Appendix. Supplementary Results

1. Tabular data

Additional results for Case 6 - Case 10 are presented here. We have uploaded all the problem instances, source data, and interactive figures to the Github link https://github.com/LiangZhao13/EPCPP.git

Table 1 Statistical data for Case 6 – Case 10

	Metrics	EPCPP (ours)	CALA-TORRES	CALA-RCPP	EP-RCPP
Case 6 (60)	N_R	11	13	16	11
	$\mathcal{L}$ *	89	30	53	89
	t (s)	21.65	29.94	32.41	25.12
	E (Wh)	2831.83	3040.45	3224.85	3089.29
	L (m)	118748.08	131685.87	139448.60	125830.85
Case 7 (70)	N_R	12	14	16	12
	$\mathcal{L}$	77	35	26	77
	t (s)	27.11	36.24	42.18	35.34
	E (Wh)	2930.05	3165.11	3494.04	3255.50
	L (m)	122651.75	135969.81	150204.54	139323.62
Case 8 (80)	N_R	13	16	18	13
	$\mathcal{L}$	77	20	38	77
	t (s)	32.75	45.16	47.94	40.62
	E (Wh)	3471.04	3800.98	4153.61	3828.93
	L (m)	145573.20	163782.75	178726.84	163657.41
Case 9 (90)	N_R	14	18	20	14
	$\mathcal{L}$	77	37	62	77
	t (s)	40.59	52.84	57.33	50.34
	E (Wh)	3904.44	4257.14	4692.85	4298.51
	L (m)	164022.27	183084.57	201708.93	183893.36
Case 10 (100)	N_R	15	18	21	15
	$\mathcal{L}$	88	52	74	88
	t (s)	47.91	59.07	64.61	55.93
	E (Wh)	4663.01	4795.08	5316.53	5143.71
	L (m)	195940.23	205909.11	228517.76	220263.05

* $\mathcal{L}$ denotes the reward accumulated at first two rounds

From the tabular data, we can observe several advantages of the EPCPP proposed in this paper. First, EPCPP significantly reduces the number of survey rounds, leading to a substantial improvement in task efficiency. This is due to EPCPP achieving the highest reward in the earlier rounds, as indicated by the $\mathcal{L}$ data in the table. In contrast, both methods using the MRVRP model (CALA-TORRES and CALA-RCPP) require more rounds to complete the survey task. Second, EPCPP has the fastest convergence rate, achieving approximately 30% higher efficiency even when compared to the CALA-TORRES model, which uses meta-heuristics to find suboptimal solutions. Lastly, when comparing the total path length and the energy consumption calculated through semi-physical simulation, it is further confirmed that EPCPP provides a survey plan with lower energy consumption.

Our visualized results below will further substantiate our points:

2. Visualized

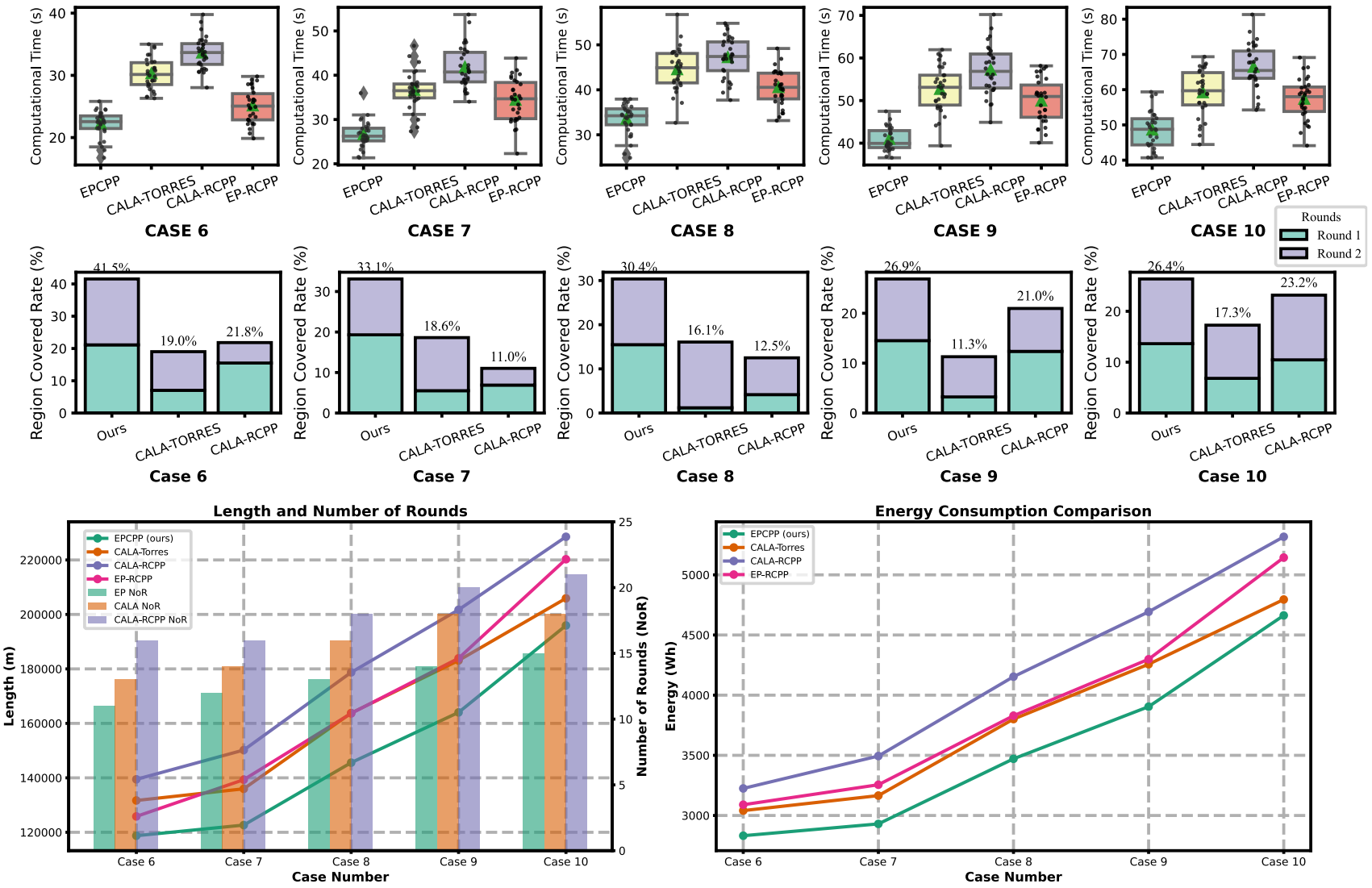

Fig. 1. First row: Computational time; Second row: region coverage rate at first two rounds

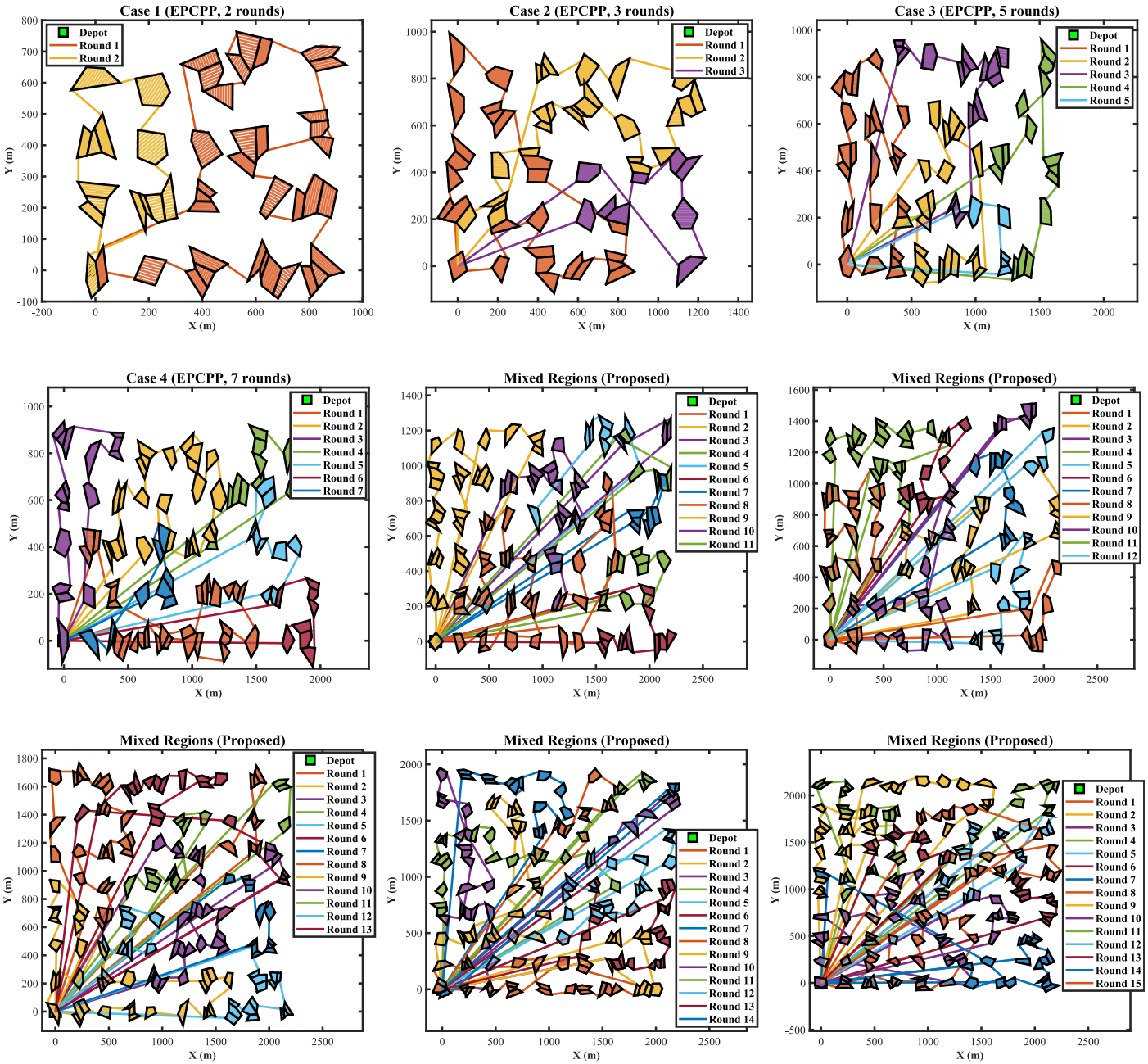

Fig. 2. Results of EPCPP (proposed), Case 1 - Case 9 (left to right)

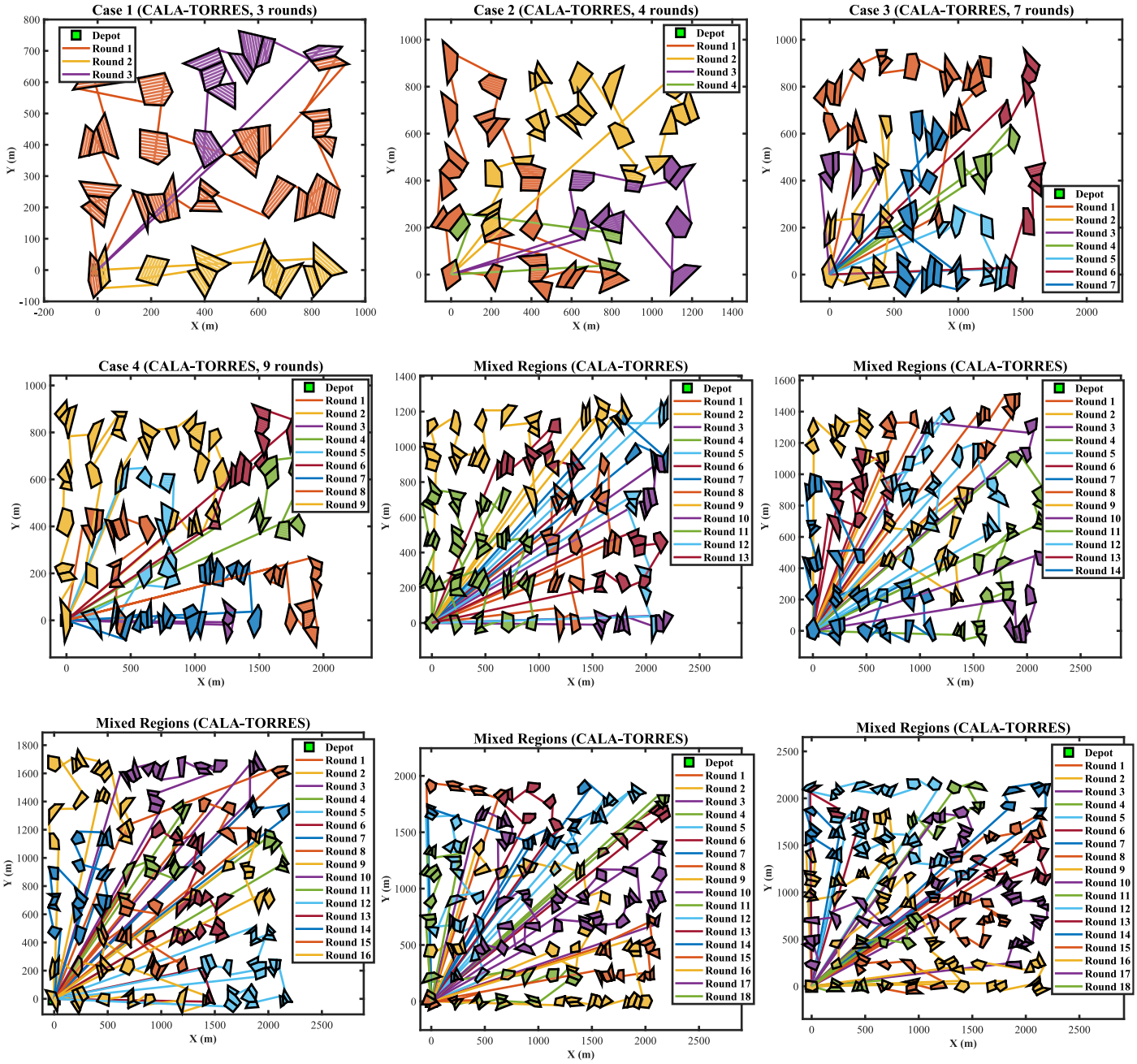

Fig. 3. Results of CALA-TORRES, Case 1 - Case 9 (left to right)

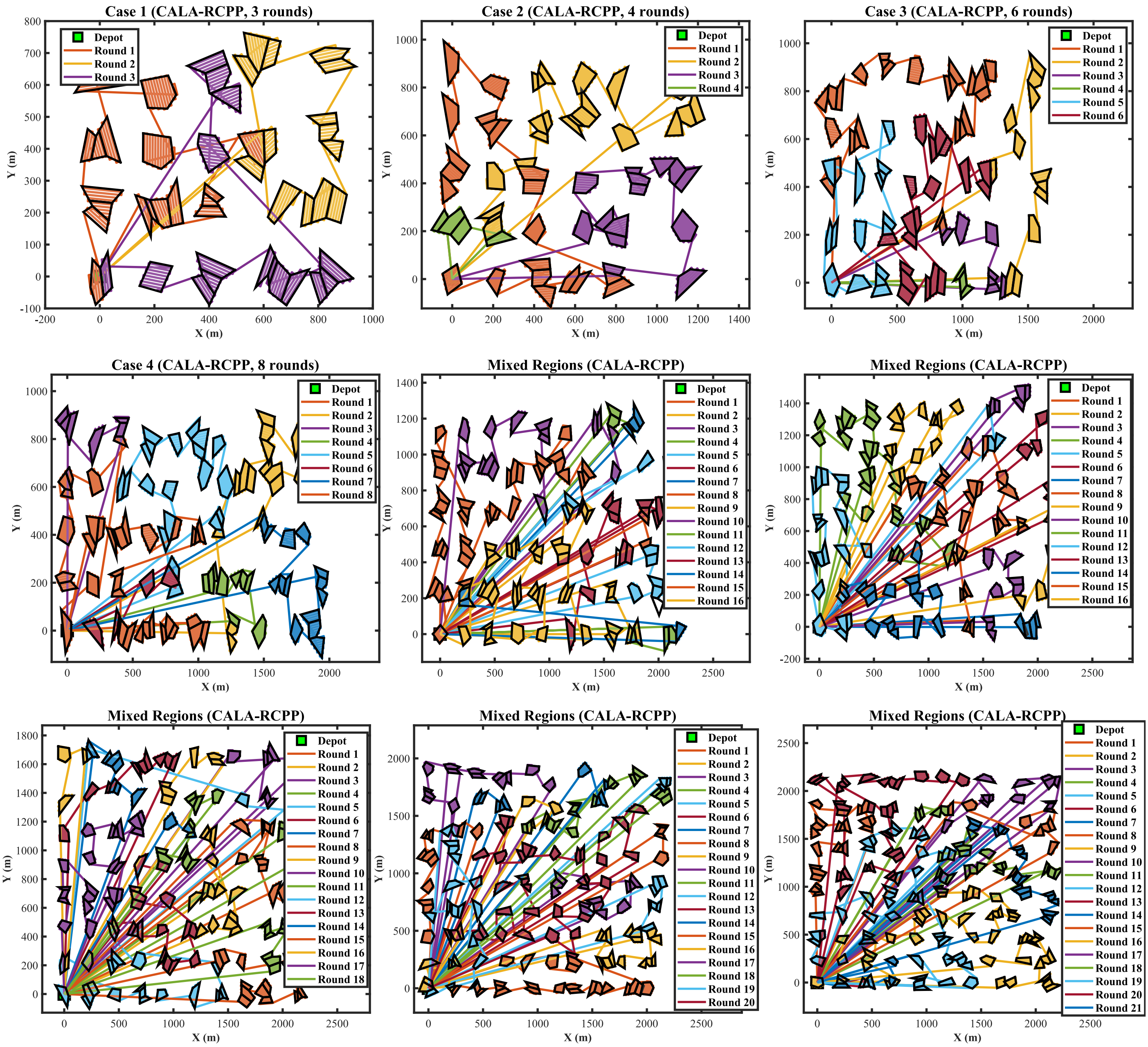

Fig. 4. Results of CALA-TORRES, Case 1 - Case 9 (left to right)

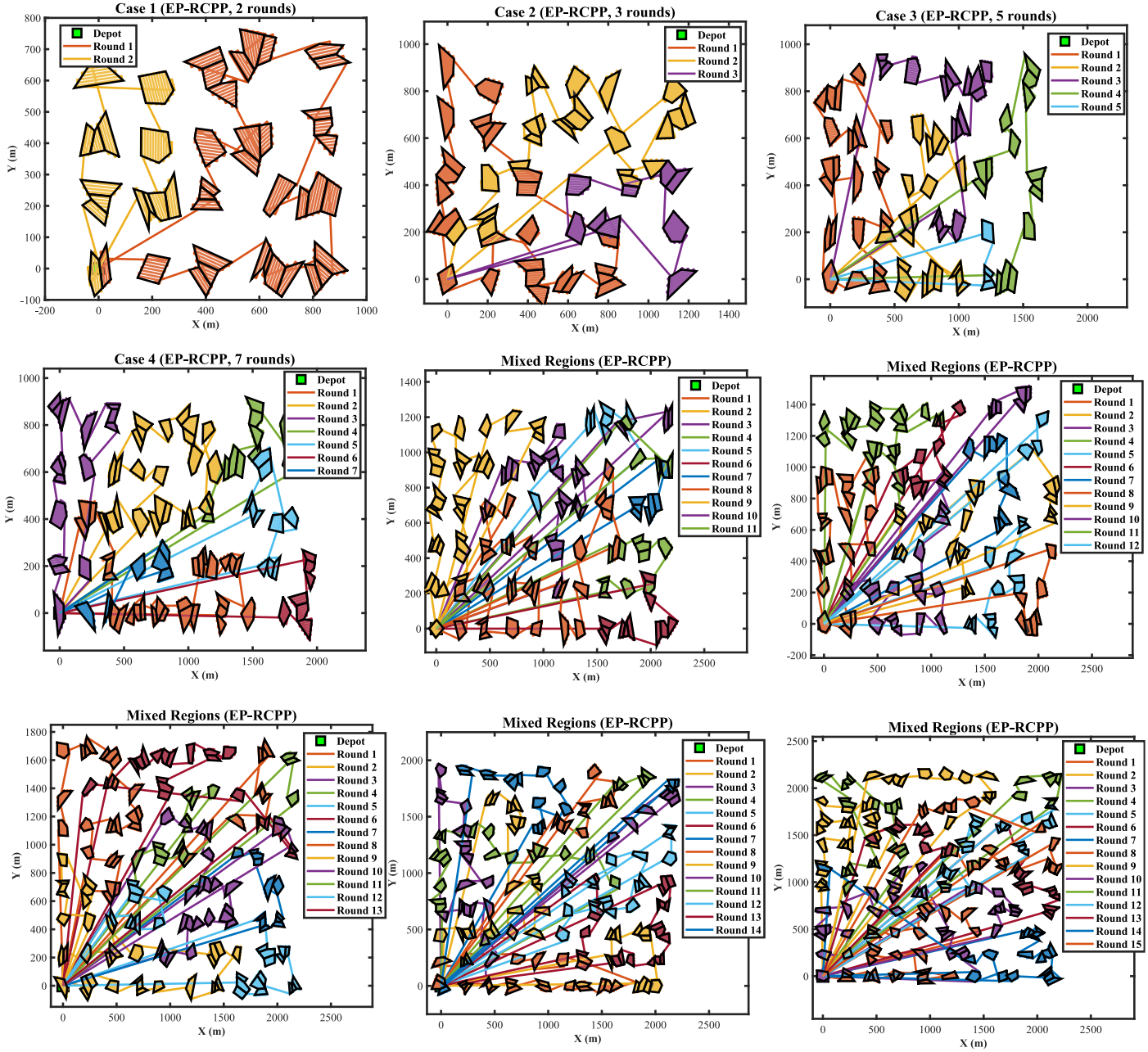

Fig. 5. Results of EP-RCPP, Case 1 - Case 9 (left to right)

3. Appended lake trial results

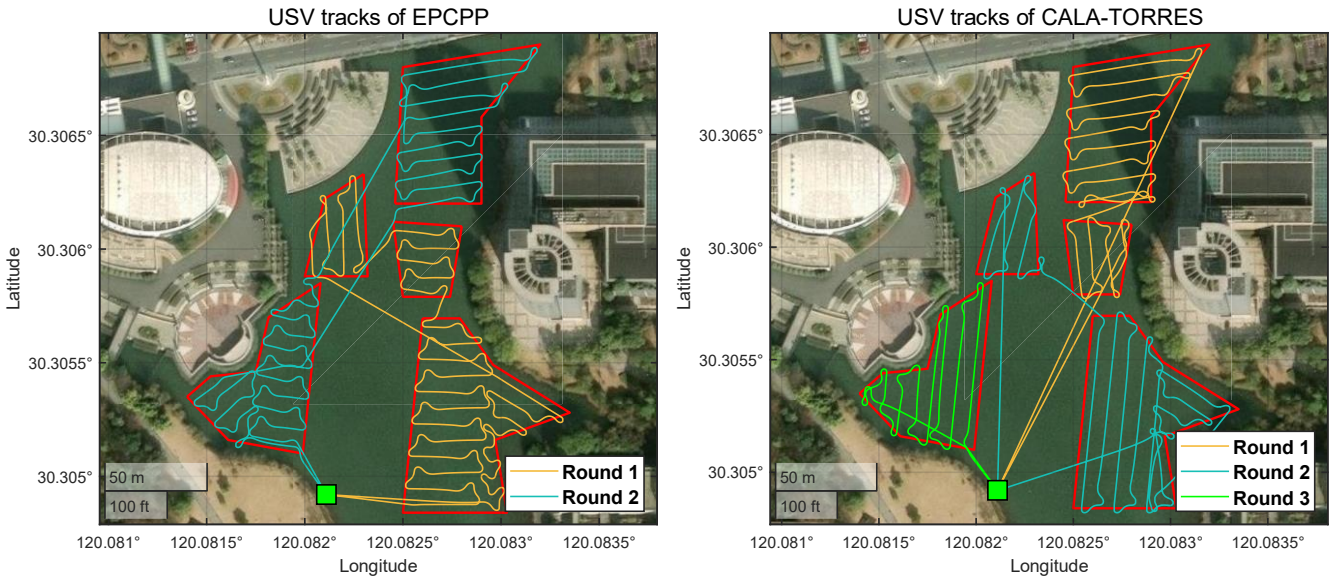

Fig. 6. (a) USV tracks of EPCPP, (b) USV tracks of CALA-TORRES

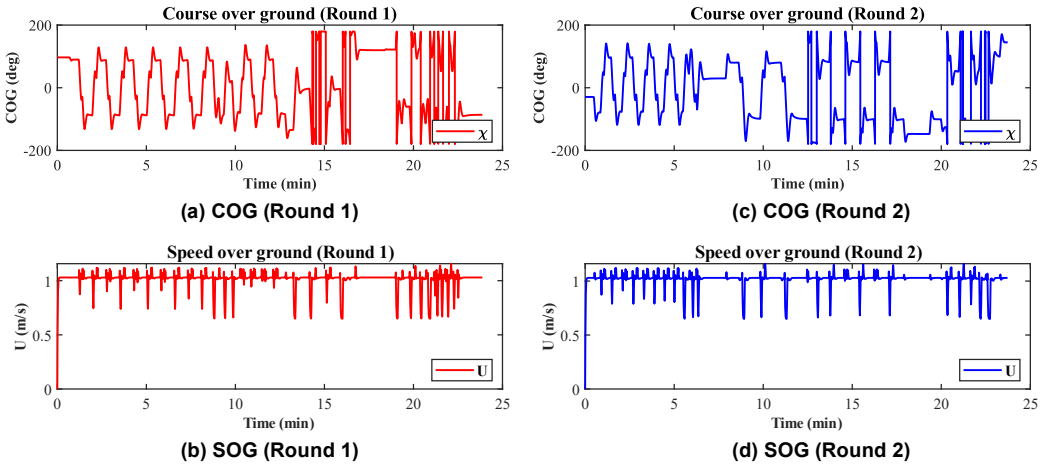

Fig. 7. (a) Course over ground (Round 1), (b) Speed over ground (Round 1), (c) Course over ground (Round 2), (d) Speed over ground (Round 2)

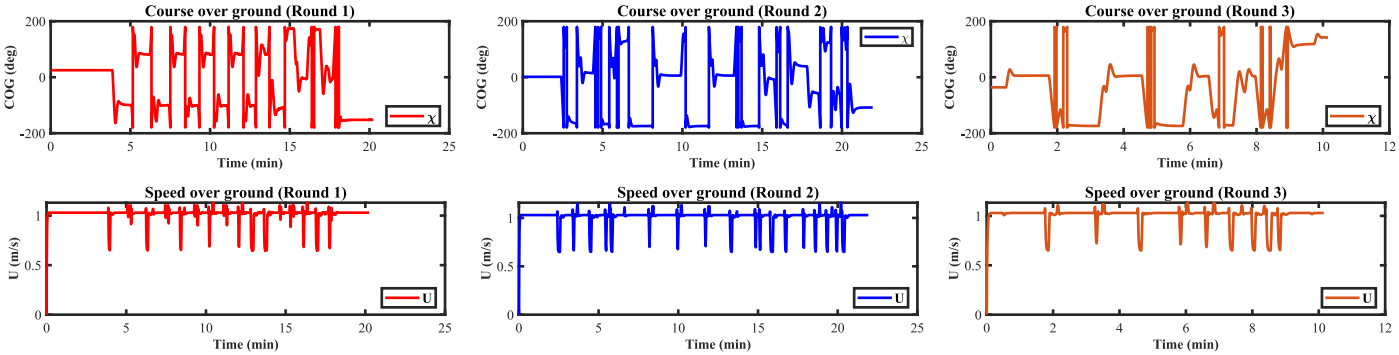

Fig. 8. USV profile of CALA-TORRES, Round 1 – Round 3