ASSET and the world of Kites

Throughout the ages, kites have captured the imagination of millions. From the Chinese over three thousand years ago up until the researchers of today, kites have played a role in the fields of science, religion and entertainment. During the twentieth century, more and more scientific knowledge was being applied to kites and people are discovering new techniques and new applications for this old idea. At the ASSET chair (AeroSpace for Sustainable Engineering and Technology), under supervision of Prof. Dr. Wubbo Ockels, we look at kites in a scientific manner. We want to understand and control kites so they can be used in a number of applications such as the generation of sustainable energy and the propulsion of ships.

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[source: ASSET]

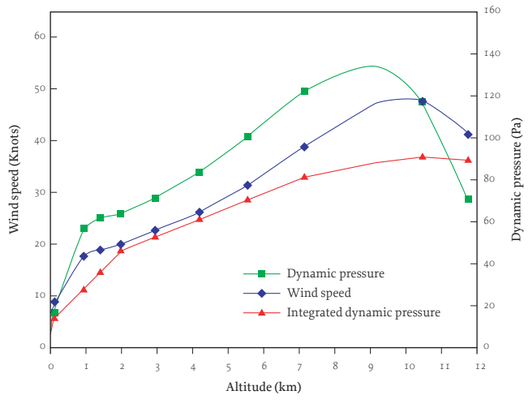


figure 1: Wind speed and dynamic pressure from sea level to 12km altitude. [source: KNMI]

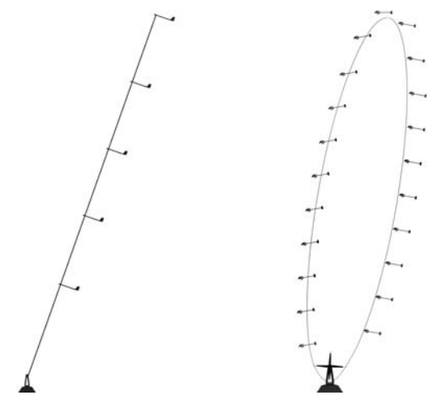


figure 2: Pumping laddermill (left) and rotating Laddermill (right). [source: J. Breukels]

figure 3: A small control surface. [source: B. Lansdorp]

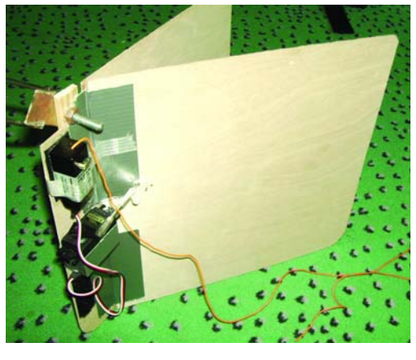
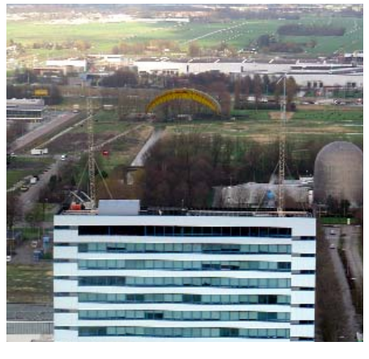


figure 4: The high L/D kiteplane. [source: J. Breukels]

figure 5: ASSET's KiteLab. [source: J. Breukels]



Laddermill

The Laddermill is an innovative concept for generating energy from wind power using large kite-like wings on a tether. The wings are able to fly in both the regime of airplanes and kites. We therefore call these structures "kiteplanes". By providing recurring motion with a large lift during ascending and a lower lift during descending, energy can be generated. The laddermill will enable us to generate sustainable energy using the high speed winds at high altitude (see figure 1). Thus far, two versions of the laddermill have been analyzed. A pumping laddermill (see figure2) and a rotating loop laddermill (see figure2). The pumping laddermill consists of a single tether with multiple kites ascending and descending, and the rotating loop laddermill consists of a loop of kites, connected to an endless cable. The pumping laddermill is the simpler concept, and therefore selected for initial development. The laddermill project currently has the support of Shell research, Fugro, Gasunie, University of Groningen, Delft University of Technology, the county of Groningen, the municipality of Groningen and the municipality Delft.

Controllable kites

In order to use kites as an energy generation device, we need to be able to control the kite. Initially, this will be established using radio control. Later versions will have their own flight computer on board which will steer the kite into any desired position. Currently, radio control is being tested on a 8.5 m^2 Peter Lynn Kite. This kite is normally used for kite surfing. But ASSET outfitted the kite with small control surfaces, enabling the kite to be steered from left to right (see figure 3). This configuration has been tested successfully and was demonstrated at the Kiteplane challenge 2005. Currently, the ASSET researchers are looking into powering and de-powering the kite. This would enable the kite to ascend and descend, making sustained energy generation a possibility.

Low drag kites

Part of this research started as the KitEye project in conjunction with the European Space Agency (ESA). The goal was to design a kite which could break the world altitude record for a single kite on a single line. It was concluded that a high lift over drag ratio was necessary. In conventional kites, drag is largely responsible for its stability. Drag works as a dampening mechanism. Also, when the drag is high, the position of the kite is lower and farther away from the anchor point, causing the center of gravity to be lower with respect to the cable attachment point. Such a position of the center of gravity will cause a larger stabilizing moment. Creating a low-drag kite means compromising the stability.

For this research, an airplane-like kite was designed and constructed (see figure 4). It was constructed from polyprop foam which proved to be both flexible and durable. The kite was outfitted with control flaps in the wing tips. Flight tests proved the kite to be very nervous and twitchy. Over-controlling the kite was a serious problem. However, it was able to stay aloft for some time, and proved to be very responsive to control inputs.

Currently, research on this 3-meter span model is being finalized and preparations are being made for the design and construction of a fifteen-meter span version of this kite, consisting of sails and inflatable members.

Energy generation

In order to generate energy, there needs to be a generator on the ground. This "ground station" is also under development at ASSET. There are currently two winches in use. A small one for small scale testing and a larger one for larger, more powerful kites. The winches have been mounted on a small trailer for easy transportation. Tests have been conducted using a glider and using the Peter Lynn kite mentioned above. In both cases, energy was generated by letting the kites ascend. And also, both kites were used to test "cross wind power", a maneuver where the glider would make slow turns to the left and to the right to generate more power. Cross wind power is a procedure often used in kite surfing and it dramatically increases the tug force on the cable.

KiteLab

Up until now, the ASSET team always had to move to the beach or "de Maasvlakte" in order to do the tests. It meant testing far away from the facilities we have at the faculty coupled with long travel time. The team looked at locations closer to the facilities, which would be suitable for kite testing. After reviewing several locations, the ideal location was found: on the roof of the faculty building (see figure 5). Most of the time the prevailing winds in Delft blow out of an ideal direction to the test kites on the roof. The building itself has an effect on the flow over the roof. However, by placing tufts on a twelve meter high pole, it was determined that about six to eight meter above the roof surface, the flow of air is steady.

Flying kites on the roof has to be done safely. To prevent the kites from crashing into the side of the building, two 25 m high towers are being erected on the roof of the building. These towers have been designed and built by Prolyte B.V. The main tether of the kite will pass through a ring, suspended from the tops of the two towers. This means that, as long as the kite's altitude above the roof surface is no more than twice that of the altitude of the ring, the kite can never hit the side of the building. This creates a safe environment to test kites of several different configurations. Meteorological instruments will gather data concerning wind speed, wind direction, barometric pressure and air temperature. A camera placed on the roof and on the 100m high smokestack, across the river, "de Schie", will observe the kite in flight. All data will be transferred and logged onto computers on the 14th floor where the monitoring section of KiteLab is located. In the same building, there also is a fabrication facility where kites are built and prepared for flight-testing on the roof. KiteLab is a unique facility in the world and people in the world of kites have already shown interest in working together in the KiteLab to do unique, cutting-edge research on kites.

Future developments

In the immediate future, we will officially open KiteLab for use by ASSET. Research will continue on the controllable surf kite and its use as an energy generation device.

Theoretical work will be done on stability and aero-elasticity of kites and the fifteen-meter span kiteplane will be developed and built. We still have several thesis subjects open to students. Are you interested in working with us in this exciting field? Drop by on the tenth floor sometime!