Integrated Coastal Zone Management via Increased Situational Awareness through Innovations on Unmanned Aircraft Systems

3i European Project Presentation

10 Avril 2014

GT UAV, ENSAM

Lab-STICC

ENSTA Bretagne

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OSM : Ocean Sensing and Mapping

- Staff :
  - 25 permanent people
  - 8 PhD Students
  - 4 Post doc
- Facilities
  - A robotic hall
  - A water tank
  - 2 vessels

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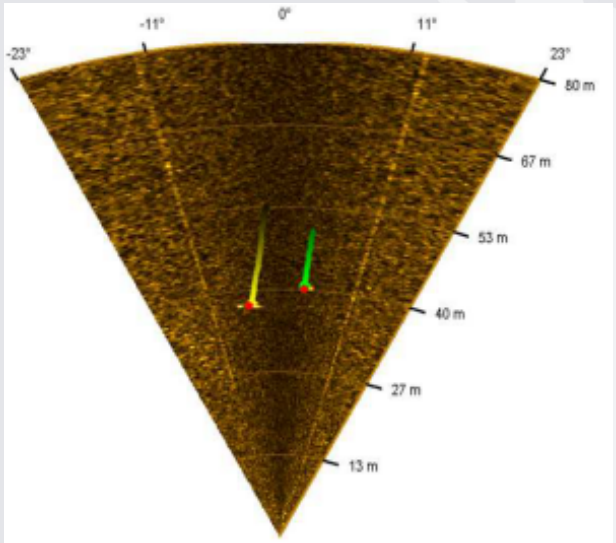
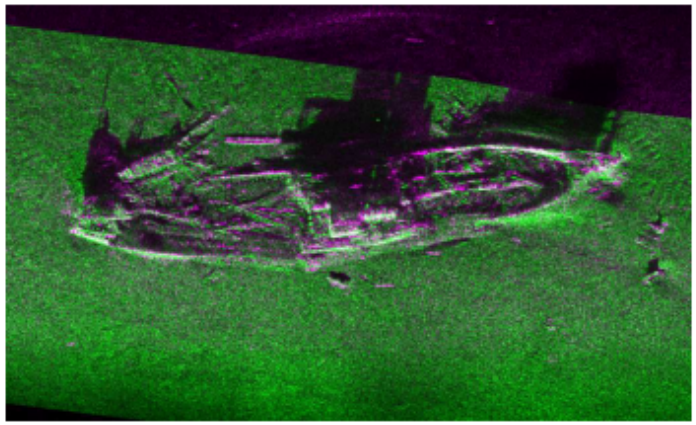
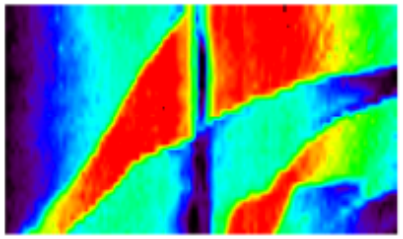
OSM activities - 1/4

- Sonar Systems
  - Global approach of the sonar processing chain...
  - from the sensor design to the high-level information extraction

- Beam forming, synthetic aperture & new sonar technology
- Design of multi-purpose “low cost” sonars
- Obstacle detection and avoidance
- Acoustic positioning and communication
- Image registration and matching





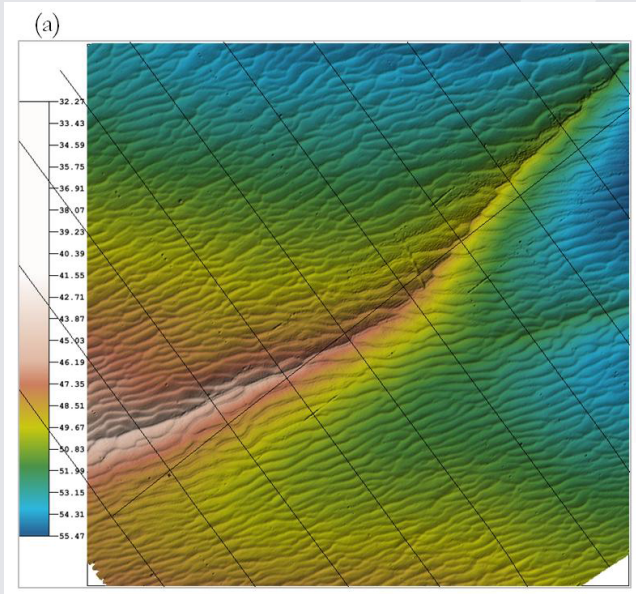


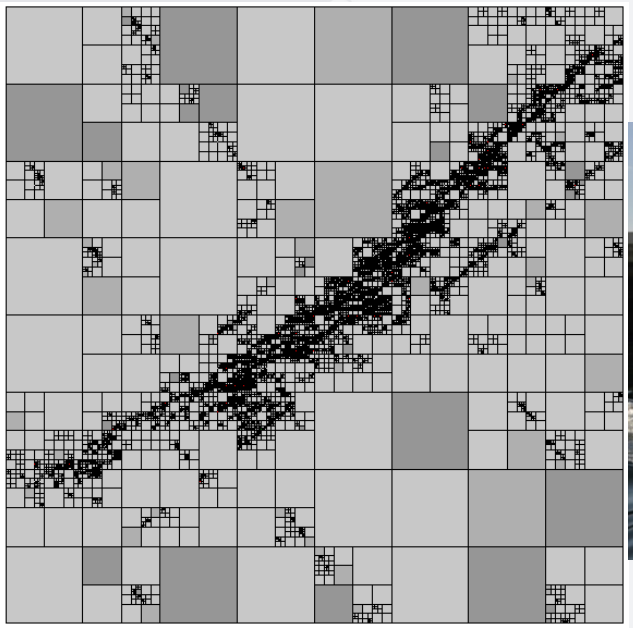
OSM activities - 2/4

- Hydrography Oceanography

  Research activity tightly linked to education (20 to 30 hydrographers A cat. per year)

- Improving accuracy of underwater terrain model (ex. CHARM algorithm)
- Underwater sensor characterization
- Optimization algorithms





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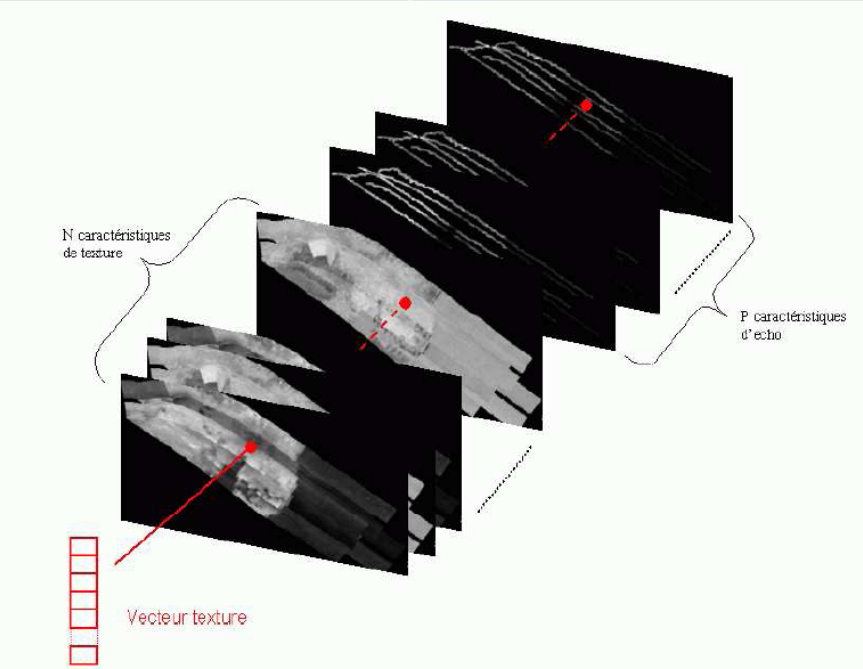
OSM activities – 3/4

- Information fusion
  - Knowledge of the underwater environment relies on : acquisition, processing and combination of information from sensors of different types



- Classification/fusion algorithm
- Automatic recognition of man made objects
- Seabed characterization
- Using Dempster-Shafer theory of evidence

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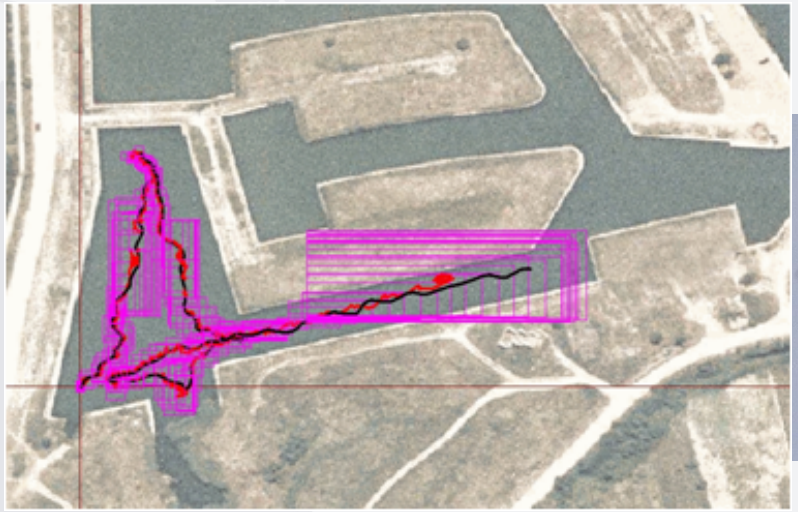
OSM activities - 4/4

- Robotics



- Improving navigation using interval arithmetic
- Participating to student contest in underwater robotics
- Control/command strategy and navigation for groups (swarm) of robots
- Design and study of underwater (AUV, Glider) and surface (sailing boat, electric boat) robots

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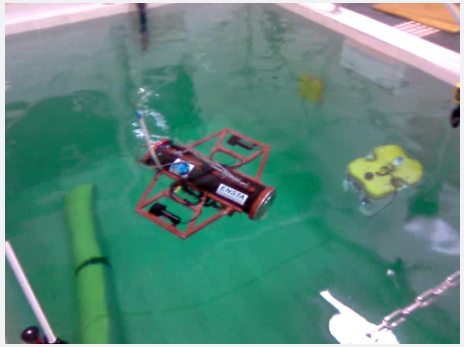
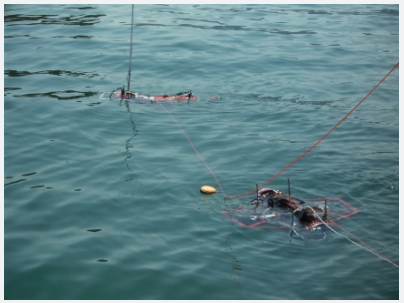
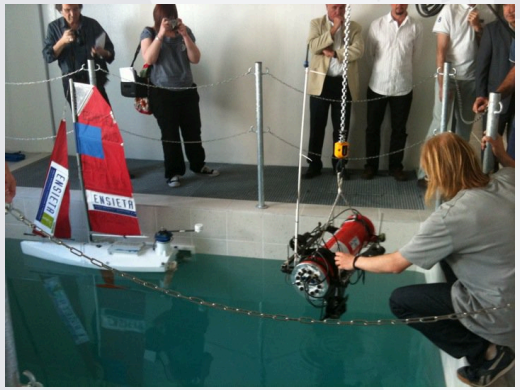
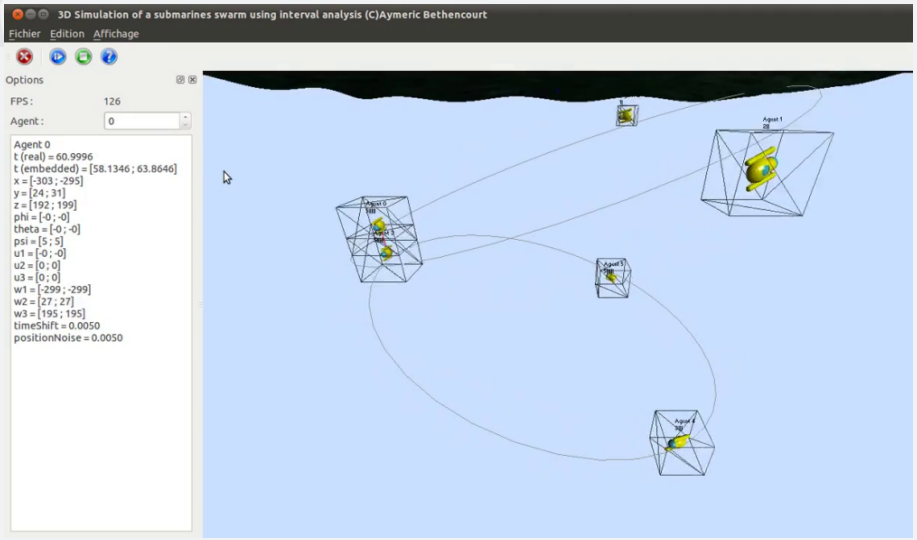
Robotics: Research topics

- Surface and underwater autonomous marine robotics (USV and UAV)
- Groups of robots (swarm)
- Improving Navigation, Control, Localization with
  - Interval Analysis Methods
  - Robust Control









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Description of 3i project

- 1. Project outline
- 2. UAV application examples
- 3. Project partners
- 4. 3i UAV System
- 5. Progress status
- 6. ENSTA-Bretagne contribution

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1. Project outline

- Police, harbors and environmental organizations interested in monitoring the activities of vessels
- Increased need to collect data for the maritime safety partners
- Unlikely to be achieved using conventional systems (radar, automatic beacons and ‘manned’ aircraft)
  - Limited range
  - Cost structures

1. Project outline

- New, cost effective and reliable monitoring service thanks to UAV's
  - Remotely piloted aircraft
  - Autonomous systems
- Primary mission for the UAV: information gathering using optical sensors
- Demonstrator realization

2. UAV application examples

- **Main port fire**
- **Environmental pollution or chemical spill monitoring**
- **Locating missing persons at sea**
- **Other objects at sea, like lost cargo**
- **Identification and tracking of small high speed boats entering harbour at night**
- **Escort of “critical ships” (like cruise ships) in the harbour.**
- **Monitoring anchorage in the vicinity of the harbour**
- **Illegal fishing**
- **Illegal diving near protected wreckages**
- **Small, high-speed vehicles cross the Channel illegal**




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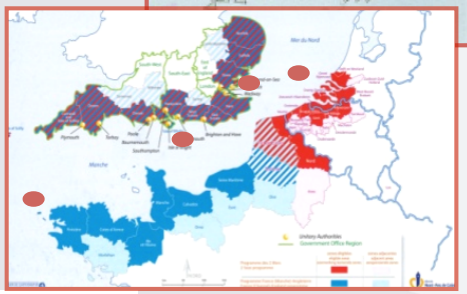
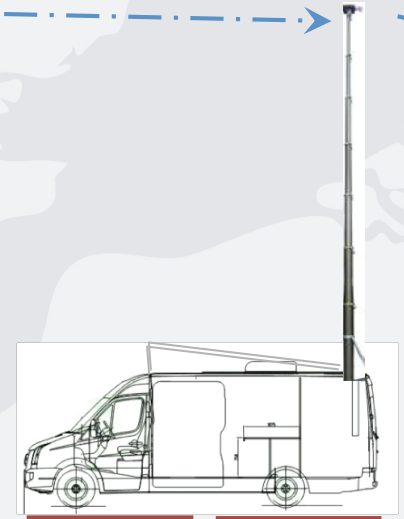
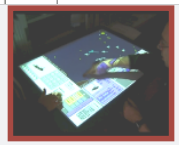
3. Project partners

PP	Partner name	Member State	Region/NUTS III
LP	Delft University of Technology	The Netherlands	Delft en Westland
2	ROC West Brabant - Aircraft Maintenance and Training school	The Netherlands	West-Noord-Brabant
3	Digital & Media Solutions	The Netherlands	West-Noord-Brabant
4	Ensta Bretagne	France	Finistère
5	Kent Police	England	Kent CC
6	Politie Rotterdam Rijnmond	The Netherlands	Groot-Rijnmond
7	Technopôle Brest-Iroise	France	Finistère
8	Havenbedrijf Rotterdam NV	The Netherlands	Groot-Rijnmond
9	Rewin	The Netherlands	West-Noord-Brabant
10	Deev Interaction SAS	France	Finistère
11	Institut Telecom / Telecom Bretagne	France	Finistère
12	University of Southampton	England	Southampton

4. 3i UAV System







Channel & North Sea Area

Coastal Area

Harbour/HQ Area

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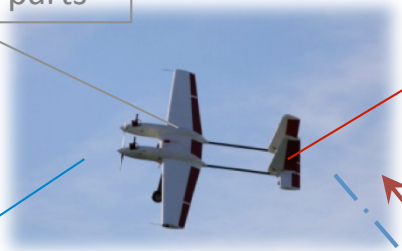
-Air frame
-Electrical parts
-Mechanical parts

-Navigation communication (Autopilot)
-Safety (Sense & Avoid)

-Video decoding at HQ
-(mobile) Internet connection
-Data fusion (eg. radar images)



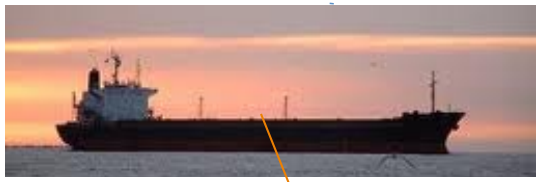
-Navigation communication link (UAV<->Groundstation)

-Camera/sensor
-Data/video Compression on board UAV

-Videolink 3 (Encoded video from ground station to Harbor/Police HQ)

-Videolink 2 (UAV to ground station)

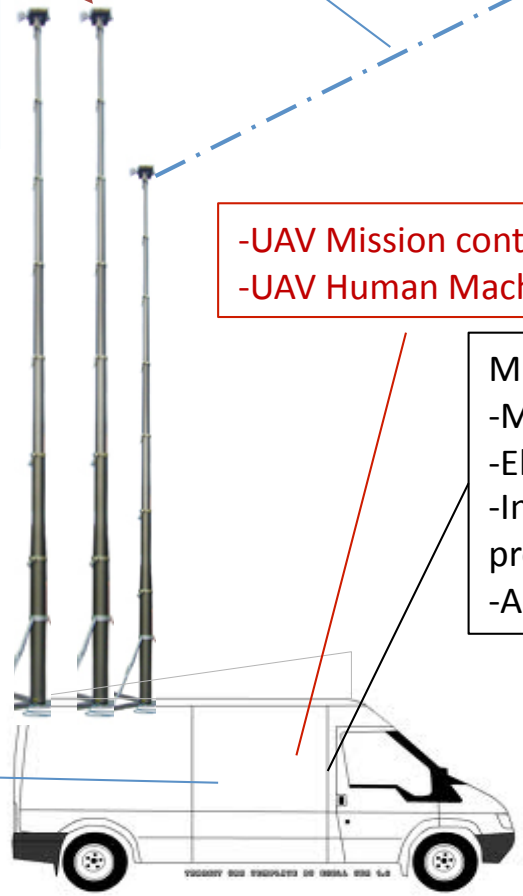
-Video capture link (scenario info to UAV)



-UAV Mission control (Table top)
-UAV Human Machine Interface

Multi Media VAN & Ground Station:
-Mechanical and structure work
-Electrical & wiring installations
-In & Exterior, Workplaces (pilot, officer, programmer)
-Auxiliary systems (power, airco, launching eq)

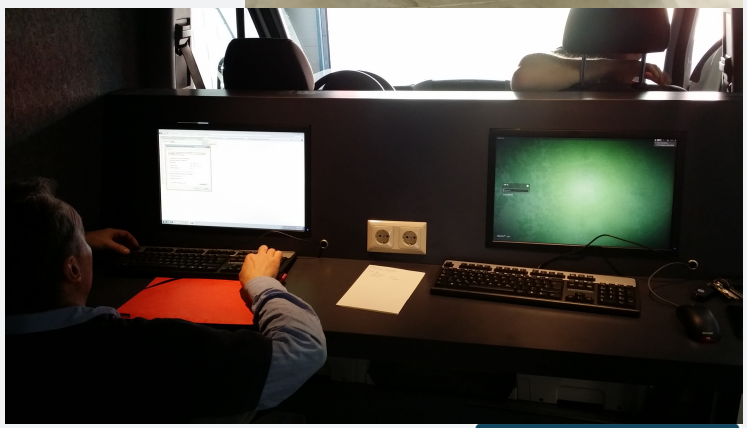
Maritime safety scenario's:
-anchor locations, smuggling , etc.
-mission preparation activities

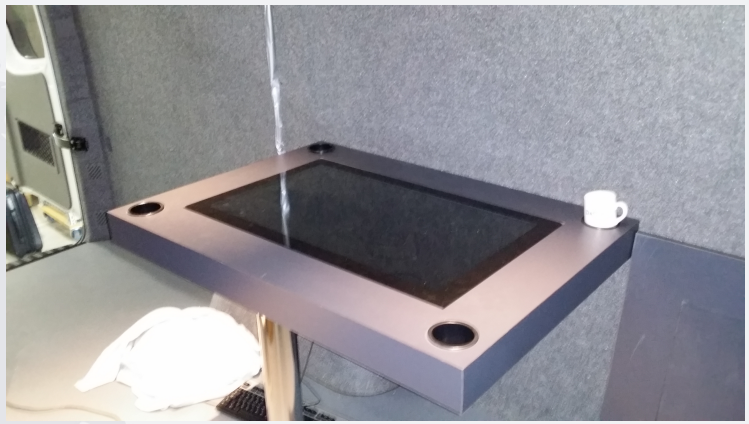


-Video decompressing from UAV
-Video/data enrichment
-Video encoding before transmission
-Video transmission (to HQ)

5. Progress status

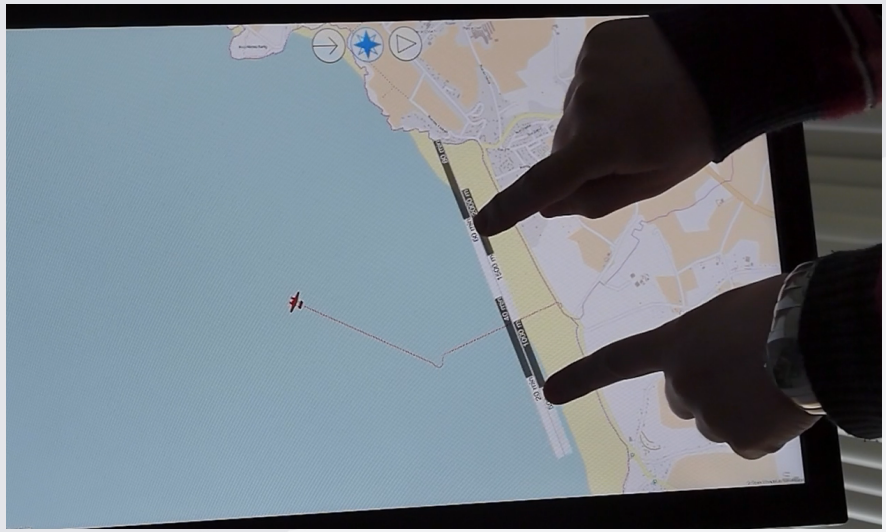
- Van conception
- Demonstration (date to be confirmed)
  - UK, 17th July
  - France, 1st week, September
  - Netherlands, 3rd week, September





5. Progress status

- IHM demonstration
- Flight demonstration



2SEAS-20 UAV Test Flights, Port of Ramsgate, February 2014 -…

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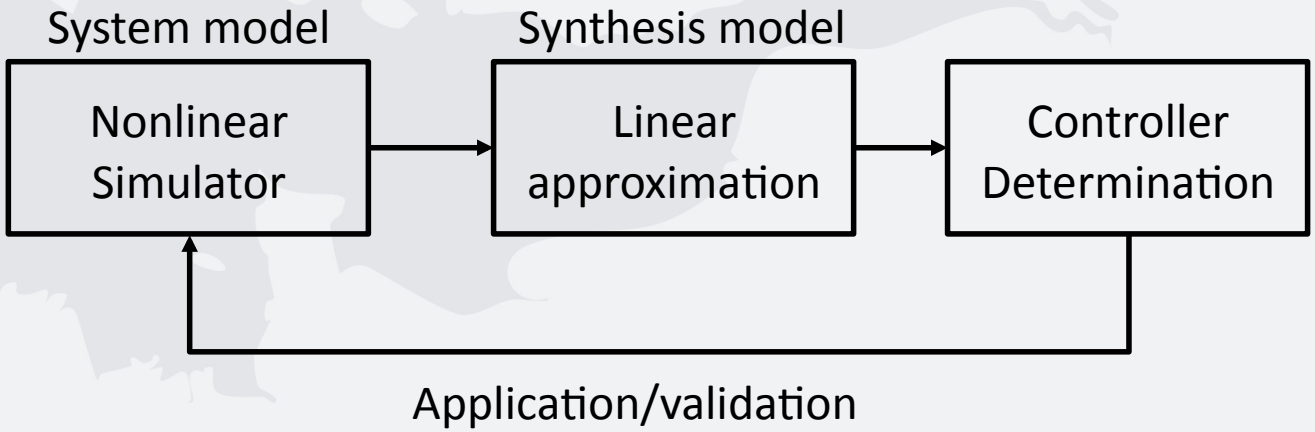
6. ENSTA-Bretagne contribution

- Main objective: improve UAV control
  - Proportional (sometimes Proportional and Integral) controllers
  - Advanced (and robust) control wanted: LQG, H_{inf}, LPV…
- Implicit objectives
  - Development of an aircraft simulator
  - Data filtering improvement
  - Interaction with 3i project team (data, sensors, integration with paparazzi platform…)

6. ENSTA-Bretagne contribution

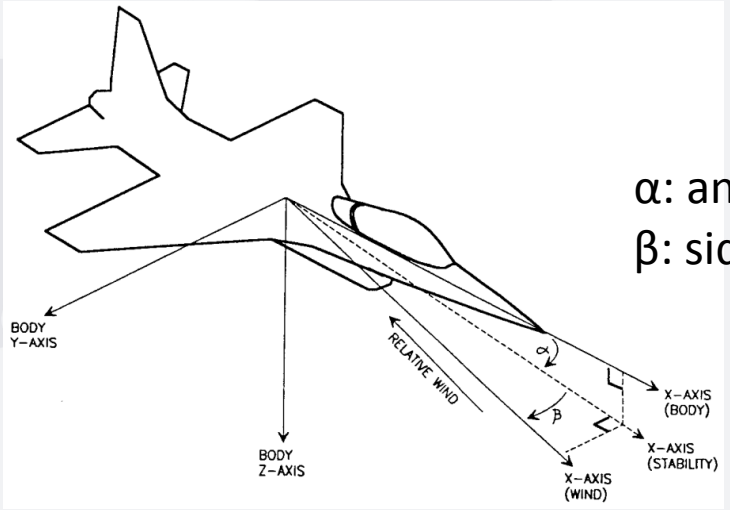
- Controller synthesis principle



- Experimental validation

Simulator construction

- Frame definition
  - Body axes
  - Stability axes
  - Wind axes



α: angle of attack
β: sideslip angle

Simulator construction

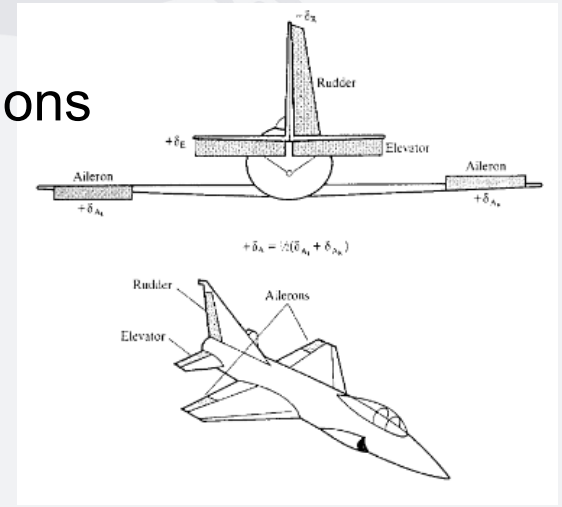
- 12 states (kinetic and kinematic)

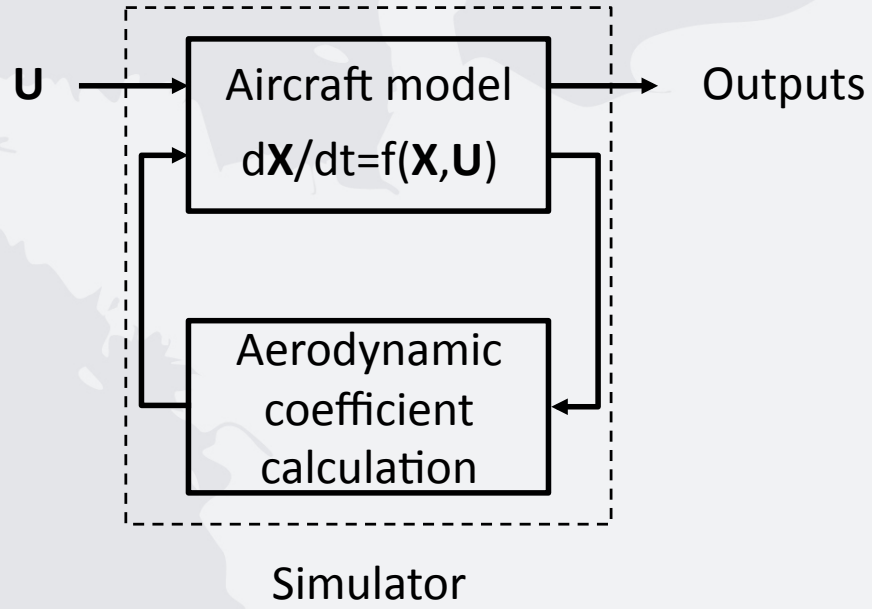
$$\mathbf{X}_1 = \begin{bmatrix} V_T \\ \alpha \\ \beta \\ P \\ Q \\ R \end{bmatrix} = \begin{bmatrix} \text{total speed} \\ \text{angle of attack} \\ \text{sideslip angle} \\ \text{roll rate} \\ \text{pitch rate} \\ \text{yaw rate} \end{bmatrix} \qquad \mathbf{X}_2 = \begin{bmatrix} X_E \\ Y_E \\ Z_E \\ \Phi \\ \Theta \\ \Psi \end{bmatrix} = \begin{bmatrix} \text{Earth fixed x-position} \\ \text{Earth fixed y-position} \\ \text{Earth fixed z-position} \\ \text{roll angle} \\ \text{pitch angle} \\ \text{yaw angle} \end{bmatrix}$$

  - Generalized state vector: $\mathbf{X}=[\mathbf{X}_1|\mathbf{X}_2]^T$
  - Kinetic equations deduction by *Newton*'s second law

Simulator construction

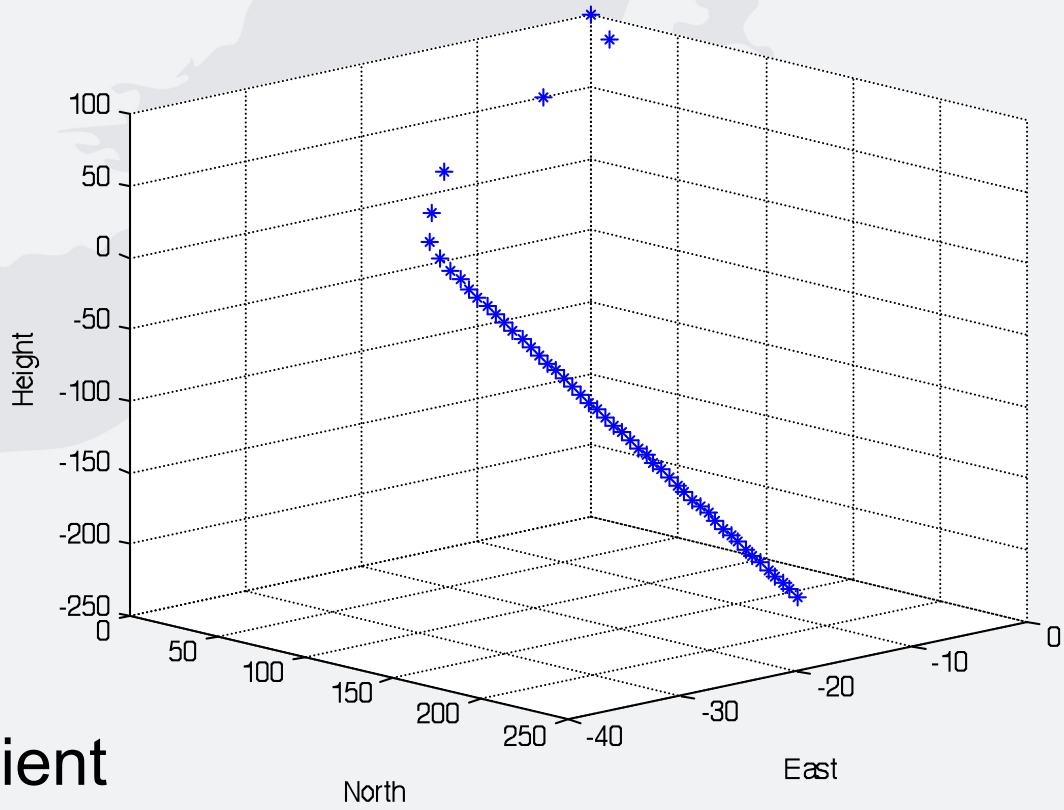
- Nonlinear state-space expression d**X**/dt=f(**X**,**U**)
  - Input vector: **U**=[T δC_X δC_Y δC_Z δC_l δC_m δC_n]^T
    - Propeller thrust
    - Aerodynamic coefficient variations





Simulator construction

- First results



- Probable cause
  - Aerodynamic coefficient misunderstanding
  - Parameter sensitivity

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