

GDC[®]

Rebuilding Your Engine During Development: Lessons from

MAFIAIII

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Technical Director

Hangar 13 games

GAME DEVELOPERS CONFERENCE[®] | MARCH 19-23, 2018 | EXPO: MARCH 21-23, 2018 #GDC18







Mafia III overview

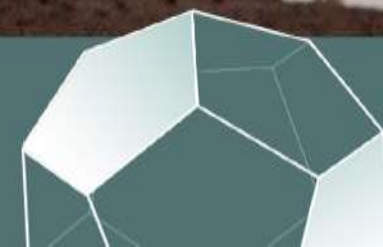
Open world, 3rd person, action adventure

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

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camera_pz -1552.46;-114.03;206.01 29.41 FPS Generic Local 50 m/s EDIT Mode petrz_3_2018

WeatherPresets

Time template

Sun Moon

Axes deflection:

Z axis -2.70

Y axis 23.00

Curve limits:

Start 5.00

End 19.00

Horizon angle:

Sun 20.00

Curve visualization

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

Save Reset Delete

Time: TT12_part_all

March 2018

Mon	Tue	Wed
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- newsbox_z_07
- newsbox1
- newstand_new
- para_kanal_01_z
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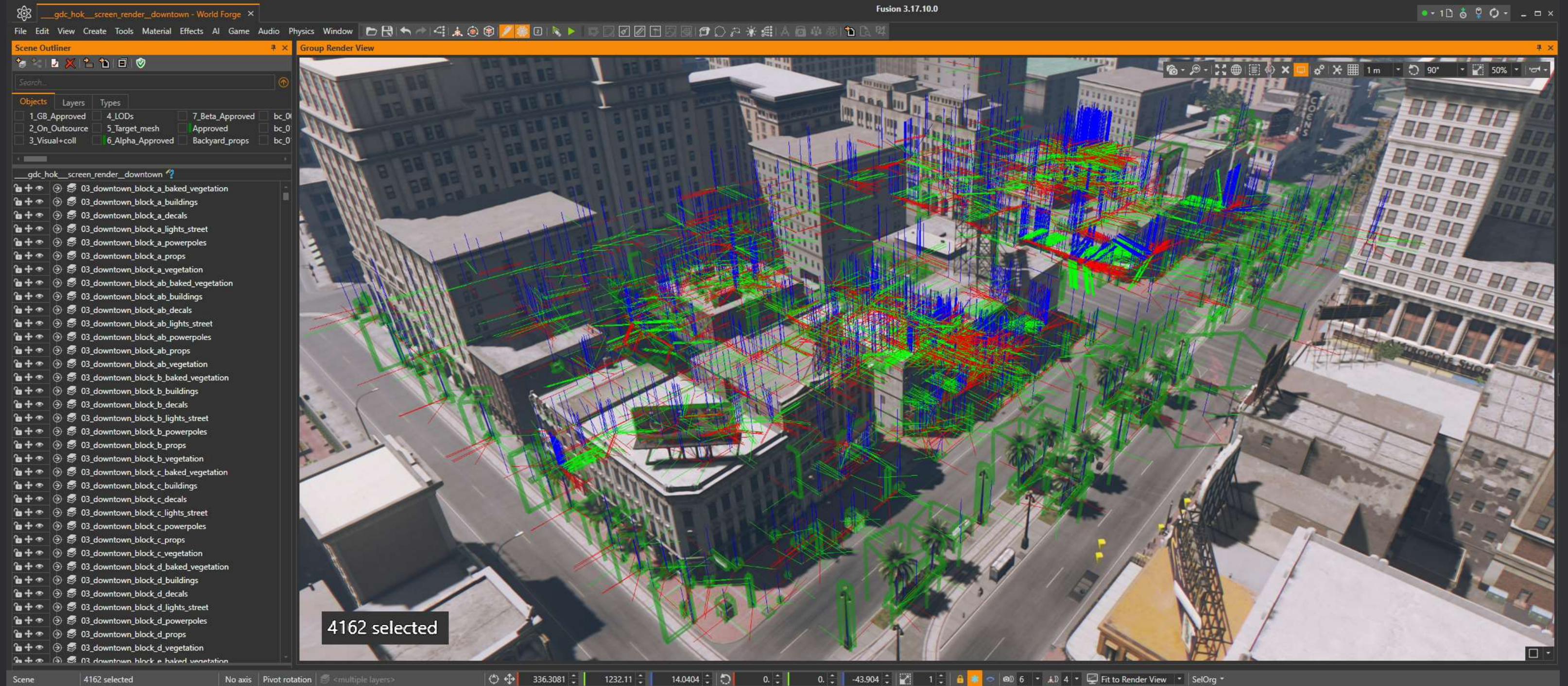
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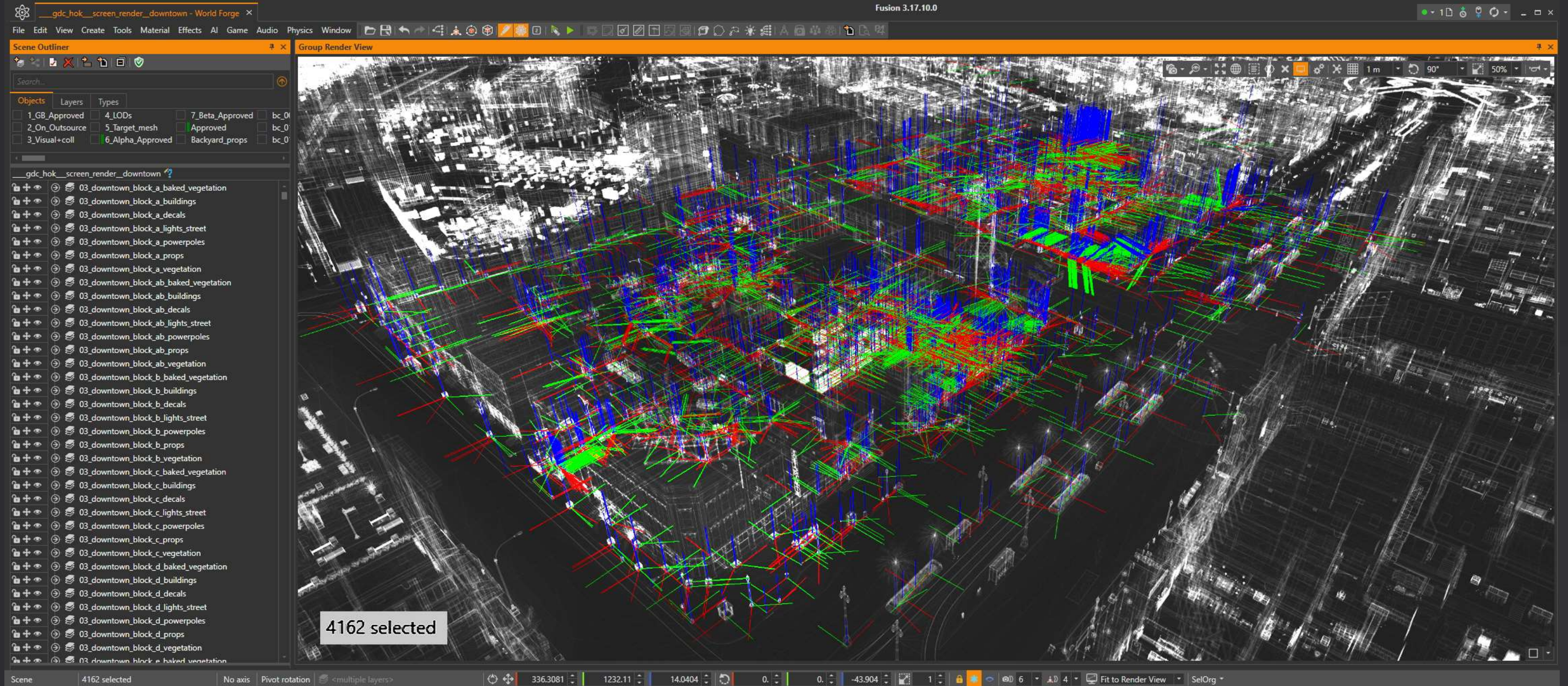
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- newsbox_z_02
- newsbox_z_07
- newsbox1
- newstand_new
- para_kanal_01_z
- para_kanal_01_z1
- para_kanal_01_z10
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WeatherPresets

MAP CITY OF EMPIRE BAY

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camera_pz -1552.46;-114.03;206.01 29.41 FPS Generic





test_pzavesky_map_render_downtown - World Forge

Fusion 3.17.10.0

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

Group Render View

1 m 90° 50%

19201 selected

Scene 19201 selected No axis Pivot rotation

243.1772 818.8552 264.2544 42.485 -16.262 18.573

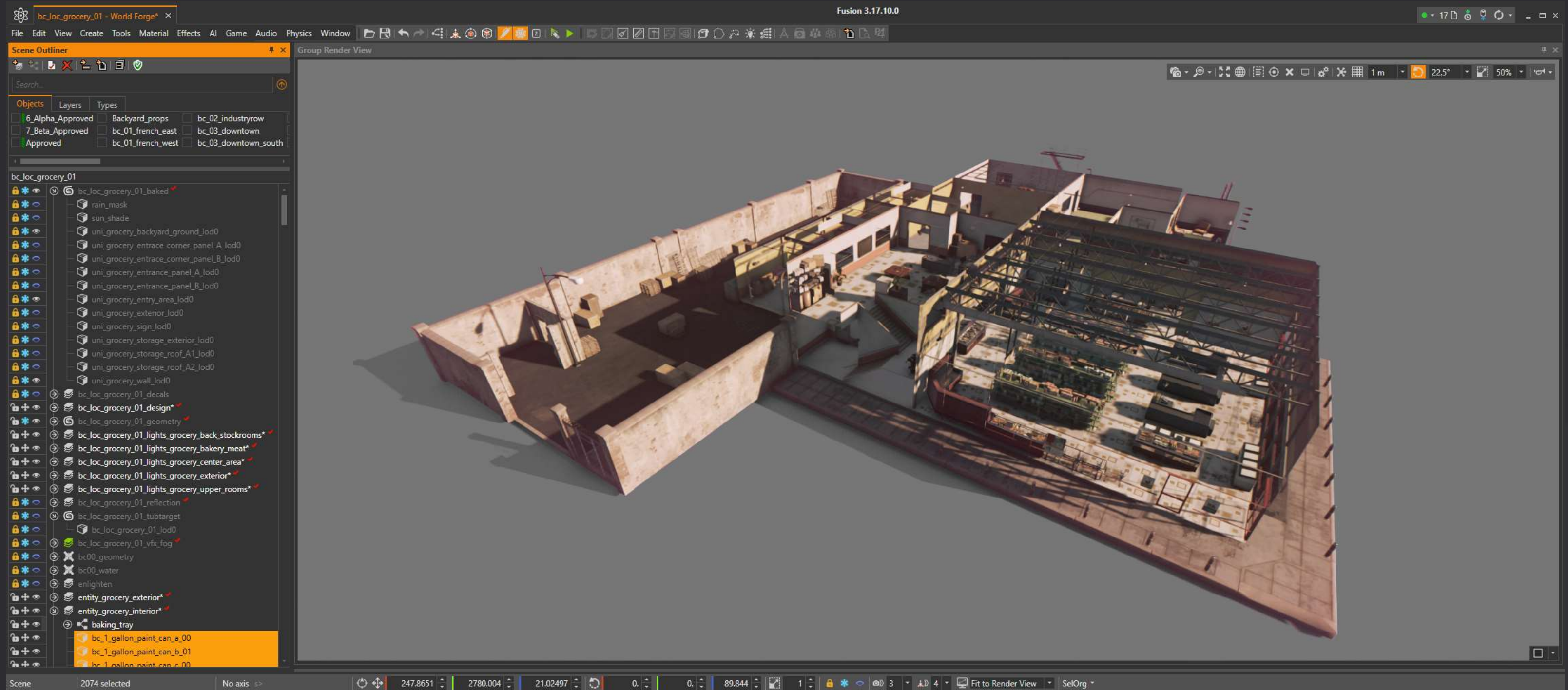
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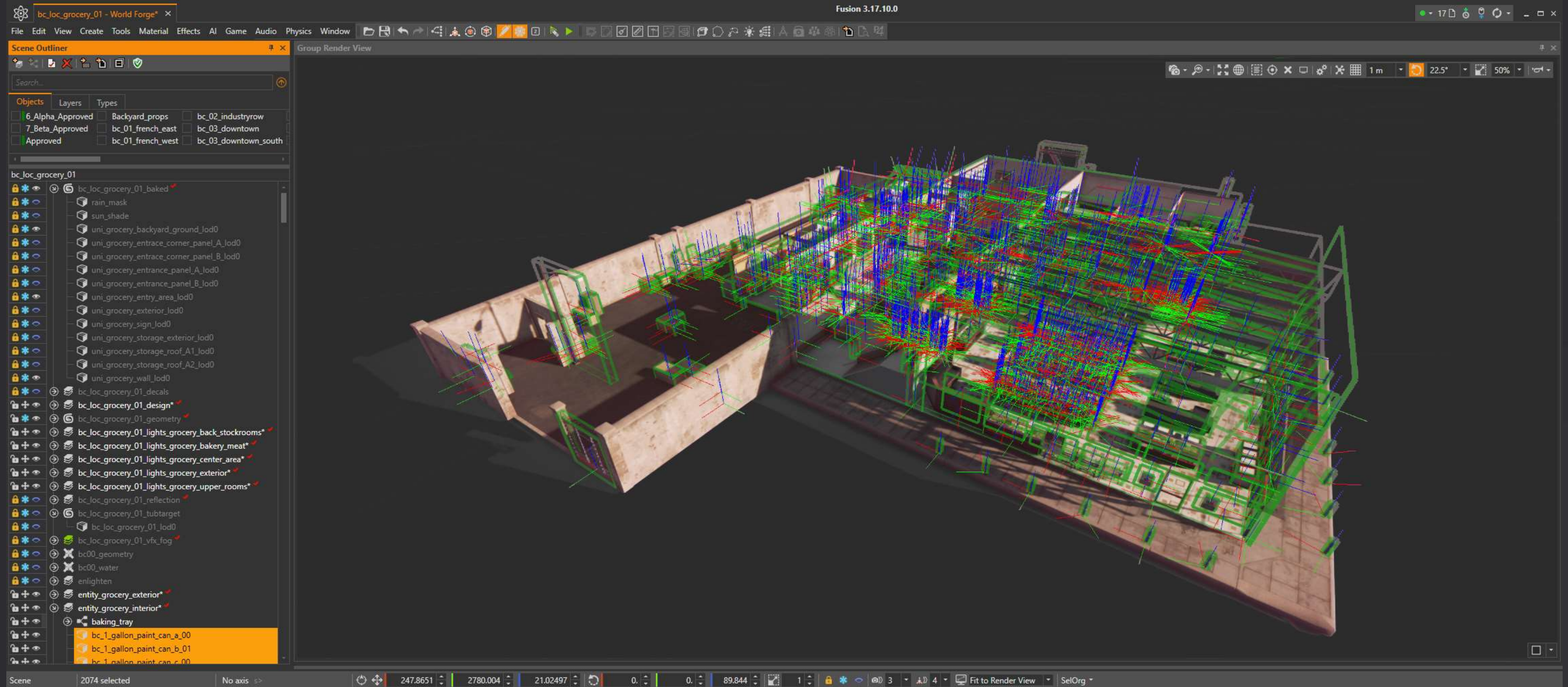
Fit to Render View SelOrg













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

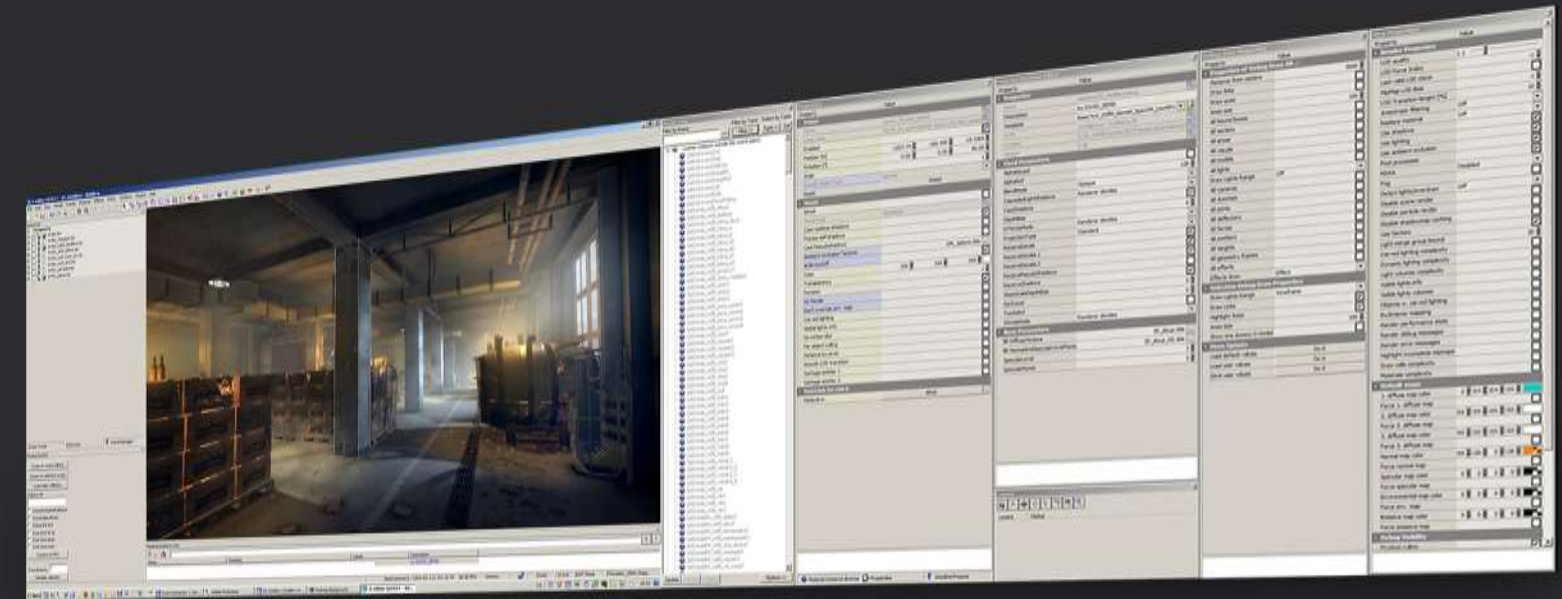




World editor

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

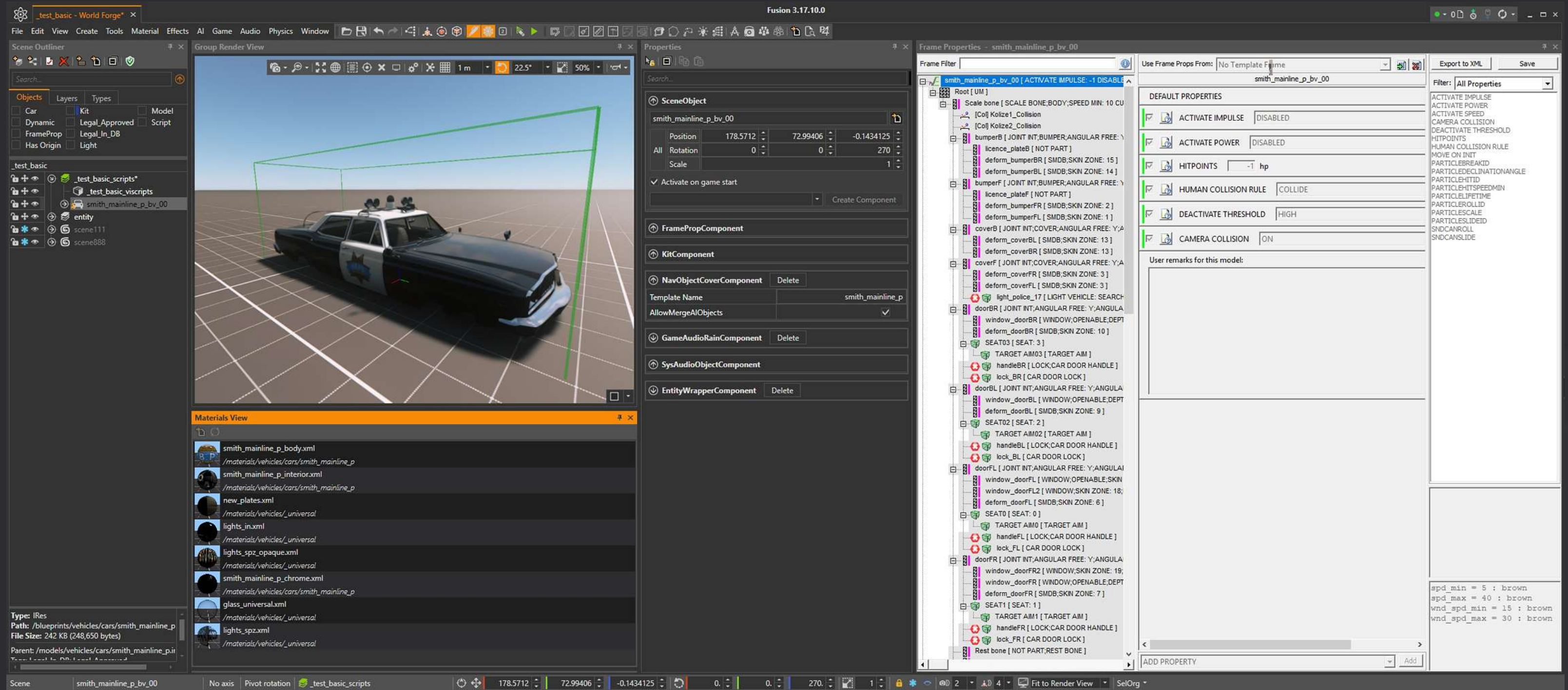
WinAPI plugins fluently integrated in .NET app

There is a price

- Performance of whole editor

- Old plugins don't fit nicely







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...

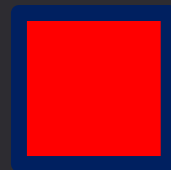
Comparing parent with child on save is fragile





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





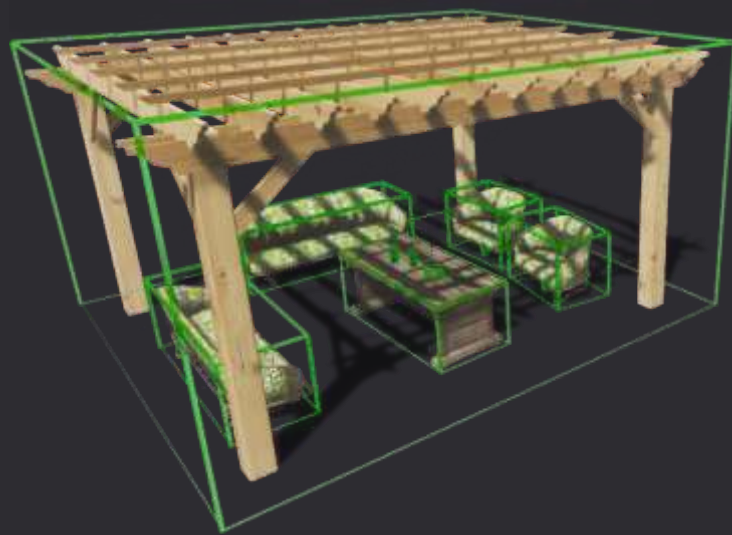
Flexibility disadvantages

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

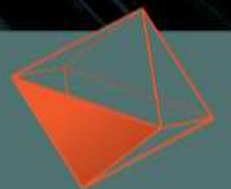
Giving power to user exceeded our expectation

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?

Jan Kratochvil

jan.kratochvil@2kgames.com

<https://hangar13games.com>

