PRISMMATIC

User Manual

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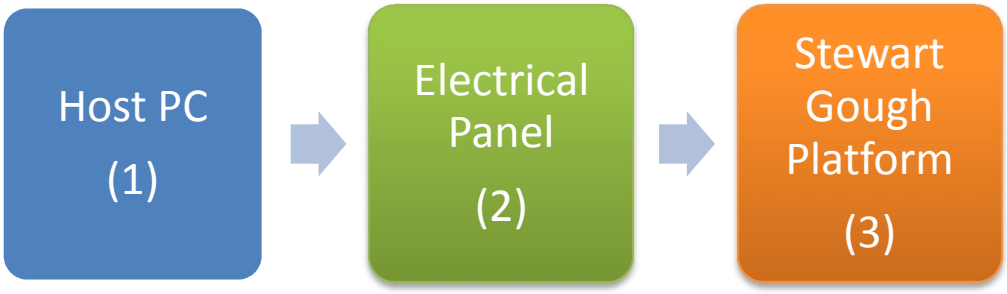
This user manual describes the operation modes and software to control a Stewart – Gough platform for manufacturing purposes. This document is presented as a result of the program “jovenes investigadores 2011” founded by Colciencias and Universidad Nacional de Colombia.

This manual is designed for end users who want to use the platform for Manufacturing. Users who want to perform some modification to the hardware or software migth require additional information. The first section provides a quick overview of the main components of the system. The second section explains the basic steps to set up your system to be ready to work. Section three provides examples an explanations to use the main fuctions within the system. Finally, section four and five introduce troubleshooting and technical specifications respectively.

Section 1. Stewart Gough at a glance

This section describes the main components of the Stewart Gough platform (SGP) in addition to some essential concepts:

The main components in a SGP are:

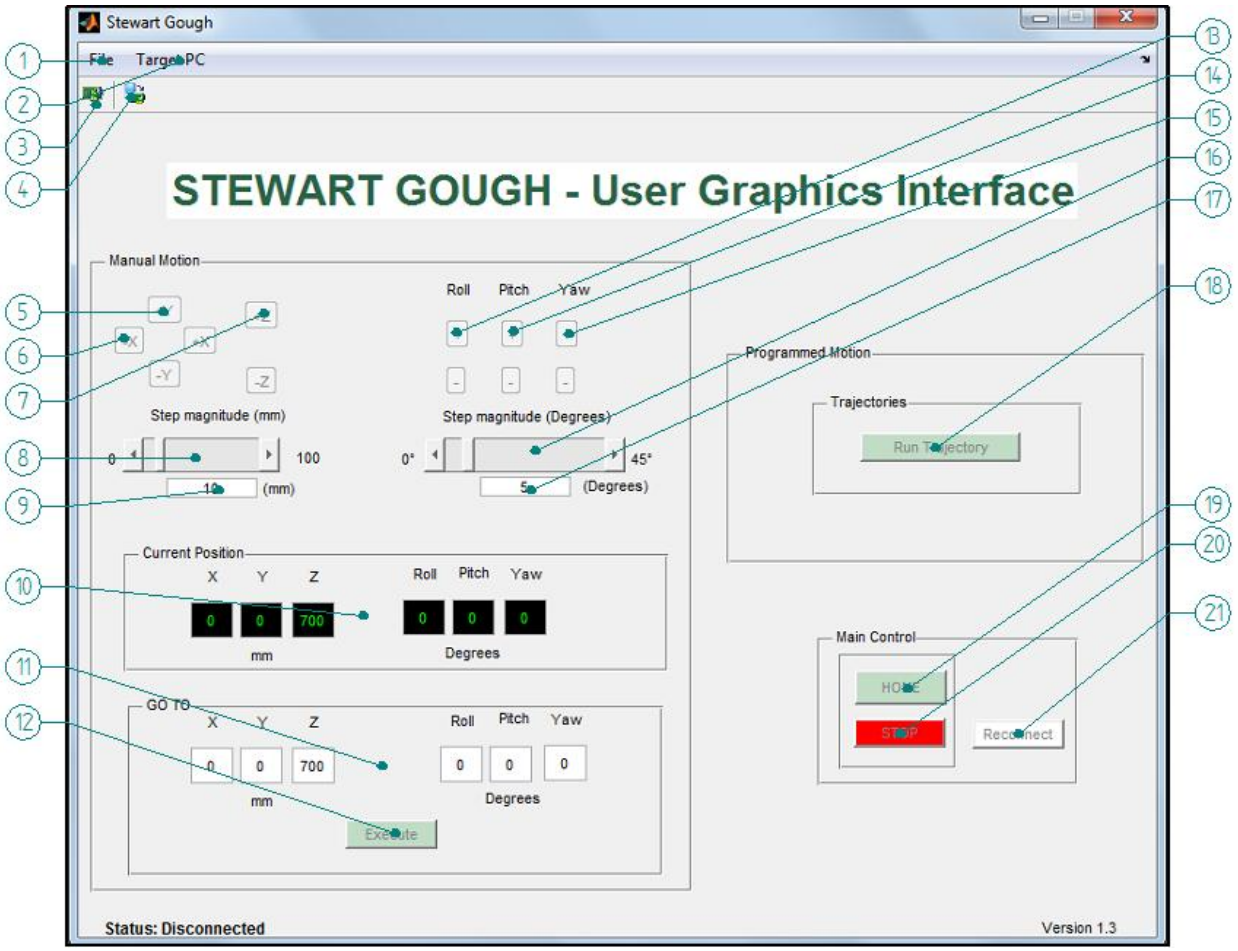


Host PC

Conventional PC with an Ethernet connection Windows 7 and Matlab 2011a installed. It provides a user interface to control the SGP. From the Host PC you can:

- Provide motion routines to the SGP.
- Execute manual control of the SGP.
- Set SGP to an specific or home position.

The host PC interacts mainly through the following User Graphics Interface.



1) File menu, it allows you to open a ".dat" file to export trayectories into the platform.
2) Target PC menu, from there you can build your application, connect and disconnect the platform to the interface.
3) Export file to xPC target button. It allows you to load an specific trajectory into the target PC.
4) Build application into target PC.
5) +Y, moves the platform in the positive Y direction, the length of the movement is equal to the step defined on display (7). If this button is disabled, enable it by executing a "*go to*" operation by setting (9) and then pressing (10), or by clicking on the Home button (17). The –Y button (not marked) does the same but in the negative direction of Y.
6) -X, moves the platform in the negative X direction, the length of the movement is equal to the step defined on display (9). If this button is disabled, enable it by executing a "*go to*" operation by setting (9) and then pressing (10), or by clicking on the Home button (17). The +X button (not marked) does the same but in the positive direction of X.

7) +Z, moves the platform in the positive Z direction, the length of the movement is equal to the step defined on display (7). If this button is disabled, enable it by executing a "*go to"* operation by setting (9) and then pressing (10), or by clicking on the Home button (17). The –Z button (not marked) does the same but in the negative direction of Z.
8) This slider can set the value for the motion step shown in (7). Each time a motion button ±X, ±Y and ±Z is clicked, the platform will move in that direction with a distance equal as shown in (7).
9) Display the step magnitude, you can set this value manually by clicking on the dialog box and setting its value or by the slider (6). Each time a motion button ±X, ±Y and ±Z is clicked, the platform will move in that direction with a distance equal as shown in (7).
10) Indicate the current position of the end effector. To enable this indicator execute a "*go to"* operation by setting (9) and then pressing (10), or by clicking on the Home button (17).
11) Set these six edition boxes to a desired point in the work space where you want to locate the platform, then press (12) to execute motion to that point.
12) Set the six edition boxes in (9) to a desired point in the work space where you want to locate the platform, then press (12) to execute motion to that point.
13) +R, moves the platform in the positive roll direction, the length of the movement is equal to the step defined on display (17). If this button is disabled, enable it by executing a "*go to"* operation by setting (11) and then pressing (12), or by clicking on the Home button (19). The –R button (not marked) does the same but in the negative direction of roll.
14) +P, moves the platform in the positive pitch direction, the length of the movement is equal to the step defined on display (15). If this button is disabled, enable it by executing a "*go to"* operation by setting (11) and then pressing (12), or by clicking on the Home button (19). The –R button (not marked) does the same but in the negative direction of pitch.
15) +Y, moves the platform in the positive yaw direction, the length of the movement is equal to the step defined on display (15). If this button is disabled, enable it by executing a "*go to"* operation by setting (11) and then pressing (12), or by clicking on the Home button (19). The –R button (not marked) does the same but in the negative direction of yaw.
16) This slider can set the value for the motion step shown in (17). Each time a motion button ±R, ±P and ±Y is clicked, the platform will move in that direction with a distance equal as shown in (17).
17) Display the step magnitude, you can set this value manually by clicking on the dialog box and setting its value or by the slider (16). Each time a motion button ±R, ±P and ±Y is clicked, the platform will move in that direction with a distance equal as shown in (17).
18) Load and execute the trajectory that has been uploaded through the File menu (1).
19) Set the actuator to Home position X =0 mm, Y=0 mm, Z=700 mm, Roll = 0 Deg, Pitch = 0 Deg, Yaw = 0 Deg.
20) Stop any motion beeing performed and freeze actuators in that state.
21) Reconnect option to reestablish communication with the target PC.

Electric panel

Electric components to communicate the SGP with the host PC. Its main function is to receive instructions from the user interface (host PC) and execute them into the SGP. From the electrical panel you can:

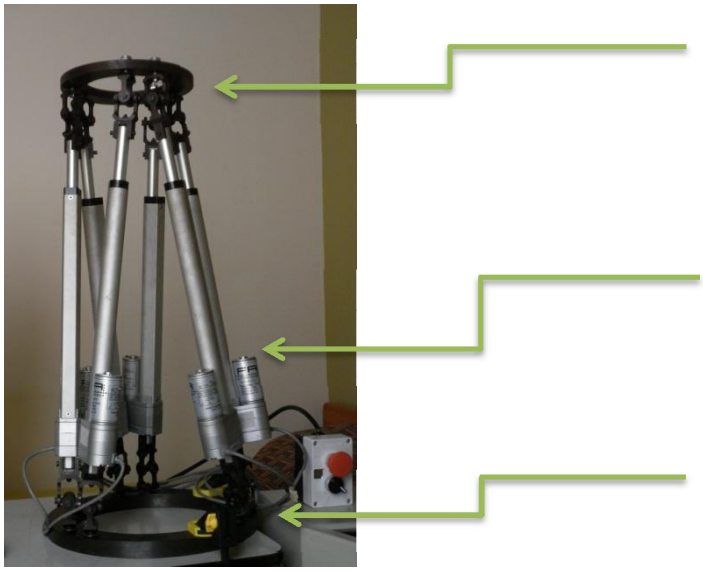
- Move individual actuators in case the SGP gets into a undesired position.
- Execute emergency stops.

1. Fuse case with spare fuse. Prevent overcurrent supply on lower and upper fans.
2. Main connections, *please do not attempt to connect or disconect wires on these conectors without shutting down power and disconnecting from the power outlet.*
3. DC – Power supply 1.
4. Main breakers.
5. PC104 – PCM4153.
6. VGA connector.
7. Ethernet connector.

8. PS/2 connector
9. Lower fan.
10. Upper fan.
11. DC – Power supply 2.
12. Discovery STM32F4.
13. POWER stage.
14. Connectors to actuators.
15. Auxiliar connectors.

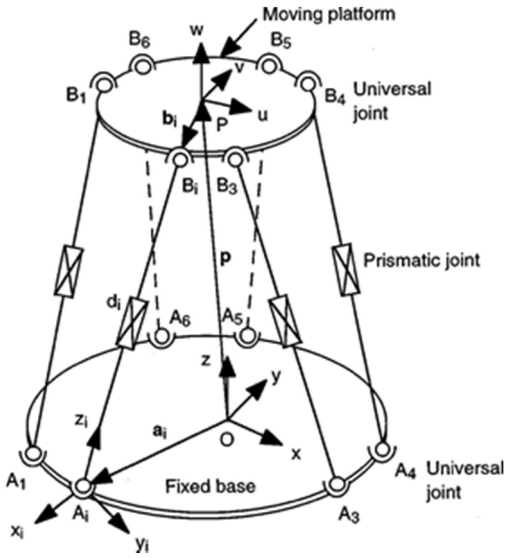
Stewart Gough Platform

The SGP has six linear actuators, a moving ring and a fixed ring.



- Moving ring
- Linear actuators.
- Fixed ring

The reference frame (O) in the picture below is used to establish any coordinate in space.



Section 2. Getting Started

What you need

Please make sure you have the following components before you continue with this guide.

- Stewart Gough Platform with labeled cable extensions.
- Electric panel with emergency and On\Off switch box.
- Desktop PC with Windows 7, ethernet connection and Matlab R2011a installed (*Microsoft Visual Studio 2010 pro , Optional for control programming*).
- Instalation CD.

Setting up your Host Computer (Desktop PC)

Follow the steps below to set up your desktop PC, these steps require a Desktop PC with Windows 7 and Matlab 2011a installed.

1. Enable custom drivers into MATLAB.
    a. To enable the custom drivers for the Diamond16AT in matlab, open the instalation CD and copy all the files within the folder "CD\Software\thirdpartydrivers" into the directory:

```
…\matlabroot\toolbox\rtw\targets\xpc\target\build\xpcblocks\third
partydrivers
```

    b. At the MATLAB Command Window, type:

```
>>rehash toolbox
```

    When you are done open the library browser in simulink, a new library called "xPCTarget: Diamond 16-AT UNAL" will appear.

2. Include custom simulink block library "Stewart Gough UNAL" into the simulink library browser.
    a. Open the instalation CD and copy the folder "CD\Software\Stewart_Gough_library" into a known location in your hard drive.

b. Set the MATLAB path to include the following folders in your hard drive without subfolders:
   …\Stewart_Gough_library
   …\Stewart_Gough_library\Trajectories
   …\Stewart_Gough_library\Functions
c. Open the simulink library browser and press F5 to reload. The process is correct if the library "Stewart Gough UNAL" appears in the library browser.

3. Configuring the xPC Target Host PC for Your C Compiler (*Optional for control programming)*. First, install Microsoft Visual Studio 2010 pro, then at the MATLAB Command Window, type:

```
>>xpcsetCC('setup')
```

The function queries the host PC for C compilers that the xPC Target environment supports. It returns output like the following:

```
Select your compiler for xPC Target.
[1] Microsoft Visual C++ Compilers 2008 Professional Edition
(SP1) in
c:\Program Files (x86)\Microsoft Visual Studio 9.0
[2] Microsoft Visual C++ Compilers 2010 Professional in
C:\Program Files (x86)\Microsoft Visual Studio 10.0
[0] None
Compiler:
```

At the Compiler prompt, enter the number for the compiler you want to use. For example,2.

The function verifies that you have selected the correct compiler:

```
Verify your selection:
Compiler: Microsoft Visual C++ Compilers 2010 Professional
Location: C:\Program Files (x86)\Microsoft Visual Studio 10.0
Are these correct [y]/n?
```

Type y or press Enter to verify the selection. The function finishes the dialog.

```
Done...
```

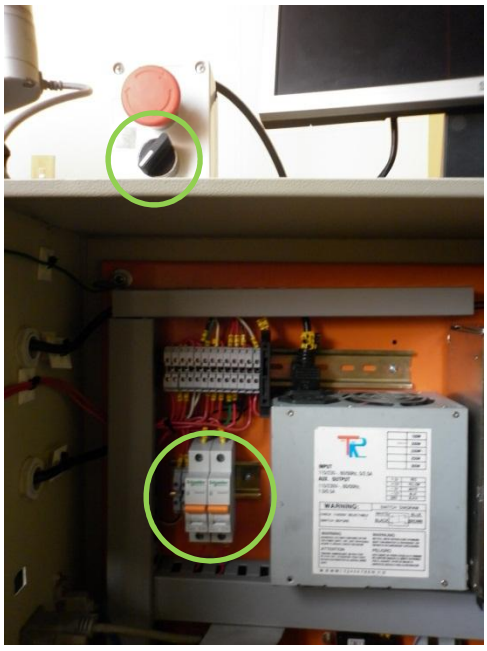
4. Set the environment variables to specify the configuration on the xPC target (*Optional for control programming)*. In the MATLAB Command Window, type:

```
>>tgs = xpctarget.targets;
>>tgs.makeDefault('TargetPC1');
>>env = tgs.Item('TargetPC1');
>>env.TargetBoot = 'DOSLoader';
>>env.TcpIpTargetAddress = '192.168.1.12';
>>env.TcpIpSubNetMask = '255.255.255.0';
```

5. Change the IP address of your hest computer to 192.168.1.13. with subnet mask: 255.255.255.0. To do this, go to **Control Panel >> View network status and tasks >> Change adapter settings**. Right-click on the icon of your ethernet nethwork adapter, choose Properties and select Internet Protocol Version 4 (TCP/IPv4) and then properties. Set the values IP address 192.168.1.13. and subnet mask: 255.255.255.0. under the option "Use the following IP address".

Setting up your Electric Panel

1. Set the On\Off switch to the **Off** position, make sure the emergency stop is released and the circuit breakers are enabled.



2. Connect the Ethernet cable from the electrical panel to your host computer.

3. (Optional) Connect a VGA monitor to the VGA port on the electrical panel.
4. Connect the six motor labeled cables to the electric panel. Make sure the label on the cables do match labels on the panel. *Wrong connections migth result in harmful operation.*
5. Connect the Electrical Panel to a power outlet using the power cable attached to the panel.

Setting up your Stewart Gough Platform

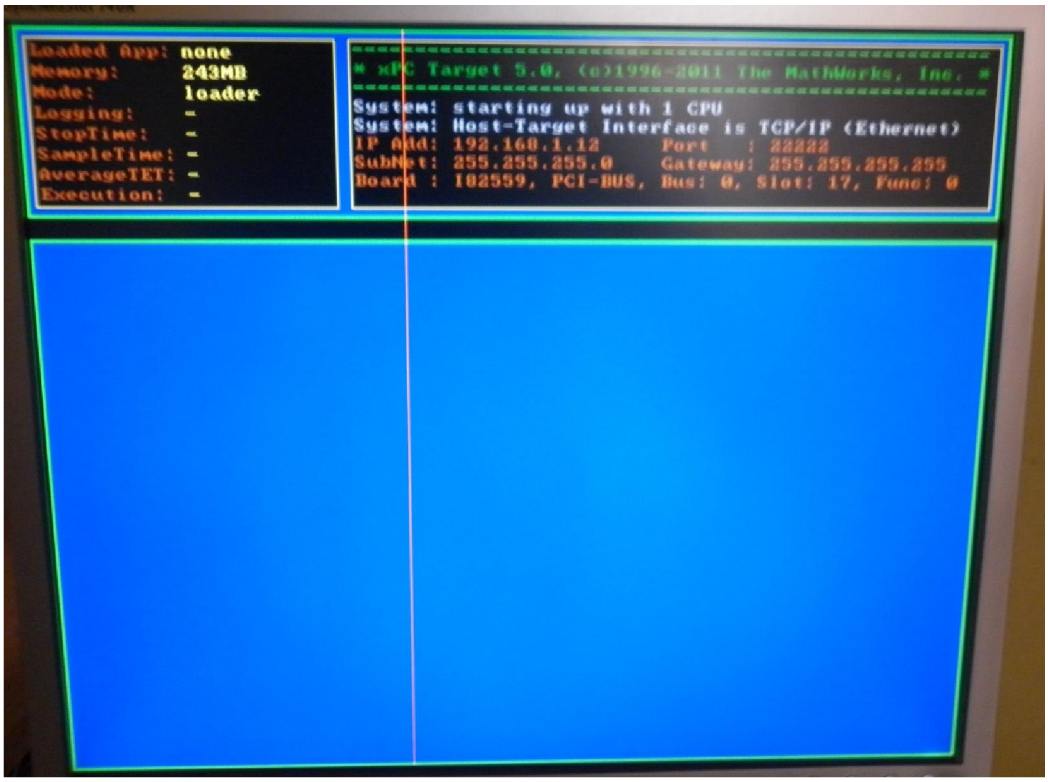
The SGP does not requiere a particular setup besides the conection of the motor cables to the electrical panel. Nevertheless, make sure the structure is firmly installed to a rigid surface. Ommiting so allows the platform to fall in extreme positions, this might be harmfull for your integrity or the platform.

Section 3. Basic operations

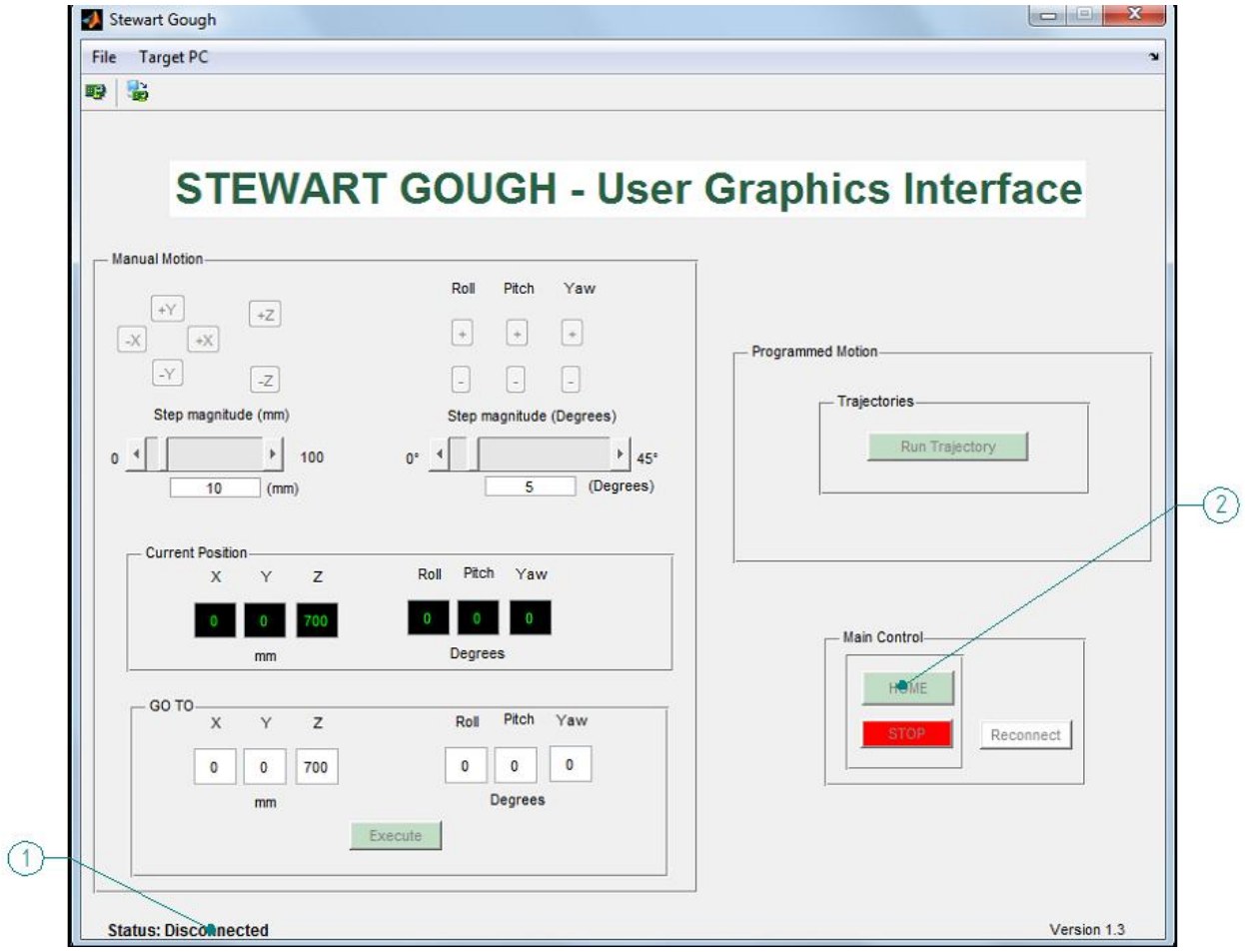
Move SGP to home position.

Follow the steps bellow to drive the SGP to home position. Make sure you acomplished all steps in the previous section “Getting Started” before this procedure.

1) Turn ON the Electric Panel from the switch box. If you have a VGA monitor connected to the electric panel, you can verify the execution of each instruction at the xPC target display. Your VGA monitor should ilustrate something like the following.



2) Open Matlab 2011a and open the file “`GUI_V3.m`” located in the Instalation CD at the folder “CD\Software\GUI_V3”. Then run the code by pressing F5 or clicking at the  icon.
3) Connect the SGP to your desktop PC by using the connect button at the Menu bar **TargetPC>> Build and program.** To verify please check the indicator at the bottom left side of the interface.



4) Finally, click on the HOME button (labeled “2” in the previous figure).

Buid a pre-defined routine file

Your pre-defined routine file enables you to create complex routines for your SGP. This might be useful if you want to perform manufacturing processes. The file is a “.dat” file with the following format.

It has N rows and 19 colums, each colum separated by a coma. Each row represents a reference to the actuators at a given time, taking into account that each actuator requieres position, velocity and aceleration references to perform motion, this information is organized in the following order.

M1, M1P, M1PP, M2, M2P, M2PP, … M6PP, time,

Where Mi, MiP and MiPP represent position (mm), velocity (mm/s) and aceleration (mm/s^2) of motor *i* respectively. Bear in mind that each motion step executes every 1 ms.

As an example, lets suppose we want all the actuators to be at a position 70mm and then at 71mm, 2ms after. A possible file for this motion could be:

```
70,   0,   0,   70,   0,   0,   70,   0,   0,   70,   0,   0,   70,   0,   0,   70,   0,   0,   70,   0,   0,   0,
70.5, 0,   0,   70.5, 0,   0,   70.5, 0,   0,   70.5, 0,   0,   70.5, 0,   0,   70.5, 0,   0,   70.5, 0,   0,   0.1,
71,   0,   0,   71,   0,   0,   71,   0,   0,   71,   0,   0,   71,   0,   0,   71,   0,   0,   71,   0,   0,   0.2,
```

Load and run a pre-defined routine

Follow the steps below to load and run a pre-defined routine. Make sure you have acomplished all steps in section "Getting Started" before getting into this procedure.

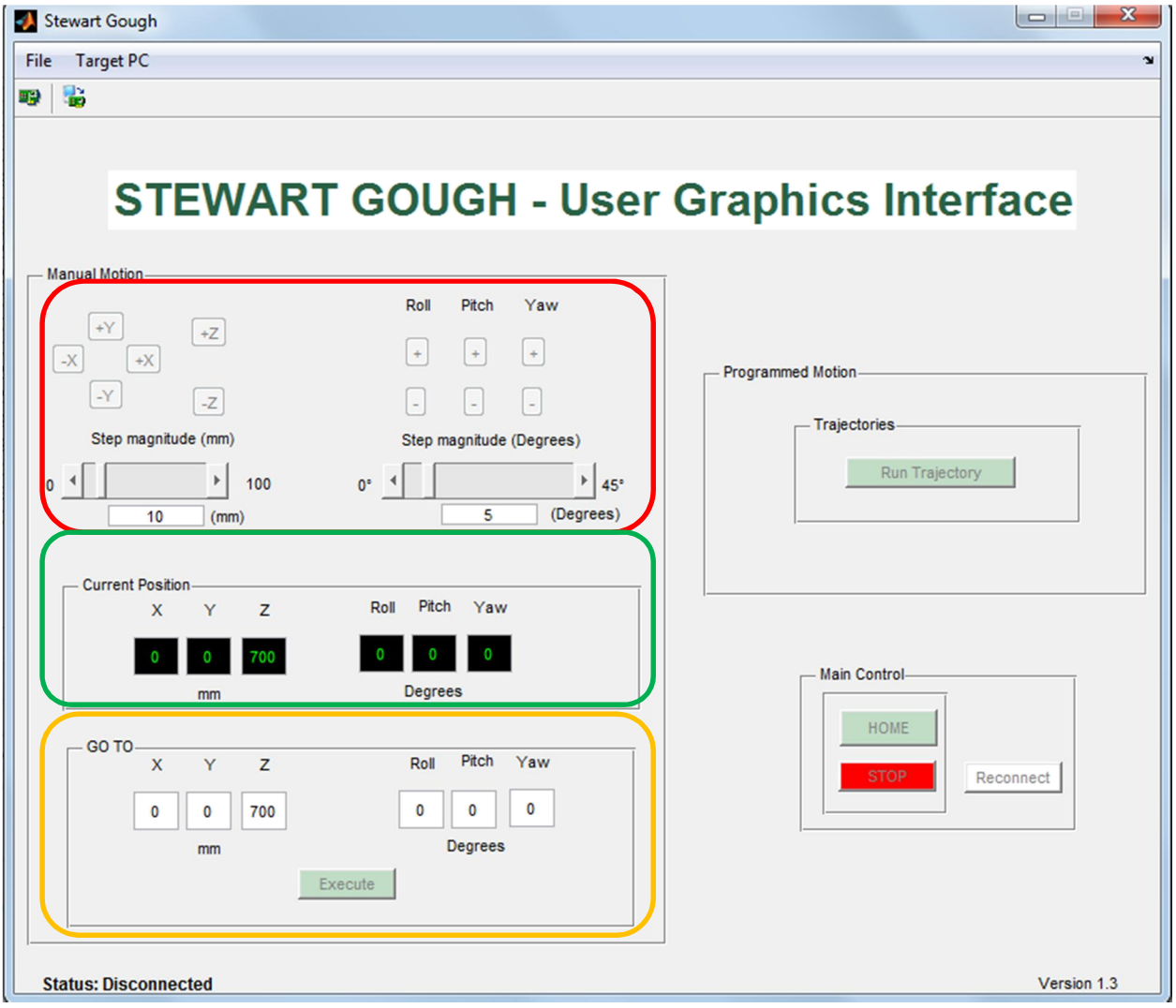
1) Turn ON the Electric Panel from the switch box. If you have a VGA monitor connected to the electric panel, you can confirm the execution of each instruction at the xPC target display.
2) Open Matlab 2011a and open the file "`GUI_V3.m`" located in the Instalation CD at the folder "CD\Software\GUI_V3". Then run the code by pressing F5 or clicking at the  icon.
3) Disconnect the SGP from your desktop PC by using the disconnect button at the Menu bar **TargetPC>>Disconnect.** To verify please check the indicator at the bottom left side of the interface.
4) Finally, load the ".dat" file for your pre-defined routine. Go to **Menu>>Export>> File to XPC target** and search for your file. Please follow the instructions in section Buid a pre-defined routine file in order to generate this file.
5) Connect the SGP to your desktop PC by using the connect button at the Menu bar **TargetPC>> Build and program.** To verify please check the indicator at the bottom left side of the interface.
6) Finally execute motion. Click on the button "Run trayectory" at the user interface.

Manual motion and the "go to" option.

Some times manual motion is requiered for fine tunning of your SGP. The following steps will guide you through this process.

1. Turn ON the Electric Panel from the switch box. If you have a VGA monitor connected to the electric panel, you can confirm the execution of each instruction at the xPC target display.
2. Open Matlab 2011a and open the file "`GUI_V3.m`" located in the Instalation CD at the folder "CD\Software\GUI_V3". Then run the code by pressing F5 or clicking at the  icon.
3. Connect the SGP to your desktop PC by using the connect button at the Menu bar **TargetPC>> Build and program.** To verify please check the indicator at the bottom left side of the interface.
4. Click on the HOME button
5. Use the Manual motion controllers to move the platform at the X, Y, Z directions and its respective angular movements Roll, Pitch and Yaw. Use the slider to setup the magnitude of

each step. Verify your position at the "Current position" indicator. If your prefer, fill in the spaces at the "Go to" panel and then click execute to move your SGP to an especific location.



Manual motion without host PC

Some times manual motion is requiered when the platform has achieved singular positions or for maintance purposes. The following steps will guide you through this process.

1. Turn ON the Electric Panel from the switch box.
2. Use the switches at the red board located at the right side of the electric panel. Note that each swith is labeled with the number of actuator and with a direction to indicate wheter it moves the actuator up or down.

Section 4. Troubleshooting

I clicked on the "connect" menu option, but the electric panel does not connect.

First, check the command promt in Matlab when you execute the option "connect" at the menu. If you get an error such as:

Unable to find target

Or

(TCP/IP) error, port closed

Type `>>tg = xpctarget.xpc, tg.reboot` at the command prompt. Then restart Matlab. If the command `tg.reboot` does not execute, reboot the electric panel by turning off and On the switch at the switch box.

If the error you get at the command promt is

Undefined function or method 'GUI_V2' for input arguments of type 'struct'.

Make sure the Matlab path is set at the same location where you have the file "GUI_V3.m".

The motion at the SGP does not match the motion I programed at the user interface.

Make sure the labels of your motor conector do match the labels at the electric panel. Check the section "Manual motion without host PC" to learn how to move each

actuator independently. This might help you to confirm that the motors you are moving are connected in the rigth order.

Section 5. Technical especifications.

- Electric Panel
  - ✓ Sample time 1kHz.
  - ✓ PWM's with a period of 1ms.
  - ✓ Up to 6 DC - motors, at 40v@ 5A each.
  - ✓ Serial or Ethernet connection to Host PC.
  - ✓ 1 VGA port.
  - ✓ 1 KB/MS connector.
  - ✓ 1 Parallel port.
  - ✓ PC104 / PCM 4153 – With a AMD LX-800 processor clocked at 500 MHz.
- Stewart Gough platform.
  - ✓ Workspace volume (0.4447 m^3 aprox).
  - ✓ Actuators Firgelli Atomations, 12V @3A "FA-PO-20-12-12".
  - ✓ Actuator's speed (50 mm/sec).