

# **PRESENTATION AT ESA/ESTEC NOORDWIJK, NL, 22 JAN 2008**

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## **D-STAR – BASED STUDENT CUBESAT OF UNIVERSITY OF LIEGE (LEODIUM)**

**Stefania GALLI**

**Jonathan PISANE, ON7JPD**

**University of Liège, Belgium**

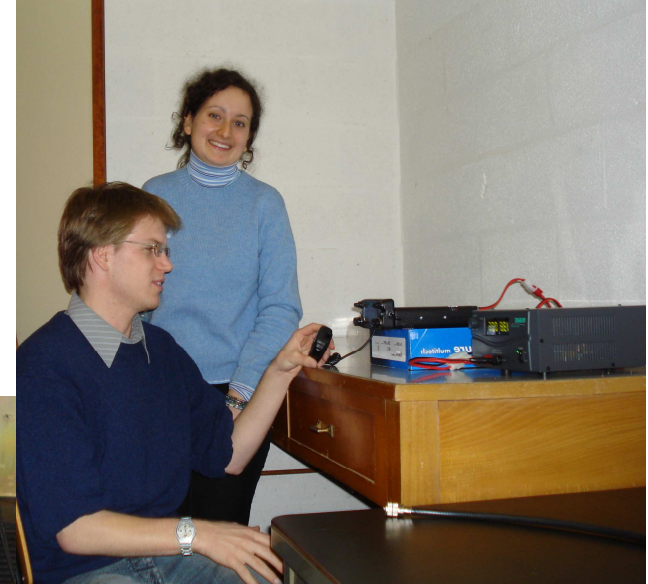
# UNIVERSITY OF LIEGE (ULg) BELGIUM



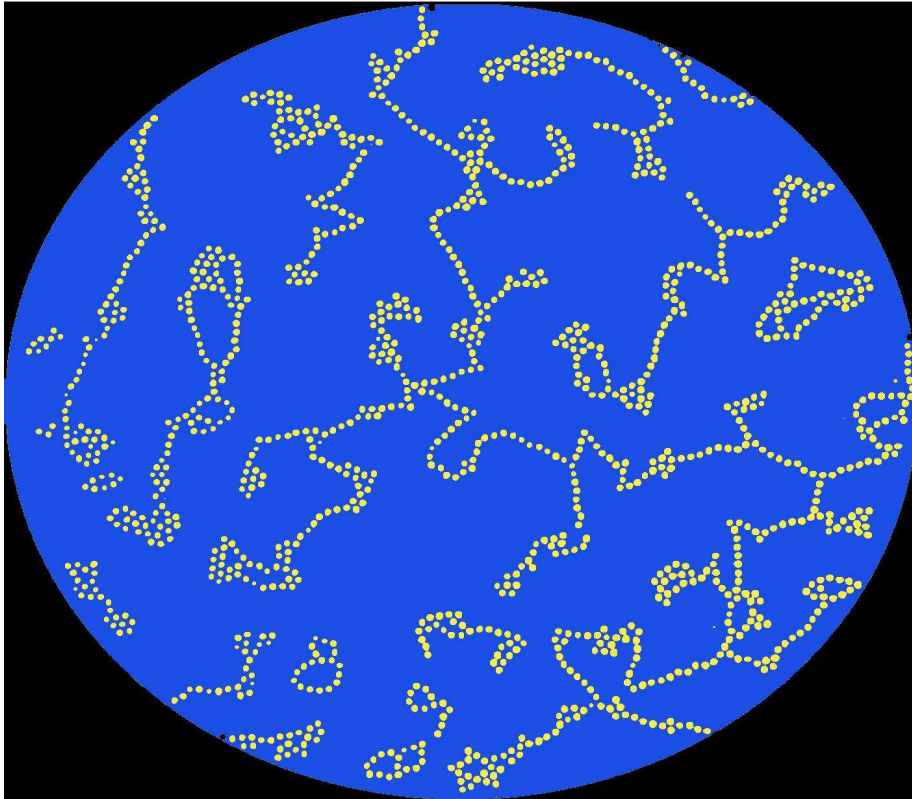


# LONG-TERM OBJECTIVES (1):

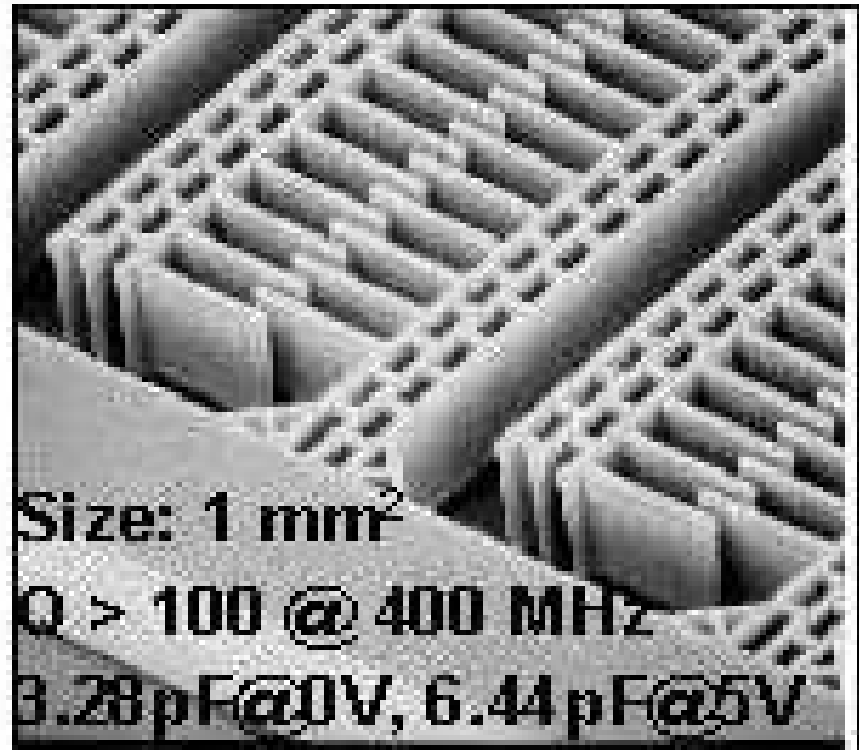
## HANDS-ON SATELLITE EXPERIENCE FOR STUDENTS



# LONG-TERM OBJECTIVES (2): SERIES OF CUBESATS FOR SCIENTIFIC EXPERIMENTS



**Granular materials  
(Prof. Vandewalle)**

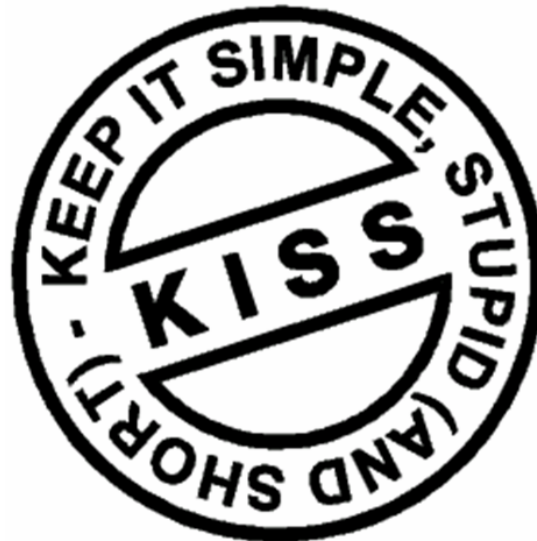


**MEMS  
(ULg - CSL)**

# SHORT-TERM PLAN

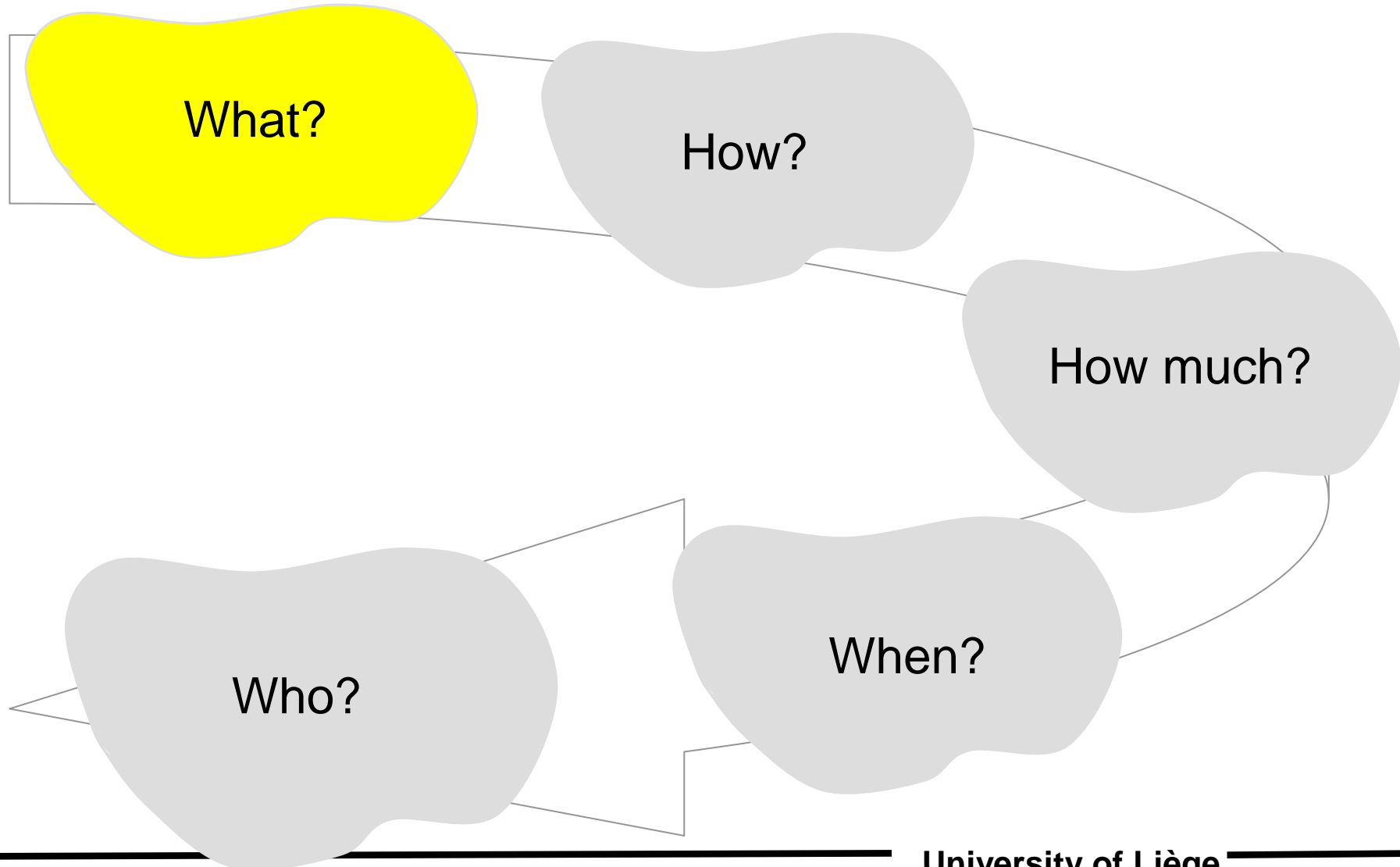
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- **World's first: CubeSat + D-STAR**
- **Corresponding D-STAR ground station and ground repeater**



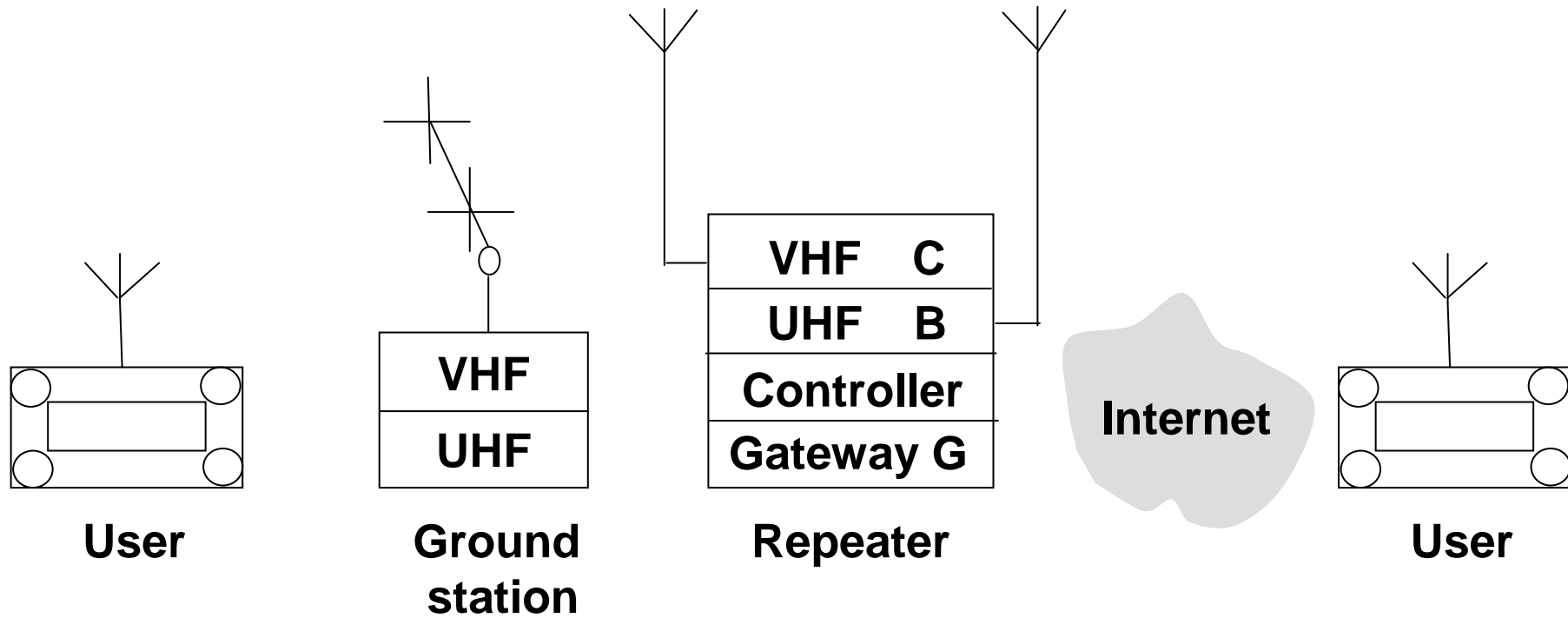
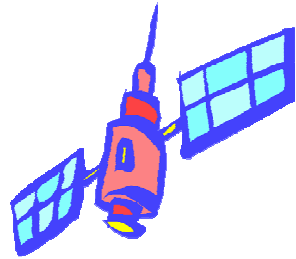
# OUTLINE

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# MAIN SYSTEM COMPONENTS

CubeSat





# MAIN FEATURE OF PROJECT: D-STAR

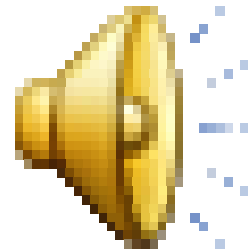
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- **Amateur-radio digital radiocommunications protocol**
- **Simultaneous voice & data transmission**
- **Complete routing capacity, including roaming**
- **“Amateur radio over Internet”**
- **3 frequencies and 2 data rates**
  - **144 MHz (2 m, VHF), 4.8 kbit/sec**
  - **440 MHz (70 cm, UHF), 4.8 kbit/sec**
  - **1.2 GHz (23 cm, SHF), 4.8 kbit/sec or 128kbit/sec**
- **Open protocol**
- **“Cross-band” capability**



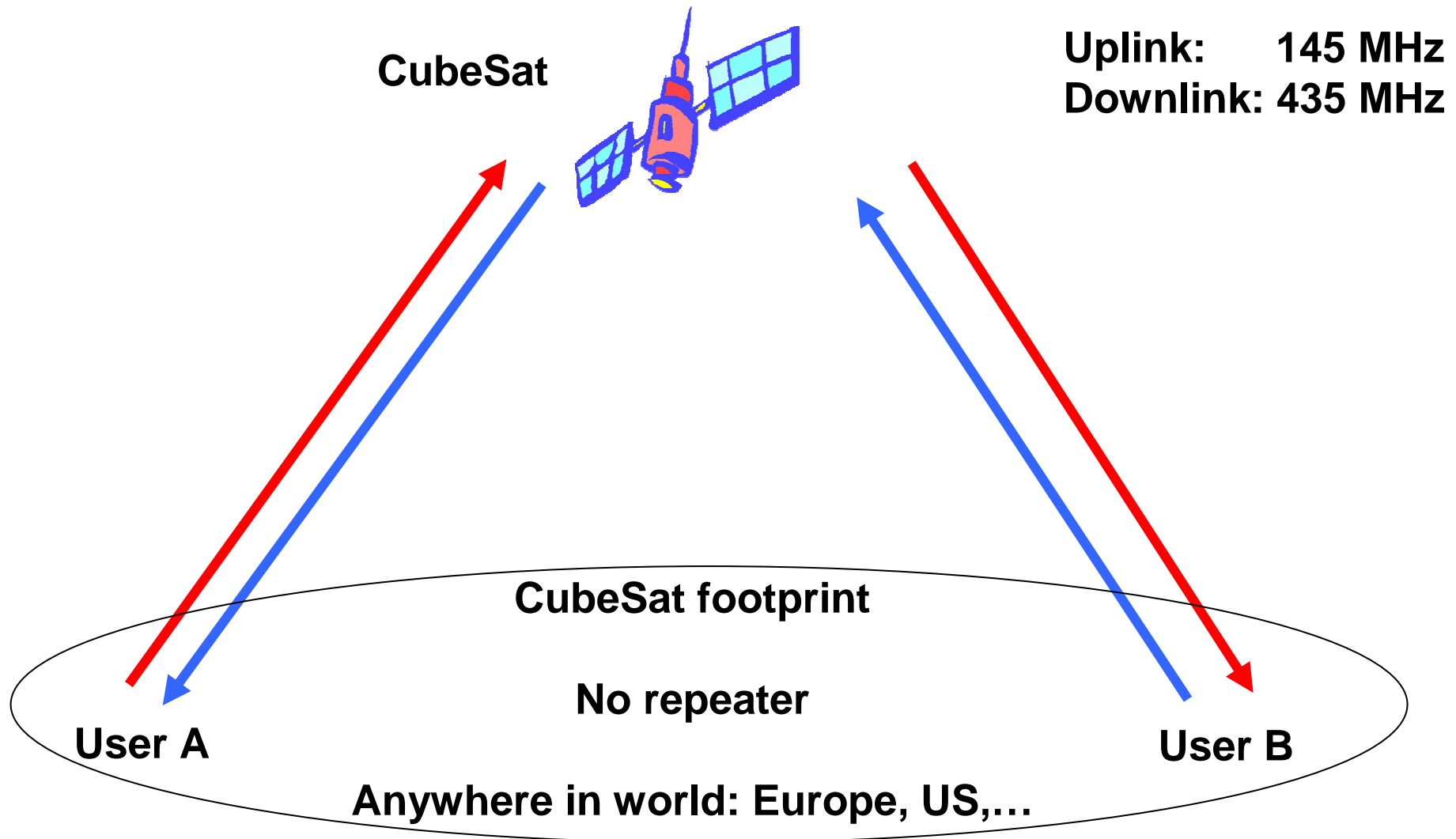
# COMPARISON BETWEEN D-STAR AND TRADITIONAL - FM AUDIO SIGNALS

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**D-STAR  
VS.  
FM**

# SITUATION 1: USERS IN CUBESAT'S FOOTPRINT



# TYPICAL USER RADIO EQUIPMENT (FIXED OR MOBILE)

## ICOM IC-E2820

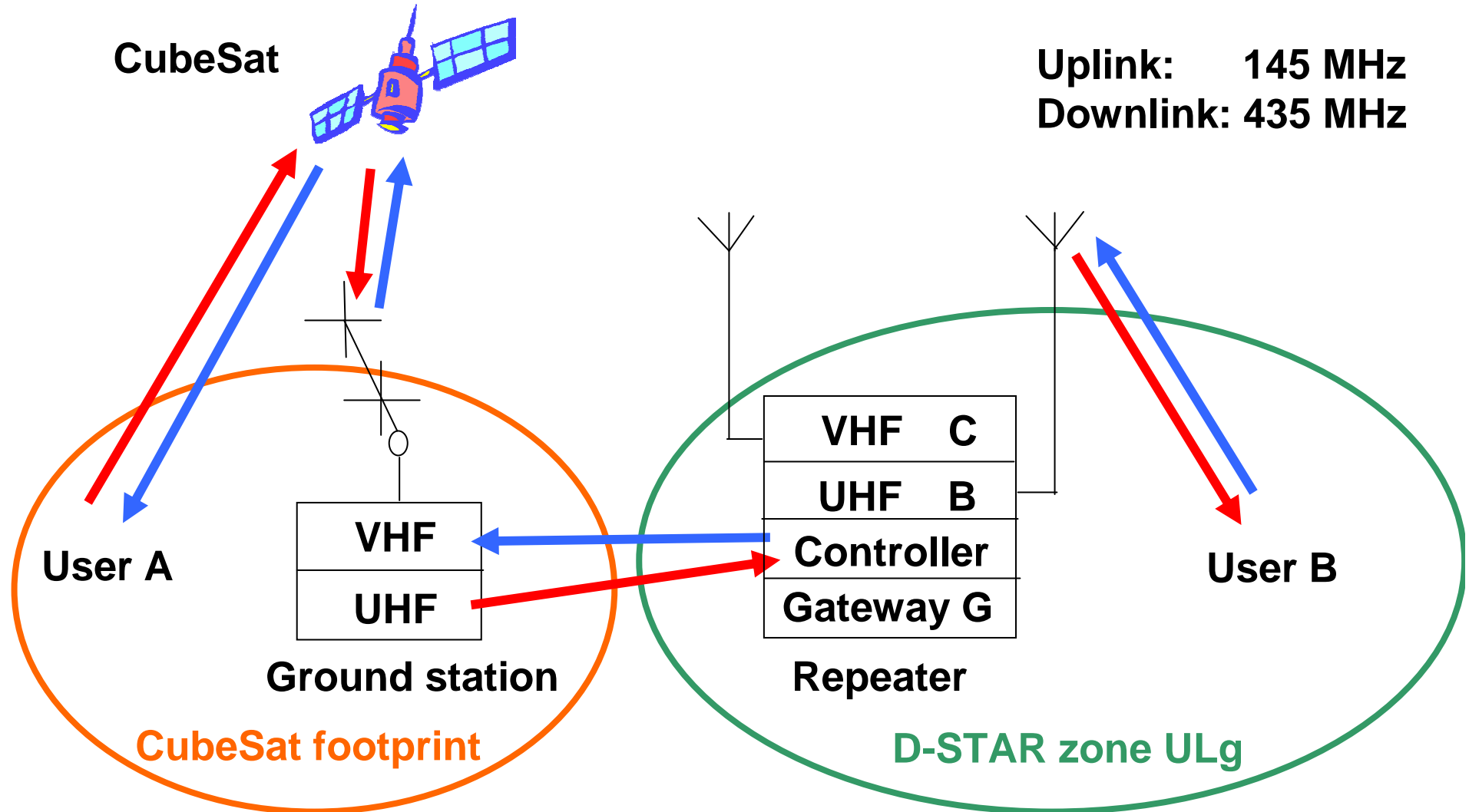
- 2 receivers
- 1 transmitter



VHF: 144 MHz (2 m)

UHF: 440 MHz (70 cm)

# SITUATION 2: USING CUBESAT AND ULG REPEATER

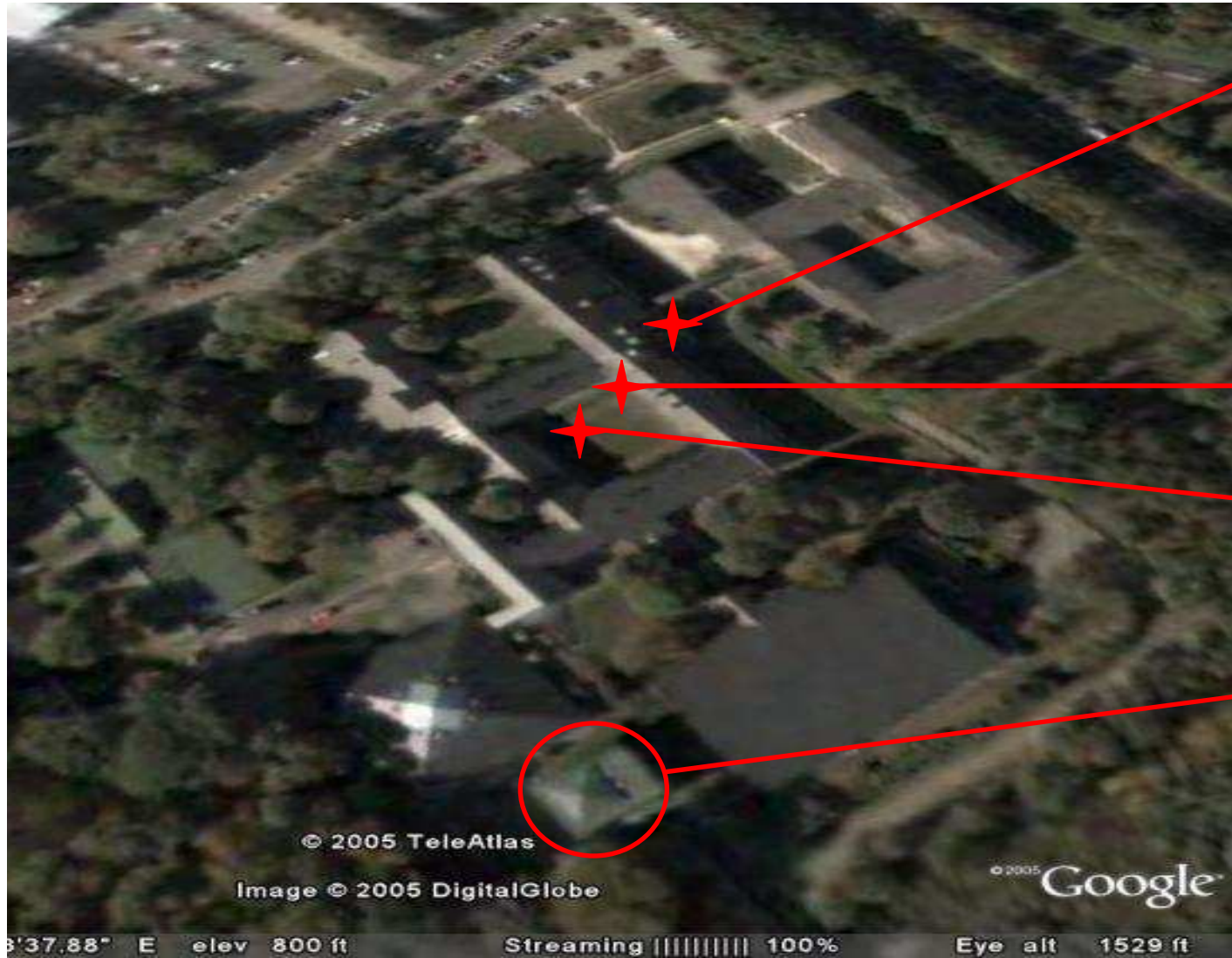




# D-STAR GROUND REPEATER



# GROUND EQUIPMENT AT ULG-EECS (MONTEFIORE INSTITUTE)



Satellite  
tracking  
antennas

Montefiore  
ham radio station  
(ON4ULG)

Antenna  
tower

D-STAR  
repeater  
(ON0ULG)  
&  
antennas

© 2005 TeleAtlas

Image © 2005 DigitalGlobe

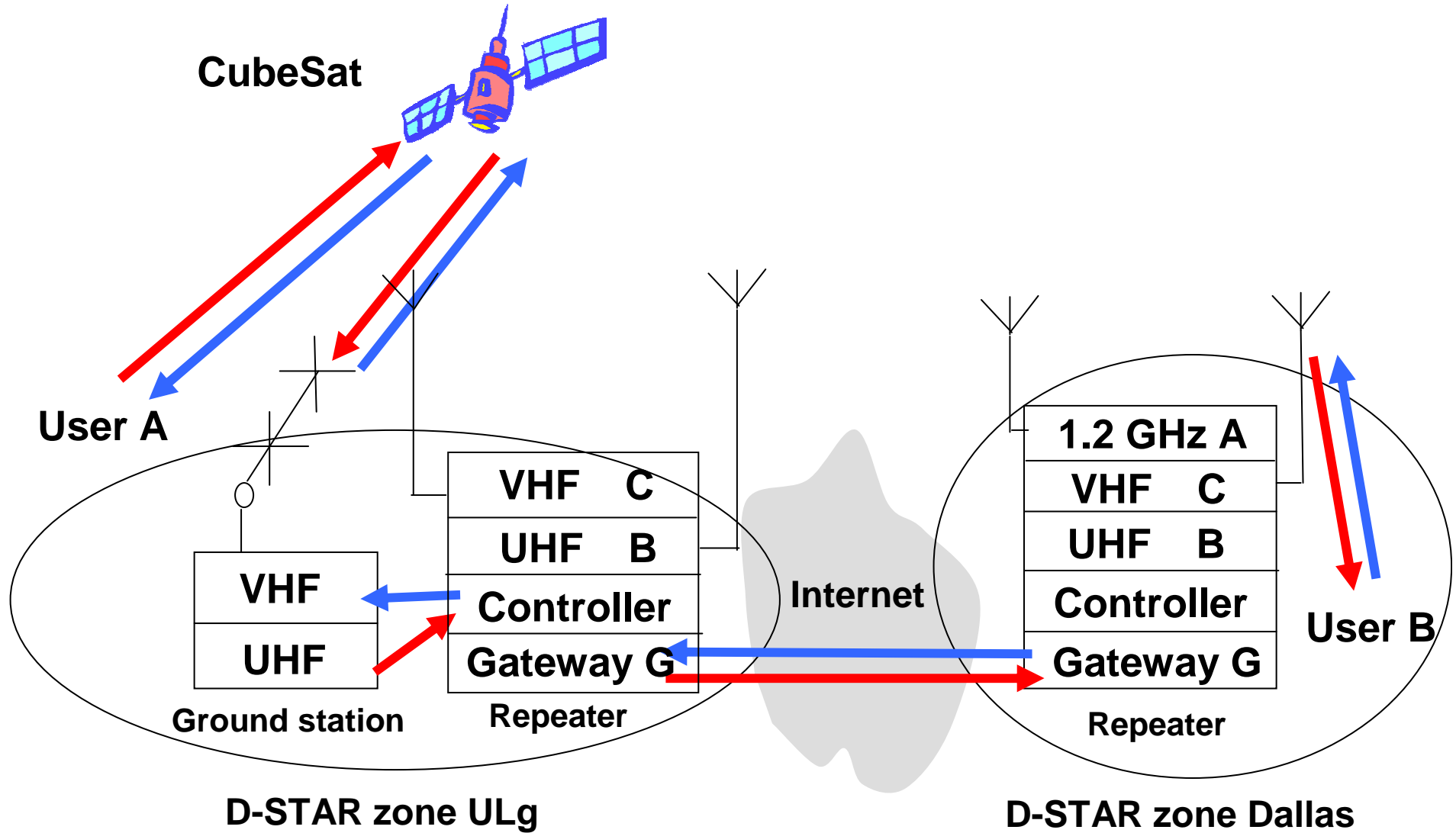
© 2005 Google

37.88" E elev 800 ft

Streaming ||||| 100%

Eye alt 1529 ft

# SITUATION 3: USING CUBESAT, ULG REPEATER, & INTERNET









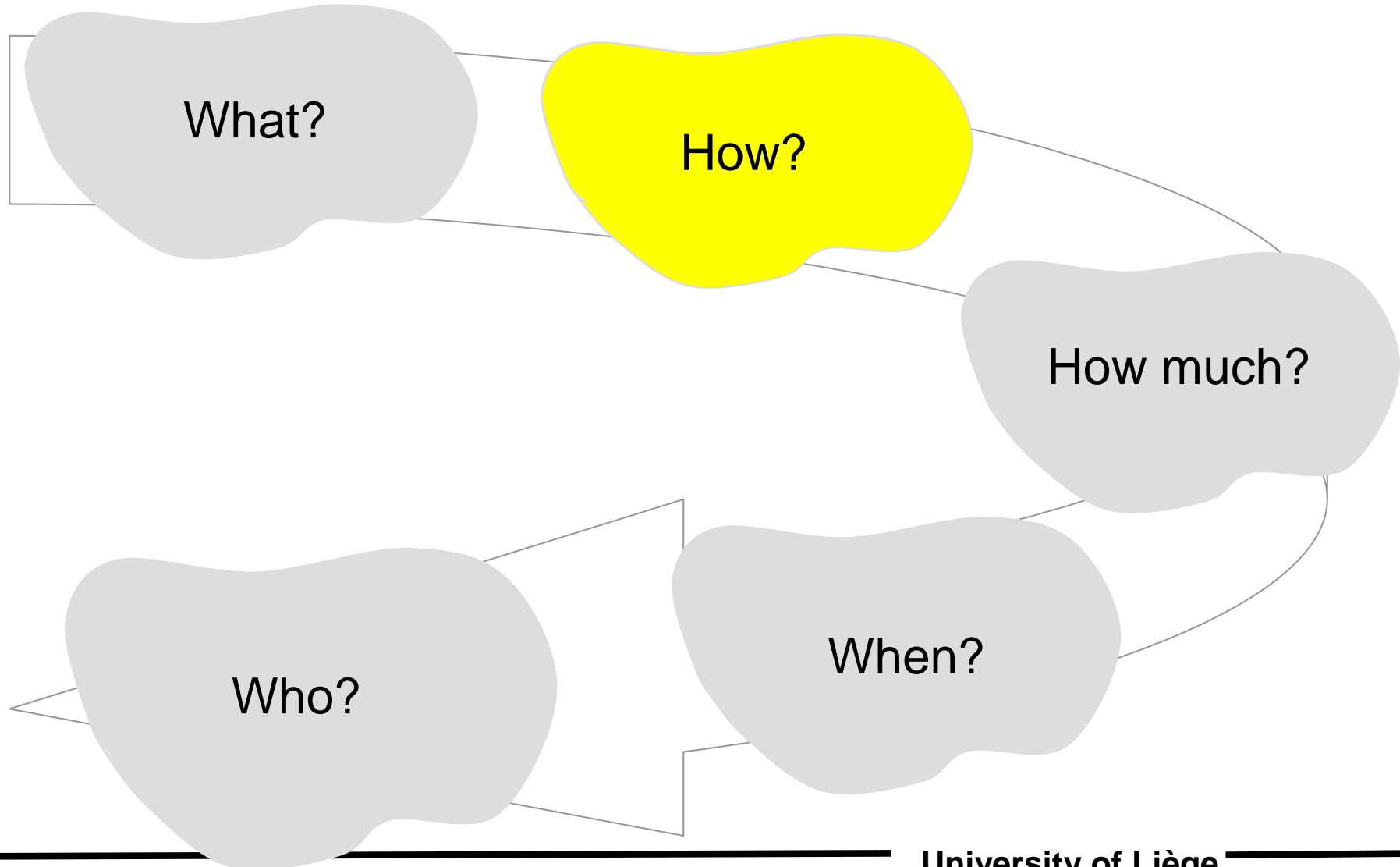
# FIRSTS!

- **Belgium's first radio contact using D-STAR repeater (3 January 2008)**
- **World's first CubeSat using D-STAR**



# OUTLINE

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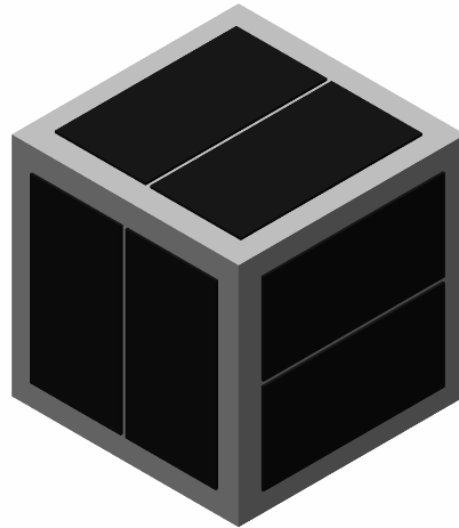
# CUBESAT

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**Structures and mechanisms**

**Thermal system**

**ADCS**



**C&DH**

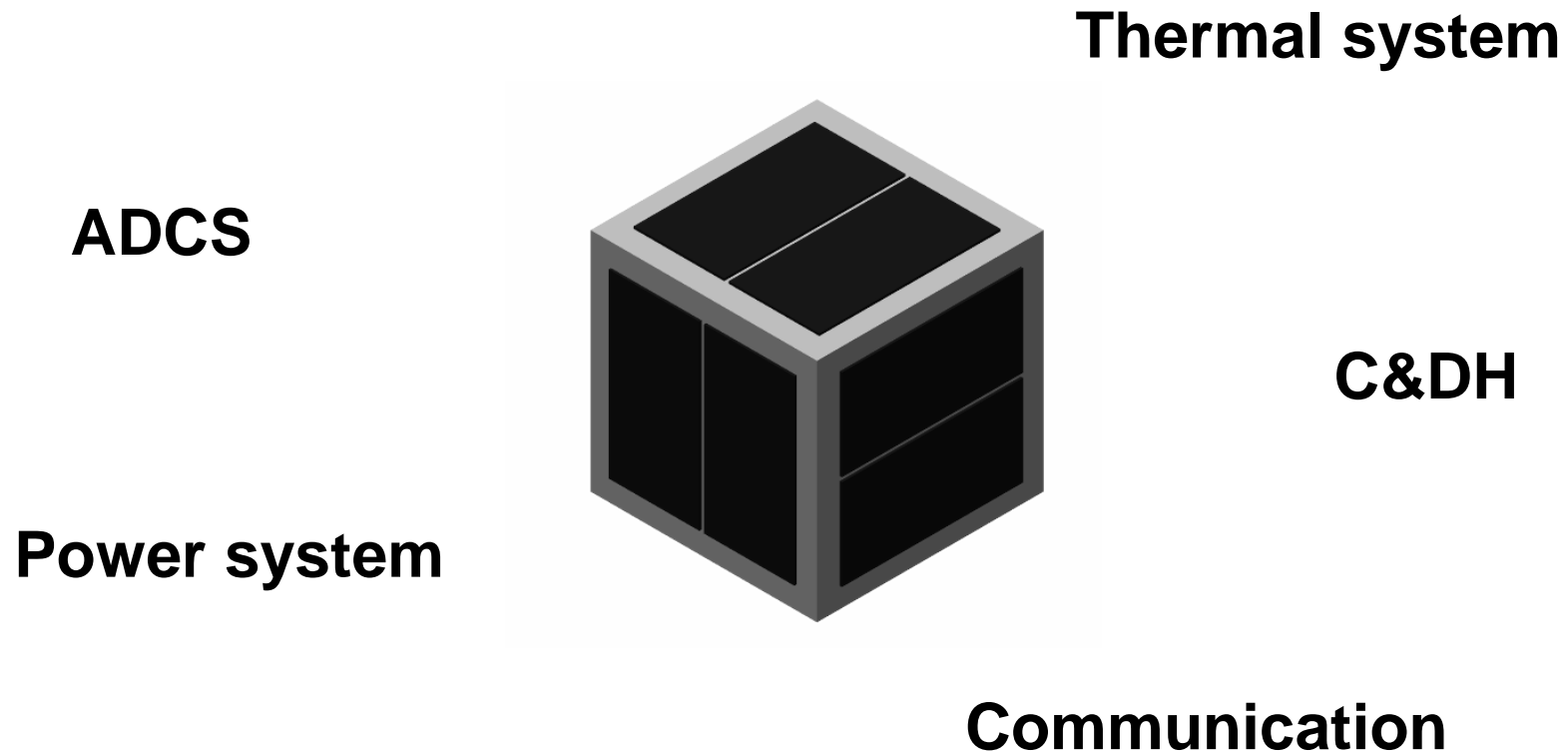
**Power system**

**Communication**

# CUBESAT

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## Structures and mechanisms





# STRUCTURES AND MECHANISMS

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- **CubeSat kit**



- **Flexible on the deployment system**

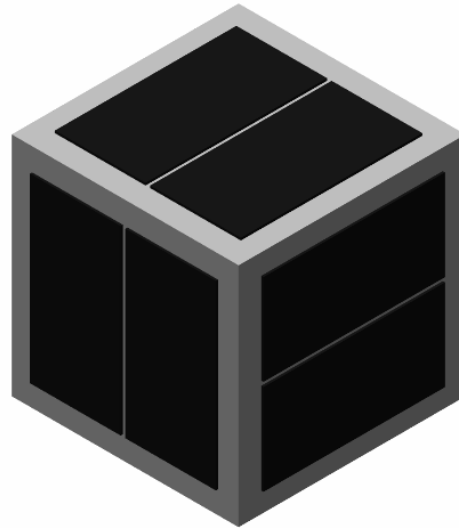
# CUBESAT

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Structures and mechanisms

Thermal system

**ADCS**



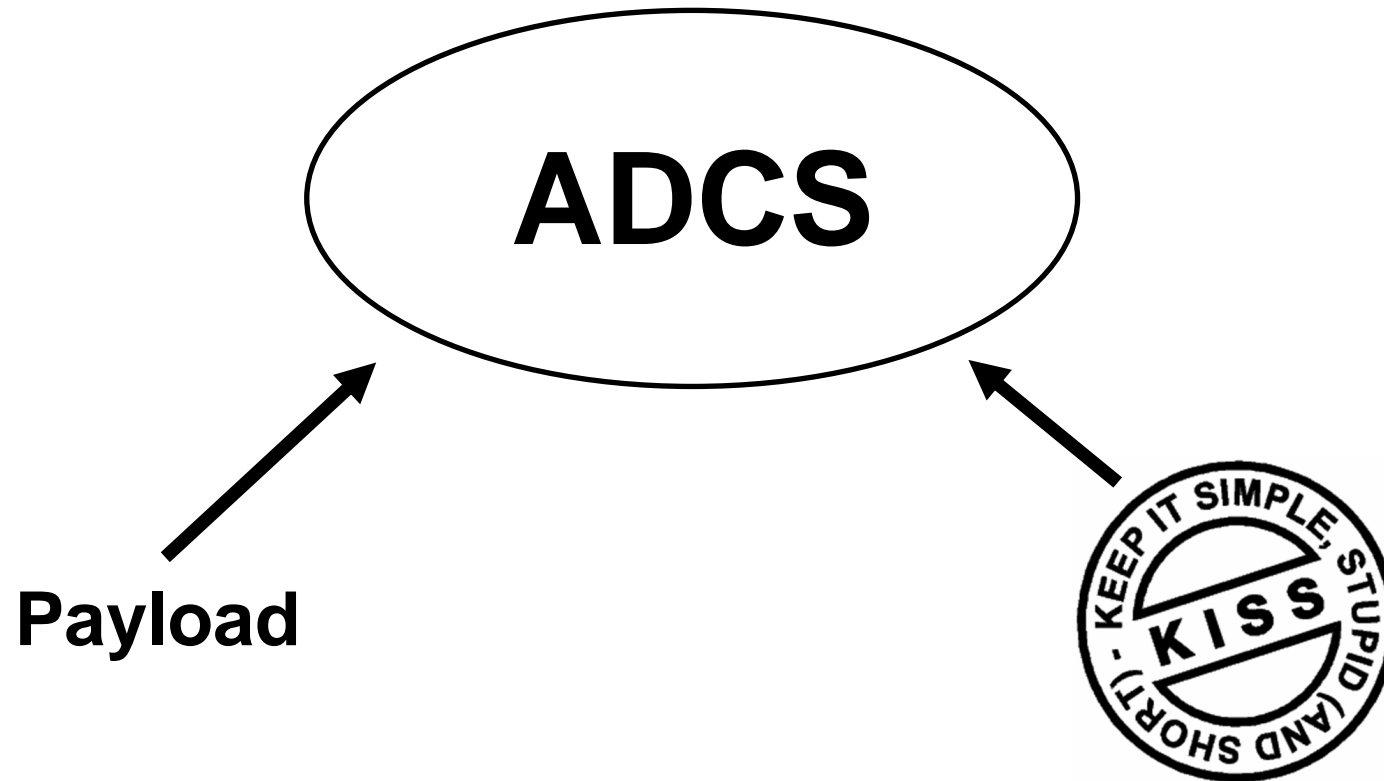
C&DH

Power system

Communication

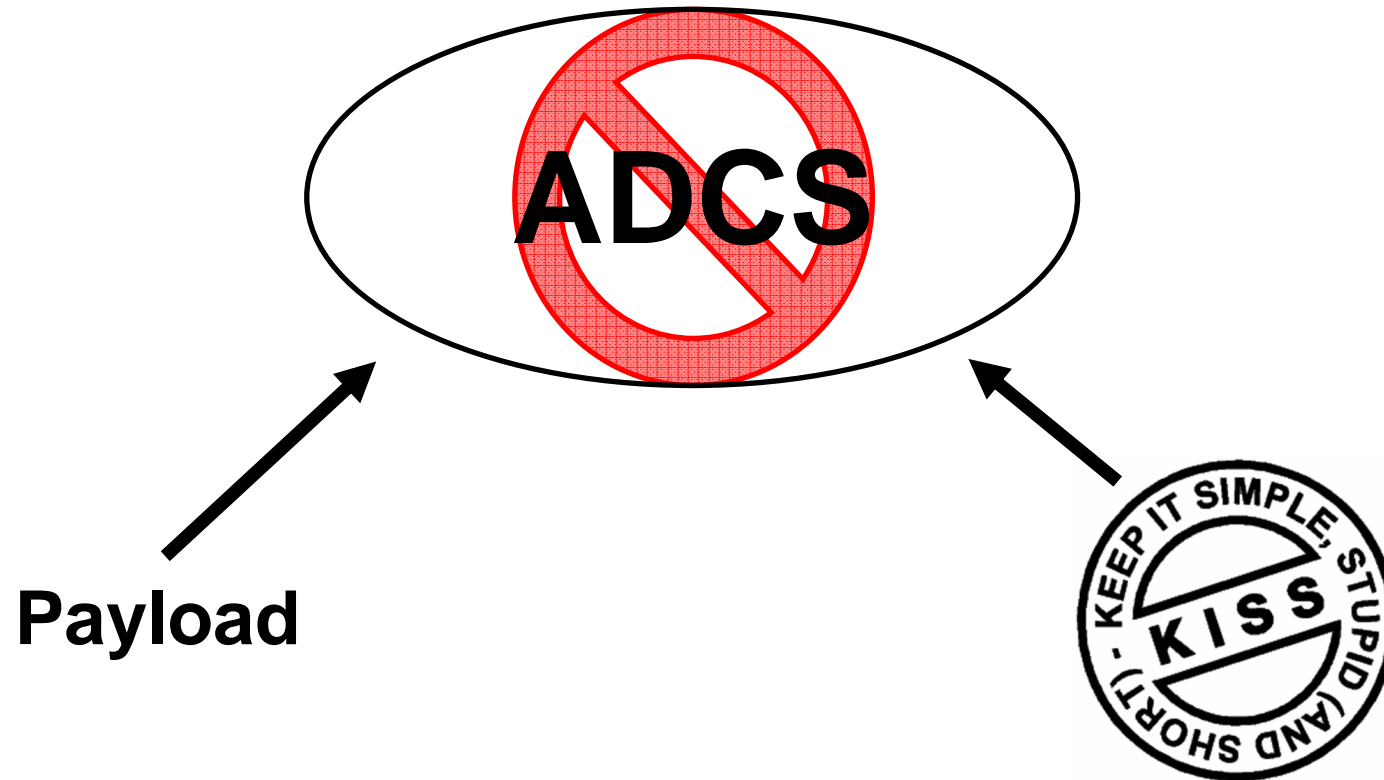
# ATTITUDE DETERMINATION AND CONTROL SYSTEM

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# ATTITUDE DETERMINATION AND CONTROL SYSTEM

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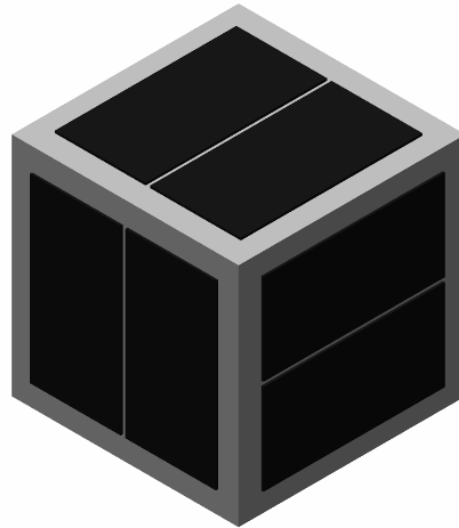
# CUBESAT

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**Structures and mechanisms**

**Thermal system**

**ADCS**



**C&DH**

**Power system**

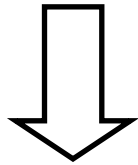
**Communication**



# POWER SYSTEM (1)

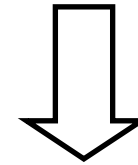
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**POWER  
GENERATION**



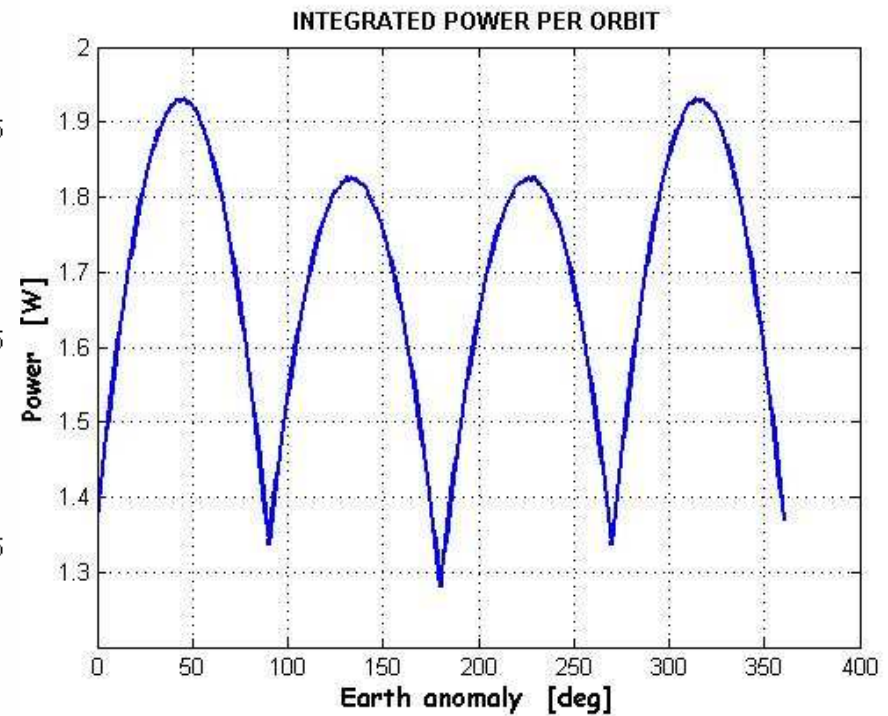
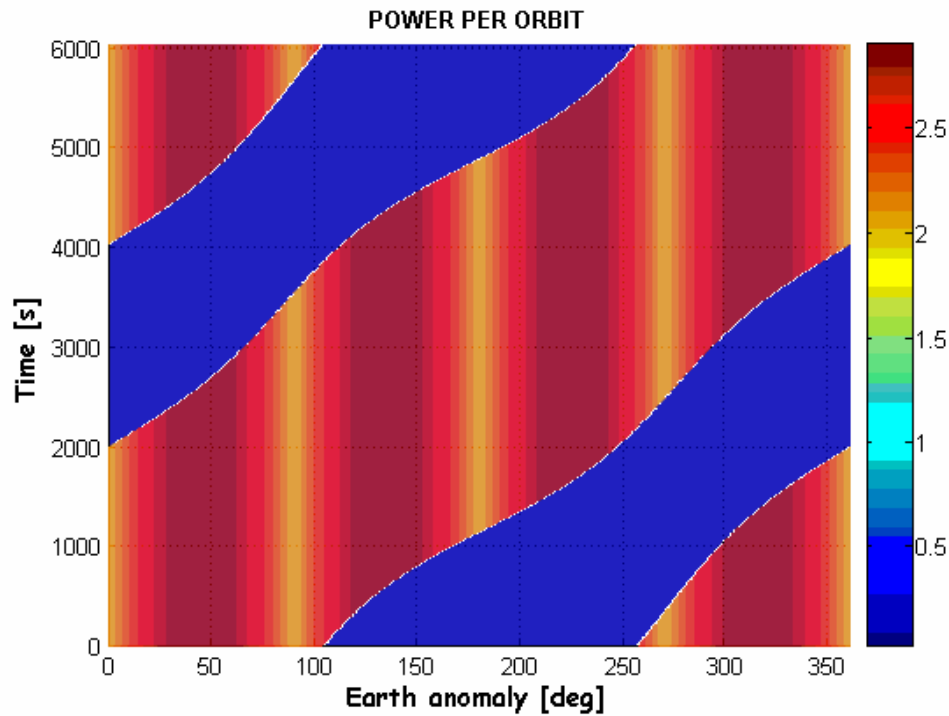
**GaAs solar cells**  
**Efficiency ~ 27%**

**POWER  
STORAGE**



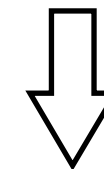
**Lithium-ion battery**

# POWER SYSTEM (2)



**RAAN = 0**

**Argument of perigee = 0**



**Enough power**

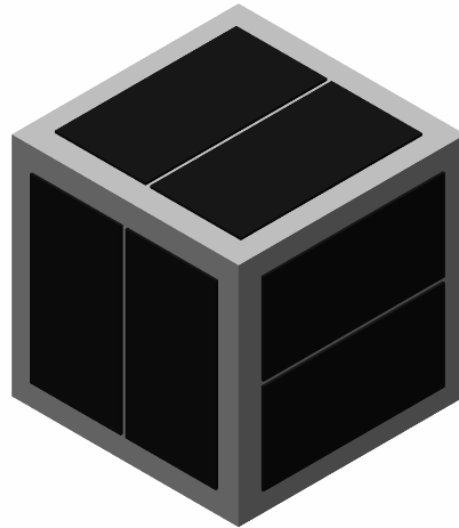
# CUBESAT

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**Structures and mechanisms**

**Thermal system**

**ADCS**

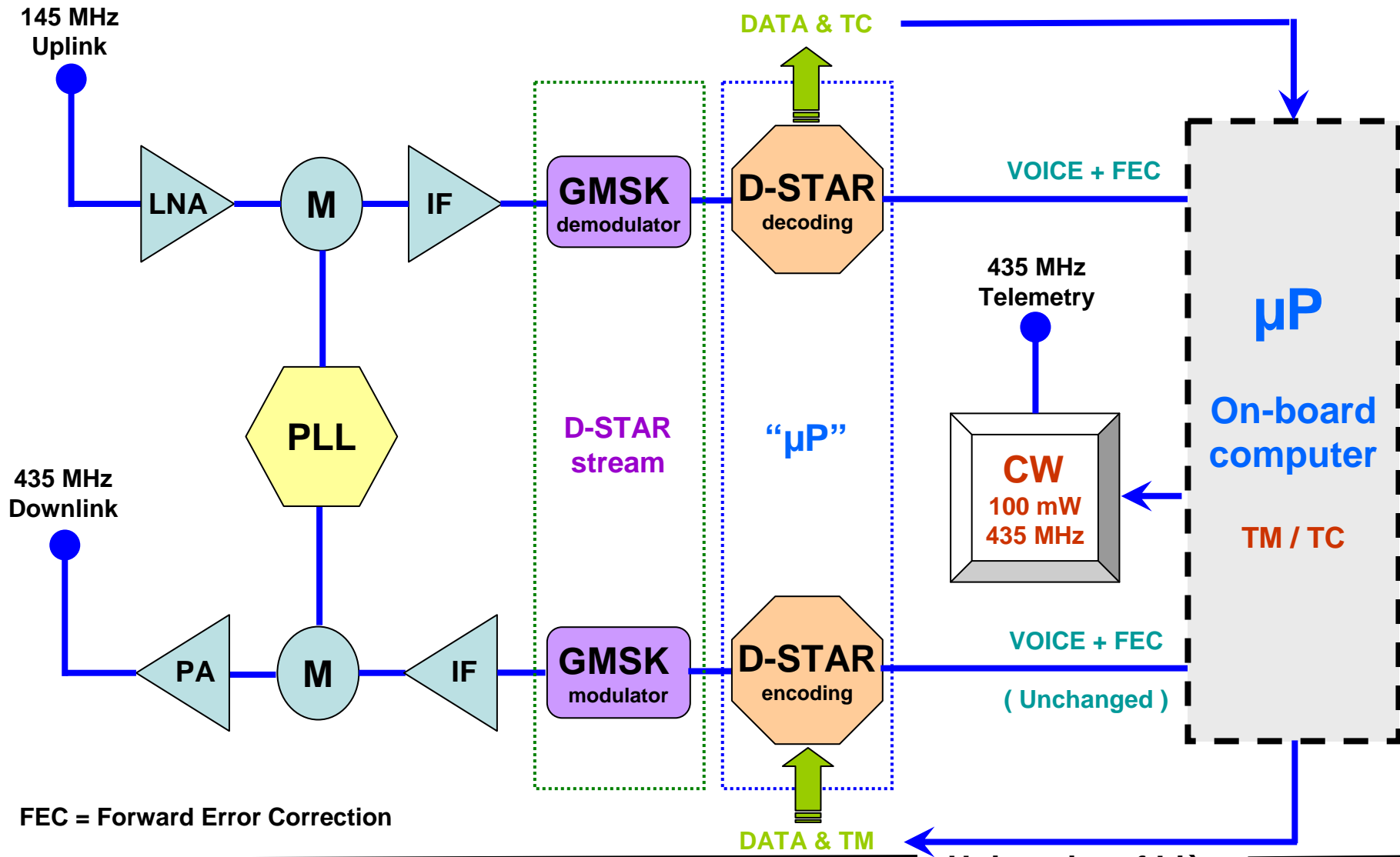


**C&DH**

**Power system**

**Communication**

# COMMUNICATION



FEC = Forward Error Correction

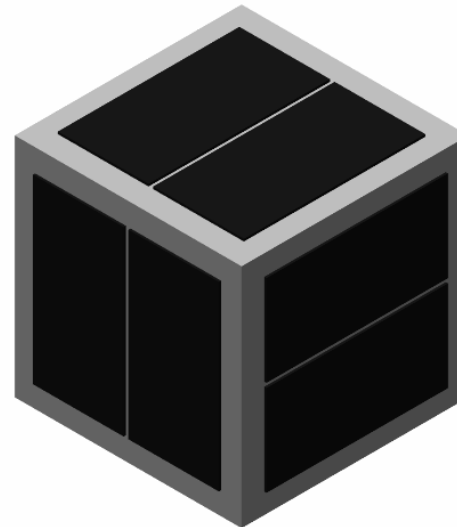
# CUBESAT

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**Structures and mechanisms**

**Thermal system**

**ADCS**



**C&DH**

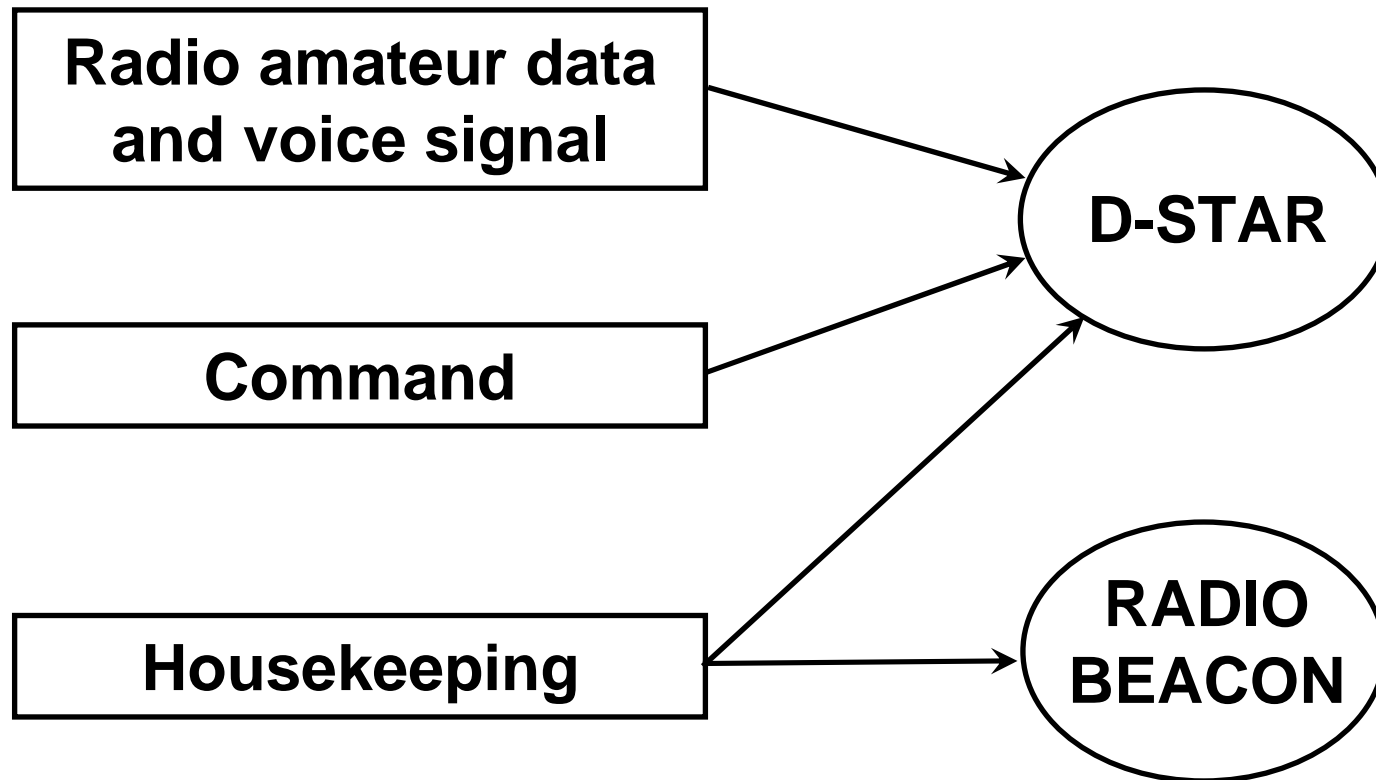
**Power system**

**Communication**



# COMMAND AND DATA HANDLING

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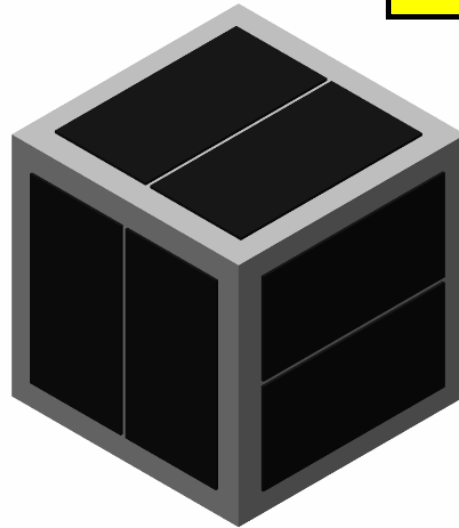
# CUBESAT

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**Structures and mechanisms**

**Thermal system**

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**C&DH**

**Power system**

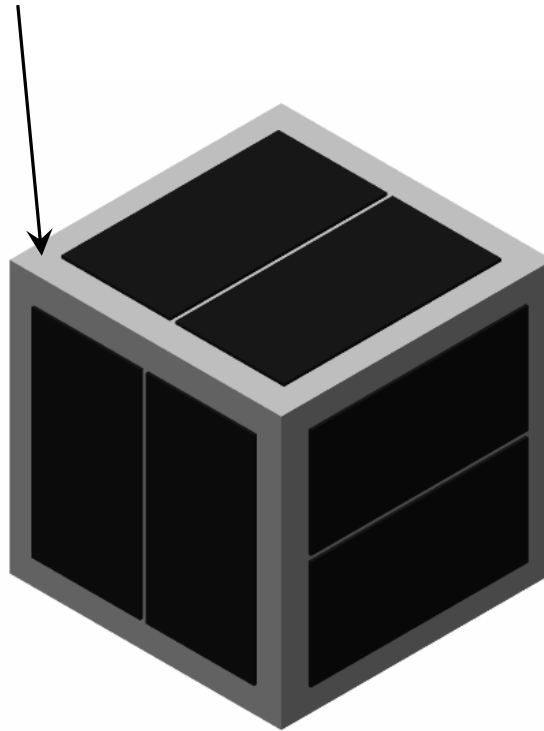
**Communication**

# THERMAL SYSTEM

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**Thermal balance to be studied:**

**exploit available space**



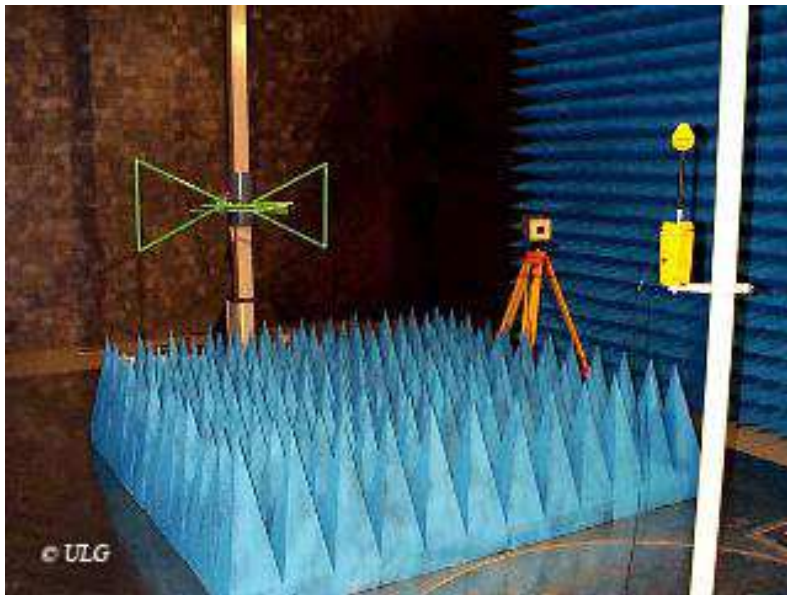
# TESTS

Electromagnetic compatibility

Thermal environment

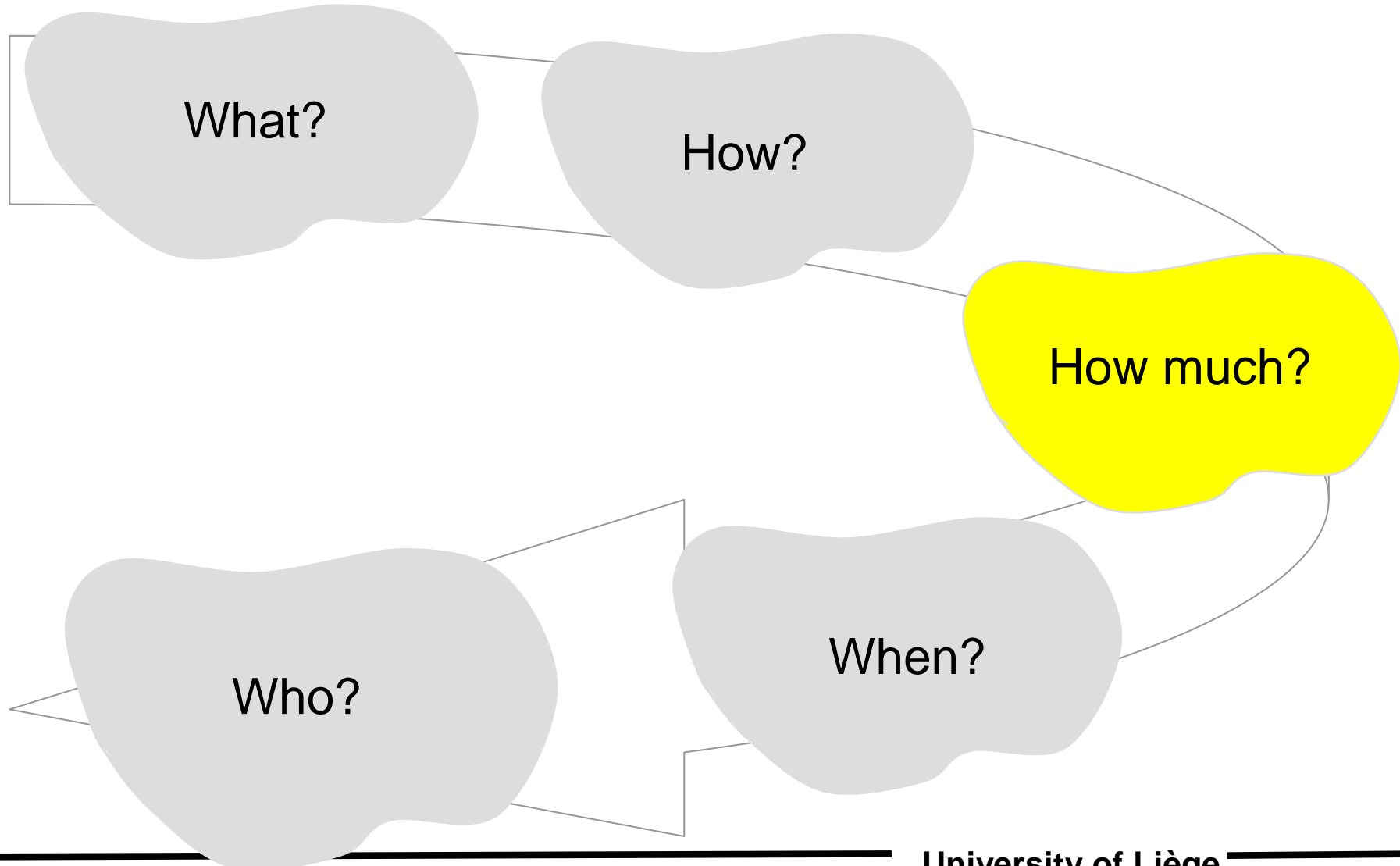
Vibrations

EECS



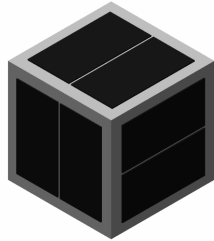
# OUTLINE

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# ESTIMATED COSTS

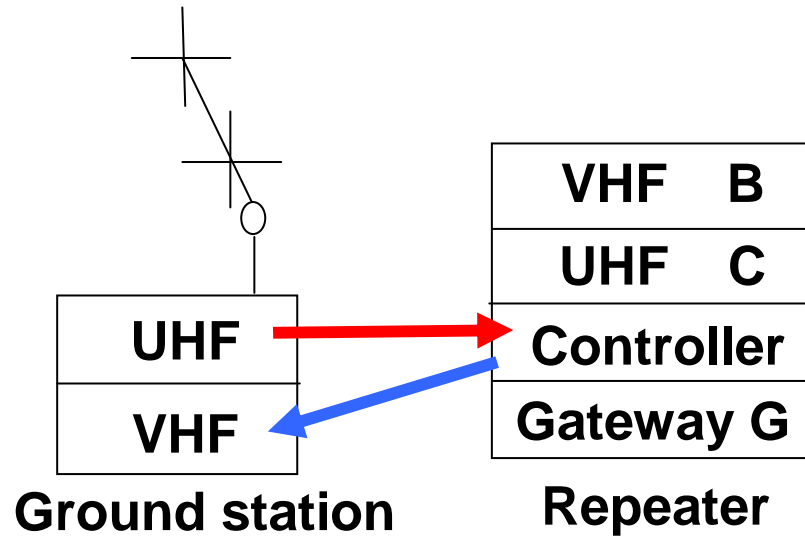


40,000 €

- Internal funding
- Industrial sponsorship



400-800 €



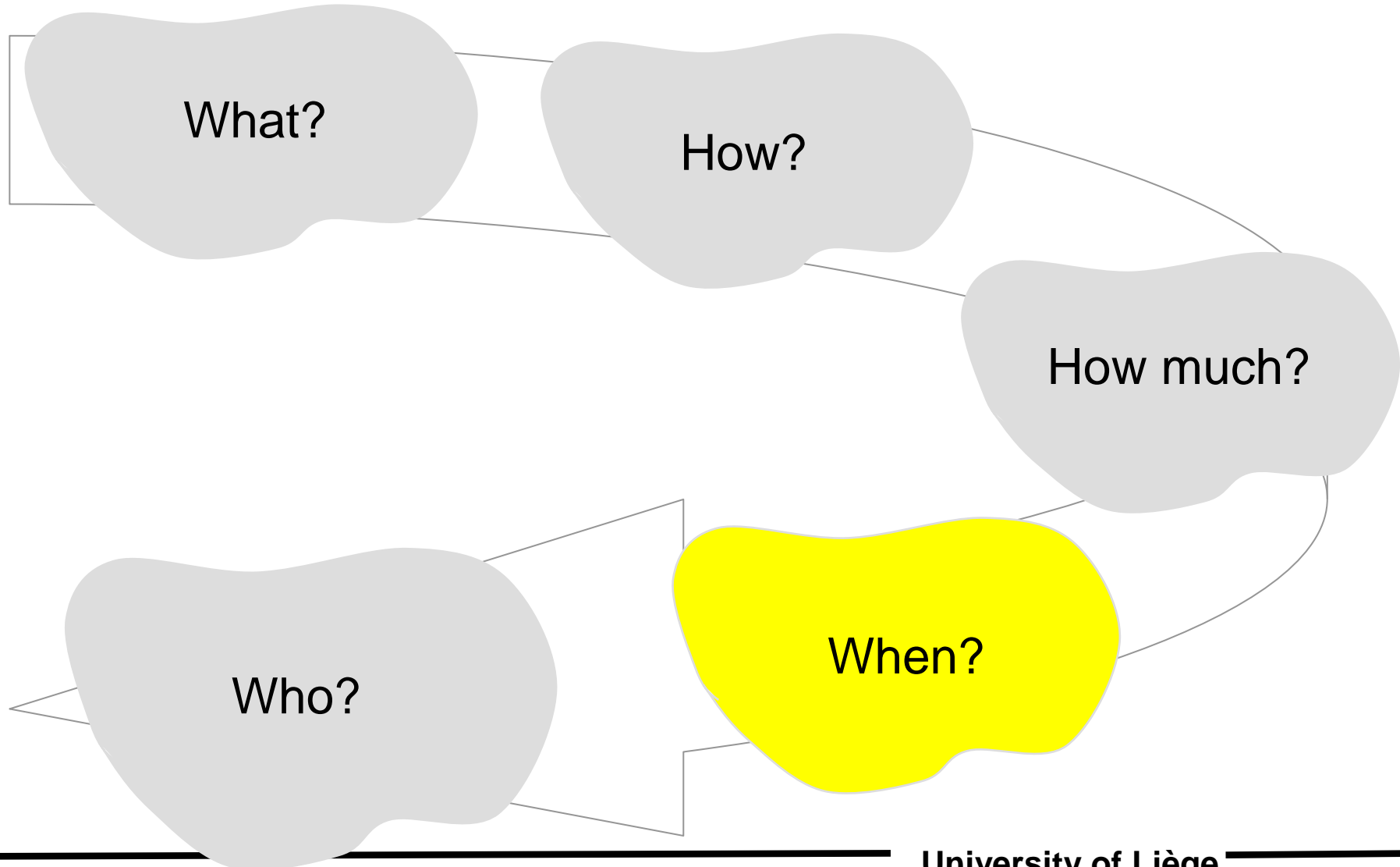
Ground station

Repeater

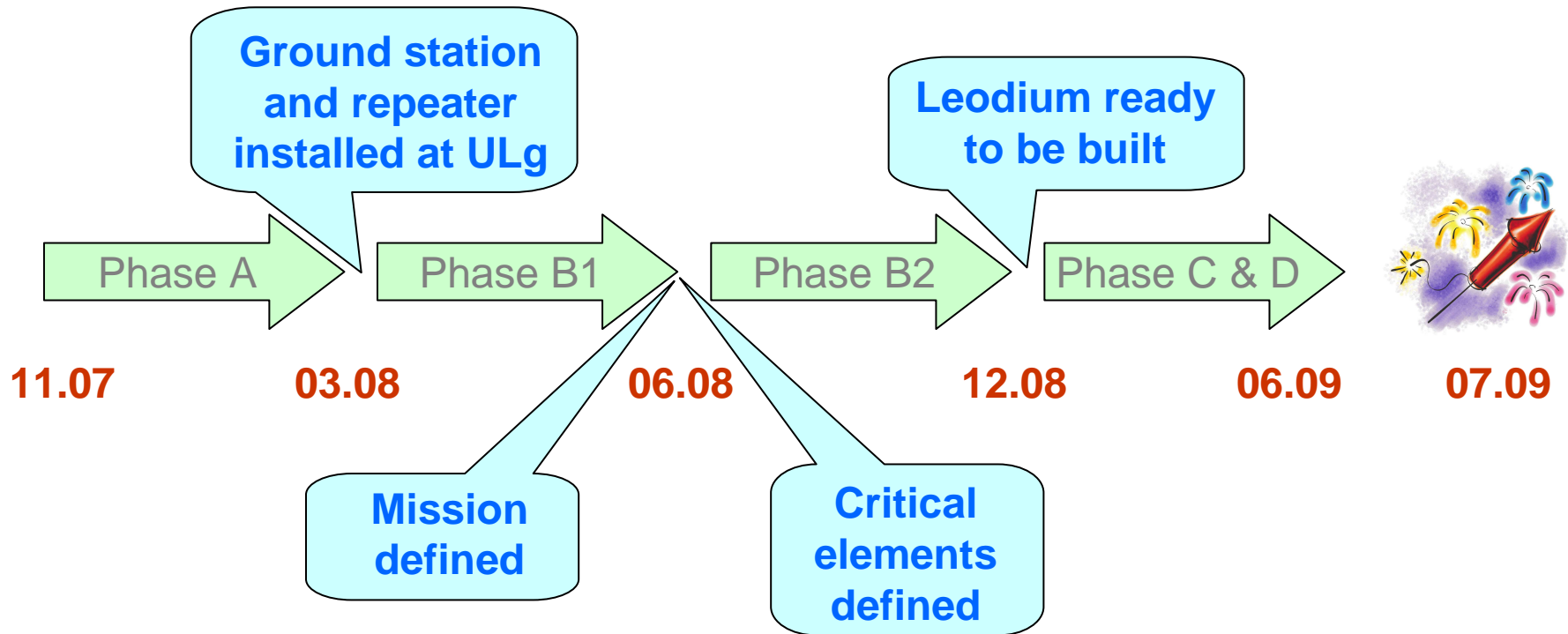
10,000 €

10,000 €

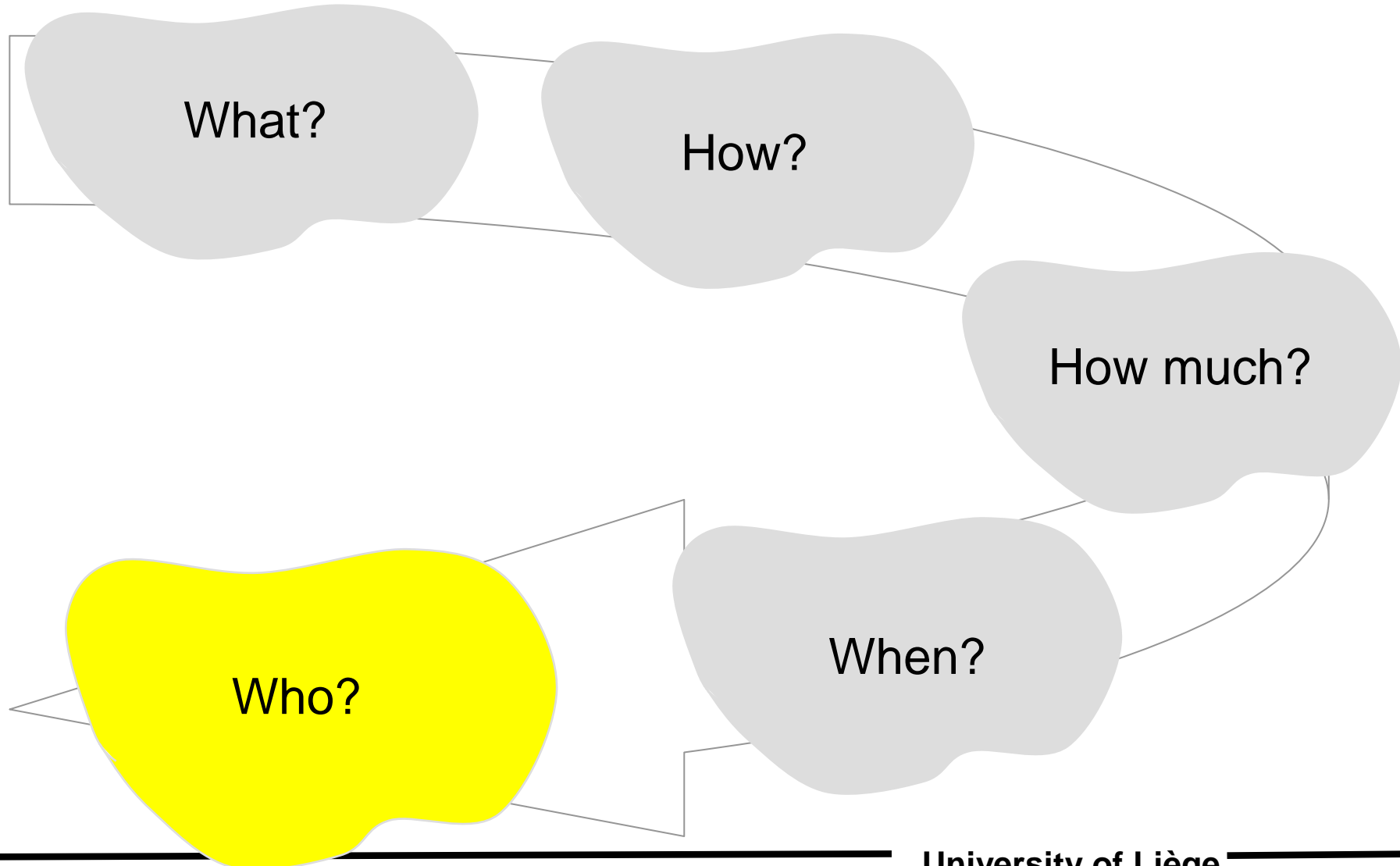
# OUTLINE



# SCHEDULE



# OUTLINE

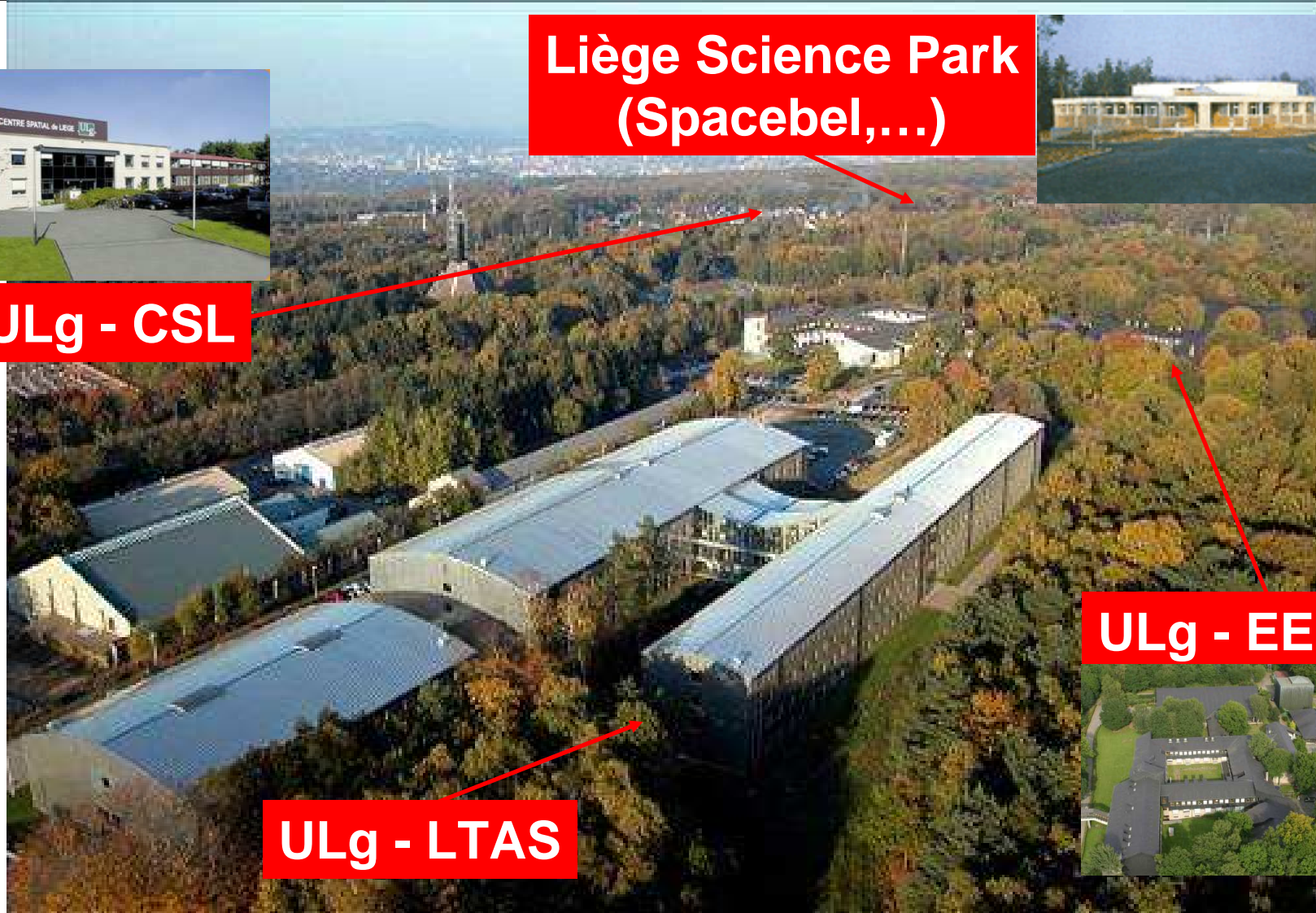


# TEAM



**ULg - CSL**

**Liège Science Park  
(Spacebel,...)**



**ULg - LTAS**

**ULg - EECS**





# TEAM

## EECS Dept.

Prof. Jacques Verly  
ON9CWD  
100 persons

## STUDENTS

- Jonathan Pisane (EECS), ON7JPD
- Stefania Galli (LTAS)
- Philippe Ledent (EECS)
- Amandine Denis (PhD, LTAS)
- Jean-François Vandenrijt (PhD, CSL)



Prof. Gaetan Kerschen  
120 persons

## Astrophysics Dept.

Prof. Jean-Pierre Swings



Prof. Pierre Rochus  
100 persons

## LIEGE ESPACE



Luc Halbach  
ON6JY



# TEAM

## EECS Dept.

Prof. Jacques Verly

ON9CWD

100 persons

## Astrophys

Prof. Jean-Pier

- ## STUDENTS
- Jonathan Pisane (EECS), ON7JPD
  - Stefania Galli (LTAS)
  - Philippe Ledent (EECS)
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  - Jean-François Vandenberghe (PhD, CSL)

Prof. Pierre Ros

100 persons

Prof. Frédéric Halbach

ON6JY



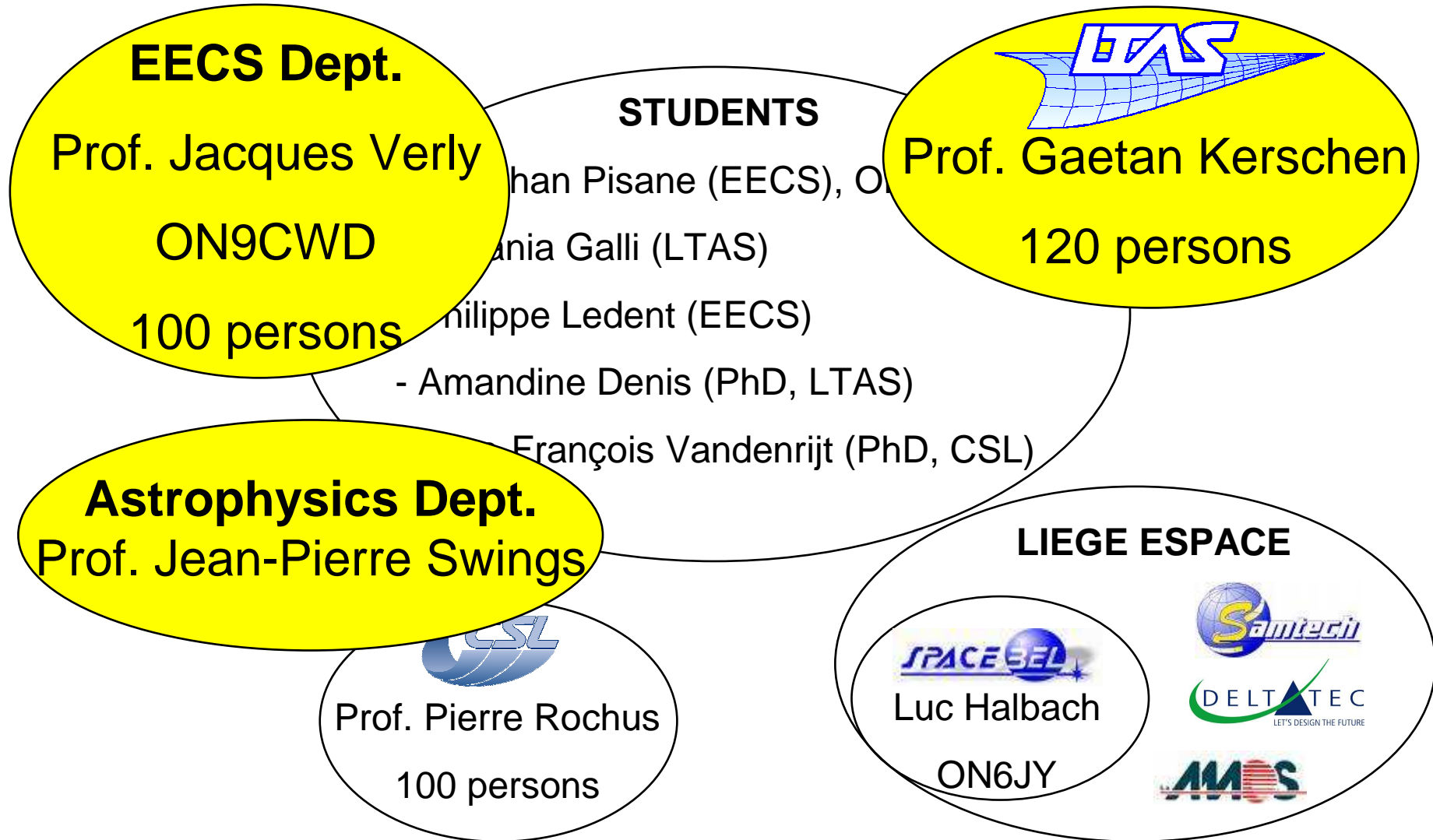
Prof. Gaetan Kerschen

120 persons

SPACE



# TEAM



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## LIEGE ESPACE



Luc Halbach

ON6JY



# CONCLUSION

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- **Innovative** communications system
  - Simultaneous digital transmission of voice and data
  - Routing and roaming
  - Worldwide connectivity via internet
- **Belgium's first D-STAR repeater**
- **World's first D-STAR satellite**

# FINAL WORD

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## Challenging schedule but...

- **Motivated team**
- **Simplicity**
- **Strong academic and industrial support**

**D-STAR – BASED  
STUDENT CUBESAT  
OF UNIVERSITY OF LIEGE  
(LEODIUM)**

**Stefania GALLI**

**Jonathan PISANE, ON7JPD**

[www.leodium.ulg.ac.be](http://www.leodium.ulg.ac.be)

**Thanks for your attention**