California's experience with implementing GIS to support equitable healthcare accessibility

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Abstract
The California Office of Statewide Health Planning and Development (OSHPD) is a state department charged with planning equitable healthcare accessibility for California. OSHPD has recently approved a feasibility study report for implementing an enterprise geographic information system (GIS). This paper describes OSHPD’s process for implementing enterprise GIS technology and articulates the business process GIS will support. It further demonstrates the suite of applications OSHPD plans to offer internal and external clients. Future goals and objectives are also described, including the direction for enterprise GIS activities at OSHPD.

Introduction
The California Office of Statewide Health Planning and Development\(^1\) (OSHPD) is the state department charged with planning for the equitable healthcare distribution in the State. While it is a small department in the California Health and Human Services Agency (only about 400 employees), its responsibilities and jurisdiction are significant. OSHPD is the: 1) hospital construction approval and seismic safety review agency 2) clearing house for all hospital patient, financial and utilization data 3) healthcare workforce planning and analysis entity 4) healthcare outcomes analysis entity and 5) healthcare facility mortgage insurance provider. In short, OSHPD is responsible for a wide range of healthcare access, planning and implementation needs for the state.

In order to be successful in these diverse responsibilities, it is imperative that OSHPD have the ability to provide internal staff and external partners alike with consistent, timely and accurate information about healthcare in California. The ready availability of this information is not simply worthwhile, it is imperative to meet the growing healthcare needs of California’s diverse population. Recognizing this need, OSHPD leaders embarked on an impressive implementation of Geographic Information Systems (GIS). The goal of OSHPD’s GIS strategy was to ensure the proper use of GIS and information technology into every aspect of the department. This ‘enterprise’ implementation, taken over several years, will improve the ability of the department, external

\(^1\) [http://www.oshpd.ca.gov](http://www.oshpd.ca.gov)

California Office of Statewide Health Planning and Development
stakeholders and the public assessment of healthcare accessibility and other supply issues.

This paper gives an overview of OSHPD’s total enterprise GIS implementation. We then focus specifically on our experience in fostering GIS technology in the Healthcare Workforce and Community Development Division. Several vignettes of GIS implementation are presented and considered for effectiveness. We review the division implementation strategy to see how execution compares with planning. We finish the paper by summarizing our accomplishments to date and redefine our strategy for successful GIS maintenance.

**OSHPD Enterprise GIS Implementation Overview**

As a state department, OSHPD is required to adhere to the business rules established by the State Department of General Services (DGS) and Department of Finance (DoF) when implementing large Information Technology (IT) projects. The process typically follows the path:


OSHPD has contracted with several GIS consultants to aid in the entire process. A limited number of OSHPD staff are required for project management and some long-term implementation tasks (e.g., GIS specialists, technical support, database and network administration). These resources have been included from other organizational areas as needed to participate in the GIS project team.

The concept of enterprise GIS technology supporting state healthcare programs originated with a commissioned study by the California Health and Human Services Agency. OSHPD was the first department to adopt the concept and move it forward as an IT project initiative. OSHPD leadership outlined areas in the organization which would benefit from GIS services being implemented. A project team was established, including project management and Office-wide coordination. Executives were briefed on overarching project goals. Generating high-level support, securing executive sponsorship and identifying a project champion was a critical step during the concept planning phase. Establishing a solid business case is critical to the success of an IT project. The business case for GIS technology at OSHPD was clearly defined and presented no difficulties in this phase. Support came from not only the OSHPD Chief Information Officer, but also the Department Director, and the Secretary of Health and Human Services, a California Cabinet position.
The Feasibility Study Report (FSR) is the next step in the state IT business process. During this phase, OSHPD was required to perform an analysis of the business opportunity which results in tangible benefits or cost savings to the organization implementing the technology project. The FSR phase also includes an analysis of alternatives, selection of preferred alternative, and guidelines for implementing of the selected alternative. The FSR is then reviewed for additional work or approval by the sponsoring department, cabinet member and state control agencies DoF and DGS. A well-prepared FSR is critical to the planning of an IT project and greatly increases the probability of a successful implementation. This phase of the project was completed in approximately six months at a cost of less than $50,000 for contract services, plus staff time. To date OSHPD is the only state department with an FSR approved Enterprise GIS program.

With an approved FSR, OSHPD submitted a Budget Change Proposal (BCP) to the state DoF. The BCP is a state defined process where dollars are allocated to support new or expanding projects and programs, and is typically processed in conjunction with an FSR. Source of funds and analysis of costs are required. OSHPD revenue flows from Special Funds (outside of the General Fund), based on fees and assessments from healthcare facilities. This circumstance served to smooth the BCP approval process since no new taxation or fees were required to fund the three-year GIS implementation project at an approximate cost of $1.9 million, plus an ongoing annual budget of approximately $400,000.

During the FSR and BCP, OSHPD actually developed a small pilot GIS technology project that served as proof-of-concept. Following approval of both FSR and BCP, the Office moved forward to define a suite of best practices guidelines and work plans for GIS technology implementation. The best practices guidelines are standard in software development, database management, and technical architecture, providing a blueprint for project management and technical implementation through each phase of the project. This process of best practices planning and documentation represented the first phase (about one year) of the project at a cost of less than $300,000, which has been invaluable to the success of the project. Any new contractor coming on to support the project is provided these guidelines to follow for structured implementation of each component, providing OSHPD a mechanism to consistently apply and evaluate software development standards for any contractor.

The enterprise GIS project (EGIS) now had executive support, state government approval and financing. While the FSR included a needs assessment for all OSHPD program areas generally, the next step required more in-depth analysis of business needs in each program area that would define specific steps for GIS implementation. In the case of the Healthcare Workforce and Community Development Divisions (HWCDD), this assessment was completed January 2003.
The assessment was performed by interviewing all staff in the division as well as critical stakeholders. The assessment includes a Business Process Overview, specific Business Activities, Information Needs, and Recommendations for implementation. This process was completed about $50,000.

Figure 1 - Generalize HWCDD Workflow (from the Needs Assessment)

The final planning piece was the Implementation Strategy. Again using consultant OSHPD prepared this document for each division. For HWCDD, this document was produced in June 2003. The results of the Implementation Strategy phase is 1) a framework based on the component architecture of the EGIS program as a whole 2) phased approach focusing on internal then external stakeholders 3) definition of critical components including software/applications, people/expertise, management, data/DBMS, harware/network and 4) specific budget. In the HWCDD a dedicated GIS analytical staff was determined necessary for successful implementation. This staff was first hired in June 2004. The entire HWCDD assessment and implementation planning process was completed in less than a year at an approximate cost of $50,000.

Figure 2 - HWCDD Implementation Concept (from the Strategic Implementation)
In the HWCDD, GIS implementation continued parallel to the EGIS architecture, but supporting the specific business process in the Division. EGIS provided department wide software licenses, network support, DBMS, and implementation expertise, while the Division provided the content specific expertise for implementing GIS to better healthcare workforce analysis.

**Overview Architecture / Technology Employed**

OSHPD has employed a multi-tiered approach is deploying an enterprise GIS architecture, using the ESRI suite of software products. The first tier includes a central database services based on ArcSDE and MSSQL Server. Tier two includes ArcGIS Desktop, in both local, thick desktop and Citrix-based thin deployments. The third tier includes access to OSHPD data through web-based, ArcIMS applications or direct connections to ArcIMS map services.

The foundation of the enterprise GIS environment is a centralized database server running ArcSDE atop Microsoft SQL Server 2000. This database system allows for the rapid dissemination of spatial data to all enterprise applications, including ArcIMS and ArcGIS Desktop. It also allows for connections into read-only views of the OSHPD Data Warehouse, which runs on an Oracle DBMS. ArcSDE allows OSHPD to offer up very large data sets, such as DOQQ imagery and detailed street networks, without maintaining multiple, redundant data sets and placing excessive demands on individual desktop systems.

Moving large data sets efficiently presents a challenge in the enterprise GIS environment. OSHPD is a geographically dispersed organization, with four offices in the Sacramento area and a fifth office in Los Angeles. In planning, it was estimated that each remote user of ArcGIS Desktop would require a full T1 line to operate the software at an acceptable performance level. With many of our desktop users located at remote sites, some distance from the servers, bandwidth requirements quickly presented a major issue. The second tier of OSHPD system architecture specifically addresses this issue. A pilot program testing Microsoft Terminal servers was launched. The performance of this system was adequate, but management and transparency to the users was lacking. Citrix Metaframe Presentation Server and the ArcGIS Desktop were deployed on high-end dual processor servers. Applications are published seamlessly, appearing as simple desktop icons to the users. Other advantages to implementing GIS applications through Citrix include the ability to fully test and easily deploy software updates and new data sets seamlessly, with limited interruption to users. Citrix also allows for transparent load balancing across systems based on performance and expected load.

The third tier enables OSHPD to publish healthcare data and maps to the public via ArcIMS map services. OSHPD map services are available through interactive
mapping applications that provide users the ability to generate their own custom maps depicting OSHPD-collected healthcare data. Also included are links to other healthcare data sets, such as patient information, financials and utilization. For performance reasons the application system was split across multiple servers, with the application being hosted on a single web server and ArcIMS services hosted on a dedicated map server. A reverse proxy system completes the architecture, providing secured limited access to production GIS servers.

Figure 3 - OSHPD Enterprise System Architecture

The benefits of the enterprise GIS architecture are expanding through integration with the OSHPD Data Warehouse, which provides centralized management and dissemination of healthcare data sets from multiple collection systems. The warehouse includes Oracle database, ETL (extract-transform-load) tools, and Business Objects reporting software. Business Objects allows for custom queries that can be consumed and mapped by GIS applications, or the GIS can interface directly through database connections to Oracle. This integration supports ArcIMS application development in the ASP.NET environment, establishing GIS-based portals to rich healthcare information stored in the OSHPD Data Warehouse (e.g. healthcare facility information, patient information, etc.)
Healthcare Workforce and Community Development Overview

The Implementation Strategy not only articulated the framework for implementation, but also specifically defined the processes for which the division is responsible. These processes or programs generally fall under the following five categories.

- Framework for workforce and community analysis (Medical Service Study Areas / Rational Service Area)
- Meet Community Healthcare Workforce Needs/Shortage Designation
- Promote Healthcare Facility Expansion via Loan Guarantees (National Health Service Corps/ State Loan Repayment Program)
- Resident Training Program (Song-Brown)
- Community Outreach

Medical Service Study Area

As a critical component to shortage designation the HWCDD is responsible for determining the Medical Service Study Areas for the state. Defined from aggregates of US Census Bureau’s Census Tract geography these areas become
the basis for nearly all business processes in the HWCDD. The HWCDD has an agreement with HRSA that these MSSA’s are the Rational Service Area’s (RSA) for HRSA designations. This means that MSSA’s, once defined are the RSA and therefore the analysis unit for shortage applications for the life of the US census. California is the only state to have this predefined RSA in place.

After the 2000 census, OSHPD transformed the process by using GIS as the central component in health care resource planning for California. OSHPD organized community stakeholder meetings around GIS technology to capture the needs and desires of the public in defining these boundaries. With this method, OSHPD authorized at least one community meeting to be held in each of the 58 counties, a significant number of which were wholly rural or frontier counties. For populous Los Angeles County, 11 community meetings were held.

As a result, health resource data in California are collected and organized by 541 geographic units. The boundaries of these units were established by community healthcare experts, with the objective of maximizing their usefulness for needs assessment purposes. The most dramatic consequence was introducing a process by which all local stakeholders could see relevant socioeconomic and healthcare resource data simultaneously displayed in a GIS format. The graphics below illustrate the instant change in designation status following the release of Census 2000 and the incorporation of GIS tools to the process in Los Angeles County.

**Figure 5 - Before and after reconfiguration**

California Office of Statewide Health Planning and Development
Cooperative Agreement / Shortage Areas

The HWCDD is the Primary Care Officer (PCO) and Cooperative Agreement agent in California for Shortage Designation under the Health Resources Services Administration (HRSA). Under this agreement, the HWCDD helps process Medically Underserved Areas (MUA), Medically Underserved Populations (MUP), and Health Professional Shortage Areas (HPSA). HWCDD staff process the applications that community leaders, safety net providers and healthcare system executives submit for these designations. Once approved, the facilities in these regions are open up approximately $500 million in federal funding for increasing healthcare service in California annually.

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**Figure 6 - Annual Funding for Designated Areas**

In order to maximize potential federal dollars flowing into California, it is imperative that HWCDD staff do two things for shortage designation. First perform effective, accurate and timely analysis on applications. Second provide the best possible tools for applicants to prepare their submissions. Focusing on these two ideas we preprocessed all the key elements in shortage designation to the common RSA geography in a GIS. These elements include:

- Key demographics aggregated by RSA
- Three year average Birth Weight, and Infant Mortality by RSA from state vital records
- Population Center (weighted by census block) for each RSA
- Distance to nearest source of care by RSA
- Phone directory of all practicing physicians by RSA

California Office of Statewide Health Planning and Development
Then we created a lightweight MS Access front end for HWCDD staff to simply and easily confirm the required indicators for shortage designation from an applicant's submission. This application contains over 20 individual geographic indicators, aggregated to one common RSA so staff can quickly review the applicant's submission for accuracy. Staff who are infinitely familiar with the RSA geography do not have to know any GIS manipulations, but simply enter a RSA unique key and be returned the pertinent information. Since some of this information is proprietary, we also released similar application to the public to make their preparation of these applications easier. Below is a series of graphics from our ‘Dashboard’ application.

Figure 7 - Staff Dashboard for Physician Survey

Figure 8 - Staff Dashboard for Nearest Source of Care
State Loan Repayment Program

The HWCDD implements the National Health Service Corps / State Loan Repayment Program (NHSC/SLRP) for HRSA in California. The HWCDD oversees approximately $1 million annually in loan forgiveness for healthcare professionals\(^2\) statewide. We enter into contractual agreements with individuals to assume portions of their loans. We also enter into Memorandums of Understanding with clinics and healthcare systems for which these individuals work. Having the full suite of shortage designation geography in place is required in order for us to determine eligibility in the NHSC/SLRP.

As the implementing office for the NHSC/SLRP the HWCDD must determine that the site at which a contract awardee is working is eligible to participate in the program. The site must be located in a Health Professional Shortage Area (HPSA). Prior to GIS use in the division, this process was arduously performed through a series of phone calls, faxes, and disparate www queries. To solve this problem we 1) instituted a core database application storing all contract information including site locations and 2) created a series of HPSA GIS layers. Using Python scripting in ArcGIS, the site is address matched, queried against the RSA and the HPSA GIS layers in ArcSDE and confirmed as eligible all in one automatic motion.

Figure 9 - SLRP Site Database

\(^2\) Medical Doctors (MD), Doctor of Osteopathy (DO), Dentists (DDS), Nurse Practitioners (NP), and Family Nurse Practitioners (FNP).

California Office of Statewide Health Planning and Development
Song Brown

The HWCDD implements the state run Song-Brown program for increasing Family Practice residency in the State. Each year, medical institutions supporting residency programs apply to the HWCDD for grants which allow for the continuation or expansion of Family Practice, Nurse Practitioner and Family Nurse Practitioner residents. HWCDD staff requires the knowledge of resident locations and past graduate locations in shortage designation areas in order to rank applications.
In order to process, rank and comment on the applications received for Song-Brown funding, the HWCDD staff are required to identify the relative location of 250 annual training sites and nearly 1000 past graduates within five different healthcare designations. These designations are: 1) Rural/Urban/Frontier MSSA status, 2) Primary Care Shortage Area 3) Health Professional Shortage Area - Primary Care 4) Medically Underserved Areas and 5) Medically Underserved Populations. This process was repeated annually and typically took staff four to six weeks to complete. With a database capturing incoming applications and the successful implementation of shortage GIS layers, we were able to automate the process using Model Builder. Now all sites and past graduate locations were automatically scored for the location inside or not of the seven shortage areas. Returned to staff was a table automatically tallying the number of points an applicant got for being inside each of the designation areas.

Figure 11 - Song Brown Database
Figure 12 - Song Brown Processing Model
Figure 13 - Song Brown Output Score Sheet

Figure 14 - Output Map showing Song Brown Sites for one program. The blue circles are inside HPSA’s and the red circles are outside HPSA’s.

**Community Outreach and Data Publishing**

Community Outreach is a general category encompassing anything from providing data to stakeholders to performing special request analysis to being present at conferences, education fairs and healthcare events.

As mentioned in the Cooperative Agreement Shortage Designation section, many external stakeholders need to consume GIS data of areas in the State which are designated as medically underserved. Prior to GIS implementation in the California Office of Statewide Health Planning and Development
HWCD no such mechanism existed. Once implementation occurred our first step was to create GIS layers of all the designation types for the HWCD stewards. We then wrote a metadata template, robust metadata, and a policy paper on the release procedure for each of these datasets. Using ArcCatalog’s xml metadata standard, we created a metadata catalog using the State GIS metadata server to host our metadata and GIS data for delivery to the public. We post at this site metadata, statewide jpegs of the shortage areas and personal geodatabase GIS files. This service has a search by spatial domain, keyword, and catalog creator. The catalog is cached and can be reached by googling “California Healthcare Workforce Catalog.” Any stakeholder can down quickly access these designations for use as either stand alone MS Access files or for full incorporation into existing GIS libraries.

Figure 15 - Using ArcCatalog to define metadata
Figure 16 - Entering metadata in ArcCatalog

Figure 17 - Exporting metadata as XML
Results

The following measurable results can be directly attributed to the successful continued implementation of the EGIS project.

1. Permeated each division of the organization with back office, enterprise systems architecture, scalable Desktop/Intranet/Internet GIS applications, training and/or integrated databases. Expanding OSHPD capacity to apply spatial analysis methods to the assessment of healthcare access and supply issues.

2. MSSA delineation in a GIS, rather than paper method, has had the effect of increasing California’s ability to clearly define areas know to be medically underserved.

3. The reconfiguration process, which once took years to accomplish (without any notion of spatial accuracy) now is accomplished with full input from each county in less than a single year.

4. The time it takes HWCCD staff to process and recommend areas for shortage designation has decreased from nearly 90 days to about 45.

5. Data managed to support State Loan Repayment is now centralized, accurate, automatically updated and normalized. Applications which took clerical staff weeks to verify and write contracts for are now done in days.

6. Staff time to sort, rank and provide summaries for Song-Brown applications, which took four – six weeks, is now down in one afternoon.

7. Framework data available to all partners allows for the ability of real quantitative research on health disparities to finally take place.

California Office of Statewide Health Planning and Development
Conclusions

Our experience implementing enterprise GIS in OSHPD has been challenging but by and large very successful. We feel first and foremost that the primary reason for the success is due, not to the amount of funding we had budgeted for the project, but the effort we put forward in planning for the implementation. Clearly the FSR, Best Practices and Needs Assessment stages were not cheap in terms of both staff hours and contract dollars. However, these expenses pale in comparison to the potential cost of 1) multiple FSR’s if the first one wasn’t approved, 2) software, hardware and network purchases which are not scaleable to meet specific needs and most importantly 3) exorbitant costs of software redesign, data copying and wasted staff hours due to incorrect assessment of GIS needs at the beginning of the process. The documents and planning set forth in the Best Practices framework have given us an adaptable blueprint for success, which we are now just beginning to realize.

The Implementation Strategy paper is structured around six key components; 1) People, 2) Management, 3) GIS Software, 4) Data, 5) Hardware & Network and 6) Applications. Within two years of implementation, HWCDD had in place adaptable and scalable solutions for the first five including a dedicated fulltime position in the division for GIS implementation and research. Application development will occur over a longer time line. It is our assessment that we are meeting and exceeding the goals laid out in the strategy document. See Appendix A for an Implementation Overview.

Due to our success, we have had the opportunity of leading collaboration not only within our Department, but also within our Agency and in the State as a whole. Our successful FSR implementation has allowed us to increase our purchasing power by partnering with Departments in our Agency with similar needs, but not as mature GIS applications. We now have a new leadership role to helping develop state partnering of enterprise applications like geocoding solutions for all of California Health and Human Services Agency. Moreover, our success has placed us in the position of representing the Secretary of Health and Human Services on the California GIS Council.

We look forward to the next phases of our work which include two primary functions. First, delivering data through Internet Mapping systems and second researching health accessibility in the State. By leveraging ArcIMS we hope to provide the best possible streams of data we manage to our stakeholders, the legislature, research institutions and the public alike. In having greater access to this data, internally we hope to drive the policy agenda of increasing healthcare access and decreasing healthcare disparities in underserved communities. We hope these next phases of our work can affect California healthcare policy with similar success as our implementation has thus far.
Acknowledgements

Please recognize that none of the success described above could have been possible had it not been for many dedicated hours, weeks, months and years from many individuals. Below is a list of many of them.

- John Kriege, Deb Wong, Mike Kassis
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- Tony Laferty, Ken Blankenship and the ESRI California Regional Office
- Bruce Davenhall, Ann Bossard and the ESRI Health Solutions Group
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California Office of Statewide Health Planning and Development
Appendixes

Acronyms

OSHPD        Office of Statewide Health Planning and Development
BCP          Budget Change Proposal
DGS          Department of General Services
DoF          Department of Finance
EGIS         Enterprise GIS
FSR          Feasibility Study Report
GIS          Geographic Information Systems
HPSA         Health Professional Shortage Areas
HRSA         Health Resources Services Administration
HWCDD        Healthcare Workforce and Community Development Division
IT           Information Technology
MSSA         Medical Service Study Areas
MUA          Medically Underserved Areas
MUP          Medically Underserved Populations
NHS/SLRP     National Health Service Corps / State Loan Repayment Program
PCO          Primary Care Officer
RSA          Rational Service Area
Appendixes

Data Integration Model

OSHPD Databases
- Hospital Annual Financials
- Hospital Quarterly Financials
- Patient Discharge
- Hospital Construction Tracking
- Patient Outcomes
- Hospital Utilization
- Health Facility Mortgage Insurance Tracking
- Healthcare Special Summaries and Studies
- Medical Services Study Areas (MSSA)
- Health Professions Shortage Areas (HPSA)
- Hospital Community Benefits
- Education Grant Recipients
- Health Facility Mortgages

OSHPD Programs
- Hospitals/Health Care Facilities
- OSHPD Programs
- Mapping and Demographics
- External Data Providers (Census, Streets/Addresses, Physician)
- Program Information Needs

Customers
- Other Facility, Staffing and Outcomes Info
- Other HHS Departments (DHS, EDD, DSS)
- OSHPD Directors Office
- State Legislature
- Federal Government
- Other State Agencies
- Local Government
- Health Care Providers
- Health Care Industry
- Researchers
- Marketing Firms
- Health Insurance Purchasers
- Philanthropic Organizations
- Health Professions Students
- Recent Health Graduates
- Health Education Institutions
- Community Based Organizations
- The Public

Information Requests
- Health Facility Mortgage Tracking
- Healthcare Special Summaries and Studies
- Medical Services Study Areas (MSSA)
- Health Professions Shortage Areas (HPSA)
- Hospital Community Benefits
- Education Grant Recipients

Required Reporting
- Voluntary Reporting
**HWCDD Data Model**

**OSHPD**
- HWCDD
  - Cooperative Agreement
    - Medical Service Study Areas
    - HPSA
      - Primary Care
      - Mental Health
      - Dental
    - MLHP
      - Nearest Source of Care
  - SLRP
    - Survey
    - Invoices
    - Contracts
  - Song-Brown
    - Graduates
    - Sites

**HID**
- Facilities
- Financial Utilization

**Other State**
- DHS
  - Vitas
    - Birth Weight
    - Infant Mortality
  - Fluoridated Water
- Licensed Facilities
- MED-CAL

**Federa**
- US Census Bureau
  - Census Tracts
  - Demographics
- HRSA
  - Designations
  - Rules

**Third Party Proprietary**
- InfoUSA
  - Physicians
- American Medical Association
  - Physicians
- Academia
  - Research Outcomes

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California Office of Statewide Health Planning and Development

Page 24 of 25
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