrastructure spend</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>~1,000</td>
<td>Including roads, bridges and tunnels (~85%) as well as rail, air and seaport infrastructure</td>
</tr>
<tr>
<td>Utilities</td>
<td>~2,500</td>
<td>Down stream energy and water supply + telecom</td>
</tr>
<tr>
<td>Public social infra</td>
<td>3,400</td>
<td>Upper stream energy + waste and storm water + construction</td>
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<tr>
<td>Real Estate</td>
<td>3,600</td>
<td>Mainly residential real estate</td>
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<tr>
<td>Total</td>
<td>~7,000</td>
<td>‘Narrow’ infrastructure covering ~50% of capital formation</td>
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1 Rounded to the nearest USD 100 bn. Based on 2010-2014 forecast
2 Core infrastructure is based on the OECD definition, i.e. “the system of public works, including roads, utility lines and public buildings” whereas Expanded infrastructure is based on the World Bank definition, which includes “energy, oil/gas, communications, housing, all transportation, urban development, and water supply and sanitation.” More detail included in the appendix.

SOURCE: Global Insight, Euroconstruct, IMF, McKinsey

$7 trillion/yr
Increasing risk of extreme events and disasters

2010/2011 Queensland floods: ERGON Energy

2011 Tornadoes: Alabama Power

July 2012 Colorado wild fires: CSU

Black Saturday bushfires February 2009
IEA estimated cost of climate change over 40 years

US$45 tn

International Energy Agency estimate of adapting to and mitigating the effects of climate change over the next 40 years to 2050 (about US$1 trillion per year)

OECD report on Infrastructure to 2030 (volumes 1 and 2) published in 2006/2007
Environmental Impact of Buildings

U.S. Building Impacts:

- 12% water use
- 39% CO₂ emissions
- 65% waste output
- 71% electricity consumption
Greening the building/infrastructure market

Globally $6-7 trillion annually

Today 6% qualifies as “green”

In 2020 75% will be “green”

Green buildings and infrastructure driven by regulation, owner and investor demands, resource cost, security concerns, and third party standards.

Source: Global Insight
Building Energy Efficiency in Australia

Commercial buildings 2000 square meters and over

*Building Energy Efficiency Disclosure Act 2010* requires a Building Energy Efficiency Certificate (BEEC)

- NABERS Energy star rating for the building
- Assessment of tenancy lighting in the area of the building that is being sold or leased
- General energy efficiency guidance
- Publicly accessible on the online Building Energy Efficiency Register

Residential

In 2009, The Council of Australian Governments committed to phase in the mandatory disclosure of residential building energy, greenhouse and water at the time it is offered for sale or lease.
Who is going to finance this?
Infrastructure – government social reduce capital formation expenditures

Institutional investors

Pension funds, insurance companies and mutual funds

US$65 trillion
(assets held at the end of 2009 in OECD countries)

ROI

“Institutional investors could be key sources of capital, financing long-term, productive activities that support sustainable growth, such as green energy and infrastructure projects.”

Who is going to do all this?
Engineers vs. Age

Engineers total 122 employees and overall average age of 39 with 13 years of service with a noticeable gap in years of service

Mark Carpenter, ONCOR
Workforce challenges facing electric power

Productivity & Knowledge transfer

US Workforce Survey: Age Distribution

- Survey Participants
  - 55 Electric & Gas Utilities
  - All Electric Cooperatives
  - ~½ of all US electric & combination utility employees

- Done in 2007, 2008 & 2009
- Engineers that may need replacement by 2014 ~51%

Source: Center for Energy Workforce Development — Gaps in the Energy Workforce Pipeline Survey
Technology is rapidly evolving to meet these challenges
New geospatial data sources

Radar-derived High-resolution digital terrain models
New geospatial data sources

High resolution aerial photogrammetry

Oblique aerial photogrammetry

“Streetview”
New geospatial data sources: laser scanning
Engineering design
Engineering design + geospatial
Evolution of CAD to Model Based Design (BIM)

**CAD**
- Graphics only
- Lacks intelligence
- Lacks domain knowledge

**Model based design or BIM**
- Integrates geospatial and engineering design data
- Enforces business and engineering rules
- Automates clash detection
- Automates change propagation
- Reduces data redundancy
- Improves collaboration among design teams
- Automates bill of materials and job costing
- 3D visualization involves non-technical stakeholders in design process

**Benefits**
- Increases productivity
- Reduces risk
- Reduces costs
- Improves design quality

Deliverable is **paper**
Deliverable is an **intelligent digital model**
Heavy civil construction projects – BIM + geospatial

- LIDAR
- Structures / Facilities
- Roads / Rail
- Land / Development
- Project Documentation
- Integrated Model
- Visualization
- Quantification
- Estimating
- 4D Sequencing & Machine Control
- Scheduling
- Coordination
- PM / ERP / SCM / O & M
Visualization – BIM + geospatial + gaming

Lighting Design & Analysis

SF Presidio Parkway Project
Analysis and simulation – BIM + geospatial

- Building performance simulation
  *Visualize environmental performance*

- Visualization of building performance and environmental characteristics

- Visualize environmental factors
  *Solar, Shading, Daylighting, Weather*

- Conceptual design analysis such as basic form and building orientation, internal layout, and external materials.
Building performance analysis in the cloud

Energy and cost analysis

Water usage analysis
Rapid energy modeling – reality capture + geospatial
Convergence of model-based design and geospatial is changing how we design and build infrastructure
5D - BIM+geospatial+project management

SF Presidio Parkway Project

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- DESIGN
- AWARD / ADVERTISEMENT
- CONSTRUCTION

12/15/2008
Machine control – BIM + GPS

- McAninch: Reduce fuel consumption by 43%, GHG emissions
- RCPS:
  - Fine grading 214 passes down to 60 – 1 mile of road
  - Providing our clients with a more accurate product – base course grade checking 45% accurate vs 98%

“Traditional processes of paper plans, stakeout sheets and grade stakes used to take up to a week to implement. Now with GPS machine control and 3D models from designers, that same size project can take hours “

- Tim Tometich, GPS division manager, McAninch
Transportation projects - BIM + geospatial
Laser Scanning to Models for ROW Planning, Design, and Construction

SF Presidio Parkway Project
Geospatial reality capture to BIM
NYCT Tunnel Rehabilitation

- Terrestrial Laser Scan to 3D Model to Automated Tunnel Panel Manufacturing

Raw Point Cloud Scan

3D Geometric Model

As-Built Tunnel Model

Creation of new steel reinforcing panels from 3D Model

Geospatial reality to virtual to reality
Substation design
Key Benefits

- **Improves efficiency**
  - Estimate 50% productivity improvement
  - Estimate 27,000 person-hrs saved per year

- **Improves quality**
  - Integrates with other enterprise systems including GIS to reduce data redundancy

- **Facilitates knowledge transfer**
  - Critical to address the challenge of an aging workforce

- **Estimated ROI ~ Just over one year**
Operating the smart grid – integration of engineering and geospatial
Real-time monitoring of intelligent networks

Burlington Hydro Background

- GridSmartCity™ Initiatives
  - Smart Automated Distribution Switching (Self Healing, High Reliability)
  - 65,000 Smart Meters deployed with Time-of-Use Billing
  - Distributed Renewable Generation is spreading
  - Electric Vehicle Charging Stations
  - Factory Ride-Through Systems
  - Battery-Based Electricity Storage as a deployable grid resource
Burlington Hydro: Real-time transformer monitoring
Real-Time Smart Grid for Operations and Asset Analytics e.g. Overload Analysis Example

Detailed Geographic View. Transformer Overloading
Smart Grid for Operations and Asset Analytics

Loading Profile at Transformer
Color Coded by % Overload In 15 min. Intervals
Smart Grid for Operations and Asset Analytics

Transformer Daily Summary Report (July 5, 2010)

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<td>Peak Demand:</td>
<td>79.66 KWh</td>
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<td>Outage Duration:</td>
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<td>Loss of Life:</td>
<td>1.11%</td>
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<td>Coincidence Factor:</td>
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<td>Throughput:</td>
<td>1227.27 KWh</td>
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**Overload: 64% of the time**

**Loss of Life: 1.11%**
Smart Grid for Operations and Asset Analytics
Transformer Weekly Summary Report (July 5 to July 9, 2010)

Overload: 74% of the time
Loss of Life: 6.7%
“100% accurate, real-time”

Optimize information flows for data quality

- Improve design quality
- Eliminate redundant data
- Resolve the as-built problem
- Reduce paper flow

Smart grids require reliable data
Data quality and disaster management

2010/2011 Queensland floods: ERGON Energy

2011 Tornadoes: Alabama Power

July 2012 Colorado wild fires: CSU

2010 San Bruno gas explosion: PG&E
Building performance modeling - integration of BIM and geospatial
Energy performance analysis for a new building
New building electric power optimization

- Begin with an architect’s BIM model

- Extract a simplified BIM model that contains the key elements required for energy modeling
  - simplified walls and floors,
  - room bounding elements,
  - complete volumes, and
  - window frames and curtain walls.

- Export simplified BIM model as gbXML
Building performance analysis

- Thermal, lighting and airflow simulations by integrating BIM and geospatial information
  - Surrounding natural and man made structures
  - Local climatic conditions

- Analyze alternative options
  - Compute annual energy consumption, CO2 emissions, occupant comfort, light levels, airflow, and LEED certification level
  - Ontario Power Authority’s High Performance New Construction (HPNC) program pays $400 to $800 per kW saved over code

- 40% reduction in annual electric power bills achievable
Improving energy efficiency of existing buildings

US Government owns and leases about half a million buildings

Example:

- 140 year-old, large government building
- Combined annual building energy use about 5.5 million kWh
  - Space heating and cooling
  - Miscellaneous equipment loads
  - Lighting
Reality Capture

Historical building
BIM model

Historical building
Energy performance analysis – BIM and geospatial
60% reduction in annual energy consumption achievable through

- Zoning
- Natural ventilation
- Daylighting and advanced lighting systems
- Decoupling interior spaces
- Solar photovoltaic
Immediate business benefit of these technologies are efficiencies in the $7 trillion construction industry
Convergence breaks down silos
Interoperability

Standards

CAD
AutoCAD
NavisWorks
AutoCAD Map3D
Civil3D
BIM
Revit
Inventor

Visualization
3D
MotionBuilder
FDO
NavisWorks

GIS
Imagery
Laser Scanning

FME
DXF
LandXML
IFC
fbXML
DWF

Urban Modeling

Sustainability Analysis

Sustainability

Ecotect
Green Build Studio

CityGML
OWS
Standards
BIM For Infrastructure

Intelligent Design Models to Enable Intelligent Cities

OUTSIDE

Exterior, above ground
Including:
- Transportation networks (roads)
- Full city blocks
- Precise spatial orientation
- 3D buildings
- Pedestrian networks

INSIDE

Full interior
Including:
- Utility / HVAC systems
- Floor plans
- Mechanized lifts / elevators
- Walls, doors, windows
- Staircases

BELOW

Subterranean
Including:
- Water and sewer systems
- Utility / Phone systems
- Electrical systems
- Access – manholes, poles
- Transportation networks (tunnels)
Vision for sustainable city design

Reality Capture → Energy Modeling → Mapping

City 3D Model

BIM models

Conceptual design – integrate architectural and engineering designs and city 3D model

Environmental impact
Integrating model-based design and geospatial

Integrate geospatial maps and engineering designs

Sketch designs

Analyze alternatives
Communicate
Planning, Design, Visualization, Collaboration, Public Outreach, Agency Approvals
Some takeaways

- We are facing global challenges: increasing urbanization means increasing energy demand, water stress, and environmental impact
  - more to do, fewer people to do it

- Business drivers are changing how we design, build, and operate infrastructure
  - model-based design + geospatial underlies most of this

- Convergence enables
  - intelligent models of entire cities
Designing for a sustainable future