Societal Requirements

Chapter 5

Maintaining a modern society

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Presentation outline

- Geodesy contribution to the functioning of modern society
- Example applications and their defining requirements wrt geodesy
  - Space-based PNT: of special importance to modern society
  - Engineering, mapping and remote sensing applications: modern requirements
  - Disaster management – towards rapid mapping
  - Infomobility
- Chapter 5: progress summary

Underlying theme

- Geodesy contributes to the functioning of modern society
  - Contribution is critical (reference systems, timing, spatial data infrastructure, etc.) but not necessarily well understood
  - Information gap exists between geodetic scientists and policy makers, advocacy groups, application groups (environmental, weather, engineering, etc.) and general public
  - Need for outreach, coordination and interoperability with application groups, other professional organizations, policy makers
  - Need to promote geodesy and GGOS to wider professional community

Geodesy's contribution to the functioning of a modern society

- Navigation → Positioning - Navigation – Timing (PNT)
- Engineering, Surveying & Mapping
- Precision Agriculture
- Timing Applications
- Emergency Management/Response
- Infomobility (Location Based Services, Intelligent Transportation, personal tracking, etc.)
- Water Management & Hydrology
- Ice Caps & Global Warming, Climate Change
- GPS Meteorology & Space Weather
- Energy Supply
- Other?

Space-based PNT: of special importance to modern society

- Space-based PNT refer to the capabilities enabled by:
  - The Global Positioning System (GPS)
  - U.S. and international augmentations to GPS, and
  - Other global navigation satellite systems: GLONASS, Galileo, other future systems…
- PNT Executive Committee established by Presidential directive in 2004
- GPS Modernization Program

Interoperability - key to seamless global operations

System of systems

Galileo: current services definition

Open Service (OS)

Commercial Service (CS)

Safety-of-Life Service (SoL)

Search and Rescue Service (S&R)

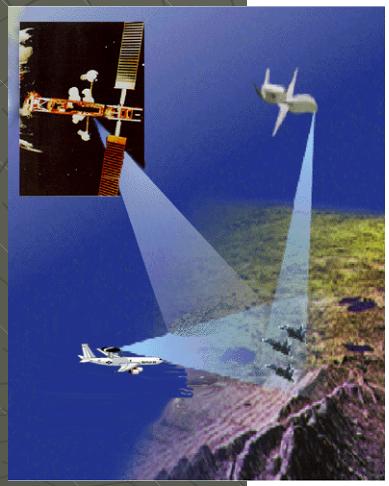
Public Regulated Service (PRS)

Space-based PNT: of special importance to modern society

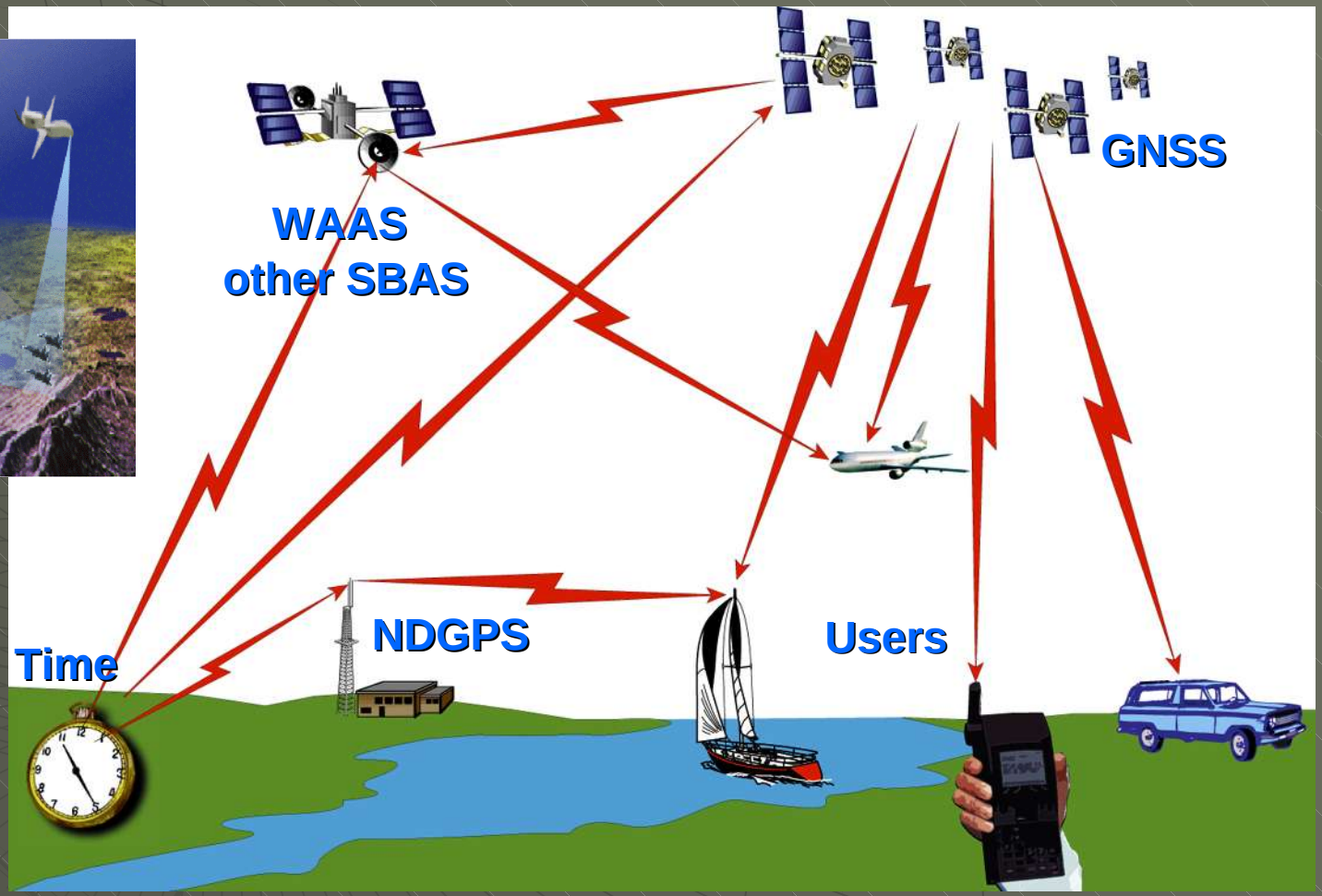
- GNSS applications require high-accuracy reference frame (geodesy)
  - IGS products & CORS networks
  - Local rather than global applications lead to "*blurring*" of distinction between geodetic GNSS networks and state/national CORS networks →
- Interface to outside GNSS communities, such as FIG & ION

Space-based PNT is a centerpiece of the future remote sensing applications

More than GNSS: “system of systems”



LEOs, airborne LiDAR, InSAR….



Engineering, mapping and remote sensing applications: modern requirements (1/2)

- *Current trend:* Paradigm shift: static → kinematic, point → image, post-processing → real-time
- Data and sensor fusion methodologies & algorithms for increasingly *integrated* systems
  - Multi-platform data fusion
    - Space
    - Airborne
    - Land-based
  - Reference system and timing are crucial!
- Real-time operations - reliability/QC, automation, sensor calibration
- New/improved navigation sensor technologies - MEMS IMUs, terrestrial ranging and scanning systems, signals of opportunity, etc.

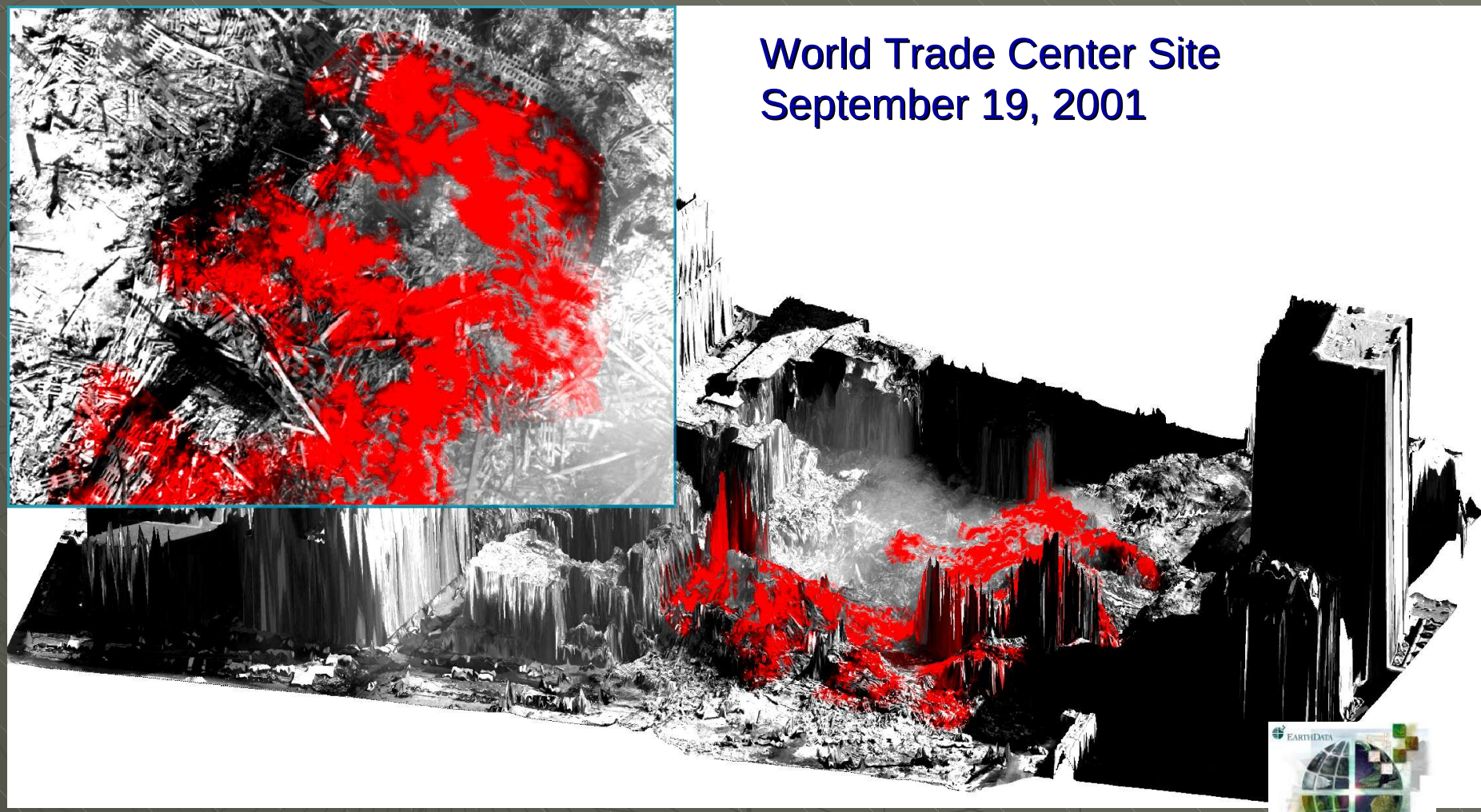
Engineering, mapping and remote sensing applications: modern requirements (2/2)

- New applications - pedestrian/indoor navigation/positioning
  - Seamless transition from outdoor to indoor navigation
  - Remote sensing and imaging are integral components
  - Blending of local and global reference system; timing
- New applications in “precise navigation”, “geodetic remote sensing”, “engineering geodesy”…accuracy is addictive
- Autonomous navigation (e. g., DARPA Challenge), machine control
- New and more effective methods for geodetic observations based on satellite & airborne imaging systems
- Theories that better bridge the gap between geodetic observations & geophysical phenomena of Earth
- ***Reference system and timing are crucial!***
- ***Understanding of geometrical and geophysical phenomena***
- ***Requirements for precise positioning and surveying are steadily increasing***

Disaster management: technological advances

- Recent developments
  - Totally digital systems (at the sensor level) → automation and real-time processing
  - Wireless communication
  - Improving databases – content and access
  - Practically unlimited processing power

Disaster management: Ground Zero



B&W Digital and Thermal Imagery over LiDAR TIN – needed 6-12 hours to process

Towards rapid mapping

- Time elapsed between data acquisition and final mapping product
  - Analog camera, aerial triangulation, map compilation, cartographic finishing, hardcopy — 6 months
  - Digital camera, LiDAR and GPS/IMU-based georeferencing, digital product preparation — 1-4 weeks
  - 9/11 Emergency Mapping by EarthData Group — 6-12 hours
  - Demonstration of ARIES (Airborne Rapid Imaging for Emergency Support) by various government agencies and EarthData Group — 1-2 hours
- Increasingly autonomous platforms (UAVs, under-water and land-based UVs)
- High-accuracy real-time PNT – crucial!
- Linkage to ISPRS, IEEE

Infomobility and Telegeoinformatics

- An emerging discipline of *telegeoinformatics*
  - Geospatial technology that integrates the theory and applications of *geoinformatics*, *telecommunications*, and *mobile computing technologies*
  - Geoinformatics, combining *GIS*, *remote sensing* and *geolocation techniques* supported by *wireless communication* and mobile Internet translates to *mobile computing*, which forms a framework for *real-time mobile WebGIS*
  - *Location-aware computing, context-aware computing*
  - *Increasingly used for problem solving and decision making*

Chapter 5 (1/5)

- Spatial Data Infrastructure (SDI): concept, importance, international perspective (examples)
  - Status – complete draft
- Navigation – land, air, sea
  - Focus on GNSS-based navigation
  - Blend of navigation and geospatial technology (digital maps, imagery, geospatial databases)
  - Status - complete draft
- Engineering, surveying and mapping
  - Impact of GNSS on productivity, reliability and accuracy
  - RTK application – importance and limitations
  - Machine guidance
    - Augmentation of GNSS (inertial navigation)
    - Automation
    - Indoor navigation
    - Increasing reliance on geodesy

Chapter 5 (2/5)

- Engineering, surveying and mapping (continuation)
  - Land titling and development
    - Land development and infrastructure engineering
    - Geodetic cadastre
      - Inclusion of cadastral survey observations into regional geodetic adjustment constrained by geodetic techniques
    - Mining applications
      - GNNS augmentation
      - Spatial Data Infrastructure – layered geospatial information
  - Engineering geodesy and structural monitoring
    - Use of GNSS, accelerometers, geotechnical sensors
    - Growing trend of complete “structural health monitoring”
    - Precise, consistent and time-stable geodetic reference frame is crucial (may be local)

Chapter 5 (3/5)

- Engineering, surveying and mapping (continuation)
  - Geographic Information Systems
    - Increasingly decision-making tool
    - GIS, geopositioning and spatial information are necessary for natural and built environmental monitoring, natural resource managements, land development, transport planning, etc.
  - Height Systems
    - Use of LiDAR systems for DEM and DSM development
    - LiDAR requires direct georeferencing by GPS/INS
    - Reliable and accurate geoid model needed, as LiDAR DEM/DSM is referred to an ellipsoid
      - Local geoid models normally used
    - Geodesy must unify vertical datums to ensure intercompatibility
  - Status – needs subsurface infrastructure, coastal engineering, trends in precision agriculture, time-dependence of coordinates, geographical databases, building and monitoring of roads, tunnels…

Chapter 5 (4/5)

- Timing applications
  - Status - brief initial draft; needs significant extension
- Early warning and emergency management
  - Input from geodetic observing system for early warning, distribution of warning messages, disaster prevention
  - Example systems, importance of GNSS
  - Status – complete draft
- Infomobility
  - Wireless communication plus geolocation = location-aware computing, context-aware computing, telegeoinformatics
  - geoIT – one of the most important emerging and evolving fields
  - Location Based Services
  - Intelligent transportation systems, personal tracking
  - Massive growth of infomobility applications…
  - Status – complete draft

Chapter 5 (5/5)

- Management of and access to natural resources
  - Water management and hydrology
    - SDI as a framework for water management
    - 3D networks plus geoid models are important
  - Energy resources
    - Needs exploration, monitoring of exploration…
  - Status - needs adjustments based on Chapter 4
- Environmental issues
  - Should summarize monitoring of global change, impact through sea level, improved weather forecasting, early warnings, etc. – refer to relevant sections in the previous chapters
  - Impact of climate change (not done)
  - GPS meteorology - needs adjustments
  - Space weather – needs adjustments

Questions, comments, suggestions

- Are we on track?
- Too many storylines/applications?
- Are we too "conservative" about the accuracies & other capabilities? Or,
- Should we anticipate/predict much more regarding future accuracies and capabilities?