NAUTILUS

D5.2 – Report on battery management unit (BMU)

Project Acronym:	Nautilus
Project Title:	Nautical Integrated Hybrid Energy System for Long-haul Cruise Ships
Project coordinator:	Dr. Asif Ansar, Deutsches Zentrum für Luft – und Raumfahrt (DLR)
Programme:	Horizon 2020 Framework Programme
Topic:	LC-MG-1-8-2019 Retrofit Solutions and Next Generation Propulsion for Waterborne Transport
Instrument:	Research & Innovation Action (RIA)

Deliverable D5.2 – Report on battery management unit (BMU)

Short summary: This deliverable is the report on the Battery management unit (BMU), which ensures that the battery is working within a safe operation window and provides information of the battery system for diagnosis and the control unit. The battery is supposed to ensure fast transient operations based on the ship's electrical load profile. Additionally, the BMU will predict the available power or energy for upcoming time intervals (e.g. next 5 s, 30 s, 60 s, 15 min for FC-ramp up) with prediction algorithms (e.g. state of
available power/energy). The control strategy will utilize these algorithms to conduct the power management for the components (battery and fuel cell system).

Due date: 31/12/2022
WP, leader: WP5, RWTH Aachen University
Authors: Cem Ünlübayir, Alexander Blömeke, Dirk Uwe Sauer

Dissemination Level

PU	Public	☐
PP	Restricted to other programme participants (including the Commission Services)	☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☒

Document history

Version	Date	Name	Chapters edited	Reason for change
V0.1	20/12/22	Cem Ünlübayir	All	Document prepared
V0.2	21/12/22	Cem Ünlübayir	All	Document prepared
V1.0	22/12/22	Cem Ünlübayir, Alexander Blömeke	All	Document approved

List of participants		
Participant No	**Participant organisation name**	**Country**
1 Coordinator	Deutsches Zentrum für Luft –und Raumfahrt (DLR)	DE
2	Chantiers de l'Atlantique (CdA)	FR
3	Carnival Maritime GmbH (CM)	DE
4	Ecole Polytechnique Fédérale de Lausanne (EPFL)	CH
5	GRANT Garant (GG)	CZ
6	Lloyd's Register EMEA (LR)	UK/DE
7	MAN Energy Solutions (MAN)	DE
8	Meyer Werft PAPENBURG (MW)	DE
9	Rijksuniversiteit Groningen (RUG)	NL
10	Rheinisch-Westfälische Technische Hochschule Aachen (RWTH)	DE
11	SOLIDPower SPA (SP_SPA)*	IT
12	Technische Universiteit Delft (TUD)	NL
13	Lunds Universitet (ULUND)	SE
14	Teknologian tutkimuskeskus VTT (VTT)	FI
15	SOLIDPower SA (SP_SA)*	CH

*SOLIDPower SA is fully owned by SOLIDPower SPA

Content

1 Introduction

Marine transport, which accounts for about 90% of the global trade goods in the economy, is one of the largest producers of greenhouse gases and is responsible for 2.9% of pollutants [1]. Within the frames of a research project, a novel propulsion system for a marine application is developed. To operate the battery and the energy management, an essential component for the additional monitoring of a battery system is developed. Parts of the development are described in this report. The drivetrain is powered by a novel propulsion system consisting of a lithium-ion battery and a solid oxide fuel cell. The battery aims to cover the transient power demands as the fuel cell is not capable to cover the dynamic load fluctuations. Within the NAUTILUS research project, a complete process design and digital demonstrator of a fully integrated onboard energy system of a size between 5 and 60 MW will be developed. This system will be developed for two types of cruise ships: 1000 and 5000+ passenger vessels.

To ensure safe operation, battery systems require a battery management system (BMS). The BMS keeps track of the condition of the battery cells and ensures that the battery cells are operated within a safe operating range. In addition, various algorithms can be used to calculate important battery states, such as state of charge (SOC) similar to a fuel gauge or state of health (SOH), which is the remaining usable capacity of the battery. To connect the battery system to an energy management unit, additional state signals can be calculated to increase efficiency. To achieve the purpose of calculating additional state signals, a battery management unit (BMU) was developed for the test bench stages within this research project. The BMU will act as a gateway between BMS and EMU and additionally calculate signals, which are used in the EMU to enhance the overall fuel economy of the propulsion system. Based on the measurements from the battery system, the BMU calculates additional battery state signals. The results of these calculations can be directly processed by the energy management unit for efficient power distribution.

This report describes the development of a hardware submission D5.1 “Battery management unit from RWTH Aachen” that was conducted in month 24 of the project period (June 2022). This final report shall describe and present the development work, as well as the achieved results of the hardware within the scope of the cruise ship application and the current test bench development status.

The BMU will be utilized within the different test bench systems. Firstly, in the proof of concept (PoC)-test bench and secondly within the 60 kW-demonstrator unit to demonstrate the functionality of the target propulsion system. Therefore, the deliverables D5.3, as well as D5.4, depend on the completion and submission of the BMU.

Within the scope of this research, the BMS is required to monitor the battery system and cells and additionally set the operating state. Therefore, BMSs should be able to communicate with the battery system. During the communication process, signals are transferred, and requests are made. That leads to the key task of this report, which can be divided into the following two parts.