

# A Tailored Approach to Implementing Open-Source Electronic Disease Surveillance Tools

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The World Health Organization issued revised International Health Regulations (IHR) in 2005, calling for significantly increased reporting and responding capabilities for all signatory nations and potentially improving the capacity of all countries to detect, assess, communicate, and respond to public health threats. Electronic disease surveillance is an important component of a comprehensive global public health disease prevention and control strategy and can contribute significantly to IHR 2005 compliance. The Johns Hopkins University Applied Physics Laboratory (APL) has created SAGES (Suite for Automated Global Electronic bioSurveillance), a suite of open-source electronic disease surveillance tools for resource-limited environments. Engineers and epidemiologists at APL use a tailored approach when implementing these tools, working with local stakeholders to identify specific needs, constraints, and expectations to increase overall adoption and sustainment of the system. The resulting system has the potential to facilitate local and regional electronic disease surveillance, regional public health collaborations, and international disease reporting. SAGES tools have been implemented in several countries around the world.

## INTRODUCTION

Emerging public health threats often originate in countries that have limited public health resources and infrastructure.<sup>1</sup> In recognition of this fact, the World Health Organization issued revised International Health Regulations (IHR) in 2005,<sup>2</sup> calling for significantly increased reporting and responding capabilities for all signatory nations. If implemented fully, the IHR will improve the capacity of countries to detect, assess,

communicate, and respond to public health threats. The mission of the Global Emerging Infections Surveillance and Response System, a division of the Armed Forces Health Surveillance Center (AFHSC-GEIS), is to support global surveillance, training, research, and response with regard to emerging infectious disease threats, in support of health protection among U.S. forces, the Military Health System, and the global public health

community. Electronic disease surveillance is an important component of a comprehensive global public health disease prevention and control strategy and contributes significantly to support for IHR 2005 compliance in partner nations. AFHSC-GEIS is committed to enhancing electronic disease surveillance capacity in resource-limited settings around the world.<sup>3</sup> Use of electronic methods for data collection and analysis has the potential to improve the accuracy and timeliness of outbreak detection as well as to provide situational awareness during or in the aftermath of an outbreak or pandemic.<sup>4</sup>

To support AFHSC-GEIS in its goals, the Johns Hopkins University Applied Physics Laboratory (APL) is leveraging its extensive experience in the design and implementation of ESSENCE (Electronic Surveillance System for the Early Notification of Community-based Epidemics) in the DoD, the U.S. Veterans Health Administration, and multiple state health departments to create and implement SAGES (Suite for Automated Global Electronic bioSurveillance). SAGES is an open-source electronic disease surveillance system for use in resource-limited settings around the world. The tools are customized for the organization (for example, a Ministry of Health or Ministry of Defense) that will be using them. In most instances, the introduction of SAGES tools represents a paradigm shift from a paper-based disease surveillance system to an electronic system. To ensure success in this environment, APL epidemiologists and software engineers follow a tailored implementation process to implement SAGES tools in partner nations.

## PLANNING PHASE

The implementation process begins when AFHSC-GEIS identifies a host nation that is interested in implementing SAGES within a specific organization in their country (typically, Ministry of Defense or Ministry of Health). The organization is the public health authority that will own, use, and maintain the SAGES system. AFHSC-GEIS also identifies an implementing partner who will work closely with the organization and APL during the implementation process. Typically, the implementing partner is U.S. personnel of other AFHSC-GEIS-funded collaborators located in the host nation or region. Historically, many of these collaborators have been part of the AFHSC-GEIS network of overseas laboratories that support AFHSC-GEIS public health initiatives.<sup>5</sup>

The implementing partner plays the critical role of ensuring that all stakeholders are on board and the implementation goes as smoothly as possible. The partner identifies one or more points of contact (POCs) within the host nation with whom to coordinate system design and approval of the final system design. The implementing partner engages with the host organization to ensure that there are no conflicting priorities, because there may be competition for limited public

health resources. In this phase, the implementing partner and the host nation POC will establish initial buy-in for the SAGES system within the host government and commit to meet with the APL team in-country.

## DESIGN PHASE

After obtaining the initial approvals, the APL team begins designing the SAGES system for the partner nation. The APL team consists of one or more software engineers and an epidemiologist. The implementing partner and partner nation POC assist in scheduling a site visit for the APL team, which includes meetings with decision makers, public health officers responsible for disease surveillance, and local information technology (IT) support. The team assesses country-level capabilities and needs for the surveillance system in question. The assessment must consider the requirements and objectives of the partner nation while keeping in mind infrastructure, finance, and personnel constraints within the host organization. The eventual design reflects the best-fitting, low-cost technology for the locale, enabling the system to be locally supported and not sponsor driven.<sup>6</sup> Table 1 summarizes some of the questions asked during this phase.

The answers to these questions inform the design of the proposed SAGES system for the host organization. During the assessment visit, the APL team completes a draft version of the design to share with the implementing partner and the POC to gain agreement on the way forward.

## DESIGN APPROVAL PHASE

After returning to the United States, the APL team further reviews the findings from the in-country assess-

**Table 1. Design phase questions**

Focus Area	Question
Public health	What is the purpose or objective of the system?
	Who are the users of the system?
	What data will be collected?
	Where will the data collection happen?
	How will the data be collected?
	What diseases are of most importance?
	How frequently will data be analyzed?
Technical	What types of analyses are needed?
	What kind of hardware is available?
	What is the nature of the available network infrastructure (Internet, Wi-Fi, cellular)?
	Who will pay for the necessary hardware and services (SMS, Internet, Wi-Fi)?
	Will routine training and support be available?

SMS, Short message service.

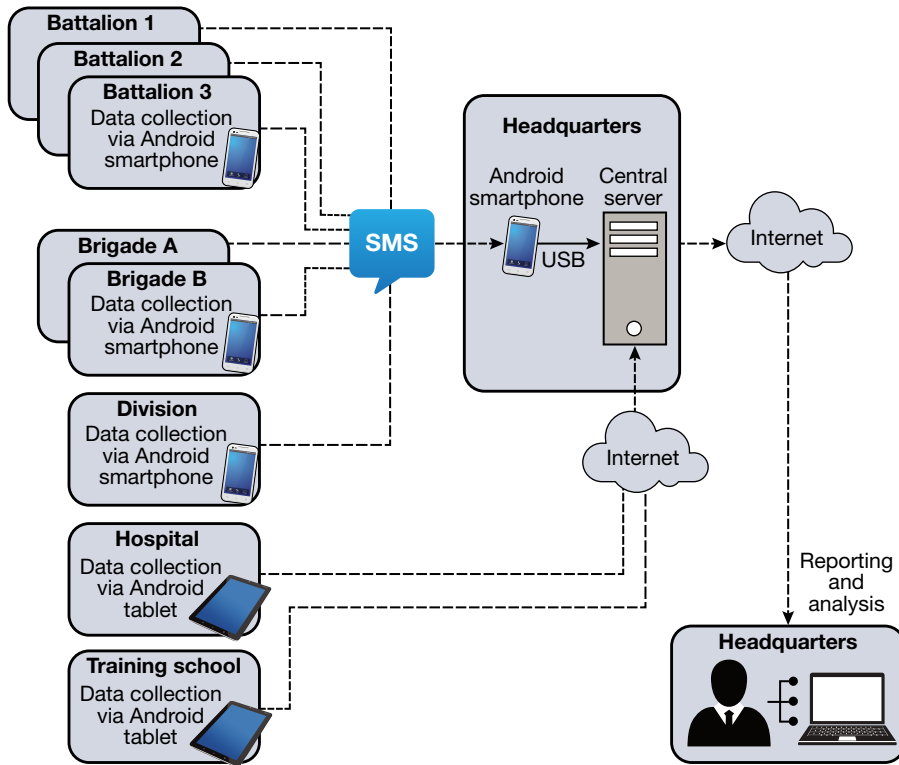


Figure 1. An example of a SAGES system design.

ment and refines the draft design for the SAGES system. The team provides the final design to the implementing partner and POC for review and feedback and then modifies the design as needed based on any feedback. The APL team then finalizes the design and distributes it to the implementing partner and POC. In most cases, the initial design reflects a pilot system with a small number of users and data collection sites. The pilot system model allows problems to be identified and resolved quickly without jeopardizing the overall system adoption process.

The POC seeks review and approval of the design from the appropriate authority in the partner nation. Implementation will not move forward until approval has been received. Figure 1 shows an example of a SAGES system design.

## DEVELOPMENT PHASE

Once approval for the architecture has been received, the development of the customized SAGES system begins. The system includes OpenESSENCE, which is an open-source multiuser network-accessible data entry, analysis, and visualization tool that enables an epidemiologist to monitor population health data from any computer connected to that network. OpenESSENCE supports dynamic query capability, GIS (geographic information system) mapping, and graphical analysis via time series charts, bar charts, and pivot tables. It also supports anomalous event detection for outbreak investigation.

Using the information gathered from the assessment phase, APL software engineers customize features in OpenESSENCE such as labels, fields, database structure, data entry screens, customized reports and queries, data types, and the theme (colors and logo). OpenESSENCE supports internationalization and can easily accommodate any language. Field labels and other user interface items are translated into the native language of the partner nation, with help from the implementing partner or POC (Fig. 2 shows an OpenESSENCE system customized with a Spanish user interface). Shape files for GIS mapping are acquired and added to the system. The system is implemented on a server that is accessible by the partner nation so that stakeholders can review

the customized system and offer feedback before final implementation in-country. This process is iterative; stakeholders are encouraged to offer feedback during this phase before the APL team arrives in-country for the installation.

The implementing partner and POC are responsible for acquiring all hardware and telecommunication services as described in the system design. They also make sure that appropriate space is available to house the

Figure 2. OpenESSENCE with Spanish user interface.

hardware that will be required and provide space for the system operator. The SAGES tools have minimal hardware requirements: a laptop or desktop computer that acts as the OpenESSENCE web server and cell phones that are used for mobile data collection. All equipment and software should be staged appropriately before the installation. All parties will then agree on a date for another visit by the APL team for in-country installation.

## INSTALLATION PHASE

In this phase, the APL team travels to the country to install the agreed-upon SAGES system, in concert with local IT personnel. Final system adjustments and troubleshooting are performed at this time. The team installs the software tools, makes sure all of the necessary hardware components are in place and functioning, and if existing data are available, imports data into OpenESSENCE.

As with any system, training the users to use the new system is a key component to successful implementation. During the in-country training, the APL team teaches the new users how to enter new data, either directly into OpenESSENCE via a web interface or indirectly via a mobile device. This is on-the-job training; the new users enter into the SAGES system new health surveillance information that would have gone into a paper logbook previously. The team answers questions and troubleshoots any problems that arise. As part of the learning exercise, users are given an opportunity to see how and when error messages appear and learn how to correct the errors. The training can take place in a traditional classroom-style setting or in small informal groups gathered around a computer. (Figure 3 shows APL SAGES team members and members of the Royal Thai Army after training).

The APL team also provides standard operating guidelines that describe how the system should be used in daily operations. The procedures describe daily or weekly monitoring and data entry using the new SAGES tools. The guidelines include specific queries and reports that might be useful and describe actions to take if an increase in disease cases is suspected. This type of training improves the adoption of the new system because it clearly shows new users how the system can help improve their normal routine. It is especially helpful in an environment where health care workers may already be overworked and have limited time.

Just as important as the content of the training are the people who attend. The time spent in-country is valuable but short, so it is important to gather as many end users as possible for the training opportunities. Although this is not always feasible, the APL team plans the visit well in advance to maximize participants' availability. While in-country, the APL team may need to travel to multiple sites to meet with various groups of end users. The team also works closely with an individual identified as the "superuser" for the SAGES system. This person takes on the role of trainer when new end users need training and is the main POC for APL team members after they depart the country. This train-the-trainer approach is effective because it enables the transfer of knowledge without the need for the APL team to be continuously involved. When personnel roles and responsibilities change, the SAGES adoption process continues with the presence of a strong champion within the organization.

The in-country training affords a valuable opportunity to build important collaborative relationships with stakeholders, improving the adoption process and potentially improving outcomes. The APL team listens to the questions and concerns of the end users and adjusts the software or the process as needed. This type of collaboration builds a level of trust that is very important when working with a foreign partner.

## OPERATIONAL PHASE

The APL team provides post-installation support and troubleshooting as needed to ensure the system is operating as expected. This phase typically lasts throughout the pilot process. Communication occurs via e-mail or scheduled conference calls. The post-installation phase



**Figure 3.** APL team members and members of the Royal Thai Army after training in Thailand.





**Figure 4.** An APL team member implements SAGES in Cambodia.

is vitally important because this is when the local stakeholders take ownership of the system. The system will not succeed in the long term without local ownership. During this phase, the APL team elicits feedback from end users regarding various aspects of the SAGES tools, such as usability, feature gaps, and ease of administration. The feedback informs future development of the SAGES tools, which can be used in the current implementation as well as future implementations.

## CONCLUSION

SAGES tools are currently deployed in several countries throughout the world, including Cambodia (Fig. 4), Cameroon, Uganda, and Peru. Many chal-

lenges exist when implementing electronic disease surveillance tools in resource-limited settings,<sup>6</sup> but using a tailored approach to implementation in which the design team collaborates with local stakeholders to identify specific needs, constraints, and expectations increases the overall adoption and sustainment of the system. The resulting system has great potential to facilitate local and regional electronic disease surveillance, regional public health collaborations, and international disease reporting.<sup>3</sup>

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