Games for Learning in Freight Transportation Systems

Zahir Balaporia
Director
Intermodal Operations
Schneider National, Inc.
3101 S. Packerland Drive
Green Bay, WI 54313, USA
+1 (920) 592-2597
balaporiaz@schneider.com

Mike Zeimer
Sr. Engineer
Engineering and Business Transformation
Schneider National, Inc.
3101 S. Packerland Drive
Green Bay, WI 54313, USA
+1 (920) 592-2533
zeimerm@schneider.com

Abstract

*This paper describes two games developed and in use over the last few years at Schneider National Inc. The first is the **Trucking Game** which addresses the management of a three node closed loop truckload transportation network. The second is the **Dispatch Game** which is used to help dispatchers understand how human decision making and optimization work together in their daily dispatch problem. The objective of the paper is to share the history and purpose of each game, the hurdles to take them from concept to general adoption, and their impacts on the business.*

The paper starts with an introduction to Schneider National to provide an organizational context. It then describes each of the games and how each game is played at a high level. Application areas are shared for the Trucking Game. A section on changing beliefs in the use of optimization technology is included for the Dispatch Game. Implementation challenges are also discussed for both games.

About Schneider National

Schneider National, Inc. is a premier provider of truckload, logistics and intermodal services. Serving more than two-thirds of the FORTUNE 500® companies, Schneider National offers the broadest portfolio of services in the industry. The company's transportation and logistics solutions include Van Truckload, Dedicated, Regional, Bulk, Intermodal, Transportation Management, Supply Chain Management, Warehousing and International Logistics services. Headquartered in Green Bay, Wisconsin, Schneider National has provided expert transportation and logistics solutions for over 75 years. A $3.4 billion company, Schneider National provides services throughout North America and China.

Core Values

Safety first and always. We have an obligation to our associates and the public to operate safely. Nothing we do is worth hurting ourselves or others.

Integrity in every action. We conduct our business with the highest ethical standards. Truth and honesty are essential to the way we operate.
Respect for all. We seek and value diversity of perspective, experience, and background as the foundation of the enterprise. We treat all stakeholders with dignity and respect.
Excellence in all we do. We strive to provide the highest quality services to our customers. We have a relentless passion for innovation and improvement.

Tradition of Leadership

Schneider has always been viewed as a leader in the adoption and application of new technologies in the freight transportation industry. This tradition was established under the leadership of Don Schneider who led the company from 1976 to 2002. The early examples were related to communication systems (satellite based tracking of trucks) and information systems (transportation management systems). But the examples continue in a variety of areas across the company, including the Engineering group which supports the organization in the application of quantitative models for strategic, tactical and operational decision support. The **Trucking Game** and the **Dispatch Game** were both developed in the Engineering group as a new approach to improving our thinking about some of our common but toughest problems.

The Trucking Game©

Like many useful tools and technologies, this game started out with a different purpose. Schneider was evaluating competing strategies on how to manage shared pools of 30,000+ trailers between separate lines of its business. Therefore, it was originally called the Box Game, box being a generic term for a trailer. However, once the basic setup was created, the idea to turn it into the Trucking Game by adding the tractor into the equation became a natural progression.

This game was modeled after the classic Beer Game. In a well facilitated session of the Beer Game, we see how the agents in the supply chain react to a single, simple shift in the demand signal in ways that amplify the problem generally and leave everybody believing that the demand signal is in fact chaotic. It beautifully illustrates the impact of delays in higher order systems resulting often in significant oscillations in supply and demand; the bane of every production and inventory control manager. It focuses attention directly on the point and creates the “Ah hah!” moment that represents real learning. Therefore the goals for the Trucking Game were to create something as effective as the Beer Game, but in the context of a transportation network. It should be:

- Easy to learn and play
- Capture the essential dynamics and business elements
- Address fundamental business questions
- Create the opportunity for “Ah hah!” moments

Basic Setup

The board version has 3 basic components. They are:

1. The game board that represents a three node closed loop network.
2. Poker chips of two colors, representing tractors and trailers.
3. A spreadsheet that is used to log decisions at each turn and calculate metrics for the game.

The figures below show a representation of the game board with a game in progress, and the spreadsheet used for logging moves and calculating metrics i.e. scoring.

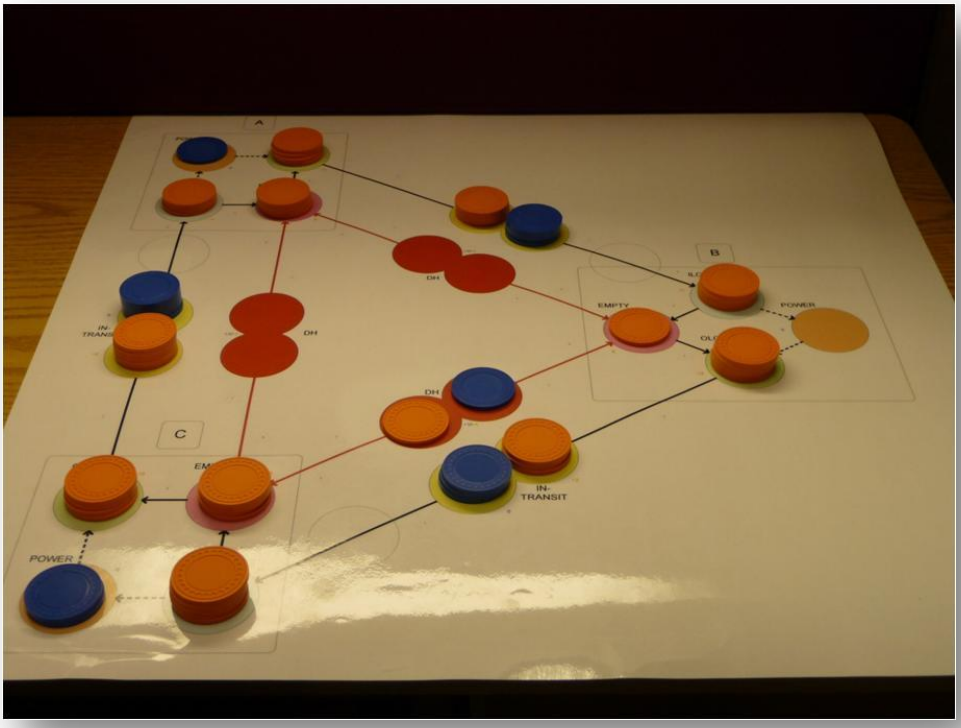

Figure 1 - Game board with poker chips

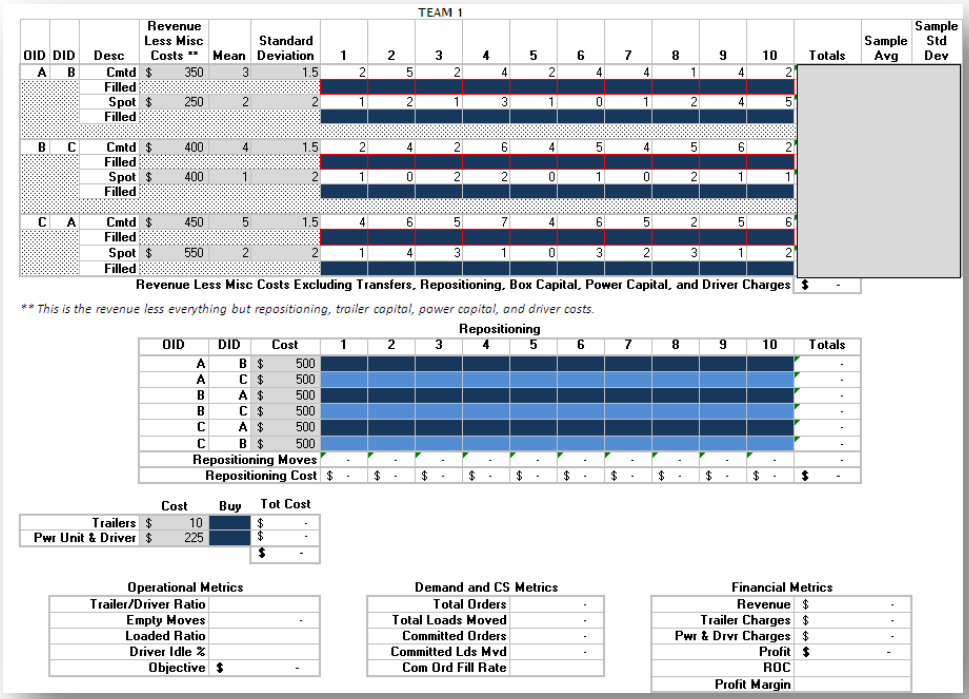

Figure 2 - Spreadsheet used to track decisions and overall metrics

The 3 nodes in the network (A, B & C), represent locations where orders need to be filled, and where tractors and trailers can be used to fill orders. Orders are simplified to represent demand on only three lanes; A->B, B->C and C->A. However, the reverse lanes are allowed for repositioning tractors and/or trailers. At the risk of stating the obvious, a trailer cannot move between nodes without a tractor. The decisions at each turn are (1) how many orders to accept at each node and (2) what, if any, equipment to reposition. The essential elements of the game are as follows:

- Trucks used to fill orders at A today are available to fill orders at B tomorrow i.e. filling today's demand creates tomorrow's supply.
- Demand variability and commitments to customers makes it difficult to know how many trucks are needed at each location tomorrow.
- Tractors and trailers have different cycle times – tractors do not have to be loaded and unloaded.
- Network balance is achieved by a combination of
    - accepting non-committed loads,
    - asking drivers to wait, and/or
    - moving empty.

- With enough capital (tractors and trailers) it is easy to meet customer service goals but hard to make money; in order to make money you must balance the cost of capital and customer service.

Application Areas

The Trucking Game has been used in three primary applications at Schneider. Each application is summarized and includes what was learned from each experience.

Application Area 1: Trailer Management

A series of games were played with teams of decision makers, allowing players to organize themselves into roles. Key takeaways from these sessions were:

- Even when the system is simple enough to understand the whole system, people tended to gravitate toward their compartmentalized roles.
- Teams that split up roles functionally performed better (made more money) than teams that split up geographically.
- Teams that took a whole system view performed the best.

Strategic implications were that work roles are a deeply ingrained part of the culture, but they may not be the best roles / structure for the overall system.

In another set of games, a formal monetary system for trading trailers between teams was provided. The thinking was that teams would negotiate hard with each other over the price of a scarce resource. Key takeaways from these sessions were:

- Teams cooperated informally, naturally, and efficiently with each other without the need of the monetary system.
- Teams took ownership of repositioning trailers and making decisions that would put trailers in the right places.
- Over time, teams relied less on trading and more on making better decisions in the first place.

Strategic implications were that business units having their own trailers will result in the business units taking ownership and responsibility for the decisions that relate to them, and that trading between business units would not be a problem.

Application Area 2: Network Management

A series of games were played with the Engineering team in order to try to understand how people who are not biased by current network management practices would manage a trucking network if they could see the whole system. Key takeaways from these sessions were:

- There are two basic winning strategies
    - Balance the network with non-committed loads – low capital, few empty miles
    - Chase high revenue loads – higher capital, more empty miles, higher revenue
- Because trailers and tractors have different cycle times, accepting a large number of loads one day can cause an imbalance between the number of tractors and trailers in subsequent days.

Strategic implications were that consistent flow from day to day minimizes the number of trailers required to be successful.

Application Area 3: Customer Management

A valued customer was interested in finding win-win strategies to lower total supply chain costs. They did not understand how their decisions affected us, and they were looking for innovative solutions and cost saving opportunities. The game was played with three mixed teams from their company and ours. It was a great relationship building exercise that they learned from and used as context for questions and discussions the following day. As issues were discussed, there were multiple references back to "like in the game yesterday". One of the key points that they realized was that re-bidding freight too often creates imbalances in their transportation provider networks that often raises costs in the long run. The data that showed rising costs existed, but we believe the game provided the right context for the conversation that changed the thinking.

Based on the success of this example, we have since facilitated two additional game sessions with large strategically important customers to help their transportation management and purchasing people better understand the services they are purchasing from the perspective of the supplier. There is some anecdotal evidence from our sales force that this has been successful in transforming organizations that view loads as being independent from one another, to organizations that understand transportation networks as systems.

Next steps for the Trucking Game

The trucking game has been growing and evolving over the last 5 years. A major next step in its evolution is to build out an online version of the game. This step is progressing well with the help of a partnership between Harvard Business School Publishing, Forio Online Simulations and Schneider National. The **Schneider Trucking Game** will be generally available as a packaged online simulation from Forio in the near future.

The board version of the game is also becoming part of the standard training curriculum at Schneider. It will be used to help new associates learn about the nature of the business. The authors are very optimistic for its future use within Schneider and beyond.

A Note on Adoption of Games as Learning Tools

Although we have had great success with the Trucking Game with our customers, adoption of the Trucking Game as a learning tool within Schneider National has been more challenging. We believe there are two primary reasons for this intransigence:

1. Some people do not believe anything can be learned from games because simple games cannot represent the richness and complexity of real problems, and
2. Some people believe that trucking is "simple" and building in complex network effects into network management is unnecessarily complicating the business.

It has taken five years for the Trucking Game to be fully adopted at Schneider National, and at several points it was nearly shelved. In 2011, persistence paid off when we got executive sponsorship and began to explore a direct partnership with Human Resources. After a series of sessions in which we played the Trucking Game with leaders from Human Resources and our training team, they made the decision to begin the development of a curriculum around the game. The curriculum is now complete, and this year we will have nearly 400 internal associates trained in 33 sessions with the Trucking Game.

The Dispatch Game

This game started as an exercise within the Engineering group at Schneider. Originally developed a few years ago by a Senior Engineer at Schneider, it was an interesting exercise using an assignment problem to determine the gap between an optimal solution, and the assignments created by people familiar with optimization but without using optimization tools. As expected the gap was significant, ranging from 5% to 25% above the optimal solution. With such potential to improve operating performance, this exercise generated interesting discussion on why optimization based decision support systems struggled to be adopted. But that's where it stayed for many months.

Dispatch optimization technology had been present within intermodal dispatch operations for the last few years. However, its usage had been sporadic although its potential benefits had been regularly demonstrated. When one of the authors moved from the corporate engineering group into the Intermodal line of business and started to work more closely with dispatchers, he quickly realized that most dispatchers did not have a good understanding of how the technology worked. In fact, their understanding was biased in ways that would provide little incentive to use the technology. Therefore, as part of a separate and corporate wide new technology implementation, the Dispatch Game was introduced into the training to help dispatchers understand how dispatch optimization technology worked and why it was beneficial to them, our drivers, our customers and the overall business.

Basic Setup

The game is setup as a simple assignment problem in Microsoft Excel. There are 12 loads and 12 trucks. (NOTE: Loads are synonymous with shipments, and trucks are synonymous with drivers). They are randomly placed on a map in a relatively small geographic area that would resemble a small local dispatch region for Intermodal. The objective is to assign one load to one truck so that all loads are covered. The distance from the truck to the load incurs empty miles. The goal is to find the set of assignments that minimize total empty miles. One added twist is that one of the trucks (Truck#12) is a third party resource, thereby incurring a 25% up-charge on the empty miles. Information provided in the spreadsheet is shown below.

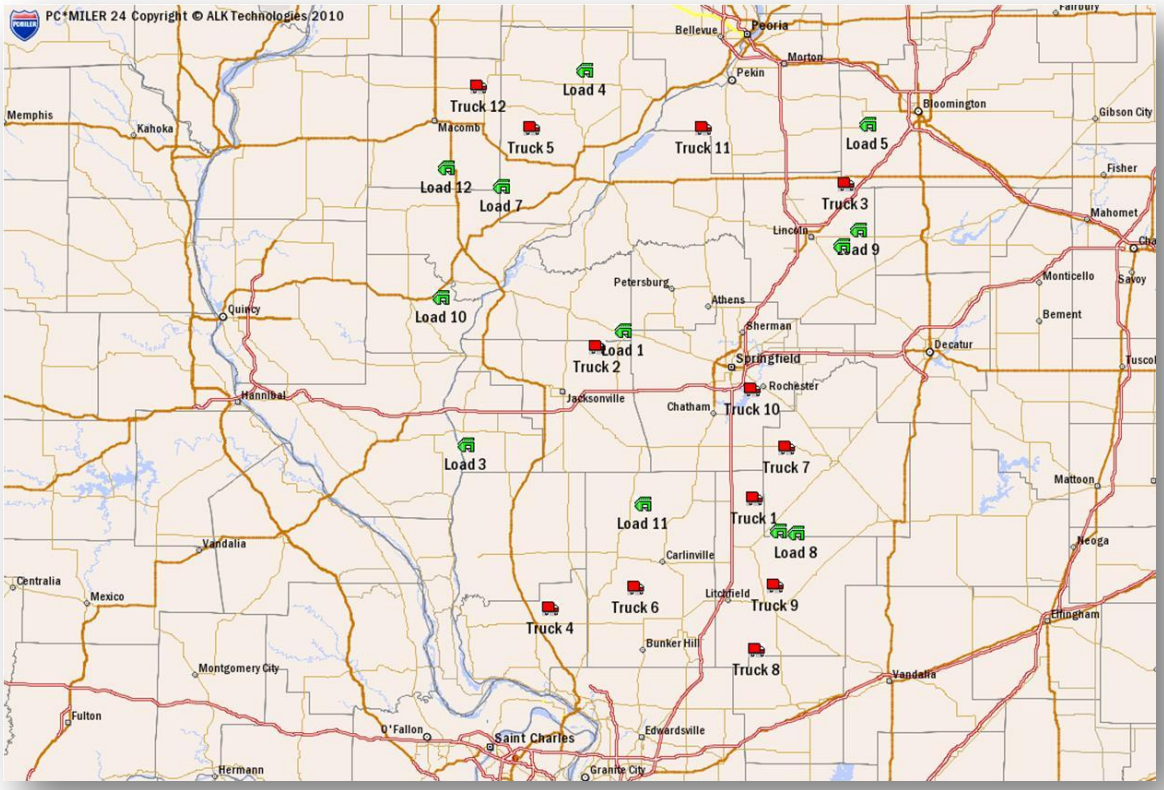

Figure 3 - Map View of Loads and Trucks

	Load 1	Load 2	Load 3	Load 4	Load 5	Load 6	Load 7	Load 8	Load 9	Load 10	Load 11	Load 12
Truck 1	53	26	85	108	95	69	105	32	71	92	46	104
Truck 2	9	75	50	68	91	64	54	81	67	41	67	53
Truck 3	74	100	118	72	34	32	72	106	35	90	99	91
Truck 4	77	60	53	126	147	120	110	66	123	93	40	108
Truck 5	67	123	90	21	84	83	31	129	86	58	114	31
Truck 6	70	40	62	120	126	100	110	46	103	93	23	109
Truck 7	49	29	81	103	91	65	101	30	67	88	41	100
Truck 8	85	33	117	139	127	101	137	39	103	124	66	136
Truck 9	71	20	104	126	113	87	124	26	90	110	54	123
Truck 10	30	50	69	104	70	44	82	42	46	69	50	81
Truck 11	66	112	130	47	41	48	66	118	51	84	111	85
Truck 12	73	132	81	25	86	92	22	138	95	49	123	23

Figure 4 - Heat map with pre-calculated actual road miles from each truck to each load

	Load 1	Load 2	Load 3	Load 4	Load 5	Load 6	Load 7	Load 8	Load 9	Load 10	Load 11	Load 12
Truck 1	53	26	85	108	95	69	105	32	71	92	46	104
Truck 2	9	75	50	68	91	64	54	81	67	41	67	53
Truck 3	74	100	118	72	34	32	72	106	35	90	99	91
Truck 4	77	60	53	126	147	120	110	66	123	93	40	108
Truck 5	67	123	90	21	84	83	31	129	86	58	114	31
Truck 6	70	40	62	120	126	100	110	46	103	93	23	109
Truck 7	49	29	81	103	91	65	101	30	67	88	41	100
Truck 8	85	33	117	139	127	101	137	39	103	124	66	136
Truck 9	71	20	104	126	113	87	124	26	90	110	54	123
Truck 10	30	50	69	104	70	44	82	42	46	69	50	81
Truck 11	66	112	130	47	41	48	66	118	51	84	111	85
Truck 12	73	132	81	25	86	92	22	138	95	49	123	23

Total Empty Miles

559

3rd Party Premium

1.25

Zahir Balaporia:
Truck 12 is a 3rd party carrier. Don't forget to take the premium into account when assigning.

	Load 1	Load 2	Load 3	Load 4	Load 5	Load 6	Load 7	Load 8	Load 9	Load 10	Load 11	Load 12
Truck 1					1							
Truck 2	1											
Truck 3									1			
Truck 4										1		
Truck 5												1
Truck 6			1									
Truck 7								1				
Truck 8											1	
Truck 9		1										
Truck 10						1						
Truck 11				1								
Truck 12							1					

Figure 5 - Full worksheet with an example of manual assignments filled in and total empty miles calculated

Each class is divided into small teams and given a laptop with the spreadsheet. Each team is asked to come up with a manual assignment in 5 minutes (which is a luxury in the fast paced world of local dispatch) and share their answer. The team with the lowest empty miles wins a token prize. The teams are also offered a larger prize if they can beat the "optimizer". This is obviously a very safe bet for the facilitator.

Once all teams have reported their scores, the problem is solved with the Microsoft Excel Solver. Before hitting the solve button, the actual formulation is described in general terms helping people understand how mathematical programming formulates a business problem into equations that the computer can solve. The optimal answer and assignments in the optimal solution are compared with the manual assignments.

Sample results from one class are shown below. The optimal answer for the problem described above is shown under team name Optimal and the percent improvement over each team's manual assignment is shown. The map displays the optimal assignments.

Team	Miles	Vs Optimal
Louie's Low Miles	553	14%
Penn and Teller	635	25%
Winkies	609	22%
The Milk Cartons	598	20%
The Deadheads	687	30%
The Slowpokes	619	23%
Optimal	478	

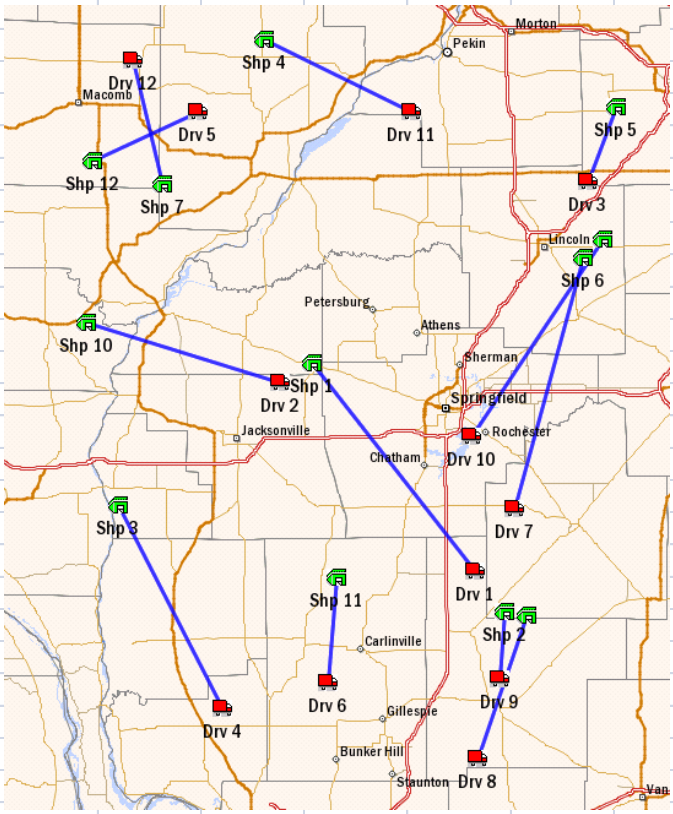

Figure 6 - Sample results with comparison to optimal and map showing optimal assignments.
NOTE: Shp=>Load and Drv=>Truck in the map above.

Changing Beliefs

This exercise only sets the stage for change. It doesn't convince people; it only creates the opportunity to convince people that the technology might have something to offer. Change in long held beliefs does not occur because of new data. True lasting change in behavior only occurs when people change their beliefs. In the conversation after the exercise, we discuss

how optimization works, not in mathematical terms but in more general terms. Some of the topics we discuss are:

- The limitations for humans to evaluate only a few options even on a small problem like this one, versus the computer's ability to evaluate hundreds of thousands of options in seconds.
- The difference between a greedy assignment and an optimal assignment. This is stressed by showing that in the optimal solution Drv 2 is NOT assigned to Shp 1.
- The optimization is solving the whole problem, whereas in the human process it is necessary to divide and conquer. In fact, larger offices are setup to divide the drivers and freight so an individual can reasonably dispatch. The optimization technology does not need to do this.
- Other counterintuitive examples are shared in terms of familiar patterns that a dispatcher might see. For example:
    - The obvious dispatch for two loads with 100% loaded ratio (i.e. no empty miles) in some cases can be sub-optimal when considered in the context of two other loads.
    - As a general rule, a greater than 70 mile empty move is considered a bad dispatch. However, dispatchers have been known to do two 60 mile loads, one a pickup and the other a delivery with 50% loaded ratio i.e. 120 empty miles in total. However, a tour between those two loads would have connected the delivery with the pickup and incurred only 100 empty miles saving 20 empty miles.

Implementation Challenges

The dispatchers sit at the confluence of customer satisfaction, driver satisfaction, and cost control satisfaction. A missed pickup or delivery upsets the customer. Drivers are paid by the mile so if they are not dispatched productively, they are upset. And costs increase if empty miles aren't managed or too much third party capacity is used to meet service needs. Needless to say it's a tough job because in balancing those three factors, dispatchers often go home at the end of the day having made one of the three unhappy.

So why would anyone like the work? Our belief is that they are most attracted to solving the daily dispatch puzzle, while trying to balance the three objectives outlined above. So, to inject an optimization routine into their work potentially reduces their job satisfaction because they don't get to solve the puzzle, and the optimization is not aware of many of the soft factors that affect driver job satisfaction. So the implementation challenge goes beyond elegant math and computational complexity. No doubt there is significant computational complexity in the actual problem in a large region. Generating 500,000 to 1,000,000 columns representing valid tours

with the right relative cost, and solving for least cost while satisfying multiple constraints in under 3 minutes, is worthy of significant recognition. But the impact to the business is not realized if the optimal solution is not accepted or executed by a human decision maker because it does not agree with their thinking.

We believe that the Dispatch Game creates the difference in changing a dispatcher's thinking by providing the following guiding principles for the dispatcher's decision making.

1. The optimal assignment is not perfect. But in terms of cost, it is always better compared to anything a human can do at the speed of business.
2. The optimization has a strong incentive to utilize our drivers as much as possible. So the optimal assignment is good for our drivers when viewed as a whole.
3. You cannot selectively improve it. Take the solution as a whole.
4. Take the recommended optimal solution as long as it doesn't violate any constraints that only you are aware of e.g. Driver D is new and backing into the dock at Customer C is tricky so do not assign driver D to customer C.
5. If you see an assignment that is feasible, but you don't "like it", remember the Dispatch Game, why driver 2 was not assigned to shipment 1, how the optimization works, and follow the recommendation. It is taking more into account than a person can.
6. Derive job satisfaction from nurturing the optimization with high quality data and watch it work for you and make your life easier. The only thing that creates a bad solution is bad or missing data.

Armed with these guiding principles, we believe the desired change to increase acceptance of the optimization technology will take effect over time, especially as more dispatchers use the solutions and share their successes. We are 6 months into the larger technology implementation and are starting to see some positive results while we work through larger technical issues unrelated to the optimization technology. While the Dispatch Game and the ensuing conversation have always received positive feedback, it is still early in the new technology implementation to declare success. We hope to achieve that within the next 6 months.

Conclusion

The **Trucking Game** and the **Dispatch Game** took many years to develop and grow into their current forms. They are continuing to gain momentum within the organization, and their overall value proposition is still developing. There was some early resistance to the idea that a game could be useful, but patience and perseverance allowed the authors to find the right opportunities that created additional exposure and built additional momentum. The response of players in both games continues to convince the authors that the value delivered is captured well in terms of positive feedback. There is also a strong belief that as younger generations

enter the workforce, they will take to these learning games as a natural way to accelerate their engagement into the business and the technology that supports it. It will also create a shared understanding of key business fundamentals and decision support technology that the business has invested in, thereby helping to enable a more profitable future for Schneider National.