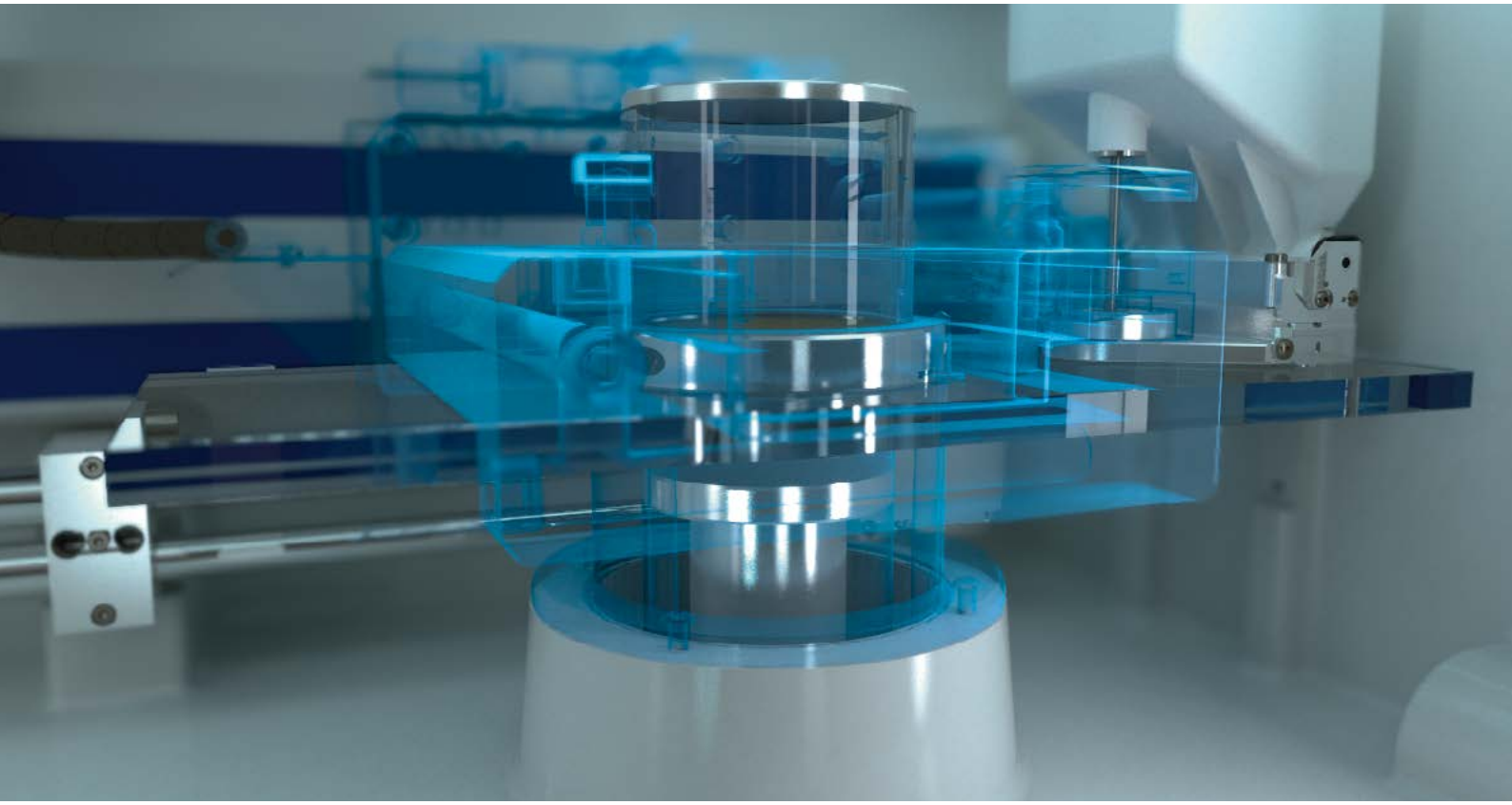
Whitepaper



Open and Flexible: EOS Part Property Management Provides both Individualization and Standardization

Additive Manufacturing (AM): the Key Technology for e-Manufacturing

EOS laser sintering solutions provide systems, materials and parameter sets for additive manufacturing (AM). These solutions are the key to e-Manufacturing – the fast, flexible and cost-effective production directly from electronic data. The technology enables the manufacturing of high-end polymer and metal parts at a repeatable industry level of quality.

Designers, and therefore end-use parts, are no longer restricted by the constraints of conventional manufacturing. Therefore, EOS e-Manufacturing contributes to a paradigm shift in product design and manufacturing.

Organizations across the globe and across almost every industry are facing critical key business and market challenges, including:

- the demand for faster time-to-market
- a trend toward shorter product lifecycles
- a trend toward increased manufacturing flexibility
- the goal to enable mass customization of products and increased differentiation from competitors
- high cost pressure and high productivity standards

Historically, additive manufacturing was predominantly used for rapid prototyping (RP). While AM is still significant in this realm, it is also increasingly being used in industrial production applications. In the RP market, the AM technology customer focus is on high flexibility, fast turnover time, adequate surface structures and similar – but not identical – parts. In contrast, in the industrial manufacturing realm, specified and reproducible part qualities – among many other factors – are most important.

EOS Part Property Management

Due to their origins in rapid prototyping, parameter sets were designed for use in many different applications. Case-by-case modifications, which also influence part properties, were often a benefit or even a necessity to gain a competitive advantage. Determining and specifying the individual parameters can be very complex and time-consuming due to their large number and manifold interactions. In prototyping, this flexibility is the foundation for pragmatic solutions and is subsequently a crucial success factor.
To meet these customer needs, EOS now offers the ExposureEditor and start values for the entire material portfolio. This enables the optimization of parameter sets starting from a baseline.

In series production processes, however, this route reveals weaknesses such as lack of standardization, consistency and intellectual property (IP) protection as well as time- consuming optimization of the parameter set(s) for one or a few manufacturing parts. As a rule, the designer makes a decision at the beginning of the design process about which manufacturing process will meet the requirements of a specific application in the best way possible. In order to make an educated decision about the properties of the planned part, the designer needs material data. In this decision process, EOS ParameterSets with their defined Part Property Profiles (PPPs) come into play. These are components of the Part Property Management (PPM) concept that customers can use to optimize the implementation of the EOS technology and EOS solutions for their specific applications.

Part Property Management – an expanded concept
The Part Property Management concept was first introduced at the EUROMOLD 2009 fair, and it focused on standardization in e-Manufacturing. It met with very positive reception from the market. Due to the many ideas from the later, the concept has now been expanded. In addition to standardization, it now allows customers to flexibly define and adapt part properties. The expanded PPM is an open concept.

Customers can freely and flexibly choose from a wide range of solutions for manufacturing their parts. They can implement EOS standards for multiple laser sintering systems in the AM process as well as defining individual application requirements or even defining their own customer-specific standards. That allows them to influence the part quality themselves in a customized way, according to their individual quality requirements and standards.

Quality Assurance (QA) is another key element for business success in both prototyping and series manufacturing. The PPM concept enables QA throughout the entire process. The three software modules of EOSTATE 1.2 (Quality Assurance, Controlling, and Machine Park Management) provide various reports to meet customer requirements with regard to quality assurance and documentation.

ExposureEditor and start values enable optimization by the customer
Based on licences, EOS offers its customers the freedom to adjust the EOS technology to their specific requirements. At the same time, application training and consulting from EOS ensures a fast learning curve for the customer. The ExposureEditor offers an editing function to modify the parameter values in the exposure settings. The modified parameter sets can then be run on the EOS systems.

Process-critical parameters are protected to avoid undesirable effects during the building process. The start values include factory default values for the respective materials and layer thicknesses, ensuring that a standard build is optimally achieved.

EOS ParameterSets for Plastic Laser Sintering

EOS ParameterSets –
standardization with the AM technology

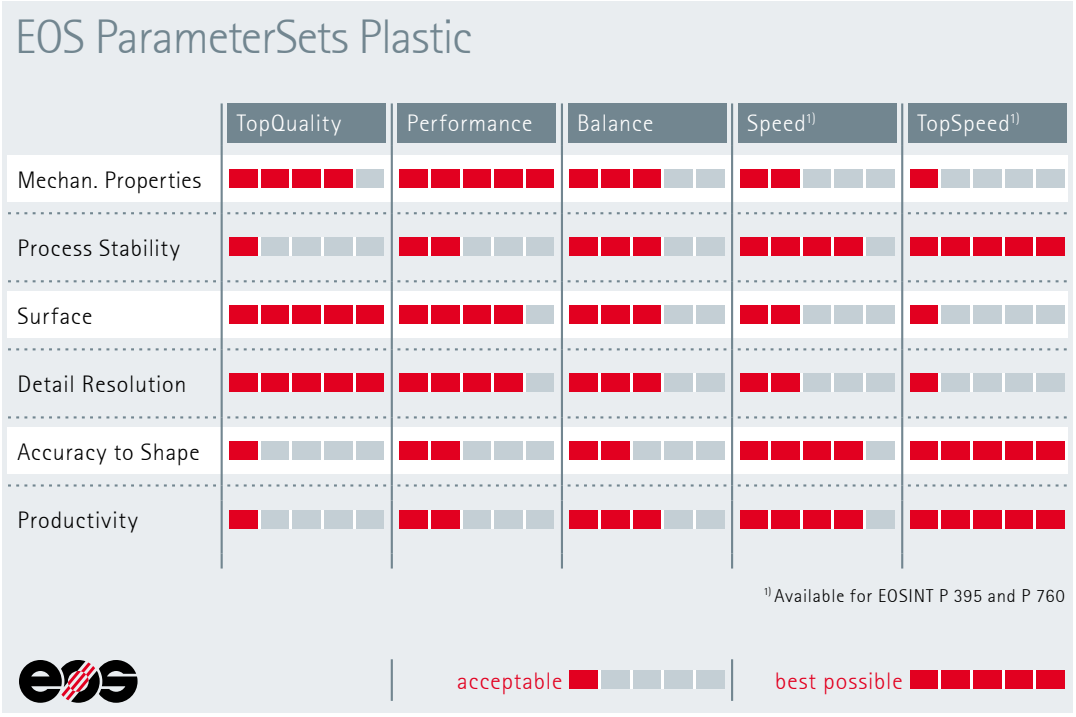
EOS ParameterSets offer standardization across all metal or plastics systems by ensuring defined Part Property Profiles (PPPs). These provide reliable values for the dimensioning of laser sintering designs. Among these are values for tensile strength, elongation at break, and moduli of elasticity for the horizontal X/Y direction. EOS is the first AM technology supplier to offer values for the vertical, orthogonal Z direction.

EOS Custom ParameterSets –
defined by the customer, developed by EOS

Partnering with EOS under this model means that – based on customer specifications – EOS develops a parameter set specific to the customer's application and part quality needs with protected or editable parameter values as well as a licensing model. This ensures consistency of the part quality regardless of the manufacturer, e.g. 3rd party suppliers. Invisible parameter values protect the customer's IP. The licensing model gives the customer the ability to control usage and payment.

The definition of the PPPs arises from typical requirements regularly requested today from the global market. Parts manufactured via laser sintering must fulfil certain quality requirements, to varying degrees and with various focal points. The most important factors include surface quality, mechanical attributes, accuracy, and detail resolution, for example. Generally, cost targets are also defined in addition to quality standards. Since the quality requirements often conflict with the need for lower costs, optimum compromises must be reached for each individual part. The five EOS ParameterSets for plastic correspond to five different PPPs. They focus either on cost, different quality aspects, or carefully balanced compromises.

EOS provides the specific values for the different PPPs on M-Base, a well-established public database in the plastics industry. M-Base is accessible via the EOS website at www.eos.info; click on the link to the MaterialDataCenter and select EOS from the database in order to go to the PPPs.



Exhaustion bend for EOSINT P 800
Material: PA 2200 (source: EOS GmbH)

TopSpeed

(180 µm layer thickness) – highest productivity

TopSpeed is a parameter set for parts with medium to high quality and mechanical load requirements as well as high cost pressure. It is well suited for parts where high productivity is a priority. Particularly large and relatively thick-walled parts can usually benefit from the fast build-up rates at this layer thickness, mostly without any noticeable impairment. In comparison to today's usual 120 µm layer thickness, production costs are typically 15 to 20 per cent lower. This layer thickness also enables high levels of accuracy, making it ideal for parts sensitive to warpage.

Cone insert for EOS IPCM (Integrated Process Chain Management)
Material: PA 2200 (source: EOS GmbH)

Speed

(150 µm layer thickness) – good surface quality with a higher productivity

The Speed parameter set applies the classic 150 µm layer thickness which is popular and widespread on the market due to its universal qualities. This parameter set offers slightly higher surface quality than the TopSpeed parameter set and typically lowers production costs by 10 to 15 per cent incomparison with the current 120 µm standard.

Switch cover for FORMIGA P100
Material: PA 2200 (source: EOS GmbH)

Balance

(120 µm layer thickness) – good productivity and surface quality

The advantage of the Balance parameter set is its equilibrium. The layer thickness of 120 µm offers a perfect balance between production costs, mechanical properties, surface quality and accuracy. It is therefore suitable for parts with varying geometries, dimensions and requirements.

Small compensator for IPCM, FORMIGA P 100
Material: PA 2200 (source: EOS GmbH)

Performance

(100 µm layer thickness) – good productivity and surface quality

Performance is the parameter set of choice for parts with high demands on mechanical properties and fracture behaviour, especially when the part will be subjected to multi-axial loading in all three directions. Performance parts are characterized by the highest degree of isotropic strength and rigidity. The choice of 100 µm layer thickness results in fine resolution and also very high surface quality and detail resolution.

Chain conductor for EOSINT P 390
Material: PA 2200 (source: EOS GmbH)

TopQuality

(60 µm layer thickness) – high surface quality and detail resolution

This parameter set takes AM to a new level. Very small- to medium-sized parts with extremely fine, fragile geometries and geometric elements and the strictest requirements in surface quality are best served by this parameter set. It applies a layer thickness of 60 µm, which is approximately the thickness of a grain of the plastic powder normally used today. The typical stair-step effect on upward and downward-pointing geometry elements is significantly reduced when using the TopQuality parameter set. The mechanical attributes of TopQuality parts are thus gratifyingly close to the levels of Performance parts.

Optional features for plastic applications

The new EOSINT P 7xx and EOSINT P 3xx series systems can be upgraded with significantly improved process modules to optimally support the PPP strategy. A completely re-engineered laser optics module – called the Surface Module – improves the quality of vertical surfaces in regions which until now have been exclusive to parts build on the FORMIGA P 100. FlashRecoating, a new x-axis control, further increases productivity by accelerating the recoating speed up to 400 mm/s when the TopSpeed and Speed parameter sets are used. Based on speed optimization of build-up rates, volumes of up to 700 cm³/h are achievable. FlashRecoating is available for the EOSINT P 760.

The recoating unit in the EOSINT P 395 has also been further improved. The introduction of PPPs has led to the integration into the EOSINT P 395 of EOS' highly successful blade cartridge concept that was introduced in 2007 in the EOSINT P 730, making it simple to carry out adjustments and change the layer thickness.

Additional hardware requirements

	TopQuality	Performance	Balance	Speed	TopSpeed
Surface Module [1]	Required	Required	Recommended	Recommended	Recommended
FlashRecoating [2]	Not applicable	Not applicable	Not applicable	Required	Required

[1] Available for EOSINT P 395 and P 760 [2] Available for EOSINT P 760

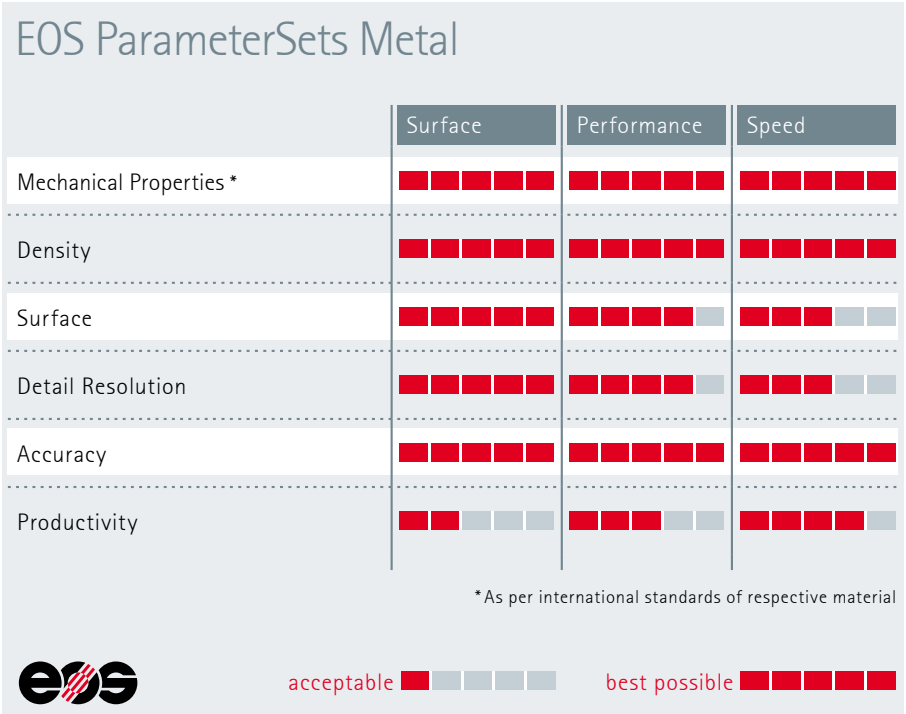
EOS ParameterSets for Direct Metal Laser Sintering (DMLS)

EOS ParameterSets are also available for Direct Metal Laser Sintering (DMLS) on EOSINT M 270 Dual Mode and EOSINT M 280 systems. Parts produced with EOS ParameterSets are very dense and the mechanical and thermal properties are almost identical, thus also meeting international standards for the respective materials. Each material is assigned one or more ParameterSets with corresponding PPPs. These PPPs typically include the following groups of properties:

- Geometric properties such as minimum wall thickness and surface roughness
- Mechanical properties such as tensile strength, yield strength, elongation at break, modulus of elasticity and hardness, and where applicable dynamic fatigue life
- Thermal attributes such as thermal conductivity, specific heat capacity and thermal expansion coefficient
- Properties affecting cost such as build-up rates (mm^3/s)

These properties are given for different states wherever relevant, for example before and after defined heat treatment. The specific values are defined in the respective material data sheets which are available from EOS on request (email to info@eos.info).

EOS ParameterSets Metal



Lightweight turbine cover door hinge for Airbus A380
Material: EOS Titanium Ti64
(source: EADS/EOS)

Tooling insert for child cup
Material: EOS MaragingSteel MS1
(source: Polymold)

Jewellery chain
Material: EOS StainlessSteel 316L
(source: Towe Norlén)

Speed

(30-60 µm layer thickness) – higher productivity, good surface quality

The Speed ParameterSet represents a good compromise between building speed and surface quality. The building time is shorter compared to the Performance ParameterSet.

Performance

(30-40 µm layer thickness) – good surface quality

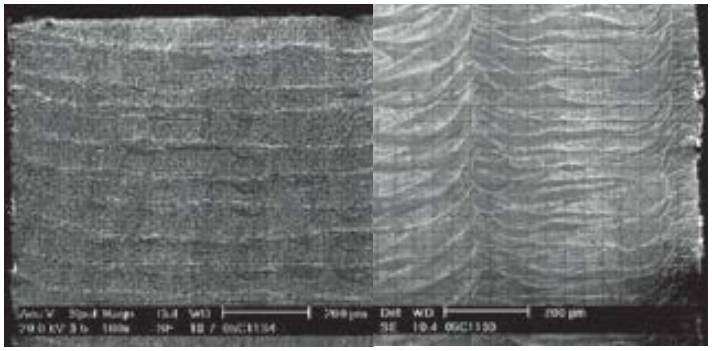
This parameter set is ideally suited when the focus is good surface quality. Compared to the Surface ParameterSet, it offers a higher productivity due to thicker powder layers which helps to reduce production costs.

Surface

(20 µm layer thickness) – fine details, high surface quality

Compared to the above parameter sets, the Surface ParameterSet is built with the lowest layer thickness. Therefore, it is the perfect choice for parts that require fine and high detail resolution and best surface quality.

SEM micrographs of EOS CobaltChrome MP1 parts built with different parameter sets



Left: build with 20 µm layer thickness throughout the entire part.
Right: build with 40 µm layer thickness in the core for rapid build-up combined with 20 µm layer thickness in the skin and contour regions for high surface quality. In both cases the metal was fully melted and the resulting parts are almost pore-free.

Summary: Your Advantages

The EOS ParameterSets with their defined PPPs bring plenty of advantages to the AM process of laser sintering:

- For the designer, who can now access standardized property profiles at any time as well as the corresponding material values relevant for dimensioning.
- For people in purchasing and quoting, who will profit from the clearly defined quality levels. These will make quotes comparable, the quoting process more efficient and eliminate expensive misunderstandings.
- On the manufacturer's side, the PPPs will also increase efficiency and reduce costs for data preparation and production planning. Other aspects of data preparation can be automated because the allocation of the parameter sets will already have been prescribed by the designer with the choice of a PPP. The validity across a number of systems of the PPPs creates flexibility in production planning.
- Finally, the quality assurance processes also profit from the defined standards and improved transparency.

The ExposureEditor with its start values enables a high level of flexibility and openness so that customers can meet their specific requirements and implement customized optimizations. The integrated editing function allows parameters to be modified in the exposure settings, and the modified parameter sets can then be implemented in the EOS systems.

Only process-critical parameters are protected. The start values can be used to execute a standard building job. Customers are granted additional freedoms through the EOS Custom ParameterSets, which allow tailor-made solutions: EOS develops a parameter set for the customer's planned application, based on customer specifications and the required part quality. This model protects the customer's intellectual property and uses a licensing model that allows the customer to control usage and payments. It includes protected as well as editable parameters.

The EOS ParameterSets and their PPPs enable a standardization of part properties, since they guarantee defined PPPs. Overall, the concept offers a real choice between the need for a standardized and ready to use parameter set and the possibility to edit company and/or application-specific parameter sets with the help of EOS.

Overall, AM as provided by EOS is taking another important step towards becoming a fully established manufacturing method which, due to its unique strengths, can help improve established products and processes and then enable the creation of completely new products.

Authors

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Florian Pfefferkorn graduated in mechanical engineering at University of Applied Science Munich, Germany where he wrote his thesis on "Production Planning and Control in the Foundry Industry." After two years working in quality management for Ariane 5 booster production, Florian started his career at EOS GmbH in 2001, where he developed customer applications for plastic laser sintering. In 2003 he took over responsibility as a Product Support team leader for plastic laser sintering. In 2005 he became Product Manager for the EOS plastic laser sintering product line. He has more than 16 years of experience in the Rapid Prototyping and manufacturing industry.

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Joseph Weilhammer studied mechanical engineering at Technical University Munich, Germany where he prepared his diploma thesis on post-processing methods for Direct Metal Laser Sintering (DMLS) tools and parts for EOS GmbH. In 1996 he joined EOS, working in the DMLS development department. Then he moved on to the application department in 2007 and became Product Manager for DMLS technology. He has more than 16 years of experience in the Rapid Prototyping and manufacturing industry.

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