APPENDIX A: COMPARISON OF EXISTING SURVEY REGARDING ASVS

TABLE A.1: Comparison of existing survey regarding ASVs.

Surveys	Publish Year	Focus	P	N	G	C	R	N&C	Co	DL
Caccia [1]	2006	Recently developed autonomous surface crafts, the research, and legal issues.	✓	✓	✓	✓	✓	+	+	
Bertram [2]	2008	Several military and research ASV prototypes.	✓							
Manley [3]	2008	Several typical ASVs developed during 1993 and 2008.	✓							
Rynne *et al.* [4]	2009	Introducing the motivation, navigation, control, application, and policy of unmanned autonomous sailing craft.	✓	✓		✓	✓			
Yan *et al.* [5]	2010	The applications, developments, and challenges of Navy ASVs.	✓			+				
Ashrafiuon *et al.* [6]	2010	The development of set-point, trajectory tracking, and path following control algorithms and methodologies for autonomous underactuated marine vehicles.				✓				
Stelzer *et al.* [7]	2011	Architecture, developments, and competitions of robotic sailing boat.	✓			✓				
Campbell *et al.* [8]	2012	The ASVs' prototypes, subsystems, and NGC, especially how to comply with COLREGs guidelines.	✓	✓	✓	✓	✓	+	✓	+
Zheng *et al.* [9]	2013	The architecture, typical prototypes, and technologies for improving the intelligence of marine surface vehicle.	✓	✓	✓	✓			+	+
Othman [10]	2015	Several ASVs' prototypes.	✓							
Azzeri *et al.* [11]	2015	The review of research work on control system approaches of ASVs, especially the course keeping control.	+			✓				+
Manley [12]	2016	The reviews of sub-component technology and developments for unmanned maritime vehicles system over the past 20 years.	✓				+	+		
Liu *et al.* [13]	2016	A comprehensive survey about the existing ASV prototypes, and NGC methods, along with their applications, methodologies, and challenges.	✓	✓	✓	✓	✓	✓	✓	+
Schiaretti *et al.* [14]	2017	Definition and categorization of autonomy levels for autonomous surface vessel.							✓	
Schiaretti *et al.* [15]	2017	A comprehensive review of existing autonomous surface vessel prototypes.	✓							
Prasad *et al.* [16]	2017	A comprehensive overview of various approaches of video processing for object detection and tracking in the maritime environment.		✓						
Liu *et al.* [17]	2018	Techniques related to the operation of multi-vehicle systems in different environmental domains.		+	✓	✓		+	✓	+
Cappelle *et al.* [18]	2018	Technology developments related to autonomous shipping and their technology readiness level.		✓	✓	✓	+	✓		+
Ge *et al.* [19]	2018	Wireless communication techniques for ASVs.	+					✓		
Zereik *et al.* [20]	2018	The present status of marine robotics and their applications.	+					+	+	
Polvara *et al.* [21]	2018	Collision detection and path planning methods for ASVs.		✓	✓	✓	+	+		+
Moud *et al.* [22]	2018	Applications of unmanned surface, underwater and ground vehicles in construction.	+							
Zolich *et al.* [23]	2019	Communication and networking technologies that could help the integration of autonomous systems in maritime scenarios.	+				+	✓	+	
Ellefsen *et al.* [24]	2019	DL techniques based intelligent prognostics and health management system for auto-ships.								✓
Verfuss *et al.* [25]	2019	Recent trends of unmanned vehicles suitable for marine animal monitoring.	+							
Jorge *et al.* [26]	2019	Applications and roles of ASVs for Disaster Management.	+	+		+	+	+	+	+
Munim [27]	2019	Development, and benefits of Autonomous Ship from an economic, environmental and social perspective.	+							
Wang *et al.* [28]	2019	Development and application related to ASV in China.	✓	+	+	+		+		
Thompson *et al.* [29]	2019	Current advances in automated planning for autonomous marine vehicle fleets.	+					✓	✓	+
Silva *et al.* [30]	2019	Developments of rigid wing sailboats in terms of hardware and software.	✓	+		✓		✓		
Wang *et al.* [31]	2019	Motion control of MASS.	+	+		✓				+
Huang *et al.* [32]	2020	Collision prevention techniques based on motion and conflict detection, and conflict resolution both for manned and unmanned ships.	+	✓	+	✓	✓	+	+	+
Jing *et al.* [33]	2020	Path planning and navigation methods for autonomous vessels and sailboats.	+	+	✓		+			
Zhou *et al.* [34]	2020	The path planning of multi-modality constraint research including Route Planning, Trajectory Planning and Motion Planning.			✓		+			
Peng *et al.* [35]	2020	Recent advances and challenges in coordinated control of multiple ASVs.	+	+	+	✓		✓	✓	+
Chen *et al.* [36]	2020	A comprehensive overview on cooperative control methods for waterborne transport.				✓	✓	✓	✓	+
Zhang *et al.* [37]	2021	The major advancements in maritime collision avoidance navigation technologies applied in several different scenarios, from transportation to scientific research.	+	+	✓	+	✓	+		+
Karimi *et al.* [38]	2021	Recent developments on guidance and control methods for marine robotic vehicles.		+	✓	✓		+	+	✓
Vagale *et al.* [39]	2021	Path planning algorithms of autonomous surface vehicles and their classification.	+	+	✓	+	✓			
Thombre *et al.* [40]	2021	State-of-the-art in situational awareness for autonomous vessels.		✓			✓			✓
Gu *et al.* [41]	2022	Overview of recent advances in LOS guidance for path following.				✓				
Our Work	2022	A comprehensive survey about application of DL methods on NGC system of ASVs and maritime cooperative operations, as well as their challenges.	✓	✓	✓	✓	✓	✓	✓	✓

Notes: The symbol "✓" marks publications that discuss the topic in detail; "**+**" indicates corresponding scope is briefly mentioned instead of careful investigation. "**P**" is for prototypes or projects: including the physical ASV prototypes and their hardware, software and applications, or the projects that develop these prototypes; "**G**" is for Guidance; "**N**" is for Navigation; "**C**" is for Control; "**R**" is for rules or regulations, e.g., the effect to comply with COLREGs guidelines; "**N&C**" is for Networking and Communications; "**Co**" refers to cooperation between multi-vehicles; "**DL**" is for deep learning.

APPENDIX B: OVERVIEW OF COMMERCIAL AND RESEARCH ASV PROJECTS

TABLE B.1: Overview of Commercial and Research ASV projects I

Prototype	Navigation							Guidance	Control		COMM.	Purpose	REF.
Name	Sensors						SE/DE	Path-plan	Controller	Steering			
	G	I	Ra	So	Ca	Co	Algorithm						
ARTEMIS	✓					✓	DR		fuzzy controller	rudder	radio	data collection	[42]
ACES	✓			✓						rudder	radio	data collection	[43]
Kayak	✓					✓			PID	rudder	radio	fish tracking	[44]
Autocat	✓			✓						DT		survey platform	[45]
MESSIN	✓					✓	NOMOTO			rudder	UHF	measuring tasks	[46]
ASV[1]	✓	✓				✓				DT	BreezeNet acoustic	support UUV	[47]
SCOUT[1]	✓			✓	✓	✓			PID		WiFi,RF acoustic	test platform	[48]
Charlie	✓				✓	✓	KF	LOS	PID	DT	WLAN	data collection	[49]
OASIS	✓	✓	✓		✓	✓				rudder	WiFi,cellular radio,sattelite	data collection	[50], [51]
ASV	✓				✓		EKF/RAA			DT		shoreline mapping	[52]
Springer	✓					✓			GA-MPC	DT		environment monitoring	[53]
Atlantis	✓		✓			✓	OKID		LQG	rudder		test platform	[54]
Delfim[1]	✓			✓			KF			DT	radio,acoustic	data collection	[55]
ROAZ[1]	✓	✓		✓	✓	✓	EKF/EBD	LOS	HA		radio,acoustic	environment monitoring	[56]
ROAZ II	✓	✓		✓	✓		KF/EBD		HA		WiFi	search and rescue	[57]
ROSS	✓	✓				✓	NOMOTO	LOS	PD	DT	RF	data collection	[58]
ASMV[1 2]	✓			✓	✓	✓			NN		WLAN,cellular	coastal observation	[59]
Swordfish	✓	✓		✓	✓	✓				DT	WiFi,Freewave GSM,acoustic	survey and relay	[60]
Zarco	✓	✓				✓	EKF			DT	WiFi	data collection	[61]
Fast	✓					✓	FSM			rudder	WiFi,radio GSM,satellite	oceanographic missions	[62]
ALANIS	✓		✓			✓	KF	LOS	PD	rudder	radio,wireless	coastal monitoring	[63]
ASV	✓			✓	✓	✓	KF	PFA	Proportional	rudder and DT	WLAN	environment monitoring	[64]
USV	✓				✓					DT	WLAN	surveillance,sampling	[65]
Nereus	✓				✓	✓			PI	DT		coastal observation	[66]
Wave Glider	✓				✓	✓	DR				satellite,RF acoustic	environment monitoring	[67]
WASP	✓	✓				✓				rudder		oceanographic missions	[68]
ASV	✓	✓		✓		✓	EKF		PI	rudder	wireless	caging missions	[69]
SOTOB II	✓					✓			PID	rudder	satellite	monitoring of oil spills	[70]
ASC	✓								PI	DT	RF	environment monitoring	[71]
Squirtle	✓	✓		✓	✓		EKF	DWA		DT	WiFi,Xbee	environment monitoring	[72]
ASB	✓	✓		✓	✓		/CC	PFA	PD	rudder	radio,WiFi	long-term missions	[73]
WHOI	✓	✓							PID		radio,WiFi	data collection	[74]
HydroNet	✓			✓		✓	EKF		sliding mode	rudder	radio	environment monitoring	[75], [76]
SMIS USV[1]	✓		✓	✓						rudder	WiFi,satellite UHF,acoustic	communication relay	[77]
mini-ASV	✓	✓						LOS	PID	rudder	wireless	experimental use	[78]
BUSCAMOS[1]	✓		✓	✓	✓	✓		SODMN	neuro controller	rudder and DT	WiFi,radio satellite	monitoring of oil spills	[79]
USV	✓	✓					KF		PID	rudder		environment monitoring	[80]
ASV	✓	✓				✓				DT	RF	swarming application	[81]
USV[2]	✓	✓	li	✓	✓		UKF		PID	rudder	radio	sampling and rescuing	[82], [83]
UACP	✓	✓						LOS	inner-outer loop		WiFi	search and rescue	[84]
PlaDyPos[1]	✓	✓		✓	✓						WiFi,acoustic	environment monitoring	[85]
JingHai-I	✓	✓	✓	✓	✓	✓		VGA	GPC-PID	rudder	RF,satellite microwave	test platform	[86]
USV	✓	✓						A*		rudder	GPRS	research	[87]
Roboat	✓	✓	li				EKF		NMPC		RF,WiFi	transportation	[88]
USV	✓	✓								DT	WiFi	monitoring of oil spills	[89]
Jetskins[2]	✓	✓	li	✓	✓		/ML	RTT	ardupilot	DT	WiFi	environment monitoring	[90]
USV	✓					✓	/YOLO3				GSM/GPRS XBee	environment monitoring	[91]
Roboat II	✓	✓	li		✓		NMHE	A*	NMPC	DT	WiFi	urban transportation	[92]
Catabot	✓	✓	li	✓	✓	✓				DT	WiFi,radio	environmental monitoring	[93]
ASV	✓	✓	li	✓	✓	✓	EKF	LOS	PD	DT	WiFi	test platform	[94]
VIAM-USV2000	✓		li					GA,LOS	PD	DT	WiFi,radio	environmental monitoring	[95]

Notes: 1.Cooperation with AUV 2.Cooperation with UAV
Navigation: G: GPS, I: INS, Ra: Radar(li: lidar), So: Sonar, Ca: Camera, Co: compass, SE: State Estimate, DE: Detection
Control: HA: Hybrid Automation, NMPC: Nonlinear Model Predictive Control, DT: Differential Thrust
Algorithm: DR: Dead-Reckoning, KF: Kalman Filter, EKF: Extended Kalman Filter, UKF: Unscented Kalman Filter, RAA: Radial Analysis Approach, OKID: Observer/Kalman System Identification, EBD: Edge and Blob Detection, FSM: Finite State Machines, CC: Colorimetric Criteria based Algorithm, ML: Machine Learning, LOS: Line-Of-Sight Algorithm, PFA: Potential Field Approach, DWA: Dynamic Window Approach, SODMN: Self Organization Direction Mapping Network, VGA: Visibility Graph Algorithm, GA: Genetic Algorithm, NMHE: Nonlinear Moving Horizon Estimation

TABLE B.2: Overview of Commercial and Research ASV projects II

Prototype		Institution		Dimension		Parameters				Components		Applications
Name	Year	Country	Corp.	L(m)	W(m)	Wt(kg)	Sp(m/s)	En	Type	Propulsion	Power	
ARTEMIS	1996	USA	MIT	1.4	0.4	29.5	1.2	4h	M	a thruster motor	batteries	
ACES	1997	USA	MIT	1.8	1.3	90.7	2.6	12-18h	C	a stepper motor	gasoline	[96]
Kayak	1998	USA	MIT	3	0.68	19.5	1.5	24h	M	a propeller	batteries	
Autocat	2000	USA	MIT	1.22	0.61	10	3.8	6h	C	two propellers	batteries	
MESSIN	2000	Germany	University of Rostock						C	propeller	batteries	
ASV	2003	USA	FAU				2.6	24h	C	two trolling motors	batteries	
SCOUT	2005	USA	MIT			81.6	2.6		M	a trolling motor	batteries	[97]
Charlie	2005	Italy	CNR-ISSIA	2.4	1.8	300			C	two propellers	solar	[98]–[100]
OASIS	2006	USA	CIT	5.48	1.52	1360	1.3	3-6m	M	propeller	solar	[101]
ASV	2006	USA	Virginia Tech	2.7	1.5	125	1.6	3-4	C	two thrusters	gasoline	
Springer	2006	UK	University of Plymouth	4	2.3		2		C	two propellers	batteries	
Atlantis	2006	USA	UC	7.2	3				C	a sail	wind	
Delfim	2006	Portugal	ISR/IST	3.5	2	320	2.6		C	two propellers	batteries	
ROAZ	2006	Portugal	ISEP	1.5	1				C	two thrusters	solar	[102]
ROAZ II	2007	Portugal	ISEP	4.5	2.2	200			C	two trolling motors	batteries	[103]
ROSS	2007	India	NIO	1.84	0.36	95.5		7h	M	two propellers	batteries	
ASMV	2007	USA	FIT	2.13	0.91	176	1.2	7.5h	M	two propellers	batteries	
Swordfish	2007	Portugal	University of Porto	4.5	2.2	190	2	6h	C	two thrusters	batteries	[104]
Zarco	2007	Portugal	University of Porto	1.5		50	1.5	6-10h	C	two thrusters	batteries	
Fast	2008	Portugal	University of Porto	2.5	0.67				M	two sails	wind, solar	
ALANIS	2009	Italy	CNR-ISSIA	4.5	2.2	600		12h	M	two servo motors	batteries	
ASV	2009	Australia	CSIRO	4.88			2.8		C	two trolling motors	solar	[105]
USV	2009	China	SMU	2.7	1.48	60	3.1	2h	C	two propellers	batteries	
Nereus	2009	USA	FAU	1.7	0.21		2		C	four propellers	batteries	
Wave Glider	2009	USA	Liquid Robotics	2.1	0.6	75	0.8	1year	M	wave energy converter	wave energy solar	[106]–[108]
WASP	2009	USA	UMiami	4.2	0.8	50	2.6		M	a sail	wind, solar	
ASV	2010	USA	USC	2.1	0.7	48	1.5		C	two thrusters	batteries	[109], [110]
SOTOB II	2012	Japan	Osaka University	2.64	0.76	60	2	1week	M	a sail	wind, solar	[111], [112]
ASC	2013	Canada	MUN	1.5	1	146	1		C	two propellers	batteries	
Squirtle	2013	Portugal	University of Coimbra						C	two motors	solar	
ASB	2013	France	UPMC						M	a sail	wind, solar	
WHOI	2014	USA	WHOI	3.35		135	5.5	8-10h	M	waterjet	gasoline	
HydroNet	2014	Italy	SSSUP	1.99	1.16	82.8	1	10h	C	two propellers	batteries	
SMIS-USV	2015	Germany	University of Rostock					7days	M	propeller	batteries	
mini-USV	2016	China	HUST	1.33	0.33	5.1	3.1		M	propeller	batteries	
BUSCAMOS	2016	Spain	UPCT	5.1		1.97		6h	M	two propellers	solar, diesel	
USV	2016	Spain	UTB	1.3					M	two motors		
ASV	2016	Malaysia	USM	0.4	0.4	5.3	1	0.5h	M	two waterjets	batteries	
USV	2016	China	SIA CAS	2.8	0.7		10	2h	M	waterjet	batteries	
UCAP	2016	Protugal	INESC TEC	1.5		25	2	1h	M	waterjet	batteries	
PlaDyPos	2017	Croatia	University of Zagreb	1		30	1		M	four thrusters		
JingHai-I	2017	China	Shanghai University	6.28	2.86	2300	9.3	5h	M	waterjet	diesel	
USV	2017	China	BIT	1.9	0.4	34.3			C	a sail, two thrusters	solar, wind	
Roboat	2018	USA	MIT	0.9	0.45	9.2	1.1	2h	M	four thrusters	batteries	
USV	2019	Oman	SQU	0.9		15	1		C	two propellers	batteries	
Jetskins	2019	France	University of La Rochelle	1.8	0.66	28	1.5	10h	M	four motors	batteries	
USV	2019	Philippines	CARSU	1.5	1	40	0.5		C	propeller	batteries	
Roboat II	2020	USA	MIT	2.0	1.0	80	2.0	2h	M	four thrusters	batteries	
Catabot	2020	USA	Dartmouth College	2.4	1.4	25			C	two propellers	batteries	
ASV	2020	Korea	KRISO	4.1	2.4		3.3		C	two thrusters	batteries	
VIAM-USV2000	2021	Vietnam	HCMUT	2	1	150	2.1	3h	C	6 thrusters	batteries	

Note: 1.Because all the prototypes have power supplied by batteries, “batteries” here denotes batteries are the only power.
Dimension: L: Length, W: Width **Type**: M: Monohull, C: Catamaran **Parameter**: Sp: Speed, Wt: Weight, En: Endurance

References

[1] M. Caccia, "Autonomous surface craft: prototypes and basic research issues," in *2006 IEEE 14th Mediterranean Conference on Control and Automation*, June 2006, pp. 1–6.

[2] V. Bertram, "Unmanned surface vehicles-a survey," *Skibsteknisk Selskab, Copenhagen, Denmark*, vol. 1, pp. 1–14, 2008.

[3] J. E. Manley, "Unmanned surface vehicles, 15 years of development," in *IEEE OCEANS 2008*, September 2008, pp. 1–4.

[4] P. F. Rynne and K. D. von Ellenrieder, "Unmanned autonomous sailing: Current status and future role in sustained ocean observations," *Marine Technology Society Journal*, vol. 43, no. 1, pp. 21–30, 2009.

[5] R.-j. Yan, S. Pang, H.-b. Sun, and Y.-j. Pang, "Development and missions of unmanned surface vehicle," *Journal of Marine Science and Application*, vol. 9, no. 4, pp. 451–457, 2010.

[6] H. Ashrafiuon, K. R. Muske, and L. C. McNinch, "Review of nonlinear tracking and setpoint control approaches for autonomous underactuated marine vehicles," in *Proceedings of the 2010 American Control Conference*, June 2010, pp. 5203–5211.

[7] R. Stelzer and K. Jafarmadar, "History and recent developments in robotic sailing," in *Robotic Sailing*. Springer, 2011, pp. 3–23.

[8] S. Campbell, W. Naeem, and G. W. Irwin, "A review on improving the autonomy of unmanned surface vehicles through intelligent collision avoidance manoeuvres," *Annual Reviews in Control*, vol. 36, no. 2, pp. 267–283, 2012.

[9] H. Zheng, R. R. Negenborn, and G. Lodewijks, "Survey of approaches for improving the intelligence of marine surface vehicles," in *16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013)*, 2013, pp. 1217–1223.

[10] E. Othman, "A review on current design of unmanned surface vehicles (usvs)," *J. Adv. Rev. Sci. Res*, vol. 16, pp. 12–17, 2015.

[11] M. Azzeri, F. Adnan, and M. Zain, "Review of course keeping control system for unmanned surface vehicle," *Jurnal Teknologi*, vol. 74, no. 5, pp. 11–20, 2015.

[12] J. E. Manley, "Unmanned maritime vehicles, 20 years of commercial and technical evolution," in *OCEANS 2016 MTS/IEEE Monterey*, September 2016, pp. 1–6.

[13] Z. Liu, Y. Zhang, X. Yu, and C. Yuan, "Unmanned surface vehicles: An overview of developments and challenges," *Annual Reviews in Control*, vol. 41, pp. 71–93, 2016.

[14] M. Schiaretti, L. Chen, and R. R. Negenborn, "Survey on autonomous surface vessels: Part i-a new detailed definition of autonomy levels," in *International Conference on Computational Logistics*. Springer, 2017, pp. 219–233.

[15] ——, "Survey on autonomous surface vessels: Part ii-categorization of 60 prototypes and future applications," in *International Conference on Computational Logistics*. Springer, 2017, pp. 234–252.

[16] D. K. Prasad, D. Rajan, L. Rachmawati, E. Rajabally, and C. Quek, "Video processing from electro-optical sensors for object detection and tracking in a maritime environment: a survey," *IEEE Transactions on Intelligent Transportation Systems*, vol. 18, no. 8, pp. 1993–2016, 2017.

[17] Y. Liu and R. Bucknall, "A survey of formation control and motion planning of multiple unmanned vehicles," *Robotica*, vol. 36, no. 7, pp. 1019–1047, 2018.

[18] L. E. van Cappelle, L. Chen, and R. R. Negenborn, "Survey on short-term technology developments and readiness levels for autonomous shipping," in *International Conference on Computational Logistics*. Springer, 2018, pp. 106–123.

[19] J. Ge, T. Li, and T. Geng, "The wireless communications for unmanned surface vehicle: An overview," in *International Conference on Intelligent Robotics and Applications*. Springer, 2018, pp. 113–119.

[20] E. Zereik, M. Bibuli, N. Mišković, P. Ridao, and A. Pascoal, "Challenges and future trends in marine robotics," *Annual Reviews in Control*, vol. 46, pp. 350–368, 2018.

[21] R. Polvara, S. Sharma, J. Wan, A. Manning, and R. Sutton, "Obstacle avoidance approaches for autonomous navigation of unmanned surface vehicles," *The Journal of Navigation*, vol. 71, no. 1, pp. 241–256, 2018.

[22] H. I. Moud, A. Shojaei, and I. Flood, "Current and future applications of unmanned surface, underwater, and ground vehicles in construction," in *Proceedings of the Construction Research Congress*, April 2018, pp. 106–115.

[23] A. Zolich, D. Palma, K. Kansanen, K. Fjørtoft, J. Sousa, K. H. Johansson, Y. Jiang, H. Dong, and T. A. Johansen, "Survey on communication and networks for autonomous marine systems," *Journal of Intelligent & Robotic Systems*, vol. 95, no. 3-4, pp. 789–813, 2019.

[24] A. L. Ellefsen, V. Æsøy, S. Ushakov, and H. Zhang, "A comprehensive survey of prognostics and health management based on deep learning for autonomous ships," *IEEE Transactions on Reliability*, vol. 68, no. 2, pp. 720–740, 2019.

[25] U. K. Verfuss, A. S. Aniceto, D. V. Harris, D. Gillespie, S. Fielding, G. Jiménez, P. Johnston, R. R. Sinclair, A. Sivertsen, S. A. Solbø *et al.*, "A review of unmanned vehicles for the detection and monitoring of marine fauna," *Marine pollution bulletin*, vol. 140, pp. 17–29, 2019.

[26] V. A. Jorge, R. Granada, R. G. Maidana, D. A. Jurak, G. Heck, A. P. Negreiros, D. H. Dos Santos, L. M. Gonçalves, and A. M. Amory, "A survey on unmanned surface vehicles for disaster robotics: Main challenges and directions," *Sensors*, vol. 19, no. 3, p. 702, 2019.

[27] Z. H. Munim, "Autonomous ships: a review, innovative applications and future maritime business models," *Supply Chain Forum: An International Journal*, vol. 20, no. 4, pp. 266–279, 2019.

[28] X. Wang, X. Song, and L. Du, "Review and application of unmanned surface vehicle in china," in *2019 5th International Conference on Transportation Information and Safety (ICTIS)*, July 2019, pp. 1476–1481.

[29] F. Thompson and D. Guihen, "Review of mission planning for autonomous marine vehicle fleets," *Journal of Field Robotics*, vol. 36, no. 2, pp. 333–354, 2019.

[30] M. F. Silva, A. Friebe, B. Malheiro, P. Guedes, P. Ferreira, and M. Waller, "Rigid wing sailboats: A state of the art survey," *Ocean Engineering*, vol. 187, p. 106150, 2019.

[31] L. Wang, Q. Wu, J. Liu, S. Li, and R. R. Negenborn, "State-of-the-art research on motion control of maritime autonomous surface ships," *Journal of Marine Science and Engineering*, vol. 7, no. 12, p. 438, 2019.

[32] Y. Huang, L. Chen, P. Chen, R. R. Negenborn, and P. van Gelder, "Ship collision avoidance methods: State-of-the-art," *Safety Science*, vol. 121, pp. 451–473, 2020.

[33] W. Jing, C. Liu, T. Li, A. M. Rahman, L. Xian, X. Wang, Y. Wang, Z. Guo, G. Brenda, and K. W. Tendai, "Path planning and navigation of oceanic autonomous sailboats and vessels: A survey," *Journal of Ocean University of China*, vol. 19, pp. 609–621, 2020.

[34] C. Zhou, S. Gu, Y. Wen, Z. Du, C. Xiao, L. Huang, and M. Zhu, "The review unmanned surface vehicle path planning: Based on multi-modality constraint," *Ocean Engineering*, vol. 200, p. 107043, 2020.

[35] Z. Peng, J. Wang, D. Wang, and Q.-L. Han, "An overview of recent advances in coordinated control of multiple autonomous surface vehicles," *IEEE Transactions on Industrial Informatics*, 2020.

[36] L. Chen, R. Negenborn, Y. Huang, and H. Hopman, "Survey on cooperative control for waterborne transport," *IEEE Intelligent Transportation Systems Magazine*, vol. 13, no. 2, pp. 71–90, 2020.

[37] X. Zhang, C. Wang, L. Jiang, L. An, and R. Yang, "Collision-avoidance navigation systems for maritime autonomous surface ships: A state of the art survey," *Ocean Engineering*, vol. 235, p. 109380, 2021.

[38] H. R. Karimi and Y. Lu, "Guidance and control methodologies for marine vehicles: A survey," *Control Engineering Practice*, vol. 111, p. 104785, 2021.

[39] A. Vagale, R. Oucheikh, R. T. Bye, O. L. Osen, and T. I. Fossen, "Path planning and collision avoidance for autonomous surface vehicles i: a review," *Journal of Marine Science and Technology*, pp. 1–15, 2021.

[40] S. Thombre, Z. Zhao, H. Ramm-Schmidt, J. M. V. García, T. Malkamäki, S. Nikolskiy, T. Hammarberg, H. Nuortie, M. Z. H. Bhuiyan, S. Särkkä *et al.*, "Sensors and ai techniques for situational awareness in autonomous ships: A review," *IEEE Transactions on Intelligent Transportation Systems*, 2021.

[41] N. Gu, D. Wang, Z. Peng, J. Wang, and Q.-L. Han, "Advances in line-of-sight guidance for path following of autonomous marine vehicles: An overview," *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 2022.

[42] T. W. Vaneck, C. D. RODRIGUEZ-ORTIZ, M. C. Schmidt, and J. E. Manley, "Automated bathymetry using an autonomous surface craft," *Navigation*, vol. 43, no. 4, pp. 407–419, 1996.

[43] J. E. Manley, "Development of the autonomous surface craft 'aces'," in *Proceeding of IEEE/MTS Oceans'97*, vol. 2, 1997, pp. 827–832.

[44] C. A. Goudey, T. Consi, J. Manley, M. Graham *et al.*, "A robotic boat for autonomous fish tracking," *Marine Technology Society. Marine Technology Society Journal*, vol. 32, no. 1, p. 47, 1998.

[45] J. E. Manley, A. Marsh, W. Cornforth, and C. Wiseman, "Evolution of the autonomous surface craft autocat," in *Proceeding of IEEE/MTS Oceans'00*, vol. 1, September 2000, pp. 403–408.

[46] J. Majohr, T. Buch, and C. Korte, "Navigation and automatic control of the measuring dolphin (messin™)," *IFAC Proceedings Volumes*, vol. 33, no. 21, pp. 399–404, 2000.

[47] A. Leonessa, J. Mandello, Y. Morel, and M. Vidal, "Design of a small, multi-purpose, autonomous surface vessel," in *Proceeding of IEEE OCEANS 2003*, vol. 1, September 2003, pp. 544–550.

[48] J. Curcio, J. Leonard, and A. Patrikalakis, "Scout-a low cost autonomous surface platform for research in cooperative autonomy," in *Proceedings of IEEE/MTS OCEANS 2005*, September 2005, pp. 725–729.

[49] M. Caccia, M. Bibuli, R. Bono, G. Bruzzone, G. Bruzzone, and E. Spirandelli, "Unmanned surface vehicle for coastal and protected waters applications: The charlie project," *Marine Technology Society Journal*, vol. 41, no. 2, pp. 62–71, 2007.

[50] J. R. Higinbotham, P. G. Hitchener, and J. R. Moisan, "Development of a new long duration solar powered autonomous surface vehicle," in *Proceeding of IEEE OCEANS 2006*, September 2006, pp. 1–6.

[51] J. R. Higinbotham, J. R. Moisan, C. Schirtzinger, M. Linkswiler, J. Yungel, and P. Orton, "Update on the development and testing of a new long duration solar powered autonomous surface vehicle," in *Proceeding of IEEE OCEANS 2008*, September 2008, pp. 1–10.

[52] A. Subramanian, X. Gong, J. N. Riggins, D. J. Stilwell, and C. L. Wyatt, "Shoreline mapping using an omni-directional camera for autonomous surface vehicle applications," in *Proceeding of IEEE OCEANS 2006*, September 2006, pp. 1–6.

[53] W. Naeem, R. Sutton, and J. Chudley, "Modelling and control of an unmanned surface vehicle for environmental monitoring," in *UKACC International Control Conference*, 2006, pp. 1–6.

[54] G. H. Elkaim, "The atlantis project: A gps-guided wing-sailed autonomous catamaran," *Navigation*, vol. 53, no. 4, pp. 237–247, 2006.

[55] J. Alves, P. Oliveira, R. Oliveira, A. Pascoal, M. Rufino, L. Sebastiao, and C. Silvestre, "Vehicle and mission control of the delfim autonomous surface craft," in *2006 IEEE 14th Mediterranean Conference on Control and Automation*, June 2006, pp. 1–6.

[56] H. Ferreira, A. Martins, A. Dias, C. Almeida, J. M. Almeida, and E. P. Silva, "Roaz autonomous surface vehicle design and implementation," *Robótica Controlo, Automação, instrumentação*, 2007.

[57] A. Martins, H. Ferreira, C. Almeida, H. Silva, J. M. Almeida, and E. Silva, "Roaz and roaz ii autonomous surface vehicle design and implementation," in *International Lifesaving Congress 2007*, 2007.

[58] E. Desa, P. K. Maurya, A. Pereira *et al.*, "A small autonomous surface vehicle for ocean color remote sensing," *IEEE Journal of Oceanic Engineering*, vol. 32, no. 2, pp. 353–364, 2007.

[59] S. Wood, M. Rees, and Z. Pfeiffer, "An autonomous self-mooring vehicle for littoral & coastal observations," in *IEEE OCEANS 2007*, June 2007, pp. 1–6.

[60] H. Ferreira, R. Martins, E. Marques, J. Pinto, A. Martins, J. Almeida, J. Sousa, and E. Silva, "Swordfish: an autonomous surface vehicle for network centric operations," in *IEEE Oceans 2007*, June 2007, pp. 1–6.

[61] N. Cruz, A. Matos, S. Cunha, and S. O. da Silva, "Zarco-an autonomous craft for underwater surveys," *7th Geomatic Week*, 2007.

[62] J. C. Alves and N. A. Cruz, "Fast-an autonomous sailing platform for oceanographic missions," in *IEEE OCEANS 2008*, September 2008, pp. 1–7.

[63] M. Caccia, M. Bibuli, R. Bono, G. Bruzzone, G. Bruzzone, and E. Spirandelli, "Aluminum hull usv for coastal water and seafloor monitoring," in *IEEE OCEANS 2009*, May 2009, pp. 1–5.

[64] M. Dunbabin, A. Grinham, and J. Udy, "An autonomous surface vehicle for water quality monitoring," in *Australasian Conference on Robotics and Automation (ACRA)*. Citeseer, December 2009, pp. 2–4.

[65] J. Wang, W. Gu, J. Zhu, and J. Zhang, "An unmanned surface vehicle for multi-mission applications," in *2009 IEEE International Conference on Electronic Computer Technology*, February 2009, pp. 358–361.

[66] T. C. Furfaro, J. E. Dusek, and K. D. von Ellenrieder, "Design, construction, and initial testing of an autonomous surface vehicle for riverine and coastal reconnaissance," in *IEEE OCEANS 2009*, October 2009, pp. 1–6.

[67] R. Hine, S. Willcox, G. Hine, and T. Richardson, "The wave glider: A wave-powered autonomous marine vehicle," in *IEEE OCEANS 2009*, October 2009, pp. 1–6.

[68] P. F. Rynne and K. D. von Ellenrieder, "Development and preliminary experimental validation of a wind-and solar-powered autonomous surface vehicle," *IEEE Journal of Oceanic Engineering*, vol. 35, no. 4, pp. 971–983, 2010.

[69] F. Arrichiello, H. Heidarsson, S. Chiaverini, and G. S. Sukhatme, "Cooperative caging using autonomous aquatic surface vehicles," in *2010 IEEE International Conference on Robotics and Automation*, May 2010, pp. 4763–4769.

[70] H. Senga, N. Kato, H. Suzuki, T. Akamatsu, L. Yu, M. Yoshie, and T. Tanaka, "Field experiments and new design of a spilled oil tracking autonomous buoy," *Journal of Marine Science and Technology*, vol. 19, no. 1, pp. 90–102, 2014.

[71] Z. Li and R. Bachmayer, "The development of a robust autonomous surface craft for deployment in harsh ocean environment," in *2013 IEEE OCEANS*, September 2013, pp. 1–7.

[72] J. Fraga, J. Sousa, G. Cabrita, P. Coimbra, and L. Marques, "Squirtle: An asv for inland water environmental monitoring," in *ROBOT2013: First Iberian Robotics Conference*. Springer, 2014, pp. 33–39.

[73] F. Plumet, C. Pêtrès, M.-A. Romero-Ramirez, B. Gas, and S.-H. Ieng, "Toward an autonomous sailing boat," *IEEE Journal of Oceanic Engineering*, vol. 40, no. 2, pp. 397–407, 2014.

[74] P. Kimball, J. Bailey, S. Das *et al.*, "The whoi jetyak: An autonomous surface vehicle for oceanographic research in shallow or dangerous waters," in *2014 IEEE/OES Autonomous Underwater Vehicles (AUV)*, October 2014, pp. 1–7.

[75] G. Ferri, A. Manzi, F. Fornai, B. Mazzolai, C. Laschi, F. Ciuchi, and P. Dario, "Design, fabrication and first sea trials of a small-sized autonomous catamaran for heavy metals monitoring in coastal waters," in *2011 IEEE International Conference on Robotics and Automation*, May 2011, pp. 2406–2411.

[76] G. Ferri, A. Manzi, F. Fornai, F. Ciuchi, and C. Laschi, "The hydronet asv, a small-sized autonomous catamaran for real-time monitoring of water quality: From design to missions at sea," *IEEE Journal of Oceanic Engineering*, vol. 40, no. 3, pp. 710–726, 2014.

[77] E. Rentzow, D. Dewitz, M. Kurowski, B. P. Lampe, S. Ritz, R. Kutz, M. Golz, and F. Boeck, "Design and automation of an ocean-going autonomously acting usv," in *IEEE OCEANS 2015*, May 2015, pp. 1–6.

[78] H. Liu, S. Gan, J. Zhang, and X. Xiang, "Control system of a mini-asv prototype: Design and implementation," in *2016 IEEE International Conference on Underwater System Technology: Theory and Applications (USYS)*, December 2016, pp. 110–114.

[79] A. Guerrero-González, F. García-Córdova, F. J. Ortiz, D. Alonso, and J. Gilabert, "A multirobot platform based on autonomous surface and underwater vehicles with bio-inspired neurocontrollers for long-term oil spills monitoring," *Autonomous Robots*, vol. 40, no. 7, pp. 1321–1342, 2016.

[80] J. Villa, J. Paez, C. Quintero, E. Yime, and J. Cabrera, "Design and control of an unmanned surface vehicle for environmental monitoring applications," in *2016 IEEE Colombian Conference on Robotics and Automation (CCRA)*, September 2016, pp. 1–5.

[81] M. Majid and M. Arshad, "Design of an autonomous surface vehicle (asv) for swarming application," in *2016 IEEE/OES Autonomous Underwater Vehicles (AUV)*, November 2016, pp. 230–235.

[82] J. Xiong, F. Gu, D. Li, Y. He, and J. Han, "Design, implementation and modeling of flooding disaster-oriented usv," *Recent Advances in Robotic Systems*, pp. 27–46, 2016.

[83] J. Zhang, J. Xiong, G. Zhang, F. Gu, and Y. He, "Flooding disaster oriented usv & uav system development & demonstration," in *IEEE OCEANS 2016*, April 2016, pp. 1–4.

[84] B. M. Ferreira, A. C. Matos, and J. C. Alves, "Water-jet propelled autonomous surface vehicle ucap: System description and control," in *IEEE OCEANS 2016*, April 2016, pp. 1–5.

[85] A. Vasilijević, . Na, F. Mandić, N. Mišković, and Z. Vukić, "Coordinated navigation of surface and underwater marine robotic vehicles for ocean sampling and environmental monitoring," *IEEE/ASME Transactions on Mechatronics*, vol. 22, no. 3, pp. 1174–1184, 2017.

[86] Y. Peng, Y. Yang, J. Cui, X. Li, H. Pu, J. Gu, S. Xie, and J. Luo, "Development of the usv 'jinghai-i'and sea trials in the southern yellow sea," *Ocean Engineering*, vol. 131, pp. 186–196, 2017.

[87] X. Zhou, L. Ling, J. Ma, H. Tian, Q. Yan, G. Bai, S. Liu, and L. Dong, "The design and application of an unmanned surface vehicle powered by solar and wind energy," in *2015 IEEE 6th international conference on power electronics systems and applications (PESA)*, December 2015, pp. 1–10.

[88] W. Wang, L. A. Mateos, S. Park, P. Leoni, B. Gheneti, F. Duarte, C. Ratti, and D. Rus, "Design, modeling, and nonlinear model predictive tracking control of a novel autonomous surface vehicle," in *2018 IEEE International Conference on Robotics and Automation (ICRA)*, May 2018, pp. 6189–6196.

[89] W. Al Maawali, A. Al Naabi, M. Al Yaruubi, A. Saleem, and A. Al Maashri, "Design and implementation of an unmanned surface vehicle for oil spill handling," in *2019 IEEE 1st International Conference on Unmanned Vehicle Systems-Oman (UVS)*, February 2019, pp. 1–6.

[90] A. Gaugue, M. Menard, E. Migot, P. Bourcier, and C. Gaschet, "Development of an aquatic usv with high communication capability for environmental surveillance," in *IEEE OCEANS 2019*, June 2019, pp. 1–8.

[91] A. T. Demetillo and E. B. Taboada, "Real-time water quality monitoring for small aquatic area using unmanned surface vehicle," *Engineering, Technology & Applied Science Research*, vol. 9, no. 2, pp. 3959–3964, 2019.

[92] W. Wang, T. Shan, P. Leoni, D. Fernández-Gutiérrez, D. Meyers, C. Ratti, and D. Rus, "Roboat ii: A novel autonomous surface vessel for urban environments," in *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE, 2020, pp. 1740–1747.

[93] M. Jeong, M. Roznere, S. Lensgraf, A. Sniffen, D. Balkcom, and A. Q. Li, "Catabot: Autonomous surface vehicle with an optimized design for environmental monitoring," in *Global Oceans 2020: Singapore–US Gulf Coast*. IEEE, 2020, pp. 1–9.

[94] J. Choi, J. Park, J. Jung, Y. Lee, and H.-T. Choi, "Development of an autonomous surface vehicle and performance evaluation of autonomous navigation technologies," *International Journal of Control, Automation and Systems*, vol. 18, no. 3, pp. 535–545, 2020.

[95] N.-H. Tran, Q.-H. Pham, J.-H. Lee, and H.-S. Choi, "Viam-usv2000: An unmanned surface vessel with novel autonomous capabilities in confined riverine environments," *Machines*, vol. 9, no. 7, p. 133, 2021.

[96] J. E. Manley and T. W. Vaneck, "High fidelity hydrographic surveys using and autonomous surface craft," Ph.D. dissertation, Massachusetts Institute of Technology, Dept. of Ocean Engineering, 1998.

[97] J. Curcio, J. Leonard, J. Vaganay, A. Patrikalakis, A. Bahr, D. Battle, H. Schmidt, and M. Grund, "Experiments in moving baseline navigation using autonomous surface craft," in *Proceedings of IEEE/MTS OCEANS 2005*, September 2005, pp. 730–735.

[98] M. Caccia, G. Bruzzone, and R. Bono, "Modelling and identification of the charlie2005 asc," in *2006 IEEE 14th Mediterranean Conference on Control and Automation*, June 2006, pp. 1–6.

[99] ——, "A practical approach to modeling and identification of small autonomous surface craft," *IEEE Journal of Oceanic Engineering*, vol. 33, no. 2, pp. 133–145, 2008.

[100] G. Bruzzone, G. Bruzzone, M. Bibuli, and M. Caccia, "Autonomous mine hunting mission for the charlie usv," in *IEEE OCEANS 2011*, June 2011, pp. 1–6.

[101] G. W. Podnar, J. M. Dolan, A. Elfes, S. Stancliff, E. Lin, J. C. Hosler, T. J. Ames, J. Moisan, T. A. Moisan, J. Higinbotham *et al.*, "Operation of robotic science boats using the telesupervised adaptive ocean sensor fleet system," in *2008 IEEE International Conference on Robotics and Automation*, May 2008, pp. 1061–1068.

[102] A. Martins, J. M. Almeida, H. Ferreira, H. Silva, N. Dias, A. Dias, C. Almeida, and E. Silva, "Autonomous surface vehicle docking manoeuvre with visual information," in *Proceedings 2007 IEEE International Conference on Robotics and Automation*, April 2007, pp. 4994–4999.

[103] H. Ferreira, C. Almeida, A. Martins, J. Almeida, N. Dias, A. Dias, and E. Silva, "Autonomous bathymetry for risk assessment with roaz robotic surface vehicle," in *IEEE Oceans 2009*, May 2009, pp. 1–6.

[104] H. Ferreira, R. Martins, E. Marques, J. Pinto, A. Martins, J. Almeida, J. Sousa, and E. Silva, "Marine operations with the swordfish autonomous surface vehicle," in *IEEE Robótica 2007-7th Conference on Mobile Robots and Competitions*, 2007.

[105] M. Dunbabin and A. Grinham, "Experimental evaluation of an autonomous surface vehicle for water quality and greenhouse gas emission monitoring," in *2010 IEEE International Conference on Robotics and Automation*, May 2010, pp. 5268–5274.

[106] J. Manley and S. Willcox, "The wave glider: A persistent platform for ocean science," in *IEEE OCEANS'10*, May 2010, pp. 1–5.

[107] T. Daniel, J. Manley, and N. Trenaman, "The wave glider: enabling a new approach to persistent ocean observation and research," *Ocean Dynamics*, vol. 61, no. 10, pp. 1509–1520, 2011.

[108] P. J. Fitzpatrick, Y. Lau, R. Moorhead, A. Skarke, D. Merritt, K. Kreider, C. Brown, R. Carlon, G. Hine, T. Lampoudi *et al.*, "A review of the 2014 gulf of mexico wave glider® field program," *Marine Technology Society Journal*, vol. 49, no. 3, pp. 64–71, 2015.

[109] S. Bhattacharya, H. Heidarsson, G. S. Sukhatme, and V. Kumar, "Cooperative control of autonomous surface vehicles for oil skimming and cleanup," in *2011 IEEE International Conference on Robotics and Automation*, May 2011, pp. 2374–2379.

[110] F. Arrichiello, H. K. Heidarsson, S. Chiaverini, and G. S. Sukhatme, "Cooperative caging and transport using autonomous aquatic surface vehicles," *Intelligent Service Robotics*, vol. 5, no. 1, pp. 73–87, 2012.

[111] S. S. Rathour, N. Kato, N. Tanabe, H. Senga, Y. Hirai, M. Yoshie, and T. Tanaka, "Spilled oil autonomous tracking using autonomous sea surface vehicle," *Marine Technology Society Journal*, vol. 49, no. 3, pp. 102–116, 2015.

[112] S. Rathour, N. Kato, H. Senga, T. Tanabe, M. Yoshie, and T. Tanaka, "Development of a robotic floating buoy for autonomously tracking oil slicks drifting on the sea surface (sotab-ii): Experimental results," in *Applications to Marine Disaster Prevention*. Springer, 2017, pp. 95–127.