A User-Centered Framework for Next-Generation Field Data Collection

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Imagine …

You've been sent to investigate a report of possible soil contamination

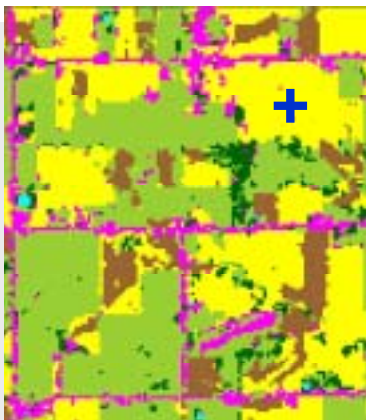
In the field, you have …

Seamless remote access to digital geospatial data via your mobile computer

Your glasses offer …

An augmented vision field that annotates the environment

- Land cover map
- Soil map unit data
- Plant species information
- Building name and location

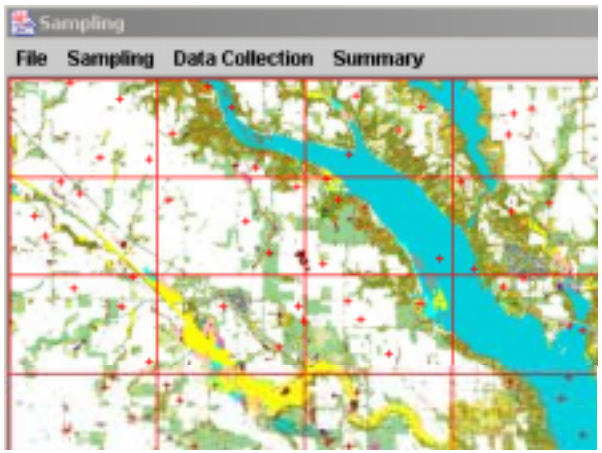


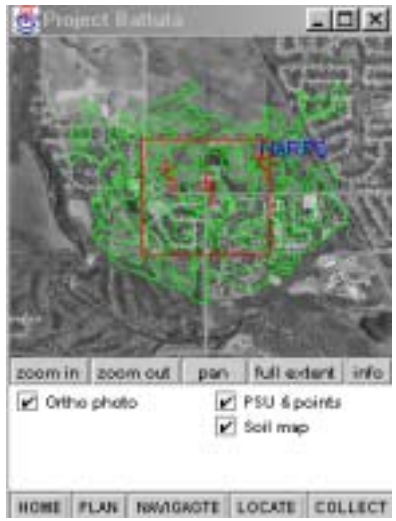
HARPS SERIES

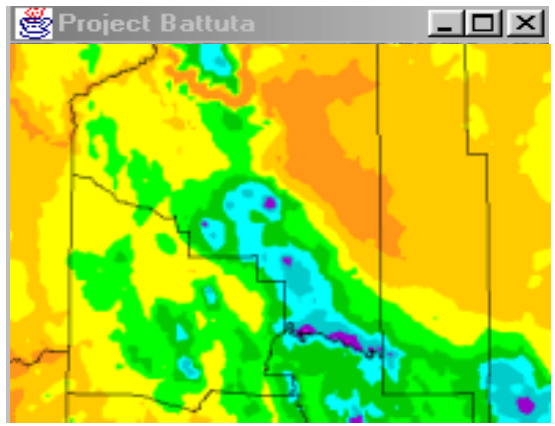
The Harps series consists of very deep, poorly drained, moderately permeable soils formed in glacial till or alluvium on uplands. Slope ranges from 0 to 3 percent. Mean annual air temperature is about 48 degrees F. Mean annual precipitation is about

To collect data …

you have access to tools to select a sample, integrate geospatial resources, analyze geospatially-linked data







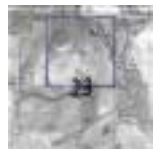
Using and collecting digital geospatial data in the field

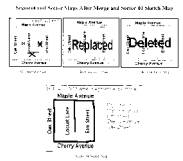
- Goal
  - Develop an extensible model and component prototypes to support the use of digital geospatial data in limited mobile computing environments using emerging information technologies
- Government partners
  - Federal statistical system
    - Census Bureau, Bureau of Labor Statistics, USDA (Forest Service, NASS, NRCS), USGS
    - Video: data collection for statistical surveys

Today's data collection systems

Field Users

Printed Maps & Photos (reams)





Client-server

Data Collection Campaign Repositories

FIPS	PSUid	LgWater
08125	100201R	23.8
08125	100202R	11.0
08125	100203R	3.4
08125	100204R	49.1

Battuta vision

Field Users

Infrastructure

Data Collection Campaign Repositories

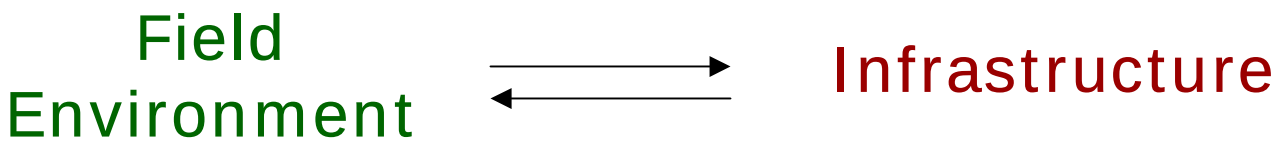
FIPS	PSUid	LgW
08125	100201R	23.8
08125	100202R	11.0
08125	100203R	3.4
08125	100204R	49.1

Other Information Resources Available via Internet

Challenges

- Field environment
  - Focus: working with geospatial data in limited computing environments
  - How to present geospatial information in small screen or augmented vision displays
  - How to accommodate variation in task, user characteristics and computational resources
- Infrastructure
  - How to support seamless retrieval, manipulation, collection of geospatial data
  - How to accommodate heterogeneity and limitations in field environment

User-centered framework

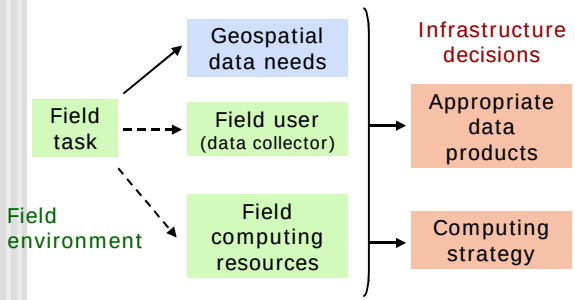


- Goal: seamless mediation of user request to generate results that are appropriate for field setting
  - Field environment influences infrastructure decisions
  - Infrastructure returns appropriate products

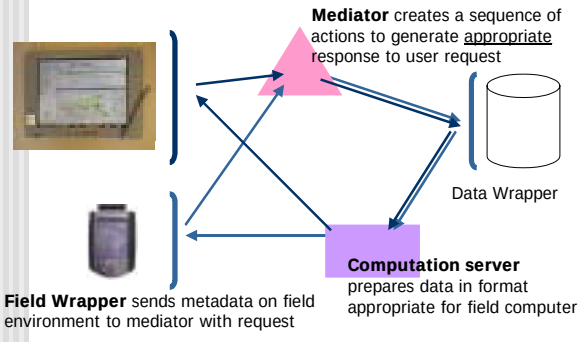
User-centered framework

Field Environment ⇄ Infrastructure

Field environment model



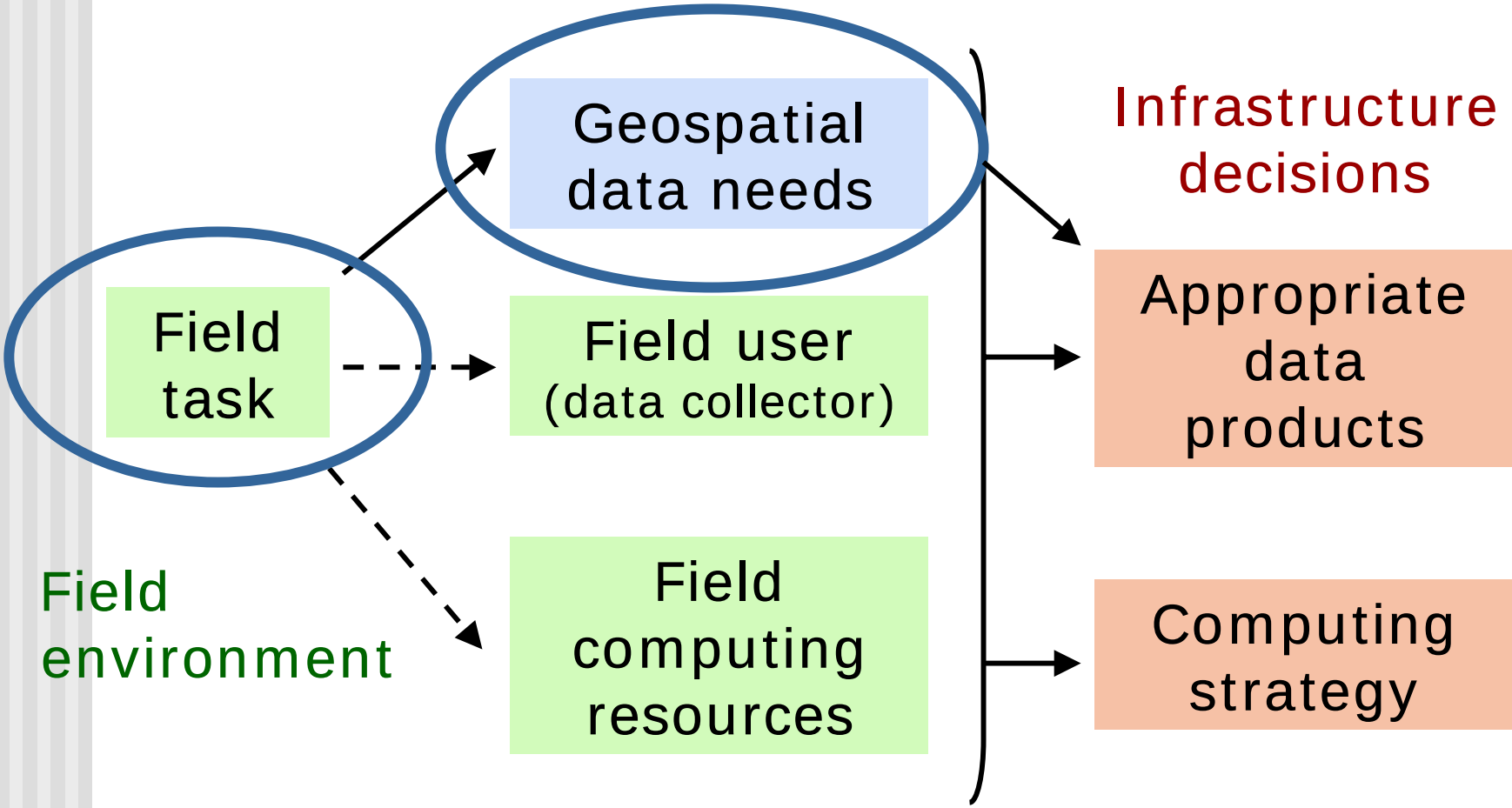
Infrastructure model



Demonstrations Tonight

- Les Miller, Sheng Qu, Sarah Nusser, et al.
  Iowa State University
  - Infrastructure design and prototype
  - Handheld and tablet spatial data applications
- Keith Clarke, et al.
  University of California, Santa Barbara
  - Wearable interface designs and prototype

Field environment model



Field tasks in data collection

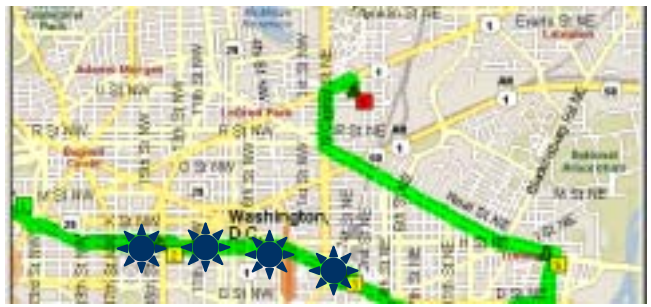
- Planning
- Navigation
- Data collection

Field tasks in data collection

- Planning
  - Creating routes, navigation path, workload sequence
  - Geospatial data needs: road maps, photographs, topographic maps
  - Non-mobile

Field tasks in data collection

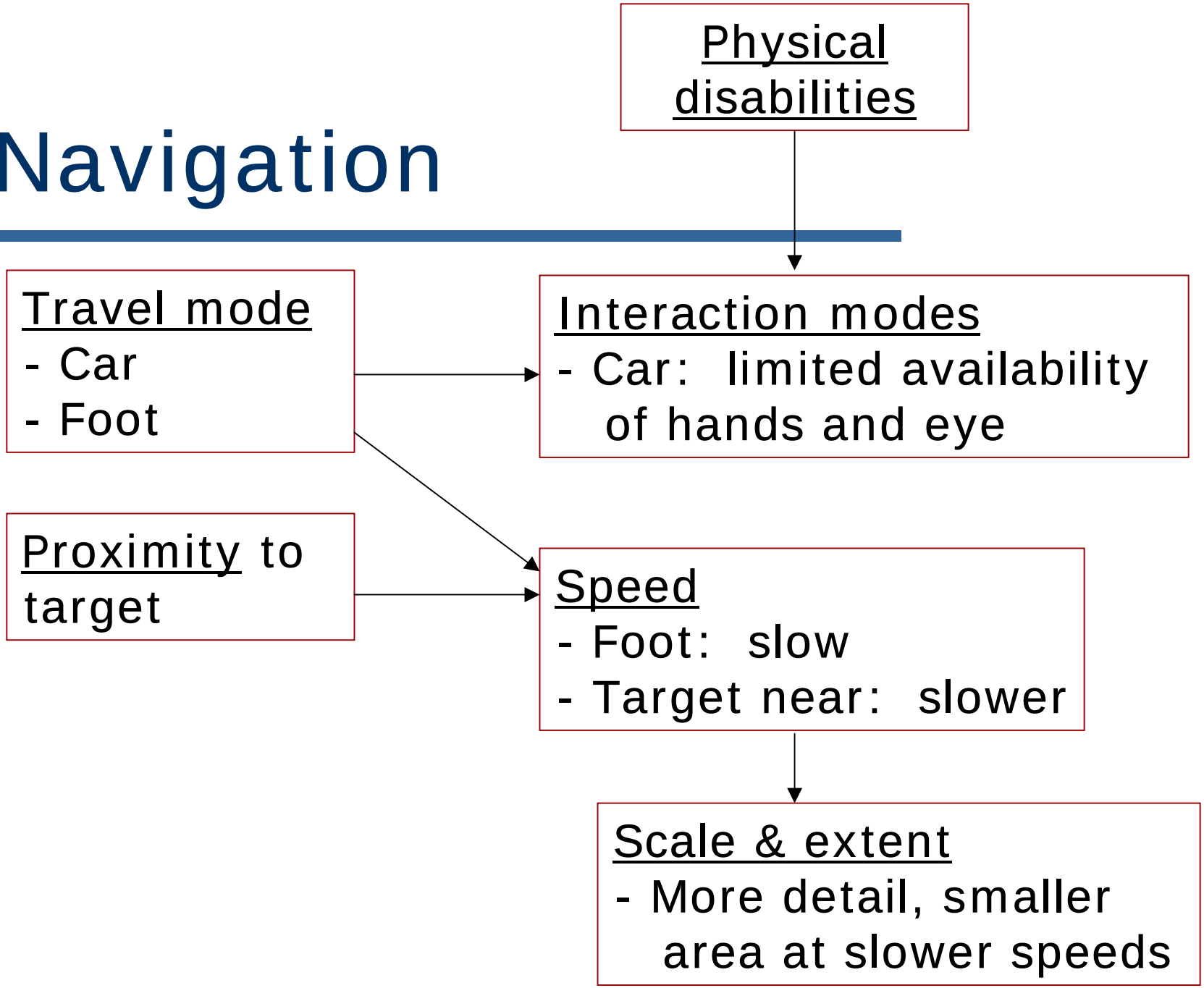
- Navigation
  - Moving by car, on foot to each data collection site
  - Geospatial data needs: add GPS, compass to planning data resources



Navigation

- Impact of mobility
  - Digital map becomes dynamic (GPS, compass)
  - Ability to quickly identify actual location/path in relation to planned route (GPS)
- Travel mode and proximity to target destination
  - Speed
  - Scope of map, map scale
  - Allowable interaction modes

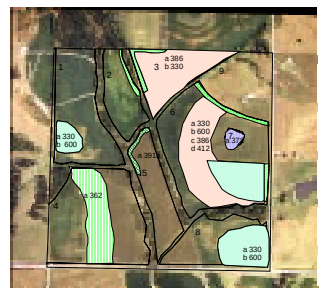
Navigation


Physical disabilities
Travel mode
- Car
- Foot
Interaction modes
- Car: limited availability of hands and eye
Proximity to target
Speed
- Foot: slow
- Target near: slower
Scale & extent
- More detail, smaller area at slower speeds

Field tasks in data collection

- Data collection
  - Involves focused attention, limited local movement on foot
  - Geospatial data needs: add thematic data to navigation resources

Geospatial data & data collection

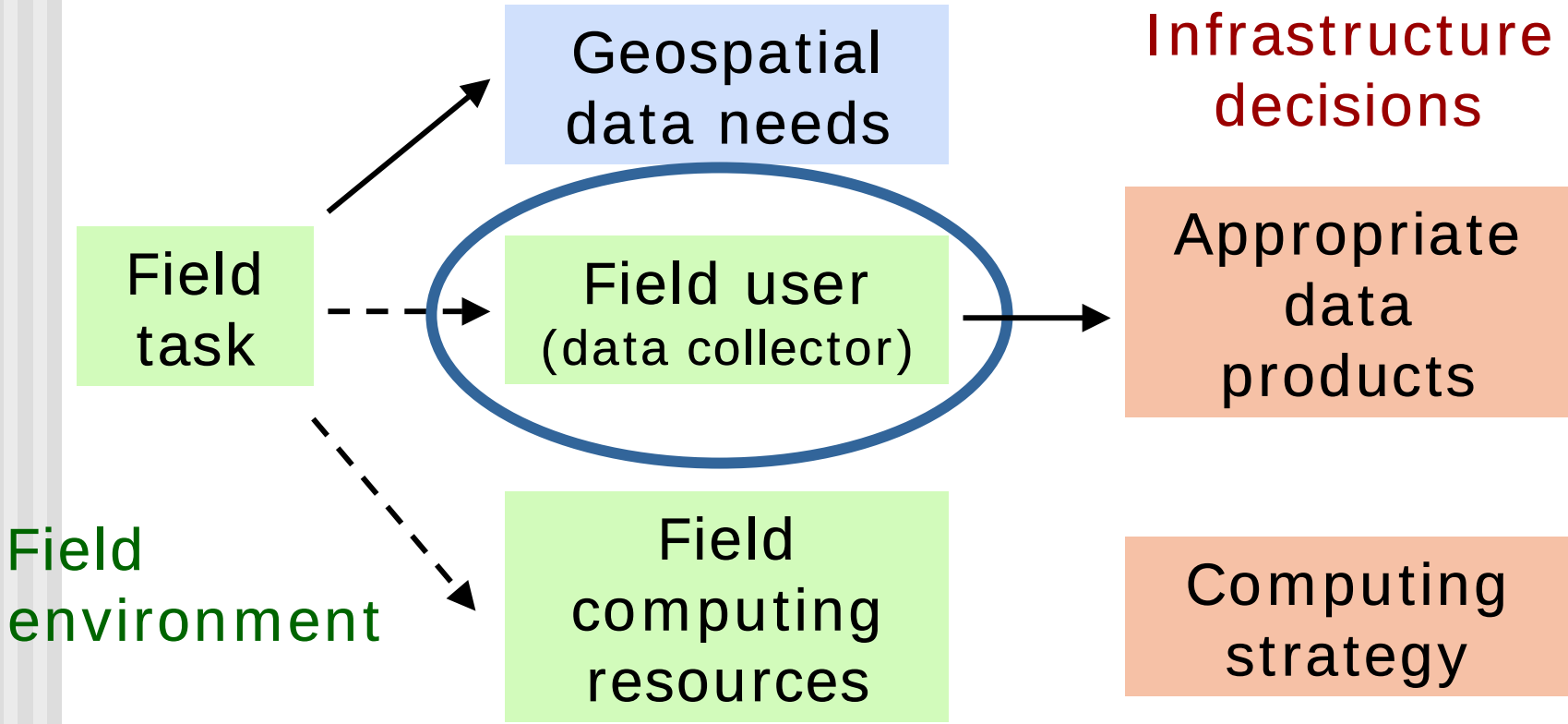


- Reference
  - Context for interpretation
  - Base for data capture
  - Input data for analysis
- Object of data collection
  - Coordinates
  - Polygons
    - GPS-derived, free-hand
  - Location-based link for audio, text, photographic annotations or data

Field tasks in data collection

- Impact of task on infrastructure
  - Determines type of geospatial data needed
  - Working prototype
    - Client software application used to support task specifies basic geospatial data needs
    - Characteristics of user and field computing environment impact format for geospatial data returned to application

Field environment model



Field user characteristics

- Baseline experience with spatial information
- Preferred spatial strategy
- Physical aspects

Field user characteristics

- Baseline experience with spatial information
  - Broad array of geospatial resources part of primary job
    - Soil scientist
  - Maps used for navigation, but other resources not primary
    - Field interviewer
  - No experience with geospatial resources assumed
    - Citizen enumerator in decennial census

Field user characteristics

- Preferred spatial strategy & display

Route-based		**Map-based**
Low	Familiarity w/ area	High
More difficult	Map orientation & mental rotation	Relatively easy
Sequence of steps, personal ref frame	Conceptual model for route	Embedded in external ref frame
Written	**Preferred format**	Map

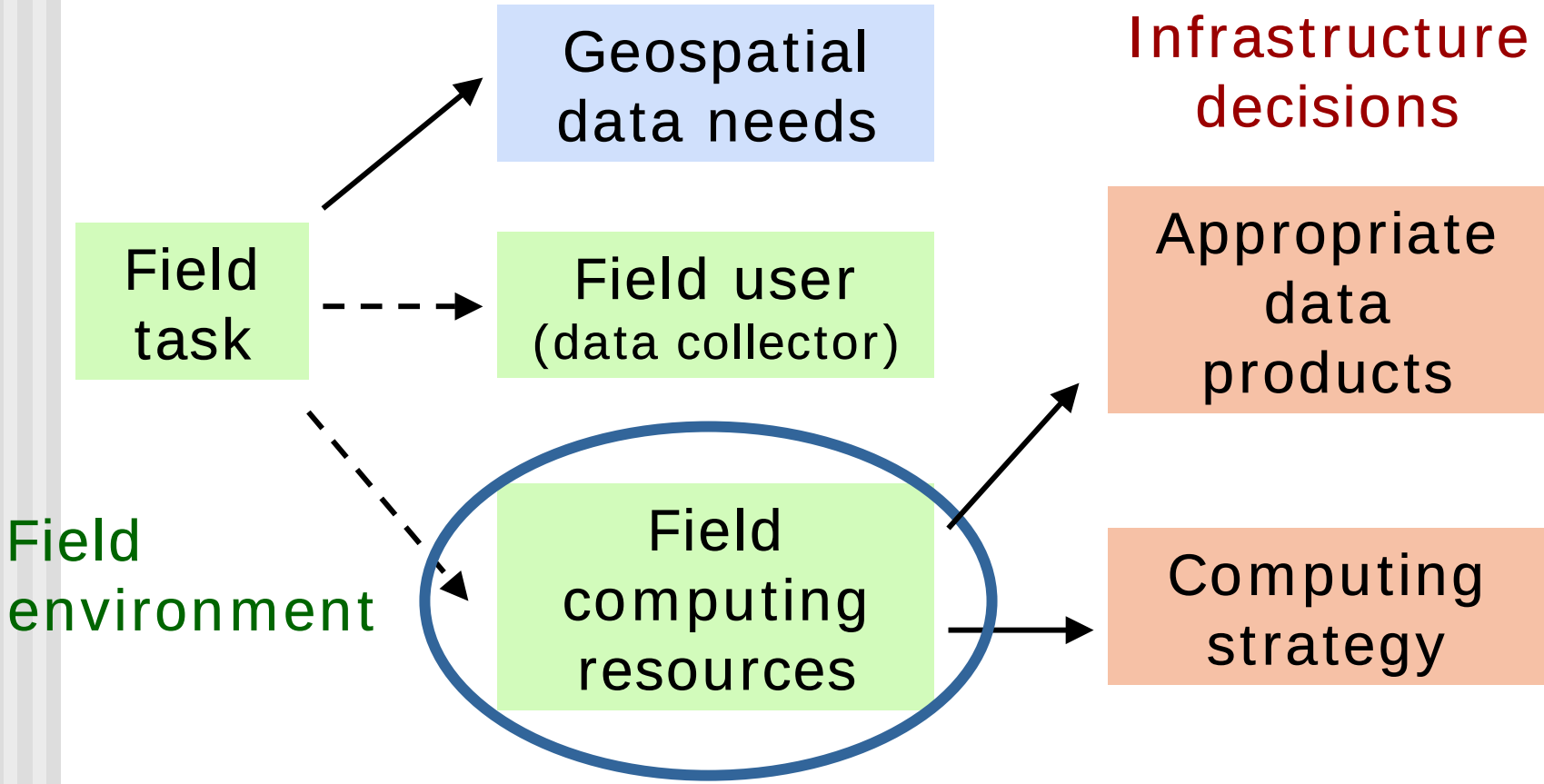
Field user characteristics

- Physical aspects
  - Travel mode and speed
    - Interaction mode
    - Update frequency (infrastructure-field interactions)
  - Work activity
    - Equipment use may limit availability of hands
  - Disability profile for user
    - Poor visual, inability to use one hand

Field user characteristics

- Impact of user profile on infrastructure
  - Guides appropriate formats to be returned
  - Baseline experience with spatial information
    - Ability to handle more complex visual formats
  - Spatial strategy
    - Route-based: list of steps (+ map)
    - Map-based: visualization (+ list)
  - Physical aspects
    - Allowable and preferred interaction modes
    - Extent, detail, update frequency of geospatial resource

Field environment model



Field computing environment

- Screen characteristics
  - Exists?, size, resolution, …
- Interface modalities
  - Visual, audio, pen, mouse, absence, …
- Device capacity
  - Storage, processing, power, …
  - Dynamic components
- Communications
  - Bandwidth, connectivity, …
- Peripherals
  - GPS, compass, …
- Application software
  - Sampling, conflation, krigging

Nanocomputer

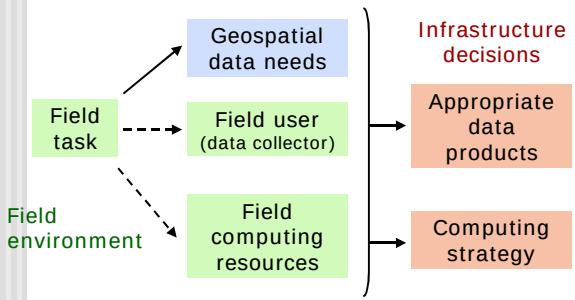
Field computing environment

- Impact of computing on infrastructure
  - Determines computing strategy and appropriate data formats
  - Screen characteristics, interface modalities, ... influence appropriate data format
  - Limited computing resources and continuous connection
    - Computation load borne by *infrastructure*, *small and frequent* data transfers
  - Ample capacity and periodic high-speed connection
    - Computation load borne by *field computer*, *large and occasional* data transfers

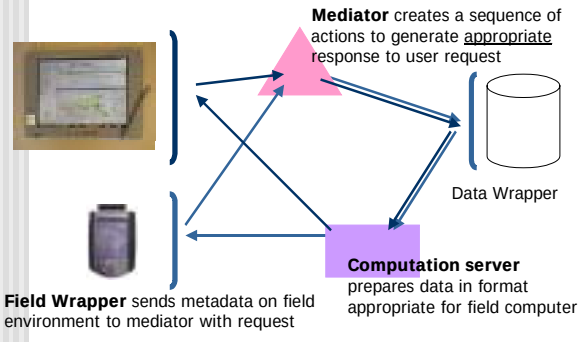
User-centered framework

Field Environment ⇄ Infrastructure

Field environment model



Infrastructure model



Infrastructure goal

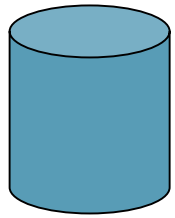
- Seamlessly deliver digital geospatial data in formats appropriate for the field environment
  - Task being performed
  - User profile
  - Computing resources

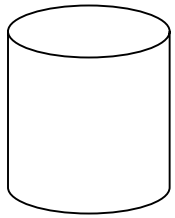
Infrastructure strategies

- Field wrappers
  - Accommodate field environment heterogeneity
- Mediators
  - Use field environment parameters to decide on query and processing instructions to obtain appropriate result
- Computation servers
  - Enable infrastructure-based computation in limited field environments
  - Wrappers provide accommodate heterogeneity of server capabilities and infrastructure protocols (mobile view agent, CORBA, client-server)

Infrastructure model

COMPUTING INFRASTRUCTURE





Data Wrapper provides interface between data source and computing infrastructure

Field Wrapper provides interface between field environment and infrastructure

Infrastructure model

Mediator creates a sequence of actions to generate appropriate response to user request

Object-oriented views

Data Wrapper

Computation server prepares data in format appropriate for field computer

Field Wrapper sends metadata on field environment to mediator with request

Ames testbed

- 9 sq mi area on edge of town
- Transitioning from riparian & agricultural land to urban development
- Environmental, household sample surveys
- Geospatial resources
  - Many years of photographs (color, ortho)
  - Plat maps
  - DOT roads
  - Topographic maps
  - Soils maps
  - Digital elevation model

From field to infrastructure

- Registration process to record static information
  - Record static attributes (e.g., device type, user characteristics, data collection project)
- Client application provides real-time specs
  - User specifies
    - Type of activity (e.g., plan, navigate, collect data)
    - Geographic extent (e.g., Census block, set of samples)
  - Software identifies
    - Type of geospatial data to retrieve (e.g., road map, photograph, soils map)
    - Current computing resource status (e.g., current storage, software tools, peripherals, connectivity specs)

Decennial census planning example

Field environment

- Task
  - Planning for non-response households in Story Co
- User profile
  - Census enumerator
  - Map-based
  - Car road navigation
- Computing resources
  - iPAQ
  - No routing software
  - Wireless connection
  - GPS

Infrastructure

- Max footprint
  - Story Co
- Useful data for field
  - Housing unit list
  - Map (TIGER & MAF)
- Final product
  - Run routing utility on computation server
  - Provide road maps as primary material
    - georegistered
    - .wav files for audio cues
  - Include route instructions

Natural resource data collection example

Field environment

- Task
  - Data collection for area sample (PSU) 19169_01S
- User profile
  - Soil scientist
  - Map-based
  - Off-road work
- Computing resources
  - iPAQ with microdrive
  - Conflation software
  - Office internet
  - GPS

Infrastructure

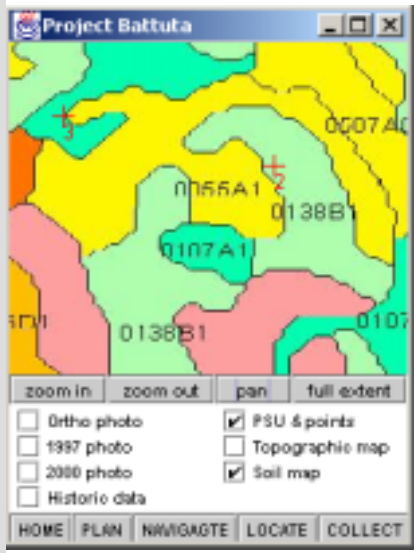
- Max footprint
  - PSU + 2 km buffer
- Useful data for field
  - Photos (current, historical)
  - PSU/point locations
  - Historical sample data
  - Soils map, topo map
- Final product
  - Resolution high (3 m pixel)
  - Send separate geospatial files

Ortho photo

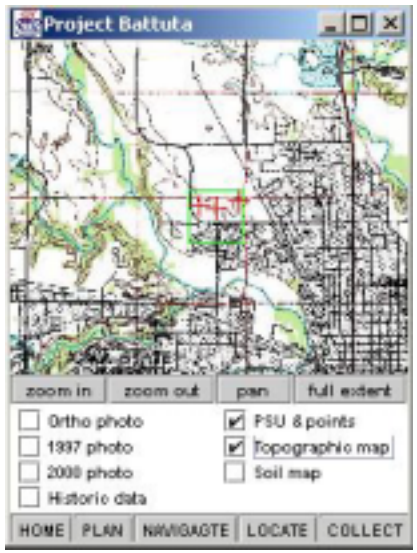
1997

2000

Soils



Topographic Map



Historical Data

A Digital Government Collaboration

ISU UCSB ❖ NSF ❖ Census BLS USDA USGS

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