SORMAS-MI: Surveillance Outbreak Response Management and Analysis System (SORMAS) - Maturity Improvement through Community Engagement, Internationalization and Applicability Enhancement.

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Executive Summary

SORMAS (Surveillance and Outbreak Response Management and Analysis System) is an open source mobile and web application to **detect outbreaks**, manage **response measures**, validate cases, coordinate laboratory confirmation and perform follow-up of contact persons. SORMAS is fully integrated in the public health governance structures and contains **11 user-specific interfaces** and disease specific management algorithms for **10 high priority epidemic prone diseases**. SORMAS is currently being used in **15 federal states** and 155 local government areas, covering a total population of 36 million inhabitants in Nigeria.

In a consortium of 10 software-, public health- and research-organizations from **Burkina Faso**, **Ghana**, **Germany** and **Nigeria** we aim to target the following sub-indicators of the Global Goods Maturity Model: Source Code Accessibility, Community Governance, Software Roadmap, User Documentation, Multi-Lingual Support, Technical Documentation, Software Productization, Interoperability and Data Accessibility and Scalability.

This proposal foresees three modules A, B and C which are based on each other with the option to choose only A, AB or ABC. They include 11 work packages (WP) that synergistically contribute to improvements in these sub-indicators:

Module A focuses around the **Community Engagement**. One essential component is building a **Software Roadmap** (WP1). By establishing a **SORMAS Developers Academy** (WP2) we prepare the foundation for a **SORMAS-Hackathon** (WP3) to be organized in **Nigeria**. We will furthermore install a **creative commons repository** to make all user guides, training- and evaluation- materials available (WP4).

Module B focuses on **International Localization**: In **Design Thinking** workshops (WP5) in **Ghana** and **Burkina Faso** we will develop process models and specifications to improve internationalization and localization. The output of these work packages will feed directly into the programming for respective **productization** (WP6). Furthermore we will develop a **translation manager** (WP7) complementary to existing translation platforms to develop **multilingual** support and providing interfaces in the **main West African languages** (WP8).

Module C addresses **Applicability Enhancement**: The establishment of an integrated **Laboratory Information Management System** with basic functionalities (**LIMS light**) will support laboratory tasks in low resource settings (WP9). The introduction of the **One Health** approach (WP11) allows the information exchange with the environmental and the veterinary health sector. By integrating functionalities for **disease specific vertical programs** (WP10) aims to streamline the utilization of digital health tools and to **reuse** the **technical assets** developed and validated in SORMAS for other applications. By implementation of all three modules, SORMAS will eventually reach **full total score** of 30/30 of the **Global Goods Maturity Model**.

Consortium Team

The SORMAS-MCR Consortium is an established network of IT-enterprises, public health institutes and research organizations from **Nigeria, Ghana and Germany**, who have joint experience in developing and implementing the open source "Surveillance, Outbreak Response Management and Analysis System" (SORMAS). The consortium is organized according to

the **PRINCE 2** scheme, and its members represent **technical** and **scientific experts**, **users**, and **owners**:
HZI - Helmholtz-Centre for Infection Research, Braunschweig, Germany (lead);
Symeda - Symeda GmbH, Braunschweig, Germany;
NCDC - Nigerian Center for Disease Control, Abuja, Nigeria;
AFENET - African Field Epidemiology Network, Abuja, Nigeria;
CRSN - Center for Health Research, Nouna, Burkina Faso;
CISSE - Centre of Health Information and Epidemiologic Surveillance, Ouagadougou, Burkina Faso;
GHS - Ghana Health Services, Accra, Ghana;
KCCR - Kumasi Center for Collaborative Research in Tropical Medicine, Kumasi, Ghana;
GCNet - Ghana Community Network Services limited, Accra, Ghana;
RCDC - ECOWAS Regional Centre for Disease Surveillance and Control (R-CDC), Abuja, Nigeria;

HZI, initiator of SORMAS, provides the scientific and organizational lead. Symeda is a software company specialized in IT-solutions for health services and will execute necessary software adaptations and further development of SORMAS. CISSE, GHS and NCDC assure sustained integration within the public health system of Burkina Faso, Ghana and Nigeria. AFENET provides field supervision and training of users. GCNet establishes and maintains local server services. HZI, CRSN and KCCR provide quality assurance and scientific evaluation. R-CDC, assures alignment of activities within multi-national West African Surveillance Strategy and Evaluation.

Inclusion of additional organizations which would facilitate implementation of the aims described below would be most welcome.

Financial Sustainability

The listed partners have already signed joint **Memoranda of Understanding**. In different combinations they have jointly acquired funding for development and deployment of SORMAS from the following five sources: World Health Organization (**WHO**), German Center for Infection Research (DZIF), German Federal Ministry for Education and Research (BMBF), German Society for International Cooperation (GIZ). Additional intramural funding by HZI assures for core development and maintenance until the year 2021 and is likely to be renewed for another **5 year period**.

Project Description

Need

Infectious disease outbreaks are particularly difficult to control if transmission occurs person-to-person. The epidemiological situation can change drastically within few days and any disease control infrastructure requires real-time information exchange from remote areas via the district level towards the national level. Information also needs to flow the other way around to assure efficient disease control measures, such as border control, quarantine measures, hygienic measures, vaccinations, or preventive treatment. These are "**core capacity requirements** for surveillance and response" laid out in annex 1 of the **International Health Regulations** (IHR) and thus obligatory for every United Nation member state [1].

The challenge for most countries in Africa is not primarily to formally adhere to the IHR, but to efficiently allocate its **limited resources** for outbreak response, which in turn requires efficient alignment and quality monitoring of respective public health measures. This **technological gap** became tragically apparent during the Ebola epidemic in 2014/15 where early detection and timely management and monitoring of response measures were virtually non-existent.

Any tool that improves timeliness of detecting infectious disease outbreaks and increasing efficiency and quality of containment and response measures will directly control the spread of the disease and thus **reduce the burden of disease and economic loss** related to it. Due to this **exponential relationship** between proper detection and response to an outbreak on one hand and its potential to spread on the other hand, a digital health toll addressing these challenges has tremendous **health impact**.

Background

The **Surveillance, Outbreak Response Management and Analysis System (SORMAS®)** is a software, that assures effective and comprehensive execution of these response measures in addition to assuring that outbreaks are immediately detected in the first place, even if they originate in remote areas with **poor infrastructure** (www.sormas.org). In SORMAS, informants in hospitals and primary health centers (PHCs) use mobile tablets to enter data on new patients with infectious notifiable diseases. As the data set appears in the system, several validation procedures are being executed, partly automatically and partly manually by the surveillance officer. Based on this, the surveillance supervisor takes action by deploying a team to identify and monitor persons who had been in close contact with that patient. This is referred to as **contact follow-up** and is being done by contact officers and contact supervisors. The surveillance supervisor also gives tasks to the case supervisor which may be assuring isolation measures or safe burials. All these different officers use SORMAS, which assures real-time and **multi-directional** information exchange and management of measures among all those involved. This also includes **laboratories** executing confirmation of clinical diagnosis. Complementary to this, SORMAS processes information on events and other relevant information coming from the community, either formally via the community informant or informally via **community hotlines and social media**, which will be triaged by the rumor officer, another dedicated user of SORMAS [2-4] (Figure 1).

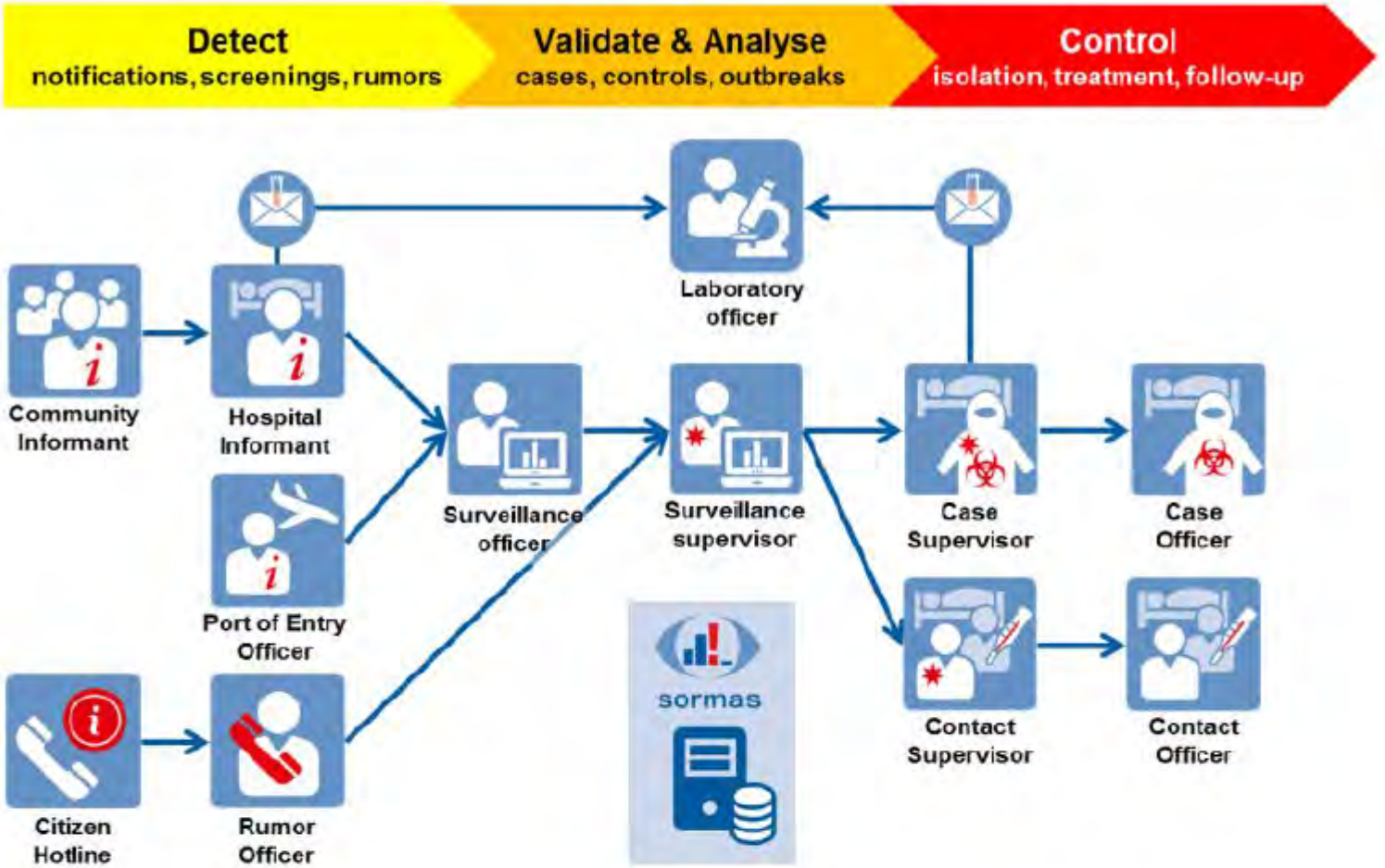


Figure 1: Information exchange among personas in SORMAS.

SORMAS is therefore **fully integrated** in the public health governance structures and adheres to the mandated and practiced roles of the respective health personnel. By integrating all these **needs** into one comprehensive approach, SORMAS **leverages existing technologies**, which tend to address isolated aspects in this domain. SORMAS contains disease management algorithms for the following 10 diseases: **Cholera, Dengue Fever, Ebola Virus Disease, Highly Pathogenic Avian Influenza, Lassa fever, Measles, Meningococcal Meningitis, Monkeypox, Plague and Yellow Fever plus an adaptable process model for emerging diseases**. It thus covers the high priority diseases for the Integrated Disease Surveillance and Response (IDSR) as laid out by the WHO Regional Office for Africa [5].

The system was designed by those involved in public health surveillance and disease control in Africa. Although development of SORMAS was initially done in cooperation with SAP, it was fully re-designed on an open source basis in 2017 and the SAP based SORMAS version is no longer available. SORMAS is free of charge and adheres to the open access policy. All codes, definitions, procedures and project plans are handled via the GitHub platform (https://github.com/hzi-braunschweig/SORMAS-Open). In the following we exclusively refer to the open source version of SORMAS.

Application Status and Level of Adoption

SORMAS is currently being used in 83 private and public health facilities, 20 laboratories and 15 Public Health departments from 155 local government areas (LGA) in Nigeria covering a population of 36 million. A recent report in Nature stated that with SORMAS, the Nigerian Centre for Disease Control is now much better equipped to respond to the current Lassa Fever outbreak [6].

Based on multiple design thinking workshops, supervisors and facilitator trainings, user trainings and field pilots from 2015 to 2017, a comprehensive multi-media repository of training materials, standard operating procedures, check lists, hardware and work force infrastructure has been established and used in Nigeria. IT and public health experts from **Ghana** have already been incorporated into the different training activities in **Nigeria** and Germany and the HZI team has conducted multiple feasibility assessment visits and training activities on SORMAS in **Burkina Faso** and Ghana in 2017. The West African Health Organization (**WAHO**) in Ouagadougou, Burkina Faso and the **Africa Center of Disease Control** in Addis Ababa, Ethiopia are both formally endorsing SORMAS for surveillance and outbreak response.

Immediate Project Aim

In the **Global Goods Maturity Model** (GGMM), SORMAS currently ranks high for global utility, medium for community support and low for software maturity (see chapter on GGMM below). This proposal will complement ongoing measures and its execution will make it possible for SORMAS to reach nearly the highest possible score in **all three GGMM-core-indicators**. We aim to reach this objective by improving the following sub-indicators of GGMM within this project:

- Source Code Accessibility
- Community Governance
- Software Roadmap
- User Documentation
- Multilingual Support
- Technical Documentation
- Software Productization
- Interoperability and Data Accessibility
- Scalability

By addressing those targets, this proposal will **leverage third party** funding support that SORMAS currently receives from the German Agency of Technical Cooperation (GIZ) for measures addressing **Country Utilization and Security**.

Vision for Contextual Expansion and Application for other Settings

Our vision is to gradually expand SORMAS conceptually and practically. Conceptually, SORMAS is currently focused on detecting and managing outbreaks for epidemic prone high priority diseases among humans. During the recent field implementations in Nigeria, SORMAS has gained visibility and representatives of other disease programs have queried on the possibility to apply SORMAS for their disease control program purposes as well. These include maternal and child health (MCH), expanded program on immunizations (epi) and vertical disease control programs such as those on **Tuberculosis, HIV, Polio, and Malaria**. Furthermore, Ghana Health Services and Ghana Veterinary Health Services have expressed the desire to use SORMAS for a truly "**One Health**" approach, by integrating activities of both services within SORMAS. Two workshops have already taken place to that respect. We also envision a non-governmental version of SORMAS, which does not aim to be integrated within existing governmental or administrative structures, especially if those are too weak to refer to. Emergency relief organizations such as Médecins Sans Frontiers (MSF), Red Cross or UNICEF could use such a NGO-SORMAS-version to be established in refugees' camps or during disaster response.

Practically or **geographically**, SORMAS is so far being used in different states of a typical West African, Anglophone, and federal government setting. We envision this proposal will contribute to SORMAS soon being used also in other government settings and other language environments. First we aim to gradually expand within the multi-national portfolio of the **West African** Health Organization (WAHO) but soon also in other areas of the continent and possibly also in **Asia** and **Latin-America**.

Use Cases, User Stories and Activities

Use Case "Community Roadmap Platform"

Team members, users and the public want to get a quick idea on the current state and future progress of SORMAS. This will help them to relate to the project and to plan their own activities in accordance. This need will be addressed by a "**community roadmap platform**" (WP1) which will be made available on the web, but which will also offer a user group via **WhatsApp** and a **SORMAS Wiki**. The roadmap will be the central place to inform them about current, near-term and future features and goals of SORMAS. It will offer Users, the developer community, interested parties and the broader scientific community a shared space to request, discuss and vote for new features. This roadmap platform will also enhance other activities towards community involvements such as the SORMAS-Academy (WP2), the SORMAS-Hackathon (WP3) and the creative commons repository of instructional materials (WP4).

Use Case "Multi-national WAHO Application":

Members of the West African Health Organization (WAHO) consist in five **Anglophone**, eight **Francophone** and two **Portuguese** speaking countries. For **cross-border** approaches to strengthen the population health, the multi-lingual situation can represent a challenge. However, how important the exchange between the countries is for a rapid and efficient intervention strategy, was emphasized by the Ebola virus outbreak in 2014/15 as infectious diseases do not halt in front of state borders. WAHO has formally endorsed the deployment of SORMAS in further countries from its region. The effectiveness of SORMAS for the region is enhanced by a full **multilingual support** function (WP7 and WP8). The provided choice of language allows an easy and efficient data entry by the user and task specific communication between the users through SORMAS. SORMAS will facilitate that **situation reports** of WAHO can easily be generated in all four official languages, thus, allowing for real-time reporting across borders which is highly relevant for an efficient outbreak management and surveillance system and overall contributes to improved health related communication within the region.

Internationalization and localization, however, are not only driven by language barriers. Different countries also have different administrative and legal settings and procedures. In West Africa differences typically exist between **central versus federal** government structures and between with a British versus French colonial history. These differences will be addressed through design thinking workshops on localization (WP5)

Use Case "Multi-ethnic Localization"

To adapt SORMAS to the individual local setting and to facilitate the deployment of SORMAS, multiple **non-colonial African languages** will be included in SORMAS. These are better understood by many of the less academically trained public health staff and especially also the patients themselves, particularly in very remote rural areas. By also offering interfaces in widespread African languages of non-European origin such as Hausa, Yoruba and Ibo communication errors and incorrect data entries can be prevented further (WP7 and WP8). Therefore SORMAS will increase cultural acceptability and also prevent communication errors during interaction between patients and health care staff. By that SORMAS will contribute to equal access, e.g. **women**, who in some areas tend to not have access to schooling in any of the official, formerly colonial languages.

Use Case "LIMS-light"

Public health and reference laboratories in Africa and other low resource settings are currently rarely using laboratory information management systems which would assure fully automated integration of the technical diagnostic devices being used. SORMAS on the other hand currently includes Laboratory officers as integrated users, up to the functional interface of organizing and monitoring sample shipment, exchanging clinical data from patients and feeding diagnostic findings into SORMAS. However, the current SORMAS-lab function is not involved in organizing organizational and documentary aspects of laboratory work itself, which is what LIMS usually do. LIMS however are very heavy due to their ability to digitally integrate the output of a large variety of diagnostic devices and to adopt a large variability of workflows of different kinds of laboratories. In principle such functionality would also be desirable for public health and reference laboratories in the area of

infectious diseases. Yet the threshold to get involved in this full set of functionalities is high, because it requires server infrastructure at the laboratory level and personnel to maintain it, in addition to the high cost of the LIMS software itself and its adaptation, even if the it is open source. The consequence is, that most public health and reference laboratories keep using paper laboratory books or cumbersome excel sheets instead. We therefore propose to **fill the gap** by offering a light version of a LIMS. Such "LIMS-light" would offer the most basic organizational and documentation functionalities, only little beyond those currently managed by paper-based laboratory books or excel sheets (WP9). LIMS-light would not aim to assure automated digital interfaces between the diagnostic devices, but would still require staff in the lab to manually transfer lab findings from a diagnostic device into the LIMS-light. On the other hand no highly qualoified It staff would be required to maintain a local server within the remote laboratory because LIMS-light would run on a **central server**, which will **enhance applicability**. Furthermore **complexity** of LIMS would be **reduced** tremendously, by not having to offer digital interfaces with countless variations of different laboratory devices. On the other hand labs using LIMS-light would already have the most essential benefits of quality control, data exchange and documentation.

Use Case "One Health"

One Health is the holistic approach to align disease prevention and control in the **veterinary** and **environmental health** sector with that in the human public health sector so to create **synergies**. Digital health solutions are a formidable area to put this approach into action, because the biggest deficit in its implementation lies within the information exchange between different sectors. SORMAS already now includes process models that relate and interact directly to veterinary and environmental health (WP10): the management of high pathogenic avian influenza interacts with veterinary health measures of chicken flocks and swine farms. The Lassa fever, Plague, Ebola and Monkeypox include issues of animal reservoirs. Dengue Fever and Yellow Fever encompass vector control measures and Cholera control concludes environmental water sanitation. It therefore appears desirable to expand the user portfolio of SORMAS from the human public health sector to veterinary and environmental health sector, since multiple activities and information needs are related to each other. The **Ghana Ministry of Health** has already approached the SORMAS team with the desire to incorporate One-Health functionalities in SORMAS. Two scoping workshops have already taken place to that respect.

Use Case "Disease Specific Vertical Programs"

Currently SORMAS covers already 10 different disease specific process models. They encompass a broad range of very different of infectious diseases but all have in common that they belong to the list of the **high priority epidemic prone diseases** as defined by **WHO**. This list does typically not include diseases such as **Polio, HIV, Malaria and Tuberculosis**, which are also of high public health importance but which for historic reasons are still being handled by **disease specific vertical programs**. Some of these programs have come up with their own disease specific digital tools. In the periphery of the public health service it is often the same individuals dealing with one or the other disease. Local public health officers and health care providers they are confronted with a variety of different digital tools, one of each disease specific vertical program often to be handled even in separate mobile devices. This results in unnecessary additional cost for hardware, training and supervision and also stands in the way of comprehensive and holistic disease prevention and control. Many process models in SORMAS encompass and go beyond the functional scope of the disease specific digital tools. Additionally SORMAS covers response management and bidirectional communication, while some disease specific tools are limited to transporting case counts from the periphery to the center. Therefore SORMAS appears to be the ideal platform for offering a "one-shop approach", that will **leverage existing technologies** of vertical disease specific programs (WP10). This would also facilitate seamless feeding into the DHIS2 and would likely enhance acceptability at all levels.

Activities and Work Packages

Module A: Community Engagement (WP1-WP4)

Module A addresses the area of SORMAS with the biggest potential for enhancement within the **Global Goods Maturity Model**. It aims to bring processes to the next level which have already been initiated and prepared through other funding sources of SORMAS. SORMAS is already very successful with respect to implementation, but the community of developers from different institutions still needs to grow. For this reason, Module A contains a set of works packages which will simultaneously stimulate community engagement directly and at the same time generate functional output, which in turn will enhance community engagement.

WP1: SORMAS Software Roadmap

We will create a publicly accessible roadmap that will be the central documentation of new feature requests and announcements of release cycles to ensure that the community is kept abreast on the development of SORMAS and has a format to contribute inputs to improving the tool. In order to facilitate **community participation** which involves the participation of the software community, stakeholders and IT experts, our processes on the roadmap will include strategies developed in interaction with the **External Advisory Board (EAB).** The roadmap will also include milestones of content management, document libraries. Novel procedures for creation and suggestions of new features will be set up in a new collaboration platform, which will include a pilot discussion board to stimulate exchange on future pilot and launch protocols, news service on new releases and a SORMAS blog to keep the **non-IT community abreast** of the development and maturity of SORMAS over time. The web based platform will be installed on the existing SORMAS Web site and contain version upgrades, storage capacities and disaster recovery systems while integrating an **eLearning** system for capacity building on SORMAS as we continue to develop the tool (see also WP4). We will link all current features to more detailed descriptions and, if already available, the actual implementation **tickets on GitHub** (https://github.com/hzi-braunschweig/SORMAS-Open). Features will be grouped into categories/themes to increase overview and readability of the roadmap. We will develop a procedure to document in a non-technical way, all new release information during our release cycles and new features to this platform from our existing SORMAS GitHub platform. In addition to the existing SORMAS social media platforms (Facebook and Twitter), we aim to enhance chatrooms and discussion forums in those platforms that are currently most popular among the relevant stakeholders and users. For the field of public health in Africa this is currently **WhatsApp** (https://www.whatsapp.com/). Thus we will also establish a WhatsApp group for SORMAS, in which we will not only communicate new developments and support, but in which we will also encourage users to share their ideas for novel functionalities and improvements. The SORMAS team will feed these suggestions into the product backlog in GitHub. Complementary to these activities we will initiate a **SORMAS Wiki**, to further enhance visibility and participation of the roadmap.

WP2: SORMAS Developer Academy

The SORMAS Academy aims to provide IT experts with the basic insights of the SORMAS concept and architecture to enable them to contribute new ideas, tests, and thematic expansions to SORMAS **complementary to the core-developer team**. The main objective of such an advanced SORMAS user's platform is to be able to dynamically grow a community of SORMAS developers who can contribute to the many facets of SORMAS development. This will in turn also increase the use of SORMAS in additional regions and countries. The establishment and growth of such a software community will enhance the SORMAS related content in GitHub and creating **new functionalities** and plugins for SORMAS. A **certificate** will be awarded upon successful completion of such a course, which will serve as an additional incentive for companies or IT consultants who wish

to apply for future programing tenders related to SORMAS.

WP3: SORMAS Hackathon

We will conduct a West-African SORMAS Hackathon in **Yabacon Valley** in Lagos, Nigeria - the so called "Silicon Valley of Africa" – which will be preceded by a workshop of the SORMAS Developer Academy. The funding requested through this proposal will allow us to sponsor participation of programmers throughout West Africa. The Hackathon will serve multiple purposes at once. A) It will motivate the international and especially regional **IT community** to get involved in the SORMAS development; B) it will help **developing concepts** for the other use cases (see below); C) it will increase **visibility** and attractiveness of the SORMAS Developer Academy and D) SORMAS-Academy and SORMAS-Hackathon will both contribute to **community feedback**.

Participants of the hackathon will be offered to choose from a variety of possible applications for which they are invited to develop proof of concepts, such as:

- Interoperability with LIMS used in Africa
- Curated translation manager
- Tools for one-health application of SORMAS
- Data analysis tools within SORMAS
- Tools for automated situation reports on outbreaks

WP4: Creative Commons Instructional Materials

SORMAS already has a comprehensive repository of audiovisual instructional materials, including **video cartoons**, lectures, **multi-lingual trouble shooting guides**, check-lists, standard operating procedures for field deployment, **supervision schemes**, **user-surveys** etc. However, most of this material requires some final revision after its repeated intensive use during the SORMAS deployment from November 2017 to March 2018. It is now the aim to execute theses revisions and to then make this material publically available under **creative commons** license. This will not only serve the community involvement of SORMAS itself but also may be very useful for other software initiatives in the health sector. Whenever new instructional materials, user guides and reference documents become available they will be advertised through the communication channels developed in WP 1.

Module B: International Localization (WP5-WP8)

Based on the mobilization, capacity building and developments resulting from module A, Module B aims to turn these into products and to engage in specific programming of new features that will enhance localization and multilingual support.

WP5: Design Thinking on Localization

We will conduct two **Design Thinking workshops**, one in **Accra**, Ghana and one in **Ouagadougou**, Burkina Faso with potential future users and stakeholders. The workshop in Ghana will generate specifications that become relevant when deploying SORMAS in a non-federal nation, as compared to the federal states in Nigeria, where SORMAS is currently being used. The Design Thinking workshop in Ouagadougou will have the aim to develop specifications for the typical administrative setting of a francophone African country. Furthermore, since the headquarters of the West African Health Organization (WAHO) is

located in Burkina Faso, this workshop will also develop concepts and process models, necessary for the deployment of SORMAS at multinational, WAHO-specific level.

WP6: Productization

The output of the Hackathon and of the Design Thinking workshops will directly feed into implementing respective tools and functionalities within SORMAS. This will occur at a variable level of predictability, since the output of the **Hackathons**, cannot be foreseen beforehand. But with respect to the Design Thinking workshops, we envision to come up with a new product version of SORMAS that assures sufficient performance and administrative adaptability for multi-country and multi-year use of SORMAS.

WP7: Translation Manager

In order to assure reliable and efficient generation of different language interfaces we aim to develop a tool, which complements existing translation-platforms (e.g. www.translatewiki.net) to better suit the need of SORMAS. SORMAS is dealing with medical and public health procedures that are legally sanctioned under national law and International Health Regulations. For this reason, translation of technical terms cannot be left fully at random of crowd-based procedures. We envision building an **interface** that on one hand does facilitate multiple users to contribute to the translations procedure. On the other hand the process will be **curated** to assure a scientifically and legally consistent outcome. Such curated translation tool will be one task offered at the SORMAS Hackathon, so that the output of the second will be expected to support development of the first.

WP8: Translation

With the help of the curated translation tool and **back-to-back** to aforementioned Design Thinking workshops in Ghana and Burkina Faso, interfaces of SORMAS will become available in different languages allowing easy switching between different languages. This will at first cover **English, French, Hausa, Portuguese, Spanish** and allow easy addition of other languages such as **Yoruba** and **Ibo**, without need of "hard-wire" software changes.

Module C: Applicability Enhancement (WP9-WP11)

To address the need described in use cases "LIMS-light" and "Disease specific vertical programs" Module C aims to expand the portfolio of SORMAS functionalities so that synergies with digital health solutions from other related diseases and sectors can be established and enhance **applicability**. The objective of this module is also to **re-use the assets** of SORMAS a Design Thinking workshop with stakeholders of the respective topic, with the aim to assess and assure **adoptability** and maximize **impact**. The objective of these Design Thinking workshops will be, to identify commonalities and complementarities between the existing programs and to develop a **joint strategy** on how to integrate the functionalities of existing tools into SORMAS. This will then be programmed accordingly while assuring full compatibility with existing external programs.

WP9: LIMS light

The SORMAS LIMS-light will be designed so, that it assures full compatibility with the most common existing open source LIMS with the aim to later facilitate migration to a **full-scale LIMS**, which would no longer be part of SORMAS.

LIMS-light will be developed on the basis of a Design Thinking workshop with participation of the **Lyon office of WHO**, working on LIMS and also other stakeholders in the field, such as **African reference and public health laboratories.** The programming itself will be commissioned via open tender to further enhance the possibility for new programmers to get involved in developing SORMAS.

WP10: One Health

We plan to organize multidisciplinary and multi-sectorial design thinking workshops in Ghana which will result in specifications and process models for an One Health approach within SORMAS. This will inevitably result in a **multi-sectorial expansion** of the user-groups of SORMAS. Execution of the programing will follow the example described in work packages 9.

WP11: Integration of Disease Specific Vertical Programs

Similar to aforementioned approach in WP9, we will conduct Design Thinking workshops with actors and **stakeholders** of the respective **disease specific vertical programs** and those who have developed the respective digital tools. Based on these workshops we will develop specifications for plug-ins and APIs for SORMAS for those diseases and commission their programing in an open tender to further enhance community involvement and to also include the possibility for the creators of the disease specific digital solutions to execute this programing themselves.

Digital Health Technologies

SORMAS is relying on a few frameworks and standards that are not specifically health related, but are especially important for web based systems in the health domain. This includes secure data transfer using the **Transport Layer Security protocol** (TLS) and a **Java Enterprise Edition** (JEE) based server backend which provides security mechanisms, transaction management, a generalized persistence layer and **Representational State Transfer** (REST) **web services** for mobile app integration. We are planning to migrate to **Vaadin 8**. Vaadin is most suited for business applications and allows for very fast and comfortable coding which directly benefits the speed of the development process. Both technology stacks will allow us to create a software that is fast and responsive, which features a modern user interface and supports all functionalities. The Payara server is relatively lightweight with an **active community and commercial support**. It also has frequent updates and security patches. The PostgreSQL has a high performance tuning with a **full Atomicity, Consistency, Isolation, and Durability** (ACID) **compliant**. It supports **JavaScript Object Notation** (JSON) data type and has the possibility to **encrypt** individual columns with sensitive data. With an active community and open source platform, PostgreSQL stands to be one of the greatest advantage we have had using it as the core database of SORMAS. **DHIS2** is also built with the same software architectural modules using PostgreSQL and JAVA as its backend platform. This makes it seamless to integrate servlets to interact between each system via a **Cron-job**. SORMAS architecture contains an **Enterprise JavaBeans** (EJB) **business layer** which is a link between the **encrypted PostgreSQL database**, via a Java Database Connector (JBDC) to the REST API and Vaadin. In regards to extensibility, also by other developers outside of the core development team, programming user interfaces in Vaadin is easy to learn. The SORMAS technology stack has been successfully used numerous times for e-health products in Germany.

For **quality management,** the development team has incorporated **internal reviews** of the implemented features and the **written code** every day; new versions are always deployed on a test system and extensively tested there before they are released on the productive system. The development team uses an **agile programming** methodology and **SCRUM** to do regular reviews (every two weeks) to make sure that the course of the development complies with the actual needs of the SORMAS users.

The following diagram (Figure 2) visualizes the general way SORMAS can interact with other platforms using an API built on common standards like **Health Level Seven International** (HL7). Communication servers allow a customized communication with the different API of other systems.

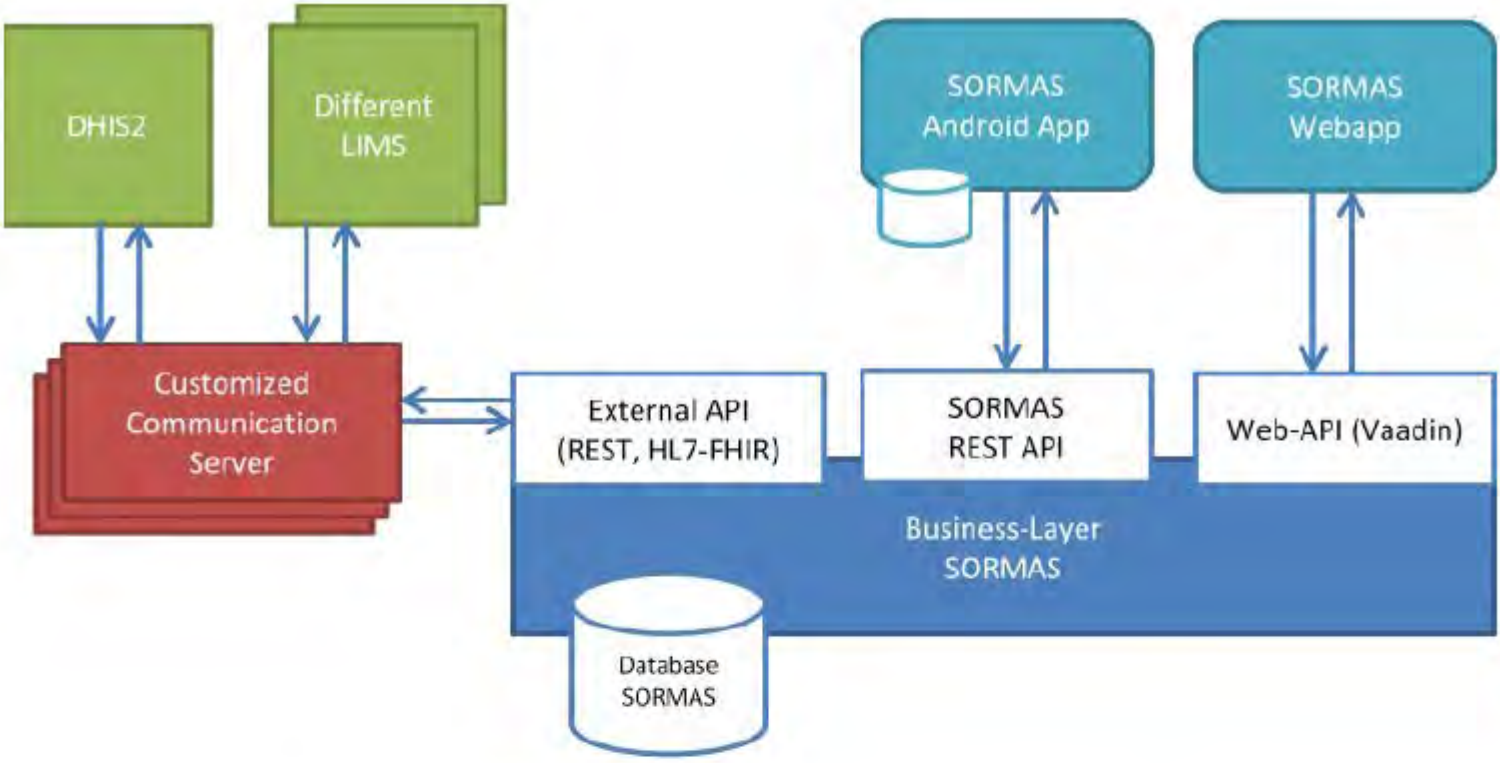


Figure 2: Visualization of the general way SORMAS can interact with other platforms using an API built on common standards

With respect to the Work package 9 (LIMS light) we will use the **Laboratory Testing Workflow** (IHE-LTW) to cover the workflow related to tests performed in vitro specimens by a clinical laboratory.

Besides these known requirements the SORMAS will use operational standards like IHE-PIX "**Patient Identifier Cross Referencing**" to identify cases cross system. For interoperability with third party systems HL7-FHIR (**Fast Healthcare Interoperability Resources**) (http://hl7.org/fhir/) is envisioned. This next generation framework defines standards to represent and exchange data based on real world concepts in the healthcare system.

Community Feedback

Aforementioned work packages synergistically contribute to enhancement of community feedback. The **SORMAS Academy** and the **SORMAS Hackathon** targets mainly at enhancing engagement among software developer community. The measure towards multilingual interfaces aims to reduce the threshold for large parts of the **Public Health community** but also the general African population to get involved in expressing user needs. It is also for this purpose that we will organize the Hackathon in Nigeria and Design Thinking workshops in Burkina Faso and Ghana, so to maximize local community participation.

The software roadmap plays a crucial role in community feedback. The SORMAS vision, mission and design principles will form the framework for defining a roadmap, while the requirements of the users will be the driving force. Based on both, the SORMAS team will update the roadmap regularly as part of the development and review process. The two main sources guiding the roadmap will be (a) **Requests and suggestions from stakeholders** – mostly the actual users, members of the SORMAS team and the community and (b) **technical and regulatory requirements** like **scalability**, **flexibility** or **security**.

Aforementioned **SORMAS roadmap** approach will be an important part to collect feedback from users and other parties and will enable the SORMAS team to actively interact with the community and to refine ideas and requests. A moderator will

eventually specify new requests by an individual feedback interview to assure full understanding and former migration into the backlog and roadmap. The **hackathon** and **Design Thinking workshops** in the other works packages will further increase the reach of this platform and **facilitate communi**cation to be stimulated beyond these singular events.

A SORMAS **external advisory board (EAB)** is being installed currently with funding from GIZ. In the framework of the Digital Square project, the EAB will receive two additional functions: a) the EAB will serve as the jury to select the winner of aforementioned hackathon. b) The winner of the hackathon will be invited to participate in the EAB meeting following the Hackathon not only as an incentive but also to stimulate personal exchange between the EAB and the young IT-community around SORMAS.

Self-Assessment on the Global Good Maturity Model

We used the Global Good Maturity Model version 1.0 to determine the SORMAS maturity level following the WHO Digital Health Intervention guide [7]. Currently SORMAS has total score of 15 in the Global Goods Maturity Model (GGMM) partly because SORMAS does not yet have an implemented publicly accessible and routinely maintained platform for new feature requests and because planned performance testing and load statistics are not yet completed. The score will however progress to a total score of 20 by December 2018 due to activities currently funded by third parties independently from Digital Square. After implementation of Module A, the total GGMM score will rise to 27 by June 2019 mainly due to significant improvements in community involvement. Additional execution of Module B will result in further rise to a score of 29 by June 2019 due to measures in internationalization and multilinguality. Implementation of Module C would further increase the total score to the maximum possible score of 30 (Figure 3).

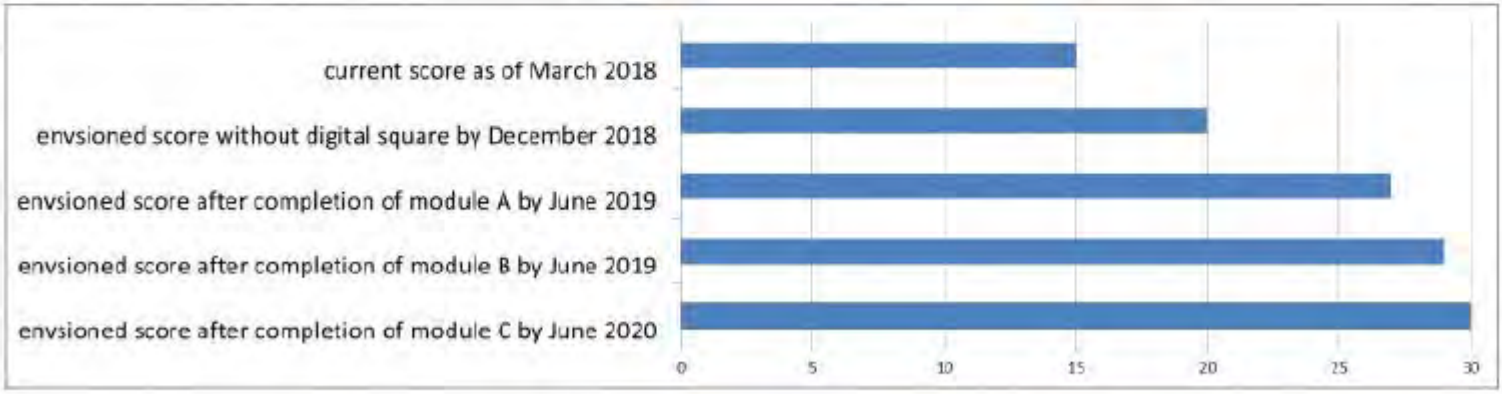


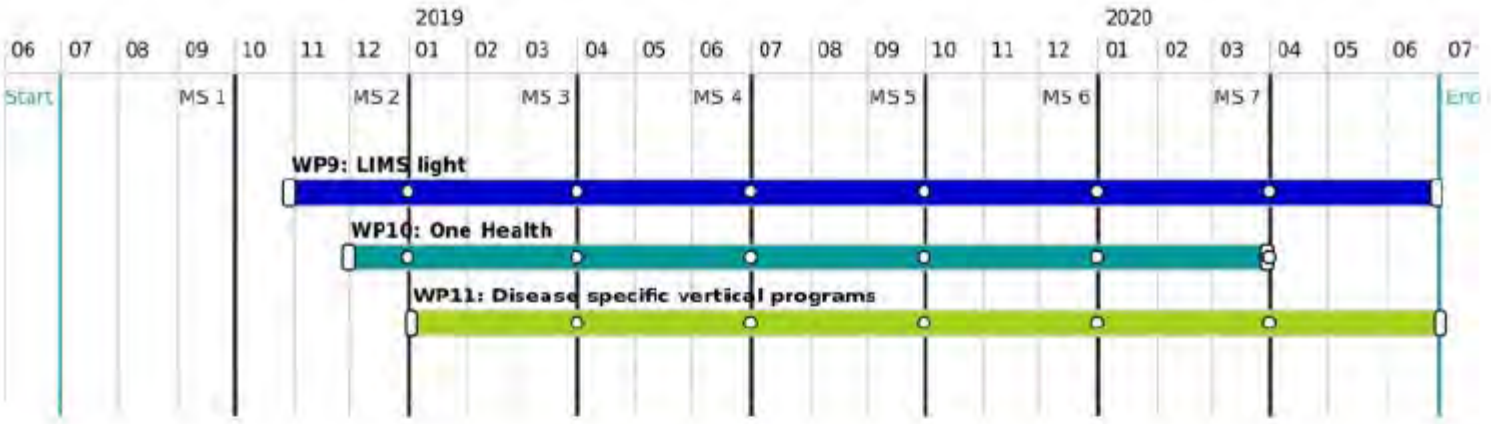
Figure 3: Expected increase of total score in Global Goods Maturity Model as a result of Module A, B and C.

Workplan, Project Deliverables and Schedule

GANTT Chart Schedule

Module A

Module B



Module C

RACI Chart

Work package	Area of focus	Scientific Lead	IT Lead	Community Support Burkina Faso	Community Support Ghana	Community support Nigeria
	MODUL A					
1	Software Roadmap	A	R	I	I	I
2	SORMAS Developers Academy	A	R	I	I	I
3	SORMAS Hackathon	A	R	I	I	R
4	Creative Commons	A	I	C	C	C
	MODUL B					
5	Design Thinking on Localization	A	I	R	R	C
6	Productization	R	A	C	C	C
7	Translation Manager	A	R	C	C	C
8	Translation	A	C	C	C	C
	MODUL C					
9	LIMS light	A	R	I	I	I
10	One Health	A	R	I	I	I
11	Disease specific vertical programs	A	R	I	I	I

R Responsible A Accountable C Consulted I Informed

Project Deliverables

Module A: Community Engagement

Work-package	Milestone	Indicator of success	Milestone
WP2	IT experts are provided with basic insights of SORMAS' concept and architecture through a Developers Academy	1. Min 10 participants have completed certified training	MS2 Nov 2018
WP3	The IT community supported the development of concepts for use cases and SORMAS visibility was increased	1. A SORMAS Hackathon was performed 2. Technical concept for at least one use case presented	MS2 Dec 2018
WP4	A comprehensive repository of audiovisual instructional materials is publically available under creative commons license	1. Available instructional material is revised 2. Repository is formed from the	MS2 Dec 2018
WP1	In the framework of a roadmap near- and long-term decisions for SORMAS are steered, regularly updated and strengthened by community input	1. Roadmap is created 2. Roadmap is publicly accessible 3. Roadmap updated regularily	MS3 Feb 2019

Module B: International Localization

Work-package	Outcome	Indicators of success	Milestone
WP5	Identification and definition of the design-issues of SORMAS that result from addressing the one-health aspect which is the comprehensive management of animal and human health	1. A Design Thinking workshop is performed in Ghana 2. Spefications for One Health application on SORMAS defined	MS2 Dec 2018
WP5	Specifications are determined which become relevant when deploying SORMAS in a non-federal nation	1. Spefications defined for aplicability in non-federal nation	MS2 Dec 2018
WP5	A concept and a process model are developed, necessary for deployment of SORMAS at multinational, WAHO-specific level	1. A Design Thinking workshop is performed in Burkina Faso 2. Specifications defined for WAHO specific applicability	MS2 Dec 2018
WP5	Specifications for the typical administrative setting of a francophone African country are developed	1. Specifications defined for francophone African administrations	MS2 Dec 2018
WP7	Reliable and efficient generation of different language interfaces is ensured	1. A tool available complementing existing translation platforms	MS3 Mar 2019
WP8	Different language interfaces are established in SORMAS that allow easy switching of the user configuration to	1. SORMAS interfaces available in at least 3 different languages	MS4 Jun 2019
WP6	Implementation of further functionalities within SORMAS is advanced	1. At least one novel application in SORMAS developed	MS4 Jun 2019

Module C: Applicability Enhancement

Work-package	Outcome	Indicator of success	Milestone
WP10	The SORMAS user portfolio is expanded to the veterinary and envrionmental health sector	1. A Design Thinking Workshop on One Health completed 2. A concept for One Health application defined 3. A prototype of One Health application fully programmed	MS7 Mar 2020
WP9	A basic laboratory information management version with only organizational and documentation functionalities complememts SORMAS	1. A Design Thinking Workshop on LIMS light completed 2. A concept for LIMS light defined 3. A prototype of LIMS light application is programmed	MS8 Jun 2020
WP11	The SORMAS repertoire is increased to disease specific vertical programs	1. A Design Thinking Workshop disease specific programs completed	MS8 Jun 2020

Narrative budget

In order to perform the described activities of module A to C, the following budget is required.

Module A

The main activities in module A are the creation of a roadmap (WP1), the initiation of an Academy (WP2), the realization of the hackathon (WP3) and the creation creative commons instruction material (WP4). The budget is dedicated to salaries for field and headquarter (HQ) staff, items required for the hackathon realization, travel costs and programming of the roadmap.

The field staff consists of one IT-experts and one field manager, who will contribute to module A with 6% for eight months. They will contribute to the logistic and technical organization as well as realization of the Academy workshop and the hackathon in Nigeria (WP2 and WP3). The IT personnel will also provide input to the roadmap realization (WP1). The HQ staff, situated in Germany, include an epidemiologist, a statistician, a technician and a project manager. They will contribute to module A for eight months with 19%, 24%, 24% and 19%, respectively. The first three provide content related input to the realization of the roadmap, the academy, the hackathon and the creative commons instruction material. The latter manages the organizational aspects of the project. Further budget is dedicated to IT consulting for the programming required to establish the roadmap and the academy. A certain budget is dedicated to the organization and realization of the academy and the hackathon and travel costs for participants and staff. This includes travels for two persons from Germany to Nigeria and travels within Africa for the 10 participants. Module A amounts to a total costs of $ 136,831.

Module B

The activities of module B are based on the achievements of module A. A Design Thinking Workshop (WP5) is realized and its results will be productizated along with the results from the hackathon (WP6). Furthermore, a Translation Manager (WP7) is implemented and the translation (WP8) of SORMAS into different languages is performed.

The staff composition described in module A is complemented by an IT- Expert for the field staff and an administrator for the HQ staff. The roles described in Module A remain similar. Each member of the field staff will contribute to the 12 months with 25%. From the HQ staff the epidemiologist and the project manager will contribute with 25% each for 12 months. The technician and the statistician will contribute with 16% each for 12 months and the administrator will contribute for 12

technician and the statistician will contribute with 16% each for 12 months and the administrator will contribute for 12 months with 10%. According to their expertise, they will contribute to the logistical and content-related organization and realization of the Design Thinking workshop. For WP5 and WP6 content-related knowledge will be provided by the respective staff. The project manager and administrator will be in charge of the overall organization of the different work packages. IT consulting will be responsible for the programming required for WP5, WP6 and WP7. Translators will be consulted for WP8. Further budget will be required for travel costs within Africa and from Germany to Ghana and Burkina Faso for the Design Thinking workshop (WP5). Module B amounts to a total costs of $ 276,238.

Module C

Module C consists of advanced activities to expand the portfolio of SORMAS and the required funding period is two years. The following work packages are included in module C: LIMS light (WP9), one health (WP11) and integration of disease specific vertical programs (WP11). Budget includes salary for field and HQ staff who is present in a similar composition and with similar roles as described in module B. Concerning the field staff, the field manager will contribute for 20 months with 30%, the IT Experts will contribute with 60% each for 20 months. From the HQ staff the epidemiologist and the project manager will contribute with 30% each for 20 months. The technician and the statistician will contribute with 20% each for 20 months and the administrator will contribute for 6 months with 12%. A major item on the budget are programming costs. Workshop costs and travel costs will occur to consult with experts in the field for an effective realization of the work packages adjusted to the actual setting. Module C amounts to a total costs of $ 1,360,671.

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2. Fähnrich, C., Denecke, K., Adeoye, O. O., Benzler, J., Claus, H., Kirchner, G., ... & Tom-Aba, D. (2015). Surveillance and Outbreak Response Management System (SORMAS) to support the control of the Ebola virus disease outbreak in West Africa. Euro surveillance: bulletin Européen sur les maladies transmissibles= European communicable disease bulletin.

3. Adeoye, O., Tom-Aba, D., Ameh, C., Ojo, O., Ilori, E., Gidado, S., ... & Lamshoeft, M. (2017). Implementing surveillance and outbreak response management and analysis system (SORMAS) for public health in West Africa-lessons learnt and future direction. Int J Trop Dis Health, 10(22), 1-17.

4. Moyer, D., Tom-Aba, D., Sharma, S., & Krause, G. (2017). Taking Digital Innovation into the Field of Infectious Diseases: The Case of SORMAS®. In Shaping the Digital Enterprise (pp. 219-236). Springer, Cham.

5. World Health Organization, & World Health Organization. (2008). Integrated disease surveillance and response.

6. Maxmen A: (2018) Deadly Lassa-fever outbreak tests Nigeria's revamped health agency. Reforms put in place after Ebola epidemic in West Africa have built Nigeria's capacity to diagnose diseases and track their spread. Nature Vol 555: 421-422.

7. World Health Organization. (2016). Monitoring and evaluating digital health interventions: a practical guide to conducting research and assessment.

Appendix

Global Good Maturity Model score,

SORMAS Dashboard Screenshot for Monkeypox Cases,

SORMAS Trouble Shooting Guide,

Informants Inject for Supervision,

Summary of SORMAS Deployment as of February 2018