University of Bordeaux 1 - Science and Technology

# Mobility Models for UAV Group Reconnaissance Applications

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*IEEE lecture 2006*

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**Master 2 Computer Science** **Study and Research Project** **2013-2014**

# Plan

- Context
- Problematic
- Study of existing
- Our article
- Models of our study
- Experiments
- Comparison of 2 models
- Our Implementation
- Conclusion

# Context

- UAV
- Swarm of UAVs
- Mobility models

➔ How do they move ?

# Problematic

**Figure 1 .** Source : "http://www.swiss-uav.com "

## How well scan an area ?

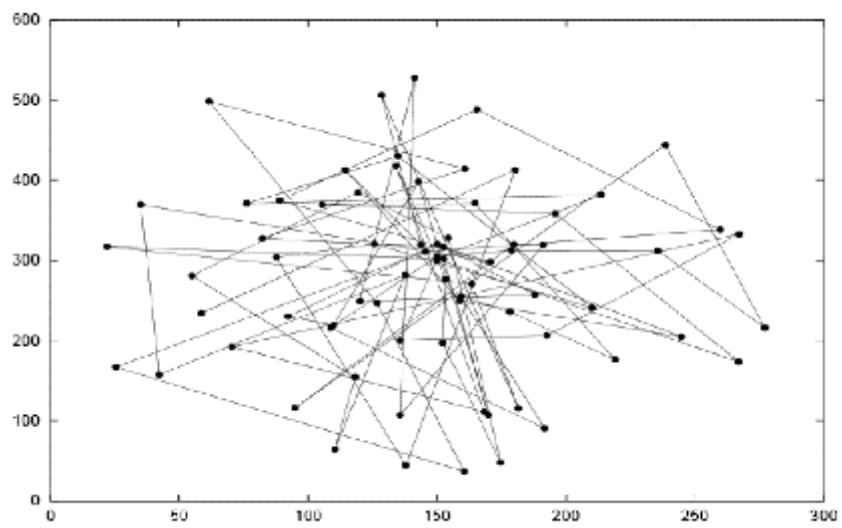
*As much and as quickly possible, in a limited time and at least, once every hour.*

**Figure 2.** Source : " http://technorati.com "

# Study of existing

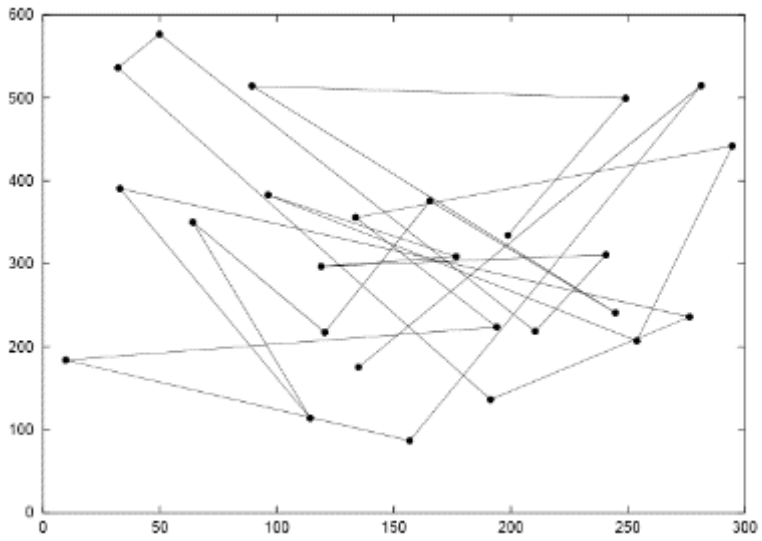
Existing Models

- Random Walk




[1] : Result pattern of Random Walk

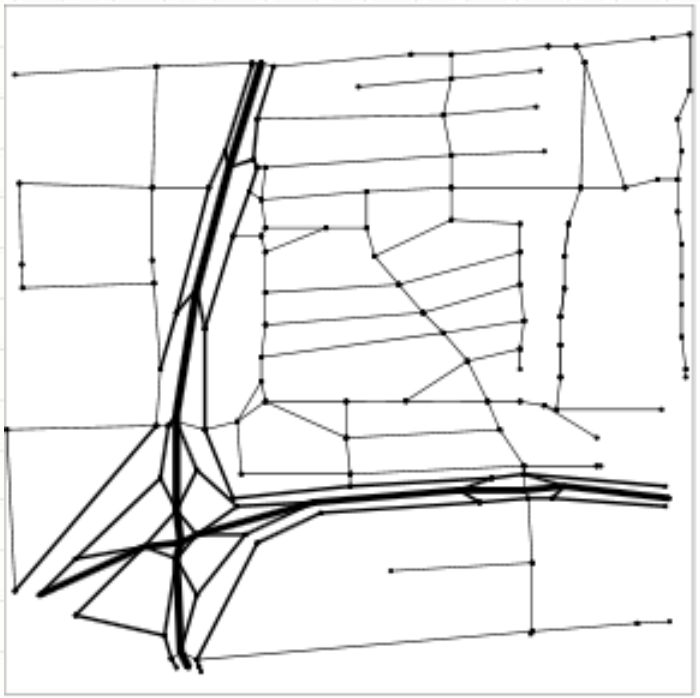
- Random WayPoint




[2] : Result pattern of Random Walk

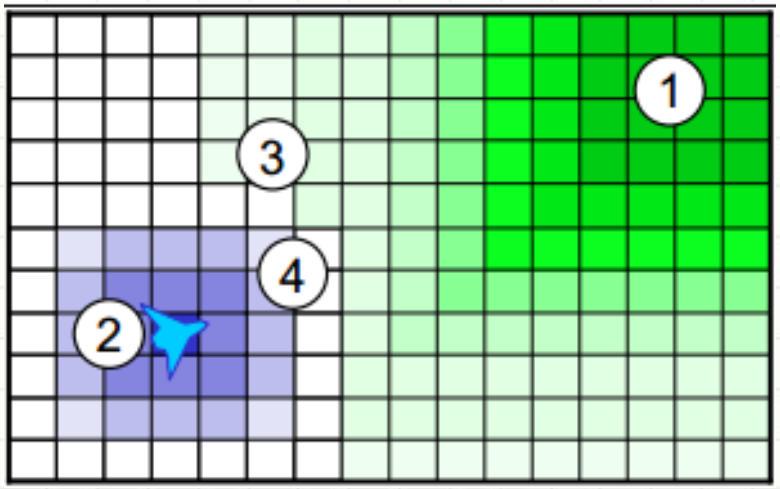
# Study of existing

- City Section



[3] : **(b) Region *B***: Street scenario corresponding to a square area of size 1900 m×1900 m

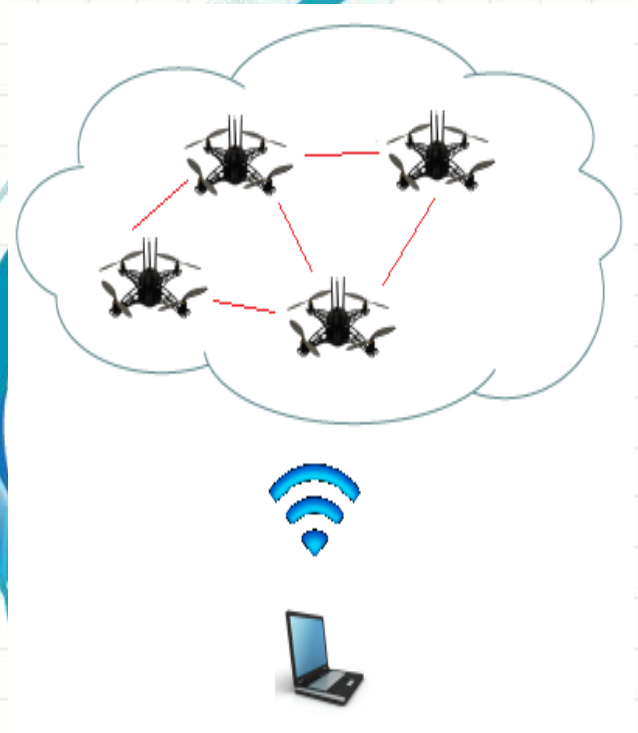
- Distributed Pheromone Repel




[4] : Attractive and Repulsive Pheromones For Surveillance

Blue : repulsive
Green : attractive

# Our Article



## Introduction

- MANET
  - Mobile Ad Hoc Network
  - Networks of mobile entities
  - Collect, process and transmit data
- UAV
  - Application of mobility models with UAVs
- 2 differents mobilities models
  - Random Waypoint
  - Distributed Pheromone Repel

# Models of our study

Random Waypoint model

- Each drones are independant
- No backup position
- Random target

# Models of our study

## Random Waypoint model

**Table 1. UAV random action table.**

| | Probability of action | | |
|---|---|---|---|
| **Last action** | **Turn left** | **Straight ahead** | **Turn right** |
| **Straight ahead** | 10% | 80% | 10% |
| **Turn left** | 70% | 30% | 0% |
| **Turn right** | 0% | 30% | 70% |

***From :*** "*Mobility Models for UAV Group Reconnaissance Applications*"
***By :*** *E. Kuiper and S. Nadjm-Tehrani.*

# Models of our study

Distributed Pheromone Repel model

- Coordination of UAVs thanks to pheromones
- Dynamic UAV

# Models of our study

Distributed Pheromone Repel model

- One pheromone map per UAV
- Marks the areas when they have been scanned
- Broadcast regularly a local area pheromone map (when a distance is inferior to 8 km)

# Models of our study

## Distributed Pheromone Repel model

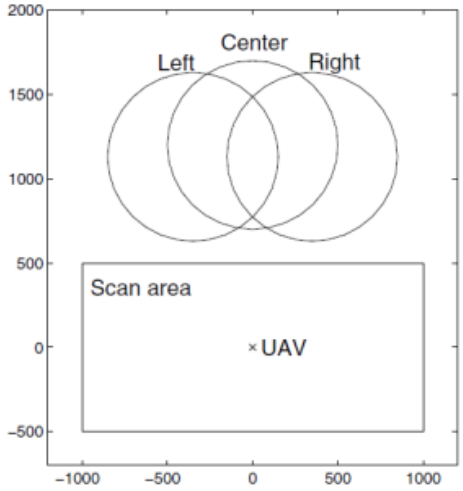



**Figure 2. Pheromone search pattern**

**Table 2. UAV pheromone action table.**

| Probability of action | | |
|---|---|---|
| **Turn left** | **Straight ahead** | **Turn right** |
| (Total – Left) / (2 * Total) | (Total – Center) / (2 * Total) | (Total – Right) / (2 * Total) |

***From :*** *"Mobility Models for UAV Group Reconnaissance Applications"*
***By :*** *E. Kuiper and S. Nadjm-Tehrani.*

# Experiments

Scenarios for the 2 models

- Characteristics
  - Square with a side length of 30 Km
  - 10 UAVs per run
  - Fixed wing aircraft

- Requirements
  - Data must be returned to the C&C
  - No excessive use of bandwidth (communication of 1 message/s/UAV)

# Experiments

Expected results :

Scan the area in 40 min

Obtained results :

| Mobilities Models | RandomWayPoint | Pheromone |
|---|---|---|
| Time to scan the area | 80% of the area in 120 min | 90% of the area in 50 min |
| Connectivity | Low | Low |

# Experiments

Limitations

- Speed and shift (direction)
- Coverage and connectivity of communications are two conflicting objectives.
- Absolutely unrealistic !!!!!!

# Comparison of 2 models

## *Scan characteristic*

Both models manage quite well to avoid rescanning a recently scanned area.

**Table 3. Never scanned area**

| | Max | Median | Min |
|---|---|---|---|
| **Random** | 16.2% | 3.2% | 0.5% |
| **Pheromone** | 0.21% | 0.03% | 0.01% |

***From :*** *"Mobility Models for UAV Group Reconnaissance Applications"*
***By :*** *E. Kuiper and S. Nadjm-Tehrani.*

# Our Implementation

## All models

- Everything was done
- 10 nodes/models
- Margin calculation
- Percentage of scan
- Tracking display

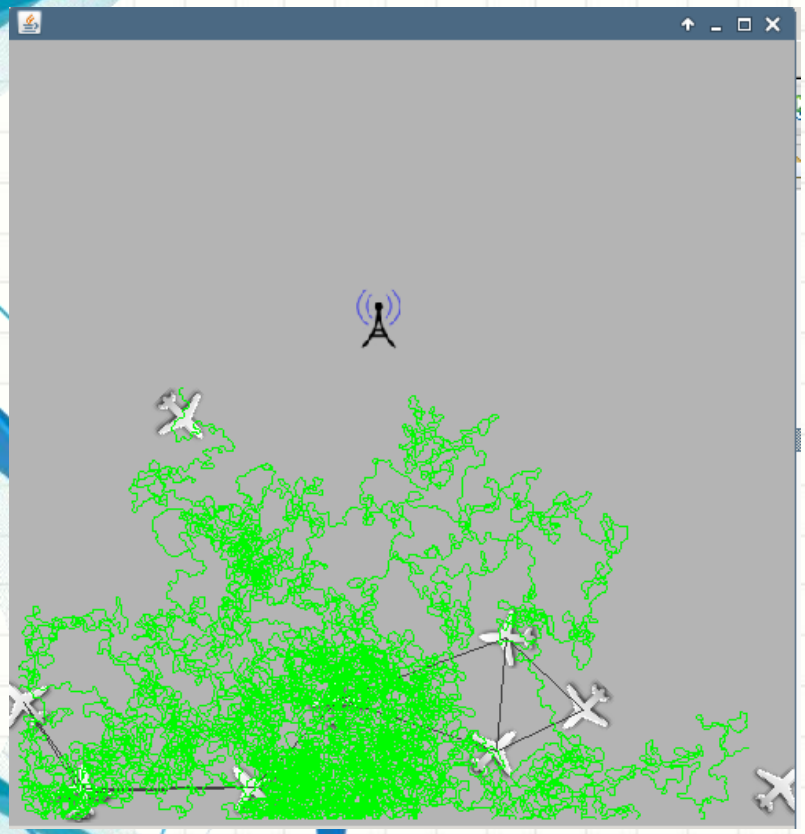
## Pheromone model

- Presence of C&C does not move
- Communication

# Our Implementation

JBotSim

Pheromone model



Problems @ Javadoc Declaration Consol

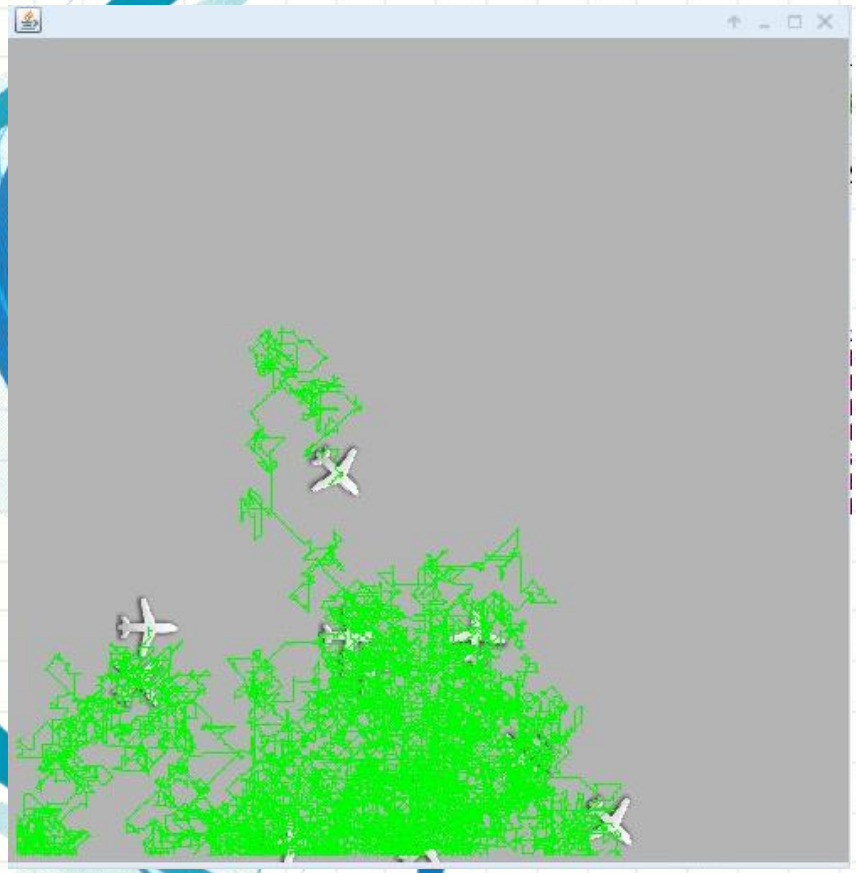
<terminated> Main [Java Application] /usr/lib/jvm/jdk-7-

```
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
```

# Our Implementation

JBotSim

Random Walk model



Problems @ Javadoc Declaration Consol

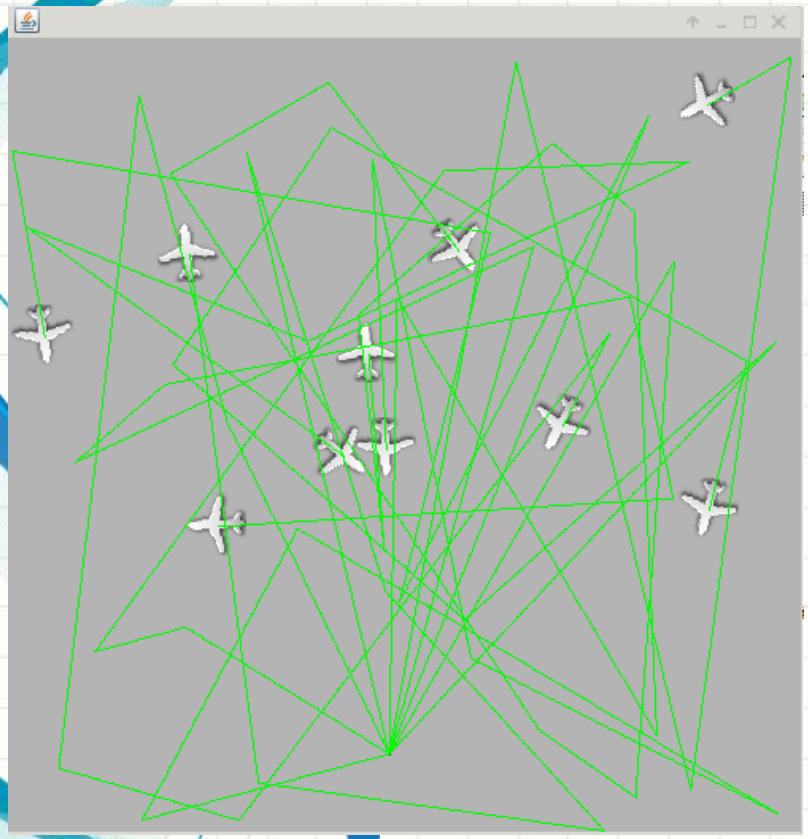
Main (2) [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/b

```
Scan : 22.65264473136193% during 2 min 0 sec
Scan : 22.65264473136193% during 2 min 0 sec
Scan : 22.65264473136193% during 2 min 0 sec
Scan : 22.653061224489797% during 2 min 0 sec
Scan : 22.653061224489797% during 2 min 0 sec
Scan : 22.65347771761766% during 2 min 0 sec
Scan : 22.653894210745523% during 2 min 0 sec
Scan : 22.65431070387339% during 2 min 0 sec
Scan : 22.65431070387339% during 2 min 0 sec
Scan : 22.65431070387339% during 2 min 0 sec
Scan : 22.654727197001247% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655560183256977% during 2 min 0 sec
```

# Our Implementation

JBotSim

Random Waypoint model



Problems @ Javadoc Declaration Consol

Main (1) [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/b

```
Scan : 35.723958333333336% during 2 min 0 sec
Scan : 35.724392361111114% during 2 min 0 sec
Scan : 35.724826388888886% during 2 min 0 sec
Scan : 35.725260416666664% during 2 min 0 sec
Scan : 35.725260416666664% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72612847222222% during 2 min 0 sec
Scan : 35.72612847222222% during 2 min 0 sec
Scan : 35.7265625% during 2 min 0 sec
Scan : 35.72699652777778% during 2 min 0 sec
Scan : 35.72743055555556% during 2 min 0 sec
Scan : 35.72743055555556% during 2 min 0 sec
Scan : 35.727864583333336% during 2 min 0 sec
Scan : 35.727864583333336% during 2 min 0 sec
```

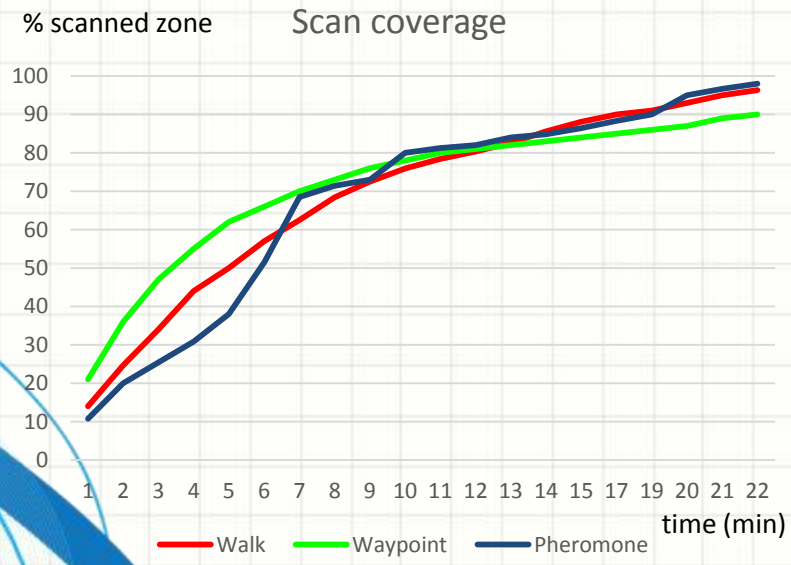
# Our Implementation

## Interpretation of results

- At the beginning, Random model more efficiency
- Pheromone : sharp increase because of C&C communication
- At the end, random models are stable
- Pheromone model is more effective that the others models to reach 100% of scan.

# Our Implementation

## Comparison with article



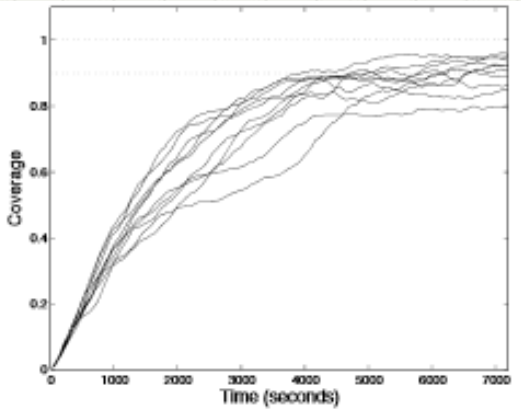




**Figure 3. Random mobility coverage**

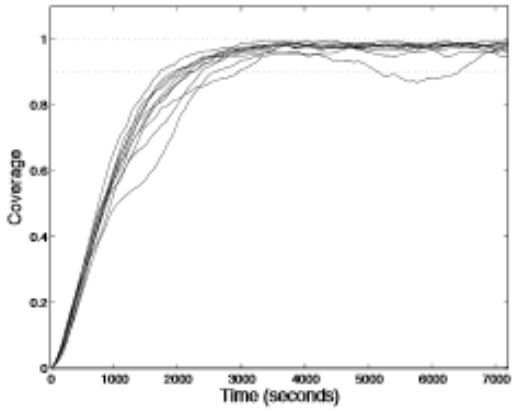



**Figure 4. Pheromone mobility coverage.**

# Conclusion

- Good model  for scan coverage and reconnaissance scenario.
- Absolutely unrealistic
- Possiblity amelioration is to temporary storage data and relax the limited bandwidth.

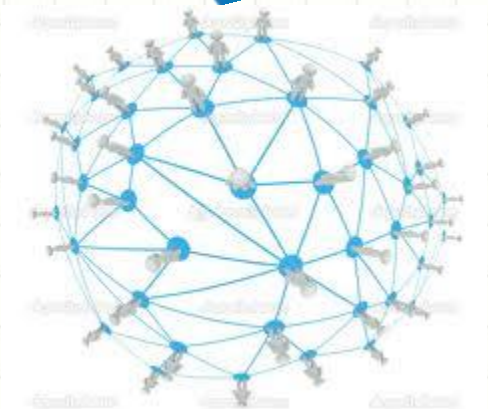


**Figure 4.** Source : " http://fr.depositphotos.com "

**Figure 3.** Source : " http://www.vikingaero.com "


**Figure 5.** Source : " http://titanaerospace.com "

# DO YOU HAVE ANY QUESTIONS ?

**Figure 6.**

# Ressources


- E. Kuiper and S. Nadjm-Tehrani.

*Mobility models for uav group reconnaissance applications. In Wireless and Mobile Communications, 2006. ICWMC '06. International Conference on, page 33, July 2006.*

"http://dept-info.labri.fr/~desbarat/PER/sujets/Autefage1-article.pdf "

[1] && [2] : A. Jardosh, E. M. Belding-Royer, K. C. Almeroth, S. Suri. Towards Realistic Mobility Models for Mobile Ad Hoc Networks. 9th annual International Conference on Mobile Computing and Networking. September 2003. ACM Press

[3] A. K. Saha, D. B. Johnson. Modeling Mobility for Vehicular Ad Hoc Networks. First ACM Workshop on Vehicular Ad Hoc Networks. October 2004. ACM Press

[4] J. A. Sauter, R. Matthews, H. V. D. Parunak, S. A.Brueckner. Performance of Digital Pheromones for Swarming Vehicle Control. Fourth International Joint Conference on Autonomous Agents and Multi-Agent Systems. July, 2005. ACM Press