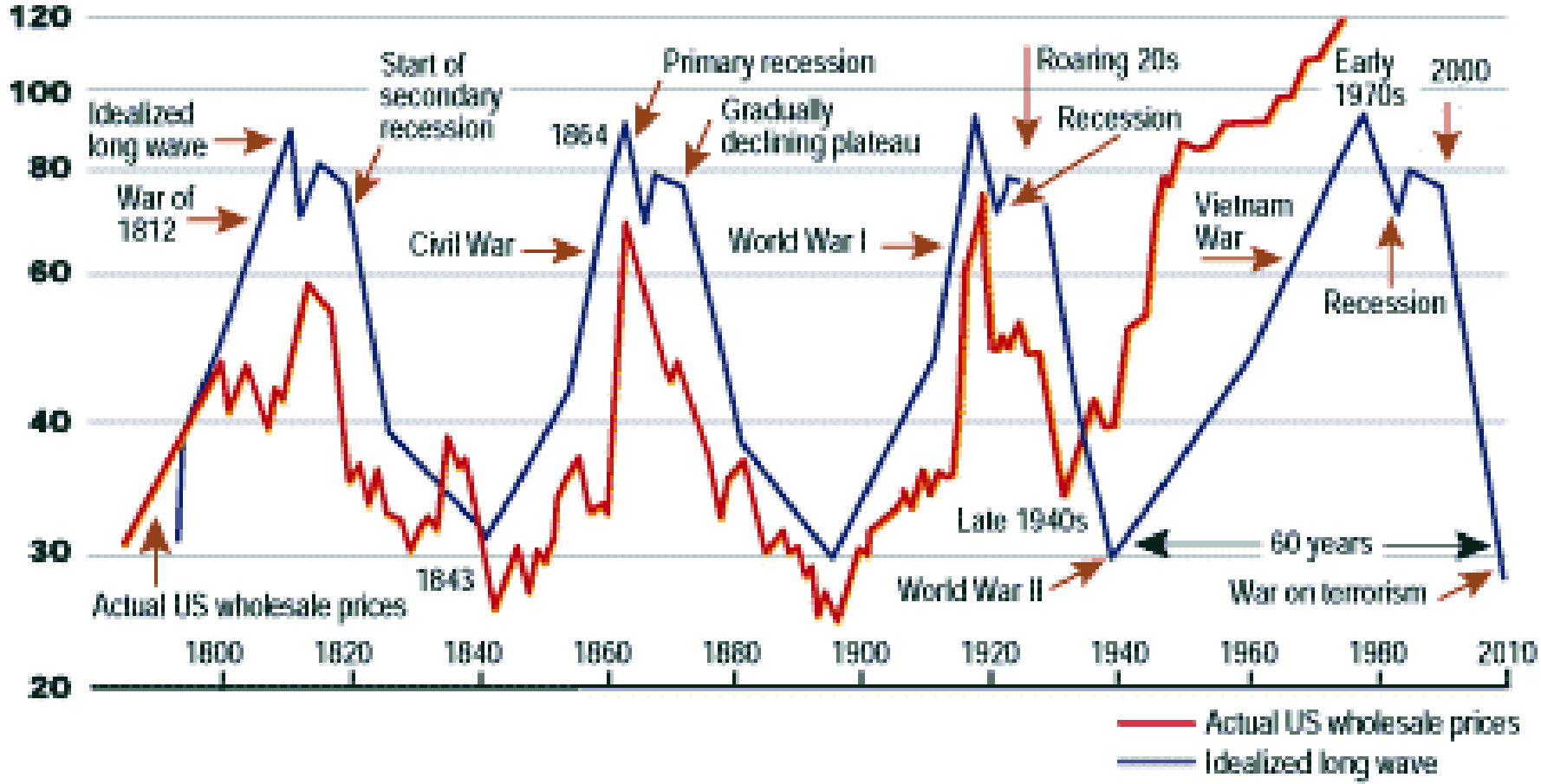
New Developments in Geoinformation Technology and their Impacts on Photogrammetry and Remote Sensing

FIG & SSGA Workshop
Ulan Baatar, Mongolia, Sept 4 - 8, 2011

Presentation by

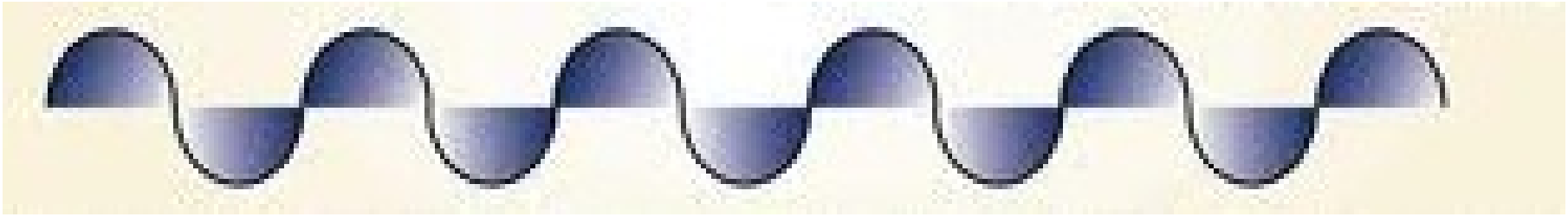
Gottfried Konecny
Emeritus Prof. Leibniz University Hannover

The Kondratieff Wave



The Kondratjev Cycles

Steam Engine Textile Industry	Railway Steel	Electricity Chemistry	Automobile Petrochemistry	Information Technology	Health
Clothing	Transport	Mass Consumption	Individual Mobility	Globalization Communication	Wellness



1 st Cycle	2nd Cycle	3rd Cycle	4th Cycle	5th Cycle	6th Cycle
1800	1850	1900	1950	1990	20xx

100 year Anniversary of ISPRS in Vienna 2010

Election of Honorary Fellows of the Society:

Li Deren, China; Costas Armanakis, Canada; Ivan Antipov, Russian Federation; George Zarzicky, Canada; Stan Morain, USA

New Technology made it possible,
that tasks, which were not affordable before,
are available now,
they can be used for partial automation:

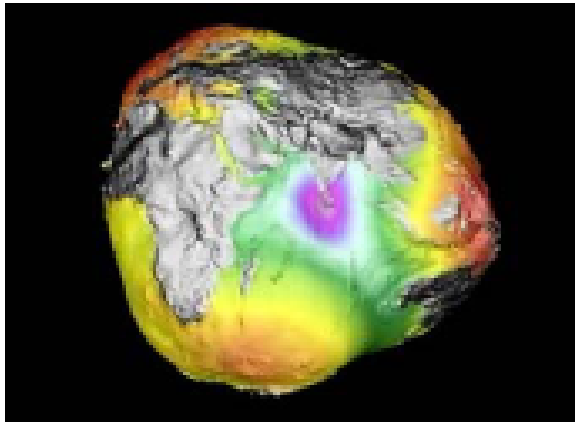
1. Satellite Positioning to cm accuracy (GNSS-GPS)
2. Imaging by digital aerial photography (ortho mapping)
3. Satellite Imagery covering the Globe (Google Earth)
4. Laser Scanning
5. Computer Technology Advances (Moore´s Law)
6. Database Technology (Object Relational Data Bases)
7. Web Applications (Geoportals, Crowd Sourcing)
8. Mobile Technology Applications (Smart Phones)

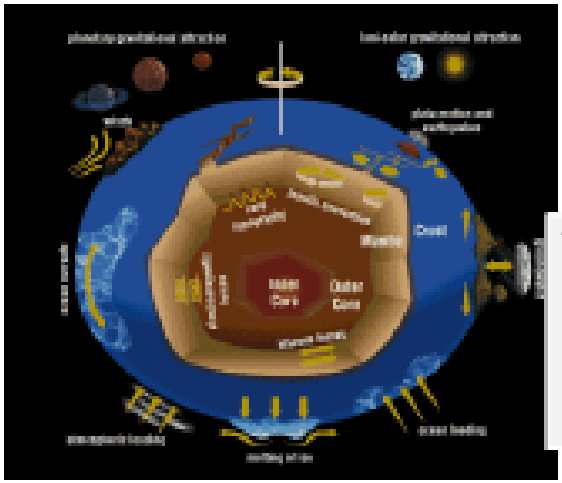
1. Satellite Positioning GNSS-GPS

1.1 The objective of geodesy

Geometrical figure of the Earth: precise coordinates

Physical figure of the Earth: gravity field, geoid





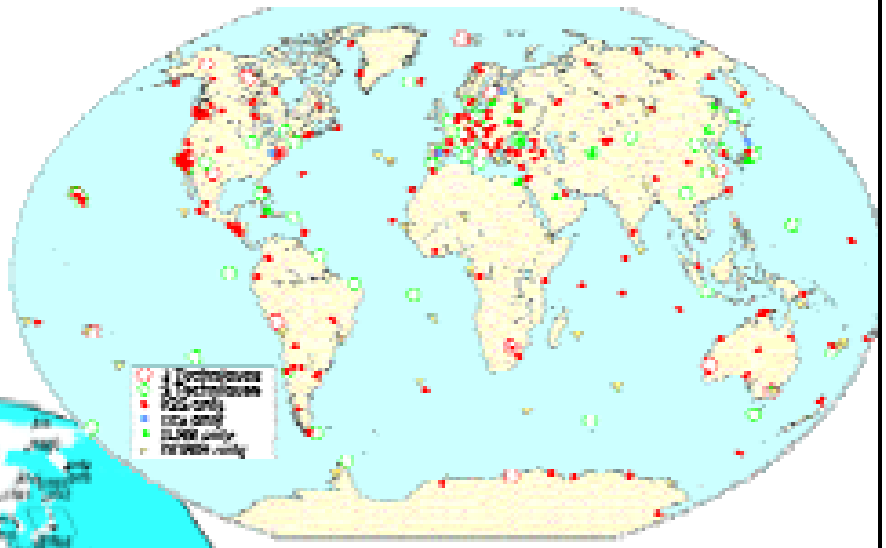
Variations thereof: dynamic Earth, Earth rotation, crustal motion

1.2 Scientific and technical questions solved with GPS

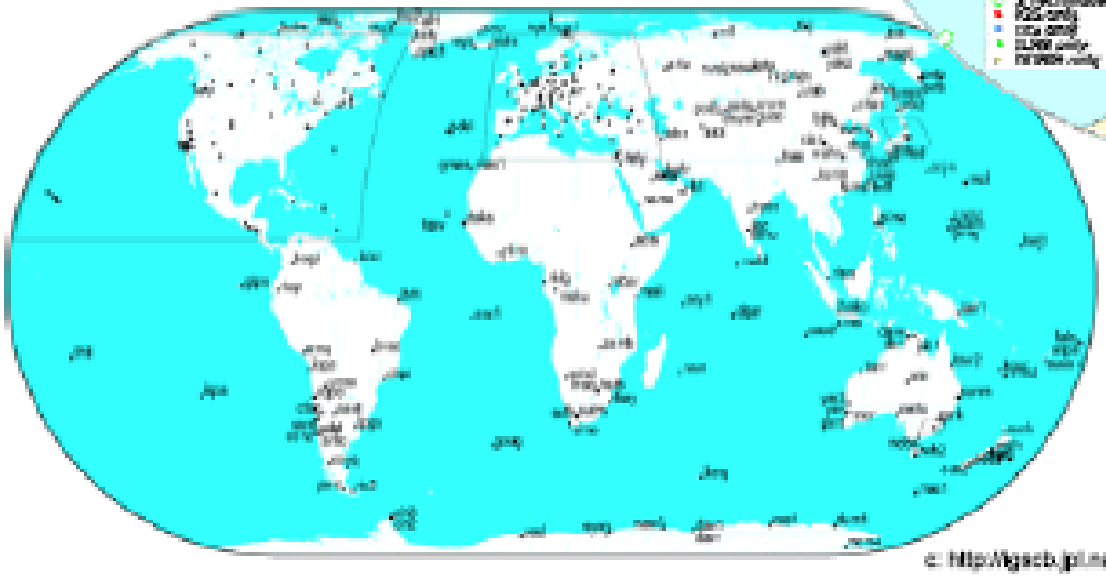
- 1.) Determination of a high-precision, three-dimensional terrestrial reference frame

  - International Terrestrial Reference Frame (ITRF)

  - International GNSS Service (IGS)



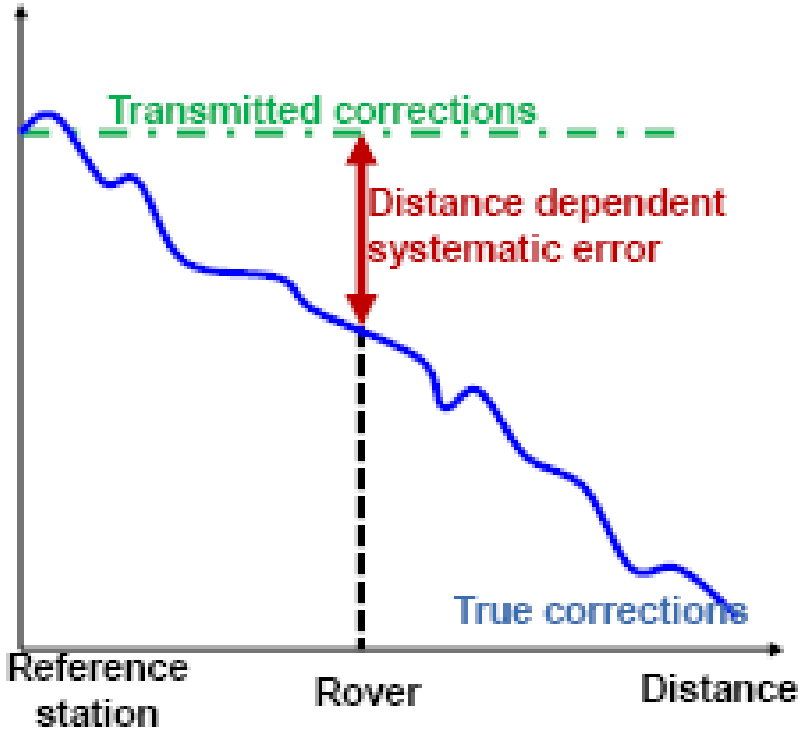
c: http://itrf.ensg.ign.fr/



c: http://igscb.jpl.nasa.gov/images/maps/all_world.png

6.2.4 Realizations

- Idea:
  - Interpolation of distance dependent systematic errors
- Realizations
  - Least-squares collocation
  - Interpolation polynomial
  - Interpolation functions
  - correction surface
  - State space representation of the errors in a network
- Representation
  - Virtual reference station
  - Area correction parameters

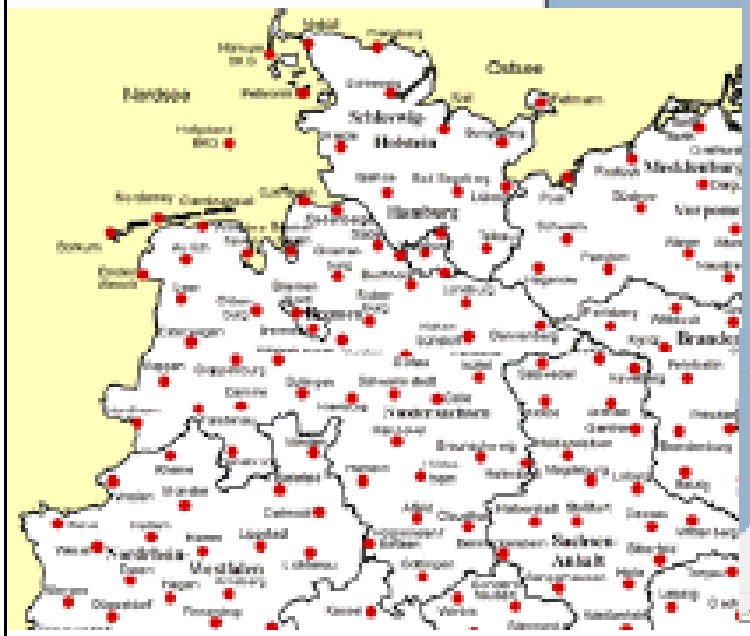


1.2 Scientific and technical questions solved with GPS

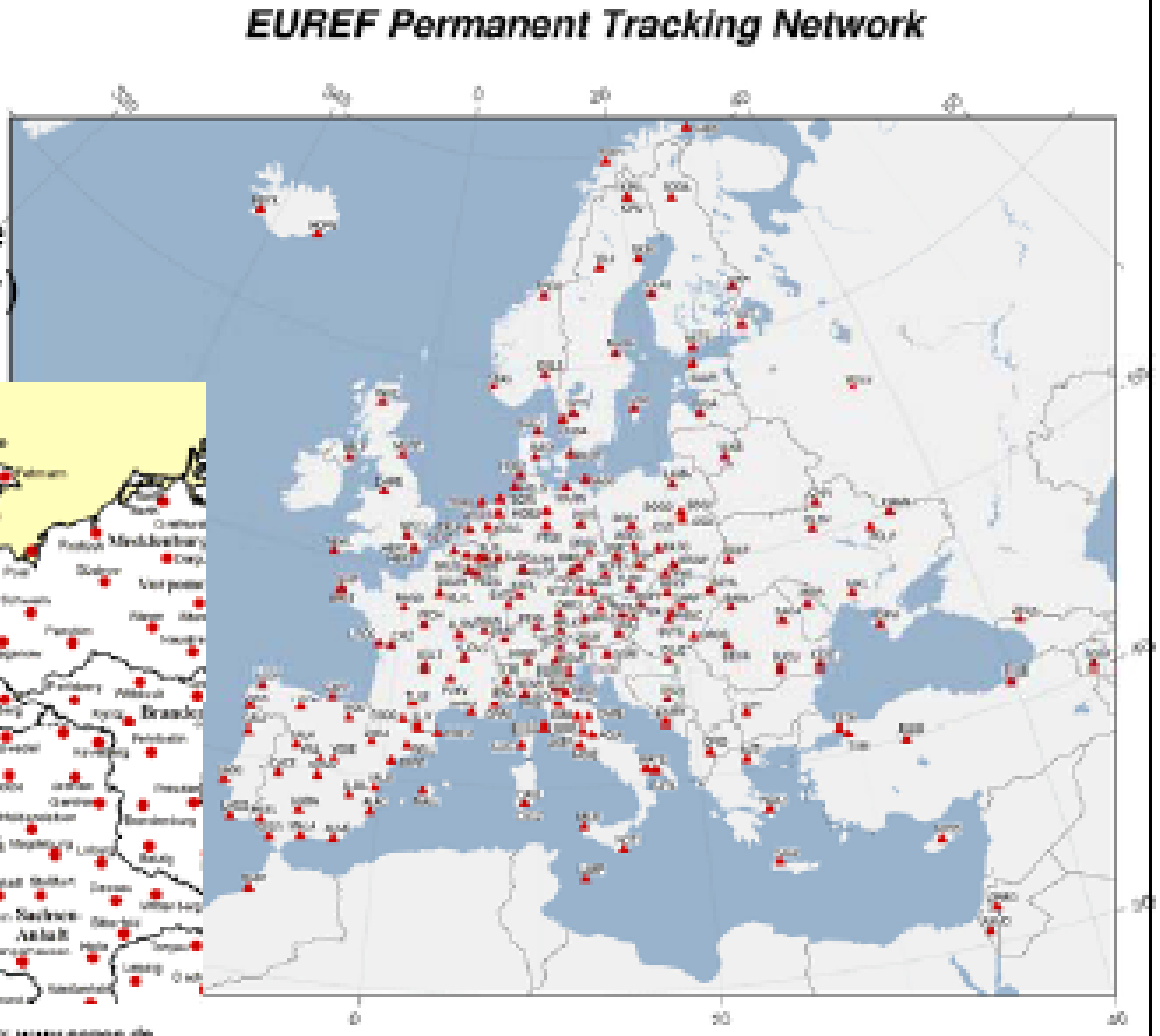
- EUREF

c http://www.epncb.oma.be/

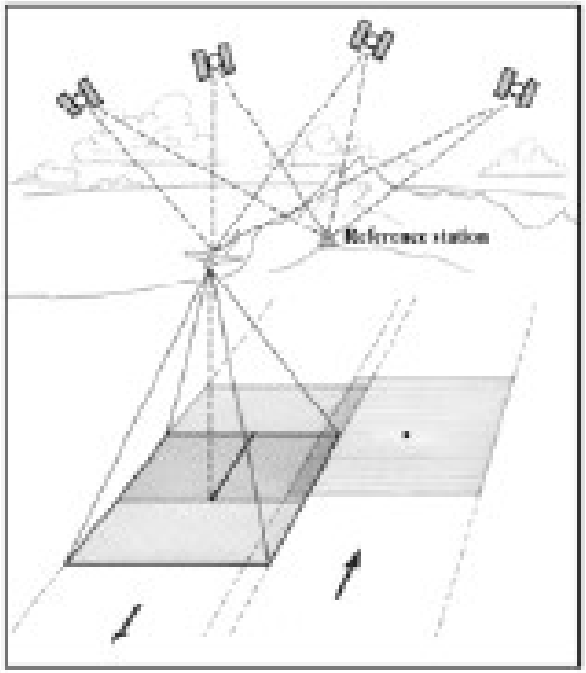
- SAPOS (satellite positioning service of the state survey)

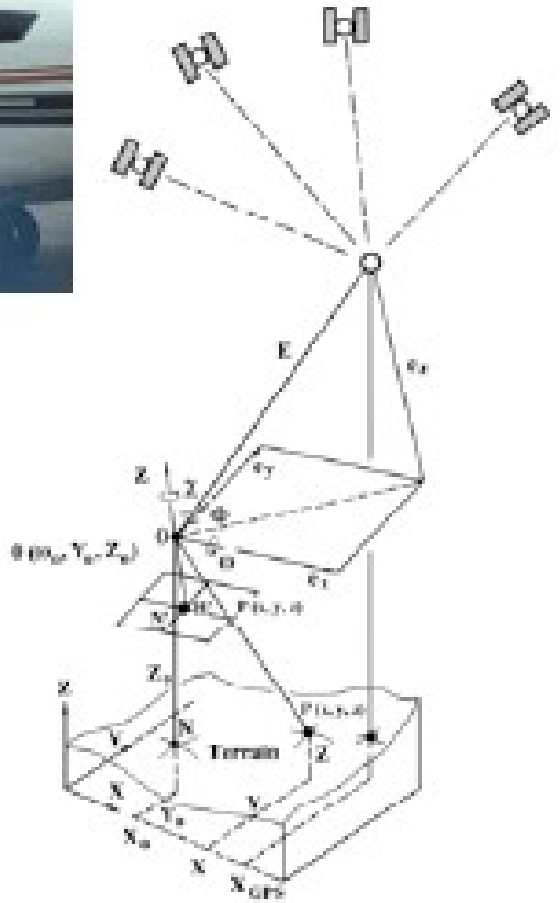


c www.sapos.de



1.5 GPS supported photogrammetry





Result:

1. Augmented Accuracy Systems such as
   EGNOS, WAAS, NTRIP and Omnistar permit
   static geolocation anywhere on the globe with
   +/- 50cm accuracy with inexpensive code receivers

2. Phase receivers operating in RTK mode at a range of 10km
   or in CORS networks with station up to 50km range
   permit +/- 1cm accuracy

3. Mobile applications with RTK or CORS reference permit
   +/- 1 dm accuracy

2. Digital Aerial Photography

1. Digital Aerial Cameras







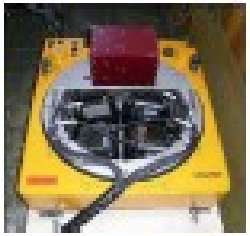
In most countries aerial film cameras not more accepted – Kodak and Agfa stopped production of aerial film

Aerial frame cameras (CCD-array) and CCD-line-scan cameras

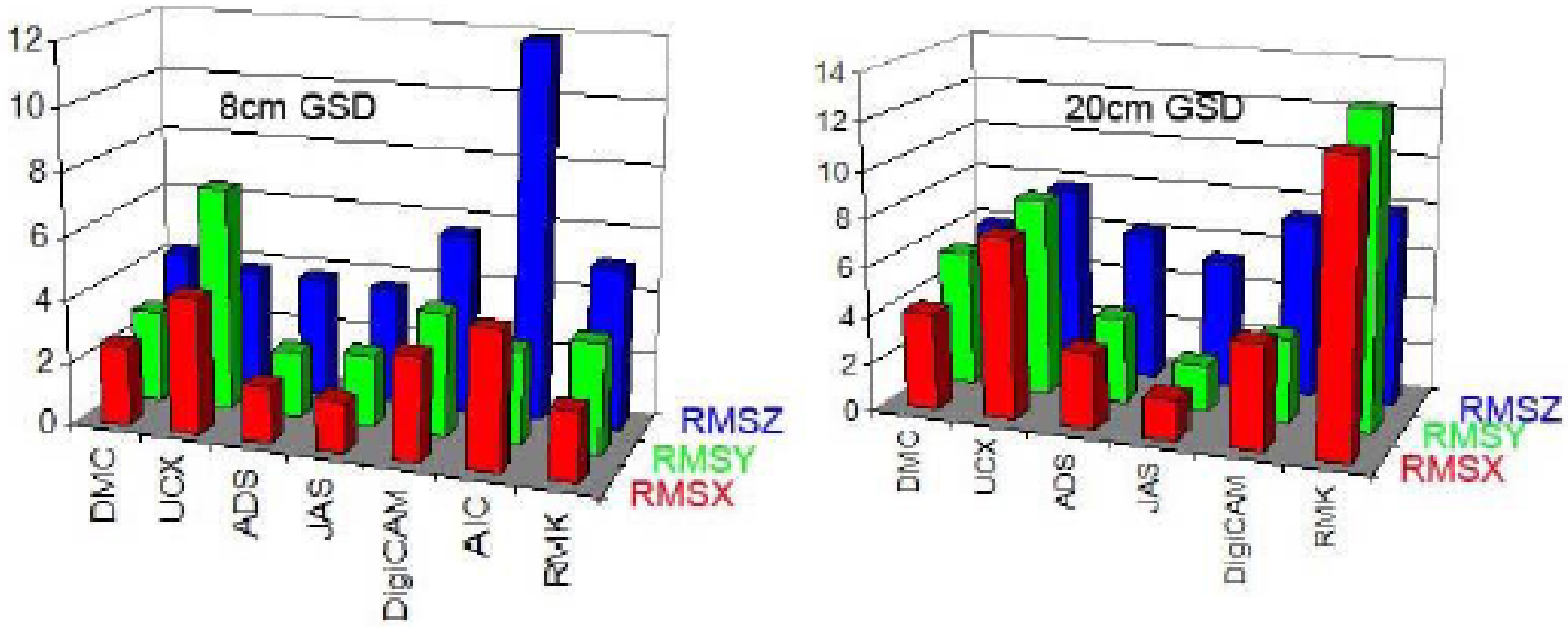
Aerial frame cameras: large format (DMC, UltraCam), mid format cameras – several (only cameras with stable body respected, fix-focus – not cameras as Canon EOS)

also combinations of mid format cameras (2 up to 5 cameras), for UAVs tiny cameras in use



Geometric performance



Results of camera test by German Society of Photogrammetry, RS and Geoinf.

Bundle block adjustments: root mean square errors at independent check points

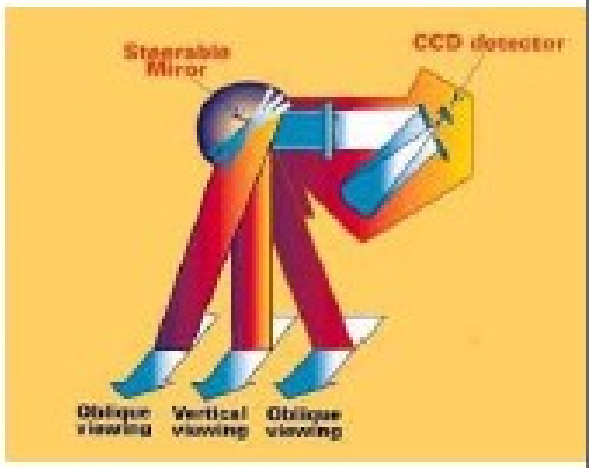
3. High Resolution Satellites

2. Optical space imagery for mapping purposes

Limited to civilian available systems and systems usable for mapping (~<6.5m GSD)

GeoEye-1

Cartosat-2

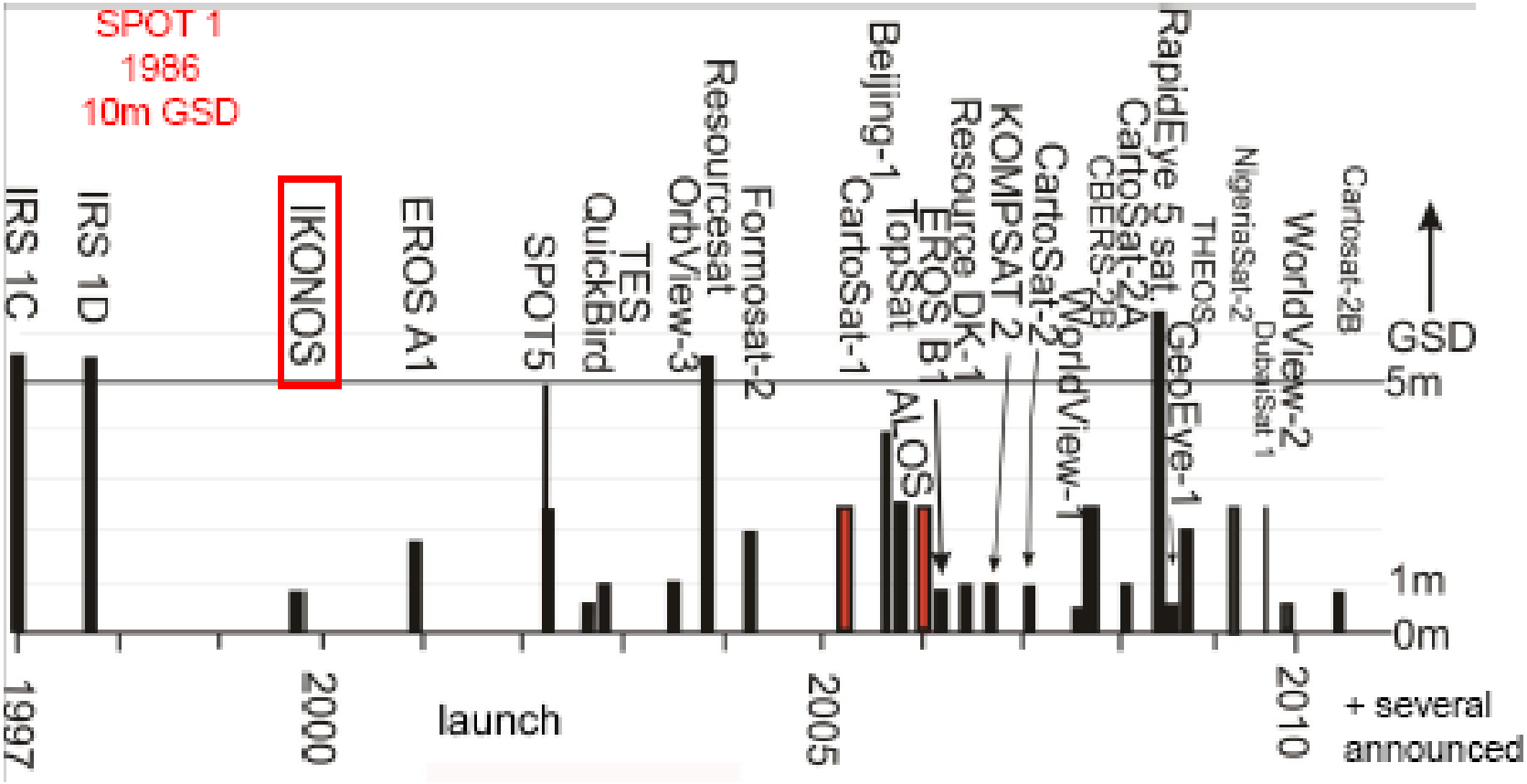


SPOT

Old systems: different view direction to side by rotating mirror or slowly rotating satellite – big satellite with cameras

New systems: one large camera, fast rotating satellite (big optical system with components around)

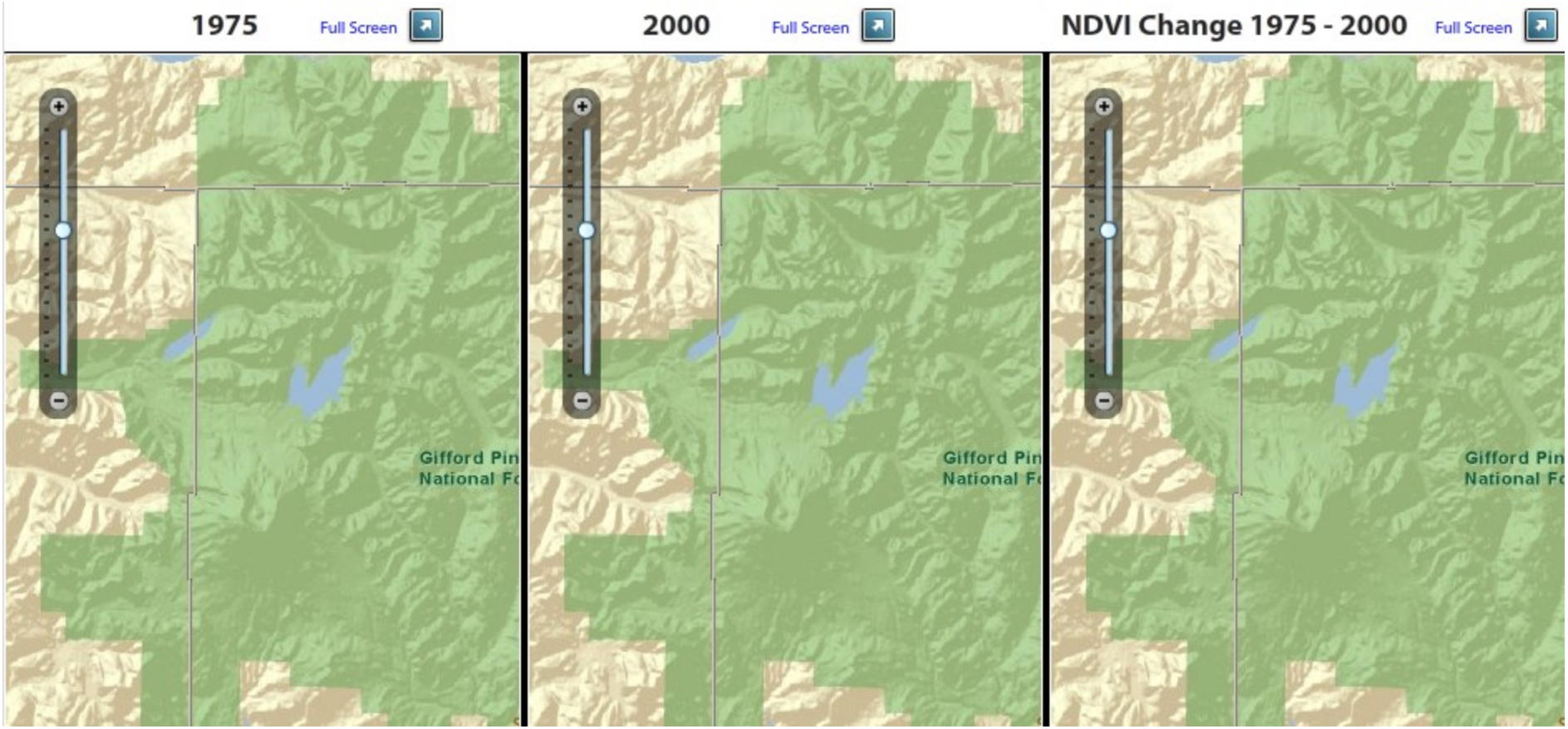
High and very high resolution optical satellites



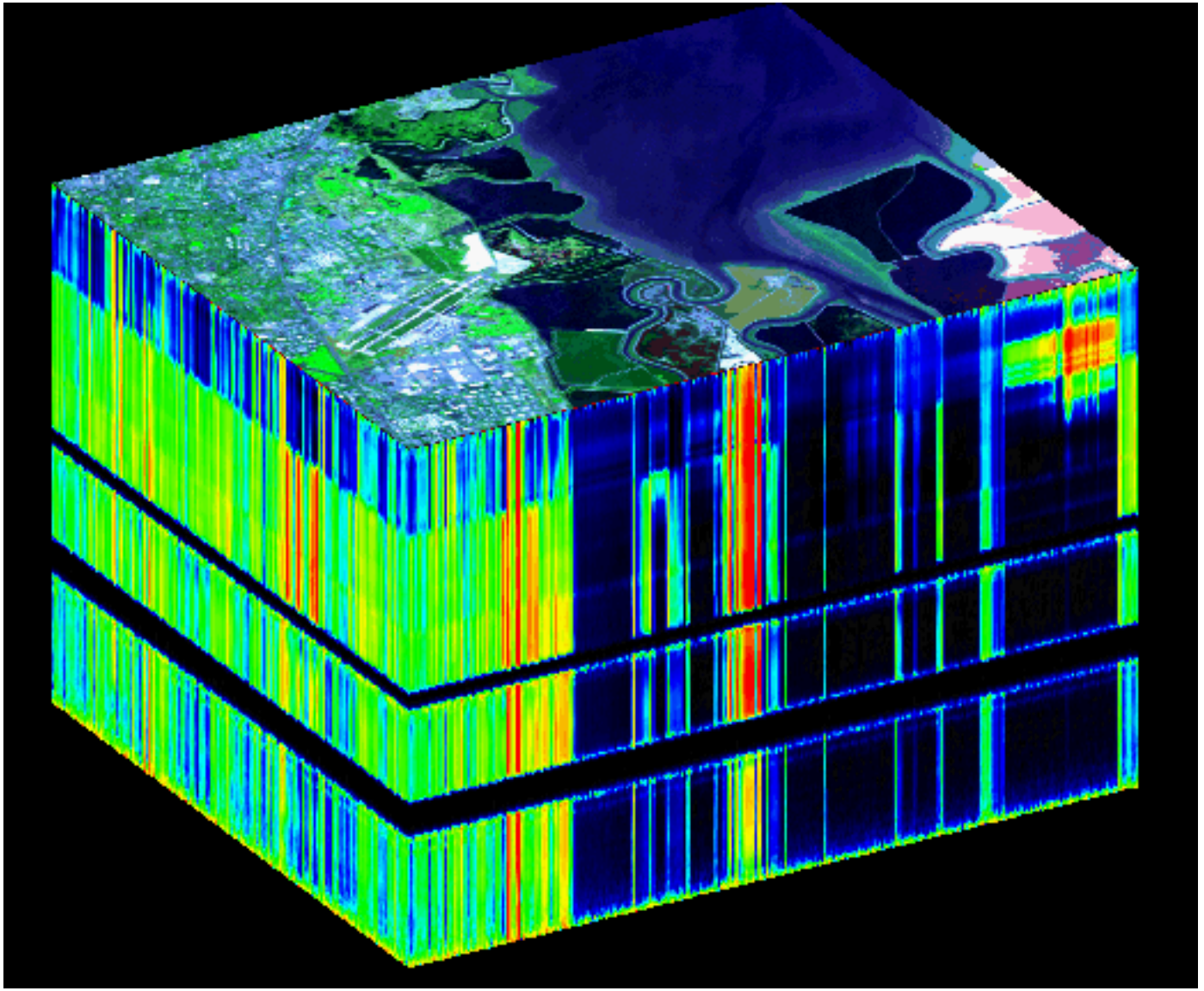
SPOT 1 (1986) start of mapping from space

IKONOS (1999) competition with aerial images

ESRI Viewer for Change Detection of Landsat Images

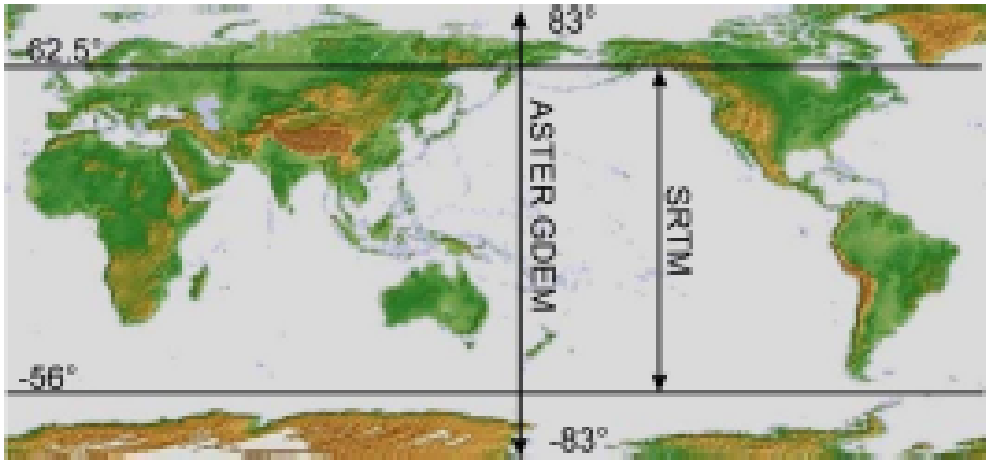


Hyperspectral Cube (AVIRIS Data)



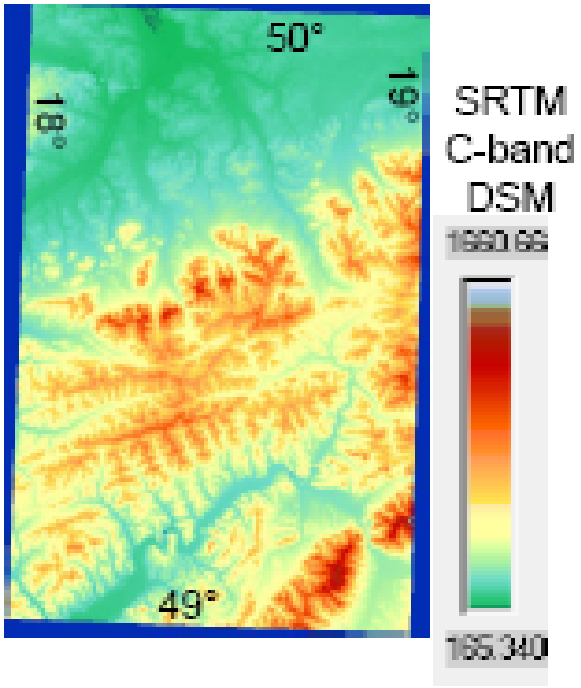
Competition between Optical and Radar Systems

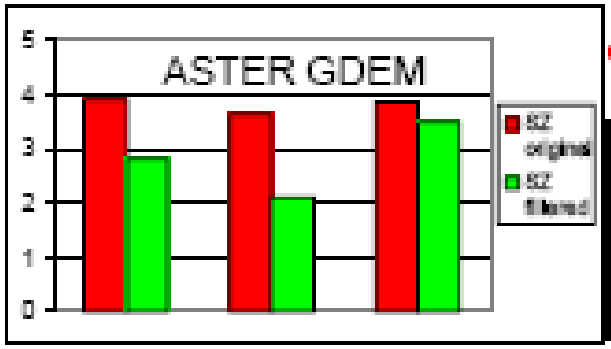
Nearly world-wide height models: ASTER GDEM – SRTM C-band DSM



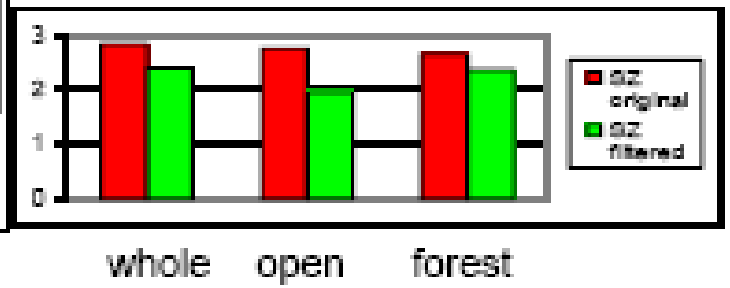
SRTM C-band DSM (Radar), 3 arcsec spacing ~90m

ASTER GDEM DSM based on ASTER images,
1 arcsec spacing ~ 30m





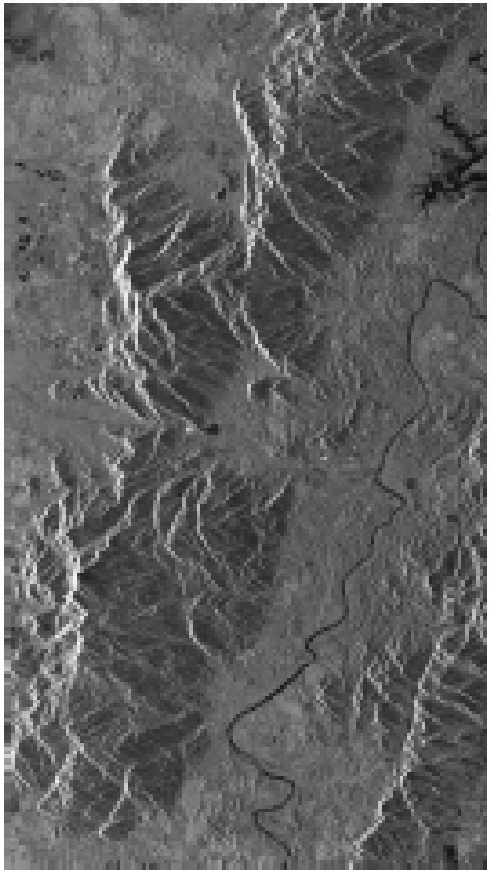
original SZ – filtered SZ



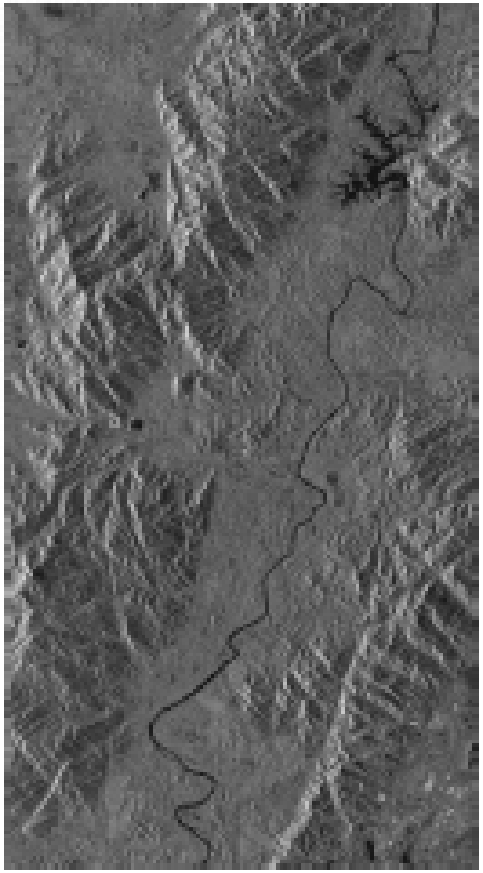
Test area Atlantic County
flat, partially forest with bushes and low trees

Experiment

TerraSAR-X stereo pair



Sep. 13, 2009
Incidence angle:21.4°



Sep. 18, 2009
Incidence angle:42.7°

SAR Stereo:

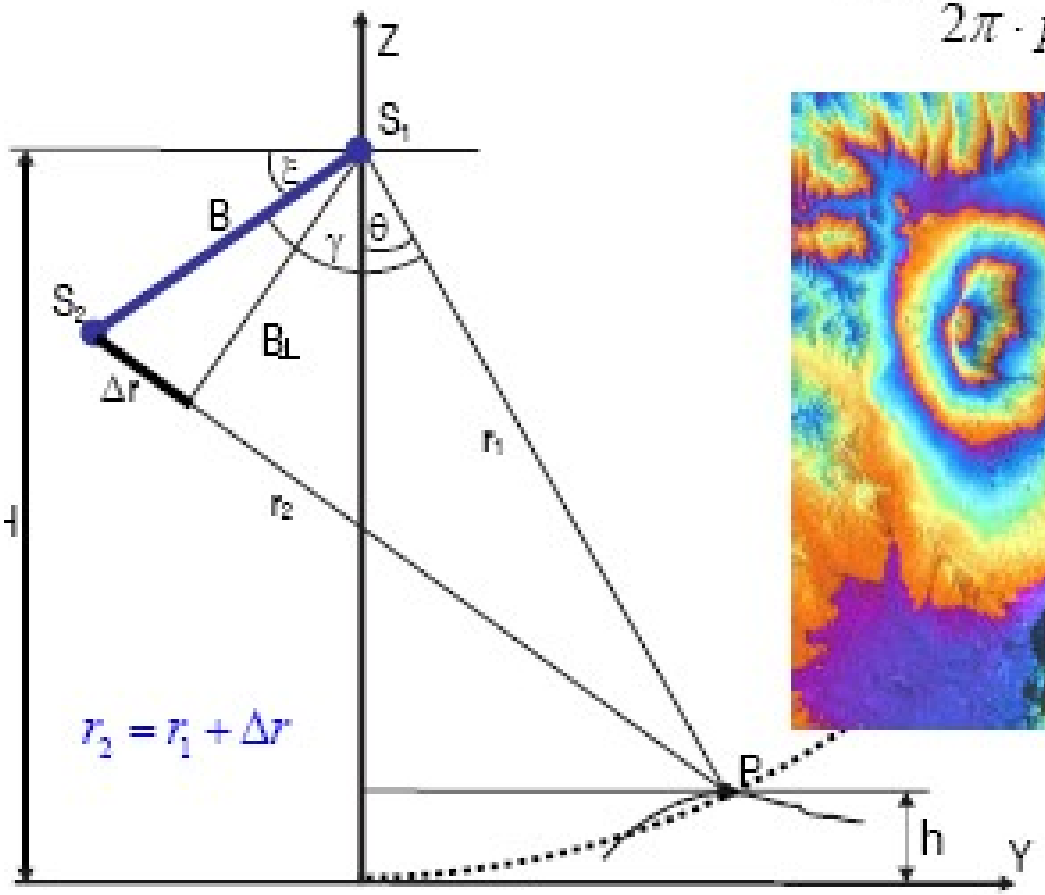
- similar to Photogrammetry
- uses image amplitude

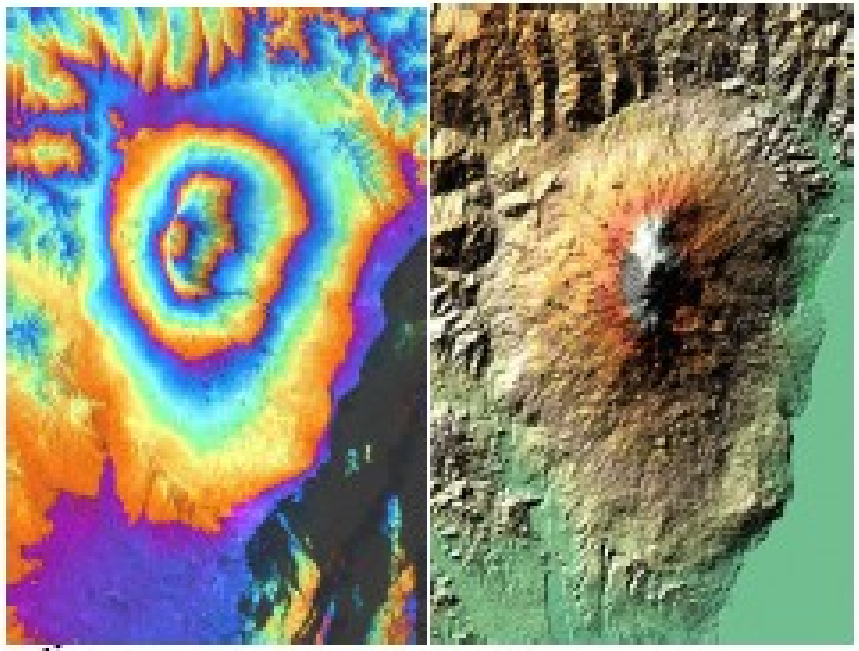
  → matching
- more robust against temporal decorrelation then InSAR
- requires sufficient basis (different θ)

Digital Elevation Models (DEM) from InSAR

- Standard InSAR

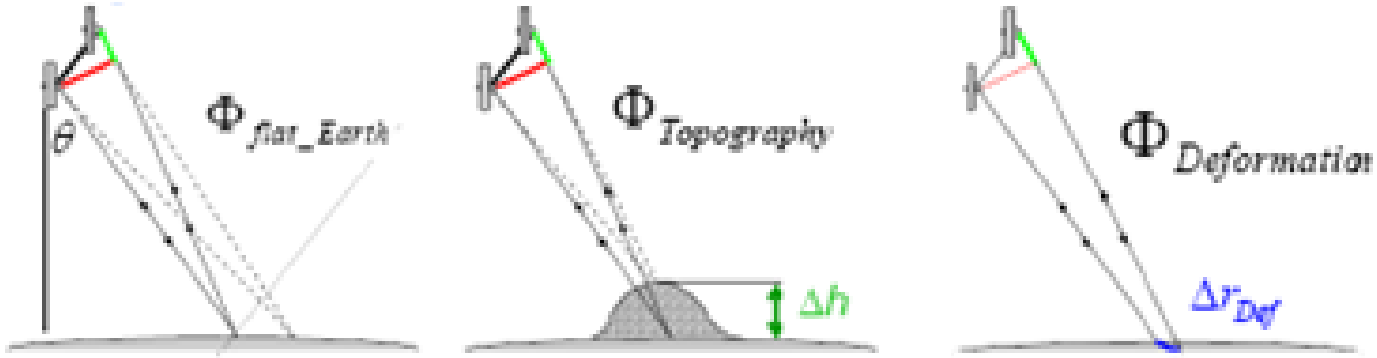
$$h \approx \frac{\lambda}{2\pi \cdot p} \cdot \frac{r_1 \cdot \sin(\theta_0)}{B \cdot \cos(\theta_0 - \xi)} \cdot \Delta\varphi$$





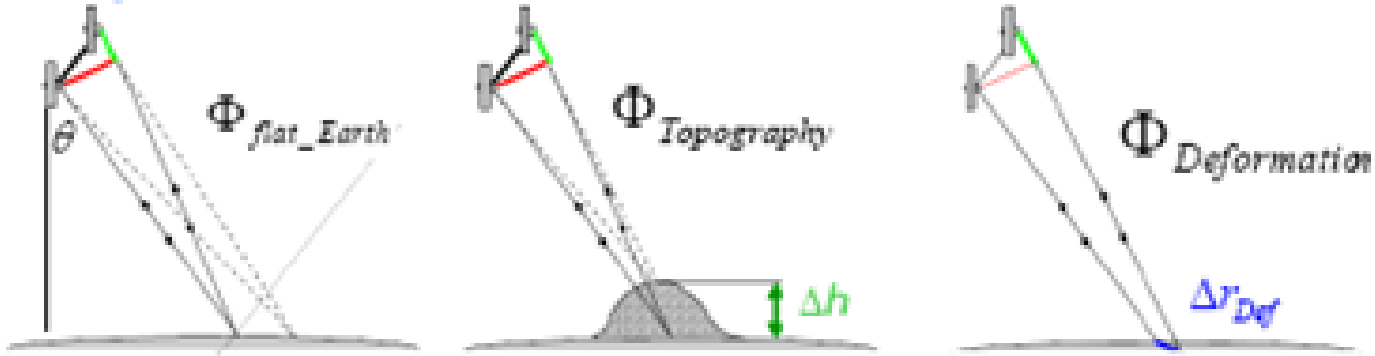
ERS-1/2, ©ESA

Surface motion: Interferometry



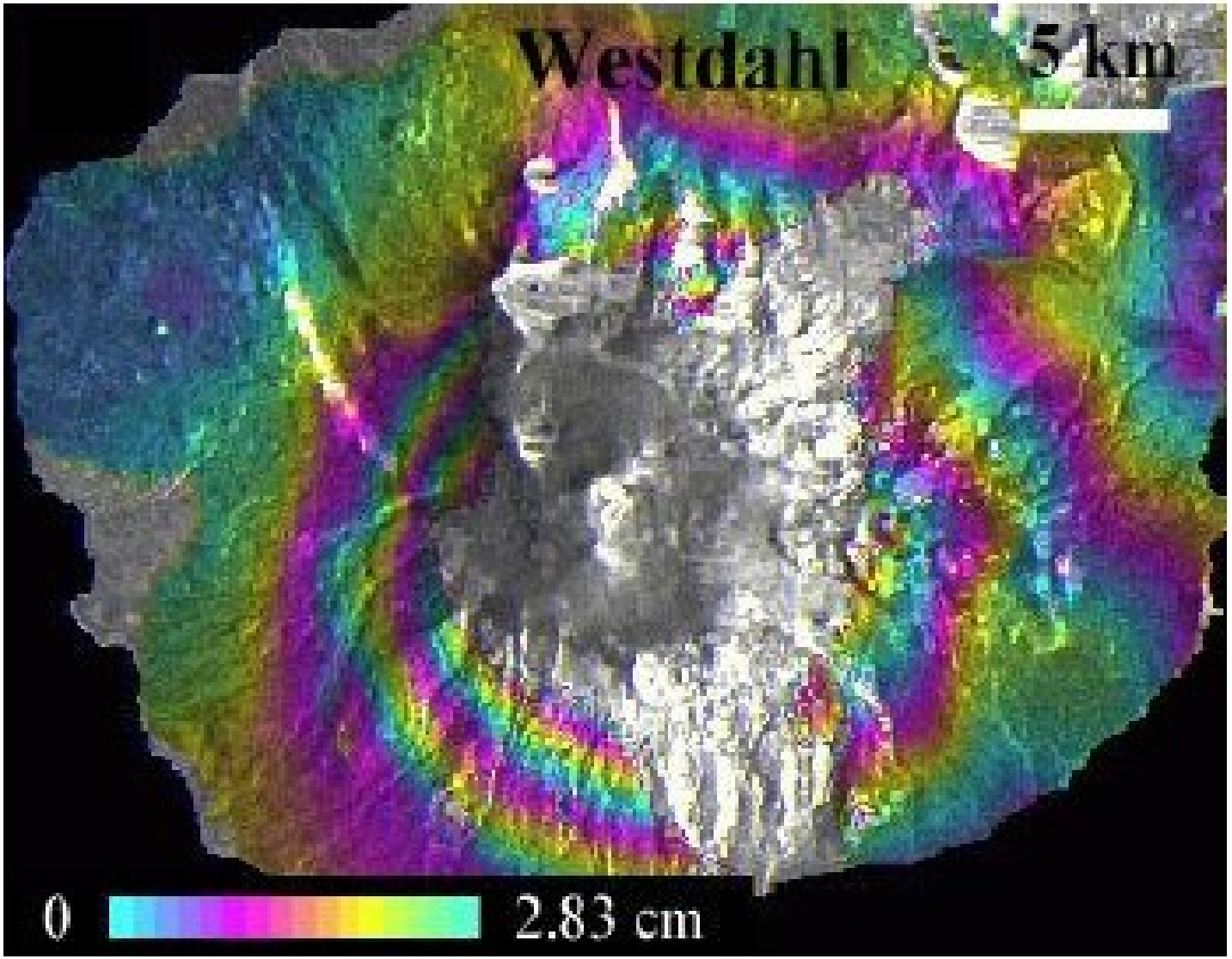
$$\Phi = W\left\{\Phi_{flat\_Earth} + \Phi_{Topography} + \Phi_{Deformation} + \Phi_{Error}\right\}$$

Surface motion: Differential Interferometry



$$\Phi = W\left\{\cancel{\Phi_{flat\_Earth}} + \cancel{\Phi_{Topography}} + \Phi_{Deformation} + \Phi_{Error}\right\}$$

Motion of Vulcano



4. Laser Scanning

- TLS Terrestrial Laser Scanning

- ALS Airborne Laser Scanning

- MLS Mobile Laser Scanning

TLS Terrestrial Laser Scanning

Scanner and Camera

Properties of 3D Laserscanners

Model	RIEGL LMS VZ400
Distance	up to 500 m for Laser Class I
Scan range horizontal	total 100° (+60° / -40°)
Scan range vertical	max. 360°
Distance accuracy	± 5 mm
Data rate	125 000 points/sec.
Measurement	Interference

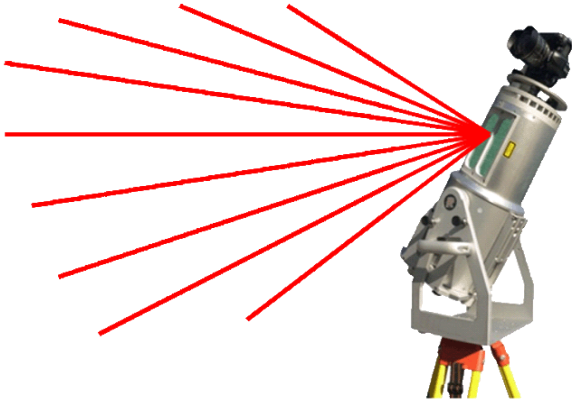
ALS Airborne Laser Scanning

Geoservice GmbH

Aero-Complex-M
Universal Data Collection System

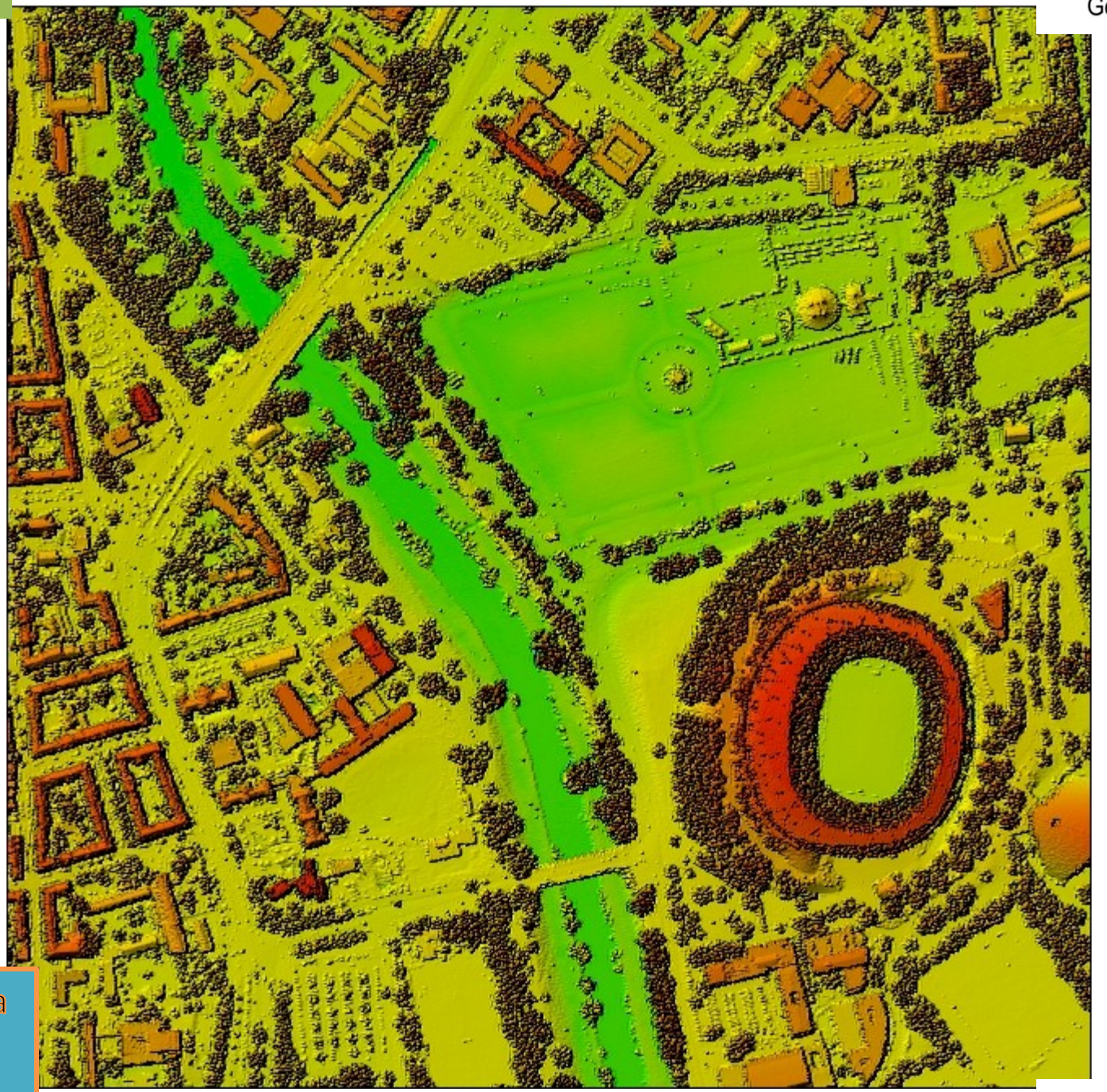
with

- **Airborene Laser Scanning**
- **Infrared Thermography**
- **Terrestrisches Laser Scanning**
- **Digital RGB Images**
- **Imaging Spectrometer**



DHM erzeugt mittels ALS
DSM Shaded Relief

Geoservice GmbH

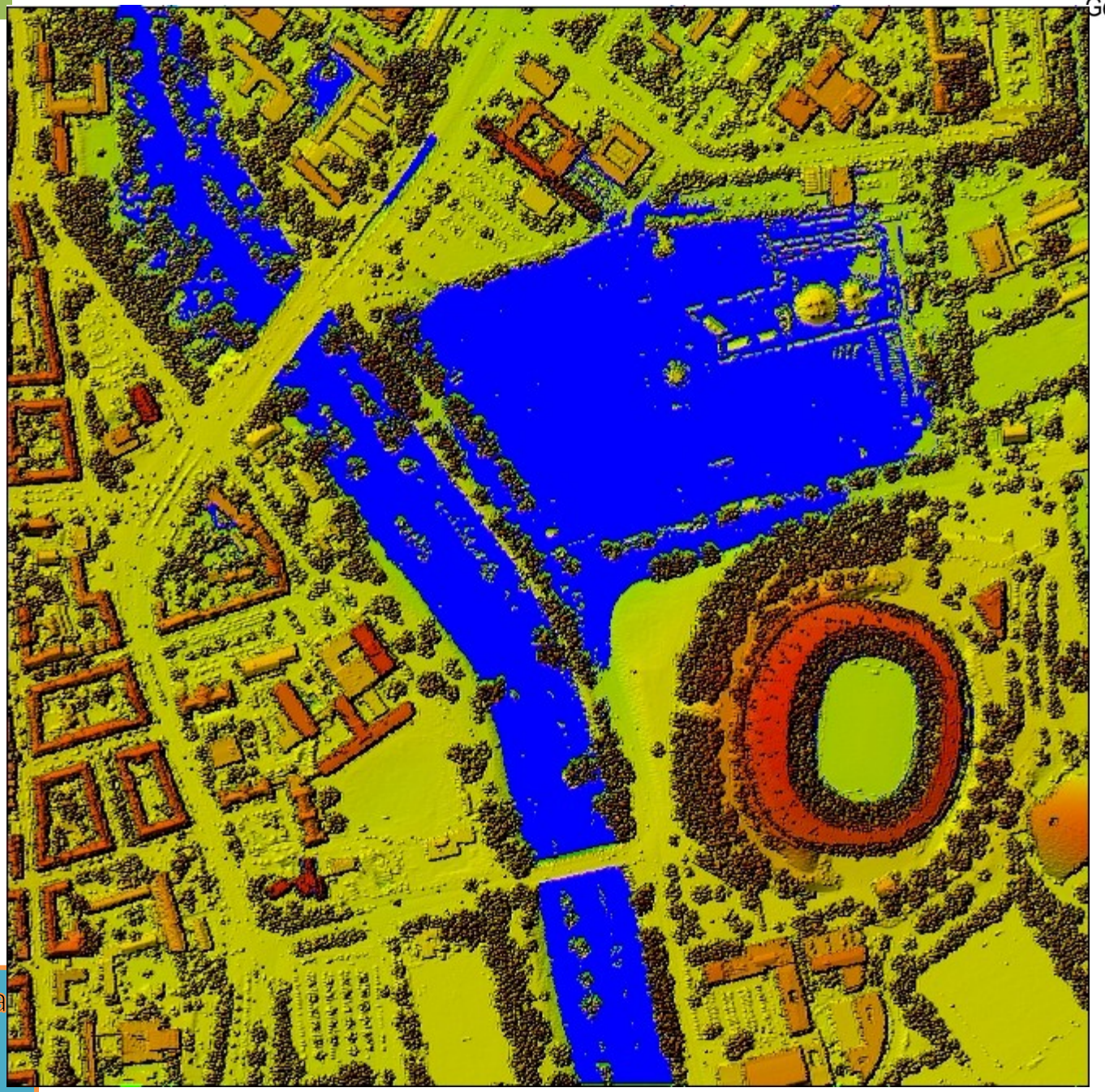


AWD – Arena

90 m

DHM erzeugt mittels ALS
DSM Shaded Relief

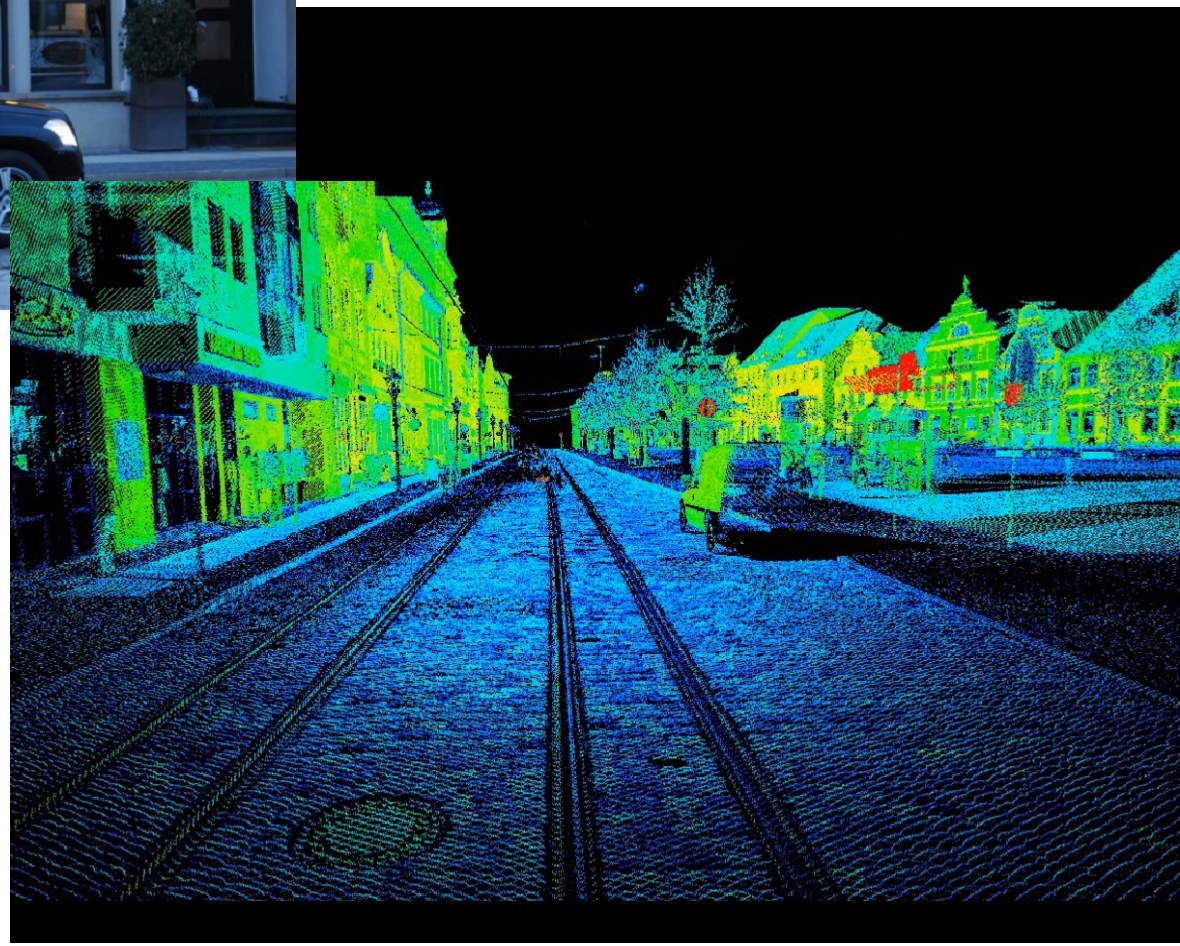
Geoservice GmbH



AWD – Arena

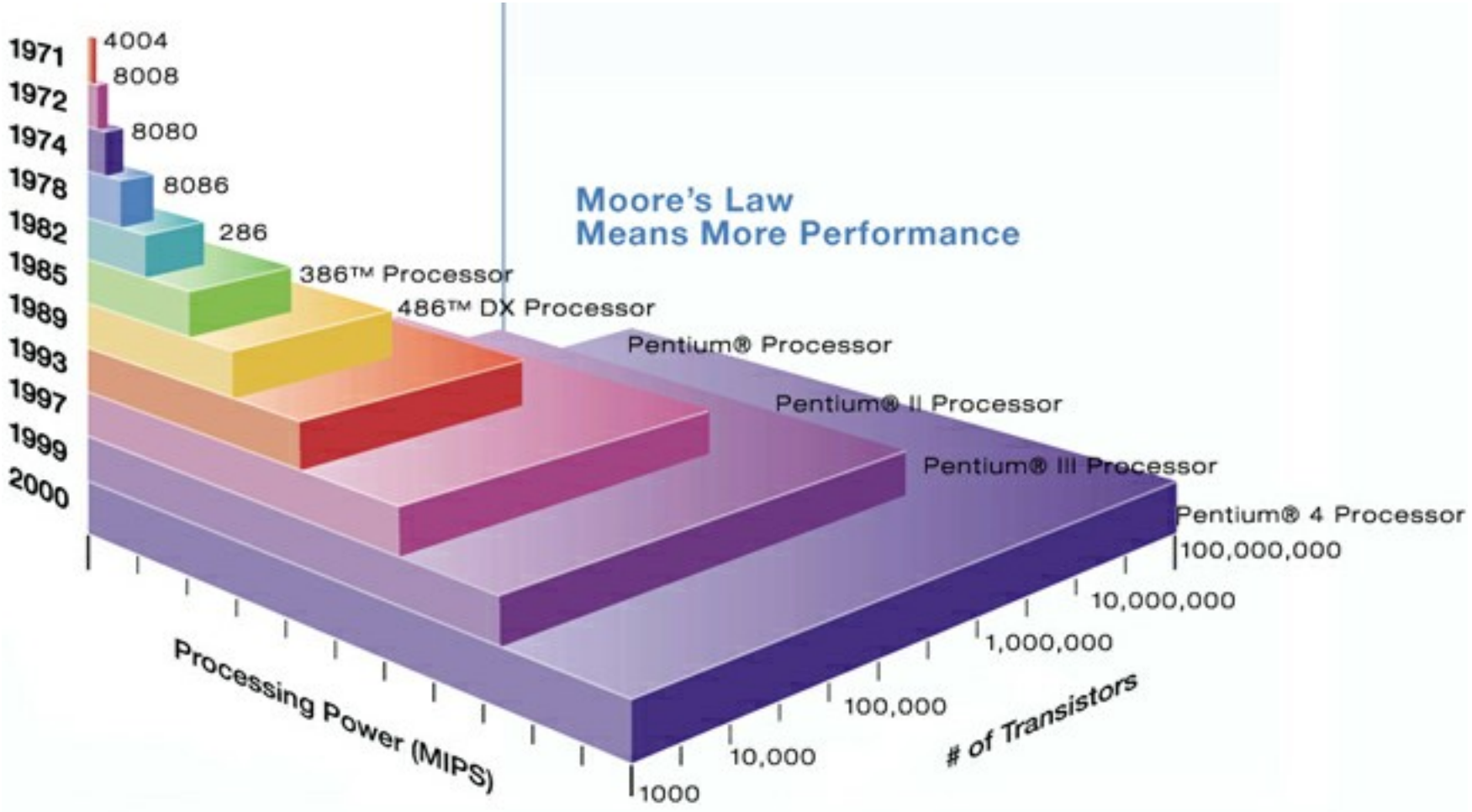
94 m

MLS - Mobile Laser Scanning



Stadt Cottbus

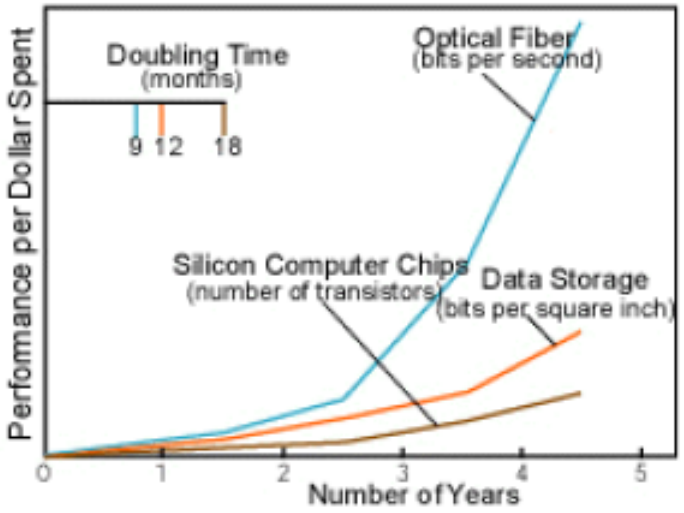
5. Exponential Growth of Computer Technology



Exponential Growth in Network Performance

Network exponentials

- Network vs. computer performance
  - computer speed doubles every 18 months
  - network speed doubles every 9 months
  - difference: order of magnitude per 5 years
- 1986 to 2000
  - computers: x 500
  - networks: x 340,000;
    factor 1000
- 2001 to 2010
  - computers: x 60
  - networks: x 4000;
    factor: 100

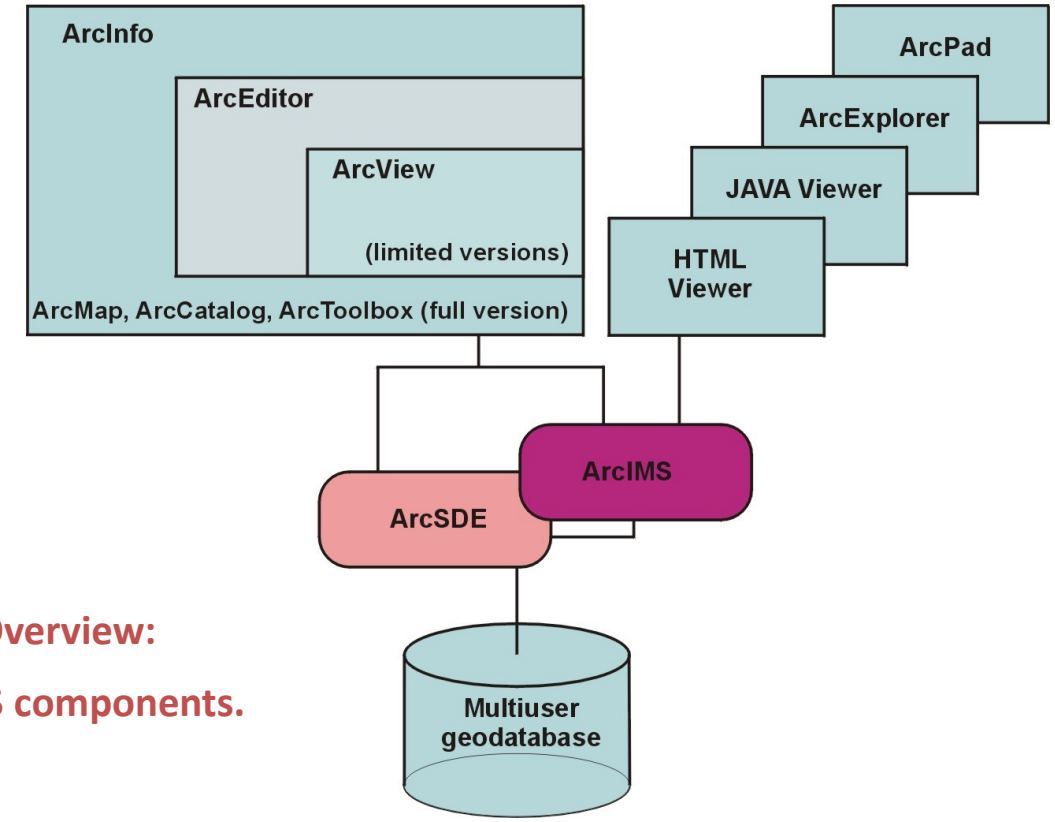


Moore's Law vs. storage improvements vs. optical improvements. Graph from **Scientific American** 2001) by Cleo Vilett, source Vined Khoslan, Kleiner, Caufield and Perkins

6. GIS and Database Technology

an example: ArcGIS

Software components in ArcGIS (1)



Overview:

ArcGIS components.

Test Plots - Level 1 Map

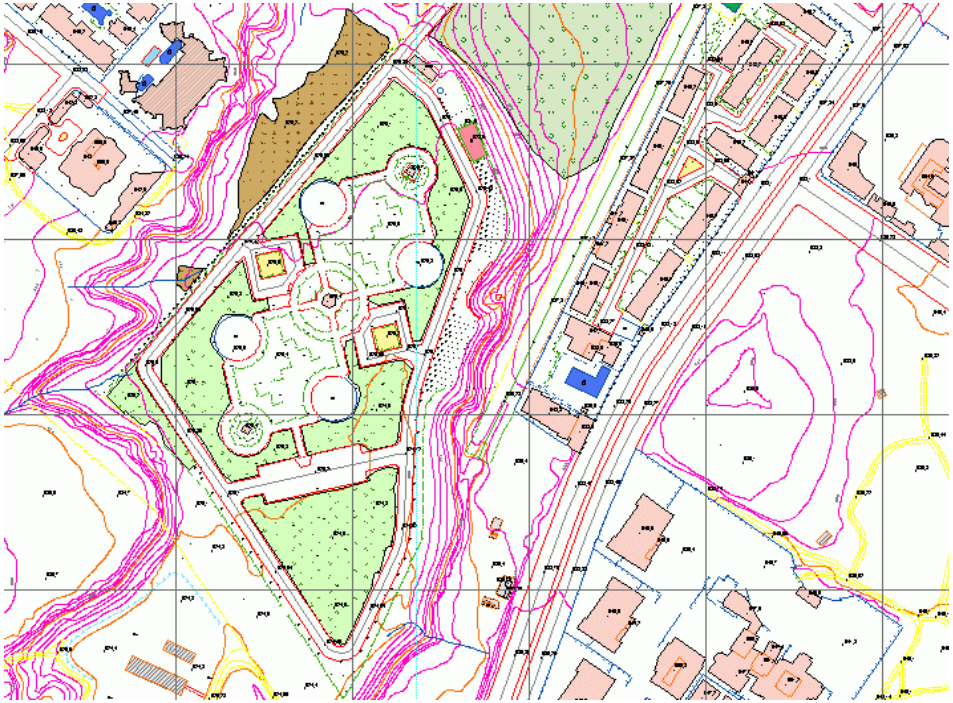
Introduction

Objectives

Materials & Methods

Results

Conclusions / Outlook



Result of import into ArcGIS/ArcInfo and automated polygon closure & attribute allocation.

Test Plots - Level 2 Map

Introduction

Objectives

Materials & Methods

Results

Conclusions / Outlook

Result of import into ArcGIS/ArcInfo and manual polygon closure & attribute allocation.

Image or Raster Data and the Geodatabase (3)

1. Storage of raster data in database tables

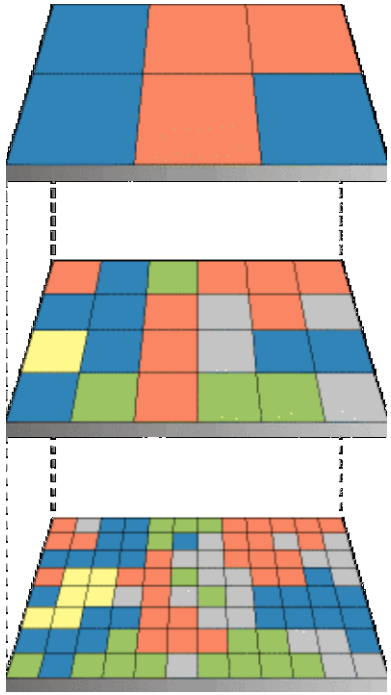
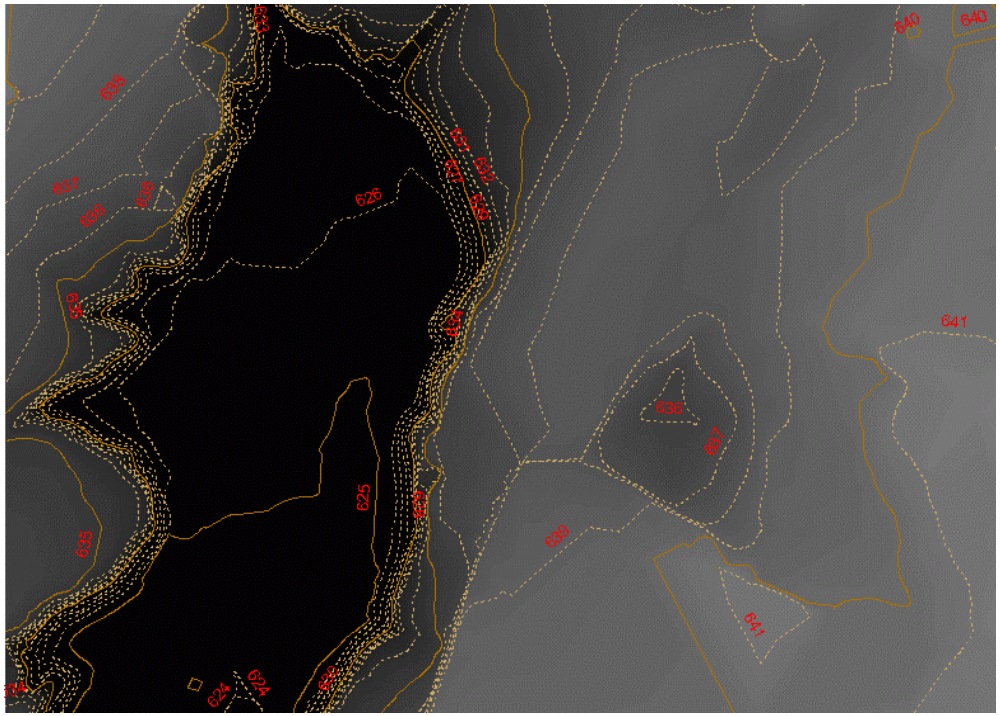


Image pyramid.

The geographical extent remains identical in every pyramid layer.

Test Plots - Level 2 Map



DEM from elevation information with automatically generated contours.

Software components in ArcGIS (11)

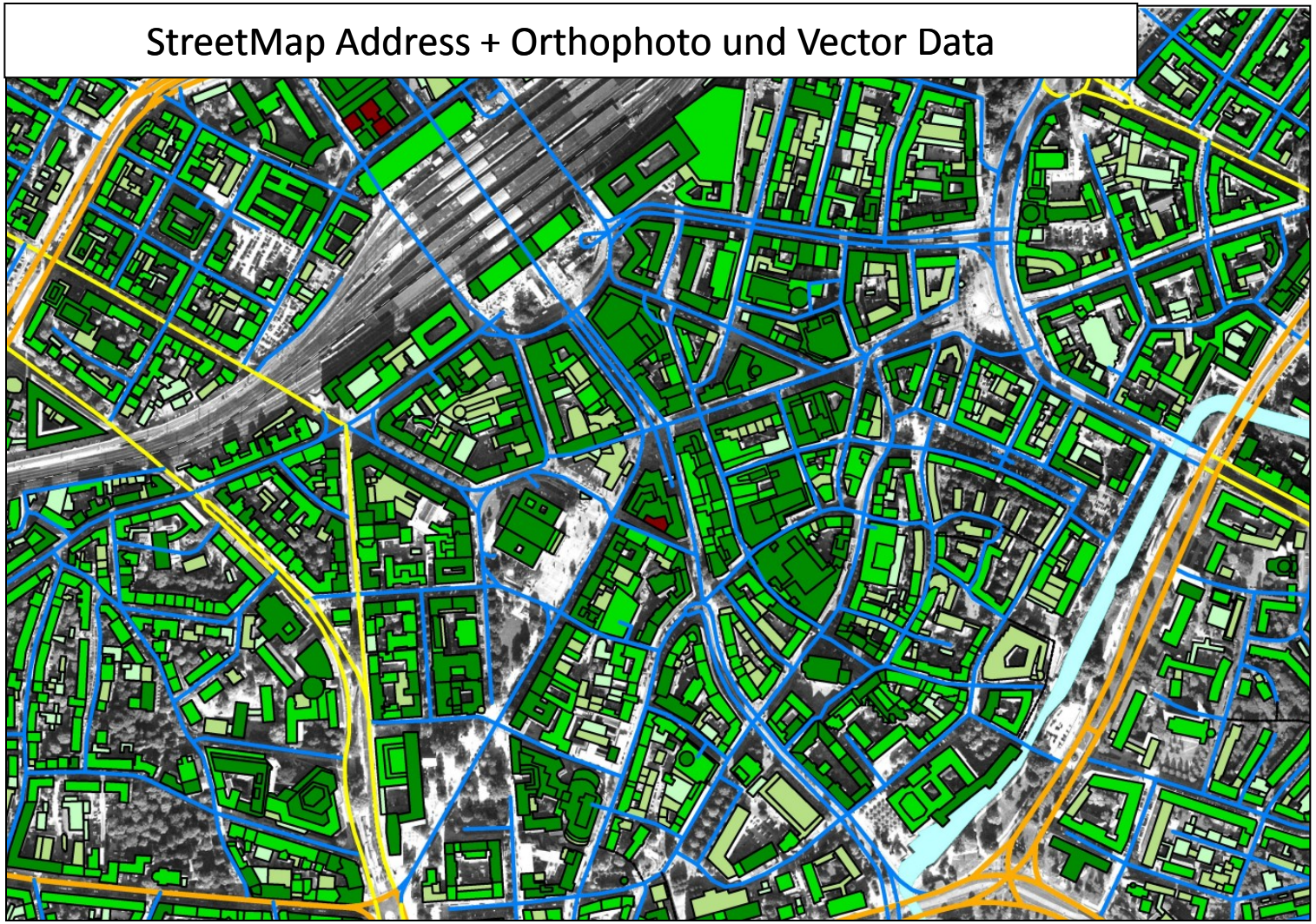
Components of ArcGIS desktop software (6):

Extensions (additional components):

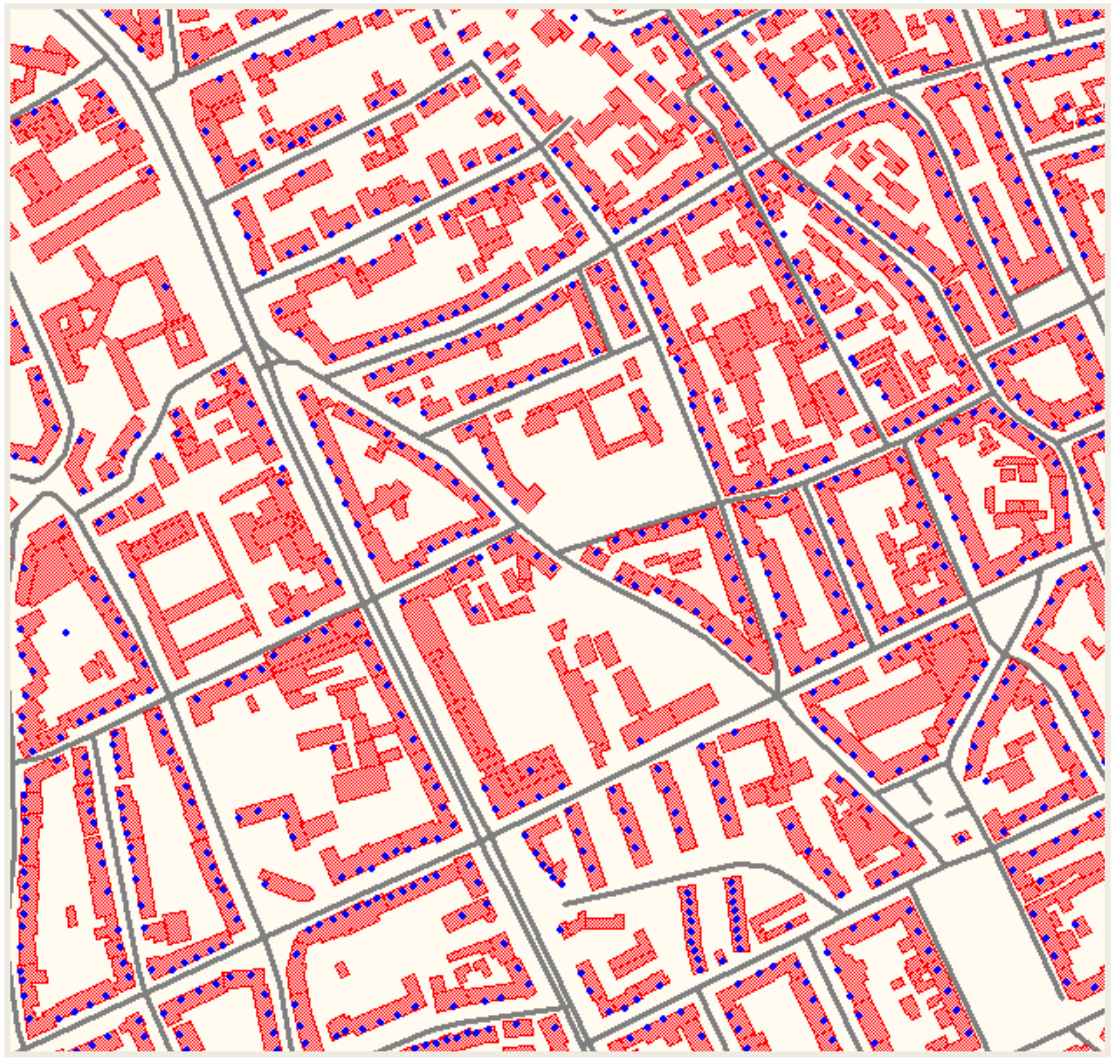
- ArcGIS Spatial Analyst for processing and modelling surface information in grids
- ArcGIS 3D Analyst for processing surface information in TINs
- ArcGIS Geostatistical Analyst
- ArcGIS Survey Analyst
- ArcPress for printing
- etc.

City models: Vector data

StreetMap Address + Orthophoto und Vector Data



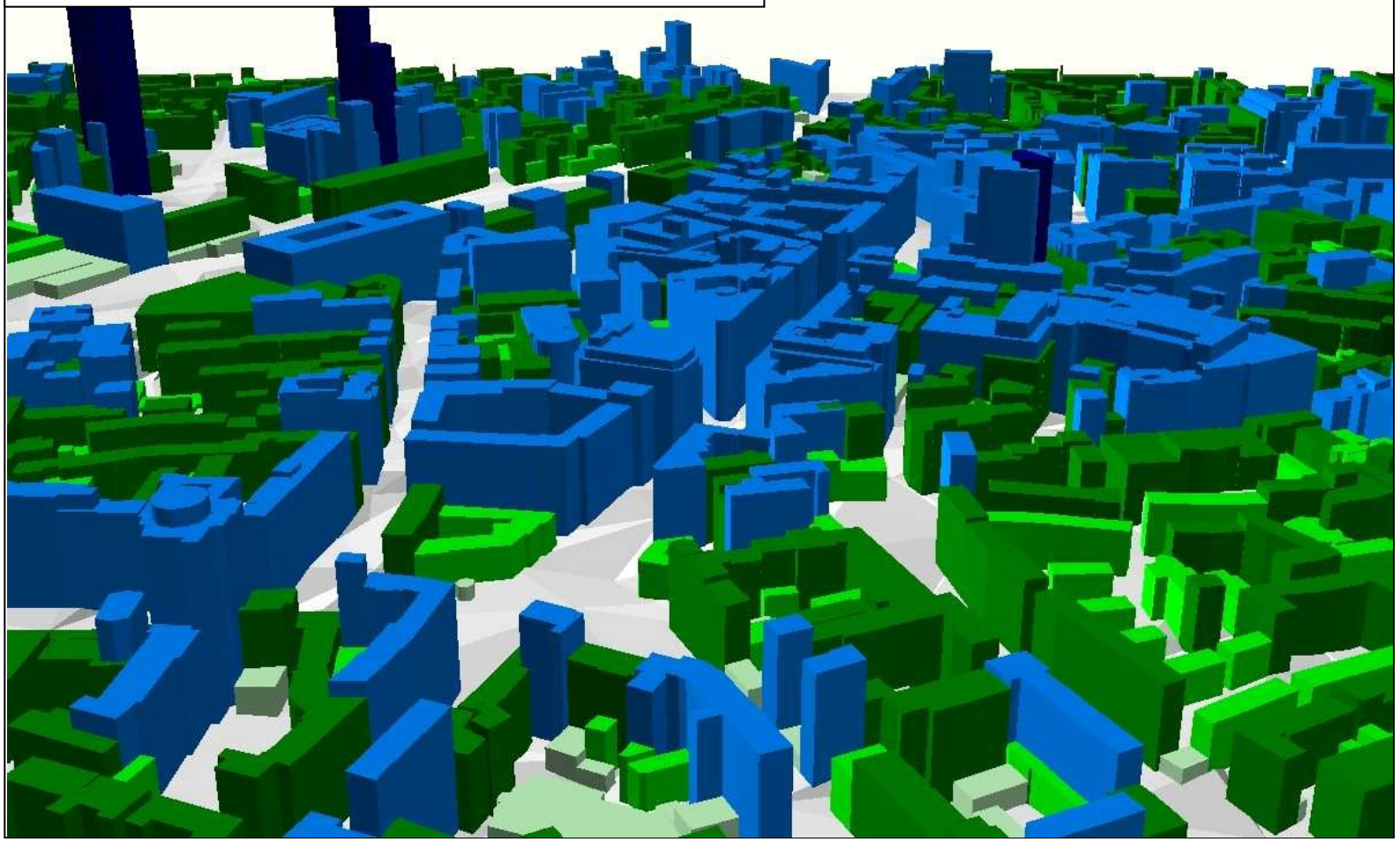
City models: Address information



- Point: address information
- Polygon of the building
- Road network

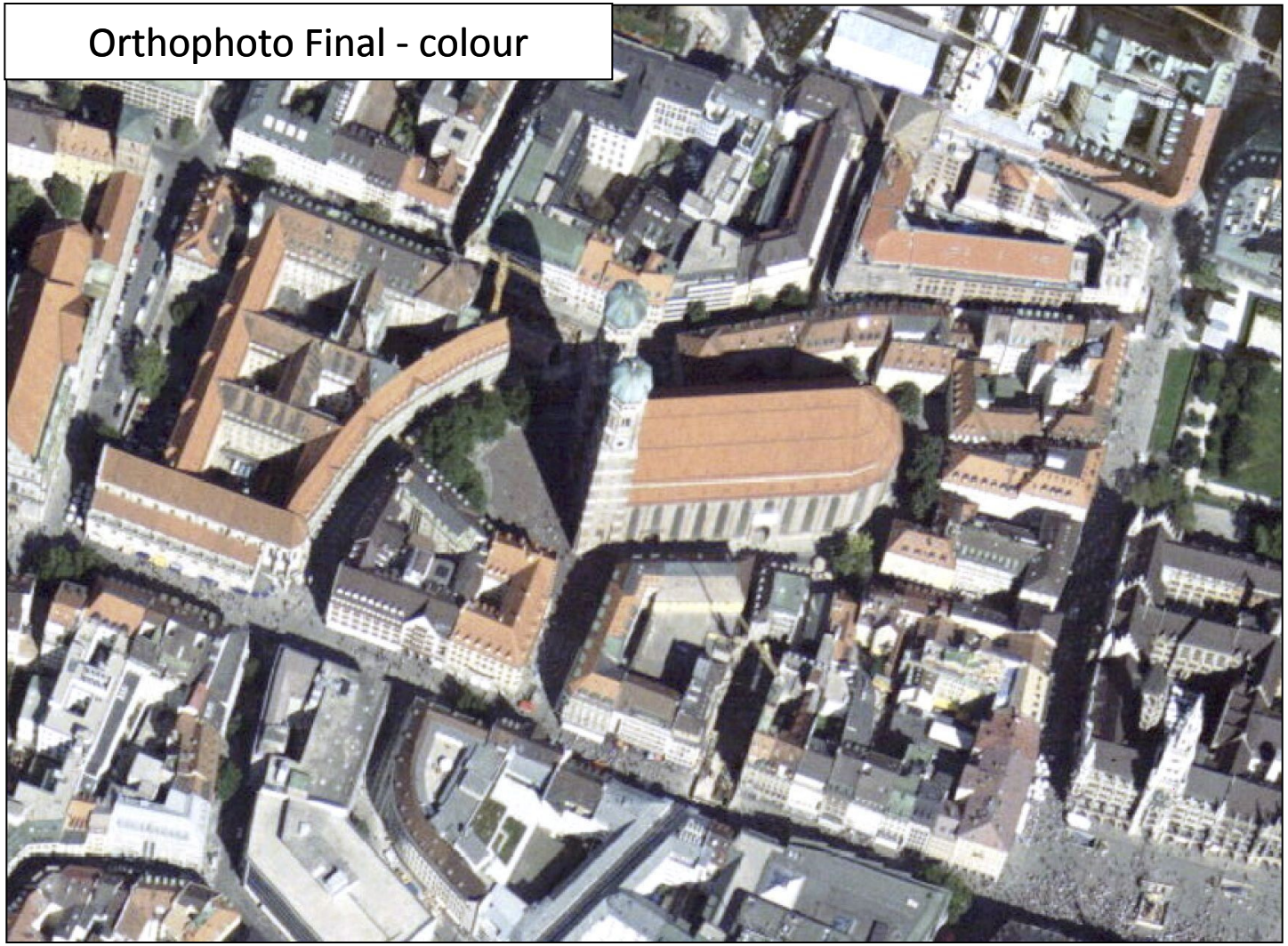
City models: Vector data

Building model: 3D presentation



City models: Orthophoto

Orthophoto Final - colour



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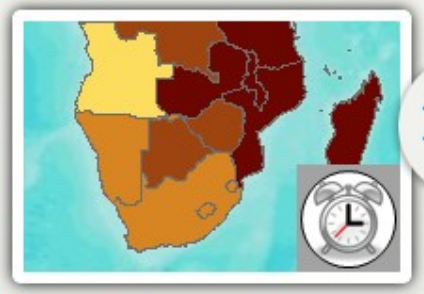
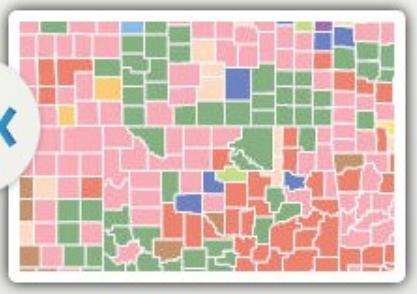
Ocean Basemap



World Bank Pump Price, Diesel and Gasoline



USA Tapestry Segmentation

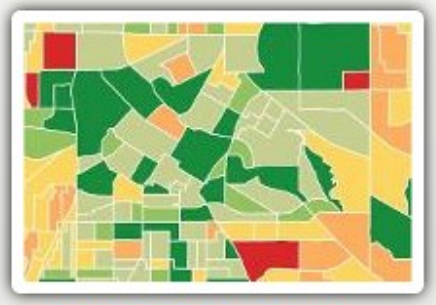
USA Soil Survey

Canada Basemap

Hong Kong Street Map

Landsat Time Enabled Imagery

Spain



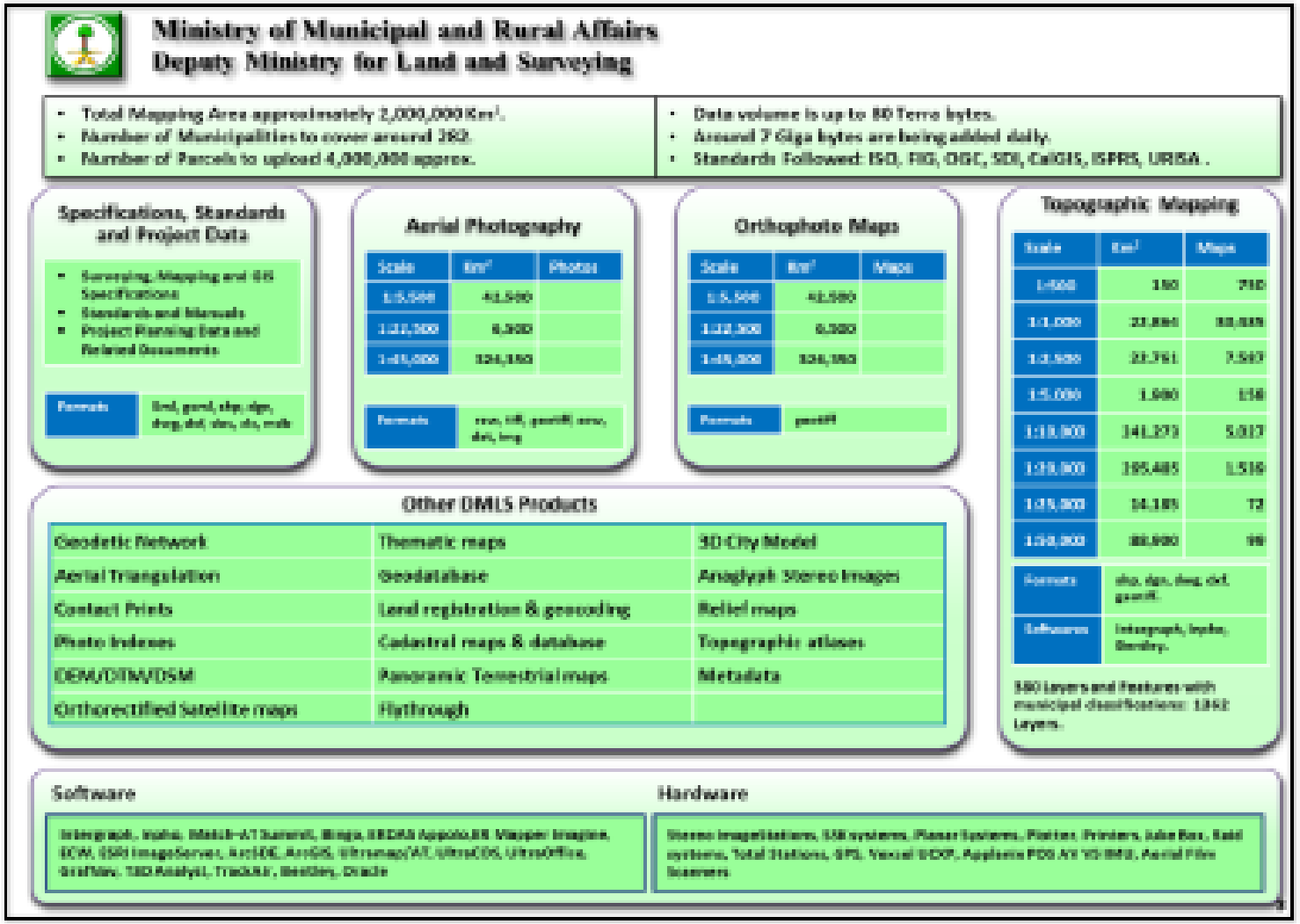
USA Population Change 2000-2010

Portugal Imagery

7. Web Portal, Web Services, Data Management

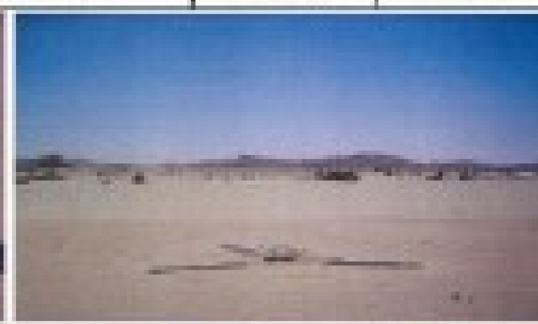
Components	Element	Environment	Functions
Web-Portal	Web Site,Web Control	.NET	Search, Map Viewer, Publish, Administrate Query, Gazetteer, Mapping, Edit, Geo-coding
Web-services	Geographical Web-services	XML, SOAP, WSDL, WMS, WFS	Query, Map render/feature, Transaction, Geocode
Data Management	DBMS	Oracle	Raster,vector, Tabular

Data to be distributed through the Portal



Geodetic description information:

SECOND ORDER REFERENCE STATION OF NAJRAN AREA					
Station ID:	5010	Marker/Monument Type:		Concrete with 4 inch plastic pipe and point ID	
Description of Location: For that point you have to go on the road south of Yadamah. After 2 km you turn left and go 3 km on the road. Turn to the right and go 1,5 km inside the area.					
Station Coordinates (WGS 84)					
Latitude	Longitude	Ellips. Height	X	Y	Z
16°59'51,7300''	44°14'35,6030''	1 187,369	4 396 640,862	4 302 112,060	2 011 077,614
UTM Co-ordinates (WGS 84, Zone 38)					
Easting		Northing		Ellipsoidal Height	Orthometric Height
38 419 759,610		2 046 418,804		1 187,269	1191,966



GMN: Search by Region, Muhafza, GMN Number

Ownership Information

8. Smart Phones

Apple

I Pod

I Pad

I Phone

I Phone G3

Blackberry

Samsung Omni

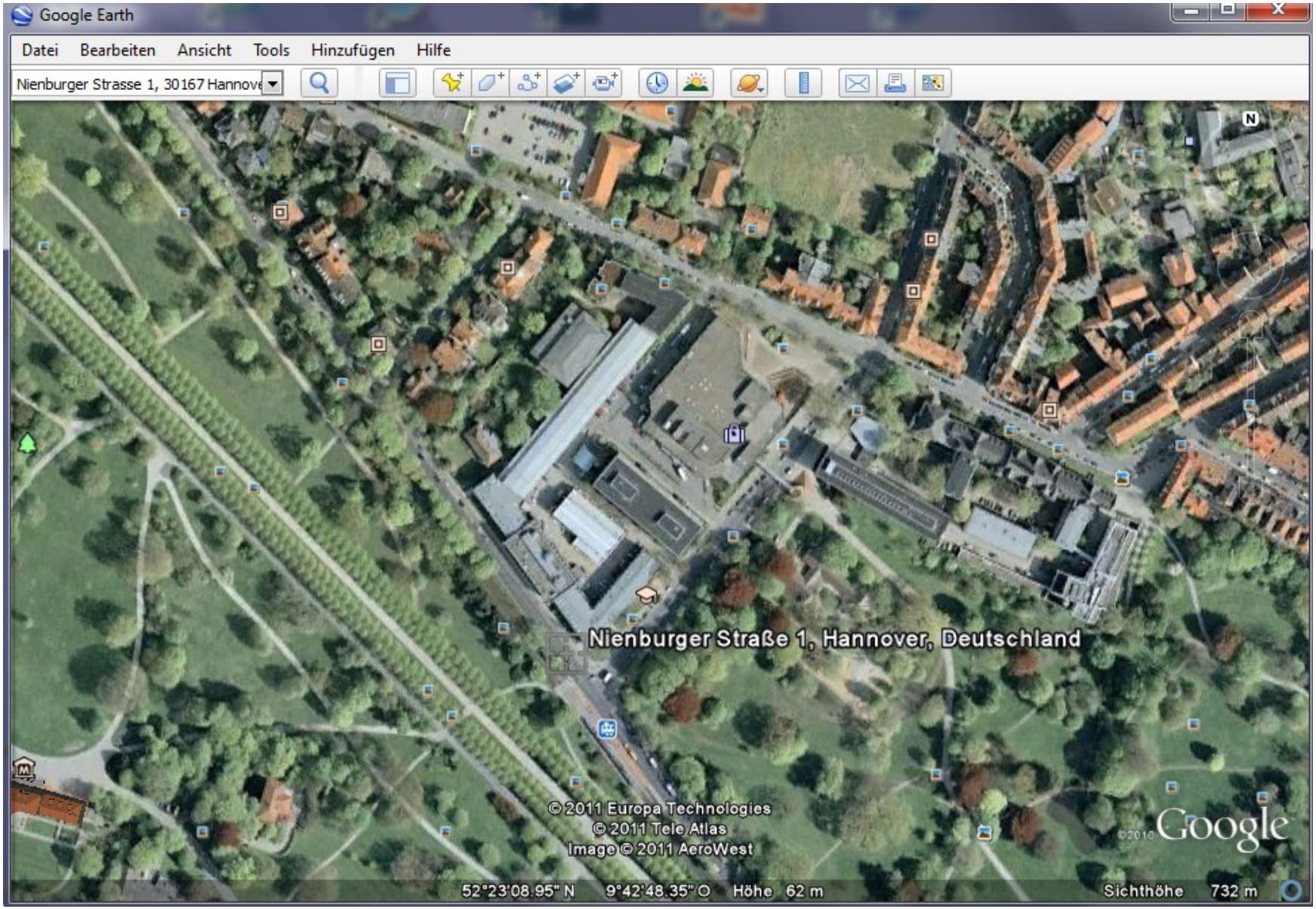
Smartphone

Ein Samsung I8910HD (Symbian S60)

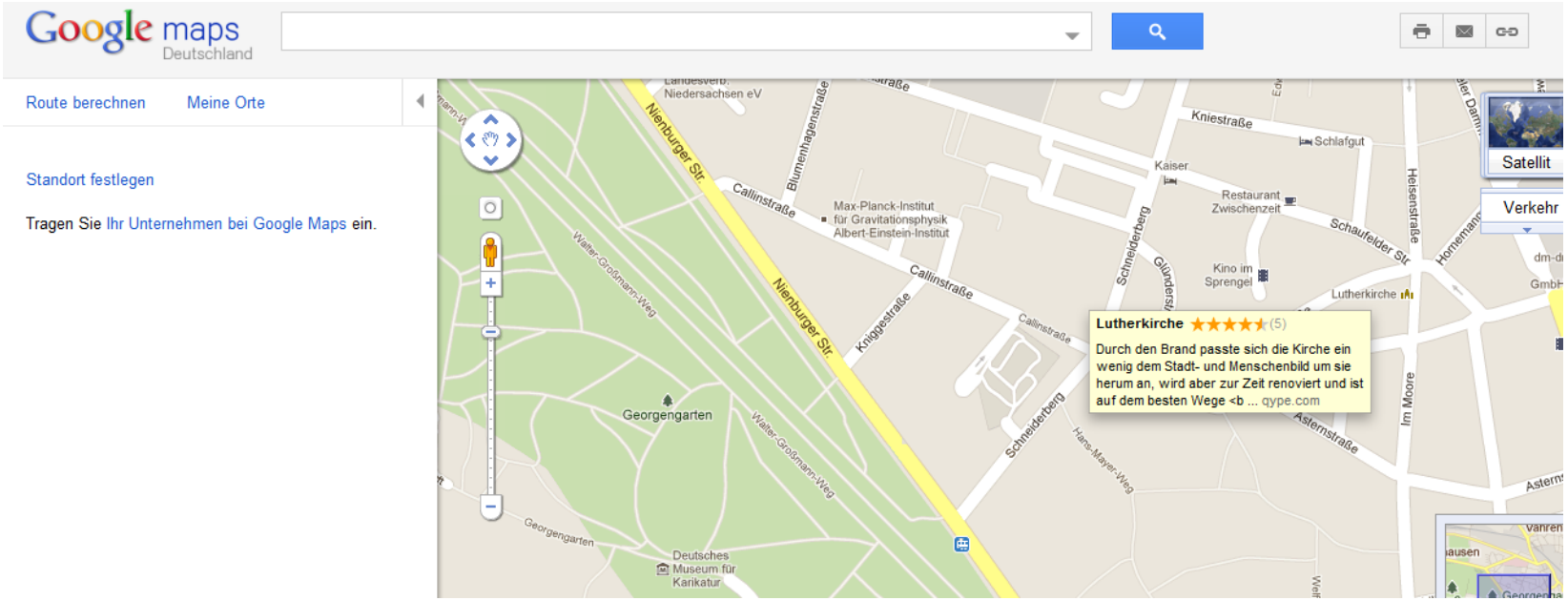
Versatility
lies in the
downloadable
„Apps“
making the
Smartphone

a Navigation Device
(Google Maps, Navtech, Tom Tom)
an Internet Browser
a phone
a data base

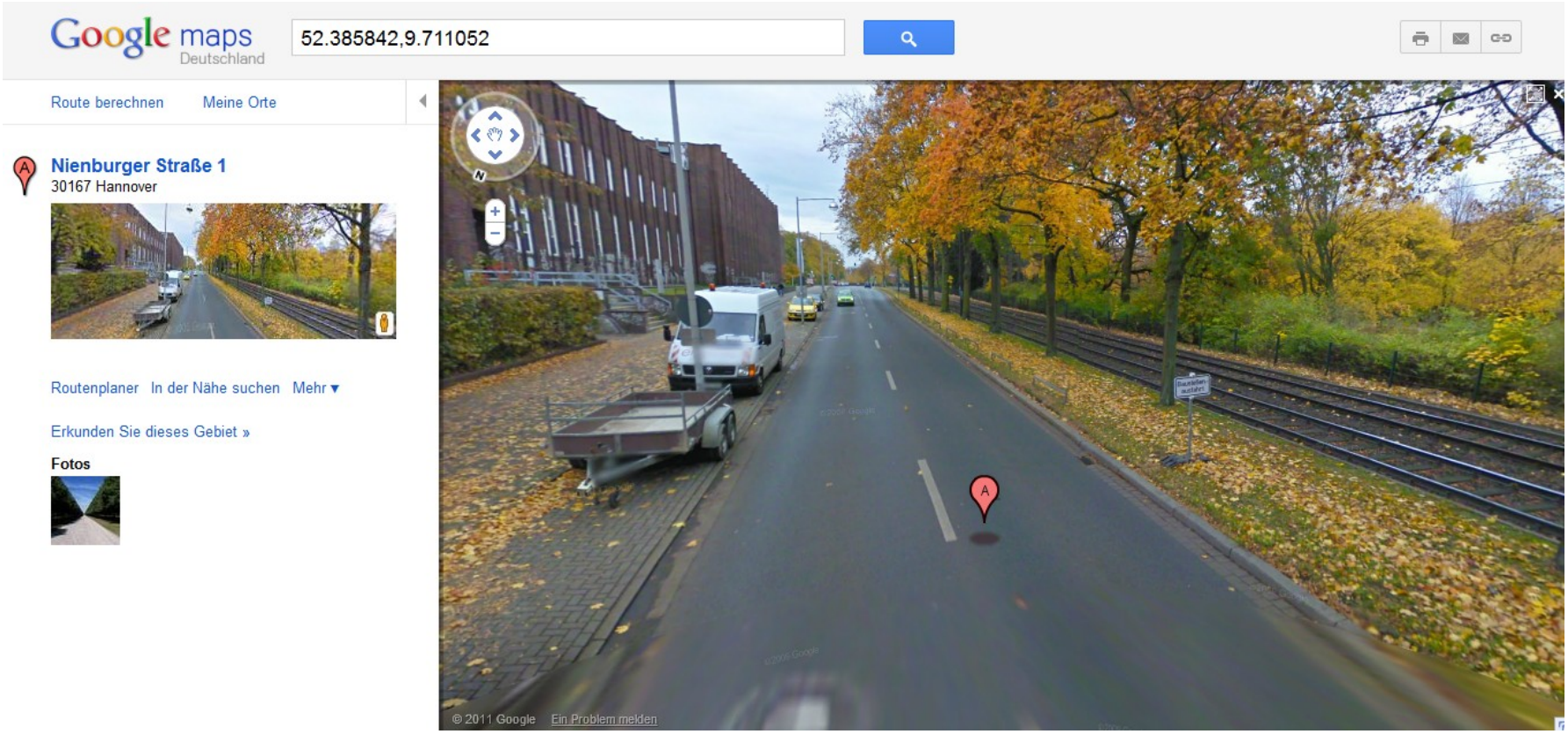
Google Earth Images



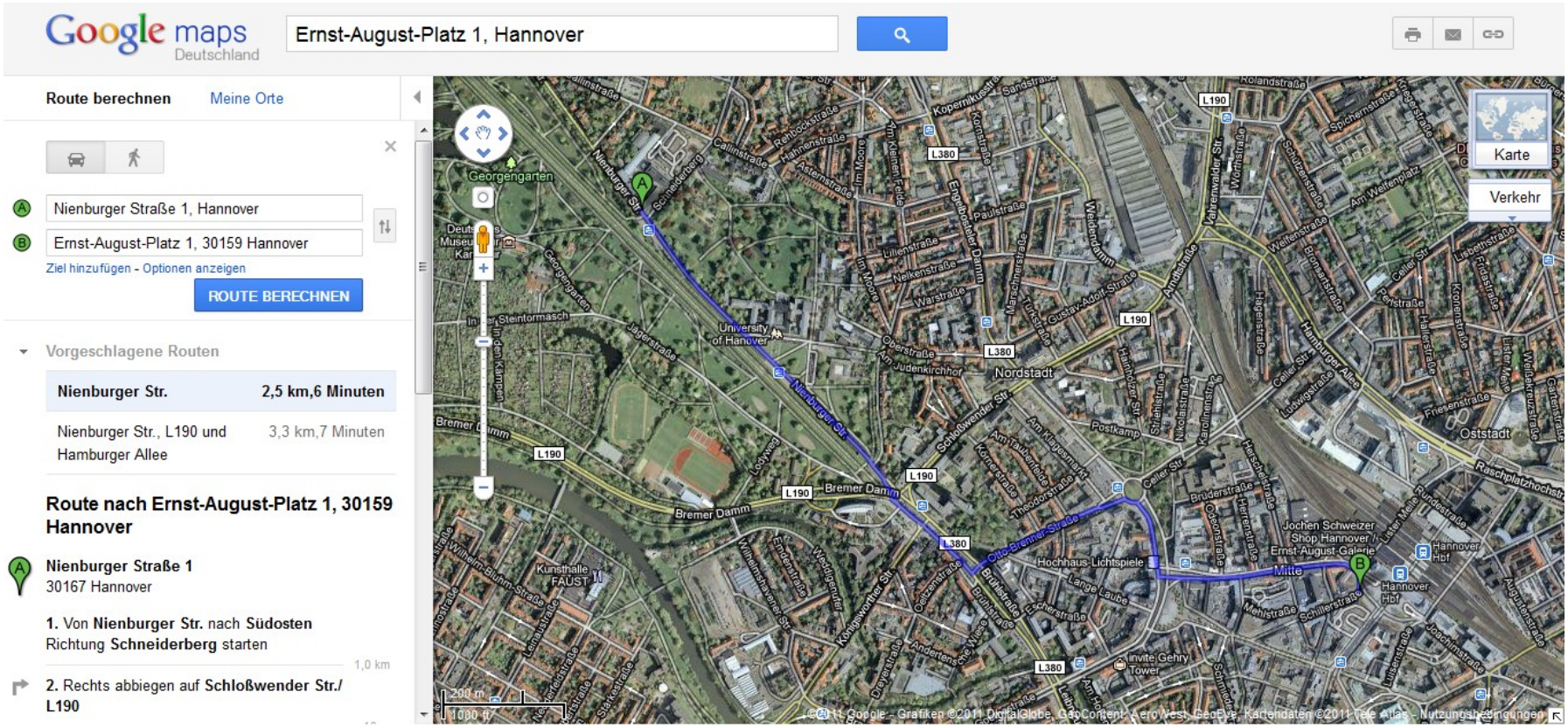
Google Maps and Address Search



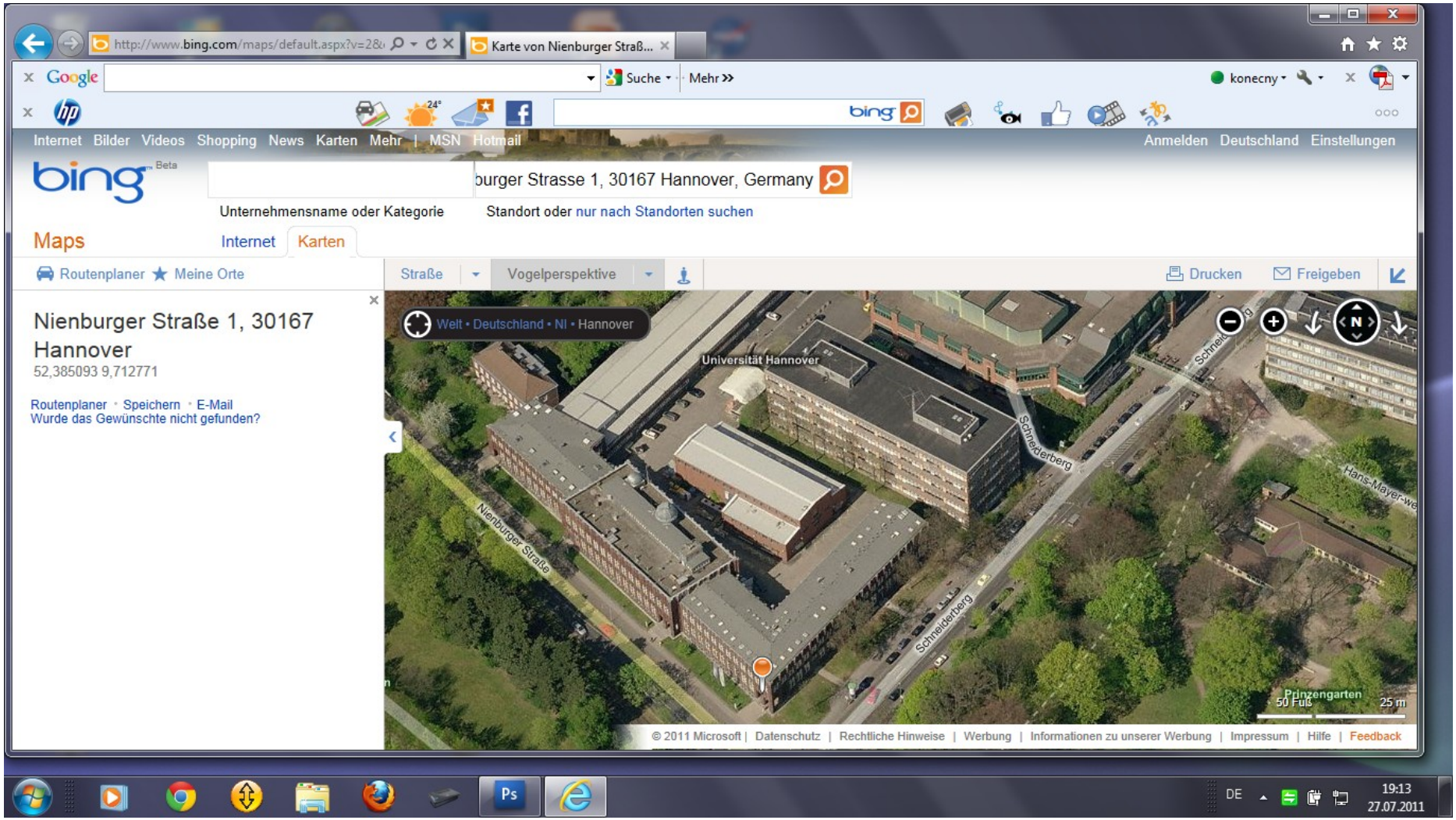
Google Street View



Google Maps Navigation



Bing Maps 3D View



1. **GIS has integrated aerial and satellite images**
2. **It is able to display available and augmented maps**
3. **It can incorporate address searches with street views**
4. **It has become a navigation device**
5. **It can incorporate 3D views (3D city models)**

What are then the problems our disciplines are facing?

The problems are sociological in nature:

1. do we have political support?
2. do the laws sufficiently protect our professional interests?
3. what is the esteem scientists and engineers have in society?

If we are not sufficiently heard, what are the alternatives for us?

1. to get engaged in social, economic, political and ultimately ethical issues issues

2. who can give us guidance in our approach to solve problems in integrating photogrammetry and remote sensing into a greater context?