# Advanced COLREGS

The core MOOS-IvP distribution includes several libraries supporting a Helm behavior for collision avoidance based on the Coast Guard Collision Regulations (COLREGS). This code was part of the 2017 release and field tested on several USV platforms in several countries. The 2019 release included slight improvements over the 2017 release. The Advanced COLREGS project further improves the robustness and efficiency of the existing publicly released COLREGS behavior, and to develop an automated testing environment for stress testing the behavior with multiple simultaneous contacts, static and moving obstacles, uncooperative contacts and other mitigating mission factors. It also augments to the underlying math libraries to consider varying turn characteristics and vessel shapes. The new behavior also allows for re-structuring of COLREGS rules to account for collaborating vessel teams that may, for example, always enable the Rule 14 Head-on rule, but may wish to suspend the Rule 17 Stand-on rule when travelling in a stable formation.
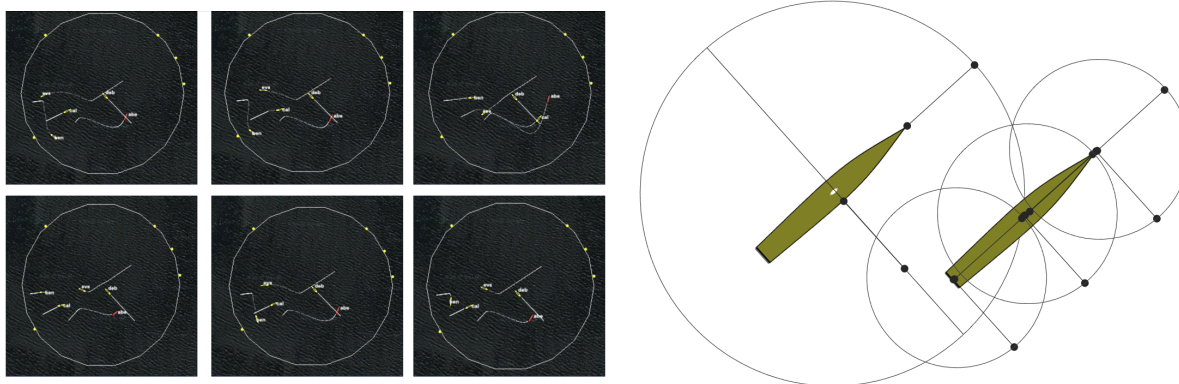
Status:	Ongoing since August 2019
People:	Mike Benjamin (PI)
Robots:	https://oceanai.mit.edu/pavlab/robots/herons
	https://oceanai.mit.edu/pavlab/robots/philos
Related Projects:	Sea Train, Swarm Autonomy Toolbox, MTASC, MOOS-IvP

Related Publications

2018 (2 items)

1. Michael R. Benjamin. Capturing velocity function plateaus for efficient marine vehicle collision avoidance calculations. In *OCEANS 2018 MTS/IEEE Kobe Japan*, May 2018.
2. Kyle L. Woerner and Michael R. Benjamin. Real-time automated evaluation of colregs-constrained interactions between autonomous surface vessels and human operated vessels in collaborative human-machine partnering missions. In *OCEANS 2018 MTS/IEEE Kobe Japan*, May 2018.

2017 (4 items)

3. Michael R. Benjamin. Fast-CPA: A layered caching algorithm for rapid closest point of approach calculations in marine collision avoidance. In *OCEANS 2017 MTS/IEEE Anchorage*, Anchorage, AK, September 2017.

4. Michael R. Benjamin. Autonomous colregs modes and velocity functions. Technical Report MIT-CSAIL-TR-2017-009, MIT Computer Science and Artificial Intelligence Lab, May 2017.

5. Kyle L. Woerner, Michael Novitzky, Michael R. Benjamin, and John J. Leonard. Legibility and predictability of protocol-constrained motion: Evaluating human-robot ship interactions under COLREGS collision avoidance requirements. In *In Workshop on Mathematical Models, Algorithms, and Human-Robot Interaction at RSS 2017*, Cambridge, MA, July 2017.

6. Joseph W. Leavitt. Intent-aware collision avoidance for autonomous marine vehicles. Master's thesis, Massachusetts Institute of Technology, June 2017.

2016 (2 items)

7. Kyle L. Woerner, Michael R. Benjamin, Michael Novitzky, and John J. Leonard. Collision avoidance road test for colregs-constrained autonomous vehicles. In *OCEANS 2016 MTS/IEEE Monterey*, pages 1–6, September 2016.

8. Kyle L. Woerner. *Multi-Contact Protocol-Constrained Collision Avoidance for Autonomous Marine Vehicles*. PhD thesis, Massachusetts Institute of Technology, June 2016.

2015 (1 item)

9. Kyle L. Woerner and Michael R. Benjamin. Autonomous collision avoidance tradespace analysis for high-speed vessels. In *13th International Conference on Fast Sea Transportation. Society of Naval Architects and Marine Engineers*, 2015.

2014 (2 items)

10. Kyle Woerner. Colregs-compliant autonomous collision avoidance using multi-objective optimization with interval programming. Master's thesis, Massachusetts Institute of Technology, Cambridge MA, June 2014.

11. Kyle Woerner and Michael Benjamin. Safety and efficiency analysis of autonomous collision avoidance using multi-objective optimization with interval programming. *Naval Engineers Journal*, 126(4):163–168, 2014.

2006 (2 items)

12. Michael R. Benjamin, John J. Leonard, Joseph A. Curcio, and Paul M. Newman. A method for protocol-based collision avoidance between autonomous marine surface craft. *Journal of Field Robotics*, 23(5):333 – 346, 2006.

13. Michael R. Benjamin, Joseph A. Curcio, and Paul M. Newman. Navigation of unmanned marine vehicles in accordance with the rules of the road. *Proceedings 2006 IEEE International Conference on Robotics & Automation, 2006. ICRA 2006*, page 3581, May 2006.

References

[1] Michael R. Benjamin. Autonomous colregs modes and velocity functions. Technical Report MIT-CSAIL-TR-2017-009, MIT Computer Science and Artificial Intelligence Lab, May 2017.

[2] Michael R. Benjamin. Fast-CPA: A layered caching algorithm for rapid closest point of approach calculations in marine collision avoidance. In *OCEANS 2017 MTS/IEEE Anchorage*, Anchorage, AK, September 2017.

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[12] Kyle L. Woerner, Michael R. Benjamin, Michael Novitzky, and John J. Leonard. Collision avoidance road test for colregs-constrained autonomous vehicles. In *OCEANS 2016 MTS/IEEE Monterey*, pages 1–6, September 2016.

[13] Kyle L. Woerner, Michael Novitzky, Michael R. Benjamin, and John J. Leonard. Legibility and predictability of protocol-constrained motion: Evaluating human-robot ship interactions under COLREGS collision avoidance requirements. In *In Workshop on Mathematical Models, Algorithms, and Human-Robot Interaction at RSS 2017*, Cambridge, MA, July 2017.