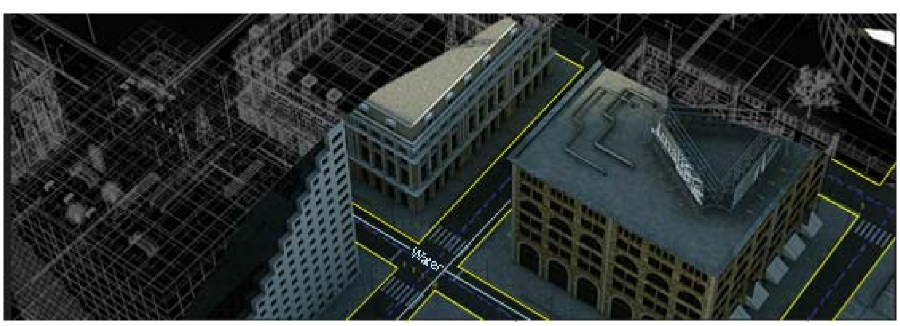
Autodesk U-Vis™ 360 Visual Data Integration

Increasing the value of visual data by combining inside, outside, and under into one.

CONTENTS

There's no shortage of useful graphical information—building designs; environmental maps; utility designs; public works map books; mechanical, electrical, and plumbing diagrams; facility and geographic information system (GIS) databases; and more. As more and more graphical data sets become available in digital form, organizations can see the value of combining these visual data sets and making the information available to a greater number of people. Similar to textual-based enterprise resource planning (ERP) systems, people are looking to filter and integrate their graphical data sets and then present the information in a single business application. They can use this knowledge to improve design, planning, management, and training functions. Organizations can find great value in seeing spatial relationships in a single comprehensive view and finding related attribute data quickly.

Yet, site designers, facility managers, mission planners, and others are challenged to make use of this information and struggle to combine multiple departmental and mission graphical data sets into a seamless visual environment. Site designers need to assess and present the overall effect of placing a building into an existing neighborhood. Facility managers use floor plans, spreadsheets, and sticky notes to manage space allocation, track assets, and manage moves. Then they are expected to provide easily comprehensible reports with up-to-the-minute status. Mission planners need to quickly compile maps, floor plans, terrain models, infrastructure data, and more and then deliver the data so that teams can plan and rehearse missions. Often, the result is a collage of pictures and textual reports, leaving the user to make the link between the various data sets.



The Vision**—**Smart data, filtered specifically for an individual's perspective.

The Autodesk® U-Vis™ 360 framework provides a powerful yet straightforward means of using multiple data sources—in particular, *smart data* sources selected through *task-*

oriented filtering—and delivering data to a *choice of interface* to present information in useful ways.

Autodesk technologies span the full range of graphic design applications: computer-aided design (CAD), geospatial, building information modeling (BIM), mechanical design, and document management plus 3D visualization, rendering, and animation. Autodesk offers unique capabilities by providing visual and attribute data integration through the U-Vis 360 solution framework.

Visual and Attribute Data Integration—The Vision

Ideas are quickly growing of what can be accomplished by combining various data sets. Many organizations are already combining 3D data sets to produce animations for improved design presentations. Now they are beginning to enrich the combined visual data by including the textual attributes to support analysis functions. For example, an analyst should be able to quickly query for and highlight all buildings in the downtown area that have applied for a building permit in the past eight months. The analyst should then be able to select any building to view the building design submitted with the permit application. They then query the design to identify the location of the natural gas main shutoff valve to confirm that the building in compliance with newly legislated regulations.

Another example is how an integrated view of an airport facility could be used to manage and coordinate a response to a security threat. An airport security officer could see the location of a breached access point highlighted on a map and then see the security camera viewsheds overlaid on the floor plans to quickly confirm which tapes to review. The officer may want to highlight the security badge reader locations to identify where a particular individual has entered in the past four hours. Another function would be to mark a defined area to be secured and then use the defined area to create a call list for specific airline officials. Finally, the officer could quickly provide floor plans to external organizations assisting with the response. At the command post the team could view a 3D representation of the area to determine the best ingress to the location.

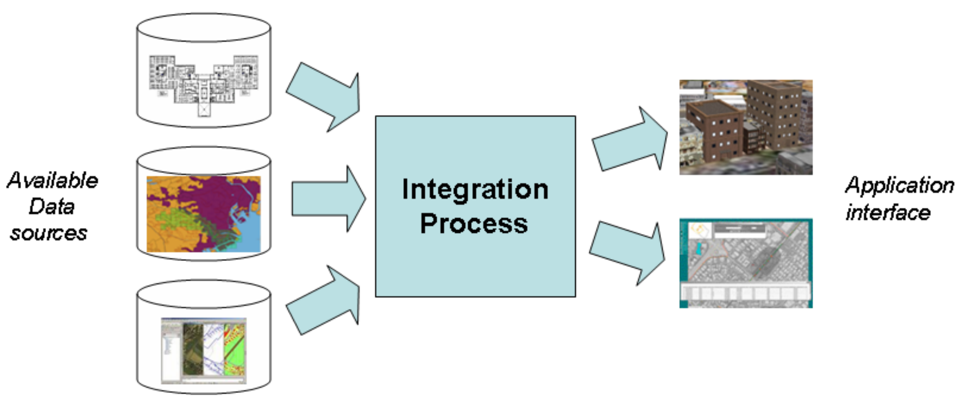


Figure 2—Typical High-Level Visual Integration Process

There are many examples of how visualizing textual data can improve the overall design, management, training, and operational functions for an organization. Of course, the details vary in terms of what data needs to be included, how it might best be integrated, and what interface and tools will work best.

Visual Data Integration—The Reality

Today, most organizations are limited to viewing a collage of visual data. This collage consists of a collection of drawings, blueprints, sketches, maps, and so forth, viewed through a multitude of applications and documents. Visual data is stored in a variety of formats and drawing scales, using a mixture of data standards. This situation is similar to what organizations faced when they began to implement ERP systems, integrating various financial, customer record, work management, and material management systems. The return on investment of ERP implementations has set a precedent for integrating visual data sets with textual databases. Also, experience with ERP systems has provided most of the methodologies to proceed with the next step in the evolution of data integration. Autodesk can help organizations meet the unique challenges of integrating visual data:

- **Visual data compatibility**—Visual data is usually available in multiple formats, managed by different groups with different business needs. Scales, projections, and data definitions can be inconsistent. Security or network limitations may make the data hard to access. Autodesk can work with hundreds of data formats and can provide tools to natively read many industry-leading formats.
- **Data security and ownership**—Coordinating multiple organizations that control the data is often a big challenge. People are cautious about sharing data because of security and liability issues. Digital visual data may be stored in databases or files. Autodesk can provide both tools and direction on processes to help agencies organize and manage their visual data sets while protecting security and ownership.
- **Richness of data**—Business functions often implement solutions that are designed to support a specific job function. The value of departmental data to the rest of the organization has to be communicated. Autodesk can provide direction and tools to increase the richness of visual data models. Other business functions can then use this added intelligence.

Creators of data often use tools that support only their requirements without considering how other parts of the organization can use the data. In addition, data standards are often not enforced. This makes it difficult to merge data even within a single department.

The next section focuses on these challenges, and evaluates the expectations and requirements to successfully integrate diverse data sources based on user needs.

Requirements for Successful Visual Data Integration

Several elements are required for successful data integration. These elements are similar to those of other textual database integration efforts, with the addition of the spatial relationship of the graphical data:

- **Data access rules**—Where is the data? How is it accessed? Is it current? Is it the right version? Are special permissions required to access the data?
- **Filtering and aggregation**—What data will be used and what can be ignored? What details are not needed? How are such details aggregated for effective use?
- **Source normalization**—How are disparate data sources reconciled so they can be used and visualized together?

Data Use Considerations

It is important to consider how data will be used in any given application. Here are the major categories to keep in mind when designing a data use approach:

Graphic Background

If data provides only visual context or background, then the interaction model is simple and detail and high-precision spatial position are less important.

Graphic Interaction

When users need to interact with graphics, more data is needed and spatial location precision becomes an issue. An example would be a "nearby" building. While entering the building is unnecessary, the user still has to move around it; the building's presence affects interaction.

Data Interaction

Consider an application where entering a building is part of the scenario. Not only the door's graphics, but the behavior—a data-driven characteristic—is important.

Data Drill-Down

Another form of graphic interaction might be to query it for underlying data. This is especially common in 2D mapping environments, where the user might query on a parcel to determine ownership.

The following sections take a more in-depth look at some of these issues.

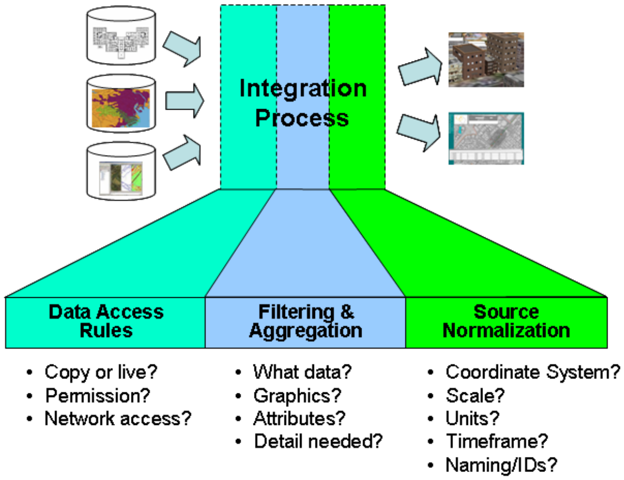


Figure 3—Details of the Integration Process

Data Access Rules

In *Mission Impossible,* agents appear to view real-time data. Alas, real-world data is only as good as the latest update, which depends on the organization that owns and maintains the data. Access depends on practical issues: access permissions, storage location, and network performance. Permission to access data is usually established in advance. One must also consider the performance of the system. Fast display refresh times or walk-throughs of visual data generally require using a local copy of the data. Making a copy of any record then introduces the problem of version management.

The integration process must define the *data access rules* for every data source:

- Which department/agency maintains the data?
- Where is data located on the network?
- What login and rights are needed to access the data?
- Will a copy be made, or will “live” data be accessed directly?
- If a copy is used, what synchronization and refresh rules apply?

Ideally, these rules are implemented in a flexible fashion rather than being hard coded for each data source. Such flexibility allows the application using the data to easily evolve over time.

Filtering and Aggregation

Filtering data with the end-task in mind is crucial. The easy approach is to take everything that is available. However, most detailed engineering drawings contain information that other departments in the organization do not need. For example, firefighters do not need the notes on architectural design drawings. These notes add clutter to the drawings and make it more difficult for firefighters to see the information that is relevant to them. This is where task-based filtering and aggregation are crucial.

When the source data has too much detail, rules can be established to filter the information and aggregate it to an appropriate level of detail. Consider that the California coastline can be drawn with as few as 10 line segments, or as many as one million, depending on the scale and application. Higher scales provide better detail but require managing and displaying much more information. With respect to integrating multiple data sets, filtering and aggregation can be broken into the following aspects:

- What is the intended use of the data? If not all of the data is required, should it be filtered out completely? If it is needed only on rare occurrences for reference, should there be a means to access it when it's needed?
- What is the level of detail within the source data, compared to the level needed in the application? If source data has too much detail, rules are established for aggregation.
- By what process should data be filtered and aggregated? This can be done once, and a copy maintained, or done on-the-fly if the data is changing (but with a potential resulting performance penalty).

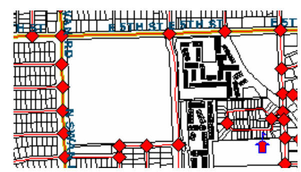
For visual data integration, the key elements to retain are those that will have a visual impact *at the scale that will be used for visualization*.

Document versioning introduces an additional filtering issue. Often multiple versions of the same information exist, representing historical information or design alternatives. It's important in the filtering process to recognize what version of the data is relevant to the design and scenario visualization project, and filter out the rest.

3D Gaming Interface

Source Normalization

Different organizations use tools, terminology, and standards that make sense for their needs but may be inconsistent from one to another. Combining data from multiple sources means that data will be provided in different formats, at different scales, and in different geographic projections. Some is 2D, and some 3D. Even more challenging, nomenclature and identification information vary from one source to another. Consider that the word *tank* could refer to a large water container, a gas storage vessel, or a vehicle with a large gun attached. To use the data together, it needs to be *normalized*—mapped to some consistent standard useful to the specific business application. Important factors include the geometry (2D or 3D, geographic reference, projection, units), the ways objects are identified, and the definitions of the objects themselves.



2D Map-Style Interface

There are two steps to normalization.

- **Target definition**—Everything needs to be defined *from the perspective of your application*. This includes questions of geometry, and most important the objects and elements that will exist in application environment.
- **Information mapping**—Once the target definition is in place, it is possible to implement the mapping that determines how the source information is normalized to match the target environment.

Key to Successful Integration

Key to success is to maintain a focus on the end business function to be supported. Autodesk uses a *task-based* approach to filtering and data integration, with a focus on clear business goals, simplicity, and implementation using state-of-the-art technology.

It is also important to note that visual data integration does not require that the application *reconcile* disparate data sources. The challenge is to choose the data that best meets the application requirements and determine how, within the application, that data will be compared and referenced.

Interface Alternatives

The *U-Vis 360 Solution Framework* can deliver data to a variety of formats and visualization applications. Of course, there are differences in *what* will be visualized, but from an interaction perspective it's most important to consider *how* things will be visualized for each specific application.

Autodesk recognizes that one size does not fit all. Therefore, the U-Vis 360 framework supports delivering the data to various web-based or client-based visualization platforms such as Autodesk MapGuide® Enterprise, Google Earth™, Microsoft® Virtual Earth, and even 3D gaming engines such as Quest 3D™. This paper considers two types of visualization interfaces: 2D map-like environments, and 3D game-like environments. The characteristics of each are very different:

3D Game-like Interfaces

The 3D environment enables users to simulate the interaction with design and scenario elements, making 3D environments ideal for showing plans and alternatives to decision makers, citizens, and interest groups, where the *look and feel* is the primary focus. 2D environments can be confusing for nontechnical personnel, who may find it difficult to create a mental 3D picture from a 2D drawing. The uniqueness of 3D visualization tools is that users can fly or walk through the scenario as they choose and are not restricted to predefined paths. 3D environments are also ideal for training and simulation, where the *experience* of being in the environment is essential to achieving the training goals. The typical 3D environment requires software on a client machine and usually is focused on data for a smaller, defined geographic area. Examples of 3D interface environments within the U-Vis framework include the Quest 3D (a game development environment), NavisWorks™, and Google Earth applications.

2D Map-like Interfaces

Architectural and engineering plans are commonly shown in 2D. Much of the original data may have been created using a 2D representation. 2D applications are often preferred by technical personnel who have the training to visualize the 3D scenario while looking at the 2D detail. 2D representations are effective when it's important for users to understand the spatial relationships over a large geographic area, for example, showing distances, boundaries, and environmental impact areas. These data sets are often created using geospatial tools such as AutoCAD® Map 3D or ESRI® ArcGIS® software. Also, a 2D representation is generally more compact in file and application sizes, allowing the picture to be viewed on lower-end computers. Examples of 2D U-Vis environments include websites built with Autodesk MapGuide Enterprise technology.

The Autodesk U-Vis 360 Framework

The Autodesk U-Vis 360 framework (U-Vis) provides the tools, technologies, and processes for organizations to leverage smart visual data, filtered using a task-specific approach, and then to visually interact with the data using the most appropriate interface. U-Vis combines products and methods to deliver data from a variety of data sources to a specific visualization environment using a streamlined, repeatable process.

This framework is a logical extension of the Autodesk product family. With ever-increasing interoperability between design products, growing use of 3D modeling, and the introduction of tools that make it easier to manage the design process, Autodesk is helping organizations use true engineering data in business applications.

Framework Overview

The architecture of the U-Vis framework must consider various data source types, the filtering of the data, and the delivery to the interface of choice. This general workflow is similar for each U-Vis–based solution; however, the details differ for each unique implementation. The following figure shows the high-level architecture of the U-Vis 360 framework:

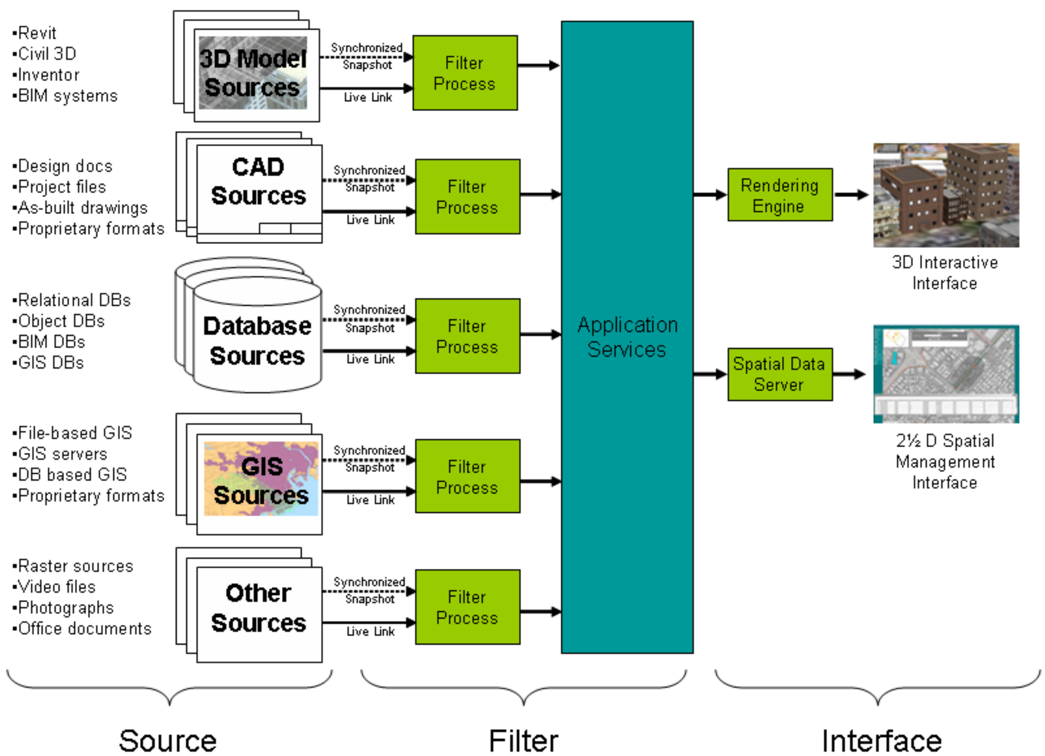


Figure 4—Autodesk U-Vis 360 Architecture

Data Sources

The U-Vis 360 framework is designed to accommodate a wide variety of data sources, including Revit models, AutoCAD® Civil 3D® models, Autodesk® Inventor™ models, satellite imagery, aerial photos, scanned documents, relational databases, DWG™ files, SHP files, ArcSDE® databases, DWF™ files, PDF files, DGN files, and more.

Some data sources consist of simple line work representations or raster images, while others are smart 3D models. These *smart data sources* provide far more potential for the end-user application. It is easier to simplify a full model than add intelligence to a simple drawing. For these reasons, data created in tools such as Revit-based applications, AutoCAD Civil 3D, Autodesk Inventor, and AutoCAD Map 3D inherently provide more useful functionality in the end application. For example,

- AutoCAD Civil 3D models provide full contour information associated with land development projects. This allows both 2D site planning analysis and 3D visualization to originate from the same smart source data.
- Autodesk FMDesktop directly ties architectural floor plans to underlying databases, providing the foundation for both facility layout and facility utilization analysis.

Data Filtering

U-Vis *task-based filtering* takes into account all elements discussed earlier: data access rules, filtering and aggregation, and source normalization. Task-based filtering starts with the end in mind and considers what must happen within the filtering process to ensure that the necessary information is available and can be mapped into the right form. The actual tools used to perform filtering depend on the nature of the filtering; U-Vis can use a wide variety of tools from Autodesk and others. The normalization aspect of filter processing is made easier when model-based data sources such as Revit-based applications or AutoCAD Civil 3D are used, because these applications help enforce consistency and data standards. The fact that the underlying models are internally consistent simplifies the required filtering and normalization process.

Technologies that Autodesk can apply for data linking and filtering include the following:

- Autodesk® FDO technology, which allows applications to seamlessly integrate a variety of spatial and nonspatial data sources
- Autodesk® 3ds Max® software, which provides a common framework to aggregate 3D graphics for use and export to a variety of animation, simulation, and training applications
- Autodesk MapGuide® Studio, which provides tools to aggregate, link, and display a variety of visual and nonvisual data sources
- NavisWorks JetStream, which provides collaborative tools and can help streamline the design review process
- Service-oriented architecture (SOA) tools such as web mapping services (WMS)
- Oracle® Fusion

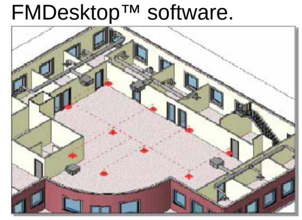
User Interface

The U-Vis framework supports both 2D and 3D interface platforms, including Autodesk technologies such as Autodesk MapGuide Enterprise and Autodesk 3ds Max. Data can also be published to web-based products such as Google Earth and Microsoft Virtual Earth, as well as interactive gaming engines such as Quest 3D, Unreal, and Gamebryo™. These platforms are core tools that can be used to support a wide range of task-specific applications such as emergency operations, facilities management, physical security, operations training, mission rehearsal, design reviews, and more. The key is flexibility to provide the *business function interface of choice*.

Smart Data

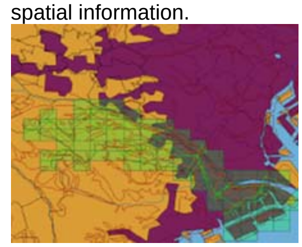
Buildings and Structures

Smart data on building design and use is often available in advanced 3D BIM models such as Revit® Architecture and facilities management systems such as Autodesk® FMDesktop™ software.



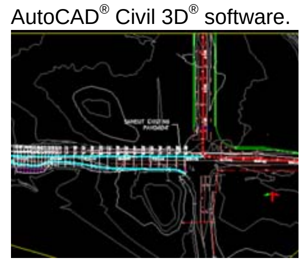
Landforms

Advanced mapping and GIS software such as AutoCAD® Map 3D provides a wealth of information on landforms, transportation, natural and legal boundaries, and other spatial information.



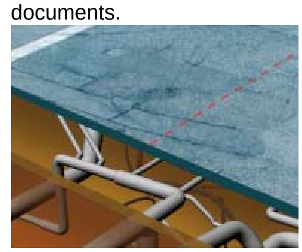
Smart Site Plans

Detailed site, land, and drainage data is often now available from model-based design products such as AutoCAD® Civil 3D® software.



Smart Utility Data

Smart utility data is available in GIS systems and, in more detail, from CAD as-built documents.



Practical Applications of the Autodesk U-Vis 360 Framework

The following case studies illustrate how the U-Vis 360 framework can be applied to a variety of business functions.

Urban Site Plan Review

Engineering and architectural firms often must present proposed designs to approval committees. The challenge is to be able to address a wide variety of issues generated from many different individuals. These committees generally meet on a regular basis, but the meetings could be weeks apart and agenda topics must be submitted well in advance. Concerns that cannot be answered at the meeting may result in a return session. Therefore, the objective is to present the design in such a way that all issues can be addressed at that time. By meeting this objective, firms can reduce the time spent presenting the design and accelerate the project timeline.

Many issues center around the visual impact a project may have on individual businesses or residents. For example, the replacement of transmission towers by an electric utility may affect the viewshed of a community. Concerns may be raised even if the new towers are only 10 feet taller. It is difficult to assess the impact of this minimal difference with a 2D drawing or a scaled table-top model.

A solution would be to present the design in a virtual 3D gaming environment so that staff and other interested parties can better understand the effect of the proposed construction. The interactive environment could provide the ability to simulate a 3D walk-through of the urban environment near a proposed city government building, including the effect on views from surrounding buildings and from the lobby and conference rooms. The advantage of the gaming environment is that it enables nontechnical users to go wherever they want to. They are not restricted to a predefined path. This flexibility makes it easier to address unanticipated questions during the presentation.

Data Sources

In this case study, data could come from several sources:

- **Satellite images**—Detailed (1 meter or better) satellite imagery is now available for most cities. This imagery can serve as an accurate base map for urban information. Such images are an especially cost-effective means of providing detail beyond the study boundary.
- **Adjacent building data**—For surrounding buildings, it is possible to use building footprint information, architectural drawings, photographs, and aerial photography to quickly create a 3D model using the Autodesk 3ds Max and Precision Lightworks® nVerse™ products.
- **Detailed building data**—For buildings within the study focus, detailed design and building information models from Revit-based applications can provide accurate data for interiors and exteriors.
- **GIS data**—Information on property boundaries, zoning, utilities, streets, and other infrastructure provides additional context for the visual environment.

Task-Based Filtering Process

Table 1 shows an analysis of the filtering process that could be applied to the different data sources. The filtering process considers how each data source might be accessed and then filtered for use in the application.

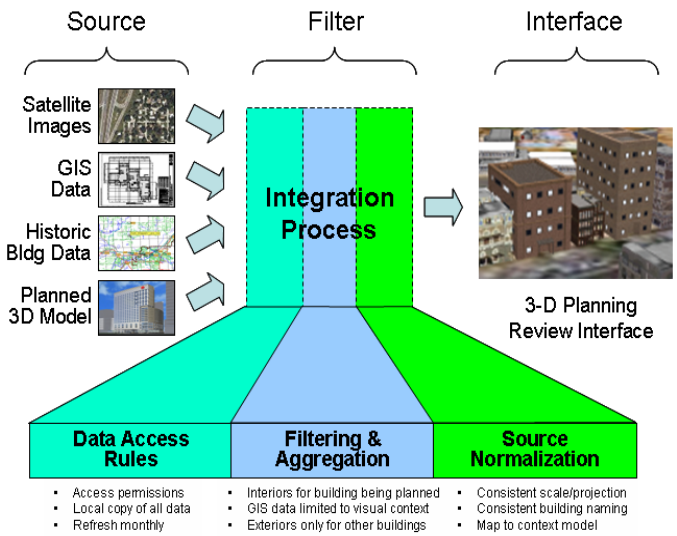


Figure 5–Practical Application of U-Vis

The satellite imagery can serve as an example. In terms of data access, satellite imagery would probably not be updated during the project design phase. Most satellite imagery is updated every one to two years. Because the data is not changing rapidly, using a local copy of the data would help increase performance. Satellite imagery is a photograph media format, which means it is a static snapshot taken in time. When a new image is taken, it replaces the previous version. No synchronization of data is necessary. There are few commercial sources for satellite imagery because of the expense of launching satellites. Aerial photography, which is more widely available, could be used instead. Permission is generally granted as a single request for the image.

The filtering of the satellite imagery should consider the area of interest. Images often span large geographic areas. The image can be trimmed to include just the area of interest. This reduction in area size helps to reduce the overall file size and can help to increase performance. Because satellite imagery has no associated attribute data, only the graphic component is used. Satellite images can be stored in various formats. File compression techniques can reduce the overall file size and help to increase system performance.

This overall process would be reviewed for each of the data sources. Other considerations such as the vintage of the data and the accuracy confidence levels should also be taken into account. For example, you would have a higher level of confidence in the data source if the satellite image was five years old for a downtown area where little development was occurring. You would have a low confidence level if the imagery was for an area with a high level of construction and development.

Data Source	***Satellite Imagery***	***Adjacent Buildings***	***Building Model***	***GIS Data***
Data Access Considerations				
Source changing	Not in project timeframe	No	Yes, as design evolves	Slowly over time
Live or local snapshot	Local snapshot	Local snapshot	Local snapshot	Local snapshot
Need synchronization	Not applicable	No	Yes	Probably no[1]
Source location	GeoEye and Digital Globe[2]	Planning dept. archives	Architect's Buzzsaw[3] site	City GIS department
Permissions	Access once for copy	Access once for copies	Need Buzzsaw access	Need access to GIS DB[4]
Filtering and Aggregation				
Use all data or subset	Subset	Subset	Subset	Subset
Graphics, data, both?	Graphics	Graphics	Both	Varies by data layer[5]
Source reduction	Bitmap consolidation	Exterior drawings only	No construction detail	Only visible features
Detail aggregation	Not applicable	Ground plan only	Exterior and interior detail aggregation[6]	Aggregate tiny features to be visible

Notes

(1) Depending on how GIS data is used, refreshes may be important, but in most cases these changes are gradual and can be ignored for project-oriented work.

(2) Commercial sources

(3) Design firms often use the Autodesk® Buzzsaw® online project management service to manage documents and control access and updates across multiple teams and organizations.

(4) Nature of permissions depends on how the GIS information is stored. Assuming an Oracle® Spatial database, access requires Oracle read-only access rights.

(5) Only graphic information is likely required for this planning scenario, but for some scenarios users may need to interact with the graphics that mandates availability of the underlying data.

(6) Aggregation depends on features. Subtle differences in wall materials might be aggregated, whereas individual lighting fixtures would not. Since the design building is the focus, decisions are made feature by feature.

Table 1—Case Study Filtering Analysis

Interface Choice

One of the main objectives of presenting the urban site development design is to assess the visual impact of the planned changes. Therefore, using a 3D model presented in a gaming interface environment would provide the most flexibility. With the data included, users could view a realistic 3D environment with detailed components showing both the interior and exterior of the building. Users would be able to interactively zoom in and navigate the proposed building. Since the building was generated using a full BIM approach, this experience could include details of doors, walls, windows, ceilings, floors, lightings, HVAC, piping, furniture, and more. This rich experience provides an excellent simulation of what the actual building and surrounding environment will be like.

Note that this scenario is focused on 3D interaction with an emphasis on the visual experience. Other users may need to complement this with a 2D analysis to present the potential effect on wetlands or other environmental issues. Within this world, high data precision is needed, as well as the ability to highlight data through graphic views using thematic mapping or presentation. While this example emphasizes the 3D potential of U-Vis, 2D analysis is also important and entirely within the capabilities of the U-Vis framework.

Campus Visualization and Facilities Management

A campus (or military base) consists of a contained geographic area with several buildings and defined usage areas. The information maintained is similar to that of a small municipality. There is information about the interior of the buildings, including space allocation to specific departments and people. Often a building manager is assigned to each building. There is utility information outside the buildings and under the ground. Environmental data and infrastructure data may be maintained, such as street, pavement, and signage information. Finally, a work management system is normally used to track work requests and projects related to both the interior and exterior of the buildings.

The business challenge is that the records related to infrastructure are usually stored in a central engineering records office or a variety of computer systems. Some building managers stay in the same job for a long time and know all the history: when certain carpet was replaced, when the walls were last painted, which contractor painted the walls, and so forth. But when building management staff is rotated, this knowledge disappears. New facilities management personnel must spend time hunting down records, requesting copies, and linking the information together—and then wait until the engineering records staff can get the information to them.

A potential solution would be to link these records together through a single intranet-based application. Building managers could view an overview map of the entire campus area showing the building footprints, exterior infrastructure features all overlaid on the satellite image. They could select a specific building footprint and retrieve the detailed floor plans, which would link to the space allocation records. In addition, building managers could search the work management system database to retrieve historical, scheduled, and proposed project records related to a building and surrounding areas. They could plot drawings or print documents at their desk. They could access records at any time to deal with routine activities or emergency situations.

Data Sources

In this campus management scenario, data could come from the following sources:

- **Satellite images**—Detailed (1 meter or better) satellite imagery is now available for most areas. This imagery can serve as an underlay to the base map and can provide additional visual reference data such as sidewalks and roadways. Such images are an especially cost-effective means of providing additional detail.
- **Infrastructure data**—Engineering data for building footprints, electrical, gas, water, wastewater, and roadways could be accessed from engineering design tools such as AutoCAD Map 3D or Autodesk® Topobase™ software. This data could be stored in an Oracle Spatial database.
- **Floor plan and space allocation data**—Floor plan and space allocation data could be maintained in an Autodesk FMDesktop database. AutoCAD Map 3D could be used for maintaining these drawings. The floor plans would be stored as DWG files. Attribute data could be stored in Microsoft® SQL Server™ software.
- **Work management data**—A variety of products are available for work management systems. Most of these systems are based on relational databases such as Oracle or Microsoft SQL Server.
- **GIS data**—Environmental data could be provided by an ESRI ArcSDE database. This data may be stored in SHP files.

Task-Based Filtering Process

Table 2 shows the analysis of the filtering process that could be applied to the different data sources for the campus facilities management application. The process considers each data source, and how it might be accessed and then filtered for use in the application.

The utility data is an example. Utility infrastructure does change but would do so infrequently for an established campus facility. A snapshot of the utility data could be taken once a month or more frequently if major projects are under way. To simplify the process, the snapshot of the entire utility infrastructure data set could be updated rather than trying to synchronize individual updates. This approach would be feasible for a small to mid-size campus. The data could be stored in a replicated Oracle Spatial database to minimize maintenance work for database administrators. The security tools provide by

Oracle could be used to control access to the records. Building managers may not need to see all of the details contained in the master utility database records. For example, a building manager may not need to know where all the joints, reducers, cathodic protection, and similar fixtures are on a water main. However, building managers may want to see additional textual attribute data associated with a water main such as the year installed, material, and date last inspected. Also, detailed construction drawings may not be required.

Data Source	***Satellite Imagery***	***Utility Data***	***Building Data***	***Work Management***
Data Access Considerations				
Source changing	Every two years	Yes	Yes	Yes
Live or local snapshot	On server	Snapshot on server	Live access	Live access
Need synchronization	Not applicable	No	No	No
Source location	GeoEye and Digital Globe	Oracle Spatial	DWG files and Oracle	Oracle
Permissions	Login security	Oracle security	Oracle security	Oracle security
Filtering and Aggregation				
Use all data or subset	All	Subset	Subset	Subset
Graphics, text, both?	Graphics	Both	Both	Text
Source reduction	Bitmap consolidation	No construction detail	No construction detail	No

Table 2—Campus Facilities Management Filtering Analysis

Interface Choice

Most building and facility managers are comfortable reading 2D floor plans. In addition, 3D models are not widely available for existing buildings and infrastructure. Therefore, a 2D graphical representation of the data is acceptable to this community. More important to these users, however, is to simplify the application menu structure so that they can easily find the relevant information. The Base Visualization Tool built on Autodesk MapGuide Enterprise technology is an excellent approach for this solution. As 3D building models become available, these files could be stored and accessed as 3D DWF files.

Conclusion

As more digital data becomes available, organizations will be able to more easily integrate visual and attribute data sets. The general public already knows that many records are automated or computerized. They are aware that links can be made between systems through common links. The public is also familiar with digital maps, global positioning systems (GPSs), and 3D building models from newscasts, websites, television programs, and movies. Therefore, the expectation is that organizations should be able to combine various visual data features into a single view and be able to use these views to access feature attribute data. Organizations should also be able to query these combined data sets in an ad hoc manner.

Organizations need to be able to provide these rich visual data sets to all staff within an organization so they can provide better service and reduce operating costs. Organizations need to remove the barriers that keep these graphic records segregated from each other and the related textual data.

Firefighters, police, or military personnel could benefit from having a full 3D building model for training purposes before going into the physical location. The additional data available could help users determine whether a specific wall is penetrable, for example. Being able to see the size and shape of a window could help determine potential entry points for personnel carrying equipment of a certain size.

Engineering and architectural firms could benefit by accelerating the project approval process. Decision makers and influencers could virtually experience the terrain, infrastructure, machines, and buildings in an environment controlled by the audience rather than the presenter.

Facility and building managers could reduce time spent locating and maintaining records. The end result is the ability to take action sooner by having access to campus maps, building floor plans, space assignments, utility infrastructure drawings, and work management data from a single visual portal.

Reality has practical limits, however. But by using smart data, filtering data based on the task at hand, and then enabling users to choose the appropriate interface, organizations can provide useful and compelling inside-outside-under design and scenario visualization solutions today. Rich functionality can be provided as the data creation process uses full 3D model design tools. Yet, 2D data sets available today also can be used.

Autodesk can help achieve these solutions using the three basic building blocks of the U-Vis 360 framework.

- **Leverage smart data**—While the U-Vis 360 framework can work with virtually any data source, smart data sources such as CAD, GIS, 3D models, BIM technology, databases, and so forth provide the power to simplify implementation and enhance the user's experience.
- **Task-based filtering**—Because filtering and integrating data is complex, it needs to be approached methodically. By breaking down filtering into multiple stages and staying focused on the required task, users can analyze each stage and make the best decisions.
- **Interface choice**—2D and 3D, web, and client applications all play an important role and can be part of the solution. 3D works better when it is important to get a complete visual sense of the environment. On the other hand, 2D is more typical for engineering and analysis work.

Autodesk is in a unique position to bring U-Vis 360 capabilities to market. Autodesk has a vast range of smart design technologies that cover 3D architectural models, 3D land and corridor development, mechanical, and geospatial. Combine this with Autodesk's advanced 2D server technology and photorealistic 3D rendering and animation tools, and it's clear that Autodesk is in the best position to help organizations, agencies, and partners meet their visual and attribute data integration needs.