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The MCAD Evaluator

The Competitive Product Evaluation Tool for Mechanical CAD/CAM Application Packages

Produced in Association with Albert Consulting Group

Published by Dataquest Incorporated

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Introduction

The CAD vendor with a comprehensive and accurate knowledge of competitors' capabilities is in a strong position. Product renhancement decisions can be made with a clear understanding of the resultant effect on competitive positioning. Competitive advantages can be clearly presented to customers. An accurate analysis of competitive capabilities is a powerful marketing tool.

Armed with the same information, CAD users can make informed system selection decisions. Even though most of today's popular systems are adequate for almost any application, most users prefer to make the best choice, not just an adequate choice. The difference can add up to substantial savings through improved productivity over the life of the CAD installation.

Unfortunately for both vendors and users, that information has not been available. Both groups have been left to fend for themselves.

In the past, the typical CAD system evaluation was made by a team representing the needs of a customer with a large budget and several months to make a selection. Vendors relied on feedback from those evaluations to keep track of competitive capabilities. A number of factors are combining to make that type of painstaking evaluation an unrealistic undertaking. Many of today's systems are so complex that a thorough evaluation is beyond the means of most prospective users. Decision cycles have been compressed while system capabilities have expanded, squeezing the evaluation process from both ends.

Simple checklists of system capabilities have been published, but they have proven inadequate. Users and vendors have found that "yes or no" responses are open to a wide range of interpretations, and the resultant analysis often fails to present a clear picture.

In response to the need for a comprehensive evaluation of CAD capabilities, Dataquest offers The MCAD Evaluator. The MCAD Evaluator provides a thorough inventory of system capabilities—over 600 functions. Each function is carefully evaluated, using expert operators. A specific score (from 0 through 4) is assigned. Weights are applied to each function, and functions are arranged hierarchically to present summary scores. CAD capabilities of each product are evaluated, based on user interface, geometric modeling, and drafting functions. In addition, finite element modeling and data management capabilities are presented for some of the products.

The MCAD Evaluator is designed to fill the need for a comprehensive inventory of system capabilities. It is not intended to be a complete system selection tool. Additional factors, including price, throughput, and service and support, must necessarily be considered in making a system selection. This system inventory should be valuable to prospective purchasers, to vendors who need competitive information, and to industry analysts who must understand product positioning.

The MCAD Evaluator was developed by the Albert Consulting Group (ACG). ACG members involved in system evaluation have from 10 to 20 years' CAD experience. Evaluation team members have been users, managers, developers, marketers, and supporters of a long list of CAD systems.

Products Evaluated

Dataquest and ACG have collaborated to prepare this report, bringing you the most comprehensive competitive tool available. Products selected represent a meaningful cross-section of today's market. The products are mainframe, workstation, and personal computer-based. They include both turnkey and unbundled products, sold through direct and indirect sales channels. Each product selected has a strong market reputation and presence. The following is a list of programs evaluated in this report:

Product	Revision	Vendor
Anvil 5000	1.1.2	MCS
AutoCAD	9.0	Autodesk, Inc
CADAM	20.1	CADAM Inc.
CADDs	4X-4.00C/5.0Solid	Computervision
CATIA	Ver 2 2.0	Dassault
Generic CADD	3.0	Generic Software
I-DEAS Geomod/ Geodraw	4.0	SDRC
IGDS	8.8.2	Intergraph
Prism/DDM	5.0	GE/Calma
VersaCAD	5.2	Versacad Corp.

Note: MCS is Manufacturing and Consulting Services. Dassault is Dassault Systems. SDRC is Structural Dynamics Research Corporation

Finite Element Modéling (FEM) evaluations are presented for CADDs, I-DEAS Geomod, IGDS, and Prism. Data management evaluations were performed on Anvil, CADAM, CADDs, CATIA, and IGDS.

Identification of the computer systems and peripherals used in the evaluation is included in the Product Summary section of this report.

The MCAD Evaluator

The MCAD Evaluator was used to collect and present product capability information for this report. The MCAD Evaluator is a spreadsheet based tool for tallying and comparing CAD software. The MCAD Evaluator has proven to be excellent at identifying significant differences between CAD programs. It clearly identifies areas of deficiency or superiority.

Scoring

In performing an evaluation, each function or command is given a score from zero to four.

Score	Description
4	Exceptional Implementation
3	Meets Requirements
2	Significant Deficiencies
1	Minimal Implementation
0	Absence of a Function

A score of three indicates the product meets state-of-the-art requirements for the function. A score of zero indicates absence of the function or command. Minimal implementation receives a "one," while a two indicates significant deficiencies. A score of four indicates an exceptional implementation beyond industry standards.

This method measures direct capability only. Workaround solutions are not credited. The evaluation does not measure software reliability. In general, bugs are ignored. If bugs are severe enough to completely prevent use of a function, that function is given a zero score.

Categories

The MCAD Evaluator is a hierarchical matrix of capabilities. The matrix is divided into five major categories: user interface, geometric construction, drafting, finite element modeling (FEM), and data management.

No.	Category Type
1	User Interface
2	Geometric Construction
3	Drafting
4	Finite Element Modeling
5	Data Management

These five categories are subdivided as appropriate for each section. Approximately 600 functions or commands are tabulated in the matrix. Refer to the glossary for definitions of the 600 functions in The MCAD Evaluator.

The major sub-categories of the user interface section are screen layout, interactive modes, customization, user assists and viewing, and display.

The geometric construction section of The MCAD Evaluator addresses modeling, editing and other aids the program provides to create mechanical designs. Geometry creation is evaluated for both 2D and 3D items. Some 3D programs have special 2D construction functions. Other 2D programs have limited 3D construction functions. These special or limited functions are reflected in the evaluations. The geometric item types considered in 3D construction are wireframe, surfaces, and solids. Other abilities evaluated in this section are item editing, item manipulations, transformations, and construction aids.

Item editing allows modification of existing geometric items. The section covers functions that edit items and the ability of the program to automatically make related changes. For example, if the end of a part is lengthened, the dimension value for the length of the part should be automatically updated to reflect the new part length.

Item manipulations are divided into grouping and relimiting functions. Relimiting functions trim or extend geometric items. Standard parts handling, mechanical assemblies and symbols are difficult to manage without grouping and library storage functions.

Construction aids assist the user during geometry creation and manipulation operations. Examples of construction aids are grids, coordinate systems, and verification of existing geometric items.

The drafting functions evaluated facilitate creation of a standard engineering drawing from a geometric model. The major categories evaluated in this section are model and drawing association, annotation, dimensions, crosshatching, and detail magnification area.

Association of a drawing with a geometric model is a measure of how well the design geometry is used to generate a drawing. Dimensioning and annotation functions allow the final details to be placed on a drawing. These tasks usually take the most time in drawing creation. The process of generating drawing views from the model, laying them out on a drawing sheet and labeling and dimensioning the model are all evaluated. Other features such as crosshatching and detail magnification area are also reviewed.

The key areas evaluated for the FEM application are node and element specification, initialization of parameters, element types, loading and constraint capabilities, editing of nodes and elements, verification abilities, output to finite element analysis (FEA) programs, display control, results display, and mass properties calculations using a FEM model.

The data management section covers system management, nongraphic data management, part management, report generation and data transfer and communication.

Weights

Not all functions are equally important. A weighting system has been devised to properly reflect the importance of each function. Beginning at the top of the hierarchy, entries at each level are assigned a percentage value that corresponds to the contribution of that entry to the category. For example, to determine a category score when five subcategories are considered, each of the subcategories is assigned a weight such that the total of the five is 100%. The raw score for each category is then multiplied by its weight, and the results are summed to give the final score.

Within each major section, the process is repeated. In the geometric construction section, for example, the six subcategories are likewise weighted and summed to determine the total score for the section. The process is repeated throughout the hierarchy. Note that the printed scores in the tabulated results reflect contribution to the next level up. The top level score for geometric construction, for example, is multiplied by its weighting factor to determine the score.

A characteristic of The MCAD Evaluator is that the result tends to favor products with extensive lists of features. The premise is that providing multiple options or functions improves the product. A side effect that is not reflected is the fact that products with many features can be confusing and harder to learn.

The weights used in determining the results published in this report are representative of the needs of an experienced user in a metalworking company with a requirement for 3D CAD. This requirement is broadly representative of the mechanical CAD market, and therefore is chosen as a basis of this report.

The MCAD Evaluator is designed for use by system developers and vendors as well as end users. In the case of system vendors, weighting factors can be applied to reflect the requirements of a targeted market segment. Experienced users respond differently than the novice users. Features differ in importance from one application to another.

The weighting factors that were used to derive the scores presented in this report reflect requirements typical of an experienced CAD user (3 to 5 years CAD use or more) in a metalworking company. A need for both 2D and 3D capability is represented. This set of weighting factors has been selected as representative of buyers who make large purchases of mechanical CAD software.

An inventory of product functions does not represent a complete picture of product capability or suitability for any given task. In order to provide that complete capability, other types of evaluation are often in order. As a first step, weighting factors should be applied that most closely reflect specific requirements. Next, throughput tests should be designed and executed that model the ability to complete design tasks in a test environment.

Test Methodology

The methodology used in the evaluation is designed to make the results as objective as possible. The evaluation begins with a review of the system documentation. The documentation is used to gain an understanding of system operation and to do the initial inventory of functions. Actual system testing is completed at a user facility whenever possible. Expert operators are used to minimize the impact of operator bias or skill. ACG personnel observe the tests and guide the evaluation. The initial inventory of functions is checked by testing each function.

After the inventory of individual operations is completed, a series of hands-on tests is run. The tests consist of five major tasks. The tests are used to model, document, analyze, modify, and manage a simple mechanical assembly.

The first task is to build a simple 2D plate. The geometry of the plate is then used to create a drawing with dimensions and annotation. A finite element model (FEM) of the plate is then constructed. The plate is modified to check dimension, annotation, and FEM associativity. The 2D profile is then made into a 3D wireframe model and then a solid model. This solid model is saved in a parts library for use in an assembly.

The second part of the hands-on test is to model a simple housing using 3D wireframe, solid and/or surface modeling techniques. The housing is used to verify shading and hidden line capabilities. The housing is placed in a drawing and annotated with dimensions. It is then placed in a parts library.

A solid bolt is created for the third part of the test. The bolt is added to the part library.

All three parts are assembled in a single model database. A bill of materials (BOM), and where used report, are generated for the assembly for the fourth task.

The fifth task is modification of the bolt. The assembly is checked to verify that the modification to the bolt is properly reflected.

A history report for the project of creating and modifying the assembly is collected at the completion of all tasks. This part of the hands-on evaluation is only done to those programs evaluated for data management.

Product Summary

A. Introduction

This product summary section is divided into four sections, including this introduction. The first section after this introduction covers the key functions of a CAD program: user interface, design, and drafting. Bar charts display the resulting ratings for user interface, geometric construction and drafting for all evaluated programs. A second set of bar charts displays the resulting ratings for the first expanded level of categories under user interface, geometric construction and drafting.

Following the bar charts is an overview of each of the CAD programs in alphabetical order by program name. This overview includes comments about the program, with identification of strengths and weaknesses in the three basic functional areas. The discussion of each CAD program follows the outline of The MCAD Evaluator.

Following the basic CAD section, the next section covers FEM capabilities for four programs. This section is structured much like the previous section. A bar chart displays the top level FEM ratings for the four programs. Another set of bar charts displays ratings for the major subcategories for FEM. An overview of FEM capabilities for each of the four programs follows. This overview includes comments about the program's FEM strengths and weaknesses.

The final section covers data management capabilities for five of the CAD programs. This section is structured like the previous sections. A bar chart displays the top level data management ratings for the five programs evaluated. Another set of bar charts displays ratings for the major data management subcategories for the five programs. Following is an overview of data management capabilities for each of the five programs. This overview includes comments about the program's data management strengths and weaknesses.

B. Design and Drafting Functionality

Figures 1 through Figure 5 display the results of the next level of the user interface section. These charts show results of screen layout, interactive modes, customization, user assists, and viewing/display.

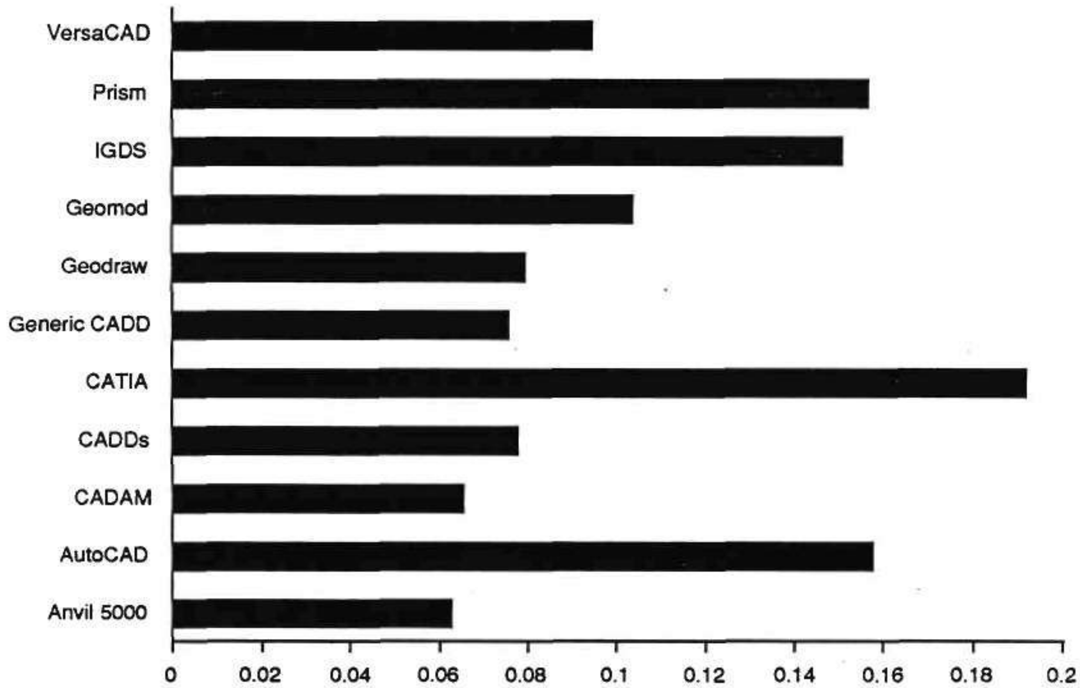
Figures 6 through 11 display the results of the next level of the geometric construction section. These charts show results of 2D items, 3D items, item editing, item manipulations, transformations and construction aids.

Figures 12 through 16 display the results of the next level of the drafting section. These charts show results of model/drawing association, annotation, dimensions, crosshatching and detail magnification area.

The discussions of individual programs follow. These discussions follow the order or outline of The MCAD Evaluator. They generally cover strengths and weaknesses of a program.

Figure 1

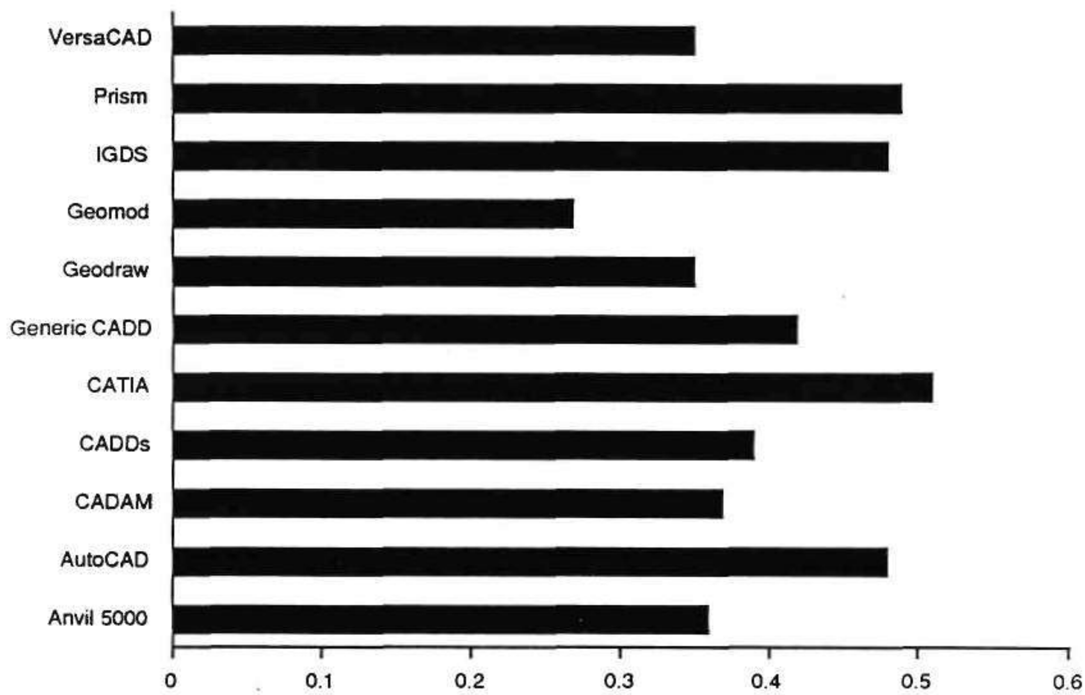
User Interface — Screen Layout



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure 2

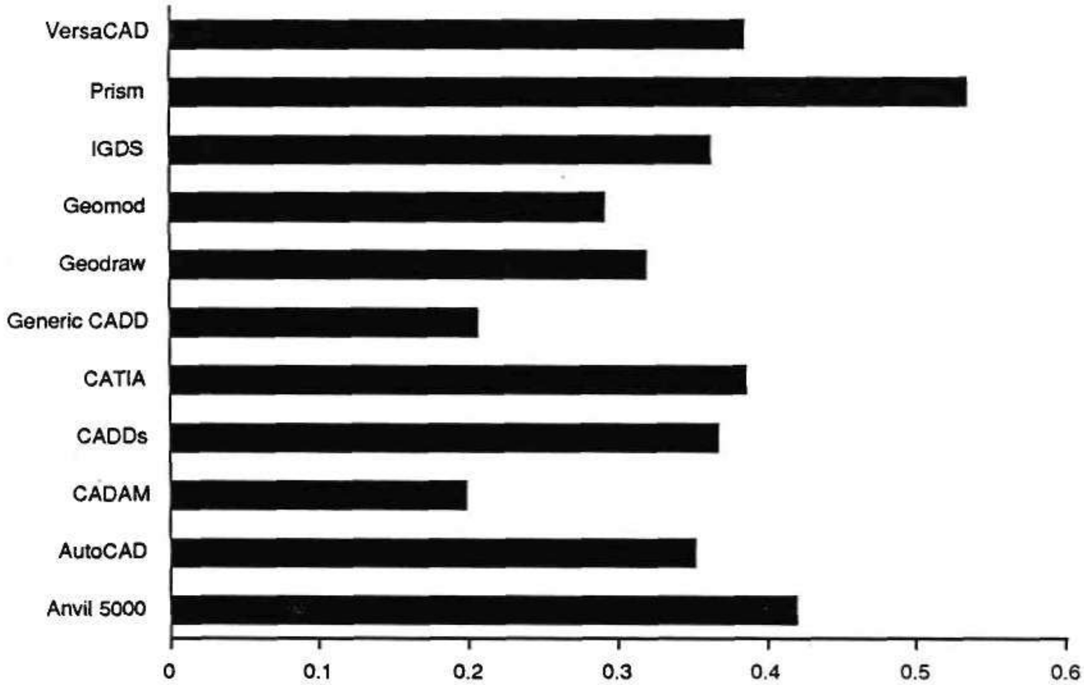
User Interface — Interactive Modes



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure 3

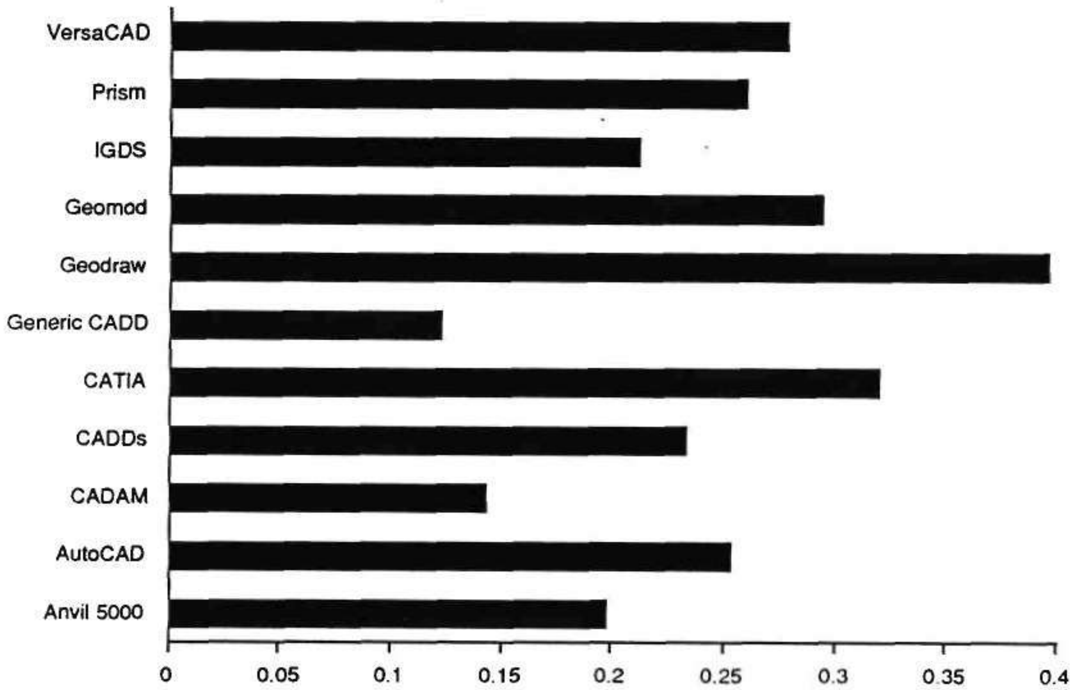
User Interface — Customization



Maximum score attainable for feature 1.000 — Source: Albert Consulting Group

Figure 4

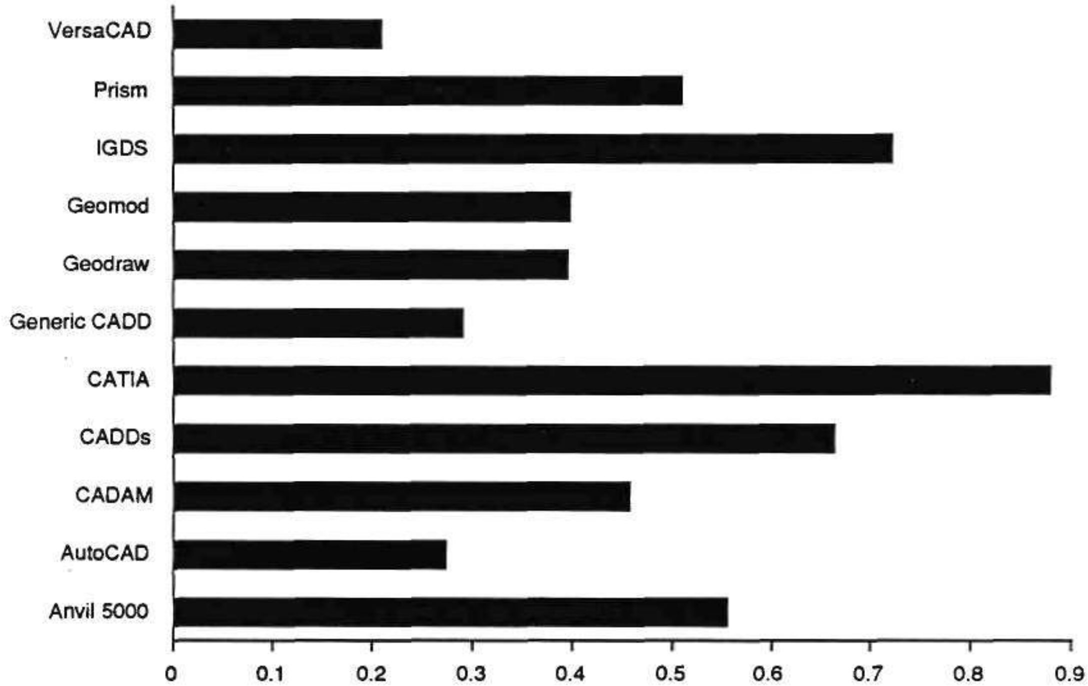
User Interface — User Assists



Maximum score attainable for feature .600 — Source: Albert Consulting Group

Figure 5

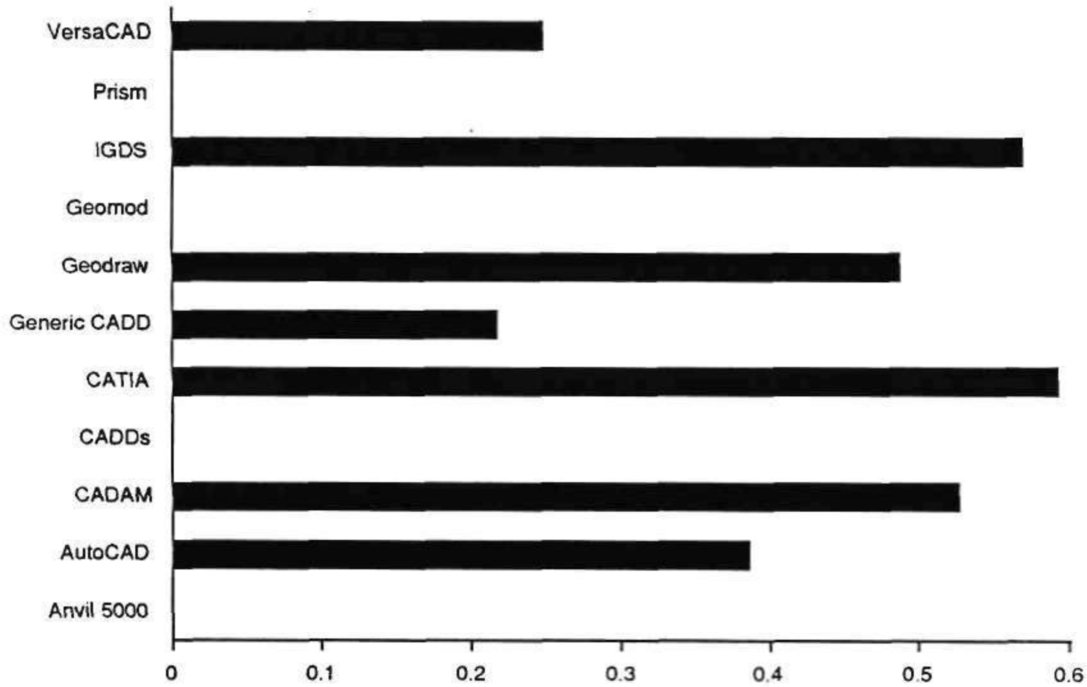
User Interface — Viewing/Display



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure 6

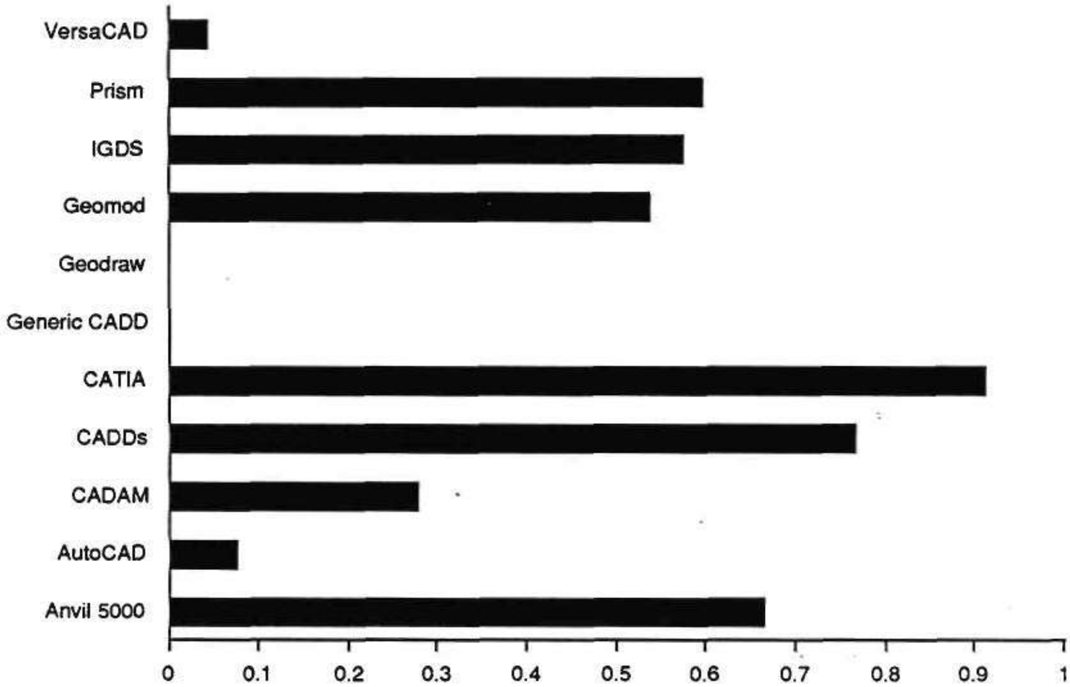
Geometric Construction — 2D Items



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure 7

Geometric Construction — 3D Items

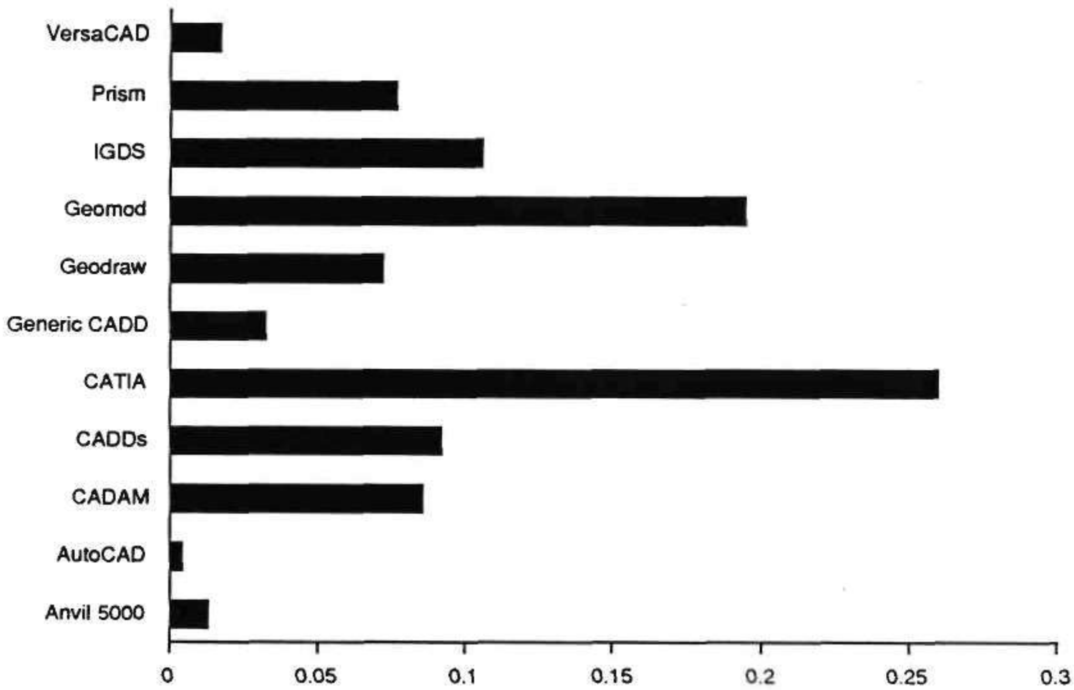


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure 8

Geometric Construction — Item Editing

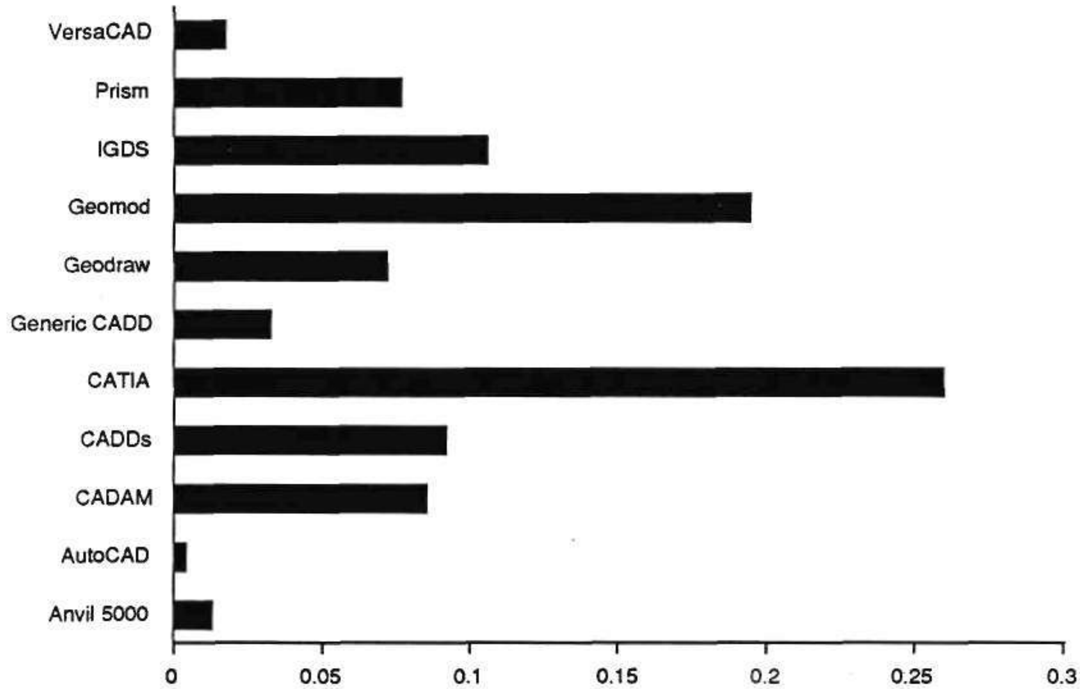


**Maximum score attainable for feature .600*

Source: Albert Consulting Group

Figure 9

Geometric Construction — Item Manipulations

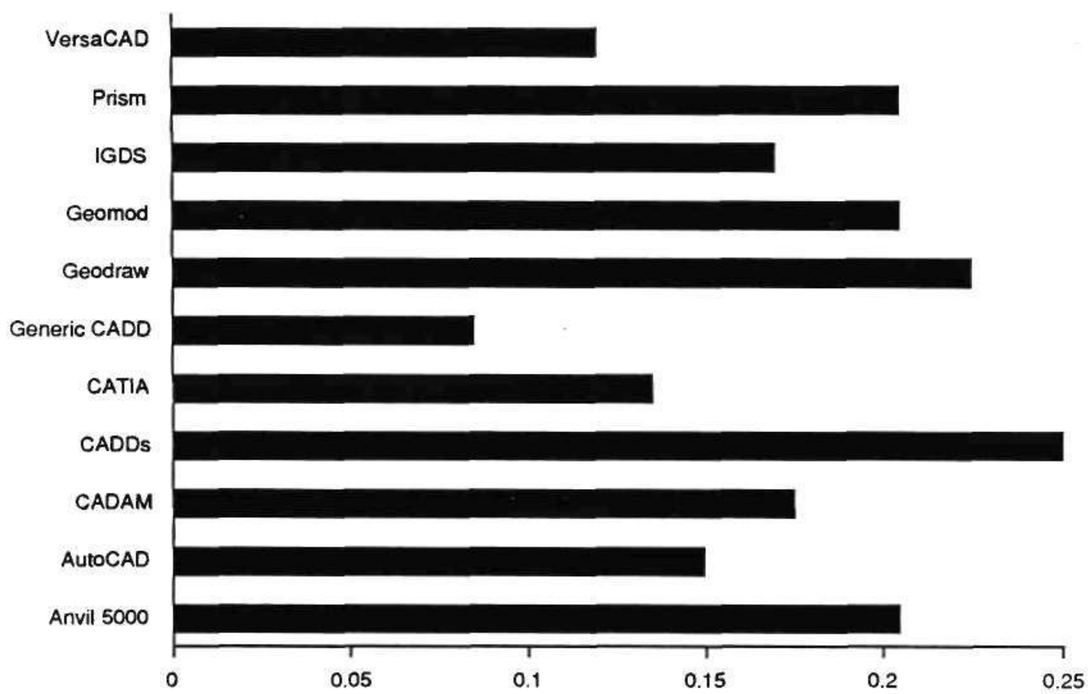


**Maximum score attainable for feature .600*

Source: Albert Consulting Group

Figure 10

Geometric Construction — Transformations

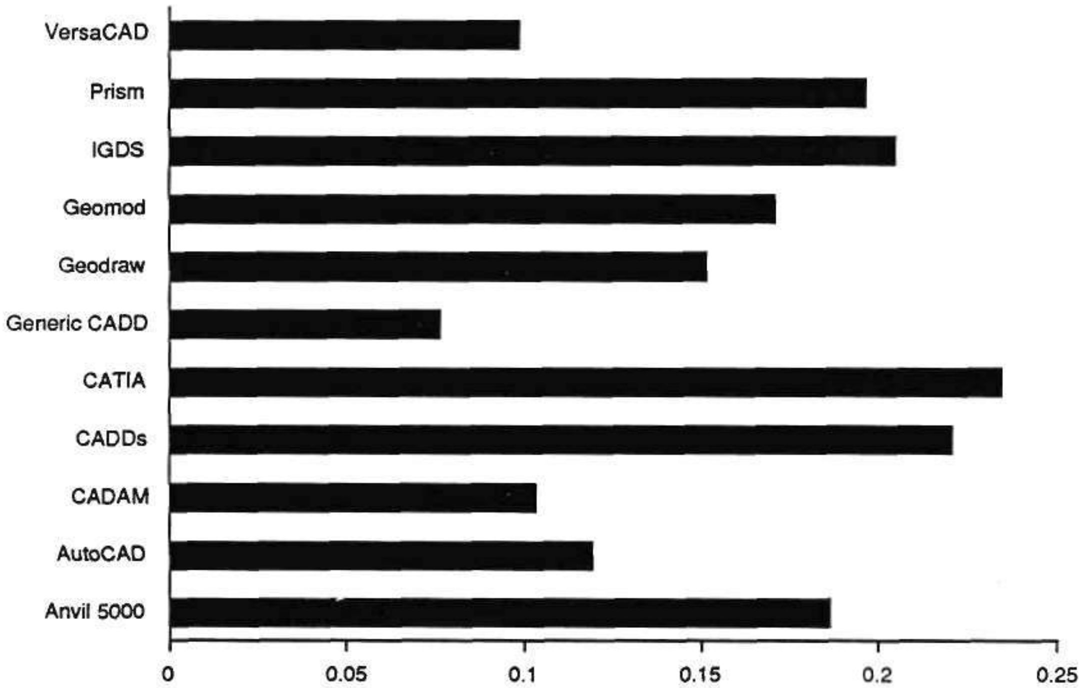


**Maximum score attainable for feature .400*

Source: Albert Consulting Group

Figure 11

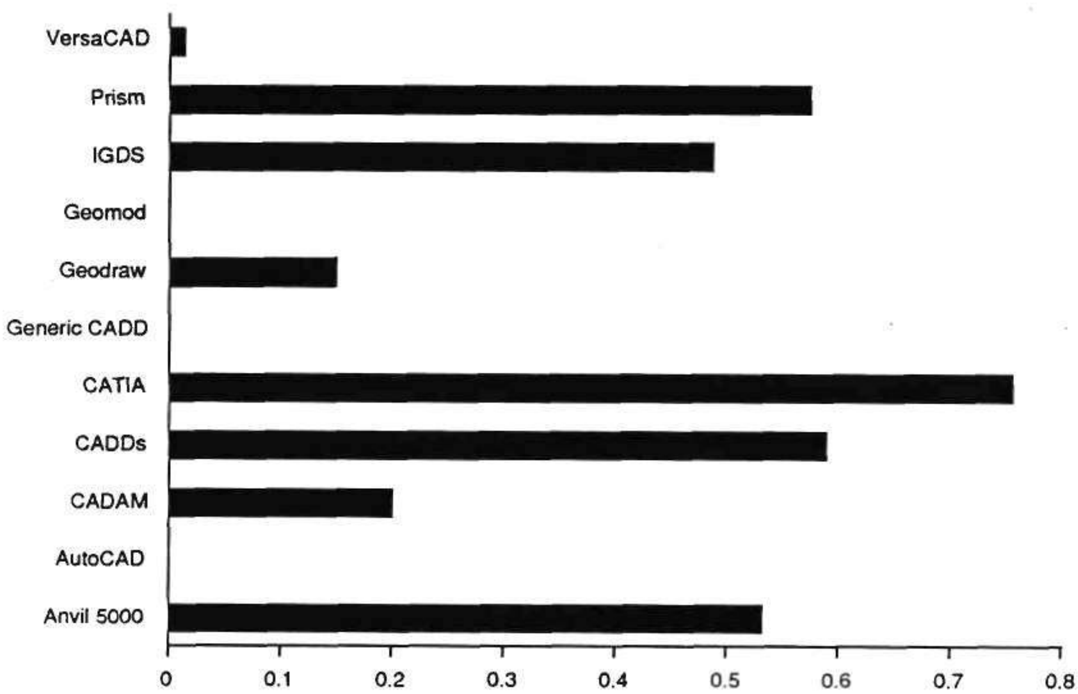
Geometric Construction — Construction Aids



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure 12

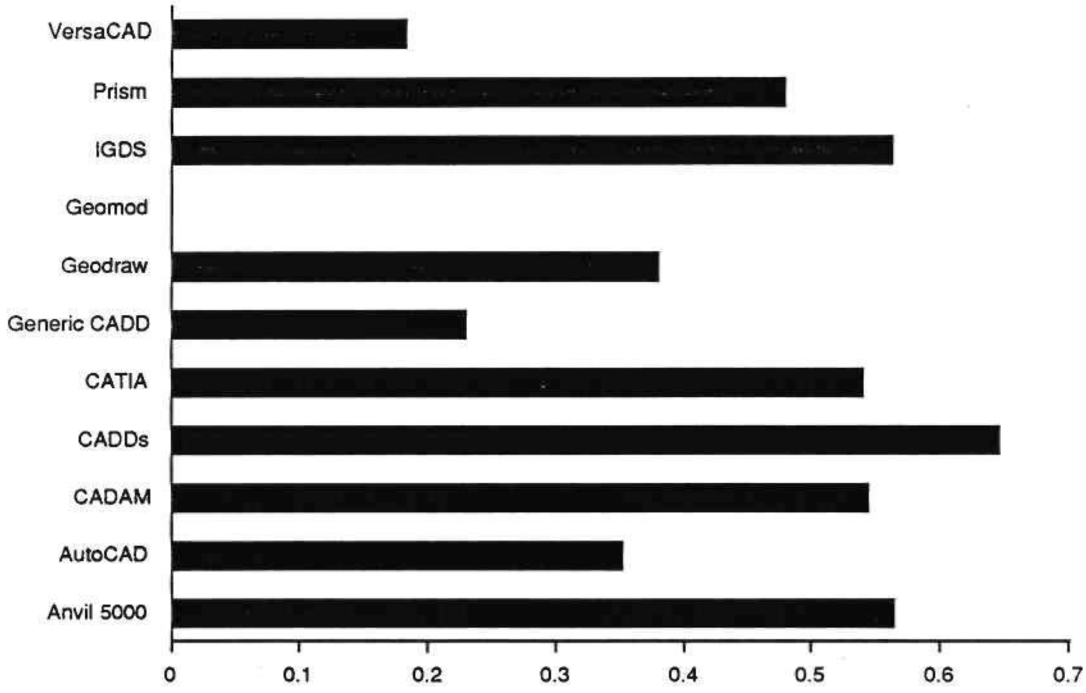
Drafting — Model/Drawing Association



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure 13

Drafting — Annotation

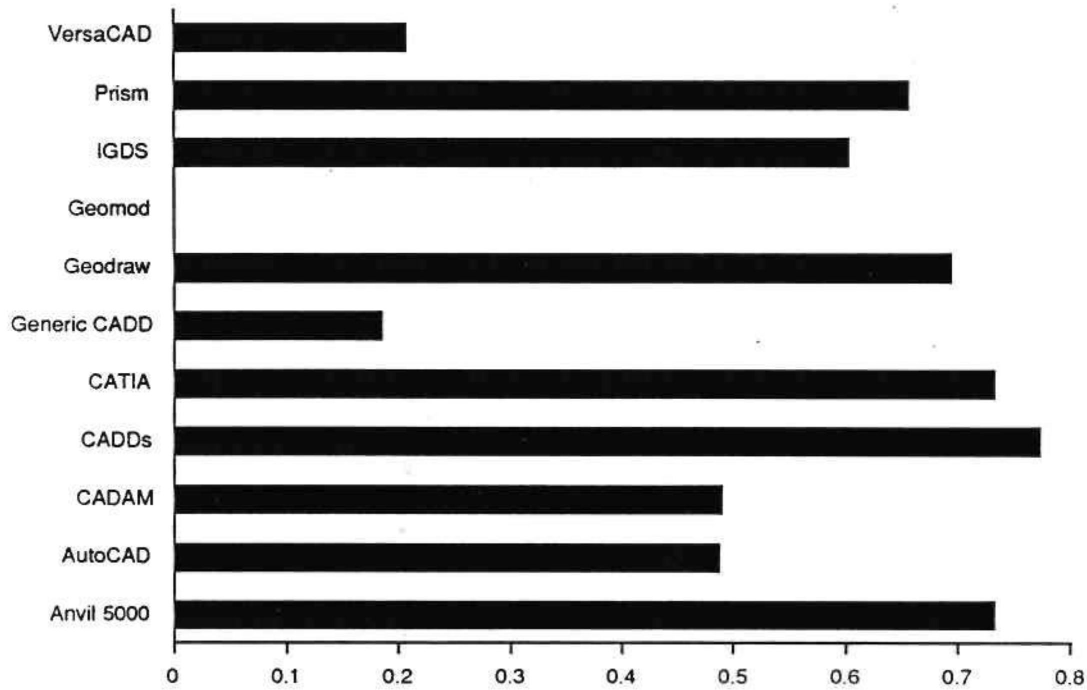


**Maximum score attainable for feature 1.000*

Source: Albert Consulting Group

Figure 14

Drafting — Dimensions

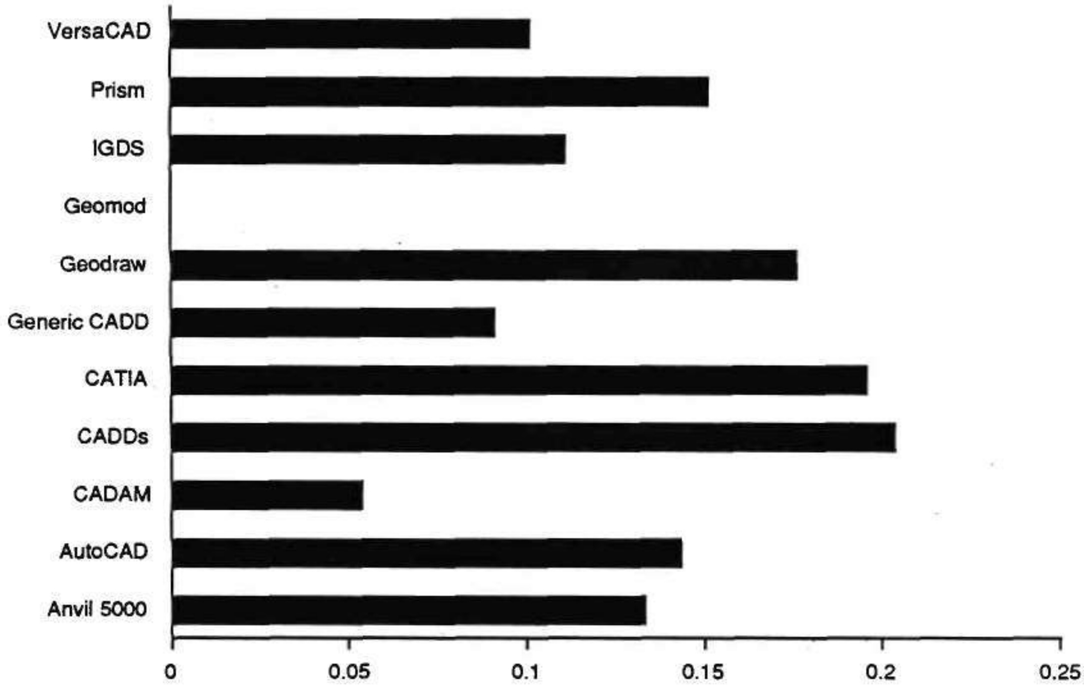


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure 15

Drafting — Crosshatching

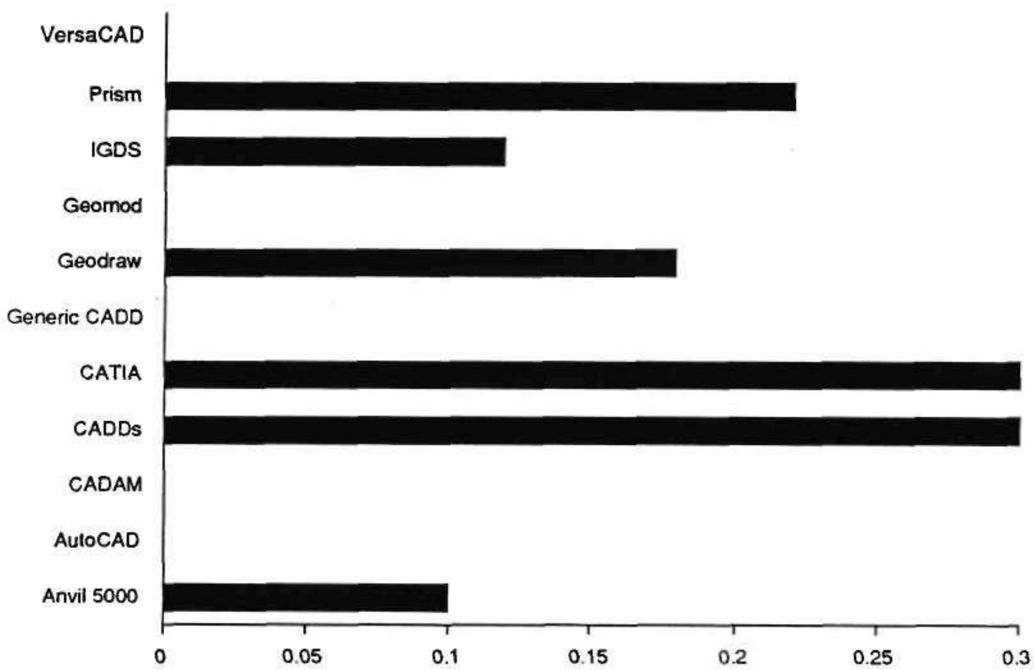


**Maximum score attainable for feature .400*

Source: Albert Consulting Group

Figure 16

Drafting — Detail Magnification Area



**Maximum score attainable for feature .400*

Source: Albert Consulting Group

Program: Anvil 5000

Company: Manufacturing and Consulting Services

Revision: 1.1.2

Equipment Used: HP 9000/550, Tektronics 4125 display

User Interface. The user interface consists of text-based menus. There is no support for icons, pop-up windows, pull-down menus, forms, dialog boxes, and no status area. On-screen menus, function keys and a tablet are available for user interaction with the program. The responsiveness of the program to user input is adequate.

Although the on-screen menus cannot be changed, customization of the tablet, a macro language and a full programming language make Anvil 5000 flexible. This flexibility allows customization of the user interface to a user's or company's requirements.

Anvil 5000 is not strong in the area of user assists, such as graphic feedback and screen dynamics, but it does support journaling and has an excellent calculator function.

Viewing and display functions available in Anvil 5000 are adequate. There are preset view layouts and the user can define layouts then save and recall them by name. There are several predefined 3D views; the user can also define more views and save and recall them. Dynamic viewing and transforms are less than industry standards.

Anvil offers limited shading methods for its solids. Light source control is limited.

Geometric Construction. All geometric construction in Anvil 5000 is 3D. There are many line creation methods available, such as construction lines, line segments, polylines and polygons. All conic constructions are available. A wide variety of spline and surface type constructions are supported.

Anvil 5000 has a very limited set of solid primitives. Some user definable solids can be constructed, using sweep, extrusion, offset-surface and surface-bounding techniques. The normal set of solid operations (add, subtract and intersect) are supported. The benchmark test used for solid operations revealed that Anvil is inconsistent in handling coplanar faces.

Anvil 5000 has no item editing capabilities. This means that items must be deleted and created again, if they are created incorrectly. This may be time consuming, and therefore received low ratings.

Composite curves, surfaces and solids can be defined and manipulated in Anvil 5000. Either 2D or 3D symbols can be defined, but a symbol can only be retrieved by typing its name. This slows down symbol placement in a drawing. Symbols may have nongraphic data assigned. There is no symbol nesting, exploding, symbol subitem access or editing. The lack of these symbol capabilities results in a lower than industry standard ranking.

Fillet and chamfer creation is excellent and allows easy construction techniques that result in correct geometry on the first try.

Intersection constructions including curves with surfaces to define points, curve projections onto surfaces to define new curves and curves defined by surface intersections are abundant, and exceed basic evaluation requirements.

Anvil 5000 supports many transformation functions including linear move and copy, circular move and copy, rectangular and circular arrays, and wireframe projection. Other transformation functions are available, but no 3D orient, or combination transformation, is supported.

Anvil's item selection philosophy is consistently prefix. A prefix philosophy means the function is selected first, followed by the items the function effects. This consistency makes the program easy to learn. Display of selected items is very clear.

Access to sub-items is nonexistent. This lack of important functionality decreases the overall rating for construction aids. Filtering or masking may only be accomplished by item type or layer, but item type masking is easy to use and excellent.

Anvil 5000 uses a Cartesian coordinate system for most operations, but allows polar coordinate input. Construction planes are supported, but received a below average score for the implementation. Rectangular and isometric grids are supported.

Very little in the way of temporary constructions are supported. Only temporary points are allowed for some functions. This implies that geometry normally has to be created before some functions can be used. This geometry must then be blanked or deleted after its use.

Drafting. Anvil 5000 model and drawing association is based on its exceptional interactive and automatic model display modification capabilities. Association of the drawing items to the model is maintained with changes to line styles, blanking and even trimming curves.

The rating of annotation is high. Although the text editor is weak, Anvil supports multiple line notes, fonts, text size, justification, text along curves, and fitting. Special drawing items such as labels, bubbles, datum targets, surface finish symbols and feature control symbols are supported.

All dimension types are well supported. In addition, Anvil offers point-to-point, baseline, chain, dual, basic, and datum dimension styles. There is adequate text control, tolerancing capabilities and dimensioning editing. ANSI dimensioning standards are well supported in addition to other dimensioning standards. Anvil 5000 supports dimension regeneration. Extension line, dimension line and arrowhead appearance may be easily changed or controlled. Dimensioning is a strength of this CAD program, scoring near the top of all programs evaluated.

Although crosshatch boundary specification methods are not particularly strong, the patterns used for crosshatching have flexibility. Line fill patterns, standard material patterns or user defined patterns may be used. The size, spacing and angle of these patterns may be changed upon crosshatch generation. A new pattern may be substituted for an existing pattern on the drawing. There is no associativity to the crosshatch boundary. This means, if the boundary geometry changes, the crosshatching is no longer correct. It must be deleted and recreated using the new boundary.

Anvil 5000 supports a detail magnification area. This area is a scaled version of the area selected for the detail magnification. Dimensions may be placed on the object in this area, but the text of the dimension must be replaced to reflect the correct dimension value.

Program: AutoCAD

Company: Autodesk, Incorporated

Revision: 9.0

Equipment Used: PC/AT Compatible, EGA Compatible display

General Comments. AutoCAD's total score is less than half that of the highest rated program, CATIA. The outstanding characteristic of AutoCAD is not reflected by The MCAD Evaluator. That characteristic is value. For the user who may not demand the advanced characteristics of a high-end program, AutoCAD's price may overcome the attraction of a longer list of capabilities.

User Interface. AutoCAD leads the three personal computer based packages evaluated here in user interface capabilities; however, it falls short of the standard set by the higher-end packages.

A long list of supported graphics devices contributes to AutoCAD's strong score in the user interface section. The many devices range from basic IBM PC color graphics to high-resolution displays offering instantaneous pan and zoom functions. AutoCAD release 9 offers a rich set of on-screen user interface functions, including pull-down menus, forms, and dialog boxes in addition to the previously available hierarchical menus and status displays. Graphic icons are not yet extensively used by AutoCAD—a point of weakness.

As with graphic monitors, AutoCAD supports a long and varied list of input devices, giving it a strong score in the interactive modes category.

Customization has been an AutoCAD strength from its inception. AutoCAD's menu customization and user programming capabilities have given rise to an industry of AutoCAD customizers. AutoCAD's customization capabilities are competitive with most of the high-end packages evaluated.

AutoCAD's user assists are average among the programs evaluated. The undo function is a strong point of this category.

AutoCAD scores particularly low in the viewing/display category. This is partly due to the fact that many of the functions included in this category apply only to 3D programs. However, when compared to other predominantly 2D programs, AutoCAD fails to distinguish itself.

Geometric Construction. AutoCAD scores poorly in geometric construction for two reasons: it is predominantly a 2D program and it lacks the sophisticated editing and manipulation capabilities of its high-end competitors.

As may be expected, 2D item constructions are a point of strength for AutoCAD in geometric construction.

AutoCAD release 9 offers a small set of 3D geometric item constructions that are not competitive with the non PC programs in this evaluation.

Item editing (the ability to modify a geometric item after it has been defined) is nearly absent in AutoCAD. CATIA, the leader in item editing, scored nearly 50 times higher.

AutoCAD's item manipulation capabilities are competitive among the 2D programs evaluated. AutoCAD's strongest points within item manipulation are its relimiting functions and its symbol library capabilities.

Although AutoCAD leads the other two PC based packages in the transformation category, it falls below average when compared to the entire field of programs evaluated. This is partly attributable to the fact that AutoCAD is a 2D program, but even 2D transformations are below standard.

AutoCAD leads the PC based packages in construction aids, but falls short of the average for the programs evaluated. A major deficiency is the absence of filtering or masking for item selection. Another weakness is the lack of a local reference (coordinate) system.

Drafting. In drafting functions, AutoCAD leads the three PC based packages, but trails the high-end programs.

AutoCAD's inability to associate 2D views with a single 3D model is a major weakness relative to the high-end programs. Some 2D programs score points in model and drawing association by offering functions that assist in projecting orthographic and isometric or auxiliary views. AutoCAD offers no support for these functions.

AutoCAD scores slightly below average in annotation, again leading the PC programs but trailing the others. Support of multiple text fonts is a relative strength, while the absence of special symbols such as geometric tolerance, weld symbols, or surface finish symbols is a weakness.

In the dimension category, AutoCAD is nearly average, and well ahead of its PC competitors in the evaluation. Although AutoCAD offers a feature that it refers to as "associative dimensioning," the implementation is far short of the standard set by the leading programs in this evaluation.

Crosshatching is AutoCAD's strongest drafting feature, placing it in midrange among the high-end competitors. Support of standard patterns and a complete pattern specification capability are strong points. AutoCAD cannot edit an existing crosshatch.

AutoCAD does not support detail magnification.

Program: CADAM

Company: CADAM Incorporated., A Subsidiary of Lockheed Corporation

Revision: 20.1

Equipment Used: IBM 4381, IBM 5080 display

General Comments. CADAM is the program that IBM used to establish its position in the CAD/CAM market. This evaluation is based on Rev 20.1. At the time of this evaluation, Rev 21 has been released and is considerably different. It has not yet achieved production status in the test installations.

User Interface. The CADAM user interface is ranked considerably lower than industry norms. The user interface does not make use of any of the on-screen modes that contribute to ease of use. CADAM supports a text menu system. There are no pop-up windows, no use of dialog boxes or forms. This accounts for the poor rating in the screen layout section.

In the interactive mode section CADAM has exceptional ratings for function keys, which is the major mode of interaction, and for command responsiveness. CADAM's reputation for fast response contributes to its strong market position in production drafting. Other interactive modes are not implemented or receive poor ratings, accounting for the average rating in this category. In the section for customization, CADAM ranks low due to a lack of support for user language, macros or other tools for tailoring the program to specific user applications.

Few user assists are provided. There is good implementation for interrupt that is consistent throughout the program, but functions such as on-line reference, abort, rubberbanding, dragging, journaling, and calculator entry are unsupported. Graphic feedback from the user interface is minimal, bringing down the rating.

In the viewing/display section, CADAM's ranking meets the industry norm. Pan and zoom capabilities are very good. There is no support for view layout tools to assist in arranging views on the screen and storing and recalling views. In the 3D viewing transformation section, CADAM ranked low because it is fundamentally a 2D program. The same is true of the display attribute section where the lack of 3D functionality hurts the ranking.

Geometry Construction. CADAM ranks well in the 2D areas of geometry construction, giving it an overall rating within the industry norms. The 2D items, where CADAM ranks exceptionally well, are points, lines and splines. Arc construction commands are not directly supported, accounting for the poor rating. CADAM has some 3D wireframe constructions and a few surface types, including ruled and Coon's Patch surfaces. Solids, or solid operations, are not supported. Editing lines and splines is a strength. CADAM does not support 3D edits, nor does it use associativity in editing.

The item manipulation section includes the grouping and symbol functions. Capabilities in these areas are average. CADAM has good symbol manipulation facilities. Grouping and symbol definition are below average. CADAM has extensive curve relimiting features and ranks very well. The functions include fillet, chamfer, trimming, extend, and corner. The 2D intersection operations are also good. CADAM has no 3D surface, solid relimiting or intersection calculations. The 2D transformations are well supported, but not the 3D transformations.

CADAM does not rank well in the construction aid section. The lack of item selection filtering, including item type and layer, detracts from the score. There is good implementation of select list and selecting single items. CADAM supports only Cartesian coordinate systems. Polar coordinates are not supported. The verification capabilities are complete for the geometry supported, but CADAM's general weakness in 3D detracts from this category. Use of a rectangular grid is good, but there is no support for polar or isometric grids. Temporary construction is not supported by CADAM.

Drafting. CADAM is widely accepted as a production drafting program. Only the PC-based programs scored lower in this category. The strength of CADAM for the drafting application is in annotation and simple dimensioning functionality. The weaknesses come from not having a 3D model that can be used to make drawings. The model drawing association ranking for CADAM is low because no model with which to associate drawings is maintained. CADAM exceeds the industry norms for annotating drawings, and has good capabilities for creating text and line styles. Text nodes are not supported. CADAM does have an easy way to fit text into a constrained area of a drawing. The feature control symbol creation and editing are implemented well. In the dimensioning section CADAM does well with the basic types of dimensioning such as horizontal, parallel, and projected, but does not support baseline or chain dimensioning. There is good control over dimension text parameters, but weakness in the tolerancing area. CADAM does a poor job in observing ANSI standards for drafting and in controlling the appearance of arrowheads and extension lines. There is very poor dimension to geometry associativity. CADAM is weak in the creation and editing of crosshatching and does not support detail magnification.

Program: CADDs

Company: Computervision Corp.

Revision: 4X-4.00C/4X-5.00 Solids

Equipment Used: CGP200X, Instaview C display, APU for solids

User Interface. The CADDs 4X user interface consists of text-based commands. These commands are abbreviations or representations of functions. There is no support for icons, pop-up windows, pull-down menus, forms and dialog boxes. There is a status area on the screen that presents all necessary information about the current model, except an x-y readout. The program always displays the text based commands even if a tablet or on- screen menus are used. The program is not rated as responsive as some of the other CAD programs evaluated. Lack of fast text or curve display may contribute to the slower response.

Although the appearance of the screen cannot be modified, customization of the tablet, menu text and message and prompt modifications can be made. An exceptional capability is available for tablet programming. In addition, a full macro or programming language with subroutine and file access capabilities is supported. Macros can be created in a "do after me" mode, greatly improving programming ease.

The need to always set defaults is a weakness. They are not saved, therefore taking the user more time to enter values for item creation.

CADDs has a clear, easy-to-use on-line reference material. This is necessary because prompts and messages are not always clear. Abort and interrupt do not always work. The rating for user assists is average. CADDs supports screen dynamics, journaling and calculator entry.

Viewing and display functions are rated higher than most other programs evaluated. This higher rating is attributed to the variety of display characteristics: the number and quality of blanking methods and display attributes such as shading methods and shading parameters. Mesh display on rendered objects may be iso-parametric, silhouetted, or with hidden lines removed or styled. Shading may be smooth or flat, and can have edge curves displayed. The rendered objects may be saved as an image and recalled when desired. Light source control is weak due to the lack of many multiple light sources and brightness and color control.

CADDs provides preset views, but no preset view layouts. If a particular view layout is desired for all new models, users can create a layout and store it in a startup model.

Geometric Construction. All geometric construction in CADDs is 3D. Consequently CADDs receives no credit for 2D constructions. This contributes to the impression that CADDs is difficult to use as a drafting program. The number and quality of 3D constructions in CADDs is better than most programs evaluated. There are adequate point constructions, but line constructions except for line segments are rated low due to limited polygon constructions. Construction of conics, such as arc, ellipses and rho-conics is exceptional. Spline constructions for B-splines, offset splines and composite splines are also rated above average. A wide variety of surfaces are supported including plane, ruled, revolved, B-spline, fillet, tapered fillet, offset and an exceptionally well implemented curve-driven surface.

Available solid items include extruded, sweep and surface-bounded user-defined solids. The normal set of solid operations, such as add, subtract and intersect are supported. Coplanar face handling is implemented, but is not adequate. This inadequacy was determined during the benchmark. The solids functions, while demonstrating some good concepts, are far from production worthy, failing often on simple constructions and operations. CADDs is one of the few programs available that checks the clearance of solids.

CADDs has very limited item-editing capabilities. Splines are the only item type with full editing capabilities. Conics can be edited to a lesser extent.

Grouping of items is supported. These items may then be manipulated as a single item. Either 2D or 3D symbols can be defined. A symbol can only be retrieved by its name. This slows down symbol placement in a drawing. CADDs supports the nesting of symbols and a symbol part association. Manipulation of symbols in CADDs is well above average. They may quickly and easily be scaled, exploded, oriented and updated.

Relimiting capabilities in CADDs are abundant and, in general, above average. Filleting of curves, and the corner and break functions, are rated as excellent. Single and multiple trimming of curves and chamfer functions are available. Trimming of surfaces is available, but trimming of solids is not.

There is a full set of intersection constructions of curves projected onto surfaces to define new curves and curves defined by surface intersections. Solid section curves may be generated.

CADDs supports many transformation functions including linear move and copy, rotate, mirror, combination transformations, stretch, rectangular arrays, circular arrays, and stretching in one direction. The project wireframe capability is outstanding.

A powerful feature in CADDs is the ability to select sub-items in polylines, grouped items, symbols, surfaces, solid primitives, user-defined solids and solid composites for construction.

CADDs supports Cartesian, polar and cylindrical coordinate systems, and allows use of construct planes. Access to these coordinate systems for coordinate entry and verification is available. Rectangular and polar grids are provided.

Some of the more complex verification or query functions for surface area and curvature are implemented in CADDs. CADDs is one of the few programs that supports these functions. Most other query functions are provided.

Drafting. CADDs model and drawing association scores above most other programs evaluated. It has capabilities to create independent and dependent drawing views that represent exact geometries. Curves, surface edges and solid edges are accessible in dependent drawing views. Second, CADDs supports excellent model display modification, both interactive and automatic. There is drawing mode with drawing items and multiple drawing sheets.

Annotation is rated higher than any other program evaluated, because of the above average set of standard line styles, multiple line notes, a good text editor, number of text fonts and characters available, and text size, justification and fitting. Text font functionality is extensive. Text nodes are provided. Special annotation items such as labels, flags, and feature control symbols are available.

Most dimension types and styles are supported, but angular dimensioning is rated as weak. There is adequate text control, tolerancing capabilities and dimensioning editing. Unlike most other programs, a tolerance stackup analysis function is implemented. ANSI and other dimensioning standards are provided. CADDs supports dimension regeneration. Extension line, dimension line and arrowhead appearance may be easily changed or controlled.

Good crosshatching capabilities are available. Boundary specifications include islands, but not intersecting boundaries. Line fill patterns, standard material patterns or user-defined patterns may be used. The size, spacing and angle of these patterns may be changed upon crosshatch generation. CADDs maintains associativity between crosshatching and boundary geometry.

CADDs incorporates a detail magnification area function. This area maintains an association with the original geometry it is magnifying. If any modification is made to the geometry, the magnified area reflects the change. Dimensions scale to reflect the part measurement.

Program: CATIA

Company: Dassault Systems

Revision: Version 3

Equipment Used: IBM 4341/12, IBM 5080 model 2 display

General Comments. CATIA, began as a surface design package for an airframe manufacturer and has evolved into a good, general-purpose 3D design and drafting tool. It is distributed exclusively by IBM in the U.S., and is available on mainframes and the IBM RT.

User Interface. The integration of CATIA's user-interface software with the IBM graphics terminal hardware is excellent, making the user interface fast and easy to use. CATIA's screen layout is flexible and good. A variety of on-screen modes are supported including pop-up windows, dialog boxes and forms. Icons are used for some functions but are not used consistently throughout the program. In the interactive mode category, the ranking is high due to the number of modes supported and the responsiveness of the program. CATIA makes excellent use of the dynamic display functions that are available with the IBM 5080. CATIA has implemented good graphic feedback by highlighting active menu areas, thus guiding the user through commands. Menus cannot be customized for particular applications. Only menu location can be changed. User programing facilities are extensive but are oriented toward computer professionals, not users. The language is nonstandard.

CATIA provides good capability for assisting users with undo, abort, and interrupt functions that are consistently implemented throughout the program. Integration with the IBM graphics terminal provides fast, flexible viewing and display functions. Dynamic display functions are very easy to use, and are well integrated with the program. Rankings for view layout and view transformations are high, based on the ability to store and retrieve user-defined layouts and dynamic viewing as well as z-clipping capabilities.

CATIA provides good control over display attributes. Blanking by layer and by type is easy to use. Unblanking of items previously blanked is a useful feature. Blanking by view is not supported. Rendering functionality is excellent. Hidden line removal and silhouette views are created in real time. A variety of shading techniques, with good control over shading parameters is provided. Light source placement and control is good. Multiple light sources are not well supported. CATIA provides a fast display mode for text but not for curves or subcomponents.

Geometry Construction. CATIA has both 2D and 3D items; they are well integrated. Points, construction lines and line segments have broad functionality, and are easy to use. Polygon creation is not very well implemented. Arcs, circles, conics and splines are well supported in the 2D mode, but there is no 2D B-spline. The functions that control construction operations for the cubic spline and the composite spline functionality are excellent. The 3D wireframe items are well supported. The 3D mode has an excellent B-spline construction function. Surface design is the strongest set of geometry construction functions. CATIA supports a large variety of surface types including constructed surfaces such as B-spline (NURBS), bounded plane, composite surfaces, and computed surfaces such as fillet, blended and lofted. Solid modeling element creation is well done, allowing solids to be constructed in a natural way using existing geometry. The user-defined solid techniques such as extrude, sweep, and curve driven are all supported. Normal solid operations are provided, including executing multiple Booleans in a single command, as well as good coplanar face handling. Clearance checking is not provided in the solid operations.

CATIA ranks very high in the item editing section. The ability to modify existing geometry is good. Changing of splines and surfaces is excellent. There is item associativity in the 2D mode. It is not supported consistently throughout. The grouping functionality is industry standard. Symbol creation functionality is good. The use of nongraphic data for symbols is excellent, supporting the creation of "families" for easy retrieval of components from libraries. The manipulation of library items is very good and the ability to update and manage updates to library items is excellent. Subitems in library items are easy to access. CATIA ranks very high in geometry relimiting. Wireframe operations are well supported. Trimmed-surface capabilities are very good as are the solid trimming functions. Intersection constructions are very strong, with the line-to-plane and line-with-surface being superior. Generation of curves from surface edges and solid edges is excellent. Transformation functions are not complete. Array functions, scale and stretch are not supported.

In the construction aids category, CATIA ranks high due to the variety of aids that are implemented. The item selection capability is very good, especially with the access to the sub-item level in surfaces and solids. The variety of selection techniques is also very good. Included are rectangle and polygon selections, by name, chain, by nongraphics, and toggle select. Control of filtering is good with commands that allow filters of different types to be used in a single command. The use of coordinate systems by CATIA is good. CATIA's use of construction planes, and the ability to store and recall coordinate systems, is very good. An excellent verification functionality that is very complete is implemented. Good facilities are provided for controlling grid parameters in both rectangular and isometric views. CATIA makes average use of temporary construction geometries.

Drafting. CATIA's drafting is built on the integrated 2D and 3D geometry capabilities. Model/drawing associativity is excellent. The generation of drawing views from the model is very strong. It is based on the ability to use curves in solids and surfaces. It is very easy to select and use standard views and to create isometrics. Automatic generation of hidden line views is very effective. The drawing-to-model and model-to-drawing associativity are the most advanced in the industry. The annotation functionality is good. A variety of line styles are supported, and there are good text creation and editing functions. CATIA supports excellent capabilities in fonts, and international and engineering character sets. The support of special items is sporadic. The creation of feature control symbols is very powerful, as are simple labels. There is no support for datum targets, weld symbols or flags. In the dimension section CATIA is ranked high, getting credit for supporting the full range of dimension types. CATIA supports the full range of styles from point-to-point through dual dimensioning. The control of the dimension text is industry average. Tolerancing functionality is limited. Dimension editing is average. The ability to modify the location of a dimension is very good. All other dimensioning parameters can be modified with the exception of units. Automatic regeneration of dimensions is excellent. Dimensions can be automatically updated when geometry is changed, and geometry can be modified by changing the numeric value in a dimension. Crosshatching functions are very well implemented. Boundary specification techniques are very easy to use and pattern creation and control is very good. The only crosshatch editing that is supported is the ability to change the pattern. CATIA supports a detail magnification area and maintains associativity to the original geometry.

Program: Generic CADD, AutoDimensioning, Drafting Extensions -1, -2

Company: Generic Software, Incorporated

Revision: 3.0

Equipment Used: IBM PC/AT Compatible, EGA Compatible display

General Comments. Generic CADD has the lowest score of the programs evaluated for this report, with less than one third of the points scored by the highest ranking program. However, Generic CADD delivers a usable product at a remarkably low price. The software tested is by far the lowest-priced product considered in this evaluation. Generic CADD sells for one-tenth of the price of the next lowest PC package in this evaluation. Even though the Generic CADD user sacrifices capability, price is a strong incentive.

User interface. User interface is an area of strength for Generic CADD, relative to the other two major categories. In this area, Generic CADD scores nearly half the points of CATIA, giving Generic CADD its strongest rating in the three major categories. Nonetheless, Generic CADD is well below average in this category.

Generic CADD scores low in screen layout. The selection of displays supported is modest compared to AutoCAD, and on-screen command modes are limited to text based menu selection and command entry.

Interactive modes are a source of strength for Generic CADD, due to support of a wide range of input devices. The lack of a predefined tablet menu is a minus for many users.

Generic CADD scores well below average on customization. Generic CADD offers a strong macro capability, as well as a complete menu, function key, and tablet programming capability. There is no user programming language.

In the user-assist category, Generic CADD lacks on-line help facilities, but provides adequate prompting. Undo and redo functions are provided, but are weak. Journaling of user input and can be used for macro generation.

Although Generic CADD scores well below average in the viewing/display category, it is rated higher than the other two PC programs. Options for fast display of text and curves are unique among the PC packages. The ability to store and recall views by name is also unique.

Geometric Construction. Of the three PC-based packages evaluated, Generic CADD is the only program with no pretense of 3D capability in the product evaluated. The complete absence of 3D capability is partially responsible for Generic CADD's weak score, however the product is uniformly weak in other aspects of geometric construction.

Support of 2D geometric items is the strongest function in a weak set of geometric construction capabilities for Generic CADD. The set of geometry types supported is minimal, and the implementations are below industry standard.

Generic CADD supports no 3D items. Although Generic CADD scored very low in the item-editing category when compared to CATIA, its score is the highest of the PC-based programs. This is the result of the ability to move points on lines, arcs, and splines.

Item manipulations are a significant weakness for Generic CADD. It has the lowest score of all programs evaluated. A rudimentary symbol capability is the strongest aspect of this section. Relimiting functions are limited to fillets and simple trims.

In the transformations category, Generic CADD falls to the bottom of the list. Capabilities are largely limited to substandard implementations of move, copy, and rectangular-array functions.

Generic CADD is weak in construction aids, with only the most basic features offered.

Drafting. In drafting functions, Generic CADD scores one-fifth of the points of CATIA, the leader; about one-half the points of AutoCAD; and ties with VersaCAD. Generic CADD makes its strongest showings in crosshatching and annotation.

In the annotation category, Generic CADD offers standard drafting line styles and supports multiple line notes. Special annotation items are limited to a label function.

Generic CADD's dimension function is competitive with VersaCAD, but is very weak relative to the programs evaluated. The ability to dimension in units other than model units is a strength.

Although well below average, crosshatching is one of Generic CADD's strongest functions, with a score slightly less than one half that of Computervision CADDs, the leader in this category. The "strength" comes from supporting standard patterns and allowing user-defined patterns.

Generic CADD does not support a detail magnification function.

Program: Geomod/Geodraw

Company: Structural Dynamics Research Corporation

Revision: I-DEAS 4.0

Equipment Used: MicroVAX II, Tektronix 4208 display

General Comments. I-DEAS is a combination of separate programs that comprise SDRC's mechanical CAD offering.

Geomod and Geodraw were evaluated separately because of major differences in user interface and geometry constructions available. Although they are called by the same main program, they are separate programs. Geomod has no drafting capabilities. They are capable of sending and receiving information to and from each other by way of IGES or a universal file format.

If both Geomod and Geodraw could be evaluated as one product, the rating would be comparable to or higher than some other evaluated integrated programs.

User Interface (Geomod). The Geomod user interface consists of text-based command menus. The commands are abbreviations or representations of functions. There is no support for icons, pop-up windows, pull-down menus, forms or dialog boxes. There is a status area at the top of the screen that presents necessary information about the current model. The status area lacks an x-y readout. Response was sluggish on the benchmark system.

Menus appear on both left and right sides of the screen. Menus on the left side spill onto the graphics window sometimes making it hard to see details on the model. The menus can be turned off, but only by a very experienced user who can remember the commands. Other than turning the menus on and off, no other customization of the screen or menus is available.

Geomod supports a macro language. Macros can be created either by capturing keystrokes or by entering text into a file using a text editor. The language is not a full programming language, but allows for looping, branching and calculations.

A good on-line reference is available. This is necessary because of the complexity of the program.

Viewing and display functions are rated below average for pan/zoom, view layout and 3D view transformations. Z-clipping is extensive, and allows one plane, two planes as well as box clipping. Display attributes are generally adequate, but line weights and fast text and curve display are missing. Light source control is exceptional allowing many sources, each with its own control of color, brightness and direction.

Geometric Construction (Geomod). All geometric construction in Geomod is 3D. Since Geomod is primarily a solid modeler there is not much need for special geometry used on drawings. Also, since most models can be created using Geomod solids, surfacing functions are not required. These two facts effect the score Geomod receives in 3D geometry construction even though it is a powerful solid modeler.

Geomod is divided into three main modules for geometry creation. The first module creates working sets. Working sets can be created anywhere in 3D model space. Points, lines, arcs, circles and splines can be used to create a working set. The second module is used to create a profile. Profiles have to be constructed before user defined solids can be created. Profiles are easily created and can have holes in them. If a profile has to be geometrically constructed, a working set is constructed and a profile is easily created from the working set. The third module creates solid objects. Both faceted and exact solids are initially created and maintained. Exact solids are destroyed by some editing functions.

Only B-splines are available in Geomod. The offset spline function is excellent, producing correct solutions with no spikes or bow ties. Fillet, tapered fillet, blended, offset and point mesh solid functions are available. Geomod was given full credit for these functions in the surface section. Solid primitives are available, but are always created in the same direction about the model origin. These primitives then have to be moved or oriented to their correct positions. This same practice applies to user-defined solids. This factor caused the rating of Geomod solids to be lower than other programs that allow solids to be created anywhere in 3D space.

Most solid primitives are available as well as user defined extruded, sweep, curve driven and offset solids. The normal set of solid operations, such as add, subtract and intersect are supported, but multiple boolean operations are not. Coplanar face handling works well.

Geomod has very limited item editing functions. Splines are the only item type with full editing capabilities. Lines can also be edited to a lesser degree. Symbols are not supported, but Geomod has a powerful system-assembly module, therefore credit was given for the symbol/part library items section. The system assembly module is normally used for analyzing mechanisms.

Relimiting is almost absent from Geomod except filleting of curves and solids. Intersection constructions producing curves are nonexistent. Most transformation functions pertaining to a single solid object are adequately supported. They are very important in orienting a solid object once it has been created. Other transformations, such as rectangular and circular array are not supported.

Selection methods are adequate and Geomod sometimes uses a select list, but most of the time uses a prefix philosophy. There is no filtering or masking as defined in the evaluation, but Geomod keeps track of working sets, working set items, profiles and solids.

Geomod supports Cartesian, polar and cylindrical and spherical coordinate systems. It also allows the use of construct planes for working set geometry. There are no grid functions.

Verification and query functions are abundant, and contain all information about items including solid facet data. Many temporary construction types are used in Geomod by construction and manipulation functions.

User Interface (Geodraw). The Geodraw user interface consists of text-based command menus. The commands are abbreviations or representations of functions. The commands are not at all like the commands in Geomod. Icons along the right side of the screen are used. There is no support for pop-up windows, pull-down menus, forms and dialog boxes as defined for this evaluation. Geodraw does use a box in the bottom right corner of the screen to display selections, which sometimes toggle when selected. Response was sluggish on the benchmark system.

The combination of text-based menus, icons and the other information box make Geodraw an easy-to-use drafting program. There are no help facilities. The graphic feedback in interactive mode helps in stepping through construction of geometry and annotation.

Customization of the screen and menus is not possible, but a macro programming language is available. This language is not a full programming language, lacking subroutine and file access capabilities. A strength, not seen in very many of the evaluated programs, is the ability to save defaults to a file. The new default file is then used for any subsequent drawings.

User assists such as undo and redo functions work very well. The undo functions backs up as many steps as desired. The redo function undoes an undo function. Journaling, a good calculator and screen dynamics are also supported.

Geodraw has user defined view layouts and preset views. It can bring in view dependent information from Geomod, but has little or no 3D construction and viewing capabilities. Color, line style and line weights are supported, but rendering must be done in Geomod. For these reasons Geodraw did not excel in user-interface functions.

There is fast curve display, but no fast text display.

Geometric Construction (Geodraw). Geodraw is a mainly a 2D drafting program with the capability of bringing in some geometry items and view dependent information from Geomod. The 2D geometry constructions meet the state-of-the-art for a drafting program. There are therefore no surface or solid constructions, since they can be created in Geomod and transferred into a view in Geodraw.

Item editing for lines, conics and splines is available. There is no item associativity. Symbol creation and placement capabilities are adequate, but there is no sub-item access or editing.

Relimiting of curves by all methods except jog are available, but no 3D intersection constructions exist. This is again due to the lack of surfaces and solids. Most transformation functions are supported.

The item selection philosophy is all prefix. This means the function is selected followed by the items the function effects. There is no sub-item granularity. This is a weakness especially for symbols. Geodraw has good filtering and masking of items by item type, color and by layer.

Both cylindrical and polar coordinate systems are supported. Most 2D verification and query functions are also available. Rectangular, polar and isometric grids are available. Rectangular grids were much faster than polar and isometric grids. Grid origin, display and spacing are all user controllable. Temporary points and lines are used extensively for constructions.

Drafting (Geodraw). Geodraw is not directly linked to Geomod therefore a rating of zero was given for independent and dependent drawing views. Credit was given for orienting of views and standard drafting views. A zero rating was also given to Geodraw for model display modification.

The rating for annotation was lower than most other programs evaluated because of the lack of real multiline notes, text font and character support, text along curves, text fitting and text nodes.

Geodraw excels in the creation of feature control symbols. The program has intelligence during the creation function, and leads the user through building a correct symbol. Once the feature control symbol is constructed, it is made a symbol with no editing capabilities. Other special annotation items supported are labels, bubbles, datum targets and surface finish symbols.

Dimensioning in Geodraw is excellent. Modification of any dimension parameter during creation is readily available and easily accomplished. Editing of dimensions after they are created is also supported. Most dimension styles, and text and tolerance control are available. In addition to the full set of dimension creation and editing capabilities, dimension regeneration is supported. If the part is changed, the associated dimension is automatically updated. Unlike most other programs evaluated, if the dimension value is modified, the geometry is modified. The geometry must be a line or conic. Dimensions can either be associated or disassociated with geometry. Dimensioning is a definite strength of Geodraw.

Crosshatching boundary specifications are rated as adequate. Geodraw allows intersecting boundaries. Pattern control is not as extensive as it could be, lacking size and angle control. When a crosshatch pattern is created, it becomes a symbol. It therefore does not have any associativity with the boundary. If the boundary geometry is modified, the symbol has to be deleted and new crosshatching defined.

Geodraw supports a detail magnification area. Dimension values are correct even though the scale of the detail magnification area is different than the part, but if the part geometry is changed, the detail magnification area does not change.

Program: IGDS

Company: Intergraph Corporation

Revision: 8.8.2

Equipment Used: VAX 785, Interact workstation

User Interface. The user interface consists of icons and text-based commands. There is no support for pop-up windows, pull-down menus and dialog boxes, but forms are used to input data. There is a status area on the screen that presents all necessary information about the current model including a x-y readout. Mouse buttons are used for some functions, and are programmable. In addition, a tablet and function keys can be used for interaction between the program and the user. The program is responsive, providing good interaction with users.

Although the screen appearance cannot be changed, menus and forms can be customized. IGDS also has good facilities for modifying the command tablet. A limited programming language supports prompts, character data entry, looping and conditional execution, but does not support graphic data entry. It also supports subroutines, shell access, menu definition and file access.

The strongest IGDS user assist function is an on-line reference. A good on-line reference is necessary because prompts and messages are not always clear. Dragging is supported, but rubber-banding is not. There is no journaling capability and the calculator function is rated as weak.

Viewing and display functions are rated higher than most programs evaluated. This high rating can be attributed to preset and user-definable view layout and view transformations. IGDS rates higher than any other program on display characteristics because of the many methods available for blanking items, display attributes, such as color, linestyle, line weight, mesh display, shading methods and shading parameters. Fast text, curves and subcomponents are supported and increase the rating.

Geometric Construction. IGDS has a special 2D geometry subset. Point, construction line and polyline capabilities in the 2D subset are excellent. Also supported are 2D conics and splines.

In 3D geometry construction, IGDS supports a limited number of spline types, but B-splines are rated above average. Also, a limited number of surface types are supported. Solid-modeling capabilities are weak.

Item editing of lines is very powerful, but editing of solids is nonexistent. Spline editing works to evaluation standards, but editing of conics and surfaces less than average. There is no item associativity.

Either 2D or 3D symbols can be created. Symbol capabilities are not rated as high as for some of the other programs evaluated. This is due to the lack of sub-item editing and the mediocre scores on orienting and updating of symbols.

Relimiting capabilities in IGDS are abundant, but not very powerful. Only the trim single function is rated as adequate. There is no relimiting of surfaces or solids. There is also a limited set of intersection constructions. There is no surface-to-solid intersection function. Transformations are not rated as high as other programs evaluated because of below average circular and rectangular array, linear move and copy, rotate and mirror functions. IGDS does have an above average scale function allowing different scales in the x, y and z directions.

IGDS consistently uses a select list for item selection. This is a strength. A weakness is that display of selected items is not always clear. IGDS allows selection of sub-items of some item types such as polylines, grouped items, symbols and surfaces. Filtering or masking is very weak, because there are few methods available for filtering or masking items for selection.

IGDS supports Cartesian, polar/cylindrical and spherical coordinate systems and construct planes. Access to the coordinate systems and construct planes for coordinate entry and verification of units is available. The only type of grid supported is rectangular grid. Most verification or query functions are supported. The functions that query for distance, area and perimeter are exceptional. All other query functions are provided, some minimally, except for curvature which is not available.

Limited temporary constructions for points, planes and vectors are available.

Drafting. IGDS model/drawing association rates below most other programs evaluated because of its inability to interactively make model display modifications. Automatic model display modifications are substandard. Standard drafting views are missing.

Annotation is very good compared with the other programs evaluated, but several items rated below standard, such as standard line styles, multiple-line notes, text editing, bring the rating down.

Weakness of angular and dual dimension constructions, and the lack of some dimension editing capabilities, reduced the rating for dimensioning. There is also no dimension regeneration, except automatic edit of dimension.

Overall crosshatching capabilities are below average. Boundary specification is below what is considered adequate for this evaluation; there is no editing capability. This means, if the boundary is modified, the crosshatching must be deleted and recreated for the new boundary.

A detail magnification area function is available, but it also does not measure up to evaluation standards because of its lack of associativity to the part.

Program: Prism/DDM

Company: GE CALMA Corporation

Revision: 5.0

Equipment Used: MicroVAX Q5, Graphicon G700 display

User Interface. The Prism user interface consists of text-based commands. These commands are abbreviations or representations of functions. Many of Prism's functions are written in DAL, CALMA's user programing language that is distributed with the base program. There is support of icons, function keys and pull-down menus and forms on the MDI (menu driven interface) system that is available with some hardware configurations. The program always displays text based commands even if a tablet or on-screen menus is used. The program is not rated as responsive as some other evaluated CAD programs.

The program rates higher than all other programs evaluated for customization of the user interface. Icons can be created using any geometry or annotation construction available. On-screen menus may or may not be used. These menus may have multiple pages. Cell, key and tablet programming are all available. A macro language and a full programming language (DAL) are supported. The programming language supports every type of function being rated in the evaluation. This language is a definite strength of Prism.

The requirement to set defaults in almost all circumstances is a weakness. They are not saved from session to session.

Prism supports journaling, and has a good calculator function. Prompting and an on-line reference are adequate, but there are no tutorials. Screen dynamics are supported on the Graphicon graphics processor, but could not be demonstrated during the evaluation.

The viewing and display rating is lower than some of the other programs evaluated. There are only a few predefined view layouts, and 3D view transformations must be stored in a startup model. Most normal display characteristics are supported, but fast text and curve display are not. Shading and mesh display renderings are supported, but specular and diffuse reflectance as well as light source color and ambient brightness are missing. Anti-aliasing would help the jagged appearance of the solid edges.

Geometric Construction. All geometry construction in Prism is 3D. Prism rates somewhere in the middle of the high-end programs evaluated. Limitations are the lack of, or limited number of, some construction types. For example, there are no construction lines or polylines. There are limited polygon construction programs and a limited number of arc, ellipse, and rho-conic functions. Prism does support many different spline and surface types.

Most solid primitives are available as well as user-defined extrusion, sweep and curve driven. The rating for all primitive solid-creation functions is lower than the standard, because solids have to be created in the z direction at the model origin. Faceted solids are interactively created. If an exact solid is required a batch program is run.

The normal set of solid operations, such as add, subtract and intersect are supported. Boolean operations are well supported. They include multiple booleans, and a textual boolean tree that can be edited. Editing the tree changes the boolean operations on the solid model. Coplanar face handling worked well on the benchmark part.

Prism has very limited item-editing functions. Line end points can be edited. Editing for splines, surfaces and solids is not adequate. There is no item associativity.

Either 2D items may be used in symbol creation or 3D items may be used in part library creation. Prism's symbol and part library capabilities surpass those of most other programs evaluated. This is mainly due to a strong symbol package, as well as strong subassembly capability. The rating for this section reflects functions in both areas. Where the symbol package is lacking a function, it is found fully implemented in the subassembly functions.

Relimiting of curves is adequate in some areas, but chamfer, corner, break and jog functions are missing. Prism does a good job of surface trimming, but has no solid trimming. There are no point-intersection constructions, but there are many surface-intersection constructions that produce curves.

Prism's item-selection philosophy is a mixture of prefix, postfix and selection list. Selection list is the most prevalent. The variety of methods used increases the difficulty of the using the program. Selected items may be displayed highlighted, blinking or with a marker. Selection methods are abundant, but not all are fully implemented. For example, items may be selected inside a rectangle or polygon. They cannot be partially inside or all outside.

A model and local-reference system is available for coordinate entry. Many verification and query functions are available. Prism rated high in this area. Rectangular, polar and isometric grids are available. Their origin and spacing are user controllable.

Temporary point, planes and vectors are frequently used in other construction functions. This alleviates the need to construct these items then delete or blank them after use.

Drafting. Prism's model and drawing association rate high, but not as high as some other programs evaluated. This is due to the lack of solid edge access, standard drafting views, interactive trimming of model items in the drawing, and drawing-to-model drawing-mode functions. All other functions in this section are adequate.

The rating of annotation is low for Prism because of the lack of predefined line styles, but the standard set is adequate, and the user-defined line styles functions are powerful. Multiple-line notes can be created and edited. Text-font functions are limited, but text size, justification and fitting are available.

A limited set of special annotation items include labels, bubbles and feature control symbols, but do not include datum targets, flags, weld symbols and surface finish symbols.

Dimensioning capabilities are adequate, including types and most styles. Text and tolerance control are also available. Dimension editing capabilities are in some cases above average, but there is no dimension regeneration available.

Crosshatch boundary specifications work well, but pattern support is limited. There is no standard set of crosshatch patterns. Crosshatching is not associated with boundary geometry, therefore if the boundary geometry changes, the crosshatching has to be deleted and recreated.

Prism does not have a detail magnification area function, but the picture function can be used. Pictures can be scaled and dimensions reflect the real part measurement. Pictures also maintain associativity with the model.

Program: VersaCAD

Company: Versacad Corporation

Revision: 5.2

Equipment Used: IBM PC/AT Compatible, EGA Compatible display

General Comments. VersaCAD's total score falls between AutoCAD and Generic CADD. VersaCAD scored approximately one third the total points of CATIA, the overall leader. As with Generic CADD, VersaCAD's strength is in the user interface category.

User Interface. User interface is VersaCAD's strongest area, with a point total well over half that of CATIA. Customization and user assist are the biggest contributors, with viewing/display as the weakest category.

VersaCAD's list of supported PC graphics-display devices falls between Generic CADD and AutoCAD. Primary interaction is through text-based on-screen menus. Of the programs evaluated, only Geomod scores lower on interactive modes. However, VersaCAD does score 69 percent of the total for CATIA, a respectable rating.

VersaCAD finishes first among PC programs for customization, well above average for the total group. Only Calma's Prism scores substantially higher. VersaCAD scores strongly in menu and function-key programming, macro capabilities, and user programming. The only significant competitive weaknesses are an absence of graphic entry as a macro definition technique, and the inability to perform geometric calculations in a user program. As with most of the programs evaluated, the ability to set user determined defaults is limited.

VersaCAD leads the other PC programs evaluated in user assists, and is competitive with many of the high-end programs. Strengths are the on-line reference capability and journaling. Calculator entry is not supported. Many other user assists are provided, but are not implemented as effectively as state-of-the-art competitors.

Viewing/Display category is VersaCAD's weakest rating in user interface. This is due in large part to the fact that few 3D viewing and display functions are supported. VersaCAD earned the lowest score of all programs evaluated in this category. VersaCAD's strengths in this area are its support of color, line styles, and line weights.

Geometric Construction. VersaCAD exceeds only Generic CADD in geometric construction. VersaCAD scores approximately one-fourth the points of CATIA, the category leader. The strongest scores are in 2D items, transformations, and construction aids. The 3D item constructions and item editing capabilities are very weak.

VersaCAD falls just short of average for the evaluated programs in 2D item construction. The number of 2D item types supported is competitive; however, the implementations are generally substandard.

VersaCAD offers a minimal 3D point definition capability. VersaCAD's item editing is limited to moving points in its rudimentary 3D surface definitions. VersaCAD ranking lies between Generic CADD and AutoCAD in item manipulation, with about one third the points of the category leader, CATIA. Symbol and part library support are particularly weak. In the transformations category, VersaCAD again scores between the two PC packages. Transformation capabilities are in general not up to the state-of-the-art.

In the construction aids category, VersaCAD again scores between Generic CADD and AutoCAD with less than half the points of the category leader. Unlike the other two PC packages, VersaCAD offers several item selection mask functions. Verification and query functions are strong relative to the PC competitors evaluated.

Drafting. Of the packages offering drafting functions, VersaCAD ties with Generic CADD for last place, with one-fifth of the points of the leader, CATIA. VersaCAD offers support for isometric-view projection, earning a nominal score in the model/drawing association section. VersaCAD's annotation capability scored lowest of any program offering drafting capability. A standard set of line styles and multiple-line notes are supported.

VersaCAD receives a weak score in dimensions, surpassing only Generic CADD. Neither tolerancing, dimension editing, nor regeneration (associative dimensioning) are supported.

With half the points of Computervision's CADDS, the category leader, crosshatching is VersaCAD's strength in drafting. Again, VersaCAD scores between AutoCAD and Generic CADD. Crosshatch editing is not supported. VersaCAD does not support a detail magnification function.

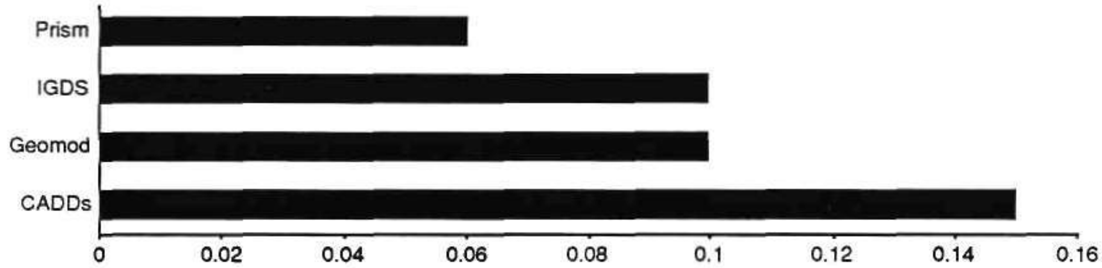
C. FEM Capabilities

The following twelve bar charts, Figures 17 through 28, display the results of the next level of the FEM section.

These charts show results of initialization, node specification, elements, loading, constraints, material specification, editing, verification, output, display control, results display, and mass properties.

Figure 17

FEM — Initialization



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

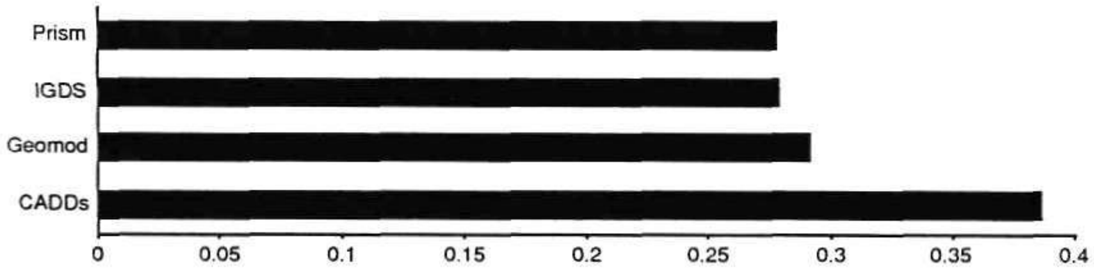
Figure 18

FEM — Node Specification

**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure 19

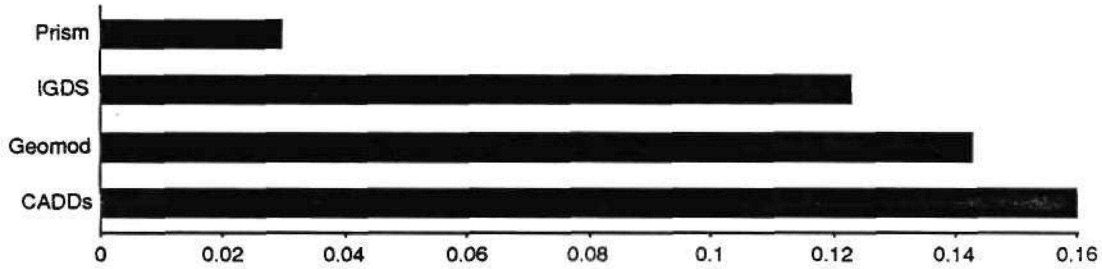
FEM — Elements



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure 20

FEM — Loading

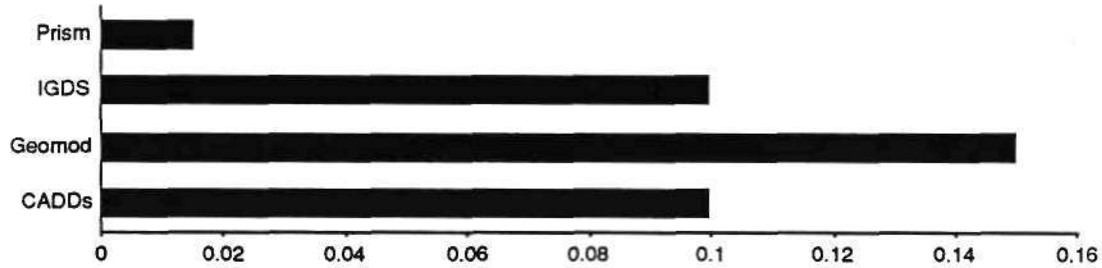


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure 21

FEM — Constraints

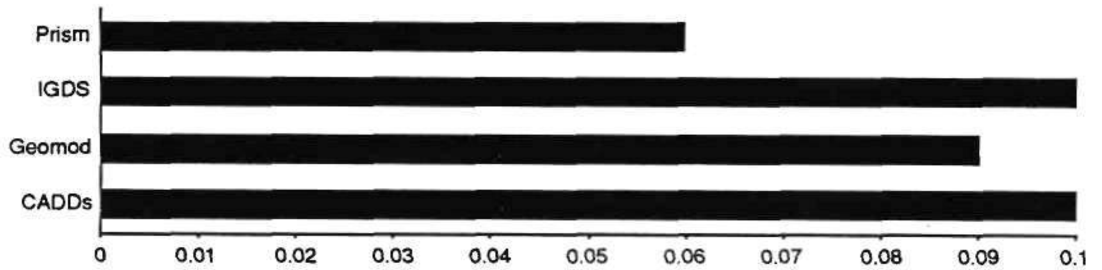


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure 22

FEM — Material Specification

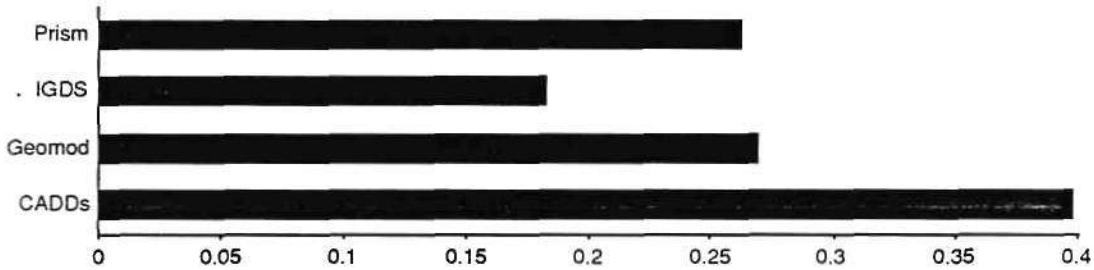


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure 23

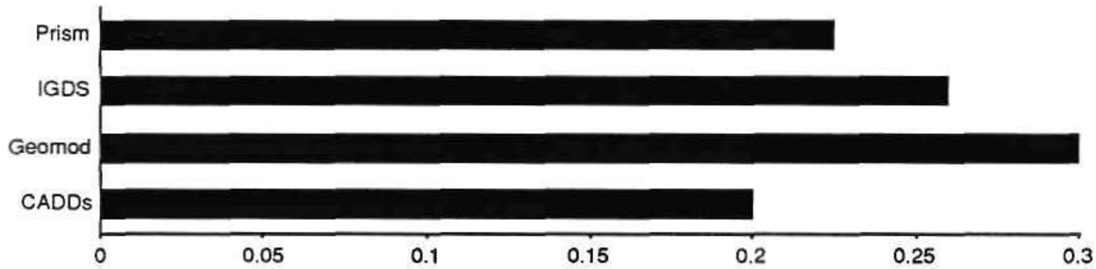
FEM — Editing



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure 24

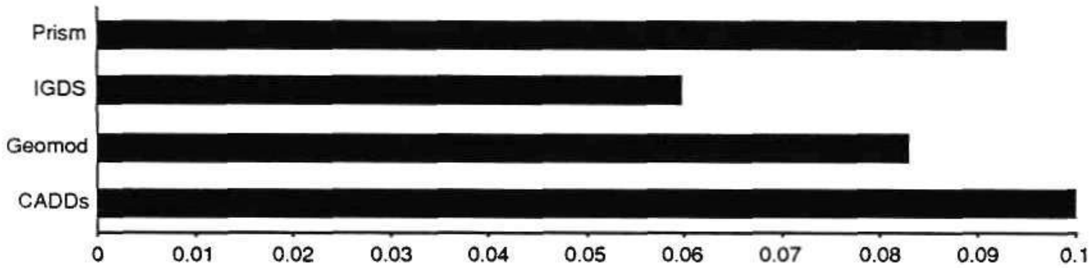
FEM — Verification



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure 25

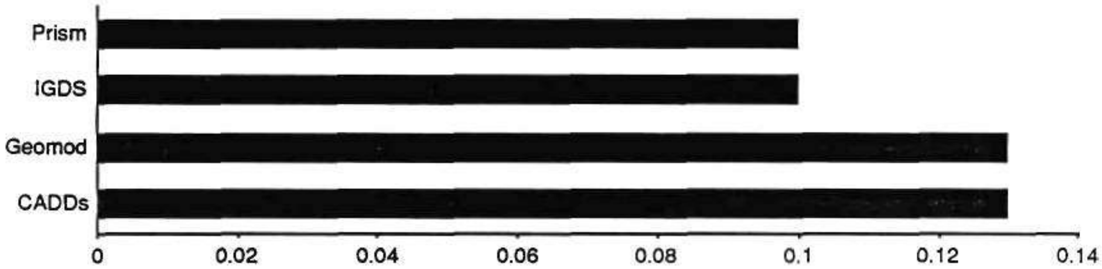
FEM — Output



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure 26

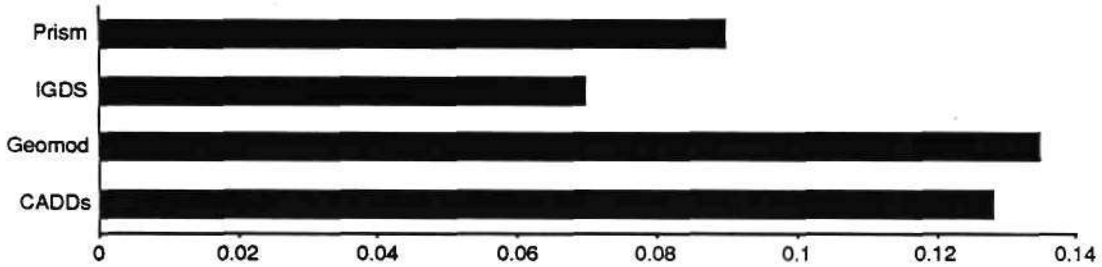
FEM — Display Control



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure 27

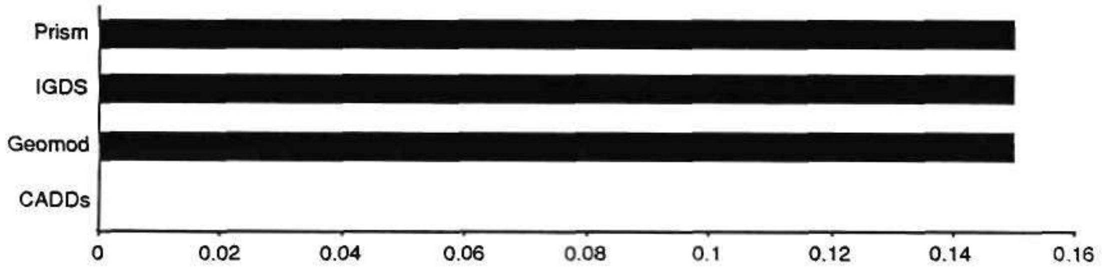
FEM — Results Display



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure 28

FEM — Mass Properties



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Program: CADDs

Company: Computervision Corp.

Revision: 4X-4.00C/4X-5.00 Solids

FEM Comments. CADDs FEM capabilities are very good. The program has excellent abilities to store and recall models and parameters that were used in the FEM analysis. The node generation facility of CADDs is very good. The full point creation facility of CADDs is used to create nodes. Automatic node numbering is excellent and coincident node removal is very good.

CADDs supports a complete set of element types. A variety of ways to automate the mesh generation process is offered. CADDs lacks an automated transition region facility. CADDs is also weak in automating the generation of the mesh around a hole.

For generating loading conditions, CADDs is very easy to work with, including excellent facilities for force and moment loading and functional definition for loads. Constraint specification and material specification facilities are good.

Editing is excellent with the ability to control numbering and properties of nodes and elements through moving and copying nodes and elements. The verification techniques in CADDs are weak, missing support for aspect-ratio checks, for element's interior angle checks, and element warp.

The output from CADDs is available for many FEA programs. CADDs results display functionality is broad, providing support in the evaluated areas. Mass property calculations are not supported in the FEM package.

Program: Geomod FEM

Company: Structural Dynamics Research Corporation (SDRC)

Revision: 4.0

FEM Comments. The FEM functionality of Geomod is very good. FEM is a separate application under I-DEAS, requiring a data transfer from the solid modeler. Some of the geometry functions are duplicated in the FEM application.

The initialization of the model and FEM parameters is accomplished through a start model. The node specification capability is very broad and excellent. The options to automatically number nodes, as well as to create nodes spaced between nodes, is easy to use and effective.

The element-creation ranking is average. The FEM capabilities for defining beam cross sections is excellent. There is no support for user-defined elements. Mesh specification capabilities are good. The program supports very good capabilities to automatically mesh simply connected regions, but cannot mesh regions with interior loops automatically.

The program is very flexible in adding the boundary conditions and loads. Sets of conditions can be specified and functions can be used to automatically add loads as the position changes. Geomod's editing shows the lack of association of the FEM model with the geometry. Move, copy and delete functionality is good. Verification functionality is excellent, supporting all the evaluated capabilities but element aspect ratio.

The output from Geomod FEM conforms to ANSYS, NASTRAN, SUPERB, and SAP. The display control is very good. The results display functions are excellent, missing only dynamic display and animation. The FEM calculational capabilities support mass property calculations.

Program: IGDS

Company: Intergraph Corp.

Revision: 8.8.2

FEM Comments. Intergraph's FEM program is good but lacks integration with the modeling functions. The initialization of the FEM parameters and defaults is accomplished through a start model. The node specification is weak for the automatic modes, giving Intergraph a low ranking.

The types of elements supported by Intergraph are limited. User-defined elements are not supported, nor are cubic elements. The automated mesh generation functionality is very good. The program does not handle regions with interior loops very easily.

Loading and boundary condition specifications are average. The editing of nodes, elements and meshes is weak. The verification functionality is strong, lacking only the checks for element aspect ratios. The support for output to FEA programs is minimal. The display control functions are difficult to use. Mass property calculations are well supported.

Program: Prism/DDM

Company: GE CALMA Corp.

Revision: 5.0

Equipment Used:

FEM Comments. The PRISM FEM capabilities are good, but suffer from lack of integration with the modeler and lack of a consistent user interface. The initialization functions are ranked low because they require a start model; some parameters must be set for every model. The node creation capabilities are very good.

The element creation is low. Some of the elements can only be created by selecting nodes in an ordered fashion. The mesh specification is weak. Automated techniques are weak. For instance a region is restricted to being bounded by four curves. No holes are supported.

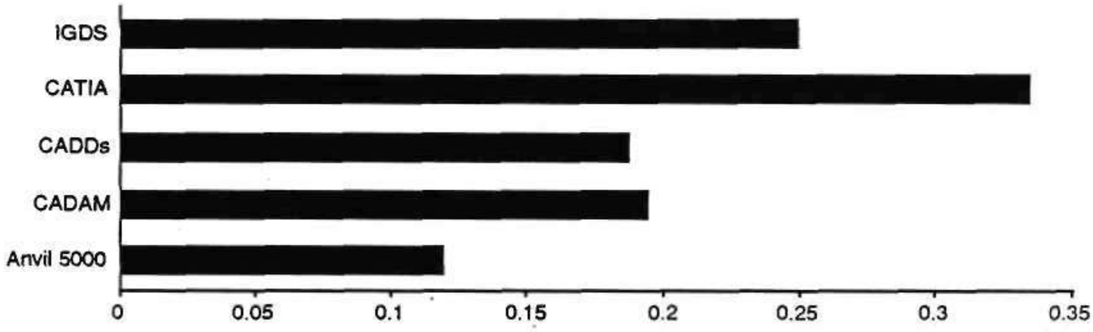
The loading and boundary condition specifications are weak. The node and element editing functions are good. Only a few types of verification are available. The display control is difficult to use, forcing a long sequence of selections to be made each time a change is made. Mass properties are well supported.

D. Data-Management Capabilities

The following five bar charts, Figures 29 through 33, display the results of the next level of the data-management section. These charts show results of system management, nongraphic data, part management, report generation, and data transfer/communication.

Figure 29

Data Management — System Management

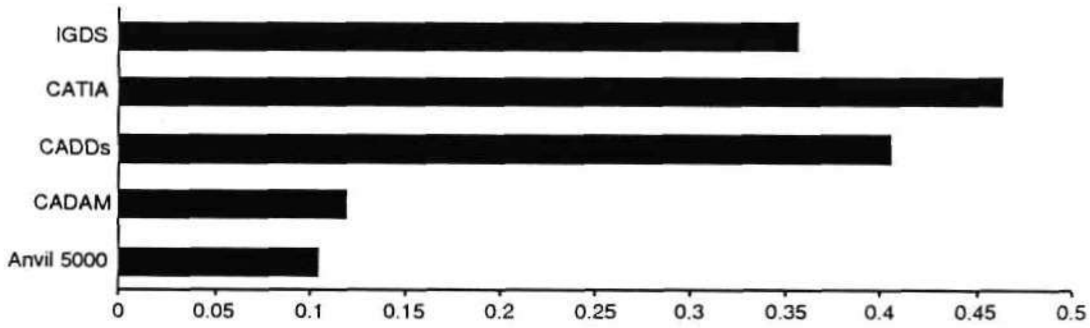


**Maximum score attainable for feature .800*

Source: Albert Consulting Group

Figure 30

Data Managment — Nongraphic Data

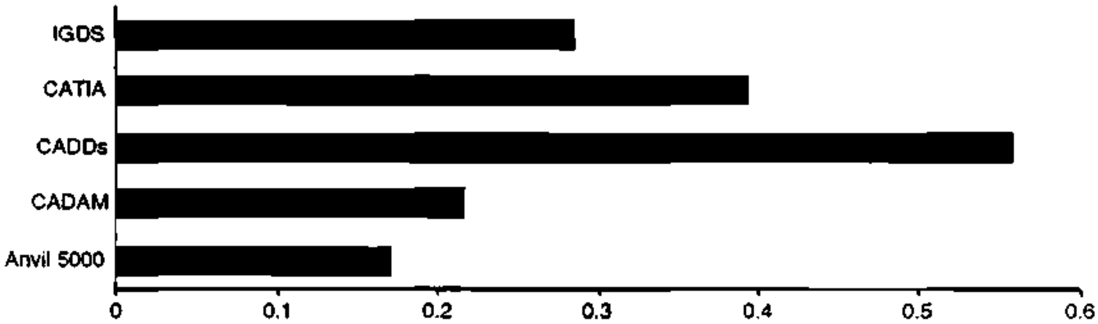


**Maximum score attainable for feature .800*

Source: Albert Consulting Group

Figure 31

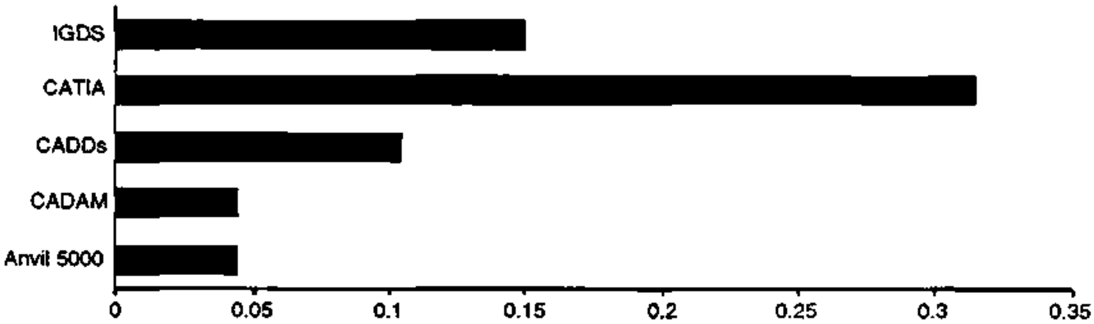
Data Management — Part Management



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure32

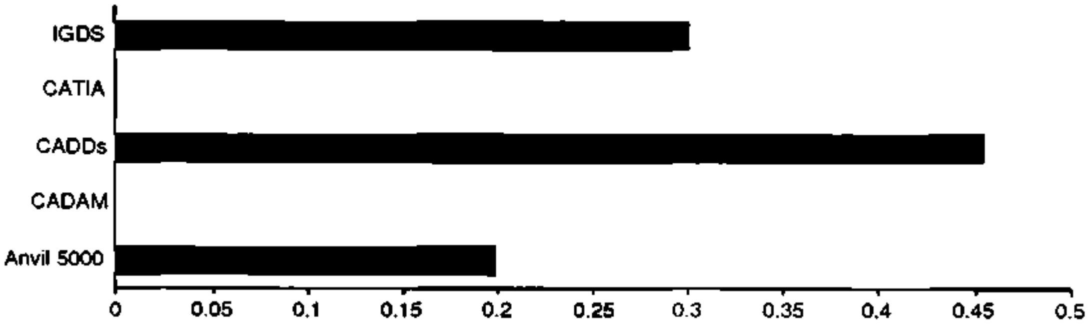
Data Management — Report Generation



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure 33

Data Management — Data Transfer/Communications



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Program: Anvil 5000

Company: Manufacturing and Consulting Services

Revision: 1.1.2

Data-Management Comments. System-management capabilities are lower than most other programs upon which the data-management evaluation was run. This is mainly due to the lack of customization of data structures, user-interface and release procedures. User data hierarchy, passwords, account numbers, description, user-defined data, as well as user create and modify privileges are also missing.

Reporting on nongraphic data is nonexistent, therefore the rating in the nongraphic data section is also very low compared to most other programs evaluated.

Part management is also rated low because of the lack of data stored, for example, names, project, classification and user defined. Anvil does keep versions and some status information, but no other revision data is supported. Access security can be maintained by name and by group. There are little or no part management functions such as check-in and -out, revision review, archiving, locate or ECO generation.

Report-generation rating is low because of limited accounting functions and lack of BOM (where used), user query, ECO tracking capabilities and work in process reports.

Data-transfer and communication ratings are mediocre, but better than some other evaluated programs that have none. IGES IN an IGES OUT are both adequately supported. Anvil also allows some item types to be read in a generic file format.

Anvil rated low in the data-management category.

Program: CADAM

Company: CADAM Incorporated, A Subsidiary of Lockheed Corporation

Revision: 20.1

Data-Management Comments. System management capabilities are lower than all other programs upon which the data management evaluation was run. This is mainly due to the lack of customization of user interface and release procedures. Also missing are user create-and-modify privileges.

Reporting on nongraphic data is very weak, therefore the rating on the nongraphic data section is also very low compared to most other programs evaluated.

Part management is rated lower than any other program evaluated, because of the lack of revision data available. Access security can be maintained by name only. There are few functions such as check in and out, revision review, locate or ECO generation, but there is an adequate archiving function.

Report-generation rating is low because of the lack of BOM, (where used), user query, ECO tracking capabilities and work in process reports.

Data-transfer and communication functions: nonexistent.

CADAM rated lowest of all programs evaluated in the data-management category.

Program: CADDs

Company: Computervision Corp.

Revision: 4X-4.00C/4X-5.00 Solids

Data-Management Comments. System-management capabilities are rated below other programs evaluated. This is mainly due to the lack of customization of data structures and release procedures. Also missing are user create-and-modify privileges and data-controlled libraries and projects.

Nongraphic data stored, reporting and modification are almost fully implemented.

Part management is rated higher than any other program evaluated because of the types of data that can be stored, including almost all revision data types. Access security can be maintained by name, by group and for multiple users. There are also functions such as check-in and -out, revision review, archiving and ECO generation.

Report generation rating is low because of the lack of accounting functions, but there are limited BOM and ECO tracking functions.

Data transfer and communication ratings are better than other programs evaluated. IGES IN an IGES OUT are both supported. CADDs also allows item types to be read in, or output to a generic file format.

CADDs rated highest of all programs evaluated in the data-management category.

Program: CATIA

Company: Dassault Systems

Revision: Version 2 Release 2.0 PTF2

Data-Management Comments. System-management capabilities are higher than other programs evaluated. This is mainly due to the ability to define user data names, hierarchy, passwords, account numbers and descriptions. User-create and -modification privileges are also more adequate than other programs evaluated.

Reporting on nongraphic data is, in some cases, above average. All evaluated types of nongraphic data are supported in CATIA. An excellent attribute grouping function is implemented. Reporting query functions are also very good, and CATIA supports program access to the nongraphic data.

Part management is rated higher than most programs evaluated because of the above-average access security. Not many revision data functions are implemented, but identification is well supported. There are few functions such as check-in and -out, revision review, sign-off, locate or ECO generation, but archiving is fully supported.

The report-generation rating is higher than other programs evaluated because of the excellent BOM, and the inclusion of where used and user query functions. Some limited accounting functions also exist.

Data-transfer and communication functions are available.

CATIA rated second, but close to the highest rated program, in the data management category.

Program: IGDS

Company: Intergraph Corp.

Revision: 8.8.2

Data-Management Comments. System-management capabilities are rated lower than the top program evaluated. This is mainly due to the weak implementation of user data and user create-and-modify privileges, but IGDS is one of the only programs evaluated with fully implemented customization of data structures, user interface and release procedures.

Nongraphic data stored, reporting and modification are partially implemented. Missing are modification functions.

Part management is rated low because of the lack of revision data and other functions, such as check-in and -out, status check, revision review, sign-off, locate and ECO generation. Access security can be maintained by name, by group and for multiple users.

Report generation rating is low because of the lack of accounting functions, but there are limited BOM functions.

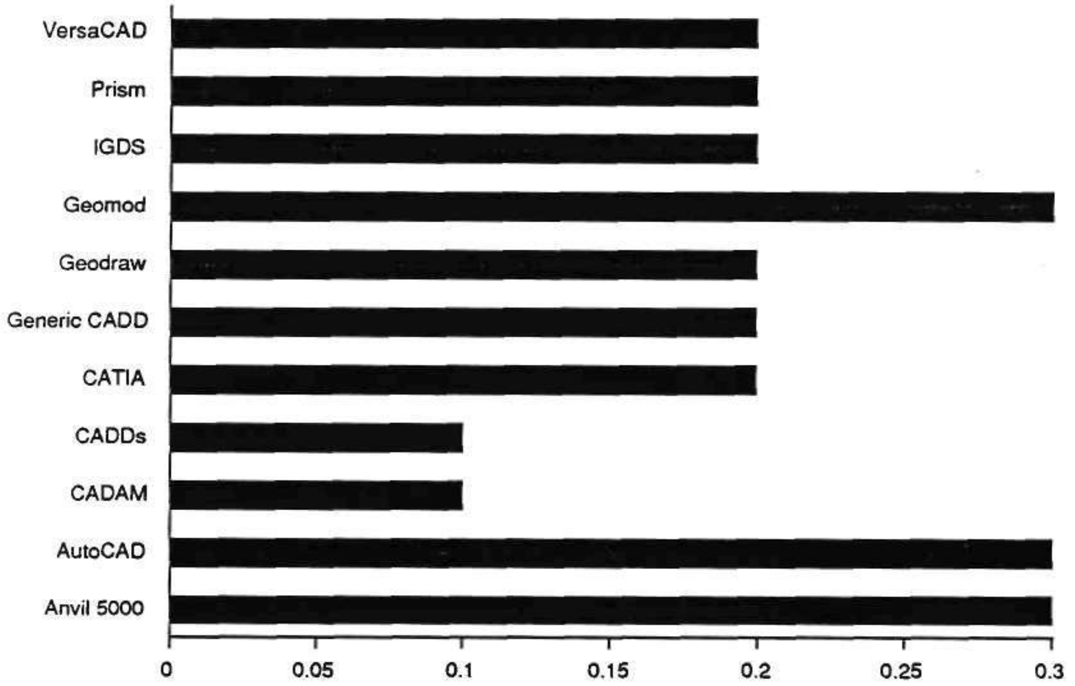
Some data transfer and communication functions are available. IGES IN an IGES OUT are both supported. IGDS also allows item types to be read in or output to a generic file format.

IGDS rated third highest of all programs evaluated in the data-management category.

Appendix A: Graphs

Figure A-1

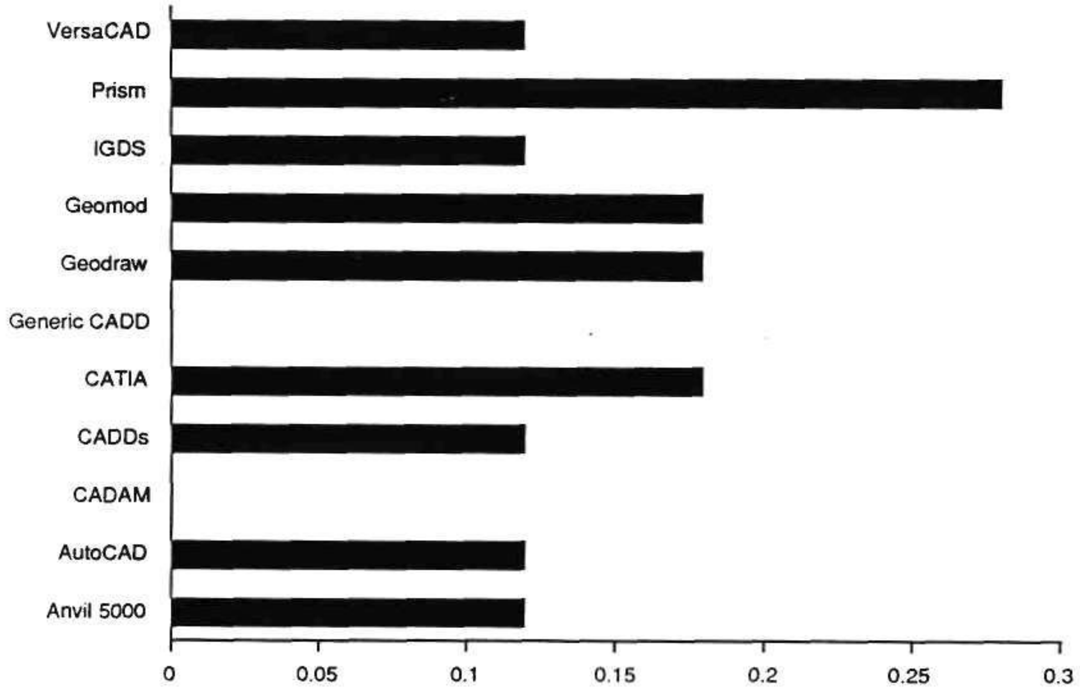
User Interface — Screen Layout: Monitors



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-2

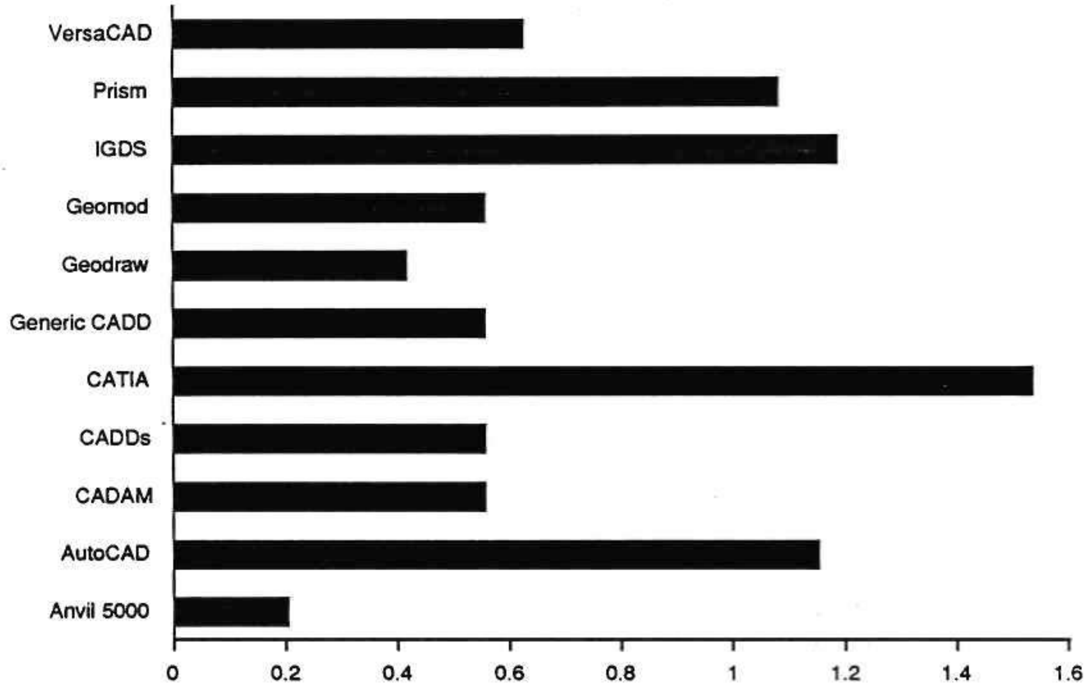
User Interface — Screen Layout: Graphic Windows



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-3

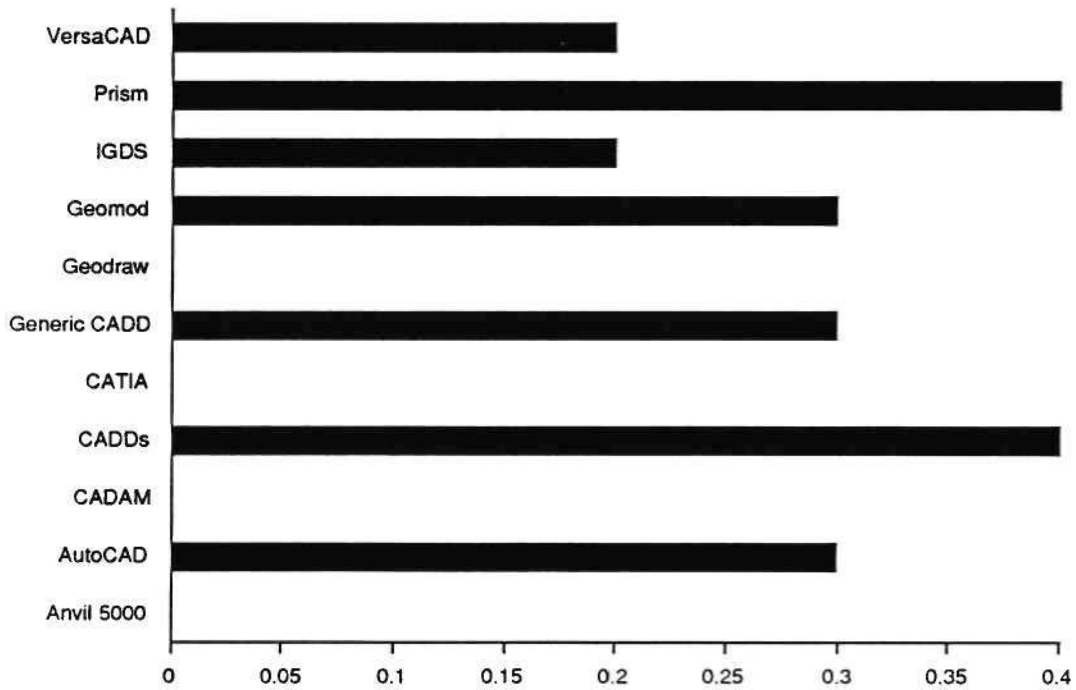
User Interface — Screen Layout: On-Screen Modes



**Maximum score attainable for feature 2.800* *Source: Albert Consulting Group*

Figure A-4

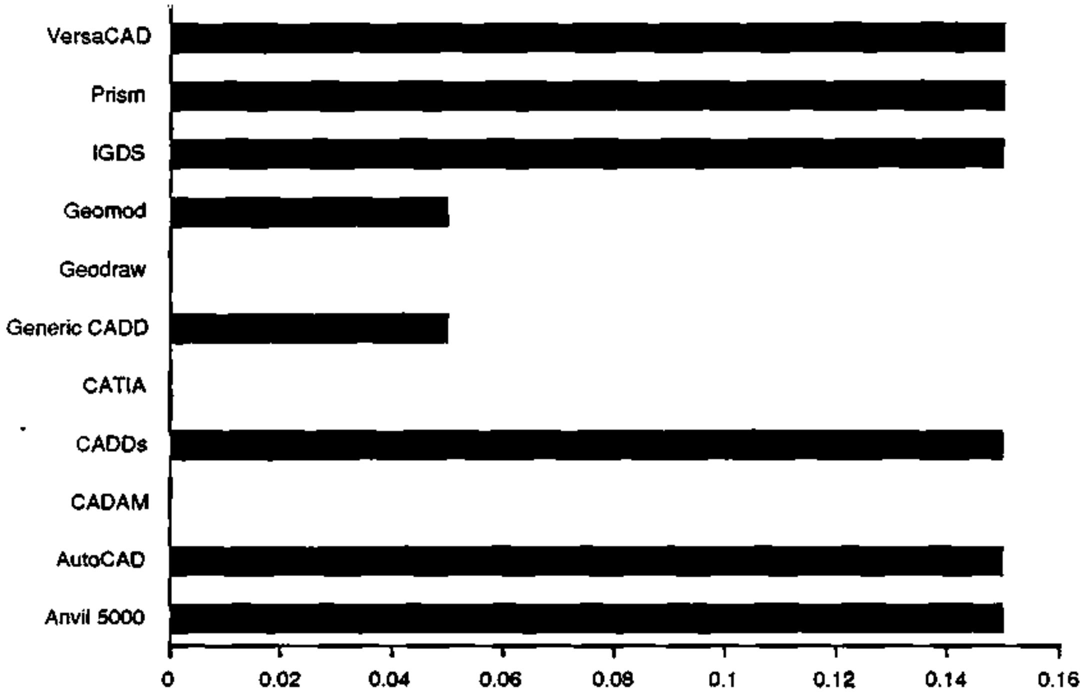
User Interface — Interactive Modes: Commands



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-5

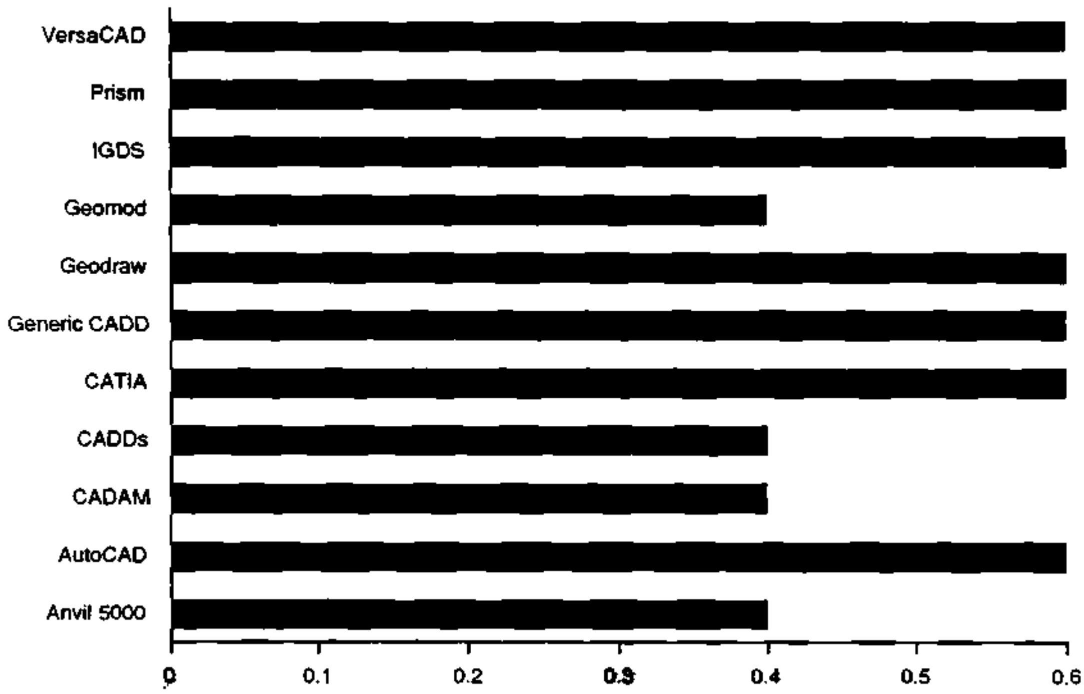
User Interface — Interactive Modes: Tablet



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-6

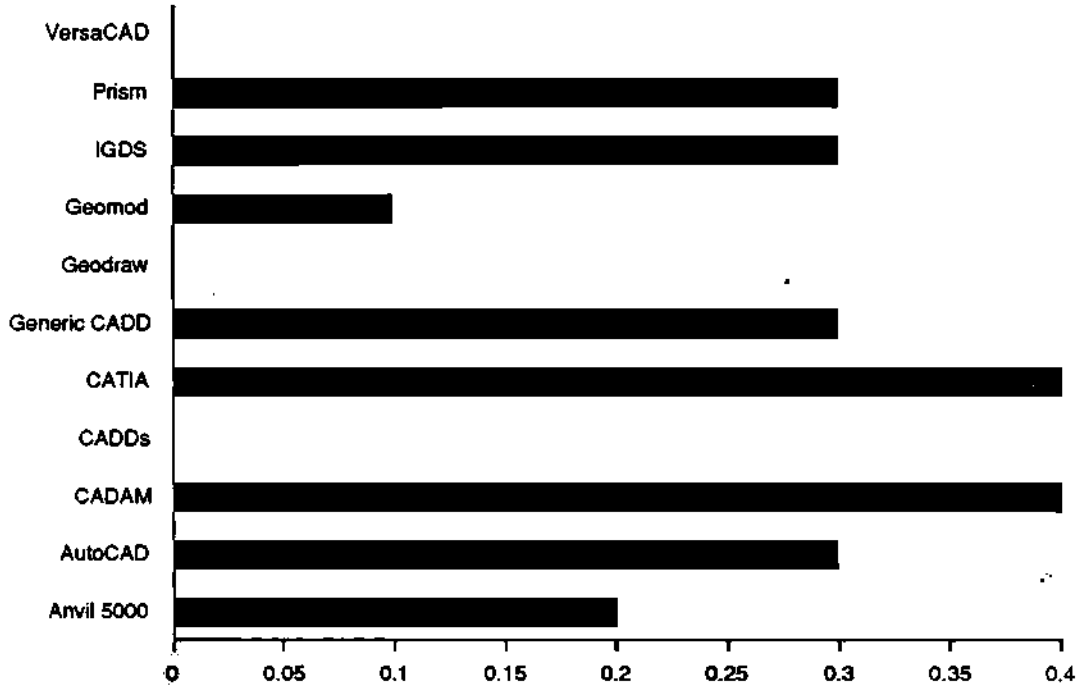
User Interface — Interactive Modes: On-Screen Menus



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-7

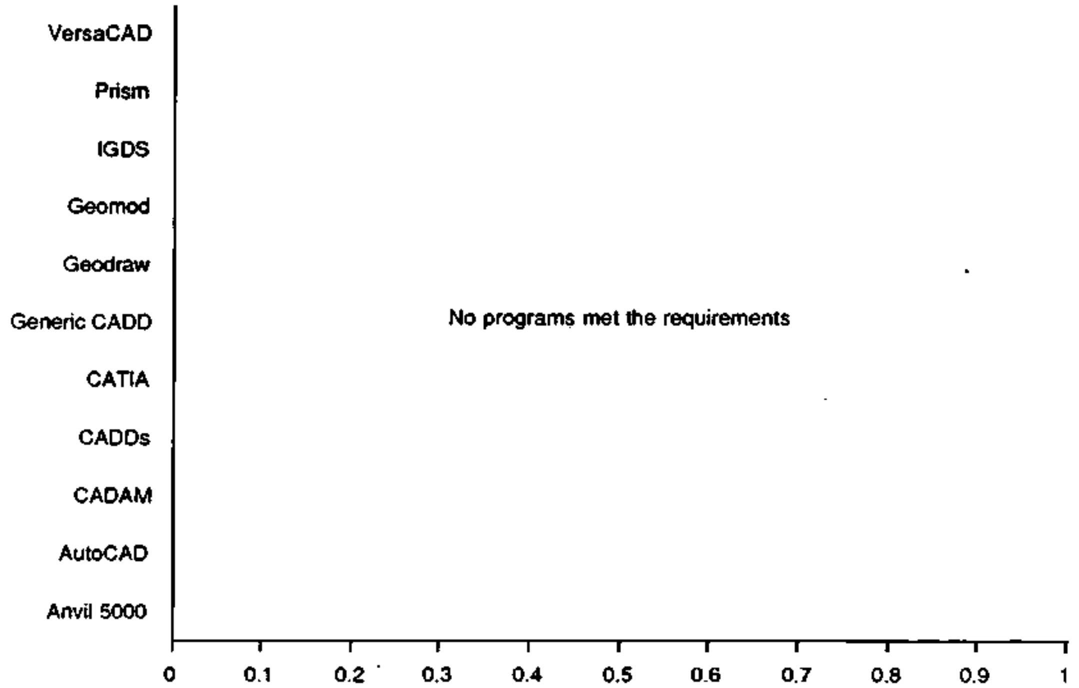
User Interface — Interactive Modes: Function Keys



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-8

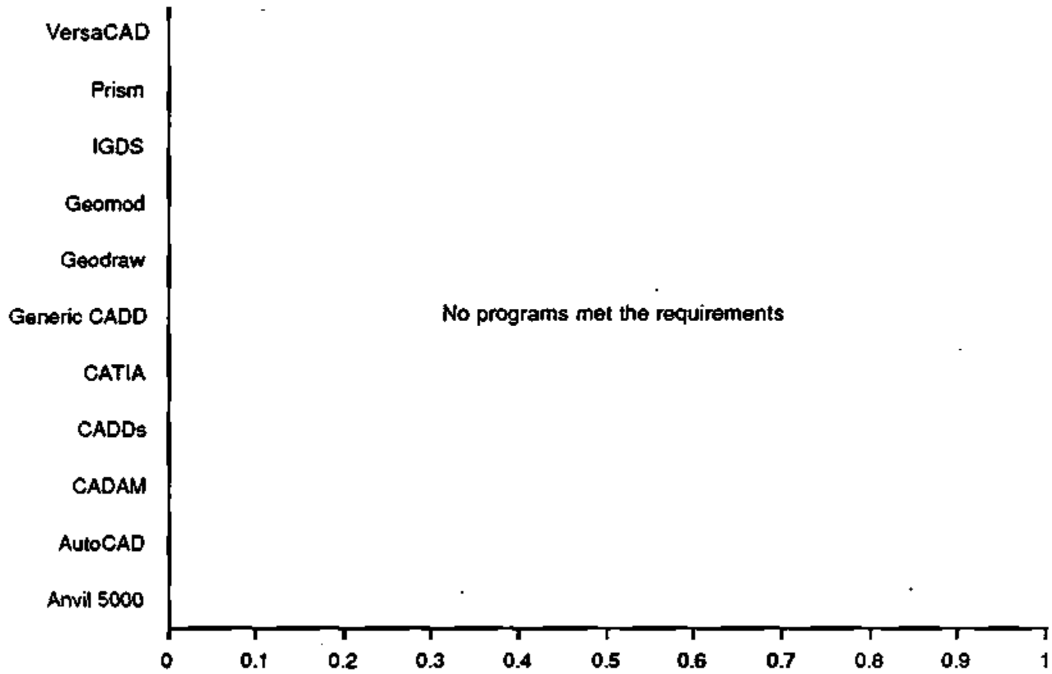
User Interface — Interactive Modes: Stroke Recognition



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-9

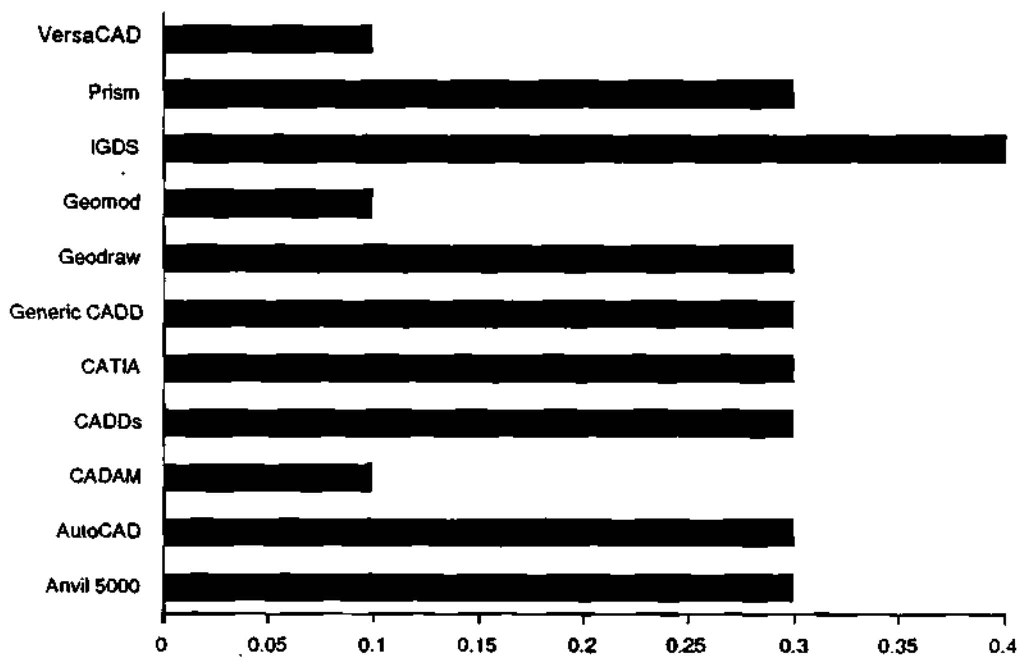
User Interface — Interactive Modes: Voice Recognition



**Maximum score attainable for feature .200* — *Source: Albert Consulting Group*

Figure A-10

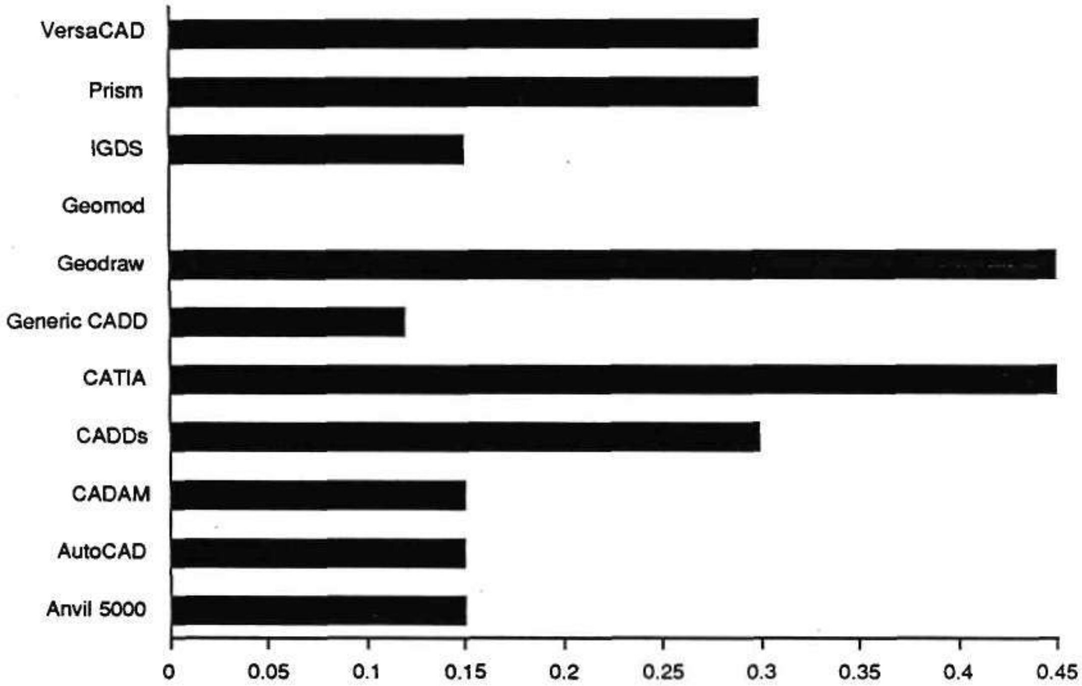
User Interface — Interactive Modes: Mouse Buttons



**Maximum score attainable for feature .400* — *Source: Albert Consulting Group*

Figure A-11

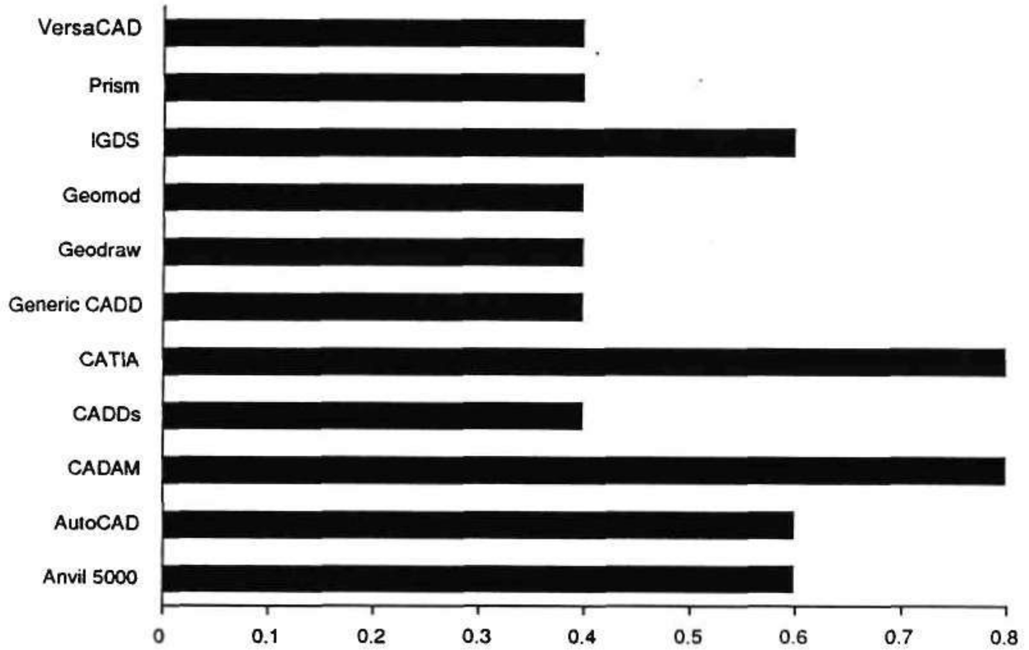
User Interface — Interactive Modes: Graphic Feedback



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-12

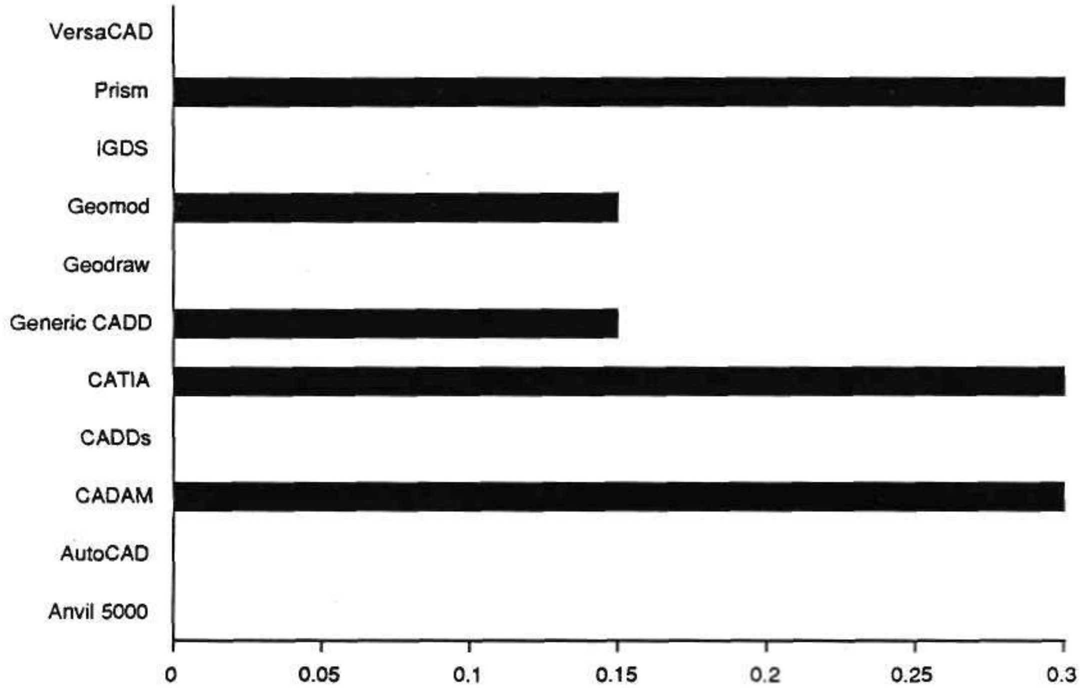
User Interface — Interactive Modes: Responsiveness



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-13

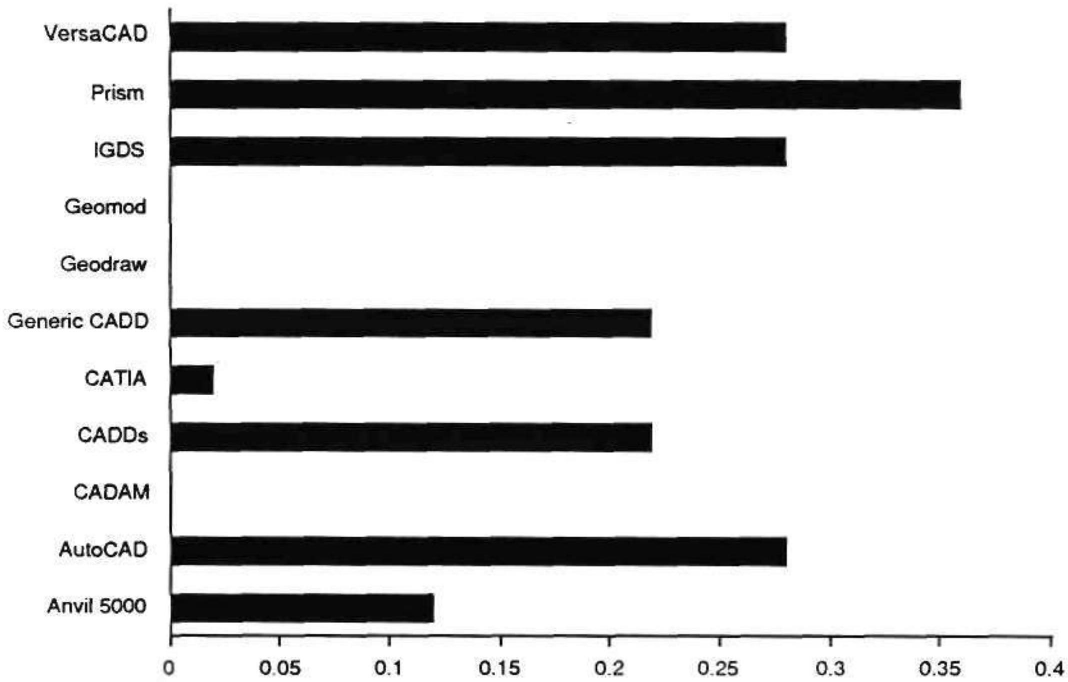
User Interface — Customization: Screen Appearance



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-14

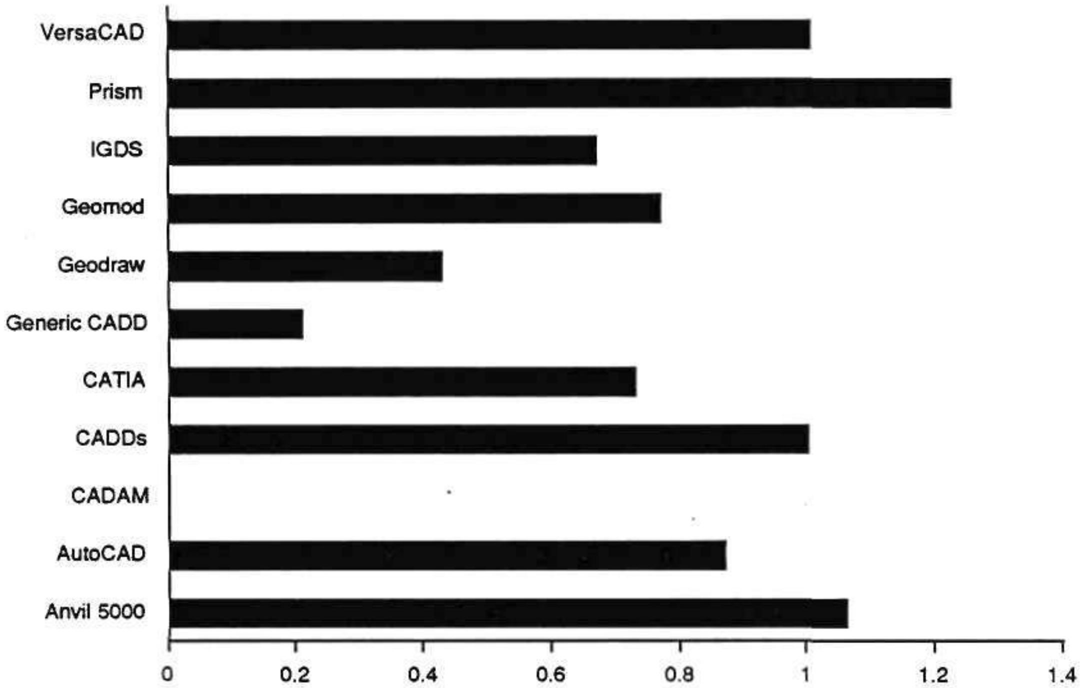
User Interface — Customization: Menus



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-15

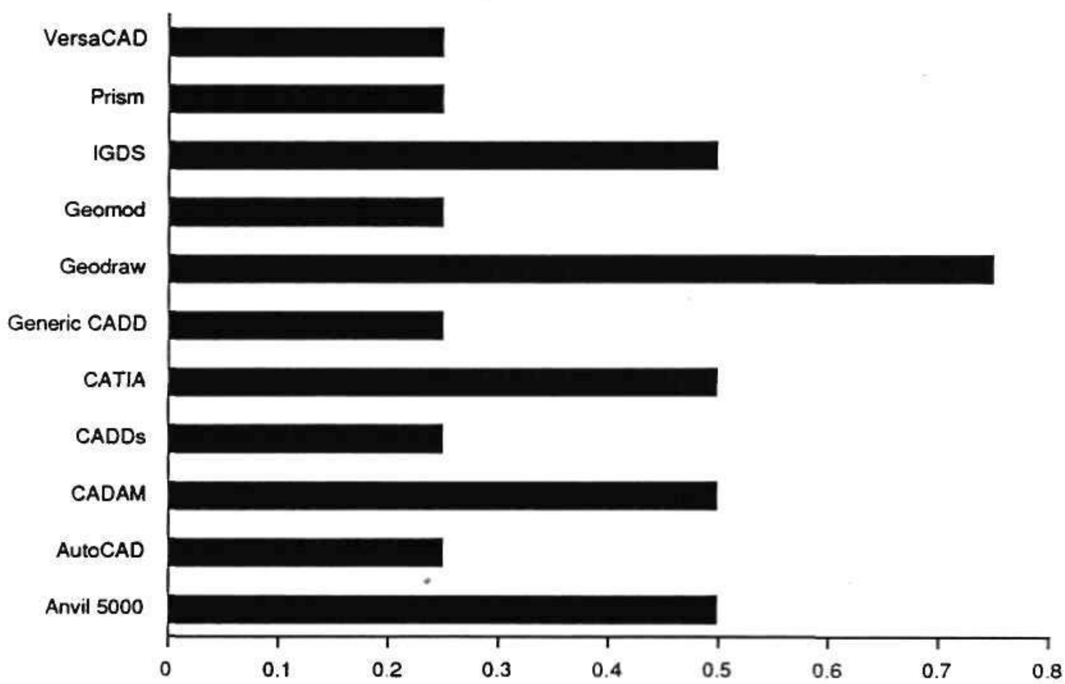
User Interface — Customization: Macros/User Programing



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-16

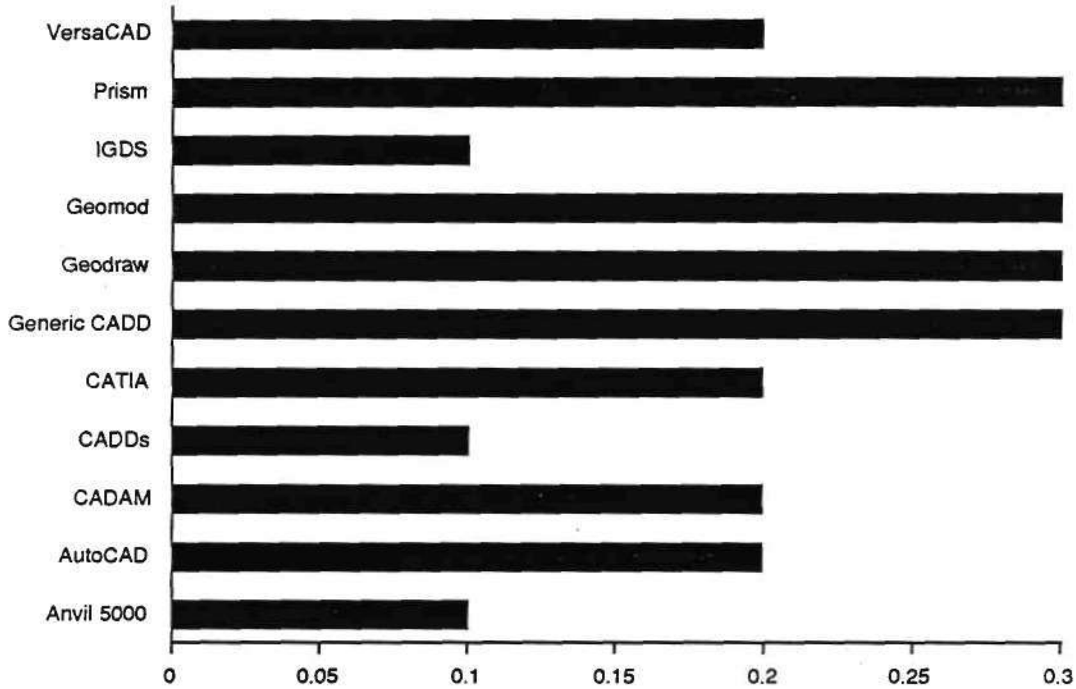
User Interface — Customization: Defaults



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure A-17

User Interface — User Assists: Prompting

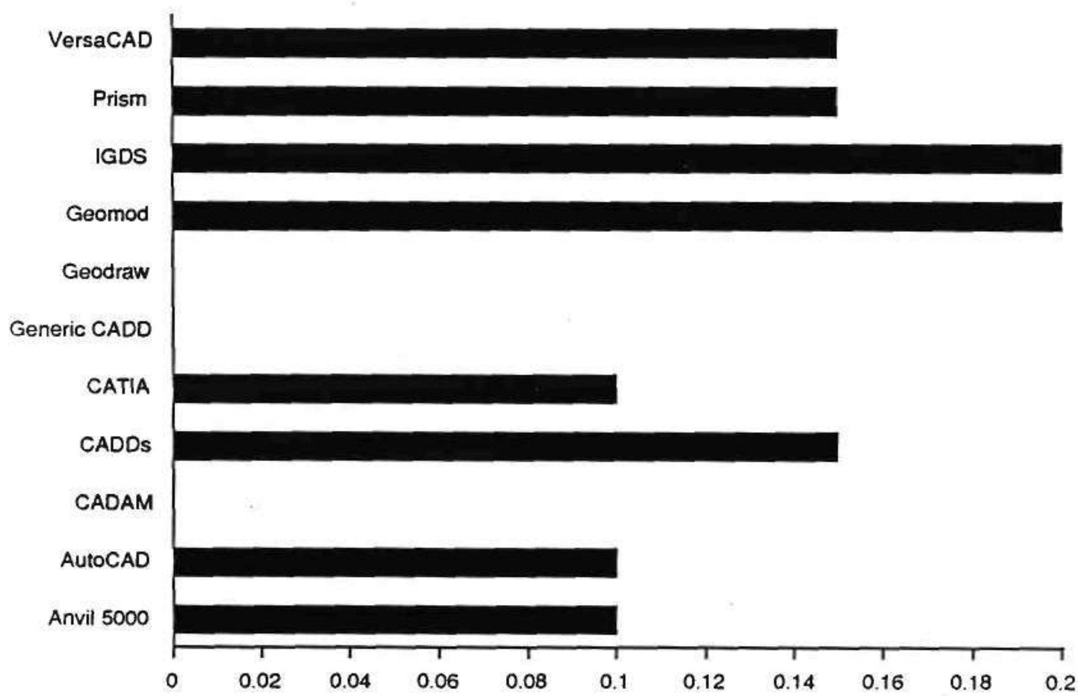


**Maximum score attainable for feature .400*

Source: Albert Consulting Group

Figure A-18

User Interface — User Assists: On-Line Reference

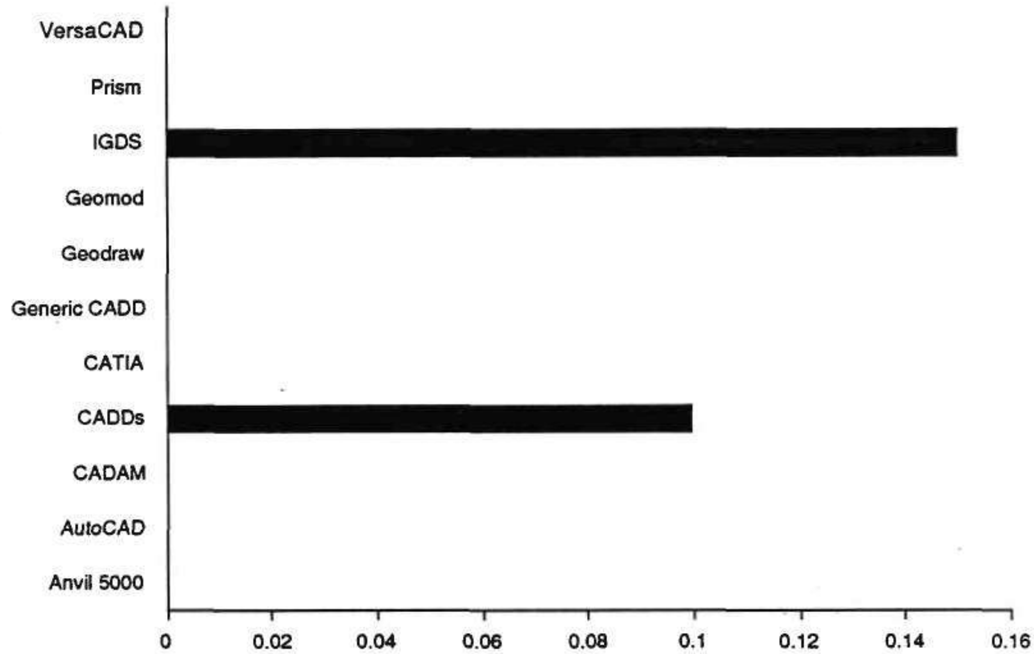


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure A-19

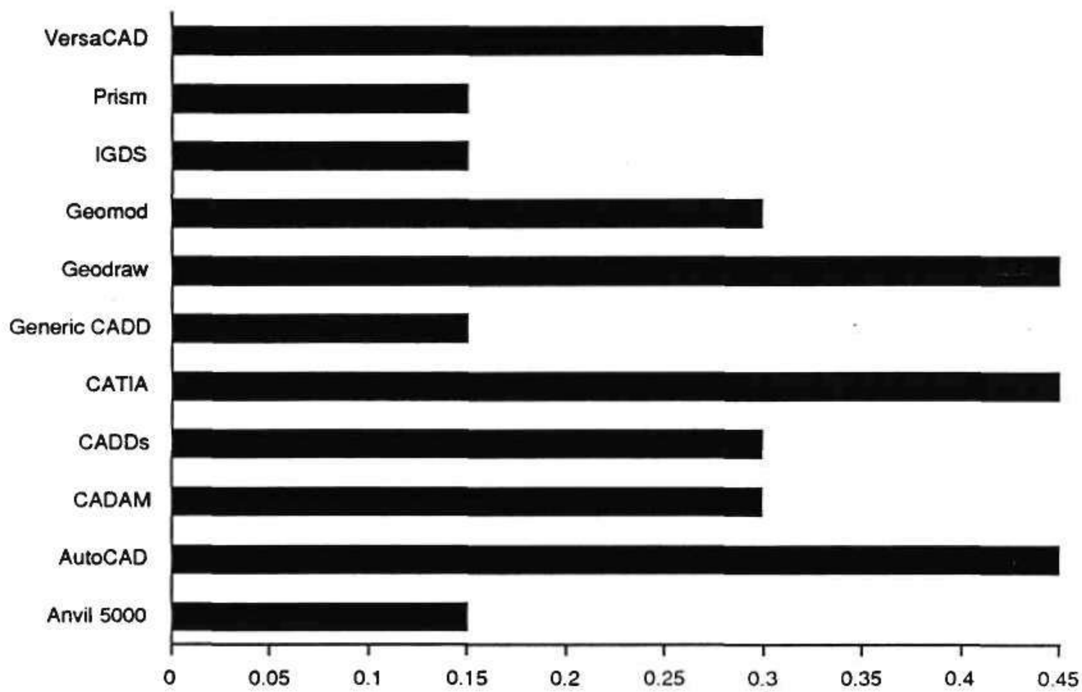
User Interface — User Assists: Tutorials



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-20

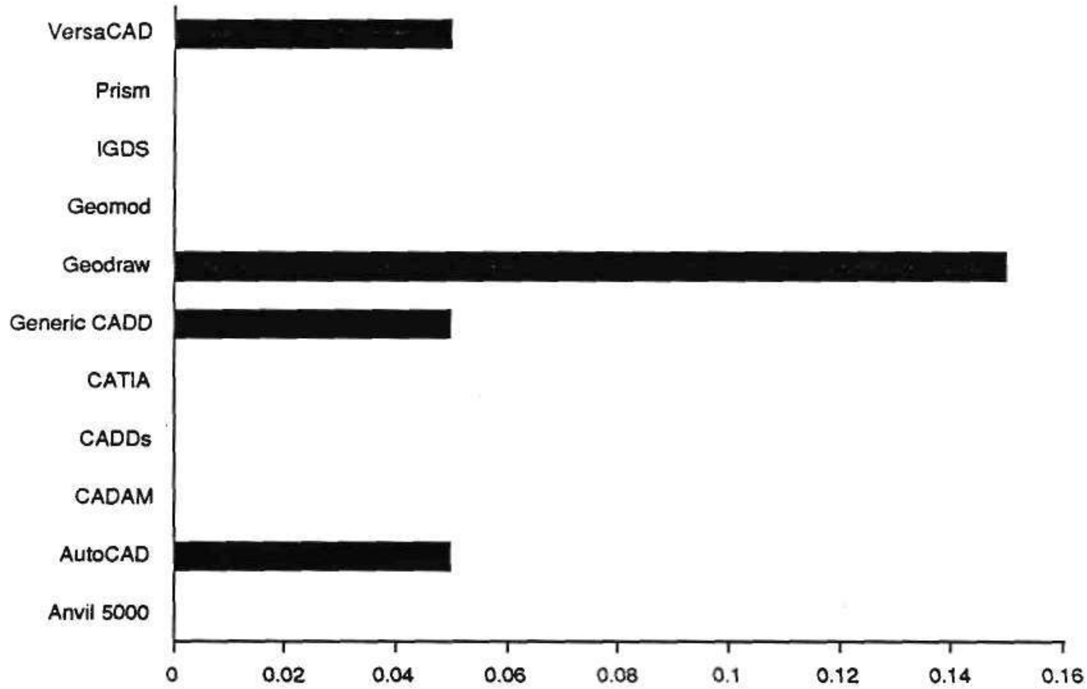
User Interface — User Assists: UNDO Functions



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-21

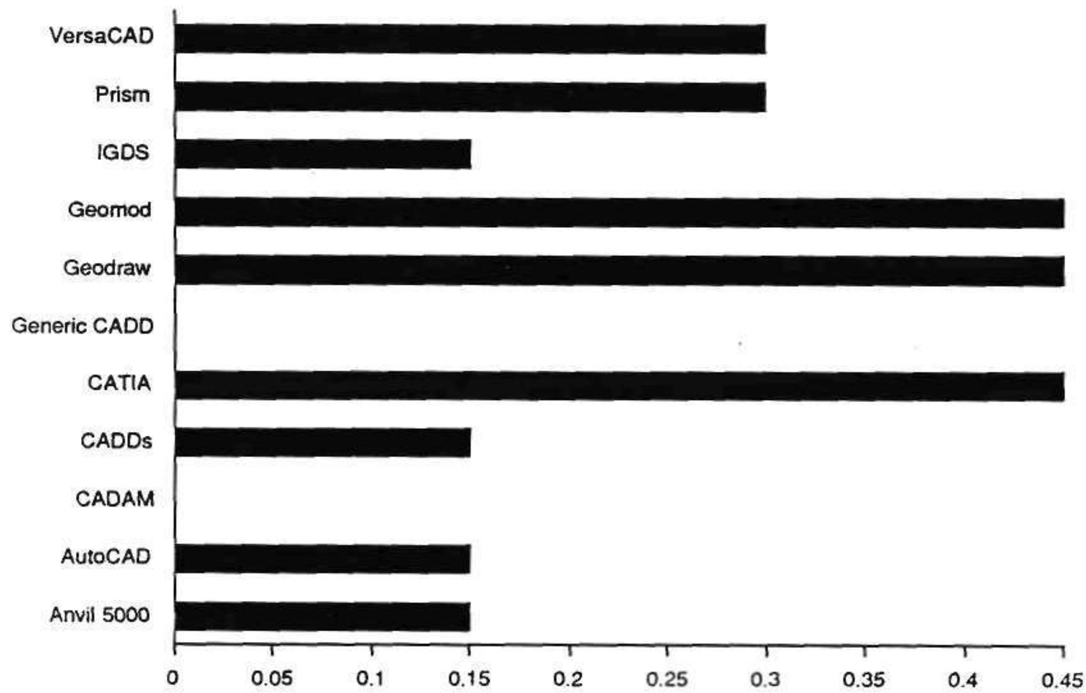
User Interface — User Assists: REDO Function



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-22

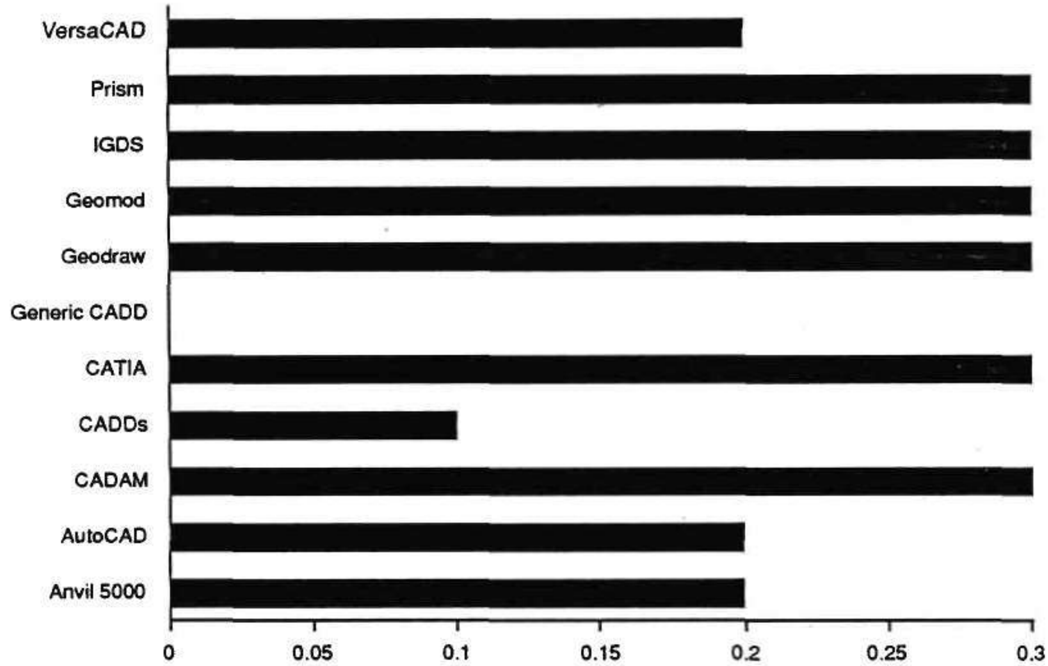
User Interface — User Assists: Abort Function



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-23

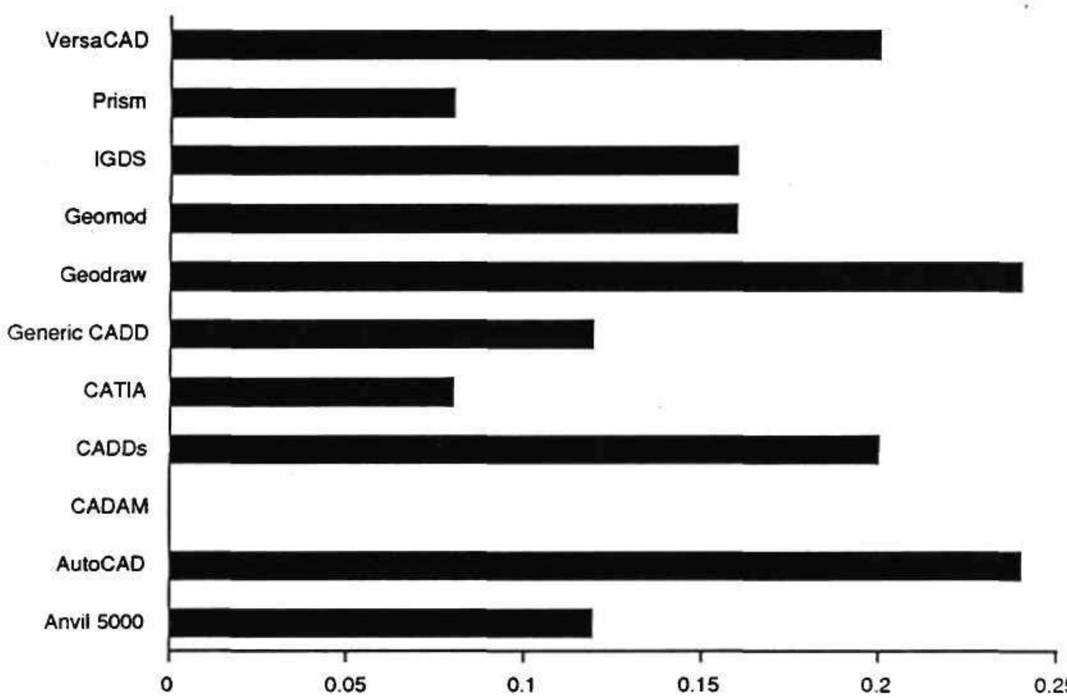
User Interface — User Assists: Interrupt Function



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-24

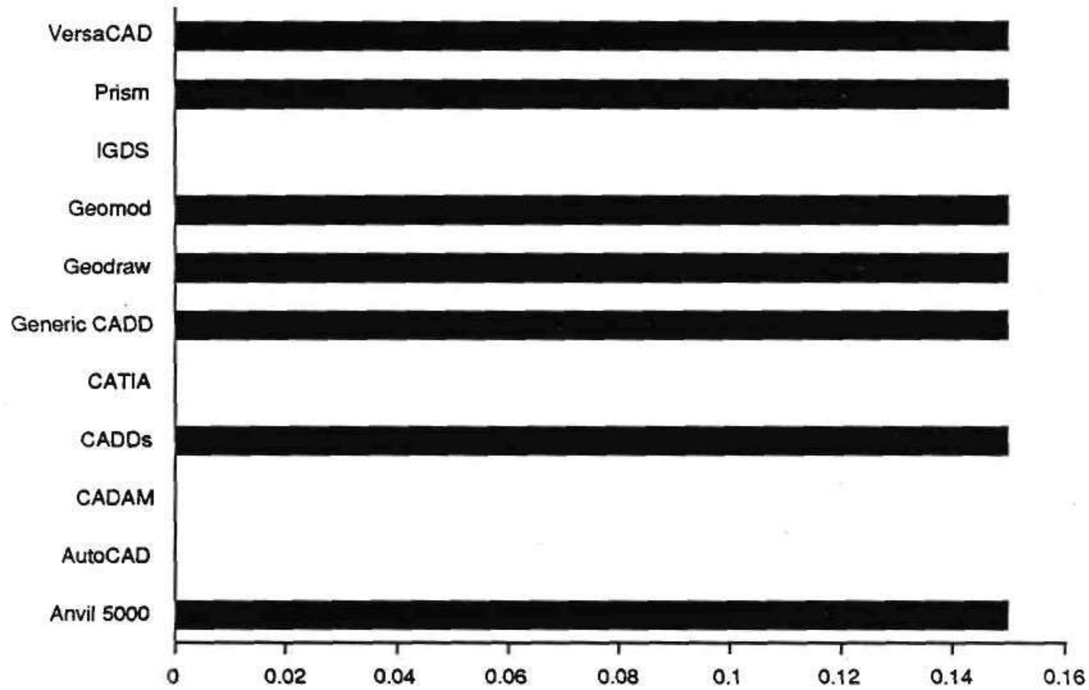
User Interface — User Assists: Screen Dynamics



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-25

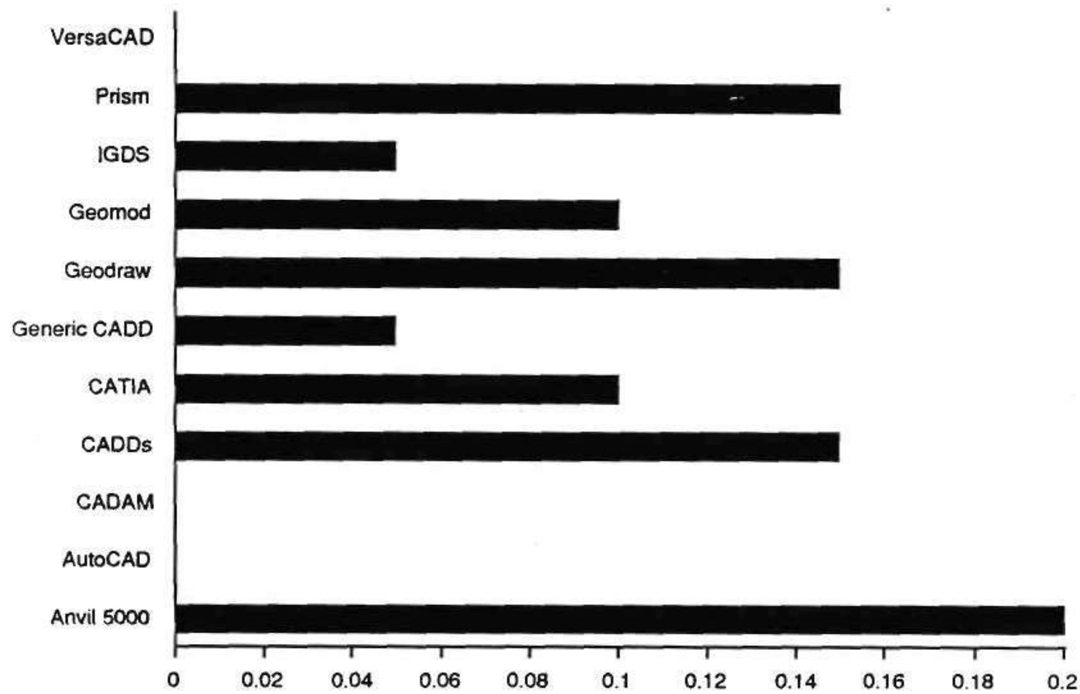
User Interface — User Assists: Journaling



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-26

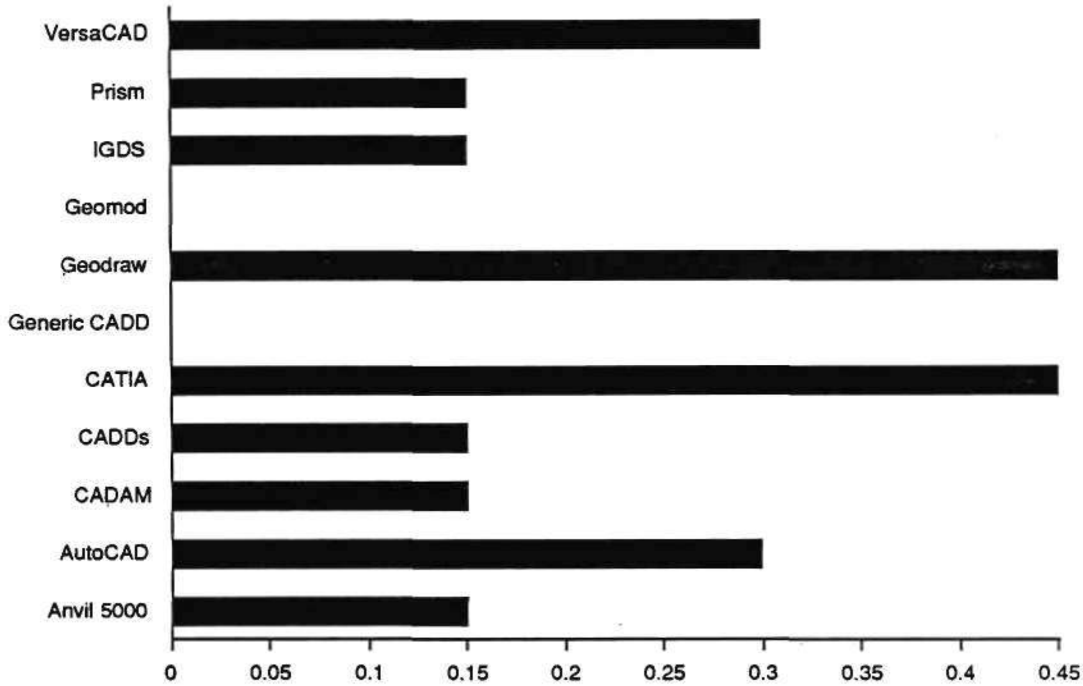
User Interface — User Assists: Calculator Entry



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-27

User Interface — User Assists: Graphic Feedback

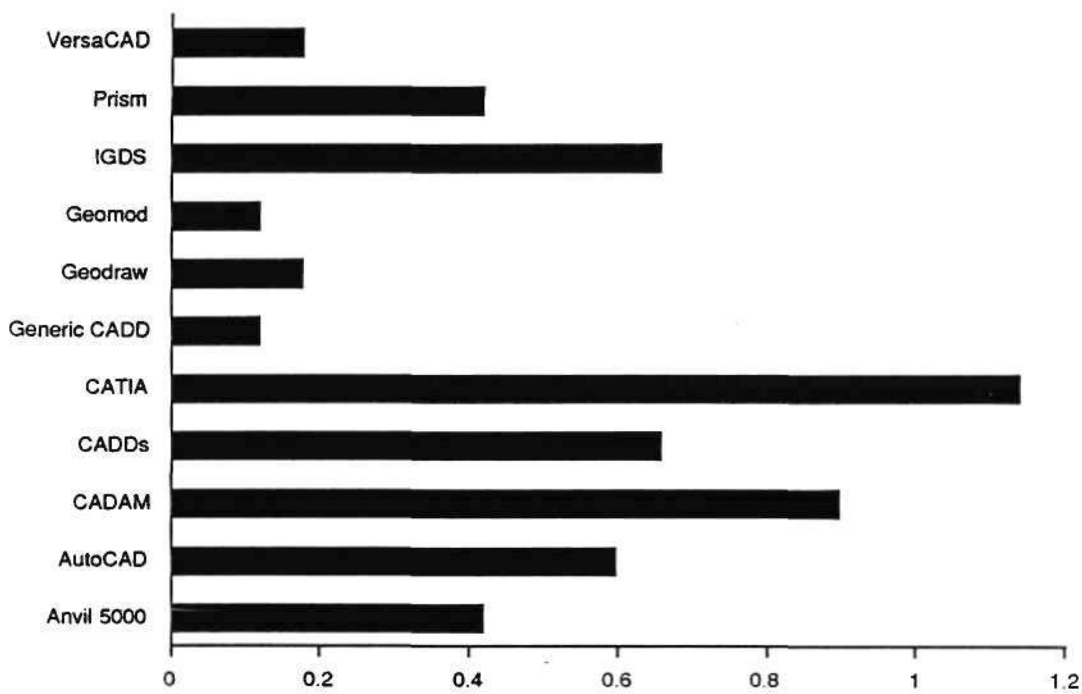


**Maximum score attainable for feature .600*

Source: Albert Consulting Group

Figure A-28

User Interface — Viewing/Display: Pan/Zoom

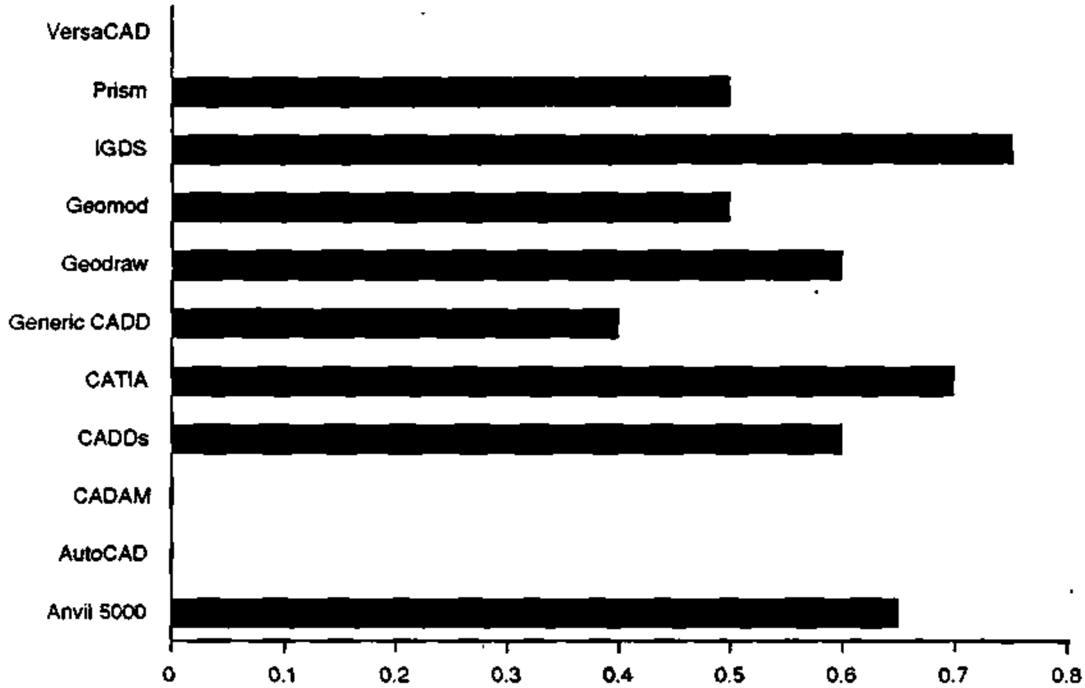


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure A-29

User Interface — Viewing/Display: View Layout

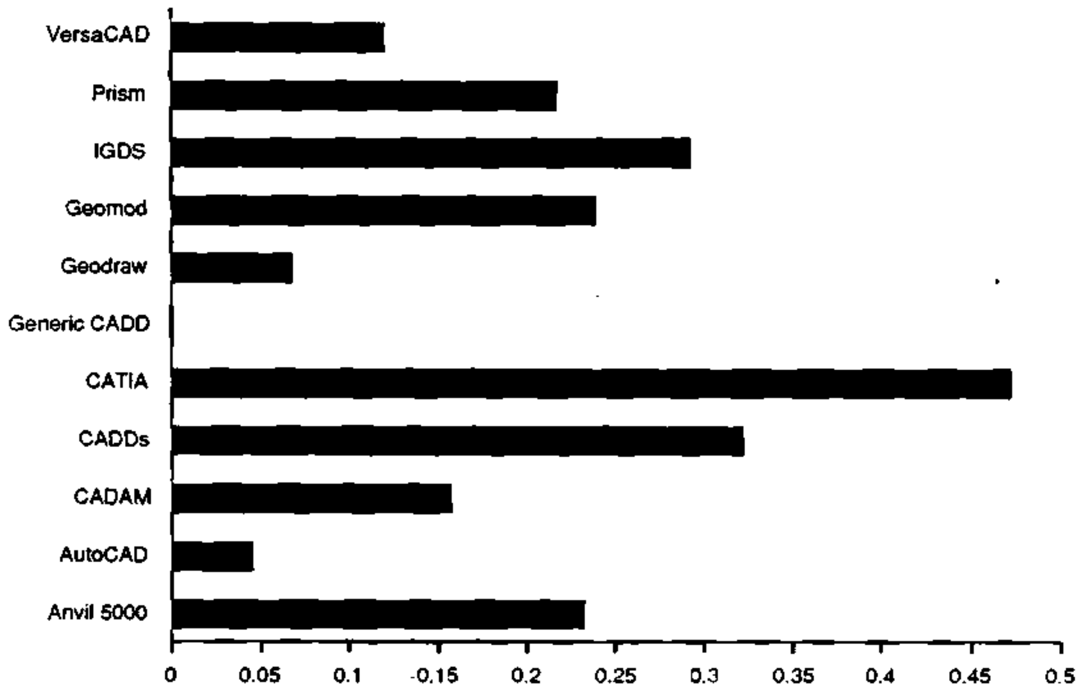


**Maximum score attainable for feature 1.000*

Source: Albert Consulting Group

Figure A-30

User Interface — Viewing/Display: 3D View Transformations

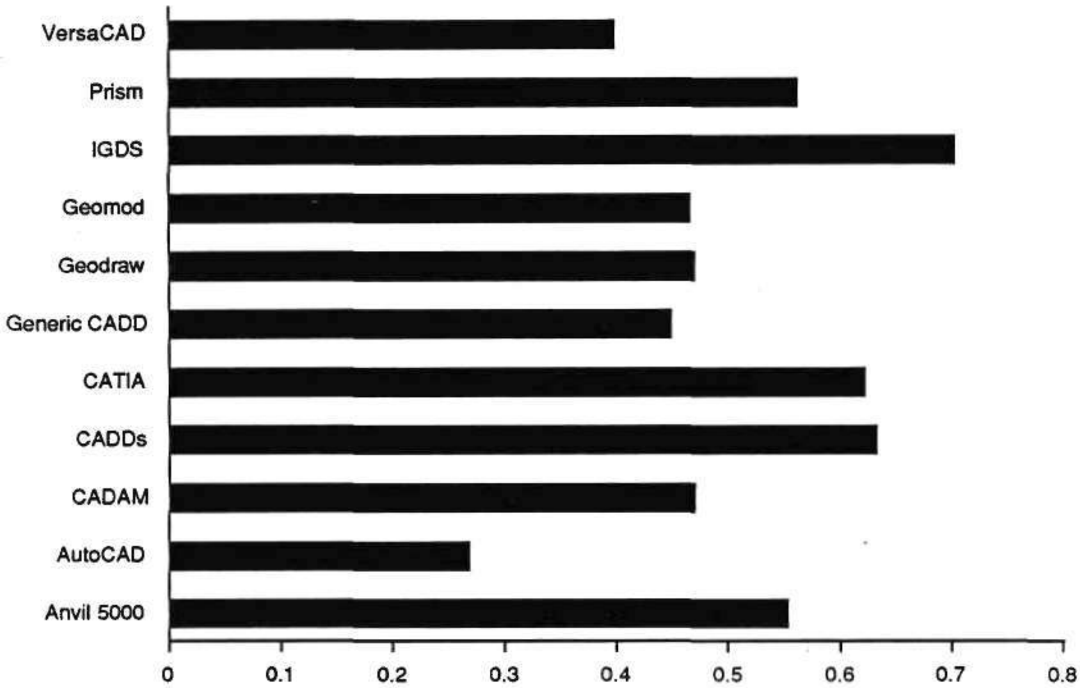


**Maximum score attainable for feature 600*

Source: Albert Consulting Group

Figure A-31

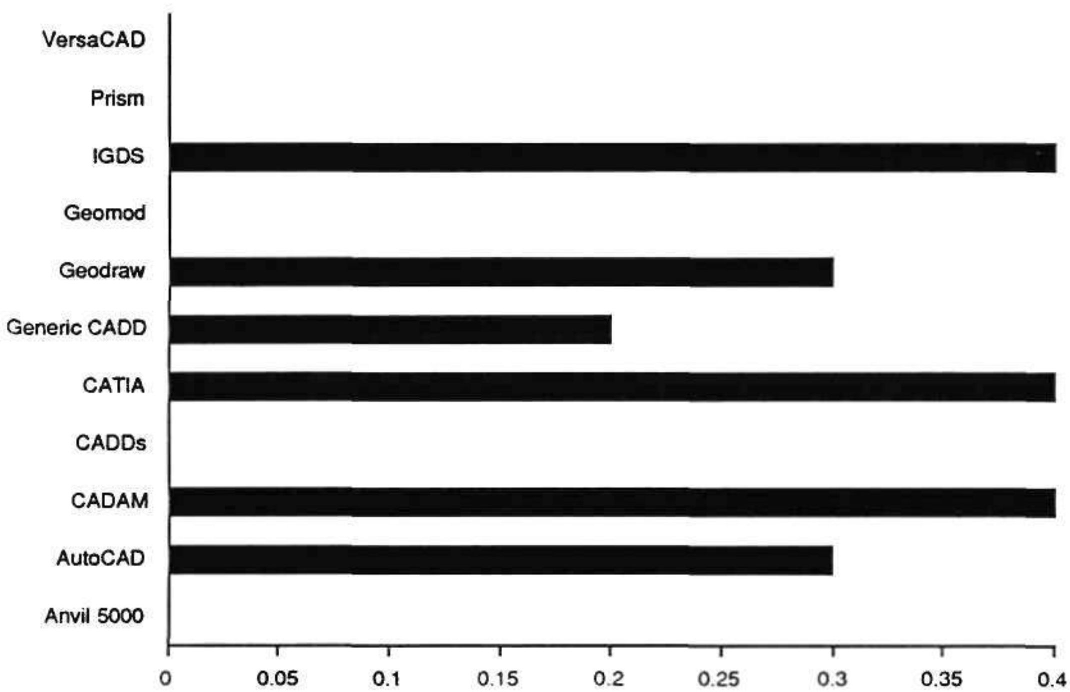
User Interface — Viewing/Display: Display Characteristics



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure A-32

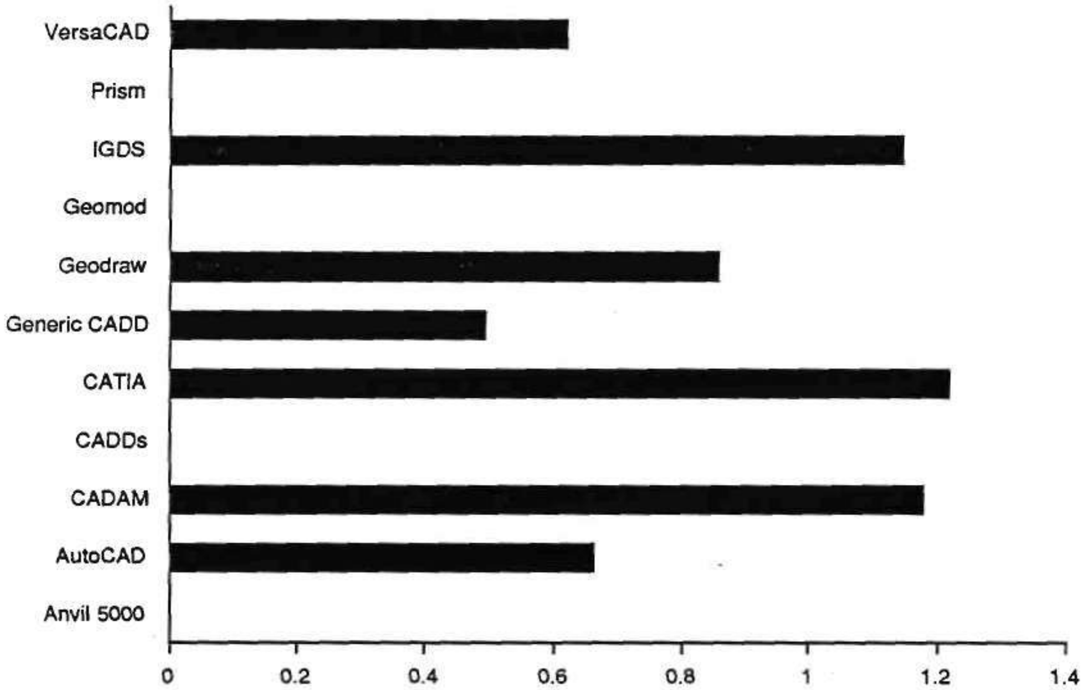
Geometric Construction — 2D Items: Points



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-33

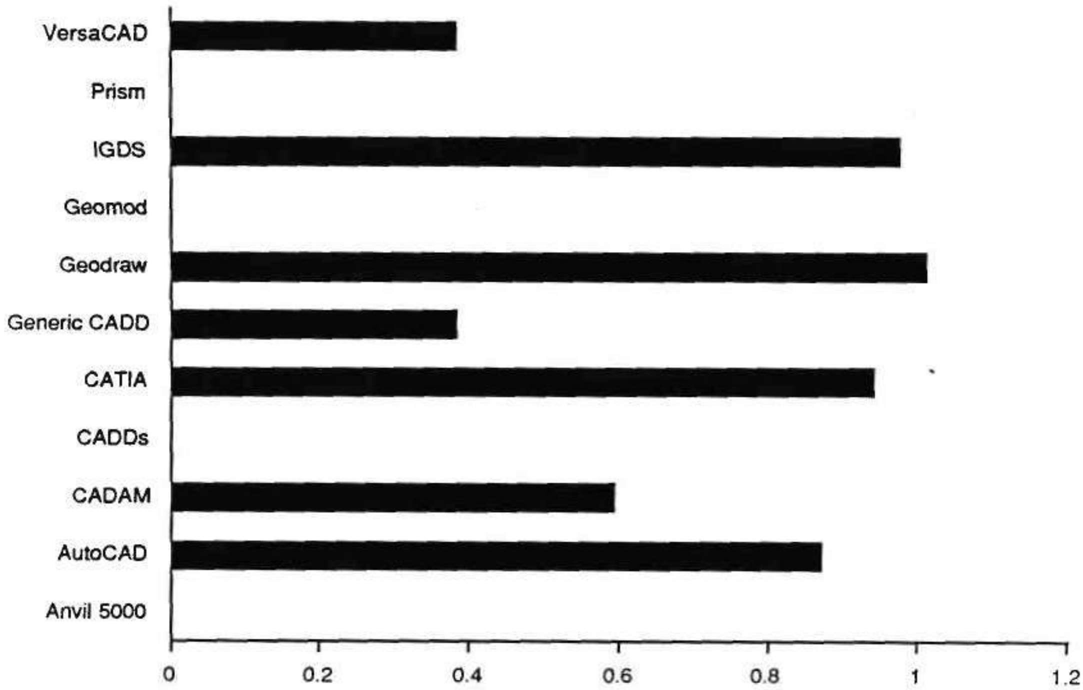
Geometric Construction — 2D Items: Lines



**Maximum score attainable for feature 1.400* *Source: Albert Consulting Group*

Figure A-34

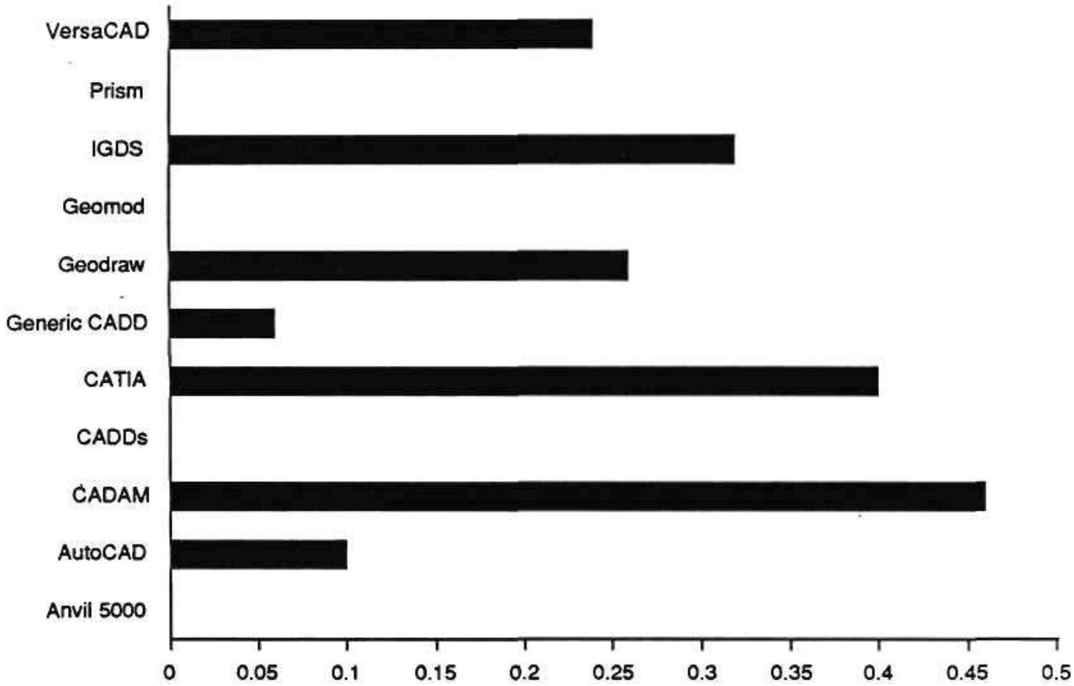
Geometric Construction — 2D Items: Conics



**Maximum score attainable for feature 1.400* *Source: Albert Consulting Group*

Figure A-35

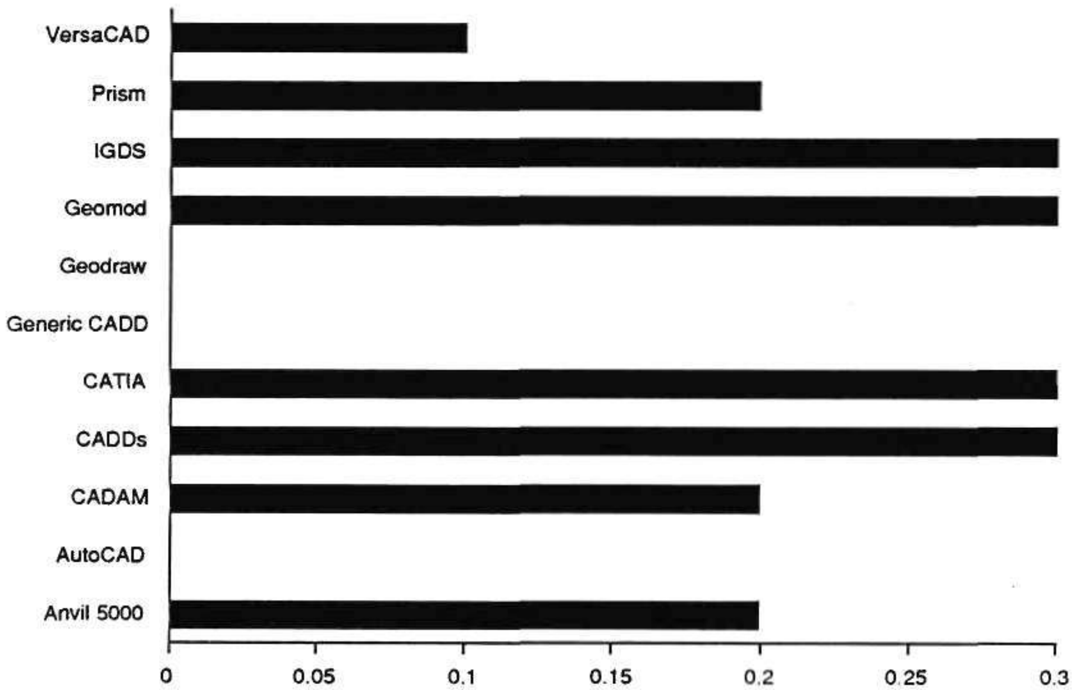
Geometric Construction — 2D Items: Splines



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-36

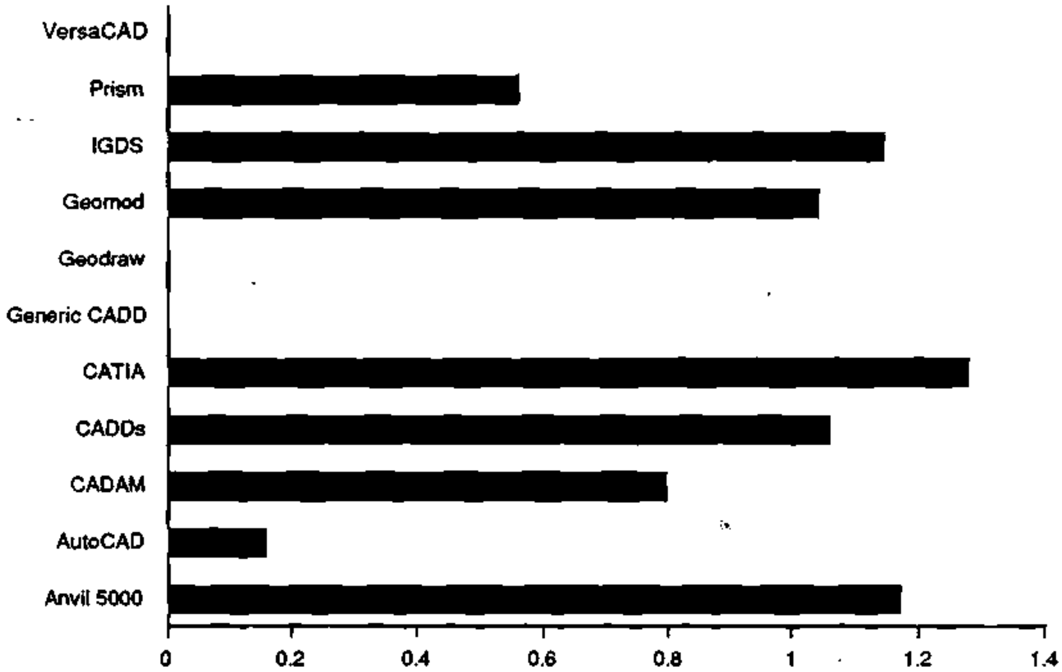
Geometric Construction — 3D Items: Points



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-37

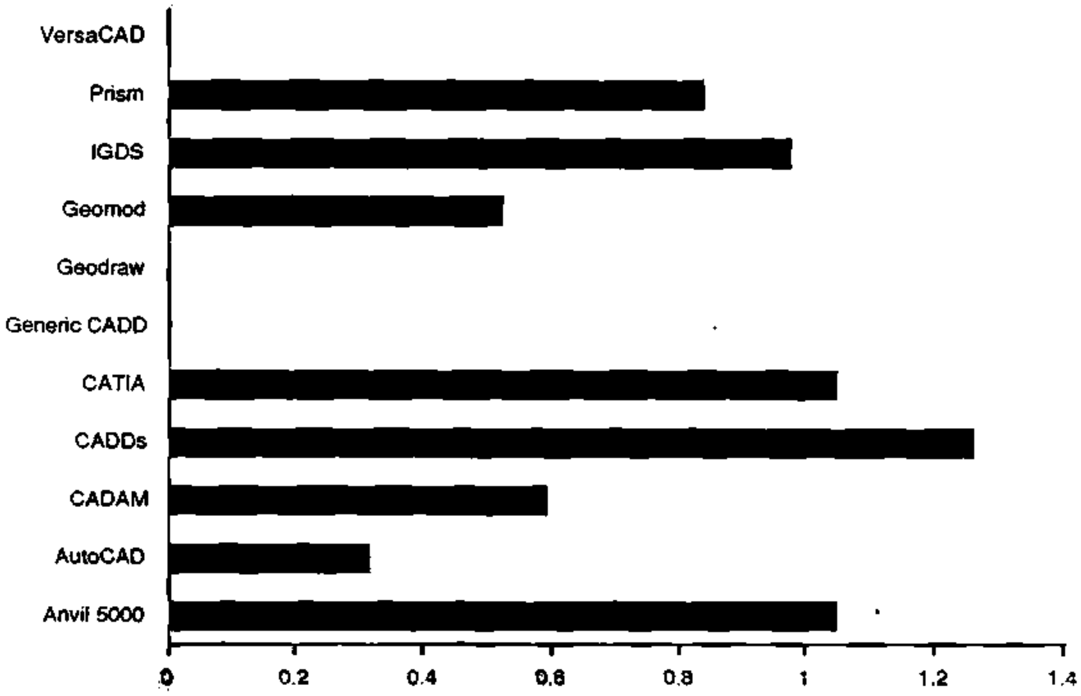
Geometric Construction — 3D Items: Lines



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-38

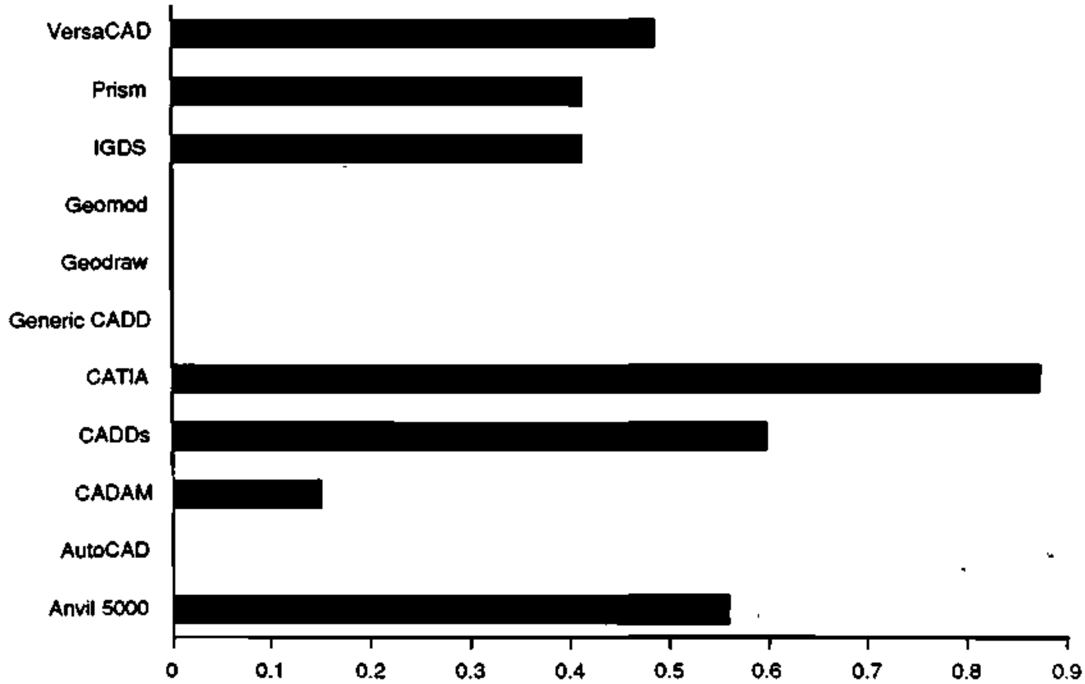
Geometric Construction — 3D Items: Conics



**Maximum score attainable for feature 1.400* *Source: Albert Consulting Group*

Figure A-39

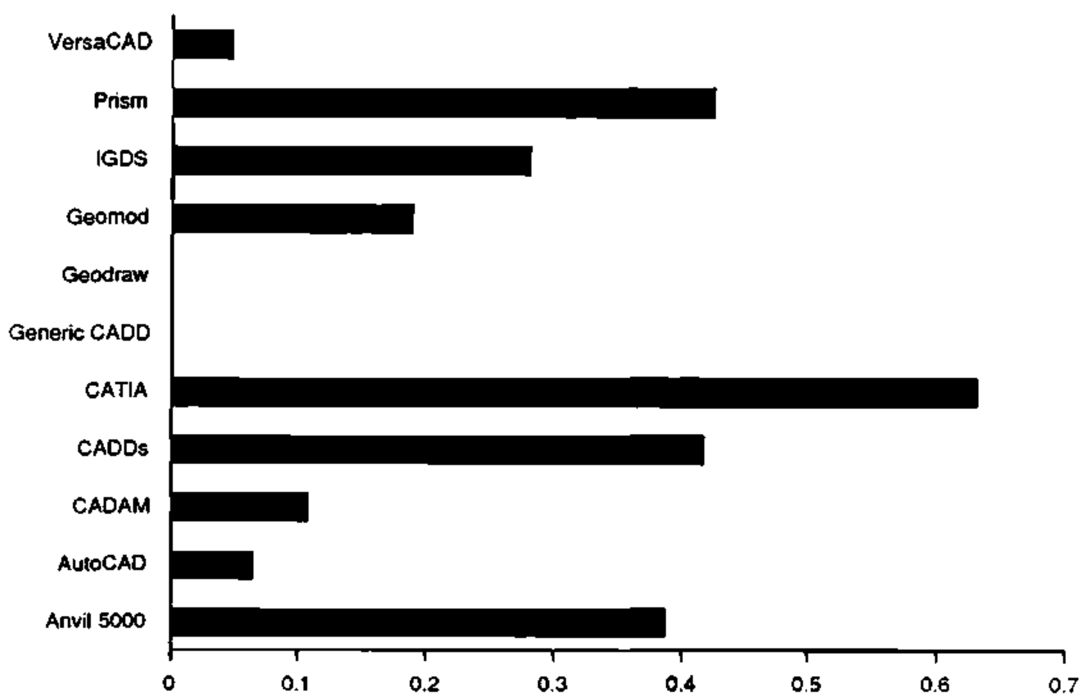
Geometric Construction — 3D Items: Splines



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure A-40

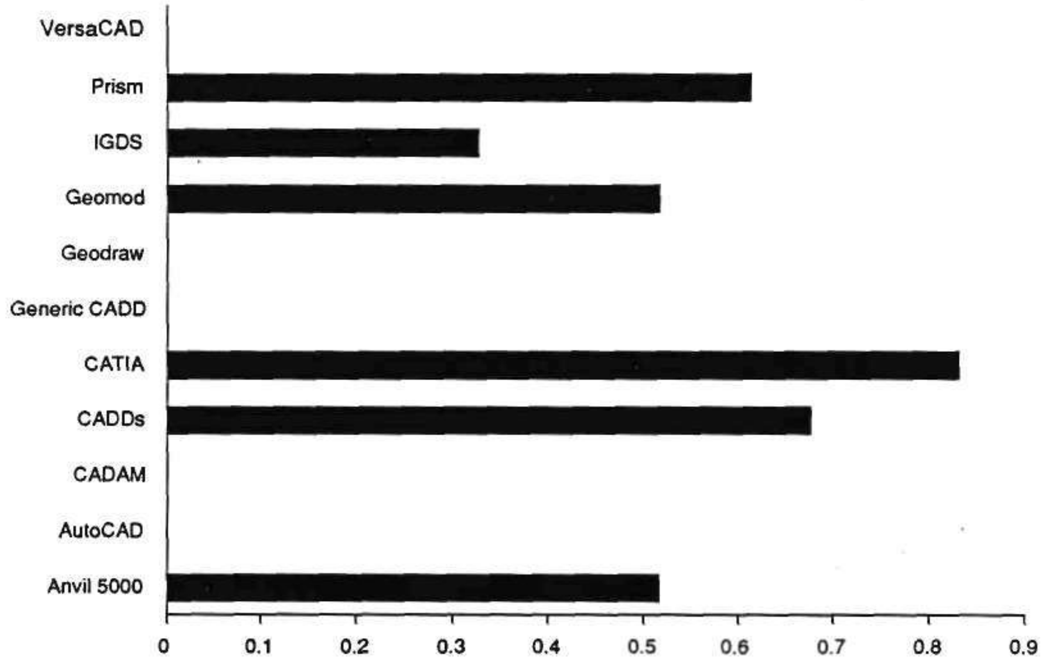
Geometric Construction — 3D Items: Surfaces



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-41

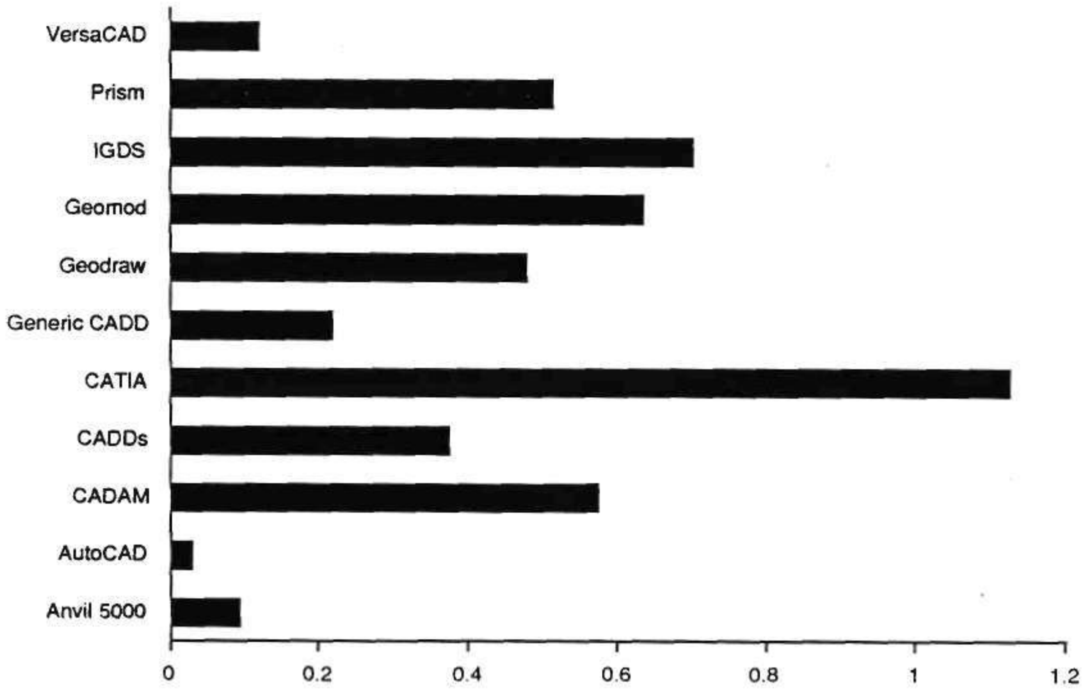
Geometric Construction — 3D Items: Solids



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure A-42

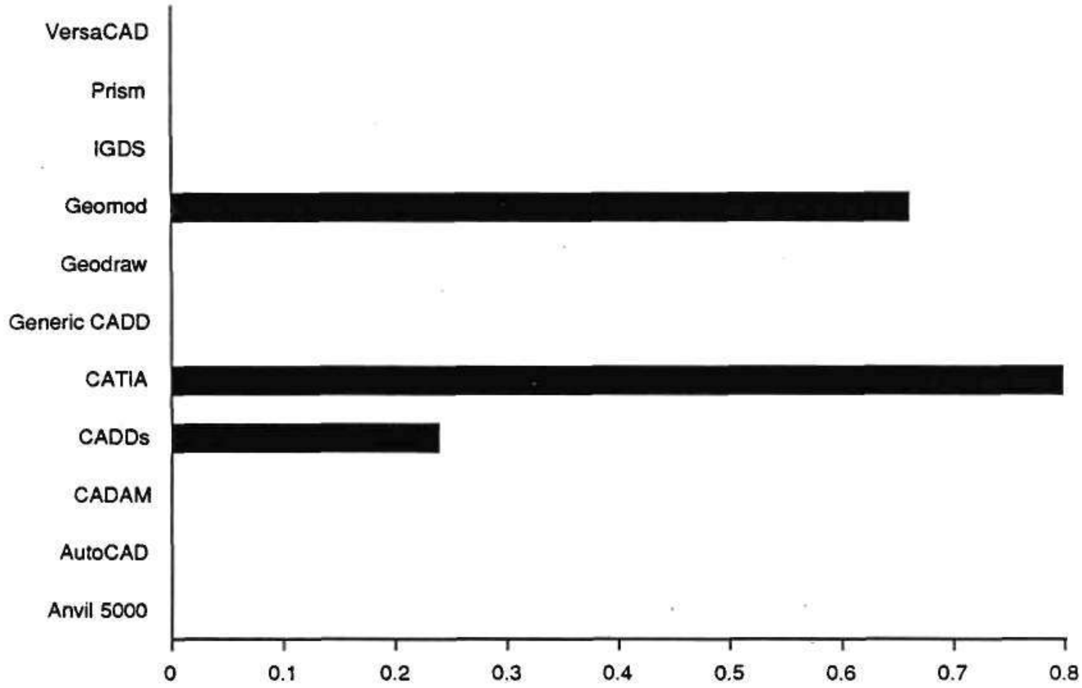
Geometric Construction — Item Editing: Change Item Geometry



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-43

Geometric Construction — Item Editing: Item Associativity

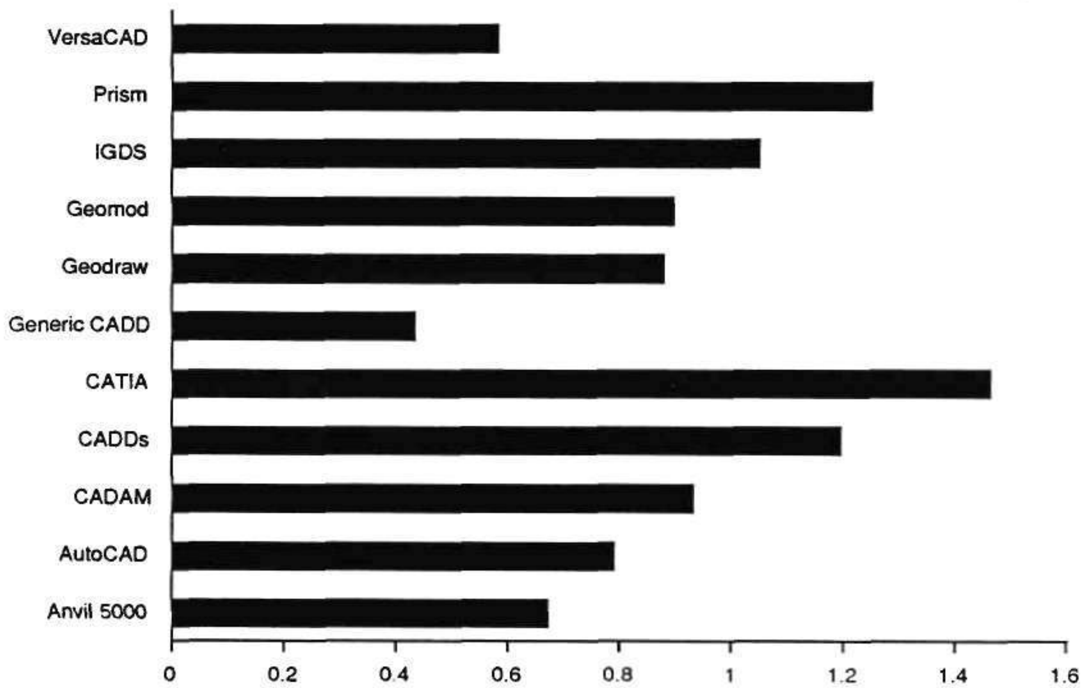


*Maximum score attainable for feature 2.400

Source: Albert Consulting Group

Figure A-44

Geometric Construction — Item Manipulations: Grouping

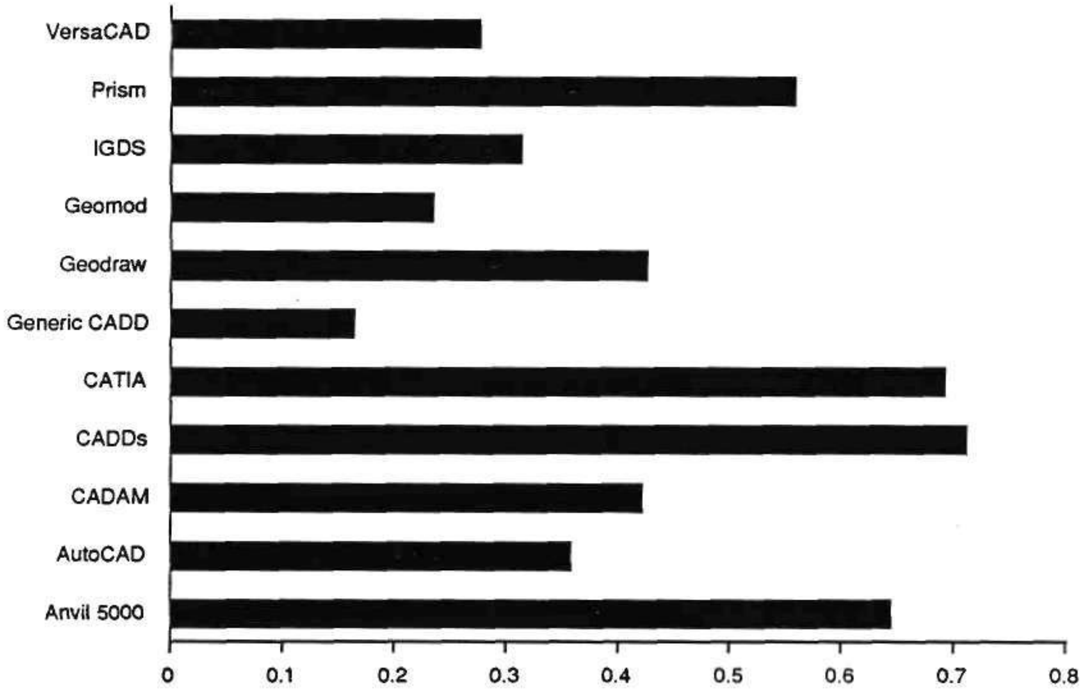


*Maximum score attainable for feature 2.000

Source: Albert Consulting Group

Figure A-45

Geometric Construction — Item Manipulations: Relimiting

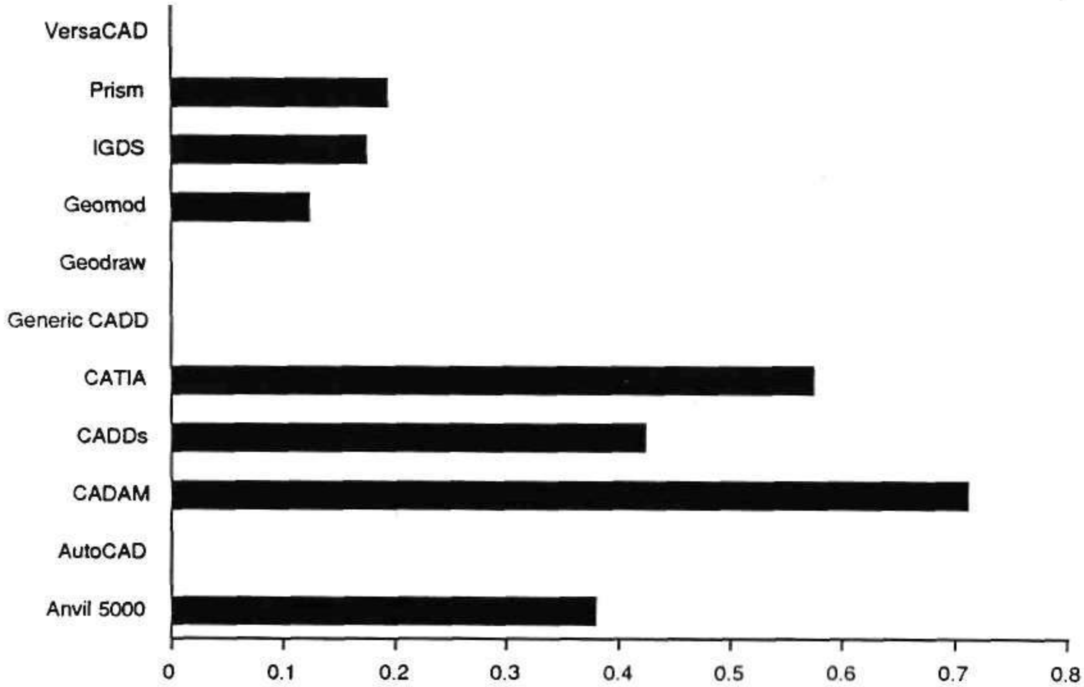


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure A-46

Geometric Construction — Item Manipulations: Intersection Constructions

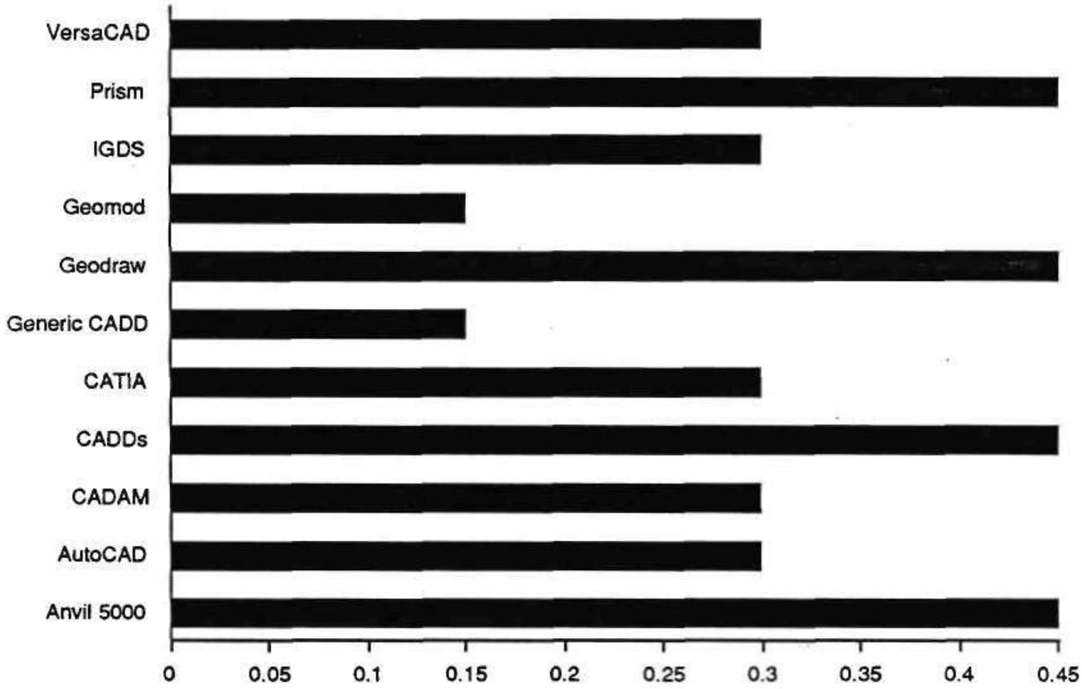


**Maximum score attainable for feature .800*

Source: Albert Consulting Group

Figure A-47

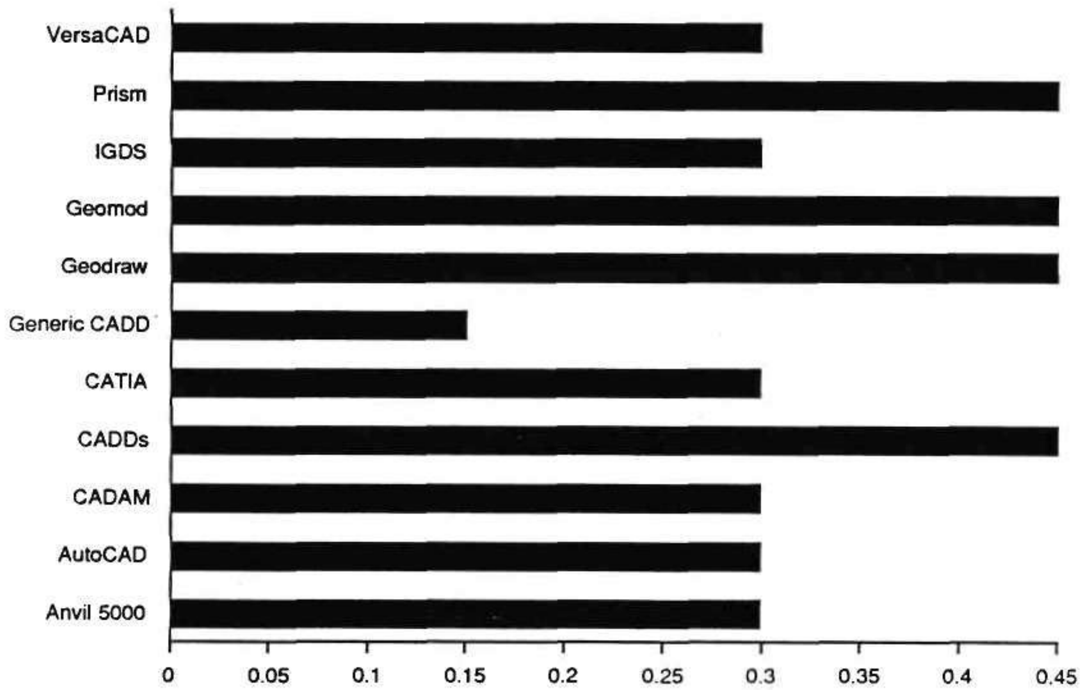
Geometric Construction — Transformations: Linear Move/Copy



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-48

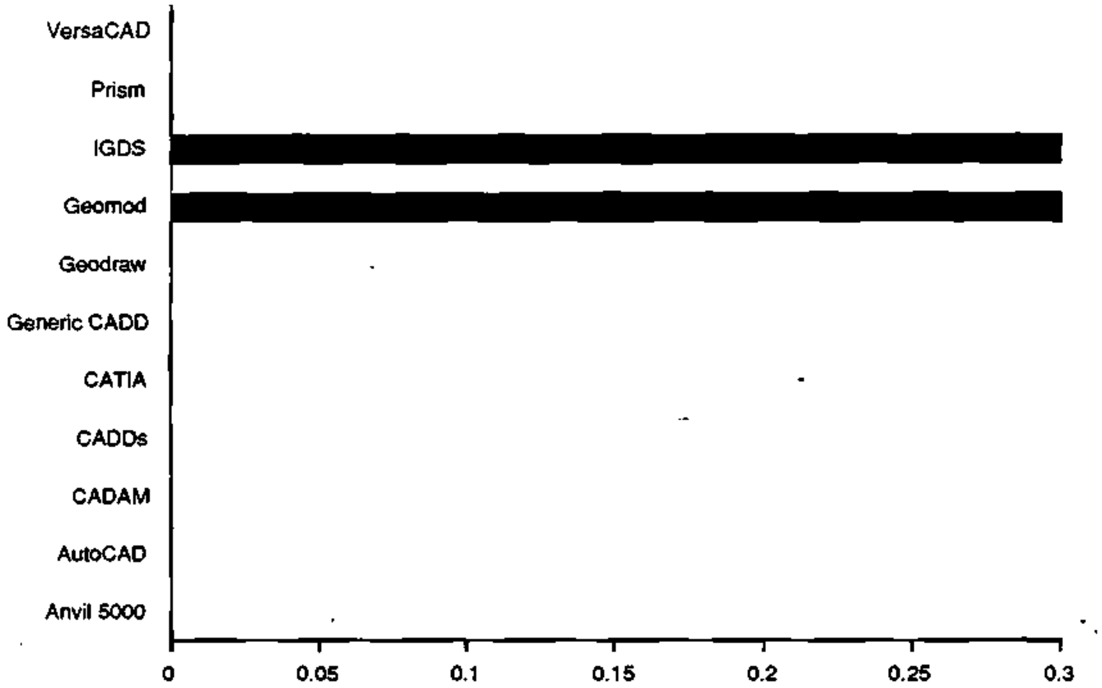
Geometric Construction — Transformations: Rotate



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-49

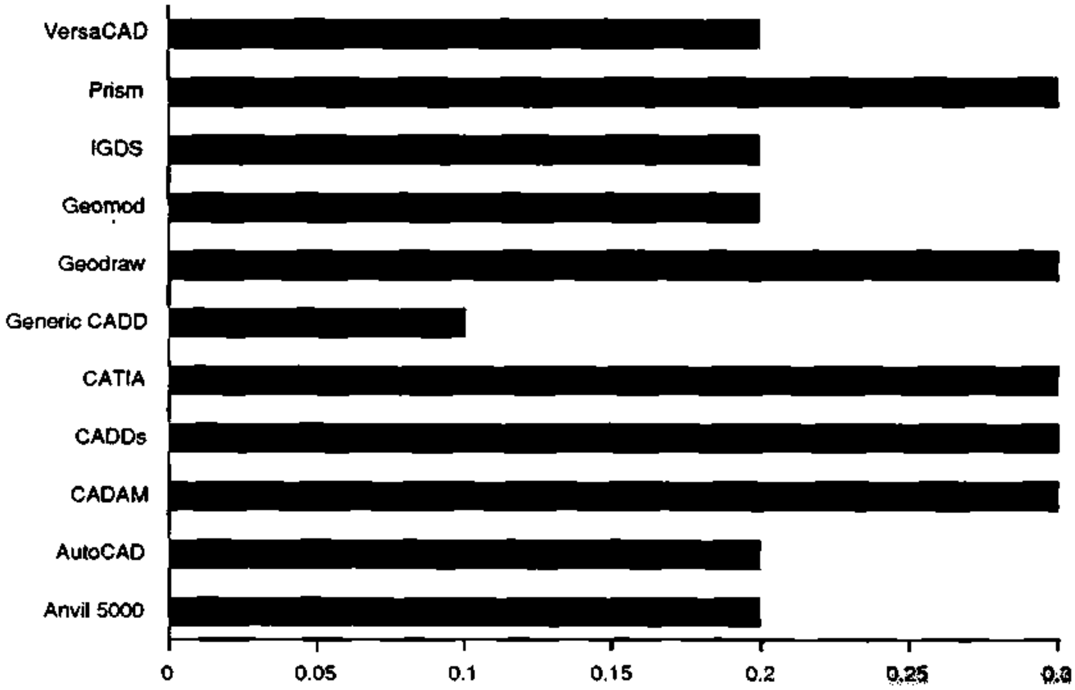
Geometric Construction — Transformations: 3D Orient



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-50

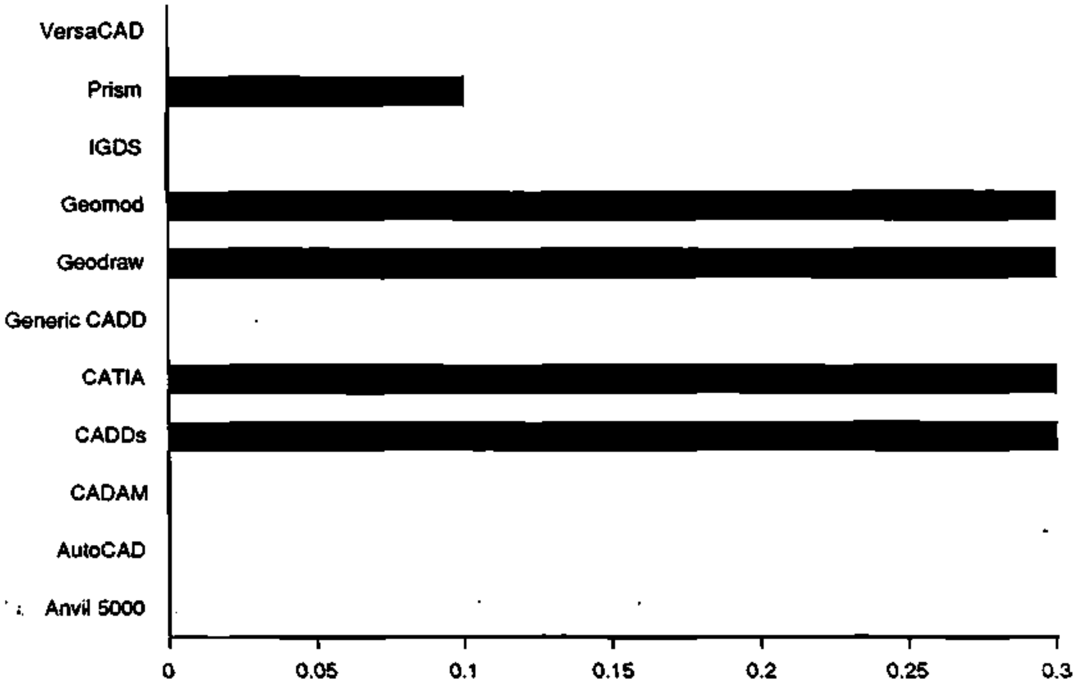
Geometric Construction — Transformations: Mirror



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-51

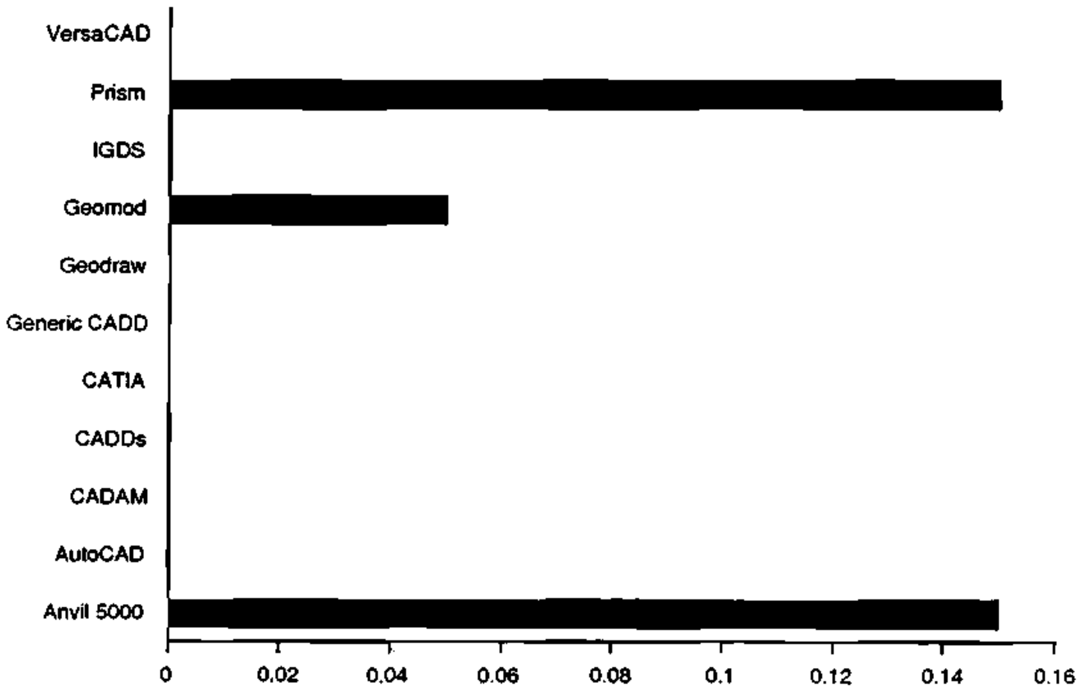
Geometric Construction — Transformations: Combination Transformations



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-52

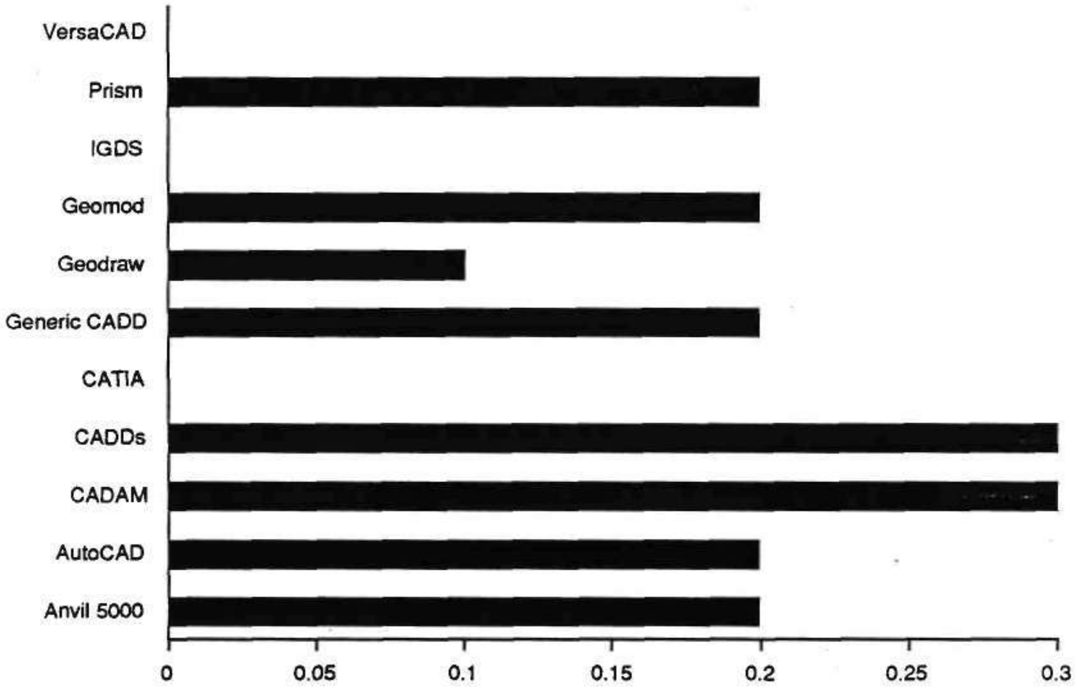
Geometric Construction — Transformations: Circular Move/Copy



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-53

Geometric Construction — Transformations: Stretch

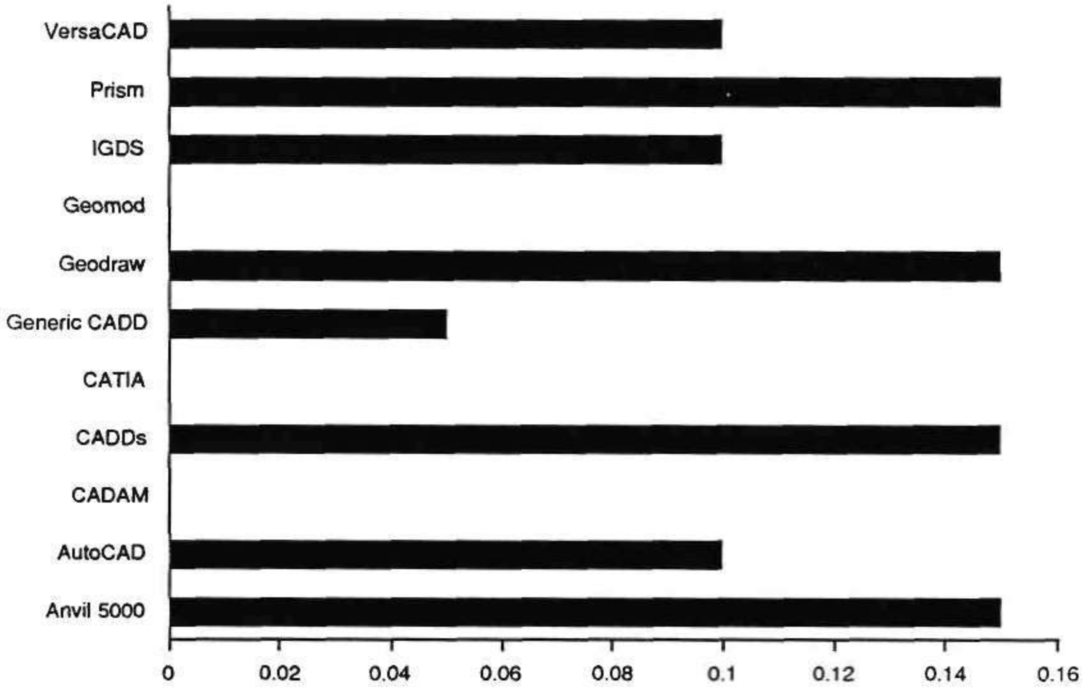


**Maximum score attainable for feature .400*

Source: Albert Consulting Group

Figure A-54

Geometric Construction — Transformations: Rectangular Array

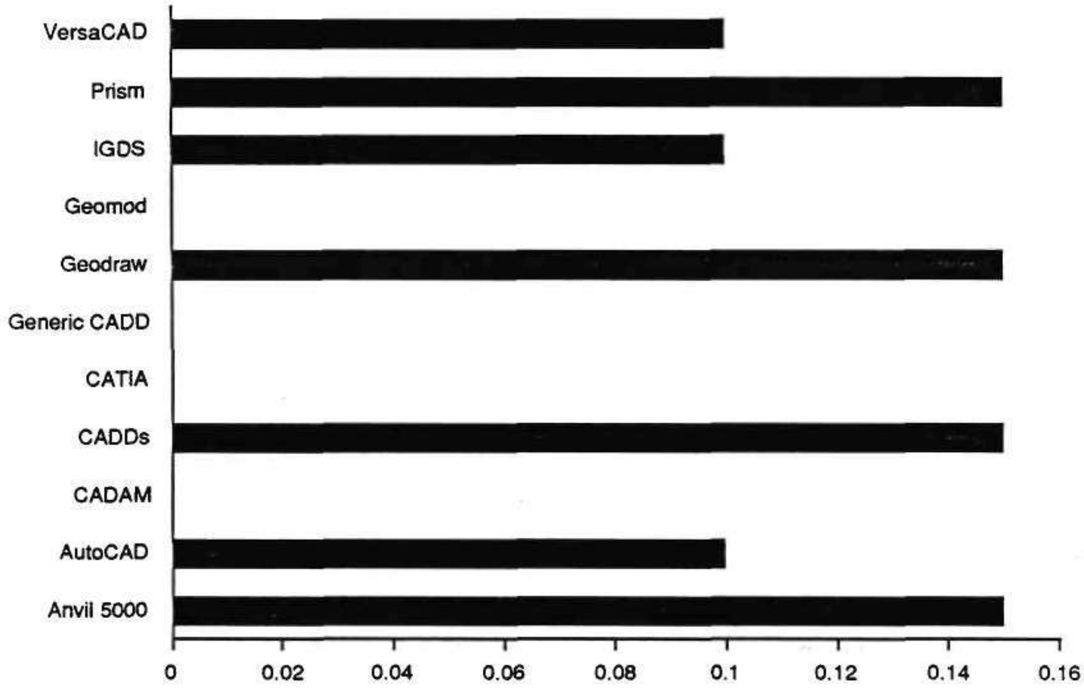


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure A-55

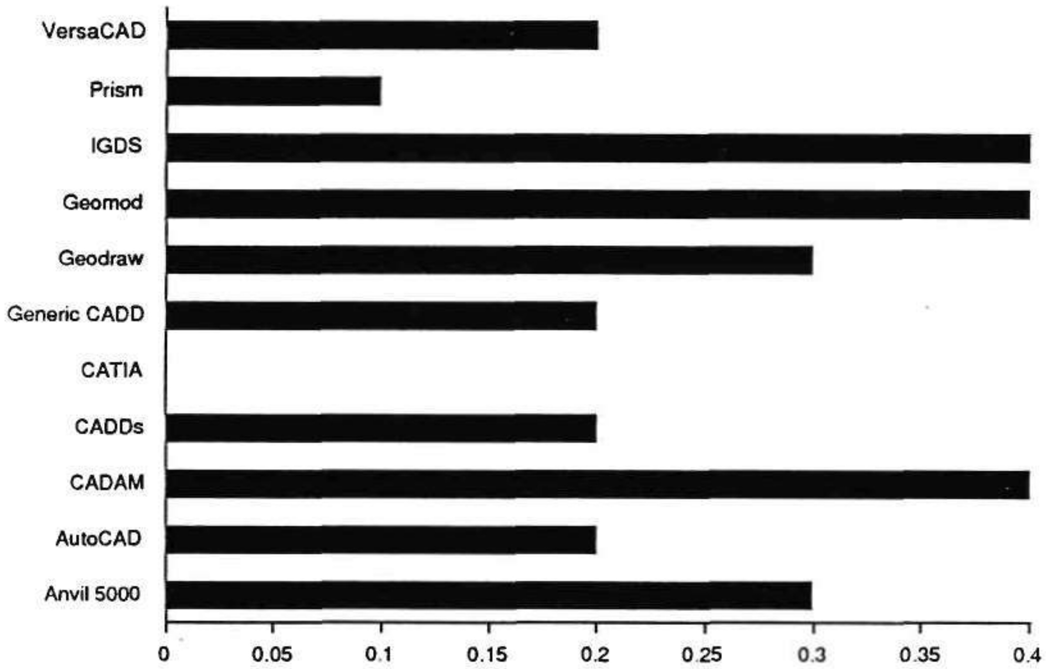
Geometric Construction — Transformations: Circular Array



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-56

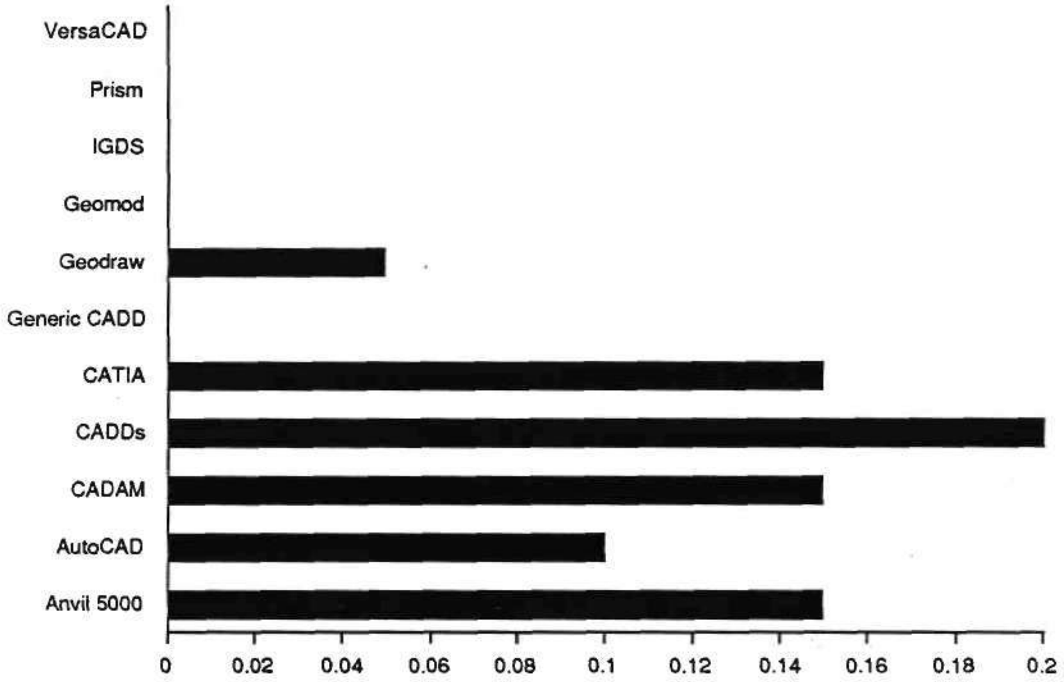
Geometric Construction — Transformations: Scale



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-57

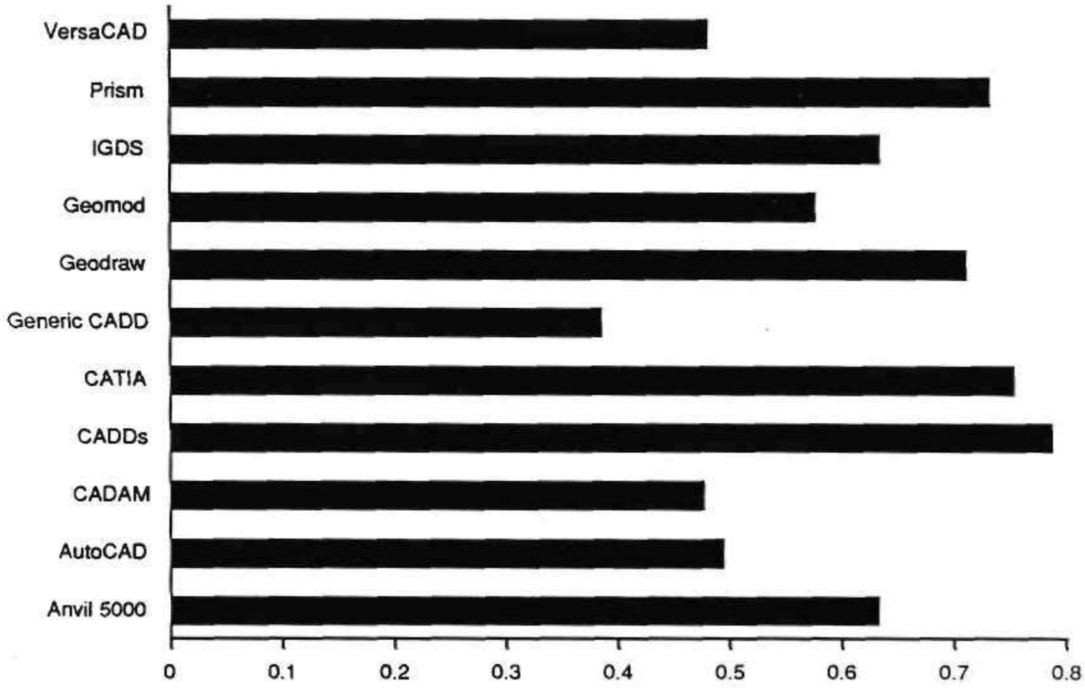
Geometric Construction — Transformations: Project Wireframe



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-58

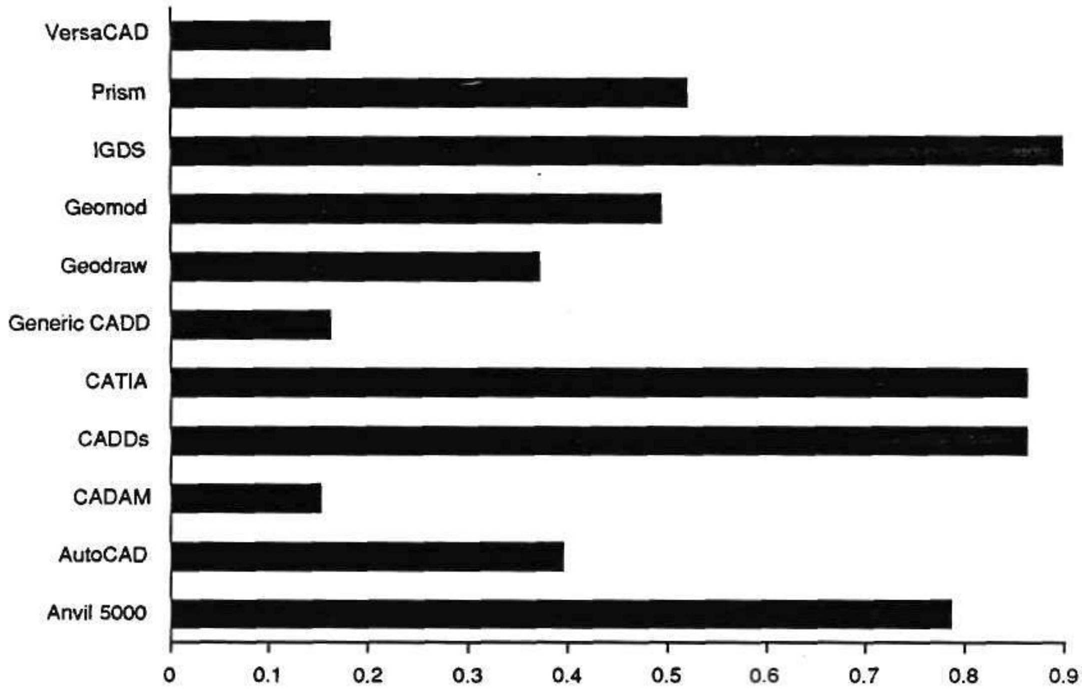
Geometric Construction — Construction Aids: Item Selection



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-59

Geometric Construction — Construction Aids: Coordinate Systems

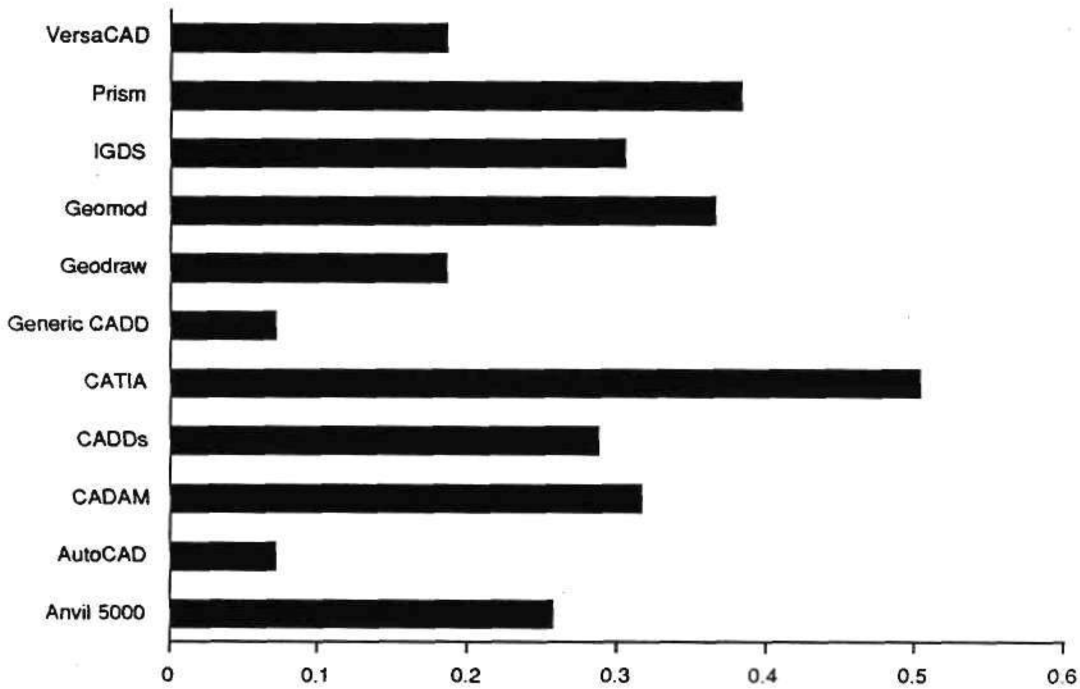


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure A-60

Geometric Construction — Construction Aids: Verification/Query

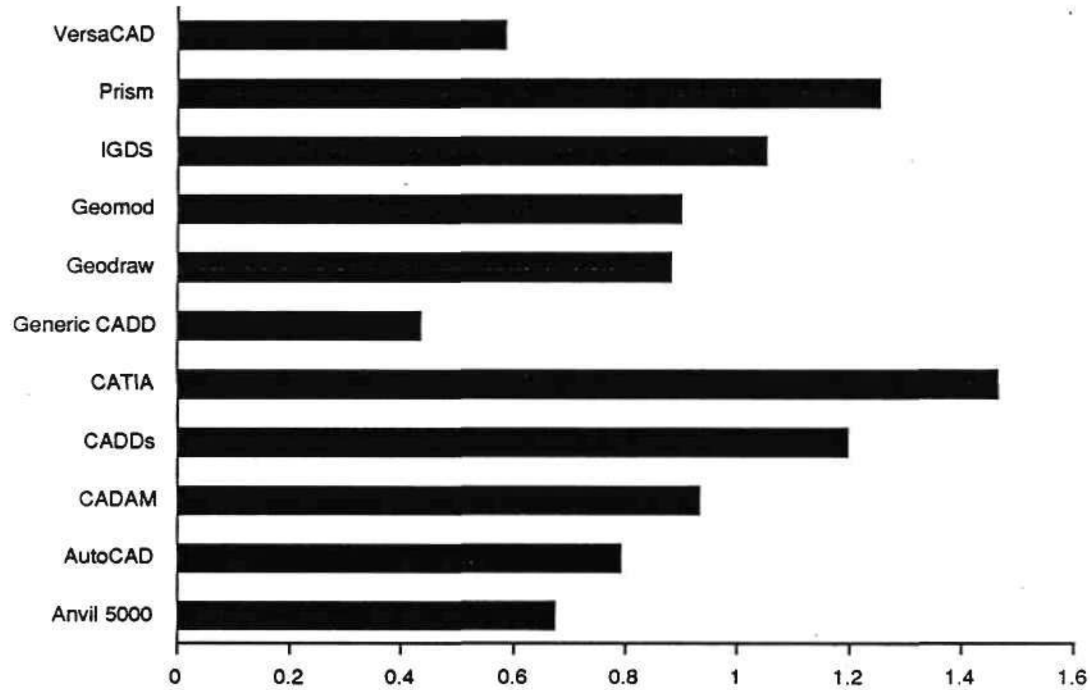


**Maximum score attainable for feature .600*

Source: Albert Consulting Group

Figure A-61

Geometric Construction — Construction Aids: Grids

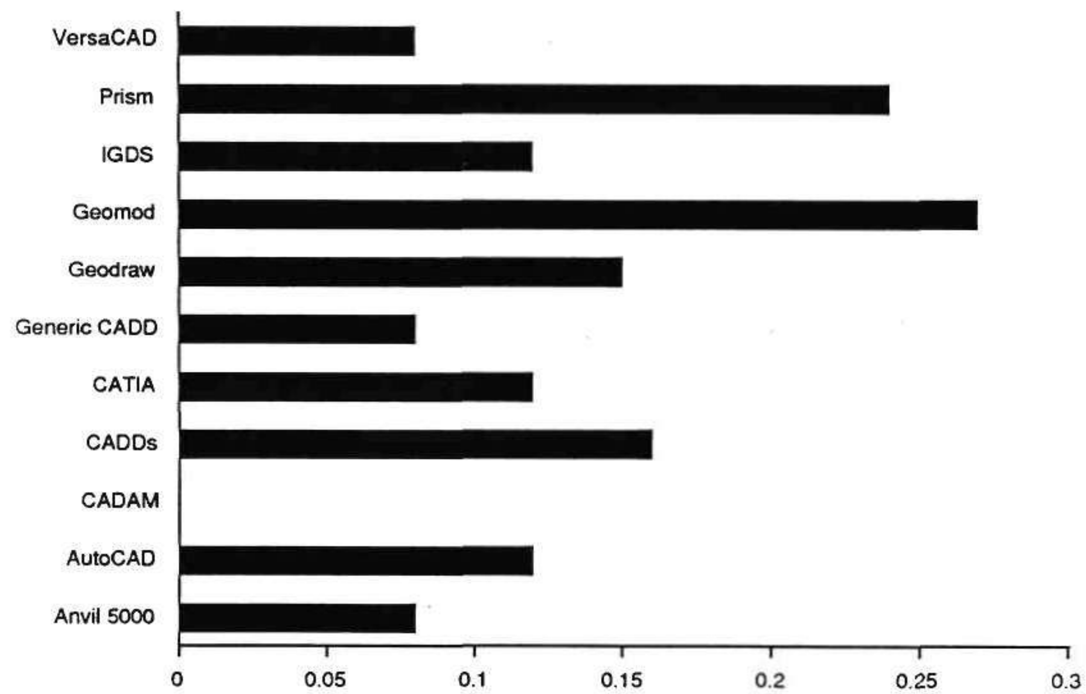


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure A-62

Geometric Construction — Construction Aids: Temporary Constructions

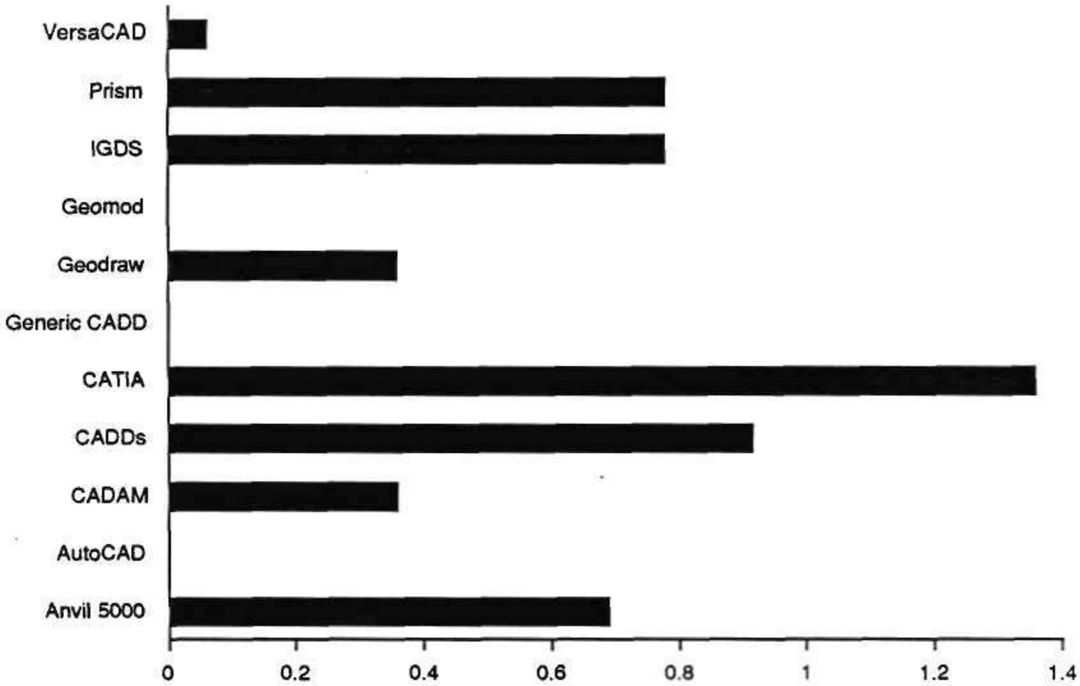


**Maximum score attainable for feature .400*

Source: Albert Consulting Group

Figure A-63

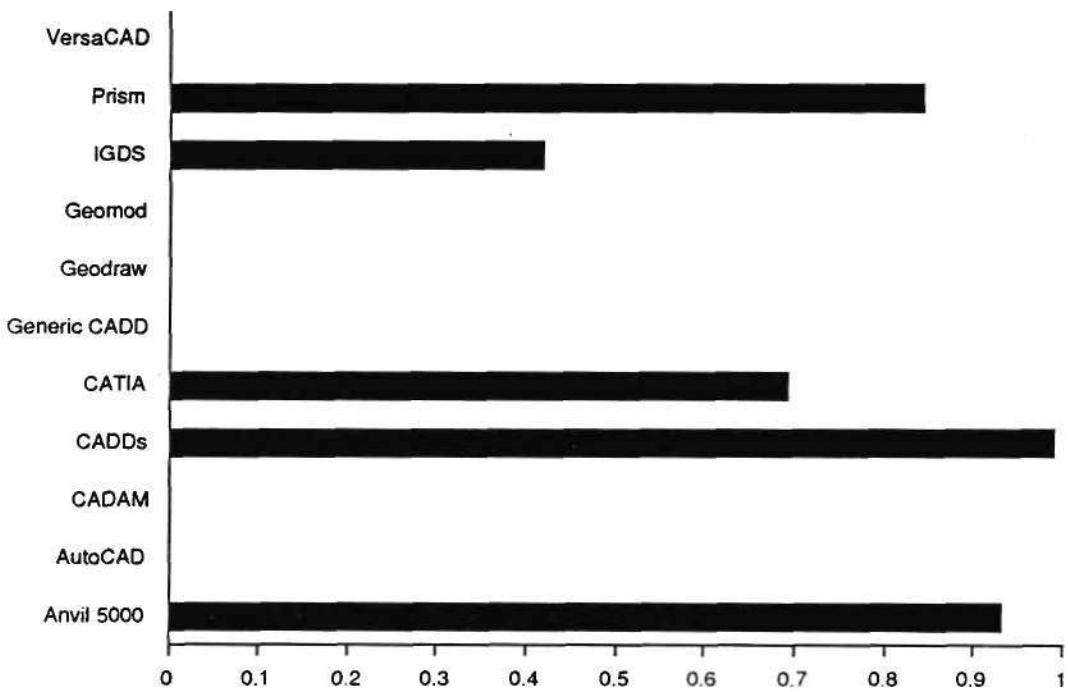
Drafting — Model/Drawing Association: View Functions



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-64

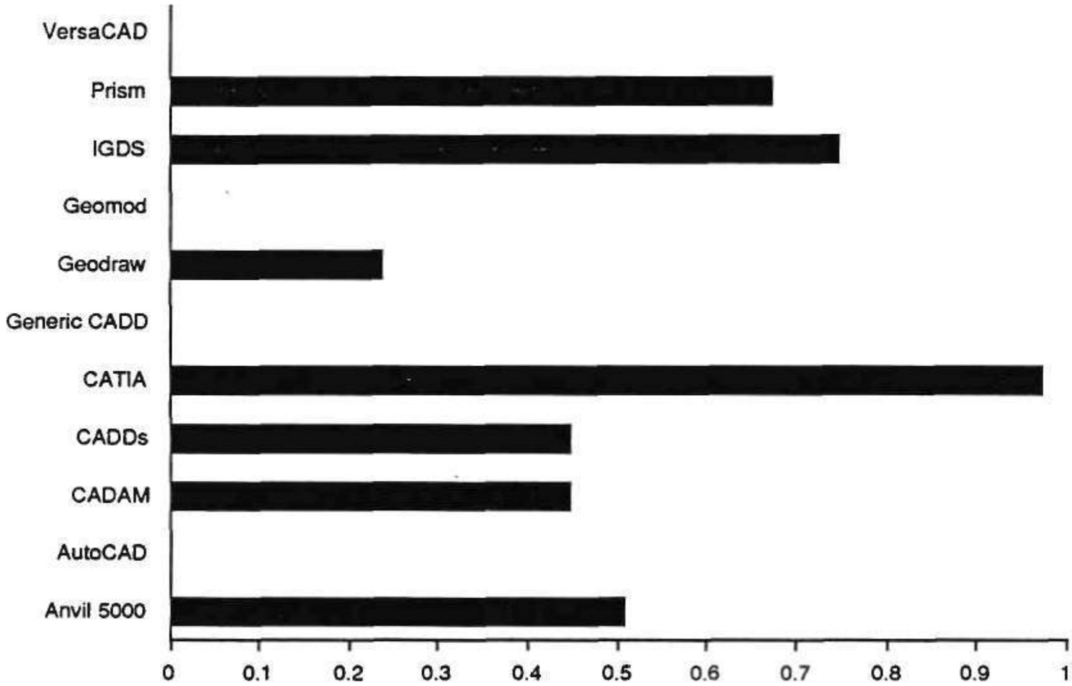
Drafting — Model/Drawing Association: Model/Display Modification



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure A-65

Drafting — Model/Drawing Association: Drawing Mode

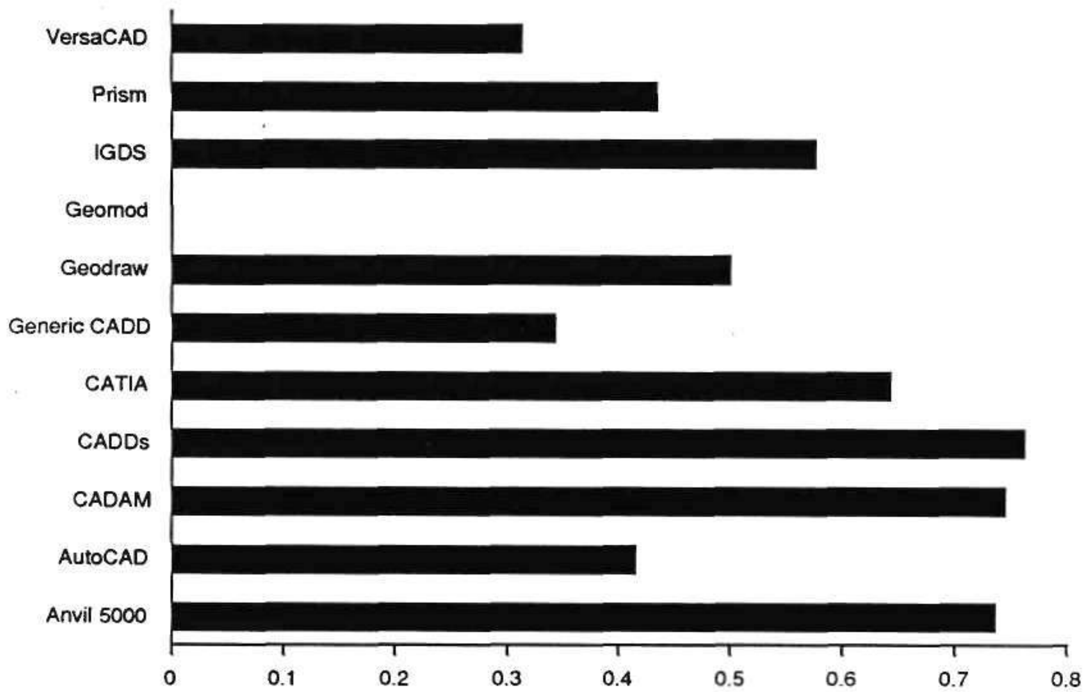


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure A-66

Drafting — Annotation: Line Styles

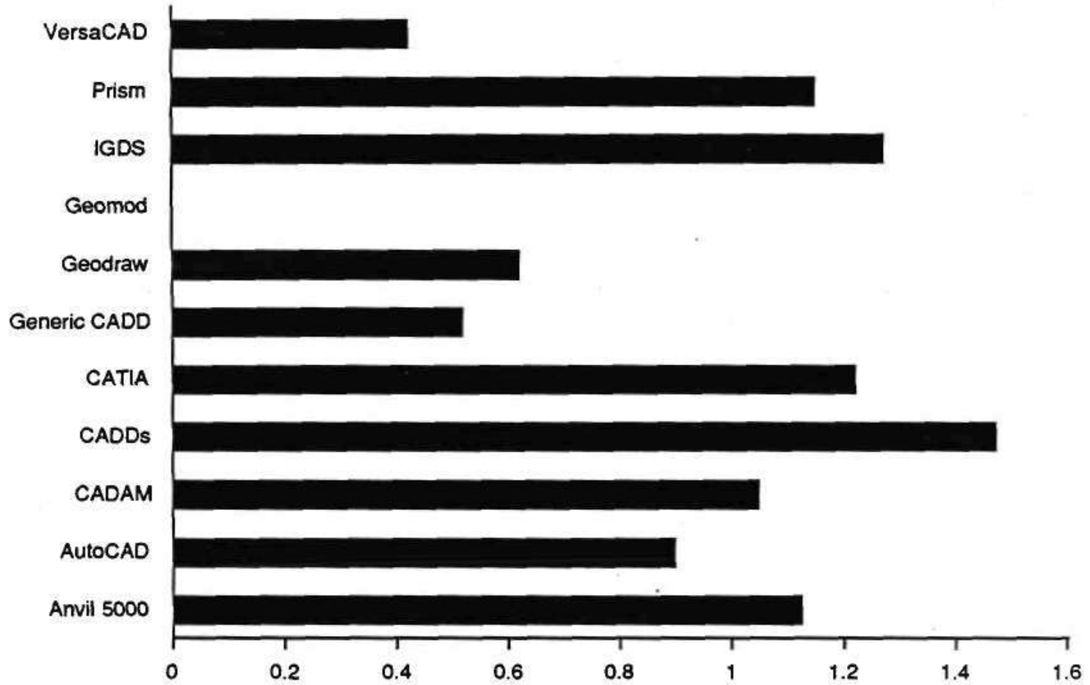


**Maximum score attainable for feature 1.200*

Source: Albert Consulting Group

Figure A-67

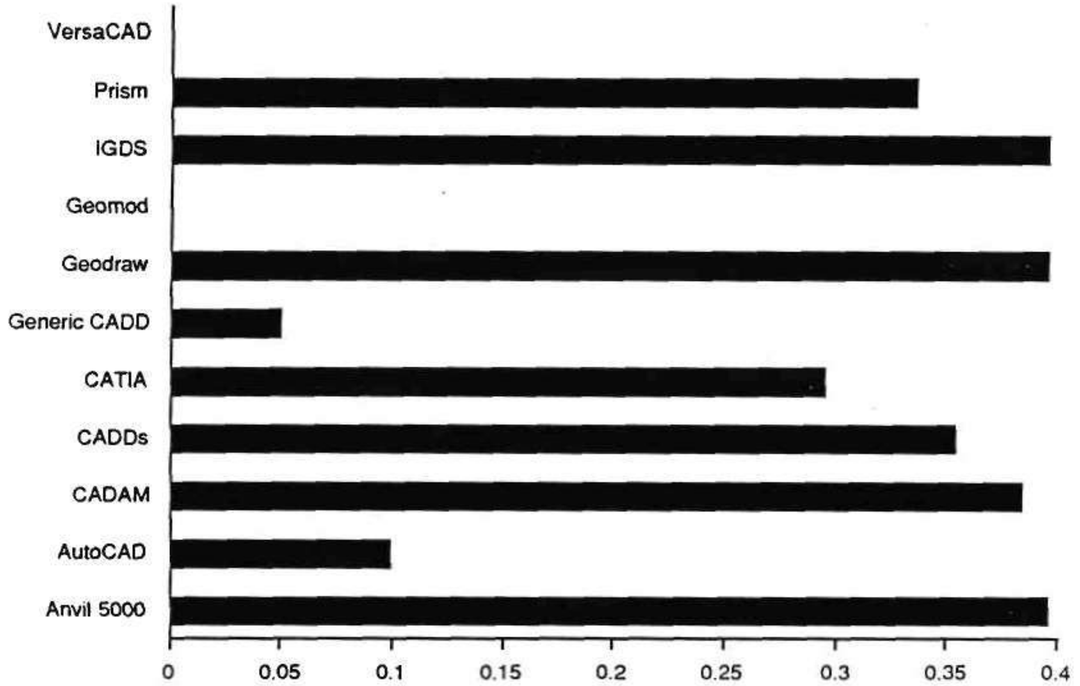
Drafting — Annotation: Text



**Maximum score attainable for feature 2.000* *Source: Albert Consulting Group*

Figure A-68

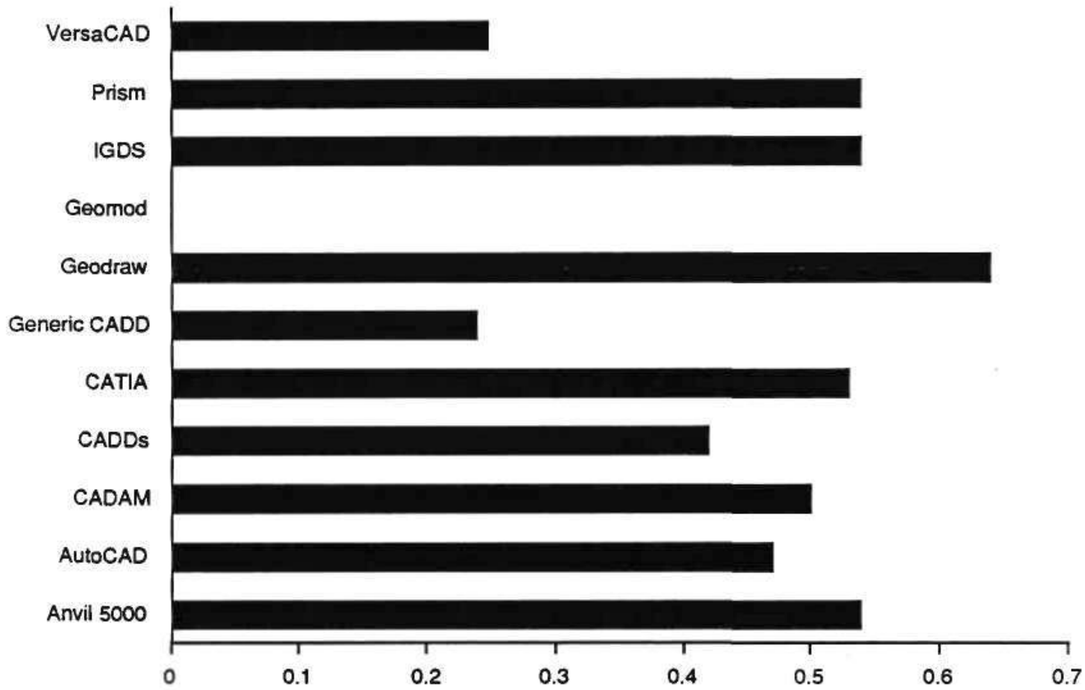
Drafting — Annotation: Special Items



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-69

Drafting — Dimensions: Types

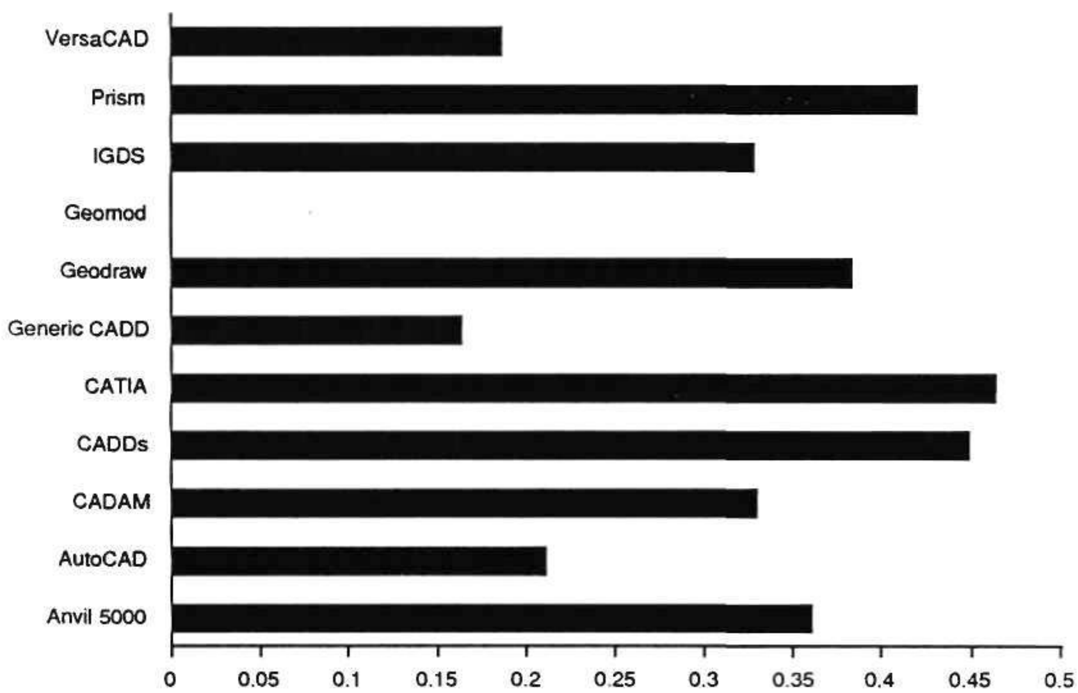


**Maximum score attainable for feature .800*

Source: Albert Consulting Group

Figure A-70

Drafting — Dimensions: Styles

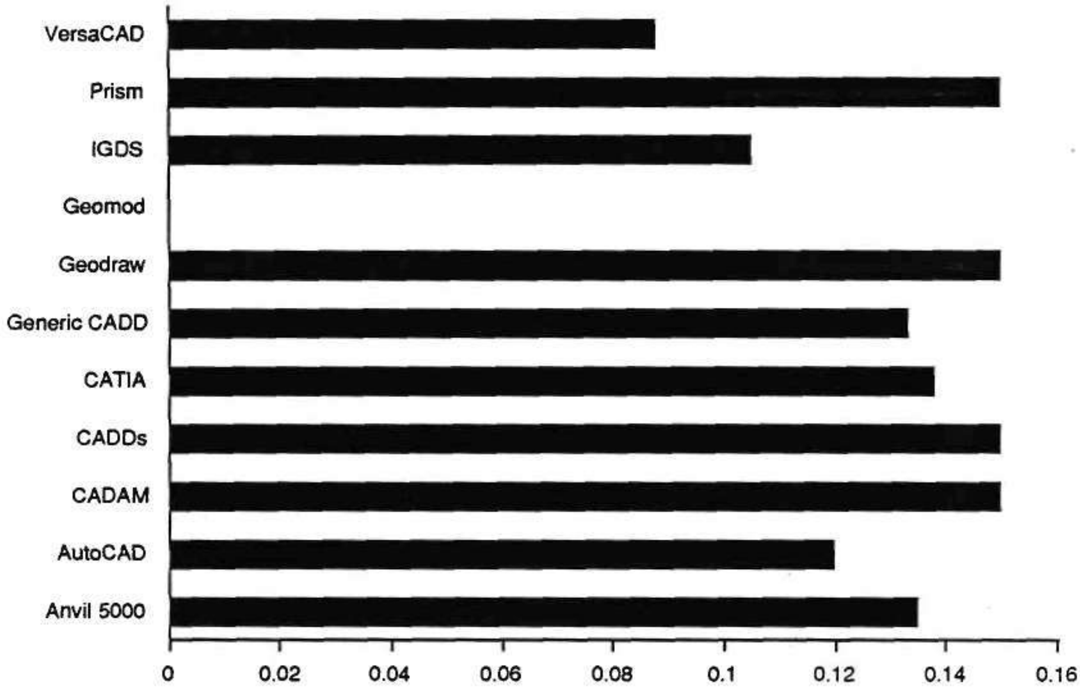


**Maximum score attainable for feature .600*

Source: Albert Consulting Group

Figure A-71

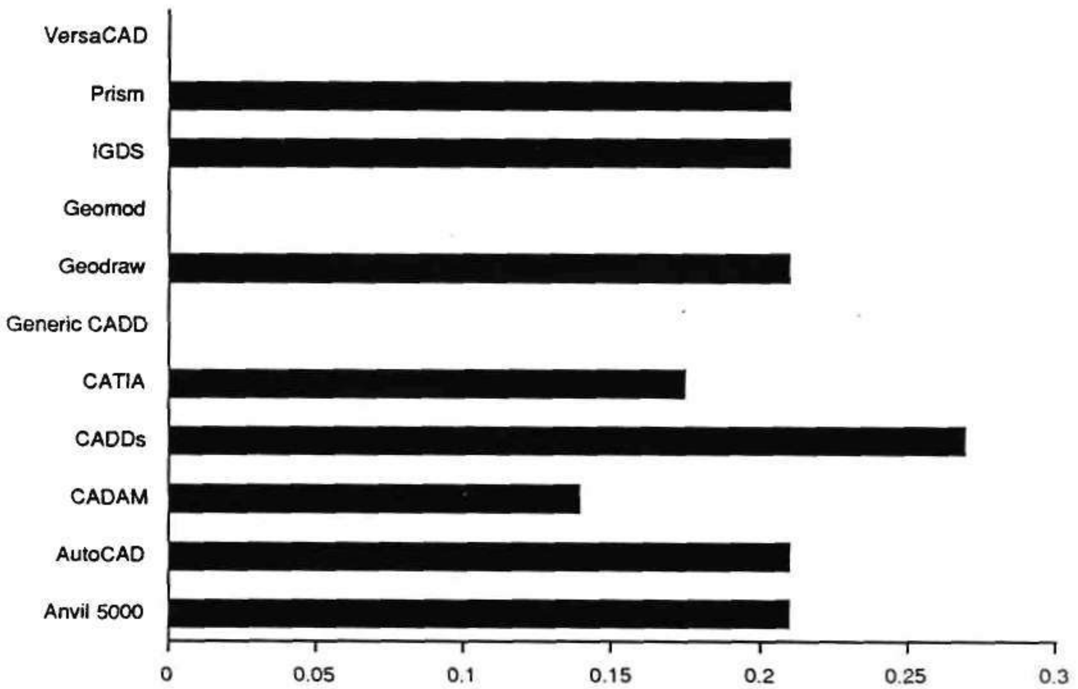
Drafting — Dimensions: Text Control



**Maximum score attainable for feature .200* *Source: Albert Consulting Group*

Figure A-72

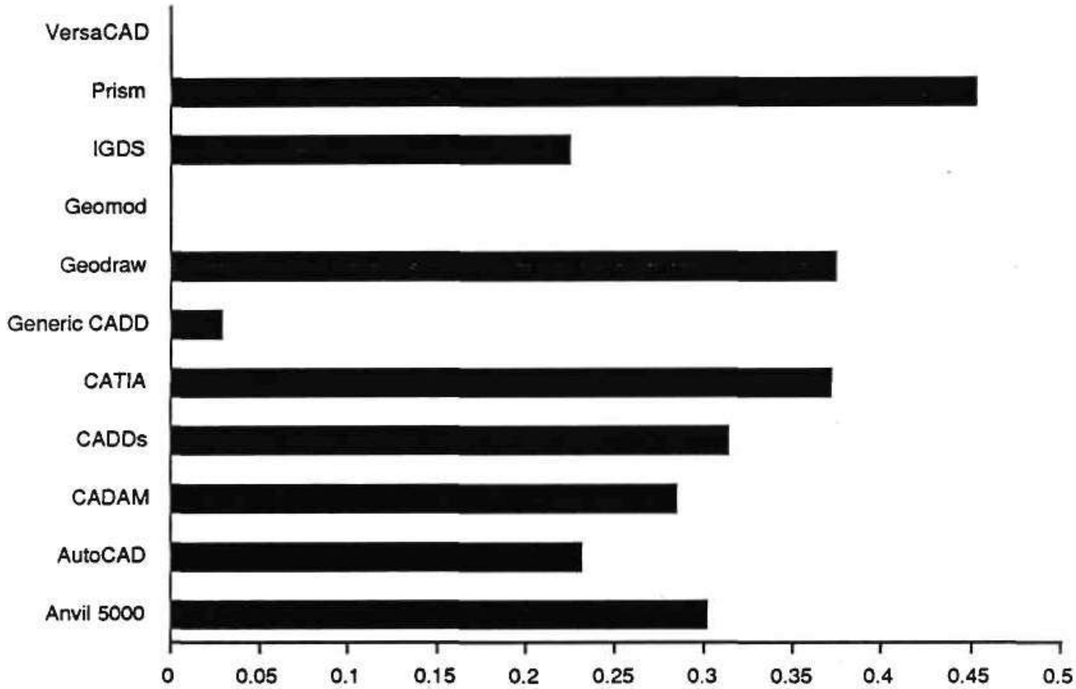
Drafting — Dimensions: Tolerance



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-73

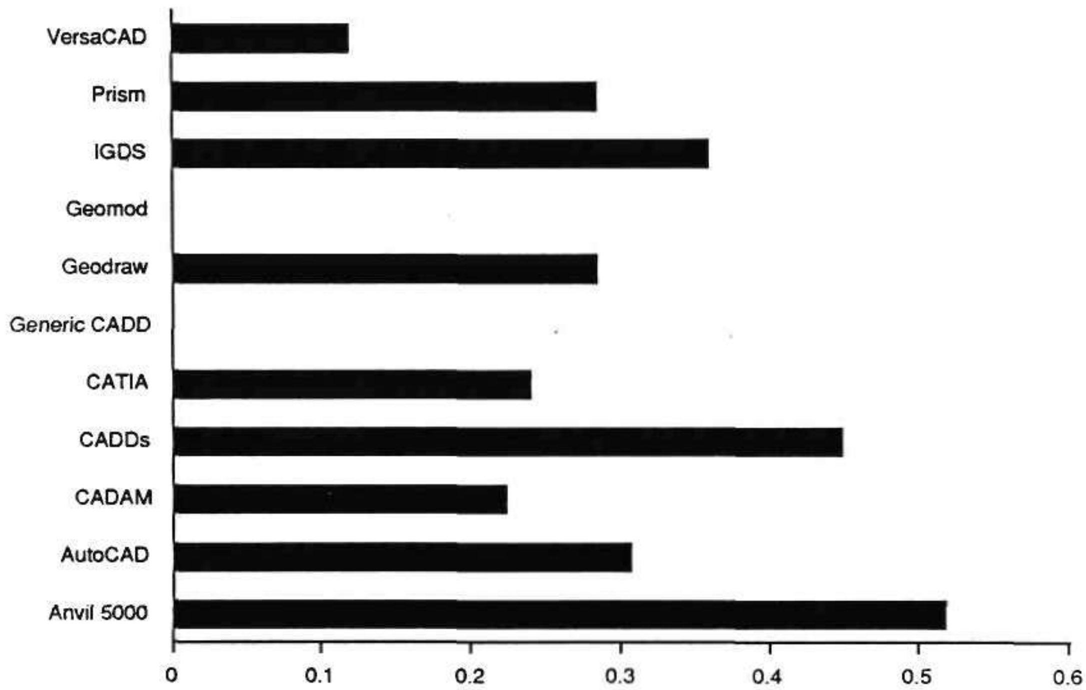
Drafting — Dimensions: Editing



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-74

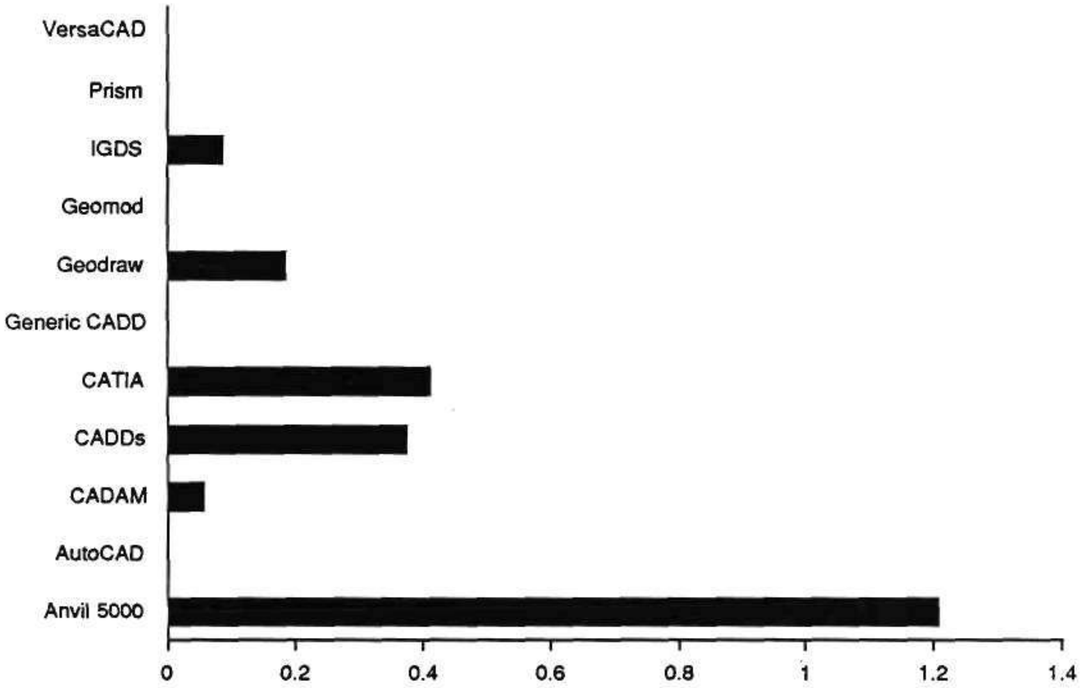
Drafting — Dimensions: Standards



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-75

Drafting — Dimensions: Regeneration

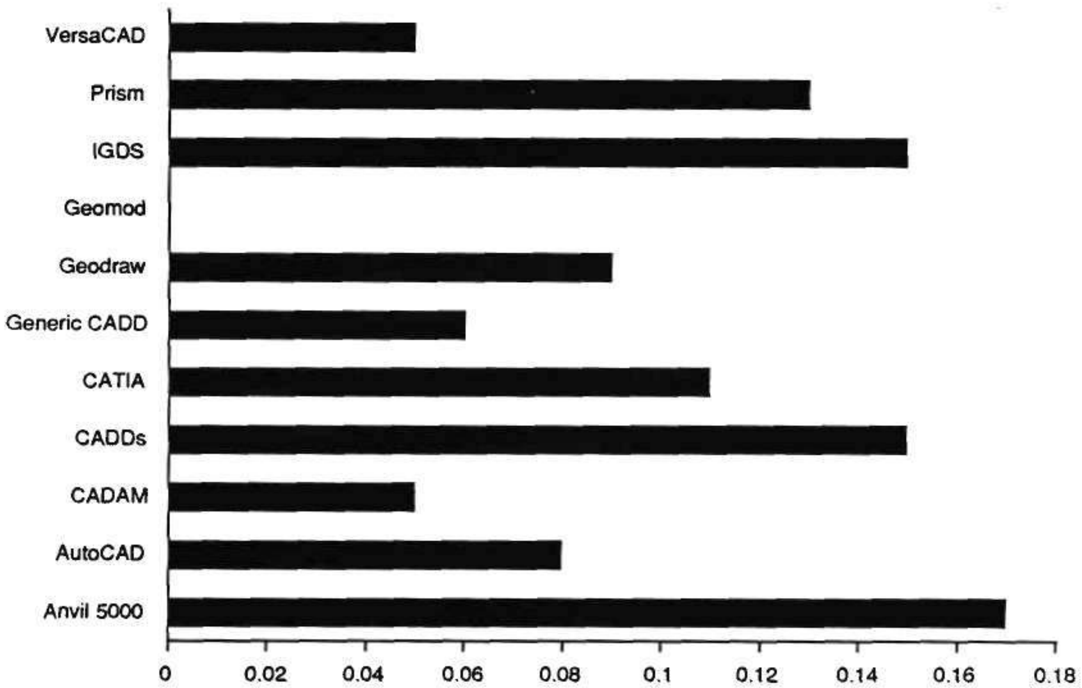


**Maximum score attainable for feature .600*

Source: Albert Consulting Group

Figure A-76

Drafting — Dimensions: Appearance Control

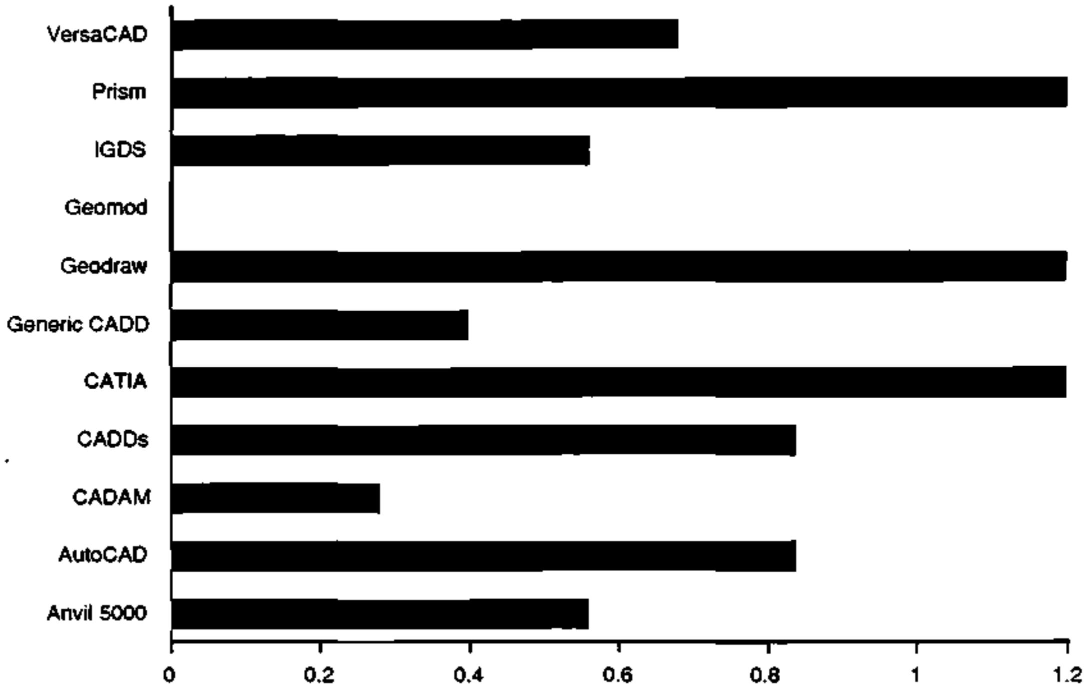


**Maximum score attainable for feature .200*

Source: Albert Consulting Group

Figure A-77

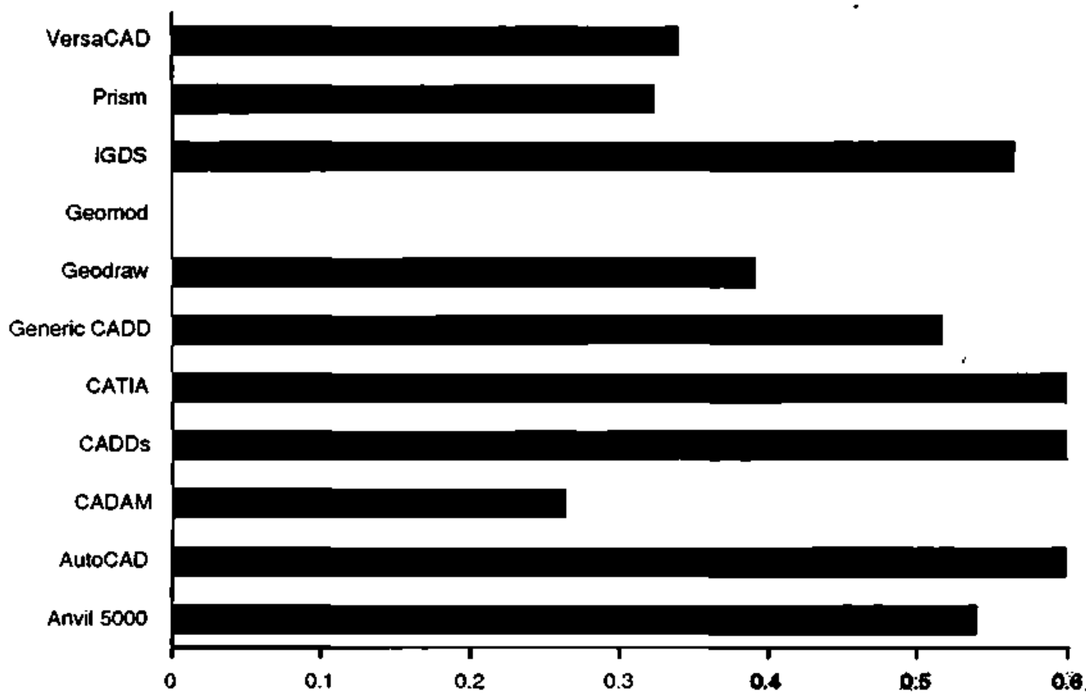
Drafting — Crosshatching: Boundary Specification



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-78

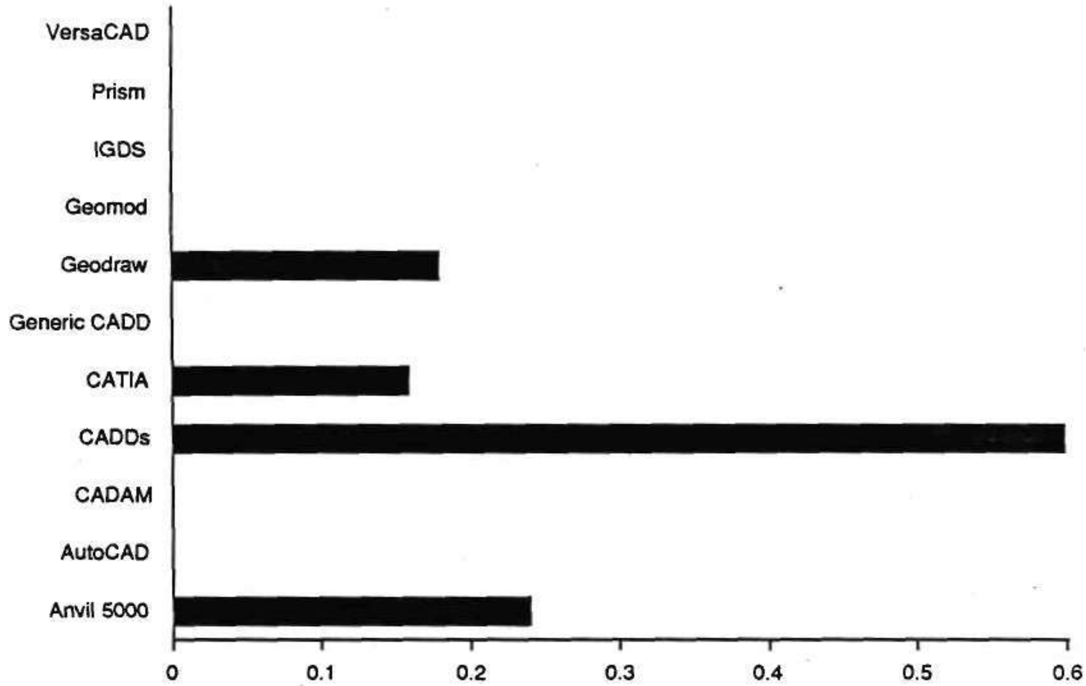
Drafting — Crosshatching: Patterns



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-79

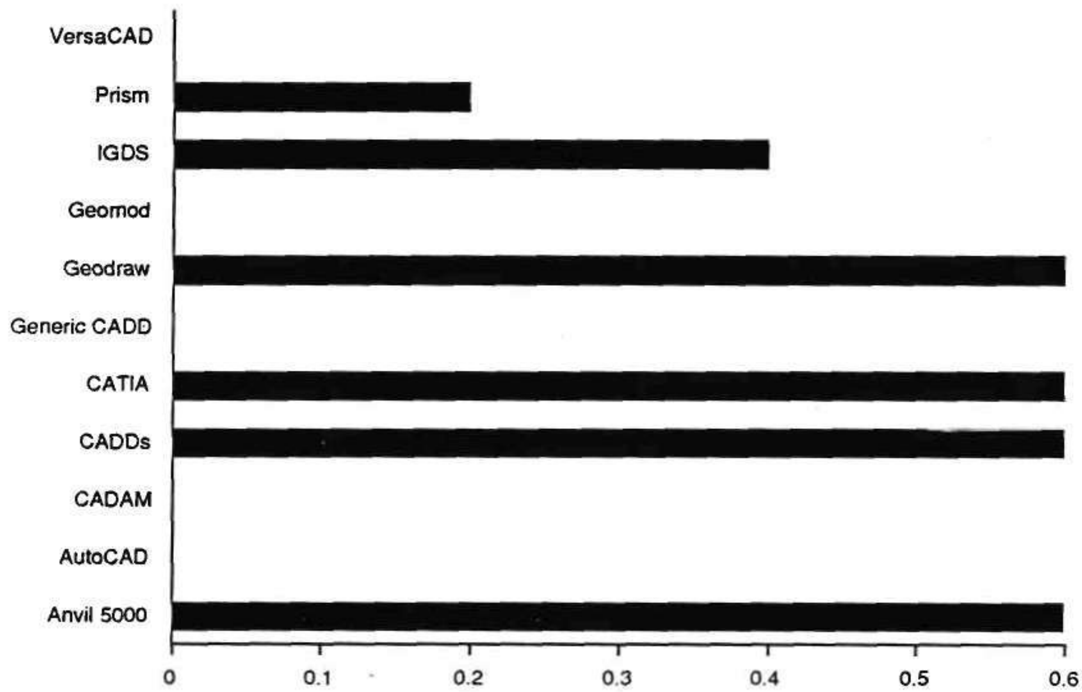
Drafting — Crosshatching: Editing



**Maximum score attainable for feature 1.600* *Source: Albert Consulting Group*

Figure A-80

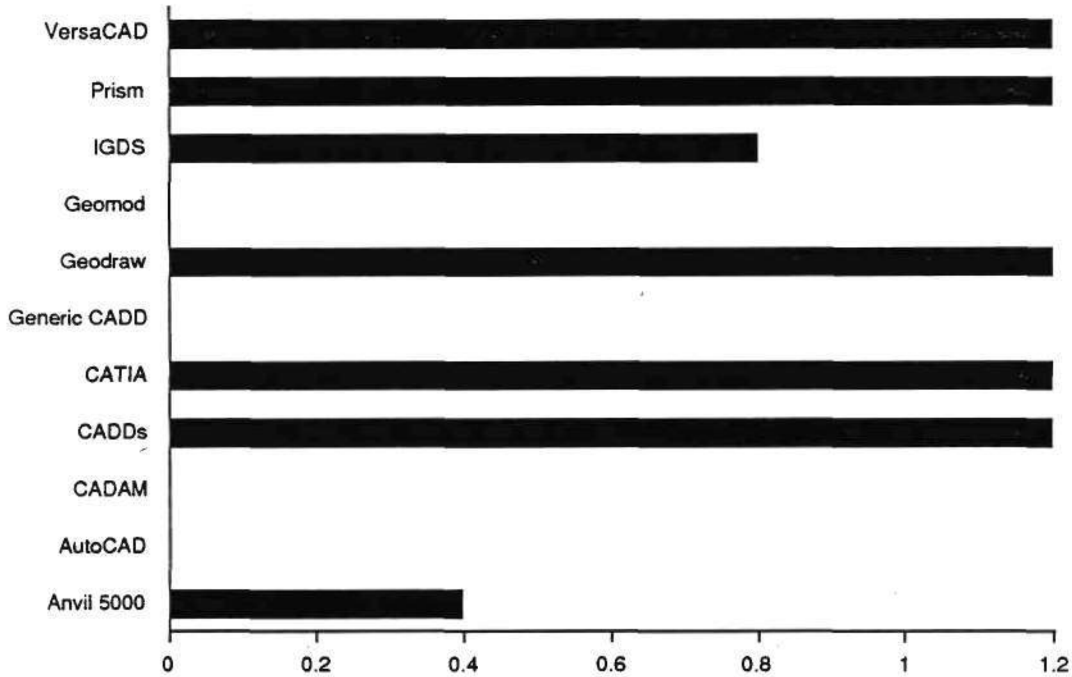
Drafting — Detail Magnification Area: Specification



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-81

Drafting — Detail Magnification Area: Dimensioning

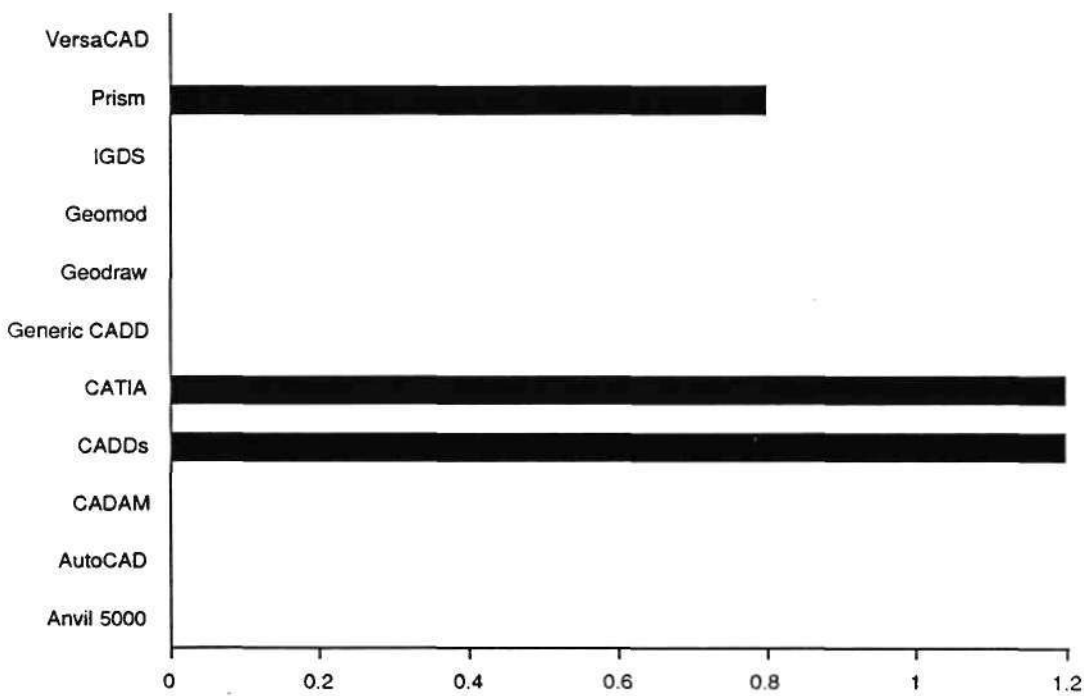


**Maximum score attainable for feature 1.600*

Source: Albert Consulting Group

Figure A-82

Drafting — Detail Magnification Area: Associativity

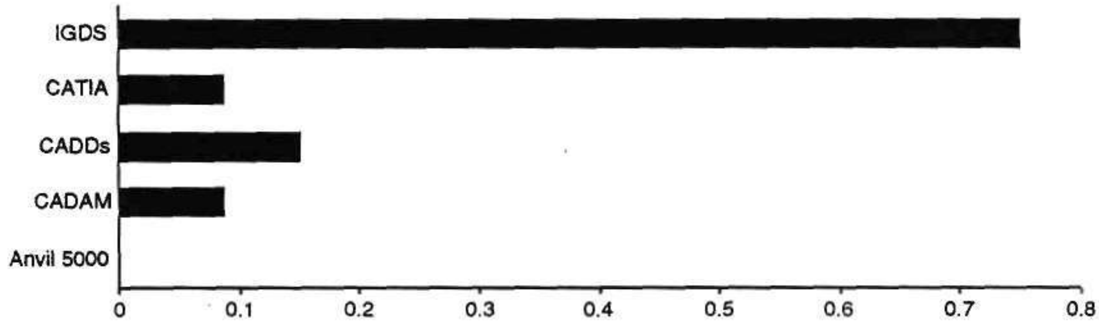


**Maximum score attainable for feature 1.600*

Source: Albert Consulting Group

Figure A-83

Data Management — System Management: Customization

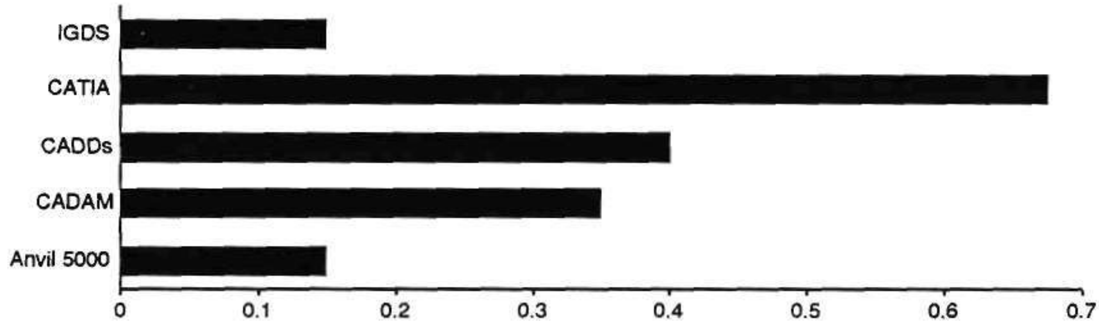


*Maximum score attainable for feature 1.000

Source: Albert Consulting Group

Figure A-84

Data Management — System Management: User Data

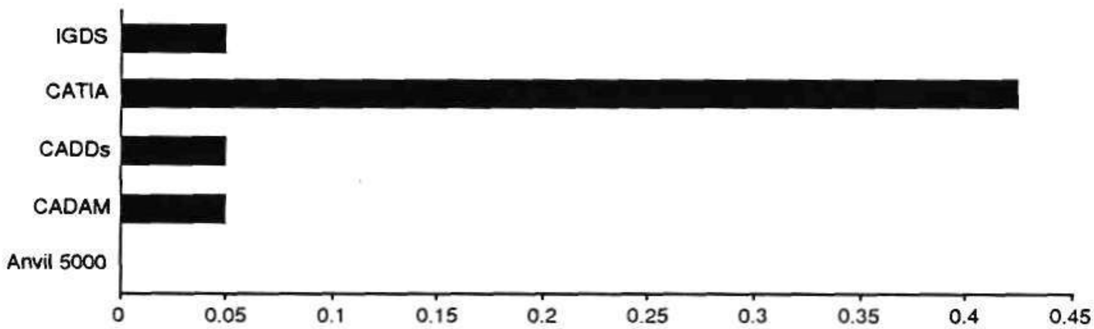


*Maximum score attainable for feature 1.000

Source: Albert Consulting Group

Figure A-85

Data Management — System Management: User Create/Modify Privileges

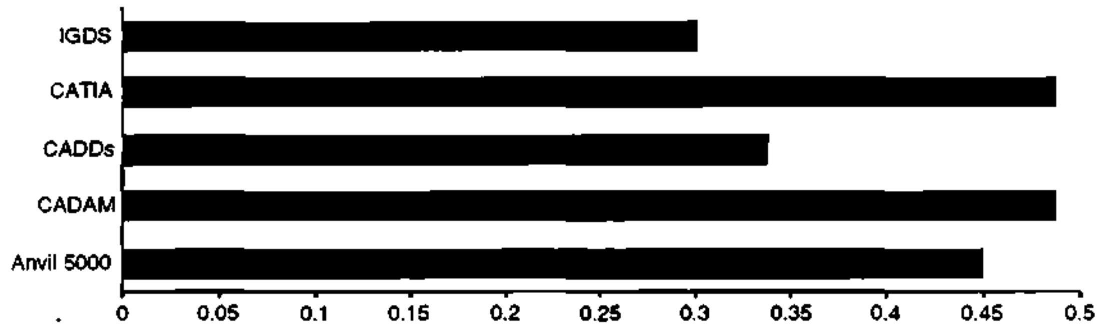


*Maximum score attainable for feature 1.000

Source: Albert Consulting Group

Figure A-86

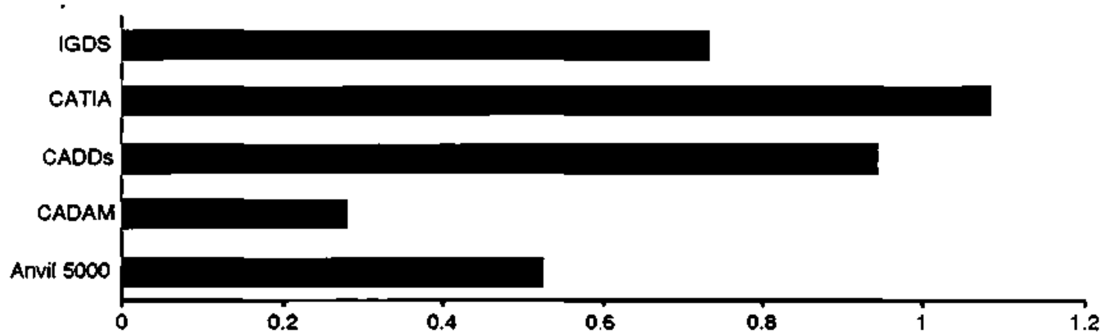
Data Management — System Management: Data Controlled



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure A-87

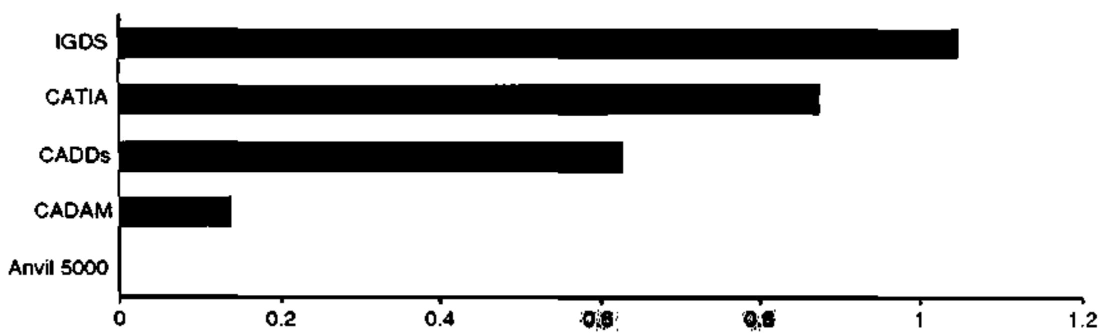
Data Management — Nongraphic Data: Data Stored



**Maximum score attainable for feature 1.400* *Source: Albert Consulting Group*

Figure A-88

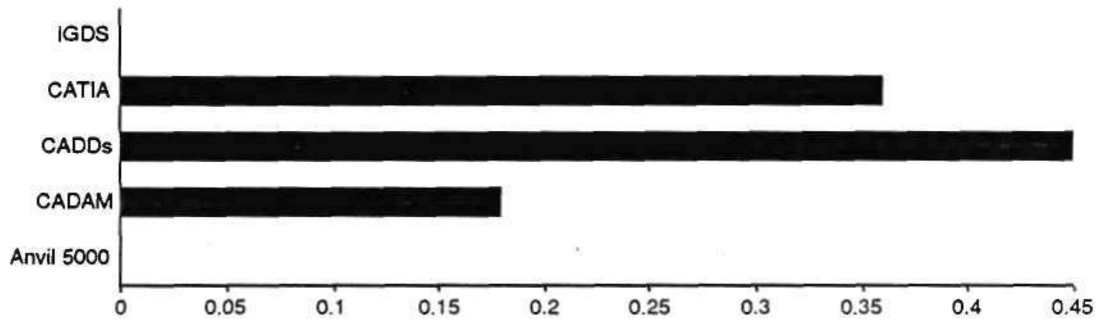
Data Management — Nongraphic Data: Reporting



**Maximum score attainable for feature 1.400* *Source: Albert Consulting Group*

Figure A-89

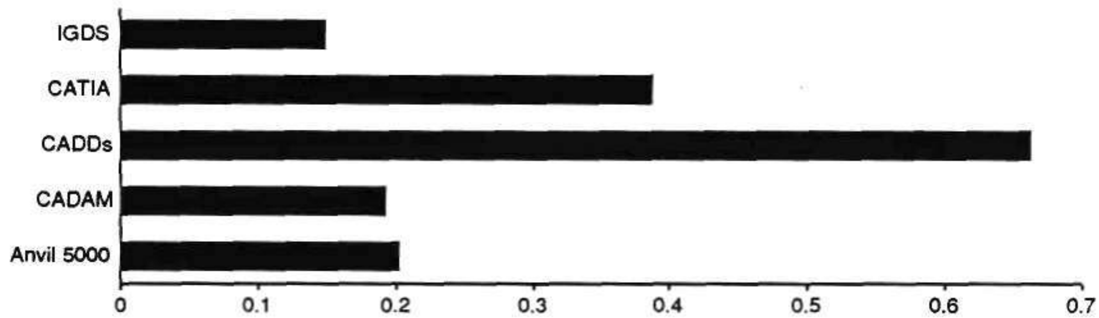
Data Management — Nongraphic Data: Modification



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure A-90

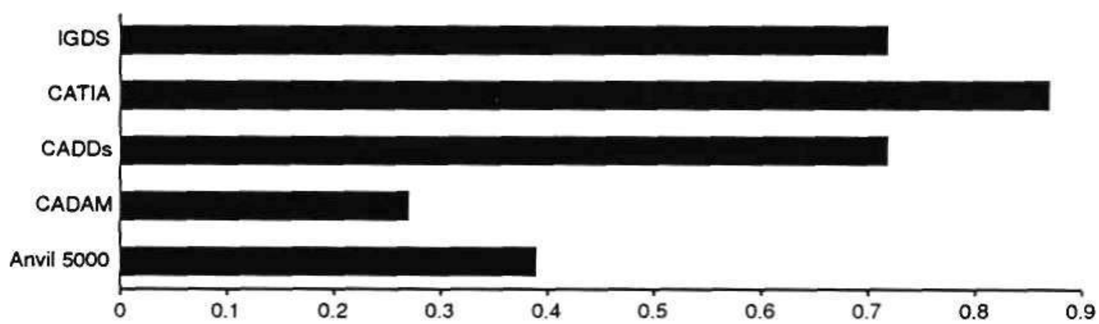
Data Management — Part Management: Data Stored



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure A-91

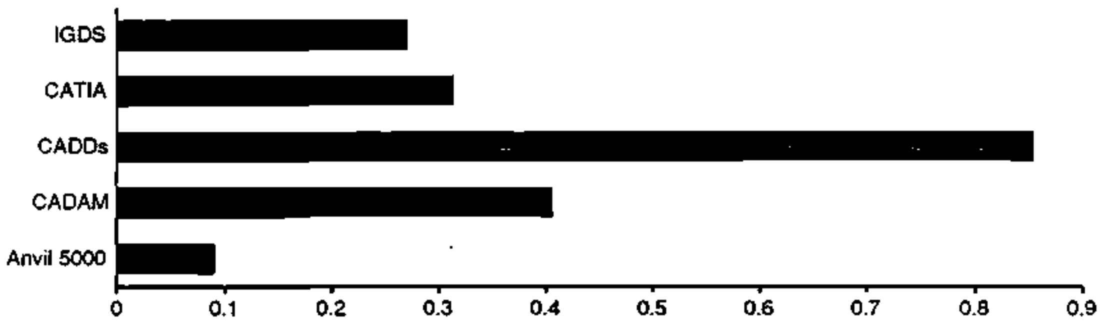
Data Management — Part Management: Access Security



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure A-92

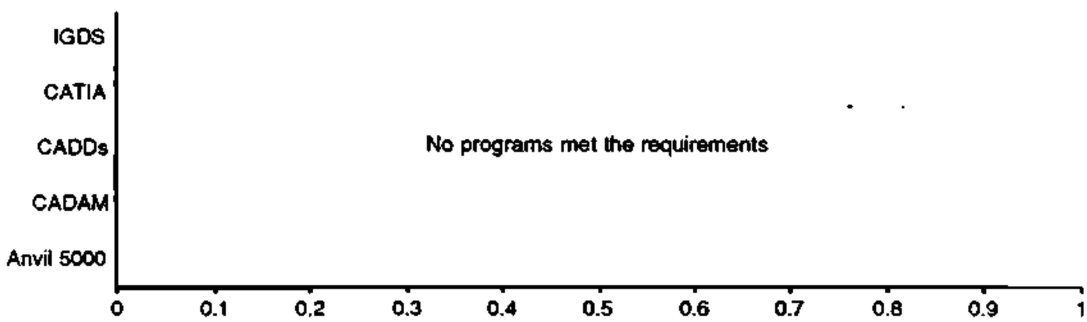
Data Management — Part Management: Functions



**Maximum score attainable for feature 1.800* *Source: Albert Consulting Group*

Figure A-93

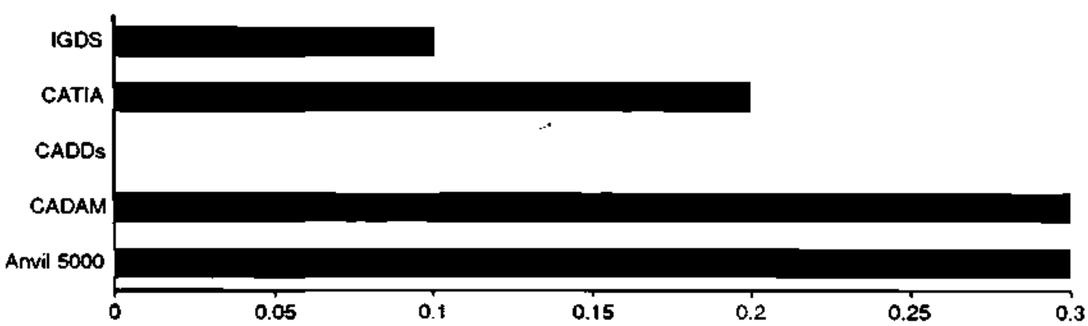
Data Management — Report Generation: In Process



**Maximum score attainable for feature .600* *Source: Albert Consulting Group*

Figure A-94

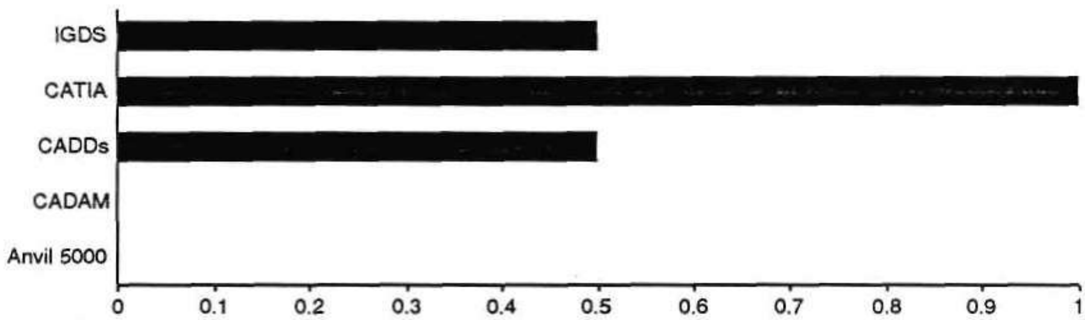
Data Management — Report Generation: Accounting



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-95

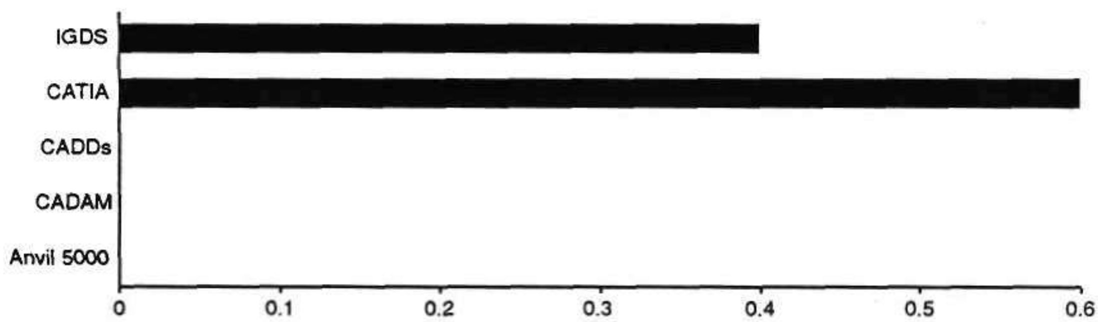
Data Management — Report Generation: Bills of Material (BOM)



**Maximum score attainable for feature 1.000* *Source: Albert Consulting Group*

Figure A-96

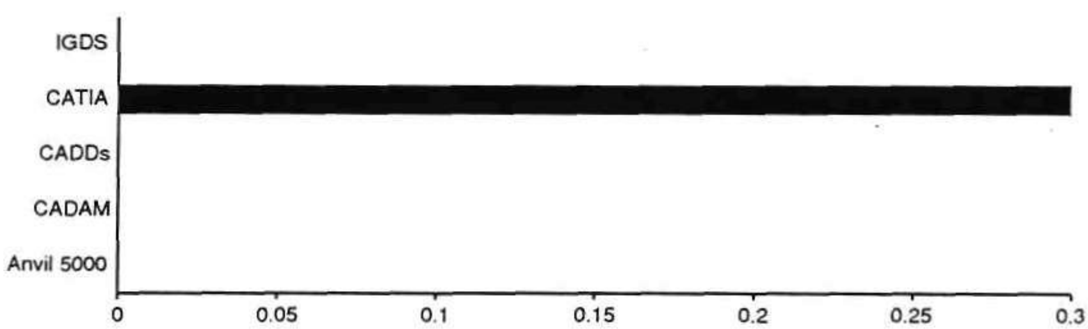
Data Management — Report Generation: Where Used



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Figure A-97

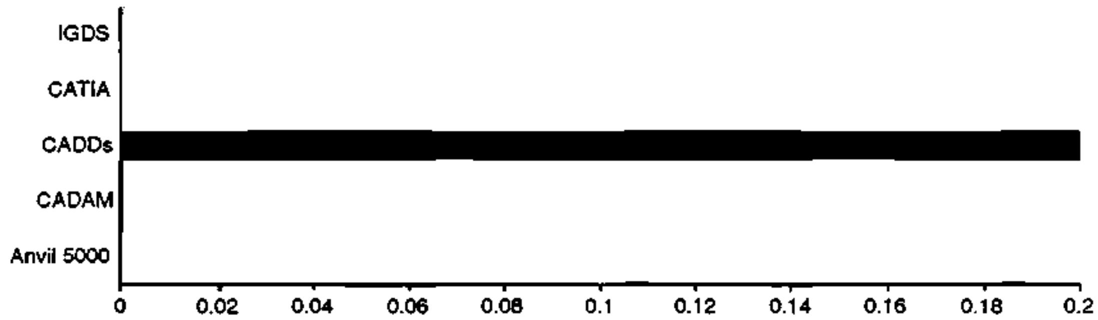
Data Management — Report Generation: User Query



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-98

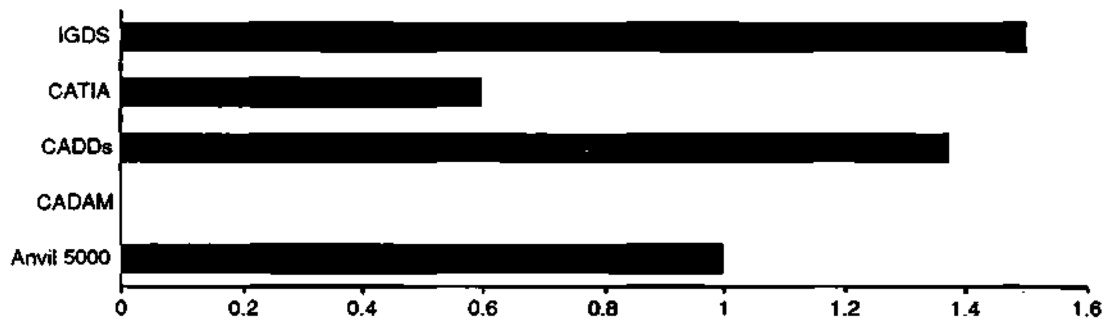
Data Management — Report Generation: ECO Tracking



**Maximum score attainable for feature .400* *Source: Albert Consulting Group*

Figure A-99

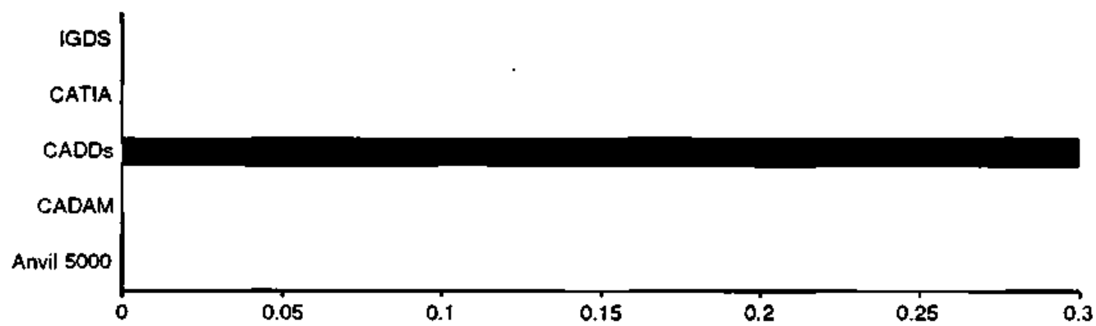
Data Management — Data Transfer/Communications: Model Translation



**Maximum score attainable for feature 2.000* *Source: Albert Consulting Group*

Figure A-100

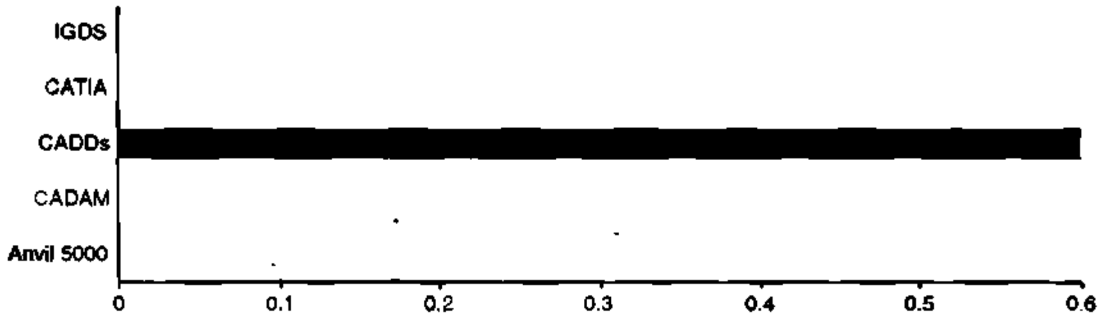
Data Management — Data Transfer/Communications: Intermachine Transfer



**Maximum score attainable for feature 1.200* *Source: Albert Consulting Group*

Figure A-101

Data Management — Data Transfer/Communications: User Notification



**Maximum score attainable for feature .800* *Source: Albert Consulting Group*

Appendix B: Tables

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
1. User Interface	1.000	0.400	0.379	0.309	0.434
1.1 Screen Layout	0.400	0.063	0.158	0.066	0.078
1.1.1 Monitors	0.400	0.300	0.300	0.100	0.100
1.1.2 Graphic Windows	0.800	0.120	0.120	0.000	0.120
1.1.2.1 Multiple Windows	2.000	0.000	0.000	0.000	0.000
1.1.2.2 Shell Access	1.200	0.600	0.600	0.000	0.600
1.1.2.3 Modification	0.800	0.000	0.000	0.000	0.000
1.1.3 On-Screen Modes	2.800	0.210	1.155	0.560	0.560
1.1.3.1 Icons	0.600	0.000	0.150	0.000	0.000
1.1.3.2 Text Based	0.400	0.300	0.300	0.200	0.200
1.1.3.3 Pop-Up Windows	0.600	0.000	0.000	0.000	0.000
1.1.3.4 Pull-Down Menus	0.600	0.000	0.300	0.000	0.000
1.1.3.5 Forms	0.800	0.000	0.400	0.000	0.000
1.1.3.6 Dialog Boxes	0.200	0.000	0.100	0.000	0.000
1.1.3.7 Status Areas	0.800	0.000	0.400	0.600	0.600
1.2 Interactive Modes	0.800	0.360	0.480	0.370	0.390
1.2.1 Commands	0.400	0.000	0.300	0.000	0.400
1.2.2 Tablet	0.200	0.150	0.150	0.000	0.150
1.2.3 On-Screen Menus	0.800	0.400	0.600	0.400	0.400
1.2.4 Function Keys	0.400	0.200	0.300	0.400	0.000
1.2.5 Stroke Recognition	0.200	0.000	0.000	0.000	0.000
1.2.6 Voice Recognition	0.200	0.000	0.000	0.000	0.000
1.2.7 Mouse Buttons	0.400	0.300	0.300	0.100	0.300
1.2.8 Graphic Feedback	0.600	0.150	0.150	0.150	0.300
1.2.9 Responsiveness	0.800	0.600	0.600	0.800	0.400
1.3 Customization	1.000	0.421	0.352	0.200	0.369
1.3.1 Screen Appearance	0.600	0.000	0.000	0.300	0.000
1.3.2 Menus	0.800	0.120	0.280	0.000	0.220
1.3.2.1 Location	0.400	0.000	0.000	0.000	0.100
1.3.2.2 Icons	0.400	0.000	0.200	0.000	0.000
1.3.2.3 Text	0.400	0.100	0.300	0.000	0.300
1.3.2.4 Pop-Up Menus	0.400	0.000	0.000	0.000	0.000
1.3.2.5 Pull-Down Menus	0.400	0.000	0.300	0.000	0.000
1.3.2.6 Forms	0.400	0.000	0.000	0.000	0.000
1.3.2.7 Cell Programming	0.400	0.000	0.300	0.000	0.000
1.3.2.8 Key Programming	0.400	0.200	0.000	0.000	0.000
1.3.2.9 Tablet Programming	0.400	0.300	0.300	0.000	0.400
1.3.2.10 Message/Prompt Modifications	0.400	0.000	0.000	0.000	0.300
1.3.3 Macros/User Programming	1.600	1.064	0.876	0.000	1.004
1.3.3.1 ASCII	0.280	0.140	0.210	0.000	0.210
1.3.3.2 Graphic Entry	0.280	0.140	0.000	0.000	0.210
1.3.3.3 Keystroke Replay	0.200	0.200	0.000	0.000	0.150
1.3.3.4 Comments	0.200	0.150	0.150	0.000	0.100
1.3.3.5 Looping	0.280	0.210	0.210	0.000	0.210
1.3.3.6 Conditional Execution	0.280	0.210	0.210	0.000	0.210
1.3.3.7 Prompting	0.400	0.300	0.300	0.000	0.300
1.3.3.8 Character Data Entry	0:200	0.150	0.150	0.000	0.150

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.573	0.280	0.386	0.340	0.482	0.488	0.329
0.192	0.076	0.080	0.104	0.151	0.157	0.095
0.200	0.200	0.200	0.300	0.200	0.200	0.200
0.180	0.000	0.180	0.180	0.120	0.280	0.120
0.000	0.000	0.000	0.000	0.000	0.500	0.000
0.900	0.000	0.900	0.900	0.600	0.900	0.600
0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.540	0.560	0.420	0.560	1.190	1.085	0.630
0.150	0.000	0.300	0.000	0.300	0.300	0.000
0.300	0.200	0.300	0.200	0.200	0.300	0.300
0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.300	0.000
0.600	0.000	0.000	0.000	0.600	0.400	0.200
0.050	0.000	0.000	0.000	0.000	0.050	0.000
0.800	0.600	0.000	0.600	0.600	0.200	0.400
0.510	0.420	0.350	0.270	0.480	0.490	0.350
0.000	0.300	0.000	0.300	0.200	0.400	0.200
0.000	0.050	0.000	0.050	0.150	0.150	0.150
0.600	0.600	0.600	0.400	0.600	0.600	0.600
0.400	0.300	0.000	0.100	0.300	0.300	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.300	0.300	0.300	0.100	0.400	0.300	0.100
0.450	0.150	0.450	0.000	0.150	0.300	0.300
0.800	0.400	0.400	0.400	0.600	0.400	0.400
0.388	0.208	0.321	0.293	0.363	0.535	0.385
0.300	0.150	0.000	0.150	0.000	0.300	0.000
0.020	0.220	0.000	0.000	0.280	0.360	0.280
0.100	0.000	0.000	0.000	0.200	0.100	0.000
0.000	0.000	0.000	0.000	0.200	0.300	0.200
0.000	0.300	0.000	0.000	0.100	0.300	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.300	0.000	0.000
0.000	0.300	0.000	0.000	0.300	0.300	0.300
0.000	0.300	0.000	0.000	0.000	0.300	0.300
0.000	0.200	0.000	0.000	0.300	0.300	0.300
0.000	0.000	0.000	0.000	0.000	0.200	0.300
0.732	0.212	0.532	0.772	0.672	1.228	1.008
0.210	0.210	0.000	0.140	0.070	0.280	0.210
0.000	0.070	0.210	0.140	0.000	0.210	0.000
0.000	0.100	0.150	0.150	0.000	0.150	0.150
0.100	0.000	0.000	0.150	0.150	0.150	0.150
0.140	0.000	0.000	0.210	0.140	0.210	0.210
0.140	0.000	0.000	0.140	0.140	0.210	0.210
0.200	0.000	0.300	0.300	0.200	0.300	0.300
0.100	0.000	0.150	0.150	0.150	0.150	0.150

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
1.3.3.9 Graphic Data Entry	0.280	0.210	0.210	0.000	0.210
1.3.3.10 Interrupt	0.200	0.050	0.150	0.000	0.150
1.3.3.11 Calculations	0.400	0.300	0.300	0.000	0.260
1.3.3.11.1 Numeric	1.600	1.200	1.200	0.000	1.200
1.3.3.11.2 String	0.800	0.600	0.600	0.000	0.600
1.3.3.11.3 Geometric	1.600	1.200	1.200	0.000	0.800
1.3.3.12 Subroutines	0.200	0.150	0.150	0.000	0.200
1.3.3.13 Shell Access	0.200	0.150	0.000	0.000	0.000
1.3.3.14 Search Path	0.200	0.000	0.000	0.000	0.000
1.3.3.15 Menu Definition	0.200	0.150	0.000	0.000	0.000
1.3.3.16 File Access	0.200	0.150	0.150	0.000	0.150
1.3.4 Defaults	1.000	0.500	0.250	0.500	0.250
1.4 User Assists	0.600	0.198	0.254	0.143	0.233
1.4.1 Prompting	0.400	0.100	0.200	0.200	0.100
1.4.2 On-Line Reference	0.200	0.100	0.100	0.000	0.150
1.4.3 Tutorials	0.200	0.000	0.000	0.000	0.100
1.4.4 UNDO Function	0.600	0.150	0.450	0.300	0.300
1.4.5 REDO Function	0.200	0.000	0.050	0.000	0.000
1.4.6 Abort Function	0.600	0.150	0.150	0.000	0.150
1.4.7 Interrupt Functions	0.400	0.200	0.200	0.300	0.100
1.4.8 Screen Dynamics	0.400	0.120	0.240	0.000	0.200
1.4.8.1 Rubber Banding	1.600	0.400	1.200	0.000	0.800
1.4.8.2 Dragging	1.600	0.800	0.800	0.000	1.200
1.4.8.3 X-Y Readout	0.800	0.000	0.400	0.000	0.000
1.4.9 Journaling	0.200	0.150	0.000	0.000	0.150
1.4.10 Calculator Entry	0.200	0.200	0.000	0.000	0.150
1.4.11 Graphic Feedback	0.600	0.150	0.300	0.150	0.150
1.5 Viewing/Display	1.200	0.557	0.275	0.459	0.665
1.5.1 Pan/Zoom	1.200	0.420	0.600	0.900	0.660
1.5.1.1 Basic Pan/Zoom	0.800	0.600	0.400	0.600	0.600
1.5.1.2 Dynamic Pan/Zoom	3.200	0.800	1.600	2.400	1.600
1.5.2 View Layout	1.000	0.650	0.000	0.000	0.600
1.5.2.1 Preset Layouts	0.800	0.600	0.000	0.000	0.000
1.5.2.2 User Defined Layouts	1.600	1.200	0.000	0.000	1.200
1.5.2.3 Name/Store/Recall	1.600	0.800	0.000	0.000	1.200
1.5.3 3D View Transformations	0.600	0.233	0.045	0.158	0.323
1.5.3.1 Preset Views	0.600	0.450	0.300	0.450	0.450
1.5.3.2 User Defined Views	0.800	0.600	0.000	0.600	0.600
1.5.3.3 Perspective Views	0.400	0.200	0.000	0.000	0.200
1.5.3.4 Depth Cueing	0.400	0.000	0.000	0.000	0.000
1.5.3.5 Dynamic Transforms	1.200	0.000	0.000	0.000	0.600
1.5.3.6 Z-Clipping	0.600	0.300	0.000	0.000	0.300

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.140	0.000	0.210	0.140	0.000	0.210	0.210
0.100	0.150	0.150	0.150	0.000	0.150	0.150
0.200	0.000	0.160	0.260	0.280	0.300	0.180
0.800	0.000	0.400	1.200	1.600	1.200	1.200
0.400	0.000	0.000	0.600	0.400	0.600	0.600
0.800	0.000	1.200	0.800	0.800	1.200	0.000
0.100	0.000	0.000	0.000	0.100	0.150	0.150
0.100	0.000	0.000	0.000	0.150	0.150	0.150
0.100	0.000	0.000	0.000	0.000	0.150	0.000
0.100	0.000	0.000	0.000	0.150	0.150	0.150
0.100	0.000	0.000	0.000	0.150	0.150	0.150
0.500	0.250	0.750	0.250	0.500	0.250	0.250
0.320	0.123	0.396	0.294	0.212	0.260	0.278
0.200	0.300	0.300	0.300	0.100	0.300	0.200
0.100	0.000	0.000	0.200	0.200	0.150	0.150
0.000	0.000	0.000	0.000	0.150	0.000	0.000
0.450	0.150	0.450	0.300	0.150	0.150	0.300
0.000	0.050	0.150	0.000	0.000	0.000	0.050
0.450	0.000	0.450	0.450	0.150	0.300	0.300
0.300	0.000	0.300	0.300	0.300	0.300	0.200
0.080	0.120	0.240	0.160	0.160	0.080	0.200
0.800	0.800	1.200	0.800	0.000	0.400	0.800
0.000	0.000	1.200	0.800	1.200	0.400	0.800
0.000	0.400	0.000	0.000	0.400	0.000	0.400
0.000	0.150	0.150	0.150	0.000	0.150	0.150
0.100	0.050	0.150	0.100	0.050	0.150	0.000
0.450	0.000	0.450	0.000	0.150	0.150	0.300
0.881	0.291	0.396	0.399	0.722	0.511	0.210
1.140	0.120	0.180	0.120	0.660	0.420	0.180
0.600	0.400	0.600	0.400	0.600	0.600	0.600
3.200	0.000	0.000	0.000	1.600	0.800	0.000
0.700	0.400	0.600	0.500	0.750	0.500	0.000
0.400	0.000	0.000	0.400	0.600	0.400	0.000
1.200	0.800	1.200	0.800	1.200	0.800	0.000
1.200	0.800	1.200	0.800	1.200	0.800	0.000
0.473	0.000	0.068	0.240	0.293	0.218	0.120
0.450	0.000	0.450	0.000	0.450	0.300	0.000
0.600	0.000	0.000	0.400	0.600	0.400	0.600
0.300	0.000	0.000	0.300	0.000	0.300	0.200
0.000	0.000	0.000	0.300	0.000	0.000	0.000
1.200	0.000	0.000	0.000	0.600	0.300	0.000
0.600	0.000	0.000	0.600	0.300	0.150	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
1.5.4 Display Characteristics	1.200	0.554	0.270	0.471	0.634
1.5.4.1 Blanking	1.600	0.780	0.280	0.480	0.800
1.5.4.1.1 By Item	0.600	0.450	0.000	0.450	0.450
1.5.4.1.2 By Layer	0.600	0.450	0.300	0.000	0.450
1.5.4.1.3 By Type	0.600	0.450	0.000	0.150	0.450
1.5.4.1.4 By Color	0.400	0.000	0.000	0.000	0.000
1.5.4.1.5 By View	0.600	0.000	0.000	0.000	0.450
1.5.4.1.6 By Nongraphic	0.400	0.000	0.000	0.000	0.000
1.5.4.1.7 Unblank	0.800	0.600	0.400	0.600	0.200
1.5.4.2 Display Attributes	1.600	0.967	0.621	0.790	1.315
1.5.4.2.1 Color	1.200	0.900	0.900	0.900	1.200
1.5.4.2.2 Line Style	0.800	0.600	0.600	0.600	0.800
1.5.4.2.3 Line Weight	0.800	0.400	0.000	0.400	0.600
1.5.4.2.4 Rendering	1.200	0.518	0.053	0.075	0.686
1.5.4.2.4.1 Mesh Display	1.000	0.550	0.175	0.250	0.675
1.5.4.2.4.1.1 Iso-Parametric	0.800	0.600	0.200	0.600	0.600
1.5.4.2.4.1.2 Contours	0.400	0.000	0.000	0.000	0.000
1.5.4.2.4.1.3 Silhouette	0.800	0.600	0.000	0.400	0.600
1.5.4.2.4.1.4 Hidden Lines Removed	1.000	0.500	0.500	0.000	0.750
1.5.4.2.4.1.5 Hidden Lines Styled	1.000	0.500	0.000	0.000	0.750
1.5.4.2.4.2 Shading Methods	1.000	0.125	0.000	0.000	0.613
1.5.4.2.4.2.1 Smooth	1.000	0.500	0.000	0.000	0.750
1.5.4.2.4.2.2 Flat	1.000	0.000	0.000	0.000	0.500
1.5.4.2.4.2.3 Anti-Aliased	0.400	0.000	0.000	0.000	0.000
1.5.4.2.4.2.4 With Curves	0.600	0.000	0.000	0.000	0.450
1.5.4.2.4.2.5 Save/Restore Image	1.000	0.000	0.000	0.000	0.750
1.5.4.2.4.3 Shading Parameters	1.000	0.600	0.000	0.000	0.625
1.5.4.2.4.3.1 Color	1.200	0.900	0.000	0.000	0.900
1.5.4.2.4.3.2 Specular Reflectance	1.000	0.750	0.000	0.000	0.750
1.5.4.2.4.3.3 Diffuse Reflectance	1.000	0.750	0.000	0.000	0.250
1.5.4.2.4.3.4 Transparency	0.800	0.000	0.000	0.000	0.600
1.5.4.2.4.4 Light Source Control	1.000	0.450	0.000	0.000	0.375
1.5.4.2.4.4.1 Multiple Sources	1.200	0.600	0.000	0.000	0.300
1.5.4.2.4.4.2 Brightness	0.400	0.000	0.000	0.000	0.000
1.5.4.2.4.4.3 Color	0.400	0.000	0.000	0.000	0.000
1.5.4.2.4.4.4 Direction	1.200	0.600	0.000	0.000	0.600
1.5.4.2.4.4.5 Ambient Brightness	0.800	0.600	0.000	0.000	0.600
1.5.4.3 Fast Display	0.800	0.100	0.000	0.300	0.000
1.5.4.3.1 Text	2.000	0.000	0.000	1.500	0.000
1.5.4.3.2 Curves	1.000	0.500	0.000	0.000	0.000
1.5.4.3.3 Subcomponent	1.000	0.000	0.000	0.000	0.000

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.623	0.450	0.471	0.468	0.703	0.564	0.399
0.660	0.340	0.660	0.600	0.700	0.900	0.420
0.450	0.000	0.450	0.450	0.000	0.450	0.000
0.600	0.450	0.450	0.000	0.600	0.450	0.450
0.000	0.000	0.450	0.000	0.300	0.450	0.000
0.000	0.000	0.300	0.000	0.200	0.000	0.000
0.000	0.000	0.000	0.450	0.450	0.300	0.000
0.000	0.000	0.000	0.200	0.200	0.200	0.000
0.600	0.400	0.000	0.400	0.000	0.400	0.600
1.118	0.760	0.760	0.962	1.043	0.981	0.909
1.200	0.900	0.900	0.900	0.900	0.600	0.900
0.400	0.400	0.600	0.600	0.600	0.600	0.600
0.400	0.600	0.400	0.000	0.600	0.600	0.600
0.795	0.000	0.000	0.904	0.506	0.653	0.173
0.850	0.000	0.000	0.725	0.525	0.600	0.125
0.600	0.000	0.000	0.800	0.600	0.600	0.000
0.000	0.000	0.000	0.000	0.000	0.300	0.000
0.800	0.000	0.000	0.600	0.000	0.000	0.000
1.000	0.000	0.000	0.750	0.750	0.750	0.250
1.000	0.000	0.000	0.750	0.750	0.750	0.250
0.675	0.000	0.000	0.713	0.563	0.675	0.125
0.250	0.000	0.000	0.750	0.750	0.750	0.000
1.000	0.000	0.000	0.750	0.750	0.750	0.500
0.000	0.000	0.000	0.300	0.000	0.000	0.000
0.450	0.000	0.000	0.300	0.000	0.450	0.000
1.000	0.000	0.000	0.750	0.750	0.750	0.000
0.575	0.000	0.000	0.750	0.150	0.375	0.150
0.900	0.000	0.000	0.900	0.600	0.900	0.600
0.500	0.000	0.000	0.750	0.000	0.000	0.000
0.500	0.000	0.000	0.750	0.000	0.000	0.000
0.400	0.000	0.000	0.600	0.000	0.600	0.000
0.550	0.000	0.000	0.825	0.450	0.525	0.175
0.300	0.000	0.000	1.200	0.300	0.900	0.000
0.200	0.000	0.000	0.300	0.000	0.300	0.200
0.200	0.000	0.000	0.300	0.000	0.000	0.000
0.900	0.000	0.000	0.900	0.900	0.900	0.300
0.600	0.000	0.000	0.600	0.600	0.000	0.200
0.300	0.400	0.150	0.000	0.600	0.000	0.000
1.500	1.500	0.000	0.000	1.500	0.000	0.000
0.000	0.500	0.750	0.000	0.750	0.000	0.000
0.000	0.000	0.000	0.000	0.750	0.000	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
2. Geometric Construction	1.000	0.332	0.228	0.350	0.421
2.1 2D Items	0.800	0.000	0.388	0.527	0.000
2.1.1 Points	0.400	0.000	0.300	0.400	0.000
2.1.2 Lines	1.400	0.000	0.667	1.178	0.000
2.1.2.1 Construction Lines	1.200	0.000	0.000	0.900	0.000
2.1.2.2 Line Segments	2.000	0.000	1.500	2.000	0.000
2.1.2.3 Polylines	0.400	0.000	0.300	0.400	0.000
2.1.2.4 Polygons	0.400	0.000	0.105	0.065	0.000
2.1.2.4.1 Triangles	0.600	0.000	0.000	0.150	0.000
2.1.2.4.2 Rectangles	2.000	0.000	0.000	0.500	0.000
2.1.2.4.3 Regular Polygons	1.400	0.000	1.050	0.000	0.000
2.1.3 Conics	1.400	0.000	0.875	0.595	0.000
2.1.3.1 Arcs	1.200	0.000	0.900	0.000	0.000
2.1.3.2 Circles	1.600	0.000	1.200	0.800	0.000
2.1.3.3 Ellipses	0.800	0.000	0.400	0.600	0.000
2.1.3.4 Rho Conics	0.400	0.000	0.000	0.300	0.000
2.1.4 Splines	0.800	0.000	0.100	0.460	0.000
2.1.4.1 Linear	0.400	0.000	0.000	0.300	0.000
2.1.4.2 Cubic	1.200	0.000	0.000	1.200	0.000
2.1.4.3 B-Splines	1.200	0.000	0.300	0.000	0.000
2.1.4.4 Composite	0.400	0.000	0.000	0.000	0.000
2.1.4.5 Offset	0.800	0.000	0.200	0.800	0.000
2.2 3D Items	1.200	0.666	0.077	0.278	0.769
2.2.1 Points	0.400	0.200	0.000	0.200	0.300
2.2.2 Curves	1.600	1.114	0.190	0.618	1.168
2.2.2.1 Lines	1.600	1.172	0.160	0.800	1.060
2.2.2.1.1 Construction Lines	1.200	0.900	0.000	0.600	0.600
2.2.2.1.2 Line Segments	1.600	1.200	0.400	0.800	1.600
2.2.2.1.3 Polylines	0.800	0.600	0.000	0.600	0.400
2.2.2.1.4 Polygons	0.400	0.230	0.000	0.000	0.050
2.2.2.1.4.1 Triangles	0.800	0.400	0.000	0.000	0.000
2.2.2.1.4.2 Rectangles	2.000	1.000	0.000	0.000	0.500
2.2.2.1.4.3 Regular Polygons	1.200	0.900	0.000	0.000	0.000
2.2.2.2 Conics	1.400	1.050	0.315	0.595	1.260
2.2.2.2.1 Arcs	1.200	0.900	0.300	0.000	1.200
2.2.2.2.2 Circles	1.600	1.200	0.400	0.800	1.200
2.2.2.2.3 Ellipses	0.800	0.600	0.200	0.600	0.800
2.2.2.2.4 Rho Conics	0.400	0.300	0.000	0.300	0.400
2.2.2.3 Splines	1.000	0.563	0.000	0.150	0.600
2.2.2.3.1 Linear	0.200	0.000	0.000	0.000	0.000
2.2.2.3.2 Cubic	0.800	0.600	0.000	0.600	0.400
2.2.2.3.3 B-Splines	1.200	0.900	0.000	0.000	1.200
2.2.2.3.4 Offset	0.600	0.450	0.000	0.000	0.600
2.2.2.3.5 Bezier	0.200	0.150	0.000	0.000	0.000
2.2.2.3.6 Polynomial	0.800	0.000	0.000	0.000	0.000
2.2.2.3.7 Composite	0.200	0.150	0.000	0.000	0.200

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.637	0.126	0.283	0.325	0.464	0.345	0.165
0.593	0.218	0.487	0.000	0.569	0.000	0.249
0.400	0.200	0.300	0.000	0.400	0.000	0.000
1.220	0.445	0.859	0.000	1.145	0.000	0.620
1.200	0.000	0.600	0.000	1.200	0.000	0.000
2.000	1.000	1.500	0.000	1.500	0.000	1.500
0.200	0.100	0.100	0.000	0.400	0.000	0.100
0.085	0.170	0.255	0.000	0.170	0.000	0.170
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.500	1.000	1.500	0.000	1.000	0.000	1.000
0.350	0.700	1.050	0.000	0.700	0.000	0.700
0.945	0.385	1.015	0.000	0.980	0.000	0.385
0.600	0.300	0.900	0.000	0.900	0.000	0.300
1.200	0.400	1.200	0.000	1.200	0.000	0.400
0.600	0.400	0.800	0.000	0.600	0.000	0.400
0.300	0.000	0.000	0.000	0.100	0.000	0.000
0.400	0.060	0.260	0.000	0.320	0.000	0.240
0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.200	0.300	0.000	0.000	0.900	0.000	0.600
0.000	0.000	0.900	0.000	0.000	0.000	0.600
0.400	0.000	0.000	0.000	0.300	0.000	0.000
0.400	0.000	0.400	0.000	0.400	0.000	0.000
0.914	0.000	0.000	0.540	0.576	0.599	0.044
0.300	0.000	0.000	0.300	0.300	0.200	0.100
1.282	0.000	0.000	0.791	1.015	0.755	0.000
1.280	0.000	0.000	1.040	1.144	0.560	0.000
1.200	0.000	0.000	0.600	0.900	0.000	0.000
1.600	0.000	0.000	1.200	1.200	1.200	0.000
0.400	0.000	0.000	0.800	0.600	0.000	0.000
0.000	0.000	0.000	0.000	0.160	0.200	0.000
0.000	0.000	0.000	0.000	0.000	0.400	0.000
0.000	0.000	0.000	0.000	1.000	1.000	0.000
0.000	0.000	0.000	0.000	0.600	0.600	0.000
1.050	0.000	0.000	0.525	0.980	0.840	0.000
0.900	0.000	0.000	0.300	0.900	0.600	0.000
1.200	0.000	0.000	1.200	1.200	1.200	0.000
0.600	0.000	0.000	0.000	0.600	0.400	0.000
0.300	0.000	0.000	0.000	0.100	0.200	0.000
0.875	0.000	0.000	0.413	0.413	0.488	0.000
0.200	0.000	0.000	0.000	0.000	0.000	0.000
0.800	0.000	0.000	0.000	0.000	0.000	0.000
0.900	0.000	0.000	0.900	1.200	0.600	0.000
0.450	0.000	0.000	0.600	0.450	0.450	0.000
0.150	0.000	0.000	0.000	0.000	0.150	0.000
0.800	0.000	0.000	0.000	0.000	0.600	0.000
0.200	0.000	0.000	0.150	0.000	0.150	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
2.2.3 Surfaces	0.800	0.388	0.066	0.108	0.418
2.2.3.1 Plane	0.400	0.200	0.200	0.000	0.300
2.2.3.2 Ruled	0.400	0.200	0.000	0.300	0.300
2.2.3.3 Extruded	0.360	0.360	0.090	0.000	0.270
2.2.3.4 Revolved	0.360	0.270	0.000	0.000	0.270
2.2.3.5 Curve Driven	0.120	0.090	0.000	0.000	0.120
2.2.3.6 B-Spline	0.320	0.160	0.000	0.000	0.240
2.2.3.7 Composite	0.160	0.080	0.000	0.000	0.000
2.2.3.8 Bicubic Patch	0.160	0.000	0.000	0.120	0.000
2.2.3.9 Coons Patch	0.160	0.080	0.000	0.120	0.000
2.2.3.10 Gordan Surface	0.120	0.000	0.000	0.000	0.000
2.2.3.11 Fillet	0.280	0.140	0.000	0.000	0.210
2.2.3.12 Blended	0.280	0.000	0.000	0.000	0.140
2.2.3.13 Offset	0.160	0.080	0.000	0.000	0.120
2.2.3.14 Tapered Fillet	0.160	0.000	0.000	0.000	0.120
2.2.3.15 Primitives	0.160	0.080	0.040	0.000	0.000
2.2.3.16 Lofted	0.280	0.140	0.000	0.000	0.000
2.2.3.17 Point Mesh	0.120	0.060	0.000	0.000	0.000
2.2.4 Solids	1.200	0.518	0.000	0.000	0.676
2.2.4.1 Primitives	1.000	0.250	0.000	0.000	0.663
2.2.4.1.1 Block	0.800	0.600	0.000	0.000	0.400
2.2.4.1.2 Cylinder	0.800	0.400	0.000	0.000	0.600
2.2.4.1.3 Cone	0.400	0.000	0.000	0.000	0.300
2.2.4.1.4 Sphere	0.400	0.000	0.000	0.000	0.300
2.2.4.1.5 Wedge	0.600	0.000	0.000	0.000	0.450
2.2.4.1.6 Torus	0.200	0.000	0.000	0.000	0.150
2.2.4.1.7 Truncated Cone	0.600	0.000	0.000	0.000	0.450
2.2.4.1.8 Pyramid	0.200	0.000	0.000	0.000	0.000
2.2.4.2 User Defined Solids	1.400	0.718	0.000	0.000	0.770
2.2.4.2.1 Extrusion	1.200	0.600	0.000	0.000	0.900
2.2.4.2.2 Sweep	1.200	0.900	0.000	0.000	0.900
2.2.4.2.3 Curve Driven	0.400	0.000	0.000	0.000	0.000
2.2.4.2.4 Surface Bounded	0.800	0.400	0.000	0.000	0.400
2.2.4.2.5 Offset Surface	0.200	0.150	0.000	0.000	0.000
2.2.4.2.6 Polyhedron	0.200	0.000	0.000	0.000	0.000
2.2.4.3 Solid Operations	1.600	0.760	0.000	0.000	0.820
2.2.4.3.1 Add	0.600	0.450	0.000	0.000	0.450
2.2.4.3.2 Subtract	0.600	0.450	0.000	0.000	0.450
2.2.4.3.3 Intersect	0.600	0.450	0.000	0.000	0.450
2.2.4.3.4 Exclusive Or	0.200	0.000	0.000	0.000	0.000
2.2.4.3.5 Section with Plane	0.200	0.000	0.000	0.000	0.000
2.2.4.3.6 Section with Surface	0.200	0.000	0.000	0.000	0.000
2.2.4.3.7 Multiple Booleans	0.800	0.400	0.000	0.000	0.400
2.2.4.3.8 Coplanar Face Handling	0.600	0.150	0.000	0.000	0.150
2.2.4.3.9 Clearance Checking	0.200	0.000	0.000	0.000	0.150

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.632	0.000	0.000	0.190	0.280	0.426	0.048
0.400	0.000	0.000	0.000	0.200	0.300	0.000
0.400	0.000	0.000	0.000	0.300	0.300	0.000
0.360	0.000	0.000	0.000	0.270	0.090	0.090
0.360	0.000	0.000	0.000	0.270	0.270	0.090
0.120	0.000	0.000	0.000	0.000	0.000	0.000
0.240	0.000	0.000	0.080	0.240	0.240	0.000
0.080	0.000	0.000	0.000	0.000	0.000	0.000
0.120	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.080	0.000
0.000	0.000	0.000	0.000	0.000	0.060	0.000
0.210	0.000	0.000	0.210	0.000	0.210	0.000
0.210	0.000	0.000	0.210	0.000	0.210	0.000
0.120	0.000	0.000	0.120	0.000	0.120	0.000
0.160	0.000	0.000	0.120	0.000	0.120	0.000
0.080	0.000	0.000	0.000	0.120	0.040	0.000
0.210	0.000	0.000	0.210	0.000	0.000	0.000
0.090	0.000	0.000	0.000	0.000	0.090	0.060
0.831	0.000	0.000	0.520	0.327	0.615	0.000
0.750	0.000	0.000	0.375	0.350	0.400	0.000
0.800	0.000	0.000	0.400	0.400	0.400	0.000
0.800	0.000	0.000	0.400	0.400	0.400	0.000
0.300	0.000	0.000	0.200	0.000	0.200	0.000
0.300	0.000	0.000	0.200	0.200	0.200	0.000
0.000	0.000	0.000	0.000	0.000	0.300	0.000
0.150	0.000	0.000	0.000	0.100	0.100	0.000
0.450	0.000	0.000	0.300	0.300	0.000	0.000
0.200	0.000	0.000	0.000	0.000	0.000	0.000
0.980	0.000	0.000	0.578	0.560	0.630	0.000
0.900	0.000	0.000	0.600	0.600	0.600	0.000
0.900	0.000	0.000	0.600	0.900	0.600	0.000
0.200	0.000	0.000	0.300	0.000	0.200	0.000
0.600	0.000	0.000	0.000	0.000	0.400	0.000
0.150	0.000	0.000	0.150	0.100	0.000	0.000
0.050	0.000	0.000	0.000	0.000	0.000	0.000
1.040	0.000	0.000	0.780	0.180	1.020	0.000
0.450	0.000	0.000	0.450	0.150	0.450	0.000
0.450	0.000	0.000	0.450	0.150	0.450	0.000
0.450	0.000	0.000	0.450	0.150	0.450	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.100	0.000	0.000	0.050	0.000	0.150	0.000
0.100	0.000	0.000	0.050	0.000	0.000	0.000
0.600	0.000	0.000	0.000	0.000	0.600	0.000
0.450	0.000	0.000	0.450	0.000	0.450	0.000
0.000	0.000	0.000	0.050	0.000	0.000	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
2.3 Item Editing	0.600	0.014	0.005	0.086	0.092
2.3.1 Change Item Geometry	1.600	0.096	0.032	0.576	0.376
2.3.1.1 Points	0.200	0.000	0.000	0.000	0.000
2.3.1.2 Curves	1.600	0.240	0.080	0.840	0.840
2.3.1.2.1 Lines	0.800	0.000	0.200	0.600	0.000
2.3.1.2.2 Conics	1.200	0.600	0.000	0.000	0.600
2.3.1.2.3 Splines	2.000	0.000	0.000	1.500	1.500
2.3.1.3 Surfaces	1.200	0.000	0.000	0.600	0.000
2.3.1.4 Solids	1.000	0.000	0.000	0.000	0.100
2.3.1.4.1 Primitives	1.000	0.000	0.000	0.000	0.000
2.3.1.4.2 User Defined Solids	1.400	0.000	0.000	0.000	0.000
2.3.1.4.3 Boolean Editing	1.600	0.000	0.000	0.000	0.400
2.3.2 Item Associativity	2.400	0.000	0.000	0.000	0.240
2.3.2.1 Moving Items	1.200	0.000	0.000	0.000	0.000
2.3.2.2 Editing Items	1.600	0.000	0.000	0.000	0.400
2.3.2.3 Relimiting Items	0.400	0.000	0.000	0.000	0.000
2.3.2.4 Point Constructions	0.400	0.000	0.000	0.000	0.000
2.3.2.5 Other Constructions	0.400	0.000	0.000	0.000	0.000
2.4 Item Manipulations	0.600	0.256	0.173	0.230	0.351
2.4.1 Grouping	2.000	0.678	0.793	0.934	1.200
2.4.1.1 Within Part	1.200	0.600	0.420	0.702	0.684
2.4.1.1.1 Features/Sets	2.800	1.400	1.400	2.100	2.100
2.4.1.1.2 Composites	1.200	0.600	0.000	0.240	0.180
2.4.1.1.2.1 Curves	1.600	0.800	0.000	0.000	0.000
2.4.1.1.2.2 Surfaces	1.600	0.800	0.000	0.800	0.000
2.4.1.1.2.3 Solids	0.800	0.400	0.000	0.000	0.600
2.4.1.2 Symbol/Part Library Items	2.800	0.756	1.166	1.166	1.715
2.4.1.2.1 Definition	0.800	0.360	0.390	0.160	0.480
2.4.1.2.1.1 2D Items	0.600	0.450	0.450	0.300	0.450
2.4.1.2.1.2 3D Items	1.000	0.750	0.500	0.500	0.750
2.4.1.2.1.3 Drawing Mode Items	0.400	0.000	0.000	0.000	0.300
2.4.1.2.1.4 Nongraphic Data	0.800	0.600	0.400	0.000	0.000
2.4.1.2.1.5 Nesting	0.800	0.000	0.600	0.000	0.600
2.4.1.2.1.6 Part Association	0.400	0.000	0.000	0.000	0.300
2.4.1.2.2 Retrieval	1.200	0.270	0.225	0.405	0.270
2.4.1.2.2.1 By name	1.200	0.900	0.600	0.900	0.900
2.4.1.2.2.2 From Displayed Items	0.800	0.000	0.000	0.000	0.000
2.4.1.2.2.3 From Item List	0.600	0.000	0.150	0.450	0.000
2.4.1.2.2.4 By Criteria	1.000	0.000	0.000	0.000	0.000
2.4.1.2.2.5 By Graphic Selection	0.400	0.000	0.000	0.000	0.000
2.4.1.2.3 Manipulations	2.000	0.450	1.050	1.100	1.700
2.4.1.2.3.1 Scaling	0.200	0.100	0.150	0.150	0.150
2.4.1.2.3.2 Orienting	0.400	0.100	0.200	0.300	0.400
2.4.1.2.3.3 Exploding	0.600	0.000	0.450	0.450	0.450
2.4.1.2.3.4 Updating	1.200	0.600	0.600	0.900	1.200

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.260	0.033	0.072	0.195	0.106	0.077	0.018
1.130	0.220	0.480	0.639	0.704	0.516	0.120
0.000	0.150	0.000	0.000	0.000	0.000	0.000
1.400	0.400	1.200	0.760	1.160	0.440	0.000
0.600	0.200	0.600	0.400	0.800	0.600	0.000
0.900	0.300	0.900	0.000	0.600	0.000	0.000
2.000	0.500	1.500	1.500	1.500	0.500	0.000
1.200	0.000	0.000	0.300	0.600	0.600	0.300
0.225	0.000	0.000	0.538	0.000	0.250	0.000
0.500	0.000	0.000	0.750	0.000	0.250	0.000
0.000	0.000	0.000	1.400	0.000	0.350	0.000
0.400	0.000	0.000	0.000	0.000	0.400	0.000
0.600	0.000	0.000	0.660	0.000	0.000	0.000
0.300	0.000	0.000	0.300	0.000	0.000	0.000
0.400	0.000	0.000	0.400	0.000	0.000	0.000
0.100	0.000	0.000	0.200	0.000	0.000	0.000
0.100	0.000	0.000	0.200	0.000	0.000	0.000
0.100	0.000	0.000	0.000	0.000	0.000	0.000
0.410	0.091	0.197	0.190	0.232	0.301	0.129
1.466	0.439	0.884	0.902	1.055	1.253	0.585
0.810	0.000	0.630	0.618	0.702	0.738	0.420
2.100	0.000	2.100	1.400	2.100	2.100	1.400
0.600	0.000	0.000	0.660	0.240	0.360	0.000
0.800	0.000	0.000	1.200	0.800	1.200	0.000
0.800	0.000	0.000	0.400	0.000	0.000	0.000
0.400	0.000	0.000	0.600	0.000	0.000	0.000
2.121	0.879	1.138	1.187	1.407	1.768	0.749
0.460	0.180	0.390	0.450	0.440	0.620	0.250
0.300	0.300	0.450	0.000	0.450	0.450	0.450
0.500	0.000	0.000	0.750	0.750	0.750	0.500
0.000	0.000	0.300	0.000	0.000	0.300	0.200
0.800	0.000	0.600	0.600	0.600	0.600	0.000
0.600	0.600	0.600	0.600	0.400	0.600	0.000
0.100	0.000	0.000	0.300	0.000	0.400	0.100
1.170	0.225	0.360	0.270	0.495	0.405	0.270
1.200	0.600	0.900	0.900	0.900	0.900	0.600
0.800	0.000	0.000	0.000	0.000	0.000	0.000
0.600	0.150	0.000	0.000	0.000	0.150	0.300
1.000	0.000	0.000	0.000	0.750	0.000	0.000
0.300	0.000	0.300	0.000	0.000	0.300	0.000
1.400	0.850	0.875	0.975	1.075	1.500	0.550
0.150	0.150	0.100	0.150	0.150	0.150	0.150
0.300	0.100	0.300	0.300	0.200	0.300	0.100
0.450	0.450	0.450	0.000	0.450	0.450	0.450
1.200	0.300	0.900	0.900	0.600	0.900	0.300

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
2.4.1.2.3.5 Subitem Access	0.800	0.000	0.600	0.400	0.600
2.4.1.2.3.6 Subitem Editing	0.600	0.000	0.000	0.000	0.450
2.4.1.2.3.7 Layer Control	0.200	0.100	0.100	0.000	0.150
2.4.2 Relimiting	1.200	0.647	0.360	0.428	0.713
2.4.2.1 Curves	2.000	1.425	1.200	1.425	1.575
2.4.2.1.1 Fillet	0.800	0.800	0.400	0.600	0.800
2.4.2.1.2 Chamfer	0.400	0.400	0.200	0.300	0.300
2.4.2.1.3 Trim Single	0.800	0.600	0.600	0.600	0.600
2.4.2.1.4 Extend	0.200	0.100	0.150	0.150	0.000
2.4.2.1.5 Corner	0.400	0.200	0.300	0.300	0.400
2.4.2.1.6 Break	0.600	0.300	0.300	0.300	0.600
2.4.2.1.7 Jog	0.200	0.000	0.000	0.150	0.000
2.4.2.1.8 Trim Multiple	0.600	0.450	0.450	0.450	0.450
2.4.2.2 Surfaces	1.600	0.640	0.000	0.000	0.800
2.4.2.2.1 Surface-to-Curve	1.600	0.800	0.000	0.000	1.200
2.4.2.2.2 Surface-to-Surface	0.800	0.400	0.000	0.000	0.400
2.4.2.2.3 Surface-to-Plane	0.800	0.400	0.000	0.000	0.400
2.4.2.2.4 Surface-to-Solid	0.800	0.000	0.000	0.000	0.000
2.4.2.3 Solids	0.400	0.090	0.000	0.000	0.000
2.4.2.3.1 Solid-to-Plane	1.600	0.000	0.000	0.000	0.000
2.4.2.3.2 Solid-to-Surface	1.200	0.000	0.000	0.000	0.000
2.4.2.3.3 Solid-to-Solid	1.200	0.900	0.000	0.000	0.000
2.4.3 Intersection Constructions	0.800	0.380	0.000	0.172	0.425
2.4.3.1 Points	0.800	0.600	0.000	0.510	0.300
2.4.3.1.1 Line with Plane	1.200	0.900	0.000	0.900	0.600
2.4.3.1.2 Curve with Plane	1.200	0.900	0.000	0.900	0.900
2.4.3.1.3 Line with Surface	1.000	0.750	0.000	0.750	0.000
2.4.3.1.4 Curve with Surface	0.600	0.450	0.000	0.000	0.000
2.4.3.2 Curves	2.000	1.000	0.000	0.350	1.375
2.4.3.2.1 Project Curve Onto Plane	0.400	0.300	0.000	0.200	0.300
2.4.3.2.2 Project Curve Onto Surface	0.400	0.300	0.000	0.200	0.300
2.4.3.2.3 Plane with Plane	0.400	0.300	0.000	0.000	0.300
2.4.3.2.4 Plane with Surface	0.400	0.300	0.000	0.300	0.300
2.4.3.2.5 Surface with Surface	0.400	0.200	0.000	0.000	0.300
2.4.3.2.6 Surface Definition	0.600	0.300	0.000	0.000	0.000
2.4.3.2.7 Solid Edges	0.600	0.300	0.000	0.000	0.450
2.4.3.2.8 Solid Section	0.800	0.000	0.000	0.000	0.800
2.4.3.3 Surfaces	1.200	0.300	0.000	0.000	0.450
2.4.3.3.1 Solid Definition	2.000	1.000	0.000	0.000	1.500
2.4.3.3.2 Solid with Plane	1.200	0.000	0.000	0.000	0.000
2.4.3.3.3 Solid with Surface	0.800	0.000	0.000	0.000	0.000
2.5 Transformations	0.400	0.205	0.150	0.175	0.250
2.5.1 Linear Move/Copy	0.600	0.450	0.300	0.300	0.450
2.5.2 Rotate	0.600	0.300	0.300	0.300	0.450

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.600	0.600	0.000	0.600	0.600	0.600	0.000
0.000	0.000	0.000	0.000	0.000	0.450	0.000
0.100	0.100	0.000	0.000	0.150	0.150	0.100
0.692	0.165	0.428	0.237	0.315	0.558	0.278
1.525	0.550	1.425	0.550	1.050	0.900	0.925
0.600	0.400	0.600	0.600	0.400	0.600	0.400
0.400	0.200	0.300	0.000	0.200	0.000	0.000
0.600	0.200	0.600	0.400	0.600	0.600	0.400
0.100	0.050	0.150	0.100	0.100	0.150	0.100
0.300	0.100	0.300	0.000	0.200	0.000	0.200
0.450	0.000	0.450	0.000	0.150	0.000	0.450
0.150	0.000	0.000	0.000	0.000	0.000	0.000
0.450	0.150	0.450	0.000	0.450	0.450	0.300
0.480	0.000	0.000	0.000	0.000	0.960	0.000
1.200	0.000	0.000	0.000	0.000	1.200	0.000
0.000	0.000	0.000	0.000	0.000	0.600	0.000
0.000	0.000	0.000	0.000	0.000	0.600	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.300	0.000	0.000	0.240	0.000	0.000	0.000
1.200	0.000	0.000	1.200	0.000	0.000	0.000
0.900	0.000	0.000	0.300	0.000	0.000	0.000
0.900	0.000	0.000	0.900	0.000	0.000	0.000
0.577	0.000	0.000	0.126	0.177	0.195	0.000
0.710	0.000	0.000	0.000	0.360	0.000	0.000
1.200	0.000	0.000	0.000	0.900	0.000	0.000
0.900	0.000	0.000	0.000	0.900	0.000	0.000
1.000	0.000	0.000	0.000	0.000	0.000	0.000
0.450	0.000	0.000	0.000	0.000	0.000	0.000
1.725	0.000	0.000	0.000	0.525	0.825	0.000
0.400	0.000	0.000	0.000	0.000	0.300	0.000
0.300	0.000	0.000	0.000	0.000	0.300	0.000
0.300	0.000	0.000	0.000	0.300	0.300	0.000
0.300	0.000	0.000	0.000	0.300	0.300	0.000
0.300	0.000	0.000	0.000	0.000	0.300	0.000
0.600	0.000	0.000	0.000	0.450	0.000	0.000
0.450	0.000	0.000	0.000	0.000	0.150	0.000
0.800	0.000	0.000	0.000	0.000	0.000	0.000
0.450	0.000	0.000	0.630	0.000	0.150	0.000
1.500	0.000	0.000	1.000	0.000	0.500	0.000
0.000	0.000	0.000	0.900	0.000	0.000	0.000
0.000	0.000	0.000	0.200	0.000	0.000	0.000
0.135	0.085	0.225	0.205	0.170	0.205	0.120
0.300	0.150	0.450	0.150	0.300	0.450	0.300
0.300	0.150	0.450	0.450	0.300	0.450	0.300

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
2.5.3 3D Orient	0.400	0.000	0.000	0.000	0.000
2.5.4 Mirror	0.400	0.200	0.200	0.300	0.300
2.5.5 Combination Transformations	0.400	0.000	0.000	0.000	0.300
2.5.6 Circular Move/Copy	0.200	0.150	0.000	0.000	0.000
2.5.7 Stretch	0.400	0.200	0.200	0.300	0.300
2.5.8 Rectangular Array	0.200	0.150	0.100	0.000	0.150
2.5.9 Circular Array	0.200	0.150	0.100	0.000	0.150
2.5.10 Scale	0.400	0.300	0.200	0.400	0.200
2.5.11 Project Wireframe	0.200	0.150	0.100	0.150	0.200
2.6 Construction Aids	0.400	0.187	0.120	0.104	0.221
2.6.1 Item Selection	1.600	0.633	0.496	0.479	0.789
2.6.1.1 Philosophy	0.200	0.030	0.050	0.090	0.030
2.6.1.1.1 Prefix	0.800	0.600	0.400	0.000	0.600
2.6.1.1.2 Postfix	0.800	0.000	0.000	0.000	0.000
2.6.1.1.3 Select List	2.400	0.000	0.600	1.800	0.000
2.6.1.2 Display	0.200	0.200	0.150	0.000	0.000
2.6.1.3 Granularity	1.200	0.342	0.441	0.387	0.873
2.6.1.3.1 Item Level	1.200	0.900	0.900	0.900	0.900
2.6.1.3.2 Subitems	2.400	0.000	0.270	0.390	1.710
2.6.1.3.2.1 Polylines	0.200	0.000	0.150	0.000	0.150
2.6.1.3.2.2 Grouped Items	0.800	0.000	0.000	0.000	0.600
2.6.1.3.2.3 Symbol/Part Library Items	0.400	0.000	0.300	0.200	0.300
2.6.1.3.2.4 Surfaces	0.600	0.000	0.000	0.450	0.300
2.6.1.3.2.5 Solid Primitives	0.600	0.000	0.000	0.000	0.450
2.6.1.3.2.6 User Defined Solids	0.600	0.000	0.000	0.000	0.450
2.6.1.3.2.7 Solid Composites	0.800	0.000	0.000	0.000	0.600
2.6.1.3.3 Pick Aperture	0.400	0.240	0.300	0.000	0.300
2.6.1.3.3.1 Control	1.600	1.200	1.200	0.000	1.200
2.6.1.3.3.2 Display	2.400	1.200	1.800	0.000	1.800
2.6.1.4 Methods	1.600	0.620	0.600	0.720	0.740
2.6.1.4.1 Single	0.800	0.600	0.600	0.800	0.600
2.6.1.4.2 In/Out Rectangle	0.600	0.450	0.300	0.300	0.450
2.6.1.4.3 In/Out Polygon	0.400	0.000	0.000	0.200	0.300
2.6.1.4.4 By Name	0.200	0.100	0.000	0.000	0.150
2.6.1.4.5 Chain	0.200	0.150	0.000	0.000	0.150
2.6.1.4.6 By Nongraphics	0.200	0.150	0.000	0.000	0.000
2.6.1.4.7 Toggle Select	0.600	0.000	0.300	0.300	0.000
2.6.1.4.8 Cycle Select	0.600	0.000	0.000	0.000	0.000
2.6.1.4.9 Unselect	0.400	0.100	0.300	0.200	0.200
2.6.1.5 Filtering/Masking	0.800	0.390	0.000	0.000	0.330
2.6.1.5.1 By Item Type	1.200	1.200	0.000	0.000	0.900
2.6.1.5.2 By Color	0.600	0.000	0.000	0.000	0.000
2.6.1.5.3 By Nongraphic	0.800	0.000	0.000	0.000	0.000
2.6.1.5.4 By Layer	1.000	0.750	0.000	0.000	0.750
2.6.1.5.5 By Area	0.200	0.000	0.000	0.000	0.000
2.6.1.5.6 By Size	0.200	0.000	0.000	0.000	0.000

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.000	0.000	0.000	0.300	0.300	0.000	0.000
0.300	0.100	0.300	0.200	0.200	0.300	0.200
0.300	0.000	0.300	0.300	0.000	0.100	0.000
0.000	0.000	0.000	0.050	0.000	0.150	0.000
0.000	0.200	0.100	0.200	0.000	0.200	0.000
0.000	0.050	0.150	0.000	0.100	0.150	0.100
0.000	0.000	0.150	0.000	0.100	0.150	0.100
0.000	0.200	0.300	0.400	0.400	0.100	0.200
0.150	0.000	0.050	0.000	0.000	0.000	0.000
0.235	0.077	0.152	0.171	0.205	0.197	0.099
0.754	0.386	0.702	0.579	0.636	0.734	0.482
0.090	0.020	0.030	0.050	0.090	0.080	0.050
0.000	0.400	0.600	0.400	0.000	0.200	0.000
0.000	0.000	0.000	0.000	0.000	0.200	0.400
1.800	0.000	0.000	0.600	1.800	1.200	0.600
0.000	0.150	0.150	0.150	0.000	0.200	0.100
0.675	0.324	0.414	0.648	0.549	0.495	0.405
0.900	0.900	0.900	0.900	0.900	0.900	0.900
1.350	0.060	0.360	1.140	0.750	0.630	0.450
0.000	0.000	0.000	0.150	0.100	0.000	0.150
0.000	0.000	0.600	0.400	0.400	0.600	0.600
0.300	0.100	0.000	0.300	0.300	0.300	0.000
0.450	0.000	0.000	0.150	0.450	0.150	0.000
0.450	0.000	0.000	0.450	0.000	0.000	0.000
0.450	0.000	0.000	0.450	0.000	0.000	0.000
0.600	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.120	0.120	0.120	0.180	0.120	0.000
0.000	1.200	1.200	1.200	0.000	1.200	0.000
0.000	0.000	0.000	0.000	1.800	0.000	0.000
0.840	0.360	0.660	0.600	0.780	0.760	0.460
0.600	0.600	0.600	0.600	0.400	0.600	0.400
0.300	0.150	0.450	0.450	0.450	0.150	0.150
0.300	0.000	0.000	0.300	0.300	0.100	0.100
0.150	0.000	0.000	0.150	0.000	0.150	0.050
0.100	0.000	0.100	0.000	0.000	0.150	0.000
0.150	0.000	0.000	0.000	0.000	0.150	0.050
0.300	0.000	0.300	0.000	0.150	0.300	0.300
0.000	0.150	0.000	0.000	0.450	0.000	0.000
0.200	0.000	0.200	0.000	0.200	0.300	0.100
0.280	0.110	0.500	0.000	0.170	0.300	0.190
0.600	0.300	0.900	0.000	0.000	0.900	0.300
0.300	0.000	0.450	0.000	0.000	0.000	0.150
0.000	0.000	0.400	0.000	0.000	0.000	0.200
0.250	0.250	0.750	0.000	0.750	0.500	0.250
0.100	0.000	0.000	0.000	0.000	0.000	0.050
0.150	0.000	0.000	0.000	0.100	0.100	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
2.6.2 Coordinate Systems	1.200	0.786	0.396	0.153	0.864
2.6.2.1 Units	0.400	0.170	0.070	0.270	0.210
2.6.2.1.1 Model Units	2.800	1.400	0.700	2.100	2.100
2.6.2.1.2 Local Reference	1.200	0.300	0.000	0.600	0.000
2.6.2.2 Types	0.800	0.350	0.410	0.240	0.570
2.6.2.2.1 Cartesian	1.600	1.200	1.200	1.200	1.200
2.6.2.2.2 Polar/Cylindrical	0.600	0.150	0.450	0.000	0.450
2.6.2.2.3 Spherical	0.200	0.000	0.000	0.000	0.000
2.6.2.2.4 Construct Planes	1.600	0.400	0.400	0.000	1.200
2.6.2.3 Access	2.800	2.100	0.840	0.000	2.100
2.6.2.3.1 Coordinate Entry	1.600	1.200	1.200	0.000	1.200
2.6.2.3.2 Verification Units	0.800	0.600	0.000	0.000	0.600
2.6.2.3.3 Store/Recall	1.600	1.200	0.000	0.000	1.200
2.6.3 Verification/Query	0.600	0.258	0.072	0.318	0.288
2.6.3.1 Item Data	0.800	0.600	0.000	0.600	0.600
2.6.3.2 Geometric Data	3.200	1.120	0.480	1.520	1.320
2.6.3.2.1 Location	0.200	0.150	0.150	0.150	0.150
2.6.3.2.2 Distance	0.200	0.100	0.150	0.150	0.150
2.6.3.2.3 Minimum Distance	0.400	0.200	0.000	0.300	0.200
2.6.3.2.4 Angle	0.200	0.100	0.050	0.150	0.150
2.6.3.2.5 Length	0.400	0.200	0.200	0.300	0.400
2.6.3.2.6 Curvature	0.400	0.000	0.000	0.000	0.400
2.6.3.2.7 Area	0.200	0.100	0.050	0.150	0.000
2.6.3.2.8 Perimeter	0.200	0.100	0.000	0.000	0.000
2.6.3.2.9 Surface Area	0.200	0.050	0.000	0.000	0.200
2.6.3.2.10 Centroid	0.400	0.100	0.000	0.400	0.000
2.6.3.2.11 Volume	0.400	0.100	0.000	0.100	0.000
2.6.3.2.12 Center of Gravity	0.400	0.100	0.000	0.100	0.000
2.6.3.2.13 Moments of Inertia	0.400	0.100	0.000	0.100	0.000
2.6.4 Grids	0.200	0.109	0.114	0.094	0.114
2.6.4.1 Types	2.000	1.050	1.150	0.600	1.050
2.6.4.1.1 Rectangular	1.600	1.200	1.200	1.200	1.200
2.6.4.1.2 Polar	0.800	0.000	0.000	0.000	0.600
2.6.4.1.3 Isometric	1.200	0.900	0.900	0.000	0.000
2.6.4.1.4 Angle Lock	0.400	0.000	0.200	0.000	0.300
2.6.4.2 Control	2.000	1.125	1.125	1.275	1.225
2.6.4.2.1 Origin	0.600	0.450	0.450	0.450	0.450
2.6.4.2.2 Display	1.200	0.900	0.900	0.900	0.900
2.6.4.2.3 3D Orientation	1.000	0.000	0.000	0.000	0.500
2.6.4.2.4 Spacing	1.200	0.900	0.900	1.200	0.600
2.6.5 Temporary Constructions	0.400	0.080	0.120	0.000	0.160
2.6.5.1 Points	1.600	0.800	1.200	0.000	0.800
2.6.5.2 Lines	0.400	0.000	0.000	0.000	0.000
2.6.5.3 Planes	0.800	0.000	0.000	0.000	0.400
2.6.5.4 Vectors	0.800	0.000	0.000	0.000	0.400
2.6.5.5 Coordinate Systems	0.400	0.000	0.000	0.000	0.000

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.864	0.162	0.372	0.495	0.900	0.522	0.162
0.210	0.210	0.070	0.210	0.300	0.300	0.210
2.100	2.100	0.700	2.100	2.100	2.100	2.100
0.000	0.000	0.000	0.000	0.900	0.900	0.000
0.570	0.330	0.330	0.600	0.600	0.600	0.330
1.200	1.200	1.200	1.200	1.200	1.200	1.200
0.450	0.450	0.450	0.450	0.450	0.450	0.450
0.000	0.000	0.000	0.150	0.150	0.150	0.000
1.200	0.000	0.000	1.200	1.200	1.200	0.000
2.100	0.000	0.840	0.840	2.100	0.840	0.000
1.200	0.000	1.200	1.200	1.200	1.200	0.000
0.600	0.000	0.000	0.000	0.600	0.000	0.000
1.200	0.000	0.000	0.000	1.200	0.000	0.000
0.504	0.072	0.186	0.366	0.306	0.384	0.186
0.800	0.200	0.600	0.800	0.200	0.600	0.600
2.560	0.280	0.640	1.640	1.840	1.960	0.640
0.150	0.000	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.200	0.150	0.150
0.400	0.000	0.000	0.000	0.300	0.300	0.200
0.150	0.050	0.150	0.150	0.150	0.150	0.100
0.300	0.100	0.200	0.100	0.100	0.300	0.100
0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.050	0.050	0.000	0.150	0.200	0.100	0.000
0.050	0.000	0.150	0.000	0.200	0.100	0.100
0.150	0.000	0.000	0.150	0.100	0.000	0.000
0.300	0.000	0.000	0.300	0.300	0.300	0.000
0.400	0.000	0.000	0.300	0.200	0.300	0.000
0.400	0.000	0.000	0.300	0.200	0.300	0.000
0.400	0.000	0.000	0.300	0.200	0.300	0.000
0.109	0.068	0.111	0.003	0.085	0.094	0.083
1.050	0.600	1.100	0.050	0.750	1.200	0.750
1.200	1.200	1.200	0.000	1.200	1.200	1.200
0.000	0.000	0.400	0.000	0.000	0.600	0.000
0.900	0.000	0.600	0.000	0.000	0.600	0.000
0.000	0.000	0.000	0.100	0.300	0.000	0.300
1.125	0.750	1.125	0.000	0.950	0.675	0.900
0.450	0.000	0.450	0.000	0.150	0.450	0.000
0.900	0.900	0.900	0.000	0.900	0.000	0.900
0.000	0.000	0.000	0.000	0.250	0.000	0.000
0.900	0.600	0.900	0.000	0.600	0.900	0.900
0.120	0.080	0.150	0.270	0.120	0.240	0.080
0.400	0.800	1.200	1.200	0.400	1.200	0.800
0.200	0.000	0.300	0.300	0.000	0.000	0.000
0.200	0.000	0.000	0.600	0.400	0.600	0.000
0.400	0.000	0.000	0.600	0.400	0.600	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
3. Drafting	1.200	0.620	0.296	0.388	0.755
3.1 Model/Drawing Association	1.000	0.533	0.000	0.203	0.590
3.1.1 View Functions	1.600	0.692	0.000	0.360	0.920
3.1.1.1 Independent Drawing Views	0.800	0.400	0.000	0.000	0.600
3.1.1.2 Dependent Drawing Views	2.000	1.050	0.000	0.000	1.500
3.1.1.2.1 Curve Access	1.600	1.200	0.000	0.000	1.200
3.1.1.2.2 Surface Edge Access	1.200	0.900	0.000	0.000	0.900
3.1.1.2.3 Solid Edge Access	1.200	0.000	0.000	0.000	0.900
3.1.1.3 Orienting	0.400	0.000	0.000	0.300	0.200
3.1.1.4 Standard Drafting Views	0.800	0.280	0.000	0.600	0.000
3.1.1.4.1 Orthographic	2.400	0.600	0.000	1.800	0.000
3.1.1.4.2 Isometric	1.600	0.800	0.000	1.200	0.000
3.1.2 Model Display Modification	1.200	0.932	0.000	0.000	0.990
3.1.2.1 Interactive	1.200	1.005	0.000	0.000	1.200
3.1.2.1.1 Line Styles	1.400	1.050	0.000	0.000	1.400
3.1.2.1.2 Trimming	1.200	0.900	0.000	0.000	1.200
3.1.2.1.3 Blanking	1.400	1.400	0.000	0.000	1.400
3.1.2.2 Automatic	2.800	2.100	0.000	0.000	2.100
3.1.2.2.1 Line Styles	1.400	1.050	0.000	0.000	1.050
3.1.2.2.2 Trimming	1.200	0.900	0.000	0.000	0.900
3.1.2.2.3 Blanking	1.400	1.050	0.000	0.000	1.050
3.1.3 Drawing Mode	1.200	0.510	0.000	0.450	0.450
3.1.3.1 Drawing Items	1.600	0.000	0.000	1.200	1.200
3.1.3.2 Drawing Sheets	0.400	0.200	0.000	0.300	0.300
3.1.3.3 Model-to-Drawing	1.000	0.750	0.000	0.000	0.000
3.1.3.4 Drawing-to-Model	1.000	0.750	0.000	0.000	0.000
3.2 Annotation	1.000	0.565	0.354	0.545	0.648
3.2.1 Line Styles	1.200	0.738	0.417	0.747	0.762
3.2.1.1 Standard Set	1.400	1.050	1.050	1.050	1.400
3.2.1.2 Section Lines	0.400	0.200	0.000	0.300	0.300
3.2.1.3 Centerlines	1.400	0.910	0.140	0.840	0.840
3.2.1.3.1 Linear	1.600	0.800	0.000	1.200	1.200
3.2.1.3.2 Radial	1.600	1.200	0.400	1.200	1.200
3.2.1.3.3 Circle Pattern	0.800	0.600	0.000	0.000	0.000
3.2.1.4 Break Lines	0.400	0.000	0.000	0.300	0.000
3.2.1.5 User Defined	0.400	0.300	0.200	0.000	0.000
3.2.2 Text	2.000	1.125	0.900	1.050	1.475
3.2.2.1 Multiple Line Notes	0.800	0.600	0.600	0.400	0.600
3.2.2.2 From a File	0.400	0.300	0.000	0.100	0.200
3.2.2.3 Editing	0.600	0.150	0.000	0.300	0.450
3.2.2.4 Math/Engineering Characters	0.200	0.050	0.100	0.150	0.150
3.2.2.5 International Characters	0.200	0.100	0.000	0.150	0.150
3.2.2.6 Font Support	0.400	0.300	0.300	0.200	0.400
3.2.2.7 Size	0.400	0.300	0.300	0.300	0.300

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.758	0.153	0.475	0.000	0.565	0.625	0.153
0.757	0.000	0.150	0.000	0.488	0.575	0.016
1.360	0.000	0.360	0.000	0.780	0.780	0.064
0.800	0.000	0.000	0.000	0.600	0.600	0.000
1.500	0.000	0.000	0.000	1.050	1.050	0.000
1.200	0.000	0.000	0.000	1.200	1.200	0.000
0.900	0.000	0.000	0.000	0.900	0.900	0.000
0.900	0.000	0.000	0.000	0.000	0.000	0.000
0.300	0.000	0.300	0.000	0.300	0.300	0.000
0.800	0.000	0.600	0.000	0.000	0.000	0.160
2.400	0.000	1.800	0.000	0.000	0.000	0.000
1.600	0.000	1.200	0.000	0.000	0.000	0.800
0.693	0.000	0.000	0.000	0.420	0.846	0.000
0.210	0.000	0.000	0.000	0.000	0.720	0.000
0.000	0.000	0.000	0.000	0.000	1.050	0.000
0.000	0.000	0.000	0.000	0.000	0.300	0.000
0.700	0.000	0.000	0.000	0.000	1.050	0.000
2.100	0.000	0.000	0.000	1.400	2.100	0.000
1.050	0.000	0.000	0.000	0.700	1.050	0.000
0.900	0.000	0.000	0.000	0.600	0.900	0.000
1.050	0.000	0.000	0.000	0.700	1.050	0.000
0.975	0.000	0.240	0.000	0.750	0.675	0.000
1.200	0.000	0.000	0.000	1.200	1.200	0.000
0.300	0.000	0.300	0.000	0.300	0.300	0.000
0.750	0.000	0.250	0.000	0.750	0.750	0.000
1.000	0.000	0.250	0.000	0.250	0.000	0.000
0.542	0.230	0.381	0.000	0.563	0.480	0.185
0.645	0.345	0.501	0.000	0.579	0.435	0.315
1.050	1.050	1.050	0.000	0.700	1.050	1.050
0.200	0.100	0.000	0.000	0.300	0.000	0.000
0.700	0.000	0.420	0.000	0.630	0.000	0.000
0.800	0.000	0.000	0.000	1.200	0.000	0.000
0.800	0.000	1.200	0.000	0.400	0.000	0.000
0.400	0.000	0.000	0.000	0.200	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.200	0.000	0.200	0.000	0.300	0.400	0.000
1.225	0.525	0.625	0.000	1.275	1.150	0.425
0.400	0.400	0.200	0.000	0.400	0.600	0.200
0.200	0.000	0.300	0.000	0.300	0.000	0.000
0.150	0.150	0.150	0.000	0.300	0.450	0.150
0.150	0.050	0.000	0.000	0.100	0.050	0.000
0.200	0.050	0.000	0.000	0.000	0.050	0.000
0.400	0.200	0.000	0.000	0.400	0.200	0.000
0.400	0.200	0.300	0.000	0.300	0.300	0.300

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
3.2.2.8 Justification	0.400	0.200	0.200	0.300	0.300
3.2.2.9 Along Curves	0.200	0.150	0.000	0.000	0.100
3.2.2.10 Fitting	0.200	0.100	0.150	0.200	0.150
3.2.2.11 Nodes	0.200	0.000	0.150	0.000	0.150
3.2.3 Special Items	0.800	0.396	0.100	0.384	0.354
3.2.3.1 Labels	1.000	0.750	0.500	0.750	0.750
3.2.3.2 Bubbles	0.600	0.450	0.000	0.450	0.000
3.2.3.3 Datum Targets	0.200	0.150	0.000	0.000	0.000
3.2.3.4 Flags	0.400	0.000	0.000	0.000	0.300
3.2.3.5 Weld Symbols	0.400	0.000	0.000	0.000	0.000
3.2.3.6 Surface Finish Symbols	0.200	0.150	0.000	0.000	0.000
3.2.3.7 Feature Control Symbols	1.200	0.480	0.000	0.720	0.720
3.2.3.7.1 Creation	1.600	0.800	0.000	1.200	1.200
3.2.3.7.2 Editing	1.600	0.800	0.000	1.200	1.200
3.2.3.7.3 Intelligence	0.800	0.000	0.000	0.000	0.000
3.3 Dimensions	1.200	0.734	0.489	0.492	0.774
3.3.1 Types	0.800	0.540	0.470	0.500	0.420
3.3.1.1 Horizontal	0.600	0.450	0.450	0.450	0.450
3.3.1.2 Vertical	0.600	0.450	0.450	0.300	0.450
3.3.1.3 Parallel	0.600	0.450	0.450	0.450	0.450
3.3.1.4 Radial	0.400	0.300	0.200	0.200	0.300
3.3.1.5 Angular	0.600	0.450	0.300	0.300	0.150
3.3.1.6 Diameter	0.400	0.300	0.200	0.200	0.300
3.3.1.7 Projected	0.400	0.300	0.300	0.300	0.000
3.3.1.8 Curve Length	0.400	0.000	0.000	0.300	0.000
3.3.2 Styles	0.600	0.362	0.212	0.231	0.450
3.3.2.1 Point-to-Point	1.000	0.750	0.750	0.750	0.750
3.3.2.2 Baseline	0.400	0.300	0.300	0.000	0.300
3.3.2.3 Chain	0.400	0.300	0.200	0.000	0.300
3.3.2.4 Dual	0.800	0.360	0.160	0.240	0.600
3.3.2.4.1 Position	2.400	1.800	0.000	1.200	1.800
3.3.2.4.2 Bracket	1.600	0.000	0.800	0.000	1.200
3.3.2.5 Basic	0.400	0.300	0.000	0.000	0.300
3.3.2.6 Not-to-Scale	0.200	0.000	0.000	0.150	0.150
3.3.2.7 Datum	0.800	0.400	0.000	0.400	0.600
3.3.3 Text Control	0.200	0.135	0.120	0.150	0.150
3.3.3.1 Units	1.200	0.600	0.300	0.900	0.900
3.3.3.2 Decimals	1.400	1.050	1.050	1.050	1.050
3.3.3.3 Text Size	1.400	1.050	1.050	1.050	1.050
3.3.4 Tolerance	0.400	0.210	0.210	0.140	0.270
3.3.4.1 Limit	1.400	1.050	1.050	0.700	1.050
3.3.4.2 Plus-Minus	1.400	1.050	1.050	0.700	1.050
3.3.4.3 Coded	0.400	0.000	0.000	0.000	0.000
3.3.4.4 Stackup/Analysis	0.800	0.000	0.000	0.000	0.600

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.400	0.000	0.300	0.000	0.300	0.300	0.200
0.000	0.000	0.000	0.000	0.150	0.100	0.000
0.000	0.000	0.000	0.000	0.150	0.150	0.000
0.150	0.000	0.000	0.000	0.150	0.100	0.000
0.296	0.050	0.396	0.000	0.396	0.336	0.000
1.000	0.250	0.750	0.000	0.750	0.750	0.000
0.000	0.000	0.450	0.000	0.600	0.450	0.000
0.000	0.000	0.150	0.000	0.150	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.150	0.000	0.000	0.000	0.000
0.480	0.000	0.480	0.000	0.480	0.480	0.000
1.600	0.000	1.600	0.000	1.600	0.800	0.000
0.000	0.000	0.000	0.000	0.000	0.800	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.733	0.188	0.696	0.000	0.603	0.656	0.209
0.530	0.240	0.640	0.000	0.540	0.540	0.250
0.450	0.300	0.600	0.000	0.450	0.450	0.300
0.450	0.300	0.600	0.000	0.450	0.450	0.300
0.450	0.300	0.600	0.000	0.450	0.450	0.300
0.200	0.000	0.400	0.000	0.300	0.300	0.000
0.300	0.300	0.600	0.000	0.150	0.450	0.150
0.200	0.000	0.400	0.000	0.300	0.300	0.000
0.300	0.000	0.000	0.000	0.300	0.300	0.200
0.300	0.000	0.000	0.000	0.300	0.000	0.000
0.465	0.165	0.384	0.000	0.329	0.420	0.188
1.000	0.500	0.750	0.000	0.750	0.750	0.750
0.300	0.300	0.200	0.000	0.300	0.300	0.300
0.300	0.300	0.200	0.000	0.300	0.100	0.200
0.600	0.000	0.360	0.000	0.240	0.600	0.000
1.800	0.000	1.800	0.000	1.200	1.800	0.000
1.200	0.000	0.000	0.000	0.000	1.200	0.000
0.300	0.000	0.400	0.000	0.000	0.300	0.000
0.000	0.000	0.050	0.000	0.000	0.150	0.000
0.600	0.000	0.600	0.000	0.600	0.600	0.000
0.138	0.133	0.150	0.000	0.105	0.150	0.088
0.300	0.900	0.900	0.000	0.000	0.900	0.000
1.050	1.050	1.050	0.000	1.050	1.050	0.700
1.400	0.700	1.050	0.000	1.050	1.050	1.050
0.175	0.000	0.210	0.000	0.210	0.210	0.000
0.700	0.000	1.050	0.000	1.050	1.050	0.000
1.050	0.000	1.050	0.000	1.050	1.050	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
3.3.5 Editing	0.600	0.303	0.231	0.285	0.315
3.3.5.1 Break/Edit	0.800	0.000	0.400	0.000	0.000
3.3.5.2 Style	0.400	0.300	0.100	0.000	0.300
3.3.5.3 Text Location	1.600	1.200	0.400	1.200	1.200
3.3.5.4 Dimension Points	0.400	0.000	0.300	0.200	0.000
3.3.5.5 Text	0.800	0.520	0.340	0.500	0.600
3.3.5.5.1 Units	0.800	0.400	0.600	0.400	0.600
3.3.5.5.2 Tolerance	0.800	0.400	0.200	0.000	0.600
3.3.5.5.3 Values	1.200	0.900	0.900	0.900	0.900
3.3.5.5.4 Text Addition	1.200	0.900	0.000	1.200	0.900
3.3.6 Standards	0.600	0.518	0.308	0.225	0.450
3.3.6.1 ANSI	1.800	1.800	1.350	0.450	1.350
3.3.6.2 ISO	1.400	1.050	0.700	1.050	1.050
3.3.6.3 JIS	0.800	0.600	0.000	0.000	0.600
3.3.7 Regeneration	0.600	0.210	0.000	0.060	0.375
3.3.7.1 Automatic Dimensioning	0.400	0.000	0.000	0.000	0.100
3.3.7.2 Automatic Edit of Dimension	0.800	0.600	0.000	0.400	0.600
3.3.7.3 Automatic Edit of Geometry	0.800	0.400	0.000	0.000	0.600
3.3.7.4 Automatic Update w/Part Change	0.800	0.400	0.000	0.000	0.600
3.3.7.5 Disassociate	0.600	0.000	0.000	0.000	0.450
3.3.7.6 Deleted Items	0.600	0.000	0.000	0.000	0.150
3.3.8 Appearance Control	0.200	0.170	0.080	0.050	0.150
3.3.8.1 Arrowheads	1.600	1.600	0.800	0.400	1.200
3.3.8.2 Extension Lines	1.600	1.200	0.800	0.400	1.200
3.3.8.3 Dimension Lines	0.800	0.600	0.000	0.200	0.600
3.4 Crosshatching	0.400	0.134	0.144	0.054	0.204
3.4.1 Boundary Specification	1.600	0.560	0.840	0.280	0.840
3.4.1.1 Curve Selection Methods	1.400	0.700	1.050	0.350	1.050
3.4.1.2 Island Specification	1.400	0.700	1.050	0.350	1.050
3.4.1.3 Intersecting Boundaries	1.200	0.000	0.000	0.000	0.000
3.4.2 Patterns	0.800	0.540	0.600	0.264	0.600
3.4.2.1 Line Fill	1.600	1.200	1.200	1.200	1.200
3.4.2.2 Standard Patterns	0.800	0.600	0.600	0.000	0.600
3.4.2.3 User Defined Patterns	0.400	0.000	0.300	0.000	0.300
3.4.2.4 Pattern Control	1.200	0.900	0.900	0.120	0.900
3.4.2.4.1 Size	0.800	0.600	0.600	0.000	0.600
3.4.2.4.2 Spacing	1.600	1.200	1.200	0.000	1.200
3.4.2.4.3 Angle	1.600	1.200	1.200	0.400	1.200
3.4.3 Editing	1.600	0.240	0.000	0.000	0.600
3.4.3.1 Association	2.000	0.000	0.000	0.000	1.500
3.4.3.2 New Boundary	0.600	0.000	0.000	0.000	0.000
3.4.3.3 New Fill Pattern	0.800	0.600	0.000	0.000	0.000
3.4.3.4 Explode Pattern	0.600	0.000	0.000	0.000	0.000

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.372	0.030	0.375	0.000	0.225	0.453	0.000
0.000	0.200	0.200	0.000	0.000	0.800	0.000
0.300	0.000	0.300	0.000	0.000	0.300	0.000
1.600	0.000	1.200	0.000	1.200	1.200	0.000
0.200	0.000	0.200	0.000	0.300	0.300	0.000
0.380	0.000	0.600	0.000	0.000	0.420	0.000
0.000	0.000	0.600	0.000	0.000	0.000	0.000
0.400	0.000	0.600	0.000	0.000	0.600	0.000
0.600	0.000	0.900	0.000	0.000	0.900	0.000
0.900	0.000	0.900	0.000	0.000	0.600	0.000
0.240	0.000	0.285	0.000	0.360	0.285	0.120
0.900	0.000	1.350	0.000	1.350	1.350	0.450
0.700	0.000	0.350	0.000	1.050	0.350	0.350
0.000	0.000	0.200	0.000	0.000	0.200	0.000
0.413	0.000	0.188	0.000	0.090	0.000	0.000
0.200	0.000	0.100	0.000	0.000	0.000	0.000
0.600	0.000	0.600	0.000	0.600	0.000	0.000
0.600	0.000	0.400	0.000	0.000	0.000	0.000
0.600	0.000	0.000	0.000	0.000	0.000	0.000
0.450	0.000	0.150	0.000	0.000	0.000	0.000
0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.110	0.060	0.090	0.000	0.150	0.130	0.050
0.400	0.400	0.000	0.000	1.200	0.800	0.400
1.200	0.800	1.200	0.000	1.200	1.200	0.400
0.600	0.000	0.600	0.000	0.600	0.600	0.200
0.196	0.092	0.177	0.000	0.112	0.152	0.102
1.200	0.400	1.200	0.000	0.560	1.200	0.680
1.050	0.350	1.050	0.000	0.700	1.050	0.700
1.050	0.350	1.050	0.000	0.700	1.050	0.700
0.900	0.300	0.900	0.000	0.000	0.900	0.300
0.600	0.516	0.392	0.000	0.564	0.324	0.340
1.200	1.200	0.800	0.000	1.200	0.800	0.800
0.600	0.600	0.600	0.000	0.600	0.000	0.000
0.300	0.300	0.200	0.000	0.300	0.100	0.300
0.900	0.480	0.360	0.000	0.720	0.720	0.600
0.600	0.400	0.000	0.000	0.400	0.000	0.400
1.200	0.000	1.200	0.000	0.800	1.200	0.800
1.200	1.200	0.000	0.000	1.200	1.200	0.800
0.160	0.000	0.180	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.400	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.450	0.000	0.000	0.000	0.000

Feature	*Maximum**	Anvil	AutoCAD	CADAM	CADDs
3.5 Detail Magnification Area	0.400	0.100	0.000	0.000	0.300
3.5.1 Specification	0.800	0.600	0.000	0.000	0.600
3.5.2 Dimensioning	1.600	0.400	0.000	0.000	1.200
3.5.3 Associativity	1.600	0.000	0.000	0.000	1.200

* Maximum score attainable for each feature.

CATIA	Generic	Geodraw	Geomod	IGDS	Prism	VersaCAD
0.300	0.000	0.180	0.000	0.120	0.220	0.000
0.600	0.000	0.600	0.000	0.400	0.200	0.000
1.200	0.000	1.200	0.000	0.800	1.200	0.000
1.200	0.000	0.000	0.000	0.000	0.800	0.000

Feature	*Maximum**	CADDs	Geomod	IGDS	Prism
4. Finite Element Modeling	0.400	0.243	0.244	0.187	0.193
4.1 Initialization	0.200	0.150	0.100	0.100	0.060
4.1.1 Save/Restore FEM Parameters	1.600	1.200	0.800	0.800	0.000
4.1.2 Save/Restore Defaults	0.800	0.600	0.400	0.400	0.400
4.1.3 Save/Restore Models	1.600	1.200	0.800	0.800	0.800
4.2 Node Specification	0.800	0.580	0.600	0.340	0.560
4.2.1 Coordinate Systems	0.600	0.300	0.450	0.450	0.450
4.2.2 Coordinate Entry	0.400	0.200	0.300	0.300	0.300
4.2.3 Geometric Locations	0.800	0.800	0.600	0.200	0.400
4.2.4 Automatic Specification	0.800	0.200	0.600	0.200	0.600
4.2.5 Automatic Numbering	0.800	0.800	0.600	0.400	0.600
4.2.6 Coincident Node Removal	0.600	0.600	0.450	0.150	0.450
4.3 Elements	0.600	0.387	0.292	0.280	0.279
4.3.1 Types	1.200	0.900	0.765	0.648	0.720
4.3.1.1 1D Elements	0.800	0.600	0.590	0.450	0.260
4.3.1.1.1 Mass	0.400	0.300	0.300	0.300	0.000
4.3.1.1.2 Rod	0.400	0.300	0.300	0.300	0.300
4.3.1.1.3 Bar	0.400	0.300	0.300	0.300	0.000
4.3.1.1.4 2-Node Beam	0.400	0.300	0.300	0.300	0.200
4.3.1.1.5 3-Node Beam	0.200	0.150	0.200	0.150	0.100
4.3.1.1.6 Tube	0.200	0.150	0.150	0.150	0.000
4.3.1.1.7 Pipe	0.200	0.150	0.150	0.000	0.100
4.3.1.1.8 4-Node Bend	0.200	0.150	0.150	0.150	0.100
4.3.1.1.9 3-Node Quadratic	0.200	0.150	0.150	0.000	0.100
4.3.1.1.10 4-Node Cubic	0.200	0.150	0.150	0.000	0.100
4.3.1.1.11 Spring	0.400	0.300	0.400	0.300	0.200
4.3.1.1.12 Damper	0.400	0.300	0.400	0.300	0.000
4.3.1.1.13 User Defined	0.400	0.300	0.000	0.000	0.100
4.3.1.2 2D Elements	2.400	1.800	1.620	1.440	1.740
4.3.1.2.1 Linear Triangle	1.200	0.900	0.900	0.900	0.900
4.3.1.2.2 Parabolic Triangle	0.400	0.300	0.300	0.300	0.300
4.3.1.2.3 Cubic Triangle	0.200	0.150	0.150	0.000	0.150
4.3.1.2.4 Linear Quadrilateral	1.200	0.900	0.900	0.900	0.900
4.3.1.2.5 Quadratic Quadrilateral	0.400	0.300	0.300	0.300	0.300
4.3.1.2.6 Cubic Quadrilateral	0.200	0.150	0.150	0.000	0.150
4.3.1.2.7 User Defined	0.400	0.300	0.000	0.000	0.200
4.3.1.3 3D Elements	0.800	0.600	0.340	0.270	0.400
4.3.1.3.1 Tetrahedron	0.400	0.300	0.200	0.300	0.300
4.3.1.3.2 Pyramid	0.400	0.300	0.000	0.300	0.000
4.3.1.3.3 Linear Wedge	0.400	0.300	0.300	0.300	0.300
4.3.1.3.4 Parabolic Wedge	0.400	0.300	0.300	0.000	0.300
4.3.1.3.5 Cubic Wedge	0.200	0.150	0.150	0.000	0.150
4.3.1.3.6 Linear Brick	0.200	0.150	0.150	0.150	0.150
4.3.1.3.7 Quadratic Brick	0.200	0.150	0.150	0.150	0.150
4.3.1.3.8 Cubic Brick	0.200	0.150	0.150	0.150	0.150
4.3.1.3.9 Axisymmetric Conical Shell	0.400	0.300	0.000	0.000	0.000
4.3.1.3.10 Axisymmetric Triangular Ring	0.200	0.150	0.000	0.000	0.000

* Maximum score attainable for each feature.

Feature	*Maximum**	CADDs	Geomod	IGDS	Prism
4.3.1.3.11 Axisymmetric Trapezoidal Ring	0.200	0.150	0.000	0.000	0.000
4.3.1.3.12 Rigid Body	0.400	0.300	0.300	0.000	0.300
4.3.1.3.13 User Defined	0.400	0.300	0.000	0.000	0.200
4.3.2 Mesh Specification	2.800	1.683	1.183	1.218	1.142
4.3.2.1 Interactive	0.520	0.390	0.000	0.000	0.390
4.3.2.2 Node Selection	0.160	0.120	0.000	0.000	0.120
4.3.2.3 Automatic 1D Elements on Curve	0.160	0.120	0.000	0.120	0.120
4.3.2.4 Automatic Region	0.360	0.360	0.000	0.180	0.090
4.3.2.5 Automatic Region with Holes	0.160	0.040	0.040	0.040	0.000
4.3.2.6 Automatic 2D Nodes on Surface	0.360	0.270	0.270	0.090	0.270
4.3.2.7 Extrusion of 2D Nodes to 3D	0.160	0.080	0.120	0.080	0.000
4.3.2.8 Automatic 3D Nodes in Solid	0.560	0.420	0.420	0.000	0.000
4.3.2.9 Copy	0.360	0.180	0.270	0.360	0.270
4.3.2.10 Mirror	0.160	0.080	0.120	0.160	0.120
4.3.2.11 Rotate	0.160	0.080	0.120	0.160	0.120
4.3.2.12 Transition Region	0.440	0.000	0.000	0.330	0.000
4.3.2.13 Merge Other Meshes	0.440	0.264	0.330	0.220	0.132
4.3.2.13.1 Auto-Remove Coincident Nodes	1.600	1.200	1.200	0.800	1.200
4.3.2.13.2 Automatic Renumbering	2.400	1.200	1.800	1.200	0.000
4.4 Loading	0.200	0.160	0.143	0.123	0.030
4.4.1 Forces & Moments	0.600	0.600	0.450	0.300	0.150
4.4.2 Constraints & Displacements	0.400	0.300	0.300	0.200	0.100
4.4.3 Temperature	0.200	0.150	0.150	0.100	0.100
4.4.4 Pressure	0.400	0.300	0.300	0.300	0.100
4.4.5 Rotations	0.600	0.450	0.450	0.450	0.150
4.4.6 Temperature Gradients	0.200	0.150	0.000	0.150	0.000
4.4.7 Copy	0.400	0.200	0.300	0.200	0.000
4.4.8 Symbolic Assignment	0.600	0.450	0.450	0.450	0.000
4.4.9 Function Definition	0.600	0.600	0.450	0.300	0.000
4.5 Constraints	0.200	0.100	0.150	0.100	0.015
4.5.1 Single Point	1.200	0.600	0.900	0.600	0.300
4.5.2 Sets	2.800	1.400	2.100	1.400	0.000
4.6 Material Specification	0.200	0.100	0.090	0.100	0.060
4.6.1 Symbolic References	1.600	0.800	0.000	0.800	0.800
4.6.2 Library Storage	1.600	0.800	1.200	0.800	0.400
4.6.3 User Attributes	0.800	0.400	0.600	0.400	0.000
4.7 Editing	0.600	0.398	0.270	0.183	0.263
4.7.1 Model Change Association	0.800	0.000	0.000	0.000	0.000
4.7.2 FEM Operation Association	0.800	0.400	0.000	0.200	0.000
4.7.3 Nodes	1.200	1.125	0.900	0.600	0.855
4.7.3.1 Move	1.200	1.200	0.900	0.600	0.900
4.7.3.2 Delete	0.600	0.600	0.450	0.300	0.300
4.7.3.3 Copy	1.200	1.200	0.900	0.600	0.900
4.7.3.4 Associated Data	1.000	0.750	0.750	0.500	0.750

* Maximum score attainable for each feature.

Feature	*Maximum**	CADDs	Geomod	IGDS	Prism
4.7.4 Elements	1.200	1.125	0.900	0.420	0.900
4.7.4.1 Move	1.200	1.200	0.900	0.600	0.900
4.7.4.2 Delete	0.600	0.600	0.450	0.300	0.450
4.7.4.3 Copy	1.200	1.200	0.900	0.000	0.900
4.7.4.4 Associated Data	1.000	0.750	0.750	0.500	0.750
4.8 Verification	0.400	0.200	0.300	0.260	0.225
4.8.1 Coincidence	1.000	0.750	0.750	0.500	0.750
4.8.2 Aspect	0.200	0.000	0.150	0.000	0.000
4.8.3 Free Edges	1.000	0.500	0.750	0.750	0.750
4.8.4 Interior Angles	0.200	0.000	0.150	0.150	0.000
4.8.5 Element Warp	0.600	0.000	0.450	0.450	0.000
4.8.6 Element Shrink	1.000	0.750	0.750	0.750	0.750
4.9 Output	0.200	0.100	0.083	0.060	0.093
4.9.1 Generic Format	0.600	0.300	0.450	0.000	0.450
4.9.2 ANSYS	0.600	0.300	0.450	0.300	0.450
4.9.3 NASTRAN	0.800	0.400	0.600	0.400	0.600
4.9.4 NASTRAX	0.200	0.100	0.000	0.100	0.000
4.9.5 SUPERB	0.200	0.100	0.150	0.100	0.150
4.9.6 STRUDL	0.400	0.200	0.000	0.000	0.000
4.9.7 SAP5	0.400	0.200	0.000	0.000	0.200
4.9.8 COSMOS	0.200	0.100	0.000	0.000	0.000
4.9.9 PREP7	0.200	0.100	0.000	0.100	0.000
4.9.10 COSMIC	0.400	0.200	0.000	0.200	0.000
4.10 Display Control	0.200	0.130	0.130	0.100	0.100
4.10.1 Node Numbers	0.800	0.600	0.600	0.400	0.400
4.10.2 Element Numbers	0.800	0.600	0.600	0.400	0.400
4.10.3 Element Colors	0.800	0.400	0.400	0.400	0.400
4.10.4 Material Numbers	0.800	0.600	0.400	0.400	0.400
4.10.5 Highlighting	0.800	0.400	0.600	0.400	0.400
4.11 Results Display	0.200	0.128	0.135	0.070	0.090
4.11.1 Static	0.800	0.400	0.600	0.400	0.400
4.11.2 Dynamic	0.200	0.150	0.000	0.100	0.000
4.11.3 Wireframe Displacement	0.400	0.300	0.300	0.200	0.200
4.11.4 Color	0.600	0.300	0.450	0.150	0.300
4.11.5 Shading	0.200	0.150	0.150	0.000	0.100
4.11.6 Contour	0.800	0.600	0.600	0.400	0.400
4.11.7 Value	0.400	0.200	0.300	0.000	0.200
4.11.8 Tabular	0.400	0.300	0.300	0.000	0.200
4.11.9 Animation	0.200	0.150	0.000	0.150	0.000
4.12 Mass Properties	0.200	0.000	0.150	0.150	0.150

* Maximum score attainable for each feature.

Feature	*Maximum**	Anvil	CADAM	CADDs	CATIA	IGDS
5. Data Management	0.400	0.064	0.058	0.171	0.163	0.134
5.1 System Management	0.800	0.120	0.195	0.188	0.335	0.250
5.1.1 Customization	1.000	0.000	0.088	0.150	0.088	0.750
5.1.1.1 Data Structures	1.400	0.000	0.350	0.000	0.350	1.050
5.1.1.2 User Interface	1.400	0.000	0.000	0.000	0.000	1.050
5.1.1.3 Release Procedures	1.200	0.000	0.000	0.600	0.000	0.900
5.1.2 User Data	1.000	0.150	0.350	0.400	0.675	0.150
5.1.2.1 Name	0.800	0.600	0.600	0.600	0.600	0.200
5.1.2.2 Hierarchy	0.800	0.000	0.000	0.200	0.600	0.200
5.1.2.3 Passwords	0.800	0.000	0.200	0.600	0.600	0.200
5.1.2.4 Account Numbers	0.800	0.000	0.600	0.000	0.600	0.000
5.1.2.5 Description	0.400	0.000	0.000	0.200	0.300	0.000
5.1.2.6 User Defined Data	0.400	0.000	0.000	0.000	0.000	0.000
5.1.3 User Create/Modify Privileges	1.000	0.000	0.050	0.050	0.425	0.050
5.1.3.1 User Create/Modify	0.800	0.000	0.200	0.200	0.600	0.200
5.1.3.2 Groups	0.800	0.000	0.000	0.000	0.000	0.000
5.1.3.3 Nongraphic Attributes	0.400	0.000	0.000	0.000	0.300	0.000
5.1.3.4 Models	0.800	0.000	0.000	0.000	0.200	0.000
5.1.3.5 Projects	0.400	0.000	0.000	0.000	0.300	0.000
5.1.3.6 Libraries	0.400	0.000	0.000	0.000	0.300	0.000
5.1.3.7 Privilege Grouping	0.400	0.000	0.000	0.000	0.000	0.000
5.1.4 Data Controlled	1.000	0.450	0.488	0.338	0.488	0.300
5.1.4.1 Models	1.200	0.900	0.300	0.900	0.300	0.900
5.1.4.2 Libraries	1.200	0.900	0.900	0.000	0.900	0.000
5.1.4.3 Projects	1.000	0.000	0.750	0.000	0.750	0.000
5.1.4.4 External Data	0.600	0.000	0.000	0.450	0.000	0.300
5.2 Nongraphic Data	0.800	0.105	0.120	0.405	0.464	0.357
5.2.1 Data Stored	1.400	0.525	0.280	0.945	1.085	0.735
5.2.1.1 Name	0.800	0.600	0.200	0.600	0.600	0.000
5.2.1.2 Layer	1.200	0.900	0.000	0.900	0.900	0.900
5.2.1.3 User Defined	2.000	0.000	0.600	1.200	1.600	1.200
5.2.1.3.1 Numeric	1.200	0.000	0.600	0.900	0.900	0.900
5.2.1.3.2 String	1.200	0.000	0.600	0.900	0.900	0.900
5.2.1.3.3 Discrete	0.800	0.000	0.000	0.600	0.600	0.000
5.2.1.3.4 Attribute Grouping	0.800	0.000	0.000	0.000	0.800	0.600
5.2.2 Reporting	1.400	0.000	0.140	0.630	0.875	1.050
5.2.2.1 Query Language	1.200	0.000	0.000	0.900	0.000	0.900
5.2.2.2 Query Functions	1.600	0.000	0.400	0.000	1.600	1.200
5.2.2.3 Program Access	1.200	0.000	0.000	0.900	0.900	0.900
5.2.3 Modification	1.200	0.000	0.180	0.450	0.360	0.000
5.2.3.1 Interactive	1.200	0.000	0.600	0.900	0.900	0.000
5.2.3.2 Batch	0.800	0.000	0.000	0.600	0.000	0.000
5.2.3.3 Security Control	1.200	0.000	0.000	0.000	0.300	0.000
5.2.3.4 Program Access	0.800	0.000	0.000	0.000	0.000	0.000

* Maximum score attainable for each feature.

Feature	*Maximum**	Anvil	CADAM	CADDs	CATIA	IGDS
5.3 Part Management	1.000	0.171	0.217	0.559	0.393	0.285
5.3.1 Data Stored	1.000	0.203	0.193	0.663	0.388	0.150
5.3.1.1 Identification Data	1.600	0.360	0.680	1.120	1.280	0.360
5.3.1.1.1 Names	1.200	0.900	0.900	0.900	0.900	0.600
5.3.1.1.2 Project	1.200	0.000	0.600	0.900	0.900	0.300
5.3.1.1.3 Classification	0.800	0.000	0.000	0.600	0.600	0.000
5.3.1.1.4 User Defined	0.800	0.000	0.200	0.400	0.800	0.000
5.3.1.2 Revision Data	2.400	0.450	0.090	1.530	0.270	0.240
5.3.1.2.1 Version	0.800	0.600	0.000	0.600	0.000	0.400
5.3.1.2.2 Status	0.600	0.150	0.150	0.450	0.000	0.000
5.3.1.2.3 History	0.600	0.000	0.000	0.450	0.000	0.000
5.3.1.2.4 Comments	0.600	0.000	0.000	0.450	0.450	0.000
5.3.1.2.5 Notification Lists	0.400	0.000	0.000	0.300	0.000	0.000
5.3.1.2.6 Sign-Off Lists	0.400	0.000	0.000	0.300	0.000	0.000
5.3.1.2.7 User Defined Data	0.600	0.000	0.000	0.000	0.000	0.000
5.3.2 Access Security	1.200	0.390	0.270	0.720	0.870	0.720
5.3.2.1 User Name	1.200	0.900	0.900	0.900	0.900	0.900
5.3.2.2 Group	0.800	0.400	0.000	0.600	0.600	0.600
5.3.2.3 Password	0.800	0.000	0.000	0.000	0.800	0.000
5.3.2.4 Multiple User	1.200	0.000	0.000	0.900	0.600	0.900
5.3.3 Functions	1.800	0.090	0.405	0.855	0.315	0.270
5.3.3.1 Check In/Out	0.800	0.000	0.000	0.600	0.000	0.000
5.3.3.2 Status Check	0.400	0.100	0.100	0.000	0.000	0.000
5.3.3.3 Revision Review	0.800	0.000	0.000	0.200	0.000	0.000
5.3.3.4 Sign-Off	0.400	0.100	0.100	0.200	0.000	0.000
5.3.3.5 Archive	0.800	0.000	0.600	0.600	0.600	0.600
5.3.3.6 Locate	0.400	0.000	0.100	0.000	0.100	0.000
5.3.3.7 ECO Generation	0.400	0.000	0.000	0.300	0.000	0.000
5.4 Report Generation	0.600	0.045	0.045	0.105	0.315	0.150
5.4.1 In Process	0.600	0.000	0.000	0.000	0.000	0.000
5.4.2 Accounting	0.800	0.300	0.300	0.000	0.200	0.100
5.4.2.1 User	1.000	0.500	0.750	0.000	0.500	0.500
5.4.2.2 Group	1.000	0.500	0.000	0.000	0.500	0.000
5.4.2.3 Model	1.000	0.500	0.750	0.000	0.000	0.000
5.4.2.4 Project	1.000	0.000	0.000	0.000	0.000	0.000
5.4.3 Bills of Material (BOM)	1.000	0.000	0.000	0.500	1.000	0.500
5.4.4 Where Used	0.800	0.000	0.000	0.000	0.600	0.400
5.4.5 User Query	0.400	0.000	0.000	0.000	0.300	0.000
5.4.6 ECO Tracking	0.400	0.000	0.000	0.200	0.000	0.000

* Maximum score attainable for each feature.

Feature	*Maximum**	Anvil	CADAM	CADDs	CATIA	IGDS
5.5 Data Transfer/Communications	0.800	0.200	0.000	0.455	0.120	0.300
5.5.1 Model Translation	2.000	1.000	0.000	1.375	0.600	1.500
5.5.1.1 IGES IN	1.400	1.050	0.000	1.050	0.700	1.050
5.5.1.2 IGES OUT	1.000	0.750	0.000	0.500	0.500	0.750
5.5.1.3 Generic IN	0.800	0.200	0.000	0.600	0.000	0.600
5.5.1.4 Generic OUT	0.800	0.000	0.000	0.600	0.000	0.600
5.5.2 Intermachine Transfer	1.200	0.000	0.000	0.300	0.000	0.000
5.5.3 User Notification	0.800	0.000	0.000	0.600	0.000	0.000

* Maximum score attainable for each feature.

Appendix C: Glossary

1. User Interface
The user interface is the means by which users interact with the system or program. It is the method used to tell the system or program what it is to do.

1.1 Screen Layout
A screen layout is the composition of information on a graphics screen.

1.1.1 Monitors
Monitors are devices that display the output of a program.

1.1.2 Graphic Windows
Graphic windows are rectangular areas on the screen of a monitor in which graphics can be displayed.

1.1.2.1 Multiple Windows
A system has multiple windowing capability if it can run programs or tasks in more than one window on the same screen and system at one time.

1.1.2.2 Shell Access
Shell access is the ability to access operating system commands from a program. An example is the ability to execute file manipulations while still in a program.

1.1.2.3 Modification
Graphic window modification is the ability to alter size and location of a window.

1.1.3 On-Screen Modes
On-screen modes are interactions between the user and a program that take place using the monitor as opposed to some other device, for example, a tablet.

1.1.3.1 Icons
Icons are pictures, appearing on the screen, that represent functions or files.

1.1.3.2 Text Based
Text based commands appear as words or abbreviations on the screen.

1.1.3.3 Pop-Up Windows
Pop-up windows contain menus. These windows appear at the current location of the cursor on the screen.

1.1.3.4 Pull-Down Menus
Pull-down menus are activated by selecting or positioning the cursor over an appropriate position on the screen banner. The banner runs horizontally along the top of the screen.

1.1.3.5 Forms
Forms are formatted rectangular areas on a screen. Users can enter keyboard data on the form that appears on the screen. A form reflects the context of the function being executed.

1.1.3.6 Dialog Boxes
Dialog boxes are similar to forms but normally only require a yes or no response to a question asked by a program.

1.1.3.7 Status Areas
Status areas are portions of the screen that are used to display program feedback or remarks and major program settings. For example, if a part is being drawn using inches, the word INCH may appear in a status area on the screen.

1.2 Interactive Modes
Interactive modes are techniques available to communicate commands and data to a program and receive feedback.

1.2.1 Commands
Command mode interaction requires that words or abbreviations be typed on the keyboard to execute program functions.

1.2.2 Tablet
A tablet is an input device that provides coordinate information to a program by sensing the position of a pen, stylus or puck. The coordinate information may provide the program with a position, command, data, etc.

1.2.3 On-Screen Menus
On-screen menus are lists of commands on the screen that may be selected to execute a program function.

1.2.4 Function Keys
Function keys or buttons are either on the keyboard or another device. When a function key is pressed a program function is executed.

1.2.5 Stroke Recognition
Stroke recognition is a command input technique that uses a freehand writing mode. The shape of the stroke determines the specific function a program executes.

1.2.6 Voice Recognition
Voice recognition is a command input technique that uses a speech recognition hardware unit and special software. The program is trained to recognize a voice pattern that represents a specific function.

1.2.7 Mouse Buttons
Mouse buttons are used in combination with the position of the cursor to enter commands or select items. The cursor is controlled by the position of the mouse.

1.2.8 Graphic Feedback
Graphic feedback is the use of graphics on the screen to assist in command input.

1.2.9 Responsiveness
Responsiveness is a measure of interaction speed of a program with a user.

1.3 Customization
Customization facilities allow a user to tailor a program to meet specific needs of a company or operator.

1.3.1 Screen Appearance
The appearance of the screen may be modified by a user.

1.3.2 Menus
Menus may be modified by a user.

1.3.2.1 Location
The location of menus may be modified by a user.

1.3.2.2 Icons
Icons may be created, added, deleted or modified by a user.

1.3.2.3 Text
Displayed command text may be modified by a user.

1.3.2.4 Pop-Up Menus
Pop-up menus may be modified by a user.

1.3.2.5 Pull-Down Menus
Pull-Down Menus may be modified by a user.

1.3.2.6 Forms
Forms may be modified by a user.

1.3.2.7 Cell Programming
Cell programming allows more than just a single function to be stored under an icon, pop-up or pull-down menu selection, or text command. It allows a string of functions to be executed with a single cell selection.

1.3.2.8 Key Programming
Key programming allows one or more than function to be stored under a function or keyboard key. It allows a string of functions to be executed with a single keystroke.

1.3.2.9 Tablet Programming
Tablet programming allows one or more functions to be stored under a square area on the tablet. It allows a string of functions to be executed with a single tablet selection.

1.3.2.10 Message/Prompt Modifications
Messages and prompts may be modified by a user.

1.3.3 Macros/User Programming
Macros are a collection of functions that are strung together and executed using a single command. User programming may be added to macros to allow for user input, conditional operations, prompting, etc. A macro language and a user programming language may be separate languages or they may be combined in one language.

1.3.3.1 ASCII
Macros and/or programs are defined by keying in a text or character form of a function.

1.3.3.2 Graphic Entry
Macros and/or programs are defined by selecting functions from the graphic user interface.

1.3.3.3 Keystroke Replay
Macros can be created by capturing keystrokes as they are entered. These keystrokes can then be executed as a macro.

1.3.3.4 Comments
Comments are statements included in the body of a macro or program that explain the function of the macro or program, but do not effect execution. Comments also explain steps being taken as a program is executed.

1.3.3.5 Looping
Looping capabilities permit sections of a macro or program to be executed a number of times.

1.3.3.6 Conditional Execution
Conditional execution commands permit sections of a macro or program to be executed only when specified conditions are met.

1.3.3.7 Prompting
Prompting permits display of messages during program or macro execution.

1.3.3.8 Character Data Entry
Character data can be input by a user from a keyboard during program or macro execution.

1.3.3.9 Graphic Data Entry
Graphic data can be input by a user from a screen during program or macro execution.

1.3.3.10 Interrupt
An interrupt pauses the execution of a macro or program.

1.3.3.11 Calculations
Arithmetic calculations may be executed in a macro or program.

1.3.3.11.1 Numeric
Numeric calculations may be executed in a macro or program.

1.3.3.11.2 String
String functions are available in the macro or programming language.

1.3.3.11.3 Geometric
Geometric calculations are available in the macro or programming language.

1.3.3.12 Subroutines
Subroutines are programming structures that allow sections of a macro or program to be reused. They only have to be defined one time, but can be called many times from any program or macro.

1.3.3.13 Shell Access
Shell access functions allow incorporating shell or operating system commands in a macro or program.

1.3.3.14 Search Path
A search path function allows a macro or program to search for a file on the system. The file may be in a directory that is not the current directory. A user can direct the macro or program to the file located on the system.

1.3.3.15 Menu Definition
Menu definition allows a user to construct menus for use in programs or macros.

1.3.3.16 File Access
File access functions in a program allow information on the system to be created, saved or retrieved while the user is running the program or macro.

1.3.4 Defaults
Defaults are values that are set when a program starts or a new file is created. Users may establish their own defaults. For example, the default diameter or a circle may be set to 1 when the program starts. The user may want circles of diameter equal to 0.75. The program may or may not save the last default circle diameter used.

1.4 User Assists
User assists are various aids that make a program easier to use.

1.4.1 Prompting
Prompts are messages that tell the user the next step in executing a program function. They may also be messages issued by the program when the user makes an error.

1.4.2 On-Line Reference
On-line reference is a function description available to the user during program execution. The information is displayed on the screen and references the function currently being used.

1.4.3 Tutorials
Tutorials are programmed instruction sessions available to teach a user to operate the functions available in a program.

1.4.4 UNDO Function
The UNDO function undoes the last function issued.

1.4.5 REDO Function
The REDO function redoes the last UNDO function.

1.4.6 Abort Function
An Abort function stops a program while it is executing.

1.4.7 Interrupt Functions
Interrupt functions are commonly used to stop a function during execution.

1.4.8 Screen Dynamics
Screen dynamics are special functions in a program that produce dynamic viewing of items as they are being created or moved.

1.4.8.1 Rubber Banding
Rubber banding is a line extending from the last point created to the current position of the cursor on the screen. For example, if a line is going to be created, the first point is defined. A line from the first point then follows the

cursor around the screen as it is moved until a second point is defined. Rubber banding may be used for more than just creating lines.

1.4.8.2 Dragging
Items may be dragged around on the screen. An item attaches to the cursor and follows the cursor as it moves on the screen.

1.4.8.3 X-Y Readout
As the cursor moves around on the screen a readout appears on the screen. This readout gives the x and y coordinate of the current position of the cursor in the current units display.

1.4.9 Journaling
Journaling is the ability to record a string of functions.

1.4.10 Calculator Entry
Calculator entry permits the use of arithmetic functions in a command line. For example, if a radius of half of 0.375 is required, the user enters 0.375/2. The program calculates the radius as 0.1875.

1.4.11 Graphic Feedback
Graphic feedback uses graphics on the screen to help clarify the results of a function before it is executed.

1.5 Viewing/Display
Viewing and display functions determine how a part is presented to the user in an area of the screen.

1.5.1 Pan/Zoom
The pan function determines the center of the viewing area on the screen. Zoom functions determine the magnification of items in a view.

1.5.1.1 Basic Pan/Zoom
Zoom functions permit user input of zoom scales and user defined rectangular windows to create zoomed views. These functions zoom views in or out. The pan function moves items in a view, but does not change the zoom scale. These functions effect the view in one step or motion.

1.5.1.2 Dynamic Pan/Zoom
Panning and zooming occurs dynamically or continuously until the preferred view is obtained.

1.5.2 View Layout
View layout is the organization of views on a screen. For example, a view layout may consist of the front, top and right side view of a part.

1.5.2.1 Preset Layouts
Preset layouts are view layouts that are already defined by the program. These are generally standard view layouts.

1.5.2.2 User Defined Layouts
The user may modify or replace the preset layout or create additional layouts.

1.5.2.3 Name/Store/Recall
User defined layouts can be named, stored and recalled.

1.5.3 3D View Transformations
3D view transformations extend pan and zoom to 3D by including rotations, depth and perspective.

1.5.3.1 Preset Views
Preset views are views that are already defined by the program. These are generally standard view such as right, top and front views.

1.5.3.2 User Defined Views
User defined views are views that a user defines. These are views looking at a part from other than the normal standard viewing angles or at a user specified zoom scale.

1.5.3.3 Perspective Views
Perspective views are defined by an eye point and a vanishing point and result in a realistic display of 3D geometry.

1.5.3.4 Depth Cueing
Depth cueing controls the display intensity of parts or items as a function of their distance behind the screen.

1.5.3.5 Dynamic Transforms
Dynamic transforms enable continuous changing of viewing parameters such as rotation, scale and center.

1.5.3.6 Z-Clipping
Z-clipping eliminates the display of items or parts that fall behind a specified depth plane.

1.5.4 Display Characteristics
Display characteristics of items control the appearance of geometry on the screen and are determined by their display attributes.

1.5.4.1 Blanking
Blanking allows items or sets of items to be removed from display while remaining in the data base.

1.5.4.1.1 By Item
Items may be blanked by selecting individually or in a group or set.

1.5.4.1.2 By Layer
Items may be blanked by layer.

1.5.4.1.3 By Type
Items may be blanked by item type, for example, points.

1.5.4.1.4 By Color
Items may be blanked by color.

1.5.4.1.5 By View
Items may be blanked in a selected view while remaining visible in other views.

1.5.4.1.6 By Nongraphic
Nongraphic information associated with items may be used to control blanking, for example, blank all items tagged with the identifier "plastic."

1.5.4.1.7 Unblank
Items may be redisplayed or unblanked by the same means as they were blanked.

1.5.4.2 Display Attributes
Display attributes are display characteristics that can be assigned to items.

1.5.4.2.1 Color
Items may be displayed in a specified color.

1.5.4.2.2 Line Style
Lines or curves can be solid or dashed or other standard combinations of line segments.

1.5.4.2.3 Line Weight
Lines or curves can have different thickness or line weights.

1.5.4.2.4 Rendering
Renderings are display modes for surfaces and solids that result in a shaded color display.

1.5.4.2.4.1 Mesh Display
Mesh display renderings show edge lines and curves and other defining lines and curves.

1.5.4.2.4.1.1 Iso-Parametric
Iso-parametric mesh display shows surfaces with curves of constant parameters.

1.5.4.2.4.1.2 Contours
Contours are curves resulting from an item, such as a surface, being intersected by a plane.

1.5.4.2.4.1.3 Silhouette
Silhouettes are the outer edges of a surface or solid. Curves from objects behind other objects may be visible.

1.5.4.2.4.1.4 Hidden Lines Removed
A view with hidden lines removed shows only the boundary representation of a surface or solid.

1.5.4.2.4.1.5 Hidden Lines Styled
A view with hidden lines styled shows the boundary representation of a surface or solid with hidden lines as dashes.

1.5.4.2.4.2 Shading Methods
Shading methods determine the technique used to render a surface or solid.

1.5.4.2.4.2.1 Smooth
A smooth surface display is varied according to an approximation scheme between discrete points on the surface, such as Fong and Gareau surfaces.

1.5.4.2.4.2.2 Flat
Each surface facet is filled with a constant color.

1.5.4.2.4.2.3 Anti-Aliased
An anti-aliased surface display is an averaging scheme to smooth jagged edges.

1.5.4.2.4.2.4 With Curves
A surface display with curves shows natural boundaries and silhouettes in addition to shading.

1.5.4.2.4.2.5 Save/Restore Image
Saving and restoring of rendered images is permitted.

1.5.4.2.4.3 Shading Parameters
Shading parameters control variables effecting the way surfaces and solids are rendered.

1.5.4.2.4.3.1 Color
A color shading parameter controls the color of rendered surfaces and solids.

1.5.4.2.4.3.2 Specular Reflectance
The specular reflectance shading parameter controls rendering which makes surfaces or solids appear to have a hard, shiny texture. The texture is caused by light rays bouncing off the surface or solid such that the incident angle and reflective angle are equal.

1.5.4.2.4.3.3 Diffuse Reflectance
The diffuse reflectance shading parameter controls rendering which makes surfaces or solids appear to have a rough texture. Texture is caused by light rays bouncing off the surface or solid in a random or scattered manner.

1.5.4.2.4.3.4 Transparency
The transparency shading parameter controls rendering which determines the percentage of light passing through a surface or solid.

1.5.4.2.4.4 Light Source Control
Light source control features allow the apparent illumination source or sources shining on surfaces or solids to be modified.

1.5.4.2.4.4.1 Multiple Sources
Multiple light sources allow surfaces or solids to be rendered simulating light originating from more than one light source.

1.5.4.2.4.4.2 Brightness
Light source brightness controls the relative intensity of light coming from various light sources.

1.5.4.2.4.4.3 Color
Light source color simulates light sources emitting light at only selected wavelengths.

1.5.4.2.4.4.4 Direction
Light source direction controls the orientation of light sources such that light is apparently coming from different locations in space.

1.5.4.2.4.4.5 Ambient Brightness
Ambient brightness controls the background lighting used when rendering surfaces and solids.

1.5.4.3 Fast Display
Fast display allows various item types to be graphically represented in simple forms. This speeds up redrawing them on the screen.

1.5.4.3.1 Text
Fast text is displayed in a simplified form such as a box or two parallel lines. This greatly reduces the time required to draw text on the screen.

1.5.4.3.2 Curves
Curves are displayed in a simplified form using polylines. These polylines approximate the actual curve. Fewer line segments in a polyline generally display faster.

1.5.4.3.3 Subcomponent
Drawing of library items or other groups of items by approximating them with a surrounding rectangle or polygon greatly reduces the time required to draw a subcomponent on the screen.

2. Geometric Construction
This section includes functions required to create and modify geometry.

2.1 2D Items
The following 2D geometry items are planar points and curves. A line is also considered a curve.

2.1.1 Points
A 2D point is a geometric item. It is defined by an x and y coordinate.

2.1.2 Lines
A 2D line is a straight wireframe curve. Geometrically, a line is the set of points (x,y) that satisfy the linear equation $ax + by + c = 0$, where a and b are not both zero.

2.1.2.1 Construction Lines
A construction line is a line with no endpoints. It stretches infinitely in one or both directions.

2.1.2.2 Line Segments
A line segment has two finite endpoints.

2.1.2.3 Polylines
A polyline is made up of several line segments connected end to end. A polyline is treated as a single item.

2.1.2.4 Polygons
A polygon is a closed series of line segments.

2.1.2.4.1 Triangles
A triangle is a closed plane figure formed by connecting three points with line segments. The three points are not in a straight line.

2.1.2.4.2 Rectangles
A rectangle is a closed plane figure formed by connecting four points. The line segments form right angles with each other.

2.1.2.4.3 Regular Polygons
A regular polygon is a closed plane figure with a series of line segments of the same length. The angles between each pair of line segments are equal.

2.1.3 Conics
A conic is a curve that is created when a right circular cone is intersected with a plane. The intersection of a cone and a plane is a conic curve. The type of curve created depends upon the angle of the plane with the cone.

2.1.3.1 Arcs
An arc is a continuous segment of a circle.

2.1.3.2 Circles
A circle is a closed plane curve which is equidistant from a fixed center point.

2.1.3.3 Ellipses
An ellipse is a plane curve such that the combined distance between two fixed points and any point on the curve is a constant.

2.1.3.4 Rho Conics
A rho conic is a group of plane curves including the parabola and hyperbola. They are generated by the intersection of a right regular cone and a plane.

2.1.4 Splines
A spline is a general curve that passes through or approximates a series of points. There are many types of splines. Each type of spline uses different mathematics in its computation.

2.1.4.1 Linear
Line segments join defining points in a linear spline.

2.1.4.2 Cubic
The curve connecting the defining points of a cubic spline is determined by a polynomial equation of the third power or degree. A cubic spline passes through its defining points.

2.1.4.3 B-Splines
A B-spline is defined by control polygons which generally do not lie on the spline curve. It is piecewise polynomial.

2.1.4.4 Composite
A composite spline is created from a group of curves. These curves are joined end to end.

2.1.4.5 Offset
An offset spline is created such that its distance from another defining spline is a constant.

2.2 3D Items
The following 3D items are used to create 3D models. The models may be constructed from wireframe, surface and/or solids.

2.2.1 Points
A 3D point is a geometric item. It is defined by an x, y and z coordinate.

2.2.2 Curves
A 3D curve is an item of geometry including a line.

2.2.2.1 Lines
A 3D line is a straight wireframe item. Geometrically, a line in 3D space is the set of points (x,y,z) that satisfy the linear equation $ax + by + cz = d$.

2.2.2.1.1 Construction Lines
A construction line is a line with no endpoints. It stretches infinitely in one or both directions in 3D space.

2.2.2.1.2 Line Segments
A line segment is a line with two finite endpoints.

2.2.2.1.3 Polylines
A polyline is made up of several line segments connected end to end. It is treated as a single item.

2.2.2.1.4 Polygons
A polygon is a closed series of line segments.

2.2.2.1.4.1 Triangles
A triangle is a closed plane figure formed by connecting three points. The three points are not in a straight line.

2.2.2.1.4.2 Rectangles
A rectangle is a closed plane figure formed by a set of four line segments connected at right angles to one another.

2.2.2.1.4.3 Regular Polygons
A regular polygon is a closed plane figure with a series of line segments of the same length. The angles between each pair of line segments are equal.

2.2.2.2 Conics
A conic is a curve that is created when a right circular cone is intersected with a plane. The intersection of a cone and a plane is a conic curve. The type of curve created depends upon the angle of the plane with the cone.

2.2.2.2.1 Arcs
An arc is a continuous segment of a circle.

2.2.2.2.2 Circles
A circle is a closed plane curve which is equidistant from a fixed center point.

2.2.2.2.3 Ellipses
An ellipse is a plane curve such that the combined distance between two fixed points and any point on the curve is a constant.

2.2.2.2.4 Rho Conics
A rho conic is a group of plane curves including the parabola and hyperbola. They are generated by the intersection of a right regular cone and a plane.

2.2.2.3 Splines
A spline is a general curve that passes through or approximates a series of points. There are many types of splines. Each type of spline uses different mathematics in its computation.

2.2.2.3.1 Linear
Line segments join defining points in a linear spline.

2.2.2.3.2 Cubic
The curve connecting the defining points of a cubic spline is determined by a polynomial equation of the third power or degree. A cubic spline passes through its defining points.

2.2.2.3.3 B-Splines
A B-spline is defined by control polygons which generally do not lie on the spline curve. It is piecewise polynomial.

2.2.2.3.4 Offset
An offset spline is created such that its distance from another defining spline is a constant.

2.2.2.3.5 Bezier
A Bezier spline is a special B-spline in which the order or degree of the spline is the same as the number of defining control points. The beginning and end of a Bezier spline lie on the first and last defining points.

2.2.2.3.6 Polynomial
A polynomial spline is defined by polynomial equations of varying degrees.

2.2.2.3.7 Composite
A composite spline is created from a group of curves. These curves are joined end to end.

2.2.3 Surfaces
A surface is a skin or sheet which bounds a 3D part. A cube, for example, may be thought of as six planar surfaces. Surfaces provide more useful models of parts for visualization. There are many types of surfaces which differ by mathematical definitions and methods used to create them.

2.2.3.1 Plane
A plane surface is an infinite or bounded flat surface.

2.2.3.2 Ruled
A ruled surface is constructed as a set of lines connecting two curves. It is a bounded surface.

2.2.3.3 Extruded
An extruded surface is constructed by sweeping one or more curves along a vector.

2.2.3.4 Revolved
A revolved surface is constructed by rotating one or more curves about a line.

2.2.3.5 Curve Driven
A curve driven surface is constructed by sweeping a constant or varying cross section of curve along another curve.

2.2.3.6 B-Spline
A B-spline surface is defined by a mesh of B-spline curves.

2.2.3.7 Composite
A composite surface is defined by combining surfaces.

2.2.3.8 Bicubic Patch
A bicubic patch surface is bounded on four sides by cubic curves. The four cubic edge curves control the surface.

2.2.3.9 Coons Patch
A coons patch surface is bounded on four sides by cubic curves. The surface is controlled by the four edge curves and interior curves.

2.2.3.10 Gordan Surface
A Gordan surface is a type of surface patch similar to a Coons patch surface. It is used by General Motors Corporation to design automobiles.

2.2.3.11 Fillet
A fillet surface, whose cross section is an arc or conic of constant curvature, is created tangent to two defining surfaces at its point of contact with the two surfaces.

2.2.3.12 Blended
A blended surface is computed to smoothly join two or more surfaces.

2.2.3.13 Offset
An offset surface is constructed a constant distance from the defining surface.

2.2.3.14 Tapered Fillet
A tapered fillet surface, whose cross section is an arc or conic of varying curvature, is created tangent to two defining surfaces at its point of contact with the two surfaces.

2.2.3.15 Primitives
Primitive surfaces are basic building blocks including boxes, cylinders, cones, spheres, tori, pyramids, etc.

2.2.3.16 Lofted
A lofted surface is computed to smoothly pass through a series of defining cross sectional curves.

2.2.3.17 Point Mesh
A point mesh surface is constructed to smoothly pass through an array of points.

2.2.4 Solids
A solid is a closed 3D volume of material. A solid cube is defined as one solid item. Solids are composed of subitems called faces. Faces are bounded by edges. Edges intersect at vertices. Unlike wireframe items, solids keep track of the presence or absence of material.

2.2.4.1 Primitives
A solid primitive is a basic building block used to design a solid model. The basic primitive items combine to form complex models in what is known as constructive solid geometry or CSG modeling.

2.2.4.1.1 Block
A solid block has six faces. Each face is a parallelogram. A block is also called a parallelepiped.

2.2.4.1.2 Cylinder
A solid cylinder is constructed by sweeping a circular cross section along a line segment.

2.2.4.1.3 Cone
A solid cone is the volume enclosed by a conic surface and a plane which includes the directrix. A conic surface is generated by a straight line, passing through a fixed point, moving along the intersection of a fixed circle.

2.2.4.1.4 Sphere
A solid sphere is a ball. The solid is enclosed by a surface in which all points are equidistant from a fixed center point.

2.2.4.1.5 Wedge
A solid wedge is constructed by sweeping a triangular face along a line segment.

2.2.4.1.6 Torus
A solid torus is a donut shaped solid. It is formed by revolving a circular face about a circle.

2.2.4.1.7 Truncated Cone
A solid truncated cone is a cone which is cut off by a plane. There is no pointed top.

2.2.4.1.8 Pyramid
A solid pyramid is a polyhedron with a polygonal base and triangular faces meeting in a common vertex.

2.2.4.2 User Defined Solids
User defined solids are solids constructed by the program.

2.2.4.2.1 Extrusion
A solid extrusion is constructed by sweeping a surface, which may include holes, through space along a line segment.

2.2.4.2.2 Sweep
A solid sweep is constructed by rotating a surface, which may include holes, about a vector or line segment.

2.2.4.2.3 Curve Driven
A curve driven solid is constructed by sweeping a planar surface along a curve.

2.2.4.2.4 Surface Bounded
A surface bounded solid is constructed by combining a set of surfaces that enclose volume.

2.2.4.2.5 Offset Surface
An offset surface solid is enclosed by a defining surface and a surface offset from the defining surface.

2.2.4.2.6 Polyhedron
A polyhedron solid is constructed using a set of polygons, usually triangles, enclosing a volume.

2.2.4.3 Solid Operations
Solid operations manipulate solid primitives and user defined solids to construct complex solid models.

2.2.4.3.1 Add
A solid add operation combines two or more solids. The resulting solid is the union of the solids. This operation is similar to welding parts together.

2.2.4.3.2 Subtract
A solid subtract operation removes one or more solids from another solid. This operation is similar to drilling or milling material away from a part.

2.2.4.3.3 Intersect
A solid intersect operation combines one or more solids. The resulting solid is the portion that is common to all the solids.

2.2.4.3.4 Exclusive Or
An exclusive or solid operation combines one or more solids. The resulting solid is the portion that is not common to all the solids.

2.2.4.3.5 Section with Plane
A section with plane operation cuts one or more solids with a plane.

2.2.4.3.6 Section with Surface
A section with surface plane operation cuts one or more solids with a surface.

2.2.4.3.7 Multiple Booleans
Multiple booleans allow solid operations on more than two solids at one time.

2.2.4.3.8 Coplanar Face Handling
Coplanar face handling is the capability of handling mathematical difficulties arising when solid operations are attempted on solids having faces that lie on top of one another. These are called coincident or coplanar faces.

2.2.4.3.9 Clearance Checking
Clearance checking is the capability of checking for overlapping solids.

2.3 Item Editing
Item editing capabilities include changing or repositioning items that were previously created.

2.3.1 Change Item Geometry
The following types of geometric items may be altered or repositioned.

2.3.1.1 Points
A point can be modified by changing its position or location.

2.3.1.2 Curves
The following curve items can be modified.

2.3.1.2.1 Lines
A line's length, angle or endpoints can be modified.

2.3.1.2.2 Conics
A conic's start and end point, rho value, tangency point or shoulder point can be modified.

2.3.1.2.3 Splines
A spline's definition point can be moved or deleted. A new spline point can be added. In addition, tangency conditions and spline order or degree can be modified.

2.3.1.3 Surfaces
A surface can be modified by moving points and changing its order.

2.3.1.4 Solids
A solid can be modified by changing its defining parameters.

2.3.1.4.1 Primitives
A solid primitive can be modified by changing its defining parameters.

2.3.1.4.2 User Defined Solids
A user defined solid can be modified without recreating it all over again.

2.3.1.4.3 Boolean Editing
The solid operations used to create a solid is represented as a tree having branches. Boolean editing allows the structure of the tree to be edited.

2.3.2 Item Associativity
Item associativity is the ability to automatically change items that were created referencing existing items. When the referenced items are edited, associated items are automatically modified. For example, if a circle is created with its center at the end of an existing line and the endpoint of the line is moved, the circle moves automatically.

2.3.2.1 Moving Items
Item associativity occurs when the referenced item is moved using a transformation function.

2.3.2.2 Editing Items
Item associativity occurs when the referenced item's geometry is edited.

2.3.2.3 Relimiting Items
Item associativity occurs when the referenced item is relimited. Relimiting is the ability to change bounds of an item without effecting other defining parameters.

2.3.2.4 Point Constructions
Item associativity occurs when a referenced item's point definition is modified.

2.3.2.5 Other Constructions
Item associativity occurs when a referenced item is modified.

2.4 Item Manipulations
The following item manipulation functions allow items to be modified for easier user manipulation and construction.

2.4.1 Grouping
The following grouping functions allow a collection of items to be logically associated so they can be manipulated as a single item.

2.4.1.1 Within Part
The following grouping functions allow a collection of items to be logically associated in a particular part or model.

2.4.1.1.1 Features/Sets
The features or sets function groups possibly dissimilar items so they may be manipulated and/or have data associated with them as if they were a single item.

2.4.1.1.2 Composites
The following composite functions create a collection of connected items which can be manipulated and/or have data associated with them as if they were a single item.

2.4.1.1.2.1 Curves
The composite curve function creates a collection of curves connected end to end. The curves can then be manipulated and/or have data associated with them as if they were a single curve.

2.4.1.1.2.2 Surfaces
The composite surface function creates a collection of surfaces connected by coincident edges. The surfaces can then be manipulated and/or have data associated with them as if they were a single surface.

2.4.1.1.2.3 Solids
The composite solid function creates a collection of solids. The solids can then be manipulated and/or have data associated with them as if they were a single solid.

2.4.1.2 Symbol/Part Library Items
Symbol or part library functions create a collection of items that can be stored and retrieved from disk storage outside of the current part or model.

2.4.1.2.1 Definition
The following item types are stored in a symbol or part library item.

2.4.1.2.1.1 2D Items
Planar geometry or 2D items are stored as symbols or part library items.

2.4.1.2.1.2 3D Items
Full 3D geometry items are stored as symbols or part library items.

2.4.1.2.1.3 Drawing Mode Items
View mode items which are view dependent are stored as symbols or part library items.

2.4.1.2.1.4 Nongraphic Data
Nongraphic data is stored in symbol or part library items. Nongraphic data is text or numeric data associated with graphic items.

2.4.1.2.1.5 Nesting
Nesting of symbols or part library items allows the definition of items that include other symbols or part library items.

2.4.1.2.1.6 Part Association
Symbol or part library association occurs when items that are logically attached to parts are changed. When the part is altered, the associated symbol or part library item is automatically altered.

2.4.1.2.2 Retrieval
The retrieval function gets a copy of a symbol or part library item for use in the current part or model.

2.4.1.2.2.1 By name
The retrieval function gets a copy of a symbol or part library item for use in the current part or model by name.

2.4.1.2.2.2 From Displayed Items
The retrieval function gets a copy of a symbol or part library item for use in the current part or model by selecting it from a collection of displayed graphic images.

2.4.1.2.2.3 From Item List
The retrieval function gets a copy of a symbol or part library item for use in the current part or model by selecting it from a list of names.

2.4.1.2.2.4 By Criteria
The retrieval function gets a copy of a symbol or part library item for use in the current part or model by specifying one or more nongraphic attributes which are matched against the nongraphic attributes of symbols or part library items.

2.4.1.2.2.5 By Graphic Selection
The retrieval function gets a copy of a symbol or part library item for use in the current part or model by selecting a copy of the symbol or library part already loaded into the current part or model.

2.4.1.2.3 Manipulations
The following manipulations allow modification of symbols or part library items.

2.4.1.2.3.1 Scaling
The scale of a symbol or part library item may be changed as it is being loaded into the current part or model.

2.4.1.2.3.2 Orienting
The orientation or angle of a symbol or part library item may be changed as it is being loaded into the current part or model.

2.4.1.2.3.3 Exploding
A symbol or part library item may be exploded after it is loaded into the current part or model. Exploding it breaks it into individual items.

2.4.1.2.3.4 Updating
After a symbol or part library item is modified, all copies of it are replaced with the new version.

2.4.1.2.3.5 Subitem Access
Symbols or part library items have subitem access if items within a copy of the symbol or part library item can be accessed for information.

2.4.1.2.3.6 Subitem Editing
Symbols or part library items have subitem editing capabilities if items within a copy of the symbol or part library item can be modified yet remain associated with the original item.

2.4.1.2.3.7 Layer Control
An item within a symbol or part library item maintains its individual layer attributes or control of its display for blanking, color, line style, etc.

2.4.2 Relimiting
Relimiting is the ability to change the bounds of an item without effecting other defining parameters.

2.4.2.1 Curves
The following relimiting functions operate on wireframe items.

2.4.2.1.1 Fillet
To relimit a fillet, an arc is created tangent to two defining lines or curves and the lines or curves are automatically trimmed to the tangency points.

2.4.2.1.2 Chamfer
To relimit a chamfer, a line segment is created at a specified angle and length near the corner of two items which are normally lines. The corner is then automatically trimmed to the intersection points of the new line segment and the previous lines.

2.4.2.1.3 Trim Single
The trim single relimiting function reduces the length of a single curve or line by altering one or both ends.

2.4.2.1.4 Extend
The extend relimiting function lengthens a curve or line.

2.4.2.1.5 Corner
The corner relimiting function trims two intersecting curves to meet at a corner.

2.4.2.1.6 Break
The break relimiting function breaks or divides a curve or line into two or more pieces.

2.4.2.1.7 Jog
The jog relimiting function creates two fillets that smooth the transition of lines joined with a step.

2.4.2.1.8 Trim Multiple
The trim multiple relimiting function trims several curves or lines to the same boundary at one time.

2.4.2.2 Surfaces
The following relimiting functions trim off unneeded portions of surfaces.

2.4.2.2.1 Surface-to-Curve
The surface-to-curve relimiting function trims a surface to a curve that lies on the surface.

2.4.2.2.2 Surface-to-Surface
The surface-to-surface relimiting function trims a surface to another surface with which it intersects.

2.4.2.2.3 Surface-to-Plane
The surface-to-plane relimiting function trims a surface to a plane.

2.4.2.2.4 Surface-to-Solid
The surface-to-solid relimiting function trims a surface to a solid.

2.4.2.3 Solids
The following relimiting functions allow trimming of solids.

2.4.2.3.1 Solid-to-Plane
The solid-to-plane relimiting function trims a solid to a plane.

2.4.2.3.2 Solid-to-Surface
The solid-to-surface relimiting function trims a solid to a surface.

2.4.2.3.3 Solid-to-Solid
The solid-to-solid relimiting function trims a solid to another solid.

2.4.3 Intersection Constructions
Intersection constructions compute or create geometry from intersections and projections of existing geometry.

2.4.3.1 Points
The following intersection constructions create points from existing geometry.

2.4.3.1.1 Line with Plane
A point is created by the intersection of a line with a plane.

2.4.3.1.2 Curve with Plane
One or more points are created by the intersection of a curve with a plane.

2.4.3.1.3 Line with Surface
One or more points are created by the intersection of a line with a surface.

2.4.3.1.4 Curve with Surface
One or more points are created by the intersection of a curve with a surface.

2.4.3.2 Curves
The following intersection constructions create curves from existing geometry.

2.4.3.2.1 Project Curve Onto Plane
A planar curve is created by projecting a curve onto a plane.

2.4.3.2.2 Project Curve Onto Surface
A planar curve is created by projecting a curve onto a surface.

2.4.3.2.3 Plane with Plane
A line is created by the intersection of two planes.

2.4.3.2.4 Plane with Surface
A curve or line is created by intersecting a plane with a surface.

2.4.3.2.5 Surface with Surface
A curve is created by intersecting two surfaces.

2.4.3.2.6 Surface Definition
A curve or curves are created from the edges or iso-parametric lines of a surface. Iso-parametric lines are a rectangular grid of intersecting curves that lie on a surface.

2.4.3.2.7 Solid Edges
A curve or curves are created from the edges of a solid.

2.4.3.2.8 Solid Section
A curve or curves are created by the intersection of a section plane or surface with a solid.

2.4.3.3 Surfaces
The following intersection constructions create surfaces from existing geometry.

2.4.3.3.1 Solid Definition
One or more surfaces are created from the faces of an existing solid.

2.4.3.3.2 Solid with Plane
A surface is created from the intersection of a solid and a plane.

2.4.3.3.3 Solid with Surface
A surface is created from the intersection of a solid and a surface.

2.5 Transformations
Transformation functions move and copy items without changing their size or shape.

2.5.1 Linear Move/Copy
The linear move or copy function moves and copies items from one point to another point or moves them a specified distance in a specified direction. The function allows the user to either copy or not copy the items.

2.5.2 Rotate
The rotate function rotates or copies items around a specified vector, a specified number of times.

2.5.3 3D Orient
The 3D orient function simultaneously moves and rotates items by specifying three base points and three transform points. The first three points are usually the from points. The second three points are the to points.

2.5.4 Mirror
The mirror function creates a mirror image of items by reflecting them about a specified plane.

2.5.5 Combination Transformations
Combination transformation functions combine move, rotate and mirror functions into one operation.

2.5.6 Circular Move/Copy
The circular move and copy function moves items along a circular path without altering their orientation.

2.5.7 Stretch
The stretch function moves some items of a part and

lengthens, shortens or rotates lines connected to the moved items.

2.5.8 Rectangular Array
The rectangular array function copies items to create a rectangular grid of copies of the original items.

2.5.9 Circular Array
The circular array function copies items to create a circular grid of copies of the original items.

2.5.10 Scale
The scale function changes the size or a geometric item. Scaling can be shape preserving, have equal scaling in all directions or distort the item by scaling differently in different directions.

2.5.11 Project Wireframe
The project wireframe function copies and moves one or more wireframe items and automatically connects endpoints and other key points of the copy with corresponding points on the original item.

2.6 Construction Aids
Construction aids do not directly create or modify geometry but are used to assist in the construction process.

2.6.1 Item Selection
Item selection functions allow items to be selected for use with other functions.

2.6.1.1 Philosophy
The philosophy of item selection is the principle behind the selection mechanism used by the program.

2.6.1.1.1 Prefix
The prefix selection method is a philosophy where the function to be executed is selected followed by the items which the function effects.

2.6.1.1.2 Postfix
The postfix selection method is a philosophy where the function to be executed is selected after the items which the function effects.

2.6.1.1.3 Select List
The select list method is a philosophy where the program maintains a list of selected items on which any selected function works. The list is modified by item selection functions.

2.6.1.2 Display
The display of selected items differs from unselected items.

2.6.1.3 Granularity
The granularity of item selection allows subitems to be selected for nondestructive purposes without having to explode them.

2.6.1.3.1 Item Level
Items may be selected at the item level only.

2.6.1.3.2 Subitems
The following items can have subitems selected.

2.6.1.3.2.1 Polylines
Individual line segment or vertices of a polyline can be selected.

2.6.1.3.2.2 Grouped Items
Individual subitems in a group, feature or set can be selected.

2.6.1.3.2.3 Symbol/Part Library Items
Individual subitems within a copy of a symbol or part library item can be selected.

2.6.1.3.2.4 Surfaces
Edge curves or parametric curves on a surface can be selected.

2.6.1.3.2.5 Solid Primitives
Edge curves of a solid primitive can be selected.

2.6.1.3.2.6 User Defined Solids
Edge curves of a user defined solid can be selected.

2.6.1.3.2.7 Solid Composites
Edge curves of solids created using boolean operations can be selected.

2.6.1.3.3 Pick Aperture
The following pick aperture functions allow control and display of the pick aperture.

2.6.1.3.3.1 Control
The pick aperture control function allows the user to change the distance from an item that one must position the cursor to allow it to select an item.

2.6.1.3.3.2 Display
The pick aperture display function allows the user to change the display of the pick aperture box.

2.6.1.4 Methods
The following are item selection methods.

2.6.1.4.1 Single
The single item selection method allows selection of items one at a time by positioning the screen cursor near the item and pressing a selection key or button.

2.6.1.4.2 In/Out Rectangle
The in/out rectangle method allows selection of items by graphically indicating a rectangular region on the screen. Items lying inside or outside the rectangle are selected.

2.6.1.4.3 In/Out Polygon
The in/out polygon method allows selection of items by graphically indicating a polygonal region on the screen. Items lying inside or outside the polygon are selected.

2.6.1.4.4 By Name
Items can be selected by name.

2.6.1.4.5 Chain
The chain selection method allows a series of connected curves to be selected by selecting one curve of the series and allowing the program to automatically select the remainder of the curves.

2.6.1.4.6 By Nongraphics
Items can be selected by entering nongraphic criteria, for example, layer, color or user defined nongraphic attributes.

2.6.1.4.7 Toggle Select
The toggle select method allows an item to be unselected by selecting it again.

2.6.1.4.8 Cycle Select
The cycle select method allows the program to automatically unselect the item just selected and select the next item available using the same selection location and criteria. This feature is useful when items are very close or overlap each other.

2.6.1.4.9 Unselect
The unselect feature allows all or some of the currently selected items to be unselected.

2.6.1.5 Filtering/Masking
Filtering or masking allows the set of items which may be selected to be limited by specifying a criteria that they must match.

2.6.1.5.1 By Item Type
Items can be filtered for selection by item type.

2.6.1.5.2 By Color
Items can be filtered for selection by color.

2.6.1.5.3 By Nongraphic
Items can be filtered for selection by nongraphic attributes such as cost, vendor, weight, etc.

2.6.1.5.4 By Layer
Items can be filtered for selection by layer.

2.6.1.5.5 By Area
Items within a particular screen area can be selected.

2.6.1.5.6 By Size
Items can be filtered for selection by item size.

2.6.2 Coordinate Systems
The following coordinate system functions control the coordinate system used to define items.

2.6.2.1 Units
The coordinate system units are the measurement units in which items are defined and stored, for example, inches, millimeters, meters, feet, miles, etc.

2.6.2.1.1 Model Units
A model units function allows the user to set and/or modify the measurement units in which items in the data base are defined.

2.6.2.1.2 Local Reference
A local reference units function allows the user to set and/or modify the units in which coordinate data is entered.

2.6.2.2 Types
The following are different types of coordinate systems.

2.6.2.2.1 Cartesian
A Cartesian coordinate system is a rectangular system with three mutual perpendicular axes, x, y and z. Points in a Cartesian coordinate system are defined by x, y and z values.

2.6.2.2.2 Polar/Cylindrical
A polar or cylindrical coordinate system is a circular system with points described with a height above a defined plane or z value. The projection of the point in the plane is the tip of a vector whose angle from a fixed axis and length are used to determine the remaining two coordinates.

2.6.2.2.3 Spherical
A spherical coordinate system is a system in which points are defined by the length, the angle from the x-y plane and the angle of projection of the vector in the x-y plane from the x-axis.

2.6.2.2.4 Construct Planes
The construct planes feature permits creating and altering construction planes. Construction planes are planes used in constructions during 3D modeling.

2.6.2.3 Access
The following access features are related to the use of user defined or local coordinate systems.

2.6.2.3.1 Coordinate Entry
The coordinate entry of values using a local coordinate system is allowed.

2.6.2.3.2 Verification Units
The verification of values in the current local coordinate system is allowed.

2.6.2.3.3 Store/Recall
Store and recall functions allows local coordinate systems to be stored and recalled by the user.

2.6.3 Verification/Query
Verification and query functions allow interactive extraction, display and/or output of data from the data base.

2.6.3.1 Item Data
Extraction, display and/or output of all data related to an item, including type specific parametric data and generic information such as color, line weight, layer, item name, etc., is supported.

2.6.3.2 Geometric Data
Extraction, display and/or output of all the following data related to an item is permitted.

2.6.3.2.1 Location
The location of a point in space can be extracted, displayed and/or output.

2.6.3.2.2 Distance
The distance between two points in space can be extracted, displayed and/or output.

2.6.3.2.3 Minimum Distance
The minimum distance between two curves in space can be extracted, displayed and/or output.

2.6.3.2.4 Angle
The angle between two lines, two planes or a line and a plane about their intersection point can be extracted, displayed and/or output.

2.6.3.2.5 Length
The length of a line or curve can be extracted, displayed and/or output.

2.6.3.2.6 Curvature
The ratio of change in tangent inclination over a given arc to the length of the arc can be extracted, displayed and/or output.

2.6.3.2.7 Area
The area, in square units, of a planar surface enclosed by one or more curves can be extracted, displayed and/or output.

2.6.3.2.8 Perimeter
The perimeter, which is the distance along one or more curves or lines, enclosing an area can be extracted, displayed and/or output.

2.6.3.2.9 Surface Area
The surface area of a surface, in square units, can be extracted, displayed and/or output.

2.6.3.2.10 Centroid
The centroid or balance point in all directions of a planar object can be extracted, displayed and/or output.

2.6.3.2.11 Volume
The volume or the capacity of a solid or closed set of surfaces, can be extracted, displayed and/or output.

2.6.3.2.12 Center of Gravity
The center of gravity or the mass balance point of a solid in all directions, can be extracted, displayed and/or output.

2.6.3.2.13 Moments of Inertia
The moments of inertia, which are computed by the integral product of an object's mass and its perpendicular distance from a reference axis, can be extracted, displayed and/or output.

2.6.4 Grids
A grid is a construction aid that can be displayed as a visual guide for sketching or can be used to lock screen digitized locations to fixed coordinate locations.

2.6.4.1 Types
The following types of grids are different arrangements of grid points. Different types of grids are used for different applications.

2.6.4.1.1 Rectangular
A rectangular grid is an arrangement of grid points in a array of perpendicular rows and columns.

2.6.4.1.2 Polar
A polar grid is an arrangement of grid points in an array of concentric circles.

2.6.4.1.3 Isometric
An isometric grid is an arrangement of grid points in a array in which points lie on lines at angles of 30 and 150 degrees from the positive x-axis.

2.6.4.1.4 Angle Lock
The angle lock feature causes line segments created using screen digitized points to form angles at fixed increments from a reference line.

2.6.4.2 Control
The following grid control functions permit modification of grids.

2.6.4.2.1 Origin
The grid origin function modifies the starting location for grid generation.

2.6.4.2.2 Display
The grid display function allows the grid to be shown or not shown.

2.6.4.2.3 3D Orientation
The 3D grid orientation function allows the grid to be rotated or aligned in 3D space.

2.6.4.2.4 Spacing
The grid spacing function controls and modifies spacing of grid points.

2.6.5 Temporary Constructions
Temporary constructions are items created only as an aid for construction of other geometry. These items are not typically not permanently stored in the data base. These temporary items can generally be created while executing functions that create geometry.

2.6.5.1 Points
Temporary construction points can be created.

2.6.5.2 Lines
Temporary construction lines can be created.

2.6.5.3 Planes
Temporary construction planes can be created.

2.6.5.4 Vectors
Temporary construction vectors can be created.

2.6.5.5 Coordinate Systems
Temporary construction coordinate systems can be created.

3. Drafting
This section covers features for creating drawings. Drawings may be created in a standalone mode or derived from 3D models.

3.1 Model/Drawing Association
Model and drawing association effect viewing and display functions used to create and lay out views of a drawing.

3.1.1 View Functions
View functions allow drawing views to be created and manipulated, either by creating new 2D data or by using viewing transformations of the 3D data.

3.1.1.1 Independent Drawing Views
The projection function extracts 2D views from 3D models by flattening a 3D design onto a plane, creating new 2D data.

3.1.1.2 Dependent Drawing Views
Dependent drawing views are views of a 3D model that are generated and maintained as transforms.

3.1.1.2.1 Curve Access
Curve access is the ability to select curves in a 3D model for construction or annotation on a 2D drawing without copying items into the drawing.

3.1.1.2.2 Surface Edge Access
Surface edge access is the ability to select surface edges or iso-parametric curves in a 3D model for construction or annotation on a 2D drawing without copying items into the drawing.

3.1.1.2.3 Solid Edge Access
Solid edge access is the ability to select solid edge curves in a 3D model for construction or annotation on a 2D drawing without copying items into the drawing.

3.1.1.3 Orienting
Orienting of views is required to automatically line up views on a drawing sheet. This is used for creating standard multiple view drawings.

3.1.1.4 Standard Drafting Views
Standard drafting views of parts are views required for a clearer description of the part.

3.1.1.4.1 Orthographic
Orthographic views are 2D representations of a part formed

by the perpendicular intersections of lines drawn from points on the part to a plane of projection. These are the standard front, top, right side, bottom, left side views.

3.1.1.4.2 Isometric
Isometric views are 2D representations of a part formed when the plane of projection makes equal angles with the three principal faces of the part or when the axes of the part make equal angles with the plane of projection.

3.1.2 Model Display Modification
Model display modification involves the appearance of part geometry in views on a drawing. The modifications are done either by the user or automatically.

3.1.2.1 Interactive
Interactive model display modification requires user intervention to alter the views on a drawing.

3.1.2.1.1 Line Styles
User modification of lines styles of lines or curves is required for drawings to represent, for example, hidden lines.

3.1.2.1.2 Trimming
User trimming of lines or curves on a drawing is required to create correct views from wireframe models.

3.1.2.1.3 Blanking
User blanking of lines or curves on a drawing is required to create correct isometric views from wireframe models. Blanking does not delete or remove items from the part.

3.1.2.2 Automatic
Automatic model display modification requires little or no user intervention to alter the views on a drawing.

3.1.2.2.1 Line Styles
Automatic modification of lines styles of lines or curves takes place to represent, for example, hidden lines.

3.1.2.2.2 Trimming
Automatic trimming of lines or curves on a drawing takes place to create correct views from wireframe models.

3.1.2.2.3 Blanking
Automatic blanking of lines or curves on a drawing takes place to create correct isometric views from wireframe models. Blanking does not delete or remove items from the part.

3.1.3 Drawing Mode
Drawing mode distinguishes drafting operations from geometric modeling.

3.1.3.1 Drawing Items
Drawing items can be created in drawing mode.

3.1.3.2 Drawing Sheets
The drawing sheets function allows drawing layout on drawing sheets in drawing mode.

3.1.3.3 Model-to-Drawing
Model-to-drawing association allows transferring geometric items from a 3D model to a 2D drawing.

3.1.3.4 Drawing-to-Model
Drawing-to-model association allows transferring geometric items from a 2D drawing to a selected plane in a 3D model.

3.2 Annotation
Annotation is textual, symbolic and other documentation used to describe a part on a drawing.

3.2.1 Line Styles
Lines styles are used to annotate lines and curves on a drawing. For example, a centerline style is used to depict the center of a shaft.

3.2.1.1 Standard Set
The standard set of line styles are hidden, phantom, dotted, dashed, solid and centerline.

3.2.1.2 Section Lines
Section lines are heavy cutting plane lines depicting a cut away section of a part. Another view of the part shows the inside detail.

3.2.1.3 Centerlines
Centerlines are created automatically for specific geometry items by selecting the items.

3.2.1.3.1 Linear
Linear centerlines are created through the major axis of a part.

3.2.1.3.2 Radial
Radial centerlines are created horizontally and/or vertically through the center of a circle or arc.

3.2.1.3.3 Circle Pattern
Circle pattern centerlines are a group of radial centerlines automatically created to annotate a circular or rectangular array of circles.

3.2.1.4 Break Lines
Break lines are used to emphasize that a portion of a part has been removed from a view. They are often used when

drawing long parts such as shafts or other regions of constant cross section.

3.2.1.5 User Defined
Special line styles can be defined by a user. They can consist of different length dashes and space combinations or include patterns or symbols.

3.2.2 Text
Text is used to annotate a drawing.

3.2.2.1 Multiple Line Notes
Multiple line notes contain more than one line of text which can be input, manipulated and edited as a single item.

3.2.2.2 From a File
Notes can be created by copying ASCII text from a file and placing it on a drawing.

3.2.2.3 Editing
Editing a note allows selective replacement, addition and deletion of characters, words, phrases and lines.

3.2.2.4 Math/Engineering Characters
Notes may include Greek letters and mathematical and engineering symbols, for example, integral, ohms, degree and square root.

3.2.2.5 International Characters
Notes may be written using characters required by other languages, for example, French, Spanish, German, Hebrew.

3.2.2.6 Font Support
Notes may use different text fonts, for example, Leroy and Helvetica.

3.2.2.7 Size
Characters in a note may differ in height, width and spacing from characters in another note.

3.2.2.8 Justification
A note may be justified or oriented differently in relation to its origin. For example, a note may be center justified. Typical justifications include center, upper right, lower left, upper left, etc.

3.2.2.9 Along Curves
Text follows along a curve.

3.2.2.10 Fitting
Text fitting creates a note that fits inside of and fills a specified rectangular box.

3.2.2.11 Nodes
Text nodes are predefined markers on a drawing which store character definition parameters such as justification, size, font, etc. When a note is created using a selected predefined node, the note takes on the predefined parameter characteristics.

3.2.3 Special Items
Special items are symbols used to create standard drawing notation other than notes or dimensions.

3.2.3.1 Labels
Labels are notes with one or more leader lines and arrowheads extending from the note. The leader lines point at items in the drawing.

3.2.3.2 Bubbles
Bubbles are circles containing one or two letters or numbers. Bubbles may or may not have leader lines and arrowheads.

3.2.3.3 Datum Targets
Datum targets are circles split by a horizontal or vertical line. They contain datum references.

3.2.3.4 Flags
Flags are letters or notes in a triangle.

3.2.3.5 Weld Symbols
Weld symbols denote weld information on a drawing. These symbols are specified by the American Welding Society.

3.2.3.6 Surface Finish Symbols
Surface finish symbols describe smoothness or surface preparation to be used.

3.2.3.7 Feature Control Symbols
Feature control symbols specify tolerance information of features on a drawing.

3.2.3.7.1 Creation
Creation of feature control symbols lets the user draw feature control boxes and symbols.

3.2.3.7.2 Editing
Editing of feature control symbols lets the user edit boxes and symbols without having to recreate them.

3.2.3.7.3 Intelligence
Feature control symbol intelligence is automatic interpretation and verification of information specified when creating or editing feature control symbols.

3.3 Dimensions
Dimension functions allow creation and modification of dimensions on a drawing.

3.3.1 Types
Different dimension types are necessary to describe features on a drawing.

3.3.1.1 Horizontal
Horizontal dimensions are linear dimensions annotating a measurement parallel to the x-axis.

3.3.1.2 Vertical
Vertical dimensions are linear dimensions annotating a measurement parallel to the y-axis.

3.3.1.3 Parallel
Parallel dimensions are linear dimensions annotating a measurement parallel to a line drawn between two points. The line does not have to be parallel to the x- or y-axis.

3.3.1.4 Radial
Radial dimensions measure and annotate the radius of an arc.

3.3.1.5 Angular
Angular dimensions measure and annotate an angle included between one edge of a part and a horizontal or vertical extension line or two extension lines. Extension lines extend from the edges of a part.

3.3.1.6 Diameter
Diameter dimensions measure and annotate the diameter of a circle.

3.3.1.7 Projected
Projected dimensions are linear dimensions annotating a measurement at an angle to a line drawn between two points.

3.3.1.8 Curve Length
A curve length dimension measures and annotates the distance along a curve between two extension lines.

3.3.2 Styles
Different dimension styles or methods are used to construct dimensions.

3.3.2.1 Point-to-Point
A point-to-point dimension is a linear dimension used to measure and annotate the distance between two point locations.

3.3.2.2 Baseline
Baseline dimensions are linear dimensions using one common dimension point as an origin point. A series of dimension point locations are measured and annotated from the origin point. Dimension text, dimension lines and arrowheads are stacked.

3.3.2.3 Chain
Chain dimensions are linear dimensions that use the second dimension point of the previous dimension as the first dimension point for the next dimension. Dimension text, dimension lines and arrowheads are usually aligned.

3.3.2.4 Dual
Dual dimensions annotate a measurement using two different measurement units. The primary measurement unit is the measurement unit used to create the part or drawing. For example, inches may be the primary measurement unit and millimeters the secondary measurement unit.

3.3.2.4.1 Position
The user can control the position of the secondary measurement unit, which is below or to the right of the primary measurement unit.

3.3.2.4.2 Bracket
The user may specify brackets in dual dimensions to enclose the secondary measurement units.

3.3.2.5 Basic
Basic dimensions enclose the dimension value in a box.

3.3.2.6 Not-to-Scale
Not-to-scale dimensions are underlined with a straight line or tilde shaped curve and the user overrides the actual dimension value.

3.3.2.7 Datum
Datum dimensions are linear dimensions measuring and annotating horizontal or vertical distances from a reference origin. Dimension lines and arrowheads may or may not be displayed.

3.3.3 Text Control
Text control is control of units, text size and number of decimals in dimension text.

3.3.3.1 Units
Units are measurement units, for example, inches, millimeters, feet, used when dimension values are calculated. A part may be drawn using inches, but dimensioning may be done in millimeters.

3.3.3.2 Decimals
Decimals are the number of digits displayed to the right of the decimal place in a dimension value.

3.3.3.3 Text Size
Text size is the height, width and spacing of text in a dimension.

3.3.4 Tolerance
Tolerance values may be added to or subtracted from dimensions to define a range of acceptable manufacturing dimensions.

3.3.4.1 Limit
A limit tolerance displays the upper and lower limit values of a dimension.

3.3.4.2 Plus-Minus
A plus-minus tolerance displays the tolerance values above and below the ideal or nominal dimension value.

3.3.4.3 Coded
A coded tolerance permits a letter code to be assigned to a dimension. A chart on the drawing lists the tolerance values relating to the coded letter. This type of dimensioning is also used for tabular drawings.

3.3.4.4 Stackup/Analysis
A tolerance stackup and analysis computes and reports the cumulative effect of possible part variations. These variations may show large gaps or overlapping parts.

3.3.5 Editing
Editing functions allow dimensions to be modified after they are created.

3.3.5.1 Break/Edit
A dimension may be broken into subitems such as text, lines, arcs, arrowheads, etc. These subitems may then be moved or deleted. The dimension can then be reassembled.

3.3.5.2 Style
The current dimension style, basic, dual, out-of-scale, etc., may be changed to another dimension style.

3.3.5.3 Text Location
The location of dimension text may be changed. The location of dimension lines, extension lines and arrowheads is modified when applicable.

3.3.5.4 Dimension Points
Defining dimension points may be relocated. The dimension is modified to reflect the new dimension points. For radial and diameter dimension, selection of a new arc or circle may be made and the text location does not change.

3.3.5.5 Text
Dimension text values may be modified by editing.

3.3.5.5.1 Units
The measurement units of a dimension value may be modified. For example, dimension text in inches may be changed to millimeters.

3.3.5.5.2 Tolerance
The tolerance of a dimension value may be modified.

3.3.5.5.3 Values
The dimension value of a dimension may be modified to create an out-of-scale dimension.

3.3.5.5.4 Text Addition
Text may be added before and/or after the program generated dimension text. The dimension retains its associativity.

3.3.6 Standards
Dimensioning standards support different international drafting standards.

3.3.6.1 ANSI
ANSI standards for drafting, design and documentation are published by the American National Standards Institute.

3.3.6.2 ISO
ISO standards for drafting, design and documentation are published by the International Standards Organization.

3.3.6.3 JIS
JIS standards for drafting, design and documentation are the Japanese Industry Standards.

3.3.7 Regeneration
Dimension regeneration features automatically create or update dimensions and annotation.

3.3.7.1 Automatic Dimensioning
Automatic dimensioning permits all or part of drawings to be dimensioned with a minimum of operator intervention.

3.3.7.2 Automatic Edit of Dimension
When an item of geometry is modified, dimensions associated with the geometry are automatically updated.

3.3.7.3 Automatic Edit of Geometry
When a dimension is modified, geometry items associated

with the dimension are automatically updated to reflect the new dimension value.

3.3.7.4 Automatic Update w/Part Change
When a 3D model is updated, the geometry and dimensions on a related drawing automatically update.

3.3.7.5 Disassociate
Dimensions can be disassociated with geometry. They are not updated automatically when geometry is modified or deleted.

3.3.7.6 Deleted Items
When a geometry item is deleted and a dimension is associated with it, the program alerts the user. For example, some programs automatically delete the dimension or dimensions, while others mark it as being no longer associated. The program may then allow the user to associate the dimension with another geometry item.

3.3.8 Appearance Control
Appearance of dimensions can be controlled.

3.3.8.1 Arrowheads
Arrowheads, which terminate dimension lines, may be changed to dots, slashes or nothing.

3.3.8.2 Extension Lines
Extension lines may be suppressed, have different overlaps past the arrowheads or different gaps between the geometry items and their starting points.

3.3.8.3 Dimension Lines
Dimension lines may be suppressed or drawn inside or outside of the extension lines.

3.4 Crosshatching
Crosshatching is filling of completely or partially bounded regions of items with line segments, symbols or patterns.

3.4.1 Boundary Specification
Different boundary specification methods determine the way the user defines crosshatch regions.

3.4.1.1 Curve Selection Methods
Curve selection methods such as single selection, chain selection, group or area selection are used to determine crosshatch boundaries.

3.4.1.2 Island Specification
Specification of islands that are not to be crosshatched are possible. Methods include single selection, chain selection, group or automatic selection.

3.4.1.3 Intersecting Boundaries
The program correctly crosshatches regions formed when one or more boundaries intersect or when a boundary is composed of portions of curves.

3.4.2 Patterns
Different crosshatch patterns are available.

3.4.2.1 Line Fill
The selected regions are filled with lines of various line types. The regions may be single filled with all lines parallel or double filled with two sets of orthogonal lines.

3.4.2.2 Standard Patterns
Standard crosshatch patterns include brick, steel, glass bronze, etc.

3.4.2.3 User Defined Patterns
Crosshatch patterns can be defined by a user. These user defined patterns may then be used to fill regions.

3.4.2.4 Pattern Control
Pattern control features allow control of the crosshatch patterns.

3.4.2.4.1 Size
The size of the crosshatch pattern is controlled.

3.4.2.4.2 Spacing
The spacing of the crosshatch pattern is controlled.

3.4.2.4.3 Angle
The angle of the crosshatch pattern is controlled.

3.4.3 Editing
Crosshatch editing features allow crosshatching to be modified after it is created without specifying the boundary.

3.4.3.1 Association
If crosshatching is associated with its defining boundaries, when one or more boundary curves are modified the crosshatching automatically updates.

3.4.3.2 New Boundary
If additions, deletions or replacements are made to a crosshatched region, the crosshatching automatically updates.

3.4.3.3 New Fill Pattern
A different or new fill pattern can replace the previous fill pattern. Also, the size, spacing or angle of a fill pattern can be modified.

3.4.3.4 Explode Pattern
Lines or patterns of a crosshatched region are broken into separate items. This allows editing of these items.

3.5 Detail Magnification Area
A detail magnification area is an enlarged portion of a drawing. This area shows small features on a larger scale.

3.5.1 Specification
Two methods of specifying a detail magnification area are defining a rectangular or circular region. The region is scaled or blown up and all items outside the defined region are clipped. The detail magnification area is placed on the drawing by the user.

3.5.2 Dimensioning
When a detailed magnification area is scaled or blown up, dimension values reflect the real size of the part. They do not reflect the new scale of the part.

3.5.3 Associativity
When a part is modified and a detailed magnification of the modified area exists, the detailed magnification is also modified.

4. Finite Element Modeling
Finite element modeling (FEM) is done to prepare a part for finite element analysis (FEA). Models are made up of elements with nodes. Constraints, loads, material properties, etc., are assigned to elements and nodes. All of this information is then used to perform the stress analysis of a model.

4.1 Initialization
Initialization is the process of setting variable parameters, for example units of measurement, display modes, etc., for the model.

4.1.1 Save/Restore FEM Parameters
Saving and restoring of the FEM variable parameters for the model simplifies the initialization process.

4.1.2 Save/Restore Defaults
Saving and restoring of the default conditions associated with the model simplifies the initialization process. An example of a default condition is element shrink on or off.

4.1.3 Save/Restore Models
Saving and restoring of the nodes, elements and other information comprising the finite element model simplifies the initialization process.

4.2 Node Specification
The following are methods used to specify nodes in FEM.

4.2.1 Coordinate Systems
Cartesian, cylindrical and spherical coordinate systems can be used in specifying the location of nodes.

4.2.2 Coordinate Entry
Coordinates of node locations are entered using the keyboard

4.2.3 Geometric Locations
Geometric locations defined by geometry models are used to specify the nodes.

4.2.4 Automatic Specification
Automatic specification of nodes is creation of nodes using systematic or repetitive schemes.

4.2.5 Automatic Numbering
Node numbers are automatically assigned to the nodes by the program.

4.2.6 Coincident Node Removal
Nodes at the same location can be removed.

4.3 Elements
Elements are types of geometric shapes or pieces used for FEM. An example of a shape is a rectangular block.

4.3.1 Types
The following are types of elements used for FEM.

4.3.1.1 1D Elements
The following 1D elements have one spatial coordinate.

4.3.1.1.1 Mass
A mass is a point element.

4.3.1.1.2 Rod
A rod is an element with no cross section that connects two points.

4.3.1.1.3 Bar
A bar is an element defined by two nodes and a rectangular cross section.

4.3.1.1.4 2-Node Beam
A 2-node beam element is defined by two nodes and can have an arbitrary cross section.

4.3.1.1.5 3-Node Beam
A 3-node beam element is similar to a 2-node beam except it has a third node in the middle.

4.3.1.1.6 Tube
A tube is a circular 2-node element with no thickness.

4.3.1.1.7 Pipe
A pipe is a circular 2-node element with a specified thickness.

4.3.1.1.8 4-Node Bend
A 4-node bend is a curved pipe element with curvature specified by the two interior nodes.

4.3.1.1.9 3-Node Quadratic
A 3-node quadratic element is curved with the interior node specifying the parameters of a quadratic curve.

4.3.1.1.10 4-Node Cubic
A 4-node cubic element is curved with the interior node specifying the parameters of a cubic curve.

4.3.1.1.11 Spring
A spring is a nonrigid element whose displacement is a function of the applied force.

4.3.1.1.12 Damper
A damper is a nonrigid element.

4.3.1.1.13 User Defined
A user defined element is a mechanism by which a user can create new 1D elements.

4.3.1.2 2D Elements
The following 2D elements have two running coordinate parameters.

4.3.1.2.1 Linear Triangle
A linear triangle is a triangular shaped element specified by three nodes.

4.3.1.2.2 Parabolic Triangle
A parabolic triangle is a triangular shaped element specified by three nodes at the vertices and midside nodes the vertices.

4.3.1.2.3 Cubic Triangle
A cubic triangle is a triangular shaped element specified by three nodes at the vertices and two midside nodes between the vertices.

4.3.1.2.4 Linear Quadrilateral
A linear quadrilateral is a four sided element specified by four nodes at the vertices.

4.3.1.2.5 Quadratic Quadrilateral
A quadratic quadrilateral is a four sided element specified by four nodes at the vertices and midside nodes between the vertices.

4.3.1.2.6 Cubic Quadrilateral
A cubic quadrilateral is a four sided element specified by four nodes at the vertices and two midside nodes between the vertices.

4.3.1.2.7 User Defined
A user defined element is a mechanism by which a user can create new 2D elements.

4.3.1.3 3D Elements
The following 3D elements have two running coordinate parameters.

4.3.1.3.1 Tetrahedron
A tetrahedron is a 3D element with four nodes.

4.3.1.3.2 Pyramid
A pyramid is a 3D element with five nodes.

4.3.1.3.3 Linear Wedge
A linear wedge is a 3D element with six nodes.

4.3.1.3.4 Parabolic Wedge
A parabolic wedge is a 3D element with six nodes at the vertices and midside nodes between vertices.

4.3.1.3.5 Cubic Wedge
A cubic wedge is a linear wedge with six nodes at the vertices and two midside nodes between vertices.

4.3.1.3.6 Linear Brick
A linear brick is a 3D element with eight nodes.

4.3.1.3.7 Quadratic Brick
A quadratic brick is a linear brick with eight nodes at the vertices and midside nodes between vertices.

4.3.1.3.8 Cubic Brick
A cubic brick is a linear brick with eight nodes at the vertices and two midside nodes between vertices.

4.3.1.3.9 Axisymmetric Conical Shell
An axisymmetric conical shell is a 3D element with a cross section that is a partial or complete conic shape.

4.3.1.3.10 Axisymmetric Triangular Ring
An axisymmetric triangular ring is a 3D element with a triangular cross section and a thickness along a vector that is perpendicular to the plane of the triangle.

4.3.1.3.11 Axisymmetric Trapezoidal Ring
An axisymmetric trapezoidal ring is a 3D element with a trapezoidal cross section and a thickness along a vector that is perpendicular to the plane of the trapezoid.

4.3.1.3.12 Rigid Body
A rigid body is an element that does not deform.

4.3.1.3.13 User Defined
A user defined element is a mechanism by which a user can create new 3D elements.

4.3.2 Mesh Specification
The following are mesh specification methods used to define the representation of the object being modeled.

4.3.2.1 Interactive
The cursor is used to interactively specify the nodes and elements by selecting geometry and indicating locations, one step at a time, in a user defined order.

4.3.2.2 Node Selection
An array of nodes are systematically selected to create a mesh.

4.3.2.3 Automatic 1D Elements on Curve
1D elements on a curve are created automatically by the program by indicating the curve and necessary parameters.

4.3.2.4 Automatic Region
A region is meshed automatically by indicating type, size, number and location of elements.

4.3.2.5 Automatic Region with Holes
A region is meshed automatically by indicating type, size, number and location of elements. A mesh is automatically fitted around the holes.

4.3.2.6 Automatic 2D Nodes on Surface
The program automatically generates 2D nodes on a selected surface.

4.3.2.7 Extrusion of 2D Nodes to 3D
The program creates a 3D array of nodes by copying a 2D array multiple times in a given direction.

4.3.2.8 Automatic 3D Nodes in Solid
The program automatically creates 3D nodes in a selected solid.

4.3.2.9 Copy
The copy function creates a new set of nodes by copying a set of nodes to a new location.

4.3.2.10 Mirror
The mirror function creates a new set of nodes by mirroring a set of nodes about a plane.

4.3.2.11 Rotate
The rotate function creates a new set of nodes by rotating a set of nodes about an axis or point.

4.3.2.12 Transition Region
The program automatically generates elements in a transition region where the type of element is changing. For example, a transition region may include bricks changing to pyramids to accommodate a change in shape of the model.

4.3.2.13 Merge Other Meshes
Merging other meshes is accomplished by joining contiguous meshes into a single mesh.

4.3.2.13.1 Auto-Remove Coincident Nodes
Coincident nodes which are nodes at the same location are automatically removed.

4.3.2.13.2 Automatic Renumbering
The program automatically renumbers nodes after an edit or change is made.

4.4 Loading
Loading is the process of indicating forces on the object.

4.4.1 Forces & Moments
Forces and moments are types of loads.

4.4.2 Constraints & Displacements
Constraints and displacements are boundary conditions that are allowed.

4.4.3 Temperature
Temperature is a boundary condition used in solving thermal problems.

4.4.4 Pressure
Pressure is an alternative method of specifying force loads.

4.4.5 Rotations
Rotation is an alternative method of specifying displacements.

4.4.6 Temperature Gradients
Temperature gradients are used to specify changes in temperature over a certain distance.

4.4.7 Copy
The copy function duplicates loading conditions at different specified locations.

4.4.8 Symbolic Assignment
Symbolic assignment is the use of symbols to indicate loading conditions.

4.4.9 Function Definition
Function definition is the use of a math function to indicate a loading condition. It is usually a function of time or distance.

4.5 Constraints
Constraints are used to specify the degrees of freedom at each node.

4.5.1 Single Point
Single point constraints are used to define constraints on a node by node basis.

4.5.2 Sets Constraint sets are used to assign repetitive constraint conditions to multiple nodes.

4.6 Material Specification Material specification provides material parameters that are required by a finite element analysis program.

4.6.1 Symbolic References
The program allows symbolic reference or reference to a material property by name.

4.6.2 Library Storage
A library storage facility allows material properties to be stored in a library. This library can be accessed by all models.

4.6.3 User Attributes
Material attributes can be defined by the user.

4.7 Editing The program allows editing or changing the model or its associated data.

4.7.1 Model Change Association
When the model geometry is changed the nodes, elements and other data automatically reflect the change.

4.7.2 FEM Operation Association
When a FEM node or element is changed the model is automatically updated.

4.7.3 Nodes
The following node editing operations are available to change nodes.

4.7.3.1 Move
Moving a node changes its location.

4.7.3.2 Delete
Deleting a node removes or eliminates a node.

4.7.3.3 Copy
Copying a node creates a new node with the characteristics of the old node.

4.7.3.4 Associated Data
The program allows editing of data associated with a node such as number, connectivity and boundary conditions.

4.7.4 Elements
The following element editing operations are available for editing elements.

4.7.4.1 Move
Moving an element changes its location.

4.7.4.2 Delete
Deleting an element removes or eliminates it.

4.7.4.3 Copy
Copying an element creates a new element with the characteristics of the old element.

4.7.4.4 Associated Data
The program allows editing of data associated with an element such as number, connectivity and boundary conditions.

4.8 Verification
Verification operations aid in checking correctness of a FEM model.

4.8.1 Coincidence
The coincidence operation highlights locations where there are two or more nodes.

4.8.2 Aspect
The aspect operation highlights any elements with aspect rations outside of a desired range.

4.8.3 Free Edges
The free edges operation displays any edges that are not completely contained in elements.

4.8.4 Interior Angles
The interior angles operation checks interior angles of elements to make certain they are in a desired angle range.

4.8.5 Element Warp
The element warp operation verifies the curvature of curved elements to make certain they do not exceed specified limits.

4.8.6 Element Shrink
The element shrink operation shrinks elements to aid in the verification of connectivity.

4.9 Output
Different formats of output results from the FEM program are required as input for a finite element analysis program. The following is a list of commercially available FEA programs with the exception of generic format which is easy to modify for other analysis programs.

4.9.1 Generic Format
4.9.2 ANSYS
4.9.3 NASTRAN
4.9.4 NASTRAX
4.9.5 SUPERB
4.9.6 STRUDL
4.9.7 SAP5
4.9.8 COSMOS
4.9.9 PREP7
4.9.10 COSMIC

4.10 Display Control
The following are display modes that control viewing of a FEM model.

4.10.1 Node Numbers
The node numbers control allows display of the nodes and their corresponding numbers.

4.10.2 Element Numbers
The element numbers control allows display of the elements and their corresponding numbers.

4.10.3 Element Colors
The element colors display mode displays different element types in different colors.

4.10.4 Material Numbers
The material numbers display mode displays the elements and their material numbers.

4.10.5 Highlighting
Highlighting accentuates nodes and elements based on various parameters by increasing the intensity of the display.

4.11 Results Display
Results display functions graphically display the output of the FEA program.

4.11.1 Static
Static displays are plots of pressure, stress, displacement and other responses calculated by the FEA program.

4.11.2 Dynamic
Dynamic displays are sequences of static displays that are displayed sequentially to simulate the time response.

4.11.3 Wireframe Displacement
Wireframe displacements are exaggerated or magnified to more clearly show the deformation of an object.

4.11.4 Color
Color is used to add an additional axis to a plot.

4.11.5 Shading
Shading is used to understand the shape of 3D surfaces that are used to represent results.

4.11.6 Contour
Contour plots represent curves of constant parameter value.

4.11.7 Value
Values are plotted in numerous types of charts and graphs.

4.11.8 Tabular
Tabular results represent the actual calculated numbers.

4.11.9 Animation
Animation displays the results of deformation as a function of time.

4.12 Mass Properties
The FEM program calculates mass properties of a model. These mass properties are weight, center of gravity and mass moments.

5. Data Management
Data management features allow user, item, part and project data to be stored, revised and managed.

5.1 System Management
The following system management features are used by the system manager to create and modify user names and related data.

5.1.1 Customization
Customization features allow the system to be tailored to meet the specific requirements of an individual, organization or company.

5.1.1.1 Data Structures
This customization feature allows data structures such as what data is stored or how much space is reserved for each piece of data to be user defined.

5.1.1.2 User Interface
This customization feature allows screens, forms, prompts

and messages to be tailored to match the requirements of an individual, organization or company.

5.1.1.3 Release Procedures
This customization feature allows sign-off, checking and archiving procedures to be tailored to match the requirements of an organization or company.

5.1.2 User Data
The following user data is stored for each user of the program or system.

5.1.2.1 Name
A name is stored for each user. This name is in addition to a system or program login name.

5.1.2.2 Hierarchy
Hierarchy of user data is grouping of users to form a logical organization consisting of groups and subgroups. Privileges and protections may be assigned to different hierarchy levels. Propagation of information to lower groups in the hierarchy may be automatic.

5.1.2.3 Passwords
Passwords are assigned code words which must be entered before permission is granted to log into the system or program. Passwords are also used to protect data and use of specific functions.

5.1.2.4 Account Numbers
Account numbers are used to store billing, project, work order or other reference information associated with a particular user.

5.1.2.5 Description
A description is used to store textual information associated with a user.

5.1.2.6 User Defined Data
User defined data fields of various types can be specified. They are associated with particular users of the program or system. For example, user defined data may include an employee number, phone number, mail stop, training courses completed.

5.1.3 User Create/Modify Privileges
The following features allow distribution and management of functions and operations that can be performed by different users.

5.1.3.1 User Create/Modify
This feature controls the ability to create a new or alter an existing user name.

5.1.3.2 Groups
This feature controls the ability to create a new or alter an existing group.

5.1.3.3 Nongraphic Attributes
This feature controls the ability to create a new or alter an existing nongraphic attribute.

5.1.3.4 Models
This feature controls the ability to create a new or alter an existing model or part.

5.1.3.5 Projects
This feature controls the ability to create a new or alter an existing project.

5.1.3.6 Libraries
This feature controls the ability to create a new or alter an existing library.

5.1.3.7 Privilege Grouping
Privilege grouping is the ability to logically associate a series of privileges so they can be assigned in a single operation.

5.1.4 Data Controlled
The following types of data may be regulated, tracked and recorded by the program.

5.1.4.1 Models
This features controls the collection of items in a part or assembly.

5.1.4.2 Libraries
This feature controls the collection of symbols or parts that can be stored and retrieved to use in the current part.

5.1.4.3 Projects
This feature controls the collection of parts, libraries and other data associated with a particular project.

5.1.4.4 External Data
This feature controls data not created or manipulated directly by the CADD system.

5.2 Nongraphic Data
Nongraphic data features allow creation and manipulation of nongraphic data associated with an item, part, symbol, part library item or project.

5.2.1 Data Stored
The following types of data can be associated with an item, symbol, part library item or project.

5.2.1.1 Name
A name is a group of characters identifying a particular item, symbol, part library item or project. The number of characters allowed for a name should be long enough to accommodate most company practices and standards.

5.2.1.2 Layer
A layer is a logical attribute shared by items. These items usually have a similar function in a drawing or design. The program has the ability to query or retrieve data on different layers.

5.2.1.3 User Defined
User defined nongraphic attributes can be used to store data tailored to a companies specific requirements.

5.2.1.3.1 Numeric
A user defined nongraphic numeric attribute is an integer or real value, for example, weight, cost, size, etc.

5.2.1.3.2 String
A user defined nongraphic string attribute is character data, for example, part description, part specifications, assembly instructions, etc.

5.2.1.3.3 Discrete
A user defined nongraphic discrete attribute may only be a value selected from a limited set of choices such as color, size, finish, etc.

5.2.1.3.4 Attribute Grouping
Attribute grouping allows a set of attributes to be logically grouped so they may be easily assigned to items in one operation.

5.2.2 Reporting
The following reporting features allow nongraphic data to be extracted, displayed or printed.

5.2.2.1 Query Language
A query language allows interactive data extraction using text based commands which filter, sort and manipulate the data.

5.2.2.2 Query Functions
Query functions allow interactive data extraction using menus or forms which filter, sort and manipulate the data.

5.2.2.3 Program Access
Program access is the ability to extract nongraphic data using user written external programs. Vendor subroutines are provided for data access.

5.2.3 Modification
The following modification features allow nongraphic data to be altered.

5.2.3.1 Interactive
Interactive modification of nongraphic data is accomplished using a graphic or command based system. User intervention is constantly required.

5.2.3.2 Batch
Batch modification of nongraphic data is accomplished by specifying a number of changes that are to occur in a file. The program then processes all changes at once.

5.2.3.3 Security Control
Security control allows all or part of the nongraphic data stored on a system to have security restrictions differing from that of an associated part.

5.2.3.4 Program Access
Program access is the ability to alter nongraphic attributes using an external program. The program, written by an end user, uses vendor supplied subroutines.

5.3 Part Management
The following part management features deal with data associated specifically with parts on a system.

5.3.1 Data Stored
The following types of data are stored on a part by part basis.

5.3.1.1 Identification Data
The following data assists in specification or categorization of parts.

5.3.1.1.1 Names
A name is a string of characters that uniquely identify the part.

5.3.1.1.2 Project
Project data is associated with a part being worked on for the same design or purpose.

5.3.1.1.3 Classification
Part classification relates a part to other parts similar in design, shape, function and material.

5.3.1.1.4 User Defined
User defined identification data is specified by the user to meet specific requirements.

5.3.1.2 Revision Data
Revision data is used to track design changes during the design and release process.

5.3.1.2.1 Version
The version of a design or drawing is a numeric or alphanumeric identifier that is updated each time a change is made.

5.3.1.2.2 Status
The status of a design or drawing reflects its current state, for example, in review, frozen, release, etc.

5.3.1.2.3 History
The history of a design or drawing is a cumulation of modification dates and the user name of the person doing the modification on a design or drawing.

5.3.1.2.4 Comments
Comments such as reasons for change or ECO reference are part of revision data.

5.3.1.2.5 Notification Lists
Notification lists of persons to be notified in the event of a design or drawing change are maintained.

5.3.1.2.6 Sign-Off Lists
ign-off lists of persons required to approve a particular design at a specific stage in the approval cycle before the design or drawing can proceed to the next stage is available.

5.3.1.2.7 User Defined Data
User defined revision data which is tailored to the specific requirements of an organization or company is allowed.

5.3.2 Access Security
Access security features control access to parts on a system.

5.3.2.1 User Name
Access to a part is keyed off the user name.

5.3.2.2 Group
Access to a part is keyed off the group in which a user belongs.

5.3.2.3 Password
Access to a part is keyed off a password which is a specified series of characters. The password must be entered correctly before a user can gain access to the part.

5.3.2.4 Multiple User
Multiple user access allows parts to be accessed by more than one person at a time. Provisions should be made to make certain only one person can update the part at one time.

5.3.3 Functions
The following data management functions are for part models and drawings.

5.3.3.1 Check In/Out
Check in/out is the process of electronically signing out a part to work on, much the same as checking a book out of a library. After the work on a part is complete it is checked back in. Parts can generally be checked in and out for reading only, reading and writing, appending, etc.

5.3.3.2 Status Check
Status check functions verify the current information about a part, for example, who is working on it, when it was last changed, whether or not it is released, etc.

5.3.3.3 Revision Review
The revision review feature clearly highlights changes that were made for a revision. This aids in the review or checking process.

5.3.3.4 Sign-Off
A sign-off feature allows a part to be electronically approved by a selected group of people.

5.3.3.5 Archive
The archive function allows a part to be stored and cataloged on tape, optical disk or other storage media.

5.3.3.6 Locate
The locate function quickly finds a part regardless of the storage location.

5.3.3.7 ECO Generation
ECO (engineering change order) generation is the process of initiating and tracking changes in drawings. This process is tightly coupled to the designs being effected by the ECO.

5.4 Report Generation
Report generation features allow various summaries of system and part management data to be extracted.

5.4.1 In Process
The in process report lists parts that are checked out and are currently being created or modified.

5.4.2 Accounting
Accounting reports list CPU (central processing unit) time,

elapsed system time, disk utilization and other data which might be used to track project costs.

5.4.2.1 User
ccounting reports can be sorted by user name.

5.4.2.2 Group
Accounting reports can be sorted by group.

5.4.2.3 Model
Accounting reports can be sorted by model or part.

5.4.2.4 Project
Accounting reports can be sorted by project.

5.4.3 Bills of Material (BOM)
Bills of material itemize quantities of parts in assemblies. They usually list a part number and a description along with the quantity of each part.

5.4.4 Where Used
A where used report lists all of the parts or models in which a particular part or assembly is used.

5.4.5 User Query
A user can query the system to find a particular part or drawing.

5.4.6 ECO Tracking
ECO tracking is an automated process for checking the status of parts and assemblies effected by an ECO.

5.5 Data Transfer/Communications
Data transfer and communications allow data to be moved between different or similar hardware and/or software systems.

5.5.1 Model Translation
Model translation is the transformation of a CADD data base to and from its native form into an alternate form. The following are different types of model translation formats.

5.5.1.1 IGES IN
GES (Initial Graphics Exchange Standard) IN allows certain item types to be taken from an IGES representation to the programs native data base representation. These items may then be accessed using regular program functions.

5.5.1.2 IGES OUT
GES OUT allows certain item types to be taken from a programs native data base representation to an IGES representation. These items may then be read in by another CADD program running IGES IN.

5.5.1.3 Generic IN
Generic IN allows certain item types to be translated from an ASCII file with a specific format to the programs native data base representation. These items may then be accessed using regular program functions.

5.5.1.4 Generic OUT
Generic OUT allows certain items types to be taken from a programs native data base representation to an ASCII file. These items may then be read in by another CADD program running Generic IN.

5.5.2 Intermachine Transfer
Intermachine transfer allows part data to be moved between dissimilar machines. This data may have been created on a different operating system or file system or may have different internal data representation.

5.5.3 User Notification
User notification allows communication between users of a system working on different terminals or workstations.

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