

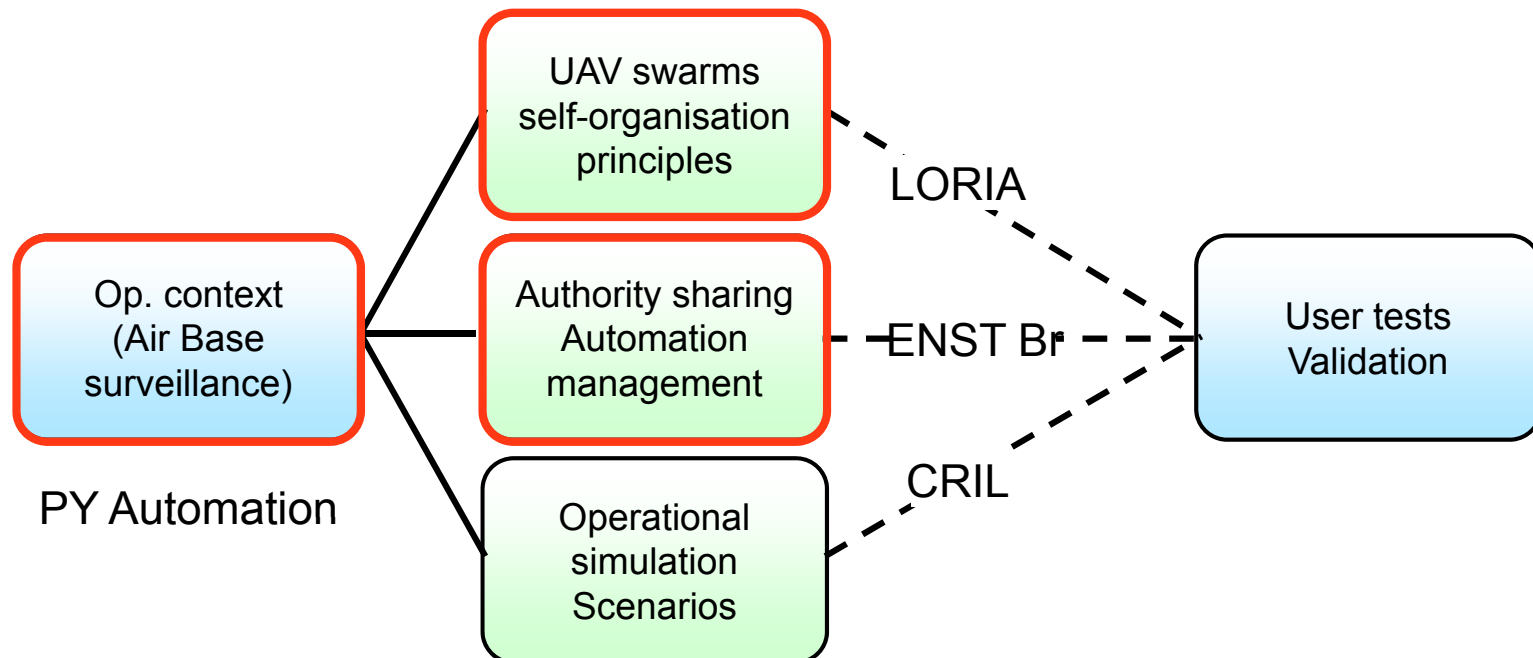
Adjustable autonomy in swarms of UAV

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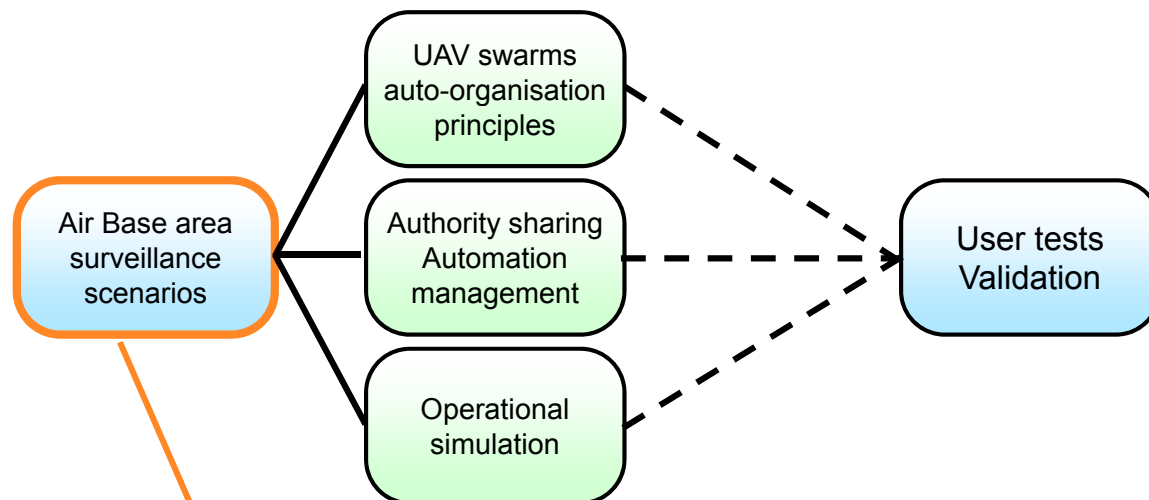
Project context

- SMAART project (“**S**ystèmes **m**ulti-**a**gents **a**daptés à la **r**econnaissance de **t**héâtre et l’auto-organisation des drones”)
- Keywords: self-organized UAV swarms + authority sharing
- Functional demonstrator



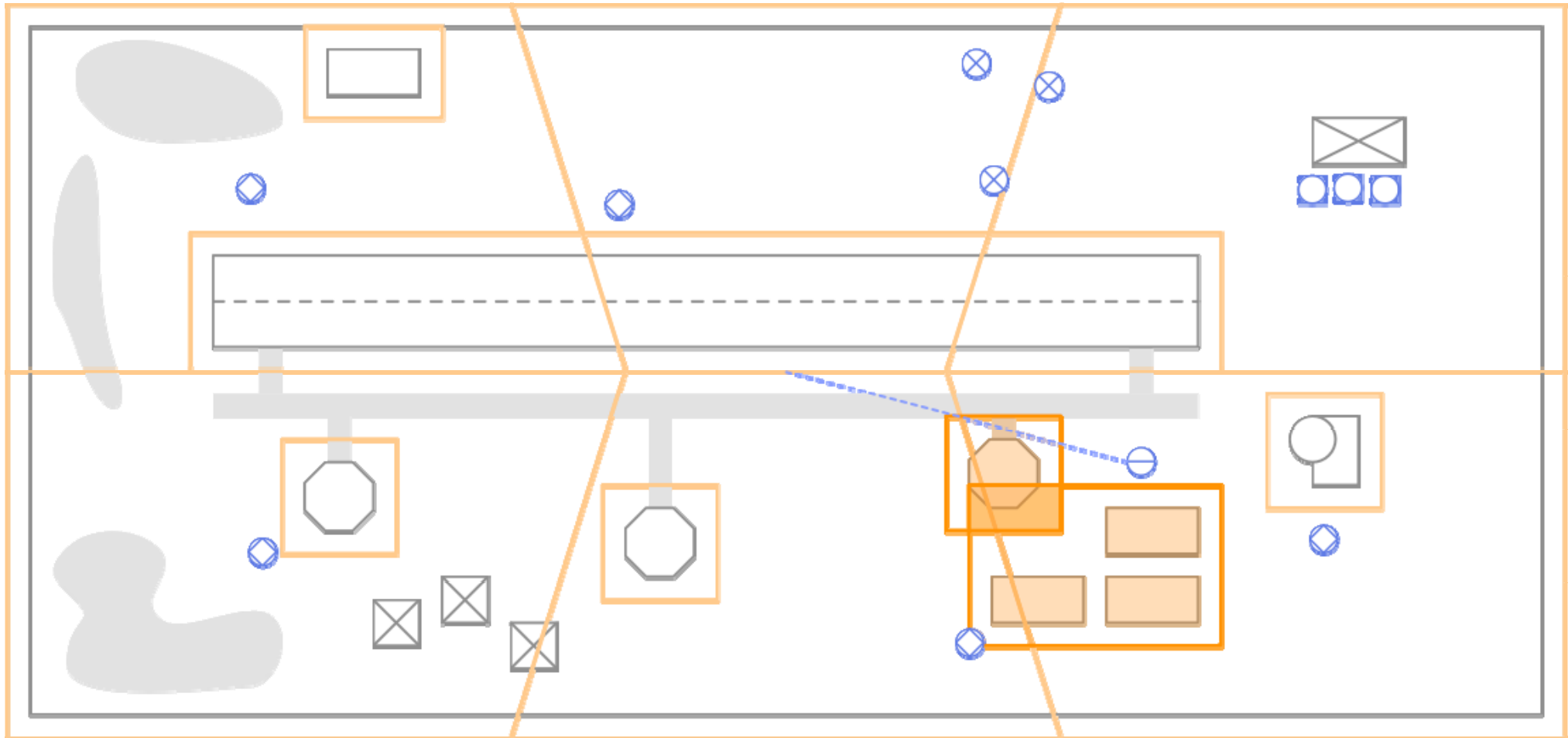
Operational context
Self-organizing
UAV swarms

Operational Context

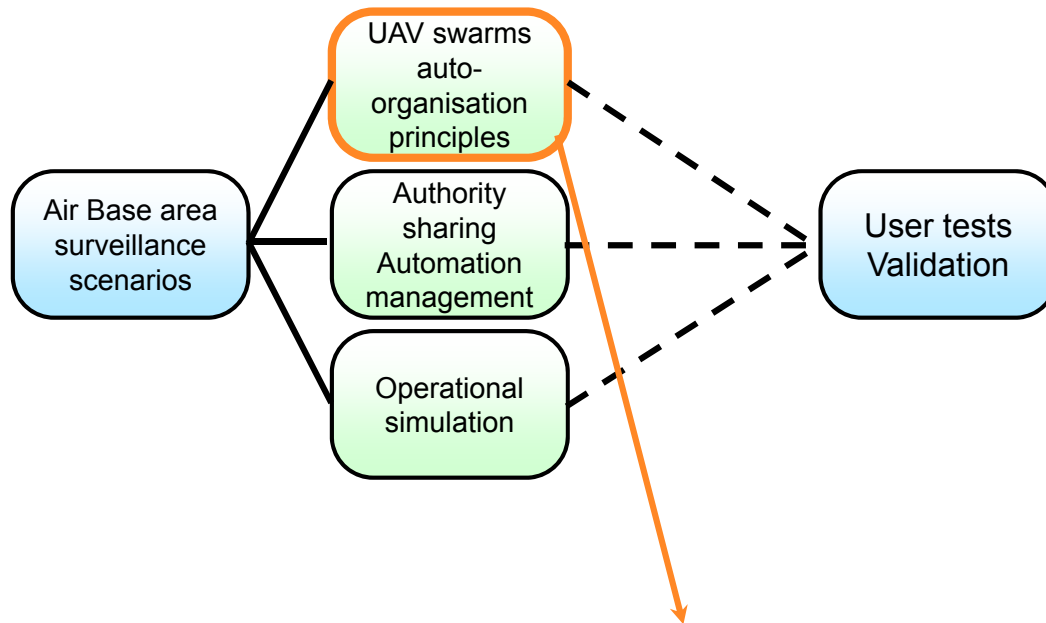


- Surveillance and intrusion management (tracking)
- Fixed and rotary wing UAVs + sensors network
- ~3-5 FW-UAV, ~12 RW-UAV

Strategic Air-Base



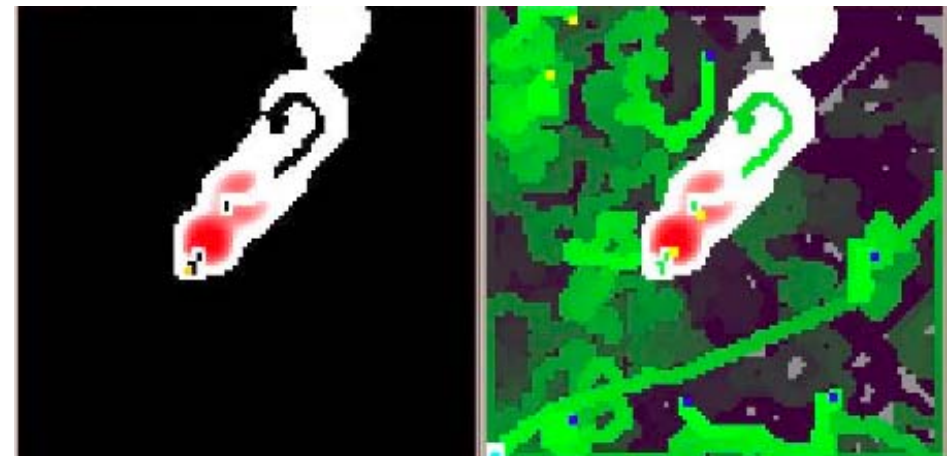
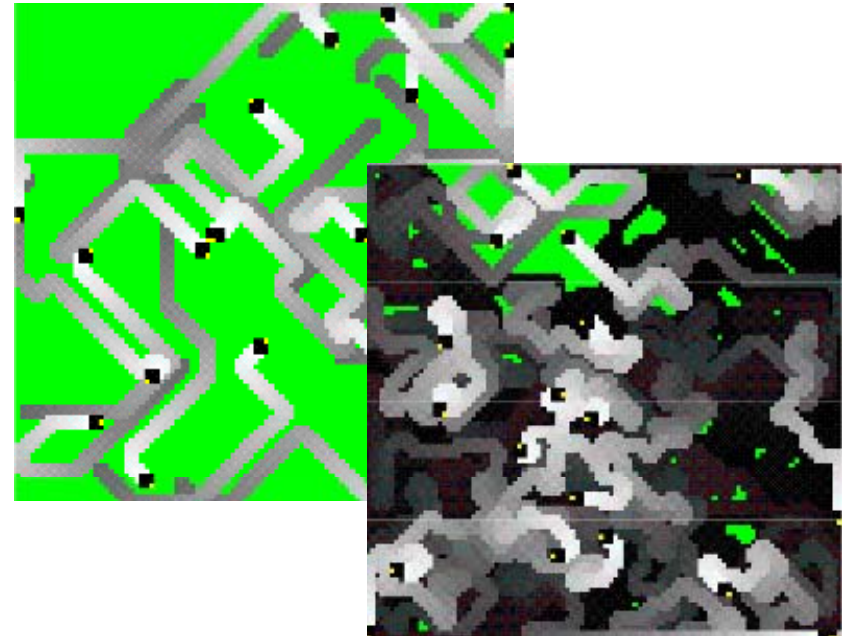
UAV self-organisation









- Applying stigmergy principle (“ant-based” behaviors)
- 2 different kinds of pheromone: surveillance and pursuit
- UAV guidance: direct objective or pheromone gradient
- Repelling effects for obstacles

Pheromone Grids

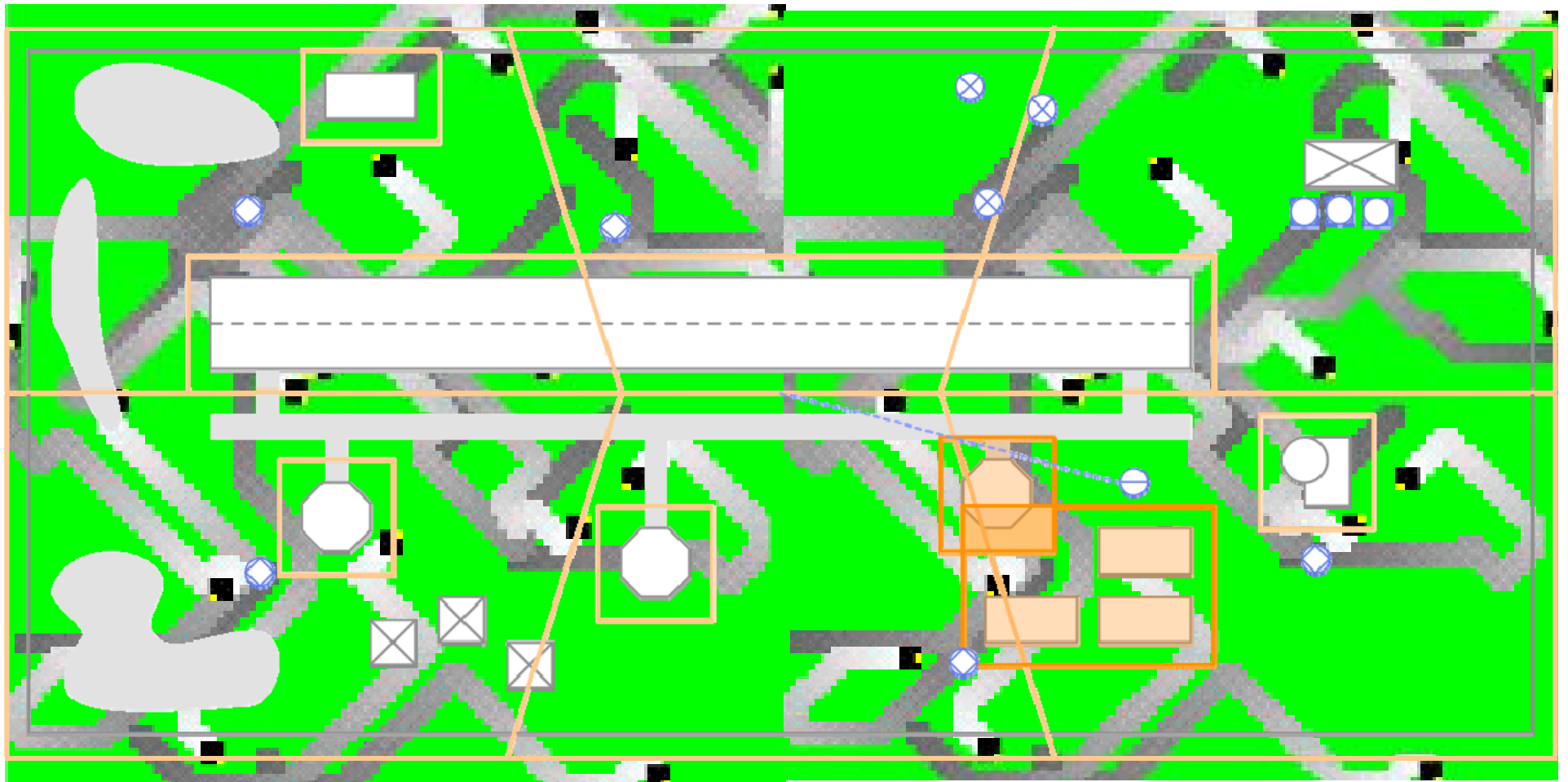
- Visit Pheromone
 - Produced by UAVs, evaporates
 - Repels patrolling UAVs
- Alarm Pheromone
 - Produced by contacts, diffuses
 - Attracts tracking UAVs, consumed



Modes & States

Mode	State/Symbol	Motivation
Patrol		Visit Pher.
Pursuit		Alarm Pher.
Auto		Visit/Alarm Pher.
Rally		Command
Hover		Command
Stopped		Command

Strategic Air-Base



Authority sharing Autonomy levels

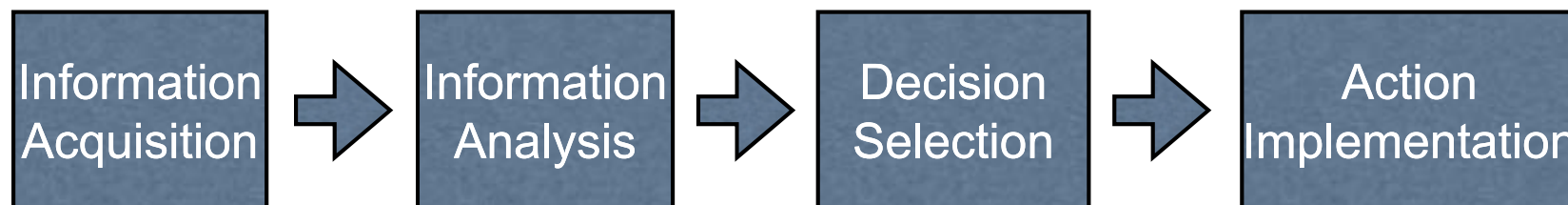
Main questions

- Which modes of control ?
- How to adapt levels of automation ?
- Which interfaces ?

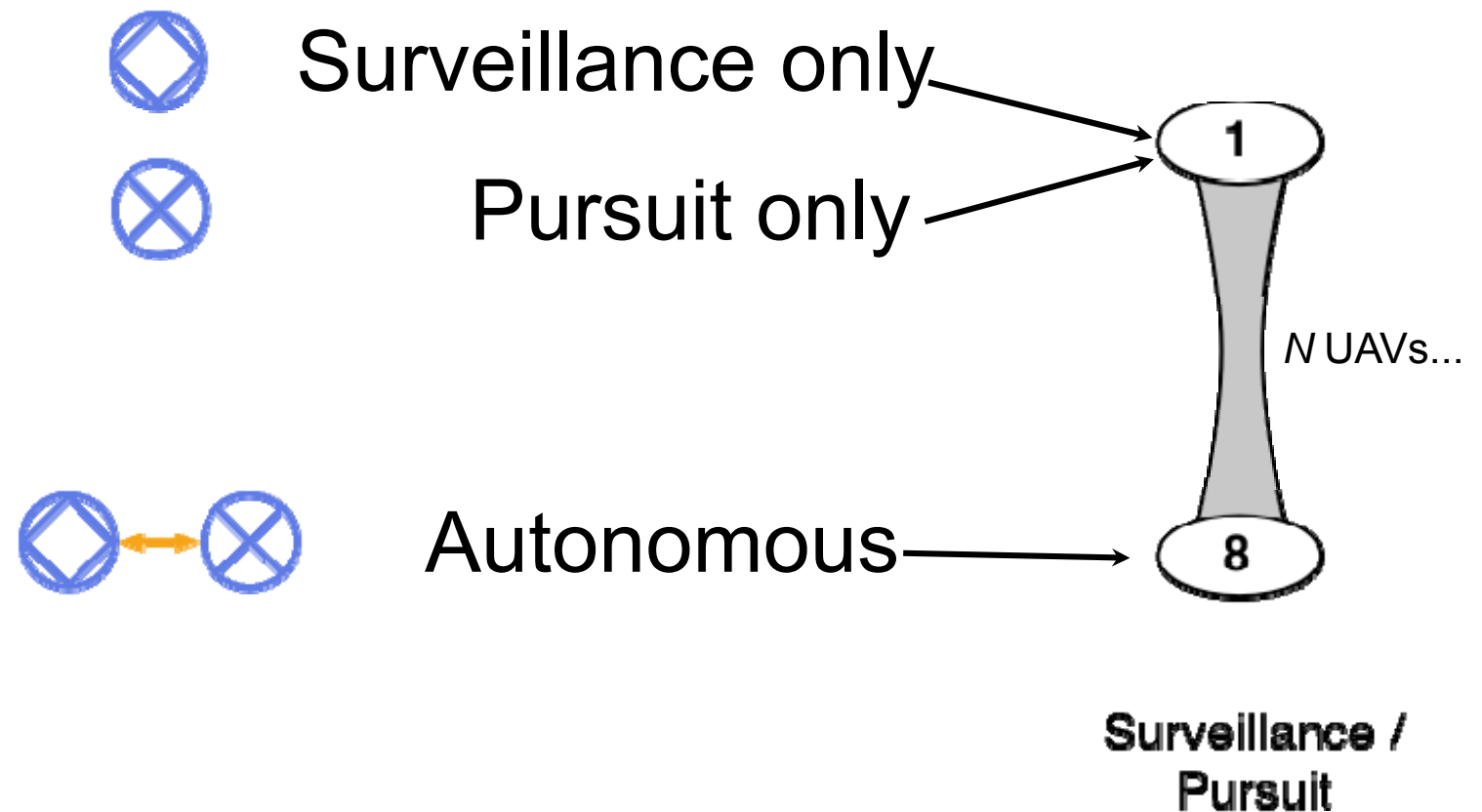
Sheridan *et al.*

1	The computer offers no assistance, human must do it all.
2	The computer offers a complete set of action alternatives, and
3	Narrows the selection down to a few, or
4	Suggests one, and
5	Executes that suggestion if the human approves, or
6	Allows the human a restricted time to veto before automatic execution, or
7	Executes automatically, then necessarily informs the human, or
8	Informs him after execution only if he asks, or
9	Informs him after execution if it, the computer, decides to.
10	The computer decides everything and acts autonomously, ignoring the human.

[Parasuraman, Sheridan & Wickens, 2000]



UAV: Decision Modes



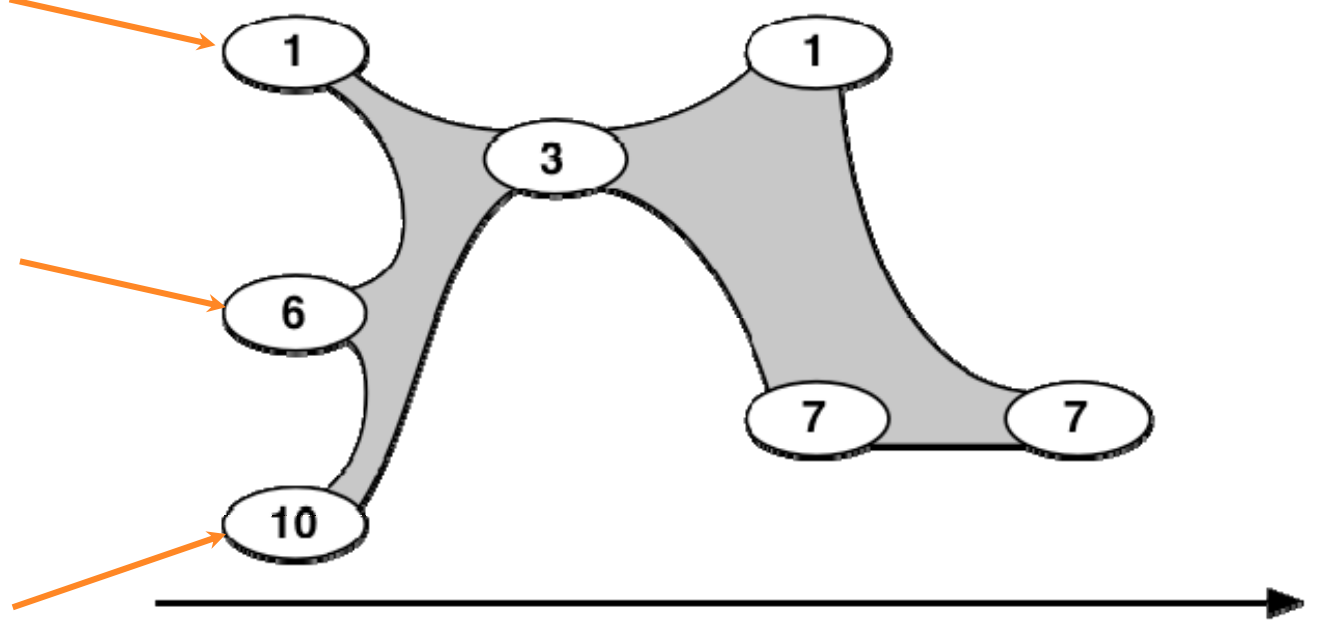
if *pheroAlarm* \neq 0 then Pursuit
else Surveillance

Surveillance

Full Pheromone
Grid

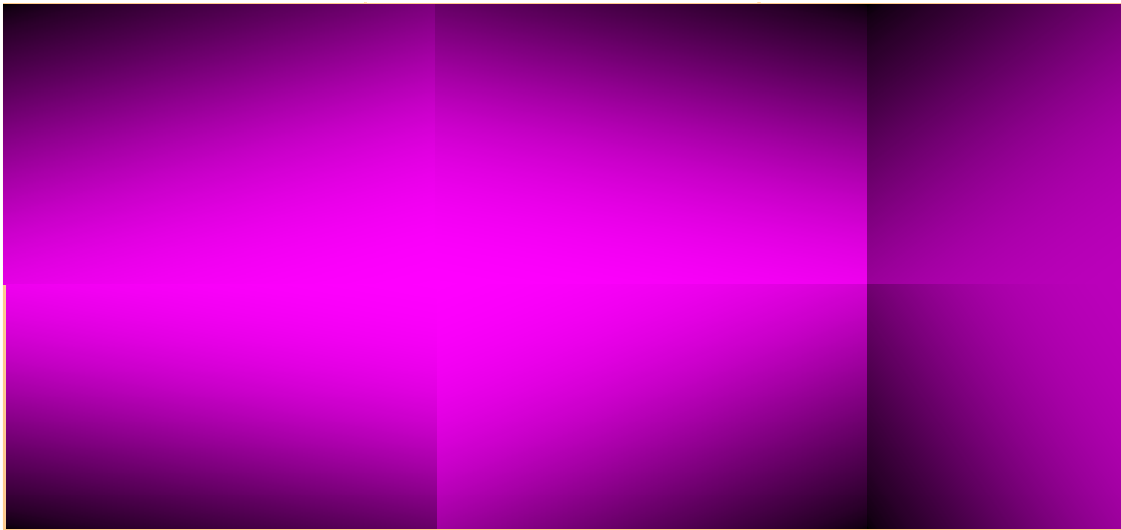
Pheromone
Grid
(Threshold)

No Grid-Zone
Info only



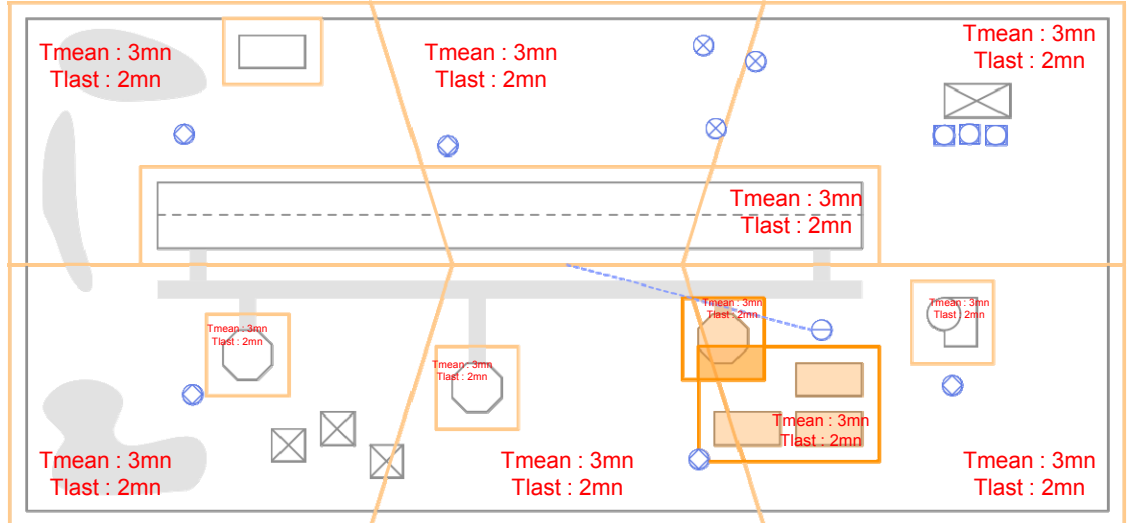
Coverage	Phero. adjust.	UAV Deploy.	Locomotion
Acquisition	Analysis	Decision	Implementation

Displaying times of visit

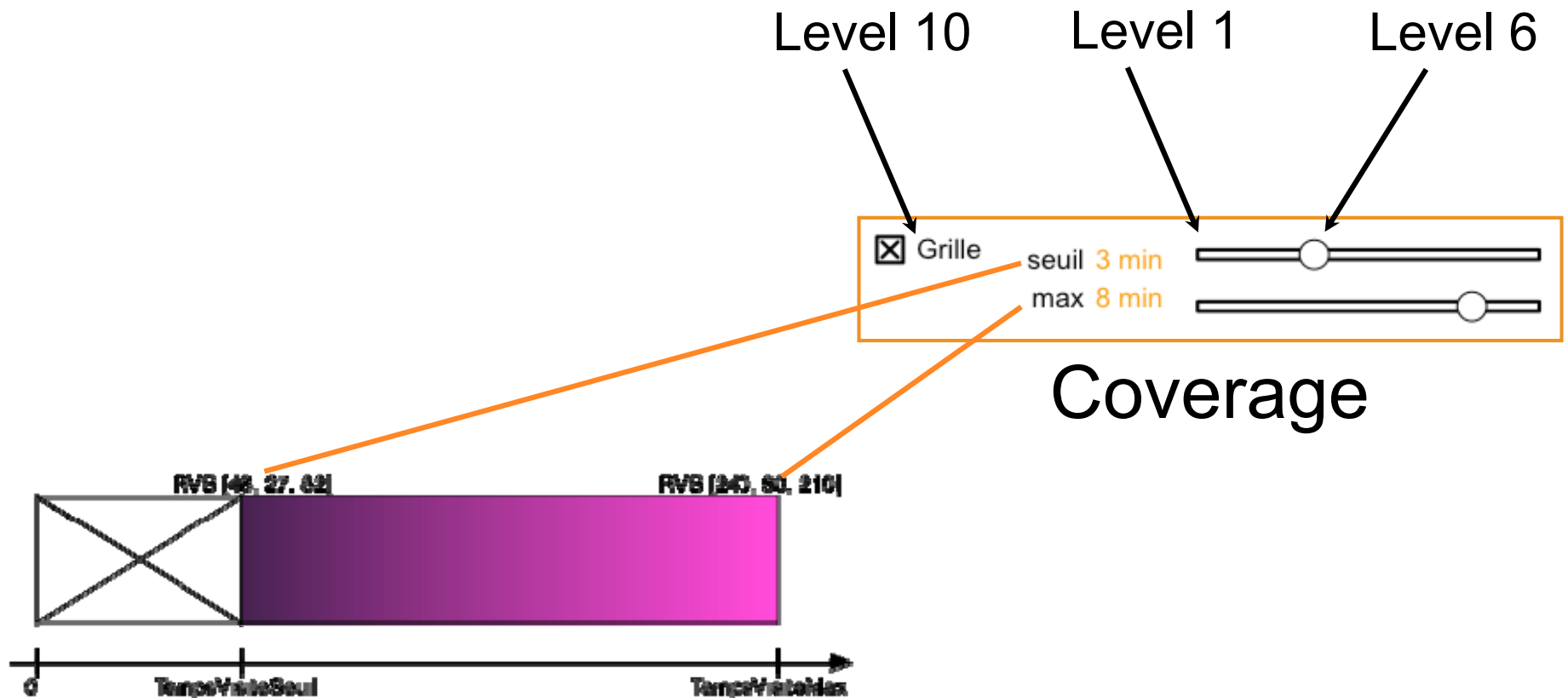


level 6

level 10



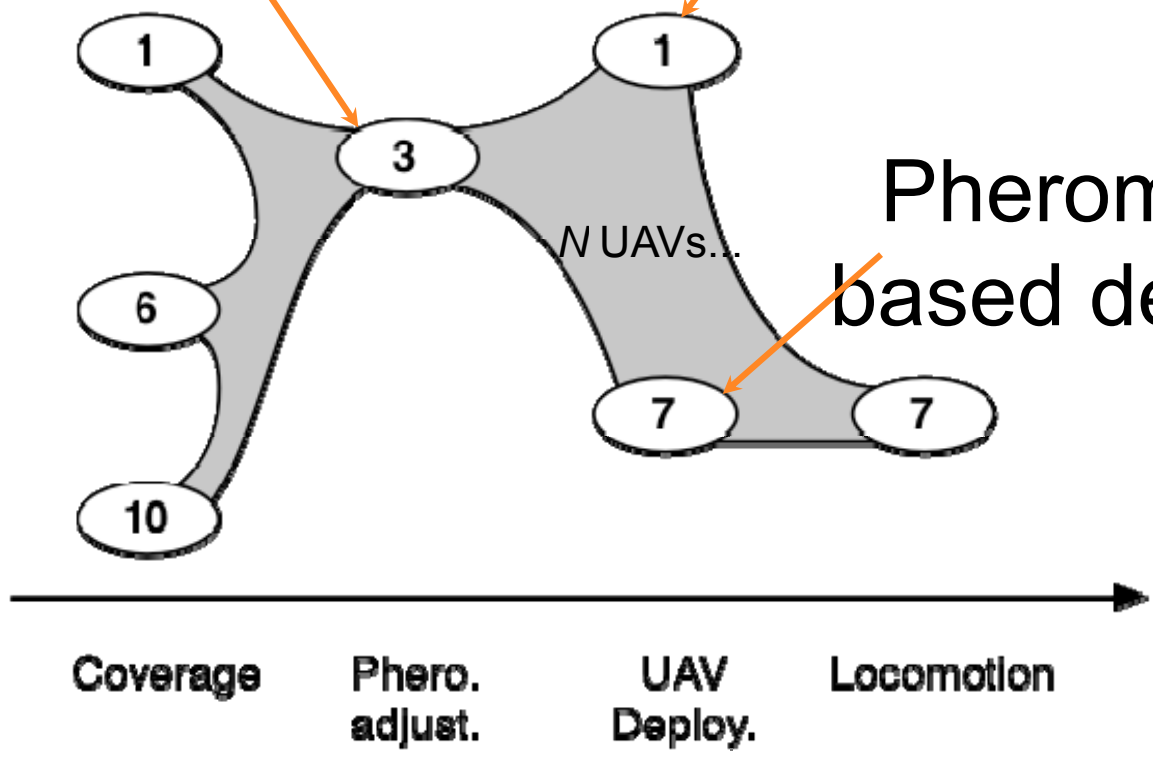
Corresponding HCI element



Surveillance

Adjust Priority
by increments

Position assigned
manually by
Operator



Pheromone-
based decision

Corresponding HCI elements

Priority links to UAV & contact

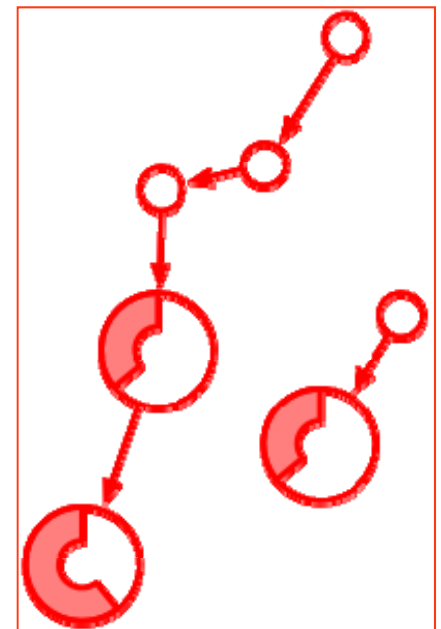
The screenshot displays the following information:

- Hangar numéro 1** (Hng1)
- Priorité :** +1 (with a small icon)
- Surface :** 6%
- 4 DVT sur zone** (with a 'DVT' icon)
- Patrouille**
- Max. 6 mn**
- Moy. 3 mn**
- 3 contact(s) depuis 42 mn**
- + récent :** -2 mn
- 3 alarmes**
- A red circular progress indicator is shown below the contact information.

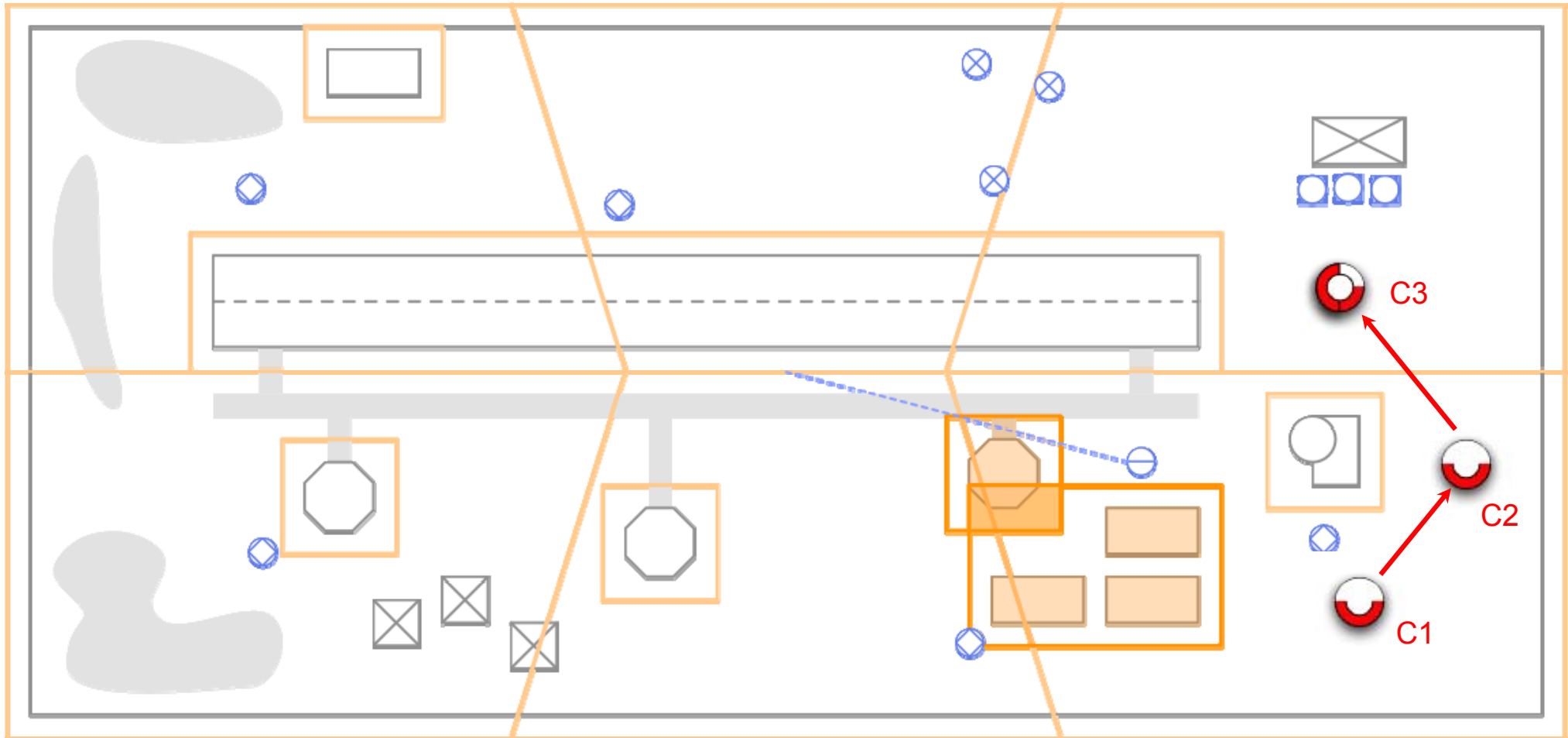
Zone info/control

Pursuit: contacts

- Alarms are automatically aggregated into Contacts (time & space threshold)
- Contacts are organized into Intrusions (contacts generated by same intruders)
 - ▶ Possibilities (new intrusion, affect to previous intrusion, *etc.*) sorted by likelihood by the system

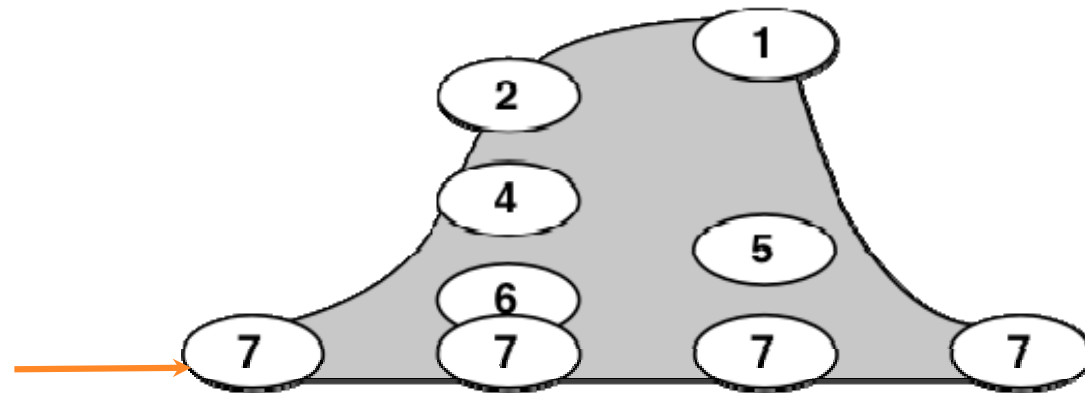


Intrusion



Pursuit

Automatic
Aggregation
of Alarms



Contacts

Intrusions

**UAV
Deploy.**

Locomotion

Acquisition

Analysis

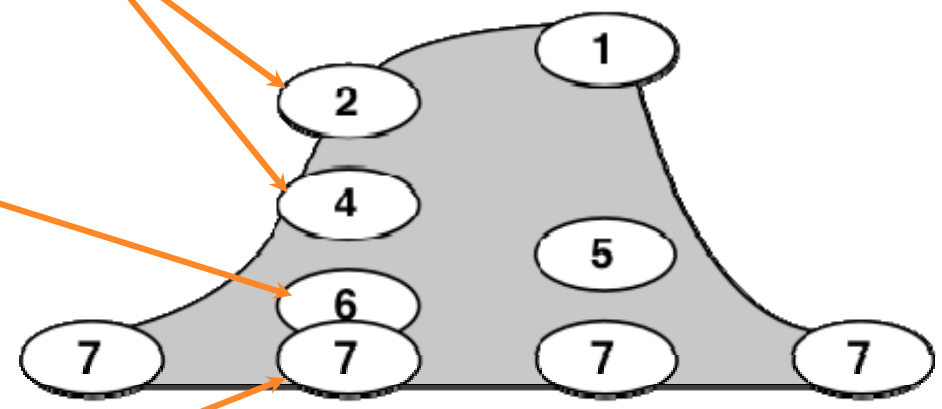
Decision

Implementation

Pursuit

Choices Sorted
by Likelihood

 Time before auto.



Auto. Most Likely



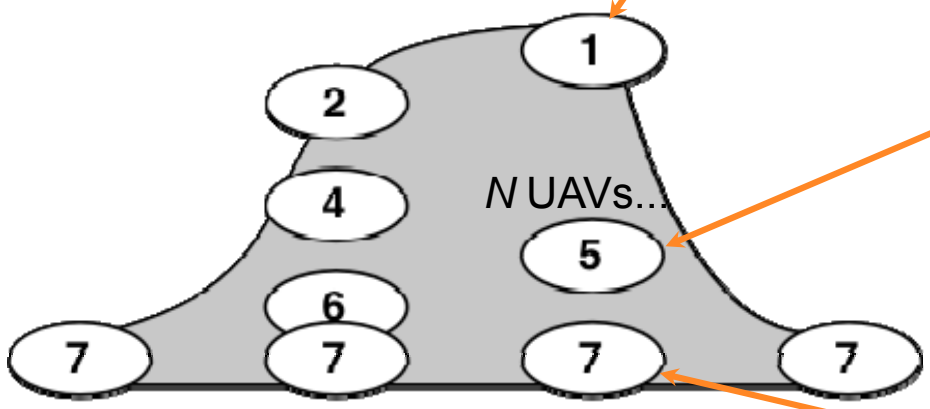
- | | | | |
|-----------------|-------------------|------------------------|-------------------|
| Contacts | Intrusions | UAV
Deploy. | Locomotion |
| Acquisition | Analysis | Decision | Implementation |

Pursuit

Position assigned manually by Operator

Deployment of UAVs via an Intrusion

Pheromone-based decision



Contacts	Intrusions	UAV Deploy.	Locomotion
Acquisition	Analysis	Decision	Implementation

Pursuit HCI elements

The Intrusion Panel displays a list of intrusions with the following details:

Intrusion #	Time	Status
Intrusion #1	22:05 (-42 min)	22:46 (-1 min)
▼ C#12	22:05 (-42 min)	QNE
4 alarme(s) <234, 45> 2 DVT 1 DVF 1 capteur		
▷ C#15	22:09 (-38 min)	QNE (Hng1)
▷ C#18	22:34 (-13 min)	QNE (Hng1)
▷ C#23	22:46 (-1 min)	QNE (Hng1)

At the bottom of the panel, there is a 'Notes...' field, a 'Sel. 2 DVT' dropdown menu, a 'Go' button, and an 'Abandonner' button.

Intrusion Panel

The Contact menu displays the following options:

- >Intru#3
- Nvelle Intru.
- >Intru#2
- Retirer
- Ignorer

Contact menu

Select nearby UAVs
& dispatch them

Conclusion

- Relying on a self-organized swarm of UAV
- Offering different levels of “autonomy” for control
 - ▶ in information display
 - ▶ in (individual) UAV mode selection
 - ▶ in UAV deployment
- Allowing to manage higher levels “semantic” patterns (intrusions)

Future work

- Prototype demonstration on air base scenarios

- Experimental comparison of performances in adaptive, fully automatic or fully manual configuration

- Connect tool to existing management framework

- Experimentation in real size



Thanks for attention !

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