A Developer's Guide for Producing and Publishing Engineering Documents.

Introduction

The goal of the Developer's Guide is to show programmers (and users) involved in the development of engineering CADD applications how technology developed for the business world can be enhanced and applied to the production of engineering documents. The Guide also highlights how the use of CADD standards, such as the Construction Specifications Institute's "Uniform Drafting System" and the Tri-Service CADD/GIS Technology Center's "A/E/C CADD Standard," can significantly improve the success of these applications. Although the Guide's focus is on engineering drawings used in the construction industry, the concepts and techniques can be applied to the production of many other types of CADD-based drawings.

A secondary goal of the Developer's Guide is to promote applications that complement the use of electronic bid solicitations. Electronic bid solicitations replace the paper process used to solicit bids for construction projects with a much more economical CDROM or Web-based electronic process.

The processes suggested within this Guide recognize the need for applications that are both intuitive and intelligent. Applications that are intuitive understand the majority of its user’s thought processes and do not require them to learn how a command functions or where it is. Intelligent applications use data contained within a drawing to assist the user in performing routine tasks. Intelligent applications are intuitive. Typical CADD applications use default plot settings that are rarely configured to a users needs. The applications have no intelligence, and therefore can not anticipate the users need.

> Example: A user wishes to print a single detail from a drawing file\sheet with numerous details. It is a fair assumption that the user desires a scaled plot printed to his\her default printer. In an intelligent application, the scale could be determined by examining the text within the defined plot area. If the word SCALE is found, the actual scale of the detail is probably just to the right of the word SCALE. If the word SCALE is not found, the scale could be determined by searching for particular strings of characters such as 1/4”=1’-0”. The height of the text associated with the drawing could also be used to determine scale. Most engineers and architects choose text heights that will plot as one-eighth inch text. Therefore, if the text size is approximately 6” tall in the electronic drawing, and the dimension units are set to English, there is a high probability that the user expects to get a 1/4”=1’-0”scaled plot. An intelligent application could configure itself to plot the drawing as such. If a 1/4”=1’-0”scaled plot will not fit on the default printer, the intelligent application would know to try 1/2”=1’-0”, a half size plot.

Determining user needs by interpreting the meaning of seemingly independent items isn’t a new idea. Computer scientists refer to these types of software components as intelligent agents. Intelligent agents, as defined by IBM, are software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires. In the following chapters, detailed decision-making workflows are presented to provide a foundation for developing intelligent agents for printing/plotting applications and electronic document creation. The ultimate goal of this guide is not to satisfy everyone, but to provoke new ways of using the data generated by 50 to 80 percent of the CAD users.

Current State of Drawing Production within the Construction Industry

Drawing production is moving towards a digital end product. Each year more and more architects and engineers are finding ways of distributing construction documents electronically. In September of 1995 the Tri-Service CADD/GIS Technology Center was tasked with developing an electronic bid solicitation (EBS) process. The developed process won a Vice-Presidential Hammer award in 1997 and is being quickly adopted by the DOD and other federal agencies. The U.S. Army Corps of Engineers has mandated that the EBS process be fully implemented by the year 2000. The EBS process has cut cost and production time significantly. Currently compact discs (CD) are used as the primary means for distributing electronic construction documents. The long-term goal is to solicit bids strictly via the World Wide Web. Data transfer rate to small and medium size construction contractors via the Web is currently the biggest deterrent from advertising strictly via the Web. The private sector architectural and engineering (AE) firms have been slow to follow suit, but this has been mainly due to legal issues involving individual State Architectural and Engineering Boards that govern how AE firms sign drawings. A few States have removed these legal obstacles and others are in the process of removing them. Larger AE firms that have international clients have been using the Web in recent years for the review of construction documents that are in the process of being developed. Time has been the driving force behind electronic delivery of construction documents internationally. It can take four days to deliver paper documents one-way internationally. The construction industry is going through an evolution and is changing from a print then deliver process to a deliver then print process. It is hoped that this guide will take this one step farther and make the final electronic media the primary end product. The benefits of quickly navigating and retrieving information from an electronic set of drawings must significantly out-way the use of paper for this to happen. Once this happens, hardware and software providers will potentially see a market for portable devices such as the Palm Pilot or Sharp Mobilon-TriPad but larger and having functionality designed specifically for use within the construction industry.

The Uniform Drafting System (UDS) and A/E/C CADD Standards are national efforts to standardize the way construction information is generated and presented to a construction contractor. The two efforts have been coordinated on a national level. The Construction Specifications Institute (http://www.csinet.org/) has coordinated the development of the UDS. The Tri-Service CADD/GIS Technology Center (http://tsc.wes.army.mil/) has coordinated the A/E/C CADD Standards. It is expected that these standards will be combined by the year 200x. The future success of the UDS is almost guaranteed. This is evident because of the success of the Construction Specifications Institute's standards used for construction specifications, which are used almost exclusively nationally. It should also be noted that significant portions of the CADD standards are based on defacto standards already in use. The formal standards only serve to document the defacto standards.

Users will spend significantly less time using a nationally recognized standardized system than they would spend using a non-standardized system. Nonstandard systems force employees of AE firms to learn new systems as they move from one company to another. It is even worse for employees of construction contractors. They have to learn multiple systems as they receive work from various AE firms. The developer's guide intent is to support the standardization effort by providing developer's ways of creating major increases in an AE firm's production and quality control. There is a large amount of support for these national standards. Developers should strongly consider enhancing current CADD packages to take advantage of these national standards. Developers, after the review of the following concepts, should realize how they could gain a significant competitive edge if they adopt the concepts.

Detailed Concept

Engineering drawings are full of information identifiers. These information identifiers can be sheet or set specific, but are essentially the same from one drawing or set to the next. An information identifier could be a key word, a symbol, an area on a drawing or a combination of the three. Information identifiers can be a property identifier or a reference identifier. Property identifiers are items that identify properties of a drawing or a set of drawings such as a contract number, an address or revision descriptions. Property identifiers are typically useful in locating a drawing or a set of drawings. Reference identifiers are items that identify references internal to a single drawing or between multiple drawings such the word INDEX, section symbols or door symbols. Reference identifiers are typically only useful within a drawing or a set of drawings. This guide will hopefully show the benefits of recognizing the information identifiers that define our engineering documents and how using them in a more organized and affective manner would make our documents even more valuable.

The word INDEX is a reference identifier. In the context of construction drawings, INDEX identifies a sheet that contains a list of all the drawings contained within a complete set of construction drawings. The simple understanding of an index drawing could be used to sort a free flowing stream of drawings into their appropriate sets. The meaning of index combined with optical character recognition (OCR) could be used as the foundation for developing an optical document recognition system (ODR). An ODR tied with an area template could be used to sort scanned drawings and populate a drawing database without human input.

Symbols are commonly used as reference identifiers, which typically identify internal information links. For example: a station (12+00) is found adjacent to a segmented linear element. This tells a user at what point along a roadway alignment they are looking. A user recognizes the station number by the "+" symbol being placed between two numbers. The user also sees the linear element displayed adjacent to the stationing. As a result the user knows he is looking at a top view of a planned roadway for example. If the user would like to see a transverse section cut at the same location, they would look for a section-cut labeled 12+00, typically on a separate drawing. A program could be designed to understand this logic. Allowing the user to select the plan station text, the program then taking the user to the section cut on another sheet. For this to happen a viewing program would have to find the station type text and the segmented linear element on the same sheet and make an educated guess as to what the user wanted. Tagging the station text as it is being placed would be more efficient than the educated guess for this particular case. In most major road design projects programs are placing the plan and section text information. If the station text was tagged as it was being placed, a viewing program would not be making an educate guess as to how the reference should be made.

Property identifiers are most commonly found within the title block of a drawing and they define a property of either a single drawing or a set of drawings. Property identifiers can take the form of text describing the property or an area that contains the property. Properties found within a title block can usually be identified by both the text and area methods. Drawing and set properties are information that can be particularly useful when contained in a database and can be used for tracking or locating a drawing more efficiently. A drawing title block in a broad sense can be thought of as a database entry form and in many cases is the most appropriate place to enter database information for a drawing. Most applications typically require a user to enter drawing information into a separate database rather than extracting the data from the drawing where the information is required. A drawing could be looked at as a database record with multiple fields within a database table. A drawing index can also be thought of as a database table.

Engineering drawings are typically generate completely independent of each other. Defining internal hyperlinks would be much easier if a program knew that a certain set of drawings were related. This is where the current concept of batch plotting needs to change. In the future it is suggested that batch plotting not only be used for plotting multiple drawings at once, but also for compiling an electronic set of drawings to create a true electronic drawing document. To date there is not a product on the market that deals with a set of engineering drawing in an effective way. Engineering drawings are generally dealt with as individual files and their interrelationship is not recognized. This has been done for a multitude of reasons, one being the file sizes and hardware restrictions. It is also because many people can be involved in the development of a set of drawings. These people are quite commonly not even in the same state. In the current EBS process a set of raster images representing each construction drawing are delivered with a document file. The document file contains all the information that defines the interrelationship between all the raster images. The current application does allow a user to create internal hyperlinks. This capability has not been used to it's fullest. The major contributing factor to its lack of use is that it can take an enormous amount of time to manually define all the information links. And since there is no direct benefit to the architect or engineering firm, it is usually not done. The primary short fall of the current process is that it does not take advantage of the meaning of the information contained within a set of drawings. Modifying existing CADD tools and introducing new tools could solve this problem. The examples shown here in this guide are presented in order to illustrate how current workflows can be significantly improved, while accomplishing the goal of defining internal hyperlinks. Resulting in a whole new class of CADD tools that could be referred to as document tools. Document tools would place elements that could be used to aid in printing, hyper-linking and organizing engineering drawings.

The Developer's guide addresses two main concepts. The first concept is to use data as is and without modifying how a user places the data. This concept is useful when dealing with pre-existing paper and electronic drawings. The second concept is to modify the user's processes in a way that recognizes the data that is being placed. This concept allows applications to use data in engineering drawings with a higher degree of reliability after the adoption of the concept. The two concepts are not separated as such because concept one justifies concept two while concept two explains concept one. The guide does not cover all aspects of how engineering drawing documents are put together. It is only hoped that this guide will provoke new ways of placing and using engineering data contained within our drawings. These new methodologies will become the foundation of the software industry's recognition of the completed engineering document. Accomplishing this goal will ultimately make viewing and using electronic engineering drawings much easier, resulting in higher reliance on the electronic media rather than the paper media.

The Typical Sheet

The typical sheet layout discussed in this section describes the paper space within an engineering drawing and can be used in the development of intelligent plotting and compiling agents for use within the construction industry. This typical sheet layout has been developed over many years as engineers and architects have learned to perform their jobs more efficiently. Recognition of this sheet layout will increase engineering drawing production by making plotting and viewing functions more intuitive.

Users, no matter how experienced or not, will almost always draw a shape that represents the exact physical paper size of a desired hardcopy print within an electronic CADD drawing. This is done because all users are spatially oriented. Drawing this box allows a user to visually and accurately place where graphics are to be plotted on a final hardcopy print. This box also allows a user to reproduce hardcopy prints consistently. A typical border layout is shown in Figure 1. The outermost shape is a box that represents the physical paper size. The next box shown in Figure 1 represents the printable area of a plotter and is not an element that is actually in an electronic drawing. The printable area is also commonly referred to as the plotter limits. The inner most box is the actual border that is printed on a hardcopy

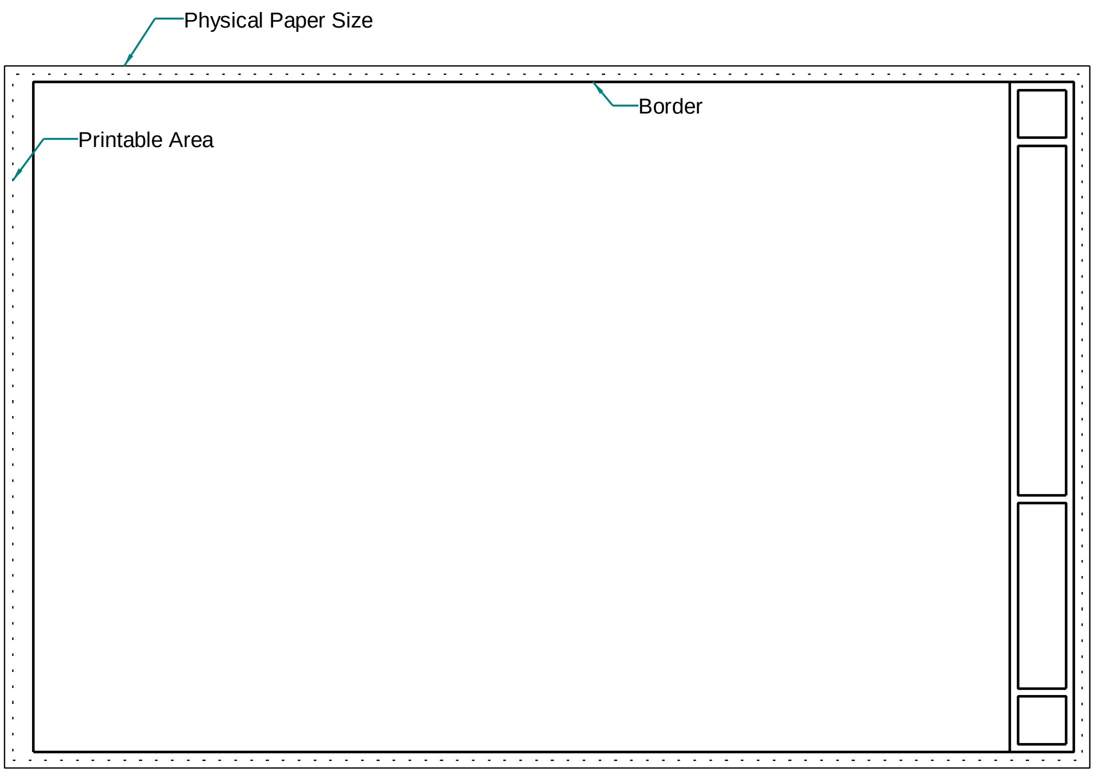


Figure 1: Typical Border Layout

print. The smaller boxes that extend up the right side represent areas where drawing and project information are placed. This area is commonly referred to as the title block area. The title block area is also commonly limited to a rectangular area in the lower right hand corner. The title block shown in Figure 1 is becoming the more commonly accepted method of laying out a title block. This is true because drawings are frequently rolled up and with the title block shown in Figure 1 the information can be read without unrolling the drawings. Graphics that depict project features are placed in the drawing area, which is the area inside the border excluding the title block area. On the left side of Figure 1, you should notice that the distance between the box representing the physical paper size and the border is larger than that of any other side. This is done to allow a set of drawings to be stapled with a binder without obstructing the information contained on the drawings.

Construction documents are unique in the fact that the industry strives to present information in a standard format. As a result there are only about 16 primary sheet sizes used around the world (see Table 1). User can now buy large and small format plotters that will accurately output these exact sheet sizes. The trend

Table 1: Standard sheet sizes for construction documents

ANSI		ISO		ARCHITECTURAL	
Mark	**Size (in)**	**Mark**	**Size (mm)**	**Mark**	**Size (in)**
A	8½x11	**A4**	210x297	**A**	9x12
B	11x17	**A3**	297x420	**B**	12x18
C	17x22	**A2**	420x594	**C**	18x24
D	22x34	**A1**	594x841	**D**	24x36
E	34X44	**A0**	841x1189	**E**	36x48
				F	30x42

has been for engineering companies to buy these new plotters as older roll feed plotters are phased out. The reason for this trend is simple economics. It is too expensive to pay an individual to manually trim plots that come off the older roll feed plotters. Construction drawings will typically contain shapes that represent one of these 16 different physical paper sizes.

Another trend has been to buy 11”x17” printer/plotters. This practice has come about because of a combination of reasons. When engineers relied primarily on bluelines for reproduction, reduced prints were virtually impossible to obtain during project development. As faster higher quality printers became available at lower cost, users were able to request smaller prints that remain legible. And since it is very easy to reduce a 22”x34” (one of the most commonly used sheet sizes) to an 11”x17” electronically, it has become a very common practice. It should also be noted that even the largest sheet size (30”x42”) can be reduce to a readable 11”x17” drawing when normal engineering drawing practices are used. Users want these smaller prints because they are more manageable when working at a computer terminal. As more and more designs were completed electronically work areas shrunk because large drafting tables were being eliminated. Leaving the workers with no where to layout full size plots. This may not seem relevant at the moment, but as you progress, you will see how this practice has affected border layout.

As it was pointed out earlier, printed graphics are quite commonly off center to allow for a binding edge on the left side. This causes problems for a typical user. The problems arise when the user tries to get a final print with the graphics properly located on an automatically cut sheet or a pre-cut sheet. The user can not define the outer most box as the area to be plotted because a properly scaled print will exceed the plotter limits. The only other choice the user has is to guess at defining an area that when properly scaled will fit within the printable area. It is virtually impossible to perform this task and have the graphics plot in their proper location consistently. One way users get around this problem is to place tick marks at opposing corners that are just inside the printable area. A user will typically set the final location of the tick marks through trial and error. After a user goes through this process a couple of times, they realize the locations of the tick marks are best located such that they define a box that is the exact same size as the printable area of the plotter that is being used. The tick mark locations vary with every make and model printer on the market. If new plotters were bought regularly and with in a short time frame, user would be very frustrated trying to locate these tick marks. What is the user actually doing when he or she is placing these tick marks? The user has defined the physical paper size by drawing the outer most box, which is typically the first thing drawn when creating a border sheet. By placing the tick marks, the user is electronically trimming their sheets, such that when the margins required to handle the paper in the plotter are added back, a final cut sheet size is obtained.

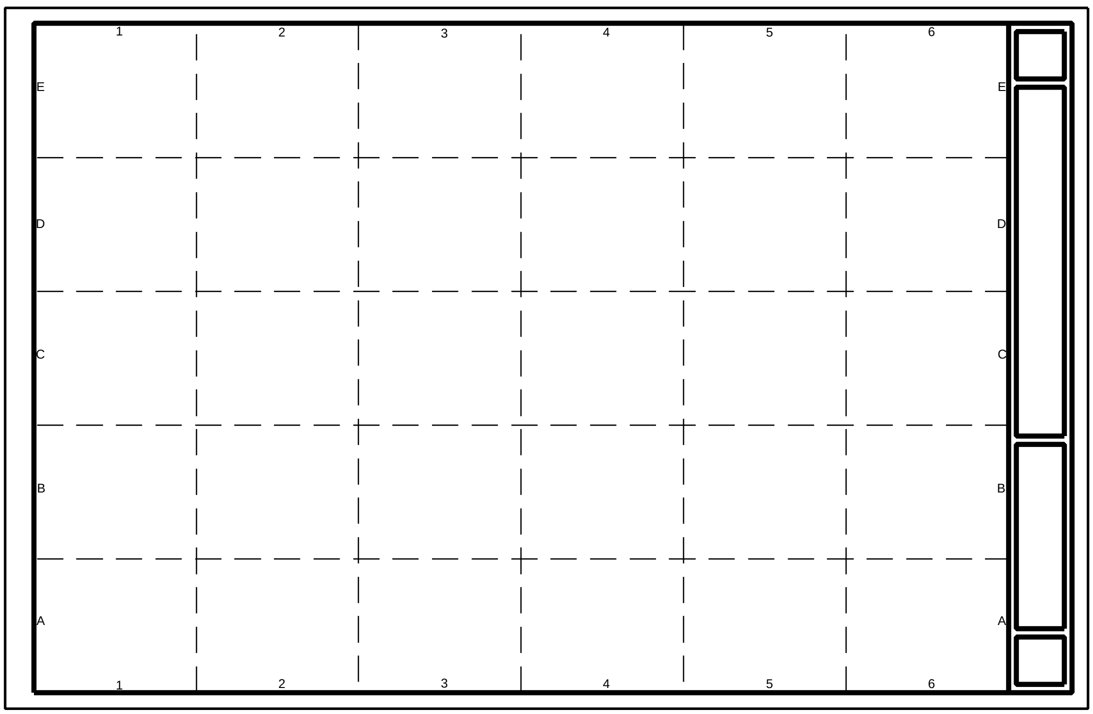


Figure 2: Typical border showing UDS drawing modules.

In module two (Sheet Organization) of the Construction Specification Institute's (CSI) Uniform Drawing System (UDS), ¾" margins are recommended on all sides except the left margin. The left margin is recommend to be 1 ½". These are not just arbitrary distances. These distances allow an "F" size architectural drawing to be printed out at a reduced scale and on an 11"x17" small format plotter without loosing graphics. The closest that can be plotted to one side of a small format plotter is 0.29". When this distance is scaled up to an "F" size sheet, the distance becomes 0.73", hence the 0.75" margin. Three quarters of an inch is also slightly larger than margins required to handle paper through a large format HP DesignJet printer, which is a very popular printer. Figure 2 shows a typical border that has the drawing area divided into 30 modules with the rows and columns labeled. Historically, the American National Standards Institute (ANSI) has placed these labels outside the border. They have been move to the inside of the border, once again, to allow reduced prints on small format printers and large prints on HP DesignJet type printers without loosing graphics.

Electronic engineering drawings are typically drawn at full scale and are reduced for printing. As a result the box that represent the physical paper size may not necessarily be 22”x34”. For example: A 22”x34” sheet that has a plot scale of 1”=20’-0” may actually be represented by a box that is 440’x680’. This size is arrived at by multiplying the sheet size in inches by 20ft/in. This can get even more complicated when more than one scale drawing is placed on one sheet. The boxes still remain unique because of their aspect ratio. If the long sides of all the standard sheet sizes are divided by their corresponding short sides, five individual numbers will be obtained. If an ANSI sheet size is found, the aspect ratio will be either 1.29 or 1.55. Aspect ratios of 1.33 or 1.5 indicate architectural sheet sizes and 1.41 ISO sizes. The aspect ratios of the ANSI and architectural sheet sizes alternate from one size to the next. The aspect ratio of the ISO sheet sizes is equivalent to the square root of two. ISO sheet sizes are also unique because any of the sheet sizes can be optically reduced or enlarged to any of the other sizes.

Engineers and architects have been taught for years that text on a finished full size paper print should be between 3/32” (2mm) and 1/8” (3mm) tall. Therefore, the text in an electronic drawing that is intended to be printed at a scale of 1/8” = 1’-0” or 8-ft. per paper inch would be represented in an electronic drawing as text between 0.75 ft. and 1 ft. tall. The electronic text height is calculated by taking the number of feet represented by one paper inch and multiplying it by the desired paper text height (8*3/32=0.75). Titles of specific items such as a drawing block, door schedule or window schedule are the only exceptions and these only occur a few times on each sheet. Title text is approximately ¼” in order to call your attention to them. The process of determining the text size required with in an electronic drawing can be reversed allowing an application to determine a sheet scale. The reverse process is described in the next section.

The outermost box, that represents a physical paper size and that can be found in most engineering drawings, is the foundation of this guide. This box defines the paper space in which an architect or engineer places all their construction data and is an electronic link to the real world. The box is the key to applications efficiently and affectivity printing and compiling electronic engineering drawings.

Automatic Sheet and Scale Selection

When a user request a print of an engineering drawing, print applications typically employ virtually no knowledge of the user's needs. This section will address automatic scale and sheet selection capabilities that could be added to current plotting routines. These capabilities would begin to anticipate user needs much like an auto-spell or grammar checker does in a word processor.

An option to auto-select sheet sizes and plot scales should be added to engineering print applications used by programs such as AutoCAD and MicroStation. This option should be defaulted to "on" when delivered. Sheet sizes and plot scales can be determined by sampling the elements within the defined plot area. The sampling should answer the following three questions: Are there any boxes with in the defined plot area that have an aspect ratio that matches one of those specified in Appendix A?, What is the most commonly used text size?, and Are there any text sequences that match the scales defined in Appendix A?

Aspect ratio checks should start with the defined plot area. This area is typically set using a window (AutoCAD), Fence (MicroStation) or an active view. If neither a window nor a fence is active, a printing application typically uses the area displayed by the active view. A third option to allow the user to always print standard sheet sizes is suggested. This option, when set, would force the printing application to search the entire file for the first occurrence of a shape that has an aspect ratio that matches a standard sheet size (see Appendix A) when a window or fence is not active. If the defined area does not have an exact aspect ratio (+/- user specified tolerances) that matches a standard sheet size, the aspect ratio of the element limits contained within the defined plot area should be checked. For example: if the view shown in Figure 3 was the defined plot area, the printing application should find the box contain within the view. If an area is found with a matching aspect ratio, it should be assumed the user wants a final hardcopy print that is an exact standard sheet size. To provide exact standard sheet sizes, a simple modification to the thought process used by most plotting applications will be needed.

Print applications should recognize the use of standard sheet sizes and typical margins. Most CADD plotting applications force a user to know what the printable area is of a specific printer, although they may not be consciously aware of it. A user can not simply define an area that represents a physical 11"x17" sheet of paper and have it plotted to scale with no manual trimming. If a user does define an 11"x17" area, they are force to reduce the print to allow it to be printed with in the printable area of the desired printer. The current printing paradigm dictates that the entire defined plot area be plotted, not recognizing the fact that clear margins are typically used. Software and hardware manufactures should work together to develop methods that use the defined plot area as the specification for the requested final sheet size. The defined plot area should then be electronically trimmed however necessary to provide the requested sheet size. If graphics fall outside the printable, a warning message should simply be provided to the users.

A print application can not determine the desired physical sheet size knowing only the aspect ratio of a box. The aspect ratio only identifies a standard drawing sheet. The actual sheet size and scale is determined using the tables in Appendix A and the most commonly used text size found during the element sampling discussed earlier. The most commonly used text size in feet can then be divide by

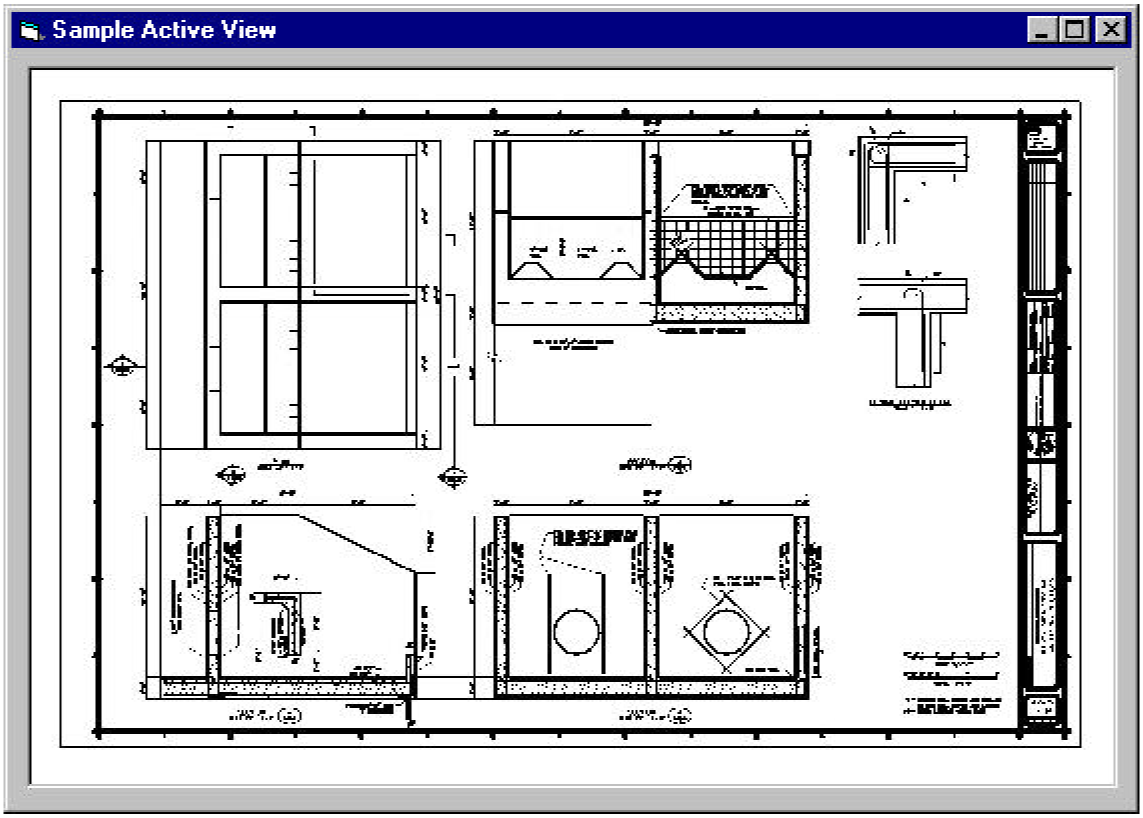


Figure 3: The aspect ratio of the element limits shown within the active view matches a standard sheet aspect ratio of 1.55.

7/64", an average text height. The resulting number is the approximate scale in feet per inch. For example: If a text sampling resulted in a text size of one foot, the approximate scale would be 9.14-ft. per inch or one foot divided by 7/64". The scale can be finalized by using the tables in Appendix A. For example: if the identified box has an aspect ratio of 1.55, an approximate scale of 9.14-ft per inch, and a short dimension of 88 feet, it can be determined using Table 1 of Appendix A that the desired scale is 1/8"=1'-0" and the physical paper size should be 11"x17".

If an area with a standard aspect ratio is not found, the text with in the defined plot area should be compared against the scales defined in Appendix A. When the comparison is made, all character such as a space should be removed from the compared strings. If a text sequence is found to match, an attempt should be made to print the area at the located scale. The printing application should first determine the element limits within the defined plot area. The paper size that is required to print the element limits at the located scale should then be determined. The print application should then select a printer and the smallest available paper size on which the element limits can be centered and printed to scale. The selection logic should also consider rotation. Matching the long side of a printer's printable area to the long side of the element limits. If a user does not like the selection that is made and changes the printer, the application should reselect the paper size using only those sizes available on the selected printer. If a scaled plot will not fit on any sheet size available on the selected printer, sheet selection with a half size scaled plot should be attempted.

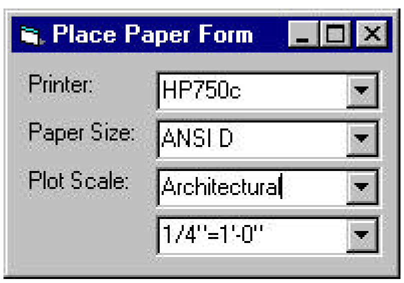
If a scale match is not found, a maximized plot of the element limits should be printed to the default printer. Before the plot is maximized, the imaginary box that defines the element limits should be rotated such that the long side of the box matches the long side of the default printer's printable area.

Several options should be added to the overall selection process discussed above. The ability to restrict the print application to selecting only Metric or English scales should be allowed. The Metric scales that should be delivered with the product are shown in Appendix A, Table III; English scales are shown in Tables I. The capability of adding or removing scales or sheet sizes should be allowed. These options need to be added to allow other industries and individuals to also take advantage of the auto-selection processes.

The underlying principle behind the selection process being discussed above is that a CADD user generally wants one of two things when printing. They want either a professionally looking print on commonly used sheet sizes or they just want a print where scale and size are not important. The above process satisfies both cases where current printing applications only satisfy the latter. The selection process discussed above could potentially be made more reliable by creating new document tools. One such tool is the manual sheet definition tool described in the following section. There are also other utilities discussed in this guide that could be used to identify sheet attributes, such as the scale. These other techniques have a major disadvantage. They require the user to be knowledgeable of a programmer's process rather than the programmer becoming knowledgeable of the user's process. As a result, the application is more difficult to learn and does not recognize the fact that great applications make simple task simple. Other techniques also would not allow easing printing of the thousands of existing CADD drawings. The automatic sheet and scale selection process also satisfies a goal to discuss new methodologies of producing drawings without regard to how impractical they may or may not be to implement.

Manual Sheet Definition

Manual sheet definition is a method of placing rectangular boxes that represent real world paper sizes with in electronic CADD drawings. As discussed in earlier sections, this box is almost always placed in an engineering construction drawing regardless of the skill level of a user. If a utility was provided to aid in the placement of these shapes, the shapes could then be used to enhance the printing and compiling of electronic engineering drawings with a higher level of confidence than the method describe in the previous section. The disadvantage to this method of defining sheet locations with in an electronic drawing is that it creates another command for a user to understand, which further complicates already complex applications. The advantage to this tool is that it allows a user to reliably define a plot area once rather every time the user requires a print.



A form as shown above should be provided with a document tool that places rectangular elements with in an electronic engineering drawing that represents real world paper sizes. The printer combo box may not be necessary and should only be provided if it is required to determine the available paper sizes on a remote print server that is being used. The paper size combo box should list all available paper sizes on a local or remote print server. Custom paper sizes should be defined using the operating system's print server properties and not with options provided with the printing application. The first combo box associated with the plot scale should group plotting scales into a minimum of two groups architectural and engineering. A third mapping group should also be considered. The second field associated with the plot scale should present the user with the various scales associated with the group defined by the first field. Appendix A list the scales that should be provided as a minimum. This command should also limit the scales present to the user to either Metric or English scales. The Metric or English option should be set using other functions that are typically provided with a CADD system.

Once a user makes their selections on the form above, they should be prompted to place the rectangle. The insertion point should be one of the rectangle corners. The rectangle size should represent the final cut paper size required by the user and it should be scaled as defined by the plot scale. Once the rectangle is placed, the command should attribute the box with the paper dimensions required. The other information provided in the form is not important to later decision making. The placed scale is not important because in most cases a user will place the rectangle at 1:1 in association with a border sheet that is then typically scaled with other CADD tools. The important information is final paper size.

When using the rectangle for printing, the printing application should use the shape in a manner similar to that described in the previous Automatic Sheet and Scale Selection section. The printing application's default settings should be set such that the application selects a black and white printer that is capable of printing a full size sheet. The application should also electronically trim the plot area as necessary to provide the defined sheet size. This shape could also be used to define the area within an electronic drawing that reference and property identifiers should be found. The usefulness of this will be demonstrated in later sections.

Electronically Organizing Drawing Sets

The Construction Specification Institute's (CSI) Uniform Drawing System (UDS) has documented a procedure for organizing a set of construction drawings that has been loosely used by architects and engineers for over 20 years. The methods described in this section take advantage of the UDS procedure and will allow a user to compile and use electronic construction documents more efficiently. The goal of this section is to describe automated methods to compile and print a set of electronic drawings and create an index sheet by simply selecting the native CADD drawings. This will be accomplished by using the filenames or information contained within the files. If an option to use the UDS sorting or not is provided, CADD users that do not use the UDS standards will not be impacted. Adoption of the methods will also assist the construction industry in their standardization efforts.

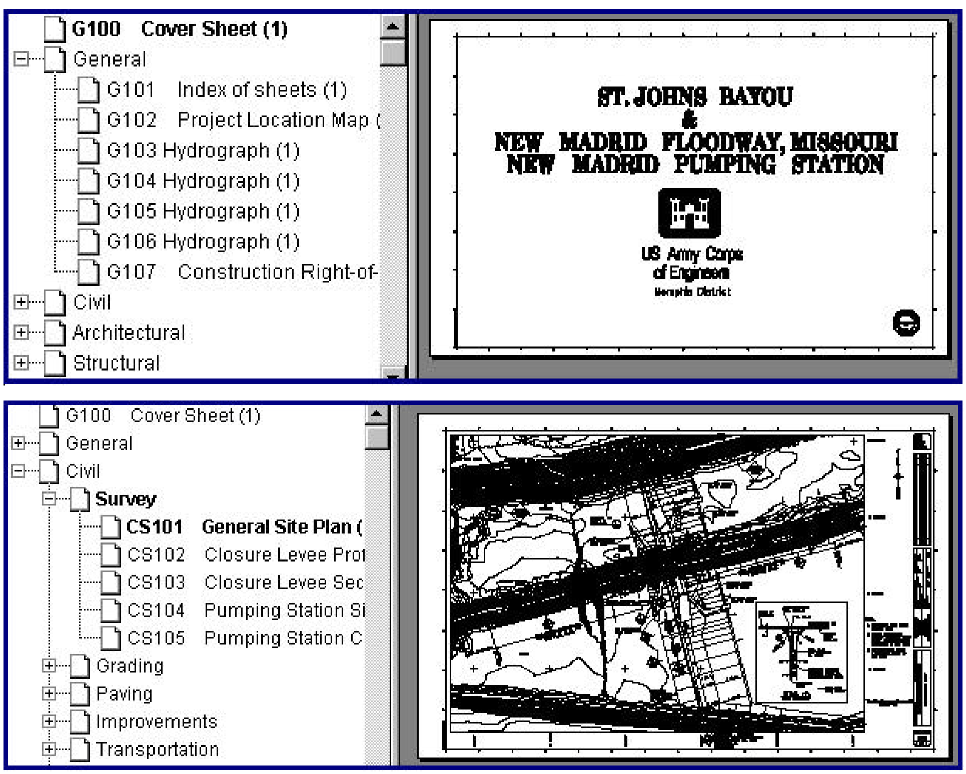
To compile or print a set of electronic construction drawings a user has to put the drawings in the correct order. Small jobs (approximately 10 drawings) may not use the UDS sheet identification (page number), but may simply be numbered 1 through 10. The order here is self-explanatory. Larger sets of drawings typically use the UDS sheet identification to determine the drawing order, which is not alphabetically or numerically ordered. The order appears to be completely random, but is related to the construction sequence of a typical project. The UDS sheet identification is based on a five-character designation (AANNN). For example: CS101 may be the General Site Plan in the Civil-Survey section of a set of plans. The first character (**A**ANNN) is the level 1 discipline designator. The second character (A**A**NNN) is a level 2 modifier for level 1's discipline designation. The third character (AA**N**NN) is a sheet type designator and is a numeric number ranging from 0 to 9. Fourth and fifth characters (AAN**NN**) are sequence numbers. A table is provided in Appendix B that shows each of the discipline designators and their modifiers. The order in which the designators are shown in the table represents the correct drawing placement with in a set. The difficulty in electronically sorting a set of drawings using the UDS system is that standard bubble sorts use the numeric numbers associated with each ASCII character and only sorts in ascending or descending order. The Visual Basic routine shown in Appendix B sorts an ascending alphabetically ordered list of sheet identification numbers using a table that defines the UDS order. UDS designations when sorted alphabetical will contain groups of files that will be ordered correctly, allowing groups of files to be sorted using only the first two characters of the designation. This is possible because the three numeric characters always fall in order when alphabetically sorted. If a list contains only numbers as in a small job, the routine in Appendix B will not affect the order.

It took over 50 pages to completely describe the sheet identification in the UDS manual. All the national CADD standards put together encompass over 1,000 pages of documentation. The shear volume of the information within these standards creates an educational problem that will never be completely solved. This is due to many factors such as a simple misinterpretation of the standards, employee turn over, the cost of the standards and the fact that the standards are voluntary. The methods describe in this section acknowledges this problem, but also recognizes the fact that the standards will be used in its general form. The UDS ordering routine will correctly order sheet identifications such as CS01, C1, S-1, A201 and almost any other misuse of the industry standard.

The UDS ordering routine has two primary applications. One application is when an application can only recognize filenames. This would typically occur when a third party printing company is printing construction documents that have been provided by an architect or an engineer for a construction contractor. The second is when a user is compiling an electronic drawings document and the compiling application has been designed to understand the information within the individual drawings.

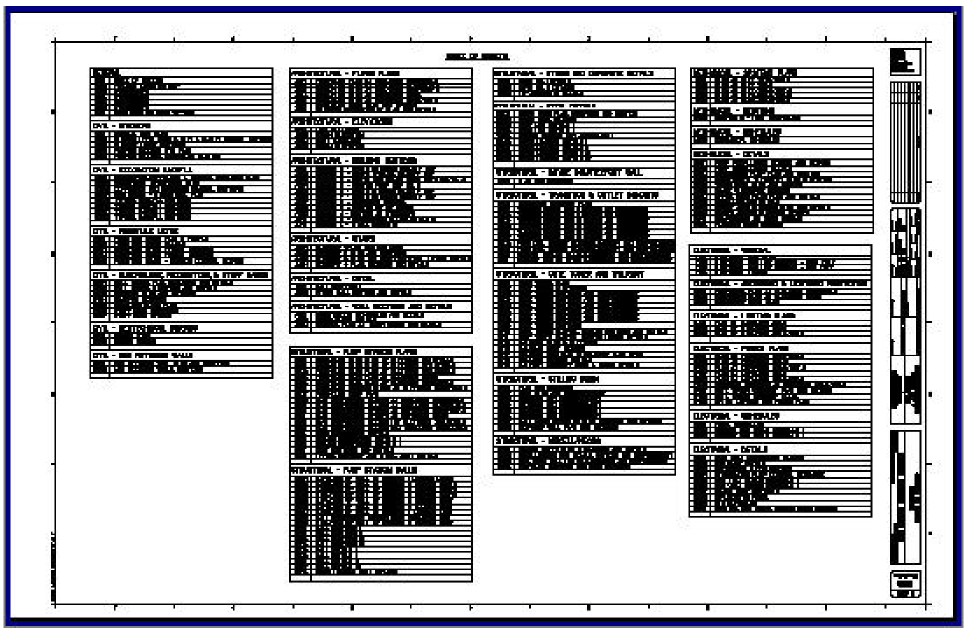
The applications used by companies that are printing construction drawings should have an option for UDS sorting. The option should be presented in a combo box with default sorting options of Normal and UDS. The user should also be capable of creating other filename maps that would define non-standard locations of sheet identifications with in the filename. As non-standard filename maps are added they should be displayed in the combo box from one session to the next. These options will provide printing companies with fast flexible sorting capabilities for dealing with multiple clients and industries.

When compiling an electronic set of engineering construction drawings, a couple of pieces of text within each drawing could be used to automate the process. CADD applications such as AutoCAD and MicroStation should allow users to attach standard element attributes (AutoCAD) or tags (MicroStation) to text, as it is being place. These standard document attributes should be present in combo box on both the text placement and text editing dialog boxes. The combo box should allow the user to identify text as normal, sheet identification or sheet title. A list of suggested standard text attributes are present in Appendix C. The goal here is to create an electronic drawing document with a table of contents in a tree view as show below. This should work much like the document map in Microsoft Word, which is generated using the levels associated with each style.



When a user selects a set of electronic drawings, the compiling application should first read all the sheet identifications and sheet titles. The application should then order the drawings utilizing the UDS ordering method. The application should then build and link the electronic table of contents. The first and second levels of the tree view should be determined and named based on the table presented in Appendix B. If the second level sheet identification modifier is not present, the second level and name should be dropped from the tree view as shown in the top example in the figure above. If both the sheet identification characters are present, a table of content as in the lower example should be generated. The last level should be generated using the sheet identifications and the sheet titles extracted out of each drawing. This same information should also be displayed in the header of the viewing window and after the document file name. This is useful when the tree view is not displayed and the use is simply paging through the document. If no sheet identification characters are found, then a single level table of contents with sheet titles only should be created.

The last item that needs to be generated is an index of drawings. The index serves the same purpose as the table of contents above, but is primarily used in conjunction with the printed paper document. On large projects an entire sheet or sheets, as shown below, are dedicated to indices. Smaller projects may only have a portion of a sheet dedicated for an index. It is suggested that an attributed box be placed on a



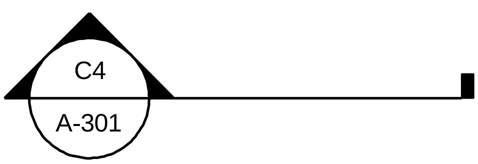
sheet to designate what portion of the sheet should be set a side for generating an index. This box should never be printed. A table definition, as shown below, should be place with in this box. The table

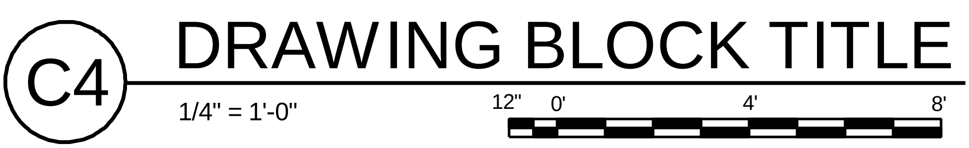
Discipline Header	
ShtID	ShtTitle

definition would define the element attributes and locations to be used when generating the index. The discipline header would be repeated for each discipline designation (Ex.: Civil – Survey) and followed by all the associated sheets. Index columns should be evenly spaced with in the defined area. An option should also be provide to allow disciplines to be broken and continued at the top of the next column. If a discipline is broken, the header should be repeated with “Cont’d” appended to the end of the header text. A discipline header should not be place at the bottom of a column, if there is not room to place a sheet title afterwards. This could be controlled further using the table definition. For example: if two sheet ID’s and sheet titles where placed after the header in the table definition, this would tell the application to move a header to the next column, if there is not space for a header and two sheet titles. As the index is being created, links should also be established between the sheet titles and the appropriate sheet. The links would be used by a viewing application to jump the user to a particular sheet, should a user click on the text while viewing the document electronically.

Detail Pointers and Markers

The Construction Specification Institute's (CSI) Uniform Drawing System has a complete section dedicated to symbols. One specific symbol categorization is a reference symbol. These symbols refer the reader to information in another area of a set of drawings, or give basic information regarding the drawing or data on the drawing. This guide breaks these symbols down even farther to what will be referred to as detail reference symbol. These symbols serve two functions, one that refers or points the reader to detailed drawings in another area of a set of drawings, the other to mark the location of a detailed drawing with in a set of drawings. A detail pointer is a symbol that has text contained within it that tells a reader where to find a specific detailed drawing. There are eight deferent type detail pointers. A detail marker simply marks the location of a detailed drawing and only has one basic type. The UDS refers to the detail marker as a drawing block title. The text with in these detail pointers and markers tie them to each other. For example: the pointer (shown below and on top) points to the marker or drawing block title "C4" that would be shown on sheet "A-301". Pointers and markers are used in every set of construction drawings. Tools that are specifically designed to place these symbols should be provided with CADD application such as AutoCAD and MicroStation. The paragraphs below describe detail workflows that should be used in placing the drawing block title and the eight type pointer symbols that are shown in Appendix D.



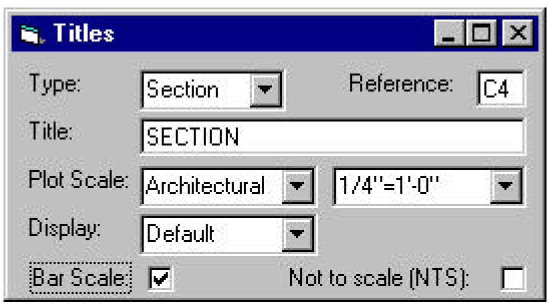


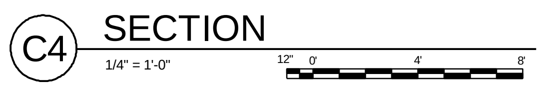
The biggest advantage to providing tools to place pointers and markers is not the increased placement efficiency, but how their usefulness would be improved in compiling and using electronic documents. When compiling a document, pointers and markers would have to be reconciled. If errors occurred, it would make sense that warnings would be present to the user. The reconciliation is therefore performing some quality control for the engineer or architect. This doesn't necessarily get the right pointer associated with the right marker, but the compiled document would make it easier to check the association. The user is now being assisted with a quality control process that is currently completely manual. When navigating a set of drawings, it can take several seconds or even minutes to recognize a pointer or marker, read the information and then move to the sheet on which the appropriate pointer or marker needs to be found. This process would be immediate with a compiled electronic document allowing engineers, architects, owners, contractors, code enforcement agencies and other individuals involved in the construction or maintenance of building to become familiar with the building much more rapidly.

These tools will also support the standardization effort and increase the efficiency of navigating paper documents. The tools will provide extra incentives for users to use standardized symbols. As a result, the physical appearance of the symbols will tend to be limited to those developed by software manufactures and not symbols developed by individual engineering and architectural firms. With the physical representation limited, it will take receivers of paper documents less time to understand and navigate the paper.

Auto-linking pointers and makers can not be accomplished without first identifying the sheet identification numbers associated with each sheet. A method of identifying sheet identification numbers is suggested in the previous section "Electronically Organizing Drawing Sets". The actual linking of these reference symbols should take place when a user selects a group of files to be linked or compiled into a finished electronic drawing document.

The tool for placing markers or drawing block titles should present the user with a form as shown below. The goal here is to aid the user in placing smart markers by attaching attributes to marker as they are being placed. The actual dimensions of the marker are defined in module 6 of the UDS. The insertion





point should be located at the right end of the horizontal line. All elements that make up the marker should be sized and located based on the active text size. The length of the horizontal line should equal either the length of the text in the title field or the minimum length required to place the scale text and the bar scale. It should be assumed that scale text (¼" =1'-0"), which is shown below the word SECTION, is to be placed at the active text size and that the active text size represents a text height of 3/32". This assumption allows a programmer to define location of the elements that make up the marker in terms of the active text height. For example: the circle is should be 5/8" diameter or 6.67 times the active text height. If the active text height is set to 0.375 ft. as it would be for a ¼"=1'-0" scale, the diameter of the circle should be 6.67 times 0.375ft. or 2.5ft.. The assumed relationship between the active electronic text height and the associated paper height is a good assumption. All text on an engineering drawing is the typically the same size with the only exception being specialty text such as the larger text associated with the marker.

The reference field is a key-in field for defining the text that is to be placed in the center of the circle on the left side of the marker. The reference field text should always be uppercase. Historically this text may have simply been a single number or letter. The construction industry however is pushing for this reference to refer to a drawing block with in the drawing area. Using this method allows a paper user to find markers on a sheet faster, because "C4" then refers to row C column 4. The row and column labels start in the lower left-hand corner of a drawing sheet and create boxes that are approximately 5.5" tall by 6.25" wide. The drawing area and drawing blocks are described in the UDS sheet organization module. If developers recognize the UDS convention, there is potential to automatically set the reference designation based on the display area and will be discussed in the "Using UDS Drawing Blocks" section. For now, we will assume the reference designation is a random attribute of the marker.

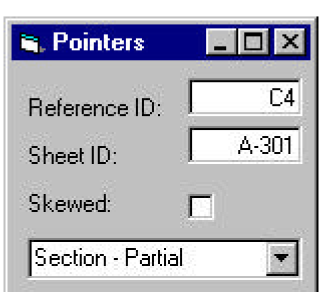
The title key in field and the type combo box are associated to each other. The combo box should have four options DETAIL, SECTION, ELEVATION or CUSTOM and is only provided to save typing time. If one of the first three options is selected, the title text should be set to that of the option. If a user begins to type in the title field, the type should be set to custom. If the user selects the custom option, the focus should be set to title field and the field cleared.

The scale option defines the intended plot scale and the scale text that is to be placed. This option has two combo boxes associated with it. The first box is provided to categorize and limit the actual number of scales provided to the user. This box should have a minimum of two categorizations, Architectural and Engineering. A third Mapping option could be added. The minimum number of scales that should be provided are shown in Appendix A. The scales should also be limited based on an English or Metric option, which is typically provide with CADD applications elsewhere. The default setting for this option should be set by dividing the active text height by 3/32". For example: As shown above the active text size used when developing a ¼"=1'-0" drawing is typically 0.375 ft.. If 0.375 ft. is divided by 3/32", four is calculated, which indicates a ¼"=1'-0" using the table in Appendix A. If the user changes the defaulted scale, the active text size should be set to provide 3/32" paper text. This is accomplished by multiplying the number of feet represented by a paper inch by 3/32. For example: Four feet per paper inch (¼"=1'-0") divided by 3/32" yields 0.375 feet. Once again the tables provided in Appendix A can be used to assist in these calculations.

The Display combo box should have three options Default, Active View and UDS Box. This option associates a scale to a given area of a drawing. The option is also used to set the area that is to be displayed when hyper-linking drawings. The future display area should be calculated relative to the bottom center of the marker. A viewing application should also put the marker at the bottom center of the active view when resetting the displayed area during a hyper-linking operation. The Default option should set the height of the displayed area to 60 times the active text height. This represents an area that is approximately 7.5" tall in the paper world and allows text to be read on a 17" monitor with a 1280x1024 resolution. A multiplier variable could also be provided to allow the user to modify the default factor, which can range from 40 to 100 depending on the monitor and its settings. This option could also force a viewing application to determine the monitor size and resolution, setting the displayed area accordingly. This would result in different users being displayed different total areas. The Active View option would set the future displayed area to that of the active view at the time of marker placement. The UDS Box option would set the future displayed area to some multiple of a UDS standard drawing module size of approximately 5.5"x6.25". The actual size of the future display area would be determined using the scale option, which relates electronic units to paper units. Use of the UDS Box option would require the user to first identify the marker location and then the drawing box by locating the diagonal corners. A temporary dashed box should be displayed as the box dimensions are being set. Immediately following the marker placement a temporary box the size of one module should be displayed. The box should be displayed such that the marker is bottom center. The box size should be increased in multiples of UDS a module while keeping the marker center bottom of the temporary box. This information would be associated to the marker as a hidden attribute.

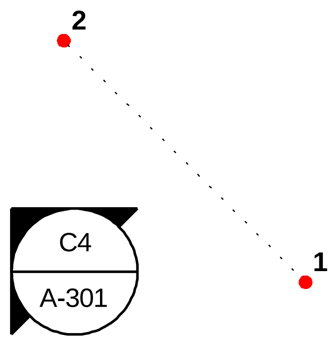
The "Not to Scale" option would be use to tell the application not to place the scale text under the marker, but to place the text "Not to Scale" or "NTS". This option is needed because even though a detail has an intended plot scale it may not necessarily be drawing to scale.

The tool for placing pointers should present the user with a form as shown below. Once again the goal here is to place smart pointer by attaching attributes that could be understood by a compiling or viewing

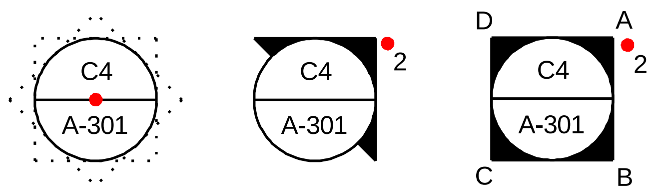


application. The actual dimensions of the pointers can be found in module 6 of the UDS. All elements that make up the pointers should be sized and located based on the active text size unless noted otherwise. The Reference and Sheet ID's are key-in fields that are arbitrarily filled in by the user and should always be uppercase. The text should be placed as attributes of the horizontal line that separates the Reference and Sheet ID. The Skewed check box tells the placing application that the user wishes to place a pointer at an angle other than 0, 45, 90, 135,180, 225, 270 or 315. The last combo box defines the type of pointer to be placed; Section Partial, Section Building, Detail Circle, Detail Rectangle, Detail Small, Election Exterior, Elevation Interior or Elevation Multiple Interior.

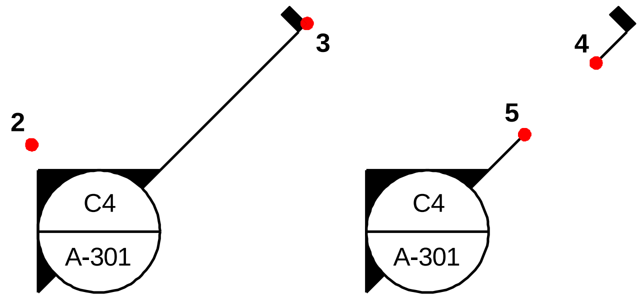
The Skewed option should not be allowed when a detail type pointer has been selected. If a section or elevation type pointer is to be place with the skewed option checked, the user should be asked to define the skewed angle by placing two points as shown below. The first point is simply a reference point. The



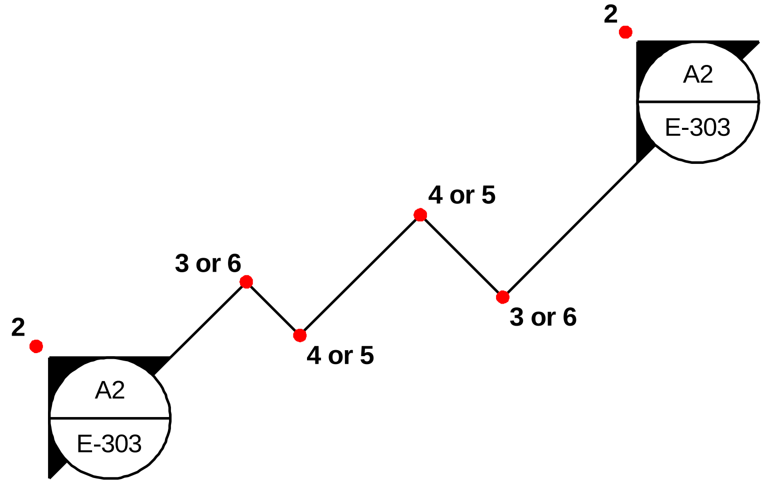
second point not only defines the angle but the direction in which the symbol should point. In the case of the multiple interior elevation symbols, the second point should define the side on which the "A" should be placed. In all cases the symbol text should always be placed horizontal to the active view. The text should be subsequently rotated, if the graphics are rotate with a view rotation command. Immediately upon placing point two, the selected symbol type should be dynamically attached to the cursor to allow placement to continue.



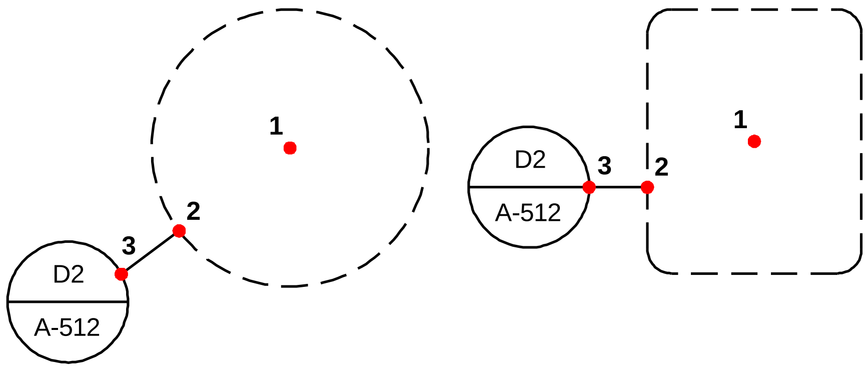
Section and elevation placement should begin by dynamically attaching the symbol above left to the cursor, when the skew option is not checked. The user should be prompted to place the symbol at this time. The dashed lines around the symbol provides the user a visual aid to where the symbol will fit without overlapping other elements. Once the symbol has been placed, the arrow direction should dynamically track the cursor in 45-degree increments. The second point should define the arrow direction. If an elevation symbol were being defined, its placement would be complete at this point. The second point should also define the location at which to place the "A" in the multi-interior elevation symbol. The remaining three characters should be placed in a clockwise fashion and keeping the characters horizontally oriented.



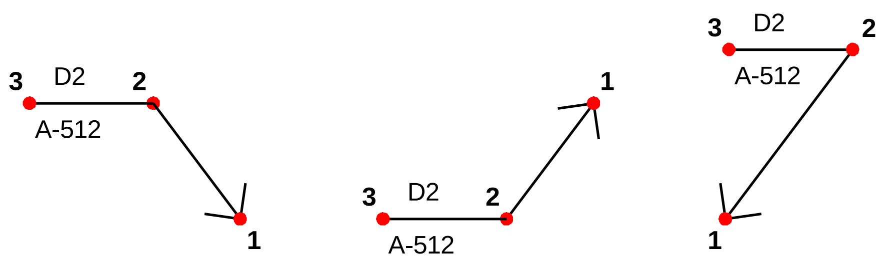
When placing a Partial Section as shown above, a third data point should define the length of the section line. A right click at this point would complete the placement of the symbol as shown on the right below. A fourth and fifth point would define where to break the section line as shown below. The command would be reset immediately following the fifth point.



When placing a Building Section as shown above, a second symbol having the same orientation as the first shall be dynamically attached to the cursor immediately following placement of point two. The third point shall place a line that is perpendicular to the direction in which the first symbol was placed. Subsequent points shall define lines that remain perpendicular to each other. A right click should be used to complete the command. The connecting line should be placed as to allow the user to partially delete portions of the line as necessary.



Three points will be required to define Circular and Rectangular Detail symbols as shown above. The first point will define the center of the circle or rectangle, which would also be the approximate center of the area that is to be highlighted. The second point will define the diameter of the circle or the length and width of the rectangle. The circle and rectangle should be dynamically displayed as they are being defined. Immediately following placement of point two, the text and circle should be dynamically displayed. The connecting line should vary in length and remain perpendicular to both connected objects.



Three points will also be required to place a Small Detail symbol as shown above. The first and second points should define the length and direction of the arrow. After the first point is placed, a minimum length tail should be dynamically displayed away from point one while point two is being defined as shown in the first two symbols. Point three will define the length of the tail and its final location. The tail should always remain horizontal.

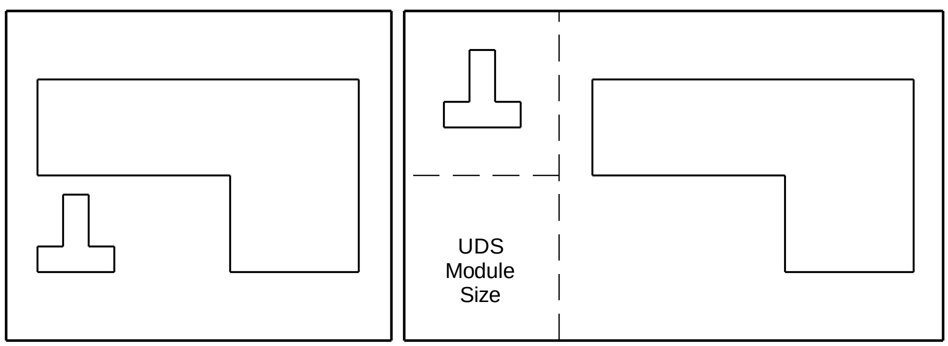
Using the tools just describe a user will place pointers and markers with in several drawings. The user would also place text in each drawing that would be attributed as a Sheet ID. Reference and Sheet IDs would be associated with each pointer. Markers would have three associated attributes (Reference ID, scale and display area). A compiling application should prompt the user to select a group of files. Once the user accepts a group of files the application should reconcile each Pointer and Marker using the Sheet IDs. If a Pointer is found that does not have a corresponding marker or vice versa, the application should warn the user.

A viewing application should have the following functionality. If the cursor is held over a pointer, the detailed drawing should be displayed much like a Visual Basic tool tip. If the user left clicks on a pointer, they should immediately be taken to the detailed drawing. Measuring tools will more than likely be provided with a free viewing application, therefore the measuring scale should be set as the application jumps from the pointer to the marker. If the user right clicks on a pointer, the user should be allowed to move to the appropriate marker or other locations at which the associate marker has pointers located. It is quite common to have several pointers associated with one Marker. When jumping to a pointer, the pointer should always be place in the center of the active view. The displayed area should be 60 times the text within the pointer or proportioned base on the monitor and it's display settings. A right click on a

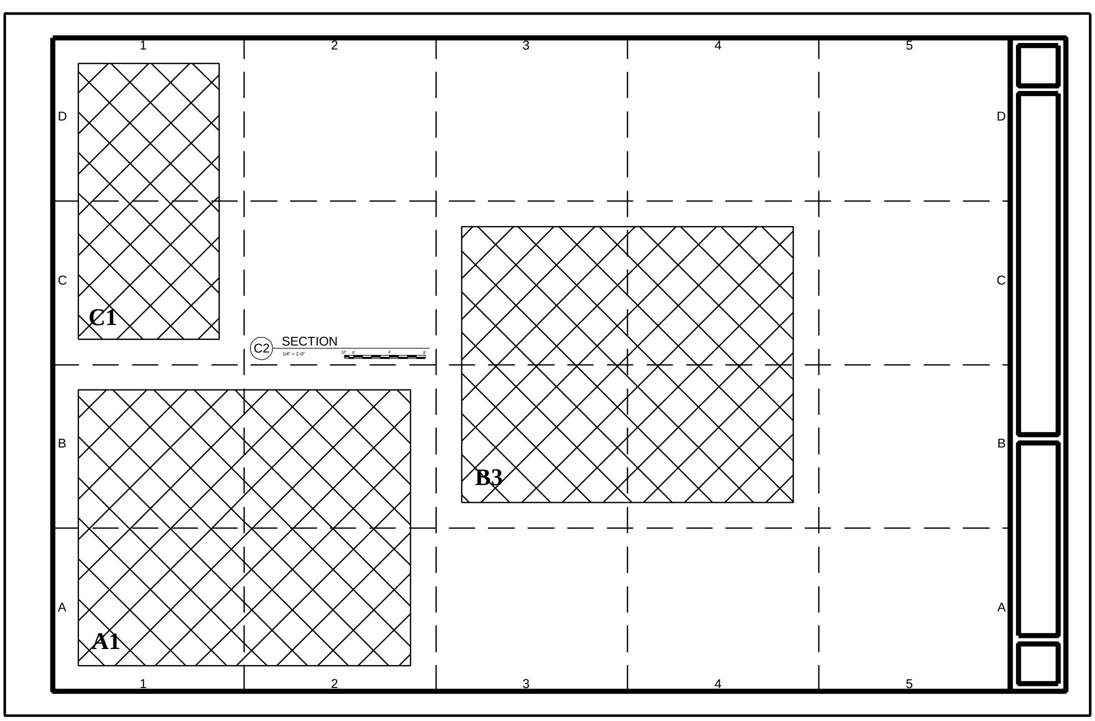
Marker should allow the user to select from a list of available pointers. A left click within the Marker circle should take the user to the first available pointer. A left click on the scale text associated with the marker should set the measuring scale provided the UDS Area Methodologies are not being used. When jumping to a marker, the attributed display area should be used.

Using UDS Drawing Blocks

The UDS drawing block concept could be taken advantage of by a CADD or viewing application. If properly developed, a CADD application could automatically scale and label standard detail drawings as they are placed on an engineering drawing sheet. Measuring within an electronic sheet that contains multiple scales could take place without the user specifying a different scale as they move from one detail

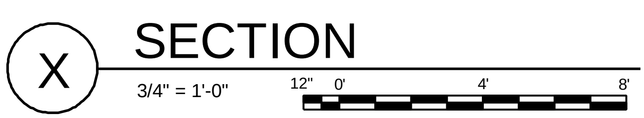


Wrong **Correct**

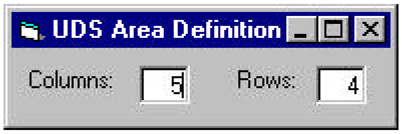


to the next. The UDS drawing block concept is based on the idea that independent drawings contained on a single sheet should not overlap as illustrated in the simplified sketches above. The sketches on the left are grouped incorrectly because they are not spaced such that drawing modules can be combined to create a rectangular drawing blocks that do not overlap. The Construction Specification Institute's (CSI) Uniform Drawing System (UDS) recommends that the drawing area of a sheet be divided into drawing modules as shown above. The size and the total number of modules will vary from one sheet size to the next, but the blocks should be approximately 5.5" tall and 6.25" wide. The modules are identified using a row-column coordinate system. The rows are labeled with alphabetical characters starting with **A** and increasing towards the top of the sheet as shown above. Columns are labeled using numeric characters beginning with **1** and increasing to the right. Individual drawing modules are combined to create drawing blocks. The crosshatched areas as shown above are drawing block examples that have been created by combining several modules. Drawing blocks are referenced using the row-column designation of the lower left module that makes up the block. Drawing blocks are identified using drawing block titles or detail markers as discussed in the previous section and shown in module **C2** in the above sheet example. The markers have the information need to determine the scale and size of a drawing block associated with them allowing automated routines to be developed.

The Tri-Service CADD-GIS Technology Center has developed a detail library that contains hundreds of standard details. The library comes with a utility that assists the user in the placement of the details. The utility recognizes the detail scale and asks the user to define the plot scale before the placement of the detail. Using this information the utility will properly scale the detail. This functionality is needed because a typical detail sheet, which can only be plotted at one scale, contains several different detail scales. For example: if a detail drawn at a ¾" scale is to be placed on a sheet that will be plotted at a 1/8" scale, the detail will need to be scaled up by a factor of 6 (3/4 divided by 1/8). The scale decision could take place automatically, if the utility recognized the marker and sheet definition discussed in the earlier sections. This is possible because the marker attributes define the intended plot scale of a detail and the sheet definition defines the actual plot scale. The existing utility would need to be modified such that when activated it would first attempt to locate a sheet definition object. This would define the actual plot scale and the plot area within the electronic drawing. When a detail is selected the intended plot scale would be read from the marker contained within the detail. If the user's cursor falls within the plot area, the detail would be scaled appropriately. If the cursor fell outside the plot area the detail would be placed at full scale. A similar operation could also take place when AutoCAD or Microstation users are placing blocks or cells that contain marker objects. This process could be taken one step farther by automatically labeling the markers as they are being placed.



Reference designations contained in standard detail markers are quite commonly indicated with an "X" as shown above. The "X" is replaced with the appropriate designation after it is placed in its correct location. If a separate utility was provide to define the drawing area much like much like the manual sheet definition utility, the "X" could automatically be replaced with the appropriate UDS designation when the detail was placed.



A UDS Area Definition utility would have to display a form as shown above to the user. The user would then be asked to define opposing corners of the drawing area. The utility would then place an attributed box that defines the number of columns and rows the user wishes to divide the drawing area into. An option to label the columns and rows according to UDS methodology could also be provided.

Detail placement routines should dynamically track the cursor and move the detail in module increments. This would result in a jerky movement of the detail. The jerky movement would be desired, because a smooth tracking of the cursor would indicate that a detail using the UDS module concept could be placed anywhere within the drawing area, which is not correct. If the cursor is outside a UDS drawing area, the detail could then be moved with a smooth tracking of the cursor. Placement routines should also recognize that the drawing blocks defined in the marker object might not be made up of modules of the exact same size of the current sheet. If this is the case, the smallest size drawing block made up of the current size modules should be used. The markers should always be placed bottom center of the current drawing block and such that markers would line up horizontally across a page.

When the UDS drawing block concept is used a viewing application that contains measuring tools can be used more efficiently. Currently viewing applications only allow the user to have one active measuring scale. This forces the user to perform a scale selection operation prior to electronically measuring an item within a drawing sheet. An application that recognizes the UDS drawing blocks and the associated scales that are defined within a drawing block title marker can allow a user to freely measure anywhere within a sheet and always get correctly scaled measurements. This is possible because UDS drawing blocks do not overlap resulting in specific areas that have a specific scale associated with them.

Database Drawing Templates

Engineers and Architect have for years put tracking and organizational information on drawings. This information can be thought of as a property of an individual drawing or a set of drawings. Information such as a sheet title would be a drawing property and an engineering firm or client's name would be a set property. The location and type of tracking information on a completed drawing varies from organization to organization. A database template is an object that would identify physical areas within a drawing at which drawing or set properties may be found. A database template would look much like a drawing border sheet with no specific project information. The function of a database template would be to associate areas on a drawing with a particular database field. In essence you are creating a database entry form using the graphics and text in the border sheet. Why would someone want to use areas rather than element attributes or tags to identify information? The reason is that identification through the use of element attributes or tags requires preplanning, which limits the use of the information within a drawing to only elements that were planned to be uniquely identified. Database templates have an advantage of requiring a user to do less when placing information while maintaining a higher level of drawing usability. A user only has to get information in the correct location, which is hard not to do in most cases. Architectural and engineering (AE) firms typically use the same border layout on every job unless a client has a standard border. At most a particular organization may need only 9 or 10 border templates to accommodate multiple client needs and border changes that may have taken place over many years. In any case, borders contain tracking and organizational information that is in a particular location with some degree of consistency.

Database template files would allow companies to generate electronic archives of existing paper or electronic drawings much more efficiently. This capability would enable a program to very efficiently and accurately extract information from a drawing for other uses. The business world refers to this type technology as data mining and has used it for years. This technology has applied by knowing the electronic order of information within an electronic document. The methodology being described is the same basic concept but uses physical location rather than electronic location to mine data. Drawing elements within an electronic engineering drawing are typically stored in the order in which they were created or placed. This in turn means these elements are store randomly within the electronic drawing file. Drawing elements on the other hand are displayed or printed in a consistent physical location relative to the paper space or border, making it possible to extract data consistently from a randomly organized electronic file.

Database templates can be used to enhance many types of workflows. They could be use enhance batch plotting, character substitution and distribution processes for example. Construction drawings typically contain an Index sheet. Database templates could be used to tell a batch-plotting program where to find information needed to order a set of drawings and fill out the index on an Index sheet. The template may associate an area of a drawing to electronic file header information such as the Word document properties. This would allow a receiving application to easily identify information, yet allow the user to enter the data in the required title block location. This would enhance a distribution process by allowing a receiver of a drawing or a set of drawings, such as a Plan Room or a Code Enforcement Agency, to more efficiently provide the information to their customers. The templates could be use to place or change information in a set of drawings that where not previous setup for character substitution processes.

A database template could be used to enhance the scanning of existing paper drawings. The template would define line work to be located within a scanned image much like OCR technology. More advance systems would compare multiple database templates to an unknown file and determine which template should be use in the extraction of information. This process would be functionally similar to OCR technology. The difference being border and not text identification. Once a border has been identified, OCR technology would be used to extract information to the associated database fields. In this type process it may also be advantages to predefine characters and/or words that are valid entries. This would potentially increase the accuracy of the overall data recognition by creating multi-level recognition processes. Applications would first identify characters. Suspect characters would then be compared with valid individual characters defined by the user. The application would then take the suspect character and adjacent recognized characters and compare them to valid words.

Engineering Drawing Document Viewer

Engineering drawing document viewers require more functionality than viewers used with business type documents. These engineering documents are very unique when compared to business type documents. They are loaded with graphical and textural information that is a language of its own. The typical business document is read from left to right and top to bottom with any references to figures or tables being in close proximity. Engineering drawings on the other hand are read quite randomly and require maneuvering from page to page to understand the information being presented. This task is hampered by the fact that a drawing cannot be viewed in its entirety while maintaining readable text. Business documents also do not require any external tools to extract the information, where as engineering documents do. It would be difficult to find a user of a engineering drawing that did not have a set of

A treeview or document map should be provided with a drawing document viewer. The treeview should be automatically generated when construction drawings are compiled into a single document. The Uniform Drawing System (UDS) ordering method and level scheme should be used when generating the treeview. This could be accomplished by either reading information out of a drawing much like Microsoft word styles or simply using filenames that use the UDS standards. If file names are used to generate the tree, the last level should be a list of filenames. Preceding levels should be set to the appropriate UDS level designations. The total number of levels typically would not exceed three and would depend on how many UDS level designations are found. A user should be able to turn the treeview on or off.

The viewer should continuously display windowing operations. Minimum windowing operations are zoom in, zoom out, window area, fit and pan and should be presented in the order given.

A measuring scale selection should be continuously displayed. The actual presentation of this command would depend on the complexity of the authoring and viewing applications. If UDS drawing blocks are supported, the option is not needed. A scale selection would not be needed because scales can be associated with blocks within a sheet drawing area during the authoring operation. It is assumed that drawing blocks do not overlap. This would be the preferred option. If drawing blocks are not supported, the second option would be to allow the user to set the scale by selecting the scale text associated with a drawing block title. This option is best because the user has to read the text before any other scale selection methods could be used. The least preferred option would be to provide the user with a scale selection combo box. The authoring application should allow the user to limit the scales provided by the viewing application. This would allow the author to limit scales too only metric, english, architectural, engineering or scales used in set. The scale limitations should apply to a set of drawings and not an individual drawing.

A user has to zoom in on text frequently to make the text readable. In many cases the user isn't interested in drawing details. They simply want to be able to read the text. For this reason, it is suggested that when a cursor is paused over a piece of text that the text is expanded much like a tool tip or Microsoft Word document comments. This would allow a user to maintain their focus on a larger drawing and be able to read text efficiently. This functionality should be a long-term goal, if processing speed is not currently sufficient to support the capability without significant losses in overall viewing performance.

Internal document hyperlinks should be supported. It should be noted that simply supporting internal document hyperlinks is not sufficient. An authoring applications must have tools that integrate hyperlinking operation into existing user workflows and needs. This has been the main focus of previous sections and should not be overlooked. This functionality will not have been executed correctly if it does not take less time for a user to generate a completely hyperlinked set of drawings than for a non-hyperlinked set of drawings. If implemented correctly, users will spend less time printing hardcopy sets as well.

End users have a need to bookmark electronic documents and viewing applications should support this need. Setting a bookmark is similar to saving an Internet favorite, but differs in that it is document specific. The functionality should work like setting an Adobe Acrobat bookmark. The user is allowed to select a piece of text and hit Ctrl-B. A bookmark is then placed in a treeview on the left side of the viewing window. If text is not selected, a blank bookmark is place. The end user's bookmarks should on the other be kept separate from the author's bookmarks. The primary reason for this is that intermixing an author's bookmarks with an end user's bookmarks could ultimately confuse an end user. For example:

> A user sets one and only one bookmark that is placed within an author's bookmarks. The user then collapses the treeview. The user now has to find his bookmark that is hidden somewhere in among the author's bookmarks.

A secondary use for not intermixing bookmarks is that the user may not have permissions to modify the existing document. For these reasons, it is suggested that the end user's bookmarks be maintained in a separate document specific file. Bookmarks should record measuring scale, zoom level and location within the paper space. The bookmarks should be displayed to the user as tab along the right side of the viewing window much like paper clips are use to mark books and drawings. A user could possibly place a significant number of bookmarks, which would restrict the ability to display text on the bookmark tab. It would be suggested that if a cursor is paused on a tab that the tab label be displayed like a tool tip.

Appendix A

Standard Sheet Sizes in Model Dimensions

TABLE I

American National Standards Institute (ANSI)

Aspect Ratios: 1.29 and 1.55

SCALES	1in.= X ft.	MODEL DIMENSIONS (FT.)					
		8.5"	11"	17"	22"	34"	44"
12"=1'-0"	0.0833	0.71	0.92	1.42	1.83	2.83	3.67
6"=1'-0"	0.1667	1.42	1.83	2.83	3.67	5.67	7.33
3"=1'-0"	0.3333	2.83	3.67	5.67	7.33	11.33	14.67
1½"=1'-0"	0.6667	5.67	7.33	11.33	14.67	22.67	29.33
1"=1'-0"	1.0000	8.50	11.00	17.00	22.00	34.00	44.00
3/4"=1'-0"	1.3333	11.33	14.67	22.67	29.33	45.33	58.67
½"=1'-0"	2.0000	17.00	22.00	34.00	44.00	68.00	88.00
3/8"=1'-0"	2.6667	22.67	29.33	45.33	58.67	90.67	117.33
¼"=1'-0"	4.0000	34.00	44.00	68.00	88.00	136.00	176.00
1"=5'	5.0000	42.50	55.00	85.00	110.00	170.00	220.00
3/16"=1'-0"	5.3333	45.33	58.67	90.67	117.33	181.33	234.67
1/8"=1'-0"	8.0000	68.00	88.00	136.00	176.00	272.00	352.00
1"=10'	10.0000	85.00	110.00	170.00	220.00	340.00	440.00
3/32"=1'-0"	10.6667	90.67	117.33	181.33	234.67	362.67	469.33
1/16"=1'-0"	16.0000	136.00	176.00	272.00	352.00	544.00	704.00
1"=20'	20.0000	170.00	220.00	340.00	440.00	680.00	880.00
1"=30'	30.0000	255.00	330.00	510.00	660.00	1,020.00	1,320.00
1"=40'	40.0000	340.00	440.00	680.00	880.00	1,360.00	1,760.00
1"=50'	50.0000	425.00	550.00	850.00	1,100.00	1,700.00	2,200.00
1"=60'	60.0000	510.00	660.00	1,020.00	1,320.00	2,040.00	2,640.00
1"=100'	100.0000	850.00	1,100.00	1,700.00	2,200.00	3,400.00	4,400.00
1"=200'	200.0000	1,700.00	2,200.00	3,400.00	4,400.00	6,800.00	8,800.00
1"=300'	300.0000	2,550.00	3,300.00	5,100.00	6,600.00	10,200.00	13,200.00
1"=400'	400.0000	3,400.00	4,400.00	6,800.00	8,800.00	13,600.00	17,600.00
1"=500'	500.0000	4,250.00	5,500.00	8,500.00	11,000.00	17,000.00	22,000.00
1"=600'	600.0000	5,100.00	6,600.00	10,200.00	13,200.00	20,400.00	26,400.00
1"=1000'	1000.0000	8,500.00	11,000.00	17,000.00	22,000.00	34,000.00	44,000.00

TABLE II

Architectural

Aspect Ratios: 1.33 and 1.50

SCALES	1in.= X ft.	MODEL DIMENSIONS (FT.)					
		9 "	12 "	18 "	24 "	36 "	48 "
12"=1'-0"	0.0833	0.75	1.00	1.50	2.00	3.00	4.00
6"=1'-0"	0.1667	1.50	2.00	3.00	4.00	6.00	8.00
3"=1'-0"	0.3333	3.00	4.00	6.00	8.00	12.00	16.00
1½"=1'-0"	0.6667	6.00	8.00	12.00	16.00	24.00	32.00
1"=1'-0"	1.0000	9.00	12.00	18.00	24.00	36.00	48.00
3/4"=1'-0"	1.3333	12.00	16.00	24.00	32.00	48.00	64.00
½"=1'-0"	2.0000	18.00	24.00	36.00	48.00	72.00	96.00
3/8"=1'-0"	2.6667	24.00	32.00	48.00	64.00	96.00	128.00
¼"=1'-0"	4.0000	36.00	48.00	72.00	96.00	144.00	192.00
1"=5'	5.0000	45.00	60.00	90.00	120.00	180.00	240.00
3/16"=1'-0"	5.3333	48.00	64.00	96.00	128.00	192.00	256.00
1/8"=1'-0"	8.0000	72.00	96.00	144.00	192.00	288.00	384.00
1"=10	10.0000	90.00	120.00	180.00	240.00	360.00	480.00
3/32"=1'-0"	10.6667	96.00	128.00	192.00	256.00	384.00	512.00
1/16"=1'-0"	16.0000	144.00	192.00	288.00	384.00	576.00	768.00
1"=20	20.0000	180.00	240.00	360.00	480.00	720.00	960.00
1"=30	30.0000	270.00	360.00	540.00	720.00	1,080.00	1,440.00
1"=40	40.0000	360.00	480.00	720.00	960.00	1,440.00	1,920.00
1"=50	50.0000	450.00	600.00	900.00	1,200.00	1,800.00	2,400.00
1"=60	60.0000	540.00	720.00	1,080.00	1,440.00	2,160.00	2,880.00
1"=100	100.0000	900.00	1,200.00	1,800.00	2,400.00	3,600.00	4,800.00
1"=200	200.0000	1,800.00	2,400.00	3,600.00	4,800.00	7,200.00	9,600.00
1"=300	300.0000	2,700.00	3,600.00	5,400.00	7,200.00	10,800.00	14,400.00
1"=400	400.0000	3,600.00	4,800.00	7,200.00	9,600.00	14,400.00	19,200.00
1"=500	500.0000	4,500.00	6,000.00	9,000.00	12,000.00	18,000.00	24,000.00
1"=600	600.0000	5,400.00	7,200.00	10,800.00	14,400.00	21,600.00	28,800.00
1"=1000	1000.0000	9,000.00	12,000.00	18,000.00	24,000.00	36,000.00	48,000.00

TABLE III

International Organization for Standardization (ISO)

Aspect Ratio: Square Root of 2 or 1.41

SCALES	1mm= X mm	MODEL DIMENSIONS (mm)					
		210 mm	297 mm	420 mm	594 mm	841 mm	1189 mm
1:1	1.0	210.0	297.0	420.0	594.0	841.0	1,189.0
1:2.5	2.5	525.0	742.5	1,050.0	1,485.0	2,102.5	2,972.5
1:5	5.0	1,050.0	1,485.0	2,100.0	2,970.0	4,205.0	5,945.0
1:10	10.0	2,100.0	2,970.0	4,200.0	5,940.0	8,410.0	11,890.0
1:20	20.0	4,200.0	5,940.0	8,400.0	11,880.0	16,820.0	23,780.0
1:50	50.0	10,500.0	14,850.0	21,000.0	29,700.0	42,050.0	59,450.0
1:80	80.0	16,800.0	23,760.0	33,600.0	47,520.0	67,280.0	95,120.0
1:100	100.0	21,000.0	29,700.0	42,000.0	59,400.0	84,100.0	118,900.0
1:200	200.0	42,000.0	59,400.0	84,000.0	118,800.0	168,200.0	237,800.0
1:250	250.0	52,500.0	74,250.0	105,000.0	148,500.0	210,250.0	297,250.0
1:300	300.0	63,000.0	89,100.0	126,000.0	178,200.0	252,300.0	356,700.0
1:400	400.0	84,000.0	118,800.0	168,000.0	237,600.0	336,400.0	475,600.0
1:500	500.0	105,000.0	148,500.0	210,000.0	297,000.0	420,500.0	594,500.0
1:600	600.0	126,000.0	178,200.0	252,000.0	356,400.0	504,600.0	713,400.0
1:1000	1000.0	210,000.0	297,000.0	420,000.0	594,000.0	841,000.0	1,189,000.0
1:1250	1250.0	262,500.0	371,250.0	525,000.0	742,500.0	1,051,250.0	1,486,250.0
1:2500	2500.0	525,000.0	742,500.0	1,050,000.0	1,485,000.0	2,102,500.0	2,972,500.0
1:5000	5000.0	1,050,000.0	1,485,000.0	2,100,000.0	2,970,000.0	4,205,000.0	5,945,000.0

Appendix B

Visual Basic Code for UDS Sorting

Option Explicit

```
Public Type UDS
  ID As String
  Lvl1 As String
  Lvl2 As String
End Type

Public Type FileInfo
  Fname As String
  ShtID As String
  ShtDescr As String
  ShtOrder As Integer
End Type

Public UDSOrder() As UDS
Public FilesToSort() As FileInfo
Public CurrentIndex As Integer
Public Lvl1Index As Integer
Public Lvl2Index As Integer

Public Sub UDSSort()
Dim i As Integer, X%, Y%, z%, Match%
Dim TempFile As FileInfo
Dim LstMtch As String
Dim newNode As Node
```

```
LstMtch = ""
Match = 1
'ASC (0-9) = 48-57 and ASC(-)=45
'If the first character of the ShtID is not a number
'attempt to sort the files using the UDS Method
If Asc(Left(FilesToSort(0).ShtID, 1)) < 48 Or _
   Asc(Left(FilesToSort(0).ShtID, 1)) > 57 Then
  'Order the FilesToSort array using the UDS method.
  'Ordering is accomplished by setting the ShtOrder
  'to the UDSOrder array location times 100 plus
  'a sequential.  The sequential number is applied
  'to files that have the same UDS designation,
  'such as SF101 and SF102. The method below assumes
  'FilesToSort are in decending ASCII order.  This
  'ensures that SF102 falls after SF101.
  For i = 0 To UBound(FilesToSort)
    If Left(LstMtch, Match) <> Left(FilesToSort(i).ShtID, _
                                    Match) Then
      For X = 0 To UBound(UDSOrder)
        If UCase(Left(FilesToSort(i).ShtID, Match)) = _
            Left(UDSOrder(X).ID, Match) Then
          z = 0
          FilesToSort(i).ShtOrder = X * 100 + z
          LstMtch = UDSOrder(X).ID
          'If the second character in the ShtID is a number
          'or a "-" don't attempt a match using a two
          'character UDS designation.
          If Asc(Mid(FilesToSort(i).ShtID, 2, 1)) > 47 And _
             Asc(Mid(FilesToSort(i).ShtID, 2, 1)) < 58 Or _
             Asc(Mid(FilesToSort(i).ShtID, 2, 1)) = 45 _
          Then Exit For
          If UCase(Left(FilesToSort(i).ShtID, 2)) = _
              Left(UDSOrder(X).ID, 2) Then
            Match = 2
            Exit For
          End If
        End If
      Next X
    Else
      z = z + 1
      FilesToSort(i).ShtOrder = X * 100 + z
    End If
  Next I
```

```
'Following FOR statement re-orders the FilesToSort array to
'reflect the UDS ordering and sets the Order(i).UDSOrder value
'to a value equal to it's array location when in UDS order.
'A bubble sort is used.
For i = 0 To UBound(FilesToSort)
  For Y = i + 1 To UBound(FilesToSort)
    If FilesToSort(i).ShtOrder > FilesToSort(Y).ShtOrder Then
      TempFile = FilesToSort(i)
      FilesToSort(i) = FilesToSort(Y)
      FilesToSort(Y) = TempFile
    End If
  Next Y
  FilesToSort(i).ShtOrder = i
Next I
```

```
'Populate the frmUDS.Sorted treeview.
 LstMtch = ""
 Match = 1
 frmUDS.Sorted.Nodes.Clear
 frmUDS.Sorted.Style = tvwTreelinesPlusMinusPictureText
 frmUDS.Sorted.LineStyle = tvwRootLines

 For i = 0 To UBound(FilesToSort)
   If Left(LstMtch, Match) <> _
      Left(FilesToSort(i).ShtID, Match) Then

     For X = 0 To UBound(UDSOrder)
       If UCase(Left(FilesToSort(i).ShtID, Match)) = _
           Left(UDSOrder(X).ID, Match) Then

         If Left(LstMtch, 1) <> Left(UDSOrder(X).ID, 1) Then
           Set newNode = frmUDS.Sorted.Nodes.Add(, , "r" & _
                         CStr(X), UDSOrder(X).Lvl1)
           Lvl1Index = newNode.Index

           If Asc(Mid(FilesToSort(i).ShtID, 2, 1)) > 47 And _
              Asc(Mid(FilesToSort(i).ShtID, 2, 1)) < 58 Or _
              Asc(Mid(FilesToSort(i).ShtID, 2, 1)) = 45 Then
             Set newNode = frmUDS.Sorted.Nodes.Add(Lvl1Index, _
                           tvwChild, , FilesToSort(i).ShtDescr)
           End If

         End If

         LstMtch = UDSOrder(X).ID

         If UCase(Left(FilesToSort(i).ShtID, 2)) = _
             Left(UDSOrder(X).ID, 2) Then
           Set newNode = frmUDS.Sorted.Nodes.Add(Lvl1Index, _
                         tvwChild, , UDSOrder(X).Lvl2)
           Lvl2Index = newNode.Index
           Set newNode = frmUDS.Sorted.Nodes.Add(Lvl2Index, _
                         tvwChild, , FilesToSort(i).ShtDescr)
           CurrentIndex = newNode.Index
           Match = 2
           Exit For
         End If
       End If
     Next X
```

```
    Else
      If Asc(Mid(FilesToSort(i).ShtID, 2, 1)) > 47 And _
         Asc(Mid(FilesToSort(i).ShtID, 2, 1)) < 58 Or _
         Asc(Mid(FilesToSort(i).ShtID, 2, 1)) = 45 Then
        Set newNode = frmUDS.Sorted.Nodes.Add(Lvl1Index, _
                      tvwChild, , FilesToSort(i).ShtDescr)
      Else
        Set newNode = frmUDS.Sorted.Nodes.Add(CurrentIndex, _
                      tvwLast, , FilesToSort(i).ShtDescr)
      End If
    End If
  Next i
Else

  '  This section of displays files that do not conform to UDS
  '  Standards to a treeview (frmUDS.Sorted).
  For i = 0 To UBound(FilesToSort)
    If i = 0 Then
      Set newNode = frmUDS.Sorted.Nodes.Add(, , , _
                    FilesToSort(i).ShtDescr)
      CurrentIndex = newNode.Index
    Else
      Set newNode = frmUDS.Sorted.Nodes.Add(CurrentIndex, _
                    tvwLast, , FilesToSort(i).ShtDescr)
    End If
  Next i
End If
End Sub
```

```
Public Sub LoadUDSOrder()
'*************Load UDS Ordering*****************
'subroutine opens an ascii file and expects to
'find a one or two character sheet identification
'separated from the description with a tab.
'Level 1 sheet designation characters are not
'kept in the UDS variable type.
'
'Sample UDS Order File: UDSOrder.txt
'G    General
'GI   Informational
'GC   Contractual
'GR   Resource
'
'H    Hazardous Materials
'HA   Asbestos
'HC   Chemicals
'HL   Lead
'HP   PCB
'HR   Refrigerants
'
'etc.…
'
'**********************************************
Dim filenum As Integer, i%
Dim UDSCurrent() As String
Dim UDSNext() As String
Dim Current As String
Dim Lvl1 As Boolean
```

```
filenum = FreeFile
Open "UDSOrder.txt" For Input As #filenum
i = 0
ReDim UDSOrder(i)
Line Input #filenum, Current
Do Until BlankLine(Current) = False Or EOF(filenum)
  Line Input #filenum, Current
Loop
If EOF(filenum) = True Then
  MsgBox "Nothing in UDSOrder.txt file."
  End
End If
UDSCurrent = Split(Current, Chr(9), 2, vbBinaryCompare)
UDSCurrent(0) = Trim(Replace(UDSCurrent(0), Chr(9), " "))
UDSCurrent(1) = LTrim(RTrim(Replace(UDSCurrent(1), Chr(9), " ")))
Do Until EOF(filenum)
  Line Input #filenum, Current
  If BlankLine(Current) = False Then
    UDSNext = Split(Current, Chr(9), 2, vbBinaryCompare)
    UDSNext(0) = Trim(Replace(UDSNext(0), Chr(9), " "))
    UDSNext(1) = LTrim(RTrim(Replace(UDSNext(1), Chr(9), " ")))

    If Len(UDSCurrent(0)) = 1 And Len(UDSNext(0)) = 2 Then
      UDSOrder(i).ID = UDSNext(0)
      UDSOrder(i).Lvl1 = UDSCurrent(1)
      UDSOrder(i).Lvl2 = UDSNext(1)
    ElseIf Len(UDSCurrent(0)) = 2 And Len(UDSNext(0)) = 2 Then
      i = i + 1
      ReDim Preserve UDSOrder(i)
      UDSOrder(i).ID = UDSNext(0)
      UDSOrder(i).Lvl1 = UDSOrder(i - 1).Lvl1
      UDSOrder(i).Lvl2 = UDSNext(1)
    ElseIf Len(UDSCurrent(0)) = 2 And Len(UDSNext(0)) = 1 Then
      i = i + 1
      ReDim Preserve UDSOrder(i)
    ElseIf Len(UDSCurrent(0)) = 1 And Len(UDSNext(0)) = 1 Then
      i = i + 1
      ReDim Preserve UDSOrder(i)
      UDSOrder(i - 1).ID = UDSCurrent(0)
      UDSOrder(i - 1).Lvl1 = UDSCurrent(1)
      UDSOrder(i - 1).Lvl2 = ""
      UDSOrder(i).ID = UDSNext(0)
      UDSOrder(i).Lvl1 = UDSNext(1)
      UDSOrder(i).Lvl2 = ""
    End If
    UDSCurrent = UDSNext
  End If

Loop
Close #filenum

End Sub
```

Level 1 - Discipline Designators & Modifiers

Designator	Defaut Description	Designator	Defaut Description
G	**General**	**F**	**Fire Protection**
GI	Informational	FA	Fire Detection and Alarm
GC	Contractual	FX	Fire Suppression
GR	Resource		
		P	**Plumbing**
H	**Hazardous Materials**	PS	Plumbing Site
HA	Asbestos	PD	Process/Plumbing Demolition
HC	Chemicals	PP	Process Piping
HL	Lead	PQ	Process Systems
HP	PCB	PE	Process Electrical
HR	Refrigerants	PI	Process Instrumentation
		PL	Plumbing
C	**Civil**		
CD	Demolition	**M**	**Mechanical**
CS	Survey	MS	Site
CG	Grading	MD	Demolition
CP	Paving	MH	HVAC
CI	Improvements	MP	Piping
CT	Transportation	MI	Instrumentation
CU	Utilities		
		E	**Electical**
L	**Landscape**	ES	Site
LD	Demolition	ED	Demolition
LI	Irrigation	EP	Power
LP	Planting	EL	Lighting
		EI	Instrumentation
S	**Structural**	ET	Telecommunications
SD	Demolition	EY	Auxillary Systems
SS	Site		
SB	Substructure	**T**	**Telecommunications**
SF	Framing	TA	Audio Visual
		TC	Clock and Program
A	**Architectural**	TI	Intercom
AS	Site	TM	Monitoring
AD	Demolition	TN	Data Networks
AE	Elements	TT	Telephone
AI	Interiors	TY	Security
AF	Finishes		
AG	Graphics	**R**	**Resource**
		RC	Civil
I	**Interiors**	RS	Structural
ID	Demolition	RA	Architectural
IN	Design	RM	Mechanical
IF	Furnishings	RE	Electrical
IG	Graphics		
Q	**Equipment**		
QA	Athletic		
QB	Bank		
QC	Dry Cleaning		
QD	Detention		
QE	Educational		
QF	Food Service		
QH	Hospital		
QL	Laboratory		
QM	Maintenance		
QP	Parking Lot		
QR	Retail		
QS	Site		
QT	Theatrical		
QV	Video/Photographic		
QY	Security		

Appendix C

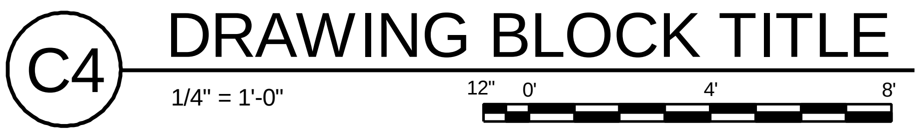
Standard Drawing Attributes

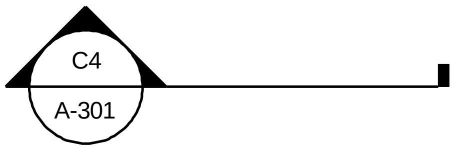
Standard Drawing Attributes	
UDS Sheet ID Location	The Uniform Drawing Systems sheet identification that defines the type of drawing and the order in which it belongs in a set.
UDS Sheet ID Reference	A reference to a UDS Sheet ID
Page Number	A sequential number that assigned to a sheet when it is group with other sheets.
Pages	The total number of sheets included in a group.
Sheet Title	A unique description given to an individual sheet.
Scale	Defines the scale to be used when measuring within an area.
Drawing Block Reference	A reference to a drawing block title location.
Drawing Block Location	Defines the location of a drawing block title.
Schedule Mark Reference	A reference to an item listed in a scheduled. Multiple reference types will be needed for items such as windows, doors, finishes, beams, etc.
Schedule Mark Location	Defines the location of a particular item on a sheet and within a table. The Location marker would also have the tabular information associated.
Designer **Client** **Owner**	Company Name
	Street Address
	City
	Zip Code
	Project Number
	Phone Number
	Contact Name
Current Date	An automatically updated text in a file
Issued Date	Fix date that defines when a drawing was officially issued.
Project or Set Latitude	Defines project Latitude location
Project or Set Longitude	Defines project Longitude Location
Sheet Latitude	Defines sheet Latitude location
Sheet Longitude	Defines Sheet Longitude Location
Match Line Reference	Same as a UDS Sheet ID Reference
Note Reference	A reference to a note at another location
Note Location	Defines the note Location

The standard document attributes are properties of an electronic drawing that are used universally. These attributes should be understood by applications that print and compile engineering drawing documents. The attributes should also be used to identify specific elements within an electronic drawing for use in performing a particular task. Many of these attributes should be associated with a piece of text. In these cases methods should be provided when placing and editing text that allows a user to easily assign or change the text attributes. This capability should work much like the dates, page numbers, style settings and bookmarks used within Word. It should be noted that information that is similar to a Word file's properties are typically found in an engineering drawings title block and this should remain the primary point of entry. Items identified as a reference could be used by a viewing application to jump the user to the reference location. When a viewing application's cursor is paused over a reference, the reference information could be displayed much like a tool tip or a Microsoft Word Comment without jumping the user to a new location. This functionality would be have to be restricted to smaller amounts of data, such as a small details, tabular information or referenced notes.

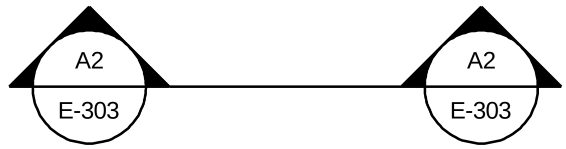
Appendix D

Reference Symbols – Detail Type

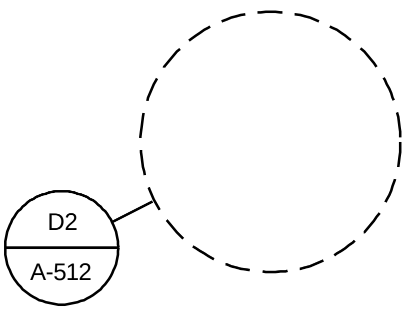




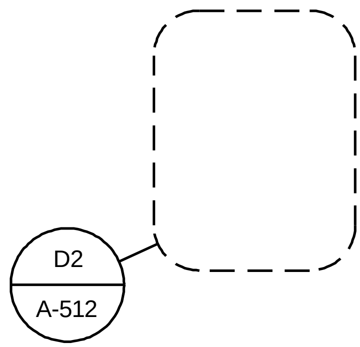
Section - Partial



Section - Building

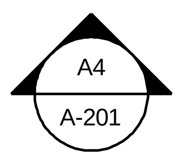


Detail - Circle

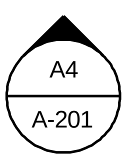


Detail - Rectangle

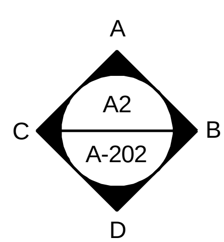
Detail - Small



Elevation - Exterior



Elevation - Interior



Elevation - Mult. Interior

Appendix E

Definitions

Active View - The form that has the focus and that contains a view of all or a portion the active drawing.

Attribute - A characteristic of a particular element and is defined by an AutoCAD attribute or a MicroStation Tag.

Paper Space - An electronic representation of a physical paper sheet and has base measuring units equal the actual physical units.

Scale - Plot scale. It is assumed that all source electronic drawings, whether scale dependent or independent, are drawn at full scale.

Treeview – An electronic control that displays data in a hierarchical nature. The control is displayed as a pane on the left side of a electronic document window and allows a user to quickly navigate a document.