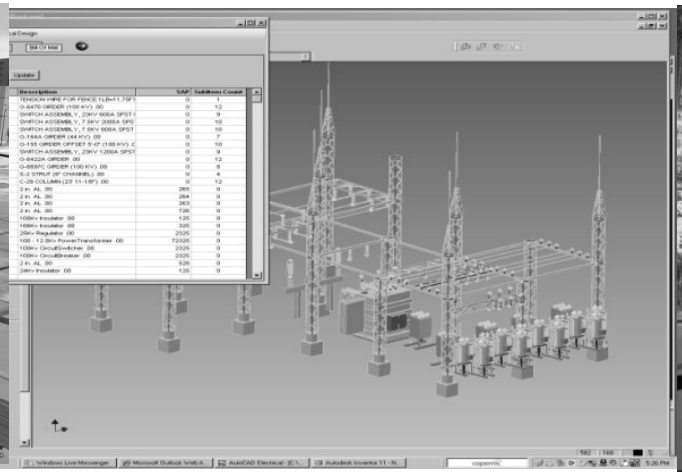
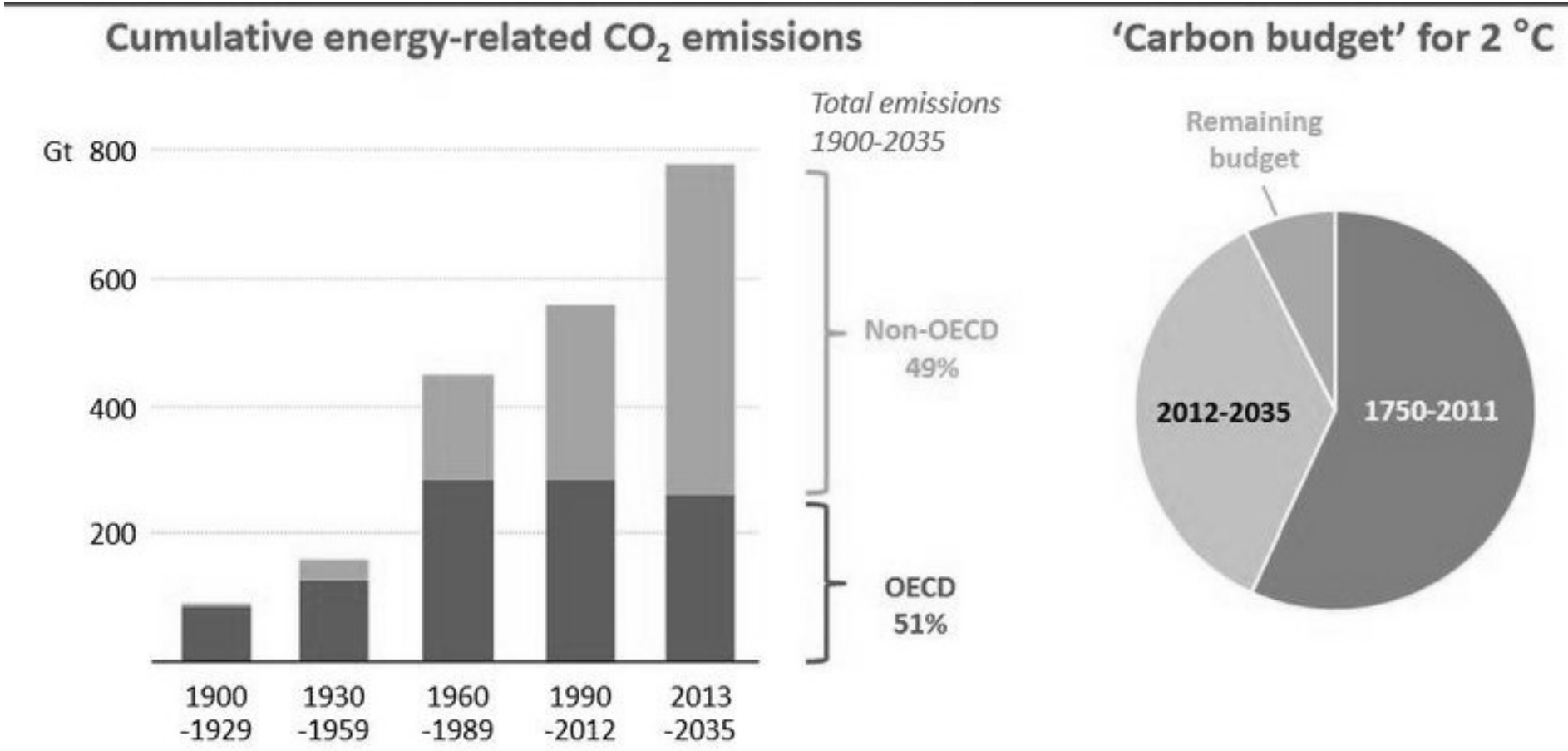


Geospatial Media

Energy demand expected to increase by a third by 2035 – IEA World Energy Outlook 2013

- China is the primary driver for increased demand through 2020.
- India becomes the primary driver after 2020.

Energy-related CO2 emissions will increase by 20% by 2035 – IEA World Energy Outlook 2013

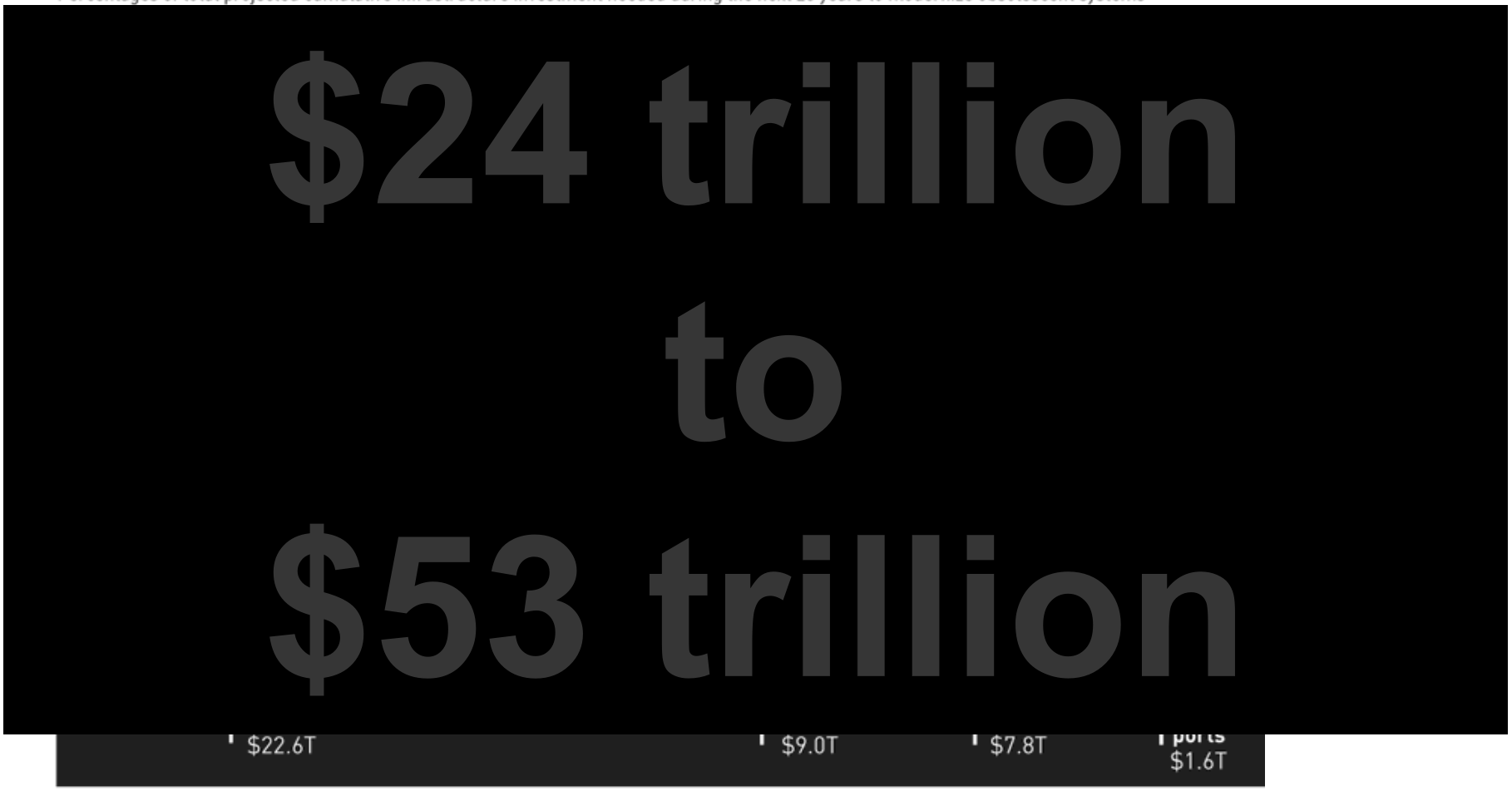


- IEA estimates that this will lead to a long-term average temperature increase of 3.6°C.

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



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

IEA estimated cost of climate change over 40 years

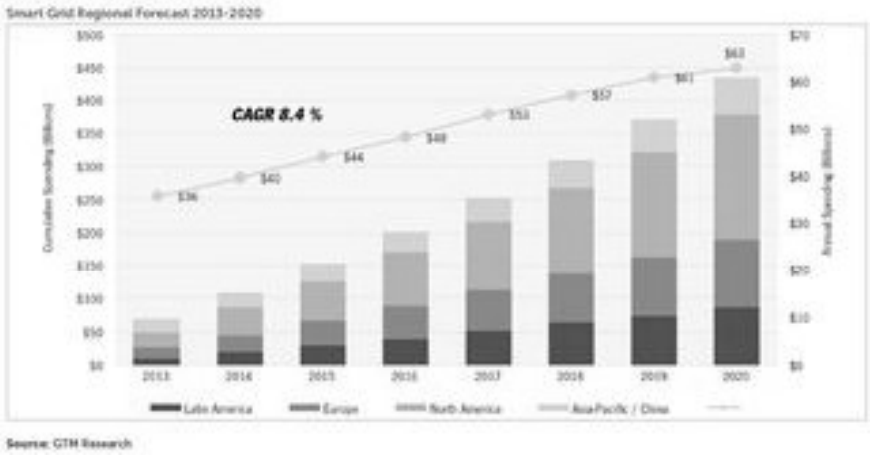
US$45 tn

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

Global smart grid market to exceed $400 billion by 2020

- Global smart grid market is projected to grow with an average compound annual growth rate of over 8%.
- Cumulative value of the smart grid market projected to exceed $400 billion by 2020.
- Leading regional markets are Asia-Pacific, China, Europe, Latin America, and North America



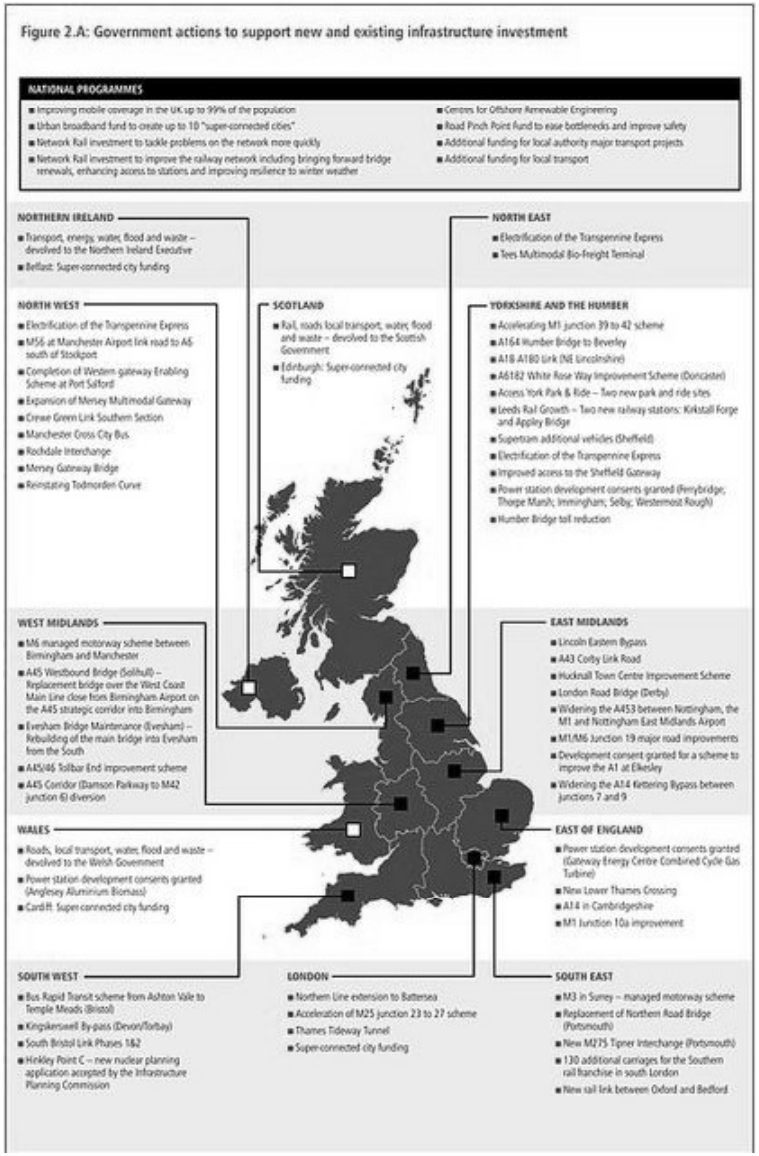
UK *National Infrastructure Plan*

The National Infrastructure Plan brings together the first ever comprehensive cross-sectoral analysis of the UK's infrastructure networks and sets out a clear pipeline of over 500 infrastructure projects. worth over £250 billion over the next 5 years.

The Government will use all the tools at its disposal to facilitate the private investment that will finance the majority of the UK's infrastructure.

Est £400 billion over next decade

Target 70% private funding



Private funding requires increasing productivity

3 LABOUR PRODUCTIVITY IMPROVEMENT COULD RESULT IN

Drives investment in technology

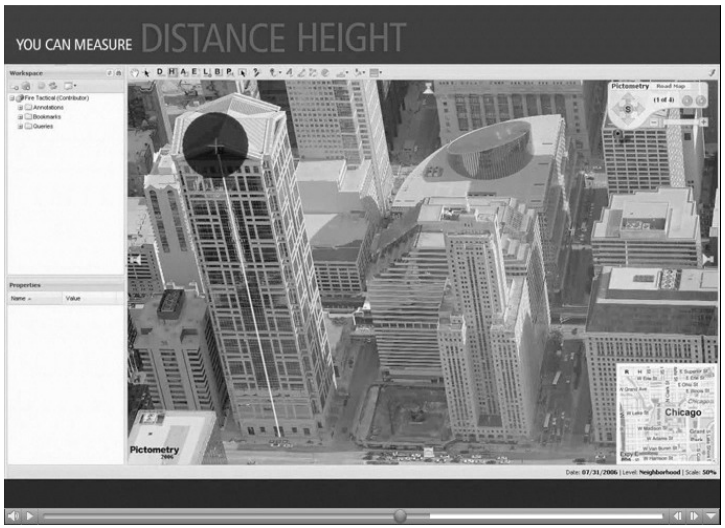
1 Estimates from CG/LA for 2010-2030 global investments, adjusted for an assumed 15% investment in telecom
2 ROCKS estimates for roads, assumed for all transport classes; EU-KLEMS data for U.S. in 2007 as proxy for water, energy, and telecom

SOURCE: McKinsey Global Institute

New geospatial data sources used by utilities

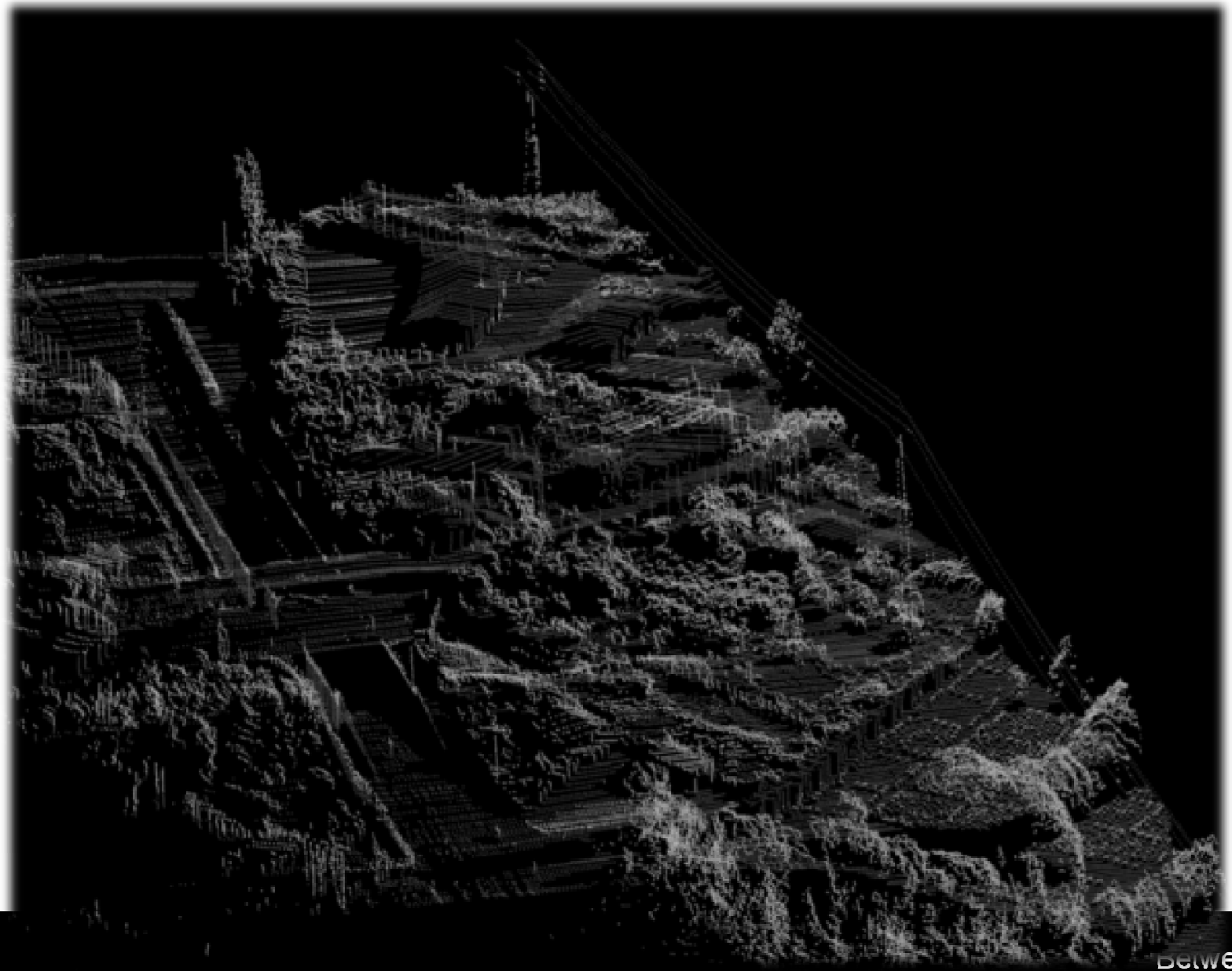
High resolution aerial photogrammetry

Oblique aerial photogrammetry



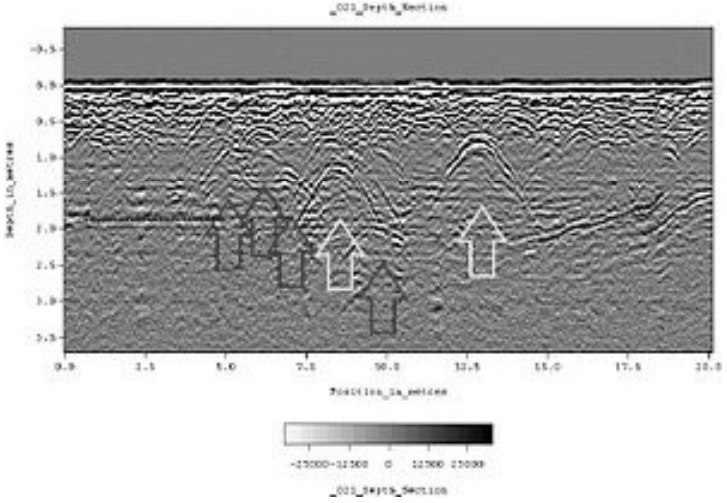
"Streetview"

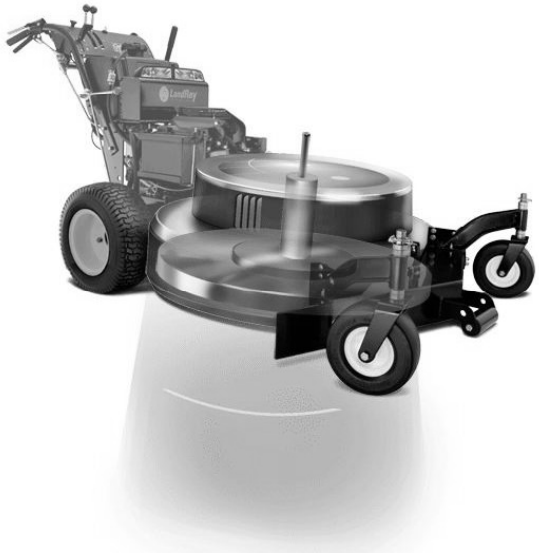
LiDAR

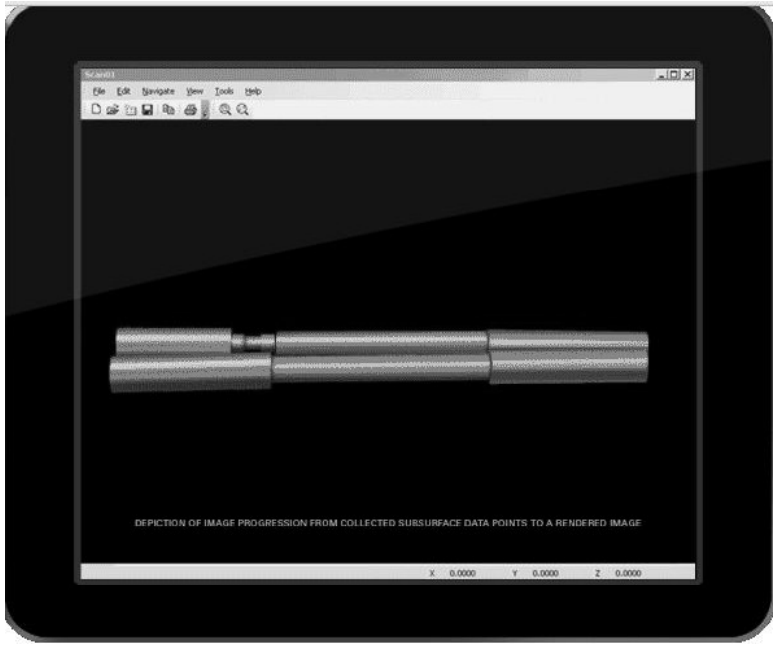


Ground penetrating radar (GPR)

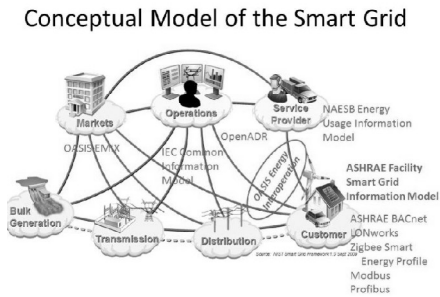
Image:Ditch Witch







Navigant predicts that geospatial will become a foundational technology of smart grid



"The smart grid is all about situation awareness and effective anticipation of and response to events that might disrupt the performance of the power grid. Since spatial data underlies everything an electric utility does, GIS is the only foundational view that can potentially link every operational activity of an electric utility including design and construction, asset management, workforce management, and outage management as well as supervisory control and data acquisition (SCADA), distribution management systems (DMSs), renewables, and strategy planning."

Utility GIS to grow 12.8% per year reaching $3.7 billion in 2017

GIS is a critical technology to bringing information technology (IT) and operations technology (OT) sides of the business together.

- Projected annual growth rate (CAGR) of 12.8%,
- $1.8 billion in 2011
- $3.7 billion in 2017 (est.)

- Forecasts accelerating penetration of GIS into **smart grid workflow applications** - MWFM, DMS, energy mgmt (EMS), outage mgmt OMS, customer information (CIS), and analytics
- Growth, but at a slower rate, in GIS in **utility construction and engineering-related GIS applications**
  - Led by the power grid build-out in Asia Pacific.

ACROSS THE UNITED STATES

THE CONCERNS

TY LINE HIT EVERY

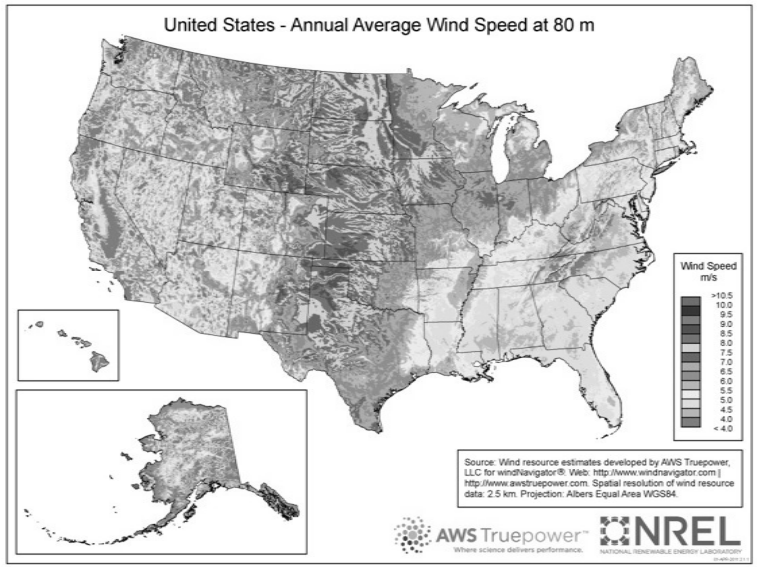
Las Vegas 3D infrastructure model

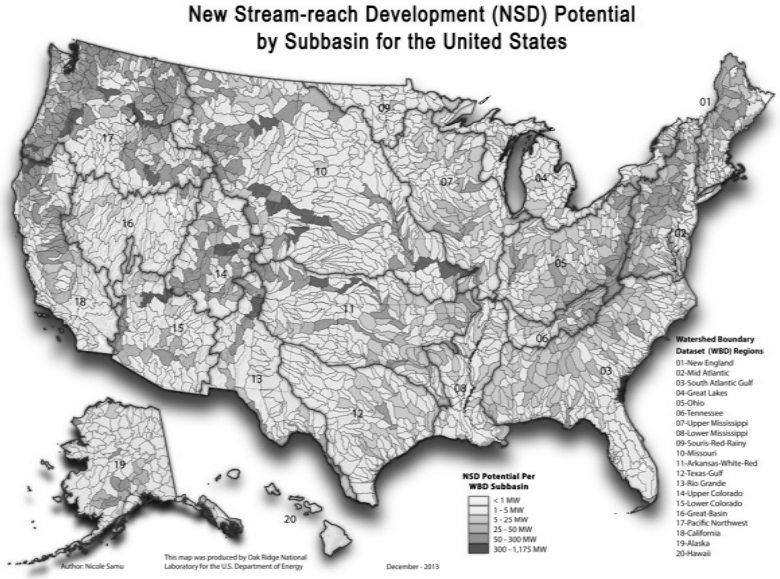
ROI of improving geolocation accuracy for underground utilities

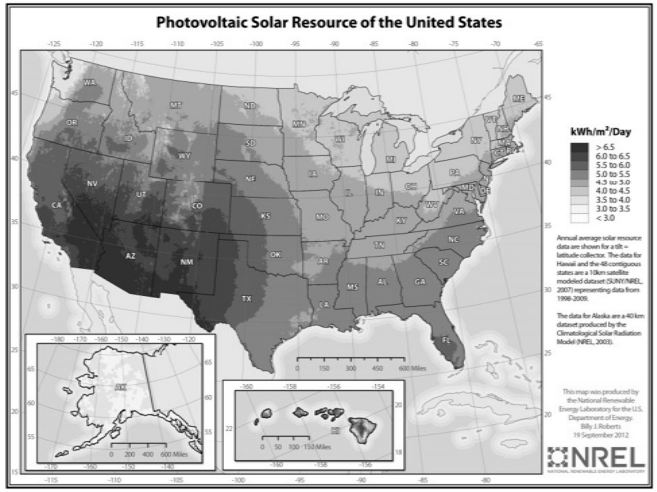
- USDOT/Purdue University - **US$4.62** in avoided costs for every US$1.00 spent
- Ontario Sewer and Watermain Contractors Association /University of Toronto in 2004 – ROI **$3.41** for each $ spent
- Pennsylvania DoT/Pennsylvania State University in 2007 - ROI **US$ 21.00** saved for every US$1.00 spent elevating the quality level of subsurface utility information
- University of Toronto – ROI ranged from $**2.05 to $6.59** for every dollar spent on improving underground utility location data.
- Lombardy, Italy – ROI of **€16** for every € invested in improving the reliability of information about underground infrastructure.

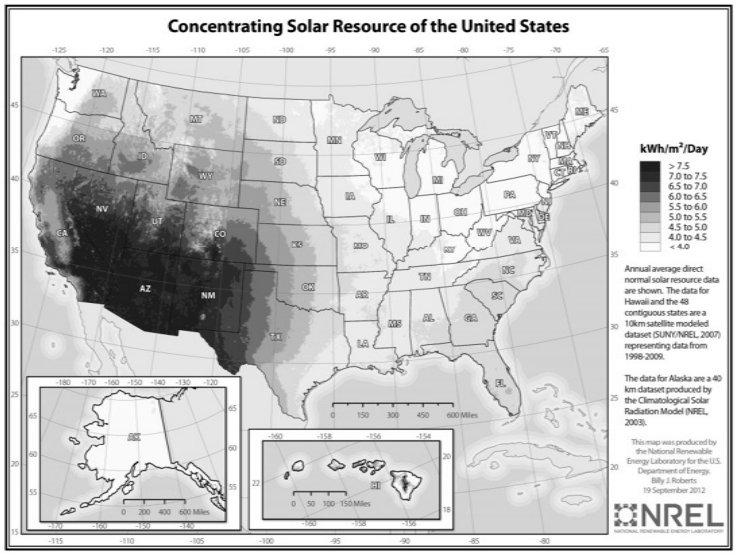
Quilt view of social media tweets during a storm event filtered by geospatial buffer around electrical distribution feeder

Geospatial and renewable energy: Planning and siting



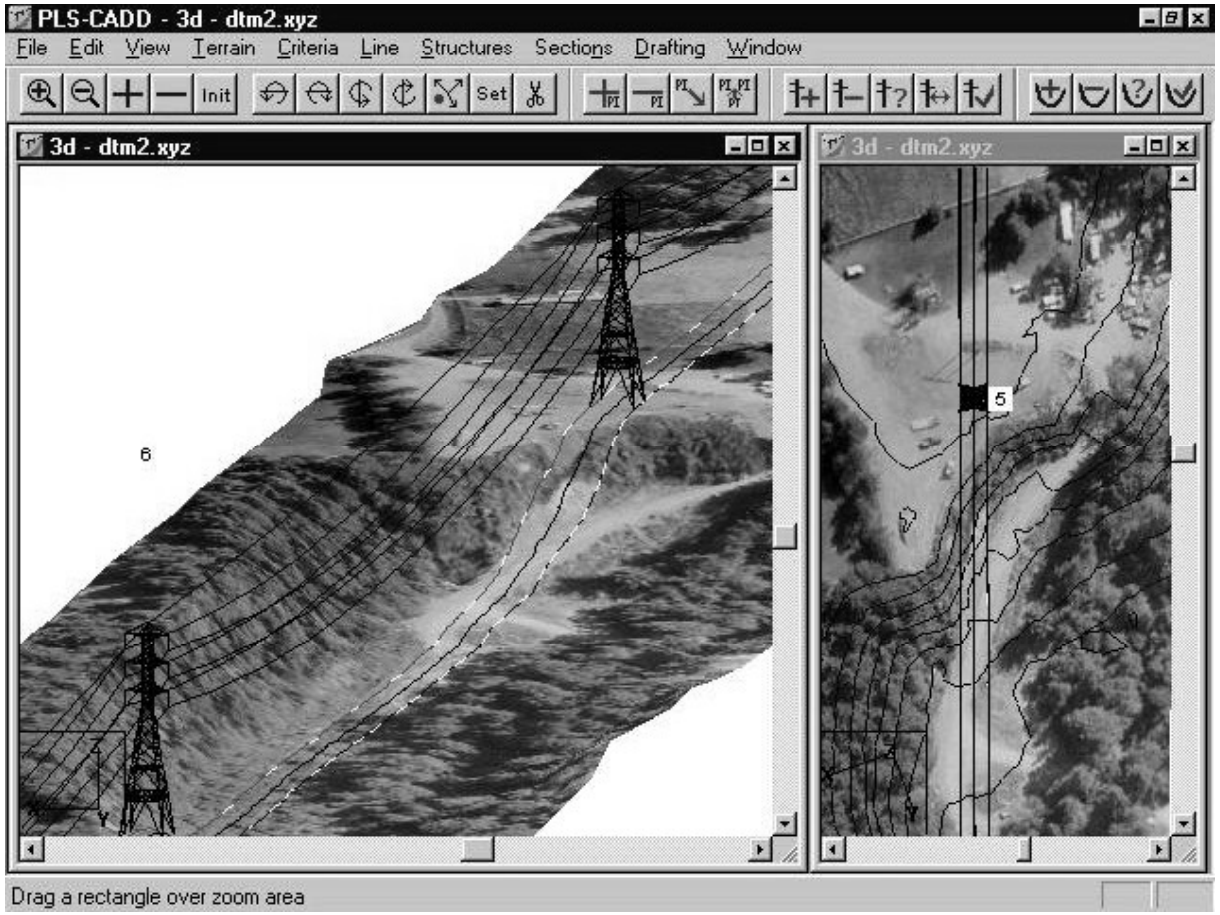






Power line siting and design

- 3D engineering model
- Digital terrain model
- Pylons structures and all the wires
- Data from total station instruments, airborne lasers and photogrammetry

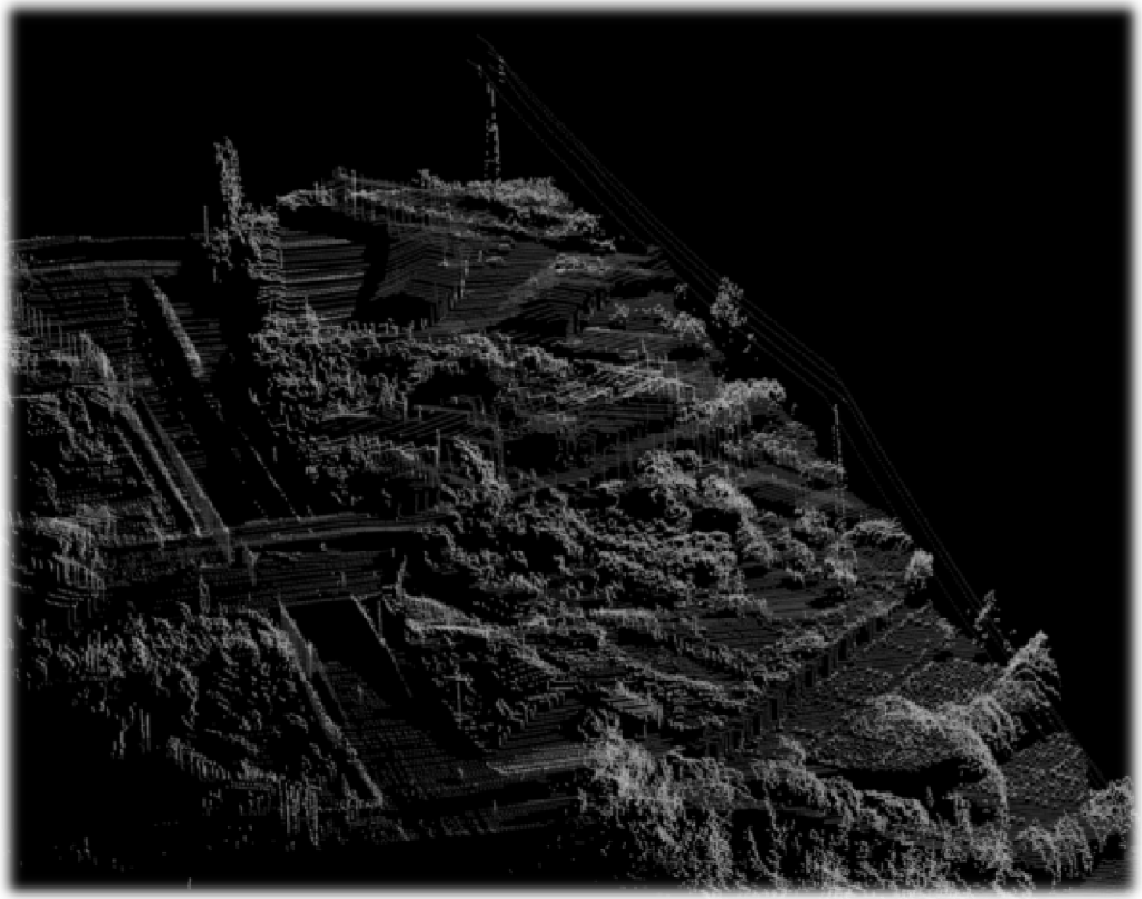


Power line visualization for consensus building

- Negotiating rights to convey power across public jurisdictions and private properties for proposed and existing transmission projects
- Require consensus from a wide range of stakeholders.
- Objective is accurate, and informative visual tools to establish a common platform.
- Enables utility developers, governing bodies and property owners to come together to establish routes, appropriate line and type of towers.

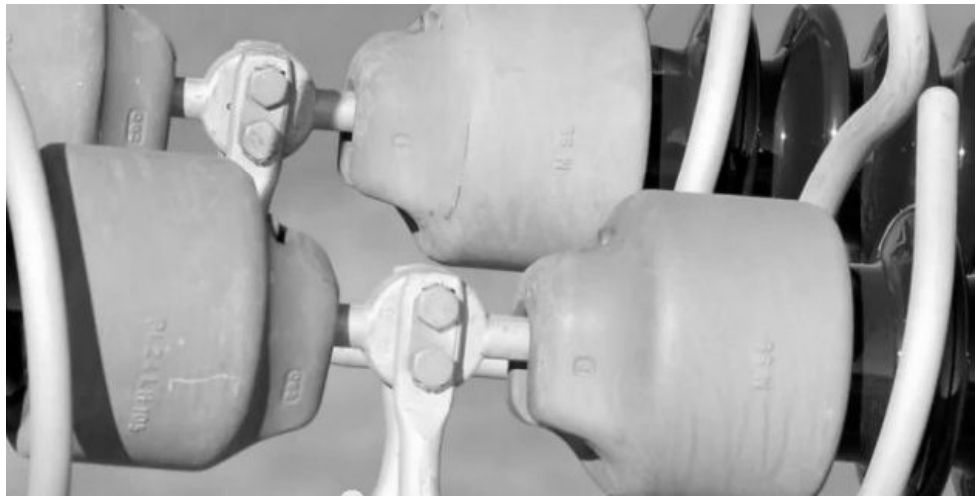
Powerline – Vegetation management

- Airborne laser scanning
  - Expensive
- Semi-automated feature extraction
  - Pylons, wires and vegetation
- Automated tree species identification
- Vegetation modeling
  - Species specific growth

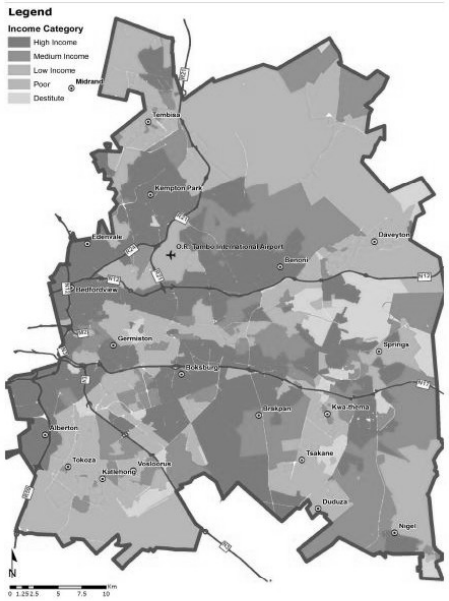


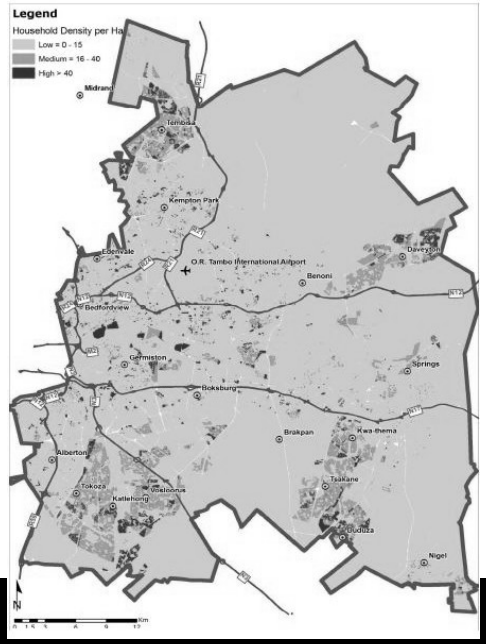
UAV for pylon inspection

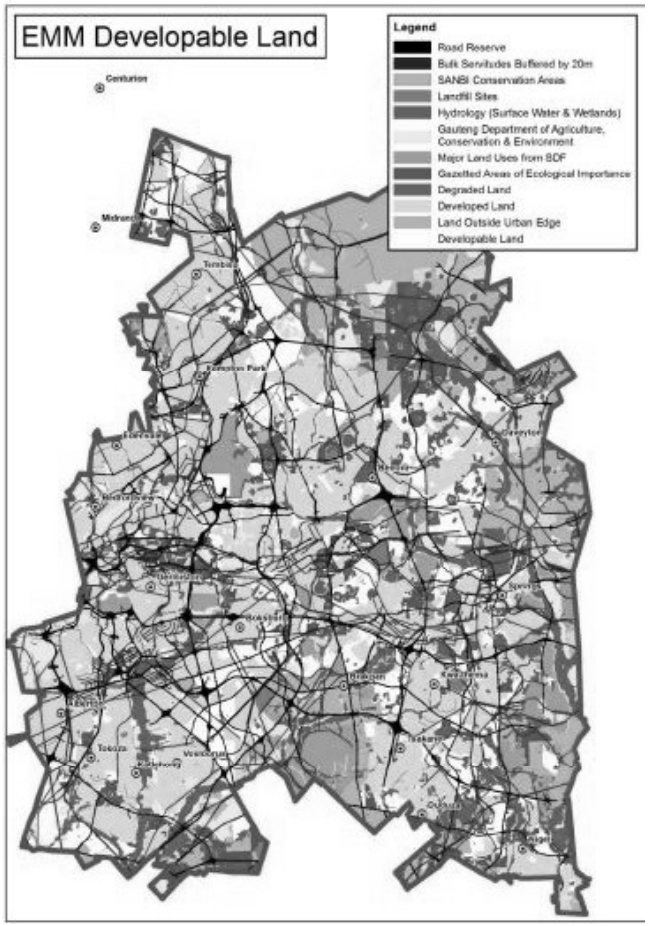
- Hexagon Aibotix
- Hexacopter that can carry a payload, typically a camera, of up to 5 kg for 45 minutes.
- Flies preprogrammed flight paths autonomously and autonomously take predefined aerial photos.
- Records detailed aerial photos for the maintenance of power lines

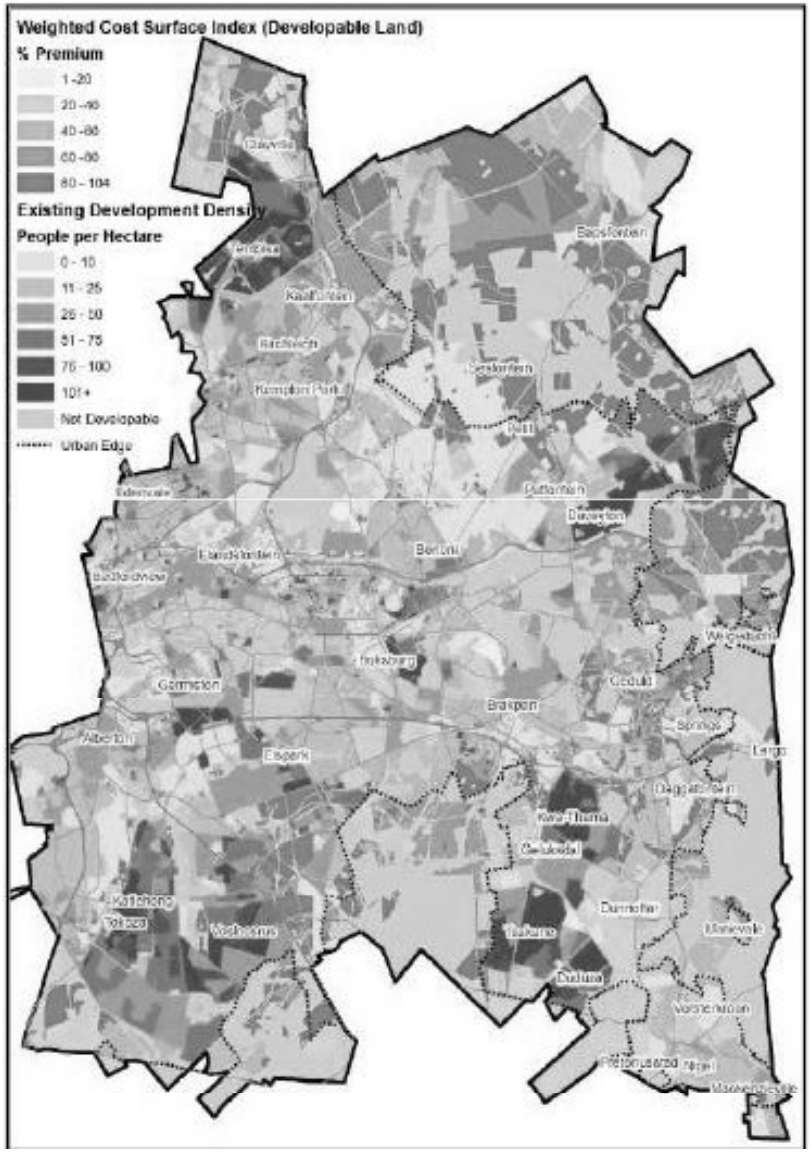


Universal electrification: Planning in South Africa (ESKOM)

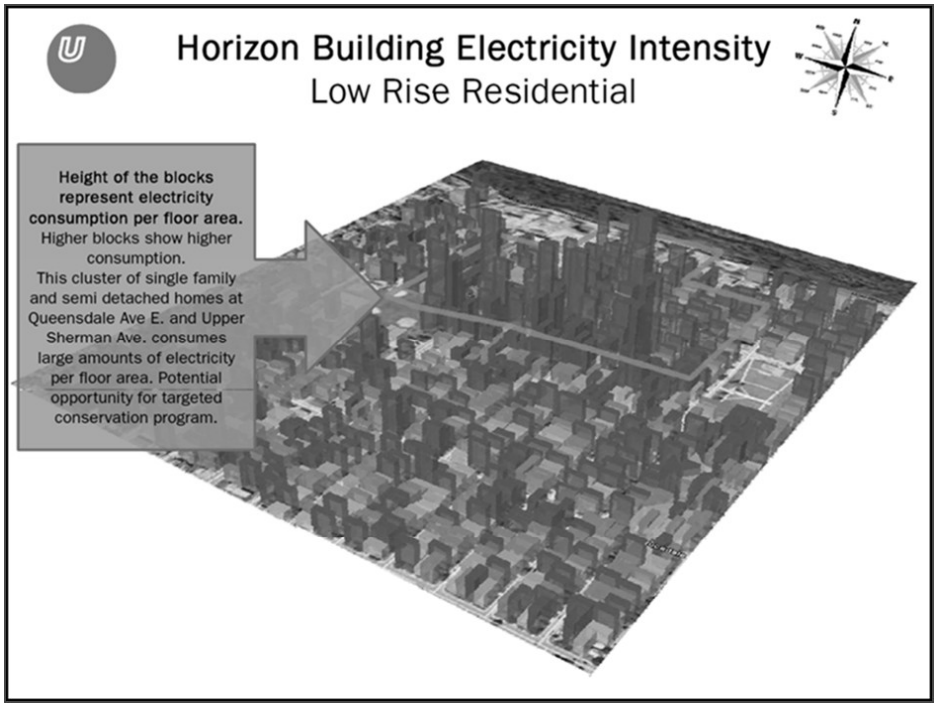




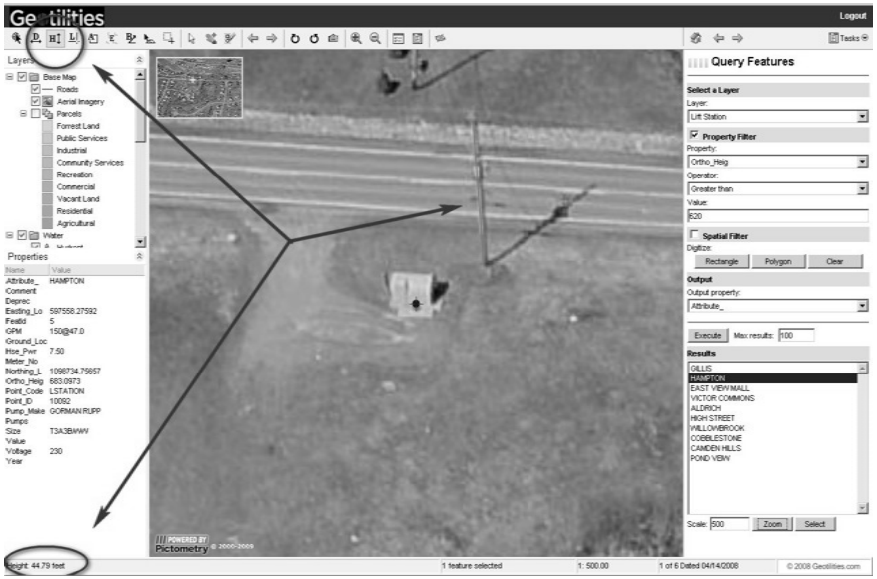




Energy density mapping



Bringing the field into the office reduces truck rolls



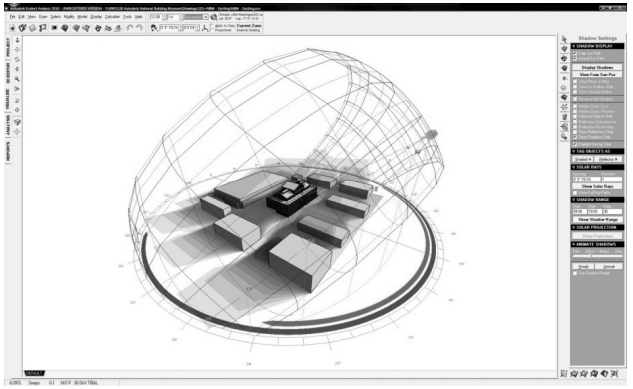
Between the Poles

Disaster management

Some takeaways

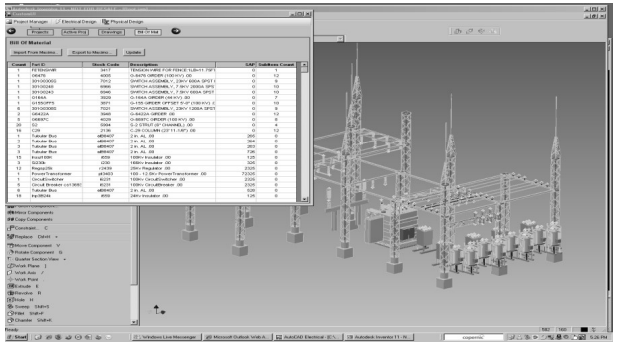
Increasing urbanization means increasing energy demand and concern about environmental impact, reliability and resilience

- Drives huge global investment in smart grid



Increasing private funding of infrastructure

- ➢Focus on productivity
- ➢Drives investment in information technology

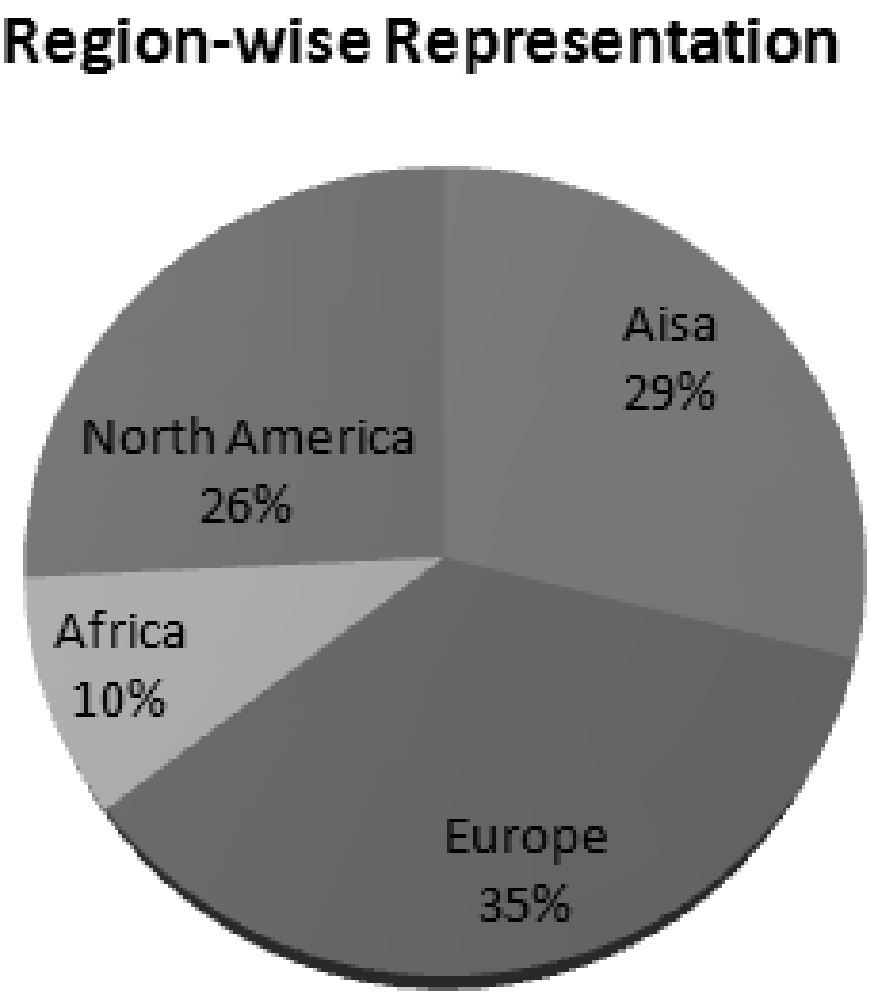


Geospatial plays a tactical role in many aspects of electric power generation, transmission, and distribution

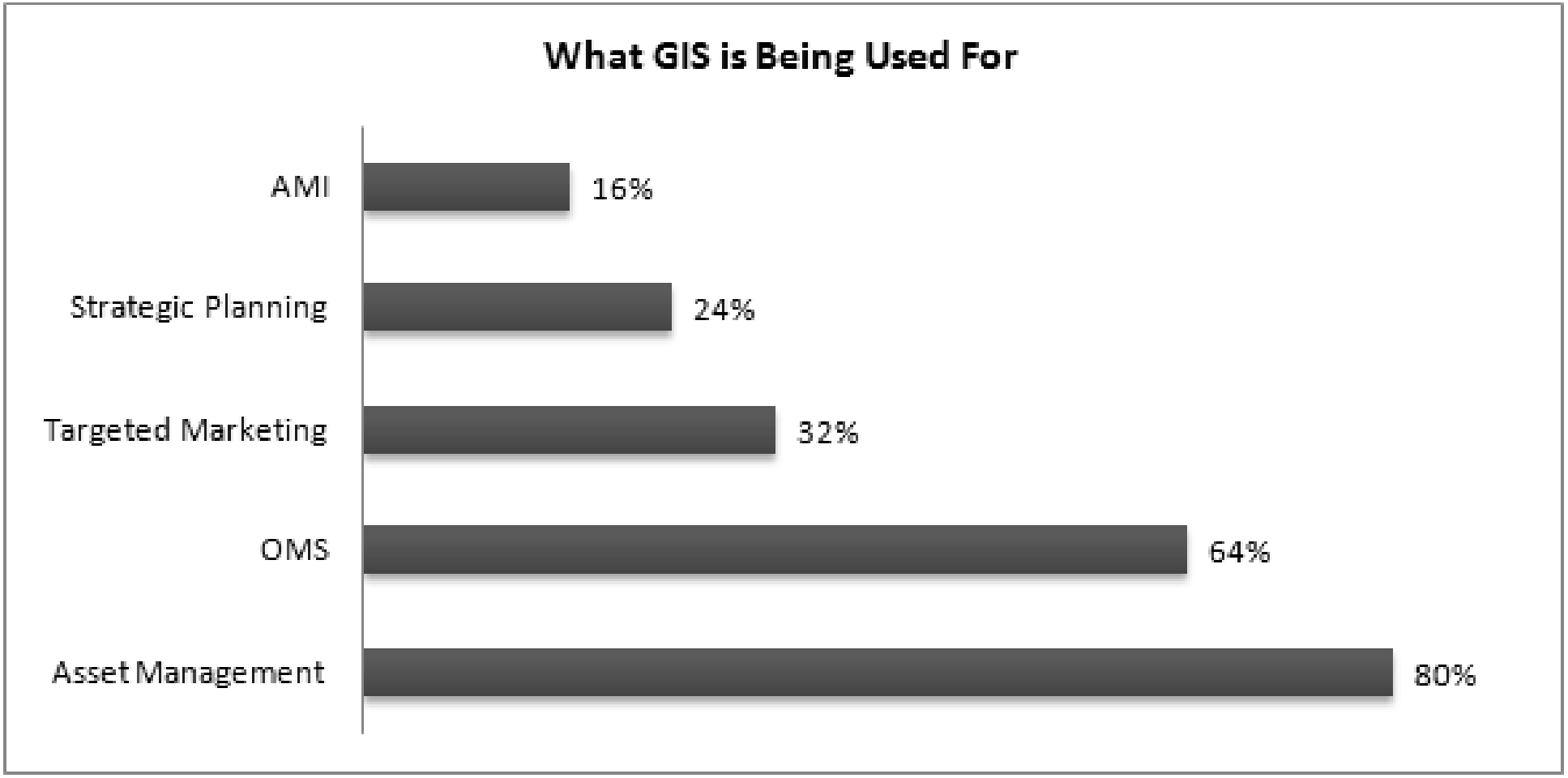
Geospatial is <u>foundational</u> for smart grid

Annual Energy Survey
Geospatial Media and Communications

Target 200 Electric Power Utilities



Geospatial Media Annual Electric Power Survey



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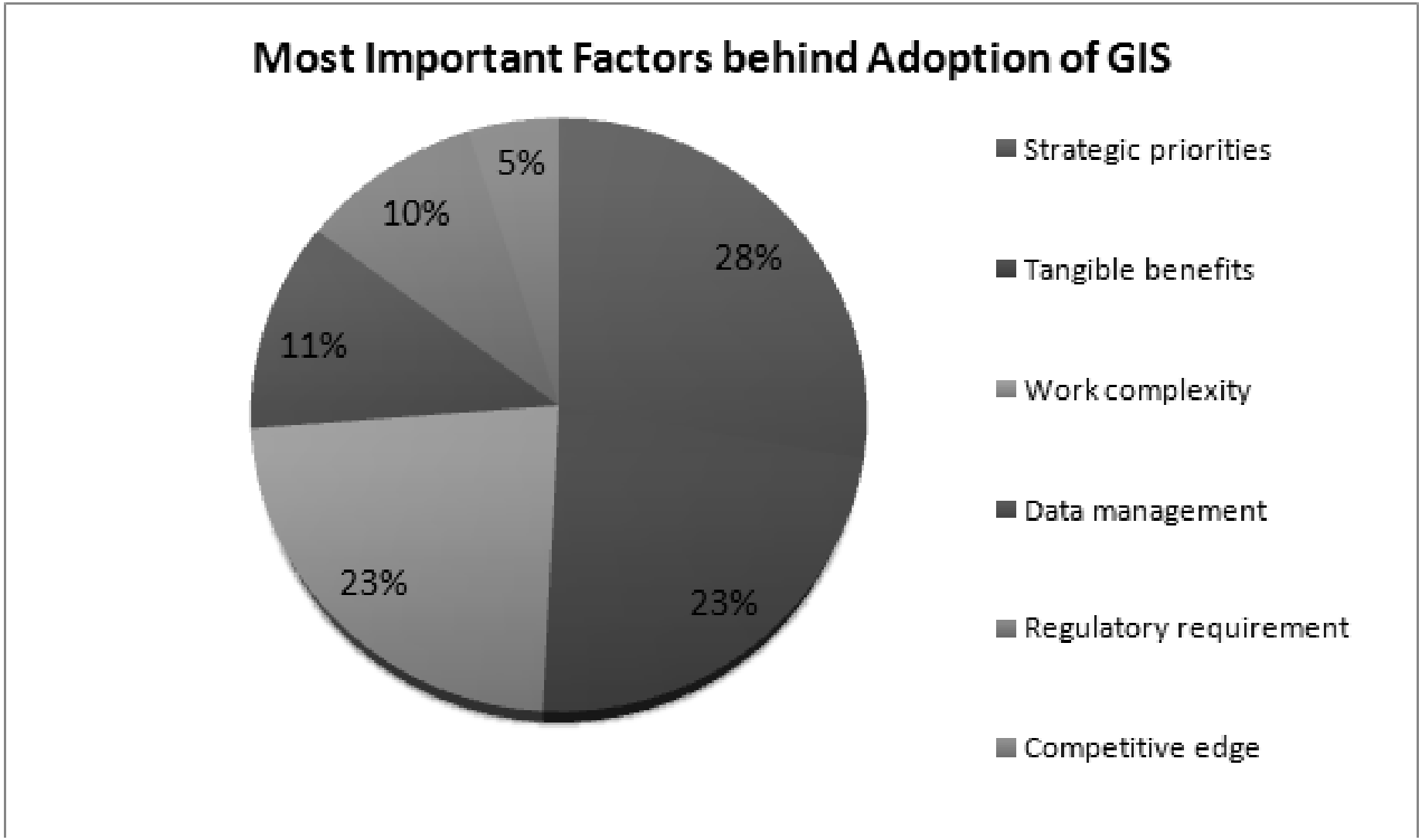

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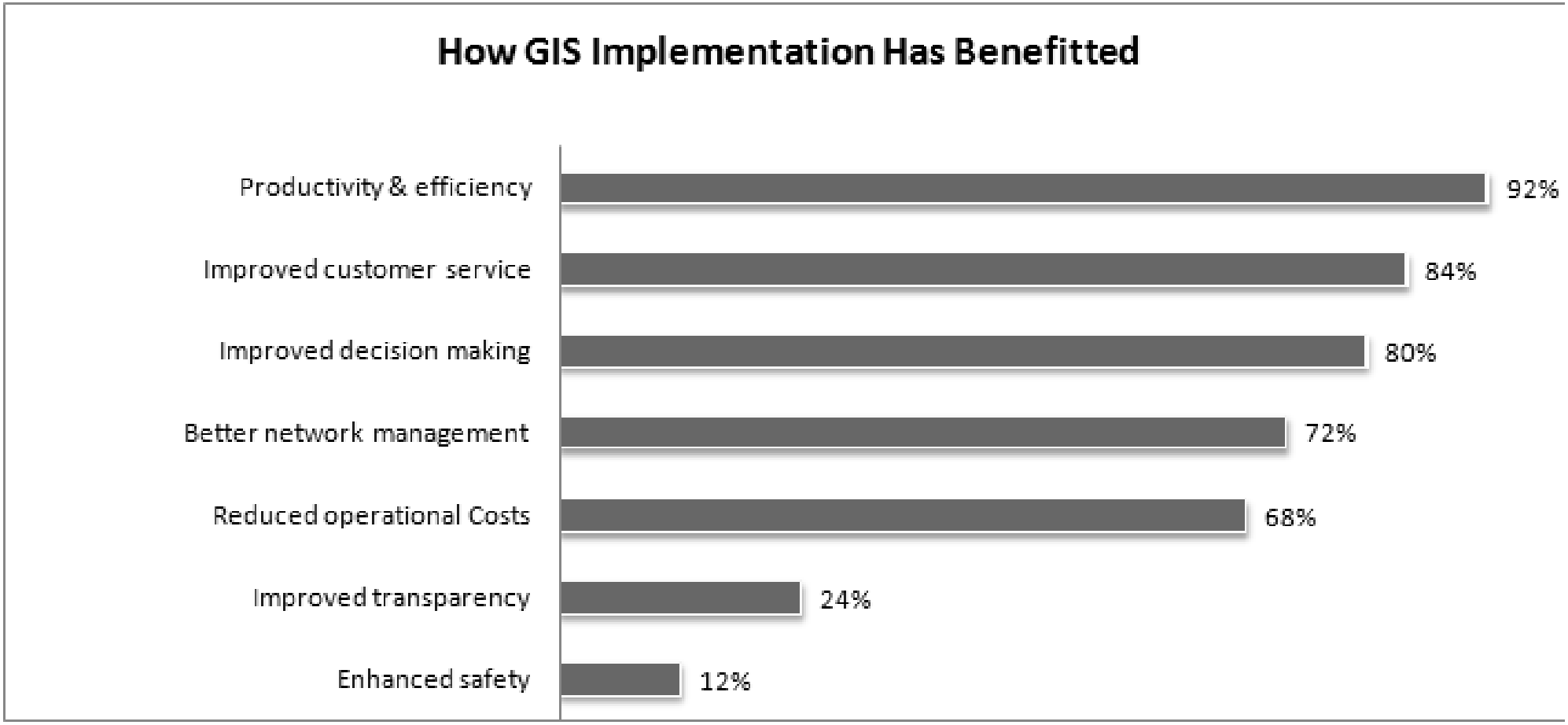

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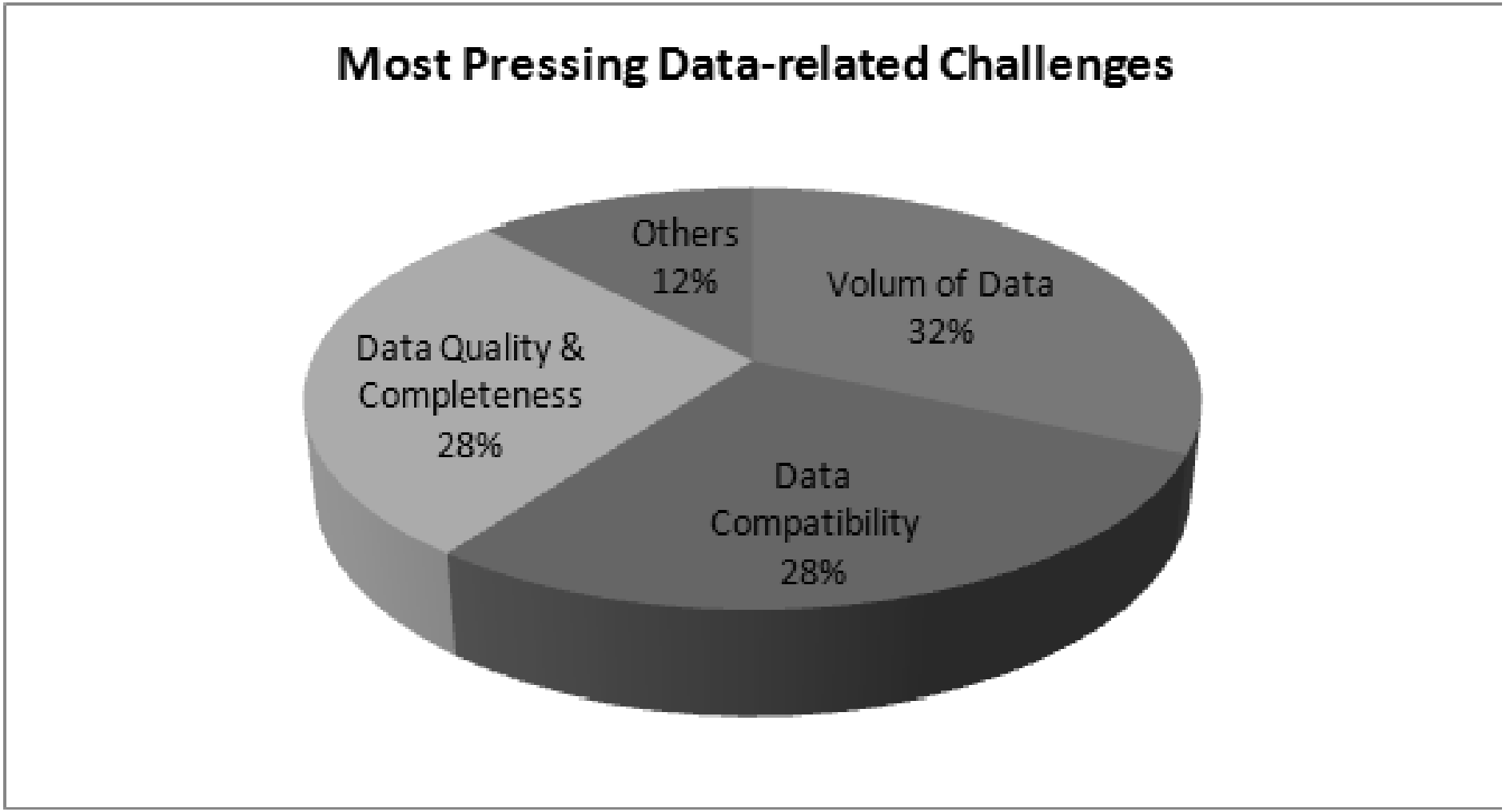

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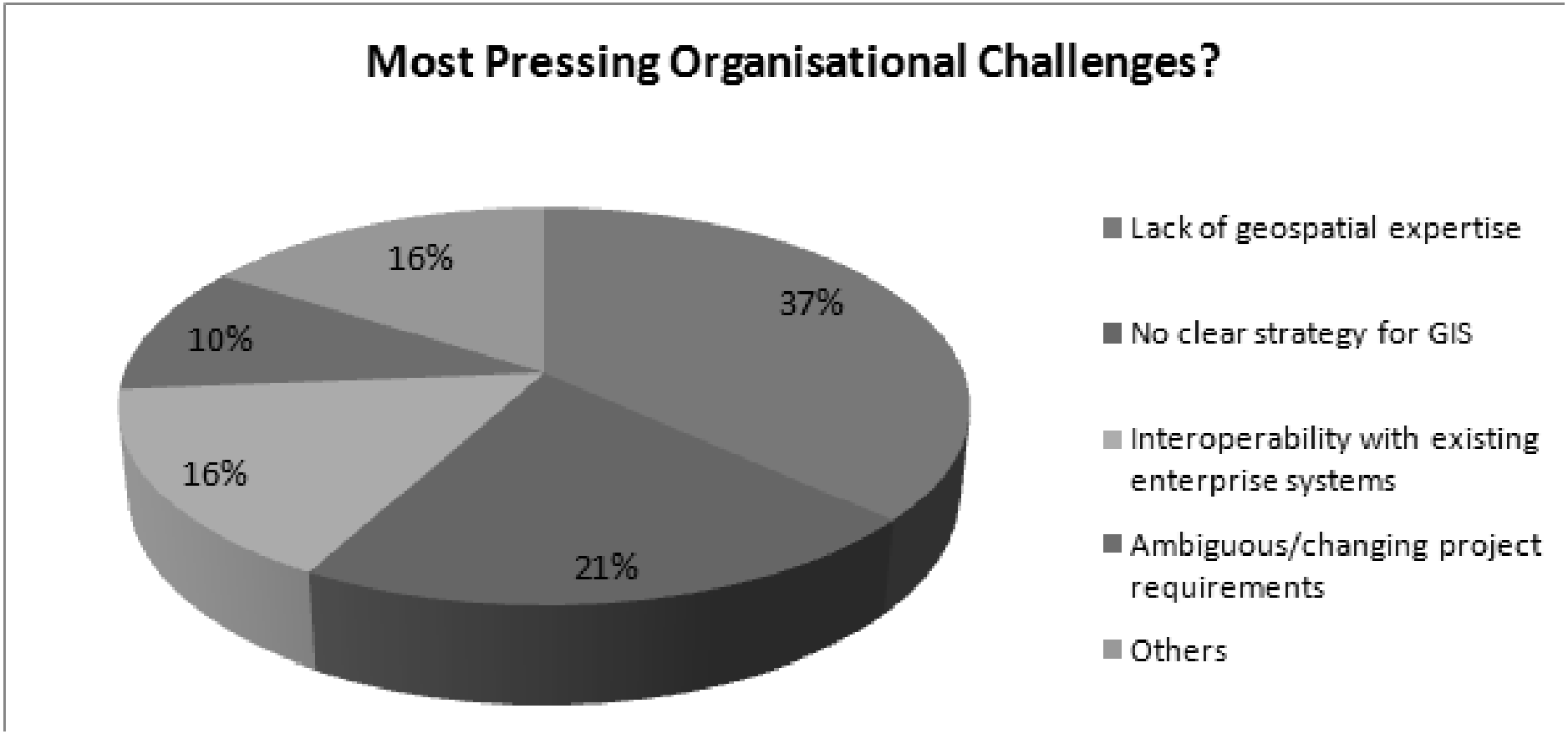

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