White Paper
Technical Specification in the Public Procurement of Computers
February 2013

(Release 1.1)

Getting the Most for your Money

Every small business, large corporation, or government entity is responsible for getting the best value for its purchases. This white paper is intended to provide guidelines for technical specifications in requests for proposal (RFP), requests for quotation (RFQ), and purchase contracts for desktop and notebook personal computer systems as a means to assist organizations in accurately and effectively tailoring the specifications to meet their specific needs while promoting choice and competition. The technical specifications described in this document are meant to demonstrate how to get the best fit for the intended use of a computer system while achieving the optimal balance between cost, features, and performance.

The computer market is rapidly changing and new technologies are constantly being introduced; therefore, to maximize value, it is important to set the correct level of requirements within the RFQ to assure the computer is appropriate to the user's actual needs.

More than just Performance

In the earliest days of the personal computer the value of the system was largely measured by the clock frequency (MHz) of the processor. PCs with higher processor speeds were more costly and more capable. But today many dimensions exist to consider. These include:

- CPU computational performance
- GPU computational performance
- Graphical display quality and performance
- Capacity and speed of main memory
- Type (HDD or SSD), capacity, and speed of mass storage
- Networking and connectivity capability

In addition to the factors above, a number of important features can also affect overall system performance, as well as the overall utility and productivity of the system. Important features such as security, power management and energy efficiency, and manageability are critical elements of overall system performance and essential functions for enterprise-class computing.

How much capacity or performance is enough? What features do you need? That depends on the class of the applications being used. Here are some basic categories of worker and type of work they perform. These workloads are then correlated to the relative capacity or performance in each of the metrics above for both desktop and notebook personal computers.

Usage Classifications

- The "**General Office/Task**" worker – this worker uses popular applications like Microsoft® Office, an Internet browser, an email program, and other standard office and enterprise network applications to do the majority of their personal computing work.
- The "**Content Creator**" – this is an office worker who uses all the above applications plus additional applications for creating and editing images (e.g., Adobe® Photoshop®), web development (e.g., Adobe® Dreamweaver®), video editing (e.g., CyberLink PowerDirector), or other content creation programs for a significant amount of their personal computing work.
- The "**Analyst, Engineer, or Scientist"** – this class of worker uses compute intensive programs for data analysis (e.g., financial data or scientific data), or to run engineering, design or CAD programs (e.g., Autodesk® applications). Again, there are different requirement within this category. While a certain level of CPU computational capacity is generally critical to all these applications, many also require a significant GPU capability for either 3D graphical rendering or parallel compute.

Performance and Capacity Requirements by Worker Classification

Let's take a look at the requirements classes for CPU Compute, GPU Compute, Graphics Rendering Capability, Video Capability, System Memory, Mass Storage, and Network Connectivity typically required by each of these workers. Following that, we will give guidance as to the meaning of those classes in the form of recommendations for use in RFQs in today's market. In addition, guidance will be given as to how these requirements may change in the next two years. Sample phrasing for RFQs will be provided to ease the process of writing and to ensure the text encourages fair and open competition.

Relative Performance/Capacity Requirements for Usage Classifications

Usage Class	CPU Compute	GPU Compute	Graphics Rendering	Video Capability	System Memory	Mass Storage	Network Connectivity
General Office	L1 - Good L2 - Better	L1 - Good L2 - Better	L1 - Good L2 - Better	L1 - Good L2 - Better	Smaller	Smaller	Good
Content Creator	L1 - Better L2 - Best	L1 - Better L2 - Best	L1 - Better L2 - Best	L1 - Better L2 - Best	Medium	Medium	Better
Analyst... Scientist	L1 - Best L2 - Custom	L1 - Best L2 - Custom	L1 - Best L2 - Custom	L1 - Best L2 - Custom	Largest	Largest	L1 - Best L2 - Custom

Note that there is a range of solutions or "usage classes" that accommodate these situations:

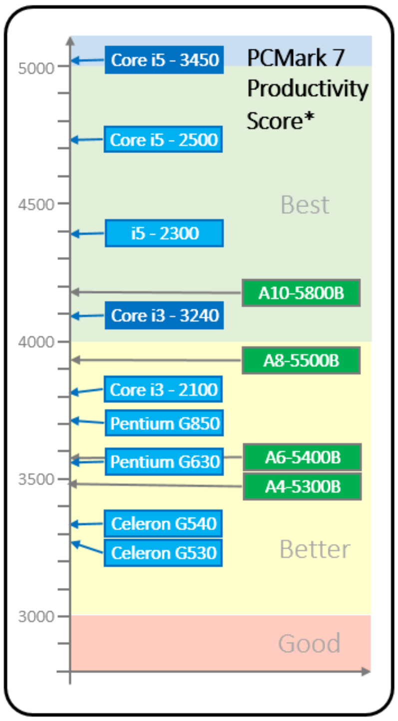
- General Office Level 1 – general office use for email, web browsing, data entry and retrieval, and office productivity applications like Microsoft® Office.
- General Office Level 2 – increasingly, general office operations are extending into the use of content creation applications like Adobe® Photoshop and Dreamweaver. Users who use content creation applications for up to 33% of their compute activity should be upgraded to this level.

- Content Creator Level 1 – this user spends approximately half of their time using content creation applications like Photoshop®, Dreamweaver®, and video editing software like Adobe® Premiere® or Sony Vegas®, but also handles a significant amount of general office work.
- Content Creator Level 2 – this user's primary task is content creation and he/she may use advanced applications like Adobe® After Effects®, Blender™ or Autodesk® Maya® in addition to those listed for Level 1.
- Analyst, Engineer, and Scientist Level 1 – users who do significant numeric analysis fall into this category. These users need above average graphics capability to display their analysis and may use multiple screens.
- Analyst, Engineer, and Scientist Level 2 – users who require responsive, high quality 3D rendering of their work fall into this category. This includes animators, CAD operators, 3D modeling of products, magazine layout artists, and similar professions. This white paper refers to this small percentage of platforms as "Custom" solutions. Most often, these solutions will require a discrete graphics card instead of, or in addition to, the graphics integrated on the processor chip.

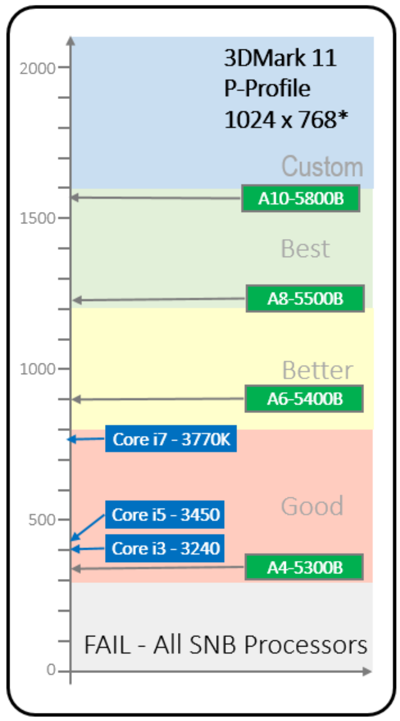
(Please note: a more extensive list of typical application software appropriate for each usage class can be found in Appendix A.)

The absolute level of performance associated with these types of usage differs for desktop, notebook and other personal computing systems (e.g., tablets). For example, performance and capacities for notebook computers are generally lower than for desktop computers. While this is a compromise necessary for notebook systems to have good mobility (usually measured as being thin and light with good battery life) today's notebook systems are generally capable of performing much better than typical desktop systems of just a few years ago and should easily meet the majority of worker's needs.

What about Benchmarks?



* Based on testing in AMD's Labs



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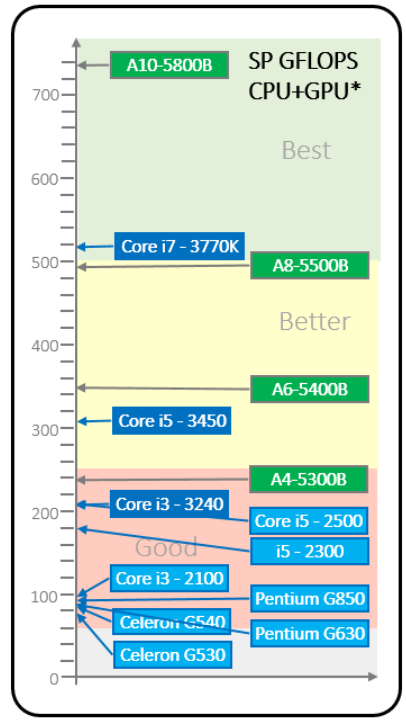

* AMD and Intel Export Requirement Metrics

Benchmarks can be an important part of the specification process but the purchasing agency should be cautious of a one-benchmark-fits-all approach. Consider the above set of results for desktop PCs based on AMD Accelerated Processing Units (APUs) and Intel integrated processors. Other than the processor, the configurations are fundamentally the same.[1]

The left two boxes contain results for two popular benchmarks PCMark 7 Productivity and 3DMark 11 "P-profile" at 1024 x 768 pixel resolution. The right most box contains the double precision GFLOPS performance calculations required for government export documentation. This score is an indication of the peak total compute capability of the processor.[2]

In the left benchmark, PCMark 7 Productivity, AMD APUs are distributed along the middle of the scale sometime referred to as the "mainstream." In center benchmark, 3DMark 11, the APUs made by AMD generally have much higher scores compared to Intel processors due to AMD APU's more powerful graphics engines. In the third box, AMD APUs again have the highest scores because AMD APUs have significant compute capability available from their GPU cores.

[1] See Appendix D for PCMark 7 Productivity and 3DMark 11 'P"- Profile details and Appendix E for platform configurations.
[2] See Appendix F for AMD GFLOPS calculation details and Intel's website for DP GFLOPS specifications in their Microprocessor Export Compliance Metrics: http://www.intel.com/support/processors/sb/CS-017346.htm. Single precision GFLOPs are 2X double precision GFLOPS listed in the export compliance metrics.

As you can see there is significant variance in performance based on how you measure it. AMD believes PCMark 7 Productivity and 3DMark 11 P-profile are key benchmarks that should be considered for government, education, and business PC purchases. The peak GFLOPS is an important indicator of future proofing for the system. New software revisions are entering the market that make use of the GPU compute capability and are significantly accelerated by the graphics engines integrated into AMD APUs.

The PCMark 7 Productivity Score

PCMark 7 is an easy to run and relatively inexpensive benchmark from a reputable source, the Futuremark Corporation. Futuremark is a private company whose benchmarks are frequently used by well-known industry analysts and reviewers. Futuremark consults with all major CPU and GPU manufacturers during their development process. AMD believes PCMark 7 to be the best current choice for comparing personal computer CPU and APU performance in a well-documented, widely supported, and unbiased manner.

Like many benchmarks, PCMark 7 has sections devoted to specific types of tasks that correlate well with the user types and tasks described above. For example, PCMark 7 has a "Productivity" section simulating the use of applications like Microsoft® Office. For more information consult their website: http://www.futuremark.com/benchmarks/.

Here are AMD's recommended minimum PCMark 7 Productivity Scores for each usage class.

Usage Class	**Desktop** Minimum PCMark 7 Productivity Scores by Usage		**Notebook** Minimum PCMark 7 Productivity Score by Usage	
General Office	**L1 – Good =**	**1800+**	**L1 – Good =**	**500+**
	L2 – Better =	**3000+**	**L2 – Better =**	**1000+**
Content Creator	**L1 – Better =**	**3000+**	**L1 – Better =**	**1000+**
	L2 – Best =	**4000+**	**L2 – Best =**	**1250+**
Analyst, Engineer, Scientist	**L1 – Best =**	**4000+**	**L1 – Best =**	**1250+**
	L2 – Custom =	**5000+**	**L2 – Custom =**	**1500+**

Why Not Use Only SYSmark Scores?

AMD recommends against using SYSmark alone as an indicator of suitability of a PC platform for a given task. Here's why:

- Intel is the only CPU and GPU manufacturer involved with BAPCo, the publisher of SYSmark benchmarks. All others CPU and GPU manufacturers (i.e., Nvidia, VIA, and AMD) have withdrawn their participation. Intel is now the sole chip manufacturer influencing BAPCo's development.
- AMD believes SYSmark 2012 has failed to evolve from prior revisions and does not reflect the importance of graphics rendering performance and the capacity to use the GPU for compute.
- The U.S. Federal Trade Commission requires the following statement, usually buried in the legal statements at the end of Intel documents referencing SYSmark scores:

> *"Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and Mobile Mark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary.* ***You should consult other information and performance tests to assist you in fully evaluating your contemplated purchase, including the performance of that product when combined with other products."*** [3]

AMD recommends that you follow the U.S. Federal Trade Commission's advice and not use the BAPCo SYSmark benchmarks as a sole criterion for purchase. AMD recommends you use PCMark 7 Productivity and 3DMark 11 P-profile in your RFQs. This will help you to get the maximum value for each PC configuration you purchase due to more open and fair competition between AMD- and Intel-based PCs.

What About Using SPECint?

SPEC® benchmarks rarely appears in client personal computer reviews. SPECint is a measure of integer processing performance. Personal computer performance is a complex amalgam of integer, floating point and parallel computing performance. SPECint is a measure of just one dimension of that performance and AMD recommends it be used only a supplement to other benchmarks like those available from Futuremark® which are targeted at client PCs. More information on SPECint and suites of server tests like SPECint 2006 can be found on the Standard Performance Evaluation Corporation website. A summary is available on Wikipedia.[4]

How Do I Specify Graphics 3D Rendering Performance?

Both standard and custom office applications are using more complex graphics and graphical interfaces and this trend should continue. The GPU performance on 3D graphics rendering tasks is an important component of measuring overall system performance.

AMD recommends the Futuremark 3DMark 11 benchmark for a reliable overall assessment of 3D graphics performance. Scores published using the "P" or performance profile at a resolution of 1280x720 pixels and a 32-bit color depth are appropriate measures of 3D graphics performance.[5] In addition, support of graphics APIs, DirectX® 11.1 and OpenGL® 4.0, should be specified.

Below is a chart with recommended minimum scores for PC in late 2012 through the first half of 2013.

Usage Class	Desktop Minimum 3DMark 11 P-profile 1280x720x32b Scores by Usage		Notebook Minimum 3DMark 11 P-profile 1280x720x32b Scores by Usage	
General Office	**L1 – Good =**	**400+**	**L1 – Good =**	**300+**
	L2 – Better =	**800+**	**L2 – Better =**	**600+**
Content Creator	**L1 – Better =**	**800+**	**L1 – Better =**	**600+**
	L2 – Best =	**1200+**	**L2 – Best =**	**900+**

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[3] http://www.intel.com/content/www/us/en/benchmarks/resources-benchmark-limitations.html?wapkw=benchmark+limitations.

[4] http://www.spec.org and http://en.wikipedia.org/wiki/SPECint respectively.

[5] 1280x720 pixels is not a platform resolution recommendation. Many platforms are capable of higher resolutions, but it is important to use the same resolution when comparing 3DMark 11 benchmark results. 1280x720 is that "standard" resolution.

Analyst, Engineer, Scientist	**L1 – Best =** **L2 – Custom =**	**1200+** **1600+**	**L1 – Best =** **L2 – Custom =**	**900+** **1200+**

Note for Content Creator – Level 2 and Analyst/Engineer/Scientist – it is recommended the buyer consult with the end user. Generally, this class of user is well equipped to set the criteria for the GPU in the platform. In addition, there may be special needs critical to the performance of specific software. Fortunately for the buyer, the number of users in this class is generally limited.

Does GPU Computational Capability Matter to Me?

Many applications can benefit from the unique parallel processing capability of application languages such as OpenCL and Microsoft's C++ AMP that can run significantly faster on the GPU[6]. This in turn, enhances user productivity and experience for all user levels. Examples of GPU accelerated applications include recent releases of Corel® WinZip®, Microsoft® Office, Adobe® Photoshop® CS6, and many internet browsers, as well as other programs that are graphics intensive. A more comprehensive list is available at **http://www.amd.com/coolapps.**

How Do I Specify GPU Computational Capability?

This depends on the Usage Type. For the first two types just the presence of the feature should be sufficient. For users that use the types of applications most likely to benefit from GPU Computation a "Peak Single Precision GFLOPS" score for the GPU gives an indication of the performance potential. Here are AMD's recommendations:

Usage Class	Desktop Single Precision GFLOPS		Notebook Single Precision GFLOPS	
General Office	**L1 – Good =** **L2 – Better =**	**100+** **250+**	**L1 – Good =** **L2 – Better =**	**75+** **200+**
Content Creator	**L1 – Better =** **L2 – Best =**	**250+** **500+**	**L1 – Better =** **L2 – Best =**	**200+** **400+**
Analyst, Engineer, Scientist	**L1 – Best =** **L2 – Custom =**	**500+** **750+**	**L1 – Best =** **L2 – Custom =**	**400+** **600+**

Note: The Peak Single Precision GPU GFLOPs is calculated peak performance number provided by the manufacturer for export purposes and is not a benchmark measurement.

In addition, AMD recommends that the RFQ explicitly require the graphics support the most recent versions of GPU programming languages OpenCL (which is OpenCL 1.1) and Microsoft's C++ AMP. The computational ability of the platform is dependent on these features which can be provided either integrated into the processor or in a discrete graphics chip on the motherboard or on card.

Examples of Vendor Neutral Specifications for IT Tenders

1. Start with the usage classification for the computers to be purchased.
2. Ensure fair and open competition by clearly stating that vendors should offer processors and systems that provide the appropriate level of performance for the user. Ensure that more than

[6] GPU compute capability has been integrated in three out of the four world's fastest super computers on the Green500.org list.

one processor manufacturer and OEM is able to respond to the tender by avoiding the use of brand names, model numbers, or features that are specific to a single product or manufacturer.

3. Consider self-testing system level performance using the OS and applications that will be used.
4. If self-testing is not an option, use uncontested third party benchmarks such as PC Mark 7 and 3D Mark 11 to provide benchmark comparison.
5. Remember, no single benchmark is an accurate measure of all system performance. Instead, it is a specific measure of a specifically defined set of applications and/or testing features. Hence, AMD recommends using the geometric mean of the PCMark 7 Productivity and 3DMark 11 P-profile scores as a combined figure of merit for the platforms bid. See the Additional Considerations section below and Appendix B for details.
6. Be sure to include a requirement for supporting graphical APIs DirectX 11.1 and OpenGL 4.0; and GPU compute programming languages OpenCL 1.1 and Microsoft's C++ AMP.

Specification Examples

Non-Public Authority

Most organizations will need to set metrics for performance minimums in their RFQs. Generally, the requirement will be stated as follows:

> "Processor: An AMD A-Series APU or an Intel Core i-series processor that achieves a minimum PC Mark 7 Productivity score of ####."
>
> "GPU: The computer should have a GPU (either discrete or integrated with the processor) with a 3DMark 11 P-profile score at 1024x768 pixel resolution and 32 bit deep color of at least ####. The graphics rendering engine must support DirectX 11.1 and OpenGL 4.0 or more recent."
>
> *Optional addition for future proofing:*
> "GPU Compute: The computer should have a GPU (either discrete or integrated with the processor) capable of at least #### Single Precision GFLOPS. The GPU compute capability must support Microsoft C++ AMP and OpenCL 1.1 or more recent."

Public Authority

Public authorities are often required to state specific recommendations instead of a minimum score. A RFQ for a public authority may read, "Processor: An AMD A# or an Intel Core i# processor."

The processor can be chosen from the following recommendations table based on the usage requirements. If the model number of interest is not shown you can use the series (e.g., AMD A8-#### or Intel Core i5-####) as a reasonably accurate representation of performance.

Desktop Usage Class	AMD APUs / Processors	Intel Processors
General Office	L1 – Good = E-350 through E2-2000 L2 – Better = A4-5400B	L1 – Good = Pentium G-series L2 – Better = Core i3-2xxx
Content Creator	L1 – Better = A6-5400B L2 – Best = A8-5500B	L1 – Better = Core i3-3xxx L2 – Best = Core i5-2xxx or -32xx
Analyst, Engineer, Scientist	L1 – Best = A10-5800B L2 – Custom = FX-Series	L1 – Best = Core i5-3xxx L2 – Custom = Core i7-3xxx

Notebook Usage Class	AMD APUs / Processors	Intel Processors
General Office	L1 – Good = E-350 through E2-2000 L2 – Better = A4-4300M	L1 – Good = Mobile Celeron/Pentium L2 – Better = Core i3-2xxxM
Content Creator	L1 – Better = A6-4400M L2 – Best = A8-4500M	L1 – Better = Core i3-3xxxM L2 – Best = Core i5-2xxxM or 32xxM
Analyst, Engineer, Scientist	L1 – Best = A10-4600M L2 – Custom = NA	L1 – Best = Core i5-33xxM L2 – Custom = Core i7-3xxxQM

Additional Considerations

Reconciling Multiple Metrics or Benchmarks

If you chose to use multiple metrics or benchmarks in your RFQs you will get responses that may be hard to evaluate. You can combine multiple types of benchmarks into one figure of merit using a geometric mean of each of the scores. This is particularly helpful because some PCs may score better on one benchmark (e.g., a graphics score) while other PCs may score better on a different benchmark (e.g., a CPU performance score). The geometric mean makes comparisons easier.

The geometric mean indicates the central tendency or typical value of a set of numbers. The geometric mean is used by most popular benchmarks to combine their individual test results into one score. Similarly, you can use the geometric mean to combine multiple benchmark scores into one figure of merit.

AMD recommends you use the geomean of the PCMark 7 Productivity score and the 3DMark 11 Performance-profile score to get just one figure of merit for comparing systems offered in response to your RFQ. Appendix B explains more about the geometric mean, how to calculate it, and how to use the GEOMEAN function in Microsoft Excel®.

Balancing Performance and Value

It is important that the platform provide sufficient performance for the intended applications without unnecessarily exceeding the requirement. This is because for most applications there is a point of diminishing return for increasing CPU performance. Once the computer responds to human input in what is perceived as instantaneous manner, further increases in CPU performance will only decrease the PC's response time by an imperceptible amount. Beyond this point, purchasing greater performance may not be a good value. This is especially true for the General Office user.

Future Proofing

One question computer hardware purchasers often ask is, "shouldn't I buy the most capable CPU available to ensure future proofing?" Our experience is this is not true for most government and enterprise users for three reasons:

1. Newer versions of PC operating systems are actually more efficient than past versions. For example, Windows® 7 was more efficient in handling CPU responses than either Windows XP or Windows Vista®, and now Windows 8 offers even better responsiveness.
2. Many of the next generation of applications are being designed to perform well on tablet computers with even lower CPU capability than desktops and notebooks.
3. Increasingly, software will run in "the cloud" with access to applications online through the browser. In such cases, the CPU compute requirements are minimal while graphical rendering capability will be critical to responsiveness.
4. The software that requires the greatest platform performance (e.g., CAD, 3D modeling, and professional content creation) increasingly rely on the GPU to enable performance increases.

Discrete Component or SoC

The Central Processing Unit (CPU) may be a separate component or integrated with other functions in a System on a Chip (SoC). AMD's Accelerated Processing Unit (APU) products are SoCs that include the GPU. A separate CPU and GPU gives the greatest flexibility in configuration and at the high-end, the greatest performance. However, the majority of new personal computers use a CPU integrated into a SoC along with a GPU because it provides greater value.

PCMark 8

PCMark 8 is under development and should be available late in the first half of 2013. In addition to a Productivity score, Futuremark plans to include a Workstation score in PCMark 8. Once available, AMD will evaluate PCMark 8 and provide recommended minimum scores.

Total Design Power (TDP)

It is not useful, and may be detrimental, to specify TDP in an RFQ. TDP is just one of a handful of metrics used by processor manufacturers to tell a PC manufacturer's engineers what is the best thermal solution to optimize the balance between cost, performance, and acceptable system operational temperature. Additional factors that are considered include the average power, voltage regulator peak current, and system airflow. Specifying only a TDP rating or a specific series of processors with a low TDP ratings may unnecessarily limit the performance for the platforms bid in response to the RFQ.

It is appropriate to specify a performance level and form factor where required. For example, "a notebook less than *A* mm thick and weighing less than B pounds and having a PCMark 7 Productivity score of *X* and a 3DMark 11 Performance-profile score of Y," is an appropriate specification for a mobile platform's form factor and performance level. There are typically a wide range of platforms with processors having different TDP ratings, and all may meet typical system specifications if they utilize properly engineered cooling systems.

Management Standards

Some IT departments remotely manage PC platforms throughout their domain. There are a number of software and hardware solutions offered by both processor and PC manufacturers. Some such solutions have proprietary features that may be useful. Before specifying a proprietary solution offered by one manufacturer, check with the IT department to make sure it is actually used. Otherwise, you may pay an additional amount for a proprietary solution that is not in use in your organization. Worse, the selection of a proprietary PC management solution may limit future PC choices to those that maintain compatibility.

AMD recommends that your business or agency use remote management hardware and software compatible with the Distributed Management Task Force, Inc. (DMTF) standards. Many AMD business-class platforms support the DMTF Desktop and Mobile Architecture for System Hardware (DASH) standard. For more information visit the DMTF website at http://www.dmtf.org/standards/dash.

Appendix A – Additional Software Applications for Usage Classes

Here are some common applications used in each usage class:

General Office Level 1

Email: Microsoft® Outlook®, Mozilla® Thunderbird®, Windows® Live Mail®, and IBM® Lotus Notes® – also email clients that are accessed through a browser: Hotmail®, Yahoo!® Mail, and Google Mail™.
Web Browser: Internet Explorer® (IE) 8/9/10, Mozilla® Firefox®, Chrome™, Safari®, and Opera™.
Data Entry and Retrieval: database applications: Microsoft® Access® and MySQL™ – also systems accessed via desktop virtualization software or through the browser: Citrix®, Go-To-Meeting®, LogMeIn®, and WebEx®
Office Productivity Software: Microsoft® Office® 2003/2007/2010/2013, WordPerfect®, OpenOffice™, LibreOffice®, and IBM® Lotus Symphony® – also office productivity software available through the browser: Microsoft® Office 365™ and Google Apps™ – and document reader software like Adobe® Reader®.

General Office Level 2

General Office Level 1 applications plus light use of content creation applications listed below.

Content Creation Level 1

Document Management: Adobe® Acrobat® Pro 8/9/X/XI
Newsletter Creation: Microsoft® Publisher® 2010
Photo Editing and Image Manipulation: Adobe® Photoshop® CS5/CS6, Adobe® Photoshop® Elements, GIMP
Video Editing: Adobe® Premiere® CS5/CS6, Adobe® Premiere® Elements, Sony Vegas® Pro, CyberLink PowerDirector
Web Design: Adobe® Dreamweaver® CS5/CS6

Content Creation Level 2

More extensive use of Content Creation Level 1 applications plus:
Video Post-Production: Adobe® After Effects® CS5/CS6
3D Model and Animation: Blender™ and Autodesk® Maya®
Design/Build: Autodesk® AutoCAD®, Autodesk® Revit®, and Trimble® SketchUp™

Analyst, Engineer and Scientist Level 1 and Level 2

This usage class tends to use highly targeted software applications. The following is a small sample.
Circuit Design/PCB Layout: Cadence® Design Systems and Cadence® OrCAD®
Civil Engineering Design: AutoCAD® Civil 3D®
Data Analytics: S.A.S. Software®
Mechanical Engineering/Design: Autodesk® AutoCAD®

Appendix B – Geometric Mean of PCMark 7 and 3DMark 11

A geometric mean is used when comparing different items – finding a single "figure of merit" for these items – when each item has multiple properties that have different numeric ranges."[7] Even though PCMark 7 Productivity and 3DMark 11 P-profile have different scales the resulting Geomean is still equally affected by variations in either benchmark.

For the simple case of two numbers X and Y (i.e., PCMark 7 Productivity Score and 3DMark 11 P-profile score) the formula is the square root of the product of X and Y or $GM = \sqrt{X \times Y}$.

For example: Processor 1: PCMark 7 Productivity = 3920 & 3DMark 11 P-profile = 122 GM = 2190
Processor 2: PCMark 7 Productivity = 5027 & 3DMark 11 P-profile = 770 GM = 1967

Conveniently, Microsoft Excel® has a built in function for the Geometric Mean called "geomean". To find the function place the cursor in the cell where you want to make the calculation and from the program's menu's choose **Formulas** -> **Insert Function** -> Search for a function: **Geomean** -> **Go** -> **OK**. A pop-up windows shows you how to list the function's arguments. Use a comma to separate the references to the cells containing the PCMark 7 Productivity and 3DMark 11 P-profile scores.

I Can Only Find PCMark 7 Overall Scores or 3DMark Vantage Scores

If necessary you can use either or both of the PCMark 7 Overall score or 3DMark Vantage P-profile scores if you cannot obtain the PCMark 7 Productivity or 3DMark 11 P-profile scores. **But all processors being compared should use the same version of the benchmarks**[8].

Appendix C – 3DMark 11 "P"-profile Score Approximation

AMD has observed that 3DMark Vantage Performance-profile scores using a resolution of 1280x1024 pixels and 32-bit color depth correlate well with 3DMark 11 Performance-profile scores using a resolution of 1280x720 pixels with 32-bit color depth. This allows an approximation of a 3DMark 11 "P" score to be made from a 3DMark Vantage "P" score.

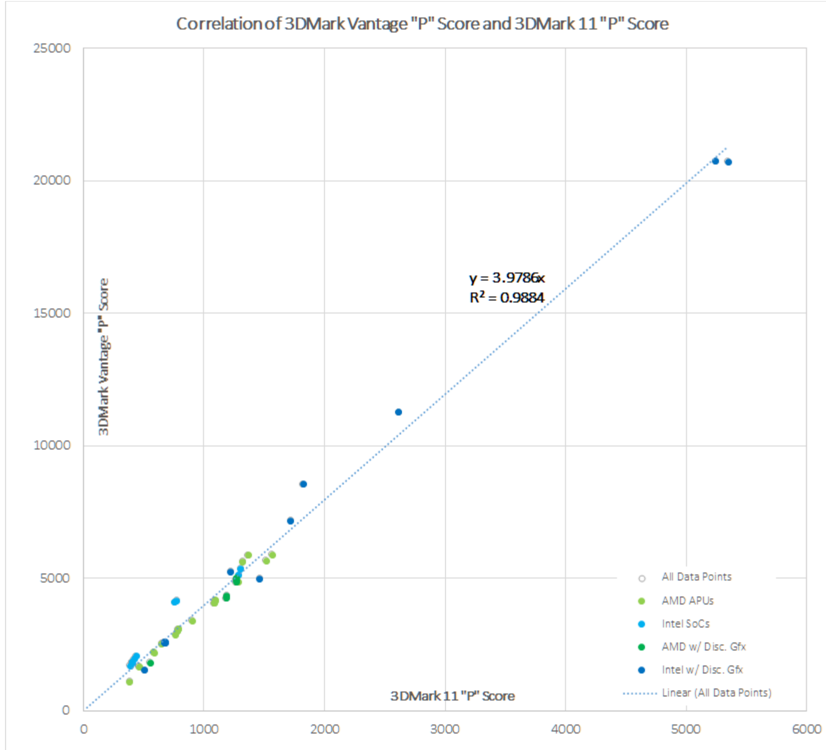
AMD does not recommend a conversion of the scores unless there is no other way to compare two competing platforms. However, for 50 AMD and Intel platforms using processors with integrated graphics the R Square value for 3DMark Vantage "P" scores vs. 3DMark 11 "P" scores was 0.98, which indicates a very good correlation. (An R Square value of 1 would indicate a perfect correlation and an exact conversion is possible.)

[7] Wikipedia entry on November 9, 2012: http://en.wikipedia.org/wiki/Geometric_mean
[8] In some cases a 3DMark Vantage P-profile score can be scaled. See Appendix C.

Using a linear fit to the data you can see below that to make an approximation of a 3DMark 11 “P” score, divide the 3DMark Vantage “P” score by 3.9786. Since this is a method of rough estimation, dividing the 3DMark Vantage “P” score by 4 should be sufficient. Please be aware, that while 76% of estimates made by dividing the 3DMark Vantage “P” score were within 5% of the measured 3DMark 11 “P” score, 22% had an error greater than 10% with a worst case error of 37%. Estimates with error’s 10% or greater are highlighted in the table with boldface type.

The “Motherboard” designation in the table corresponds to the platform definitions in Appendix E.

An asterisk after a motherboard designation indicates a prerelease motherboard design with prerelease BIOS.



APU/Processor Brand & Name	Family Codename	AMD Radeon Graphics Card	Motherboard	3DMark Vantage "P"	3DMark 11 "P"	3DMark11 "P" Est.	Estimate % Error
AMD E2-2000 APU	"Brazos"	None	"Inagua"	1101	380	277	**-27%**
AMD E2-3200 APU	"Llano"	None	GA-A75M-UD2H	1678	460	422	-8%
AMD A4-3300 APU	"Llano"	None	GA-A75M-UD2H	1679	458	422	-8%
AMD A4-3400 APU	"Llano"	None	GA-A75M-UD2H	2205	582	554	-5%
AMD A4-3420 APU	"Llano"	None	GA-A75M-UD2H	2220	580	558	-4%
AMD A6-3500 APU	"Llano"	None	GA-A75M-UD2H	2890	760	726	-4%
AMD A6-3600 APU	"Llano"	None	GA-A75M-UD2H	3018	776	758	-2%
AMD A6-3620 APU	"Llano"	None	GA-A75M-UD2H	3042	778	765	-2%
AMD A6-3650 APU	"Llano"	None	GA-A75M-UD2H	3083	781	775	-1%
AMD A6-3670 APU	"Llano"	None	GA-A75M-UD2H	3083	787	775	-2%
AMD A8-3800 APU	"Llano"	None	GA-A75M-UD2H	4078	1081	1025	-5%
AMD A8-3820 APU	"Llano"	None	GA-A75M-UD2H	4097	1085	1030	-5%
AMD A8-3850 APU	"Llano"	None	GA-A75M-UD2H	4175	1091	1049	-4%
AMD A8-3870 APU	"Llano"	None	GA-A75M-UD2H	4184	1088	1052	-3%
AMD A4-5300 APU	"Trinity"	None	GA-A85X-D3H*	2537	645	638	-1%
AMD A6-5400K APU	"Trinity"	None	GA-A85X-D3H*	3406	900	856	-5%
AMD A8-5600K APU	"Trinity"	None	Annapurna	4885	1282	1228	-4%
AMD A10-5700 APU	"Trinity"	None	Annapurna	5642	1317	1418	8%
AMD A10-5700 APU	"Trinity"	None	GA-A85X-D3H*	5669	1511	1425	-6%
AMD A10-5800K APU	"Trinity"	None	Annapurna	5875	1362	1477	8%
AMD A10-5800K APU	"Trinity"	None	GA-A85X-D3H*	5903	1564	1484	-5%
AMD A4-3400 APU	"Llano"	6570	GA-A75M-UD2H	4257	1180	1070	-9%
AMD A4-3420 APU	"Llano"	6570	GA-A75M-UD2H	4347	1184	1093	-8%
AMD Athlon™ x4 638 Processor	"Llano"	6570	GA-A75M-UD2H	4983	1264	1252	-1%
AMD Athlon™ x4 641 Processor	"Llano"	6450	GA-A75M-UD2H	1832	549	461	**-16%**
AMD Athlon™ x4 641 Processor	"Llano"	6570	GA-A75M-UD2H	5007	1267	1258	-1%
AMD Athlon™ x4 651 Processor	"Llano"	6570	GA-A75M-UD2H	4966	1270	1248	-2%
AMD Athlon™ x4 631 Processor	"Trinity"	6570	GA-A75M-UD2H	4864	1262	1223	-3%
Intel® Core™ i3-2120 Processor	"Sandy Bridge"	None	DZ77GA-70K	1720	382	432	13%
Intel® Core™ i5-2320 Processor	"Sandy Bridge"	None	DZ68DB	5125	1284	1288	0%
Intel® Core™ i3-3220 Processor	"Ivy Bridge"	None	DZ77GA-70K	1837	401	462	**15%**
Intel® Core™ i3-3220T Process	"Ivy Bridge"	None	DZ77GA-70K	1828	400	459	**15%**
Intel® Core™ i3-3240 Processor	"Ivy Bridge"	None	DZ77GA-70K	1839	400	462	**15%**
Intel® Core™ i5-3450 Processor	"Ivy Bridge"	None	DZ77GA-70K	1967	416	494	**19%**
Intel® Core™ i5-3450 Processor	"Ivy Bridge"	None	DZ77GA-70K	5376	1300	1351	4%
Intel® Core™ i5-3550 Processor	"Ivy Bridge"	None	DZ77GA-70K	2064	435	519	**19%**
Intel® Core™ i5-3570 Processor	"Ivy Bridge"	None	DZ77GA-70K	4101	752	1031	**37%**
Intel® Core™ i7-3770K Process	"Ivy Bridge"	None	DZ77GA-70K	4156	770	1045	**36%**
Intel® Celeron® G460 Processor	"Sandy Bridge"	6450	DZ68DB	1544	505	388	**-23%**
Intel® Celeron® G460 Processor	"Sandy Bridge"	6670	DZ68DB	5002	1458	1257	**-14%**
Intel® Celeron® G530 Processor	"Sandy Bridge"	6450	DZ68DB	2571	671	646	-4%
Intel® Pentium® G620 Processor	"Sandy Bridge"	6450	DZ68DB	2569	673	646	-4%
Intel® Pentium® G620 Processor	"Sandy Bridge"	6670	DZ68DB	7182	1716	1805	5%
Intel® Pentium® G850 Processor	"Sandy Bridge"	6450	DZ68DB	2593	666	652	-2%
Intel® Pentium® G860 Processor	"Sandy Bridge"	6450	DZ68DB	2607	673	655	-3%
Intel® Core™ i5-2310 Processor	"Sandy Bridge"	6470	DZ68DB	8560	1818	2152	**18%**
Intel® Core™ i5-2500 Processor	"Sandy Bridge"	6950	DZ68DB	20735	5346	5212	-3%
Intel® Core™ i5-2500 Processor	"Sandy Bridge"	6950	DZ68DB	20745	5244	5214	-1%
Intel® Core™ i5-2500 Processor	"Sandy Bridge"	7750	DZ68DB	11284	2612	2836	9%
Intel® Core™ i5-3450 Processor	"Ivy Bridge"	6570	DZ77GA-70K	5264	1218	1323	9%

Appendix D – PCMark 7 Productivity and 3DMark 11 "P" Profile

The following table documents the results of PCMark and Cinebench testing done in AMD labs. The configurations used are listed in Appendix E and can be referenced by the "Motherboard" designation in the table.

APU/Processor Brand & Name	Family Codename	Motherboard	PCMark 7 Productivity	3DMark 11 "P" Profile
AMD A10-5800 APU	"Trinity"	GA-A85X-D3H*	4188	1564
AMD A8-5500B APU	"Trinity"	GA-A85X-D3H*	3923	1223
AMD A6-5400B APU	"Trinity"	GA-A85X-D3H*	3583	900
AMD A4 -5300B APU	"Trinity"	GA-A85X-D3H*	3486	645
Intel® Core™ i7-3770K Processor	"Ivy Bridge"	DZ77GA-70K	5398	770
Intel® Core™ i5-3450 Processor	"Ivy Bridge"	DZ77GA-70K	5027	416
Intel® Core™ i5-2500 Processor	"Sandy Bridge"	DZ68DB	4731	
Intel® Core™ i5-2300 Processor	"Sandy Bridge"	DZ68DB	4396	
Intel® Core™ i3-3240 Processor	"Ivy Bridge"	DZ77GA-70K	4097	400
Intel® Core™ i3-2100 Processor	"Sandy Bridge"	DZ68DB	3811	
Intel® Pentium® G850 Processor	"Sandy Bridge"	DZ68DB	3710	
Intel® Pentium® G630 Processor	"Sandy Bridge"	DZ68DB	3569	
Intel® Celeron® G540 Processor	"Sandy Bridge"	DZ68DB	3339	
Intel® Celeron® G530 Processor	"Sandy Bridge"	DZ68DB	3285	

Note: Intel "Sandy Bridge" processor family does not support the DirectX 11 requirement to run the 3DMark 11 benchmark. Hence, in the tablet above "Sandy Bridge" processors show no 3DMark 11 score.

Appendix E – Test Configurations

AMD "Llano" APU Configuration

PLATFORM	Gigabyte GA-A75M-UD2H
Video	UMA 8.911.0.0
Display	1920x1080
System Memory	8GB (4x2GB), DDR3-1600, MT16JTF25664AZ-1G6G1
Hard disk	Real SSD C300 (256G)
Chipset	AMD A75
Audio	Realtek High Definition Audio 8/12/2011 6.0.1.6433
Network	Realtek PCIe GBE Family Controller 5/31/2011 7.46.531.2011
BIOS	F5
Operating System	Microsoft Windows 7 Ultimate 64-bit, SP1
DirectX	Microsoft DirectX 11

AMD "Trinity" Configuration

PLATFORM	MSI E350IS-E45
Video	APU 8.911.0.0
Display	1920x1080
System Memory	4GB (2x2GB), DDR3-1333
Hard disk	Real SSD C300 (256G)
Chipset	Hudson M1
Audio	Realtek High Definition Audio 5/3/2011 6.0.1.6363
Network	Realtek PCIe GBE Family Controller 3/21/2011 7.43.321.2011
BIOS	V1.5
Operating System	Microsoft Windows 7 Ultimate 64-bit, SP1
DirectX	Microsoft DirectX 11

AMD "Brazos" APU Configuration

PLATFORM	"Inagua" Reference Board
Video	APU 8.911.0.0
Display	1920x1080
System Memory	4GB (2x2GB), DDR3-1333
Hard disk	Real SSD C300 (256G)
Chipset	Hudson M1
Audio	AMD High Definition Audio Device 7.12.0.7701 3/29/2011
Network	Atheros AR8151 PCI-E Gigabit Ethernet Controller 1.0.0.46 9/27/2010
BIOS	WNG1B30N_Weekly_11_11_30 X64
Operating System	Microsoft Windows 7 Ultimate 64-bit, SP1
DirectX	Microsoft DirectX 11

Intel Platform for Most Integrated Graphics Tests

Two Exceptions: not used for integrated graphics testing of the Intel i5-2320 Processor (see the DZ68DB configuration below); and used for the Intel i5-3450 Processor tests with discrete AMD Radeon 6570 graphics card.

PLATFORM	Intel DZ77GA-70K
Video	Intel® HD Graphics Family 8/31/2011 8.15.10.2509
Display	1920x1080
System Memory	8GB (4x2GB), DDR3-1600, MT16JTF25664AZ-1G6G1
Hard disk	Real SSD C300 (256G)
Chipset	Z77
Audio	Realtek High Definition Audio
Network	Intel®
BIOS	GAZ7711H.86A.0035.2012.0410.2011
Operating System	Microsoft Windows 7 Ultimate 64-bit, SP1
DirectX	Microsoft DirectX 11

Intel Platform for All Other Tests

This platform was used for the Intel i5-2320 Processor tests with integrated graphics only. It was used for the graphics tests with a discrete AMD Radeon graphic card with the exception of the Intel i5-3450 Processor with the AMD Radeon 6570 graphics card which used the Intel configuration above.

PLATFORM	Intel DZ68DB
Video	Intel® HD Graphics Family 8/31/2011 8.15.10.2509
Display	1920x1080
System Memory	8GB (4x2GB), DDR3-1333, CMX4GX3M2A1600C9
Hard disk	Real SSD C300 (256G)
Chipset	Intel Z68
Audio	Realtek High Definition Audio 8/16/2011 6.0.1.6438
Network	Intel® 82579V Gigabit Network Connection 7/20/2011 11.13.51.0
BIOS	DBZ6810H.86A.0032.2011.0928.1502
Operating System	Microsoft Windows 7 Ultimate 64-bit, SP1
DirectX	Microsoft DirectX 11

Appendix F – AMD GFLOPS Calculations

This is how to calculate the maximum single precision **G**iga **FL**oating **O**perations **P**er **S**econd (SP GFLOPS) for AMD APUs:

CPU SP GFLOPS = (CPU Freq. X No. of CPU Cores X 8)

GPU SP GFLOPS = (GPU Freq. X No. GPU Cores X 2)

Both CPU and GPU cores can be used to perform calculations using languages like OpenCL and Microsoft's AMP C++. Hence, the total maximum SP GFLOPS is the sum of the maximum CPU SP GFLOPS and the GPU SP GFLOPS.

AMD SP GFLOPS calculations do not use "Turbo" or "Boost" frequencies. These boosted states are generally sustained briefly and may only occur with fewer than the full number of cores active.

"Brazos" Family

A fully capable "Brazos" Family die has 2 CPU cores and 128 GPU cores.

"Llano" Family

There are two "Llano" Family die. The smallest has 2 CPU cores and 160 GPU cores. The largest has 4 CPU cores and 400 GPU cores. Variants of the largest die are sold with different numbers of CPU and GPU cores enabled. This is a common industry practice.

"Trinity" Family

There are two "Trinity" Family die. The smallest has 2 CPU cores and 128 GPU cores. The largest has 4 CPU cores and 384 GPU cores. Both Trinity CPU and GPU cores are a new, more capable design. Variants of the largest die are sold with different numbers of CPU and GPU cores enabled. This is a common industry practice.

What About Benchmarks? Calculations

Below are the calculations for the AMD APUs in the chart in the "What About Benchmarks?" section.

APU Model	No. CPU Cores	CPU GHz	CPU SP GFLOPS	No. GPU Cores	GPU MHz	GPU SP GFLOPS	Total GFLOPS
A10-5800B	4	3.8	121.6	384	800	614.4	736.0
A8-5500B	4	3.2	102.4	256	760	389.1	491.5
A6-5400B	2	3.6	57.6	192	760	291.8	349.4
A4-5300B	2	3.4	54.4	128	724	185.3	239.7