

SAFEPower

D5.5 Survey and target audience definition for public demonstrator platform evaluation

V1.0

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Change log

VERSION	DESCRIPTION OF CHANGE
V0.1	First draft by OFF
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V0.4	Reviewed and format consolidation by IKL
V1.0	Submitted version

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1. EXECUTIVE SUMMARY

In this document, we will present a survey (questionnaire) and an analysis method for this survey to evaluate the usage of the SAFEPower reference platform in other domains not tackled within SAFEPower. This survey will be directly linked to the public SAFEPower demonstrator platform (which is the output of T4.3).

Furthermore, the targeted audience and possible distribution channels of the SAFEPower demonstrator platform and the survey will be defined. The targeted audience includes all members of the IAB (Industrial Advisory Board). The distribution of the public demonstrator will be supported in a comfortable and accessible way (e.g., by providing a virtual machine image containing a fully configured test system with the public demonstrator platform and a set of benchmarks on a dedicated website).

The execution monitoring of this survey and the results analysis and publication will be made available in D5.6.

2. INTRODUCTION

2.1. Purpose

This report describes the survey evaluation strategy for public demonstrator with respect to the SAFEPOWER overall goals.

The main objective is to validate the usability of the public demonstrator in the industrial context and to assess the exploitability of SAFEPOWER reference architecture.

2.2. Main view

This document is organized into 3 main sections in addition to the introductory sections and the final glossary:

- ◆ **Section 3** gives a general description of the goals of the public demonstrator to be assessed by the survey.
- ◆ **Section 4** presents the planned evaluation workshop of the public demonstrator, its target audience and its execution frame.
- ◆ **Section 5** sketches how these objectives can be evaluated through a survey questionnaire and presents the scientific methodology behind it.

3. GOALS OF THE SURVEY

The main objective of SAFEPOWER project is to enable the development of mixed-criticality systems with low power (LP), energy and temperature in combination with safety, real-time and security support by a reference architecture orchestrating different local power management techniques. SAFEPOWER builds a comprehensive suite of multi-core platform technologies as well as analysis, simulation and verification tools for low-power mixed-criticality systems, including hardware and software reference platforms assisting the implementation, observation, and test of such applications. SAFEPOWER architecture will provide connectivity, security and performance functions to the railway use case.

3.1. SAFEPOWER objectives

SAFEPOWER project targets achieving the following objectives:

- ◆ **O1: LOW POWER: To decrease the power consumption of Critical Real-Time Embedded Systems (CRTES) up to 50%**
- ◆ **O2: ENVIRONMENTAL: To improve the environmental friendliness of CRTES**
- ◆ **O3: DEVELOPMENT COST AND TIME: To reduce the development time by 25%**
- ◆ **O4: CERTIFICATION – STANDARDS:**
 - To pave the way towards the present or future certifiability
 - To decrease certification effort thanks to architectural core-services
- ◆ **O5: EXPLOITATION AND MARKET UPTAKE:**
 - To prepare the project results for market uptake and commercial exploitation
 - To promote low-power mixed criticality systems across the different target application domains and industrial sectors

For these objectives to be achieved and evaluated, basic features should be supported by the SAFEPOWER platform:

- 1) **Observability** of timing and other resource usage, i.e., memory and power consumption.
- 2) **Schedulability** of hard real-time applications under dynamic power and temperature management.
- 3) **Controllability** of power and temperature in mixed-criticality systems.
- 4) **Space, Weight and Power (SWaP)** and cost reductions compared to a traditional single-core distributed system implementation (energy/cost efficiency).
- 5) **Scalability** of hardware resource management with several applications of different criticalities.

- 6) **Portability** of power and temperature management techniques in “generic” COTS architecture and platforms.
- 7) **Effectiveness** of power and temperature management techniques in FPGAs.
- 8) **Accuracy** of virtual platforms with power and temperature models:
 - Degree of relative accuracy
 - Predictability and check of power peaks (IR-drop) and thermal peaks
- 9) **Certiability** of power and temperature management techniques.

Table 1: Mapping evaluation features to SAFEPOWER Goals

O1 Low Power (also O2)			O3: Development Cost and time (also O2)					O4: Certification
Controllability	Observability	Schedulability	Scalability	Accuracy	Portability	Effectiveness	Space, Weight, Power	Certiability

Table 1 shows the mapping of some basic features/metrics to the SAFEPOWER high-level objectives (O1- O4). E.g., to be able to achieve low power (O1, O2), *controllability* of the system resources should be established.

On the other hand, *observability* of the voltage rails or the power consumption should also be supported. Low-power schedules (*schedulability*) of the software tasks will help to achieve low power consumption. Similarly, to achieve O3, *scalability*, *portability*, *effectiveness*, *accuracy* and *SWaP* should be supported.

3.2. Survey goals

For the survey, the main goal is to test the effectiveness of the SAFEPower methodology with the help of the public demonstrator in terms of:

1. *Power saving*: of the public demonstrator with SAFEPower low-power techniques compared to an implementation not supporting that.
2. *Development & Debugging Time* (virtual platform versus PCB): here is the focus to show that with the help of the virtual platform, users are able to reduce long development times and have better-debugging options.
3. *Usability*: How easy to use are the development tools?

4. SURVEY EXECUTION & MONITORING PLAN

4.1. Target audience

The survey will be mainly executed within the project and direct outreach of the project. This includes all SAFEPower consortium member and all members of the Industrial Advisory Board (IAB). Participation of IAB members will be based on availability. A call for external evaluation and feedback will also be made publicly available to give other external parties the chance to participate.

The target audience which can be addressed by the survey can be categorized into two main groups:

1. *Virtual platform developers:* These are developers who are integrating or building their HW/SW verification environment with the help of virtual platforms (VP). As virtual platform developer this group is involved in the setup of a custom virtual platform. This involves adding of virtualized hardware components or modifying existing virtual platform configurations. In SAFEPower this group consists out of the Virtual Platform provider IMP and the developers of the virtual platform for the three use-cases: OFF for the public demonstrator and CAF and SAA for the industrial use-cases. Interesting would be here to evaluate the productivity improvement when using SAFEPower VPs compared to the traditional development process. In addition, the usability could also be assessed here.
2. *Virtual Platform users:* These are developers are using virtual platforms for the verification of their software without performing any modification on the virtual platform components (except for changing component configurations). Virtual platform users in the project are FEN (running an XtratuM on a VP), IKL (XDAL validation and fault injection), USI (XDRAL validation and functional testing of NOC functionality), SAA (avionics software integration testing) and CAF (railway software integration testing).
3. *End Users:* This group of users uses the infrastructure of SAFEPower and integrate it into their applications on top of the VP. From the project perspective these are end-users of the SAFEPower reference architecture outside the consortium. We consider the SAFEPower IAB (Industrial Advisory Board) members to be a representative candidate of this group. We will also start a call for external evaluation and feedback and invite project external parties to join the evaluation of the SAFEPower technology.

In the following we will address mainly the third group “End Users” and describe how to conduct the survey targeting this group within a one day meeting. For the other group SAFEPower consortium members will be interviewed and asked to fill out the survey based on their personal experiences.

4.2. Survey execution plan

4.2.1. Prerequisites

Before the execution of the survey the following prerequisites should be fulfilled (main responsible partner names in round brackets):

1. Publish announcement of SAFEPower evaluation workshop and call for participation on website and other dissemination channels. Personal invitation of dedicated parties (IKL)
2. Explicit Invitation of IAB members (IKL)
3. Virtual machine image preparation with ready to use SAFEPower virtual platform (IMP).
4. The final SAFEPower public demonstrator implementation on the virtual platform and on the PCB (OFF).
5. Planning and executing a Hands-on session (OFF, further responsibilities see below)
 - Tutorials of different SAFEPower technologies
 - Concrete tasks that the audience should achieve during Hands-on session

A first draft of these prerequisites will be described in the next sections. The final descriptions will be made available in the final deliverable D5.6.

4.2.2. Agenda/program of planned hands-on sessions

The target audience has been defined in section 4.1. IAB members and other external parties will be invited. All invited parties are potential end-users of the SAFEPower results.

MORNING (10:00-11:30 and 12:00-13:00)

10:00-10:10: “Welcome and Introduction” (10 min, Mikel Azkarate-askasua – IK4-IKERLAN)

The introduction motivates the research of mixed-criticality architectures and outlines the goals addressed by the SAFEPower project and more specifically by this survey.

10:10-11:30: SAFEPower Technologies and Demonstrator

Tutorial 1: *“OVP Zynq Virtual MPSoC -- Basics”* (20 min, Duncan Graham – IMPERAS)

Tutorial 2: *“How to setup multiple partitions with the help of XtratuM for Quadcopter public demonstrator”* (20 min, Salvador – FentiSS)

Tutorial 3: *“How to use SAFEPower virtual platform for Quadcopter public demonstrator”* (20 min, Sören Schreiner – OFFIS)

Tutorial 4: *“Adaptive scheduling for Quadcopter public demonstrator”* (20 min, Adele Maleki– University of Siegen)

11:30-12:00: Coffee Break

12:00-13:00: Hands-on session Part 1 (60 min, Peio Onaindia – IKERLAN)

13:00-14:00: Launch Break

AFTERNOON (14:00-16:00)

14:00-15:00: Hands-on session Part 2 (60 min, Adele Maleki – University of Siegen)

15:00-16:00: Survey execution session (60 min, Maher Fakhri – OFFIS)

4.2.3. Hands-on session

In the following a first draft of the Hands-on session is presented:

Title: Integration of mixed-criticality subsystems on multi-core and manycore processors with the help of SAFEPower virtual platform (VP).

Organizers:

- ◆ IK4-IKERLAN
- ◆ OFFIS
- ◆ Imperas
- ◆ University of Siegen
- ◆ FentISS

Place: TBD (Siegen)

Date: 3. Quarter of 2018

Website: Will be announced through <http://safepower-project.eu/> website

Description: Modern embedded applications typically integrate a multitude of functionalities with potentially different criticality levels into a single system. Without appropriate preconditions, the integration of mixed-criticality subsystems can lead to a significant and potentially unacceptable increase of engineering and certification costs. This session focuses on solutions for the integration of mixed-criticality subsystems on multi-core processors and virtualization solutions such as hypervisors. Key topics are multicore architectures, software solutions (tools & building blocks) and extra-functional requirements such as energy-power-thermal management, security and safety. Major technical results from most representative EC research projects in the field of mixed-criticality will be presented.

4.2.3.1. Hands-on session (PART 1)

This hands-on session will provide basic concepts on the use and the configuration of XtratuM hypervisor, the Open Virtual Platform (OVP) and the low power techniques defined in SAFEPOWER.

4.2.3.1.1. PART I: Basics of Hypervisor partition development

This session will teach the basic concept to configure and run several partitions into the CPUs of the Zynq 7000 platform. Among others, it will be shown how to assign the partitions to the CPUs and define the memories and peripherals accessed by partitions.

This first part focuses on the basics of XtratuM partition development:

- ◆ Configure the xDRAL partitions on the XtratuM Configuration File (XMCF). This activity is in charge of allocating resources needed by the applications running inside a XtratuM partition:
 - Define the partition cyclic scheduling plan and define how to assign partitions to CPUs.
 - Define the memory areas accessible by a partition
 - Define the HW devices/peripherals accessible by a partition (e.g. Ethernet, I2C)
 - Define the communication channels accessible by a partition
- ◆ Compilation of xDRAL partitions and builds of final system deployment image (resident_SW).
- ◆ Running the partitioned system on the Open Virtual Platform (OVP)

4.2.3.1.2. PART II: Low power techniques

The second part of the hands-on session will teach how to implement, configure and run the low power techniques defined in SAFEPOWER project. Furthermore, we will show how the monitoring partition generated in SAFEPOWER project [1] manages the power, temperature and slack services of the project platform.

In this session, the audience get the task to configure, implement and execute an XtratuM partitioned system with low power techniques defined in SAFEPOWER project:

- ◆ **Frequency scaling technique** enables to exploit the performance to continue meeting time constraints but reducing power consumption. This technique is based on the Xoncrete analysis tool from Fentiss/UPV that allows optimizing the scheduling of partitions executed over the system. The hands-on addresses how to use Xoncrete analysis tool to generate, a scheduling plan applying frequency scaling of the CPU ARM clocks.

- ◆ **Power Monitoring services:** The power monitoring services are offered by the monitoring partition generated in the SAFEPower project. The monitoring partition that manages the power, temperature, and, slack services of the project platform. The hands-on addresses how to configure, build, and, access the power monitoring services through the eXtended abstraction layer (XDRAL) that extends the DREAMS abstraction layer (DRAL).
- ◆ **Voltage scaling** allows manipulating the supply and threshold voltages to reduce the voltage and the number of switching transistors. This technique is performed by the monitoring partition using the services provided by the Safe Low Power library (SLP).
- ◆ **Clock gating** can be used to disable or suspend unnecessary clocks, thus reducing the power consumption. This technique is based on the services provided by the Safe Low Power library (SLP).
- ◆ **Power gating** disables the voltage domains/components which are not used in the operation domain. This technique allows reducing the leakage power of the system.

4.2.3.1.3. PART III: Fault injection framework (Optional)

It will be shown an overview of the fault injection framework where the user could modify and execute certain fault conditions and run the fault injection simulation over a partitioned multi-core Zynq 7000 platform.

4.2.3.2. Hands-on session with (PART 2)

The objective of this hands-on session is to exhibit how the SAFEPower solutions help to achieve a power-efficient design. During this session, the adaptive time-triggered communication at the NoC level is presented. In order to demonstrate the concept of adaptive communication, a real-world scenario (control circuit of a quad-copter) has been used. The session consists of a short presentation, which gives an overview of the platform, and a simple task.

The use case is based on the public demonstrator application (i.e., the control board of a quad-copter which carries a camera) and presents the adaptation of the communication schedule based on the change of the application modes. The operation of the quad-copter can be classified into the following modes; Firstly, the take-off mode, in which, all system components are fully activated. Secondly, the normal flight mode, in which the system collects video data as an information source for the area evaluation. In the third mode, which is known as degraded flight, an emergency landing can be realized, when a major error is detected or battery/temperature budget are violated. The fourth mode relates to landing, in which the quad-copter lands at the final location.

The hardware platform for the above-described use case contains Nostrum as the communicating backbone and the Time-Triggered Extension Layer (TTEL) at the on-chip NI for the establishment of the time-triggered communication. The communication infrastructure interconnects four processor cores (one dual-core ARM A9 and three

MicroBlazes) which control the quad-copter. Due to different requirements of the above mentioned operation, different resources are activated in different modes. For instance, in the third mode (i.e., degraded flight), only one MicroBlaze and the flight controller remain active. In order to achieve the minimal power usage, the remaining resources that are not needed can be switched off.

In this set-up, the TTEL establishes the adaptive communication for the time-triggered messages and the switching between different power modes. This layer is aware of the injection time of the messages (based on the schedule stored in the memory) and also state of the system that are two important metrics to change from one state to another one. In addition to the mode switching (which is the aim of this session), the TTEL can also handle slack, battery and fault event that due to the short allotted time, will not be demonstrated in this session.

During this hands-on session, it is assumed that the platform is designed for the first, the second and the fourth operational mode and the audience designs the schedules for the third mode. During this work the audience will learn how to generate the new schedule, how to produce the configuration files and how to run the system.

The following concepts are considered as essential for accomplishing this task:

- ◆ The concept of port, time-triggered communication paradigm in the TTEL
- ◆ What is a network-on-chip and how it generally works?
- ◆ The concept of agreement layer and the adaptation manager

4.3. Evaluation and publication of the survey

After execution of the survey, the productivity win can be assessed based on “End users” experience reports (interview, questionnaire). In addition, the “Virtual Platform developers” among the SAFEPower consortium will be interviewed and the productivity win will be assessed depending on appropriate means to measure development time. All results will be made available online under the following url, among them all experiments and surveys:

<http://safepower-project.eu/>

In addition, we will elaborate within D5.6 on the surveys final results and their conclusions.

5. SURVEY METHODOLOGY & QUESTIONNAIRE

5.1. Survey methodology

In order to test the usability of the SAFEPower framework, we have chosen a survey of PUPEU (Perceived Usefulness and Ease of Use) presented by Davis in [4]. Basically this survey addresses as the name says, the usefulness and the ease of use of a given framework and evaluates it according to the following criteria (as suggested in [4]):

I) PERCEIVED USEFULNESS

1. Using the system in my job would enable me to accomplish tasks more quickly.
2. Using the system would improve my job performance.
3. Using the system in my job would increase my productivity.
4. Using the system would enhance my effectiveness on the job.
5. Using the system would make it easier to do my job.
6. I would find the system useful in my job.

II) PERCEIVED EASE OF USE

7. Learning to operate the system would be easy for me.
8. I would find it easy to get the system to do what I want it to do.
9. My interaction with the system would be clear and understandable.
10. I would find the system to be flexible to interact with.
11. It would be easy for me to become skilful at using the system.
12. I would find the system easy to use.

In the next section an HTML template of the PUPEU questionnaire [5] is presented, which will be used for the evaluation of SAFEPower methodology.

5.2. Questionnaire template

Please rate the usefulness and ease of use of the system.

- Try to respond to all the items.
- For items that are not applicable, use: **N/A**
- Make sure these fields are filled in: **System: Email to:**

- Add a comment about an item by clicking on its , or add comment fields for all items by clicking on **Comment All**.
- To mail in your results, click on: **Mail Data**

System: Email to:

Optionally provide comments and your email address in the box.

◀
▶

PERCEIVED USEFULNESS		1	2	3	4	5	6	7	N/A
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1. Using the system in my job would unlikely likely
enable me to accomplish tasks more quickly 

2. Using the system would improve my unlikely likely
job performance 

3. Using the system in my job would unlikely likely
increase my productivity 

4. Using the system would enhance my unlikely likely
effectiveness on the job 

5. Using the system would make it easier unlikely likely
to do my job 

6. I would find the system useful in my unlikely likely
job 

PERCEIVED EASE OF USE		1	2	3	4	5	6	7		N/A
-----------------------	--	---	---	---	---	---	---	---	--	-----

7. Learning to operate the system would unlikely likely
 be easy for me

8. I would find it easy to get the system unlikely likely
 to do what I want it to do

9. My interaction with the system would unlikely likely
 be clear and understandable

10. I would find the system to be flexible unlikely likely
 to interact with

11. It would be easy for me to become unlikely likely
 skillful at using the system

12. I would find the system easy to use unlikely likely

			1	2	3	4	5	6	7		N/A
--	--	--	---	---	---	---	---	---	---	--	-----

List the most **negative** aspect(s):

1.
2.
3.

List the most **positive** aspect(s):

1.
2.
3.

6. ACRONYMS

ACRONYMS	DEFINITION
COTS	Commercial off-the-shelf
CRTES	Critical Real-Time Embedded Systems
EC	European Commission
HW	Hardware
IAB	Industrial Advisory Board
LP	Low Power
LPT	Low Power Techniques
MPSoC	Multi-Processor System-on-Chip
NoC	Network-on-Chip
OVP	Open Virtual Platform
PCB	Printed Circuit Board
PL	Programmable Logic
PS	Processing System
PUPEU	Perceived Usefulness and Ease of Use
SLP	Safe Low Power
SWaP	Space, Weight and Power
TTEL	Time-Triggered Extension Layer
VP	Virtual Platform
XDRAL	eXtended DREAMS Abstraction Layer
XMCF	XtratuM Configuration File

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