

GAME ENGINE

ARCHITECTURE, GAME LOOP, UNITY

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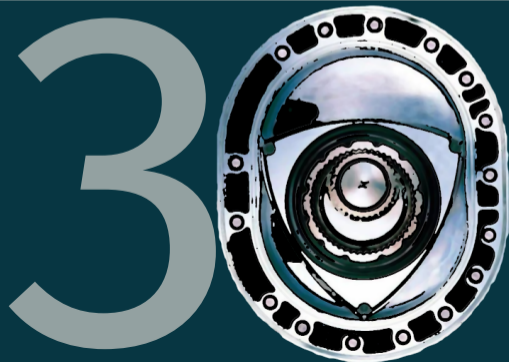
BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF INFORMATION TECHNOLOGY

DCGM, CPhoto@FIT

FACULTY OF FINE ARTS

GAME MEDIA STUDIO



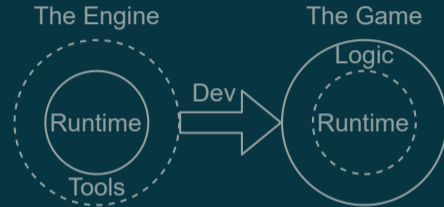
WHAT IS A GAME ENGINE?

- 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

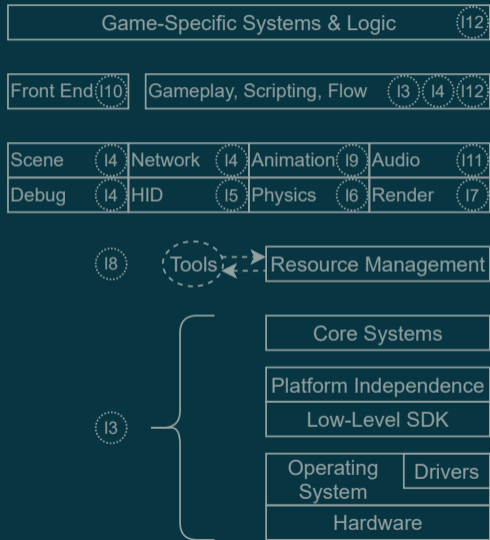


Source: Game Engine Architecture [1]

ENGINE ARCHITECTURE

GAME ENGINE OVERVIEW

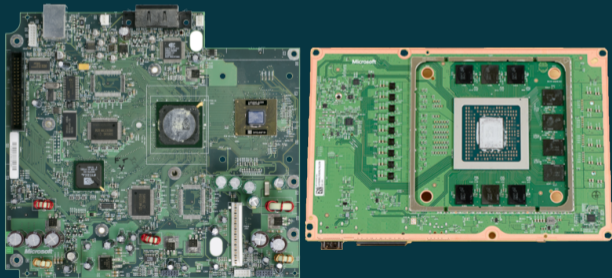
- **Complex** Software Architecture ¹
- Layers & Dependencies
- System Overview



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

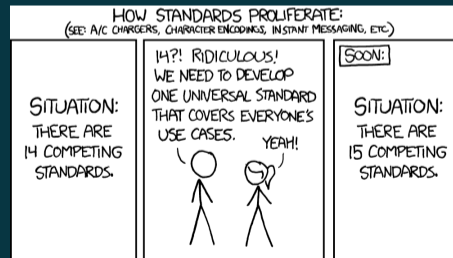
- APIs, SDKs, Standard Library, ...

Low-Level Libraries

Middleware

SDKs

APIs



Source: XKCD – Standards

PLATFORM INDEPENDENCE LAYER

- Platform Independence
- Unified Interface
- Multiplatform Development

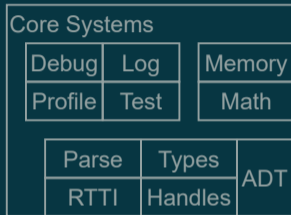
Platform Independence	
FS	Detection
Threads	Wrappers
Network	Unification



Source: Unreal, Unreal Engine 5

CORE SYSTEMS

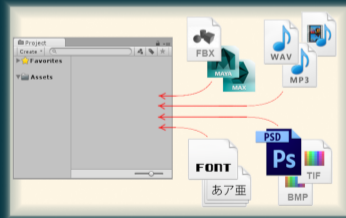
- Library of Utilities
- Base Debugging & Logging
- Memory Management
- Data Types
- Serialization, RTTI, Parsing
- Mathematics – Transform, Geometric, Solvers
- ...



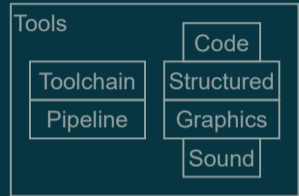
```
Player player = new Player();  
player.level = 1;  
player.health = 100.0f;  
player.name = "Thomas";  
  
{  
    "level": 1,  
    "health": 100.0,  
    "name": "Thomas"  
}
```

RESOURCE MANAGEMENT

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



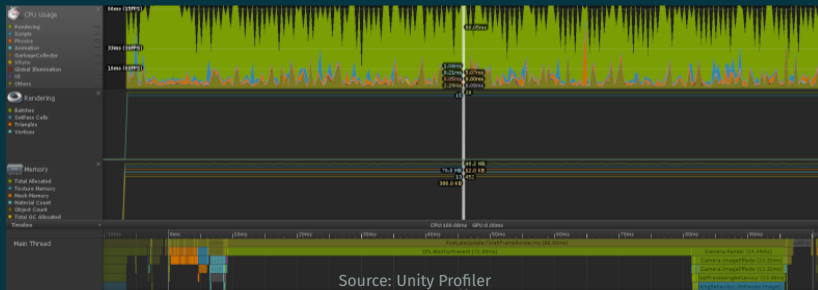
Source: Unity Manual – Asset Workflow



DEBUGGING & PROFILING

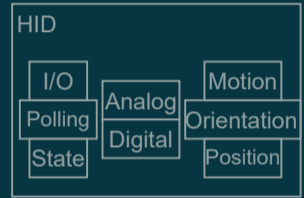
- Complexity → Bugs
- What is Wrong?
- **Instrumentation & Logging**
- Playtime Statistics, Core Dumps
- Remote Debugging & Profiling

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



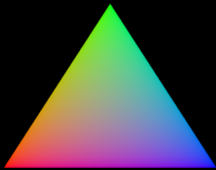
HUMAN INTERFACE DEVICES

- **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

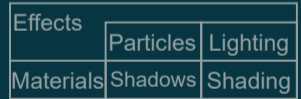
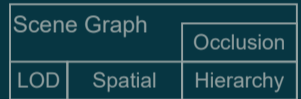
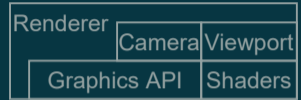


Source: Vulkan Samples

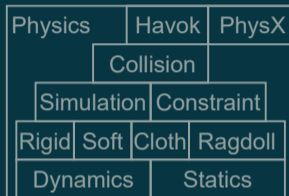


Source: Cyberpunk 2077

Rendering Engine



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



ANIMATION

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

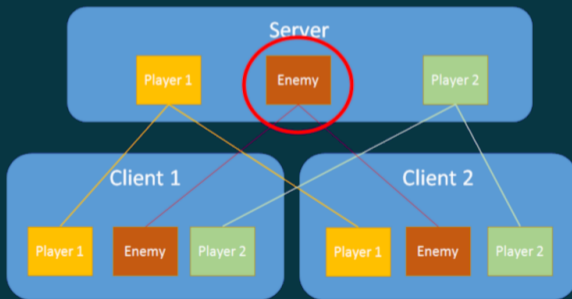


Source: Unreal, Unity

Animation		
Texture	Rigid	Skeleton
Sprite	Vertex	Morph
Kinematics		Skinning
Dynamics		Rigging

NETWORK

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

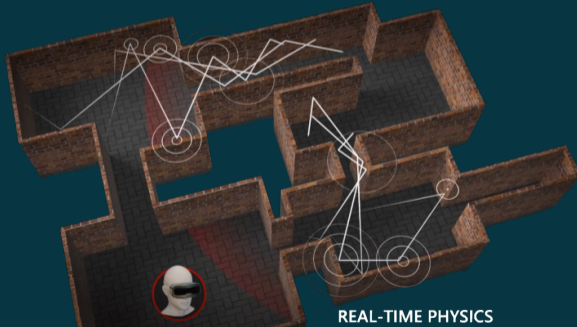


Source: Unity

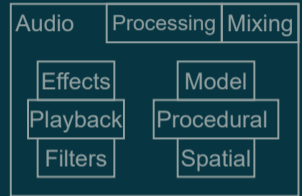
Network		
	Latency	VoIP
Frontend	Authority	Chat
Backend	Replication	
MatchMaking		Infrastructure

AUDIO

- Often Neglected
- Fidelity & Procedural
- Realistic Modeling

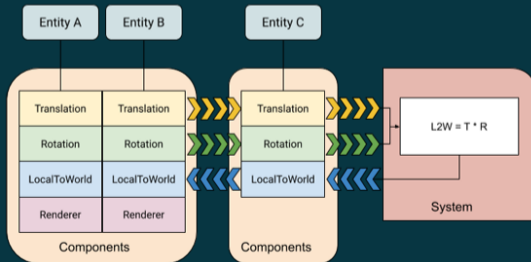
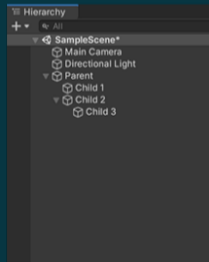


Source: AMD TrueAudio Next

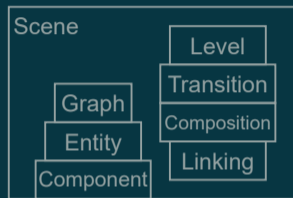


SCENE

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

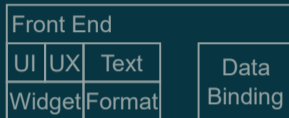


Source: Unity



FRONT END

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



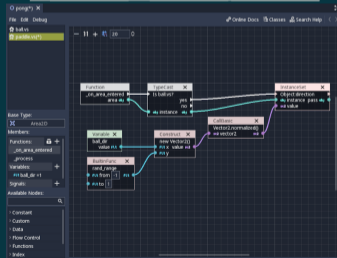
Source: Unity UI Builder

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



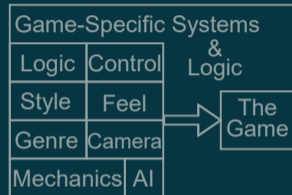
Source: Godot Visual Scripting

GAME-SPECIFIC SYSTEMS

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



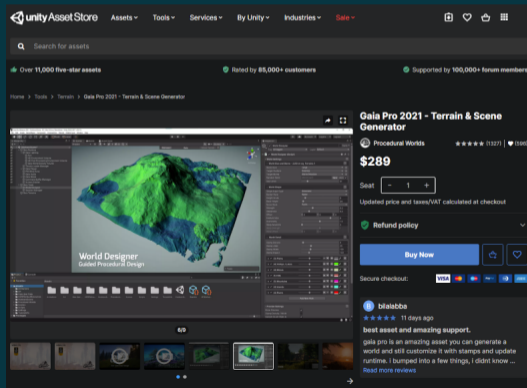
Source: Unity Bolt

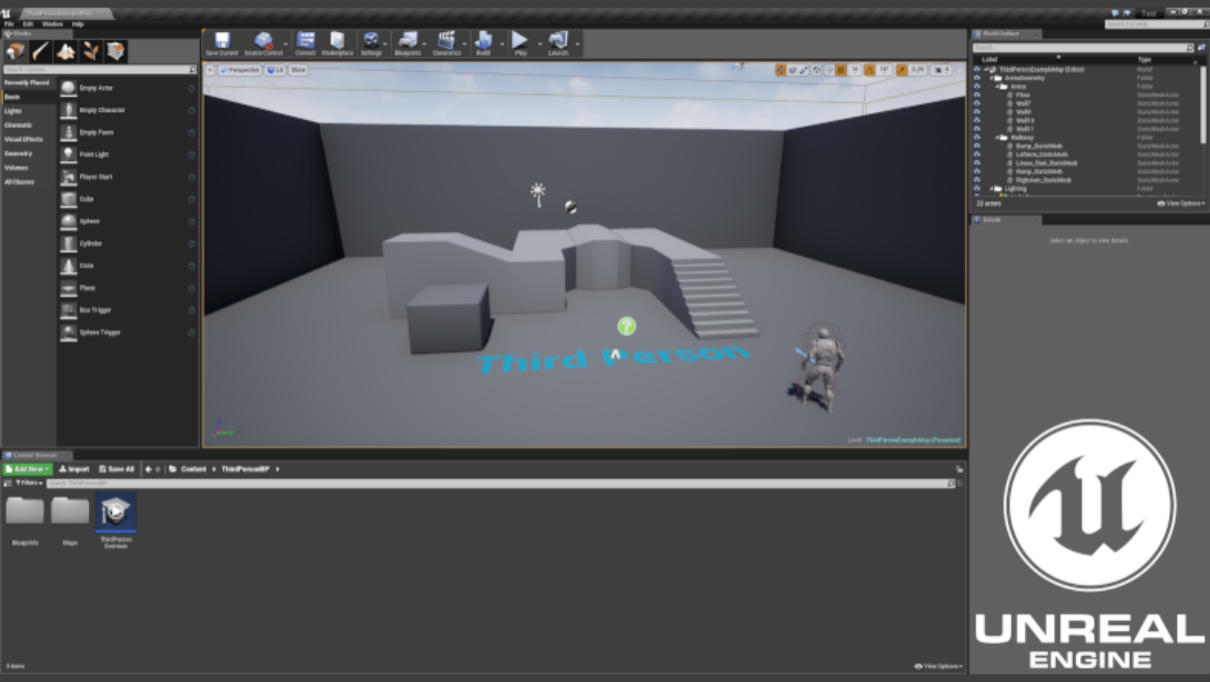


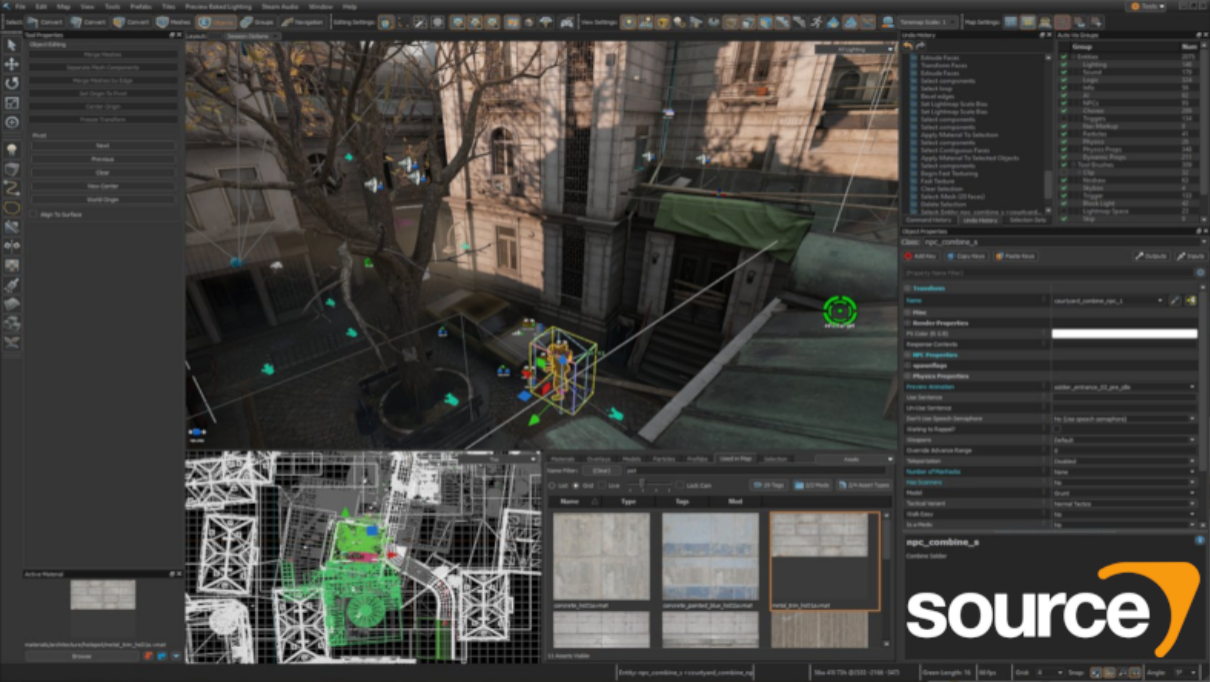
UNITY ENGINE

WHAT IS UNITY?

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







source



Use Ctrl+Drag to Arrange Layers

100	AB1
100	AB2
100	AB2_Art
100	AB2_Landscape
100	AB2_Lens
100	AB2_Navigation
100	AB2_Particles
100	AB3
100	AB4
100	Boundary Collision
	LightScrubbers
100	Man
100	Shaman
100	Thun
100	Water Submarine
100	World




CRYENGINE®

Scene Objects

- 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_teeth
 - Rosad_Cinematic_teeth
 - Rosad_Cinematic_teeth
 - Rosad_Cinematic_teeth
 - Rosad_Cinematic_teeth
 - Rosad_Cinematic_teeth
 - teeth_OcclusionRoughn



Rosad_Cinematic_FBX



Empty Inspector

Name: Rosad_T

Status: Start active

Empty ID: 48999241175

Add Component +

Search

Transform

Parent empty: []

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: Original relative transform

Static:

Mesh

Mesh Asset: rosad_cinematic

Mesh Key: 0

Lod Override: Low Str

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_sword
- eye: matc_rosad_eyes
- eyebrow_01: mat_rosad_belt
- hair: cinematic_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

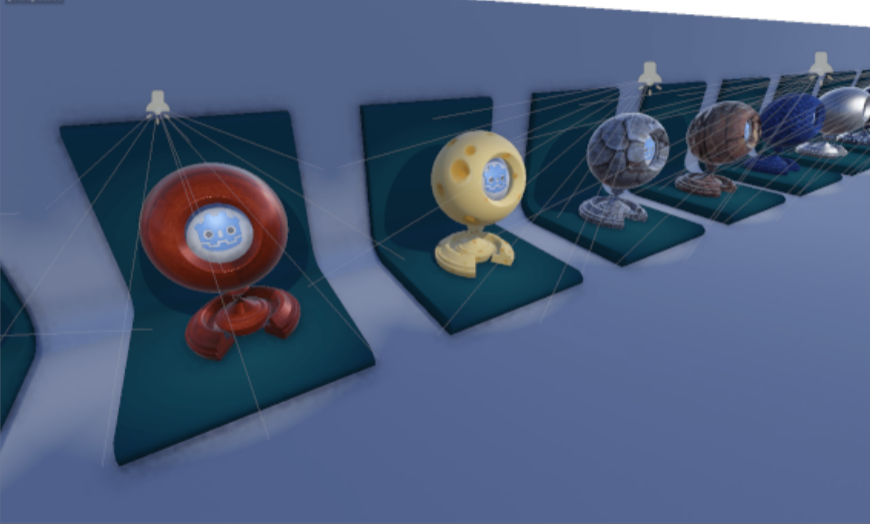
Search files

- ★ 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

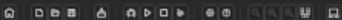
Perspective



Inspector Node

tester

Filter properties



Workspace 1 x Sequence1*



(-326, -271) «PickupGear»

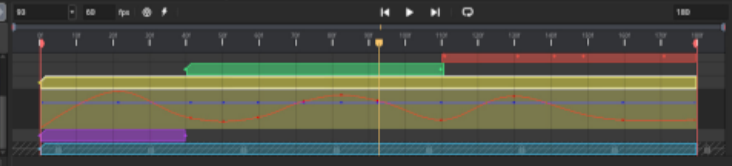
Sequence1

Track Panel

- swan_spr
- scweb
- «PickupGear»

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
 - «BGGrad_grass»
 - «BGGrad_sand»
 - «BGHill_grass»
 - «BGHill_sand»
 - «BGHill1_grass»
 - «BGHill1_sand»
 - «cCloud_grass»
 - «cCloud_sand»
 - «cCloud1_grass»
 - «cCloud1_sand»
 - «cMoon»
 - «spr_bg»
 - «cStar_grass»
 - «cStar_sand»
 - Enemy
 - «cGhost»
 - «cGhost_left»
 - «cGhostShadow»
- Level
- Pickup
 - «cHeart»
 - «cPickupGear»
- 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




Call View

World Space

Selected: []

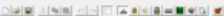
Loaded: []

Class: []

Class: []

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

Editor ID	Type	On	Lock L	Lock R	Pin	Hide	Is
u100000021	Static	-	-	-	-	-	-
u100000022	Static	-	-	-	-	-	-
u100000023	Static	-	-	-	-	-	-
u100000024	Static	-	-	-	-	-	-
u100000025	Static	-	-	-	-	-	-
u100000026	Static	-	-	-	-	-	-
u100000027	Static	-	-	-	-	-	-
u100000028	Static	-	-	-	-	-	-
u100000029	Static	-	-	-	-	-	-
u100000030	Static	-	-	-	-	-	-



Team
Units
Buildings



Test Feature

Color Palette
[Color Picker]

Apply Texture NSID:
[Texture Selection Grid]

Apply GDI NSID:
[GDI Selection Grid]

GDI Type NSID:
[GDI Type Selection Grid]

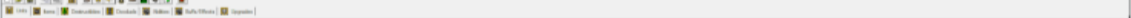
Apply Hinge NSID:
[Hinge Selection Grid]

Size 1
[Size Selection Grid]

Shape Code:
[Shape Code Selection Grid]

Object Editor

File Edit View Miscellan Windows



Object Editor Panel

- Item
- Area
- Restrictions
- Checks
- Hitbox
- Collisions
- Initial Effects
- Triggers

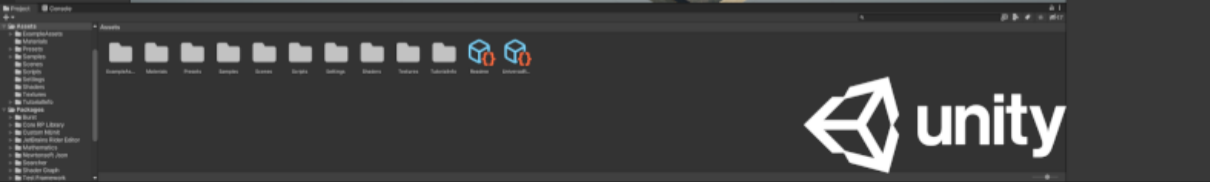
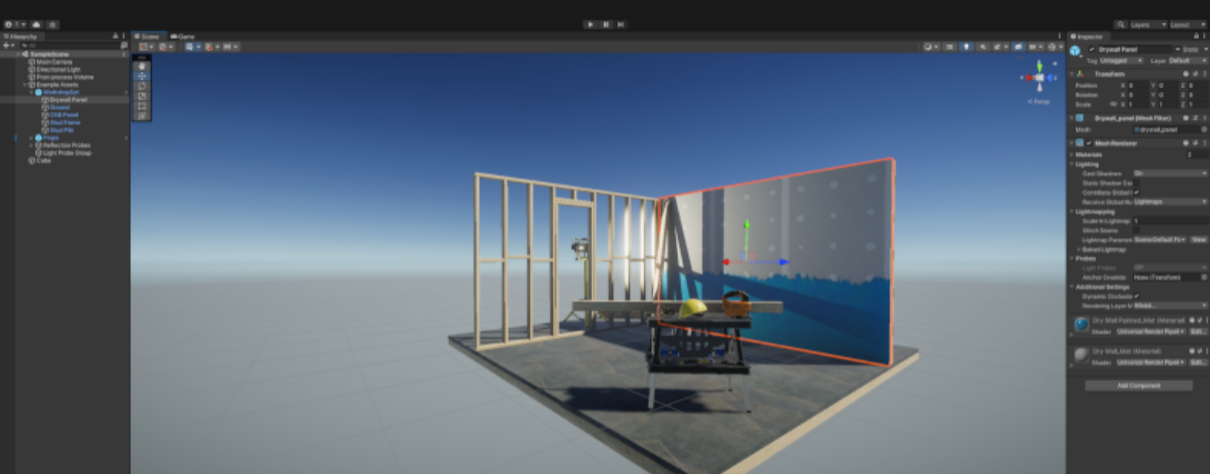
Expanded Lists (25)
Nomenclature (25)
Powers (25)
[Detailed List of Object Properties and Values]

Warcraft
Frozen Throne

Bluish Terrain Selection

Selection Menu

Time: 0:10
Map: Map 16



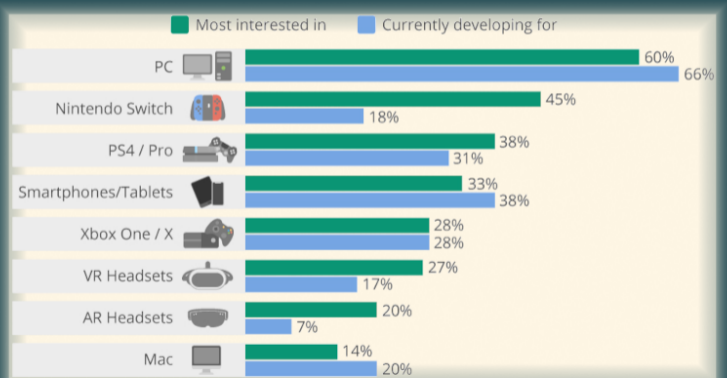
WHICH TO CHOOSE?

- 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.