PROJECT FINAL REPORT

Grant Agreement number:	218691
Project acronym:	KITVES
Project title:	Airfoil-based solution for Vessel on-board energy production destined to traction and auxiliary services
Funding Scheme:	Collaborative projects – Small or medium-scale focused research
Period covered:	from 1 October 2008 to 30 September 2013

Project co-ordinator name, title and organisation: Massimo Ippolito, R&D Director, Sequoia Automation S.r.l.

Tel:	+39 011 941 57 45
Fax:	+39 011 940 21 68
E-mail:	m.ippolito@sequoiaonline.com
Project website address:	www.kitves.com

CONTENTS

1 Final publishable summary report

1.1 The KitVEs Project

KitVes project started in October 2008. The main objective were to provide and test an innovative solution to energy supply aboard vessels, available for the following purposes: supplying electric energy for traction purposes and/or to the on board services and auxiliaries; supplying an (eventual) extra (traction) force to the vessels, to be used in emergency situations.

As the name implies, the KitVes system foresees the use of KITes on VESsels for energy production. The project represents a potential deployment of a concept already tested "on shore", in a context of increasing interest in the field of high altitude winds, where there are promising projects for the future of renewable energy production.

The main innovation is given by the fact that the technology is aimed to exploit an unexploited, virtually endless and almost universally available energy power: high altitude winds. To reach altitude winds and exploiting their higher kinetic energy, a radical change of perspective has been pursued, no longer heavy and static devices like wind turbines, but instead light, dynamic and intelligent ones: in the air, to subtract energy from the wind at an altitude of 800 / 1,000 m, power kites, semi-rigid automatically piloted high efficiency air foils. On vessel, all the heavy machinery for power generation. To connect the two systems, high resistance lines transmitting the traction of the kites and at the same time controlling their direction and angle to the wind. The wing pulls the cables that, through a pulley system, activate the alternators on board the vessel, which in turn produce electricity. When cables are entirely unwound, the wing is guided to a position where it looses its wind resistance and the cables are wound in. Energy consumption of the winding phase is a minor fraction of the energy generated during the unwinding phase. At the very core of the project is the software that autonomously pilots the power kites, so that the flight patterns can be controlled and normally directed to maximise the production of energy.

In fact, at first the KitVes project was meant to use the KSU1 (Kite Steering Unit number "1"), the first 40kW prototype developed in 2006 by the project coordinator (Sequoia Automation), that successfully produced energy by exploiting high altitudes winds. The generator has evolved substantially from its initial configuration, in fact the idea of the adaptation of the existing Kite Steering Unit (KSU1), has been substituted with the creation of an improved brand new unit, manufactured ad hoc for on-board vessel energy production.

The KSU (Kite Steering Unit) is the unit that allows to automatically pilot the wing over a predefined flight path, by differentially unrolling and recovering the two lines on two winches controlled by engines.

The first project period generally focused on the analysis of the state of art, planning of activities and initial researching; while afterwards activities have been focused on the final researches, prototypes design & manufacturing, control system development & implementation and the optimisation of some of the components.

In particular the partners devoted their effort in activities like tests on ropes, development of kite's profiles for energy production, installation and interaction of sensors, manufacture of main structure/engines/drums/stem, risks and life cycle assessment etc...

In the last phase of the project the partners focused their efforts mainly on the final manufacturing of the single components, logistics for their transport and assembly of the generator. Due to the several delays accumulated the final set up and test sessions of the generator had to be postponed after the conclusion of the project and will be presumably performed within the year 2014.

1.2 Outcomes of the project

Up to now, as result of the project, a thoroughly new on vessel generator has been conceived, designed, manufactured and assembled. Almost 80% of the components of the generator have been tailored designed and manufactured. The system, for description purposes, may be divided in 3 main parts: "on-ground", "on-air" and Control.

1.2.1 On ground system parts realized:

- A steel structural frame, designed to host ad let duly operate all generator

Fig. 1 The KSU base frame with alternators and drums

- A lifting system aimed to rotate around the x-axys the boom (called "Stem").

Fig. 2 The Stem lifting system

- A 11 meters carbon fibre "Stem" with inserted lower flange, manufactured by autoclave and six moulds.

Fig. 3-4 The carbon fibre Stem and its parts

- Some other additional mechanical devices have been designed and manufactured, like the "Stem" interfaces and the exit swivel roller system placed on top of it, in order to allow a smooth and safe rope path.

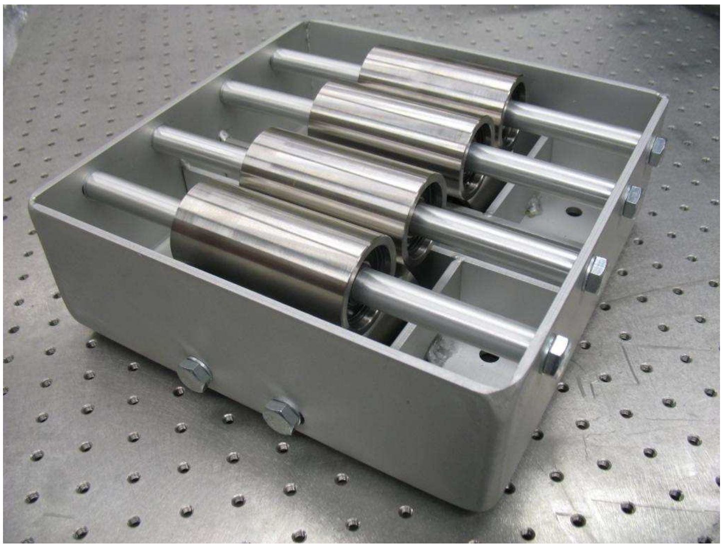


Fig. 5 The exit sviwel rollers

- a specific energy storage system, based on ultracapacitors, had to be designed and provided, in order to allow the system to reach a stand-by position during operations even in case of black out of the electric line and to provide peak power sometime required and likely to be hardly provided by vessel's line.

Fig. 6 Ultracapacitors with their specific charge control circuit

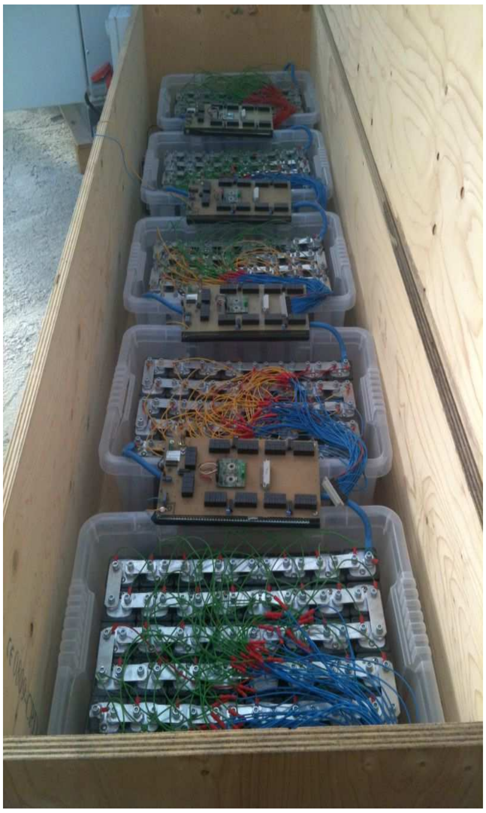
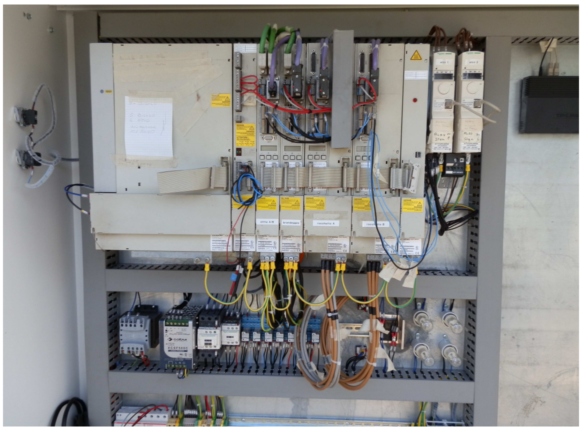


Fig. 7 Pack of ultracapacitors for system's energy storage

- On the shelf components gathered are mostly related to power electronics (alternators, electrical cabin, servodrives, cabling, etc.)



Figg. 8-9 Power electronics components assembled on generator and connections

- Generator has been assembled at Sommariva Perno (ITA), where a no fly zone has been settled in order to allow the system to perform the on-shore preliminary tests

Fig. 10 The KitVes generator assembled for on shore tests

1.2.2 "On the air" system parts:

- New kites, designed for the kitves application, have been studied, developed, designed, manufactured and tested.

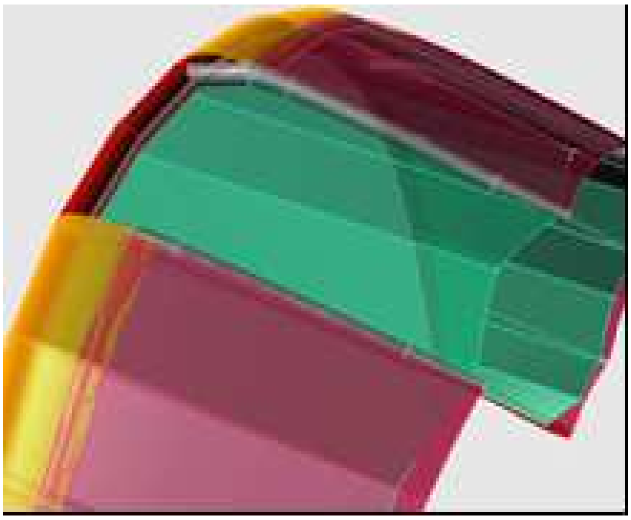


Fig. 11 The optimized kite wing study and design

Fig. 12 optimized wing profile made for preliminary wind tunnel tests

Fig. 13 The optimized wing preliminary performance test with a specially manufactured pilot testbench device

Fig. 14 optimized wing tested on the KiteGen generator

- Different systems of on-wing electronics devices (sensors, radio, batteries) has been manufactured and tested. To this purposes, some on the shelf products have been tested but, considering the specific requirements of the system, an electronic board to be placed on wing have been designed, manufactured, assembled and tested as well.

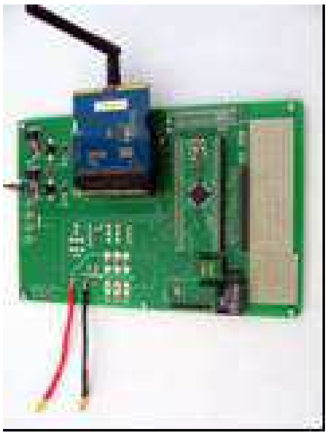


Fig. 15 The on wing electronic control board, with radio transmission device

- In order to provide energy to the on wing electronics a powering micro turbine with dedicated BMS has been developed, realized and tested.

Fig. 16 The on-wing microturbine with its control electronics board

Fig. 17 Turbine performance test on-wing

- Since one of the main issues related to the system's performances is related to the life length of the ropes, the determination of the MTTF of the lines has successfully been performed and completed. The approach developed in order to determine the MTTF is also usable for future line test runs.

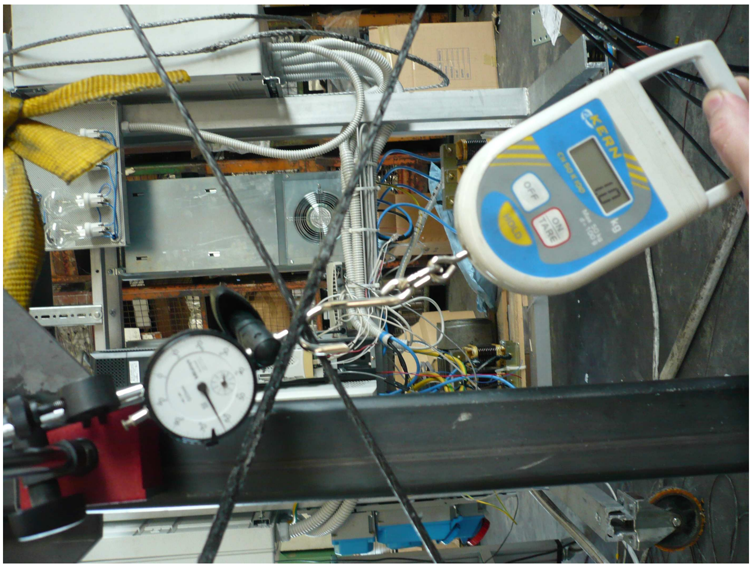


Fig. 18 Testing the ropes in order to determine the MTTF

1.2.3 Control system

- A static and a dynamic numerical model have been developed and validated in order to simulate and optimize the whole KitVes system.
- Two different high level control systems for piloting the kite for energy generation purposes have been developed

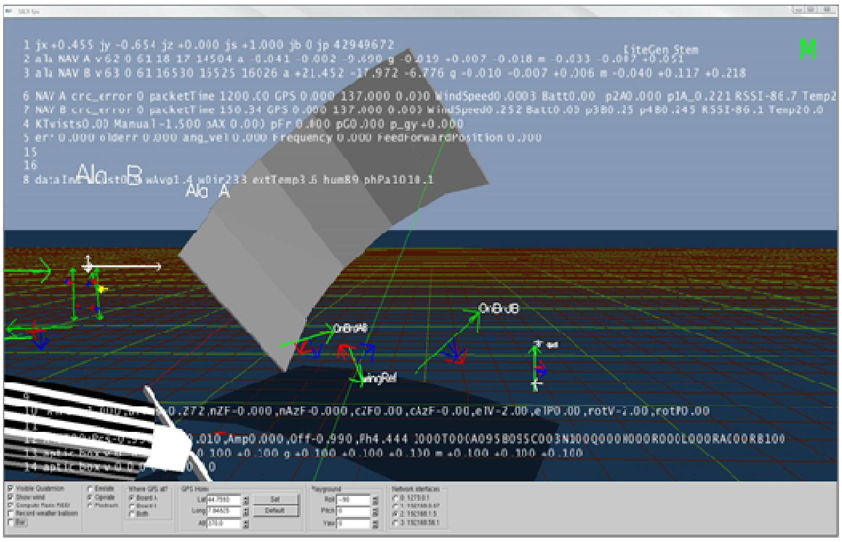


Fig. 19 High Level Control with quaternions screenshot

Moreover, as far as the whole system is considered, the following outcomes have been obtained:

- A system model using the DeCoDe Method has been developed, depicting all functions, components and processes of the KitVes system. The information contained in the DeCoDe system model were basis of several methods such as the RBD (WP 5) or the Risk Assessment (WP 8).
- The DeCoDe Method has been used to further detail the KitVes system model. It was then used as a data basis for the implementation of different methods, especially during several FMECA-Workshops.
- Workshops on the issue of FMECA have been accomplished.
- Several vessels have been identified and preliminary evalutations have been made in order to prepare tests. These include vessels like MV Prince Madog, the Gorgona, the MN Aries Tide and the Cefas Endeavour.
- Area tests have been assessed and some preliminary authorizations have been obtained.

1.3 Final results and their potential impact and use.

The project has been aimed to demonstrate the operability of a Kite based generator on board a vessel, producing electric energy from high altitude wind, able to power the on board services and motors of the vessel. Even if the final tests on board a vessel have not been realized within the project, several results have been obtained and a deeper theoretical basis has been given to the concept. The adoption of the system on board, according to the work performed, seems to grant a significant saving in terms of fuel consumption: final performances of the KitVes system are expected in a significant fuel saving, according to the kind of vessel on which will be installed. The generator may also help in emergency maneuvering under certain conditions thus becoming an emergency safety device able to apply thrust onto the vessel's hull even in case of total loss of control by mean of standard procedures (e.g. engine or helm failure). Finally the system contributes to the reduction of the footprint of vessels, which is nowadays (together with the bulk costs) one of the main problem of sea transport.

1.4 Societal implications

Indirect societal significant benefits may be envisaged following to the reduction of the vessel's footprint and from the cost reduction due to the fuel costs restraint, both resulting from the usage of the system. Potentially interested target groups are:

- ship makers, ship owners, fleet owners
- Policy makers active in the maritime transportation sector
- Policy makers active in the environment regulations sector

1.5 List of beneficiaries

Beneficiary	**Sequoia Automation S.r.l.** (coordinator)
Address	Corso Lombardia 63C 10099 S. Mauro Torinese (Torino) ITALIA
Contact person:	Mr. Marcello Corongiu
☎	+39 011 22 36 826
✉	m.corongiu@sequoiaonline.com
Beneficiary	**Bergische Universität Wuppertal**
Address	Gaußstraße 20 42119 Wuppertal DEUTSCHLAND
Contact Person:	Mrs. Prof. Dr.-Ing. Habil. Petra Winzer
☎	+49 202 439-2060
✉	fgproqu@uni-wuppertal.de
Beneficiary	**Centro Studi Industriali - Ce.S.I.**
Address	Cologno Monzese, (MI) ITALIA
Contact person:	Mr. Angelo Merlo
☎	+39 02 25118098
✉	merlo@cesi.net
Beneficiary	**Haute Ecole Arc Ingénierie**
Address	Espace de l'Europe 11 2000 Neuchâtel SUISSE
Contact Person:	Ms. Valerie Briquez
☎	+41 32 930 13 13
✉	valerie.briquez@he-arc.ch
Beneficiary	**Katholieke Universiteit Leuven**
Address	Oude Markt 13 - bus 5005 3000 Leuven BELGIUM
Contact Person:	Mr. Farid Al-Bender
☎	+32 16 3 24010
✉	farid.al-bender@mech.kuleuven.be

Beneficiary	**Modelway**
Address	Via Livorno, 60 10144 Torino ITALIA
Contact person:	Mr Ilario Gerlero
☎	+39.011.2258261
✉	ilario.gerlero@modelway.it
Beneficiary	**Sheffield University - AMRC**
Address	Advanced Manufacturing Park Wallis Way, Catcliffe Rotherham S60 5TZ UNITED KINGDOM
Contact Person:	Mr. Keith Ridgway –
☎	+44 (0)114 222 1747
✉	k.ridgway@sheffield.ac.uk
Beneficiary	**SVMtec**
Address	Bergnelkenstr. 7 D-70563 Stuttgart DEUTSCHLAND
Contact Person:	Mr. Detlef Bergmann
☎	+49 (0)711 391867-0
✉	bergmann@svm-tec.de
Beneficiary	**TECNALIA**
Address	Parque Científico y Tecnológico de Gipuzkoa Mikeletegi Pasalekua, 7 E-20009 Donostia - San Sebastián (Gipuzkoa) ESPANA
Contact Person:	Mr. Alex Estevez Plaza
☎	+34 946.430.850
✉	alex.estevez@tecnalia.com
Beneficiary	**TEKS Scarl**
Address	23 Rue du Praya 05100 Montgenevre FRANCE
Contact Person:	Mr. Roland Krain
☎	+44 77 02 27 49 79
✉	roland.krain@teks.eu.com

Project logo:

Website: www.kitves.com