Enterprise GIS: Business Impact, System Architecture, and Information Management

John Young
Ty Fabling
Sandy Milliken
A Geographic Information System (GIS)

Manages, Analyzes, Visualizes, Disseminates information on a geographic foundation ...

Spatial Analysis Models
Maps & Visualization
Geographic Data
Data Models
Metadata
Workflows

... for effective, timely, and efficient Collaboration, Problem solving, and Decision-making
GIS is Evolving
Based on Infrastructure, Architecture, Application, and Content Advances...

Desktop/Workgroup  Enterprise Platform  Pervasive Geography

Client  Desktop  Internet (2.0)  Internet

Server  Mobile  Server  Online

Personal Productivity  Information Management  Business Transformation  Universal Reach

... and Impact—quality, speed, efficiency, community—in Business and Society
Exploiting **ubiquity**...more than 80 percent of all knowledge is spatially referenced

Capturing, validating, sharing, and teaching **tradecraft**

Providing an intuitive foundation for collaborative analysis and decision-making

*Expanding application opportunities*
Applying Core GIS Capabilities: Emerging Patterns of Geo-enabled Business

A Complete Integrated System

Asset Management
- Collect, organize & exchange data
- Geodatabase

Planning & Analysis
- Transform data into actionable information
- Geoprocessing

Field Mobility
- Get information in and out of the field
- Mobile

Operational Awareness
- Disseminate knowledge where & when it’s needed
- Web Maps

Application templates, and implementation solutions—software, data, data models, workflow, applications, infrastructure
Delivering Business Value on an Enterprise Platform

Supporting an organization, or a community of interest

- Information Integration
- Tradecraft
- Visualization
- Asset Management
- Planning & Analysis
- Field Mobility
- Operational Awareness
- Workflow
- Architecture Infrastructure

More than maps and imagery ... a Common Operating foundation for business planning and execution
Enterprise GIS Impact

Quality
- Agriculture
- Land Use
- Environment
- Energy

Evaluate patterns, interdependencies, trade-offs

Efficiency

Increase productivity

Timeliness
- Military Adaptive Planning
- Prediction & Planning
- Decision
- Execution

Accelerate decision-making

Community
- Agency Operational View
- Executive View
- Public View

Engage, collaborate, integrate
# Implementation: Enterprise Technology *Different*

*Mission Critical*

<table>
<thead>
<tr>
<th>Key stakeholders</th>
<th>Workgroup</th>
<th>Enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>Commanders, mission and IT managers, overseers</td>
<td></td>
</tr>
<tr>
<td>evaluate</td>
<td>Application functionality</td>
<td>System capabilities, cost, interop, scalability, security</td>
</tr>
<tr>
<td>select</td>
<td>Products, Applications</td>
<td>Solutions and platforms</td>
</tr>
<tr>
<td>design &amp; develop</td>
<td>Workflow</td>
<td>Architecture (policy), data mgt (and workflow), integration</td>
</tr>
<tr>
<td>implement</td>
<td>Project</td>
<td>Program</td>
</tr>
<tr>
<td>support</td>
<td>Functional Capabilities</td>
<td>Continuity of Ops (stability)</td>
</tr>
<tr>
<td>and want</td>
<td>Vendors</td>
<td>Partners</td>
</tr>
</tbody>
</table>
Implementation: Build on Heterogeneous Legacy

Independent GIS Users and Workgroups

Workgroup Geo-enabled Solutions

... and Evolve to an Enterprise Foundation

Rationalizing Support for Traditional Users

Enabling New Devices and User Types

Extending Solutions—Geocentric and geo-enabled

Providing New Content—and New Perspectives

Mitigate risk, extend use, deliver business and IT benefits—and preserve agility
Meeting Enterprise GIS Customer Requirements

Comprehensive support over the life cycle

ArcGIS Platform
- Products
- Content

Enterprise GIS
- Architecture
- Performance & Scalability
- Security

Enterprise Licensing

Enterprise Project Implementation

Support
- Training
- Tech

Extended Support
- Enterprise Advantage
- Implementation Services
- Premium Tech Support

Business Partners

Solutions
- Templates
- Patterns

Marketing

Sales

Product Development

Implementation

Create

Sustain

Product Management

Skills Certification

… supported by new facilities for performance evaluation and solution demonstrations
Bottom Line

Enterprise GIS offers…

- Timely access to better information
- Increased operational awareness
- Improved communication and collaboration
- Rich analysis
- Improved decision-making

... and requires

- Inclusive and sustained management and governance—business led
- Corporate management of data and tradecraft
- Agile architecture and systems

“Getting value from enterprise systems is not a project but a way of life.”
System Architecture
GIS Architectural Issues

- Centralized vs. Distributed Architectures (Apps & Data)
- Enterprise vs. Federated Architectures
- GIS Centric vs. GIS Enabled
- Cloud Computing: Public vs. Private and Virtual Apps vs. Virtual Data
- Maintenance environment (Desktop GIS Editors) vs. Publish environment (Web-based Read Only)
- Desktop Apps (Editors and Analysts) vs. Web Apps (Consumers)
- Direct access to data (ArcSDE Direct Connect) vs. Web Services (OGC: WMS, WFS, WCS, KML, etc.)
- Base data vs. Operational data
- Vector data vs. Imagery data
- Vector Data: Dynamic vs. Static Cached data (Map Cache Tiles)
- Web Apps: Server based Web Apps (Web ADF: Java or .NET) vs. REST-based JavaScript or Rich Internet Apps - RIA (Flash or SilverLight)
- Mobile: Connected over Broadband or Satellite (Low bandwidth/High latency) vs. Sometimes connected (ArcGIS Mobile: Distributed app & data)
Architectural Design Considerations – Trade Offs

What You Know

- Mission Requirements/Needs
  - Imagery to the field
  - Capture data in field
  - Communicate back to Command / NGA
  - …

- Existing Capabilities & Systems
  - MCS
  - AFATDS
  - …

- GIS Has Unique Demands
  - Processing Intensive (CPU)
  - Memory Intensive (RAM)
  - Network I/O Intensive
  - Disk I/O Intensive
  - Graphics Intensive (GPU)

Design Criteria—applied to systems …

- Primary
  - Functionality
  - Performance
  - Security
  - Policy Issues

- Other
  - Scalability
  - Availability / Reliability
  - Mobility
  - Quality
  - Maintainability
  - Flexibility
  - Cost Considerations

… over time

Stepwise Migration

Capability

Time
Three Core Elements & Two Networks

Three Major Elements:
1. Users
2. Applications
3. Data

- Where do each reside (Data Center, Regions, etc)?
- What is the network connectivity like between these three?
  - LAN vs. WAN
  - Network Bandwidth and Latency
  - Frequency of Outages or Drops

Diagram:
- Users
- Applications
- Data
  - User-to-App Connectivity
  - App-to-Data Connectivity
  - High Bandwidth
  - Thin Connection
GIS is deployed in many ways:

**Traditional**
- Departmental
  - Traditional GIS Workstations
    - Single GIS
      - Geodatabase
    - File-based data
  - Distributed Data
- File Based

**Emerging**
- Enterprise
  - Centralized GIS
    - Central DBMS with Multiple Users
- Federated GIS
  - GIS Portal
  - GIS Networks
    - Spatial Data Infrastructures
    - Stovepipe GIS Integration
- Services-Oriented Architecture
  - Workflow integration via web services and messaging
  - Enterprise Service Bus
Centralized Infrastructure

Centralized Systems
Centralized Application near Centralized Data
(Web Apps & Citrix)
Distributed Infrastructure

Distributed Systems
Distribute Replicated Data
(9.2 Replication)

Data Center
Master Database
File Server

Regional Office
Field Office

User & App.
Local Server ("Replica")
Region
Field User

User & App.
User & App.
User & App.

Replicate Deltas Only
Replicate Deltas Only
Replicate Deltas Only
### Centralized vs. Distributed System Trade Offs

#### Centralized Systems
- Uses Citrix or Web Service apps
- Single point-of-access for data, centralized management
- Dependant upon network for Application & Data
- Reduced WAN & LAN traffic
- Increased O&S at Data Centers
- Decreased O&S at Region

#### Distributed Systems
- Uses desktop apps on local workstation
- Multiple replicas of data at Regions, synched w/ master
- Less dependant upon WAN
- Increased LAN traffic
- Decreased O&S at Data Centers
- Increased O&S at Regions

#### High Points:
- Minimizes resource requirements at regional centers
- Centralized database and system administration – integrity

#### Low Points:
- Network is a single point of failure

#### High Points:
- Editing data offline (during outages)
- Data distribution (i.e. outsourcing to data vendors, outside agencies)

#### Low Points:
- Increased resources, O&S support maintaining client software and data at regional centers, etc.
- Posting/synchronizing local data with master database(s) – data currency
GIS Common Solution Architecture - SOA

- **Presentation Tier**
  - Desktop
  - Web/Rich Internet Applications
  - Mobile

- **Services Tier**
  - Exposure of information

- **Enterprise Messaging**
  - Messaging methods, protocols

- **Application Tier**
  - Session management
  - Business Logic
  - User interaction

- **Data Tier**
  - Databases, Files
GIS Enterprise Architectures

GIS Centric

Clients
- Desktop

Application Servers
- GIS
- ERP
- CRM
- GIS
- SFA

Data Servers

GIS Enabled

Browser

Web Server
Elements of a Web Map

1. Base Maps
   - Static content
   - One or more maps that provide a framework or context for displaying operational information layers
   - Ideal for Map Cache data (Local or Remote service)

2. Operational Layers
   - Dynamic content
     • Working layers
     • Feeds, observations, sensor, incidents
     • Query results
     • Model results
SOA Migration Strategies

Requires Multiple Initiatives

- Understand Business Processes
  - Distill Processes
  - Define Services
- Construct Common Services
- Develop Applications
  - Rapidly Prototype
  - Understand/engage Mission
- Select SOA Platform
  - Bus & Orchestration Tools
- Implement Web Service Standards
  - WSDL, UDDI, XML, SOAP, REST, FLEX, WMS, KML

Three Migration Approaches

- Existing Capabilities
- Service Enabled Components

- Wrap
  - Legacy
  - Legacy

- Replace
  - Legacy
  - Legacy
  - COTS-Based Replacement

- Retire
  - Legacy
  - COTS-Based Capability

Build on What You Have ....

... SOA Is Evolutionary, Not Revolutionary

More of a change in strategy ...... Less of a change in Technology
Services provide the most security options
Dealing with Communication Constraints

**Bandwidth & Latency**

- Compression (SSL)
- Change-based Updates
- Sometimes connected synchronization
- Forward deployed appliances
- Manage application transaction rates
**Example of Network Latency Impact**

**Chatty LAN Protocols**
- Example: 200 trips to server for single map display

**Local Network (LAN)**
- Latency: 0.001 sec
- Transport Time: 5 Mb / 200 trips
  - CPU Time: 0.06 sec
- 0.2 sec
- 0.5 sec
- 1.32 sec per display, maximum 3.78 Mbps traffic (5 Mb/1.32 sec)

**500 miles (WAN)**
- Latency: 0.03 sec
- Transport Time: 5 Mb / 200 trips
  - CPU Time: 0.06 sec
- 6.0 sec
- 0.5 sec
- 7.12 sec per display, maximum 0.71 Mbps traffic (5 Mb/7.12 sec)
  (5.4 times slower than local environment)
Expanding Deployment Options

Remote Access Client Options

- **ArcGIS Mobile**
  - Supports Windows XP and Mobile Operating Systems
  - Requires development

- **ArcPad**
  - Complete Application

- **Browsers**
  - ArcGIS Server and ArcIMS

- **ArcEngine**
  - Rich Client Development environment
  - Can consume web services

- **Windows Terminal Services / Citrix**
  - Full Rich Client Functionality
  - Typically utilized by “Authors”

- **ArcMap**
  - Full Rich Client Functionality
  - Can consume web services and new GeoData disconnected Editing

A single Web Service can support any of these clients

Technology

- Phone
- PDA
- Tablet
- Laptop
- Workstation

Network

Increasing Bandwidth / Connectivity / Richness

Software

- ArcGIS Mobile
- Browser
- ArcEngine
- Citrix
- ArcMap
Example of Architectural Design Recommendation

For Optimized, High Performing ArcGIS Servers to Support GIS Web Applications and Web Services

1. New Hardware
   - Intel 5500 Nehalem Chip Set
   - 64bit OS
     ✓ Especially important for Virtualized Environments

2. New Optimized Server Graphics Engine
   - ArcGIS Server 9.3.1
   - Optimized Map Service Document (MSD)

3. Pre-cook Static Base Map Data
   - Pyramid Image Tiles – Map Cache
   - Optimized Image Services – Service Overviews

4. REST-based Web Applications (Browser-based)
   - JavaScript
   - Rich Internet Applications (RIA)
   - Flex/Flash
   - SilverLight

Need to deal Comprehensively with Mission, GIS and IT Considerations
Information Management
# Information Products

*Mission deliverable (content and services)*

<table>
<thead>
<tr>
<th>Old School:</th>
<th>New School:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maps and Data Sets</td>
<td>Time critical information on the network</td>
</tr>
<tr>
<td>Single-use products</td>
<td>Multi-purpose</td>
</tr>
<tr>
<td>Inflexible production pipeline</td>
<td>Collaborative information flows</td>
</tr>
<tr>
<td>Production-driven push through distribution channels</td>
<td>User-driven pull via web services</td>
</tr>
<tr>
<td>Product specifications</td>
<td>Information Management; Quality of Service Contracts</td>
</tr>
<tr>
<td>Slow response to mission changes</td>
<td>Agile response to mission changes</td>
</tr>
</tbody>
</table>

Map out how information products are produced, maintained, and delivered. **Assure capability to produce and deliver the information users need.**

Evaluate usage of organization’s deliverables. **Establish Quality of Service (QoS) requirements for your information products.**
### Knowledge Management

An organizing principle for the enterprise

<table>
<thead>
<tr>
<th>Objective/Need</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission focus and clear allocation of services</td>
<td>Identify and prioritize candidate services</td>
</tr>
<tr>
<td>Strong data stewardship and geo data management</td>
<td>Identify information producers and consumers</td>
</tr>
<tr>
<td>Quality of Service</td>
<td>Consistency, currency, accuracy–authoritative</td>
</tr>
<tr>
<td>Flexibility</td>
<td>When a new capability is required, know where and when to add it</td>
</tr>
</tbody>
</table>

Business units are stewards—and are both producers and consumers
Information Management
- Business Stewardship

- Address all mission-relevant information
  - Foundation data
  - Value-added (analytics, overlays, business)
  - Real time/near-real time information
  - Logistics, facilities, etc.

- Tradecraft captures organizational knowledge and workflows
  - Job tracking
  - Models
  - Service orchestration

- Provide well defined information flows
  - Versioned databases
  - 2-way synchronization
  - Replication strategies
Apply technical and data standards…

• SOA is standards-based
• Standards help the enterprise work
  – Interoperability
  – Consistency
  – But they can be moving targets
• IT standards support and enable the enterprise:
  – For services: XML, SOAP, WSDL (W3C)
  – For data interoperability: ISO, FGDC, OGC, SQL
• Common data understanding
  – Data dictionary
    – Well defined, performant data models (industry-based)
• Keep it as simple and straightforward as practical

Don’t wait for standards to mature; exploit them and stay focused on providing mission capabilities
How to approach Implementing Web Services

- Clarify mission deliverables as **Information Products**
- Establish **Business Units** as the Organizational framework
- Identify and apply IT (Services) and Geospatial **Standards**
- **Security**
- Plan for incremental migration and develop strategies to leverage **legacy systems**
- Establish strong enterprise **governance** with mission focus
- Adopt an agile **development and operational strategy**
Bottom Line
Quality, Timeliness, Efficiency, Community

• Think big—extend to new business areas, and serve the generalist as well as the specialist
  • Geography as a foundation
• Manage information—data and tradecraft—as corporate resources with strong governance
  • Incentivize sharing, and incentivize using
• Engage and recruit every stakeholder in a collective
  • Make mission success the paramount objective
• Move small, but quickly, to deliver capabilities incrementally
  • Capitalize on web services to build and maintain agile systems
• Prepare for the long haul

“Getting value from enterprise systems is not a project but a way of life.”
Enterprise GIS

- ArcGIS Application Architectures
- ArcGIS Security
- ArcGIS Performance and Scalability
- ArcGIS Interoperability and Standards

resources.esri.com

Building a GIS
By Dave Peters
Gartner Hype Cycle for Emerging Technologies 2009
What’s Peaking, What’s Troughing? (as of July 2009)

- Cloud Computing
- eBook Readers
- Wireless Power

* Extracted from Gartner Hype Cycle of Emerging Technology 8/2009
Gartner Hype Cycle for Emerging Technologies 2009

What’s Peaking, What’s Troughing? (as of July 2009)
Open Source at ESRI

- Pervasive use in software development
- Encourage users and developers to complement ESRI solutions with open source & interoperability

Open Approaches & ESRI

- Continue work with the open source community to further GIS research & development
- Active participant in open source & interoperability standards communities
Summary of GIS Architectural Issues

- Centralized vs. Distributed Architectures (Apps & Data)
- Enterprise vs. Federated Architectures
- GIS Centric vs. GIS Enabled
- Cloud Computing: Public vs. Private and Virtual Apps vs. Virtual Data
- Maintenance environment (Desktop GIS Editors) vs. Publish environment (Web-based Read Only)
- Desktop Apps (Editors and Analysts) vs. Web Apps (Consumers)
- Direct access to data (ArcSDE Direct Connect) vs. Web Services (OGC: WMS, WFS, WCS, KML, etc.)
- Base data vs. Operational data
- Vector data vs. Imagery data
- Vector Data: Dynamic vs. Static Cached data (Map Cache Tiles)
- Web Apps: Server based Web Apps (Web ADF: Java or .NET) vs. REST-based JavaScript or Rich Internet Apps - RIA (Flash or SilverLight)
- Mobile: Connected over Broadband or Satellite (Low bandwidth/High latency) vs. Sometimes connected (ArcGIS Mobile: Distributed app & data)
Questions

Please fill out and turn in your evaluation forms
Cloud GIS Support

Providing ESRI customers with Cloud-ready software, support and services

ArcGIS Online
- Free & Premium Content
- Publish, Share Maps & Apps

ArcGIS for Amazon Cloud
- ESRI Supported Product
- Standard PS Package
- Extended Support via PS

ESRI Managed Services
- Hosted Web Apps & Services
- Hardware, Network, Facilities, Security
- Software (ESRI & Third Party)
- Enterprise Data Management
- Tech Support & Monitoring

Custom Cloud Implementation
- PS Project Support for Custom & Private Cloud Impl.
- e.g. NGA, NSA, etc.

Amazon Infrastructure
ESRI Infrastructure
(support for other cloud providers in future)
Custom Infrastructure