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UAVs for Humanitarian Missions: Autonomy and Reliability

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Presented by Neslihan Kose

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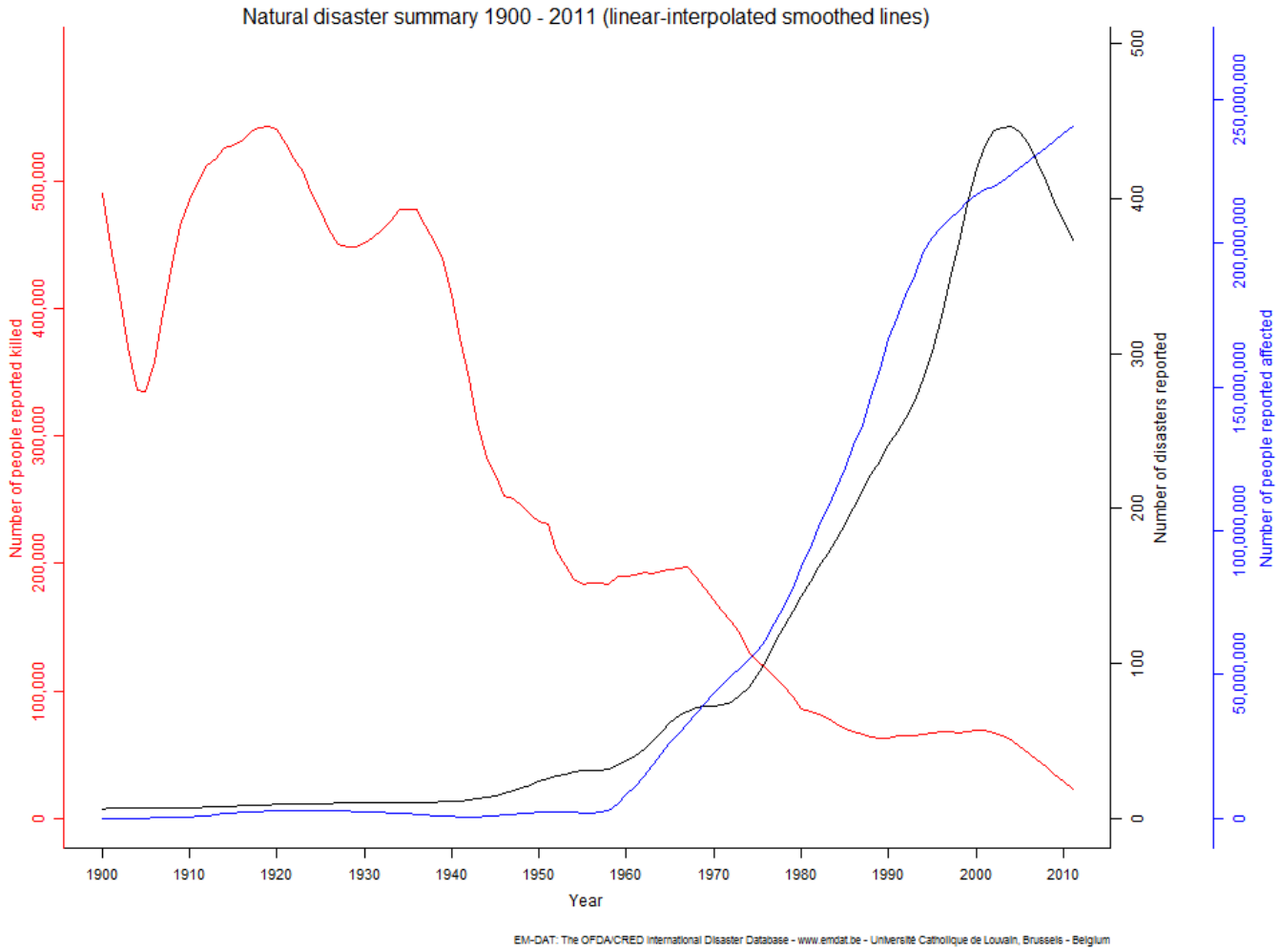
Outline

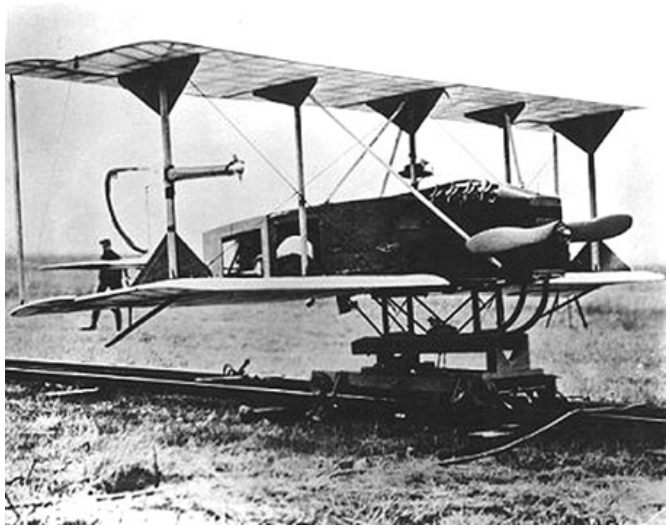
- **Humanitarian Data**
  - Natural Disasters
- **Mini Drones**
  - What is it?
- **Potential Objectives for Humanitarian Drones**
  - People detection
  - People classification and counting
  - Contact and inform, …
- **Technical Challenges**
  - Current Limitations
  - New Architecture
  - Data Inputs and Processing
- **Conclusion**

Natural Disasters

Source: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium);



Mini Drones (UAV)



Since the Hewitt-Sperry automatic airplane (1917), Drone Ancestor.

Potential Objectives

- **Communication and coordination:**
  - Address communication black-out through an alternative network
  - Secure Data Sharing
- **Terrain reconnaissance:**
  - Exploration of areas of interest
  - Using appropriate sensors (Optical, Microwave, etc.),…
- **Search And Rescue (SAR) operations:**
  - People detection
  - People categorization and counting
  - Contact and inform, …

‘Humanitarian’ Drone Challenges

- **Autonomy of the Drone:**
  - Do not require specific skills for rescue teams
  - Do not create additional work for rescue teams
  - Scattered and fast moving victims
  - Evolving terrain conditions
- **Reliability of the Drone:**
  - Prevent additional casualties
  - Operating in hostile environments
  - Adapted to a low level of equipment maintenance
  - Preventing drone hijacks
- **Strong ethical and deontological aspects:**
  - Respect for disaster victims and relief team
  - Controlled use of acquired data, …

Drone Safety and Security

- **Dependability:**
  - Understanding of the environment (collision avoidance)
  - Limitation of the impact in case of unexpected return to the ground
  - Real time deadlines
- **Secure Design:**
  - Securing communications (authentication / encryption)
  - Protection of acquired data
  - Validation of embedded architecture
- **Energy management:**
  - Batteries weight vs. flight duration
  - Optimization of power consumption
  - Compliance with the constraints of the new generation of batteries (LiPo, etc.)

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Our Contributions

- **New Architecture for Drone**
- **Spatial completeness**
  - Comprehensive coverage of the area for establishing an emergency terrain mapping
  - Autonomous Navigation and 3D Reconstruction
- **Detection, classification and counting**
- **Affected people supervision**
  - Individual and group movements
  - Estimation of people speeds

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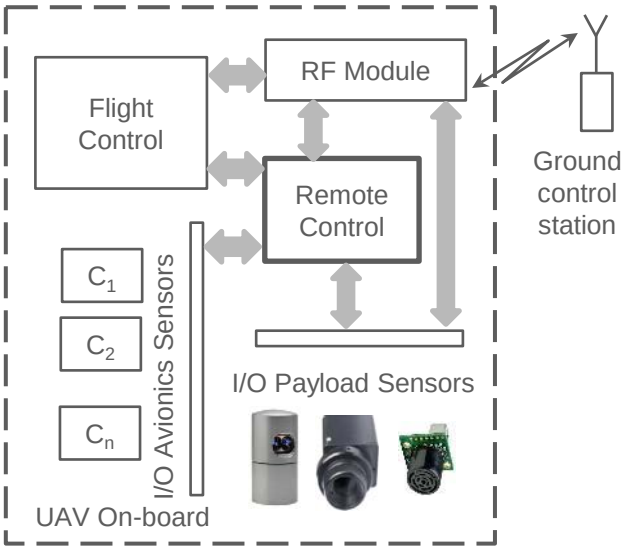
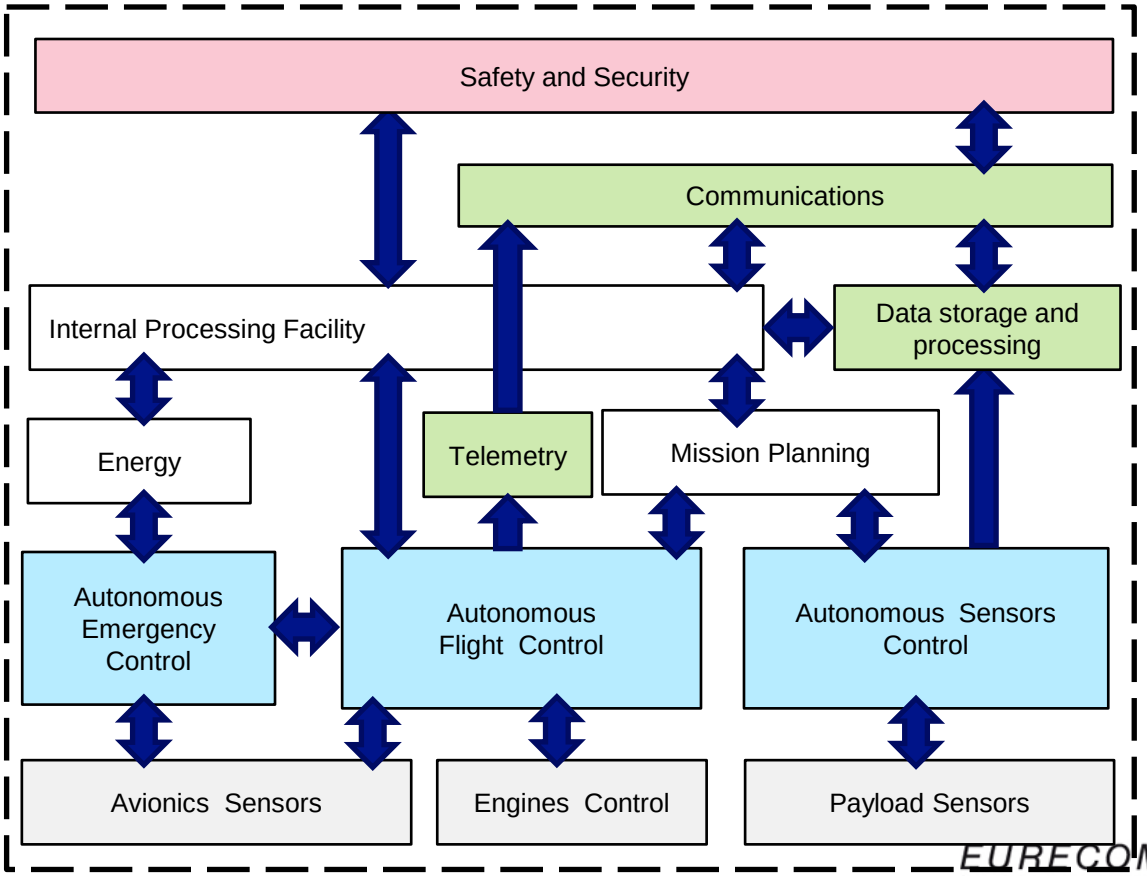
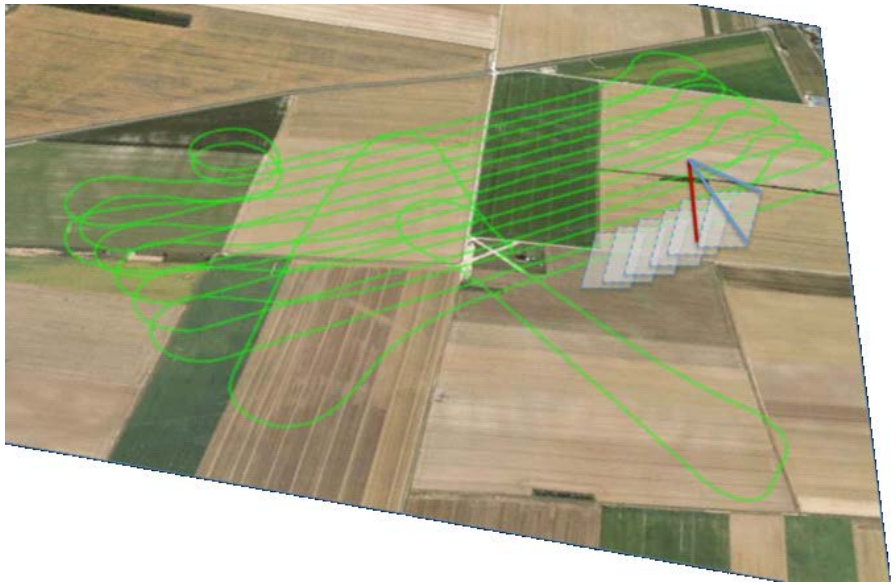
Towards New Architectures





Spatial Completeness

- **Find a optimal drone trajectory to cover the entire disaster area:**
  - Simple strategy for plane areas
  - Require more complex strategies for a rugged terrain area, to optimize energy consumption



Autonomous Navigation and 3D Reconstruction

3D Vision with a mono-vision camera:

- Dense reconstruction (Fig A) requires to stop the flight
- Sparse reconstruction (Fig B) combined with a *corkscrew flight* trajectory

Videos: **http://drone4u.telecom-paristech.fr/**

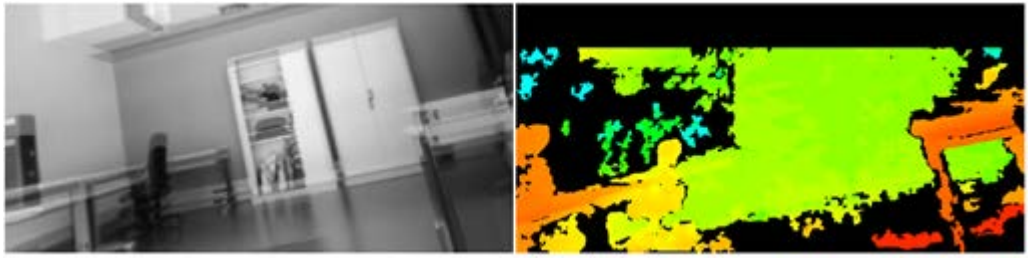


Figure A

Figure B

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People Detection and Tracking

Conventional image processing techniques:

- Face: Haar + Adaboost
- Body: HOG + SVM
- etc.

Tracking People:

- Follow the movements of people (Kalman, *particles filtering*, etc.)

Next Phase:

- Extract human traits (age, height, etc.)

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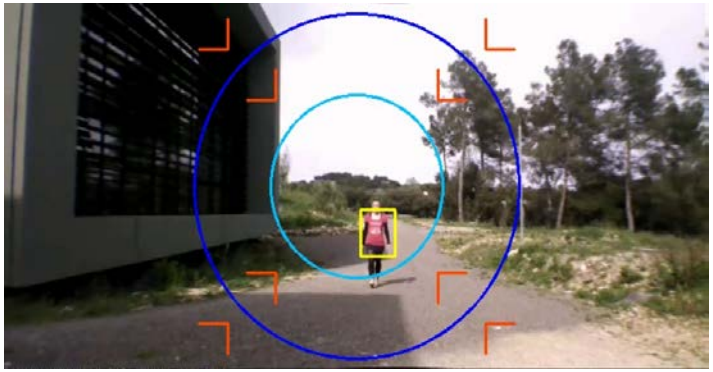
Detection and Control (1)

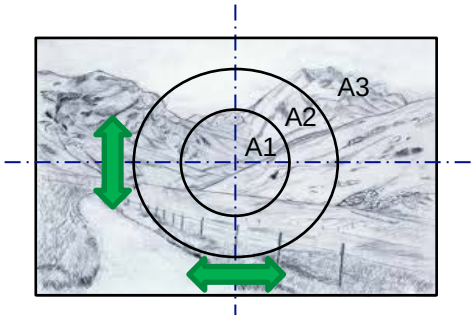


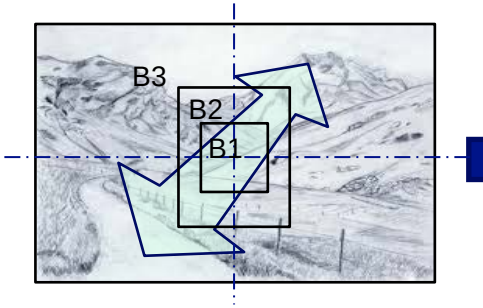
Video based Detection

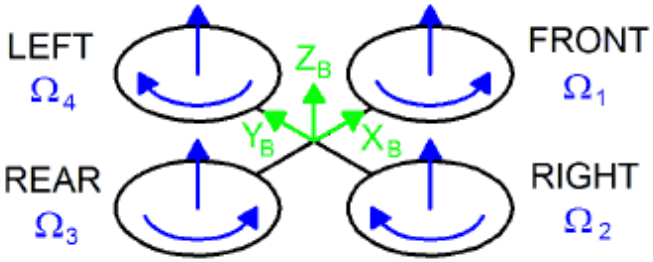
Interface

Drone Cmds

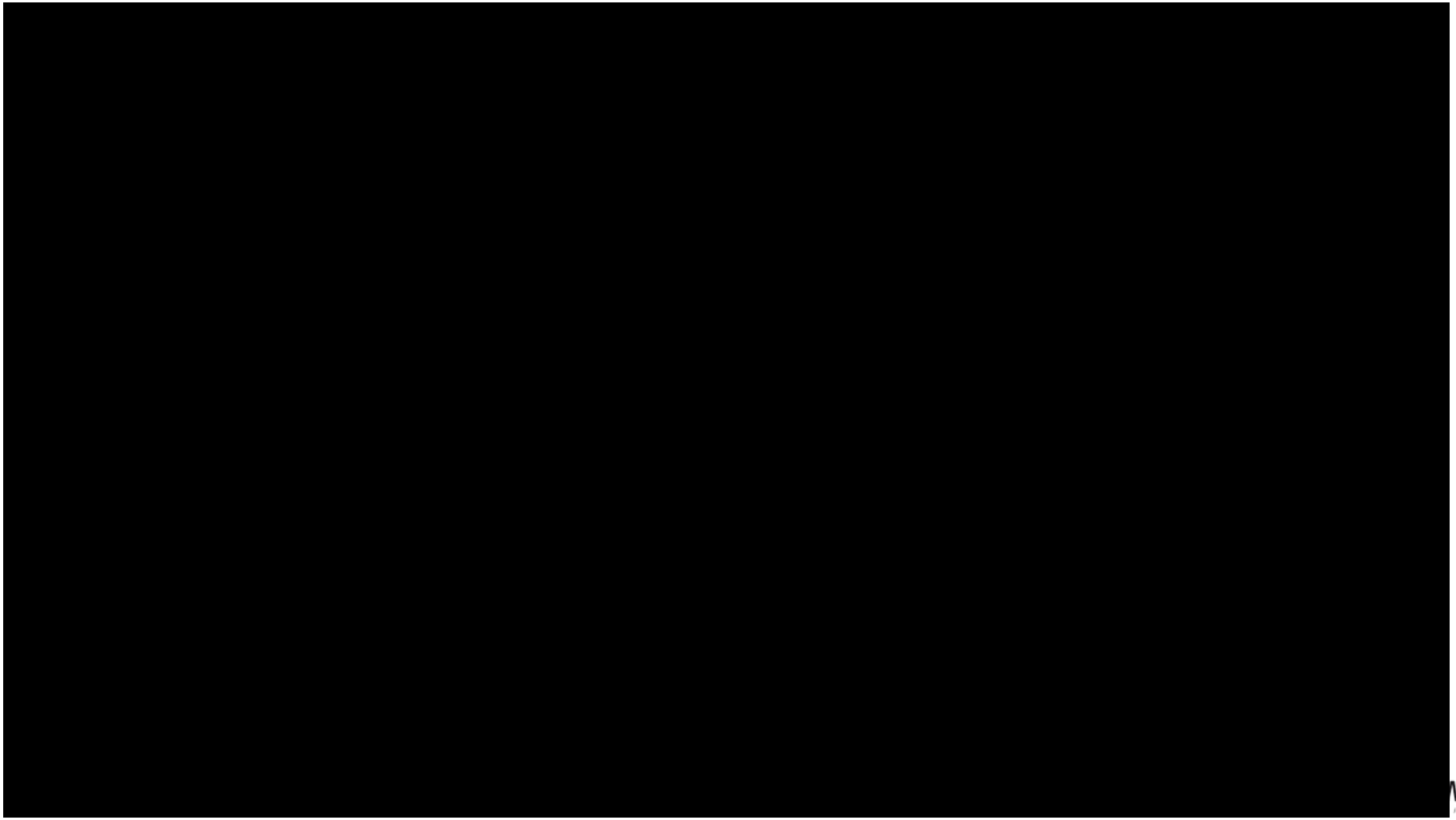
Right, left, up, down,
away, close,
...





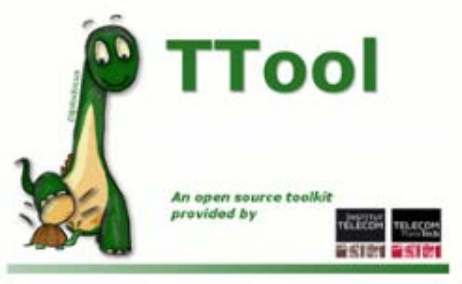


Detection and Control (2)



Conclusion

- **Design a "civilian" Drone**
- **Towards on-board intelligence:**
  - Flight autonomy
  - Mission autonomy
- **Safety and security since the design stage**
- **Multi-source data fusion (Lidar, Radar, IR, etc.)**
- **Regulatory obligations (FAA in USA, DGAC, CNIL in France, etc.)**
- **Privacy (European Directive 95/46/CE: private data protection)**
- **Usage and acceptability *versus* "operational capability"**



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Perspectives …

- **Links between communicating objects and human:**
  - Definition and design of embedded antennas intended for the detection of EM emission such as the ones produced by mobile phones (GSM, UMTS, etc.) and wireless networks (Wi-Fi, Bluetooth, etc.)
- **Integrate complex sensors:**
  - Radar, Lidar (DEM)
  - Ground Penetrating Radar (GPR)
- **Prototype validation in real conditions**

Thanks for your attention …

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