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# Using Autodesk Civil 3D 2007 for Large Subdivision Design

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# Introduction

This white paper outlines best practices for large subdivision design using Autodesk® Civil 3D® 2007 software. Large subdivision design projects are often multiphased, involving several professional disciplines and large amounts of data, and result in the production of contract documents required for construction.

For projects of this nature, the following elements require special consideration:

- AutoCAD® drawing and Autodesk Civil 3D object data management
- Optimization of Autodesk Civil 3D functionality for completing the design
- Drawing architecture, or the assembly of drawings and data to represent a completed set of contract drawings

Concepts presented in this paper are relevant to a typical subdivision design process, describing applicable Autodesk Civil 3D functionality and best practices for drawing architecture and data management.

As with all large engineering projects, organizations need to consider much more than just engineering design. Because of the size, complexity, and multidisciplinary nature of large subdivision design projects, data management often poses a significant impediment to process and technology optimization.

Data must be effectively used and managed throughout the entire project lifecycle, with minimal duplication of both data and effort. Standards are required for business processes and drawing architecture. Efficient mechanisms for sharing data must also be in place throughout all project phases.

Autodesk Civil 3D 2007 offers a powerful set of tools that enable design teams to address the challenges associated with designing large subdivisions. These tools have been developed to take into consideration the design changes that are inevitable for these types of projects.

Simplifying the overall effort is the fact that design changes are easier because of the dynamic nature of Autodesk Civil 3D design objects and label styles. For example, when a designer changes a horizontal alignment, the profile updates automatically. This in turn results in automatic updates to the corridor model. Similarly, changes to the pavement structure in an assembly (typical section) also result in automatic updates to the corridor model. Associated annotation also updates dynamically.

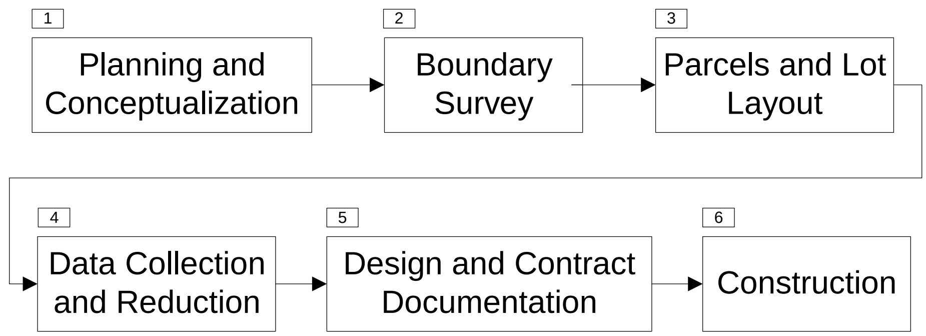
Using Autodesk Civil 3D on large subdivision design projects warrants strategies for both design methodologies and data assembly standards for the final production of a contract drawing set. Drawing templates (DWT) contain organizational and client drafting standards, Autodesk Civil 3D label and object styles, and paper space layout definitions. Templates should be centrally located on the server for all to access.

# Subdivision Design Process Overview

First, this paper assumes a typical subdivision design business process. The business process is charted against the organization structure. This arrangement makes clear not only where the hand-offs occur but also the nature of the deliverable.

Large subdivision projects are usually designed and tendered for construction by large, multidisciplinary civil engineering consulting firms with several departments, each having responsibility for an individual project phase. Data sharing and management are therefore crucial.

A typical subdivision design process involves the following project phases:




Designers can use Civil 3D 2007 functionality throughout all phases of large subdivision design projects. The following sections elaborate on the requirements of design phase and applicable Civil 3D functionality. These phases are generalizations, and variations will exist for the municipal jurisdiction and agencies involved in the process.

## Planning and Conceptualization

The first phase of a large subdivision design project involves planning and conceptualization. During this phase preliminary alignment and parcel layout are determined. Planners have the greatest ability to affect the total cost of a project. Autodesk Civil 3D can contribute significantly to this phase of a project because of the dynamic nature of parcel and alignment objects, and associated annotation. Designers can use Civil 3D to quickly develop and analyze alternatives design scenarios.

Large subdivision projects are themselves multiphased. The subdivision plan may incorporate several contract packages that are individually tendered for construction. Planning and conceptualization are usually completed for the entire subdivision before the creation of the individual detailed design packages.

## Boundary Survey

Once the preliminary alignment and parcel layout have been determined, the next phase is the boundary survey. A boundary survey is the process of finding, identifying, measuring, and reporting the legal location of the boundary lines of a parcel of land. Boundary surveys also involve a traverse analysis that mathematically adjusts and distributes any naturally occurring survey errors throughout the survey network.

Autodesk Civil 3D 2007 survey functionality enables surveyors to work directly with field observation data, including measurements such as horizontal angle, vertical angle, slope distance, keyed-in control coordinates, height of instrument, and height of rod. Survey adjustments are made solely with observation data and cannot be performed on reduced coordinates. Changes made to survey observation data result in automatic updates to the survey network. Surveyors can use Autodesk® Vault data management functionality, the survey observation database, and survey networks to facilitate management of large amounts of survey data.

## Alignment and Parcel Layout

After the boundary survey has been completed, designers and planners can start the detailed design of the alignment and parcel layout. Alignment data and parcel layout configuration developed during the planning and conceptualization phase are tightened to meet the geometry of the boundary survey. Once again, the dynamic nature of alignment objects, parcel objects, and annotation streamlines the finalization of the subdivision plan geometry.

## Data Collection and Reduction

*Data collection and reduction* refers to the preengineering collection and reduction of either total station or global positioning system (GPS) data to reduced point coordinates, an existing-conditions base plan, and an existing ground surface model. Subsurface models may also be included in this phase.

As for boundary surveys, Autodesk Civil 3D enables the surveyor to work directly with observation data to create a preengineering base plan, existing ground surface model, and a reduced point file. These are all created as a by-product of the total station or GPS survey through both standardization and the application of field connectivity codes.

Symbol representation is automated with description key sets. The application of connectivity codes in the field allow for the automatic generation of *figures*, or base plan linework. Specific figures are automatically defined as breaklines for the existing ground surface model. Predefined point groups that originate in the prototype drawing (DWT) can be used for surface modeling. These point groups are created based on description criteria and filter nonrepresentative surface points such as inverts and hydrant tops from the existing ground surface model.

## Design and Contract Documentation

This phase of a large subdivision design project involves the design and preparation of documents required for construction. Contract documents typically include plan/profile and other construction drawings, quantity reports, and construction staking data.

Resources allocated to the design of these projects vary with the organization. Design data also needs to be shared. For example, road network design data can be sourced for both the utility design and for the design of the site grading.

Design elements include the subdivision roads (plan, profile and corridor, site grading, and public services such as water distribution, sanitary sewer, and storm sewer). Autodesk Civil 3D 2007 design functionality addresses each of these subdivision components.

Data sharing is integral to large subdivision design projects. Civil 3D project data sharing capabilities along with AutoCAD external references (xrefs) offer organizations the tools they need tools to develop best practices for standardized data sharing techniques.

## Construction

Aside from geographic information system (GIS) data collection and reduction, construction represents the last phase of large subdivision projects. Designs are typically created in a grid (UTM—Universal Trans Mercator) coordinate system. Transformation settings available in Autodesk Civil 3D 2007 allow grid coordinates to be converted to ground-level coordinates for field staking. Transformation settings take into account a base point, rotation point, and grid scale factor.

Construction staking data generated in Autodesk Civil 3D 2007 can be uploaded to data collectors in either reduced coordinate or LandXML format.

# Autodesk Civil 3D 2007 Subdivision Design Functionality

This section addresses functionality in Civil 3D 2007 that organizations can apply to large subdivision design projects.

The following is a list of available functionality and how it can be applied to these types of projects:

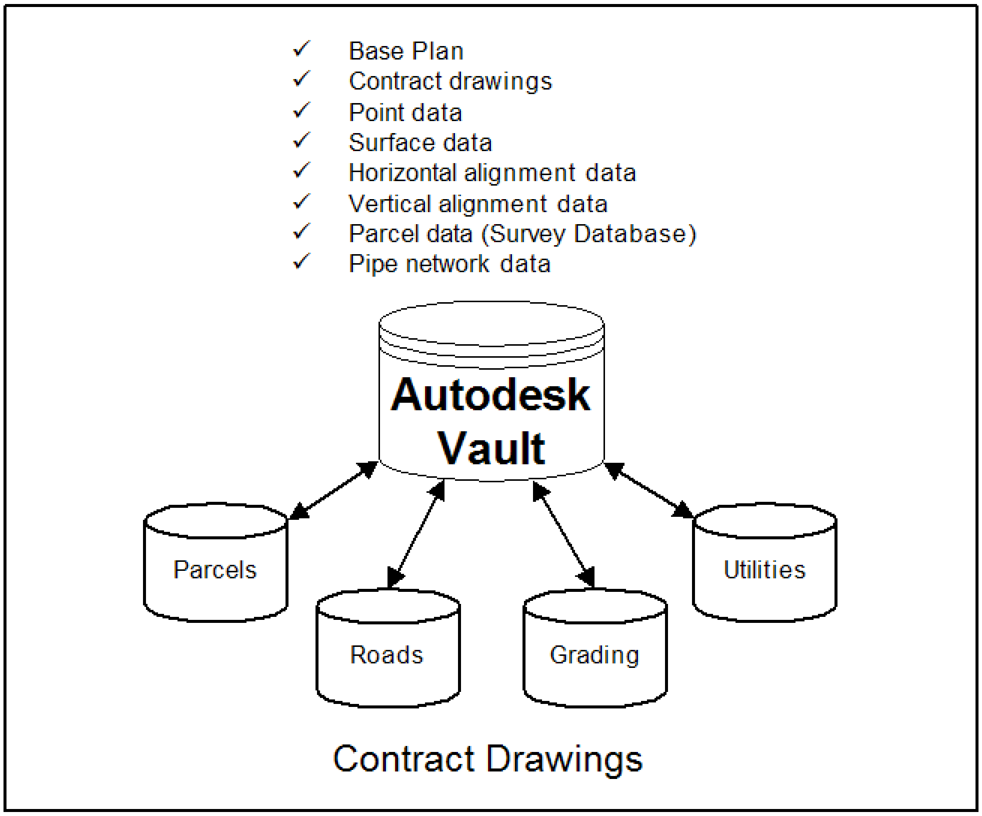
- **Autodesk Vault Project Management:** Data sharing and project document management.
- **Survey:** Preengineering boundary surveys and topographic data collection. Observation-based automatic base plan creation and existing ground surface modeling.
- **Points:** Preengineering boundary surveys, topographic data collection, and construction staking data.
- **Surfaces:** Preengineering existing ground surface modeling and design surface creation.
- **Parcels:** Parcel planning layout and final parcel creation.
- **Alignments:** Subdivision road layout, preliminary and final.
- **Profile:** Surface (existing and interim grading) and design profiles.
- **Corridors:** Road design, including capabilities to effectively model intersections and cul-de-sacs.
- **Grading:** Site grading and volume calculations.
- **Pipe Networks:** Design of storm sewer, sanitary sewer, and water main.

The next sections highlight this functionality in more detail.

## Autodesk Vault Project Management and Data Sharing

Engineering organizations face many challenges when designing large subdivisions. Data management represents one of the more significant challenges. Historically, data management practices in the industry have been substandard, introducing roadblocks to efficiency. Autodesk Civil 3D 2007 introduces project management, document management, and data sharing capabilities that enable project teams to efficiently use and manage data throughout the entire project lifecycle.

A project-based design environment in Autodesk Civil 3D uses the core data management capabilities of Autodesk Vault. The entire project team can now directly access the latest drawing file or design iteration required for their specific discipline. The Vault is shown in the following graphic.




Autodesk Vault facilitates the organization and distribution of files over a network. Team members can check both drawing data and Autodesk Civil 3D object data into and out of the project Vault. When a team member checks data out of a project, locking mechanisms prevent other users from modifying that data.

A subdivision contract drawing set contains several drawings that reference the same data sources. Until recently, maintaining design concurrency and ensuring that all team members have access to the same data have been significant challenges.

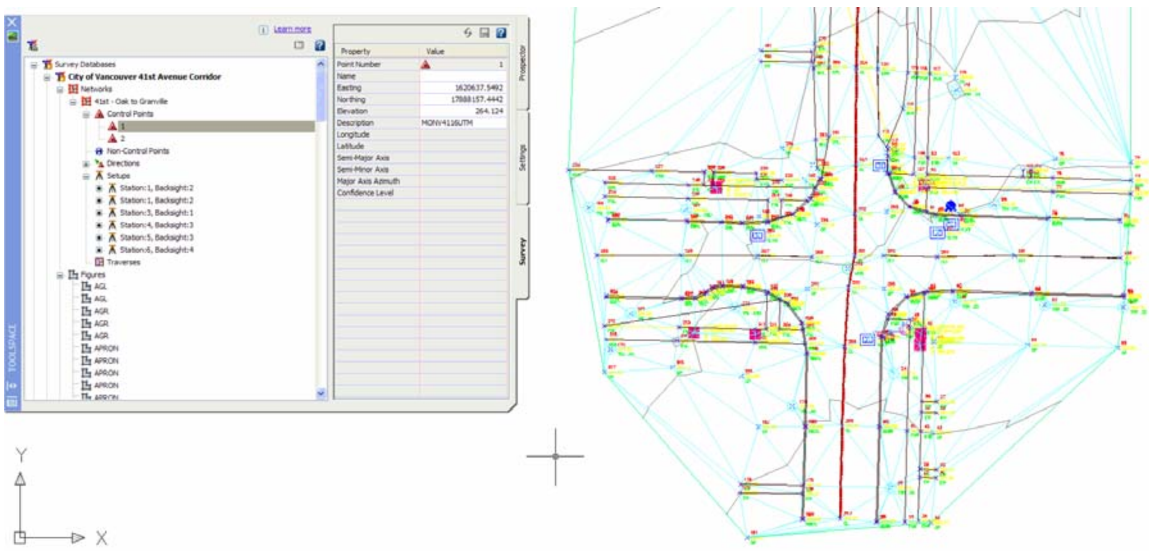
AutoCAD xrefs enable design teams to share graphical data. Autodesk Vault and Civil 3D 2007 data shortcuts and reference objects enable design teams to share drawings and object data such as surfaces, alignments, profiles, and pipe networks. The mechanisms for setting up systems of data sharing, discussed further in “Drawing Architecture” later in this white paper, vary with the organization and municipal jurisdiction.

## Survey

Survey functionality in Autodesk Civil 3D 2007 enables users to work directly with survey observation data in a graphical environment. Autodesk Civil 3D 2007 survey functionality can be applied to both boundary survey production and preengineering topographic data collection, base plan creation, and existing surface modeling.

Boundary survey calculations are facilitated with a range of traverse adjustment techniques, including least squares and compass rule network analysis tools. Surveyors now have the ability to make any changes to observation data directly in the Civil 3D environment. Any changes made to control coordinates, back-sight angles, prism heights, and other observation data result in automatic updates to the survey network.

Transformation settings enable surveyors to equate grid-level coordinate data to ground-level data, and vice versa. A base point, rotation point, and grid scale factor are required. This way, designers can work in a grid (UTM)–based coordinate system and still produce ground-based data for use in construction staking.



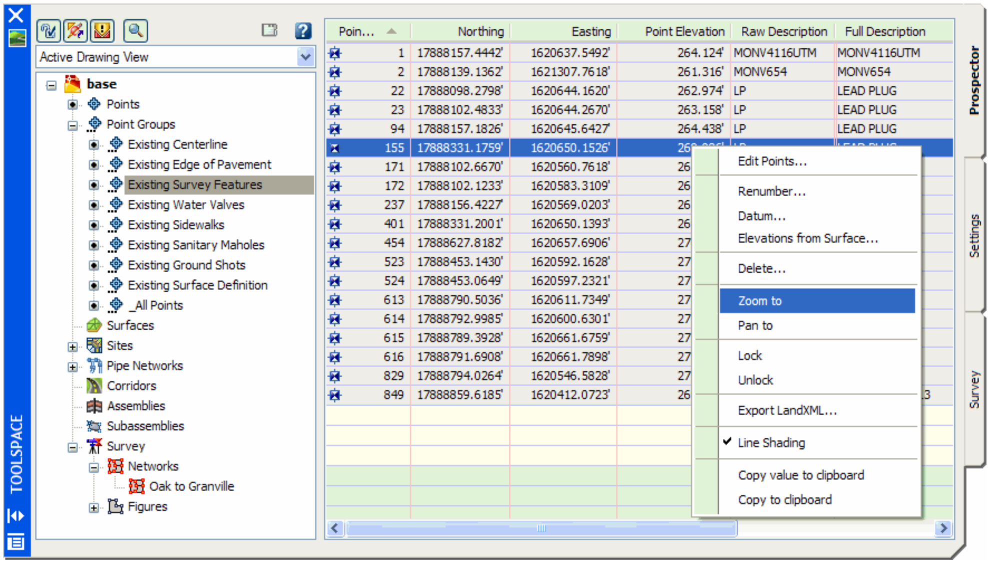

By using correct field procedures and standards, team members can automate creation of the preengineering base plan and existing ground surface model. Surveyors enter line connectivity codes in the field to automate creation of the figures, or the base plan linework. Survey figures are automatically assigned to the correct layers based on the figure name, which was assigned in the field with the Begin statement. Surveyors complete the base plan by using Autodesk Civil 3D description key sets to automatically assign point styles and point label styles to points. Points are therefore represented with the correct symbol and assigned to the correct layer.

The existing ground surface model is created from a point group and breaklines. The point group is predefined in the drawing template (along with other point groups) and excludes points that should not be included in the surface model, such as invert and top of hydrant observations. Survey figures are automatically converted to breaklines for the existing ground surface model.

## Points

Points are an elemental component of designs for large subdivisions. Points are used in the preengineering phases of boundary surveys and topographic data collection. Designers also use points to assist with specific design tasks. Points are also created to model final surfaces and to represent staking data required for the construction phase.

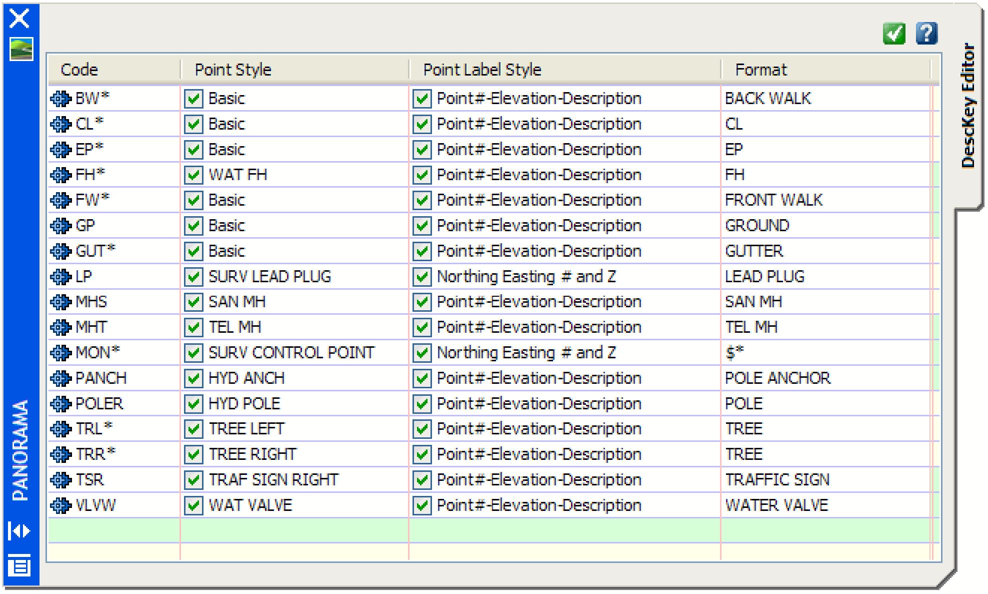
Points are organized into point groups, which are most often created with either a description or point number range criteria. Good survey and design practices involve the assignment of point number ranges to points used for different purposes during a project lifecycle. For example, point numbers 1–99 may be reserved for survey control and boundary surveys. Each day of preengineering topographic survey may start with a point number that is a factor of 500. Design and construction staking points could start at the next 1,000 point number range above all other points. Points can be selected with point number ranges, so it is important to apply this type of organization to project points.



Point group definitions are saved in the prototype drawing, or drawing template. When points are created from survey download, point import, or manual creation methods, the software automatically assigns them to the respective point group definitions. Point groups can also be defined while points are created via survey data or reduced coordinate point import routines. This practice is useful for organizing points in terms of survey details that could account for date of survey or the company providing the survey data.

Point display is controlled with the point style and the point label style. The point style controls the display of the point node and can be defined with AutoCAD blocks to represent specific features. The point label style controls the display of the point label. Designers can create their own label style to display point data in any format. Common point label styles show just the description, just the elevation, or a combination of point number, elevation, and description. Point styles and point label styles can be preassigned to point groups originating in the prototype drawing.

Description keys are used to automate the assignment of point styles and point label styles to points. To effectively work with description key sets, surveyors must use standardized point descriptions. Description key sets in Autodesk Civil 3D 2007 are essentially lookup tables that assign a point style, point label style, point layer, and a full description.

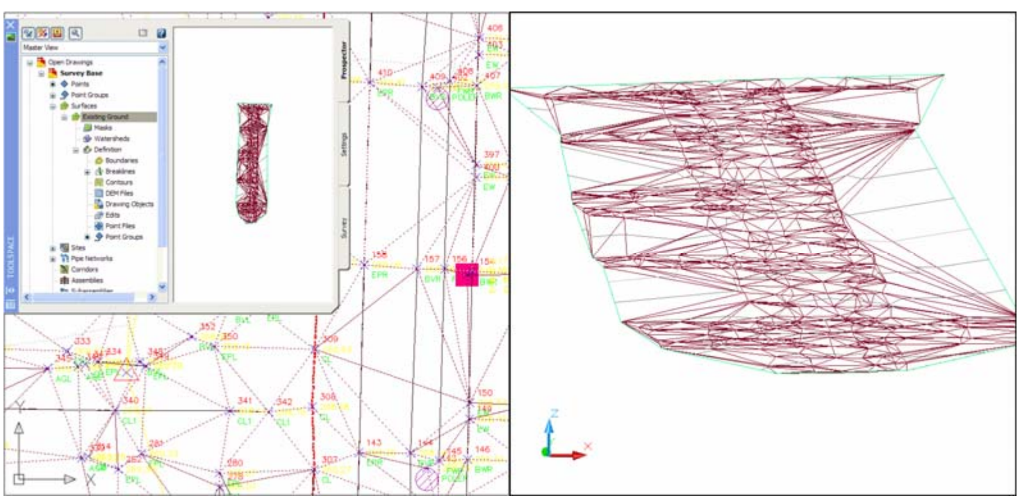



| Code | Point Style | Point Label Style | Format |
|---|---|---|---|
| BW* | Basic | Point#-Elevation-Description | BACK WALK |
| CL* | Basic | Point#-Elevation-Description | CL |
| EP* | Basic | Point#-Elevation-Description | EP |
| FH* | WAT FH | Point#-Elevation-Description | FH |
| FW* | Basic | Point#-Elevation-Description | FRONT WALK |
| GP | Basic | Point#-Elevation-Description | GROUND |
| GUT* | Basic | Point#-Elevation-Description | GUTTER |
| LP | SURV LEAD PLUG | Northing Easting # and Z | LEAD PLUG |
| MHS | SAN MH | Point#-Elevation-Description | SAN MH |
| MHT | TEL MH | Point#-Elevation-Description | TEL MH |
| MON* | SURV CONTROL POINT | Northing Easting # and Z | $* |
| PANCH | HYD ANCH | Point#-Elevation-Description | POLE ANCHOR |
| POLER | HYD POLE | Point#-Elevation-Description | POLE |
| TRL* | TREE LEFT | Point#-Elevation-Description | TREE |
| TRR* | TREE RIGHT | Point#-Elevation-Description | TREE |
| TSR | TRAF SIGN RIGHT | Point#-Elevation-Description | TRAFFIC SIGN |
| VLVW | WAT VALVE | Point#-Elevation-Description | WATER VALVE |

The full description expands on an abbreviated survey raw description. Description key sets enable designers to create design data that also represents final drafted conditions. Point group overrides are incorporated to remove conflicts between styles assigned from both description key sets and point group definitions.

## Surfaces

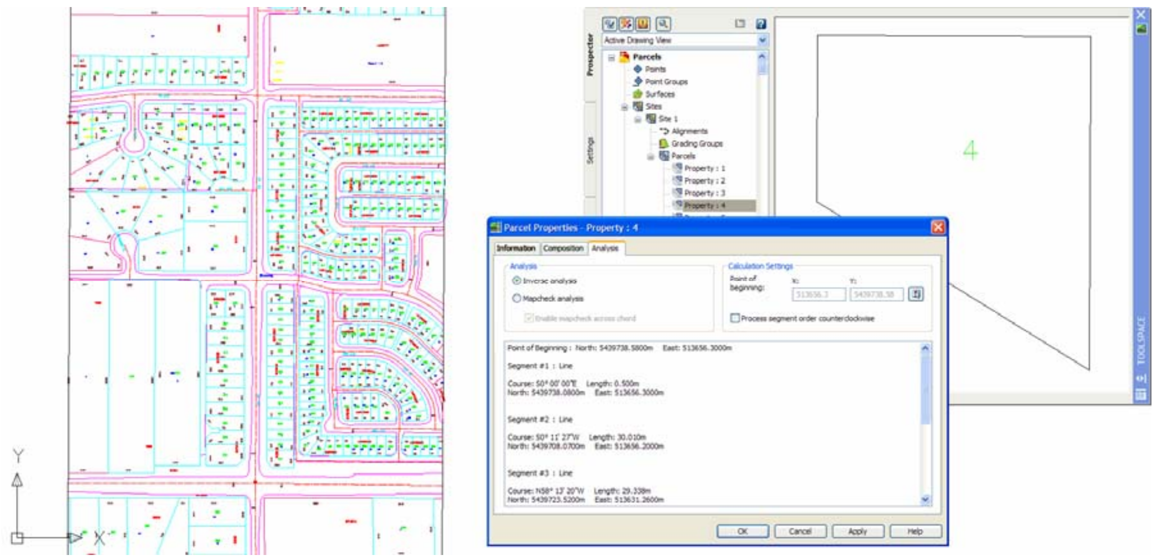
Surfaces are used to represent both existing and proposed conditions. Once again, the actual surface in the drawing is displayed with customized styles so it can be displayed and plotted in final engineering plans. Surface styles can be developed to show the surface as either individual or combined contours, 3D grids, triangles, and a range of other formats. Designers can also create styles that suppress the display of surfaces. This is an alternative to suppressing surface display with layer visibility settings.



Surfaces representing existing conditions are used for both display and design purposes. Surfaces representing proposed conditions are compared with existing ground surface to calculate earthwork quantities. Resulting volume surfaces can also be used to create cut/fill contours or cut/fill grid ticks. These are both useful for contractors involved with the final site grading. Proposed surface can also be used to generate construction staking data, which can then be uploaded to data collectors or machine control grading systems.

## Parcels

Parcel functionality in Autodesk Civil 3D 2007 offer planners and surveyors the functionality necessary to quickly generate parcel layout configurations and the final parcel layout. Designers can subdivide a larger parcel of land into smaller parcels by specifying the frontage line, minimum parcel frontage length, and minimum area. When the designer make changes to a single parcel, adjoining parcels resize automatically.




Parcel styles, parcel area label styles, and parcel line and curve label styles are used to automatically annotate parcels. Annotation is standardized to meet the submission requirements of clients or business partners. Reporting capabilities in Autodesk Civil 3D 2007 allow for the efficient production of parcel map check and closure reports.

## Road Design

This section addresses road design capabilities in Autodesk Civil 3D 2007 and covers functionality specific to alignments, profiles, subassemblies, assemblies, and corridor models.

Horizontal alignments can be created with the layout tools or by selecting existing polylines. A wide range of alignment geometry creation tools—both graphical and tabular—is available to tackle the most complicated alignments. Designers assign label sets that combine predefined major station labels, minor station labels, and geometry point labels. Alignment styles control the display of the horizontal alignment components. Designers can control the display of all Civil 3D objects by either assigning display properties of object components to a layer (By Layer) or assigning display properties of object components directly within the style.

Finished design road profiles are created based on surface profiles from both the existing ground surface and the interim grading surface. The interim grading surface is a preliminary surface with an earthworks balance that models the overall grading and drainage characteristics of a site. Design profiles are created to match the interim grading surface profile as closely as possible.

The profile view represents the grid that contains the profile data. Profile data is created in the profile view and can be either surface profiles or layout (design) profiles. Designers can also create superimposed profiles. Annotation for finished ground profile vertical curves is located either relative to the PVI, to the top or bottom of the profile view, or at an absolute elevation. As with horizontal alignments, layout profiles can be edited either tabularly or graphically. Team members can use Autodesk Vault to share horizontal and vertical alignment data.

Once the profile has been completed, the next step is to create the assembly. Assemblies are the typical section for the subdivision roads and are created from subassemblies. Subassemblies represent different components of the assembly.

Subassemblies used in a subdivision design generally include the following:

- LaneOutsideSuper subassembly—Subassembly used for the travel lanes.
- UrbanCurbgutterGeneral subassembly—Curb and gutter subassembly.
- UrbanSidewalk subassembly—Sidewalk subassembly that can accommodate both inside and outside boulevards.
- Generic subassemblies—A range of subassemblies that enable designers to create subassembly links with several options, including slope, offset, and elevation change.

A subassembly daylight to the surface is typically not used. Designers essentially “float” the corridor model along the horizontal and vertical alignment. The corridor model represents the typical section up to the right-of-way lines. Corridor feature lines at the right-of-way locations are then imported as grading feature lines. The grading feature lines extracted from the corridor model are used with the grading feature line tools to create the grading feature lines for the lots in the subdivision.

Most subdivision roads are fairly simple and do not require many different subassemblies. Generic subassemblies are useful when designers want to model the lot grading with the corridor model. For example, designers could use the LinkOffsetAndSlope subassembly to modify a parcel setback and attach it directly to the UrbanSidewalk subassembly at the right-of-way location.

The final corridor model is created from the horizontal alignment, design profile, and assembly. Designers can specify the insertion frequency of the assembly. When creating the corridor, designers add specific stations for assembly insertion that are perpendicular or radial to the parcel lot line corners to generate design elevations to which grading feature lines can be attached.

Designers can use corridor baselines to switch control of the corridor creation to another horizontal alignment, profile, and assembly. Corridor baselines are used to model both cul-de-sacs and intersection locations.

After creating the subdivision corridor models, designers can then create a corridor surface representing either the top or the datum of the subdivision roads. These surfaces are combined (pasted) with surfaces created from grading groups and grading feature lines to create an overall finished design surface. The designer then compares this surface with the existing ground surface to generate cut-and-fill quantities. The corridor top surface is also used to calculate manhole rim elevations for the sanitary and storm sewers in the subdivision.

## Grading

Autodesk Civil 3D 2007 provides tools to tackle the most complicated grading scenarios. The grading toolset is useful for creating the interim surface and the final design surface. The automated earthworks balancing routine available with grading groups facilitates the earthworks optimization of the interim grading surface.

A wide range of tools for manipulating grading feature lines enables designers to create feature lines by elevation and slope. Designers can also create feature lines by extracting elevations from a surface. This surface could be the interim surface that models the overall drainage and grading characteristics of the site. Feature lines can be automatically annotated with elevations and slope. Designers can use this capability to efficiently interact with the design data to get the results they want.

The grading feature lines can then be used to create grading objects, which are based on target and slope. Designers can grade from feature lines to surfaces, absolute elevations, relative elevations, and distances using either grade or slope criteria.

The final set of feature lines and grading objects is combined to create a surface. This design surface is merged with the corridor surface to create a final design subdivision surface. Designers then calculate quantities by comparing this surface to the existing ground surface. The surface can also be used to generate construction staking data and design elevation annotation at crucial locations.

## Pipes

Pipe design functionality in Autodesk Civil 3D 2007 lends itself to the layout and drafting of sanitary sewers, road sewers, and water-main profiles. All pipe networks are dynamic and interactive. Designers can modify pipe networks either graphically or tabularly. Designers can plot pipes in plan, profile, and section, and display and annotate them with styles to meet the standards of an agency, client, or business partner. Pipe labels containing pipe data are automatically updated with changes to the pipe network. Pipe and structure rules help ensure that pipes satisfy minimum slope and cover requirements. Autodesk Civil 3D 2007 introduces functionality to check for pipe run interferences between several pipe networks.

# Large Subdivision Design Considerations

Before delving into specific strategies and design functionality available in Autodesk Civil 3D 2007, it is important to understand the role of data sharing, drawing architecture, and employee roles in large subdivision design.

## Data Sharing

Currently, one of the most widely adopted AutoCAD practices for data sharing is the xref. Xrefs introduce a mechanism to share drawing data among several users with different drawings. For example, a preengineering base plan that shows existing conditions is an xref to a proposed parcel drawing, or a subdivision road plan and profile design drawing. A drawing containing finished road design information may serve as an xref to a drawing that shows a storm sewer design.

Autodesk Civil 3D introduces additional data sharing mechanisms. This functionality includes Autodesk Vault and data shortcuts or reference objects. Designers can use these mechanisms to reference individual object data that resides in one drawing from an entirely different drawing. Autodesk Civil 3D 2007 enables team members to share drawing, point, surface, alignment, profile, and pipe data. This functionality plays a significant role in an organization's standard for drawing architecture.

# Drawing Architecture

*Drawing architecture* refers to the way in which drawing data is assembled to produce a final set of contract drawings. Drawing architecture standards must meet an organization's needs to both manage large amounts of data and share this data efficiently. Base AutoCAD functionality that contributes to drawing architecture includes xrefs, xref clipping, Sheet Set Manager, and paper space layout definitions.

Some Civil 3D objects cannot exist independently of one another. For example, an alignment is required for a profile to exist. The corridor can exist only if a design profile is present. These object dependencies introduce new challenges for drawing architecture and assembly standards.

As mentioned earlier, a single detailed design contract package for a large subdivision project involves a significant amount of data. It would be impractical for all of this data to reside in a single file. Not only would the file size become unmanageable, but multiuser access also becomes significantly restricted. The key is to understand Autodesk Civil 3D object dependencies and structure drawings accordingly.

**Object Types and Contract Drawings**

This section offers an example of a drawing assembly standard for a large subdivision project designed with Autodesk Civil 3D. It assumes that designers for the project are discipline specific and responsible for their own drafting. It also assumes that the following Autodesk Civil 3D functionality is fully used in the project:

- Points
- Existing terrain surfaces
- Parcels
- Alignments
- Profiles and profile views
- Section sample lines, section views, and sections
- Corridors and corridor surfaces
- Grading objects and grading surfaces
- Pipes

Team members must also understand Autodesk Civil 3D object data dependencies. These object dependencies should be considered in terms of the drawings that become part of a final design contract package. They must also be considered in terms of the Autodesk Civil 3D mechanisms that promote the sharing of this data (data shortcuts, reference objects, and Autodesk Vault). Examples of drawings typical for a large subdivision design project are as follows:

- Preengineering base plan

- Master grading and drainage plan
- Parcel layout and lot grading (design elevations at parcel corners)
- Subdivision roads, including plan alignments, surface profiles, design profiles, and corridors
- Plan and profile for subdivision pipes (storm sewer, sanitary sewer, and water distribution)

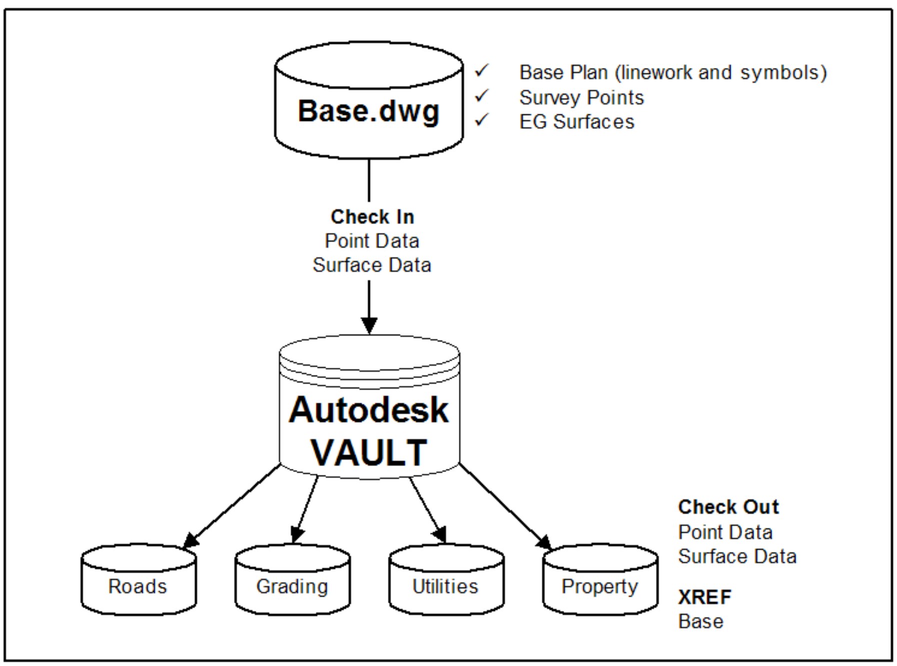
The following sections discuss each of these drawing categories and strategies on how to assemble and manage the data in these different drawings. It is assumed that Autodesk Vault is the mechanism for sharing Autodesk Civil 3D object data.

**Preengineering Base Plan and Existing Ground Surface Model**

The preengineering base plan is used to represent site conditions before design and construction. Source data for the preengineering base plan is usually total station or GPS reduced survey point data. Reduced point data is used to create the base plan drawing and the existing ground surface model. Project surveyors (or a survey division) are primarily responsible for creating and managing this data. The base plan drawing shows existing features, property lines, and the existing ground surface represented with contours.

Data created as part of the base plan includes the following:

- Survey point data—checked into the Vault
- Base plan drawing—xref to contract drawings
- Existing ground surface and subsurface—checked into the Vault




Assuming the use of Autodesk Vault, team members add point data or check it into a project from the base drawing. Other users with drawings linked to the project then have access to the preengineering point data. This data is useful to sewer designers who require information on existing storm/sanitary/water pipe networks that their designs tie into. Subdivision road designers may also use existing elevations to design proposed curb returns to match existing road networks. With discipline-specific styles, the same data can be displayed in a variety of formats.

Surveyors also add both existing surface and subsurface data to the Vault for other project team members to access. Designers involved with the grading and master drainage design could create an existing ground surface reference object from the Vault and display this surface data in a way that best suits their needs.

Finally, surveyors produce a base plan drawing with a surface displayed as labeled contours. This drawing then serves as an xref to any number of drawings in the contract set.

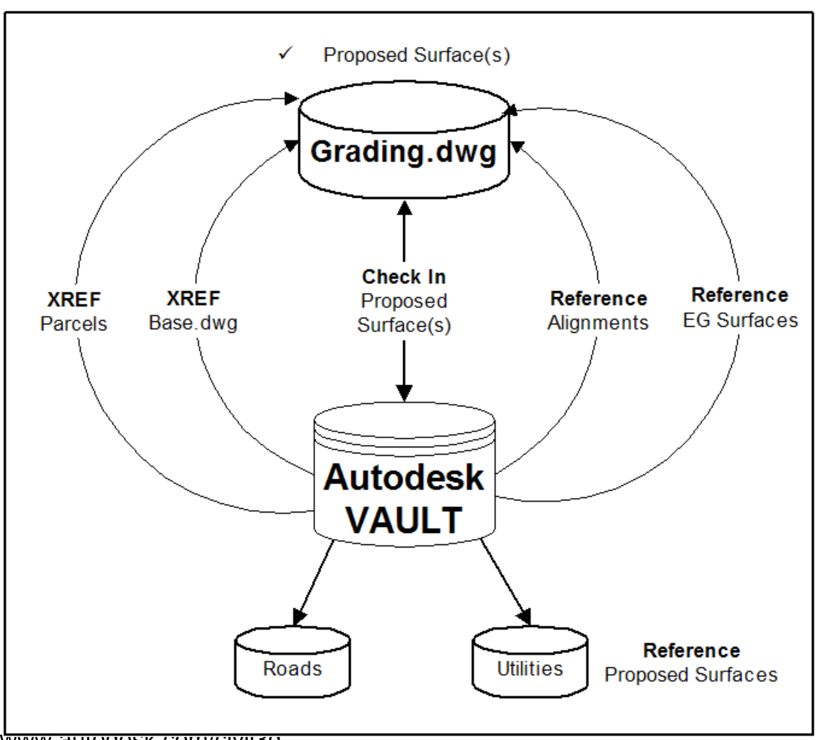
**Site Grading and Drainage Plan**

A primary goal of subdivision design is to balance earthworks quantities. Subdivision design is often an iterative process that requires a final quantity balance.

Grading strategies for subdivision design vary with terrain. In steep terrain road profiles usually dictate and therefore introduce the constraints to the subdivision grading design. In flatter areas, subdivision grading is usually constrained by drainage outlet locations.

Regardless of the constraint, a common practice is to design an interim grading surface that models the overall grading and drainage characteristics of the site. The grading surface is designed using the existing ground surface model (from the Vault) as base data and approximates a balanced earthworks condition. Autodesk Civil 3D tools for feature line and grading object optimization enable the designer to quickly and efficiently generate this surface. As the project progresses the grading surface evolves to a finished design surface. Designers involved with site grading may also require alignment geometry and parcel layout data, which could also be referenced from the Vault.

The following figure demonstrates grading drawing and object data relationships with the project Vault and other project drawings.



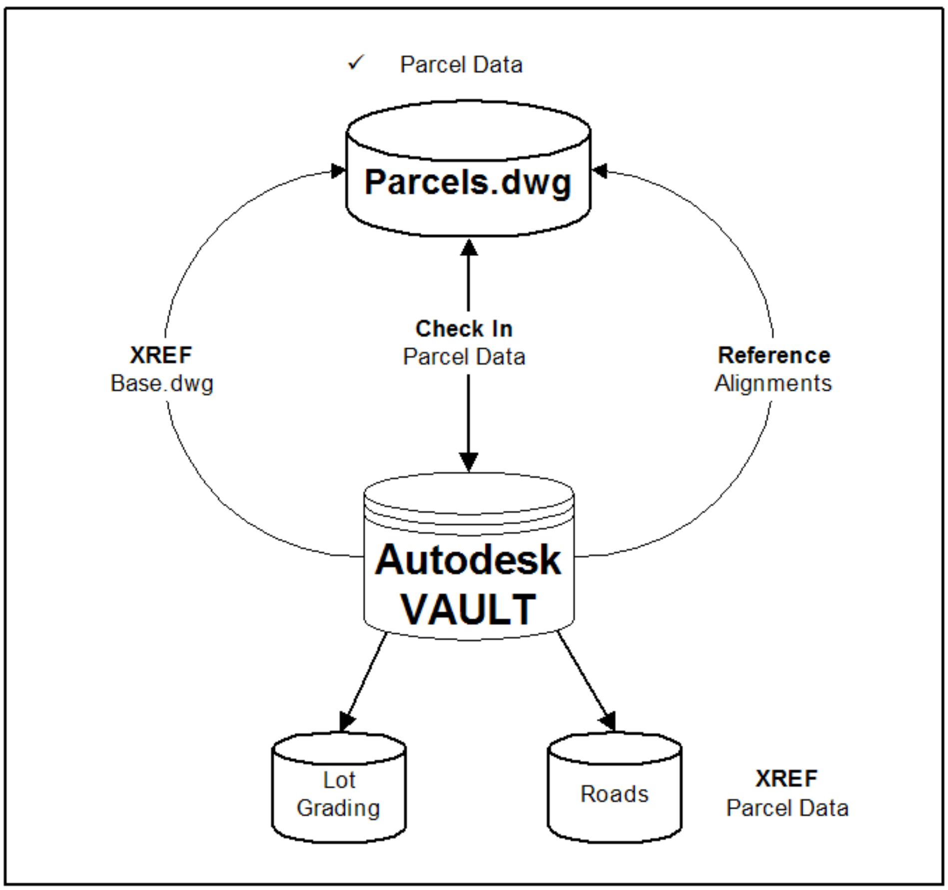
Once the grading surface has been designed, team members can check it into the Vault, where subdivision road designers can reference it when creating preliminary surface profiles for subdivision roads. Design profiles for subdivision roads are then created to follow the interim grading surface profile. This process results in the best initial approximation of a balanced earthworks scenario. Utilities designers can also use the site grading surface for preliminary design of the storm, sanitary, and water-main networks in the subdivision.

**Parcel Layout and Horizontal Alignment Plans**

Parcel layout in a large subdivision is completed with the road alignments. Horizontal alignments are offset to create the right-of-ways and subsequently adjusted to allow for the maximum number of parcels given the available land and the subdivision by-laws.

Data required for the development of the parcel layout plans includes the following:

- Preengineering base plan (xref)
- Preliminary horizontal alignment geometry (reference object from Vault)




**Note:** Parcel data cannot currently be saved as reference data in the project. Designers should store the drawing itself in the project and then reference it using standard AutoCAD reference capabilities. When intelligent parcel geometry is needed in additional drawings, team members can copy the necessary parcels into these drawings. Users must thus manage any changes to the parcels in all drawings. Autodesk recommends that project teams maintain only one instance of the parcels if possible.

Designers involved with the detailed lot grading create reference parcel objects. Finished design elevation and slope data is then referenced and attached. Road designers may want to check out parcel data and create reference objects using parcel and parcel label styles suited to their needs.

**Subdivision Roads—Alignments, Profiles, and Corridors**

In a classic case of Autodesk Civil 3D object dependency, individual horizontal alignment data and profile data need to coexist in a drawing. Furthermore, a large subdivision project would require an alignment and profiles (surface and layout) for each of the roads in the subdivision. Road alignments and profiles are coordinated in both plan and elevation. Most subdivision road designers, therefore, require ready access to all alignment and profile data from within one drawing to efficiently coordinate plan locations and profile elevations.

Corridors are a natural extension of the road alignment and profile design in a subdivision. Corridor models representing subdivision roads are created with surface boundaries at the right-of-way location. Corridor design elevations at the right-of-way locations can then be used for subdivision lot grading.

Subdivision corridors are required to do the following:

- Create grading feature lines at the right-of-way locations that serve as a starting point for the lot grading. Alternatively, design points could be created from the corridor feature lines at the right-of-way location. These points could be checked into the Vault and referenced by the designer responsible for the subdivision lot grading.
- Create corridor surface representing the datum design elevations. This surface is then incorporated with the proposed lot grading surface to create an overall design surface for the site.
- Create corridor surface representing the top design elevations. This surface is checked into the Vault and referenced by designers responsible for the storm sewer, sanitary sewer, and water-main design in a subdivision.
- Create proposed gutter or edge of pavement alignments from corridor feature lines. Alignment geometry is checked into the Vault for reference by designers responsible for storm sewer, sanitary sewer, and water-main design.

Organizations should consider two primary methods for breaking up alignment design, profiles, and corridor modeling. For most projects a combination of these two methods probably makes the most sense.

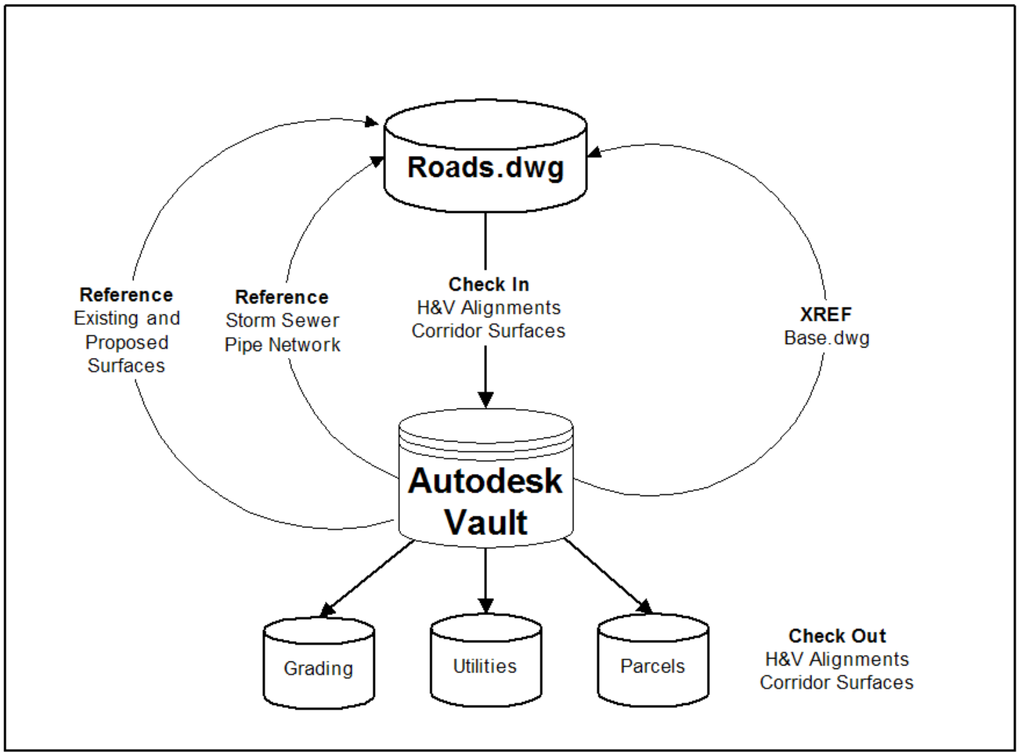
**Method 1:** In smaller projects where it is reasonable to have a single person designing all alignments, profiles, and corridor models, the most efficient method is to have all these data elements in a single drawing. The downside is that only one person at a time can edit any of these elements. However, alignments, profiles, and surfaces created from the corridor model can be saved as project references and then used by other team members.

A variation is that the alignment and profile be created in one drawing (drawing A) and then added to the Civil 3D project as reference objects. The designer creates the corridor model in a new drawing (drawing B) that references the alignment and profile. This technique helps to ensure that the alignment and profile cannot be modified. However, if the alignment or profile is adjusted in the alignment/profile drawing (drawing A), the reference is updated in the corridor model.

**Method 2:** The second method is to break all alignments (with their corresponding existing ground and design profiles) into individual drawings. References to the alignments and profiles are then used in new drawings to create the corridor models. Designers can then use this reference data in separate drawings to design the corridor model and surfaces. Variations include the following:

- One drawing that contains a single corridor model for the entire project. This option is suitable for smaller projects. The result is design surfaces (top, datum, and so forth) that can then be stored as reference data in the Civil 3D project. The downside of this technique is that only one designer at a time can model the corridor.
- Many drawings, each containing corridor models for parts of the project. This strategy enables several designers to work on zones or specific roads in a project. For example, User A can model a branch in a subdivision that includes a series of knuckles and a cul-de-sac while User B is doing the same on a different part of the project. They would both create design surfaces that would then be stored as reference data in the Civil 3D project. The final step is to create a new surface that is built by pasting references of these surfaces together into a new "quilted" surface.

The following figure shows project data dependencies:




Horizontal and vertical alignments, along with the corridor datum surface, are checked into the Vault. Designers involved with the detailed site grading, utilities design, and parcel layout then reference this data. Reference objects can be created and displayed using styles best suited to the type of drawing.

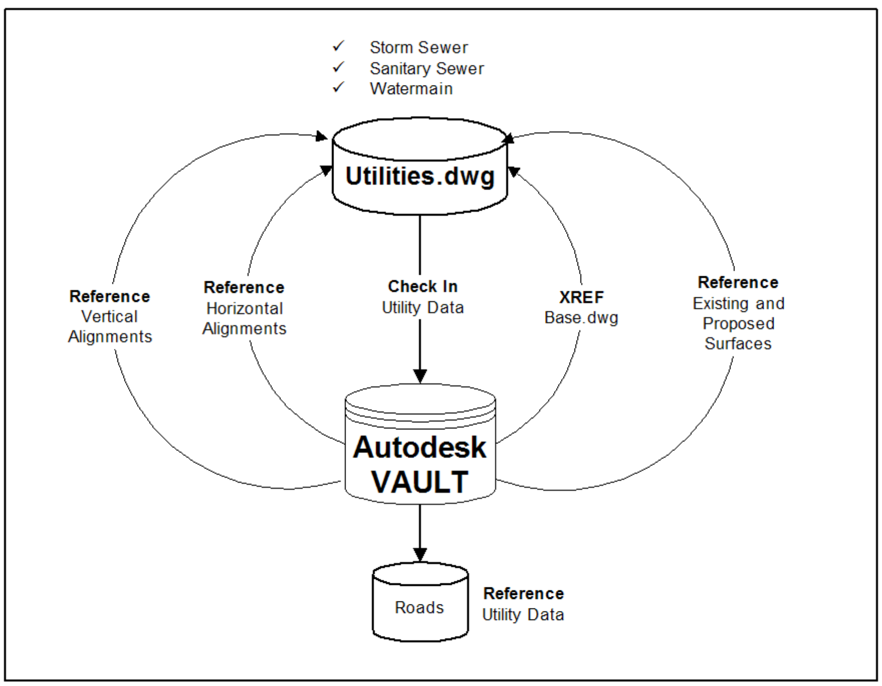
**Underground Utilities**

Autodesk Civil 3D pipe networks are created to represent the storm sewer, sanitary sewer, and water main in the subdivision. Often, designers create a separate set of drawings to show the design for each of these pipe networks.

Data required for the design of subdivision pipe networks includes the following:

- Preengineering base plan (externally referenced)
- Proposed subdivision road horizontal and vertical alignment geometry (create reference objects from the Vault)
- Finished design surface elevations (referenced from the Vault)

As shown in previous examples, this data is managed through the Vault. The following figure shows the data dependencies:




Often, subdivision road drawings show manholes and catch basins from a storm sewer network. Storm sewer utility data can then be checked out of the Vault and referenced by designers responsible for the subdivision road design.

# Employee Roles

Another significant contributing factor to drawing architecture and data sharing mechanisms are the specific employee roles within an organization.

The following represent possible scenarios:

- Multidisciplinary designers supported by drafting staff
- Multidisciplinary designers responsible for their own drafting

- Discipline-specific designers supported by drafting staff
- Discipline-specific designers responsible for their own drafting

Standards for drawing architecture have evolved based on individual involvement with projects. Autodesk Civil 3D is a design tool where the drafting is a by-product of the design. This represents a substantial shift from traditional design practices that involve a redline markup exchange between designer and drafter. In an optimal situation the roles of designer and drafter converge.

Whether designers are multidisciplinary or discipline specific, the drawing architecture must support the process and the roles of the individuals within the process.

# Summary

There is no specific standard in place that dictates precise procedures and methodologies for assembling many different types of data into a contract design package for a large subdivision design. Organizations must develop, implement, and adhere to a standard that accommodates the specific needs of large subdivision design projects. It's essential to fully understand the available functionality, specific employee roles, and project deliverable requirements of your client or organization.

Available functionality that promotes data sharing includes AutoCAD xrefs to share drawing data and Autodesk Vault to share Civil 3D object data. Organizations could use data shortcuts and reference objects themselves (without Autodesk Vault) to share surface, alignment, profile, and pipe network data.

Autodesk Civil 3D functionality significantly diminishes the role of the traditional drafter. It also automates time-consuming repetitive processes. Drafting roles, and hybrids thereof, still exist to a large extent in the industry. Both unidisciplinary and multidisciplinary designers are often responsible for their own drafting. As the roles of drafter and designer converge, drawing assembly standards for large subdivision projects must be established and perhaps changed to suit the way in which specific offices complete their designs. Large civil engineering firms may create and implement different drawing assembly standards for regional offices simply because of the differences in the ways they operate.

Finally, reference objects, Civil 3D styles, and AutoCAD xrefs enable users to display the same data in a variety of different formats. A road designer uses a template different from that of a utilities designer. Organizations must consider a system of styles and drawing templates that are required to tackle large subdivision projects. Standards (DWT files) must be centrally located on a server for all to access.

Finally, one of the biggest challenges is data management. Appropriate and consistent naming standards for drawings, layers, and objects must also be in place, organized within a project folder structure that is also well named and understood by all. This information needs to be documented in a corporate CAD standards manual that outlines processes, roles, and project hand-off requirements for large subdivision projects.