



Application of GIS Technologies in Port Facilities and Operations Management

ASCE

Edited by
Neal T. Wright, P.E.

This is a preview. Click here to purchase the full publication.



APPLICATION OF GIS TECHNOLOGIES IN PORT FACILITIES AND OPERATIONS MANAGEMENT

SPONSORED BY
Ports and Harbors Committee of
The Coasts, Oceans, Ports, and Rivers Institute (COPRI)
of the American Society of Civil Engineers

EDITED BY
Neal T. Wright, P.E.
Jaewan Yoon, Ph.D.



Published by the American Society of Civil Engineers

Library of Congress Cataloging-in-Publication Data

Application of GIS technologies in port facilities and operations management / sponsored by Ports and Harbors Committee of the Coasts, Oceans, Ports, and Rivers Institute (COPRI) of the American Society of Civil Engineers ; edited by Neal T. Wright, Jaewan Yoon.

p. cm.

ISBN 0-7844-0869-6

1. Harbors. 2. Geographic information systems. 3. Facility management. I. Wright, Neal T. II. Yoon, Jaewan. III. American Society of Civil Engineers. Ports and Harbors Committee. IV. Coasts, Oceans, Ports, and Rivers Institute (American Society of Civil Engineers). Ports and Harbors Technical Committee.

VK321.A66 2006

387.10285--dc22

2006048359

American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4400

www.pubs.asce.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefore. This information should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

Photocopies and reprints.

You can obtain instant permission to photocopy ASCE publications by using ASCE's online permission service (www.pubs.asce.org/authors/RightslinkWelcomePage.html). Requests for 100 copies or more should be submitted to the Reprints Department, Publications Division, ASCE, (address above); email: permissions@asce.org. A reprint order form can be found at www.pubs.asce.org/authors/reprints.html.

Copyright © 2007 by the American Society of Civil Engineers.

All Rights Reserved.

ISBN 13: 978-0-7844-0869-8

ISBN 10: 0-7844-0869-6

Manufactured in the United States of America.

Acknowledgments

CONTRIBUTING AUTHORS AND EDITORS:

Neal T. Wright, P.E., PMP

GIS Subcommittee Chair, ASCE COPRI Ports and Harbors Committee
Michael Baker Jr., Inc.

Jaewan Yoon, Ph.D.

GIS Subcommittee Co-Chair, ASCE COPRI Ports and Harbors Committee
Old Dominion University

CONTRIBUTING AUTHORS AND REVIEWERS:

Kurt Arend, P.E., Port of Los Angeles

Ken Dierks, Kimley-Horn and Associates

Tony Gioiello, Port of Los Angeles

Gary A. Jasper, CarteGraph Systems

Bryan Jones, P.E., Ocean and Coastal Consultants, Inc

John D. Kochanowski, US Air Force Air Combat Command

Patrick Moore, Integral GIS, Inc.

John Pregler, CarteGraph Systems

Ryan Reich, England, Thims & Miller, Inc.

John Roberts, Michael Baker Jr., Inc

Jonathan Soulen, Michael Baker Jr., Inc.

Bryan Stewart, England, Thims & Miller, Inc.

John Walsh, P.E., Waterway Surveys

COMMITTEE SUPPORT

Kelly Barnes, American Society of Civil Engineers, Coasts Oceans Ports and
Rivers Institute

Michelle Langer, Michael Baker Jr., Inc

List of Figures

Figure 1.	Global Positioning System Constellation	19
Figure 2.	Schematic of GPS/GIS Integration	20
Figure 3.	Data Layers and Photogrammetry	21
Figure 4.	Examples of three types of Imagery: Overhead, High Oblique and Low Oblique	25
Figure 5.	Satellite Imagery of Norfolk Port Facility with Ground Control Points	27
Figure 6.	Geo-rectification of Imagery to known coordinates, San Diego, CA	28
Figure 7.	Layers and Functionalities of Data in the GIS Application Framework	29
Figure 8.	The MIMS GIS Module Depicting a Radius Search of Stormwater Information	34
Figure 9.	Common Installation Picture (CIP) GeoBase, Air Combat Command (ACC), USAF	40
Figure 10.	Database Model used in Asset Management System (AMS) - Core Databases	44
Figure 11.	Database Model used in Asset Management System (AMS) - Data Access	44

Table of Contents

I. INTRODUCTION	1
I.A. Concept of a Port GIS	1
I.A.1. Basic Concepts	2
I.A.2. Data Models	4
I.A.3. From Database to GIS to Applications.....	6
I.A.4. General Hardware and Software Requirements for GIS Users	9
I.A.4.1. Hardware	9
I.A.4.2. Software.....	11
II. DATA	14
II.A. Data in Facility Management	14
II.A.1.1. Data Assessment and Collection	14
II.A.1.2. Types of Data Used in GIS	14
II.A.1.3. Data QA/QC.....	15
II.A.1.3.1. Dimensions of Data Quality.....	17
II.A.1.3.2. Accuracy	17
II.A.1.3.3. Resolution	17
II.A.1.3.4. Consistency	17
II.A.1.3.5. Completeness	18
II.A.1.3.6. Sources of Error	18
II.A.1.3.7. Controlling Error.....	18
II.A.1.4. Data Collection	18
II.A.1.4.1. Surveying	18
II.A.1.4.2. Satellite/Global Positioning System.....	19
II.A.1.4.3. Photogrammetric Mapping	21
II.A.1.4.4. Photogrammetry and Case Study Examples	21
Case Study 1: Naval Facilities Survey, Norfolk, Virginia	25
Case Study 2: NOAA Harbor Mapping Revision	27
II.B. Concept of a GIS Framework in Facility Management	28
III. IMPLEMENTATION OF PORT FACILITY GIS SYSTEMS	30
III.A. Ports' Implementation of GIS.....	30
III.A.1. Port of Los Angeles (POLA), California.....	30
III.A.2. Jacksonville Port Authority (JAXPORT), Florida.....	33
III.A.3. Port of Virginia, Virginia.....	35
III.B. Benefits of a GIS Implementation	36
III.C. Factors for a Successful Implementation.....	37
IV. CURRENT GIS APPLICATIONS IN OTHER FACILITY MANAGEMENT AND OPERATIONS MANAGEMENT SYSTEMS	38
IV.A. Integrated Facility Maintenance Operations Air Combat Command (ACC), USAF	38

IV.B. Asset Management Applications	40
IV.C. Hydrographic Surveying and Dredging Applications	46
IV.C.1. Hydrographic Surveying	46
IV.C.1.1. Dredging Measurement and Payment Surveys	47
IV.C.1.2. Berth and Entrance Channel Condition Surveys	48
IV.C.1.3. Elapsed Time Between Condition Surveys	48
IV.C.2. Dredging Applications.....	48
IV.C.3. Current Dredging Application for the Port of Virginia	49
IV.D. Environmental Management Applications	51
IV.D.1. Environmental Constraints and Opportunities Analysis	51
IV.D.1.1. Environmentally Sensitive Land and Water Areas	51
IV.D.1.1.1. Wetlands	52
IV.D.1.1.2. High Quality Waters and Shellfish Resources	52
IV.D.1.1.3. Protected Species	52
IV.D.1.1.4. Riparian and Water Quality Buffers	53
IV.D.1.1.5. Cultural Resources.....	53
IV.D.1.2. Environmental Management Enhancement and Pollution Prevention Opportunities	53
IV.D.1.2.1. Viewsheds.....	53
IV.D.1.2.2. Water Quality Restoration Opportunities	53
IV.D.1.2.3. Restoration of Riparian Buffers.....	53
IV.D.1.2.4. Pollution Prevention (P2) Programs	54
IV.D.2. Water Quality Compliance	54
IV.D.2.1. Drainage Area Maps and Drainage System Databases	54
IV.D.2.2. Storm Water Treatment Facilities	54
IV.D.2.3. NPDES Sampling Locations	55
IV.D.2.4. Groundwater Monitoring Wells	55
IV.D.3. Air Quality Compliance	55
IV.D.3.1. Air Emissions	55
IV.D.4. RCRA and CERCLA (Solid and Hazardous Waste) Compliance.....	55
IV.D.4.1. Solid Waste Management Units (SWMU's)	55
IV.D.4.2. HAZWASTE Sites	55
IV.D.5. Lead and Asbestos Compliance.....	56
IV.E. Engineering Project Applications	56
V. GIS IN SECURITY OPERATIONS, CRITICAL INFRASTRUCTURE VULNERABILITY ASSESSMENT AND PROTECTION.....	57
VI. CONCLUSIONS AND RECOMMENDATIONS	59
REFERENCES	60
APPENDIX: GLOSSARY	64
INDEX	75

I. INTRODUCTION

The port engineering community is a diverse body of professionals charged with maintaining facilities that vary in complexity from the Ports of Los Angeles and Long Beach on one hand, to small niche facilities specializing in one commodity. The staff available to manage port infrastructure and material handling equipment also varies widely. However, regardless of the size of staff employed or contracted, the port engineer faces a myriad of problems very similar to those encountered by a city or county Director of Public Works.

Managing port infrastructure, and the attendant heavy material handling equipment, is by nature a capital-intensive business. Marine terminal facilities may be state owned and run, leased to large terminal management firms, or owned and operated by private industry. However, regardless of the form of ownership and operation, port engineers are responsible for the proper maintenance and upkeep of existing assets, projecting necessary expansion of new facilities as well as planning to meet port security requirements. The Maritime Transportation Security Act of 2002 (MTSA), signed on November 25, 2002, was fully implemented on July 1, 2004 (USDHS, 2003) and mandates a number of additional security measures.

Marine terminal infrastructure and equipment function in the harshest of environments, causing accelerated deterioration and failure of assets when compared to inland facilities such as highways and bridges. For example, exposure to the combination of tidal action, sustained winds, wave action, high chloride concentrations and invasive marine life is quite unique to marine terminals. Severe operating loads further compound the accelerated aging of a marine infrastructure. Marine terminal facilities are subjected to heavy loadings, impact damage from ships and cargo handling equipment, and a sustained high tempo of operations that lead to massive wear and tear on structures and upland pavements. The result is a significant backlog of maintenance and repair that never seems to be resolved. A critical issue facing port engineers and their leadership is how to balance the need for new construction with the expense of major maintenance of current assets.

I.A Concept of a Port GIS

How then can port managers and engineers best identify and prioritize projects among competing demands? We believe the key to successful port engineering is the integration of vital infrastructure information in a robust and functioning Geographic Information System (GIS). Regardless of the type of port facilities, similar basic facilities data is maintained, often in hard copy format only. Property surveys, facility base maps, soil-boring data, building plans and facility as-built drawings are fairly common types of records maintained by port engineers. All of such data can be referenced and tied together using a spatial context – thus creating a geographic port data framework.

Applying an integrated GIS to a port offers facility management professionals

the opportunity to catalog this disparate information using established standards and data conventions. The catalogued data can then be managed according to parameters set by the users to provide better integration of information and yield better decision support products. Information is no longer fragmented or isolated, and multiple data types and scales start providing critical and usable correlations to support both short-range and long-term decision making processes.

I.A.1 Basic Concepts

In past few decades, rapid spread of technology has transformed the conventional port engineering and facility management activities into highly information and data-driven decision-making process. Such transformation driven by information/data has enabled the development of extremely complex systems for handling and processing information to assess, analyze, communicate and make decisions on our activities on daily basis. This trend has been particularly accelerated by proliferation of personal computers in late 80's and the growing availability of spatial data.

Many of our decisions are largely depending on the details of our immediate surroundings and require information about specific places on the Earth's surface (and increasingly over and under the surface) in relationship to the specific problem. Such information is called Geographic or Spatial. Thus, a Geographic Information System (GIS) is a container for spatial information that allows us to apply general principles to the specific conditions of each location, and allows us to track what, why, and how is happening at a given location (Longley et al., 2005). Geographical information, intrinsically, becomes essential for effective planning and decision making in the modern society. For many years, though, GIS has been considered to be too difficult, expensive, and proprietary. The advent of graphical user interface (GUI), powerful and affordable hardware and software, and public digital data have broadened the range of GIS applications and brought GIS to mainstream use.

There are many different definitions of GIS that have been evolved over the years, as they were needed. The definition of GIS would often depend on the application of geospatial data. Among them, the most frequently used definition of GIS is based on a simple description of its components; (1) map element (=spatial), (2) data element (=attributal), (3) software and hardware element (=georeferencing), and (4) knowledgeable users (=problem solving). Here, it is imperative to emphasize the importance of the 'knowledgeable users' element. Without the 'knowledgeable users' element, it is highly likely that the GIS implementation would probably end up with a loosely bound mass of top-rated, expensive data, software and hardware that is incapable of functioning in problem solving and facilitating useful information for effective decision making process. The result would likely be a unsuccessful GIS implementation with a depreciated ROI (Return On Investment) potential.

Some other well-known definitions of GIS include the classical one by Dueker (1979), "GIS is a special case of information system where the database consists of observation on spatially distributed features, activities or events, which are