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**SARA, Inc.**

# **Making the Right (Starboard) Turn: Developing and Deploying COLREGs Behaviors**

**MOOS Development and Applications Working Group**  
**Cambridge, MA, August 24-25, 2010**

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# Overview

- **About SARA**
- **Objective: COLREGs**
- **Vehicles**
- **Deployment Strategy**
- **Demo**

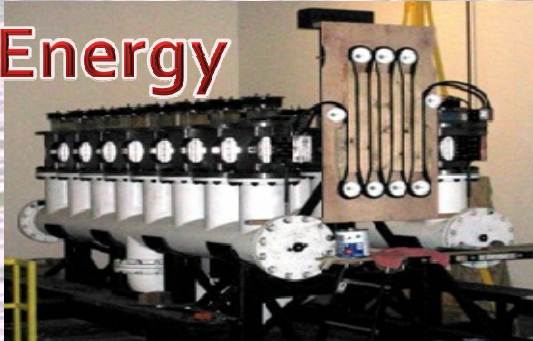


# SARA, Inc.

*"The special projects division  
of a Major Defense Contractor ...  
...Without the Major Defense Contractor"*



**Alternative  
Energy**



**Advanced RF**



**High Power  
Microwave**



**EMP  
Hardening**



**High Power  
Acoustics**



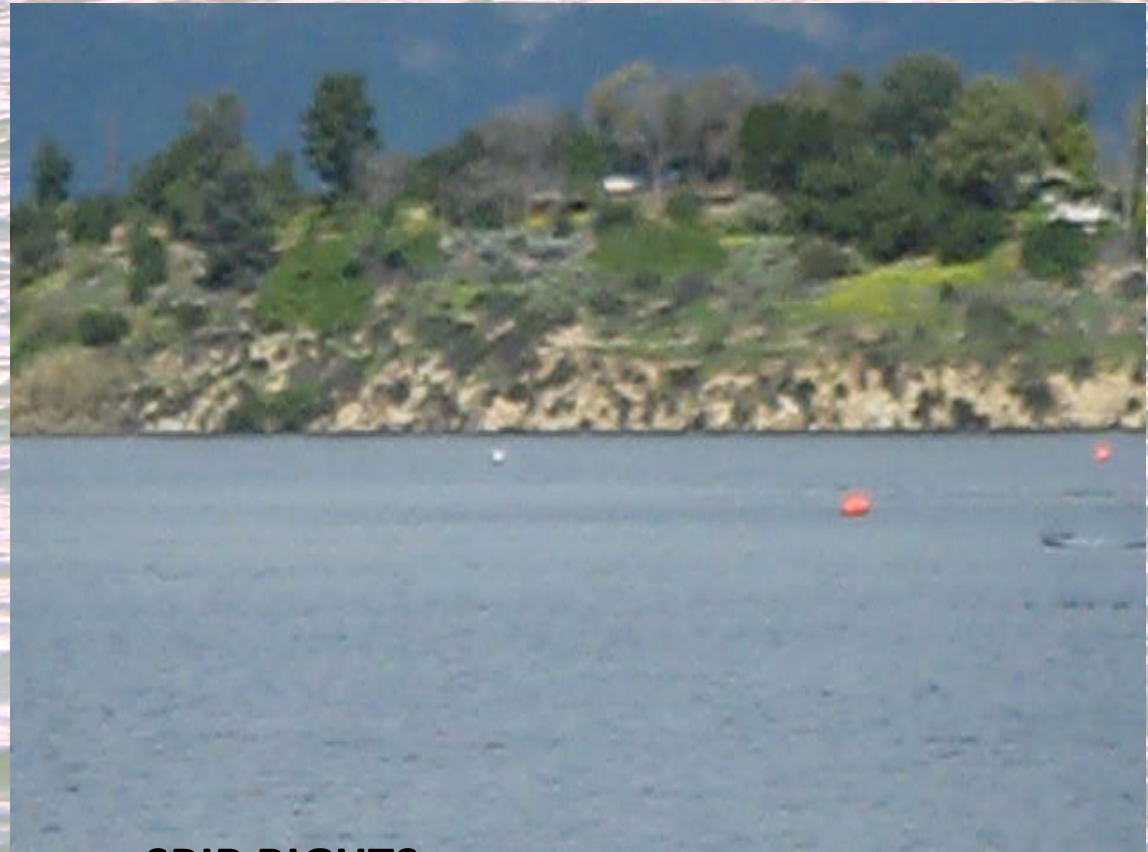
**Ground  
Robotics**





# Objective: COLREGs

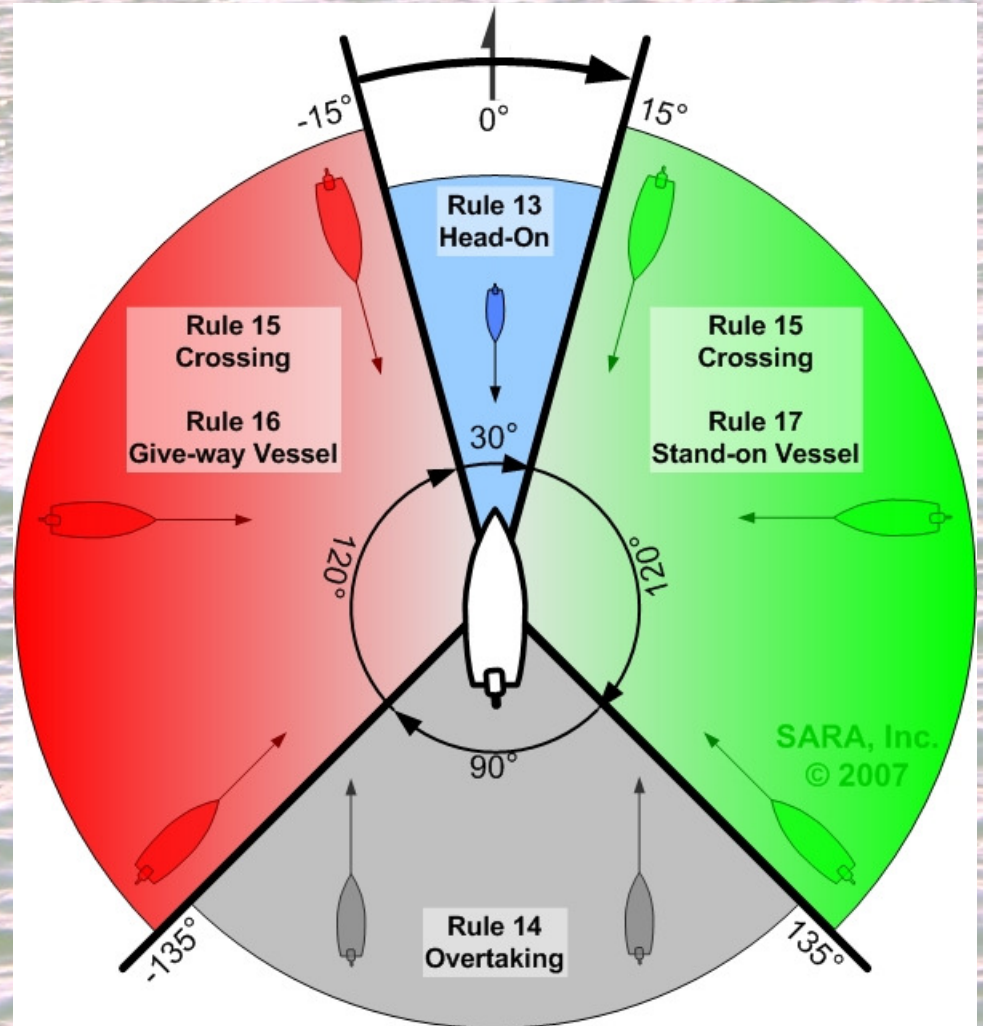
- Collision Avoidance
- Follow int'l rules of the road





# Objective: COLREGs

- Head-On
- Crossing
  - Give-way
  - Stand-on
- Overtaking
  - Overtaking
  - Being OT







# Vehicles

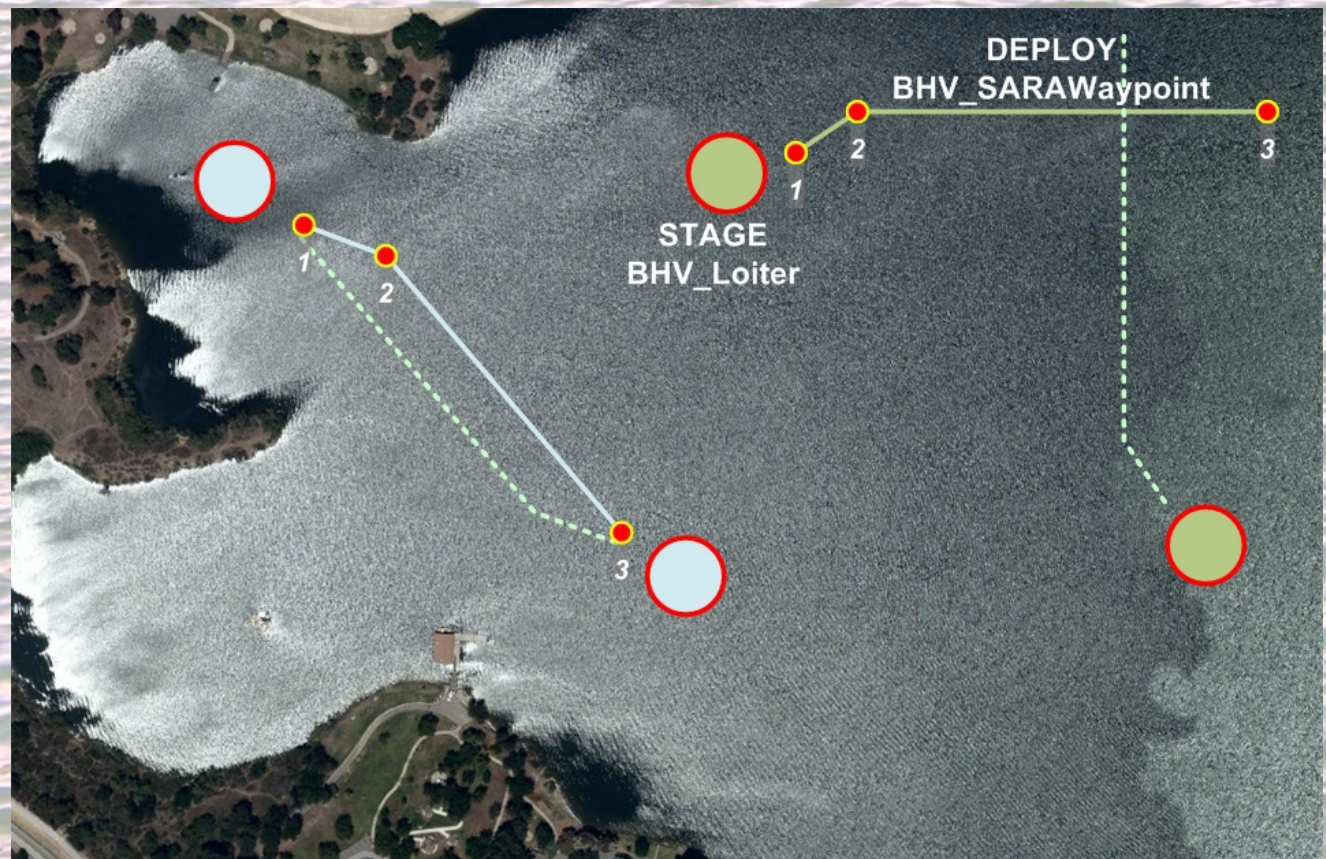
- AHab, CHab, SimHab
- QBoat
- HAB1, HAB2...





# Deployment Strategy

- Logistics
  - GoHere
- Scenarios
  - Stage
  - Deploy







# Deployment BHV Strategy

```
initialize STAGE = false  
initialize DEPLOY = false  
initialize GOHERE = false  
initialize IDLE = true
```

Start in IDLE

```
Behavior = BHV_StationKeep  
  name = STAGE_HAB1  
  UPDATES = STAGE_UPDATE  
  condition = STAGE = true
```

STAGE

```
Behavior = BHV_StationKeep  
  name = GOHERE_HAB1  
  UPDATES = GOHERE_UPDATE  
  condition = GOHERE = true
```

GOHERE

```
Behavior = BHV_SARA_WAYPOINT  
  UPDATES = TRACK_UPDATE  
  condition = DEPLOY = true
```

DEPLOY





# COLREGs BHV Strategy

```

initialize COLREG_OT           = false
initialize COLREG_B_OT         = false
initialize COLREG_HO           = false
initialize COLREG_CROSSGW      = false
initialize COLREG_CROSSSO      = false

```

Start with no active BHV

```

Behavior           = BHV_SARA_CROSSING_GW
condition          = CROSS           = true
condition          = (COLREG_OT      != true)
condition          = (COLREG_B_OT    != true)
condition          = (COLREG_CROSSSO != true)
condition          = (COLREG_HO      != true)
activeflag         = COLREG_CROSSGW  = true
inactiveflag      = COLREG_CROSSGW  = false

```

Only runs when user flag = T

Only runs when other COLREGs BHV are off

When active, stop other COLREGs BHV

When inactive, let other COLREGs BHV know

HAB1	HAB2
Avoid <input checked="" type="checkbox"/>	Avoid <input checked="" type="checkbox"/>
Cross <input checked="" type="checkbox"/>	Cross <input checked="" type="checkbox"/>
HeadO <input type="checkbox"/>	HeadO <input type="checkbox"/>
OverT <input type="checkbox"/>	OverT <input type="checkbox"/>

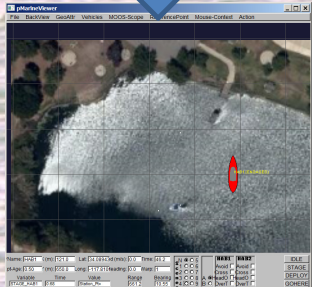




# Deployment Strategy

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User click



MVIEWER\_xCLICK

iClickLoiter

GOHERE\_HABx

pMOOSBridge

UPDATE\_GOHERE



User selects scene then DEPLOY



SCENE

DEPLOY (= T)

iClickLoiter

TRACK\_HABx  
DEPLOY (= T)

pMOOSBridge

TRACK\_UPDATE  
DEPLOY (= T)



User toggles behaviors



Avoid\_HABx (T/F)  
Cross\_HABx (T/F)  
HO\_HABx (T/F)  
OT\_HABx (T/F)

pMOOSBridge

Avoid (T/F)  
Cross (T/F)  
HeadOn (T/F)  
Overtake (T/F)

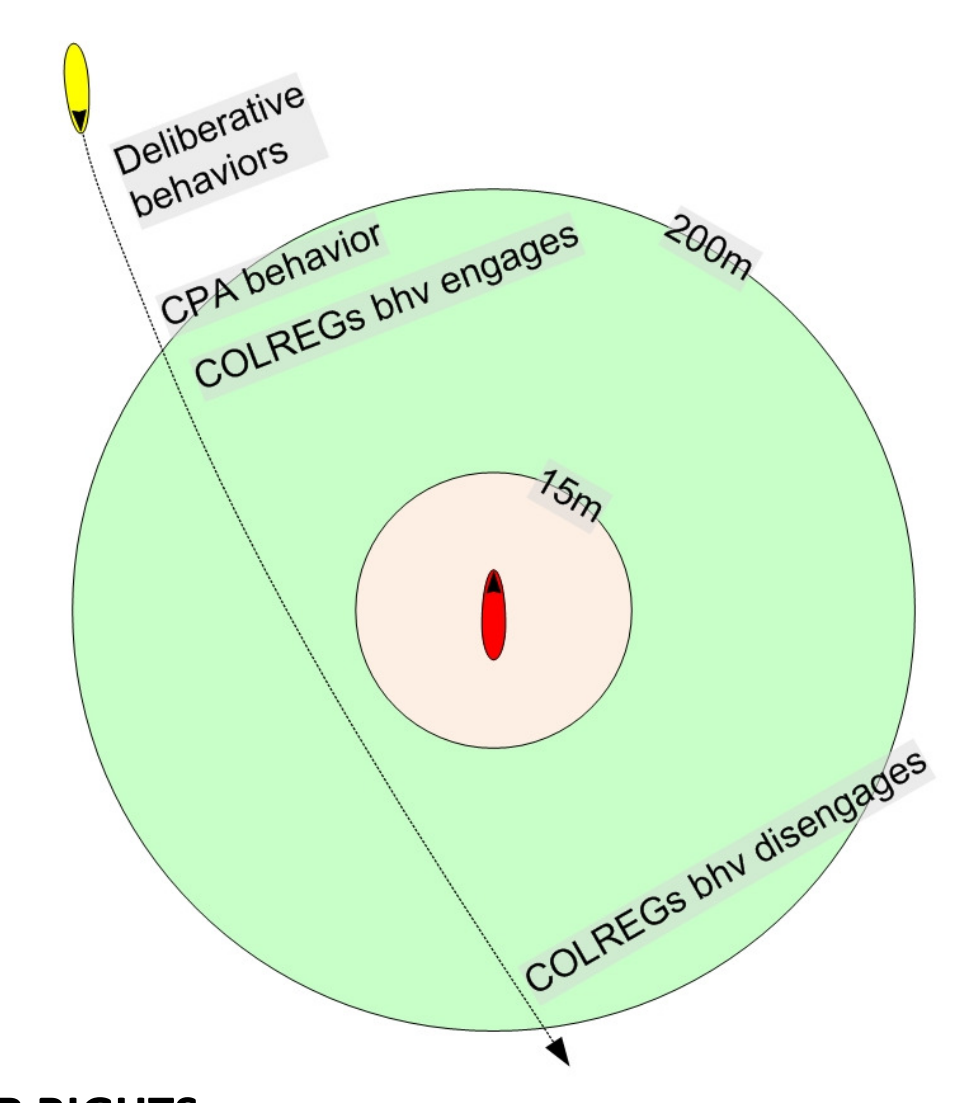
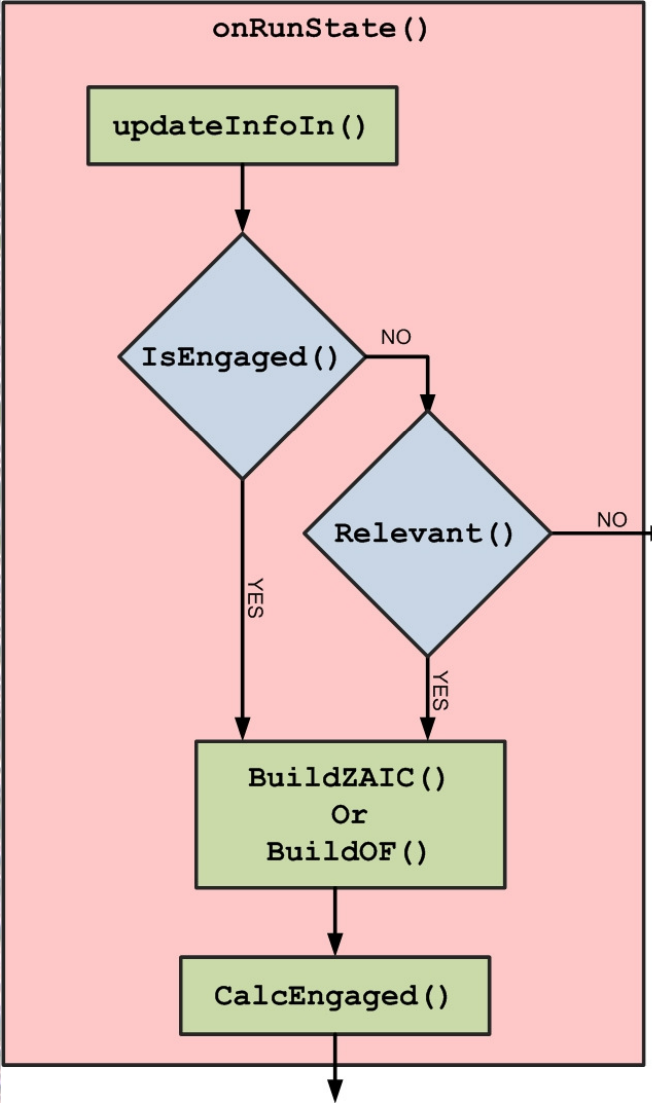


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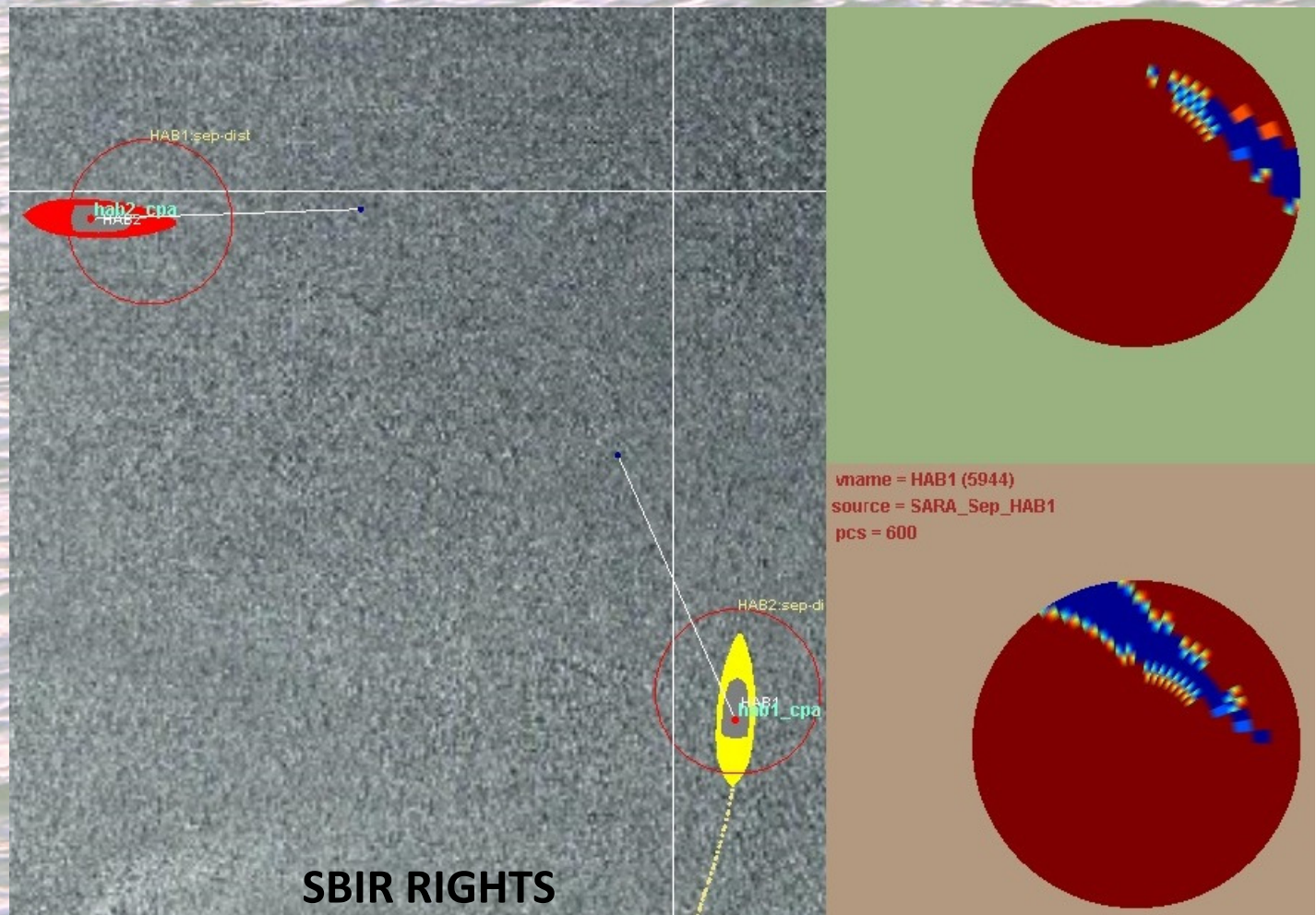
# Deployment BHV Strategy





# COLREGs BHV Strategy

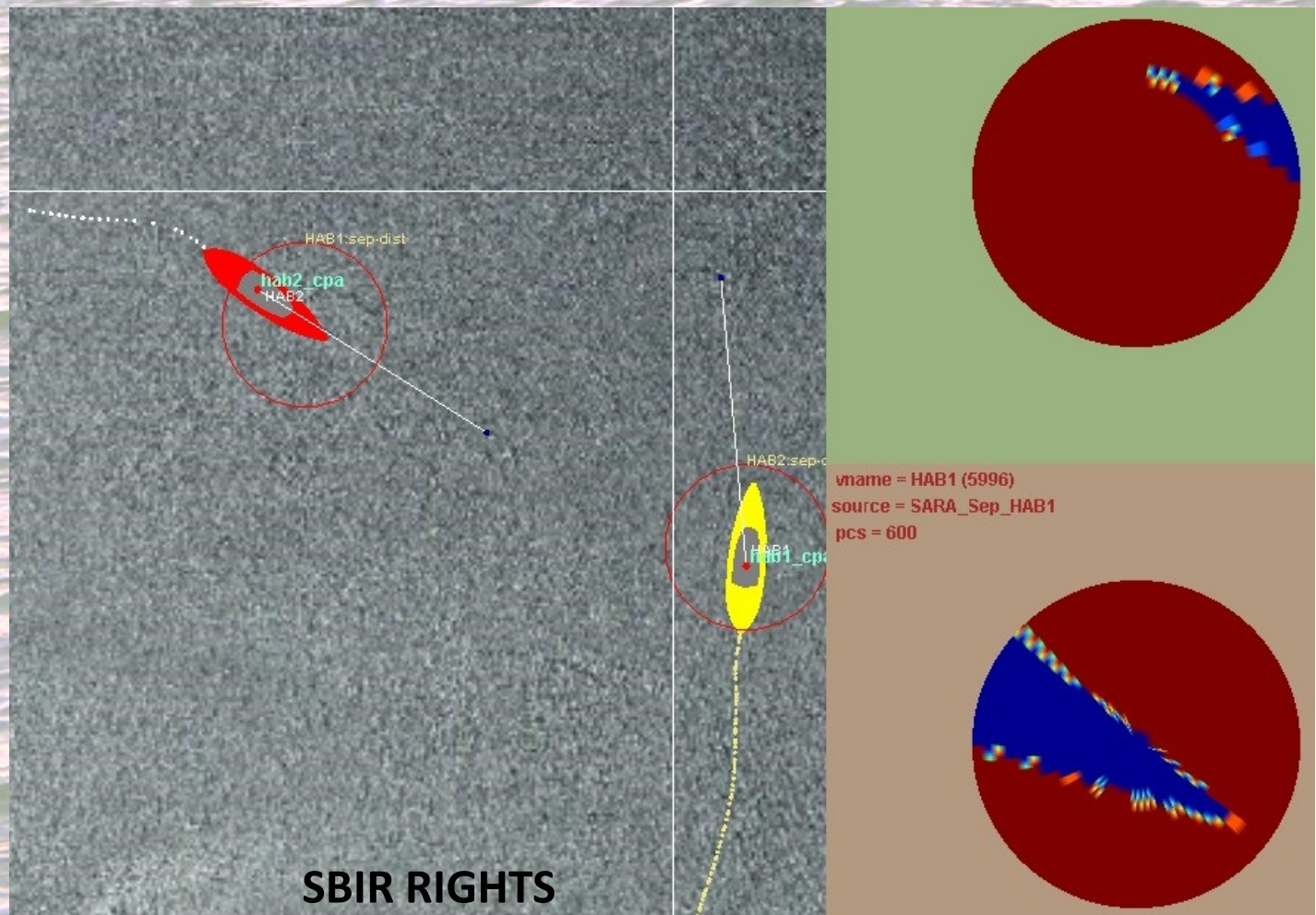
- Separation Behavior





# COLREGs BHV Strategy

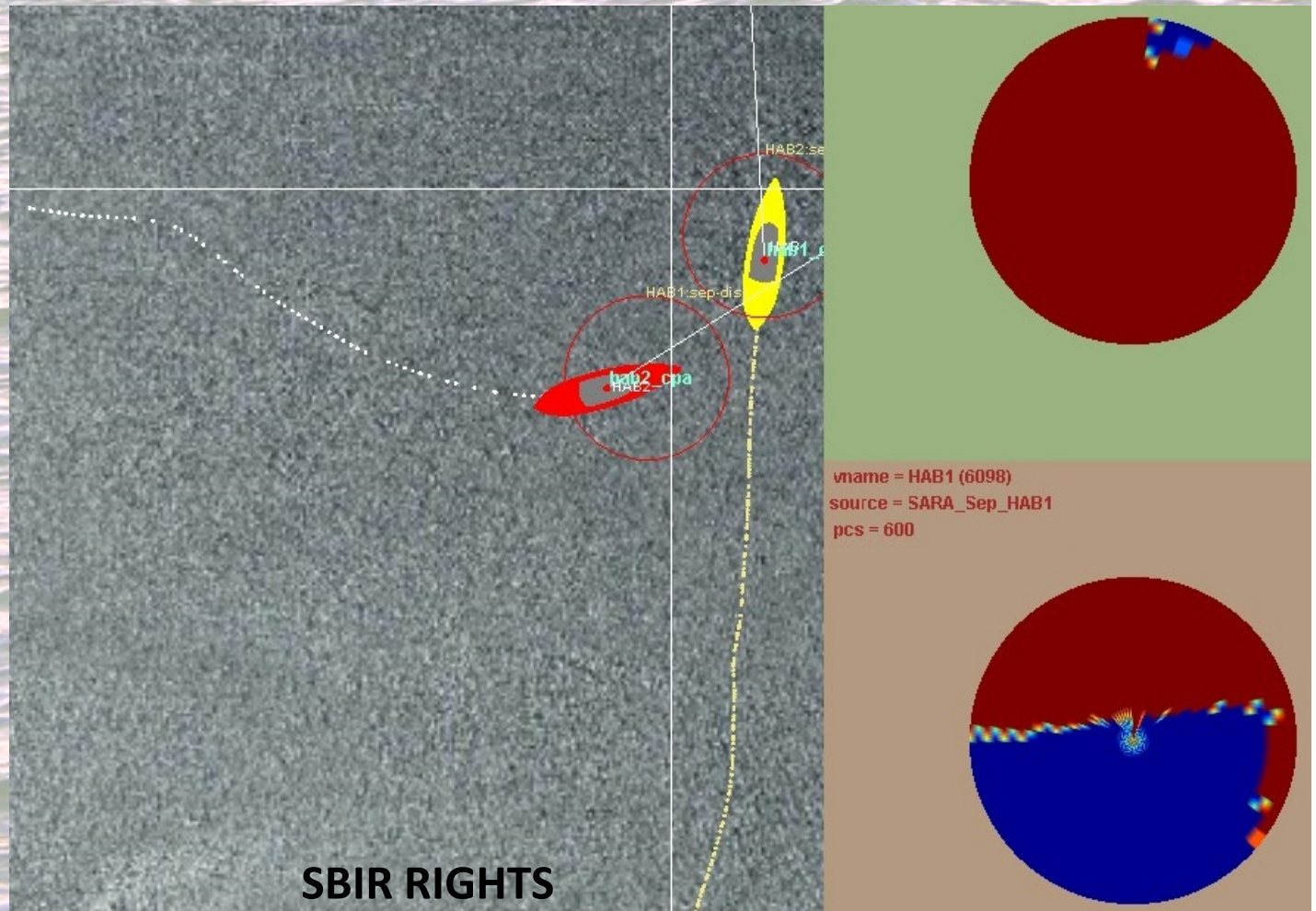
- Separation Behavior





# COLREGs BHV Strategy

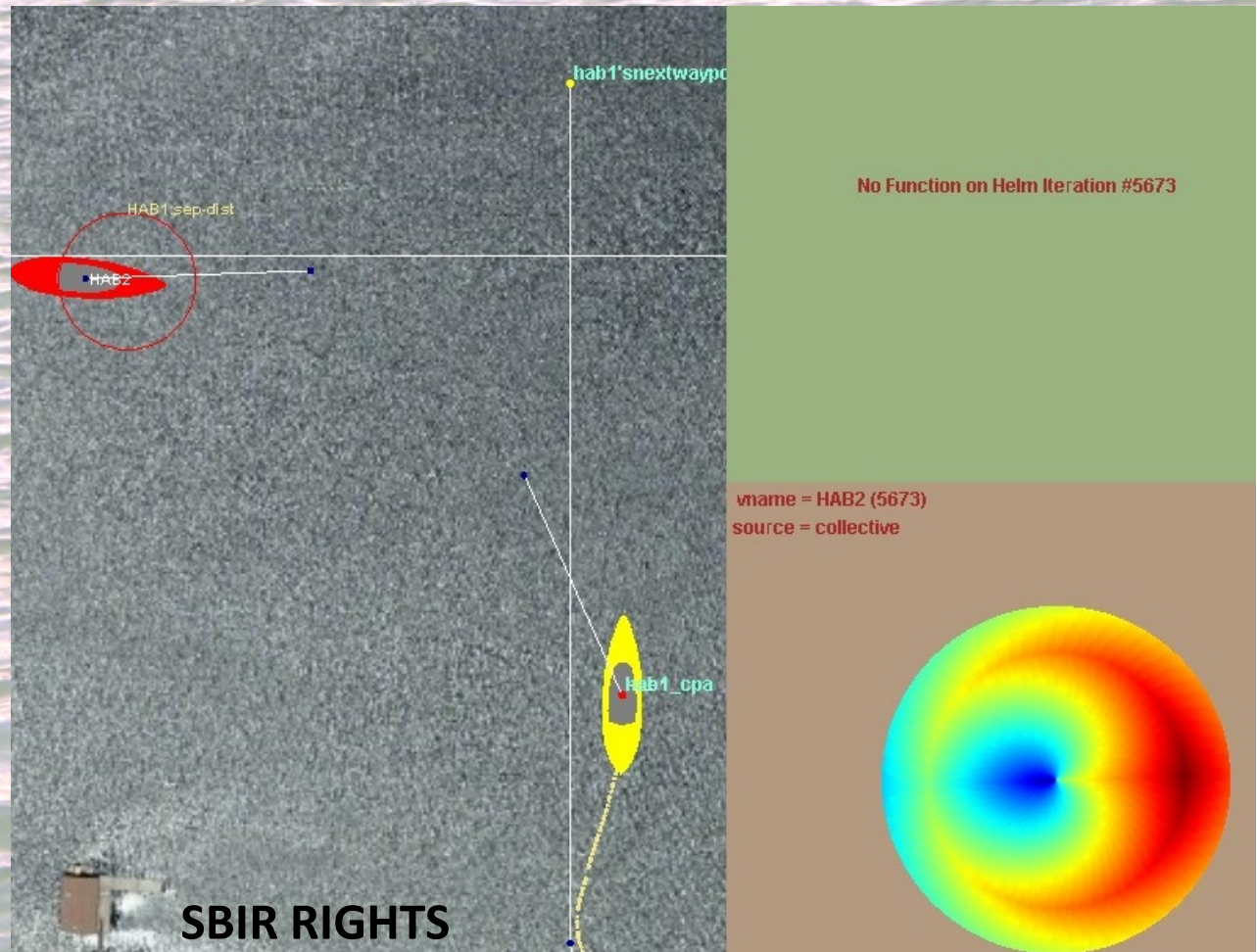
- Separation Behavior





# COLREGs BHV Strategy

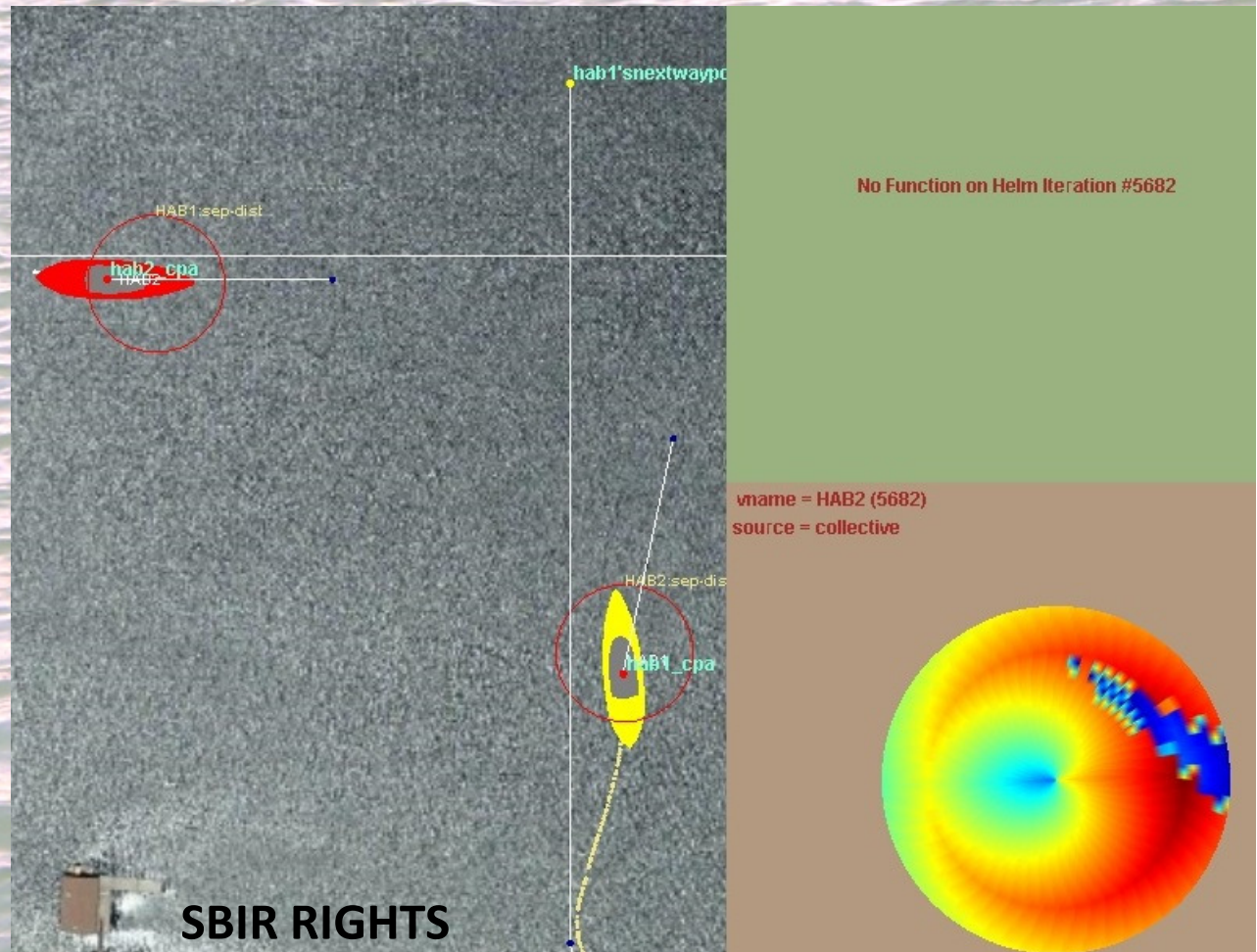
- Crossing Give-Way Behavior





# COLREGs BHV Strategy

- Crossing Give-Way Behavior







# Multi-Vehicle UI

**pSARViewer** [Window Title Bar]

ALL	TBD1	TBD2	TBD3	TBD4	TBD5
<b>Scenarios</b> ○ 1 ○ ○ 2 ○ ○ 3 ○ ○ 4 ○ ○ 5 ○ ○ 6 ○ ○ 7 ○ ○ 8 ○ ○ 9 ○ A B	No Connection Rel. Range Rel. Bearing 000° 2.00 0.0 m/s Role 1 2 3 4 5	No Connection Rel. Range Rel. Bearing 000° 2.00 0.0 m/s Role 1 2 3 4 5	No Connection Rel. Range Rel. Bearing 000° 2.00 0.0 m/s Role 1 2 3 4 5	No Connection Rel. Range Rel. Bearing 000° 2.00 0.0 m/s Role 1 2 3 4 5	No Connection Rel. Range Rel. Bearing 000° 2.00 0.0 m/s Role 1 2 3 4 5
<input type="checkbox"/> AVOID <input type="checkbox"/> CROSS <input type="checkbox"/> HEAD ON <input type="checkbox"/> OVERTAKE	<input type="checkbox"/> AVOID <input type="checkbox"/> CROSS <input type="checkbox"/> HEAD ON <input type="checkbox"/> OVERTAKE	<input type="checkbox"/> AVOID <input type="checkbox"/> CROSS <input type="checkbox"/> HEAD ON <input type="checkbox"/> OVERTAKE	<input type="checkbox"/> AVOID <input type="checkbox"/> CROSS <input type="checkbox"/> HEAD ON <input type="checkbox"/> OVERTAKE	<input type="checkbox"/> AVOID <input type="checkbox"/> CROSS <input type="checkbox"/> HEAD ON <input type="checkbox"/> OVERTAKE	<input type="checkbox"/> AVOID <input type="checkbox"/> CROSS <input type="checkbox"/> HEAD ON <input type="checkbox"/> OVERTAKE
<b>IDLE</b>	<b>IDLE</b>	<b>IDLE</b>	<b>IDLE</b>	<b>IDLE</b>	<b>IDLE</b>
PAUSE	PAUSE	PAUSE	PAUSE	PAUSE	PAUSE
LOITER NOW	LOITER NOW	LOITER NOW	LOITER NOW	LOITER NOW	LOITER NOW
GO HERE	GO HERE	GO HERE	GO HERE	GO HERE	GO HERE
STAGE	STAGE	STAGE	STAGE	STAGE	STAGE
DEPLOY	DEPLOY	DEPLOY	DEPLOY	DEPLOY	DEPLOY