Crazy Taxi (PC) - Texture Modding Guide, Limits & Engine Constraints

Welcome to **LyrasTextureMod** for *Crazy Taxi* (PC Steam / 2002 Direct3D 9 Port). This technical guide details how to modify textures, the engine's architectural limits, and where the mod automatically assists you behind the scenes.

---

1. How to Modify Textures (The Golden Rules)

A. Strict Power-of-Two (POT) Rule (2^n)

Graphics cards and Direct3D 9 texture sampling pipelines require texture dimensions to be **Powers of Two**:

$$\mathbf{16, 32, 64, 128, 256, 512, 1024, 2048}$$

> [!CAUTION] **Why $128 \to 1280$ broke performance:** 1280 is **Non-Power-of-Two (NPOT)** ($1024 < 1280 < 2048$). Arbitrary scalings like $10\times$ violate GPU hardware expectations. Always upscale by binary factors:
>
> - $2\times$ **Upscale:** $128 \to 256$
> - $4\times$ **Upscale:** $128 \to 512$
> - $8\times$ **Upscale:** $128 \to \mathbf{1024}$ *(Recommended HD standard)*
> - $16\times$ **Upscale:** $128 \to \mathbf{2048}$ *(Maximum safe limit)*

B. Aspect Ratio Preservation ($1{:}1$, $2{:}1$, $4{:}1$)

Maintain the original aspect ratio of the texture:

- **Square Textures ($1{:}1$):** $128 \times 128 \to 512 \times 512$ or 1024×1024.
- **Rectangular Textures ($2{:}1$):** $256 \times 128 \to 1024 \times 512$ or 2048×1024.
- **Wide Banner Textures ($4{:}1$ / $8{:}1$):** $512 \times 64 \to 2048 \times 256$.

C. 3D World / Vehicle Models vs. 2D UI Sprites

- **3D Vehicle Bodies, Pedestrians & Buildings (`3D_OBJECT__`, `3D_STAGE__`):** Fully support upscaling up to 2048×2048. The engine maps these via normalized UV coordinates ($0.0\text{f} - 1.0\text{f}$).

- **2D HUD, Menus & Subtitles (`2D_SPRITE__`, `2D_UI__`):** Up to $2\times$ or $4\times$ upscaling is supported. However, legacy Sega 2D vertex slicing uses fixed screen-space pixel coordinates. Test your custom HUD textures in-game to verify bounding box alignment.

D. File Naming Convention (CRITICAL)

Never rename extracted texture files. The mod uses a deterministic hash and offset lookup scheme:

```
None
{Category}__{ArchiveName}__{ChunkIndex:04d}__GBIX_{Hex}__FMT_{Format}_{Width}x{Height}__HASH_{CRC32}.png
```

You may save files as `.png`, `.jpg`, or `.jpeg`. The mod dynamically resolves both names and will automatically select the file with the most recent timestamp.

---

2. Hard Engine Limits & VRAM Budget

Constraint	Limit	Technical Consequence of Exceeding
Max Texture Dimension	2048×2048	Direct3D 9 texture allocation fails on resolutions ≥ 4096, triggering a fallback to native low-res textures.
Max VRAM per Texture	**16 MB** (2048×2048 32-bit ARGB)	Single textures above 16 MB cause GPU memory bus stalls.
Process Memory Budget	**$\sim 1.8\text{ GB}$** (32-bit `CrazyTaxi.exe`)	Upscaling every single game texture to 2048×2048 will exhaust the 32-bit virtual address space (`Out Of Memory` crash). Recommended: 1024×1024 for primary cars and roads, 512×512 for secondary props.

Constraint	Limit	Technical Consequence of Exceeding
DirectX Sampler Filter	**8x Anisotropic Filtering**	Handled automatically by the mod for all high-res replacements.

---

3. Where and How LyrasTextureMod Automatically Protects You

You do not need specialized retro development tools. **LyrasTextureMod** provides built-in automated safeguards:

1. Automatic HD Dimension Snapper & Aspect Ratio Guardian

- If you accidentally save an image with non-power-of-two dimensions (e.g., 1280×1280), the mod's **HD Dimension Snapper** automatically snaps and resamples it down to the nearest valid power-of-two (1024×1024) using high-quality bicubic filtering before passing it to Direct3D.
- If you save a texture with a distorted aspect ratio, the **HD Aspect Alignment Guardian** automatically resamples it to match the 3D model's UV layout, preventing stretched car decals.

2. Smart Format & Alpha Restoration Engine (MS Paint & JPG Friendly)

- Many modern painting programs or `.jpg` formats strip transparency and save 24-bit RGB, which traditionally caused transparent trees, glass, and fences to render as black boxes.
- **LyrasTextureMod automatically detects opaque user files:** It loads the pristine vanilla texture from `originals/`, resamples its original alpha channel, and applies it to your modded artwork.
- **Magenta Color-Keying:** Pure magenta (`#FF00FF` / `RGB 255, 0, 255`) is automatically turned into 100% transparent pixels.

3. Guaranteed Mipmap Pyramid & Cache Thrashing Prevention

- The mod automatically generates complete hardware mip chains (`D3DUSAGE_AUTOGENMIPMAP` + `GenerateMipSubLevels()`).
- If your GPU driver does not support hardware autogen, the mod automatically calculates a high-speed CPU 2x2 box-filter downsampling pyramid down to 1×1.

Distant objects sample from tiny mip levels, guaranteeing **rock-solid 60 FPS without stutter or texture shimmering**.

4. Smart Binary Cache System (`cache/`)

- Modified `.png` and `.jpg` files are compiled into optimized `.cache` binaries on startup (accompanied by a sleek GDI progress window). Subsequent game launches load these in microseconds without any frame drops.

5. Live In-Game Toggling & Hotkeys

- **Shift + F1** (or **F11** / **Insert**): Opens the in-game ModMenu to toggle mods and view memory statistics.
- **F9**: Instantly flushes the cache and reloads modified textures without restarting the game.
- **F10**: Live toggle between custom textures and 100% native vanilla textures for instant comparison.