The City of Pittsburgh Modernizes Their Waste Collection Process While Combating Climate Change

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Pittsburgh, Pennsylvania, is a city rich with industrial legacy, but is forward thinking in its relationship with technology. When city leaders were tasked with updating their waste collection process to reduce inefficiencies and provide cleaner streets, they turned to a data-driven solution. A solution that fits hand-in-glove with their ambitious goals in the fight against climate change – taking steps towards reducing greenhouse gases, curbing CO2 emissions, increasing renewable energy use, and attempting to achieve Zero Waste.

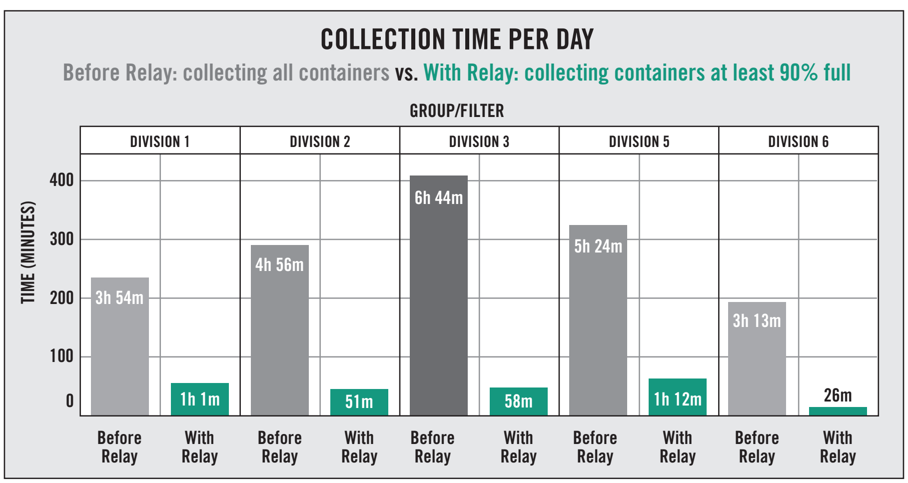
For the modernization of their trash collection system, the city recognized a significant problem of not knowing which of their 2,000 litter receptacles required collection at any particular time. Without data about fill levels, they had no choice but to drive the full collection routes every day. Inevitably, some containers would be already overflowing by the time the crew arrived, and other areas would have no containers requiring collection, but each receptacle had to be serviced.

In 2016, Pittsburgh began implementing the Victor Stanley Relay™ smart waste management system to upgrade to a more efficient waste collection process. Using sensors embedded within their litter receptacles that measure how full the containers are, and then transmit that information to the people responsible for collecting them, the city found a way to create and utilize real-time data – from the very company whose containers were already ubiquitous on the city's streets. With the Relay system's built-in GPS used for managing their waste receptacle inventory, the city planned a staggered rollout of more than 200 containers in each of its six divisions and has deployed more than 1,200 Relay containers as of June 2019.

Relay sensor with replaceable batteries embedded within dome lid

The data gathered from this deployment reflected the astonishing statistic that, on any given day, an average of only 13% of the city's containers would reach the 90%-full threshold that represents critical need for collection.

Relay-enabled SD-42 being serviced on a Pittsburgh street



Number of containers collected (Daily sample)

Division	Before Relay	At least 90% full
DIVISION 1	158	2
DIVISION 2	300	41
DIVISION 3	290	16
DIVISION 5	250	26
DIVISION 6	134	6
TOTAL	1,132	91

Costs		
Type	Unit	Daily
Laborer*	$19.52	$193.64
Driver*	$21.52	$213.48
Equipment & Fuel**	$36.84	$294.72

Actual Collection Efficiency Rate % by Collection Preference & Savings		
SAVINGS (EQUIPMENT & LABOR)		
Percent	Monthly	Yearly
Original Estimate	*$45,734.76*	*$548,817.11*
At >=75%	$85,051.96	$1,020,623.53
At >=80%	$91,355.06	$1,096,260.78
At >=90%	$128,369.87	$1,540,438.38
SAVINGS (EQUIPMENT ONLY)		
Percent	Monthly	Yearly
Original Estimate	*$22,280.83*	*$267,369.98*
At >=75%	$43,931.90	$527,182.78
At >=80%	$46,997.79	$563,973.47
At >=90%	$65,238.00	$782,855.98

A cost savings analysis (1) provided even further justification for collecting only the containers which reach at least 90% full, instead of collecting containers regardless of fill level. Incorporating wages for the truck drivers and laborers, and the costs of equipment and fuel, the savings analysis shows that the 90% full collection model can achieve an average monthly savings of more than $128,000. This translates to roughly $1.54 million over the course of a year. Even if the city took a more conservative approach and collected only containers at least 75% full, they would still save an average of more than $1 million per year.

"I believe it's going to be almost a couple million dollars savings."

-Mike Gable, City of Pittsburgh Public Works Director (2)

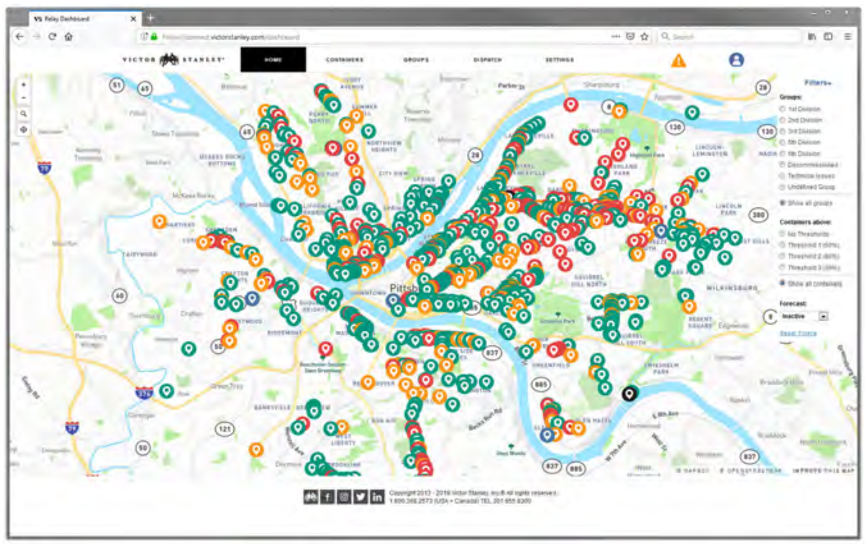
Equipment depreciation costs are reduced, fuel use is significantly reduced, and the laborers previously making superfluous trips to unfilled containers can be reallocated towards higher priority items instead. Many of these tasks have an immediate and tangible impact on the public, such as responding to citizen-initiated 311 requests, street cleaning, and filling potholes. Pittsburgh's Public Works Department used this data to determine that they could reduce the number of employees previously occupied exclusively with trash collection from 25 down to 9. Instead of downsizing the department, the other 16 employees are being reassigned to tasks such as "more lot cleanup, more getting into the catch basins, pruning trees, things that have been waylaid for years" according to Public Works Director Mike Gable. (2) Internalizing this information and having a better understanding of how many containers are filling up on a given day – and how much time was being spent servicing containers unnecessarily – also gave the city confidence to consolidate their six divisions

A recent version of the Relay sensor

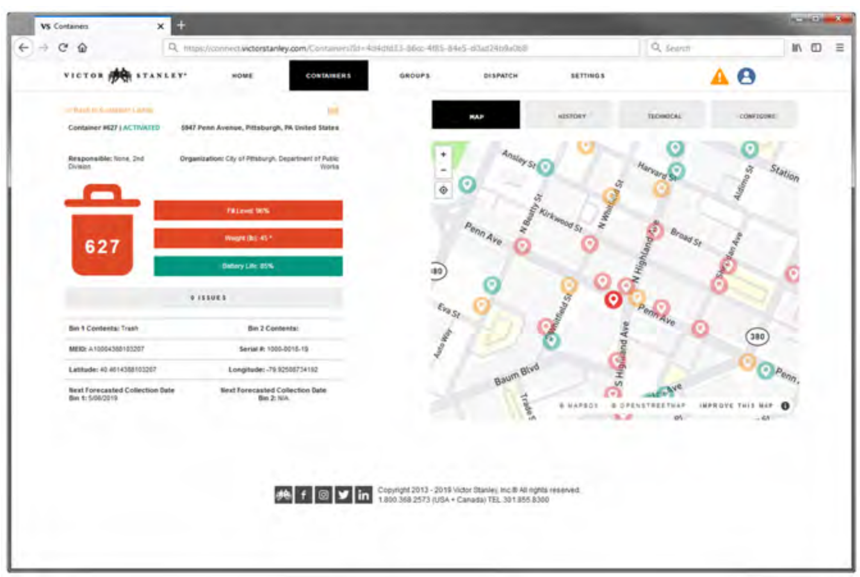
into a single, streamlined central litter division. "Based on our analysis, we expect that the smart litter cans will give us the ability to make process improvements that will reduce the amount of labor hours spent on emptying garbage cans by at least half," said Matthew Jacob, a project manager with the city's Department of Innovation and Performance.(3)

Pittsburgh is also gathering statistics – recorded by the Relay sensors – about which containers are being over-utilized and are filling up extremely quickly, and which are being under-utilized, and going days at a time without filling up. This allows Pittsburgh to make data-driven decisions on where would be the optimal areas to relocate containers within the city, or to determine if additional containers are needed to contend with the amount of trash generated in specific locations.

In May 2018, Pittsburgh approved the Climate Action Plan 3.0, which spells out their goals for helping to curb climate change by 2030. Among those goals are a 50% reduction in transportation emissions and reaching Zero Waste throughout the city. To help attain the goal of diverting trash from landfills, Pittsburgh will continue to leverage their existing Relay containers and the data they gather, which measures key factors, including how long it typically takes for containers to fill up, and how often collections are taking place.



Relay web portal showing the locations of all of Pittsburgh's containers

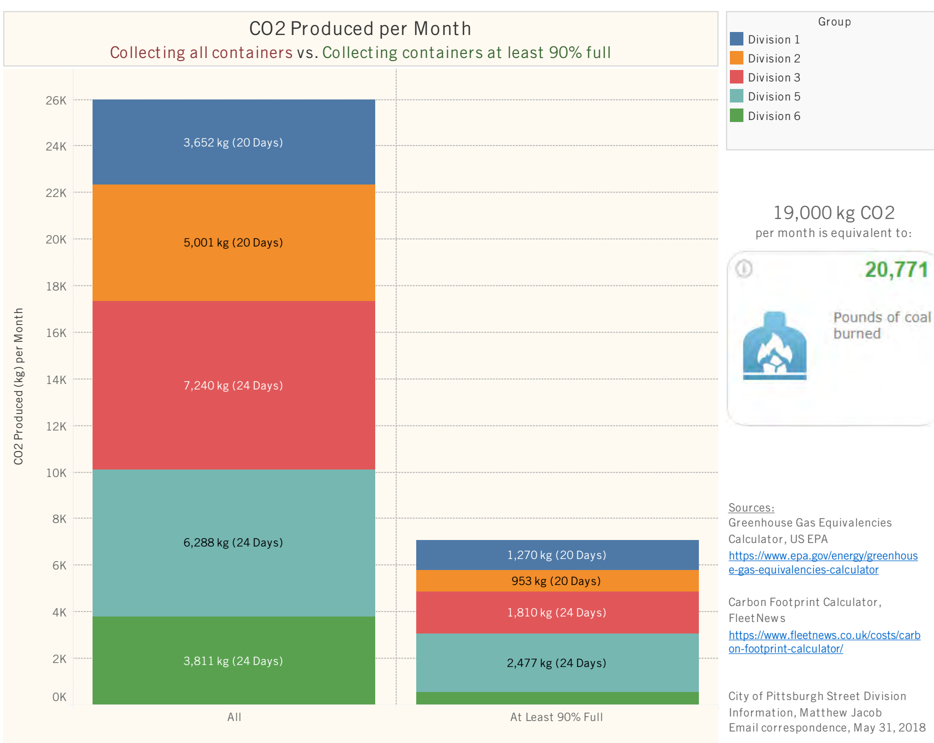


Relay web portal showing detailed information on a specific container

The Relay routing system navigates to only the containers in need of collection

Using the Relay routing algorithm to determine the most efficient path for reaching only the containers that require collection will also reduce the amount of time that these diesel heavy trucks will spend on the road. The amount of CO2 produced by heavy diesel trucks in Pittsburgh's fleet that are maintaining a standard waste collection operation – driving to every container – could be reduced dramatically by changing to a more efficient collection operation, where only containers reaching at least 90% full are serviced. This reduction could be as high as 19,000 kg of CO2 per month, which is roughly equivalent to 20,000 pounds of coal burned. Additionally, the more efficient collection route would mitigate emissions not only from the collection vehicles themselves, but also from the other vehicles nearby, which will experience fewer traffic delays caused by trucks on prolonged collection routes. "The supervisors on any given day should be able to generate the number of cans that need to be emptied and the route that the driver should take" Gable said. [2]

Additionally, once enough data has been gathered to determine exactly how many of these refuse trucks are actually required for a full collection schedule, the city can strategically decide how best to downsize its fleet.



CO2 reduction potential with Relay deployment

Relay-enabled SD-42

The city is also approaching the task of CO2 reduction by way of carbon sequestration from the 40,000 trees the city currently has street-side. The Relay system can enhance this initiative as well, using its environmental sensors to measure the temperature of every container within the city. When these sensors determine an area has atypically high temperatures, the city can then evaluate and determine if there is insufficient tree coverage, which would provide analytical support for planting trees there in the future.

"The smart cans allow DPW to offer better refuse services to Pittsburgh residents and neighborhood business districts, while freeing up our workers to do other work to keep the city tidy."

-Mike Gable, City of Pittsburgh Public Works Director [4]

Using the Victor Stanley Relay system, the City of Pittsburgh is overhauling not just the day-to-day practice of their waste collection, but also determining how best to pick up trash within the city. Instead of being constrained by the "this is how we've always done it" process of many other major cities, Pittsburgh looked to the edge of innovation to completely modernize this crucial aspect of public works, using an approach driven by real data collected from the actual city streets. With the Relay system's data and the other technological tools at their disposal, Pittsburgh is well positioned to lead the way on two fronts – the global, ongoing battle against climate change, and the seemingly simple task of improving the way they collect trash.

Appendix:

Resources & Divisions (Current Operations & Deployment)

	1	2	3	4	5	6	7	8	9	10
Daily Laborer FTEs	1	1	1		1	1				
Daily Driver FTEs	1	1	1		1	1				
Average No. Workdays Per Month	20	20	24		24	24				
No. Shifts	1	2	2		2	4				
Containers Serviced	160	278	288		248	143				
Monthly Labor Cost	$8,142.34	$12,015.10	$14,418.12		$14,418.12	$23,712.77				
Monthly Equipment Cost	$5,894.40	$11,788.80	$14,146.56		$14,146.56	$28,293.12				
Monthly Monitoring Cost	$784.00	$1,362.20	$1,411.20		$1,215.20	$700.70				
Total Monthly Cost	**$14,820.74**	**$25,166.10**	**$29,975.88**		**$29,779.88**	**$52,706.59**				
Original Estimated Monthly Savings	$4,446.22	$7,549.83	$8,992.77		$8,933.97	$15,811.98				
Collections at >= 75% Full	$5,937.44	$17,316.24	$19,164.69		$16,849.36	$25,784.23				
Collections at >= 80% Full	$6,875.31	$17,949.92	$20,081.93		$18,215.27	$28,232.64				
Collections at >= 90% Full	**$11,425.07**	**$21,466.83**	**$25,520.07**		**$24,746.93**	**$45,210.95**				
Original Estimated Equipment Savings Alone	$1,768.32	$3,536.64	$4,243.97		$4,243.97	$8,487.94				
Collections at >= 75% Full	$2,673.20	$8,749.72	$9,710.41		$8,581.34	$14,217.22				
Collections at >= 80% Full	$3,046.21	$9,046.56	$10,143.28		$9,230.20	$15,531.54				
Collections at >= 90% Full	**$4,855.71**	**$10,694.02**	**$12,709.71**		**$12,332.99**	**$24,645.57**				

Collection Efficiency Rate % by Collection Preference & Savings

Savings (Equipment & Labor)		
Percent	Monthly	Yearly
Original Estimate	*$45,734.76*	*$548,817.11*
At >= 75%	$85,051.96	$1,020,623.53
At >= 80%	$91,355.06	$1,096,260.78
At >= 90%	$128,369.87	$1,540,438.38

Savings (Equipment Only)		
Percent	Monthly	Yearly
Original Estimate	*$22,280.83*	*$267,369.98*
At >= 75%	$43,931.90	$527,182.78
At >= 80%	$46,997.79	$563,973.47
At >= 90%	$65,238.00	$782,855.98

Assumptions

Vehicle	Truck Model NPR Rear Loader | Diamondback | Isuzu 4HK1-TC, 215HP Transmission Aisin A465 automatic
Fuel Economy	4.4 mpg
Salary*	Full-time equivalent (FTE) with benefits (Bill Crean - Superintendent of Streets & Operations - 1/30/2019)
Diesel	$2.49 Per Gallon (2017 Average Price)
Equipment & Fuel**	An Analysis of the Operational Costs of Trucking 2018 - Average Marginal Costs per Hour
	The American Transportation Research Institute (ATRI)
	Fuel Costs, Truck Lease or Purchase, Repair & Maintenance, Insurance Premiums, Permits and Licenses, Tires
	Actual (Deployment field data below)
Savings	Savings derived from actual field data, service utilization, and ATRI research

Table 9: Average Marginal Costs per Hour, 2009-2017

Year	2010	2011	2012	2013	2014	2015	2016	2017
Fuel Costs	$19.41	$23.58	$25.63	$25.78	$23.29	$16.13	$13.45	$14.50
Payments	$7.37	$7.55	$6.94	$6.52	$8.59	$9.20	$10.20	$10.39
Repair & Maintenance	$4.97	$6.07	$5.52	$5.92	$6.31	$6.23	$6.65	$6.58
Truck Insurance Premiums	$2.35	$2.67	$2.51	$2.57	$2.89	$2.98	$3.00	$2.95
Permits and Licenses	$1.60	$1.53	$0.88	$1.04	$0.76	$0.78	$0.88	$0.92
Tires	$1.42	$1.67	$1.76	$1.65	$1.76	$1.72	$1.41	$1.50
Driver-based	$37.12	$43.07	$43.24	$43.48	$43.60	$37.04	$35.59	$36.84
Driver Wages (2017 Actual)	$17.83	$18.39	$16.67	$17.60	$18.46	$19.95	$20.91	$21.52
Driver Benefits	$6.47	$6.05	$4.64	$5.16	$5.15	$5.22	$6.18	$6.78
TOTAL	**$61.90**	**$68.21**	**$65.29**	**$67.00**	**$68.09**	**$62.98**	**$63.66**	**$66.65**

Appendix:

Containers Requiring Collection (Daily Average) | Only collecting at 90% full or higher

Year	Month / Division:	1	2	3	4	5	6	7	8	9	Total Average
2019	May 2019	18	53	41		37	17				33
	April 2019	31	57	46		35	21				38
	March 2019	24	53	44		39	14				35
	February 2019	27	47	45		46	15				36
	January 2019	30	44	39		45	16				35
2018	Total Average 2018	29	7	23		28	19				23
	December 2018	36	31	38		32	19				31
	November 2018	34	11	42		29	17				27
	October 2018	31	1	43		32	17				25
	September 2018	35		52		44	29				40
	August 2018	30		31		48	20				32
	July 2018	33		27		25	25				28
	June 2018	27	1	15		22	20				17
	May 2018	26	0	1		29	21				16
	April 2018	21	0	2		16	7				9
	March 2018	25		1		13					13
	February 2018	23		2		17					14
	Average	**28**	**25**	**29**		**32**	**18**				
	Requiring Collection %	**18%**	**9%**	**10%**		**13%**	**13%**				**13%**
	Collection Reduction Rate %	**82%**	**91%**	**90%**		**87%**	**87%**				**87%**

Containers Requiring Collection (Daily Average) | Only collecting at 80% full or higher

Year	Month / Division:	1	2	3	4	5	6	7	8	9	Total Average
2019	May 2019	42	106	76		74	36				67
	April 2019	79	134	142		111	64				106
	March 2019	80	135	128		140	48				106
	February 2019	71	105	145		111	41				95
	January 2019	84	93	106		107	46				87
2018	Total Average 2018	80	21	64		76	74				67
	December 2018	78	78	107		86	77				85
	November 2018	87	44	99		70	51				70
	October 2018	79	1	98		71	92				68
	September 2018	87		140		109	96				108
	August 2018	89		93		119	70				93
	July 2018	81		80		86	109				89
	June 2018	83	2	66		68	82				60
	May 2018	83	0	6		71	73				47
	April 2018	65	0	7		47	18				27
	March 2018	69		6		50					42
	February 2018	80		5		59					48
	Average	**77**	**60**	**82**		**86**	**65**				
	Requiring Collection %	**48%**	**22%**	**28%**		**35%**	**45%**				**36%**
	Collection Reduction Rate %	**52%**	**78%**	**72%**		**65%**	**55%**				**64%**

Containers Requiring Collection (Daily Average) | Only collecting at 75% full or higher

Year	Month / Division:	1	2	3	4	5	6	7	8	9	Total Average
2019	May 2019	52	116	88		87	41				77
	April 2019	92	148	153		122	70				117
	March 2019	86	150	144		148	54				116
	February 2019	83	117	157		127	43				105
	January 2019	92	108	114		118	51				97
2018	Total Average 2018	90	23	72		87	82				71
	December 2018	88	86	118		101	87				96
	November 2018	104	46	112		82	58				80
	October 2018	95	1	121		81	104				80
	September 2018	99		152		121	106				120
	August 2018	98		101		137	74				103
	July 2018	92		84		103	122				100
	June 2018	91	2	75		79	88				67
	May 2018	91	0	6		77	78				50
	April 2018	78	0	7		58	20				33
	March 2018	75		8		55					46
	February 2018	83		5		65					51
	Average	**87**	**70**	**90**		**98**	**71**				
	Requiring Collection %	**55%**	**25%**	**31%**		**39%**	**50%**				**40%**
	Collection Reduction Rate %	**45%**	**75%**	**69%**		**61%**	**50%**				**60%**

Information based on: City of Pittsburgh Deployment Field Data, Cost Savings Analysis Operating Assumptions (above), and Item 1 of Sources page (below)

Sources:

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