

PHASE ONE INDUSTRIAL

Analog vs. Digital – the Facts Add Up

Introduction

With so many changes caused by the digital revolution, occasionally one has to ask if a change is just for the sake of change or if it is a means of improving the quality of and cost of the deliverables. Before a conversion to digital happens, a cost-benefit analysis has to be undertaken to determine if the switch makes sense from a financial point of view, otherwise, one simply has to follow the age-old advice, “If it ain’t broke, don’t fix it.”

When looking at aerial data acquisition, various factors contribute to the decision on switching from analog to digital:

- Cost of acquiring images
- Accuracy and quality of end product
- Speed of delivery
- Convenience
- Ease of integration and making the transition

Cost of acquiring images

The cost of acquiring images with a large format analog camera is mainly affected by two aspects:

- Cost and time of using film
- Operational flying costs

Assuming that film for large format analog cameras continues to be available, the costs of acquiring images will continue to rise as fewer sources of film and chemicals for processing must be supported by fewer users. Traditionally, when the demand drops for specific films and emulsions, the prices rise, until eventually the processing lines are shut down.

Cost and time of using film

Below is a breakdown of average prices for film, processing and scanning. The prices are based on external suppliers performing the work and do not include the cost of acquiring, managing and maintaining this equipment in-house.¹

Analog		Digital
Film	\$6.00	\$0
Processing	\$10.00	\$0
Scanning	\$20.00	\$0
Total cost per image	\$36.00	\$0

Digital images are also processed, but this process is largely automated and conversion to TIFF files can be performed in-flight. This quick look at pricing does not include post-processing, which is done for both digital and scanned images.

Operational flying costs

Beyond the extra costs associated with using film, the larger and heavier analog camera adds additional costs to acquiring images.

- A large format analog camera typically weighs in excess of 250 pounds (113 kg) adding weight to the aircraft. Carrying such a heavy camera means flying a much larger aircraft than is needed for a medium format digital camera. A Phase One medium format camera weighs less than five pounds. You may choose to switch to a lighter aircraft or even an ultra-light, gyro copter or UAV. Smaller aircraft have significantly lower operation costs, reducing your overall costs in bidding on projects.
- Flying with a lighter load on a larger aircraft enables you to take more gas, which translates into longer assignments, which can add to the efficiencies of medium format cameras.

Accuracy and quality of end product

A comparison of analog to digital outputs is difficult, because digital technology is cutting edge, while film camera technology stays frozen in time and has not developed in many years.

Accuracy

One of the differences between analog and digital cameras is that digital cameras do need to rely on an elevation height baseline (H/B) ratio for accuracy. With large format analog cameras, a minimum of a 60 percent overlap is needed to form the basis for stereo pairs with enough tie-points to produce accurate results. To increase the accuracy, a greater overlap is needed, which causes the price of the project to rise dramatically, due to the film, processing and scanning costs. With a medium format digital camera capturing more overlapped images, the added redundancy produces more stereo models. The

¹ Contact Phase One Industrial for specifics calculations.

additional data used for calculations contribute to greater accuracy. And with automated post-processing and, users of medium format digital find that mismatches can be discarded, thus improving the accuracy for more stable triangulation.

Users of Phase One aerial cameras find the accuracy to be one of the outstanding features. In order to determine just how accurate the cameras are, a photogrammetry surveying firm performed an evaluation of the accuracy using an iXA180-R-50. An area of five square kilometers was used and 20 ground control points and 28 test points were utilized. The GSD was five centimeters. The accuracy results were: RMSx=3.7 cm RMSy=3.3 cm, RMSz=4.8 cm. These numbers, which are better than one pixel accuracy, conform to ASPRS accuracy requirements for accurate engineering measurements.

High dynamic range

Digital sensors and the 16 bit readout they offer today results in a high dynamic range. This means that digital captures offer a greater color and light level gamut than film captures. Film images with very bright areas or strong shadows might not be recoverable, but digital images can offer a recovery that might require a reshoot of a film-shot mission.

This is one of the very strong benefits of digital sensors today, as it allows users to fly missions under poor light conditions. If a rapid response is needed, this could be the difference between flying or being grounded.

Styles

RAW images captured with Phase One aerial cameras can be converted to TIFF files with any of the Phase One software solutions, including the popular iX Capture. When converting RAW files, Lens Cast Calibration (LCC) and a number of other “styles” can be applied to the images, creating results that are far superior to analog images.

Speed of delivery

The time to deliver projects today is one of the most crucial aspects of the airborne photogrammetric business. Customers are used to the quick turnaround of digital shooters and have come to expect the elevated level of service.

Shooting digital means:

- No need to ship film to and from the processing lab (If you don't have your own film processor).
- Zero time allocated for processing film.
- No chance of film being damaged in the processor or en route to a lab.
- No scanning time.

Digital cameras eliminate much of the risk and at the same time speed up the delivery time of the final images. In fact,

the turnaround time needed for some projects is so short, some analog users are unable to take on these projects. Users of Phase One aerial cameras and iX Capture can process files in-flight, using preset digital processing recipes. The faster you can hand over deliverables, the faster you can invoice.

Big cameras have big problems

With big cameras, come big problems. Sending an analog camera out for maintenance (if parts are available) and calibration can be a logistical nightmare that comes with an expensive price tag. The camera needs to be placed on a pallet, boxed up and then the entire 500 lb shipment has to be sent to the repair depot for maintenance.

Every three years, large format cameras needs to be sent to the USGS for calibration, adding to the possibility of the camera being damaged in transit.

A Phase One aerial camera comes in a rugged travel case that can be easily hand carried or used to ship the camera for maintenance. Calibration is performed quickly and inexpensively, enabling users to get back to making money by capturing images.

The mechanical process of winding a roll of film through a camera, then winding it through the rollers of a processor is fraught with hazards. A small particle on a roller or rack can cause a scratch on the film or negative that when fixed with Dust and Scratch removal software, can cause a loss of details that may represent an important aspect.

The process of developing the film involves a winding a roll of film through a soup of chemicals that must be closely monitored with control strips that are checked on a densitometer. If the processor is defective, it can affect the film during processing, causing a color or density shift between images. If the fault happens during the run, the head or tail of the film can look radically different, or even destroyed completely.

Clear advantages

Using a Phase One aerial camera offers many advantages over film. Besides the lower material and operational costs, the digital system enables users to accomplish some things that were impossible with analog systems. Below are just a few examples.

Real time monitoring

With digital cameras the real time monitoring of captures gives the pilot/operator a confidence that does not exist with film. Although large format analog cameras have a long history and might be robust, a simple error can cause a failure that can't be spotted until the film is processed, sometimes days later. Viewing of images while being captured enables operators to change settings either manually with automatic functions.

Multiple camera arrays

An advantage large format users have after converting to medium format is that the mounts that hold large format analog cameras, when adapted for medium format use, can hold an array of two or more medium format digital cameras. This opens up the possibility of simultaneous captures of RGB and NIR or 3D oblique/nadir imagery.

ISO

Changing ISO from shot to shot is like having a camera loaded with multiple rolls of film with different ISOs. With a digital camera you are able to better respond to changing light conditions and get the job done, instead of being grounded, waiting for a change in weather.

An easy transition

Current users of analog equipment can take advantage of the experience garnered by thousands of other users that have successfully made the transition from analog to digital. Phase One partners with integrators around the world who can assist you in making the transition as they have with many other users.

The transition involved two steps:

- Integration of the camera with your aircraft and flight management system
- Adaption of new workflow

Below are the key components that need to be adapted.

Mount

Nearly all analog cameras use a gyro-stabilized mount for photogrammetry. Most of these mounts can be used for Phase One aerial cameras.

Since the size of analog cameras is substantially larger than a Phase One medium format camera, an adapter plate needs to be fitted to the mount. This plate can be purchased or easily created in a metal workshop. Phase One has downloadable drawings of all cameras in 2D or 3D (CAD) file formats on <http://industrial.phaseone.com/downloads-installation.aspx>. They can be used to create a plate/adaptor for your mount. The camera is then locked to the mounting plate with four M4 screws. If the mount requires a heavier weight, the mounting plate can be constructed to provide the extra weight needed.

An advantage analog users have is that the mounts that hold large format analog cameras, when adapted for medium format use, can hold an array of two or more medium format digital cameras. This opens up the possibility of simultaneous captures of RGB and NIR or 3D oblique/nadir imagery.

Trigger

Captures with Phase One aerial cameras can be triggered by a flight management system (FMS). Most flight management systems used with existing large format analog cameras can be used to trigger Phase One aerial cameras. If an FMS is not used, the free Phase One software, iX Capture, can be used to automatically capture images at predetermined time intervals.

IMU/GNSS

Phase One aerial cameras, like most analog large format cameras, utilize the mid-exposure pulse (MEP) to geo-reference images in post processing. The Phase One aerial cameras offer an advantage over analog cameras to improve projects and secure data by receiving data directly from the IMU/GNSS receiver and writing this data to the metadata of each image file. The benefit here is the fact that each image contains the geo-referencing data or geo-tracking data of its position and the angles under which it was taken. Normally all IMU/GNSS systems store this data for later post processing.

All Phase One aerial cameras come preconfigured to support the main systems used in the market, such as Applanix, NovAtel and IGI.

Power

All Phase one cameras work on 12 to 32 volt power and can be connected directly to the aircraft's power supply. Phase One recommends the use of a UPS between the camera and the aircraft power as aircraft power can be unstable. If the aircraft does not have a power supply, a small 12 volt battery, such as a motorcycle battery, can be used. Due to the low current consumption of the camera, the small battery will be sufficient to power the camera for thousands of images.

The integration of a Phase One camera into any system that had previously been used for large format cameras is very easy and can usually be performed in a single day.

Bottom line – just do the math

It is not surprising that today's market is ruled by digital cameras and that film-based photogrammetric cameras are fading out. The number of actively used large format analog cameras is shrinking every year while film costs keep rising. It will not be long before manufacturers of film stop producing aerial film. The analog method is slow and fraught with dangers, sometimes causing substandard results and the need to re-fly a mission.

At the same time, digital cameras have become more powerful and although the Phase One aerial cameras, are called "medium format", they rival the older analog film cameras in quality and efficiency.

Integration of Phase One aerial camera is easier than ever and the transition to digital is an opportunity to lower costs and increase revenue.

- No film costs
- No processing expenses
- No densitometry issues in processing
- No dust and scratches
- No boxing a heavy camera for maintenance
- No expensive calibration by USGS
- No heavy aircraft needed
- Higher dynamic range
- Ability to fly under poor light conditions
- Longer flights/fuel efficiencies
- Immediate verification of image/quality
- Easy adaptation to changing light conditions
- Fast file conversion
- IMU/GNSS data written to each file
- Fast production of deliverables
- Multiple camera configurations possible when switching to medium format
- Compatible with popular FMS and IMU/GNSS systems

To get a rough idea of the ROI, let's take the numbers listed above and assume that every analog capture converted to a scanned image is \$36.00.²

The list price of a Phase One iXU-R 80 MP with a 50 mm Rodenstock lens and the optional Forward Motion Compensation is about \$77,000.

$\$77,000 \div \36.00 is 2138 captures.

Every job is different, but if we take a line survey as an example, shooting a 400-mile pipeline or coastline at a GSD of 10 cm, the camera is paid for at the end of the project. If you shoot a lot of smaller projects, just calculate the savings and check out how fast you can start saving money.

If you take into consideration the savings from not having expensive boxing and shipping fees every time the camera needs to be repaired or shipped to the USGS for calibration, the occasional ruined or substandard film and missions that need to be reflown, the savings are even greater.

The facts add up

Switching from analog to digital is a straightforward task that has been successfully performed by many others before you. Phase One medium format aerial cameras not only present the opportunity for financial savings that you can realize in a short amount of time, but a digital workflow, which avoids issues such as dust and scratches, faster and more convenient turnaround times, which clients appreciate, added convenience and reductions of risks associated with analog technology and images that are truly outstanding.

Personalized analysis

I would be pleased to perform a personalized analysis of your workflow to show you how you can reduce costs and improve both service and deliverables by switching to a Phase One aerial camera.

Please contact me at kcl@phaseone.com or call me on my mobile at +1 631 662 6895 (PDT) for more details.

Ken Clickenger

North America Sales Manager

Phase One Industrial

² Based on prices for color film and no discount for multiple images

About Phase One

Phase One A/S is based in Copenhagen with offices in New York, London, Cologne, Tokyo and Hong Kong. Phase One Industrial is a division of Phase and is dedicated to research, development and manufacturing of advanced hardware and imaging software solutions that meet the unique requirements of aerial photography users.

To find out more about Phase One products, please visit <http://industrial.phaseone.com> and set up an appointment with one of our aerial photography experts for a demonstration.