The Leica RCD30 Medium Format Camera: Imaging Revolution

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ABSTRACT

The Leica RCD30 medium format camera is the first 60MP camera to acquire co-registered multispectral RGB and NIR imagery from one camera head. In addition, with its wide range of innovative features to support photogrammetric and remote sensing mapping applications as well as its configuration flexibility, the Leica RCD30 is set to open up a whole new world of opportunities.

1. INTRODUCTION

Since the introduction of digital mapping cameras over ten years ago, the majority of firms with a focus on the traditional segment of the airborne mapping market and who have made the switch from analog to digital data acquisition have opted for a so-called large-format digital camera with an across track performance of 11000 pixels and beyond. Smaller, so-called medium format cameras often equipped with a RGB Bayer array of up to 60MP have in recent years seen some significant growth as part of a LiDAR/imager package. Whilst together with a LiDAR they may have become an industry standard, as standalone mapping systems these medium format imagers have yet to make a comparable breakthrough.

Whilst there may be a plethora of obvious and viable reasons as to why these medium format imagers have not been accepted really well as standalone photogrammetric mapping cameras, let us look briefly at a few of these concerns and how they are currently been addressed:

- Standard Bayer arrays give limited area performance. As a consequence, multi-head systems using several camera heads would not only bring improved productivity but also flexibility.
- Although standard in commercial and professional photography, the image quality of Bayer arrays was (and probably still is) sceptically considered by at least some photogrammetrists. Today, with the help of the commercial photography markets, better post-processing algorithms have improved the image quality significantly. As a result, and as shown by the increase in LiDAR systems sold with a Bayer array imager, today Bayer array image quality is perfectly accepted in the world or airborne mapping.
- A cheaper design of the medium format camera in comparison to the designs of the much more complex large-format cameras challenged their suitability for photogrammetric mapping applications in terms of achievable stability, geometric accuracy and image quality when put under the stress of airborne applications. Despite these reasonable doubts, to date amazingly few manufacturers have introduced Forward Motion Compensation, stabilized lens systems and a specialized, more stable connection between lens and camera body.
- Lastly, and probably most importantly, an increasing number of photogrammetric projects today require co-registered four-band multispectral imagery in RGB and Near-Infrared (NIR). With traditional medium format camera designs this is impossible to achieve and an alternate solution is to fly a dual head configuration with one camera head producing RGB and one Camera Head producing Colour Infrared (CIR). Whilst this produces two set of images, both images can not be combined to four-band imagery, a standard deliverable with most large-format cameras.

- Effective July 2011, this has changed. The Leica RCD30 medium format camera is the world's first 60MP imager that produces co-registered 4-band imagery in RGB and NIR from one camera head and has a plethora of innovative features to support all types of airborne mapping applications, from photogrammetry to remote sensing.

2. THE LEICA RCD30 – IMAGING REVOLUTION

Although available in three configurations, at the core, the Leica RCD30 series consists of the Camera Head CH61 or CH62 and the Camera Controller CC31 or CC32 (Fig. 1).

Figure 1: Leica RCD30 Camera System with Operator Controller OC52, Camera Head CH62 and Camera Controller CC32

2.1. Basic Design Principles of the Leica RCD30

2.1.1. The Leica RCD30 Camera Head CH61 and Camera Head CH62

Based on a common design platform, the Leica RCD30 camera head has a number of unique design features.

Co-registered multispectral imagery
The Camera Head is available in two versions: the Camera Head CH61 delivers only RGB imagery, Camera Head CH62 delivers unique co-registered multispectral imagery in RGB and NIR. This is achieved by a unique beamsplitter design that separates the incoming light into RGB and NIR at 780nm. Whilst the CH61 is equipped with a 60MP Bayer array (8956 x 6708 pixels with 6µm), the CH62 employs two 60MP CCDs (same size as CH61). The first CCD records the RGB portion with a Bayer pattern and peak quantum efficiencies of blue 470nm, green 530nm and red 590nm respectively. The second CCD records the NIR portion of the incoming light across 780 – 900nm simultaneously and across the same area as the RGB sensor. This, combined with highly accurate camera calibration, allows the creation of co-registered, perfectly fitting 4-band imagery in RGBN (Fig. 2). Upgrades from Camera Head CH61 to a Camera Head CH62 are available.

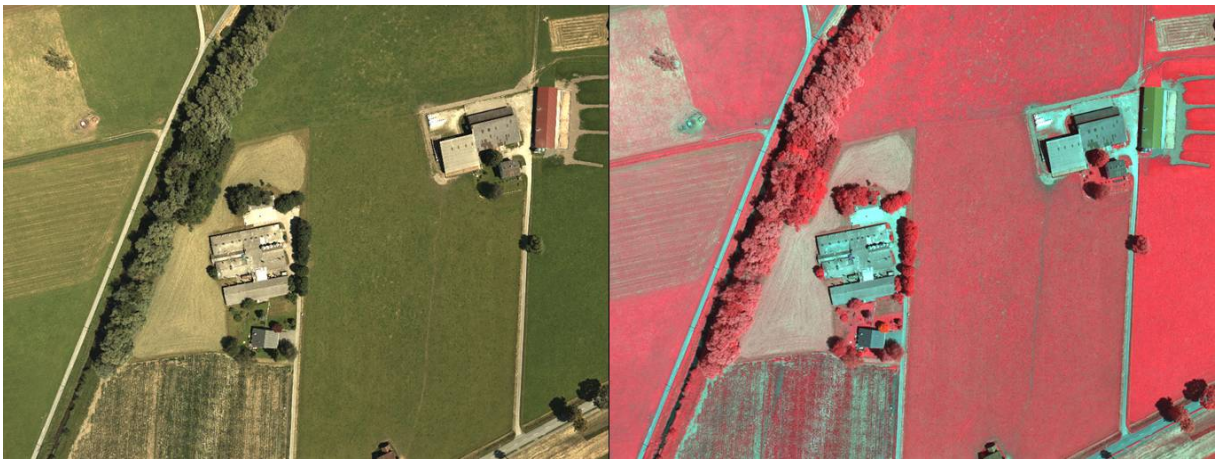

Figure 2: Leica RCD30 co-registered image data RGB (left) and FCIR (right)

Light-weight and High Frame Rate
The CH62 weighs roughly 3.5kg without lens and supports frame rates of up to 1 frame/second.

Bi-directional Motion Compensation
The Camera Heads CH61 and CH62 are equipped with mechanical motion compensation during image acquisition in flying direction, laterally, as well as diagonally (in case of drift). Hereby, the entire beamsplitter cage is moved. Bi-directional motion compensation has the advantage that it supports most camera installations, inclusive of 90 degree turns. The available motion range is up to +/- 0.3mm, with a maximum speed of 20mm/sec. In standard operation, it is expected that the motion range does not exceed +/- 0.15mm or 50pixels.

To use the full motion compensation, the use of a GNSS/IMU system is mandatory. Is only GPS installed in the aircraft, only forward motion compensation is available.

For any photogrammetric application the use of a gyro-stabilized mount is recommended to provide vertical photographs to compensate angular motion in drift, roll and pitch. If the Leica RCD30 is installed with a mount, the motion compensation of the RCD30 will work complimentary to the drift compensation of the mount. For installations without a mount such as some LiDAR installations, the RCD30 delivers improved results.

Lens System and shutter
Currently, two lens systems are available with focal lengths of 50mm (NAG-D 50) and 80mm (NAT-D 80) (Fig. 3). The temperature compensated RCD30 lens system is specifically designed for

Fig 3: Leica NAG-D 50 and NAT-D 80

airborne applications and is characterized by its robustness, ruggedness and stability that support high accuracy mapping applications.

The lens connects to the camera body with a special bayonet mount (Fig. 4), which is unique in airborne mapping and supports uniform connection, perfect fit and best stability. In addition, it supports easy handling and exchange without the use of any additional tools and a repeater accuracy of approximately 2µm. Each lens system is operated with automatically controlled aperture settings of 2.8, 4.0, 5.6, 8.0 for NAT-D 80 and 4.0, 5.6, 8.0, 11 for NAG-D 50.

Fig 4: Bayonet Mount

The central shutter is embedded in the lens and due to the special lens design can easily be exchanged by the user without the need for recalibration of the lens. It is certified for up to 200000 exposures and offers shutter speeds ranging from 1ms to 50ms.

Config	Res	Flying height m	Field across m	Field along m	Angle across	Angle along	x/h	y/h	b/h
50mm single	8957 x 6708	420	450	338	56	44	1.07	0.8	0.32
80mm single	8957 x 6708	670	450	338	37	28	0.67	0.5	0.20
80mm dual	13216 x 8956	670	666	451	53	37	0.99	0.67	0.27

Table 1: Performance of Leica RCD30 configurations

2.1.2. The Leica RCD30 Camera Controller

The Camera Controller for the RCD30 is available in two versions:

- the CC31 does not include a GNSS/IMU boardstack and is thus designed for integration of the RCD30 with a Leica ALS LiDAR as it integrates with embedded Leica IPAS of the Leica ALS
- the CC32 comes with an GNSS/IMU boardstack and allows direct connection to a wide range of supported IMUs. As a result of driving synergies across the Hexagon Group, Leica Geosystems has for the first time integrated a Novatel SPAN GNSS/IMU board stack.

The Camera Head CH61 or CH62 is connected to the Camera Controller CC31 or CC32 with one cable of up to 7m lengths. One Camera Controller (L x W x H 300 x 260 x 140) weighs about 5.5 kg without Mass Memory and can support and connect to up to five Camera Heads CH6x to allow multi-head operations. The Camera Controller CC3x holds two Mass Memory MM30 with SSDs and a storage capacity of 256GB, 512GB or 1024GB per MM30. This allows a total data recording time of up to 24000 images RGBN when using two MM30s in joint volume. As was already realized in the Leica ADS, the data recording can be performed in joint volume, single mode or backup mode using any combination of MM30. MM30s are inflight exchangeable.

2.2. Calibration and Corrections

The Leica RCD30 series employs for the first time a fully automated goniometric lab calibration.

During post processing with Leica FramePro, two corrections DSNU and PRNU are applied. The Dark Signal Non-Uniformity (DSNU) for dark signal correction is a dynamic correction and is corrected by real data captured during flight after each flight line. The Photo Response Non Uniformity (PRNU) for bright correction is separated into sensor effects (such as non uniform pixel sensitivity) and lens effects (such as light fall-off). The sensor related effects are captured individually for each camera and stored on the camera. The lens related parts are measured for each objective.

2.3. Accuracy

First assessments of the Leica RCD30 using RGBN data with 5cm GSD show very good accuracies. The measurement precision Sigma0 from AT is 0.9µm. Initial tests of achievable horizontal and vertical accuracies from stereo measurements show accuracies on GCP's in the range of x = 0.06, y = 0.04 and z = 0.04m.

2.4. Available Configurations

The Leica RCD30 is available in three different configurations:

- as a standalone fully integrated camera system
- as a camera system integrated with a Leica ALS70
- as a camera system for integration with a third party LiDAR and/or a third party GNSS/IMU system and/or a third party flight management system (can also be UAV).

2.4.1. Leica RCD30 standalone

The Leica RCD30 standalone consists of one or multiple Camera Head CH6x, a Camera Controller CC32 with embedded GNSS/IMU system SPAN and IMU, Leica PAV80 gyro-stabilized mount, Operator Controller OC52 and Pilot Interface OC50 and/or Guidance Indicator GI40. For single head operation, one Camera Head CH6x is installed in the RCD30 Single Pod together with an IMU (Fig. 5 and Fig. 6).

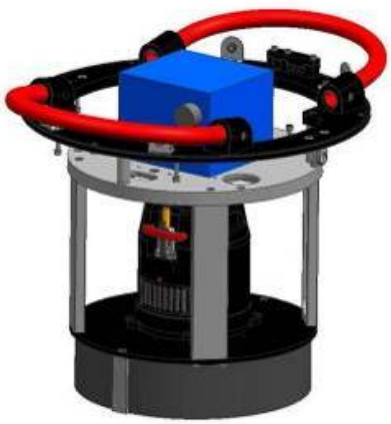

Fig 5: Standalone POD with Leica RCD30 and IMU

For dual-head operation, two CH6xs with 80mm lens are installed in the same pod using a different insert to ensure tilt and geometric stability during data acquisition.

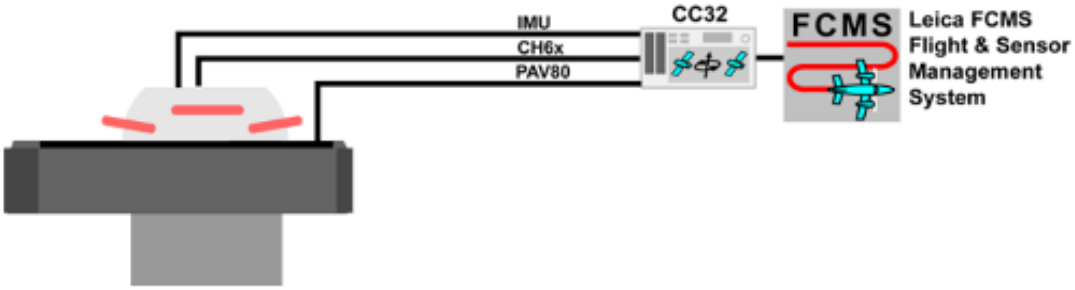

Fig 6: Standalone Installation

2.4.2. Leica RCD30 and Leica ALS70

The Leica RCD30 for ALS consists of one Camera Head CH6x, a Camera Controller CC31 without embedded GNSS/IMU SPAN and IMU. GNSS/IMU and Operator Controller/Pilot Interface are shared with the ALS integration. Both systems can be operated from one Operator Controller (Fig. 7).

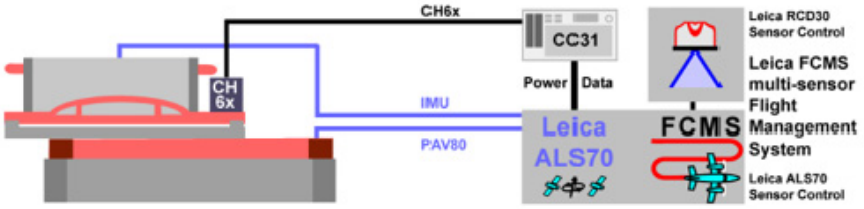

Fig 7: Leica RCD30 and Leica ALS70

2.4.3. Leica RCD30 third party

This depends usually on configuration, but the core consists of one Camera Head CH6x and a Camera Controller CC31. In order to ensure that the RCD30 can be integrated with a third party LiDAR system, a third party GNSS/IMU and/or third party Flight Management System the interface has been opened up and detailed documentation and a developer kit are available from Leica Geosystems upon request (Fig. 8).

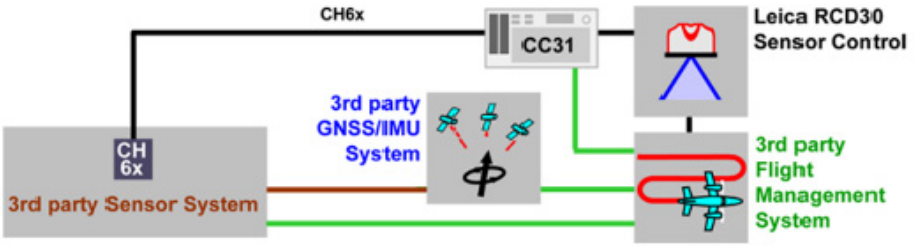

Fig 8: Leica RCD30 and 3rd party integration

3. SOFTWARE

As with all Leica Geosystems Products, the Leica RCD30 is fully integrated into the proven Leica Geosystems workflow. Starting from Flight Planning with Leica FPES to Flight Management and in-flight Quality Control with Leica FCMS and post-processing with Leica FramePro, the Leica RCD30 provides an end-to-end solution for all those who seek high efficiency during data acquisition.

3.1. Leica FramePro

Leica FramePro provides post-processing for the Leica RCD30. It enables data download, quality control, data management as well as post-processing for all Leica RCD30 cameras. Image data can be processed to suit orthophoto production with a focus on best image quality or remote sensing applications, with a focus on radiometry. Leica FramePro produces co-registered multispectral images in .tif format in either 8- or 16-bit. As all corrections are already applied to the image data, photogrammetric processing in Erdas LPS, Image Station or any other DPW software can begin immediately after image generation in Leica FramePro. In the case of Leica RCD30 standalone or ALS, GNSS/IMU processing is performed in Leica IPAS TC and applied to the imagery using Leica IPAS CO+.

4. SUMMARY AND OUTLOOK

The Leica RCD30 boasts a plethora of innovative designs and features and thus sets new standards not only in performance but also in flexibility and scalability for medium format imaging. It is not only an ideal tool for those who seek to replace their film camera, but with its wide range of possibilities is already reaching beyond the traditional photogrammetry market to a whole world of new applications.