Submitted to *Transportation Science*
manuscript TS-2021-0371

The Dial-A-Ride Problem with School Bell time Adjustment
Online appendix

Samuel Vercraene
Laboratoire DISP, INSA de Lyon,
21 avenue Jean Capelle, 69621 Villeurbanne, France. samuel.vercraene@insa-lyon.fr

Fabien Lehuédé
IMT Atlantique, LS2N,
4 rue Alfred Kastler, F-44307 Nantes Cedex, France., fabien.lehuede@imt-atlantique.fr

Thibaud Monteiro
Laboratoire DISP, INSA de Lyon,
21 avenue Jean Capelle, 69621 Villeurbanne, France. thibaud.monteiro@insa-lyon.fr

Olivier Péton
IMT Atlantique, LS2N,
4 rue Alfred Kastler, F-44307 Nantes Cedex, France., olivier.peton@imt-atlantique.fr

History:

Appendix A: Additional results

		Impact of school bell time adjustment				Gap to scenario 20 (%)		
				SBA			SBA	
	Instance	0	20	20/60	60	0	20/60	60
Heterogeneous fleet	S1-50-5-h	804.00	772.18	685.76	678.45	4.12	-11.19	-12.14
	S2-53-7-h	690.30	555.48	502.89	478.89	24.27	-9.47	-13.79
	S3-54-4-h	582.70	539.81	507.12	464.96	7.95	-6.06	-13.87
	S4-67-3-h	1,282.00	1,190.91	1,177.51	1,089.57	7.65	-1.13	-8.51
	S5-75-3-h	1,169.60	1,121.12	1,091.38	1,016.37	4.32	-2.65	-9.34
	S6-81-5-h	1,408.50	1,269.41	1,178.43	1,128.25	10.96	-7.17	-11.12
	S7-96-4-h	2,336.00	2,180.65	2,114.13	2,047.11	7.12	-3.05	-6.12
	S8-99-3-h	950.30	855.94	783.12	678.52	11.02	-8.51	-20.73
	M9-124-13-h	1,733.40	1,453.64	1,310.64	1,210.29	19.25	-9.84	-16.74
	M10-138-10-h	2,312.70	2,081.58	1,899.15	1,791.60	11.10	-8.76	-13.93
	M11-139-5-h	3,057.40	2,860.87	2,775.24	2,664.33	6.87	-2.99	-6.87
	M12-174-6-h	2,119.90	1,940.02	1,758.17	1,667.23	9.27	-9.44	-14.06
	L13-249-15-h	3,848.30	3,493.99	3,177.49	2,999.93	10.14	-9.06	-14.14
	L14-326-19-h	5,375.20	4,796.63	4,393.73	4,076.76	12.06	-8.40	-15.01
	Average					10.44	-6.97	-12.60
Homogeneous fleet	S1-50-5	886.70	843.80	713.77	706.12	5.08	-15.41	-16.32
	S2-53-7	854.50	633.96	580.01	546.41	34.79	-8.51	-13.81
	S3-54-4	661.30	594.05	538.81	505.21	11.32	-9.30	-14.96
	S4-67-3	1,335.00	1,221.71	1,207.96	1,115.02	9.27	-1.13	-8.73
	S5-75-3	1,211.20	1,117.87	1,078.40	1,017.62	8.35	-3.53	-8.97
	S6-81-5	1,481.10	1,308.10	1,217.31	1,148.89	13.23	-6.94	-12.17
	S7-96-4	2,490.00	2,289.49	2,185.86	2,119.58	8.76	-4.53	-7.42
	S8-99-3	1,053.90	911.34	854.99	759.95	15.64	-6.18	-16.61
	M9-124-13	1,985.60	1,585.31	1,403.29	1,310.68	25.25	-11.48	-17.32
	M10-138-10	2,493.80	2,191.66	1,976.31	1,857.39	13.79	-9.83	-15.25
	M11-139-5	3,229.30	2,967.28	2,850.29	2,744.06	8.83	-3.94	-7.52
	M12-174-6	2,265.20	1,961.92	1,801.48	1,707.13	15.46	-8.18	-12.99
	L13-249-15	4,102.60	3,626.82	3,245.63	3,071.77	13.12	-10.51	-15.30
	L14-326-19	5,871.30	5,056.96	4,683.20	4,261.22	16.10	-7.39	-15.74
	Average					14.07	-7.65	-12.88
Average						*12.32*	*-7.30*	*-12.84*

Table 1 Detailed result for the DARP with school bell time adjustment

Appendix B: Insights on the MILP solving and reformulation

Table 2 presents insights for SBAM related to the solving of the r-DARP-SBA with a MILP solver. Each group of columns compares solving the MILP with the r-DARP-SBA reformulation to solving the MILP with the DARP-SBA model adapted to integrate the dynamic time windows relaxation and objective g:

- *# solved MILP* shows the average number of iterations of SBAM over 5 runs. One MILP is solved at each SBAM iteration.
- N presents the average number of LNS iterations over five runs and all SBAM iterations.
- $|\Omega'|$ presents the average number of columns in the route pool Ω' over five runs and all iterations.

Note that the pool management is reactive and adapts the value of N so that the MILP can be solved to optimality within the time limit T^{SCP}. The greater the number of LNS iterations between two SBAM iterations, the greater the number of routes in Ω' and the smaller the number of SBAM iterations.

	# solved MILP		N		$\|\Omega'\|$	
	r-DARP-SBA	DARP-SBA	r-DARP-SBA	DARP-SBA	r-DARP-SBA	DARP-SBA
S3-54-4-h	225.40	826.20	823.97	160.94	3,173.37	2,159.93
S4-67-3	382.60	828.40	550.78	159.14	2,209.31	2,173.42
S5-75-3	340.00	755.60	688.60	154.34	3,275.53	2,280.90
S7-96-4-h	296.20	775.80	543.29	165.62	2,811.34	2,534.03
M9-124-13	288.60	972.40	632.33	81.95	2,864.28	1,934.76
M12-174-6-h	388.60	915.40	157.70	43.82	1,950.80	1,651.61
L13-249-15	560.40	1,010.20	285.42	55.78	3,582.86	927.52
Average	354.54	869.14	526.01	117.37	2,838.21	1,951.74

Table 2 MILP analysis. Comparison between the r-DARP-SBA model (SBAM) and the DARP-SBA formulation.

In column $|\Omega'|$ we observe that the r-DARP-SBA reformulation can solve problems with around 3000 routes in the route pool for almost all instances whereas the DARP-SBA formulation is efficient for about 2000 routes. As a result, the number of LNS iterations between two MILP solving tends to be significantly higher for SBAM and the total number of SBAM iterations is about two times smaller with the reformulation than without. Comparing instances (noting that different run-times were used for small, medium and large instances), it is interesting to notice that instance M12-174-6-h has a peculiar profile. This confirms that this instance is relatively hard to solve, combining difficulties related to the heterogeneous fleet and to the problem size. Regarding the time limit given to the MILP solver to solve the r-DARP-SBA, an extensive set of experiments on the test instances showed that the algorithm is not really sensitive to this parameter and that taking $T^{SCP} = 10$ seconds provides the best results.