

ParTec AG

Germany / Technology
 Frankfurt
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Initiating coverage

RATING **BUY**
PRICE TARGET **€ 220.00**
 Return Potential 84.9%
 Risk Rating Medium

A MORE EFFICIENT SUPERCOMPUTER FOR THE AI REVOLUTION

Partec has designed, patented and brought to market a new type of supercomputer, which for a given initial financial outlay, performs calculations faster, has lower operating cost, and is more readily scalable than competing designs. Partec's machines are based on its patented dynamic Modular System Architecture (dMSA). dMSA represents a breakthrough in supercomputing architecture. This is because it allows all the CPUs (central processing units) and GPUs (graphic processing units) within a supercomputer to communicate with each other - even those in different nodes. This is not possible with the two main competing supercomputer architectures, massively parallel processing systems and cluster supercomputers. The advantage of dMSA is that it avoids the inefficiency of static node architecture, where one of the nodes may be overloaded, while another node might still have remaining computing power. dMSA reduces the hardware resources required to perform a given computation at a given speed. It also allows processing tasks to be more readily allocated away from more energy intensive CPUs to less energy intensive GPUs, thereby lowering operating costs. Furthermore, dMSA-based computers are easier to scale in both directions than MPP systems or cluster computers. Partec is an established player in supercomputers. Together with its partners, it has delivered five modular supercomputers since 2017, all of which placed among the world's top 40 fastest machines upon introduction, and generated own sales of ca. €174m. In November 2024 Partec plans to complete construction of JUPITER, Europe's first exascale supercomputer (10¹⁸ floating point operations per second) for the Jülich Research Centre in Germany. JUPITER is expected to generate ca. €100m in revenue for Partec and be the second fastest supercomputer in the world when it begins operations. So far supercomputers have mainly been the preserve of governments and research institutes. We expect supercomputer market growth to accelerate in coming years because of increased deployment of AI machines. Using a DCF valuation model, we value Partec at €220 per share. Our recommendation is Buy.

(p.t.o.)

FINANCIAL HISTORY & PROJECTIONS

	2022	2023E	2024E	2025E	2026E	2027E
Revenue (€m)	39.71	107.04	335.15	663.73	864.82	1006.86
Y-o-y growth	n.a.	169.5%	213.1%	98.0%	30.3%	16.4%
EBIT (€m)	17.30	15.55	79.14	182.36	291.06	348.94
EBIT margin	43.6%	14.5%	23.6%	27.5%	33.7%	34.7%
Net income (€m)	11.20	10.46	57.51	141.55	227.48	276.60
EPS (diluted) (€)	1.40	1.31	7.19	17.69	28.44	34.57
DPS (€)	1.25	1.25	1.25	1.25	1.25	1.25
FCF (€m)	3.99	25.53	57.21	107.01	206.81	262.19
Net gearing	36.2%	-7.7%	-71.8%	-73.1%	-82.2%	-87.0%
Liquid assets (€m)	0.16	15.72	48.78	145.79	342.59	594.78

RISKS

Risks include but are not limited to, a strong dependence on key persons that helped share the company and ongoing and future patent litigation.

COMPANY PROFILE

ParTec AG is a global leader in the development and manufacture of modular supercomputers and the high performance computing software that accompanies it. The company went public in July of 2023 with a direct listing on the Frankfurt stock exchange and had 60 employees as of year-end 2023.

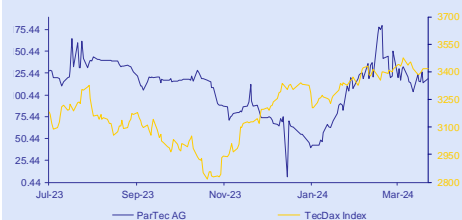
MARKET DATA

As of 25 Mar 2024

Closing Price	€ 119.00
Shares outstanding	8.00m
Market Capitalisation	€ 952.00m
52-week Range	€ 6.95 / 180.00
Avg. Volume (12 Months)	783

Multiples	2022	2023E	2024E
P/E	85.0	91.0	16.6
EV/Sales	23.9	8.9	2.8
EV/EBIT	54.9	61.1	12.0
Div. Yield	1.1%	1.1%	1.1%

STOCK OVERVIEW



COMPANY DATA

As of 30 Jun 2023

Liquid Assets	€ 0.58m
Current Assets	€ 107.93m
Intangible Assets	€ 3.17m
Total Assets	€ 111.22m
Current Liabilities	€ 58.38m
Shareholders' Equity	€ 37.86m

SHAREHOLDERS

BF Tec Holding GmbH	60.5%
HSC Beteiligungs GmbH	15.6%
R. Falter	5.0%
Prof. Dr. Tichy	5.0%
Free Float	13.9%



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INVESTMENT CASE

Exploding data volume leading to accelerating demand for supercomputers

Supercomputers are used to solve advanced computation problems, usually involving large data sets. In recent years, the amount of data generated has been growing at an exponential rate. According to some estimates, ~90% of the world's data has been generated in the past two years alone. With the recent developments in the world of AI, as well as advances in the fields of genomics, astrophysics and climate modelling, there is no reason to believe that this trend will stop anytime soon. This explosion in data volume is leading to accelerating demand for supercomputers such as ParTec's machines.

Modular supercomputers offer huge performance at a fraction of the price

Modular supercomputers can be constructed with off-the-shelf hardware, instead of requiring custom hardware like MPP systems. This makes them cheaper to produce. Because of their dynamic allocation of computing resources, they can also achieve extraordinary performance by scaling their booster module, without needing to scale their cluster module along with it. This feature allows for greater hardware efficiency. This is exemplified by the JUPITER supercomputer. To get an accurate comparison, the JUPITER is contrasted with the Frontier supercomputer, as it is the only other exascale supercomputer in the world. The Frontier supercomputer requires 74 hardware cabinets and about 8.7 million cores to be able to break the exaflops barrier. In comparison, the JUPITER was able to break the exaflops barrier with only 1.9 million cores, distributed over 28 cabinets. Due to this efficient hardware usage, the JUPITER supercomputer has been constructed for about half the cost of the Frontier supercomputer, thereby saving USD300m. This is despite the JUPITER being constructed two years later, after hardware prices had increased.

Modular supercomputers cost less to upgrade

At the architectural level, modular supercomputers combine different hardware clusters into modules. Each modular supercomputer is made up of several different modules. This makes it possible to customize a supercomputer down to the modules to match the needs of a customer. As technology advances, it will be possible to create further modules that can be added and integrated into modular supercomputers. By being able to upgrade individual modules instead of upgrading the entire supercomputer, modular supercomputers can be individually upgraded at a more competitive price than other supercomputer architectures. This means that even as the world of high performance computing keeps growing at an exponential rate, it will be possible to keep an already constructed modular supercomputer competitive without high additional financial outlay.

Energy efficiency of dMSA as demonstrated by Mare Nostrum V

The Green500 list measures the performance of supercomputers based on their energy efficiency in gigaflops/watts. At the module level, modular supercomputers are able to operate in an energy efficient manner by dynamically distributing the processing power between the energy intensive cluster and the energy efficient booster. At the chip level, the dynamic modular system architecture makes sure that the nodes, or the cores they are made up of, are allocated efficiently depending on availability. This increases energy efficiency by ensuring that there are no processors that use energy while remaining idle. The energy efficiency achieved by the combination of these properties of dMSA is exemplified by the Mare Nostrum V supercomputer. In the most recent publication of the Green500 list, it came in at rank 6. This made it the most energy efficient supercomputer with a performance of more than 100 petaflops. For reference, the supercomputer which ranked 1st on the Green500 list has a processing power of 2.8 petaflops and comes in at place 293 on the top500 list.

**We expect AI machines to be Partec's biggest business by the end of this decade**

With the know-how developed by constructing large supercomputers for academia, Partec is moving into the business of providing the private sector with supercomputers that can be used for purposes such as local training, the building of foundation models, data processing, and memory management for AI. Partec's new AI machines will be available from May, when the company plans to introduce them at the International Supercomputing Conference (Hamburg, 12-16 May). By using their software suite and their dMSA, Partec is able to scale down the budget and hardware requirements of their top-of-the-line supercomputer without a loss of per-cabinet performance. This linear downsizing of size without a loss of per-cabinet performance is only achievable by modular supercomputers. This means that instead of providing 28 cabinets to reach over 1 exaflop of FP64 performance with JUPITER (FP64 = 64-bit floating precision, which offers the highest precision among mainstream options), Partec can deliver one to three cabinets, which each have a FP64 performance of ~35 petaflops. AI machines and private sector supercomputers do not require the same precision as academic supercomputers, which is why their performance is measured at FP16 precision. Partec is able to provide a per-container AI performance of about 3.6 exaflops. This means that a large AI machine with three cabinets can achieve over 10.7 exaflops of AI performance. Because of the synergy between their patented dMSA and their software suite, which allows for more efficient hardware usage, Partec is able to offer AI machines at a fraction of the price of its competitors. Cerebras for example is currently constructing AI machines with 4 exaflops of AI performance for ~USD100m a piece. A large AI machine constructed by Partec can deliver 10.7 exaflops for a price of about USD40m. This represents an increase in performance of >150% at less than half the price. We expect AI machines to be Partec's largest segment by the end of this decade. We model a segment gross margin of ca. 30%.



SWOT ANALYSIS

STRENGTHS

- **Patented supercomputer architecture** Partec has over 150 patents covering its dynamic modular system architecture (dMSA). This supercomputer architecture allows for more efficient usage of hardware, leading to cost reductions.
- **Strong business relationship with Nvidia** Due to Partec's relationship with Nvidia, it is able to source hardware such as Nvidia's top-of-the-line GH-200.
- **Well connected in the HPC sector** Through over 15 years of cooperation, the company has developed a strong relationship with one of the largest supercomputing research centers in the world, Forschungszentrum Jülich. Partec has also developed a close relationship with Europe's leading supercomputer producer, Atos Eviden, with which it is currently constructing JUPITER, Europe's first exascale supercomputer.
- **Licensing fees with ~90% EBIT-margins** Due to extensive patent protection of Partec's dMSA, the company expects to continue to receive up to 5% of the total budget of modular supercomputer projects. The EU has set aside a budget of about €7bn for the funding of HPC projects until 2027.

WEAKNESSES

- **Lack of revenue diversification** While Partec is currently kick-starting their AI machines sector, they have so far seen most of their revenue come from projects funded by the European Union. Recent projects Leonardo I and Mare Nostrum V, which accounted for 69% of Partec's aggregate revenue between 2018 and 2022, were funded by a consortium of the EU, academia and local governments. This reliance on public funding for projects leaves the company vulnerable to unforeseen budget cuts or changes in the political landscape.
- **Low employee number** Partec currently has around 72 employees. While this represents a more than 50% increase from H1 2023 (45 employees), having so few employees while aggressively expanding its operations could hamper growth. As Partec's largest business segment constructs supercomputers for the public sector, which tends to involve a lot of paperwork, delays or insufficient oversight in regulatory matters can lead to penalties.
- **Lack of geographical diversification** The projects that Partec has tendered for, as well as the contracts for projects that they have already won, are all located in Europe. Should there be a downturn in European HPC projects, the company could see its revenue decrease.



OPPORTUNITIES

- **Growing demand for HPC** With the recent AI boom and the ever-growing need to be able to process big data sets, the demand for exascale and pre-exascale supercomputers has been steadily growing. ParTec is able to provide top-end supercomputers at prices that make it attractive to buy a modular supercomputer instead of paying to outsource the workload to the cloud.
- **Nearshoring presents opportunity for European HPC companies** Because supercomputers can have national security applications, governments are reluctant to outsource the projects to foreign companies. This presents an opportunity for ParTec, both for supercomputer projects it will construct alone, or for projects they want to do with Atos Eviden, the business partner with which they have worked on several recent European supercomputer projects.
- **Full-service provider for AI** ParTec is able to provide AI solutions in the form of constructing low-cost AI machines for the private sector, but also by constructing large supercomputers to help process the data generated by AI. This places ParTec in a position where it can profit from both sides of the AI boom.

THREATS

- **Key person risk** There is a strong dependence on the key persons who have helped build and shape the company over the last 20 years.
- **Patent litigation could strain business relations** According to management, key players in the high-performance computing world have infringed on ParTec's patented dMSA. Patent litigation could negatively impact ParTec's ability to cooperate with other players in the HPC sector in the future.
- **Patent valuation could fluctuate** ParTec recently included the present value of the expected future licensing revenue in their balance sheet. If their licensing revenue strays too far from their estimates, they might have to write the value of their balance sheet position up or down.



VALUATION

We value Partec based on a DCF model which discounts free cash flows generated in the future to the present value.

We use a two-phase model, which estimates phase 1 up to and including 2040E in detail. The second phase calculates the terminal value.

We use the concept of weighted average cost of capital (WACC) to calculate the discount rate. This calculates the discount rate from the weighted average of the cost of equity and debt. We calculate the cost of equity according to the capital asset pricing model by adding the risk-free interest rate and the market risk premium multiplied by the company-specific risk factor.

We assume a risk-free interest rate of 2.3%. This estimate is based on long-term yields on government bonds that are considered safe. The 10-year German government bond currently yields around 2.3%.

We calculate the company-specific risk factor using a proprietary model that incorporates factors such as earnings quality, management strength, financial risk, competitive position, corporate governance, transparency in the publication of financial figures, regulatory certainty, brand awareness, market capitalisation and free float. We have calculated a value of 2.27 for Partec. Our risk rating, which is based on the company-specific risk factor, is "Medium". Our risk rating is divided into the risk levels "Low risk", "Medium risk", "High risk" and "Speculative".

For the market risk premium, we assume a value of 5.0% as determined in scientific empirical studies. This yields a cost of equity of $2.32\% + 2.27 * 5.0\% = 13.7\%$.

We assume a long-term target capital structure of 100% equity. This weighting yields a WACC of 13.7%, which we use as the discount rate.

The assumptions for the first phase (2024E-2040E) are discussed in detail in the "Financial outlook" section.

The second phase calculates the terminal value. This is based on the following assumptions:

- Sales growth is 3%.
- The terminal EBIT margin is 23.0%.
- The terminal tax rate is 23.0%.

The DCF model below shows the fair value calculation for Partec. The present value of free cash flows for the explicit period (phases 1) is €1,464m. The present value of free cash flows in the terminal period (terminal value) is €291m. The sum of the values from both periods yields an enterprise value of €1,755m. To determine the shareholder value, the net debt must be deducted or the net cash position added. We estimate that net cash amounted to €1.6m at the end of 2023. Adding this amount to the enterprise value, our DCF model yields an equity value for Partec of €1,757m. On our forecasts, future capital raises will not be necessary and so the diluted number of shares is equivalent to the current share count of 8,000,000. Dividing our equity valuation by the number of shares yields a fair value per share of €219.6. Our target price derived from this is €220.



DCF MODEL

All figures in EUR millions	2024E	2025E	2026E	2027E	2028E	2029E	2030E	2031E	2032E
Net sales	335.2	663.7	864.8	1,006.9	1,084.2	1,177.7	1,254.6	1,300.1	1,302.6
NOPLAT	57.8	140.4	224.1	268.7	265.0	283.6	298.2	305.9	298.8
+ depreciation & amortisation	0.3	0.6	1.1	1.3	1.5	1.6	1.7	1.8	1.8
Net operating cash flow	58.1	141.0	225.2	270.0	266.4	285.2	299.9	307.7	300.6
- total investments (CAPEX and WC)	-1.0	-35.5	-22.1	-16.1	-9.4	-11.2	-9.6	-6.3	-1.8
Capital expenditures	-1.4	-2.6	-2.0	-1.9	-1.7	-1.9	-1.9	-1.8	-1.6
Working capital	0.4	-32.9	-20.1	-14.2	-7.7	-9.3	-7.7	-4.6	-0.2
Free cash flows (FCF)	57.1	105.5	203.1	253.9	257.0	274.0	290.3	301.3	298.8
PV of FCF's	51.8	84.1	142.4	156.6	139.4	130.7	121.8	111.2	97.0

All figures in millions	
PV of FCFs in explicit period (2024E-2040E)	1,464
PV of FCFs in terminal period	291
Enterprise value (EV)	1,755
+ Net cash / - net debt (pro forma)	2
+ Investments / minority interests	0
Shareholder value	1,757
Diluted number of shares	8
Fair value per share in	219.58

Terminal growth:	3.0%
Terminal EBIT margin:	23.0%

WACC	13.7%
Cost of equity	13.7%
Pre-tax cost of debt	7.0%
Tax rate	23.0%
After-tax cost of debt	5.4%
Share of equity capital	100.0%
Share of debt capital	0.0%
Price target	219.58

WACC	Terminal growth rate						
	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%	4.5%
10.7%	288.8	292.9	297.5	302.7	308.6	315.4	323.3
11.7%	259.4	262.2	265.4	269.0	273.0	277.5	282.7
12.7%	235.1	237.1	239.4	241.9	244.7	247.8	251.2
13.7%	214.6	216.1	217.8	219.6	221.6	223.7	226.2
14.7%	197.2	198.3	199.5	200.9	202.3	203.9	205.6
15.7%	182.2	183.0	183.9	184.9	186.0	187.1	188.4
16.7%	169.1	169.7	170.4	171.1	171.9	172.8	173.7

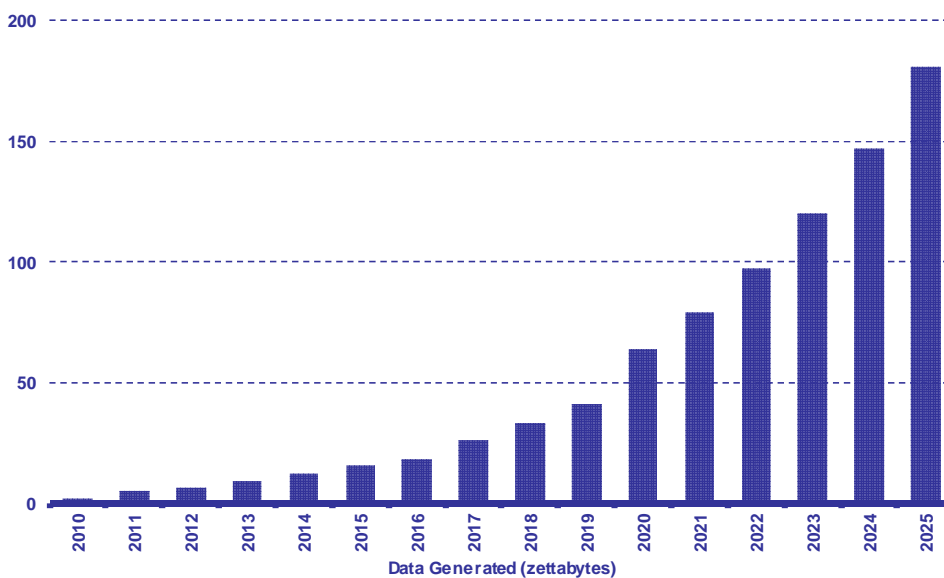
* for layout purposes the model shows numbers only to 2032, but runs until 2040

SUPERCOMPUTERS

HIGH PERFORMANCE COMPUTING

High performance computing (HPC) refers to the use of supercomputers to solve advanced computation problems, usually involving large data sets. In recent years, the amount of data generated has been growing at an exponential pace. According to some estimates, ~90% of the world's data has been generated in the past two years alone. With the recent developments in the world of artificial intelligence (AI), as well as advances in the fields of biology, astrophysics and climate modelling, there is no reason to believe that this trend should stop anytime soon. This explosion in data has further raised demand for powerful computers that are able to process all of this information. This is where supercomputers come in.

Figure 1: Global data generated annually between 2010 and 2025E



Source: Statista, First Berlin

SUPERCOMPUTERS

Supercomputers and general purpose computers Supercomputers are a type of computer that is specifically designed to solve complex calculations or problems. They share some similarities with general purpose computers (GPC), such as a desktop, but they vary drastically in their scale, performance, costs and complexity. For example, a desktop is generally made up of one to two processors and can process several hundred billion floating point operations per second (FLOPS). A Supercomputer in comparison is made up of tens of thousands of processors working in parallel and can process up to one quintillion FLOPS. That's equivalent to the processing power of several million general purpose computers.

Design of a supercomputer At a macroscopic level, supercomputers are made up of many different containers, which each contain many different nodes. Each of these nodes is like a very powerful computer in its own right. The nodes are made up of a CPU (central processing unit), several GPUs (graphics processing unit), memory and storage. The nodes are connected via a high-speed network, so they can work in tandem, and connected to large cooling systems and power supply units.

These nodes are then combined by the dozens and in some cases by the hundreds and placed in large containers. In the case of the Leonardo supercomputer depicted below, which was constructed by ParTec, about 5000 nodes are distributed across over 150 different containers.

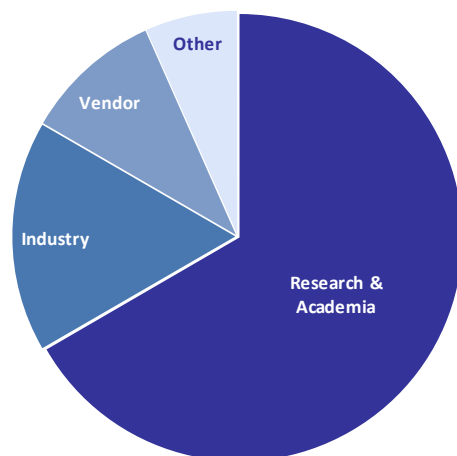
Figure 2: Leonardo supercomputer



Source: HPCwire

Areas of application for supercomputers Historically the primary sector in which supercomputers have been constructed has been research & academia. This is in part because of the need to process large data sets for research purposes, but also because constructing a top-end supercomputer can cost hundreds of millions of euros. At research institutions supercomputers are designed to be versatile so that they can be used for many different purposes such as astrophysics, climate modelling, genome sequencing and fluid dynamics. After research & academia, industrial supercomputers are the second largest sector for which supercomputers are constructed. Here the two big application areas are oil & gas exploration and telecommunications. The last big sector in which supercomputers are present at the top-end is cloud supercomputers. These supercomputers are used in part to offer supercomputing as a service to cloud customers.

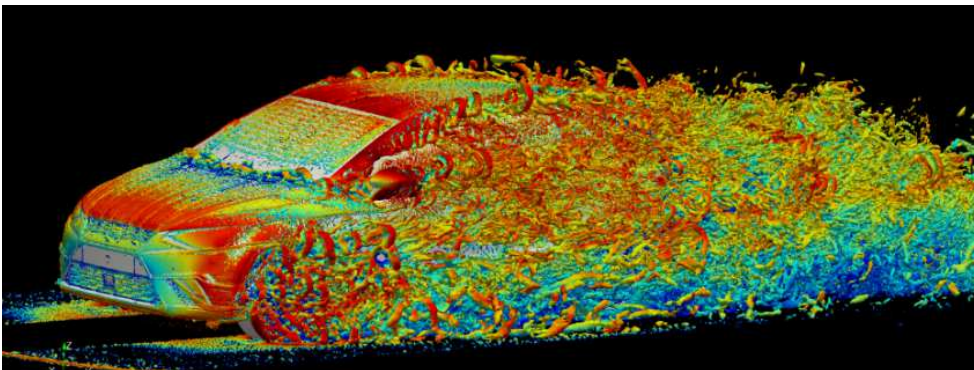
Figure 3: Top 30 supercomputers by area of application



Source: top500.org, First Berlin

Examples of supercomputer applications Some of the data-intensive fields for which supercomputers are indispensable are climate modelling and fluid dynamics. Because there are thousands of inter-correlated variables which themselves are dynamic, the complexity of these calculations rapidly exceeds anything that a regular computer could achieve. By being able to model the aerodynamics of turbine designs or even automobile designs without first needing to construct them, companies are able to avoid unnecessary costs and waste. For this reason, companies such as Volkswagen or Rolls Royce use supercomputers for solving problems in the field of computational fluid dynamics (CFD). An example of the application of a supercomputer for calculating CFD can be seen below.

Figure 4: Simulation of the aerodynamics of an automobile



Source: Barcelona Supercomputing Center

HISTORY OF SUPERCOMPUTERS

From single processors to parallel processing The first supercomputer, the CDC 6600, was constructed in 1964 at the Control Data Corporation (CDC) by Seymour Cray. It was the fastest computer in the world at the time and had a top performance of about 1.2 megaflops or 1.2 million calculations per second. In 1972 Seymour Cray founded Cray Research and developed the Cray-1 supercomputer. The decade that followed is often described as the “Cray era”, due to the success of their supercomputers. When the limitations of single-processor supercomputers became apparent in the 1980s, the concept of parallel processing became more popular. This led to the dominance of massively parallel processing (MPP) systems from the mid-1980s until the late 1990s as a way to construct supercomputers. Because MPP systems were very expensive to produce, scientists began working on more cost-effective alternatives.

Cluster supercomputers make supercomputing more economically viable In 1994, NASA's Beowulf project developed the first cluster supercomputer. It was constructed by connecting several computers built with off-the-shelf hardware to a local network to act as one unit. This relatively inexpensive supercomputer architecture quickly became the most popular way to construct high-end supercomputers. The first cluster supercomputer to enter the top500 list was the Berkley NOW, which came in at place 344 with a performance of about 10 gigaflops in June 1997. By November of 2007, 10 years after the first cluster supercomputer entered the top500, over 400 of the top 500 supercomputers were constructed based on cluster supercomputing architecture. In June of 2008, the Roadrunner cluster supercomputer broke the petaflop barrier by being the first supercomputer to perform one quadrillion (1×10^{15}) operations per second, showing that cluster supercomputers were not only economically viable, but could also compete with MPP systems. By 2010 the only supercomputer architectures left at the top-end of supercomputing were MPP systems and cluster supercomputers, with the latter being the more prevalent due to their economic viability.

A new supercomputing architecture developed as a combination of the dominant architectures

In 2010, Prof. Dr. Dr. Lippert, the head of the Jülich Supercomputing Center, created a research group together with ParTec with the aim of creating a new supercomputer architecture on the basis of his longstanding idea to disaggregate the different types of processor thereby making the processors or their cores independently accessible. The processors/cores would then be dynamically assigned to each other as dictated by the requirements of the task at hand. The goal was to combine the raw processing power and energy efficiency of MPP systems with the cost effectiveness of cluster supercomputers. After several years of research and work on different prototypes, the world's first commercial modular supercomputer was constructed in 2017 at the Forschungszentrum Jülich. This new supercomputer architecture, known as dMSA became established among the top-end supercomputers in Europe after the JUWELS Booster, which was based on dMSA, entered the top10 supercomputers at place 8 in 2021. Since then, several other noteworthy modular supercomputers, such as Meluxina, Mare Nostrum V and the Leonardo I were constructed, the last two of which both placed in the top10 supercomputers. In August of 2023 a consortium of Partec and Atos Eviden received the contract to construct JUPITER, Europe's first exascale (1×10^{18} FLOPS) supercomputer, based on Partec's dMSA.

PRIMARY SUPERCOMPUTER ARCHITECTURES

MPP systems MPP systems are made up of many individual processing nodes, each with their own memory and processing systems, which are connected through a network. This means that the individual nodes do not work as stand-alone machines, but only function when combined as a unit. To process large data sets, MPP systems divide the complex calculations into many sub-calculations and distribute these sub-calculations across the nodes, with each of the sub-calculations being processed in parallel. MPP systems are built from the bottom up, with their sole purpose being supercomputing. The hardware is tailor-made to match the specific needs of an MPP system. This makes the construction of MPP systems very expensive. However, supercomputers based on MPP architecture have very high processing power and are also highly energy efficient. Four of the current top five fastest supercomputers by processing power are based on MPP architecture.

Cluster supercomputers The term cluster supercomputer refers to a cluster of individual computers, which are connected via a local network and are able to work together as one unit. Like MPP systems, cluster supercomputers divide large tasks in to many sub-tasks which are distributed across the nodes and calculated in parallel. Because cluster supercomputers are built as a combination of standard regular computers, they do not require custom hardware. This makes them reliant on a local network for the nodes to communicate, making bandwidth and latency a constraining factor in their scalability. What cluster computers lack in raw processing power and scalability they make up for in economic viability. Because of this, about 88.5% of the supercomputers in the current list of the top 500 fastest supercomputers by processing power are cluster computers (including modular computers such as the machines designed by Partec), with the remaining 11.5% being MPP systems.

Modular supercomputers These are a novel supercomputer architecture. The principal idea behind modular supercomputers is that computer code can usually be divided into two groups: scalable code, which is easily parallelized and complex code, which isn't easily parallelized.

Modular supercomputers are made up of several different modules, with the primary HPC modules being the cluster module and the booster module. The cluster module processes the complex code, which isn't easily parallelized.

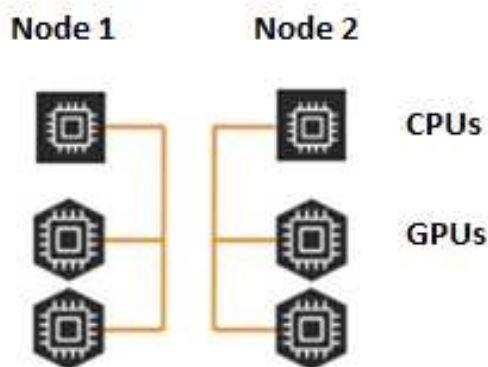
The cluster module then dynamically distributes the easily parallelizable part of the code to the much more powerful and energy efficient booster module. This dynamic resource allocation allows for a more efficient hardware usage, without sacrificing performance. This hardware efficiency leads to economic advantage both in the construction and in the operation of modular supercomputers. Along with the primary HPC modules, modular supercomputers can feature an array of further modules which each be scaled up or down based on individual needs. This makes modular supercomputers more customizable and adaptable to unforeseen changes. The different modules are described in more detail in the next segment.

MODULAR SUPERCOMPUTING

History The idea behind modular supercomputing can be traced back to before 2010. In 2010 there were two high-end supercomputers located at the Forschungszentrum Jülich: JUGENE and JUROPA. Both supercomputers placed within the top10 fastest supercomputers in the world, and were the only European supercomputers to make it into the top10. With a performance of 825.5 teraflops and 274.8 teraflops, JUGENE and JUROPA came in at places 3 and 10 respectively. JUGENE was constructed as a massively parallel processing (MPP) supercomputer, while JUROPA was constructed as a cluster supercomputer. At the time, these were the two primary ways to construct a supercomputer.

As the head of the Jülich Supercomputing Center, Prof. Dr. Dr. Lippert was working closely with these different supercomputers. This led him to use his longstanding idea to create a supercomputer architecture combining the flexibility and cost-effectiveness of cluster supercomputers with the high performance and energy efficiency of MPP systems. At the time, the trend was to improve the performance of the supercomputer nodes by attaching several general purpose graphics processing units (GPGPUs) to the CPUs, as can be seen below in figure 5. This statically increases the performance of the individual computing nodes. These nodes would then be replicated thousands of times and combined into one monolithic supercomputer.

Figure 5: Static node architecture

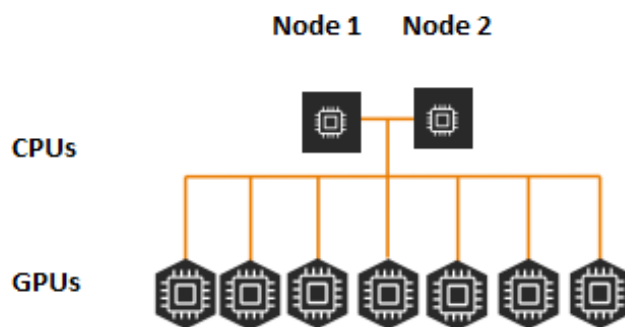


Source: Partec AG, First Berlin

This static node architecture often leads to inefficiencies, where one of the nodes may be overloaded, while another node might still have remaining computing capacity available. To try and work around these inefficiencies, Prof. Dr. Dr. Lippert devised a way to dynamically allocate computing resources based on availability.

This became a cornerstone of the dynamic modular system architecture (dMSA), which is often simply referred to as modular supercomputer architecture (MSA). In dMSA, the nodes are organized in a manner, such that each CPU and GPU, as well as the cores within them are connected to all the other CPUs and GPUs and their cores. This way, all the processors and cores are connected to all the other processors and cores, even those in different nodes. A graphic representation of the connections can be seen below in Figure 6. This allows for the theoretical optimization of computing resources based on availability.

Figure 6: Dynamic node architecture



Source: Partec AG, First Berlin

So that these excess computing resources, which are theoretically available can be optimally allocated, specific software known as middleware is required. This middleware, among other things, is able to dynamically distribute the calculations based on availability of computing resources. The usage of a software stack to dynamically allocate the available resources is what makes a supercomputer modular.

The DEEP projects After discussing this idea with several key persons in the industrial and academic world of high performance computing, a consortium of 16 members was founded in November of 2011. A series of EU-funded projects, known as the DEEP projects, examined the feasibility of a modular supercomputer. There were several iterations of the DEEP projects, each designed to further improve modular supercomputing.

Cluster-booster as a basis for dMSA At the architectural level, the idea behind the first modular supercomputer was to create a hardware cluster made up primarily of GPUs, known as the booster module, and to connect it to a cluster made up entirely of CPUs, known as the cluster module. The cluster module takes on the more technical and complex calculations, while delegating the more parallelizable parts of the code to the more powerful and energy-efficient booster module. This dynamic allocation of resources makes it possible to perform a given computational task with fewer hardware resources. The first prototype of a modular cluster-booster supercomputer was constructed in 2013, several years after the start of the DEEP projects. While the first prototype was promising, it would take another four years until the first commercially viable cluster-booster supercomputer, JURECA, would be constructed.

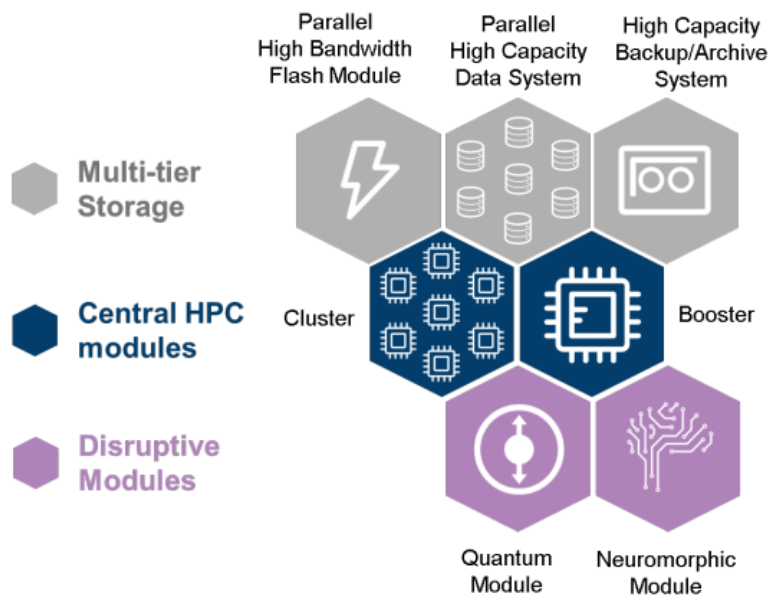
Modularity allows customisation One of the promising features of modular supercomputers is that in addition to the cluster module and the booster module, additional modules can be created. This can be done by segregating different hardware clusters based on specific needs. This possibility was explored in the later iterations of the DEEP project.

In 2019, in the DEEP-EST project, a data analytics module was added to a modular supercomputer prototype. The data analytics module used FPGAs (field-programmable gate arrays) as a low-latency accelerator, in addition to GPUs. The addition of this third module made it possible to further optimize resource allocation and improve the utility of modular supercomputers. By creating different specialized modules, each individual module can be fine-tuned to optimize its individual performance, which in turn can provide better overall performance.

Modular supercomputing reaches exascale The most recent and largest modular supercomputer to be constructed, JUPITER, which is expected to be operational by November of 2024, is composed of 7 different modules. These 7 modules can further be divided into three categories: the primary HPC modules, the storage modules and the peripheral modules.

The two primary HPC modules are the cluster module and the booster module, which are the basis for the cluster-booster architecture. The (multi-tier) storage modules are made up of three different types of storage. The flash storage module, the high-capacity data storage module, and the high-capacity back-up/archive module. The use of three different storage modules, which are suited for different types of storage, makes it possible to scale them up or down based on individual storage needs. Finally there are two peripheral modules which assist with very specific types of computing. These are the neuromorphic and the quantum module, which are designed to assist with neuromorphic computing and quantum computing. The different modules are further explained below.

Figure 7: The different modules present in the JUPITER supercomputer



Source: Jülich Supercomputing Center

Primary HPC modules The primary or central HPC modules are the cluster module and the booster module. These are the basis on which modular supercomputers are constructed. The cluster module is made up entirely of CPUs and is the brains of a modular supercomputer. It processes the complex parts of the code and is therefore the more energy intensive of the two primary modules. Because of this, the highly scalable parts of the code are distributed to the energy efficient booster module. The booster module is almost entirely made up of GPUs, with some CPUs to assist with logic. The booster module is where most of the performance of a modular supercomputer is concentrated.



In the case of the JUPITER supercomputer, the cluster module has a performance of ~5 petaflops, while the booster module has a performance of ~1000 petaflops. For reference, this would position the booster module in second place globally, in terms of performance, while the cluster module would not even place in the top 150.

Storage modules There are three storage modules in the JUPITER: the flash storage module, the high-capacity data storage module, and the high-capacity back-up/archive module. The JUPITER has 21 petabytes (21×10^6 gigabytes) of flash storage, which is a type of storage that can be electrically erased and reprogrammed easily. The flash module is used as scratch storage, or intermediate data storage, and is suited for high-bandwidth, low-latency storage of partial results. The high-capacity data storage module has over 300 petabytes of raw storage capacity for the final results. Finally, there is the high capacity backup/archive module which has over 700 petabytes of storage. With the high-capacity storage module and the high-capacity backup module, the JUPITER supercomputer has over one Exabyte of total storage.

Peripheral modules The peripheral modules are the most recent additions to modular supercomputers. The two peripheral modules in the JUPITER supercomputer are the neuromorphic module and the quantum module. The neuromorphic module is designed to assist the supercomputer with neuromorphic computing. Neuromorphic computing is modelled after the brain and nervous system. Here the cores work like neurons in the brain and pass on the inputs from core to core. The second peripheral module, the quantum module, it designed to assist the supercomputer with quantum computing. Quantum computing is a rapidly growing type of computing, which can perform certain tasks more efficiently than standard supercomputers. It is based on quantum computers, which operate at close to absolute zero (-273.15 °C). Neuromorphic computing or quantum computing are currently not considered to be superior to standard supercomputing, but certain types of tasks can benefit from the ability to access these modules. This also means that while these modules will not be required for most of the tasks performed by the JUPITER supercomputer, if there are any breakthroughs in these fields, they can be integrated and implemented, unlike in non-modular supercomputers.

ADVANTAGES OF MODULAR SUPERCOMPUTERS

Modular supercomputers offer huge performance at a fraction of the price One large economic advantage of modular supercomputers is that they can be constructed with off-the-shelf hardware, instead of requiring customer hardware like MPP systems. This makes them cheaper to produce. Because of their dynamic allocation of computing resources, they can also achieve extraordinary performance by scaling their booster module, without needing to scale their cluster module along with it. This feature allows for greater hardware efficiency and is exemplified by the JUPITER supercomputer. To get an accurate comparison, the JUPITER is contrasted with the Frontier supercomputer, as it is the only other exascale supercomputer in the world. The Frontier supercomputer requires 74 hardware cabinets and about 8.7 million cores to be able to break the exaflops barrier. In comparison, the JUPITER was able to break the exaflops barrier with only 1.9 million cores distributed over 28 cabinets. Due to this efficient hardware usage, the JUPITER supercomputer is being constructed for about half the cost of the Frontier supercomputer, thereby saving USD300m. This is despite the JUPITER being constructed two years later, after an increase in hardware price.

Figure 8: Comparison between Frontier and the JUPITER supercomputer

	Frontier	JUPITER
Performance (exaFLOPS)	1.19	1
Cost (in USD m)	600	300
Cabinets	74	28
Cores	8,699,904	1,915,200

Source: Partec AG, Oak Ridge Leadership Computing Facility, First Berlin

Modular supercomputers cost less to upgrade At the architectural level, modular supercomputers combine different hardware clusters into modules. Each modular supercomputer is made up of several different modules. This makes it possible to customize a supercomputer down to the modules to match the needs of a customer. As technology advances, it will be possible to create further modules that can be added and integrated into modular supercomputers. By being able to upgrade individual modules instead of upgrading the entire supercomputer, modular supercomputers can be individually upgraded at a more competitive price than other supercomputer architectures. This means that even as the world of high performance computing keeps growing at an exponential rate, it will be possible to keep an already constructed modular supercomputer competitive without high additional financial outlay.

Modular architecture is more energy efficient The central HPC modules are the cluster module and the booster module. The cluster module acts like the CPU of a general purpose computer. It takes on the more complex logistical tasks, which are difficult to parallelize. The cluster module is entirely made up of CPUs, and it is therefore one of the more resource-intensive modules. To operate in a more energy efficient manner, the cluster module distributes the tasks which are more easily parallelized to the booster module. This module is primarily made up of GPUs with some CPUs to assist with the logistics. The booster module is the more energy efficient module of a modular supercomputer, and it is also usually where most of the processing power of a modular supercomputer lies. This dynamic workload distribution makes modular supercomputers far more energy efficient than other cluster computers and also more energy efficient than MPP systems with comparable performance.

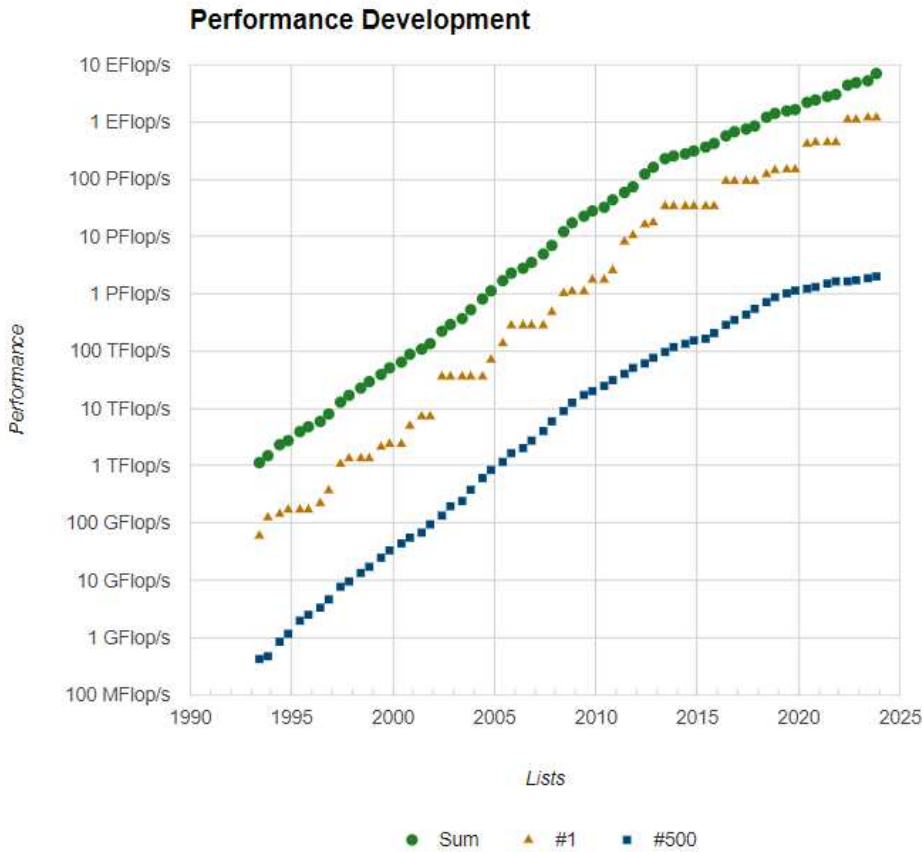


Energy efficiency of dMSA as demonstrated by Mare Nostrum V The Green500 list measures the performance of supercomputers based on their energy efficiency in gigaflops/watts. At the module level, modular supercomputers are able to operate in an energy efficient manner by dynamically distributing the processing power between the energy intensive cluster and the energy efficient booster. At the chip level, the dynamic modular system architecture makes sure that the nodes, or the cores they are made up of, are allocated efficiently depending on availability. This increases energy efficiency by ensuring that there are no processors that use energy while remaining idle. The energy efficiency achieved by the combination of these properties of dMSA is exemplified by the Mare Nostrum V supercomputer. In the most recent publication of the Green500 list, it ranked sixth. This made it the most energy efficient supercomputer with a performance of more than 100 petaflops. For reference, the supercomputer which ranked 1st on the Green500 list has a processing power of 2.8 petaflops and comes in at place 293 on the top500 list.

TOP500 LIST

History The top500 list is published biannually, once in June and once in November. It was started in 1993 as a project for tracking and detecting trends in the world of high performance computing. The top500 project publishes a list with the 500 fastest supercomputers based on their performance as measured by the Linpack benchmark. When the first list was published in 1993, four of the top five supercomputers had been constructed by Thinking Machines, with their CM-5 supercomputer taking the number one spot with a maximum performance of 59.7 gigaflops. Since the first list was published in 1993, the performance of the top supercomputer on the top500 list has grown exponentially. The maximum performance of the top supercomputer has even outpaced Moore's law, doubling every 14 months on average. The current fastest supercomputer on the latest iteration of the top500 list is the Frontier supercomputer, which has a maximal performance of almost 1.2 exaflops. This exponential growth in the processing power of the fastest supercomputers can be seen below on the chart (figure 8) that tracks performance development over time on a logarithmic scale. The current fastest supercomputer, Frontier, is over 20 million times faster than CM-5, the fastest supercomputer in June of 1993.

Figure 9: Performance development of the top 500 fastest supercomputers from 1993 until 2023



Source: top500.org

Partec on the top500 list Before Partec started constructing supercomputers, they provided software to top500 supercomputers as far back as 2009. Their ParaStation software was used in the JUROPA supercomputer, the 10th fastest supercomputer in the world at the time. Their message passing interface software was used in several other German supercomputers during the following years, such as the SuperMUC and the JUQUEEN.

In 2017, Partec made its first appearance on the top500 list, when the world’s first modular cluster-booster supercomputer, JURECA, entered at place 30. While Partec did not construct this supercomputer, it was based on their patented dMSA and used their ParaStation Modulo software.

In 2022, Partec was able to increase its presence on the top500 list when it took on the role of co-vendor for the Leonardo I and the Mare Nostrum V supercomputers. Partec was involved in the planning and development of these modular supercomputers, both of which made it into the top10 fastest supercomputers. Most recently, Partec, along with its business partner Atos Eviden, won a contract to construct Europe’s first exascale supercomputer, JUPITER. Completion of this modular supercomputer is scheduled for November 2024. Maximum performance will be over 1 exaflops. Partec was involved in the construction of three of the supercomputers that made it into the top30 globally, as can be seen below in figure 10.


Figure 10: Current list of top 30 supercomputers ranked by processing power

Rank	System	Performance (PFlop/s)	Architecture	Efficiency rank	Installation year	Manufacturer	Country
1	Frontier	1,194	MPP	8	2021	HPE	USA
2	Aurora	585	MPP	37	2023	Intel	USA
3	Eagle	561	Cluster	288	2023	Microsoft	USA
4	Fugaku	442	MPP	54	2020	Fujitsu	Japan
5	LUMI	380	MPP	7	2023	HPE	Finland
6	Leonardo	239	Cluster	18	2023	EVIDEN	Italy
7	Summit	149	Cluster	58	2018	IBM	USA
8	Mare Nostrum 5 ACC	138	Cluster	6	2023	EVIDEN	Spain
9	Eos NVIDIA	121	Cluster	302	2023	Nvidia	USA
10	Sierra	95	Cluster	63	2018	IBM	USA
11	Sunway TaihuLight	93	MPP	87	2016	NRCPC	China
12	Perlmutter	79	MPP	28	2021	HPE	USA
13	Selene	63	Cluster	36	2020	Nvidia	USA
14	Tianhe-2A	61	Cluster	150	2018	NUDT	China
15	Explorer-WUS3	54	Cluster	497	2023	Microsoft	USA
16	ISEG	47	Cluster	15	2023	Nebius AI	Netherlands
17	Adastra	46	MPP	3	2022	HPE	France
18	JUWELS Booster Module	44	Cluster	31	2020	EVIDEN	Germany
19	Mare Nostrum 5 GPP	40	Cluster	80	2023	Lenovo	Spain
20	Shaheen III - CPU	36	MPP	83	2023	HPE	Saudi Arabia
21	HPC5	35	Cluster	53	2020	DELL EMC	Italy
22	Sejong	33	Cluster	298	2023	Nvidia	South Korea
23	Voyager-EUS2	30	Cluster	290	2022	Microsoft Azure	USA
24	Crossroads	30	MPP	114	2023	HPE	Australia
25	Setonix - GPU	27	MPP	4	2022	HPE	Australia
26	Discovery 5	26	MPP	26	2022	HPE	USA
27	Polaris	26	Cluster	229	2021	HPE	USA
28	SSC -21	25	Cluster	327	2021	HPE	South Korea
29	Frontera	24	Cluster	484	2019	DELL EMC	USA
30	CEA-HF	23	Cluster	116	2021	EVIDEN	France

Sources: top500.org, First Berlin



COMPANY PROFILE

Partec AG is a global leader in the development and manufacture of modular supercomputers and the high performance computing software that accompanies it. The company was founded in 1999 as a software spin-off from the University of Karlsruhe. It has since expanded its scope and operates in different facets of the high performance computing and artificial intelligence sector. The company developed and owns the patents to its dynamic modular system architecture (dMSA), which is the basis for the construction of Europe's fastest supercomputer, JUPITER. Partec is one of the few global players with the know-how required to design, construct and service top-end supercomputers. The company went public in July of 2023 with a direct listing on the Frankfurt stock exchange and had 60 employees as of year-end 2023.

HISTORY

Partec as a software company In 1995, Walter F. Tichy, a professor at the computer science department of Karlsruhe University, first presented the ParaStation communication hardware and software system. By 1998, when the successor ParaStation2 was presented, ParaStation had moved away from hardware to focus entirely on communication software. When ParaStation became commercial in 1999, Partec AG, which owned the patents to ParaStation, was founded as a software spin-off from the University of Karlsruhe. The company continued improving and advancing its ParaStation software, leading to ParaStation FE and then ParaStation 4 being launched in 2002 and 2003 respectively. In 2004 the rights were transferred from Partec AG to Partec Cluster Competence Center GmbH. A year later, Partec started its close collaboration with Forschungszentrum Jülich (FZJ), one of the largest interdisciplinary research centers in Europe. At the end of 2007, Partec further improved ParaStation and released its message passing interface (MPI) software ParaStation MPI, which was backwards compatible with the previous version: ParaStation 4. ParaStation MPI would be used in several notable supercomputers such as the JUROPA and the JUQUEEN.

Development of Partec's patented dMSA After working with some of the most advanced supercomputers in the world for several years, Professor Dr. Dr. Lippert, the head of the Jülich Supercomputing Centre, became aware of some limitations of the most prevalent supercomputing architectures. Together with Partec, he worked on developing a supercomputing architecture that could dynamically distribute processing workload depending on specific requirements instead of statically distributing it, which was the norm at the time. This idea led to the DEEP (Dynamical Exascale Entry Platform) projects, which tried to determine their feasibility. In these projects they built the first cluster-booster prototype, which combined the cluster architecture of the JUROPA supercomputer and the booster architecture of the JUGENE supercomputer. To enable the dMSA, Partec improved and adapted its ParaStation software and developed the ParaStation Modulo software suite, designed to facilitate modular supercomputing. With majority shareholder and CEO Bernhard Frohwitter's decades of expertise in patent law, Partec applied for and was granted the relevant patents surrounding modular supercomputing. This makes it possible for Partec to charge licensing fees for constructing modular supercomputers.



Move into licensing business In 2017 after years of development, Partec was able to bring the world's first commercially viable modular supercomputer, JURECA, to the market at the FZJ. The JURECA came in at place 30 on the top500 list. This milestone deepened the relationship between the FZJ and Partec, while also laying the foundation for their second revenue stream: licensing. Partec expects to receive approximately 5% of the budget of a supercomputer that is based on dMSA as licensing fees. This new revenue stream simultaneously strengthened their software business, as their ParaStation Modulo is the only universally implementable software for dMSA.

Partec becomes a vendor Using the know-how developed by working on and with high-end supercomputers for over a decade, Partec moved into the vendor business. A consortium made up of Partec and Atos Eviden bid for the contract to oversee the entire construction of a supercomputer. This included the procurement of hardware, the integration of software, the planning of the supercomputer architecture and finally the construction of the supercomputer. Under this consortium, in 2021 Partec and Atos won the contracts to construct the supercomputers Leonardo I in Bologna, Italy and Mare Nostrum V in Barcelona, Spain based on Partec's dMSA. These supercomputers made it to place 4 and 8 on the top500 list respectively, further demonstrating the feasibility and scalability of Partec's patented dMSA. The success of these HPC projects led to the consortium of Partec and Eviden being awarded the contract for Europe's first exascale supercomputer, JUPITER, in 2023. This project has a construction budget of ~EUR 300m, with an additional ~EUR 200m for operational costs over the next 5 years. JUPITER is expected to be the second fastest supercomputer in the world and the fastest supercomputer in Europe when construction finishes in November of 2024.

BUSINESS MODEL

Partec has developed the ability to provide a variety of services to facilitate the construction, maintenance and running of supercomputers. This has made Partec one of the few companies that can act as a full service provider in the HPC sector. Their different services can be divided into four primary segments: licensing, software & support, vendor projects and industrial supercomputers. In addition to their primary business segments, Partec will continue generating revenue from R&D projects with research institutions.

Licensing Due to extensive patent protection, Partec is in the unique position of being able to charge licensing fees to construct supercomputers that are based on its patented dMSA. Partec receives up to 5% of the budget involved in constructing any supercomputer that has a dynamic modular architecture. The company is currently in discussions with HPE to receive licensing fees for computers that Partec claims have already been constructed based on their patented dMSA. In these cases Partec expects to receive up to 5% of the budgets. This segment has a gross margin of about 90%.

Software & support With its ParaStation Modulo software suite, Partec has the only hardware-agnostic communication software that is tailor-made for modular supercomputers. Partec expects to receive ~10% of the project budget for implementing its ParaStation Modulo software suite and providing supporting services.



Because the ParaStation Modulo software is specifically made for modular supercomputers, licensing fees are payable to ParTec if a supercomputer uses this software. This means that ParTec can expect to receive ~15% of the project budget for software & support and licensing fees. Their software & support segment has a gross margin of about 80%.

Vendor projects As a vendor, ParTec takes on full responsibility for the procurement of hardware, planning, maintenance, and construction of modular supercomputers. In addition to the vendor fees it receives as a full service provider, ParTec also receives licensing and software fees for the third-party use of the dMSA and the ParaStation modulo software. In order to keep up to date with current developments in the HPC world, ParTec aims to be involved in about one to two large vendor projects per year. By being involved in the construction of supercomputers at the cutting edge of HPC, they expect to be able to improve their patent protection to cover any further developments and strengthen their patent portfolio. The vendor segment has a gross margin of about 20%.

AI machines With the know-how developed by constructing large supercomputers for academia, ParTec is moving into the business of providing the private sector with supercomputers that can be used for purposes such as local training, the building of foundation models, data processing, and memory management for AI. By using their software suite and their dMSA, ParTec is able to scale down the budget and hardware requirements of their top-of-the-line supercomputer without a loss of per-cabinet performance. This linear downsizing without a loss of per-cabinet performance is only achievable by modular supercomputers. This means that instead of providing 28 cabinets to reach over 1 exaflop of FP64 performance with JUPITER, ParTec can deliver one to three cabinets, which each have a FP64 performance of ~35 petaflops. AI machines and private sector supercomputers do not require the same precision as academic supercomputers, which is why their performance is measured at FP16 precision. ParTec is able to provide a per-container AI performance of about 3.6 exaflops. This means that a large AI machine with three cabinets can achieve over 10.7 exaflops of AI performance. Because of the synergy between their patented dMSA and their software suite, which allows for more efficient hardware usage, ParTec is able to offer AI machines at a fraction of the price of its competitors. Cerebras for example is currently constructing AI machines with 4 exaflops of AI performance for ~USD100m a piece. A large AI machine constructed by ParTec can deliver 10.7 exaflops for a price of about USD40m. This represents an increase in performance of over 250% at less than half the price. ParTec expects that this will be their fastest growing segment. Their AI machines segment has a gross margin of about 30%.

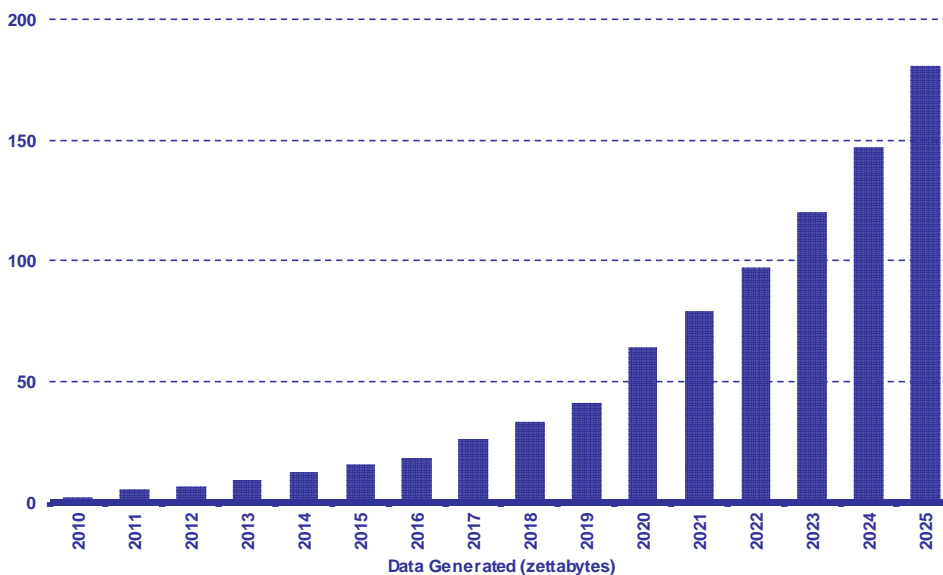
Research & development The European High Performance Computing Joint Undertaking (EuroHPC JU) plans to develop a European supercomputing ecosystem. To achieve this aim, the EuroHPC JU has set aside €7bn between the years 2021-2027 to fund the construction of supercomputers and further research in the HPC field. Due to ParTec's close connections with the Forschungszentrum Jülich and the EuroHPC JU, it will continue to be involved in R&D projects aimed at advancing HPC technology. These projects will generate revenue in the low single-digit millions but are crucial for further developing and improving their patented dMSA. This segment has a gross margin of about 10%.



MARKET ENVIRONMENT

As data generation has drastically increased in scale and complexity, the need for systems to be able to process this data has increased along with it. Until recently, this increase in data could be traced back to breakthroughs in measuring techniques and the large amount of data generated on the internet. Now, with the breakthroughs in the artificial intelligence sector, the scale of data generated has increased even further. Because of this, the field of high performance computing, in which supercomputers are used to solve complex problems with large data sets, has become crucial. The need to process data at high speeds is no longer unique to scientific institutions trying to create complex climate models or process genomes, but is also important for many private companies. The growth of the HPC sector can be traced back to two primary factors: the increased need for data processing and the need for AI solutions.

Figure 11: Global data generated annually between 2010 until 2025E

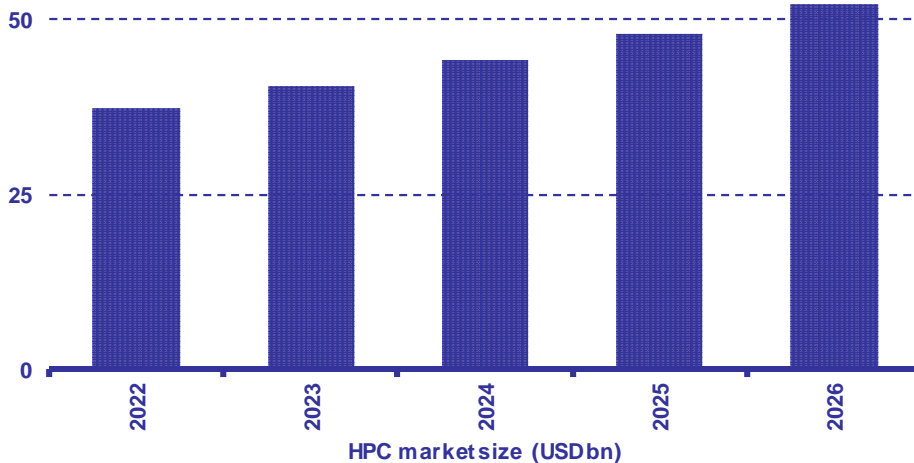


Source: Statista, First Berlin

HPC SECTOR

The high performance computing market is expected to grow at a compound annual rate of 8.8% for the next four years, according to Hyperion Research. This expected growth rate would take the market from USD37.3bn at the end of 2022 to over USD 50bn by the end of 2026.

Figure 12: Size of the High Performance Computing market between 2022 and 2027



Source: Hyperion Research, First Berlin

This growth is driven by several key factors. The first major growth driver is rising demand for data processing. This is in part because of the sheer volume of data that is being produced, but also because as our understanding of certain fields increases, the questions become increasingly complex. Because supercomputers have become more economically viable in recent decades, companies have increasingly been relying on them to improve their efficiency. Oil & gas companies have been one of the first industries to realize the need for industrial supercomputing. Of the top 50 supercomputers, six belong to oil & gas companies. These supercomputers are used for oil & gas exploration, which is a very data intensive field. Similarly, the automotive and defense industry has increasingly been using supercomputers to help determine the aerodynamics of prototypes or even to simulate collisions, without needing to waste resources on physical tests.

EUROHPC JU

The European High Performance Computing Joint Undertaking (EuroHPC JU) is a project that aims to pool European resources to develop top-of-the range exascale supercomputers based on competitive European technology. The EuroHPC JU has a total budget of around EUR 7bn that is to be spent by the end of 2027 with the goal of developing a supercomputing ecosystem in Europe. This involves funding for several exascale and pre-exascale supercomputers as well as funds for research and development projects. For the projects funded by the EuroHPC JU, the host country and/or state of the supercomputer will contribute about two thirds of the funding with the remaining third being paid for by the EuroHPC JU. This means that the total HPC budget by end of 2027 exceeds EUR 20bn.

PARTEC'S PATENT PORTFOLIO

Partec AG owns an extensive patent portfolio, which is of considerable importance in the high-performance computing sector, and more specifically for modular supercomputing. This patent portfolio, which extensively covers the construction and operation of modular supercomputers, can be divided into six primary patent families:

Figure 13: List of Partec's six primary patent families

Priority number	Title	Valid until
EP2010187436	A computer cluster arrangement for processing a computation task and method for operation thereof	13 th October 2031
EP2016192430	High performance computing system and method	5 th October 2037
EP2018152903	Application runtime determined dynamical allocation of heterogeneous compute resources	13 th January 2039
EP2018172497	Apparatus and method for efficient parallel computation	n.a.
EP2019171779	Apparatus and method to dynamically optimize parallel computations	n.a.
EP2020174913	Automatic tunings of a heterogeneous computing system	n.a.

Source: *df-mp, Partec AG, First Berlin*

MODULAR SUPERCOMPUTING

Modular supercomputing architecture (MSA) is a novel way to construct supercomputers. The primary idea behind MSA is that a computer's code can usually be divided into a two groups. One part that can be parallelized easily, known as scalable code, and one part which isn't easily parallelized, known as complex code. Instead of statically distributing this code to nodes that are designed in a similar fashion, MSA bundles different hardware into modules and then distributes the complex code to one module and the scalable code to another module. This means that to improve the processing power of a supercomputer, instead of increasing the speed of all the nodes, a modular supercomputer can selectively improve the speed of the nodes where necessary. When coupled with software that allows for dynamic and efficient resource allocation, modular supercomputers are able to make better use of the available hardware, which leads to an economic advantage.

APPLICATION AREAS OF PATENTS

High performance computing One of the main applications of the licensing of the patent portfolio of Partec AG lies in the area of high performance computing (HPC).

HPC refers to the use of supercomputers and parallel processing techniques to solve complex calculations and computing-intensive tasks. Supercomputers are used across different academic, industrial and technical fields to create complex simulations, data analyses and scientific calculations. An essential characteristic of HPC is parallel processing, in which multiple processors, or computing cores, work simultaneously to solve a problem.



This drastically increases the available computing power. Due to the increased demand for Cloud-services and AI technologies, the world of data processing techniques finds itself before uncharted challenges. These circumstances are creating an increased need for neuronal networks. For high performance systems to meet these challenges and reach their full computing potential, they require an efficient processing technique and a modular system- and software architecture. Similarly, the application of AI services in daily life is steadily increasing. From autonomous cars, to personalised health services, and automated production processes – the use of AI requires a modular system and software architecture to easily adapt to the ever changing demands and versatility of AI services.

Partec's extensive patent protection surrounding modular supercomputing will mean that anyone who wishes to construct a modular supercomputer will have to pay licensing fees to Partec. If the field of HPC continues to evolve in a similar fashion, this could lead to an appreciation of Partec's patent portfolio.

Cloud computing Another main function of the licensing portfolio of the Partec AG lies in Cloud Computing. Using Cloud Computing with a modular architecture drastically reduces the number of physical computing units required. Virtual computing units allow the decentralisation of machines previously communicating over a local network (LAN). This decentralisation creates communication via so-called nodes, which subsequently requires the creation of fewer large cluster systems. This ensures a more efficient and cost-effective use and protection of computing systems.

Through the patent portfolio, Partec AG provides a range of technologies further increasing the efficiency of high-performance data processing. Hardware accelerators contribute to a sensible and economic use of resources such as electricity. This is especially noticeable in the use of hardware accelerators in the expansion of cloud systems. Cloud Computing is a massive market that is used both in private as well as in the public sector and therefore has an extensive global application potential



PRODUCTS AND SERVICES

Partec offers a variety of products and services within the HPC sector. Their ParaStation software suite contains a set of tools to facilitate the operation of dMSA based supercomputers. There are five different components to the ParaStation software: ParaStation Modulo, ParaStation MPI, ParaStation ClusterTools, ParaStation Healthchecker and ParaStation TicketSuite.

PARASTATION SOFTWARE SUITE

ParaStation Modulo This is a supercomputing software suite that enables the Modular Supercomputing Architecture (MSA) and is extensively used in production environments. A central pillar of the suite is ParaStation MPI and its versatile processes management subsystem, both perfectly tailored to meet the demands of MSA computing towards exascale. This pillar, in turn, is embedded into a complete framework for providing modular supercomputing: Besides a robust and efficient cluster middleware, the ParaStation software suite also comprises sophisticated management components like the ParaStation ClusterTools (for provisioning and administration), the ParaStation HealthChecker (for automated error detection and integrity checking) and the ParaStation TicketSuite (for analyzing and keeping track of issues).

ParaStation MPI ParaStation MPI is the MSA-enabled MPI (Message Passing Interface) library and runtime of ParaStation Modulo. It contains a high-performance communication library especially designed for HPC supporting different communication transports concurrently and offers a complete process management system integrated with the batch queuing system and job scheduler.

ParaStation ClusterTools The ParaStation ClusterTools as part of the ParaStation Modulo offer a set of tools to ease different tasks of setting up and maintaining an HPC system. It supports common Linux distributions and system configurations, and is generally hardware agnostic, providing a uniform interface to system administrators.

ParaStation HealthChecker The ParaStation HealthChecker as part of ParaStation Modulo is an elaborated test suite for ensuring the usability of all components (HW and SW) of an HPC system. It includes a framework for configuring and executing a set of predefined tests, where each test analyzes a particular function within the system to ensure the most efficient and undisturbed operation of the system.

ParaStation TicketSuite This is an essential tool for maintaining large HPC installations. It helps keeping track of all issues that may arise with the hardware and software setup of such a system, thereby integrating well with the other components of the ParaStation Modulo Software Suite, like the ParaStation HealthChecker.

FULL SERVICE PROVIDER

Partec has the ability to design, customize and construct modular supercomputers based on a customer's wishes. The interplay between their software and their patented dMSA allows them to easily construct supercomputers that range from the low double digit petaflop scale (~35 petaflop) all the way to exascale (>1 exaflop). These services can be further divided in two segments: vendor projects and AI machines. Their vendor project segment refers to supercomputers constructed for research institutions, while their AI machines segment refers to supercomputers constructed for commercial use in the private sector.



Vendor Since the inception of the top500 list in 1993, research and academia have always been the largest primary area of application for the fastest supercomputers. In the latest iteration of the top500 list, 8 of the top 10 supercomputers by performance have research and academia as their primary applications. With the recent European high performance computing joint undertaking committing approximately 7 billion euros to further support the development of European supercomputers, we can expect that research and academia will remain one of the top areas of applications.

As we have seen recently, several research institutions have opted for constructing their top-end supercomputers based on modular supercomputing architecture. Because supercomputers at research institutions are used for a variety of different applications from weather forecasting and climate research to quantum mechanics and molecular modelling, they need to be versatile. The modularity of Partec's supercomputers allows for the dynamic distribution of the computing resources and even allows for the integration of a quantum module to support quantum mechanical research. This advantage makes dMSA based supercomputers the gold standard for academic supercomputers.

Through working as a vendor on large projects such as the Leonardo I and Mare Nostrum V supercomputers, Partec has demonstrated that they can implement supercomputing projects as a vendor at the highest level. This track record along with the contract to construct Europe's first exascale supercomputer has built the basis for Partec's largest revenue source: their vendor business.

AI Machines Partec's fastest growing segment and their second biggest contributor to their revenue from 2024 onwards is their AI machines business. In this segment, Partec delivers supercomputers to meet the individual needs of an industrial client. Many of these companies currently outsource their data intensive calculations to research institutions or to the cloud. By providing supercomputers directly to these customers, Partec gives these companies control over their data, while also allowing them to reduce operating expenses. Because of the interplay between their ParaStation software and their dMSA, Partec is able to scale down the size of supercomputers without a loss of per-cabinet performance. As an example, the JUPITER supercomputer is made up of 28 cabinets and has a performance of over one exaflops, which equals a per-cabinet performance of ~35 petaflops. This is equivalent to an AI performance of 3.6 exaflops per cabinet. ParTec can deliver these AI machines to their customers at a price that is far below their competitors. By selling these AI machines to industrial clients, Partec aims to expand the scope of its operation and diversify their clientele. The company believes that their AI Machines segment should overtake their vendor projects in revenue by 2028 to become their largest segment.

FINANCIAL HISTORY AND OUTLOOK

Move into Vendor business changes Partec's revenue profile In 2022, Partec started acting as a full service provider for supercomputers. This changed their revenue makeup, which had consisted chiefly of software & support and licensing to primarily vendor projects. The switch to being a vendor has increased their revenue, but it has decreased their margins as well. In 2022 Partec's EBIT margin decreased from 88% to 48%. The EBIT-margin dropped further in H1 2023 to 37%.

Figure 14: Revenue split by segment H1/24E to 2027E

Revenue Split	H1 2024E	H2 2024E	2024E	2025E	2026E	2027E
Total Revenue	9,314	325,839	335,153	663,733	864,823	1,006,860
% change Y/Y	-82%	641%	246%	98%	30%	16%
of which:						
Vendor	8,624	193,154	201,778	344,216	375,945	412,748
% total	93%	59%	60%	52%	43%	41%
% change Y/Y	-83%	347%	112%	71%	9%	10%
AI Machines	-	72,000	72,000	179,000	251,000	332,500
% total	0%	22%	21%	27%	29%	33%
% change Y/Y	0%	100%	100%	149%	40%	32%
Software/support	197	29,564	29,761	66,311	117,448	127,101
% total	2%	9%	9%	10%	14%	13%
% change Y/Y	100%	13912%	7160%	123%	77%	8%
Licensing	-	29,750	29,750	71,354	117,618	131,417
% total	0%	9%	9%	11%	14%	13%
% change Y/Y	0%	100%	100%	140%	65%	12%
Research & development	493	1,371	1,864	2,852	2,812	3,093
% total	5%	0.4%	0.6%	0.4%	0.3%	0.3%
% change Y/Y	-4%	168%	82%	53%	-1%	10%
Gross profit by segment	H1 2024E	H2 2024E	2024E	2025E	2026E	2027E
Total gross profit	1,952	108,663	110,615	234,209	355,419	418,680
% margin	21%	33%	33%	35%	41%	42%
of which:						
Vendor	1,725	38,631	40,356	68,843	75,189	82,550
% margin	20%	20%	20%	20%	20%	20%
AI Machines	-	18,000	18,000	44,750	74,270	109,725
% margin	25%	25%	25%	25%	29%	33%
Software/support	178	26,608	26,785	59,680	105,703	114,391
% margin	85%	85%	85%	85%	85%	85%
Licensing	-	25,288	25,288	60,651	99,976	111,705
% margin	85%	85%	85%	85%	85%	85%
Research & development	49	137	186	285	281	309
% margin	10%	10%	10%	10%	10%	10%

Source: First Berlin Equity Research estimates



Vendor We expect Partec will generate 57% of its 2024 revenue from the vendor segment. Vendor revenue can be divided into ongoing and upcoming projects. The JUPITER supercomputer accounts for 91% of the ongoing projects and 30% of the total expected revenue for 2024. The other big upcoming projects that we expect will contribute to Partec's vendor revenue for 2024 are the FENIX project, the French exascale supercomputer Jules Verne, as well as the pre-exascale supercomputers Daedalus, Levente and CASPIr. Due to the nature of the vendor projects, there is good visibility as to when these payments can be expected. The majority of Partec's vendor revenue is expected to come in the second half of 2024, with only 4.3% of their expected revenue for the year coming in H1.

Because of Partec's close relationship to the EuroHPC JU, we expect that they will be able to successfully bid for at least one to two of the large upcoming exascale supercomputers per year. According to the management, they do not want to bid for much more than one to two large vendor projects per year. Because of this, we believe that their Vendor segment will grow to a size of about €400m, after which we believe it will expand at a slower rate of around 10% per year.

AI Machines The AI machines segment is Partec's newest segment. Partec expects to launch the division in May 2024 and will therefore only generate sales in the second half of the year. We expect the AI machines segment to account for 20% of Partec's total revenue in 2024 and to grow to over 30% of revenue by 2027. We believe that this will be the company's fastest growing segment, once the dMSA-based AI machines have established themselves. If Partec is able to successfully launch the AI machines division and reach the target sales, our estimates will have been too conservative.

Software/support Similar to their its vendor business, Partec has good short-term visibility for its revenues from software and support. This is because the company has applied for, or has been asked to provide software for several upcoming vendor projects. We expect the software and support business will account for approximately 10% of total revenues, and we believe that this segment will grow in line with the vendor business.

Licensing Partec expects to receive licensing payments for modular supercomputers in its vendor segment, but also for the use of their MSA in the cloud segment as well as for other modular supercomputers. Because it is uncertain how much of their licensing revenue will come in, and more importantly when it will come in, we have discounted the probabilities and thereby the expected revenues from licensing. If Partec is able to get one large licensing agreement from a cloud provider or from one of the large HPC producers, then we believe that our estimates will have been too conservative.

In December 2023, Partec spun off its patent protection rights to a wholly owned subsidiary, FL Systems AG & Co KG. Partec's patent protection rights have been valued by an independent consultant, KL&P, at €767m. On 21 February 2024, Partec published a press release indicating its intention to book the €767m as revenue in the 2023 P&L. Given that our license forecasts are lower than those of KL&P, we have opted not to book €767m in the P&L. Indeed, in view of the above average uncertainty associated with forecasting Partec's license income, we have chosen not to book any revenue in connection with the present value of future license income. Instead, we simply include our annual license income forecasts in the P&L.



MANAGEMENT BOARD

Bernhard Frohwitter, CEO

Mr. Frohwitter is the majority shareholder of Partec and has been the Chief Executive Officer since he joined the company in 2004. The graduate engineer and lawyer began his career in 1974 as a development engineer and later in patent protection at Messerschmitt-Bölkow-Blohm GmbH. In 1998, he founded the law and patent law firm Frohwitter Intellectual Property Counselors and continued to focus on obtaining, enforcing and commercializing patents for high-tech inventions in the fields of chemistry, biotechnology, pharmaceuticals, computers and mobile telecommunications in Europe and the USA. In 2007, Mr. Frohwitter founded IPCom GmbH & Co. KG. This company held patents in the field of mobile communications, which it licensed worldwide. Under the leadership of Mr. Bernhard Frohwitter, the company generated license revenues of almost €1.5bn, as per his own statements.

Hans Kilger, CFO

Mr. Kilger has been the Chief Financial Officer of Partec since August 2023, before which he was the Chairman of the Supervisory Board. Hans Kilger has founded or been a majority shareholder in numerous companies in various sectors since the early 1990s, such as Bayern Treuhand Obermeier & Kilger AG, Stern Immobilien AG and Domaines Kilger Firmengruppe. He also holds various supervisory board positions. At Partec, Mr. Kilger is responsible for all strategic and operational financial issues such as reporting and annual financial statements and is responsible for the company's transparent external communication with the financial markets, supervisory authorities and other important stakeholders.

Hugo Falter, COO

Mr. Falter has been the Co-CEO and Chief Operating Officer since 2016. He is a fully qualified lawyer and long-standing member of the ParTec management team. He has been responsible in particular for cooperation with the relevant global industry and industry associations as well as the European research and development centers, in particular with Forschungszentrum Jülich, and maintains contacts with various institutions in the supercomputing and quantum computing sectors (including EuroHPC JU, EU Commission, national ministries). Mr. Falter is a member of the Research & Advisory Group (RIAG) and a founding member of the European Technology Platform for HPC (ETP4HPC). Mr. Falter is a founding member and managing director of the European OFS SCE mbH, which is primarily dedicated to the promotion of parallel data systems

Dominik Ulmer, CSO

Mr. Ulmer has been the Chief Customer Solutions Officer at Partec since 2022. He heads the Customer Success division and is responsible in particular for the development, construction and sale of modular super and quantum computers. Until March 2020, he coordinated European sales at HPE as Senior Director HPC&AI Technical Sales. Prior to that, he was Vice President Business Operations EMEA at Cray and General Manager of the Swiss National Supercomputing Center. Mr. Ulmer is also a member of the Board of Non-Executive Directors at NAG and has held senior IT management positions in industry and the public sector. In particular, he is responsible for the further expansion of quantum computer development and production.

**Thomas Moschny, CTO**

Mr. Moschny has been the company's Chief Technology Officer since April 2013 and was appointed to the management board in 2022. Previously, the graduate physicist conducted research in the field of computer science at the Karlsruhe Institute of Technology. His focus was on high-speed networks and parallel programming environments. He joined the company in September 2007 as a software developer and became Partec's CTO in 2013. At Partec he is driving the development of the ParaStation Modulo software suite as well as the technology of the dynamic modular system architecture.

Frank Westermann, CHRO

Mr. Westermann has been the company's chief corporate development and HR officer since October of 2022. He is responsible for the areas of personnel and business development. Previously, the economics graduate worked in management positions at Deutsche Post and Deutsche Bahn, among others.

Nurcan Rasig, CSO

Ms. Rasig has been the Chief Sales Officer since March 2023. At Partec, she is responsible for setting up and developing the sales structure, customer relationship management and customer acquisition functions. Previously, the graduate mathematician (FH) worked in management positions at IBM, Cray and, following the acquisition of Cray at the end of 2019, also at HPE. As an expert in high performance and supercomputing, she has led some of the large and complex projects in this innovative market in Europe, such as JUGENE at Forschungszentrum Jülich, HERMIT and HORNET at the High Performance Computing Center Stuttgart (HLRS) at the University of Stuttgart, HLRN-III for the North German Network for High Performance and Supercomputing and supercomputers for the German Weather Service in Offenbach.

Ina Schmitz, CPO

Ms. Schmitz has worked in project management at ParTec AG since 2010 and was appointed chief projects and consulting officer in October of 2022. She is responsible for the management of research and development projects. She also advises hosting sites in the areas of supercomputers and quantum computers on participation in tenders and supplier coordination.

SUPERVISORY BOARD

Reimund Neugebauer, Chairman

Prof. Dr. Neugebauer is the Chairman of the Board of Partec. He has held several positions in the worlds of science, business and the industry. He has been the Chairman of the High-Tech Forum of the German government and was President of the Fraunhofer-Gesellschaft e.V.

Iram Kamal, Vice Chairman

Ms. Kamal is the Vice Chairman of the Board of Partec. She has a Master of Business Law & Taxation and has been a lawyer for over 25 years. For more than 20 years she has been a Managing Partner at BT Bayern Treuhand GmbH tax consultancy and its predecessor companies.

Thomas C. Schulthess, Member of the board

Prof. Dr. Schulthess is a member of the board of Partec. He is the Director of the Swiss National Supercomputing Center (CSCS) in Manno. He is an IT physics professor at ETH Zurich.



SHAREHOLDERS & STOCK INFORMATION

Stock Information	
ISIN	DE000A3E5A34
WPK	A3E5A3
Bloomberg ticker	JY0
No. of issued shares	8.0m
Transparency Standard	Medium
Country	Germany
Sector	Technology
Subsector	High Performance Computing

Source: Börse Frankfurt

Shareholder Structure	
BF Tec Holding GmbH	60.5%
HSC Beteiligungs GmbH	15.6%
R. Falter	5.0%
Prof. Dr. Tichy	5.0%
Free Float	13.9%

Source: ParTec AG



INCOME STATEMENT

All figures in EUR '000	2022	2023E	2024E	2025E	2026E	2027E
Revenues	36,093	96,790	335,153	663,733	864,823	1,006,860
Change in inventory	3,474	9,827	0	0	0	0
Output	39,567	106,617	335,153	663,733	864,823	1,006,860
Cost of goods sold	16,192	77,176	224,539	429,524	509,404	588,180
Gross profit	23,519	29,863	110,615	234,209	355,419	418,680
Personnel expenses	3,111	5,297	12,013	16,129	18,177	20,139
Other operating income	145	422	0	0	0	0
Other operating expenses	2,822	8,727	19,131	35,128	45,134	48,308
EBITDA	17,586	15,839	79,470	182,952	292,109	350,232
Depreciation & amortisation	288	288	332	590	1,051	1,293
Operating income (EBIT)	17,298	15,551	79,138	182,362	291,057	348,939
Net financial result	-372	-607	-354	1,463	4,374	10,278
Pre-tax income (EBT)	16,927	14,944	78,784	183,825	295,431	359,217
Tax result	5,728	4,483	21,272	42,280	67,949	82,620
Net income / loss	11,198	10,461	57,512	141,546	227,482	276,597
Diluted EPS (in €)	1.40	1.31	7.19	17.69	28.44	34.57
Ratios						
Gross margin	65.2%	30.9%	33.0%	35.3%	41.1%	41.6%
EBITDA margin	48.7%	16.4%	23.7%	27.6%	33.8%	34.8%
EBIT margin	47.9%	16.1%	23.6%	27.5%	33.7%	34.7%
Net margin	31.0%	10.8%	17.2%	21.3%	26.3%	27.5%
Tax rate	33.8%	30.0%	27.0%	23.0%	23.0%	23.0%
Expenses as % of revenue						
Personnel costs	8.6%	5.5%	3.6%	2.4%	2.1%	2.0%
Net other op. expenses	7.4%	8.6%	5.7%	5.3%	5.2%	4.8%
Depreciation & amortisation	0.8%	0.3%	0.1%	0.1%	0.1%	0.1%
Y-Y Growth						
Revenue	45.5%	168.2%	246.3%	98.0%	30.3%	16.4%
Operating income	-18.2%	-10.1%	408.9%	130.4%	59.6%	19.9%
Net income/ loss	-21.5%	-6.6%	449.8%	146.1%	60.7%	21.6%



BALANCE SHEET

All figures in EUR '000	2022	2023E	2024E	2025E	2026E	2027E
Assets						
Current assets, total	71,661	76,316	168,654	380,721	647,960	949,915
Cash and cash equivalents	158	15,718	48,775	145,788	342,593	594,781
Receivables	62,680	48,395	83,788	165,933	216,206	251,715
Inventories	6,348	9,679	33,515	66,373	86,482	100,686
Other current assets	2,475	2,525	2,575	2,626	2,679	2,733
Non-current assets, total	3,338	3,428	4,462	6,514	7,465	8,062
Deferred income	-	-	-	-	-	-
Property, plant & equipment	42	387	1,676	3,982	5,189	6,041
Goodwill & other intangibles	3,293	3,038	2,783	2,528	2,273	2,018
Financial assets	3	3	3	3	3	3
Total assets	74,999	79,745	173,116	387,234	655,426	957,978
Shareholders' equity & debt						
Current liabilities, total	29,346	26,449	83,788	165,933	216,206	251,715
Short-term debt	2,252	2,252	-	-	-	-
Accounts payable	20,351	24,197	83,788	165,933	216,206	251,715
Shareholder loans	6,743	-	-	-	-	-
Long-term liabilities, total	25,712	32,893	21,412	21,841	22,278	22,723
Long-term debt	5,131	11,900	-	-	-	-
Other liabilities	6,894	7,032	7,173	7,316	7,462	7,612
Tax provisions	13,488	13,758	14,033	14,314	14,600	14,892
Other provisions	199	203	207	211	215	220
Shareholders' equity	19,941	20,402	67,915	199,460	416,942	683,539
Total consolidated equity and debt	74,999	79,745	173,116	387,234	655,426	957,978
Ratios						
Current ratio (x)	2.4	2.9	2.0	2.3	3.0	3.8
Quick ratio (x)	2.2	2.5	1.6	1.9	2.6	3.4
Net cash/(net debt)	-7,225	1,566	48,775	145,788	342,593	594,781
Net debt / EBITDA	-0.4	0.1	0.6	0.8	1.2	1.7
Net gearing	36.2%	-7.7%	-71.8%	-73.1%	-82.2%	-87.0%
Equity ratio	26.6%	25.6%	39.2%	51.5%	63.6%	71.4%
Book value per share (in €)	2.5	2.6	8.5	24.9	52.1	85.4
Return on equity (ROE)	52.8%	51.9%	130.2%	105.9%	73.8%	50.3%



CASH FLOW STATEMENT

All figures in EUR '000	2022	2023E	2024E	2025E	2026E	2027E
Net income	11,198	10,461	57,512	141,546	227,482	276,597
Depreciation and amortisation	288	288	332	590	1,051	1,293
Other non-cash items	0	0	0	0	0	0
Operating cash flow	11,486	10,749	57,845	142,136	228,533	277,890
Changes in working capital	-7,464	15,163	730	-32,481	-19,725	-13,812
Net operating cash flow	4,022	25,912	58,575	109,655	208,809	264,078
Investments in PPE	-30	-378	-1,366	-2,642	-2,003	-1,890
Investments in intangible assets	0	0	0	0	0	0
Cash flow from investing	-30	-378	-1,366	-2,642	-2,003	-1,890
Free cash flow	3,992	25,534	57,209	107,013	206,806	262,188
Debt financing, net	5,960	26	-14,152	0	0	0
Equity financing, net	0	0	0	0	0	0
Paid dividend	-10,000	-10,000	-10,000	-10,000	-10,000	-10,000
Cash flow from financing	-4,040	-9,974	-24,152	-10,000	-10,000	-10,000
Net cash flow	-48	15,560	33,057	97,013	196,806	252,188
Cash, start of the year	206	158	15,718	48,775	145,788	342,593
Cash, end of the year	158	15,718	48,775	145,788	342,593	594,781
EBITDA/share (in €)	2.20	1.98	9.93	22.87	36.51	43.78
Y-Y Growth						
Net op. cash flow	n.a.	544.2%	126.1%	87.2%	90.4%	26.5%
Free cash flow	n.a.	539.6%	124.1%	87.1%	93.3%	26.8%
EBITDA/share	-17.9%	-9.9%	401.7%	130.2%	59.7%	19.9%

GLOSSARY

HPC – High performance computing (HPC) refers to the solving of advanced computations, usually with large data sets, performed by a supercomputer. Some examples of large data sets with many variables that require supercomputers to solve would be climate models, genome sequencing, nuclear tests and fluid dynamics.

Supercomputer – Supercomputers are a type of computer that is specifically designed to solve complex calculations or problems. Unlike general purpose computers that are usually made up of one CPU and one to two GPUs, supercomputers can be made up of tens of thousands of CPUs and GPUs. Supercomputers divide up large calculations into many smaller calculations and then calculate them in parallel. At the top-end of supercomputing, the two most common supercomputer architectures are cluster supercomputers and MPP systems.

Parallel processing – Parallel processing refers to the concept of splitting a large calculation into many sub-calculations, which are then calculated in parallel. This method became popular in the 1980s as the top supercomputers neared the computational limits of single-processors. Now every single supercomputer in the top500 list makes use of parallel processing.

Nodes – Supercomputer nodes can be imagined as individual computers with many processors and cores. Each node consists of at least one CPU and memory. To perform parallel processing a supercomputer delegates the individual sub-tasks to the separate cores in the nodes.

FLOPS – Floating-point operations per second (FLOPS) is the unit of measurement used to quantify the processing power of supercomputers. A floating point value is a data efficient way to express a value without requiring absolute precision. There are different floating point (FP) precision levels, that determine how many digits and decimal points can be expressed. Because supercomputers are able to perform many operations per second, the term FLOPS is used with a prefix. Below is a table of prefixes.

Figure 15: Metric prefixes from 1 million to 1 sextillion

Prefix	Multiple	Scientific notation
Mega-	1,000,000	10^6
Giga-	1,000,000,000	10^9
Tera-	1,000,000,000,000	10^{12}
Peta-	1,000,000,000,000,000	10^{15}
Exa-	1,000,000,000,000,000,000	10^{18}
Zetta-	1,000,000,000,000,000,000,000	10^{21}

Source: First Berlin

Petaflops – One petaFLOPS, often written as one petaflops, represents the ability for a computer to perform one quadrillion (1×10^{15}) floating point operations per second.

Exaflops – One exaFLOPS, often written as one exaflops, represents the ability for a computer to perform one quintillion (1×10^{18}) floating point operations per second.

FP precision – There are different types of floating point (FP) precision that can be used to express a floating point number. The usual metric by which supercomputers are measured is FP64 precision. This degree of precision can represent numbers with up to 308 digits before the decimal point (4.94×10^{308}) and about 15 to 17 digits after the decimal point. This



degree of precision is not always required and is very data intensive. Another common form of high precision is FP32 precision, as it can represent numbers with up to 38 digits before the decimal (3.4×10^{38}) and about 7 to 8 digits after the decimal. For machine learning and AI applications FP16 or even FP8 precision is often enough. For reference, the JUPITER supercomputer that Partec is constructing has approx. 1 exaFLOPS of FP64 precision and about 46 exaFLOPS of FP16 precision.

CPU – A central processing unit (CPU) is the primary processor in a computer, which is made up of many cores. It is designed to be versatile so that it can perform a variety of tasks. The CPU takes inputs or instructions and processes them and passes on tasks to the rest of the computer. In the case of supercomputers, the cores in the CPUs take the different complicated inputs and are able to help divide them up and send these tasks to the cores in the GPUs to calculate in parallel. They can then take these results, interpret them and give an output or further distribute calculations where needed.

GPU – A graphics processing unit (GPU) is the secondary processor in a computer, and is also made up of many cores. By design a GPU is made to accelerate graphics and image processing, which is why it is often called an accelerator. While they were initially only used to process graphics, they are now used to accelerate parallel processing in the form of GPGPUs. In a supercomputer, once the inputs from the CPU are divided into simpler more parallelizable tasks, they are distributed to the GPUs, which very rapidly calculate these simpler tasks in parallel. GPUs only acts on instructions from the CPU, which is why the booster module, which is primarily made up of GPUs, includes several CPUs to assist with logistics.

GPGPU – A general purpose graphics processing units (GPGPU) is a GPU that is programmed to perform tasks other than graphics processing. Because GPUs can perform certain tasks much faster than a CPU, these tasks are often delegated to the GPUs in supercomputers to achieve maximal performance.

FPGA – A field-programmable gate array (FPGA) is a type of microchip that is often used for AI applications. FPGAs are suited for applications where parallel processing with low latency is required, which is why they are used alongside GPUs in the data analytics module of modular supercomputers. Like GPUs, FPGAs are also referred to as accelerators.

Cores – A core is the processor of processing units. CPUs tend to have complex cores that can perform logic operations, arithmetic and input/output operations. A GPU has far more cores than a CPU, but the cores are much simpler. A GPUs cores are optimized for parallel processing.

Cluster supercomputer – Cluster computers are the most common supercomputer architecture. They are made up of a cluster of different computers that communicate via a local network to function as one unit. Because they can be constructed with off-the-shelf hardware, they are one of the more economically viable and therefore the most popular supercomputer architecture. Due to their reliance on a network for the individual nodes to communicate, latency and bandwidth are a limiting factor in their scalability and performance.

MPP – Massively parallel processing (MPP) systems are the second most common supercomputer architecture. They are made up of individual processing nodes that are connected through a network. These nodes only work in unison when they are combined; they do not function as stand-alone computers. Massively parallel systems are able to achieve impressive processing power, which is why four of the top five supercomputers by processing power are based on MPP architecture. The trade-off for their strong performance is a high price tag, due to MPP systems requiring custom hardware.

dMSA – Dynamic modular system architecture (dMSA) is a novel way to construct supercomputers, which is patented by Partec. The basis for dMSA is a combination of the two most popular supercomputing architectures; cluster computers and MPP systems. A modular supercomputer is made up of several different modules, which each perform different parts of the functions of a supercomputer. The two central HPC modules are the cluster module and the booster module. The combination of the cluster and the booster works similar to a CPU and a GPU in a general purpose computer. The cluster module processes the information and takes care of complex decision making and then delegates the workload to the booster module. This feature of dMSA allows for dynamic distribution of the workload, which in turn makes modular supercomputers more hardware efficient and in turn cheaper. These primary modules can be complemented by other modules, such as a data analytics module, multi-tier storage modules and other peripheral modules like a quantum module or a neuromorphic module. Each of these modules can be individually scaled.

Cluster module – The cluster module is one of the two primary modules in a modular supercomputer. The cluster module is entirely made up of CPUs and takes care of the more technical and complex decision making. It is usually more cost effective to construct than the booster module, but it is very resource intensive to run. As the hardware composition of the module might suggest, it works like the CPU of a modular supercomputer.

Booster module – The booster module is the other primary module in a modular supercomputer. The booster module is primarily made up of GPUs and provides the majority of the supercomputers processing power. It is best suited for calculations that can be massively parallelized such as data analysis, simulations or machine learning. The booster module is usually the fastest and most expensive module to construct and can be thought of as the GPU or the workhorse of a modular supercomputer.

EuroHPC JU – The European High Performance Computing Joint Undertaking (EuroHPC JU) is a project that aims to pool European resources to develop top-of-the range exascale supercomputers based on competitive European technology. The EuroHPC JU has a total budget of around EUR 7bn that is to be spent by the end of 2027 with a goal of developing a supercomputing ecosystem in Europe. For the projects funded by the EuroHPC JU, the host country and/or state of the supercomputer contribute about two thirds of the funding with the remaining third being paid for by the EuroHPC JU. This means that the total HPC budget by end of 2027 exceeds EUR 20bn.

Top500 – The top500 list is a biannual publication of the 500 fastest supercomputers based on processing power. It was first published in 1993 and is published every June and November. A modular supercomputer based on Partec's dMSA made its first appearance on the top500 list in 2017 with the construction of the JURECA supercomputer. It landed on place 30. Since then several other dMSA based supercomputers were constructed, with the modular supercomputers Leonardo I and Mare Nostrum V both making it into the top10 globally and top5 in Europe. Partec is currently constructing the JUPITER modular supercomputer which is expected to enter the list in November of 2024 as Europe's fastest supercomputer and number two in the world.

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Add	An expected favourable price trend of:	0% to 25%	0% to 15%
Reduce	An expected negative price trend of:	0% to -15%	0% to -10%
Sell	An expected negative price trend of:	< -15%	< -10%

¹ The expected price trend is in combination with sizable confidence in the quality and forecast security of management.

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