UNIT 68 - IMPLEMENTATION STRATEGIES FOR LARGE ORGANIZATIONS

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Compiled with assistance from Ken Dueker, Portland State University

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would provide a useful illustration for this unit.

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A. INTRODUCTION

- this unit examines issues that arise when GIS is implemented in large organizations
- these issues include:
  - where in the organizational structure to locate the GIS operation
  - problems and advantages of multi-participant projects

B. LOCATION WITHIN THE ORGANIZATION

- even though a GIS may be an organization-wide tool and is seen as a decentralized resource within the organization, centralized coordination of the GIS operation is still necessary
  - is needed to ensure efficiency and cost- effectiveness in the operation of the GIS
    - e.g. avoid redundancy in the collection of data
    - e.g. ensure expensive hardware is being used efficiently
- the location of the GIS manager and the support staff will be seen as the location of the GIS unit within the organization
  - the location of this unit will affect the way the GIS staff interacts with the rest of the organization
- Somers (1990) suggests there are three basic options for the location of the GIS:

1. operational department location
   - e.g. planning, public works, engineering or assessments
   - GIS often develops from a small system obtained to deal with specific needs which have grown to support activities outside the mandate of the original department
   - advantages:
     - such systems are very responsive to original users needs
   - disadvantages:
     - departmental focus makes it difficult for other users to have their needs and priorities recognized
     - may not have high level management support
2. support department location
   - e.g. data processing, MIS or management services
   - in these locations GIS is seen as a service operation like payroll, personnel and DP and will be supported by the organization as such
   - advantages:

        - objectivity of system design and management

    - disadvantages:
        - remote from the users of the GIS
        - may not be responsive to the needs of users
        - priorities of department may be different than users'

3. executive level location
    - advantages:
        - high level visibility, support and attention
        - objectivity
    - disadvantages:
        - distance from the real operations of the organization
        - users may feel GIS support staff is out of touch with their needs

- the actual location of the GIS unit within an organization will reflect the circumstance of its introduction, the management structure and the organizational policies and mandates

C. MULTIPARTICIPANT PROJECTS

- increasingly, GISs are being implemented by consortia of agencies with a wide range of legal foundations, including:
    - local government agencies
    - county governments
    - state and federal government agencies
    - public utilities
    - non-profit organizations

- diverse organizations cooperating in such multi- participant GIS are bound by a common geographic setting and are motivated by the need for fiscal responsibility
    - costs for data collection and management for a common geographic area can be shared among organizations

- are guided and coordinated through inter-agency committees consisting of representatives from the departments and agencies involved in the use and design of the GIS
    - such committees generally have two structural levels:
        - policy level - senior management
        - technical level - technical and middle management

Issues for multiparticipant projects

- Forrest et al (1990) list several issues that have to be addressed by these inter-agency committees:

- participation
    - involved agencies need to commit financial and other resources to the project

- data ownership

    - who owns the data collected?

- data maintenance
    - which agency or agencies will have the ultimate responsibility of data maintenance and update
    - how will this responsibility be partitioned?

- hardware and software ownership and maintenance
    - how will the necessary hardware and software be distributed across the agencies?
    - which vendors' products will be supported by the multi-agency agreement

- standards
    - what standards will be used for data exchange and communications

- financing
    - how will the project be funded? how will the costs be shared equitably?

- new business activities
    - GIS may provide the involved agencies the opportunity to venture into new business areas
        - e.g. sale of digital data, maps

D. US FOREST SERVICE EXAMPLE

- the following sections describe the development and implementation of a national GIS strategy within the US Forest Service

- Forest Service is an agency of the US Department of Agriculture

- responsible for management of nearly 200 million acres of federal lands organized into 155 National Forests
    - mandate to manage land for multiple uses - timber and pulp production, mineral resources, recreation, wildlife, conservation

Organization

- National Forests grouped into regions

- each National Forest has a headquarters, several district offices

- nature of each Forest varies depending on resources
    - those in the Pacific Northwest are heavy timber producers
    - others may have significant oil and gas, e.g. in Rocky Mountains
    - "wealth" (annual budget) of Forest depends on resources, leases

- pattern of jurisdiction is typically complex
    - area of Forest is not singly bounded
    - many islands of private ownership within boundary
    - complex system of access rights, grazing and timber leases

map - a map of a local National Forest would be useful at this point, plus a description of its resources, management activities

E. EARLY GIS ACTIVITIES

- many Forests and regional offices acquired assorted types of GIS prior to 1987
- determining factors in early acquisition included:
  - availability of funds - "rich" forests were early adopters
  - presence of a "missionary" on Forest staff, able to persuade management that available funds should be spent on this high risk innovation
- examples of status of GIS circa 1985:

San Juan National Forest

- large Forest in southern Colorado
  - extensive mineral resources, recreation
  - little marketable timber
- Forest broken into 80,000 irregularly shaped units, often called "integrated terrain units" (ITU)
  - the ITU is an area object which is homogeneous on all attributes in the database
    - i.e. a "smallest common denominator" parcel of land with uniform land use, vegetation, soil
  - in essence, these units are the result of overlaying maps of all relevant themes
  - in practice the map is divided up into areas which are both (a) as large as possible and (b) as homogeneous as possible
- each unit assigned a unique number
  - attributes assigned to each unit, covering
    - forest cover (species, age, density)
    - administrative unit (county, ranger district)
    - slope and aspect
    - watershed
    - soil type, drainage
    - etc.
- data matrix of 80,000 units by 600 attributes (close to 50,000,000 individual data items) maintained at Region

  computing facility using System/2000 hierarchical database
- benefit:
  - low cost of data entry - no digitizing
- problems:
  - no geography - just a "flat file" of attributes
    - no way of aggregating units based on spatial adjacency, making spatial

queries
        - no point or line objects, no associated operations, e.g. buffers around line objects
        - no map products

    - problems with quality control
        - unlike geographical files, cannot make internal consistency checks, every entry must be checked individually - no possibility of using maps for data checking
        - virtually impossible to achieve high quality
    - redundancy
        - if extended to too many attributes, the ITU approach leads to high levels of redundancy in the database
        - e.g. there are only two counties in the Forest, these could be represented accurately as a single layer with two area objects, but using the ITU approach 80,000 entries must be made for county attribute
        - thus while only two possible errors could occur in entering county attribute if county is a separate polygon layer, there are 80,000 chances of error with ITU approach

Flathead National Forest

- large Forest in western Montana adjacent to Glacier National Park
    - much marketable timber, some mineral resources
    - wildlife conservation important because of adjacency to National Park

- heavy reliance on Landsat imagery as primary data source

- imagery interpreted with ground checks to provide forest inventory

- imagery registered to topographic mapping and DEM

- other layers input by rasterizing vector coverages (e.g. climatic variables)

- multi-layer raster database at Landsat resolution (80 m) manipulated using remote sensing system (VICAR)

- benefits:
    - easy to use system for mapping, production of images
    - easy to combine layers for modeling

- problems:
    - difficult to use system to manage timber resource
        - raster database has no concept of homogeneous stand
        - difficult to link ground checks of timber type/size/density to pixels
    - not easy to handle point or line datasets

        - e.g. campsites, points of historical significance, sightings of endangered species e.g. Grizzly Bear, roads, streams

    - difficult to attach extensive lists of attributes to pixels
        - each attribute treated as a separate layer, no easy way of relating objects between layers

Summary

- Flathead and San Juan NFs illustrate the problems of delivering GIS products using image processing and conventional database technology respectively

- other examples illustrate the problems of CAD systems

- by 1985 Forest Service had experience of many GISs in different Forests and regions:
    - vector systems: COMARC ARC/INFO (ESRI) Strings (Geo-Based) Intergraph MOSS
    - raster systems: ERDAS VICAR WRIS
    - input methods included digitizing, scanning and interpretation of imagery

Other technical issues

- in the early 1980s the Forest Service began implementation of a nationwide system of networked computing resources to automate office functions
    - functionality includes electronic mail, word processing, limited database and analysis capabilities
    - supplied by Data General, installed in every Forest, region and Washington headquarters
    - compatibility of an eventual GIS with the DG hardware is therefore a major technical issue in GIS planning and acquisition
    - could the GIS run on the (possibly expanded) DG network?

- of the GISs installed in various parts of the Forest Service, one vector system (MOSS) had been developed largely within the Department of the Interior and appeared to have much of the necessary functionality
    - how should this system be judged relative to the remaining vendor-supplied systems in the acquisition process?

F. 1984/5 FUNCTIONAL REQUIREMENTS STUDIES

- as a result of pressure from both inside and outside the Service to acquire GISs for their operations, FRSs were conducted for a small sample of forests in order that functional requirements for the entire Forest Service could be determined

- 6 Forests with a variety of sizes, resource mixes were selected:
    - George Washington (Virginia)
    - Nicolet (Wisconsin)
    - Flathead (Montana)
    - San Juan (Colorado)
    - Siuslaw (Oregon)
    - Shasta/Trinity (California)

- full Functional Requirements Studies for GIS were carried out
  - fully internal strategy (see Unit 61)
  - contracted to consultant - Tomlinson Associates Inc.
  - contract period of 8 months

- 30-60 information products identified per Forest, similar numbers of input datasets
  - 60-90% of these were new products not previously generated

Siuslaw National Forest FRS

- 60 information products identified:
  - 10 are simple cartographic products generated by reformatting, rescaling and/or resymbolizing input data
  - 2 require 3D graphics
  - 7 are lists generated from input data
  - 37 require use of GIS functions for simple analysis of input data
  - 8 are the result of sophisticated analysis
  - some are common to most Forests, e.g. timber inventory maps
  - some are specific to local conditions, e.g. map to predict areas suitable for growing marijuana required by law enforcement department

- database requires input of data from approx. 15,000 map sheets during the 6 year planning period
  - many of these are repeated updates
  - 1200 in year 1 rising to 3500 in year 6
  - the 1200 maps in year 1 contain approx. 60,000 polygons and 13,000 points, plus 300,000 cm of line objects

G. THE NATIONAL GIS PLAN

- the circa-1985 situation was clearly uncoordinated
  - duplication of effort, high cost of maintaining expertise in a range of systems
  - no analysis of what was optimal for the Forest Service as a whole

- was an awareness that information should be a corporate resource and managed as such
  - corporate information is that information which must be commonly used, understood and shared to meet the agency's mission
  - must be freely exchangeable between different departments, Forests, regions
  - must have compatible formats and definitions - well- developed standards

- although the software to handle this information need not be standardized, the interfaces, methods of analysis and planning, and data structures and formats should be standard

- in January 1988 the Forest Service approved a plan for implementing a service-wide GIS by 1991

Objectives of the GIS

- support the management information needed by the Forest Service to accomplish its mission
- facilitate understanding and sharing of information horizontally and vertically within the organization, and with other organizations where possible
- allow access to information by managers through a non- technical, user-friendly interface
- take full advantage of existing Forest Service hardware and networks
- be flexible enough to incorporate new technologies in the future

H. COMPONENTS OF THE PLAN

- plan is composed of 5 major components or phases:

1. Information Base and Structure

- identify the objectives, principles and assumptions of GIS implementation - the "vision" - and convert this into a "blueprint" for structuring resource information
- assemble information from a survey of 34 Forests to identify the kinds of data being used to characterize resources
    - need to distinguish between "basic" and "interpreted" data
        - "basic" is raw but relatively stable and accurate
        - "interpreted" is more immediately useful for management
        - which is more appropriately stored in the database?
    - is there a relatively small set of data types common to many Forest management efforts, but complicated by differences in definition and practice?
- describe the NFS GIS corporate information structure and the database environment
    - describe the characteristics and functionality of the GIS database environment needed to support the information structure
    - develop standards for the corporate information structure
- define the requirements for the user interface

2. Organizational Readiness

- improve awareness of the GIS plan
- develop guidelines for planning local implementations
- develop strategy for data conversion and acquisition
    - the data currently available varies widely and falls short of the requirements of the plan

3. Technology Procurement

- document the functional requirements
- cost/benefit analysis (late 1988/early 1989)
- Technical Approval Request (1989)
  - the approval to proceed with RFP
- RFP and procurement

4. External Coordination

- during 1989, similarly scaled procurements were making their way almost simultaneously through the Bureau of Land Management, US Geological Survey, Defense Mapping Agency
- other agencies with interest in resource management applications of GIS include Soil Conservation Service (also under Department of Agriculture), National Park Service, Fish and Wildlife Service
- federal government formed the Federal Interagency Coordinating Committee on Digital Cartography (FICCDC) to attempt to coordinate some of this activity
  - main thrust of coordination is in data collection and exchange of initiatives (see Unit 69)

5. Implementation

- training of managers and users
  - general training in technology
  - more specific training to follow selection of system
- data acquisition, conversion and entry
- installation

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EXAM AND DISCUSSION QUESTIONS

1. Summarize the Forest Service's "vision" for a national GIS to manage corporate information.

2. In what ways does the Forest Service plan differ from previously discussed principles of GIS implementation? What do you see as its strong and weak points?

3. Summarize the factors which might explain the extreme differences in the status of GIS implementation across the Forest Service circa 1985.

4. Describe the impact of the Forest Service plan on the day-to-day activities of its managers and decision-makers. In what ways does the plan attempt to anticipate and deal with these impacts?

5. A public agency like the Forest Service must continually guard against the accusation that its decisions are "arbitrary and capricious" in the way they affect Forest users, leaseholders etc. In what ways will the implementation of the GIS plan make this accusation more or less appropriate?

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