

WheelTug Pushback Time Savings Analysis

31 March 2016

WheelTug has collected data on in-service aircraft to calculate the time which can be saved each cycle. A non-WheelTug pushback operation has the following broad components:

Standard Pushback Process	
Ground-crew Preparation:	When the ground-crew and aircraft are ready, the pilot radios the ATC (Tower) requesting pushback clearance. In some airports, ground crew delays can cause departure slots to be missed. Unavailability of pushback tugs is a common cause of ground crew delays.
Tower Clearance:	The tower confirms pushback will not cause safety or traffic management issues. Among the tower concerns are jet blast risks involving the aircraft being pushed and risks of traffic blockage by a stationary aircraft having its pushback tug disconnected and its engines started.
Pushback Operation:	After clearance is given, the aircraft is pushed back. There are often delays in this process. Even without delays, after pushback is complete, the tug must then be disconnected, ground comms disconnected, steering pin removed and engine started. Separate ATC clearance secured for taxi-forward must then be secured.

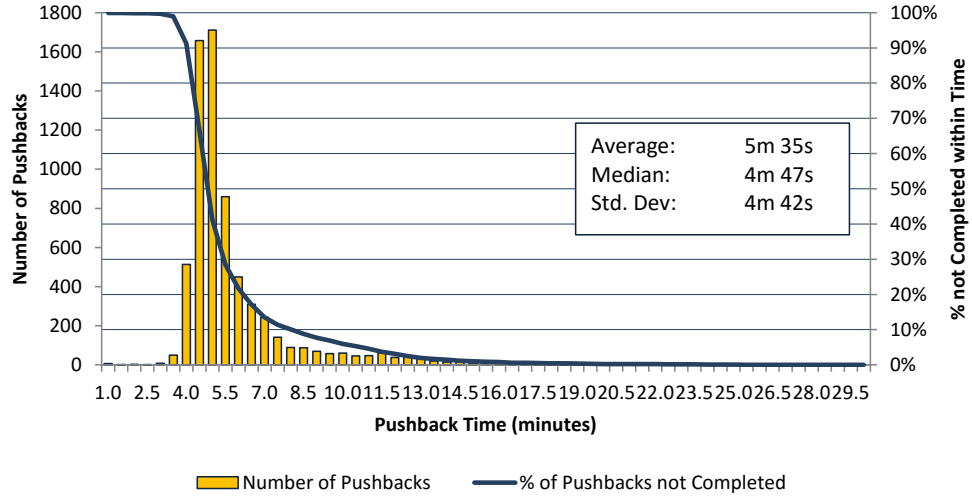
WheelTug can positively impact each of these stages.

WheelTug Time Benefits	
Ground-crew Preparation: Time Savings: 2-3 minutes	<p><i>Areas of Savings:</i></p> <ul style="list-style-type: none"> • WheelTug does not require a tug, eliminating delays associated with tug on time availability, hookup and other preparations • WheelTug with TaxiCam will cut or eliminate ground crew reliance, further speeding the departure process • Last minute baggage loadings (possibly including hand luggage that is checked due to a lack of space, last minute transfers or strollers) will not significantly delay departure as the same ground crew will not need to man a tug in order to use it <p><i>Notes:</i></p> <ul style="list-style-type: none"> • These time savings have been estimated through informal conversations with pilots. Most have indicated an average time savings of 4+ minutes, but that has been discounted in our estimates. • Because there is no method of shortening this time at present, the necessary variables are not currently measured. WheelTug would compare operations of WheelTug and non-WheelTug operations to measure savings in service.

<p>Tower Clearance:</p> <p>No Time Savings Included</p>	<p>WheelTug aircraft will not generate engine-blast in the ramp area.</p> <p><i>Areas of Savings:</i></p> <ul style="list-style-type: none"> • WheelTug aircraft arrives at the gate with engines-off, and ground crew can start servicing aircraft immediately when it stops at the final position. Ground crew doesn't need to wait for the engine fan to fully stop. • WheelTug aircraft nearer the ramp-area exit will be able to pushback and taxi forward faster than other aircraft can detach tugs – and without generating jet blast for nearby aircraft. This will enable these aircraft to pushback during the pushback of adjacent aircraft while alleviating both safety and blockage concerns. • Aircraft in positions that normally require a long-push to reach an engine clearance area will be able to move more quickly and cause fewer blockages due to greater maneuvering flexibility. This will speed their clearances. <p><i>Notes:</i></p> <ul style="list-style-type: none"> • Simulations showed 4 minutes of average time savings from this benefit, but that was for a saturated airport. Every airport will be significantly different, so no time savings was included for this category.
<p>Pushback Operation Time Savings</p> <p>Time Savings: 4+ minutes</p>	<p><i>Areas of Savings:</i></p> <ul style="list-style-type: none"> • WheelTug aircraft will not require tug disconnect or engine start clearance after the pushback is complete. • WheelTug aircraft, by being more reliable on pushback times, would reduce scheduled block times significantly, substantially increasing utilization. • WheelTug aircraft, on an airport-by-airport basis, could request a single clearance for pushback, engine start and taxi-forward. • WheelTug aircraft may be permitted to engage in tighter maneuvers due to a lack of engine blast. They could turn prior to the taxiway to enable faster forward motion (Twirl). <p><i>An analysis of a 12-hour segment of global ADS-B aircraft movement data provided by FlightRadar24, confirms the airline-specific dataset provided below. That analysis is ongoing.</i></p> <p><i>Notes:</i> A WheelTug pushback to taxi-forward operation would require less than 60 seconds. Working with FlightWatching, WheelTug has collected substantial data on existing pushback times as summarized below and shown in Appendix A.</p>

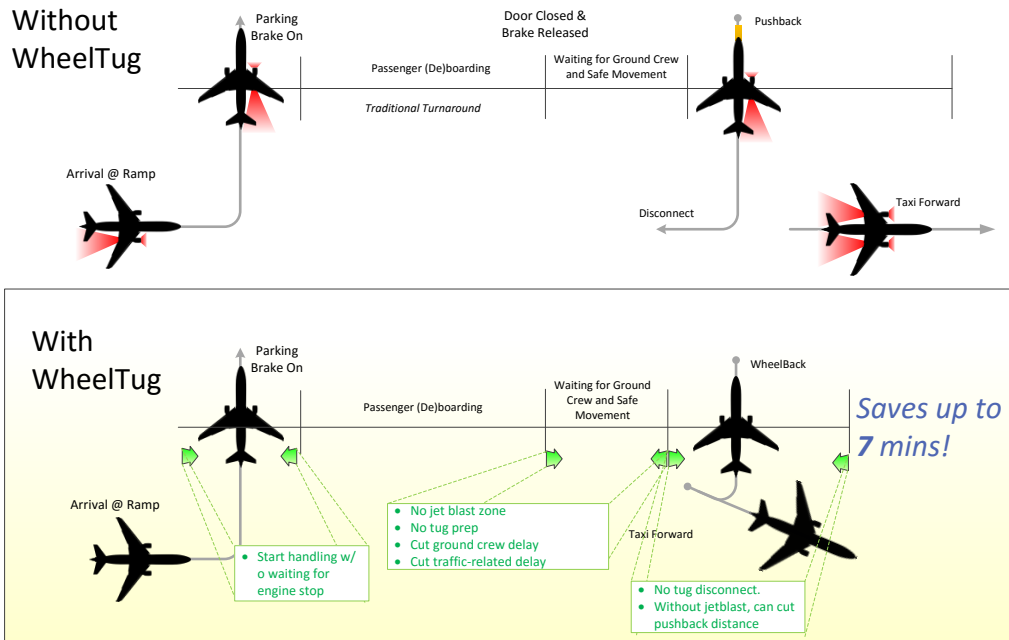
Pushback Times

Unnamed Airline, Source: *FLIGHT WATCHING*



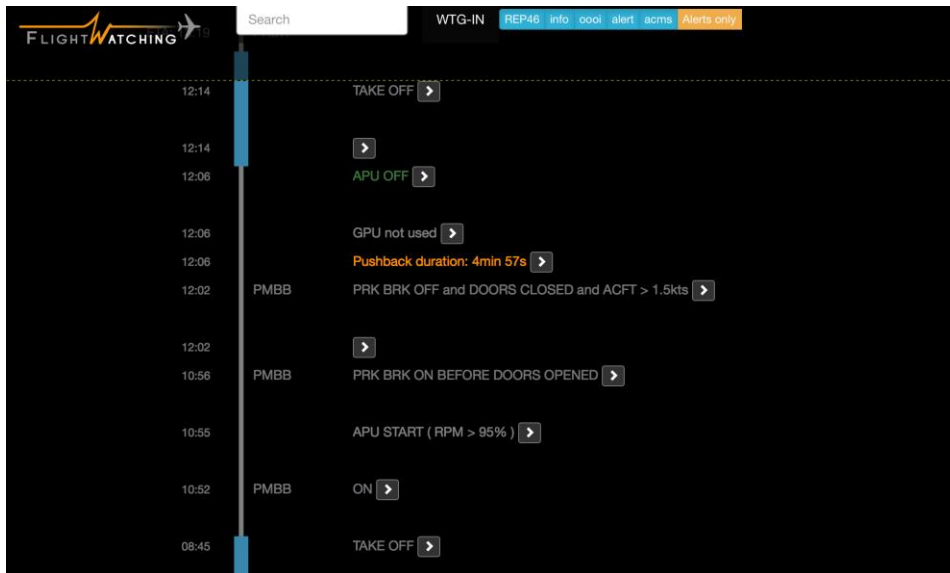
Total Savings: 6-7 Minutes

The savings are summarized in the following graphic:

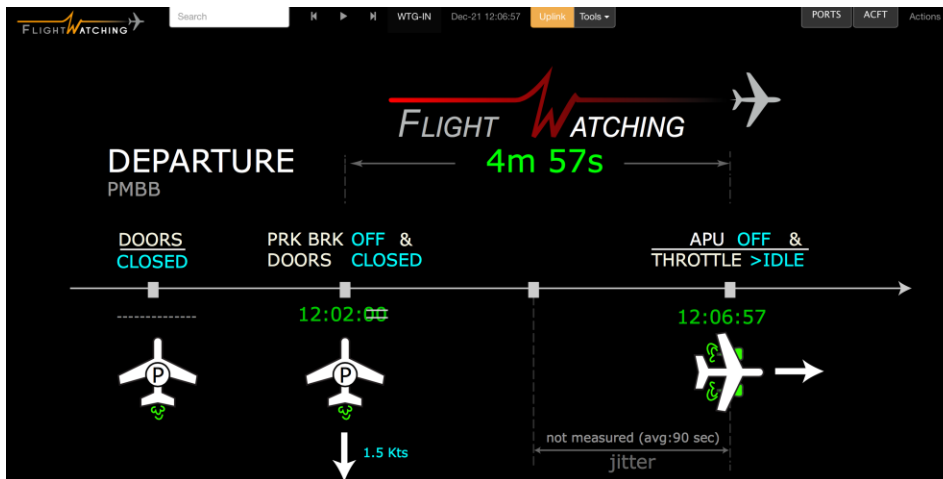


Appendix A

A typical operation is represented as:



Graphically, this can be shown as:



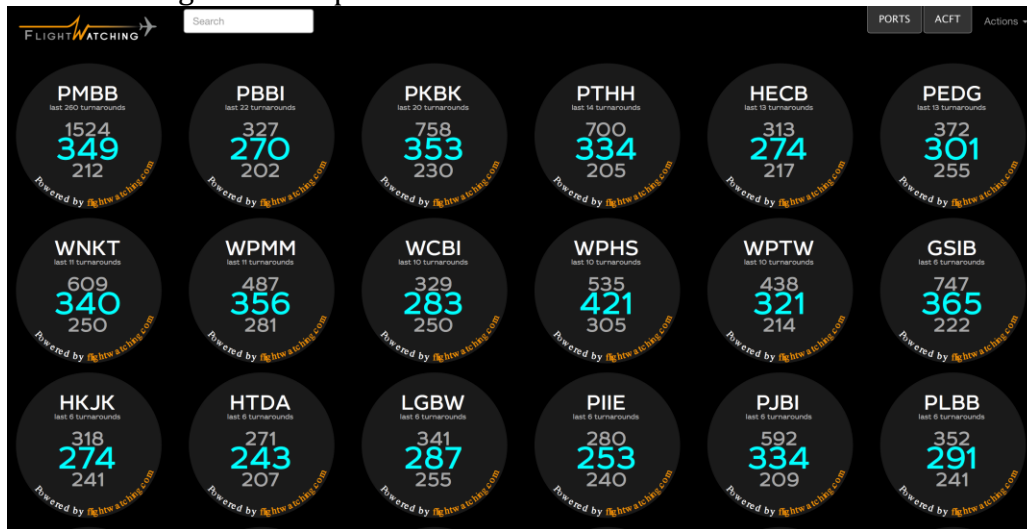
The following snapshot of the same operation across part of a flying day shows the time benefits:

Time	Pushback duration
12:06	4m 57s
12:06	4m 41s
11:50	4m 57s
11:36	4m 37s
11:04	3m 54s
10:32	3m 40s
10:20	4m 47s
10:10	6m 14s
09:58	4m 42s
09:54	5m 43s
06:46	4m 29s
06:20	5m 58s
06:06	25m 24s
05:54	5m 04s
05:43	3m 59s
05:39	8m 48s
05:39	8m 48s
05:28	5m 13s
05:17	4m 11s
05:07	4m 47s
05:04	4m 19s
04:59	5m 00s

The time cost is not only the 3-25 minutes, but also the consequences of the very wide spread: the wide time distribution, which leads to unpredictable delays across the network.

WheelTug has access to this data across the entire operating fleet, at every airport that fleet uses and for every aircraft in the fleet (Specific identities are scrambled as required by existing non-disclosure agreements).

The following shows airports.



The below shows aircraft.



The data demonstrates that the existing operation from beginning the backward roll to beginning forward motion averages 5 minutes per flight given delays. WheelTug would accomplish the same operation in less than a minute, saving 4 minutes/flight

Appendix B: 10-Day Pushback Data Sample

Jan 22 to Feb 1

Pushback Time					
Stamp	Duration				
		23-Jan-16 17:44:00	4m 30s	24-Jan-16 18:02:00	18m 37s
		23-Jan-16 17:50:00	4m 23s	24-Jan-16 18:15:00	3m 49s
22-Jan-16 17:38:00	3m 46s	23-Jan-16 18:01:00	12m 27s	24-Jan-16 19:20:00	5m 04s
22-Jan-16 17:44:00	4m 19s	23-Jan-16 18:03:00	3m 33s	24-Jan-16 20:30:00	4m 27s
22-Jan-16 17:47:00	4m 21s	23-Jan-16 18:21:00	5m 12s	24-Jan-16 20:48:00	4m 58s
22-Jan-16 17:51:00	12m 30s	23-Jan-16 20:11:00	4m 58s	24-Jan-16 21:33:00	4m 27s
22-Jan-16 17:52:00	4m 05s	23-Jan-16 20:18:00	5m 45s	24-Jan-16 21:38:00	5m 02s
22-Jan-16 17:52:00	4m 07s	23-Jan-16 20:40:00	5m 09s	24-Jan-16 22:39:00	3m 42s
22-Jan-16 17:59:00	5m 26s	23-Jan-16 21:11:00	4m 06s	24-Jan-16 22:49:00	5m 03s
22-Jan-16 18:16:00	4m 38s	23-Jan-16 21:27:00	4m 42s	24-Jan-16 23:03:00	3m 32s
22-Jan-16 18:17:00	16m 33s	23-Jan-16 21:33:00	4m 18s	24-Jan-16 23:12:00	4m 25s
22-Jan-16 18:47:00	3m 52s	23-Jan-16 22:44:00	4m 42s	24-Jan-16 23:52:00	5m 39s
22-Jan-16 19:13:00	4m 00s	23-Jan-16 22:57:00	4m 23s	25-Jan-16 00:38:00	4m 11s
22-Jan-16 20:07:00	4m 07s	23-Jan-16 23:22:00	13m 06s	25-Jan-16 03:40:00	4m 33s
22-Jan-16 21:23:00	3m 58s	24-Jan-16 04:04:00	6m 00s	25-Jan-16 04:01:00	5m 20s
22-Jan-16 21:32:00	4m 19s	24-Jan-16 04:28:00	4m 29s	25-Jan-16 04:26:00	6m 33s
22-Jan-16 23:41:00	4m 39s	24-Jan-16 04:32:00	4m 25s	25-Jan-16 04:37:00	4m 24s
23-Jan-16 00:17:00	4m 12s	24-Jan-16 04:42:00	4m 30s	25-Jan-16 04:38:00	4m 34s
23-Jan-16 00:19:00	6m 08s	24-Jan-16 04:55:00	4m 58s	25-Jan-16 04:56:00	4m 21s
23-Jan-16 01:04:00	3m 29s	24-Jan-16 04:57:00	4m 39s	25-Jan-16 04:59:00	4m 19s
23-Jan-16 03:55:00	3m 54s	24-Jan-16 05:06:00	4m 31s	25-Jan-16 05:00:00	4m 27s
23-Jan-16 04:53:00	7m 29s	24-Jan-16 05:08:00	4m 29s	25-Jan-16 05:10:00	4m 22s
23-Jan-16 05:48:00	4m 29s	24-Jan-16 05:23:00	5m 18s	25-Jan-16 05:20:00	4m 40s
23-Jan-16 06:01:00	4m 36s	24-Jan-16 05:56:00	5m 28s	25-Jan-16 05:56:00	9m 48s
23-Jan-16 06:18:00	5m 02s	24-Jan-16 06:12:00	4m 12s	25-Jan-16 06:28:00	6m 36s
23-Jan-16 06:36:00	4m 27s	24-Jan-16 06:43:00	4m 28s	25-Jan-16 06:30:00	4m 01s
23-Jan-16 06:40:00	4m 32s	24-Jan-16 07:05:00	6m 42s	25-Jan-16 06:53:00	4m 18s
23-Jan-16 06:46:00	5m 15s	24-Jan-16 09:26:00	5m 19s	25-Jan-16 09:47:00	4m 19s
23-Jan-16 07:05:00	4m 09s	24-Jan-16 09:54:00	6m 00s	25-Jan-16 09:52:00	4m 03s
23-Jan-16 07:45:00	5m 12s	24-Jan-16 09:57:00	5m 15s	25-Jan-16 09:55:00	4m 17s
23-Jan-16 10:24:00	12m 43s	24-Jan-16 10:29:00	5m 16s	25-Jan-16 10:00:00	5m 04s
23-Jan-16 10:41:00	10m 06s	24-Jan-16 10:55:00	4m 57s	25-Jan-16 11:15:00	4m 31s
23-Jan-16 10:45:00	4m 44s	24-Jan-16 11:22:00	5m 10s	25-Jan-16 11:21:00	5m 35s
23-Jan-16 10:54:00	4m 53s	24-Jan-16 11:26:00	5m 12s	25-Jan-16 11:28:00	5m 05s
23-Jan-16 11:12:00	3m 57s	24-Jan-16 11:30:00	6m 12s	25-Jan-16 11:36:00	6m 50s
23-Jan-16 11:19:00	6m 35s	24-Jan-16 11:46:00	7m 40s	25-Jan-16 11:45:00	4m 33s
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23-Jan-16 12:15:00	5m 17s	24-Jan-16 17:49:00	4m 25s	25-Jan-16 17:49:00	12m 35s
23-Jan-16 13:10:00	4m 46s	24-Jan-16 17:50:00	7m 40s	25-Jan-16 17:49:00	4m 18s
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25-Jan-16 18:13:00	7m 20s	26-Jan-16 22:38:00	4m 30s	27-Jan-16 23:28:00	23m 14s
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25-Jan-16 20:21:00	11m 52s	26-Jan-16 23:08:00	3m 59s	28-Jan-16 04:25:00	4m 42s
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26-Jan-16 05:15:00	11m 44s	27-Jan-16 06:05:00	4m 57s	28-Jan-16 10:30:00	4m 46s
26-Jan-16 05:34:00	18m 30s	27-Jan-16 06:42:00	10m 51s	28-Jan-16 10:53:00	4m 21s
26-Jan-16 06:00:00	10m 05s	27-Jan-16 06:55:00	4m 51s	28-Jan-16 11:14:00	4m 10s
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29-Jan-16 17:40:00	8m 15s	30-Jan-16 23:03:00	11m 06s	01-Feb-16 04:56:00	4m 30s
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29-Jan-16 17:50:00	5m 08s	30-Jan-16 23:12:00	3m 45s	01-Feb-16 05:09:00	4m 29s
29-Jan-16 18:30:00	4m 47s	30-Jan-16 23:12:00	4m 10s	01-Feb-16 05:10:00	10m 12s
29-Jan-16 19:20:00	4m 19s	31-Jan-16 04:02:00	4m 43s	01-Feb-16 05:31:00	4m 04s
29-Jan-16 20:51:00	5m 02s	31-Jan-16 04:58:00	10m 04s	01-Feb-16 05:31:00	9m 34s
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30-Jan-16 06:23:00	4m 26s	31-Jan-16 10:59:00	5m 18s		
30-Jan-16 06:39:00	4m 04s	31-Jan-16 11:06:00	6m 52s		
30-Jan-16 06:56:00	4m 35s	31-Jan-16 11:12:00	5m 26s		
30-Jan-16 09:29:00	3m 58s	31-Jan-16 11:20:00	5m 07s		
30-Jan-16 09:58:00	5m 52s	31-Jan-16 11:29:00	4m 00s		
30-Jan-16 09:59:00	6m 46s	31-Jan-16 11:49:00	5m 40s		
30-Jan-16 10:18:00	4m 16s	31-Jan-16 12:01:00	4m 24s		
30-Jan-16 10:34:00	3m 46s	31-Jan-16 12:30:00	10m 45s		
30-Jan-16 10:49:00	4m 34s	31-Jan-16 16:25:00	4m 58s		
30-Jan-16 11:12:00	4m 27s	31-Jan-16 17:18:00	6m 19s		
30-Jan-16 11:16:00	4m 22s	31-Jan-16 17:38:00	4m 44s		
30-Jan-16 11:33:00	5m 17s	31-Jan-16 17:46:00	2m 41s		
30-Jan-16 12:00:00	4m 48s	31-Jan-16 17:55:00	4m 08s		