Multi vehicle control

The DVZ approach

- 287 People
  - 125 researchers, 28 engineers, 134 Ph.D.
- 3 departments
  - Microélectronics
  - Computer Science
  - Robotics
    - Medical Robotics
    - Vision
    - Networked robotics :
      - Underwater division

Underwater Robotics division

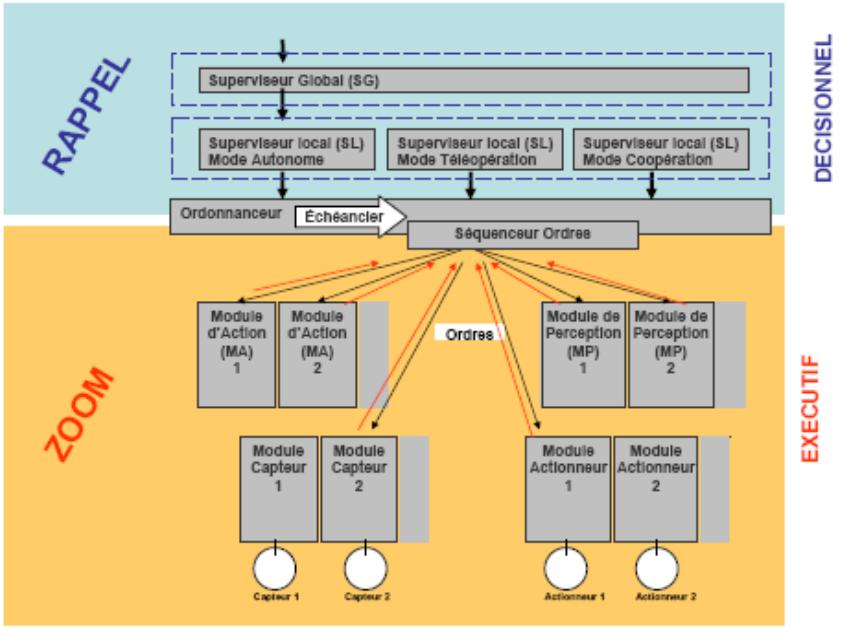
- Head : Bruno Jouvencel
- Associate : Lionel Lapierre
- Ph.D. : O. Parodi, X. Xiang, A. Eljalaoui, Open posit° (Sept 08)
- Collaborator s: D. Andreu, P. Fraisse, D. Crestani
- Vehicles : Taipan 2, 300.
- Topics : Software architecture, real time simulation, Mission control and programming, Collaborative control,

Underwater Robotics division

- Software architecture

  (A. Eljalaoui, D. Andreu, L. Lapierre)

  – Non interfering sensors recruitment
  – Real-time aspects
  – Modular design
  – Reusability



Underwater Robotics division

- Hardware architecture

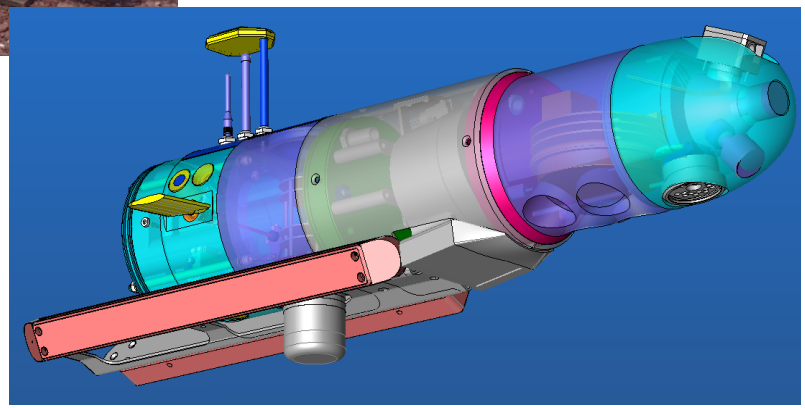
  (B. Jouvencel, A. Eljalaoui, O. Parodi, L. Lapierre)

Underwater Robotics division

- HIL Simulation

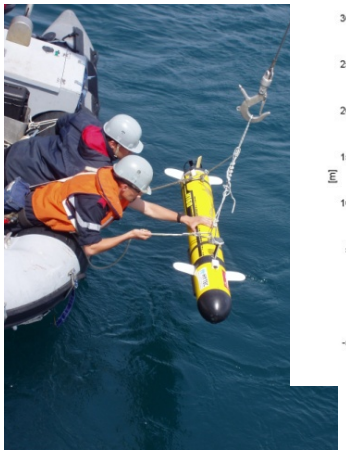
  (D. Andreu, A. Eljalaoui, O. Parodi, L. Lapierre)

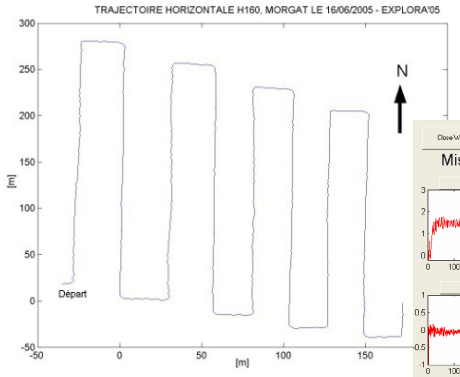
Vehicles

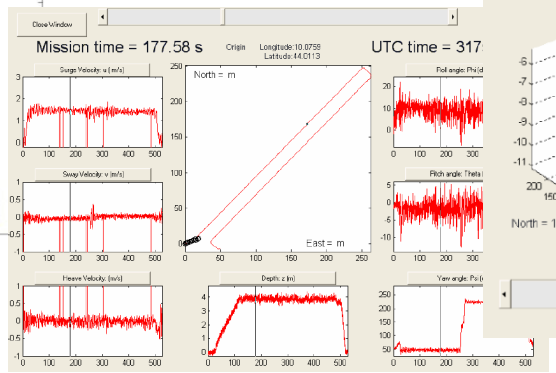


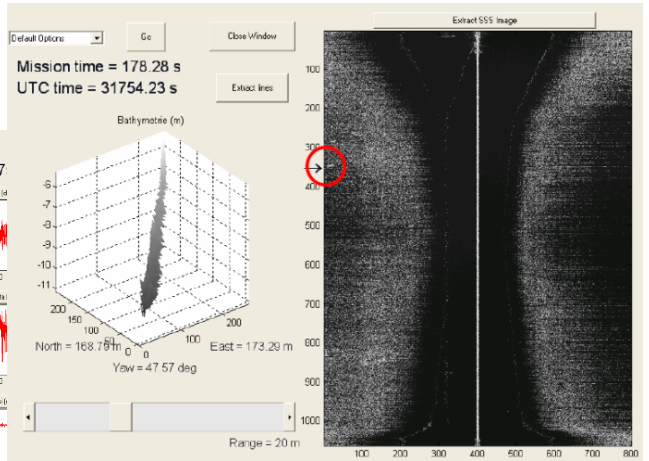
Side Scan Sonar
Elec. Pencil beam sonar
3 Echo sounders
DVL
2 MTI, 1 3DMG
2 depth sensors
CTD sensor
GPS, Radio, Wifi
Acoustic modem
Camera

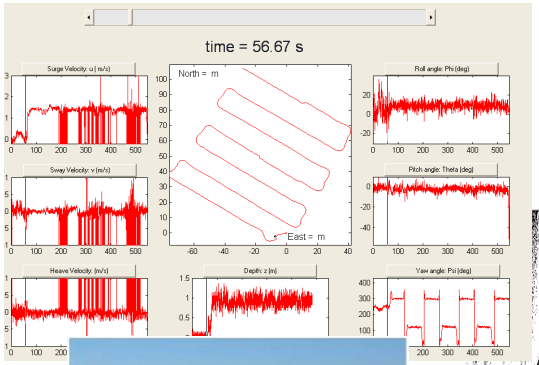
Missions

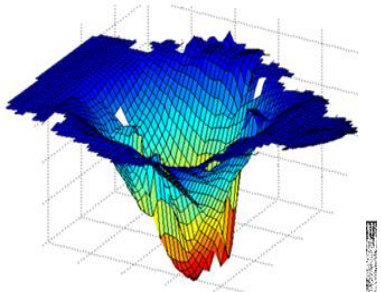


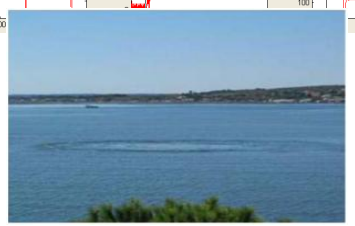


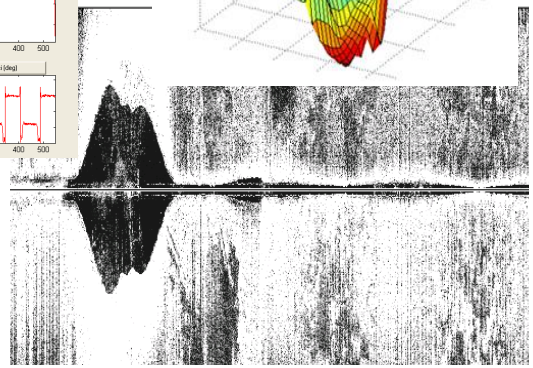






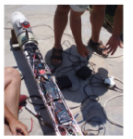






a. Emergency repair after the loss of a stabilizer.

b. Analysis of the internal heating problem.

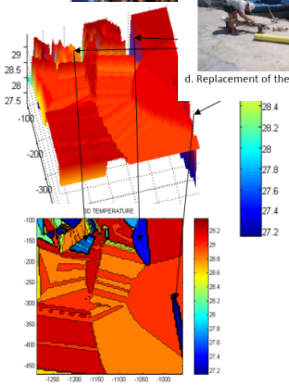


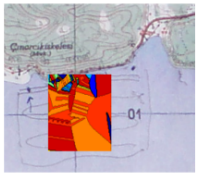
c. Replacing the defective wires

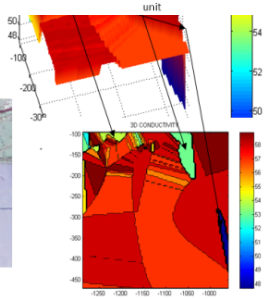
d. Replacement of the batteries

e. Finishing the reparation in the hotel room

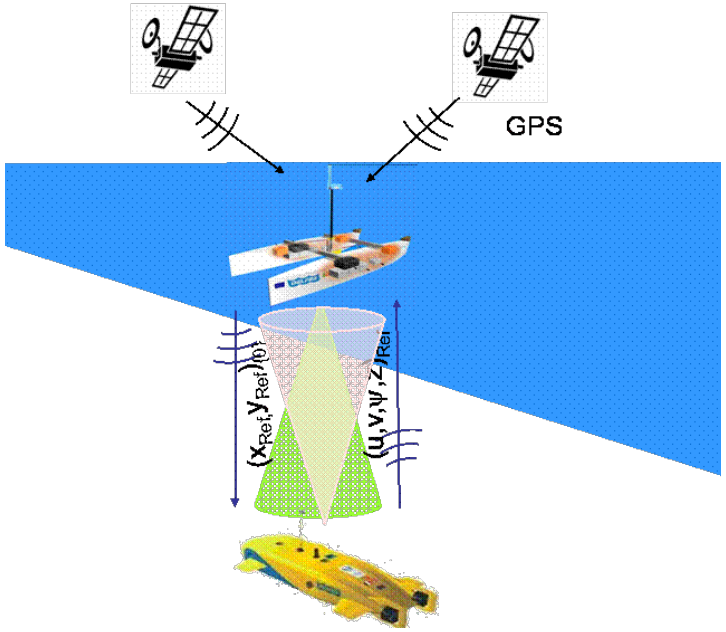
f. Emergency calibration of the attitude unit







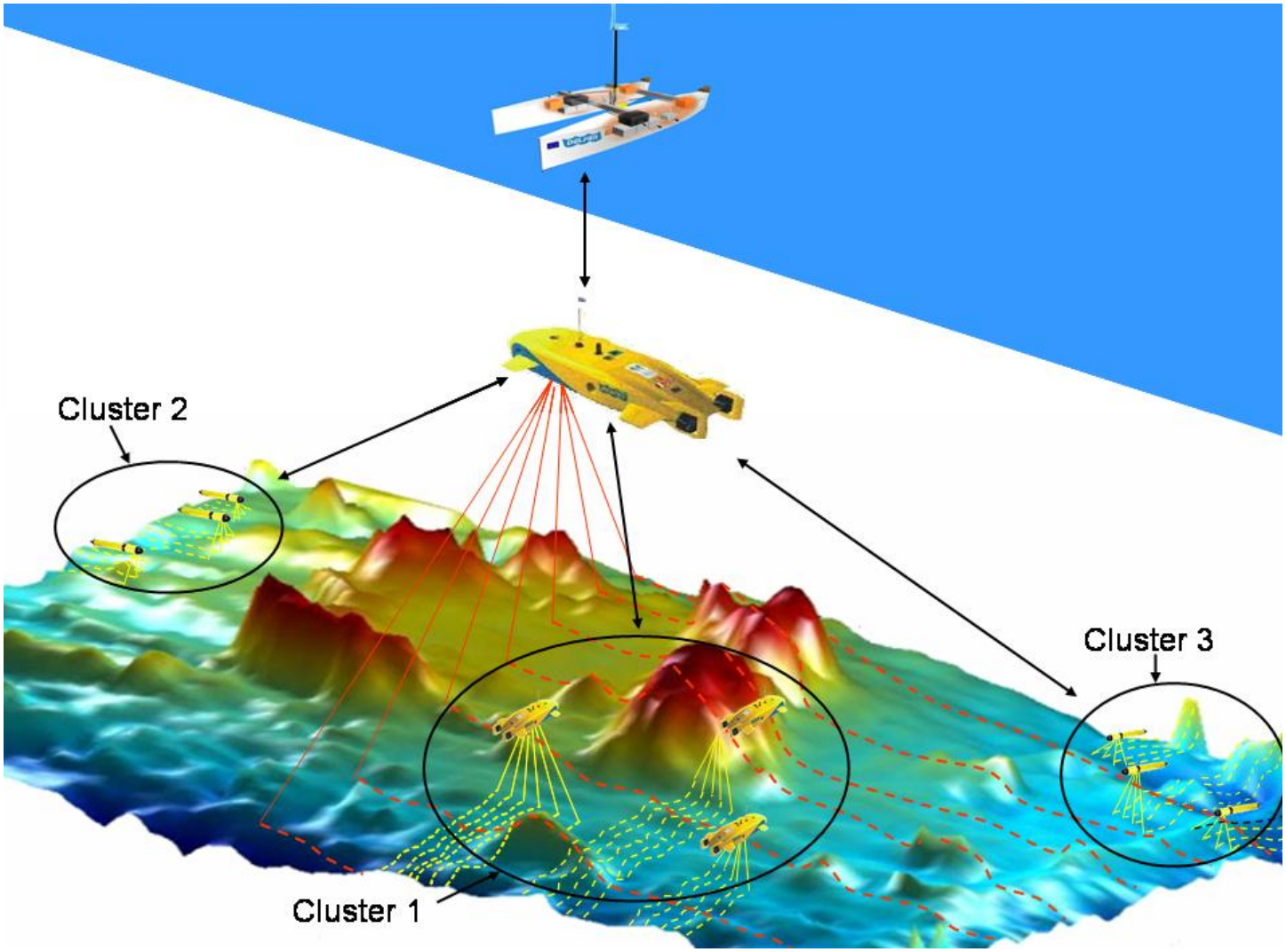
Missions




Charlie : catamaran autonome (CNR-ISSIA)


Taipan 2 : AUV (LIRMM)

Objectives

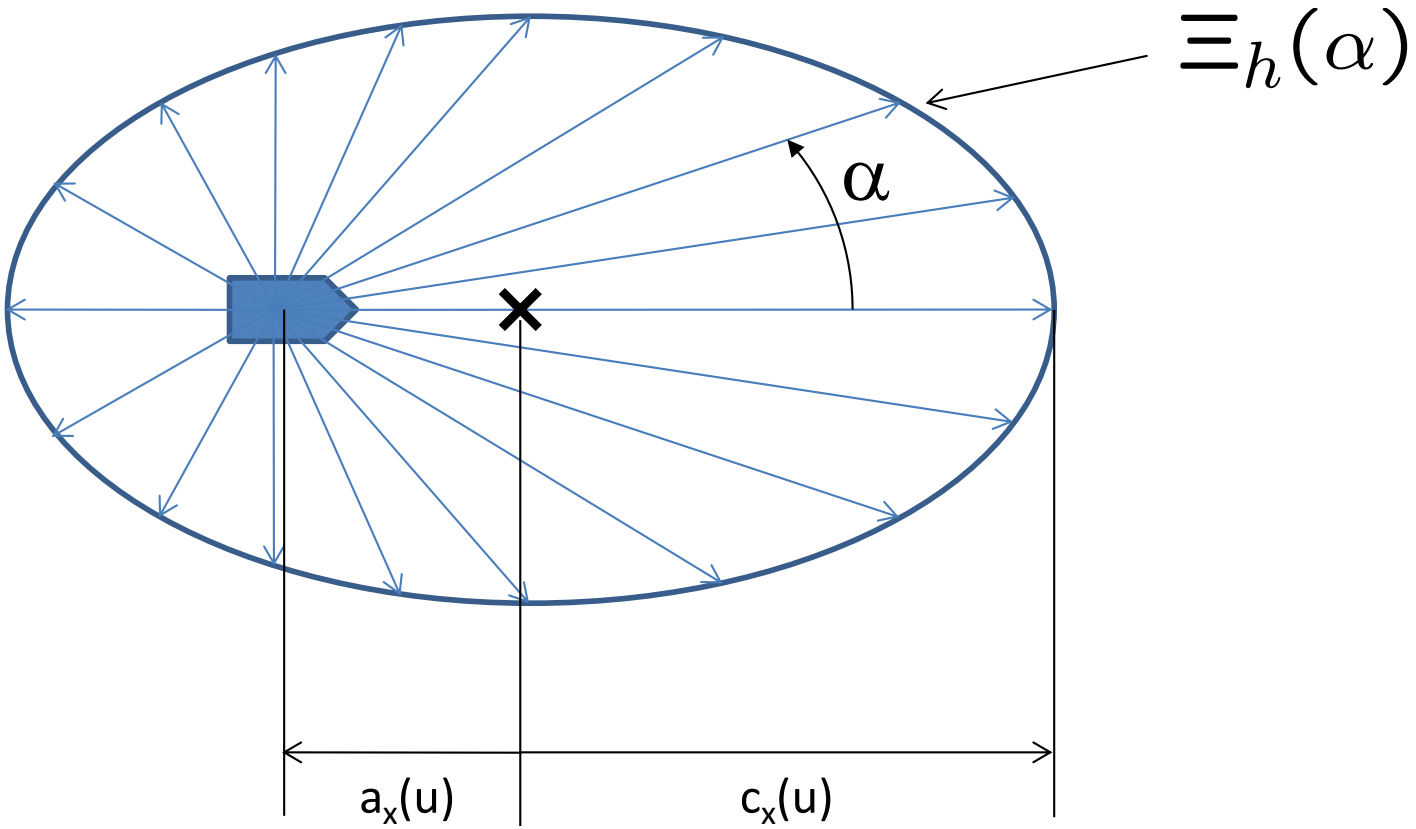


Underwater Robotics

- Main topics
  - Robust Control
  - Collaborative control
  - Software architecture
- Collaborative control
  - Collaborative path following
  - Formation control
  - Obstacle avoidance
  - Communication contraints and sensors recruitment
  - Delay in sensors acquisition and communication

DVZ Principe

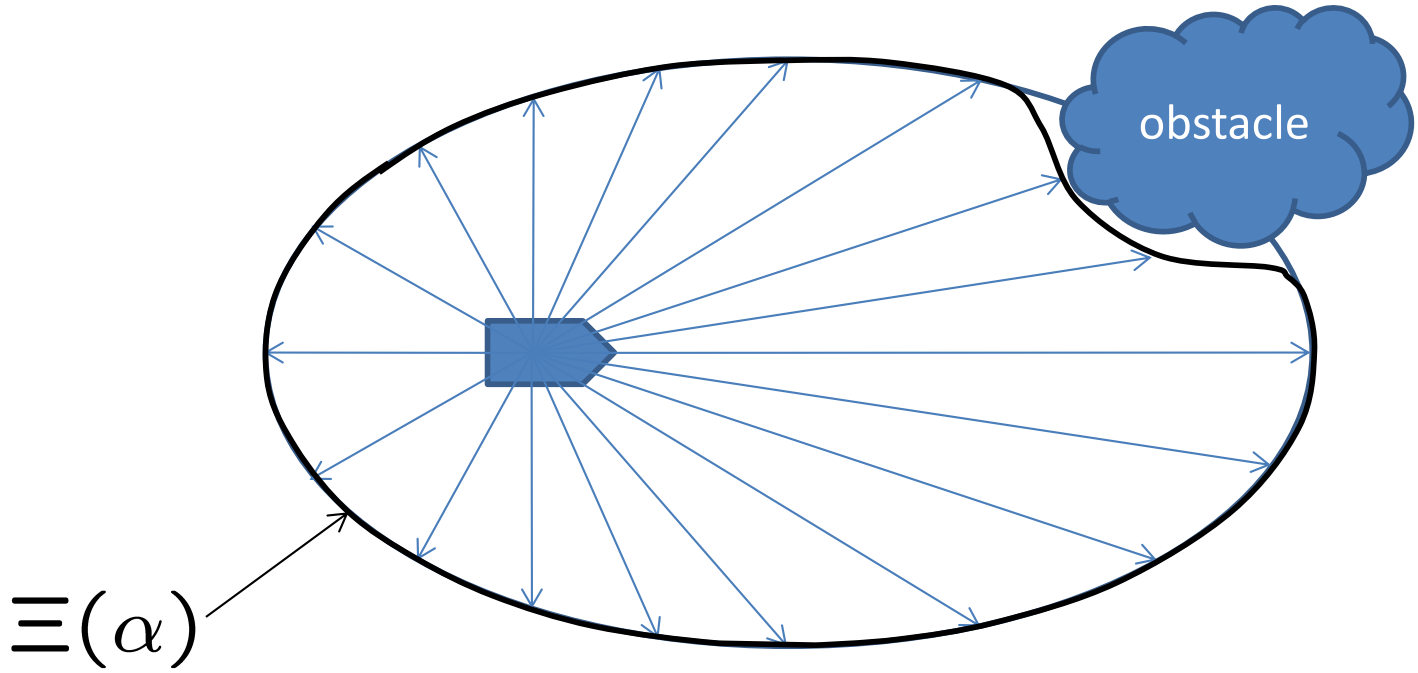
- Nominal DVZ composition



[Zapata]

DVZ Principe

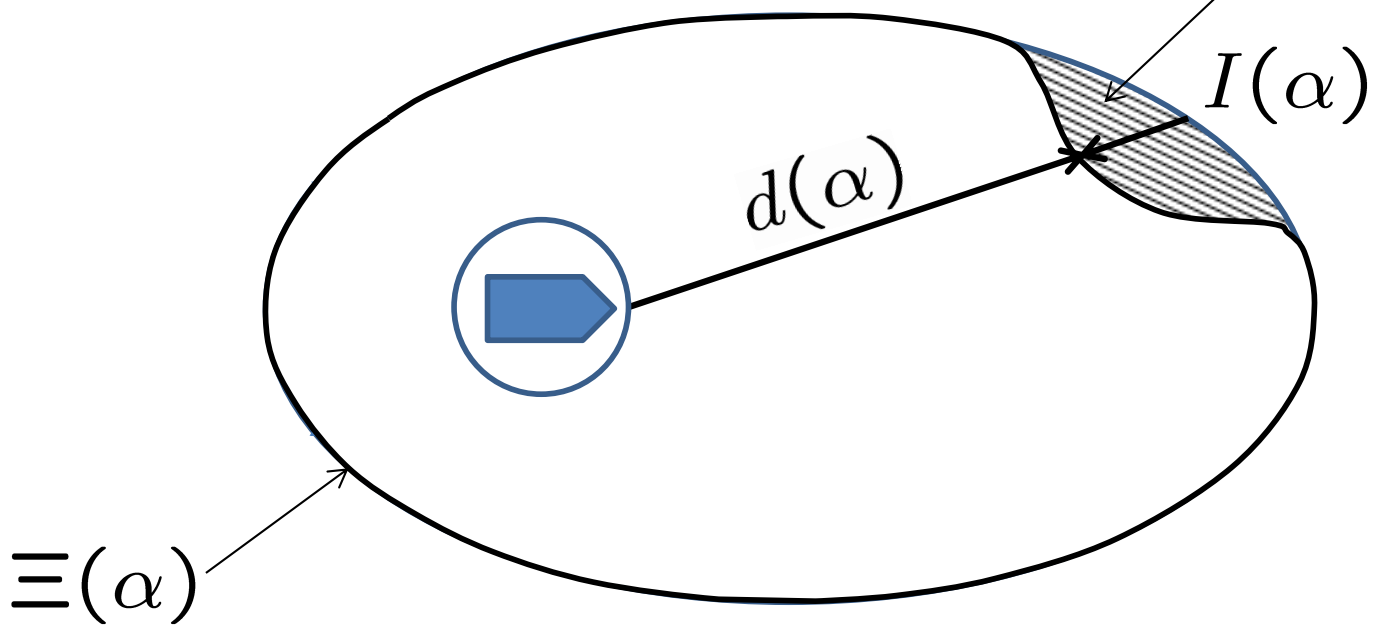
- Current DVZ composition



[Zapata]

DVZ Principe

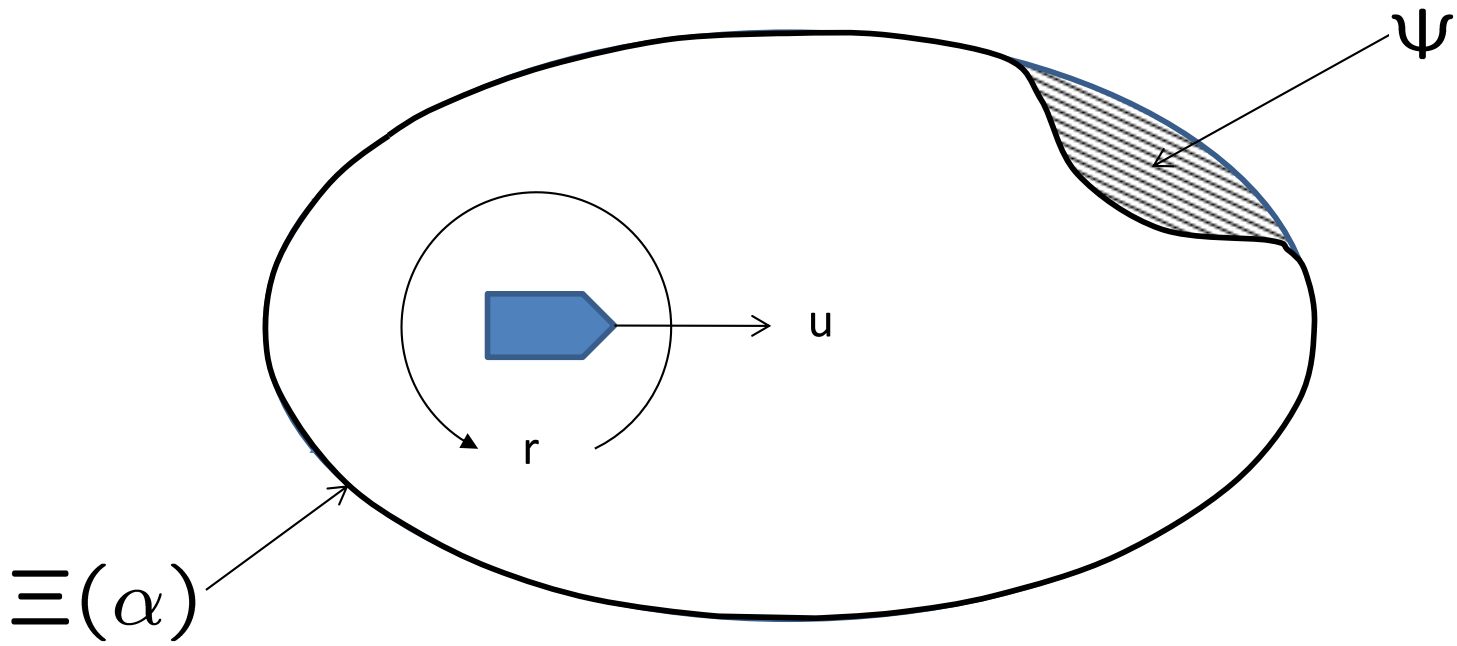
- The Intrusion function $\Psi = \int_0^{2\pi} I(\alpha) d\alpha$



[Lapierre, Zapata]

DVZ Principe

- The control reaction : $(\dot{u}, r)?/\Psi \rightarrow 0$

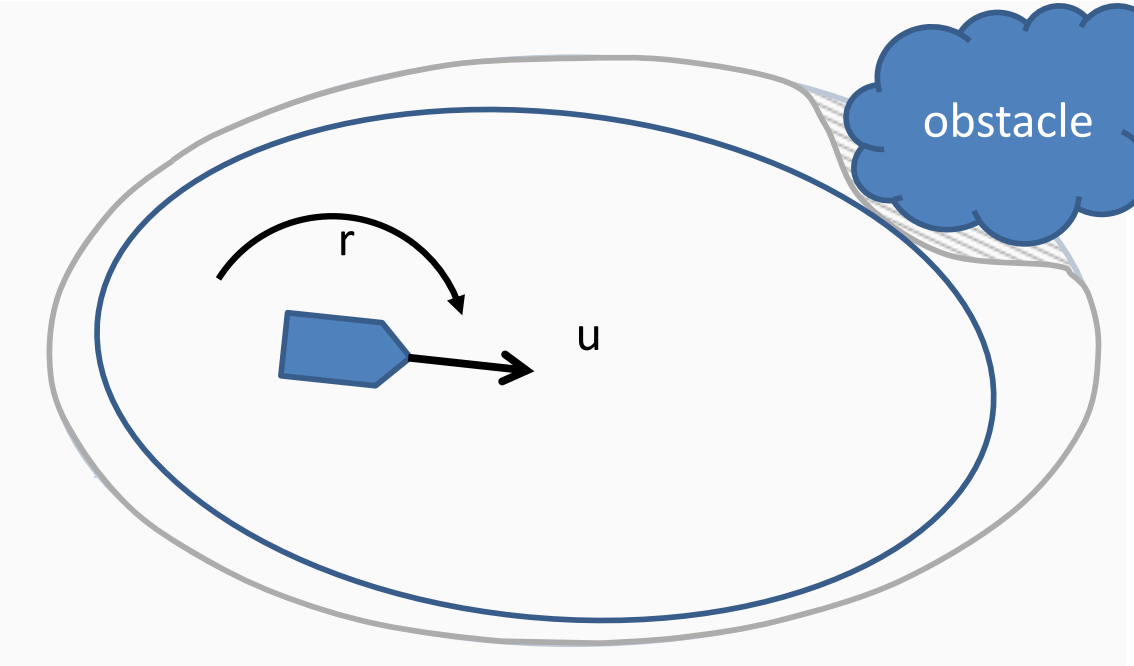


- Jacobian relation : $\dot{\psi} = J^{u}_{\Psi}\dot{u} + J^{\theta}_{\Psi}r + F^{Rob.vel}u + F^{Obst.vel}$

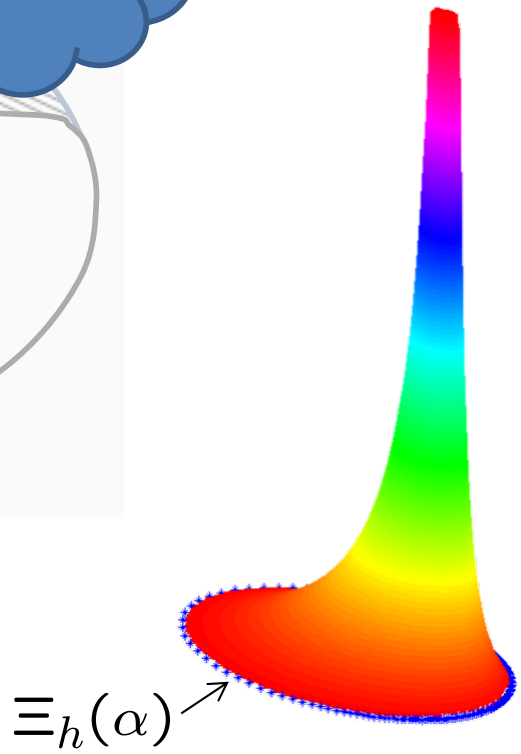
[Lapierre, Zapata]

DVZ Principe

- The control reaction :



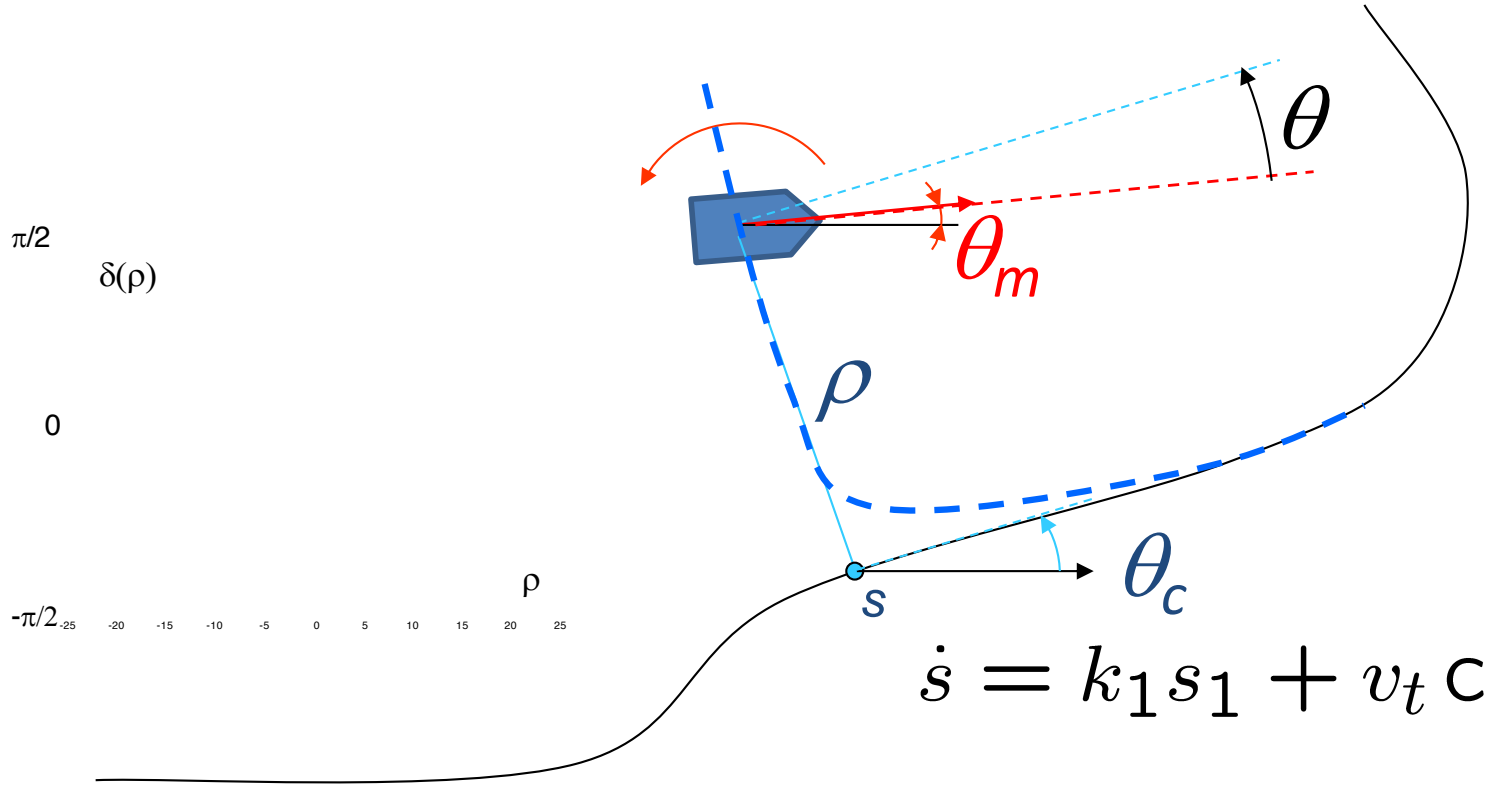
- Amplitude of the reaction :



[Lapierre, Zapata]

Coupling OA and Path Following

- Non singular Path Following



$$\dot{s} = k_1 s_1 + v_t \cos(\theta)$$

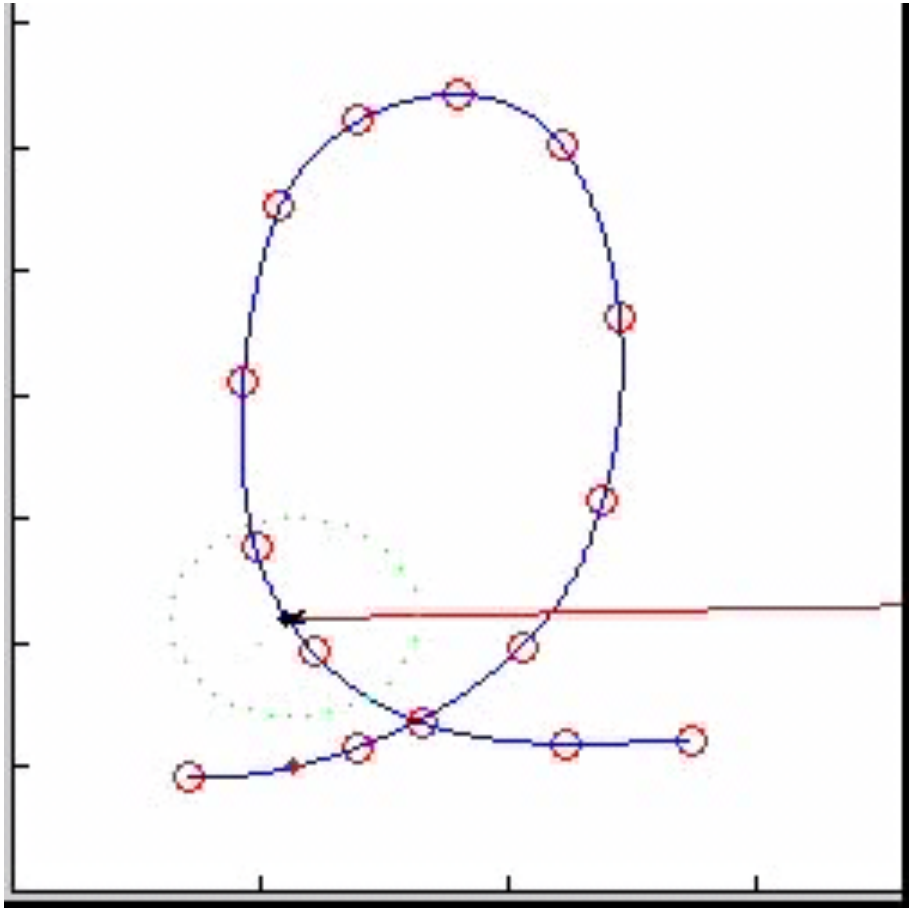
- The control objective:

$$(u, r)?/(\theta - \delta) \rightarrow 0$$

[Lapierre]

Coupling OA and Path Following

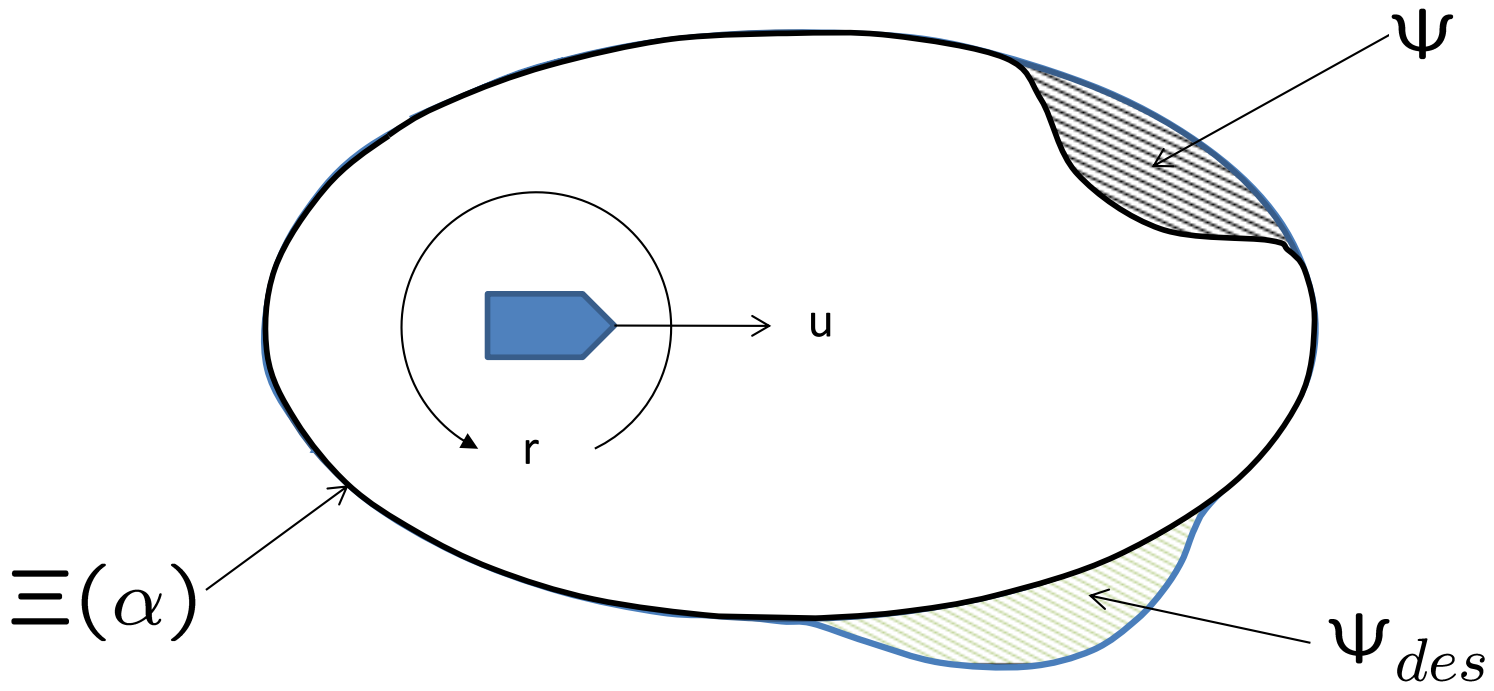
- Non singular Path Following



[Lapierre]

Coupling OA and Path Following

- Guidance combination



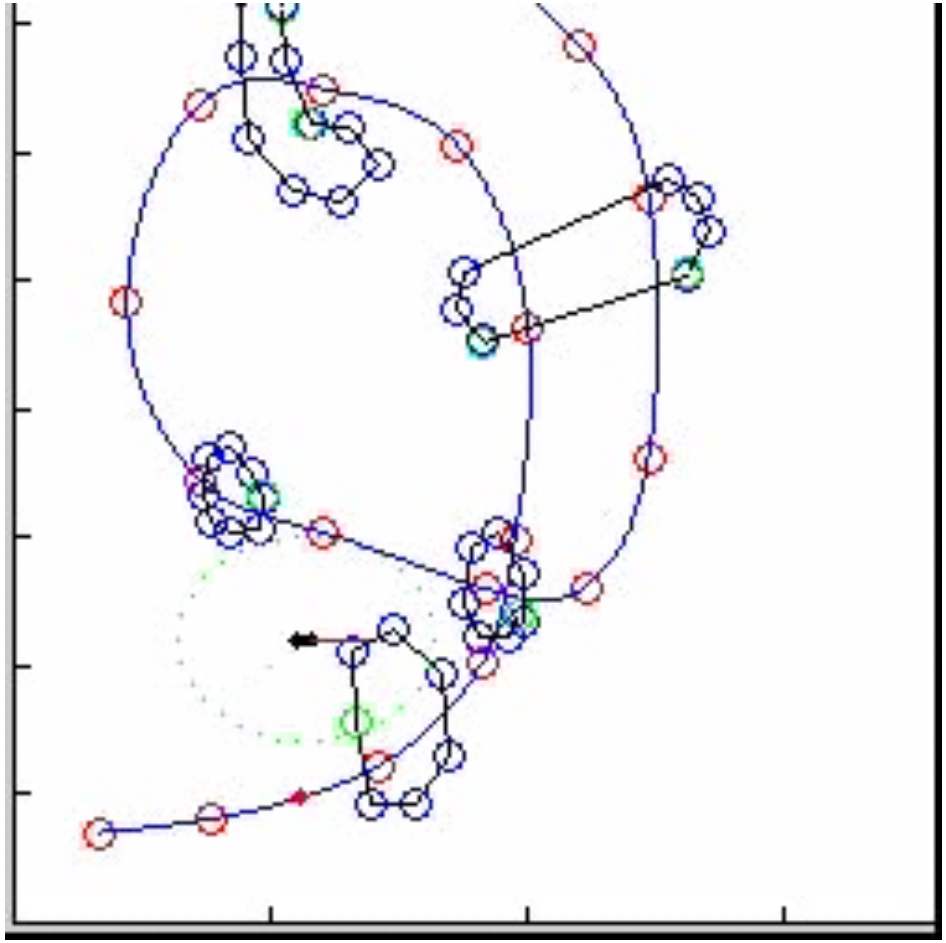
$$\Psi_{des} = K_d \tanh(\lambda_d(\theta - \delta))$$

$$[(\Psi_{des} - \Psi) \rightarrow 0] \Rightarrow [(\theta - \delta) \rightarrow 0]$$

[Lapierre, Zapata]

Coupling OA and Path Following

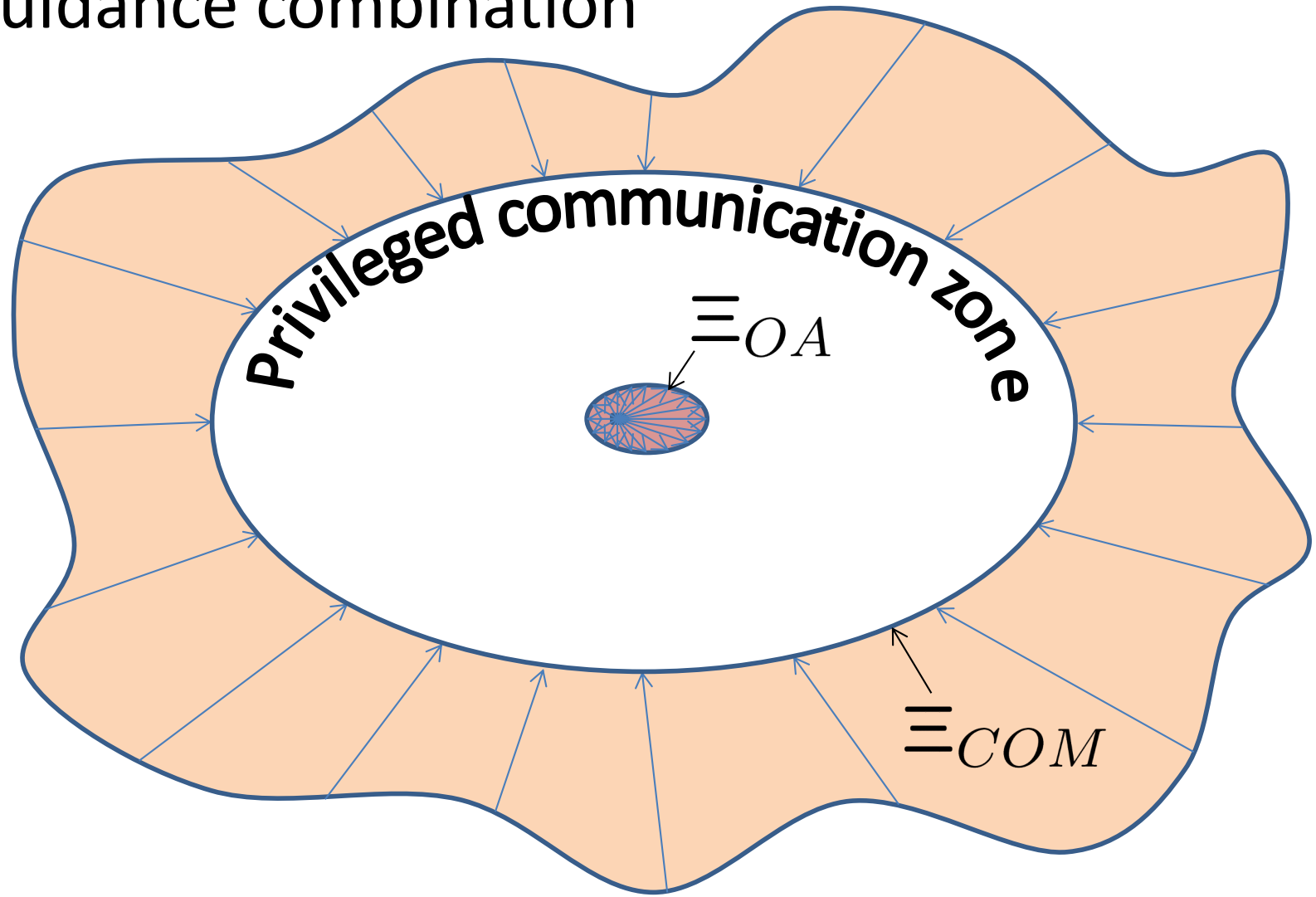
- Guidance combination



[Lapierre, Zapata]

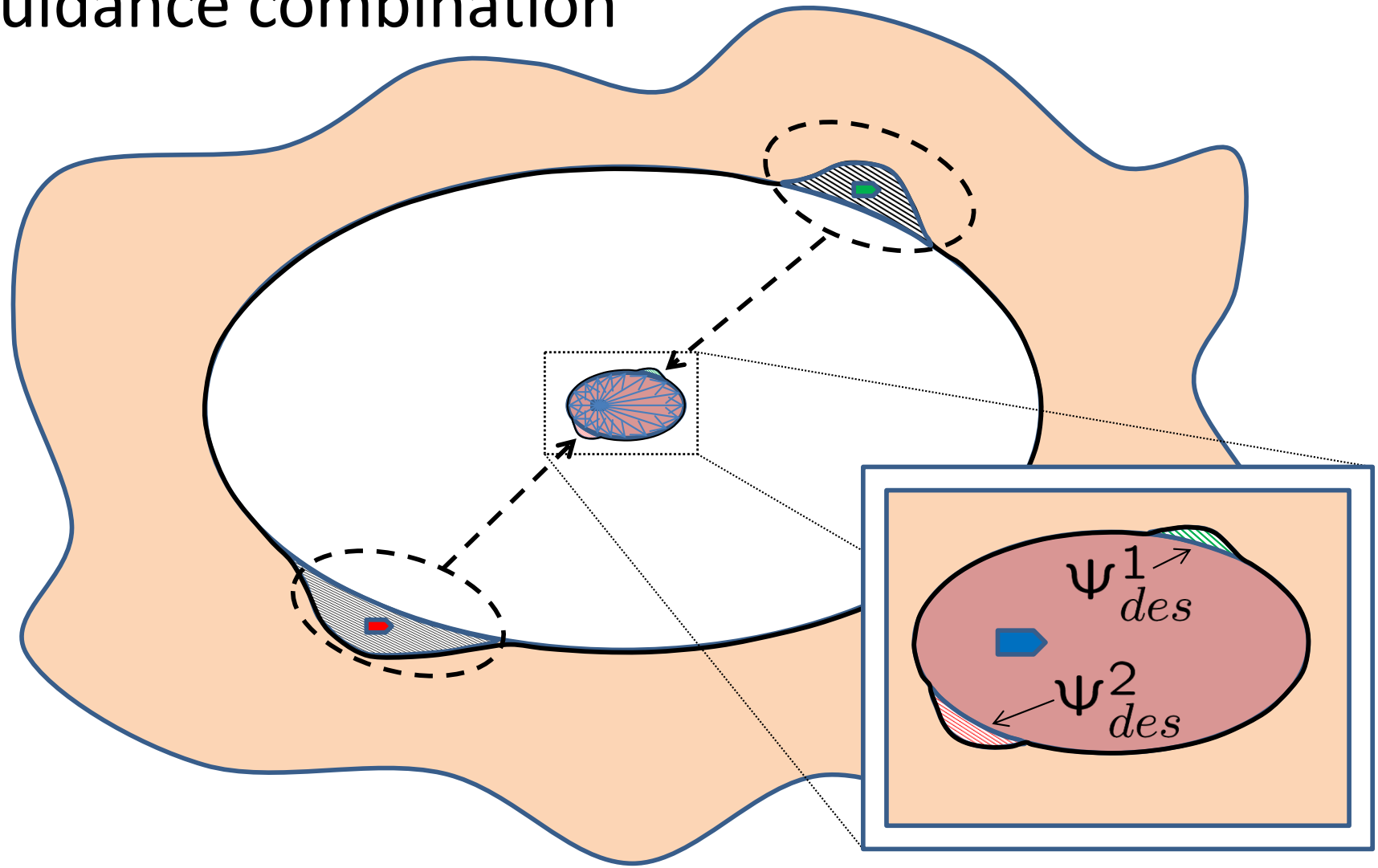
Communication constraints

- Guidance combination



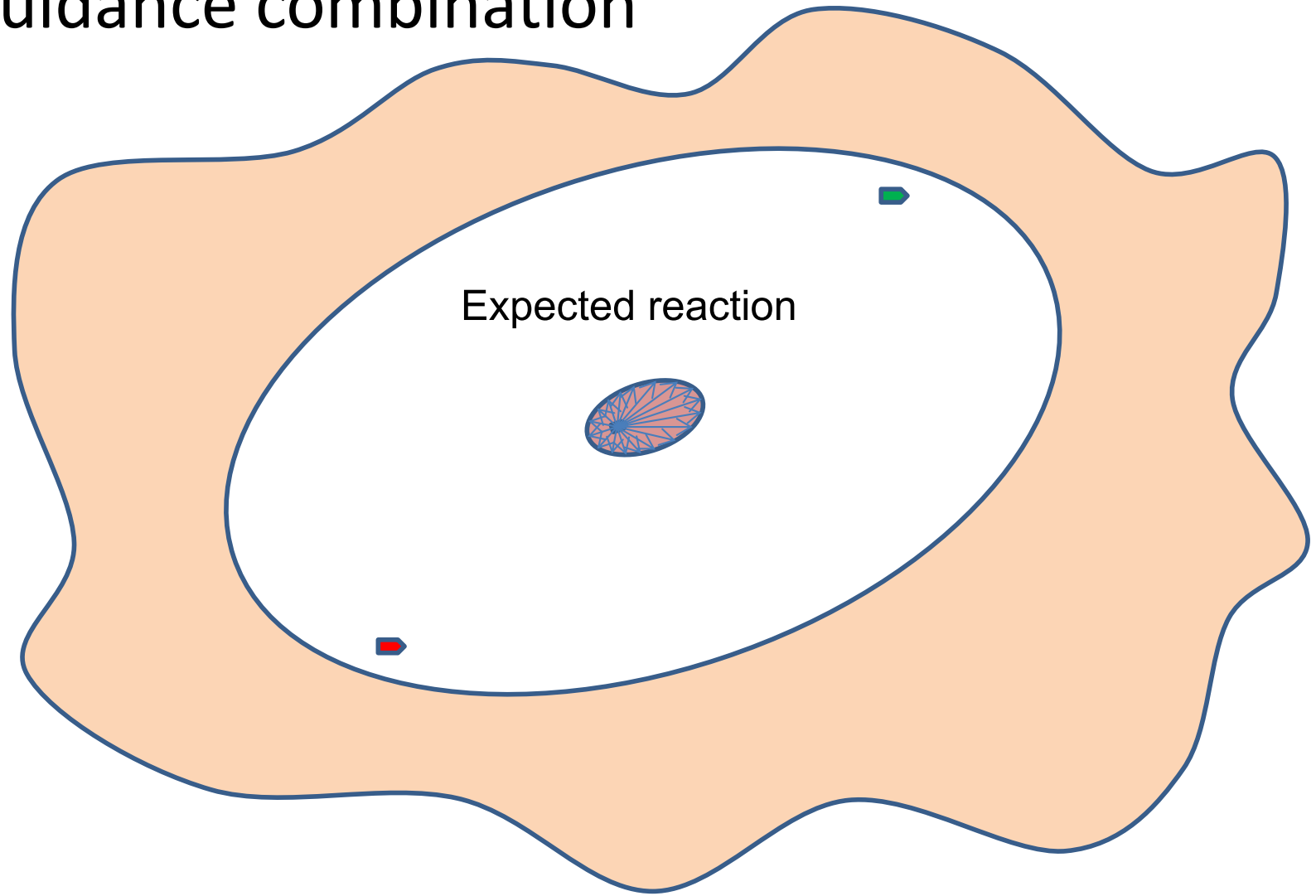
Communication constraints

- Guidance combination



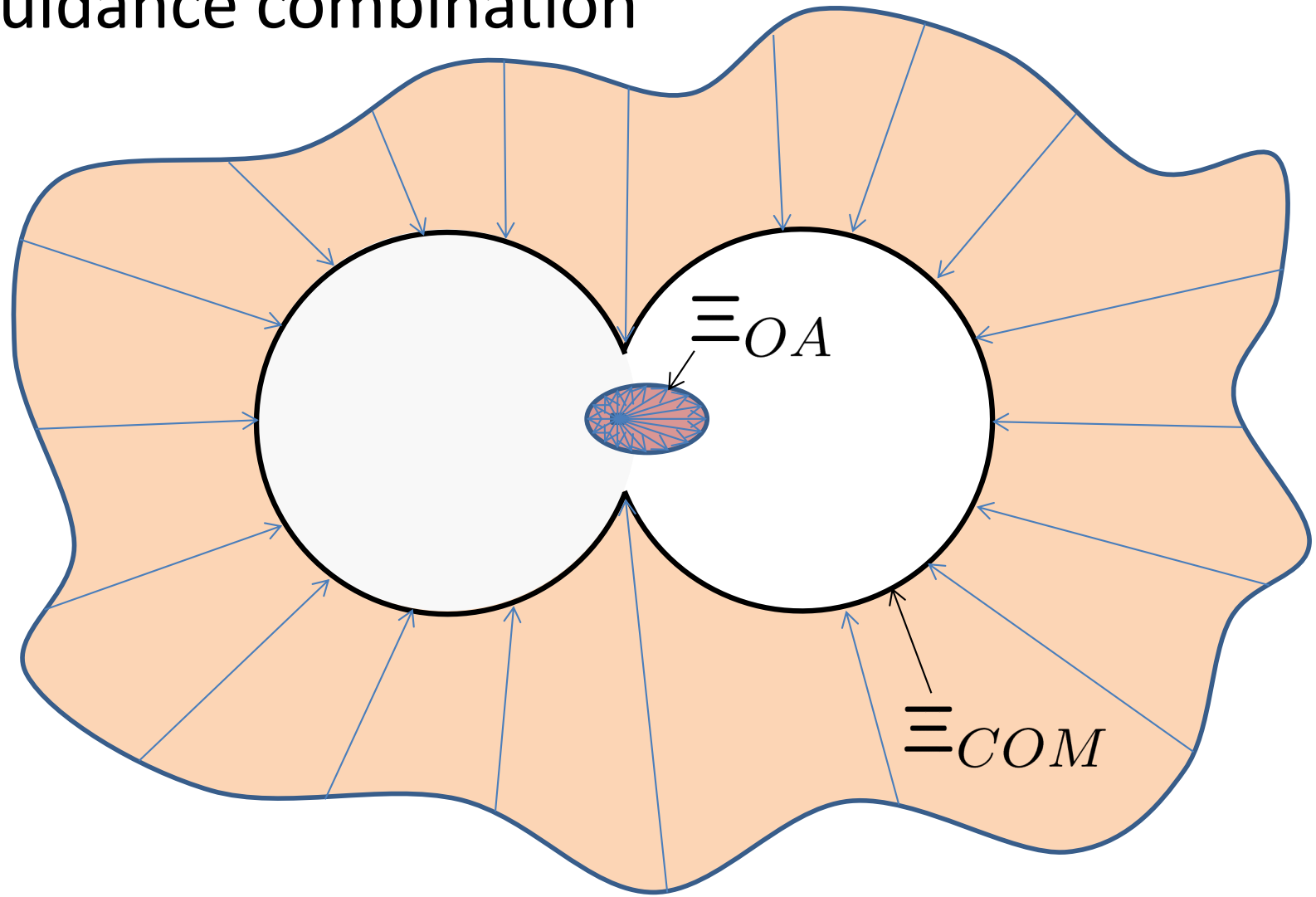
Communication constraints

- Guidance combination



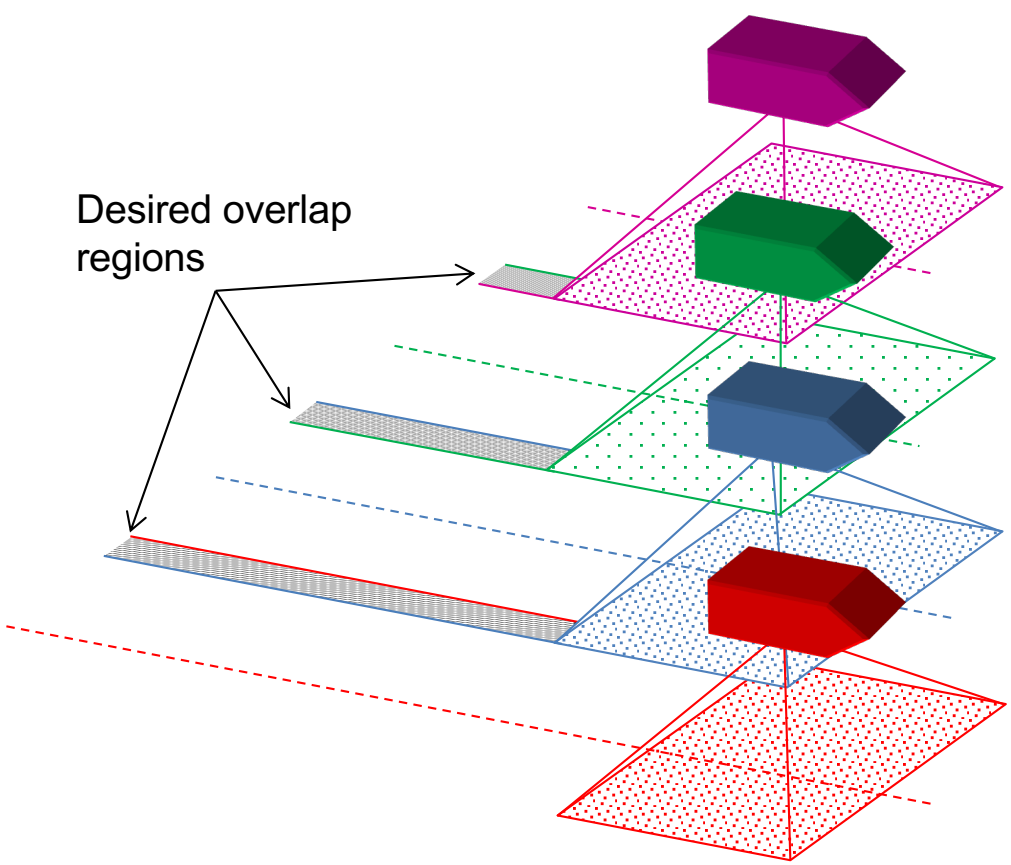
Communication constraint

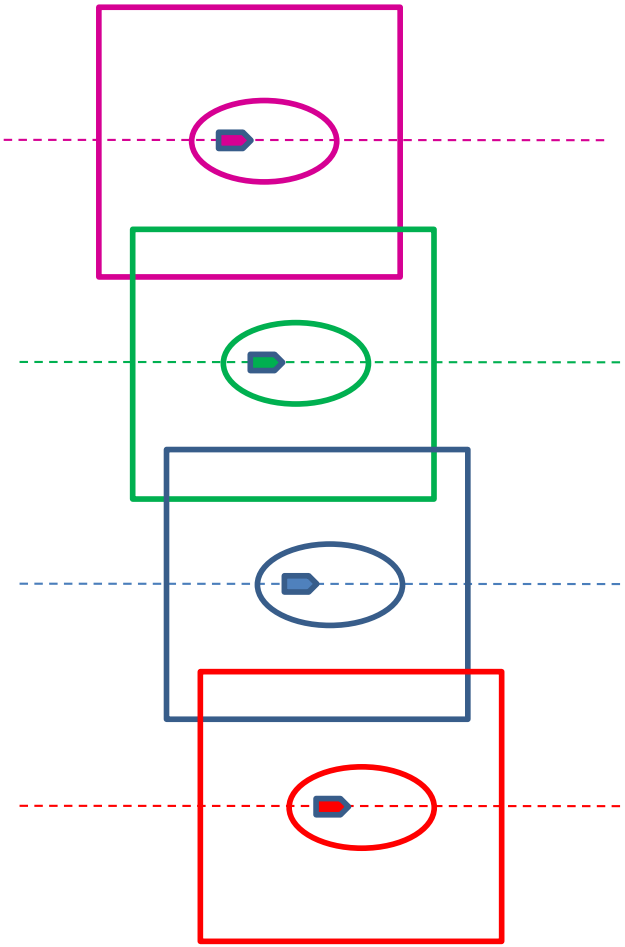
- Guidance combination



Sensor based approach

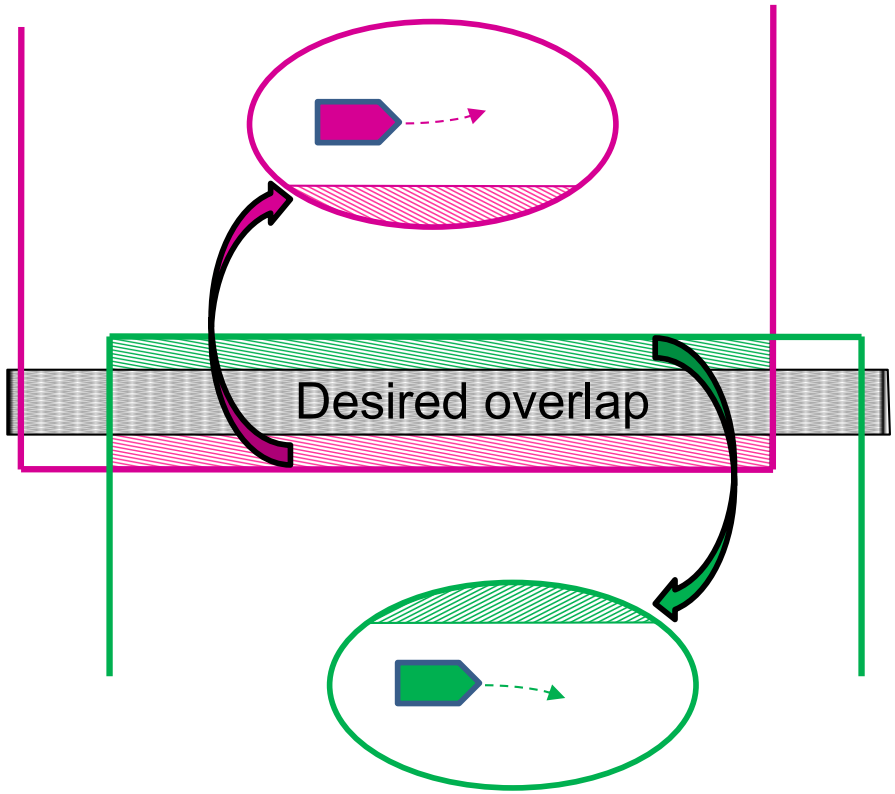
- Collaborative sampling

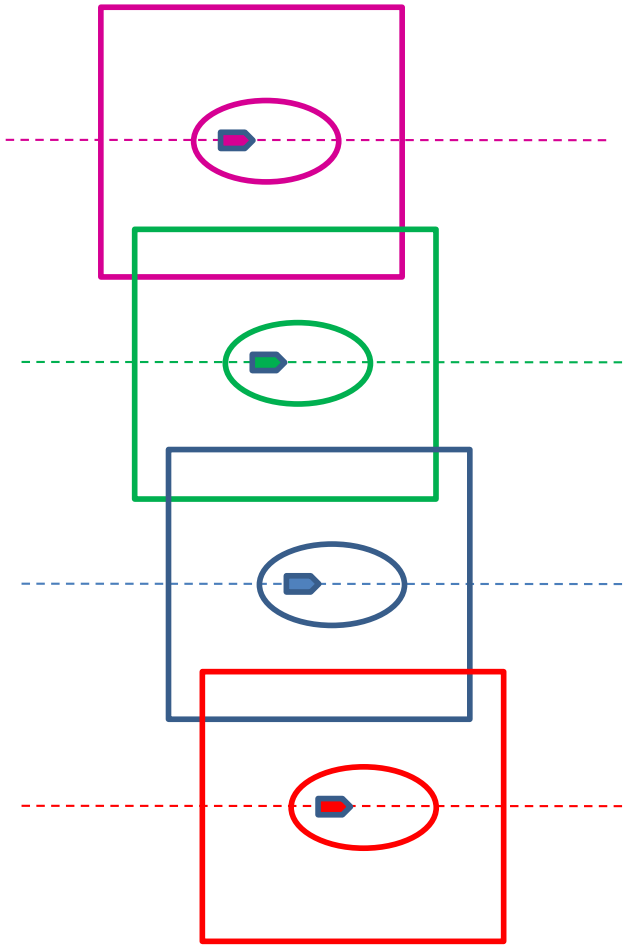




Sensor based approach

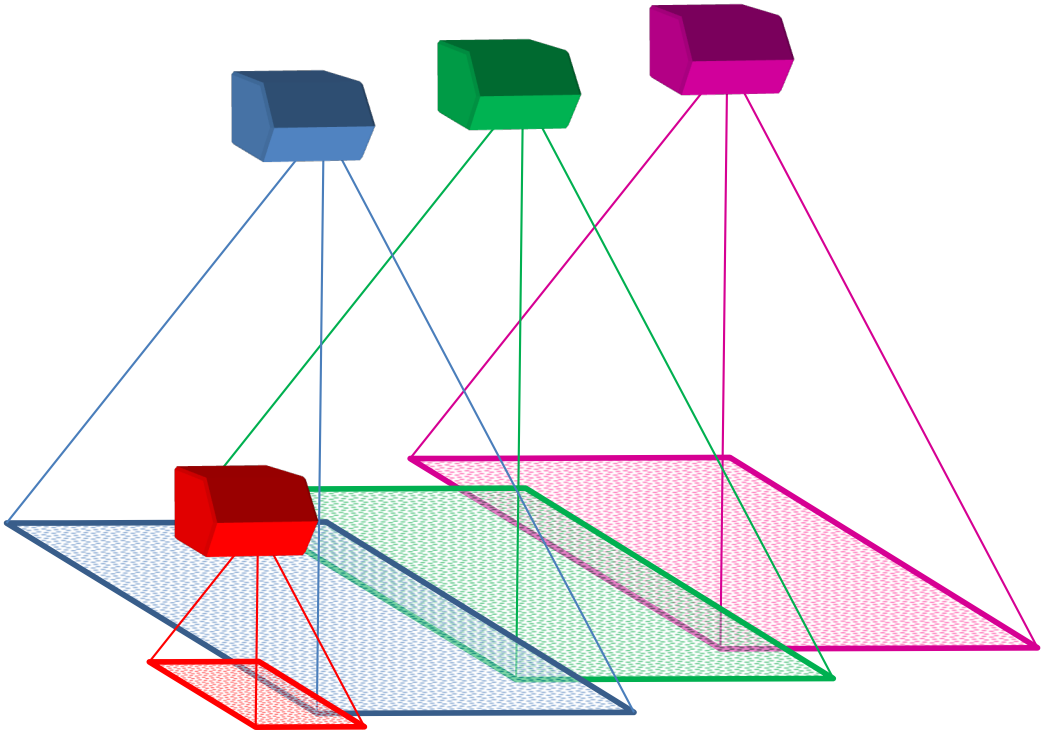
- Collaborative sampling

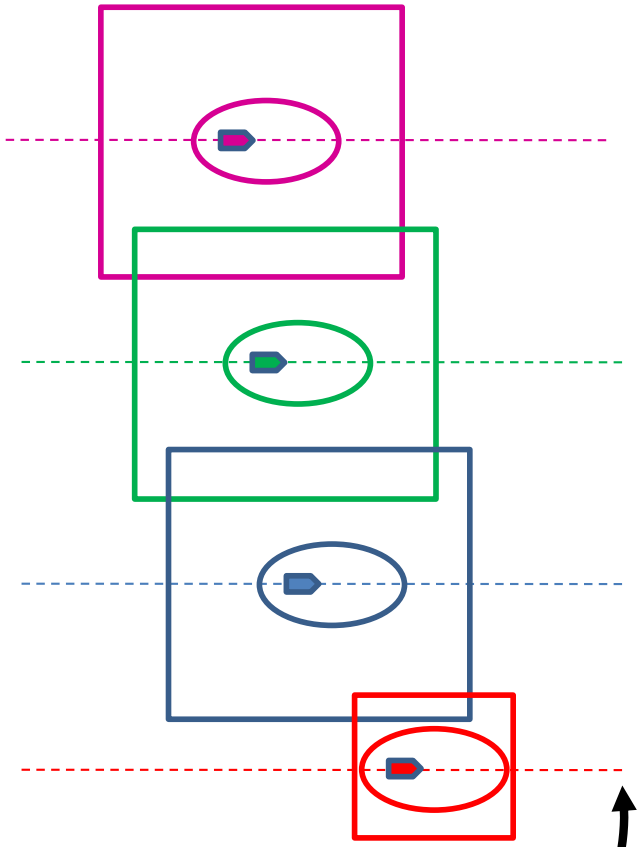




Sensor based approach

- Adaptive sampling

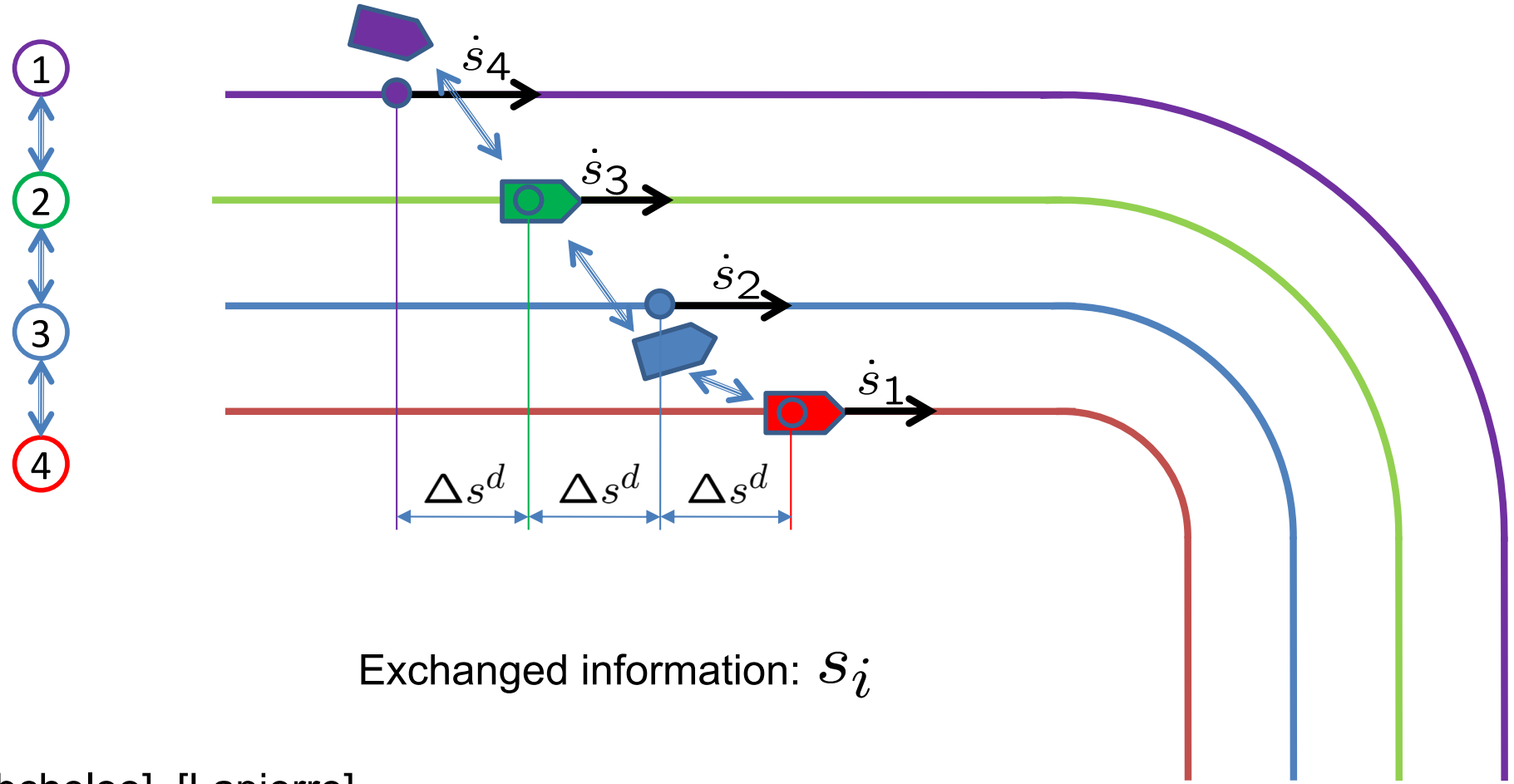




Increase precision → Decrease altitude → adapt lateral offset

Formation control

- Collaborative Path-following

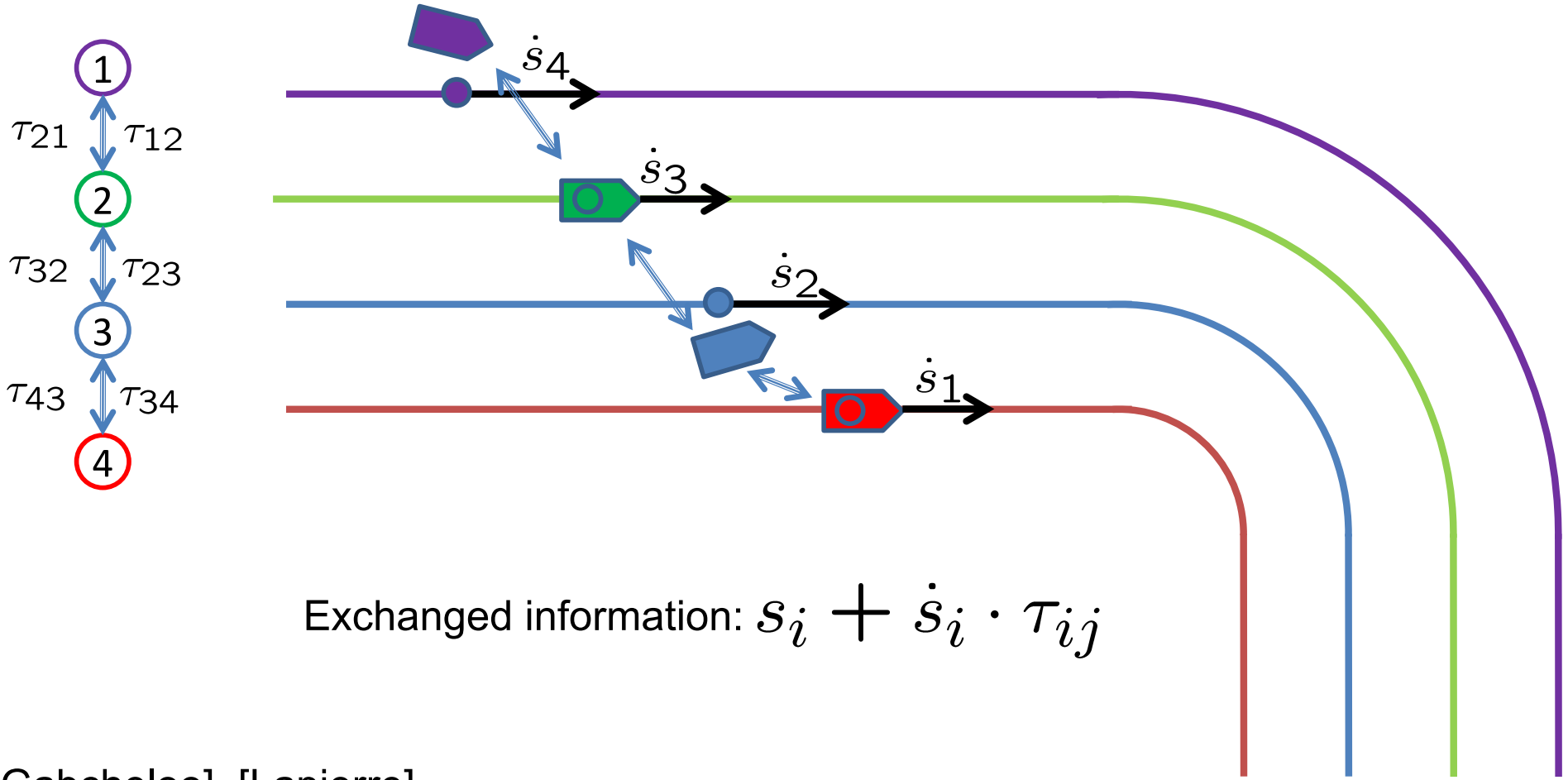


Exchanged information: s_i

[Gabcheloo], [Lapierre]

Formation control

- Collaborative Path-following (incl. comm delay)

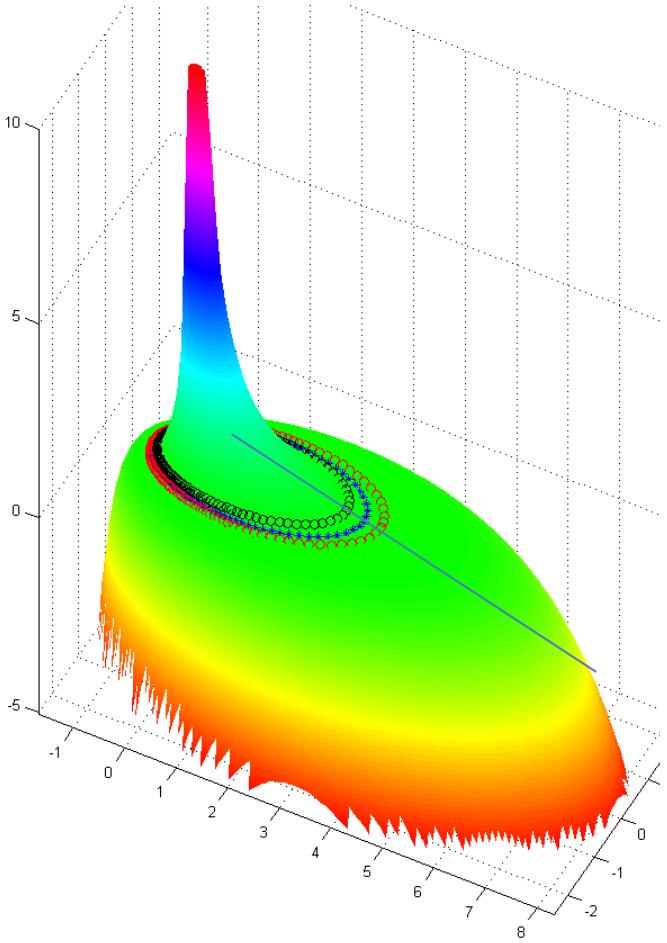


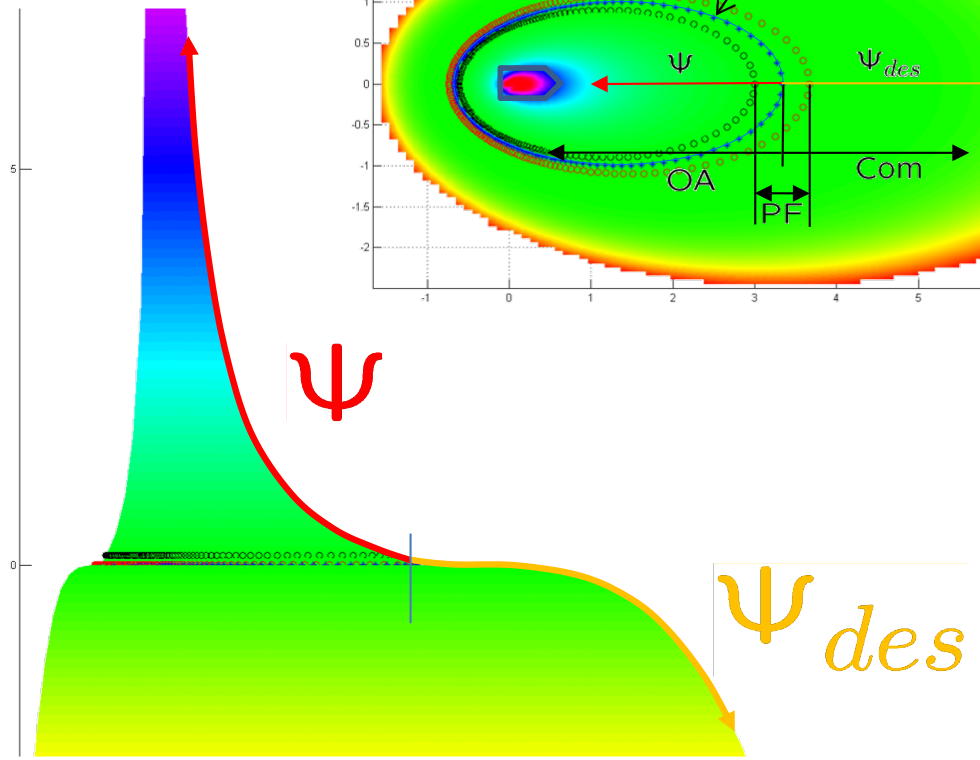
Exchanged information: $s_i + \dot{s}_i \cdot \tau_{ij}$

[Gabcheloo], [Lapierre]

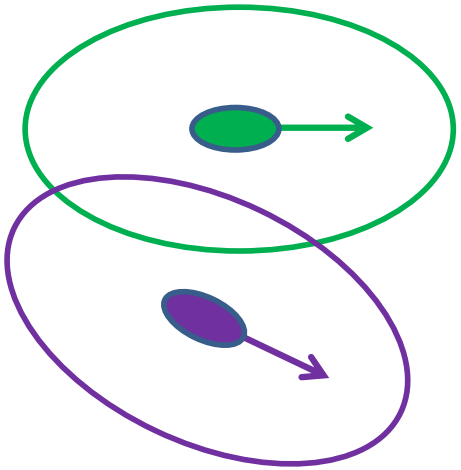
Global fusion

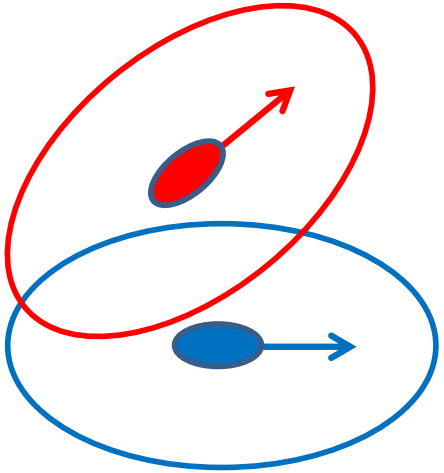
- Global view of the DVZ-induced reaction

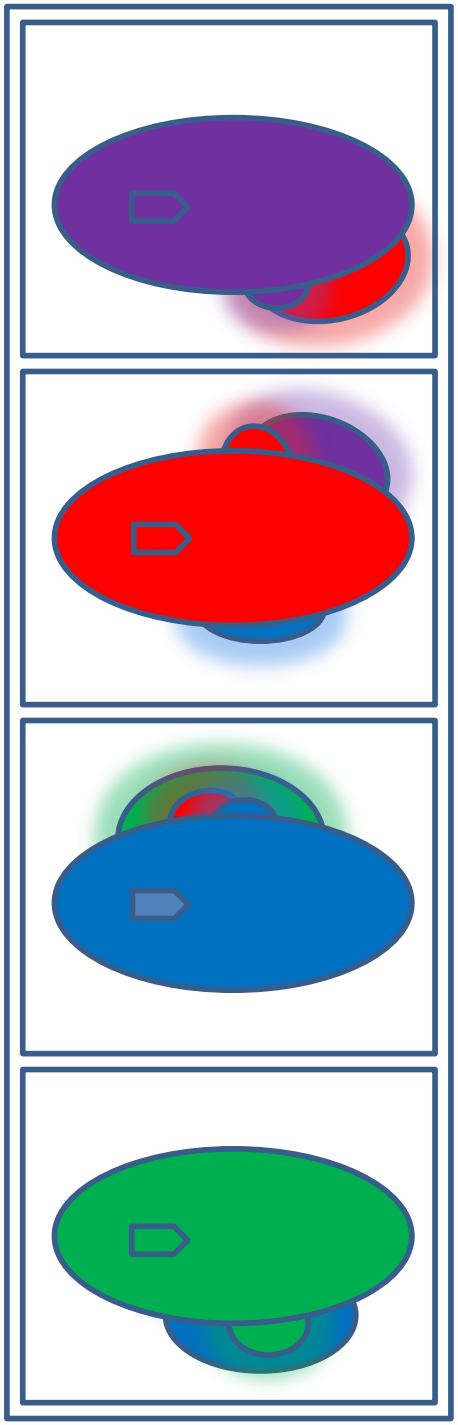




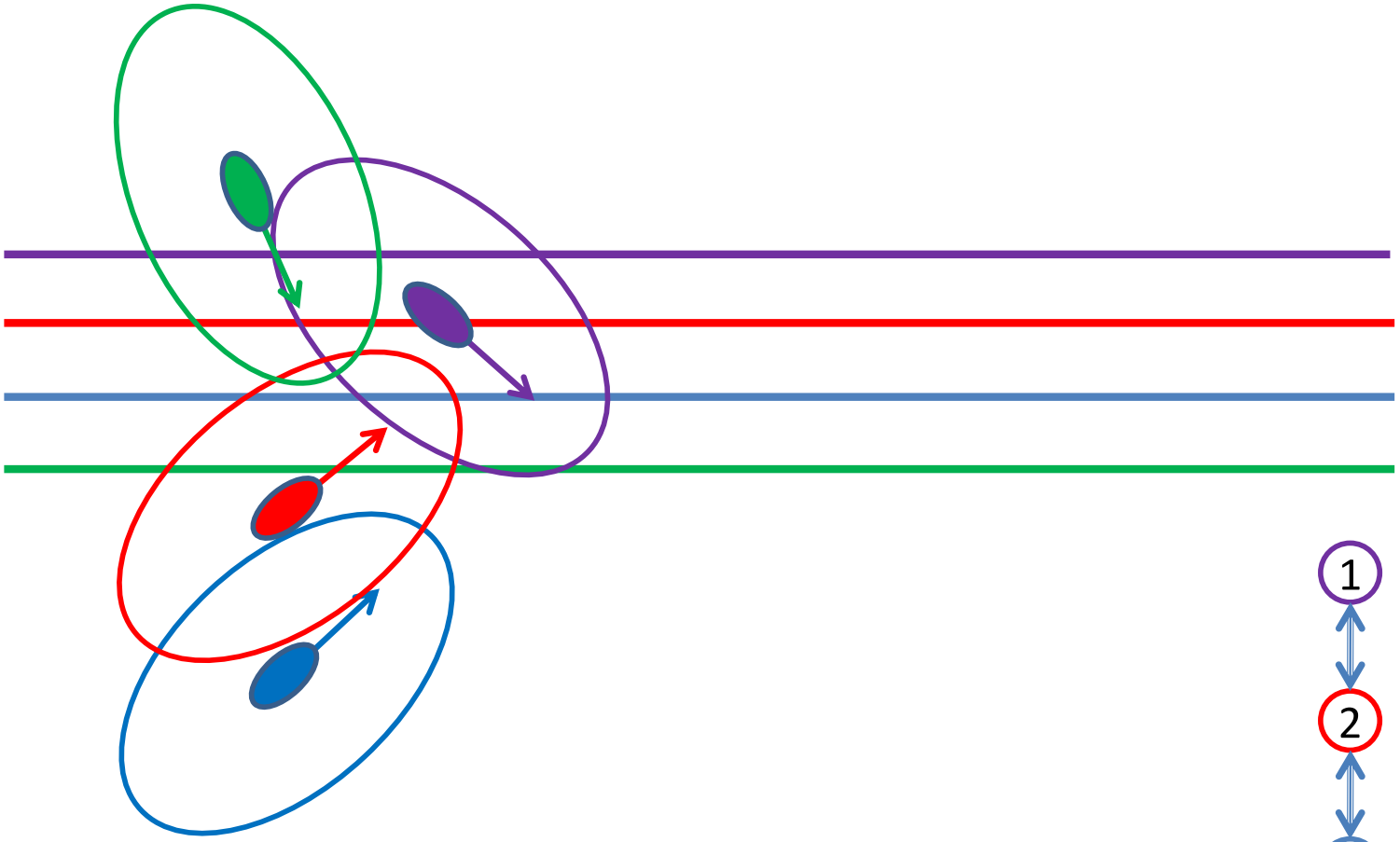
Expected behavior

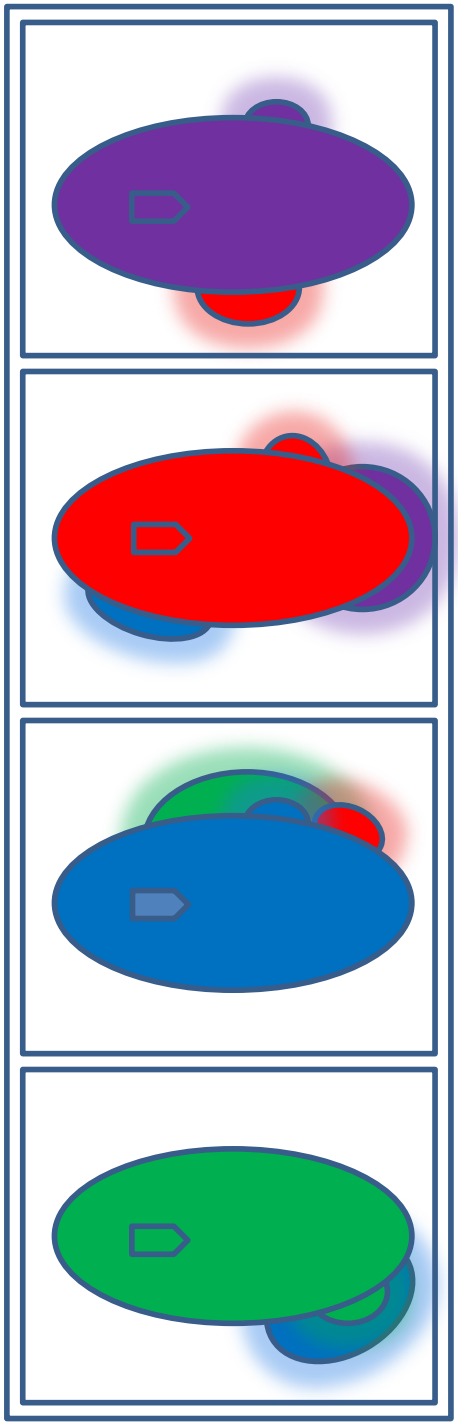




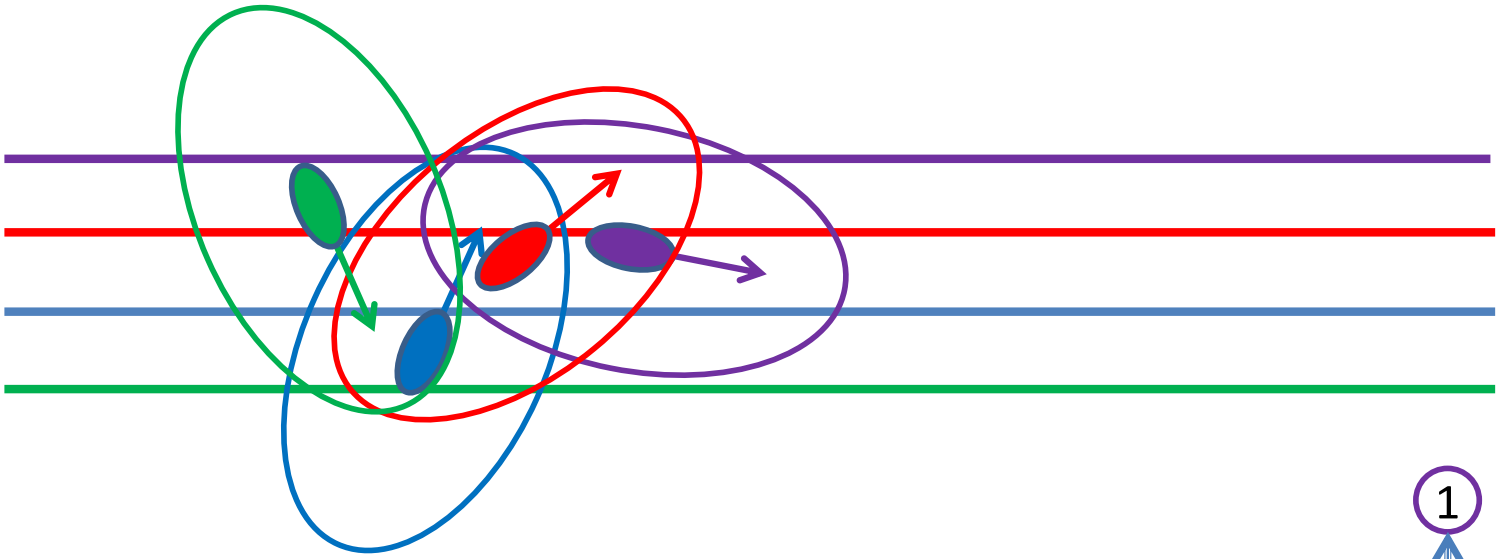


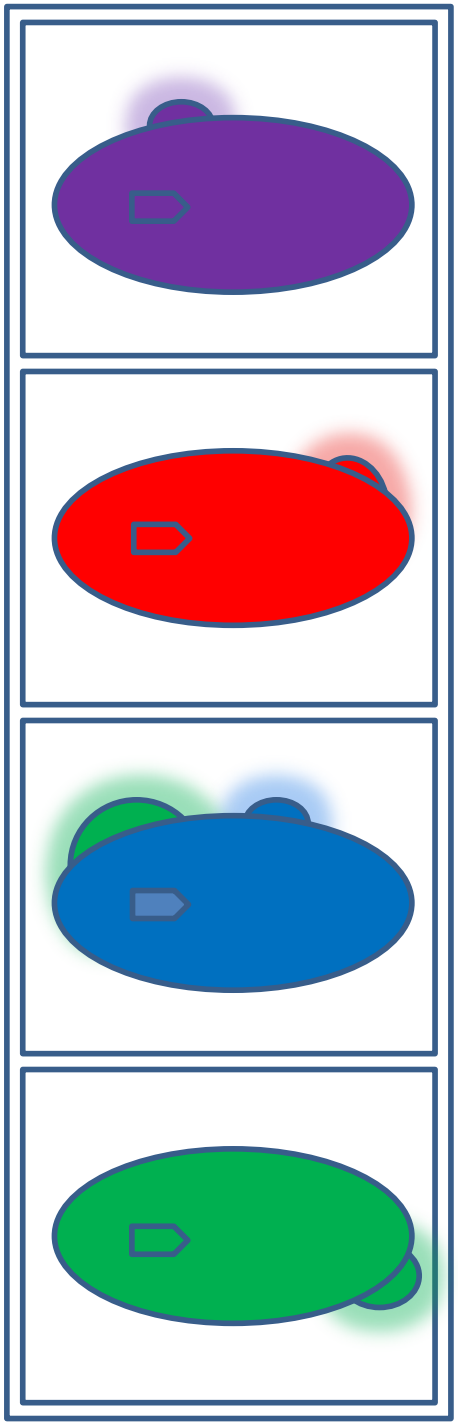
Expected behavior



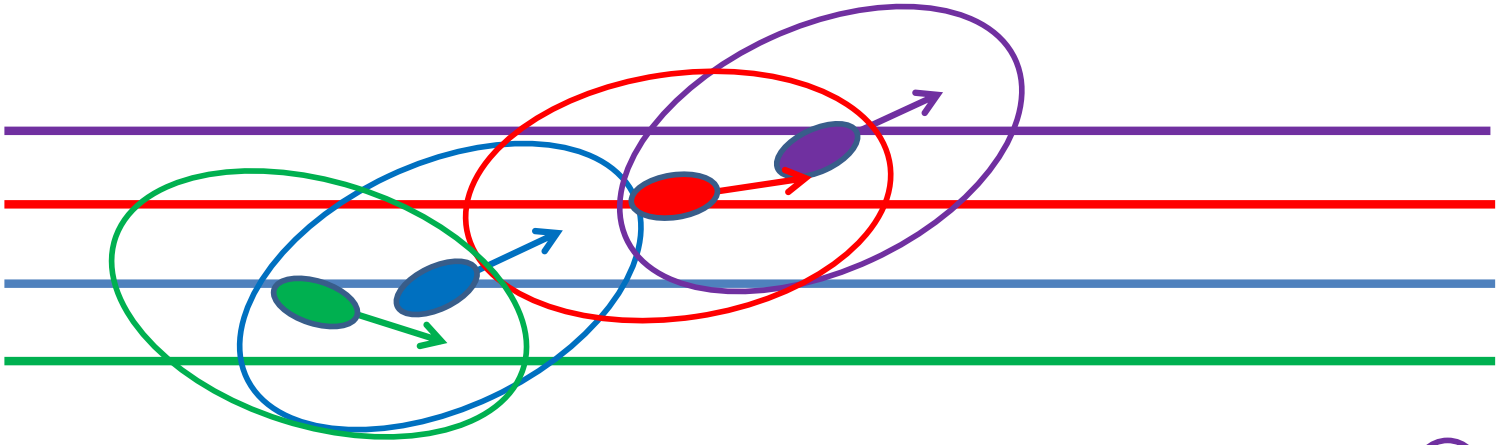


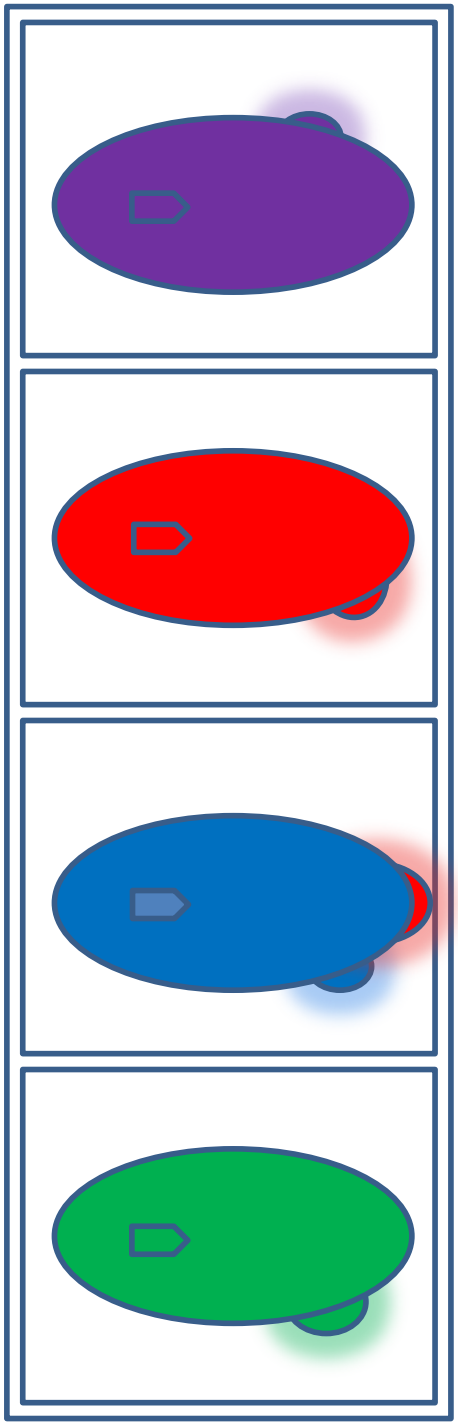
Expected behavior



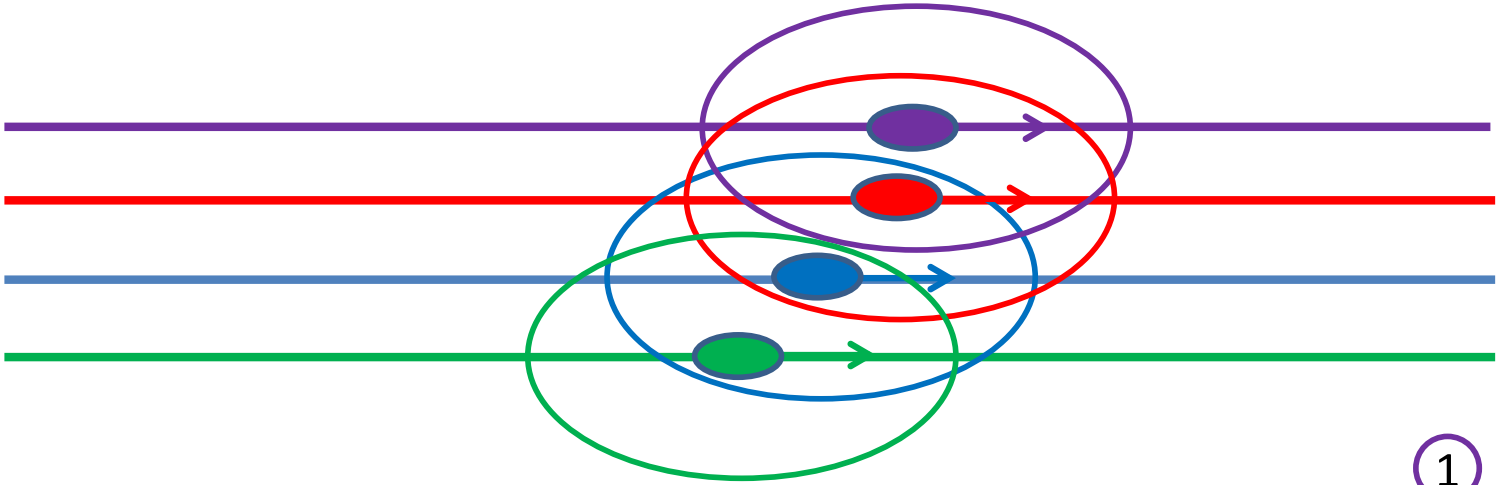


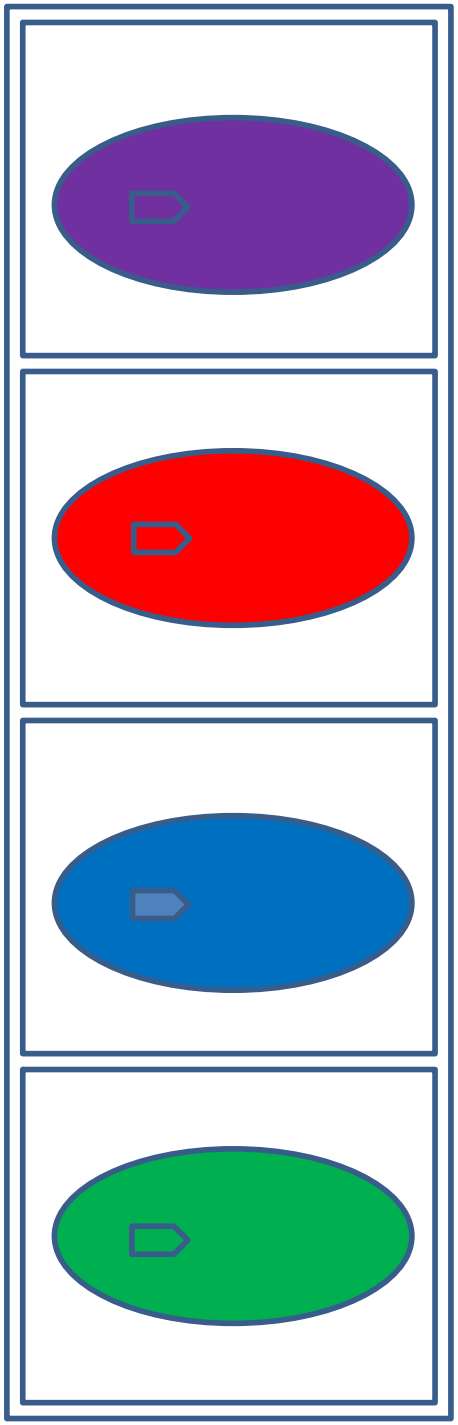
Expected behavior



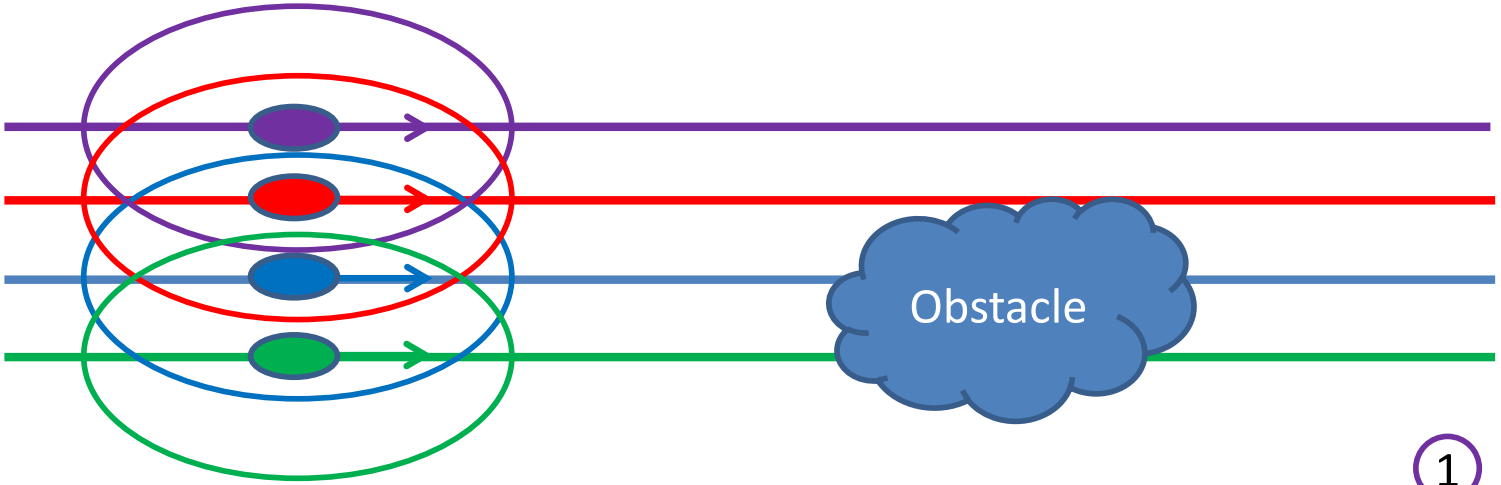


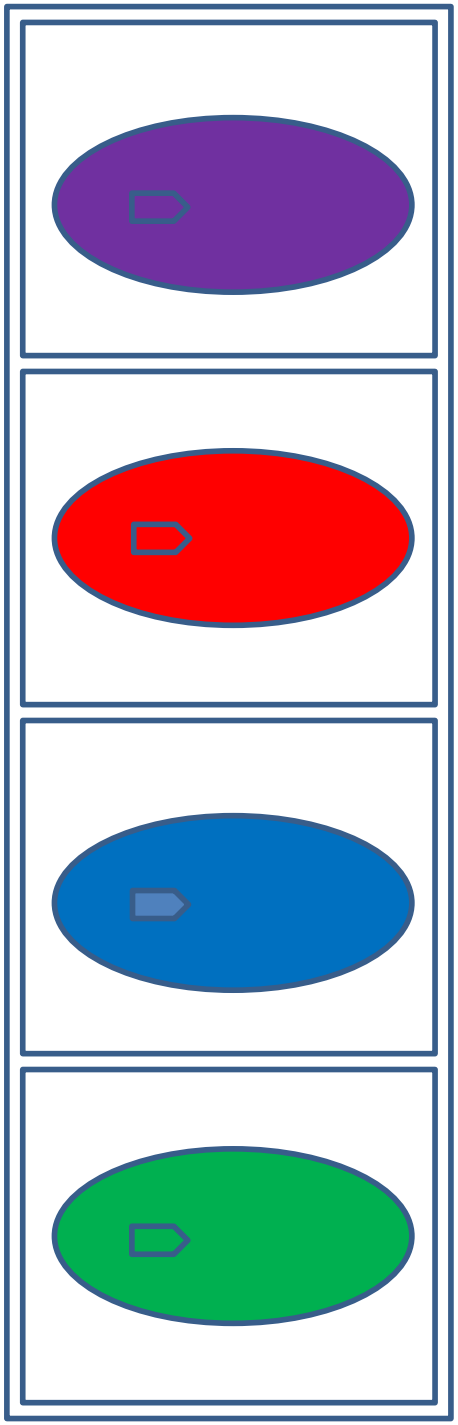
Expected behavior



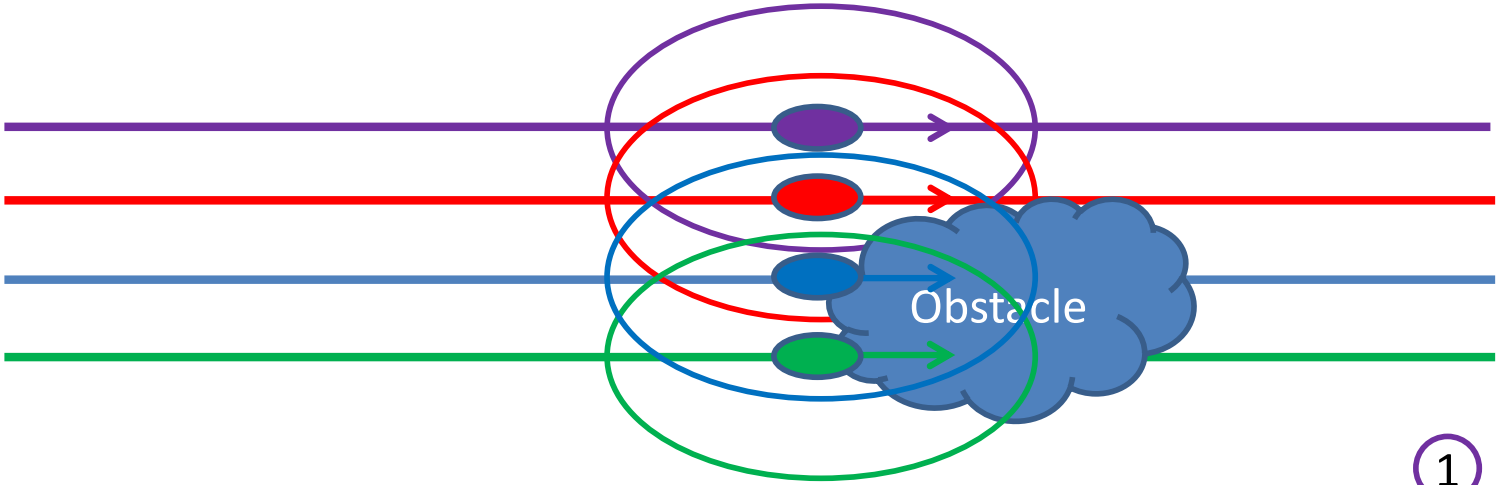


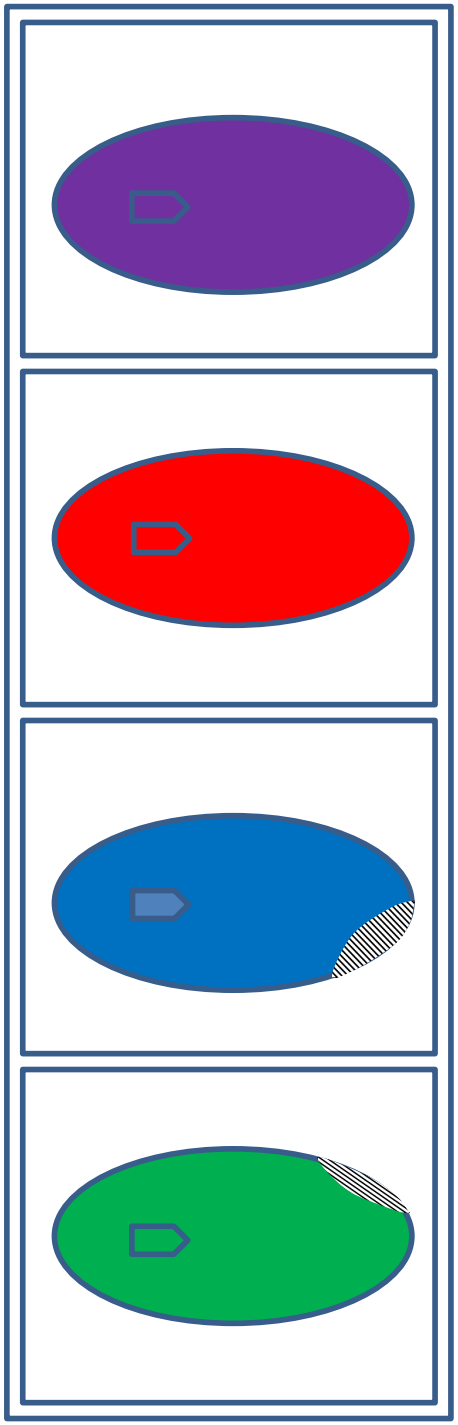
Expected behavior



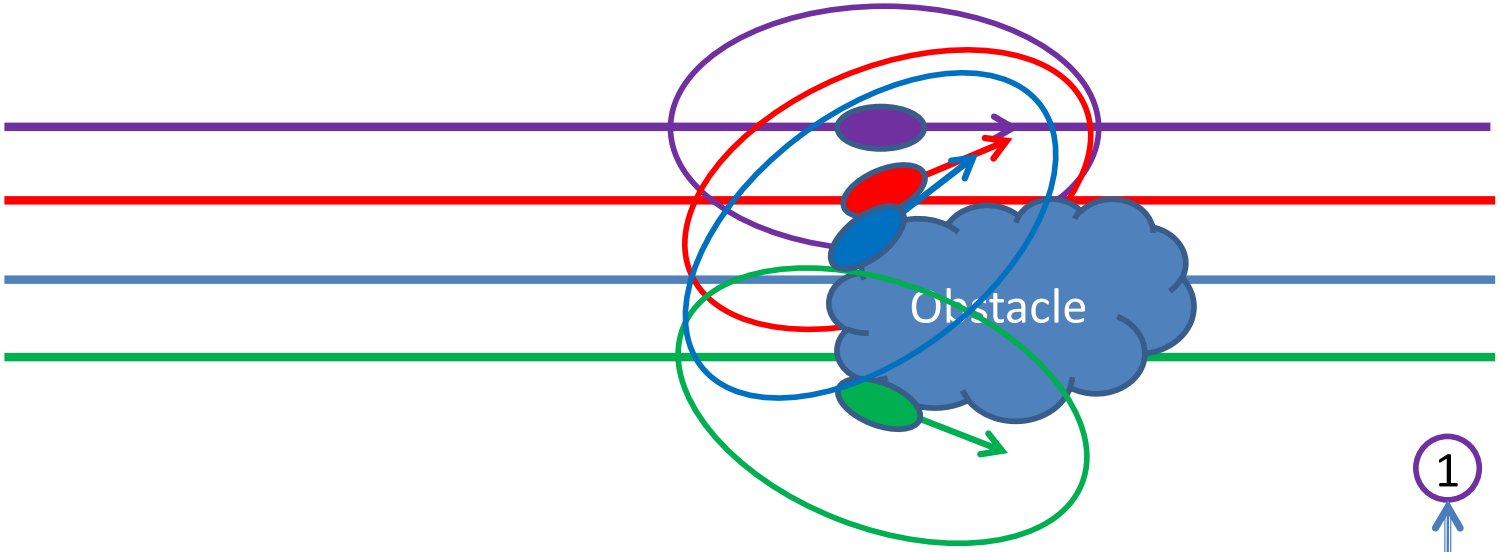


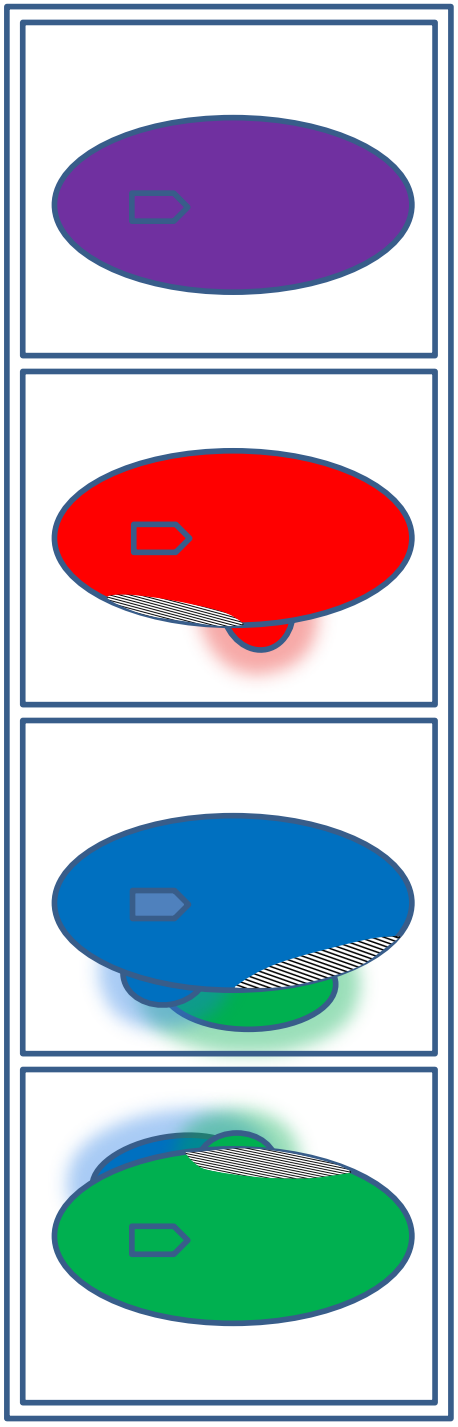
Expected behavior



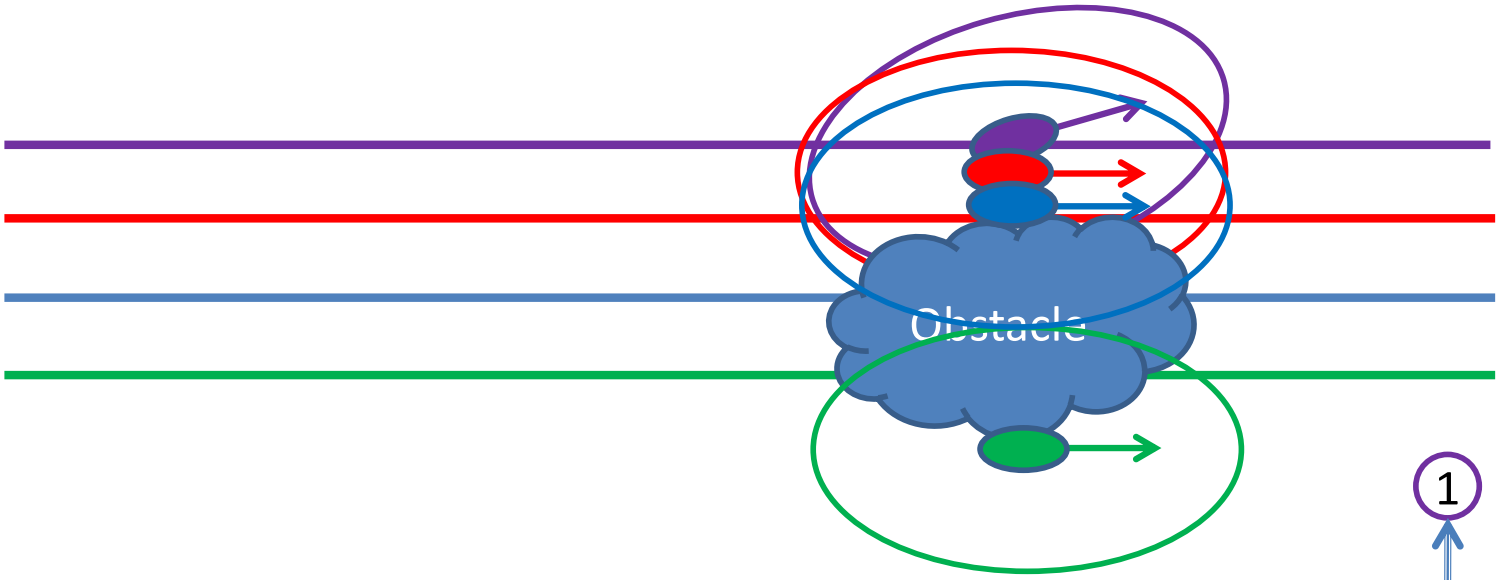


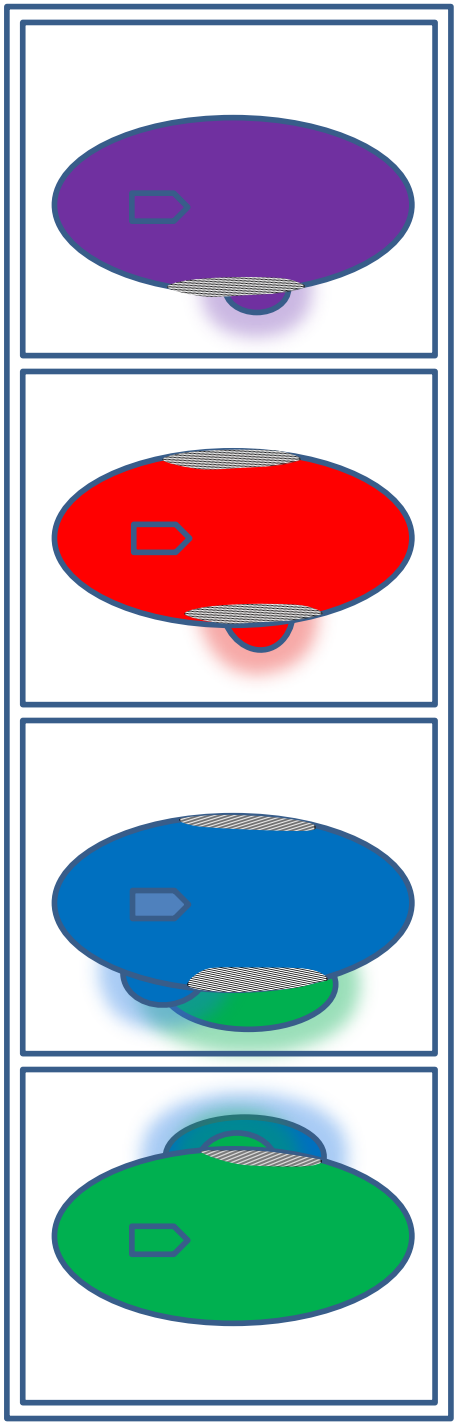
Expected behavior



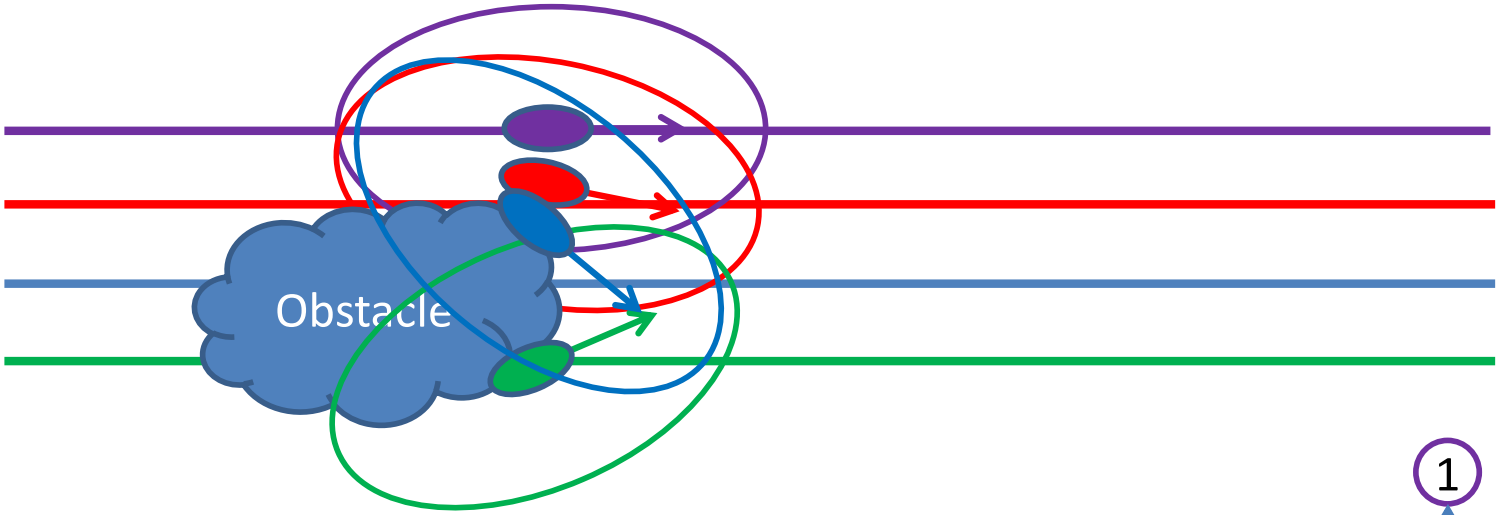


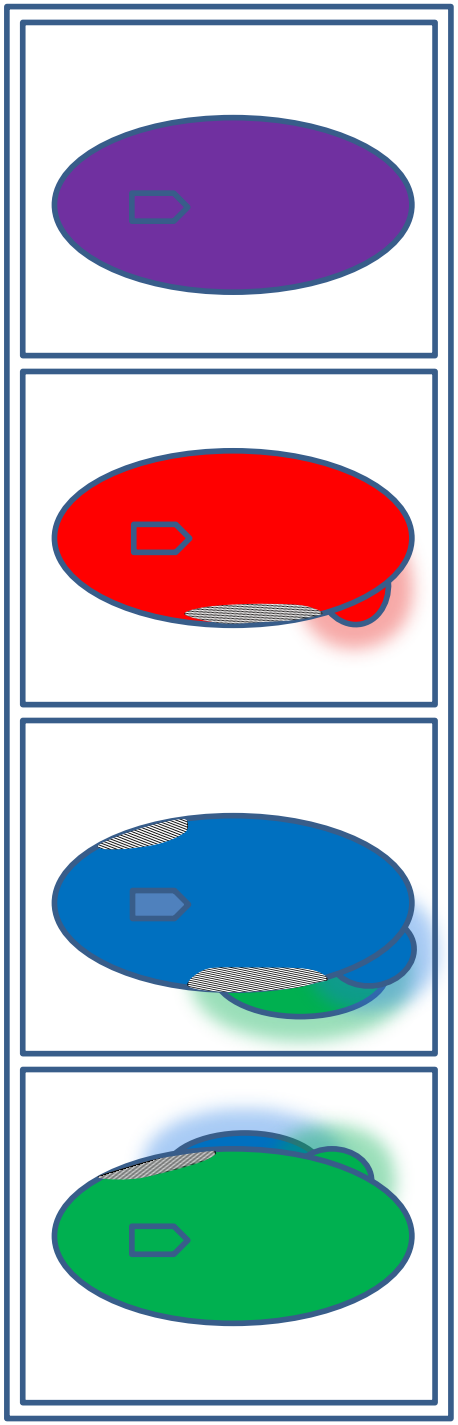
Expected behavior





Expected behavior





Expected behavior