

GAME ENGINE

ARCHITECTURE, GAME LOOP, UNITY

TOMÁŠ POLÁŠEK IPOLASEK@FIT.VUTBR.CZ

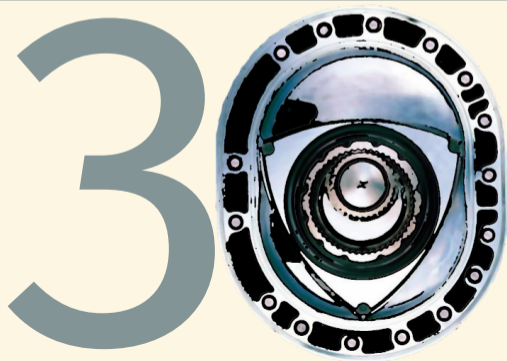
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FACULTY OF FINE ARTS

GAME MEDIA STUDIO



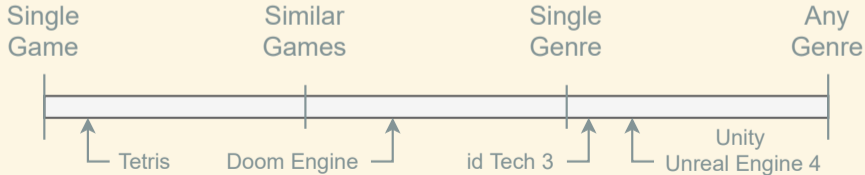
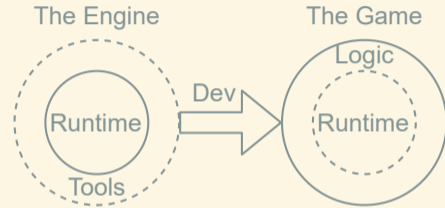
WHAT IS A GAME ENGINE?

- Reusable Software → Platform
- **Goal:** Simplify Game Development
- There is **One** There are **Many**
- Build Your Own?
- “Choosing the Right Tool for the Job”
 - ▶ Licensing & Royalties
 - ▶ Internal tools
 - ▶ Ecosystem Integration
 - ▶ Target Platform
 - ▶ Game Genre, Style, Gameplay
 - ▶ Community



GAME ENGINE SOFTWARE

- “Fun Activity” vs “Soft Real-Time Simulation”
- Game Engine = **Runtime** + **Tools**
- Gamut of **Reusability**
- Generality × Optimality

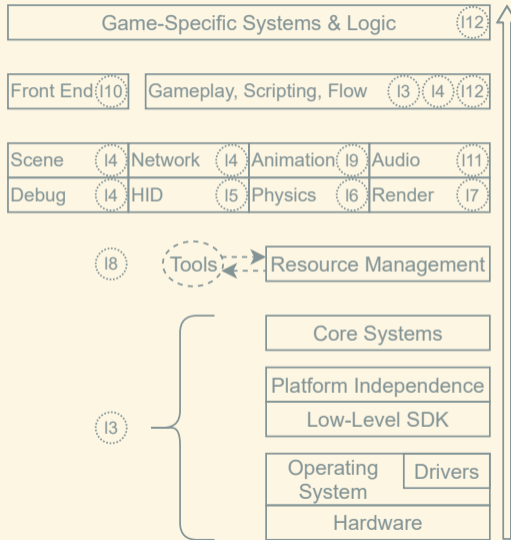


Source: Game Engine Architecture [1]

ENGINE ARCHITECTURE

GAME ENGINE OVERVIEW

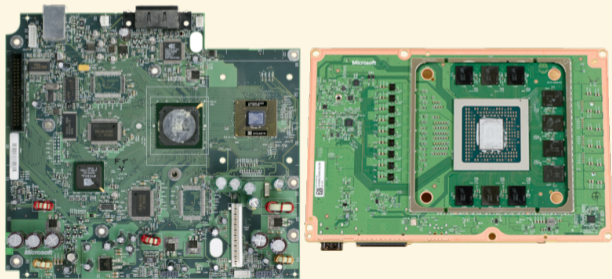
- **Complex** Software Architecture ¹
- Layers & Dependencies
- System Overview



¹Jason Gregory – Game Engine Architecture [1]

HARDWARE & OS

- Architecture, Optimization
- Varied → Uniform
- Operating System = Software Layer
- Drivers = Hardware Interface



Source: Xbox 2001, Xbox Series S 2020

Operating System	Drivers
Security	Resources
Scheduling	Processes

Hardware		
CPU	GPU	Memory
Acceleration	Storage	

LOW-LEVEL LIBRARIES

- APIs, SDKs, Standard Library, ...

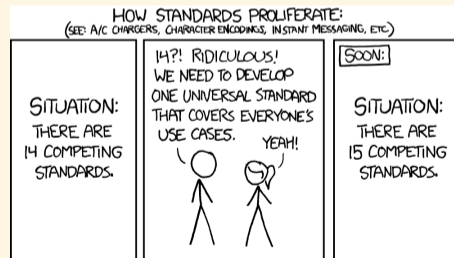


Low-Level Libraries

Middleware

SDKs

APIs



Source: XKCD – Standards

PLATFORM INDEPENDENCE LAYER

- Platform Independence
- Unified Interface
- Multiplatform Development

Platform Independence		
	FS	Detection
Threads		Wrappers
Network		Unification



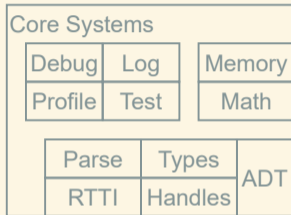
Source: Unreal, Unreal Engine 5



CORE SYSTEMS

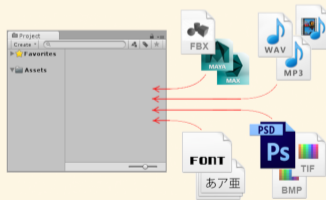
- Library of Utilities
- Base Debugging & Logging
- Memory Management
- Data Types
- Serialization, RTTI, Parsing
- Mathematics – Transform, Geometric, Solvers
- ...

```
Player player = new Player();  
player.level = 1;  
player.health = 100.0f;  
player.name = "Thomas";  
    {  
        "level": 1,  
        "health": 100.0,  
        "name": "Thomas"  
    }
```

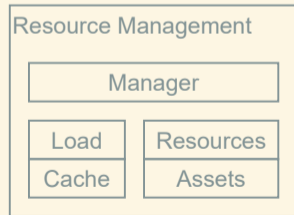
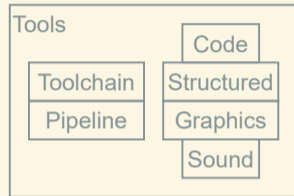


RESOURCE MANAGEMENT

- Unified Data Access
- Resources & Assets
- **Toolchain** → **Pipeline** → **Assets**
- “Mark of Style”



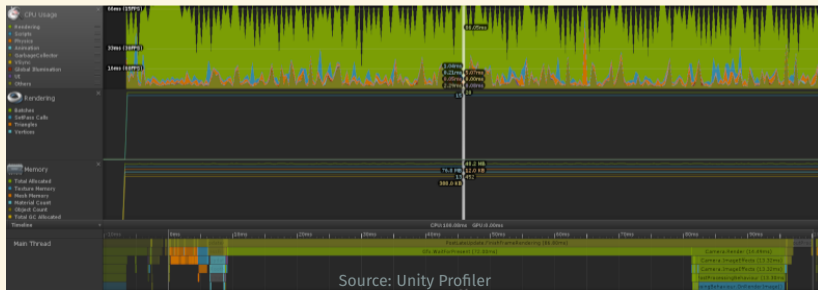
Source: Unity Manual – Asset Workflow



DEBUGGING & PROFILING

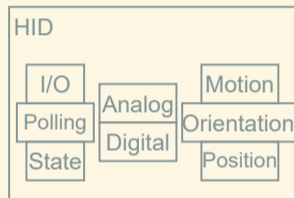
- Complexity → Bugs
- What is Wrong?
- **Instrumentation & Logging**
- Playtime Statistics, Core Dumps
- Remote Debugging & Profiling

Debug	D&P Server
	Statistics
Assert	Playback
Logging	Cheats
Instrumentation	Console



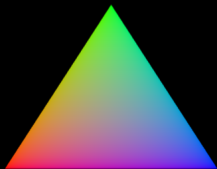
HUMAN INTERFACE DEVICES

- **Input & Output**
- Raw I/O → API
- Wide Range
- Device Sensors
- User Feedback



RENDERING ENGINE

- Visualization of the Game
- “From Zero to Mirrors”
- Scene Graph
- Materials, Effects, Lighting
- Interface Rendering

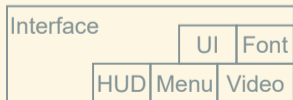
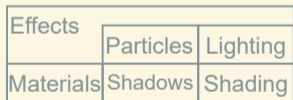
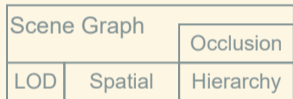
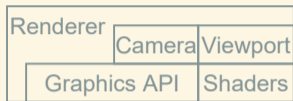


Source: Vulkan Samples

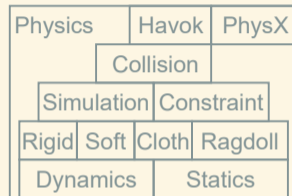


Source: Cyberpunk 2077

Rendering Engine



- Collision Detection → Resolution
- Physical Simulation
- Simplified Models
- Static & Dynamic Objects



ANIMATION

- Making Things Move
- Animation vs Physics
- Kinematics & Dynamics
- Rigging, Skinning

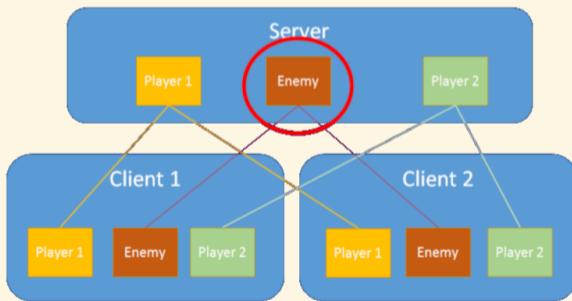


Source: Unreal, Unity

Animation		
Texture	Rigid	Skeleton
Sprite	Vertex	Morph
Kinematics		Skinning
Dynamics		Rigging

NETWORK

- Network Stack
- Frontend × Backend
- Latency, Replication, Authority

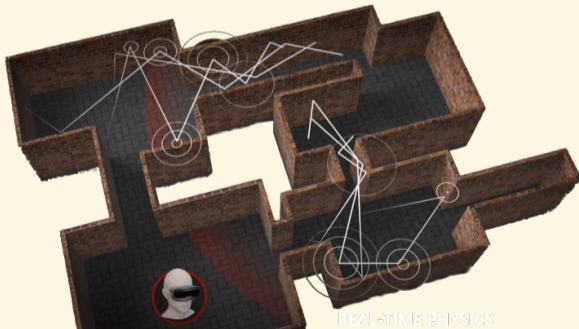


Source: Unity

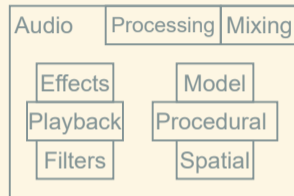
Network		
	Latency	VoIP
Frontend	Authority	Chat
Backend	Replication	
MatchMaking		Infrastructure

AUDIO

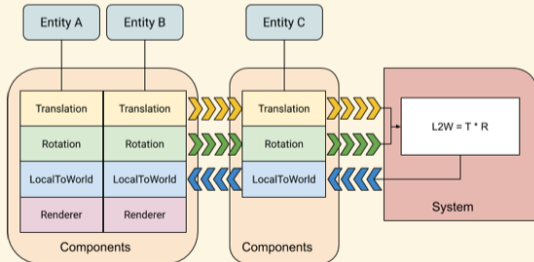
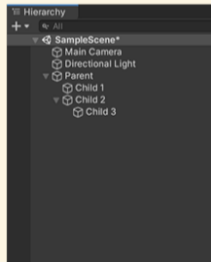
- Often Neglected
- Fidelity & Procedural
- Realistic Modeling



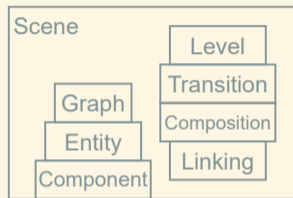
Source: AMD TrueAudio Next



- Graph Data Structure
- World Hierarchy
- Entity-Component-System
- Composition & Linking

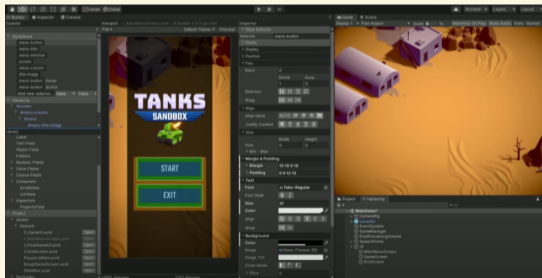
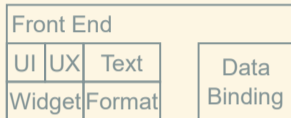


Source: Unity



FRONT END

- UI & UX
- Aural Feedback
- Widgets, Layouts
- Data Binding



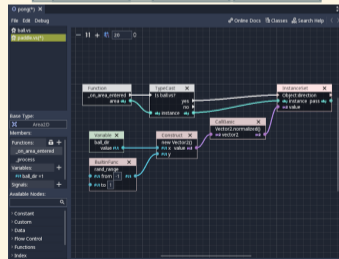
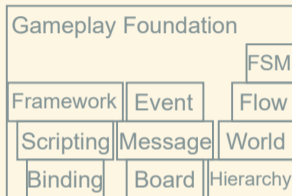
Source: Unity UI Builder

GAMEPLAY FOUNDATION

- Framework for Building the Game
- Scripting Utilities
- Low-Level \iff Gameplay
- Game Object Hierarchy
- Game Loop [2]



Source: Robert Nystrom – Game Programming Patterns



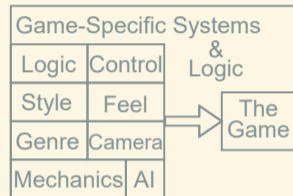
Source: Godot Visual Scripting

GAME-SPECIFIC SYSTEMS

- This is **The Game**
- Gameplay Implementation



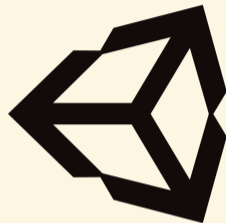
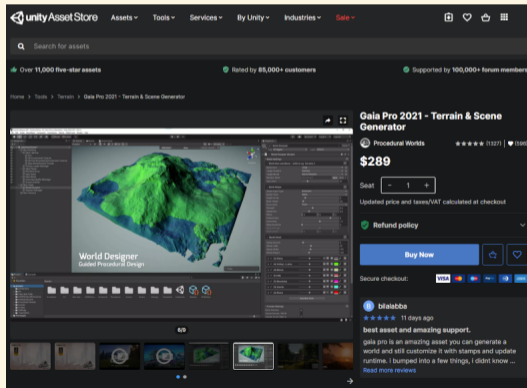
Source: Unity Bolt

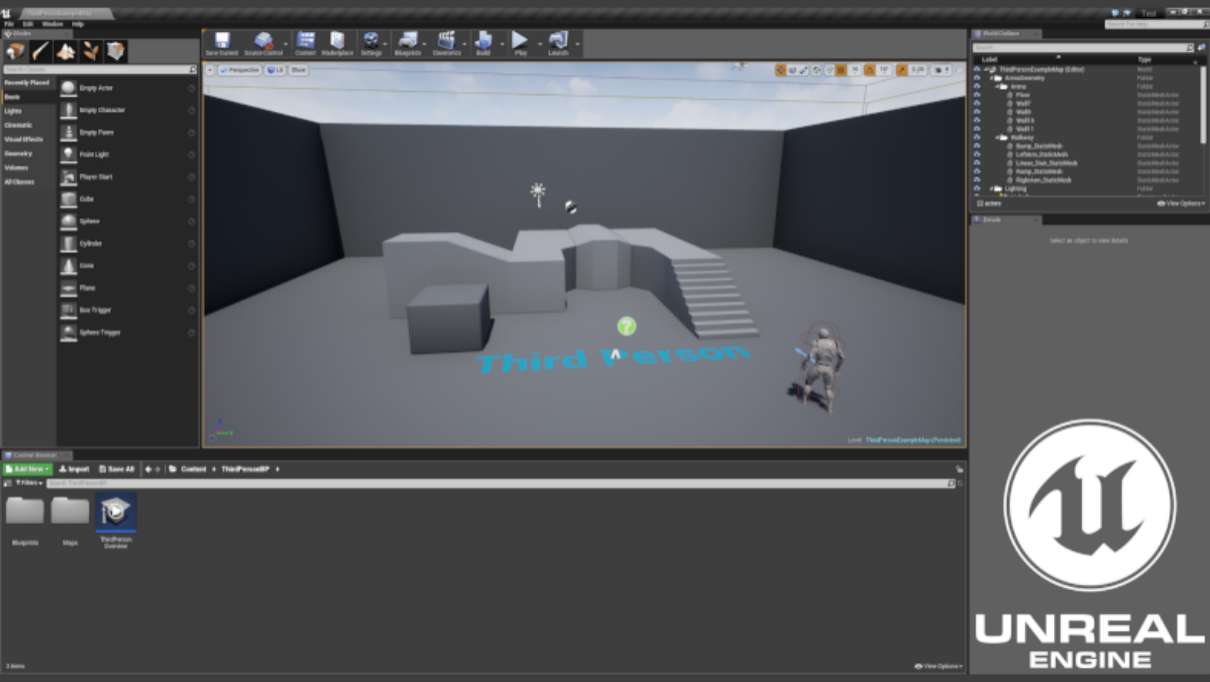


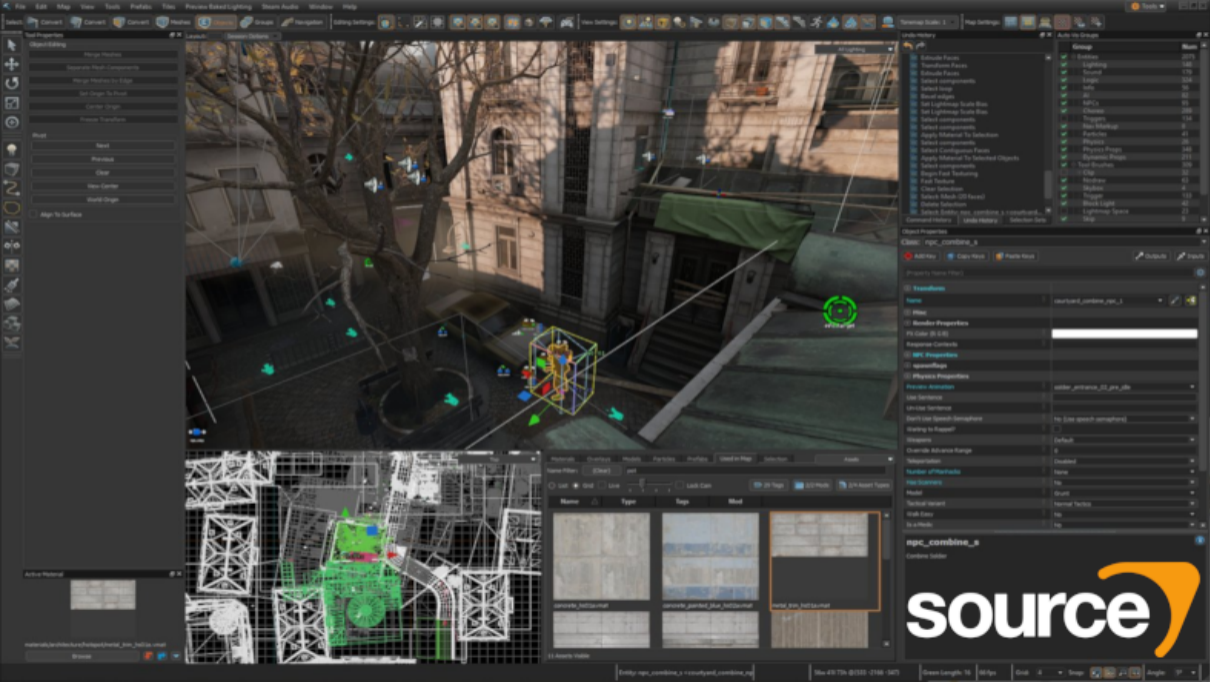
UNITY ENGINE

WHAT IS UNITY?

- Game Engine
- Development Platform
- Documentation & Community
- **Why Unity?**







Tool Properties

Selection

- Place Window
- Separate Mesh Components
- Merge Meshes by Edge
- Join Objects by Point
- Center Origin
- Reverse Transform

Reset

- Reset
- Preview
- Clear
- View Center
- World Origin
- Align To Surface

Lighting

- Subdivide Facets
- Transform Facets
- Subdivide Planes
- Subdivide components
- Subdivide Image
- Reset angles
- Set Lightmap Scale Bias
- Set Lightmap Scale Bias
- Subdivide components
- Subdivide components
- Apply Material To Selection
- Subdivide components
- Subdivide components
- Apply Material To Selected Objects
- Subdivide components
- Stage Full Texturing
- Full Texture
- Full Intermission
- Subdiv Check GPU Record
- Entity Selection
- Subdiv Entities menu: combine a material, command history, update history, selection data

Entity Properties

Classic: npc_combine_s

Property Name Filter

- Team
- Render Properties
- PS Color (0-1)
- Response Contents
- NPC Properties
- speakRange
- Physics Properties
- Previous Animation
- Use Sentence
- Use-Like Sentence
- Start Use Speech-Envelope
- Waiting to Repeat
- Weapons
- Overide Advance Range
- Temperature
- Number of Healths
- Has Senses
- Model
- Technical variant
- Walk Easy
- Is a Medic

Wireframe View

Entity: npc_combine_s

Color: green

Texture Browser

Name	Type	Tags	Model
combine_metal			
combine_painted_blue_metal			
npc_combine_s			

Property Inspector

npc_combine_s

Combine Soldier

npc_combine_s





Use Ctrl+Drag to Arrange Layers

100	+	AB1
100	+	AB2
100	+	AB2_A01
100	+	AB2_Landscape
100	+	AB2_Lens
100	+	AB2_Navigation
100	+	AB2_Particles
100	+	AB3
100	+	AB4
100	+	Boundary Collision
100	+	LightScrubbers
100	+	Man
100	+	Shaman
100	+	Shark
100	+	Water Submarine
100	+	World



CRYENGINE®

- 0.0 Characters
- Rosad_T
- legionnaire_posed
- Default Asset Environment
- Light

- Swords
 - Rosad_Cinematic_sword
 - Rosad_Cinematic_sword
 - Rosad_Cinematic_sword
 - Rosad_Cinematic_sword
 - Rosad_Cinematic_sword
 - swords_OcclusionFougl
- Teeth
 - Rosad_Cinematic_tooth
 - Rosad_Cinematic_tooth
 - Rosad_Cinematic_tooth
 - Rosad_Cinematic_tooth
 - Rosad_Cinematic_tooth
 - Rosad_Cinematic_tooth
 - teeth_OcclusionRough



Rosad_Cinematic_PBR



Name: Rosad_T

Status: Start active

Entity ID: 48999241175

Add Component +

Transform

Parent entity: []

Values

Translate: X: 0.0 m Y: 0.0 m Z: 44.0 m

Rotate: X: 0.0 deg Y: 0.0 deg Z: 190.0 deg

Uniform Scale: 1.0

Add non-uniform scale

Parent activation: Default relative transform

Static:

Mesh

Mesh Asset: Rosad_Cinematic

Mesh Key: 0

Lod Override: Low Sqr

Exclude from reflect:

Use Forward Pass L:

Material

Generate/Manage Source Materials...

Default Material: []

Model Materials: 17 elements

- arms1: [] matc_rosad_arms
- belt1: [] cinematic_rosad_belt
- brooch1: [] matc_rosad_brooch
- cape1: [] matc_rosad_cape
- chainmail1: [] cinematic_chainmail
- default_material: [] matc_rosad_tooth
- eye: [] cinematic_rosad_eyes
- eyebrow_01: [] matc_rosad_belt
- hair: [] cinematic_rosad_hair





Scene Import

+ Filter nodes 🔍

- tester
- environment
- testers
 - white plastic
 - MeshInstance
 - mirror
 - MeshInstance
 - dark wood
 - MeshInstance
 - cheese
 - MeshInstance
 - stones
 - MeshInstance
 - brick
 - MeshInstance
 - wood
 - MeshInstance

FileSystem

< resur

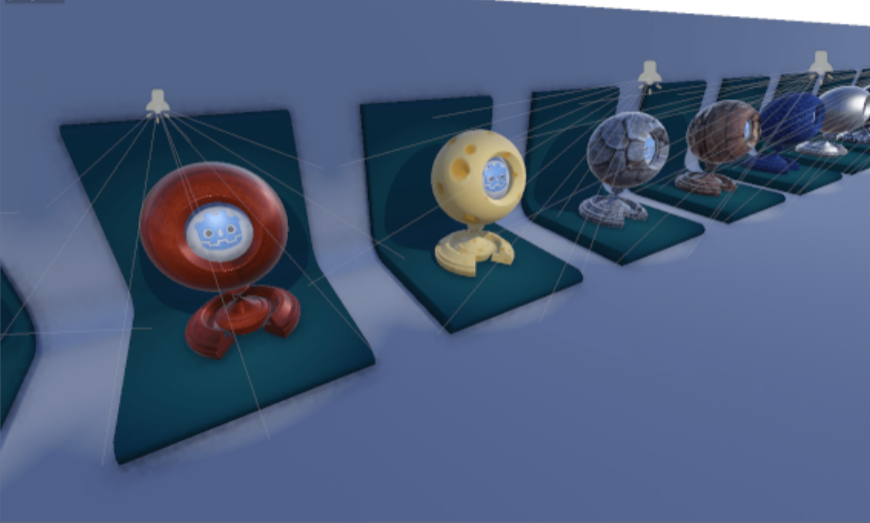
Search files 🔍

- ★ Favourites:
- resur
 - aluminium_albedo.png
 - aluminium_flow.png
 - aluminium_normal.png
 - experiment.hdr
 - GodotBall.dae
 - godot_ball.mesh
 - icon.png
 - lobby.hdr
 - marble_albedo.png
 - night.hdr
 - park.hdr
 - pbr_bed.dae
 - rock_albedo.png

tester x +

Transform View

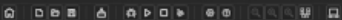
Perspective



Inspector Node

tester

Filter properties 🔍



Workspace 1 x Sequence1*



(-326, -271) oPickupGear

Sequence1

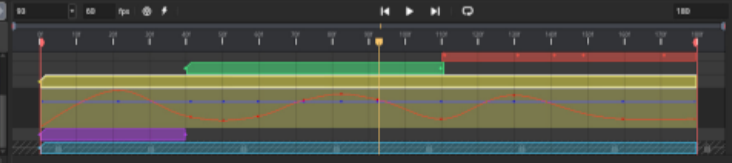
Track Panel

- swan_spr
- swan
- oPickupGear

Position: XY 225.28, 225.29 px

swan

spr_bg



Windows | Local | VM | Default | Default

Assets

Asset Browser

Search...

- Quick Access
- Recent
- Favourites
- Room Order
- Saved Searches
- Tags
- Game Options

Rooms

- Objects
- Rooms
- Scripts

Sprites

- Background
 - oBGGrad_grass
 - oBGGrad_sand
 - oBGHill_grass
 - oBGHill_sand
 - oBGHill1_grass
 - oBGHill1_sand
 - oCloud_grass
 - oCloud_sand
 - oCloud1_grass
 - oCloud1_sand
 - oMoon
 - spr_bg
 - oStar_grass
 - oStar_sand
- Enemy
 - oGhost
 - oGhost_left
 - oGhostShadow
- Level
 - oPickupGear
 - oHeart
- Player
- Tile Sets
- Sequence1

37 items, 1 selected, 100%

Object Window

Class: []

Editor ID: [] Count: [] View: [] Path To: []

Objects within 10 units

- Archer
- Asak
- Chandelier
- Door
- Map
- WallBanner
- Special Boat
- WallData
- WallDecor
- Archway
- Chest
- Door
- Flare
- Furniture
- Grass
- Light
- WallDecor
- Water
- Static Collection
- Tree

780



Call View

World Space

Selected: []

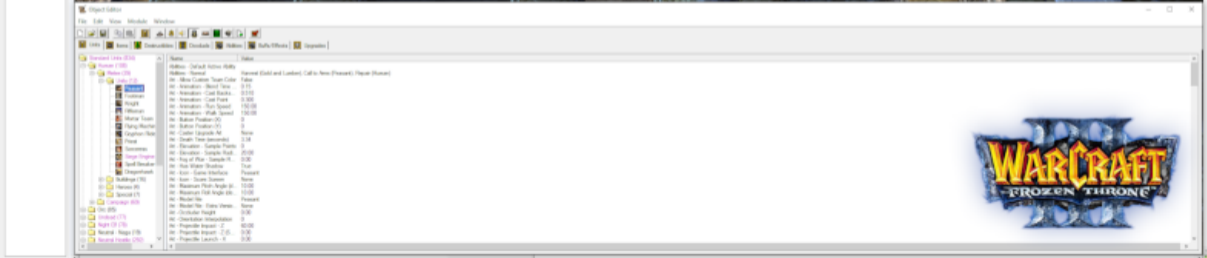
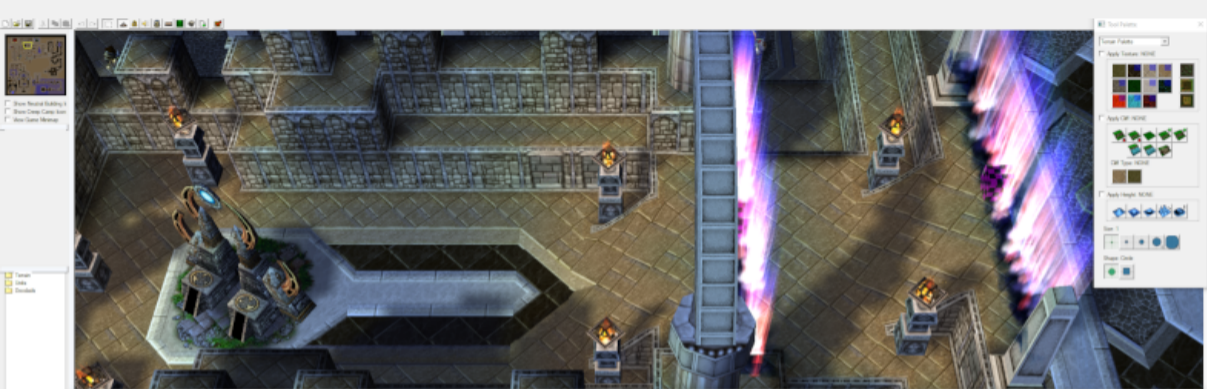
Loaded: []

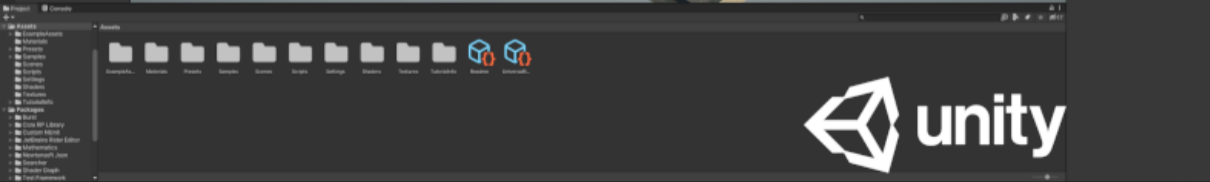
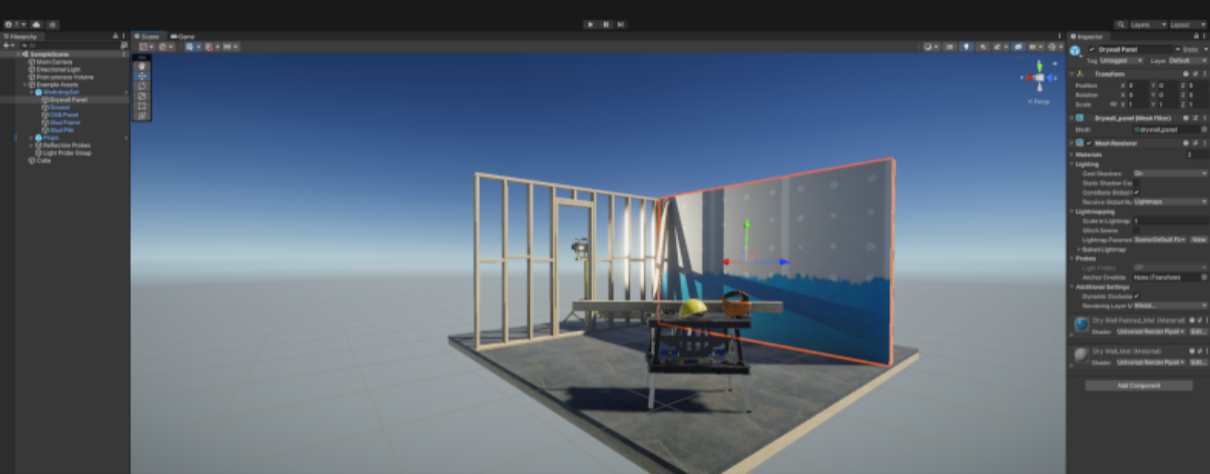
Class: []

Class: []

Editor ID	Name	L	Count	Location	Class
u100000000	u100000000	...	...	...	...
u100000001	u100000001	...	...	...	...
u100000002	u100000002	...	...	...	...
u100000003	u100000003	...	...	...	...
u100000004	u100000004	...	...	...	...
u100000005	u100000005	...	...	...	...
u100000006	u100000006	...	...	...	...
u100000007	u100000007	...	...	...	...
u100000008	u100000008	...	...	...	...
u100000009	u100000009	...	...	...	...
u100000010	u100000010	...	...	...	...
u100000011	u100000011	...	...	...	...
u100000012	u100000012	...	...	...	...
u100000013	u100000013	...	...	...	...
u100000014	u100000014	...	...	...	...
u100000015	u100000015	...	...	...	...
u100000016	u100000016	...	...	...	...
u100000017	u100000017	...	...	...	...
u100000018	u100000018	...	...	...	...
u100000019	u100000019	...	...	...	...
u100000020	u100000020	...	...	...	...







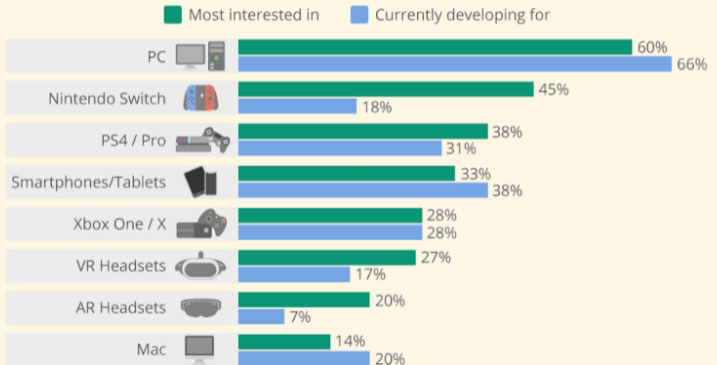
WHICH TO CHOOSE?

- AAA & Realistic → **Unreal Engine**
- Agile & Indie → **Unity Engine**
- Non-Programmer → **Game Maker**
- Open & Free → **Godot Engine**
- Learn Engine-ering → **Roll Your Own**
- Learn GameDev → **Unity Engine**



ADDITIONAL RESOURCES

- [Thesis] James Lear: The Video Game Asset Pipeline
- [Online] Robert Nystrom: Game Loop
- [Online] Unity: Order of Execution for event functions



Source: Statista – The Most Important Gaming Platforms

MENTAT

OPTIONS

Credits

10

Thanks For
Your Attention!



TANK



DMG

ATTACK

MOVE

RETREAT

GUARD



Dune 2 : The Building of a Dynasty

REFERENCES I

- [1] JASON GREGORY. ***GAME ENGINE ARCHITECTURE, SECOND EDITION***. 3rd. USA: A. K. Peters, Ltd., CRC Press, 2018. ISBN: 1351974288.
- [2] R. NYSTROM. ***GAME PROGRAMMING PATTERNS***. UK: Genever Benning, 2014. ISBN: 0990582906.