Assessing Antenna Performance and Electromagnetic Impact (SAR) on the Head Using Variously Structured Models of Wearable Radiofrequency Communication Devices

Patryk Zradziński, Jolanta Karpowicz, Krzysztof Gryz
CIOP-PIB, Warszawa, Poland
pazra@ciop.pl; jokar@ciop.pl; krgry@cop.pl

INTRODUCTION

Many new technologies (Industry 4.0, Internet of Things, e-Health, e-mobility etc.) employ applications based on the wireless data transmission using a radiofrequency module (**RFM**).

A key part of these systems are specific devices worn on or close to the body, which need (in accordance with safety requirements) assessment of compliance with SAR limits (Directive 2013/35/EU).

AIM OF THE STUDY

To examine the impact of the structure of models of device equipped with a communication **RFM** on its key functional parameters (antenna performance, battery operating time), and associated SAR.

MATERIAL AND METHODS

- ❑ **RF EMF source**: wearable RF communication device (**W-RFCD**) (equipped with a RFM operating @ 2.45 GHz) in **free space** and located on the **head**
- ❑ **W-RFCD structure (complexity and spatial configuration)**:
  exposure scenarios regarding:
  - model: (**A**) RFM only, (**B**) RFM and its battery or (**C**) RFM, battery and case;
  - battery placement: (**1**) the battery side to the RFM or (**2**) covering it.

  RF module located 1 mm away from battery (7 mm away from head model).
- ❑ **Head model**: multi-layer ellipsoids (skin, fat/SAT, bones and grey matter)
- ❑ **Simulations**: Sim4Life software (Zurich Med Tech, Zurich, Switzerland), expanded uncertainty estimated as ±(40-50)%

RESULTS

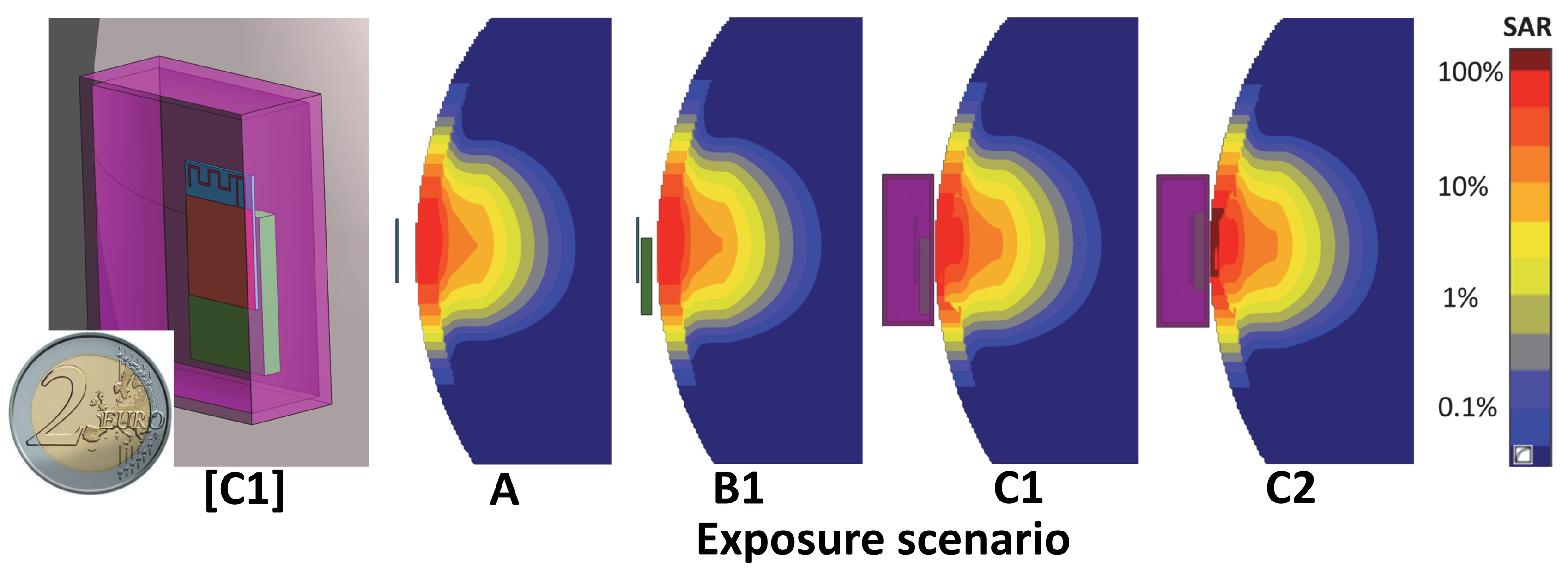

Fig. 1. Numerical model and 10g-SAR distributions in the user's head of W-RFCD (operating @ 2.45 GHz)

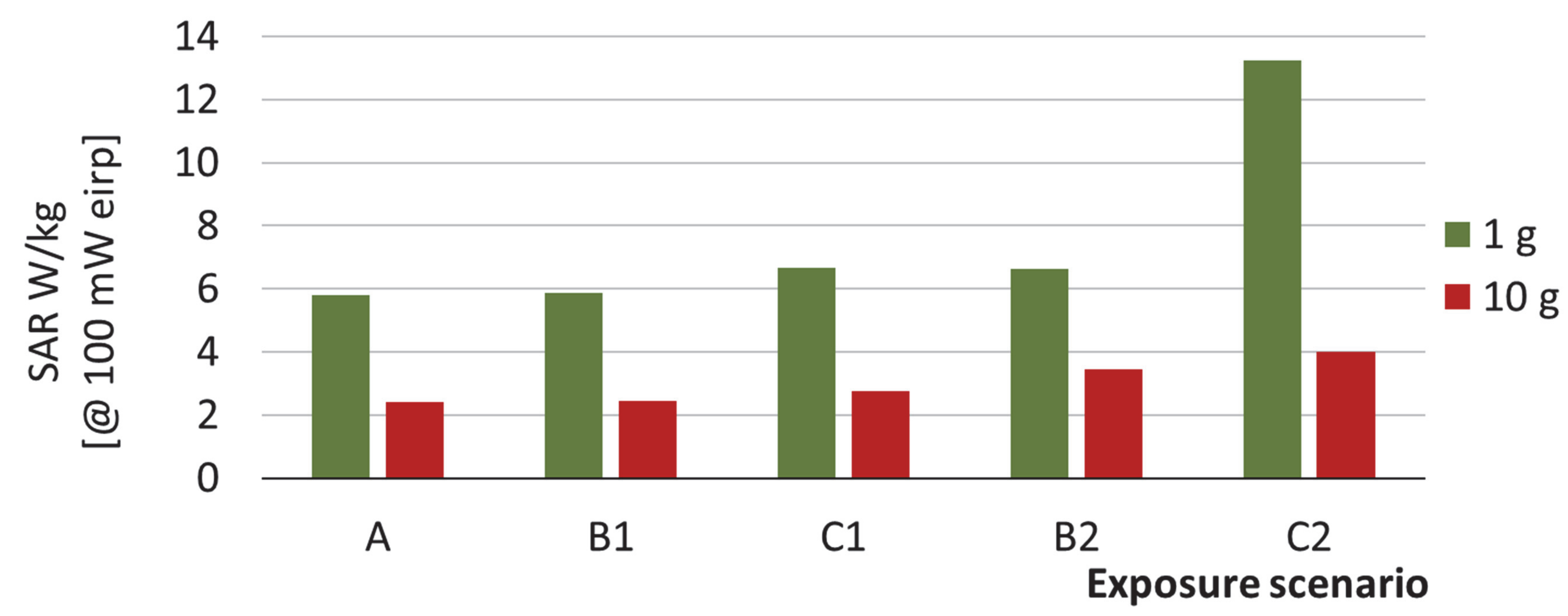

Fig. 2. Local SAR in the user's head of W-RFCD (operating @ 100 mW eirp, 2.45 GHz)

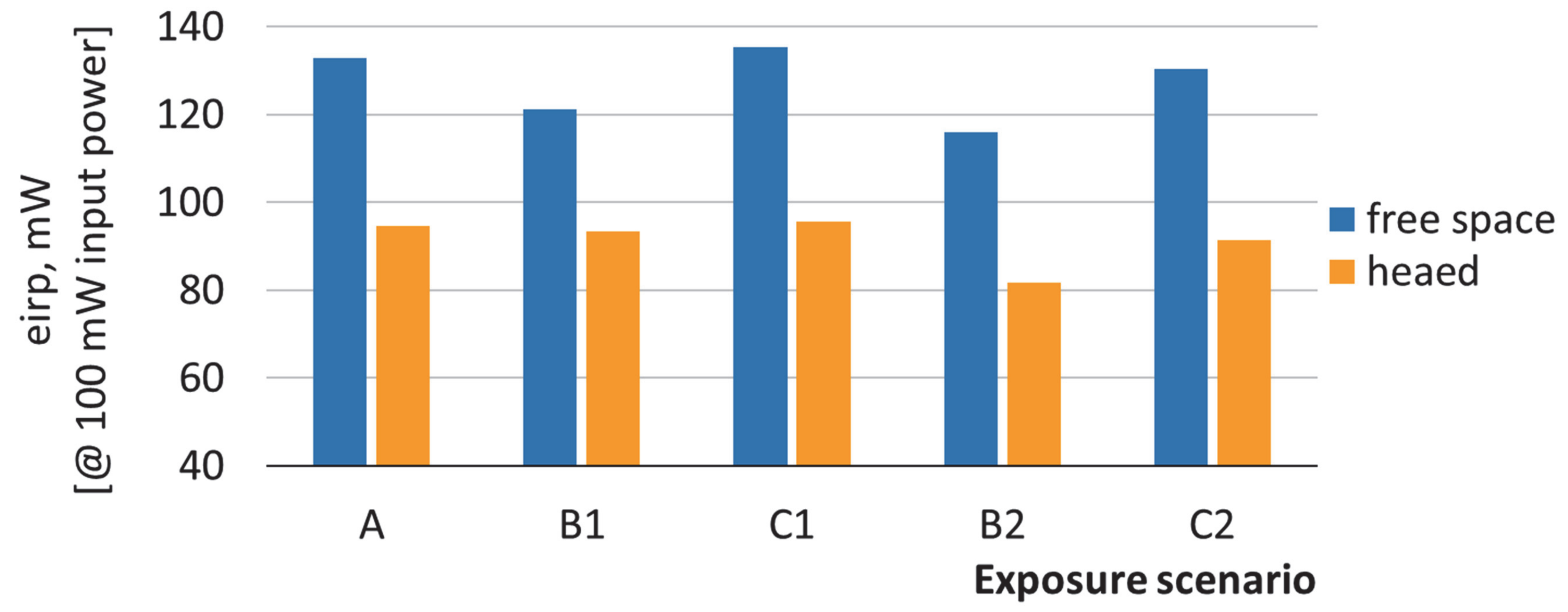

Fig. 3. Eirp (equivalent isotropic radiated power) of antenna of W-RFCD in free space and located on the head (operating @ 100 mW input power, 2.45 GHz)

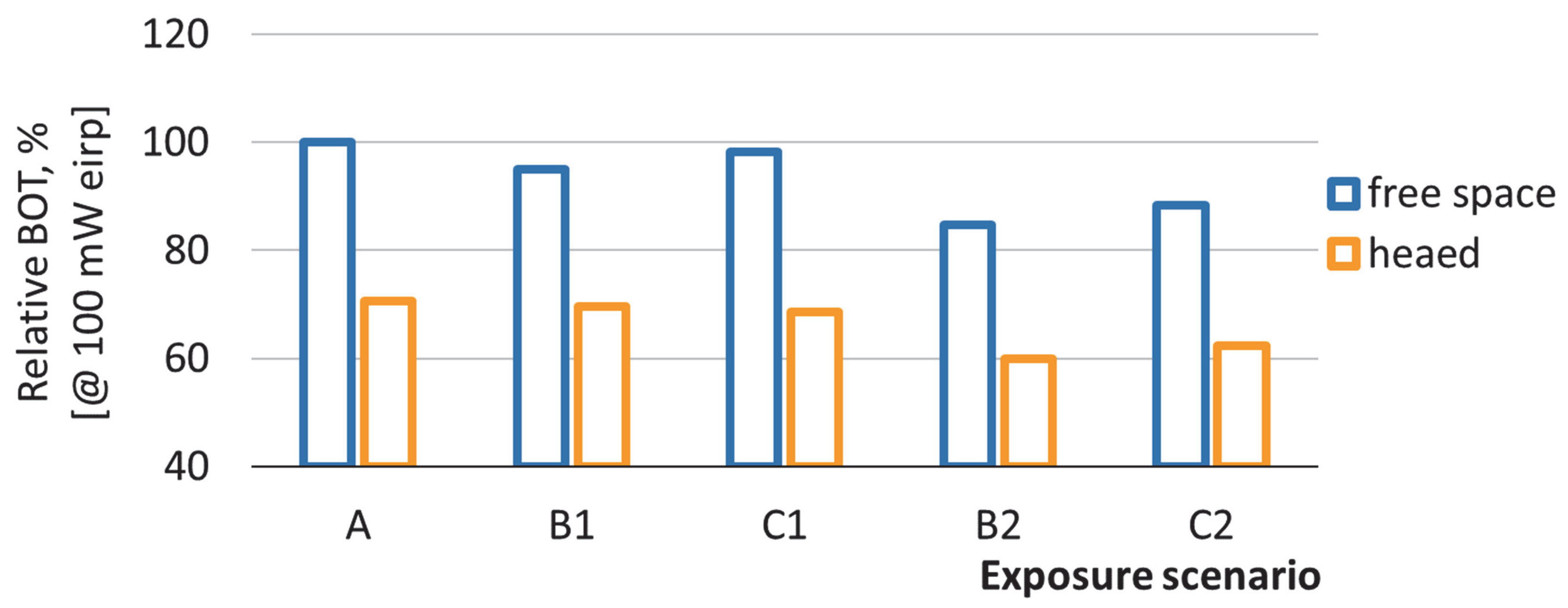

Fig. 4. Relative Battery Operating Time (BOT) of antenna of W-RFCD in free space and located on the head (operating @ 100 mW eirp, 2.45 GHz) [reference exposure scenario: A in free space]

Results regarding the 10g-SAR in the user's head:

- ❑ up to **66%** higher in exposure scenario C2 compared to A
- ❑ up to **45%** higher in exposure scenario C2 or B2 compared to C1 or B1
- ❑ up to **3-time**s lower compared to 1g-SAR
- ❑ may exceed the limits for general public exposure @ **55** mW input power (**51** mW eirp) in exposure scenario C2

Results regarding key functional parameters of antenna emissions:

- ❑ **20-30 %** decrease in antenna performance when it is located close to human body (comparing eirp level obtained for RFM near the head and in free space)
- ❑ **30-40 %** reduction in battery operating time compared to battery operating time for the antenna only (scenario A) in free space

CONCLUSIONS

Optimization of the W-RFCD (simultaneous maintenance of its functionality and the reduction of SAR) should take into account:

- ❑ significant impact of device structure (complexity and spatial configuration) on: (1) antenna performance, (2) related battery operating time and (3) the associated SAR in the user's head
- ❑ W-RFCD modelling covering at least main components and their spatial configuration, especially in relation to the antenna

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