Prototypes volants expérimentaux

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Introduction

Introduction

Plan

- Pionniers de l'aviation
- Différents types d'aéronefs
- 36 Erreurs souvent commises
- Différents types de portances
- Mécanique du vol

Pionniers de l'aviation

- Victor Tatin (1943-1913)

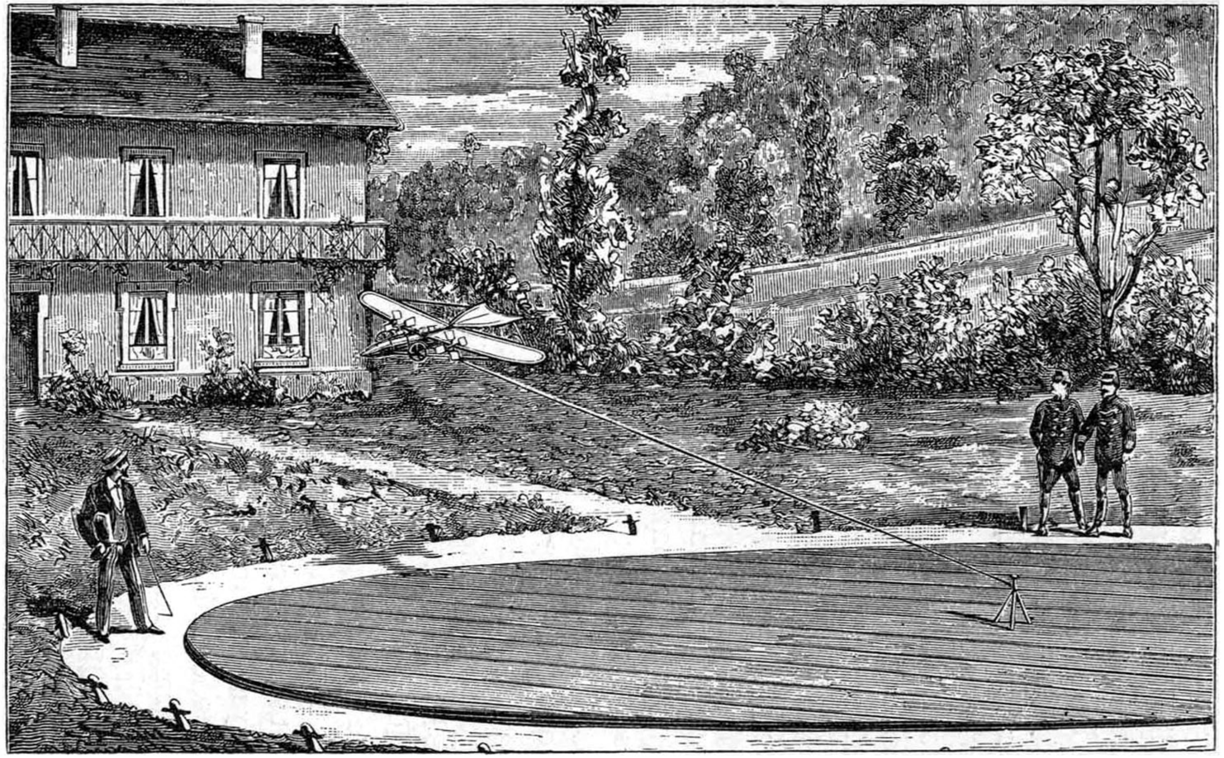
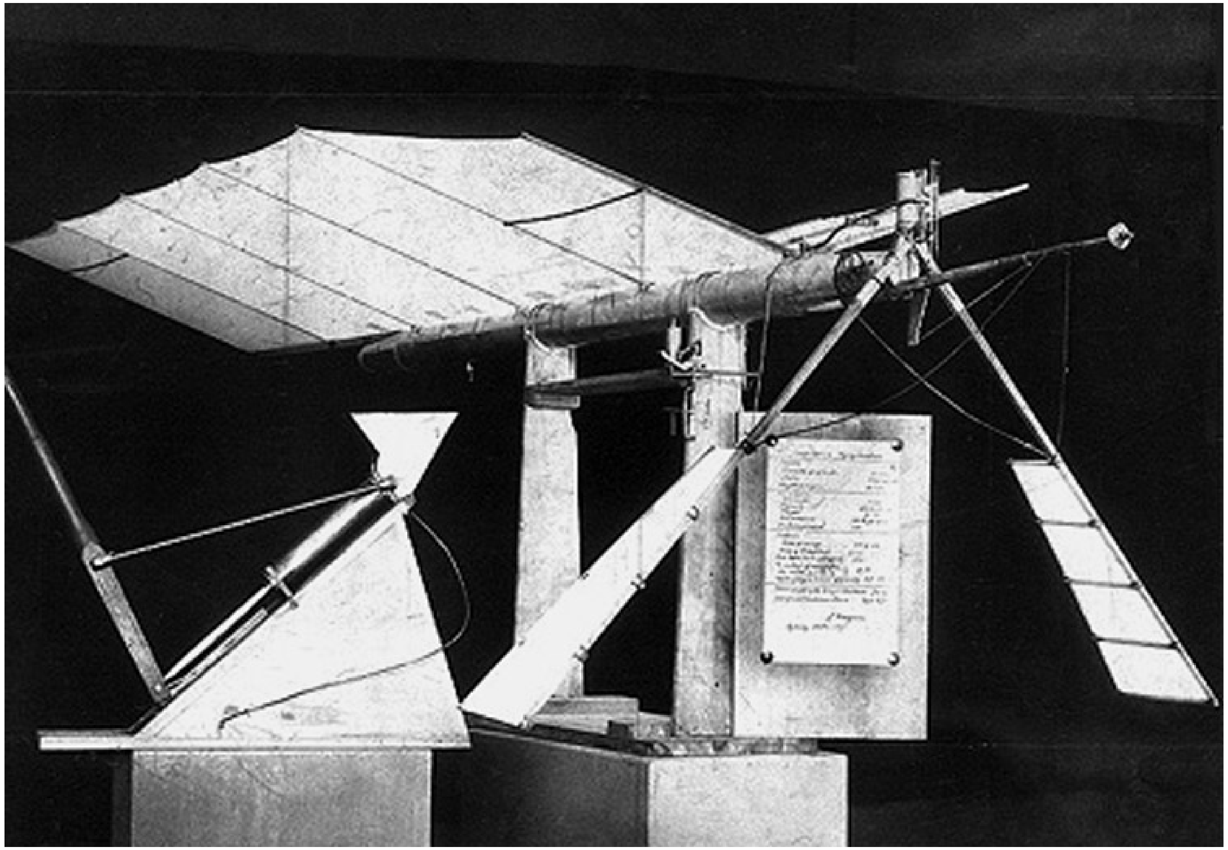
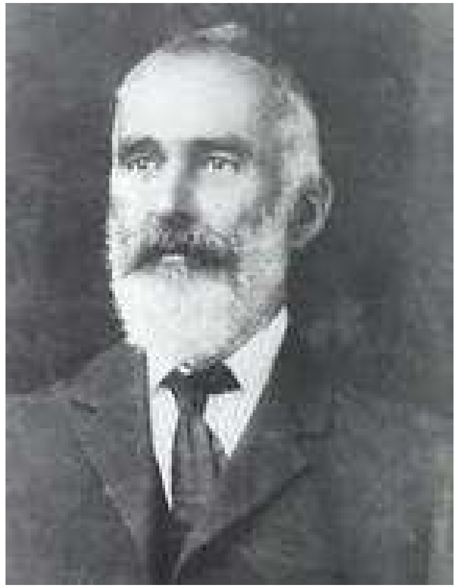


Fig. 48. — Disposition d'une expérience de l'aéroplane à air comprimé.

Pionniers de l'aviation

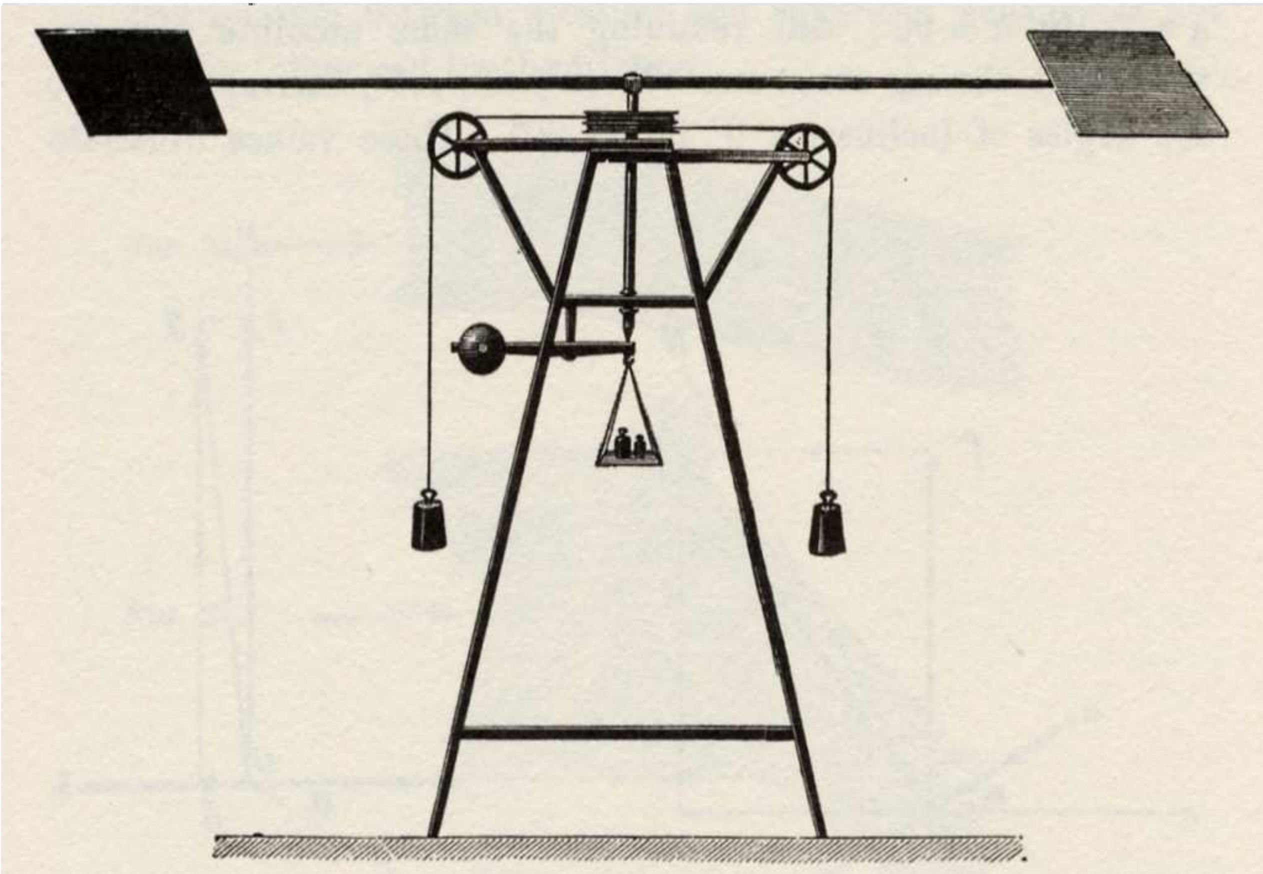
- Lawrence Hargrave (1850 – 1915)





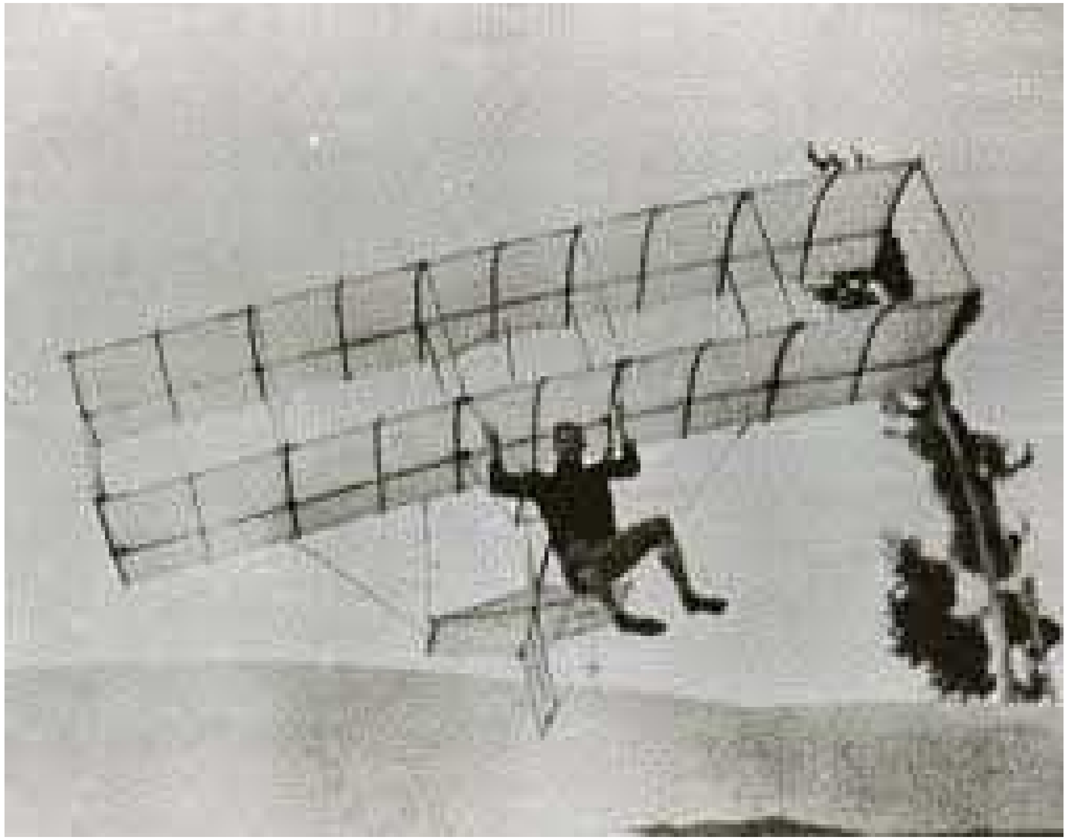
Pionniers de l’aviation

- Otto Lilienthal (1848 – 1896)



Pionniers de l'aviation

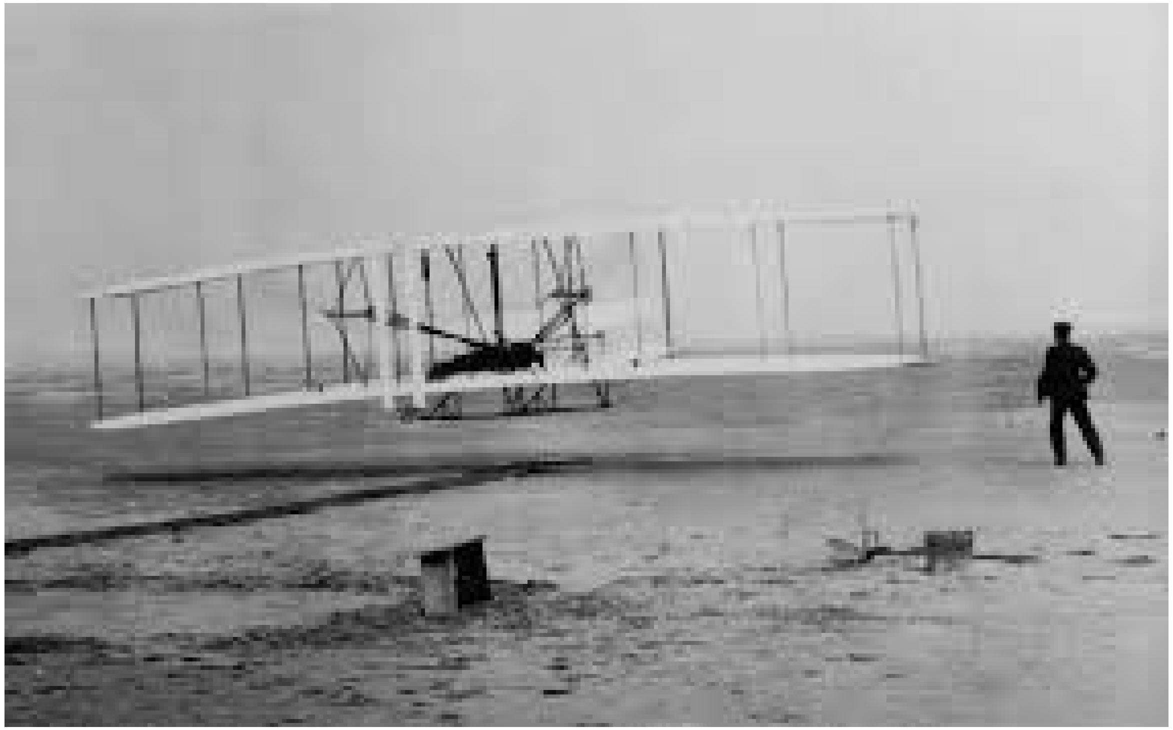
- Octave Chanute (1932 – 1910)



Pionniers de l’aviation

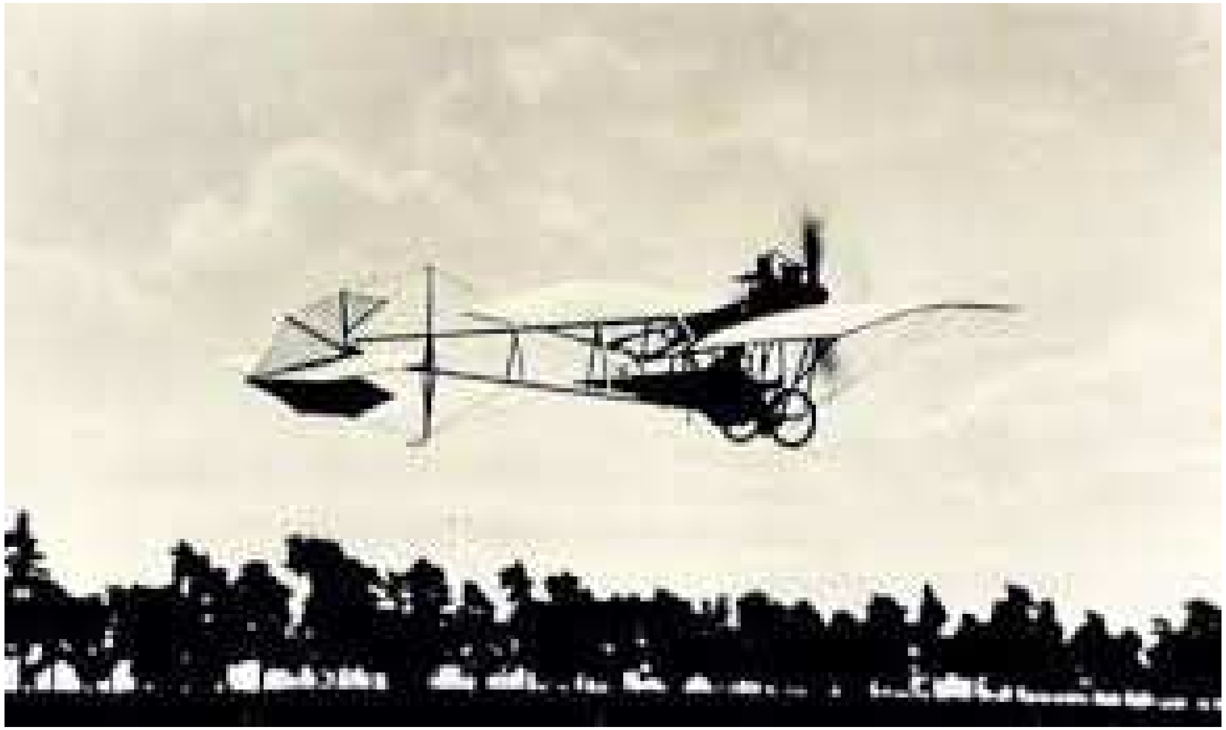
- Wright brothers

(1871 – 1948 , 1867-1912)



Pionniers de l'aviation

- Santos Dumont (1873 – 1832)



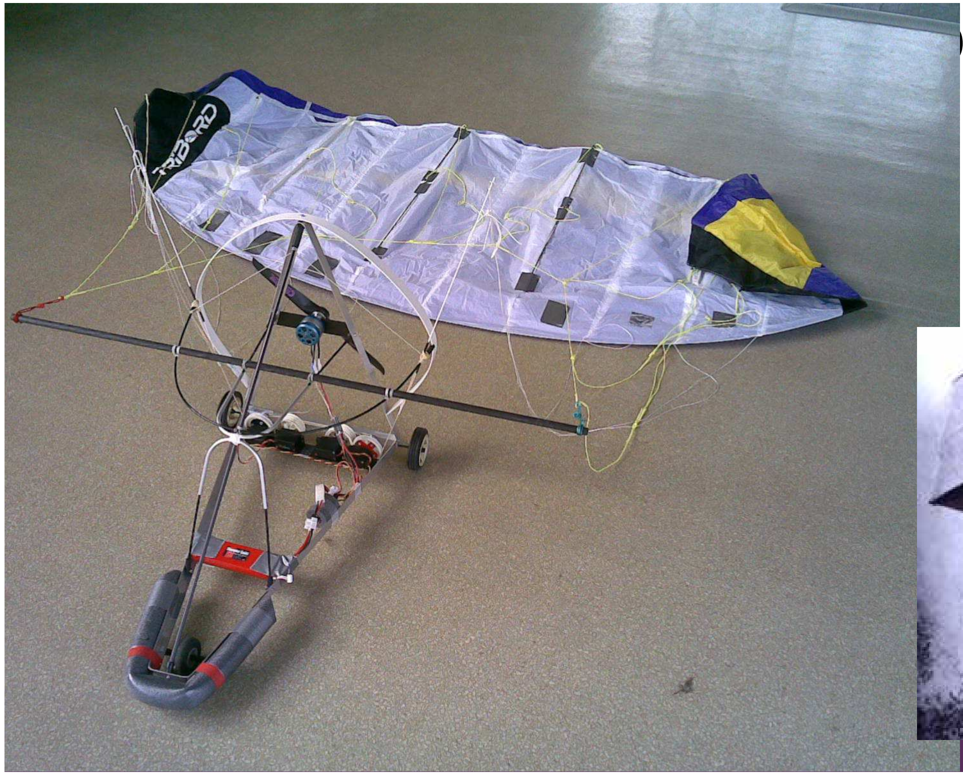
Pionniers de l'aviation

- Louis Blériot (1872 -1936)

36 Erreurs souvent commises

Conception

- Objectif: prevue de concept / prototype final ?
- Ajout de travail non nécéssaire (structure, qualités aero, capteurs)



Conception

- Crash proof - easy fix – pièces fusibles (video)
- Développer ce qui existe déja: elec, études, ailes, pièces
- Plus léger plutôt que plus puissant
- Durée de vie d’un proto.

- Optimisation et suite du projet:

Qui va vouloir quoi et à quel prix ?

Construction

- Construire sans faire de plans
- Balance électronique
- Lunettes sécurité
- 4 Scotchs: utilisation et excés
- Mauvaises soudures, câbles maltraités
- Câbles kevlar
- Coller l'incollable: kevlar, aluminium, servos

Matériaux

- Alu vs carbone
- Super glue et polystyrene
- Rigidité continue / superflue
- Vapeurs toxiques
- Solidité

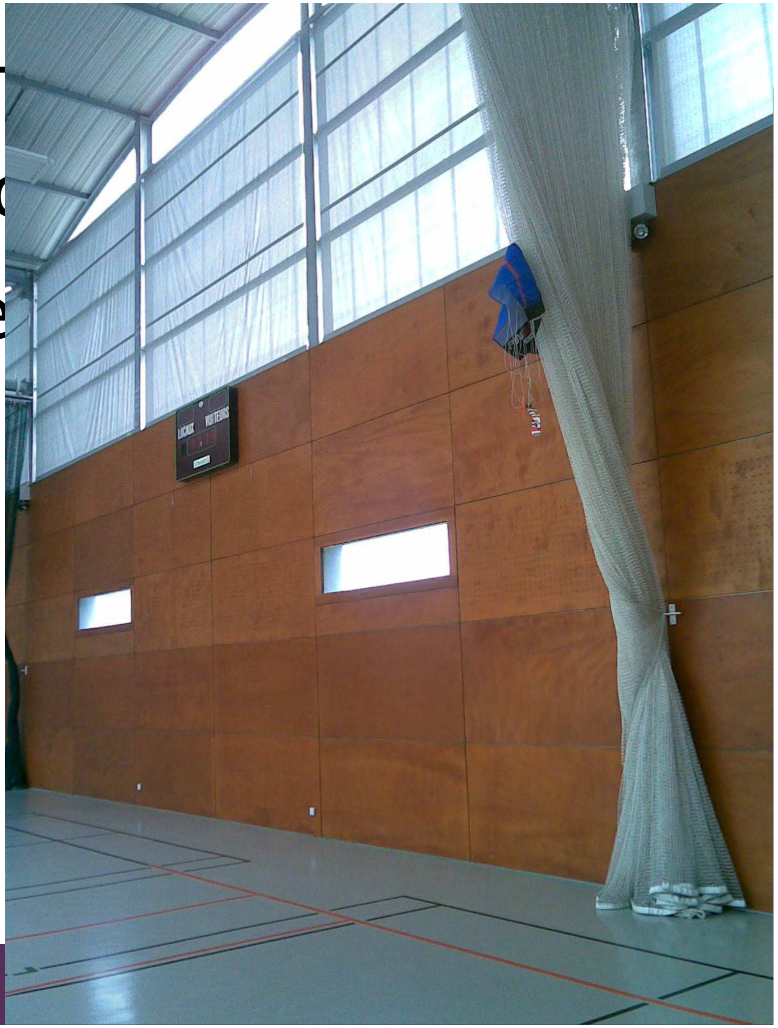
Organisation

- Check list / liste de materiel / carnet de vol
- 1 seul chef / organisation détaillée / responsable tache
- Plan B, version -1
- Occasion de faire un vol
- Reserve de consommables
- Carnet de charge batteries

<u>Ne pas dépenser l'énergie inutilement</u>

Tests

- Check list / plan de vol / liste de matériel
- 1 seul chef (irréprochable) +
- Sécurité: lunettes, helices , c
- Désespération / émotion de
  euphorie
- Les must have: Scotch, colli



Check list

Tests

- Type de vol, rester dans le domaine de vol
- Soleil, sens de vol, animaux, déconcentration du pilote, nuits blanches, pylones electriques, liste des modifs.
- Caméra embarquée: boite noire
- Caméra sur trépied, fix focus

- Les 10 premières secondes

Les faux…

- 1 vidéo de 3 min avec 5 sec de vol en boucle.
- Explications sans hypothèses de départ
- Analogies sorties de nulle part
- Optimisme et contrôle automatique
- Parlent des améliorations futures sans savoir comment faire fonctionner le prototype présent
- Test de l'explication bidon
- Conversations de comptoir

Différents types de portances

- Classique
- Tourbillonaire
- Effets de sol
- Magnus
- Aspiration de couche limite

Mécanique du vol

- Formules de base
- Poids optimal de batteries
- Profil de l'aile
- Stabilité longitudinale

Compenser le poids

Différents types d'aéronefs

Aérodynamique appliquée

Techniques de construction

Previous work

Why to work on kite energy?

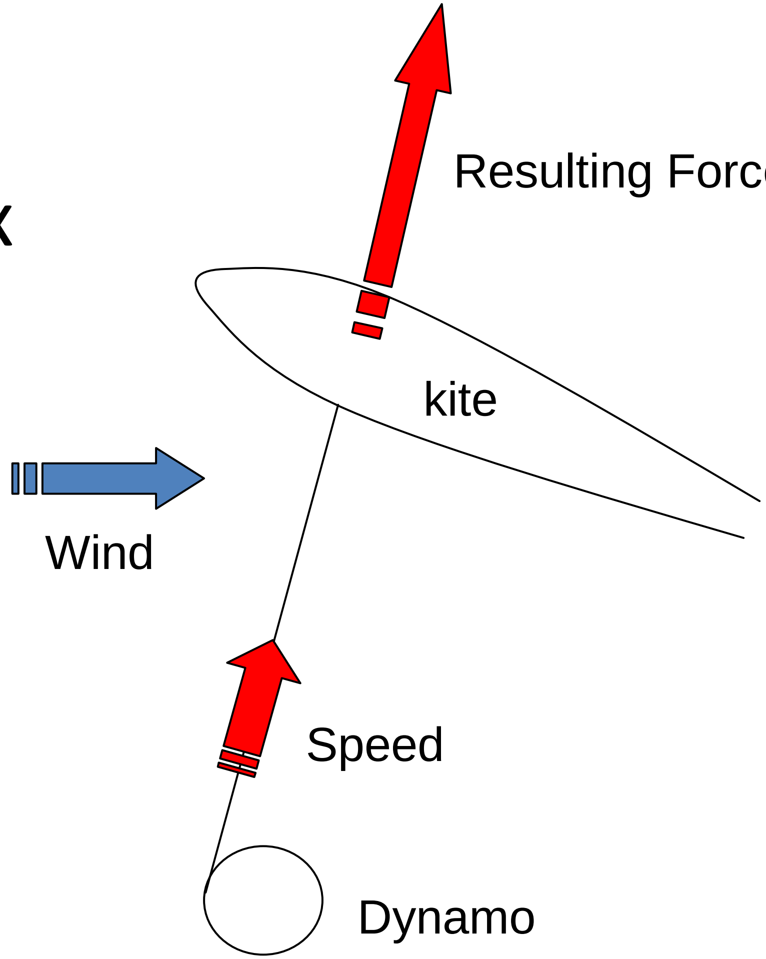
- Increasing needs of energy
- Kite power VS wind turbines
- New kind of UAV
- Working for environement and for peace
- 300 000 W

How to produce energy with a kite?

- Generation phase:

- Rope length : rmin→rmax

- High AOA



How to produce energy with a kite?

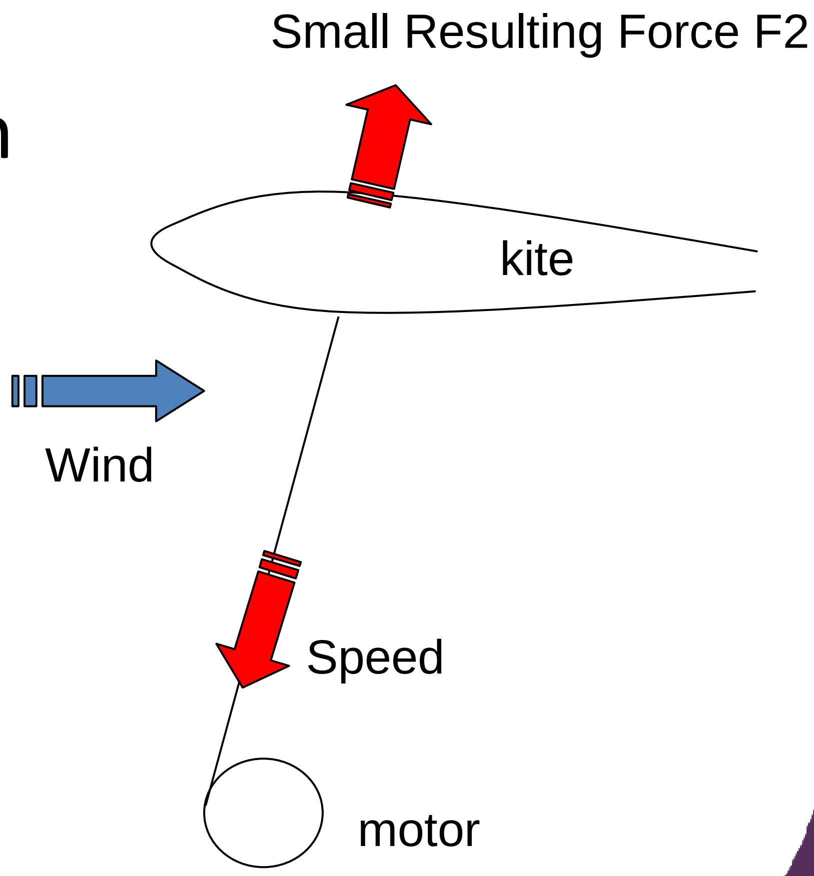
- Recovery phase:

- Rope length : rmax→rmin

- Very small AOA

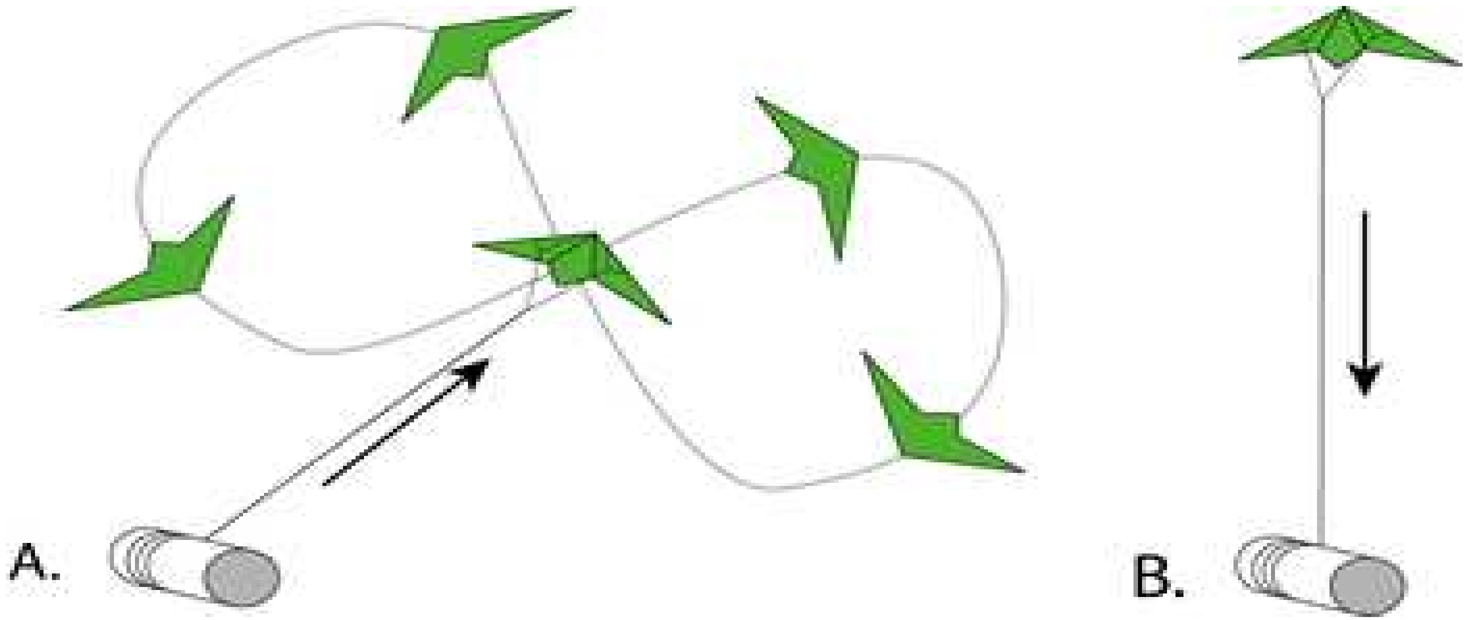
- If F1>F2:

Generated energy > 0



How to produce energy with a kite?

- Two different kind of flights:



A. Crosswind pumping B. Yo-yo pumping

State of art

- On ground energy transformation

State of art

- Onboard transformation « flying wind turbines »

Flight pioneers

- Video_Clips_Of_Early_Flight_Attempts.wmv

Cyclogyro_.wmv

Questions

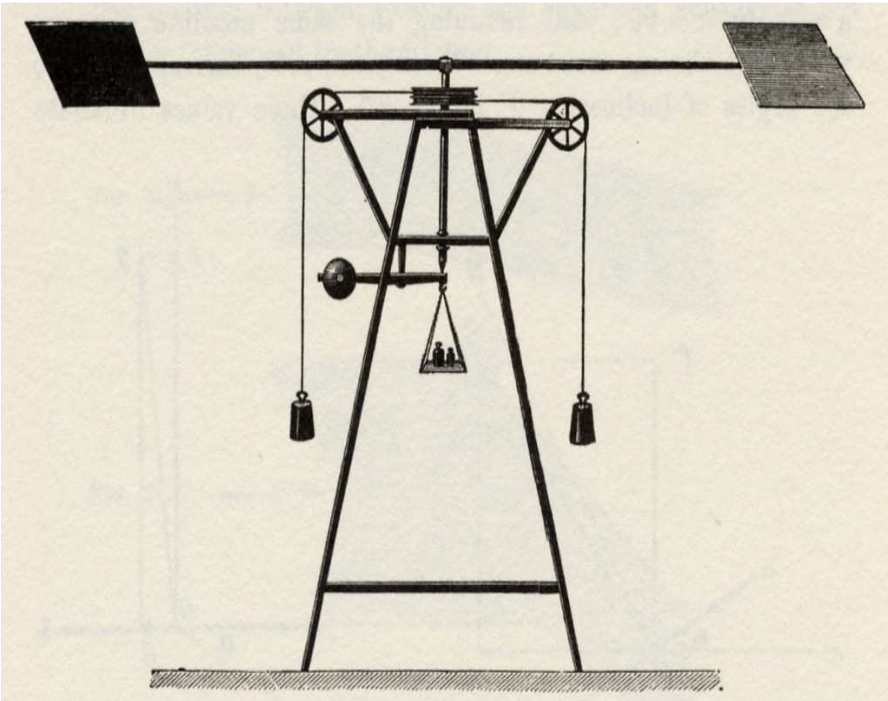
What makes the difference?

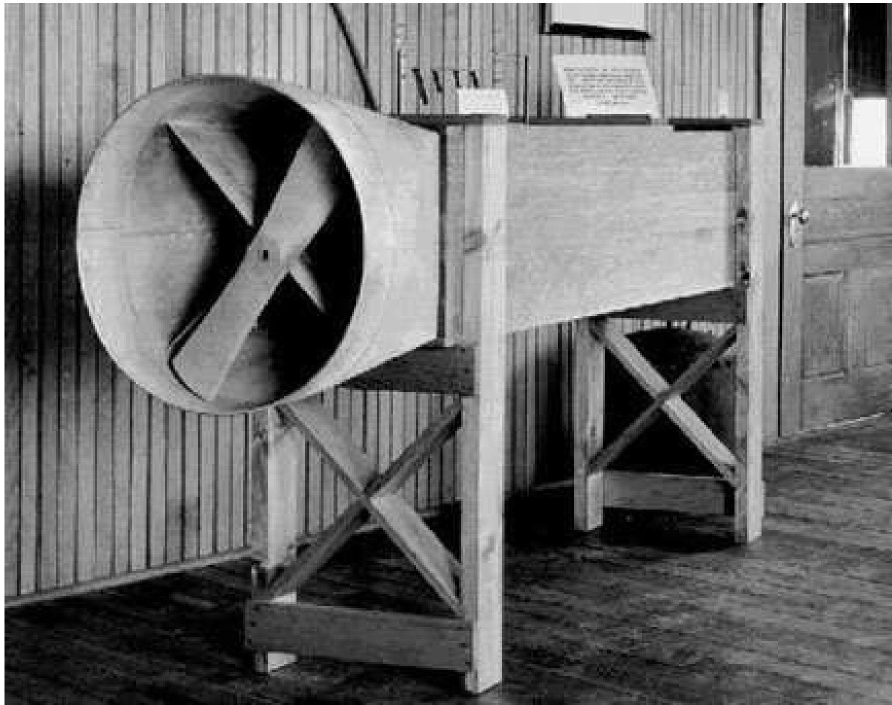
Why did it took so long to make these machines fly?

What is the best way to build a prototype?

➔ Study of pioneers

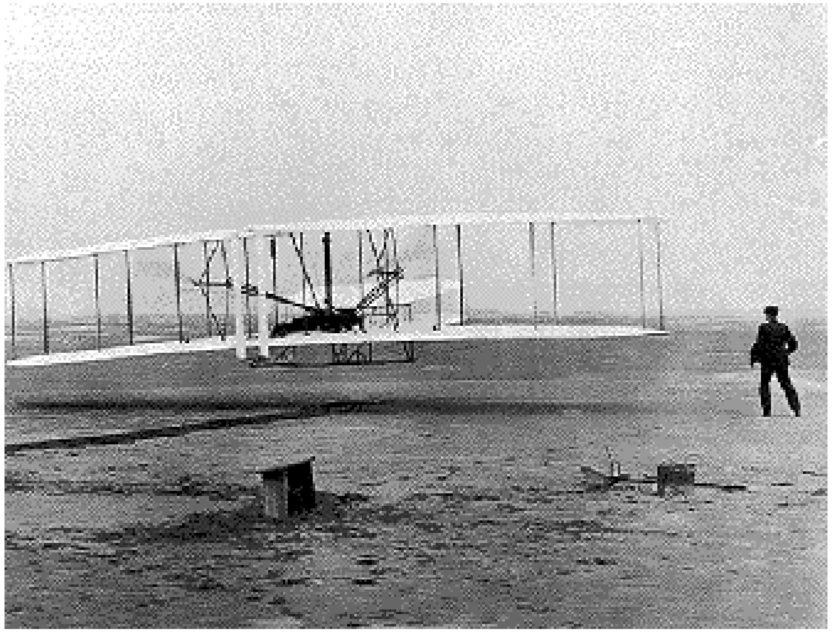
First glider and first aeroplane





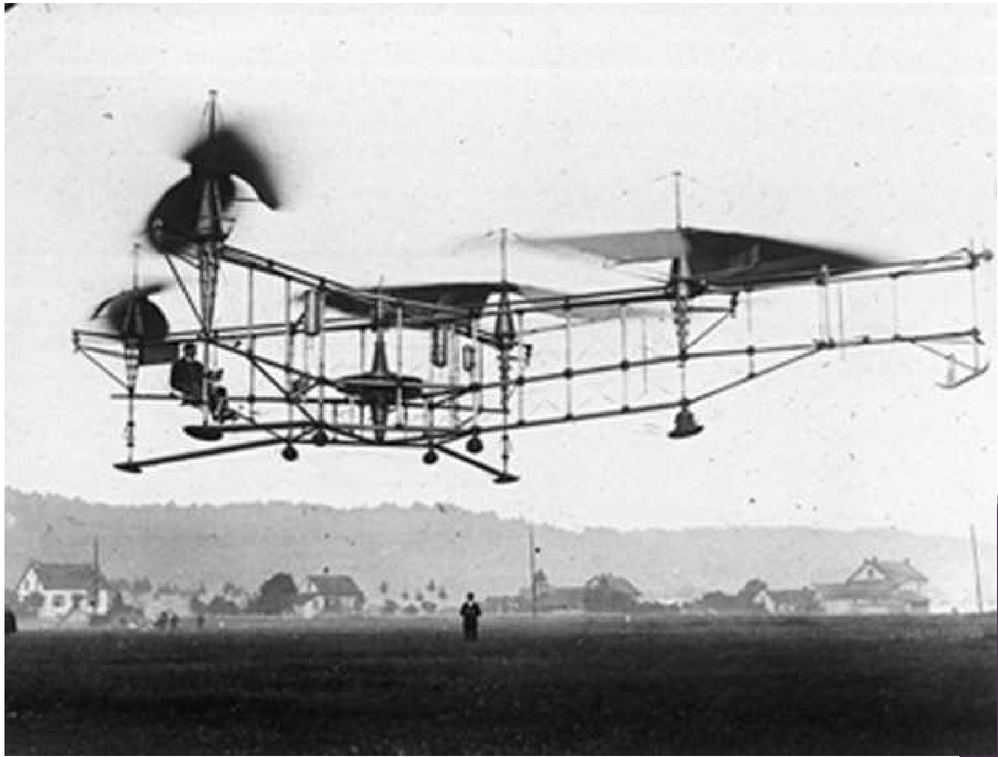
Study aerodynamics in a restricted domain

First glider and aeroplane



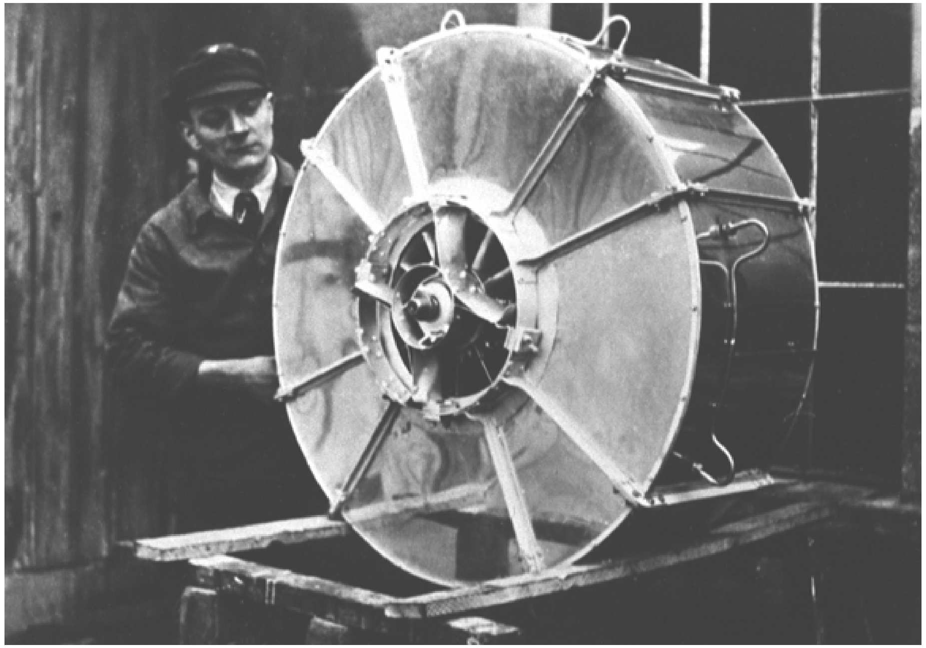
- Fly only in this in the «possible flight» domain

First helicopter

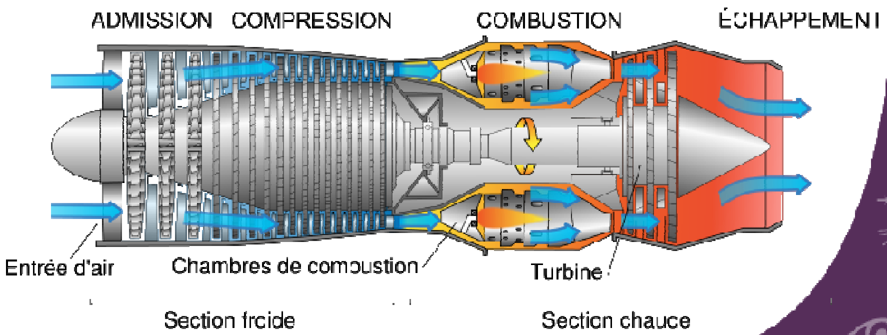


- Start by solving one problem at the time.

First turbojet



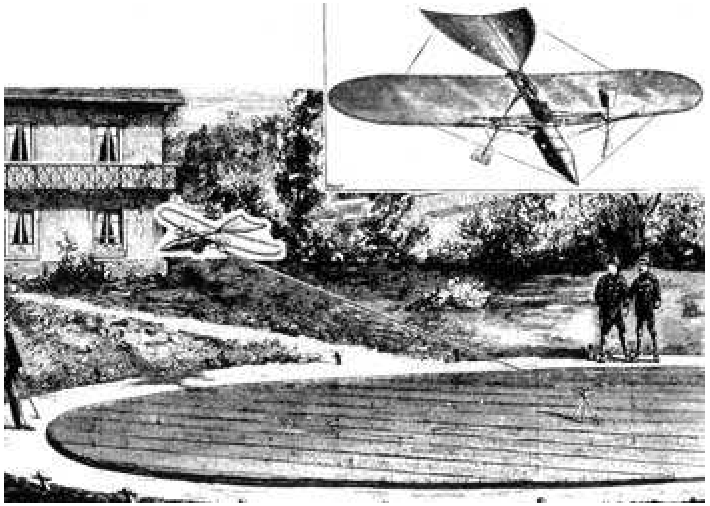
- Simplify the system



First human powered airplane

- Use the « crash proof concept » as much as you can.

First ekranoplane



- Simplify the movements by blocking axes.

Top 6 « how to make it fly » rules:

- Study aerodynamics in a restricted domain
- Fly only in this in the «possible flight» domain
- Start by solving one problem at the time.
- Simplify the system
- Use the « crash proof concept » as much as you can.
- Simplify the movements by blocking axes.

Exam

- Question: Is it possible to Jump from high altitudes, fly like a bird and land safely ?

(with no parachute…)

oiseau.wmv

Is it possible ?

What were the problems?

- Study aerodynamics in a restricted domain
- Fly only in this in the «possible flight» domain
- Start by solving one problem at the time.
- Simplify the system
- Use the « crash proof concept » as much as you can.
- Simplify the movements by blocking axes.

Answer:

- yes!

gary connery.wmv

Our approach of the problem

- Study of yo-yo trajectories

(Simplify the movements by blocking axes)

(one problem at the time)

- Simulations

(Study aerodynamics in a restricted domain)

- Wind tunnel validation

(Fly only in this in the «possible flight» domain)

- Simple aerodynamical configuration

(Simplify the system)

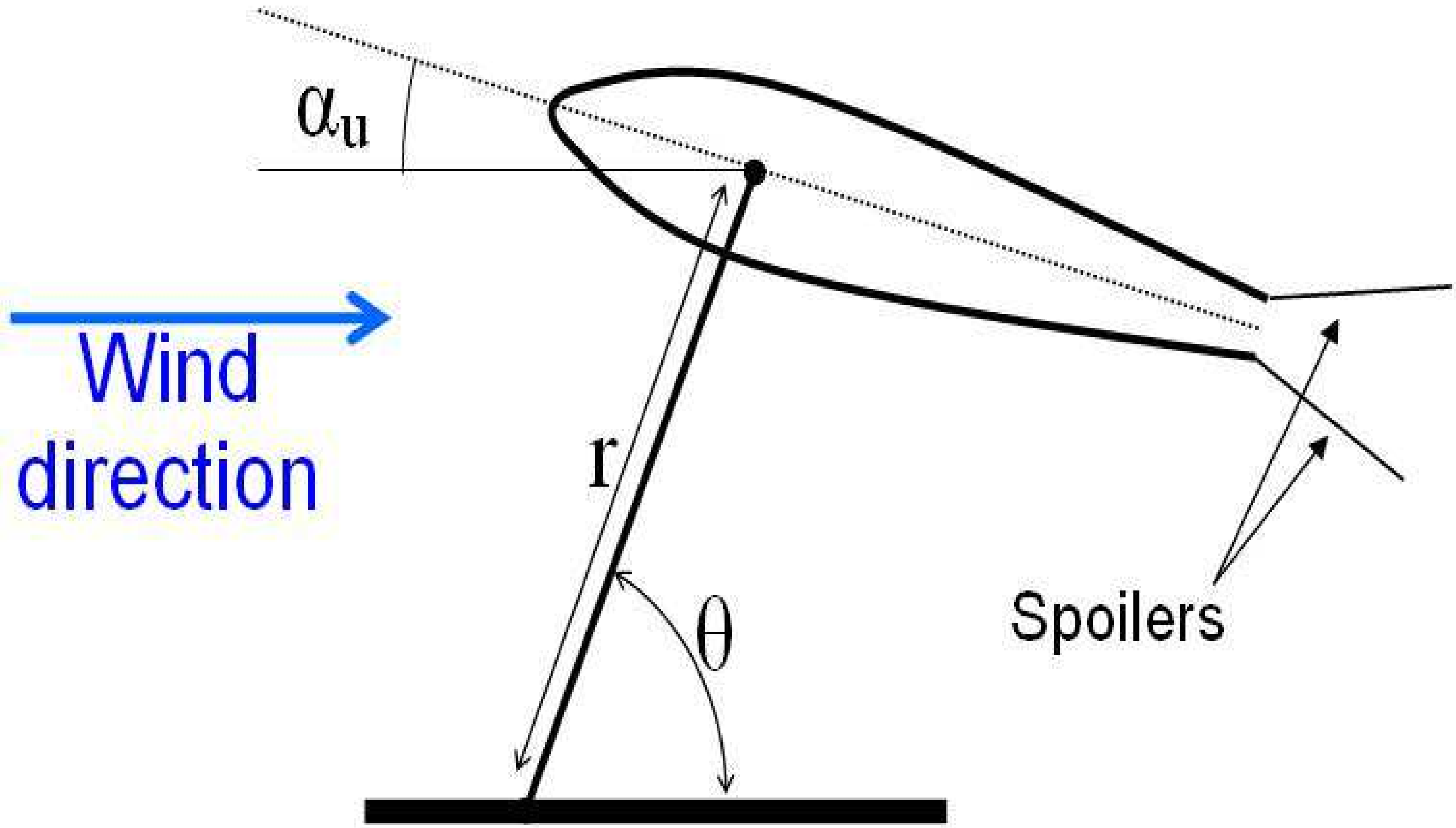
Our Goals:

- Improve safety
- Control of the system
- Optimisation of flight plan

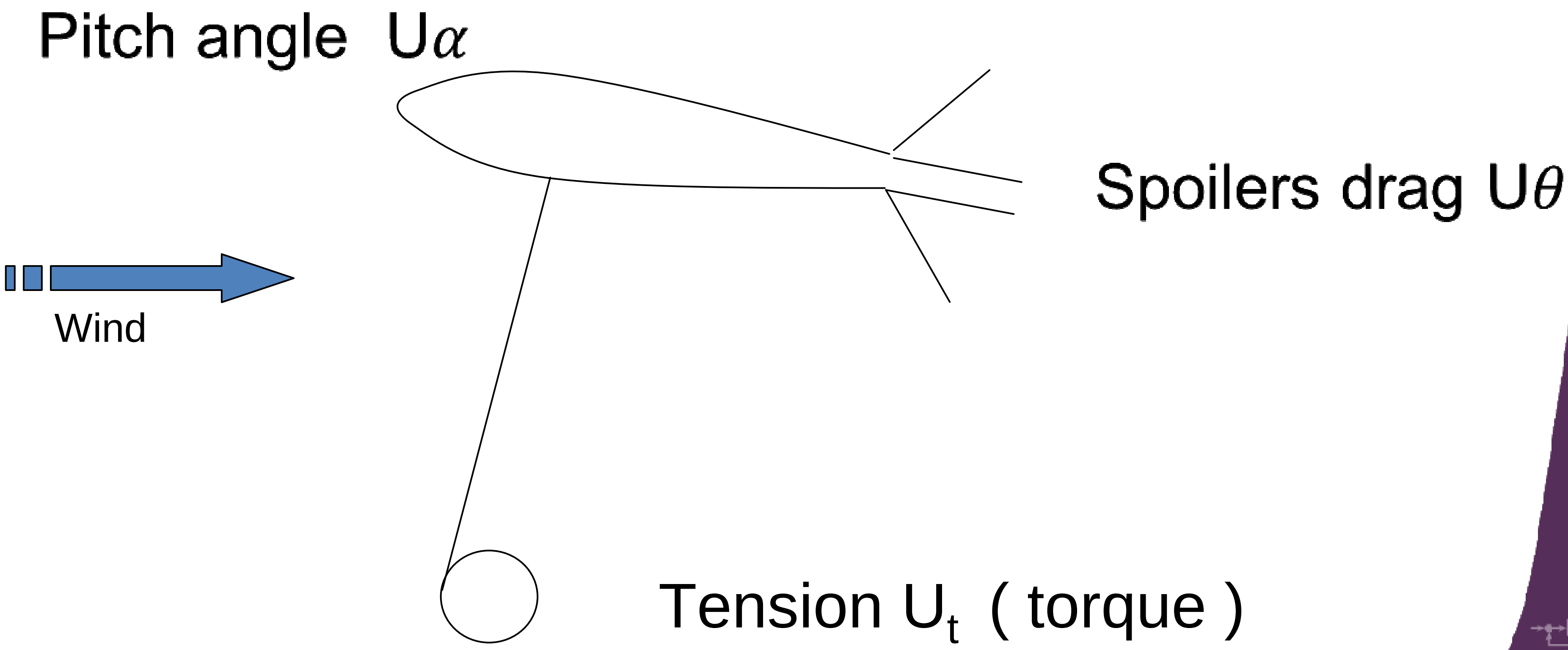
ONCE IT WORKS:

build a more complex kite system

The kite system

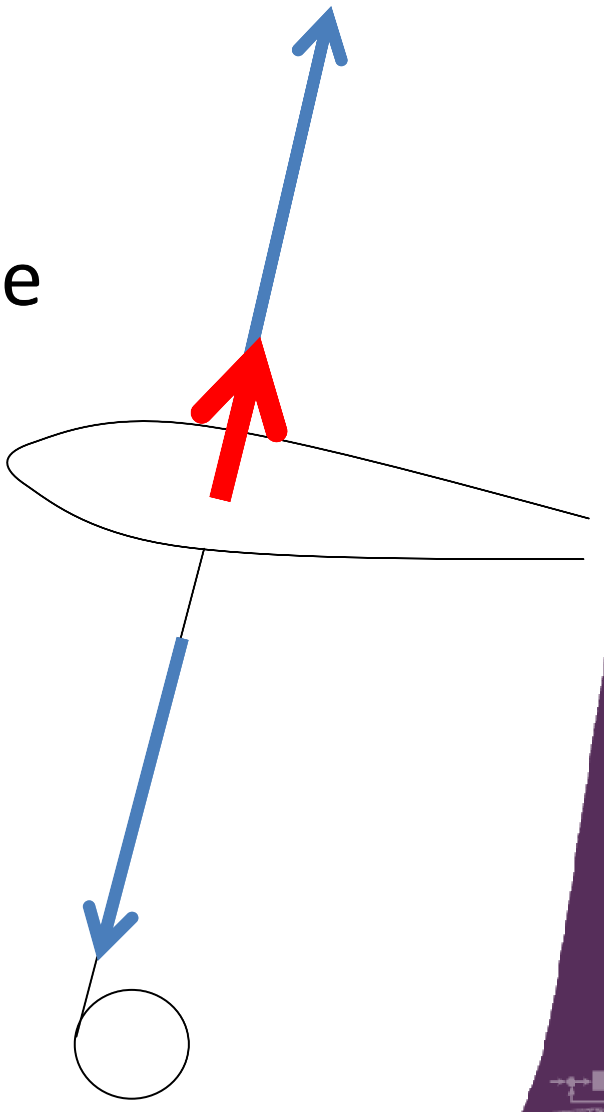


Model inputs



Forces

- Lift Drag Weight : resulting force
- Tension



Forces

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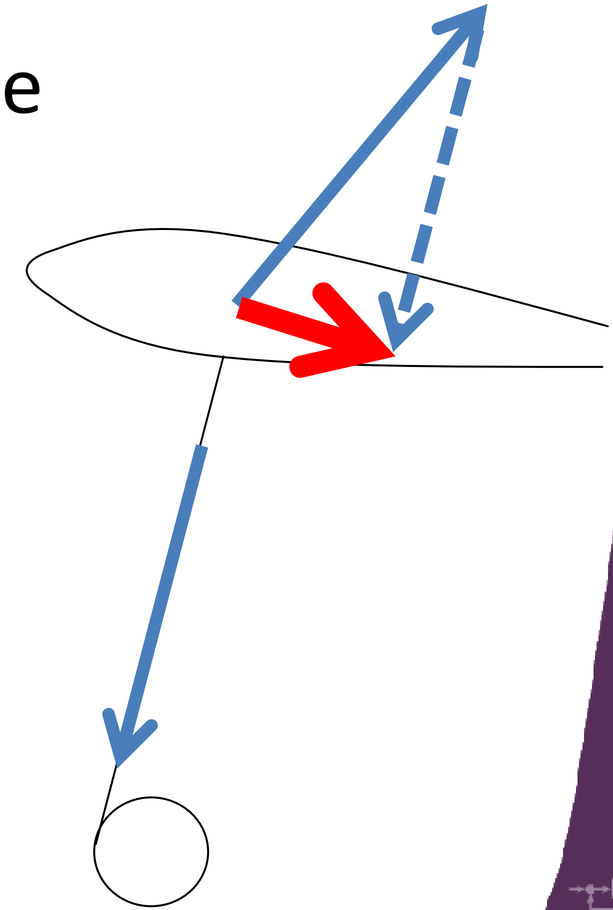


Assumptions

- No cable drag or perturbations
- 2D movement
- Accurate control of angle of attack
- Symetric airfoil NACA 0018
- Spoiler’s drag and Lift are independent
- Wind speed: 8m/s

Mathematical model

- Model

$$\ddot{r} = r\dot{\theta}^2 + \frac{1}{M}[F_r - T] \quad (1)$$

$$\ddot{\theta} = \frac{1}{r}[-\frac{1}{M}F_t - 2\dot{r}\dot{\theta}] \quad (2)$$

- Tangential and radial forces

$$F_r = L\sin(\theta - \alpha_w) + D\cos(\theta - \alpha_w) - w\sin\theta \quad (3)$$

$$F_t = L\cos(\theta - \alpha_w) - D\sin(\theta - \alpha_w) - w\cos\theta \quad (4)$$

Aerodynamic forces

- Lift and drag

$$L = \frac{1}{2}\rho S v_r^2 C_L \qquad (5)$$

$$D = \frac{1}{2}\rho S v_r^2 C_D \qquad (6)$$

$$C_L = \frac{\partial C_L}{\partial \alpha}(\alpha_w + \alpha_u) + C_{L0} \qquad (7)$$

$$C_D = \frac{C_L^2}{\pi e \lambda} + C_{D0} + \beta_\theta u_\theta \qquad (8)$$

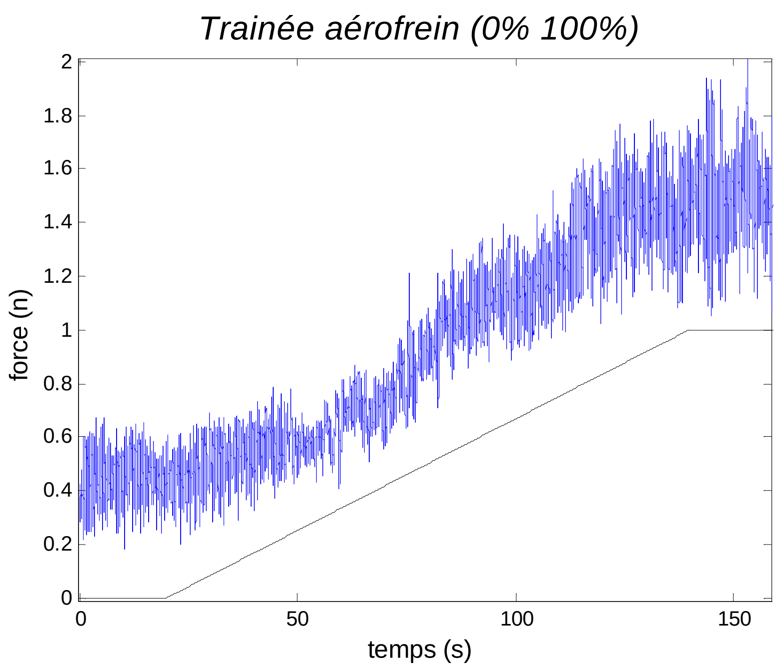
Relative wind

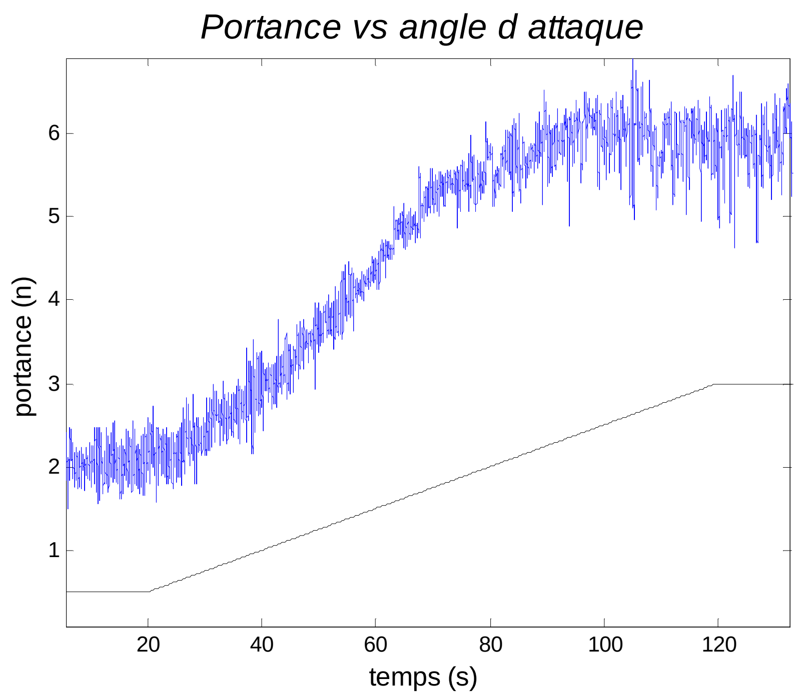
- Relative windspeed and wind angle

$$\alpha_w = \arctan \frac{r\cos(\theta)\dot{\theta} + \dot{r}\sin(\theta)}{V + r\sin(\theta)\dot{\theta} - \dot{r}\cos(\theta)} \tag{11}$$

$$v_r = \sqrt{(r\cos(\theta)\dot{\theta} + \dot{r}\sin(\theta))^2 + (V + r\sin(\theta)\dot{\theta} - \dot{r}\cos(\theta))^2} \tag{12}$$

Wind tunnel testing

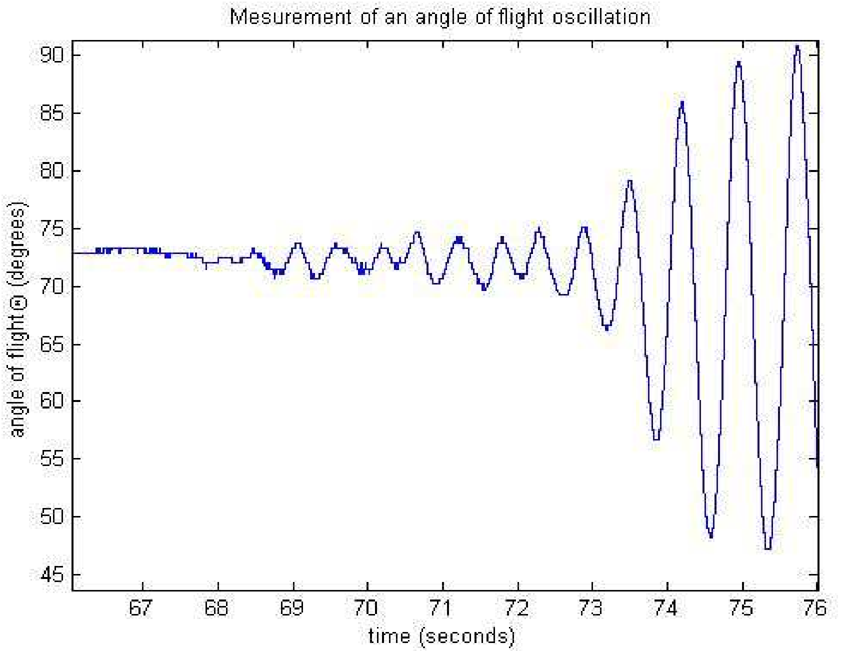


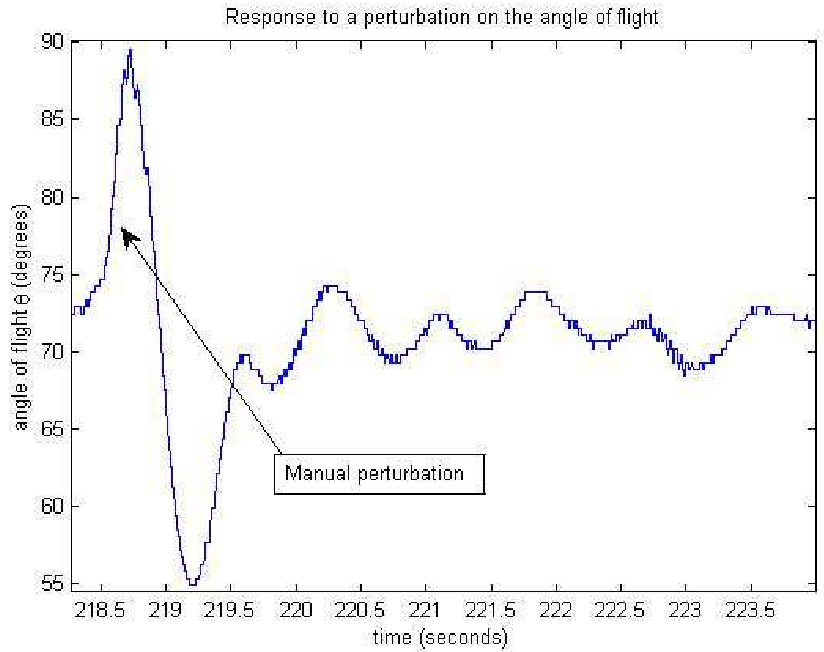


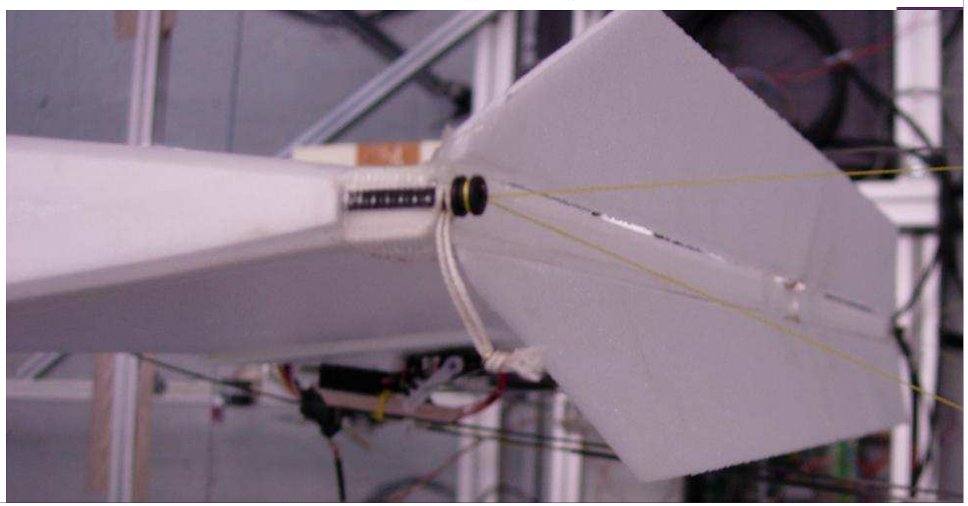
« Study aerodynamics in a restricted domain »

Angle of flight control

- Feedback linearisation
- Observer based control
- [perturbation lacet1_co]
- Strong wind gusts





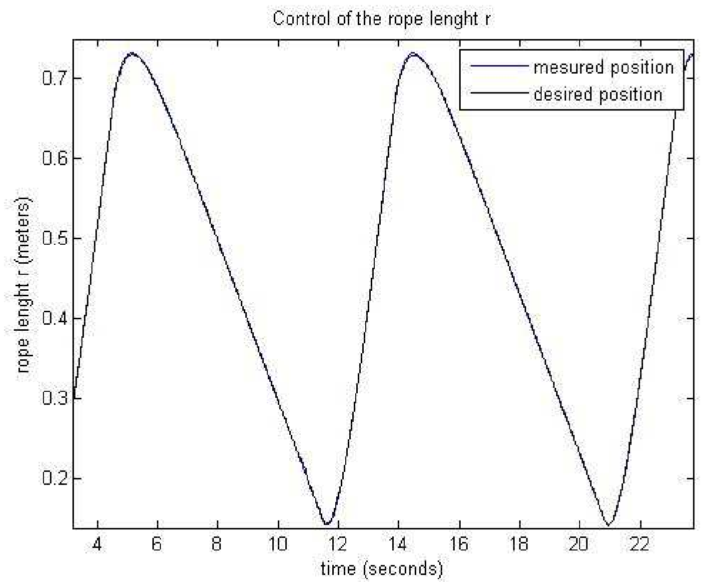


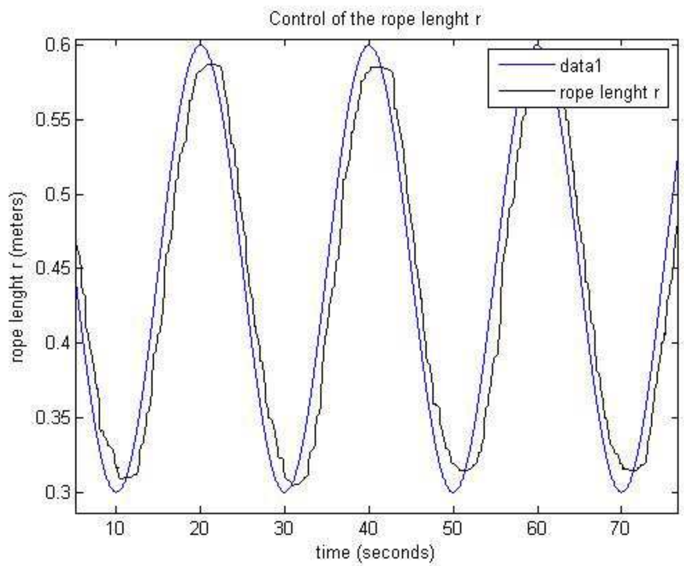
Rope lenght control

Two different strategies:

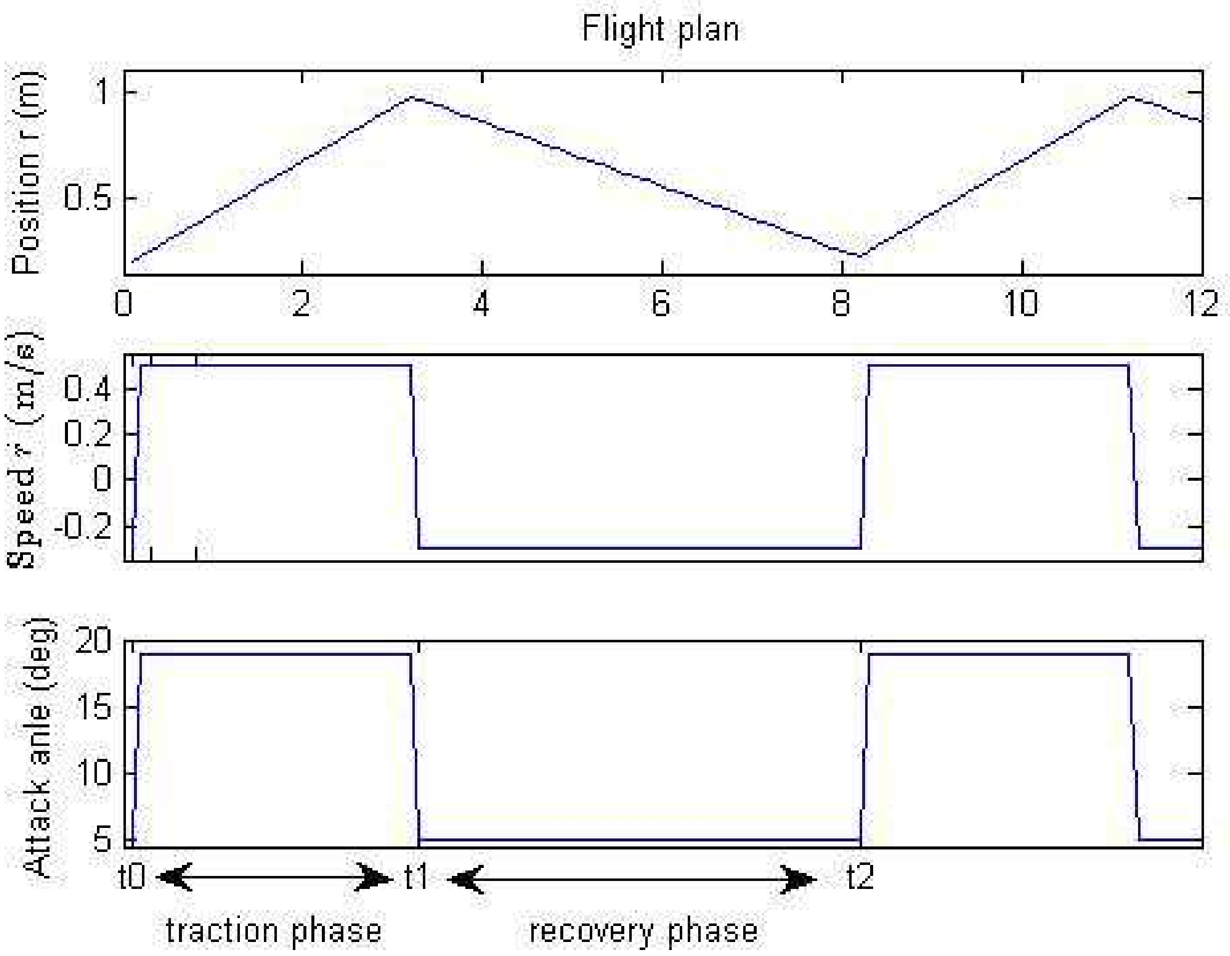
•AOA as control input and « Fixed » tension

•Tension as control input and « Fixed » AOA





The Flight Plan

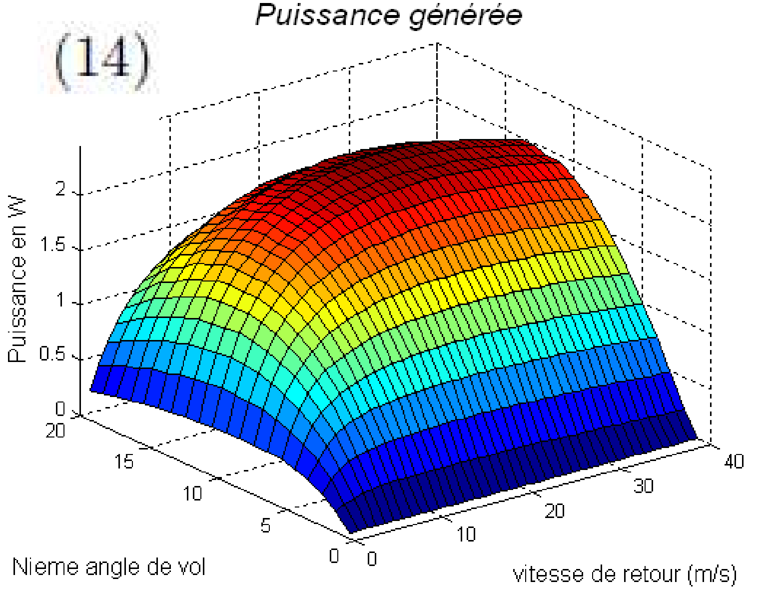


- Produced Energy

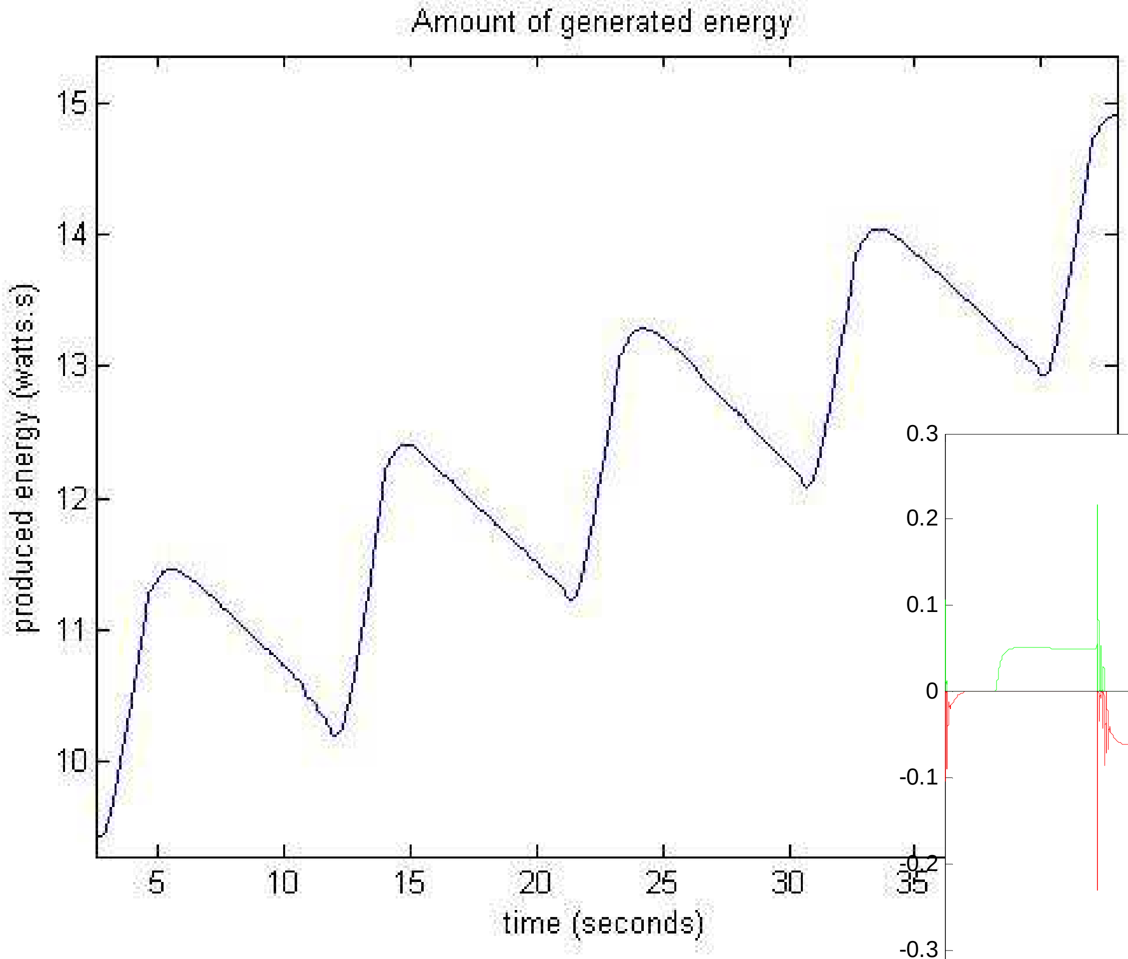
$$E(t_0, t_1, t_2) = \int_{t_0}^{t_1} F_{r1}\dot{r}_1 dt + \int_{t_1}^{t_2} F_{r_2}\dot{r}_2 dt \qquad (13)$$

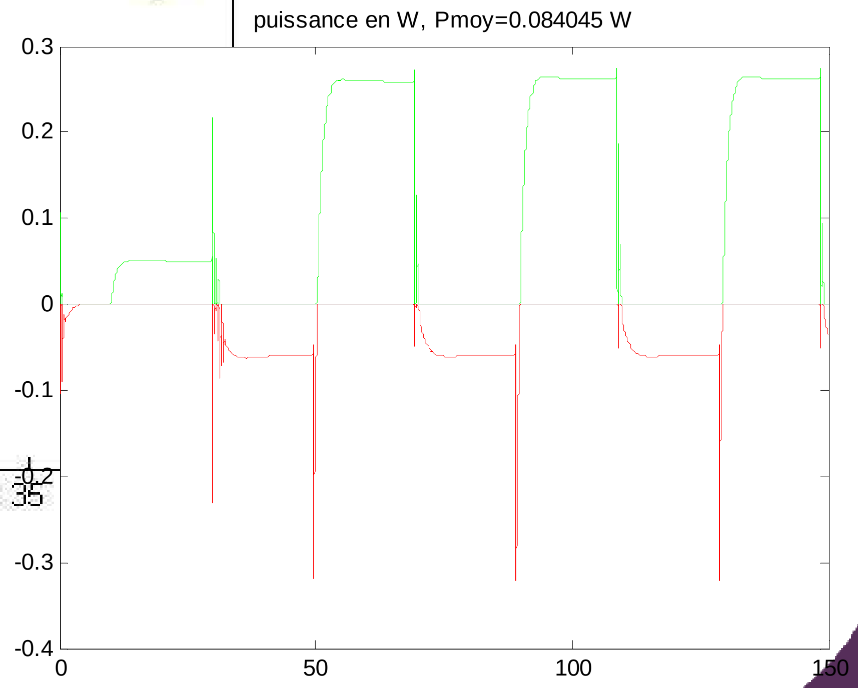
- Power

$$P(t_0, t_1, t_2) = \frac{E(t_0, t_1, t_2)}{t_2 - t_0} \qquad (14)$$



The produced energy





Experimental setup

The kite:

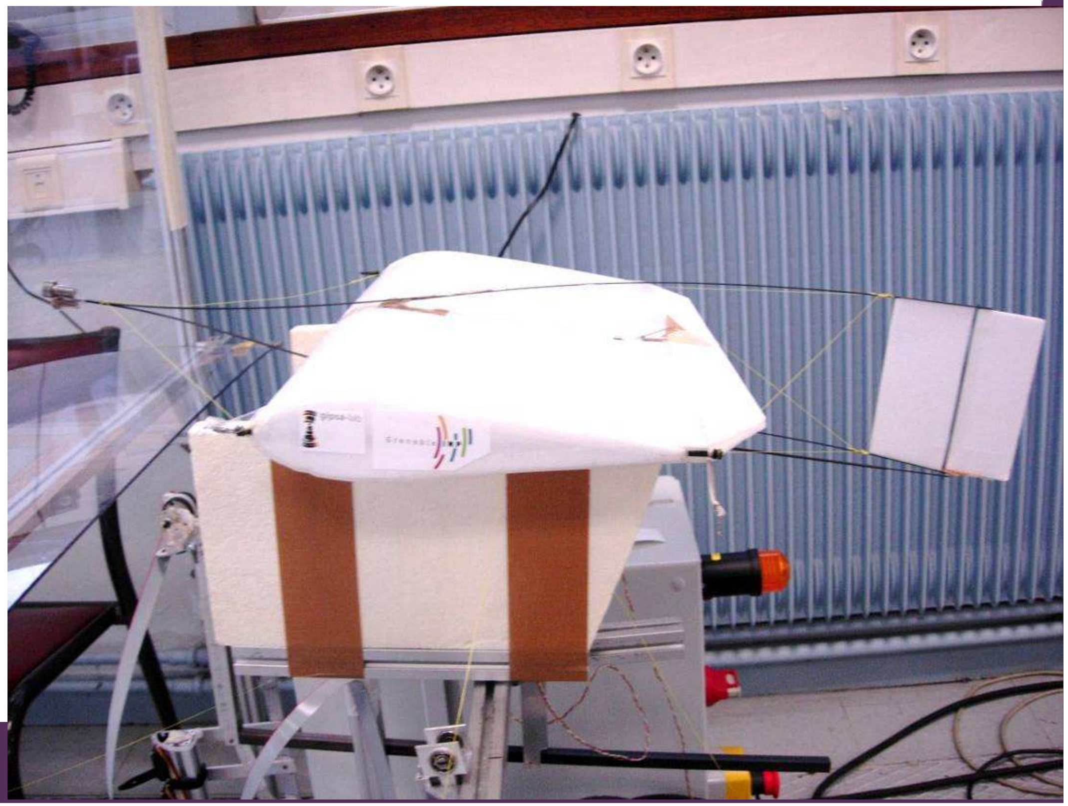
•Foam-carbon structure

•« crash proof concept »

•3 onboard servos

•« PID » yaw control

•100 g



Experimental setup

Results

Future work and conclusions

- Crosswind flights
- Outdoor models
- 3D flight model
- Aerodynamical model

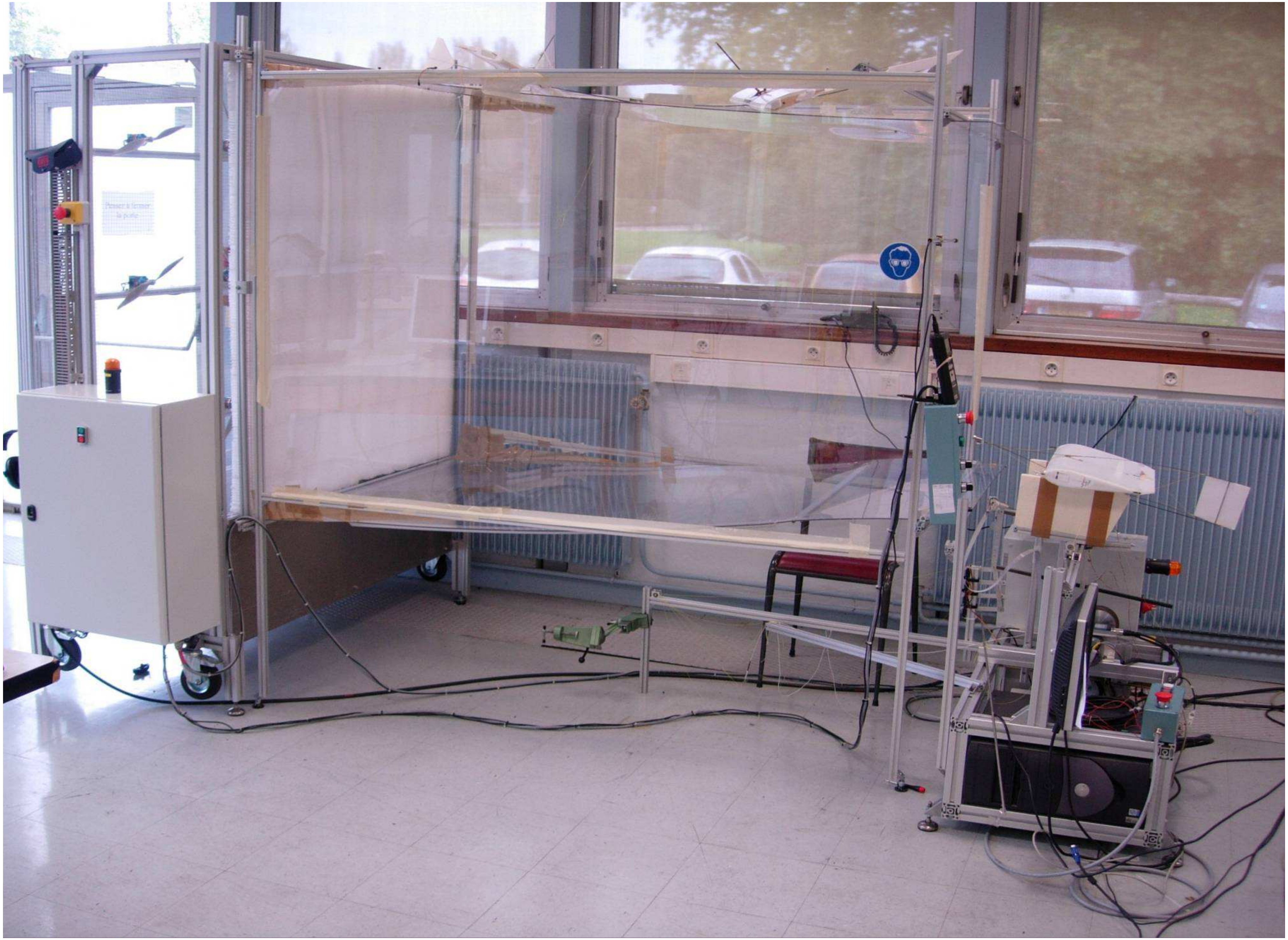
- Fly with no wind
- High performance wings

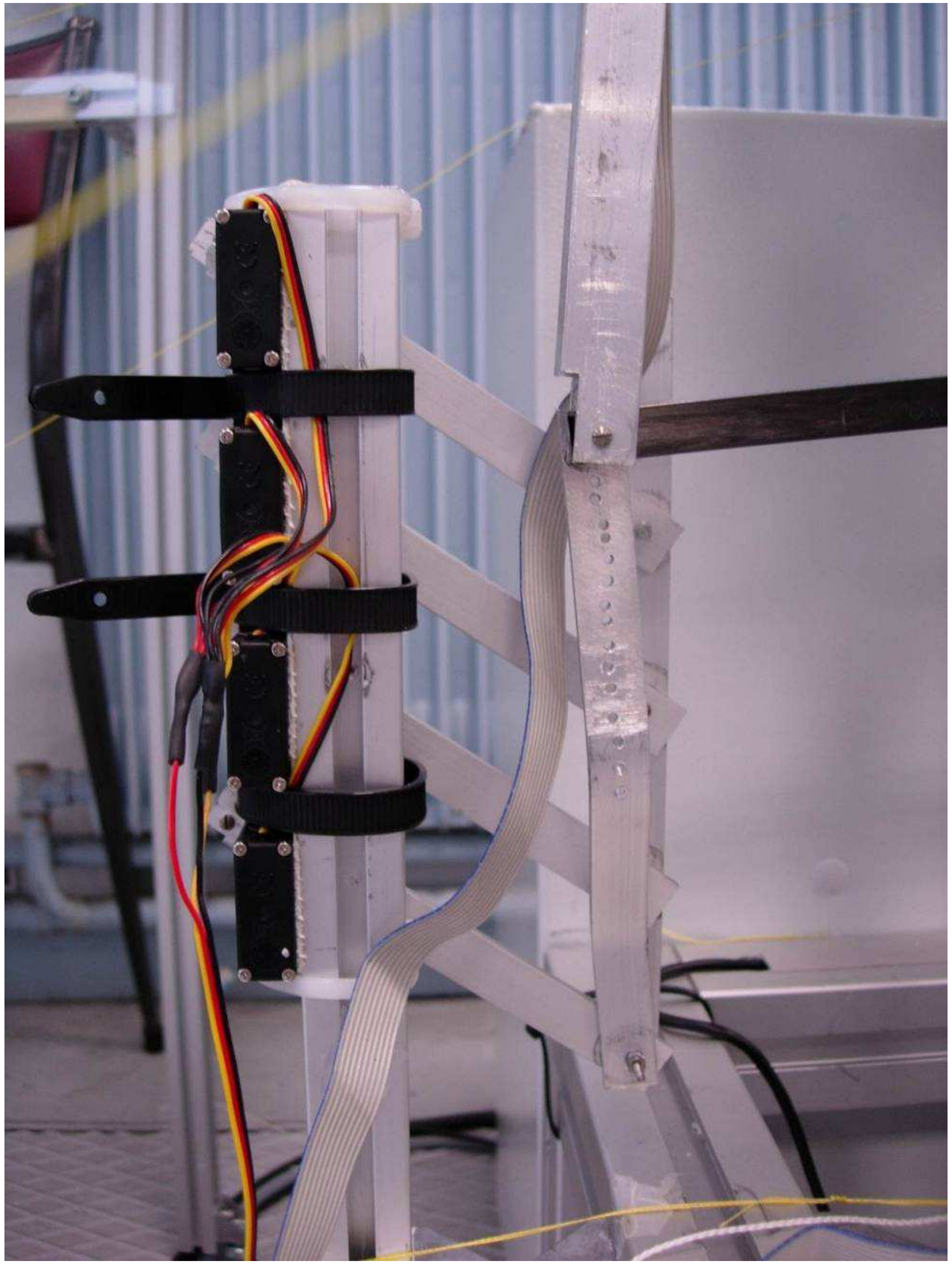
Questions?

Thank you !

Experimental setup

- The wind tunnel
- The control system
- The dynamo
- The actuators





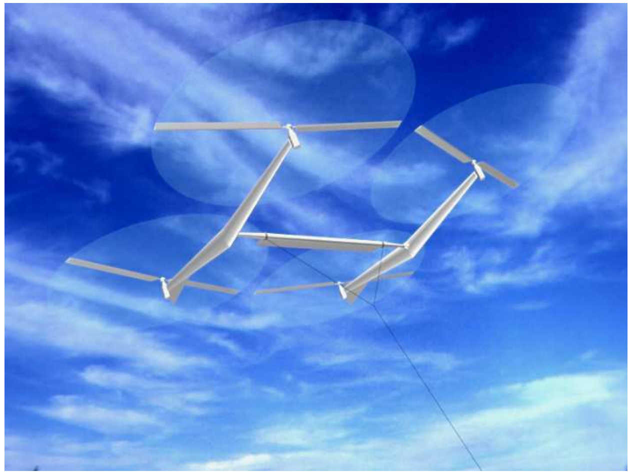
Comparaison des systèmes

- Yoyo- 8 kite

- 8 Plane

Comparaison des systèmes

- 4 rotor Wind turbine



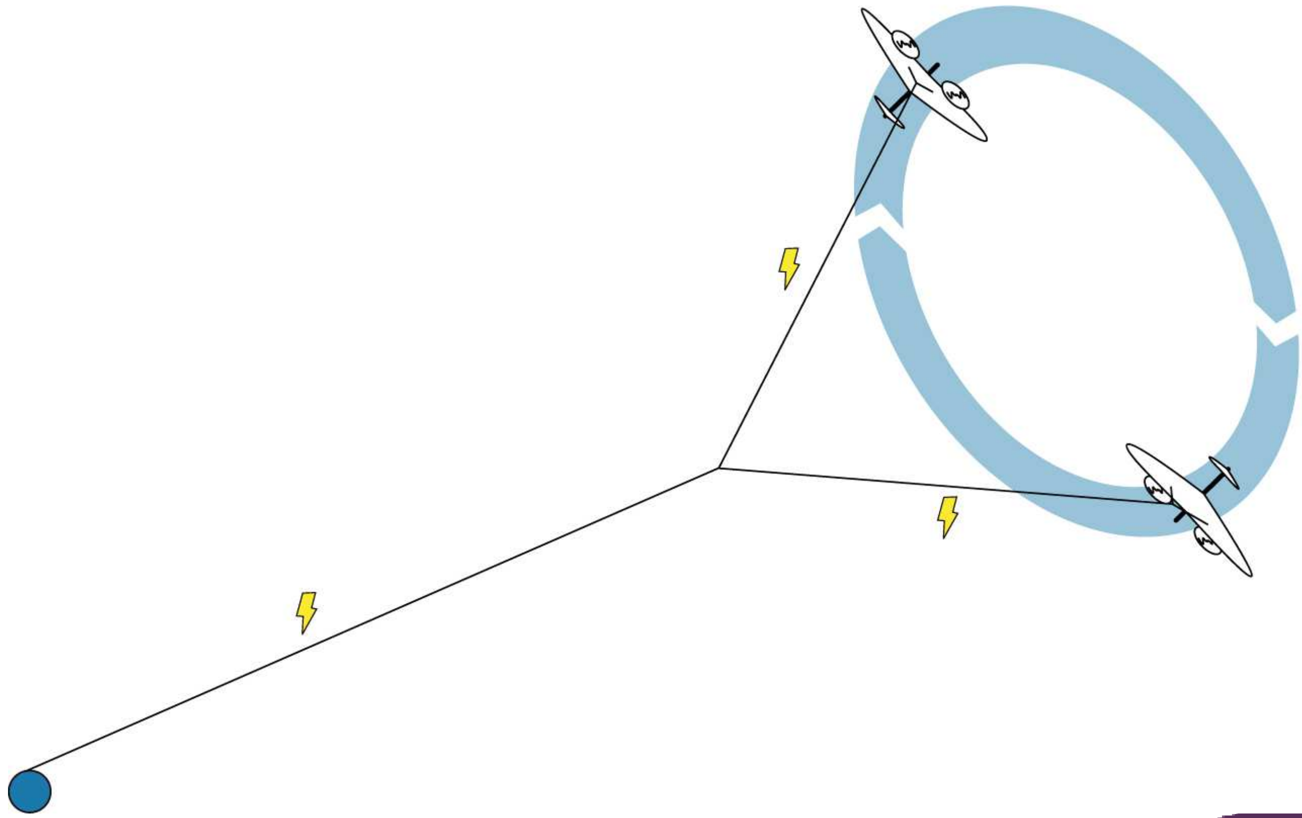
- Makani

Comparaison des systèmes

- Magnus kite

- Blimp wind turbine

- Multi kites system



Comparaison des systèmes

- sécurité

	Crash proof	Stabilité passive	flexibilité du système	Energie cinétique emmagasinée (Vitesse de vol²)
yoyo	4	0	3	3
8kite	4	0	3	3
8 plane	0	0	0	0
Magnus	5	4	5	5
Altaeros	5	5	5	5
Kite Wind energy	0	0	0	0
Makani	0	0	0	0
Multi kite system	4	0	3	1

Comparaison des systèmes

- énergie

	Energie par surface de l'aile	Energie/surface au sol	Systèmes empilables	Types de câbles	Pertes d'énergie
yoyo	1	5	5	S	5
8kite	3	2	0	S	5
8 plane	4	2	0	S	4 (poids)
Magnus	2	5	5	S	5
Altaeros	2	5	5	E	5
Kite Wind energy	5	5	5	E	4(poids)
Makani	4	2	0	E	4(poids)
Multi kite system	4	4	5	S	5

Comparaison des systèmes

- Type de vol

	Trajectoire de vol nominal	Nombre de vols différents	Vent minimal (retour à la base)	Vent maximal (retour à la base)	Effet des rafales
yoyo	2	2 (2)	2	2	2
8kite	0	1 (3)	2	2	2
8 plane	0	1 (3)	0	2	2
Magnus	2	2 (2)	2	0	0
Altaeros	2	2 (1)	2	0	0
Kite Wind energy	2	2 (1)	0	1 ?	2
Makani	0	2 (1)	0	2	2
Multi kite system	1	2 (2)	2	2	2

Comparaison des systèmes

- Contrôle

	Nombre d'axes de rotation stables (fixes ?)	Nombre d'axes de translation stables	Nombre d'axes ayant un temps de réponse critique	Pertes d'énergie dues à une déviation de la trajectoire
yoyo	1 (lacet)		1 (AOA)	0
8kite			3 (AOA, lacet)	0
8 plane	0		3 (AOA, lacet)	0
Magnus	1		0	5
Altaeros			0	5
Kite Wind energy			0	3 ?
Makani			3	0
Multi kite system			1	3

Comparaison des systèmes

- Durée de vie, consommables

	Consommables	Détérioration de la structure	Estimation de l'investissement initial
yoyo	5	0 (tissu)	5
8kite	5	0 (tissu)	5
8 plane	5	5	3
Magnus	0 (hélium)	5	5
Altaeros	0 (hélium)	5 ?	4
Kite Wind energy	5	5	1
Makani	5	5	1
Multi kite system	5	5	5

Comparaison des systèmes

- Décollage atterrissage

	Nécessité d'une structure spéciale	Espace nécessaire - vitesse	Complexité
yoyo	5	5	5
8kite	5	5	5
8 plane	0 (treuil puissant)	0	0
Magnus	0 (poutre)	5	5
Altaeros	0 (hélium)	5	5
4 rotor Kite Wind energy	5 poutre	5	2
Makani	5 poutre	5	5
Multi kite system	5 ?	0	0

Sensors & control unit

- Schema electronique

Sensors & control unit

- Schema electronique

Sensors & control unit

- Schema electronique

Sensors & control unit

- Schema electronique

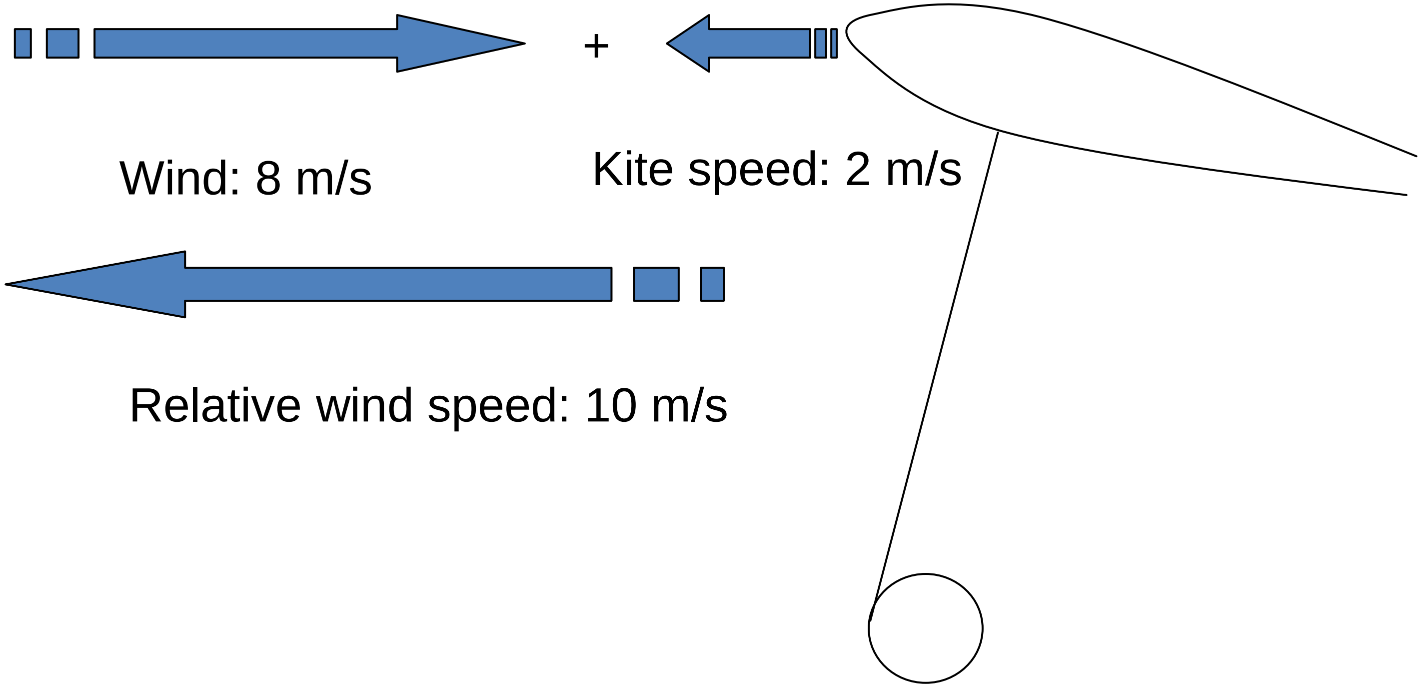
Sensors & control unit

- Schema electronique

Sensors & control unit

- Schema electronique

Model: relative wind



Model: forces