THE USE OF GABLE OMS (OBJECT MODELLING SYSTEM) IN THE BUILDING DESIGN PROCESS

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GABLE CAD SYSTEMS comprise a suite of integrated sub-systems, one of which is OMS. The use of OMS in the development of a building design enables three dimensional graphical modelling of objects associated with buildings. Thus furniture, fittings and fixtures may be located within any room in a building or outside a building or in relation to other groups of objects unrelated to a building. Once located, objects and building may be seen in 2D plan and elevation/section projection or 3D projection (perspectives, axonometrics, isometrics, etc.) In this way furniture, people, cars, trees, landscape objects may all be modelled and graphically represented in addition to the modelling capabilities enabled using GABLE BMS (Building Modelling System). These graphically represented 2D and 3D views of objects can then be passed into GABLE IDS for further embellishment, annotation or dimensioning to produce detailed working drawings.

The presentation studies the use of OMS in relation to the design of a Brewery. GABLE BMS is used to model the building; OMS is used to model all the internal plant and equipment together with external landscape features; IDS is used to generate the final detailed design drawings. The paper describes the philosophy behind the design of GABLE articulated in terms of these three sub-systems.

INTRODUCTION

GABLE - Graphical Aids for Building Layout and Evaluation - is the name given to several integrated computer aided architectural design (CAAD) systems now available to architects.

The computer can now usefully fulfil many roles in the architectural design office of which perhaps the most well recognised are two-dimensional drafting, three-dimensional visualisation and building performance calculations. Any good CAAD system should integrate these three roles to avoid unnecessary duplication of input.

GABLE articulates these roles in terms of the following:

IDS - Integrated Drafting System is a 2D drafting system which may be used independently from other GABLE systems but which enhances the power of these other systems when used with them.

BMS - Building Modelling System - enables three dimensional visualisation and building performance modelling and generates automatic input to IDS.

OMS - Object Modelling System - enables three dimensional visualisation of objects typically representing furniture to be seen in relation to the building model. The system may also be used independently from other GABLE systems.

GMS - Ground Modelling System - enables site survey data to generate a three dimensional model of the site which may be used to generate automatic input to IDS and onto which buildings modelled with BMS and OMS may be located

Diagram 1 illustrates the integrated relationship of these separate systems. The concepts behind the design of these systems will now be discussed in more detail in order to provide a sound understanding of why and how GABLE is different from other CAAD systems.

BMS (See Diagram 2)

GABLE BMS provides simple two dimensional input techniques to enable designers to describe their buildings to the computer by means of conventional sketch plans which can be altered or accurately dimensioned later.

GABLE BMS is further provided with software which interprets these sketch plans and develops a full three-dimensional model of the interior of every space and the external skin of the building. Finally, GABLE is able to use this interpreted three-dimensional model for perspective and other visualisation drawings, for building performance evaluation such as energy, daylighting and solar penetration studies, and finally to generate co-ordinated conventional two dimensional drawings such as plans, elevations and sections, which are passed into IDS.

Information Input

The problem of getting the computer to understand a building three-dimensionally as a building, not just as a collection of abstract drawings, is made considerably more difficult if architecture is seen, as realistically it must be, as an organic process rather than purely one of component assembly. The latter view is of course quite acceptable when working with grid planned, dimensionally co-ordinated system building, but not all buildings are constructed that way. The existing building stock, which we must maintain, re-use and extend, is often irregular in form and reliant on traditional constructional techniques. A satisfactory computer system cannot rely upon such artificial restrictions as planning grids or assumptions of rectangular form and component assembly.

Solution evaluation studies by definition take place before the design is finished and often before many characteristics of the final solution are known. We are thus faced with the problem of designing computer systems which can understand not just finished solutions but emergent, ill formed and incomplete building designs. The designer must be able to describe his solution to the computer gradually as it develops. Since no two designers work in quite the same way and no two design problems are precisely the same, it is reasonable to assume that our system must be able to accept information in virtually any sequence and allow the designer to change any aspect of his design at any stage.

This requirement has profound implications for the kinds of data structures which such computer programs must establish. When a designer is sketching during design, components of the solution may not only disappear but may be moved around or change in size, shape and construction. As a result of these changes such components may change in their topological relation to other elements in the solution. For example, a window may not only be changed in size and shape but may be moved so that it lies in a different wall. Such a movement may cause the window to be in a different elevation even though opening into the same room, or alternatively the window may change rooms but remain in the same elevation.

Thus an analysis of the date required to describe a particular building element shows it to consist of three quite distinct forms of information. We shall call these LOCATIONAL, SPECIFICAIIONAL and RELATIONAL, and explain them by reference to a simple window. The locational data quite simply describes where the window is in space. The specificational data describes the performance characteristics of the element. In the case of a window this would normally include the width and height, glazing pattern and frame material. The third, and by far the most problematic and interesting kind of data, relational, describes how the element fits into the building as a whole. In the case of our window this would include the wall in which it is found, the space into which it looks and perhaps the elevation to which it belongs. The part of BMS which generates this relational data entirely automatically is called MIDAS.

A further analysis of building elements shows that there are three geometrically distinct categories of element, which are normally specified in quite different ways according to the manner in which they fit into the building. To illustrate this principle we shall take as examples a window, a wall and an eaves. During construction, the window will normally be offered up into the building as a complete pre-assembled unit. It can therefore be specified geometrically in all three dimensions with its width, height and thickness defined. A wall, however, is often a different proposition. Normally we specify a wall by drawing a typical cross section defining the thicknesses and relations of its constituent layers. Many walls in the building may share this common section while having quite different shapes in elevation. We similarly use a cross section to define elements such as an eaves detail. However, unlike the wall these linear elements can only vary in length while all dimensions shown in the section remain constant.

In buildings then we encounter three kinds of elements; UNIT assemblies such as windows and doors, SURFACES such as walls and floors and LINEAR elements such as eaves or balustrades. Early computer aided architectural design systems have only allowed users to define units, that is geometrically fully defined elements. Such systems work well for system building, where the construction process is indeed largely a matter of assembling components, but are quite inadequate for more traditional or flexibly designed buildings.

This then brings us to how the computer is to be instructed by the designer about the locations, specifications and relations of all the building elements. To achieve a high level input technique BMS seeks to use a method of describing the building to the computer which resembles, as closely as possible, the method which would be used by the architect without a CAAD system to describe his building to other members of the design team. Normally, he would describe locational data by means of drawings, frequently two-dimensional and usually a plan view. Specificational data is usually described separately in text or annotated drawn form in schedules with cross references to the drawings. Interestingly, relational data is largely not described explicitly at all, but rather is derived by those looking at all the drawings. Members of the design team can tell simply by looking at a floor layout, in which room or elevation a window belongs and can find the same window on plans, sections, elevations or perspective views.

MIDAS

MIDAS consists of three parts: ISAAC, RODIN and SAGE.
In GABLE, MIDAS represents the perceptual ability to look at two-dimensional layouts, relate them to specifications and to other drawings and deduce the three-dimensional interrelatedness of all the elements. The objective in designing MIDAS was that it should not ask questions of the user which would seem unreasonable if they were asked by another architect looking at the plans. In fact MIDAS takes the single line diagrammatic layouts input by the user and combines these with the various building elements specifications to generate three-dimensional models of the outside skin and inside of interior spaces. This joint designer computer synthesis of a building model works as follows.

The designer generates all the locational data needed about the building by inputting three kinds of drawings; floor layouts, roof layouts and elevations. These drawings parallel the conventional architectural design drawings and are usually created in the order listed here, but need not be. Not all of the drawings are needed before MIDAS can begin work, and for sketch design stage the elevations may not be needed at all as will be shown later.

Floor Layouts

The floor layouts may include external walls, interior partitions, windows, doors and floors. The command structure allows for these elements to be added, deleted, moved, respecified, redimensioned and, in most cases repeated. In general, elements are located by pointing either with the screen cursor or digitising plotter pen and then pressing an alphabetical key. The key pressed is deemed to represent the specification to be attached to that element.

Walls are drawn simply by indicating either end of the centre line. Windows and doors are located in walls by pointing to their centre. The floor is assumed by the system to occupy all of the area inside the external wall and to be of the same specification and height throughout. However, the user can add any irregular polygonal shape of floor panel

and associate with this different heights or specifications.
Alternatively, any room can in its entirety be so altered with the additional facility of raising or lowering the ceiling. When drawing around a floor panel the specification keys pressed for each line are taken to be that particular "edge" or balcony thus associating details such as upstand or downstand walls and handrails with each line. Complete rooms or floor panels can similarly be removed altogether thus allowing for any combination of stepped platforms, mezzanines and multistorey spaces.

ISAAC - Interior Spaces Assembly and Contents

Once floor plans have been so created and stored MIDAS is able to operate the space modelling routine ISAAC. ISAAC examine the relationships of all the external and internal walls and from these develops an outline in plan of each space, taking account of the thicknesses of the walls. ISAAC also allows for the possibility that spaces may have more than one boundary in plan as with courtyards or internal partitions which are entirely freestanding within the space. It is of course also possible for spaces actually to contain other spaces in the manner of Russian dolls. At this point ISAAC has allocated all the internal faces of external walls and both faces of partitions to their appropriate spaces. It is therefore possible next to identify the spaces to which openings such as windows and doors will belong. Finally, ISAAC associates any floor panels with their spaces and also considers openings in the ceiling resulting from holes in the floor above. At this point, the interior space model for the floor level is complete and the user can run programs such as interior perspectives or daylighting studies which rely on that data.

Roof Layouts

Roof layouts are created in a similar manner to floor layouts except that the element added is the roof plane which is shown bounded by eaves, verge, ridge, hip or valley lines. Of course the user must also give some information about the section of the roof and this is done. either by adding heights to points of intersection or giving pitches to planes or a combination of the two as the designer finds most convenient

RODIN - Roof Design Interpretation

As with floor layouts MIDAS is able to build a three-dimensional model of the roof, this time using the roof interpretation routine RODIN. In fact, RODIN also allows the designer the luxury of not accurately positioning fold lines such as ridges, hips and valleys since the precise locations of these are calculated from the intersections of the roofplanes. All that RODIN requires is that the equation of each roof plane is soluable either because at least three points have been given both plan locations and heights or because at least two points and a pitch are supplied. RODIN will operate interactively using planes already calculated to supply information about points to enable further planes to be calculated, and so on. RODIN, for example, assumes all points on eaves lines to be fixed in plan location and eaves and ridge lines to be horizontal, so that heights of points calculated on one end of such lines can be transferred to any other points on the line. If RODIN finds either insufficient or conflicting information, error messages indicating the nature of the problem related graphically to locations on the roof plan are made available to the designer.

SAGE - System for Analysing the Geometry of Exteriors

A third routine in MIDAS automatically operates as each floor layout is stored, to create crude projected elevations. SAGE in fact simply generates a vertical rectangle for each external wall drawn in plan with the height of the rectangle set to the overall floor to ceiling height assigned to that floor level. This means that the designer is able to generate rough three-dimensional output about the exterior, such as block perspectives having only drawn floor plans. In sow cases these SAGE generated elevations will be very nearly correct, whilst in others typically, for example, a gable wall, the user may wish to draw on accurate elevational shapes. For final detailed design and production drawings these finished accurate elevations will usually be needed. However, at early sketch design stage, before the final building form has emerged, the designer can rely entirely on SAGE generated elevations and thus create 3D visualisation drawings from very simple plan input.

Elevations

Elevations are added in a similar way to roof plans except that all planes are assumed to be vertical. The user indicates which elevation is to be added by pointing to a key plan. GABLE will then display an elevation from that direction showing all the SAGE generated elevations and the roof planes if they exist. The designer can then draw on any number of planes. These planes may be given their depth (into the screen) and specification manually or more normally, by pointing to the appropriate SAGE elevation or fascia displayed by GAELE. The designer can also call for a section to be taken through the building at any depth to assist in this process.

Those parts of the GABLE system which allow for the inputting of floor layouts, roof layouts and elevations, also enable the user to reposition, redimension and respecify elements. MIDAS continually monitors the alterations made by the designer to the building and will re-run only the necessary routines on the relevant areas of the building to reestablish the complete three dimensional model required for the evaluative software. In addition MIDAS will, if requested, create neat and dimensionally faithfull two-dimensional drawings such as floor plans or roof plans and elevations, sections and room elevations all entirely automatically from the three dimensional model. These drawings, unlike the single line diagrams input by the user, obey architectural graphics conventions for example showing the thicknesses of elements, using different pens to emphasise major sectional lines and include hatching. The part of BMS which generates these drawings entirely automatically is called MIDAS GRAPHICS.

OMS (See Diagram 3)

In any building there are likely to be many objects which we only wish to represent graphically. For example, furniture is unlikely to feature in any evaluative software such as structural or thermal calculations. However, we would like to see the furniture both in 3D views such as interior perspectives and in 2D projections such as plans or room elevations.

illustrated on diagram 4.

As has already been described MIDAS GRAPHICS is a routine in GMS, BMS and OMS which entirely automatically generates graphics files representing plans, sections, elevations, perspectives of sites, buildings and objects. These OUTPUTS feed into IDS which may then be used to modify files, annotate them, generate other files overlaid onto them allowing for the creation of fully detailed production drawings. Unlike conventional 2D drafting systems however this technique ensures that all drawings tell the same three dimensionally co-ordinated story. That is the plans, elevations and sections and perspectives are all consistent. As the design develops and changes are made this consistency can be maintained by the designer modifying not the drawings themselves but the three dimensional computer model. MIDAS will then recreate the drawings from this model. Thus, if a wall is to be moved this requires a single act on the designer's part in adjusting its position in the original input floor plan. MIDAS will then re-establish the three dimensional building model and all subsequent drawings as well as building evaluations will show the change.

Thus we find that the use of three dimensional building model brings benefits of reduced manual effort in updating drawings as well as the expected advantages of related three dimensional visualisation and building evaluation capabilities.

This powerful automatic link between a performing and visual model and a drafting system is a feature unique to GABLE. The reverse of this link enables any graphics file whether created by MIDAS GRAPHICS or by the USER to be used as a reference drawing when using GMS, BMS and OMS. For example any one of a site plan, grid plan, floor plan, roof plan, furniture layout, surrounding townscape or any other graphics file may be used as a reference drawing with respect to which floor layouts, roof layouts, room layouts and site layouts may be designed.

In GABLE objects are generated from cuboids which can either be distorted to form polyhedral primitives or be embellished graphically. These cuboid BLOCKS may be grouped into ASSEMBLIES which may then be located in any room in the building or outside the building using BMS or located on the site using GMS. In the case where OMS is used with BMS, MIDAS automatically associates assemblies of objects with the room in which they are found and will generate perspectives, elevational and sectional views of them as appropriate when creating drawings of the building. MIDAS GRAPHICS will also generate plans, sections, perspectives of assemblies which may then be used with IDS. This system is illustrated in diagram 3.

It can be seen from studying this diagram that while OMS can be used separately to model objects unrelated to buildings or sites it is also integrated with IDS, BMS and GMS, IDS feeds into OMS on two levels. Firstly existing graphics files can be used in designing block faces; secondly graphics files can be used as reference drawings when designing assemblies (e.g. site plan, floor plan, room plan, grid). OMS feeds into BMS and GMS by nominating a room inside the building or outside the building or the site to be the location for an assembly. OMS feeds back into IDS through the MIDAS GRAPHICS route.

<u>IDS (See Diagram 4)</u>

IDS is a powerful 2D drafting system which enables the full range of architectural drafting facilities including full text annotation and dimensioning of drawings. Drawings may be easily assembled from three graphical elements. SHAPES, LINES and ARCS. Previously stored DRAWINGS may be incorporated as whole elements into a new drawing, patches of a drawing may be manipulated (i.e. deleted or moved) in relation to the rest of the drawing so that considerable flexibility exists for generating new versions of old drawings or entirely new drawings.

However, in addition to these conventional facilities IDS has important INPUTS to BMS and OMS and receives equally important OUTPUTS from GMS, BMS and OMS which considerably enhance the power of IDS. These integrated links between GABLE IDS and other GABLE systems are illustrated on diagram 4. As has already been described MIDAS GRAPHICS is a routine in GMS, BMS and OMS which entirely automatically generates graphics files representing plans, sections, elevations, perspectives of sites, buildings and objects. These OUTPUTS feed into IDS which may then he used to modify files, annotate them, generate other files overlaid onto them allowing for the creation of fully detailed production drawings. Unlike conventional 2D drafting systems however this technique ensures that all drawings tell the same three dimensionally co-ordinated story. That is the plans, elevations and sections and perspectives are all consistent. As the design develops and changes are made this consistency can be maintained by the designer modifying not the drawings themselves but the three dimensional computer model. MIDAS will then recreate the drawings from this model. Thus if a wall is to be moved this requires a single act on the designer's part in adjusting its position in the original input floor plan. MIDAS will then re-establish the three dimensional building model and all subsequent drawings as well as building evaluations will show the change.

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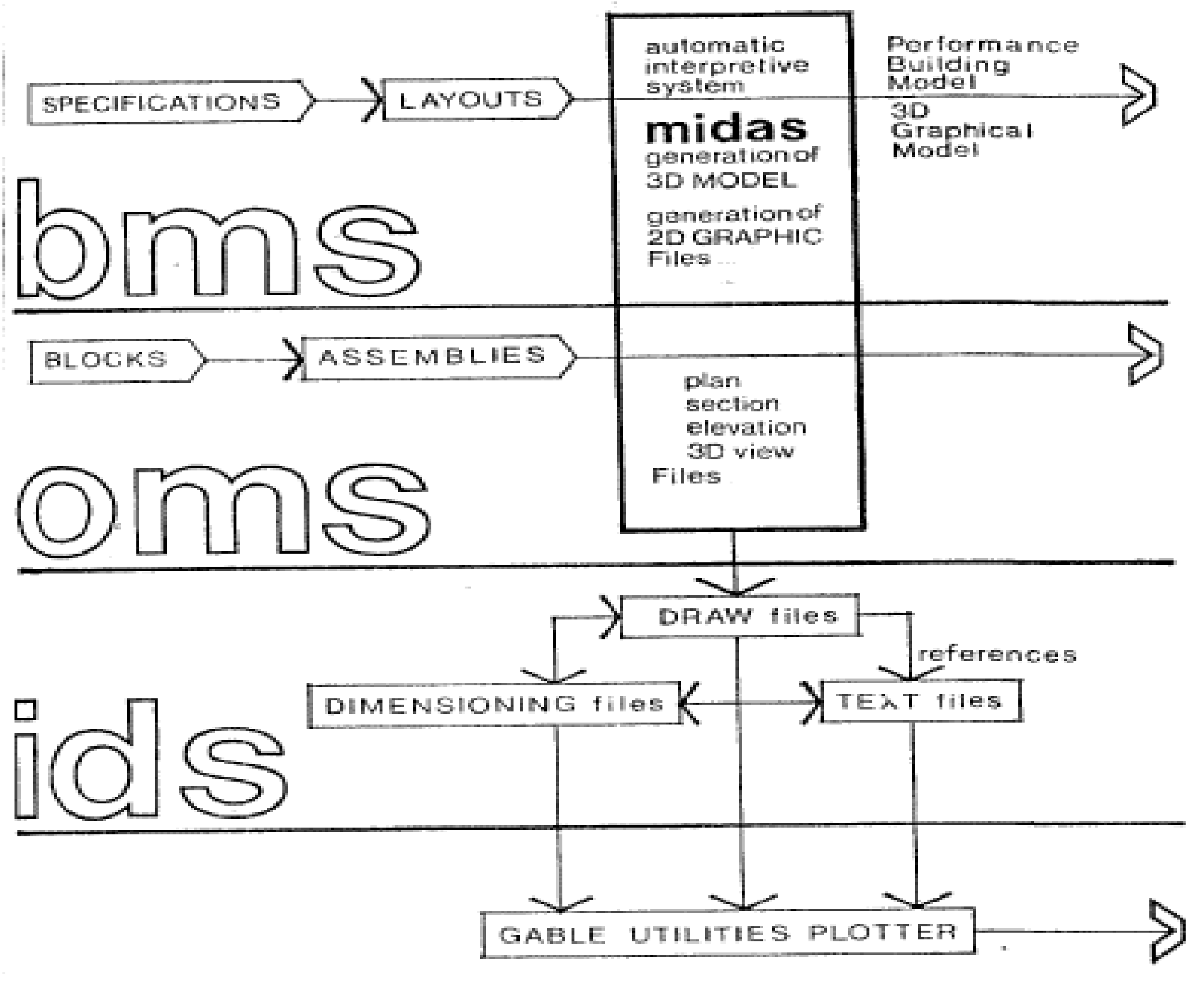
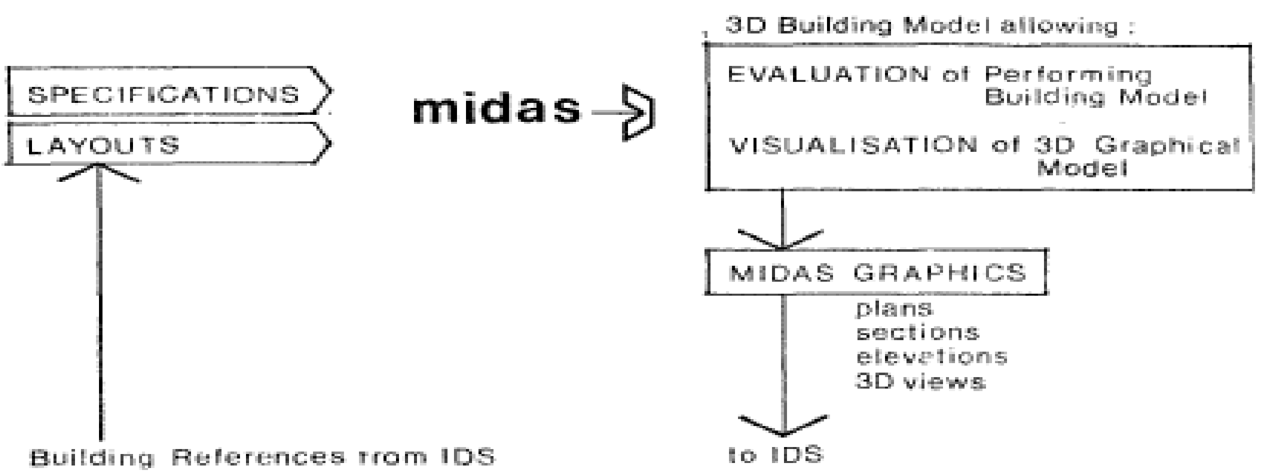


gable VERSION 2

UTILITIES
GMS (ground modelling system)
BMS (building modelling system)
IDS (integrated drafting system)
OMS (object modelling system)

diagram 1



Building Modelling System

300 MIDAS ISAAC/RODIN
310 MIDAS GRAPHICS
311 MIDAS TEXT

320 FLOOR LAYOUT
321 ROOF LAYOUT
322 ELEVATION LAYOUT
323 ELEV/SECT LINE LAYOUT
324 ROOM LAYOUT

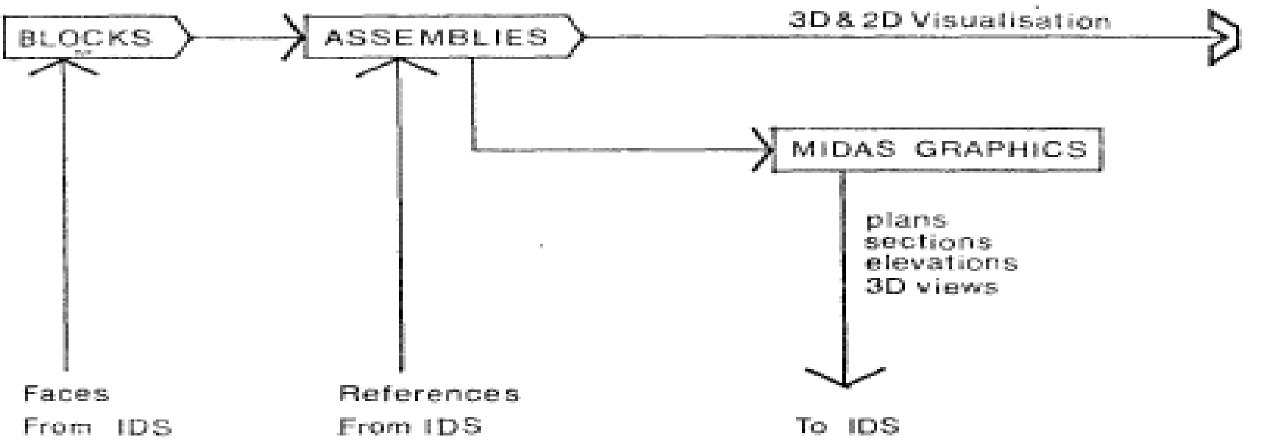
330 SPACES
331 EXTERIOR PERSPECTIVES
332 INTERIOR PERSPECTIVES

370 SURVEYOR
371 PART F/FF BUILDING REGS
372 HEAT LOAD

390 WINDOW/DOOR SPECIFICATI
391 SURFACE SPECIFICATION
392 EDGE SPECIFICATION

bms

diagram 2

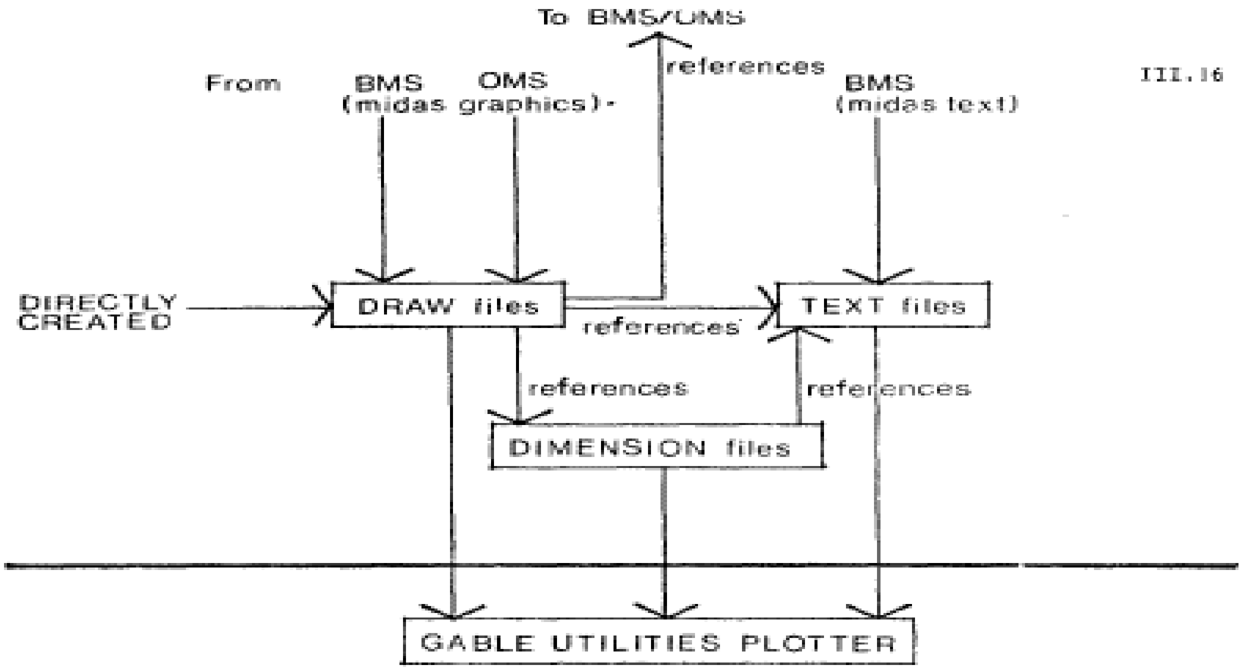


Object Modelling System

500 BLOCKS
501 ASSEMBLIES

oms

diagram 3



Integrated Drafting System

400 DRAW LAYOUT
401 TEXT LAYOUT
402 DIMENSIONS LAXOUT

ids

diagram 4

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