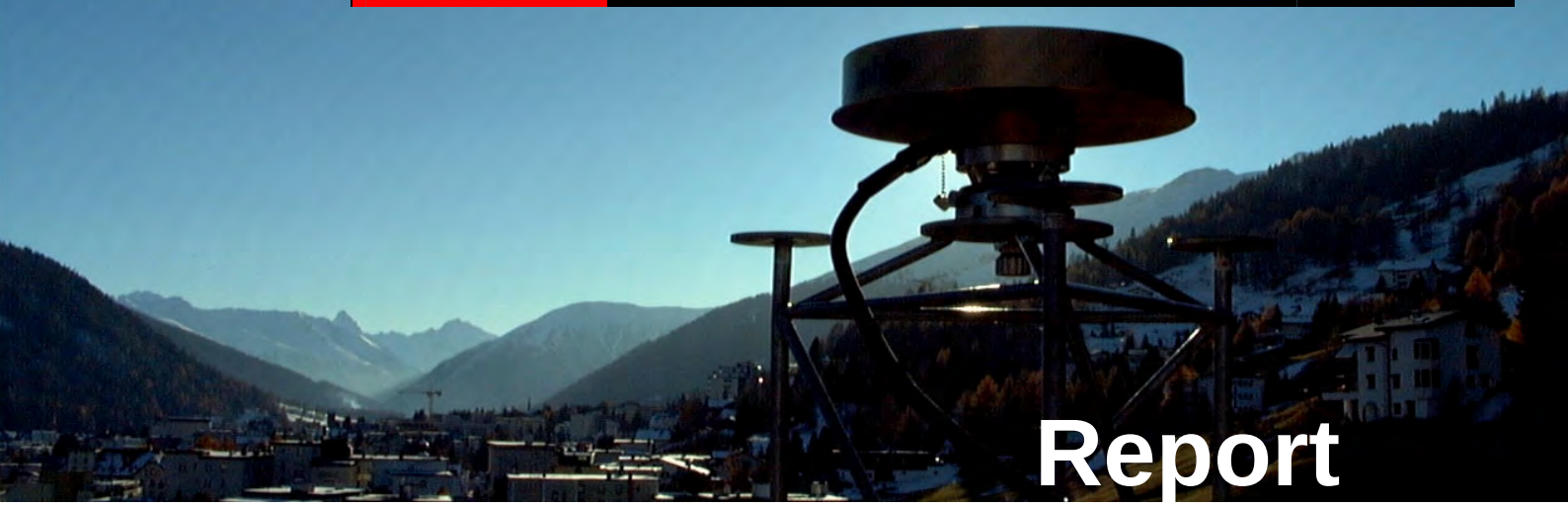

Report

REFRAME .NET / COM library

09-07 A

January 2014 Jérôme Ray

Developer's manual

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Table of contents

1 Introduction 1
2 Technical aspects 2
3 Minimal system requirements 2
4 Installation 3
5 Using the REFRAME DLL 4
5.1 Main class 4
5.2 Properties ..... **Erreur ! Signet non défini.**
5.3 Methods and returns 4
6 Code samples 8
6.1 C# .NET 8
6.2 C++ 9
6.3 VB/VBA 10

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swisstopo Report ist die Nachfolgeserie der Reihe "Technische Berichte" in welcher über die wichtigen Arbeiten aus den Bereichen von swisstopo berichtet wird.
swisstopo Report est la suite de la série "Rapports techniques", qui décrivent les projets et activités les plus importants de swisstopo.
swisstopo Report is the follow-up of the series "Technical Report" in which important projects and activities of swisstopo are described.

1 Introduction

REFRAME is a planimetry and/or altimetry transformation software for technical surveying or cadastral surveying applications, with the highest precision requirements.

This product supports the following Swiss reference frames/systems:

- Plane coordinates LV03 (CH1903)
- Plane coordinates LV95 (CH1903+)
- Global geographic or geocentric coordinates CHTRS95/ETRS89/WGS84
- National levelling network LN02 (levelled heights)
- National height network LHN95 (orthometric heights, CHGeo2004)
- Ellipsoidal heights (Bessel[1] or GRS80)

REFRAME can compute transformations in interactive mode (manual input of coordinates) or file mode (supports several formats like ESRI Shape, Interlis, DXF, swisstopo LTOP, Topobase, Excel CSV, text) and can also be used as batch tool through the command line.

Since version 1.5 (January 2009), this software can also transform the metadata of raster files (World files, GeoTIFF or ECW).

A free REFRAME geoservice is also online since 2007.

For more information about REFRAME desktop software or web service, please refer to our website:

→ *http://www.swisstopo.ch/geosoftware*

And for technical aspects about Swiss reference frames and the new frame LV95:

→ *http://www.swisstopo.ch/lv95*

The REFRAME DLL allows software developers to implement REFRAME computing in their own applications through .NET or COM components (.NET or C++ applications, VBA macros, further DLL or plug-ins, etc.).

For some technical reasons, the computations are splitted in two methods/modules in this DLL:

- **REFRAME** (method “ComputeReframe”) for transformations between Swiss reference frames (planimetry and altimetry)
- **GPSREF** (method “ComputeGpsref”) for transformations between Swiss and global (European/World) coordinates (and reference ellipsoid change)

[1] The CHGEO2004 geoid model has to be purchased and installed separately, see chapter 2.

2 Technical aspects

The REFRAME DLL can compute planimetric and altimetric reference frame changes. All the transformations are not linear and are based on binary datasets organized in grids (altimetry) or triangular networks (planimetry).

The following datasets are embedded in this DLL:

- **CHENyx06 (FINELTRA)**

  The transformation from LV03 to LV95 coordinates and reverse is based on the FINELTRA algorithm[2] (affine transformation with finite elements). It is based on a triangular network transformation dataset named CHENyx06. Current version: 03.2007.

- **HTRANS**

  The transformation from LN02 (levelled) to LHN95 (orthometric) heights is based on the HTRANS transformation dataset. This transformation is based on 3 regular grids (with a resolution of 1km x 1km) containing data depending on the influence of the gravimetric field, the incidence of kinematics (alpine rising over 100 years) and distortions of LN02 (quality of the precise levelling 1864-91). Current version: 2005.

- **CHGeo2004**

  The transformation from LHN95 (orthometric) to Bessel (ellipsoidal) heights is based on the Swiss geoid model. This model is defined as a regular grid (of a resolution of 1km x 1km). Current version: 2004.

  Warning: the REFRAME DLL is free of charge, but the geoid model dataset (CHGeo2004) isn't and costs CHF 600.-. For this reason, you won't be able to transform heights to or from ellipsoidal heights (Bessel) directly after the standard DLL installation. If you already purchased the CHGeo2004 dataset with other software or with a GNSS receiver, you just need to copy the binary file (CHGEO04.grd) into the DLL installation folder, in the "datasets" subdirectory. Contact us if you want to purchase the geoid data or need help.

For the transformation from Swiss LV95 plane coordinates to global geographic or geocentric coordinates (CHTRS95/ETRS89/WGS84) or reverse, the rigorous projection formulas are used (**Oblique Mercator and "LV95" parameters**[3]). If you want to transform LV03 coordinates to global coordinates, you'll have to transform them to LV95 first, and then to ETRS89. The same intermediate step applies for the reverse computation: ETRS89 to LV95 and then to LV03.

3 Minimal system requirements

- Hardware: PC Pentium 400 MHz or compatible with 96 Mb RAM (or more, depending on operating system)
- Operating system: Microsoft Windows XP, Vista, 7 or Server 200X
- Software: Microsoft .NET Framework[4] 3.5 (or further)

[2] More information about FINELTRA and the LV03-LV95 transformation : *http://www.swisstopo.ch/lv95*

[3] More information about the Swiss projection and "LV95" parameters : *http://www.swisstopo.admin.ch/internet/swisstopo/en/home/topics/survey/sys/refsys.html*

[4] Microsoft .NET Framework is not included in the provided setup to limit the file size, but it can be downloaded for free on the Microsoft website (*http://www.microsoft.com/downloads/*)

4 Installation

swisstopo delivers a standard Windows Installer setup which installs all required files and automatically registers the DLL in the system. You just have to execute it and follow the onscreen indications.

To optimize file size and download time, we didn't integrate neither the Microsoft Windows Installer engine nor the Microsoft Windows .NET Framework. If they aren't already installed on your computer, they will be automatically downloaded[5] and installed.

After the installation's process, you'll find a shortcut to a PDF version of this manual in the Windows start menu.

If you want to create your own distribution or install the DLL on another computer without our setup, you'll have to copy the files as follows:

1. Copy the program library file into the chosen installation directory:

   - swisstopoReframeLib.dll

   Note: you have to register the DLL file properly with the "regasm" tool (see below), and eventually update the reference in your source code (e.g. "#import" instruction in C++).

2. If the REFRAME DLL is called through COM components (and not directly referenced in a .NET application), you have to register the .NET assembly into the Windows registry by running the following command:

   regasm swisstopoReframeLib.dll /codebase /tlb

   *Warning: on systems where Microsoft .NET Framework SDK (or Visual Studio) isn't installed (but only the .NET Framework redistributable), you'll have to type the full "regasm" path, e.g. "C:\WINDOWS\Microsoft.NET\Framework\v4.0.30319\regasm.exe …". You will need to specify explicitly "…\Framework**64**\..." for the 64 bits version.*

   Note: this registration can be done automatically with most of the setup software, as they support natively the "COM Interop" registration.

3. *Copy the datasets binary files into a "datasets" subdirectory (relative to the DLL):*

   - bougan.grd HTRANS
   - CHENyx06.bin CHENyx06
   - CHENyx06_sidx.bin CHENyx06
   - CHGEO04.grd[6] CHGeo2004
   - korrektur.grd HTRANS
   - norm-ln02.grd HTRANS

   *Note: this path can be changed when you deploy your own application on other workstations: you just have to use the "SetDatasetsDir" method of your "Reframe" object. Refer to chapter **Erreur ! Source du renvoi introuvable.** for more information about this setting.*

[5] They also can be obtained through the Windows Update service or downloaded manually : http://www.microsoft.com/downloads

[6] This file is only available if you installed the Swiss geoid model, which is sold separately. More information under "CHGeo2004", chapter 2.

5 Using the REFRAME DLL

5.1 Main class

The REFRAME DLL main class is named "**Reframe**" and is accessible through an interface named "**IReframe**".

The only one constructor is standard and doesn't take any argument:

```
public Reframe()
```

5.2 Methods and returns

The "reframeLib" class contains three public methods:

- **ComputeGpsref**:
  Transformation of Swiss plane coordinates LV95 and ellipsoidal heights on Bessel to global geographic or geocentric CHTRS95/ETRS89/WGS84 coordinates and ellipsoidal heights on GRS80, or reverse.
- **ComputeReframe**:
  Transformation of Swiss plane coordinates LV03 to LV95 or reverse, and transformations between Swiss levelled heights LN02, orthometric heights LHN95 and ellipsoidal heights on Bessel.
- **SetDatasetsDir**:
  Definition (change) of the directory where the datasets (binary files containing CHENyx06, HTRANS and CHGeo2004 definitions) are installed.

ComputeGpsref

This method needs 4 arguments:

```
int ComputeGpsref(ref double east_x_lon, ref double north_y_lat,
                  ref double height_z,
                  int flag);
```

1. **east_x_lon:**
   Swiss LV95 easting coordinate in meters [m], CHTRS95/ETRS89/WGS84 geocentric X coordinate in meters [m] or CHTRS95/ETRS89/WGS84 geographic longitude (λ) in decimal degrees [°]. This argument is passed by reference, which means that the input value is replaced by the output coordinate after the processing.
2. **north_y_lat:**
   Swiss LV95 northing coordinate in meters [m], CHTRS95/ETRS89/WGS84 geocentric Y coordinate in meters [m] or CHTRS95/ETRS89/WGS84 geographic latitude (φ) in decimal degrees [°]. This argument is passed by reference, which means that the input value is replaced by the output coordinate after the processing.
3. **height_z:**
   Ellipsoidal Height in meters [m], on Bessel 1841 if input values are Swiss plane coordinates in LV95, on GRS80 if input values are global coordinates in CHTRS95/ETRS89/WGS84. This argument is passed by reference, which means that the input value is replaced by the output height after the processing.

4. **flag:**
   A code that defines the transformation to compute (input and output reference frames). Available choices:
   - 0: Global geocentric coordinates (CHTRS95/ETRS89/WGS84) and height on GRS80 → Swiss plane coordinates LV95 (CH1903+) and height on Bessel 1841
   - 1: Global geographic coordinates (CHTRS95/ETRS89/WGS84) and height on GRS80 → Swiss plane coordinates LV95 (CH1903+) and height on Bessel 1841
   - 2: Swiss plane coordinates LV95 (CH1903+) and height on Bessel 1841 → Global geocentric coordinates (CHTRS95/ETRS89/WGS84) and height on GRS80
   - 3: Swiss plane coordinates LV95 (CH1903+) and height on Bessel 1841 → Global geographic coordinates (CHTRS95/ETRS89/WGS84) and height on GRS80

This method returns an integer value, a code which defines if the transformation was done successfully, or describes the error if not:

- 1: Computation successfully executed: the coordinates passed by reference have been updated with the new output values
- -1: Error: coordinates are outside the Swiss boundaries (invalid input coordinates)
- -2: Error: unsupported value for “flag” argument (only “0”, “1”, “2” or “3” are allowed)

It is hardly recommended to check this value, because no exception will be thrown. If you ignore this code, your are not able to know if the results are correct!

ComputeReframe

This method needs 7 arguments:

```
int ComputeReframe(ref double east, ref double north, ref double height,
                   int plaFrameIn, int plaFrameOut,
                   int altFrameIn, int altFrameOut)
```

1. **east:**
   Easting coordinate in meters [m]. This argument is passed by reference, which means that the input value is replaced by the output coordinate after the processing.
2. **north:**
   Northing coordinate in meters [m]. This argument is passed by reference, which means that the input value is replaced by the output coordinate after the processing.
3. **height:**
   Height in meters [m]. This argument is passed by reference, which means that the input value is replaced by the output height after the processing.
4. **plaFrameIn:**
   The planimetric reference frame of your source data. This setting will be automatically checked when REFRAME looks for the corresponding coordinate in the triangular transformation network; if the input coordinates are outside of the definition bounds and so outside of the dataset extents, you will get an error. Available choices:
   - 0: Swiss plane coordinates LV03 (CH1903)
   - 1: Swiss plane coordinates LV95 (CH1903+)

5. **plaFrameOut:**
   The planimetric reference frame of your destination data. If you don't need a planimetric transformation but only want to compute an altimetric transformation, you have to use the same values for input and output. Available choices are same as for input:

   - 0: Swiss plane coordinates LV03 (CH1903)
   - 1: Swiss plane coordinates LV95 (CH1903+)

6. **altFrameIn:**
   The altimetric reference frame of your source data. This setting cannot be automatically defined or checked, so you have to be careful and ensure yourself that your choice really corresponds to the current source data. Otherwise you will get incorrect results and you won't see anything! Available choices:

   - 0: National levelling network LN02 (levelled heights)
   - 1: National height network LHN95 (orthometric heights, CHGeo2004)
   - 2: Ellipsoidal heights (on Bessel 1841)

   Warning: the REFRAME DLL is free of charge, but the geoid model dataset (CHGeo2004) isn't and costs CHF 600.-. For this reason, you won't be able to transform height to or from ellipsoidal height ("2") after the standard DLL installation. If you already purchased the CHGeo2004 dataset with other software or with a GNSS receiver, you just need to copy the binary file (CHGEO04.grd) into the DLL installation folder, in the "datasets" subdirectory. Contact us if you want to purchase the geoid data or need help.

7. **altFrameOut:**
   The altimetric reference frame of your destination data. If you don't need an altimetric transformation but only want to compute a planimetric transformation, you have to use the same values for input and output. Available choices are same as for input:

   - 0: National levelling network (levelled heights)
   - 1: National height network LHN95 (orthometric heights, CHGeo2004)
   - 2: Ellipsoidal heights (on Bessel 1841)

   Warning: the REFRAME DLL is free of charge, but the geoid model dataset (CHGeo2004) isn't and costs CHF 600.-. See the upper warning, under "altFrameIn".

This method returns an integer value, a code which defines if the transformation was done successfully, or describes the error if not:

- 1: Computation successfully executed: the coordinates passed by reference have been updated with the new output values
- -1: Error: specified point outside of the CHENyx06 triangular network (input coordinates outside boundaries)
- -2: Error: specified point outside of the HTRANS or CHGeo2004 grid (input coordinates outside boundaries)
- -3: Error: problem occurred when reading a binary file. Check that all the binary files (datasets definitions) are correctly installed and valid (try to recover/recopy the original versions). Reinstall the REFRAME DLL if the problem persists.
- -4: Error: unsupported value for "plaFrameIn" or "plaFrameOut" argument (only "0" or "1" are allowed)
- -5: Error: unsupported value for "altFrameIn" or "altFrameOut" argument (only "0", "1" or "2"[7] are allowed)
- -6: Error: input and output reference frames (planimetry and altimetry) are the same, there isn't any transformation to do!

[7] "2" (= ellipsoidal heights) works only if the CHGeo2004 dataset is installed

- -10: Error: CHENyx06 dataset inaccessible (binary file “CHENyx06.bin” not found). Check if the file exists in the “datasets” subdirectory or if the path defined with the “SetDatasetsDir” method is correct and that the file is accessible (enough rights). Reinstall the REFRAME DLL if the problem persists.
- -11: Error: HTRANS dataset inaccessible (binary file “bougan.grd”, “”korrektur.grd” or “norm-ln02.grd” not found). Check if the file exists in the “datasets” subdirectory or if the path defined with the “SetDatasetsDir” method is correct and that the file is accessible (enough rights). Reinstall the REFRAME DLL if the problem persists.
- -12 Error: CHGeo2004 dataset is inaccessible (binary file “CHGEO04.grd” not found). Check if the file exists in the “datasets” subdirectory or if the path defined with the “SetDatasetsDir” method is correct and that the file is accessible (enough rights). *Warning: this file isn’t provided in the standard REFRAME DLL setup and has to be purchased separately (see previous page for more information).* Reinstall the CHGEO2004 dataset if the problem persists.

It is hardly recommended to check this value, because no exception will be thrown. If you ignore this code, your are not able to know if the results are correct!

SetDatasetsDir

This method can be used to set the folder where the transformation datasets can be found.

This method needs 1 argument:

```
void SetDatatsetsDir(string datasetsDirectory)
```

1. **datasetsDirectory:**
   The absolute path where the datasets binary files are installed (CHENyx06, HTRANS, CHGeo2004). You must always end your path with a directory separator character (“\”).

If you don’t call this method (which is the same as passing “**null**” as argument), the default location that will be expected is a **“datasets” subdirectory relative the DLL** (“swisstopoReframeLib.dll”).

If the path is not properly defined, you will get a “binary file not found” error message when trying to perform a computation (“ComputeReframe” method).

6 Code samples

6.1 C# .NET

Before you can use the DLL, you have to add a .NET reference to **"swisstopo REFRAME library 2.0 (02.2012)" (swisstopoReframeLib.dll)**. The namespace is "swisstopo.geodesy.reframe".

Example of C# code:

```
// Reference to the REFRAME DLL
using swisstopo.geodesy.reframe;
…

// Instantiate a Reframe object
Reframe oReframe = new Reframe();

// If you need to change the binary data folder
oReframe.SetDatasetsDir(@"C:\MyApplication\Data\");

// Input coordinates: read in a file, got from a textbox,
// or obtained through another method or library...
double c1 = 601000.0; // East in LV03
double c2 = 197500.0; // North in LV03
double c3 =    555.0; // Usual height (LN02)

// Transform LV03 coordinates to LV95 and LN02 height to Bessel
int result =
    oReframe.ComputeReframe(ref c1, ref c2, ref c3, 0, 1, 0, 2);

// Analyze result
if (result==1)
    … // OK
else
    … // Error
```

After this code, c1 (east in LV95) = 2601000.030 m, c2 (north in LV95) = 1197500.037 m, c3 (ellipsoidal height on Bessel) = 554.335 m and result = 1 (if binary files are correctly installed).

```
// Succession of the first part above

// Transform LV95 coordinates to ETRS89 longitude/latitude
// and ellipsoidal height on Bessel to GRS80
result =
    oReframe.ComputeGpsref(ref c1, ref c2, ref c3, 3);

// Analyze result
if (result==1)
    … // OK
else
    … // Error
```

After this code, c1 (longitude) = 7.451764 °, c2 (latitude) = 46.928595 °, c3 (ellipsoidal height on GRS80) = 604.004 m and result = 1.

6.2 C++

Before you can use the DLL, you have to import the COM type library (*.tlb) "**swisstopoReframeLib.tlb**" and initialize the COM library with "**CoInitialize**".

Example of C++ code:

```
// Reference to REFRAME DLL
#import <swisstopoReframeLib.tlb>[8]
…

// Initialize COM connection
CoInitialize(NULL);

// Create a pointer to the Reframe class from DLL
swisstopoReframeLib::IReframePtr
    pReframe(__uuidof(swisstopoReframeLib::Reframe));

// If you need to change the binary data folder
pReframe->SetDatasetsDir("C:\\MyApplication\\Data\\");

// Input coordinates: read in a file, got from a textbox,
// or obtained through another method or library...
double c1 = 601000.0; // East in LV03
double c2 = 197500.0; // North in LV03
double c3 =    555.0; // Usual height (LN02)

// Transform LV03 coordinates to LV95 and LN02 height to Bessel
int result = pReframe->ComputeReframe(&c1, &c2, &c3, 0, 1, 0, 2);

// Analyze result
if (result==1)
    … // OK
else
    … // Error
```

After this code, c1 (east in LV95) = 2601000.030 m, c2 (north in LV95) = 1197500.037 m, c3 (ellipsoidal height on Bessel) = 554.335 m and result = 1 (if binary files are correctly installed).

[8] If the REFRAME DLL and the type library are correctly registered in the system with "regasm" (see chapter 4). If not, or if you are experiencing problems when you try to instantiate a Reframe object, you can import the TLB file giving the full path (e.g. "C:\MyApplication\swisstopoReframeLib.tlb"). This will be more "secure", but less flexible.

```
// Succession of the first part above

// Transform LV95 coordinates to ETRS89 longitude/latitude
// and ellipsoidal height on Bessel to GRS80
res = pReframe->ComputeGpsref(&c1, &c2, &c3, 3);

// Analyze result
if (result==1)
    … // OK
else
    … // Error
```

After this code, c1 (longitude) = 7.451764 °, c2 (latitude) = 46.928595 °, c3 (ellipsoidal height on GRS80) = 604.004 m and result = 1.

6.3 VB/VBA

Before you can use the component, you have to add a reference to **"swisstopo REFRAME library 2.0 (02.2012)" (swisstopoReframeLib.tlb)**.

Example of VB code:

```
'Create a new Reframe object
Dim oReframeLib As New swisstopoReframeLib.Reframe

'If you need to change the binary data folder
oReframeLib.SetDatasetsDir "C:\MyApplication\Data\"

'Input coordinates: read in a file, got from a textbox,
'or obtained through another method or library...
Dim c1 As Double, c2 As Double, c3 As Double
c1 = 601000# 'East in LV03
c2 = 197500# 'North in LV03
c3 = 555#    'Usual height (LN02)

'Transform LV03 coordinates to LV95 and LN02 height to Bessel
Dim intResult As Long
intResult = oReframeLib.ComputeReframe(c1, c2, c3, 0, 1, 0, 2)

'Analyze result
If intResult = 1 Then
    … 'OK
Else
    … 'Error
End If
```

After this code, c1 (east in LV95) = 2601000.030 m, c2 (north in LV95) = 1197500.037 m, c3 (ellipsoidal height on Bessel) = 554.335 m and result = 1 (if binary files correctly installed).

```
'Succession of the first part above

'Transform LV95 coordinates to ETRS89 longitude/latitude
'and ellipsoidal height on Bessel to GRS80
intResult = oReframeLib.ComputeGpsref(c1, c2, c3, 3)

'Analyze result
If intResult = 1 Then
    … 'OK
Else
    … 'Error
End If
```

After this code, c1 (longitude) = 7.451764 °, c2 (latitude) = 46.928595 °, c3 (ellipsoidal height on GRS80) = 604.004 m and result = 1.

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Geodetic developments and contracts

Jérôme Ray