HYCELTEC 2017
VI Symposium on Hydrogen, Fuel Cells and Advanced Batteries
Porto, Portugal, 19-23 June 2017

Improving efficiency and operational range in unmanned vehicles using fuel cells (IUFCV Project)

E. López González[1*], F. Isorna Llerena[1], M.A. Ridao Carlini[2], C. Bordons Alba[2], A. Elfes[3], E. Hernandez[3]

[1] Instituto Nacional de Técnica Aeroespacial (INTA), Área de Energías Renovables-CEDEA, Ctra. S.Juan-Matalascañas, km.34, 21130, Mazagón-Moguer (Huelva), Spain

[2] Universidad de Sevilla, Departamento de Ingeniería de Sistemas y Automática, Camino de los Descubrimientos s/n, 41092, Sevilla, Spain

[3] CSIRO, Data 61 Robotic Group, QCAT 1 Technology Court, Pullenvale, Queensland, 4069, Australia

(*) lopezge@inta.es

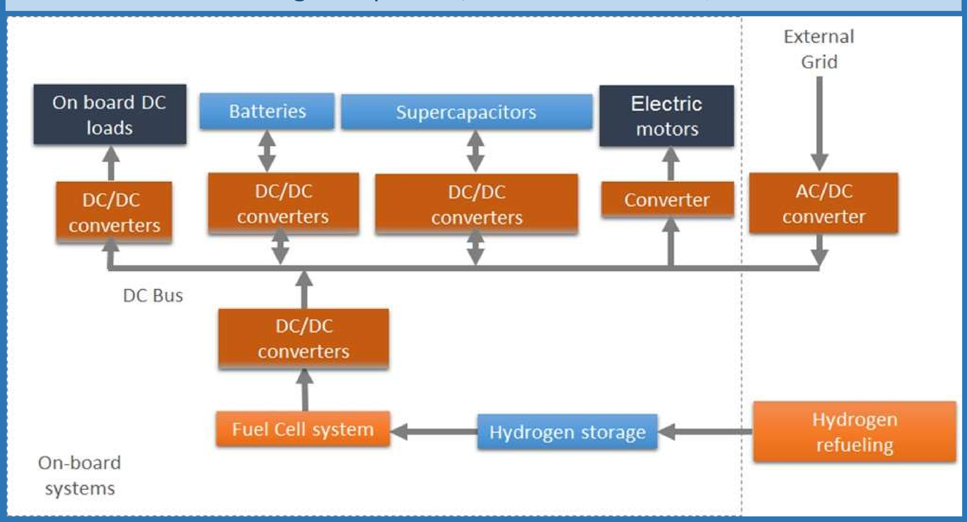
http://www.iufcv.com

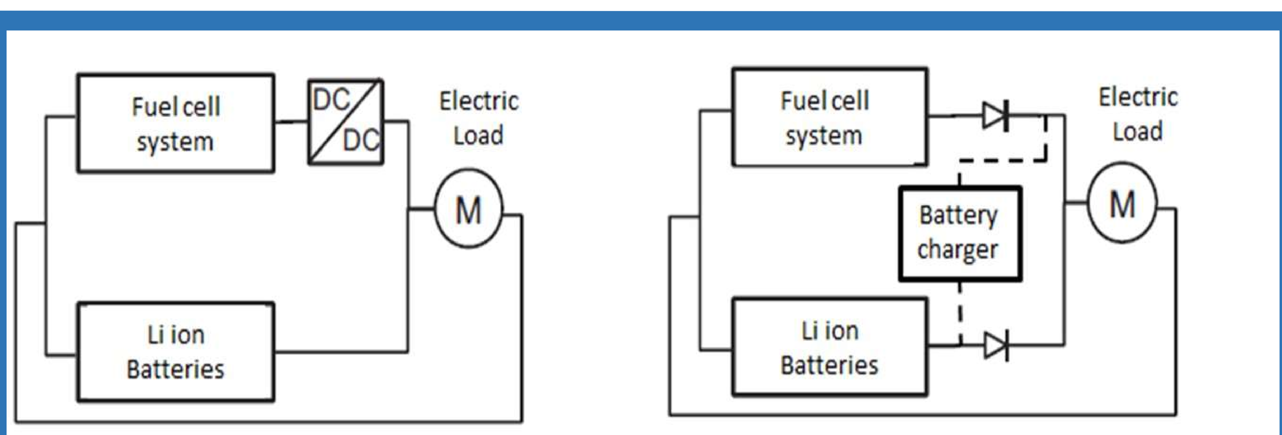
Introduction

Unmanned systems offer many possibilities for industrial, scientific and security applications, due to their ability to provide in real-time high quality data at lower cost than conventional techniques commercially available.
Most of the current electric unmanned vehicles use lead acid or lithium ion batteries, providing a limited endurance and performance. The use of hybrid systems, which combine different energy storage and conversion technologies, is an interesting option for power systems in unmanned vehicles , due to their ability to achieve higher specific energy and energy density than pure battery systems, and improve in this way the endurance of the vehicles.

Hybrid power systems in unmanned vehicles

The joint use of fuel cells with batteries and/or supercapacitors is taking an increasing role in several unmanned mobile platforms. Typically, fuel cells and batteries are arranged in parallel, with or without DC/DC converters





a) Conventional hybrid system (active configuration) b) Direct hybrid system (passive configuration)

Hybrid power systems with fuel cells and batteries can be arranged in topologies with active control systems (typical configuration with DC/DC converters) or passive (with direct coupling among components system).

	Active configuration	Passive configuration
Advantages	• Decoupling of sizing and operating conditions in batteries and fuel cell • More precise control of the power system	• Lower losses • Reduced cost • Simpler architecture
Disadvantages	• More complex system topology • Reduced efficiency due to losses at the voltage • Higher system cost • Higher weight and volume	• Active power control is not possible, • Careful design and integration of fuel cells and batteries

Project description

Objectives

- Design, development, implementation and testing of hybrid power systems, based on batteries and proton exchange membrane (PEM) fuel cells.
- Evaluation in three existing autonomous vehicle platforms for exploration and reconnaissance applications(two unmanned ground vehicles, UGVs, and one autonomous underwater vehicle, AUV) , in order to analyze the improvement in performance in relation to current configurations based on batteries

Partners and roles

- National Institute for Aerospace Technology (INTA), Area of Energy:
  - Development of hybrid power systems, using COTS components and prototypes. Integration in an UGV. Evaluation of unmanned vehicles.
- Commonwealth Scientific and Industrial Research Organization (CSIRO), Robotics Group, Autonomous Systems Lab, Data61:
  - Development of two autonomous vehicles (an AUV and a UGV) based on existing platforms. Integration of hybrid power systems. Evaluation of unmanned vehicles.
- University of Seville, System Engineering and Automation Department:
  - Development of advanced control algorithms and their implementation to optimize the operation of the hybrid power systems in robotic platforms.

End Users

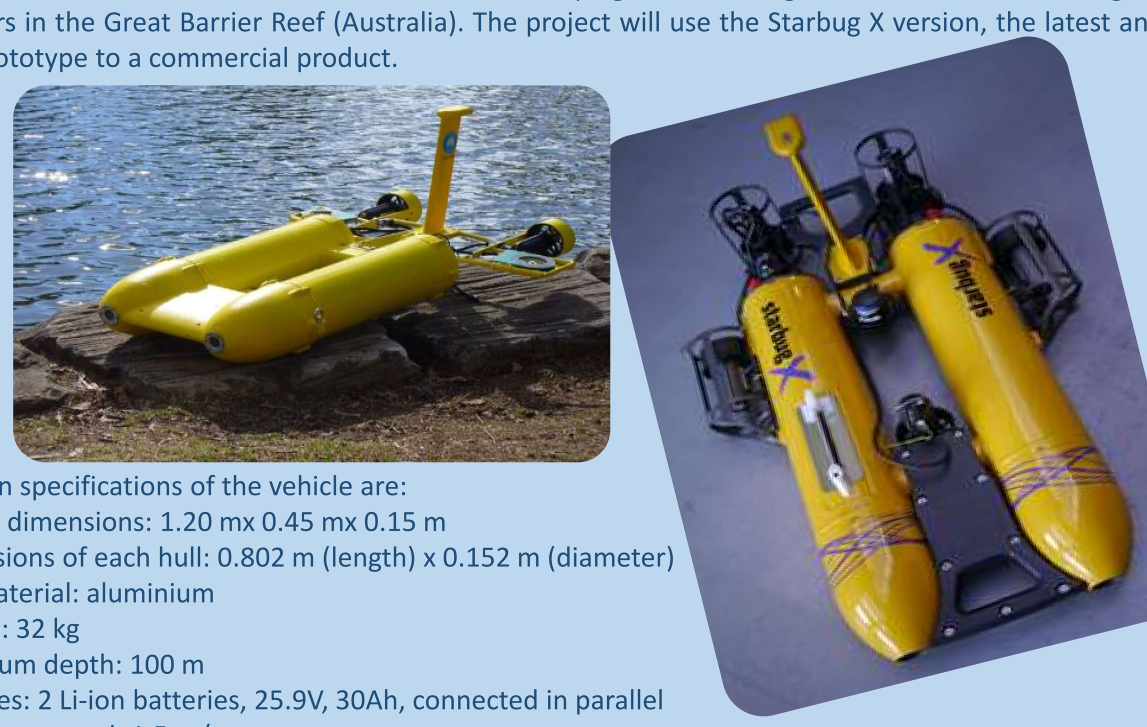
- Queensland State Department for Agriculture and Fisheries (QDAF), Australia
- Biodiversity and Ecology of Marine Invertebrates Team of the University of Seville (BEMI-US), Spain
- NBCR Department, INTA, Spain

Criteria for success

- Specific energy of the fuel cell hybrid power systems > 180 Wh/kg (without O_2 storage in AUV) (typical values in Li ion batteries, at system level, are around 130-150 Wh/kg)
- Endurance of fuel cell UGVs (in runtime-nominal usage) > 7 hours
- Endurance of fuel cell AUV > 10 hours
- Recharging time < 5 min (pressurized hydrogen)
- Availability of the power system > 95%
- Achievement of end user requirements
- Application of existing RCS related to the safe use of hydrogen and fuel cells

Unmanned platforms in the project

The Starbug unmanned underwater vehicle has been designed and built by CSIRO for shallow water surveillance and monitoring missions, primarily on coastal reefs, harbours and estuaries, and inland lakes. This platform has been used in several surveillance campaigns, measuring environmental and biological parameters in the Great Barrier Reef (Australia). The project will use the Starbug X version, the latest and closest prototype to a commercial product.



The main specifications of the vehicle are:

- Overall dimensions: 1.20 mx 0.45 mx 0.15 m
- Dimensions of each hull: 0.802 m (length) x 0.152 m (diameter)
- Hull Material: aluminium
- Weight: 32 kg
- Maximum depth: 100 m
- Batteries: 2 Li-ion batteries, 25.9V, 30Ah, connected in parallel
- Maximum speed: 1.5 m/s
- Maximum autonomy (at 0.6 m/s): 8 hours

The Husky unmanned ground vehicle (UGV), used by the Robotic Group in CSIRO, is an all-terrain platform used for rapid prototyping and field testing of sensors and actuators. This platform is used by CSIRO in different projects, such as gas detection in mining applications, by the integration and evaluation of specific sensors. The platform has been retrofitted also with a Terabot-S manipulator.

The main specifications of the Husky platform, according to the manufacturer, would be:

- Weight: 50 kg
- Maximum payload (bitumen or concrete / flat ground): 75 kg
- Maximum payload (all terrain): 20 kg
- Maximum speed: 3.6 km / h
- Batteries: Lead acid, 24 V and 20 Ah capacity
- Autonomy: nominal 3 hours, basic 8 hours

The Energy Area of INTA has in its facilities in Huelva a Summit XL UGV, used for testing different power systems configurations and technologies, as well as to integrate sensors and simulate missions defined by other users.

The main characteristics of this platform, according the manufacturer, are as follow:

- Weight: 45 kg
- Max. payload: 20 kg
- Speed: 3 m/s
- Drive system: 4 wheel, 4 brushless motors
- Batteries: 8x3.3V LiFePO4
- Autonomy: 5 hours (continuous usage), 20 hours (standard laboratory usage)

The main innovations in the project for the UUV would be:

- **Power system based on a 400-500 W liquid cooled PEFC and batteries. hydrogen storage in metal hydride or complex hydrides cartridges (e.g. NaBH4).**
- **Oxygen in pressurized tank. In addition, a system for on-board oxygen generation from hydrogen peroxide will be developed and tested.**

The main innovations in the project for the UGVs would be:

- **To increase the autonomy for both platforms up to seven hours of continuous usage, maintaining its core capabilities in terms of payload.**
- **Power systems based on open cathode and air cooled PEFCs and Li ion batteries.**
- **Compressed hydrogen and metal hydrides will be the hydrogen storage technologies used in the platforms.**
- **Passive hybrid configuration, with direct coupling between batteries and fuel cells.**
- **More information: http:// www.iufcv.com**

Acknowledgements
"Improving efficiency and operational range in low-power unmanned vehicles through the use of hybrid fuel-cell power systems" (IUFCV) is a project co-funded by the Science Program for Peace and Security (SPS) of NATO (SPS Ref. No. G5079), which aims to promote scientific cooperation and research between NATO members and third countries.

NATO OTAN
This project is supported by: The NATO Science for Peace and Security Programme