

# GDC<sup>®</sup>

## Rebuilding Your Engine During Development: Lessons from

### **MAFIA** III

Jan Kratochvil

Technical Director

Hangar 13 games





# Mafia III overview

Open world, 3<sup>rd</sup> person, action adventure

Story driven, yet not linear

Set in 1968 New Bordeaux

Released October 2016

PS4, Xbox One, Windows, Mac OS





# Why rebuilding the engine?

More data

Bigger team

Multiple studio locations





X-editor 72897+ - city01\_Sandisland - entity\_script

File Edit View Mouse Create Material Audio Entity Windows Plugins Help

Profile av/oa Filter by Type: Select by Type: Type >> Sel

- mailbox\_08
- mailbox\_09
- mailbox\_10
- mailbox\_3
- mailbox\_4
- mailbox\_5
- mailbox\_6
- mailbox\_z\_01
- mailbox\_z\_02
- mailbox\_z\_03
- mailbox\_z\_3
- mailbox\_z\_4
- newsbox
- newsbox\_z\_02
- newsbox\_z\_07
- newsbox1
- newstand\_new
- para\_kanal\_01\_z
- para\_kanal\_01\_z1
- para\_kanal\_01\_z10
- para\_kanal\_01\_z11
- para\_kanal\_01\_z12
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- para\_kanal\_01\_z5
- para\_kanal\_01\_z6
- para\_kanal\_01\_z7
- para\_kanal\_01\_z8
- para\_kanal\_01\_z9
- para\_kanal\_b\_z
- para\_kanal\_b\_z1

Multiple selection: 475 Frames

WeatherPresets

Time template

Sun Moon

Curve visualization

Axis deflection:

Z axis -2.70

Y axis 23.00

Curve limits:

Start 5.00

End 19.00

Horizon angle:

Sun 20.00

Preview

0 12

Play Pause Stop Time: (hh:mm)

Time (game vs real): 30min = 1min Speed: 1s

Weather template

Global Sun Glow Wind Clouds Fog Rain Snow Li

Traffic (%) 100

Pedestrians (%) 100

Parked cars (%) 50

Headlights (%) 0

Night emissivity 1.00

Post process <- Select value ->

Lamps

Shop lights

Traffic lights

Signal lights

Advert. lights

Other night lights

Day template

DT12\_part\_all March 2018

|     |     |     |     |
|-----|-----|-----|-----|
| Mon | Tue | Wed | Thu |
| 26  | 27  | 28  | 29  |
| 5   | 6   | 7   | 8   |
| 12  | 13  | 14  | 15  |
| 19  | 20  | 21  | 22  |

Time: TT12\_part\_all

Properties View Properties WeatherPresets

camera\_pz -1552.46;-114.03;206.01 29.41 FPS Generic Local 50 m/s EDIT Mode petr3\_2018





The screenshot shows the X-editor 72897+ interface for editing a city environment. The main view is a 3D scene with a wireframe overlay on a large building structure. The left sidebar contains a file browser with a list of assets such as mailbox\_08, newsbox, and various para\_kanal\_01\_z assets. The top menu includes File, Edit, View, Mouse, Create, Material, Audio, Entity, Windows, Plugins, and Help. The bottom status bar displays camera\_pz, coordinates, FPS (29.41), and other system information.

**WeatherPresets**

Time template: [Dropdown] Save Reset

Sun  Moon

Curve visualization: [Diagram]

Axes deflection:

Z axis: -2.70

Y axis: 23.00

Curve limits:

Start: 5.00

End: 19.00

Horizon angle:

Sun: 20.00

Preview: [Timeline 0-12] Play Pause Stop Time: (hh:mm)

Time (game vs real): 30min = 1min Speed: 1s

Weather template: <- Select value -> Save Reset

Global Sun Glow Wind Clouds Fog Rain Snow Li

Traffic (%) 100

Pedestrians (%) 100

Parked cars (%) 50

Headlights (%) 0

Night emissivity 1.00

Post process <- Select value ->

Lamps

Shop lights

Traffic lights

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Advert. lights

Other night lights

Day template: DT12\_part\_all March 2018

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| Time: TT12_part_all | 12  | 13  | 14  | 15  |
|                     | 19  | 20  | 21  | 22  |

Properties View Properties WeatherPresets

Local 50 m/s EDIT Mode petr3\_2018

Multiple selection: 475 Frames





X-editor 72897+ - city01\_Sandisland - entity\_script

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- para\_kanal\_01\_z7
- para\_kanal\_01\_z8
- para\_kanal\_01\_z9
- para\_kanal\_b\_z
- para\_kanal\_b\_z1

Multiple selection: 475 Frames

WeatherPresets

Time template: Save Reset

Sun  Moon

Curve visualization

Axes deflection:

Z axis: -2.70

Y axis: 23.00

Curve limits:

Start: 5.00

End: 19.00

Horizon angle:

Sun: 20.00

Preview: 0 12

Play Pause Stop Time: (hh:mm)

Time (game vs real): 30min = 1min Speed: 1s

Weather template: <- Select value -> Save Reset

Global Sun Glow Wind Clouds Fog Rain Snow Li

Traffic (%): 100

Pedestrians (%): 100

Parked cars (%): 50

Headlights (%): 0

Night emissivity: 1.00

Post process: <- Select value ->

Lamps

Shop lights

Traffic lights

Signal lights

Advert. lights

Other night lights

Day template: DT12\_part\_all March 2018

|                     |     |     |     |     |
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Properties View Properties WeatherPresets

camera\_pz -1552.46;-114.03;206.01 29.41 FPS Generic Local 50 m/s EDIT Mode petrz\_3\_2018





gdc\_hok\_screen\_render\_downtown - World Forge x Fusion 3.17.10.0

File Edit View Create Tools Material Effects AI Game Audio Physics Window

Scene Outliner Group Render View

Search...

| Objects                                 | Layers                                    | Types                                    |
|-----------------------------------------|-------------------------------------------|------------------------------------------|
| <input type="checkbox"/> 1_GB_Approved  | <input type="checkbox"/> 4_LODs           | <input type="checkbox"/> 7_Beta_Approved |
| <input type="checkbox"/> 2_On_Outsource | <input type="checkbox"/> 5_Target_mesh    | <input type="checkbox"/> Approved        |
| <input type="checkbox"/> 3_Visual+coll  | <input type="checkbox"/> 6_Alpha_Approved | <input type="checkbox"/> Backyard_props  |

gdc\_hok\_screen\_render\_downtown ?

- 03\_downtown\_block\_a\_baked\_vegetation
- 03\_downtown\_block\_a\_buildings
- 03\_downtown\_block\_a\_decals
- 03\_downtown\_block\_a\_lights\_street
- 03\_downtown\_block\_a\_powerpoles
- 03\_downtown\_block\_a\_props
- 03\_downtown\_block\_a\_vegetation
- 03\_downtown\_block\_ab\_baked\_vegetation
- 03\_downtown\_block\_ab\_buildings
- 03\_downtown\_block\_ab\_decals
- 03\_downtown\_block\_ab\_lights\_street
- 03\_downtown\_block\_ab\_powerpoles
- 03\_downtown\_block\_ab\_props
- 03\_downtown\_block\_ab\_vegetation
- 03\_downtown\_block\_b\_baked\_vegetation
- 03\_downtown\_block\_b\_buildings
- 03\_downtown\_block\_b\_decals
- 03\_downtown\_block\_b\_lights\_street
- 03\_downtown\_block\_b\_powerpoles
- 03\_downtown\_block\_b\_props
- 03\_downtown\_block\_b\_vegetation
- 03\_downtown\_block\_c\_baked\_vegetation
- 03\_downtown\_block\_c\_buildings
- 03\_downtown\_block\_c\_decals
- 03\_downtown\_block\_c\_lights\_street
- 03\_downtown\_block\_c\_powerpoles
- 03\_downtown\_block\_c\_props
- 03\_downtown\_block\_c\_vegetation
- 03\_downtown\_block\_d\_baked\_vegetation
- 03\_downtown\_block\_d\_buildings
- 03\_downtown\_block\_d\_decals
- 03\_downtown\_block\_d\_lights\_street
- 03\_downtown\_block\_d\_powerpoles
- 03\_downtown\_block\_d\_props
- 03\_downtown\_block\_d\_vegetation
- 03\_downtown\_block\_e\_baked\_vegetation

4162 selected

Scene 4162 selected No axis Pivot rotation <multiple layers> 336.3081 1232.11 14.0404 0. 0. -43.904 1 6 4 Fit to Render View SelOrg





gdc\_hok\_screen\_render\_downtown - World Forge x Fusion 3.17.10.0

File Edit View Create Tools Material Effects AI Game Audio Physics Window

Scene Outliner Group Render View

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- 03\_downtown\_block\_a\_lights\_street
- 03\_downtown\_block\_a\_powerpoles
- 03\_downtown\_block\_a\_props
- 03\_downtown\_block\_a\_vegetation
- 03\_downtown\_block\_ab\_baked\_vegetation
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- 03\_downtown\_block\_b\_baked\_vegetation
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- 03\_downtown\_block\_b\_lights\_street
- 03\_downtown\_block\_b\_powerpoles
- 03\_downtown\_block\_b\_props
- 03\_downtown\_block\_b\_vegetation
- 03\_downtown\_block\_c\_baked\_vegetation
- 03\_downtown\_block\_c\_buildings
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- 03\_downtown\_block\_c\_vegetation
- 03\_downtown\_block\_d\_baked\_vegetation
- 03\_downtown\_block\_d\_buildings
- 03\_downtown\_block\_d\_decals
- 03\_downtown\_block\_d\_lights\_street
- 03\_downtown\_block\_d\_powerpoles
- 03\_downtown\_block\_d\_props
- 03\_downtown\_block\_d\_vegetation
- 03\_downtown\_block\_e\_baked\_vegetation

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Scene 4162 selected No axis Pivot rotation <multiple layers> 336.3081 1232.11 14.0404 0 0 -43.904 1 6 4 Fit to Render View SelOrg





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- para\_kanal\_01\_z9
- para\_kanal\_b\_z
- para\_kanal\_b\_z1

Multiple selection: 2476 Frames

WeatherPresets

MAP CITY OF EMPIRE BAY

Global Sun Glow Wind Clouds Fog Rain Snow Li

Traffic (%) 100 Pedestrians (%) 100 Parked cars (%) 50 Headlights (%) 0 Night emissivity 1.00 Post process <- Select value ->

Lamps Shop lights Traffic lights Signal lights Advert. lights Other night lights

Day template DT12\_part\_all March 2018

|     |     |     |
|-----|-----|-----|
| Mon | Tue | Wed |
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| 12  | 13  | 14  |
| 19  | 20  | 21  |

Time: TT12\_part\_all

Properties View Properties WeatherPresets

camera\_pz -1552.46;-114.03;206.01 29.41 FPS Generic Local 50 m/s EDIT Mode petr3\_2018





\_\_test\_pzavesky\_\_map\_render\_downtown - World Forge x Fusion 3.17.10.0

File Edit View Create Tools Material Effects AI Game Audio Physics Window

Group Render View

19201 selected

Scene 19201 selected No axis Pivot rotation 243.1772 818.8552 264.2544 42.485 -16.262 18.573 1 4 4 Fit to Render View SelOrg

NEW BORDEAUX STREET AND GUIDE MAP

LEWIS SPRINGS

MAP LEGEND

- Streets
- Buildings
- Water
- Greenery
- Landmarks
- Points of Interest
- Public Buildings
- Industrial Buildings
- Commercial Buildings
- Residential Buildings
- Government Buildings
- Religious Buildings
- Educational Buildings
- Medical Buildings
- Entertainment Buildings
- Other Buildings





X-editor 72897+ - DLC\_Supermarket\_x - Supermarket

File Edit View Mouse Create Material Audio Entity Windows Plugins Help

Entity List

- Temporary
  - entity\_destro.bin
    - C\_CrashObject
      - SM\_00
      - SM\_03
      - SM\_04
      - SM\_6900
      - SM\_crash\_window\_for\_car00
      - SM\_MP00
      - SM\_REGALxxx\_BIG00
      - SM\_REGALxxx\_BIG01
      - SM\_REGALxxx\_BIG02
      - SM\_REGALxxx\_BIG03
      - SM\_REGALxxx\_BIG04
      - SM\_REGALxxx\_BIG05
      - SM\_REGALxxx\_BIG06
      - SM\_REGALxxx\_BIG08
      - SM\_REGALxxx\_BIG15
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      - SM\_REGALxxx\_BIG19
      - SM\_REGALxxx\_BIG20
      - SM\_REGALxxx\_BIG21
      - SM\_REGALxxx\_BIG23
      - SM\_REGALxxx\_BIG24
      - SM\_REGALxxx\_BIG27
      - SM\_REGALxxx\_MIDD00
      - SM\_REGALxxx\_MIDD01
      - SM\_REGALxxx\_MIDD02
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      - SM\_REGALxxx\_MIDD05
      - SM\_REGALxxx\_MIDD06
      - SM\_REGALxxx\_MIDD07
      - SM\_REGALxxx\_MIDD08
      - SM\_REGALxxx\_MIDD12
      - SM\_REGALxxx\_MIDD13
      - SM\_REGALxxx\_MIDD14
      - SM\_REGALxxx\_SMALL01
      - SM\_REGALxxx\_SMALL02
      - SM\_REGALxxx\_SMALL03
      - SM\_REGALxxx\_SMALL04
      - SM\_REGALxxx\_SMALL05
      - SM\_REGALxxx\_SMALL06
      - SM\_REGALxxx\_SMALL07
      - SM\_REGALxxx\_SMALL08
      - SM\_REGALxxx\_SMALL09
      - SM\_REGALxxx\_SMALL10
      - SM\_REGALxxx\_SMALL11

Debug | Scene T Entity List | Materia

No selection

BaseCamera -1519.43:-356.83:12.43 115.78 FPS Generic World 10 m/s EDIT Mode petr3 2018

WeatherPresets

Time template

<- Select value ->

Sun  Moon

Axis deflection:

Z axis 30.00

Y axis 20.00

Curve limits:

Start 5.00

End 19.00

Horizon angle:

Sun 15.00

Preview

0

Play Pa

Time (game vs real): 3

Weather template

<- Select value ->

Global Sun Glow

Traffic (%) 10

Pedestrians (%) 10

Parked cars (%) 50

Headlights (%) 0

Night emissivity 1.

Post process <-

Day template

DT\_JA\_FreeRideDay

Save Reset

Time: TT\_JA\_FreeRi

Weather: WT\_JA\_FreeRi

Winter





The screenshot shows the Unreal Engine 4 editor interface. The main viewport displays a 3D model of a supermarket interior with various shelves, aisles, and a central display. The Entity List on the left shows a hierarchy of objects, including a 'Temporary' folder containing 'entity\_destro.bin' and a 'C\_CrashObject' folder containing numerous 'SM' (Static Mesh) objects. The WeatherPresets panel on the right shows settings for a 'Time template' (Sun/Moon), 'Axes deflection' (Z axis: 30.00, Y axis: 20.00), 'Curve limits' (Start: 5.00, End: 19.00, Horizon angle: Sun 15.00), and 'Weather template' (Global/Sun/Glow) with sliders for Traffic, Pedestrians, Parked cars, Headlights, Night emissivity, and Post process. The status bar at the bottom indicates 'BaseCamera -1519.43:-356.83:12.43 115.78 FPS Generic World 10 m/s EDIT Mode petrz 3 2018'.

Multiple selection: 185 Frames





bc\_loc\_grocery\_01 - World Forge\* x Fusion 3.17.10.0

File Edit View Create Tools Material Effects AI Game Audio Physics Window

Scene Outliner Group Render View

Search...

| Objects                                   | Layers                                     | Types                                         |
|-------------------------------------------|--------------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> 6_Alpha_Approved | <input type="checkbox"/> Backyard_props    | <input type="checkbox"/> bc_02_industryrow    |
| <input type="checkbox"/> 7_Beta_Approved  | <input type="checkbox"/> bc_01_french_east | <input type="checkbox"/> bc_03_downtown       |
| <input type="checkbox"/> Approved         | <input type="checkbox"/> bc_01_french_west | <input type="checkbox"/> bc_03_downtown_south |

bc\_loc\_grocery\_01

- bc\_loc\_grocery\_01\_baked
- rain\_mask
- sun\_shade
- uni\_grocery\_backyard\_ground\_lod0
- uni\_grocery\_entrance\_corner\_panel\_A\_lod0
- uni\_grocery\_entrance\_corner\_panel\_B\_lod0
- uni\_grocery\_entrance\_panel\_A\_lod0
- uni\_grocery\_entrance\_panel\_B\_lod0
- uni\_grocery\_entry\_area\_lod0
- uni\_grocery\_exterior\_lod0
- uni\_grocery\_sign\_lod0
- uni\_grocery\_storage\_exterior\_lod0
- uni\_grocery\_storage\_roof\_A1\_lod0
- uni\_grocery\_storage\_roof\_A2\_lod0
- uni\_grocery\_wall\_lod0
- bc\_loc\_grocery\_01\_decals
- bc\_loc\_grocery\_01\_design\*
- bc\_loc\_grocery\_01\_geometry
- bc\_loc\_grocery\_01\_lights\_grocery\_back\_stockrooms\*
- bc\_loc\_grocery\_01\_lights\_grocery\_bakery\_meat\*
- bc\_loc\_grocery\_01\_lights\_grocery\_center\_area\*
- bc\_loc\_grocery\_01\_lights\_grocery\_exterior\*
- bc\_loc\_grocery\_01\_lights\_grocery\_upper\_rooms\*
- bc\_loc\_grocery\_01\_reflection
- bc\_loc\_grocery\_01\_tubtarget
- bc\_loc\_grocery\_01\_lod0
- bc\_loc\_grocery\_01\_vfx\_fog
- bc00\_geometry
- bc00\_water
- enlighten
- entity\_grocery\_exterior\*
- entity\_grocery\_interior\*
- baking\_tray
- bc\_1\_gallon\_paint\_can\_a\_00
- bc\_1\_gallon\_paint\_can\_b\_01
- bc\_1\_gallon\_paint\_can\_c\_00

Scene 2074 selected No axis 247.8651 2780.004 21.02497 0. 0. 89.844 1 3 4 Fit to Render View SelOrg





bc\_loc\_grocery\_01 - World Forge\* x Fusion 3.17.10.0

File Edit View Create Tools Material Effects AI Game Audio Physics Window

Scene Outliner Group Render View

Search...

| Objects                                   | Layers                                     | Types                                         |
|-------------------------------------------|--------------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> 6_Alpha_Approved | <input type="checkbox"/> Backyard_props    | <input type="checkbox"/> bc_02_industryrow    |
| <input type="checkbox"/> 7_Beta_Approved  | <input type="checkbox"/> bc_01_french_east | <input type="checkbox"/> bc_03_downtown       |
| <input type="checkbox"/> Approved         | <input type="checkbox"/> bc_01_french_west | <input type="checkbox"/> bc_03_downtown_south |

bc\_loc\_grocery\_01

- bc\_loc\_grocery\_01\_baked
- rain\_mask
- sun\_shade
- uni\_grocery\_backyard\_ground\_lod0
- uni\_grocery\_entrance\_corner\_panel\_A\_lod0
- uni\_grocery\_entrance\_corner\_panel\_B\_lod0
- uni\_grocery\_entrance\_panel\_A\_lod0
- uni\_grocery\_entrance\_panel\_B\_lod0
- uni\_grocery\_entry\_area\_lod0
- uni\_grocery\_exterior\_lod0
- uni\_grocery\_sign\_lod0
- uni\_grocery\_storage\_exterior\_lod0
- uni\_grocery\_storage\_roof\_A1\_lod0
- uni\_grocery\_storage\_roof\_A2\_lod0
- uni\_grocery\_wall\_lod0
- bc\_loc\_grocery\_01\_decals
- bc\_loc\_grocery\_01\_design\*
- bc\_loc\_grocery\_01\_geometry
- bc\_loc\_grocery\_01\_lights\_grocery\_back\_stockrooms\*
- bc\_loc\_grocery\_01\_lights\_grocery\_bakery\_meat\*
- bc\_loc\_grocery\_01\_lights\_grocery\_center\_area\*
- bc\_loc\_grocery\_01\_lights\_grocery\_exterior\*
- bc\_loc\_grocery\_01\_lights\_grocery\_upper\_rooms\*
- bc\_loc\_grocery\_01\_reflection
- bc\_loc\_grocery\_01\_tubtarget
- bc\_loc\_grocery\_01\_lod0
  - bc\_loc\_grocery\_01\_vfx\_fog
- bc00\_geometry
- bc00\_water
- enlighten
- entity\_grocery\_exterior\*
- entity\_grocery\_interior\*
- baking\_tray
  - bc\_1\_gallon\_paint\_can\_a\_00
  - bc\_1\_gallon\_paint\_can\_b\_01
  - bc\_1\_gallon\_paint\_can\_c\_00

Scene 2074 selected No axis 247.8651 2780.004 21.02497 0. 0. 89.844 1 3 4 Fit to Render View SelOrg





# Pain points

World editor

Difficult to use pipelines

Very bad iteration times

No asset management

Code bound entity system





# Goals

More accessible tools

Able to deal with large amounts of data

Data driven





# Major changes

New world editor

New object system

Build system

Local iteration

Visual scripting

Middleware integration

Physics

Animation

Navigation

UI

Audio

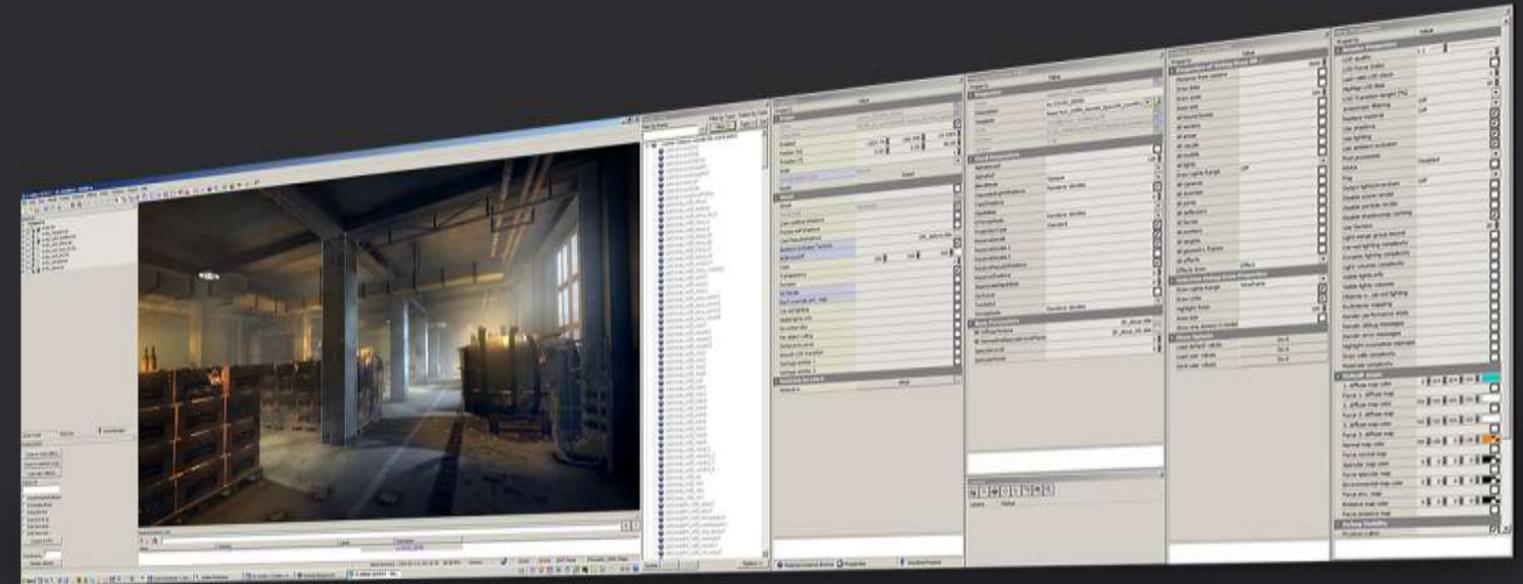




# World editor

## Object system

## Deployment





# Old World Editor

Bread and butter for most content creators

Obsolete technology used (WinAPI)

Difficult to extend

We had lot of other C# based tools





# New world editor goals

Increase productivity

Simple to extend

Production ready ASAP





# New world editor decisions

New tool in C#/WPF w/ DevExpress

Integrate old editor plugins in new editor

Use C++/CLI for engine communication

Get users involved early on





# C# and WPF

It is indeed faster to write tools

Difficult to write responsive tools

It is difficult to hire engineers with WPF experience

DevExpress has its issues

DirectX9 support only





# Integrate old editor plugins

WinAPI plugins fluently integrated in .NET app

There is a price

- Performance of whole editor
- Old plugins don't fit nicely





The screenshot displays the Unity 3.17.10.0 development environment. The central 3D view shows a dark-colored car model on a grid floor. The interface is divided into several panels:

- Scene Outliner:** Lists the current scene hierarchy, including `_test_basic`, `_test_basic_scripts`, `_test_basic_viscripts`, `smith_mainline_p_bv_00`, `entity`, `scene111`, and `scene888`.
- Group Render View:** Shows the car model with a green wireframe bounding box around it.
- Properties:** Displays the properties for the selected `smith_mainline_p_bv_00` object, including position, rotation, and scale. It also lists components like `FramePropComponent`, `KitComponent`, `NavObjectCoverComponent`, `GameAudioRainComponent`, `SysAudioObjectComponent`, and `EntityWrapperComponent`.
- Frame Properties:** Shows a detailed list of frame properties for the `smith_mainline_p_bv_00` frame, such as `Scale bone`, `bumperB`, `licence_plateB`, `doorBR`, `SEAT03`, `SEAT02`, `SEAT0`, `SEAT1`, and `Rest bone`.
- Materials View:** Lists various material files used in the scene, including `smith_mainline_p_body.xml`, `smith_mainline_p_interior.xml`, `new_plates.xml`, `lights_in.xml`, `lights_spz_opaque.xml`, `smith_mainline_p_chrome.xml`, `glass_universal.xml`, and `lights_spz.xml`.
- Default Properties:** A panel on the right showing various default properties for the model, such as `ACTIVATE IMPULSE` (DISABLED), `ACTIVATE POWER` (DISABLED), `HITPOINTS` (-1 hp), `HUMAN COLLISION RULE` (COLLIDE), `DEACTIVATE THRESHOLD` (HIGH), and `CAMERA COLLISION` (ON).

The bottom status bar shows the current scene is `smith_mainline_p_bv_00` and provides navigation and view controls.





# Use C++/CLI for engine communication

It looks ugly and doesn't support modern C++

Linking was very expensive

Debugging is slow and not reliable





# Get users involved early on

Shared ownership

Iterative development based on early feedback

Trap of too many iterations

Dealing with layout/colors too soon





# Lesson learned

C# and DevExpress was a good choice

WPF not so much

C++/CLI was a terrible choice

Involving users early on is great

Keeping WinAPI plugins was necessary





# World editor Object system Deployment





# New object system

Asset and file management

Inheritance and grouping

Empowering content creators





# Asset and file management goals

Easy tracking of dependencies

Support binary & text format with minimal effort

Identify objects by ID

Backward and forward compatible





# Asset and file management decisions

Use C++ Reflection for serialization

**Every** object has a unique identifier





# Use C++ Reflection for serialization

Very simple for engineers to expose data

Macro based internal framework





```
BEGIN_REFLECTION_DEFINITION(C_SkeletonComponent)
  BEGIN_REFLECTION_ATTRIBUTES();
    ADD_REFLECTION_ATTRIBUTE(m_ImmutableData);
    ADD_REFLECTION_ATTRIBUTE(m_VirtualBoneImmutableData);
    ADD_REFLECTION_ATTRIBUTE(m_WorldAABB);
    ADD_REFLECTION_ATTRIBUTE(m_LocalAABB);
    ADD_REFLECTION_ATTRIBUTE(m_SkeletonActivation);
  END_REFLECTION_ATTRIBUTES();
END_REFLECTION_DEFINITION();
DEFINE_RTTI(C_SkeletonComponent, 0x0fa73185);
```





# Use C++ Reflection for serialization

Very simple for engineers to expose data

Reasonable backward and forward compatibility

No need for versioning system

Strong code-data dependency





# Every object has a unique ID

Free movement of assets around

Service reading TOC and tracking IDs

Easy to query for dependencies

There were a lot of objects

We had to disable them for some classes





# Unique ID system issues

Service on the background is quite annoying

You can't copy files anymore

Export from external tools is tricky





# Inheritance system

Increase reusability of assets

Easy to use

- By engineers

- By content creators

Ability to override anything





# Inheritance system

Dealt within serialization code

Based on reflection and unique IDs

No restrictions of what can be modified





# Inheritance system

It worked out great

But...

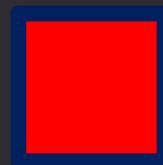
Comparing parent with child on save is fragile



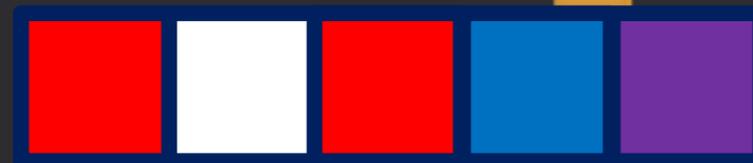


# Inheritance system

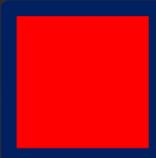
Parent



Child



Stored data

Add  after 2nd





# Inheritance system

It worked out great

But...

Comparing parent with child on save is fragile

Resave dependents





# Inheritance system

Expectation

Vase ID:  
0xff9e6565a0159a6e  
0x8466158f84f60f15



Resource A

Last save: Vase



Resource B

Red table



Resource C

Yellow vase





# Resave dependents

We didn't figure out how to fix in production

Introduced a "feature" to resave dependents

Very difficult to understand when to use it





# Empowering content creators

Ability to compose objects

Grouping of objects together

Object level scripting using visual language





# Flexibility advantages

Content creators got more powerful

Very fast prototyping of new features

Some prototypes can turn into features as is





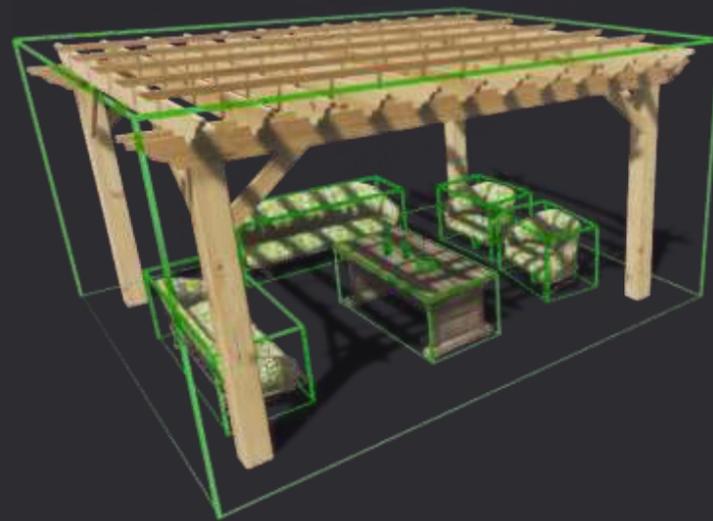
# Flexibility disadvantages

Loss of control





# Expectation



13 objects

# Reality



1006 objects





# Flexibility disadvantages

Loss of control

Generic approach is not always great

Object level scripting is scary





# Lesson learned

Having unique ID per object is great

Generic Inheritance system based on comparing parent with child is tricky

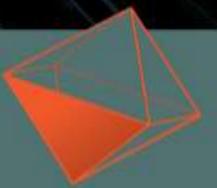
Giving power to user exceeded our expectation

Everything that the tech allows will be used





# World editor Object system Deployment





# Context for release

Production started before we were done

We spent a year in isolation

Painful merges from main branch

Long data conversions





# Changing plans

World Editor and Object system together

Changed our mind on backward compatibility





# QA testing

QA involved

Very early for tools

Just 3 months before deployment for game

Game testing was simple

World editor testing was not very effective





# Power user testing

Power user group assembled!

We got better feedback

Quality of feedback declined rapidly

Lost focus on throw away work

Importance of having real goals





# Training people

Power users helped again

Presentations of new tools and concepts

Workstation with new World Editor





# Last days before deployment

Merging to new engine branch every day

Locking tricky content on main branch

Moving some gameplay engineers ahead of time





# D-Day

Friday everyone submits and go home early

Dealt with the move over weekend

Monday everyone goes to office and starts working  
on new branch

Production helped with setting up everyone





# Post deployment

Issues not found by Power users or QA

Found few rare workflows engineers didn't know about

Early feedback not very positive





# Deployment lessons

Deployment breaks illusions

Testing on artificial content is not effective

Missing documentation/explanations

New features were misused or misunderstood

- Inheriting object instead of copying

- Still copying files outside of our tools





# First year after deployment

Latent issues like resave dependents

Lot of bullet proofing

Explosion of new components





# Conclusion

Upgraded to modern engine

Faster learning curve for new users

Consistent control for editor

Deployment during production is not fun





# Bright future

We were mature on release

DLC production proved the technology





# Thanks! Questions?

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