Delivering to the Last Mile in Tanzania
Route Optimization with Medical Stores Department

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Acknowledgments

Thanks are offered to the Medical Stores Department (MSD) and Tanzania office of the USAID | DELIVER PROJECT, which dedicated many resources to ensure that the trainings and zonal ride-alongs were successful. Specifically, the project wishes to thank Mr. Msangi Muja, Mr. Edward Terry, Mr. Faraji, Holo Mabwaia, and Evans Elias from MSD for their outstanding contribution to the facilitation, design, and implementation of the Last Mile activity. Additional thanks are offered to Nicodemus Mwakalinga, Diane Kibwana, George Emmanuel, and Marasi Mwencha from the USAID | DELIVER PROJECT field office for their management and operational contributions, without which the activity would not have been possible.

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Route Optimization with Medical Stores Department

September 2015

USAID | DELIVER PROJECT, Task Order 4

The USAID | DELIVER PROJECT, Task Order 4, is funded by the U.S. Agency for International Development (USAID) under contract number GPO-I-00-06-00007-00, order number AID-OAA-TO-10-00064, beginning September 30, 2010. Task Order 4 is implemented by John Snow, Inc., in collaboration with PATH; Crown Agents Consultancy, Inc.; Eastern and Southern African Management Institute; FHI360; Futures Institute for Development, LLC; LLamasoft, Inc; The Manoff Group, Inc.; Pharmaceutical Healthcare Distributers (PHD); PRISMA; and VillageReach. The project improves essential health commodity supply chains by strengthening logistics management information systems, streamlining distribution systems, identifying financial resources for procurement and supply chain operation, and enhancing forecasting and procurement planning. The project encourages policymakers and donors to support logistics as a critical factor in the overall success of their healthcare mandates.

Recommended Citation

Jankowski, Karlan. 2015. *Delivering to the Last Mile in Tanzania*. Arlington, Va.: USAID | DELIVER PROJECT, Task Order 4.

Abstract

The Medical Stores Department (MSD) in Tanzania was established to procure, store and distribute quality medicines, medical supplies, and equipment at affordable prices, made available through approved government and non-government health care facilities throughout the country.

Through the use of Supply Chain Guru, the USAID | DELIVER PROJECT and LLamasoft committed to transportation modeling and route optimization activities in Mtwara, Moshi, Dar, Mwanza, and Tabora zones.

Cover photo: In Sengerema district, MSD drivers use ferries and boats to transport health commodities to facilities on islands and peninsulas in Lake Victoria.

USAID | DELIVER PROJECT
John Snow, Inc.
1616 Fort Myer Drive, 16th Floor
Arlington, VA 22209 USA
Phone: 703-528-7474
Fax: 703-528-7480
Email: askdeliver@jsi.com
Internet: deliver.jsi.com

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Background

Background

The shift to a direct delivery model—from zonal warehouses to health facilities—has greatly increased the importance of last mile distribution in Tanzania. Using practical distribution analysis and design, the Medical Stores Department (MSD) has increased efficiency in this important leg of the supply chain. By taking a hands-on approach to transportation and distribution design, Dar es Salaam, Moshi, Mtwara, Mwanza, and Tabora zones have already substantially reduced their quarterly expenses for fuel and per diem. Not content with the benefits already realized, MSD, with the USAID | DELIVER PROJECT, have included the technical innovation of Transportation Guru to provide a roadmap for continuous improvement though route optimization.

Using Transportation Guru, mathematical models of delivery routes were developed within the software, which enabled MSD to optimize routes and find additional savings in time and cost. Equally important, optimization efforts allowed MSD to ask the "what if" questions; for example, what if carton volumes increase, or what if facilities are inaccessible in the rainy season. This analysis offers visibility into the limits of current route plans while also creating a set of robust plans for various circumstances.

> "… optimization efforts allowed MSD to ask the "what if" questions; for example, what if carton volumes increase, or what if facilities are inaccessible in the rainy season."

Zonal Route Optimization Results

Results

The following sections reflect findings and results specific to each of the MSD zones included in the transport optimization study—Dar es Salaam, Moshi, Mtwara, Mwanza, and Tabora zones.

Background

All zones included in the route optimization operate a mobile warehouse distribution method wherein delivery vehicles leave the zonal warehouse stocked with pre-packed orders for as many facilities as truck capacity will allow—depending on the volume for each facility, the trucks may have the capacity to deliver to multiple districts during one delivery round. If volumes are low, MSD can fill their 10 or 15 trucks, 3.5 ton truck and land cruisers (LCs) to capacity and carry orders to more facilities than would be possible during high volume periods.

For each delivery route, the drivers and zonal managers determine the fleet requirements and route sequencing based on volume—calculated in number of boxes each facility will receive. The LCs and 3.5 ton trucks make deliveries along the way to a district hospital or other set location along the route, where they meet up with the 10/15 ton truck, acting as the mobile warehouse. In many zones, the 10/15 ton truck moves dynamically during the delivery cycle, repositioning to serve the LCs and 3.5 ton truck as they move along the delivery routes. The 10/15 ton truck also makes deliveries to facilities located along the major roads but the location of its end-of-day stop varies depending on the volumes and locations the LCs and 3.5 ton routes.

MSD Mwanza zone uniquely relies on ferries and man-powered boats to complete deliveries to health facilities. The zonal manager and drivers consider the ferry departure schedule and locations of ports as they plan their routes. Additionally, they closely coordinate with the receiving committees on islands to ensure their availability to meet drivers at the ports or designated off-loading site if the delivery is taken by boat.

Mobile Warehousing

Benefits

By using the mobile warehousing model, the Dar zonal manager is able to respond to different order volumes. Once the orders have been placed, the number of vehicles can be selected depending on the fleet's capacity. The mobile warehouse also allows the zonal manager to consolidate districts, reducing the number of return trips; reducing fuel costs because the vehicles do not have to return to the zonal warehouse every time the land cruisers or 3.5 ton trucks are empty. Before the mobile warehouse model was implemented in 2011, delivery costs were approximately 4 percent higher based on a significantly higher per diem payments.

Mtwara zone uncovered substantial benefits—reduced cost and time savings—while maintaining a high level of customer service. Fuel costs decreased from approximately 20M Tsh/quarter to 7.8M Tsh/quarter. After ride-alongs and route optimization, deliveries could be completed to all facilities in Masasi district, which was not possible during the quarter previous to optimization.

The district decreased the number of days needed for deliveries from six–seven days to a maximum of four days. A net decrease of 36 percent distribution costs against the total annual budget estimates for fiscal year 2013/2014 was achieved.

In Mwanza zone, based on the study completed in Sengerema district, delivery costs were approximately 12 percent lower when compared with costs from before the mobile warehouse model was implemented. Mobile warehousing decreased per diem payments significantly and reduced fuel consumption through more efficient, shorter routes.

All zones returned results that support cost savings and efficiencies gained by using a mobile warehouse model for Tanzania's direct delivery.

Mobile warehousing saves time and fuel because it uses the entire capacity of trucks and eliminates back and forth trips from the zonal warehouse to each district.

Lessons Learned

In the zones where the 10/15 ton truck—typically only delivering to facilities close to the major roads—drives along routes that would be designated as LC-only in the optimized model, total costs were driven up because the fuel and maintenance costs for the 15 ton are just over double the LC costs. This is important to note as a risk when implementing a mobile warehouse as a potential risk when the model shifts or is changed from the original design.

Additionally, if facilities place the average volume of orders, the fleet does not have the capacity to run the mobile warehouse and deliver to all facilities within the 90 day delivery cycle. A second 15 ton truck would need to be used to reach all facilities during the quarter, but would increase total costs.

When comparing the savings offered by mobile warehousing across zones it is important to remember that zones vary greatly in population density—as seen by the number of facilities per km—and average distance from the zonal warehouse. Examining the zones in which mobile warehousing offers most benefits, provides a roadmap of the characteristics which are the most promising for implementing mobile warehousing and realizing savings.

Wet Season versus Dry Season

Through interviews with MSD drivers and staff, one of the most significant factors impacting delivery times was rainy season delays. Some districts and zones were affected more than others, but overall, total costs increased by 5-10 percent per zone during the rainy season.

In Dar zone, the districts that are particularly more affected than the rest of the zone include Bagamoyo, Kilombera, Kisarawe, Morogoro Mvomelo, Mkurunga, Ngomera, and Ulanga Mahenge. In these districts, drivers report that they can only reach two facilities per day, at most. By increasing the transit time in these districts, the total costs increase by about 8.6 percent. These costs include per diem rates, distance cost which includes fuel and maintenance, and casual labor. The increase can be explained by the decrease in number of sites possible per day due to slow transit times, thereby increasing the number of days needed for deliveries and therefore added per diem.

In Moshi zone, when the transit time (time spent driving from one facility to the next) is increased by 100 percent to account for added time used on muddy washed out roads and detours, there is a 5 percent increase in total cost.

In Mwanza zone, MSD identified Barladi, Meatu, Kishapu, Rorya, and Itilima as the districts that are particularly more affected than the rest of the zone. By increasing the transit time in these districts, the total costs increase by about 11 percent. These costs include per diem rates, distance cost which includes fuel and maintenance, and casual labor. Overall, the impact of the slow-down in these seven districts results in total zone cost increase of about 7 percent.

Tabora zone was the least affected by changes to transit time in the wet season. The total costs increase by about 2.5 percent in the districts most affected, but overall, costs increased by only 0.6 percent.

The increase in transportation cost during the rainy season can be explained by the decrease in number of sites possible per day due to slow transit times, thereby increasing the number of days needed for deliveries and therefore added per diem.

Volume Variation

During the route optimization study, the order volumes were observed to be lower than previous order cycles. Lower volumes impacts the consolidation of districts—the key feature of the mobile warehousing model—with high volume conditions, each district would fill an entire truck and increase the number of kilometers driven, increasing time and total costs. When box numbers are low and several districts can be consolidated into mobile warehousing routes, mobile warehousing offers substantial benefits. When box numbers are high, it becomes impossible to consolidate districts into one large vehicle and the number of LC deliveries gets pushed up, resulting in a less applicable mobile warehousing model with fewer benefits.

The analysis examined what happens if volumes were double what was being delivered during the study ride-alongs. Across zones, the effect of doubling box numbers (increasing volumes) has very different impacts on cost—25 percent increase in Moshi and 84% in Dar. This shows that some zones have the ability to absorb increases in volume with their existing vehicle fleet, while others are operating much closer to full utilization and will need to acquire several more vehicles to accommodate a large increase in volume.

In Dar zone, if the amount of volume to be delivered doubled, costs would go up approximately 51 percent. The fuel and maintenance costs would increase from about 43 M Tsh to 87 M Tsh. Additionally, current Dar zone volumes are higher than truck capacity in four districts, which means additional vehicles are being used to deliver all orders or additional days are needed so that trucks can return to the warehouse for repacking. In another three districts, the volume is within ten percent on the capacity for a 15 ton truck. When volumes increase by a factor of two, all but four districts would require an extra trip or additional large truck to be able to deliver all orders within the 90 day cycle.

In Moshi, if the amount of volume to be delivered doubled, costs would go up approximately 25 percent. The fuel and maintenance costs would increase from 24.3 M Tsh to 28.5 M Tsh, but the cost for casual labor would stay the same at 1.5 M Tsh.

The driver of the total cost increase is per diem, which would increase from 16.9 M Tsh to 27 M Tsh due to the 37 percent increase in total days needed for delivery to all facilities.

In Mwanza, if the amount of volume to be delivered doubled, costs would go up approximately 48 percent. The fuel and maintenance costs would increase from about 85 M Tsh to 164 M Tsh.

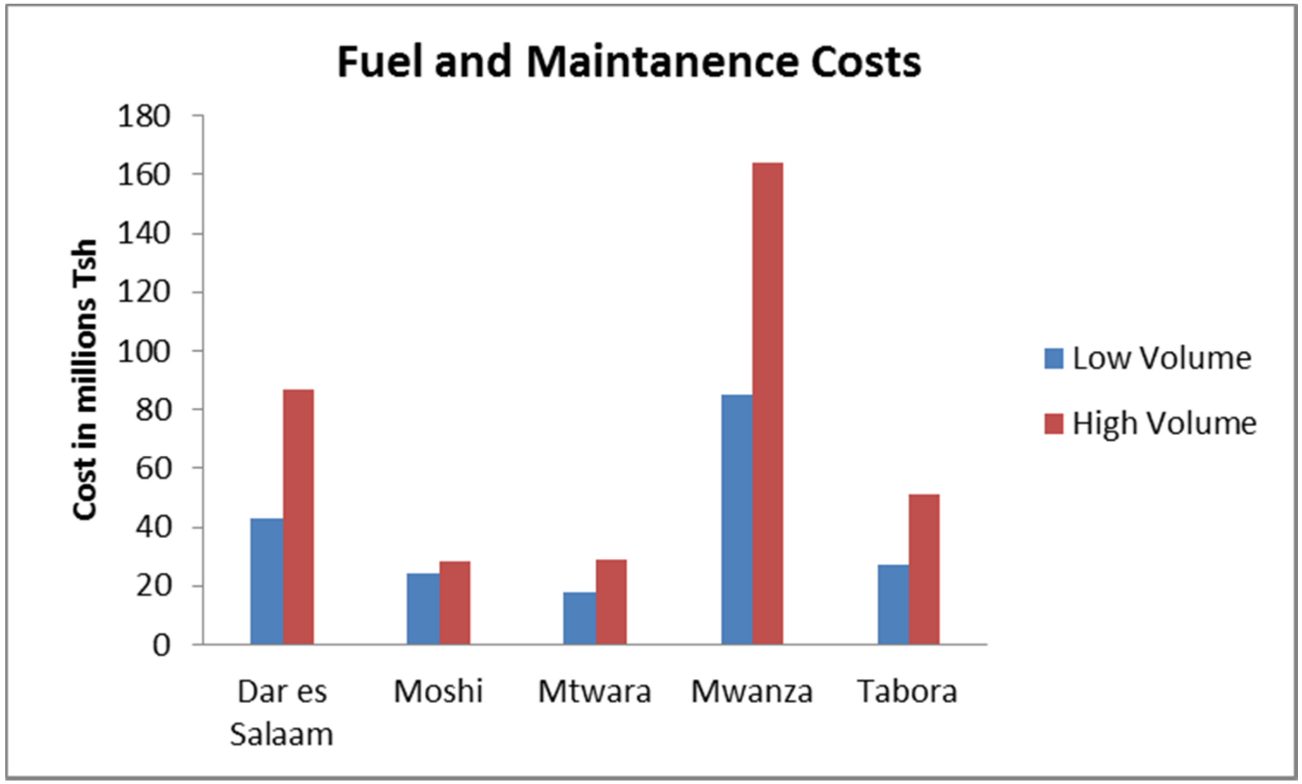
Additionally, current Mwanza zone volumes are higher than truck capacity in six districts, which means additional vehicles are being used to deliver all orders or additional days are needed so that trucks can return to the warehouse for repacking. When volumes increase by a factor of two, 21 of the 30 districts would require an extra trip or additional large truck to be able to deliver all orders within the 90 day cycle. Six of these 21 districts would require three or four return trips because the volume increases to four time the capacity of the 15 ton truck.

Some zones have the ability to absorb increases in volume with their existing vehicle fleet, while others are operating much closer to full utilization and will need to acquire several more vehicles to accommodate a volume increase.

Volume Variation

In Tabora, if the amount of volume to be delivered doubled, costs would go up approximately 46 percent. The fuel and maintenance costs would increase from 27.4 M Tsh to 51.1 M Tsh. The driver of the total cost increase is per diem, which would increase from 3.4 M Tsh to 4.2 M Tsh due to the increase in total days needed for delivery to all facilities. If the volume were to double, the current fleet of vehicles would only have the adequate capacity to carry deliveries for two of the districts; the other six districts' volume would exceed the total capacity and more vehicles would be needed to make all deliveries within the quarterly cycle.

In Mtwara, high volume increased costs by 36 percent, from 18.5 M Tsh with low volume to 28.9 M Tsh with high volume.



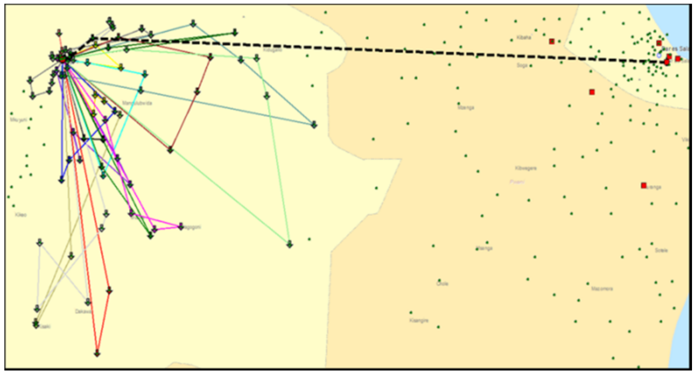
Optimized Results

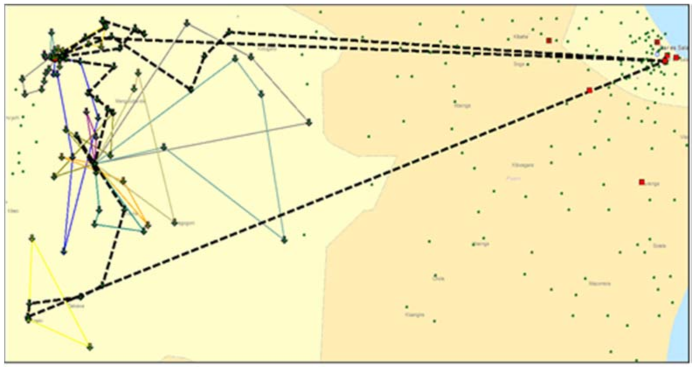
Dar es Salaam Zone

Findings from ride-alongs with MSD drivers in the Morogoro district of Dar zone showed that the model for how the mobile warehouse completes deliveries needed to be adapted. The previous model assumed the 10/15 ton truck drove to a district hub, making some deliveries along the way, and remained at the hub while LCs returned to its location at the end of each day to reload for deliveries the following day. The reality is that the 10/15 ton truck moves dynamically with the LCs, stopping at safe locations along the route, nearby the LCs' final delivery locations. **Based on current volumes, this fully mobile warehouse provides 24 percent savings in total distribution costs** compared to a more stationary mobile warehouse.

If the 10/15 ton truck remains stationary at a central district hub, the number of total days to complete the route may be lower than in the fully mobile warehouse model, but savings on LC distance costs are significant enough to lower total costs by 24 percent. Total delivery distance for LCs decreases by 54 percent—from 3,181 kilometers to 1,455 kilometers.

The first map shows the baseline Morogoro routes where the 15 ton truck moves with LCs, making deliveries to facilities on secondary and tertiary roads and stopping at safe locations along the route which are nearby LC routes. The second map shows the mobile warehouse model where the 15 ton truck drives to the district hub and all LCs return to that one location during the delivery run.



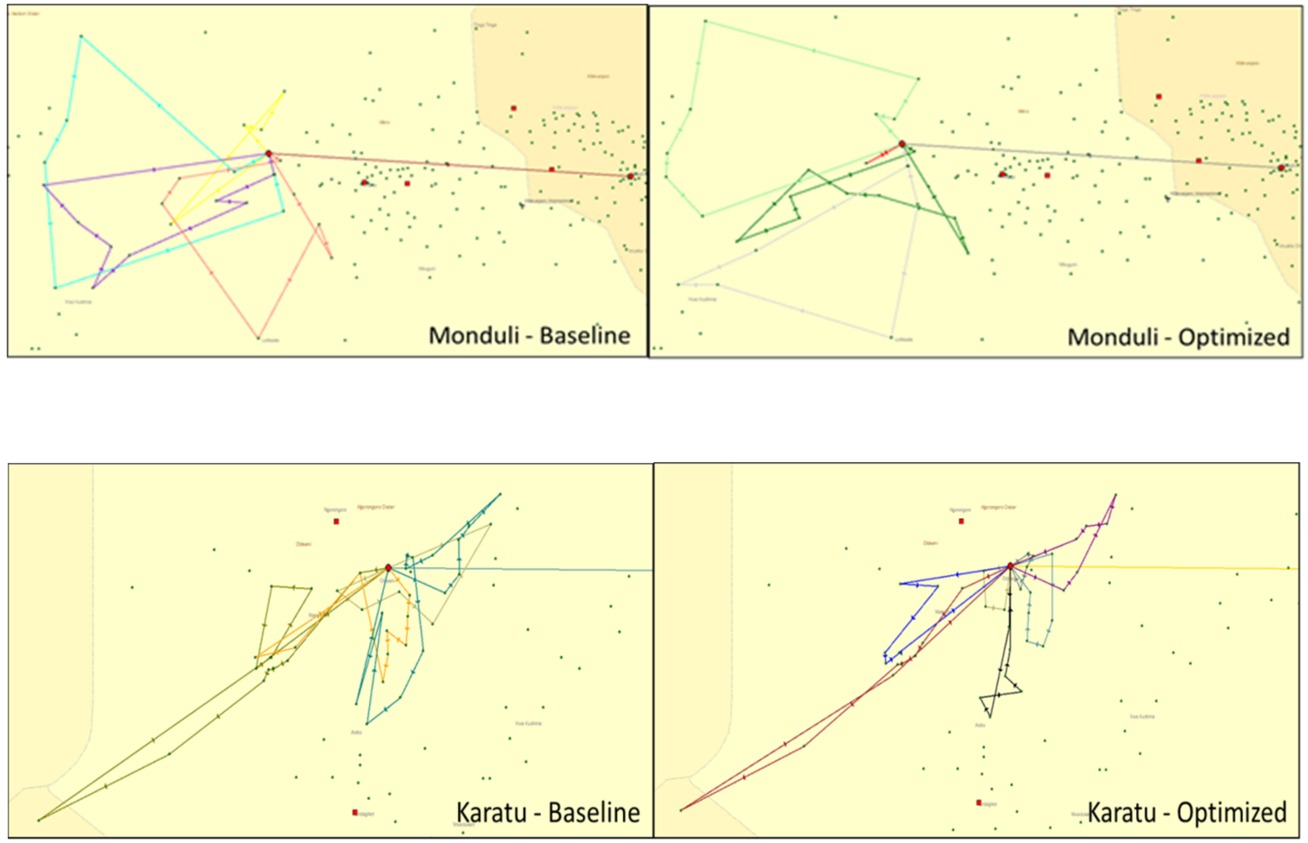


Optimized Results

Moshi Zone

Based on a comparison of the optimized model with baseline routes in Karatu and Monduli districts, there is a potential total cost savings of 10 percent in Moshi zone. The potential improvement is a result of more efficient route sequencing which reduces the total kilometers driven and thereby decreases the fuel consumption and per diem needed to stay additional days.

In Karatu, there is a 5 percent decrease in total cost for the optimized routes; this is a result of few routes (8 total LC routes in the baseline compared to the optimized 7 LC routes) which decreased overall distance cost. In Monduli, the baseline total cost is 1.8 M Tsh with 5 total LC routes, compared to the optimized total cost of 1.5 M Tsh with 4 LC routes; a 18 percent change in cost. Higher cost savings were found in Monduli because the number of days needed to deliver to all facilities in the optimized model was one day less, thus reducing fixed costs such as per diem. **Where districts can follow the optimized routes and reduce the kilometers driven as well as days needed to complete deliveries, there is potential for overall cost savings of 10 percent or more**.

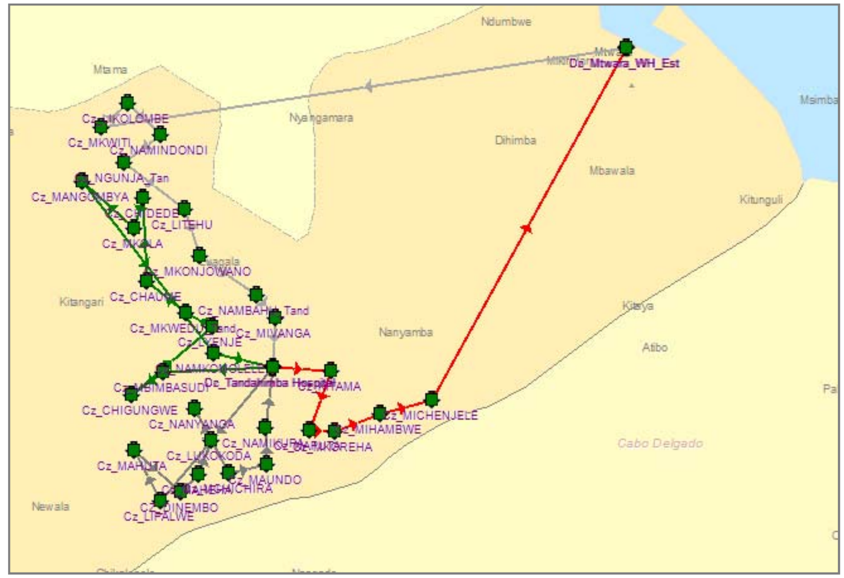


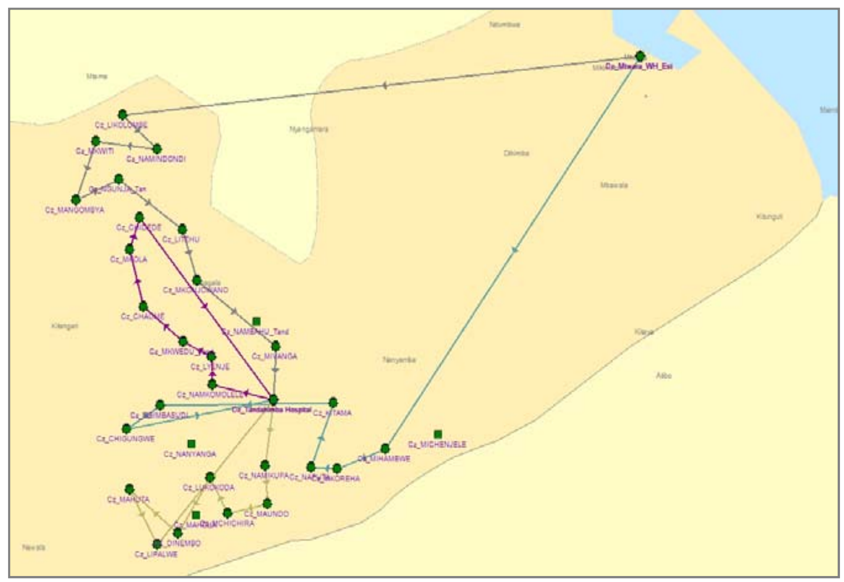
Optimized Results

Mtwara Zone

In Mtwara, when looking at the four districts for which we had baseline routes (Liwale, Nachingwea, Ruangwa, and Tandahimba), the potential savings are on the order of approximately 10 percent and come primarily from reduction in kilometers driven due to consolidation and sequencing. **Savings can be attributed to the decrease in number of LC routes as well as the decrease in LC delivery distance—from 2,198 kilometers to 1,542 kilometers—which reduces the LC distance cost by 30 percent**.

The maps show before and after from the route optimization in Tandahimba district.





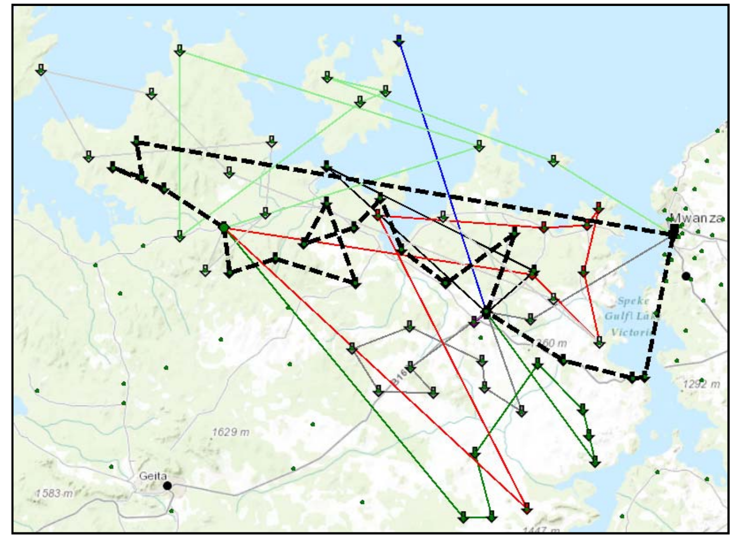
Optimized Results

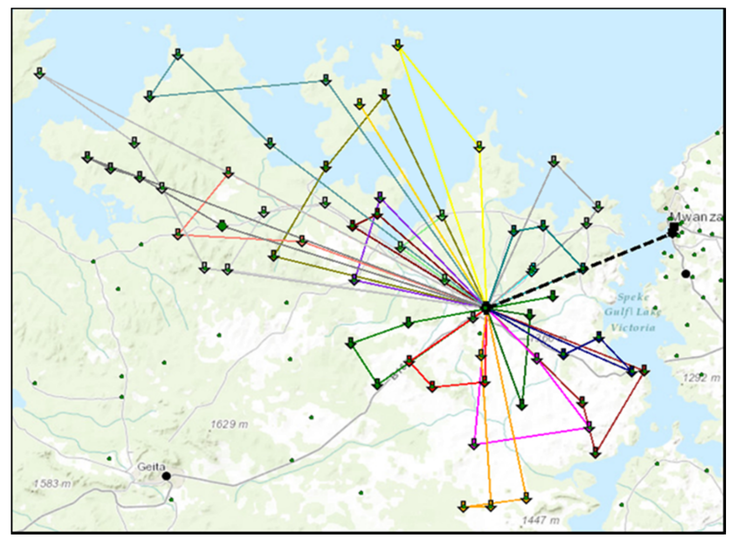
Mwanza Zone

In Mwanza, if the 10/15 ton truck remains stationary at a central district hub, the distance costs for the 10/15 truck decreases by 36 percent compared to the fully mobile warehouse model, but 35 percent savings on LC distance costs in the fully mobile warehouse model offsets those savings. The overall costs decrease in the fully mobile warehouse due a reduction in the number of delivery days—from 12 days to 10—which reduces the fixed costs. Total delivery distance for LCs decreases by 34.5 percent—from 1,973 kilometers to 1,292 kilometers.

Findings from ride-alongs with MSD drivers in the Sengerema district of Mwanza zone showed that the model for how the mobile warehouse completes deliveries needed to be adapted. The previous model assumed the 10/15 ton truck drove to a district hub, making some deliveries along the way, and remained at the hub while LCs returned to its location at the end of each day to reload for deliveries the following day. The reality is that the 10/15 ton truck moves dynamically with the LCs, stopping at safe locations along the route, nearby the LCs' final delivery locations. **Based on current volumes, operating the fully mobile warehouse in Sengerema has benefits over operating from a single location with a total savings of 14 percent**.

The first map shows the baseline Sengerema routes where the 15 ton truck moves with LCs, making deliveries to facilities along the major roads and stopping at safe locations along the route which are nearby LC routes. The second map shows the mobile warehouse model where the 15 ton truck drives to the district hub and all LCs return to that one location during the delivery run.



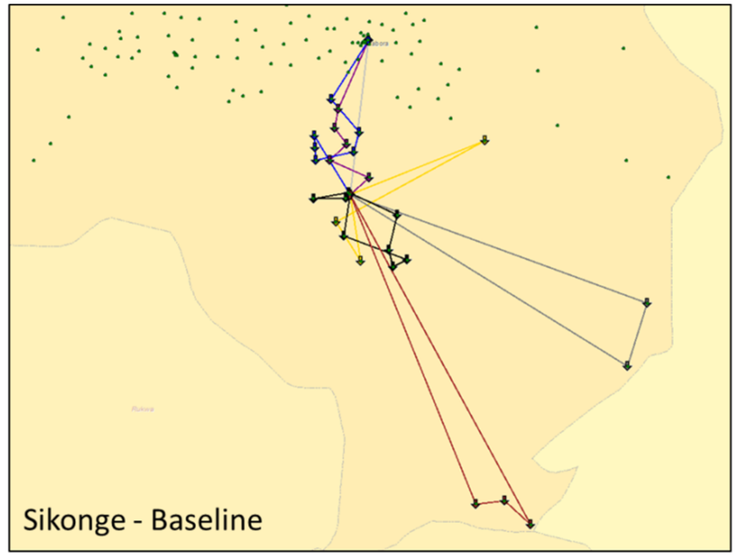


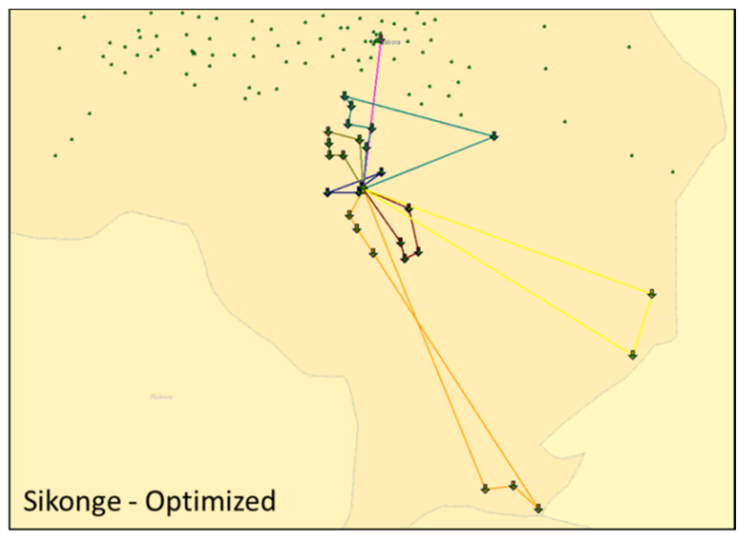
Optimized Results

Tabora Zone

In Tabora zone, based on a comparison of the optimized model with baseline routes in Sikonge district, there is a potential total cost savings of 13 percent. The potential improvement is a result of more efficient route sequencing which reduces the total kilometers driven and thereby decreases the fuel consumption and per diem needed to stay additional days. Overall, even with conservative estimates, there is an indication that we have the potential to further reduce costs throughout the zone by using the optimized routes.

The optimized routes impact LCs most significantly by reducing the number of kilometers driven from 1,835 in the baseline, to 1,659 in the optimized model. With this reduction in kilometers driven, about 10 percent decrease, the zone will see lower fuel costs and the potential to reduce per diems if drivers can reach more facilities in each day and return to the zonal warehouse a day or two early.





MSD Central Operational Findings and Recommendations

Findings

It is the policy of MSD that when an order is delivered to any health facility, a receiving committee must verify and sign that all items were received; if any items from the order are missing, it is the MSD driver and committee members that are responsible for completing a claim form to be submitted to the zonal warehouse.

However, each zone manages the receiving committees differently which creates inconsistencies in amount of time stopped during each delivery, posing a challenge for optimizing delivery routes. The zonal drivers and zonal managers have autonomy to decide who may act as a committee member and how many people are needed to fulfil the requirement. Although all zones reported that waiting for committee members to arrive and then verify the delivery was a great challenge—drivers would wait from 30 minutes to two hours for committee members to arrive—some zones were more flexible while in the field and making deliveries which resulted in lower waiting time at facilities. In Moshi, project staff rode along with an MSD driver who accepted any community member as a part of the committee and did not require a certain number of witnesses to confirm receipt; this led to stop times of ten to fifteen minutes per facility. In contrast, when the project rode along with a driver in Tabora, all committee members who had received the consignment in the past had to be present for the current delivery, resulting in a stop time of 2 hours at one hospital during the route. Overall, the study found that variation in stop time depends on the zonal policy, the driver's policy, or the receiving health facility itself.

These delays and uncertainty greatly impact the ability to manage the transportation and distribution activities in the supply chain. When MSD drivers and managers do not know how much time each delivery will take, they cannot plan the most optimal delivery routes. The optimization study found that the average fixed stop time at each facility should be 30 minutes to account for time to complete paperwork, unload and unpack boxes, and get committee approval; then an additional 1.5 minutes would be added per box to account for volume variation. However, since these times are not reliable and vary by zone, driver, or facility, when trying to optimize routes, the model could return savings unrealistic savings.

Recommendations

The central team at MSD can review each zone's current policy concerning the receiving committee. Interviews should be conducted with drivers, zonal managers, facilities, and current committee members to understand how to standardize stop times while ensuring the customers are verifying deliveries and satisfied with MSD service.

Paper Forms and Signatures

Findings

Each time an order is delivered to the facility, the receiving committee must verify and sign that the quantities match the invoice. The process of signing the documents varies by zone due to differences in the paper forms—including invoice, packing slips, and claim forms. In some zones, the drivers were given invoices printed on carbon copy paper in quadruplicate, while in other zones, invoices were printed from a computer on plain paper.

The deliveries made using the carbon copy versions of the invoices were simple and quick for committee members to sign and verify quantities received. The committee members were familiar with these forms and only had to sign one time, the drivers could quickly instruct any new committee members on where to sign, and the facility was trained on how to keep the copies for bookkeeping. The deliveries that were made with the invoices printed on plain paper required committee members to sign four sets of papers without giving them a designated signature line which often resulted in confusion among the drivers and committee members.

Verifying the delivery took a longer time without the invoice in carbon copy since time was spent explaining where to sign and then repeating the process three to four times for each copy.

Recommendations

Deliveries made with carbon copy forms were more efficient and friendly to the receiving committee. MSD Central staff can assess the policy for each zone regarding how the invoices are printed and what drivers bring to the facilities for receipt of delivery.

Secondary Outcomes of the Route Optimization

Road Mapping

One of the critical data inputs needed in order to complete a model of the distribution system is a verified road network. In order to model how long it will take to drive from one facility to the next, it is necessary to know how fast trucks can drive along the road, how far each facility is from one another, and if the roads even connect to the location of facilities listed.

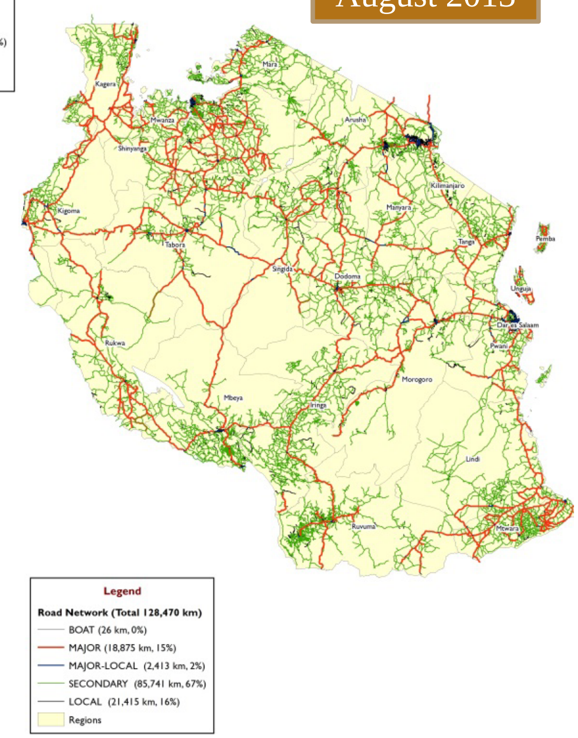
The project brought together several different complex data points to achieve the goal of mapping Tanzania's road network. Using the data collected from delivery trucks' GPS devices, the project team was able to map the secondary road network across the entire country and classify all roads in terms of travel speeds.

The number of kilometers mapped on major roads increased from 12,898 at the baseline in March 2014 to 18,875 in August 2015 upon completion of the national exercise. The total number of kilometers now mapped in Tanzania is 128,470 kilometers, an increase of 38% from 2014.

In addition to helping the MSD more effectively and efficiently deliver health commodities, the project doubled the digital road network that is available in Tanzania. The road network is being uploaded to OpenStreet Maps so that it is available for everyone to access.

March 2013

August 2013



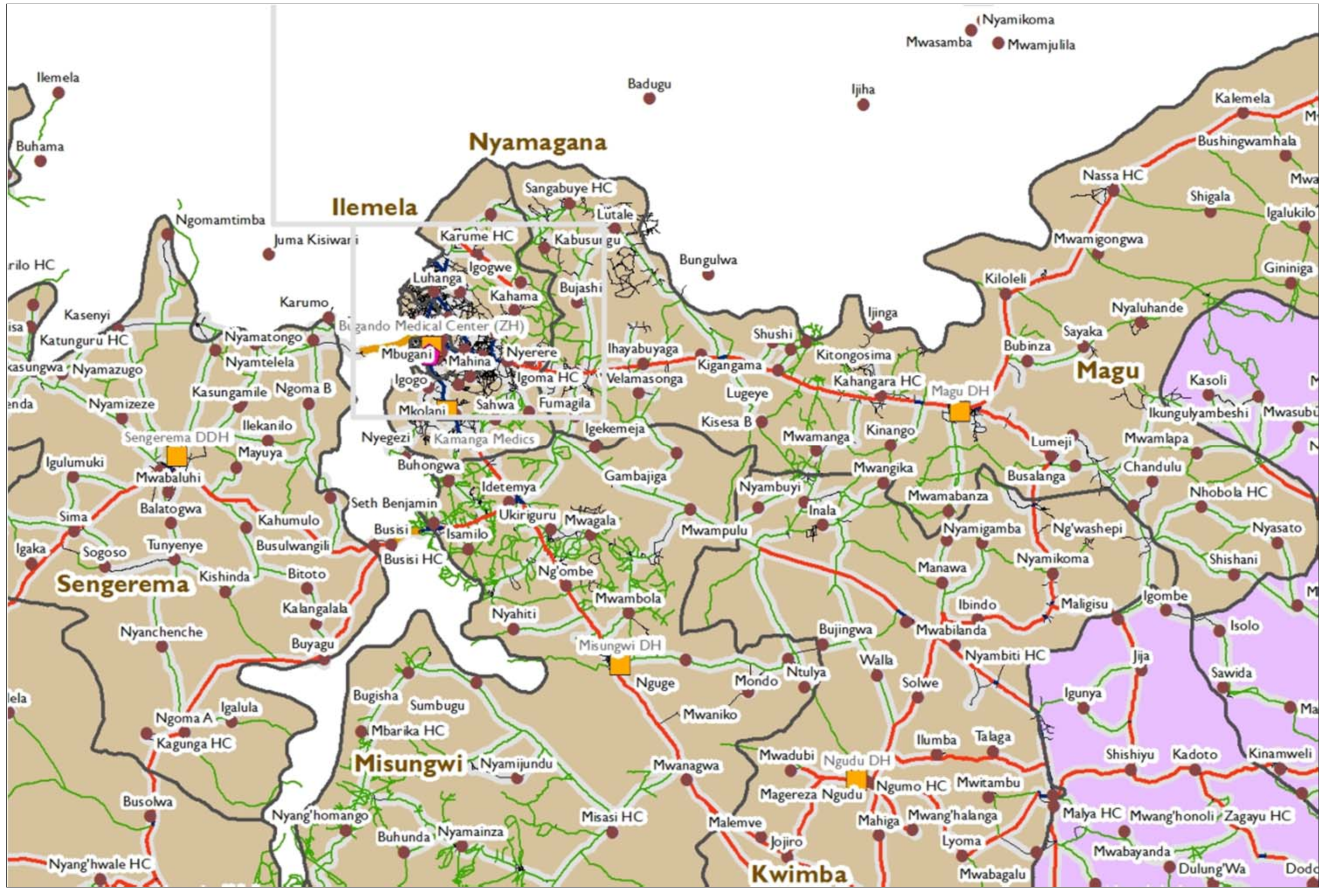
Facility Location and Geocoding

In order to provide a representative model of Tanzania's health system, the locations of all health facilities included in the ILS direct delivery distribution needed to be recorded and validated. At the start of the Route Optimization activity, only 60 percent of health facilities had a geocode which was validated. To collect and verify the location of these facilities, the project team in-country along with the MSD staff, visited each health center and dispensary that was missing a validated geocode and recorded their GPS coordinates. The GPS data was sent to the GIS team to confirm.

As a result, 3,452 facilities have been geocode validated in the six zones optimized (Dar, Moshi, Mtwara, Mwanza, Tabora and Zanzibar), which represents around 61% of the surface of the country.

With this data, it is possible to provide distances between facilities and the time needed to drive from one to the next.

The list of health facility locations was shared with MSD for use in any future modeling or optimization activity.



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USAID | DELIVER PROJECT
John Snow, Inc.
1616 Fort Myer Drive, 16th Floor
Arlington, VA 22209 USA
Phone: 703-528-7474
Fax: 703-528-7480
Email: askdeliver@jsi.com
Internet: deliver.jsi.com