PARADIGM CHANGES IN ISPRS FROM THE FIRST TO THE EIGHTEENTH CONGRESS IN VIENNA

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It is a special honour, that I have been asked by the Congress Director Karl Krauss to deliver this keynote address. This means very much to me. Like Eduard Dolezal, the founder of the International Society for Photogrammetry and Remote Sensing, I was born in the territory of what was once the Austro-Hungarian monarchy. This territory was a melting pot between many nations in Central Europe. The monarchy can be considered as a forerunner for a United Europe, which we are trying to establish now, but one century ago such an effort was still doomed to fail.

Nevertheless Vienna was the cultural centre of this territory. What better could express its significance than the music we have just enjoyed. Dolezal, born in 1862 and myself, born in 1930, both of Moravian roots, always considered Vienna as our cultural home. It is not a coincidence that the International Society for Photogrammetry and Remote Sensing was founded here in Vienna in 1910, and that it was founded by a multicultural individual such as Eduard Dolezal **(Figure 1).**

The topic of my address is "Paradigm Changes in ISPRS from the First to the Eighteenth Congress in Vienna". I owe this topic to my respected friend Friedrich Ackermann, who recently on his visit to Hannover presented a paper with the title "Digital Photogrammetry - a Paradigm Shift".

Paradigm changes have been defined by the German American science philosopher Thomas Kuhn, who traced the development of the natural sciences, and found that progress came about by the fact that the same event previously considered a negative influence, suddenly became a positive jump in advancing progress. He cited the Copernican World Concept, Newton's mechanics, the theory of the atom, the biological evolution, and the theory of relativity as examples.

Ackermann found that paradigm a shift is also applicable to digital photogrammetry, and I wish to expand this thought to the four phases in which photogrammetry has evolved from plane table photogrammetry, to analog to analytical and to digital photogrammetry.

Thomas Kuhn's ideas are not in contradiction with those of Nikolai Dmitrijewitsch Kondratjev. Kondratjev was an economist in the Soviet Union of the 1920's who analyzed the economic development of the World and found that progress evolves in 50 year cycles. Each cycle begins with a paradigm shift of a major invention, which is followed by rapid development, subsequent application and gradual stagnation, until a new paradigm shift occurs. His examples are the mechanical weaving and the steam engine, the utilization of electricity and the introduction of motorized land and air transportation. We can now add the computer and advances to communications to this list.

Inventions had occurred previously, but they needed paradigm shifts before the respective cycles could begin. Surprisingly the development of photogrammetry in phases follows such cycle patterns.

Fig. 1: Prof. Eduard Dolezal, the Founder of ISPRS

Fig. 2: Sketch from Albrecht Dürer's Text on the Perspective

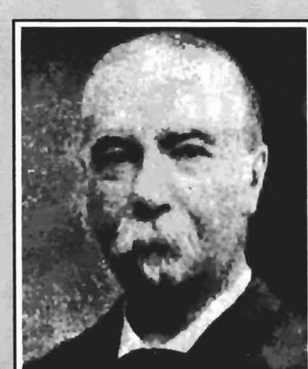


Fig. 3: Aimé Laussedat, the Founder of Iconometry"

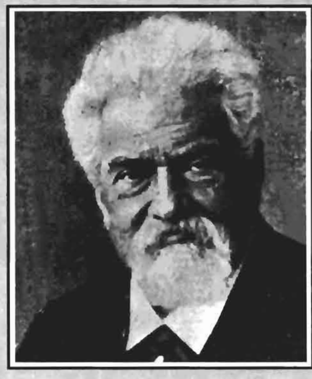


Fig. 4: Albrecht Meydenbauer, the Founder of Architectural Photogrammetry

Fig. 5: Eduard Dolezal's Home, Mährisch Budwitz in Moravia

Fig. 6: Theodor Scheimpflug, an Early Inventor of Aerial Photogrammetry

Let me explain this:

The geometrical properties of perspective images had been known for many centuries, commencing in the Italian Renaissance. The painter Albrecht Dürer, whose paintings are hanging only a few 100 meters away from here in the Art Museum, wrote a first text on the use of the perspective in 1525 **(Figure 2).** But the possibility to capture the perspective automatically by photography came through the invention of Nièpce in 1826 and its improvement by Daguerre in 1837. This discovery was presented by Arago in 1839 to the French Academy of Sciences, and in the same year Baron von Ettinghausen heard it and brought it to Vienna. Emperor Ferdinand and Metternich were impressed, but not much happened thereafter. The father of what he then called "iconometry" became A. Laussedat 1851 in France, who presented a survey of the city of Paris in 1859 to the French Academy, without receiving much recognition **(Figure 3).**

Independently the architect Meydenbauer began to use "photogrammetry" as he termed it, when he used images to survey the cathedral of the city of Wetzlar in Germany **(Figure 4).** He too had a long struggle to convince his superiors before him, until he succeeded in convincing the German emperor William in 1885 to establish an "Image Archive" for Cultural Monuments in Berlin.

In these times Dolezal grew up in Mährisch Budwitz in Moravia **(Figure 5).** At the age of 14 his father, a weaver, had to move to Vienna for economic reasons. This brought Dolezal the opportunity to graduate from a good high school and to become a teacher for mathematics and descriptive geometry. During this studies he enrolled in relevant courses at the Technical University, which he passed with distinction. He then became a teacher of geometry in Sarajewo in 1889 in a new technical school. Due to his dedication he soon became director of that school. Seven years later he returned to the Technical University Vienna where he was given the opportunity to work as an engineer to teach the new discipline photogrammetry. To prepare himself better for this task he spent the summer 1896 with Meydenbauer in Berlin. In the summer of 1897 he joined the Military Topographic Office in Vienna, which had introduced photography to survey Alpine mountains. During this activity he came into close contact with Theodor Scheimpflug, a visionary photogrammetrist, being preoccupied with balloon photogrammetry, the theory of rectification, and of radial triangulation **(Figure 6).** Scheimpflug died young. At his grave in 1911 Dolezal commented "He was way ahead of his time. Because of this his ideas found little support, especially in his country, but brought much disappointment."

Dolezal was so fascinated with Scheimpflug's ideas that both travelled to Braunschweig in 1898 to attend the Congress of German natural scientists and physicians, where they met all important German photogrammetrists like Koppe, who used photogrammetry for the construction of the Gotthard tunnel **(Figure 7),** Jordan, who had used it on expeditions in Libya **(Figure 8),** and Sebastian Finsterwalder, who was known because of his photogrammetric glacier surveys **(Figure 9).**

In 1899 he accepted a professorship at the Mining Academy in Leoben. He returned to the Technical University of Vienna as professor in 1905, soon to take up the presidency of the University from 1908 to 1909. In these times of nationalistic turmoil among the students, his international liberal and reconciling leadership was well respected from all sides.

At the University he introduced guest lectures in photogrammetry, and one after-math session resulted in the creation of an Austrian Society for Photogrammetry in 1907, at which he was appointed chairman. The first lecture of that society by Dolezal was on A. Laussedat, who had just passed away. In 1908 Dolezal created the

"International Archive for Photogrammetry", a multi-language publication series.

While attending Carl Zeiss' seminary in Jena on stereo-photogrammetry introduced by Pulfrich **(Figure 10),** he met Max Gasser, and was present at the foundation of the German Photogrammetric Society **(Figure 11).**

On July 4, 1910 Dolezal founded the International Society for Photogrammetry. The Austrian and the German groups became the first two sections. It was now Dolezal's task to organize the First International Photogrammetric Congress. It took place from 24 to 26 Sept 1913 in Vienna. It had over 300 participants from many nations.

Only 10 papers were presented at this congress, they were review papers by Dolezal, papers about stereo restitution by von Orel **(Figure 12),** as well as contributions on aerial photogrammetry built on the developments of Scheimpflug. But the exhibit brought about many applications developed in France, Italy, Germany, the Austro-Hungarian Monarchy, Norway, Sweden, England, Spain, Canada, and the USA.

The 1[st] International Congress showed the signs of a paradigm change. Many applications were still devoted to practical works shown in the exhibition with the aid of plane table photogrammetry, for which the graphical restitution procedures had their roots during the preceding centuries. But the papers of the Congress concentrated on photogrammetry as a new stereo-measurement tool and the potential of imaging from the air rather than from the ground.

The significant events were the introduction of stereovision and the invention of the floating mark by Stolze in 1892, the construction of the Stereocomparator by Pulfrich in Jena in 1901, the design and construction of analog restitution devices, the stereoautograph by von Orel in 1907, the invention of the motorized airplane by the Wright brothers in 1903, the construction of the first aerial survey camera for overlapping vertical photos by Messter in 1915, and Gassers patent of an optical photo projector for stereoviewing in 1915.

This was the time when each of the nations applying photogrammetry cherished its own technical history higher than that of other nations. In South Africa we hear that Fourcade had invented the Stereocomparator, and in England we find that Thompson had designed the first stereo-restitution instrument. In Germany even the opinion is prevalent that Lilienthal was the inventor of the airplane, even though it did not have a motor.

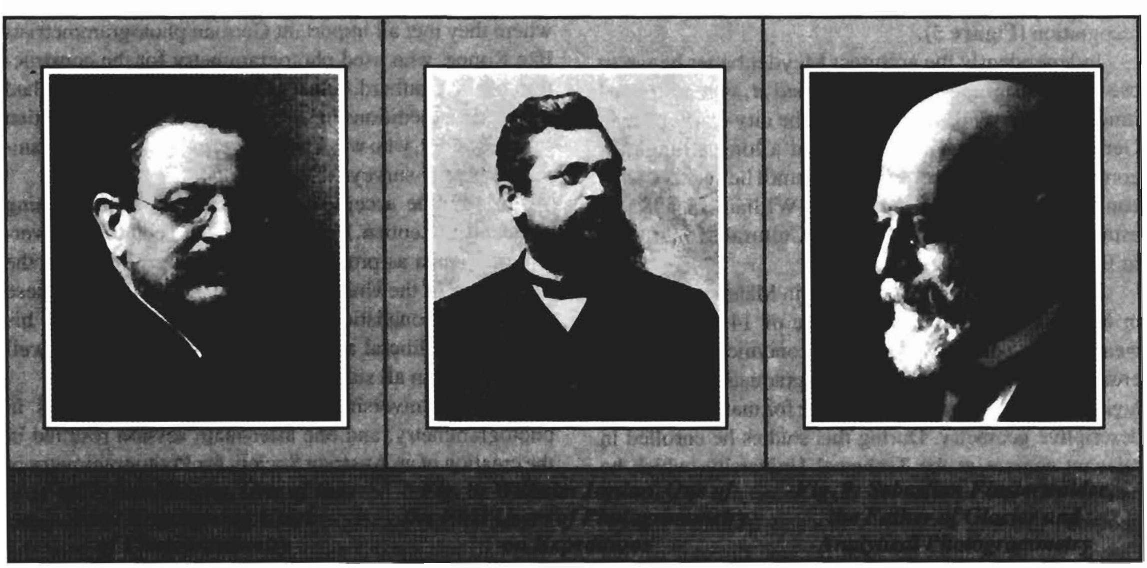
The Dutch entertainer Rudi Carell puts it that way:

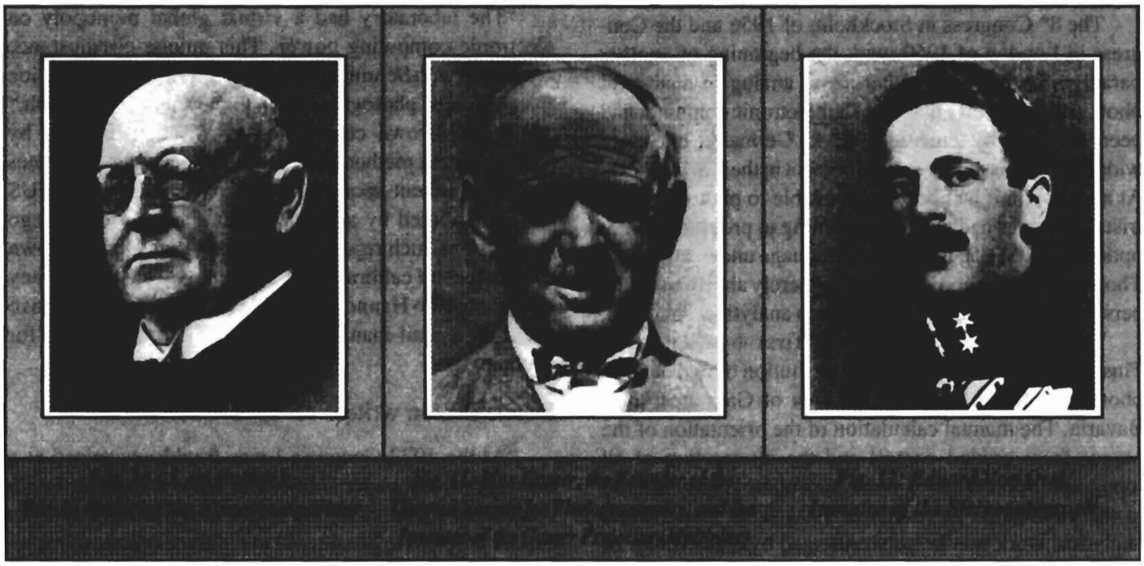
"You can recognize a good idea by the fact that it is stolen."

Did somebody steal? Who was it? Or is a good idea generally invented twice independently? In our times and in our society we do not need lone heroes, but we need people like Dolezal to pull forces together to have a synergistic outcome, which is more important than a wreath on a lonely grave.

During the first World War the use of aerial photography became dominant. The war had, of course, disrupted the relations established by Dolezal. But his international stature greatly helped to reassemble the World's photogrammetrists in 1926 in Berlin. Here the paradigm change became very visible.

While terrestrial applications were not forgotten at this second Congress, the predominant number of the 18 papers presented was on aerial photography and on aerial photogrammetric restitution instruments. The exhibit showed a great number of different optical, optical-mechanical and mechanical instruments for the restitution of aerial photos. Photogrammetry had become the art to avoid computations, or as von Gruber put it: "He who computes much does not think."





And yet Dolezal, who had become Honorary President, remarked in Berlin: "Germany and Austria have made a significant and important contribution to the development of photogrammetry. On all continents photogrammetry and especially aerial photogrammetry is being used now, but the Germans are almost not involved in this effort."

Nevertheless industry was represented at the Congress exhibit, not only manufacturers of instruments, but also the first private aerial survey companies.

The 3rd Congress in Zürich in 1930 was marked by continued interest of the photogrammetric instrument industry from Switzerland, Germany and France. The scientific preoccupation was with orientation procedures on the instruments. Aerial triangulation and orthophotography were also presented as topics.

The 4th Congress in Paris 1934 demonstrates that rectification was used increasingly. Italian photogrammetric industry joined the other exhibitors, and the attempt to determine the orientation by auxiliary systems such as the Finnish horizon camera was made.

The 5th Congress in Rome in 1938 was already marked by international tensions. Dolezal, the Honorary President could not be there, but wrote a welcoming note, possibly with a double meaning: "Man proposes - God disposes". Willem Schermerhorn of the Netherlands, a friend of Otto von Gruber, who had worked in New Guinea developing aerial triangulation in what was called "Colonial Photogrammetry" at the time, was elected President of the Society **(Figure 13).**

Little did he know then that the 6th Congress would have to wait to be held in Scheveningen as late as 1948. Schermerhorn, who despite his friendship with Germans had to suffer imprisonment during the war years, nevertheless wrote in the Archives of 1948: "We hope this Volume will come into the hands of all those interested in photogrammetry, the word is meant in its widest sense all over the world, and thus it will help in furthering the application of this tool to the benefit and welfare of the world". This perhaps was also meant to refer to the Germans, who had temporarily not been admitted to the Congress after the war years, to the new nations, such as Indonesia, who had not yet become members of the Society, and to those who did not use aerial photos for mapping but for interpretation of resources and the state of the environment.

In 1948 Schermerhorn laid down the present ISPRS Commission structure from 1 to 6, which at the 7th 1952 Congress in Washington was augmented by Commission 7 dealing with interpretation. Schermerhorn soon thereafter became Prime Minister of the Netherlands. He was instrumental in establishing the independence of Indonesia as a sovereign state, and in creating the ITC. This Centre gave to 1000's of international students, the technology to be able to map the empty portions of the globe by photogrammetry, a mapping technology which had proved highly successful in the US, Britain, the USSR and Germany, to map the war sites of World War II, but which was now more appropriate for assisting in resource development of the third world. The need for this activity was known to Dolezal as early as 1911, when he wrote: "85 % of the earth's surface are topographically unknown, the knowledge depends greatly on vague descriptions by explorers."

During the 7th Congress in Washington Germany became readmitted to the Society. It had to rebuild its photogrammetric manufacturing and service industry. Internationally the trend for analog stereomapping and for graphically interpolated aerial triangulation became fully developed.

European organizations were perhaps too much occupied with doubts, whether photogrammetry could be applied to large scale problems of the urban environment and the cadastre, while organizations of other continents saw it as the only solution to map their territory.

The 8th Congress in Stockholm of 1956 and the Congress in London of 1960 mark the beginning of another paradigm change, the switch from analog to analytical photogrammetry. By that time the electronic computer had been invented by Zuse in 1941 in Germany, but more widely known is Aiken's development in the USA in 1943. At about 1956 it had become available to photogrammetrists. Whoever had the joy of learning to program a time-optimized IBM 650 in machine language understands that Thompson, Schut and Rinner were merely able to translate perspective geometry principles into analytical solutions.

The way had been paved first by Sebastian Finsterwalder, who calculated a restitution of two balloon photos point by point over the area of Gars am Inn in Bavaria. The manual calculation of the orientation of the photos from ground control and the intersection of all topographic points took 3 years from photography in 1900 to the publication of results in 1903. This fundamental analytical work was heavily criticized by the inventor of the forerunner of the Multiplex, Max Gasser, for its incapacity to deliver results fast. It was particularly Karl Rinner, from Graz, who had a solid mathematic knowledge of projective and perspective geometry who formulated the various analytical orientation steps in an elegant vector algebra model, which was still lacking in Finsterwalder's time **(Figure 14).**

But the biggest paradigm jump was probably initiated by Helmut Schmid, who as a collaborator of Wernher von Braun had reached the United States in late 1945 with the task to build up ballistic photogrammetry by analytical means. As former assistant to Hugershoff in Dresden, he had known least squares adjustment and he knew the formulation of the collinearity equations published in Gast's textbook of Photogrammetry of 1930 and their linearization in von Gruber's papers. Duane Brown, who worked with Helmut Schmid from 1952 to 1955 at the Ballistic Research Laboratories at Aberdeen Proving Grounds writes about this as follows:

"The laboratory had a virtual global monopoly on electronic computing power. This unique circumstance combined with Schmid set the stage for the rapid transition from classical photogrammetry to the analytic approach."

Duane Brown contributed to this development by adding matrix methods and statistical analysis. He states that government-sponsored research results in the US were distributed by reports, which generally did not go abroad. One such report of 1970, in which Duane Brown introduces self calibration was brought by me to Germany when I came to Hannover in 1971, and I am happy to have acted as a mail-man when I gave it to Dr. Bauer for eventual use.

Duane Brown writes:

"At the 1972 Congress I was frankly surprised at a most significant paper entitled: "Bundle Adjustment with Additional Parameters" by Bauer and Müller. I did not expect progress to be so rapid to embrace practical implementation. The significance lay not so much in the program, but its actual application to the Oberschwaben test block prepared by Friedrich Ackermann. This brought amazing improvements of accuracies, 300 % in position, 50 % in height."

At the 10th Congress in Lisbon 1964, at the 11th Congress in Lausanne 1968 and at the 12th Congress in Ottawa 1972 the paradigm shift to analytical solutions may have been won for aerial triangulation involving point determinations, but the analytical plotter invented by Helava in 1957 **(Figure 15),** and the image correlator invented by Hobrough in 1958 were still not considered as acceptable solutions, even though their use has been demonstrated as innovations in Lisbon for U.S. military systems. Instrument manufacturers still produced what we could call today, the last dinosaurs of photogrammetry in many forms and variations.

It is noteworthy, however, that just during the Ottawa Congress in 1972 NASA launched the first Landsat satel-

Fig. 13: Willem Schermerhorn, the Founder of the ITC

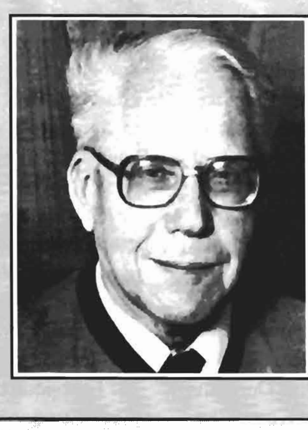


Fig. 14: Karl Rinner, Theoretician of Analytical Photogrammetry

Fig. 15: Uki Helava, the Inventor of the Analytical Plotter and Pioneer in Digital Photogrammetry

lite, opening the way to applications of remote sensing on a worldwide scale. Landsat was an earth oriented extension of first developments in analytical and digital technology which have been made in the U.S. with NASA systems exploring the moon and the planets of the solar system. The Society established its first working groups to develop satellite image restitution technology.

The 13th Congress 1976 in Helsinki was particularly significant to indicate a paradigm change from analog to analytical photogrammetry. Industry had almost exclusively switched over from the production of analog instruments to analytical plotters, and even orthophoto devices began to use analytical control.

At the 14th Congress 1980 in Hamburg remote sensing and photogrammetry activities were merged in all technical commissions, and since then ISPRS has the name "Photogrammetry and Remote Sensing". Out of respect for our forefathers, like Dolezal, Photogrammetry still remained first in the name, even though the reverse order would seem more logical. Digital techniques of image processing began to be applied.

The 15th Congress 1984 in Rio de Janeiro and the 16th Congress 1988 in Kyoto were the first major Society events in the continents of South America and Asia offering the opportunity to become a true international society spanning the developments over the globe.

The 17th Congress 1992 in Washington was a confirmation of this trend when participants from 74 countries attended the Congress.

Starting with the Kyoto Congress another paradigm change became visible. While digital processing in terms of grey level filtering, multispectral analysis, geometric transformation, image correlation and image analysis from low level to high level has been the concern since the 1960's in research, practical applications have evolved in industrial applications and in supplying data for geographic information systems, in which geocoded vector and raster image data are merged together in photogrammetric digital work stations. The capabilities of high resolution and hyperspectral imaging, of radar imaging and interferometry, and of laser scanning from satellites or aircraft are increasing, and the distribution of images through Internet or Intranet is at our doorsteps. Indeed we live in exciting times.

When will the next paradigm jump occur?

I don't know: Wernher von Braun once said, basic research is what I do, when I don't know what I am doing.

I apologize to you in two respects:

I may have overemphasized in my review the local historic events, but at my age I know that nobody is perfect. And I may have omitted many important contributions of our living photogrammetrists. But remember, recognition is a plant, which grows on graves. In this respect we can truly admire Eduard Dolezal. He has given our Society direction, which was followed by others. And this is our tradition, which we can be proud of. After Hamburg 16 years ago ISPRS meets in Europe again, after 83 years photogrammetrists are back in Vienna, the cradle of our Society.

I enjoy being in Vienna today, and I hope you do too.