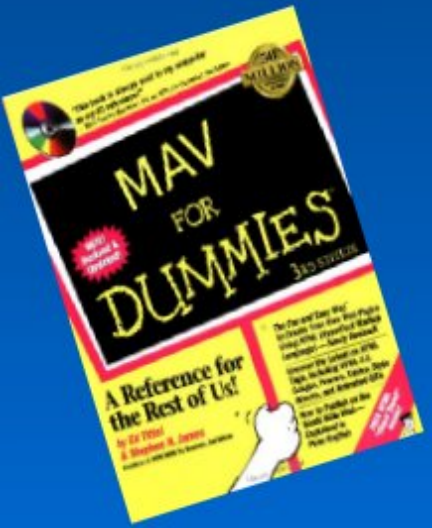
PaparaDzIY

Pascal Brisset and Antoine Drouin

ENAC-CENA
Toulouse, France

September 15, 2004



Project Paparazzi

Quick and Dirty UAV

- Hobby
- Low budget
- Two persons
- Two years
- JMD'03, EMAV'04 flight competitions

Learned lessons ?

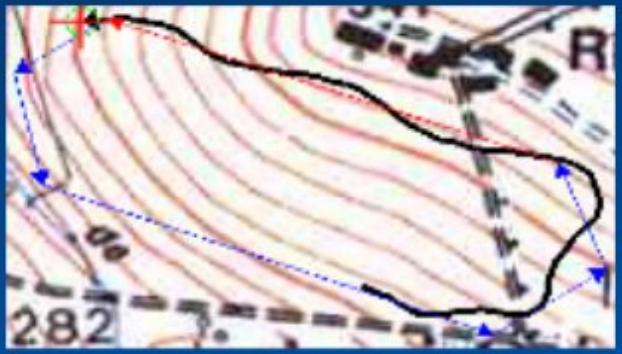
Do It Yourself: Guidelines and tools for amateurs.

Outline

- **Objectives and Motivation**
- Components
  - Aircraft Model
  - Autonomous Flight
  - Simulation and Flight Tests
- Methodology
  - Safety
  - COTS
- Conclusion

Goals

- Autonomous flight
- Safety
- Low cost
- Low weight
- Open project



www.nongnu.org/paparazzi

Motivations

- To understand and learn
  - Electronics (sensors, EMI, RF,...)
  - Automatics (data fusion, control loops)
  - Software (airborne systems, datalink, HMI,...)
  - Flight mechanics and aerodynamics
- To have fun
- To take part in flight competitions

Outline

- Objectives and Motivation
- **Components**
  - Aircraft Model
  - Autonomous Flight
  - Simulation and Flight Tests
- Methodology
  - Safety
  - COTS
- Conclusion

Model Aeronautics

Not well described in books. Based on experience

- Assembly : nothing to reinvent - capitalize on model aircraft experience.
- Pilot : good skills for tricky situations.

Airframe

First goal: To fly

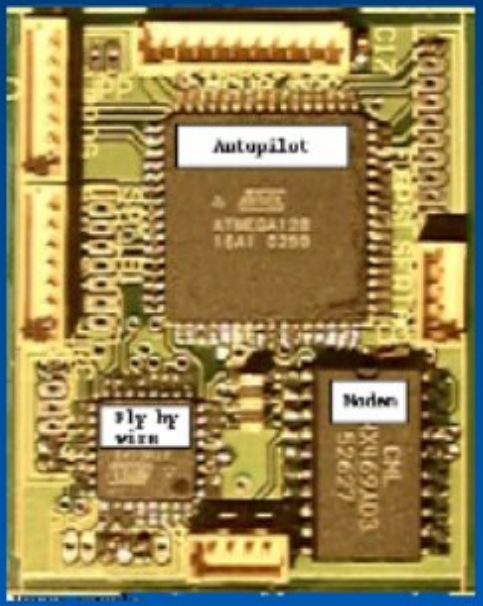
Ex: Twinstar Multiplex

- "Ready to fly"
- Easy to operate
  - Electric
  - Hand launch
  - Heavy duty

Fly well, fly often

Safe Manual Control

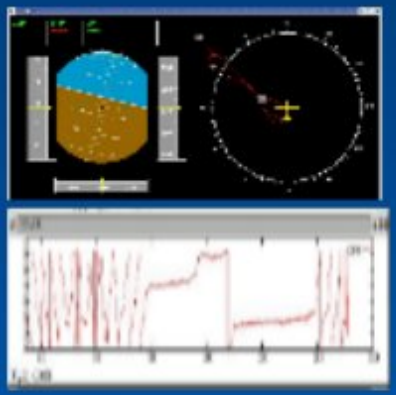
- PPM/PCM decoding
- Actuators command
- No radio-command programming
- Robust minimal code



Paparazzi solution:

- Automatic code generation
- 4ko

Downlink



Monitoring of the flight parameters is required:

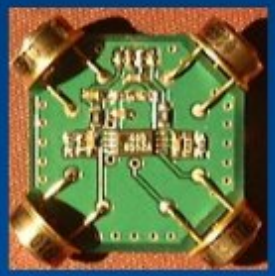
- Real time
- Post flight analysis

Paparazzi solution:

- Modems and audio channel of video camera transmitter
- Generic protocol

Sensors

- Attitude : differential infrared thermometer
  - absolute data
  - no drift - computationally light



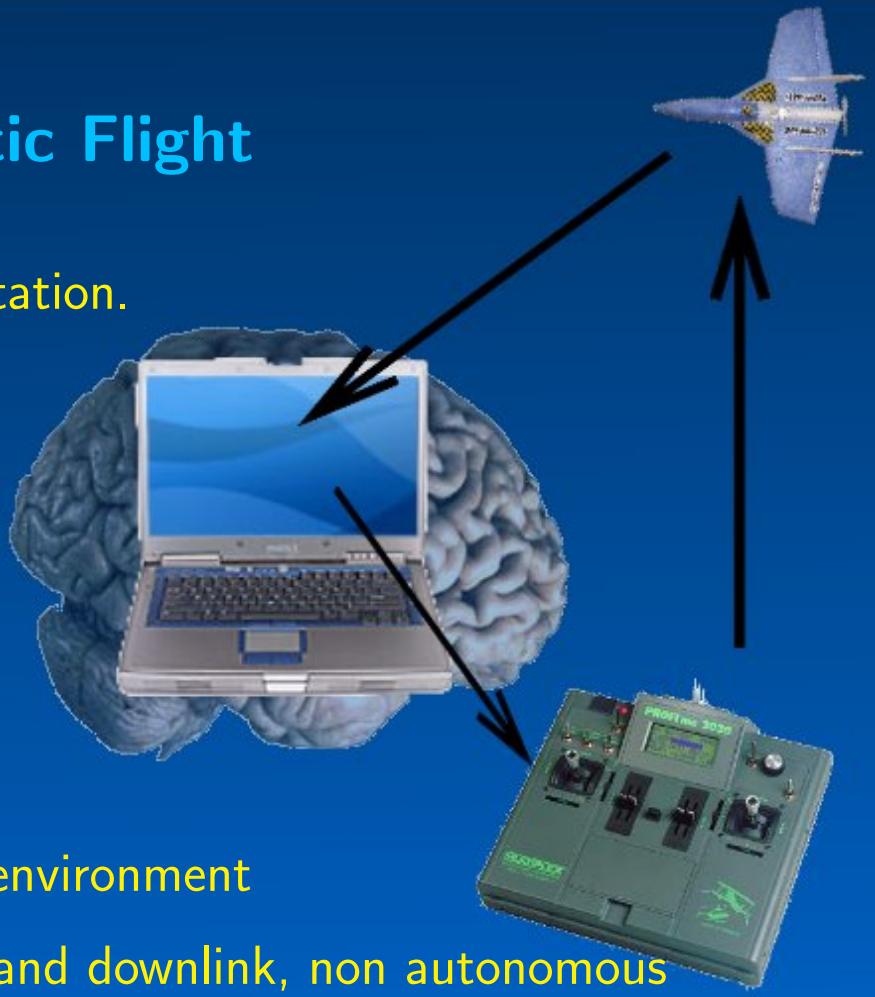
- GPS
  - Position
  - Course
  - Altitude
  - Speed

1st step : Automatic Flight

Control from the ground station.

Requires only:

- Stabilizer
- GPS receiver
- Computer-RC link



Pros: Simplicity, software environment

Cons: Latency, critical up and downlink, non autonomous

2nd step : Autonomous Flight

Airborne controllers: stabilization and navigation

- Attitude
- Heading
- Waypoint
- Track
- Mission

Simulation

Basic flight model

- Debug and non-regression test
- Help to adjust navigation algorithms
- Difficult to be realistic for low level controllers tuning

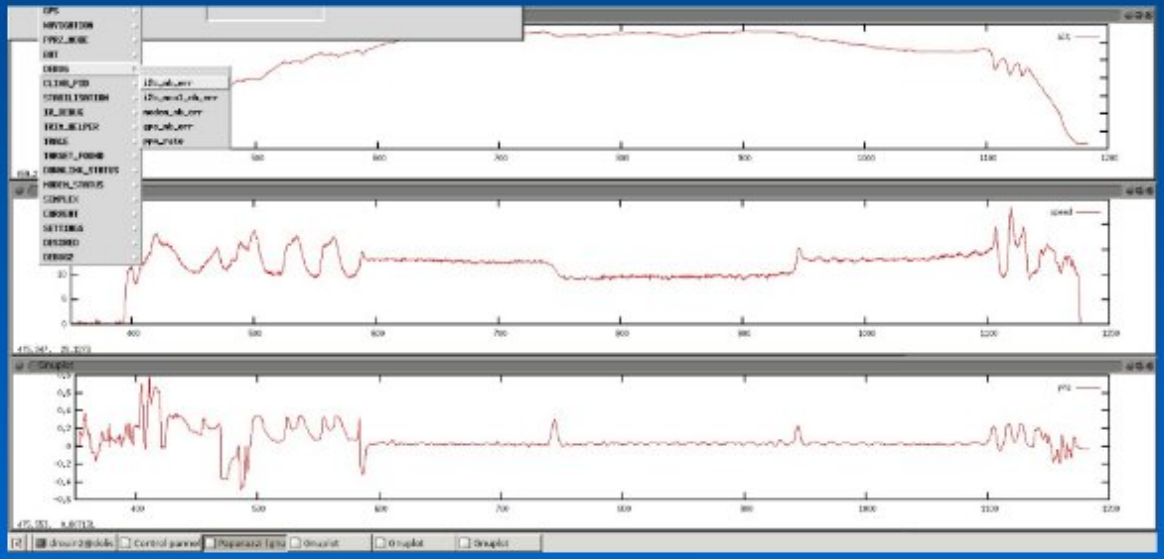
Paparazzi solution: “Hardware in the loop” simulator

Flight Tests

- Prepare a program
- Follow the program as much as possible
- Monitor the flight
- Analyze recorded data
- Archive them

Post flight data analysis

- Replay
- Detect hidden failures
- Help future simulation



Outline

- Objectives and Motivation
- Components
  - Aircraft Model
  - Autonomous Flight
  - Simulation and Flight Tests
- **Methodology**
  - Safety
  - COTS
- Conclusion

Safety

- Design
  - Segregate critical code
  - Implement fail safe modes
    - Automatic motor cut upon ground proximity
    - Basic “back home” navigation mode
- Operation
  - Be paranoid (if it may fail, it will fail)
  - Use check lists
  - Respect model aircraft rules

Extreme Programming

`www.extremeprogramming.org` : a software methodology for "risky projects with dynamic requirements"

Some rules:

- Refactor whenever and wherever possible
- Unit tests
- Integrate often
- Make frequent small releases
- All production code is pair programmed

Use “open” COTS

Need for a full control of the components.

- RC receiver:
  - Difficult to tune and build (HF part)
  - Piggy-backed a commercial unit
- FMA stabilizer:
  - Keep the infrared sensor
  - Dump the controller

Open Software

Natural answer: the Free Software solution (FSF, GNU)

- Understanding and fixing
- Active support
- Expanding, adapting

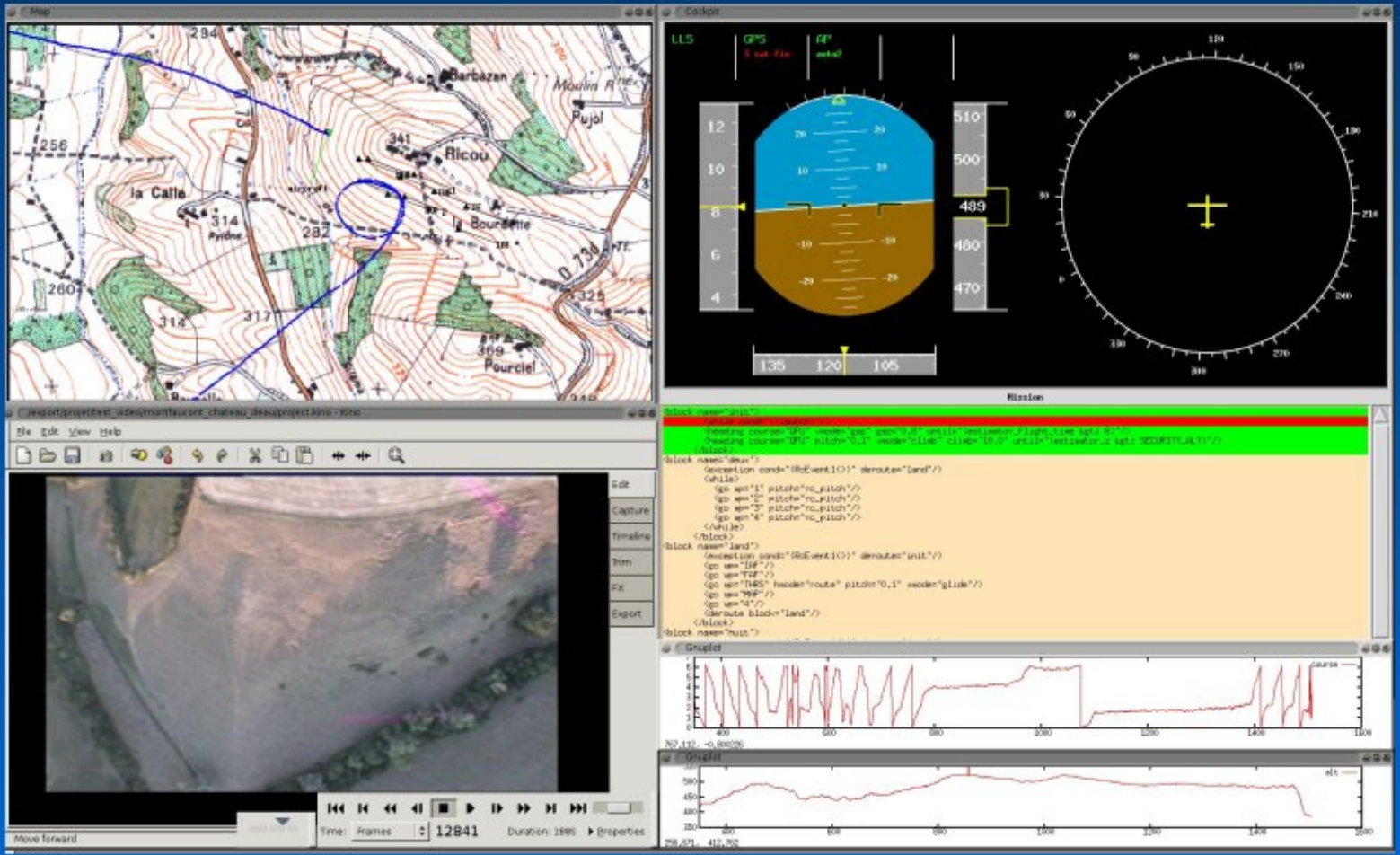
Examples : Linux, Gcc, Autopilot, Rtty, FlightGear, Ivy, Zinc,...


www.openatc.org


www.flightgear.org


UAV control station

Paparazzi Control Station



Real UAV is to expensive to play!

Do it yourself with Paparazzi

- Request for support, documentation, features
- Find bugs!

First users

- Fondtech: Minimal cost landmine survey
- Adelaide University: Computer vision
- ENAC: Teaching

http://www.nongnu.org/paparazzi

By the way : nothing new for terrorists

Recurrent question on open project UAV forums

- Commercially available elsewhere
- Not a turnkey system
- High complexity, low payload, small range

Why would they bother building their own?