

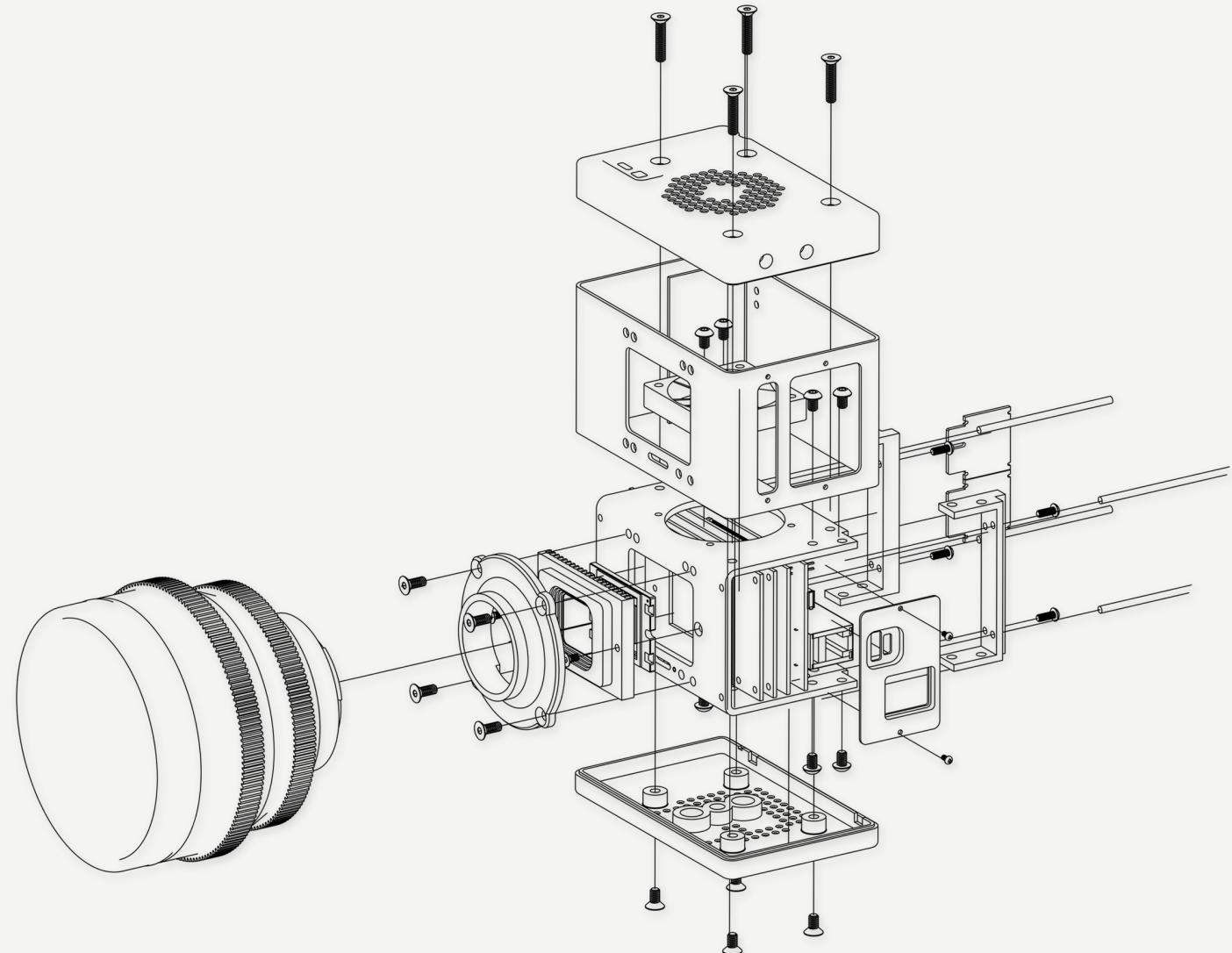
AXIOM Beta

Product Brochure

A comprehensive introduction to the world's first open source, open hardware, digital cinema camera.

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www.apertus.org



Community Driven

From the humble beginnings of a forum thread yesterday, to pioneering cutting-edge technology today, the AXIOM community has refined a powerful and versatile camera built for film-makers by film-makers.

[Project Background](#)

Introduction

The AXIOM Beta is the world's first open source, open hardware, digital cinema camera. It comprises a sophisticated, modular component architecture, hosts the Linux operating system on-board, and can be reconfigured to meet the demands of a wide range of specific use applications.

When the community began the process of designing a camera it was agreed that its most important design features would be for it to be completely open to scrutiny and made freely available so that anyone had the ability to copy, redesign, develop further, or upgrade its individual components, and for its users to have the freedom to control, examine and optimise data capture and processing.

Building on these principles a camera that can evolve continuously was gradually brought to life.

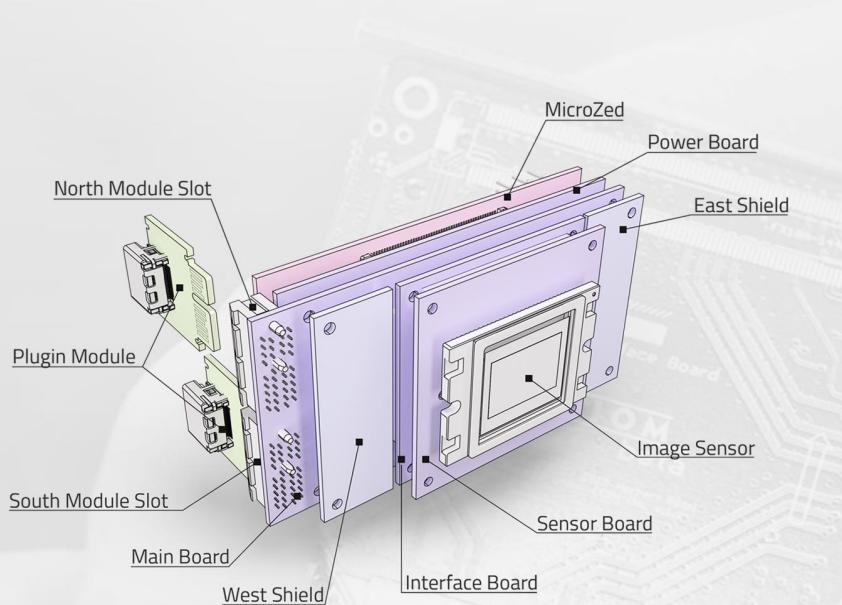
Professional applications for the AXIOM Beta are typically, but not limited to, environments suited with compact form-factor, high performance cameras e.g. aerial recording, car mounting, gimbals, cranes, jibs, cable cams, action cams, handheld etc. The camera is used in various configurations across all sorts of disciplines, e.g. film-making, photography, astronomy, aerial mapping, scanning, industrial and scientific fields. With a small form factor, the AXIOM Beta is also ideally suited to environments where DSLRs have become commonplace.



Specifications

Image Sensor :	ams Sensors Belgium CMV12000 - 4K resolution, Super 35mm diameter, global shutter with up to 300 frames per second at full resolution (This sensor has been used for research and development purposes but more options will become available. For other compatible alternatives see Wiki: Image Sensor Table)
Lens Mount:	Passive E-mount Compatible with mechanical adapters to accommodate every manual lens, active lens mounts planned for the future.
Camera Control:	SSH WebGUI (Smartphone, Tablet, Laptop, etc.) AXIOM Remote
Expansion:	2x High-speed plugin module slots 1x Medium-speed shield slot 1x Low-speed shield slot 2x Center Solder On (CSO) modules
Expansion Modules:	Single HDMI 1080p60 (4:4:4) output plugin module Dual 6G SDI output plugin module (in development) Genlock, Trigger, Timecode, LANC shields (in development) 4K Displayport/HDMI plugin module (in development) CSO Module for Motion Tracking (3D Accelerometer, 3D magnetometer, 3D gyroscope, air pressure e.g. for 3D tracking or image stabilization) (in development) 3x PMOD debug plugin module 1x PMOD debug plugin module
General Connectivity:	USB / Serial Console / Gigabit Ethernet / WiFi (optional)
Internal Image Processing:	Matrix color conversion Look-Up-Tables (LUTs) Fixed Pattern Noise (FPN) compensation False color display Overlays
Hardware Architecture:	Xilinx Zynq 7020 based MicroZed FPGA + Dual ARM Core
Operating System:	Embedded Linux (Arch)
Power Supply:	5V DC supply module (swappable) Wide input voltage range module 5-40V (planned)

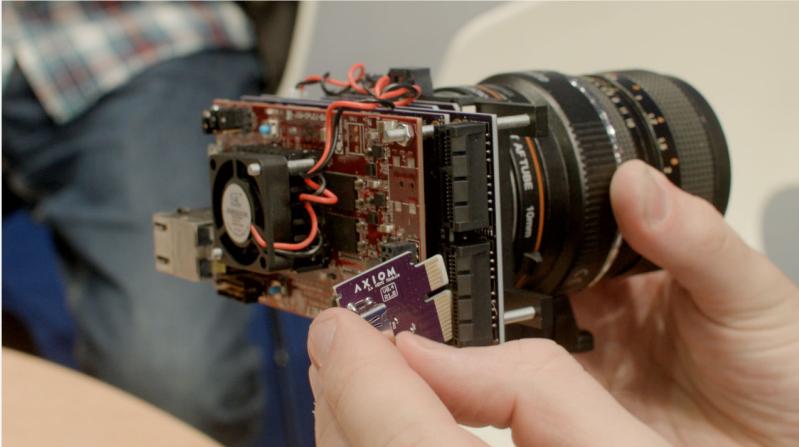
Camera Structure



The AXIOM Beta comprises five main printed circuit boards (PCBs):

1. The **Image Sensor Board** hosts the camera's sensor - For research and development the ams Systems Belgium CMV12000 (4K, 12 bit, Global Shutter, Super35/APS-C, 300 FPS @ 4K) was used. Additional modules with different sensors are in development.
2. The **Interface Board** acts as a bridge between the image sensor board and the rest of the camera. It converts communication between the aforementioned components to a standard protocol so that almost any image sensor that becomes available in the future can be used with the AXIOM Beta without replacing the rest of the hardware. For example, if AXIOM users in the future felt that 8K was in demand they would simply swap the sensor board for one capable of capturing images in that desired resolution.
3. The **Main Board** is the equivalent of a PC's motherboard. It hosts two external medium-speed shield connectors and two high-speed plugin module slot connectors. These act as a central switch for defining where data captured by the sensor and other interfaces gets routed to inside the hardware. In this regard, all specifics can be dynamically reconfigured in software opening up a lot of new possibilities such as adding shields for audio recording, genlock, timecode, remote control protocols or integrating new codecs and image processing inside the FPGA. In the centre of the main board a 'solder-on' area has been incorporated, this will for example host chips capable of sensing the camera's 3D orientation and acceleration (the same chips used to stabilise quadcopters and track head movements in VR headsets). Being situated directly behind the image sensor centre means that these sensors are ideally positioned to supply data for image stabilisation or metadata about the camera's orientation and movement during a shot.
4. Finally, the **Power Board** PCB, the last board in the stack before the MicroZed™, generates all the different supply voltages for the chips and logic on the other PCB's inside the camera. It also monitors currents so when using batteries it can estimate remaining power based on the recorded consumption. In the current revision of the camera a predefined set of supply voltages matching the current application with the rest of the camera have been generated, in the future however, it will be possible for users to dynamically reconfigure voltages according to their needs through the camera's software.
5. The **MicroZed™** is a development board based on the Xilinx Zynq®-7000 All Programmable SoC (System-on-a-Chip). It can be used as both a stand-alone development board for SoC experimentation or in a product like the AXIOM Beta.

Modules and Shields



Completed Modules

1x PMOD Plugin Module: Single PMOD debug inputs/outputs for connecting a wide range of external PMOD devices - mainly intended for development and testing when General Purpose Input/Output (GPIO) is required.

1x HDMI Plugin Module: The AXIOM Beta can accommodate two 1080p60 4:4:4 output HDMI plugin modules and supply each with independent video streams.

3x PMOD Debug Plugin Module: Triple PMOD debug inputs/outputs for connecting a wide range of external PMOD devices - mainly intended for development and testing when General Purpose Input/Output (GPIO) is required.

Debug Shield: 2x10 GPIO banks as LED indicators plus two power LEDs. 4 LVDS pairs routed to external connectors JP1/JP2 (plus one GND).

The AXIOM Beta has two high speed module slots with PCIe connectors (these are not really PCIe cards, we just utilize PCIe for the connectors). Each module has a total bandwidth to/from the main processing FPGA of at least 6 Gbit/s. This makes the modules perfect for dealing with high bandwidth video outputs like HDMI/Displayport/SDI.

The name shields was inspired by the Arduino plugin boards that are also called "shields". AXIOM Beta sports two shield slots with space for connectors going to both sides of the camera. In contrast to modules the shields in the Beta have slow and medium speed interfaces to the main processing FPGA, and, therefore, are perfect for tasks like: trigger IN/OUT, genlock IN/OUT, timecode IN/OUT, sync IN/OUT or connecting external sensors or buttons, LCDs, etc.

Due to the flexibility that this arrangement provides this could also allow us to create a dedicated solid-state media recorder module in the future. For now the AXIOM Beta relies on external recording though.

The AXIOM Beta has 2 medium speed IO interfaces to be used in conjunction with "shields".

Modules in Development

SDI Plugin Module: An industry standard serial digital interface (SDI) connection plugin module will provide a nominal data transfer rate of 3G/6G.

Triple DisplayPort Link Plugin Module: Three independent DisplayPort Links act as diverse video output ports. Also supports adapters eg. to HDMI directly.

4K HDMI Plugin Module: Allows recording 4K/UHD video on an external recorder with a standard 2160p signal. Will also work to supply 4K/UHD screens with a signal of course.

USB 3.0 Plugin Module: (1 Plugin Module Slot) Offers 3.2 Gbit/s throughput which corresponds to 400MByte/s, enough to record uncompressed 4096x2160 raw 12 bit video at 25 FPS to a connected computer.

Genlock, Trigger, Timecode, LANC shields.

Applications



Several pioneering organisations in the technology sector work with the AXIOM Beta because it allows them to reconfigure a camera around their own hardware designs whilst also maintaining high quality video data capture. Being able to process data onboard, and seamlessly integrate the camera's Arch Linux operating system with other devices running in conjunction, brings a tremendous degree of freedom when compared with existing cameras.

Example Case Study

"In the interests of safety the pre-certified flight pods we attach to the wings of light aircraft are tightly regulated. For our purposes (aerial mapping) using more typical cameras is impossible, but thanks to the flexibility of the AXIOM Beta we were able to reconfigure its PCBs and utilise three cameras, each filtering its own band of spectral data to our custom software systems." - Anthony May, Mavrx Inc.



Mavrx adapted the AXIOM Beta by rotating and moving its sensor then removing one of the PCBs. This allowed them to fit three Betas, a DSLR and a Control and Image Storage Computer snuggly into their airborne camera pods. Ingenuity and collaboration helped them prototype a next-generation, multi-spectral camera system.

For more examples of the camera's flexibility see our [Case Studies](#).



AXIOM Beta Developer Kit

This version of the camera is suitable for anyone who'd like to work on development, reconfigure its software and or core components, or build their own enclosures etc...

Developer Kits are supported by a custom CNC-milled skeleton framework and provide easy access to the camera's printed circuit boards - With this in mind associated design files, board layouts, BOMs, CAD models, software source code repositories, etc. are all made freely available.

€ 3,990 (excl. VAT + free shipping)

[Purchase.](#)



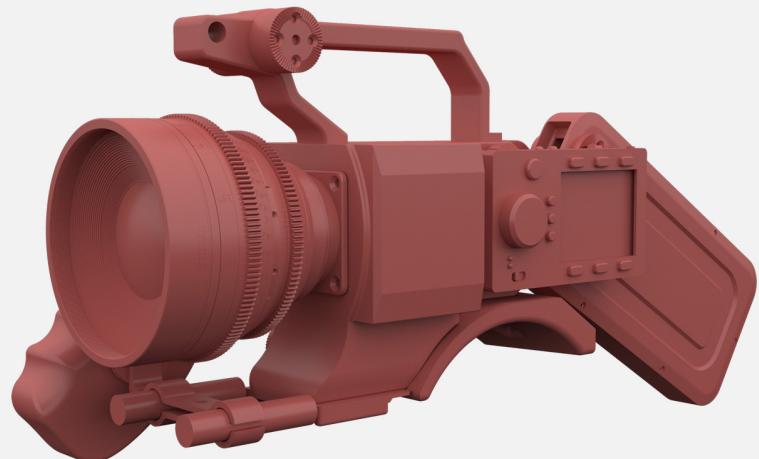
AXIOM Beta Compact

This enclosure option provides a solid but lightweight aluminum layer around the camera's electronics and incorporates several mount points and future expansion slots. Individual modules are swappable (eg. lens mount, plugin modules) and extra care has been taken to use screws instead of glue so that customisation, and, should the need arise, simple repairs are made easy.

AXIOM Beta Compact is purpose-built for rig integration and general in-the-field protection, making it ideally suited to most photo and video production environments.

€ 5,990 (excl. VAT + free shipping)

Enter an email address to receive a pre-order notification.



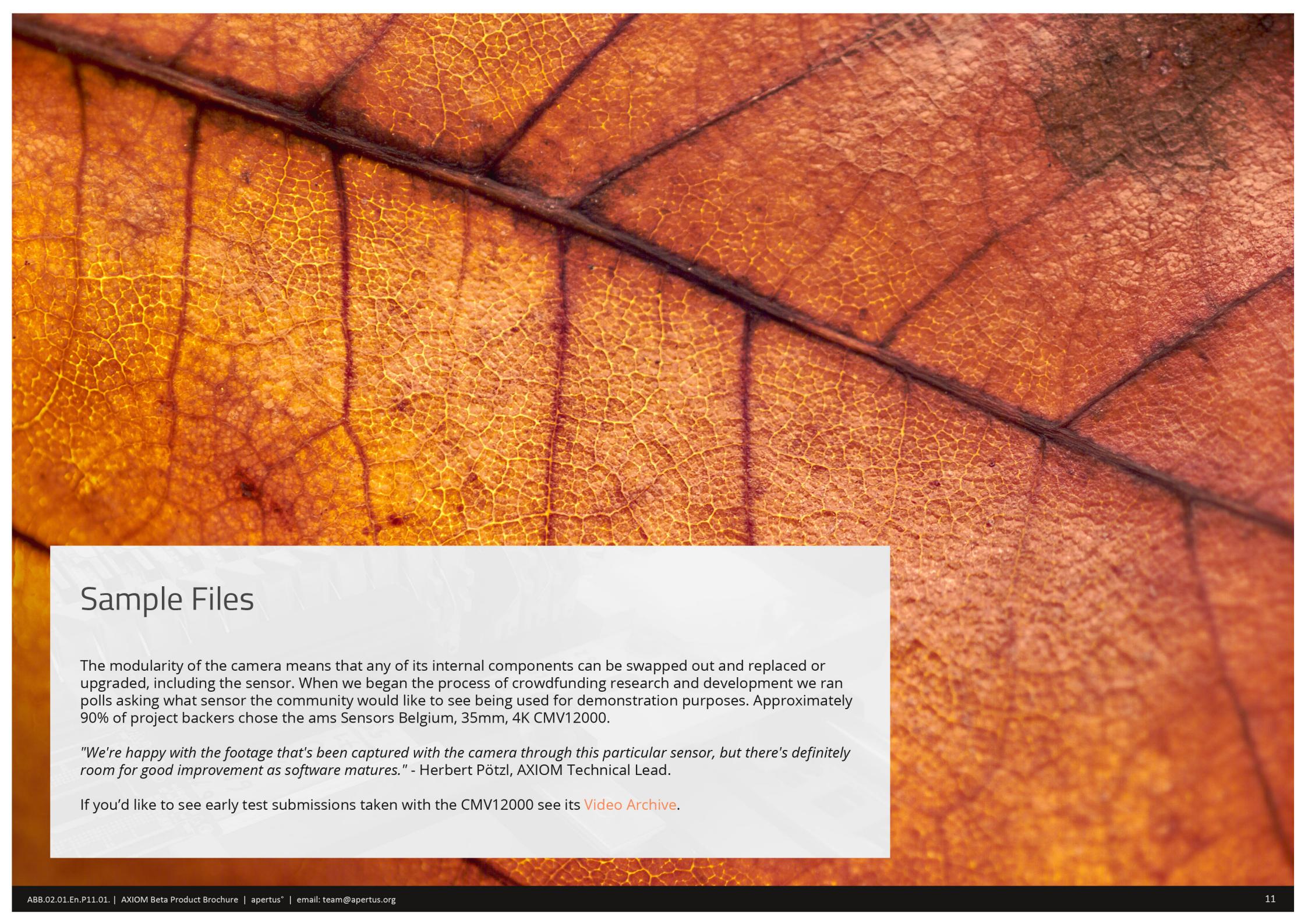
AXIOM Beta Extended

Currently in a state of early development, and inspired by the 35mm film magazines of yesteryear's golden age of analog film cameras, this enclosure is ideal for any film production scenario and rests well on the DOP's shoulders. With ergonomics in mind and providing space for a more sophisticated airflow system, AXIOM Beta Extended is a camera and integrated AXIOM Recorder combination that plans to incorporate an INTEL NUC and 2.5" SSD(s). AXIOM Recorder module can be attached in various locations around the enclosure and at different angles.

Price to be determined.

[Enter an email address to receive a pre-order notification.](#)

Above images are concept renders and as such are subject to change as improvements are made.



Sample Files

The modularity of the camera means that any of its internal components can be swapped out and replaced or upgraded, including the sensor. When we began the process of crowdfunding research and development we ran polls asking what sensor the community would like to see being used for demonstration purposes. Approximately 90% of project backers chose the ams Sensors Belgium, 35mm, 4K CMV12000.

"We're happy with the footage that's been captured with the camera through this particular sensor, but there's definitely room for good improvement as software matures." - Herbert Pötzl, AXIOM Technical Lead.

If you'd like to see early test submissions taken with the CMV12000 see its [Video Archive](#).

Feedback

"Seriously, this is one of the coolest and most advanced open hardware projects I have ever seen.

The AXIOM is professional-grade gear. Quality components, highly capable, with headroom to grow because it runs Linux. A respectably complex product and it's great to see technical Wiki and LaTeX documentation to accompany the camera advanced and complete. Comparing to computers (even though it basically is one on its own), the comparison is not hobbyist, single-board computers, the better comparison here is some insane Pogo Linux Server or a System76 powerhouse laptop or workstation."

- Harris Kenny, Lulzbot/Aleph Objects Inc.

"The most interesting aspect of the AXIOM cameras is that, because they're infinitely upgradeable, they have the potential to be the last camera you will ever need.... They won't eventually become technologically obsolete like most cameras."

- Robert Hardy, NoFilmSchool.

"This whole idea is crazy awesome and gives the power back to the people on a new level... With existing manufacturers a few specialists decide how images should look, what camera innovation is, and what features to present to the market next. They cripple cameras to increase sales for instance. apertus° Axiom opens up everything and creates a platform where everybody can contribute. Every single aspect of what a camera is will be questioned and innovation can take place on many levels. Ideas can come from all kinds of backgrounds, cultures and personal experiences and people can contribute just on a single tiny aspect of the camera. Well done apertus° and I hope this will be a huge success. This is open source at its best."

- Bart van den Boogaard, videographer.

"The beauty of an open source camera to me is a step back toward the dark room, in which making the tools is part of the joy of making the art."

- Lee Parker, cinematographer.

"We need a camera that is fully customisable. I can build my PC, pick every single part to fit my needs and upgrade each part as and when needed. I know cameras are more complex than that but it would great to just upgrade the AF system, or upgrade to a new sensor instead of buying a whole new camera."

- Adam Cross, stills photographer.

"Everyone should support the development of this camera and others like it. Why? Because the existing companies need something to break up their monopolies within the industry. It's time. By supporting open development, you are taking an active role in helping to increase competition and drive down prices. This camera system is built on the premise "for filmmakers, by filmmakers", not returning shareholder investment."

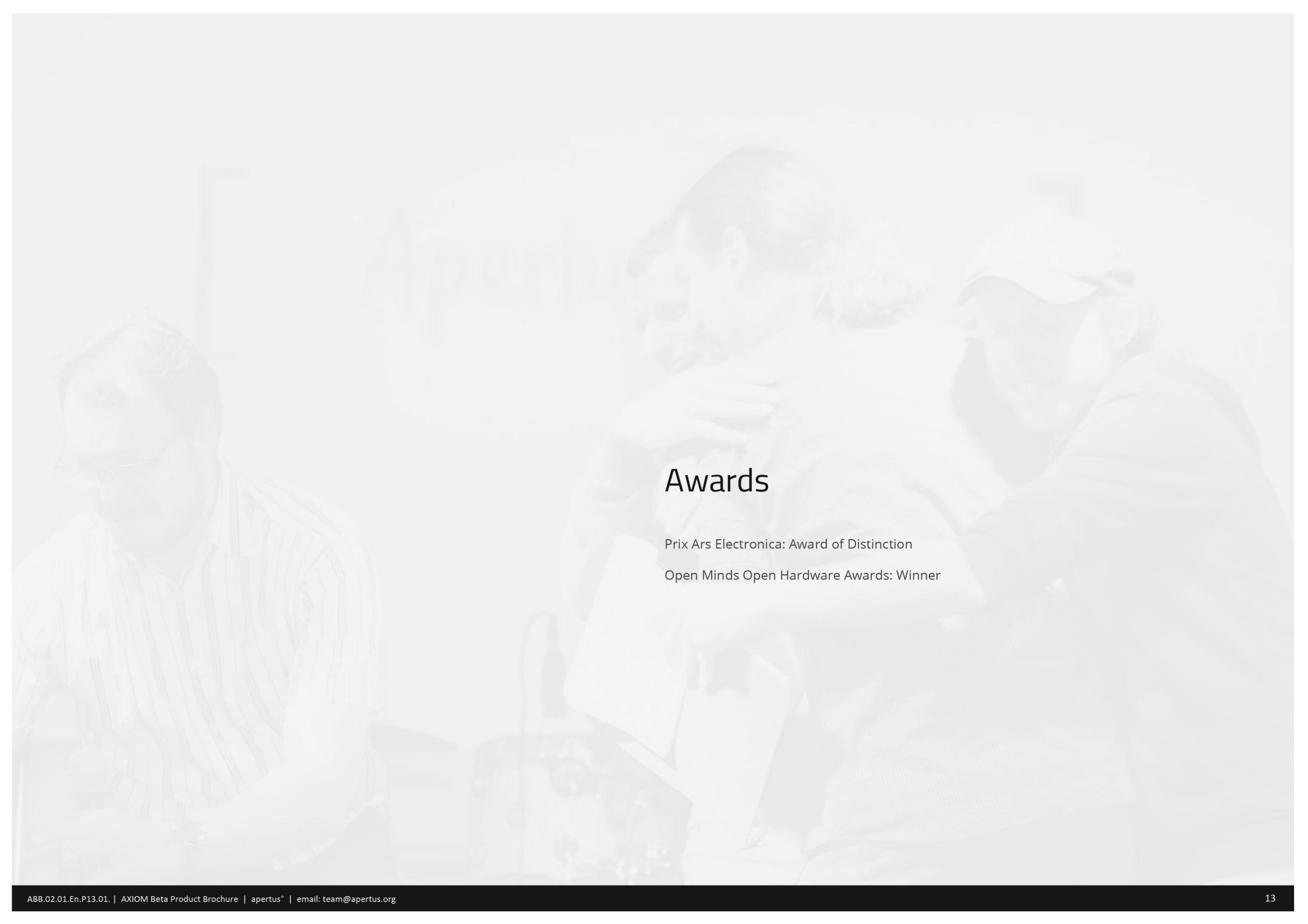
- Matthew Hartman, film-maker.

"... regardless of the open source aspect of the project, it's different to other cameras because of how they implement the hardware. Whereas [other manufacturers] use their own ASICs (Application Specific Integrated Circuits) for the image & data processing, the AXIOM Beta uses an FPGA (Field Programmable Gate Array)... With an FPGA you can change the entire operation of the camera down to how it handles handshakes with the analog-to-digital converters from the sensor. Thus, the apertus° team can continuously provide updates and new features easier than any other manufacturer."

- Anthony Kouttron, Salvaged Circuitry.

"More importantly, it will get that resolution with 15 stops of Dynamic Range, shooting it in up to 132FPS RAW 12-bit, or 300FPS 10-bit. There's nothing - NOTHING within its price range that competes with that. The color science is looking very good thus far as well. But we do need to see more - ungraded and graded. On the software side, this camera is using something very well established among hardcore users - Magic Lantern. Pretty likely they've got the software aspect covered well."

- Nate Sorrentino, film-maker.



Awards

Prix Ars Electronica: Award of Distinction

Open Minds Open Hardware Awards: Winner

Mission Statement

Foundation

Our intention is to create affordable, free software (FOSS) and open hardware (OSHW), digital, motion picture technology for the professional production environment. All the things we pioneer or learn on this path shall be shared and made available to anyone.

Open Networks

We establish networks around open source technologies in the area of audiovisual media production so that the entire community stands to benefit.

Fundamental Freedoms

The apertus° project is based on software that's free to be used for any purpose - Free to be studied, examined, modified and redistributed (which includes the prospect of users distributing their own modified versions of software and hardware).

Conscientiousness

Reuse instead of reproduce - We will make sure all our parts/products are properly recyclable and, if not otherwise possible, properly disposable.

In an effort to reduce the carbon emissions produced in relation to logistics local facilities and services are used for our production process.

Free

The apertus° association proudly serves the common good and does not seek profit in any way. It has been created to support and nurture the creation and distribution of knowledge. We release all of our software under the GNU General Public License V3, all our documentation under the Creative Commons License, and all hardware under the Cern Open Hardware License.

Associated

The association is run by a set of rules - our Association Bylaws. These clearly define what can and cannot be done and establish a fundamental, democratic organisation structure. The board of directors run the association and are elected by association members.

Respecting Privacy

We will not limit privacy or freedom. To correspond we favour platforms or technologies that also do not limit privacy or freedom. Organisations that fail to respect user privacy risk being avoided and/or disregarded.

Fair Labour

Endorsing fair labour - We do everything we can to make sure people are not exploited when working with us. This includes selecting companies that exercise fair labour as contractors (fair trade).

We endeavour to boycott the use of toxic chemicals in our manufacturing and assembly processes. In addition, when working with third parties, we favour organisations that also live up to these

Empowering

We seek to empower users by helping them reclaim the liberties that proprietary manufacturers have previously and routinely taken away. We will not exploit the users of the tools we develop. As such we will not engage in or adopt conventional, for-profit growth strategies e.g. the planned obsolescence of products, limiting the functionality of products, etc.

Cultivation

We actively cultivate: free technology, free information, free education, free knowledge, free culture, free arts, etc. This requires that everything we create shall be freely available to anyone. Where possible we favour platforms, technologies and services that also live up to these ideals.

Fairness

We will not charge unreasonable prices for products or services.

Open Infrastructure

Where possible we use open source applications for internal design, communications and web related workings.

Contribution

Anyone is free to contribute towards and help steer project developments.

If you'd like to assist the project by getting directly involved please see [Join The Team](#).

As the apertus° Association is a non-profit organisation there are limits to what can be achieved without a certain amount of financial contribution. For example the acquisition of essential hardware and licenses such as safety certs, and paying for external services like prototype manufacture, all require funding. There are aspects to project development that stand a greater chance of completing more quickly where the Association is able to ensure that these costs are met. apertus° Association's finances are handled transparently and accounts are reviewed and approved by an independent registered auditor annually. Individuals aren't able to profit from donations.

If you'd be willing to help in this way then please see [Sponsors](#)... and thank you.

In the event that you're in a position to donate or loan the project vital equipment then the gesture would be gratefully received. Please [contact us](#).

For any other queries or enquires feel free to email team@apertus.org