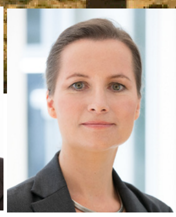

GOING GREEN WITH AI

AN INNOVATIVE LOOK INTO INTERMODAL RAIL

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INFORM AIS PAGE

Artificial Intelligence (AI) is seemingly popping up everywhere these days. As a niche AI system provider, INFORM has been delivering AI solutions for just over two decades, and we have found that within the maritime sector, optimization modules deliver value across terminals. This is because as decision-making is improved, efficiency is realized across the terminal in both the short- and long-term. Short-term savings often translate directly to the bottom line. Efficiencies such as reductions in vehicle travel, crane travel, and yard re-handles are the easiest to see and calculate. Long-term savings, as well as potential revenue increases, can be harder to see initially, however.

Reductions in overall handling equipment as well as delaying or avoiding new equipment purchases happen slowly as operators adjust operational procedures to maximize the efficiency gains possible. Furthermore, increasing yard, truck, and rail handling capacities are intangible results that are the byproducts of more efficient terminals. All of these long-term outcomes deliver significant value, and through these activities, there are also strong environmental sustainability outcomes that can be achieved simultaneously. This paper focuses on one optimization module, INFORM's Train Load Optimizer, and forms a case study for how strong optimization can deliver cost savings while also improving environmental performance.

SUSTAINABILITY IN RAIL OPERATIONS

It shouldn't come as a surprise that rail has been growing since the mid-2000s and is forecasted to continue growing well into the 2020s. Rail is the most efficient way to transport goods over land. When compared to truck transportation, rail is 3.5 times more efficient averaging just over 184 ton-km/l (480 ton-mi/gal) of fuel consumption compared to around 42 ton-km/l (110 ton-mi/gal) for trucks.

The subsequent growth in rail volume has challenged our industry to improve the way we optimize train load planning. The most basic measure considered when planning a train is slot utilization. This applies for both single and double stacked trains. However, as was well articulated in the 2005 research paper, "Options for Improving the Energy Efficiency of Intermodal Freight Trains" by Lai and Barkan[1], slot utilization is only the most basic measure. Two trains can be identical in slot utilization (i.e., number of loaded containers) but present very different loading patterns and aerodynamic resistance.

To keep this paper legible to the non-mathematicians out there, essentially the "Davis Equation" developed by W.J. Davis in 1926 laid the foundation for measuring the resistance forces on a train. It has been modernized multiple times to account for new equipment and track structure, but its foundation holds true. It outlines three

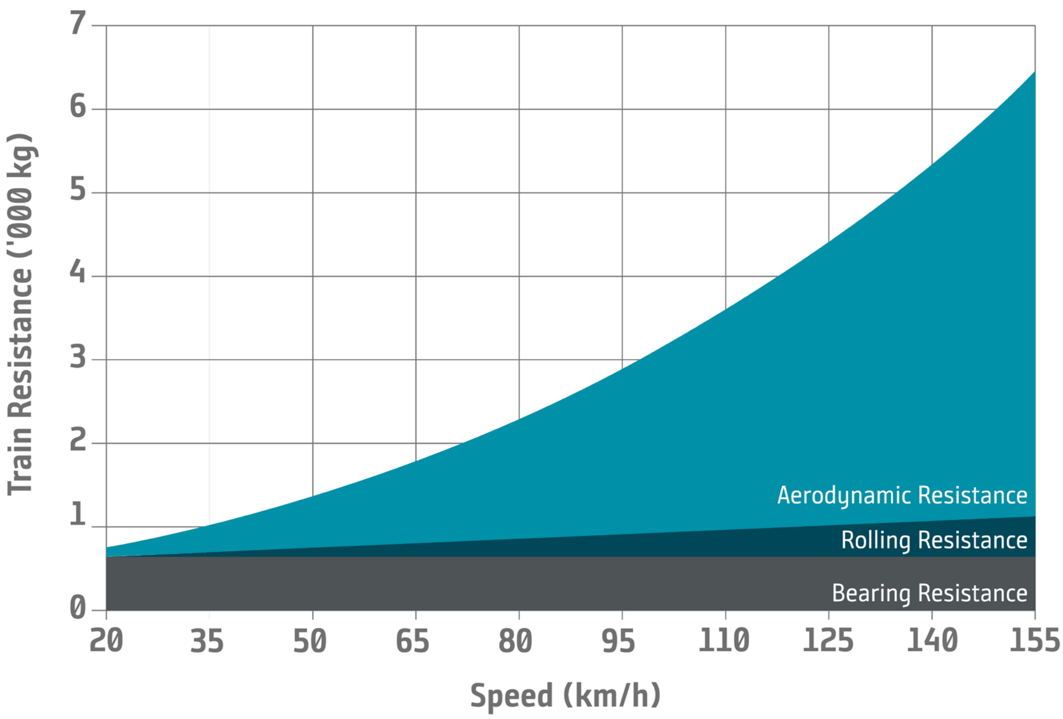

Figure 1 – Train Resistance Variables Impact at Speed

variables that impact a train's resistance: bearing resistance, flange resistance, and aerodynamic resistance. In the Lai and Barkan study, they identified that for intermodal trains traveling at 60kph (35mph) aerodynamic resistance becomes the single largest factor which impacts a train's resistance (see Figure 1).

GAP LENGTH IS IMPORTANT

While Lai and Barkan outline several factors that impact the individual elements of aerodynamics, the paper ends up focusing on one in particular – the size of the space between containers on adjacent railway cars, or, what they term as "Gap Length." In short, the smaller the Gap Length, the more aerodynamic a train is. In addition, smaller Gap Lengths at the front of the train have the largest impact on the trains overall aerodynamic efficiency. As an example, a Gap Length of 1m (3ft) produced approximately 33% less aerodynamic resistance compared to one that was 4m (12ft) in length.

TRAIN PLANNING IS IMPORTANT

By matching the load unit size to the railcar size (e.g., placing a 40-foot container on a 40-foot railcar or a 53-foot container on a 53 foot railcar, et cetera.) significant fuel savings can be reached. In the Lai and Barkan study, a train with 100 railcars loaded with a perfect matching led to a 13% savings in fuel consumption over a 166 km (103 mi) route when compared to placing the same 40-foot containers on 48-foot railcars. Additionally, there was a 53% reduction in fuel consumption when a 40-foot container was placed in a 53-foot railcar (see Figure 2). In short, optimizing your rail load plan to assign containers to the most appropriate railcar where possible to minimize Gap Length is crucial as it leads to a reduction in the trains overall aerodynamic resistance reducing operating costs.

GOOD AERODYNAMICS ADD TO THE BOTTOM LINE

The study concluded that effective aerodynamic planning could save as much as 2.4 l/km (1 gal/1 mi) in fuel consumption. The US route from Los Angeles to Chicago is just over 3,540km (2,200 miles). The price of a liter of diesel in the US on 16 Sep 2019 was listed as 0.776 USD (0.705 EUR). A train operator planning their trains for both slot utilization and aerodynamic efficiency can save approximately 6,500 USD (6,000 EUR) on this route.

For our friends "Down Under," the new Inland Rail being constructed between Melbourne and Brisbane will be 1,700km (1,100 mi) when finished. On 16 Sep 2019, the price of diesel in Australia was listed as 1.468 AUD (0.911 EUR). A well-loaded train operating on this route would save approximately 6,000 AUD (3,000 EUR).

UNDERSTANDING CO_2 SAVINGS

In addition to the financial benefit of using an optimization module to load a train to be as aerodynamically efficient as possible given its existing railcar makeup, there are environmental benefits as well. For clarity, we will focus in this section on just the Los Angles to Chicago route. An aerodynamically efficient train prevents about 22.2 tons of CO2 emissions on the Los Angeles to Chicago route.

To help you understand the impact of this, it is important for you to be able to understand what preventing one ton of CO2 equates to. According to the US Environmental Protection Agency (EPA), the "average" passenger vehicle emits about 250g CO2/km (400g CO2/mi). In other words, an average passenger vehicle in the US will produce one ton of CO2 for every 4,000 km (2,500 miles) driven. On one journey, optimization would save the equivalent of 88,800 km (55,500 miles) of driving a passenger vehicle. In the US, that is the equivalent of removing four cars worth of CO2 on each journey.

Another way of looking at the same savings is through volume – specifically, shipping volume, or twenty-foot equivalent unit (TEU)." At room temperature and one atmospheric bar of pressure, one ton of CO2 has a physical volume of 556.2 m3. For those of you familiar with standard shipping containers, a TEU has a volume of approximately 33.2 m3. In other words, it would take just under 16.75 TEUs to store a single ton of CO2. The savings from a single journey on the Los Angeles to Chicago route would fill 372 TEUs with CO2.

Annually, these numbers stack up quickly. A train that is optimized to be aerodynamically efficient that runs return, three times per week will prevent 6,925 tons of CO2 from being produced. That is the equivalent of removing 27,700,000 km (17,312,500

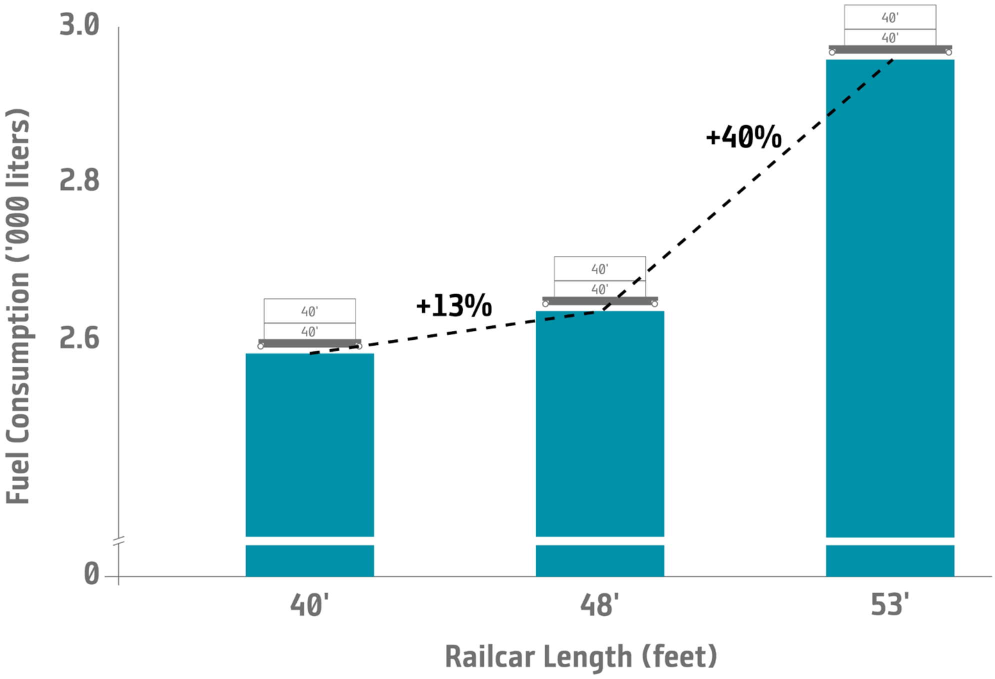

Figure 2 – Fuel Consumption vs Railcar Length for Double Stacked 40-foot Container Loads

miles) of CO2 from driving passenger cars or removing 1,250 cars annually – and that is just one route. Taking the analogy of shipping volume, using optimization will prevent just over 116,000 TEU of CO2 being produced. Interestingly, if you loaded those containers onto a single train, it would be about 800km (500 miles) in length.

ADD-ON "GREEN"

INFORM's optimization modules do not replace an existing TOS, but rather work in conjunction with them to drive terminal efficiency. This "add-on" relationship allows terminals to implement the "green" power of optimization modules without significant changes. While deployment timeframes vary from case to case, it is measured in months, making it quick in comparison to a typical TOS implementation.

Furthermore, in most cases, optimization modules work in the background without direct user interaction. Users interact with their existing software environment while benefiting from optimization with no timely retraining required. In many instances, the operator's process and procedures are not modified either.

Using INFORM's optimization modules not only offers terminal operators the normal optimization outcomes like the ability to reduce costs and increase resilience. They also simultaneously provide terminal operators a powerful resource in their arsenal to curb their environmental impact and improve their long-term sustainability. While this paper has only focused on one optimizer, INFORM's Train Load Optimizer, similar benefits exist for the entire range of add-on Optimization Modules. As shown herein, an investment in operational efficiency and cost reduction (a win in-and-of-itself) can also deliver a measurable impact on sustainability. When applied across the terminal, the cost savings and environmental benefits add up quickly.

MORE INFORM TECH PAPERS

REFERENCES

Yung-Cheng, Rex, and Christopher P. L., Barkan. 2005. Options for Improving the Energy Efficiency of Intermodal Freight Trains: https://journals.sagepub.com/doi/abs/10.1177/0361198105191600108

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Matthew Wittemeier is responsible for Marketing at INFORM's Logistics Division where he's become a thought-provoking contributor to many industry publications and conferences. He's co-author of the award winning 2038: A Smart Port Story – a story about the future of technology and the social challenges it may bring. He's a member and judge at The Academy of Interactive and Visual Arts (AIVA), the senior producer and host of the buzzITtalk podcast, as well as an award-winning designer.

ABOUT THE ORGANIZATION

INFORM specializes in AI to improve operational decision making in container terminals. Based in Aachen, Germany, the company has been in the optimization business for 50 years and serves a wide span of logistics industries including maritime and intermodal terminals.

ENQUIRIES

http://infrm.co/GreenerwithAI