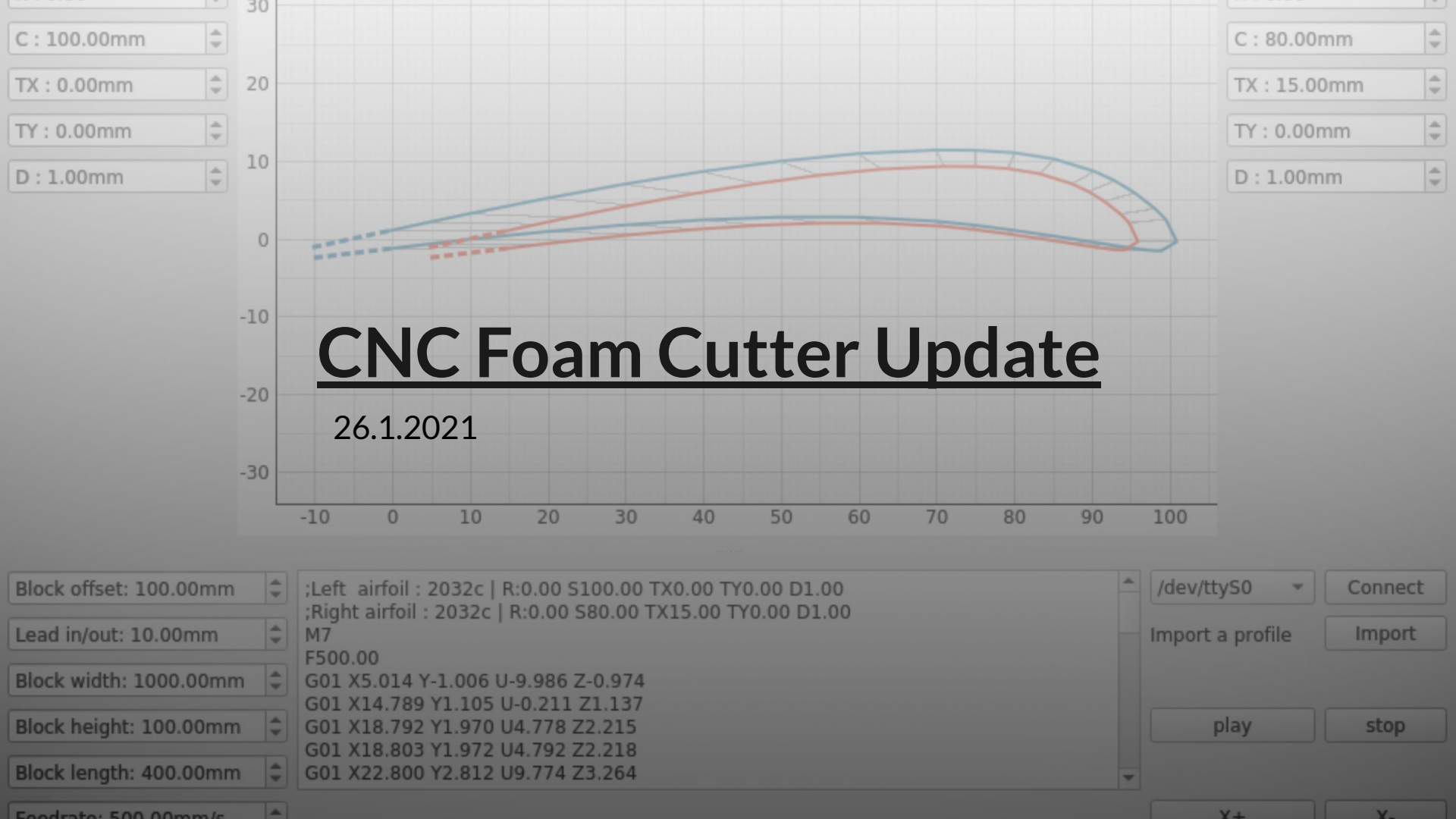
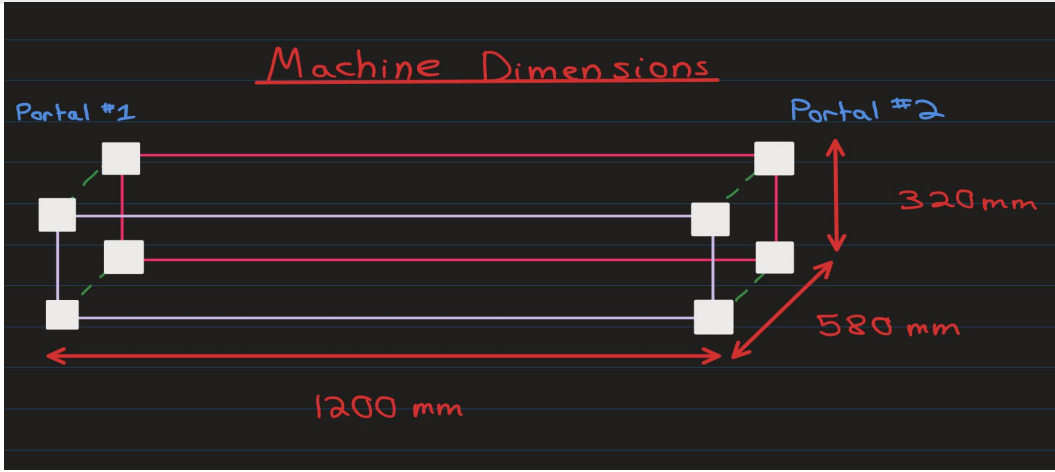
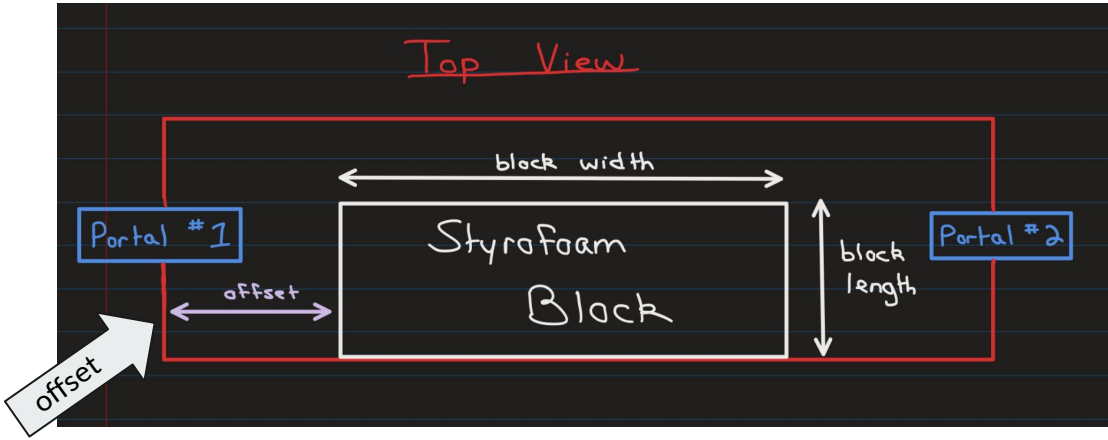

C : 100.00mm
TX : 0.00mm
TY : 0.00mm
D : 1.00mm
C : 80.00mm
TX : 15.00mm
TY : 0.00mm
D : 1.00mm
30
20
10
0
-10
-20
-30
-10
0
10
20
30
40
50
60
70
80
90
100
CNC Foam Cutter Update
26.1.2021
Block offset: 100.00mm
Lead in/out: 10.00mm
Block width: 1000.00mm
Block height: 100.00mm
Block length: 400.00mm
;Left airfoil : 2032c | R:0.00 S100.00 TX0.00 TY0.00 D1.00
;Right airfoil : 2032c | R:0.00 S80.00 TX15.00 TY0.00 D1.00
M7
F500.00
G01 X5.014 Y-1.006 U-9.986 Z-0.974
G01 X14.789 Y1.105 U-0.211 Z1.137
G01 X18.792 Y1.970 U4.778 Z2.215
G01 X18.803 Y1.972 U4.792 Z2.218
G01 X22.800 Y2.812 U9.774 Z3.264
/dev/ttyS0
Connect
Import a profile
Import
play
stop

Styrofoam Block Dimensions, Offset

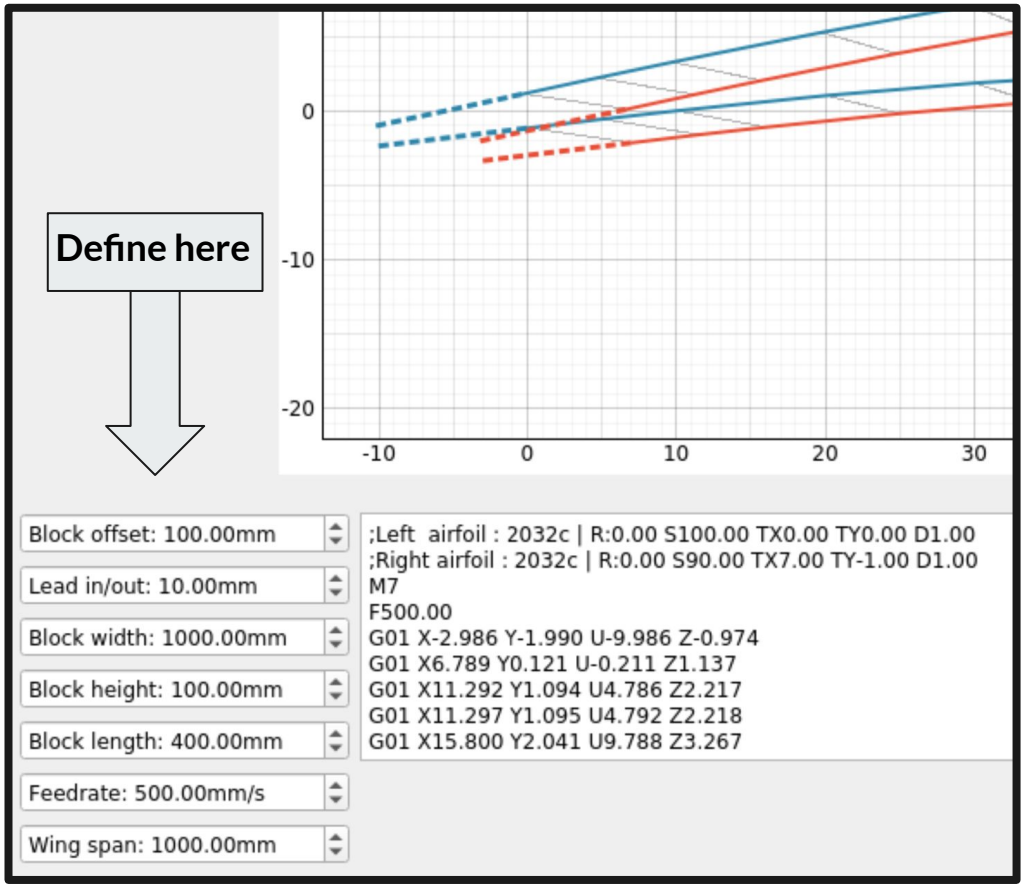
- Once a block of styrofoam is placed in the machine, the user simply needs to measure the **dimensions** of the block and its **offset** from portal #1.
- Then, the user can define the wing **span**, import two airfoils, and define the **chord** for each airfoil.

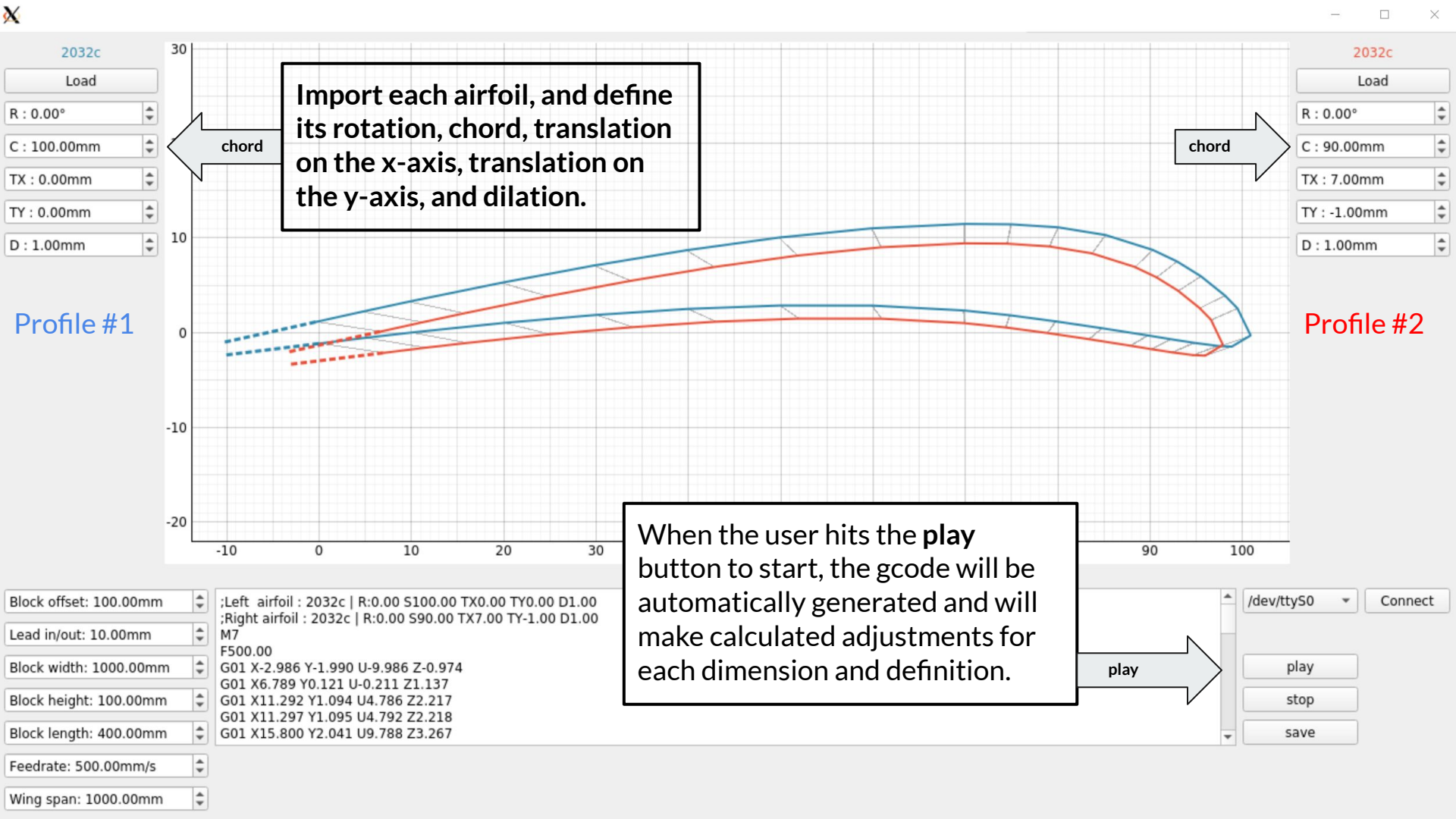




Styrofoam Block Dimensions, Offset (continued)

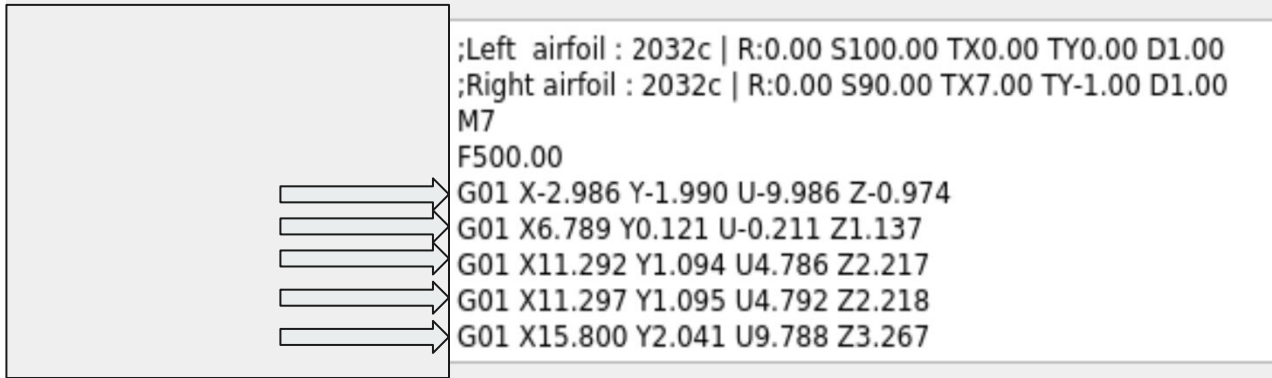
- Once a block of styrofoam is placed in the machine, the user simply needs to measure the **dimensions** of the block and its **offset** from portal #1.
- Then, the user can define the wing **span**, import two airfoils, and define the **chord** for each airfoil.



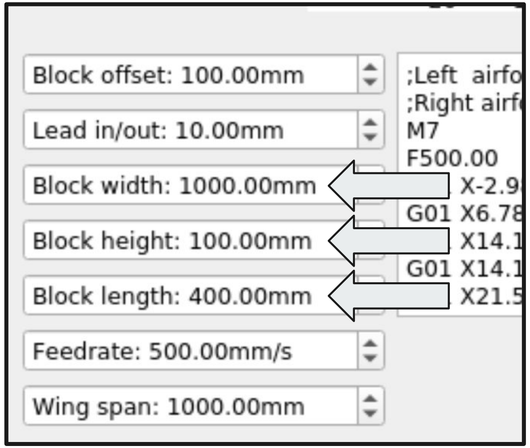

2032c
Load
R : 0.00°
C : 100.00mm
TX : 0.00mm
TY : 0.00mm
D : 1.00mm
Profile #1
chord
Import each airfoil, and define its rotation, chord, translation on the x-axis, translation on the y-axis, and dilation.
30
10
0
-10
-20
-10
0
10
20
30
90
100
2032c
Load
R : 0.00°
C : 90.00mm
TX : 7.00mm
TY : -1.00mm
D : 1.00mm
chord
Profile #2
When the user hits the play button to start, the gcode will be automatically generated and will make calculated adjustments for each dimension and definition.
Block offset: 100.00mm
Lead in/out: 10.00mm
Block width: 1000.00mm
Block height: 100.00mm
Block length: 400.00mm
Feedrate: 500.00mm/s
Wing span: 1000.00mm
;Left airfoil : 2032c | R:0.00 S100.00 TX0.00 TY0.00 D1.00
;Right airfoil : 2032c | R:0.00 S90.00 TX7.00 TY-1.00 D1.00
M7
F500.00
G01 X-2.986 Y-1.990 U-9.986 Z-0.974
G01 X6.789 Y0.121 U-0.211 Z1.137
G01 X11.292 Y1.094 U4.786 Z2.217
G01 X11.297 Y1.095 U4.792 Z2.218
G01 X15.800 Y2.041 U9.788 Z3.267
play
/dev/ttyS0
Connect
play
stop
save

Adjusting the Portal Speed for Wing Taper

- In order to avoid distortion, the portal speeds needed to be adjusted so the portals start at the leading edge at the same time and end at the trailing edge at the same time.
- This is done in the firmware loaded onto the Arduino. **G01** gcode commands have been changed to make these speed calculations.
- Whenever a **G01** code is sent over the USB serial port to be processed by the firmware, it is interpreted according to wing chord + taper and automatically adjusts the speeds of the portals.



Cutting the Styrofoam Block to Size

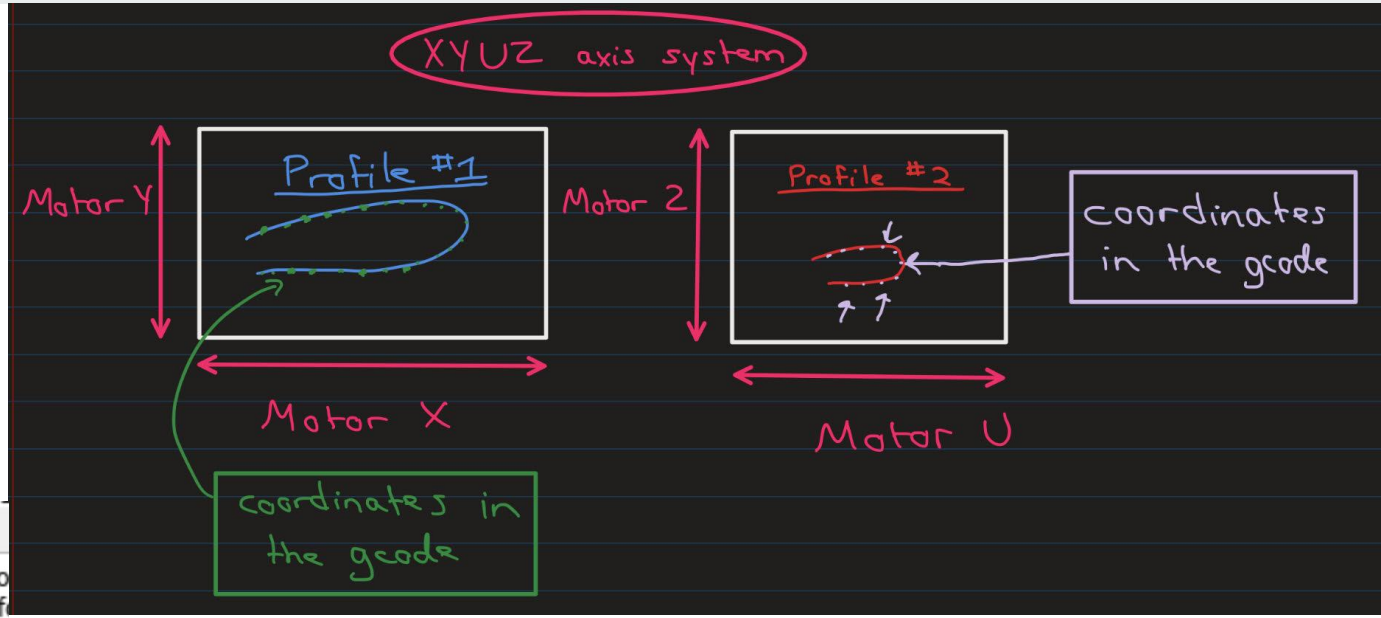


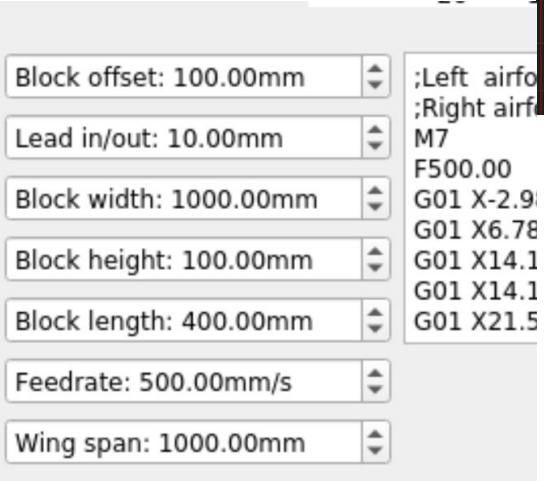
- The user inputs the desired dimensions for the styrofoam block.
- The dimensions will then determine the beginning of the hot wire's cutting path.

- Gcode is then automatically generated and prepended to the gcode stream to cut the block to size before cutting the wing.

```
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
['M7\n', 'F500.0\n', 'G91 X10 F500.0\n']
```

Wing Span Calculations

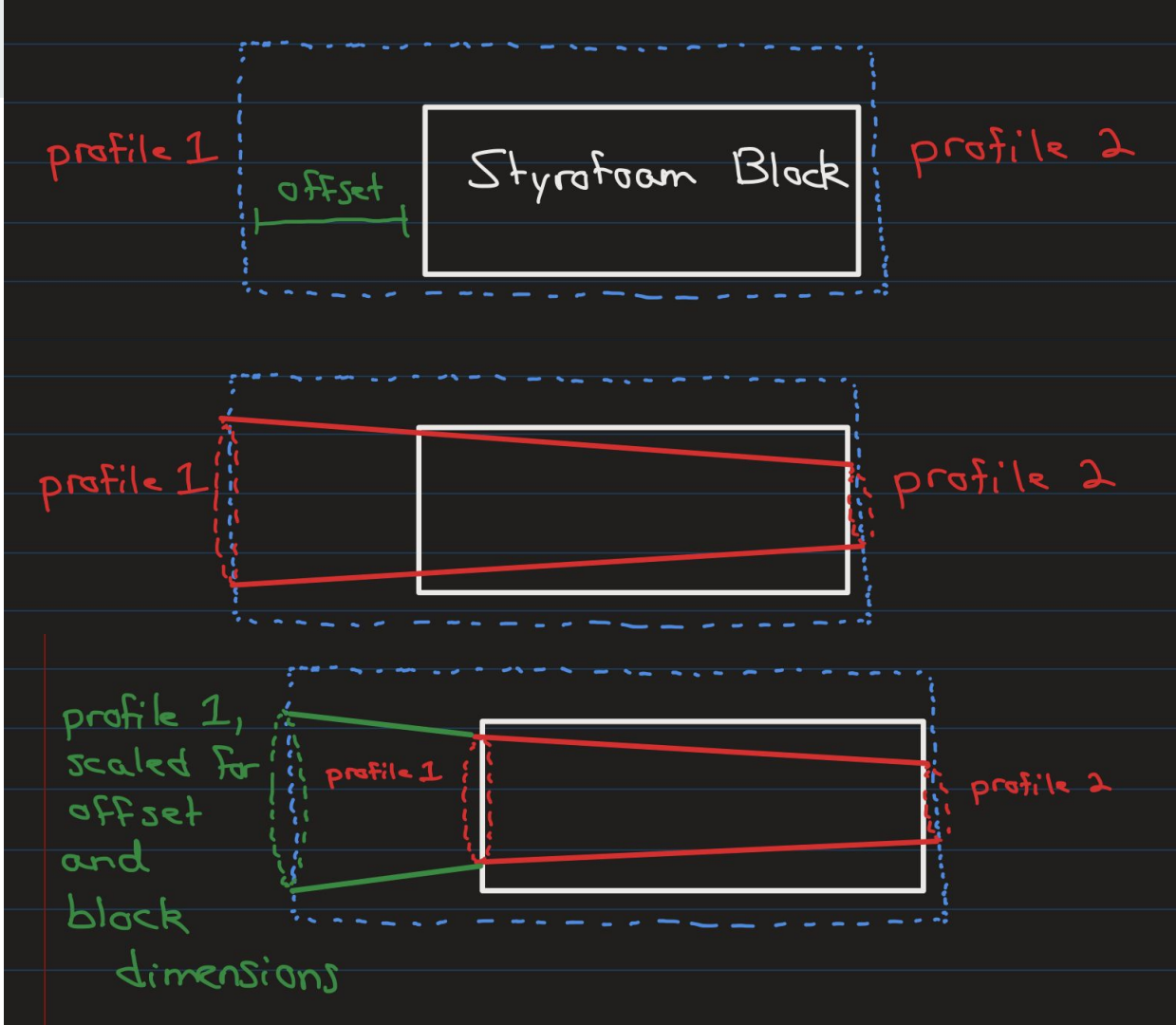




- Since gcode being sent to the stepper motors are in terms of a coordinate system, wingspan has to be implicitly defined.
- This means that the wing span's value is dependent on: the dimensions of the **machine**, the **styrofoam block**, the **scale** of the airfoils, and the **position** (offset) of the block.

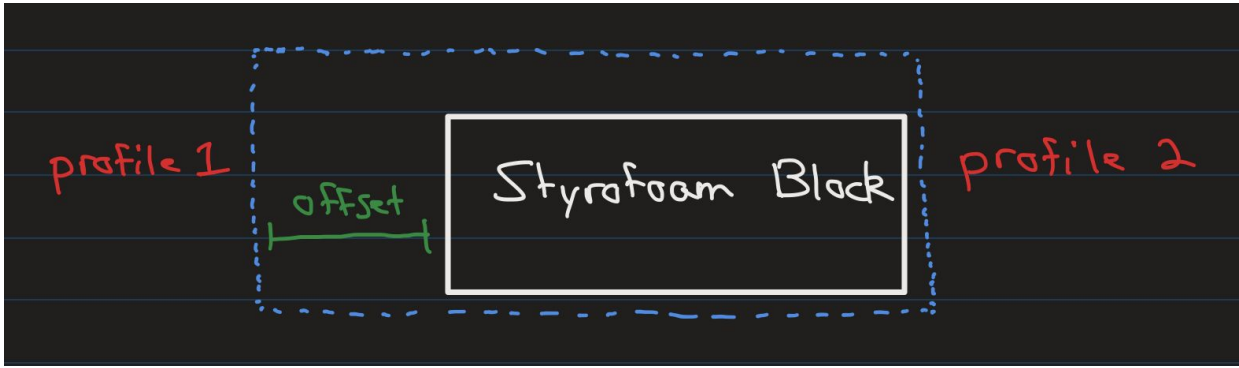
Wing Span Calculations (continued)

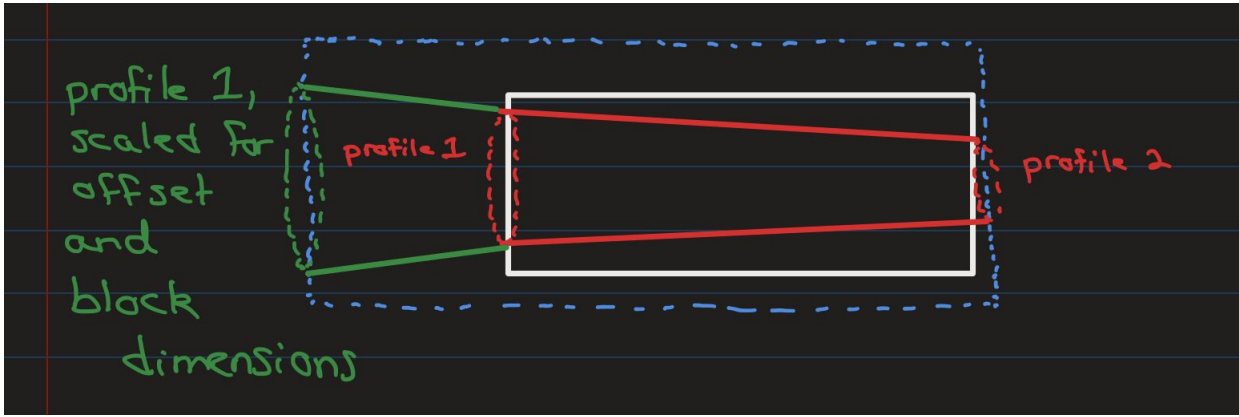
- As seen here, the gcode only controls the movement of the portals.
- Thus, the gcode for each profile needs to be **scaled** to accomodate for the wing planform, block size, and the block offset.



Wing Span Calculations (continued)

- This calculation is done by plotting points from profile #1 to profile #2, and then using 3D vector projection to draw a 3D line to portal #1.
- These calculations are used to estimate the appropriate scale to accomodate for planform and block size.





(A brief drawing of the calculations are shown on the next page)

Wing Span Calculations (continued)

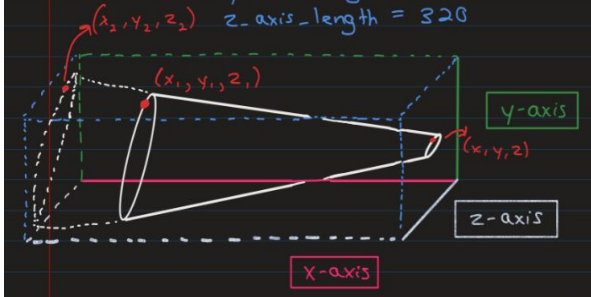
using: offset, length of x, y, z axes

offset is whatever value is read from the GUI spbox.

x_axis_length = 1200

y_axis_length = 580

z_axis_length = 320



(x, y, z) & (x_1, y_1, z_1) ⟶ projected (x_2, y_2, z_2)

(x_axis_length, profile_2_x_coord, profile_2_y_coord)

↓

(offset, profile_1_x_coord, profile_1_y_coord)

↳ (0, x-prime, y-prime)

P_1 (x_axis_length, profile_2_x_coord, profile_2_y_coord)

P_2 (offset, profile_1_x_coord, profile_1_y_coord)

P_3 (0, x, y)

vector that points from P_1 to P_2.

$$\vec{v} = P_2 - P_1 = (x_2 - x_1, y_2 - y_1, z_2 - z_1)$$

make sure the vector is of length == 1.

$$|\vec{v}| = \sqrt{x_v^2 + y_v^2 + z_v^2}$$

$$\vec{v}^* = \frac{\vec{v}}{|\vec{v}|} = \left(\frac{x_v}{|\vec{v}|}, \frac{y_v}{|\vec{v}|}, \frac{z_v}{|\vec{v}|} \right)$$

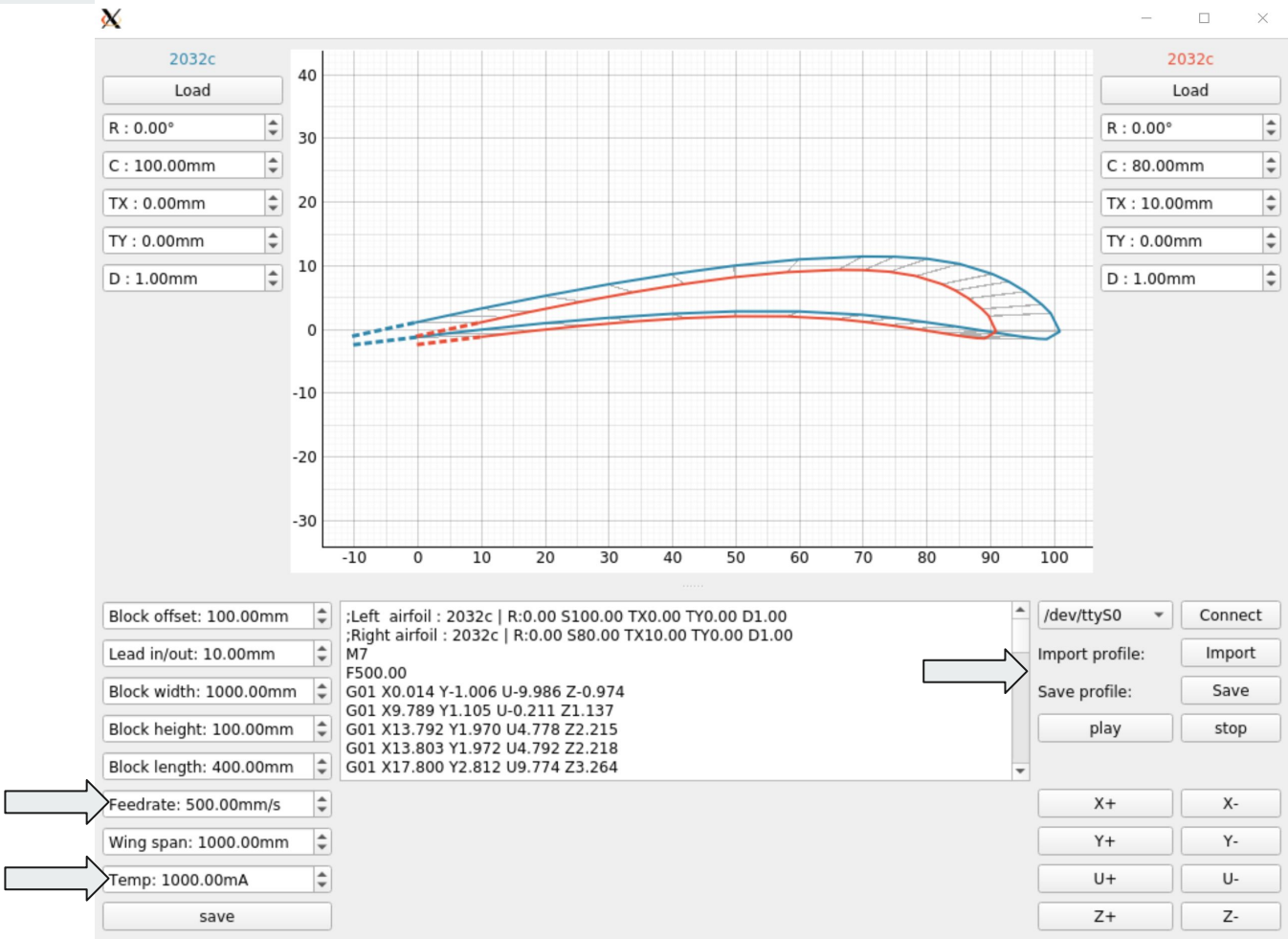
And now, find a vector of length D in that same direction.

$$d = (Dx_v^*, Dy_v^*, Dz_v^*)$$

P_3 is now d away from P_2.

Defining Pairs of Speed & Amperes

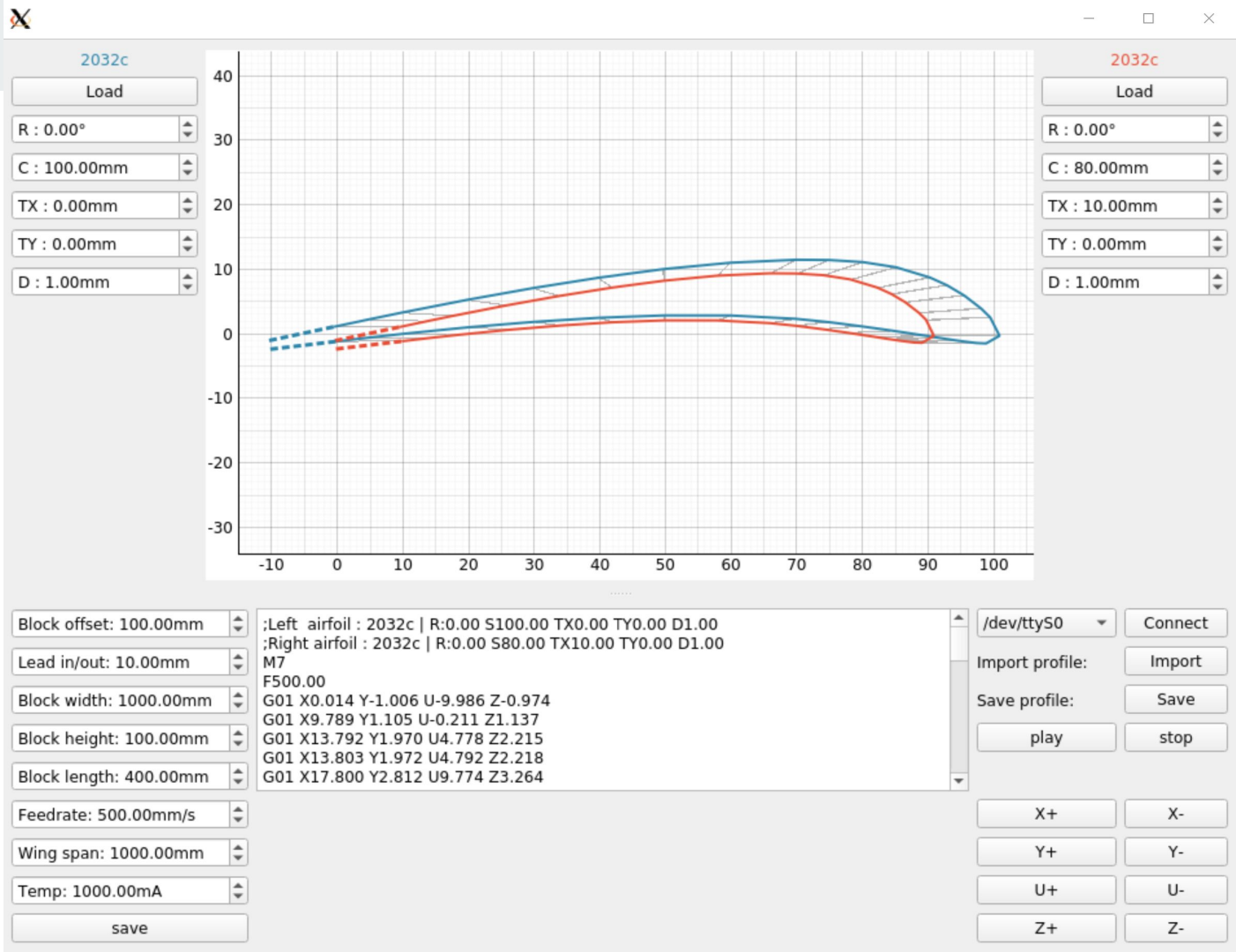
- Feedrate (speed) and Temperature can be set manually
- The current values can also be **saved** as a profile
- Or, a previously saved profile can be **imported**



Progress and Testing

- Wing span calculation algorithm:
  - Software is completed
  - Being tested this week
- Adjusting portal speed:
  - Already tested and working
- Block dimensions + offset adjustments:
  - Already tested and working
- Automatically cutting the foam block to size:
  - Software is completed
  - Being tested this week
- GUI updates for dimensions, block, offset
  - Software completed
  - Already tested and working
- Defining pairs of speed + amperes
  - Software is being tested this week

GUI Layout


2032c
Load
R : 0.00°
C : 100.00mm
TX : 0.00mm
TY : 0.00mm
D : 1.00mm
2032c
Load
R : 0.00°
C : 80.00mm
TX : 10.00mm
TY : 0.00mm
D : 1.00mm
Block offset: 100.00mm
Lead in/out: 10.00mm
Block width: 1000.00mm
Block height: 100.00mm
Block length: 400.00mm
Feedrate: 500.00mm/s
Wing span: 1000.00mm
Temp: 1000.00mA
save
;Left airfoil : 2032c | R:0.00 S100.00 TX0.00 TY0.00 D1.00
;Right airfoil : 2032c | R:0.00 S80.00 TX10.00 TY0.00 D1.00
M7
F500.00
G01 X0.014 Y-1.006 U-9.986 Z-0.974
G01 X9.789 Y1.105 U-0.211 Z1.137
G01 X13.792 Y1.970 U4.778 Z2.215
G01 X13.803 Y1.972 U4.792 Z2.218
G01 X17.800 Y2.812 U9.774 Z3.264
/dev/ttyS0
Connect
Import profile:
Import
Save profile:
Save
play
stop
X+
X-
Y+
Y-
U+
U-
Z+
Z-