MobileMark® 2018

An Overview of MobileMark® 2018

January 2019

Revision 1.0

Revision History:

1.0 – Initial publication of the MobileMark 2018 White Paper

About BAPCo

Business Applications Performance Corporation (BAPCo®) is a non-profit consortium with a charter to develop and distribute a set of objective performance benchmarks for personal computers based on popular computer applications and industry standard operating systems.

For more information about BAPCo® or a complete list of the current membership, see our website at http://www.bapco.com.

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1 Introduction

MobileMark® 2018 is the latest version of the premier performance qualified battery life benchmark for mobile PCs. It features real world applications, updated workloads, and support for Microsoft Windows® 10 64-bit.

MobileMark 2018 gives commercial and government IT decision makers, retailers, media, channel buyers, consultants, component designers, hardware designers, and manufacturers an objective, easy-to-use tool to evaluate the performance-qualified battery life of mobile PCs across the wide range of activities that a user may encounter.

MobileMark 2018 is designed for those who want to:

- Evaluate and compare Windows x64-based mobile PC devices on performance-qualified battery life.
- Provide useful information to their audience(s) to assist in the evaluation and purchase of these devices.
- Evaluate mobile PC devices to better tune & optimize.

Unlike benchmarks that only measure battery life, MobileMark 2018 measures battery life and performance simultaneously, showing how well a system design addresses the inherent tradeoffs between performance and power management.

Unlike synthetic benchmarks, which artificially drive components to peak capacity or attempt to deduce performance using a static simulation of application behavior, MobileMark 2018 uses real applications, real user workloads, and real data sets to accurately measure how overall system performance impacts user experience.

MobileMark 2018 builds upon BAPCo's 27-year history of building benchmarks to evaluate platform technologies. Benchmarks designed by BAPCo are the result of cooperative development between companies representing the breadth of the computing industry. They harness a consortium of knowledge to better reflect today's and tomorrow's emerging business trends.

This document describes the methodologies employed in the development of MobileMark 2018. For detailed instructions on how to install and run MobileMark

products, please refer to the documentation provided on the installation media and the BAPCo web site (www.bapco.com).

2 BAPCo Development Process

BAPCo creates benchmarks in accordance with the BAPCo Development Process, a set of milestones and checkpoints collaboratively developed and agreed upon by the BAPCo membership.

Early in the process, prevailing business mobile PC usage models are identified and grouped into scenarios according to their fit within a workflow. Applications are selected for each usage model on the basis of market research and technical feasibility.

BAPCo members then join together with expert application users in development sessions to collaboratively develop a workload specification for each scenario, defining each user/computer interaction which is to be simulated by the benchmark.

The goal of the development sessions is to produce representative business application workloads for the benchmark. Each application workload consists of three elements: the input data set, the tasks performed on the input data set, and the generated output. An example of generated output would be an image generated through an iterative process of steps to create a desired appearance. These three elements of the workload are chosen to represent the workflow of a user skilled in each given application.

After the workload specifications are created at the development sessions, BAPCo developers implement the workloads according to those specifications while satisfying benchmarking constraints to ensure the stability of the benchmark, the consistency of results, and the feasibility of implementation and distribution of the benchmark.

2.1 Milestone Overview

The BAPCo development process is divided into six major phases (Initialization, Design and Planning, Implementation, Validation, Characterization and Launch). Each phase consists of a series of milestones, some of which may be worked on concurrently.

The membership must vote to close each milestone. Once all the milestones within a phase are complete, the membership must vote to exit the current phase and enter the next phase. BAPCo members work in a collaborative process where decisions regarding products are sometimes made by majority vote rather than unanimously.

The following is the list of the development phases and the corresponding milestones. Some of these milestones are explained in greater detail in the following sections, as noted in this list.

1. Initialization Phase
    a. Milestone 1 – Committee kickoff
    b. Milestone 2 – Benchmark market and customer analysis
    c. Milestone 3 – Product positioning and customer value proposition
    d. Milestone 4 – Preliminary marketing requirements document
    e. Milestone 5 – Final marketing requirements document
2. Design and Planning Phase
    a. Milestone 6 – Preliminary engineering requirements document
    b. Milestone 7 – Usage model selection (see section 2.2)
    c. Milestone 8 – Application selection (see section 2.3)
    d. Milestone 9 – Define member resource commitments
    e. Milestone 10 – Define development infrastructure
    f. Milestone 11 – Define scoring methodology (see section 2.4)
    g. Milestone 12 – Define application/API licensing requirements
    h. Milestone 13 – Plan and execute workload development sessions (see section 2.5, 2.6)
    i. Milestone 14 – Define product release criteria
3. Implementation Phase
    a. Milestone 15 – Create implementation schedule
    b. Milestone 16 – Determine reference system (see section 2.7)

   c. Milestone 17 – Software engineering (see section 2.8)
4. Validation Phase
   a. Milestone 18 – Validation testing
   b. Milestone 19 – Define risk management plan
5. Characterization Phase
   a. Milestone 20 – Characterization testing
6. Launch Phase
   a. Milestone 21 – Product pricing
   b. Milestone 22 – Pre-launch materials
   c. Milestone 23 – Release to manufacture vote and sign-off
   d. Milestone 24 – Distribute early press evaluation
   e. Milestone 25 – Duplicate and distribute media
   f. Milestone 26 – Post-launch materials

2.2 Usage Model/Scenario Selection

In Milestone 6 of the BAPCo Development Process, usage models are chosen for inclusion in a benchmark. For MobileMark 2018, BAPCo chose a wide variety of usage models in which the user experience is influenced by system performance.

BAPCo then groups related usage models into the following three scenario groups (for detailed descriptions of each scenario, please see section 2.6):

Productivity

The Productivity scenario models productivity usage including word processing, spreadsheet data manipulation, financial analysis, software development, application installation, file compression and email creation/management.

Creativity

The Creativity scenario models creating and editing digital photos, video and using artificial intelligence for facial detection in photos.

Web Browsing

The Web Browsing scenario models loading and switching between various web sites as well as full screen local video playback.

2.3 Application Selection

In milestone 7, after the usage models have been collected into scenarios, applications are chosen for the scenarios on the basis of market research and technical feasibility.

Sufficient lead time is needed after the applications are selected for BAPCo to develop workloads, integrate the applications into the benchmark, and perform validation of the benchmark. Therefore, some of the application versions are not the newest available at the time of the launch of MobileMark 2018.

The criteria that BAPCo uses for application selection includes, but is not limited to:

- Ability of the application to perform the needed task
- How widely used the application is
- Minimum system requirements of the application
- Hardware support of the application
- Diversity of application vendors

For MobileMark 2018, BAPCo has identified the following representative applications for the three usage scenarios.

Application	Version	Document Type
Adobe® Acrobat®	Pro DC	Portable document files, image files
AutoIt	3.3	AU3 scripting files
Microsoft® Excel®	2016	Spreadsheets
Microsoft® OneNote®	2016	Free-form information gathering and multi-user collaboration
Microsoft® Outlook®	2016	E-mails
Microsoft® PowerPoint®	2016	Presentation files, image files, video files
Microsoft® Word®	2016	Word processing documents
Microsoft® Windows® Built-in File Compression	N/A	Zip files, assorted document files

Table 1: Productivity Applications

Application	Version	Document Type
Adobe® Lightroom®	CC Classic	Image files
Adobe® Photoshop®	CC (2018)	Image files
CyberLink® PowerDirector™	15	Video files

Table 2: Creativity Applications

Application	Version	Document Type
Google® Chrome®	70	Web pages
Microsoft® Movies & TV	N/A	Video files

Table 3: Web Browsing Applications

2.4 Scoring Methodology

MobileMark 2018 produces a battery life rating and a performance qualification rating. Each scenario will also report a scenario rating which is given as a secondary result to the overall MobileMark 2018 battery life and performance qualification ratings.

Battery Life Rating

The battery life rating for MobileMark 2018 is calculated by measuring the actual battery duration observed (from a fully charged state to a fully depleted state), in whole minutes, while running all scenarios (PR->CR->WB) in repetition.
The MobileMark 2018 battery life rating for a given machine may differ from the actual battery life real end users. Some reasons for this include but are not limited to:

- Different usage characteristics when using the system
- An old or degraded battery
- Additional OEM/IT software installed on the system
- Heavier network traffic
- Different power settings/optimizations
- Different screen brightness

Scenario Rating

Each scenario has a rating calculated by taking the sum of the response times of tasks in that scenario as performed on the test system and then comparing it with the sum of those same task response times as performed on the calibration system (see section 2.7). The calibration sum is divided by the measured sum on the test system and multiplied by 1000. The result is then rounded to the nearest integer. The calibration scenario rating number is obtained by performing a complete MobileMark 2018 rundown test on the calibration machine and for each scenario taking the median value of the sum of response times in the set of completed iterations for that scenario.

Performance Qualification Rating

The MobileMark 2018 Performance Qualification is calculated by taking the geometric mean of all the scenario ratings (prior to rounding). The result is then rounded to the nearest integer.

Battery Life Estimation

During testing, once a scenario has completed, projected battery life ratings are calculated and displayed in the heads-up display. These values are rough estimates, reflecting the system behavior in the benchmark up to that point, and subject to the accuracy of the test system's battery level reporting mechanism. The battery life rating estimate b_e is calculated using the following formula:

$$b_e = \frac{t(c_t)}{c_t - c_n}$$

Where:

t is the elapsed time since the test was started, in minutes.

c_t is the level of charge the battery reports having the capability to hold when fully charged, in any units as reported by the battery (typically amp-hours or watt-hours).

c_n is the level of charge reported by the battery presently, in the same units as c_t.

2.5 Workload Development Sessions

Once the usage models, scenarios, application models, and scoring methodology for the benchmark are decided, BAPCo members and application experts meet to create the application workloads that will be used in the benchmark.

For MobileMark 2018, the workload development sessions consisted of one week of face-to-face meetings that included representatives from BAPCo member companies and expert application users who had professional experience with the applications chosen for the benchmark. The application experts included professionals in the fields of small business marketing, financial forecasting, graphic design, video editing, web development, and enterprise IT deployment.

In the workload development sessions, the experts take the lead, weaving the usage models supplied by BAPCo into a storyboard of user interactions with a series of application models. Each user interaction is written down in a workload specification, which is later used to automate the workloads.

At the end of the workload development sessions, BAPCo comes away with a detailed workload specification for each of the benchmark scenarios and all of the input data sets needed to reproduce the workloads created at the sessions.

Additional Workload Considerations

The following additional factors were considered at the workload development sessions:

Input Data Set
Frequently in the sessions, the experts need raw digital content to serve as input data set for a workload. Examples of such content might include a video to transcode, an email to modify, or photos to manipulate. When experts need such content, care is taken to ensure that they use something that is functionally representative of content they might use or encounter professionally.

For instance, if pictures are needed in order to create a photo slideshow, an expert might walk outside and take pictures using the same equipment

he/she uses professionally. If a song track is needed as the background music for creating a movie, an expert might purchase a stock track from his/her usual online resource. Like the user interactions, all of these source materials are captured at the development session and used later in the development of automated workloads.

2.6 Scenario Workload Descriptions

The scenario workloads created at the workload development sessions for MobileMark 2018 are described below:

Productivity

Read and manipulate notes from a notebook. Archive a diverse set of files into a single compressed file. Convert a PDF document into an editable word processing document. Perform a mail merge. View a complex presentation that includes multimedia and export it to PDF/video. Combine multiple scanned pages from a complex document into an encrypted PDF document using optical character recognition (OCR). Execute a rule on email inbox. Unpack a single compressed archive with a diverse set of files. Use a spreadsheet program to do data analysis. Perform financial analysis using a spreadsheet program.

Creativity

Create a panoramic image using an image editing application, combine a set of photos into one high dynamic range (HDR) image, and adjust and prepare both images for print. Import photos into a catalog. Export a large set of photos from a catalog. Detect faces using machine learning and artificial intelligence on a catalog of photos for labeling and grouping. Transcode a video into a different format. Encode the video to a format suitable for web publishing using a video editing application.

Web Browsing

Browse 26 different locally stored web sites. The sites include an Internet discussion site, a feature film promotional site, an online banking site, a government site, several travel tourism sites, news sites, online shopping site, restaurant site, mapping site, and video streaming site. Switch between various web browser tabs. Video playback of a 1080p h.264 movie clip that is approximately 8 minutes long.

2.7 Calibration System

The calibration system is a system chosen in Milestone 16 as a reference point for all other MobileMark 2018 results. BAPCo chose the configuration below for its wide availability and its representation of a typical mainstream notebook/2-in-1 computer at the time of release of MobileMark 2018.

MobileMark 2018 has been calibrated in such a way that a notebook/2-in-1 computer with performance equivalent to this calibration system for a given workload will have a scenario performance rating of 1000. A system twice as fast as the calibration system on a given workload (or, equivalently, that responds in half the time on average) will have a scenario performance rating of 2000. This is true for each of the scenario performance ratings.

The calibration system for MobileMark 2018 has the following configuration:

- Lenovo® ThinkPad® T480s
- Intel® Core® i5-8250U Processor (4 cores, 8 threads, 6MB Cache, 1.60 to 3.40 Ghz)
- 14.0” FHD (1920 x 1080) IPS anti-glare, 250nit
- 8GB DDR4 2400 MHz (Single channel 1x8 GB)
- Integrated Intel UHD Graphics 620
- Microsoft® Windows® 10 Pro x64 version 1803
- Samsung® 256GB M.2 NVMe SSD
- 3 cell Li-Ion 57Wh Battery
- Intel Dual Band 8265 Wireless AC (2 x 2) & Bluetooth 4.1 with vPro

A fresh operating system installation is performed on the system.

For more details about the configuration of the calibration system, please contact support@bapco.com.

2.8 Benchmark Implementation

Once the workload specifications have been created, BAPCo begins the work of translating the workload specifications into an automated benchmark in milestone 17.

MobileMark 2018 is built upon scripts that do things in much the same way as a user would, using controls like buttons, text input boxes, and menus to navigate applications. See Appendix C for screenshots of the benchmark in action.

To ensure that MobileMark 2018 has deterministic behavior, BAPCo uses a framework to install applications, collect system information, run the scenario scripts, record performance measurements, calculate performance ratings, and display test results. The framework is kept lightweight, consuming a minimal amount of memory and compute resources, in order to ensure that battery life and performance measurements reflect the workload behavior and do not include overhead from the framework.

The fundamental performance unit upon which the MobileMark 2018 performance qualification rating is based is *response time*. Response time is defined as the time it takes the computer to complete a task that has been initiated by the automated script. A task can be initiated by a mouse click or a keystroke. The duration of each task is measured by the framework. Examples of tasks include launching an application, finding text in a document, copying a file, encoding a video, and performing an image manipulation.

The framework has several methods of detecting task completion, depending upon the method the application uses to signal task completion to the user. For example, the framework may wait for the application to show a completion message in the form of a pop-up window, or it may wait for a progress dialog to disappear and for control of the application to be returned to the user.

2.9 Workload Characterization

Once the scenario workloads are implemented and validated against the workload specifications created at the development sessions, BAPCo members then run the benchmark on a wide variety of systems to ensure that the benchmark produces results that are valid, representative, and reproducible.

During this process, BAPCo members share data, raise concerns, and suggest workload changes. Any workload change requires a majority vote of the committee.

MobileMark 2018 is primarily a tool for measuring battery life; therefore, it's important that the power characteristics of its scenario workloads are reasonably representative of user experiences and expectations. BAPCo members work together to arrive at an estimation of a representative level of user activity, but acknowledge that individual user experience could vary from the results reported by the MobileMark 2018 scenarios.

The battery life reported by MobileMark 2018 is an approximation of the battery life a typical user would expect from the same system.

One way BAPCo members adjust the power profile of the workload is by determining an appropriate proportion of user idle time relative to active time.

MobileMark 2018 User Activity States

Users of mobile PC devices often leave their systems idle for a period of time between sessions of active use. The idle periods consist of two states, one which the display is still on and one which the screen is off but can be instantly switched on. MobileMark 2018 simulates this behavior in the Productivity, Creativity, and Web Browsing & Video Playback scenarios by interspersing both types of system idle periods throughout the workload.

Inclusion of these idle periods better models real-world mobile usage and allows the hardware and software power management features of the system under test to behave in a realistic manner.

MobileMark 2018 includes user idle time in the Productivity, Creativity, and Web Browsing & Video Playback scenarios in order to reflect the benefits of power-saving optimizations that are enabled by the power policy of the system under test and permitted by the MobileMark 2018 Benchmarking Rules. In order to provide a battery life metric that more closely aligns with user expectations of battery life, BAPCo chose not to model extended periods of system standby in MobileMark 2018.

Below is a chart which details the breakdown of the user activity states on the calibration system. Due to system implementation differences, this chart is accurate for the calibration system only. These contributions will vary from one system to the next.

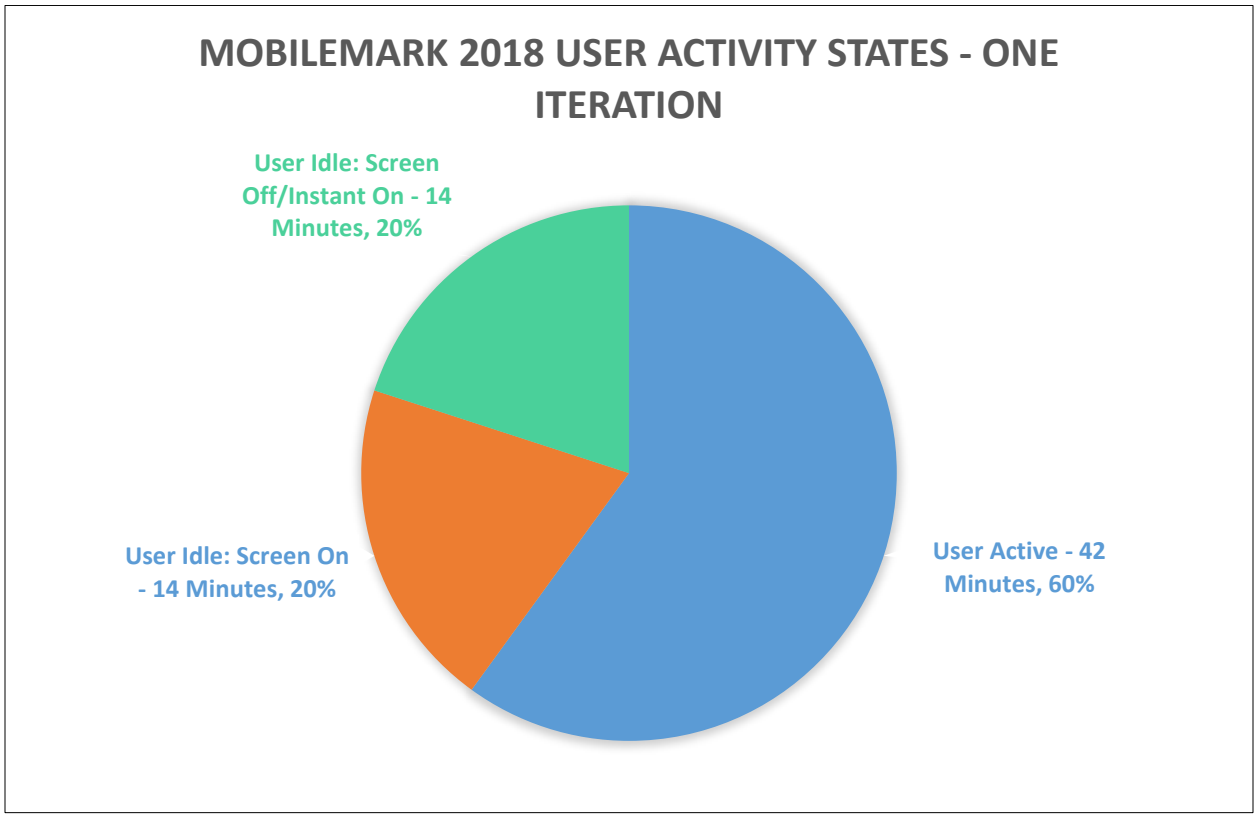


Figure 1: MobileMark 2018 User Activity States aggregate runtimes for one iteration on the Calibration System (See Section 2.7 for system details).[i]

The 60% active, 20% screen-on idle, and 20% screen-off/instant on distribution on the calibration system was derived using a large amount of real life user telemetric data from various sources. For the user idle screen off/instant on activity state, the benchmark will utilize Modern Standby if available.

3 Workload Characteristics

This section provides data illustrating the battery life and performance characteristics of MobileMark 2018.

3.1 Sensitivity Analysis

The series of tables below shows the sensitivity of MobileMark 2018 to different system characteristics, including the amount of system memory (RAM), number of CPU cores, type of storage device, and display resolution.

Within each study only one system component (e.g. memory) is varied. All the other system components are held constant. To best illustrate the sensitivity, one configuration is chosen as a baseline and the ratings for the other configurations are shown as the percentage difference relative to the baseline.

In order to give better control over system configuration, not all sensitivity charts use the same baseline configuration. Note that component sensitivities will vary from one configuration to the next.

Also note, that all performance data in each table is relative to the baseline configuration with the exception of the machine used for the I/O subsystem test.

Baseline configuration:

- Notebook model: Dell Precision 5530
- CPU: Intel Core i9-8950HK Processor (2.90 GHz, 6 cores, 12 threads, 6MB cache)
- Operating system: Windows 10 Pro 64-bit version 1803 (“Redstone 4”)
- Operating system language: US English
- Display type: 15.6” UHD (3840 x 2160) LED
- System graphics: Nvidia Quadro P2000 w/4GB GDDDR5
- System RAM: 16 GB DDR4
- Hard drive: 256GB NVMe SSD
- Battery: 6 cell 97 Watt Hour Li-Ion

I/O subsystem baseline configuration:

- Notebook model: Lenovo T480
- CPU: Intel Core i7-8550U Processor (1.8-4.0 GHz, 4 cores, 8 threads, 8MB cache)
- Operating system: Windows 10 Pro 64-bit version 1803 (“Redstone 4”)
- Operating system language: US English
- Display type: 14.0” Full HD (1920 x 1080) LED
- System graphics: Intel Integrated UHD Graphics 620
- System RAM: 16 GB DDR4
- Hard drive: 240GB SATA SSD
- Battery: 48 Watt Hour Li-Ion (2 x 24 Wh batteries)

For the tables below, the following components were substituted as noted:

- System Memory:
  - 4 GB Single Channel (1 DIMM)
  - 8 GB Single Channel (1 DIMM)
  - 8 GB Dual Channel (2 DIMM)
  - 16 GB Dual Channel (2 DIMM)
- CPU - Cores adjusted in OS settings
  - 2 cores
  - 4 cores
  - 6 cores
- Hard drive
  - Seagate Momentus ST9160314AS 160GB 5400RPM
  - Seagate Momentus ST500LT012-9WS142 500GB 7200RPM
  - Intel 530 Series SSDSC2BW240A401 2.5" 240GB
- Resolution
  - 1366 x 768 @ 60Hz
  - 1920 x 1080 @ 60Hz
  - 2560 x 1600 @ 60Hz
  - 3840 x 2160 @ 60Hz

3.1.1 Sensitivity to System Memory

The total system memory is changed from 4 GB single channel to 8 GB single channel to 8 GB dual channel to 16 GB dual channel. Turbo and HyperThreading were disabled for this study.

Performance Qualification Rating				
System Memory Sensitivity	4 GB (4 x 1 GB)	8 GB (8 x 1 GB)	8 GB (4 x 2 GB)	16 GB (8 x 2 GB)
MobileMark 2018	Baseline	+8.6%	+13.9%	+21.6%

Table 4: System Memory Sensitivity[ii]

3.1.2 Sensitivity to CPU Cores

The total number of CPU cores available to the system is changed from 2 core to 4 cores to 6 cores. Turbo and HyperThreading were disabled for this study.

Performance Qualification Rating			
CPU Core Sensitivity	2 Core, 2 Threads	4 Cores , 4 Threads	6 Cores, 6 Threads
MobileMark 2018	Baseline	+31.1%	+38.7%

Table 5: CPU Core Sensitivity[iii]

3.1.3 Sensitivity to I/O Subsystem

The primary storage device is changed, from a 5400 RPM hard disk drive to a 7200 RPM hard disk drive to a 240 Sata SSD to a 256 M.2 NVMe SSD.

Performance Qualification Rating			
I/O Subsystem Sensitivity	160GB 5400 RPM HDD	500GB 7200 RPM HDD	240 GB SSD
MobileMark 2018	Baseline	+0.9%	+2.2%

Table 6: I/O Subsystem Sensitivity[iv]

3.1.4 Sensitivity to Display Resolution

The system display resolution is changed, from 1366 x 768 to 1920 x 1080 to 2560 x 1440 to 3840 x 2160. Turbo and HyperThreading were disabled for this study.

Performance Qualification Rating				
	1366 x 768	1920 x 1080	2560 x 1600	3840 x 2160
MobileMark 2018	Baseline	-0.3%	-0.8%	-2.3%

Table 7: Display Resolution Sensitivity[v]

3.2 Battery Life Rating Analysis

The following chart shows the approximate contribution of each scenario to the MobileMark 2018 Battery Life rating on the calibration system.

Due to system implementation differences, this chart is accurate for the calibration system only. These contributions will vary from one system to the next.

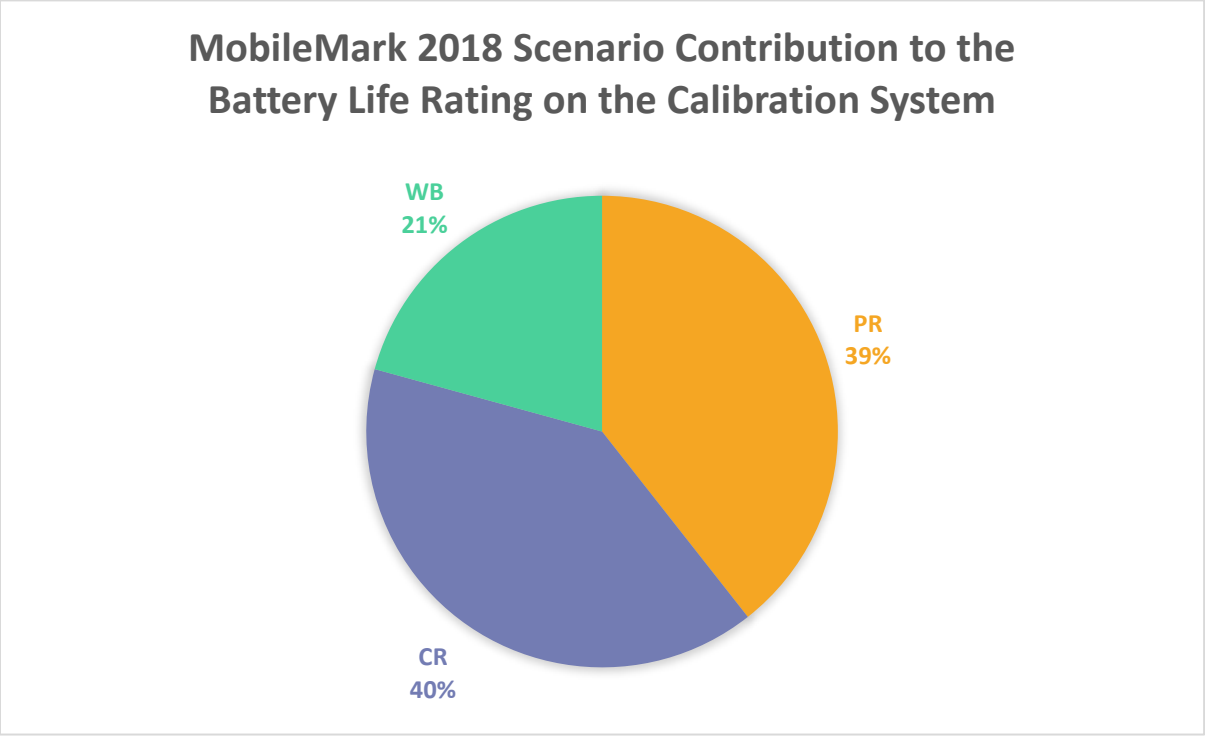


Figure 2: Scenario contribution to the MobileMark 2018 Battery Life rating on the Calibration System (See Section 2.7 for system details).[vi]

3.3 Iteration User Activity Analysis

The following chart shows the order each activity is run in and its relative time in an iteration for all three scenarios.

Due to system implementation differences, this chart is accurate for the calibration system only. These contributions will vary from one system to the next.

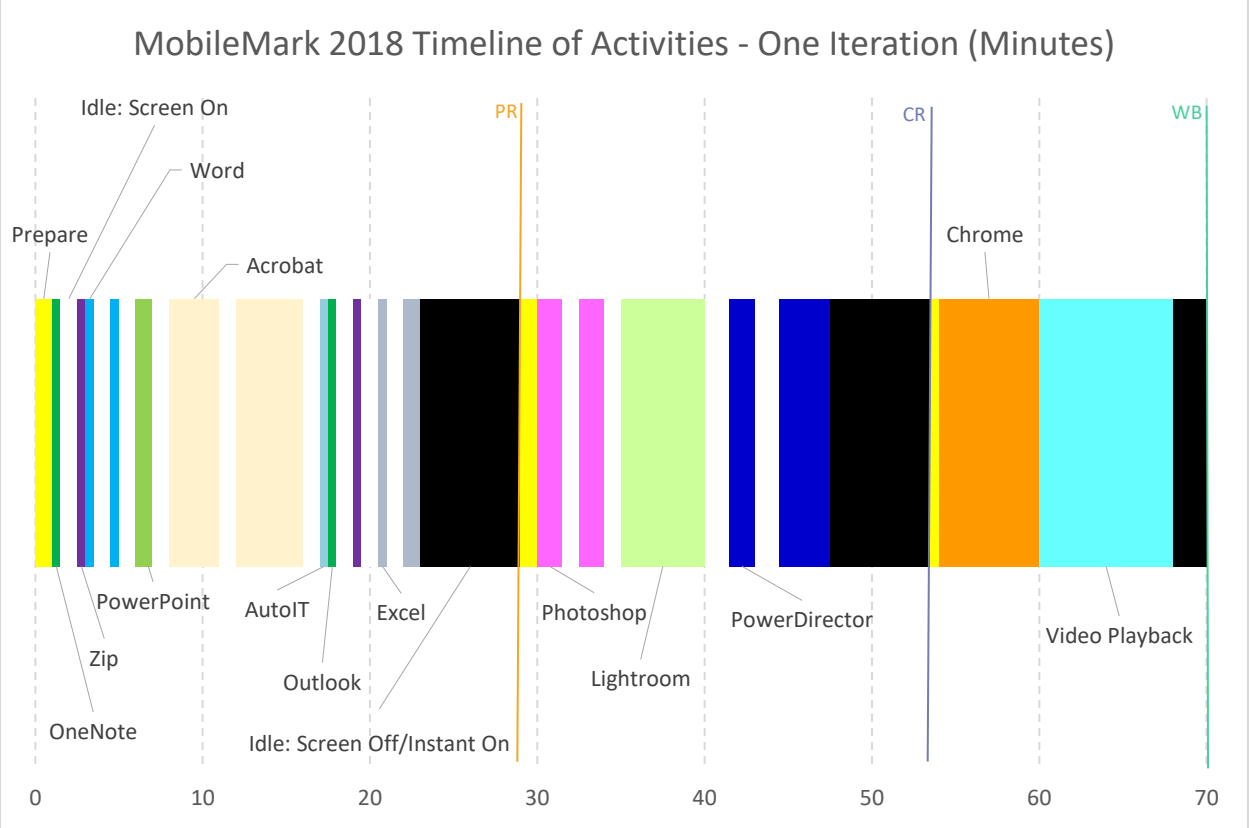


Figure 3: MobileMark 2018 timeline of activities for one iteration on the Calibration System (See Section 2.7 for system details).[vii]

3.4 Performance Qualification Rating Analysis

The following charts shows the approximate contribution of each application to the MobileMark 2018 Performance Qualification rating on the calibration system.

Due to system implementation differences, this chart is accurate for the calibration system only. These contributions will vary from one system to the next.

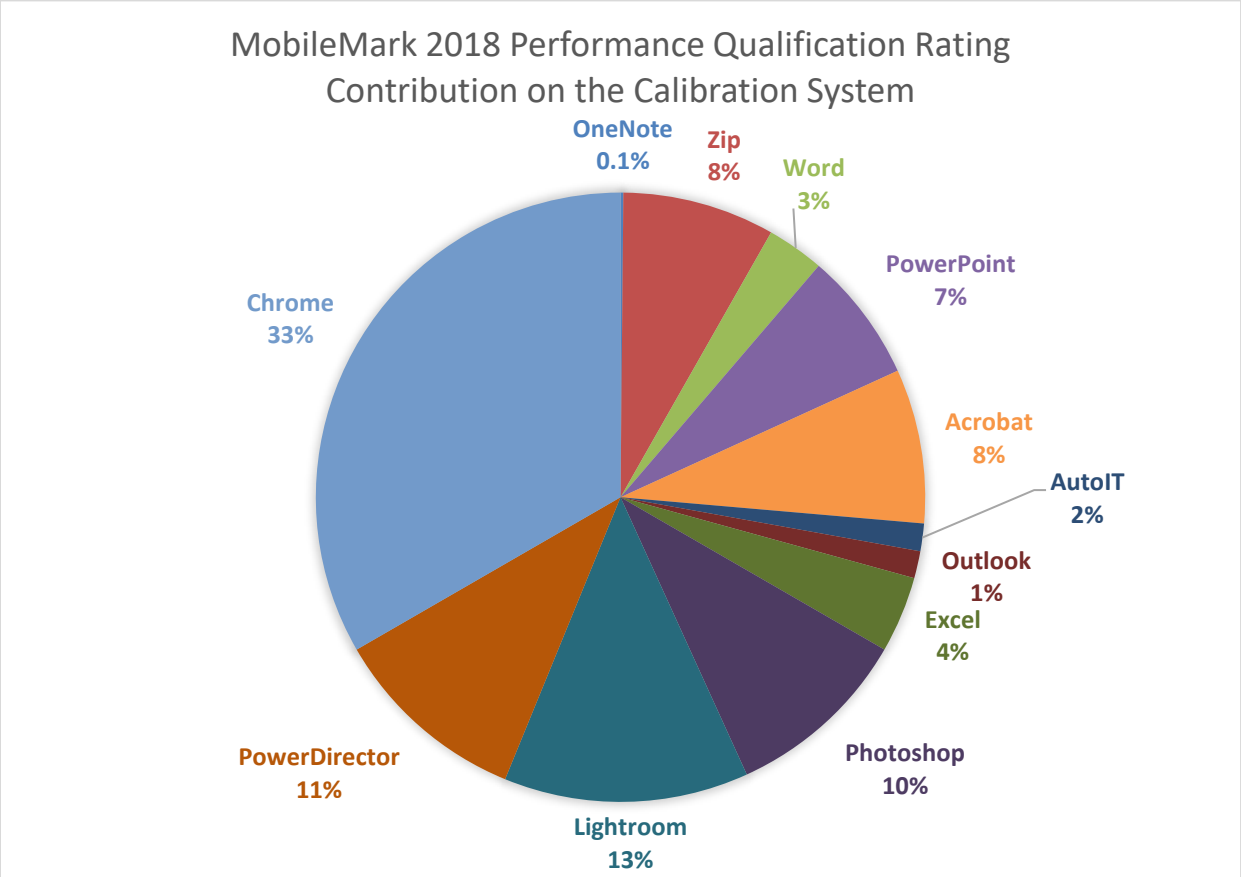


Figure 4: Application contribution to the MobileMark 2018 Performance Qualification rating on the Calibration System (See Section 2.7 for system details).[viii]

APPENDIX A: System Requirements

MobileMark 2018 has the following requirements:

- **CPU**: 1.5 GHz AMD® or Intel® dual core processor
- **RAM**: 4 GB
- **Drive Space**: 25 GB of free space on the primary drive
- **Operating System**: Microsoft® Windows® 10 64-bit
- **Video Resolution**: 1280 x 800 or 1366 x 768
- **Graphics**: DirectX 10 compatible
- **Other**: Wireless Router

APPENDIX B: Screenshots

The screenshots below are included to illustrate the user interface and workloads included in the current version of MobileMark 2018. These screenshots may not accurately depict future releases of MobileMark 2018.

Figure 5: MobileMark Launch Screen

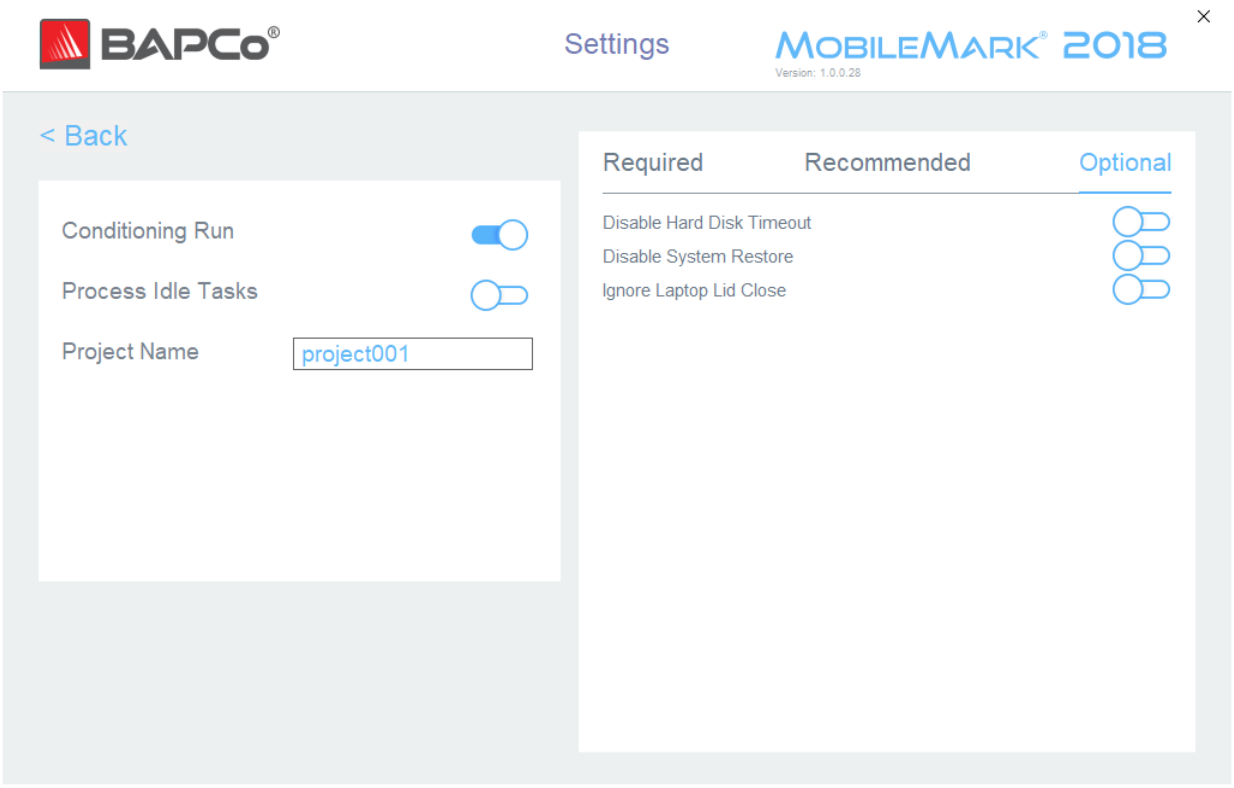


Figure 6: MobileMark Settings Page

Figure 7: MobileMark Heads-Up Display

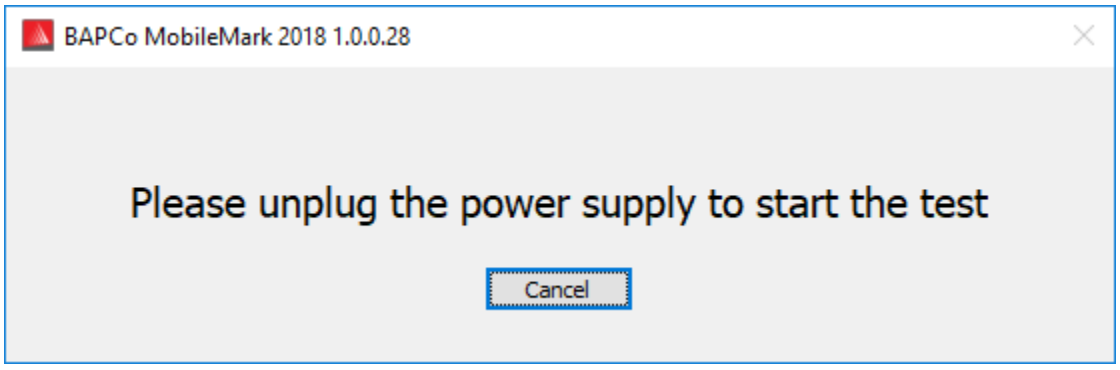


Figure 8: MobileMark Unplug Prompt

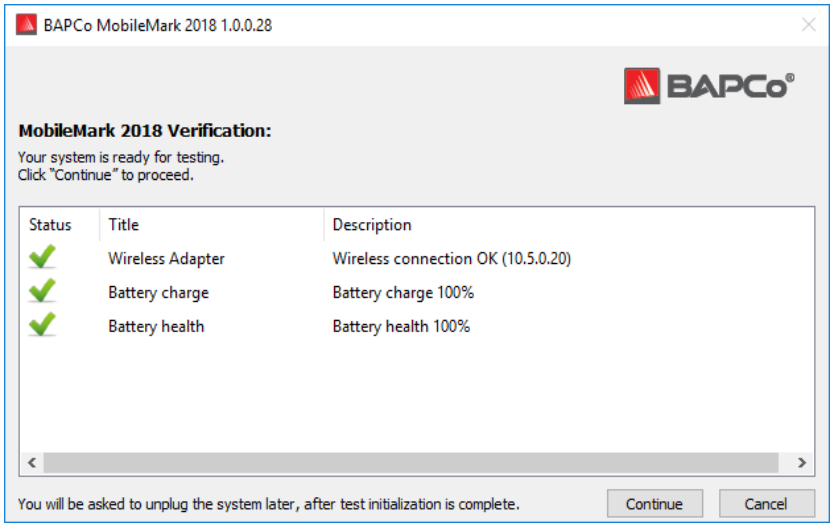


Figure 9: MobileMark Verification Windows

Figure 10: MobileMark Productivity Scenario

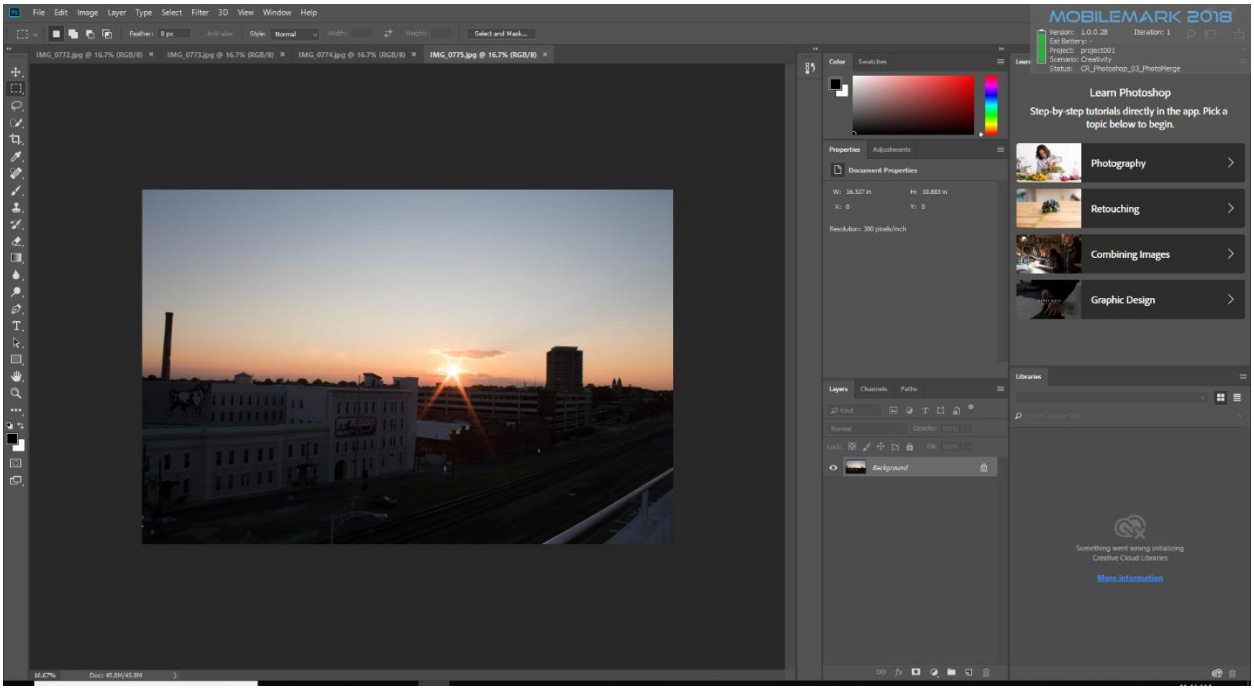


Figure 11: MobileMark Creativity Scenario

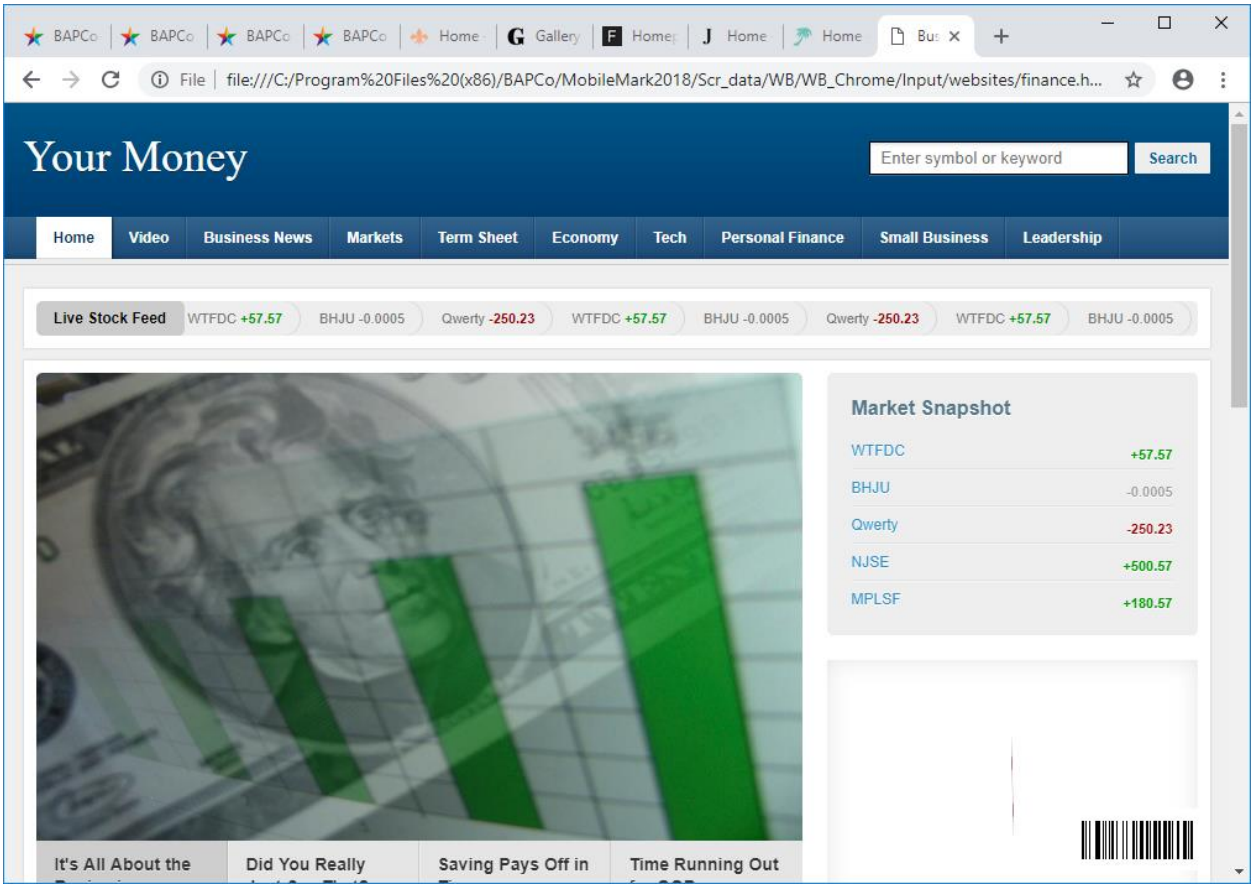
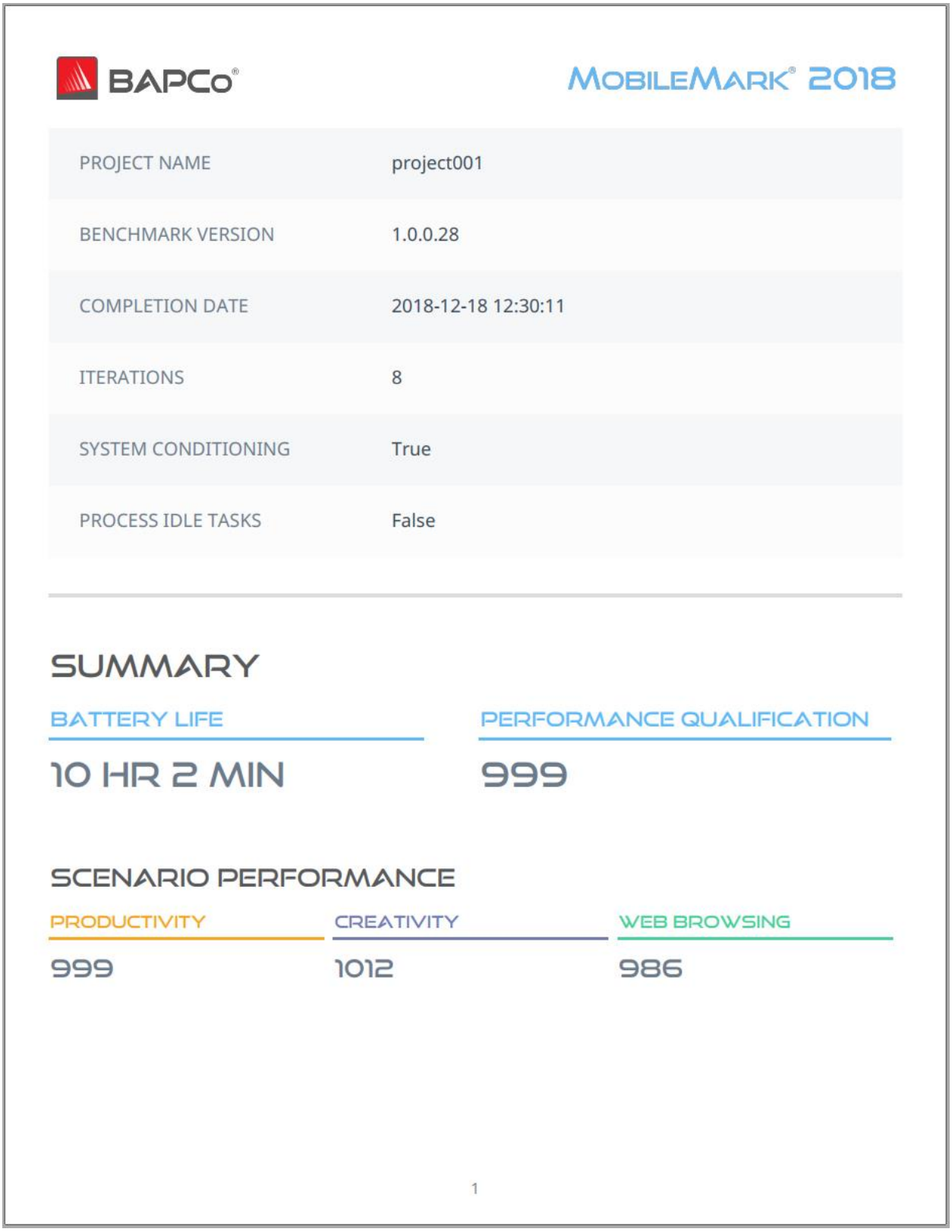


Figure 12: MobileMark Web Browsing and Video Playback Scenario



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MOBILEMARK® 2018

PROJECT NAME	project001
BENCHMARK VERSION	1.0.0.28
COMPLETION DATE	2018-12-18 12:30:11
ITERATIONS	8
SYSTEM CONDITIONING	True
PROCESS IDLE TASKS	False

SUMMARY

BATTERY LIFE

10 HR 2 MIN

PERFORMANCE QUALIFICATION

999

SCENARIO PERFORMANCE

PRODUCTIVITY	CREATIVITY	WEB BROWSING
999	1012	986

1

Figure 13: MobileMark Results PDF

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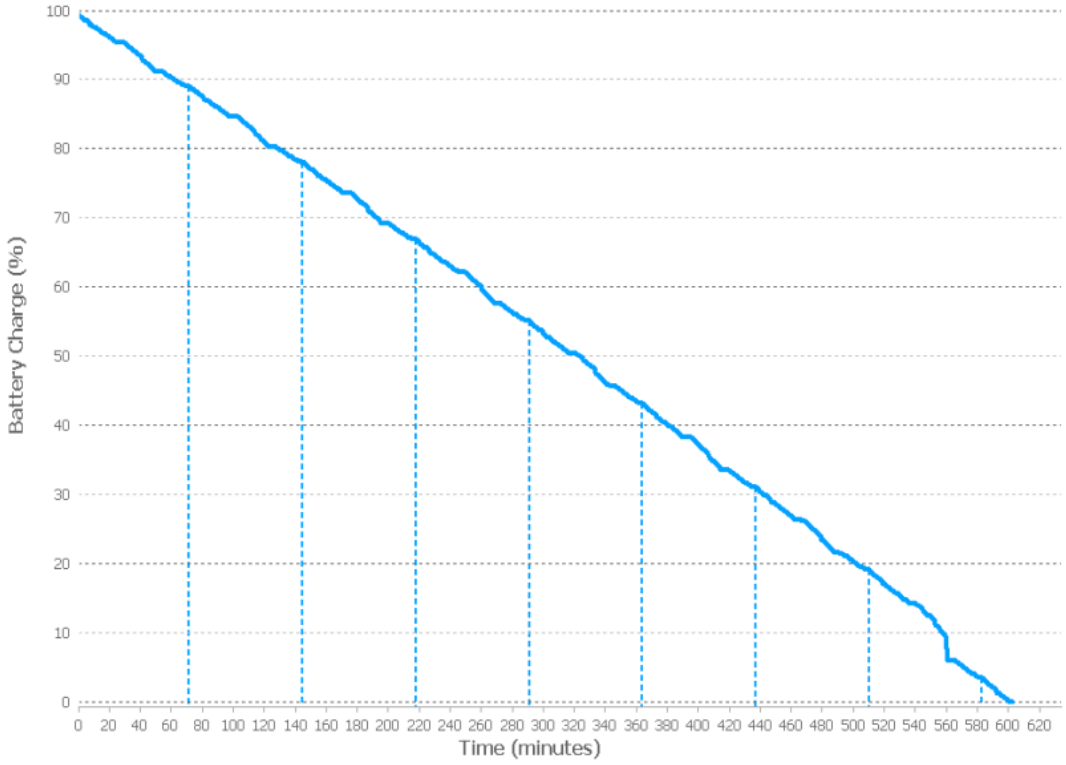
MobileMark® 2018

BATTERY LEVEL



2

Figure 14: MobileMark Results PDF (cont.)

BAPCo® MOBILEMARK® 2018

SYSTEM INFORMATION COMPARISON TABLE

System Info	This System	Calibration System
BIOS	LENOVO N22ET48W (1.25), 7/18/2018	LENOVO N22ET48W (1.25), 7/18/2018
Core + Memory		
Motherboard type	20L7CTO1WW	20L7CTO1WW
CPU	Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz, 1800 Mhz, 4 Core(s), 8 Logical Processor(s)	Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz, 1800 Mhz, 4 Cores, 8 Logical Processors
Memory Size	8.00 GB	8.00 GB
Virtual Memory	9.73 GB Total, 8.26 GB Free	9.73 GB Total, 8.28 GB Free
Virtualization	Yes	Yes
Secure Boot	Secure Boot StateOn	Secure Boot StateOn
Video		
Resolution	1920 x 1080 x 60 hertz	1920 x 1080 x 60 Hertz
Brightness	92%	92%
GPU 0	Intel(R) UHD Graphics 620 (version: 24.20.100.6223)	Intel(R) HD Graphics 620 (version: 24.20.100.6223)
Storage		
Drive 0	238.47 GB (256,052,966,400 bytes) SAMSUNG MZVLB256HAHQ-000L7	238.47 GB (256,052,966,400 bytes) SAMSUNG MZVLB256HAHQ-000L7
Policies	Write caching: Default; Power protected: Default	Write caching: Default; Power protected: Default
Battery		
Battery 0	LGC 01AV478 1432LGC01AV478	LGC 01AV478 1321LGC01AV478
Design Capacity	57000 mWh	57000 mWh
Full Capacity	59780 mWh	58930 mWh

3

Figure 15: MobileMark Results PDF (cont.)

APPENDIX C: Notes

[i] Data for this study collected on 12/18/2018
[ii] Data for this study collected on 12/20/2018
[iii] Data for this study collected on 12/20/2018
[iv] Data for this study collected on 12/16/2018
[v] Data for this study collected on 12/18/2018
[vi] Data for this study collected on 12/18/2018
[vii] Data for this study collected on 12/18/2018
[viii] Data for this study collected on 12/18/2018