DIGITAL RECORDING, DOCUMENTATION AND CONSERVATION FOR BYZANTINE MONUMENTS USING A PC-BASED SIS

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ABSTRACT

A SIS (Spatial Information System) application is developed for the purpose of recording, documentation and conservation of Byzantine monuments and particular for Byzantine churches, while the open structure of the application can easily be adjusted for applications regarding other kind of monuments. Extensive care is exercised on topology and terminology regarding the kind of monuments used in this application. The monuments are grouped in a number of categories and feature-levels and this classification is used in SIS tabling.

1. INTRODUCTION

In the current paper a SIS system is proposed that is based on data related to monuments and particular to Byzantine churches. Intergraph's MGE-PC GIS s/w on MicroStation PC CAD environment is used as the implementation platform of the application. Mapping and SIS data are organized into a project (ByzMN.mge) that contains three basic parts: maps and drawing files, database information and multimedia data. The MGE-PC uses a relational database management system which requires that all non-graphic data (i.e. database information and multimedia data) be contained in database files known as **tables**. The ByzMN.mge project consists of **system tables** related to categories and feature-levels of the monuments and of **attribute tables** related to particular structural elements used in Byzantine monuments.

Despite the fact that the SIS application is organized - for documentation and conservation purposes - having in mind Byzantine monuments-churches, any kinds of monuments are supported by its open environment. In this case the user has to adjust the categories and extend the feature-levels and attribute tables.

Documentation of rescue archaeological excavations regarding Byzantine monuments could also be supported. Combination of terrestrial photogrammetry and SIS systems speeds up recording and documentation of archaeological excavations, reduces their cost, introduces new quality in this process and conserves data recording for future study as meta-data.

The state-of-the-art information technology (like SIS, GIS, digital photogrammetry and multimedia systems) facilitates the recording and documentation of more than the material monument data. The social influence and significance of the monuments can now also be recorded and demonstrated (Ogleby C., 1995).

2. GIS ANALYSIS - DATA ORGANIZATION AND CLASSIFICATION

The geographic information for Byzantine churches is divided in three main parts. The **graphic information** (maps, drawings, etc), the **text information** (documents, texts, reports, etc) and the **multimedia information** (photos, sounds, videos, animation, walkthroughs). In GIS environments, like Intergraph's MGE-PC, graphic information in digital form is stored in graphical files known as **Digital Maps**, whilst text information in ASCII or binary form is stored in databases using **Tables** and multimedia information in digital form is stored in **Media Files** (wav, avi, fli).

2.1 Digital Maps

The **Digital Maps** for the Greek Byzantine monuments are grouped *geographically* in six **categories** according to Antriano Alpago Novello & George Dimitrokallis (Novello A., et al., 1995) (i.e Northern Greece (mainly: City of Thessaloniki), western continental Greece (mainly: city of Kastoria), south Greece and islands, the island of Chios, St Mount Athos, and St Meteora) and *thematically* in ten **categories** (cemeteries, crypts, sketes, churches, baths, monasteries, graves, chapels, towers and tombs). The relationship between the members of these two groups is N-to-N, for instance for the category Chios there are digital maps for byzantine churches, baths, monasteries and graves, whilst for the category byzantine churches there are digital maps in all these six geographic areas.

On the maps and for each thematically oriented category there is a number of monuments (**features**) enrolled in the project as **GIS-features or geographic elements** which are related to particular objects-byzantine monuments of the current category. These monuments-features are grouped in feature-levels according an approved typology (Vocotopoulos P., 1987).

This layering system operates well and the maximum number of the feature-levels depends on the GIS platform used. For instance for MGE-PC on MicroStation PC CAD platform this number is 63, i.e. the number of layers (levels) supported by this CAD s/w. In the current project (ByzMN.mge) and for the category Byzantine churches there are thirty three (33) feature-levels according to Bouras Ch., 1994 and Gioles N., 1992 (see: Table 1).

Geographic Index Files

The following six Geographic Index Files are used for feature-level grouping as far as the Byzantine monuments category is concerned:

- Early-Christian Monuments (First-Christian period: up to 312)
- Old-Christian Monuments (312-527)
- Justinian Age Monuments (527-600)
- After Justinian Age Monuments (600-850)
- Middle-Byzantine Monuments (850-1204)
- Late-Byzantine Monuments (from 1204 on)

Using the indexing technique the retrieval process is speed up and a semi-spatio temporal SIS is introduced (for chronology related subjects see: Megaw A., 1931-1932 and Krautheimer R., 1965).

The following two Geographic Index Files are used for Byzantine monuments category grouping:

- Thematical group of categories
- Geographical group of categories

The Monuments Categories:

A. Roman
B. Venetians (included Veneto-Byzantine)
C. Gothic
D. Ottoman (Islamic, Muhammedan)
E. **Greek**
F. Egyptian
G. Buddhistic
H. Romanesque (8th-12th century)
I. Slavic

The Greek Monuments Categories:

E1. Archaic Greek
E2. Early Greek
E3. **Greek Byzantine**
E4. Modern Greek

The Geographically related Categories for Greek Byzantine Monuments:

Northern Greece (mainly: City of Thessaloniki)
Western Continental Greece (mainly: City of Kastoria)
South Greece and Islands
The island of Chios
St Mount Athos
St Meteora

The Thematically related Categories for Greek Byzantine Monuments:

1. Byzantine Cemeteries
2. Byzantine Crypts
3. Byzantine Sketes
4. **Byzantine Churches**
5. Byzantine Baths
6. Byzantine Monasteries
7. Byzantine Graves
8. Byzantine Chapels
9. Byzantine Towers
10. Byzantine Tombs

1. Early-Christian Cemeteries	Early-Christian Churches
2. Early-Christian Crypts	(up to 312)
3. Simple Dromedary Basilicas	Old-Christian
4. Cross-Aisled Basilicas (type A,B,C,D)	Churches
5. Cruciform Basilicas	(312-527)
6. **Centralized Churches** (circular, octagonal)	
7. **Domed Basilicas**	Justinian Age Churches
8. Octagonal Churches	(527-600)
9. Basilica Order Churches	After Justinian Age
10. **Basilica with Dome Churches**	Churches
11. Single-Space Domed Churches	(600-850)
12. **Cruciform domed Churches** (Cross-Shaped Churches)	
13. Greek Cruciform inscribed domed eight-pillared Churches	
14. Greek Cruciform inscribed domed transitive Churches	
15. Mid-Byzantine Basilicas	Middle-Byzantine Age
16. Single-space dromedary Churches	Churches
17. Free-cross shaped domed Churches	(850-1204)
18. Single-space triconch domed Churches	
19. Tetraconch domed Churches	
20. Cruciform semi-inscribed domed Churches	
21. Circular domed Churches	
22. Churches with dome and loggia	
23. Transitive Cruciform Inscribed domed Churches	
24. **Cruciform inscribed domed (complex)**	
25. Cruciform inscribed domed (semi-complex)	
26. Inscribed Cross-like with dome (with 4 Pillars)	
27. Inscribed Cruciform domed (with 2 Pillars)	
28. Inscribed Cruciform domed (with 2 Columns)	
29. Inscribed Cruciform domed (a special case)	
30. Inscribed Cruciform domed (concise)	
31. Cross-shaped sheltered domed Churches	
32. Complex Octagonal Churches	
33. Simple Octagonal domed Churches	

Table 1. The Feature-Levels for Byzantine Churches Category.

2.2 Tables

In SIS project, **feature** is any monument (church) that is represented graphically on a map. An unlimited number of features can be placed in the project, but only 63 kinds-of-features in each category. Each kind-of-feature in a category should be stored on a different drawing level, which in MGE-PC is called a **feature-level**. This layering spports the display of any given combination of features on a map.

Feature information is stored in **Feature Tables** (see: Table 2). The feature tables can be created and populated using appropriate MGE-PC GUI commands. The following table is a representation of the relevant columns of the feature table used in ByzMN.mge SIS project. For instance the records for a 13th century byzantine church and for the four most important Greek and Orthodox old-christian Byzantine churches in Thessaloniki have as follows: The **St. Panteleimon** church (built in 1250) is characterized as cruciform inscribed domed (Flevel=25), the **St. Dimitrius** church (built in 413 (324)) is characterized as a five-aisled basilica of the so called hellenistic type (Flevel=4), the church of **Aheropeitos** (built in 431) is characterized as a three-aisled basilica (Flevel=4), the **St. Sophia** church (built in 780 (550)) is characterized as a domed basilica (feature-level = 7), and the church **Panagia Halkeon** (built in 1028) is characterized as complex cruciform inscribed domed (Flevel=24).

RETURN

mslink	Fcode	Fname	Category tableN	Ftype	Flevel	Fstyle	Fweight	Fcolor	digcmd	
23	1098	StPanteleimon	E3-4	CCntrR	Raster	2	1	1	5	place R
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
79	2107	StDimitrius	E3-4	CityCntr	Vector	4	6	2	9	place V
88	2108	Aheropeitos	E3-4	CityCntr	Vector	4	6	2	9	place V
108	2109	StSophia	E3-4	CityCntr	Vector	7	6	2	9	place V
166	2110	PanagiaHalkeon	E3-4	CityCntr	Vector	24	6	2	9	place V

Table 2. The Feature Table used in ByzMN.mge Project.

Vector files related to features (churches) are stored in **Maps Tables** (see Table 3), whilst raster files are stored in **Media Files** (see Table 6). The maps tables can be created and populated using appropriate MGE-PC GUI commands (like: Set Up MGE Tables).
The following is an example of a populated map table with the name CityCntr having 50 entries.

mslink	MapName	Category	Importance
1	AllSaints.dgn	E3-4	39
...	.....	.....	.....
11	StDimitr.dgn	E3-4	1
12	Aheropei.dgn	E3-4	4
13	StSophia.dgn	E3-4	3
14	PanHalkn.dgn	E3-4	2
...	.....	.....	.....
50	CuleCafe.dgn	E3-5	29

Table 3. The CityCntr Maps Table.

A special kind of non-graphic Attributes of monument-features, as names of materials, construction details, decoration details, descriptions, type or kind of primitives used and technical specifications, are stored in **Attribute Tables** (Wallis M., 1973). For instance the name, description and the technical specifications of cylindrical arcades or the origin of marble doorposts are examples of this kind of information stored in Attribute Tables.
An **attribute table** contains at least two required columns: mslink and mapid. Other columns could be defined using a suitable editor (eg. in MGE-PC: the Column Builder editor). The column mapid holds the number of the map containing the linked monument, while the column mslink holds the occurrence number in attribute linkages, i.e. links the record to a monument. The user-defined columns hold the user-defined attributes associated with the monuments, like type of Arcades, type of Domes, kind of Drainpipes, etc.
The following tables 4.1 and 4.2 are examples of attribute tables used in ByzMN.mge SIS project.

MapID	mslink	Class	Description	Type	Kind
...	.....	...	.....	.....	.....
2	223	A	Arcade	Cylindrical	Brick
2	125	D	Doorpost		Marble
4	332	C	Cornices		Stone
...	.....	...	.....	.....	.....
5	980	P	Dies (Checkers)	Spherical	Stone
...	.....	...	.....	.....	.....

Table 4.1. Attributes Table used in ByzMN.mge Project.

MapID	mslink	Name	Construction-Details	Decoration	Materials used
16	22	Door-frames		No	red brick
18	23	Columns		No	imported marble
18	24	Capitals		No	reg-shaped stones
25	180	Architraves		No	sun-dried bricks
25	181	Mosaic floor	pictures in mosaic		color marble
33	182	Wall mosaics	glass-melt pictures		glass
43	228	Roof	Basilica Order Roof with long walls	No	cypressed joists (country timber)
44	229	Roof	Central Roof with centralized walls	No	pined&junipered joists (country timber)
67	322	Wall	built in two faces with stones and a rubble core between surfaces	well dressed stones	plaster incrustation

Table 4.2. Attributes Table used in ByzMN.mge Project.

The data for Table 5 (Table of Characteristics) are taken from the book **"Monuments of Thessaloniki"** (Papagiannopoulos A. 1995).

msLink	Church-Name	Characteristics	Wall Paintings	Erection
23	St. Panteleimon	"School of Macedonia". Stone and Bricks. Open aisle (peristoon). Two Chapels.	YES	1380
79	St. Dimitrius	Five-aisled basilica without dome. Timber roofed. Stone and Bricks. Peristyle (atrium).	YES	413 (324)
88	Aheropeitos	Three-aisled basilica,Apse. Timber roofed. Trilova windows Peristyle (atrium) Small chapel.	YES	431
108	St. Sophia	Cruciform Domed Basilica	YES	780 (550)
166	Panagia Halkeon	Cruciform High drum-domed Apse (with Prothesis and Diakonikon) Bricks only. Tomb of Hristoforos (founder)	NO	1028

Table 5. The Characteristics Table used in ByzMN.mge project.

2.3 Media Files - Multimedia Data

Multimedia technology helps SIS and GIS systems become more productive. An integrated Multimedia-SIS strategy that includes the common multimedia presentation (raster images, audio descriptions, video clips, etc) has been added to ByzMN.mge project through pointers pointing to suitable MDL event-handlers (drivers) (Styliadis A., 1995). The following table is related to CCntrR media file used raster image connections for Thessaloniki's City Center churches.

mslink	RasterImageName	Category	The MDL Connection
1	AllSaints.tif	E3-4	dialog display *.tif
...	.....	.....	.....
11	StDimitr.bmp	E3-4	dialog display *.bmp
12	Aheropei.bmp	E3-4	
13	StSophia.bmp	E3-4	
14	PanHalkn.bmp	E3-4	
...	.....	.....	.....
50	CuleCafe.gif	E3-5	dialog display *.gif

Table 6. The CCntrR Media File.

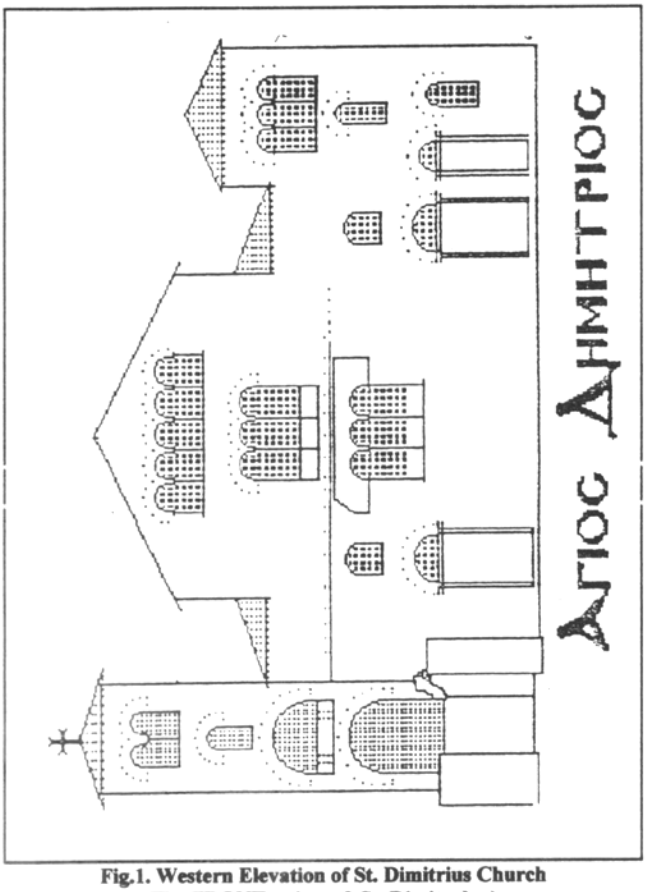


Fig.1. Western Elevation of St. Dimitrius Church (The FRONT - view of St. Dimitr.dgn).

The following Figure (Fig. 2) illustrates the relationship between **Feature-Levels** and **Attributes** used in Byzantine churches for ByzMN.mge project. Once again the displaying of any combination of monuments (i.e. features or geographic elements) that have been placed on any map is helped by this layering.

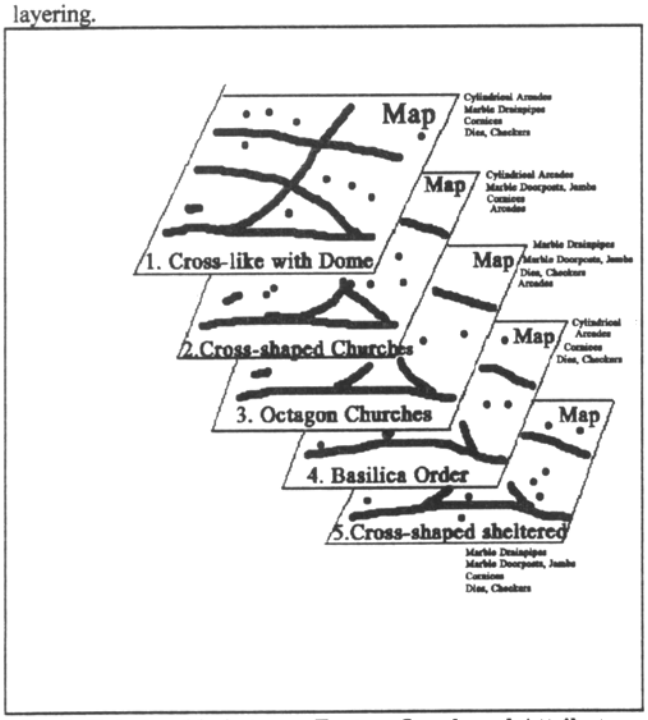


Fig. 2. Relationship between Feature-Levels and Attributes.

3. GIS FUNCTIONALITY

Database functionality is based on **XBASE** (i.e. DBF format) and particular on dBaseIII+. Users are able to create and edit local-disk database structures for every category of thematically or geographically related Byzantine monuments. They are also able to define additional feature-levels for particular categories within the limit of 63 (MicroStation PC environment).
A fully functional link to external database management systems compatible with MGE-PC (like Oracle and RIS) supports relations 1:N.
Multimedia functionality is based on event-handlers implemented in **MDL** and embedded in GIS tables throught pointer-values. In this way raster images of various market formats (BMP, GIF, TIFF, etc) can be attached to geographical elements (Byzantine churches) enhancing the functionality of SIS processing. Alternately the Vista Map extension s/w could be used for multimedia functionality.
Modelling functionality is supported of existing **vector files** of Byzantine monuments (DGN format) or of input vector data through digitizing existing maps or scanned raster images.
Intergraph's I/RAS B and I/RAS C connections enable handling of binary and continuous tone raster images of up to hundreds of MB files.

MGE-PC Functionality

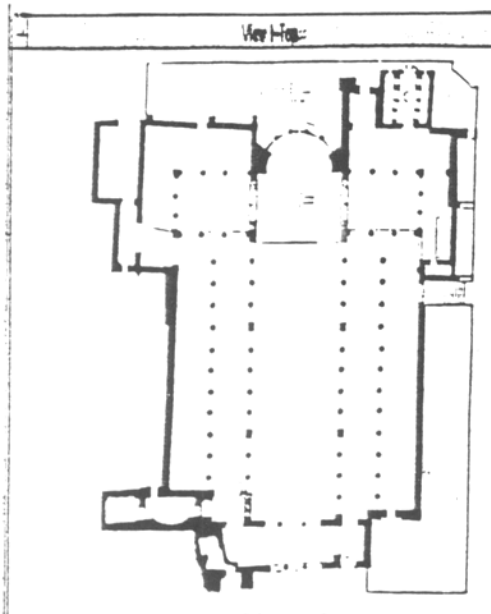
Intergraph's MGE-PC environment provides a friendly GUI for map and feature handling. In this s/w there are: the **Map menu** to perform all map related tasks (eg. creating, opening and setting up maps) and the **Feature menu** to perform feature-related tasks (eg. digitizing geographic elements, reviewing properties).
The following workflow (Fig. 3) is used for Byzantine churches recording, documentation and conservation.

A) Setting up the Data Base
- set up MGE System Tables
- set up Categories
- set up Features
- set up Attribute Tables
- set up Multimedia Files
- |
- set up co-ordinate system for spatial analysis and spatial queries

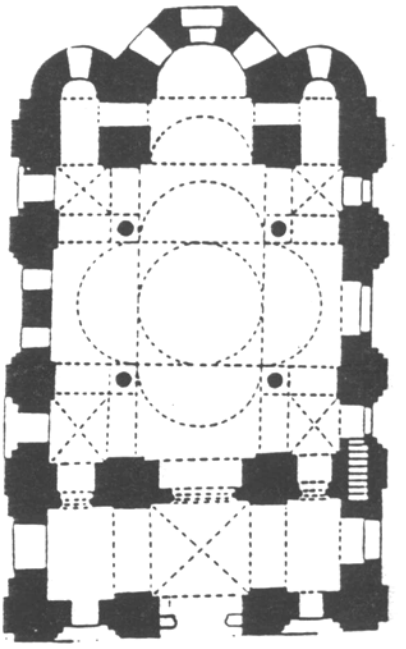
B) Adding Data to Data Base
- create map files
- digitize features (geographic elements) onto maps
- define attribute values for these features
- |
- create index files
- |
- create vicinity map

C) Verify and Update Data

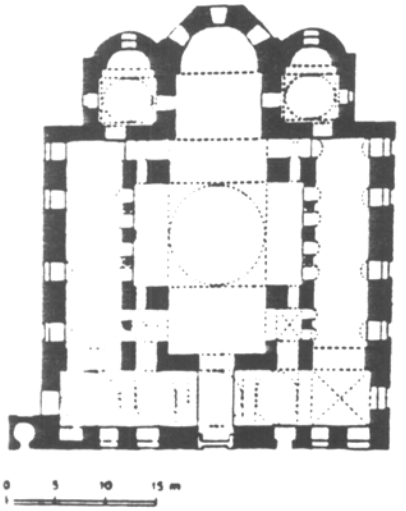
Fig. 3. The workflow used in ByzMN.mge SIS Project.



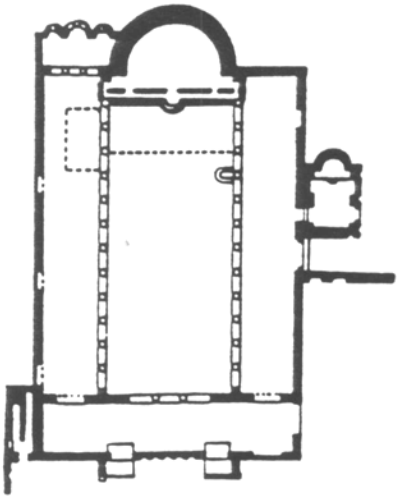
St. Dinitrius Church



Panagia Halkeon
(St. Mary of the Coppersmiths)

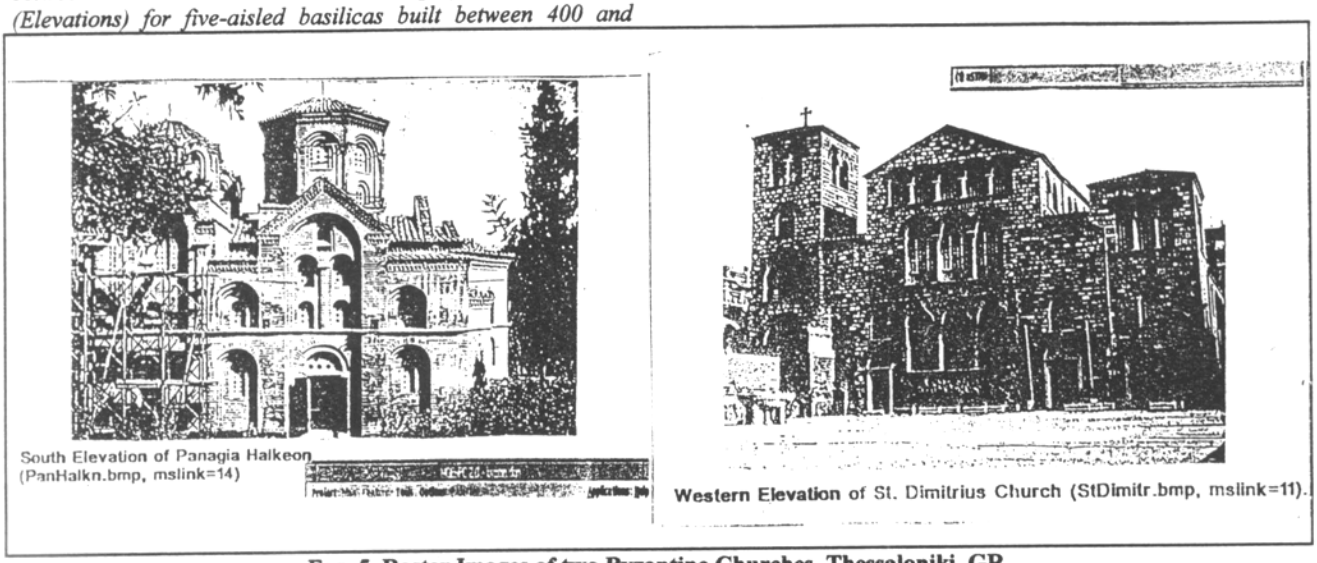


St. Sophia of Thessaloniki



Aheropeitos

Figure 5 displays raster images of two Byzantine churches in Thessaloniki. The compression used was based on Run Length Encoding form. The spatial questions to SIS were: *"Display raster images (Elevations) for cruciform domed churches built between 1020 and 1030"* and *"Display raster images (Elevations) for five-aisled basilicas built between 400 and 420"*. As result the image of the South Elevation of **Panagia Halkeon** Church (cruciform domed - 1028 AC) and the image of the Western Elevation of **St. Dimitrius** Church (five-aisled basilica - 413 AC) are displayed.



Fog. 5. Raster Images of two Byzantine Churches, Thessaloniki, GR.

4. CONCLUSIONS AND FUTURE ENHANCEMENTS

SIS software provides a wealth of data documentation and conservation tools as well as tools for data-handling, data-analysis and data-retrieving purposes. SIS documented data can be retrieved faster and maintained so that the most current information is always available (Patias P., et al., 1995), (Paraschakis J., et al., 1992).

In current SIS application a feature is any monuments (geographic element) that is represented graphically on a map. An unlimited number of features can be existed in a SIS project, but only 63 kinds of features (feature-levels) in each category for MGE-PC MicroStation CAD platform. Each monument in a category should be stored on a different drawing level, which in MGE-PC is called a **feature-level**. In this way any required combination of monuments on a map could be displayed.

Future enhancements will based on new Object-Oriented SIS Systems using Object-Oriented design techniques and methods regarding monuments as **objects** with various attributes, e.g.text data, raster and vector files, multimedia data

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