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PUBLIC VERSION

In the published version of this decision, some information has been omitted pursuant to Article 17(2) of Council Regulation (EC) No 139/2004 concerning non-disclosure of business secrets and other confidential information. The omissions are shown thus […]. Where possible the information omitted has been replaced by ranges of figures or a general description.

Advanced Micro Devices, Inc.
2485 Augustine Drive
Santa Clara, CA 95054
United States

Subject: **Case M.10097 – AMD/Xilinx**
Commission decision pursuant to Article 6(1)(b) of Council Regulation No 139/2004[1] and Article 57 of the Agreement on the European Economic Area[2]

Dear Sir or Madam,

(1) On 26 May 2021, the European Commission received notification of a proposed concentration pursuant to Article 4 of Council Regulation (EC) No 139/2004 (the "Merger Regulation") by which Advanced Micro Devices, Inc. ("AMD", United States) intends to acquire, sole control of Xilinx, Inc. ("Xilinx", United States) within the meaning of Article 3(1)(b) of the Merger Regulation (the "Transaction").[3] AMD and Xilinx together are hereinafter referred to as the "Parties" and AMD is also referred to as the "Notifying Party".

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1 OJ L 24, 29.1.2004, p. 1 (the 'Merger Regulation'). With effect from 1 December 2009, the Treaty on the Functioning of the European Union (the 'TFEU') has introduced certain changes, such as the replacement of 'Community' by 'Union' and 'common market' by 'internal market'. The terminology of the TFEU will be used throughout this decision.

2 OJ L 1, 3.1.1994, p. 3 (the 'EEA Agreement').

3 Publication in the Official Journal of the European Union No C OJ C 210, 3.6.2021, p. 10.

1. THE PARTIES

(2) **AMD** is a publicly listed global semiconductor company headquartered in Santa Clara, California, United States. AMD is active primarily in the supply of central processing units ("CPUs"), also known as microprocessors, based on the x86 instruction set architecture and graphics processing units ("GPUs"). AMD is also active in the supply of semi-custom processors for the gaming console market that combine a CPU, a GPU and other customer IP as well as chipsets.

(3) **Xilinx** is a publicly listed global semiconductor company headquartered in San Jose, California, United States. Xilinx is active primarily in the supply of field programmable gate arrays ("FPGAs"). Xilinx is also active in the supply of a range of FPGA-based devices, primarily FPGA systems-on-a-chip, FPGA-based accelerator cards and an adaptive compute acceleration platform ("ACAP"). Xilinx does not offer CPUs, GPUs, APUs or semi-custom processors comparable to AMD's offerings.

2. THE CONCENTRATION

(4) Pursuant to an Agreement and Plan of Merger dated 26 October 2020, Thrones Merger Sub, Inc., an indirect wholly owned subsidiary of AMD, will merge with and into Xilinx, with Xilinx surviving the merger as a wholly owned indirect subsidiary of AMD. As a result, AMD will acquire sole control of Xilinx within the meaning of Article 3(1)(b) of the Merger Regulation.

3. UNION DIMENSION

(5) The undertakings concerned have a combined aggregate world-wide turnover of more than EUR 5 000 million (AMD: EUR 8 547 million; Xilinx: EUR 2 846 million).[4] Each of them has a Union-wide turnover in excess of EUR 250 million (AMD: EUR […] million; Xilinx: EUR […] million), and they do not achieve more than two-thirds of their aggregate Union-wide turnover within one and the same Member State.[5] The Transaction therefore has a Union dimension pursuant to Article 1(2) of the Merger Regulation.

4. RELEVANT MARKETS

4.1. Introduction

(6) AMD and Xilinx are both global suppliers of semiconductor products, more precisely integrated circuits, also known as chips or microchips. Chips can be found in virtually every electronic device or equipment today, such as personal computers, smartphones, servers, cameras, washing machines, medical equipment, telecommunication and network equipment, but also in automotive and industrial applications.

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4 Turnover calculated in accordance with Article 5 of the Merger Regulation.

5 Form CO, Section 4.

4.1.1. The Parties' products

(7) AMD's main products are i) CPUs and ii) discrete GPUs (i.e. GPUs that are not integrated with another processor on the same chip), in various configurations. In addition, AMD offers iii) semi-custom CPUs for the gaming market and iv) chipsets.

(8) Xilinx supplies a wide range of FPGAs with various technical parameters and in various configurations, as well as FPGA-based SoCs and FPGA-based accelerator cards. It also offers software and hardware development tools that enable customers to customize Xilinx's FPGA products.

4.1.2. Description of the products

4.1.2.1. CPUs

(9) CPUs operate as general purpose centralised "brains" of computer systems or other non-computer equipment (e.g. industrial machines, cameras etc.). They are able to perform all types of operations. Typical CPU operations include running software, analysing data, managing networking traffic, and fetching data from memory, as well as transferring information to and from other system resources.[6] In addition, the CPU is the required component to execute the operating system of the host. In general, the complexity and performance of a CPU vary according to the field of application.

(10) CPUs consist of one or multiple cores,[7] which represent the basic processing unit of a CPU, and other components that are included in the same chip. Depending on the intended use of the CPU, these additional components can include memory, memory controller, links based on the PCIe standard, hard disk drive (HDD) or solid state drive (SSD) interface, video and audio codecs, sensor fusion hub, integrated chipset etc.[8] This design of incorporating other components of a computer system next to the CPU core on the same chip is often referred to as a "system on a chip" ("SoC"). There is no standardised definition of the term "SoC", which means that different respondents to the Commission's market investigation understand the term differently.[9] The Parties consider that an SoC is a device that combines several, almost all, or even all elements of a computer system on a single chip.[10] The Commission will adopt this definition for the purpose of this Decision, while acknowledging, where appropriate, that other definitions are also possible. Under the Parties' definition, all CPUs are SoCs as nowadays there are virtually no chips that only have a CPU core or only several cores without other interfaces or components.

(11) The main advantage of such a configuration is that it allows higher bandwidth communication between the CPU and the various components. In addition, the SoC design saves space and results in lower power consumption relative to having the

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6 Form CO, paragraph 215.

7 Marwedel, P., Embedded System Design, 2021, 4th Edition, Springer Open Access, https://doi.org/10.1007/978-3-030-60910-8, p. 157 et ss.

8 Notifying Party's Response to the Commission's RFI 2, paragraphs 3.15-3.16.

9 See the responses to the Commission's Questionnaire Q1 to competitors and trade associations ("Q1 – Questionnaire to competitors and trade associations"), question 31; and to the Commission's Questionnaire Q2 to customers ("Q2 – Questionnaire to customers"), question 21.

10 Notifying Party's Response to the Commission's RFI 3, paragraph 3.4

components on separate chips. These aspects make the SoC design particularly suitable for mobile devices (tablets, smartphones), where the form factor of the chips and power consumption are important parameters. For the same reasons, a CPU SoC design can incorporate not only peripherals but also a different type of processor, namely a GPU. In fact, most CPUs in laptops, desktops and smartphones also contain a GPU.[11]

(12) For completeness, the Commission notes that under the above definition of SoC, an SoC does not have a fixed content and its components vary depending on the task the SoC was designed for.[12] This also means that not only CPU cores but other processors, such as GPUs or FPGAs can also be configured as SoCs. There are, for example, SoCs based on FPGAs[13] or complex SoCs that combine various processing engines. Thus, while under the definition proposed by the Notifying Party and adopted for this Decision all CPUs follow an SoC design (are SoCs), there are many SoCs that are not CPUs. The dividing line between SoCs that are CPUs and those that are not is the SoC's main functionality: as long as the SoC chip's main functionality are the CPU cores, the SoC will be a CPU. As mentioned in paragraph (10) above, this means that next to the CPU cores, the chip contains a number of other components (memory, memory controller, PCIe links etc.) and often an integrated GPU.

(13) CPU cores are modelled around an instruction set architecture ("ISA"), which represents the computer language that a CPU is capable of reading to receive instructions from the system where it is incorporated.[14] AMD's CPUs are based on the x86 ISA, which was initially developed by Intel. Currently AMD and Intel are the only two players having access to the x86 ISA. CPUs based on the x86 ISA ("x86 CPUs") represent the majority of CPUs for servers today. The main alternative to x86 CPUs is represented by CPUs based on the architecture developed by ARM, a British technology company ("ARM-based CPUs").[15]

4.1.2.2. GPUs

(14) GPUs were first introduced to offload simple graphics operations from the CPU but today they are also used for workload acceleration in data centres, including in many of the world's supercomputers. Even though GPUs have more limited functionalities than CPUs, they are much better suited to processing graphic images or computations that require the parallel execution of an enormous number of relatively simple computational tasks (for example, parallel computation of hundreds of thousands of matrix calculations).[16] These kind of tasks can often overburden a CPU, which uses sequential (instead of parallel) computation.[17] As GPUs are often used to

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11 Notifying Party's Response to the Commission's RFI 3, paragraph 4.2. See also Intel's response to Q1 – Questionnaire to competitors and trade associations, question 32.

12 Notifying Party's Response to the Commission's RFI 2, paragraph 3.15.

13 Notifying Party's Response to the Commission's RFI 1, paragraph 1.5. See also Intel's explanation on FPGA SoCs at https://www.intel.com/content/dam/www/programmable/us/en/pdfs/literature/ab/ab1_soc_fpga.pdf.

14 See: Instruction Set Architecture by Dr. A. P. Shanthi at https://www.cs.umd.edu/~meesh/411/CA-online/chapter/instruction-set-architecture/index.html.

15 Form CO, paragraph 258.

16 Responses to Q1 – Questionnaire to competitors and trade associations, question 4; Q2 – Questionnaire to customers, question 4, in particular Microsoft's response.

17 See one customer's response to Q2 – Questionnaire to customers, question 4.

offload computational tasks from the CPU for which the GPU is well suited and accelerate their execution, they are referred to as "*accelerators*". Accelerators include, but are not limited to, GPUs.

(15) As mentioned in Section 4.1.2.1, GPUs that are integrated into CPUs are parts of CPUs. For the purpose of this Decision, the rest of the GPUs, i.e. GPUs that are not integrated another processor technology, are referred to as "discrete GPUs". Discrete GPUs are used in many areas, which broadly fall into two use cases: i) high performance computing and AI applications in data centres and ii) applications requiring high quality graphics or visualisation, such as gaming, computer-aided design (CAD), flight simulators etc.[18] Discrete GPUs are also commonly offered as SoCs,[19] in which the GPU is the main functionality. Furthermore, GPUs are often sold as a graphics card, i.e. a ready-made hardware that can be plugged into a computer, instead of as a discrete chip.

4.1.2.3. FPGAs

(16) FPGAs are a type of programmable logic device that can be configured by customers after fabrication to perform logic and processing tasks.[20] The ability to reprogram FPGAs with desired application or functionality requirements after manufacturing (i.e., "in the field") distinguishes them from other chips, which cannot be changed after fabrication. Due to this feature, FPGAs are an attractive option for applications with evolving standards and algorithms.[21] Like GPUs, FPGAs can be used in data centre servers to offload and accelerate a variety of workloads from a CPU. As such, FPGAs are also included among accelerators, along with GPUs. Lower performance FPGAs are used to perform system control and power management tasks in data centres.[22] Other than data centres (servers), FPGAs are also used in a variety of vertical industries, including in the telecommunications, automotive, aerospace and defence sectors, and in industrial controls.[23]

(17) Contrary to CPUs and GPUs, which are programmed to perform tasks through the use of software, in the case of FPGAs engineers program directly the hardware. Thus FPGAs are deployed for tasks that benefit from dedicated hardware. In such tasks FPGAs offer better latency, connectivity and thus performance than a CPU or GPU in combination with software.[24] However, programming directly the FPGA is much more difficult than programming via software and thus their use involves higher engineering costs relative to CPUs or GPUs.[25]

(18) FPGAs, including some of the FPGAs offered by Xilinx, can be sold as SoCs, i.e. with other elements of a computer system on the same die,[26] but this is not

18 Notifying Party's Response to the Commission's RFI 2, paragraph 18.2; Resposes to Q1 – Questionnaire to competitors and trade associations, question 33; Q2 – Questionnaire to customers, question 23.

19 Notifying Party's Response to the Commission's RFI 1, paragraph 1.5.

20 Form CO, paragraphs 223-224.

21 Form CO, paragraphs 223-224.

22 See for example: https://www.latticesemi.com/en/Blog/2020/02/25/19/33/Different_Types_of_FPGAs.

23 Form CO, paragraph 312; minutes of a phone call with Intel, paragraph 5.

24 Minutes of a phone call with Intel.

25 Minutes of a phone call with Intel.

26 Notifying Party's Response to the Commission's RFI 1, paragraph 1.5. See also Intel's explanation on FPGA SoCs at https://www.intel.com/content/dam/www/programmable/us/en/pdfs/literature/ab/ab1_soc_fpga.pdf.

necessarily always the case. For example, [20-30]% of Xilinx's FPGAs are sold as SoCs.[27] FPGA SoCs usually incorporate also an ARM-based CPU, which provides low-power compute functionality to support the FPGA.[28] The benefits of the SoC design are similar to those discussed in relation to CPUs: printing the CPU, other components and the FPGA logic blocks on the same die results in lower power consumption, smaller board size, and higher bandwidth communication between the processor and FPGA.[29] Even though a CPU is included in these SoCs, the main functionality of the chip remains the FPGA technology. As such, these FPGA SoCs are very different from the CPU-based SoCs offered by AMD.

(19) FPGAs can also be sold as FPGA accelerator cards, i.e. as ready-to-use hardware that can be inserted into a server's expansion slot. These cards have the same function as the FPGA, i.e. to accelerate the processing of certain workloads by offloading them from the server CPU to the FPGA. A type of FPGA accelerator card, for example, is the so-called Smart Network Interface Card or Smart NIC, which accelerates in particular networking functions.

4.1.2.4. ASICs and ASSPs

(20) By way of context, accelerators include not only GPUs and FPGAs but also application-specific standard products (ASSPs) and application-specific integrated circuits (ASICs).[30] ASSPs are custom-designed for a specific function that appeals to a wide market. As such they are "off-the-shelf" products that can be purchased in identical form by a number of different customers. By contrast, ASICs are custom designed chips for a specific customer.[31] As they are custom designed for a specific task both chip types offer superior performance for that particular task. ASICs are generally used when superior performance (including optimal energy consumption properties) is desired but an ASSP for the specific application is not available and the large development cost of a customised chip results in economical unit cost in light of the large volume of products[32] that will contain the chips. Neither Party offers ASSPs or ASICs.

4.1.2.5. Other products

(21) Other than the core products mentioned above, AMD also offers **semi-custom SoCs for the gaming market**. These are semi-customised chips designed for Microsoft and Sony game consoles, built to the order of these customers for their Xbox and PlayStation products respectively.[33] Because of their semi-customised nature, they are quite different from AMD's general CPUs and discrete GPUs.

(22) Finally, AMD also offers **chipsets**, which are integrated circuits that manage the data flow between the CPU, the main memory, and peripherals such as graphics cards,

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27 Notifying Party's Response to the Commission's RFI 1, paragraph 1.5.

28 Form CO, paragraphs 128 – 133.

29 See: https://www.intel.com/content/dam/www/programmable/us/en/pdfs/literature/ab/ab1_soc_fpga.pdf.

30 Form CO, paragraphs 219-226.

31 Form CO, paragraphs 225-226.

32 Responses to Q1 – Questionnaire to competitors and trade associations, questions 6-7. Q2 – Questionnaire to customers, questions 5-6.

33 Form CO, paragraph 363.

Ethernet, USB or audio devices.[34] Often the chipset is integrated with the CPU on the same chip in an SoC configuration, but sometimes it is sold separately from the CPU.[35] Even in the case of a separate sale, however, a chipset is only compatible with the CPU it was designed for and does not work with any other CPU.[36] For instance, AMD makes its chipsets for use with its own CPUs, and an AMD chipset cannot be used with an Intel CPU or vice versa. In this sense, chipsets can be regarded as CPU accessories rather than independent products.

4.1.2.6. Interconnect technologies

(23) In computer systems, the various components need to be connected with the CPU using an interconnect technology. The Peripheral Component Interconnect express (PCIe) is an open interconnect standard available to everyone on FRAND terms and widely used to interconnect high-speed devices, including CPUs and accelerators, especially in servers. In this regard, PCIe ensures interoperability between the different components in servers, regardless of the manufacturer that supplied such components. All chips supplied by the Parties, as well as by their main competitors, are compatible with the PCIe interconnect technology.[37]

(24) In recent years, a new open interconnect standard has emerged, the Compute Express Link (CXL**),** that may replace the PCIe standard. CXL has been designed to target intensive workloads and to offer superior interconnect technology between CPUs and specialised chips such as GPUs, FPGAs etc. compared to the PCIe (e.g. improved speed and larger bandwidth). This, among other elements, makes the CXL standard more suitable especially for data centres. The CXL standard is backed by a consortium that includes the main semiconductor suppliers (such as Intel, AMD, ARM, IBM and Xilinx).[38]

(25) Last, certain semiconductor suppliers other than the Parties (e.g., Nvidia and Intel) have developed proprietary interconnect technologies in order to increase the performance of their processor systems.

4.2. Product market definition

4.2.1. Distinction between CPUs, discrete GPUs and FPGAs

4.2.1.1. Commission precedents

(26) The Commission dealt with the market definition of semiconductors, and in particular CPUs, GPUs and FPGAs in several previous cases. These include the Intel antitrust decision ("Intel"),[39] and the *Intel/McAfee*[40], *Intel/Altera*[41] and

34 Form CO, paragraph 293.

35 Notifying Party's Response to the Commission's RFI 3, paragraph 20.12.

36 Notifying Party's Response to the Commission's RFI 3, paragraph 20.12.

37 Form CO, paragraph 242 – 250.

38 Form CO, paragraph 242 – 250.

39 Case COMP/37.990 – Intel, Commission decision of 13 May 2009. The decision is currently under appeal in case T-286/09 RENV Intel v. Commission.

40 Case COMP M.5984 - Intel/McAfee, Commission decision of 26 January 2011.

41 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015.

Nvidia/Mellanox[42] merger decisions. In these cases, the Commission never considered a product market wider than the markets for CPUs, discrete GPUs or FPGAs. In other words, it never included CPUs, discrete GPUs and FPGAs in the same product market. By contrast, in some of these cases it defined narrower markets than all CPUs or all GPUs.

(27) More specifically, in *Nvidia/Mellanox,* the Commission considered that different types of accelerators (i.e. GPUs, FPGAs, ASSPs and ASICs) are generally suitable for different applications, and therefore they are likely not part of the same market.[43] In particular, especially as regards data centres, the market investigation indicated that different types of data processing solutions are suitable for different kinds of tasks.[44] Respondents indicated that discrete GPUs have become the default solution for specific parallel workloads in datacentres[45] and several customers submitted they would not be willing to perform certain compute-intensive workloads with other accelerators than discrete GPUs for datacentres. On this basis, the Commission considered possible product markets for discrete GPUs that did not include other processor technologies such as CPUs and FPGAs.

4.2.1.2. The Notifying Party's views

(28) The Notifying Party submits that different types of accelerators such as GPUs and FPGAs belong to separate product markets in line with the Commission's approach in *Nvidia/Mellanox*.[46] The Notifying Party does not expressly consider the distinction between CPUs and FPGAs, or that between CPUs and discrete GPUs. However, the Notifying Party's view that CPUs, GPUs and FPGAs all fall into separate market is implicit from the fact that it only discusses distinctions within these chip types and the technical description of the products. Namely, the Notifying Party explains that CPUs are general purpose processors capable of performing all types of operations, while accelerators (which include FPGAs and GPUs) are specialised chips that improve the processing performance of CPUs by offloading certain computational tasks from the CPU.[47] The specialised chips are better suited to certain tasks than the CPU but they cannot do everything that a CPU can do and entail some drawbacks such as the difficulty of programming, higher power consumption etc.[48] The Notifying Party further explains that each accelerator is suitable for different operations with GPUs being ideal for processing graphic images or computations that require massive parallel execution of relatively simple computational tasks and reprogrammable FPGAs being an attractive option for applications with evolving standards.[49] The Notifying Party also notes that FPGAs offer high performance with low latency but programming an FPGA is difficult.

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42 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019.

43 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 27.

44 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 27.

45 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 28.

46 Form CO, paragraphs 368. Precisely, the Parties consider distinct GPUs a separate product market from "data centre processing and acceleration solutions (such as FPGAs, ASICs / ASSPs or other acceleration technologies).

47 Form CO, paragraphs 215-226.

48 Form CO, paragraphs 215-226.

49 Form CO, paragraphs 219-226.

4.2.1.3. The results of the market investigation and the Commission's assessment

(29) In line with the Commission's consistent case practice, the market investigation confirms that CPUs, discrete GPUs and FPGAs belong to different product markets.

(30) A large majority of both customers and competitors was of the view that FPGAs are almost never credible alternatives to CPUs and GPUs or that any substitution between these chips is limited to some very specific applications.[50] For example a customer submitted that FPGAs can only replicate GPUs in limited circumstances within a networking context and that FPGAs cannot typically operate a software like a CPU.[51] Another customer considered that GPUs excel in processing information streams in a highly parallel manner and FPGAs generally cannot do the same. If this is possible in the case of very performant FPGAs, the power consumption and cost of an FPGA would be higher than that of a GPU so as to exclude substitutability. This view was echoed by another customer who submitted that even if an FPGA can be programmed to execute similar tasks as a CPU, it would have a different power consumption and cost profile.[52] In the same vein, another respondent observed that if multicore GPU and CPU functions are implemented via an FPGA, the FPGA would have lower clock speed, higher power consumption and thus would not be competitive.[53] A competitor submitted that CPUs are more versatile than FPGAs and are consequently far more suitable for performing general computing workloads, which have a large quotient of serial computations. GPUs are typically more efficient and cost-effective than FPGAs in performing parallel computations, which are used in many high-performance computing (HPC) and AI workloads. FPGAs, on the other hand, are better suited than CPUs or GPUs to workloads for which an application-specific chip design is desirable and the FPGA implementation is economical[54] (versus ASSPs or ASICs).

(31) The responses thus confirm that CPUs are optimised for general purpose computing and sequential processing, while GPUs are optimised for the parallel execution of a very large number of simple tasks. Although FPGAs can be programmed to do similar computational tasks, they are a poor substitute for both GPUs and CPUs in these functions in terms of energy consumption, cost and/or performance. By contrast, FPGAs are better suited to, and offer superior performance in, workloads requiring a specific hardware. Thus, the Commission considers that there is no demand-side substitution between CPUs and GPUs on the one hand and FPGAs on the other hand.

(32) The results of the market investigation were equally conclusive on the demand-substitutability between CPUs and GPUs. A very large majority of both competitors and customers considered that CPUs and GPUs are almost never credible alternatives to each other or that any substitution is limited to certain very specific cases.[55] Almost all qualitative replies pointed to the distinction mentioned before,

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50 Responses to Q1 – Questionnaire to competitors and trade associations; Q2 – Questionnaire to customers, question 3.

51 One customer's response to Q2 – Questionnaire to customers, question 3.

52 One customer's response to Q2 – Questionnaire to customers, question 3.

53 One customer's response to Q2 – Questionnaire to customers, question 3.

54 One competitor's response to Q1 – Questionnaire to competitors and trade associations, question 3.

55 Responses to Q1 – Questionnaire to competitors and trade associations, question 4; Q-2 Questionnaire to customers, question 4.

namely that CPUs are general purpose processors that can do all tasks but operate with sequential processing (which most computational tasks require) and thus do not handle well tasks that require parallel sequencing of a large number of simple tasks (e.g. hundreds of thousands of matrix calculations in parallel or rendering an image or video, which requires the parallel processing of a multitude of pixels). By contrast, GPUs are specialised chips exactly for this type of computational tasks but as specialised chips they are less suited to general computational tasks. Contrary to CPUs, GPUs are also not able to do all types of computations as many algorithms are not suited for GPU execution.[56]

(33) In line with the results of the market investigation, the Parties' internal documents show that [evaluation of AMD's and Xilinx's products].[57] [58]

(34) As regards supply-side substitution, all responding competitors confirmed that a semiconductor company that is only active in the design and supply of either of the three chips (CPUs, discrete GPUs, or FPGAs) cannot switch to supplying one of the other two chips within 6 months and at modest costs.[59] Respondents submitted that the relevant timeframe for new chip development is 3-5 years and the requisite investment is very substantial. In addition, de novo developments of GPUs or FPGAs by players active in the supply of other chips are exceptional (one case of de novo GPU development by Intel) or non-existent (FPGAs).[60]

(35) Accordingly, for the purpose of the present Decision, the Commission concludes that CPUs, discrete GPUs and FPGAs belong to separate product markets.

4.2.2. CPUs

4.2.2.1. Commission precedents

(36) In *Intel,*[61] the Commission found that there is no substitutability between (i) x86 CPUs and ii) non-x86 CPUs. Demand substitution was excluded because non-x86 CPUs were incompatible with the Windows operating system and the x86 architecture was the standard architecture in the market, and products and applications designed for the x86 CPUs would not run on a CPU with a non-x86 architecture.[62] The Commission also excluded supply-side substitution in light of the evidence, which indicated that switching production between CPUs of different architectures requires several years and very large sunk costs.[63] In the same decision, the Commission also found that there is no substitutability between (i) CPUs for computers; and (ii) CPUs for non-computer devices.[64] From the demand side, the

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56 Responses to Q1 – Questionnaire to competitors and trade associations, question 4; Q-2 Questionnaire to customers, question 4.

57 [Internal document].

58 Parties' internal documents submitted under Form CO section 5.4 and in copy under US-HSR section 4-c and 4-d; Minutes of a call with Microchip.

59 Responses to Q2 – Questionnaire to customers, question 5.

60 Responses to Q2 – Questionnaire to customers, question 5.

61 Case COMP/37.990 – Intel, Commission decision of 13 May 2009.

62 Case COMP./37.990 – Intel, Commission decision of 13 May 2009, paragraphs 803-808.

63 Case COMP/37.990 – Intel, Commission decision of 13 May 2009, paragraphs 821-824.

64 Case COMP/37.990 – Intel, Commission decision of 13 May 2009, paragraphs 814, 831, 835. These non-computer devices include cameras, washing machines, calculators, fridges, industrial robots, medical devices,

performance of non-computer CPUs was insufficient for use in computer systems and they were incompatible with the operating systems that run on computers. There was also no supply-side substitutability based on the time and cost necessary to switch production between these CPU types.[65] The Commission also considered, but eventually left open, whether the relevant product market for x86 CPUs should be further segmented based on the different computer devices in which x86 CPUs are incorporated, i.e. x86 CPUs for: (i) desktops; (ii) laptops; and (iii) servers.[66]

(37) In *Intel/McAfee,* the Commission concluded, in line with the *Intel* decision, that x86 CPUs constituted a relevant product market separate from non-x86 CPUs.[67] In the same decision, the Commission again considered the possible segmentation of the market for x86 CPUs into x86 CPUs for (i) servers; (ii) desktops; (iii) notebooks; and (iv) certain new types of devices, such as netbooks, tablets, handheld devices and consumer electronics. However, the Commission eventually left such possible segmentation open.[68]

(38) In *Intel/Altera,* the Commission considered product markets for CPUs segmented by device type and architecture. The market investigation suggested that it is appropriate to segment the CPU market by device type,[69] whereas the results regarding a possible segmentation by architecture were mixed[70] in that respondents indicated a lack of substitutability for computer devices and a certain degree of substitutability for CPUs for non-computers. The Commission, in any case, left the product market definition open.[71]

4.2.2.2. The Notifying Party's views

(39) The Notifying Party agrees with the Commission's approach in *Intel/Altera* insofar as the Commission determined that a single relevant product market might exist encompassing all CPUs, but that further segmentation might be appropriate.[72] However, in the Notifying Party' view, for the purpose of this Decision it can be left open whether the relevant product market for CPUs should be segmented based on (i) the type of architecture used (x86 CPUs vs. non-x86 CPUs); (ii) CPUs used in computer or in non-computer devices; and, within CPUs for computer devices, (iii) the type of device into which the CPU is incorporated (e.g. servers, desktops, laptops etc.). According to the Notifying Party, the Transaction does not raise any competition concerns regardless of the precise market definition.

(40) With regard to these distinctions, the Notifying Party adds that CPUs for computer devices and CPUs for non-computer devices (i.e. CPUs used in an industrial machine) may constitute separate relevant product markets.[73] In this regard, the

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cars, cash registers, ATMs etc. The industry sometimes refers to these as "embedded CPUs". The Commission will use the term "CPUs for non-computers" to designate these CPUs.

65 Case COMP/37.990 – Intel, Commission decision of 13 May 2009, paragraphs 825-830.

66 Case COMP/37.990 – Intel, Commission decision of 13 May 2009, paragraph 835.

67 Case COMP M.5984 - Intel/McAfee, Commission decision of 26 January 2011, paragraph 28.

68 Case COMP M.5984 - Intel/McAfee, Commission decision of 26 January 2011, paragraphs 29 - 30.

69 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraphs 19-20.

70 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 21.

71 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 22.

72 Form CO, paragraph 344.

73 Form CO, paragraph 355.

Notifying Party submits that there is limited substitutability on the demand side, as non-computer applications require certain characteristics, such as longevity, low-power consumption and mechanical and thermal robustness that CPUs for computer devices do not have. Buyers of CPUs for non-computer applications require devices with a high degree of reliability rather than fast and powerful compute engines. Furthermore, industrial systems are often certified, therefore non-computer CPUs need to resist for a longer period in the same system than computer CPUs, in order to avoid expensive re-certification process.[74]

(41) However, on the supply side, the Notifying Party considers that there is substitutability between these types of CPUs, as suppliers of one type can easily switch to designing and supplying CPUs of the other type. The Notifying Party submits that AMD and Intel are a case in point, as they both offer a range of CPUs for non-computers alongside their high-performance CPUs for computer devices. More specifically, AMD's CPUs for non-computers are based on their computer CPUs, which are modified to meet the requirements of customers in the non-computer space.[75] In any event, the Notifying Party considers that the relevant product market definition can remain open, since the assessment of the Transaction remains unchanged whether or not CPUs for computer and for non-computer devices belong to separate product markets.[76]

(42) The Notifying Party submits that SoCs in which the main element is a CPU should be regarded as CPUs and thus part of the CPU product market.[77] In the notifying Party's view, even if SoCs include a number of different components of a computer system, an SoC's primary functionality is what defines it as a device. Furthermore, the Notifying Party explained that today, CPU cores are always sold with additional functionalities on the same chip, i.e. packaged as an SoC, although the industry has continued to refer to them as CPUs. Therefore, it should not be considered that a chip containing CPU cores plus additional functionalities, where the CPU technology remains the central element of the chip, forms a separate product market from the "pure" CPU cores, which are almost no longer sold on a standalone basis.[78]

(43) Likewise, the Notifying Party considers that CPUs (SoCs) that incorporate both CPU and GPU technologies are a type of CPU and should not be regarded as part of a separate product market. AMD uses the term Accelerated Processing Unit (APU) for these CPUs. This is because the CPU is the central element of the chip, the chip's primary function is to act as compute engine. The Notifying Party submits that today, a CPU contains a built-in GPU in approximately 80% of notebooks (laptops) and desktops, and almost 100% of all notebooks (laptops).[79]

(44) In sum, the Notifying Party submits that the relevant product market for CPUs is the same as SoCs in which the principal element is the CPU cores. In its view, this includes also CPUs with a built-in GPU, which the Notifying Party refers to as APUs. As regards possible segmentations of the market for all CPUs, the Notifying

74 Form CO, paragraph 356.

75 Form CO, paragraphs 357 – 358.

76 Form CO, paragraph 359.

77 Form CO, paragraph 346.

78 Form CO, paragraphs 148 – 169.

79 Form CO, paragraph 351 and paragraphs 190 – 196.

Party considers that, for the purpose of this Decision, it can be left open whether the CPU product market should be further segmented based on: (i) the architecture used; (ii) CPUs for computer or non-computer devices; and, within CPUs for computer devices, (iii) the type of device in which they are incorporated.

4.2.2.3. The results of the market investigation and the Commission's assessment

(45) The Commission will first consider the Notifying Party' explanations on CPUs, CPU-based SoCs, and CPUs containing an integrated GPU, followed by the potential distinctions considered in the precedents.

A) CPUs, CPU-based SoCs and CPUs containing an integrated GPU

(46) Half of competitors and a majority of customers who have replied to the market investigation considered that, indeed, most CPUs are supplied as SoCs.[80] A significant minority of all respondents did consider the statement to be incorrect but, as indicated in Section 4.1.2.1, this is mainly because the term "SoC" does not seem to have a consistent meaning in the industry. For example, one respondent only considers a CPU an SoC if the chip incorporates certain input/output functions and under this definition not all CPUs are SoCs.[81] However, the same respondent also noted that even the CPUs that are not SoCs under its definition contain components (such as graphics rendering) that once had been handled by separate chips, i.e. it confirmed that CPUs contain other components than cores. Some respondents used the term SoC as the opposite of a "discrete CPU" i.e. they considered SoCs to be only those chips that contain more than one type of processors, e.g. a CPU and a GPU.[82] One respondent noted that the issue appears to be more semantic than substantive.[83] Indeed, as factually almost all, if not all, CPUs contain elements other than the cores, under the definition put forward by the Notifying Party and adopted for the purpose of this Decision (see Section 4.1.2.1), CPUs are sold in an SoC form and are thus SoCs.

(47) It also appears to be very common that CPUs include a GPU on the same die, in particular in smartphones, tablets, laptops and desktops.[84] Specifically, in 80% of all notebooks (laptops) and desktops, and in 100% of notebooks (laptops), the CPU includes an integrated GPU.[85] Given that in these cases the main functionality of the SoC is a CPU (the integrated GPU mainly handles image and video rendering but this is just one of the many functions of a computer) and that the competitive reality is that in the notebook (laptop) and desktop segments CPUs generally contain a GPU, it is a reasonable approach to regard these SoCs as CPUs. Thus, under the SoC definition proposed by the Notifying Party and adopted for this Decision, it appears to be correct that all CPUs are sold as SoCs and that these include CPUs with an

80 Responses to Q1 – Questionnaire to competitors and trade associations, question 31; Q2 – Questionnaire to customers, question 21.

81 Responses to Q2 – Questionnaire to customers, question 21.

82 See for example the responses of several customers to Q2 – Questionnaire to customers, question 21.

83 Responses to Q2 – Questionnaire to customers, question 21.

84 Notifying Party's Response to the Commission's RFI 3, paragraph 4.2 and Form CO paragraphs 192 – 196. See also one competitor's response to Q1 – Questionnaire to competitors and trade associations, question 32.

85 Notifying Party's Response to the Commission's RFI 3, paragraph 4.2 and Form CO paragraphs 192 – 196. See also one competitor's response to Q1 – Questionnaire to competitors and trade associations, question 32.

integrated GPU.[86] On that basis and for the purpose of the present Decision, the Commission will not distinguish CPUs from CPU-based SoCs or discrete CPUs from CPUs that contain an integrated GPU.[87]

(48) For completeness, as explained in Section 4.1.2.1, the Commission notes that there are SoCs that are not CPUs, e.g. FPGAs are also sometimes sold as SoCs. Thus while under the definition proposed by the Notifying Party all CPUs are SoCs, the reverse is not true (i.e. not all SoCs are CPUs).

B) Distinction between CPUs for computers and CPUs for non-computers

(49) All competitors and roughly half of customers that expressed a view considered that CPUs for computers and CPUs for non-computers are substantially different and that they are not substitutable.[88] The factors mentioned are consistent with those mentioned by the Notifying Party: CPUs for computers have to be more performant, whereas CPUs for non-computers need to produce less heat, consume less power and be more resistant to high and low outside temperatures and other weather conditions.[89] However, half of the customers considered that CPUs for computers and CPUs for non-computers are interchangeable and many responses indicated that in certain cases computer CPUs can be used in non-computer systems.[90] Contrary to the Notifying Party's view, supply-side substitution appears to be excluded as respondents indicated that switching production involves much longer timeframes than 6 months and involves significant investments.[91] This is all the more so in the case of CPU suppliers using the x86 instruction set (such as Intel and AMD) as a majority of CPUs for non-computers are based on the ARM architecture.[92] Overall, taking all the responses into account, CPUs for computers and CPUs for non-computers (sometimes also referred to as "embedded CPUs in the industry) are more likely than not to constitute separate markets. However, as the distinction does not change the competitive assessment, the Commission leaves the definition open.

C) Distinction between CPUs based on architecture

(50) As regards a possible distinction between CPUs based on the architecture, a majority of customers and competitors that responded to the market investigation indicated that ARM CPUs and x86 CPUs are credible alternatives to each other.[93] In the same vein, some respondents submitted that these two architectures compete with each other. However, several respondents noted that the constraints are not symmetrical in

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86 As mentioned before AMD refers to CPUs with an integrated GPU as APUs. However, this is an AMD product name and the term is not used universally in the industry.

87 The Commission reiterates that these are largely semantic issues. If CPUs containing a GPU were not CPUs, then in certain segments (e.g. laptops, desktops) there would not be a CPU market to speak of, whereas the industry generally considers that laptops do have CPUs. The competitive reality would not change, however, as the same firms would compete in the segments where CPUs with integrated GPUs are common, just the product name would be different.

88 Respones to Q2 – Questionnaire to customers, question 17.

89 Respones to Q1 – Questionnaire to competitors and trade associations, question 24.

90 Respones to Q2 – Questionnaire to customers, question 17.

91 Respones to Q1 – Questionnaire to competitors and trade associations, question 25.

92 See one competitor's response to Q1 – Questionnaire to competitors and trade associations, question 25.

93 Responses to Q1 – Questionnaire to competitors and trade associations, question 26; Q2 – Questionnaire to customers, question 18.

that ARM-based CPUs constrain x86-based CPUs, but this is not true vice-versa.[94] Consistent with this, a competitor noted that switching between architectures have so far been observed only in the direction towards ARM architecture from x86 and not vice-versa.[95]

(51) Furthermore, all but one respondents considered that switching between the two architectures involves substantial costs as it requires the re-writing of the software stack and rethinking the whole hardware architecture.[96] This is consistent with the finding in the precedents that CPU architecture and the software running on the computer have to be compatible. This clear feedback on high switching costs indicates that users may not be able to switch between the different architectures as a result of a 5-10% relative price increase in the price of CPUs of either architecture. Even if a switch happens, it is likely to be a long term choice that is not likely to be reversed in the short term due to the same switching costs. Put differently, switching between CPUs of different architectures involves switching between two ecosystems, which would not necessarily happen in response to relative price changes of 5-10% in the price of the CPUs. In other words, the constraints of the different architectures on each other may be weaker and less immediate than that which would justify placing the CPUs in the same product market; rather, the constraints may be out-of-market constraints that trigger one-off type switching in the long term. The Commission also notes that CPU users that do not write their own software could only switch if their software supplier creates a version of the software suitable for another CPU architecture. However, the software vendor is unlikely to produce such a version unless there is significant customer demand for it, which creates a negative feedback loop that may hinder switching.

(52) Thus, while there appears to be some level of competitive constraint between CPUs of different architectures, the indications are that these are unidirectional (ARM CPUs constrain x86 CPUs but not vice-versa) and not immediate enough for including the CPUs of different architectures in one product market. However, as the distinction would not change the competitive assessment of this case, the Commission leaves the definition open.

D) Distinction by device type within CPUs for computers

(53) Respondents provided some indication that CPUs used in different device types (e.g. servers, desktops, laptops, smartphones etc.) have different characteristics due to different requirements, for instance, in terms of performance and size.[97]

(54) In any case, the Commission considers that, for the purpose of this Decision, it can be left open whether the product market for CPUs should be segmented according to any of the distinctions set out above, as the Transaction does not raise competition concerns under any of the possible product market definitions.

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94 Responses to Q1 – Questionnaire to competitors and trade associations, question 26, and Q2 – Questionnaire to customers, question 18.

95 Respones to Q1 – Questionnaire to competitors and trade associations, question 26.

96 Respones to Q1 – Questionnaire to competitors and trade associations, question 27; Q2 – Questionnaire to customers, question 19.

97 Respones to Q1 – Questionnaire to competitors and trade associations, question 29; Q2 – Questionnaire to customers, question 20.

E) Conclusion

(55) In sum, the Commission leaves the question whether the product market for CPUs should be further segmented based on (i) the architecture; (ii) the use in computer or non-computer devices; and, iii) within CPUs for computer devices, the different device types. Moreover, the Commission considers that, for the purpose of this Decision and under the definition set out in Section 4.1.2.1, all CPUs are SoCs, and that it is very common that CPUs include an integrated GPU. Thus, the Commission will not distinguish CPUs from CPU-based SoCs or discrete CPUs from CPUs that contain a GPU.

4.2.3. Discrete GPUs

4.2.3.1. Commission precedents

(56) In *Nvidia/Mellanox,* as explained in paragraph (27), the Commission considered that discrete GPUs are part of a separate product market compared to other types of processing solutions.[98] In this context, the Commission also concluded that GPUs integrated into another chip are distinct products compared to discrete GPUs, i.e. GPUs that do not comprise another processor technology.[99]

(57) Within discrete GPUs, the Commission considered a distinction between: (i) discrete GPUs for datacentres; and (ii) discrete GPUs for gaming. In this respect, the market investigation confirmed that (i) discrete GPUs for data centres, on the one hand, and (ii) discrete GPUs for gaming, on the other hand, are in different relevant product markets. Respondents indicated that, despite these products having the same architecture, they have different levels of performance due to, among other reasons, technical limitations of discrete GPUs for gaming.[100]

(58) Against this background, the Commission found that there is a separate relevant product market for discrete GPUs for datacentres.[101]

4.2.3.2. The Notifying Party's views

(59) The Notifying Party agrees with the Commission's findings in *Nvidia/Mellanox* with respect to distinct product markets for i) discrete GPUs for data centres and ii) discrete GPUs for gaming. In that that regard, the Notifying Party states that the architecture of discrete GPUs for gaming is optimised for a maximum of frames per minutes while the architecture of discrete GPUs for data centres is optimised for flops per second.[102] The Notifying Party submits that these two architectures continue to diverge in terms of capability and performance, and that substitutability between discrete GPUs for data centres and discrete GPUs for gaming will likely decrease further in the future.[103] According to the Notifying Party, there is no basis for any additional distinctions further to the one between discrete GPUs for data

98 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraphs 27-34.

99 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 30.

100 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 26.

101 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 38.

102 Form CO, paragraph 369.

103 Form CO, paragraph 369.

centres and for gaming, as GPUs are flexible enough to be used, for instance, across different industrial sectors (e.g. automotive, telecommunications etc.).[104] The Notifying Party adds that the term discrete GPUs for gaming should be understood broadly, i.e. their use includes not only gaming but all other applications where professional visualisation is necessary, such as computer aided design (CAD), flight simulation and other application etc., even if gaming remains the primary use for such GPUs.[105]

(60) The Notifying Party also submits that integrated GPUs are not substitutable with discrete GPUs, in particular for data centre and high performance computing applications. The Notifying Parties considers that only discrete GPUs are capable of performing compute-intensive workloads or guarantee the video quality for gaming and other professional visualisation tasks.[106]

(61) Moreover, according to the Notifying Party, graphics cards should not be considered as forming a separate product market. In the Notifying Party's view, graphics cards are a mere way of selling a GPU, and they bring only limited additional value in comparison to the GPU technology that graphics cards contain. This is true in particular as regards graphics cards used in data centres, where the GPU is more expensive and the cost of the add-on board, which remains fixed, accounts only for a small proportion of the final price of the graphics card.[107] Further, [information on AMD's products]. Therefore, the Notifying Party notes that any distinction between discrete GPUs would also apply to graphics cards. In any case, the Notifying Party notes that only [5-10]% of AMD's GPUs are offered as graphics cards,[108] and that the distinction between discrete GPUs and graphics cards can be left open, since this does not affect the competitive assessment of the Transaction.[109]

(62) In any case, the Notifying Party argues that the exact scope of the GPU product market can be left open due to the absence of competition concerns in relation to this Transaction under any plausible product market definition.[110]

4.2.3.3. The results of the market investigation and the Commission's assessment

(63) In line with the *Nvidia/Mellanox* precedent and with the Notifying Party's view, an overwhelming majority of respondents to the market investigation confirmed the approach taken in *Nvidia/Mellanox*. Thus, respondents confirmed that integrated GPUs on the one hand, and discrete GPUs on the other hand belong to separate product markets and that discrete GPUs for gaming and discrete GPUs for data centres form separate product markets.[111] As a customer summarised, "*Integrated GPUs are really marketed under the CPU brand, not the GPU itself so the two markets are distinct. Furthermore, GPU architectures has specialized to the point*

104 Form CO, paragraph 371.

105 Notifying Party's Response to RFI 3, paragraph 18.2.

106 Form CO, paragraph 370.

107 Notifying Party's Response to Commission's RFI 5.

108 Ibid.

109 Form CO, paragraph 372. The Parties further note that that AMD does not distinguish revenues from add-on boards without GPUs separately from revenue from GPU chips.

110 Form CO, paragraph 368.

111 Responses to Q1 – Questionnaire to competitors and trade associations, question 33; Q2 – Questionnaire to customers, question 23.

where a data center or AI type GPU is no longer as computationally efficient at video processing [as] *a gaming GPU even though their constituent design IP library is identical"*[112] This also confirms that, as discussed in relation to CPUs and GPUs (Section 4.1.2.1 and 4.2.2.2), integrated GPUs are mainly sold as parts of CPUs.

(64) Furthermore, discrete GPUs and graphics cards appear to fall into the same market based on supply-side substitution. Indeed, the core component of a graphics card is the discrete GPU, whereas the card that houses the GPU is a simple and relatively inexpensive device that can be added at little cost by any discrete GPU supplier. Based on the information provided by the Notifying Party, the costs related to the manufacturing of the card by an external manufacturer, in case of data centre graphics cards, account for [percentage range] of the total production costs, and the component that determines the final price of a graphics card is the GPU technology.[113] Thus, AMD could easily and at modest cost redirect this volume of GPUs to manufacturing own-brand graphics cards using an external manufacturer for add-on boards. In addition, no proprietary knowledge is necessary to build such boards, unlike the design of a GPU that requires specific technical know-how.[114]

(65) In light of the precedents and of the results of the market investigation, the Commission concludes, for the purpose of the present Decision, that discrete GPUs constitute a separate product market from integrated GPUs, which are usually integrated into CPUs. Likewise, the Commission concludes that discrete GPUs for data centres and discrete GPUs for gaming and professional visualisation constitute separate markets. Graphics cards would fall into the same market as the discrete GPU they house.

4.2.4. FPGAs

4.2.4.1. Commission precedents

(66) In *Intel/Altera*[115], the Commission considered the potential distinction between FPGAs and Complex Programmable Logic Devices ("CPLDs"), i.e. are another type of programmable logic devices that can be configured by customers and are primarily used as "glue logic" to interface with other integrated circuits in a system. The Commission also assessed the potential distinction between FPGAs and ASICs and ASSPs, which are also specialised, albeit not reprogrammable, hardware.

(67) In addition, the Commission also examined distinctions within FPGAs based on (i) performance characteristics (i.e., between high-end, mid-range, and low-end devices); and (ii) the type of device FPGAs are installed into (i.e., desktops, laptops, and servers). Moreover, the Commission considered whether FPGA for servers could be further distinguished based on (iii) the FPGA's intended use

112 Response of one customer to Q2 – Questionnaire to customers, question 23.

113 Notifying Party's Response to the Commission RFI 5.

114 Notifying Party's Response to the Commission RFI No 5. The Notifying Party explained that the only factor that prevents AMD from manufacturing their own boards is the investment required to build a manufacturing facility, while manufacturers, rather than owning specific IP or know-how, benefit from economies of scale and therefore offer lower costs for the manufacturing process, that make it convenient for AMD to outsource the manufacturing.

115 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015.

(i.e. computing, networking, storage) and whether, iv) within FPGAs for computing in servers, there is a separate market for FPGAs for workload acceleration.

(68) With respect to FPGAs and CPLDs, the market investigation indicated that these two products are not interchangeable as they have different functionalities and characteristics, target different user categories and are built upon different architectures. In particular, compared to FPGAs, CPLDs are generally significantly less performant in terms of computing capability and speed, while being more complex and less configurable.[116]

(69) With respect to FPGAs and ASICs or ASSPs, the market investigation indicated that FPGAs could be an alternative ASICs or ASSPs, but also underlined important differences. In particular, FPGAs can be configured to a higher degree by customers using specialised software.[117] Furthermore, FPGAs come with lower time-to-market, lower fixed costs and higher variable cost than ASICs or ASSPs. Given the different cost structure, ASIC and ASSPs can offer significant performance advantages vis-à-vis FPGAs for companies with sufficient financial and technical resources who need larger quantities.[118]

(70) Eventually, the Commission found that: (i) FPGAs and CPLDs; and (ii) FPGAs and ASICs/ASSPs fall into different product markets, but left open the issue whether segmentations within FPGA products are warranted, as the transaction did not raise any concerns under any market definition based on the considered distinctions.[119]

4.2.4.2. The Notifying Party's views

(71) The Notifying Party submits that FPGAs fall into separate product markets from GPUs, ASICs, ASSPs and other acceleration technologies.[120] However, the Notifying Party submits that the Commission should not segment the FPGA market further based on (i) performance characteristics, (ii) type of device, (iii) intended use (in particular, as between computing, networking, or storage in a data centre), nor based on (iv) the vertical industry in which FPGAs are used (e.g. automotive, communications etc.). This is because FPGAs are generic, programmable logic devices that can serve all purposes.[121]

(72) Moreover, the Notifying Party submits that the Commission has never considered segmenting the market for FPGAs between FPGAs for computer devices (mostly servers) and embedded FPGAs (i.e. FPGAs used in non-computer devices). In the Notifying Party's view, such segmentation is not warranted, because: (i) there is no fundamental difference between FPGAs used in servers and FPGAs used in embedded applications; (ii) conditions in the supply of FPGAs are broadly similar

116 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 41.

117 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 43.

118 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 43.

119 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraphs 40, 53.

120 Form CO, paragraph 379.

121 Form CO, paragraph 380.

across all industry sectors; and (iii) the majority of FPGAs are used in embedded applications in any case.[122]

(73) In any case, the notifying Party submits that the exact scope of the product market for FPGAs can be left open due to the absence of competition concerns raised by the Transaction under any plausible definition.[123]

4.2.4.3. The results of the market investigation and the Commission's assessment

A) Distinction between FPGAs and CPLDs, ASICs and ASSPs

(74) As regards CPLDs, respondents to the market investigation nearly unanimously confirmed that they are not substitutable with FPGAs neither from a demand, nor from a supply perspective, due to the wide performance gap and the large differences in production know-how.[124]

(75) The market investigation also confirmed, in line with the precedents, that although in some cases both FPGAs and ASICs could be deployed for the same task, there is a large difference in their cost structure.[125] Namely, respondents indicated that designing an ASIC involves very substantial fixed costs and thus they are worth to deploy only in large quantities. By contrast, FPGAs have low unit costs but programming the FPGA involves considerable variable costs. Thus, FPGAs are mostly worth deploying in small or medium quantities, while ASICs are worth deploying in large quantities which implies that the substitutability between FPGAs and ASICs is minimal.[126]

(76) By extension, the same applies to ASSPs with the difference that, contrary to ASICs, the cost of the ASSP development can be spread over several customers. Thus, if the need for a specific optimised hardware is large enough in the overall market so as to lower the unit cost of ASSPs, ASSPs will be preferred over FPGAs as they do not need to be programmed and are off-the-shelf products. However, if there are no ASSPs for a given application where specialised hardware is needed or the expected volumes are not large enough to make the ASSP development economical, FPGAs will be preferred. Moreover, regardless of economics, FPGAs will be preferred for workloads where specialised hardware is desired but the methods are evolving and thus the chip needs to be reprogrammed from time to time. ASSPs and ASICs not being reprogrammable, they cannot be deployed in such cases.

B) Potential distinctions within FPGA products

(77) The feedback received in relation to a possible segmentation of FPGAs based on the performance levels (i.e. high-end, mid-range and low-end FPGAs), was somewhat mixed as regards demand-side substitution. Respondents were close to equally split

122 Form CO, paragraphs 382 – 383.

123 Form CO, paragraph 378.

124 Responses to Q1 – Questionnaire to competitors and trade associations, question 9; Q2 – Questionnaire to customers, question 7.

125 Responses to Q1 – Questionnaire to competitors and trade associations, question 6; Q2 – Questionnaire to customers, question 5.

126 Responses to Q1 – Questionnaire to competitors and trade associations, question 7; Q2 – Questionnaire to customers, question 6.

on whether FPGAs with different performance profiles are credible alternatives.[127] However, the qualitative answers point to a lack of substitution as FPGA performance also correlates with cost and energy consumption, resulting in significant trade-offs between FPGAs with different performance profiles.[128] The responses also indicate that the categories of high-end, mid-range and low-end FPGAs are not clear-cut and thus substitution between FPGAs close to the cut-off points of two different performance brackets is likely.[129] This, however, does not mean that the distinction would not have merit. While demand-side substitution is unlikely, the results are inconclusive as regards supply-side substitution. Switching production from lower performance towards higher performance versions is not possible in a short timeframe and without incurring significant costs but switching supplies in the other direction seems easier.[130] This one-directional substitution may result in a unified market as, with the exception of one small player (Microchip), all suppliers are capable of supplying high-end FPGAs. However, lower-end FPGA designs also have challenges especially as regards power consumption and thus it may not be easy to switch supplies in this direction either.[131] As the distinction does not influence the outcome of the competitive assessment, the Commission leaves the market definition in this regard open.

(78) Replies were also inconclusive as regards a possible distinction between FPGAs for computers (almost exclusively servers) and for non-computer devices.[132] Certain responses indicate that if the performance (and thus power consumption, cost and size) parameters are equivalent, the same FPGA can be used in computers and in non-computers.[133] However, other responses indicate that there may be differences that would not be captured by the distinction based on performance, such as reliability, number of pins and security features.[134] Furthermore, just like in the case of CPUs for non-computers, the replies indicate that in certain cases FPGAs in non-computers need to be resistant to extreme weather conditions.[135] While such aspects would most likely exclude demand substitution in certain non-computer applications, supply-side substitution is unclear in this regard. As the potential distinction does not influence the outcome of the competitive assessment, the Commission leaves the definition open in this regard.

(79) As regards a possible distinction between FPGAs used in different industrial sectors (e.g. automotive, telecommunications etc.), the responses generally indicate that, from a demand perspective, due to their programmability, the same FPGAs can be used across different vertical industries.[136] However, as indicated before, it appears that this is only true across certain industries as certain industrial uses require

127 Responses to Q1 – Questionnaire to competitors and trade associations, question 14; Q2 – Questionnaire to customers, question 10.

128 See for example one customer's response to Q2 – Questionnaire to customers, question 10.

129 See for example one competitor's response to Q1 – Questionnaire to competitors and trade associations.

130 Respones to Q1 – Questionnaire to competitors and trade associations, question 15.

131 Minutes of a call with Achronix.

132 Responses to Q1 – Questionnaire to competitors and trade associations, question 18; Q2 – Questionnaire to customers, question 13.

133 See one customer's response to Q2 – Questionnaire to customers, question 13.

134 See one customer's response to Q2 – Questionnaire to customers, question 13.

135 See one customer's response to Q2 – Questionnaire to customers, question 13.

136 Responses to Q1 – Questionnaire to competitors and trade associations, question 20; Q2 – Questionnaire to customers, question 14.

resistance to environmental factors that FPGAs used in a more standard environment cannot provide.[137] For example, FPGAs used in 5G base stations need to be temperature resistant,[138] while FPGAs used in the aerospace industry need to be resistant to radiation.[139] However, as indicated before, the market feedback lacks sufficient clarity as to whether or not suppliers could add such features without major difficulties. As defining separate markets for FPGAs in certain industries would not influence the competitive assessment, the Commission leaves the market definition open.

(80) A large majority of customers also indicated that there are specific use cases for FPGAs that would require specific product characteristics and technical parameters such that the FPGAs are not substitutable across these use cases.[140] However, the qualitative responses revealed few differences beyond the distinctions considered previously (performance, size, power consumption, resistance to environmental factors etc.) and the feedback on suppliers' ability to adjust production in relation to these parameters,[141] if there are any, was insufficient. However, as the competitive assessment does not change regardless of any distinction within FPGAs, the Commission can also leave the definition open in this regard.

(81) Finally, the Commission also leaves open the question whether FPGAs used in data centres constitute separate markets, as the results were inconclusive as to whether data centre FPGAs have different features relative those used outside data centres that are not captured by the potential distinction on performance. [142]

(82) The market investigation confirmed that some FPGAs are also often offered as SoCs.[143] On the demand side, the majority of customers indicated that FPGA SoCs are regarded as more complex, distinct products from standalone FPGAs, although the issue remains that the term "SoC" is not used consistently.[144] However, there appears to be supply-side substitutability between standalone FPGAs and FPGA SoCs. The Commission recalls that FPGA SoCs are standalone FPGAs that have been pre-emptively combined with other semiconductors, typically an ARM-based CPU, for efficiency reasons. Any FPGA supplier, when it has the capability to design FPGA programmable logic, can easily combine the latter, in a short timeframe and at modest costs, with the components required to create an SoC.[145]

(83) As regards FPGAs and FPGA accelerator cards, the market investigation indicates that they are not substitutable. From the demand side one is a chip level product, while the other is a board level product i.e. they are at different levels of a server's

137 Responses to Q1 – Questionnaire to competitors and trade associations, question 20; Q2 – Questionnaire to customers, question 14.

138 See the response of one customer, Q2 – Questionnaire to customers, question 14.

139 Minutes of a phone call with GE.

140 Responses to Q1 – Questionnaire to competitors and trade associations questions 22/22.1; Q2 – Questionnaire to customers, questions 15/15.1.

141 Responses to Q1 – Questionnaire to competitors and trade associations, question 22.

142 Responses to Q1 – Questionnaire to competitors and trade associations, question 16; Q2 – Questionnaire to customers, question 23.

143 Responses to Q1 – Questionnaire to competitors and trade associations, question 10; Q2 – Questionnaire to customers, question 8.

144 Responses to Q2 – Questionnaire to customers, question 9.

145 See Notifying Party's Response to the Commission's RFI 5.

architecture. As such they cannot be used interchangeably.[146] From the supply-side, some responses indicate that switching from supplying FPGAs to supplying FPGA accelerator cards takes two years and significant financial investment. However, only a few respondents provided feedback on this issue, and the Notifying Party argues that substitutability exists on the supply side because the FPGA architecture is the central element of FPGA accelerator cards and FPGA suppliers can easily, and at modest costs, switch to supplying FPGA accelerator cards from standalone FPGAs.[147] The Notifying Party also argues that contract manufacturers can easily create an FPGA card from an FPGA; however, this was not confirmed in the market investigation. The Commission considers that, for the purpose of this Decision, it can be left open whether FPGA accelerator cards are part of the same product market as FPGAs, as the outcome of the competitive assessment does not change regardless of such distinction.

C) Conclusion

(84) Based on the above the Commission considers that, for the purpose of this Decision, it can be left open whether the market for FPGAs should be further segmented according to the segmentations indicated above, i.e.: (i) based on the performance level; (ii) between FPGAs for computer and non-computer devices; (iii) between FPGAs used in different industrial sectors; (iv) based on the specific use cases; and (v) between FPGAs for data centres and FPGAs used outside data centres. The Commission considers that the outcome of the competitive assessment does not change regardless of any market definition based on these distinctions. The Commission further considers that, for the purposes of this Decision, standalone FPGAs and FPGA SoCs are in the same market, and that it can be left open whether FPGA accelerator cards are part of the same market as FPGAs.

4.2.5. The Parties' other products

4.2.5.1. Chipsets

(85) In *Intel/McAfee*, the Commission detailed that chipsets are generally designed to work with a specific family or generation of CPUs and that, in order to function together, chipsets and CPUs have to be compatible.[148] The Commission also discussed whether chipsets could constitute a separate product market in particular from CPUs, as they can be bought and sold independently,[149] and considered possible distinction within chipsets based on the separate CPU (after)markets, i.e. between chipsets compatible with (i) Intel CPUs; or (ii) AMD CPUs, respectively.[150] However, the relevant product market was left open.[151]

(86) The Notifying Party submits that chipsets are part of the same product market as CPUs. According to the Parties, changes in the way CPUs are designed and manufactured make a distinction between chipsets and CPUs even less appropriate

146 Responses to Q1 – Questionnaire to competitors and trade associations, question 13.

147 See Notifying Party's response to the Commission's RFI 5.

148 Case COMP M.5984 – Intel/McAfee, Commission decision of 26 January 2011, paragraph 13.

149 Case COMP M.5984 – Intel/McAfee, Commission decision of 26 January 2011, paragraph 34.

150 Case COMP M.5984 – Intel/McAfee, Commission decision of 26 January 2011, paragraph 35.

151 Case COMP M.5984 – Intel/McAfee, Commission decision of 26 January 2011, paragraph 36.

today than it was at the time of the Commission's 2011 *Intel/McAfee* decision. In particular, today chipsets and CPUs are mostly sold in an integrated way (i.e. in the same SoC). If they are sold separately (as it happens sometimes e.g. for the *do-it-yourself* – "DIY" desktop market), there is always a one-to-one relationship between every AMD CPU and AMD chipset sold. Likewise, the Notifying Party explained that also Intel CPUs only work with Intel chipsets. In addition, chipsets have a low value compared to the CPU itself.[152] Consequently, the Notifying Party submits that chipsets do not fall into a separate market from CPUs.

(87) In this regard, the Commission notes that chipsets may be considered as parts of CPUs. To the extent they are distinct products, a chipset for a given CPU would not be substitutable with a chipset designed for another CPU. For the purpose of this Decision, the Commission considers that the question whether chipsets belong to the same product market as CPUs can be left open as the distinction would have no effect on the competitive assessment. If they do not fall into the same market as CPUs on the grounds that they are CPU parts, they clearly would not belong to the same market as FPGAs either as chipsets are non-programmable hardware complements to CPUs. Further, if they are excluded from the market of CPUs, to which they most closely relate, they also cannot be part of the market for any other AMD product (any discrete GPU market, or any market where semi-custom SoCs for the gaming market would belong).

4.2.5.2. Semi-custom SoCs for the gaming market

(88) Semi-custom SoCs for the gaming market typically describe SoCs which incorporate CPU(s) and GPU(s) on a single chip and are built into video gaming consoles (e.g. Sony PlayStation, Microsoft Xbox, Nintendo Switch). Notably, the Notifying Party explains that they do not refer to discrete GPUs for gaming (Section 4.2.3.1), which are mainly used for desktops or laptops with dedicated performance needs for gaming.[153] Furthermore, such SoCs do not contain, and are not used together with, FPGAs.

(89) The Commission has not considered semi-custom SoCs for the gaming market in previous decisions. The Notifying Party note that such product market is likely to be distinct from other CPUs, as semi-custom SoCs for gaming are bespoke products that have distinct characteristics and are designed specifically on customer order. Furthermore, semi-custom SoCs for gaming are designed and manufactured under long-term contracts with customers lasting approximately [time range].[154]

(90) The Commission considers that semi-custom SoCs for the gaming market are not part of any of the potential CPU markets discussed in Section 4.2.2 or any of the discrete GPU markets discussed in Section 4.2.3. These are semi-bespoke products developed for specific customers and not substitutable with AMD's CPUs or GPUs. Likewise, as they are customised SoCs based on CPU and GPU technology, they do not belong to the same market as FPGAs. Their exact market definition can be left open because it would not change the outcome of the competitive assessment.

152 Form CO, paragraph 361.

153 Form CO, paragraph 193.

154 Form CO, paragraph 363.

4.3. Geographic market definition

4.3.1. Commission precedents

(91) In *Intel*, the Commission found that the geographic market for CPUs is worldwide in scope, as (i) CPU suppliers compete globally, (ii) CPU architectures are the same around the world, (iii) OEMs operate on a worldwide basis, and (iv) the cost of shipping CPUs around the world is low compared to CPU manufacturing cost.[155] Likewise, in *Intel/McAfee*, the Commission found that the geographic markets for x86 CPUs and chipsets are both worldwide in scope.[156] The same conclusion was also reached by the Commission in *Intel/Altera* in relation to all CPUs and possible segments thereof.[157]

(92) Similarly, in *Intel/Altera* and *Nvidia/Mellanox,* the Commission concluded that the markets for FPGAs and GPUs (and possible segments thereof) are worldwide in scope.[158] The market investigation indicated a lack of significant differences in pricing, supply or purchasing patterns across the globe, as well as low shipping and handling costs.[159]

4.3.2. The Notifying Party's view

(93) The Notifying Party submits that, in line with the relevant Commission precedents, the geographic markets for semiconductors should be worldwide in scope.[160]

4.3.3. The results of the market investigation and the Commission's assessment

(94) A large majority of respondents to the market investigation indicated that, regardless of the precise distinction on product level, the geographic market for CPUs, GPUs and FPGAs is worldwide in scope.[161]

(95) Some respondents indicated that certain issues such as trade restrictions and geopolitical dynamics might affect the conditions of competition in China. However, the majority of respondents submitted that the identification of a separate geographic market for China is not warranted due to the fact that customers are located in every region of the world, including China, and that possible barriers are not significant in such a way as to affect the global scope of supplying and purchasing patterns.[162]

(96) In line with the precedents and with the results of the market investigation, the Commission therefore considers that, for the purpose of this Decision, the relevant geographic market for CPUs, FPGAs and GPUs, regardless of the exact definitions at product level, is worldwide in scope.

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155 Case COMP/37.990 – Intel, Commission decision of 13 May 2009, paragraph 836.

156 Case COMP M.5984 - Intel/McAfee, Commission decision of 26 January 2011, paragraph 32 – 33, 37.

157 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 25.

158 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraph 25; Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 38.

159 Case COMP M.9424 – Nvidia/Mellanox, Commission decision of 19 December 2019, paragraph 56.

160 Form CO, paragraph 387.

161 Responses to Q1 – Questionnaire to competitors and trade associations, question 34; Q2 – Questionnaire to customers, question 24.

162 Responses to Q1 – Questionnaire to competitors and trade associations, question 35; Q2 – Questionnaire to customers, question 25.

5. COMPETITIVE ASSESSMENT

5.1. Introduction

(97) There is no horizontal overlap between the Parties' activities. First, as discussed in Section 4.2.1, FPGAs on the one hand (offered by Xilinx), and CPUs or discrete GPUs on the other hand (offered by AMD) belong to separate markets regardless of any distinction within these processor types. Second, as discussed in Section 4.2.5, AMD's chipsets and semi-custom SoCs for the gaming market on the one hand and FPGAs on the other hand also belong to separate markets regardless of the precise market definition for these products.

(98) As both Parties supply final chips or hardware incorporating those chips and neither are active in markets for any product that is upstream or downstream relative to the products of the other party, there is also no vertical relationship between them.[163]

(99) However, as CPUs and FPGAs are used, or can be used, together in some servers, in particular in data centres,[164] as well as in a number of non-computer devices,[165] there is a conglomerate relationship between the two products and the Parties. To a lesser extent discrete GPUs and FPGAs could also be used together in data centres,[166] and in some other applications,[167] which results in another conglomerate relationship.[168] To the extent FPGA accelerator cards form a separate market from FPGAs, then a conglomerate relationship would arise between accelerator cards and CPUs/GPUs, as they can be used together in data centres.

(100) In addition to these links, there are no further conglomerate relationships involving other products. To the extent they do not belong to the same market as CPUs themselves, chipsets do not give rise to conglomerate relationships. Chipsets being a close complement of CPUs, they are used together with CPUs and not FPGAs. FPGAs are not used in gaming consoles,[169] and therefore there cannot be a conglomerate relationship between semi-custom SoCs for gaming and FPGAs. Should FPGA based accelerator cards form a separate market, there would be no conglomerate relationship between them and chipsets and semi-custom SoCs for gaming for the same reasons as in the case of FPGAs.

5.2. Analytical framework

(101) Pursuant to the Commission's Non-Horizontal Merger Guidelines[170], conglomerate mergers are mergers between firms that are in a relationship which is neither

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163 Form CO, paragraph 463.

164 Notifying Party's Response to the Commission's RFI 1, paragraph 3.1., Notifying Party's Response to the Commission's RFI 2, question 7.

165 Notifying Party's Response to the Commission's RFI 1, paragraph 3.2.

166 Notifying Party's Response to the Commission's RFI 1, paragraph 13.3. Notifying Party's Response to the Commission's RFI 3, paragraph 19.2.

167 Responses to to Q2 – Questionnaire to customers, question 36.

168 Form CO, paragraph 464.

169 Responses to Q1 – Questionnaire to competitors and trade associations, question 17; Q2 – Questionnaire to customers, question 12.

170 Guidelines on the assessment of non-horizontal mergers under the Council Regulation on the control of concentrations between undertakings, OJ C 265, 18.10.2008, p. 6–25.

horizontal (as competitors in the same relevant market) nor vertical (as suppliers or customers). In conglomerate mergers, the relevant companies are active in closely related markets, for instance supplying complementary products or products that belong to the same product range.[171]

(102) It is acknowledged that, in the majority of cases, conglomerate mergers will not lead to any competition problems. In this regard, conglomerate mergers, like vertical mergers, provide substantial scope for efficiencies.[172] However, in certain specific cases, there may be harm to competition.

(103) The main concern in the context of conglomerate mergers is that of foreclosure. The combination of products in related markets may confer on the merged entity the ability and incentive to leverage a strong market position from one market to another market, in order to foreclose rivals on the latter, by means of tying or bundling or other exclusionary practices.[173]

(104) Pursuant to the Non-horizontal Merger Guidelines, bundling refers to the way products are offered and priced by the merged entity. In particular, products can be sold only together in fixed proportions (pure bundling), or they can also be available separately, but the sum of their standalone prices is higher than the bundled price (mixed bundling). Tying refers to situations in which customers that purchase one product (the tying product) are required to also buy another good from the same producer (the tied product). Tying can be implemented on a technical basis (i.e. via exclusive technical compatibility between the products) or on a contractual basis.[174]

(105) Tying and bundling as such are common practices that often have no anticompetitive consequences. Companies may engage in tying and bundling in order to provide their customers with better products or offerings in cost-effective ways.

(106) Nevertheless, in certain circumstances, these practices may reduce the competitive pressure on the merged entity. In assessing the likelihood of such a scenario, the Commission examines, first, whether the merged firm would have the ability to foreclose its rivals, second, whether it would have the economic incentive to do so and, third, whether a foreclosure strategy would have a significant detrimental effect on competition, thus causing harm to consumers. In practice, these factors are often examined together as they are closely intertwined.[175]

5.3. Market shares and sales values

5.3.1. CPUs

(107) The following tables indicate the market shares of the Parties and their competitors under the following plausible product market definitions: (i) all CPUs, (ii) x86 CPUs, (iii) CPUs for non-computers, (iv) x86 CPUs for non-computers, (v) CPUs for computer devices, (vi) x86 CPUs for computer devices, (vii) CPUs for servers

171 Non-horizontal Merger Guidelines, paragraphs 5 and 91.

172 Non-horizontal Merger Guidelines, paragraph 13.

173 Non-horizontal Merger Guidelines, paragraph 93.

174 Non-horizontal Merger Guidelines, paragraphs 96 – 97.

175 Non-horizontal Merger Guidelines, paragraph 94.

and viii) x86 CPUs for servers. The geographic scope of these markets is worldwide. All market shares are in value.

(108) **Table 1** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising all CPUs, irrespective of the architecture, the general application (i.e., CPUs for computer devices, CPUs for non-computers) and, the different types of computer devices (e.g. servers, desktops, laptops etc.).

Table 1: Shares and sales values in worldwide market for all CPUs (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[40-50]%	[40-50]%	[40-50]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[0-5]%**	**[0-5]%**	**[…]**	**[…]**	**[…]**
Others	[50-60]%	[50-60]%	[50-60]%	[…]	[…]	[…]
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Sources: IDC, Mercury and Parties' estimates[176]

(109) In a possible worldwide market comprising all CPUs in 2020, AMD holds a market share of [0-5]% (sales: USD […] million), Intel holds a market share of [40-50]% (sales: USD […] million), while other competitors hold [50-60]% (sales: USD […] million) together.

(110) **Table 2** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising all x86 CPUs, irrespective of the general application and the type of computer device.

Table 2: Shares and sales values in worldwide market for all x86 CPUs (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[90-100]%	[90-100]%	[90-100]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[5-10]%**	**[5-10]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: IDC, Mercury and Parties' estimates

(111) In a possible worldwide market comprising all x86 CPUs in 2020, AMD holds a market share of [5-10]% (sales: USD […] million) and Intel holds a market share of [90-100]% (sales: USD […] million).

(112) **Table 3** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising CPUs for non-computers, irrespective of the architecture.

176 AMD notes that the market size for the embedded segment available from IDC may include [AMD's competitor] revenues in embedded applications related exclusively to self-supply, however to the best of AMD's knowledge these revenues are negligible and do not materially affect the overall market size.

Table 3: Shares and sales values in worldwide market for CPUs for non-computers (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[10-20]%	[10-20]%	[10-20]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[0-5]%**	**[0-5]%**	**[…]**	**[…]**	**[…]**
Non-x86 suppliers	[80-90]%	[80-90]%	[80-90]%	[…]	[…]	[…]
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: IDC and Parties' estimates

(113) In a possible worldwide market comprising CPUs for non-computers in 2020, AMD holds a market share of [0-5]% (sales: USD […] million), Intel holds a market share of [10-20]% (sales: USD […] million), while other competitors, who are all suppliers of non-x86 CPUs, hold [80-90]% altogether (sales: USD […] million).

(114) **Table 4** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising x86 CPUs for non-computers.

Table 4: Shares and sales values in worldwide market for x86 CPUs for non-computers (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[90-100]%	[90-100]%	[90-100]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[0-5]%**	**[0-5]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: IDC and Parties' estimates

(115) In a possible worldwide market comprising x86 CPUs for non-computers in 2020, AMD holds a market share of [0-5]% (sales: USD […] million) and Intel holds a market share of [90-100]% (sales: USD […] million).

(116) **Table 5** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising CPUs for computer devices, irrespective of the architecture and the type of computer device (e.g. servers, desktops, laptops etc.).

Table 5: Shares and sales values in worldwide market for CPUs for computer devices (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[70-80]%	[70-80]%	[70-80]%	[…]	[…]	[…]
Qualcomm	[10-20]%	[10-20]%	[10-20]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[5-10]%**	**[5-10]%**	**[…]**	**[…]**	**[…]**
MediaTek	[0-5]%	[0-5]%	[5-10]%	[…]	[…]	[…]
HiSilicon	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Unisoc	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Marvell	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Ampere	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
AllWinner	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Rockchip	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Phytium	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Ingenic Semiconductor	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Nvidia	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Others	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Total	**100.0%**	**100.0%**	**100%**	**[…]**	**[…]**	**[…]**

Source: IDC, Mercury and Parties' estimates

(117) In a possible worldwide market comprising CPUs for computer devices in 2020, AMD holds a market share of [5-10]% (sales: USD […] million), Intel holds a market share of [70-80]% (sales: USD […] million), Qualcomm holds [10-20]% (sales: USD […] million), MediaTek holds [5-10]% (sales: USD […] million), while other competitors hold [5-10]% altogether (sales: USD […] million).

(118) **Table 6** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising x86 CPUs for computer devices, irrespective of the type of computer device (e.g. servers, desktops, laptops etc.).

Table 6: Shares and sales values in worldwide market for x86 CPUs for computer devices (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[90-100]%	[90-100]%	[80-90]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[5-10]%**	**[10-20]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: IDC, Mercury and Parties' estimates

(119) In a possible worldwide market comprising x86 CPUs for computer devices in 2020, AMD holds a market share of [10-20]% (sales: USD […] million) and Intel holds a market share of [80-90]% (sales: USD […] million).

(120) **Table 7** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising all CPUs for servers, irrespective of the architecture.

Table 7: Shares and sales values in worldwide market for CPUs for servers (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[90-100]%	[90-100]%	[90-100]%	[...]	[…]	[…]
AMD	**[0-5]%**	**[0-5]%**	**[5-10]%**	**[...]**	**[…]**	**[…]**
Marvell	[0-5]%	[0-5]%	[0-5]%	[...]	[…]	[…]
Ampere	[0-5]%	[0-5]%	[0-5]%	[...]	[…]	[…]
HiSilicon	[0-5]%	[0-5]%	[0-5]%	[...]	[…]	[…]
Phytium	[0-5]%	[0-5]%	[0-5]%	[...]	[…]	[…]
Others	[0-5]%	[0-5]%	[0-5]%	[...]	[…]	[…]
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: IDC, Mercury and Parties' estimates

(121) In a possible worldwide market comprising CPUs for servers in 2020, AMD holds a market share of [5-10]% (sales: USD […] million), Intel holds a market share of [90-100]% (sales: USD […] million), while other competitors hold less than [0-5]% each and [0-5]% together (sales: USD […] million).

(122) **Table 8** indicates the market shares and sales values of AMD and its competitors in a possible worldwide market comprising x86 CPUs for servers.

Table 8: Shares and sales values in worldwide market for x86 CPUs for servers (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Intel	[90-100]%	[90-100]%	[90-100]%	[…]	[…]	[…]
AMD	**[0-5]%**	**[0-5]%**	**[5-10]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: Mercury and Parties' estimates

(123) In a possible worldwide market comprising x86 CPUs for servers in 2020, AMD holds a market share of [5-10]% (sales: USD […] million) and Intel holds a market share of [90-100]% (sales: USD […] million).

(124) The market shares indicated in the tables above exclude CPU suppliers that only self-supply CPUs.[177] However, the Parties' market shares in all of the possible market segments for CPUs considered above would not change materially if such competitors are included in the market shares calculation.

5.3.2. Discrete GPUs

(125) The following tables set out the market shares of the Parties and their competitors in hypothetical worldwide markets for (i) all discrete GPUs, and the worldwide markets for (ii) discrete GPUs for datacentres and (iii) discrete GPUs for gaming. All market shares are in value.

(126) **Table 9** indicates the market shares and sales values of AMD and its competitors in hypothetical worldwide market comprising all discrete GPUs.

Table 9: Shares and sales values in worldwide market for all discrete GPUs (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Nvidia	[80-90]%	[80-90]%	[90-100]%	[…]	[…]	[…]
AMD	**[10-20]%**	**[10-20]%**	**[5-10]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: Mercury and Parties' estimates

177 These "self-suppliers" are in particular Apple, Samsung, Fujitsu, IBM, AWS and Oracle.

(127) In the hypothetical worldwide market comprising all discrete GPUs in 2020, AMD holds a market share of [5-10]% (sales: USD […] million), Nvidia holds a market share of [90-100]% (sales: USD […] million).

(128) **Table 10** indicates the market shares and sales values of AMD and its competitors in the worldwide market for discrete GPUs for data centres.

Table 10: Shares and sales values in worldwide market for discrete GPUs for data centres (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Nvidia	[90-100]%	[90-100]%	[90-100]%	[…]	[…]	[…]
AMD	**[5-10]%**	**[5-10]%**	**[0-5]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: Mercury and Parties' estimates

(129) In the market for discrete GPUs for data centres in 2020, AMD holds a market share of [0-5]% (sales: USD […] million) and Nvidia holds a market share of [90-100]% (sales: USD […] million).

(130) **Table 11** indicates the market shares and sales values of AMD and its competitors in the worldwide market for discrete GPUs for gaming.

Table 11: Shares and sales values in worldwide market for discrete GPUs for gaming (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Nvidia	[80-90]%	[80-90]%	[80-90]%	[…]	[…]	[…]
AMD	**[10-20]%**	**[10-20]%**	**[10-20]%**	**[…]**	**[…]**	**[…]**
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: Mercury and Parties' estimates

(131) In the worldwide market for discrete GPUs for gaming in 2020, AMD holds a market share of [10-20]% (sales: USD […] million) and Nvidia holds a market share of [80-90]% (sales: USD […] million).

5.3.3. FPGAs

(132) The following tables set out the market shares of the Parties and their competitors in the plausible worldwide markets for (i) all FPGAs and (ii) FPGAs in data centres. All market shares are in value.

(133) **Table 12** indicates the market shares and sales values of Xilinx and its competitors in a worldwide market comprising all FPGAs.

Table 12: Shares and sales values in worldwide market for all FPGAs (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Xilinx	**[50-60]%**	**[50-60]%**	**[50-60]%**	**[…]**	**[…]**	**[…]**
Intel	[30-40]%	[30-40]%	[30-40]%	[…]	[…]	[…]
MicroChip Technology / Microsemi	[5-10]%	[5-10]%	[5-10]%	[…]	[…]	[…]

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Lattice Semi-conductor	[5-10]%	[5-10]%	[5-10]%	[…]	[…]	[…]
Achronix	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Others	[0-5]%	[0-5]%	[0-5]%	[…]	[…]	[…]
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: Garner, OMDIA and Parties' estimates

(134) In a possible worldwide market comprising all FPGAs in 2020, Xilinx holds a market share of [50-60]% (sales: USD […] million), Intel holds a market share of [30-40]% (sales: USD […] million), MicroChip Technology / Microsemi holds [5-10]% (sales: USD […] million), Lattice Semiconductor holds [5-10]% (sales: USD […] million), Achronix holds [0-5]% (sales: USD […] million) and other competitors hold [0-5]% altogether (sales: USD […] million).

(135) **Table 13** indicates the market shares and sales values of Xilinx and its competitors in a possible worldwide market comprising FPGAs for data centres.

Table 13: Shares and sales values in worldwide market for FPGAs for data centres (2018 – 2020)

Supplier	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Xilinx	**[30-40]%**	**[40-50]%**	**[50-60]%**	**[…]**	**[…]**	**[…]**
Intel	[60-70]%	[50-60]%	[40-50]%	[…]	[…]	[…]
Total	**100.0%**	**100.0%**	**100.0%**	**[…]**	**[…]**	**[…]**

Source: Parties' estimates

(136) In a possible worldwide market comprising FPGAs for datacentres in 2020, Xilinx holds a market share of [50-60]% (sales: USD […] million) and Intel holds a market share of [40-50]% (sales: USD […] million).

(137) Furthermore, **Table 14** addresses Xilinx's activities in FPGAs for non-computers (embedded applications), providing a breakdown of Xilinx's market shares in possible separate worldwide markets for FPGAs sold in each of the relevant industry sectors where both FPGAs and CPUs are used, i.e. aerospace & defense, automotive, industrial controls, medical imaging, security, wired & wireless. All market shares are in value.

Table 14: Xilinx's shares and sales values in worldwide markets for FPGAs in industry sectors where both FPGAs and CPUs are used (2018 – 2020)

Industry Sector	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Aerospace & Defence	[50-60]%	[50-60]%	[60-70]%	[…]	[…]	[…]
Automotive	[60-70]%	[60-70]%	[60-70]%	[…]	[…]	[…]
Industrial Controls	[30-40]%	[30-40]%	[30-40]%	[…]	[…]	[…]
Medical Imaging	[60-70]%	[50-60]%	[50-60]%	[…]	[…]	[…]

Industry Sector	Market shares			Sales (million USD)		
	2018	2019	2020	2018	2019	2020
Security[178]	n/a	n/a	n/a	n/a	n/a	n/a
Wired & Wireless	[40-50]%	[50-60]%	[40-50]%	[…]	[…]	[…]
Overall market share in the above sectors	[40-50]%	[50-60]%	[40-50]%	[…]	[…]	[…]

Source: Parties' estimates

(138) For 2020, in a potential worldwide market for FPGAs for the Aerospace & Defence sector, Xilinx would hold a market share of [60-70]% (sales: USD […] million). In the potential worldwide markets for FPGAs for the Automotive and the Medical Imaging sectors, Xilinx would hold a market share of [60-70]% and [50-60]% respectively (sales: USD […] million and USD […] million). In the potential worldwide markets for FPGAs for the Wired & Wireless and the Industrial Controls sectors, Xilinx would hold a market share of [40-50]% and [30-40]% respectively (sales: USD […] million and USD […] million). Finally, Xilinx's aggregate market share across the abovementioned sectors is [40-50]% (sales: USD […] million).

(139) In the industry segments referred to in **Table 14**, AMD has very limited presence. More specifically, in potential worldwide markets for CPUs in each of the industry segments at hand, AMD's market shares range from [0-5]% in the Automotive sector to a maximum of [0-5]% in the Industrial Controls and the Wired & Wireless sectors (2020).

(140) **Table 15** indicates an estimate of Xilinx's market shares in the market for FPGAs of different performance levels. All market shares are in value.

Table 15: Xilinx's shares in worldwide markets for FPGAs of different performance levels (2020).

Performance level	Xilinx's market share
High-end FPGAs	[50-60]% - [60-70]%
Mid-range FPGAs	[40-50]% - [50-60]%
Low-end FPGAs	[40-50]% - [50-60]%

Source: Parties' estimates

(141) The Notifying Party submits that there are no third-party reports that provide breakdowns of supplier sales and segment sizes by FPGA performance level. However, the Parties estimate that Xilinx's market shares in the potential markets for low-end and mid-range FPGAs are not materially different from its shares in the market for all FPGAs ([40-50]% – [50-60]%). Xilinx believes that its share of a theoretical high-end FPGA segment may be slightly higher, i.e., in the [50-60] – [60-70]% range.[179]

(142) Finally, the Notifying Party could not produce market shares for FPGA accelerator cards. Although given the relatively large number of suppliers in this segment[180] it is

178 Xilinx does not have reliable data for the security segment as it tracks it within the wider Wired & Wireless / Communications segment and does not believe that the market shares of both segments differ materially.

179 Form CO, paragraphs 436 – 437.

180 Notifying Party's response to the Commission's RFI 6.

unlikely that Xilinx's share would be above 30%, absent reliable information, for the purposes of the competitive assessment, the Commission is going to assume that Xilinx's share is above 30%.

5.4. Identification of affected markets

(143) As explained in Section 5.1, FPGAs or FPGA accelerator cards on the one hand, and CPUs on the other hand are sometimes used together or bought by the same customers. Namely, FPGAs can be interconnected with CPUs in data centre servers. For example, FPGAs are deployed to accelerate certain computing workloads that otherwise would be performed by the CPU.[181] Likewise, FPGAs are also used for board management in data centre servers.[182] In addition, FPGA-based Smart NICs are used to offload networking tasks from CPUs.[183] In non-computers, FPGAs and CPUs can be used together by customers in the following industrial sectors in which Xilinx is active: Aerospace & Defense, Automotive, Industrial Controls, Medical Imaging, Security and Wireless & Wired Communications.[184] Consequently, there is a conglomerate relationship between FPGAs and FPGA accelerator cards on the one hand and CPUs on the other hand.

(144) As AMD's market share stays well below 30% no matter how the CPU market is defined, using CPUs as a leveraging product is unlikely and thus its CPU market position does not give rise to an affected market.

(145) By contrast, Xilinx's market share is above 30% under all plausible market definitions for FPGAs. Having a significant market share in FPGAs (or any plausible narrower market discussed in Section 4.2.4), the merged entity could potentially leverage its market position in FPGAs to CPUs. Thus the affected market in this regard is the market for all CPUs or any of the plausible market definitions pursuant to the distinctions discussed in Section 4.2.2, with the exception of the potential markets for CPUs in the following devices: smartphones, tablets, laptops and desktops regardless of architecture. As FPGAs are virtually never used in these devices,[185] these potential markets would not be affected by any exclusionary practice.[186]

(146) If FPGA accelerator cards constituted a separate market, then the merged entity could use both i) FPGAs exluding accelerator cards and ii) FPGA accelerator cards as leverage. The first case would be almost identical to the one in which FPGAs including FPGA accelerator cards (discussed in paragraph (145) above) are used as leverage and would give rise to the same affected markets. This is because FPGA

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181 Form CO, paragraph 11.

182 Responses to Q1 – Questionnaire to competitors and trade associations, question 38.

183 Form CO, paragraph 234, Responses to Q1 – Questionnaire to competitors and trade associations, question 46. This is an example of joint use of FPGAs and CPUs under the assumption that FPGA accelerator cards belong to the same market as FPGAs.

184 Notifying Party's Response to the Commission's RFI 2, question 7.

185 Notifying Party's Response to the Commission's RFI 3, question 15.

186 In concrete, the affected markets are i) the market for CPUs for computer devices; ii) the market for CPUs for non-computers; iii) the market for x86 CPUs; iv) the market for non-x86 CPUs; within CPUs for computers the v) the market for CPUs for servers. Further any plausible combinations of markets i)-v) could also be affected.

accelerator cards are a small market,[187] and thus the list of plausible FPGA markets and the links between any potential FPGA market to any potential CPU market would remain the same even after their exclusion. In the second case, as discussed in Section 5.3, the merged entity may have market shares in excess of 30% in the market for FPGA accelerator cards. Thus the merged entity could potentially use FPGA accelerator cards to leverage its market position to certain plausible CPU markets. These include the market for all CPUs or any of the considered market definitions that include server CPUs because FPGA accelerator cards are only used in servers. That is to say, the affected CPU markets exclude the market for CPUs for non-computers regardless of architecture and the potential markets for CPUs in the following devices: smartphones, tablets, laptops and desktops also regardless of architecture.

(147) Moreover, in some cases, FPGAs and discrete GPUs are also used by the same customers in the same environment. For example, in data centres an FPGA accelerator card (concretely an FPGA-based Smart NIC) can interconnect several GPUs used for workload acceleration. More broadly, FPGAs can provide networking and board management functions in servers containing GPUs,[188] but they may be used together also outside servers, e.g. in some automotive platforms.[189] In rare occasions, both chips can be used for workload acceleration.[190] Functionally they may be used together for applications involving image processing and video recognition.[191] In addition, GPUs and FPGAs are used together in certain systems in the defence sector.[192]

(148) Just like in the case of CPUs, AMD's market share stays well below 30% in both the market for discrete GPUs for data centres and the market for discrete GPUs for gaming and other professional visualisation. Thus, using GPUs as a leveraging product is very unlikely and AMD's market position in GPUs does not give rise to an affected market.

(149) However, as Xilinx has a market share above 30% under all plausible FPGA market definitions, the merged entity could plausibly leverage that position to discrete GPUs. Thus, the affected market is the market for discrete GPUs for data centres. The Commission notes that FPGAs are not used in gaming[193] and thus the use of FPGAs together with discrete GPUs for gaming and professional visualisation is restricted to uses outside gaming, which is, at best, marginal. Therefore, the market for discrete GPUs for gaming and other professional visualisation would be potentially affected by any exclusionary practices only to the marginal extent that common usage concerns applications other than gaming. If FPGA accelerator cards constituted a separate market, then it cannot be excluded that the merged entity may have market shares in excess of 30% in this market too. The merged entity could

187 Notifying Party's response to the Commission's RFI 6. Xilinx's total sales amount to USD […] million. Thus, assmuning Xilinx's share is around [30-40]%, the market size is maximum USD [200-300] million compared to a market size of USD [5 500-6 000] million in the case of all FPGAs.

188 Responses to Q1 – Questionnaire to competitors and trade associations, question 46.

189 Responses to Q1 – Questionnaire to competitors and trade associations, question 46.

190 Responses to Q1 – Questionnaire to competitors and trade associations, question 46.

191 Responses to Q2 – Questionnaire to customers, question 36.

192 Responses to Q2 – Questionnaire to customers, question 36.

193 Responses to Q1 – Questionnaire to competitors and trade associations, question 17; Q2 – Questionnaire to customers, question 12.

potentially use these products to leverage its market position to the market for GPUs used in data centres. As FPGA accelerator cards are only used in servers, the market for GPUs for gaming and visualisation would not be affected in this scenario.

(150) In summary, the Transaction gives rise to the following affected markets

— Under the assumption that FPGA accelerator cards are not a separate market, the leveraging product is FPGAs and the affected markets are:

i) the market for all CPUs or any of the market definitions considered in Section 4.2.2, with the exception of the potential markets for CPUs in the following devices: smartphones, tablets, laptops and desktops regardless of architecture;

ii) The market for GPUs for data centres and the market for GPUs for gaming and professional visualisation.

— Under the assumption that FPGA accelerator cards form a separate market, one of the leveraging product is FPGAs excluding FPGA accelerator cards, which would give rise to the same affected markets as those indicated in the first indent.

— Also under the assumption that FPGA accelerator cards form a separate market, FPGA accelerator cards would also be a leveraging product, giving rise to the following affected markets:

i) The market for all CPUs or any of the considered market definitions that include server CPUs regardless of architecture;

ii) The market for GPUs for data centres.

(151) Therefore, in the following sections, the Commission will assess the impact of the Transaction as regards the conglomerate relationships identified in paragraphs (143)-(150) above. In sections 5.5 and 5.6, the Commission will consider the potential foreclosure of rival CPU and GPU suppliers under the assumption that the FPGA accelerator cards are not a separate market, and are thus included in the relevant plausible FPGA markets. As indicated in the Horizontal Merger Guidelines, the Commission will analyse the merged entity's ability and incentive to forcelose rival CPU and GPU suppliers as well as the overall effects of such possible foreclosure strategy. In Section 5.7 the Commission will explain how the assessment in Section 5.5 and 5.6 applies under the assumption that FPGA accelerator cards form a separate market.

5.5. Foreclosure of CPU suppliers

5.5.1. Ability to foreclose CPU suppliers

5.5.1.1. The Notifying Party's view

(152) The Notifying Party submits that the merged entity will have no ability to leverage its position in the market for FPGAs and to foreclose CPU suppliers, both in the data centre space and in the industrial space, under any scenario of contractual tying/bundling, technical tying and mixed bundling. This is because: (i) Xilinx lacks

a significant degree of market power in FPGAs; and (ii) there are not enough opportunities to bundle or tie CPUs ad FPGAs.

(153) First, the Notifying Party considers that Xilinx's worldwide market shares in the market for FPGAs, which do not change materially under the different possible definitions for the affected markets ([50-60]% in all FPGAs, [50-60]%, in FPGAs for data centres and an aggregate [40-50]% in the industrial sectors referred to in Table 14 do not confer market power to Xilinx.[194] The Notifying Party considers that Xilinx faces strong competition from Intel, which offers comparable FPGA products.[195]

(154) The Notifying Party also consider that such conclusion is not preempted by the fact that Xilinx has high market shares in FPGAs sold in certain industry sectors (e.g. Aerospace & Defence: [60-70]%, Automotive: [60-70]%). According to the Notifying Party, the industry sectors referred to in Table 14 do not constitute separate relevant markets. FPGAs are indeed widely interchangeable across such sectors, [information on FPGA prices]. In any case, the Notifying Party also points out that there is strong competition in each of the industrial sectors at hand. The Notifying Party points to the high fluctuation of Xilinx's market shares in the past years, showing that the market is contestable and that orders are lumpy, with large, infrequent orders that tend to understate or overstate Xilinx's share at a particular point in time. Therefore, there is no ground for concluding that Xilinx's higher or lower share across the relevant industry sectors indicates a higher or lower degree of market power compared to Xilinx's position in the overall FPGA market.[196]

(155) Furthermore, as regards the CPU side, Intel's market shares are overwhelmingly larger than AMD's, up to [90-100]% in the market for server CPU (**Table 7**: Shares and sales values in worldwide market for CPUs for servers (2018 – 2020) and **Table 8**: Shares and sales values in worldwide market for x86 CPUs for servers (2018 – 2020), [90-100]% for x86 CPUs, while AMD's market shares are very limited (below or even well below 10% in all possible market segments for CPUs). In the industrial space, moreover, AMD has a market share of less than [0-5]%. Therefore, the merged entity faces the presence of a comparable competitor in the market for FPGAs in data centres, as well as a much larger competitor, thus very difficult to foreclose, in the respective CPU market.

(156) In addition, the Notifying Party explained that the merged entity will face significant buyer power of end customers, especially the so-called "hyperscalers".[197] Hyperscalers, like customers in general, have a strong preference for a "mix and match" approach, sourcing separate components for their data centres and choosing what is best for their needs regardless of the supplier. Therefore, they would resist any attempt to bundle or tie different chips. According to the Notifying Party, if the merged entity tried to implement such strategies, they would lose market share in

194 Form CO, paragraphs 23, 123, 511 – 512.

195 Form CO, paragraphs 23, 511.

196 Form CO. Paragraphs 612 – 615.

197 Hyperscalers are data centre facilities built, owned and operated by the companies they support. The term applies to the largest data centres only, operated by companies such as Amazon Web Services, Apple, Facebook, Google etc.

favour of Intel or other competitors.[198] Therefore, for the reasons set out above, the Notifying Party considers that Xilinx does not have a significant degree of market power.

(157) Second, the Notifying Party considers that the size of the FPGA market is considerably smaller compared to the size of the CPU market, with common FPGA and CPU customers being just a fraction of the overall CPU customers. More specifically, as regards data centres, the Notifying Party considers that the FPGA market is worth USD […] million annually, whereas the CPU market is worth USD […] billion (2020).[199] In general, the Notifying Party estimates that in 2019 less than 15% of worldwide server expenditure was on servers that use acceleration technology, whether GPUs, FPGAs or other accelerator types. Moreover, even within single data centres that use accelerators, the percentage of accelerated servers is extremely small, at most 5-10% of the total number of servers in the data centre.[200] Likewise, in the industrial space, the Notifying Party submits that CPUs used together with an FPGA represent less than 10% of the overall potential market for CPUs for non-computer devices (i.e. used in industrial applications).[201] In addition, the Notifying Party indicates that also a minority of FPGAs, i.e. approximately [20-30]% is used together with a CPU by industrial customers.[202]

(158) Against this background, the Notifying Party considers that the merged entity would not have the ability to successfully foreclose CPU suppliers by means of contractual tying/bundling, technical tying or mixed bundling.

(159) More specifically, as regards contractual tying or bundling, the Notifying Party considers, first, that customers would be able to obtain FPGAs from Intel to be paired with other suppliers' CPUs. In any case, Intel would also be able to replicate any bundling strategy that the merged entity might attempt. Moreover, the Notifying Party notes that Intel has never imposed contractual tying with its CPUs and FPGAs, which shows that such strategy is not feasible.[203] Second, the Notifying Party considers that Xilinx's FPGAs are not must-have products for data centre and industrial customers. The choice of an FPGA usually follows the one of a CPU, especially in data centres, and it is very unlikely that the choice of an FPGA would determine purchase decisions for CPUs, especially if such FPGAs are not clearly superior to the ones offered by competitors.[204] Third, the merged entity would not be able to decrease rival CPU's market share, since the majority of CPUs are not used together with an FPGA. Therefore, CPU suppliers would retain significant opportunities to sell CPUs to customers that do not use them with FPGAs.

(160) As regards technical tying, the Notifying Party submits that the merged entity would have to degrade the interoperability of Xilinx's FPGAs with third-party CPUs, such

198 Form CO, paragraphs 88, 513, 519 – 520.

199 Form CO, paragraph 509.

200 Form CO, paragraph 233.

201 Form CO, paragraph 625 and 182. The Parties consider that this figure is a conservative estimate. In AMD's view, the true attach rate could be as low as 1% or 0.1%, as it is based on AMD's general industry knowledge, and reflects the likely proportion of customers in the industrial space that currently require both an x86 CPU and an FPGA. In AMD's view, the true attach rate could be as low as 1% or 0.1%.

202 Form CO, paragraphs 180 – 181.

203 Form CO, paragraph 524.

204 Form CO, paragraph 525.

that AMD's CPUs would secure better performance when paired with Xilinx's FPGAs. In the Notifying Party's view, such technical tying is implausible.[205] First, Xilinx's FPGAs currently interconnect with CPUs from all suppliers using the PCIe open standard protocol, and, in the future, its successor CXL. The Notifying Party notes that today, the PCIe is built into every server and, in general, is the *de facto* standard to interconnect CPUs and accelerators. Open standards have become a requirement for customers across the relevant industries, especially in data centres. Therefore, if the merged entity degraded Xilinx's FPGAs interoperability with third-party CPU, it would cut itself out of the market. Second, the merged entity, like every other company, would not be able to alter the PCIe protocol, as it is developed by an independent industry organization. Third, AMD, unlike Intel,[206] does not have any proprietary interconnect technology, […]. On the contrary, AMD, like Xilinx, relies on the PCIe standard.[207]

(161) As regards mixed bundling, the Notifying Party submits that the merged entity would not be able to leverage its position in FPGAs to incentivize customers to buy FPGAs and CPUs in a bundle, thereby foreclosing rival CPU suppliers. First, according to the Notifying Party, the merged entity lacks the market power to do so for the reasons explained in paragraphs (152)to (154). Second, Intel could match and undercut any FPGA/CPU bundle offered by the merged entity being able to afford a more aggressive pricing strategy for a longer period. Third, as mentioned above, the opportunities to bundle FPGAs and CPUs are limited, as the majority of CPUs are sold to use without an FPGA.[208]

(162) In sum, for the reasons set out above, according to the Notifying Party the merged entity would lack the ability to foreclose rival CPU suppliers by means of commercial tying or bundling, technical tying and mixed bundling. The Notifying Party submits that the merged entity would lack a significant degree of market power in the FPGA market and that there would not be enough opportunities to bundle FPGAs and CPUs due to the very small size of the FPGA market relative to the CPU market.

5.5.1.2. The results of the market investigation and the Commission's assessment

(163) As mentioned in Section 5.4, the Commission will assess the ability of the merged entity to leverage Xilinx's position in the market for FPGAs in order to foreclose rival CPU suppliers. The Commission will carry out such assessment under all possible market definitions for CPUs and FPGAs set out in sections 4.2.2 and 4.2.4 respectively, considering all possible exclusionary practices i.e. contractual tying, pure bundling, mixed bundling and technical tying. As a preliminary remark the Commission considers that the ability to foreclose means the ability to decrease substantially the sales of rivals in the leveraged market through bundling and tying. In the concrete case, this means that the merged entity, using Xilinx's FPGAs as the

205 Form CO, paragraph 527.

206 Intel has developed proprietary interconnect technologies, i.e. the QuickPath Interconnect, the Keizer Technology Interconnect and the UltraPath Interconnect. In Intel/Altera, the Commission concluded that Intel would not have the ability to pursue a foreclosure strategy despite its use of proprietary technologies. This is because, *inter alia,* rival FPGA suppliers could continue to interconnect to Intel's CPUs using the PCIe, that Intel did not have the ability to degrade.

207 Form CO, paragraphs 527 – 535.

208 Form CO, paragraphs 526 – 540 and 624 – 627.

leveraging (tying) product, would have the ability to decrease substantially the sales of its CPU rivals.

(A) Contractual tying and pure bundling

(164) The Commission considers that the merged entity will not have the ability to foreclose rival CPU suppliers by means of contractual tying or pure bundling between Xilinx's FPGAs and AMD's CPUs.

(165) First, under any of the possible market definitions for FPGAs and CPUs, the common pool of customers (i.e. sourcing both FPGAs and CPUs) is relatively small compared to the overall number of CPU customers. Therefore, in line with the Parties' arguments, the merged entity would not be able to influence a significant part of the demand for CPUs by leveraging on Xilinx's position in the market for FPGAs. In line with paragraph 100 of the Non-Horizontal Merger Guidelines, foreclosure constitutes a potential concern only if there is a large common pool of customers for the products concerned, so that demand for the individual products may be affected through bundling or tying.

(166) In this regard, the majority of respondents submitted that FPGAs and CPUs are not commonly used in the same application or device. Concretely respondents indicated that FPGAs are "*sometimes*" used with CPUs in the same application or device.[209] Respondents also pointed out that while most FPGAs are used with a CPU, the reverse is not true, i.e. most CPUs are used without an FPGA. For instance, a customer submitted that "*in data centre applications, CPUs are present in nearly every data centre solution while FPGAs are present in only a small subset of those."*[210] Likewise, a competitor stated that "*FPGAs are occasionally used alongside CPUs as workload accelerators or in smart network interface cards."*[211]

(167) In the same vein, the number of CPUs used together with FPGAs accounts for a small proportion of all CPUs. In this regard, a large majority of customers and competitors indicated that most CPUs are used without an FPGA.[212] For example, a customer specified that *"[the] FPGA market is much smaller than [the] CPU market"*.[213] Several respondents added that this is particularly true in data centres.[214] For instance, a customer indicated that CPUs are present in nearly all data centre solutions, while FPGAs are present only in a small subset of those, whereas another customer pointed out that "*the proportion of servers that deploy an FPGA is very small*".[215]

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209 Responses to Q1 – Questionnaire to competitors and trade associations, question 38; Q2 – Questionnaire to customers, question 28.

210 One customer's response to Q2 – Questionnaire to customers, question 28.1.

211 One competitor's response to Q1 – Questionnaire to competitors and trade associations, question 38.1.

212 Responses to Q1 – Questionnaire to competitors and trade associations, question 39; Q2 – Questionnaire to customers, question 29.

213 One customer's response to Q2 – Questionnaire to customers, question 29.1.

214 Responses to Q1 – Questionnaire to competitors and trade associations, questions 39/40; Q2 – Questionnaire to customers, questions 29/30.

215 Two customer's responses to Q2 – Questionnaire for customers, question 29.1 and 30 respectively.

(168) In line with the above, a large majority of respondents also indicated that only some CPU customers buy FPGAs.[216] As noted by a competitor "*Most CPU customers do not buy FPGAs. Consequently, most opportunities to sell CPUs are to customers that do not buy FPGAs.*"[217] Moreover, almost the entirety of customers and competitors that provided a qualitative answer on this point indicated that there are significant business opportunities for CPU suppliers to sell CPUs to customers who do not buy FPGAs.[218]

(169) This is consistent with the fact that, as showed by the market share tables in Section 5.3, the size of the CPU market is considerably bigger than the size of the FPGA market, regardless of the possible segmentations considered. Concretely, if all CPUs and all FPGAs belong to one market without any distinctions the CPU market is 25 times larger than the FPGA market (USD […] million vs USD […] million). Even the smallest potential CPU market (x86 CPUs for non-computers) is roughly double the size of the largest possible FPGA market, i.e. the market for FPGAs without further subdivisions (USD […] million vs USD […] million).

(170) Given the low rate of common usage and the small pool of common customers, any bundling or tying strategy by the merged entity would leave a large portion of the CPU market unaffected (under any of the considered market definitions) in accordance with the reasoning set out in paragraph 100 of the Non-Horizontal Merger Guidelines. If significant opportunities remain to sell CPUs on a standalone basis, CPU suppliers' sales will not be decreased in a meaningful way even if the merged entity could force a bundle on those customers that do buy both chips. In other words, the merged entity will not have the ability to foreclose CPU suppliers. This applies both under a pure bundling scenario, i.e. in case the merged entity stopped selling both CPUs and FPGAs on an individual basis, and under a commercial tying scenario, i.e. if the merged entity sold FPGAs exclusively tied to CPUs, but not vice-versa.

(171) Second, in addition to the general consideration that plenty of opportunities will remain for CPU suppliers to sell CPUs on a standalone basis, it appears appropriate to distinguish between two broad hypotheses for the size of the FPGA and CPU markets as this analysis further highlights the lack of foreclosure risks.

(172) Under a **broad FPGA market definition** (a relevant market comprising all FPGAs or separate relevant markets based only on performance), the Commission considers that the merged entity would not have a significant degree of market power to foreclose CPU suppliers. If all FPGAs constituted one market, Intel, with a market share of [30-40]%, as well as smaller FPGA suppliers (Lattice, MicroChip and Achronix) with a combined market share of [10-20]% would represent a competitive constraint on the merged entity in relation to FPGAs. If separate markets were distinguished based on performance, Intel and Achronix would be constraints in the high-end FPGA market, all the suppliers mentioned would be constraints in the mid-range FPGA market and Intel, MicroChip and Lattice would be constraints in the

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216 Responses to Q1 – Questionnaire to competitors and trade associations, question 42; Q2 – Questionnaire to customers, question 32.

217 Intel's response to Q1 – Questionnaire to competitors and trade associations, question 45.

218 Responses to Q1 – Questionnaire to competitors and trade associations, question 45; Q2 – Questionnaire to customers, question 35.

low range FPGA market.[219] In the presence of competitors constraining the merged entity, bundling and tying FPGAs and CPUs could lead to foreclosure only if Xilinx's FPGAs were regarded as vastly superior compared to competitors' FPGAs, especially those of Intel. However, the results of the market investigation indicated that customers do not consider Xilinx's FPGAs as clearly superior.[220] At most, they are considered superior in some narrow segments but this is irrelevant in the scenario considered (large or very broad FPGA market). Further, respondents to the market investigation indicated that Intel constitutes an alternative across the entire FPGA product range. For instance, a customer submitted that "*Xilinx and Altera* [i.e. Intel] *have similar products with similar tool support, and often compete for a given application".*[221] Therefore, it is not the case that Xilinx's FPGAs has a significant competitive edge under a hypothesis of broad FPGA markets.

(173) Another factor that would potentially make the merged entity an unavoidable trading partner and weaken the constraints exercised by competitors is if rivals faced capacity constraints and the merged entity would not. In this context, the Commission notes that all FPGA suppliers except Intel follow the fabless model, i.e. they do not have manufacturing assets and outsource manufacturing. Further, currently there is a semiconductor shortage due to capacity constraints at the manufacturing level.[222] These constraints effect all fabless suppliers, so it is not the case that the merged entity's competitors are more capacity constrained than the merged entity. Further, to the extent that there is a difference in capacity constraints between FPGA competitors, respondents considered that Intel, the only supplier with its own manufacturing capacity, is likely to manage these constraints better than its rivals as having own manufacturing assets gives it more flexibility.[223] Thus, if anything, the merged entity will be more capacity constrained than its main FPGA rival.

(174) In line with paragraph 99 of the Non-Horizontal Merger Guidelines, if the merged entity's leveraging product is not particularly important (not a must-have) and if rivals are not more capacity constrained than the merged entity, then the merged entity lacks the market power to engage in successful tying and bundling. In these circumstances, if customers do not want a CPU along with the FPGA, they can simply source FPGAs from the merged entity's FPGA competitors.

(175) Furthermore, Intel, the merged entity's main CPU competitor, cannot be foreclosed by means of bundling and tying, as it has its own FPGAs comparable to Xilinx's and thus could easily replicate a CPU-FPGA bundle. Intel also enjoys a much stronger market position than AMD under all possible market definitions for CPUs, which makes its foreclosure even more implausible. Therefore, a bundling or tying strategy could only foreclose smaller CPU-only competitors. However, even this prospect is implausible for several reasons.

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219 See one competitor's response to Q1 – Questionnaire to competitors and trade associations, question 36.

220 Responses to Q2 – Questionnaire to customers, question 26.1.

221 One customer's response to Q2 – Questionnaire to customers, question 26.1.1.

222 Responses to Q1 – Questionnaire to competitors and trade associations, question 61; Q2 – Questionnaire to customers, question 50.

223 Responses to Q1 – Questionnaire to competitors and trade associations, question 62; Q2 – Questionnaire to customers, question 51.

(176) On the one hand, under certain narrow CPU market definitions considered in section 4.2.2 (e.g. x68 CPU or x86 CPUs for servers), the market consists only of AMD and Intel and thus there would be no CPU-only suppliers to foreclose.

(177) On the other hand, under a broader CPU market definition (e.g. all CPUs, all CPUs for computer devices or CPUs for non-computer devices), many CPU suppliers supply their products to customers that do not buy FPGAs. In this regard, the market investigation confirmed that most CPUs are used in devices that are not designed to accommodate an FPGA, such as PCs (laptops, desktops), tablets and smartphones.[224] In line with this, a number of computer CPU suppliers (Qualcomm, MediaTek, Samsung, Unisoc, AllWinner, Rockhip) sell CPUs exclusively to customers that do not generally buy FPGAs.[225] Thus, foreclosure of these suppliers cannot even arise.

(178) Thus any such practice could conceivably affect only some small suppliers in CPUs for computers and some suppliers of CPUs for non-computers. These firms could have some customers that also buy FPGAs. However, as regards these suppliers the considerations that lots of opportunities remain to sell CPUs on a standalone basis (paragraphs (165) to (170) and that the merged entity lacks market power to engage in exclusionary practices in the presence of competitors (paragraphs (172)-(174)) continue to apply, excluding any ability to foreclose.

(179) Under a **narrow product markets for FPGAs** (e.g. FPGAs used in a specific industrial sector or for a specific application), the Commission considers that, even if Xilinx had a significant degree of market power with high market shares in one of these narrow markets, the merged entity would not have the ability to foreclose rival CPU suppliers. This is because under this hypothesis the considerations set out above in paragraphs (165)-(170) would apply a fortiori as any plausible CPU market would be vastly larger than the narrow FPGA markets. For example, under the narrowest possible product market for CPUs, e.g. x86 server CPUs or x86 non-computer CPUs, the size of the CPU market would be USD […] million and USD […] million respectively. By contrast, if the FPGA market was segmented only by vertical industry, typical market sizes range from USD […] million to USD […] million. If the FPGA markets are further segmented within vertical industries by performance, by specific application or both, the market sizes would even be smaller. The only slight exception is the wired and wireless telecommunication market if FPGAs are only segmented by vertical industries as in that case the market for the wired and wireless telecommunication FPGAs would be USD […] million. However, even in this case the x86 CPU non-computer market would be almost six times the size of this FPGA market. These large differences in market sizes, along with the evidence presented in paragraphs (165)-(170), show that there would still be plenty of opportunities for CPU-only suppliers to sell CPUs to customers who do not buy FPGAs, or for applications that do not require an FPGA. Thus any tying and bundling by the merged entity would not be able to influence meaningfully the sales of rival CPU suppliers.

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224 Responses to Q1 – Questionnaire to competitors and trade associations, question 16; Q2 – Questionnaire to customers, question 11. See also Intel and Nvidia's response to Q1 – Questionnaire to competitors and trade associations, question 42.1. and 39.1 respectively.

225 Notifying Party's Response to the Commission's RFI 3.

(180) Third, the market investigation revealed a number of other factors, which make tying and bundling even less likely. Namely, a large majority of respondents confirmed that bundling CPUs and FPGAs is not a market practice, although in theory this would be possible since Intel has both products.[226] Even the minority who indicated that such practice happens occasionally gave qualitative responses that point to the total absence of this practice.[227] Furthermore, the overwhelming majority of customers indicated that they have a strong preference for a "mix and match" approach i.e. to buy the best product from each type of chip regardless of supplier as opposed to buying them in a bundle.[228] Thus even customers that do buy both FPGAs and CPUs prefer to mix and match and thus would be reluctant to buy a bundle.

(181) Fourth, the Intel/Altera merger,[229] which took place in 2015, was similar to the Transaction in that a CPU producer, Intel, acquired an FPGA producer, Altera. As mentioned in paragraph (180) above, despite the fact that theoretically Intel could bundle and tie CPUs and FPGAs, the market investigation clearly indicated that this practice is almost non-existent today. Further, no CPU producer has been foreclosed since that merger. On the contrary, as can be seen from **Table 2** in Section 5.3, AMD, Intel's main rival in x86 CPUs, has successfully increased its market shares at Intel's expense in the last two years and also grew its revenues and market shares more generally since 2016.[230] [forcasts on AMD's market position].[231] This example shows the lack of foreclosure risks and further corroborates the assessment that the merged entity will not have the ability to foreclose CPU rivals.

(182) In conclusion, in light of all the reasons set out in this section (Section 5.5.1.2(A)), the Commission considers that the merged entity will not have the ability to foreclose rival CPU suppliers by means of contractual tying or pure bundling practices between Xilinx's FPGAs and AMD's CPUs.

(B) Mixed bundling

(183) In a mixed bundling scenario, the merged entity would offer discounts for a joint purchase of CPUs and FPGAs. The Commission considers that the merged entity would not have the ability to foreclose rival CPU suppliers as a result of a hypothetical mixed bundling strategy between Xilinx's FPGAs and AMD's CPUs, for the same reasons as set out above in relation to pure bundling and contractual tying.

(184) First, the Commission notes that the arguments related to the lack of a sufficiently large common pool of customers set out in paragraphs (165) to (170) apply, *a*

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226 Responses to Q2 – Questionnaire to customers, question 42; Q1 – Questionnaire to competitors and trade associations, question 52.

227 Responses to Q2 – Questionnaire to customers, question 42. For example one respondent stated that it is not aware of such practice in its business and has no insight into other businesses. Another respondent referred to the integration of FPGAs and CPUs in the same chip, i.e. FPGA SoCs, which are part of the FPGA market. Thus the response is unrelated to the bundling or tying of FPGAs (including FPGA SoCs) and CPUs. The third respondent did not give a qualitative response.

228 Responses to Q2 – Questionnaire to customers, question 42.

229 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015.

230 [Internal document].

231 [Internal document].

fortiori, to a mixed bundling scenario in which the common customers would also be able to source FPGAs and CPUs individually from the supplier that they prefer.

(185) Second, the analysis in relation to pure bundling and contractual tying under the hypotheses of large and narrower FPGA markets (paragraphs (171) to (179)) also applies *mutatis mutandis*.

(186) Specifically, under the hypothesis of a broad FPGA market, the merged entity will lack market power and thus the ability to foreclose because its FPGAs are not clearly superior compared to those of competitors and competitors are not more, and probably less, capacity constrained than the merged entity. Further, Intel, AMD's main CPU rival, cannot be foreclosed because it has its own FPGAs and could replicate the discounts offered for the joint purchase of FPGAs and CPUs. The difference in this regard relative to the pure bundling and contractual tying scenario is that Intel is even less likely to be foreclosed as it could maintain any discount much longer or give greater discounts given its much larger volume of CPUs. Thus, as explained in relation to pure bundling and contractual tying, the practice can, at best, affect smaller, CPU-only suppliers but this appears implausible too. Namely if the CPU market is narrow and restricted to x86 CPUs or subsegments within x86 CPUs, there are no firms to foreclose as in those markets Intel is AMD's only competitor. If the CPU market is wide, foreclosure of certain firms cannot even arise in the absence of customers that buy FPGAs, while the remaining firms also cannot be foreclosed due to an insufficient pool of common customers.

(187) Under the hypothesis of narrow FPGA markets, Xilinx may have market power in a narrow FPGA market, but in this case the considerations set out above in paragraphs (165)-(170) on the insufficient pool of common customers would apply with even greater force as any plausible CPU market would be vastly larger than the narrow FPGA markets. Thus under this hypothesis any bundling strategy would have a negligible effect on CPU rivals' sales.

(188) Third, respondents to the market investigation indicated that, although it can happen that discounts are offered in case FPGAs and CPUs are purchased jointly by customers, such practice is not common,[232] and most customers would not choose the bundled products due to their strong preference for a mix and match approach.[233] The difference relative to pure bunding and contractual tying in this regard is that customer preference for mix and match has a much stronger effect in the case of mixed bundling because the customer is free to choose any individual product from the merged entity.

(189) Fourth, the lack of any effect or observable systematic bundling practice after the Intel/Altera merger (paragraph (181) shows that such practices are unlikely to occur following the implementation of the Transaction.

(190) Therefore, for the reasons set out above and in line with the Commission's assessment under a pure bundling scenario, the Commission concludes that the

232 Responses to Q1 – Questionnaire to competitors and trade associations, question 53; Q2 – Questionnaire to customers, question 43.

233 Responses to Q1 – Questionnaire to competitors and trade associations, questions 43.3/46; Q2 – Questionnaire to customers, questions 33.1/36.

merged entity will not have the ability to foreclose rival CPU suppliers by means of a mixed bundling strategy between Xilinx's FPGAs and AMD's CPUs.

(C) Technical tying

(191) The Commission has assessed whether the merged entity would have the ability to tie AMD's CPUs to Xilinx's FPGAs by degrading their technical compatibility with open interconnect standards, such as the PCIe, and by developing a proprietary interconnect standard between Xilinx's FPGAs and AMD's CPUs. As a result of this strategy, the merged entity's FPGAs would be incompatible with CPUs of other suppliers and would be compatible only with the merged entity's CPUs. Alternatively, the merged entity's FPGAs could still link up with other suppliers' CPUs but the PCIe connection, and thus the chips' performance, would be compromised.

(192) A softer form of technical tying is when the merged entity develops a proprietary interconnect between its own FPGAs and CPUs but fully retains the PCIe standard. That way there would be improved performance when the merged entity's CPUs and FPGAs are paired but the FPGAs would still be fully compatible with third party CPUs. The Commission notes that this form of tying amounts to a quality improvement when the merged entity's chips are bought together. That is to say, this scenario is economically equivalent to mixed bundling in that a quality improvement replaces a price discount in the case of a joint purchase of the merged entity's CPUs and FPGAs. Thus the same assessment applies as in the case of mixed bundling and, as explained in Section 5.5.1.2(B), the merged entity will not have the ability to foreclose competitors by pursuing this strategy.

(193) Therefore the Commission only considers the first scenario of technical tying, i.e. when the merged entity's FPGAs become incompatible with, or offer worse performance, when paired third party CPUs. The Commission considers that the merged entity will not have the ability to foreclose CPU rivals this way. The assessment is again comparable to that outlined in Section 5.5.1.2(A) in relation to contractual tying and pure bundling with some differences.

(194) First, the Commission considers that, as set out in paragraphs (165) to (170) above, in the absence of a sufficiently large common pool of customers and in the presence of a lot of opportunities to sell CPUs on a standalone basis, the merged entity will not be able to impact meaningfully CPU rivals' sales in the case of technical tying.

(195) Second, the analysis in relation to pure bundling and contractual tying under the hypotheses of large and narrower FPGA markets (paragraphs (171)-(179)) also applies.

(196) Specifically, under the hypothesis of a broad FPGA market, the merged entity will lack market power and thus the ability to foreclose because its FPGAs are not clearly superior compared to those of competitors and competitors are not more, and probably less, capacity constrained than the merged entity. Further, Intel, AMD's main CPU rival, cannot be foreclosed because it has its own FPGAs and could replicate the merged entity's bundle. The difference in this regard relative to the pure bundling and contractual tying scenario is that Intel is even less likely to be

foreclosed as it already has a proprietary interconnect technology to pair CPUs and FPGAs, whereas the merged entity would still have to develop such a link.[234] As the development of a proprietary interconnect technology is a multi-year effort involving large costs,[235] Intel is even better positioned than the merged entity in this scenario than in the case of pure bundling or contractual tying. Thus, as explained in relation to pure bundling and contractual tying, the practice can, at best, affect smaller, CPU-only suppliers but this appears implausible too. Namely if the CPU market is narrow and restricted to x86 CPUs or subsegments within x86 CPUs, there are no firms to foreclose as in those markets Intel is AMD's only competitor. If the CPU market is wide, foreclosure of certain firms cannot even arise in the absence of customers that buy FPGAs, while the remaining firms also cannot be foreclosed due to an insufficiently large pool of common customers.

(197) Under the hypothesis of narrow FPGA markets, Xilinx may have market power in a narrow FPGA market, but in this case the considerations set out above in paragraphs (165)-(170) on the insufficient pool of common customers would apply with even greater force as any plausible CPU market would be vastly larger than the narrow FPGA markets. Thus under this hypothesis any bundling strategy would have a negligible effect on CPU rivals' sales.

(198) Third, as discussed in relation to pure bundling, contractual tying and mixed bundling, the market investigation confirmed that customers have a strong preference for a "mix and match" approach, as almost the entirety of customers indicated that they prefer to buy CPUs, discrete GPUs and FPGAs separately, picking the best option regardless of the supplier.[236] For instance, a customer explained that they "*typically select the supplier that provides the best technical solution",* while two other customer also submitted that they look for best of breed products. Another respondent replied that they prefer to "*have the ability to select the best option of CPU and FPGAs separately or bundled depending on the best overall solution".* Therefore, it appears evident that customers want to retain the possibility to choose how to combine the products of different suppliers, and would not favour an offering that technically limits their ability to do so by locking them into a single supplier.

(199) The prerequisite of "mix and match" from a technical point of view is open interconnect standards such as PCIe. Consistent with their preference for a "mix and match" approach, customers expressed a strong preference for open interconnect standards.[237] All respondents to the market investigation, both customers and competitors, indicated that customers have a strong preference for compatibility with open interconnect standards, especially the PCIe, when purchasing CPUs, FPGAs or discrete GPUs.[238] One respondent, for example, explained that "*open standards promote greater choice and freedom […]".* Likewise, another respondent indicated that "*open standards and interoperability provide flexibility for vendors, value chain*

234 Form CO, paragraphs 532 – 532.

235 Responses to Q1 – Questionnaire to competitors and trade associations, question 60.

236 Responses to Q2 – Questionnaire to customers, question 44.

237 Responses to Q1 – Questionnaire to competitors and trade associations, question 58; Q2 – Questionnaire to customers, question 48.

238 Responses to Q1 – Questionnaire to competitors and trade associations, question 58; Q2 – Questionnaire to customers, question 48.

providers and end users, and […] encourages technology and pricing competition". The difference in customer attitudes relative to pure bundling and contractual tying is that customers' preference for open interconnect standards is even stronger to the extent that compliance with such standard (PCIe now, CXL in the future) is a *de facto* essential requirement when purchasing chips. As a customer noted "*The pressure and demand for PCIe standard is strong*."[239] A competitor specified that degrading compatibility with PCIe would lead to customers choosing devices offered by other suppliers.[240]

(200) Fourth, the Intel-Altera merger is also instructive in this regard in that Intel's CPUs and FPGAs continue to be compatible with open interconnect standards despite the fact that Intel's position in CPUs is much stronger than AMD's. Under certain plausible CPU market definitions Intel's market share exceeds 90% and despite that strong position its CPUs comply with open interconnect standards.

(201) Therefore, for the reasons set out in this section (5.5.1.2(C)), the Commission concludes that the merged entity will not have the ability to foreclose rival CPU suppliers by means of a technical tying strategy between Xilinx's FPGAs and AMD's CPUs.

5.5.2. Incentive to foreclose CPU suppliers

5.5.2.1. The Notifying Party's views

(202) The Notifying Party considers that the incentive to foreclose CPU suppliers by bundling or tying FPGAs and CPUs depends on the trade-off between sales of FPGAs foregone (to customers that want to buy FPGAs on a standalone basis) and sales of CPUs gained. Based on this trade-off, the Notifying Party submits that if, hypothetically, the merged entity had the ability to foreclose rival CPU suppliers, it would not have the incentive to do so.

(203) More specifically, the merged entity would not have the incentive to engage in contractual tying or bundling. First, as regards data centres, the Notifying Party explains that FPGAs for data centres are not a separate product category, and can be used in a variety of other applications, including without CPUs. Notably, the majority of Xilinx's revenues are generated from market segments other than data centres. Therefore, selling all of Xilinx's FPGAs exclusively paired with AMD's CPUs would harm the merged entity's business, as it would not allow the merged entity to sell enough CPUs to data centre customers to recoup the losses on the FPGA side.[241]

(204) Second, the Notifying Party indicates that roughly 90% of Xilinx's FPGA sales is directed to industrial customers, i.e. outside of the data centre space. Also in this case, the Notifying Party submits that the merged entity would not have the incentive to engage in contractual tying or bundling strategies. As regards the industrial sectors where customers could use both FPGAs and CPUs (see Table 14), the

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239 One customer's response to Q2 – Questionnaire to customers, question 48.

240 Responses to Q1 – Questionnaire to competitors and trade associations, question 59; Q2 – Questionnaire to customers, question 49.

241 Form CO, paragraphs 547 – 551.

Notifying Party indicates that the "attach rate" for FPGAs, i.e. the estimated sales of FPGAs used together with CPUs relative to the overall FPGA sales in such sectors, range from [10-20]% (Automotive) to [30-40]% (Wired & Wireless). The average attach rate for FPGAs used with CPUs across such sectors is [20-30]%.[242] This means, according to the Notifying Party, that roughly [70-80]% of FPGAs are used without a CPU.[243]

(205) The Notifying Party calculates that Xilinx's total sales in the relevant industry sectors amount to USD […] million (2020), of which USD […] was generated from sales of FPGAs used without a CPU. Therefore, implementing a contractual tying/bundling strategy would entail the merged entity foregoing USD […] in sales. According to the Notifying Party, it is extremely implausible that such a loss could be compensated by additional CPU sales.[244]

(206) The Notifying Party estimates that AMD would have to increase its sales of CPUs by [150-200] times for this trade-off to be profitable, as in 2020 AMD sold approximately USD […] million worth of CPUs in the relevant industrial sectors at hand. The overall CPU sales in these sectors amount to USD […] billion (2020), of which a conservative 10% (USD […] million) represent CPUs used with FPGAs.[245] Given Xilinx's approximate market share of [50-60]% in the relevant industrial sectors ([40-50]%), the Notifying Party considers it reasonable to assume that the maximum revenues that the merged entity can obtain from additional CPU sales represents approximately half of such amount, i.e. USD […] million.[246] This would result in a net loss of over USD […] million. Therefore, for the reasons set out above, the Notifying Party considers that the merged entities would not have the incentive to engage in commercial tying or bundling practices.

(207) The Notifying Party also submits that the merged entity would not have the incentive to implement technical tying strategies. First, impairing the use of the PCIe interconnect standard would affect the performance of a number of AMD's products that rely on it (e.g. network controllers, switches, solid state drivers etc.). This would also reduce the value of AMD-based servers to customers, which would be counterproductive for AMD as a business strategy.[247] Second, in the Notifying Party's view, the merged entity would have no incentive to develop a proprietary interconnect technology, since this would harm interoperability between Xilinx' FPGAs and non-AMD CPUs. In this regard, the Notifying Party explains that a significant portion of Xilinx's FPGAs are actually paired with Intel CPUs, especially in data centres. Third, the Notifying Party recalls the strong demand for interoperability, especially by large customers that enjoy significant buyer power, which generates an incentive to increase the products' interoperability rather than decreasing it.[248] These factors, in the Notifying Party's view, would not allow the merged entity to gain enough CPU sales to offset the loss of business opportunities due to reduced interoperability.

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242 Form CO, Figure 10.

243 Form CO, paragraph 632.

244 Ibid.

245 Form CO, paragraph 633.

246 Ibid.

247 Form CO, paragraph 542.

248 Form CO, paragraph 544 – 545.

(208) Finally, the Notifying Party submits that the merged entity would not have the incentive to pursue a mixed bundling strategy as a means of foreclosing rival CPU suppliers by selling CPUs at a cost. First, gaining market share in the CPU market at a cost of lower margins is not sustainable given AMD's small market shares compared to Intel's overwhelmingly larger position. Such a strategy would require considerable investments over a long period of time that the merged entity cannot sustain. Second, as explained above, any discounting strategy can be replicated by Intel. Third, the Notifying Party points to the fact that if there were any significant gains stemming from a mixed bundling strategy, Intel would have already implemented it. Given the lack of ability and incentive, the Parties point out that the merged entity may actually wish to offer discounts on FPGA/CPU bundles to attract customers, which would have pro-competitive effects.[249]

(209) In conclusion, for the reasons set out above, the Notifying Party submits that the merged entity would not have the incentive to foreclose rival CPU suppliers by leveraging on Xilinx's market position in FPGAs via tying or bundling strategies.

5.5.2.2. The results of the market investigation and the Commission's assessment

(210) The Commission considers that the merged entity will not have any incentive to engage in foreclosure of competing providers of CPUs, for the following reasons. Such incentive would only exist if the merged entity's gains in the leveraged CPU market would exceed the potential losses stemming from any tying or bundling strategy.

(211) First, the Commission notes that the Parties' internal documents do not contain any indications that suggest the existence of an incentive to engage in bundling or tying practices for the purpose of foreclosing rival CPU suppliers post-Transaction. While the Transaction is expected to allow AMD to expand to new customers and industries outside data centres and to bring synergies, in line with the rationale of the Transaction,[250] there is no indication that the merged entity intends to undertake anticompetitive leverage on Xilinx's position in the market for FPGAs.

(212) Second, the results of the market investigation support the conclusion that the merged entity would not have the incentive to foreclose rival providers of CPUs. Almost the entirety of the respondents who provided a qualitative answer indicated that it is not common across the industry to bundle or tie CPUs and FPGAs.[251] Specifically majority of customers indicated that this never happens, or that it happens rarely.[252] As one customer explained, they *"[have] not experienced that CPU and FPGA components can't be procured separately*". Therefore, based on the explanations provided, it appears that there is a lack of general incentive for suppliers to bundle and tie different components, in particular CPUs and FPGAs.

(213) Third, the Commission notes that, based on the information provided by the Notifying Party on the attach rate for FPGAs and CPUs and on the limited size of the

249 Form CO, paragraphs 636 – 641.

250 Form CO, paragraphs 5 – 6.

251 Responses to Q1 – Questionnaire to competitors and trade associations, question 52; Q2 – Questionnaire to customers, question 42.

252 Responses to Q2 – Questionnaire to customers, question 42.

CPU market attributable to customers who also use FPGAs (paragraphs (204) to (206) above), which was confirmed by the market investigation (paragraphs (165)-(170)) it appears unlikely that a tying or bundling strategy would be profitable for the merged entity.

(214) Namely, in the case of pure bundling, contractual tying and technical tying, given the low overlap of customers and the limited opportunities to sell FPGAs and CPUs jointly, the gains in CPUs sales are likely to be limited. On the other hand, given customers' preference for mix and match and open interconnect standards, many customers would reject the bundle in the presence of an alternative, leading to considerable losses on standalone sales. Customers would only accept the bundles in areas where there would be no alternative to Xilinx's FPGAs, but, as explained in Section 5.5.1.2. this, at best, is limited to some very narrow plausible FPGA markets. In that case, however, losing CPU sales in a much larger CPU market (as the merged entity would have to maintain the bundle across in the entire CPU market, otherwise customers can continue to mix and match) would most probably outweigh the gains. As regards mixed bundling, the merged entity's gains in CPU sales are also likely to be limited due to low overlap of customers and the limited opportunities to sell FPGAs and CPUs jointly. These limited gains in CPU volumes are unlikely to compensate for the losses from the discounts the merged entity would give in the case of joint sales.

(215) Fourth, the lack of a general incentive to impose bundling or tying strategies is further confirmed by the fact that Intel, following the acquisition of Altera, has never engaged in such practices. More specifically, other than some ad-hoc (but not systematic) discounts in the case of joint sales, Intel has continued to offer its FPGAs and CPUs on an individual basis, and there is no indication that this policy will be discontinued. Contractual tying, technical tying and bundling have never been imposed for the purpose of foreclosing rival suppliers of CPUs or FPGAs.[253] In addition, the Commission notes that Intel, unlike AMD, has developed some proprietary interconnect technologies.[254] However, in *Intel/Altera*, the Commission concluded that, despite this fact, it would have been commercially unattractive for Intel to degrade the compatibility of their FPGAs and CPUs with the PCIe standard, given the risk of losing sales.[255] The Commission considers that the same conclusion applies *a fortiori* to the present case, since AMD has not developed any proprietary interconnect technology.

(216) Therefore, for the reasons set out above, the Commission concludes that the merged entity would not have the incentive to foreclose rival CPU suppliers by means of any hypothetical bundling or tying practices between Xilinx's FPGAs and AMD's CPUs.

253 Form CO, paragraph 524.

254 Form CO, paragraphs 532 – 532.

255 Case COMP M.7688 – Intel/Altera, Commission decision of 14 October 2015, paragraphs 156 – 157.

5.5.3. Impact on effective competition

5.5.3.1. The Notifying Party's view

(217) The Notifying Party submits that, even if the merged entity had the ability and incentive to engage in foreclosure strategies, rival CPU suppliers would not be foreclosed.

(218) First, bundling or tying practices concerning Xilinx's FPGAs and AMD's CPUs would not cover a large enough proportion of the related market for CPUs to cause anticompetitive effects. Even if the merged entity successfully offered its FPGAs exclusively bundled or tied to its CPUs, and even if Intel was not able to replicate such bundles, any reduction in sales of rival CPU suppliers would be so limited that it would not reduce their ability to compete.[256]

(219) In this regard, the Notifying Party notes that in *Nvidia/Mellanox* the Commission accepted that if the tying or bundling practice affected 30% or less of the relevant market, the conduct would not hinder competitors' ability and incentive to compete. The size of the FPGA market is significantly smaller than the size of the respective CPU market in sectors where customers use both chips together (paragraph (157) above). In data centres, expenditure on accelerated servers amounts to 15% of the overall server expenditures, with the FPGA market representing one fiftieth of the value of the respective CPU market. Likewise, in the industrial space, the Notifying Party estimates that only 10% of CPUs, at most, are used with FPGAs. Therefore, based on these data, the Notifying Party submits that the proportion of the CPU market foreclosed would be far less than 30%. Rival CPU suppliers would then still have access to sufficient CPU sales to remain competitive.[257]

(220) Second, the Notifying Party stresses that, even if the merged entity had the ability and incentive to pursue bundling or tying strategies, Intel would remain as a strong competitive constraint and would be able to counteract any foreclosure attempt replicating the merged entity's bundles by pairing Intel's CPUs and FPGAs.[258]

(221) For the reasons set out above, the Notifying Party considers that, in any case, if the merged entity bundled or tied their FPGAs and CPUs, such practices would not have anticompetitive effects. Indeed, rival CPU suppliers would not be foreclosed from the market and would maintain their ability and incentive to compete.

5.5.3.2. The results of the market investigation and the Commission's assessment

(222) The Commission considers that due to the lack of ability and incentive, it is not needed to assess whether any foreclosure strategy would have a negative impact on effective competition.

(223) In any event, even if the merged entity were successful in foreclosing certain rival CPU suppliers by means of leveraging Xilinx' position in FPGAs, this would impact only a limited portion of the market for CPUs. As explained in Section 5.5.1.2., significant business opportunities would remain for rival CPU suppliers to continue

256 Form CO, paragraphs 553 – 555.

257 Form CO, paragraph 555.

258 Form CO, paragraph 554.

selling CPUs either to customers that do not buy FPGAs, or for use cases in which an FPGA is not deployed. Therefore, if the merged entity engaged in foreclosure strategies, it is implausible that Intel and smaller CPU suppliers could be foreclosed. If rival CPU suppliers' sales cannot be impacted to a meaningful degree, they would retain their ability to compete and thus overall CPU prices and quality would not change.

(224) This conclusion is supported by the results of the market investigation. Almost the entirety of customers and competitors submitted that the Transaction would not have a negative impact on their company.[259] Rather, a number of customers indicated that the impact of the Transaction will be positive, as it will allow the merged entity to improve the product roadmap and to bring increased product offering and value to customers.[260] The Commission also did not receive any complaints in relation to the Transaction.

(225) Furthermore, and in line with the above, none of the respondents to the market investigation signaled that the Transaction would have a negative impact on any of the different markets or segments for CPUs or FPGAs considered in sections 4.2.2 and 4.2.4 above. On the contrary, respondents indicated that the impact of the Transaction on such markets would be either neutral or positive.[261] For instance, one customer and competitor of the Parties submitted that "*based on experience with the Intel/Altera merger, the impact to the market by the AMD/Xilinx merger is expected to be neutral*."[262]

(226) In sum, for the reasons set out above, the Commission concludes that if the merged entity were successful in foreclosing certain rival CPU suppliers by means of leveraging Xilinx' position in FPGAs, this would not have a negative impact on the market for CPUs under all considered product market definitions.

5.5.4. Conclusion

(227) In light of the above considerations, the Commission considers that the Transaction does not give rise to serious doubts as to its compatibility with the internal market or the functioning of the EEA Agreement with regard to any hypothetical foreclosure strategy resulting from the conglomerate relationships between the Parties' activities as suppliers of FPGAs and CPUs, given the lack of ability, incentive or possible effects of such strategy to foreclose competing CPU suppliers.

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259 Responses to Q1 – Questionnaire to competitors and trade associations, question 68; Q2 – Questionnaire to customers, question 58.

260 Responses to Q2 – Questionnaire to customers, question 58.1.

261 Responses to Q1 – Questionnaire to competitors and trade associations, question 69; Q2 – Questionnaire to customers, question 59.

262 Responses to Q1 – Questionnaire to competitors and trade associations, 69.1.

5.6. Foreclosure of GPU suppliers

5.6.1. Ability to foreclose discrete GPU suppliers

5.6.1.1. The Notifying Party's view

(228) First, the Notifying Party considers that no conglomerate relationship exists between FPGAs and GPUs. In the Notifying Party's view, FPGAs and discrete GPUs are both used as accelerators in data centres. However, data centre applications that deploy acceleration technology generally use either FPGAs or discrete GPUs, but not both.[263] More specifically, FPGAs and discrete GPUs could be used in the same data centre, but they would perform different functions and would be generally deployed in different applications (e.g. networking, computing or storage). In the few cases in which a data centre application deploys both products at once,[264] the FPGA and the GPU perform distinct functions in different locations, and are generally not interconnected. For this reason, according to the Parties, the condition set out in the Non-horizontal Merger Guidelines that both products need to be "*generally purchased by the same set of customers for the same end use"*[265] is not met. The Notifying Party also notes that, to the best of their knowledge, there are no examples of FPGAs and discrete GPUs being purchased by the same customers in any industry sectors or end application other than accelerated data centres.[266]

(229) In any case, the Notifying Party submits that the merged entity would not have the ability to foreclose discrete GPU suppliers by means of tying or bundling. First, the Notifying Party considers that the merged entity would not have a significant degree of market power, for the same reasons set out above as regards tying and bundling of FPGAs and CPUs. In data centres, Xilinx faces significant competition from Intel, that has a comparable market share in the market for FPGAs. In addition, the merged entity would face a significantly dominant rival in the GPU market (Nvidia) that would be extremely implausible to foreclose due to its [90-100]% market share in the market for discrete GPUs for data centres.[267]

(230) Second, the Notifying Party considers that the arguments related to the limited opportunities to tie and bundle FPGAs with CPUs apply, *a fortiori*, to FPGAs and discrete GPUs. Indeed, the Notifying Party submits that only in very limited cases, if any, the same data centre application deploys both an FPGA and a discrete GPU. Therefore, due to the general lack of complementarity, commercial opportunities to tie or bundle discrete GPUs with FPGAs account for a very small fraction of the addressable market for discrete GPUs for data centres.[268] For this reason, there is no possibility that rival GPU suppliers would be foreclosed from the broader market for discrete GPUs for data centres as a result of contractual tying/bundling, technical tying and mixed bundling strategies.

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263 Form CO, paragraph 233.

264 Form CO, paragraph 234. To the best of the Parties' knowledge, the only circumstances in which FPGAs and GPUs are currently deployed in the same data centre application is where an FPGA-based Smart NIC is used to interconnect multiple GPUs that are being used to accelerate compute workloads. However, in such case, the FPGA and the GPU carry out different functions that are not comparable and interchangeable.

265 Non-Horizontal Merger Guidelines, paragraph 91.

266 Form CO, paragraph 577.

267 Form CO, paragraph 585.

268 Form CO, paragraph 587. The Parties estimate that, conservatively, less than 10% of all data centre GPU purchases are made by customers that also purchase FPGAs (see paragraph 605).

(231) Third, according to the Notifying Party, even when FPGAs and discrete GPUs are purchased by the same customer, they are not purchased together. Discrete GPUs and FPGAs have different buying patterns and volume needs, and any joint buying behavior would be mostly incidental. On this point, the Notifying Party reiterates that discrete GPUs and FPGAs are never bought together to solve a technical problem for which both products are required in combination.[269] Fourth, according to the Notifying Party, also in this case there is significant countervailing buyer power among data centre customers, in particular hyperscalers.[270]

(232) In sum, the Notifying Party submits that, due to the lack of a significant degree of market power and due to very little complementarity and different purchasing patterns between FPGAs and GPUs, the merged entity would not have the ability to foreclose discrete GPU suppliers.

5.6.1.2. The results of the market investigation and the Commission's assessment

(A) Market for discrete GPUs for data centres

(233) The Commission considers that the merged entity will not have the ability to engage in foreclosure of competing providers of discrete GPUs for data centres and discrete GPUs for gaming, for the following reasons.

(234) First, information gathered from the market investigation indicates that, contrary to the Notifying Party's views, FPGAs and discrete GPUs for data centres could be used together in the same application or device by customers. However, this does not appear to be common. The majority of customers and competitors that provided their views indicated that FPGAs and GPUs are indeed "rarely" used together, although some respondents also submitted that this happens "sometimes".[271] In this regard, one competitor indicated that "*both types of devices can used for the acceleration of certain workloads. In some cases, it may be efficient to use both, but such cases are less common. […] FPGAs are sometimes used to perform board management functions alongside a GPU. It is also possible to use FPGA-based smart network interface cards alongside GPUs in the same platform.*"[272]

(235) Although the market investigation indicated that discrete GPUs for data centres could be used together with FPGAs by the same customers, it also appears that these two chips are used complementarily in a limited number of cases, and in particular less frequently than FPGAs and CPUs. In this regard, all respondent but one customer agreed with the statement that most discrete GPUs are used without an FPGA.[273] The market investigation also confirmed that a majority of GPU customers do not buy FPGAs. [274] Therefore, the Commission considers that the arguments set out in section 5.5.1.2 related to the lack of a sufficiently large common pool of

269 Form CO, paragraphs 238 – 239.

270 Form CO, paragraph 605.

271 Responses to Q1 – Questionnaire to competitors and trade associations, question 46; Q2 – Questionnaire to customers, question 36.

272 Responses to Q1 – Questionnaire to competitors and trade associations, question 46.1.

273 Responses to Q1 – Questionnaire to competitors and trade associations, question 47; Q2 – Questionnaire to customers, question 37.

274 Responses to Q1 – Questionnaire to competitors and trade associations, question 49; Q2 – Questionnaire to customers, question 39.

customers, within the meaning of paragraph 100 of the Non-horizontal Merger Guidelines, between FPGAs and CPUs apply to FPGAs and discrete GPUs for data centres as well. Absent a large pool of common customers and considering the very limited cases of common usage of FPGAs and GPUs, the sales of Nvidia, AMD's only GPU competitor, are unlikely to be affected to a meaningful degree. This applies to all forms of tying and bundling.

(236) Second, even if some customers purchase both chips, joint purchase will likely be incidental, as buying patterns for FPGAs and discrete GPUs for data centres are mostly independent. This is confirmed by the market investigation, as a majority of customers and competitors who expressed their views indicated that customers who purchase both FPGAs and GPUs do not purchase them at the same time.[275] As indicated at paragraph 98 of the Non-Horizontal Merger Guidelines, pure bundling is very unlikely if the products are not bought simultaneously. The same applies to technical tying too, while non-simultaneous purchases would very much complicate and render more difficult contractual tying and mixed bundling.

(237) Third, the Commission considers that the arguments set out in section 5.5.1.2(A) in relation to CPUs and FPGAs in relation to the different hypotheses on the size of the FPGA markets apply in this case too *mutatis mutandis*.

(238) Specifically, under the hypothesis of a broad FPGA market, the merged entity will lack market power and thus the ability to foreclose Nvidia because its FPGAs are not clearly superior compared to those of its competitors and its FPGA competitors are not more, and probably less, capacity constrained than the merged entity. This means that customers can easily source FPGAs from the merged entity's FPGA competitors, in particular from Intel, and discrete GPUs from Nvidia, which would have the means to replicate any discounts if needed. Under the hypothesis of narrow FPGA markets, Xilinx may have market power in a narrow FPGA market, but in this case the considerations set out above in paragraphs (234)-(235) on the insufficiently large pool of common customers would apply with even greater force as the market for GPUs for data centres (USD […] million) would be vastly larger than the narrow FPGA markets (e.g. USD […] million for FPGAs for data centers without any further segmentation). Thus under this hypothesis any bundling strategy would have a negligible effect on Nvidia's sales. These considerations apply to all forms of tying and bundling, including contractual tying, pure bundling, technical tying and mixed bundling.

(239) Fourth, just like in the case of CPUs and FPGAs, there are additional factors that make any form of tying and bundling less likely. Namely, customers have a strong preference for a mix-and-match approach[276] and open interconnect standards.[277] Furthermore pure bundling, tying and technical tying involving GPUs is virtually non-existent in the marketplace while discounts in the case of joint purchase are rare.[278] Thus, even if so far there has been no supplier with substantial sales of both

275 Responses to Q1 – Questionnaire to competitors and trade associations, question 51; Q2– Questionnaire to customers, question 41.

276 Responses to Q2 – Questionnaire to customers, question 42.

277 Responses to Q1 – Questionnaire to competitors and trade associations, question 58; Q2 – Questionnaire to customers, question 48.

278 Responses to Q2 – Questionnaire to customers, question 42.2 and 43; Q1 – Questionnaire to competitors and trade associations, question 52.2 and 53.

GPUs and FPGAs specifically, the Commission considers it a relevant factor that tying and bundling practices involving GPUs are absent in the market. These factors make any form of tying and bundling even less likely.[279]

(B) Market for discrete GPUs for gaming and professional visualisation

(240) As explained in paragraph (148) above, FPGAs are not used in gaming devices or consoles, therefore the market for discrete GPUs for gaming can be considered an affected market only to the extent to which, potentially, such GPUs are used together with FPGAs for end uses other than gaming. These cases are likely to be very limited.

(241) Therefore, all arguments set out above in relation to the conglomerate relationship between FPGAs and discrete GPUs for data centres apply, *a fortiori,* to the potential conglomerate relationship between FPGAs and discrete GPUs for gaming.

(C) Conclusion

(242) For all reasons indicated above, the Commission concludes that the merged entity would not have the ability to foreclose rival suppliers of discrete GPUs by means of hypothetical bundling or tying strategies between Xilinx's FPGAs and AMD's discrete GPUs.

5.6.2. Incentive to foreclose discrete GPU suppliers

5.6.2.1. The Notifying Party's view

(243) In the Notifying Party's view, even if the merged entity had the ability to foreclose rival suppliers of discrete GPU, it would not have the incentive to do so. In this regard, and in line with the arguments on foreclosure of CPU suppliers, the merged entity would face a trade-off between sales of FPGAs foregone (because customers can no longer buy FPGAs without a discrete GPU) and sales of discrete GPUs gained (because customers who buy Xilinx's FPGAs would buy AMD's GPUs instead of Nvidia's GPUs).

(244) According to the Notifying Party, this trade-off would not be profitable under any tying or bundling scenarios. First, the Notifying Party submits that, since FPGAs and discrete GPUs are almost never used together in the same data centre application, the demand for FPGA/GPU bundles is very little compared to the demand for FPGAs and discrete GPUs on a separate basis.[280] As the vast majority of FPGA sales in data centres are to customers that do not also buy discrete GPUs for use in the same data centre application, a contractual tying or bundling strategy would require the merged entity to forego almost all of its FPGA sales.

(245) Second, the Notifying Party submits that the attractiveness of tying and bundling discrete GPUs and FPGAs is further weakened by the fact that there is no such thing as data centre only FPGAs. The high-end FPGAs used in data centres are essentially the same as FPGAs used in a range of other applications. Therefore, the merged

279 Intel, which is an FPGA supplier, recently started to offer data centre GPUs. https://www.pcmag.com/news/intels-first-discrete-gpu-for-data-centers-arrives-to-power-android-cloud.

280 Form CO, paragraph 595.

entity would need to stop selling all FPGAs individually to ensure effectiveness of a contractual tying or bundling strategy.[281] The Notifying Party submits that the effects would be ruinous for the merged entity's FPGA business, and such losses could not be recouped thanks to the limited gains in additional discrete GPU sales to the few customers who buy discrete GPUs and FPGAs together.

(246) Third, the Notifying Party considers that it makes no commercial sense for the merged entity to foreclose GPU suppliers by means of mixed bundling. The demand for discrete GPUs is independent from the demand for FPGAs, and purchasing decisions are ultimately driven by technical considerations on the two different types of accelerators, not by discounts on prices.[282]

(247) In conclusion, for the reasons set out above, the Notifying Party submits that the merged entity would not have the incentive to foreclose rival suppliers of discrete GPUs by means of any tying or bundling strategies.

5.6.2.2. The results of the market investigation and the Commission's assessment

(248) The Commission considers that the merged entity will not have any incentive to engage in foreclosure of competing providers of discrete GPUs, for the following reasons.

(A) Market for discrete GPUs for data centres

(249) First, in line with the considerations set out in paragraph (211) above, the Parties' internal documents do not contain any indications that suggest an incentive to engage in bundling or tying practices for the purpose of foreclosing rival suppliers of discrete GPU for data centres post-Transaction. On the contrary, indications about possible synergies are mainly relative to Xilinx's FPGAs and AMD's CPUs rather than AMD's discrete GPUs. Therefore, there is no suggestion that the merged entity intends to undertake anticompetitive leverage on Xilinx's position in the market for FPGAs.

(250) Second, the market investigation indicated that, as discussed in paragraph (239) above and in Section 5.5.1.2(A), there are no tying and bundling practices involving GPUs or FPGAs. This suggests that the merged entity is unlikely to have the incentive to bundle and tie FPGAs and discrete GPUs.

(251) Third, the arguments regarding the unprofitability of hypothetical tying and bundling strategies between FPGAs and CPUs (Section 5.5.2) apply, also to FPGAs and discrete GPUs for data centres. Namely, in the case of pure bundling, contractual tying and technical tying, given the low overlap of customers and the limited opportunities to sell FPGAs and GPUs jointly (see Section 5.6.1.2), the gains in CPUs sales are likely to be limited. On the other hand, given customers' preference for mix-and-match chips of different suppliers and open interconnect standards, many customers would reject the bundle in the presence of an alternative, leading to considerable losses on standalone sales. Customers would only accept the bundles in areas where there is no alternative to Xilinx's FPGAs, but, as explained in

281 Form CO, paragraph 598.

282 Form CO, paragraph 600 – 601.

Section 5.5.1.2. this, at best, is limited to some very narrow plausible FPGA markets. In that case, however, losing GPU sales in a large GPU market[283] (as the merged entity would have to maintain the bundle across in the entire market for GPUs for data centres, otherwise customers can continue to mix-and-match) would most probably outweigh the gains related to increased GPU sales on a narrow FPGA market.[284] In the case of mixed bundling, the merged entity's gains in GPU sales are also likely to be limited due to low overlap of customers and the limited opportunities to sell FPGAs and GPUs jointly. These limited gains in GPU volumes are unlikely to compensate for the losses from the discounts given in the case of joint sales. In addition, the incentives to bundle and tie are likely to be even weaker than in the case of FPGAs and CPUs given that the pool of common customers is even narrower than that between FPGAs and CPUs.

(B) Market for discrete GPUs for gaming and professional visualisation

(252) As explained in paragraph (148) above, FPGAs are not used in gaming devices or consoles, therefore the market for discrete GPUs for gaming can be considered an affected market only to the extent to which, potentially, such GPUs are used together with FPGAs for end uses other than gaming. As mentioned in paragraph (148) such cases are likely to be very limited.

(253) Therefore, the Commission considers that all the arguments set out above in relation to the lack of incentive to bundle or tie FPGAs and discrete GPUs for data centres apply, *a fortiori,* to a hypothetical conglomerate relationship between FPGAs and discrete GPUs for gaming.

(254) In conclusion, for the reasons set out above, the Commission considers that the merged entity would not have the incentive to foreclose rival suppliers of discrete GPUs for data centres and discrete GPUs for gaming by means of hypothetical bundling or tying strategies leveraging on Xilinx's market position on FPGAs.

5.6.3. Impact on effective competition

5.6.3.1. The Notifying Party's view

(255) In the Notifying Party's view, even if the merged entity had the ability and incentive to implement anti-competitive tying or bundling strategies between Xilinx's FPGAs and AMD's discrete GPUs, these strategies would have no effects on competition in the market for discrete GPUs for data centres and would not lead to the foreclosure of rival GPU suppliers (i.e. Nvidia).[285]

(256) First, the arguments put forward with regard to the foreclosure of CPU suppliers apply *a fortiori* to this case. The impact of tying and bundling would be limited to an insignificant portion of the overall market for discrete GPUs in data centres since, as explained above, FPGAs and discrete GPUs are usually not used together. Therefore, in line with the Non-horizontal Merger Guidelines, the Notifying Party notes that a merger cannot be regarded as impeding effective competition if the fraction of the

283 The size of the market for discrete GPUs for data center is USD […] million, see Section 5.3.2.

284 For example the size of the market for FPGAs for data centers without any further segmentation is USD […] million.

285 Form CO, paragraph 603.

market affected by foreclosure is not large enough to remove effective single-product players.[286] In this case, the Notifying Party submits that Nvidia and Intel will remain as strong single product players in the markets for discrete GPUs and FPGAs respectively.

(257) Second, the Notifying Party considers that possible mixed bundling strategies concerning discrete GPUs and FPGAs would have a pro-competitive effect on customers, as they would contribute to the attractiveness of the merged entity's offer compared to the products offered by Nvidia.

(258) In conclusion, the Notifying Party considers that, due to the very limited portion of the market for discrete GPUs for data centres attributable to customers that use them together with FPGAs, any bundling or tying practices would not cause any anticompetitive effects on rival suppliers of discrete GPUs, in particular Nvidia.

5.6.3.2. The results of the market investigation and the Commission's assessment

(259) The Commission considers that due to the lack of ability and incentive, it is not needed to assess whether any foreclosure strategy would have a negative impact on effective competition.

(260) In any event, even if the merged entity were to engage in a foreclosure strategy by means of leveraging Xilinx' position in FPGAs, this would not have appreciable anticompetitive effects on the market for GPUs for data centres or on the market for GPUs for gaming and professional visualization, for the same reasons as those set out in section 5.5.3.2 above regarding the conglomerate relationship between FPGAs and CPUs.

(261) First, the Commission notes that hypothetical foreclosure strategies between Xilinx's FPGAs and AMD's discrete GPUs would impact only a small portion of the market for discrete GPUs for data centres, and an even smaller portion, if any, of the market for discrete GPUs for gaming and professional visualisation. Given that in both markets Nvidia is the only strong competitor with a market share above 90%, a reduction of Nvidia's share by a few percentage points, even if successful, is unlikely to impact meaningfully Nvidia's ability to compete, as well as GPU prices, quality and other competitive parameters.

(262) Second, the Commission recalls the results of the market investigation set out in paragraphs (224) and (225) above, according to which almost the entirety of customers and competitors submitted that the Transaction would not have a negative impact on their company.[287] Furthermore, none of the respondents to the market investigation signaled that the Transaction would have a negative impact on the markets for discrete GPUs for data centres or discrete GPUs for gaming.[288]

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286 Form CO, paragraph 604.

287 Responses to Q1 – Questionnaire to competitors and trade associations, question 68; Q2 – Questionnaire to customers, question 58.

288 Responses to Q1 – Questionnaire to competitors and trade associations, question 69; Q2 – Questionnaire to customers, question 59.

(263) In sum, for the reasons set out in section 5.5.3.2 and recalled above, the Commission concludes that if the merged entity succeeded in reducing the sales of rival suppliers of discrete GPUs by means of leveraging Xilinx' position in FPGAs, this would not have a negative impact on competition in the markets for discrete GPUs for data centres and discrete GPUs for gaming and professional visualisation.

5.6.4. Conclusion

(264) In light of the above considerations, the Commission considers that the Transaction does not give rise to serious doubts as to its compatibility with the internal market or the functioning of the EEA Agreement relative to any hypothetical foreclosure strategy resulting from the conglomerate relationships between the Parties' activities as suppliers of FPGAs and discrete GPUs, given the lack of ability, incentive or possible effects of such strategy to foreclose competing GPU suppliers.

5.7. Assessment under an alternative market definition for FPGA accelerator cards

(265) As discussed in Section 5.4, if FPGA accelerator cards constituted a separate market, then the merged entity could use both i) FPGAs exluding accelerator cards and ii) FPGA accelerator cards as leverage.

(266) When the plausible FPGA markets exclude accelerator cards (first case indicated in paragraph (265) above), the Commission notes that the size of the potential market for FPGA accelerator cards is maximum USD [200-300] million[289] against a market size of USD [5 500-6 000] million for all FPGAs. Given that FPGA accelerator cards are a small market, the exclusion of FPGA accelerator cards from any broadly defined FPGA market would not change materially the assessment in Sections 5.5. and 5.6, which would remain fully applicable also to any broadly defined market for FPGAs excluding FPGA accelerator cards.

(267) If the FPGA markets were narrow, the exclusion of FPGA accelerator cards would not affect the assessment under most narrow markets considered, as FPGA accelerator cards are only used in servers and mostly in data centres. The plausible market for FPGAs for data centres would be roughly halved (original market size of USD […] million, while excluding FPGA accelerator cards the market size would be USD […] million). As this plausible market would still be a narrow plausible FPGA market, the assessment in Sections 5.5 and 5.6 involving narrow FPGA markets would fully apply. In particular, the market for FPGAs for data centres without the FPGA accelerator card would be very small, and thus the consideration that CPU suppliers will have plenty of opportunities to sell CPUs or GPUs on a standalone basis would rule out foreclosure. Namely, even the narrowest linked CPU market and the relevant linked GPU market (x86 CPUs for servers with a market size of USD […] million and the market for discrete GPUs for data centres with a market size of USD […] million) would be vastly bigger than the market for FPGAs in data centres that excludes FPGA accelerator cards. Thus the sales of server CPU suppliers and data centre GPU suppliers cannot be impacted to a meaningful degree by any tying or bundling strategy by the merged entity.

289 Notifying Party's response to the Commission's RFI 6. Xilinx's total sales amount to USD […] million. Thus, assmuning Xilinx's share is around [30-40] %, the market size is maximum USD [200-300] million compared to a market size of USD [5 500-6 000] million in the case of all FPGAs.

(268) Moreover, although in Sections 5.5 and 5.6 the Commission did not exclude the possibility that Xilinx's FPGAs could be superior compared to competitors' FPGAs in some cases, the market investigation indicated that this could be true only in certain narrow segments other than data centres or servers.[290] This means that FPGA competitors, and Intel in particular, will remain strong alternatives to the merged entity's FPGAs even in a narrow market for data centres FPGAs excluding accelerator cards. Thus, as regards CPUs, Intel cannot be foreclosed also for the reason because it has its own FPGAs and could replicate the bundle. Likewise, the merged entity's only competitor in the market for discrete GPUs for data centres, Nvidia, cannot be foreclosed also because customers who prefer its GPUs can source FPGAs from the merged entity's FPGA rivals, and because Nvidia would have the means to replicate any discounts that the merged entity would offer.

(269) In the potential separate market for FPGA accelerator cards (second case in paragraph (265) above), as discussed in Section 5.4, the merged entity could potentially use FPGA accelerator cards to leverage its market position to certain considered CPU and GPU markets. These include the market for all CPUs or any of the market definitions considered that include server CPUs, as well as the market for discrete GPUs for data centres, because FPGA accelerator cards are only used in servers and mostly in data centres. In this regard, the same assessment applies as in the case of the market for FPGAs for data centers without the FPGA accelerator cards (see paragraphs (267)-(268) above). Namely, the assessment in Sections 5.5 and 5.6 applies in this case too and in particular the small size of the market for accelerator cards (USD [200-300] million) relative to the narrowest linked CPU market and the relevant linked GPU market indicates that there will be plenty of opportunities for CPU and GPU rivals to sell their products on a standalone basis. This, in turn, rules out foreclosure. Further, FPGA accelerator card competitors, in particular Intel, will remain strong alternatives to the merged entity's FPGAs even in this narrow market. Thus, in addition to having plenty of opportunities to sell CPUs and GPUs on a standalone basis, the merged entity's competitors in CPUs and GPUs (Intel and Nvidia respectively) cannot be foreclosed because Intel can replicate any bundle, while Nvidia's customers can source FPGA accelerator cards from Intel or other FPGA rivals.

(270) In light of the above considerations, the Commission considers that the Transaction does not give rise to serious doubts as to its compatibility with the internal market or the functioning of the EEA Agreement relative to any hypothetical foreclosure strategy resulting from the conglomerate relationship between the Parties' activities as suppliers of FPGAs, FPGA accelerator cards, discrete GPUs and CPUs, under the assumption that FPGA accelerator cards form a distinct market separate from other FPGAs.

290 Responses to Q1 – Questionnaire to competitors and trade associations, question 36; Q2 – Questionnaire to customers, question 26.

6. CONCLUSION

(271) For the above reasons, the European Commission has decided not to oppose the Transaction and to declare it compatible with the internal market and with the EEA Agreement. This Decision is adopted in application of Article 6(1)(b) of the Merger Regulation and Article 57 of the EEA Agreement.

For the Commission

(Signed)
Margrethe VESTAGER
Executive Vice-President