X·SPATIAL

Utilities Management System – UMS

UMS links utility maps and building plans to GIS data, using structured standards to guarantee consistent classification. UMS offers **guaranteed lossless data integration** between CAD and GIS platforms, and integrates other formats (for example, office documents, scanned images and .pdf files) through document management links.

- Data entry forms for classifying and retrieving data are generated from the structured standards, ensuring complete consistency and improving ease of use
- Retrieving and editing complete information about any utility feature can start from a click on a map or a text-based attribute search
- Data maintainers can work on a CAD platform or in a GIS environment, depending on their tasks and responsibilities
- Data administrators can implement and adapt any structured set of spatial data standards

UMS builds on an Oracle spatial database, which offers the scalability, load balancing, and fail safe features necessary for a large centralised data repository. Integration with CAD and GIS systems is supported by close co-operation with x-Spatial development partners AutoDesk and ESRI.

Key components are described in more detail in the following sections:

- central repository
- adding data
- classifying data
- publishing data
- searching and retrieving data
- maintaining data
- annotations

Single centralised data repository

UMS is built on an Oracle database for storing spatial and attribute data. All spatial data is stored in Oracle spatial (MDSYS) open architecture format, allowing for easy future migration. File-based data in the following formats is supported:

- AutoDesk: DWG, DWF, DXF, SDF
- ESRI: SHP
- Aerial photographs: most raster formats including MrSID, ECW, TIFF

In addition to managing spatial and attribute data, UMS makes it possible to link information in any file format to a spatial feature: scanned drawings or .pdf documents, for example, or text/ word-processor files such as tenancy agreements. Our solution has a built-in document management functionality, which can easily be replaced with other systems such as Documentum.

Utilities Management System (UMS)

Oracle provides an ideal foundation for a single centralised database, with scalability, load balancing, and fail-safe features. Oracle's security features make it easy to restrict access at feature-type level, using user privileges. Additionally, the database can be physically distributed across different servers to achieve ideal performance and reliability.

Figure 1 below is a simplified illustration of the centralised data repository and how the data is created and utilised by different users.
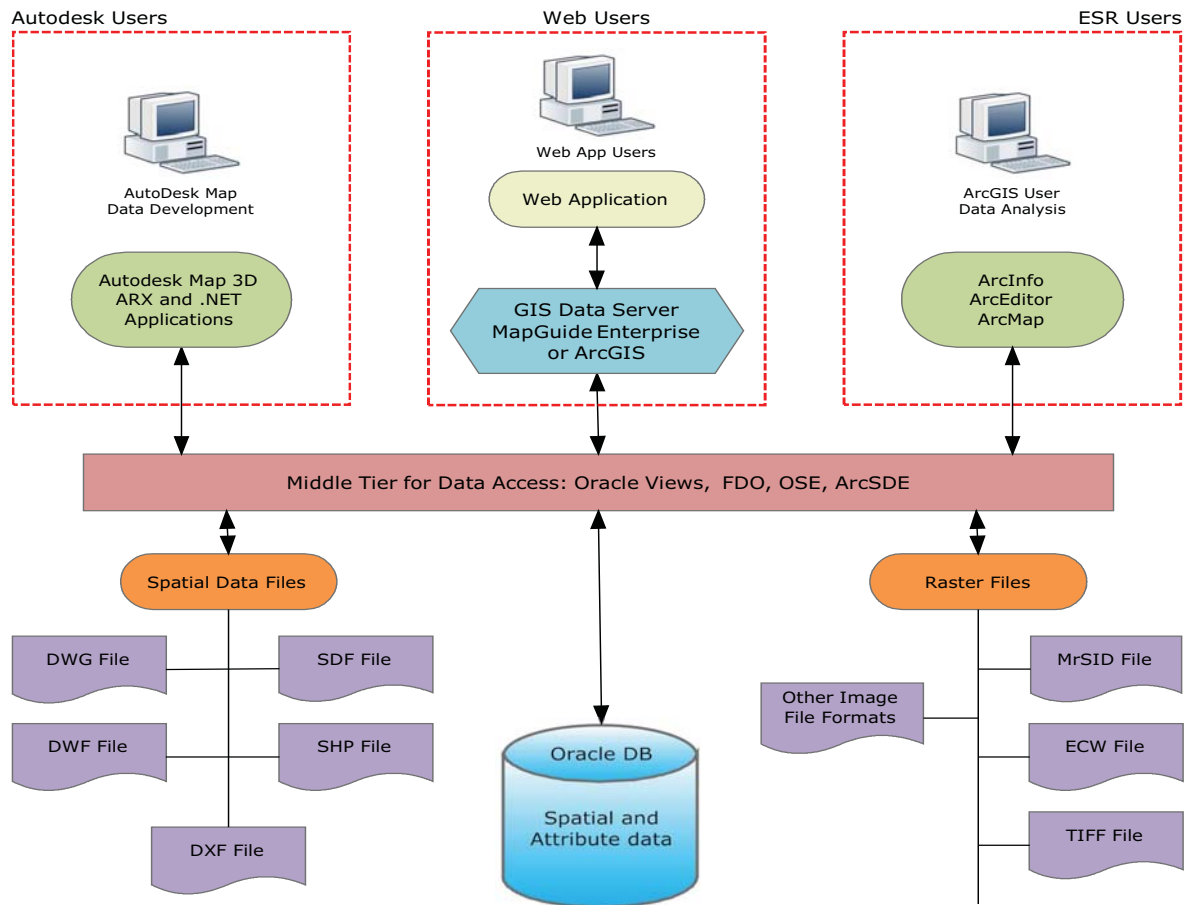

Figure 1. GIS Data Repository

The middle tier is built of Oracle views and triggers, plus industry-standard data access components that provide fully-compliant data to the CAD and GIS platform. Each platform reads its own data directly from the database, with no data conversion between CAD and GIS. Data remains completely accurate on the two platforms.

Data-access components currently include FDO and OSE for AutoCAD data and ArcSDE for ArcView data. Using "out of the box" data providers from AutoDesk ensures that AutoCAD upgrades have minimal impact on our solution.

Our solution architecture uses a dual Oracle database system, which allows separate environments for data creation (production server) and data delivery (publication server). UMS includes functionality for batch copy of data from the production environment to the publication server after quality assurance is completed.

Adding data

Our solution makes it possible to import CAD drawings or raster images such as an aerial photograph and classify features using the current spatial data standard. Integrating an aerial photograph and base map is a typical application for this feature.

Classifying data

Our system provides a flexible, hierarchical structure for classifying features by feature type, using structured standards designed for spatial data.

When a data maintainer uploads a CAD file or creates a new CAD object in UMS, the first step is to specify its entity type and discriminator. The new object is automatically given the relevant GIS attributes with default values, according to the spatial data standards, and placed on the correct CAD layer.

When a data maintainer creates a new GIS record in UMS, the record is automatically assigned CAD metadata (layer name and block name) using CAD attributes defined in the spatial data standards. Additionally, point features are assigned the correct CAD block.

Batch editing based on feature class makes bulk updates easy. Data maintainers can also copy one or more attributes from a selected entity and then paste them to all entities in the same feature class.

Integrated standards

Data administrators can implement any set of spatial data standards, then adapt the feature-type hierarchy and specify which types are relevant to their site. Administrators can also specify which standard attributes for a feature type are active, and extend the data dictionary with custom attributes.

❖ In the United States, most of our users have adopted the Spatial Data Standards for Facilities, Infrastructure and Environment (SDS/FIE) developed by the US Army Corps of Engineers.

Our integrated standards for spatial data cover both CAD and GIS:

- CAD layers, line style and colours
- GIS entities and attributes

UMS uses discriminators to map GIS feature types to standard CAD blocks and layers. In general each GIS feature type (for example water pipe) is mapped to one of a set of CAD layers, depending on GIS attributes (for example abandoned, main, fire, potable or non-potable).

Managing spatial data with CAD layers makes it possible to classify information visually, using layer properties such as colour and/or line style.

Data analysis

Any data entered through AutoCAD is immediately available to ArcGIS users (via ArcSDE connection) for spatial analysis and/or presentation. Because the database design includes a

middle tier for data access, spatial data can be created and viewed on either platform without any translation or conversion between the two.

The Mapplet application provides additional analysis and integration with other data sources built on ArcGIS map services.

Data distribution

Spatial data is delivered to end users (viewers) via our UMS web application. Data maintainers can use the same application to edit attribute values immediately, without needing AutoCAD or a fully-featured GIS application.

Linking to external data

GIS records can include links to scanned drawings and documents, and to "office" documents such as text files, word-processor files or spreadsheets. UMS includes simple document management functions, and can be integrated with industrial-strength document management platforms such as Documentum.

Quick access to all information

GIS records can be called up for a selected feature, by clicking on the feature on the map or by selecting a single feature from a list of features in the same class.

Features on the map can be located by browsing the map and selecting one or more features, or by searching for features using attribute value(s). Information for the features selected by the user or returned by the search are shown in tabular form, with a "Zoom to" option for viewing the feature on the map and a View details option for displaying more information about the feature and its attributes.

Two levels of search are available:

- quick search, using text or numbers to retrieve all related records for a selected type of information
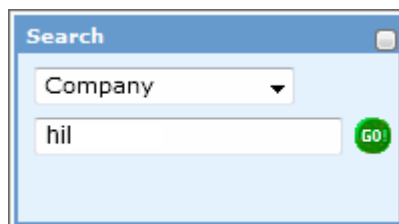
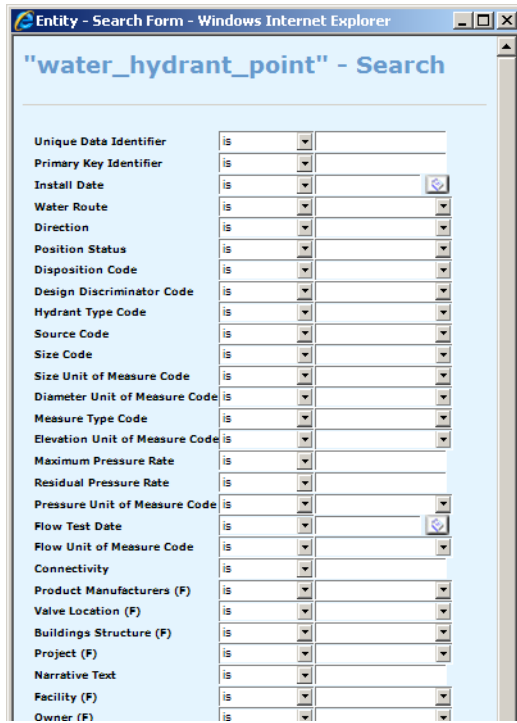- advanced search, specifying attributes and values to call up a list of all matching records

Figure 2. Dynamically-generated attribute query form

Utility data explorer

The utility data explorer lets the user drill down to feature-class level and display information on all features in that class in a spreadsheet format. The result of the search is shown in a tabular format which can be printed, sorted and filtered further.
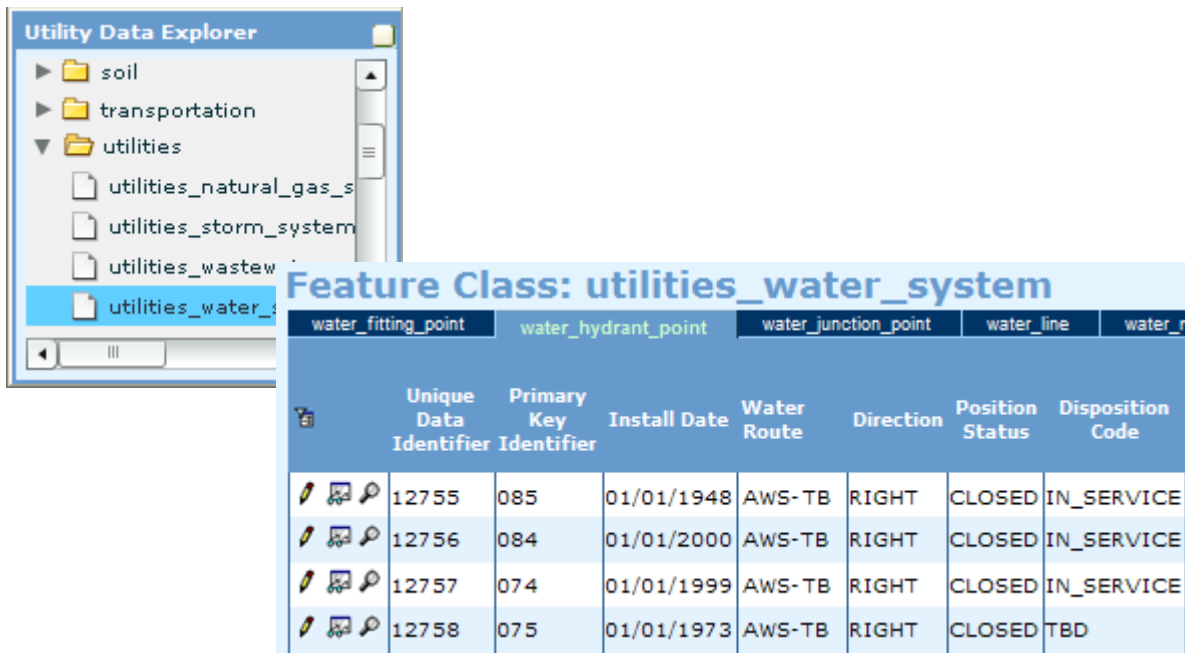

Figure 3. Utility data explorer and information for feature class

For each row in the spreadsheet, the "Zoom to" function highlights the selected feature on the map, and the View details option displays more information about the feature and its attributes. The Filter tool makes it possible to refine to list by specifying required values for one or more attributes. Users with the correct privileges can also edit atttribute values for the selected feature.

Feature classes, features, attributes and layers

UMS uses discriminators to map GIS feature types to standard CAD blocks and layers. In general each GIS feature type (for example water pipe) is mapped to one of a set of CAD layers, depending on GIS attributes (for example abandoned, main, fire, potable or non-potable).

Managing spatial data with CAD layers makes it possible to classify information visually, using layer properties such as colour and/or line style. The hierarchy of feature classes and the attributes for each feature type are defined by the data administrator, using either AutoCAD Map or the web-based UMS interface.

Data administrators can also control whether attributes are mandatory, optional or private: private attributes are visible only to people who have the right to edit them.

Attribute values for classified features are set using the dialogue box shown below.

With the UMS CAD Module, power users can create spatial features in AutoCAD Map and then assign a feature class and a default set of attributes.

Redlining – graphical annotations and text comments

Our solution provides enterprise-wide redlining capability, allowing users to create and maintain textual comments as well as symbols, lines and polygons. Redlines (markups) can be created and shared in separate layers by all users. The redline management tool shows the owner and the date of last change as well as an explanation.

Redline features are stored in a separate table in the Oracle spatial database. All redline features can be loaded into AutoCAD directly (no conversion needed) and classified if required using the UMS CAD module.

Figure 4. AutoCAD redlining for exclusion zones and incident locations

Data maintenance

By defining a geographical project area (polygon) on a map, administrators can specify which feature classes inside the project area can be updated and which data developer can carry out the updates. These project areas can also be used to make a snapshot of spatial data inside the area before the update starts, and these snapshots can then be built up into time series.

Project areas are normally used in conjunction with batch forms, with tabs for:

- boundary information – one or more polygons defining the spatial boundary of the area where changes are needed.
- layer information – one or more feature classes (and related CAD layers) defining which feature classes can be modified
- status information – workflow history and current status of the batch

Publishing and QA

The data maintenance tools make it simple to implement quality control on updates, by routing updated information to an administrator for approval before the information can be published. After a developer finishes a batch of updates, an administrator can review the batch and approve it for publication. Using a "publish updates" form, the administrator marks one or more approved batches for copying to the publication server.

Classifying new or existing information

Airport base map

Figure 5. Classified Base Map for Los Angeles International Airport (LAX)

This base map was created by displaying an aerial photograph (on its own layer) and overlaying CAD elements. Each CAD object, already positioned on the correct CAD layer, was then classified with the correct GIS attributes. Topographic data, digital elevation and contour lines can all be classified and stored in the spatial database.

Figure 6, "Feature Classification tree", shows part of the tree used to link CAD objects with GIS entities.
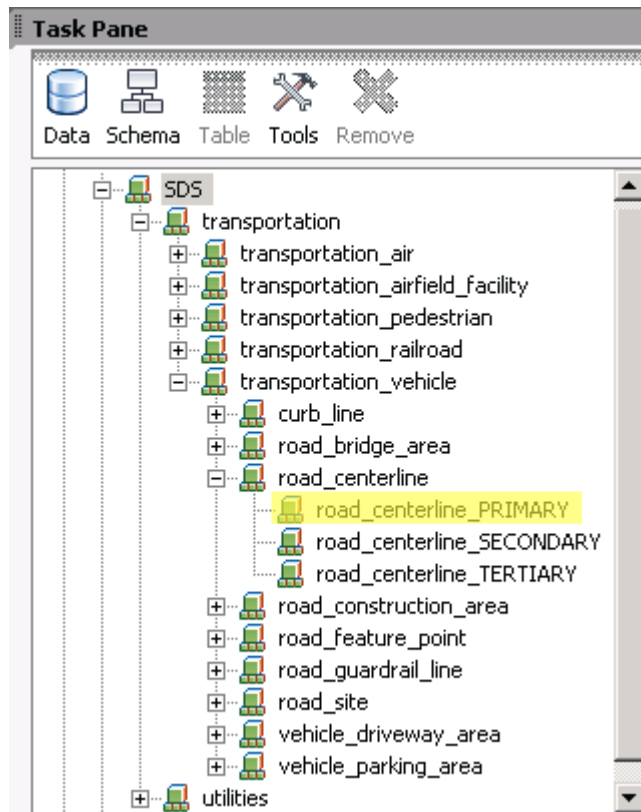

Figure 6. Feature Classification tree

Double-clicking on the required branch in the Classification tree in AutoCAD prompts for start, intermediate and end points (vertices) of the polyline. When the polyline is completed, the classification tool automatically

- places the polyline on the layer associated with this feature type
- associates the predefined GIS attributes with the newly created entity.

The single action of drawing a new polyline has created both a new CAD object on the correct layer and a new GIS record with the correct basic attributes.