AN ADVANCED DESIGN GUIDE

Written by Pipou.

The making of ***Troubled***, a map by Nehr and Pipou.

A complete and detailed guide about our incredible (and long) journey.

Preamble

This guide has for objective to cover all the advanced design techniques and strategies I had to use during the making of Troubled, a map by Nehr and me.

What would designing be without some math?

I'll skim through the basics of designing and focus on the math part mostly.

I tried my best to make it the most explicit and understandable for you to follow my steps and live the experience through me, through my words, and maybe that could help you discover some design tricks you could need now or later.

Don't hesitate to contact me if you have any question.

Have a good read!

CHAPTER I

HOW TO SCALE & ALIGN TWO LAYERS IN GROUPS OF DIFFERENT PARALLAXES

Idea:

I want to add a cloud effect to my map. The cloud effect should be over the playground, over the player.

Why would I do that?

You aim to enhance the immersive experience. While background effects are prevalent, foreground effects are less common due to their higher complexity and the need for meticulous design. However, foreground effects enrich maps by enveloping the player in both background and foreground elements simultaneously, crafting atmosphere and mood. Conversely, the absence of foreground effects may result in a simpler appearance, focusing primarily on gameplay or presenting a cross-sectional plan.

Steps: To do that I have to…

I) Choose the right parallax settings.

Summary

The clouds must move slightly faster than the players. To do that, our clouds must have a parallax setting >100 for both X and Y.

Since the clouds have a different parallax from the original playground design group, and for better visibility, we must create another group dedicated to the clouds.

Now, “group#1” is our playground group, with a parallax of Para X=Para Y=100 and “group#2” is our cloud group, with a parallax of Para X=Para Y=120.

Explanations

Parallax 0 (short for parallax X=Y=0) sticks a group (a layer or a quad) to the tee, giving the impression of having a background image, an image that doesn’t move (but it moves with the tee at the same speed).

Parallax 100 pins down a group to the playground (so it’s anchored to entities and matches the visuals and the physics).

That way, having a parallax between 0-100 creates depth, which is useful when making a background (with mountains, a sun, a forest…). The further the design element from the tee, the closer to “0” (stars could have a setting of “10”) and the closer the design element from the tee, the closer to 100 (a forest with a setting of “80” would give the player the idea to be *in* the forest).

A parallax of <0 looks like a group is moving faster than a tee in the same direction as the latter.

A parallax >100 looks like a group is moving faster than a tee in the opposite direction.

Figure 1: Parallax.

Source: https://opengameart.org/content/

Think of it like this: Picture the sand layer as our cloud layer. The sand layer is in front of the tree layer (playground layer). So, as the player moves, the sand layer moves in the opposite direction, so will our cloud layer.

If you still don’t get it, it’s the same as when you stare at the horizon when travelling by train. All the environments will move around that focal point, moving either in your direction or in the opposite direction. Our focal point here is our playground.

Our cloud layer will have a parallax of >100. I chose 120.

II) Scale the layer.

Because of the parallax, the cloud group is moving around with the camera so we must scale the cloud layer in order to cover the same area (playground) when moving around the playground layer.

The original layer I use, my playground layer in "group#1", has a size of $W_{100} = 123$ and $H_{100} = 82$. You can read it "Width at parallax 100 equals 123" and "Height at parallax 100 equals 82".

The cloud layer has to cover the same area so we must multiply the original layer's dimensions by a factor. That factor is the parallax.

When scaling a layer, you must multiply the dimensions by the new parallax x divided by 100.

$$\begin{pmatrix} W_x \\ H_x \end{pmatrix} = \begin{pmatrix} \lceil W_{100} * \frac{x}{100} \rceil \\ \lceil H_{100} * \frac{x}{100} \rceil \end{pmatrix}$$
$$\begin{pmatrix} W_x \\ H_x \end{pmatrix} = \begin{pmatrix} \lceil 0.01 W_{100} * x \rceil \\ \lceil 0.01 H_{100} * x \rceil \end{pmatrix}$$

For "group#2", the cloud layer's dimensions will be – at parallax 120:

$$\begin{pmatrix} W_{120} \\ H_{120} \end{pmatrix} = \begin{pmatrix} \lceil 0.01 W_{100} * 120 \rceil \\ \lceil 0.01 H_{100} * 120 \rceil \end{pmatrix}$$
$$\begin{pmatrix} W_{120} \\ H_{120} \end{pmatrix} = \begin{pmatrix} \lceil 147.6 \rceil \\ \lceil 98.4 \rceil \end{pmatrix} = \begin{pmatrix} 148 \\ 99 \end{pmatrix}$$

Be careful, the values must be rounded up to the highest unit to avoid empty gaps. It's best to have a bit more than a bit less. To do so, we use the ceiling function in math to represent it.

The cloud layer's dimensions will be $W_{120} = 148$ and $H_{120} = 99$.

III) Align the groups.

a) Aligning groups with different parallax settings, but with same layer size.

*We won't take step **II)** into account for now as we try to align two groups – with parallax 100 and 120 – with one layer in each group both of a size of X=123 and Y=82.*

Now, we must align the layers (so the groups) together.

The first step is to scale (if not null) $PosX_{100}$ the position offset in X at parallax 100 of the original group by multiplying it by the parallax x (the chosen, new parallax value), the same way we processed the scaling of the layer.

$$Pos\ X_x = \left\lceil PosX_{100} * \frac{x}{100} \right\rceil = \lceil 0.01 PosX_{100} x \rceil$$

The original group has a position offset of X=19616 and Y=19680 and a parallax of X=Y=100. The cloud group has a parallax of X=Y=120.

$$\begin{pmatrix} Pos\ X_{120} \\ Pos\ Y_{120} \end{pmatrix} = \begin{pmatrix} \lceil 0.01 PosX_{100} x \rceil \\ \lceil 0.01 PosY_{100} x \rceil \end{pmatrix} = \begin{pmatrix} \lceil 0.01 * 19616 * 120 \rceil \\ \lceil 0.01 * 19680 * 120 \rceil \end{pmatrix} = \begin{pmatrix} \lceil 23539.2 \rceil \\ \lceil 23616 \rceil \end{pmatrix}$$

The cloud group position offset should be $Pos\ X_{120} = 23540$ and $Pos\ Y_{120} = 23616$. Unfortunately, we aren't quite finished yet…

The groups don't seem to align in-game, it's missing an offset.

$$Pos\ X_x = \lceil 0.01 PosX_{100} x + ? \rceil$$

Looking for a solution: defining the offset

1. I created a new map and tried several configurations. You can find the map here: 

2. I made a tile layer of 50*50 in "group#1" with a standard parallax of 100. I used a tile layer instead of a quad to be able to place the 2*2 center of the square. Unfortunately, using a filled 50*50 tile layer means that borders are covered and that they will repeat infinitely. To avoid having a gigantic, unpractical, and useless layer, I had to use clipping to contain the square within the square area. Clipping, among other settings, has a value set in pixels. To clip our 50*50 tiles layer, we must define its width and height in pixels.

   You must know that **1 tile = 32 pixel**, so our layer will have a width and height of $50 * 32 = 1600$ pixels.

   The parameters of "group#1" then were:
   - Clip X: 0
   - Clip Y: 0
   - Clip W: 1600
   - Clip H: 1600

   Clip X and Clip Y are set to 0 since I didn't add a position offset yet. The group is located at the origin of the map.

3. I added game tiles that will be needed a bit later for testing. I made a 4*4 unhookable unfilled square around the 2*2 hole, and I placed a spawn tile inside that hole.

4. I created another group I'll call "group#2". I added a quad layer that I clipped around the 50*50 tile layer of "group#1", to have a quad of the same dimension.

   Doing so, both layers are perfectly aligned.

5. Then, I modified the standard parallax setting of 100 of "group#2" and set Para X to 120. I chose to only edit Para X to focus on one parameter, not to have the layer moving around the Y axis.

   Naturally, "group#2" moved to the left. But, how far?

6. First, I had to place my camera in the editor close to the center of that 50*50 square. Not doing that would be totally misleading since I'm trying to approximately find the Pos X setting to have "group#2" align perfectly with "group#1".
   To have an idea of where the center of the screen is, you have to turn on the Proof option and try to place the blue center on an object, at a specific and wanted position. I placed the blue center at about the middle of the square.
   Then, I slowly manually changed the value of Pos X of "group#2" until I had a value that seemed to work – when both squares overlap. $Pos\ X_{120} = 157$ looked good enough.

7. I went in-game, loaded the map and moved to the center manually to reach X=25.00. I used the move_raw rcon command (in F2) to be more accurate. Move_raw allows to move 1 pixel at a time, so by 0.03125 tile.

   Information that can be found on https://ddnet.org/settingscommands/:

   move_raw i[x] i[y] Moves to the point with x/y-coordinates ii

Figure 2: In-game visualization of the center of the square.

8. I zoomed out to visually check if the setting was correct and it was almost the case. I tweaked it a bit and managed to get $Pos\ X_{120} = 160$ as a satisfying result.

9. I found a correlation between $Pos\ X_{120} = 160$ and the width of the layer being 1600. The offset caused by the parallax setting looked like it would be $\frac{1}{10}$ of the width of the original layer.

10. The current formula for $Pos\ X_x$ would be:

$$Pos\ X_x = \lceil 0.01 PosX_{100} x + 0.1 * W_{100} * 32 \rceil$$
$$Pos\ X_x = \lceil 0.01 PosX_{100} x + 3.2 W_{100} \rceil$$

- W_{100} = width of the layer at parallax 100 in tiles (here 50)
- $PosX_{100}$ = position offset of the original layer at para 100 (here null)
- x = value of the parallax of the new layer (here 120)

11. I tried some other tests with that 50*50 tiles square and it looked like it was the answer (*Appendix 2*), but does it work with any parallax setting?

12. I went back to step 5 and edited the parallax to 140. It didn't work anymore. I was missing a parameter, a factor. I visually checked and it appeared that it was about $Pos\ X_{140} \approx 319$.

    Let's compare it with $Pos\ X_{120} = \lceil 0 + 3.2 W_{100} \rceil = 160$. $Pos\ X_{140}$ looks like it's twice the value of $Pos\ X_{120}$.

13. Since the position offset doesn't look like $\frac{1}{10}$ of the layer size anymore, we must focus on the latter.

$$Pos\ X_x = \lceil 0.01 PosX_{100} x + \boxed{0.1} * W_{100} * 32 \rceil$$

The issue is here.

14. Let's name "y" the parallax difference between our chosen parallax "x" and the playground default parallax 100.

$$y = x - 100$$

15. We have a 0.1($\frac{1}{10}$) factor for parallax 120 and that factor is nullified when parallax equals 100. There is a step of 0.1 for an increase of 20 parallax. We will call "Z" our real factor (*Appendix 4*).

$$Z = y * \frac{0.1}{20} \quad OR \quad Z = \frac{y}{200}$$

    We can now replace y.

$$Z_x = \frac{x - 100}{200}$$

16. Let's try with parallax 120 and 140.

$$Z_{120} = \frac{120 - 100}{200} = 0.1$$
$$Z_{140} = \frac{140 - 100}{200} = 0.2$$

17. It's time to edit our previous $PosX_x$ formula and replace the 0.1 factor by Z_x with "x" our chosen parallax. (See 10 for an explanation of the variables)

$$Pos\ X_x = \lceil 0.01 PosX_{100} x + Z_x * W_{100} * 32 \rceil = \left\lceil 0.01 PosX_{100} x + \frac{x - 100}{200} * W_{100} * 32 \right\rceil$$

$$Pos\ X_x = \lceil 0.01 PosX_{100} x + 0.16 W_{100} (x - 100) \rceil$$

18. Now let's apply it to *Troubled*.

$$Pos\ X_x = \lceil 0.01 PosX_{100} x + 0.16 W_{100}(x - 100) \rceil$$

- W_{100} = 123
- $PosX_{100}$ = 19616
- x = 120

$$Pos\ X_{120} = \lceil 0.01 * 19616 * 120 + 0.16 * 123 * (120 - 100) \rceil$$
$$Pos\ X_{120} = \lceil 23932.8 \rceil = 23933$$

19. It works!

b) Aligning groups with different parallax settings, with different layer size.

Let's have a look at what we have and what we expect (green= "group#1"; blue= "group#2"):

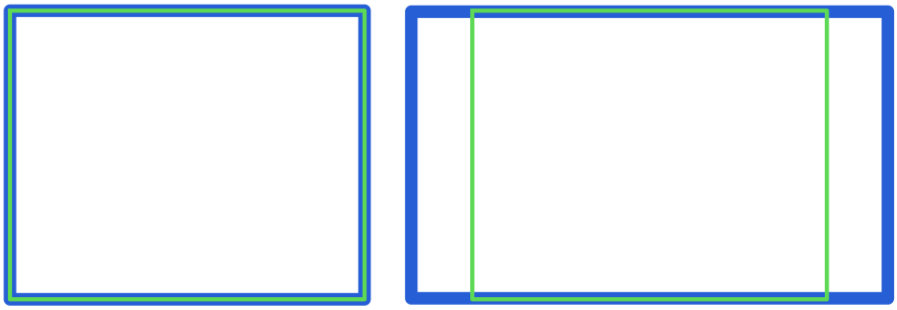


Figure 3: Representation of two layers aligned. Same layer size on the left. Different layer size on the right.

How to align and center both layers (and groups)? It's quite simple.

We can look at the difference between the two layers, divide it in two (represented in red on the image next page) and remove that value from our previous calculation to have our new Pos X value.

You can also have a peek at my handwritten sheet (Appendix *1*).

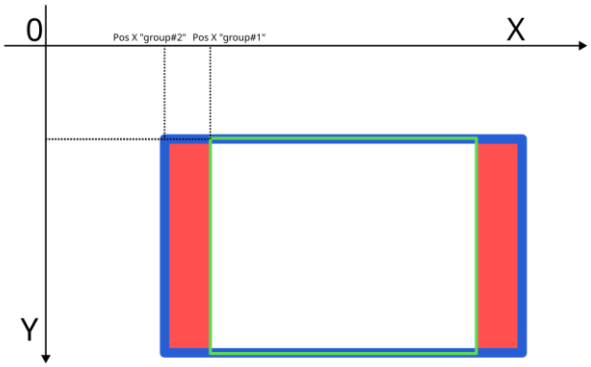


Figure 4: Position of the layers on the map.

The difference can be written with the following formula – with x parallax:

$$Difference = \frac{W_x - W_{100}}{2} * 32$$

$$Difference = 16 * (W_x - W_{100})$$

$$Difference = 16 * (\lceil 0.01 W_{100} x \rceil - W_{100})$$

The difference applied to group#2 is:

$$Difference = 16 * (\lceil 0.01 W_{100} x \rceil - W_{100})$$

$$Difference = 16 * (\lceil 0.01 * 123 * 120 \rceil - 123)$$

$$Difference = 400$$

Let's add it to our previous calculation of $Pos\ X_x$:

$$\begin{aligned} Pos\ X_x &= \lceil 0.01 PosX_{100} x + 0.16 W_{100}(x - 100) - 16 * (W_x - W_{100}) \rceil \\ Pos\ X_x &= \lceil 0.01 PosX_{100} x + 0.16 W_{100} x - 16 W_{100} - 16 W_x - 16 W_{100} \rceil \\ Pos\ X_x &= \lceil 0.01 PosX_{100} x + 16 * 0.01 W_{100} x - 16 W_{100} - 16 W_x - 16 W_{100} \rceil \\ Pos\ X_x &= \lceil 0.01 PosX_{100} x + 16 W_x - 16 W_{100} - 16 W_x - 16 W_{100} \rceil \\ Pos\ X_x &= \lceil 0.01 PosX_{100} x \rceil \end{aligned}$$

We notice that the formula to align two layers of different sizes in groups of different parallaxes, both scaled with a common factor (x, the parallax) simplifies to our very first equation in ***III) a)***.

Again, at parallax 120:

$$\begin{pmatrix} Pos\ X_x \\ Pos\ Y_x \end{pmatrix} = \begin{pmatrix} \lceil 0.01 PosX_{100} x \rceil \\ \lceil 0.01 PosY_{100} x \rceil \end{pmatrix}$$

$$\begin{pmatrix} Pos\ X_{120} \\ Pos\ Y_{120} \end{pmatrix} = \begin{pmatrix} \lceil 0.01 PosX_{100} x \rceil \\ \lceil 0.01 PosY_{100} x \rceil \end{pmatrix} = \begin{pmatrix} \lceil 0.01 * 19616 * 120 \rceil \\ \lceil 0.01 * 19680 * 120 \rceil \end{pmatrix} = \begin{pmatrix} \lceil 23539.2 \rceil \\ \lceil 23616 \rceil \end{pmatrix} = \begin{pmatrix} 23540 \\ 23616 \end{pmatrix}$$

It works! We now know how to set a $\begin{pmatrix} Pos\ X_x \\ Pos\ Y_x \end{pmatrix}$ to align and center two layers of different size in groups of different parallax.

c) *Groups alignment final equation.*

Parameters:

- $PosX_{100}$ = $Pos\ X$ of the original group at parallax 100.
- $PosY_{100}$ = $Pos\ Y$ of the original group at parallax 100.
- x = chosen parallax.
- W_{100} and H_{100} = width and height of the original layer at parallax 100.

To align and center two layers of the same size and of different parallaxes:

$$\begin{pmatrix} Pos\ X_x \\ Pos\ Y_x \end{pmatrix} = \begin{pmatrix} \lceil 0.01 PosX_{100} x + 0.16 W_{100}(x - 100) \rceil \\ \lceil 0.01 PosY_{100} x + 0.16 H_{100}(x - 100) \rceil \end{pmatrix}$$

To align and center two layers of different sizes and of different parallaxes, both scaled with the same factor:

$$\begin{pmatrix} Pos\ X_x \\ Pos\ Y_x \end{pmatrix} = \begin{pmatrix} \lceil 0.01 PosX_{100} x \rceil \\ \lceil 0.01 PosY_{100} x \rceil \end{pmatrix}$$

d) *Sheet.*

You can interact with the sheet below. Edit the settings in red.

Parameters	
$PosX_{100}$	**0**
$PosY_{100}$	**0**
x	**140**
W_{100}	**50**
H_{100}	**50**

Size of the layer

Width	Height
70	70

Offset of the group

Pos X	Pos Y	
320	320	Layer of same size and different parallax
0	0	Layer of different size and different parallax

IV) Application to Troubled.

That equation was crucial for my map as I care about it being polished and perfectly aligned and centered all together. I wanted it to be the most advanced map ever made in matters of design.

I had quite many layers and groups to deal with. I opted for 2 cloud layers per island/group (parallax 120 & 140, so two groups were required for one island), for a bit more than 26 groups (*Appendix 5*).

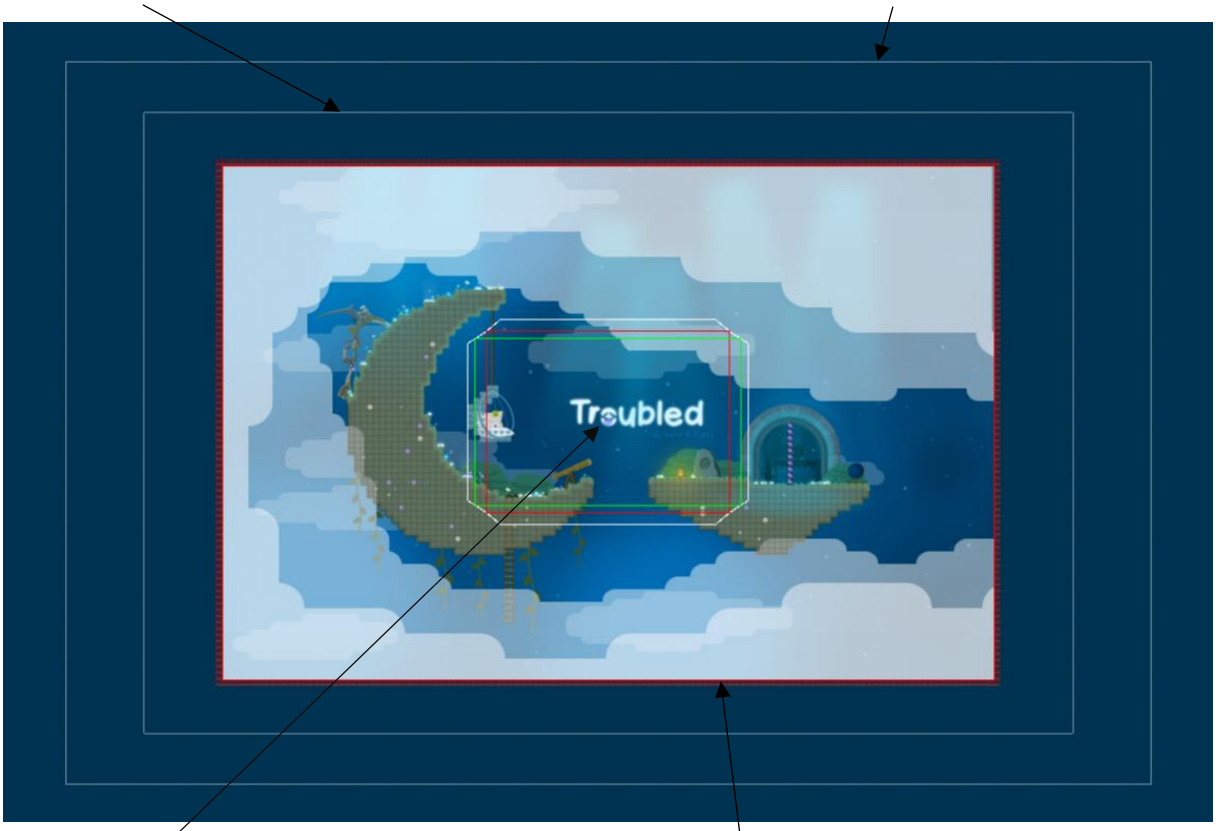
Why so many groups you'd ask? That's mainly for performances matters but I'll explore that subject in another section.

I chose tile layers instead of quad layers to take advantage of the repeating border to cover the whole map with smaller layers, and to avoid having gaps when moving the camera around the map when zooming out. Also, to prevent layers from overlapping (every layer would be displayed across the whole map), I clipped them all to their area to contain them.

Here is the result:

This is "group#2" with a parallax of 120.

This is "group#3" with a parallax of 140.



This is the Proof setting displaying the center of the groups.

The main group is outlined by the red teleport (and red line due to the clipping).

Here is an example of the settings we'll find in one of the cloud groups.

This is "group#2" entitled "#88 Clouds1.1" for "Island1". Under it you can see "group#3" entitled "#89 Clouds1.2" (second cloud layer) for "Island1" as well.

Let's have a look at the settings:

- Pos X = 23540 which we found in ***III) b)***.
- Pos Y = 23616 (see *Appendix 5*).
- Para X and Para Y = 120
- Clipping: Yes, as explained before, to avoid filling the whole map.
- Clip X = 19616, the offset of "Island1".
- Clip Y = 19680, the offset of "Island1".
- Clip W = 3936, the width of "Island1" (123 tiles * 32px).
- Clip H = 2624, the height of "Island1" (82 tiles * 32px).

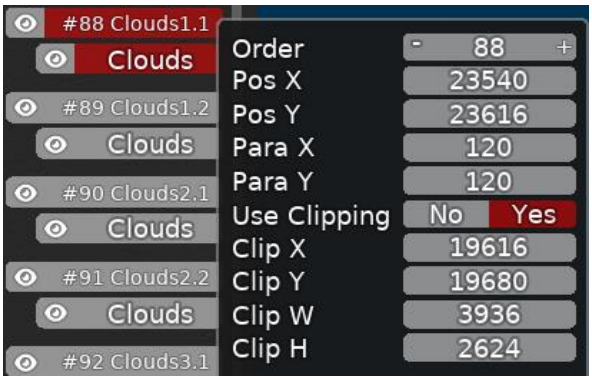


Figure 5: In-game editor screenshot of "Clouds1.1".

And these are the settings of "Island1" for you to establish the connection between the two:

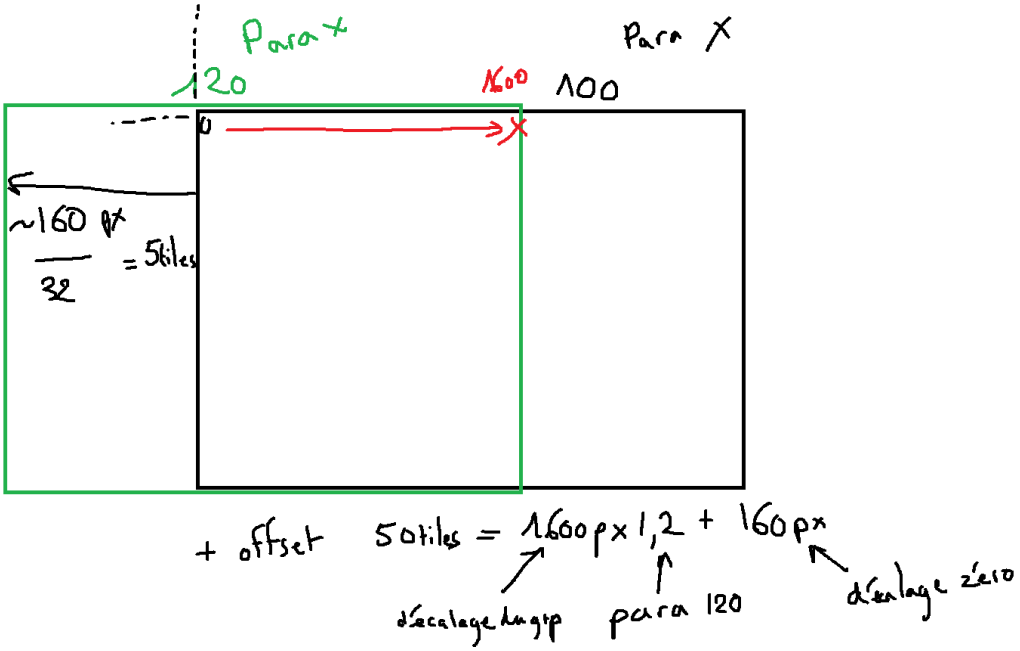
Figure 6: In-game editor screenshot of "Island1".

Appendixes.

Appendix 1: Analyzing the first parameters of the equation to check its behavior when adding a position offset.

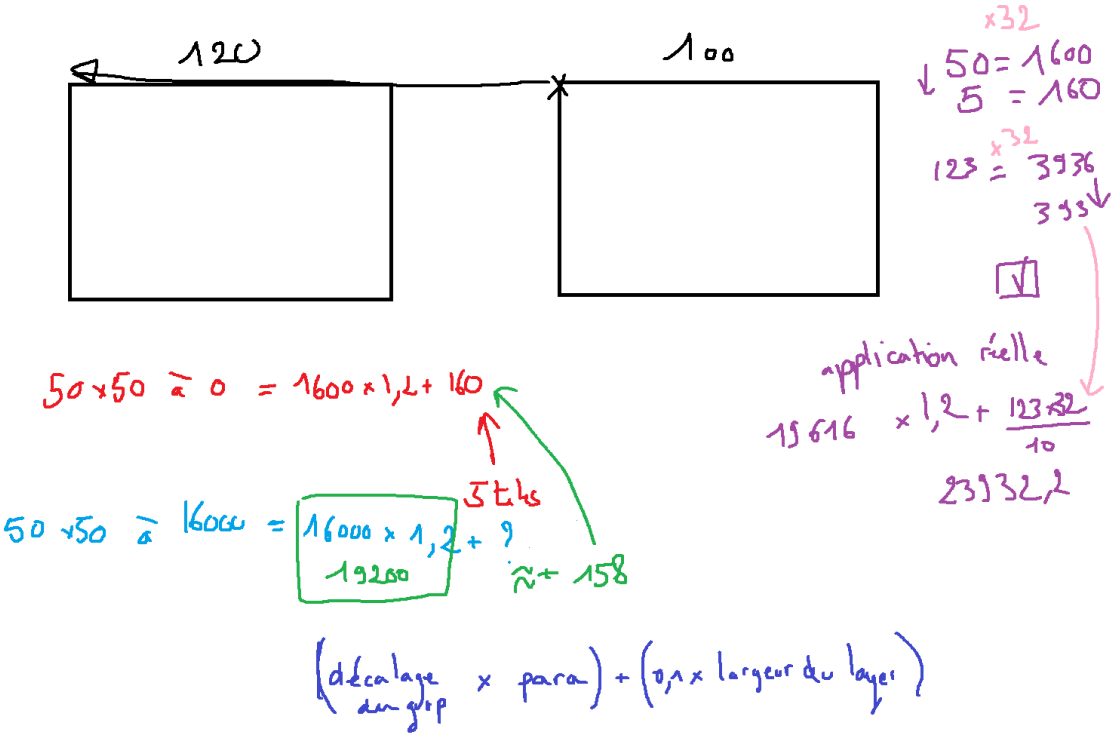
Here, there is an offset of 50 tiles so 1600px to the right. The result at parallax 120 is:

$$Pos\ X_{50\ tiles} = 50 * 32 * \frac{120}{100} + \frac{1}{10} * 50 * 32 = 1600 * 1.2 + 160$$

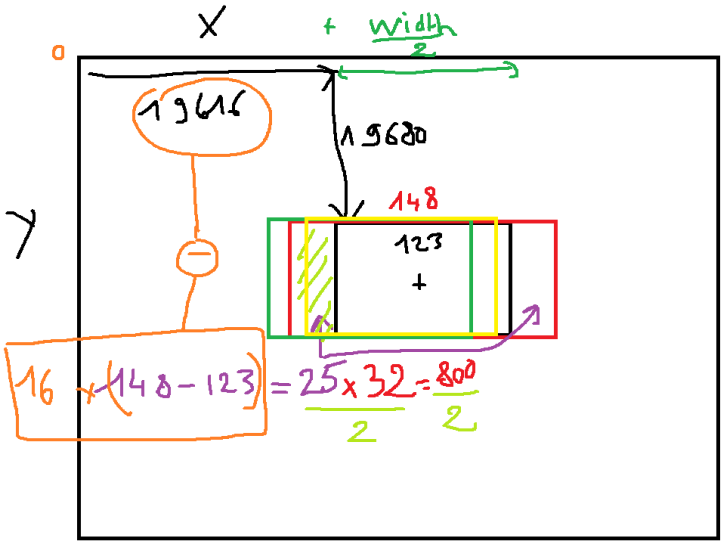


Appendix 2: First overview and application of a possible equation.

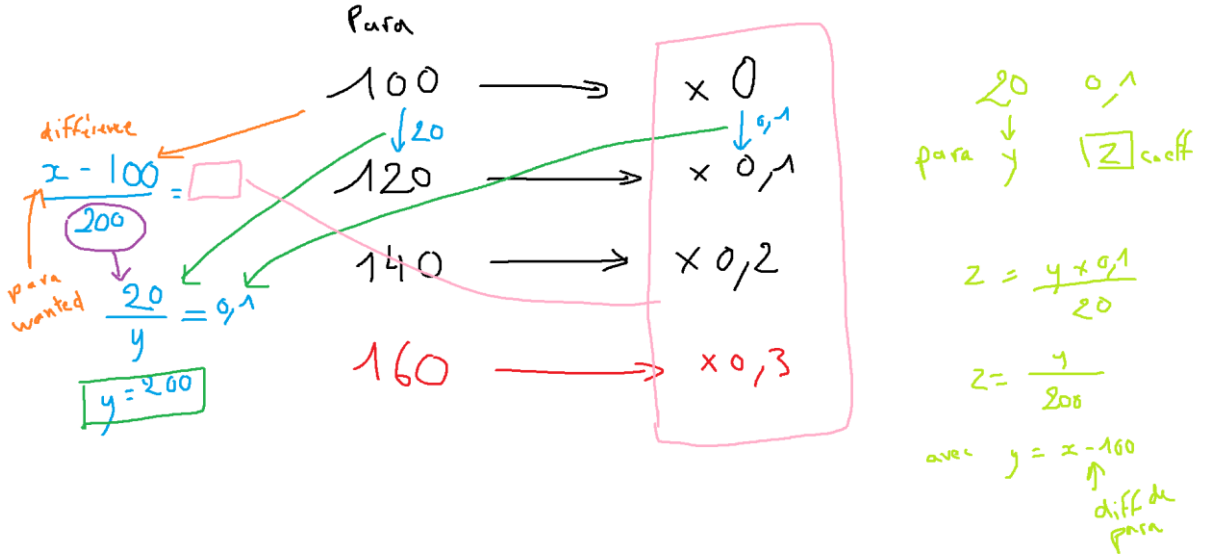
The square on the left was aligned with the square on the right before the change of parallax. We witness its movement to the left of an unknown number of pixels.



Appendix 3: Overview of the position of the layers in a map, calculation of the difference between two layers of different sizes and results applied to the original Pos X offset.



Appendix 4: Calculation of the factor to ascertain the offset induced by the parallax of a group.



Appendix 5: Automated Excel spreadsheet to determine the width and height of each layer and the groups offset positions of each layer for different parallax settings.

Resource for the map Troubled by Nehr and Pipou.

		Width and height for each para setting		
		100	120	140
Island	1	123	148	173
		82	99	115
	2	191	230	268
		113	136	159
	3	205	246	287
		78	94	110
	4	259	311	363
		162	195	227
	5	182	219	255
		144	173	202
	6	215	258	301
		75	90	105
	7	223	268	313
		101	122	142
	8	241	290	338
		165	198	231
	9	186	224	261
		71	86	100
	10	223	268	313
		144	173	202
	11	149	179	209
		109	131	153
	12	151	182	212
		79	95	111
	13	281	338	394
		136	164	191
	14			

		Groups offsets for each para setting		
		100	120	140
Island	1	19616	23540	27463
		19680	23616	27552
	2	14144	16973	19802
		1504	1805	2106
	3	13664	16397	19130
		12000	14400	16800
	4	1824	2189	2554
		7648	9178	10708
	5	4864	5837	6810
		18592	22311	26029
	6	480	576	672
		25408	30490	35572
	7	12480	14976	17472
		26816	32180	37543
	8	7936	9524	11111
		34656	41588	48519
	9	20160	24192	28224
		33760	40512	47264
	10	29856	35828	41799
		32544	39053	45562
	11	26048	31258	36468
		25120	30144	35168
	12	36800	44160	51520
		23584	28301	33018
	13	28992	34791	40589
		15072	18087	21101
	14			