



[www.armor-project.eu](http://www.armor-project.eu)  
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ADVANCED  
MULTI-PARAMETRIC  
MONITORING AND ANALYSIS  
FOR DIAGNOSIS AND OPTIMAL  
MANAGEMENT OF EPILEPSY  
AND RELATED BRAIN  
DISORDERS



ARMOR newsletter Issue 3, May 2014

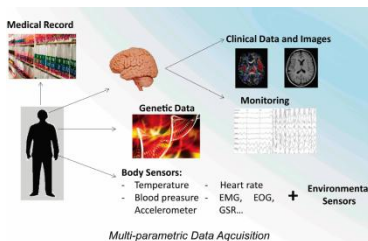
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*ARMOR: An innovative application for the management of epilepsy.*

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## ARMOR Overview

ARMOR aims to put together the components needed for an ambulatory, non-intrusive Personal Health Record based System (PHR-S) for home monitoring of epileptic patients. The design addresses the needs of patients and healthcare professionals through the development of tools for accurate diagnosis (e.g. is it really epilepsy? if yes, of what type?), monitoring and analysis for specific clinical scenarios defined by the UK clinicians in the consortium. This PHR-S would allow reliable detection of life threatening seizures by acquiring relevant data from the brain as well as several body systems at individual level and at the patient's home, thus avoiding hospital stays and drastically reducing costs while improving the level of care and the quality of life of the patient.

## Upcoming Highlights

### Future Events:

ARMOR will be presented in the following events:

- The 2014 International Conference on Wearable and Implantable Body Sensor Networks (BSN 2014) in Zürich, Switzerland, 16-19 June (<http://www.bsn2014.org>).
- The 11th European Congress on Epileptology in Stockholm, Sweden, 29 June-3 July 2014 (<http://www.epilepsystockholm2014.org>).
- The European Conference on Networks and Communications 2014 in Bologna, Italy, 23-26 June (<http://eucnc.eu>).
- The 19th International Conference on Biomagnetism in Halifax, Canada, 24-28 August (<http://www.biomag2014.org>).
- The STIFTUNG MICHAEL Foundation "Michael Forum", in Bonn, Germany, 9-12 Oct 2014 (<http://www.stiftungmichael.de>).

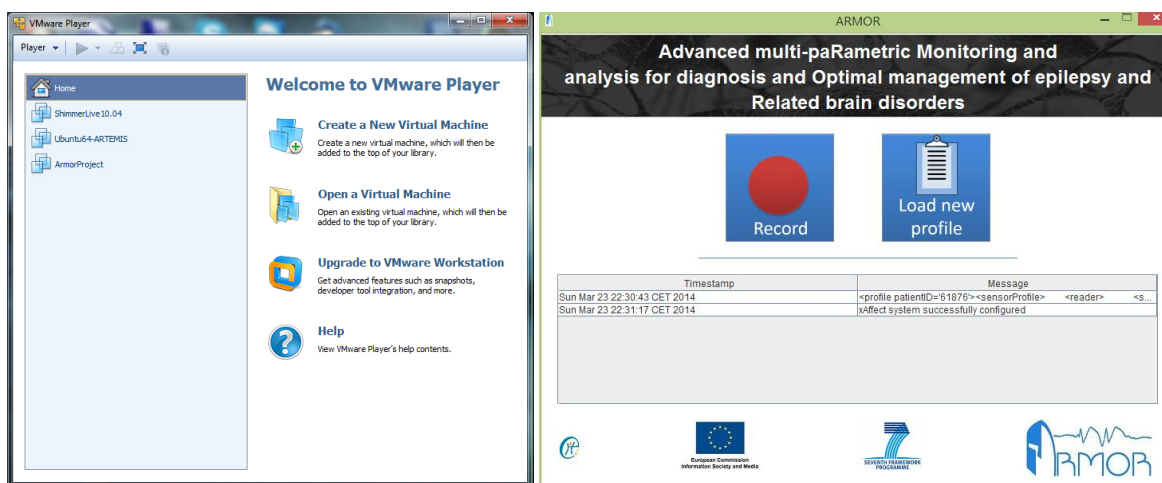
### Publication:

A book entitled "Cyberphysical Systems for Epilepsy and Related Brain Disorders - Multi-parametric Monitoring and Analysis for Diagnosis and Optimal Disease Management" has been accepted for publication by Springer in late 2014. There will be 20 chapters in the book with topics on epilepsy medical background and cyberphysical systems (i.e. integration of computation with physical processes) for multimodal monitoring.

## Latest News

### Virtual Machine (VM):

A VM has been developed to demonstrate the capabilities of the ARMOR platform to clinicians for evaluation purposes. It has two major functionalities, (1) personal health record functionality, which allows the input of user-related credentials, custom information management (e.g. sensors, equipments etc.); (2) gateway functionality, which allows online data collected and analysed in real time and transferred from sensor devices via Bluetooth connection to the home gateway. The VM was successfully installed at King's College London; multi-parametric recordings have been tested and further offline and online investigation of medical cases is in progress.



### Past Events:

- eHealth Forum 2014 in Athens, 12-14 May (<http://ehealth2014.org>).
- CeBIT 2014 (the world's largest and most international computer expo) in Hannover, Germany, 10-14 March (<http://www.cebit.de>).
- Mobile World Congress 2014 in Barcelona, Spain, 24-27 February (<http://www.mobileworldcongress.com>).
- ICT 2013 - Create, Connect, Grow, in Vilnius, Lithuania on 6-8 November, 2013 (<http://ec.europa.eu/digital-agenda/en/ict-2013>): A demo for the ARMOR platform - capture data from the sensors (EEG, ECG, Activity), pre-process, encrypt and monitor the parameters in real-time, and then the data are sent to a database for consultation.
- MEDICA 2013 in Düsseldorf on 20-23 November 2013 (<http://www.medica-tradefair.com>), an international trade fair and congress for medical technology, electro-medicine, laboratory equipment, diagnostics and drugs.
- Clustering workshop on brain and eHealth in Brussels on 5 November 2013: A summary of the ARMOR project objectives and achievements was given for sharing experiences with other eHealth projects.
- Training course "7th Migrating Course on Epilepsy" in Nicosia, Cyprus on 3-9 November 2013 (<http://www.cing.ac.cy/mce2013/>): A lecture entitled "Diagnostic Evaluation: MEG vs. EEG" and a tutorial entitled "MEG/EEG/Home monitoring" using ARMOR scenarios were given a few times during the course.



ARMOR presentation at eHealth Forum 2014



at Mobile World Congress 2014



at 7th Migrating Course on Epilepsy

## Partner News

**Sensing & Control (S&C) News:** DG CONNECT, in its preparation for Horizon 2020, is running an "Innovation Radar" pilot. The pilot focuses on identifying high potential innovators from projects and guiding them to tailor-made expertise and support that could increase their success to deliver impact in the market. In order to test the concept, through an internal procedure and from the EC project portfolio, 40 SMEs/market oriented research teams were selected by their high innovation potential. S&C, in the context of ARMOR project, was among those selected. S&C is a technology based SME company specialised in bringing to the market Internet of Things solutions and Smart Home services. For the ARMOR project, S&C is developing a business model dealing with the integration of Health services for the users of the Digital Home platform.



S&C stand of ARMOR Project at the event ICT 2013 in Vilnius (Lithuania)

**Technological Educational Institute of Western Greece (TWG) News:** Computer and Informatics Engineering Department (Embedded Systems Design and Application Lab) of TWG will co-chair 24<sup>th</sup> International Conference on Field Programmable Logic and Applications, which will take place in Munich, Germany, 2-4 September 2014 ([www.fpl2014.org](http://www.fpl2014.org)).

**University of Patras (UoP) News:** Prof George K. Kostopoulos will give an invited talk "Long term multimodal monitoring of epileptic patients at home: The experience of FP7-ICT project ARMOR (2011-2014)" at the "Michael Forum" from the STIFTUNG MICHAEL Foundation of Germany, a biannual conference of all past winners of the Michael Price in Epileptology.

**CONSORTIUM**

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For more information about the ARMOR project visit us at [www.armor-project.eu](http://www.armor-project.eu).

## ARMOR's Column:

### A Practical Example for ARMOR Usage:

John is a 27 year old civil servant who has been suffering from episodes of panic since the age of 14 when he was extremely stressed in his boarding school. He reported a sudden feeling of anxiety, and palpitations, while his girlfriend described that he would go pale and sweaty with dilated pupils, and on occasions he would faint. These episodes occurred randomly but also after stress. A diagnosis of epilepsy was initially considered, but the symptoms were highly atypical, his routine and sleep EEG and brain MRI were normal while a 10-days video telemetry as inpatient did not capture any event. ECG, echocardiography, exercise test and Holter for 48 hours were normal, while continuous loop monitoring captured only one episode of tachycardia that was not deemed causal. Tilt table test and several autonomic tests at a tertiary center were unremarkable. He had psychiatric treatment for 7 years. He lost his job but never stopped driving. At the age of 24 years he was monitored at home with an ambulatory personal health system. Habitual attacks were analyzed on line and were identified as epileptic seizures manifested with potentially life threatening autonomic symptoms. The patient was treated with antiepileptic medication and has been seizure-free for three years. He has a new job, drives safely and is no longer at risk of sudden death in epilepsy.

### Scenarios of ARMOR Usage:

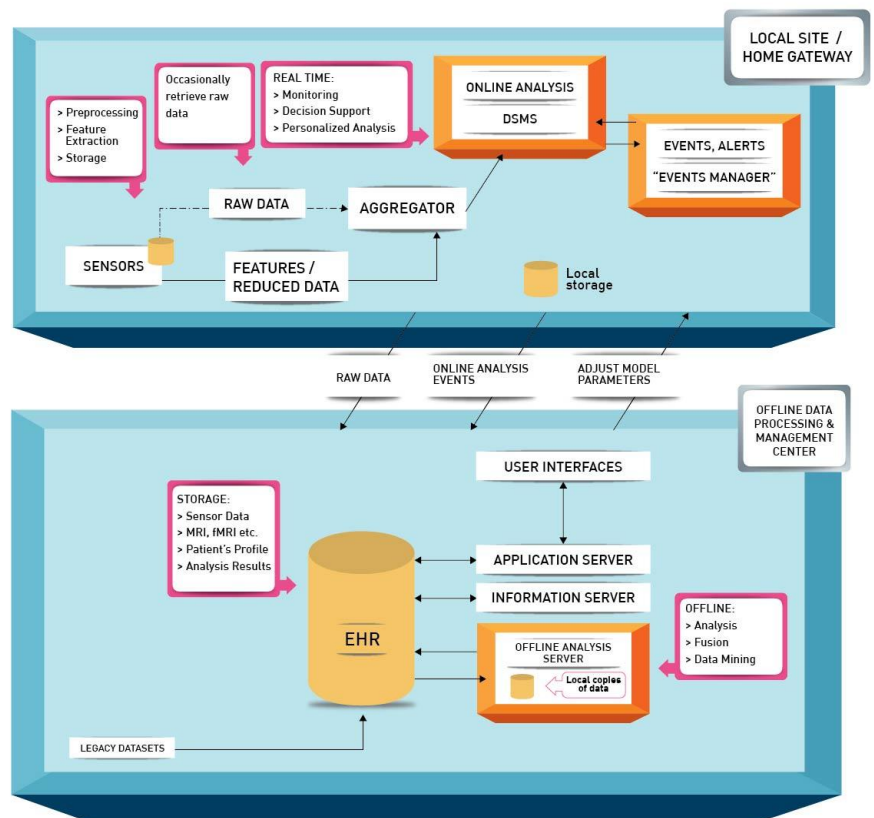
1. Is it epilepsy or non-epileptic paroxysmal events?
2. Delineation of clinical EEG expression of epilepsy types
3. Follow up - medication evaluation
4. Protection from seizures (on-line)
5. Research on signs of idiopathic generalized epilepsy
6. Pre-surgical evaluation
7. Nocturnal seizure

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*Our goal is to develop a personalized system that assists in diagnosis, prognosis and treatment of the disease. Such a system should be non-invasive, mobile, continuous and unobtrusive and all possible security and privacy aspects should be taken into account.*

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### ARMOR ICT components:



## Epilepsy and Sleep:

In ARMOR we included whole night polysomnography for two reasons. First for the unique experience offered for long term monitoring and rich data analysis, most crucial for making recommendations to ARMOR development. Second, it is known (since Hippocrates' time) that there is a strong link between sleep and epilepsy. There are types of epilepsies which are only nocturnal, or expressed at the interface between awake and sleep state or promoted by certain sleep stages. The latter as displayed in a hypnogram are usually defined through quantification of the presence of large graphoelements in the EEG, i.e. NREM stage 2 sleep (NREM2) is defined by the presence of spindles and K-complexes. It is therefore interesting that recent findings link epileptic ictogenesis more specifically to sleep instability, K-complexes and spindles. For these reasons, ARMOR medical research objectives have focused on the influence of sleep macro- and micro-structure on epileptic expression. Collaborative research efforts of three ARMOR teams (AAISCS - AAI Scientific Cultural Services Ltd, Cyprus; KCL - King's College London, UK; and UoP - University of Patras, Greece) with complementary capabilities, have already produced significant results in this direction:

- KCL is focusing on the clinical significance of sleep in seizure control not only for nocturnal seizures but also for general epileptic attacks.
- UoP has documented normal and epileptic sleep characteristics, by studying correlation between K-complexes (KC) and spindles. The work demonstrated distinct and dynamic interactions between theta bursts and KC. Furthermore previous findings relating epileptic ictogenesis to specific sleep events were expanded by a study of the spatiotemporal characteristics of the EEG ictal and interictal events.
- AAISCS has focused on the tomographic analysis of the whole-night sleep data recorded with MEG because of the superior spatial resolution provided by MEG. Unlike most earlier studies that have focused on the peaks of extreme excursions of the electrophysiological signal, the new analysis compared the gradual changes of activity that characterize the onset of sleep and the quiet periods of NREM2 sleep. This provided a framework for the analysis of the periods of spindles and K-complexes and the few seconds preceding them. The picture that emerges is one dramatic change at the onset of sleep followed by an elaboration of brain activity that allows the extreme excursions associated with spindles and K-complexes to emerge safely. A newly developed method for the tomographic analysis of EEG data was adapted to study interictal epileptic activity during specific sleep stages. The aim is to place normal (spindles and K-complexes) and epileptic (interictal rhythmic activity and spikes) graphoelements and their generators in the common context of the framework of changes identified in our tomographic analysis of sleep MEG data.

The benefit from this research might be a better understanding of mechanisms that operate during sleep that allow the emergence of large excursions in activity while preventing their generalization to pathological (e.g. epileptic) events. The utilization of this knowledge requires monitoring epileptic activity during sleep with simultaneous characterization of sleep stages. This need will be satisfied by the output of the ARMOR project: its home monitoring capability will allow such a characterization over extended periods and thus probe the evolution of epilepsy with unprecedented detail.

### Epilepsy Spike and Seizure Detection:

ARMOR's data analysis tools include the detection of epileptiform discharges (spikes) that are manifestations of an epileptogenic abnormality of the brain. The developed spike detector consists of two major steps. It first detects candidate spikes based on a mimetic approach, and then classifies the extracted waveforms based on machine learning techniques. Specifically, in the first step, the major peaks are detected and the EEG signal around the peaks is broken down into half-waves. Thresholding of morphological characteristics extracted from the half-waves, such as amplitude and duration, is applied to produce a number of candidate spike locations. The 'raw' EEG signal is then extracted from these candidate locations and classified in the second step as spike or background by performing dimensionality reduction based on Locality Preserving Projections and supervised classification using Support Vector Machines. The method achieves high sensitivity with low false positive rate in an intra-patient cross-validated setting and thus constitutes a valuable tool for automatic spike assessment.

Further, ARMOR's online tools are developed to monitor and identify abnormal brain activities that merit an alarming signal. Within the ARMOR framework, patients suffering from seizures are monitored through sensors and the multimodal data (EEG, ECG, EMG and EOG) are processed automatically (real-time by software tools) or semi-manually (offline with the support of software tools and visualizations) by neurology experts. In the ARMOR architecture, the seizure detection module (the EEG and ECG recordings) are used from the multimodal data, while EMG and EOG are mainly used for movement/artifact detection. The block diagram of the seizure detection architecture is illustrated below.

