



Kite Engineering

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Quad kites!



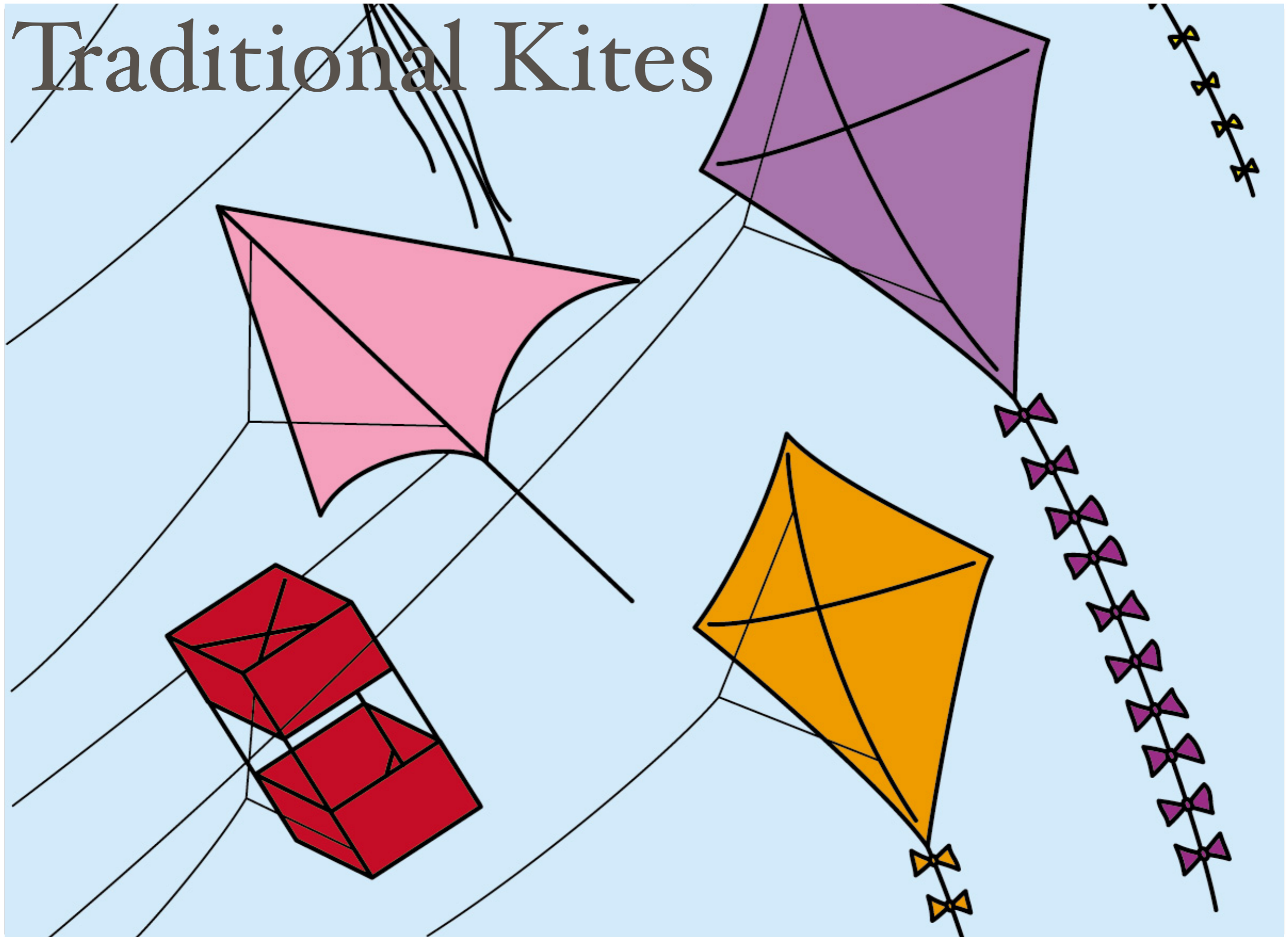
History

- ❖ Kite technology > 2800 years old
- ❖ Origins in *China*
- ❖ Materials: bamboo and silk
- ❖ Flat kites (not bowed designs)
- ❖ Later decorated with strings and sometimes whistles
- ❖ For specific occasions/events and competitions



Introduced to the
western world in
16-17th century

Traditional Kites



Modern Kite Types

- ❖ **Stunt Kites** used to perform tricks...
- ❖ 360, Axel, Backflip, Cartwheel, Cuckoo clock, Black hole, Helicopter, Walking, Pancake, Stall, Yoyo, etc.
- ❖ Also known as Sport Kites
- ❖ Typically dual or quad line kites
- ❖ For control of speed, direction and pull
- ❖ Can even go backwards and forwards!



Modern Kite Types

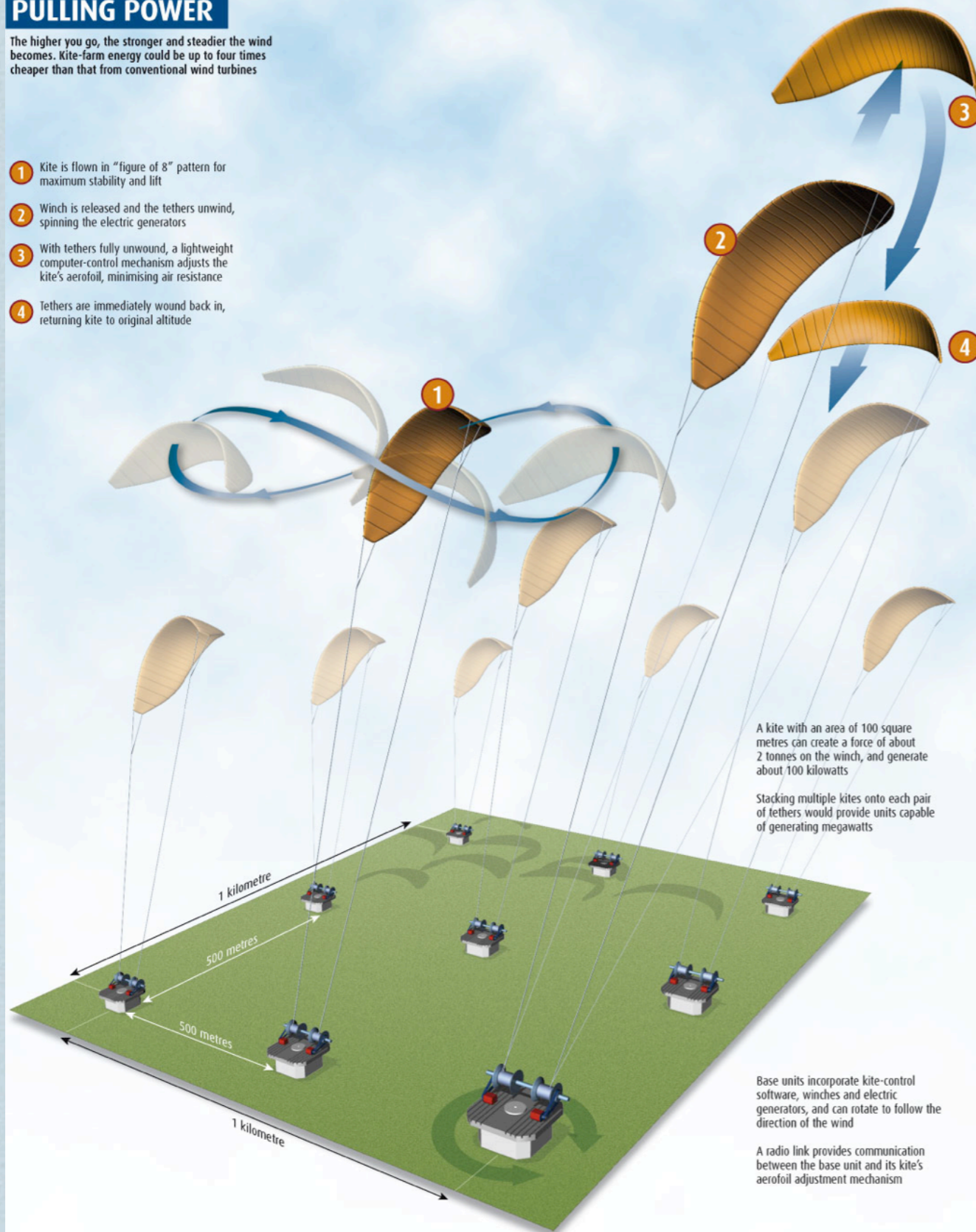
- ❖ **Power Kites** for different sort of entertainment...
- ❖ Buggying, kite sailing and kite jumping.
- ❖ Develop a tremendous pull in strong winds



PULLING POWER

The higher you go, the stronger and steadier the wind becomes. Kite-farm energy could be up to four times cheaper than that from conventional wind turbines

- 1 Kite is flown in "figure of 8" pattern for maximum stability and lift
- 2 Winch is released and the tethers unwind, spinning the electric generators
- 3 With tethers fully unwound, a lightweight computer-control mechanism adjusts the kite's aerofoil, minimising air resistance
- 4 Tethers are immediately wound back in, returning kite to original altitude



A kite with an area of 100 square metres can create a force of about 2 tonnes on the winch, and generate about 100 kilowatts

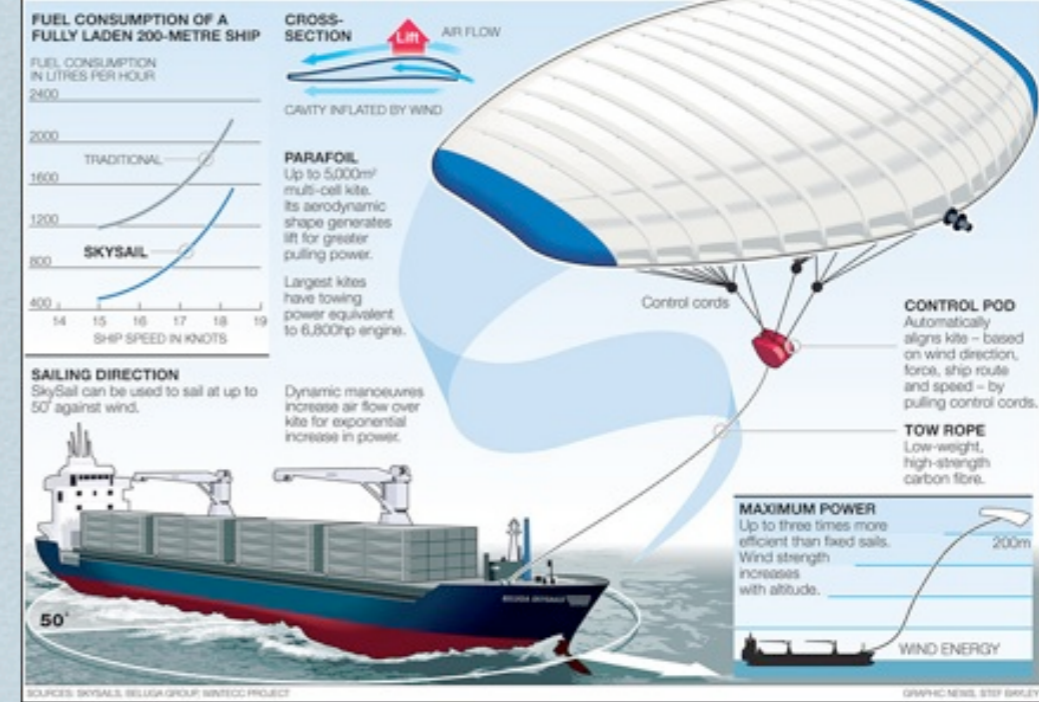
Stacking multiple kites onto each pair of tethers would provide units capable of generating megawatts

Base units incorporate kite-control software, winches and electric generators, and can rotate to follow the direction of the wind

A radio link provides communication between the base unit and its kite's aerofoil adjustment mechanism

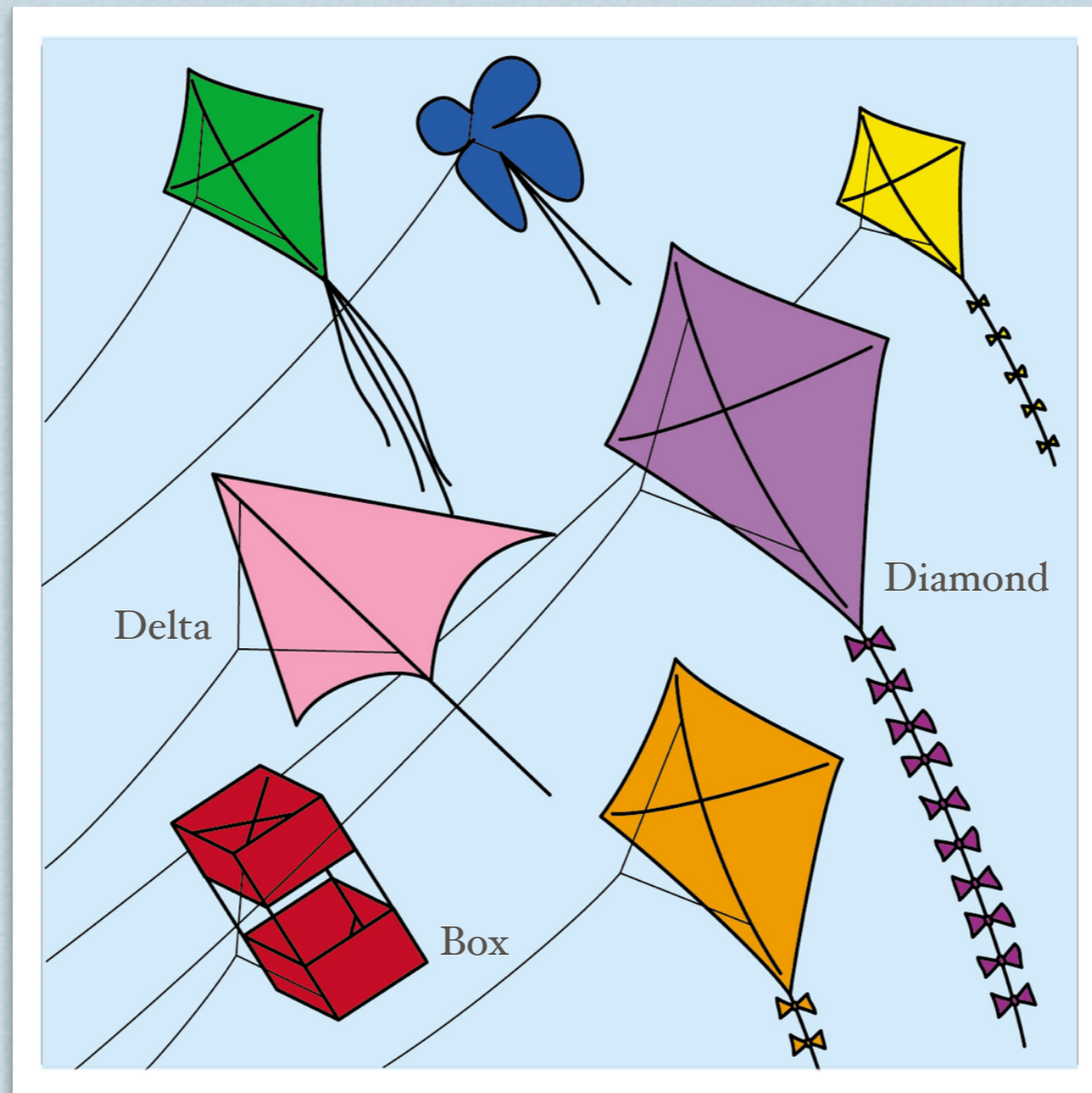


HARNESSING THE WIND



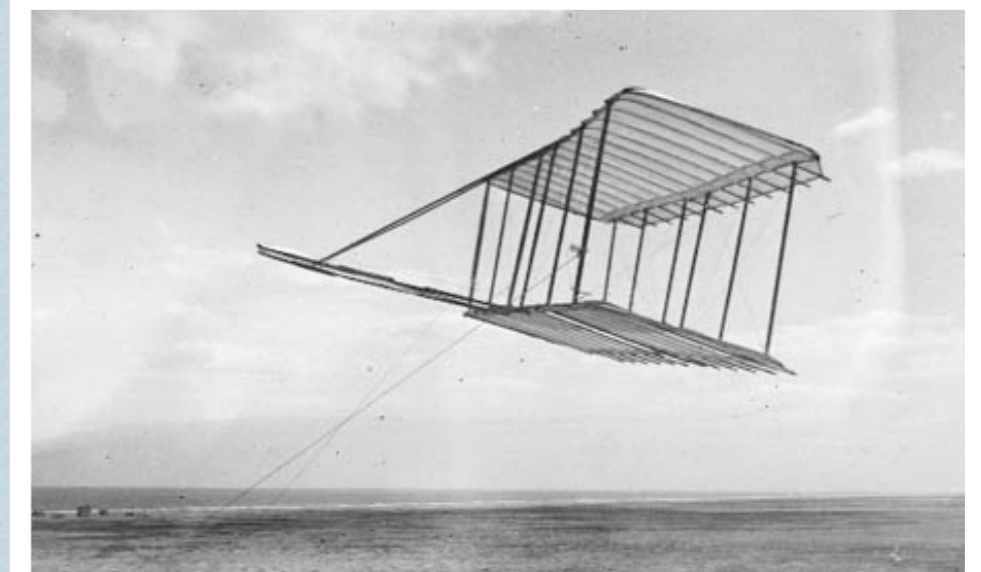
Energy from kites

Why do kites fly?



From kites to airplanes

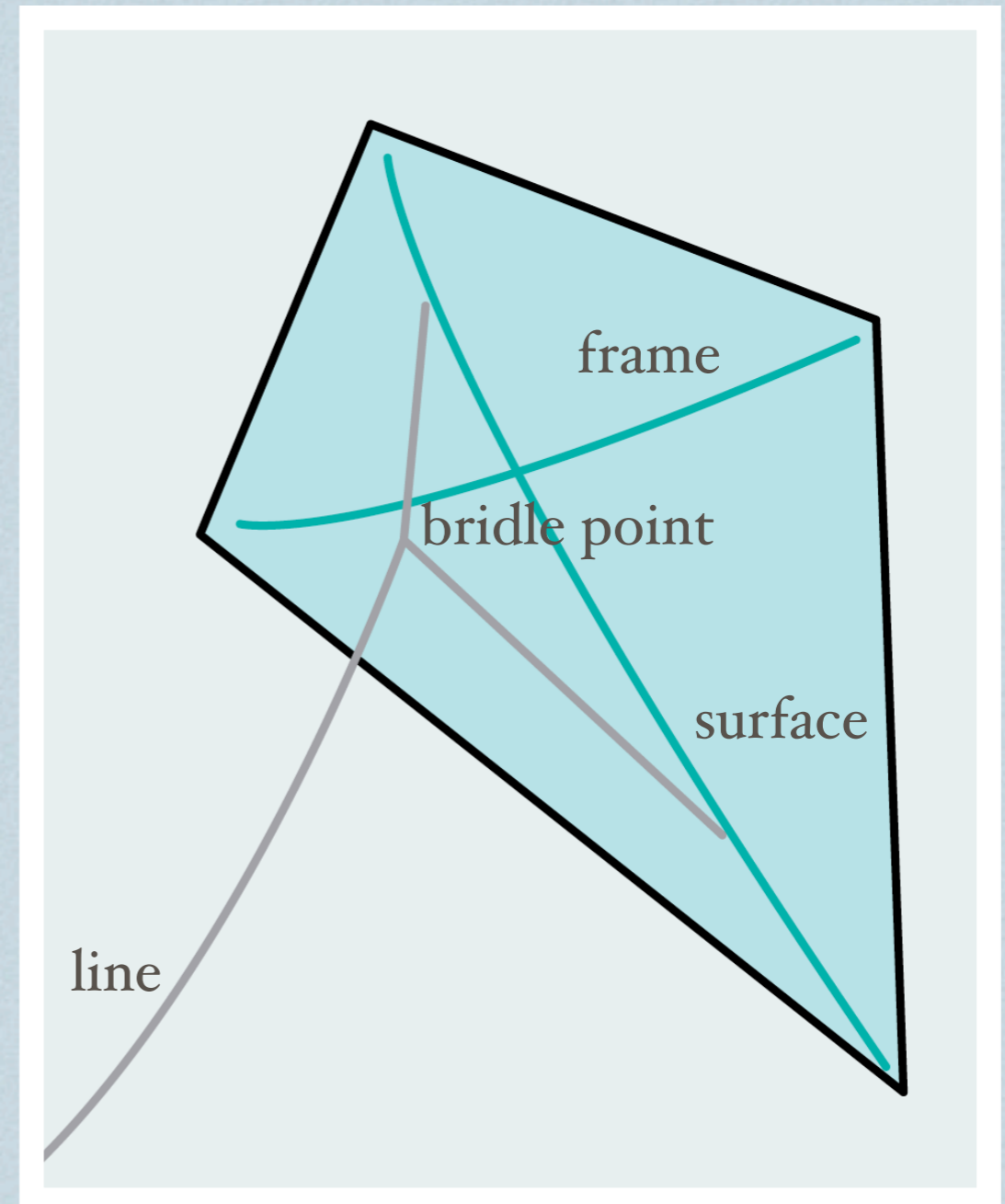
- ❖ Forces are the same as an airliner except for *thrust*
- ❖ Like aircrafts, kites are heavier than air
- ❖ Rely on *aerodynamic forces* to fly
- ❖ Need to generate *lift* to overcome its weight
- ❖ Kites need to be light but strong



1900 Wright Brother Kite

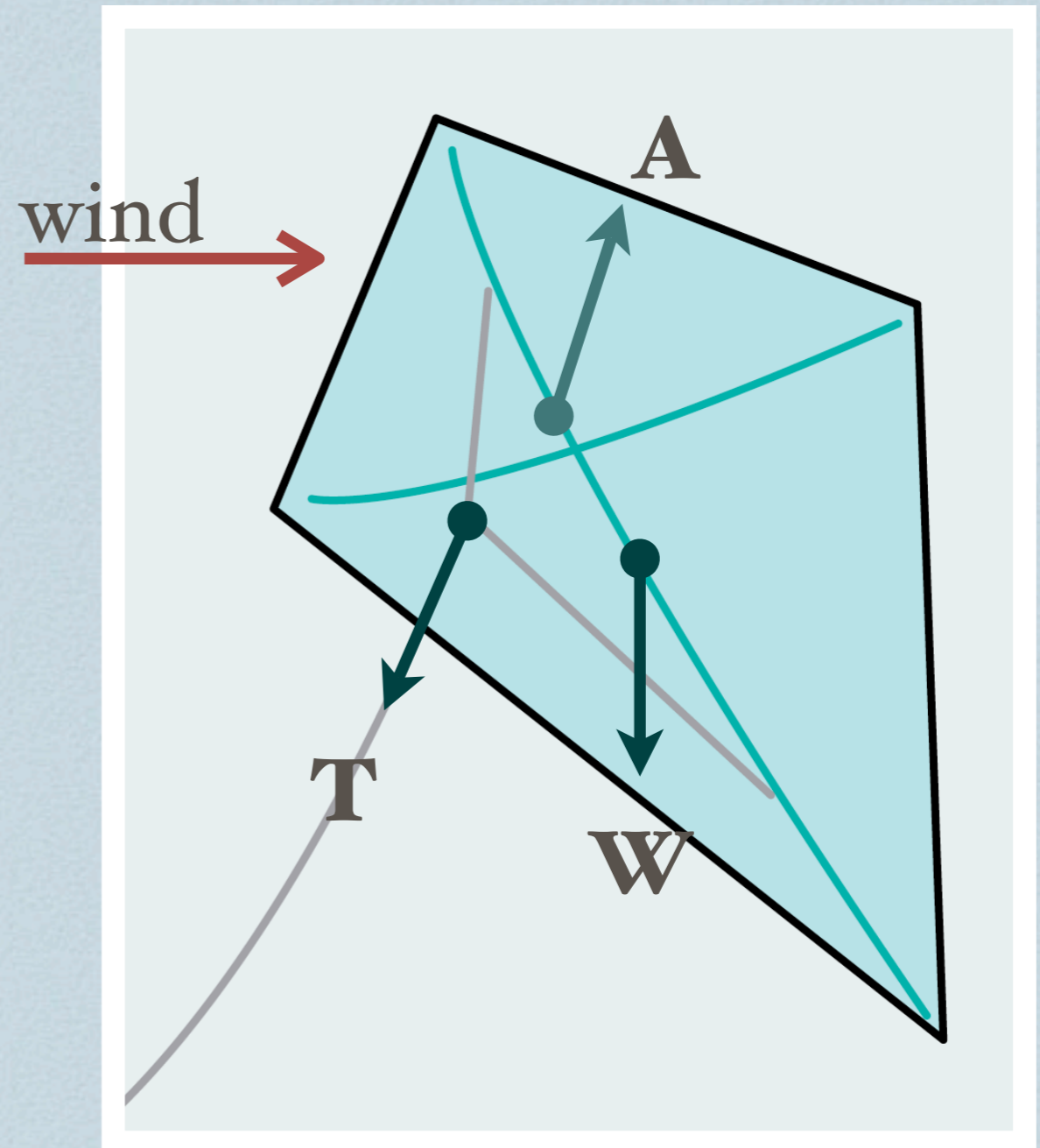
Kite components

- ❖ Kite surfaces generate aerodynamic forces for flight
- ❖ Rigid structures support the surfaces and distribute the forces
- ❖ Control provided by the *line* and the *bridle*



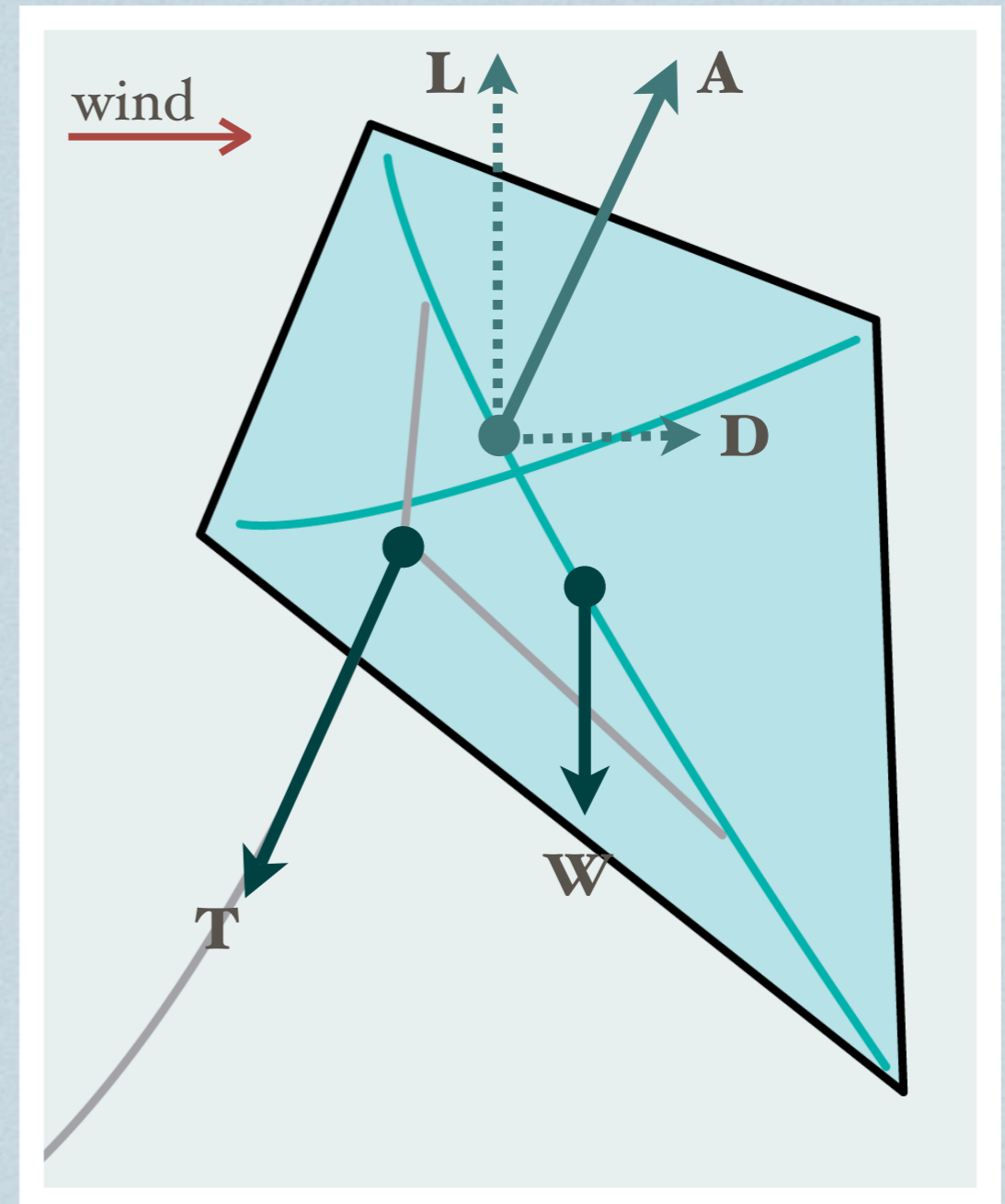
Forces on a kite

- ❖ Principle forces
- ❖ *Tension* \mathbf{T} in the line
- ❖ *Aerodynamic* force \mathbf{A}
away from the tension
- ❖ *Weight* force \mathbf{W}
towards the center of
the earth



Aerodynamic forces

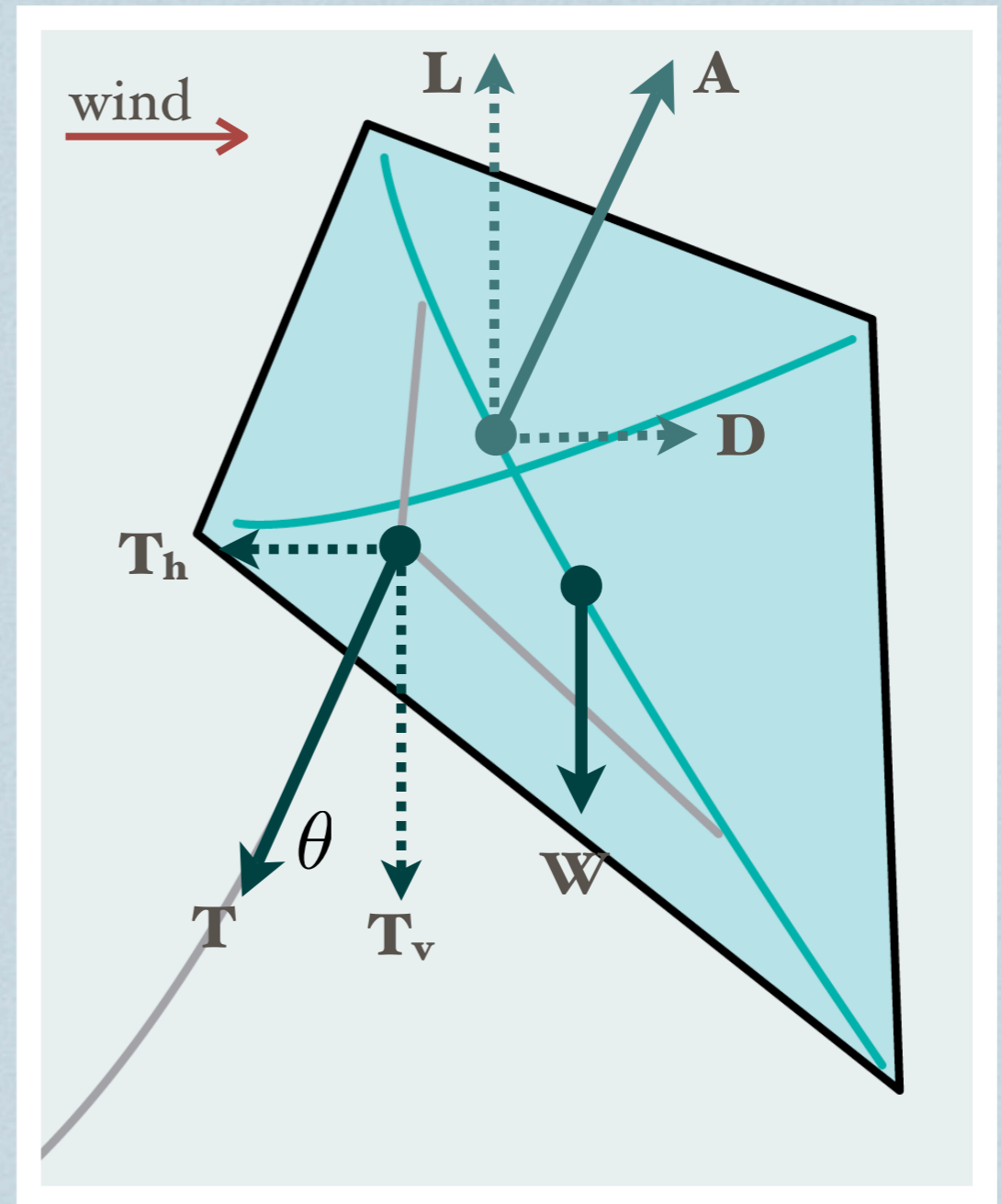
- ❖ Aerodynamic force broken down to its component forces
- ❖ *Lift* **L** perpendicular to the wind
- ❖ *Drag* **D** parallel to the wind direction



Tension forces

- ❖ Tension opposes the aerodynamic force and the weight
- ❖ T_v is the vertical component
- ❖ T_h is the horizontal component
- ❖ Related by the angle of the line

$$\tan(\theta) = \frac{T_v}{T_h}$$



A stable flight

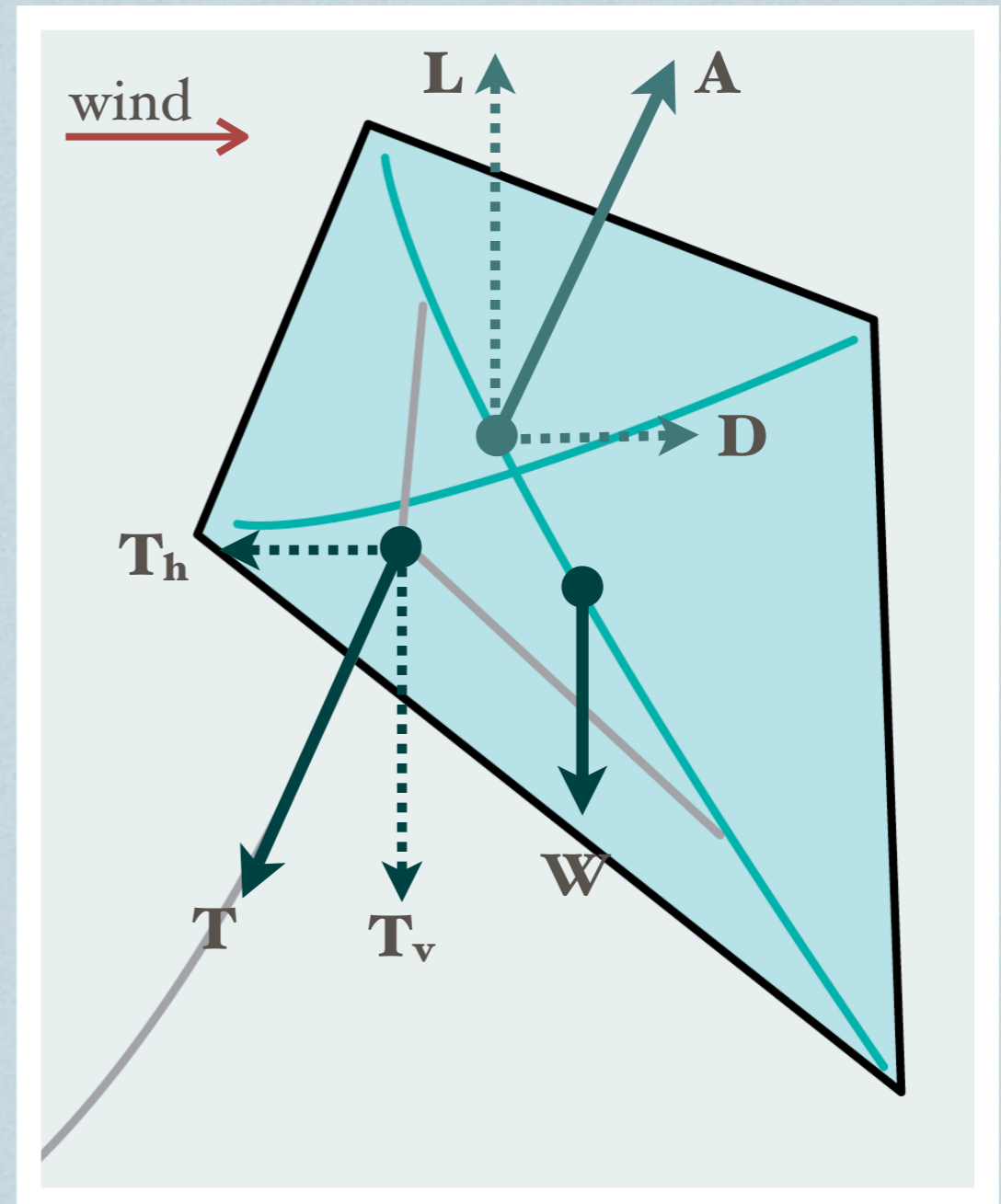
- ❖ When the kite is in stable flight the forces need to balance (Newton's laws of motion)

- ❖ Forces in vertical direction

$$T_v + W - L = 0$$

- ❖ Forces in horizontal direction

$$T_h - D = 0$$



Aerodynamics of kites

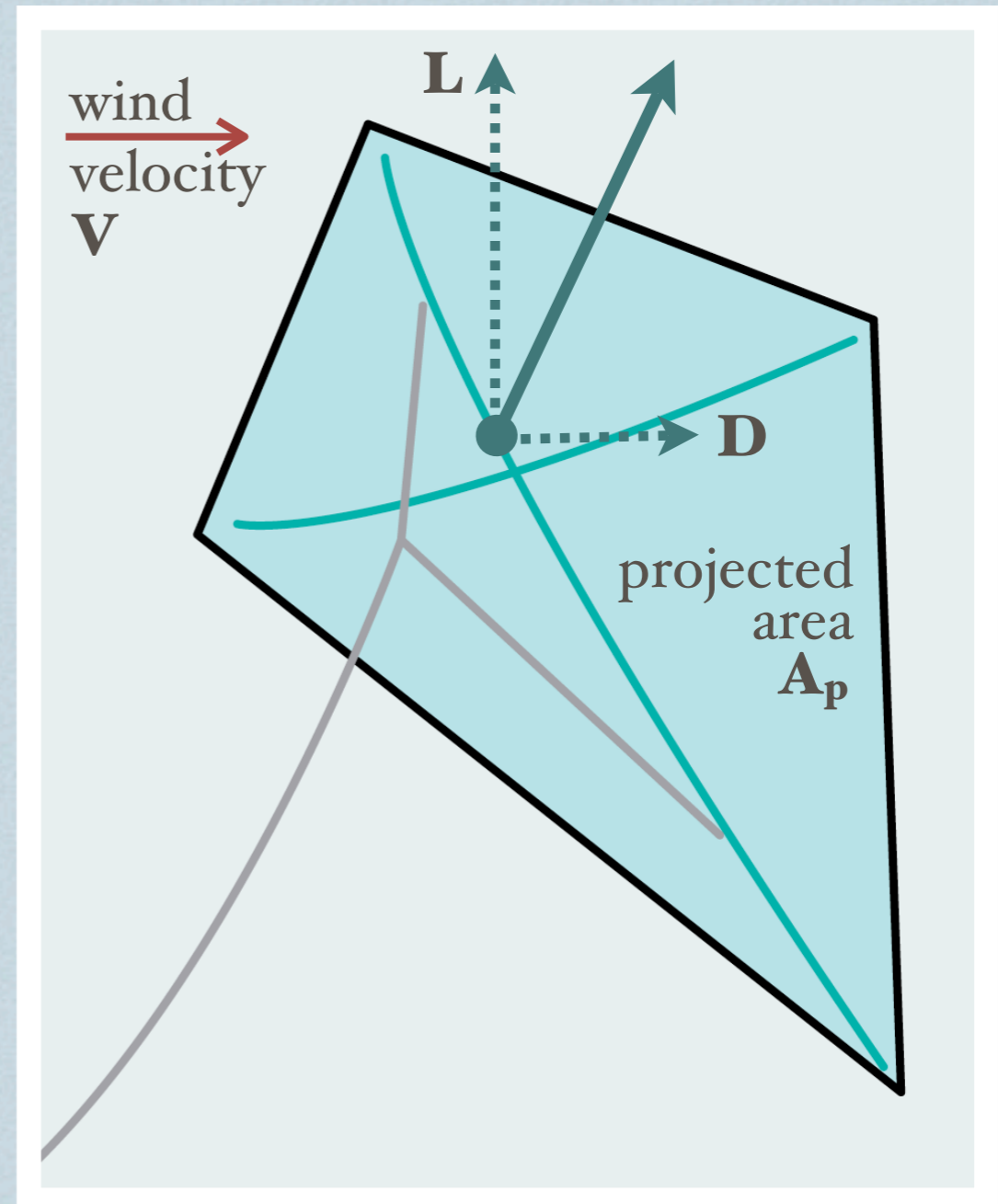
❖ What do *Lift* and *Drag* depend on?

❖ Lift equation

$$L = C_L \frac{1}{2} \rho A_p V^2$$

❖ Drag equation

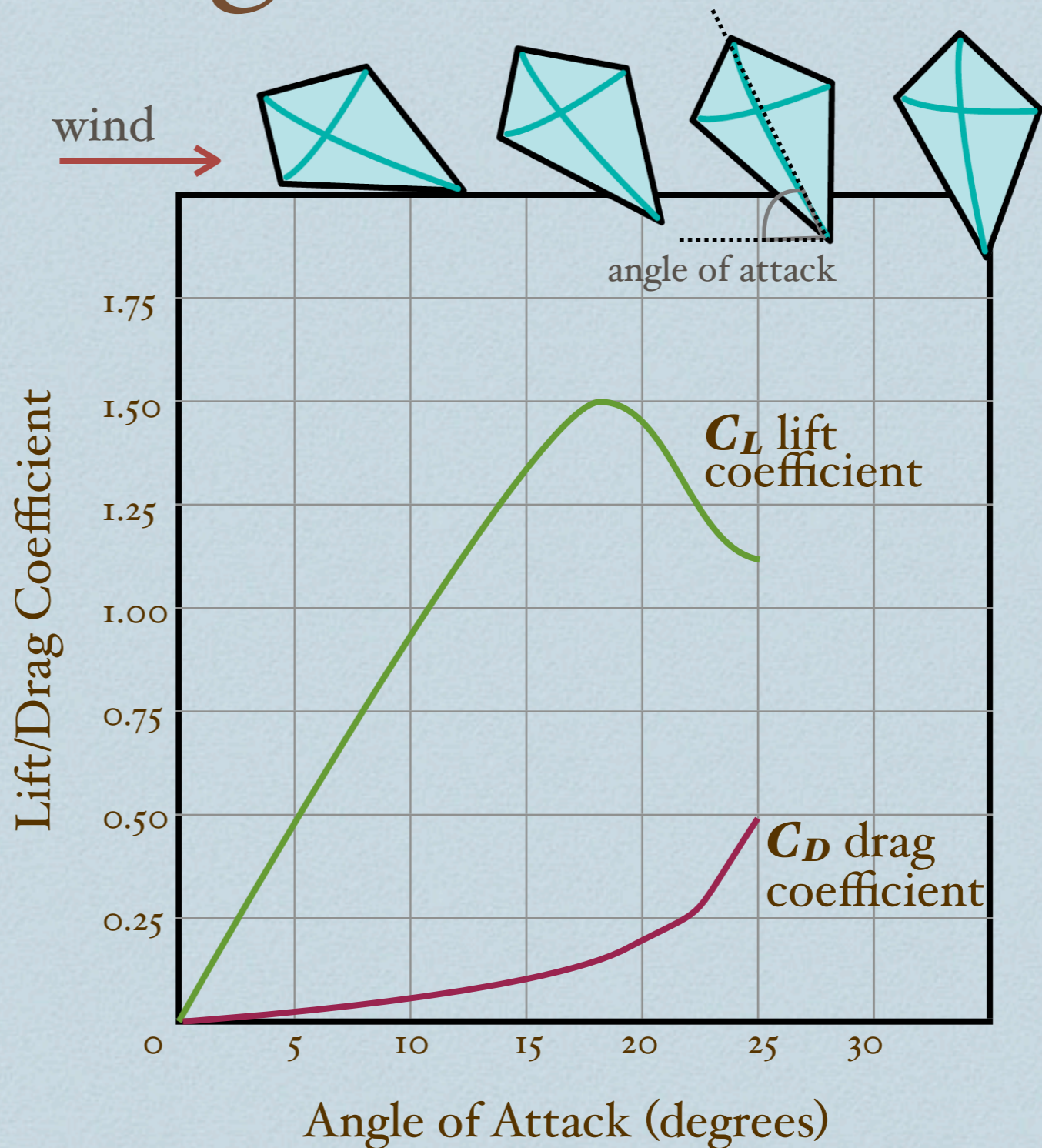
$$D = C_D \frac{1}{2} \rho A_p V^2$$



Lift and Drag coefficients

$$L = C_L \frac{1}{2} \rho A_p V^2$$

$$D = C_D \frac{1}{2} \rho A_p V^2$$



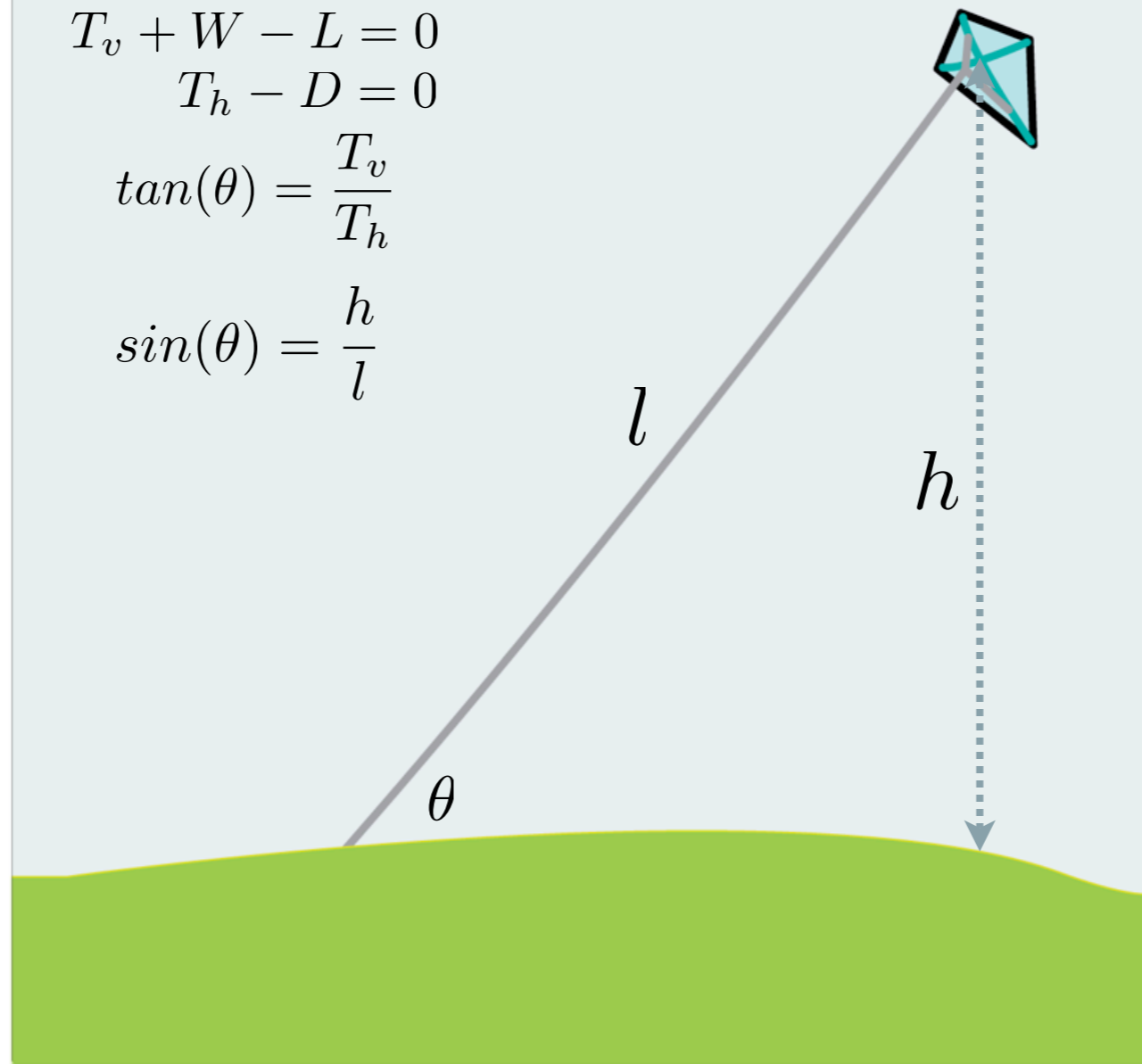
Stable height

$$T_v + W - L = 0$$

$$T_h - D = 0$$

$$\tan(\theta) = \frac{T_v}{T_h}$$

$$\sin(\theta) = \frac{h}{l}$$

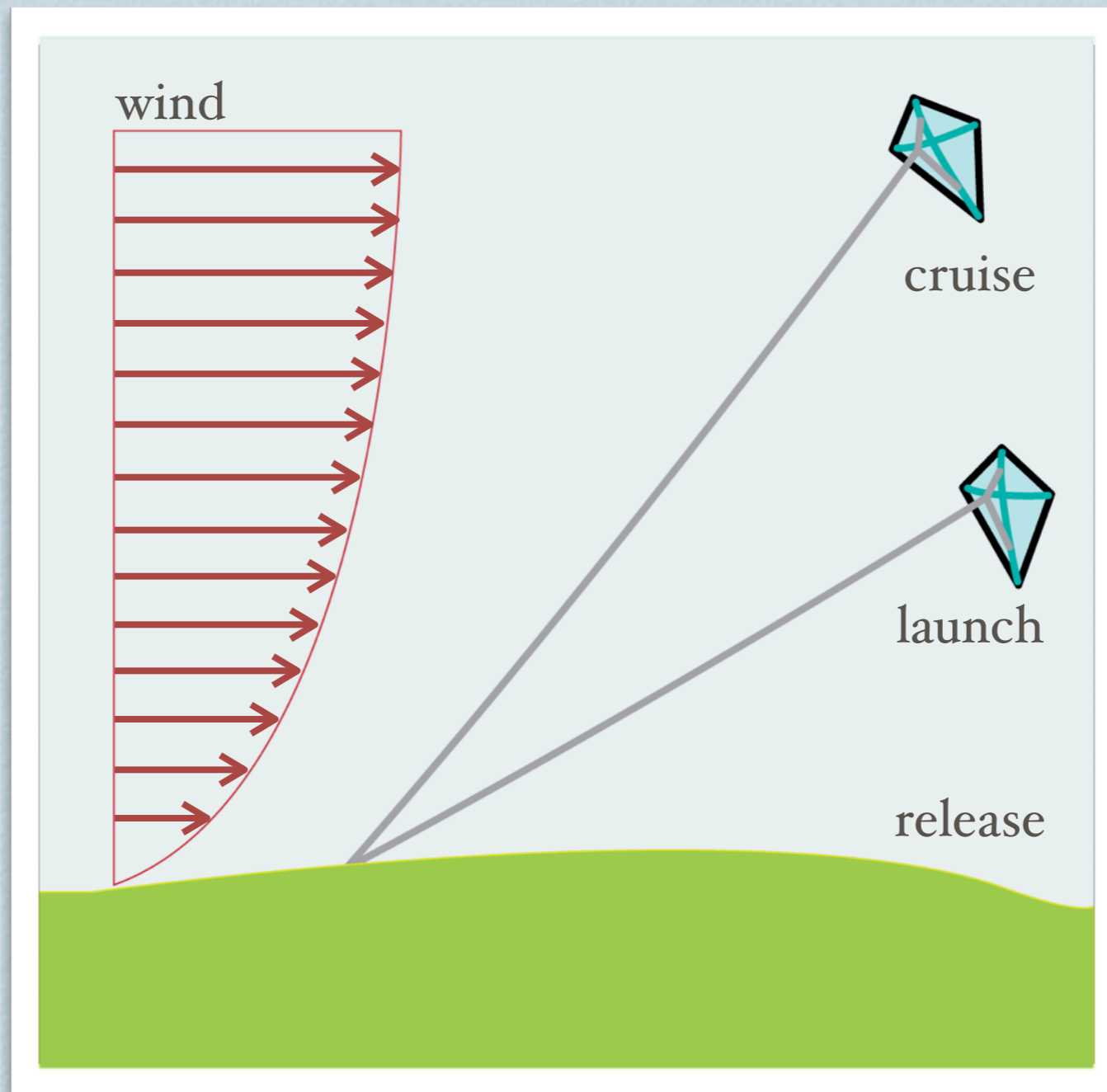


Changes in lift and drag

$$L = C_L \frac{1}{2} \rho A_p V^2$$

Tugging leads to climb

Extending the line leads to initial drop



altitude
determined by
balance of forces



References and resources

NASA Glenn Research Center

<http://www.grc.nasa.gov/WWW/K-12/airplane/guided.htm>

Kites for Everyone by Margaret Greger

NewScientist.com

Wikipedia.com

PBS Kids:

<http://pbskids.org/dragonflytv/show/kites.html>