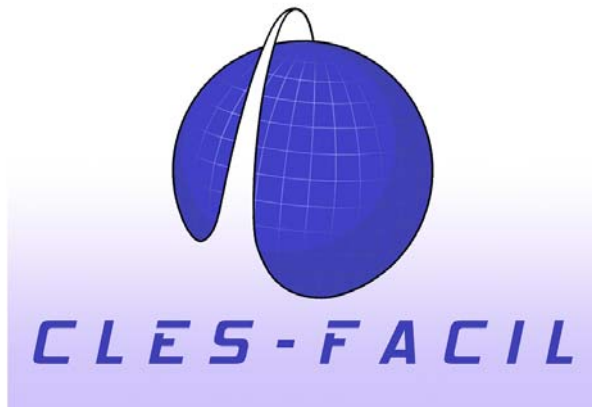


# Challenging Paraglide Control System

CLES FACIL student club developing CANSAT in cooperation with Kyushu Institute of Technology



Stanislaw Ostoja-Starzewski, Marc Dal Molin  
CLES FACIL at the National Institute of Applied Science (INSA)  
Lyon, France

# Challenging Paraglide Control System

CLES FACIL (1/2): The Club

- Autonomous Student Club with Support from INSA
- 40 Years of History
- Today ~25 members working on:
  - CanSat Project
  - ESA ESMO Project



# Challenging Paraglide Control System

CLES FACIL (2/2): The Club

- Sounding Rocket Experience at La Courtine  
CNES/Planete Sciences Rocket Launch  
Campaign
- Special Security Rules and Weight  
Restrictions
  - Sounding Rocket up to 15 kg
  - Solid Propellant Propulsion provided by CNES
- This Year's Launch Scheduled on July



# Challenging Paraglide Control System

The CanSat Project (1/10): The Launcher

- Sounding Rocket meets the restrictions of CNES
- Embedded Anti-rotation system:
  - Compressed Air Jet Propulsion System with the Output Pressure of 10-15 bars
  - System implies Weight Obstruction
- Consequence: Non Can-Sized CanSat



# Challenging Paraglide Control System

## The CanSat Project (2/10): The Module

- Use of the Nose Cone as the Ejected Module
- Nose Cone Dimensions
  - Diameter: ~15 cm
  - Height: ~40cm
- Special Ejection Mechanism
- Used Devices:
  - Paraglide
  - Servo Actuator
  - GPS Device
  - Accelerometer
  - Microcontrollers, others...



# Challenging Paraglide Control System

The CanSat Project (3/10): The Control Algorithm

- Uncertainty of GPS Positioning System
  - Cases of false Data Input
- Separate Algorithm to Calculate the Estimated Position
  - Use of Accelerometer to Optimize the Estimation



# Challenging Paraglide Control System

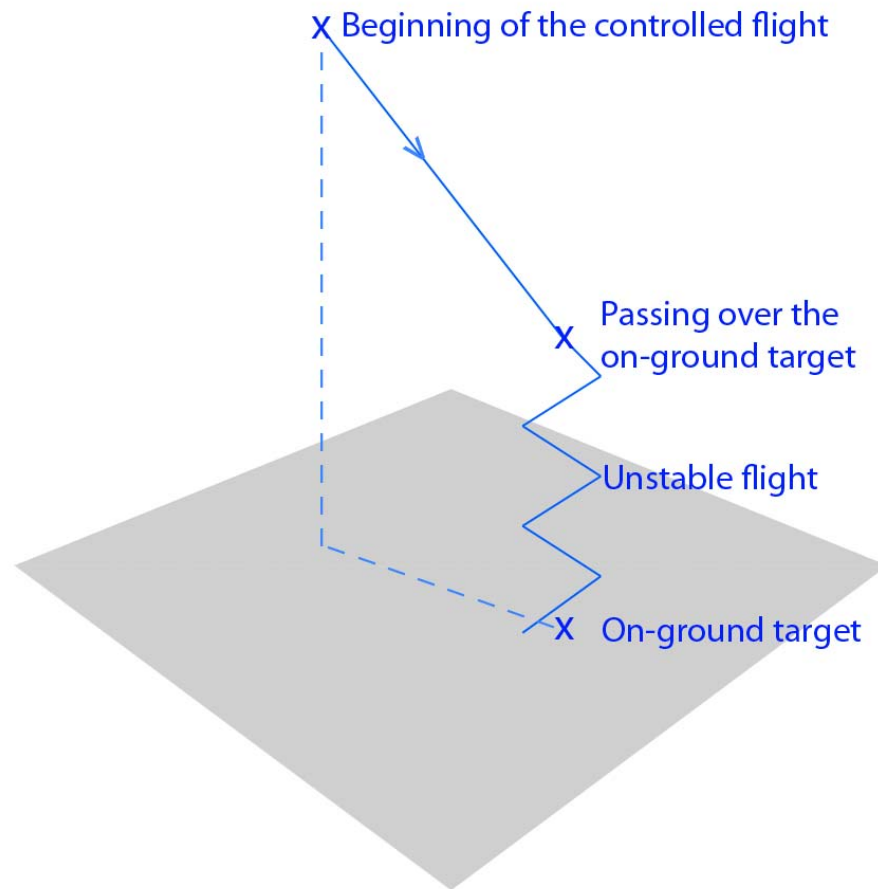
The CanSat Project (4/10): The Optimizing Control Algorithm

- Existing Control Algorithms
  - Simple nature: iterative correction of the directional vector
  - Does not take into account different scenarios
- Unstable final phase of flight



# Challenging Paraglide Control System

The CanSat Project (5/10): The Optimizing Control Algorithm



# Challenging Paraglide Control System

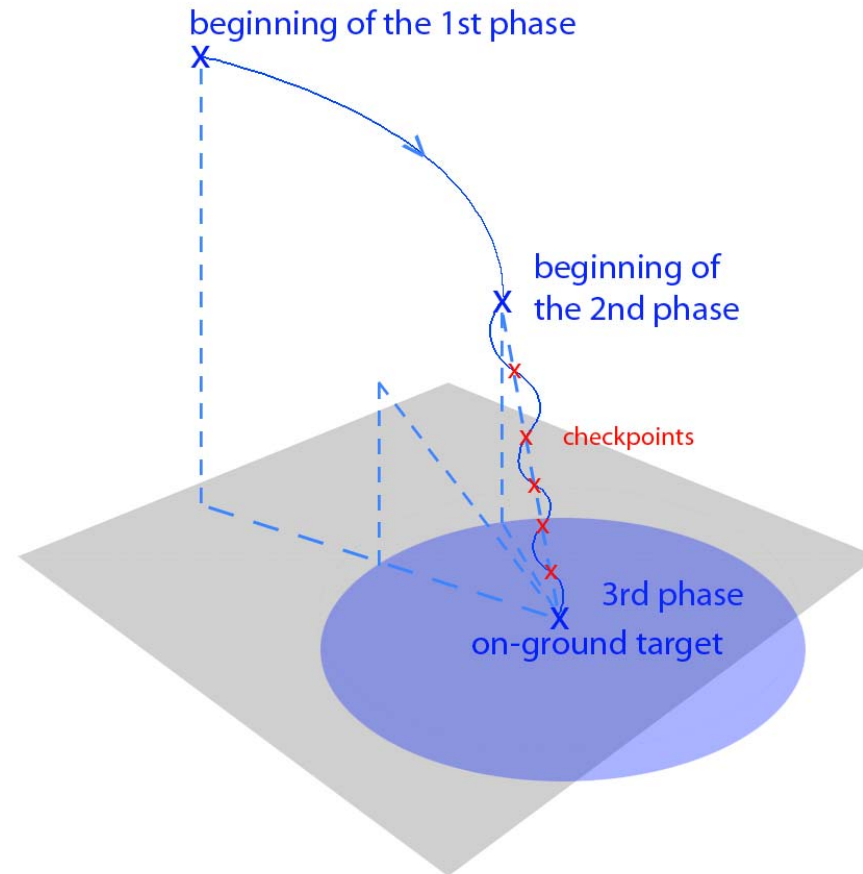
The CanSat Project (6/10): The Optimizing Control Algorithm

- Our Solution: 3-Phase Algorithm  
Elaborating the Optimal Trajectory
- Assumption: Constant Descent Angle of the CanSat
- First Phase:
  - Paraglide deployment
  - Optimal Trajectory Calculation
  - Driving CanSat to 2<sup>nd</sup> Phase Departure Point



# Challenging Paraglide Control System

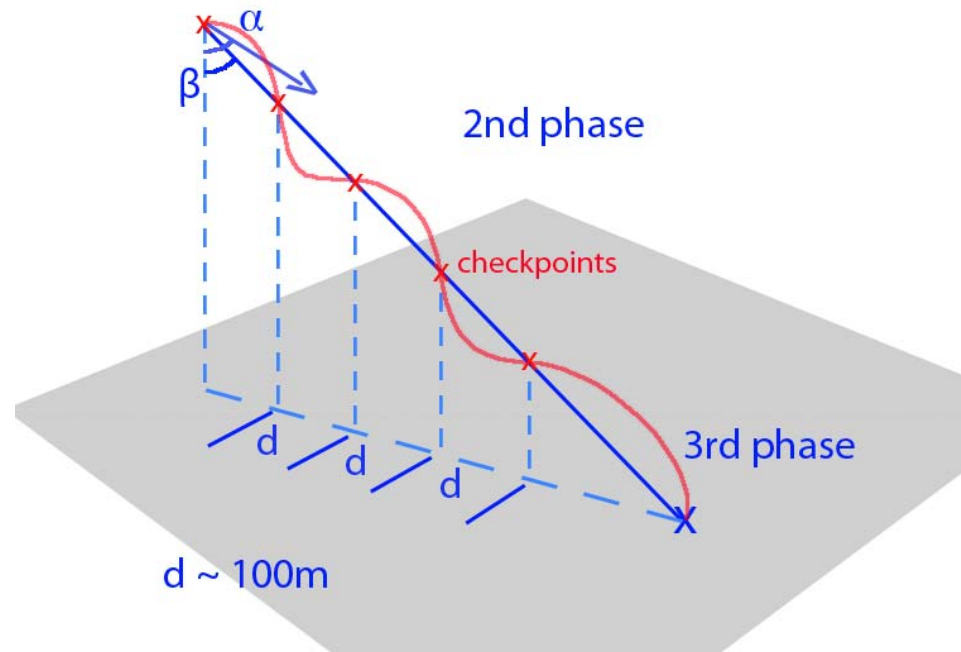
The CanSat Project (7/10): The Optimizing Control Algorithm



# Challenging Paraglide Control System

The CanSat Project (8/10): The Optimizing Control Algorithm

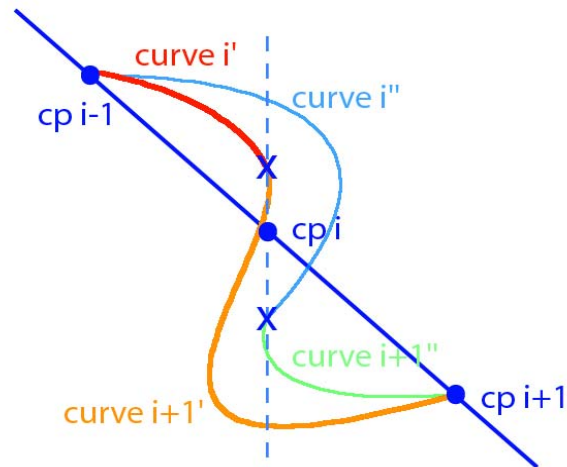
- Second Phase:
  - Checkpoints Distributed uniformly
  - alpha: CanSat Constant Descent Angle
  - beta: Optimal Trajectory Descent Angle



# Challenging Paraglide Control System

## The CanSat Project (9/10): The Optimizing Control Algorithm

- Second Phase:
  - wide curve  $\rightarrow$  longer pathway  $\rightarrow$  arriving at lower altitude
  - narrow curve  $\rightarrow$  shorter pathway  $\rightarrow$  arriving at higher altitude



- At each Checkpoint:

- Comparison of current Estimated Position with the Checkpoint position
- Calculation of curve  $i+1$  leading to  $cp_{i+1}$

# Challenging Paraglide Control System

The CanSat Project (10/10): The Optimizing Control Algorithm

- Advantages
  - Stable Flight
  - Taking into Account Different Scenarios
  - Dealing with the Wind Factor



# Challenging Paraglide Control System

The CanSat Project: The Cooperation with the KIT

- Team of Prof. Yonemoto works on similar aspects of the Navigation Control
- Cooperation includes:
  - Exchange of Know-How
  - Collaboration on Optimizing Control Algorithm
- First Expected Result: La Courtine CNES Rocket Launch Campaign, France, July 2007



# Challenging Paraglide Control System

