Benchmark results for the Quay Crane Scheduling Problem (QCSP)

This document provides computational results for the QCSP benchmark sets that have been introduced in the paper 'A unified approach for the evaluation of quay crane scheduling models and algorithms' by Frank Meisel and Christian Bierwirth (submitted for publication).

Tables 1 to 7 report vessel handling times (VHTs) for the instances in sets A to G. These solutions have been generated by the heuristic proposed in Bierwirth and Meisel: *A fast heuristic for quay crane scheduling with interference constraints*, J. Sched 12, 2009, p. 345-360.

Table 1: VHTs observed for small sized vessels (set A).

no.	$n = 10$	$n = 15$	$n = 20$	$n = 25$	$n = 30$	$n = 35$	$n = 40$
1	520	514	508	508	506	506	506
2	508	507	509	507	508	507	506
3	513	515	509	507	507	506	505
4	510	513	509	507	507	507	507
5	515	507	506	507	506	507	506
6	513	508	508	507	506	511	507
7	511	507	507	508	508	507	507
8	513	508	510	507	508	506	506
9	512	507	508	506	506	506	506
10	549	513	507	506	506	508	507
$CVHT$	5 164	5 099	5 081	5 070	5 068	5 071	5 063

Table 2: VHTs observed for medium sized vessels (set B).

no.	$n = 45$	$n = 50$	$n = 55$	$n = 60$	$n = 65$	$n = 70$
1	758	774	758	781	758	766
2	759	771	783	756	799	764
3	759	772	779	758	803	760
4	789	765	759	765	758	760
5	758	762	758	760	758	757
6	789	765	789	758	757	761
7	798	782	768	786	757	759
8	759	761	767	757	756	758
9	797	798	801	785	758	757
10	792	759	757	805	786	779
$CVHT$	7 758	7 709	7 719	7 711	7 690	7 621
ACT	713	1 251	1 078	1 317	2 118	2 231

Table 3: VHTs observed for large sized vessels (set C).

no.	$n = 75$	$n = 80$	$n = 85$	$n = 90$	$n = 95$	$n = 100$
1	1 178	1 173	1 049	1 014	1 174	1 014
2	1 011	1 023	1 017	1 020	1 090	1 104
3	1 182	1 013	1 027	1 011	1 014	1 107
4	1 107	1 202	1 186	1 063	1 138	1 202
5	1 192	1 036	1 082	1 062	1 144	1 015
6	1 123	1 117	1 010	1 193	1 055	1 136
7	1 200	1 201	1 195	1 108	1 173	1 098
8	1 174	1 040	1 105	1 094	1 015	1 151
9	1 074	1 192	1 010	1 075	1 019	1 023
10	1 188	1 207	1 166	1 049	1 011	1 015
$CVHT$	11 429	11 204	10 847	10 689	10 833	10 865
ACT	$\top$	3 248	$\top$	$\top$	$\top$	$\top$

Table 4: VHTs observed under various spatial distributions of tasks (set D).

no.	$f = 0.2$			$f = 0.8$		
	$Loc = cl1$	$Loc = cl2$	$Loc = uni$	$Loc = cl1$	$Loc = cl2$	$Loc = uni$
1	544	453	415	1 214	1 207	1 207
2	556	430	307	1 206	1 208	1 209
3	680	439	426	1 222	1 211	1 216
4	578	312	324	1 221	1 209	1 210
5	356	349	309	1 210	1 210	1 207
6	414	307	307	1 213	1 212	1 207
7	439	373	325	1 217	1 211	1 208
8	383	308	349	1 213	1 208	1 208
9	420	308	387	1 209	1 207	1 208
10	380	397	346	1 212	1 208	1 210
$CVHT$	4 750	3 676	3 495	12 137	12 091	12 090
ACT	3 240	2 212	2 100	7	508	430

Table 5: VHTs observed under various precedence densities (set E).

no.	$d = 0.80$	$d = 0.85$	$d = 0.90$	$d = 0.95$	$d = 1.00$
1	774	774	774	774	774
2	771	771	771	771	771
3	772	772	772	772	772
4	758	761	762	762	765
5	761	761	761	761	762
6	757	757	757	757	765
7	782	782	782	782	782
8	758	758	761	761	761
9	798	798	798	798	798
10	759	759	759	759	759
$CVHT$	7 690	7 693	7 697	7 697	7 709
ACT	3 306	1 958	870	481	41

Table 6: VHTs observed under various numbers of serving cranes (set F).

no.	$q = 2$	$q = 3$	$q = 4$	$q = 5$	$q = 6$
1	1 509	1 007	774	730	730
2	1 510	1 008	771	768	768
3	1 510	1 008	772	770	769
4	1 510	1 009	765	748	746
5	1 509	1 007	762	732	732
6	1 509	1 008	765	714	714
7	1 511	1 009	782	780	779
8	1 509	1 008	761	650	643
9	1 510	1 012	798	797	797
10	1 510	1 008	759	684	683
$CVHT$	15 097	10 084	7 709	7 373	7 361
ACT	11	199	1248	2892	$\top$

Table 7: VHTs observed under various safety requirements (set G).

no.	$s = 0$	$s = 1$	$s = 2$	$s = 3$	$s = 4$
1	757	774	1 059	1 381	1 501
2	759	771	950	1 288	1 328
3	759	772	976	1 098	1 275
4	759	765	1 104	1 365	1 443
5	758	762	833	1 040	1 327
6	758	765	1 031	1 262	1 622
7	760	782	1 042	1 431	1 448
8	757	761	954	1 092	1 345
9	758	798	1 075	1 252	1 328
10	759	759	930	1 190	1 437
$CVHT$	7 584	7 709	9 954	12 399	14 054
ACT	2 440	1 248	3 252	$\top$	$\top$

Tables 8 to 10 report lower bounds for the minimum vessel handling times of instances in sets A to C. These lower bounds have been delivered by ILOG CPLEX 11 within a limited runtime of two hours per instance. A '*' attached to a value indicates that an optimal solution with corresponding vessel handling time has been found. CPLEX struggles if applied to the larger instances leading to similar lower bounds for most instances within set B and within set C.

Table 8: Lower bounds on VHTs for instances in set A.

no.	$n = 10$	$n = 15$	$n = 20$	$n = 25$	$n = 30$	$n = 35$	$n = 40$
1	*520	*513	506	506	505	*506	505
2	*508	*507	507	*507	507	506	*506
3	*513	*513	507	506	506	*506	*505
4	*510	*513	507	*507	506	506	506
5	*514	*507	*506	506	*506	506	*506
6	*513	*508	507	506	505	505	505
7	*511	*507	506	506	507	506	*507
8	*513	*508	508	*507	506	505	*506
9	*512	*507	507	*506	*506	505	*506
10	*549	*513	*507	*506	*506	506	506

Table 9: Lower bounds on VHTs for instances in set B.

no.	$n = 45$	$n = 50$	$n = 55$	$n = 60$	$n = 65$	$n = 70$
1	755	753	754	753	753	753
2	754	754	754	753	753	753
3	754	754	753	753	753	753
4	755	753	753	754	753	753
5	754	753	754	753	753	753
6	754	753	754	753	754	753
7	754	754	754	753	754	754
8	755	753	753	753	754	753
9	754	754	753	753	754	753
10	754	753	754	753	754	753

Table 10: Lower bounds on VHTs for instances in set C.

no.	$n = 75$	$n = 80$	$n = 85$	$n = 90$	$n = 95$	$n = 100$
1	1003	1003	1004	1003	1003	1003
2	1003	1003	1003	1003	1003	1003
3	1003	1003	1003	1003	1003	1003
4	1003	1003	1003	1003	1003	1003
5	1003	1002	1003	1003	1003	1003
6	1003	1004	1003	1003	1003	1003
7	1003	1002	1003	1003	1003	1003
8	1003	1003	1003	1003	1003	1003
9	1003	1004	1003	1003	1003	1003
10	1003	1003	1003	1003	1003	1003