GTP-WP-19-01

GEORGIA TECH Panama
Logistics Innovation & Research Center

Adaptive Delivery Management

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April 2019

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The logistics process of delivering goods should be a very high priority for digital innovation. It significantly affects customer satisfaction, business growth and profit margins with "last-mile" delivery cost (i.e., cost for the final leg of the delivery to the store or end user) representing more than 50% of the total cost of shipping for some companies.[1] It requires paper transactions, involves significant manual effort to plan, has very limited management visibility and has obvious problems with delivery failures and inefficient delivery routes. However, as noted by the World Economic Forum, *"Logistics has introduced digital innovations at a slower pace than some other industries. This slower rate of digital adoption brings enormous risks that, if ignored, could be potentially catastrophic for even the biggest established players in the business."*[2]

The primary reasons that digital technology has not provided greater value to date for last-mile delivery systems are:

- Current technology is based on the unrealistic assumption that there are no uncertainties regarding decision outcomes.
- Current technology is fragmented into planning systems and execution systems with no systematic processes for how they should be integrated.
- Current technology provides little capability to improve the accuracy of critical delivery planning data such as customer locations, drive times and customer service times.
- Current technology does not help managers understand or improve the dynamics of their delivery systems.
- Current technology is primarily focused on decreasing delivery miles rather than increasing revenue and profit.

Since the early 1980s logistics researchers have been creating increasingly better route optimization technology and wondering why — even though it contained top-notch algorithms — it did not significantly improve delivery results. Technology to digitally monitor and analyze actual delivery performance now provides compelling evidence that the best math and optimization technology provides only limited value for managing delivery systems unless they somehow account for the dynamic reality out in the world. It also shows that when managing delivery systems, better estimates of route activity times together with better data analytics and error-correction are at least as important as better optimization.

Increasing the success of digital innovations for logistics, particularly for last-mile delivery, requires a management model focused on systematic decision-making in

[1] *The challenges of last mile logistics & delivery technology solutions,* Shelagh Dolan, Business Insider, May 2018

[2] *The digital transformation of logistics: Threat and opportunity,* http://reports.weforum.org/digital-transformation/the-digital-transformation-of-logistics-threat-and-opportunity/

uncertain environments. A key success factor is the recognition by all stakeholders that delivery systems are continuously changing and that they embody "dynamic" interactions that cannot be effectively managed using technology designed for "static" systems. Effective management requires integrated digital technology to enable continuous-improvement across the multiple goals: *reducing cost, increasing customer satisfaction and increasing sales.*

Current Delivery Technology

Most delivery enterprises have implemented some form of digital "route optimization" technology to help managers with delivery decisions. This technology determines what it considers to be an "optimum" route (*i.e.,* which delivery points should be visited on each route and the visit sequence) for each delivery by generating and comparing multiple possible routes. If the actual outcome resulting from the execution of each route is the same as the planned outcome and all possible routes are considered, then in theory this process will yield an optimum route. However, for complex last-mile delivery systems, there is always a gap — often a large gap — between planned outcomes and actual outcomes (*e.g.,* the driver could not find the delivery point or an arrival at a customer occurred after the customer was closed). This gap presents the delivery manager with the choice of (a) hoping that the planned routes can satisfactorily be executed as generated or (b) trying to modify the planned routes to account for uncertainties that are not very well understood. If the manager choses (a), then there are likely to be missed delivery windows and failed deliveries, resulting in unhappy customers and extra cost for making additional trips. If the manager choses (b), then route modifications typically consist of adding buffer times to each route to offset uncertainties. However, it is very difficult for managers to know how much buffer time to add, so the outcome is *likely* to be either similar to (a) or greatly increased cost.

Current route optimization technology assumes that all data (*e.g.,* drive times and customer service times) are completely predictable and that any shortcomings of the computer-generated delivery plans can be manually resolved in the limited time before the plans must be executed. Current software further assumes that once an initial computer model is constructed, it does not require ongoing adjustment — very few tools are provided with route optimization software to correct data or adjust underlying models. Since these key assumptions are not valid, route optimization software often produces infeasible delivery plans that either must be discarded or require excessive amounts of labor to correct. Even in the best cases, there is almost always a substantial gap between computer generated route plans and what actually happens when these plans are executed.

There is also an increasing availability of "route execution" technology that allows trucks and drivers to be tracked in real-time. However, current use of this technology is mostly limited to dispatchers watching the locations of delivery vehicles on a map as deliveries are made. While this manual tracking capability provides some value, a much bigger value can be achieved by continuously analyzing information from the monitoring process to remove uncertainty related to drive and stop times and thus improve future planning. Artificial intelligence (AI) for this purpose is available but is not yet a part of most delivery execution software. Continuous improvement of delivery management data requires that delivery planning technology and delivery execution technology be integrated. However, these technologies are generally not provided by the same vendors and are not integrated. As a result, current software provides very little systematic input to improve the delivery planning processes.

Impact of Uncertainty

Last mile delivery systems are formally classified as *complex systems* because they operate in uncertain environments where the uncertainty is caused by system components that interact in varying ways[3]. 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. As a result, delivery managers are forced to make customer critical decisions with limited knowledge of what the outcomes will be — and from a vantage point where very little of the system is visible. Since current route planning software assumes that there is no uncertainty, the result is higher delivery cost and lower customer satisfaction.

A concept for decision-making called *adaptive management*[4] has been successfully used in managing other complex systems (*e.g.,* systems of natural resources), which like delivery systems have decision outcomes that are difficult to predict. Adaptive management is an iterative process that monitors complex systems, conducts experiments and analyzes data to learn how the systems behave. It then uses what is learned to reduce uncertainty and to adapt decision-making by repeatedly making small changes based on what works.[5] The three basic concepts of adaptive management are - *monitor, analyze and adapt.* Adaptive management provides an excellent conceptual framework for closing the gap between logistics planning and execution. With the use of automated route planning, the framework also enables the evaluation of different strategies for delivery. The use of the adaptive management framework and concepts, supported by digital data and digital decision technology to manage delivery systems, will be referred to here as *adaptive*

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[3] *Learning In and About Complex Systems*, John D. Sterman, System Dynamics Review, June 1994.
[4] *Learning to Live with Complexity*, Gokce Sarguy and Rita Gunther Harvard Business Review, September 2011.
[5] *Adaptive Management of Natural Resources: Theory, Concepts, and Management Institutions,* George H. Stankey, Roger N. Clark, Bernard T. Bormann, USDA PNW-GTR-654, August 2005.

delivery management. This adaptive delivery management methodology is illustrated in Figure 1.

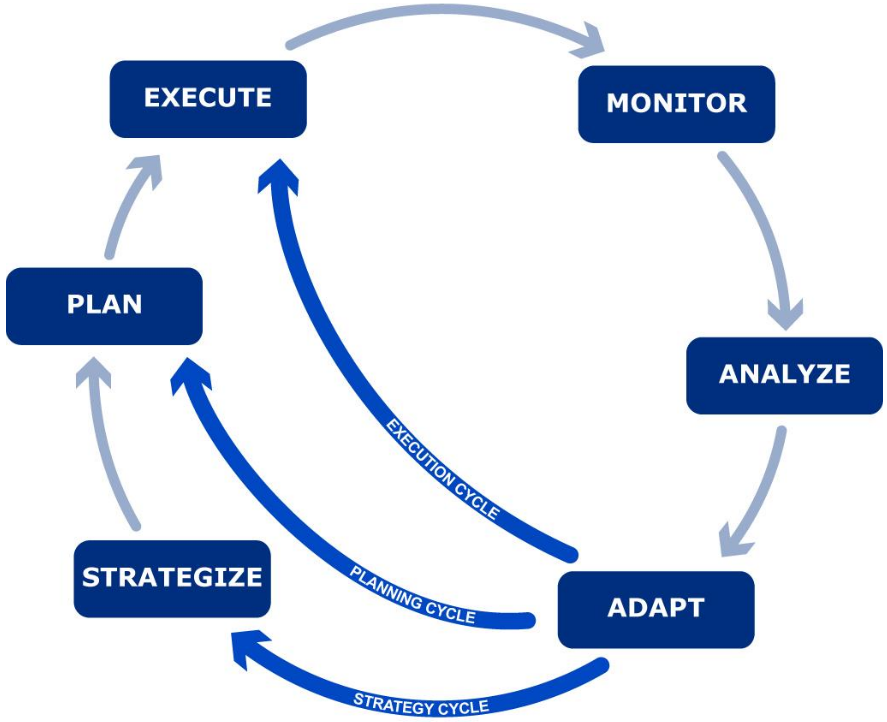

Figure 1: Adaptive Delivery Management[6]

Adaptive Delivery Management

The three cycles – execution, planning and strategy – in Figure 1 use much of the same data, aggregated in different ways, in each cycle. The analytics should all have the same look and feel. The learning from adaptive delivery management is much greater when utilized in a collaborative environment such as a digital control tower[7] with capability to analyze and visualize both the delivery system and the data models that represent the system dynamics.

The execution cycle in Figure 1 involves monitoring and analyzing the delivery system in real time. Delivery plans are adapted as necessary during execution. The primary activities in this cycle are:

- Monitor current route plans
- Analyze performance to develop exception alerts

[6] These cycles can be considered as extensions of continuous improvement cycles - *Elementary Principles of the Statistical Control of Quality*, W. E. Deming, June 1950.

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

- Resolve unexpected execution problems
- Assure compliance with standard operating procedures
- Gather data for predictive analytics and planning
- Maintain a performance baseline
- Identify errors in delivery data
- Identify opportunities for improvement

The planning cycle in Figure 1 involves monitoring the dynamics of past plans based on the data captured in the execution cycle. Plans are compared to actual deliveries and the gaps analyzed to determine root causes (*e.g.,* what was the root cause a delivery failure?). Future plans are adapted based on what is learned from the analysis of multiple historical plans. The primary activities in this cycle are:

- Compare planned with actual
- Identify and correct errors in data
- Continuously improve predictive planning parameters
- Generate optimized route plans using current strategy
- Compare optimized route performance to baseline
- Identify opportunities for improvement

The strategy cycle in Figure 1 is where new delivery strategies are developed, tested, and adapted based on what is learned. The primary activities in this cycle are:

- Generate alternative delivery strategies
- Compare performance of alternate delivery strategies to baseline using simulation
- Generate strategies for aligning sales and delivery
- Identify opportunities for improvement

Roadmap for Digital Transformation of Delivery Systems

Most delivery managers are keenly aware of the shortcomings of their last-mile logistics technology, but do not have clear evidence that investing in new technology will provide significantly better outcomes. In addition, they are concerned about the integration challenges and unanticipated consequences that often bedevil major technology changes. The following approach tries to overcome these concerns by specifying a low risk, step-by-step "roadmap" for transforming delivery systems to digital operating models and enabling adaptive management of these systems once digitized.

Step 1: Create and populate a delivery data hub

Inaccurate or missing delivery data is a major cause of uncertainty in delivery systems. This is a particular problem with the geographic data essential for delivery system management. For example, accurate customer locations are critical to delivery planning and execution. For countries such as Panama where there is no standard addressing, automated geocoding systems do not produce accurate enough results to support delivery planning. Even in the U.S., geocodes are often not accurate enough to enable drivers to find delivery locations without a lot of wasted effort. These errors are compounded when inaccurate geocodes are used in route optimization software, often making the resulting routes nonsensical. One of the few companies to recognize the importance of really accurate customer location data is UPS. They have spent more than 15 years developing their On-Road Integration and Navigation (ORION) System, which UPS says saves 100 million miles per year.[8] A critical factor in the success of the ORION system is its focus on using proprietary software together with visual observations to correct and refine map data. 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.

Fortunately, it is no longer necessary for companies to develop their own proprietary software and digital maps as UPS has done. The combination of Google Maps, GPS data, and new cloud-based AI technology is very effective in improving the accuracy of customer geocodes and lines of travel. Other available digital technology effectively uses GPS data to improve the accuracy of predictions including delivery stop times and drive times. 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 time and stop time on each route is extremely important in managing delivery systems. Particularly in dense urban areas, routes are often limited by time rather than capacity of the delivery vehicles. Accurately estimating route time becomes even more critical when there are tight delivery windows. Using crude estimates of drive times and stop times generally results in expensive failed deliveries. Fortunately, technology using GPS data combined with AI to continuously improve these time estimates is now available.

Step 2: Deploy a mobile platform

Mobile platforms provide functionality in three main areas. (1) Mobile platforms provide drivers with instructions and communications regarding their daily routes — reducing drive time and the variation in time for drivers to find their next delivery point, while allowing adjustments to routes in real time. (2) Mobile

[8] *Meet ORION, Software That Will Save UPS Millions By Improving Drivers' Routes*, Alex Konrad, Forbes, November 2013.

platforms facilitate and document transactions between drivers and customers — decreasing driver time at customer locations and reducing uncertainty regarding delays at customer locations due to driver errors. (3) Mobile platforms provide real time GPS coordinates indicating the location of each driver — providing the data necessary to better predict drive times and delivery times at customer locations and to monitor delivery performance.

Smart phones and tablets have become the most flexible and cost effective mobile devices for mobile delivery applications. They are inexpensive, enable two-way communication, and have sufficiently accurate capture of GPS trails for most delivery management requirements. These devices can automatically capture GPS trails, but they require input from the drivers to associate GPS trail stops with specific customers.

Step 3: Setup real-time delivery monitoring

Successful management of complex systems requires careful monitoring of the systems to reduce uncertainty and to learn and adjust how the systems are operating. However, since most delivery system activities are not physically visible to a delivery manager, monitoring a delivery system requires some form of "virtual visibility." Inexpensive mobile devices can capture and transmit GPS coordinates as often as 10 times per second, enabling excellent virtual visibility. Correcting errors in GPS data requires sophisticated algorithms to provide this visibility, but the technical problems have mostly been solved and good applications are available.

Simply plotting the locations of vehicles and drivers on a map does not provide the level of virtual visibility necessary to reduce uncertainty or to learn and correct system operation. However, by continuously capturing and processing the GPS coordinates, additional vehicle information can be determined including: 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 can determine a detailed view of what each driver has done, what each driver is doing, and what each driver is expected to do. From this detailed virtual visibility, it is possible to reduce uncertainty — and to learn about and adapt what the driver should do.

Step 4: Evolve a delivery control tower

A delivery control tower 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. Control towers can start small and evolve as technology and data become available.

Logistics 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. Much of the technology currently in use in delivery control towers was developed for decentralized environments with limited automation rather than for centralized, automated control tower environments. However, new technology is now available that was developed specifically for control tower environments.

Step 5: Implement analytics and develop standards

Four different types of analytics are required to enable adaptive management:

- Performance analytics enables the tracking, aggregation and visualization of key performance indicators such as each customer's estimated profitability per delivery. This allows a better understanding of the delivery process dynamics and facilitates continuous improvement.
- Predictive analytics, supported by AI, are used to continuously improve predictions of planning parameters such as drive times and customer stop times.
- Data integrity analytics are used to validate and improve data such as the location of customers and their delivery windows.
- Baseline analytics are used to establish "standard" or baseline performance markers for the various delivery system work activities.

These analytics must be highly automated in order to consider the large amounts of data added to the delivery data hub each day. They must also be flexible enough to model the specific dynamics of the delivery system.

Developing standard methods for delivery activities and determining the standard time that each activity should require, is also essential for reducing uncertainty and for predicting the outcomes of management decisions. It is impossible to accurately predict the times for activities that are performed in an ad hoc fashion. It is also impossible to measure the impact of changing a delivery system without a baseline to compare against.

Step 6: Implement the execution cycle.

The execution cycle involves adapting current plans based on what is learned as each delivery route is being executed. Execution begins with the route data loaded on the mobile devices and the orders/shipments loaded on the vehicles. The GPS capability of the mobile devices allows continuous monitoring of the position of each vehicle in real time. A delivery supervisor can normally monitor and manage

20-50 vehicles as they execute route plans. 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 alerts 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, 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. The technology should also determine whether or not the driver is using the mobile device correctly. The execution cycle is repeated each time the routes are executed. Data from the mobile devices are archived for each route to support analysis in the planning and strategy cycles.

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 is best 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.

Step 7: Install automated route optimization

The ability to consistently generate efficient routes very quickly is a critical requirement for delivery planning. Most of the route optimization technology currently being used was developed for personal computers assuming a distributed environment with a high level of user interaction. A new generation of route optimization technology has been developed for cloud-based parallel computers assuming a centralized environment with very little user interaction. It is extremely difficult to learn the root causes of last mile performance 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. Centralized and automated route optimization is a necessary component of adaptive delivery management.

Step 8: Implement the planning cycle

This cycle involves adapting future plans based on analysis of outcomes from completed routes. Technology is required to execute the analysis necessary to update standards, assess performance, and identify and adjust systemic or recurring issues. For example, if the technology detects that a route frequently takes longer than planned, the supervisor should first determine the cause of the gap between planned and actual, and then make adjustments to correct the problem. 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.

Step 9: Define the scope of the strategic decisions to be addresses

Key strategic decisions for delivery systems include how to effectively balance deliveries over days and how to coordinate sales territories with delivery routes. As a result of guaranteed driver pay, most delivery systems have a very high fixed cost, even on days when the truck and driver are not used. This puts a premium on strategies that balance work across days and use overtime rather than simply minimizing cost on each individual day. The most common way to balance workload is to have specified days for each customer to order. However, customers often have limited space for product and strong preferences regarding when they wish to receive deliveries, each of which may influence how much is ordered. This creates the need for both a structured decision making process to assign delivery days to customers and automated route optimization to evaluate each strategy. Digital technologies are available to address both objectives.

Route strategies range from "standard routes" to "dynamic routes," with a range of hybrid strategies in between. At one end of the spectrum, a "standard route" strategy executes a set of routes on a fixed schedule (*e.g.*, Monday routes are the same every week). A standard route strategy provides the greatest consistency and the most predictable outcomes, since the drivers do basically the same thing whenever they execute a route. The shortcoming of standard routes is that when there is significant variability in customer order quantities, the routes may not be efficient. A "dynamic route" strategy executes different routes each day to try to optimize for each day's particular set of orders. A dynamic route strategy provides good theoretical routes, but since for this approach drivers are frequently not familiar with customers on their routes, they often require more time to find the delivery points and are less effective in servicing customers. In between standard and dynamic route strategies, there are a variety of possible "hybrid" route strategies that deliver to some customers on the same routes every day while allowing other routes to change when such dynamism is justified by higher efficiency. Ultimately, determining the best strategy for a particular delivery scenario requires the ability to generate the best possible routes for each strategy, combined with the ability to simulate the outcomes of each strategy by evaluating the routes using actual delivery data. There is now powerful technology available to automatically generate optimized routes for any delivery strategy and to "play through" these routes using actual delivery data. This allows variations in strategy to be evaluated prior to actually executing them. It also allows rapid evaluation of different alternatives regarding how to resolve uncertainties in the delivery system.

Evaluation of route strategies must also consider the strategy's potential for causing a delivery failure. Delivery failures are extremely expensive because the order must be redelivered, the returned products must be stored or restocked, there is significant "paperwork" involved, and the failure often creates a very bad customer impression or a lost customer. A common cause for delivery failure is that the driver has not visited the customer previously and simply could not find the customer location. Another common cause is that the time allotted for driving and servicing customers on the route was not sufficient for the driver to complete all deliveries. Failures based on these causes are more likely with more dynamic routes.

Data gathered in execution process can also be used to develop and evaluate sales strategies, particularly those associated with

- Customer profitability
- Promoting product assortments based on geography and store type
- Interactions between sales territories and delivery routes
- Sales based on frequency of delivery
- Sales based on salesperson time in store
- Salesperson performance evaluation

The interaction between sales manager and delivery managers in a control tower environment also helps to focus both groups on how to increase profitability rather than just increasing sales or decreasing delivery cost.

Step 10: Implement the strategy cycle

The strategy cycle involves adapting planning models by making changes in delivery strategies. Changing delivery strategies may offer potential for delivery system improvement but also poses risks. The monitoring and adapting stages in the execution and delivery cycles can provide clues to how strategies could be improved. Technology can be used to help evaluate potential changes in strategy by simulating them using data gathered in the execution cycle. However, analysts and delivery managers must provide most of the guidance regarding what potential changes should be considered. This requires that the analysts and managers involved in this cycle have both good knowledge of the delivery execution environment and good technology to visualize and adapt the strategies being evaluated. The technology should use actual data whenever possible in simulating strategy outcomes, but even then the results require scrutiny. For example, when contemplating changing from standard routes to dynamic routes, managers should consider that the drivers will not be as familiar with the line of travel, the customer locations, and the specific processes required for delivery at each customer. Without testing in the actual delivery environment, there is no way to accurately estimate the impact of lack of familiarity on the time required for a new dynamic route. The strategizing environment should have the technical capability to simulate various strategies using the best data possible. The planning software should then have the capability to implement any changes that look promising on a small sample of customers and routes for testing and monitoring. If the changes prove valuable, then they should be implemented incrementally.

Summary

For long-haul transportation, where the trucks make only a few stops on each route and distances between customers are large, miles travelled are generally the critical factor in delivery performance. However, for last-mile delivery, where trucks make multiple stops on each route and distances between customers are small, time becomes the critical factor in delivery performance. The fact that there is much greater uncertainty and variability associated with estimating route times than estimating route distances is the root cause of many of the shortcomings of current delivery technology. The e-commerce created demand for smaller shipments with shorter delivery times, together with increasing population urbanization, will continue the trend toward time as the critical factor in delivery performance. Traditional management approaches based on static assumptions are no longer adequate for addressing the dynamics of last mile delivery.

Adaptive delivery management is a systematic continuous improvement process, integrated across strategizing, planning and execution. It provides an effective framework for addressing deliver system dynamics. The following is a summary of the elements of adaptive delivery management.

- Components
    - Monitor
    - Analyze
    - Adapt
- Characteristics
    - Structured decision making
    - Continuous systematic improvement
    - Integrated digital technology
- Management principles
    - Reduce uncertainty
    - Learn from doing
    - Repeatedly make small changes based on what works
- Technologies
    - Cloud based logistics data hubs
    - Mobile execution platforms
    - Delivery system monitors
    - AI based continuous improvement algorithms
    - Flexible analytics
    - Analytics dashboards
    - Automated route optimizers

- Delivery control towers
- Values
    - Managed versus unmanaged delivery system
    - Consistency in delivery performance
    - Increased sales performance
    - Continuous improvement in delivery cost and customer experience
    - Informed strategic decisions
    - Enhanced ability to change

Following the roadmap proposed here eliminates most unintended consequences by using the existing system to create a baseline and determine opportunities for improvement. This facilitates the adaptive management "learning by doing" approach9 without disruption to customer service. Implementing steps 1-6 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 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.

[9] *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