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About Life and Work of a Patriarch of Austrian Alpine Cartography

Gerhard Brandstätter
Institute of Remote Sensing and Photogrammetry, Graz University of Technology, Austria

Abstract

The above mentioned patriarch is the centenarian Leonhard Brandstätter, maybe the last important scientific representative of traditional alpine cartography. His life was dedicated to the idea of creating maps for practical use under the aspect of using exact data of terrestrial and air-borne photogrammetry without neglecting any detail of evaluation, that means, without arbitrary generalization

However, this rigorous principle imposes some problems, especially in the rocky areas of geologically young fold mountains because of their steep slopes. The solution of the problem was the so-called "substitution of close contour lines". Its meaning and the possibilities of representation will be explained in the paper. Besides of this feature, edges and slope-depending hatchings and shadings are applied, in order to show the relief as clearly as possible. Hence, this way of cartographic mapping is a pure geometric method and could be automated to a certain extent, using a digital terrain model.

After an eventful life, the patriarch, lives now in his home town in Carinthia and will have his 100th birthday this year. Therefore, the paper also is intended as a dedication to a remarkable journey through a century of life.

KEY WORDS: Alpine cartography, mapping, exact contour lines, topographic photogrammetry

1. Introduction

It is a rather critical task to describe the professional life and to explain the work of a well-known topographic cartographer, especially for his son. The reason may be on the one hand, a certain lack of objectivity because of close kinship, and on the other hand, a very good knowledge of his special subject „Alpine Cartography Based on Exact Contour Lines“[1] from hours of discussion and therefore a certain bias. The author will try to avoid both influences as well as possible.

The above-mentioned term Alpine Cartography using exact CL (contour lines, generally from photogrammetric evaluation) suggests a very sophisticated way of representing the mountainous parts of the surface of the earth. But, as those regions contain the most striking examples of complicated surface shapes, they can be referred to as typical features for any topo-cartographic representation problem. That means that also non-alpine terrain – even covered by vegetation – should be treated in the same careful manner (and represented in corresponding quality) as the much more spectacular alpine barren land, where exact photogrammetric data (CL or DTM = digital terrain model) can be obtained without any problem.

It is well-known that, in general, a map consisting of pure photogrammetric CL does not evoke a satisfactory spatial impression of the recorded terrain. This effect depends more or less on the local slope:

flat terrain produces CL with poor or without mutual similarity and thus without giving a visual impression of relief (► flat region),

steep terrain parts produce "black spots" because of very close or merging CL (e. g. almost vertical rock walls) without any possibility of additional topo-cartographic representation (► steep region).

Hence, the quality of relief impression depends on the density[2] of CL and its optimum will be found anywhere between the two extreme cases. The cartographic problems arising from those considerations lead to certain solutions which are typical elements of representation in all maps of our centenarian. They are explained in much detail in his book "Alpine Cartography" (Brandstätter 1983).

After a brief biography of a remarkable but modest life, in the following sections of this short paper we will give a concise description on his ideas and solutions.

1) The term „Contour Lines“ will be repeated several times. Therefore, the abbreviation CL will be used in what follows.

2) In German, for this condition there exists the characteristic term „Scharung". An appropriate official translation is unknown (International Cartographic Association 1973), p. 449.9. It means "density of CL". Therefore the term "density" will be used.

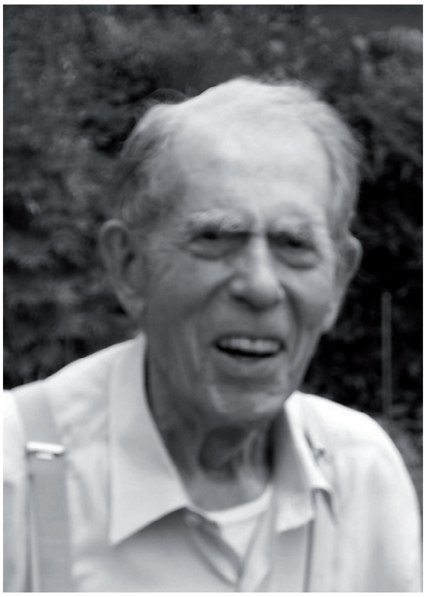

Figure 1: L. Brandstätter, July 2006.

2. Biography

About a century ago, Leonhard Brandstätter jun. (second of three children) was born in a small village in Carinthia (Obermühlbach near St. Veit an der Glan) where his father (Leonhard Brandstätter sen.) worked as a teacher at the elementary school. Some years later, the teacher and his family were transferred to Wolfsberg in the east of Carinthia. As there did not exist a secondary school at this time, the son had to move first to Klagenfurt (capital of Carinthia) and later on to Vienna. There he also got special instruction in violin, having learned to play this instrument since the fifth year of his life. His teacher was first violinist of the Vienna Philharmonic Orchestra. Finally, the ability of the young musician was adequate to play for example the well-known concerto of Jean Sibelius. Although having perfect pitch and nearly perfect skill, he did not join the Academy of Music of Vienna but the Vienna Institute of Technology in order to study architecture because of his second strong ability, drawing and painting. His father was very disappointed about this step because he wanted to have a perfect professional musician in the family.

The study was finished successfully in 1929. But instead of constructing buildings he wanted to draw maps and to become a cartographer. This unusual change of profession has to be justified in a few words: After the World War I, the school administration needed wall maps of the districts of Carinthia and after a short(!) instruction, the senior was selected to design those maps. But because of other involvements and lacking knowledge about the topic, his interest soon vanished, and so the junior spontaneously and with enthusiasm took up the opportunity to take over this extensive task. Doubtlessly the best way to cartography.

A first map (of the district of Wolfsberg) was printed in 1924 in Berlin, a second one (district of St. Veit) in 1925 in Vienna at the publishing house Freytag & Berndt. A third map (district of Völkermarkt) was designed, but it did not have a chance to get printed because of the beginning economic crisis of the twenties. However, in 1929 it served as a recommendation to get a job at Freytag & Berndt's with the intention to produce a map of the Hochschwab mountains in Styria. Moreover, he was committed to learn professional lithography, the method used at that time to prepare printing plates. By means of this special knowledge he was able to produce a map from design until readiness to print.

The three early Carinthian maps were rather conventional. In his fourth map which covers the eastern part of Hochschwab, he began to work on the problem of rock representation using exact CL. But because of economic diffi-

Client / Editor	Purpose	Scale 1:	Area km²	Data Acquisition	Printed at	Date of print
Carinthian School Administration	Wall and hand map "Wolfsberg" (Wall-maps and hand-maps denote maps used in school)			Austrian map 1:75000	Berlin ?	1924
Carinthian School Administration	Wall and hand map "St. Veit"			Austrian map 1:75000	Freytag & Berndt Vienna	1925
Austrian Alpine Club	Tourist map "Hochschwab Ost"	25000		Surveyor's table	Freytag & Berndt Vienna	1952
German Survey Authority	Research map "Dachstein Gipfelkarte"	25000	36	Terrestrial phogrammetry	Printing office of the authority Berlin	1941
Community of St. Stefan i. L.	Map of the community	10000	63	Austrian map 1.50000 + Surveyors table	Austrian Survey Authority Vienna	1951
HESPA forest administration Wolfsberg	Forestry map (three sheets)	10000	83	Air-borne photogrammetry + Surv. table	Printing office of Styria, Graz	1953 -1955
Schütte estate administration St. Andrä i. L.	Forestry map (two sheets)	10000 5000	56 5	Air-borne photogrammetry + Surv. table	Printing office of Styria, Graz	1957
Wolfsberg City Administration	City plan (nine sheets)	2000	10.4	Cadastral + Surveyor's table	Austrian Survey Authority Vienna	1958
Inst. of Photogr., Topogr. and Cartogr. TH Munich	Research map "Hoher Ifen: karst and land slide"	25000	30	Air-borne photogrammetry	Survey Authority of Bayern	1963
Carinthian School Administration	Wall and hand map "St. Veit"	125000 40000	3058	Austrian map 1.50000	Austrian Survey Authority Vienna	1964
Carinthian School Administration	Wall and hand map "Klagenfurt"	125000 40000		Austrian map 1.50000	Austrian Survey Authority Vienna	1965
Carinthian School Administration	Wall and hand map "Villach"	125000 40000		Austrian map 1.50000	Austrian Survey Authority Vienna	1965
German Research Organization (DFG)	Expedition map "Hoch-Semyen"	50000	920	Terrestrial photogrammetry	Survey Authority of Bayern	1967
German Alpine Club	Tourist map "Steinernes Meer"	25000	244	Air-borne photogrammetry	Institute of Applied Geodesy Berlin	1968
Carinthian School Administration	Wall and hand map "Völkermarkt"	125000 40000	2057	Austrian map 1.50000	Austrian Survey Authority Vienna	1971
Carinthian School Administration	Wall and hand map "Wolfsberg"	120000 40000	22178	Austrian map 1.50000	Austrian Survey Authority Vienna	1971
German Alpine Club	Tourist map "Hochkönig/ Hagengebirge"	25000	315	Air-borne photogrammetry	Institute for Applied Geodesy Berlin	1972
Federal State Niedersachsen	Research map "Northern plain: dunes"	25000	27	Air-borne photogrammetry	Survey Authority of Niedersachsen	1975
Carinthian School Administration	Wall and hand map "Oberkärnten"	150000 50000	7570	Austrian map 1.50000	Austrian Survey Authority Vienna	1975
Austrian Academy of Science	Research map "Gosaukamm"	10000	44	Air-borne photogrammetry	Austrian Survey Authority Vienna	1976
German and Austrian Alpine Clubs	Tourist map "Gosaukamm"	25000	91	Air-borne photogrammetry	Austrian Survey Authority Vienna	1976
Austrian Alpine Club	Touristi map "Hochalm-spitze/Ankogel"	25000	346	Air-borne photogrammetry	Austrian Survey Authority Vienna	1978

Table 1: List of the most important maps (22) designed and finished by Leonhard Brandstätter.

culties, the work was stopped and printed not before 1952. In 1938 he joined the governmental office of surveying and mapping where he worked until 1942. In this time he got the opportunity to design the "map of the Dachstein summit"[3)] in order to show in practice his new theories of representation using exact photogrammetric CL in very difficult terrain (steep or vertical limestone walls, rock towers, glaciers, limestone plateaus). He presented the printed result with success but because of the World War II without any continuation. On the contrary, he had to join the army and to interrupt all scientific activities.

He returned from the war in 1947. In order to care for his family (five children), he worked as violinist, painted and sold watercolours, constructed anaglyphic maps for technical projects and performed topographical field surveys in free contracts with the Austrian Federal Authority of Surveying and Mapping. Not before 1950 did the new start in cartography take place by surveying (by means of surveyor's table), designing and printing a technical map of his home town of Wolfsberg in scale 1:2000. From then on, various maps (see Tab. 1) followed, all of them based on photogrammetric CL (terrestrial and air-borne). In 1955, he obtained the doctorate (Doctor of Technical Sciences) at the Vienna Institute of Technology, Department of Geodesy, based on the thesis "Exact Contour Lines and Topographical Terrain Representation". Besides that, he wrote 16 publications, gave 13 invited special lectures at universities and cartographic offices and finally from 1973 – 1975 a series of courses on "Topographical Cartography" at the Graz University of Technology for students of Geodesy. This professional advancement became possible by the support of some academic teachers at Munich, Graz and Vienna. The most important were Prof. DDDr.h.c Dr.techn. Karl Rinner (Graz), Prof. Dr.-Ing. Rüdiger Finsterwalder (Munich) and Prof. Dr.h.c. Dr.phil. Erik Arnberger (Vienna). Last but not least, the latter was the initiator of the already mentioned book (Brandstätter 1983) (319 pages, 87 figures, 11 map sections and two enclosed maps) as part of his encyclopedia on cartography edited by the Austrian Academy of Sciences, published 1983. Since then, the cenetenarian has been living retired with one exception: in 1993 the Austrian Alpine Club published an old map of the Dachstein massif designed by Leo Aegerter in 1915 (8th revised edition) without any reference to one of his very new and most important maps, the "Gosaukamm–map" (Tab. 1), covering an significant part of this massif. His reaction to this inadvertence was the publication "Memorandum about Alpine Cartography"[4)] (Brandstätter 1996) in 1996, his definitively last expression of opinion concerning a fascinating though somewhat special sector of cartography.

3) "Dachsteingipfelkarte", published 1941
4) Denkschrift zur Alpinkartographie

3. Leonhard Brandstätter's system of representation

3.1. The CL density diagram

As already mentioned, the "natural" relief impression of maps depends to a high degree on the density d (= lines/cm in the map) of CL. In turn, the density itself depends on the constant height interval ΔZ of CL (meters), on the local inclination α (degrees), on the scale 1:M and on the graphical line width. In general, the scale is given and the line width may be taken from experience (0.2 mm or less). Hence, the first two quantities are the variables of a curve of some density d = const. and the diagram itself is the two-dimensional family of all d–curves $0<d<\infty$ (d=0 is a horizontal plane, $d=\infty$ is a vertical wall). The analytical function may be derived from the linear approximation $\tan \alpha \approx \Delta Z/W$, where W is the ground plan distance between two neighbouring CL in the terrain. From that follows the distance between two CL in the map by w = W/M and because of $d = 1/w = M/W = (M/\Delta Z) \tan \alpha$. Then the relation between inclination on the one hand and density, scale and height interval on the other hand, with

$$\alpha = \tan^{-1}(d\ \Delta Z/M)$$

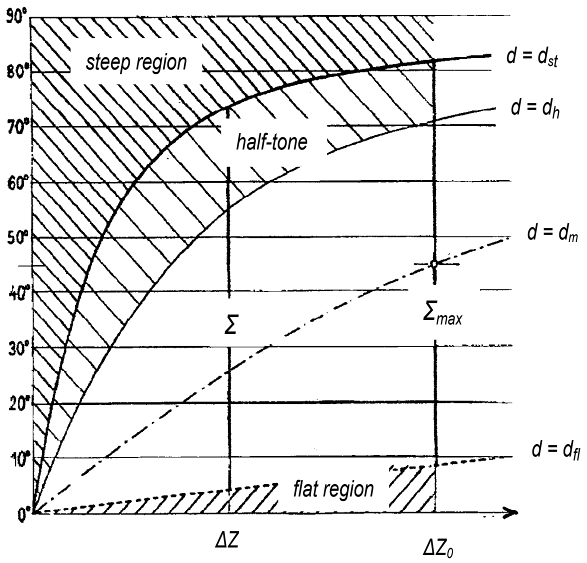

Figure 2: The CL-density diagram.

gives a family of $\tan^{-1}$–curves for a certain scale. In fact, if also M is allowed to vary, the complete function defines a three-dimensional diagram. But as only few scales are in practical use, a selected set of corresponding two-dimensional diagrams will be sufficient. The discussion of one of them (Fig. 2) shows that two regions of the diagram can be excluded:

- d < 2, that is the flat region with less then 2 CL per cm (no relief impression),

- $d > 50$, that is the steep region where the distance between the CL is so small that visual separation becomes impossible (black spots).

The boundaries of these two areas of the diagram are indicated by the densities d_{fl} and d_{st} or the slopes α_{st} and α_{fl}. Two additional boundaries have some importance, that are:

- $d_m = (M/\Delta Z) \tan \alpha_m$, the density corresponding to the mean inclination α_m of the map area,
- $d > 20$, that is the region where the CL produce a kind of half-tone since they are as close as the line width (~0.05 cm) or closer. Its boundary is indicated by d_h.or α_h.

The best application of a selected density interval will be attained by

$$\Sigma = \alpha_{st} - \alpha_{fl} = \tan^{-1}(d_{st}\Delta Z/M) - \tan^{-1}(d_{fl}\Delta Z/M) \rightarrow \text{maximum}.$$

M and the boundary parameters d_{fl} and d_{st} are constants. Differentiation with respect to ΔZ and equating with zero results in the very convenient formula

$$\Delta Z_o = \frac{M}{\sqrt{d_{st} d_{fl}}}.$$

This is the most favourable constant height difference for a map of scale 1:M between the slopes α_{st} and α_{fl}. For example M = 25 000 and $2 \leq d \leq 50$ yields ΔZ_o = 25 m. The usual ΔZ_o is 20 m and thus not the optimum. For more information about this see (Brandstätter 1983).

3.2. Additional geometric elements

The main principle of every map design was to utilize the "natural relief power" of CL as extensively as possible and to apply very sparingly additional geometric elements. The motto of our centenarian was:

"Think more, draw less and work efficiently".

Under this guideline, the determination of the optimal height difference ΔZ_o for a given map area before photogrammetric evaluation is a first necessary step of preparation. It guarantees best possible relief impression for a largest possible difference of inclination. But of course, this effect appears then and only then, when a group of equidistant neighbouring CL shows similar or equal tendency in direction and curvature (≈ conformal density). This behaviour is called group effect and represents the most important term of the alpine cartography using exact CL!

Especially in rocky terrain, the surface becomes irregular and thus edges between more or less smooth parts are conspicuous features of rock morphology. Every corner (curvature → ∞) of a CL is caused by such an irregularity and corners in CL-groups are to be connected by edge lines which are without doubt most important elements of rock representation. In terrain, unlike to CL, everybody can see these lines and it is quite necessary to map them.

Other changes in curvature are less abrupt but also irregular. They can be indicated by means of hatching in direction of the slope or by shading, which is more or less a half-tone variant of hatching. Thus, additional elements of alpine cartography are:

- strong edge-lines as for example boundaries or structure-lines of rocky areas;
- soft edge-lines, for structure-lines or breaks of slope in the basement of mountains;
- hatchings for less abrupt breaks of slope;
- shadings, in general in connection with soft edge-lines.

Skilful application of these elements makes it possible to support the understanding of the group effect even with respect to small irregular changes of the surface. The comparison of the two Figures 2a and 2b will illustrate this fact.

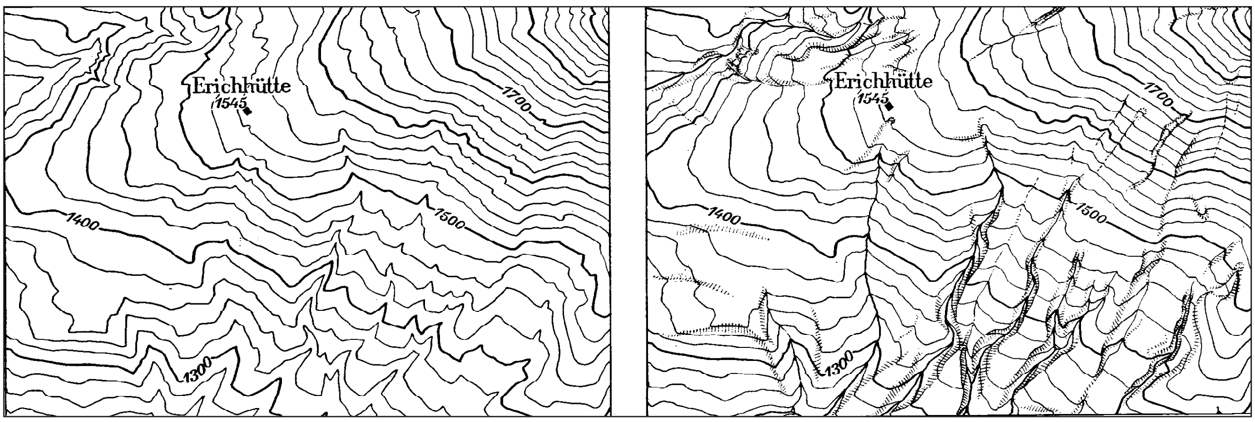

Figure 3: Section of the "Hochkönig-Hagengebirge-Map", ~1:22000. Various CL-densities without (a) and with (b) additional drawing (edge-lines, hatchings).

A phogrammetrist working for topographic cartography has to fulfil a high quality demand. It is self-evident that besides CL, all visible men-made boundaries and all natural contours (also variable ones, e. g. snow spots) at the surface must be photogrammetrically evaluated. But moreover, he has to supply the cartographer with all the above mentioned geometric characteristics and details of the terrain in order to enable the exact insertion of additional drawings. Nowadays, a lot of such details can be extracted automatically, but for some of them the direct manual interaction of the operator will be necessary.

3.3. Representation of steep and flat terrain

Outside the boundary-curves d_{st} and d_{fl} (flat and steep region) the group effect fails: in flat regions the CL-density is too low, in steep regions black spots emerge because of density $d > d_{st}$. The question of the best solution to the latter problem was the reason of various disputes with the well-known Swiss cartographer Eduard Imhof, who was the representative of the so-called artistic rock representation with accentuated relief shadowing and with little attention to the CL. Our centenarian preferred another technique, also of Swiss origin (Blumer 1937[5)]: the substitution of group effect by vertical hatching following exactly the structure of the rock given by the CL and supplementing it by means of edge-lines. Visualizing vertical rock walls or overhanging rocks occurs by very small white strips along the rock contours. These principles correspond to a rigorous construction of the projection to the ground plan according to descriptive geometry and may be called form-adequate rock representation.

Flat terrain didn’t provoke such intensive discussions as the much more prestigious representation of famous rock walls as for example those of the impressive “Matterhorn”. It has its difficulties too however. In order to achieve a correct impression of more or less horizontal but undulating terrain surfaces, the absence of the group effect demands auxiliary measures. The well-known utilization of intermediate CL (very fine or dashed lines) should not disturb the general group effect of the adopted ΔZ_o, but every change in curvature must be justified by supporting elements such as soft edge-lines, hatchings or even shading depending on the inclination. To introduce such additional features, the cartographer has to go back to the stereo model in order to identify the content of the photogrammetric evaluation and to draw these elements under stereoscopic impression. Fig. 4 demonstrates this part of topographic editing.

Although yielding a very impressive illusion of the relief, the usual general shading based on a fixed illumination from north-west is refused because of three topographical reasons:

1. Shadow pretends stronger inclination. Therefore, as the direction of illumination is constant, very often a soft slope results shady and seems to be steeper than in reality.
2. Slopes in direction south-east may become shadowy where in nature shadow does not occur
3. Because sometimes being to strong, the shadow-tone may hide topographical details which are essential for orientation in terrain using the map.

Figure 4: Leonhard Brandstätter introducing auxiliary topographic elements to a design drawing. On the left and on the right we see images of an actual stereo model; between them there is a corresponding section of the map under design. This method is quite stressful for the sight because of changing between stereo observation and plane drawing.

However, shading is not refused totally! It serves as an auxiliary element in two cases:

1. School-maps need a striking relief impression. For that, the direction of illumination can be rotated individually to a certain extent corresponding to the morphology of the map area. It may be called morphologic shading.
2. Shading can be used instead of hatching at the lower and upper boundary of larger slopes in order to indicate change in inclination. This is called slope-shading.

Both types of shading must be applied very carefully because of the above mentioned risk of hiding details. In spite of this very reduced application, the ideal remains to produce optimal relief impression without any shading, using only the group-effect, edge-lines and hatchings. In fact, in his last and best map “Hochalmspitze/Ankogel” (see Tab. 1), no shading is used and yet a good relief impression arises, certainly supported by the very favourable morphology (three large parallel valleys in east-west direction, one in north-south at the right border of the map). Therefore, topographic cartography of high quality also depends to a large extent on a sound knowledge of

5) Map of Glärnisch 1:25000, Kümmerly & Frey, Bern

geo-morphology in combination with a clear geometrical intuition. In a nutshell: the principle of modern cartography is based on exact and comprehensive terrain data.

4. Final reflections

Our cartographer celebrating his jubilee worked since 1947 as a free-lancer. That means, he depended on orders for maps assigned by some few special institutions as research organizations, alpine clubs or technical authorities. One can imagine that to get corresponding contracts was never an easy task. To produce maps of high quality under these difficult circumstances, undoubtedly is an exceptional achievement and demands a lot of idealism.

An example for that can be seen from Tab. 1. The first contract to produce a tourist map came from the German Alpine Club in 1967. At the same time, he had concluded a contract with the Carinthian highway authority to produce a technical map of parts of his home valley (Lavanttal in Carinthia) in 1:1000 for road planning purposes. However, he preferred the contract to design an alpine map ("Hochkönig/Hagengebirge") and renounced the more comfortable and more profitable job (at the age of 61!). And still he had the constitution for such a strenuous work and was able to continue with three more maps, each one better than the previous. By means of these maps he had the basic material in order to demonstrate in his book, what contemporary alpine cartography should be, even regarding modern methods as maps from orthophotos (see (Brandstätter 1983) and (Brandstätter 1996)). It's really unfortunate that a congenial successor is missing until now!

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Correspondence to:

Gerhard Brandstätter

Institute of Remote Seninsng and Photogrammetry

Graz University of Technology

Steyrergasse 30, A-8010 Graz, Austria

e-mail: gerhard.brandstaetter@TUGraz.at