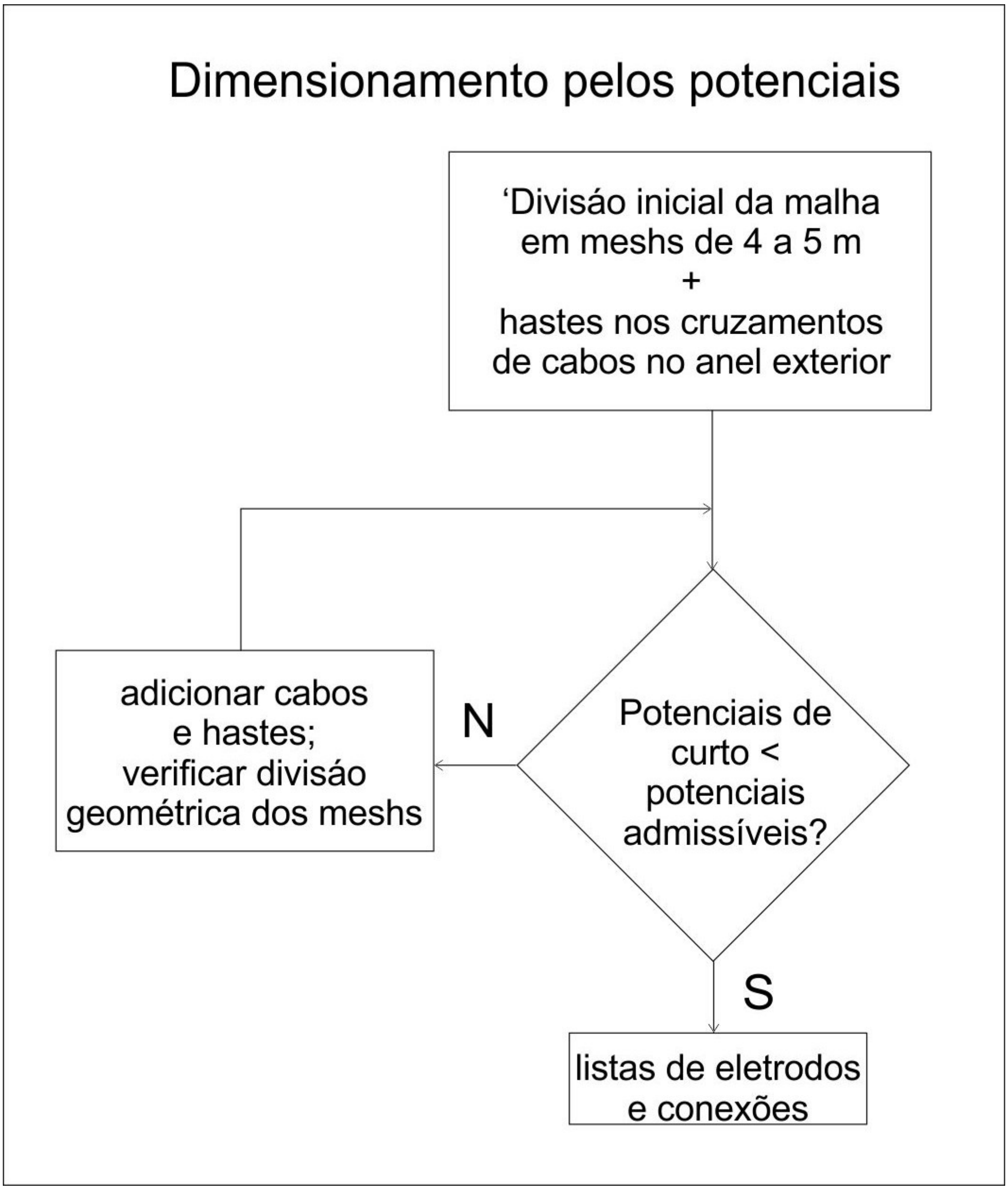
TecAt 6 - Tutorial - Grid 2 - part 2

Note: the potentials calculations are available only on version TecAt Plus, so this tutorial does not apply to both TecAt Pro and TecAt LE.

Following the example started on **Tutorial TecAt 6 - Grid 2 - part 1**:

7. Sequence of dimensioning by the potentials criteria:

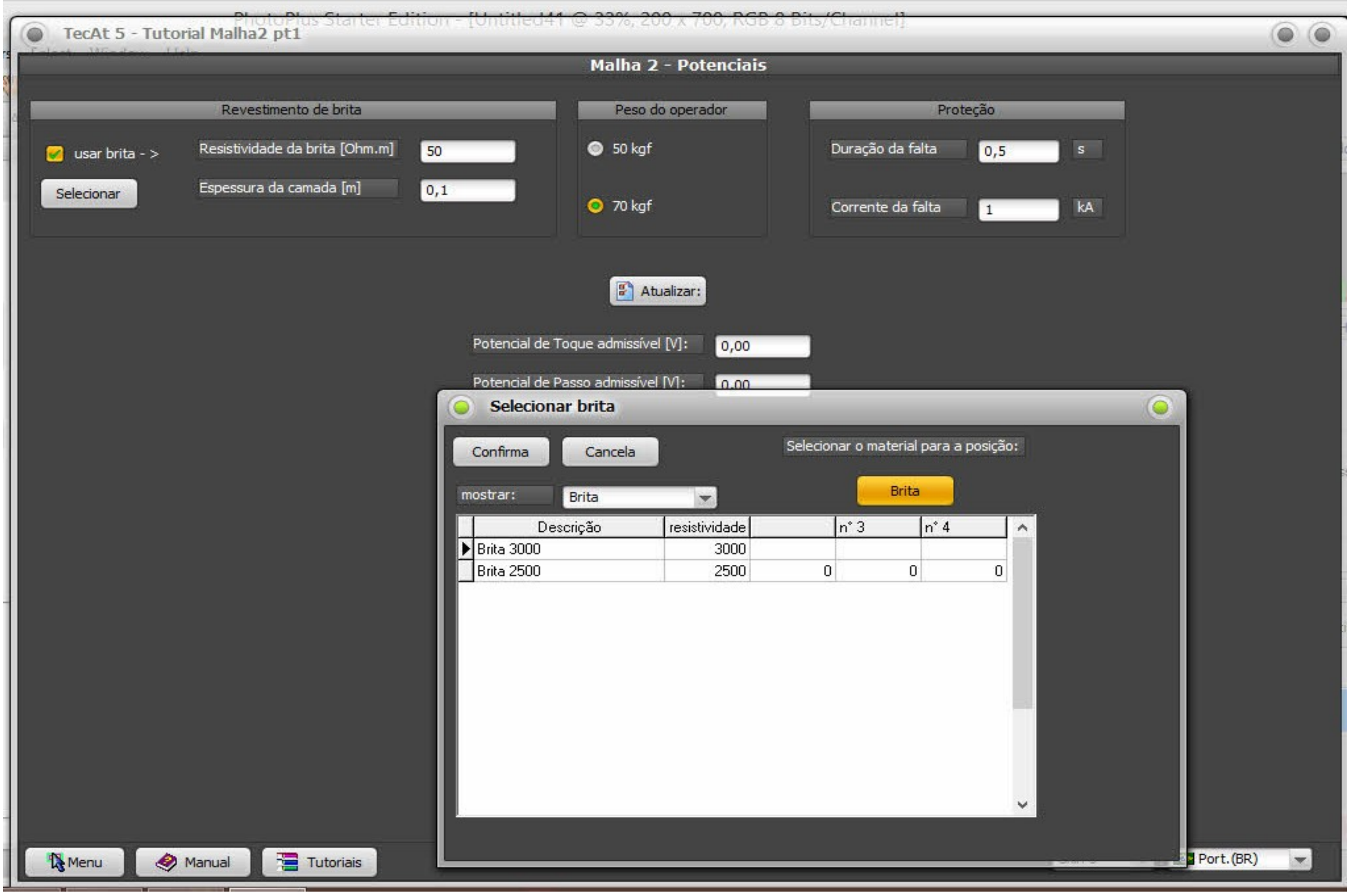


On part 1 of this tutorial, our initial grid had a resistance of 5,28 Ohm, which can be adequate for dissipate the short-circuit current of several grid applications, but probably isn't enough to secure potentials bellow the tolerable limits. As the grid current, on our example is 2 kA, we get a GPR (Ground Potential Rise, or maximum potential with reference on a distant point) of 10553 V (Ohm's law = 5.28 x 2,000).

8. Tolerable (or admissible) potentials

Tolerable potentials are calculated by TecAt according with the IEEE-80 formula.

Select Grid 2 / Admissible:



Options:

- Gravel: recomended on open substations, usually 0.10 to 0.25 meters thick (maximum value = 0.30); click at the Select button to choose one from the materials database
- Weight: usually 70 kgf are used for the substation operators (that is, inside the substation area) and 50 kgf for general people (usually outside the fenced area), please check your local regulations

Enter the grid current - that's the portion of the short-circuit current that effectively flows through the grid to the soil - and the time untill the protection cuts the current.

Note: we're resenting this calculation here for convenience, but it should be done before the resistance calculation, because TecAt will use this current value to determine the GPR (the GPR value is presented at the top of the Resistance report).

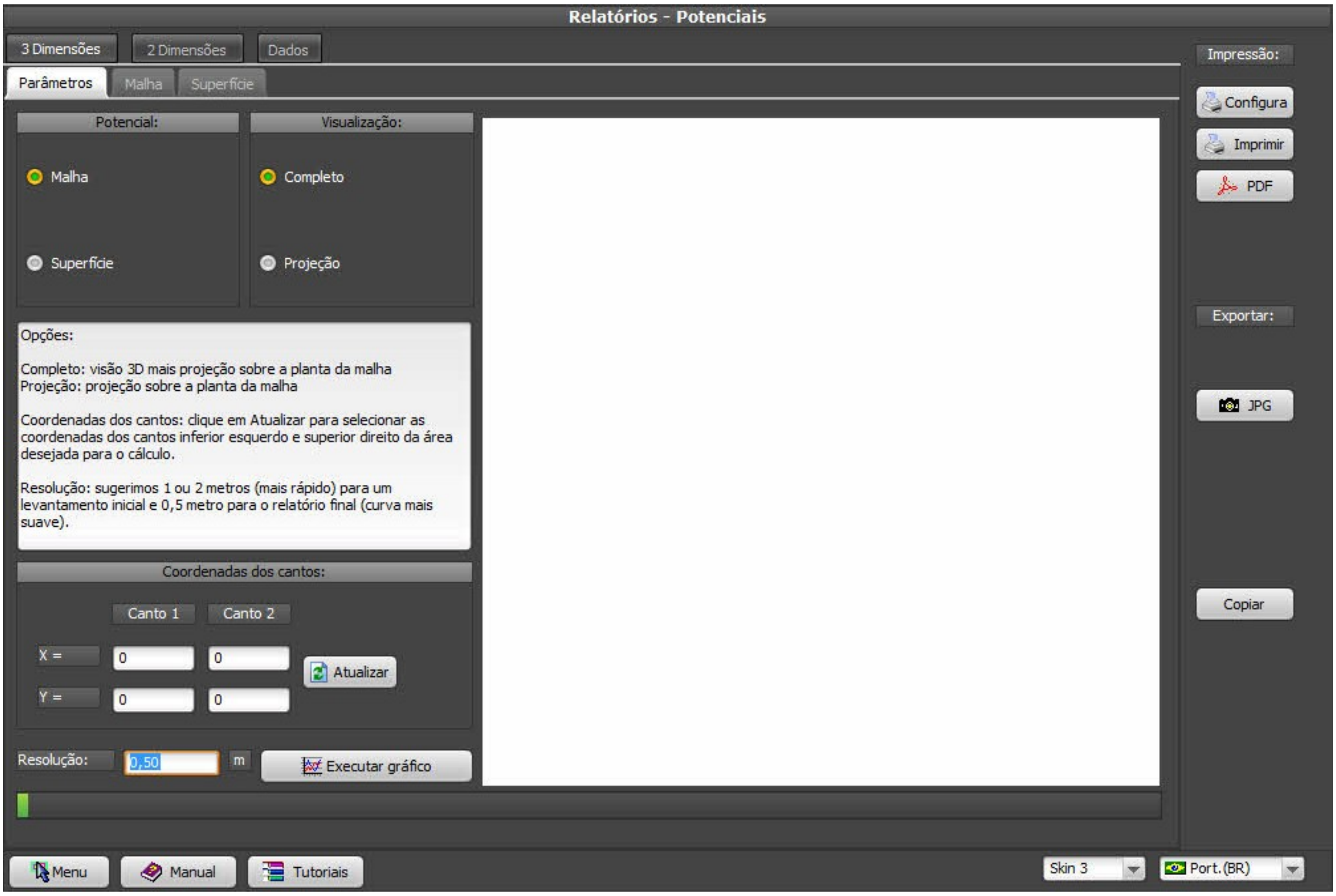
9. 3D analysis of mesh and surface potentials

After the resistance calculation for the grid, we get the GPR value that will be used internally by TecAt to determine the potentials at the substation and surroundings area.

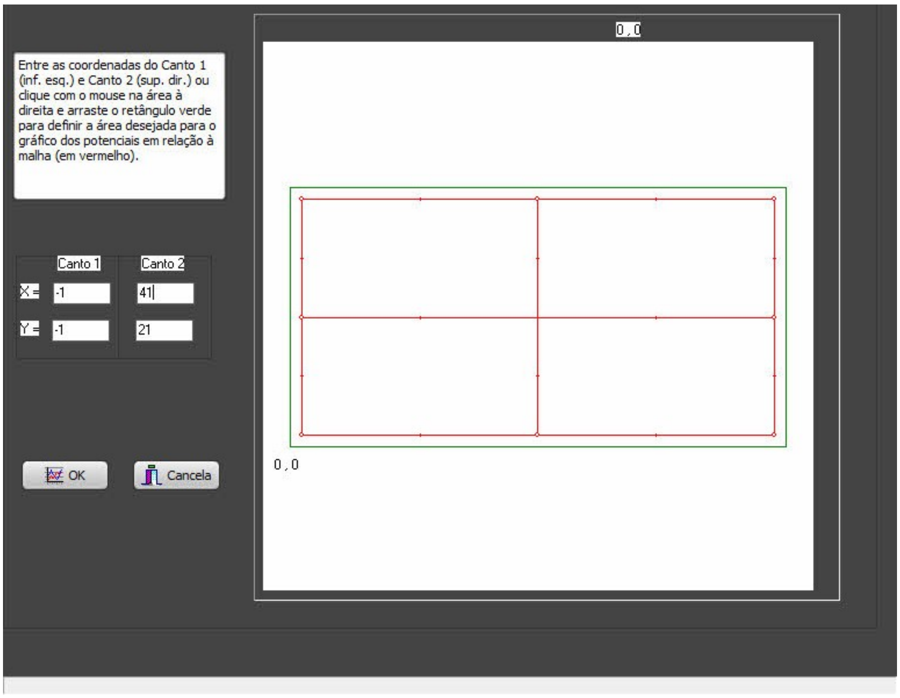
At the Menu bar, select Potentials. First, let's see the mesh and surface potentials in 3D view - we won't get numerical data here, but it will give us a good visualization of the potentias distribution.

Options at screen 3Dimensions / Parameters:

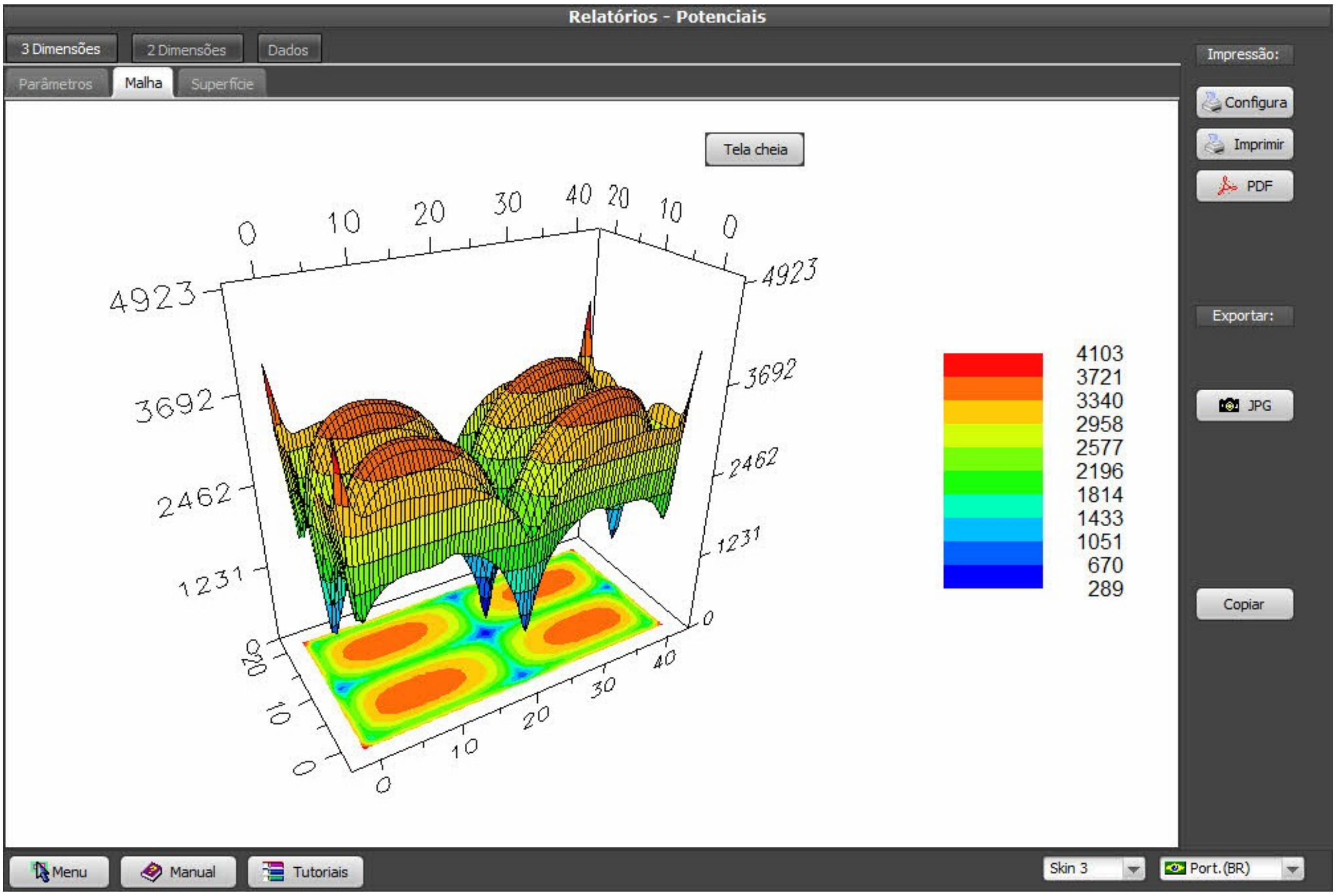
- Potential: Mesh or Surface (we'll calculate both, but one at a time)
- Visualization: "Complete" presents the 3D chart and its projection on the grid plan, while "Projection" show only that last one (as is a projection, it's actually a 2D view).
- Resolution: spacing of points on the chart - 0.5 meters generate a soft chart, but it can take some time to calculate on a big grid in a 3- or 4-layer soil, if that's your case, you can start with a 2 meters resolution then change to 1 meter or less for the final report.



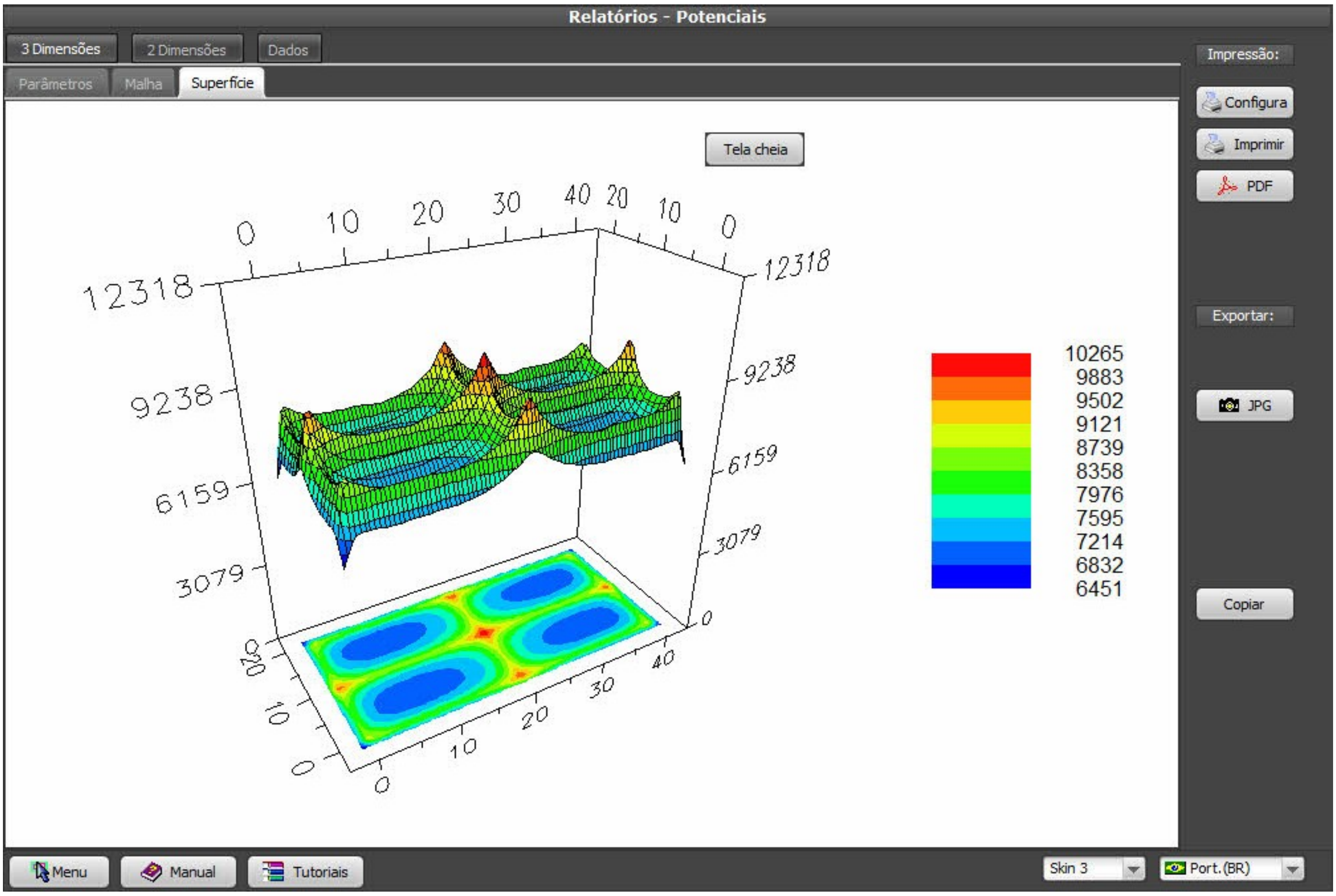
Click at Update button to set the coordinates of the desired region to analyse:



At our 40 x 20 meters grid, we can set, for example, a rectangle from (-1, -1) to (41, 21), so we'll get also the potentials up to 1 meter outside the substation area; when you click on OK, the chart selected (Mesh or Surface, Complete or Projection) will be calculated and shown:

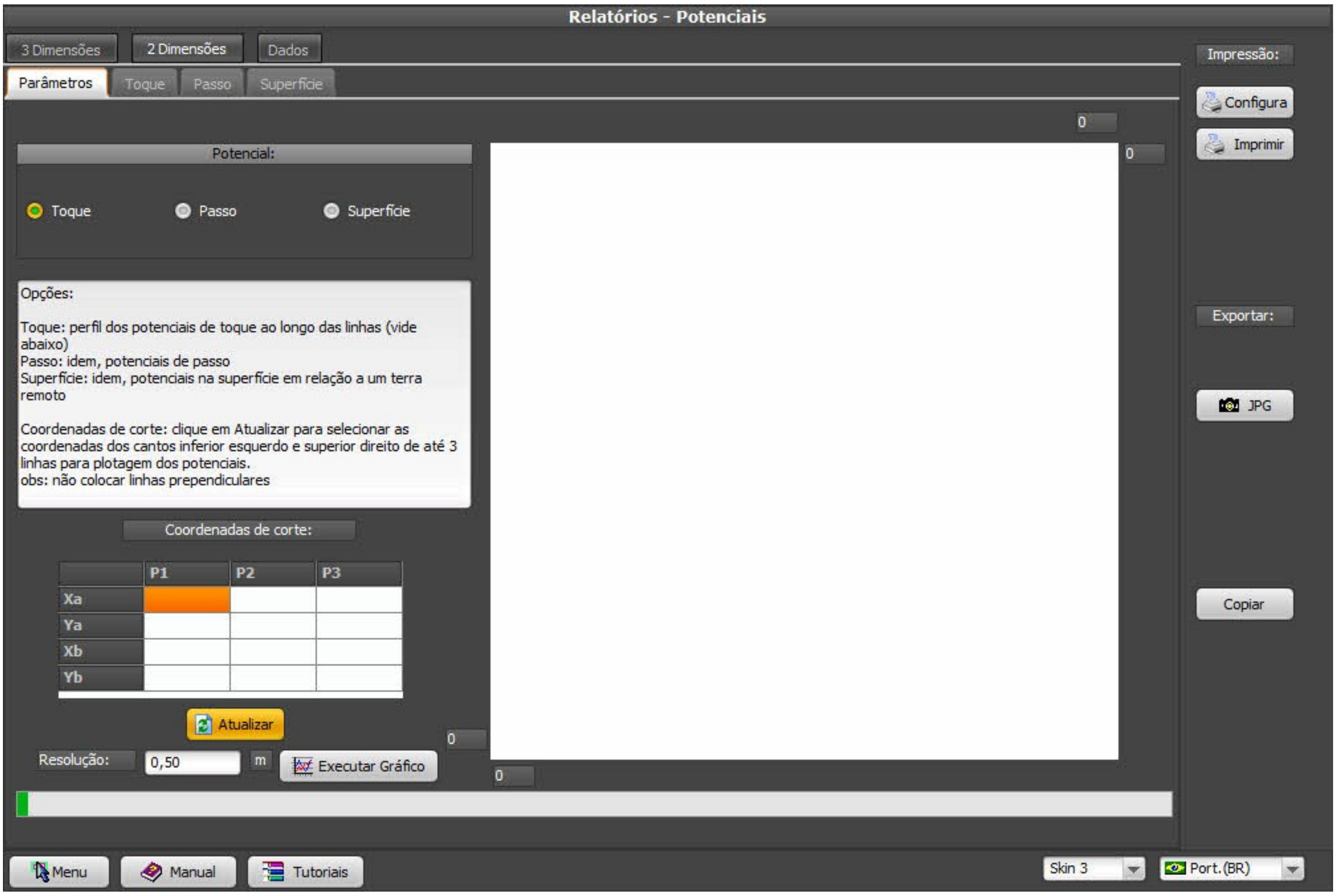


Back to the 3D parameters screen, change from Mesh to Surface and click at the Execute chart" button (if you want the same area, there's no need to go to Update the coordinates):

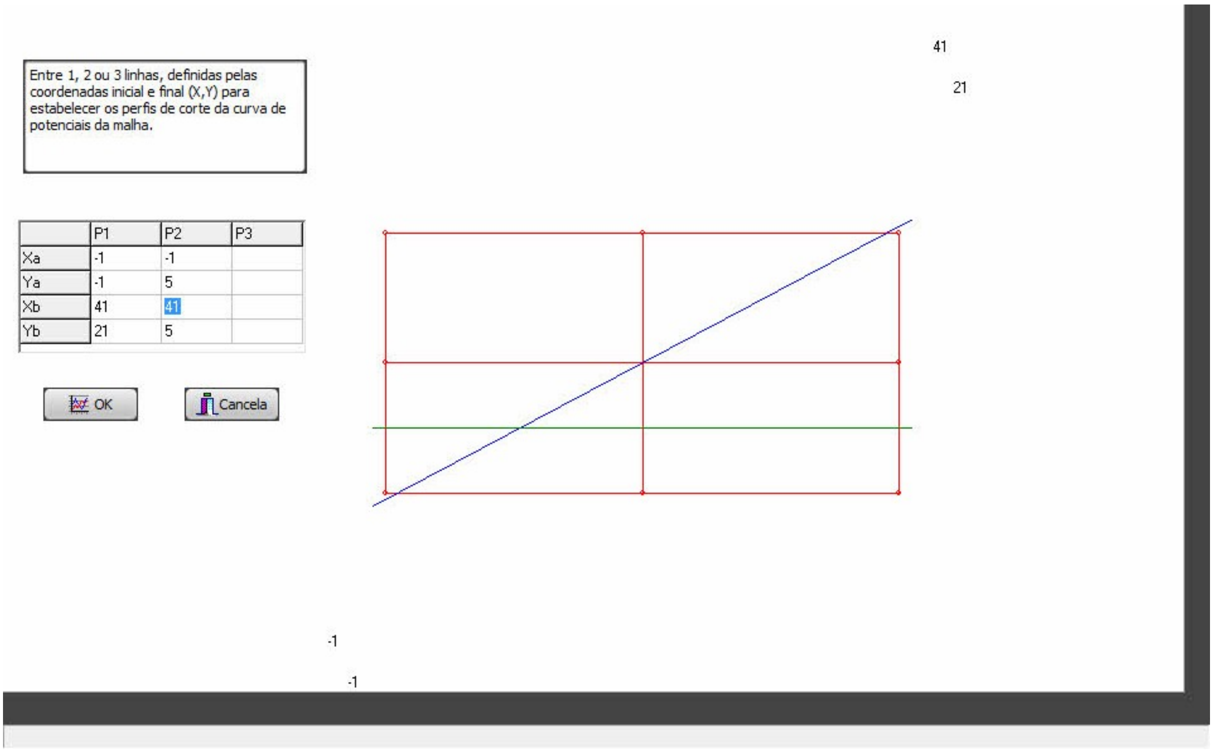


10. Analysis of Touch and Step potentials (2 dimensions)

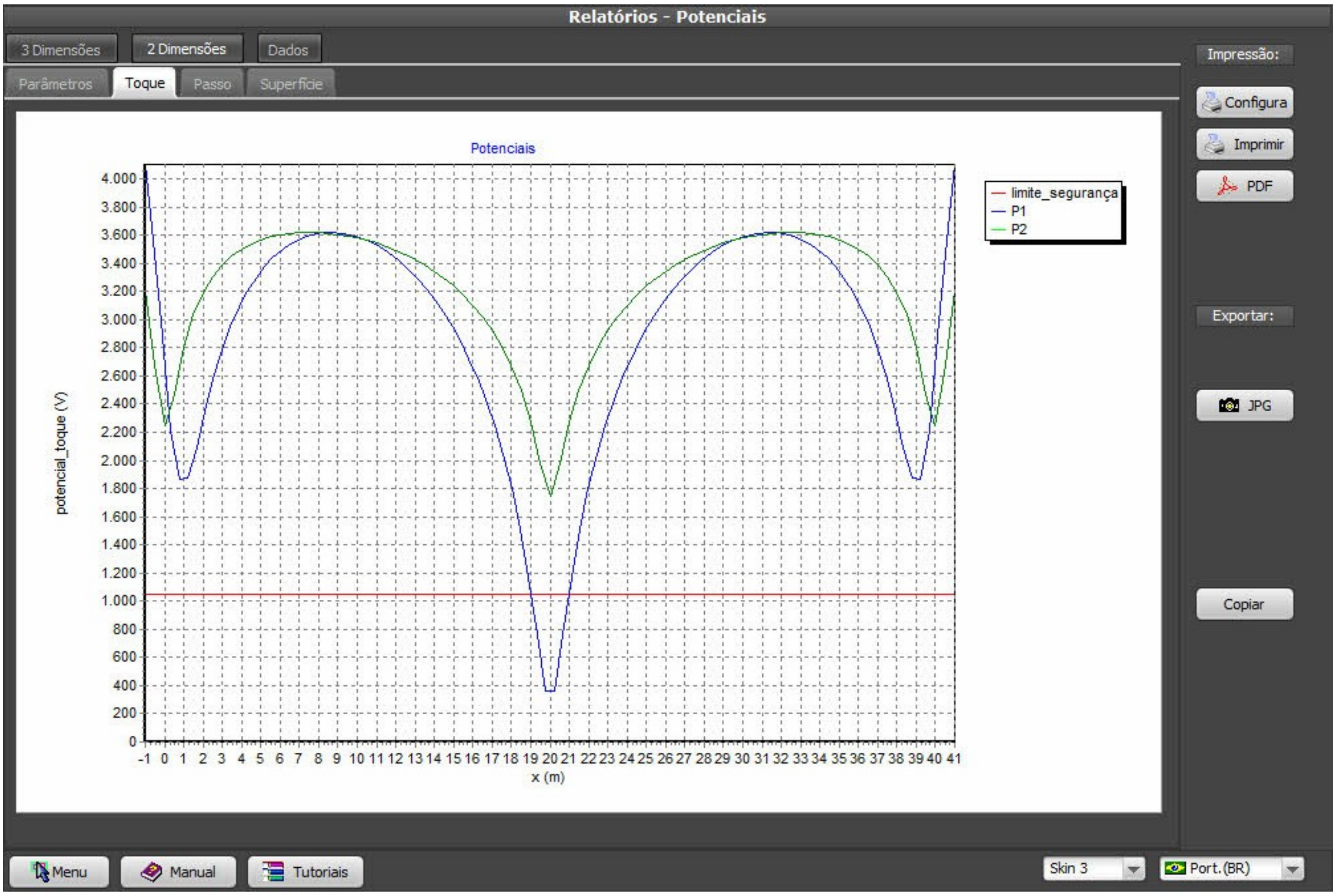
Now, let's calculate the potentials difference between the feet (step) and between hand and foot (touch); at the 2 Dimensions tab, select Touch, Step or Surface:



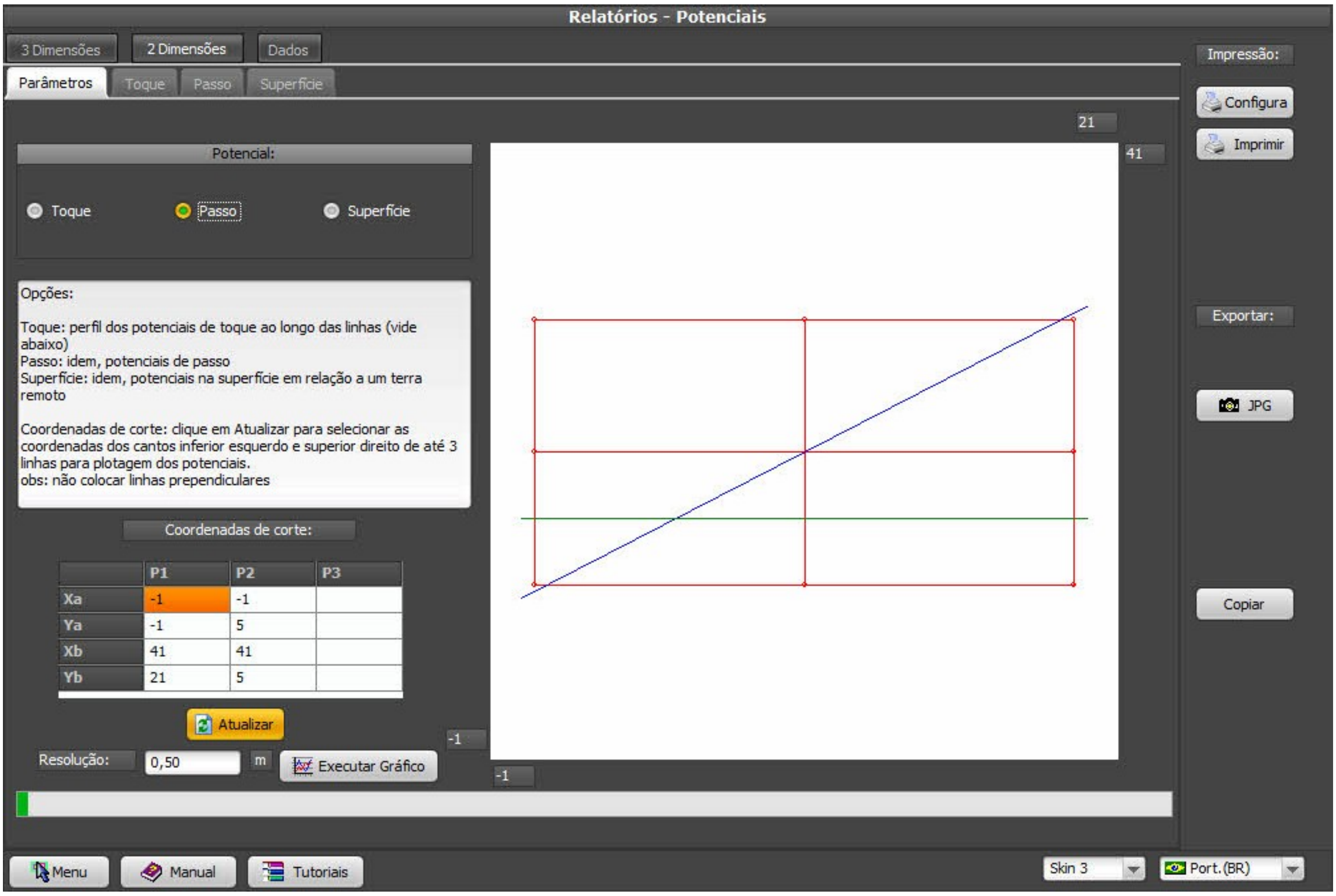
TecAt will calculate and plot the potentials as a function of the coordinate (usually X) of the grid, over 1, 2 or 3 lines each time, over the full grid or you can set just one part of the grid - for example, to get a better view of the surroundings of a grounded equipment - as it's a 2D view, you only can't set the lines on both X and Y axes at the same chart - that is, "vertical" and "horizontal" lines. Click at the Update button to set the lines:



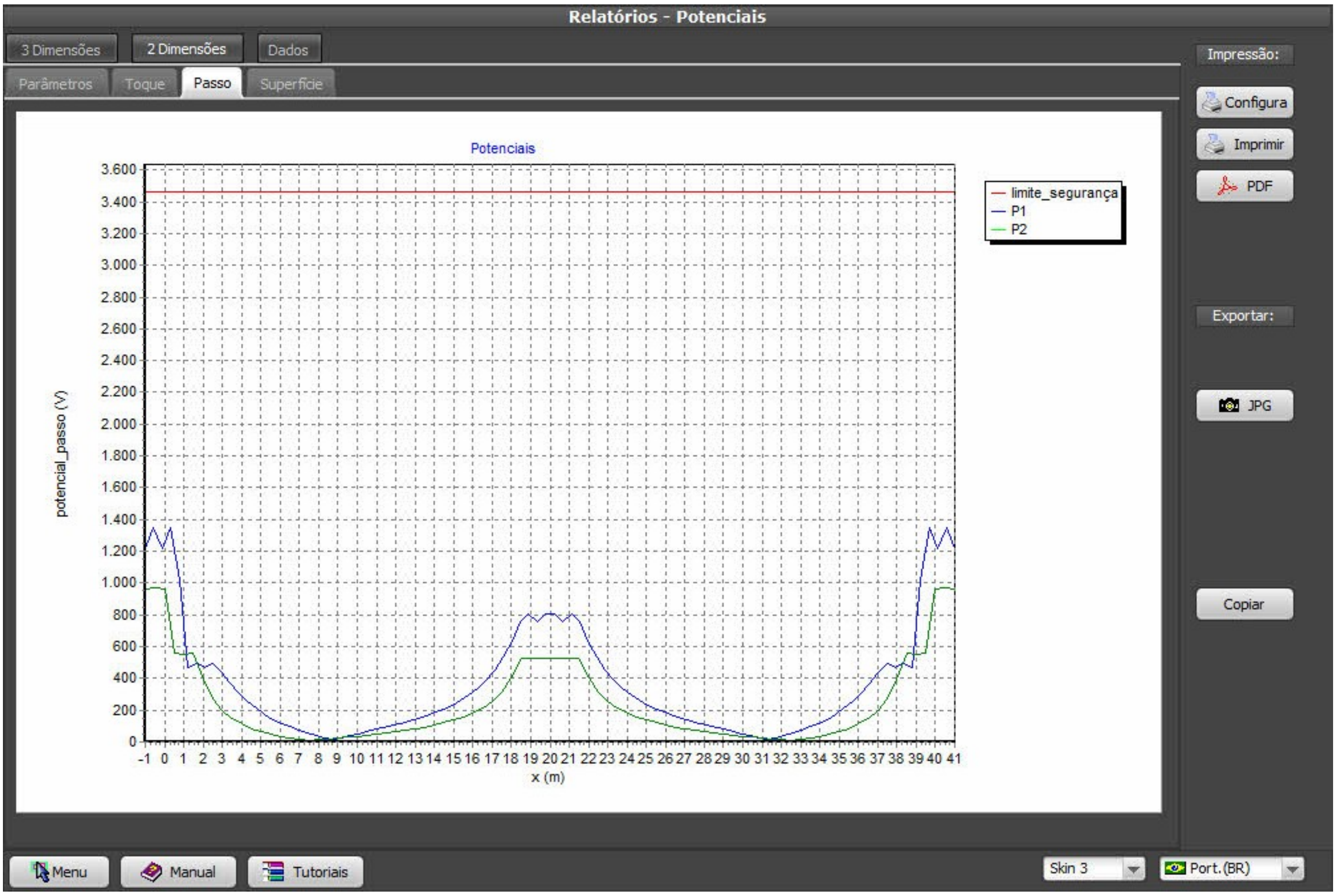
As we had the Touch potential selected, we get:



As we can see, at this grid, on this soil, with the grid current we entered, we get 3,600 Volts inside the grid against a tolerable potential of only 1.100 Volts - obviously, this grid isn't enough and we'll need to try another one with smaller meshes.

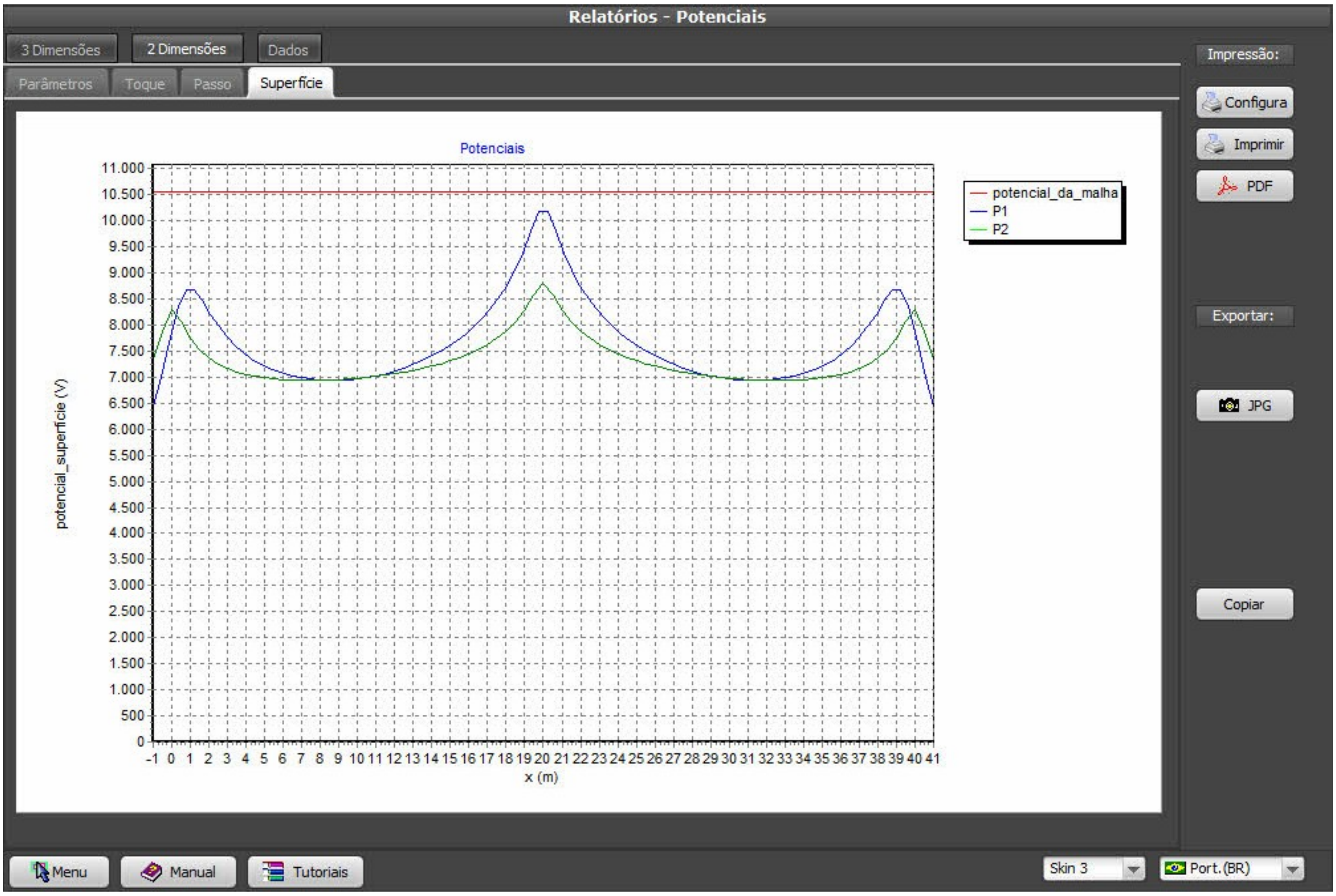


Selecting Step and clicking at "Execute chart":



The step potentials are bellow the tolerable one, so there's no danger.

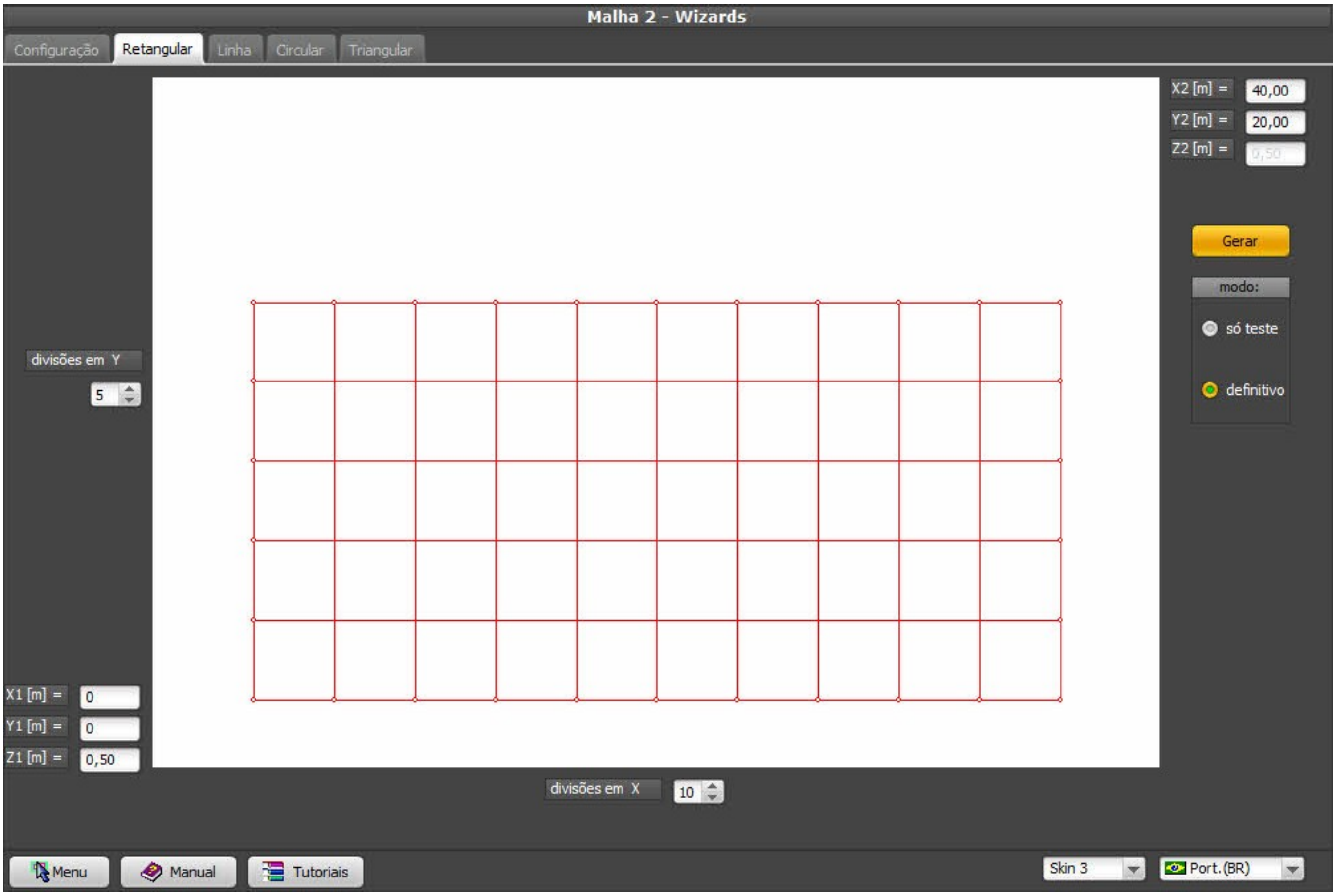
The Surface chart:



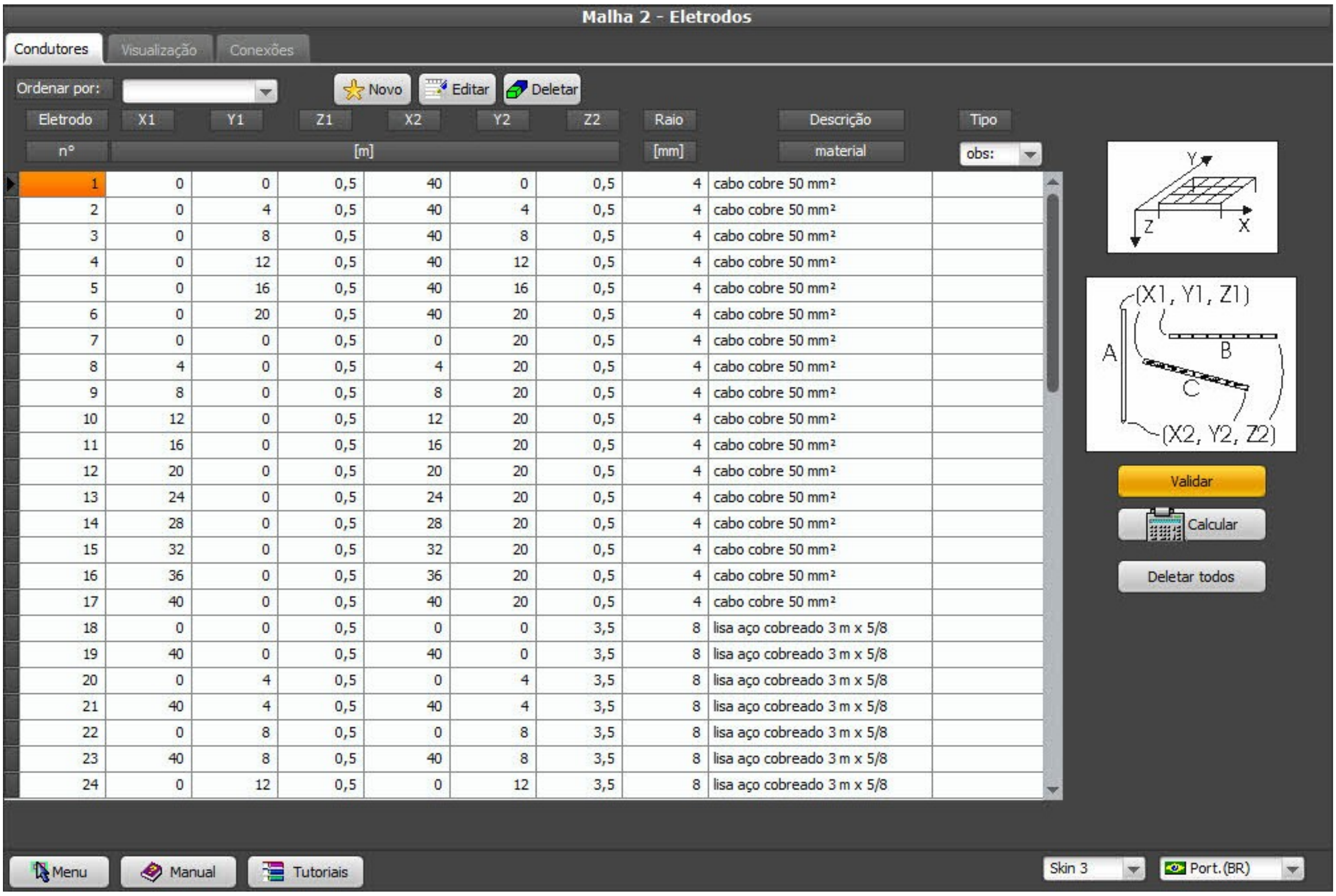
Note that, here, the red line doesn't represent any danger, it's just the GPR value.

11. Typical calculation cycle

Let's re-define the grid with a more realistic number of conductors; a reasonable initial guess is to set meshes with 4 or 5 meters, then refine according with the potentials results. At the Menu bar, go back to Grid 2 / Wizards, keep the parameters for generating cables and rods (rods only at the border), grid still regular and deleting the existing grid; setting the division for 10 meshes on direction X and 5 on Y, we get:

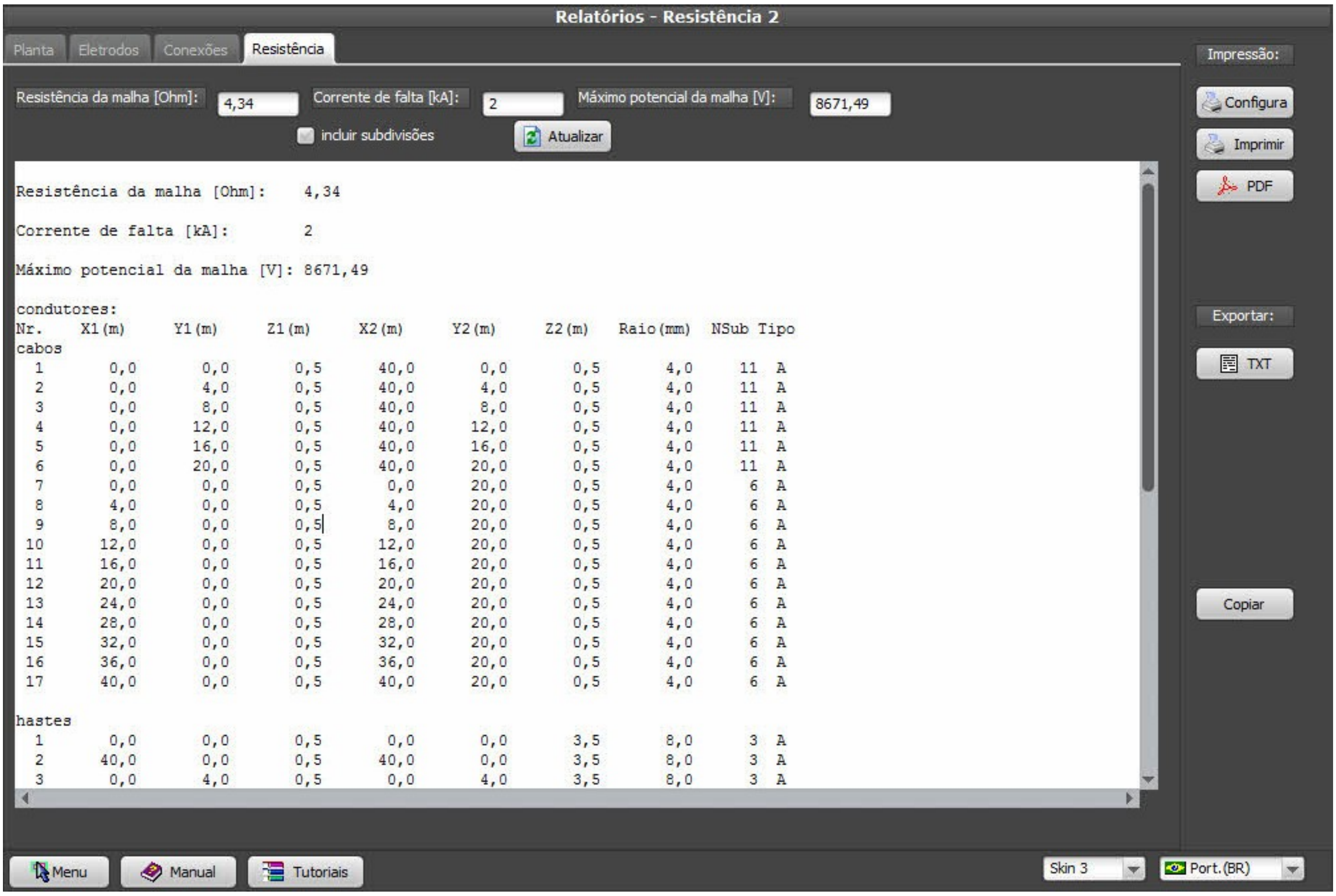


Back to Grid 2 / Electrodes, tab Conductors, we have the new table:



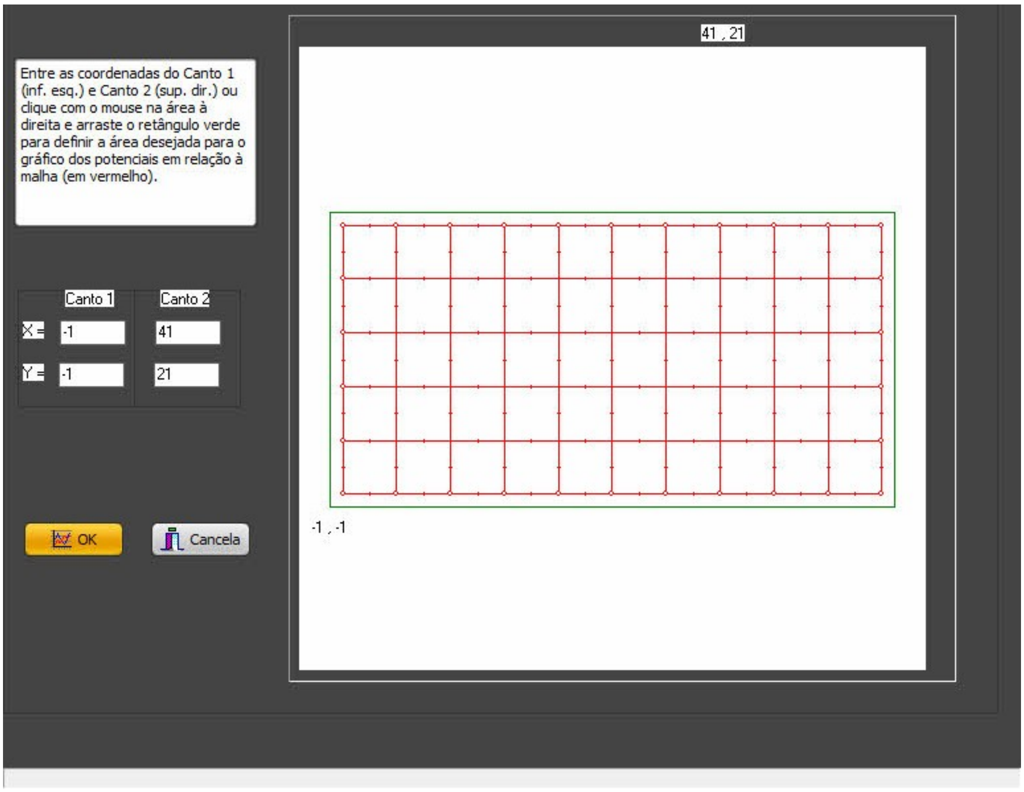
Eletrodo	X1	Y1	Z1	X2	Y2	Z2	Raio	Descrição	Tipo
nº	[m]						[mm]	material	obs:
1	0	0	0,5	40	0	0,5	4	cabo cobre 50 mm²	
2	0	4	0,5	40	4	0,5	4	cabo cobre 50 mm²	
3	0	8	0,5	40	8	0,5	4	cabo cobre 50 mm²	
4	0	12	0,5	40	12	0,5	4	cabo cobre 50 mm²	
5	0	16	0,5	40	16	0,5	4	cabo cobre 50 mm²	
6	0	20	0,5	40	20	0,5	4	cabo cobre 50 mm²	
7	0	0	0,5	0	20	0,5	4	cabo cobre 50 mm²	
8	4	0	0,5	4	20	0,5	4	cabo cobre 50 mm²	
9	8	0	0,5	8	20	0,5	4	cabo cobre 50 mm²	
10	12	0	0,5	12	20	0,5	4	cabo cobre 50 mm²	
11	16	0	0,5	16	20	0,5	4	cabo cobre 50 mm²	
12	20	0	0,5	20	20	0,5	4	cabo cobre 50 mm²	
13	24	0	0,5	24	20	0,5	4	cabo cobre 50 mm²	
14	28	0	0,5	28	20	0,5	4	cabo cobre 50 mm²	
15	32	0	0,5	32	20	0,5	4	cabo cobre 50 mm²	
16	36	0	0,5	36	20	0,5	4	cabo cobre 50 mm²	
17	40	0	0,5	40	20	0,5	4	cabo cobre 50 mm²	
18	0	0	0,5	0	0	3,5	8	lisa aço cobreado 3 m x 5/8	
19	40	0	0,5	40	0	3,5	8	lisa aço cobreado 3 m x 5/8	
20	0	4	0,5	0	4	3,5	8	lisa aço cobreado 3 m x 5/8	
21	40	4	0,5	40	4	3,5	8	lisa aço cobreado 3 m x 5/8	
22	0	8	0,5	0	8	3,5	8	lisa aço cobreado 3 m x 5/8	
23	40	8	0,5	40	8	3,5	8	lisa aço cobreado 3 m x 5/8	
24	0	12	0,5	0	12	3,5	8	lisa aço cobreado 3 m x 5/8	

Click again on Validate and, then, on Calculate, then access the report at Reports 2 / Resistance:

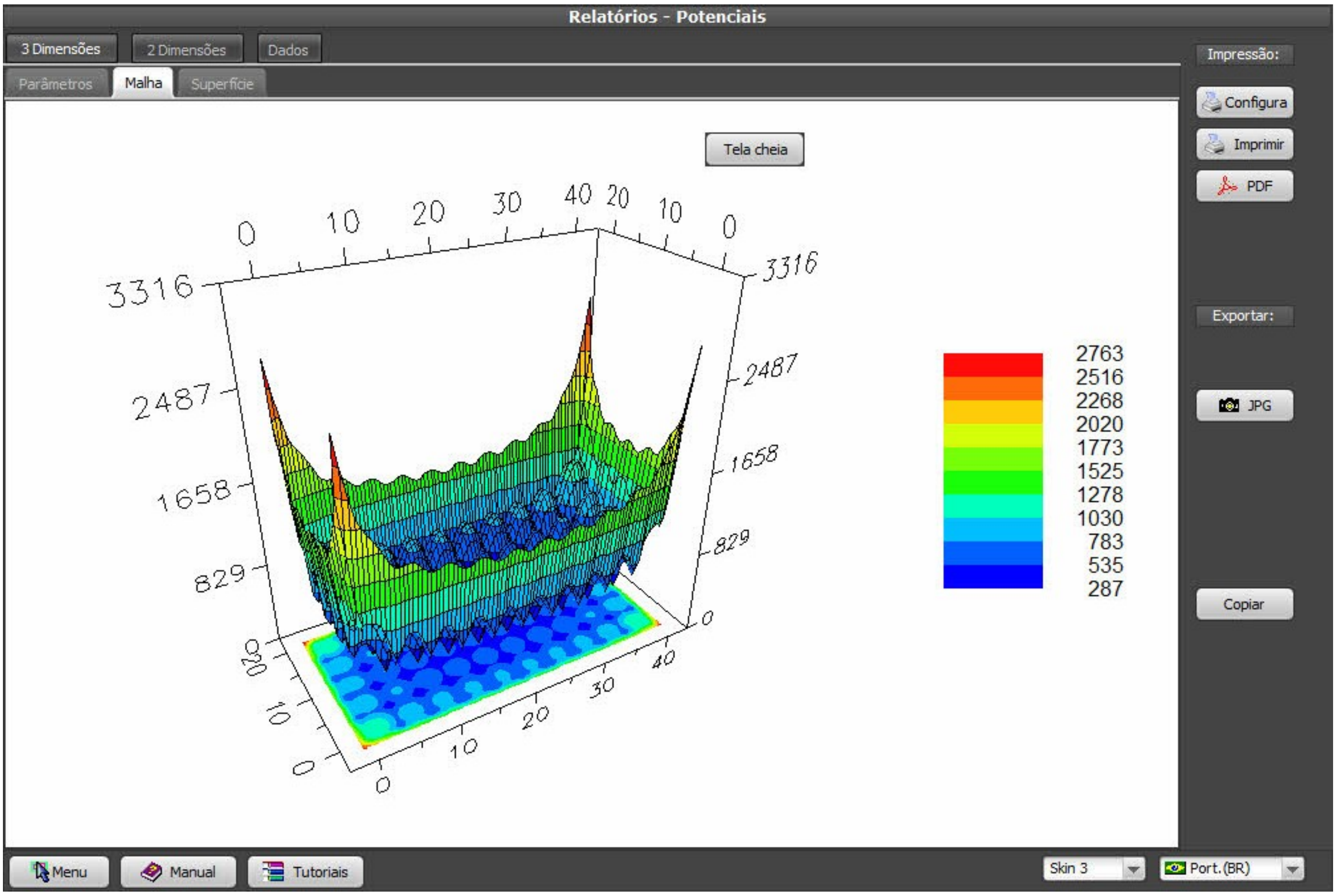


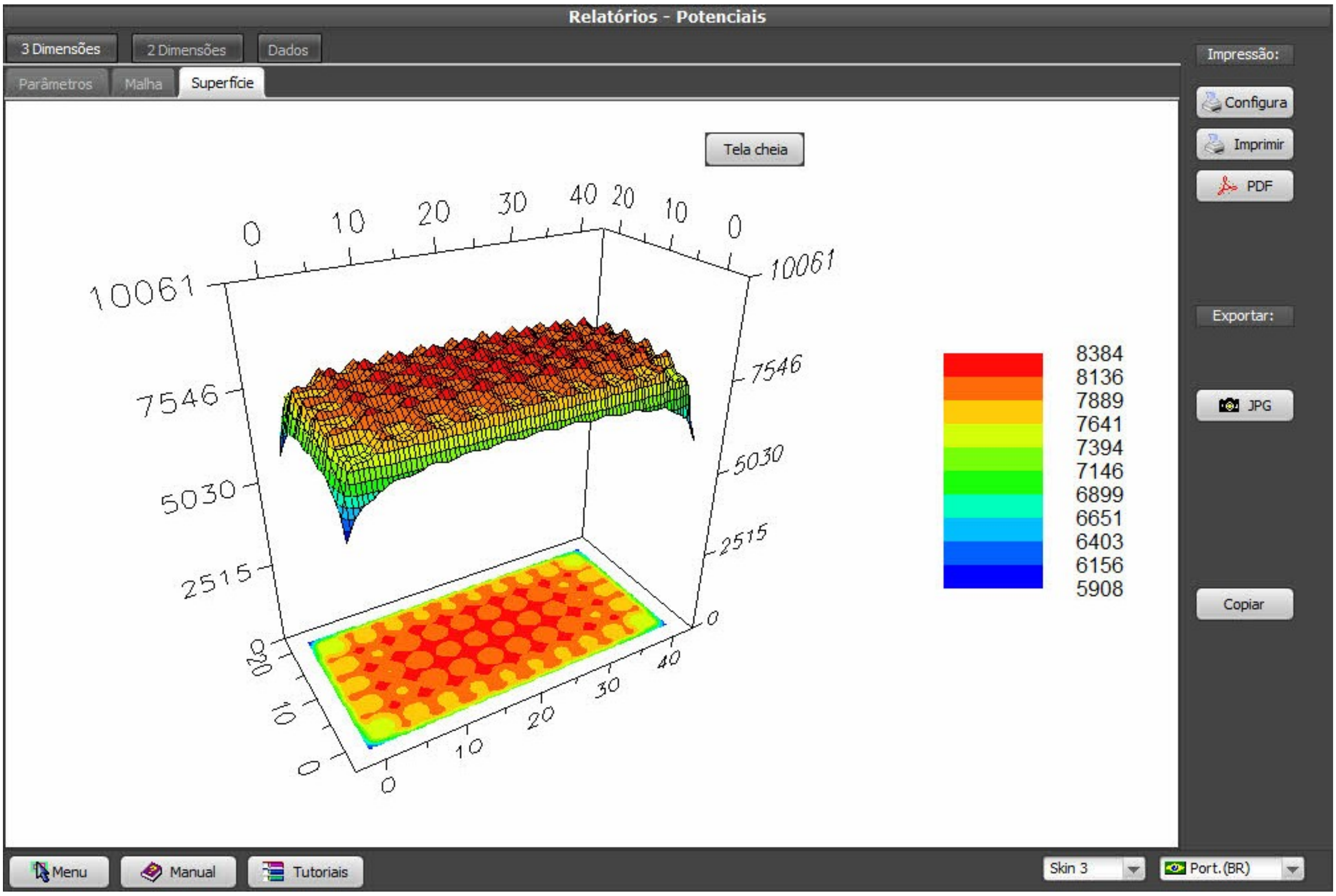
Note that, with all the new cables and rods, the resistance is down by only about 20% - that's normal, as the terrain inside the grid gets saturated with electrodes, so there's little gain at dissipating the current. Nonetheless, a smaller resistance also means a smaller GPR, so every gain counts.

Back to Potentials, 3D, click again on Update to see the new plan:



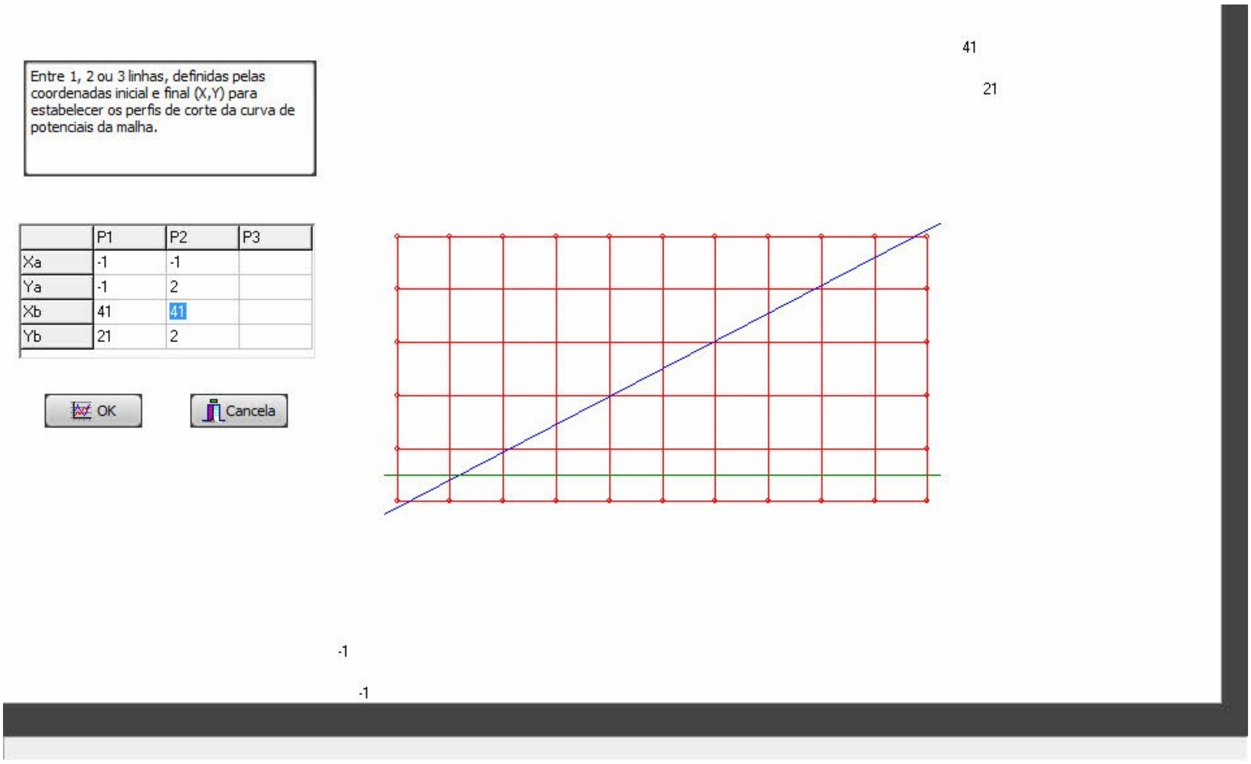
Even at the 3D view, we can see that the grid with more divisions has a potentials profile with much smaller gradients:



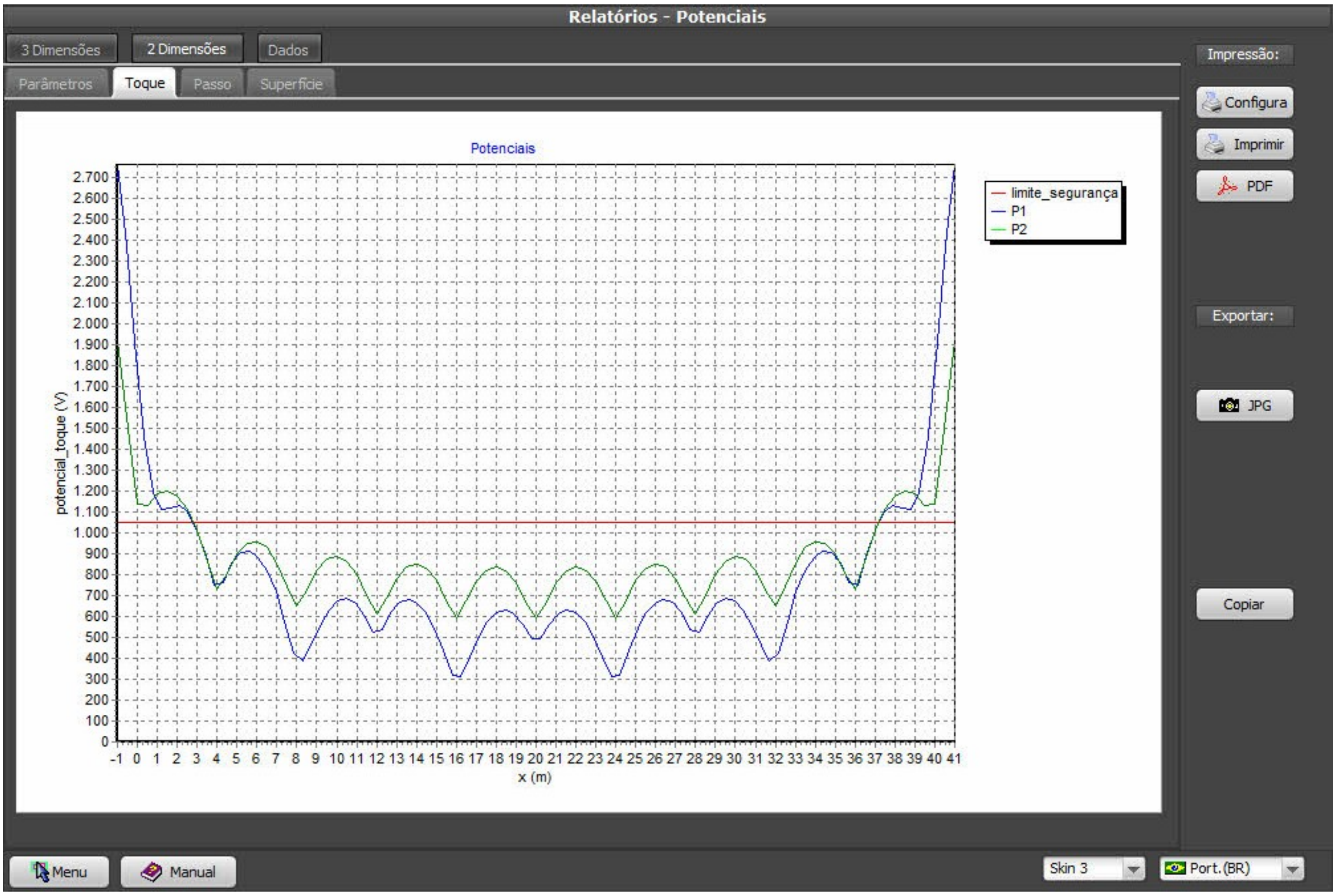


Note that, at the corners, we still have a pronounced gradient, mainly when getting out of the grid.

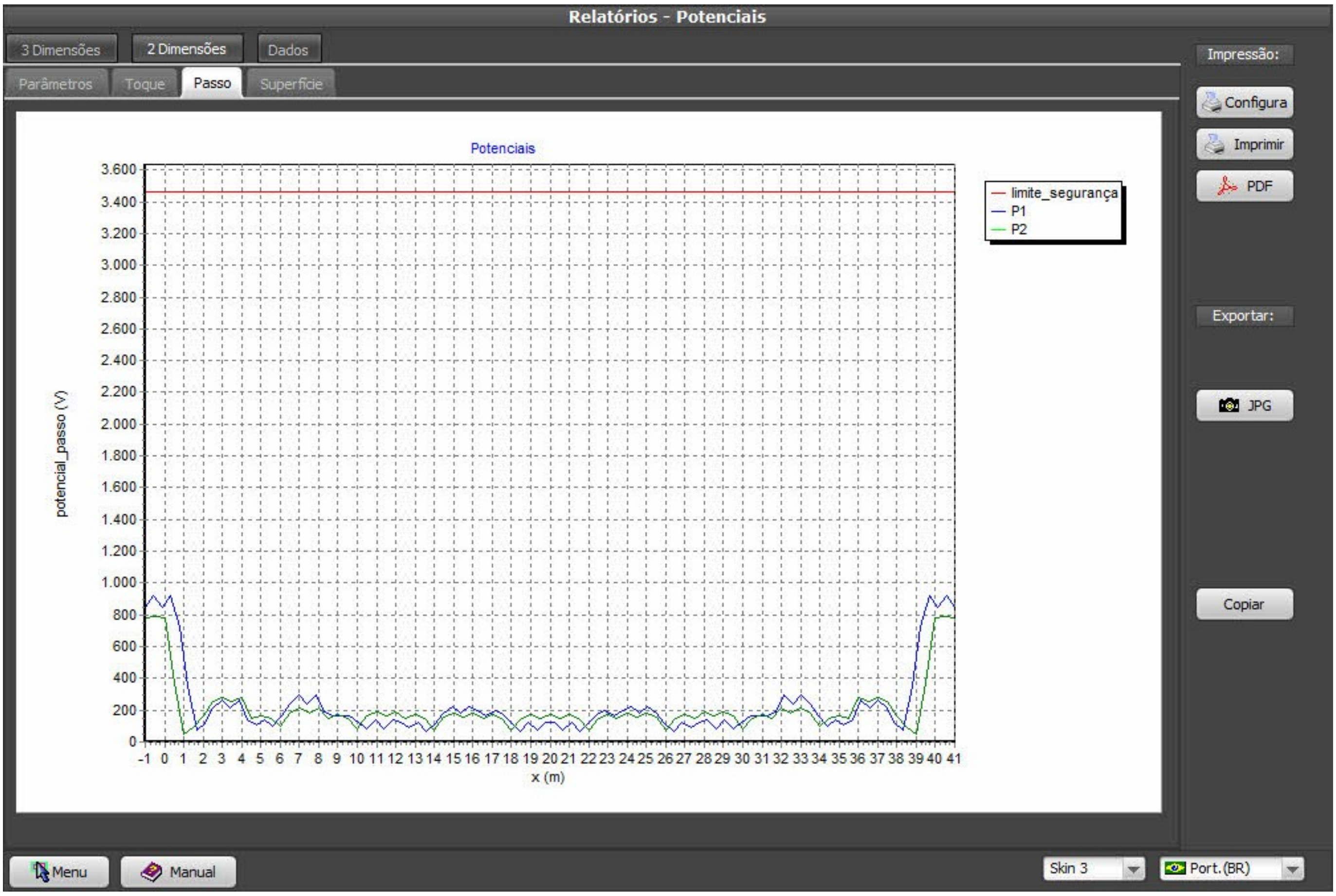
At Potentials / 2Dimensions, click on Update to set new lines coordinates, as the old ones can now be positioned on odd places (like over a cable) that don't give us a fair view of the potentials:



On a regular grid, the critical regions are usually at the corners, so we have to adjust the coordinates so the lines go through the middle of the respective meshes (Y = 2 meters instead of 5):

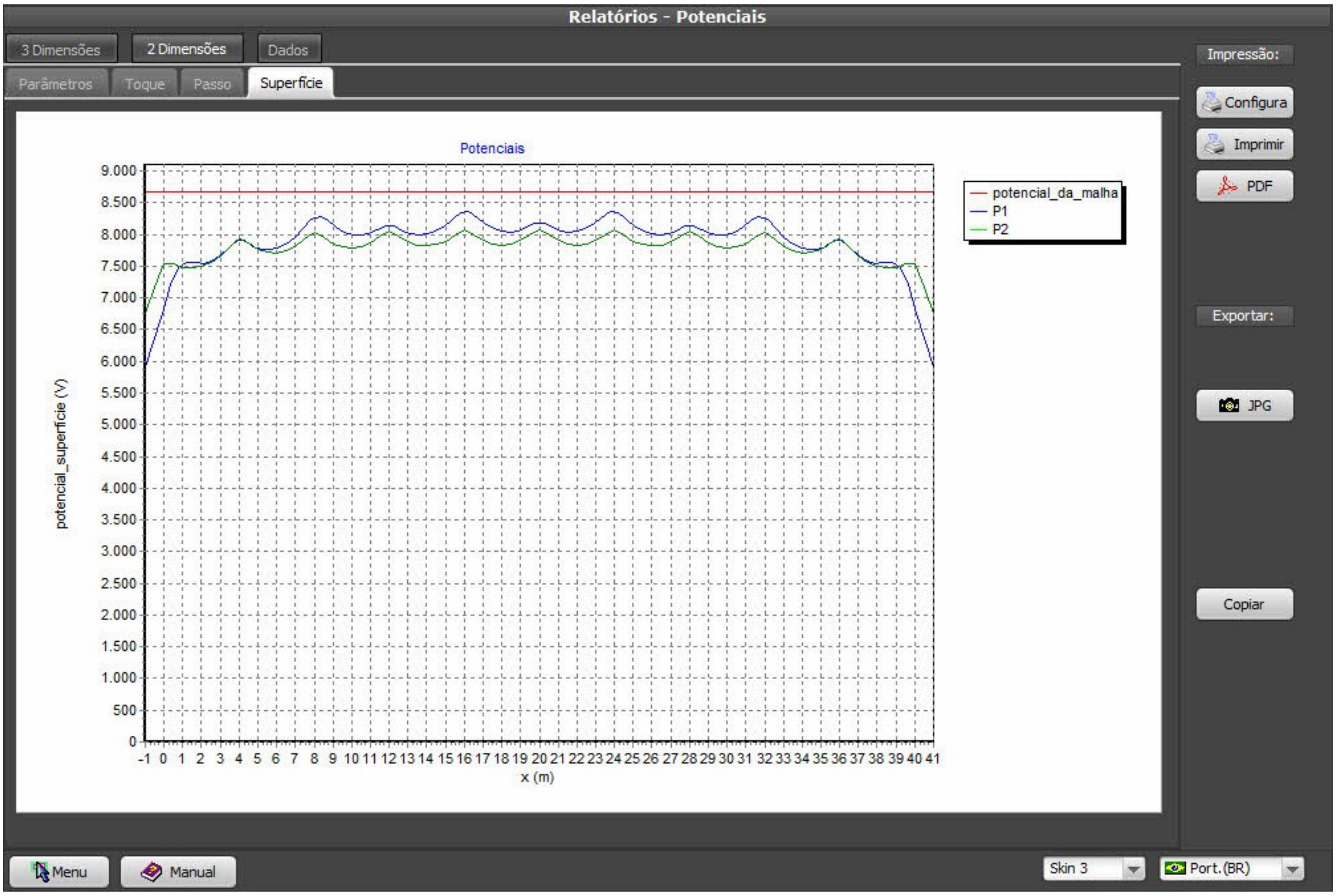


As we can see, the Touch potentials are bellow the red line on most of the substation area, but at the corners, we still get dangerous potentials.



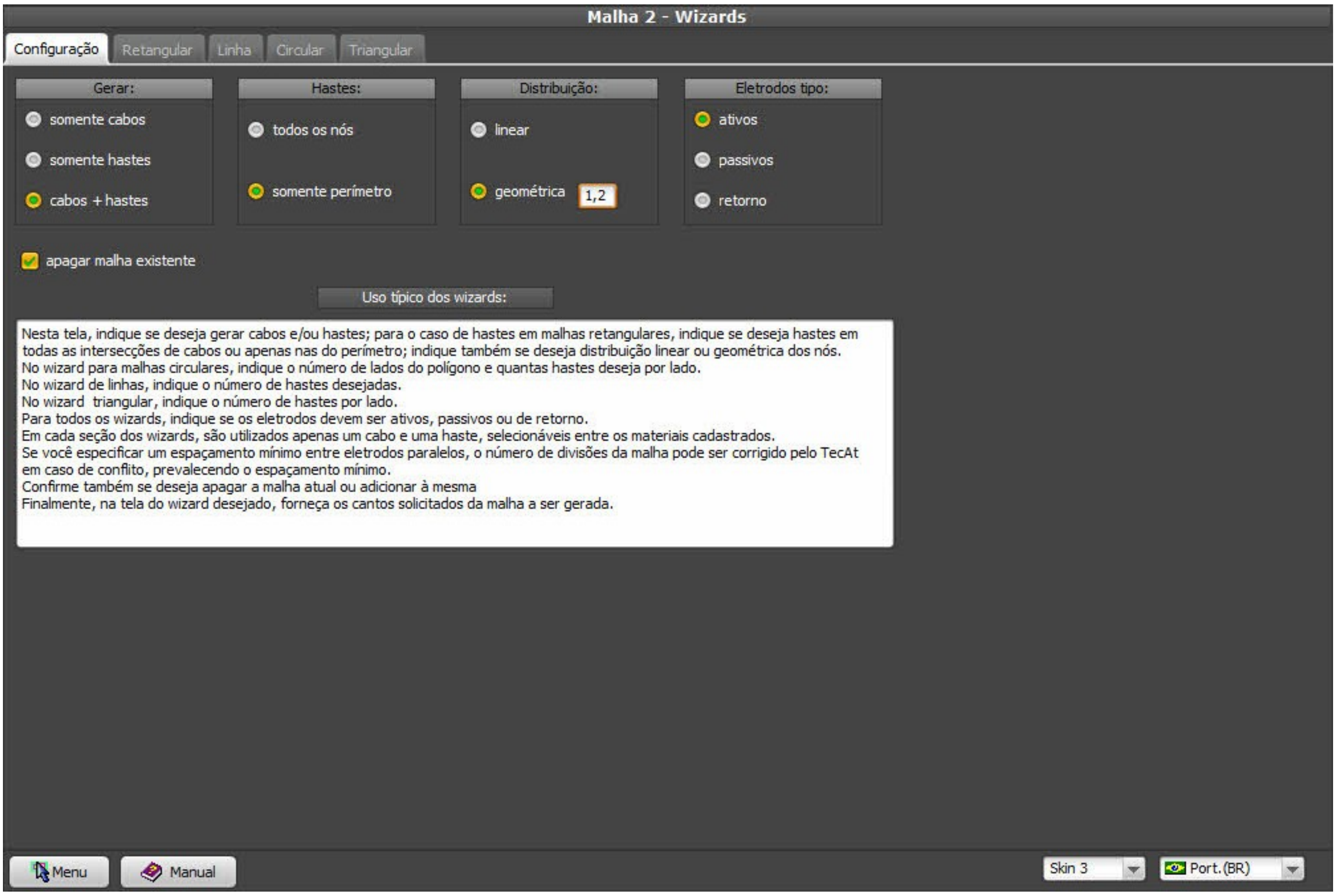
Step potentials, as expected, are even lower than before.

Surface potentials profile:

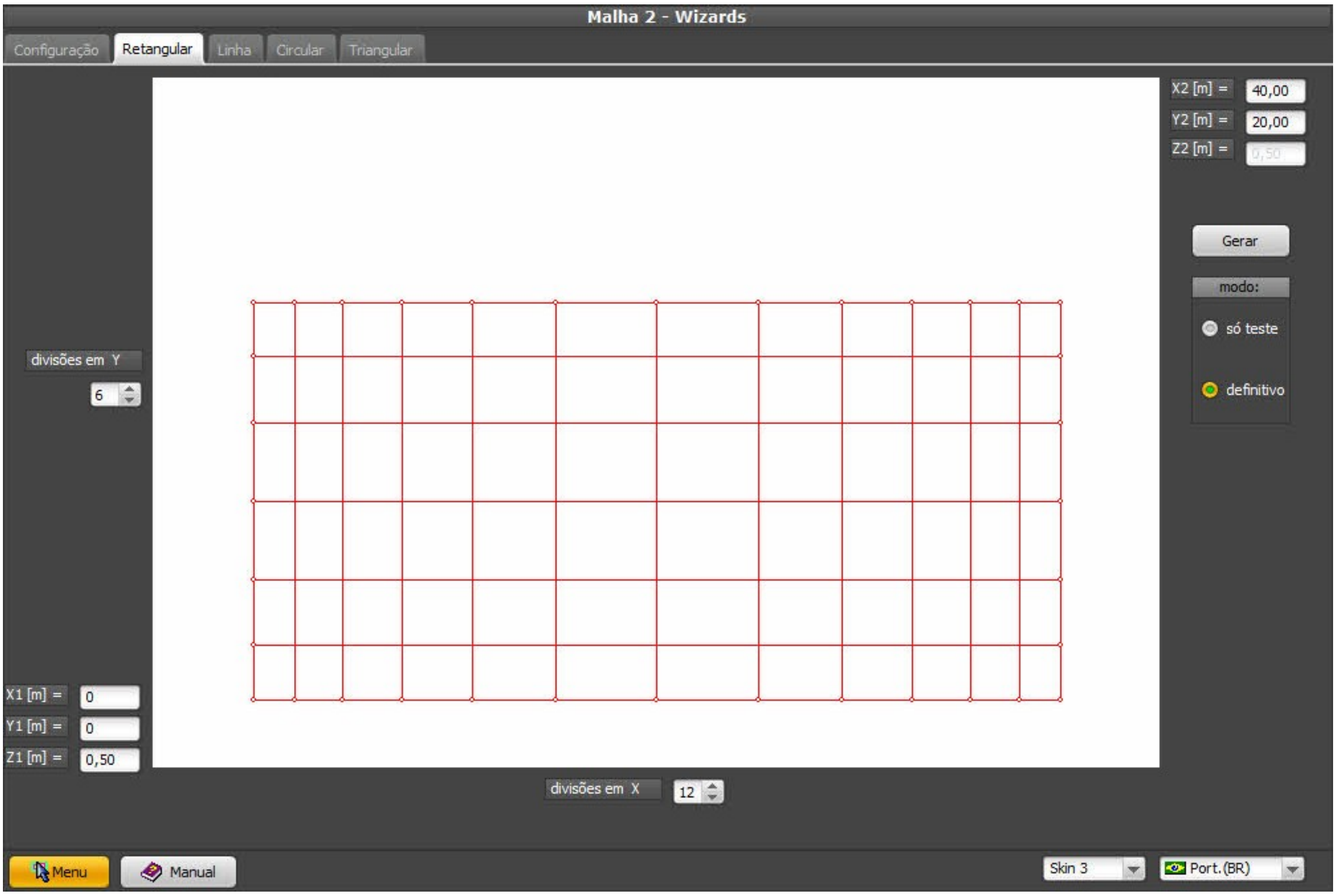


12. Wizards - grids with geometric division meshes

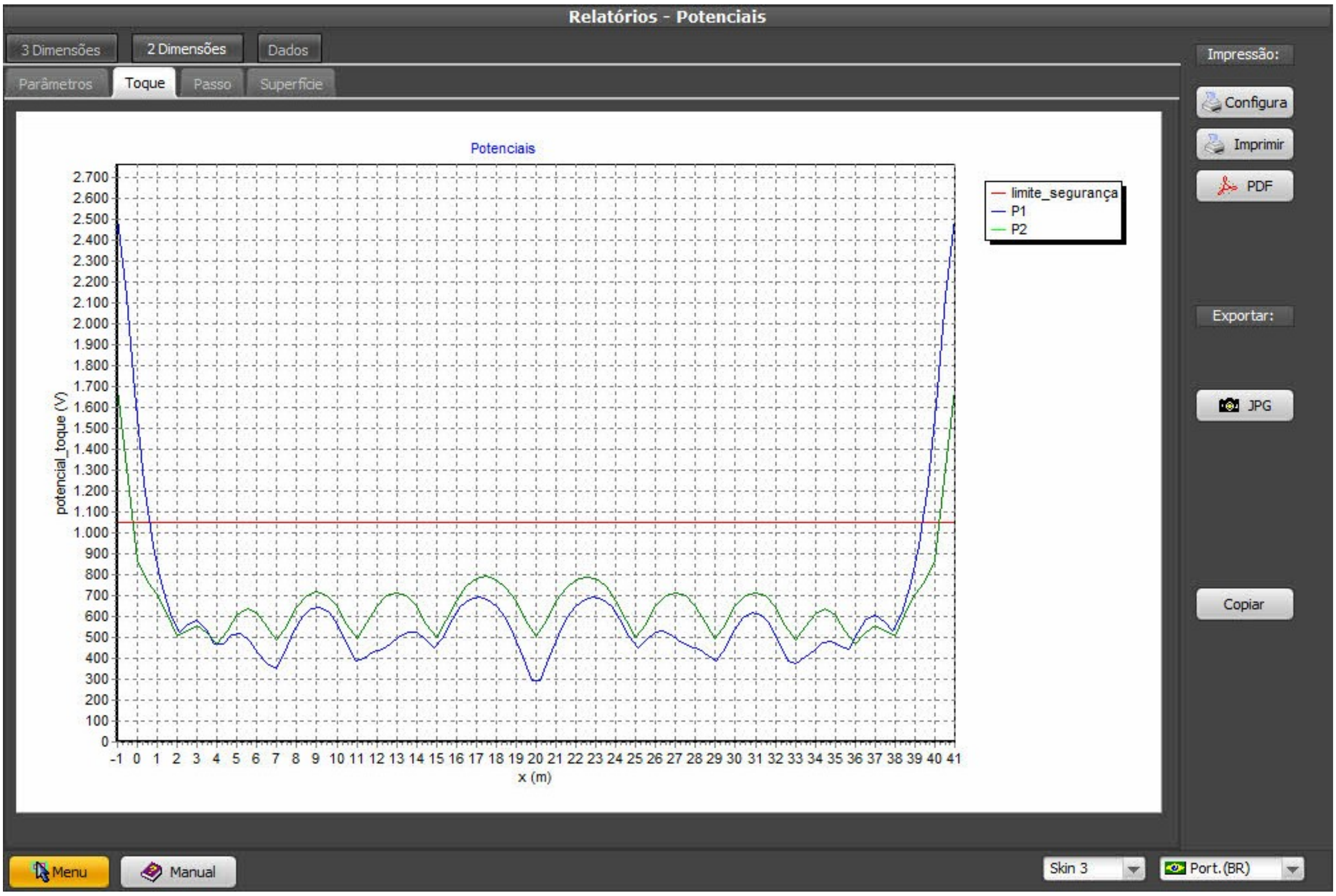
If we keep dividing the grid in smaller and smaller meshes, probably we'll reach a good potential at the corners, but a big region of the grid will be over-dimensioned - in other word, expensive and slow to build. There's a more elegant solution: we distribute the cables as to form smaller meshes at the corners and bigger ones at the middle of the grid, so we'll put our money and time where they are more effective! On the Wizard configuration, select "geometric" distribution and enter a 1.2 factor, so the second mesh will be 1.2 bigger than the first, the third will be 1.2 bigger than the second and so on up to the middle of the grid, when they start to become smaller again:



Setting the divisions at 6 at the Y axis and 12 at X, we get:



Now we repeat the cycle: at Grid 2 / Electrodes, click at Validate then Calculate; then, at Potentials, what really concerns us is the Touch chart, so here it is:



As we can see, all the inside of the substation is now safe for both Touch and Step conditions.

Actually, we only need to guarantee the whole area for step potentials, as the touch will only be dangerous at 1 meter around some metallic structure or equipment but, as it's usual to use a metallic fence, we ended checking the whole area anyway; just keep in mind that, on a big grid or high resistivity soil or high currents, maybe it pays to spend more time checking for alternatives.

13. Alternatives to control the potentials outside the substation

As can be seen on the previous item, the touch and step potentials are safe inside the substation, but we need to check also what's happening around this area; if there's a metallic fence - or a brick wall with concrete columns with rebars that goes underground - we must be aware of the possibility that someone touches it at the time of a short-circuit.

If there's no gravel at the surroundings of the fence, the tolerable potentials will be even smaller, maybe less than 300 Volts. Note that a concrete sidewalk does not work as an insulating layer, because - when in contact with the soil - the concrete absorbs water and presents a resistivity of less than 100 Ohm.m.

The solution will came according with the situation: if the substation is inside the property, you can add the gravel layer around the fence, or - better yet - a layer of asphalt; other possible solutions is to extend the grid beyond the fence (not always possible) or build the grid smaller and do not connect the fence to the grid.

Also, although less common, it's possible that the step potential presents dangerous values too, when there's no gravel or asphalt..