Spatial Decision Support Tool for Indoor Residual Spraying Implementation (mSpray)

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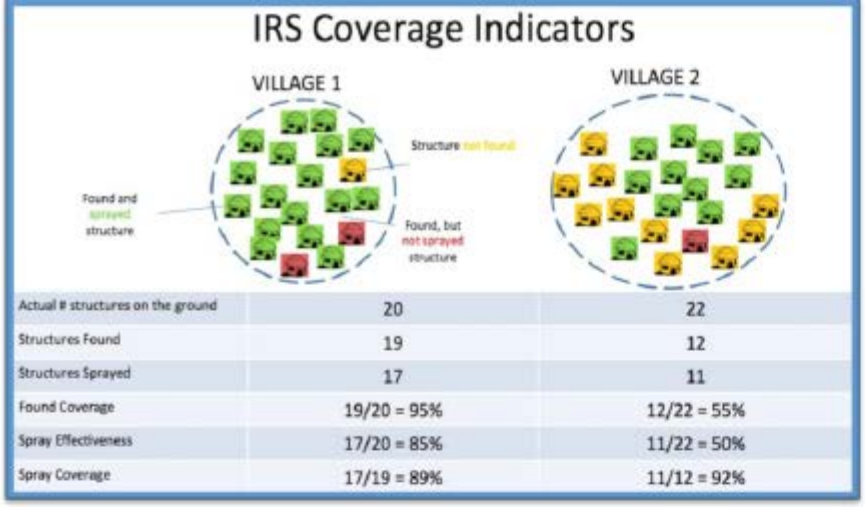
1. Executive summary

Indoor residual spraying (IRS) is a critical but expensive intervention to reduce malaria burden, and thus must be deployed and monitored judiciously. While IRS has been a malaria prevention practice for many years, there are some shortcomings. IRS coverage is measured as a percentage; the number of houses sprayed relative to the number of houses found. However, this assumes that 100% of the houses in a particular area are found, and of these, at least 85% are sprayed in order to achieve a protective effect (WHO, 2013). However, Akros data suggests that on average 40% of structures are missed simply because they have not been found. Zambia, and many other countries in the region, do not have an address system. In rural areas road names do not exist, and most structures are on traditional land and not registered. Not being able to find all structures leads to considerable overestimations of IRS coverage, due to "bad" or inaccurate denominators (Larsen, 2017). Through the availability of satellite data through Bing and Google, and mapping platforms like OpenStreetMap (OSM), enumerations down to the household level can finally take place without the need to buy expensive imagery. However, to date, the enumerated vector data has not effectively found its way into a field tool that can update this data set and can inform both the field staff and the coordinating staff with near real time intervention progress. mSpray is a software tool designed to address this gap. In collaboration with Ona Labs, Akros developed mSpray, an open-source, tablet-based, GPS-enabled field management tool that uses remote sensing technology to support indoor residual spraying, with the capacity for expansion to monitor nearly any household-level intervention.

Image 1: Spray operator holds tablet configured with mSpray in Luapula Province, Zambia

In the case of IRS, spray teams begin the process of spraying homes. In the field, spray technicians often struggle to track which dwellings they have sprayed, understand whether they are reaching enough homes to achieve the protective effect, or know how their performance compares to their peers.Using this tool, IRS performance is measured by different indicator coverage levels, which are presented as a percentages. Image 1 shows a graphic description of how these are measured. Most important to note is that reported 'spray coverage' levels can, and most often are, much lower than actual intervention coverage 'spray effectiveness' that can only be measured through mSpray as the data in the tool uses the actual number of structures enumerated using satellite data, as the denominator.



	VILLAGE 1	VILLAGE 2
Actual # structures on the ground	20	22
Structures Found	19	12
Structures Sprayed	17	11
Found Coverage	19/20 = 95%	12/22 = 55%
Spray Effectiveness	17/20 = 85%	11/22 = 50%
Spray Coverage	17/19 = 89%	11/12 = 92%

Image 2: IRS Indicator Definitions: Satellite enumeration and mSpray are used to show the actual number of houses on the ground providing a complete picture of coverage rather than only being able to show the indicator reflecting the number of structures sprayed out of those found. In Village 1, data collectors did a good job of finding nearly all structures, making spray coverage and spray effectiveness close. In Village 2 data collectors found only 12 out of 22 available structures, and of those found, sprayed just 11. The spray coverage (reported coverage without mSpray) indicates 92%, when in fact they reached a spray effectiveness of only 50% (reported coverage with mSpray).

The mSpray tool leverages satellite imagery to provide an initial, accurate denominator for structures on the ground that guide IRS teams during operations. Once loaded onto spray operator tablets, the denominator becomes flexible through field verification during data collection, allowing for non-eligible structures to be removed, reducing the denominator, and newly identified structures to be added, increasing the denominator. Systematic use of this tool during spray operations helps teams dynamically uncover, correct, and respond to measurement errors which would otherwise be invisible. Image 3 below shows this process. In 2016, the third year of mSpray implementation, the tool was used in Luapula province in Zambia, and was associated with an increase of 23.6% in the spray coverage metric (Eisele et al, Forthcoming). This success has potential applications beyond malaria; accurate denominators are a challenge to any public health metric, especially for household-level outreach programs such as mass drug administrations or insecticide-treated net distribution.

Image 3: mSpray process of enumerate, target and spray

To learn more about mSpray, you can watch this video , check out this full brochure or visit our site.

The ability of the tool to utilize household denominators and accurately measure intervention effectiveness in near real time is a necessary yet inaccessible common good. Due to the lack of birth and death registrations, and systemized address systems, many developing countries are

struggling to provide accurate, disaggregated (even to the third administrative boundary) population data. Since most indicators in health use population as their denominator for measuring success, tracking household or village level interventions, and for high resolution targeting (in cases of elimination, hitting the 95/95/95 HIV requirements etc.) a household level mapping methodology and intervention tracking tool, based on actual population is essential. To date, mSpray is only used in Zambia. Shifting the global utility of this tool to make it accessible for implementers around the globe, is the primary goal of this work. mSpray has completed the first of three phases of development (Phase I and Phase II roadmap is included in the attached work plan). Using Digital Square resources, we aim to complete Phase II, which includes three goals: first, we will modify and clean up our source code so it is easily adopted and modified to fit other applications. Second, we will develop an online spatial information management system platform, called Reveal, that provides implementers the ability to access and configure mSpray easily. Through this platform, a user-interface will enable implementers to configure mSpray without the aid of a software developer. As additional spatial tools and training materials are developed, the Reveal platform will be expanded (Phase III) . Last, we will develop supporting documentation to guide implementers through mSpray configuration and implementation in their own context.

2. Use Cases & Impact

Use Cases

mSpray was initially designed to solve an IRS indicator problem, but has since evolved into different malaria applications. The mSpray tool has to date been used to cost effectively roll out sensitisation and mobilisation for IRS, insecticide treated net (ITN) distribution programs, data quality assessments (DQAs), entomology research, household surveys, and for ground truthing satellite enumeration and IRS data.

Project Name: mSpray implementation for Indoor Residual Spraying (IRS) for Malaria control

Project Period: 2014 to 2018

Over four years of implementation, the tool and supporting systems evolved significantly. mSpray set out to correct a fundamental flaw in the way IRS activities had been measuring success by challenging the status-quo on indicator quality. It evolved into a tool that promotes mid-operation data-driven decision-making ensured through feeding back accurate spatial coverage information. The resulting successes showed a 20% to 30% increase in coverage, more accurate data collection showing what was really happening on the ground, and a 15% reduction in malaria cases where mSpray was used compared to where it was not used.

Project Name: mSpray for IRS Mobilization

Project Period: 2017-2018

A successful IRS implementation relies heavily on community readiness and acceptance of IRS primarily achieved through sensitisation and mobilisation activities. During IRS, residents need to move all items from their homes for the duration of the spraying. In rainy season this is often difficult. For this reason, mobilization activities are critical to convince spray beneficiaries of the use of the spraying and to ensure the items have been removed from the house when the spray operators arrive so that no time is wasted waiting for move of household items.

In the past there has been a disconnect between where mobilisation activities occur and IRS implementation occurs. The spatial navigation and data collection tool has been used in IRS mobilisation activities to ensure that the correct villages and structures are visited prior to spray operations. mSpray has enabled IRS teams to accurately plan out their spraying schedule and tie their mobilisation activities to this. In this instance, the tool is used to monitor which structures have been sensitized and those that have not.

Project Name: Malaria ITN Distribution Registration Data Quality Assessment using mSpray

Project Period: 2017-2018

Under the ITN distribution campaign, Akros supported the Against Malaria Fund (AMF) to conduct data quality assessments (DQA) for their household registration data that provides numbers of structures and 'sleeping spaces' per village to allow for efficient distribution of nets to the right population. Enumeration and mapping of each DQA village allowed household level data collection to be guided in the field, ensuring all structures were found,recorded and validated. Paper based registration does not spatially show village registration coverage and so a comparison between these two data sets allowed AMF to adjust the estimated number of 'sleeping spaces' and distributed nets accordingly.

Project Name: Entomology surveys for IRS operational research study

Project Period: 2017-2018

Entomology surveys often require that entire research areas are mapped down to the structure level to ensure the survey sample size and distribution are correct. This is a time and resource intensive exercise. Ensuring that the randomly selected research sites/structures are actually the ones being sampled in the field is challenging when paper-based. Enumerated structure data was utilized in the mSpray field navigation tool to ensure that pre-selected sampling homes were the ones actually included in the research.

Impact

Reduction in Malaria Burden

In a 2017 independent assessment report commissioned by NgenIRS, and conducted by PATH, Tulane, and UCSF found that a 15% reduction in confirmed malaria cases was attributed to mSpray's 2016 IRS operations (Eisele et al, Forthcoming). In this study, across all IRS districts in Zambia, the impact of IRS on malaria confirmed cases in areas without mSpray showed an 8% reduction in malaria confirmed cases while in districts where IRS was implemented with mSpray showed a 22% reduction in malaria cases. This was a significant achievement in cases averted (approximately 19,700), associated costs efficiencies gained and ultimately saved lives (approximately 1,020).

Intervention Coverage Improvements

When a spray team enters the field, they are given a target area. After scheduled spray activities are completed, mSpray teams can regroup and review data to determine where they need to revisit, or 'mop-up,' to achieve required coverage. This activity is facilitated through decision-making protocols and data feedback loops. Following 2016 spray operations, we sought to assess the frequency of mop-up activities taking place. Analysis was done to see how many spray areas were re-visited after three days of being sprayed during the first round. Out of the 2,057 spray areas, 1,024 were re-visited. As a result, within these re-visited spray areas, the spray effectiveness rose by 32%, the found coverage rose by 27% and the spray coverage rose by 15% (Table 1). mSpray allows managers to see on maps, exactly which parts of areas need mopping up, so re-visits can be well-targeted. mSpray maps show the managers the predominant reason for houses being missed (e.g. homeowner refusal, locked structure, structure not found). This allows IRS Managers to plan additional mobilization if needed, or remind teams to look for and find all structures on their map.

Table 1: Re-visits improved IRS coverage indicators for areas that were re-visited

Re-Visit Success	Before Re-visit	After Re-visit	Difference
Spray Effectiveness	53.7%	86.1%	32.4%
Spray Coverage	80.2%	95.2%	15.0%
Found Coverage	65.5%	92.4%	26.9%

Increased Number of Protected Communities

Spray effectiveness is measured at spray area or community level. The WHO recommends a spray coverage of 85% to ensure community protection. In 2015, the first year of mSpray application to IRS activities, only 21% of all targeted communities in Zambia's Luapula Province were protected. In 2016 this rose to 45% and by 2017 a total of 85.1% (table 2) of all communities visited by IRS teams in Luapula were, according to the threshold, protected.

Table 2: Communities protected increases significantly from 2015 to 2017

SPRAY EFFECTIVENESS	2015 Luapula (Communities=509)		2016 Luapula (Communities=541)		2017 Eastern (Communities=1,794)	
> 85%	108	**21.20%**	244	**45.1%**	1,527	**85.1%**
70% to 85%	98	19.30%	136	25.1%	140	7.8%
50% to 70%	166	32.60%	97	17.9%	74	4.1%
< 50%	137	26.90%	64	11.8%	53	3.0%

3. Digital Health Technologies

This section aims to articulate both the current state of mSpray development at the end of Phase I and our vision for Phases II and III of development.

Current State: mSpray

There are several key stages that make the mSpray tool successful. First, data is enumerated or taken from sources such as OSM. GIS technicians then translate the enumeration map with individual houses, into a targeting map that puts each house in a cluster based on proximity, and ranks these clusters with an intervention priority based on their risk status. These maps are then plugged into a data collection tool, based on OpenDataKit (ODK) and OpenMapKit (OMK) which supports spray teams in the field by guiding them to where structures are and capturing what is done at each structure. Data aggregates upon submission, and a dashboard displays progress to managers, showing them both the numbers and progress indicators, but also the spatial distribution of the data. This data supports decision-making and planning for these managers on a daily basis. With these dashboards, they can see areas where coverage is poor that teams need to revisit, they can see how large an area is and plan the correct number of teams to send, and they can even see why houses were not sprayed, and determine if areas need additional sensitization. Listed below are the current functions of mSpray.

User Interface - Field Operator

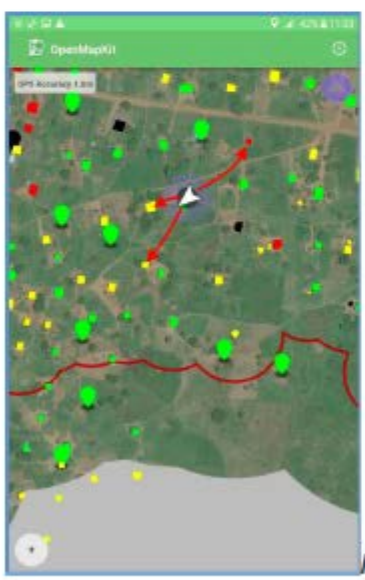


Image 4: Field Operator User Interface

- Offline basemaps maps with enumerated structures guide the user to the appropriate location using a navigation arrow using GPS.
- Operators can add field codes and data against a structure that has received an intervention to provide a real-time progress guide. This data includes the ability to indicate both that the beneficiary does not want the intervention and to explain why.

- Operators can add or delete structures based on whether the enumerated structure is actually still there or whether or not a structure is eligible for the intervention, providing a dynamic denominator for coverage estimates.
- To prevent data falsification, operators can only select and record data against structures once within close range. Unlocking this feature, or disabling the GPS, requires a password.
- Once online, data collected can be synchronized with the server to allow the operator to view other team member's progress.

User Interface - Supervisor/Coordinator

Health Facility Catchment: Chilenga

Target Area	Structures on ground	Found	Sprayed	Spray Effectiveness
01_521	994	969	946	95%
01_532	143	143	132	92%
01_533	82	82	81	99%
01_534	101	101	98	97%
01_535	72	72	69	96%
01_536	25	25	22	88%
01_537	13	13	8	62%
01_538	14	14	13	93%
01_539	5	5	5	100%
Not in Targeted Area		6	6	100%
TOTAL	1,449	1,449	1,374	95%

Image 5: Dashboard example

Hambomba Leda

Spray Operator	Number of days worked	Structures			Average structures found per day	Average start time	Average end time	Duration in field	Data Quality Check
		Found	Sprayed	Not sprayed					
Chisoni Banda	30	494	397	97	15	9:43 a.m.	3:28 p.m.	5:37:25	✗
Florence Phiri	36	568	490	78	16	9:43 a.m.	3:22 p.m.	5:39:20	✓
Pebby Nkoma	35	457	379	78	13	10:13 a.m.	3:13 p.m.	4:59:23	✓
TOTALS	101	1,479	1,266	213	44	9:53 a.m.	3:18 p.m.	5:25:03	✗

Image 6: Dashboard example

- Dashboards provide supervisors a near real time overview of achieved progress within specified catchment areas and human resource monitoring.
- Automated sms alerts are sent to supervisors when data collector protocols are breached
- Dashboards and maps articulate the spatial effectiveness of individual field staff. Image 7, below, shows poor in field coordination between two teams as they have left out a strip of 'unfound' structures between them.
- Dashboards and maps visualize reasons for intervention failure (not home/refused) enabling targeted sensitization and education campaigns.

Image 7: Interactive map, example.

Vision: Reveal Portal for mSpray

Reveal will be a spatial information-based service-planning and delivery platform, which will provide the framework and guidance for IRS implementation and other household-level campaigns. The Reveal portal will allow users to access resources, set up an instance of the tool with multiple program implementation dashboards, and provide a spatial data analysis playground across all programs within that instance. The Reveal portal will guide users to plug in structural inputs from their context (i.e. the organization unit hierarchy of implementation) and will output the dashboards and data collection tools for mSpray adapted to that context. In effect, the portal will transition the currently backend heavy mSpray tool configuration process into a user friendly platform designed with implementers in mind. The portal will also offer integration points and widgets to push and pull data sets from other commonly used MIS systems, such as DHIS2.

Installation of Reveal will take place during Phase II and Phase III of development:

- Phase II will establish the user interface and basic template of inputs that will allow a user to define their context and use the mSpray tool for IRS. This is envisaged as part of the Digital Square grant.
- Phase III will expand programs setup options to facilitate different interventions, such as mass drug administration (MDA), insecticide treated net (ITN) distribution and tracking, community mobilisation, and community disease case detection and response. Each of these will have defined setup options and templates defining structural components needed for the program context. Phase III will enable a structure level address system on the Reveal Platform, enabling users running multiple programs to integrate spatial datasets and have access to a spatial data analysis playground platform.

4. Consortium team

Akros is a cutting edge, mission-driven organization that establishes data-driven systems to improve the health and well-being of disadvantaged communities. It prides itself on its ground-level knowledge of the health systems where it works, and its ability to provide novel, lasting solutions implemented in developing regions. Akros has approximately 65 Zambia-based staff members, with varied backgrounds in public health, computer science, finance and public administration. The breadth of Akros' projects have enabled our teams to establish strong working relationships at the sub-national and community levels across all 10 provinces in Zambia and across multiple sectors—health, education, agriculture, and water and sanitation.

Akros is the lead implementer, with the mSpray roadmap and vision. Akros will partner with Ona Labs, a development lab based in Nairobi, Kenya and Washington DC. Ona is a social enterprise that builds the data infrastructure to drive change. Their belief is that technology affords new opportunities for governments and development organizations to be increasingly data driven, collaborative and accountable. Ona operates with the goal never simply to build a great product, but to support great outcomes. Ona has supported Akros in the past to build mSpray code.

Further capacity details and roles are defined in the budget narrative.

Derek Pollard, Akros (Program Manager) Derek Pollard is the Malaria Portfolio Lead at Akros and worked with the pioneering team at Akros to design and develop the mSpray technology. He has over 5 years of experience in supporting health and strategic planning and decision-making initiatives through data use, and has focused the last several years on leading mobile technology design teams to expand data access and consumption.

Anne Martin, Akros (Program Associate) Anne Martin is a public health specialist with in-depth training and experience in quantitative analysis. She has expertise in the use of statistical software for analysis in both research and programmatic evaluation, and has worked closely with the mSpray tool and it's datasets over the last two years.

Matt Berg, Ona (Chief Executive Officer) Matt has lived and worked in Africa for over 15 years. Prior to founding Ona, Matt served as the ICT Director for Modi Research Group at Columbia University and was the country director for the Geekcorps' Mali program. Matt is a PopTech! Social Innovation Fellow and was named to the 2010 Time 100 List for his technology work in Africa.

Peter Lubell-Doughtie, Ona (Chief Technology Officer) Peter has over 10 years of experience leading teams and building information systems. Before founding Ona, Peter re-built and led the data engineering team at Intent Media, served as the CTO at search startup Helioid, led data system development at the Modi Research Group at Columbia University, and was a machine learning consultant to the Center for Information Technology and Policy (CITP) at Princeton University.

5. Project description

We would like to see mSpray more widely applied, both in IRS activities and in other public health campaigns. Currently, the barrier of entry to use mSpray is high. The spatial household data collection tool and real-time dashboards code is custom, written by a handful of Ona developers. The implementation and use case definition for mSpray has not been disseminated nor have proper protocols for use. Therefore, the next steps for developing the tool should be readying it for expansion into other applications and into broader use, by addressing the following:

A. Prepare mSpray source code for easy adaptation

Development of the mSpray tool itself has been iterative over the last four years and the code reflects that evolution. Now that the workflows and outputs are finalized, the code needs to be evaluated and streamlined so that users are able to easily access and use it without dependency on the developers for the basic functionality and outputs. This includes automating the setup of Open Map Kit within the user interface, creating a data model for tasking, converting the data analytics backend from custom to an Enterprise Data Warehouse solution, and developing the Reveal architecture for OpenSRP. Akros will lead the management and delivery monitoring for result A, while Ona Labs will provide the supporting code and software development.

B. Develop the Reveal Access Portal for Implementers

An online portal, called Reveal, will become the entry point for users into the spatial intervention data management system dashboard and interface for the newly standardized mSpray tool. With the Reveal portal in place, future iterations of mSpray use cases can be featured, and additional mobile tools in development for insecticide treated net distribution, mass drug administration, active case detection, larval mapping, and surveys can become available. The Reveal portal will be built to enable end-users to:

- Define their campaign/intervention setting
- Define and load their intervention units (e.g. Households)
- Produce and intervention population summary and selection interface
- Confirm an internvention area
- Define program/campaign metrics
- Monitor progress against metrics through standardized or customized dashboards

C. Develop documentation for implementers

The mSpray code alone does not empower implementers to improve their implementations. Once configuration is complete, tool and protocol trainings are required. We will formalize both mSpray training and protocol supporting documentation. Additionally, we would like to create guides on user interface set-up and configuration. We envision the following "packages" of materials to come out of this segment of work:

1. E-Learning courses covering Satellite Imagery Enumeration, Openstreetmap uploads and file creation, data collection form creation, application installation and dashboard configuration.
2. Traning presentations, agendas, and exercises for field-based end-user training.

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3. Protocol and field guides.

A project gantt chart and deliverables table is included as an attachment to this proposal.

6. Community Engagement

Akros and Ona both have rich partnerships and relationships across the digital health community, and we plan to engage these through both formal and informal strategies, outlined below.

Establish Slack Channel(s)

Though Akros and Ona already use Slack for various projects, we do not currently have a Slack channel dedicated to mSpray tool development. Within the first month of contract award, we will establish two Slack channels: one will focus on code development and another on implementation. We will routinely pull relevant discussion, documentation, and code shared via Slack to ensure we are capturing any lessons learned and incorporating them into best practice documentation.These slack channels will be open and available for software end-users.

Participation in Digital Solutions for Malaria Elimination – Community of Practice

Akros and Ona are both members of a community of practice established through the Digital Solutions for Malaria Elimination grant. The grant aims to support a community of experts and implementers of digital malaria tools to collaborate on development of tools and policy recommendations to surround development of mobile solutions. The group is working under the leadership of VitalWave to establish common goods for best practice, such as user documentation, code source, and approach methods for implementation for mobile tools in malaria. This community meets monthly to share ideas and currently is laying the groundwork for the establishment of said common goods. Akros and Ona are both thought and material contributors and will share mSpray documentation, approach, and use cases. We will also use the best practices laid out in this community to inform our own tool roadmapping, architecture, and development so that we are in line with outlined best practices.

Participation in Principles of Digital Development Community/Forum (digitalprinciples.org)

Akros and Ona are also both members and contributors to the Principles of Digital Development Community. We plan to continue to participate in this community through case studies; specifically, we will write a case study for the newest developments of the mSpray tool by the end of 2018.

Participation in relevant conferences

Akros attends and presents at conferences focused on digital development and ICT4D at least three times a year. At theses conferences we

openly share the implementation process and use of the tool, often demo-ing to soliciting feedback from attendees on usability. We have presented the mSpray tool at the following conferences in the last year: Global Digital Health Forum, MERL Tech, and ESRI Southern Africa User Conference. ESRI is the organization responsible for the development of ArcGIS. This year Akros is a sponsor for the ICT4D conference and will be demo-ing and presenting on mSpray, with the aim to get specific feedback on the tool.

Lead trainings on mSpray tool

Akros is already an implementing partner and official trainer of DHIS2, leading trainings several times a year around the globe. We plan to adopt the same training approach with the mSpray tool, offering two different training modules, already planned for the next six months. The first training will be in Dakar, Senegal in April, the second in Lusaka, Zambia in May. These trainings will serve as a way to engage more potential users in the tool to discuss additional use cases and ensure the tool is developed to fit those use cases.

Sources

Larsen 2017, presentation at WHO, MERG, Geneva, IRS Coverage Presentation.

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