CrossMark®

Jan 26, 2022
Revision 1.2

Revision History:
1.0 – Initial release of the CrossMark White Paper
1.1 – CrossMark Android release
1.2 – Added Windows 11 references

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/.

1 Introduction

CrossMark is a new type of cross-platform benchmark that measures system performance and responsiveness using common and relevant workloads that model the performance characteristics of real-world applications. CrossMark uses a combination of open source and proprietary workloads to assess system performance scores in the areas of Productivity, Creativity and Responsiveness. CrossMark installs quickly and gives results in only a few minutes. The overall performance score is designed to track those of SYSmark 25. CrossMark also allows the comparison to be made across a range of operating systems.

CrossMark gives commercial and government IT decision makers, media, channel buyers, consultants, and system and component designers and manufacturers, government and non-government agencies and standards bodies an objective, easy-to-use tool to evaluate PC performance across the wide range of activities that a user may encounter.

CrossMark is designed for those who want to evaluate and compare desktop, notebook, 2-in-1 and tablet computers for evaluating system performance across platforms.

Additional features and highlights of CrossMark include:
- **Cross-Architecture System Benchmarking** – Runs on Windows, Android (ChromeOS, Not Supported), iOS and macOS to assess the performance, regardless of the operating system. More platforms will be added in the future.
- **System Benchmark Modeled on Real Applications** – Measures common user performance by modeling real applications using open source and proprietary workloads.
- **Realistic Performance Scaling** – Scales similarly to real applications across CPU frequency, cores and threads, system memory, storage, GPU and other capabilities.
- **Lightweight Install with Intuitive Interface Supporting Touch Screens** – Streamlined user experience beginning with a quick installation process of less than a minute, necessitating less than 1GB of storage – users can begin benchmarking with a single click, or tap of their screen.
- **Automated Run Time Support** – Provides the option to automate benchmarking tests to simplify and streamline system measurement.
- **Online System Performance Database –** Supports online results submission to enable real-time device comparison and evaluation.

CrossMark builds upon BAPCo's 30-year history of building benchmarks to evaluate platform technologies. Benchmarks designed by BAPCo are the result of cooperative development between member companies representing the breadth of the computing industry.

This document describes the methodologies employed in the development of CrossMark. For detailed instructions on how to install and run CrossMark products, please refer to the documentation provided on the installation media and/or the BAPCo web site (www.bapco.com).

Refer to the BAPCo product versions FAQ located in the CrossMark support section at http://www.bapco.com/support for more information.

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.

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 phase and enter the next phase. BAPCo members work in a collaborative process where decisions regarding products are made by majority vote rather than unanimously.

The following is the list of the development phases and the corresponding milestones.

1. **Initialization Phase**
    a. Milestone 0 – Committee kickoff
    b. Milestone 1 – Benchmark market and customer analysis
    c. Milestone 2 – Product positioning and customer value proposition
    d. Milestone 3 – Preliminary marketing requirements document
    e. Milestone 4 – Select product name
    f. 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 – Workload selection *(see section 2.4)*
    d. Milestone 9 – Define member resource commitments
    e. Milestone 10 – Define development infrastructure
    f. Milestone 11 – Define scoring methodology *(see section 2.5)*
    g. Milestone 12 – Define application licensing requirements
    h. Milestone 13 – Plan and execute workload development sessions
    i. Milestone 14 – Define product release criteria
3. **Implementation Phase**
    a. Milestone 15 – Create implementation schedule
    b. Milestone 16 – Determine reference machine *(see section 2.7)*
    c. Milestone 17 – Software engineering
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, Sub Scenario, and Scenario Selection

In milestone 7 of the BAPCo Development Process, the committee chooses PC usage models for inclusion in the benchmark. CrossMark is based on the same usage models as SYSmark 25, which is an application-based benchmark available on x86_64 Windows*.

Similar to SYSmark 25, CrossMark consists of seven sub-scenarios: – Document Editing, Spreadsheets, Web Browsing, Photo Editing, Photo Organization, Video Editing, and Responsiveness, detailed below:

- Document Editing

The Document Editing sub scenario models productivity usage of email creation/management, PDFs, presentations, and word processing.

- Spreadsheets

The Spreadsheets sub scenario models scientific simulations, forecasting, modeling within a spreadsheet application.

- Web Browsing

The Web Browsing sub scenario models website loads, web compute, and tab switching within a web browser.

- Photo Editing

The Photo Editing sub scenario models photography editing and post processing.

- Photo Organization

The Photo Organization sub scenario models photo cataloging and machine learning based image recognition.

- Video Editing

The Video Editing sub scenario models nonlinear video editing and composite video rendering for use in social media and other online venues.

- Responsiveness

The Responsiveness sub scenario models usages where the ability of the system to react quickly to the user's input impacts the experience of using the system (i.e. – users want to feel like the system responds smoothly and quickly). Some modeled usages include: application launches, file launches, and multi-tasking.

2.3   Scenario Grouping

The sub scenarios are grouped according to the descriptions below, as illustrated by Figure 1.
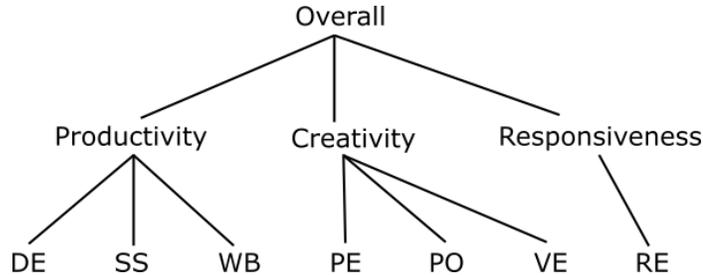
Figure 1: CrossMark Scenario Grouping

Abbreviations	Description
DE	Document Editing
SS	Spread Sheet
WB	Web Browsing
PE	Photo Editing
PO	Photo Organization
VE	Video Editing
RE	Responsiveness

Table 1 Abbreviations for sub-scenario's

2.3.1   Productivity

The Productivity scenario contains Document Editing, Spreadsheets, and Web Browsing sub scenarios.

2.3.2   Creativity

The Creativity scenario contains Photo Editing, Photo Organization, and Video Editing sub scenarios.

2.3.3   Responsiveness

The Responsiveness scenario contains usage models such as application launches, and file opens taken from other sub scenarios.

2.3.4   Overall Score

The Crossmark Overall Score is computed using the geometric mean ("Geomean") of all 7 sub scenarios (DE, WB, SS, PE, PO, VE, RE). Productivity and Creativity each represent approximately 3/7 of the overall score each and Responsiveness is 1/7.

2.4 Workloads Selection

CrossMark is a cross-platform performance benchmark that models the performance of real-world applications using open source and proprietary workloads. CrossMark is based on SYSmark 25 as its calibration benchmark. CrossMark shall give results that are comparable to SYSmark 25, which is the application-based benchmark. The benchmark reports overall score and sub scores for Productivity, Creativity and Responsiveness scenarios.

For CrossMark, workloads were chosen based on the following criteria:

Key Characteristics	Description
Cross-platform	Support for multiple platforms. Workloads were identified that would compile natively on the following operating systems: Windows, Android (ChromeOS, Not Supported), MacOS, iOS, Chrome, Windows on ARM and Linux. Currently, CrossMark supports Windows, MacOS and iOS operating systems but may support other operating systems in future.
Licensing	Workloads must either have a permissive open source license (e.g. MIT, BSD or Apache) or be contributed by BAPCo members.
Sensitivity Characteristics	CrossMark is designed to track the sensitivity characteristics of SYSmark 25 including sensitivity to CPU frequency, CPU core count, GPU, storage device, memory, architecture, etc. The combined component scaling of all the workloads must, by definition, closely match the component scaling of SYSmark 25 at the sub scenario level.
Client Usage Models	The workloads are based on typical client usage models like facial recognition, compression/decompression, file I/O, document processing etc.

Table 2: Workload Selection

CrossMark workloads are based on open-source libraries as well as proprietary application code. The workload applications used in the CrossMark are listed below in the *Table 3*. In CrossMark, source code is natively compiled for each platform (Windows, Android, macOS, iOS) using comparable compilers and flags. The compilers used for each platform are present in Workload selection section 2.4.2

2.4.1   Workload Description

The list of workloads is described below:

Workload	Description
AES Encryption	The advance encryption standard (AES) is a symmetric block cipher which uses 256-bit key length to encrypt messages. The encryption is widely used to secure communication channels and to secure information. The AES workload encrypts 128kbytes of data in memory dividing in blocks based on the number of threads in the system.
Chacha20 Encryption Chacha20 Decryption	The Chacha20 stream cipher and poly1305 authenticator are cryptographic algorithm with aim of ensuring high-security margins while achieving high performance e.g. major sites on the internet supports this type of encryption to make it more secure and blazing fast especially in browsers like Chrome. The workload reads text file and divides into the smaller blocks to do the encryption/decryption.
Zstd compression Zstd decompression Zstd stream decompression	Zstd is a fast compression algorithm providing high compression ratios. This workload assumes compression/decompression size knowing ahead of time; the complete bound or the window size of the data to be compressed/decompressed. In this workload we compress/decompress text read using the file. Zstd streaming decompression algorithm is used when upper bound of the compressed input is unknown or large window size can result to increased memory usage. The workload takes data from the file and breaks into the smaller blocks to decompress the entire input.
Zlib compression Zlib decompression	The lossless data compression provides in-memory compression/decompression including integrity checks of the uncompressed data. This method of compression/decompression technique is designed to be compact and fast for use in memory and on communication channels. The workloads using deflate/inflate take input from a file and breaks into smaller chunks to do the compression/decompression and writes into the output file.
Search	Search refers to the natural language string matching such as 'find' in word processing. This algorithm matches a set of string fragments on a character stream in memory. Each pattern matching is done via parallel processing to know the count of that pattern on given set of character stream.
File read File write	File read/write allows random access to file's contents by enabling to open the files, seek to a

	particular location and read/write to that file location. This helps to read/write to any part of the file directly. In this workload input from a file in which random read/write is performed each of small block sizes.
External Sorting	This workload is a class of sorting algorithm that can handle massive amount of data and used when data being sorted cannot fit into the main memory of a computing device (usually RAM) and instead must reside in the slower external memory (usually a hard drive). This workload executes by splitting files unsorted files into many thousands of files by doing the quicksort for each split. In the merge phase, sorted subfiles are combined into a single larger file.
SQLite	SQLite is a relational database management system contained in a C library. It is arguably the most widely deployed database engines used today in browsers, operating systems, embedded systems (mobile phones), among others. SQLite workload executes thousands recursive SQL queries to create random blobs sizes to be inserted into the database.
Rendering Frames	This workload renders thousands of frames processing the buffers in parallel doing the computation.
Object Detection	Object detection is one of the most popular computer vision algorithms out there. Its goal is to find all the objects of interest on the video and output their bounding boxes. It is applied to really a wide range of objects – all the way from cars to bacteria. When we look at images or videos, we can easily locate and identify the objects of our interest within moments. You Only Look Once or more popularly known as YOLO is one of the fastest real-time object detection algorithms used in this workload. This workload is based on inference as it starts with the pre-trained model for images, videos and does multiple object detection of 720p video stream.

Image Colorization	Colorization is the process of taking an input grayscale (black and white) image/video stream and then producing a colorized output image/video that represents the semantic colors and tones of the input (for e.g., an ocean on a clear sunny day must be plausibly "blue" – it cannot be colored "hot pink" by the model.) The novel approach used in this workload relies on deep learning utilizing neural network based on Caffe models capable of colorizing black and white images.
Video Colorization	
HDR	The workload takes five standard dynamic range images and produces high dynamic range image. There are different ways to obtain HDR images but the most common one is to use photographs of the scene taken with different exposure values.
Face recognition	Face recognition is based on the geometric features of the face based on Eigenfaces method. A facial image is a point from a high-dimensional image space and a lower-dimensional representation is found where classification becomes easy. The workload take ORL database of faces contains ten different images of distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open/closed eyes, smiling/not smiling) and facial details. The Eigenfaces model is trained with the images. The test image is provided to get the confidence of prediction.
Black Scholes (multi-threaded)	The workload is based on generating random number based on a probability distribution. The random number then uses the additional inputs of volatility and time to expiration to generate a stock price. It uses pseudo random number generator based on a matrix linear recurrence over a finite binary field and provides fast generation. The generated stock price at the time of expiration is then used to calculate the value of the option. The model then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the model, the number of uncertainties and the probability distributions used, it uses tens of thousands of recalculations before it completes. It typically relies on the average of all the calculated results as an options price.
Black Scholes (single-threaded)	
Video Tracking	The video tracking the goal is to find the object in the current frame given we have tracked the object successfully in all previous frames. This tracker tracks the object in both forward and backward directions in time for video.

Table 3 Workload Description

Workload Compilation

CrossMark uses Clang compiler based on open source compiler for the C family of programming languages for natively compiling workloads on different operating systems. Clang builds on the LLVM optimizer and code generator. CrossMark uses the -O2 optimization flag during compilation. Here is the version of Clang compiler used for each operating system:

- Windows – Clang 10.0.0
- macOS – Apple Clang 12.0.0
- iOS/iPadOS – Apple Clang 12.0.0
- Android – NDK r21 Toolchain

2.5   Workload Coefficient Mapping

The goal of workload coefficient mapping is to determine a coefficient for each CrossMark workload. BAPCo uses a set of 22 workloads with various sensitives to represent the performance of each of the seven sub scenarios ([see section 2.3](#)) in SYSmark 25. The coefficient mapping is done for each of the sub-scenarios (calibration workloads) to generate a set of workload coefficients. The set of workloads with its coefficients represents the performance of the calibration workload.
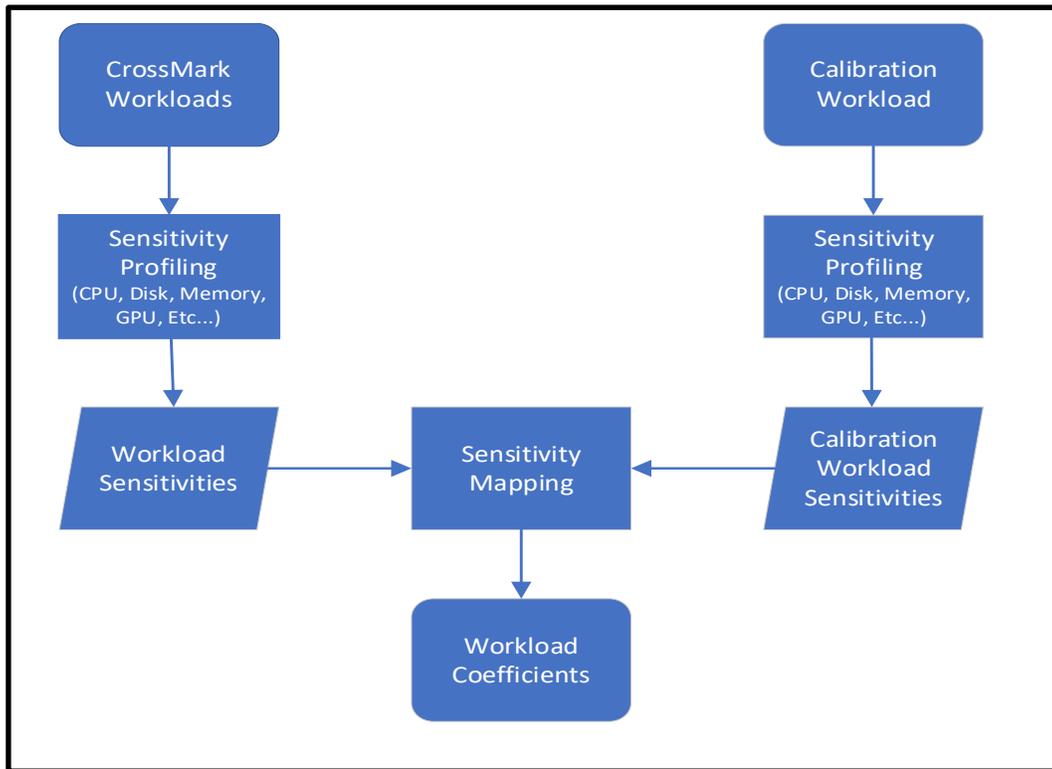
Figure 1

Here is a description of the mapping process shown in Figure 1:

1. Each of the CrossMark workloads is profiled to determine its sensitivity to various system components using a Windows 10 system. These components include CPU, Disk storage, Memory and GPU, sensitivity in addition to other secondary sensitivities. (While the exact same code base is used on all platforms, individual sensitivities may vary on other platforms.)

2. The targeted SYSmark 25 sub-scenarios are also profiled to determine the sensitivity to the same system components.

3. The matrix of sensitivities for both the CrossMark workloads and the target SYSmark 25 sub-scenario are put through a linear algebra solver which finds the best possible set of coefficients for each of the CrossMark workloads to represent the profiled sensitivities within the SYSmark 25 sub scenario.

4. These workload coefficients are configured into CrossMark and are used to scale the workload performance on the system under test to generate sub scenario scores and ultimately the overall CrossMark score.

2.6   Scoring Methodology

A complete CrossMark run will display the following performance ratings: CrossMark Overall Rating, a Productivity Rating, a Creativity Rating, and a Responsiveness Rating.

2.6.1   Workload Rating

Each workload is executed exactly once per benchmark iteration, and some workloads may appear in multiple sub-scenarios. This saves runtime and gives more consistent results. The rating for each workload is the calibration runtime divided by the measured runtime on the test system and multiplied by 1000. Workload ratings are not displayed in the benchmark output.

2.6.2   Sub Scenario Rating

The sub scenario rating is the sum of each of the workload ratings multiplied by the workload coefficients for the corresponding sub scenario, see section 2.5. Sub scenario ratings are not displayed in the benchmark output.

2.6.3   Productivity Rating

The Productivity Rating is calculated by taking the geometric mean of all the Document Editing (DE), Spreadsheets (SS), and Web Browsing (WB) sub scenario ratings (prior to rounding). The result is then rounded to the nearest integer.

2.6.4   Creativity Rating

The Creativity Rating is calculated by taking the geometric mean of all the Photo Editing (PE), Photo Organization (PO), and Video Editing (WB) sub scenario ratings (prior to rounding). The result is then rounded to the nearest integer.

2.6.5   Responsiveness Rating

The Responsiveness rating is simply the Responsiveness sub scenario rating taken as is.

2.6.6   Overall Rating

The CrossMark Overall Rating is calculated by taking the geometric mean of all seven of the sub scenario ratings (prior to rounding). The result is then rounded to the nearest integer. The goal of the CrossMark Overall Rating is to be within ±5% of the SYSmark 25 Overall Rating when running on an identical system with an identical configuration.

2.7 Calibration System

The calibration system is chosen in milestone 16 as a reference point for all other CrossMark results. BAPCo chose the configuration below for its wide availability and its representation of a typical mainstream PC at the time of release of CrossMark. This calibration system matches with SYSmark 25 calibration system as CrossMark shall give results that are comparable to SYSmark 25, which is the application-based benchmark from BAPCo.

CrossMark is calibrated in such a way that a PC with performance equivalent to this calibration system for a given workload will have a 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 performance rating of 2000. This is true for both overall ratings and scenario ratings.

The calibration system for CrossMark has the following configuration:
- Lenovo® ThinkCentre™ M720q
- Processor: Intel® Core™ i5-8500T @ 2.10 GHz
- Operating System: Microsoft Windows 10 Pro x64 20H1 (10.0.0.1863.418)
- RAM: 1x8 GB DDR4 single channel
- Graphics: Intel® HD Graphics 630
- Resolution: 1920x1080
- Audio: Integrated High Definition Audio
- Storage: 256GB NVMe SSD
- Networking: Integrated Gigabit Ethernet

A fresh operating system installation is performed on the system (not an OEM factory optimized image).

The calibration sum for each sub scenario is obtained according to the following process:
- Run CrossMark on the calibration system (conditioning run enabled, 3 iterations)
- For each sub scenario we:
  - o Identify the median iteration by finding the iteration with the median sub scenario rating score.
  - o The calibration sum for the sub scenario is the response time total from that sub scenario in the median iteration.

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

The CrossMark calibration system is the basis for determining the reference scores for the benchmark only and is not intended as an example of minimum system requirement. Refer Appendix B for information on minimum system requirements.

2.8 Cross Platform Comparisons

One of the main goals of CrossMark is to provide a measure of system performance across multiple platforms. These are the processes BAPCo followed:

The workload contributions to the overall rating are determined during Workload Coefficient Mapping refer section 2.5. The calibration system score is determined during benchmark calibration refer section 2.7. These processes are done one time and used for all systems on all platforms. Here are few more considerations:

- The same source code is used on all platforms. The majority of the code that is executed in this benchmark is code that is compiled directly from the C/C++ code supplied within the benchmark. Avoiding unnecessary system libraries makes the workloads as comparable as possible.

- Workloads are compiled natively on each platform (x86_64, ARM64) using comparable compilers (see section 2.4.2.) and flags. BAPCo may add new architectures in future to support other platforms.

3 Workload Characteristics

This section provides data illustrating the performance characteristics of CrossMark version 1.0.0.73.

3.1 Sensitivity Analysis

The series of charts below shows the sensitivity of CrossMark to different system characteristics, including the amount of CPU frequency, number of CPU cores, storage, graphics adapter, system memory, 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.

Due to system implementation differences, these figures are only accurate for the configuration description listed below in each sub-section. These sensitivities will vary from one configuration to the next.

Sensitivity Analysis Base System Configuration

CPU Model	Intel Core i9-10900k
Base CPU Frequency	3.7 GHz
CPU uArch	Intel® Core 10900k Series Processors
Physical Cores	10
Logical Cores	20
Chipset	Z490
RAM	2 x 8GB DDR4-2933 (16 GB Total)
Storage	Intel 660p SSD, 512 GB M.2 NVMe
OS	Windows* 10 x64 May 2019 Update aka "20H1"
Resolution	1920 x 1080 @ 60 Hz
Graphics	GeForce* RTX* 2060

Note: For these tests, Intel Turbo Boost Technology and Intel Hyper-Threading Technology have been disabled to better highlight the specific component being tested in each sensitivity study.

3.1.1 Sensitivity to CPU Frequency

The CPU frequency of a system is changed from 1.8 GHz to 3.6 GHz in steps of 600 MHz
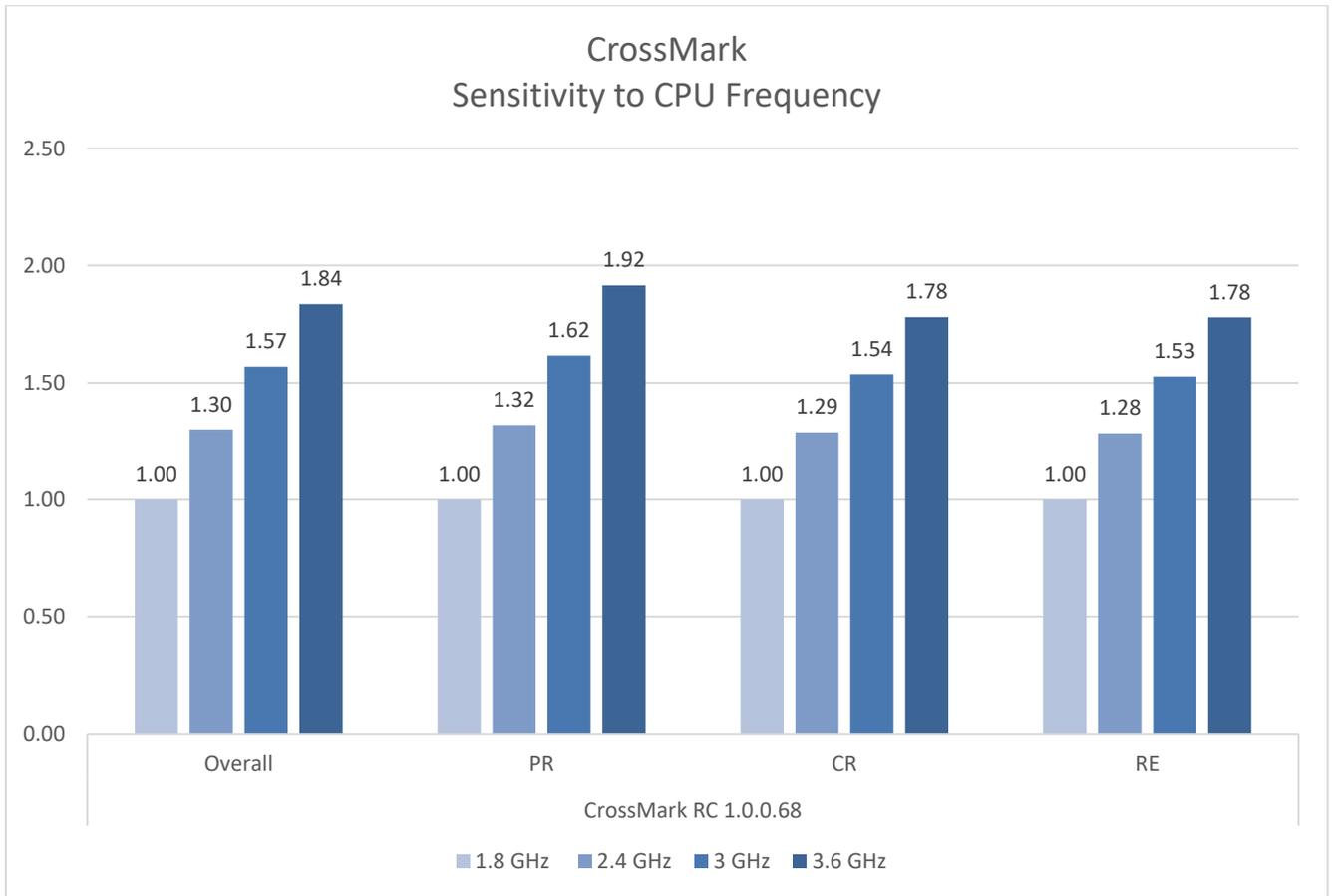
Figure 2 CPU Frequency Sensitivity

3.1.2 Sensitivity to CPU Core Count

The number of CPU cores is controlled by changing system BIOS settings to enable 2 cores, then 4 cores, 6 cores, 8 cores and finally all 10 cores of a 10-core processor.
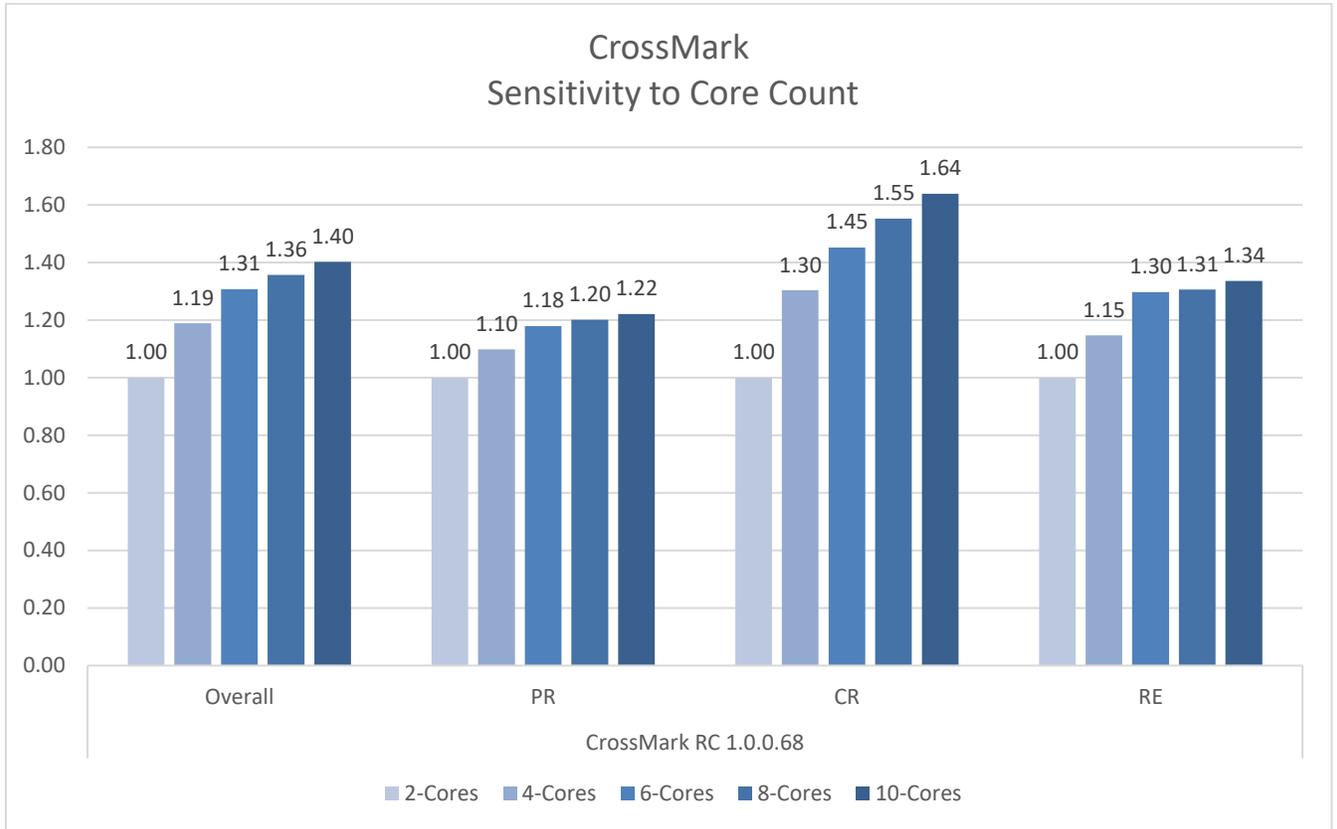
Figure 3 CPU Core Count Sensitivity

Figure 4 **SYSmark25 vs CrossMark CPU Core & Frequency Sensitivity Comparison**

3.1.3   Sensitivity to Storage

The primary storage device is changed according to the figure below. A Seagate 500GB 5400RPM hard drive, Western Digital 7200RPM SATA III 1TB hard drive, Intel® SSD 545s, Intel® SSD 660p and Intel® Optane™ SSD 900p

CrossMark
Sensitivity to Storage Device

CrossMark RC 1.0.0.68

Legend: 5400RPM HDD, 7200RPM HDD, SATA SSD (545s), NVMe SSD (660p), Optane (900p)

	5400RPM HDD	7200RPM HDD	SATA SSD (545s)	NVMe SSD (660p)	Optane (900p)
Overall	1.00	1.08	1.29	1.36	1.44
PR	1.00	1.08	1.30	1.39	1.46
CR	1.00	1.02	1.04	1.05	1.05
RE	1.00	1.30	2.37	2.80	3.46
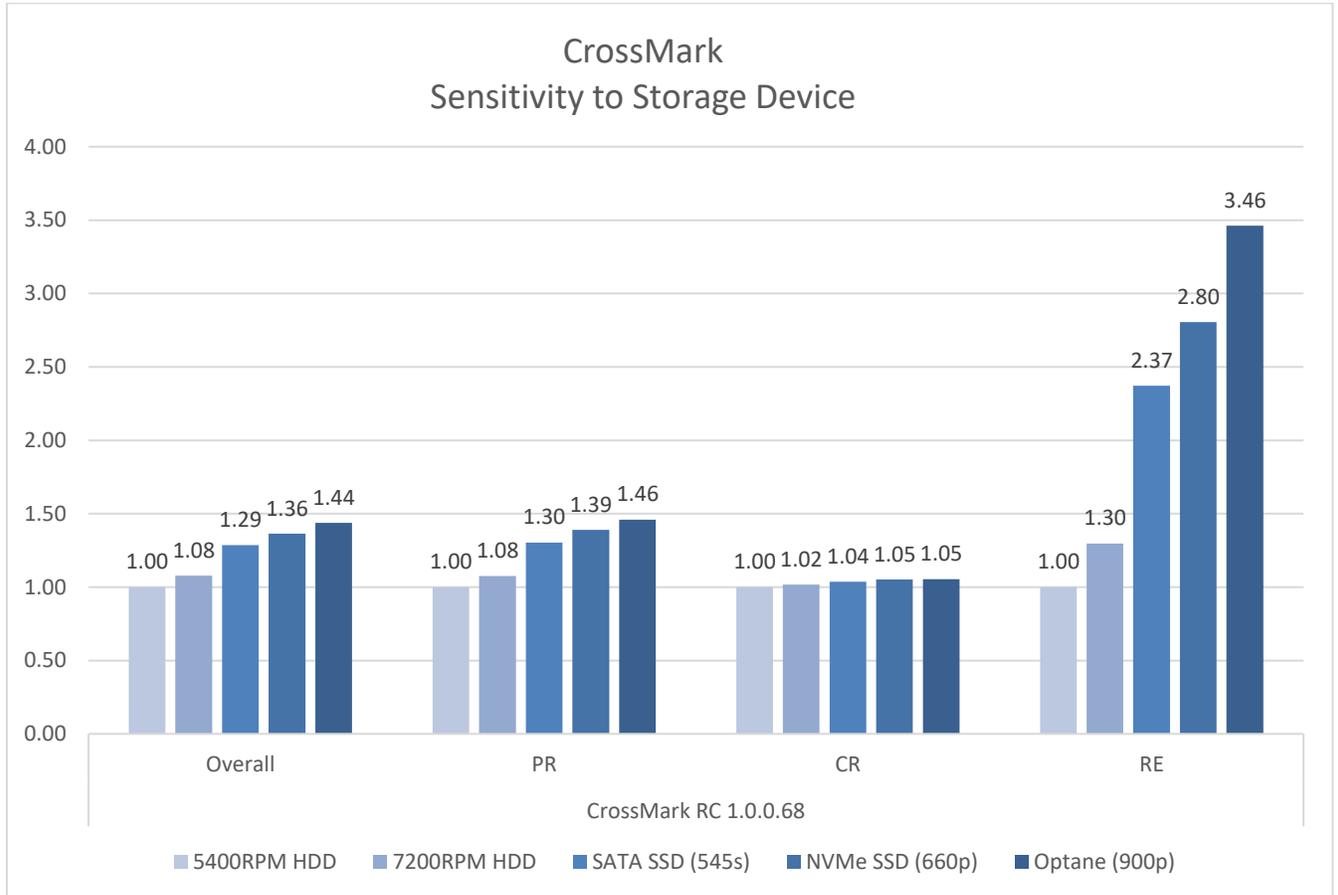
Figure 5 Storage Sensitivity

Figure 6 Storage Sensitivity SYSmark 25 vs CrossMark

3.1.4 Sensitivity to System Memory Capacity

The total system memory is changed from 4 GB single channel, 8 GB Single Channel, 16 GB Single Channel, 4 GB dual channel, 8 GB dual channel and 16 GB dual channel. The memory type for all tests is DDR4-2666. We compare single channel, dual channel, and single vs. dual channel.
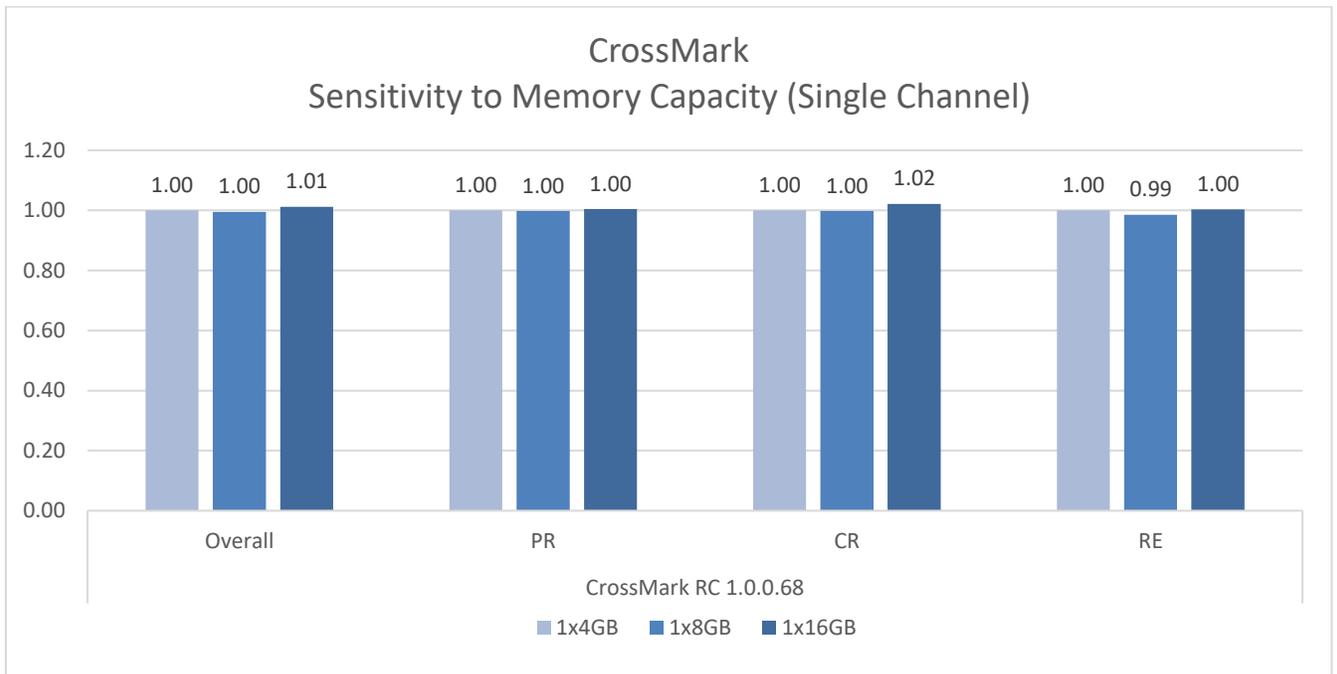
Figure 7 System Memory Sensitivity (Single Channel)

CrossMark
Sensitivity to Memory Capacity (Dual Channel)
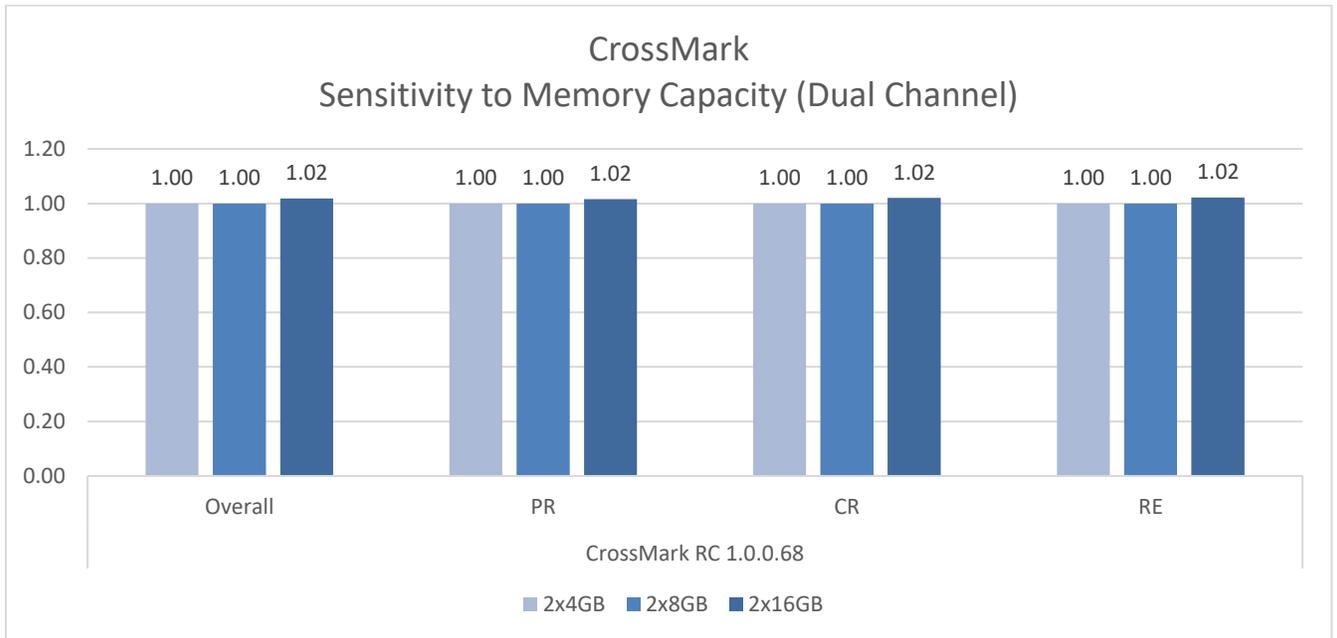
Figure 8 System Memory Sensitivity (Dual Channel)

CrossMark
Sesitivity of Memory Channels
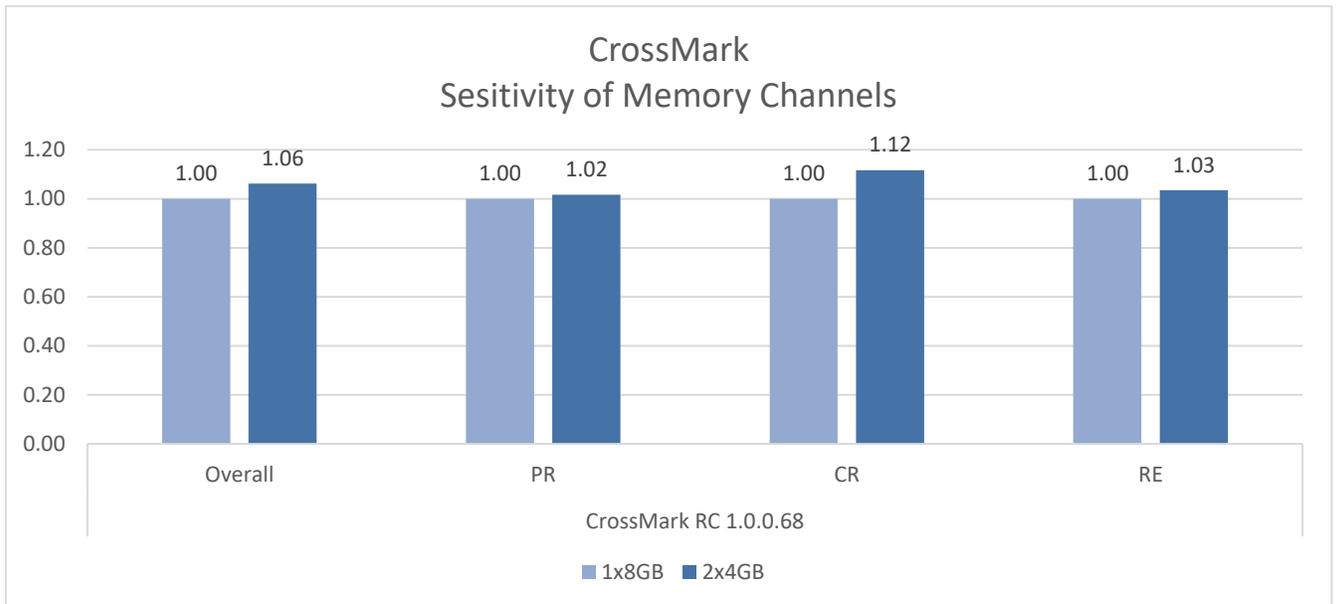
Figure 9 System Memory Channel Sensitivity (Single vs. Dual Channel)

SYSmark 25 vs CrossMark
Sensitivity of Memory Channels
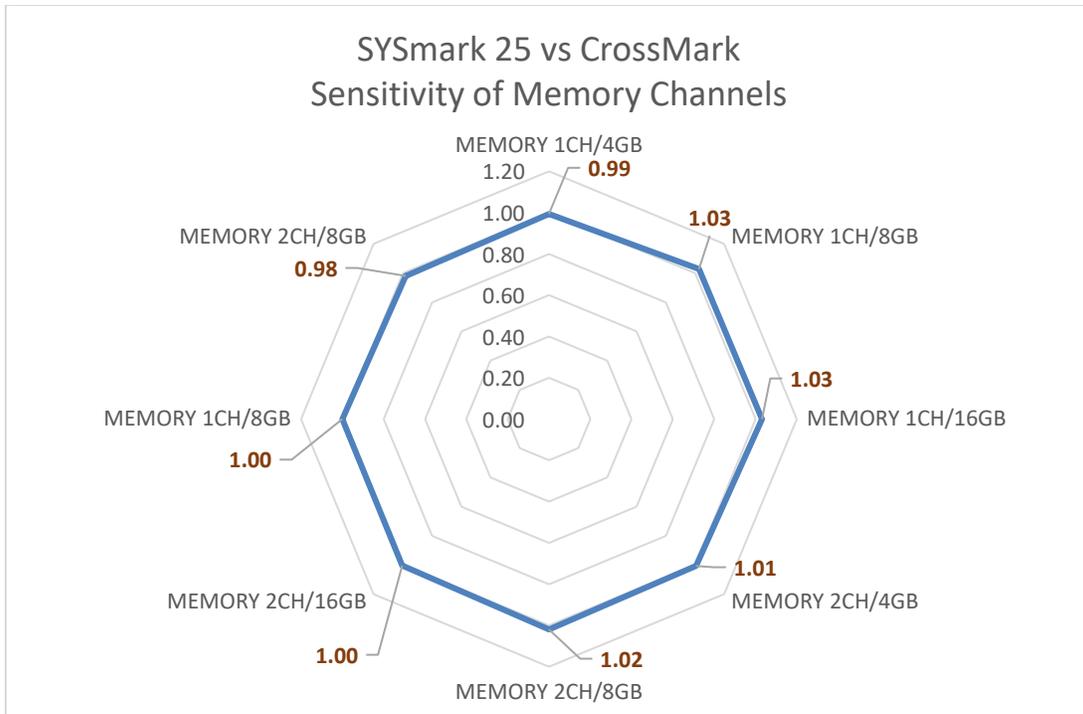
Figure 10 SYSmark25 vs CrossMark Memory Channel Sensitivity Comparison

3.1.6   Sensitivity to Graphics Subsystem

The video card is changed according to the table below. For these tests, we used discrete video cards all from the same manufacturer to ensure the graphics driver family from each configuration was constant. A Nvidia GeForce® GT 1030, GeForce® GTX 1650, GeForce RTX™ 2060, and GeForce RTX™ 2080 Ti were used.
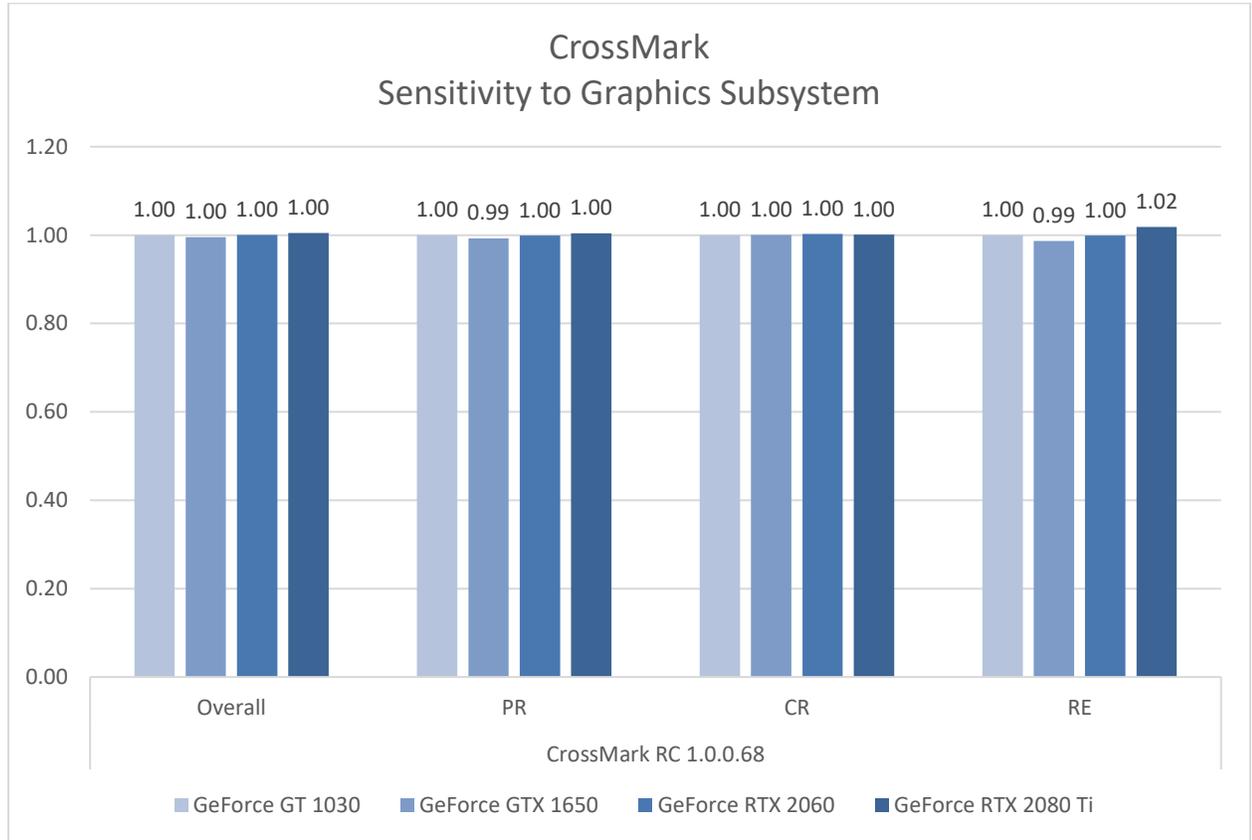
Figure 11 Graphics Subsystem Sensitivity

3.1.7   Sensitivity to Display Resolution

The display resolution is changed according to the figure below using integrated graphics.
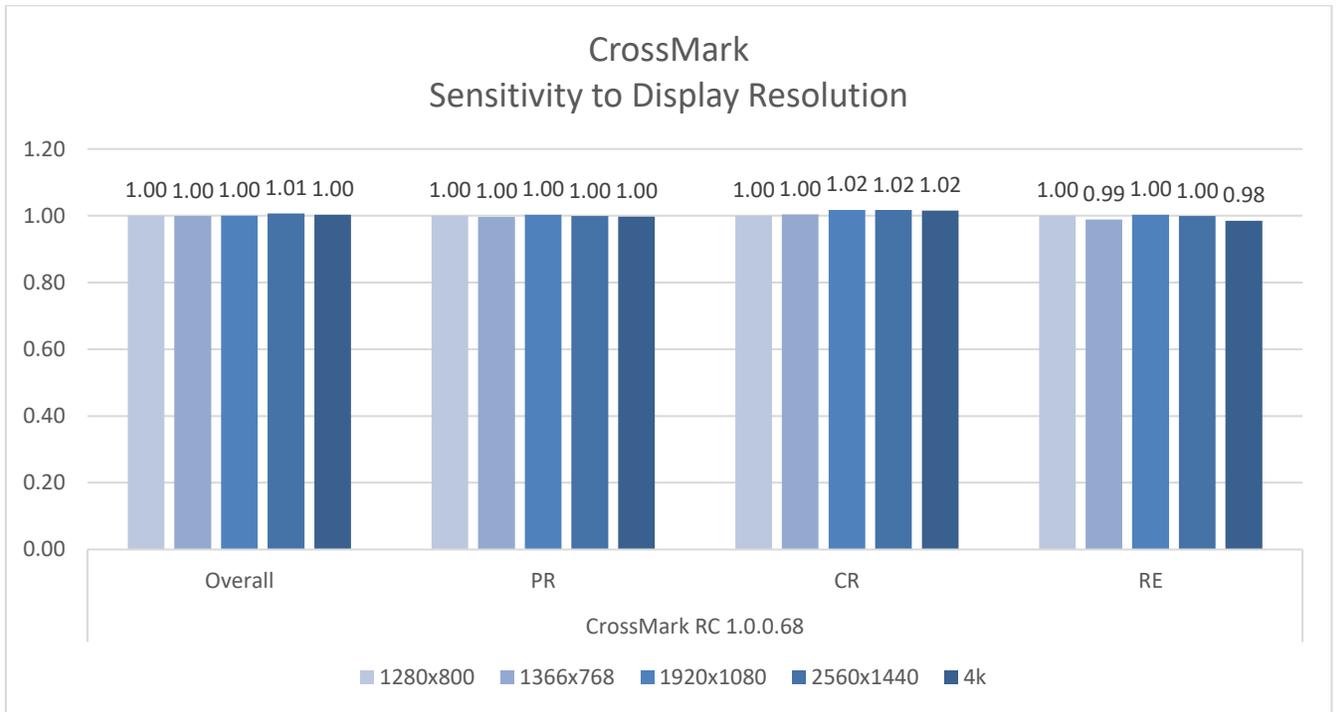
Figure 12 Display Resolution Sensitivity

Figure 13 GPU/Display Resolution Sensitivity SYSmark 25 vs CrossMark

3.2   System Configuration Tool Items List

The system configuration settings are recommended to be made before running CrossMark to obtain repeatable scores and minimize the occurrence of errors on Windows and macOS platforms. When testing CrossMark on notebook systems/phones/tablets, please be sure the system or device is plugged into AC power for best results. This section gives an overview of the required settings followed by the steps to make the required modification in system settings.

Note: Some of these settings is via registry editor. Here is the link below to back up your current setting in the registry editor. This shall help to restore the original setting back by importing them after test is run for system to return to original state

3.2.1   Required settings

Make configuration changes that are required for the benchmark to run to match the results of SYSmark 25.

3.2.1.1   *Disable User Account Control (UAC)*

Disables User Account Control to prevent Administrator elevation prompts from appearing during benchmark runs. The system must be rebooted to apply this change.

3.2.1.2   *Disable Low Battery Actions*

Prevents the system from shutting down or from posting a warning when the battery reaches the low level.

3.2.1.3   *Disable Windows Update*

Disables the Windows update service.

3.2.1.4   *Disable WinSAT service*

Disables the WinSAT service

3.2.1.5   *Disable Windows Search*

Disables Windows search service.

3.2.1.6   *Disable Diagnostic policy service*

Disables Diagnostic policy service.

3.2.1.7   *Disable SysMain service*

Disables SysMain service.

3.2.1.8   *Create BAPCo Power Scheme*

Creates a new power scheme named "BAPCo CrossMark" based on the system's currently active power scheme. If applied, all subsequent power profile configuration changes will be applied to

the newly created power scheme. If this option is not enabled, all power profile configuration changes will be applied to the currently active power scheme.

3.2.1.9   Set Power Plan Type to "High Performance"

Sets the "Power Plan Type" option (sometimes referred to as "Power Plan Personality") of the active power scheme to "High Performance". This setting tags the active power plan with an overall personality that favors performance over energy savings. Drivers and applications may query this setting to determine their respective performance vs energy savings behavior. This option may be used whether or not the "Create BAPCo Power Scheme" option is checked. If "Create BAPCo Power Scheme" is not enabled, "Set Power Plan Type" will be applied to the currently active power scheme.

3.2.1.10   Set CPU High Performance

Sets the minimum and maximum value for CPU performance state to 100% to prevent CPU throttling on both AC and DC power.

3.2.1.11   Disable Windows Defender

Sets Windows Defender to disabled. If Tamper Protection is turned on, this setting can't be altered.

3.2.1.12   Disable Tamper protection

Disables tamper protection to allow the Windows defender to be disabled.

3.2.1.13   Disable Hard Disk Timeout

Prevents the hard disk from going to sleep

3.2.1.14   Ignore Laptop Lid Close

Prevents the system from going to sleep if the lid is closed during a benchmark run

3.2.2　Steps for modifying each setting

Following are the methods to modify the system settings for each platform.

3.2.2.1　Windows
3.2.2.1.1　Adjust the power and performance settings in Windows

a) Click Windows start menu icon ▦ and select Settings ⚙ > System > Power & Sleep.
b) Click the 'Additional power settings' option found under 'Related settings' on right side of the window.
c) Click the 'Create a power plan' option as shown in (Figure 11).
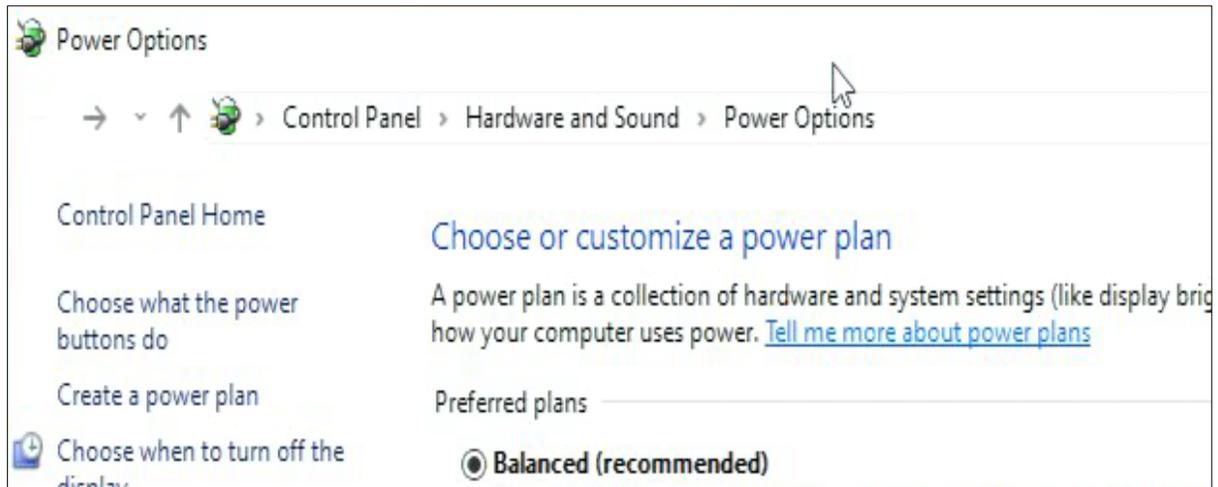
Figure 14 Power options window

d) The Balanced is selected by default. To use a power plan other than the balanced power plan, select it before proceeding. Otherwise, under plan name, type 'CrossMark' as the name to the new power scheme and click 'Next' button (Figure 12).
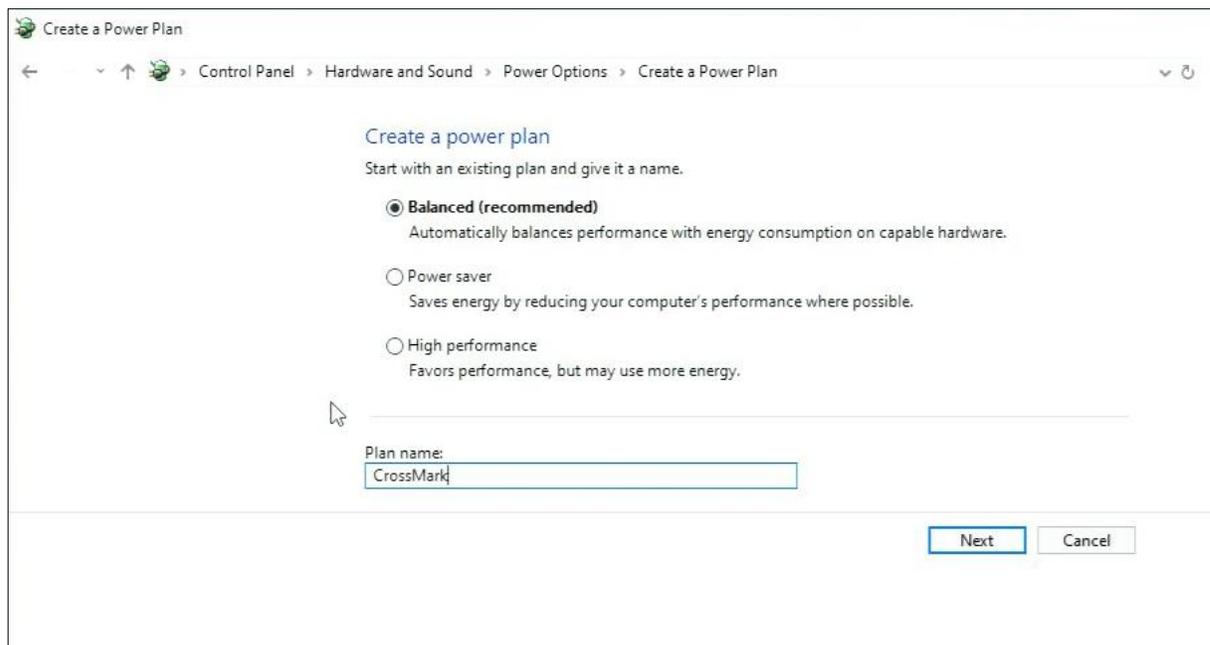
Figure 15 Name the power plan

e) Keep the default selection for the below options and click the 'Create' button to create the power scheme named CrossMark (Figure 13).

- Turn off the display
- Put the computer to sleep
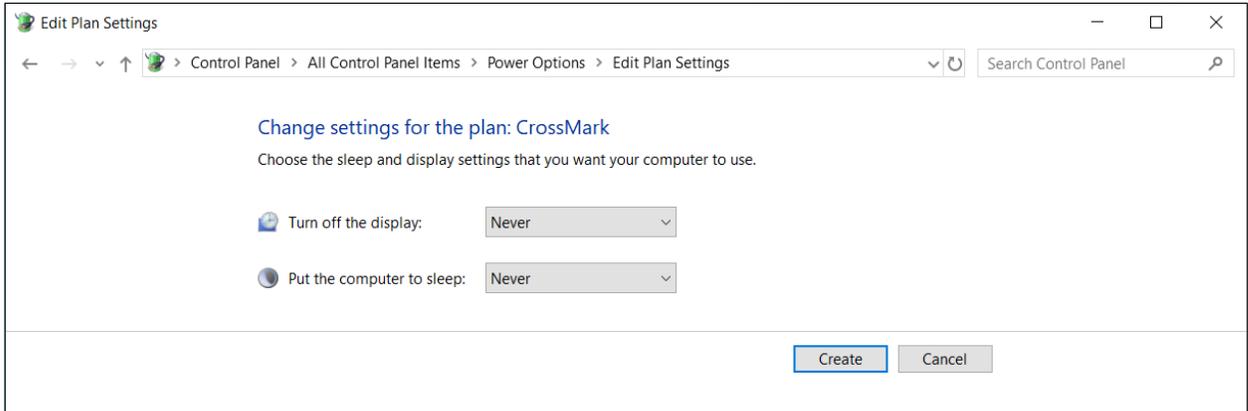
Figure 16 Create the power plan

f) Click on 'Change plan settings' link to the right of the newly created CrossMark power plan which is the active plan now.

g) Click 'Change advanced power settings' to open the advanced settings dialog and configure the follow settings (Figure 14). For notebooks, configure the 'Plugged in' setting. The 'On Battery' setting may be ignored
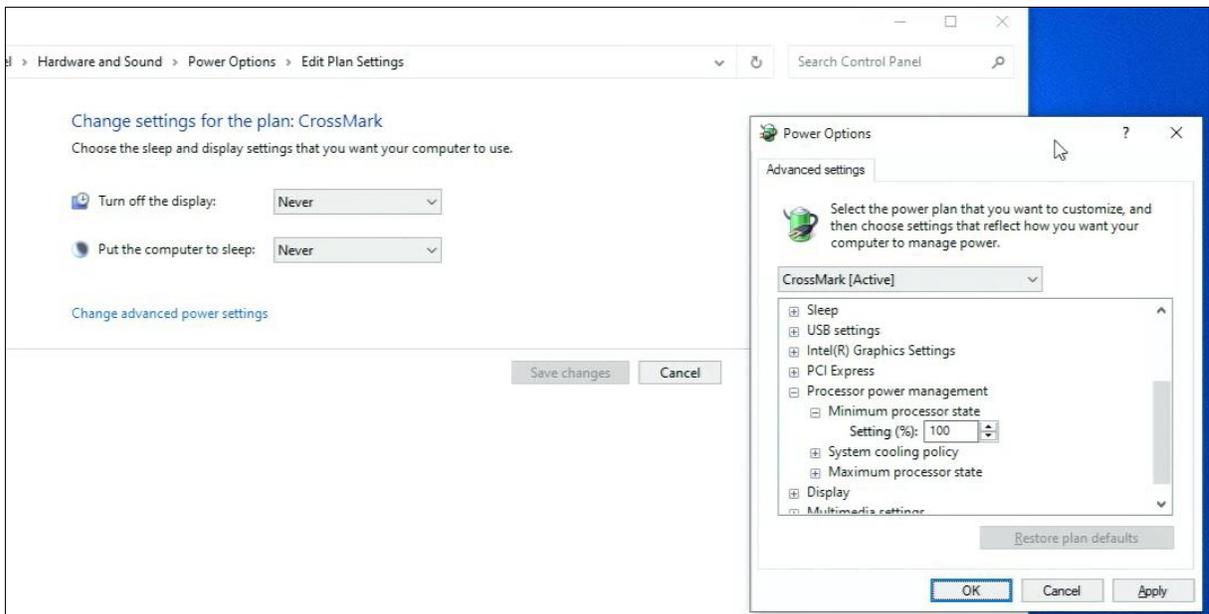
Figure 17 Advanced power settings

- Processor power management > Minimum processor state > set to 100%
- Battery > Critical battery level > set to 0% (notebooks only)
- Battery > Critical battery action > set to 'Do Nothing' (notebooks only)

- Battery > Low battery level > set to 0% (notebooks only)
- Battery > Low battery notification > set to 'Off' (notebooks only)
- Battery > Low battery action > set to 'Do Nothing' (notebooks only)
- Battery > Reserve battery level > set to 0% (notebooks only)
- Power buttons and lid > Lid close action > set to 'Do Nothing' (notebooks only)
- Power buttons and lid > Power button action > set to 'Do Nothing'
- Power buttons and lid > Sleep button action > set to 'Do Nothing'
- Hard disk > Turn off hard disk after > set to 'Never'
  - a) Click 'Apply' to save the changes, then click 'OK' to close the advanced settings dialog.
  - b) Close the power plan settings window.

3.2.2.1.2 Set Power Plan Type to "High Performance"

a) To set the power plan personality to High performance, hit Windows+X and choose the 'Windows PowerShell (Admin)' option to open PowerShell with administrative privileges. At the prompt, type (or copy and paste) the following command and then hit Enter (Figure 15): **powercfg.exe -SETACVALUEINDEX SCHEME_CURRENT SUB_NONE 245d8541-3943-4422-b025-13a784f679b7 1**

b) Close the PowerShell window.


```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

PS C:\WINDOWS\system32> powercfg.exe -SETACVALUEINDEX SCHEME_CURRENT SUB_NONE 245d8541-3943-4422-b025-13a784f679b7 1
PS C:\WINDOWS\system32>
```

Figure 18: **Power plan personality settings**

3.2.2.1.3 Disable WinSAT

a) Go to Windows start ⊞ and type 'task scheduler' in the search field and click 'Task Scheduler' in the search results.

b) Browse to Task Scheduler Library > Microsoft > Windows > Maintenance.

c) Right click on WinSAT option from the right-side pane, select 'Disable' and close the window (Figure 16).
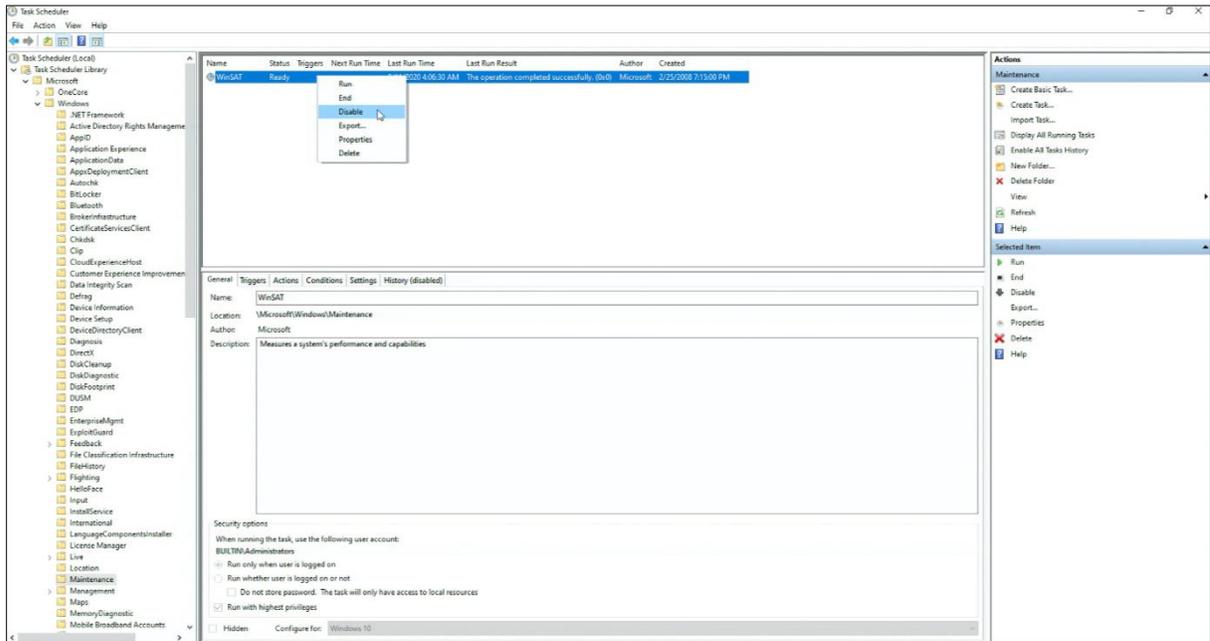
Figure 19 Task Scheduler to disable WinSAT

3.2.2.1.4 Disable all Windows updates
a) Go to Windows start ⊞ and select Settings ⚙ > Update & Security > Windows Update

b) Select 'Advanced options' from the Windows on the right and turn off all the options as shown in Figure 17 below.
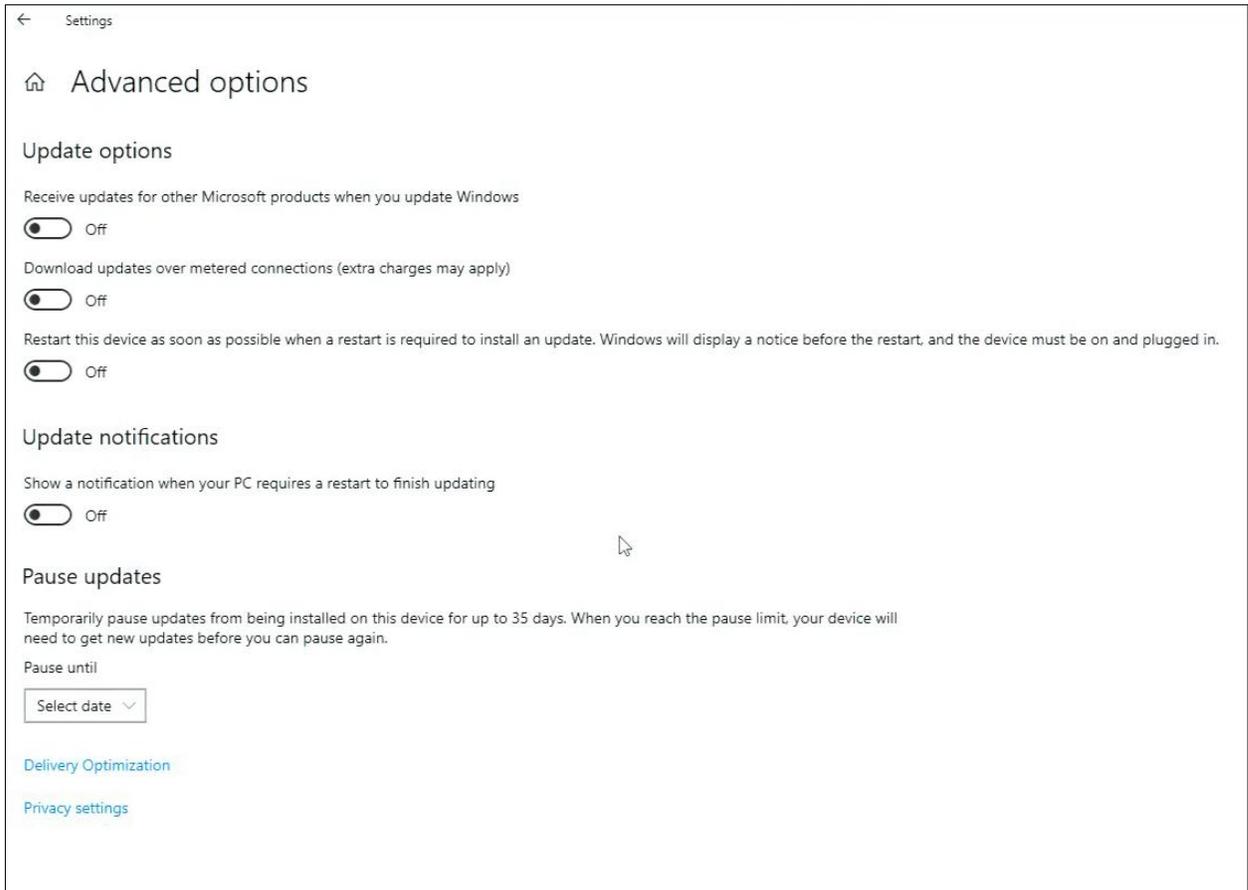
Figure 20 Settings options to disable Windows update

Disable tamper protection
a) Go to Windows start ⊞ and select Settings ⚙ > Update & Security > Windows Security.
b) Switch to Virus and Threat Protection. Select Manage Settings.
c) Scroll down to find Tamper Protection and toggle to 'Off'.
d) Close the Windows Security settings window

5. Disable Windows Search, Diagnostic Policy Service and SysMain services

a) Go to Windows start ⊞ and type 'services' in the search field and click 'Services' in the search results.
b) Find the 'Diagnostic policy service' from the list. Right click on the service and click 'Stop'.
c) Double click on the service and set 'Startup type' option to 'Disabled'. Click Apply to save the changes and then click 'Ok' to return to Service window.
d) Find 'Windows Search' from the list. Right click on the service and click 'Stop'.
e) Double click on the service and set 'Startup type' option to 'Disabled'. Click Apply to save the changes and then click 'Ok' to return to Service window.
f) Find 'SysMain' from the list. Right-click on the service and select Stop (Figure 18). If you're running an older version of Windows, right-click on the SuperFetch service and select Stop.

g) Double click on the service and set 'Startup type' option to 'Disabled' (Figure 19). Click Apply to save the changes and then click 'Ok' to return to Service window. Click the 'X' close button to close the window.
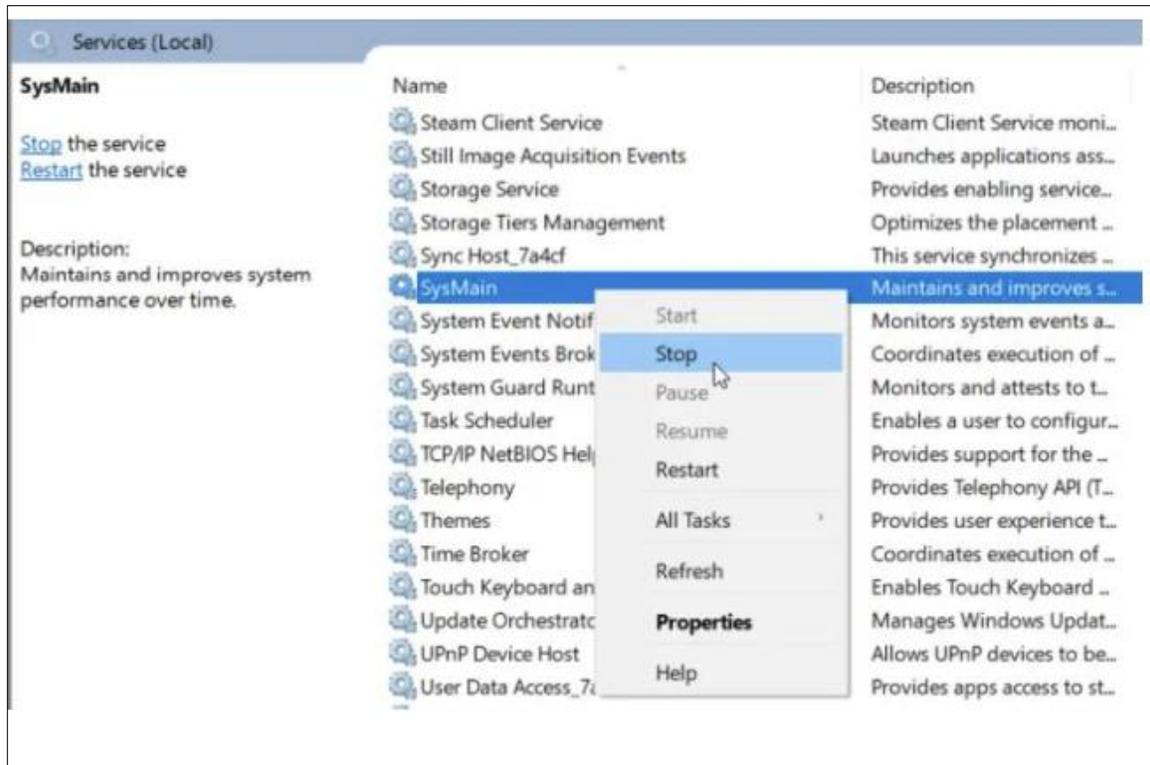
Figure 21 Services option to stop SysMain service
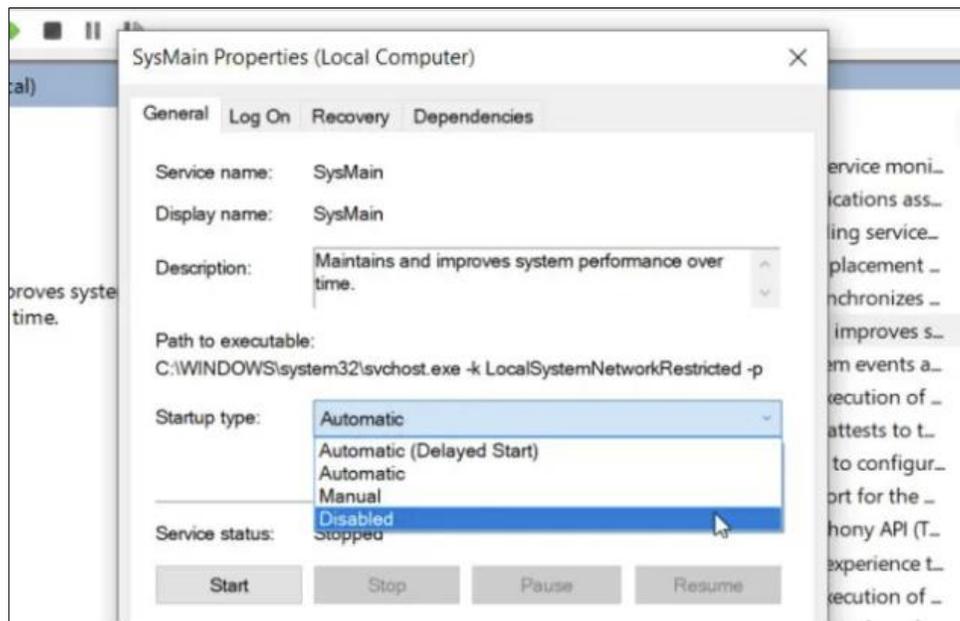
Figure 22 Services option to disable SysMain service

3.2.2.1.6   Disable Windows defender

1. *Method 1 - Using Group policy editor (Recommended)*

   a) Go to Windows start ⊞ and type 'group policy' in the search field and click 'Edit group policy' in the search results. If 'Edit group policy' is not present in the search result, follow the steps from 'Using Registry editor'

   b) Browse to Computer Configuration > Administrative Templates > Windows Components > Microsoft Defender Antivirus. On the right pane of the Local Group Policy Editor window, double-click the 'Turn off Microsoft Defender Antivirus' policy (Figure 20).

   c) Select Enabled and click Apply. Click OK to save the setting

Figure 23 Local Group Policy Editor options to disable Windows defender
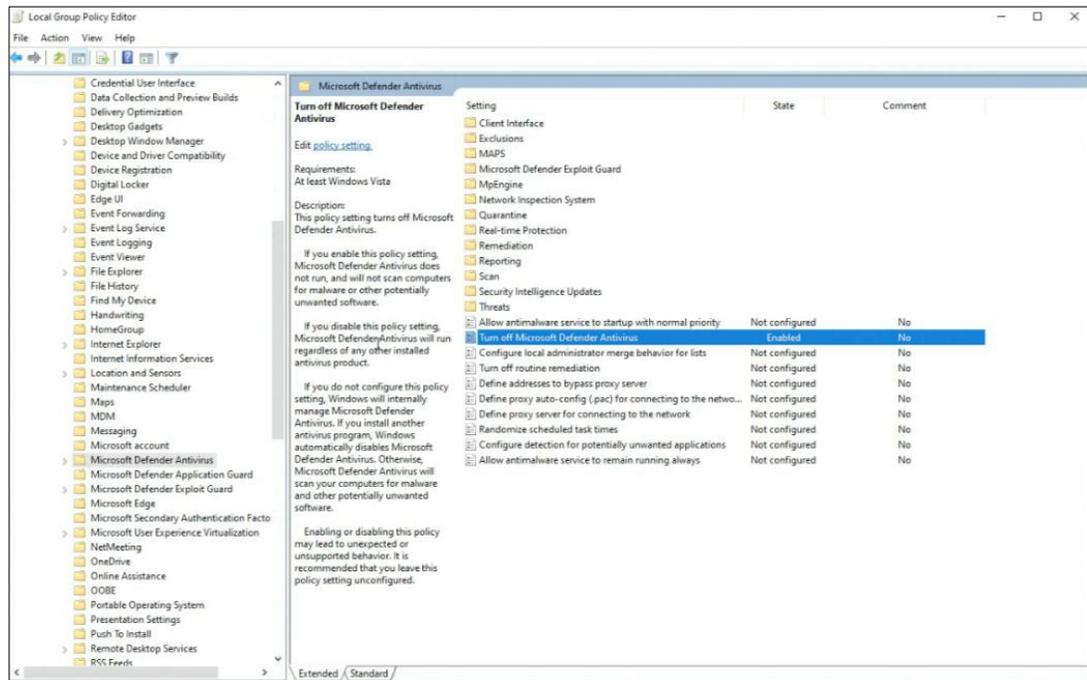
2. *Method 2 - Using Registry editor*
   a) Go to Windows start ⊞ and type 'regedit' in the search field and click 'Registry Editor' in the search results.
   b) Go to HKEY_LOCAL_MACHINE > SOFTWARE > Policies > Microsoft > Windows Defender. Right click on 'Windows Defender'. Click New > Key > DWORD (32-bit) Value. Type 'DisableAntiSpyware' and hit Enter on keyboard.
   c) Double click on the 'DisableAntiSpyware' DWORD just created and type 1 in the value data field. Click OK. (Figure 21)

Additional settings required only for Windows version: Windows 10 2004.19041.450 and above to globally turn off security setting including defender.

Windows security center is an additional setting that is required to be disabled for Windows version 2004.19041.450 and above. Below are the steps to disable Windows security center using regedit.

a) Go to Windows start ⊞ and type 'regedit' in the search field and click 'Registry Editor' in the search results.

b) Go to HKEY_LOCAL_MACHINE > SYSTEM > CurrentControlSet > Services > SecurityHealthService. Double click on the 'Start' DWORD and type 4 in the value data field. Click OK.

c) Go to HKEY_LOCAL_MACHINE > SYSTEM > CurrentControlSet > Services > wscsvc. Double click on the 'Start' DWORD and type 4 in the value data field. Click OK. Reboot the machine.
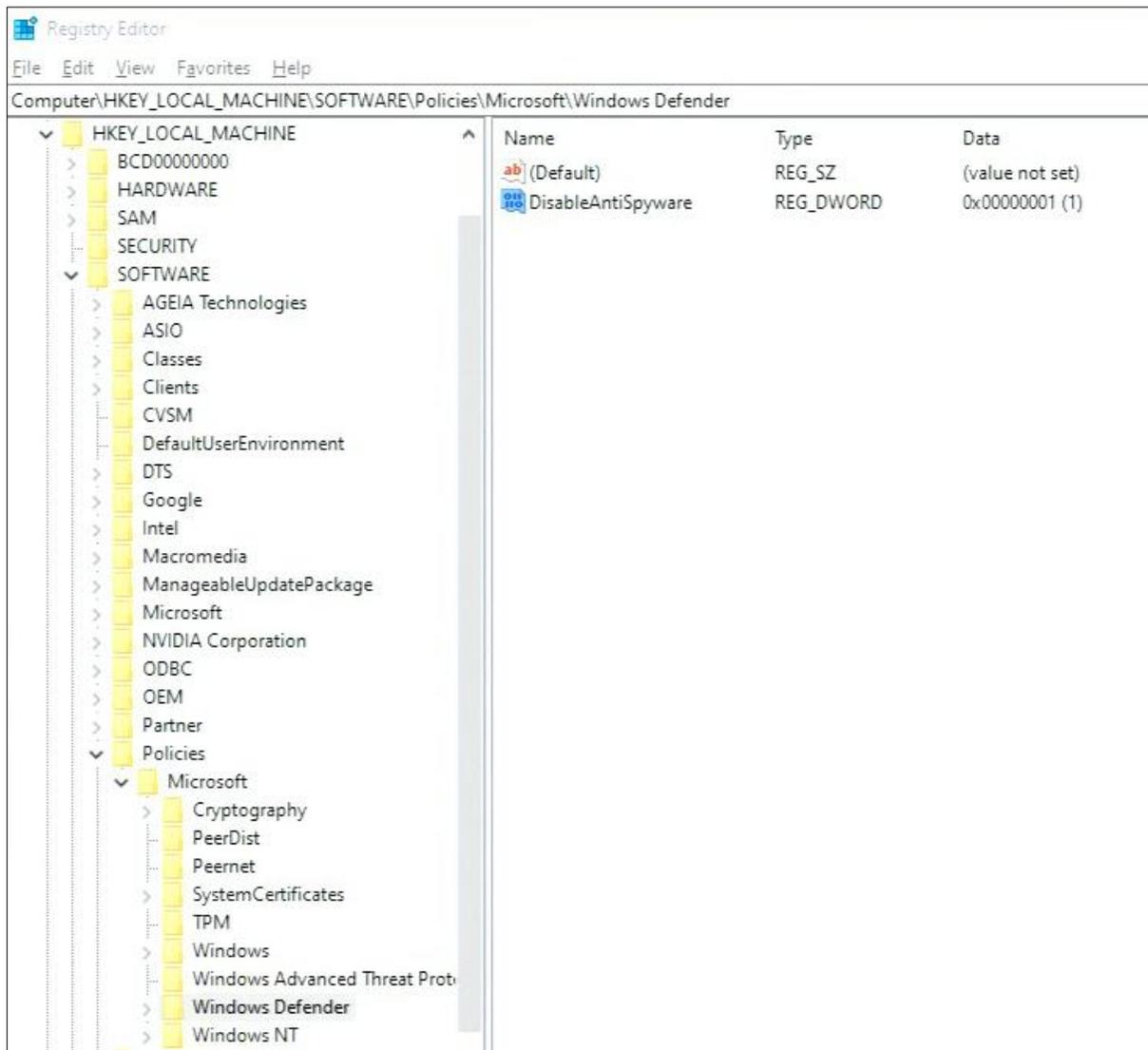
Figure 24 Disable Windows defender using Registry editor

3.2.2.1.7   Disable User Account Control Settings
Method 1 - Using Group policy editor (Recommended)

a) Go to Windows start ⊞ and type 'group policy' in the search field and click 'Edit group policy' in the search results. If 'Edit group policy' is not present in the search result, follow the steps from 'Using Registry editor'

b) Browse to Computer Configuration > Windows Settings > Security Settings > Local Policies > Security Options. On the right pane of the Local Group Policy Editor window, double-click the setting: 'User Account Control: Behavior of the elevation prompt for administrators in Admin Approval Mode' policy (Figure 22).

c) In the drop down menu, select 'Elevate without prompting' and click apply

d) Click OK to save the setting and return to the Group Policy editor window.

e) In Group Policy Editor window, locate the item 'User Account Control: Run all administrators in Admin Approval Mode' and double click it

f) Select 'Disabled' and click apply

g) Click OK to return to the Group Policy editor window.

h) Close the Group Policy editor Windows

i) Reboot the machine for all the above changes to take effect.
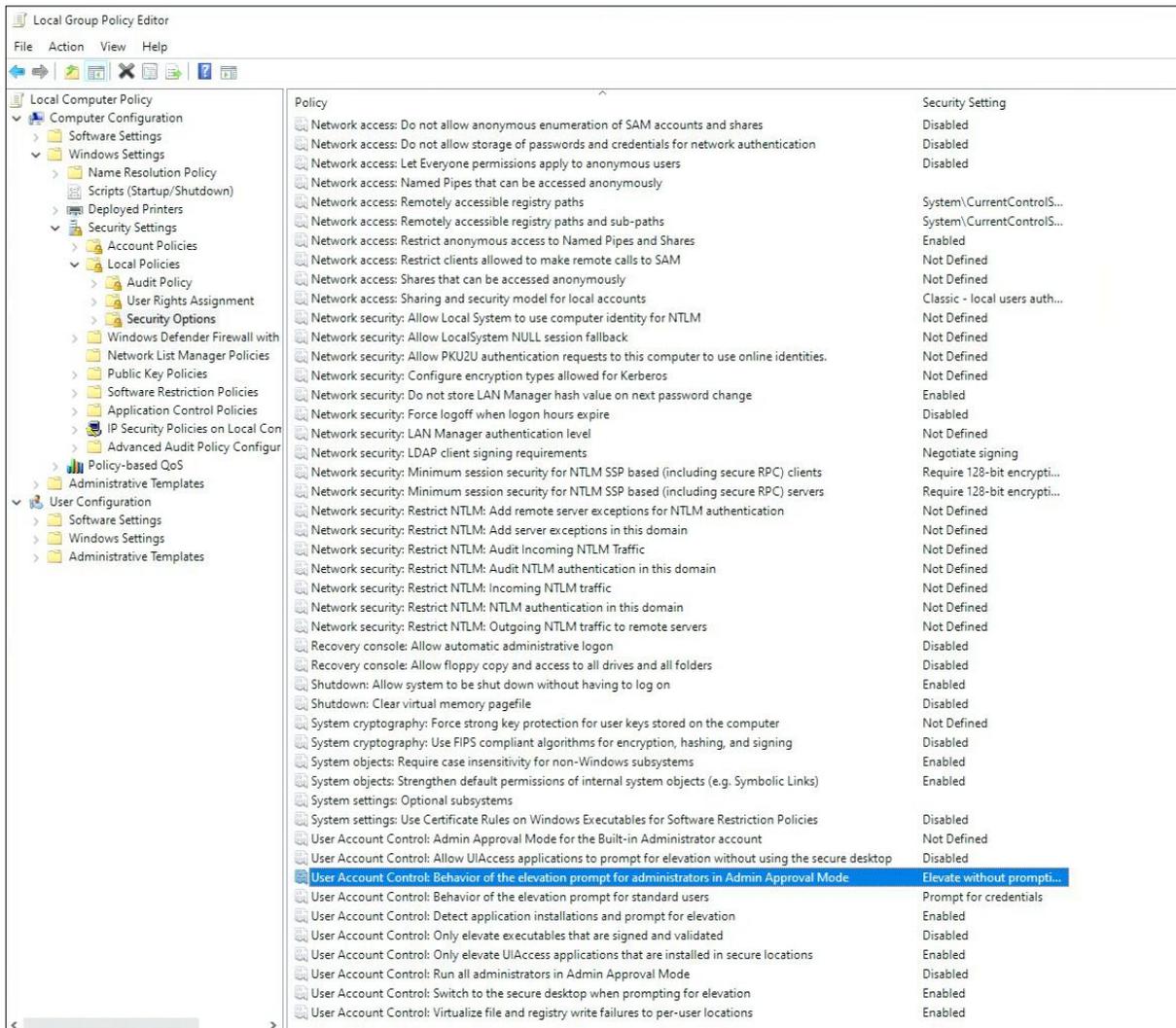
Figure 25 Disable UAC settings using Local group policy editor

Method 2 - Using Registry editor

a) Go to Windows start ⊞ and type 'regedit' in the search field and click 'Registry Editor' in the search results.
b) Go to HKEY_LOCAL_MACHINE > SOFTWARE > Microsoft > Windows > CurrentVersion > Policies > System.
c) Double click on the 'EnableLUA' DWORD and type 0 in the value data field. Click OK.
d) Double click on the 'ConsentPromptBehaviorAdmin' DWORD and type 0 in the value data field. Click OK. (Figure 23)
e) Reboot the machine for all the above changes to take effect.
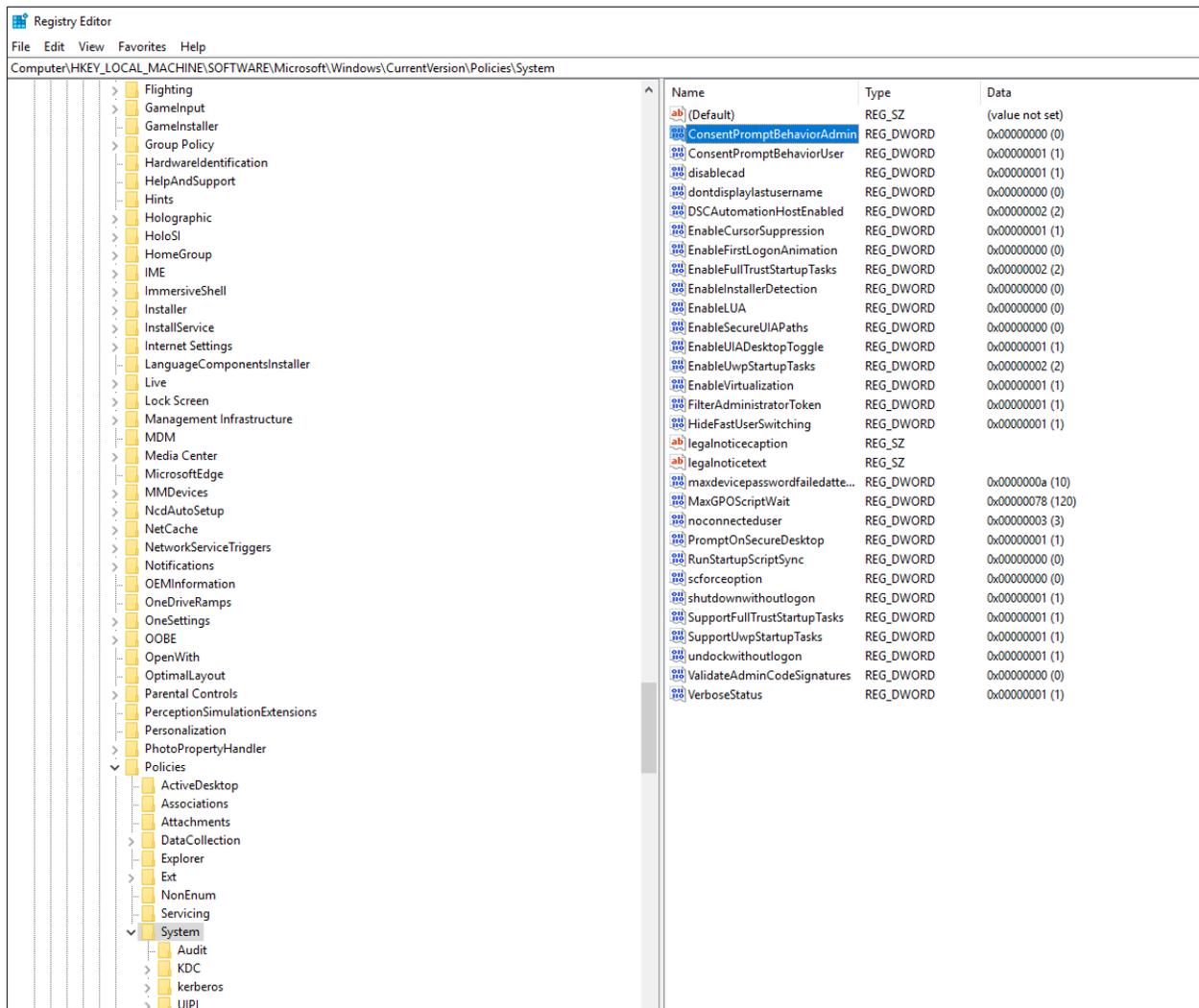
Figure 26 Disable UAC settings using Registry Editor

3.2.2.1.8   Backup Windows Registry

a) Go to Windows start ⊞ and type 'regedit' in the search field and click 'Registry Editor' in the search results.

b) In the Registry Editor window, right click **Computer** at the top left-hand side, and click **Export** (Figure 24).

c) Give the backup file a name and save it in a flash drive or cloud storage
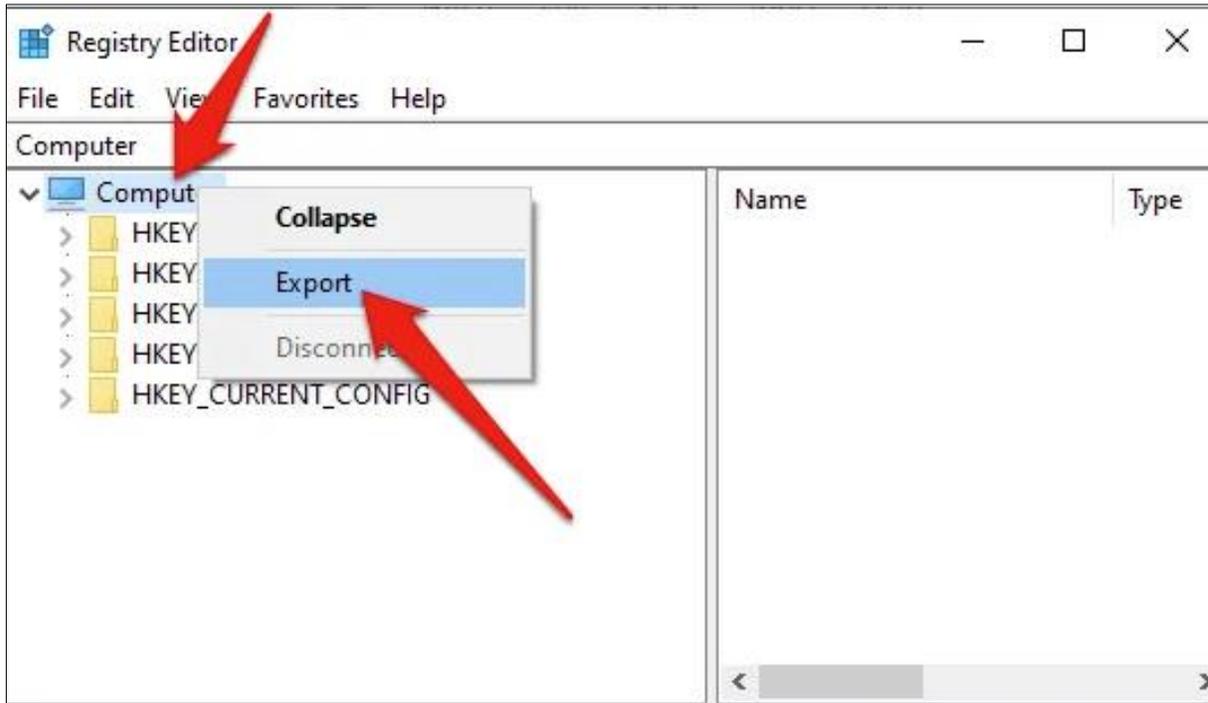
Figure 27 Back up Windows default registry

3.2.2.2   MacOS

3.2.2.2.1   Adjust the performance and sleep settings for MacOS

a)   On your Mac, choose Apple menu > System Preferences, then click Energy Saver. Set 'Turn display off after' slider to 'Never'. Set the other checkboxes as shown in Figure 25 below. Note: The setting for Automatic graphics switching will only appear on Macs which are equipped with discrete graphics cards.
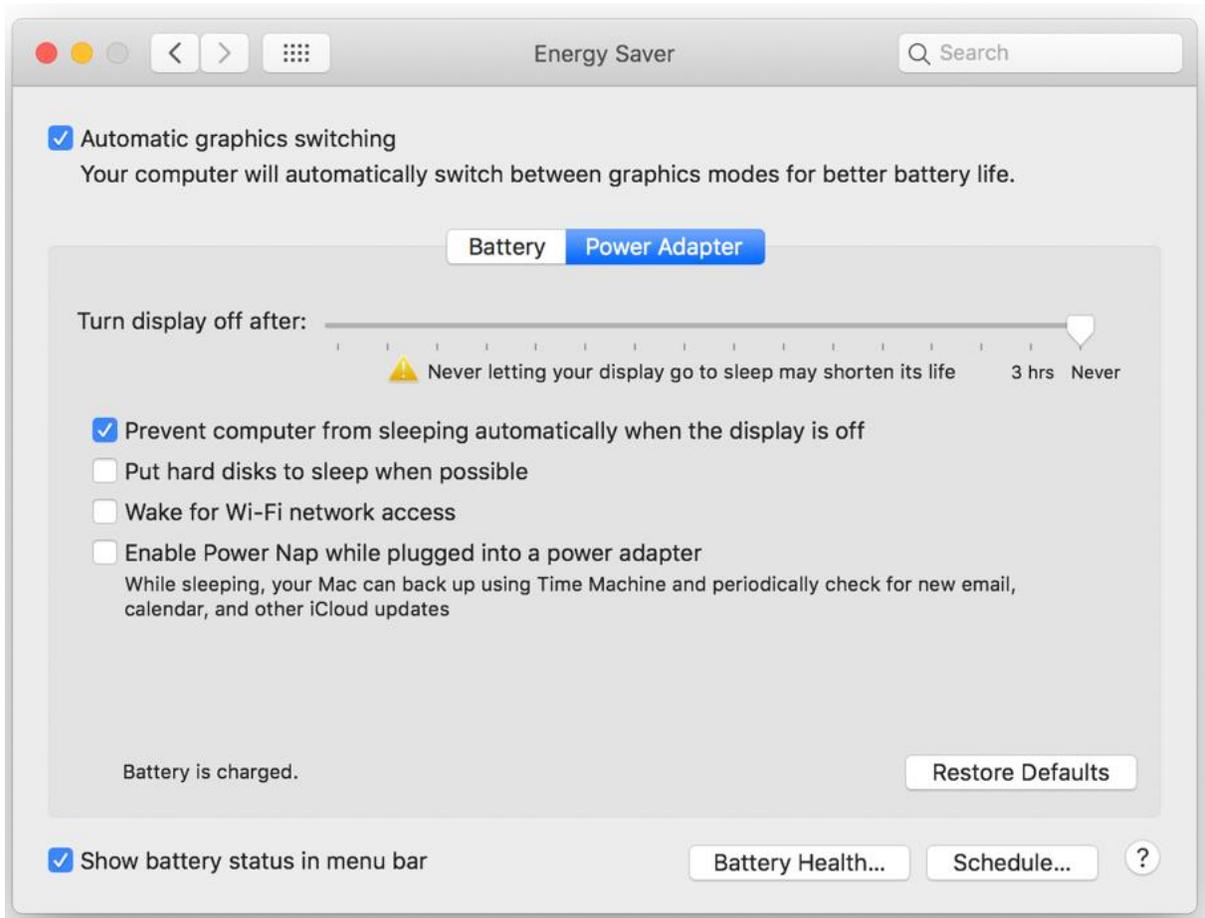
Figure 28 MacOS Energy Saver settings

4   APPENDIX A: Application Contribution

The following chart shows the approximate contribution of each application to the CrossMark version 1.0.0.73 scenario ratings on the calibration system (see section 2.7).

Due to system implementation differences, this chart is accurate for the calibration system. These contributions will vary from one system to the next.
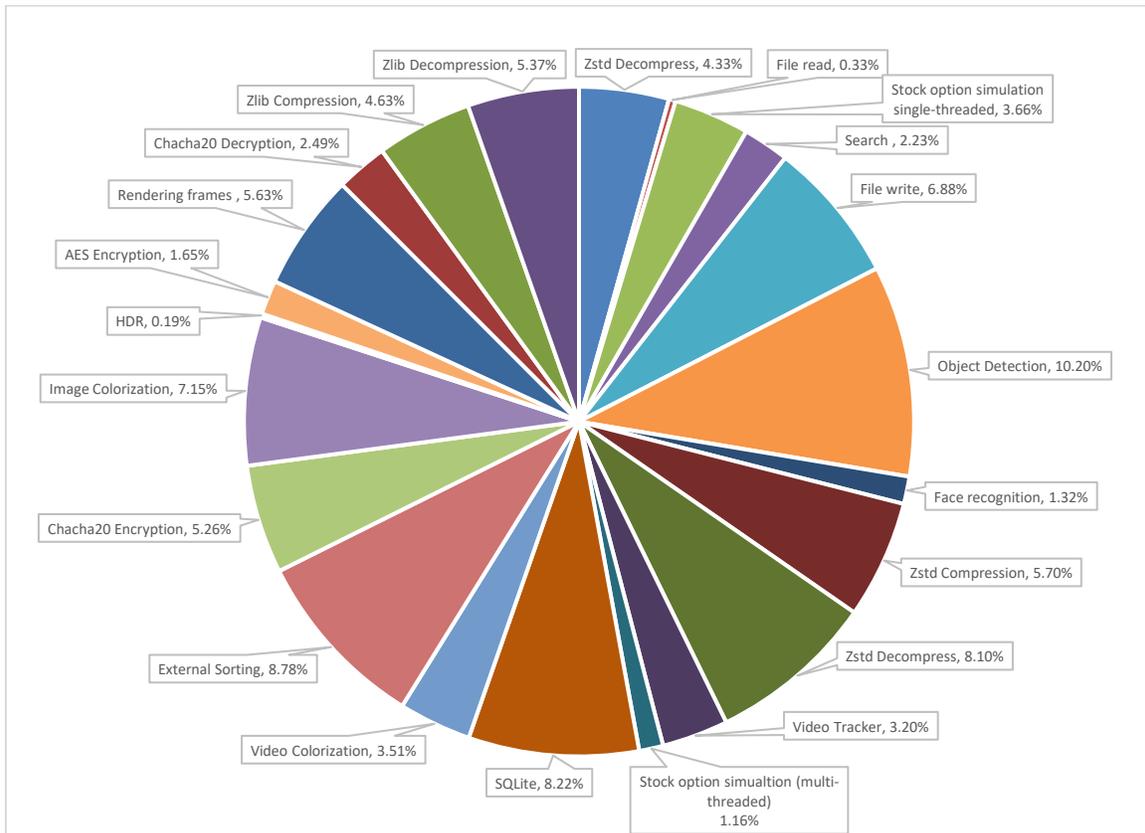
Figure 29 **Overall Workload contribution**

5   APPENDIX B: Minimum System Requirements

CrossMark has the following requirements based upon the minimum system specifications of the applications installed and used in the benchmark. BAPCo will only provide technical support for systems which meet or exceed these requirements.

Windows:

- **CPU**: 2015 or newer x86 processor (Intel 6th Generation Core or AMD 7000 series APU)
- **RAM:** 4 GB
- **HDD/SSD:** 10GB of free space on the primary drive
- **Operating System:** Microsoft® Windows® 10 64-bit version 1803 (RS4) or higher, Microsoft® Windows® 11 64-bit version 21H2 or newer
- **Resolution:** 1024x768 or 1366x768
- **Language Localization of Application on Windows:** English (US), Brazilian Portuguese, Simplified Chinese, French, German, Russian, Japanese, Polish, Spanish (SP) based on language settings of the operating systems. For all other languages, it defaults to English.

macOS:

- **RAM:** 4 GB
- **Operating System:** OSX 10.9.5(2015) or later
- **Resolution:** 1024x768 or 1366x768
- **Language Localization of Application on macOS:** English (US), Brazilian Portuguese, Simplified Chinese, French, German, Russian, Japanese, Polish, Spanish (SP) based on language settings of the operating systems. For all other languages, it defaults to English.

iOS/iPadOS:

- **RAM:** 4 GB
- **Operating System:** iOS 12.0 version or higher
- **Language Localization of Application on iOS/iPadOS:** English (US), Brazilian Portuguese, Simplified Chinese, French, German, Russian, Japanese, Polish, Spanish (SP) based on language settings of the operating systems. For all other languages, it defaults to English.

Android:

- **RAM:** 4 GB
- **Operating System:** Android 8.0 (API 26) or higher
- **Language Localization of Application on Android:** English (US), Brazilian Portuguese, Simplified Chinese, French, German, Russian, Japanese, Polish, Spanish (SP) based on language settings of the operating systems. For all other languages, it defaults to English.

6 APPENDIX C: Screenshots
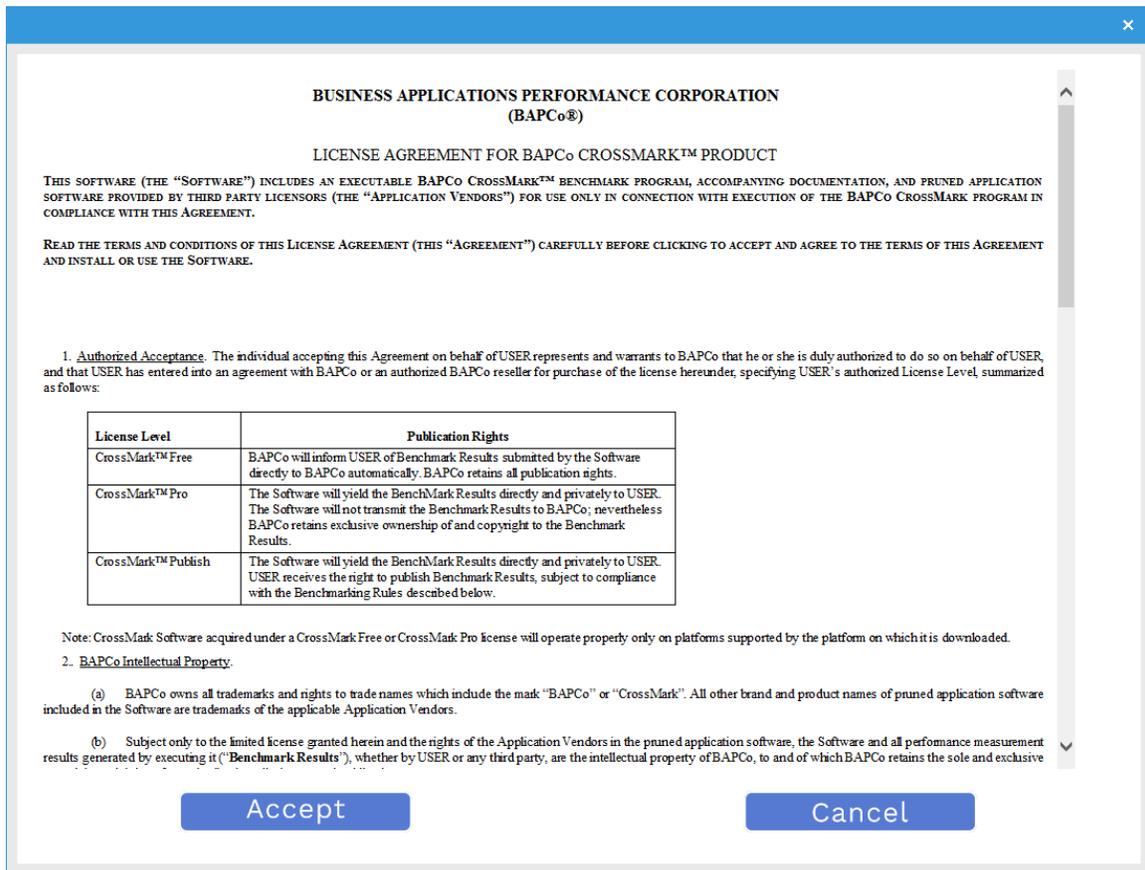
Figure 30 **CrossMark EULA**
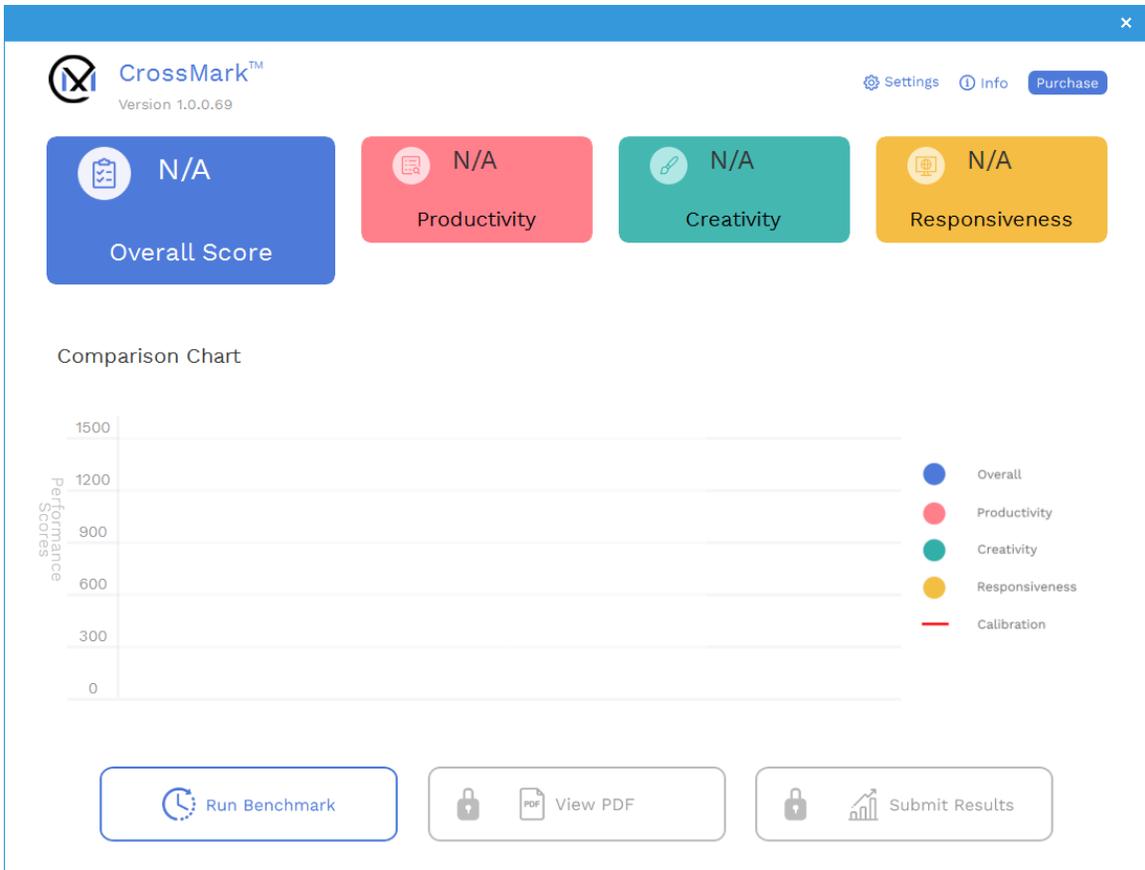
Figure 31 CrossMark main GUI interface
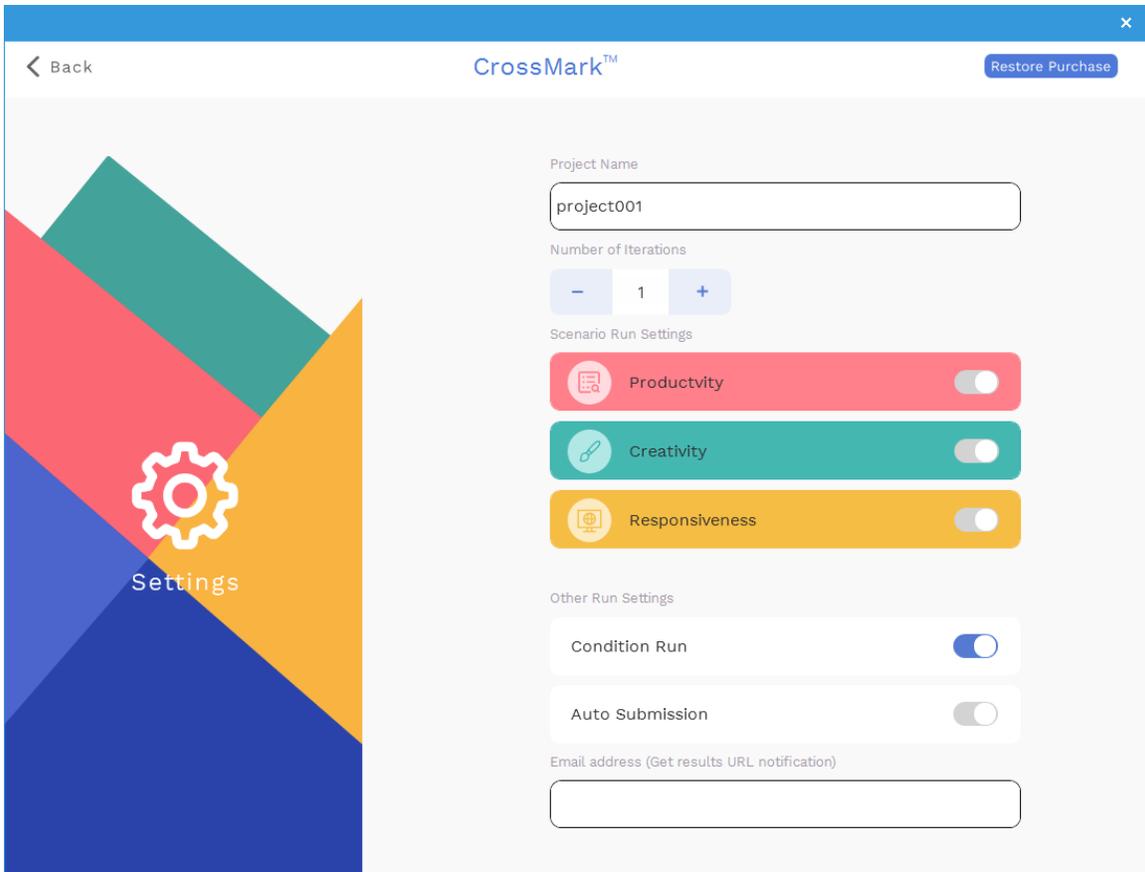
Figure 32 CrossMark Settings Page

Figure 33 CrossMark Results Submit Form
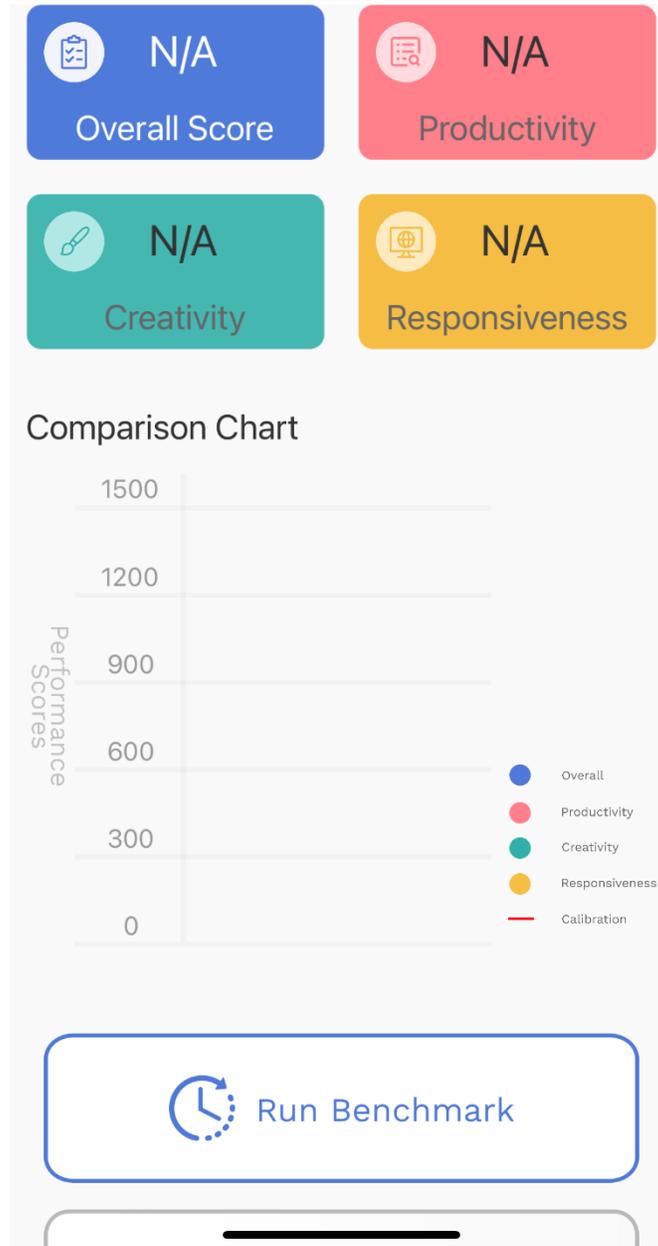
Figure 34 **CrossMark main GUI interface in portrait mode**

Figure 35 CrossMark Settings Page in portrait
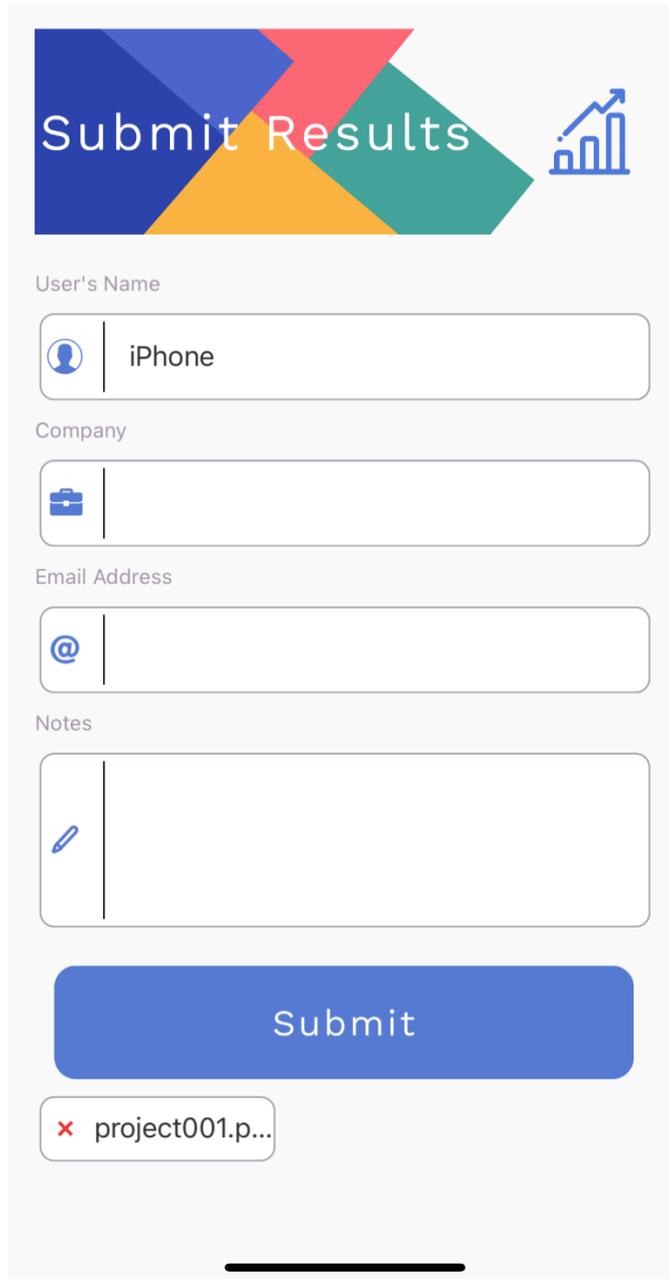
Figure 36 CrossMark Result Submit Form in Portrait mode