

# GIS at JLAB

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# Jefferson Lab has a Large and Complex Infrastructure

## ➤ CEBAF ( *24/7 electron utility* )

- \* 7 km of beamline
- \* 2000+ magnets & power supplies
- \* 338 5kW klystrons
- \* 42 Cryomodules each with 8 RF cavities
- \* 400,000L Low Conductivity Water system
- \* A 2K helium refrigeration plant
- \* 65,000 I/O Control Points
- \* 250,000 EPICS records, 140 IOCs, 80 Unix hosts

# So does Salt Lake City, Utah...

- **Water Utility District**
  - \* **29 pump stations with 104 pumps**
  - \* **1,400 miles of pipeline**
  - \* **15,000 valves**
  - \* **8500 Hydrants**
  - \* **48,000 wastewater connections**
  - \* **181,000 customers**

## Or Sacramento, California...

- **Municipal Electrical Utility District**
  - \* **900 square miles service area**
  - \* **553,337 customers**
  - \* **10 Transmission bulk substations**
  - \* **500 circuit miles of Transmission lines**
  - \* **9,885 circuit miles of Distribution lines**

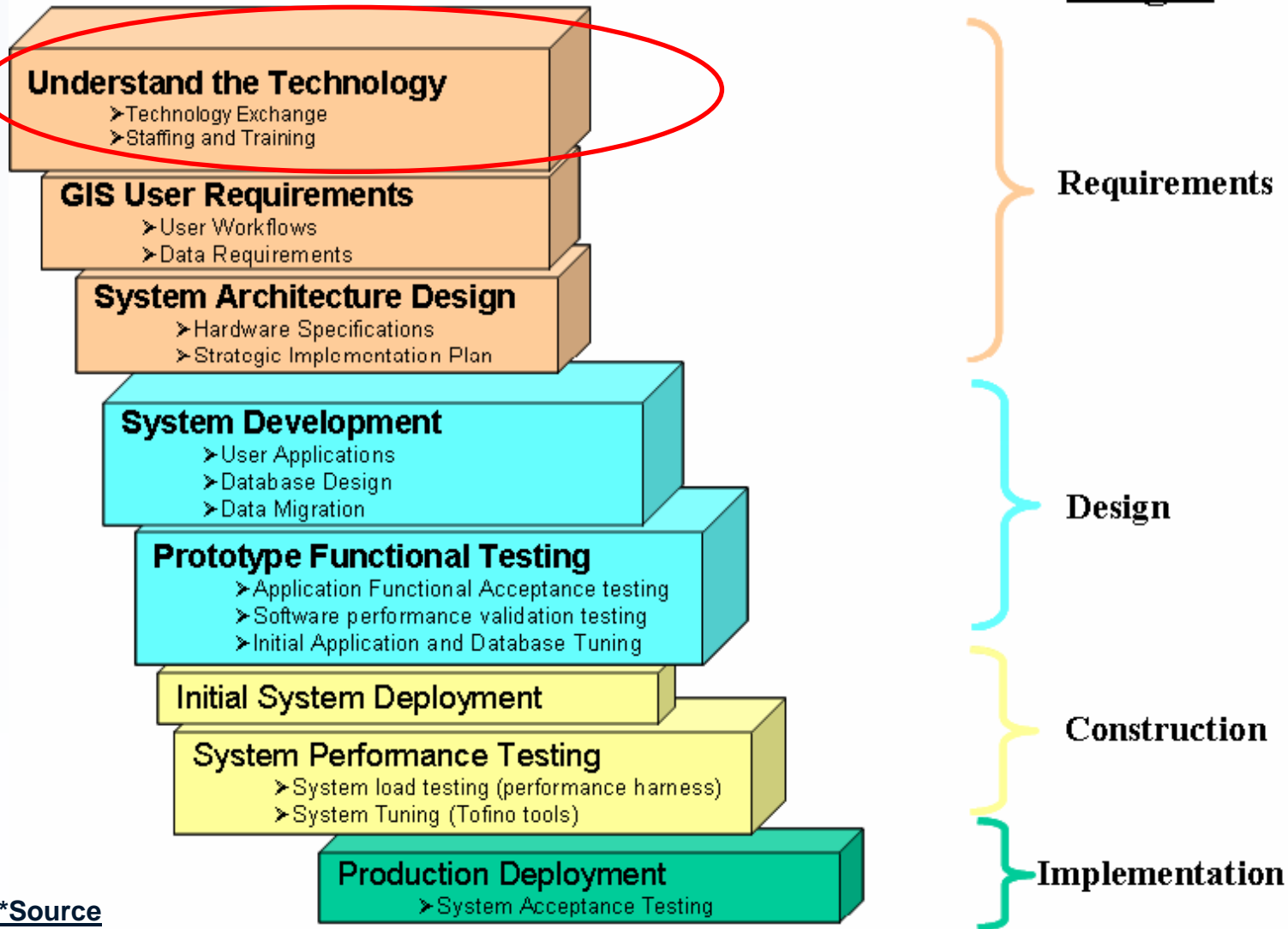
# The Premise

**Most Utility Companies use Geographic Information Systems (GIS) to operate and manage their large and complex infrastructure networks.**

*According to American Waterworks Association  
90% of water agencies now use GIS at least  
partially in their daily operation*

# Tasks

# Stages



\*Source

D. Peters. *System Design Strategies*.  
Environmental Systems Research Institute, Inc.

# What is GIS?

*A GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system.*

**\*Source**

USGS Geographic Information Systems Poster

[http://erg.usgs.gov/isb/pubs/gis\\_poster/](http://erg.usgs.gov/isb/pubs/gis_poster/)



# GIS Software (ArcGIS)

## ➤ Data Management Tools

- \* (Geo)Database
- \* Data Files (CAD, Raster, XLS, etc.)

## ➤ UI Tools

- \* View/Query
- \* Add/Edit data

## ➤ Extras

- \* SDK
- \* Tracking Server/Analyst
- \* Schematics



# Commercial GIS vendors

<b>ESRI</b>	<b>Intergraph</b>	<b>AutoDesk</b>	<b>MapInfo</b>
<b>34%</b>	<b>13%</b>	<b>7%</b>	<b>6%</b>
<b>Government, Utilities, Earth Science</b>	<b>Government, Transport, Utilities</b>	<b>Drafting, Architecture</b>	<b>Business</b>

**\*Source**

GISmonitor, November 7, 2002,  
[http://www.gismonitor.com/articles/comment/110702\\_Daratech.php](http://www.gismonitor.com/articles/comment/110702_Daratech.php)

# Open Source

## GRASS

**U.S. Army Corp of Engineers,  
now Sourceforge.**

**CLI w/Some TK GUI**

**Good support for PostgreSQL.  
Oracle still a work in progress**

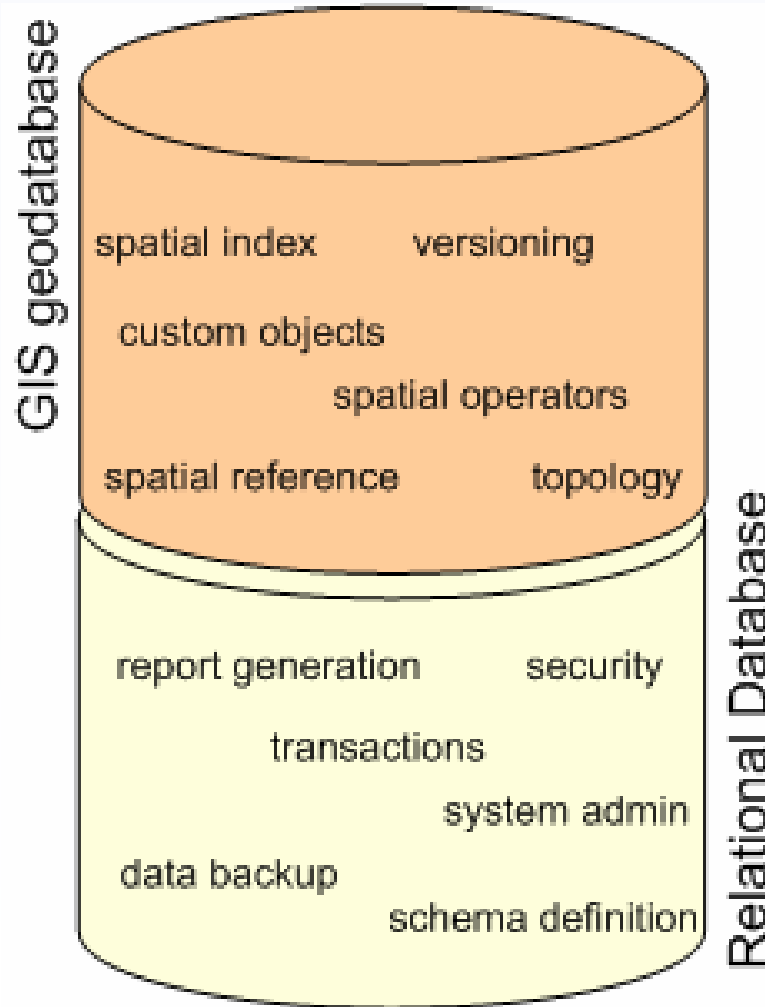
## MapServer

**University of Minnesota.**

**Environment for building  
spatially-enabled internet  
applications.**

**Excels at rendering spatial data  
(maps, images, and vector) for  
the web.**

# Geodatabase Extends RDBMS



**\*Source**

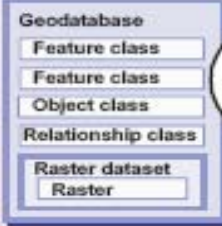
M. Zeiler, "Modeling our World"  
ESRI Press, Redlands, CA 1999

# Accessing geodatabases

Developers can access a geodatabase through the geodatabase data access objects in ArcInfo, through APIs that expose simple features, or by the internal tables.

through the geodatabase data access objects in ArcInfo and ArcSDE

## Geodatabase

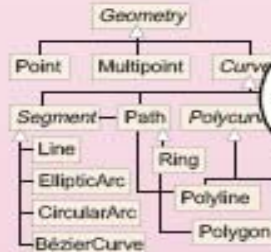


ArcInfo developer

**Via ArcObjects (Microsoft COM)**

Available in the Unix SDK via MainWin

through ArcSDE API compliant with OGC simple features

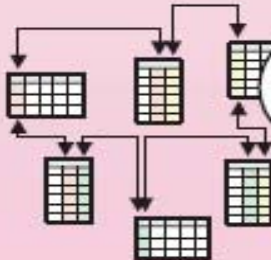


Spatial application developer

**As Simple Features (ArcSDE)**

Java & C APIs

through SQL interface in relational databases



Database developer

**Via SQL**

\*Provided by RDBMS vendor

Personal geodatabase

ArcSDE

relational databases



**\*Source**

M. Zeiler, "Modeling our World." 199pp., Environmental Systems Research Institute, Redlands, CA, 1999.

# Geodatabase Versioning

- **Conceptually similar to CVS**
  - \* **Version is named state of geodatabase**
  - \* **Multiple versions can coexist**
  - \* **A user can connect to any version**
  - \* **Differences between versions can be merged/reconciled**

# Versioning Benefits

- Create named versions at useful save points such as completion of an experiment, or prior to or following a maintenance period.
- Tables containing CAD-derived objects, software configuration, Optics all versioned consistently.

# Spatial Indexes & Operators

- **Allow efficient queries based on geometric relationships such as proximity, adjacency, and overlay.**
- **Select Objects that:**
  - \* **intersect**
  - \* **are within a distance of**
  - \* **contain**
  - \* **are contained by**
  - \* **share a line Segment with**
  - \* **crossed by outline of**
  - \* **have their center in**

# User Interfaces

- **Data Source Management (ArcCatalog)**
  - \* Usable by non-programmers
  - \* Wizard-like toolboxes Import/Export/Convert etc.
  
- **Graphical Display (ArcMap)**
  - \* View/Display Data Layers
  - \* Search/Query Data
  - \* Add/Edit Data



ArcCatalog - ArcInfo - Y:\CEBAF.mdb\BeamLine\Optim\_Element\_Locations

File Edit View Go Tools Window Help

Conversion Tools

Catalog

- Y:\
  - CAD
    - Buildings and Site
    - Songsheets
  - Maps
  - Misc Data
    - Layers and Shapefiles
    - optim
    - Photos
    - Text Files
  - Acc Bldgs.png
  - Physics Bldgs.png
  - XYhallb\_2\_xyz.shp
  - XYhallc\_2\_xyz.shp
  - CEBAF.mdb
    - BeamLine
      - Alignment\_Magnet\_Centers
      - Girder\_Elements
      - Girder\_Elements\_FeatureToPol
      - Girder\_Zones
      - Optim\_Element\_Locations
    - Controls
    - Facility
      - ELEMENT\_ALIASES
      - ELEMENT\_MULTIPOLES
      - ELEMENT\_ORIENTATIONS
      - ELEMENT\_POLE\_FACES
      - ELEMENT\_POSITIONS
      - ELEMENT\_RF
      - ELEMENTS
      - Optim\_Element\_Types
      - SECTOR\_ELEMENTS
      - SECTORS
      - Songsheets
    - CEBAF.mxd
    - Database Connections
      - Add OLE DB Connection
      - Add Spatial Database Connection
      - Oracle\_Devldb01\_AML.odc
    - GIS Servers

- ArcToolbox
- Analysis Tools
- Cartography Tools
- Conversion Tools
  - From Raster
  - To CAD
  - To Coverage
  - To dBASE
  - To Geodatabase
  - To Raster
  - To Shapefile
- Data Management Tools
  - Database
  - Disconnected Editing
  - Domains
  - Feature class
  - Features
  - Fields
    - Add Field
    - Assign Default To Field
    - Calculate Field
    - Delete Field
- General
- Generalization
- Indexes
- Joins
- Layers and Table Views
- Projections and Transformations
- Raster
- Relationship Classes
- Subtypes
- Table
- Topology
- Versions
- Workspace
- Geocoding Tools
- Linear Referencing Tools
- Spatial Statistics Tools

Contents Preview Metadata

Feature Class Properties

General Fields Indexes Subtypes Relationships

Field Name	Data Type
Shape	Geometry
NAME	Text
X	Double
Y	Double
Z	Double
TYPE	Text
OPTIM_FILE	Text
SubType Code	Short Integer

Click any field to see its properties.

Field Properties

Alias	OBJECTID
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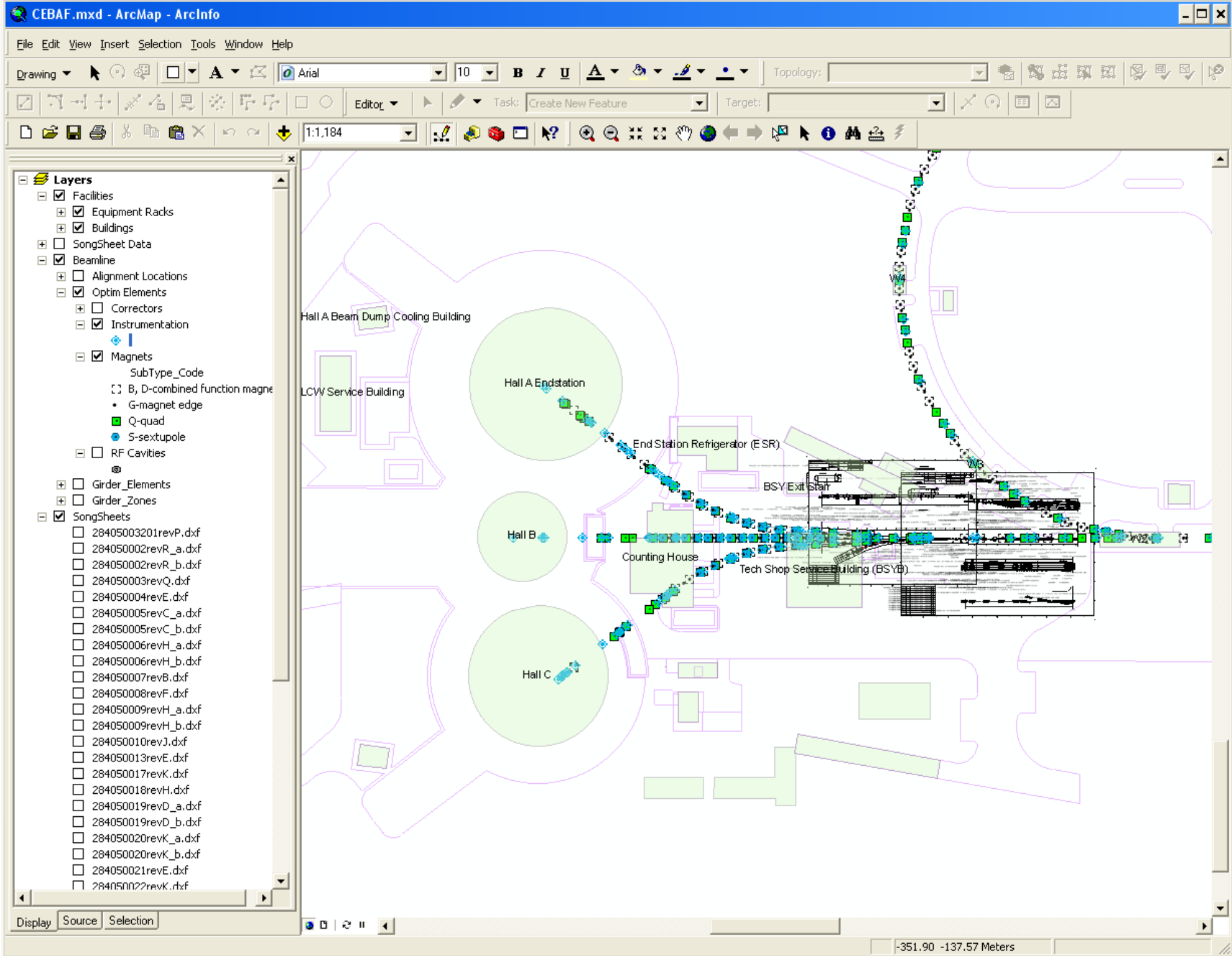
Import...

To add a new field, type the name into an empty row in the Field Name column, click in the Data Type column to choose the data type, then edit the Field Properties.

OK Cancel Apply

Preview: Geography

Displays the properties of the selected item



# Attribute or Spatial Query

**Select By Attributes** ? x

Layer: RF Cavities  
 Only show selectable layers in this list

Method: Add to current selection

[X]  
[Y]  
[Z]  
[TYPE]  
[OPTIM\_FILE]  
[SubType\_Code]

= < > Like  
> > = And  
< < = Or  
? \* ( ) Not  
Is Get Unique Values Go To:

SELECT \* FROM BeamLine.Optim\_Element\_Locations WHERE:  
[OPTIM\_FILE] = 'arc1p.opt'

Clear Verify Help Load... Save...  
OK Apply Close

**Select By Location** ? x

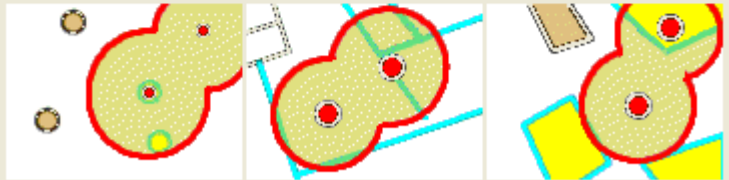
Lets you select features from one or more layers based on where they are located in relation to the features in another layer.

I want to:  
select features from  
the following layer(s):  
 Correctors  
 Instrumentation  
 Magnets

Only show selectable layers in this list  
that:  
are within a distance of  
the features in this layer:  
RF Cavities

Use selected features (0 features selected)  
 Apply a buffer to the features in RF Cavities  
of: 1.000000 Meters

Preview  
The red features represent the features in RF Cavities.  
The highlighted cyan features are selected because they are within a distance of the red features.



Points Lines Polygons

Apply Close

# Data Editing w/ArcMap

The screenshot shows the ArcMap interface with the following components:

- Layers Panel:** Lists various layers including Facilities, Equipment Racks, Buildings, SongSheet Data, Beamline, Alignment Locations (with Magnet Centers selected), Optim Elements, Correctors, and Instrumentation.
- Map View:** Displays a technical drawing of a magnet center. A purple arc is drawn around a central point, with a dimension line indicating a radius of 3438.80. Below the map, a horizontal line shows a series of magnet center symbols with red labels: QC2S05, QC2S05, QC2S05, QC2S04, and QC2S05. Vertical dimension lines below this line indicate distances of 3430.00 and 3420.00.
- Find Window:** Opened to the 'Features' tab, showing search results for 'QC2S05' in the 'Magnet Centers' layer. The search criteria are set to 'All fields' and 'OBJECTID'. A table below shows one object found.
- Attributes Window:** Opened for the selected feature, showing the following properties:

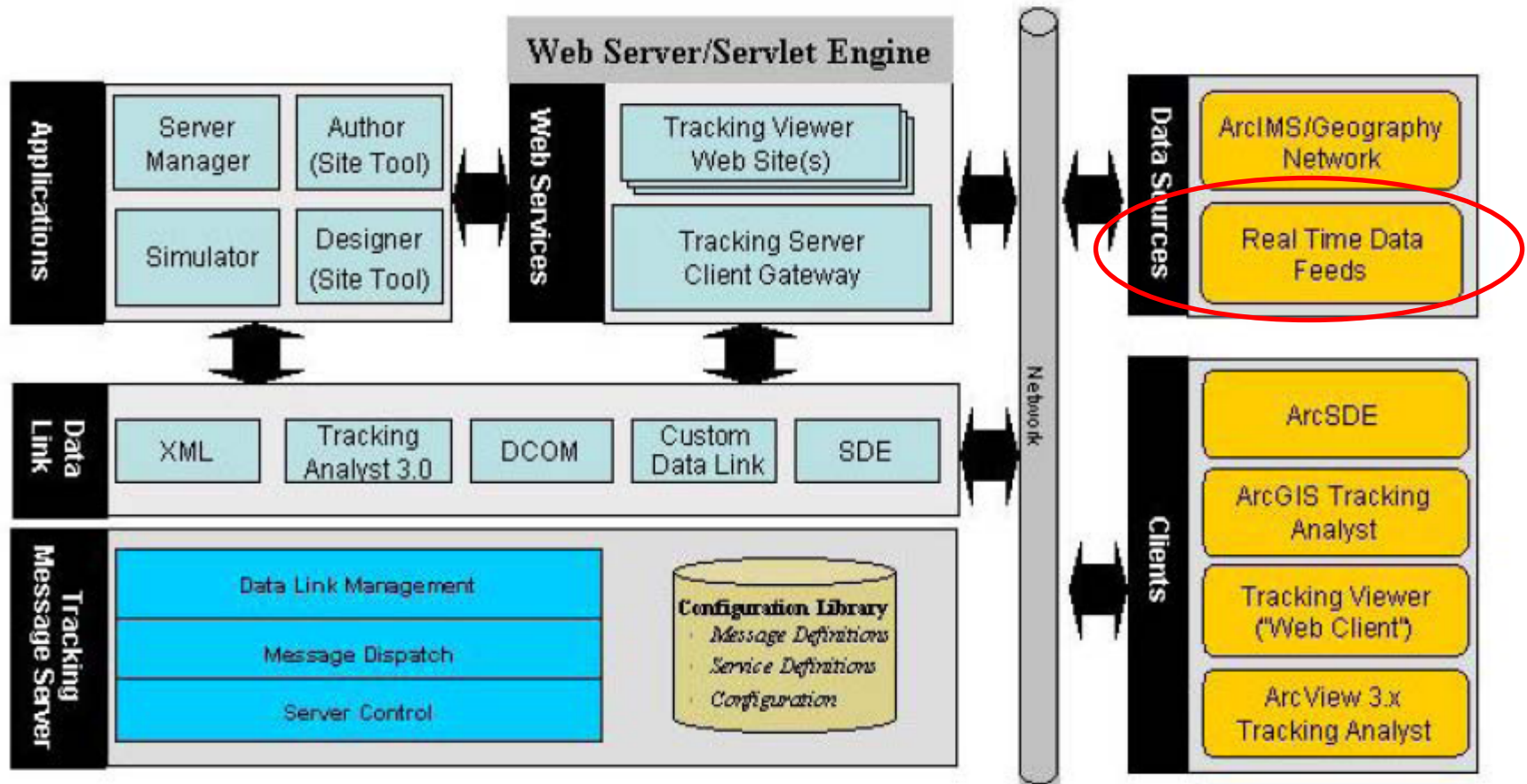
Property	Value
OBJECTID	247
MAGNAME	QC2S05
X	-80.6
Y	102
Z	-117.414
Tilt	80
Eff_Length	0

The status bar at the bottom shows the current coordinates: -115.26 -79.80 Meters.

# Tracking Server

## Architecture

Tracking Server uses an extensible architecture that allows it to receive data from new sources and to transmit that data to new clients such as a custom-built ArcObjects™ client.



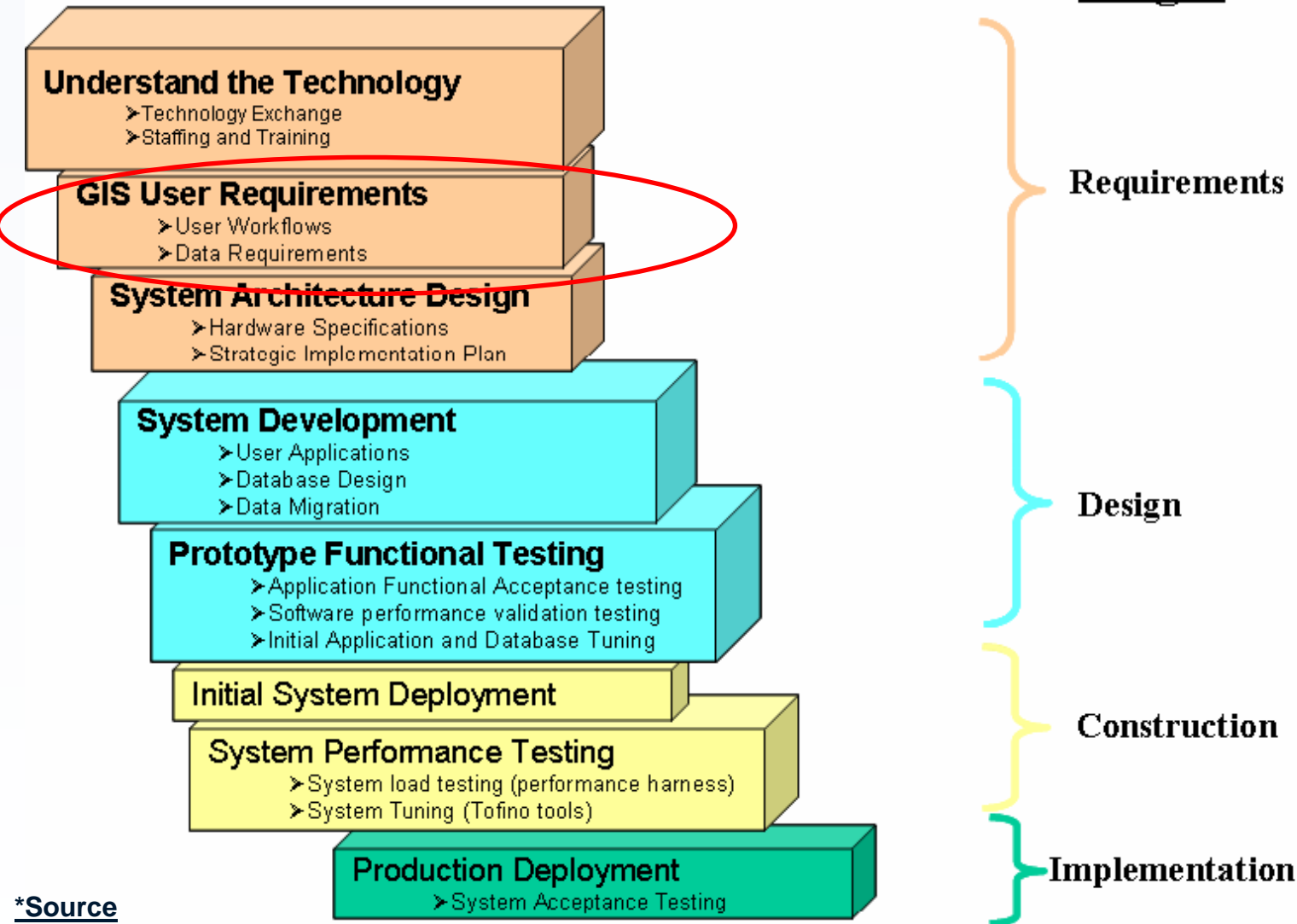
<http://www.esri.com/trackingserver>





# Tasks

# Stages



\*Source

D. Peters. *System Design Strategies*.  
Environmental Systems Research Institute, Inc.

# Potential Uses/Stakeholders

- Inventory (iocs, camac crates, power supplies, etc.)
- Configuring online model server
- Hazardous materials tracking
- Radcon tracking/mapping
- Environmental Regulatory Compliance
- Fault analysis
- Spatial selection & display of PVs and alarms





# Control system questions for a GIS to answer

- Where does the other end of this cable terminate?
- What components are inline with this non-functioning device?
- When was hardware added, changed, or removed...?
- Which module type in this system has the worst reliability history?
- How many devices of a particular model number are installed?
- Where are all the devices of a particular model number installed?
- What application software will be affected if this device is removed?
- What equipment will be affected when this breaker is locked-out?

# Data Requirements – Spatial

- Buildings
- Rooms
- Racks
- Breaker boxes
- Power supplies
- Cable-runs
- Beamline elements

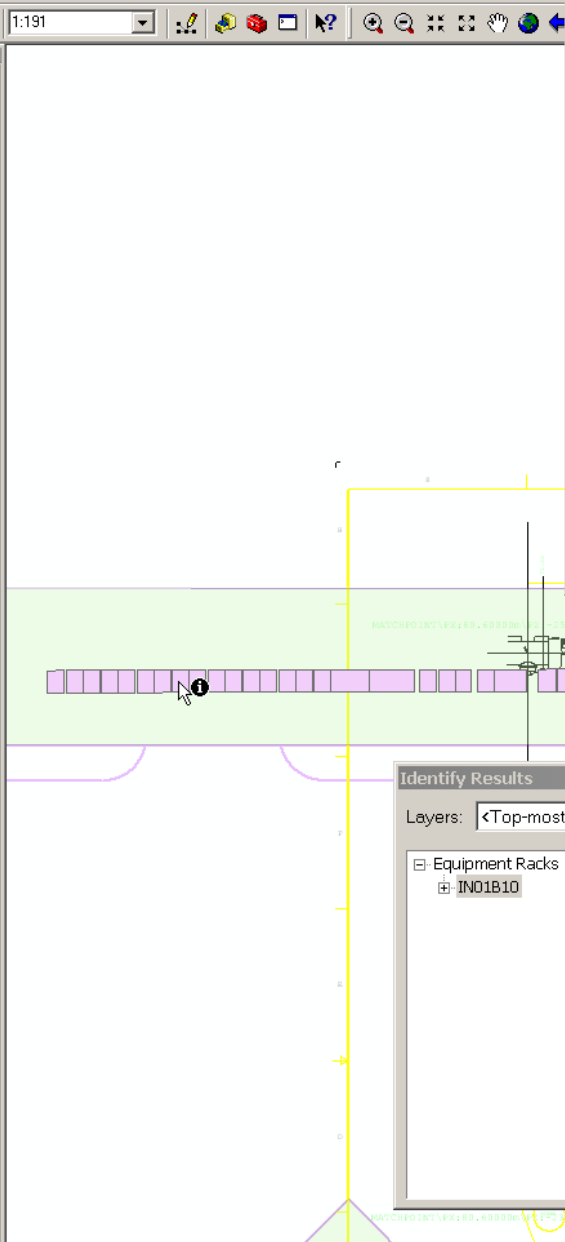
# Data Requirements - Attributes

- Name, Serial Number
- Hardware Model, Type
- Associated PV names, software applications, device support modules, etc.
- Power, Network, Other connections
- Subcomponent relationships

# Data Gathering Challenges

- Sheer volume/scale is daunting.
- Much hardware never before barcoded/tracked.
- Much spatial information not in electronic format (hand-drafted service building floorplans ca. 1987-1990).
- More difficult than anticipated to parse CAD files when we do have them.
- Different system owners currently hold subsets of data .
- Overlapping data sets require manual reconciliation.

- Layers
- Facilities
    - Equipment Racks
    - Buildings
  - SongSheet Data
  - Beamline
    - Alignment Locations
      - Optim Elements
      - Girder\_Elements
      - Girder\_Zones
    - SongSheets
      - 28405003201revP.dxf
      - 284050002revR\_a.dxf
      - 284050002revR\_b.dxf
      - 284050003revQ.dxf
      - 284050004revE.dxf
      - 284050005revC\_a.dxf
      - 284050005revC\_b.dxf
      - 284050006revH\_a.dxf
      - 284050006revH\_b.dxf
      - 284050007revB.dxf
      - 284050008revF.dxf
      - 284050009revH\_a.dxf
      - 284050009revH\_b.dxf
      - 284050010revJ.dxf
      - 284050013revE.dxf
      - 284050017revK.dxf
      - 284050018revH.dxf
      - 284050019revD\_a.dxf
      - 284050019revD\_b.dxf
      - 284050020revK\_a.dxf
      - 284050020revK\_b.dxf
      - 284050021revE.dxf
      - 284050022revK.dxf
      - 284050023revL\_a.dxf
      - 284050023revL\_b.dxf
      - 284050024revD.dxf
      - 284050025revD.dxf
      - 284050026revE.dxf
      - 284050027revD.dxf
      - 284050028revE.dxf
      - 284050029revE.dxf
      - 284050030revL\_a.dxf
      - 284050030revL\_b.dxf
      - 284050031revR.dxf
      - 284050033revK.dxf



## DC Power - Trim Card Tracker

Actions | Find | Logout

**Magnets/DC Power**

- Trim Racks
  - BSY Trim Racks
  - EA Trim Racks
  - Hall Trim Racks
  - Injector Trim Racks
    - MIN02B10
      - 01 DCPTC 0001
      - 02 DCPTC 0002
      - 03 DCPTC 0003
      - 06 DCPTC 0035
    - MIN02B11
    - MIN02B26
    - MIN04B10
  - NA Trim Racks

**Trim Card Subcomponents**  
Required fields are highlighted in blue.

**Name/Barcode:**

**Trim Card:**

**Default Assignee:**

**Supporting Users:**

**Owning Users:**

**Added by:**

**Date added:** 2006-10-10 13:37:48

**Item History**

[http://devInx13/CSUEApps/TrimCardCommander/tcc.php?command=add\\_trim\\_card&component\\_id=107575#](http://devInx13/CSUEApps/TrimCardCommander/tcc.php?command=add_trim_card&component_id=107575#)

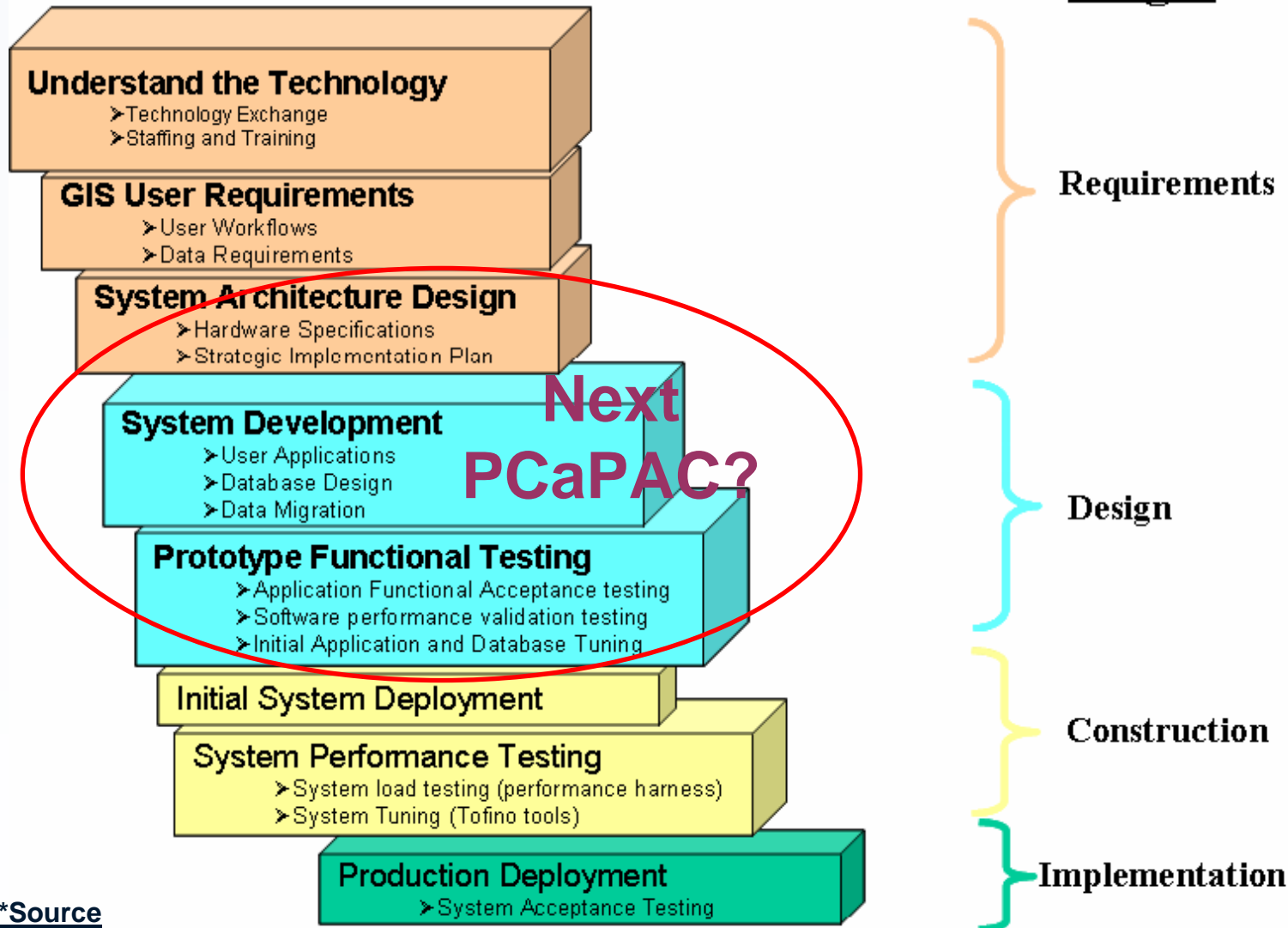
**Identify Results**

Layers:

Field	Value
OBJECTID	900
SHAPE	Polygon
Name	IN01B10
Bldg	INJSB
SHAPE_Length	2.649996
SHAPE_Area	0.429934

# Tasks

# Stages



\*Source

D. Peters. *System Design Strategies*.  
Environmental Systems Research Institute, Inc.

**“The application of GIS is limited only by the imagination of those who use it”.**

**Jack Dangermond, founder of ESRI**