Vendor-neutral tendering of desktop computers

Guidelines for public IT procurement,
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bitkom

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1 Introduction

1.1   Application of these guidelines

These guidelines are designed to offer an overview of the basis and criteria for the procurement of monitors by public bodies. It was created as a result of a working group led by the German Association for Information Technology, Telecommunications and New Media (Bitkom) and the Procurement Agency of the Federal Ministry of the Interior. This document aims to provide public contracting entities at the federal, state as well as municipal levels with a reliable and understandable resource so as to allow them to formulate their tenders for the procurement of monitors in a non-proprietary manner, i. e. in a way that avoids the use of protected brand names or the reference to a specific manufacturer, while taking into account current technical standards.

The core element of these guidelines is a list of technical criteria that can be used to describe and compare the monitors as well as the requirements for their working environments and other characteristics. It should be noted, however, that the listed technical criteria and requirements are subject to constant change and should be evaluated differently depending on where the equipment to be purchased is going to be used. Higher demands on the product will tend to produce a higher offer price, and accordingly, the range of products on the market will decrease. These guidelines are therefore not to be considered as a replacement for professional considerations and weightings of the individual criteria corresponding to the personal needs.

Nevertheless, the authors of these guidelines would like to support procurers of the public administration insofar as they draw particular attention to sensitive criteria and requirements, that may lead to market restrictions, as well as cost-related decisions. The following symbols are used for this purpose. The second and third symbols are not contained in these guidelines. However, we listed them to keep the guidelines for vendor-neutral tendering consistent.[1]

Symbol	Meaning
€	Criteria with this symbol may result in cost increases or market restrictions.
!	This symbol indicates the clarification of a common misconception or highlights critical statements in the text.
Z	This symbol indicates whether certificates can be used to verify specific criteria.

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1   Comparison, for example, ↗ **Guidelines for the vendor-neutral tendering of multi-function devices**

1.2   Vendor-neutral product tendering as a legal requirement

Under public procurement law, the equal treatment of providers and offered products is obligatory. The legal framework foresees that the procurement object is described based on factual and non-discriminatory criteria, i. e. in a non-proprietary manner (cf. Section 97(2) of the German Act against Restraints on Competition (GWB) and Section 31(6) of the German Ordinance on the Award of Public Contracts (VgV) for Europe-wide procurement procedures as well as Section 55(1) of the Federal Budget Code (BHO) and Section 2(2) of the German Sub-Threshold Procurement Ordinance (UVgO) on the award of contracts below the threshold level).[2] Specific product descriptions or brand names for tenders can only be used in duly substantiated exceptional cases, for example, if a particular description using generic names or criteria is not possible.

Vendor-neutral tenders can also be viewed as an opportunity. They ensure fair and open competition, prevent premature technical determination as well as consequential lock-in-effects. The number of competing providers increases if the procurement takes place according to the general, factual, and technical criteria. This leads to better options and savings for procurement; moreover, market opportunities caused by a change of provider can be utilised with minimal difficulty.

For public invitations to tender, the awarding office should create a list of criteria for the product to be procured that permits a comparison of the different offers, and if possible, their sufficient differentiation. The awarding authority is free to choose criteria for determining the products or services to be procured. However, the award criteria must be needs-based, vendor-neutral, and transparent.

The vendor-neutral invitation to tender for IT products is not a straightforward task. The concerned public authorities often struggle with uncertainties. The technical complexity of the topic, short product cycles, but also the difficulty of describing the desired performance of a system, taking account of all the technical requirements, often pose a substantial challenge to public procurers.

These guidelines address precisely this issue by providing a compact tool to support compliance with legal requirements when formulating technical specifications and thus ensure fair competition. The guidelines identify and explain current technical standards that enable a description of desktop computers following general pertinent characteristics. In the process, it will draw on the use of generally accepted benchmarks as an essential part of the vendor-neutral performance specification. The product features and technical requirements are presented in a compact, tabular form. The guidelines will be reviewed at regular intervals with the aim of keeping them up to date. Any revisions will consider the latest technical developments and adapt the proposed benchmark values to reflect the current state of the art.

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2   Section 42(4) of the Directive 2014/24/EU of 26 February 2014 clearly articulates this principle as well: Unless justified by the subject-matter of the contract, technical specifications shall not refer to a specific make or source, or a particular process which characterises the products or services provided by a specific economic operator, or to trademarks, patents, types or a specific origin or production with the effect of favouring or eliminating certain undertakings or certain products.

2 Desktop computers as procurement object

2.1 Benchmarks for evaluating the procurement object

The continuous evolution of computer technology has made it increasingly difficult to compare the performance of individual computer systems only in terms of their technical specifications. For example, a processor with a higher clock rate does not necessarily provide more processing power. Since the clock rate alone is no longer sufficient to compare the performance of different processors, and the products of various manufacturers with distinct internal architecture, tests, so-called benchmarks, were developed to improve comparability of the performance.

The performance of desktop computers can be captured with the help of benchmarks. Benchmarks and applications are programs that measure the overall performance of a system or individual components like a graphics card, memory, drive. The benchmark program performs a series of standardised tests that simulate specific application-typical tasks, and finally generates a score for the performance of that system. This score reflects the current performance of this system for the measured use case, thereby facilitating objective, data-driven comparability. The benchmark should be recognised by all competitors, such as hardware manufacturers, and developed independently of industry consortia or software manufacturers. The advantage of these benchmarks is that they provide a standardised, comparable and reproducible method for measuring the performance of computer systems with different parts objectively.

Benchmarks must be updated annually to reflect the rapid development of computer technology, its underlying CPU architecture, and applications.

2.1.1 Benchmark overview

Taking into account the wide variety of benchmarking programs, it is not always easy for the awarding authority to determine the most suitable benchmark(s) for its invitation to tender. Choosing an inexpedient benchmark increases the risk of procuring computer systems that are unsuitable for the user and exclude providers from the procurement procedure in a discriminatory manner, which are, in themselves, suitable.

No matter which benchmark the awarding office uses as a guideline, it is indispensable to pay attention that those benchmarks follow a coherent methodology and that they deliver reproducible results. Discrepancies of methodology can lead to unreliable and incomparable measurement results. This may even lead to a complaint in the procurement procedure.

There are two basic types of benchmarks:

- System-level benchmarking measures the overall performance of a computer system by applying defined user scenarios.
- Component-level benchmarking measures the performance of individual components, such as the CPU (Central Processing Unit), memory, or graphics card.

Notwithstanding this subdivision, a benchmark must:

- Measure the overall system performance and not only rate single components, while not disproportionally emphasising individual parts.
- Test scenarios that are aimed at the intended usage. In the case of these guidelines for desktop computers, it must thus represent applications in the context of typical office environments,
- all relevant manufacturers and computer platforms; its development process is independent and transparent.
- Adequately reflect the balance of the expected performance during the lifetime of the computer.
- Be relevant and representative: awarding offices should choose benchmarks that reflect the intended purpose of the systems to be procured.
- Be up to date: awarding offices should always rely on the versions of these guidelines.

Awarding offices should choose benchmarks from acknowledged standardisation bodies with an independent, transparent, and fair development process that was created with the help of, if possible, all relevant stakeholders.

Proper benchmarks are frequently updated. New benchmarks are regularly introduced to keep up with the rapid development and innovations of the computer industry. Using a dated benchmark to compare the performance of two computer systems can lead to erroneous results. For example, the use of benchmarks that are unable to factor in and measure new technology disadvantages state-of-the-art computer technology, which serves to improve performance. In this case, the system with the older technology could even receive a higher (better) score compared to the newer one, that comes with more modern, improved, and faster technology. In short: Outdated benchmarks can disadvantage innovative and more powerful products. Not only the benchmarking software but also the operating system must be updated to their respective latest versions.

2.1.2   Benchmark developers

Benchmark developers can be categorised as follows:

- Charitable (non-profit) benchmark consortia (e. g., BAPCo®, SPEC®, and EEMBC®),
- Non-profit open-source benchmarks (for example, Principled Technologies®),
- Commercially independent benchmark developers, for example, UL Benchmarks and Kishonti® Informatics,
- Small commercial developers (e. g., AnTuTu®).

2.1.3   Benchmark recommendations

These guidelines recommend the following benchmarks since they fully support the above requirements and therefore provide a meaningful comparison of computer systems that run in office environments:

- SYSmark* 2018 – Overall result,
- PCMark®* 10 – Standard score.

Unique application scenarios, like CAD workstations, might require more specific benchmarks.

2.1.4   Benchmark description

SYSmark* 2018 is a benchmark by the BAPCo®* consortium that measures the performance of Windows computer platforms. SYSmark®* tests three application scenarios: productivity, creativity, and responsiveness, as well as performance. It offers a supplementary energy consumption benchmark for the performance test. SYSmark®* contains applications by independent software developers like Microsoft*, Google*, and Adobe*.[3]

SYSmark®* 2018 displays its measurements as an overall result but also provides a value for each application scenario (higher scores are better). Supported operating systems: 64-bit Microsoft* Windows* 7, and 10.

PCMark®* 10 is a benchmark by UL that measures the performance of Windows computer platforms. PCMark®* 10 measures the computer performance in three groups: essential, productivity, and digital content creation. The tests require the performance of office work tasks like writing documents, browsing websites, creating spreadsheets, and using video chat. At the same time, they also test the ability to process photos and videos, as well as rendering and visualisation. PCMark®* 10 contains LibreOffice Calc and Writer by the

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3   The full list of all applications, weighting, overview, and benchmark methodology can be found in the BAPCo® ↗ **White paper on SYSmark®* 2018**. Published test results can be viewed on the BAPCo® website, in the subsection »Results« (↗ **www.Bapco.com**).

Document Foundation as well as the internally developed applications that utilise standard tools from Microsoft* and the Microsoft Media Foundation*.[4]

PCMark® 10* displays its measurements as an overall result but also provides individual values for each application scenario (higher scores are better). Supported operating systems: Microsoft* Windows* 7, and 10.

Computers that run another operating system than Microsoft Windows, for example, Linux or macOS, can use Windows benchmarks as an initial indicator. However, it is recommended to run a dedicated benchmark software designed for the specific operating system.

2.2   Recommendations for setting up the systems

The awarding office should specify minimum system requirements in the tender documents to ensure the comparability of benchmark results for the different offers. This applies not only to cases where the awarding office conducts the benchmarks or commissions a third-party to do so but also to cases where they provide the bidders with evidence of benchmark tests.

The required, recommended, and optional parameters are listed below:

Parameters	Description	Classification
Installation	It is strongly recommended to conduct a clean installation of the operating system, not using an image installation. The reason for this is that some operating systems have super/ prefetch features that make the comparison of images difficult. Furthermore, it is also expected that the default settings of the operating system will be used during installation. The installation of the operating system must be done offline to avoid the automatic updating of the OS, which would make comparability difficult.	Necessary
Operating system	Benchmark results from Windows 10 should never be compared to scores from Windows 7 or Linux.	Necessary
Operating system, updated releases	It is recommended to make the use of the most current version a requirement. The past has shown that different versions of the same operating system – Windows 10 1607 vs. Windows 10 1803, Windows 7 vs. Windows 7 SP1 et cetera – produce different benchmark results. It is, therefore, necessary to specify the exact operating system version.	Necessary

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4 The full list of all applications, weighting, and benchmark methodology can be found in the
   ↗ **Technical Guide for PCMark®* 10**. Published test results can be viewed on the UL benchmark website
   (↗ **https://benchmarks.ul.com**).

Parameters	Description	Classification
Operating system – maintenance	It is recommended to note the automatic maintenance of the operating system after its installation as a mandatory point in the invitation to tender. The benchmark result could be affected by the maintenance of the operating system running in the background if the tests are run immediately after the OS installation.	Necessary !
Operating system – changing settings	It is recommended to prohibit any changes to the operating system, which are not needed by the benchmark. An unbiased user of benchmarks should be able to replicate the benchmark results without expert knowledge or explanation. One exception to this rule is the use of power-saving settings. It is recommended to use the maximum performance setting to avoid measurement deviations.	Recommended
Operating system – automatic updates	It is recommended to deactivate the automatic updates of the operating system and to conduct the benchmarks offline, and only with the specified updates. Permitting automatic updates will lead to different software versions and make it more difficult to compare results.	Recommended
BIOS/EFI factory settings	Some of the BIOS/EFI settings can have a significant influence on the benchmarking results. Therefore, it is recommended to use the factory settings.	Recommended
BIOS/EFI versions	It is recommended to make the use of the latest BIOS/EFI version a requirement.	Recommended
Driver versions	It is recommended to make the use of the most recent drivers from the respective manufacturers a requirement.	Necessary !
Operating system – cumulative updates	The benchmark results can be affected by the operating system's release version but also its cumulative updates. However, they are not that severe. It is recommended to insist on a specific release to ensure comparability with older versions. However, if a specific operating system update is requested, it is helpful to specify the exact name – KB number (in Windows) – of the update package to be used, e. g., Windows 10 1709 KB4090913 (to include Spectre/Meltdown patches).	Optional
Operating system – security updates	Security updates have a measurable influence on performance. That is why all systems must be updated with the same security patches to yield identical benchmarking results. It is also crucial to ensure that the individual security functions and settings of the used operating system are the default ones to avoid unfair benchmarking advantages by disabling security functions. Here, it is recommended to specify the exact Windows KB numbers of the security updates used.	Optional

Parameters	Description	Classification
Number of benchmarks	It must be assumed that benchmarking scores for all tests fluctuate between two-to-five (2–5) per cent each round. Repeated measurements result in higher accuracy. However, the benchmarks recommended in these guidelines have proven to produce sufficiently reliable results in a single run. It must be noted in the tender documents if several runs are desired. In this case, it is also necessary to specify which calculation is to be used for the final score – for example, the arithmetic mean – if it is not already done so by the benchmark manufacturer.	Optional
Resolution	It is recommended to run the benchmark in the current standard FHD (full HD) resolution of 1920 × 1080 pixels. Internal measures have not shown any significant difference when measuring in low or high resolutions. A change of resolution should be considered for monitors with a resolution of 4K or higher.	Optional
Additional programs	Some of the manufacturers offer applications that can positively affect performance by adjusting specific BIOS/EFI or operating system settings. The benchmarking score might be affected, depending on the software used within the benchmark application. The awarding office must decide if the use of these products is permitted. In cases where they are approved, it is recommended to specify that the software used must be provided directly by the system manufacturer, freely available, or included in the tendered price.	Optional
Benchmark version	At the time of publication of these guidelines, two benchmarks are recommended: PCMark® 10 (Version 1.x.xxxx[5]) and SYSmark® 2018 (Version 1.x.x.xx[5]). The benchmark developers claim that the results of all major releases can be compared with one another. The included patches improve compatibility and stability with newer operating systems only. It is therefore not absolutely necessary to specify these incremental updates. However, if deviating results require the determination of a specific version, it is crucial to specify the exact version number in the tender documents.	Optional
Language of the operating system	At the moment, there are no performance differences between the English and German version of the operating system.	Optional

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5 There is no specific version mentioned here since benchmarks are under continuous development. The most recent version of the benchmark should be used.

2.3   Notes on benchmarking

These guidelines recommend noting the benchmarking procedure in the tender documents or refer to this chapter alternatively.

2.3.1   Settings

There are numerous ways to set up the operating systems, beyond the original settings of the reference system, that can lead to substantially different test results. It is recommended to create a protocol of the settings used if they go beyond the recommendations of the previous section and the default settings of the operating system. The protocol must be submitted along with the tender documents. It is essential to follow the provided benchmark procedure precisely to achieve comparable results.

2.3.2   Implementation of the benchmark

The goal of this instruction is to enable users that follow all parameters required by the awarding office to replicate the benchmark result without having any further technical knowledge. It is not permitted to make changes to the BIOS/EFI, which require further explanation unless explicitly permitted or required to conduct the benchmark.

The following steps must be followed in chronological order unless otherwise specified by the awarding office:

1. Update the BIOS/EFI to its most recent version and restore the factory settings of the BIOS/EFI.
2. Perform a »clean« installation of the required operating system with standard settings (automatic partitioning) with a medium of the operating system that comes directly from the manufacturer.
3. Install the most recent drivers provided by the respective manufacturer. Use the Device Manager to ensure that all drivers are installed, and devices are listed (without error message).
4. Install all operating system updates required by the awarding office. Use the current operating system release if there are no specific updates required.
5. Install the required benchmarking software with default settings.
6. Install any updates of the benchmark software required to run the benchmark.
7. Perform and complete a disc-cleanup and automatic maintenance. Mechanical drives must undergo a defragmentation.
8. Configure the energy-saving plan »High performance«. Some systems require a power-saving plan to be added manually.
9. Run the benchmark with the respective default settings.

2.4   Commercial models and procurement

The procurement of a desktop computers can be done by renting, purchasing, or leasing the object. Unlike renting, leasing tends to provide the contracting authority with the option to purchase the leased object at the end of the contract. Which approach the procurer chooses depends not least on whether a budget is only available once or over several years.

A decision for one of these procurement models shall precede a procurement policy within the framework of a feasibility study. It is also essential to consider whether the hardware and software should be obtained from one single source in the framework of the uniform contractual agreement (bundling) or different providers. Software manufacturers might offer specific licensing models for software used in public administration.

Following the German statutory provisions on income tax, a personal-computer use of three (3) years is permitted.[6] The directive on the operating life, singling out and recycling of IT devices and software also stipulates a minimum use of three (3) years for personal computers in public administration.[7] The procurement costs can, therefore, be estimated based on that operating life.[8]

Of significant consequence in this regard is how the choice of the procurement model affects VAT. Hire is subject to VAT based on and payable with the respective rental rates. The purchase is subject to the entire VAT upon delivery (= transfer of the equipment to the contracting authority). VAT as a whole also arises upon delivery of the device if the contract foresees that the title to the device shall only be transferred after payment of several instalments. If the transfer of title for rent-to-own depends on the exercise of a purchase option, VAT is payable on the total unit price upon exercise of the option as stipulated by the contract. Where rental payments have already been rendered before the option is exercised, the accumulated VAT payments are to be reversed if the rental payments are counted towards the purchase price. Leasing is subject to VAT at the time when the leased device is attributable to the contracting authority according to tax provisions.[9]

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6 Comparison ↗ **AfA-Tabelle [tax depreciation table] by the German Federal Ministry of Finance for general-purpose assets**, subparagraph 6.14.3.2.

7 Comparison ↗ **IT-Ratsbeschluss 2013/07 [IT council order]**.

8 However, in its ↗ **position of June 2016**, the German Federal Environment Agency notes that a short operating life, in the framework of ten years, leads to higher life cycle as well as external costs (e. g., costs based on greenhouse gas emissions).

9 Cf. comments on these taxation-related consequences by the tax administration in section 3.5 (5) and (6) of the VAT Application Decree (UStAE).

	Commercial models		
	Hardware and software from different providers	**Bundling**	**Financing (hire/leasing)**
Hardware	Purchase	Purchase	Hire or leasing
Operating system	Purchase or licensing (note the licensing model, can be free of charge depending on the operating system). Information on the different licensing models is to be obtained from the respective manufacturers.	Purchase or licensing (note the licensing model, can be free of charge depending on the operating system). Information on the different licensing models is to be obtained from the respective manufacturers.	Hire or leasing (note the licensing model, can be free of charge depending on the operating system).
Costs for hardware service (e. g., repair, maintenance)	Born by the contracting authority	Born by the contracting authority	Payment covers services
Costs for software services (e. g., deployment and installing of updates)	Born by the contracting authority	Born by the contracting authority	Payment covers services
Ownership of hardware	Contracting authority	Contracting authority	Contractor

2.5 Services

The service portfolio of the provider must not be limited to hardware and software but can also include additional services connected to the delivered object. For example, an offer based on a separate service contract or extended warranty for the delivered hardware, or potentially the maintenance of the bundled software. Furthermore, extra services like troubleshooting or hotline services can be ordered on top of the hardware and software procurement.

Appropriate support should be clarified, where necessary, specifying the response or repair time.

Common offers differ depending on:

- term of the contract,
- response time (time between failure reporting and first support response),
- recovery time (time between failure reporting and recovery of the operational system),
- spare parts logistics,
- additional technical services offered (invoicing according to expenditure at hourly rates and travel costs),
- potential penalties in the event of failure to comply with the agreed response and recovery times.

Requirements, based on demand, can be:

- Three, four, or five years on-site service.
- On-site service with a response time of x hours. A response time of one hour is typical (can also take place as an auto response) within regular office hours (e. g., between 8:00 and 17:00). Otherwise, the next working day.
- On-site service with a recovery time of x hours (type and scope depending on the intended purpose. Lower surcharge for recovery times of two working days, shorter times are also possible but affect the pricing).
- Availability of a German-speaking hotline x hours and x days per week.
- Spare part supply without exchange by the service technician.
- Customer stores spare parts.
- After sending the replacement storage medium, the commissioned party must destroy the defective medium without returning it (depending on the security requirements).

Individual arrangements can be made concerning the procurement of highly available or safety-relevant solutions. For this, a needs assessment must be made to compare requirements against created costs.

The purchase of desktop computers, if required, can follow additional requirements such as:

- maximum delivery time,
- free delivery,
- international delivery,
- delivery to different locations,
- delivery to individual rooms,
- pre-installation of the bundled operating system,
- pre-installation of additional software,
- backup creation of the bundled operating system.

3 User profiles as a reflection of the workstation

These guidelines recommend categorising the requirements into performance classes to ensure the procurement is needs-based. The recommended performance classes tend to correspond to usage scenarios in companies and public administration. There is a wide variety of offers and a plethora of devices on the market, which fall within the range of the recommended requirements of the performance classes.

3.1 Performance classes

3.1.1 Minimum requirements based on exemplary user profiles

The following two user profiles describe the computer applications that must be available on a day-to-day basis. That is why the user profiles determine the basis for specifying the system configurations (standard system, high-performance system).

User profile	Typical applications	Classification
Office worker	(1) Email client (2) Web browser (3) Word processor (4) PDF reader (5) Virus scanner (6) Isolated specialist applications (for example, time tracking, directory enquiries) (7) Browser-based specialist applications (8) Web/Video conferencing.	Standard system
Clerks, executives, workplaces with unique needs	(1) Email client (2) Web browser (3) Word processor (4) Desktop publishing software (5) Spreadsheet software (6) Presentation software (7) Visualisation software (for example, Visio) (8) project planning software (9) Desktop database (10) PDF reader (11) Virus scanner (12) Isolated specialist applications (for example, time tracking, directory enquiries) (13) Browser-based specialist applications (14) Complex client-based/server-based specialist applications (15) Graphics software – 2D/3D/Vector – (for example, AutoCAD).	High-performance system

3.1.2   Overview of the minimum technical requirements

Below is a summary of the recommended minimum requirements for the configuration of a standard and a high-performance system. The following sections explain these in detail.

System components	Standard system	High-performance system
Chassis	SFF[10]	Midi tower
Motherboard	corresponding chassis	corresponding chassis
CPU	x86 architecture (64 bit)	x86 architecture (64 bit)
Memory (RAM) DDR4	8GB	16GB
SSD	250GB SATA	512GB SATA
Graphics/PCIe card	Onboard	Onboard or dedicated (DirectX 12 support for Microsoft Windows users, otherwise OpenGL 4.4)
Network connection	RJ45 and possibly WLAN	RJ45 and possibly WLAN
Interfaces	2 digital display interfaces 4 × USB 2.0 2 × USB 3.x AUDIO	2 digital display interfaces 4 × USB 2.0 2 × USB 3.x AUDIO

3.2   Performance values

The following table compares the performance requirements according to benchmarking.

	Standard APC	High-performance APC
SYSmark® 2018[11]	850	1100
PCMark 10 Benchmark	2900	3800

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10 SFF (small form factor) describes a type of computer that is designed for a relatively small chassis, see the below comparison in chapter 4.1

11 AMD (not a member of BAPCo®) draws attention to the following fact:
BAPCo® states the following needs to be noted when running SYSmark® 2018:
The software used to test video encoding »CyberLink PowerDirector® 15« uses hardware encoders from one processor manufacturer (Intel), which are provided by the same. On all other platforms a software encoder is used, despite the availability of hardware encoders for these platforms.
The proportional encoding share of the overall result (according to BAPCo®) is 3.2% for Intel-based and 2.7% for AMD-based systems (cf. current version of the ↗ BAPCo® White Paper – latest version 1.1, page 26).
Based on the technological nature, hardware encoders (under consideration of tested setup and environment) tend to be significantly faster than software encoders. It is encouraged to adjust the test software, which would provide a uniform solution for the encoding procedure.

4 Technical criteria and requirements

The contracting authority must describe the procurement object according to general charac-teristics in a way that permits a comparison between subsequent offers. These guidelines lay out various criteria that constitute suitable parameters for the description of desktop computers, presented in a tabular format. These criteria are assigned technical requirements to make these parameters assessable and comparable. The total of all minimum requirements produces a standard, which can be expected according to the current state of the art and is achieved by all newly designed devices currently offered on the market, which it is necessary to avoid undershooting. The last column provides further information, as well as specifications about the technical requirements.

In addition to the minimum requirements, recommended here, further conditions can be formu-lated within the framework of weighted evaluation criteria. Moreover, the contracting authority may define further criteria and requirements in the tender documents if particular conditions are placed on the procurement object. Specific requirements are particularly relevant to desktop computers. The individual technical aspects will be considered below.

4.1   Types of computer cases

The use of desktop computers depends mainly on their physical measurements, expandability, and the number of interfaces.

Category	Common chassis volume	Features
Mini PC	Max. two (2) litres	• Smaller, space and energy-saving form factor with a rapidly growing market share. • Can often be placed behind a monitor to save space. • The price is comparable to SFF or towers, or more affordable. • Does not tend to have integrated optical drives or PCIe slots. • Can be fan-less and therefore silent (Caution: can affect performance).
Small Form Factor (SFF)	Max. ten (10) litres	• Significantly larger and heavier as a Mini PC. • Increased power consumption compared to Mini PCs. • Can be fitted with an optical drive and has expansion options via PCIe slots. • Tends to have more interfaces and options to connect than Mini PCs. • Lower noise-floor.
Tower (mini, medium, tower)	Max. thirty (30) litres	The market share for towers has decreased signifi-cantly. Compared to SFF models, they offer minor advantages only (more interfaces). However, they are significantly more massive and unwieldy. They are also not suitable for placement on a work desk.

4.2   Internal expansion options on the motherboard

No.	Criterion	Requirements	Suited as	Comments
1	**Maximum dimensions**	Case measurements (width × height × depth)	Minimum requirement	▪ Mini PC: 195mm × 60mm × 210mm ▪ SFF PC: 110mm × 350mm × 310mm ▪ Tower: 180mm × 420mm × 380mm
2	**PCIe slots**	Number of free slots	Minimum requirement	▪ Mini-PC: None ▪ SFF/Tower: 1× * PCIe 3.0 × 16 and 1× PCIe 3.0 × 1
3	**SATA connections**	6.0Gb/s	Minimum requirement	▪ Mini PC: 1 port ▪ SFF: 2 ports ▪ Tower: 3 ports
4	**M.2 interfaces to connect SSDs**	▪ 1 port	Minimum requirement	
		▪ Supported protocols	Evaluation criterion	Supports SATA and PCIe.
5	**Dust filter**		Evaluation criterion	Some manufacturers offer an optional dust filter to extend the device's lifetime.
6	**Tool-free access to the computer case**		Evaluation criterion	Some of the devices offer access without tools, including the exchange of optical drives and RAM.

4.3   CPU, RAM, and optical drives

No.	Criterion	Requirements	Suited as	Comments
1	**Type of processor (CPU)**	▪ x86 architecture (64-bit) ▪ multi-core	Minimum requirement	
2	**Memory (RAM)**	▪ 8GB (2×4GB / 1×8GB)	Minimum requirement	
		▪ DDR 4 or LPDDR3	Minimum requirement	Most computers tend to have two (2) slots.
		▪ Expandability	Evaluation criterion	A higher number of slots can be used as an evaluation criterion.
3	**Mass storage**	▪ 200GB Solid State Drive (SSD)	Minimum requirement	The use of HDDs is sensible if more space is needed.
4	**Optical drive**	▪ Internal DVD/RW	Evaluation criterion	Not common in Mini-PCs, based on the small form factor.

4.4   Graphics card

No.	Criterion	Requirements	Suited as	Comments
1	**Integrated graphics card**	▪ Integrated into the CPU ▪ DirectX 12 capable	Minimum requirement	The graphics card is included in the CPU/ APU unit.
2	**Discreet graphics card**	▪ Discreet ▪ DirectX 12 capable	Evaluation criterion	The graphics card is an independent unit on the logic board. For example, for workstations, e. g., CAD/CAM workspaces.

4.5   Network connections

No.	Criterion	Requirements	Suited as	Comments/Explanations
1	**Ethernet**	▪ RJ-45 Ethernet 10/100/1000Mbit/s	Minimum requirement	
		▪ Wake-on-LAN (WOL) / PXE 2.x	Minimum requirement	Wake-on-LAN (WOL) should be possible from energy saving modes S4 and S5.
2	**WLAN**	▪ WLAN according to IEEE 802.11n (Dual Band, 2.4GHz and 5GHz)	Evaluation criterion	WLAN is optional for personal computers. In cases where WLAN is used, the required standard is IEEE 802.11 (ac, a, b, g, n). If installed, it must be possible to deactivate it in the BIOS.
3	**Bluetooth**	▪ Version 4.x	Evaluation criterion	Bluetooth is optional. If installed, it must be possible to deactivate it in the BIOS. WLAN/Bluetooth tend to be combo-modules.

4.6   Interfaces/Features

No.	Criterion	Requirements	Suited as	Comments/Explanations
1	USB	• Six (6) x USB Type A, at least two of which (2) x USB 3.x in the front	Minimum requirement	At least two (2) USB interfaces must be located at the front and four (4) USB slots at the back of the device – caution: Mini PCs tend to have only a total of two-to-three (2-3) USB connections.
2	Display output	• Two (2) digital connections for screens	Minimum requirement	The exact type should be specified, e. g., HDMI or DisplayPort. Adapters should be permitted to ensure a broad spectre of competition. Sometimes, VGA connections are still available. Mini PCs often have three (3) digital connections.
3	Audio	• Audio-In & Audio-out	Minimum requirement	Available through a combined interface.
4	Keyboard	• German (or respective) keyboard layout.	Minimum requirement	
		• Boot-up of the device via the keyboard (power on via keyboard).	Evaluation criterion	Mini PCs, in particular, tend to be tucked away behind the monitor, which makes it particularly practical to switch on the device via the keyboard.
5	Mouse	Optical mouse with two buttons and scroll-wheel.	Minimum requirement	Connection tends to be via USB.
6	PS/2 interfaces			The PS/2 interface is not state-of-the-art anymore.
7	Serial interface	9 pins	Evaluation criterion €	The serial interface is not state-of-the-art anymore.
8	SD card reader	SD version ≥ 3.0	Evaluation criterion	
9	AC adapter	• Performance	Evaluation criterion	Power supply to provide enough electricity to expansion cards. Consideration of another case form factor if expansions are not possible.
		• Efficiency	Minimum requirement	Efficiency of ≥ 85%
10	Acoustic beeper	Integrated	Minimum requirement	An acoustic beeper for system messages (tends to be integrated on the mainboard).
11	Speaker		Evaluation criterion	
12	Microphone	Mono	Evaluation criterion	Is optional and should not be installed in case of security issues.

4.7   Operating system

Criterion	Requirements	Suited as	Comments/Explanations
Operating system	OEM license	Minimum requirement	The currently most used operating system is Windows 10. There is no continuous but only extended support for Windows 7[12] The procurement could be used as a reason to upgrade to a new operating system, assuming that versions older than Windows 10 are still in use. It is explicitly not recommended to use Windows LTSB/LTSC since these versions are intended for use with industrial computers and similar static IT systems only. It lacks support for newer devices and functions. For example, Office Pro Plus is not supported by LTSC, Office 2019 must be used instead. Most manufacturers of personal computers exclusively support and provide drivers for Windows 10 SAC (semi-annual channel). It is the reason why it can result in decreased functionality and rejection of support in cases of errors or incompatibilities. Furthermore, there is the risk that there will not be any processors that support LTSC in its current version (1809). Depending on the requirements, the use of Linux or macOS can also be useful. Only hardware from Apple will support macOS.

12 Further information can be found at ↗ **https://support.microsoft.com/en-us/help/13853/windows-lifecycle-fact-sheet**

5 Security

Desktop computers can become the target of cyberattacks, data theft, and data misuse. Such attacks can threaten the confidentiality, availability, and integrity of the data that is processed and stored with the devices, as well as the functionality of the devices themselves. The manufacturer can equip modern desktop computers with security functions that support the user in meeting the security requirements. Data protection and security can only be established by implementing a combination of organisational measures, due diligence of the user, as well as internal security functions of the device.

No.	Criterion	Requirements	Suited as	Comments/Explanations
1	**Mechanical theft protection**	• Fixture to mount a mechanical protection against theft • Integrated into the chassis	Minimum requirement	Matching locks, and so forth, must be bought separately. Can affect the design/thickness/measurements of the device. For additional locking options, see docking functionality.
2	**TPM**	• TPM 1.2/2.0 • If TPM available: ability to switch off via firmware (see TCG PC Client Platform Firmware Profile 6.1). The operating system must not be permitted to revert this kind of switch-off. Or • No TPM or deactivated irrevocably	Minimum requirement	The Trusted Platform Module (TPM) is a function that saves keys, passwords, and digital certificates. TPM 2.0 is recommended for the use of Windows 10. TPM 1.2 is recommended for the use of Windows 7. No or deactivated TPM Delivered without TPM or with TPM deactivated is recommended. An upgrade or downgrade (TPM 1.2 to TPM 2.0 and vice versa) might be required depending on the intended purpose.
		• Pre-boot password option for disks within the firmware	Evaluation criterion	If correctly configured, drive access is only permitted after entering a password.
		• Password option for firmware access, e.g. BIOS/UEFI	Minimum requirement	Firmware access with restricted rights via firmware passwords. Depending on the consumer's internal security policy, a password should be set during the first use.
		• Individual firmware settings	Evaluation criterion	The factory settings can contain default preset BIOS/UEFI/coreboot, which were provided by the contracting authority.
		• Secure boot for checking the integrity of hardware components • Can be deactivated in the firmware	Minimum requirement	Secure Boot must be disabled when using Windows 7. Please pay attention to the chapter »Operating systems« of these guidelines for the use of Windows 7.
3	**Out-of-band management**	If available, shipped deactivated in the factory settings; can only be disabled with the firmware password	Minimum requirement	Where present, remote servicing functions that can change the firmware/data irrespective of the operating system must be shipped deactivated. The firmware password must protect the activation of this function. When deactivated, functions are not permitted to send or receive network connections.

No.	Criterion	Requirements	Suited as	Comments/Explanations
4	BIOS/UEFI/coreboot tamper protection	Tamper recognition and protection, reliable notification of the owner or user	Minimum requirement	The system must be able to prevent the manipulation of the firmware, (e. g., by write-protection), or recognise the manipulation (e. g., by verifying the signature) and contact the owner or user.
5	Firmware, Hardware	▪ Existing patch management and information on patch management for weak spots in firmware and hardware	Minimum requirement	Firmware describes the code that runs via the central processor (e. g., BIOS/UEFI/coreboot) or can influence it (for example Intel, ME, AMD, PSP). The tenderer should provide detailed documentation on how to handle weak spots in hardware and firmware, including third-party dependency (e. g., suppliers). The expected turnaround time to fix these issues is part of this documentation.
		▪ Any vulnerability of the firmware (CVSS 2.0 Base Score 7.0-10.0) must be corrected immediately and appropriately communicated after it has become publicly known.	Minimum requirement	
		▪ Once a critical vulnerability of the hardware is publicly known, the contracting authority must be informed about it immediately. A workaround or patch must be provided within six (6) months, assuming the nature of the vulnerability permits this.	Minimum requirement	Some hardware vulnerabilities, for example, Spectre variants, cannot be patched. In these cases, the primary obligation is to inform on the issue. Workarounds can result in usage restrictions.
		▪ The firmware passes the BITS/CHIPSEC test suite without errors	Minimum requirement	The bidder runs the BITS/CHIPSEC test suite and updates these protocols during firmware updates and changes to the hardware.
		▪ The Windows Platform Binary Table (WPBT) is not used	Evaluation criterion	Can be used to introduce malware.
6	Encryption	Drive Encryption	Minimum requirement	Encryption is done either by integrated hardware/firmware of the drive, for example, Opal, eDrive, or via software.
7	Interface protection	Interfaces can be deactivated via BIOS/UEFI/coreboot	Minimum requirement	For example, ethernet, USB, WLAN, WWAN, Bluetooth, camera, microphone, et cetera.
8	User authentication	Availability of multi-factor authentication	Minimum requirement	For example, smart card, fingerprint, or other biometrics, et cetera.

6 Award criteria

The award must be granted to the most economically advantageous tender as per Section 127(1) of the German Act against Restraints on Competition (GWB). The determination of the most economically advantageous tender takes place following the best price-performance ratio. Apart from price or cost, this consideration can also take into account qualitative, environmental or social award criteria. Energy-related supplies must also adequately account for the energy efficiency of the devices as award criterion, as per Section 67(5) of the German Ordinance on the Award of Public Contracts (VgV).

The service requirements may be expressed within the framework of award criteria with minimum technical specifications or within the framework of evaluation criteria. The procurer decides what individual performance characteristics belong to which category. Criteria tend to show minimum requirements that are essential for the operation of the device. Whenever tables of these guidelines list the minimum requirements for the devices, they label them as »minimum requirement«. The guidelines recommend only to use the requirements of the evaluation criteria in cases where standards or conditions are labelled »evaluation criterion«.

The wording of the service requirements with the help of the evaluation criteria can provide competitors with specific leeway. This wiggle room permits a differentiated consideration of the tendered services in the evaluation. In doing so, the individual forms of services can be taken into account; this is favourable for the latitude of the competition. The wording of the service requirements should be concise, comprehensible, and objectively appraisable.

The increased or exclusive use of minimum technical requirements in the terms of reference can result in undesired restriction of competition.

The guidelines recommend the use of evaluation criteria to promote diverse competition.

7 Contractual provisions

7.1   Supplementary terms of contract for the procurement of it supplies/services

Relevant contracts govern the provision of the advertised services or delivery of the advertised products after the successful completion of the procurement procedures. The Federal Ministry of the Interior and Bitkom have developed several contracts that can be used to support the awarding bodies. The contracts can be found on the website of the Federal Commissioner for Information Technology.[13]

7.2   Social sustainability

The procurement procedures must consider the economic and ecological criteria as well as social aspects (Section 97(3) of the German Act against Restraints on Competition (GWB), Section 31(3) of the German Ordinance on the Award of Public Contracts (VgV) above the threshold level, Sections 2(3), 22(2) of the German Sub-Threshold Procurement Ordinance (UVgO) on the award of contracts below the threshold level). Such social aspects include, in particular, labour rights, the ban on child labour, discrimination against employees, but also the observance of bandwidth working hours by the tenderer as well as its suppliers. The awarding office can ask each bidder to provide a declaration of commitment concerning social IT sustainability to ensure that the aspects of the procurement procedures for IT products and services are guaranteed. The declaration and additional information can be found on the website of the Procurement Agency of the Federal Ministry of the Interior.[14]

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13 ↗ **https://www.cio.bund.de/Web/DE/IT-Beschaffung/EVB-IT-und-BVB/Aktuelle_EVB-IT/aktuelle_evb_it_ node. html**

14 ↗ **http://www.nachhaltige-beschaffung.info/SharedDocs/DokumenteNB/141118_Erkl%C3%A4rung_soziale_ Nachhaltigkeit_IT.html?nn=3631298**

Bitkom represents more than 2,700 companies of the digital economy, including 1,900 direct members. Through IT- and communication services alone, our members generate a domestic annual turnover of 190 billion Euros, including 50 billion Euros in exports. The members of Bitkom employ more than 2 million people in Germany. Among these members are 1,000 small and medium-sized businesses, over 500 startups and almost all global players. They offer a wide range of software technologies, IT-services, and telecommunications or internet services, produce hardware and consumer electronics, operate in the digital media sector or are in other ways affiliated with the digital economy. 80 percent of the members' headquarters are located in Germany with an additional 8 percent both in the EU and the USA, as well as 4 percent in other regions of the world. Bitkom promotes the digital transformation of the German economy, as well as of German society at large, enabling citizens to benefit from digitalisation. A strong European digital policy and a fully integrated digital single market are at the heart of Bitkom's concerns, as well as establishing Germany as a key driver of digital change in Europe and globally.

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