NCHRP 8-87 Implementing GIS for Transportation Asset Management

10th National Conference on Transportation Asset Management
April 28, 2014

spy pond partners, llc

Workshop Agenda

1) Introductions and Overview
2) Implementing GIS for Asset Management
   - Fundamentals
   - Opportunities and Implementation Levels
3) Scenario Demonstrations
   - West Virginia
   - Iowa
   - Colorado
4) Implementation Challenges and Success Factors

NCHRP Project 8-87 Objectives

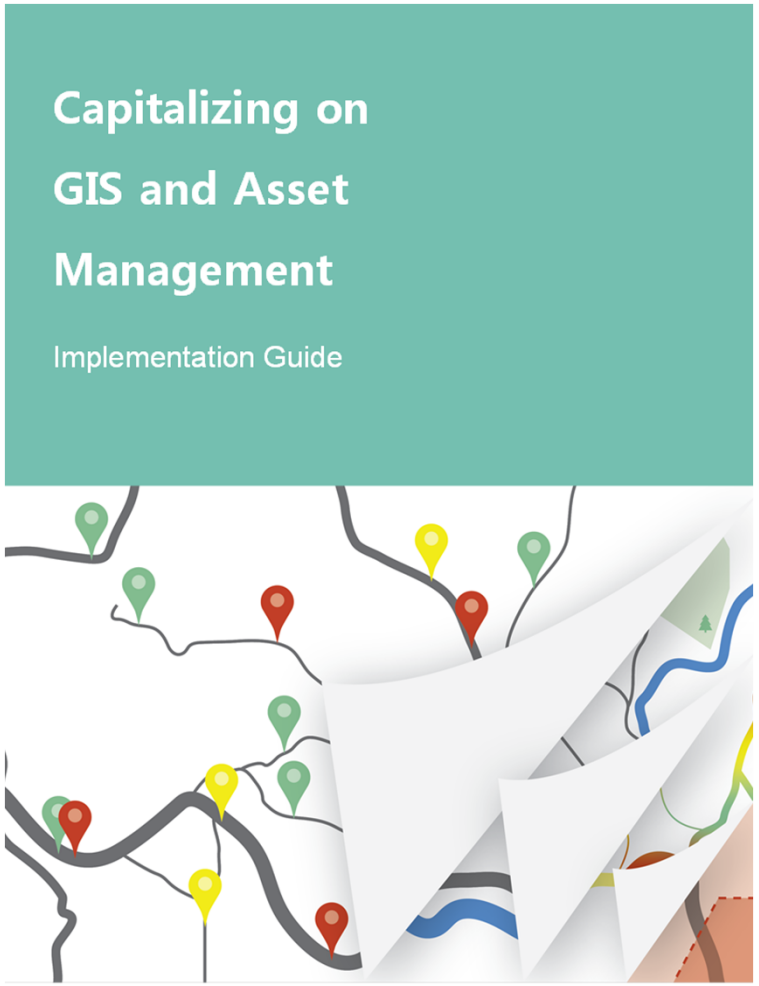
1. Develop guidance for how DOTs and other transportation agencies can enhance their asset-management capabilities through effective adoption of GIS technologies.
2. Encourage more extensive adoption of GIS applications in asset management by conducting pilot demonstrations and workshops.

NCHRP Project 8-87 Products

1. Executive Guide
2. Implementation Guide
3. Adoption Activities
    1. Pilots – Colorado, Iowa and West Virginia
    2. Workshop – New England States (February 2014)
    3. Webinars – Spring 2014

Implementation Guide Overview

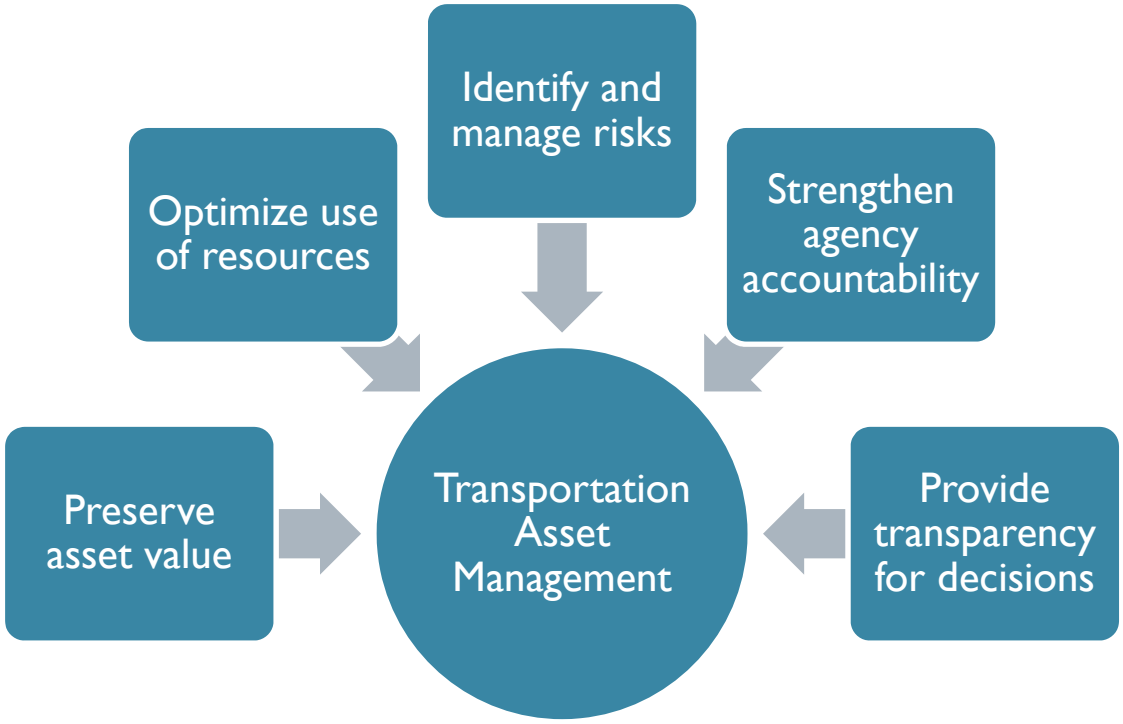
- Section 1: Fundamentals
- Section 2: Opportunities
  - How GIS can add value to transportation asset management (TAM) processes
- Section 3: Evaluating Initiatives
  - How to identify actions for furthering use of GIS
- Section 4: Implementation
  - Strategies for implementing GIS for TAM



FUNDAMENTALS

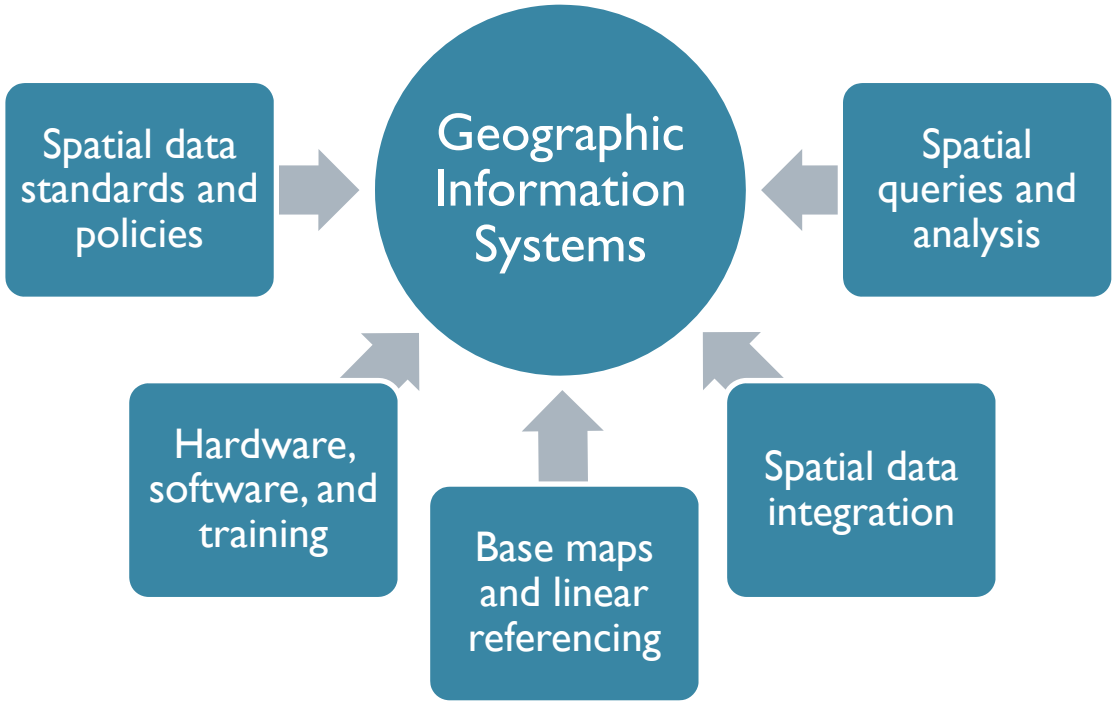
Transportation Asset Management (TAM)

Process for managing infrastructure assets throughout their lifecycle to meet agency objectives



Transportation Asset Management: Key Concepts

Geographic Information System (GIS)



Geographic Information Systems: Key Concepts

Management, analysis and presentation of spatial information

Mobile, web, desktop platforms

Benefits of Using GIS in support of TAM

- Information Integration
  - Use location as integration point to bring together information from disparate systems – internal and external
  - Provide central, unified platform for information access
- Analysis
  - Quickly visualize asset conditions, work history, planned work
  - Identify relationships and trends – condition, traffic, crash rates
  - Improve decision-making through new insights
- Communication
  - Create spatial data views to provide wide understanding of asset conditions, risks, needs, and strategies
  - Use to communicate within the agency and with external stakeholders

Assessing the Agency's GIS Foundation

- Agency-Level GIS Function
  - GIS advocate, business units to support GIS, communication and coordination across the agency, GIS Strategic Plan
- Geospatial Data and Standards
  - Road centerlines, Linear Referencing System (LRS), support for multiple location referencing methods (LRMs), central GIS data resources library, standard data integration architecture, formal updating procedures
- Tools and Technologies
  - Central database and software, geospatial data viewer, GPS data collection standards, tools for exporting data, tools for geocoding, mobile apps
- GIS Expertise, Training, and User Support
  - Active GIS user group, user training courses, process for tool deployment

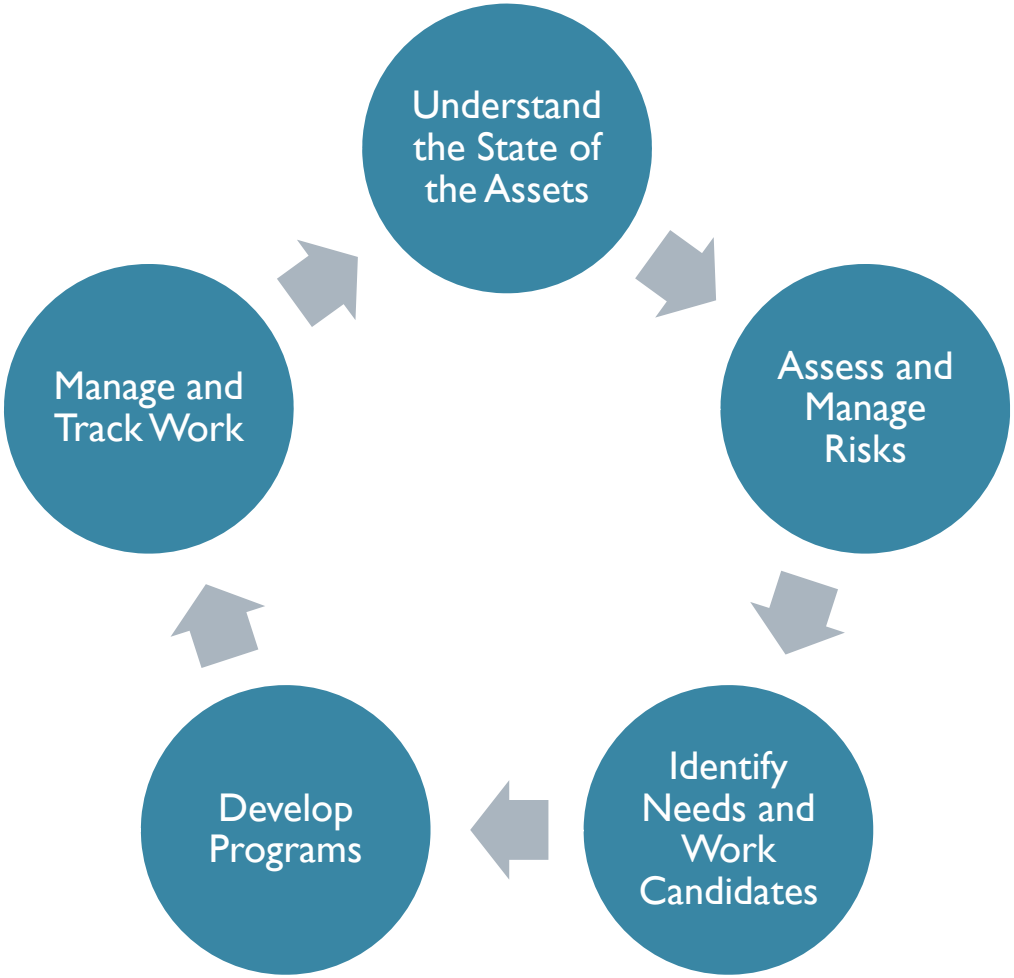
Exercise 1: GIS Capability Checklist

How many items did you check?

What's missing?

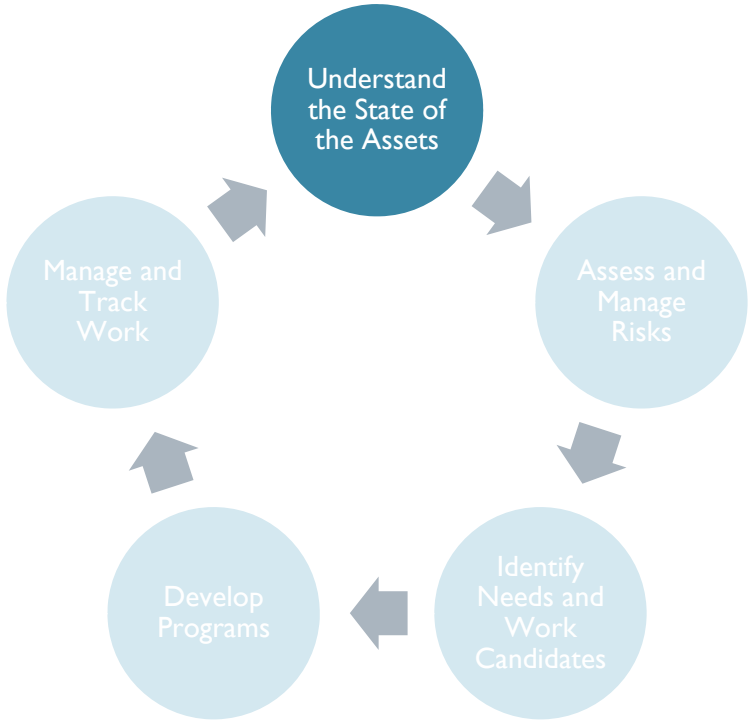
OPPORTUNITIES

Practice of Transportation Asset Management



Understand the State of the Assets

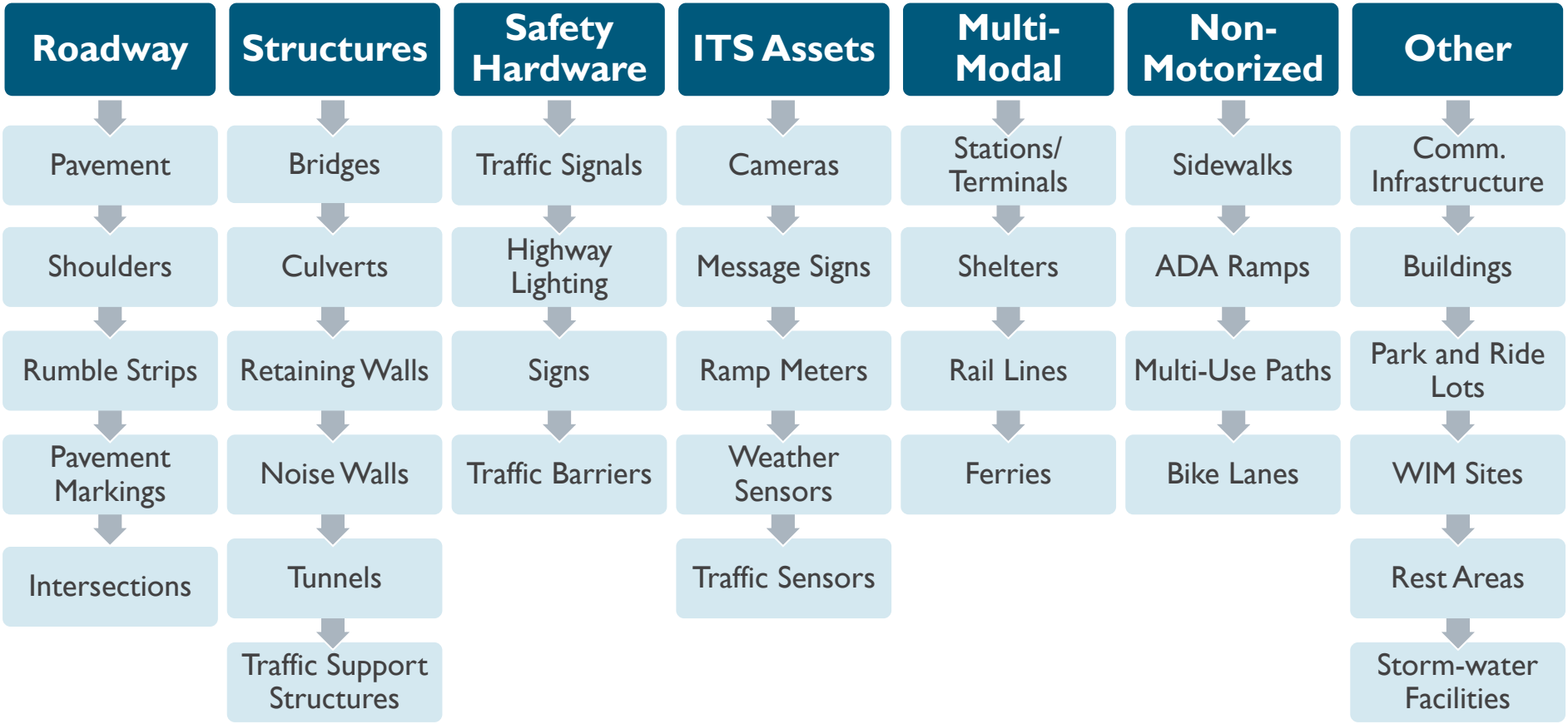
- Gather data to understand:
  - Asset inventory
  - Asset condition
  - Remaining life
  - Value/Replacement cost
- Assess network-level asset performance against established targets



Using GIS to Understand the State of the Assets

- *Data Collection*
  - collect spatially referenced data – with GPS enabled tablets, extraction from video or LiDAR sources
  - Use GIS tools for inspection planning and tracking
  - Use GIS tools for quality assurance of new data
- *Data Analysis and Communication*
  - Provide map and straight line diagram views of asset location, type, condition
  - Allow for "drill down" from aggregate performance information to map views

Data Layers for Physical Assets (Location and Condition)



Exercise 2: How Many Assets Can You Map?

- ❑ We can map pavement and bridge assets
- ❑ We can map 1-5 others on the list
- ❑ We can map more than 5 others on the list
- ❑ We also map assets not on the list

Using GIS to Understand the State of the Assets

Where are our deficient assets?

Using GIS to Understand the State of the Assets

BASIC

- Individual units collect spatially-referenced data for major assets
- Individual units produce maps to meet their needs – single asset
- Individual units share information on request

INTERMEDIATE

- Spatially-referenced data for other assets
- Agency-wide location referencing standards
- Agency-wide GPS data collection standards and procedures
- GIS used for inspection tracking and data QA
- Standard process for producing and publishing maps

ADVANCED

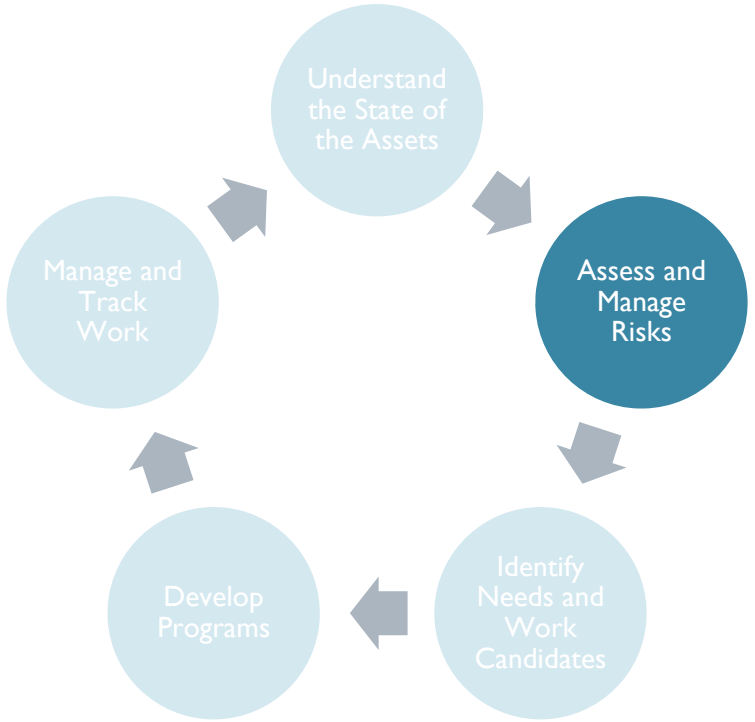
- Coordinated data collection across business units
- Business processes for work completion update inventory
- CAD-GIS integration to produce asset inventory from as-builts
- Delivery of asset data through multiple channels incl. mobile access
- Performance analysis – patterns, cross asset comparison

Exercise 3: Implementation Level for Understand the State of the Assets

- ❑ Basic
- ❑ Intermediate
- ❑ Advanced

Assess and Manage Risks

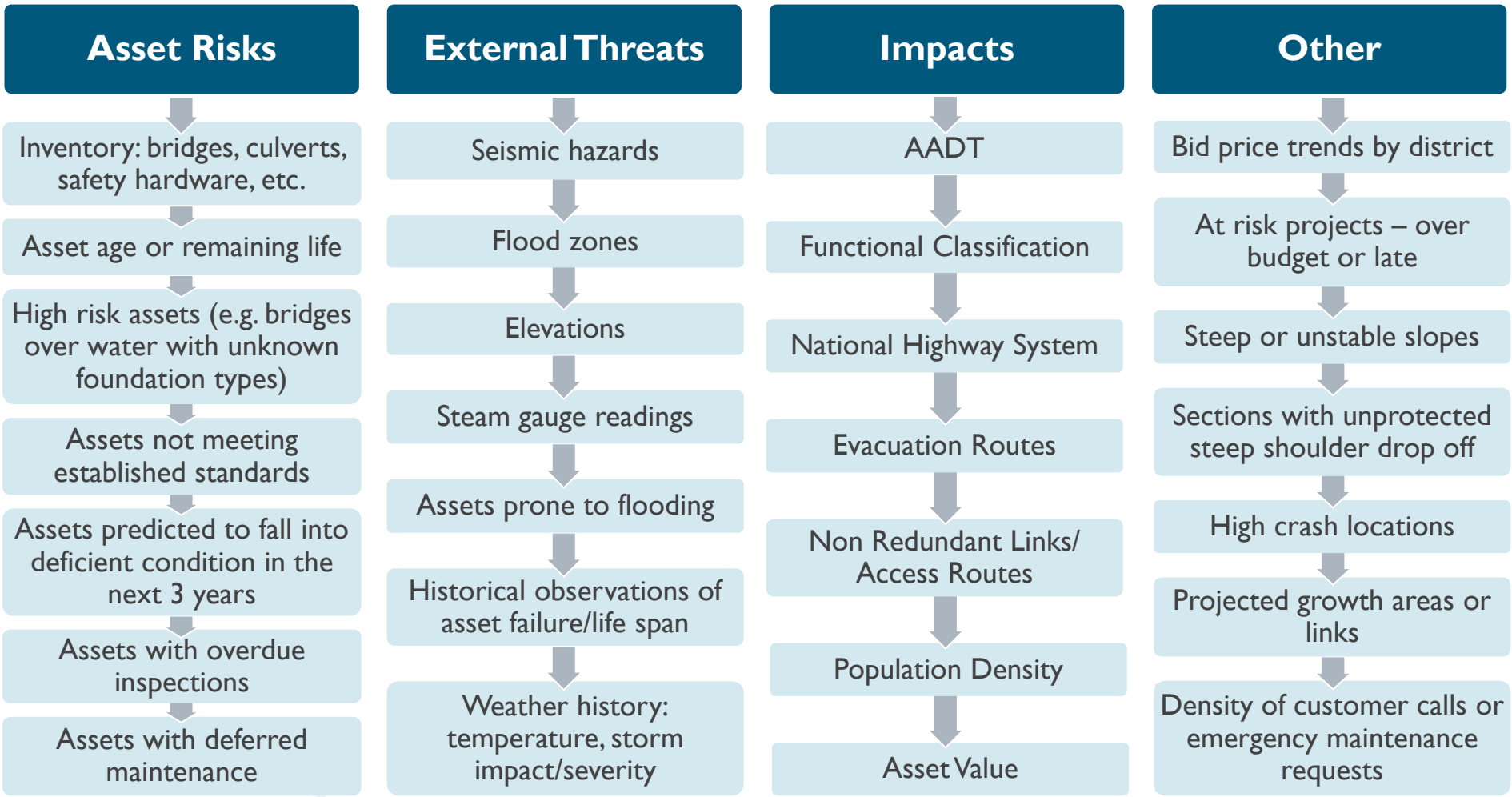
- Identify critical assets
- Assess risk and vulnerabilities
  - Identify events or conditions that could impact safety or service
- Determine likelihood and consequence of failure
- Use risk as a factor in asset rehab/replacement decisions, inspection intervals, response time policies
- Develop risk mitigation and recovery strategies



Using GIS to Assess and Manage Risks

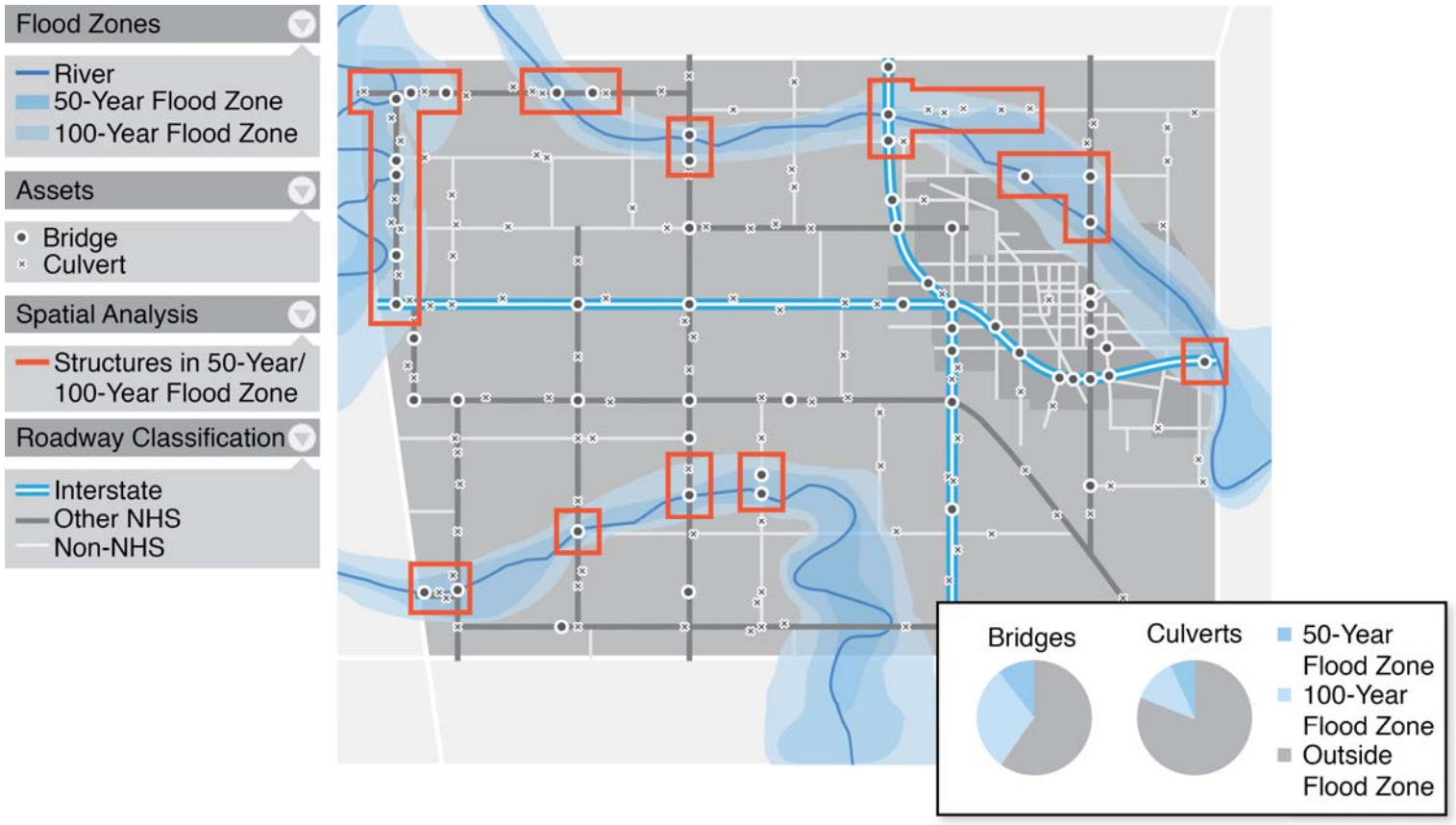
- Integrate multiple data sources to:
  - Determine the *probability* of asset failure – condition, deterioration rates, traffic loadings, environmental data
  - Determine the *consequences* of asset failure – replacement costs, exposure, detour lengths
- Visualize:
  - Critical assets
  - Areas of high vulnerability
  - Overdue inspections
  - Overdue response to maintenance requests

Spatial Data Layers Used for Risk Management



Using GIS to Assess and Manage Risks

Where are our vulnerabilities?



Using GIS to Assess and Manage Risks

BASIC

- Individual units assemble data on vulnerable assets
- Individual units develop ad-hoc maps to illustrate areas of concern
- Information from asset management systems – minimal integration

INTERMEDIATE

- Develop spatial analysis capabilities to determine affected assets
- Integrate data sources relevant to likelihood & consequences
- Calculate risk scores using spatial analysis
- Use maps to share information across the agency

ADVANCED

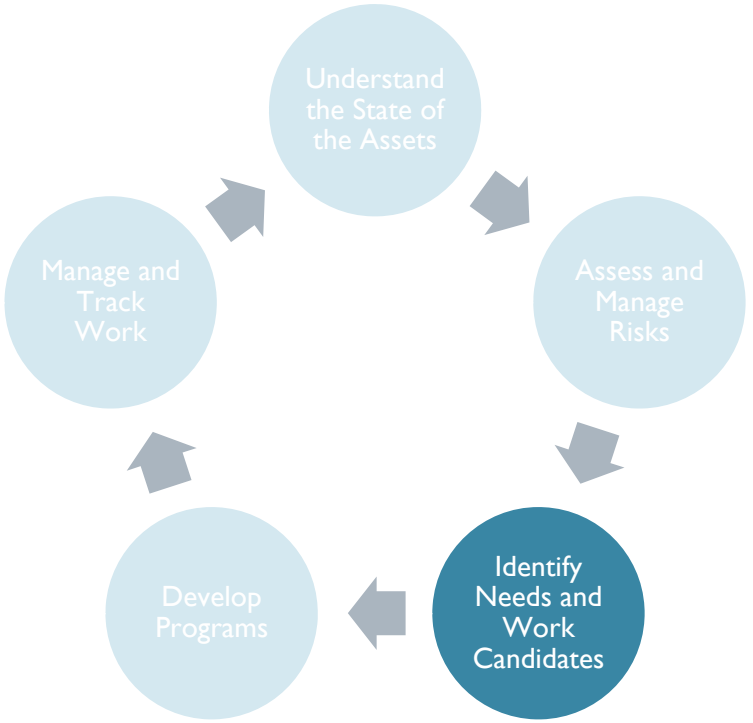
- Assemble and maintain common pool of geospatial data
- Calculate quantity and replacement cost for at risk assets
- Integrate historical information and model asset failure risk
- Develop interactive maps on investment scenarios

Exercise 4: Implementation Level for Assess and Manage Risks

- ❑ Basic
- ❑ Intermediate
- ❑ Advanced

Identify Needs and Work Candidates

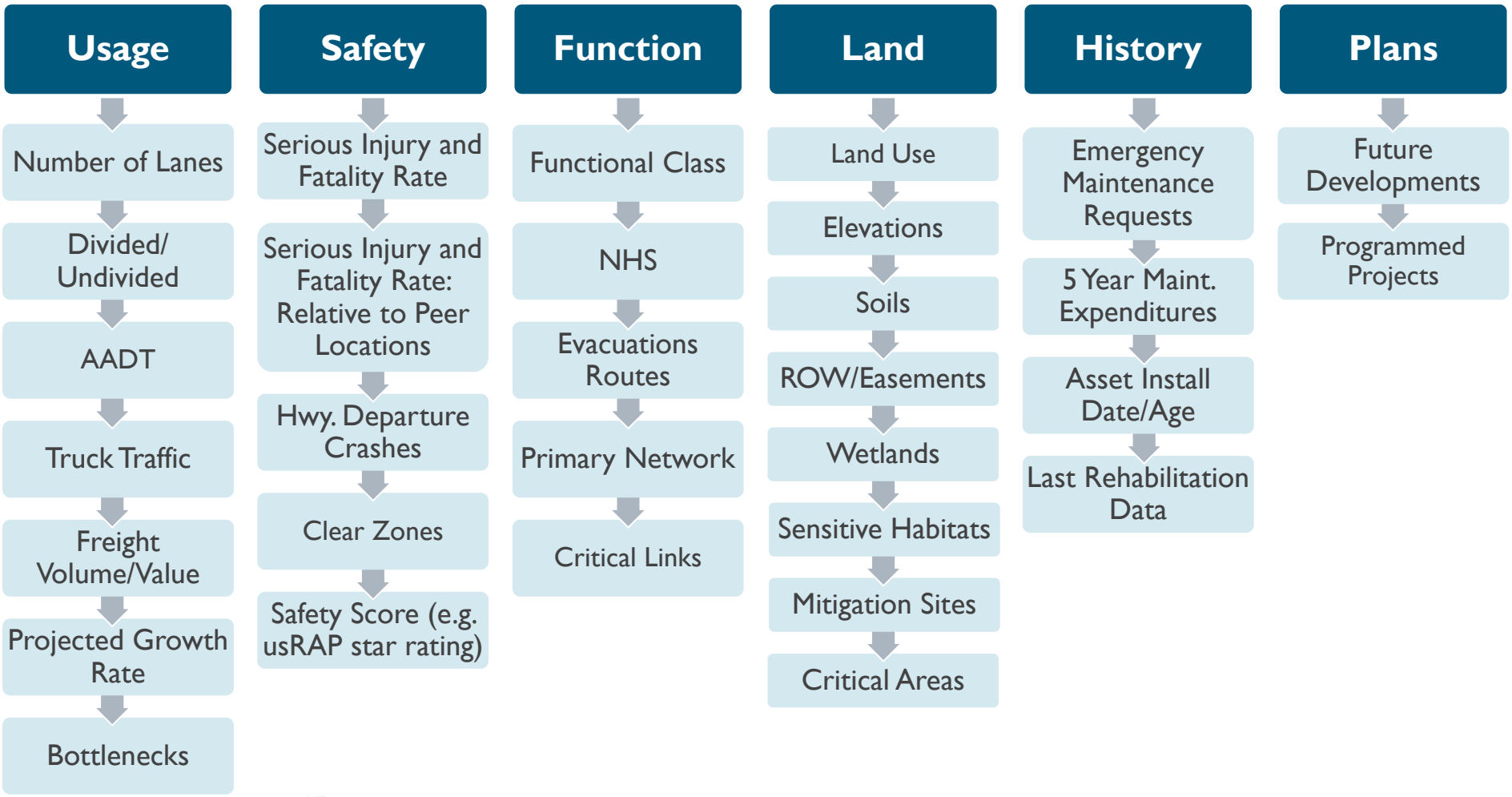
- Identify maintenance, rehab, replacement and functional improvements to address risk and minimize life cycle cost
- Develop work candidates – from management systems and work requests
- Scope construction projects and maintenance activities
- Understand current and potential future backlog



Using GIS to Identify Needs and Work Candidates

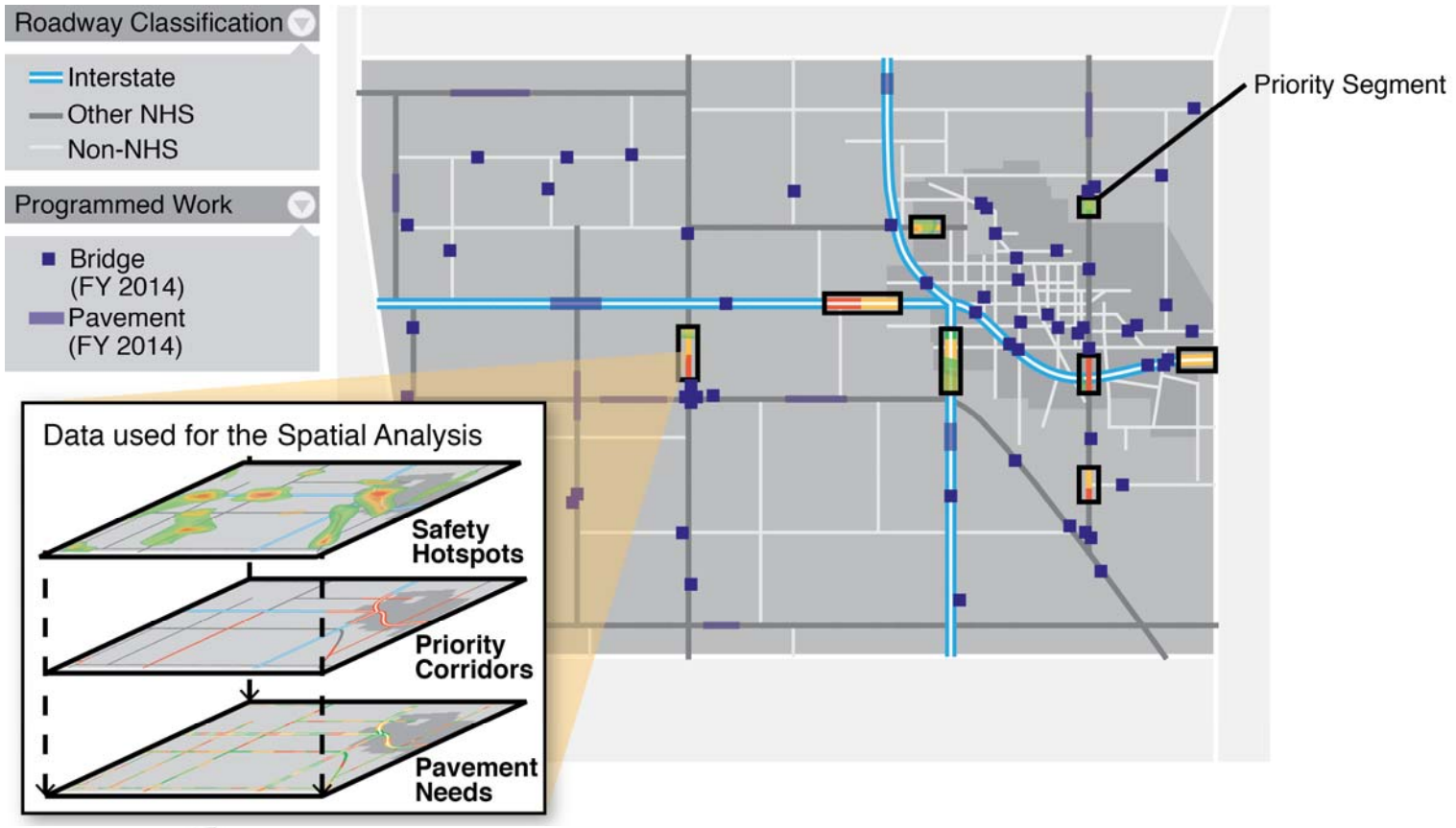
- Provide integrated view of work candidates across assets and program areas
- Use spatially located work history as input to work scoping process
- Scope work accounting for multiple factors: safety, traffic, freight, environmental

Data Layers for Needs Identification and Scoping



Using GIS to Identify Needs and Work Candidates

How can we scope work activities to incorporate multiple needs?



Using GIS to Identify Needs and Work Candidates

BASIC

- Information limited to asset condition and programmed work
- Primarily single-asset analysis
- Maps created within individual asset management systems
- Results not shared widely within agency

INTERMEDIATE

- Integrate information beyond condition data within asset "silos"
- Use data to develop spatial queries to target deficient assets
- Use spatial analysis to create uniform sections
- Produce and share maps with locations showing multiple needs

ADVANCED

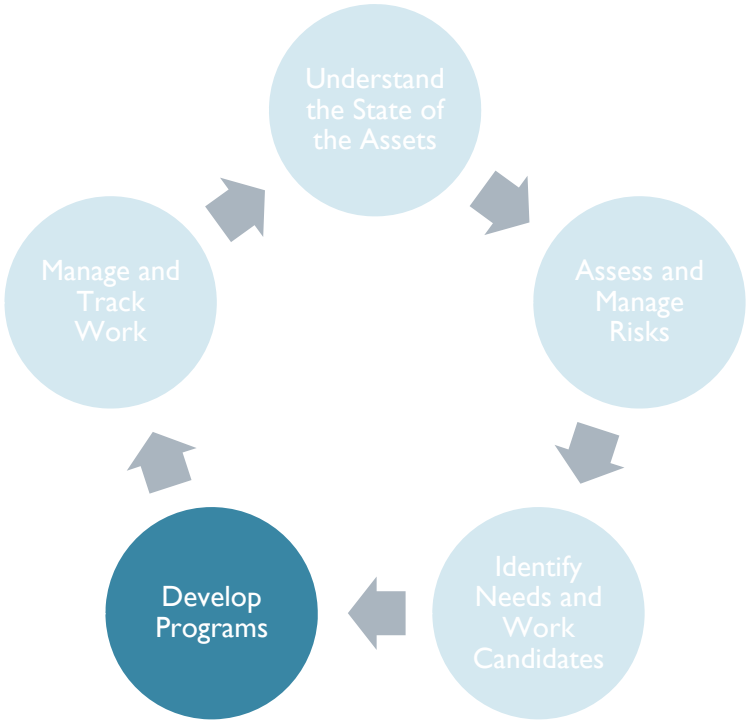
- Integrate information from multiple systems in a single platform
- Develop spatial queries to address multiple needs
- Review and assign appropriate treatments using multiple data sets
- Create interactive communication tools to aid in decision-making

Exercise 5: Implementation Level for Needs and Work Candidates

- ❑ Basic
- ❑ Intermediate
- ❑ Advanced

Develop Programs

- Package projects and maintenance activities into programs based on funding constraints
- Set priorities for work when revenue does not meet the needs
  - Consider investment versus performance tradeoffs

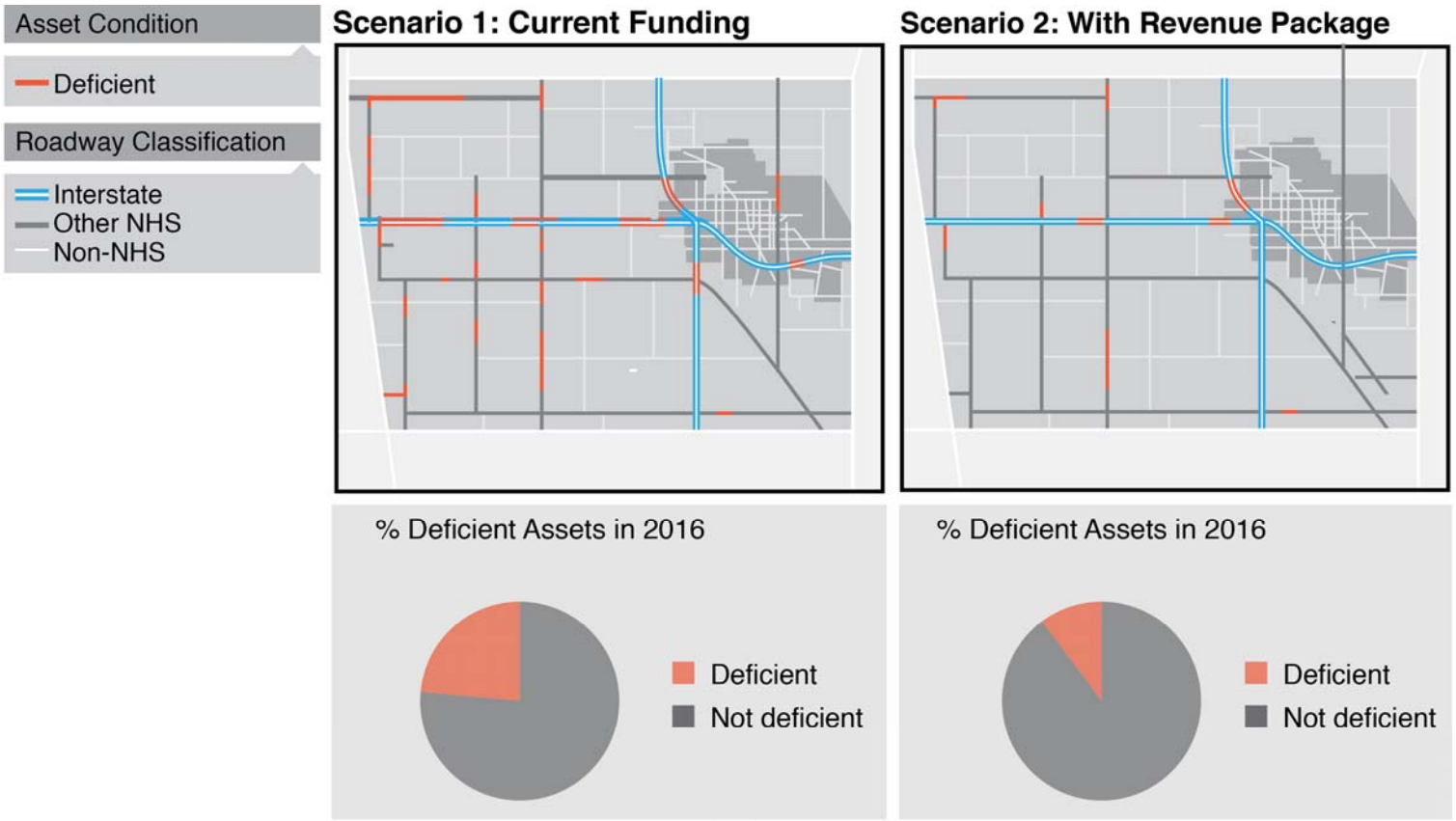


Using GIS to Develop Programs

- Visualize needs and develop logical packages of projects
- Visualize results of investment-performance tradeoff analysis
- Integrate information for prioritization – e.g. traffic, crashes, historical maintenance costs
- Coordinate timing of work across asset categories – spot or corridor
- Display locations for programmed projects for communication purposes
- Review geographic distribution for the program

Using GIS to Develop Programs

What can we achieve with a funding increase?



Using GIS to Develop Programs

BASIC

- GIS used within asset silos to inform program development
- Work candidates & existing programmed work reviewed on a map
- Limited additional spatial info used: traffic, functional class
- Use of GIS for communication limited to programmed projects

INTERMEDIATE

- Make common pool of spatial data available for prioritization
- Use spatial data to calculate priority scores for projects
- Develop tiered network of classifications for priority-setting
- Create and share maps of proposed projects

ADVANCED

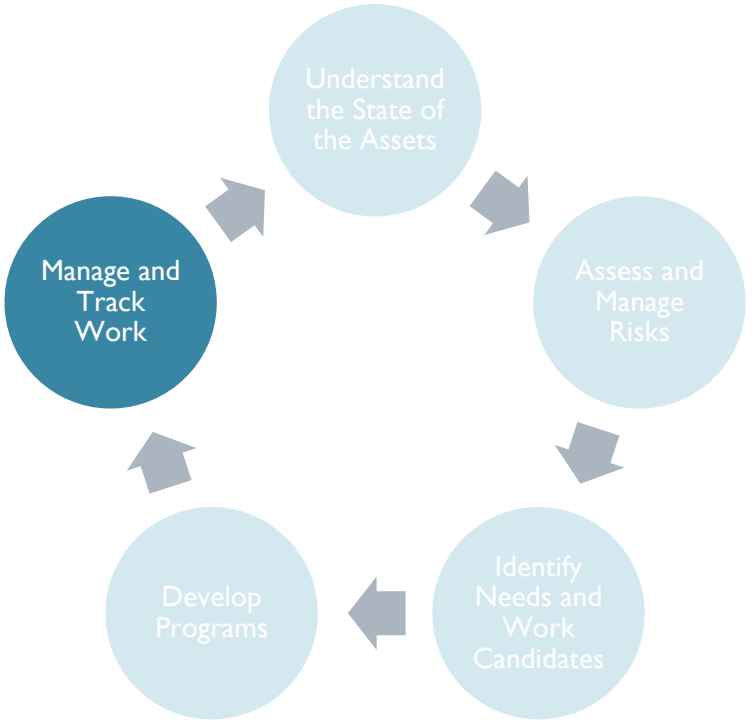
- Integrate information on work candidates across multiple programs
- Identify opportunities for project coordination based on geography
- Create system performance maps for resource allocation scenarios
- Provide public facing web applications showing planned projects

Exercise 6: Implementation Level for Develop Programs

- ❑ Basic
- ❑ Intermediate
- ❑ Advanced

Manage and Track Work

- Scheduling, delivering and tracking maintenance and construction work
  - Responding to customer requests
  - Managing maintenance crews
  - Coordinating contractor work schedules
  - Tracking completed work



Using GIS to Manage and Track Work

- Deploy crews and equipment to maximize efficiency
- Monitor crews and equipment in real-time
- Coordinate work planning and scheduling within agency and with other entities
- Link maintenance work orders and accomplishments to assets by location
- Gather location-specific work history for future analysis
- Update asset inventory based on work completed

Using GIS to Manage and Track Work

Where do we need to coordinate work?

Using GIS to Manage and Track Work

BASIC

- Field crews can access maps of assets and programmed projects
- Work requests can be routed to appropriate unit based on location
- Preventive maintenance schedules developed based on location

INTERMEDIATE

- Track locations for work – requested, planned and completed
- Share info on planned work across field and central office units
- Identify problem areas based on clusters of responsive maintenance
- Use geo-referenced asset inventory to facilitate disaster recovery

ADVANCED

- Auto-update master asset inventory based on completed work
- Monitor real-time location of maintenance vehicles/work crews
- "Crowd-source" work requests and provide external mapping tools
- Analyze reasons for high maintenance costs using spatial data

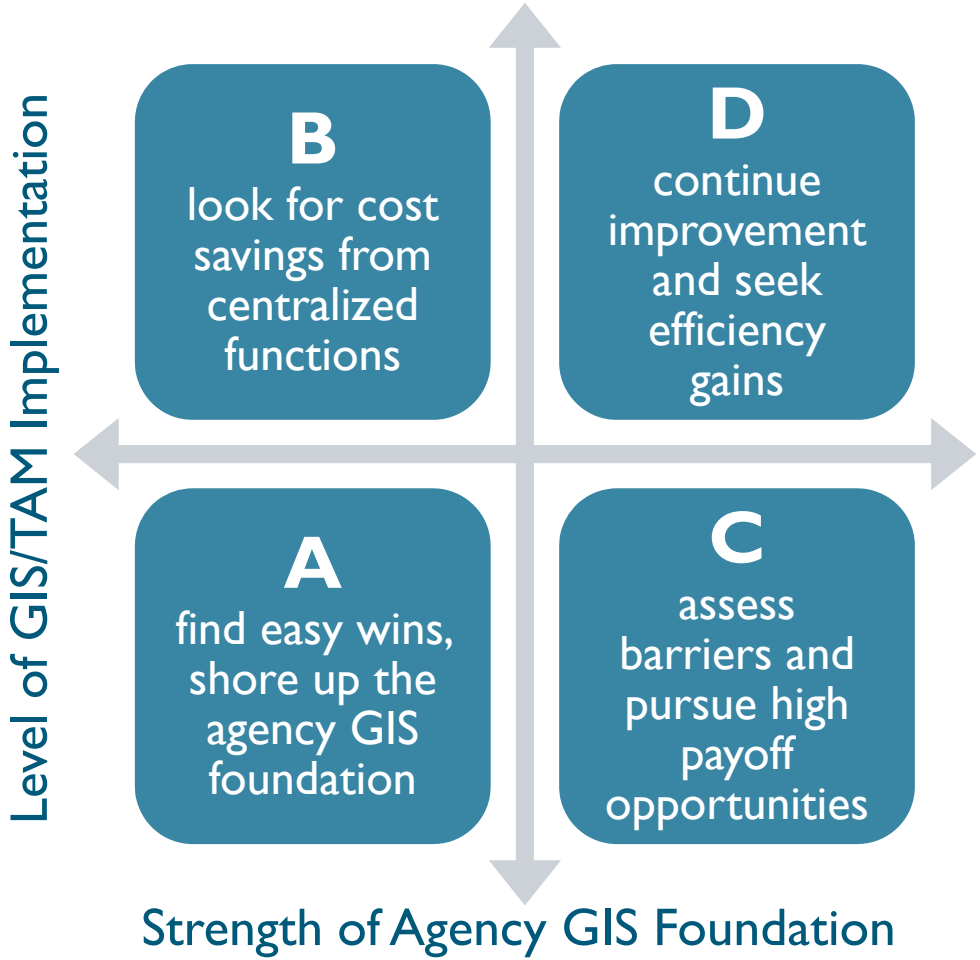
Exercise 7: Implementation Level for Manage and Track Work

- ❑ Basic
- ❑ Intermediate
- ❑ Advanced

IMPROVEMENT INITIATIVES

Developing an Overall Strategy

- A & B Agencies
  - Parallel track to undertake specific management initiatives while working to strengthen overall agency capabilities
- C & D Agencies
  - Easier to advance capabilities by leveraging existing tools



Exercise 8: Which quadrant are you?

- ❑ A - Still Building our GIS Foundation and use for TAM
- ❑ B – Still Building GIS Foundation but have GIS/TAM successes
- ❑ C – Strong GIS but at basic level of GIS/TAM
- ❑ D – Strong GIS and intermediate-advanced GIS/TAM

Options for Moving Forward

- Comprehensive: develop a comprehensive plan that incorporates all assets and all TAM business practices, identifies possibilities for using GIS, identifies a set of initiatives
- Pilot: develop a pilot project to address a specific issue
- Incremental: focus on low-cost, incremental actions to leverage existing data and GIS technologies
- Targeted – Internal: target actions that will achieve noticeable impacts within a single TAM business area
- Targeted – External: focus on external communication using GIS to strengthen the agency's relationship with stakeholders

Building a Business Case for TAM GIS Investment

1 Business Needs	• Motivation • Vision		
2 Options	• Scope • Technology	• Timeframe/Phasing • Centralized/Decentralized	• Delivery
3 Costs	• Staff Labor • Services	• Hardware/Software • Data	
4 Benefits	• Efficiency • Effectiveness		
5 Risks	• Organizational Changes • Technology Changes	• Cost Uncertainty • Benefit Uncertainty	• Funding Uncertainty
6 Summary	• Return on Investment • Intangibles		

Building a Business Case for TAM GIS Investment

- **Understand State of the Assets – GIS Data Collection**
- Understand the State of the Assets – Mapping and Communication
- Assess and Manage Risks
- Identify Needs and Work Candidates
- Develop Programs – Prioritization and Tradeoff Analysis
- Develop Programs - Internal and Public Outreach and Communication
- Manage and Track Work – Proactive Work Scheduling and Coordination
- Manage and Track Work – Work Request Management
- Manage and Track Work – Real Time Tracking and Mobile Apps

Efficiency – "Doing things right"

Lower data collection costs by:

- Collecting multiple assets in a single data collection effort
- Automating location assignment using standard methods and tools
- Optimizing inspection routing
- Using mobile devices loaded with existing inventory to speed collection

Reduce risk of injury to data collection personnel by:

- Using in-office GIS tools for asset extraction from video or LiDAR data

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Effectiveness – "Doing the right thing"

Identify and scope candidate projects that extend asset life, improve safety, minimize traffic disruption and reduce risks of adverse environmental impacts by:

- Integrating data that allows for identification of root causes for poor performance
- Integrating data that facilitates consideration of safety and environmental factors in determining maintenance and rehabilitation need
- Using spatial views of asset needs to identify opportunities for efficient packaging of work

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Efficiency – "Doing things right"

Reduce staff time by:

- Providing self-serve maps that cut down on the need for staff to fulfill special information requests and allow new staff members (and consultants) to quickly get up to speed
- Automating mapping tasks currently accomplished on an ad-hoc, manual basis

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Effectiveness – "Doing the right thing"

Improve awareness of asset condition across the agency by:

- Providing a rich, easily accessible data source integrating imagery, asset characteristics and condition

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Efficiency – "Doing things right"

Facilitate disaster recovery by:

- Providing a readily available data source on asset type, location and condition

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Effectiveness – "Doing the right thing"

Lower agency risk exposure to asset failure by:

- Developing and using a robust information base for risk assessment and mitigation

Lower insurance costs through

- Demonstrating use of preventive maintenance to lower failure risks for critical infrastructure

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Efficiency – "Doing things right"

Reduce staff time needed for data manipulation and analysis by:

- Speeding integration of data from different sources using spatial overlays and automated partitioning/aggregation of linearly referenced data
- Providing a platform for collaboration – common view of information across multiple work units – eliminating need to duplicate data integration tasks

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Efficiency – "Doing things right"

Reduce staff time needed for scenario analysis by:

- Automating and speeding data integration and presentation tasks

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Effectiveness – "Doing the right thing"

Maximize use of available resources by:

- Bringing together multiple data sets that facilitate priority setting
- Providing capabilities for visualization of the implications of different fund allocation scenarios
- Providing capabilities to easily review a proposed program for geographic balance

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Efficiency – "Doing things right"

Reduce staff time needed to support decision makers by:

- Reduced agency staff time responding to information requests and preparing presentation materials for agency executives

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Effectiveness – "Doing the right thing"

Enhance public image and increase support for funding by:

- Improving ability to communicate agency plans to customers and elected officials
- Equipping agency executives with intuitive, self-service tools for "telling the story" about asset needs and program choices

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Efficiency – "Doing things right"

Reduce time and cost of maintenance activities by:

- Reducing the proportion of reactive maintenance through systematic planning of preventive maintenance using spatial data
- Reducing need for return visits to bring additional equipment or materials due to proactive planning
- Coordinating timing of activities involving similar skill sets and equipment within the same area

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Effectiveness – "Doing the right thing"

Minimize customer impacts by:

- Packaging work to coordinate timing of multiple activities requiring lane closures
- Reducing risk of asset failure impacting traveler safety or mobility through proactive approach to maintenance

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- Develop Programs - Internal and Public Outreach and Communication
- Manage and Track Work – Proactive Work Scheduling and Coordination
- **Manage and Track Work – Work Request Management**
- Manage and Track Work – Real Time Tracking and Mobile Apps

Efficiency – "Doing things right"

Increase efficiency in deployment of maintenance resources by:

- Facilitating location of work requests and assignment to the appropriate work unit
- Automating work requests

Building a Business Case for TAM GIS Investment

- Understand State of the Assets – GIS Data Collection
- Understand the State of the Assets – Mapping and Communication
- Assess and Manage Risks
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Effectiveness – "Doing the right thing"

Enhance agency responsiveness to customers by:

- Providing easy ways to report issues (e.g. via mobile apps)
- Providing maps showing status of work requests

Minimize customer impacts by:

- Reducing risk of asset failure impacting traveler safety or mobility through faster identification of issues

Building a Business Case for TAM GIS Investment

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Efficiency – "Doing things right"

More efficient deployment of available staff and equipment by:

- Using real time location tracking information to identify the closest crew
- Lower administrative costs for record keeping
- Improved ability to select most cost-effective delivery method – through comparing in-house unit costs to private sector bids for similar work
- Improved situational awareness for dispatchers and field crews

Building a Business Case for TAM GIS Investment

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Effectiveness – "Doing the right thing"

Improve accountability through:

- Providing current information on work progress and status
- Providing timely information on work accomplishment and budget status
- Documenting work through "before" and "after" geo-tagged photos

Improve ability to optimize asset treatment by:

- Use of a rich information base on locations with high recurring responsive maintenance costs
- Improved access to work history information to help identify root causes for premature failure

IMPLEMENTATION

Introducing New TAM Spatial Data:
Implementation Steps

Goals & Requirements

- Meet with target users and stakeholders
- Establish business case and use scenarios
- Establish data and process owner(s)
- Identify related efforts and coordination needs
- Set scope: what assets, what attributes
- Identify source system of record (SSOR) and target GIS access tool(s)
- Establish spatial referencing methods

Data Planning

- Assess current data availability and quality
- Determine data gaps
- Determine data integration needs and methods
- Develop data dictionary
- Develop quality standards
- Determine ongoing data updating approach

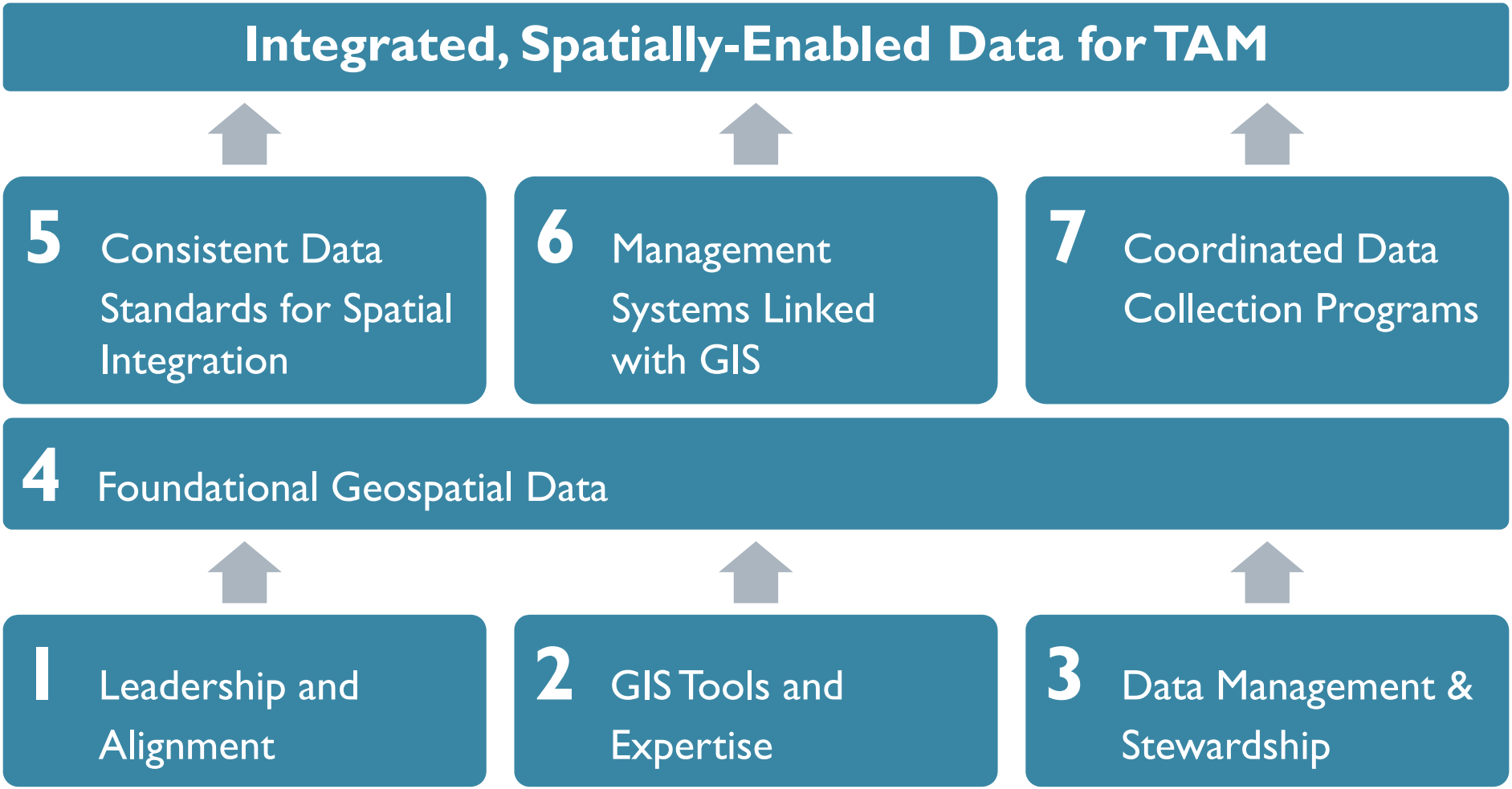
Data Collection

- Select a cost-effective technology and method
- Set up GIS planning and monitoring capability for data collection
- Plan routes/locations
- Collect data and monitor progress
- Review and correct data
- Final QA and acceptance

Data Integration & Access

- Integrate spatial and attribute data
- Implement data refresh method: batch or real time
- Assemble and integrate existing data layers
- Work with users to specify and set up data views and query options
- Set up and test mobile access to data (if required)

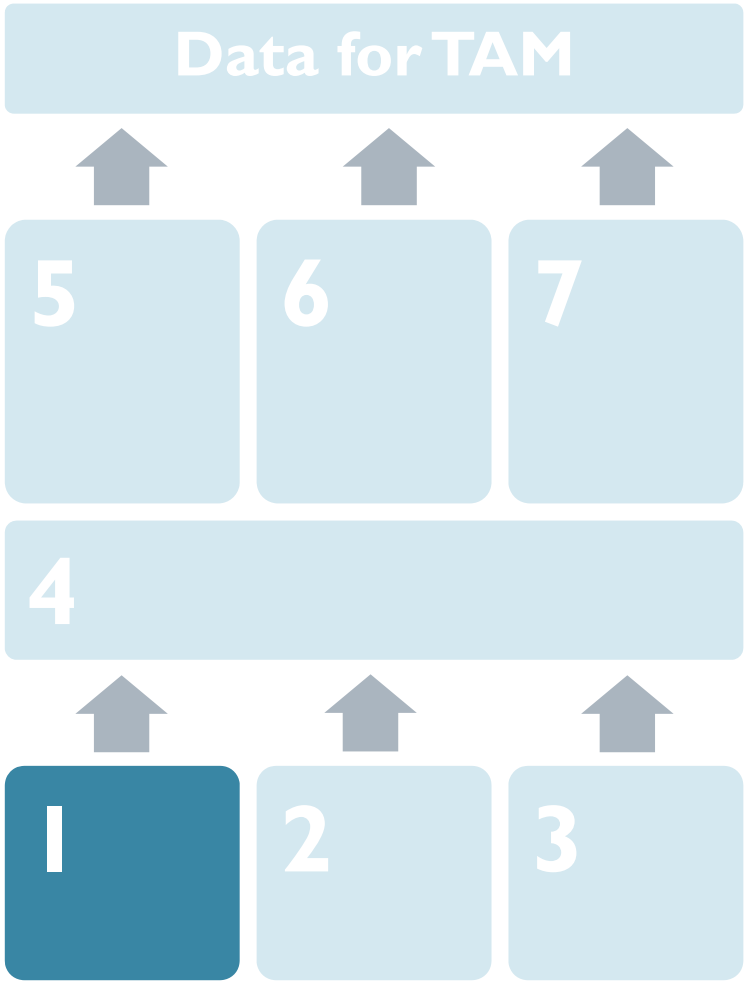
The Seven Ingredients for Success



The Seven Ingredients for Success

Ingredient 1: Management commitment and organizational alignment

- Leadership must appreciate how spatial approaches to asset management can benefit the agency
- Sustained executive support of geospatial initiatives



The Seven Ingredients for Success

Ingredient 1: Management commitment and organizational alignment

Common Challenges

- Lack of management awareness within functional areas
- Independent and duplicative GIS efforts within individual units
- Inability to justify investment
- Difficult to implement multi-year initiatives
- Day to day "fire-fighting"
- Tendency to focus on individual responsibility of business units

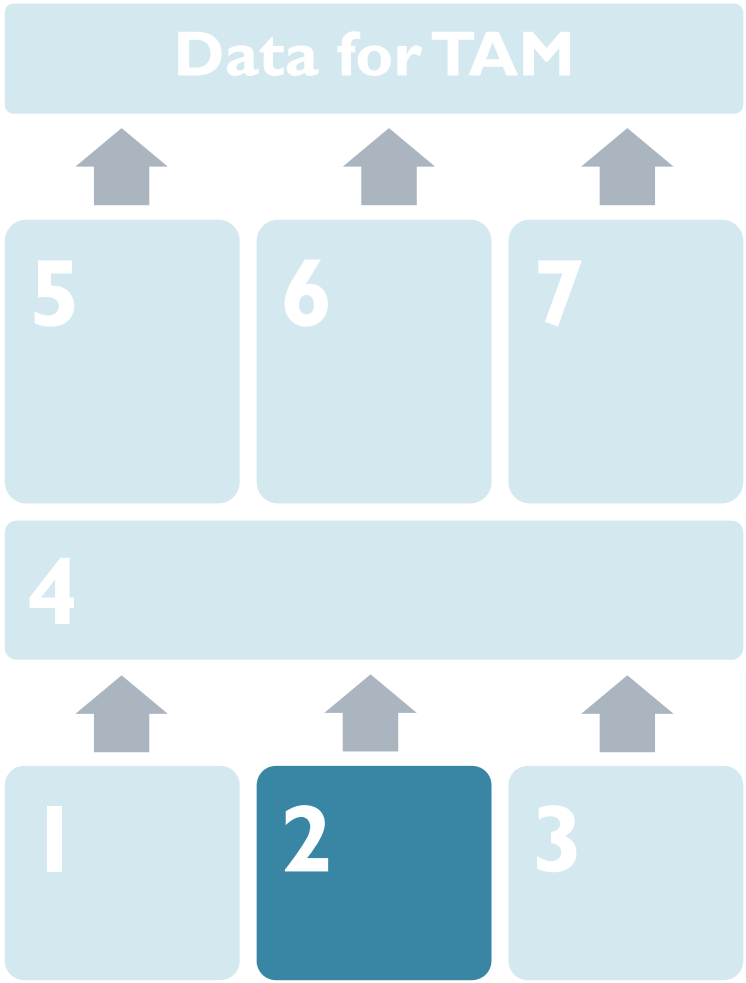
Strategies for Success

- Education: awareness and support for GIS initiatives
- GIS Strategic Plan: involve multiple business units and stakeholders
- Plan long-term: define a multi-year approach to GIS investment
- Business case: document a business case for particular initiatives
- Pilots: demonstrate project benefits
- Build bridges: agency collaboration

The Seven Ingredients for Success

Ingredient 2: GIS tools and expertise

- Staff within units responsible for specific assets and staff with cross-asset program development responsibilities need access to GIS tools and data
- Support resources including training, assistance with software configuration, and data access
- Open communication



The Seven Ingredients for Success

Ingredient 2: GIS tools and expertise

Common Challenges

- Lack of GIS skills within business units responsible for assets
- Insufficient communication between central GIS units and the user community
- Lack of formal GIS training
- No centralized data repository
- Lack of tools for downloading and exporting data in usable formats

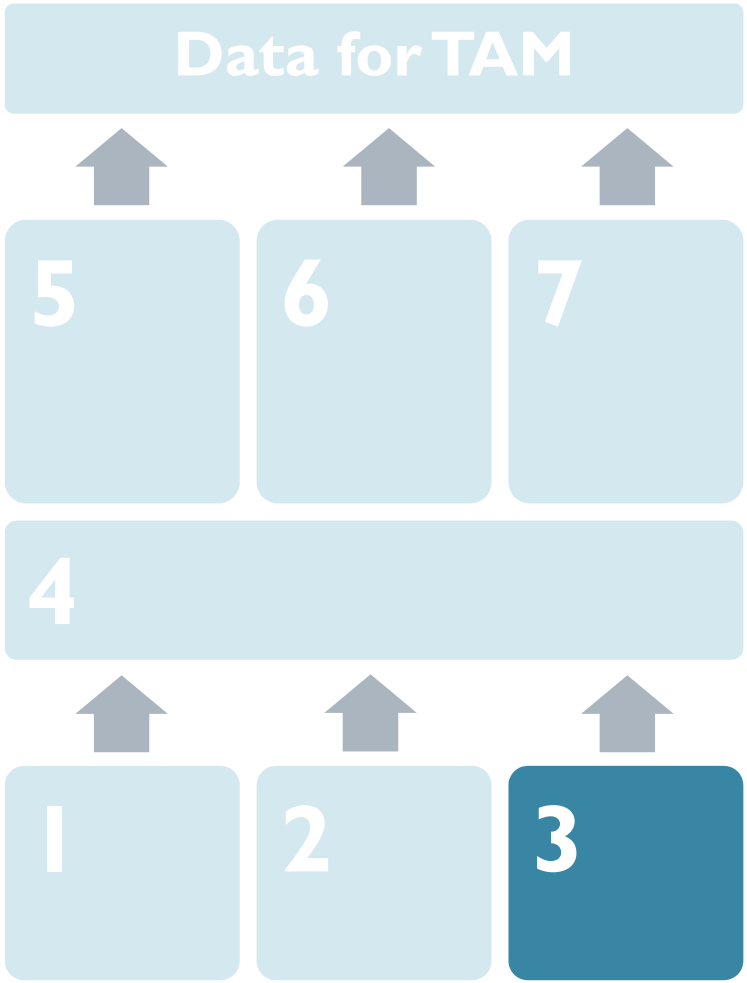
Strategies for Success

- Provide tools for casual users: tailor applications to multiple user groups
- Central data catalog: centralize data, standard metadata
- User group: establish GIS User Group for information sharing and brainstorming
- Integrate experts: central GIS staff embedded within business units
- Hiring and orientation: include GIS in employee orientation

The Seven Ingredients for Success

Ingredient 3: Well-defined and proactive data stewardship

- Data is an asset
  - How data should be used
  - Who should use the data
  - Quality expectations
  - Data storage
  - Timeline and process for updating data
  - Data integration
  - Person(s) responsible for data management



The Seven Ingredients for Success

Ingredient 3: Well-defined and proactive data stewardship

Common Challenges

- Ambiguity in data ownership
- Data sets dispersed throughout the agency, duplicative data
- Data loss due to hardware or employee turnover
- Outdated data sets
- Lack of resources to perform QA
- Data sets stored in varying formats
- Lack of consistency in coding fields for linkage across data sets

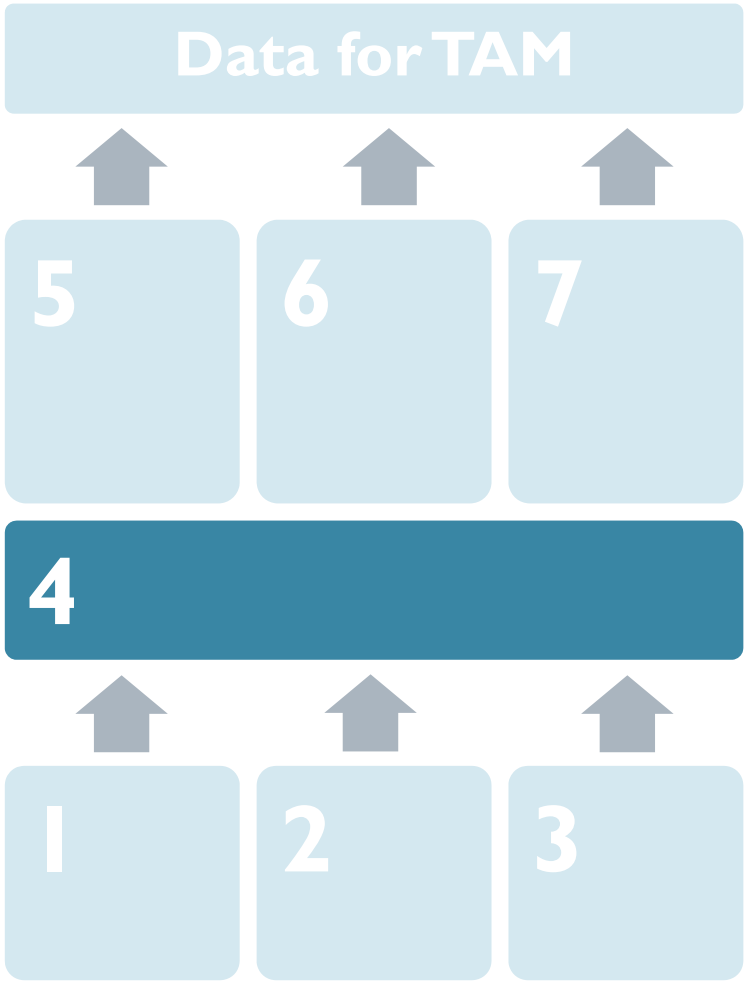
Strategies for Success

- Data Business Plan: identify data needed by functional areas with a coordinated plan for data collecting, updating, and managing
- Data management roles and responsibilities: define roles
- Data management standard practices: standardizing naming conventions, storage, metadata, etc.
- Geospatial data catalog: catalog to include definitions, metadata, etc.

The Seven Ingredients for Success

Ingredient 4: Accurate and complete foundational geospatial data

- Accurate foundational geospatial data
  - Base map
  - Road centerlines
  - Linear referencing system (LRS)
- High quality basic road inventory data
  - Geometric characteristics
  - Administrative characteristics



The Seven Ingredients for Success

Ingredient 4: Accurate and complete foundational geospatial data

Common Challenges

- Lack of a single, authoritative, centrally managed LRS
- No consistent approach to updates
- Poor quality of foundation data
- Gaps in geospatial coverage of road inventory data
- Road inventory data kept separately from the geospatial data
- Lack of quality and consistency across core geospatial data sets

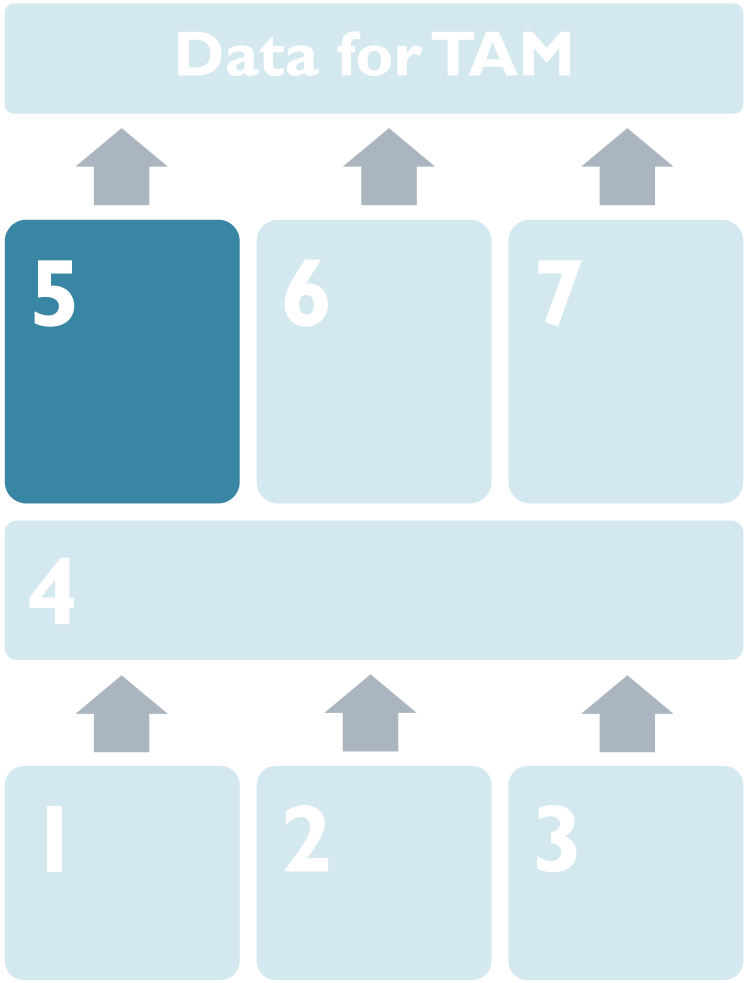
Strategies for Success

- Standardize core data: centrally managed LRS with multiple referencing methods
- Collaborate: within agency and external partners
- Investigate commercial data
- Assess and improve quality: data quality metrics, QA processes
- Incorporate technology: new technology to automate existing data collection processes

The Seven Ingredients for Success

Ingredient 5: Consistent data standards enabling spatial data integration

- Core data sets required for asset management with location referencing for spatial integration
  - Asset inventory
  - Asset condition
  - Traffic and crash data
  - Capital projects
  - Maintenance work records
- Tools for combining data



The Seven Ingredients for Success

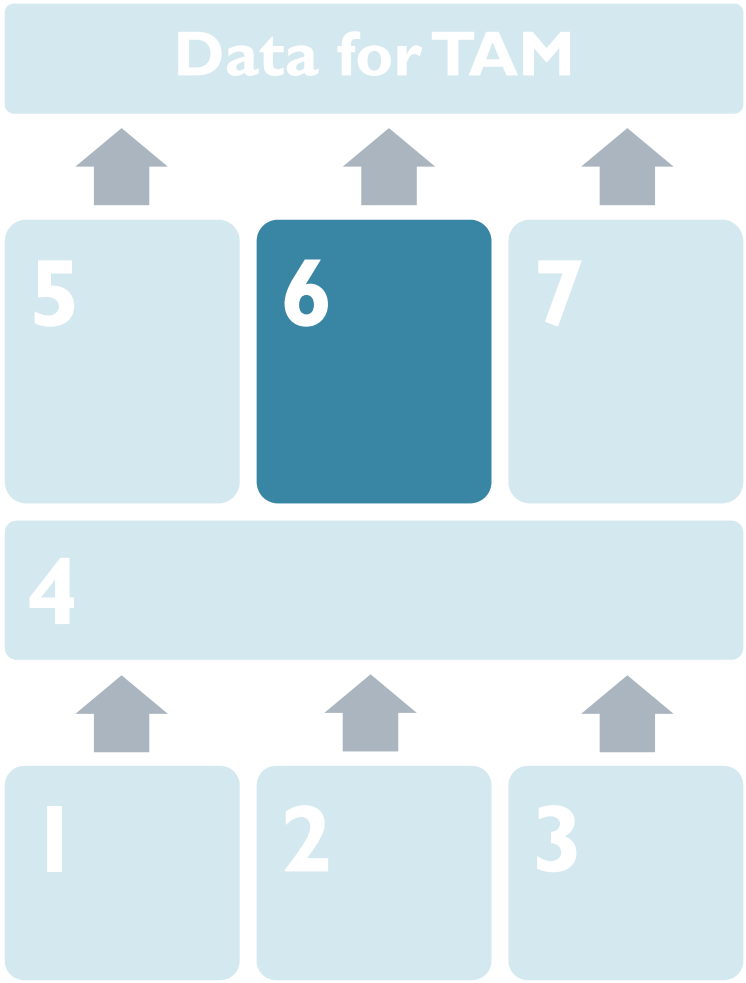
Ingredient 5: Consistent data standards enabling spatial data integration

Common Challenges	Strategies for Success
• Variations in location referencing methods across data sets • Existence of data sets with varying levels of accuracy • Lack of consistency in data collection process • Lack of automated tools for combining data sets • Lack of tools for performing QA • Inability to match GPS-located data with road network data	• Standardize: policies for new data collection consistent with LRS • Define data integration requirements: protocols for QA, timing for updates, precision • Define trend analysis requirements: use of historical data sets • Convert legacy data: attach consistent geospatial referencing to existing data sets • Provide tools

The Seven Ingredients for Success

Ingredient 6: Management systems linked with GIS

- Asset and maintenance management systems (AMS/MMS) that maintain information about proposed and programmed projects, integrated with a geospatial component



The Seven Ingredients for Success

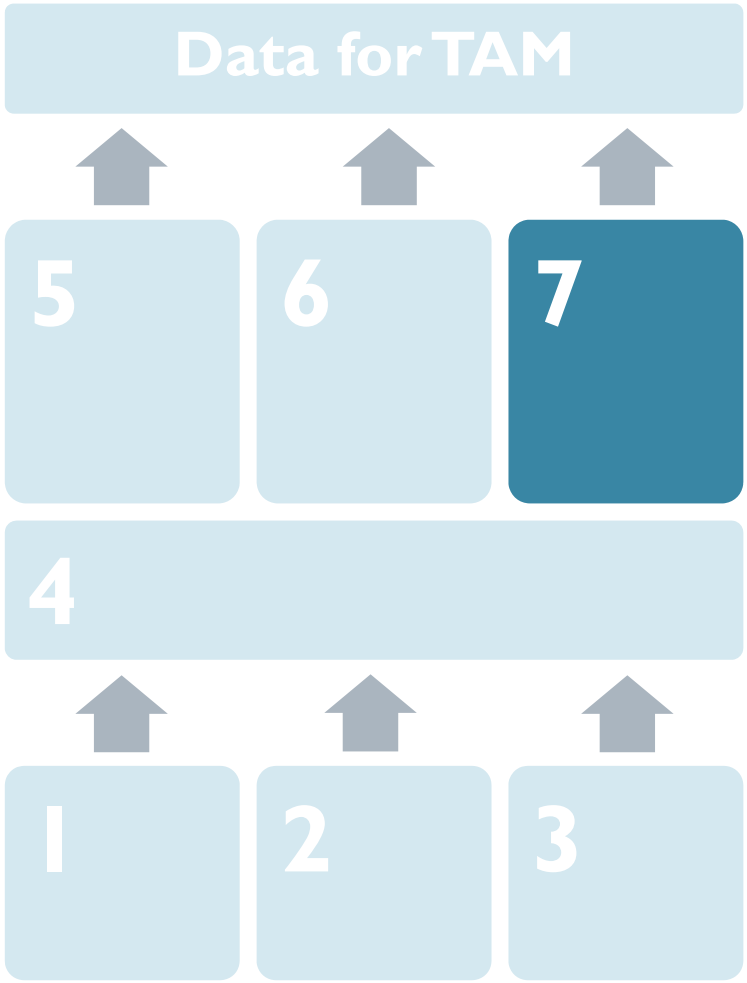
Ingredient 6: Management systems linked with GIS

Common Challenges	Strategies for Success
• AMS/MMS built with internal location referencing systems • Data can't be integrated due to inconsistencies • Location referencing data within AMS/MMS not synced automatically with master network • Project and maintenance activities not spatially located	• Target architecture: system architecture integrating GIS/LRS, AM, other management systems • Standard interfaces: manage spatial data in GIS/LRS and business data in AMS/MMS • Standardize practices for locating construction projects and maintenance activities • Simplify: consolidate software packages or use single vendor

The Seven Ingredients for Success

Ingredient 7: Coordinated data collection across the agency

- Coordinated agency-wide approach to data collection
- Identify opportunities to collect information on multiple assets at once and/or update inventory and condition data based on work accomplished across assets



The Seven Ingredients for Success

Ingredient 7: Coordinated data collection across the agency

Common Challenges	Strategies for Success
• Resistance from business units to change data collection processes • Variations in data collection requirements, e.g. frequency, accuracy, precision • Lack of a "one size fits all" data collection solutions • Difficult to coordinate timing • Cost associated with new data collection software/hardware	• Data business plan: develop plan to review cost, efficiency, and scope of data collection efforts • Standardize: consistent training and approach, link to existing inventory • Data collection review process • Consolidate: build on a single existing data collection program • Outsource: consider outsourcing software development or QA • Cloud storage

Exercise 9: What are the toughest challenges?

1. Leadership
2. Tools and Expertise
3. Data Management and Stewardship
4. Foundational Geospatial Data (centerlines, LRS)
5. Consistent Application of Standards for Spatial Data Integration
6. Asset Management System Integration with GIS
7. Coordinated Data Collection Programs