MAPPING ANALYSIS AND PLANNING SYSTEM
FOR THE
JOHN F. KENNEDY SPACE CENTER

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ABSTRACT

Environmental management, impact assessment, research and monitoring are multidisciplinary activities which are ideally suited to incorporate a multi-media approach to environmental problem solving. Geographic information systems (GIS), simulation models, neural networks and expert-system software are some of the advancing technologies being used for data management, query, analysis and display. At the 140,000 acre John F. Kennedy Space Center, the Advanced Software Technology group has been supporting development and implementation of a program that integrates these and other rapidly evolving hardware and software capabilities into a comprehensive Mapping, Analysis and Planning System (MAPS) based in a workstation/local are network environment.

An expert-system shell is being developed to link the various databases to guide users through the numerous stages of a facility siting and environmental assessment. The expert-system shell approach is appealing for its ease of data access by management-level decision makers while maintaining the involvement of the data specialists. This, as well as increased efficiency and accuracy in data analysis and report preparation, can benefit any organization involved in natural resource management.

INTRODUCTION

This paper presents an overview of a decision support system being developed at the John F. Kennedy Space Center (KSC) for use in environmental compliance, management and research. Solutions to environmental problems often involve complex, interdisciplinary subjects. Decision making must meet the requirements of such fields as engineering, hydrology, geology, ecology, geography, political science, public health, planning, demography and sociology [1]. Also, environmental management issues are by nature complex spatial and temporal phenomena. Their distribution across the landscape, in terms of quantity and quality, vary through time in response to both natural and anthropogenic factors. The pattern of landscape development (rural, agricultural, urban, industrial) historically evolved independently from environmental concerns and did not address the need to manage conflicts with natural resource protection, pollution abatement, or the quality of the human environment [2], [3].

Management of both landscape development and natural resources now requires a more diverse approach to conflict abatement. Such a pro-active approach is enhanced by using advanced computer-based technologies for information analysis, decision support, and visual display. Examples of these computer applications include but are not limited to multi-media (video, hypertext, sound, etc.), geographic information systems (maps, overlays, spatially distributed data, etc.), simulation modeling (surface and ground water, air quality,) remote sensing, expert-systems, and user friendly machine interfaces [4], [5].
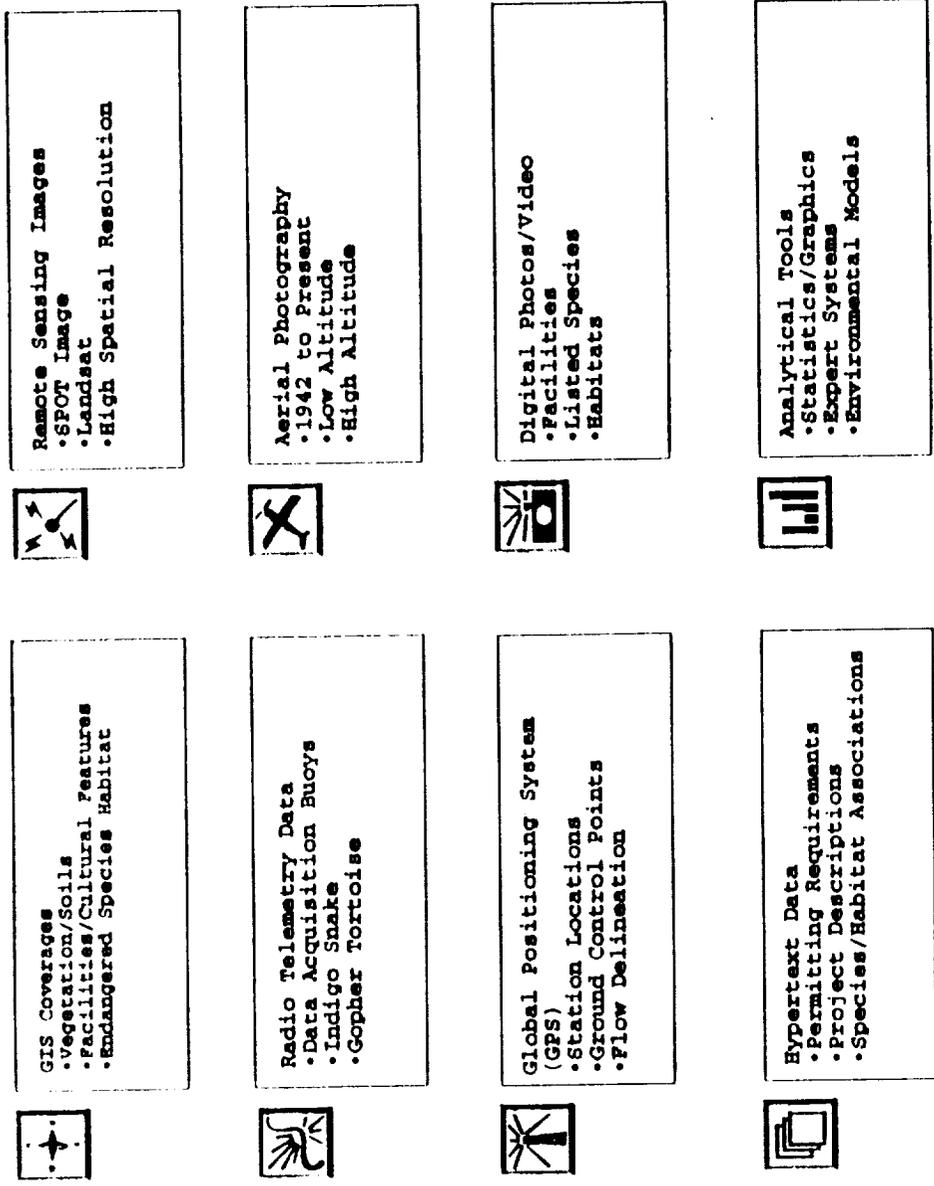
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Remote Sensing Images
•SPOT Image
•Landsat
•High Spatial Resolution

Aerial Photography
•1942 to Present
•Low Altitude
•High Altitude

Digital Photos/Video
•Facilities
•Listed Species
•Habitats

Analytical Tools
•Statistics/Graphics
•Expert Systems
•Environmental Models

GIS Coverages
•Vegetation/Soils
•Facilities/Cultural Features
•Endangered Species Habitat

Radio Telemetry Data
•Data Acquisition Buoys
•Indigo Snake
•Gopher Tortoise

Global Positioning System (GPS)
•Station Locations
•Ground Control Points
•Flow Delineation

Hypertext Data
•Permitting Requirements
•Project Descriptions
•Species/Habitat Associations

Figure 1. Schematic representation of the resources used in the development and implementation of the Mapping Analysis and Planning System.
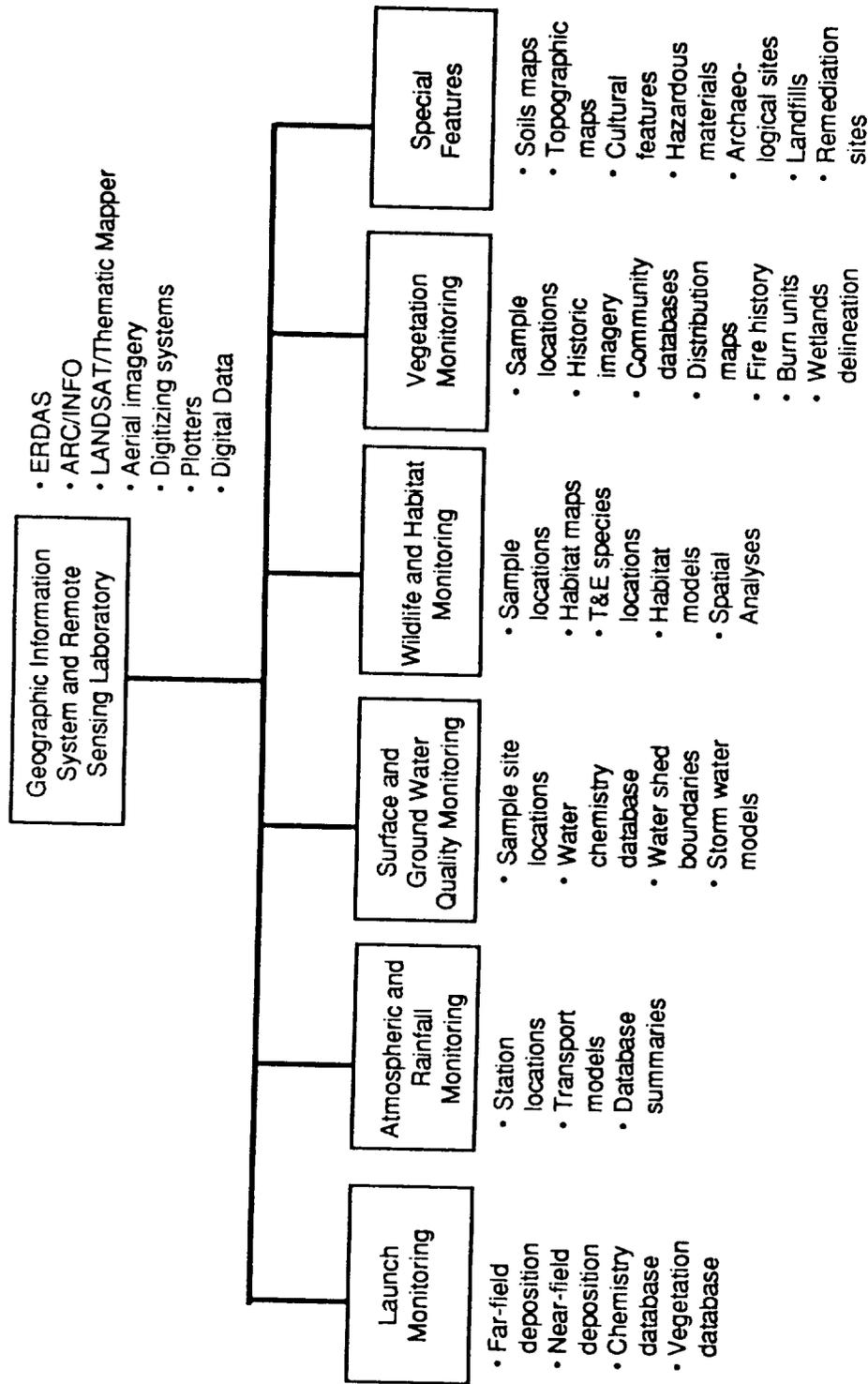
Geographic Information System and Remote Sensing Laboratory

- ERDAS
- ARC/INFO
- LANDSAT/Thematic Mapper
- Aerial imagery
- Digitizing systems
- Plotters
- Digital Data

Launch Monitoring
- Far-field deposition
- Near-field deposition
- Chemistry database
- Vegetation database

Atmospheric and Rainfall Monitoring
- Station locations
- Transport models
- Database summaries

Surface and Ground Water Quality Monitoring
- Sample site locations
- Water chemistry database
- Water shed boundaries
- Storm water models

Wildlife and Habitat Monitoring
- Sample locations
- Habitat maps
- T&E species locations
- Habitat models
- Spatial Analyses

Vegetation Monitoring
- Sample locations
- Historic imagery
- Community databases
- Distribution maps
- Fire history
- Burn units
- Wetlands delineation

Special Features
- Soils maps
- Topographic maps
- Cultural features
- Hazardous materials
- Archaeo-logical sites
- Landfills
- Remediation sites

Figure 2. Long-term ecological data compiled in the GIS/Remote Sensing Laboratory

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At the KSC, the Advanced Software Technology branch is working in conjunction with the Biomedical Operations and Research Office Pollution Control Officer to develop and implement a comprehensive, computer-based decision support system called the Mapping Analysis and Planning System (MAPS) which will be distributed across a network with the ultimate goal of making current information available to managers and planners at all levels. The MAPS will integrate the knowledge base from environmental research with policy, regulatory requirements, analytical tools and advanced display techniques (Figure 1).

Development of this concept and approach is currently a popular topic with many researchers and agencies exploring options in resource management. Results generally indicate that successful implementation of a comprehensive set of decision support tools requires that the users have available a large amount of high quality site specific data. Broad-spectrum data are needed regarding the site or landscape on which the system is directed as well as an understanding of the types of applications to which the system will be applied.

The primary database for the KSC MAPS consists of more than ten years of research involving field-collected and remotely sensed data covering a variety of subjects such as vegetation communities, wetlands, endangered species, habitats, soils, water quality , and cultural features [6] (Figure 2). Other site and project specific databases available within the MAPS include state and federal permits, permit monitoring data, identification of hazardous material storage areas, solid waste management units, landfills, space shuttle exhaust impacts, and facility siting constraints. Analytical capabilities include development of wildlife habitat association models, storm water and groundwater models and atmospheric diffusion models. Multi-media application include the ability to display digital imagery, captured video, audio, and hypertext to enhance the users understanding of environmental considerations, permit requirements, or regulatory constraints.

Both the environmental monitoring research database for KSC are in a continual state of collection and development. The KSC region is recognized as being biologically unique with more federally listed threatened and endangered species than any other protected area in the continental United States. The ongoing compilation of ecological data from such a diverse region make it some of the most current and reliable information available. In addition, the 140,000 acre facility is jointly managed by the U.S. Fish and Wildlife Service as the Merritt Island National Wildlife Refuge and the National Park Service as the Canaveral National Seashore.

In addition to the variety of sources providing an extensive monitoring and research database, environmental management responsibilities at KSC are also distributed across several NASA Offices and Contract organizations. Each has different responsibilities and information needs to meet requirements of state, and federal laws and regulations. Examples of laws and regulations that affect environmental management activities and generate various levels of information requirements include:

> Solid Waste Disposal Act
> Clear Air Act
> National Environmental Policy Act
> Resource Recovery Act
> Resource Conservation and Recovery Act
> Endangered Species Act
> Water Pollution Control Act
> National Energy Conservation Policy Act
> Pollution Prevention Act

Provisions of these laws are administered by a variety of Federal and State Agencies in Florida, including:

> Florida Department of Community Affairs
> Florida Department of Environmental Protection
> Management Districts
> Local Governments

United States Environmental Protection Agency
United States Army Corp of Engineers
United States Fish and Wildlife Service

Each of these organizations may require information or decision activities to design construction or operation of a facility for the purpose of minimizing economic or environmental risks and protecting human health. Stout and Streeter [7] state that the ultimate objective of laws and regulations is the minimization of potential risks associated with the activity of concern. Risk minimization is in turn best achieved by making informed decisions based on the best available data and information. The goal of the MAPS program is to coordinate the elements form all resources so that thoroughly informed decisions are more easily achieved.

APPROACH AND EXAMPLE

To combine regulatory requirements with other environmental information and data, the MAPS will link a variety of databases, digital imagery, GIS thematic layers, master planning files, video and legal information into a menu-driven decision support tool for KSC. A knowledge-based system shell is being developed to add expert site specific knowledge to the data fusion and query process. This will allow the users access to all available information, enhancing decision support and quality regarding environmental management. At present the system is being developed in a network environment utilizing UNIX-based work stations and DOS based personal computers. Software being incorporated into the system is a combination of commercially available packages. Basics of the system include:

GIS software
Image Processing software
Video Capture and Editing
Statistical Data Analysis
3-D Graphics
Numerical Modeling
Hypertext software
Expert-systems/Neural Net Development packages

The system is currently being used for facility sitings where concerns must be addressed following requirements of the KSC environmental checklist [8]. The following paragraphs give a description of how the MAPS is used in the decision making processes for the sighting of a new fuel storage facility.

The environmental checklist is the precursor to decision making for the siting of any facilities on KSC (Figure 3). Responses to questions on the checklist will either flag ancillary requirements, offer more detailed information on a topic, or prompt the user to input additional data. For example, a fuel storage facility will require a "yes" to the hazardous material storage question. The user is then prompted to supply the type of hazardous material as well as the amount. This system will then alert the user of any permits or official actions such as requirements for public meetings which need to be taken for that substance.

Depending on the question, there are currently different levels of maps, hypertext information, video and graphics to further the query by the user. At this time only some of these topics offer additional exploration; however, as the database size increases so will the extent of each checklist topic. Any topic in the checklist for which the user cannot provide a definitive answer must be checked "yes"; thus prompting the user to gather more information through the query process that will enable them to correctly respond. For the fuel storage facility example, the user may be unsure if the facility will be build in threatened or endangered species habitat; therefore, the user must check yes. The system then prompts the user to identify which habitats are present or, based on the location and surrounding area, defines the habitats for the user. Using GIS vegetation maps, the user finds that the proposed site is located in "scrub & slash pine" and "broadleaved woodlands". For each of these habitat types, the user may query hypertext or graphics for the following information:

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5. DOES THE CONSTRUCTION, INSTALLATION, REMOVAL, ACTIVATION, OR OPERATION OF THE PROPOSED PROJECT INVOLVE: (FILL OUT ONE PAGE FOR EACH ALTERNATIVE CONSIDERED. SEE INSTRUCTIONS. WHEN IN DOUBT, MARK YES)

ALTERNATIVE # AND DESCRIPTION:

YES   NO

a. Discharge of any substance to the environment
   Mark all appropriate media: list substance(s) in Block 6
      Air ☐   Surface Water ☐   Groundwater ☐   Soil ☐

b. Land alteration, excavation or dewatering

c. Construction in wetlands

d. Construction in floodplain
   If Yes: 100 Year ☐   500 Year ☐   (Mark both if appropriate)

e. Generation of ionizing or non-ionizing radiation or use of any radiation source

f. Asbestos-containing materials or facilities

g. PCB-contaminated materials or equipment

h. Generation of waste other than normal construction debris
   If Yes, list waste (s) in Block 6

i. Use or storage of Hazardous or Toxic Materials
   If Yes, list materials and quantities for each in Block 6

j. Aboveground or underground storage tanks
   If Yes, list material (s) stored in Block 6

k. Generation of high noise levels outdoors (above 85 dBA)

l. An area of archaeological significance
   If Yes, indicate potential :   High ☐   Medium ☐

m. Endangered species habitat

n. Solid Waste Management Unit (SWMU) site

o. Other issues which could produce environmental impacts
   If Yes, describe in Block 6

Figure 3. Environmental checklist used by NASA/KSC resource managers and planners.

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VEGETATION AND STRUCTURES
Launch complexes 39A, 39B and VAB area

Figure 4. Example of the KSC vegetation map, with existing structures overlay, that can be accessed from the MAPS

Amphibians and Reptiles	FGFWFC	USFWS	CITES	FCREPA	FNAI Global Rank	FNAI State Rank
American Alligator	SSC	T(S/A)	II	SSC	G5	S4
Loggerhead Sea Turtle	T	T	I	T	G3	S2
Atlantic Green Turtle	E	E	I	E	G3	S2
Eastern Diamondback Rattlesnake						
Leatherback Turtle	E	E	I	R	G3	S2
Eastern Indigo Snake	T	T		SSC	G4T3	S3
Atlantic Hawksbill Turtle	E	E	I	E	G3	S1
Gopher Tortoise	SSC	UR2		T	G3	S3
Mole Kingsnake				R	G5	S4S3
Eastern Kingsnake*	E					
Atlantic Ridley Turtle		E	I	E		
Eastern Coachwhip*						
Florida East Coast Terrapin*	T	T		E	G5T1Q	S1
Atlantic Salt Marsh Water Snake	SSC	UR2			G5T1Q	S?
Florida Pine Snake	SSC	UR2			G4	S3
Gopher Frog		UR2		R		
Florida Scrub Lizard						
Dusky Pigmy Rattlesnake*						
Florida Crowned Snake*						
Coastal Dunes Crowned Snake*						

Birds	FGFWFC	USFWS	CITES	FCREPA	FNAI Global Rank	FNAI State Rank
Cooper's Hawk				SSC		
Mottled Duck*						
Bachman's Sparrow	SSC	UR2			G3	S?
Roseate Spoonbill				R	G5	S2S3
Dusky Seaside Sparrow	E				G4TX	SX
Florida Scrub Jay	T	T			G5T3	S3
Limpkin	SSC			SSC	G5	S3
Burrowing Owl	SSC		II	SSC	G5T3	S3
American Bittern*						

Figure 5. Example of chart used in maps showing the listing status of species found on KSC

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	Breeding Season	Seasonal Abundance on KSC				Estimated Population Size on KSC	Autecology Characteristics (Noss and Labisky in press)
		Spring	Summer	Fall	Winter		
Florida Scrub Jay	Feb-June	C	C	C	C	2,100	1R$_1$DLUFH
Atlantic Green Turtle	April-Sept	C	O	C	C	150	
West Indian Manatee	All Year	C	C	C	R	<300	
Southeastern Beach Mouse	All Year	C	C	C	C	>5000	
Southern Bald Eagle	Dec-April	U	U	U	U	20	2/3 R$_2$ W L C
Wood Stork	Feb-July	C	C	C	C	0-600	
Eastern Indigo Snake	All Year	C	C	C	C	>5000	
Roseate Spoonbill	Mar-July	U	C	U	R	400	
Reddish Egret	Mar-July	O	O	O	O	20	
Florida Long-tailed Weasel	Nov-Feb	R	R	R	R	<500	2 R$_1$ R$_2$ WL
Atlantic Salt Marsh Snake	Mar-Sept	R	R	R	R	<500	
Florida Pine Snake	Mar-Sept	R	R	R	R	<500	2/3 R$_2$ N F H E
Florida East Coast Terrapin	Mar-Sept.	R	R	R	R	400-500	
Atlantic Loggerhead Turtle	April-Sept	L	C			1,200	

Figure 6. Example of chart used in the maps showing the breeding season , population status and ecological characteristics of species found on KSC.

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PRIMARY & SECONDARY SCRUB JAY HABITAT ON KSC

Class_Names
BACKGROUND
PRIMARY HABITAT
SECONDARY HABITAT
LAGOONAL WATERS
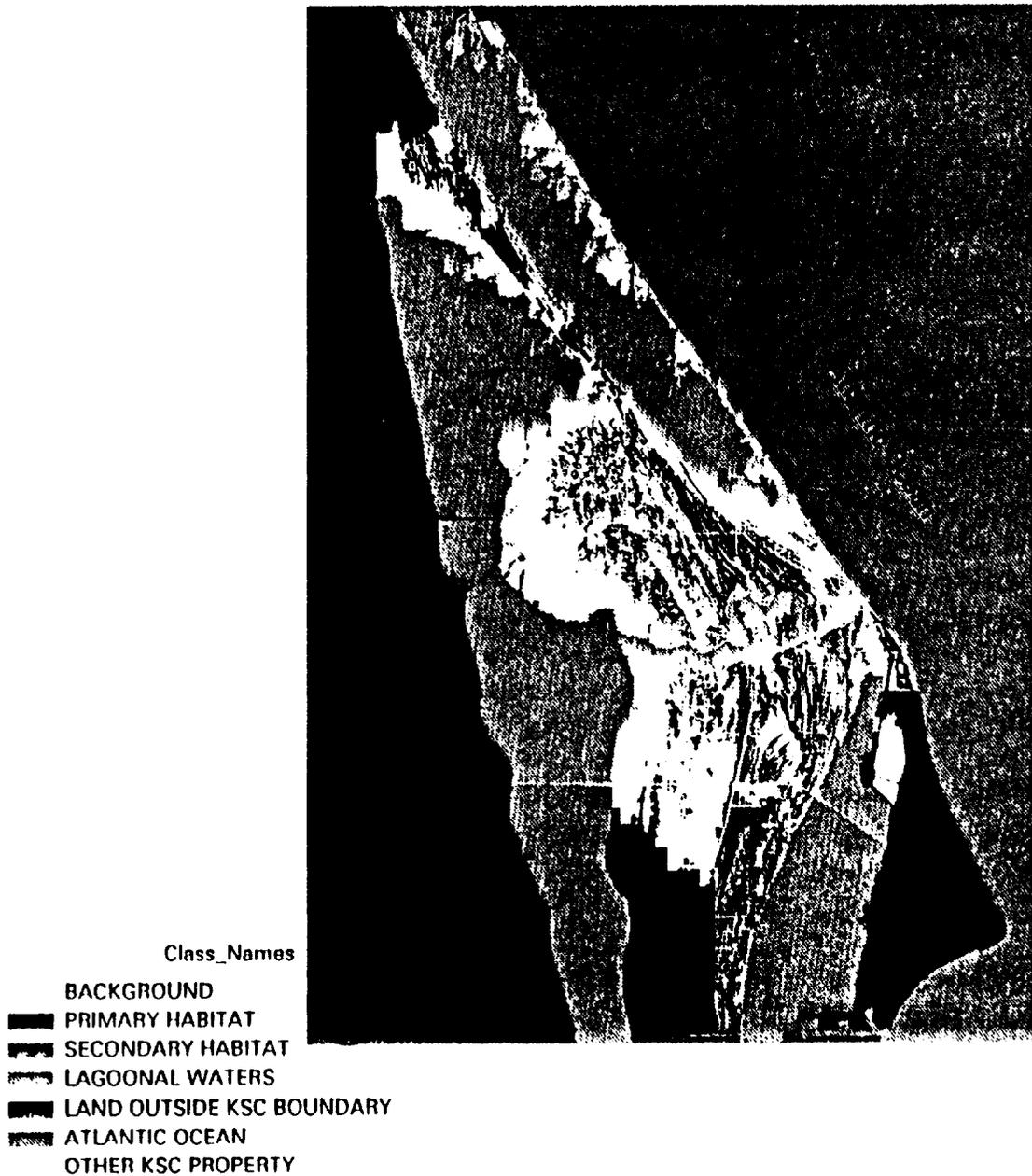LAND OUTSIDE KSC BOUNDARY
ATLANTIC OCEAN
OTHER KSC PROPERTY

Figure 7. Example of species-specific information that can be accessed from the MAPS. This map shows the locations of primary and secondary habitat for the Florida Scrub Jay on KSC.
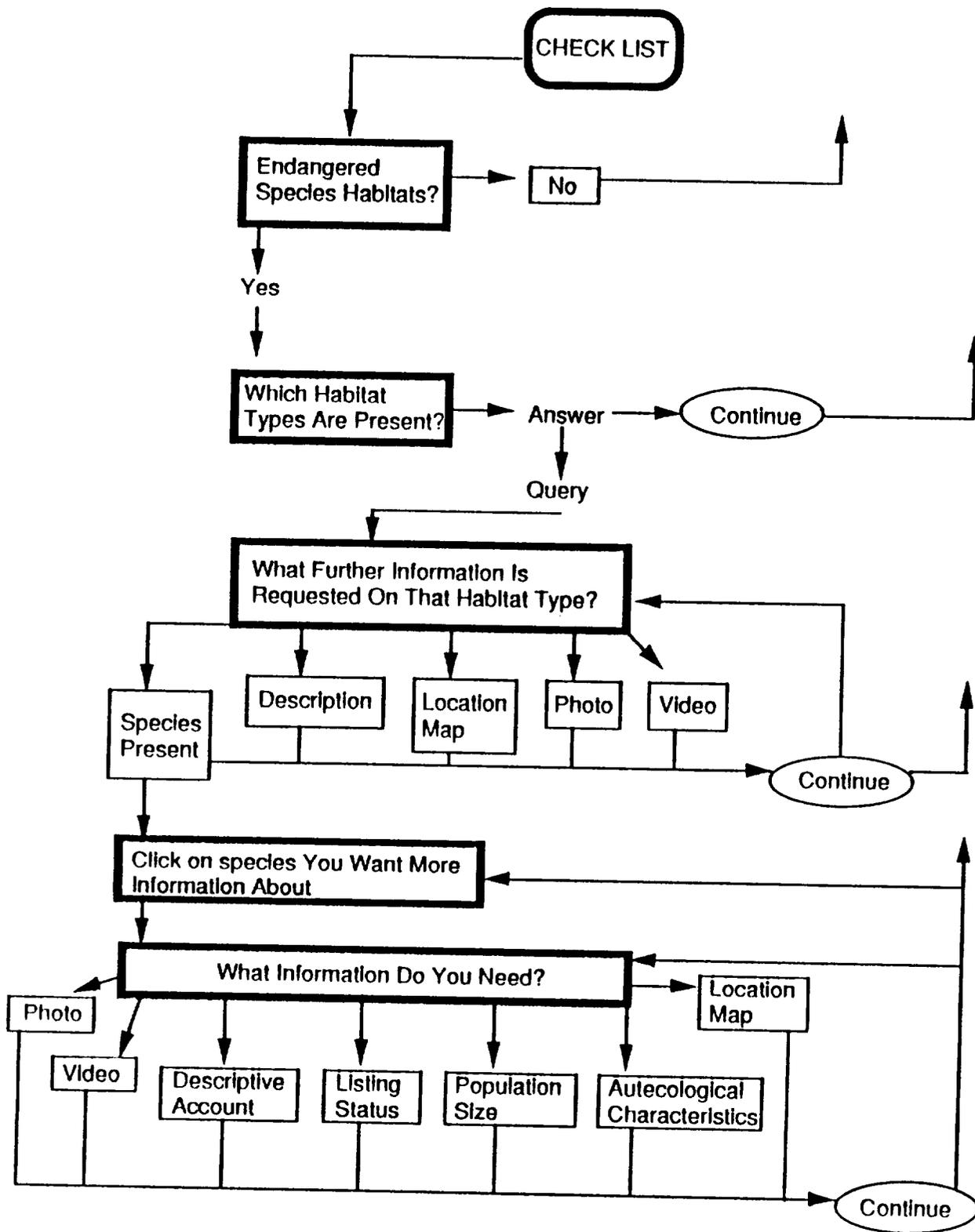
Figure 8. Flowchart of query process for endangered species habitat

1) A written description of the habitat. This description will include physical parameters, historical view points, plant and animal species typical for that habitat and NASA's influence on the habitat type within KSC.

2) A map showing the locations of that habitat on KSC (Figure 4). Further links with ARC/INFO and ArcView will provide access to finer scale maps of the site or LANDSAT and SPOT images. It will also enable the user to manipulate the map in order to query more information such as getting geographic coordinates or producing a measured radius from a site to look for possible contamination impacts.

3) Photographs and video segments of the habitat type.

4) A list of species found in that habitat. Each species can then be further explored to provide the user with detailed information on the ecology of each species.

5) The protected status of each species for five main listing agencies: U.S. Fish and Wildlife Service (USFWS), Convention on International Trade of Endangered Species (CITES), Florida Game and Fresh Water Fish Commission (FGFWFC), Florida Committee on Rare and Endangered Plants and Animals (FCREPA), and the Florida Natural Areas Inventory (FNAI) (Figure 5).

6) The species population size, breeding season, and seasonal abundance on KSC (Figure 6).

7) A map showing the locations on KSC where appropriate habitat for supporting that species is located (Figure 7).

8) A detailed, written account of each species which includes a description of the species and its typical habitat, listing status, reasons for endangerment, discussion of the species status on KSC, research results, behavioral notes, and general ecological attributes.

9) Photographs of the species.

10) A video segment of the species.

The flowchart in Figure 8 show a summary example of how a topic can be explored. One of the main advantages of this program is its ability to adapt to different user's requirements. A user can go through the query only as far as they need. For instance, not all users will need to know what certain species or habitats look like while others may need a photograph or video to confirm sightings. More users may need the listing status or population size for a species and the location of certain habitats on KSC. The user drives which information is presented. The available database can be readily updated as more information becomes available or as changes occur in legal status such as species' listings or permitting requirements.

SUMMARY

This brief paper outlines several of the development strategies and the status of the MAPS decision support process for environmental management issues at KSC. Environmental compliance and management is recognized as a multidisciplinary activity that requires large volumes of data for management and engineering decisions. Much of the data is by nature spatial or geographic. Storage, manipulation and analysis of this type of information is performed most effectively in current GIS software environments. Problems that can be addressed include facility design and siting, environmental monitoring, habitat mitigation, impact assessment and documentation, and many others. The attractiveness of adding knowledge-based expert-system software to the decision making process stems from the fact that such systems represent models of "experts" in various fields. The combination of GIS and expert-systems represents a tool that supports and enhances the reasoning and judgement process rather than only automating the procedure through prescribed computation [9], [10]. This approach will allow managers and engineers to access "expert

knowledge", covering the highly diversified set of topics associated with a pro-active environmental management strategy, easily and directly from their computer terminals.

Literature Cited

[1] Tchobanoglous, G.H. Theiaen, and R. Eliassen. 1977. Solid Wastes, Engineering Principles and Management Issues. McGraw Hill. New York. 621 pp.

[2] Arnoff, s. 1989. Geographic Information Systems: a Management Approach. WDL Publications. Ottawa, Ontario.

[3] Burrough, P.A. 1986. Principles of Geographic Information Systems for Land Resource Assessment. Oxford, Clarendon.

[4] Fedra, K. 1991. A computer Based Approach to Environmental Impact Assessment. In: Colombo, A.G. and G. Premazzi (eds). 1991. Proceedings of the Workshop on Indicators and Indices for Environmental Impact Assessment and Risk Analysis. IIASA. Austria.

[5] Fedra, K., L. Winkelbaur, and V.R. Pantulu. 1991. Expert-systems for Environmental Screening, An Application in the Lower Mekong Basin. RR-91-19. IIASA. Austria.

[6] Hall, C.R., C.R. Hinkle, W.M. Knott, and B.R. Summerfield. 1992. Environmental Monitoring and Research at the John F. Kennedy Space Center. J. Florida M.A. Vol 79, No 8, pp 545-552.

[7] Stout, D.J. and R.A. Streeter. 1992. Ecological Risk Assessment: Its Role in Risk Management. The Environmental Professional. 14:197-203.

[8] NASA. 1992. Environmental Resources Document for John F. Kennedy Space Center. KSC-DF-3080.

[9] Summic, Z. and E. Yeh. 1992. A GIS-Based Expert-system for Residential Distribution Design. In: GIS/LIS Proceedings. San Jose, CA.

[10] Zhu, X. and R. Healy. 1992. Towards Intelligent Decision Support: Integrating Geographical Information Systems and Expert-systems. In: GIS/LIS Proceedings. 1992. San Jose, CA.

REMOTE SENSING FOR HURRICANE ANDREW IMPACT ASSESSMENT

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ABSTRACT

Stennis Space Center personnel flew a Learjet equipped with instrumentation designed to acquire imagery in many spectral bands into areas most damaged by Hurricane Andrew. The Calibrated Airborne Multispectral Scanner (CAMS), a NASA-developed sensor, and a Zeiss camera acquired images of these areas. The information derived from the imagery was used to assist Florida officials in assessing the devastation caused by the hurricane. The imagery provided the relief teams with an assessment of the debris covering roads and highways so cleanup plans could be prioritized. The imagery also mapped the level of damage in residential and commercial areas of southern Florida and provided maps of beaches and land cover for determination of beach loss and vegetation damage, particularly the mangrove population.

Stennis Space Center personnel demonstrated the ability to respond quickly and the value of such response in an emergency situation. The digital imagery from the CAMS can be processed, analyzed, and developed into products for field crews faster than conventional photography. The resulting information is versatile and allows for rapid updating and editing. Stennis Space Center and state officials worked diligently to compile information to complete analyses of the hurricane's impact.