# Necessity to Work in a Reference Frame in France

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**Key words:** Reference frame, geodetic referencing.

## SUMMARY

The obligation to use the new geodetic system RGF 93 in France has been introduced by a decree, which followed the law on land management and sustainable development. Nevertheless it is difficult for private and public actors of geographic information to use this geodetic system. In order to help promoting the new system, the working group "necessity to work in a reference frame" from commission "reference frame" of the National Council on Spatial Information Management proposes the following resolutions:

- to create a conical projection with 9 areas. Each area covers the next one on 1 degree. The maximum linear alteration that results from this system is 8cm for 1 Km. This system achieves the Lambert 93 projection that continues to be the frame for any national data exchange.
- to lower the threshold in area and length for the obligation of referencing surveys which have an impact on public property. The reference frame duty shall be useful for a global management of spatial information on the whole national territory. It is the aim of the law and must work with the implementation of the RGE (large scale national reference data set).

## RÉSUMÉ

Le caractère légal relatif à l'obligation de rattacher au système RGF93 les travaux topographiques et cartographiques est défini sans ambiguïté par le décret d'application de l'article 89 de la loi d'Aménagement et de Développement Durable du Territoire. Néanmoins les acteurs de l'information géographique, qu'ils soient publics ou privés, rencontrent des difficultés pour s'y conformer car d'une part la projection unique Lambert 93 associée au RGF93 génère une altération linéaire jugée trop forte, et d'autre part, les limites de l'obligation imposées par le décret (1 ha. ou 500 m. linéaires) apparaissent maintenant trop importantes. Le groupe de travail « Obligation de Rattachement » de la Commission des référentiels du CNIG, propose d'adopter les résolutions suivantes :

- La création d'une projection conique conforme de 9 zones. Les différentes zones prises de proche en proche ont des recouvrements de 1 degré. L'altération linéaire maximum résultant de ce zonage est au maximum de 8 cm par Km. Cet ensemble complète la projection Lambert 93 qui reste la plate-forme unique d'échange.
- La baisse du seuil en surface et longueur pour les travaux topographiques et cartographiques qui ont un impact sur le domaine public. En effet l'obligation de rattachement doit être en adéquation avec la gestion cohérente et homogène des informations géographiques sur l'ensemble du territoire dans l'esprit de la loi ainsi qu'avec la mise en place du nouveau RGE (Référentiel à Grande Échelle) national.

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## 1. HISTORIC ASPECTS OF THE FRENCH GEODESY

The French geodetic network had a comparable evolution to the ones of the other countries of Western Europe, where the geodesy and the cartography began since the XVII$^{th}$ century.

During three centuries and until 1991, the French geodetic networks have been obtained by triangulation, with very precise measures of angles, and few measurement to impose the scale : in 1960, the whole " New Triangulation of France ", the NTF (begun at the end of the XIX$^{th}$ century and finished in 1991), included only 15 measures of distances (" bases ") distributed on the whole of France. In complement of these measures, a small number of astronomical observations had been performed in order to provide a very precise local orientation of some lines.

Besides there was a real impossibility to compensate in block by least squares adjustment some sets of measures of more than a few tens of unknowns, inherent limitation to the old means of "hand" calculation. To solve this delicate problem, one used the method of successive orders, the first-order coordinates being imposed to the second order, etc… (these successive orders don't correspond *a priori* to better precisions on the coordinates). The set of coordinates distributed under the name NTF resulted from a considerable number of subset adjustments calculated by least squares, with an extremely complex error model. Typically the more distant from the point of reference (Paris), the more these coordinates are different from the values that one would have got with perfect observations, and can reach some meters at the extremities of the country.

All that hardly had any consequence, since the geodesy essentially served as support to the map of France at 1/25 000$^{th}$. The NTF served rarely, in spite of the legal obligations, to establish the referencing frame done by surveyors (less than 25% of their works was “connected to the Lambert" in 1990).

In such a situation, the real reference frame was not therefore the theoretical one, but the one really available through the observed benchmarks and their published coordinates. Here was the origin of the difficulties when these benchmarks were destroyed and rebuilt, nothing permitting to guarantee that a new determination would have the same errors that the old one.

## 2. APPARITION OF THE GPS IN GEODESY

The model of errors with the modern geodesy using precise GPS and based on an absolute world reference is completely different of what we saw with the triangulation. One can speak then of absolute error in this sense that if a given point is completely reobserved in relation to the other world geodetic observatories one will recover the same coordinates, within one or two centimetres. It is obviously a situation that is completely different from the previous one.

From the moment where it became more economic to do a canvas by GPS than by triangulation, GPS being moreover much more precise than the old NTF, it was necessary to put the question of the renovation of the national marked geodetic network. Was there still any reason to finance it ? French authorities examined completely this question towards 1990, and concluded positively. Different reasons can be mentioned :

- Certainly the base map at 1/25 000$^{th}$ was finished, but the French Topographic Data Base was under development, demanding a reference homogeneous at the level of the decimetre, what was beyond the limits of capacities of the NTF.

- Some completely new needs appeared with the generalization of the GIS and the use of the GPS to reference all possible objects. More and more users can find an economic interest to survey these objects in a very well definite reference frame (as long as it is easy to access), because it permits to extricate a cross-profit between the different surveys, that become perfectly superimposable and coherent : then an added value appears, thanks to the upstream public investment. At the time of paper maps, such a profit would have been quite marginal.

- Users having, more and more, GPS capabilities to measure in a much more precise way than what is offered by the NTF, would soon have completely stop to put their works in a definite reference, making on long term lose all means to get a synergism between successive surveys.

It has been decided therefore :

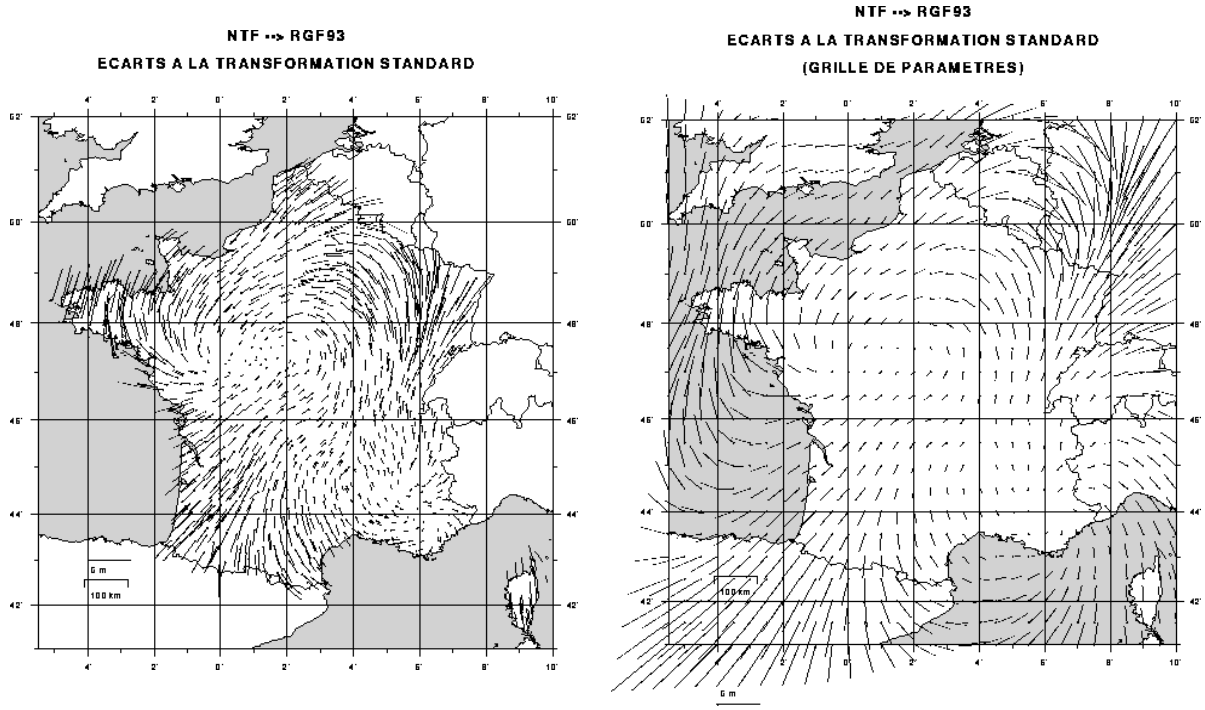
- to observe in GPS a new whole of benchmarks (the RBF, Basis French Network) with a very high precision (finished in 1995).

- to install permanent GPS stations, giving to term to users an excellent access to the national reference and helping them to equip themselves in GPS (in progress since 1997, 39 stations at the end of 2002).

- that at the time of observations of the RBF, a large number of points of the NTF would be measured by GPS in the same sessions. One got thus by global calculation a second set of coordinates for the NTF points, permitting to publish a very precise model of differences between the reference materialized by the RBF and the one materialized by the NTF.

Then there were two solutions :

- either to pursue with old NTF coordinates and to give to users the elements of distortion permitting them of distort their new observations (for example by GPS) so that they are compatible with the NTF,




**Figures 1 and 2** (left) Map of distortions of the NTF in the RGF93, under shape of vectors on points of the first order of the NTF. These vectors have been calculated in order to have a null mean value. (right) Results provided by the interpolator provided to the users in the freeware CIRCE 2000.

- either to completely change the national reference, the new works being expressed naturally and without correction in this new reference, and elders being recovered by applying this model of distortion already evoked.

These two solutions have each advantages and drawbacks, these last being bound to the unavoidable difficulty to get the old data (a very large figure, having an enormous economic importance) compatible with new ones. It is the second solution that has been adopted in France, as besides it occurred in many other countries confronted to the same problem. The new system is coherent with the world system ITRF within about 2 centimetres, and the old NTF can be used thanks to the model of distortion with a precision of the order of 5 cm.

As the official system of projection is based on the geodetic national reference, its change obliged to redefine the official projection system. The previous system (conform conical Lambert, with 4 zones, and extended Lambert II covering all zones but creating strong linear alterations) let the place to only one extended system, baptized Lambert 93, conical secant projection, and as a result the linear alteration can vary -1 m/km to +3 m/km.

A point must be considered as a drawback : it is necessary to note a certain number of difficulties that appear for surveyors operating for a long time in a given zone. They often have in this zone a set of reference marks only known by them, and whose coordinates were the result of compensations and more complex adjustments, integrating in all cases the local distortions of the NTF. Obviously, the conversion of these coordinates within the new system RGF 93 will have an insufficient precision in relation to possibilities offered by the new reference frame, and this is going to eliminate progressively these points, as their accuracy is

not compliant with the new possibilities. A transformation of coordinates in no way improves the quality of the initial determination.

Another problem to note : if the new projection is the equivalent of the old Lambert II extended, on the other hand it doesn't exist an equivalent to the old Lambert zones projections, whose modest extent resulted in very reduced linear alterations, at least impossible to detect on the paper documents. Thus many users don't have very clear ideas on these problems of projections. And when corrections can pass 2m / km, even the paper documents gives some substantial and visible discrepancies. Errors that may result are consequent !

Within the advantages of the new decree, the perspective to see the reference frame henceforth becoming immutable, whatever the destructions of benchmarks, is very satisfactory and encouraging. Otherwise, the GPS measures are completely compatible in an automatic way with the RGF 93, at the level of 1 to 2 centimetres. One thus gets an access much more comfortable to the reference than before. For example one gets the same results while installing the GPS reference receptor on a close point of the RBF, or while downloading data recorded on even very distant GPS stations, to the cost evidently of much longer measures. The gotten coordinates are, in any case, perfectly in the reference RGF 93, without any effort and without particular work.

## 3. PRACTICAL ASPECTS OF THE USE OF THE NEW LEGAL TEXTS

The application decree has been taken early 2001. It made official the new geodetic reference RGF93 (based on the ITRF 93), then the new projection Lambert 93, and it specified to what types of surveys this legal obligation applied : surveys done on publics funds, concerning surfaces superior to 1 ha or linear works of a length beyond 500 m.

It appeared in 2002 that the text of law was little or not applied. The first identified obstacle was the one of linear alteration of the new projection, considered as far too high in certain zones of the country. A lot of operators make confusion between linear alteration and error of measure, and the new legal text had besides been conceived first to facilitate the work of users of GIS : only one projection = no problems of borders between the different zones. One understood very late that there were also a lot of geographical information users who didn't use GIS : urbanists, architects, landscapists,... for them the linear alteration notion was incomprehensible, and they use mostly paper documents.

Besides, most users don't have a sufficient technical culture to understand well the difference between the geodetic reference and the projection, two concepts that they generally amalgamate. To facilitate the understanding of these problems, many articles have been written in the French technical magazines for surveyors (Géomètre, XYZ), and the Internet site of the IGN has been enriched of numerous explanatory pages, as well as the downloadable free software CIRCE 2000 permitting an easy calculation of changes of reference systems, including altimetric ones.

Finally, the legal obligation of referencing is also badly discerned by users. It is destined to facilitate exchanges of data between successive operators working on one same zone, and it has sometimes been considered like an undue manner to oblige users to pay for services of a surveyor for a possible profit, a far and very hypothetical one, and in any case badly understood.

The French National Council of the Geographical Information (CNIG) decided to create a working group to examine what amendments had to be proposed to the official texts.

In a first time this group decided to adopt a new projection in complement of the unique projection, intended mostly for local administrations users. It is based on a set of 9 conical conform projections, where every central parallel has for value of latitude a whole number of degrees (41° to 49°). Each covers a strip of 2 degrees of latitude, with a degree in common with every neighbouring zone, and the linear alteration doesn't pass 10 cm/km, it is therefore invisible on a paper document.

Otherwise it has been considered to ask for an extension of the obligation of referencing to all surveys, without limitation of dimension. This option has been repulsed when has been noticed that the cost of a referencing was only important if a local administration had not any modern appropriate means of reference for its works, for example a permanent GPS station, a large density geodetic network,... The example of a big city having a GPS station of the RGP network shows that in these conditions it is more advantageous to perform referencing, since it is a very easy operation and that it brings in counterpart some quality guarantees. It is therefore going to be proposed, as main evolution of texts in force, that there is an obligation to provide information on the type of referencing really performed, for all surveys done on public funds.

## 4. CONCLUSION

It is expected that these perfections to existing text will permit to facilitate their use by the different public users. Nevertheless the essential work that must be continuously performed is the one of a regular and efficient explanation of advantages brought by a good understanding of problems bound to reference frames in the local administrations : permanent GPS stations, geodetic network densification, calculations of distortion grids between the old system and a modernized system, data diffusion. It will pass by the pursuit of technical papers diffusion and the animation of formation seminaries, as well as the specific formation adapted to initial training, for engineers and for technicians as well.

## BIOGRAPHICAL NOTES

**Michel Kasser**, born in 1953 in Lausanne (Switzerland). Two engineer degrees, from Ecole Polytechnique (Paris, 1972-1975) and Ecole Nationale des Sciences Géographiques (ENSG, 1975-1977). In 1977-1991, with IGN-France as manager, first of the Levelling Department (in charge of the French High Precision Levelling Network), then in 1984 of LOEMI instrumentation laboratory, and then in 1988-1991 of the Commercial Department. In parallel, geophysical geodetic operations in many active areas of the world. Since 1991,

appointed as University Professor, Director of the Ecole Supérieure des Géomètres et Topographes (main French technical university in Surveying and Geomatics). Since 1999, he is the head of the Geodetic and Levelling Department, and Director of the LAREG (Laboratoire de Recherches en Géodésie) at IGN-France. President of the Association Française de Topographie since 2002, and was the main author with Yves EGELS of the book "Digital Photogrammetry" (Taylor & Francis, London 2001) edited also in French ("Photogrammétrie Numérique", Hermès Sciences, Paris, 2001). A delegate for Commission 5 of FIG since 1988 and has chaired several WG within commission 5.

**Jacques Breton** has an engineering degree from ESGT, and is surveyor. Has been President of the Higher Counsel of the French Ordre des Géomètres Experts from 1988 to 1992

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