SIGGRAPH2007

Creating Spherical Worlds

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Maxis, Electronic Arts

Background

- Spore based on “powers of 10”
  - Cell life (2D world)
  - Planet: creatures, tribes, civilisations
  - Solar System
  - Interstellar
  - Galaxy

- Want seamless transitions
  - ⇒ planets need to be **spherical**

Planet Constraints

- Need to have lots (millions? billions?)
  - many more than we can manually author
- Need to be playable
- Must look good
- Need to be fast to generate
  - We can't store all these planets
  - Would like to transmit them at some point
- Need to support terraforming
  - Player modification of planet to support life

Areas of Interest

- Parameterization
  - How do we store planet representation over surface? How do we store game data?
- Generating Heightfields
  - What are the operations? How can we make it fast?
- Texturing
  - Must be heightfield driven
- Authoring
  - Variety, art control

Parameterization

- Possible approaches:
  - Longitude/latitude (pole cap)
  - Gnomic
  - Freeform 3D: Sparse Voxel
  - Charts
    - Regular: cubemap, diamond, duodecahedron ...
    - On-the-fly (Voronoi-style)
    - Orthographic projection
    - Perspective projection

Parameterization Goals

- Minimize distortion and discontinuities
- Efficient (heightfield) storage
- Fast mapping from *(x,y,z)* to *(u,v)* and back

- Wrapping between charts
- Rectangular area splatting
- Efficient normal map generation

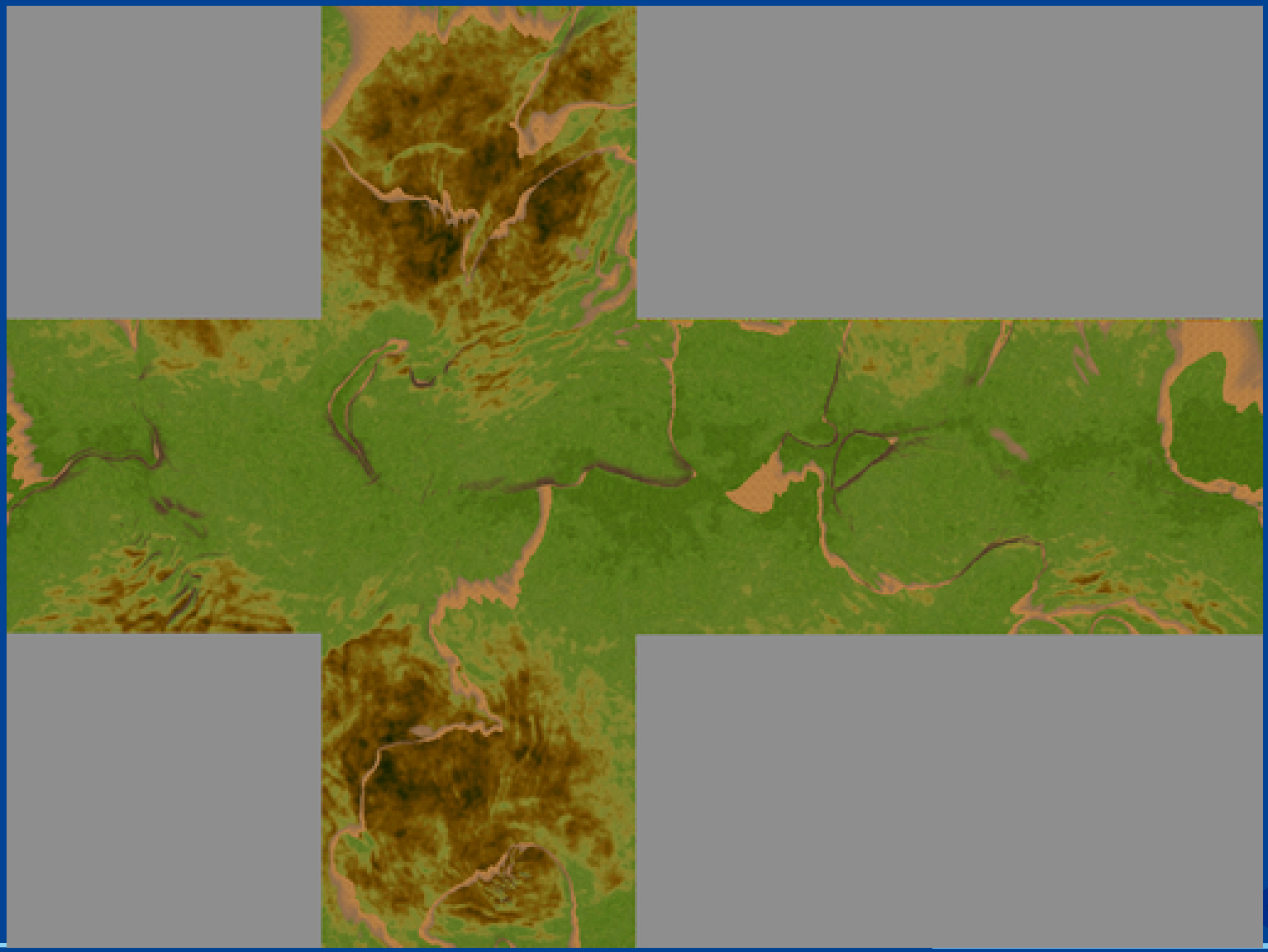
Parameterization: Cube Maps

- Chose cube maps as the best compromise

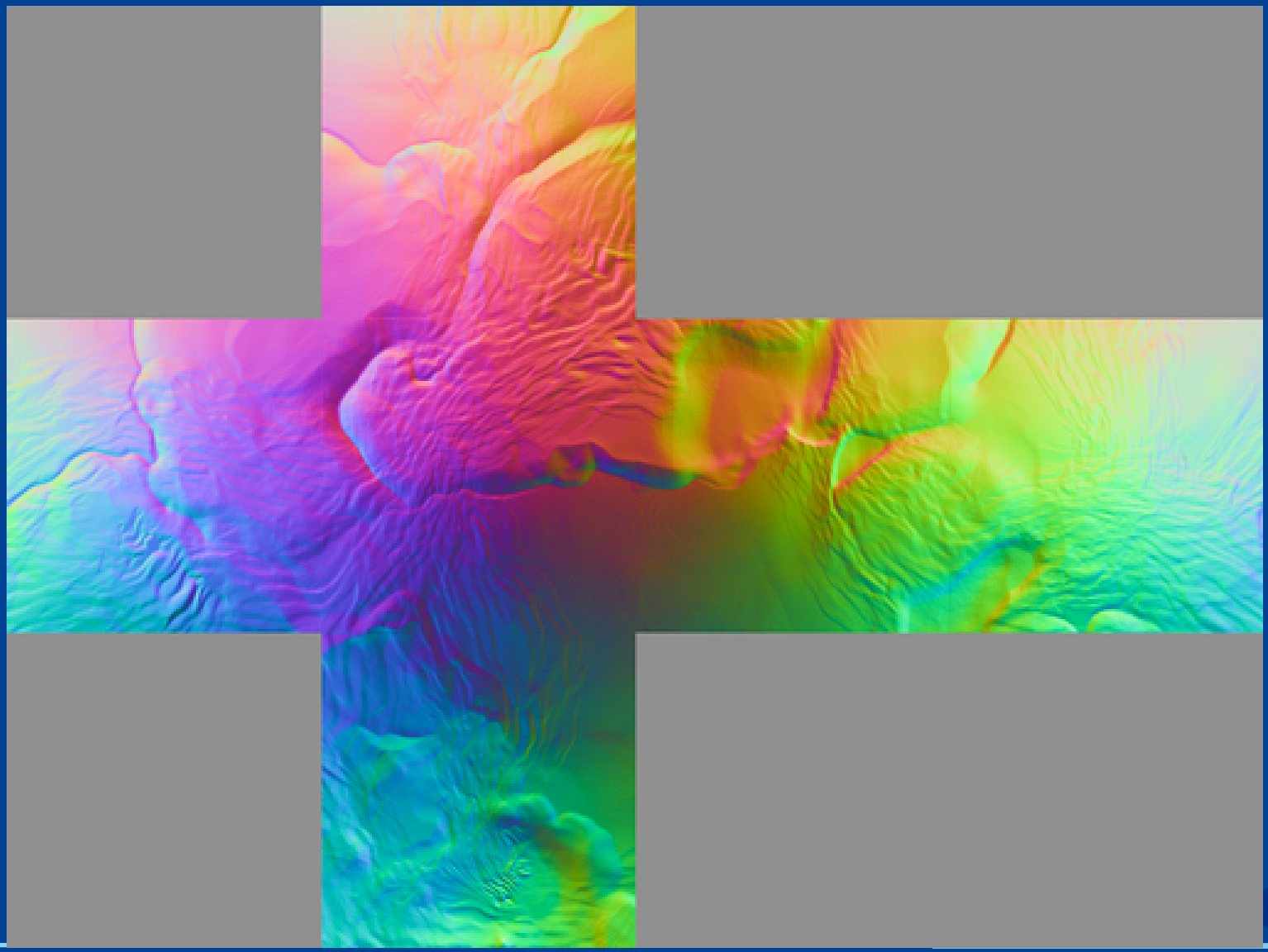
Parameterization: Cube Maps

- Chose cube maps as the best compromise
- Faces are grids
  - Familiar from previous games
- Distortion at corners
  - But not too bad, much better than pole distortion
- Face wrapping is tractable
  - Pick right face mappings -> simple permutation rules
- Projective projection
  - Lines map to great circles on sphere: very useful!

Colour Map



Normal Map



Normal Map

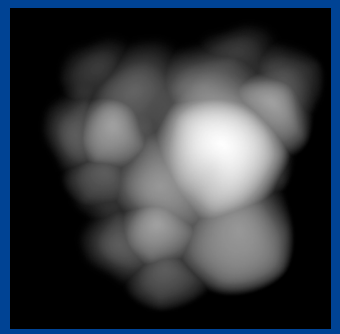
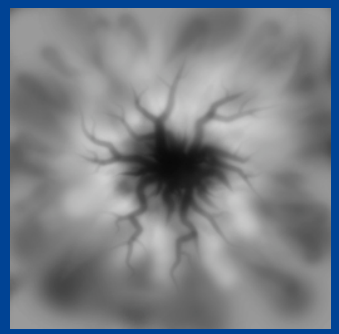
- Derived from height map
  - Large source of CPU time early on
- Standard DDF to find ‘flat’ normal map
  - Can then use Jacobian to warp to spherical form

$$J(s,t,h) = \begin{pmatrix} h/w(1-s^2/w^2) & -sth/w^3 & -sh/w^3 \\ -sth/w^3 & h/w(1-t^2/w^2) & -th/w^3 \\ s/w & t/w & 1/w \end{pmatrix}$$

$$w = \sqrt{(s^2+t^2+1)}$$

Generating Height Fields

- Brush system that operates on the sphere
- Brushes are 2D textured rects

- Several different brush operations
  - Conditionally raise or lower terrain
- Applied on GPU, after clipping brush footprint to faces

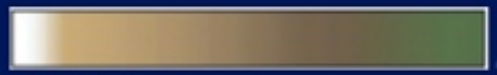
Controlling Terrain Brushes

- Use our effects system, Swarm, to run brushes over the surface

- Controlled by:
  - Particle systems (spawning other particle systems)
  - Randomized parameter ranges, random walks
  - Terrain forces
  - Force/control operates in the tangent plane

Texturing

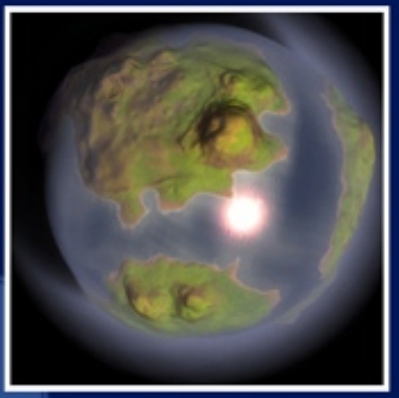
- Derive Control Map from height field
  - Filter: water level, gradient, curvature
  - Combine according to tech artist formula
- Blends source textures to form base colour
  - Blends detail maps on the fly
- Planets have type, atmosphere, temperature
  - Control colour ramps, and atmosphere/fogging



Color Ramp

Height Field

Color ramp tinted map

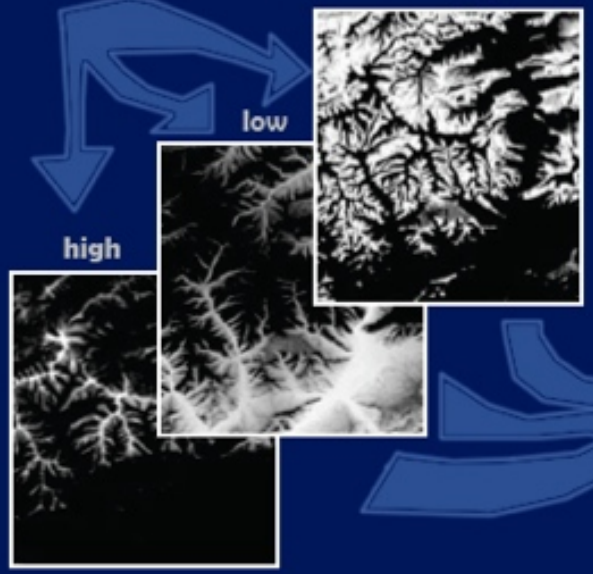


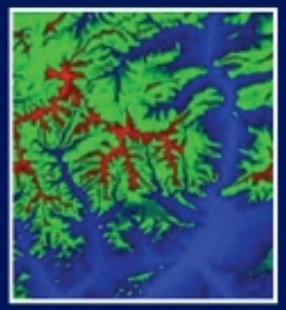
Base Texture is blended with Detail Textures (colorized and controlled by ranges)

mid

low

high

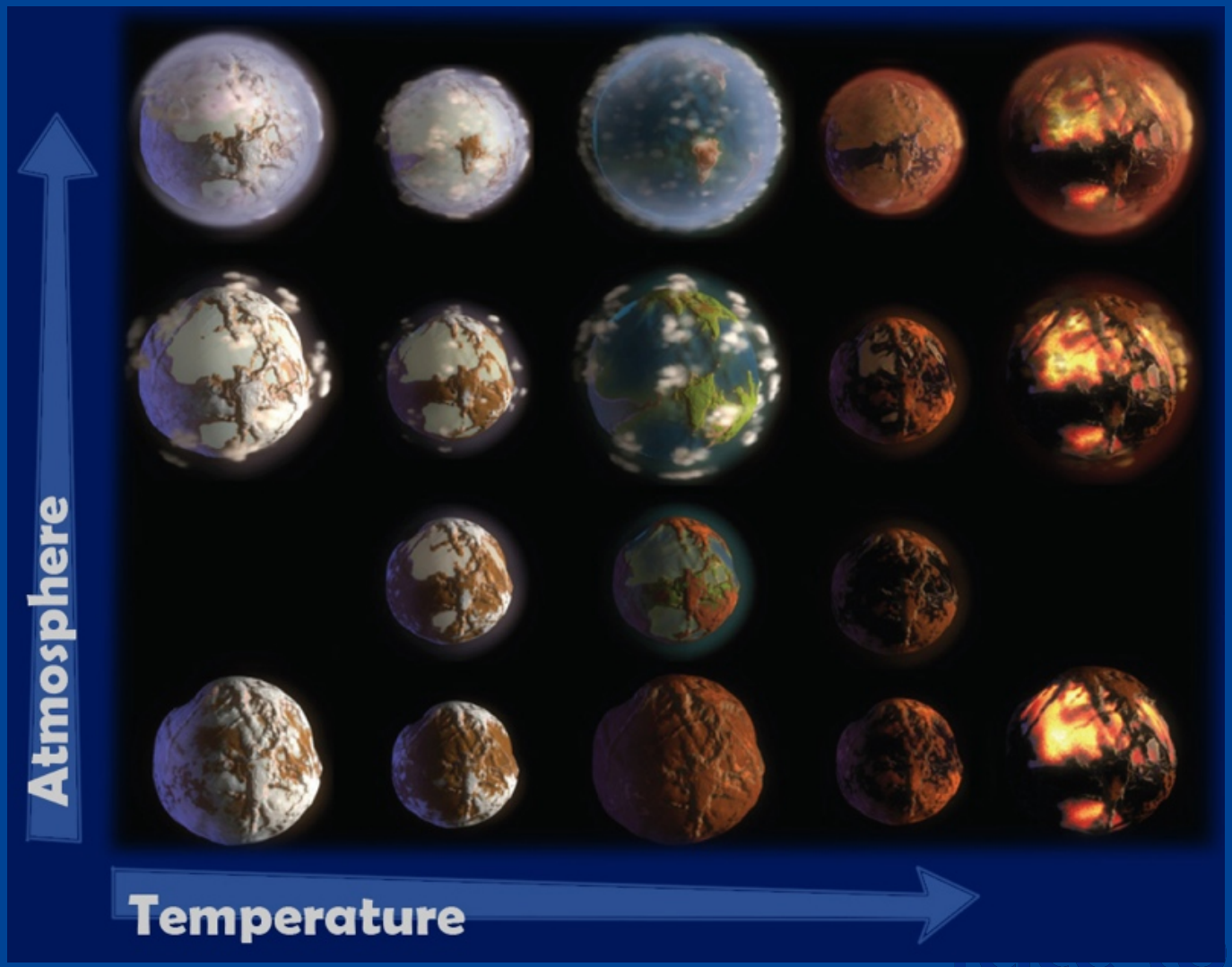




pack into RGB

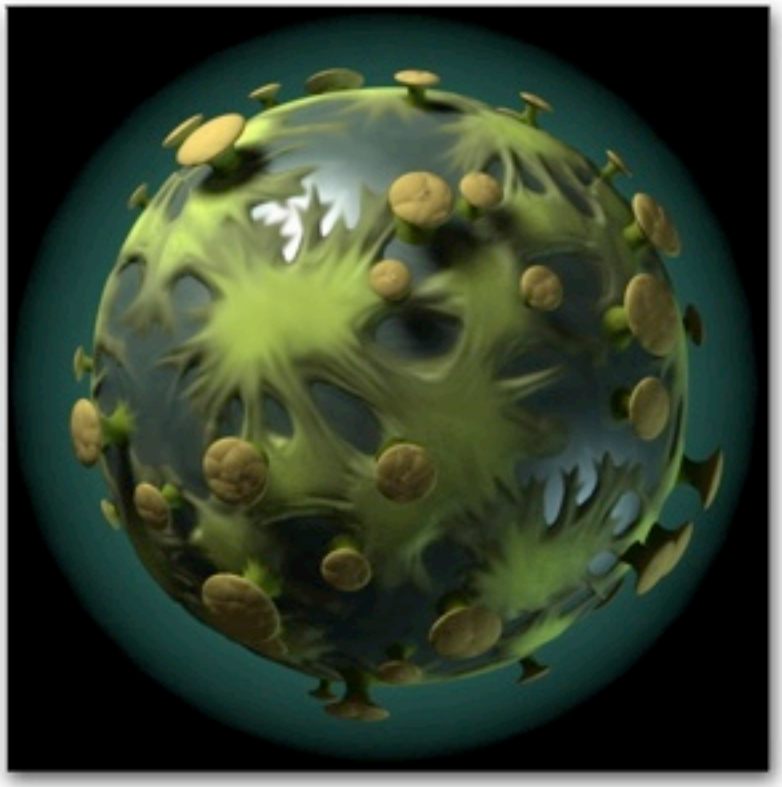
RGB Detail Map

Terraforming



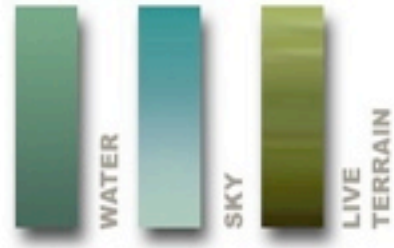
Authoring

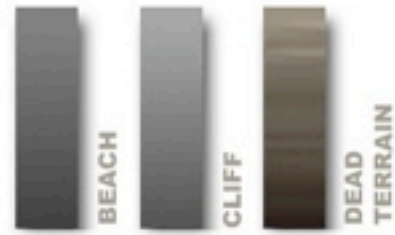
- Concept Sketches



PLAYABLE: Yes
TAXONOMY CATAGORY: Storybook

Based on the floor of an ancient forest, this planet has landforms that appear to be ginat roots covered in moss and various fungii-looking rocks.



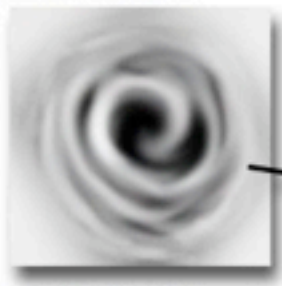


PARTICLE EFFECTS

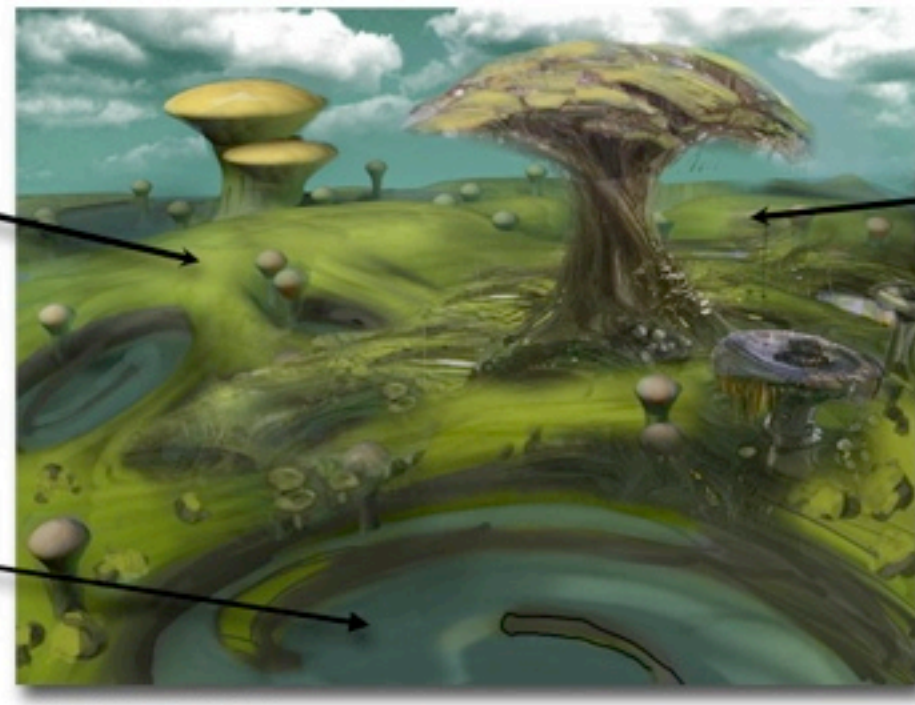
CLOUD PATTERNS

LOOPBOX PARTICLES

LAND SCRIPT



POND SCRIPT



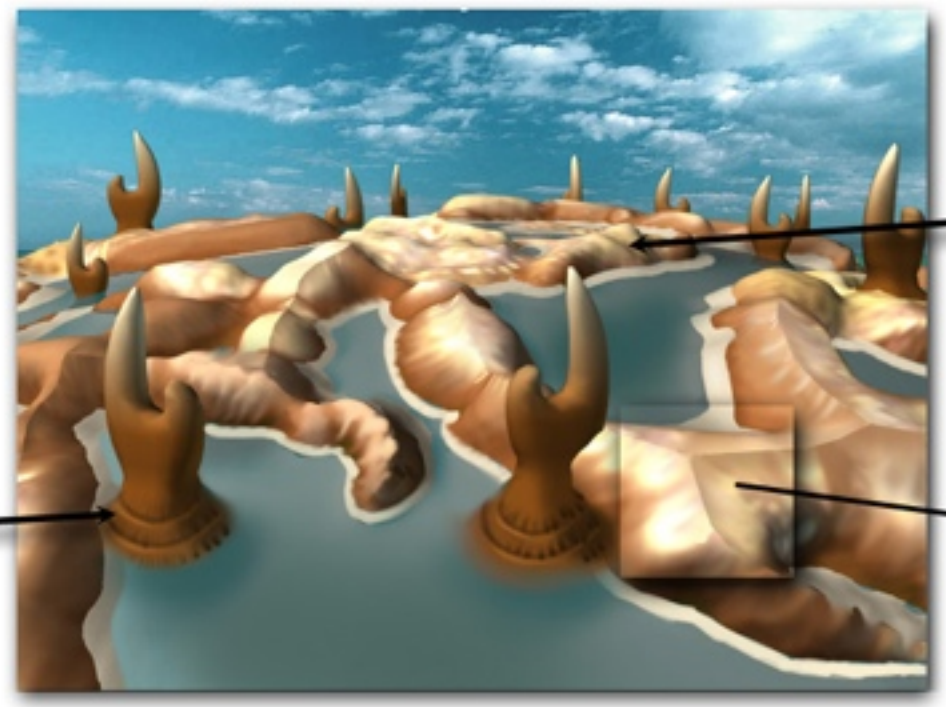
CIVILIZATION VIEW

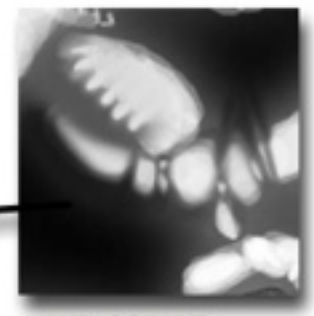
SCRIPT TO GO UNDER MASSIVE OBJECT

PLAYABLE: Yes
TAXONOMY CATAGORY: Storybook

Inspired by crab shells, this planets is made mostly of small strips of land that randomly connect to each other and to a main section where there is more room for cities.

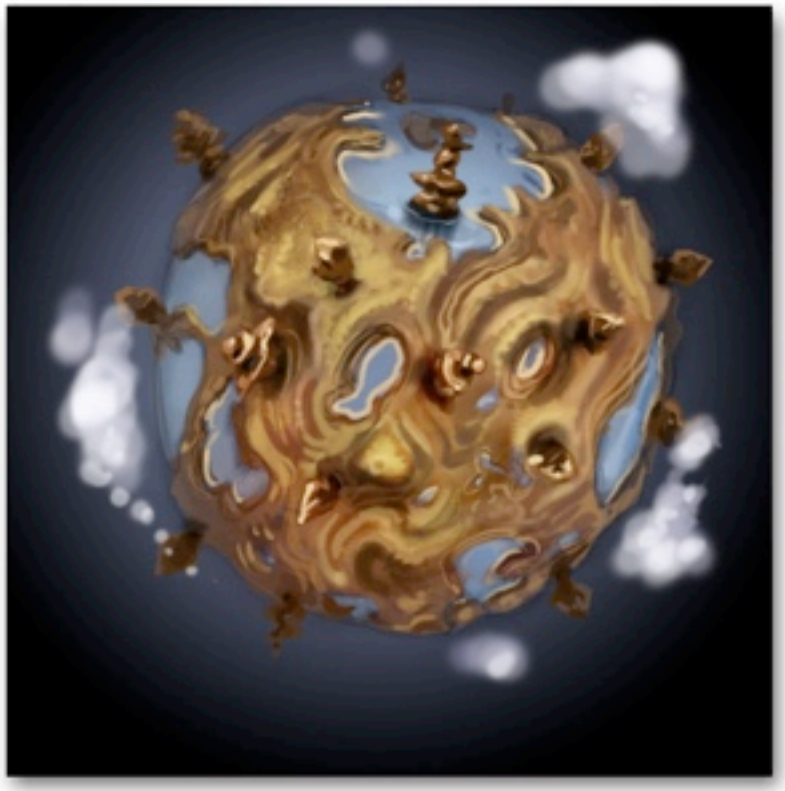
WATER
SKY
LIVE TERRAIN
BEACH
CLIFF
DEAD TERRAIN





LAND SCRIPT

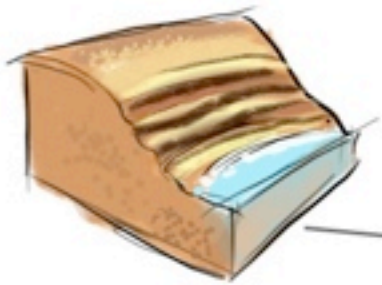
SCRIPT & DECAL GOES UNDER CLAW



PLAYABLE: Yes
TAXONOMY CATAGORY: Storybook

WATER
SKY
LIVE TERRAIN
BEACH
CLIFF
DEAD TERRAIN

moss scattered randomly near base of big rocks

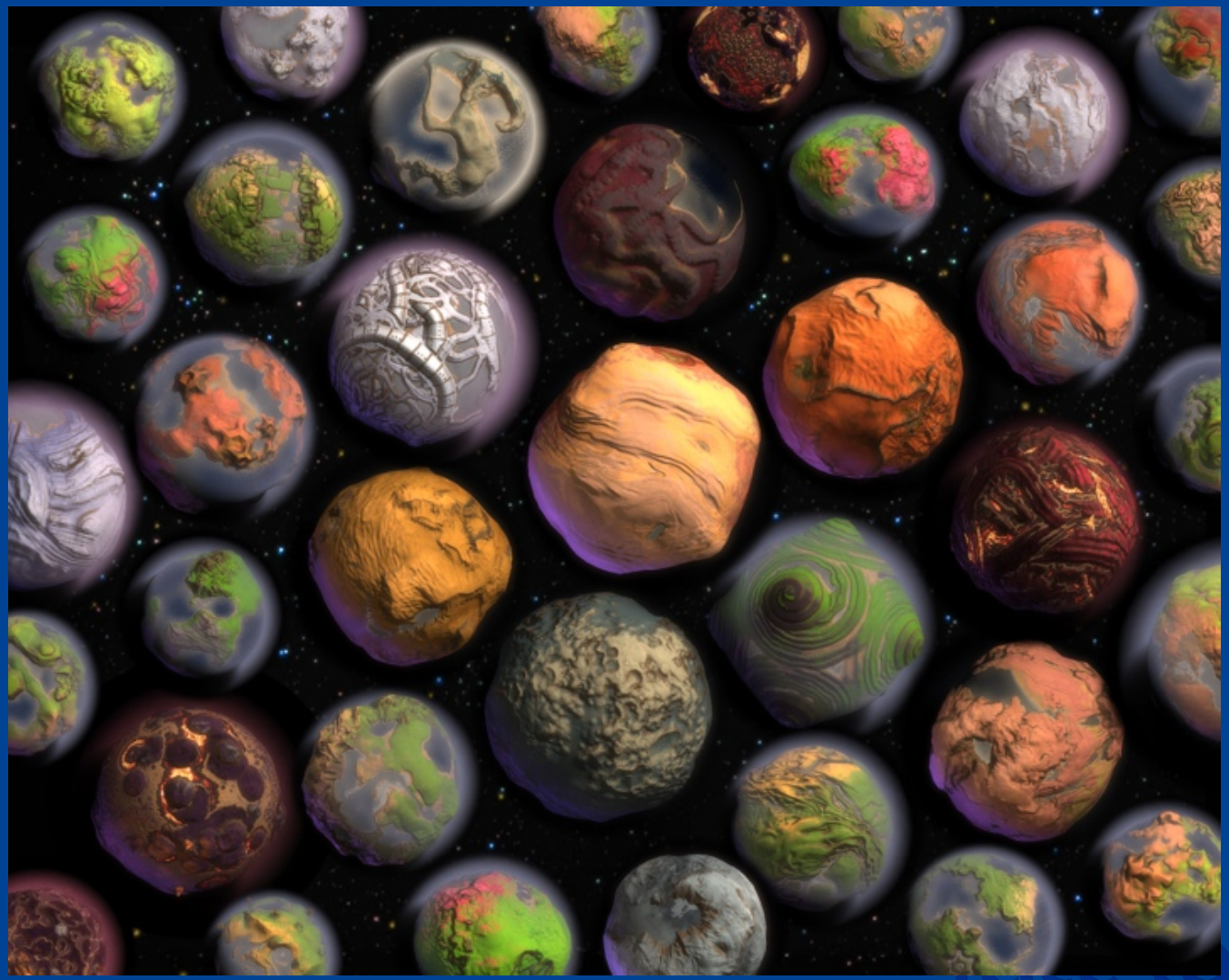


Small rocks clustered together

Authoring

- Originally one mega effects script
  - random selection between various child effects
- Difficult to control
  - Hard to get art-directed
- Introduced a top layer with more control: *terrain scripts*
- Each script produces a particular kind of planet

The Result



Authoring: Planet Editor

Demo

Questions?