<u>Guide to mipmapping textures for flight simulation</u> By Toby Rayfield 27/06/2015

Updated 02/07/2015

Flipping Section added for BMP to DDS conversion

CONTENTS

- Texture Compression
- II. Texture Formats III. Tools you will need
- IV. Why would I want mipmaps anyway? V. How to check if a texture needs converting
- VI. How to add mipmaps using Imagetool
- VII. Resizing and converting textures using Photoshop VIII. Texture Dimensions and File Size
- IX. Saving a DDS in Photoshop X. Filesizes as an indicator of optimisation
- XI. Which textures can I convert?
- XII. Naming Conventions XIII. Saving a Bitmap as DDS in Imagetool XIV. Batch Commands

There are two types of texture compression that should be used, which will allow you to balance file size with function.

DXT1 textures are for textures with no alpha channel, or a pure black or white alpha channel. DXT5 textures are for textures with greyscale Alpha layers

DXT3 textures should not be used as they show compression artifacts in the final image.

Texture Formats

Textures come in various formats, the two most common found in flight simulator add-ons are BMP and DDS format. Both formats can use DXT1 or DXT5 compression.

More information about these formats is available here

(http://www.prepar3d.com/SDKv2/LearningCenter/modeling/texturing_aircraft_%20models.html).

BMP's were used in older versions of Microsoft Flight Simulator but with the introduction of FSX, Microsoft changed to the more efficient DDS format. BMP files still work in Prepar3d but are not recommended. Quote P3D SDK: The DDS format allows images to be compressed with greater efficiency and flexibility than formats such as BMPs

If you are interested to learn more about how textures work, I highly recommend the SDK link above as a starting point.

Tools you will need

1. ACES Imagetool - included with the FSX/P3D SDK, more information about this essential tool here (http://www.prepar3d.com/SDKv2/LearningCenter/modeling/texturing_aircraft_%20models.html#Normal%20Map) 2. Adobe Photoshop

3. Nvidia Texture Tools for Adobe Photoshop (https://developer.nvidia.com/nvidia-texture-tools-adobe-photoshop)

While there are many other tools out there, these are the ones I will discuss and recommend.

<u>Why would I want mipmaps anyway?</u> In the image below, you can see unmipped and uncompressed gauge textures. Do you see how the lines appear unclear? In motion, it is much worse as the lines appear to vibrate and distract from the flight. This is because there are no mipmaps, so the computer displays the original raw and uncompressed image. As I am not sitting at exactly the correct distance from this texture, it cannot display the texture correctly, hence the unclear image.



In this second image, the gauge textures have been mipmapped. While they appear blurry in this cropped image, in the sim, they are clear and easily readable. If I had to choose between the two, I would choose the mipmapped version. As the texture now has mipmaps, the computer can choose which version is the optimal one for my distance from the texture.



!! Before you start editing textures, always create a backup of the textures that you want to edit !!

- How to check if a texture needs converting
 1. Open Imagetool
 2. Open the folder containing the textures you would like to optimise
 3. Drag the texture onto the open window of Imagetool
 One of the following things will happen:

Image Tool		
File Image View Window Help		
	Failed to load the image: "D:\c182_t.dds" (Failed to load the image: "D:\c182_t.dds" (Failed to load the image: "D:\c182_t.dds" (Failed to load the image: "D:\c182_t.dds" (Fa) OK	tis:
Ready		



If the image won't open in the official texture tool, imagine the problems that this could cause for your simulator. While the textures might display without crashing the sim, who knows what this might cause to happen behind the scenes.

All of my textures open in Imagetool. So I see no reason why anyone should provide textures that don't.

Textures can be saved, compressed and converted in a way that they appear correctly in the sim and do not open in Imagetool but if a texture opens in Imagetool, then it is correctly formatted and adheres to the official SDK format guidelines, which is what we're aiming for.

6. In the second image above, you can see on the right, under the information tab, that the image is 4096x4096 pixels large, has DXT5 compression, it is unknown if the image has an alpha channel and the image contains no mipmaps (1 Mip Level is the texture).

7. If I now open this texture in Photoshop, using the options selected below for opening DDS files, I can see that it does have an alpha channel, so I know that DXT5 is the correct format for this texture.



8. As this image is already in the correct DDS format, I now have two options, I can resize and save this file using Photoshop or I can convert it and add mipmaps using Imagetool. I will explain both methods below. It depends on personal preference, normally it is easier to batch convert multiple files with Imagetool but if you need to resize as well, then you will need to use Photoshop. Note that batch methods can be used in both programs effectively. I find it easier to create batch tools in Photoshop to automatically process large amounts of textures.

!! Before you start editing textures, always create a backup of the textures that you want to edit !!

How to add mipmaps using Imagetool

Open the image in Imagetool
 Select 'Image > Create Mipmaps' from the menu bar



Congratulations, you have now added mipmaps to the texture



Close Imagetool and save the image when prompted.

The ideal size for textures in the FSX/P3D engine is 1024x1024 pixels. As this image is 4096x4096, it has not been fully optimised. As shown in the image below, the mipped version is 5mb larger than the non-mipped version, so we still need to resize this texture to fully optimise it.



Resizing and converting textures using Photoshop 1. Open the original .dds image that you want to optimise in Photoshop, using the options as shown in the image below, when asked.

NVIDIA DDS Read Properties	x
Load Using Default Sizes	
Convert Images to 8 bits	
Convert Images to 16 bits	
Convert Images to 32 bits	
Load MIP maps	
Load Flipped Vertically	
☑ Show this dialog	OK

2. Select 'Image > Image Size' in the Photoshop menu bar.

Image Size				×
	Image Size:	12.0M (was	48.0M)	۵.
	Dimensions:	🔻 2048 px	X 2048 px	
	Fit To:	Custom		•
	— Width:	2048	Pixels	•
	ن لي Height:	2048	Pixels	•
-	Resolution:	72	Pixels/Inch	•
	Resample:	Bicubic (smo	ooth gradients)	•
and and a second				
C	Cance		ОК	

3. Enter your preferred size in the entry field, choose between 1024 or 2048, and select a resample method. I use 'smooth gradients' as 'sharpen' adds halos around lines, as shown in the zoomed in images below.



Texture Dimensions and File Size Textures should be 1024x1024 pixels. As the examples above show an external aircraft texture and I am prepared to spend a bit more VAS having nicer looking textures on my aircraft, I chose 2048x2048 pixels. 4096x4096 is uneccesarily large for these kind of external livery files and it will also take a long time to save the DDS file.

Normally an aircraft will not contain more than 2 main texture sheets, which is why I can justify using 2048x2048 for these two textures. An airport is a different matter as that has many textures, maybe as many as 50 and if half of them are 4096x4096, you shouldn't be surprised when you run out of VAS and the sim crashes.

2048x2048 should always be enough for your favourite textures, use 1024x1024 for everything else, unless the original file is smaller, then leave it as it is.

Saving a DDS in Photoshop Now, all we need to do is save this texture as a DXT5 DDS file.

Choose 'File > Save As' from the Photoshop Menu Bar
 Select the format D3D/DDS (*.DDS); *.DDS), check that Alpha Channels is checked and click**Save**.

Ps Save As			×
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Organize 🔻 Ne	w folder		• •
☆ Favorites ■ Desktop	PiperJ3_t_4096.dd		
File name:	PiperJ3_t_4096.dds		-
Save as type:	D3D/DDS (*.DDS;*.DDS)		▼
	Save Options	Save: As a Copy Notes Alpha Channels Spot Colors Layers	Color: Use Proof Setup: Working CMYK ICC Profile: sRGB IEC61966-2.1 Other: Thumbnail
Aide Folders			Save Cancel

Next, another window will open, from the NVIDIA plug-in. Set up the options as below and click 'Save'. Do not change any of the other options.

VIDIA dds Format (v8.55.0109.1800)	
DXT5 ARGB 8 bpp interpola	ated alpha 🔻 Save Cancel
2D Texture 💌	MIP Map Generation Generate MIP maps
MIP Map Filtering Sharpening	 Use Existing MIP maps All No MIP maps
Image Options Normal Map Settings	
Fading MIP maps Write Config	2D Preview 3D Preview
Read Config	Refresh Preview Preview Options
Save Flipped Vertically	Profiles
	Set Profile Directory Save Profile
	Load Profile
Comments to SDKFeedback@nvidia.com	<no loaded="" profile=""></no>

Congratulations, you now have an optimised texture.

If you were saving a texture without a greyscale Alpha Channel, then you would select DXT1 format from the drop down menu.

In the image below, you can see the results of various resizing and compression on file size and, hopefully, can understand why I chose the 2048x2048 DXT5 DDS option for this external texture.

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🔶 Favorites	Name	Size	Туре		Date
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🧮 Desktop	PiperJ3_t_4096_No Mip.dds	16,385 KB	DDS File		27/06/2015 16:44
	PiperJ3_t_2048.dds	5,462 KB	DDS File		27/06/2015 17:23
	PiperJ3_t_1024.dds	1,366 KB	DDS File		27/06/2015 17:24
	•	111			Þ
PiperJ3 DDS File	_t_2048.dds Date modified: 27/06, Dimensions: 2048 >	/2015 17:23 < 2048			

<u>Filesizes as an indicator of optimisation</u> You can use Windows Explorer to filter a folder of textures by size to quickly see if your newly purchased add on uses mipmapped textures or not. The following file sizes will normally indicate correctly mipmapped files.

43 kb 86 kb 171 kb 342 kb 683 kb 1366 kb 2731 kb 5462 kb

Anything else is either incorrectly optimised or a special texture, which we will come to in a minute.

The following image shows correctly optimised texture file sizes.

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	crew.dds	683 KB	DDS File	
	CVNHULL2.dds	683 KB	DDS File	
	INT.dds	683 KB	DDS File	
	lineasCompleteMap.dds	683 KB	DDS File	
	lineasCompleteMap_night.dds	683 KB	DDS File	
	sh60.dds	683 KB	DDS File	
	t45.dds	683 KB	DDS File	
	685CompleteMap_night.dds	342 KB	DDS File	
	hornetCompleteMap_n.dds	171 KB	DDS File	
	JBD2.dds	171 KB	DDS File	
	lines.dds	171 KB	DDS File	
	Object209CompleteMap.dds	171 KB	DDS File	
	Object209night.dds	171 KB	DDS File	
	Object217CompleteMap.dds	171 KB	DDS File	
	objg104_Default_LODCompleteMap.dds	171 KB	DDS File	
	pway.dds	171 KB	DDS File	
	sh60_n.dds	171 KB	DDS File	-
	Image: 1 to 1 t			•
sh60_ha DDS File	angar.dds Date modified: 01/06/2009 01:59 Dimensions: 512 x 512			

The next image shows incorrectly optimised texture file sizes. You will get the idea quickly enough but basically anything that you see with a filesize of 1025 kb, 4097 kb or 16,385 kb is incorrect and needs optimising.

· faceta	1				X
Q ⇒] « N	VoP3_Spitfire 🕨 texture			✓ ✓ Search text	P
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	vc1.dds	4,097 KB	DDS File	13/01/2011 14:00	
🧮 Desktop	vc1_1.dds	4,097 KB	DDS File	13/01/2011 14:00	
	vc4.dds	4,097 KB	DDS File	29/09/2011 20:25	
	vc4_1.dds	4,097 KB	DDS File	29/09/2011 20:25	
	Env.dds	1,537 KB	DDS File	04/09/2012 20:26	
	pilot_uk.dds	1,025 KB	DDS File	23/12/2010 16:58	E
	spit_c.dds	1,025 KB	DDS File	15/01/2011 08:26	
	stuff.dds	1,025 KB	DDS File	06/01/2011 11:38	
	vc_glass.dds	1,025 KB	DDS File	12/01/2011 16:18	
	vc_gxml.dds	1,025 KB	DDS File	22/09/2011 17:36	
	vc0.dds	1,025 KB	DDS File	30/09/2011 20:56	
	vc2.dds	1,025 KB	DDS File	13/03/2011 15:40	
	vc2_1.dds	1,025 KB	DDS File	30/09/2011 20:56	
	vc3.dds	1,025 KB	DDS File	08/03/2011 14:26	
	vc3_1.dds	1,025 KB	DDS File	22/09/2011 17:36	
	mech.dds	257 KB	DDS File	27/12/2010 22:32	
	stuff2.dds	257 KB	DDS File	01/12/2011 22:34	
	vc_gxml_1.dds	257 KB	DDS File	13/01/2011 14:00	
	vc_reticle.dds	257 KB	DDS File	26/05/2010 08:24	
	map.dds	129 KB	DDS File	30/12/2010 16:38	-
32 iten	ns				

Which textures can I convert? As mentioned previously, certain kinds of textures should not be converted or optimised. Environment maps (reflections), fresnel_ramps, bump maps, specular layers and prop textures should be left alone. While these textures can be optimised, it is beyond the scope of this document, to teach the techniques involved.

If you want to try converting bump maps, which are often delivered in 4096x4096 and therefore VAS consumers, you need to convert the file to 32 bit, if not already, then resave as DXT5 DDS. To avoid any artifacts or loss of quality, you would normally create a new bump map from the optimised texture that you have created instead. Read more about bump maps in the P3D SDK Documentation in the link at the very top of this document.

<u>Naming Conventions</u> The SDK recommends the following naming convention for textures: ModelName_TextureNumber_Suffix.Extension

The Suffix _T is normally used to indicate an external texture. Most developers use a version of the following suffixes but many don't. It is up to you to check each texture before you convert it.

The suffixes for each type of texture are as follows: Diffuse Map: '_T' Specular Map: '_T_Specular' Bump Map: '_T_Bump' Emmisive Map: '_T_LM'

A diffuse map is a regular texture, for example, the outside livery of an aircraft. A Specular map is used to define how and where a model reflects light, e.g. the shininess of metal. A Bump Map defines the 3d elements of a texture, for example, rivets and panel lines. An Emmisive Map displays flat textured lighting effects, as seen on the tail of an aircraft at night.

Below is an image showing these types of files and how they might be named.



Saving a Bitmap as DDS in Imagetool Bitmaps in DXT1, DXT3 or DXT5 format have already been compressed. If you convert them to DDS format, you will compress them more and create visual artifacts, which can be seen as pixelated blocks in the textures. In this case, you only need to select the 'Create MipMaps' option and save the file.

If the Bitmaps are uncompressed and in 32 bit format, then you can convert them without worrying about losing quality.

You will see a wide variety of incorrectly formatted textures. In the screenshot below, you can see a 32 bit BMP with 3 mip layers and an alpha layer open in Imagetool.



If I select 'View > Alpha Channel' from the menu, I see this. An alpha channel with black, white and shades of grey. The correct format for this texture is DDS and it should be compressed using the DXT5 method.



BMP textures need to be manually flipped by the CPU before they can be displayed in the simulator. DDS textures are already flipped, which reduces the work that your CPU needs to do before it can display the texture.

If we save a BMP in DDS format, the image will be flipped and will appear upside down in the simulator, as the developer mapped the texture to the model the other way round. To compensate for this, we need to flip the texture, before optimising it, so that it will display correctly.

!! Before you start editing textures, always create a backup of the textures that you want to edit !!

As Imagetool does not have a menu option for flipping textures, we will use the freeware DXTBMP tool from Martin Wright.

Flipping Images in DXTBMP

Open DXTBMP and drag the BMP that you want to convert to DDS onto the open DXTBMP window, as in the image below.

🕵 DXTBmp	windsock.bm	p - BMP : 1	024x1024 - 3	2 bit		_ 🗆 X
File Pref	s Image	Alpha	Preview	Help		
				No. A Marine Marine	II	Alpha Channel
			" → Q Aatin Winht		Ŧ	User Account Control This program may require elevated priviledges when saving files to protected locations. You may be presented with the UAC prompt when saving files

From the menu bar, select Image > Flip Image and Alpha, as in the image below.



From the menu bar, select File > Save and, in the window that pops up, check that Save as Type is 'Extended 32 bit 888-8' as in the screenshot below, add the appendix '_flipped' to the filename and click Save.

📩 DX	(TBmp - wir	ndsock.bmp - BN	ИР:1024x1024-	32 bit				
File	Prefs	Image Alp	oha Preview	Help				
								Alpha Channel
		🛣 Save Exter	nded Bitmap					e
		Save in:	Desktop	Size	Item type	Date mi ▲	E	MipMaps
		Comput Comput Comput Comput Comput	s roup ter k					Include when saving Use 16 bit Dither Box Scaling Filter Name
		•				P.		Processing
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wgfx.	DXTBmp C	🔛 造 🕽 Copyright (c)2000-2	C ↔ 2004 Martin Wright	<u>۳</u>				

Close DXTBmp, we have now finished using this tool.

You should now have two files, the original and the flipped version, as below.



Open Imagetool and drag the_flipped.bmp file onto the open window, as shown below.



In Imagetool, select 'Image > Format > DXT 5' and then 'Image > Create MipMaps'.



```
Which gives the following result..
```



Now **Save** this new texture with the extension **.dds** and close Imagetool. This texture is now optimised.

Do not forget to remove the_flipped suffix before copying this file back to the specific texture folder.

The simulator looks first for DDS files, then for BMP files, so there shouldn't be any problems with conflicting files but as we want to do this correctly, you should remove the original BMP file from the specific texture folder as well.

If I compare these files in Windows Explorer, I see this..

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Optimised		▼ + 2	Search Opt 👂
File Edit View Tools Help			
Organize 🔻 🏼 🎴 Open 👻	Share with 🔻 New folder	: = :=	0
🔆 Favorites	Name	Size	Туре
	windsock.bmp	5,377 KB	BMP File
🧮 Desktop	🗟 windsock_flipped.bmp	4,097 KB	BMP File
	windsock_flipped.dds	1,366 KB	DDS File
windsock_flipped.dds DDS File	 ✓ III Date modified: 02/07/2015 10:47 Dimensions: 1024 x 1024 		Þ
1 item selected			

This texture was for a windsock. A relatively small part of an airport but one of 300 textures provided in a 'general texture' folder for an airport. If we work out how much VAS these textures would consume if loaded into memory...

The optimised compressed textures require 300 x 1.3mb = 409 Megabytes of VAS to display

I know which ones I want to use.

Batch Commands You can automate the conversion process by using so-called batch files in either Photoshop or Imagetool. This next section will explain how to create and use batch files.

- Imagetool 1. Create a new folder on your desktop called MIP IN

- Create a new rolder on your desktop called MIP IN
 Create a copy of Imagetool.exe in this folder
 Open Notepad++ and paste the following text into a new documet: ImageTool -nobeep -brief -DXT5 -mip -e BMP *.bmp
 Save this file in your new MIP IN folder and call it 'mip BMP as DXT5.bat'
 Copy the BMP texture that you want to convert to DXT5 to theMIP IN folder and double click on the .bat file.
 The window below will briefly pop up, indicating that the process was successful
 Congratulations, you have optimised a texture with a batch file
 Che the file area for a first the the file have been will be a file and the file base for the file base for

- 8. Check the file size for confirmation that the file has been optimised.

Batch Process			
C:\Windows\system32\cmd.exe	_		x
D:\Z Backup P3D\Mip Mapping\MIP IN>ImageTool -nobeep -brief -DXT5 -mi	р –е	BMP	*

9. In the future, all you need to do is copy all of the BMP textures, with Alpha channels, that you want to convert to DXT5 format to the MIP IN folder and double click the .bat file.

Below is another example that can be used to create mipped DXT1 BMP files.

I. mip BMP as DXT1 No Alpha.bat ImageTool -nobeep -brief -DXT1 -mip -e BMP *.bmp

I do not recommend trying to use Imagetool to convert .dds or .psd files as the files are not viewable in Imagetool afterwards. Imagetool can generate DDS files from 8 bit .psd files but why would you do this if you have Photoshop.

Photoshop

- Photoshop
 1. Open Photoshop and in the 'Actions' tab, click on the drop down menu and select 'New Set...'
 2. Name this Set 'Texture Conversion'
 3. With this Set highlighted, click on the drop down menu and select 'New Action'
 4. Name this Action 'Resave DDS as DXT5 mipped'
 5. Press the record button on the bottom of the Actions tab
 6. In the menu bar, select 'File > Open' and select the .dds file that you want to convert in Photoshop using the options shown below.

N١	/IDIA DDS Read Properties	×
	I nad Using Default Sizes	
	Convert Images to 8 bits	
	Convert Images to 16 bits	
	Convert Images to 32 bits	
	Load MIP maps	
	🔽 Load Flipped Vertically	
	✓ Show this dialog	ОК

- In the menu bar, select 'File > Save As' and choose D3D/DDS format, as shown previously in the section Saving a DDS in Photoshop.
 Close the image and press the Stop button on the bottom of the Actions tab
 To test this batch file, or Action, create a new folder on your desktop called 'MIP IN PSD' and copy a couple of unoptimised DDS files to this folder.
 Create a new folder called 'MIP OUT PSD' on your desktop.
 In Photoshop, in the menu bar, select 'File > Automate > Batch' and set up the folders and options as below. Click the Choose button and set your 'MIP IN PSD' folder in the top part and select you 'MIP OUT PSD' folder in the bottom part.

Batch	x
Play	
Set: Default Actions	
Action: Minashta (aslastica)	Cancel
Action. Vignette (selection)	
Source: Folder	
Chases DV/Z Packup D2D/Min Mapping/MID IN/	
Choose D.12 Backup PSD (mip Mapping (mip 11)	
V Overnde Action Open Commands	
Suppress file Open Open Open of Statogs	
Destination: Folder	
Choose D:\Z Backup P3D\Mip Mapping\MIP OUT\	
Querride Action "Save As" Commands	
File Naming	
Example: MyFile.gif	
Document Name + extension + +	
• + • • • +	
• + •	
Starting Serial #: 1	
Compatibility: Vindows Mac OS Unix	
Frans: Stop for Errors	
Save As	

12. When you click OK, the batch will run and automatically Open and Convert any files that it finds in your 'MIP IN PSD' folder. We created a 'MIP IN PSD' folder to avoid any conflicts with BMP files in your MIP IN folder.

Using these very powerful tools, you should find it easy to create your own Actions to carry out the following automated processes for you. Just apply a logical step by step process and learn from your mistakes and experiments.



The biggest tip I can give you is to backup your texture folders before you start any kind of optimisation. Good Luck and happy mipping..

Toby

This document is dedicated to all of you..