

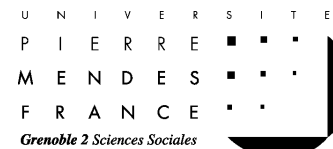
Towards a Monitoring System for High Altitude Objects

Sébastien Jean¹, Kiev Gama², Didier Donsez², André Lagrèze¹

¹ University Of Grenoble II, LCIS Lab.
(`first.last@iut-valence.fr`)

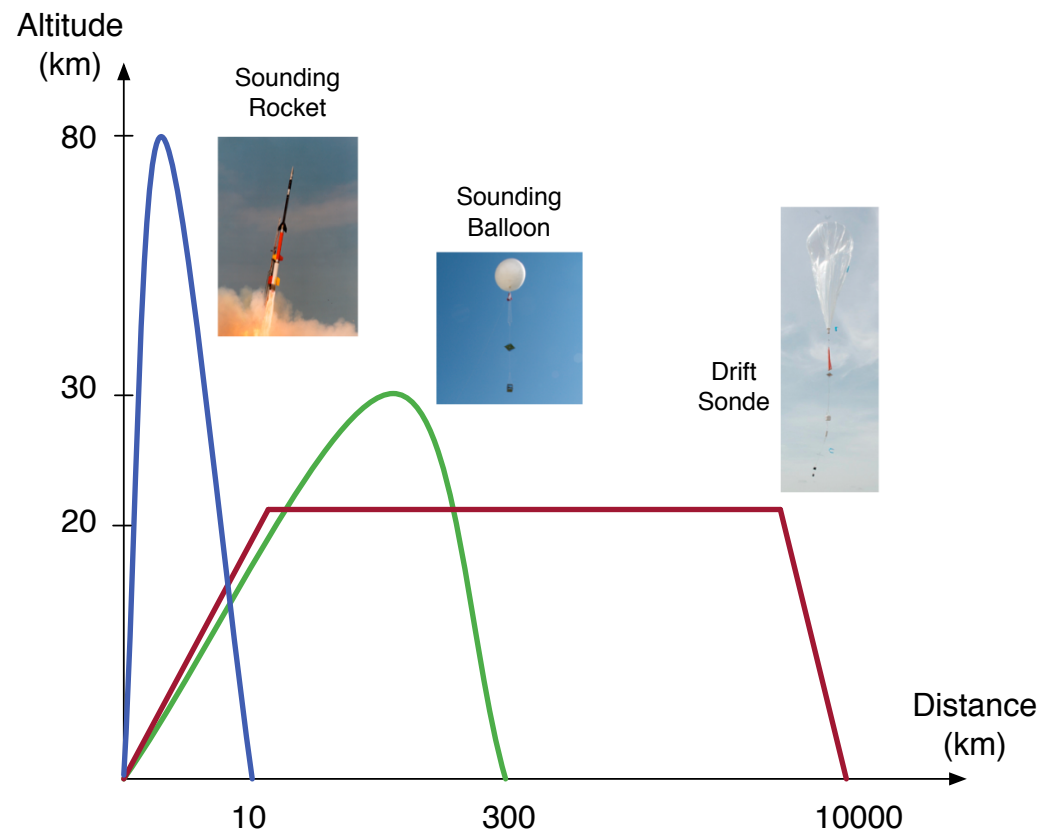
² University Of Grenoble I, LIG Lab.
(`first.last@imag.fr`)

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High Altitude Objects (HAOs)

- Flying objects reaching the stratospheric layer
- Collecting (storing and/or transmitting) environmental data
 - Weather, Pollution, ...
- And/or embedding scientific experiments



HAO Tracking and Recovery

- Why recovering?
 - Data sometimes too large to be sent (e.g. pictures)
 - On-board samples to get back for analysis
 - Payload/object cost
- Why tracking?
 - Difficultly predictable landing point
 - "Real-time" monitoring of collected data



HAO Tracking Vs Communication

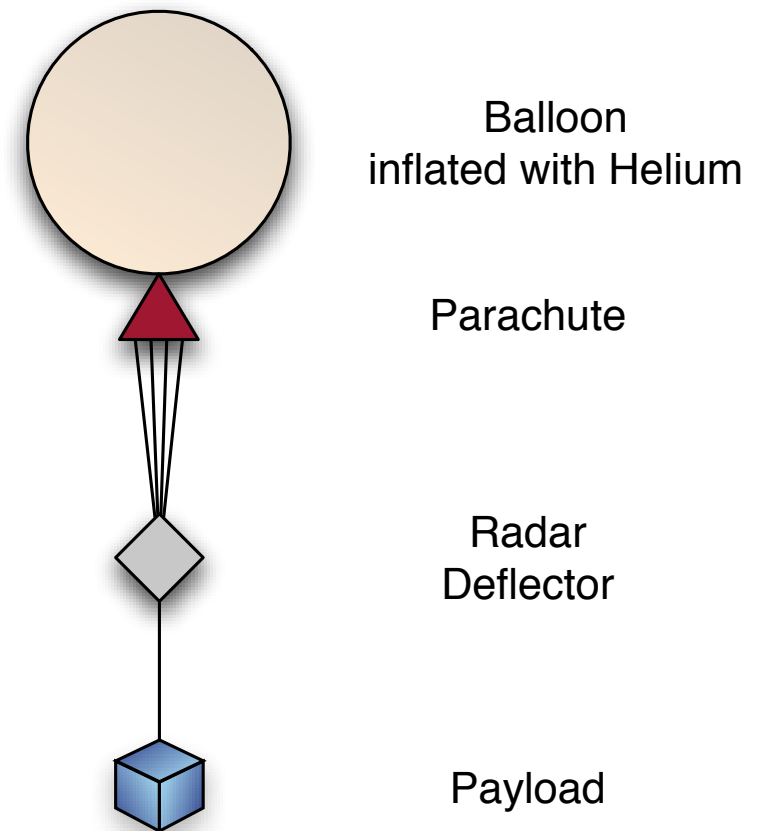
- Key factors
 - Distance, power, throughput, cost per byte (on operated networks)
- Relevant technologies
 - Satellite
 - Long range, high throughput, no blackout, but hard to set up
 - GSM (SMS / Packet)
 - Short range, low throughput, some blackouts, operated network
 - HAM Radio
 - Long range, low throughput, line of sight

HAO Tracking Vs embedded system

- Low cost
- Extensibility
 - Various set of sensors across experiments
 - Various communication technologies
- Energy efficiency

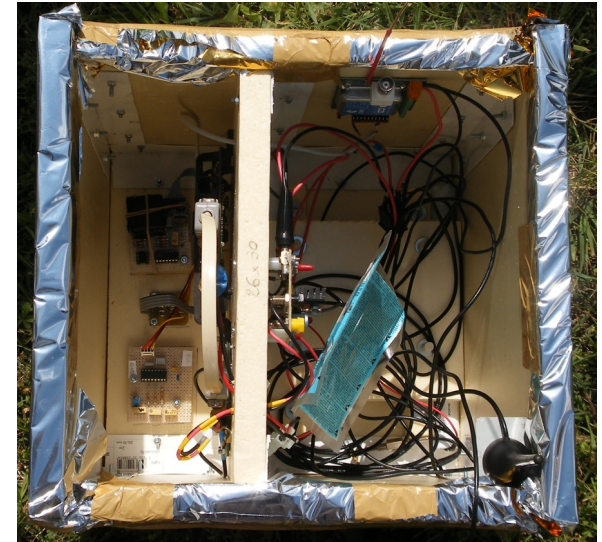
First Sounding Balloon experiment (2008)

- Educational purpose
 - Embedded system project
 - 4 undergraduate students
- CNES (French Space agency) sponsorship
 - HAM Radio emitter loan
 - Radar deflector, Helium, balloon offered



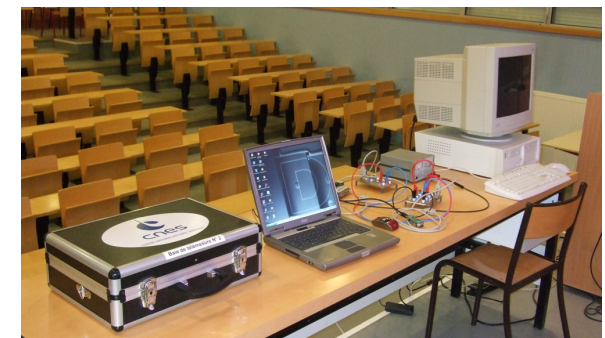
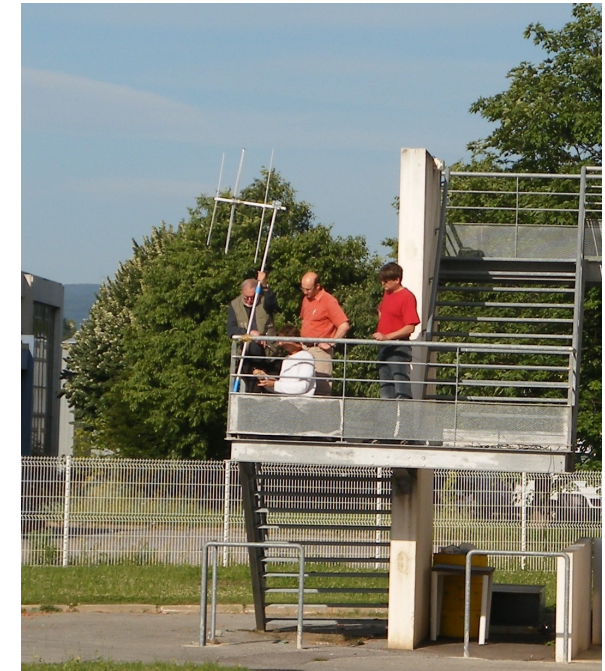
First Sounding Balloon experiment (2008)

- HAO embedded system
 - Microchip PIC18F microcontroller-based architecture
 - I^2C pressure and temperature sensors (no local storage)
 - RS232 GPS receiver & GSM interface (SMS)
- Communication
 - ASCII-based frames with time + location + sensor data
 - HAM radio, downstream only
 - SMS requests from ground to get back an instant frame by SMS



First Sounding Balloon experiment (2008)

- Ground stations
 - Fixed station
 - HAM radio receiver & FSK demodulator
 - CNES software for monitoring, raw frames local storage
 - Mobile station
 - Two HAM radio receivers (without FSK demodulator)
 - No monitoring neither storage



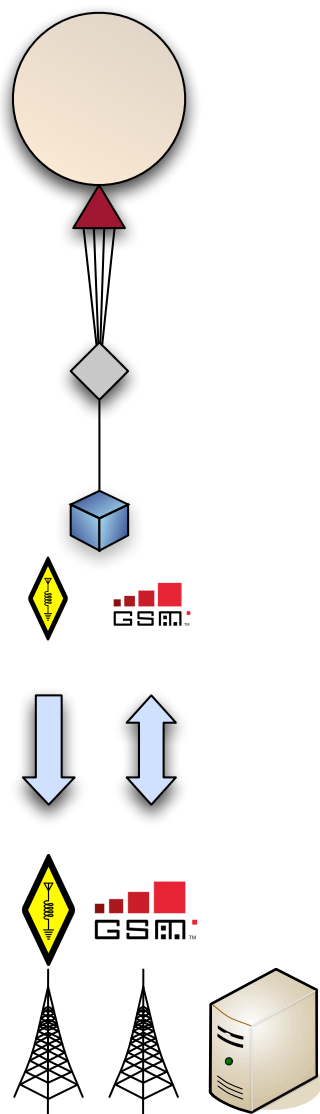
First Sounding Balloon experiment (2008)

- Results
 - 3 hours flight (2 hours up, 1 hour down)
 - $\Delta XY \simeq 150km$, $\Delta Z \simeq 31km$
 - Signal lost during the descent \rightarrow data loss
 - Landing area uncovered by GSM operated network
 - Recovery using HAM radio triangulation



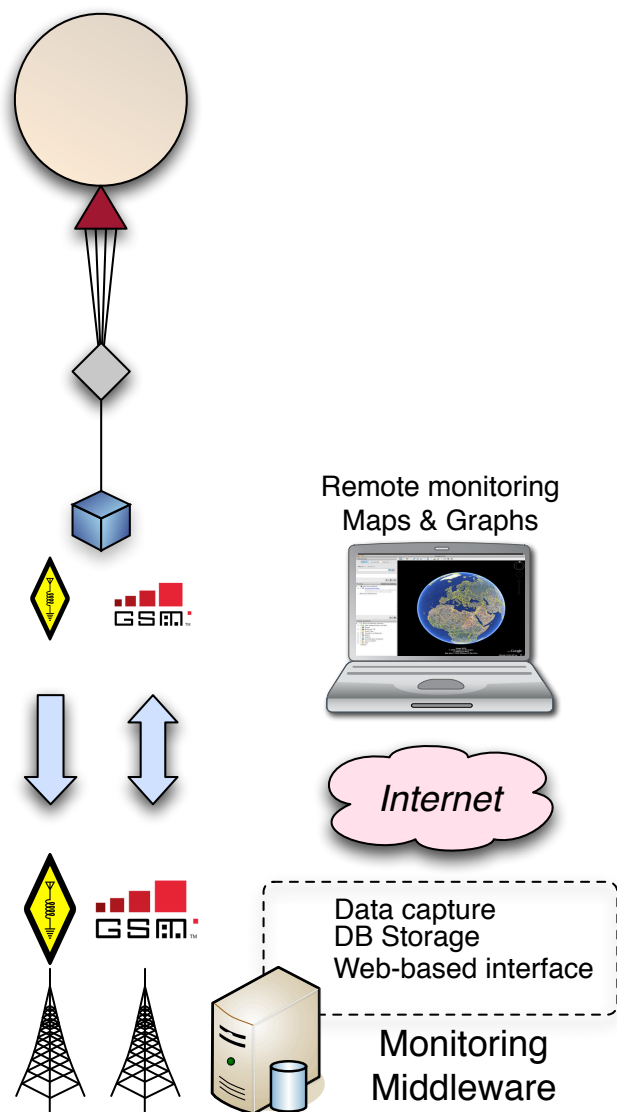
Lessons learned

- Multimodal communication as a mandatory requirement



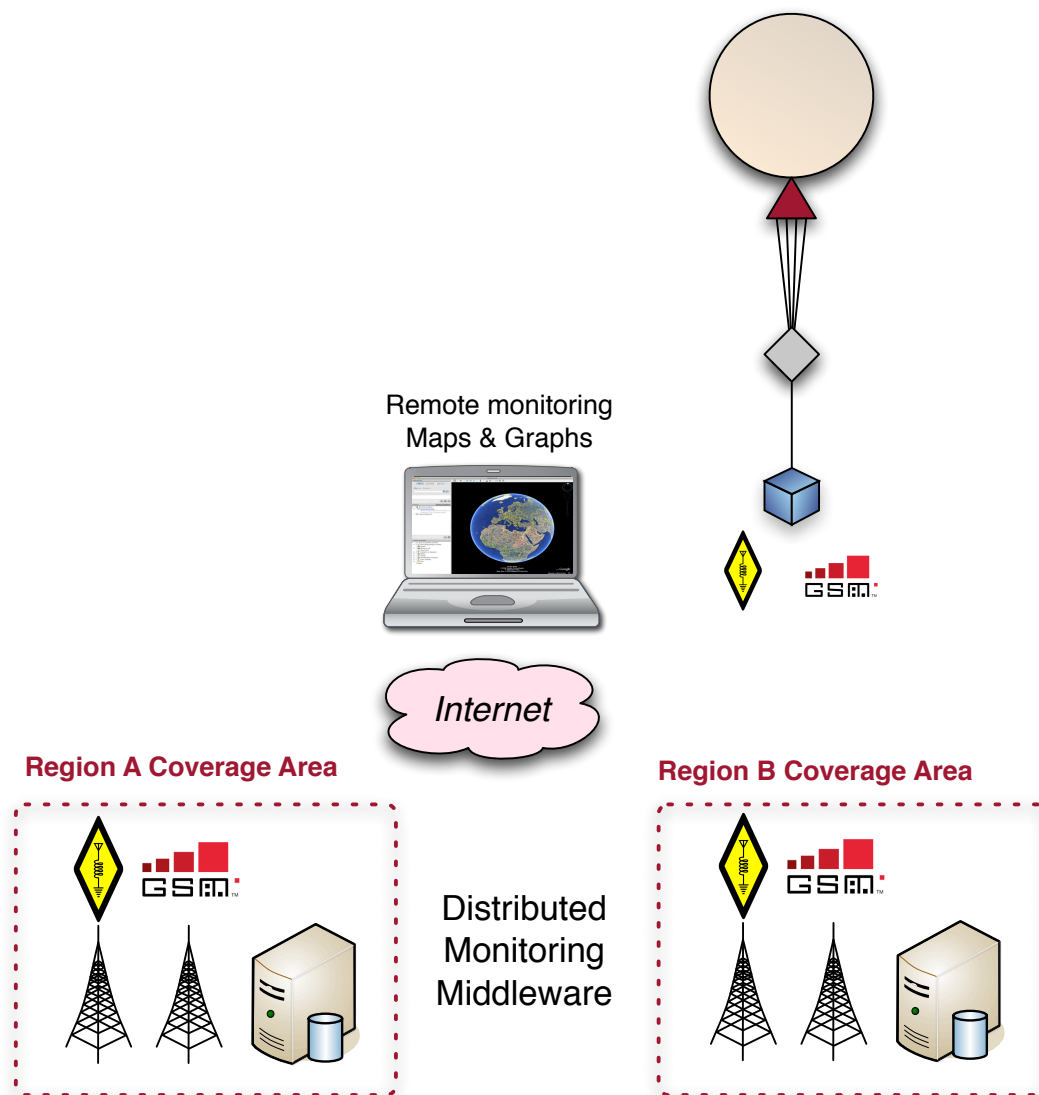
Lessons learned

- Monitoring middleware needed, with storage and rich GUI



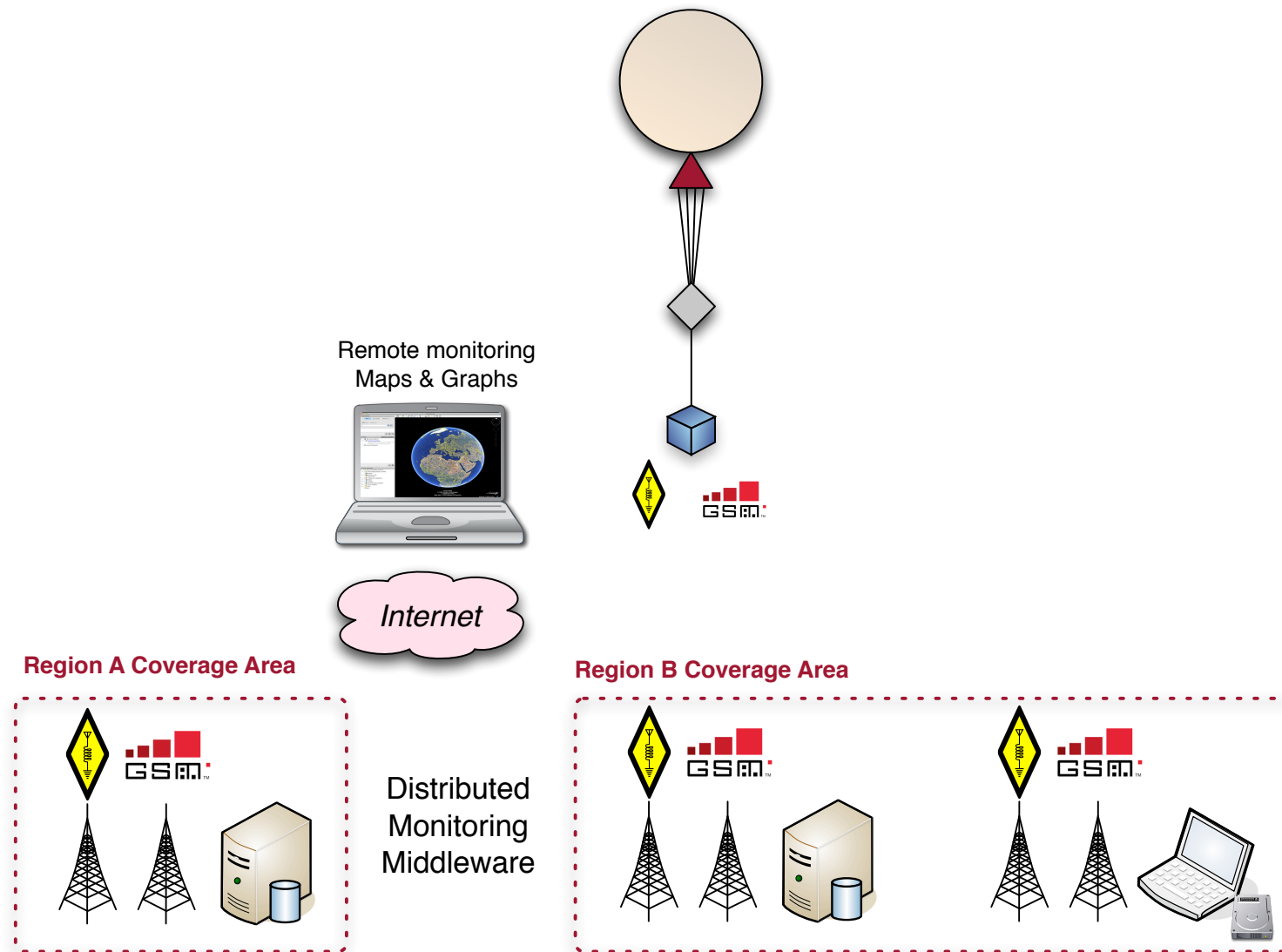
Lessons learned

- Distributed middleware, with federated DBs



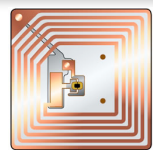
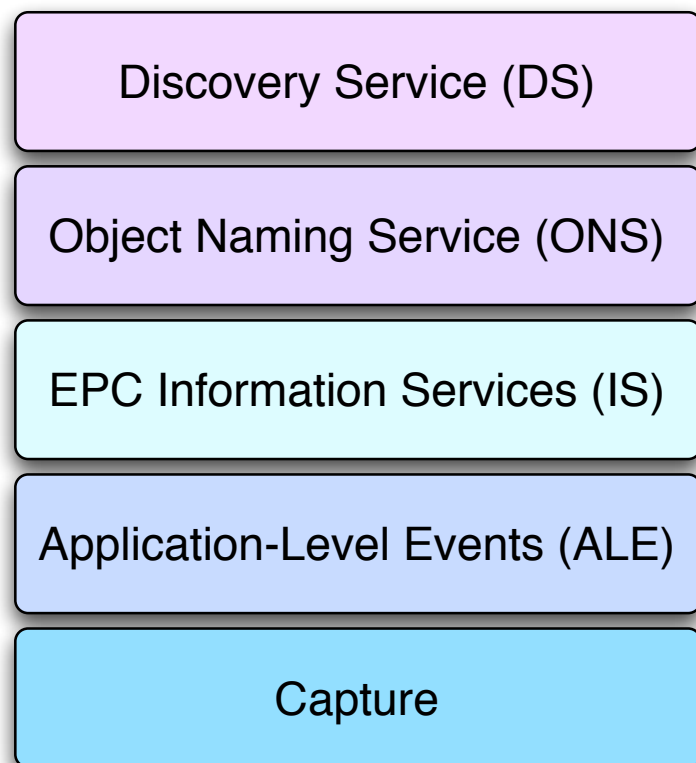
Lessons learned

- Multiple stations, fixed or mobile, online or offline data merging



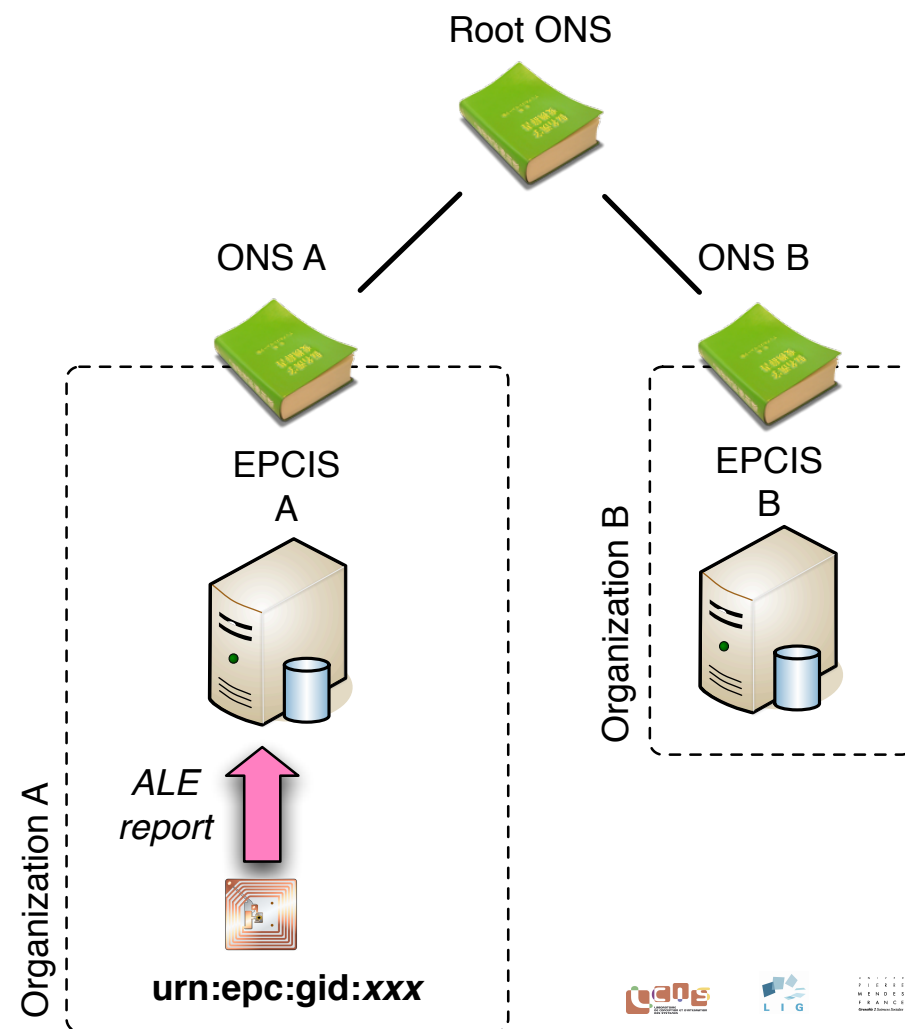
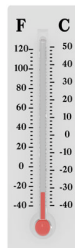
EPC global RFID-centric middleware as a candidate

- Distributed Architecture for RFID-centric supply chain management
 - Initiated by MIT's AutoID center, promoted by EPC Global



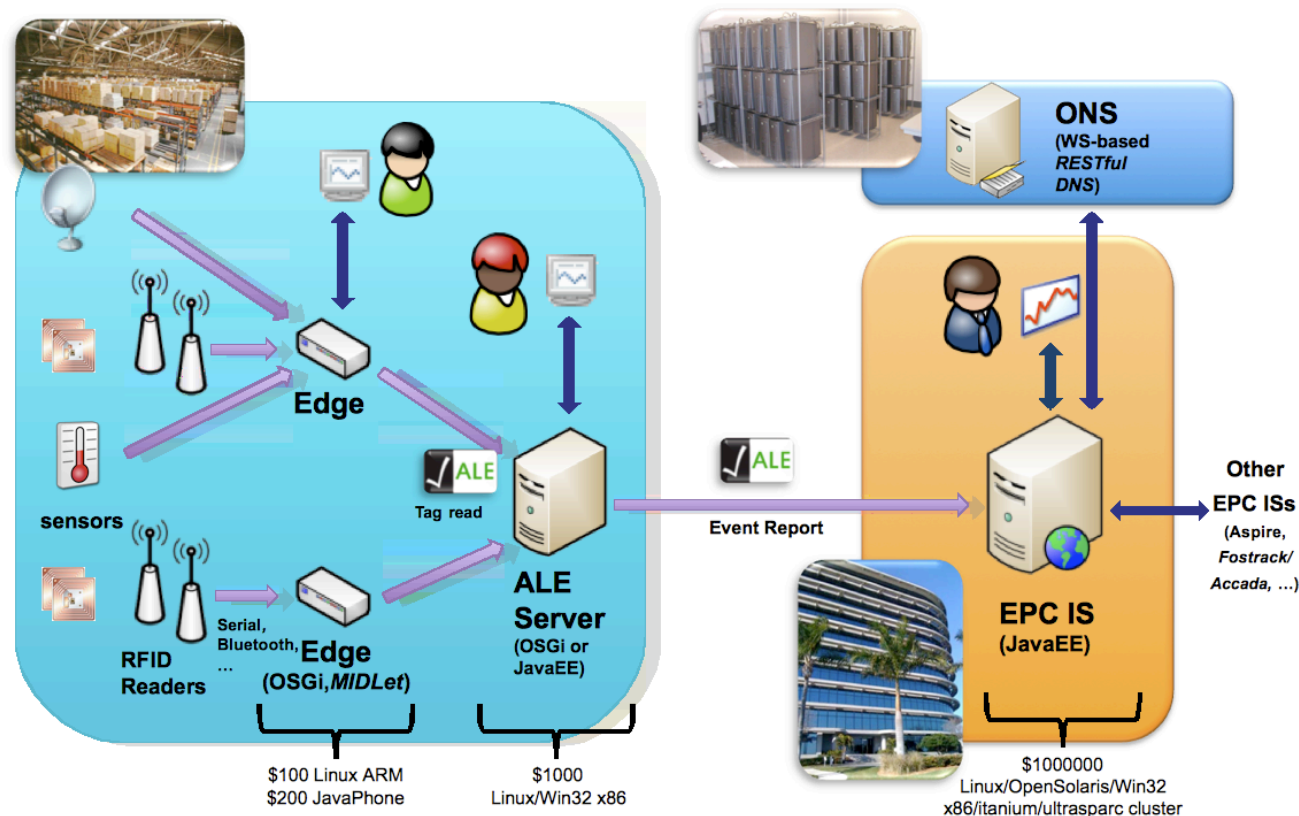
RFID tag

+ Sensor data



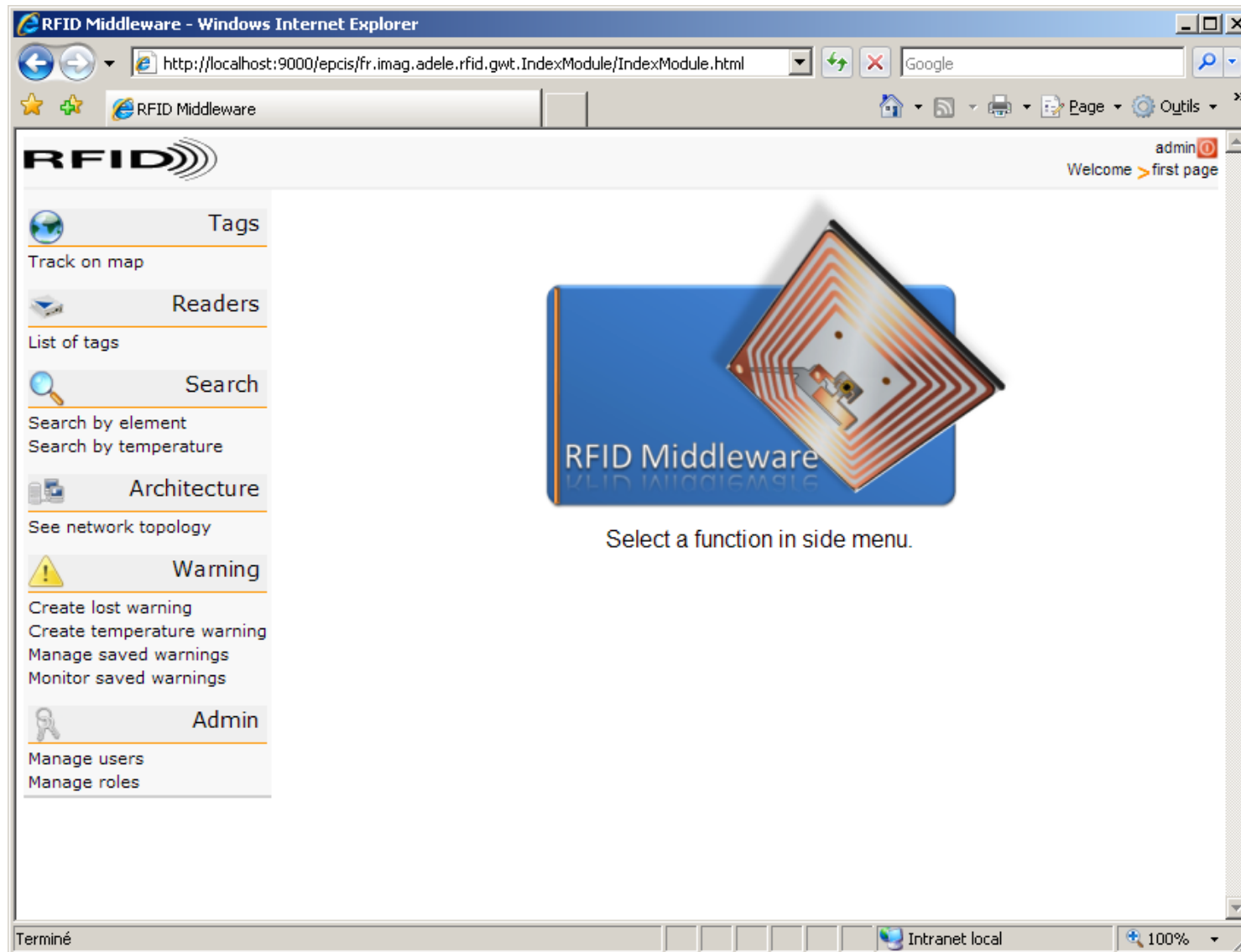
AspireRFID RFIDSuite

- Open-source EPC-compliant middleware, developed by LIG Lab.
 - ASPIRE FP7 EU Program
 - Hosted by OW2 open source consortium



AspireRFID RFIDSuite

- Web-based interface (main page)



Aspire RFID Middleware interface

- Location tracking using *Google Maps*

RFID Middleware - Windows Internet Explorer

http://localhost:9000/epcis/fr.imag.adele.rfid.gwt.IndexModule/IndexModule.html

admin Tag > Track on map

Tag: Valid Input helper Get general information

Tracking Complementary information

Information:

- Path
- Marker
- Partner information

Display Focus Clear map

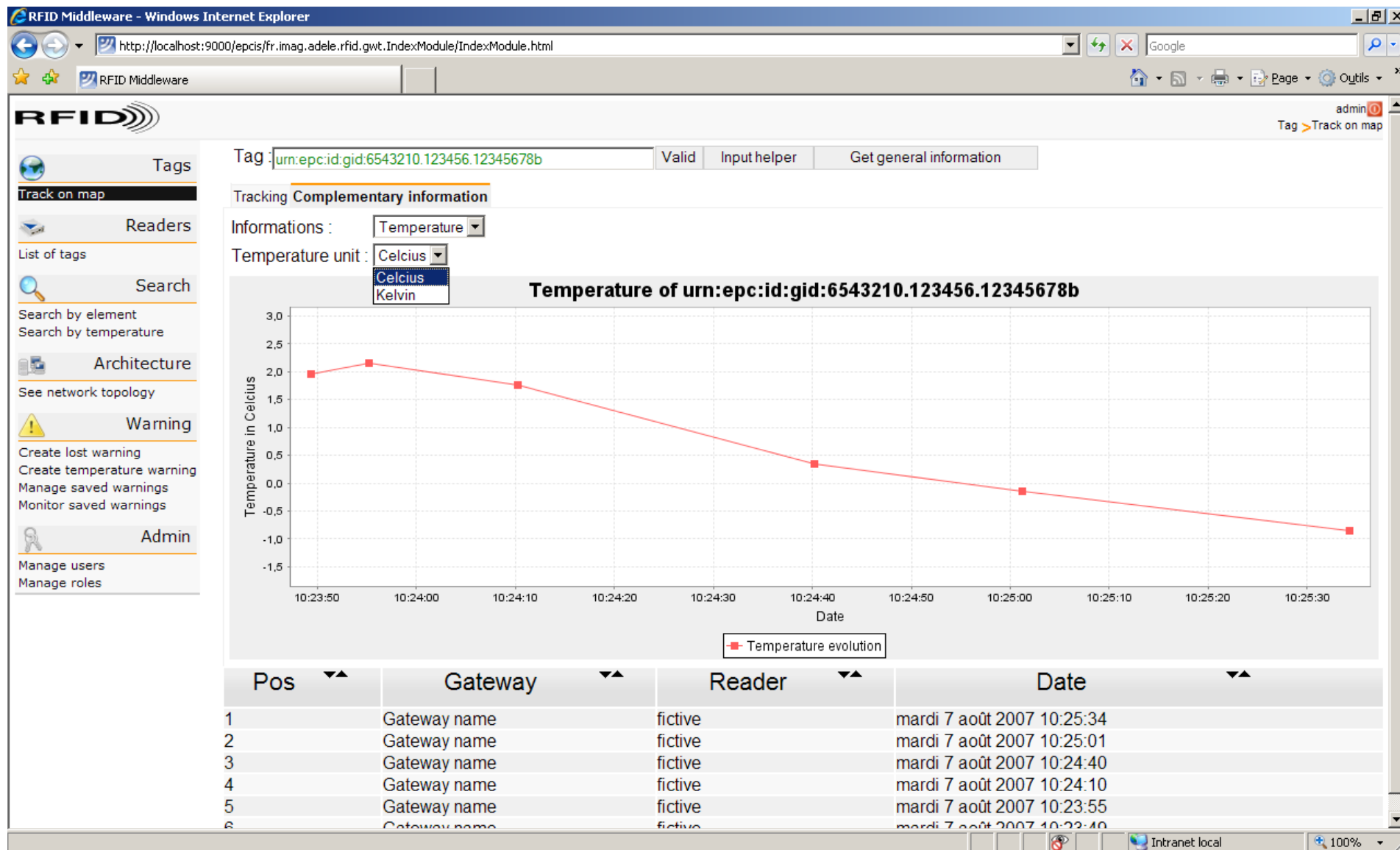
Legend:

- Start
- Intermediate
- Finish

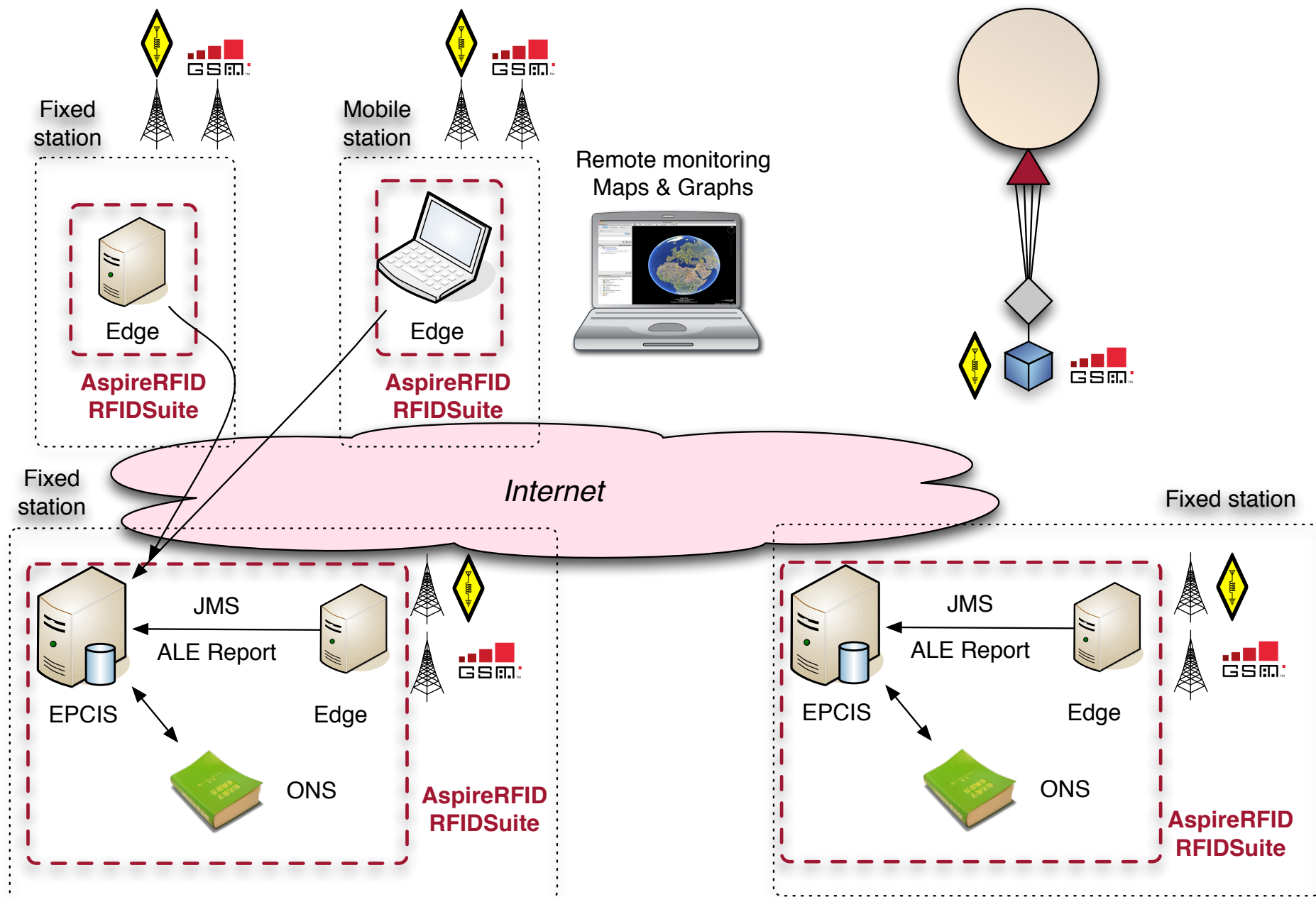
Pos	Gateway	Reader	Date
1	Gateway name	fictive	mardi 7 août 2007 10:25:34
2	Gateway name	fictive	mardi 7 août 2007 10:25:01
3	Gateway name	fictive	mardi 7 août 2007 10:24:40
4	Gateway name	fictive	mardi 7 août 2007 10:24:10
5	Gateway name	fictive	mardi 7 août 2007 10:23:55
6	Gateway name	fictive	mardi 7 août 2007 10:23:49

Aspire RFID Middleware interface

- Extensible graph engine using *JGraph*



Using AspireRFID RFIDSuite to track HAOs



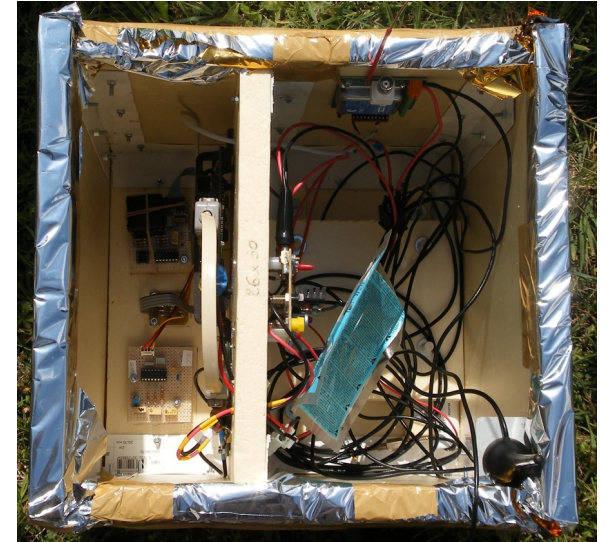
Second Sounding Balloon experiment (2009)

- Teamwork
 - Embedded System : 4 undergraduate students
 - Middleware : 1 PhD student, 1 undergraduate student
 - Sensors : 2 x 20 high school students (science course)
- CNES sponsorship



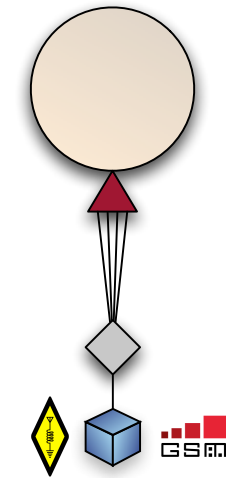
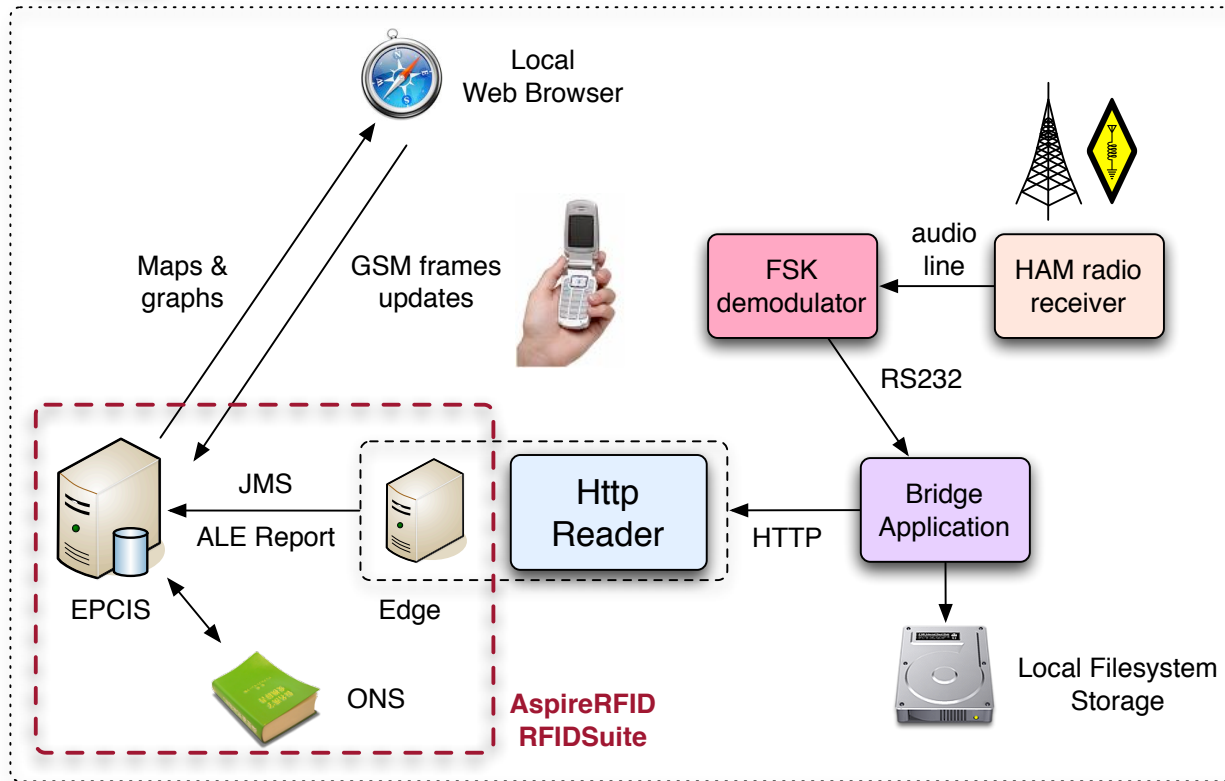
Second Sounding Balloon experiment (2009)

- Same embedded system architecture as previous +
 - Analog temperature and pressure sensors
 - Onboard sensor data storage
 - RC model lightweight VGA camera
 - Still pictures, taken every 30s
 - SDCard storage

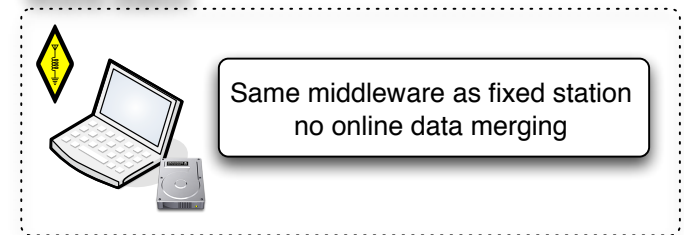


Second Sounding Balloon experiment (2009)

Fixed station



Mobile station

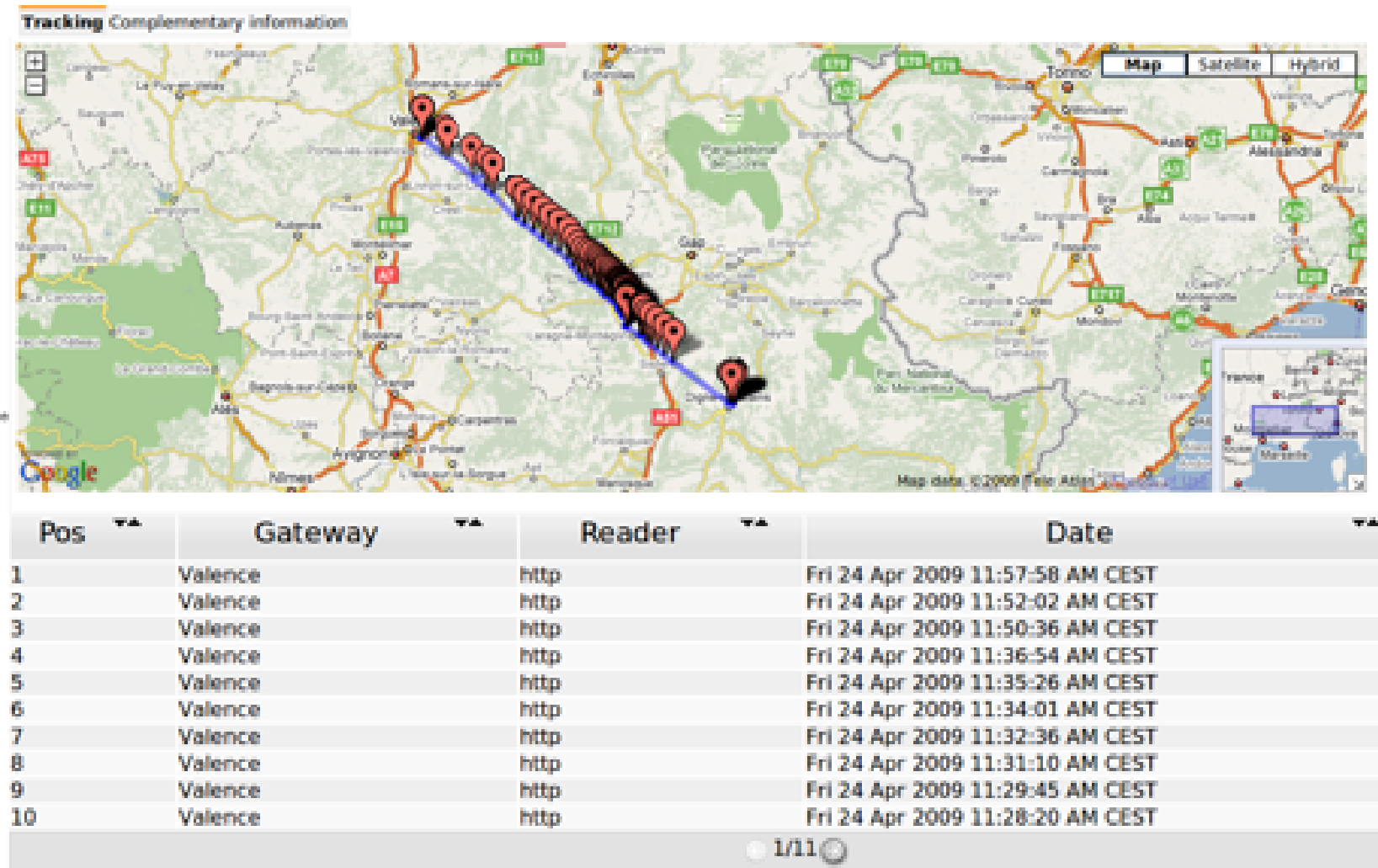


Second Sounding Balloon experiment (2009)

- Results
 - 3 hours flight, $\Delta XY \simeq 150km$, $\Delta Z \simeq 26km$
 - Signal ever received by at least one station \rightarrow no data loss
 - Landing area covered by GSM operated network
 - Easy recovery, by HAM radio operators, using final GPS location

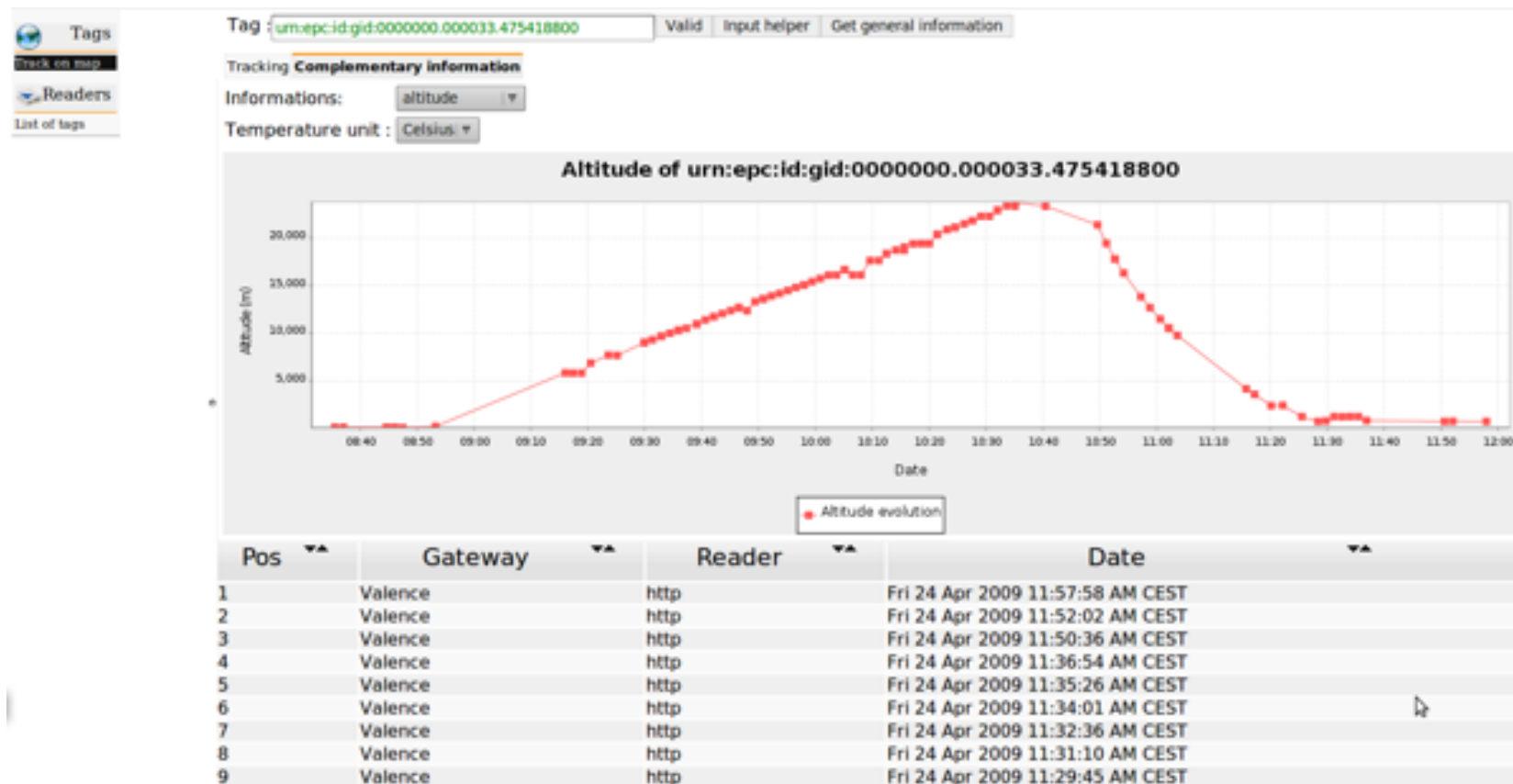


- Real-time location tracking using monitoring middleware



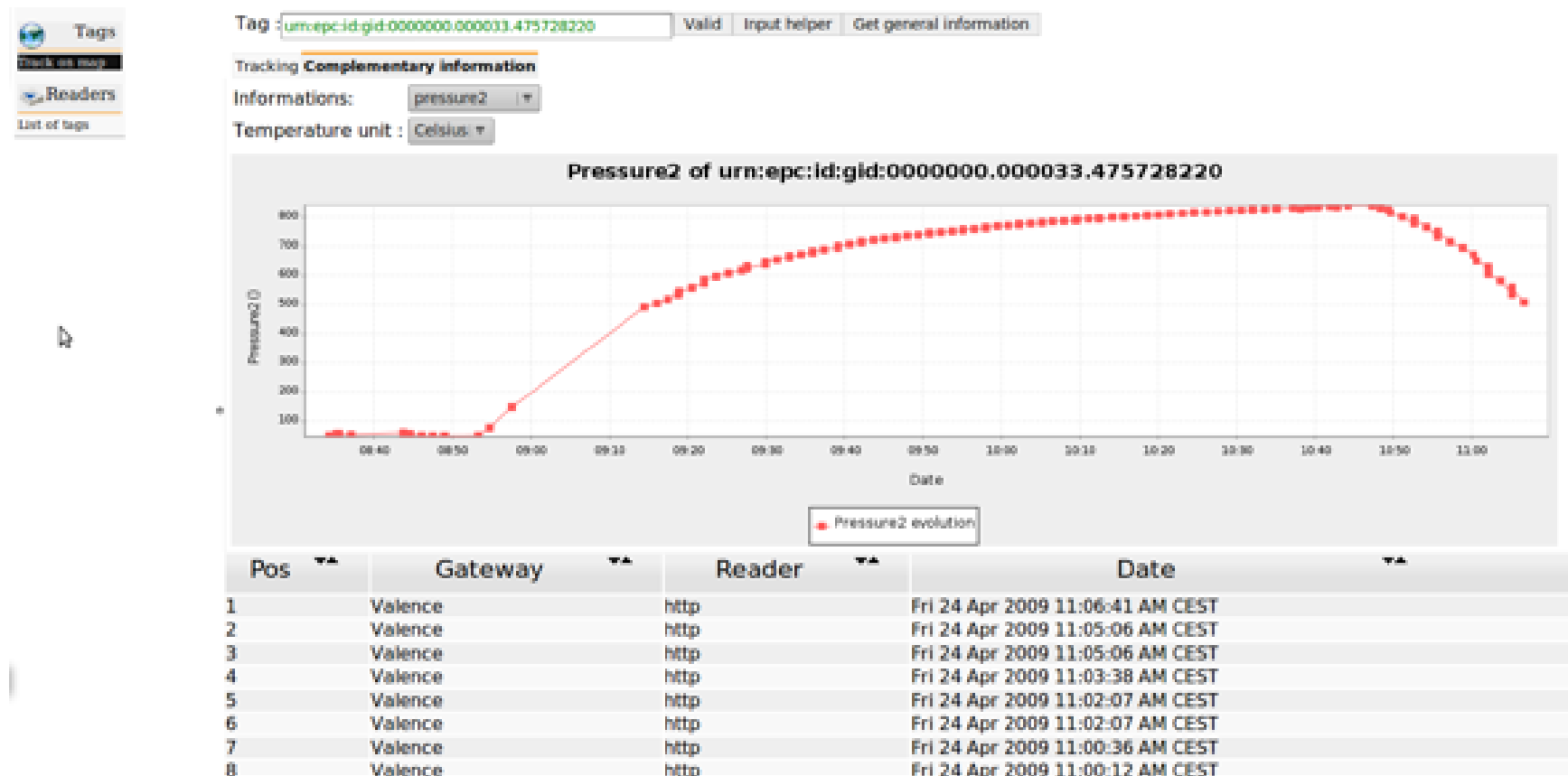
Second Sounding Balloon experiment (2009)

- Real-time data display using monitoring middleware
 - Altitude Vs time



Second Sounding Balloon experiment (2009)

- Real-time data display using monitoring middleware
 - Pressure Vs time



Conclusion and Further work

- EPC-compliant middleware is suitable for HAO tracking and monitoring
- A whole cross-organizational architecture remains to be deployed and validated
- *AspireRFID RFIDSuite* has however to be enhanced to ease
 - multimodal communication management
 - *A posteriori* data update (e.g. stored pictures of the flight)
- Software FSK demodulator, using laptop audio cards, could be a ready-to-go solution for HAM radio operators

The end

- Next flight in April 2010 !



- Questions?