# Radical Change to a Modern General Control Network

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**Key words:** control network, geodesy, fixed points

**SUMMARY:**

Referring to the technical changes during the last twenty years, there are many that affect the old general control networks of the Federal Republic of Germany. Referring to these changes in the year 2004, Germany has decided to introduce a new strategy for the general control networks. This new strategy looks toward a streamlined and homogeneous general control network for the Federal Republic. If required, it can be condensed by each state. These condensations are dependent on the different technical situations in the different states. The effects and the savings of the GNSS-technology as a part of the new strategy have been tested and examined very favourably for the State of Baden-Württemberg. Both considerations allow a theoretical concept for a general control network for every state. The presentation will be finished with an outlook on the advantages of the new general control network for the real estate cadastre.

**ZUSAMMENFASSUNG**

Ausgehend von den technischen Veränderungen der letzten zwanzig Jahre ergeben sich Auswirkungen auf die vorhandenen Festpunktfelder. Aufgrund dieser Erkenntnis hat die Arbeitsgemeinschaft der Vermessungsverwaltungen der Bundesrepublik Deutschland (AdV) im Jahr 2004 eine Strategie für die Festpunktfelder der Zukunft beschlossen. Sie sieht ausgedünnte, bundeseinheitliche, homogene Festpunktfelder vor, die je nach Bedarf von den Mitgliedsverwaltungen der AdV länderspezifisch durch weitere Festpunktfelder verdichtet werden können. Diese Verdichtungen hängen im Wesentlichen von den unterschiedlichen Ausgangssituationen in den jeweiligen Bundesländern ab.

Nachdem die GNSS-Technologie eine neue Technologie darstellt, werden die Auswirkungen und Ersparnisse durch die Einführung dieser neuen Technologie in Verbindung mit der Aufgabe der bisherigen Technologie am Beispiel des Bundeslandes Baden-Württemberg untersucht und beziffert. Beide Überlegungen führen zu einer theoretischen Konzeption für ein Festpunktfeld eines beliebigen Staates.

Mit einem Ausblick auf die Vorteile für das Liegenschaftskataster durch die neuen Festpunktfelder wird die Präsentation abgerundet.

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## 1. INTRODUCTION

In the State Surveying and Mapping Authority of Baden-Württemberg in the year 1975 there were exactly 128 workers employed in the field of position fixed points and levelling fixed points. According to present numbers of the cost-output evaluation, this number reveals a personnel expenditure of almost 5 million €.

In the year 2005 in the same field only 24 workers were employed. Their personnel expenditure is roughly 1 million €.

With that, the State Surveying and Mapping Authority annually saves about 80% of the costs, which is 4 million €, although the service standard is still the same. How can this happen?

## 2. TECHNICAL CHANGES

When we look back over the last 20 years in the field of surveying and mapping we can see the following technical changes:
Worldwide international Global Navigations Satellite Systems were and are being built e.g. GPS in the US, GLONASS in Russia and in Europe Galileo. On the basis of GNSS – technology a new type of surveying has been developed in connection with extensive hard- and software. Parallel to that, national GNSS based reference station networks have been set up e.g. SA*POS* in Germany, swipos in Switzerland and APOS in Austria. In total, those systems make a standardization for the international terrestrial reference system possible and replace the traditional national spatial reference systems. In Germany, e.g. the system of the German primary triangulation network will be replaced by ETRS89. With that, the geodetics will be able to carry out GNSS-based surveying to obtain the position and the height online without identical points.

Another obvious tendency is that in most cases under the pressure of politics, reductions of the survey standards in the official surveying and mapping will happen.

What effects do those technical changes have?

The new GNSS-technology will replace the previous old technologies. The reference station networks will realize the spatial reference system as a whole. This means in future we will only work with general control networks which are thinned out in position, height and gravity. The previous 1d- rather 2d general control networks will be replaced by 3d- to 5d general control networks. Through the combination of levelling and GPS derived heights, we will be in a position to create a new type of height surveying.

## 3. GENERAL CONTROL NETWORK IN GERMANY SINCE 2004

### 3.1.Decision

The Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) has incorporated those concepts and decided in the year 2004 to redefine homogenous, federal general control networks as a duty, and has also allowed further state specific general control networks as an option.

Homogenous federal general control networks are the SA*POS* reference stations of the system ETRS89, the height general control network of first order in the system of German primary levelling network year 1992, the general gravity points of the German primary gravity network in the system of German primary gravity network of the year 1996 and the geodetic control points with 3d-station monumenting, with 3d-coordinates, heights and gravity.

Optional state specific general control networks are the position general control networks from first to fourth order in the system of Gauß-Krüger, the height general control networks of second and third order in the system of German primary levelling network year 1992 and the gravity general control networks of second and third order in the system of the German primary gravity network year 1996.

### 3.2 Reasons

Why did we reduce the general control networks in the Federal Republic of Germany?

For the real estate cadastre, and therefore the position has to be considered that it must be possible to define points with an accuracy of +/- 2 cm. This rule is today possible with SA*POS* reference stations in connection with software for networking. This means that contrary to the presently used 1 to 2 control points per square kilometre, only roughly 1 control point per 2000 to 2500 square kilometre will be needed.

Regarding the height, the thought has emerged that there needs to be a clear separation between the scientific network and the use network. Therefore, the use network must accept a reduction of the survey standard. This will perhaps be followed by the fact that the networks of second and third order will be dropped.

Also for the gravity, only a frame network as a scientific network will be required. Moreover, a non-marked out general gravity control network of second and third order for the determination of the highly accurate geoid or quasigeoid will be needed.

### 3.3 Example of Baden-Württemberg

How does the reduction of points influence the example of Baden–Württemberg?

Up to this day we needed about 128 000 general control points for the fields of homogenous, federal general control networks and the state specific general control networks. In the future in these fields we will only have another 24 000 general control points. That means that 4/5 of the general control points are dispensable.

Theoretically, we can still manage with a minimum network configuration of 2% of the used general control points. In Baden-Württemberg, however, we have decided on an optimal network configuration of 19% of the normally used general control points.

### 3.4 Cost Savings

What cost savings can be realized in Baden-Württemberg?

In 1997 we spent 1,5 million € on the maintenance of the national trigonometric network and 1 million € on the maintenance of the national levelling network of third order. Together that was 2,5 million € per year.

In the year 2005 the costs for the maintenance of the national trigonometric network shrunk to 0,3 million €. With the renunciation of the support of the national levelling networks of third order, this adds up to a yearly saving of 1,8 million €.

Contrary to that, there was single capital outlay in 1997 for the build up of the 15 SA*POS* reference stations, for the equipment of the central office and for the administration costs which came to a total of 1,25 million €. After the set up of the SA*POS* reference station network yearly costs of 0,25 million € need to be paid.

In summary, it needs to be said that in less than a year the Satellite Positioning Service had been amortized, and starting from the year 1998, the State Surveying and Mapping Authority of Baden-Württemberg can save 1,5 million € annually. Those new numbers of the cost-output evaluation clearly underline the data of the example I mentioned at the beginning.

## 4. THEORETICAL THOUGHTS ABOUT THE GENERAL CONTROL NETWORKFOR A STATE

These thoughts were developed independently without knowledge of the momentary situation of the general control network of this state. Knowing that, you should only see it as theoretical thoughts of an outsider.

For the set up of an own Satellite Positioning Service, I postulate that an accuracy of +/- 3 cm for the fixing of a point should be reached. As a result, one reference station per 2500 km² needs to be set up and all the reference stations have to be connected by software for networking. For setting up no additional network with the geodetic control points, they need to be fairly identical to the points of the satellite positioning service and the levelling network of first order. On them, absolute measurements of gravity, should be carried out.

The levelling network of first order has to be seen as a scientific network. The use network has less accuracy and is recovered through a highly accurate geoid that still needs to be derived from ellipsoidic and levelling heights.

From these assumptions for a state with x 000 km² theoretically arise 0,45x satellite reference stations points, which should be identical to the geodetic control points. The complete levelling network exists of 200x points that usually become partly one with the marked gravity control network. Also, for the derivation of a highly accurate geoid, another 200x non-marked gravity control network points need to be measured.

In total, the general control network of the future of a state has all together about 400,45x points and 200.45 points to maintain.

## 5. EFFECTS TO THE REAL ESTATE CADASTRE

How do the modern general control networks affect the real estate cadastre?

If the spatial reference of the cadastre is identical to the spatial reference of the general control network, the measurements of the cadastre through SA*POS* reference stations automatically show the coordinates of the target system. The usual fitting into the surrounding cadastre field can be left out as the reference stations will directly show the spatial reference. This means that the expenditure of the surveying of the real estate will be reduced by factor 3 to 5 and related to that, the expense and personnel expenditure will fall accordingly.

## 6. CONCLUSION

Since seven years, the State Surveying and Mapping Authority of Baden-Württemberg has consistently worked on the reduction of general control networks. I hope I could convince you that a change to a modern general control network nowadays is, and if only for financial reasons, absolutely urgent for all Surveying Authorities.

## REFERENCES

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## BIOGRAPHICAL NOTES

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