THE KITESHIP™ PROJECT - CHAPTER 5 IN THE CONTINUING SAGA

Francis de Winter
Dave Culp
Dean Jordan
Ron Swenson
Kiteship Corporation
P. O. Box 7080, Santa Cruz, CA 95061
info@kiteship.com

ABSTRACT

Principals of the Kiteship Corporation have been working on the development of traction kites for marine propulsion for over 25 years. For many years we worked on kites with airfoils like wings, using a series of proa test beds, both in fresh water and on the ocean. A challenger for the America's Cup races recently contracted with us to develop a racing spinnaker replacement kite that would satisfy the strict rules of the 2003 America's Cup. We were successful in this effort, although the success came too late to be used in the 2003 America's Cup races. The present paper describes our work on this effort.

1. INTRODUCTION

Kiteship Corporation was established to develop the technology of pulling boats with airborne kites (1-5, 9, 17-19). We recognized that the depletion of petroleum in the world and of natural gas in the USA (6, 7) will provide an incentive to use wind power to save on shipping fuel (8, 9), and that mast and sail combinations will no longer provide the most cost effective propulsion, since so much had been learned about materials, mathematics, computation, control theory, equipment, hydrodynamics, and aerodynamics (10, 11, 15-21) since the time of the clipper ships (12).

It is often thought that the devices currently used by humanity are the result only of insight and of genius. This is not necessarily true, for things often were improved slowly (11-14) through trial and error, just like evolution did it in nature (25, 26). As in nature, one can get stuck in a dead end. Dawkins (25) mentions there are many different types of light sensitive eye-like devices in nature, as different as fish eyes, mammal or bird eyes, bee eyes, and others. A bee is stuck with bee eyes, for evolution provides no path for the bee to follow to get eyes with the different design needed to get the resolution of eagle eyes (25). The mast and sail combination is in a similar predicament. Current mast and sail technology is the end result of thousands of years of improvements, involving many millions of boats to guide humanity to the best designs. There is no easy way out, no straightforward way to modify and improve the mast and sails past to get to a kite future. One must change to a new paradigm.

Centuries ago, Franklin and others used kites for propulsion (18, 19), but the technology to do this efficiently was not available at the time. It was not possible to develop the kiteships™ that we are working on: vessels powered by large controllable kites with fairly high lift-to-drag ratios. Such kites can be wing-shaped like some modern sport parachutes, with airfoil cross sections inflated with holes in the wing leading edges. One can incorporate helium or hydrogen to make the kites buoyant in air. One can fly such kites high in the sky in higher and steadier winds, far from the effects of the waves and of the boat hull, and in a location that maximizes the driving forces in the direction one wants to sail. One can sail against the wind, like any modern sailboat.

In any mast and sail rig one needs enormous forces to keep the mast from collapsing and to give the sails an efficient shape. The boat (and the sailing rig) must be strong enough to withstand these forces, which are orders of magnitude larger than the propulsion forces that the sails generate. Kites instead are fairly relaxed devices, with no outside forces other than the wind. The kite driving force can be transmitted to the hull directly, with no overturning moment, and no need for a heavy or deep keel, or for a very strong structure. If with kites the wind speed increases to a dangerous level one need not be "over-powered" by too much kite area for more than an instant: the instant needed to "de-power" the kite. One can also simply release the kite, which can then perhaps be recovered later. Kiteships™ can be safer, faster, and more cost effective than the mast and sail rig used on clipper ships, and the cost of retrofitting traction kites on existing ships is relatively small.

Fig. 1
Match Racing, Sta Barbara

2. TECHNICAL PROGRESS MADE

The papers we presented at ASES, ISES, ANES, AIAA, and SNAME meetings earlier (1-4, 9, 17) involved a proa, and inflated, wing-like kites. In mid 2001 we contracted with one of the organizations competing in the recent (2003) America's Cup. We received a challenge: either develop and build a kite that could satisfy the requirements of a racing spinnaker and beat such a racing spinnaker in the America's Cup, or show that this cannot be done. Either result was acceptable. If it could be done rapidly enough, it could be used against the competition in the America's Cup. If it could not be done, the competition could not use it by surprise. The work had to be done in secrecy, so that for a long time we had nothing to publish or discuss.

To do the development work we rented a house with a shop in the Mojave Desert, doing the development and the traction testing on windy dry lakebeds with an instrumented pickup truck. We were successful in developing and building a legal spinnaker replacement kite, using the home shop as our sail - i.e. kite - loft for many successive design iterations. The kite qualified as a spinnaker according to the rules of the America's Cup: there is no need to use a spinnaker pole, the spinnaker need not fly close to the mast (or boat), the spinnaker may have no more than three operating lines (the "flying" lines for our kites), the spinnaker may have no double (i.e. inflated) surface sections, and the spinnaker may have no spars, battens, bridles, or discontinuous (i.e. multiply-connected) surfaces. We satisfied all those conditions, and a provisional ruling was obtained that our kite was qualified as a legal spinnaker.

Fig. 2
America's Cup, Auckland

On one of the dry lakes a kite of our final design with a surface area of 40 square meters was able to pull our pickup truck at over 35 mph (56 km/hr). In match races at sea on J-105 boats our 70 square meter kite was able to beat a larger (89 square meter) racing spinnaker (Fig. 1), and this 70 sq m kite was later demonstrated in public on our client's boat in New Zealand, as shown in Fig. 2 (24).

Fig. 3
280 sq m kite on dry lake

In the America's Cup, the racing spinnakers have a total surface area of between 280 and 480 square meters. We built a kite with a surface area of 280 square meters and tested it on a dry lakebed (Figs. 3, 4). We typically tested this kite around dawn under zero wind conditions, backing up the pickup truck to produce the wind. Testing it under windy conditions might have lifted up and destroyed the pickup truck, unless the truck had been much heavier. A kite with a surface area of 280 sq m may seem large, but we are contemplating building a kite 3 or 4 times larger still, and kites for really large merchant marine applications may be still another factor of 5 larger, for a total area of around 5,000 sq m.

Using our kite design in the recent America's Cup would have required a significant crew training and equipment testing and manufacturing effort, and our final design was not available early enough to use in the 2003 Cup. Such kites may however impact sailing yachts as much as wind-surfing has been impacted by kites: many wind-surfers have now become kite-boarders. When kite-boarding became popular just a few years ago, we decided not to get involved in building such kites, since we felt it would rapidly become a commodity business. It did.

3. CONCLUSIONS

Controlling large traction kites involves tensioning and releasing lines that are under relatively high tension. In yacht racing, this must be done by hand, assisted at most by a winch. A manually operated control system is being developed and built that makes it easy to perform these control functions even if the whole set of lines is being reeled in or reeled out. In larger boats, or in yachts not involved in racing, one needs electric or hydraulic winches operated by an autopilot or by hand controls.

Patent applications have been submitted on both the spinnaker replacement kite and on the manual control device design.

Fig. 4
280 sq m kite pulled by truck

Our racing spinnaker replacement kite proved conclusively what we had suspected for long: that traction kites can be a lot more effective than the mast and sail combinations that humanity has used for millennia. It is challenging to fly kites over water at very low wind speeds unless they are designed to be buoyant like lighter than air balloons.

The future is promising. There are many possible traction kites for marine propulsion, and there are boats of many sizes. Insofar as possible, we plan to develop new traction kites as we developed the yacht racing spinnaker replacement kite: with at least some outside sponsorship, and with no public discussion until a product is ready for the market. We plan to have at least one additional large traction kite ready in time for the next ASES meeting. Stay tuned!

REFERENCES

1. F. de Winter, R. B. Swenson, and D. Culp: "Kiteships, Sailing Vessels Pulled and Powered With a Kite," Proc. of the ASES Annual Meeting, Portland, ME, June 1999.

2. F. de Winter, R. B. Swenson, and D. Culp: "The Kiteship Project," Proc. of the ASES Annual Meeting, Madison, WI, June 2000.

3. F. de Winter, R. B. Swenson, and D. Culp: "The Kiteship ™ Project," Proc. of the Millennium Solar Forum 2000 of ISES and ANES, Mexico City, Sept. 17-22, 2000, pp 551-553.

4. F. de Winter, R. B. Swenson, and D. Culp: "The Kiteship ™ Project - Chapter 4 in the Continuing Saga," Proc. of the 2001 ASES Annual Meeting.

5. For kiteship ™ technology and literature details (including the texts of the above papers), and for photos and details on our work, see the website: http://www.kiteship.com.

6. For the future in world crude oil supplies as well as in US natural gas, see the website: http://www.hubbertpeak.com.

7. C. J. Campbell: "Myth of Spare Capacity Setting the Stage for Another Oil Shock," the Oil and Gas Journal, March 20, 2000, pp 20-21.

8. F. de Winter: "Economic and Policy Aspects of Solar Energy," Proc. of the Ninth Biennial Congress of ISES, Intersol 85, Montreal, Canada, June 23-29, 1985, Pergamon Press, NY, 1986, Vol. 4, pp. 2207-2218.

9. W. M. Roeseler, D. A. Culp, et al: "The Case for Transport Sailcraft," World Aviation Congress, Society of Naval Architects and Marine Engineers (SNAME), Los Angeles, 1996.

10. C. A. Marchaj: "Aero-Hydrodynamics of Sailing," International Marine Publishing, Camden, Maine 1988.

11. P. D. Priebe: "Modern Commercial Sailing Ship Fundamentals," Cornell Maritime Press, Inc., Centreville, MD, 1986.

12. A. A. Hurst (ed.): "The Medley of Mast and Sail, II - A Camera Record," Naval Institute Press, Annapolis, MD, 1981.

13. B. Greenhill: "Archaeology of the Boat," Wesleyan University Press, Middletown, Connecticut, 1976.

14. P. Goodwin: "The Construction and the Fitting of the English Man of War," Naval Institute Press, Annapolis, Maryland, 1992

15. "The Ancient Interface XI," Proc. of the Eleventh AIAA Symposium on the Aero/Hydrodynamics of Sailing, Vol. 27, Seattle, WA, Sept. 12, 1981.

16. "The Ancient Interface XII," Proc. of the Twelfth AIAA Symposium on the Aero/Hydrodynamics of Sailing, Vol. 28, San Francisco, CA, Oct. 30 and 31, 1982.

17. W. M. Roeseler and D. A. Culp: "Kitesailing Progress," Proc. of the Eighteenth AIAA Symposium on Sailing Technology, Vol. 35, Stanford, CA, Oct. 14 - 15, 1989.

18. Journal of the Amateur Yacht Research Society (BCM AYRS, London WC1N 3XX), ISSN 0144-1396, Numbers 114 (1993), 116 (1993), 118 (1995), 122 (1996), and 124 (1997).

19. D. Culp: "On Kite Tugs," AYRS Journal 124, 1997, pp 29 - 45.

20. B. Smith: "Sailloons and Fliptackers - The Limits to High-Speed Sailing," A book Published and Distributed by the AIAA, Washington, DC, 1989 (ISBN: 0-930403-65-7).

21. B. Smith: "The 40-Knot Sailboat," Grosset & Dunlap, NY, 1963.

22. G. L. Rogers: "Benjamin Franklin's The Art of Virtue," Acorn Pub., Eden Prairie, MN, 1990, Page 192.

23. G. Pocock: "The Aeropleustic Art, or Navigation in the Air by the Use of Kites or Inflated Sails," Self-published, Bristol, England, 1827. See also http://www.kiteship.com/history/

24. See news media references on http://www.kiteship.com, also coverage in "Latitude 38" (a yachting magazine), January 2003 page 20, February 2003 pages 50-51, and March 2003 pages 166-169.

25. R. Dawkins: "Climbing Mount Improbable," W. W. Norton & Company, NY, 1996.

26. H. Petroski: "The Evolution of Useful Things," Vintage Books (Random House), NY, 1994.