

White Paper | JULY 2020

Adaptive Delivery Management

A systematic continual improvement process for delivery system dynamics

Delivery Dynamics

Failure to employ a continual improvement process is the biggest shortcoming of most last mile delivery systems. Good data together with models that faithfully represent the delivery environment, are critical requirements for increasing the optimization and automation of delivery planning systems. However, it is extremely unrealistic to assume that critical planning data such as customer geocodes and estimated drive times are all correct. It is also unrealistic to assume that out-of-the-box deployments of complex models for delivery planning will faithfully represent the delivery environment. Unfortunately, most delivery systems implicitly assume that quickly implemented planning models and planning data are "good enough," so there is no need for ongoing learning from the execution of delivery plans or for ongoing efforts to improve data. This results in delivery systems that continually get worse rather than better.

The only way that the digital transformation of last mile delivery can provide consistent value is by employing continual improvement processes supported by appropriate technology. *The key questions then are how to specify effective continual improvement processes for last mile delivery and what technology is required to support these processes?*

The State of Last Mile Delivery Technology

There are more than 100 software providers offering technology that purports to improve management of last mile delivery by leveraging digital innovation. However, for most companies, this technology has done very little to actually improve the management of their delivery systems. This is primarily due to the following:

Bad data: Current delivery management technology provides very little capability to recognize or improve bad data. Data errors associated with customer geocodes, drive time estimates and stop time estimates cause the greatest problems.

- Route optimization technology assumes that the customer geocodes (i.e., latitudes and longitudes) are where the trucks will park to make the deliveries. However, even the best address geocodes estimate the "rooftop" location of the address, not the delivery door or loading dock. Particularly in big cities, routes based on these geocodes often cause drivers to waste a lot of time looking for locations that may not even be on the line of travel of the "optimized" route. Geocoding accuracy is much worse in most Latin American countries, often involving errors of several kilometers or providing no geocodes at all. Using GPS devices for geocoding often provides a false sense of security regarding the accuracy of geocodes. Errors in GPS require multiple samples together with sophisticated algorithms to make accurate estimates of delivery locations.

- Drive times are often estimated by some function of drive distance. However, particularly in big cities, drive times are only very crudely related to distance travel, so very big errors occur when drive time estimates are based on distance. Mapping companies such as Google and Bing provide travel time estimates based on actual trip times. These drive time estimates are clearly better than estimates based on distance and they are regularly updated by the mapping companies. However, even this data includes errors because of poor geocoding, missing streets and traffic variations by time of day and day of week. Changing traffic requires that drive time data be continually monitored and corrected.
- Delivery stop times are heavily dependent on the processes that occur at each delivery. These processes are often dictated by the customer receiving the delivery and the walk distance from the park point to the actual delivery point. Delivery stop times are typically approximated by simple functions that do not account for differences in processes among customers. As a result, estimated stop times are often very different than actual stop times.

Data errors like the ones described above almost always result in bad plans when optimizing delivery routes constrained by time. Since routes typically have at least 20 and sometimes more than 100 delivery stops and the same number of drive segments, errors of a few minutes in each drive time and stop time can cause actual route times to be hours different from planned route times. This results in very inefficient routes if the time estimates are too high and failed deliveries if the estimates are too low.

Bad data visualizations: Delivery managers and supervisors are being overwhelmed by data visualizations that look impressive but do little to help them improve delivery performance. For example, applications on mobile devices allow drivers to be monitored in real-time based on GPS data displayed on electronic maps. However, manually monitoring more than a few drivers is an arduous task and development of processes to determine how to get value from this monitoring is left to the delivery managers, with little help from the technology. Similarly, many of the data visualizations provided by business intelligence systems look impressive but are not very useful for improving delivery systems since they are not designed to address specific issues.

Fragmented technology solutions: Current technology mostly tries to address the problems associated with individual components of delivery rather than consider the delivery system as a whole. This makes integration of the resulting solutions extremely difficult since decisions made regarding one component of a last mile delivery system almost always impact other components. For example, decisions regarding assigning customers to delivery days affect not only the daily workloads of delivery drivers, but also the daily workloads of the DC and the daily workloads of the sales reps, all of which impacts cost and service. Current technology for determining sales territories and customer delivery days typically considers only sales or only delivery rather than accounting for their interaction. Hence, improving one of these activities often makes the other worse.

"Locked in" planning technology: When delivery planning technology is first installed, estimates of drive times and customer service times are developed, and parameters such as maximum route times are specified. If the plans generated seem reasonable, the estimates and parameters are typically "locked in" and seldom if ever changed, even though the delivery environment is continually changing. As a result, performance of the delivery planning technology begins declining as soon as it is deployed. The route edits required from manual planners to develop acceptable route plans continue to increase to the point where the technology is making little contribution other than serving as a calculator.

Labor intensive daily planning: Most delivery enterprises have implemented some form of computerized "route optimizer" to generate daily routes. Planners typically edit the resulting routes in an attempt resolve any shortcomings in the computer-generated delivery plans. The primary causes of these shortcomings are poor route optimizers, bad data and failure to properly tune the route optimizers when changes occur. A major problem with having planners edit daily route plans is that each planner uses their own perception of route quality and their own "tricks" for editing routes. Since the editing process is ad hoc, there is little that can be done to improve the planning process other than hope that the planners are innovative in using the limited feedback they get regarding performance of the planned routes. This approach is also expensive and often produces bad routes.

Ad hoc planning processes: Current commercial technology does not support any concept of "master planning" where all data, models and processes are accessible in one location, where strategies and goals are clearly defined, and where there are agreed upon baselines for measuring overall delivery performance. Training is provided regarding technology functionality, but it is generally left to the users to develop processes around the technology. Hence, there is little standardization regarding how delivery planning technology is used.

Failure to address variability and uncertainty: Last mile delivery systems operate in uncertain environments where the uncertainty is caused by system components that interact in varying ways. As a result, the outcomes of operational decisions often cannot be accurately predicted. For example, when a manager specifies a daily delivery plan (*i.e.,* a route and schedule for a delivery vehicle to follow during a day), the manager cannot precisely predict when, or if, all deliveries will be completed. This uncertainty increases in large urban areas with traffic congestion, limited delivery parking, hard to locate delivery points and a diverse customer base. The impact of this uncertainty is amplified by increasing customer expectations for fast and predictable delivery times. Current technology assumes that there is no uncertainty and leaves it to the judgement of human planners to adjust daily route plans to account for uncertainty.

Decentralized planning: Most current delivery planning technology was designed for single users in a decentralized environment. This is a very different environment from the rapidly growing use of logistics control towers. A delivery control tower[1] or control center is a central hub that provides enhanced visibility, analytics, learning, and collaboration to support management of complex delivery systems. Control towers evolved as environments for managing complex systems such as NASA space missions and air traffic control, but advances in digital technology have motivated many companies to adopt the control tower concept to enable better management of supply chain and logistics domains. Unilever, for example, has a control tower that supports management of Unilever's delivery of ice cream to retailers in Latin America. Delivery control towers bring together delivery system managers, delivery system status, analytics, data visualization, and subject matter experts in an environment that facilitates learning. This enables a much better understanding of what works and what does not work for both strategies and technologies. Current delivery planning technology is a major impediment to the collaborative planning and continual improvement goals of control towers.

In summary, current commercial delivery technology relies heavily on human judgement to correct and modify automatically generated daily route plans. There is very little actionable information provided to planners to aid their judgement or to reduce problem complexity by reducing uncertainty. There are few standard processes for how the technology should be used. The technologies are generally provided by different vendors, address different delivery issues and are not integrated. Technology users assume that data is good and that the models do not require regular adjustment. The technologies do not support the growing trend in logistics control towers. These are all problems that must be overcome when developing an effective continual improvement process.

A Continual Improvement Success Story

One of the few companies to recognize the importance of really accurate customer location data is UPS. They have spent more than 15 years and more than $295 million to develop and deploy their On-Road Integration and Navigation (ORION) System, which UPS says saves 100 million miles per year.[2] A critical factor in the success of the ORION system is its focus on using UPS proprietary software, together

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1 *The Death of Supply Chain Management*, Allan Lyall, Pierre Merceir, and Stefan Gstettner, Harvard Business Review, June 15, 2018.

2 *Meet ORION, Software That Will Save UPS Millions by Improving Drivers' Routes*, Alex Konrad, Forbes, November 2013.

with visual observations to continually correct and refine map data.[3] The results are very precise geocodes for UPS customer locations, with very detailed maps indicating optimum lines of travel in hard to navigate geographies such as shopping centers and apartment complexes. UPS combines this with "route optimization" and a "master route" concept which partially motivated the concepts discussed in the next section. Fortunately, there is a new generation of technology that eliminates the need for companies to make the massive investment required to develop their own proprietary software and digital maps in order to get benefits similar to those of UPS.

Adaptive Delivery Management

Adaptive Delivery Management is a continual improvement methodology developed by Delivery Dynamics which utilizes the following key principles derived from Six Sigma[4], Adaptive Management[5] and Logistics Optimization.[6]

1. Maintain comprehensive models and data that faithfully represent the delivery system characteristics, environment and desired outcomes.
2. Improve predictability by removing variability and uncertainty in delivery planning and execution processes.
3. Learn by monitoring and analyzing the execution of delivery plans and use this learning to improve by iteratively making small changes based on what works.
4. Utilize data science to identify the root causes of errors and to improve data integrity.
5. Use integrated decision technology that supports fully automated optimization and data transfer.

The Adaptive Delivery Process shown in Figure 1 is similar in spirit to the Deming and Shewhart PDCA cycle and the Lean Six Sigma DMAIC cycle which were developed for quality improvement in manufacturing.

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[3] *UPS Optimizes Delivery Routes, Chuck Holland*, Jack Levis, Ranganath Nuggehalli, Bob Santilli, Jeff Winters, Interfaces 47(1):8-23, 2017, https://doi.org/10.1287/inte.2016.0875

[4] *Key Principles of Lean Six Sigma*, N. Vivekananthamoorthy and S. Sankar, https://www.researchgate.net/publication/215576248_Lean_Six_Sigma, January 2011.

[5] *Learning to Live with Complexity*, Gokce Sarguy and Rita Gunther, Harvard Business Review, September 2011.

[6] *10 Rules for Supply Chain and Logistics Optimization,* H. Ratliff, *https://www.scl.gatech.edu/resources/whitepapers, 2010.*

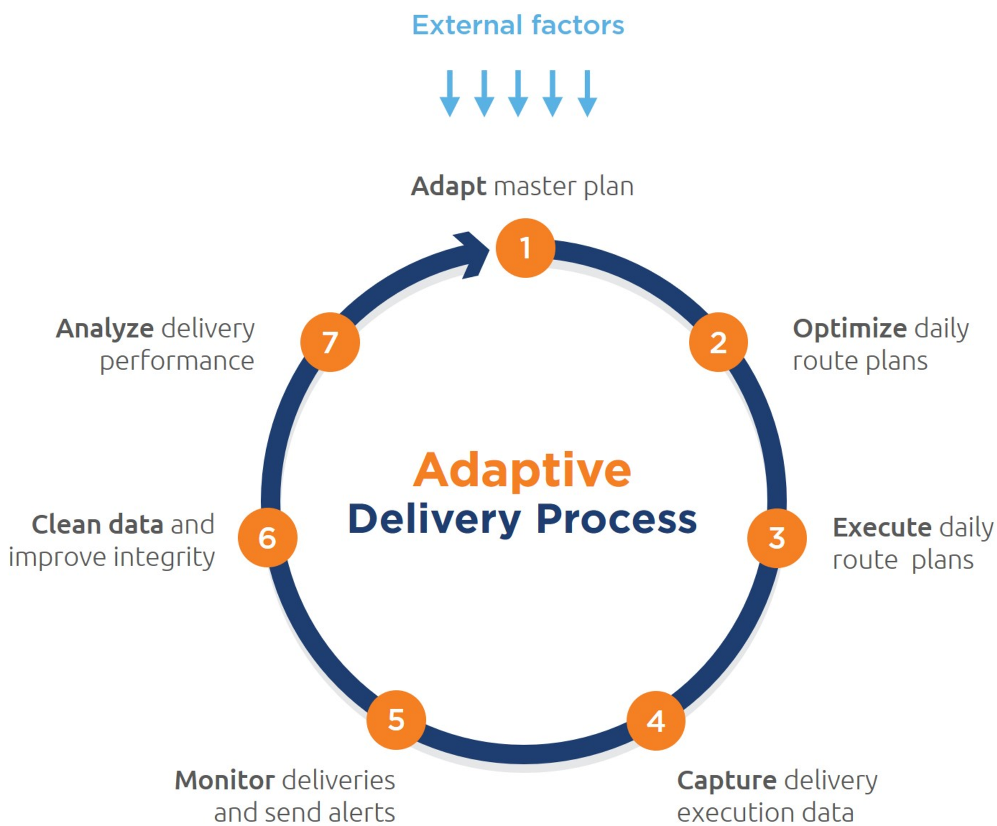

Figure 1 - Adaptive Delivery Process

The steps in the Adaptive Deliver Process are explained below.

(1) Adapt master plan

A delivery master plan is a digital framework that faithfully models a delivery system including infrastructure, objectives and constraints. All master data associated with the delivery system is imbedded in the master plan. The master plan provides the basis for continual improvement and provides guidelines, usually in the form of master routes, for daily delivery planning and execution.

Adapting the master plan typically involves iteratively making small changes to the plan based on what is learned from analysis of data from the performance of daily delivery plans. These changes must also account for outside factors, including setting up new customer. Setting up a new customer includes adding the customer and their associated data to the system and integrating them into the delivery framework. Integrating new customers requires an initial estimate of their geocodes, which ideally can be obtained using a commercial geocoder such as Google. However, in some cases this may require input from a planner familiar with the customers or from the customers themselves. The initial customer geocodes provide a starting place for continual improvement. They can then be improved based on the GPS trails after each customer visit.

External factors, such as government changes to truck regulations, may occasionally require that big changes be made to the master plan. In such cases, the best approach is to first try to make the big changes in small steps. If this is not possible, then simulate the changes and test alternative modifications of the master plan to learn as much as possible regarding what will work before actual implementation.

The concept of "master routes" is a powerful modeling tool for enabling continual improvement in delivery systems. Master routes are generated based on predictions of each day's delivery requirements. When a day's delivery requirements become known, the predictions are replaced by the actual values. If the resulting routes are acceptable, they become the daily routes. If they are not acceptable, then these routes become the starting point for further daily route optimization. This approach has the following significant advantages over other approaches:

- Using master routes as the starting point for generating daily routes allows the route optimizer to be tuned and automated so that typically, no human editing is required for daily routes.
- Using master routes as the starting point for generating daily routes results in consistent daily routes that are the same or very similar for each delivery cycle.
- Planners can adjust master routes and route parameters to account for variability and uncertainty within the routes.
- Using master routes allows balancing and synchronization of sales and delivery routes.
- There is more time to plan and tune master routes so issues can be handled that are very difficult to address under the extreme time pressures of daily route planning.
- Master routes provide a consistent core across delivery cycles, making it much easier to learn from execution of delivery plans and detect changes in the delivery environment.

The master route optimization process includes assigning delivery day patterns to customers to balance truck and driver requirements over days. This involves synchronizing the assignment of sales territories and the assignment of customer delivery days to balance work over days for both drivers and sales reps.

(2) Optimize daily routes

A new generation of automated route optimization technology has been developed for cloud-based parallel computers in a centralized environment. The best of these route optimizers can very quickly provide highly efficient route plans. These new optimizers using well-designed and maintained master routes as starting points for daily routes together with a systematic continual improvement framework should eliminate user interaction during the daily planning process. Automation is critical for continual improvement since it is extremely difficult to learn the root causes of last mile performance problems when users are manually generating route plans using their own unique thought processes. Automation reduces this variation in plans, since the same algorithmic rules are always followed. Also, in general the new automated route optimization technology yields much better route plans in much shorter time than those generated interactively.

(3) Execute daily route plans

Smart phone applications should eliminate the paperwork associated with assignment of drivers to routes and the transactions between drivers and customers. Smart phone applications should also provide drivers with driving directions and enable adjustments to routes in real time. These capabilities decrease wasted time associated with handling paper and looking for unfamiliar customers, reduce clerical errors and reduce the variability in service times and drive times.

(4) Capture delivery execution data

Smart phones can automatically capture and transmit GPS coordinates. Correcting errors in this GPS data requires sophisticated algorithms but the technical problems have mostly been solved and good technology is available. By continuously capturing and processing the GPS coordinates, additional vehicle information can be determined (e.g., line of travel, speed, stops, distance traveled between stops, stop times, etc.). By matching vehicle stops with delivery requirements, locations, and planned delivery times, a new generation of software should determine a detailed view of what each driver has done, what each driver is doing, and what each driver is expected to do. This provides the data necessary to better predict drive times and delivery times at customer locations and to monitor delivery performance. Smart phone apps can also be used to capture customer data such delivery windows and reasons for product rejection.

(5) Monitor deliveries and send alerts

Capturing GPS coordinates in real-time provides the ability to continuously track the mobile device and to plot the location on an electronic map. However, it is difficult for a supervisor to productively monitor even a small number of vehicles without some technology assistance. Technology is required to continuously analyze the status of each route and determine if there are significant deviations from the plan. If there are deviations from the plan, the technology should alert the supervisor to problems or anomalies that require some adjustment or some communication with customers. For example, if the technology detects that the delivery will not arrive at a customer until after business hours and alerts the supervisor via a mobile app, the supervisor might change the delivery sequence or contact the customer to see if a late delivery can be arranged. The technology should allow the supervisor to isolate the detailed status of any vehicle. The alerts provided by the technology need to be configurable to the delivery environment.

It is impossible to completely eliminate the uncertainty in delivery systems. However, keeping customers informed regarding delivery status at least partially mitigates the impact of this uncertainty on customer satisfaction. This should be done by establishing automated communication with customers that allows them to know the status of their delivery by either (a) being able to track the delivery vehicle and know where they are in the delivery sequence or (b) receiving messages with updates or alerts when deliveries will not occur as scheduled. Technology to support the desire communication options should be implemented with the delivery cycle and integrated with the other digital technology.

(6) Clean data and improve integrity

Inaccurate or missing delivery data is a major cause of bad decisions in delivery systems. Data science should be used to detect errors and continually improve data integrity. The keys to high quality data are rigorous structures for organizing data into databases, automated data capture whenever possible, automated transfer of data between systems, and automated tools and processes for validating and updating data. The most effective way to organize delivery data from diverse sources is by using cloud databases and cloud services. Data to accurately predict drive times and stop times on each route is extremely important in managing delivery systems. Technology using GPS data combined with artificial intelligence to continually improve these time estimates is now available and should be utilized.

(7) Analyze delivery performance

This activity involves analysis of outcomes from completed route plans to determine how to improve future plans by adapting the master plan. For example, if the technology detects that a route frequently takes longer than planned, analysis is required to first determine the cause of the gap between planned and actual, and then make adjustments to correct the problem. If the gap is caused by variability in customer demands from day to day, the buffer time for the route may be increased slightly for future days or the master route may be modified to decrease the number of highly variable customers in the same route. Another example that may occur is that a master route is frequently overloaded when predicted requirements are replaced by actual values. In this case, the master route may be modified so that fewer changes need to be made to generate an acceptable daily route. The analysis is repeated each time the routes are executed, but the "adapt" activities (*i.e.,* determine cause and adjust) are not required unless an issue is detected. Issues detected by customers or drivers are resolved in the same ways as those detected by the technology.

Summary

Adaptive Delivery Management is a systematic continual improvement process, that provides an effective framework for addressing delivery system dynamics. The primary features and benefits are shown in Table 1.

FEATURES	BENEFITS
Planning is a collaborative systematic process rather than an individual ad hoc process	✓ More effective planning ✓ Better management control
Data is systematically validated and improved based on information gained from executing route plans	✓ More accurate route plans ✓ More accurate performance assessment
Planners work on improving master planning rather than individual daily delivery plans	✓ Fewer highly skilled planners required ✓ Automatically generated daily route plans ✓ Better driver and sales rep work balance
Planning is based on a digital delivery master plan	✓ Data and models in one place ✓ Ability to recognize change and adapt ✓ Increased driver/customer familiarity
Repeatedly makes small changes based on what works	✓ Systematic continual improvement ✓ Ability to adjust for variability and change ✓ Reduced risk

Table 1: Features and Benefits of Adaptive Delivery Management

Using the existing delivery planning system to create a baseline and determine opportunities for improvement, should eliminate most unintended consequences when converting to ADM. This facilitates the Adaptive Management "learning by doing" approach [7] without disruptions to customer service. Implementing steps (3)-(7) before making any major changes in planning or operating procedures provides an opportunity to establishing a monitoring regime, correct data and resolve execution problems without the added complexity of dealing with new

[7] *'Learning by doing': adaptive planning as a strategy to address uncertainty in planning*, Sadahisa Kato and Jack Ahern, Journal of Environmental Planning and Management Vol. 51, 2008

planning technology. All of the technology to support Adaptive Delivery Management is available via cloud services models that allow users to test the concepts before committing. If done properly, implementation of Adaptive Delivery Management is simple to setup and execute, involves very little risk, and enables management to take advantage of new digital advancements as they occur. All technology necessary to enable ADM is currently available.[8]

[8] Delivery Dynamics, www.deliverydynamics.com, provides an integrated cloud-native technology platform to enable Adaptive Delivery Management and support control tower environments.

Dr. H. Donald Ratliff is founder and CEO of Delivery Dynamics Inc. He has spent more than 40 years developing and implementing new concepts in last mile delivery for enterprises including USPS, UPS and Coca-Cola. He is a member of the National Academy of Engineering and a fellow of IISE. He is Regent's Professor Emeritus and formally served as Executive Director of the Supply Chain and Logistics Institute at Georgia Tech.

About Delivery Dynamics

At Delivery Dynamics our sole focus is on the digital transformation and continual improvement of last mile delivery systems. Each member of our senior leadership team has more than 30 years of experience associated with software development and process engineering to optimize last mile delivery. The emergence of cloud based automated route optimization has finally provided the final piece necessary for true continual improvement of delivery performance. We provide a comprehensive service that includes an integrated technology platform, an analytics-based continual improvement methodology and unparalleled expertise to tailor them to your delivery needs. Our technology platform has been designed to address the unique needs of both the Latin American market and the US market by our teams in Panama City, Panama and Atlanta, USA. For more information please visit www.deliverydynamics.com.