

# Leica ADS80 and Leica XPro: A Total Solution for Photogrammetric Mapping

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## ABSTRACT

Driven by market demand and based on key lessons learned since the release of the first Leica ADS40, Leica Geosystems has over the past years focused on creating a unique photogrammetric mapping solution by integrally linking the development of sensor hardware with the development of a dedicated workflow. As a consequence, the Leica ADS80 and Leica XPro have like no other airborne sensor solution in the market revolutionized the end-to-end photogrammetric workflow through a high degree of automation without sacrificing accuracy and quality. In addition, having already taken the lead in distributed processing, on-the-fly rectification and graphical quality control for AT, the release of Leica XPro DSM once again leads the industry as it allows not only the generation of digital surface models from image data but also the generation of n-dimensional info clouds. Unlike 3-dimensional point clouds, info clouds contain x,y,z, spectral and time information and are considered one of the pillars of precise measurements in a Real 3D environment in the future.

## 1. INTRODUCTION

The introduction of the first Leica ADS40 pushbroom sensor as the digital successor to the highly successful analog frame camera RC30 in 2000 represented a departure and a new beginning of digital airborne photogrammetry. At the time it was envisioned that traditional photogrammetry and remote sensing would move closer together and that a photogrammetric airborne camera with satellite characteristics could help in this process. Even though this development may have arguably taken longer than expected, today most photogrammetric projects require at least the delivery of multispectral airborne imagery. Secondly, after investigating various technologies, it was concluded that pushbroom technology and the resulting “pixel carpet” images could help to increase productivity not only in data acquisition but also in post-processing and in the photogrammetric workflow.

It probably is a fair statement that in hindsight the willingness of the traditional market to adapt to new workflows at the time was overrated. In addition, and not unrelated, as a traditional manufacturer of hardware, a large part of the development focus was set on designing and manufacturing exactly that: world class hardware. As a consequence, Leica GPro was brought to the market soon after the introduction of the Leica ADS40, but in the early stages arguably may have lacked data throughput that really could have propelled the system into its own league of production workhorses. As so often, the market provided some valuable lessons and we learned early on, that the best system in the world is of limited use, if the data can not be accessed, processed and interpreted in a simple and effective manner.

In the case of the Leica ADS this lesson marked another significant turning point as from then onwards the focus shifted to intrinsically connecting world class hardware development with world class workflow. Over the past four years a unique collaborative effort between Leica Geosystems and Pixelgrammetry has led to the development of Leica XPro, a focused production workflow for the Leica ADS80. Today, the Leica ADS80 in combination with the new Leica XPro software is probably the best example of rapid productivity improvements in a production environment as a combination of hardware and dedicated software development. With its unique hardware design and

the innovative approach to data management, radiometry, GNSS/IMU processing, aerial triangulation and downstream tools, no other system allows producing highly accurate and high quality orthophotos and other geospatial information such as digital surface models and info clouds faster than the Leica ADS80.

## 2. HARDWARE DEVELOPMENTS

In January 2011, Leica Geosystems introduced the new generation Sensor Head SH91 and SH92 (Fig 1). As part of Leica's product philosophy, customers can benefit from upgrade paths across several generations of sensors, thus allowing them to align their investments better with their business needs.

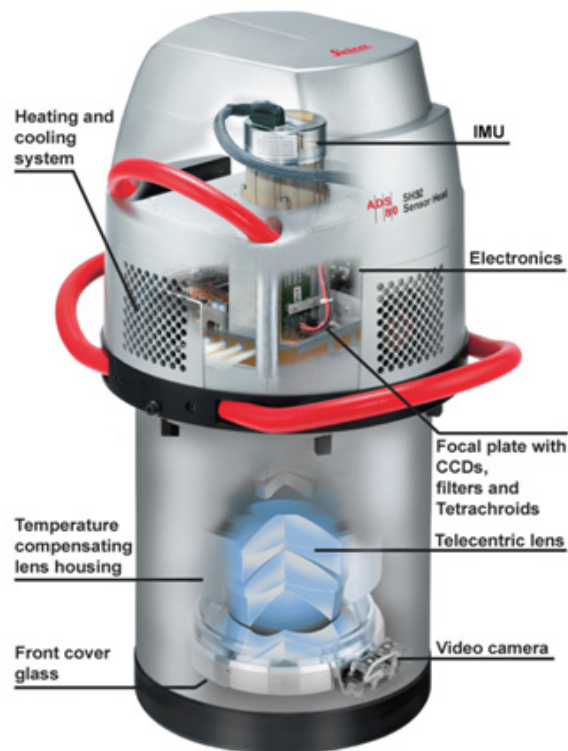


Figure 1: New Leica ADS80 Sensor Head SH9x with new optics design

The introduction of the Sensor Head SH91/SH92 (Fig. 1) does not represent radical changes or breathtaking new features, but rather an intermediate yet solid step towards a next generation sensor. The new Sensor Head SH9x has received an optical overhaul, which results primarily in a smaller and lighter sensor. The total system weight installed in the aircraft has now been reduced to around 145kg, depending on IMU. In addition, the spectral characteristics and radiometry have been improved and the new Leica ADS80 with SH9x now delivers even better images than before.

With the new Sensor Head SH9x, Leica Geosystems continues to build on the success of the two models SH91 and SH92 as a entry level ortho-machine and a high-end all-in-one sensor, respectively (Fig. 2).

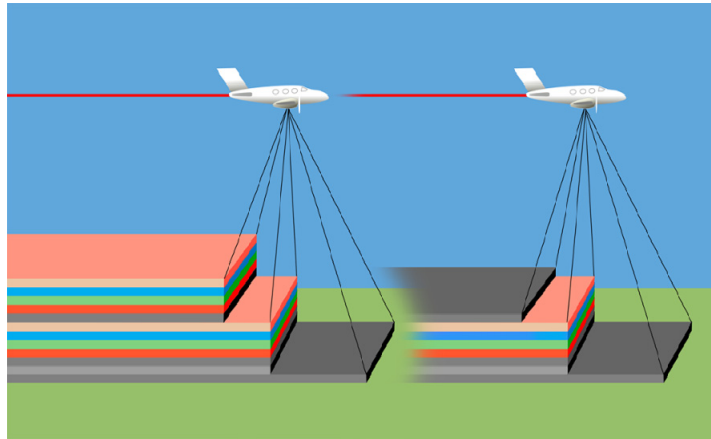


Figure 2: Data acquisition with the Leica ADS80 Sensor Head SH92 (left) and Leica ADS80 Sensor Head SH91 (right)

In addition, embedded Leica Freebird deeply coupled GNSS/IMU solution is now standard with all sensors and allows tighter turns during data acquisition, thus reducing flying time by up to 25% (Fig. 3).

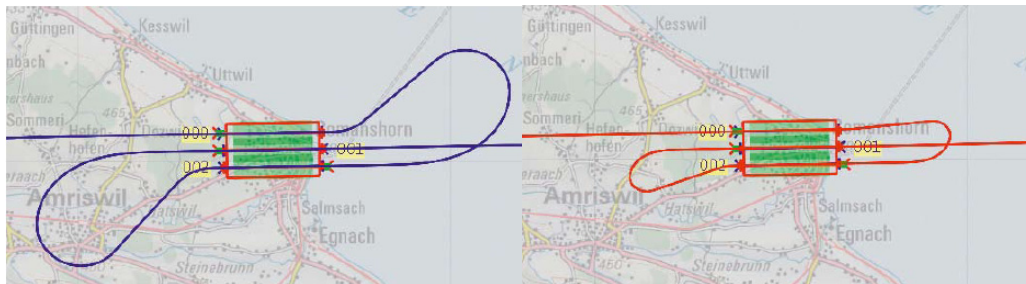


Figure 3: Flightpattern without Leica IPAS Freebird (left) and with (right) Leica IPAS Freebird

In parallel, quite a few developments on the workflow side have led to better use of the sensor design and have significantly improved productivity.

### 3. SOFTWARE DEVELOPMENTS

Leica Geosystems provides a full end-to-end workflow for its sensor solutions (Fig. 4).

#### 3.1. Flight Planning

Efficient data acquisition starts with efficient flight planning. To ensure compatibility and seamless workflow across all product lines and to reduce operational costs, all Leica Geosystems sensors are using Leica Flight Planning (FPES) and Leica Flight Management (FCMS). In addition, Leica FPES also supports other airborne frame, line or on/off sensors.

To enhance flight planning and ensure highest data quality, Leica FPES now provides a number of enhanced planning features such as graphical definition of the line direction and cutting groups of lines. As flight planning on existing DEM's become standard, Leica FPES supports planning on DTM with many features. When generating bitmaps from DTM data the height range for elevation encoded color images can now be defined and the minimum and maximum elevation in a DTM area, an AOI or in flight line footprints can now easily be detected. New computation options allow

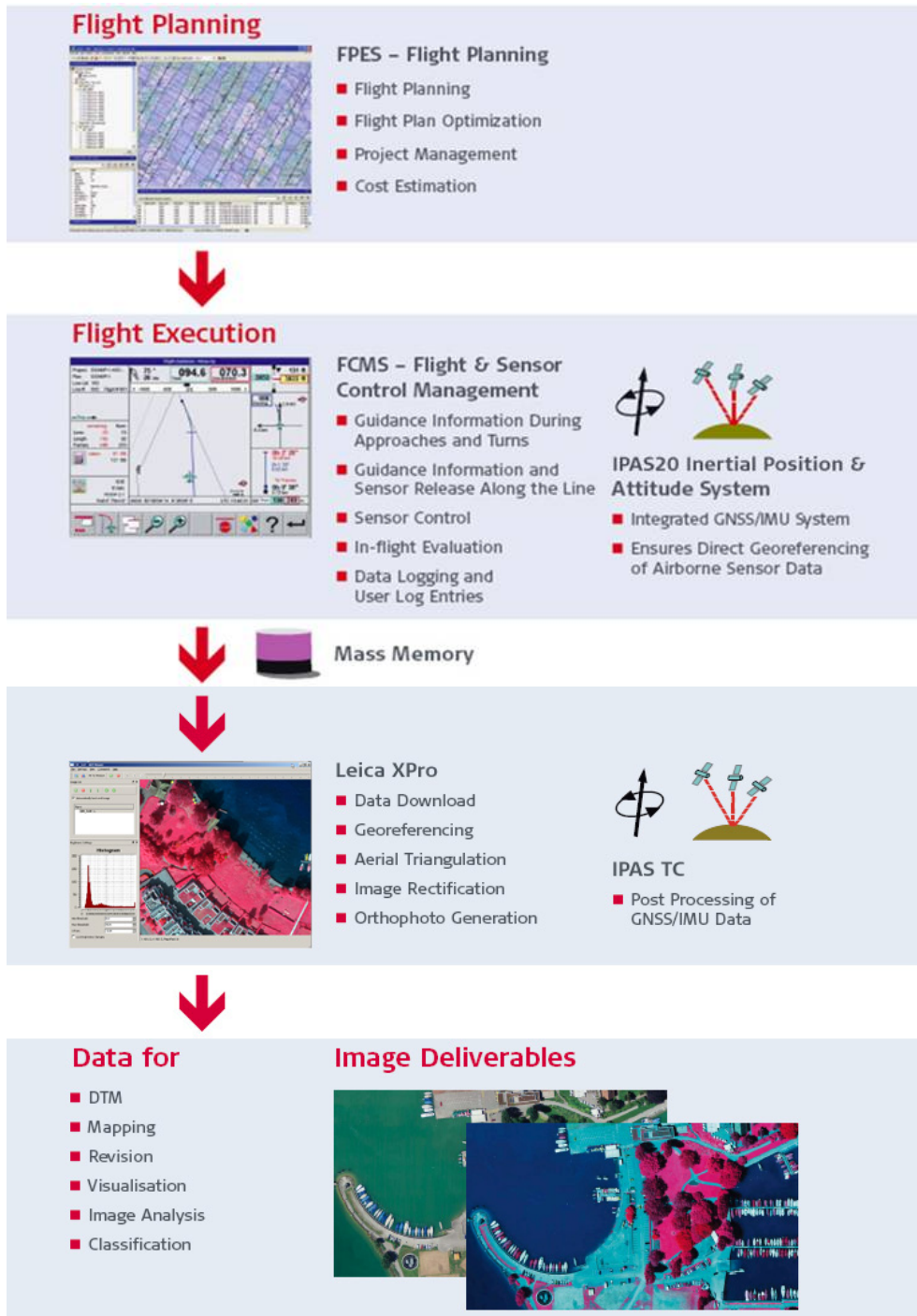


Figure 4: Leica ADS80 workflow

taking the terrain height outside the AOI into account and coordinate systems of existing flight plans can be changed to merge flight plans together. As part of driving synergies across the newly formed Hexagon Geosystems portfolio of Leica Geosystems and Z/I Imaging brands, Leica FPES v 10.2 frame flight plans can now be exported for flight execution with Z/I Inflight.

### 3.2. Leica XPro – a short review

At the outset, the development of Leica XPro was driven by key learnings from the past. The philosophy that fundamental guided the XPro development could be summarized as follows:

- Develop an easy to use image processing workflow for the Leica ADS that supports a reduction of operator involvement by automating as much as possible, without sacrificing on accuracy and image quality
- Despite all automation, giving the expert user enough tools to fully control the entire process
- Driving innovation in new algorithms and in the use of IT infrastructure to speed up all aspects of processing
- Focus on the tasks that are crucial for photogrammetric applications and those that can be improved as a direct result of features inherent in the ADS pushbroom technology and design

Based on this, the early releases of Leica XPro have focussed on bringing innovation and automation to the major building blocks of the photogrammetric workflow: Data download and data management, radiometric corrections and Aerial Triangulation. To ensure faster post processing and the more efficient use of IT infrastructure, Leica GPro and later Leica XPro were amongst the first photogrammetric workflows to take advantage of distributed processing using Condor.

By adapting the well-known and proven Orima orientation management software, Leica XPro was amongst the first to provide fully graphical quality assessments tools for aerial triangulation (Fig. 5) as well as to move the process of aerial triangulation into a black-box environment that would allow less experienced users to achieve highly accurate results.

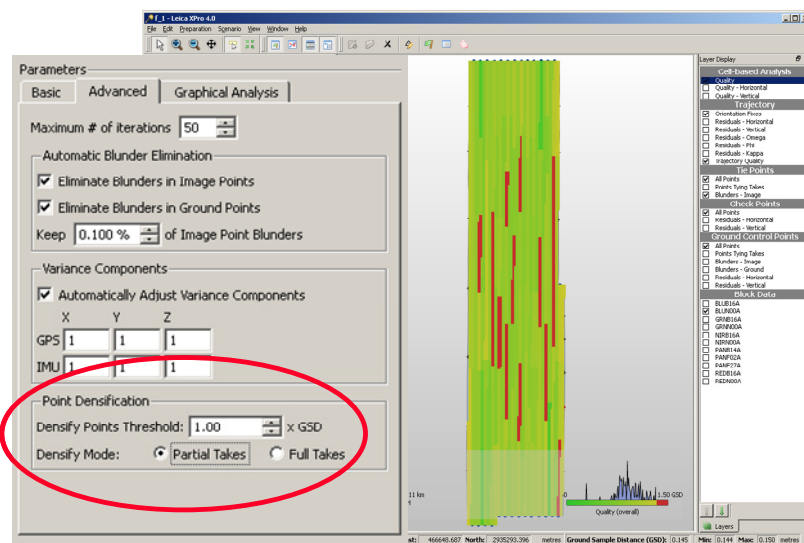


Fig 5: Graphical quality assessments for aerial triangulation in Leica XPro

The innovative approach to GNSS/IMU processing realized in Leica IPAS TC, a result of a longterm collaboration with Novatel, combines the separate steps of GNSS trajectory processing and IMU blending into a single tightly coupled processing using the GNSS raw measurement.

Building on state of the art graphics technology, the Leica XPro viewer provides on-the-fly geo-referenced data and radiometric processing tools even for the longest strips to facilitate rapid quality

control and data checks (for further reading, see Downey and Tempelmann, 2008 as well as Beisl, 2008)).

### 3.3. Latest Leica XPro Developments

In recent years, more and more customers have taken advantage of the Leica ADS's capability of acquiring data in standard mode (12000 pixels across at pan:ms ratio of 1:1) and in HiRES mode (extremely large swath of 24000 pixels at pan:ms ratio of 1:2). Both acquisition modes have distinct advantages and can be selected and planned for prior to data acquisition. In standard mode, the Leica ADS80 produces perfectly co-registered imagery with equal resolution across all bands that is ideal for any remote sensing application. In HiRES mode, the Leica ADS80 can, in addition to equal resolution imagery, produce large area orthophotos (Fig. 6). Leica XPro facilitates the easy and fast production of both RGB and RGBN data from HiRES mode.



Fig 6: Panchromatic images acquired in standard mode (10cm GSD @ 1000m AGL) and HiRES mode (10cm GSD @ 2000m AGL)

Despite the advancements realized in Leica XPro over the years, there has been a steady demand for processing data in other DPW packages. Leica XPro now supports the integration of L0 images in other DPW as well as the creation of smaller stereo-viewable frames from extended pixel carpets.

### 3.4. Leica XPro – A focus on vertical market applications

The focus of closely linking sensor hardware design with workflow has shown that the combination of Leica ADS80 and Leica XPro into one sensor solution brings distinct advantages for certain applications.

#### 3.4.1. Near-realtime Orthophotos for Disaster Management Applications

As a result of continuously driving automation during post processing as well as matching IT developments with innovative software algorithms, today Leica XPro produces orthophotos faster than any comparable image solution on the market. With the release of Leica XPro 5.1, the speed from 'Raw to Product' has yet again doubled and allows performing intermediate workflow steps

such as image QC and aerial triangulation directly on the raw Mass Memory MM80 data. The time consuming L0 image extraction step can now be skipped.

To facilitate easy and fast post processing particularly in emergency situations, where the speed of generating and delivering orthophotos plays a crucial role, Leica Geosystems has released a unique software version that offers an one-click processing option from “raw to product”.

### 3.4.2. Generating Digital Surface Models and Info-Clouds from ADS imagery

In recent years, new algorithms for pixel matching have been developed that have potential for high accuracy as well as very fast extraction speeds (Hirschmueller, 2006 and Hirschmueller, 2007)). Based on the method of semi global matching, a new module Leica XPro DSM has been developed that not only allows to create highly-dense digital surface models with over 350 points/m<sup>2</sup> (Fig. 7), but also generates those point clouds extremely fast (Gehrke et al, 2011).

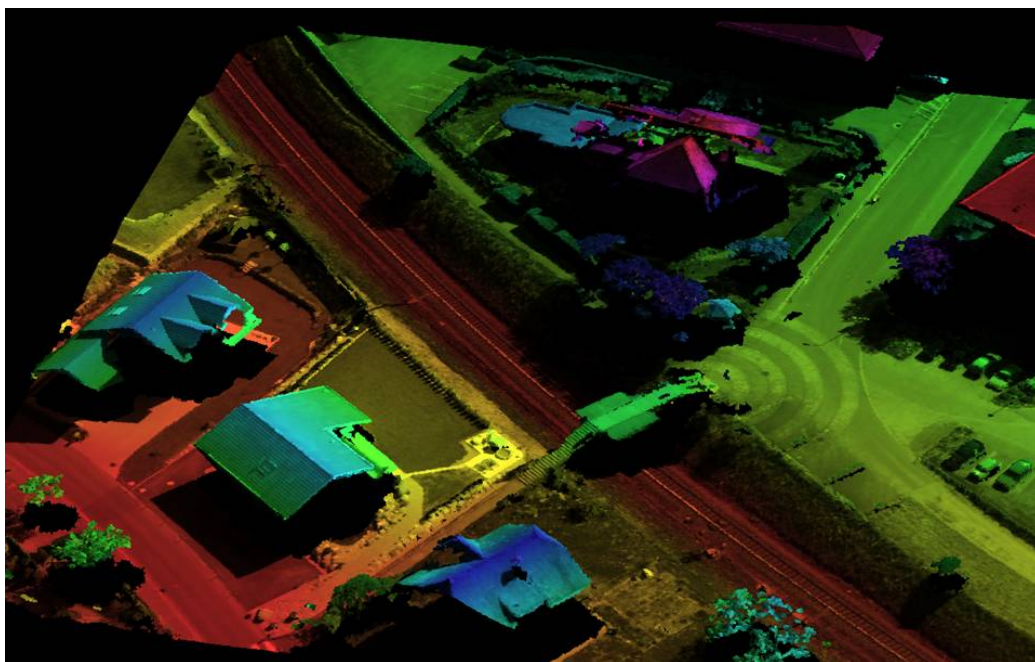


Fig 7: DSM and intensity image generated from Leica ADS data using Leica XPro DSM (5cm GSD, point density 350 points /m<sup>2</sup>)

The advantages for orthophoto production are not only the cost-savings as the DSM is generated from one flight (no additional LiDAR mission is required), but that the surface data also matches the image data perfectly. In addition, all existing ADS data can be reprocessed using Leica XPro DSM.

Leica XPro DSM can be applied for smaller as well as larger areas and has already been successfully used in production for regional mapping applications (Buehler, 2011; Uebing, 2011).

As the point clouds are generated from image data, each point in the DSM is not only characterized by x,y and z but also by its spectral value and the time information, thus creating no longer 3 dimensional point clouds but n-dimensional info clouds (Fig 8). This results in a new level of data, unprecedented image quality as well as high accuracy, a foundation for precise measurements in a real 3D world.

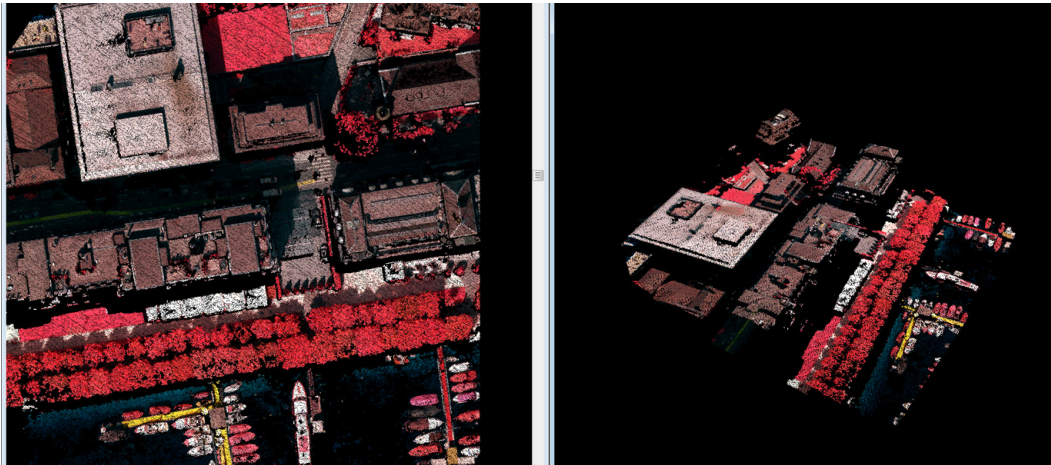


Fig 8: N-dimensional Info Cloud generated from Leica ADS80 that contains x,y,z, spectral and time information. Here displayed as FCIR point cloud.

#### 4. OUTLOOK

At the time of this publication, the understanding, processing and management of n-dimensional info clouds is at a very early stage. Simple visualisation of such huge amounts of data is proving to be a challenge. But as the benefits of such info clouds over traditional orthophotos become more and more obvious, it is probably very likely that this will have a significant impact on the way geospatial data is managed, visualized and processed. Within Hexagon, Leica Geosystems and Z/I Imaging together with Erdas and Intergraph have started to work on synergies to better harness the info cloud as an integral part of the Dynamic GIS concept (Fig 9).

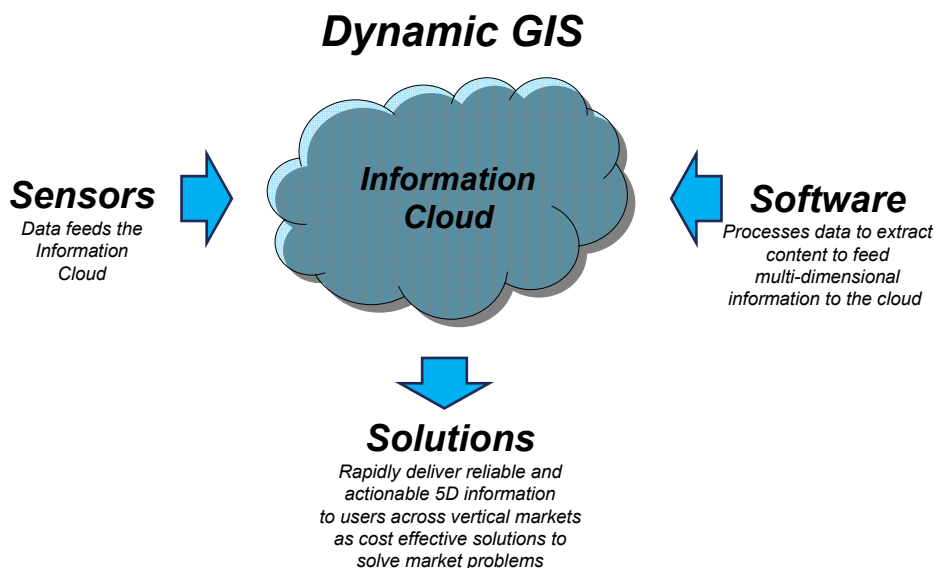


Fig 9: Hexagon's Dynamic GIS concept

More specifically, the Leica ADS and Leica XPro development has revealed some key insights in what a highly productive photogrammetric solution requires. With the newly formed GSD, Hexagon Geosystems is bringing together Leica Geosystems and Z/I Imaging, thereby creating the



largest and most comprehensive airborne sensor portfolio covering a plethora of mapping applications. Whilst the focus remains on further developing all major product lines, it is envisaged that some of these key insights will influence the combined product roadmap, thus ensuring that the new organisation will continue to provide the most effective and most productive mapping solutions to our combined customer base.

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