GDC 10 Europe

Rigged To Blow:
Powerplay Pipeline for

Matthew Rubin
Lead Programmer
Infrastructure Team
Black Rock Studio

Disney Interactive Studios

Blackrock Studio

UBM TechWeb

Trailer

Disney INTERACTIVE STUDIOS

BLACKROCK STUDIO

Smoke and Mirrors

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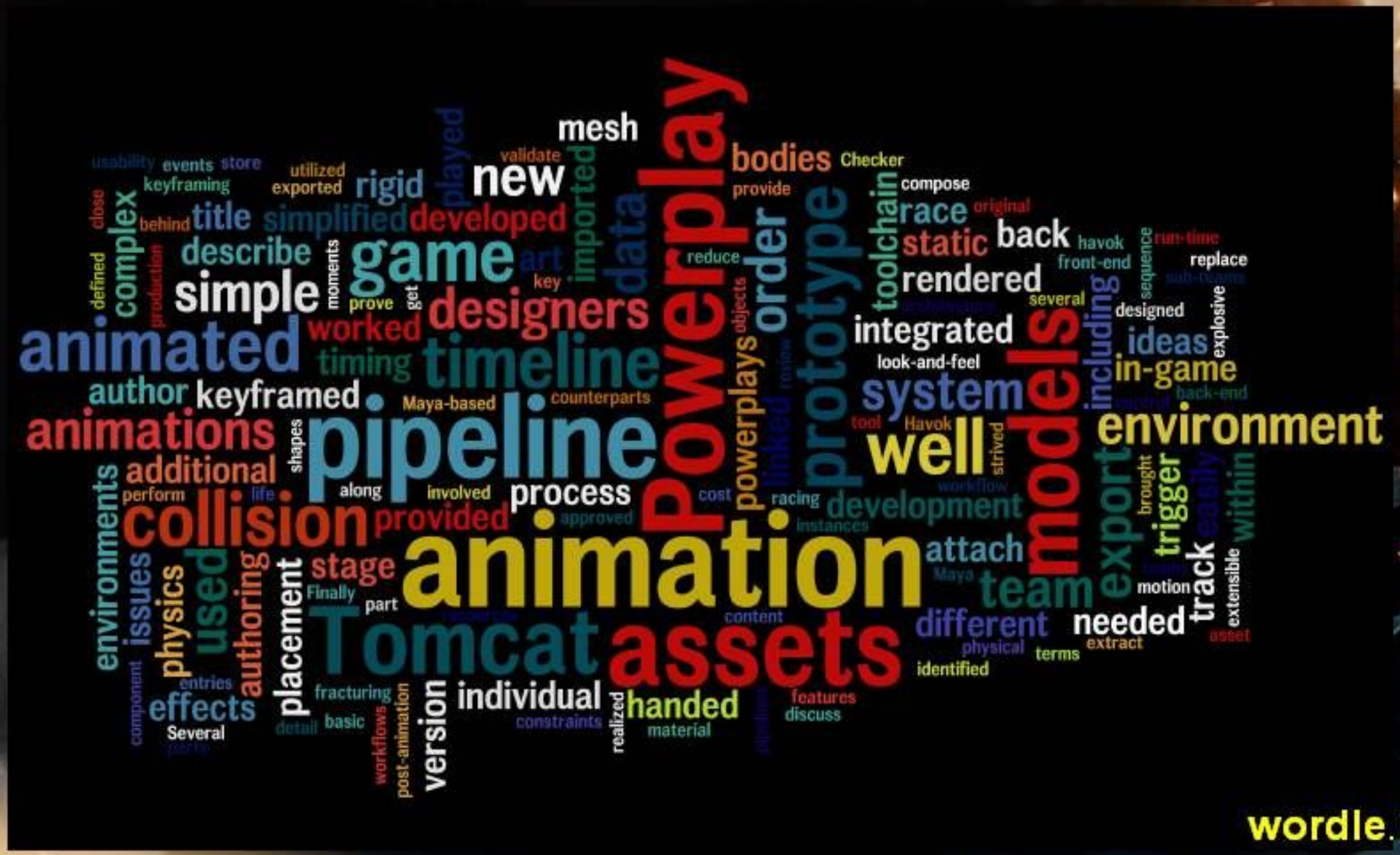
Introduction



Outline

- Part I
  - Background
  - Requirements and Tech Design
  - Pipeline Overview

Outline

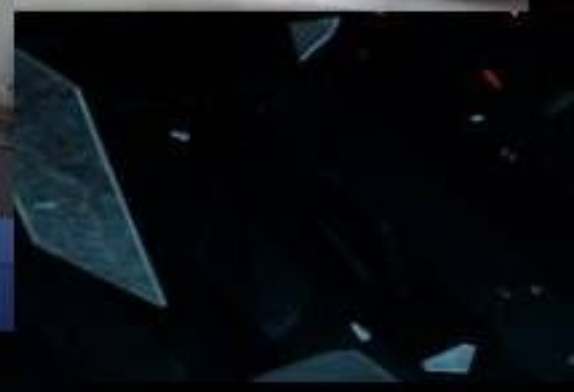
- Part II
  - Pipeline Intro
  - Prototype Pipeline
  - Production Pipeline
  - Timeline Framework

Outline

- Part III
  - Rapid iteration
  - Troubleshooting
  - Performance
  - Usability

Black Rock Studio

- Studio Culture
  - Specializing in Racing games
  - Based in Brighton
  - Acquired by Disney in 2006
- Recent games
  - Pure
  - Split/Second



GAME CRITICS AWARD 08 WINNER

GAME CRITICS AWARD 09 WINNER

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Background

- Split/Second dev began in 2007
  - Focus on innovation
    - Original game concept in racing space
    - Destructible environments as a game mechanic
      - Essentially a ‘weapon’ to take out opponents
    - “Every lap is different”
      - Routes change dynamically throughout the race
    - Set the bar high for visual quality
      - Epic effects with cinematic look-and-feel

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Early Days

- Picked up by MotoGP'07 team after ship
  - Had lots of talent and experience
    - Ambitious feature set that didn't play to our strengths
  - Team structure split by discipline
    - Needed to establish new workflow for content creation
  - Tools needed new features for game requirements
    - Animation authoring
    - Composition of Time-based objects
    - Rapid prototyping and Play testing

What is a Powerplay?

- Large scale set-piece
  - Environment specific
  - Built-to-suit
  - Multi-stage Route changers
- Smaller scale animated props
  - Reusable across levels
  - Can be easily placed in multiple locations
- Short-cuts

What is a Set-Piece?

- "...a scene or sequence of scenes the execution of which requires ***serious logistical planning*** and considerable expenditure of money"
- "...often used more broadly to describe any important dramatic [or comedic] highpoint in a film or story, particularly those that provide some kind of ***dramatic payoff, resolution, or transition***"

http://en.wikipedia.org/wiki/Set_piece_(film)

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Powerplay Examples

- Downtown
  - Tower Collapse
  - Heli-tunnel Demolition
  - Exploding Petrol Station
- Generic
  - Wrecking Ball
  - Exploding Bus
  - Claw Crane

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Economy of Scale

- Downtown stats
  - 82 powerplays
  - 97 triggers
  - 525 timelines
  - 1013 animations
  - 2503 bones
  - 6004 particle systems
  - 220 rigid bodies

Tech Requirements

- Triggered destruction events
  - Dynamically modify circuit at runtime
- Sequencing of animated instances
  - Control playback of multiple animations over time
- Animated collision support
  - Transform rigid bodies along w/ rendered animation
- Tool-Driven Pipeline – sandbox to play in!
- Performance - Maintain 30 fps!

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Tech Design

- Skeletal animation engine
  - Simple and scalable
- Deterministic collisions for predictable outcome
  - Use key-framed motion on rigid bodies
  - Rigid body transform driven by bone matrices
- Timeline system
  - Class architecture provided extensible framework for time-based objects

Tech Arsenal

- Lot of good tech in our studio
  - Heavy use of existing internal tools
    - Tomcat, Nipple, Moses
- Leverage 3rd party applications and middleware where applicable
  - Maya
  - Havok

Tech Strategy

- Author rigged models and skeletal animation clips in Maya
  - Including support for collision attachment
- Assemble multiple animated instances onto Timeline in Tomcat
- Add Timeline to Powerplay
- Place Powerplay into static environment and link to trigger box

Anatomy of a Powerplay

- Powerplay is container file for Timeline instances
- Timeline is container file for animated instances (and other timeline entries)
  - Timelines can also include other timelines
- Single Powerplay consists of several layers of nested instances
  - Complicates asset management

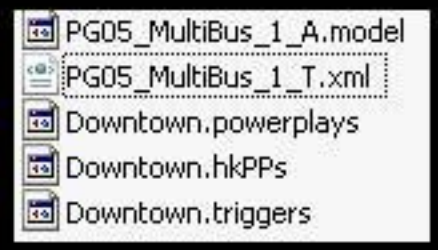
Pipeline Overview

Animation Authoring

Skinned Model
Animation
Rigid Bodies

Timeline Authoring

Powerplay Authoring



Runtime Assets

In-Game Playtesting

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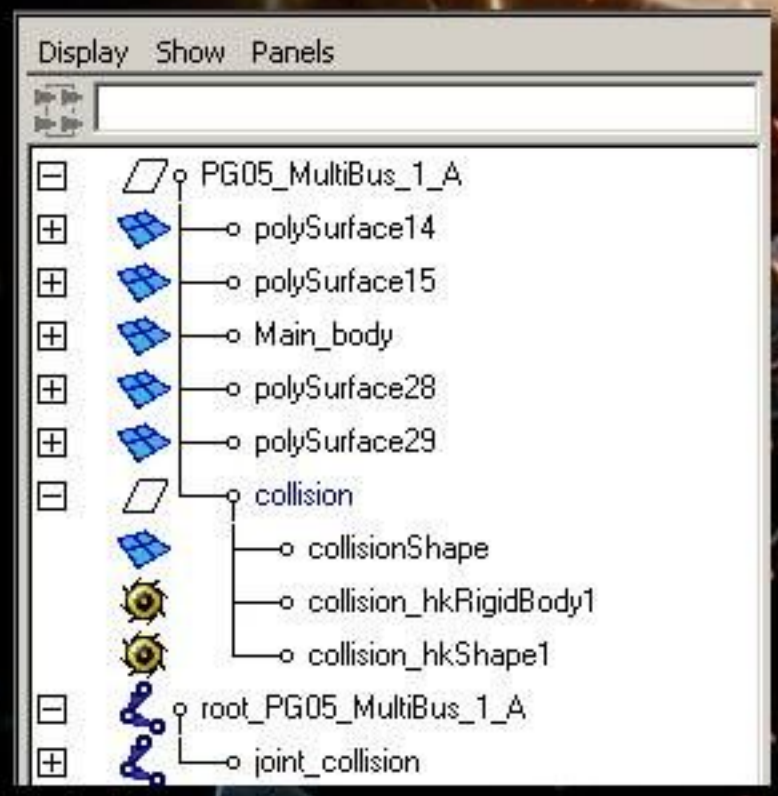
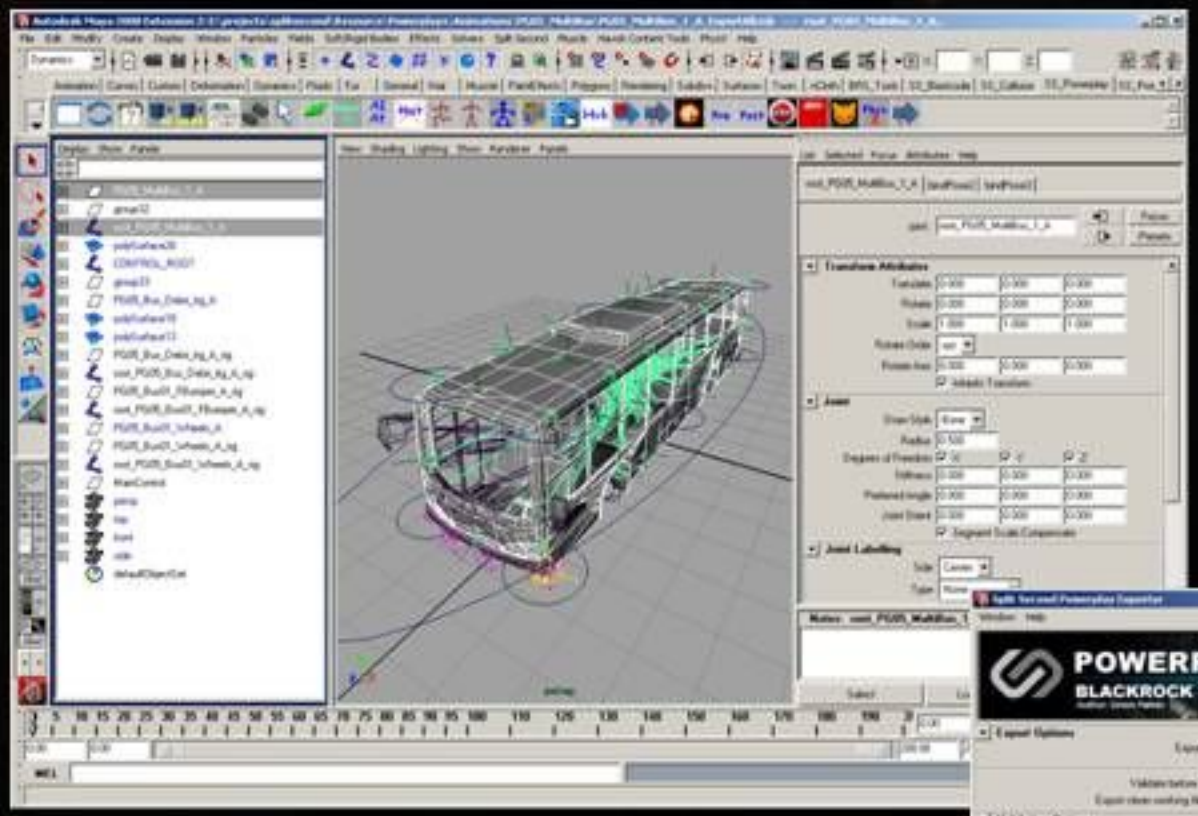
Maya Nomenclature

- Shape node hierarchy
  - XXX_A
    - Shape node YYY
  - Rigid bodies inherit node name
- Joint hierarchy
  - Root_XXX_A
    - Joint_YYY
    - Joint prefix stripped at runtime to lookup matching rigid body in exported physics system
    - Effective solution for animated collision



Maya Export



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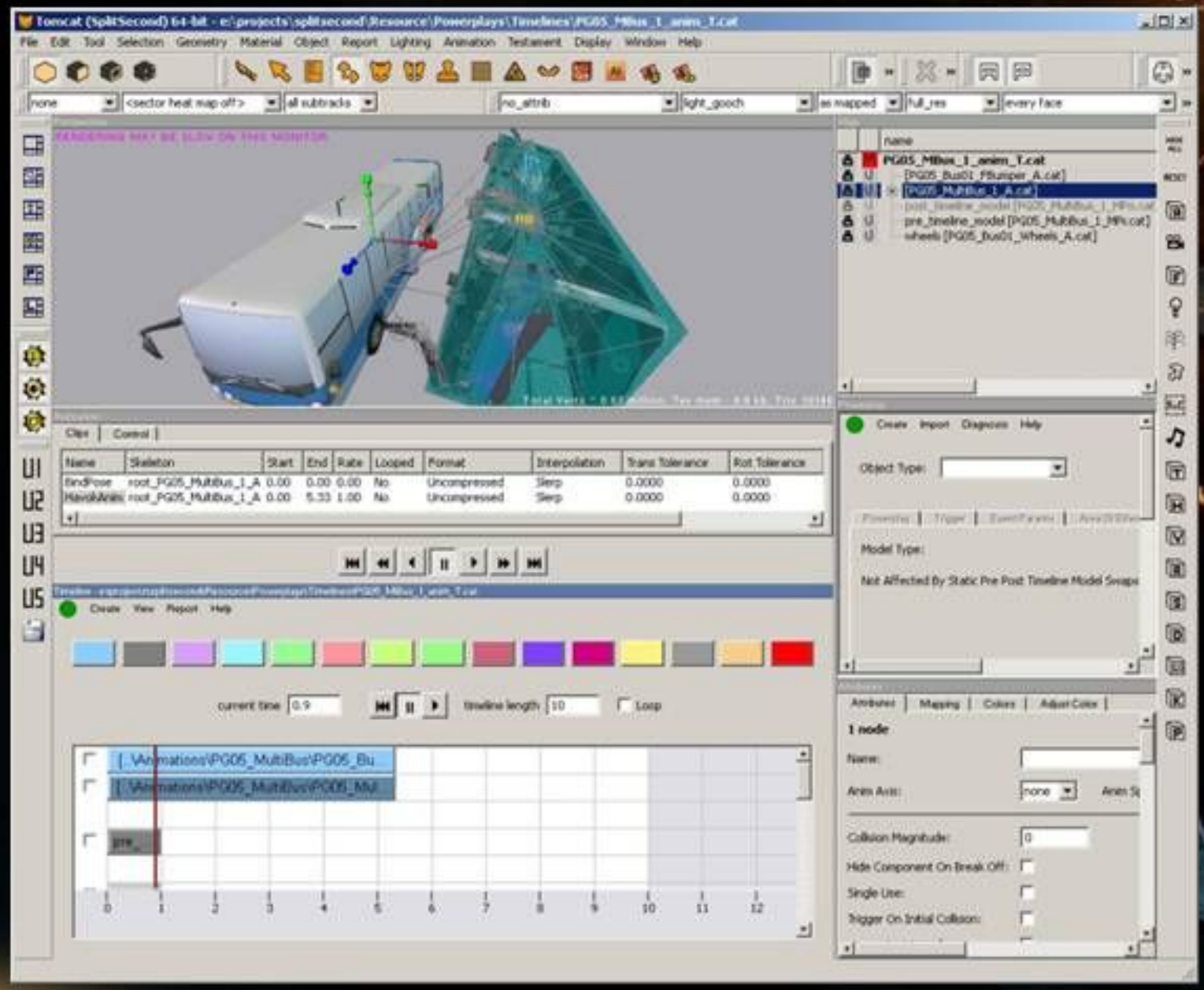
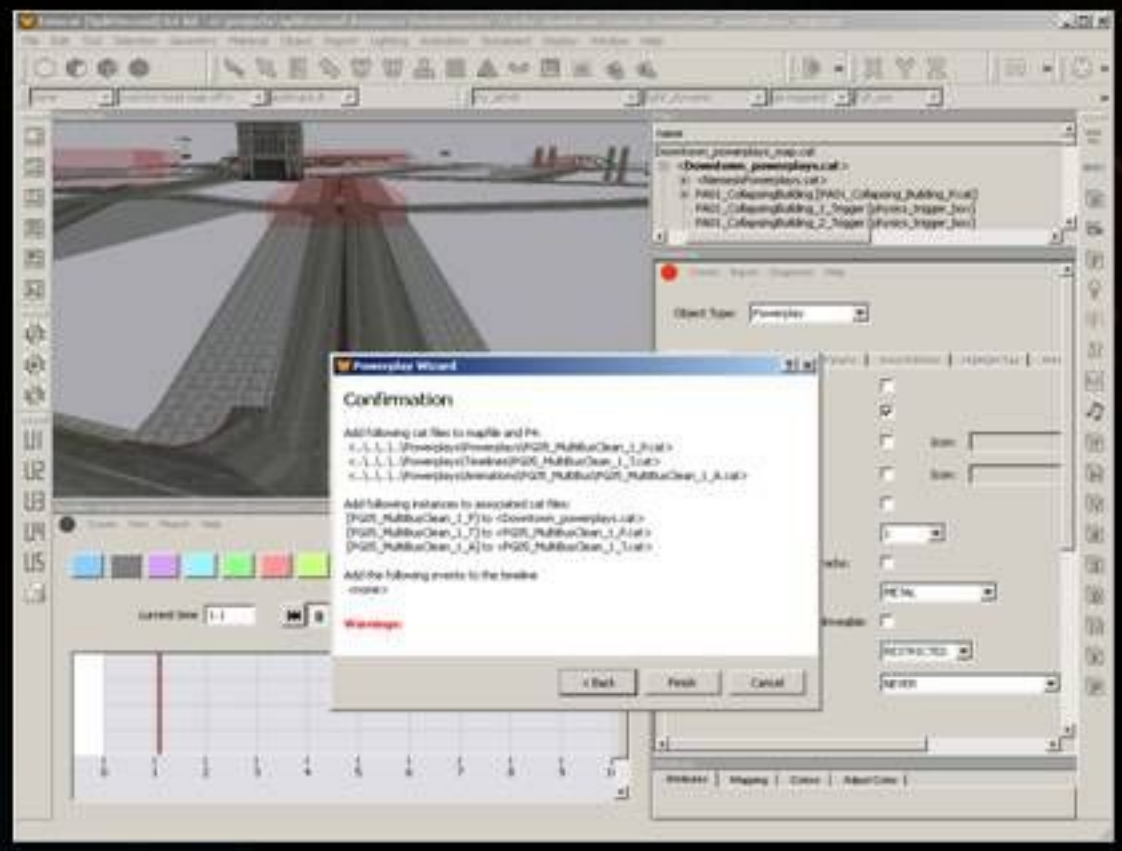
Timeline Authoring



Powerplay Creation



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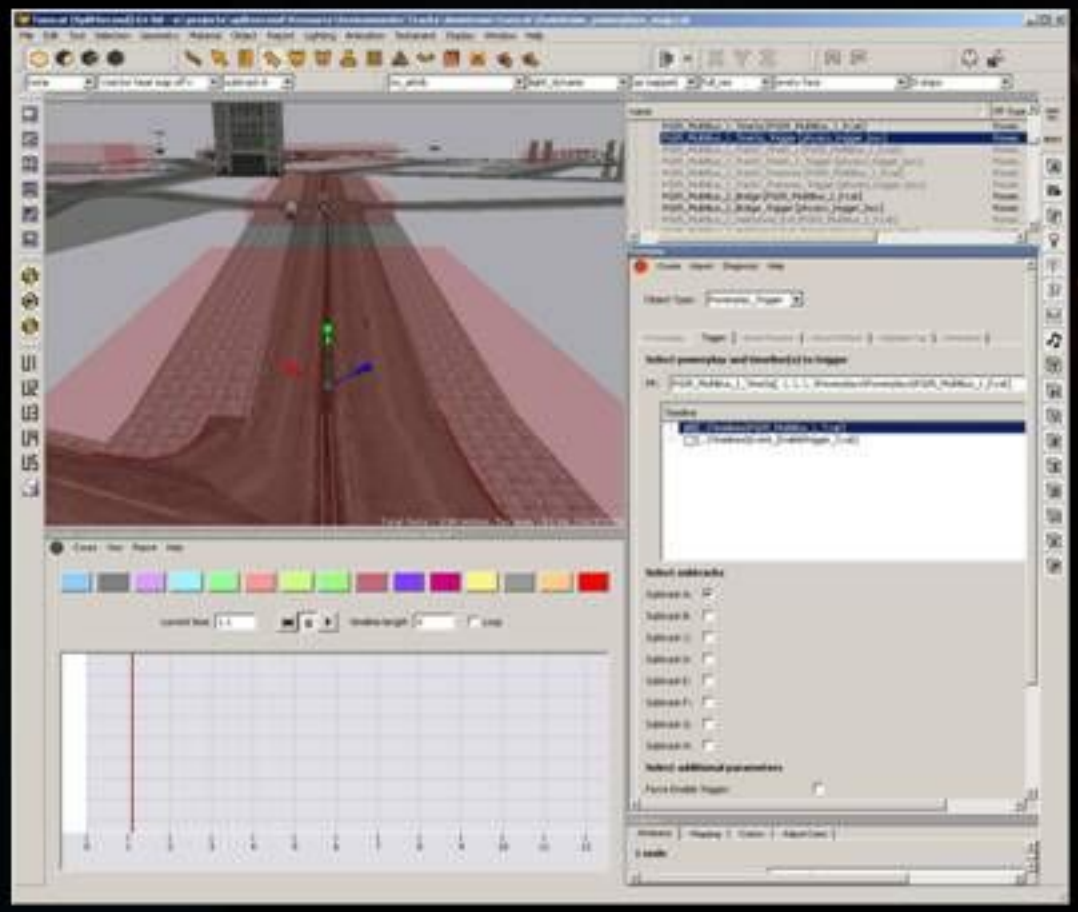
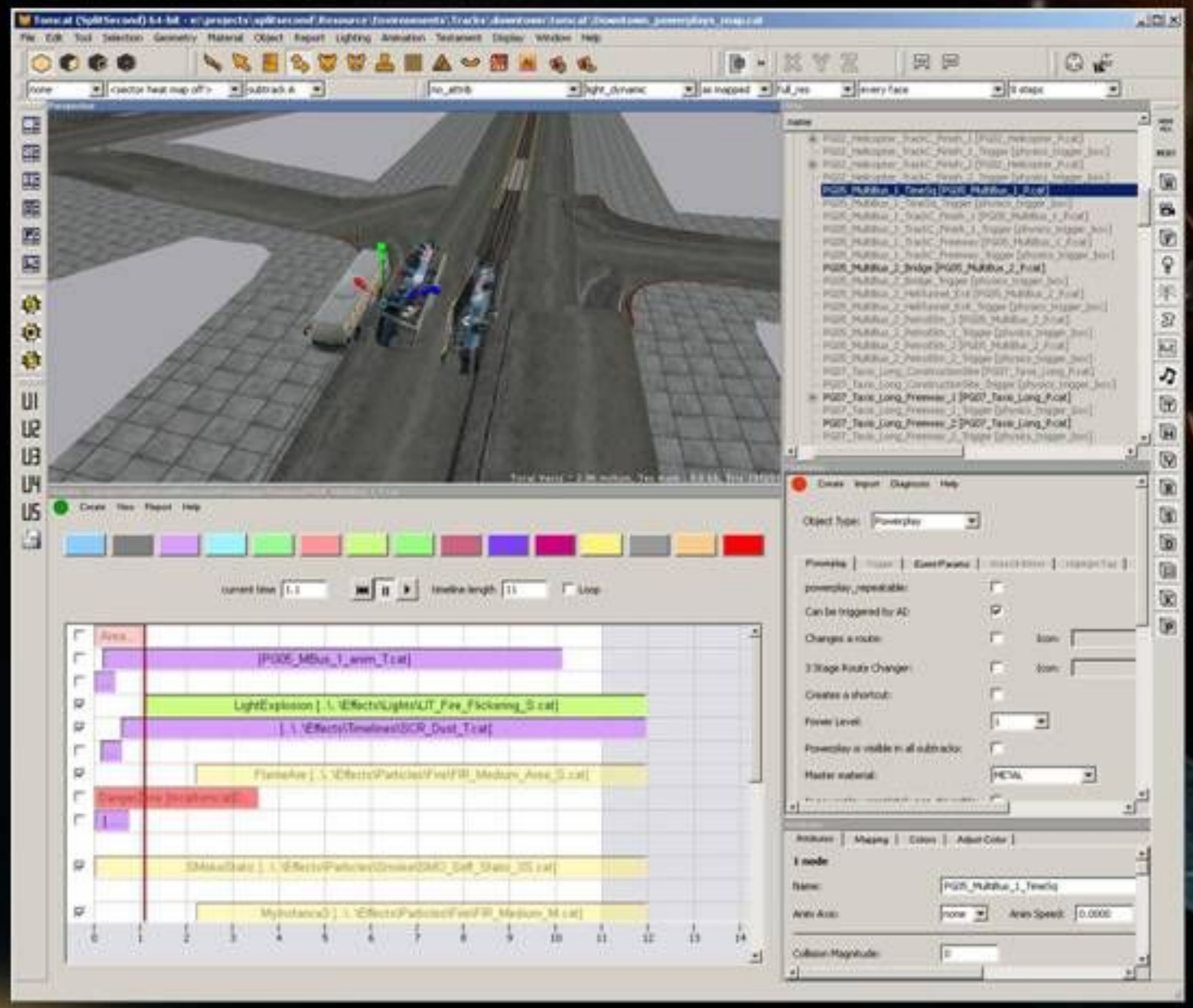
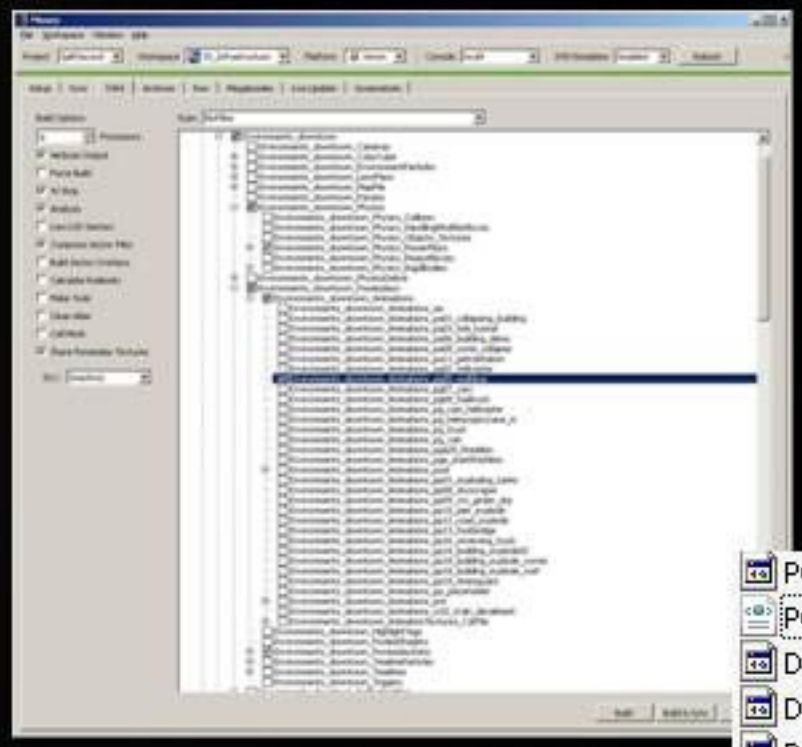
Trigger Assignment



Tomcat Preview



Databuild



PG05_MultiBus_1_A.model
PG05_MultiBus_1_T.xml
Downtown.powerplays
Downtown.hkPPs
Downtown.triggers

```
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"false" AICanTrigger="true" RouteChanging="false" OpenShortcut="false" TotallyUndriveable="false" MasterMaterial="7"
PowerLevel="1" RubberneckRestriction="1" CrashIsMessy="0" id="1260444569,-1547516386" idCRC="0xF9851C44" contextual="0">
    <worldmtx>
      <Row0 X="-0.7025656" Y="0.0008329" Z="0.7116185"/>
      <Row1 X="-0.0644659" Y="0.9958134" Z="-0.0648113"/>
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      <Row3 X="-689.69250" Y="-7.8806334" Z="-29.570667"/>
    </worldmtx>
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        <Param Name="Animation" Type="6" Value="0xF30610E4"/>
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        <Param Name="Animation" Type="6" Value="0xF30610E4"/>
      </Event>
    </EventParams>
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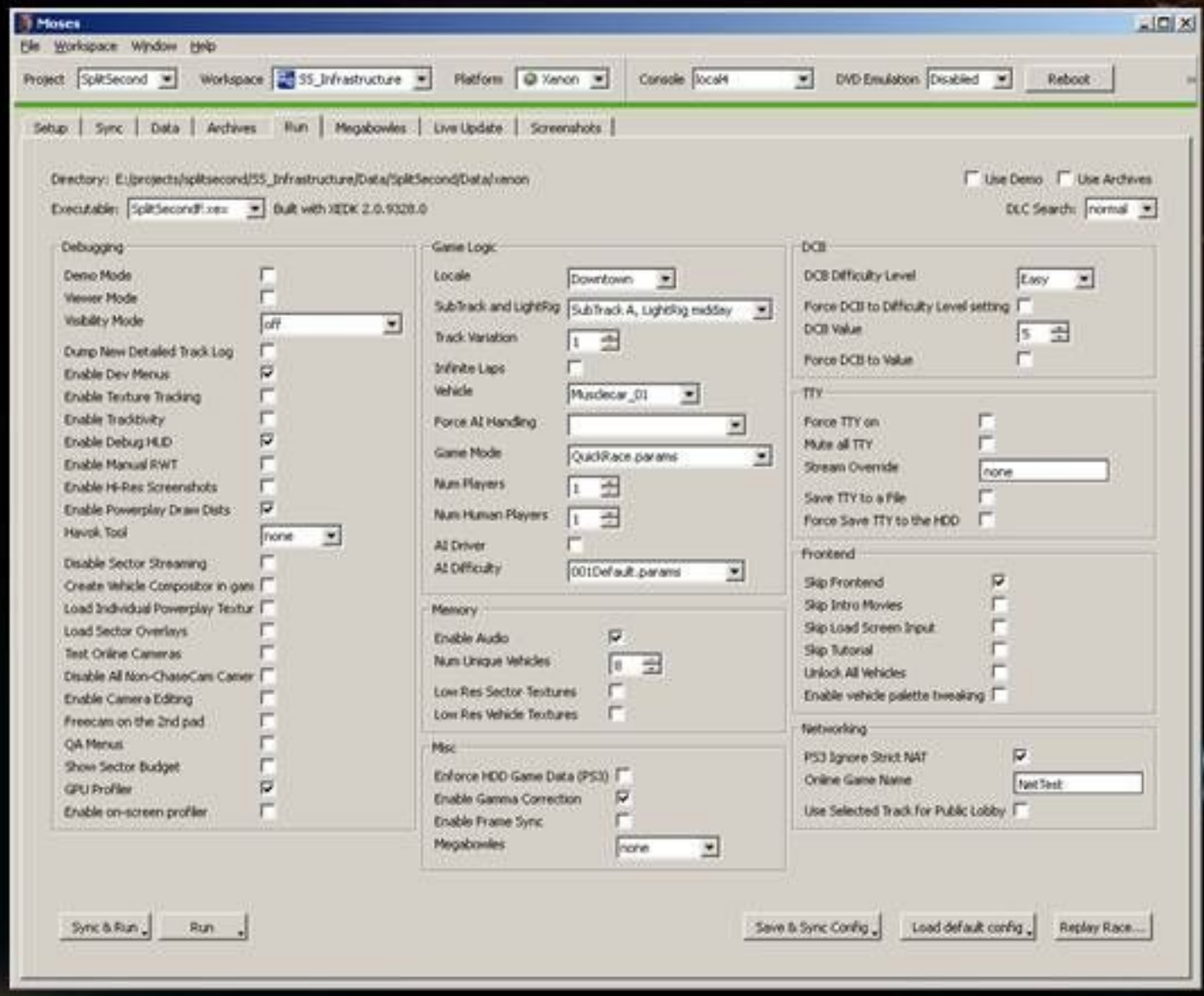
        <Row2 X="0.0000000" Y="0.0000000" Z="1.0000000"/>
        <Row3 X="0.0000000" Y="0.0000000" Z="0.0000000"/>
      </transform>
    </Timeline>
```

Runtime


Moses
File Workspace Window Help
Project SplitSecond
Workspace SS_Infrastructure
Platform Xenon
Console local4
DVD Emulation Disabled
Reboot
Setup | Sync | Data | Archives | Run | Megabowles | Live Update | Screenshots
Directory: E:\projects\splitsecond\SS_Infrastructure\Data\SplitSecond\Data\xenon
Use Demo Use Archives
Executable: SplitSecondF.xex
Built with XEDK 2.0.9328.0
DLC Search: normal
Debugging
Demo Mode
Viewer Mode
Visibility Mode
Dump New Detailed Track Log
Enable Dev Menus
Enable Texture Tracking
Enable Trackbility
Enable Debug HUD
Enable Manual RWT
Enable Hi-Res Screenshots
Enable Powerplay Draw Dists
Havok Tool
Disable Sector Streaming
Create Vehicle Compositor in gam
Load Individual Powerplay Textur
Load Sector Overlays
Test Online Cameras
Disable All Non-ChaseCam Camer
Enable Camera Editing
Freecam on the 2nd pad
QA Menus
Show Sector Budget
GPU Profiler
Enable on-screen profiler
Game Logic
Locale
SubTrack and LightRig
Track Variation
Infinite Laps
Vehicle
Force AI Handling
Game Mode
Num Players
Num Human Players
AI Driver
AI Difficulty
Memory
Enable Audio
Num Unique Vehicles
Low Res Sector Textures
Low Res Vehicle Textures
Misc
Enforce HDD Game Data (PS3)
Enable Gamma Correction
Enable Frame Sync
Megabowles
DCB
DCB Difficulty Level
Force DCB to Difficulty Level setting
DCB Value
Force DCB to Value
TTY
Force TTY on
Mute all TTY
Stream Override
Save TTY to a File
Force Save TTY to the HDD
Frontend
Skip Frontend
Skip Intro Movies
Skip Load Screen Input
Skip Tutorial
Unlock All Vehicles
Enable vehicle palette tweaking
Networking
PS3 Ignore Strict NAT
Online Game Name
Use Selected Track for Public Lobby
Sync & Run
Run
Save & Sync Config
Load default config
Replay Race...

Runtime Playback

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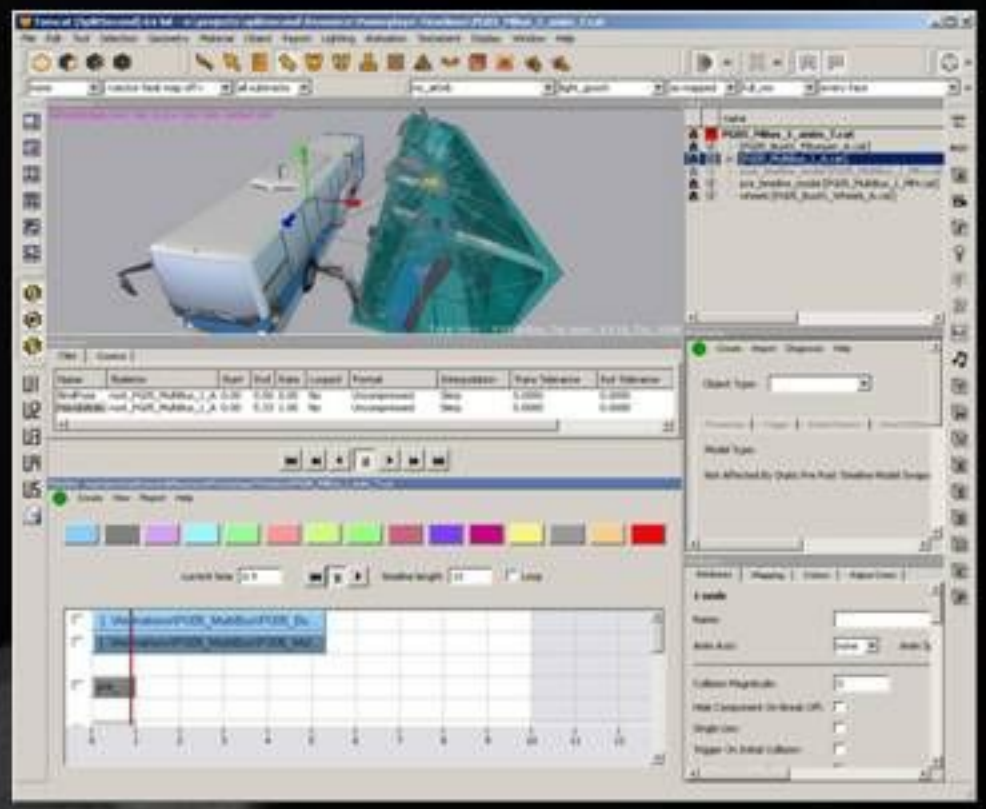
Live Update



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Part II

- Pipeline Intro
- Prototype Pipeline
- Production Pipeline
- Timeline Framework

Workflow

- Design Team
  - Mock up prototype in Maya and play-test
- Environment Team
  - Extract relevant geometry from static environment
- Animation Team
  - Build production version of Powerplay
- Secondary Effects
  - Layer additional special effects

Maya Tools Deployment

- Ensure all end-users using common configuration
- Used P4 to centralize required versions
  - Shortcuts to installers (Maya, PhsyX, HCT, etc)
  - In-house extensions
    - scripts, plug-ins, shelves and icons
  - Havok Filter Manager Configuration Sets (.HKO)
- Auto-sync at start-up to guarantee up-to-date
- Easy to push changes out to entire team

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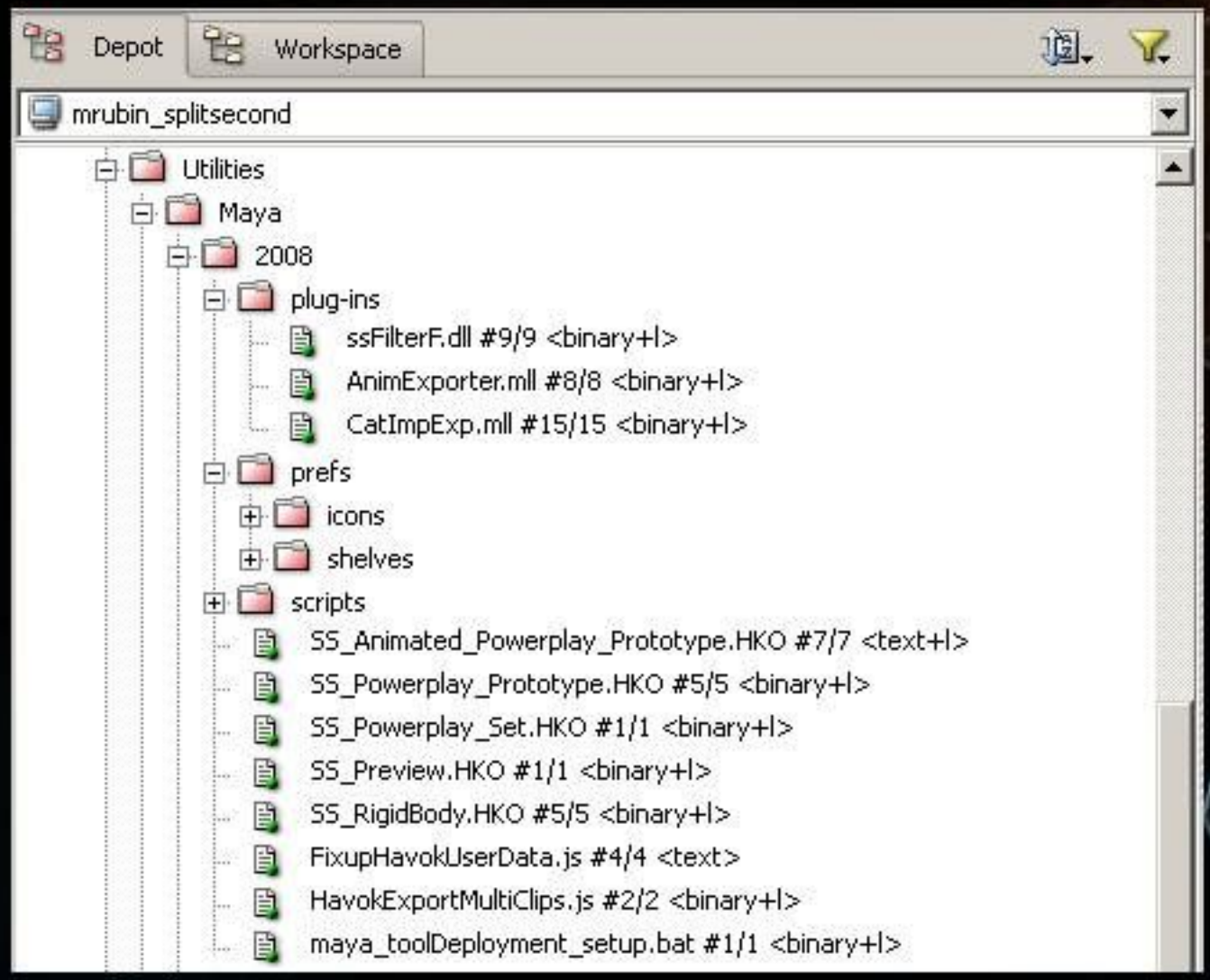
Maya Tools Deployment



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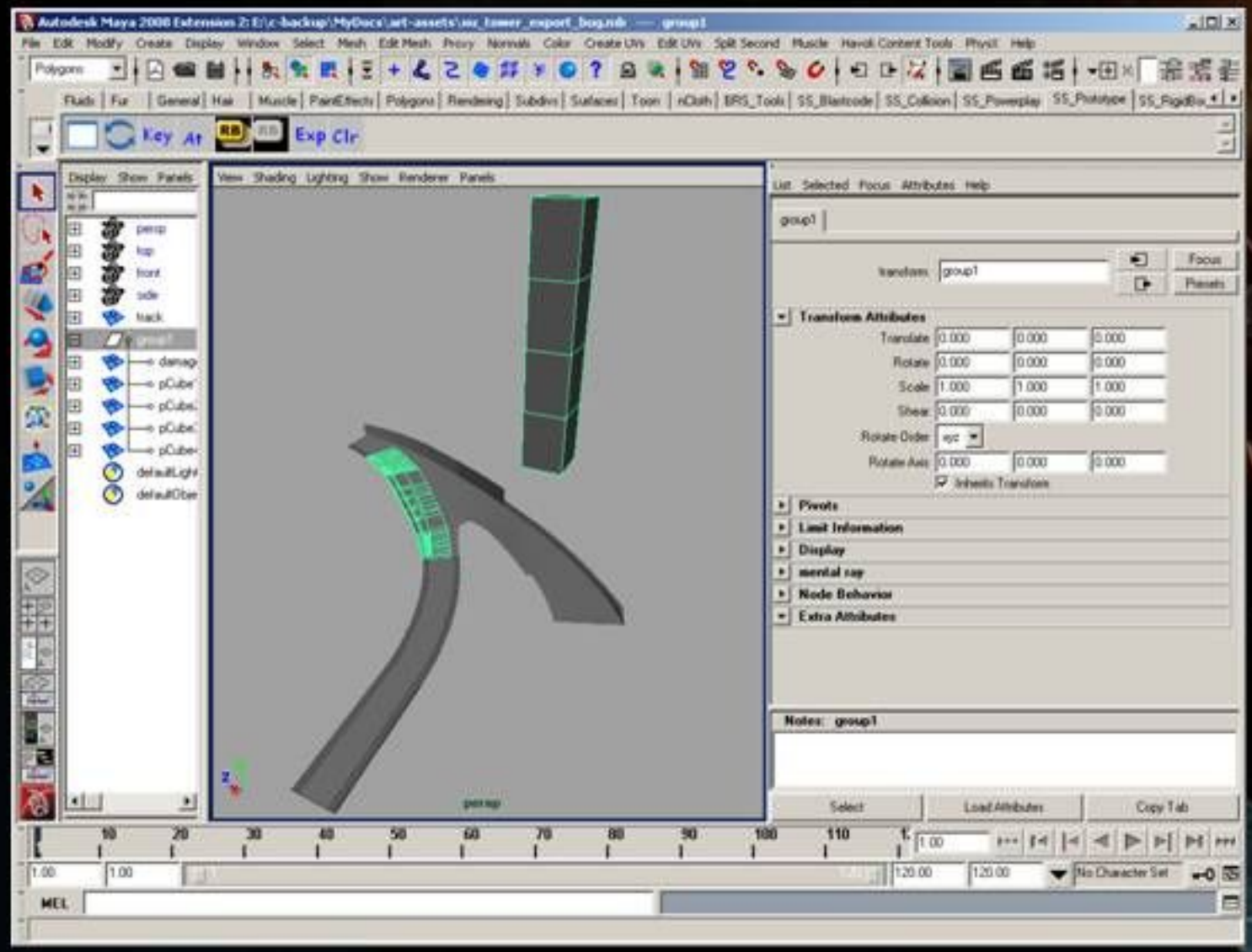
Prototype Pipeline

- Designer-Driven
  - Brainstorm ideas for each level
  - Author prototype animation in Maya
    - Not riggers but capable of key-framing
    - Use simple primitives with custom collision attributes
    - One-button export of animated instance
  - Import into level using Powerplay "Wizard"
    - Automagically creates new Timeline, Powerplay, and trigger objects
    - Version control integration

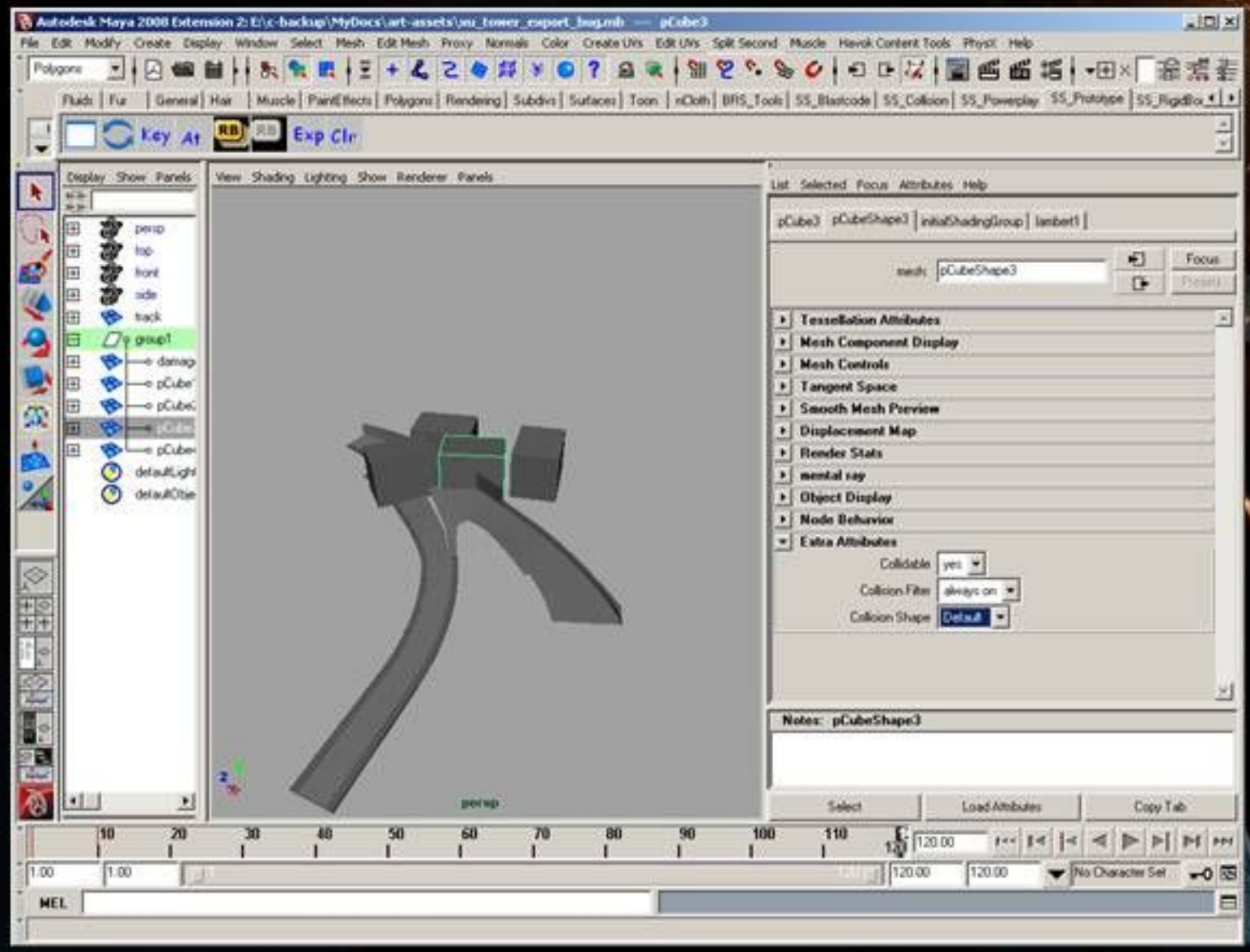
Prototype Shelf

- Exposed interface to simplify workflow
- Custom Maya shelf invoking mel scripts
  - Key-frame shape node hierarchy
  - Add custom collision attributes
  - One-button Export
  - Clear button to reset scene

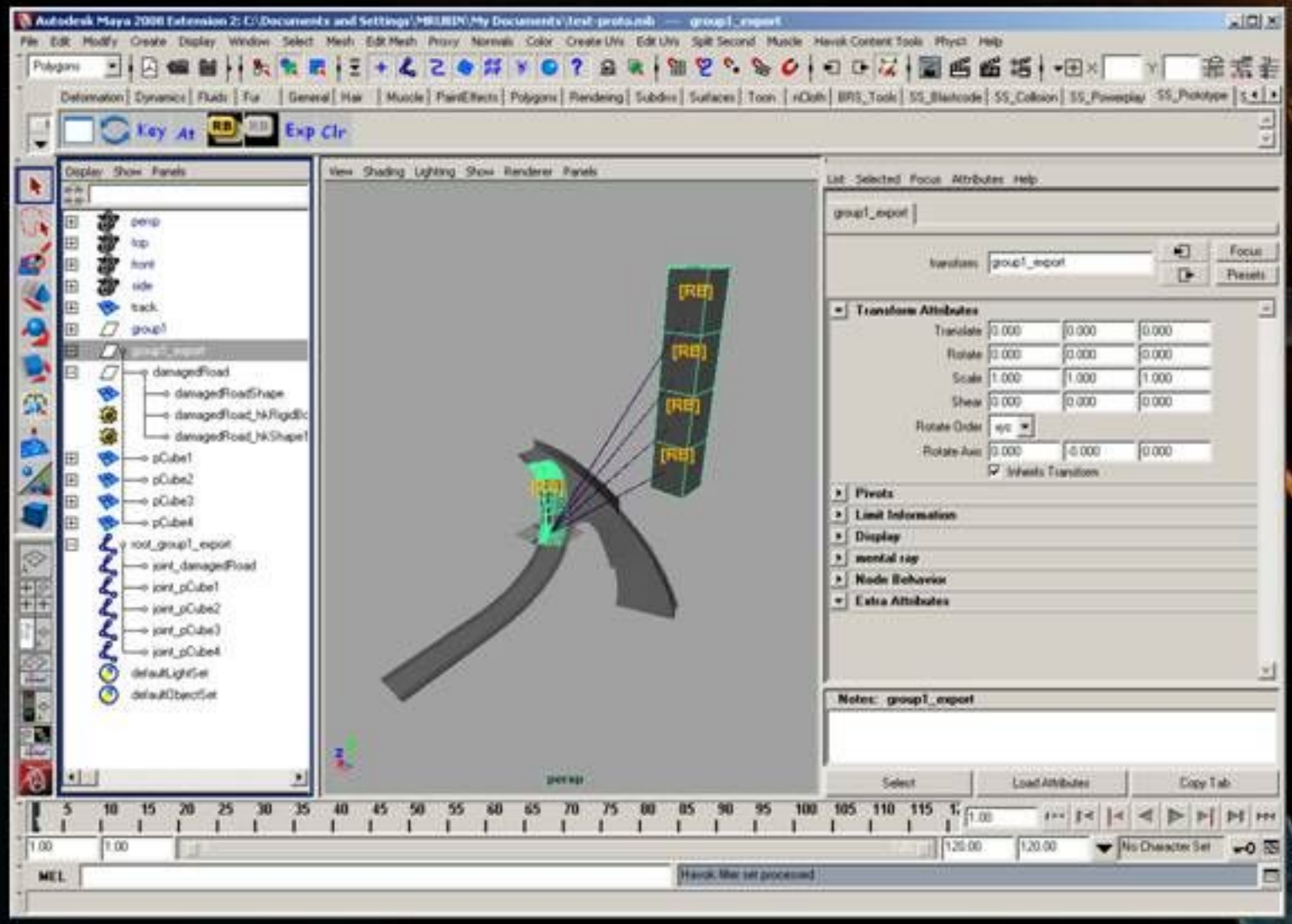
Keyframed Shape Nodes



Collision Attributes



Export Rig



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Auto-Rigging

- Duplicate group to preserve original animation
- Create joint hierarchy for key-framed shape nodes
  - Place bones at rotate pivot
- Bind shape nodes in duplicate group to corresponding joints
  - Copy key-frame data from shape node to joint
  - No support for scaling

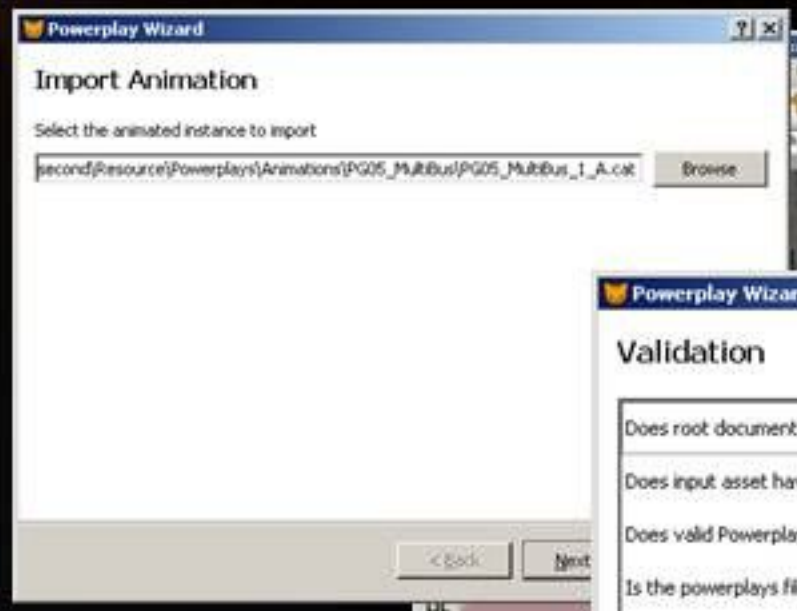
One-Button Export

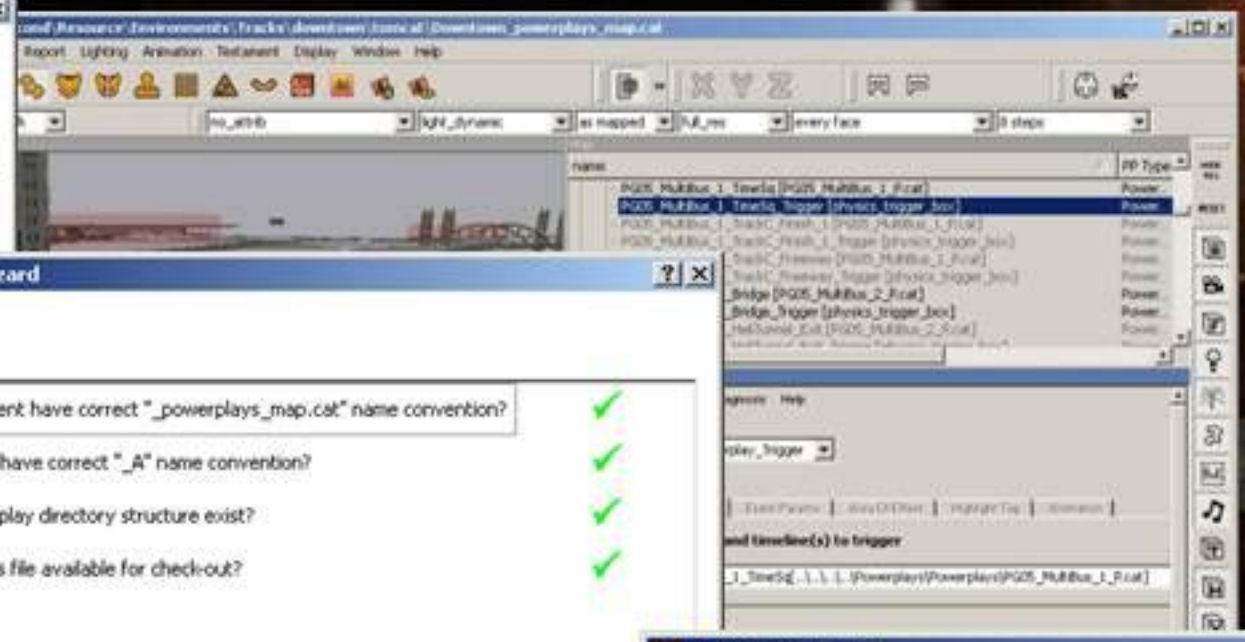
- Export skinned mesh as XXX_A.cat file using internal CatImpExp.mll
- Invoke Havok exporter silently using batch mode flag to output XXX_A.havok file (XML format)
  - Contains skeleton, animation data and rigid bodies
- Saves ‘snapshot’ of selected export group as XXX_Export.mb

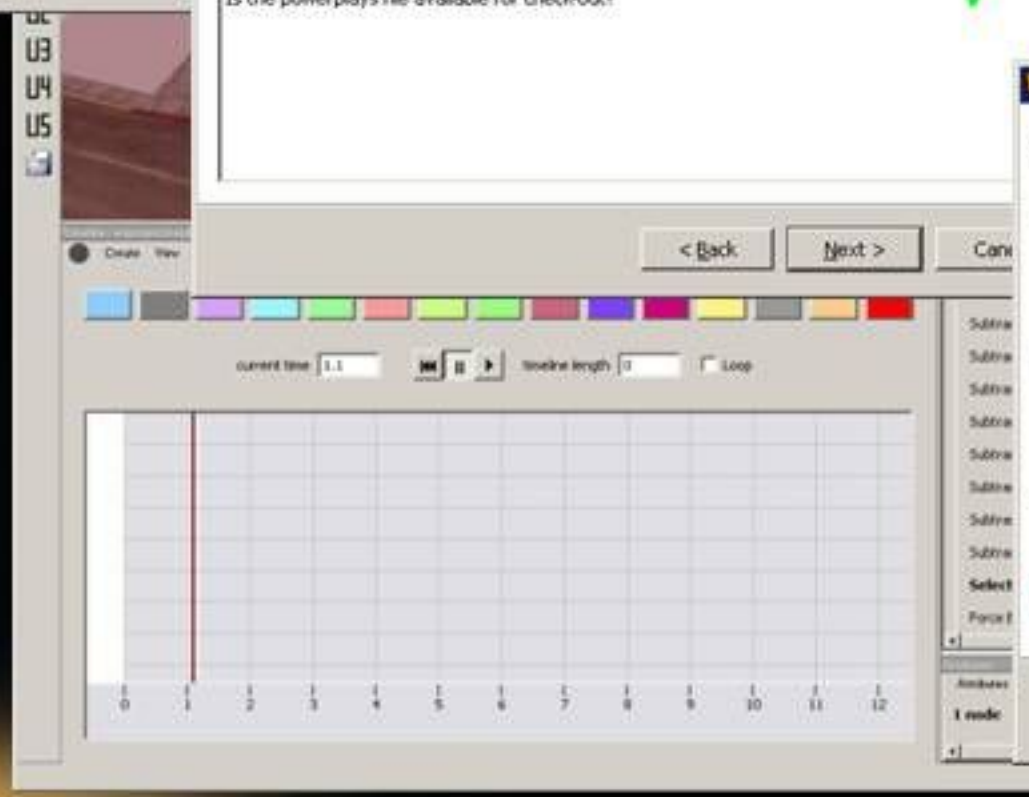
Powerplay Wizard

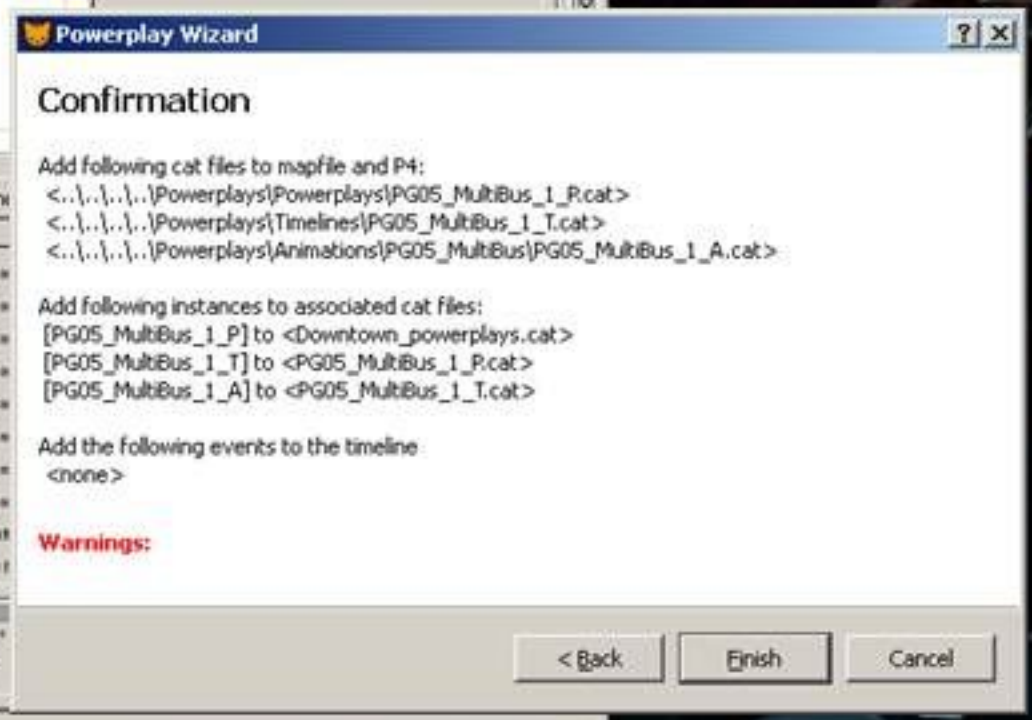
- Automates import of animation into Tomcat level
- Performs basic validation
- Creates required Timeline and Powerplay assets
- Creates trigger and Powerplay instances in level specific XXX_powerplays.cat
  - Links trigger to powerplay
- P4 integration

Powerplay Wizard









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Prototype Tweaking

- Placement and scale
  - Fit instance into existing track design
- Animation timing
  - increase/decrease speed
- Build Powerplay using Moses
  - Simplified ‘aliases’ to rebuild requisite data
- Play-testing and sign-off

Prototype Sign-off

- After sign-off production version can be built
  - Designers pair up with Animator
    - work together to add more detail (grey box)
    - Prepare brief to environment team
  - Environment artist pair up with Animator
    - extract relevant portion of Tomcat level into stand-alone model
    - Pre-triggered and post-triggered states
  - Handed-off to animation team to bring to life
    - Slot rigged model into same scene

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Asset Prep


Perspective
Perspective
Total Verts = 0.02 million, Tex mem : 0.0
Total Verts = 0.02 million, Tex mem : 0.0 kb, Tris 7865

Production Pipeline

- Animator-driven
- More powerful version of prototype pipeline
- Provided multiple shelf buttons
  - broken down into individual steps
- Allows more control over authoring process

Production Shelf

- Supported functionality
  - Fracturing
  - Rigging and animation
  - Attaching collision
  - Generation of static pre/post models
  - Validation and export

Fracturing

- Break initial static models into pieces
  - Might be necessary to extrude interior from paper-thin exterior faces
- Utilized several fracture techniques w/ varying degrees of success
  - 3rd party plug-ins (Blastcode, rayfire)
  - Chop-and-crack (noise-based cutting planes)
  - Manual cutting (splitting faces by hand)
  - Ongoing area of R&D

Rigging and Animation

- Utilized several techniques
  - Auto-rigging
    - Manually key-framed shape node hierarchies
    - Baked simulations using dynamics
  - Hand-crafted rigs
    - Manually key-framed joint hierarchies
  - Control-rigs
    - Employing IK and physical constraints
    - Drive game rig using parent constraints

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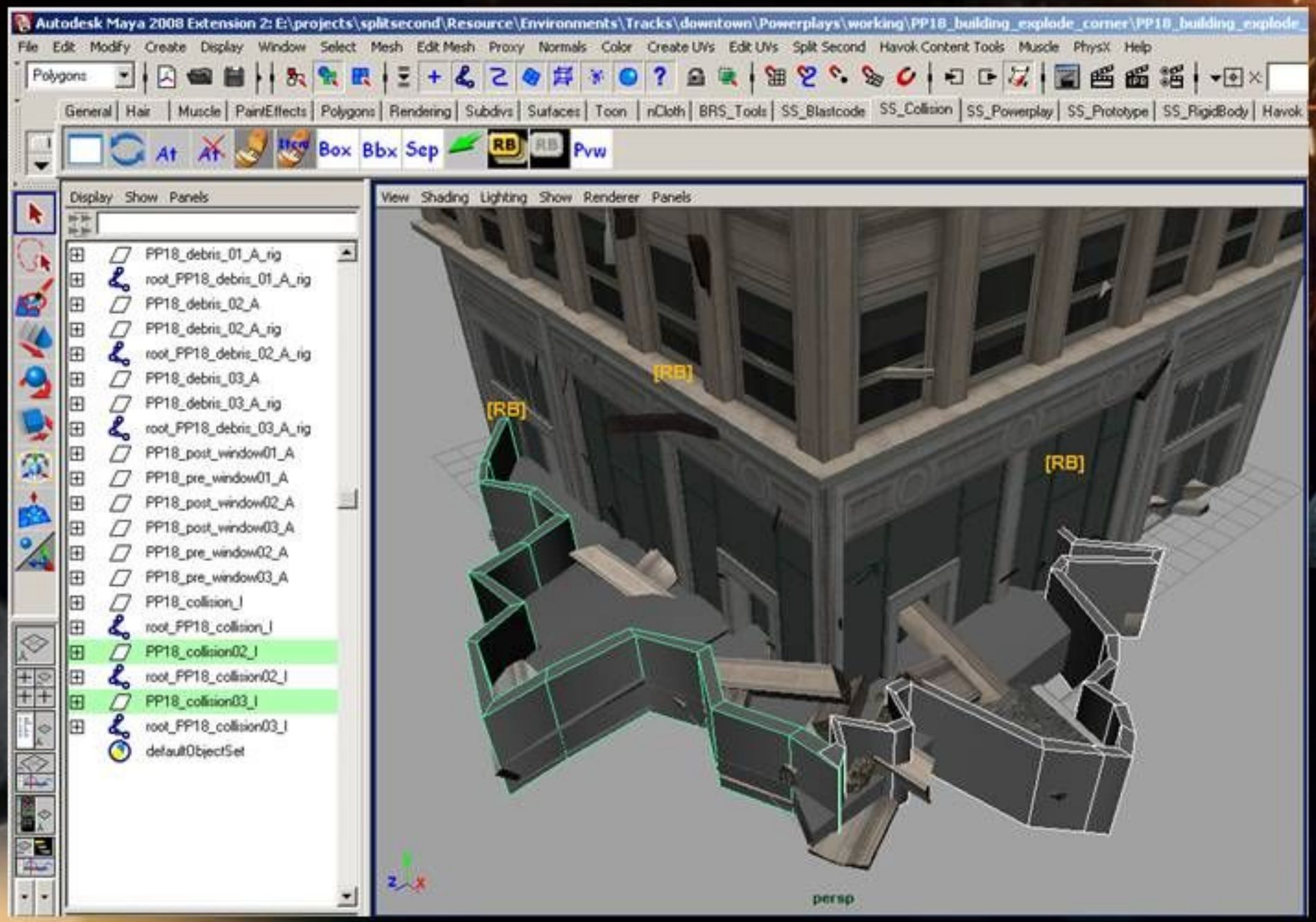
Attaching Collision

- Usually performed after animating
- Don't want to use rendered mesh as basis for collision shapes
  - Geometry is too dense
  - Best approached using simplified shapes
  - Helps avoid snags in-game
  - Essentially want to decompose non-convex mesh into simplified set of convex pieces (non-trivial)
  - List shapes help reduce number of rigid bodies

“Invisible” Rigs (XXX_I)



Pre/Post Models

- Rendering skinned mesh expensive on GPU
- Use simple model swapping strategy
  - Render static models before/after triggering Powerplay
  - avoids skinning overhead but increases memory footprint due to additional geometry
- Generate XXX_A_Pre.cat and XXX_A_Post.cat
  - Automatically created at Maya export
  - Removes binding at first and last frame

Validation and Export

- Powerplay Exporter
  - Written by Tech Art team about midway through production
  - Essentially bolted on top of existing export scripts
  - Helped provide art-friendly entry point for export process
  - Provided an extensible interface for detecting and correcting known issues prior to export

Validation and Export

Production Sign-off

- Production asset replaces prototype version on timeline
- After sign-off Powerplay handed off to additional sub-teams for layering of secondary effects on the timeline
  - Particles
  - Debris
  - Audio

Timeline Sub-System

- Pivotal piece of tech for authoring Powerplays
- Extensible architecture for time-based objects
  - TimelineEntry base class
    - Animations, particle f/x, area-of-effects, game events, audio events, debris emitters, nested timelines
- Both tool-side and run-time implementations
  - Can preview playback in Tomcat
- Exporter serializes entries into runtime format

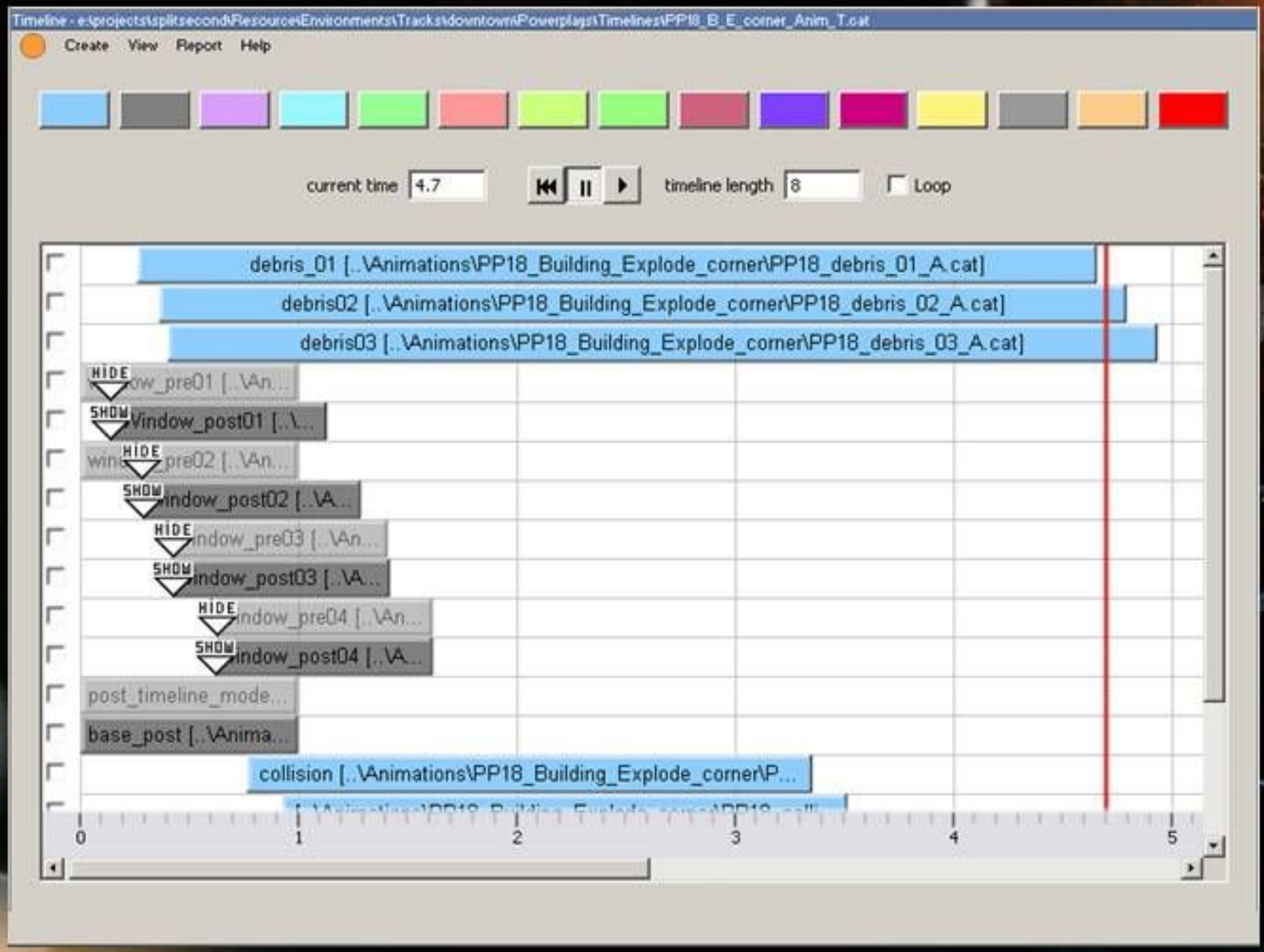
Nested Timelines

- Fostered reuse in certain cases
- Create once and instance into new powerplays
- Facilitated collaboration
  - Provided mechanism to partition entries into separate timeline files so they could be individually edited at the same time

Game Events

- Placed onto timeline to modify game state in data-driven manner
  - show/hide animations
  - enable/disable triggers
  - Pause/reset timeline
- Events and parameters defined in XML file
  - strongly typed
- Event parameters can be assigned values via built-up user-interface in Tomcat

Event Timing



Timeline Event XML

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110       <params>
111         <param name="Trigger" type="NodeId">
112           <filter name="Powerplay_Object_Type" value="Powerplay_Trigger"></filter>
113         </param>
114       </params>
115     </event>
116
117     <event name="SetPowerLevel" id="14" >
118       <params>
119         <param uiname="PowerLevel" name="PowerLevel" type="Int" min="0" max="3" def="0" ></param>
120       </params>
121     </event>
122
123     <event name="ResetTimelineTo" id="15">
124       <params>
125         <param name="Timeline" type="NodeId">
126           <filter name="Powerplay_Object_Type" value="Timeline"></filter>
127         </param>
128         <param name="Time" type="Float" min="0.00" max="1000.00" def="0"></param>
129       </params>
130     </event>
```

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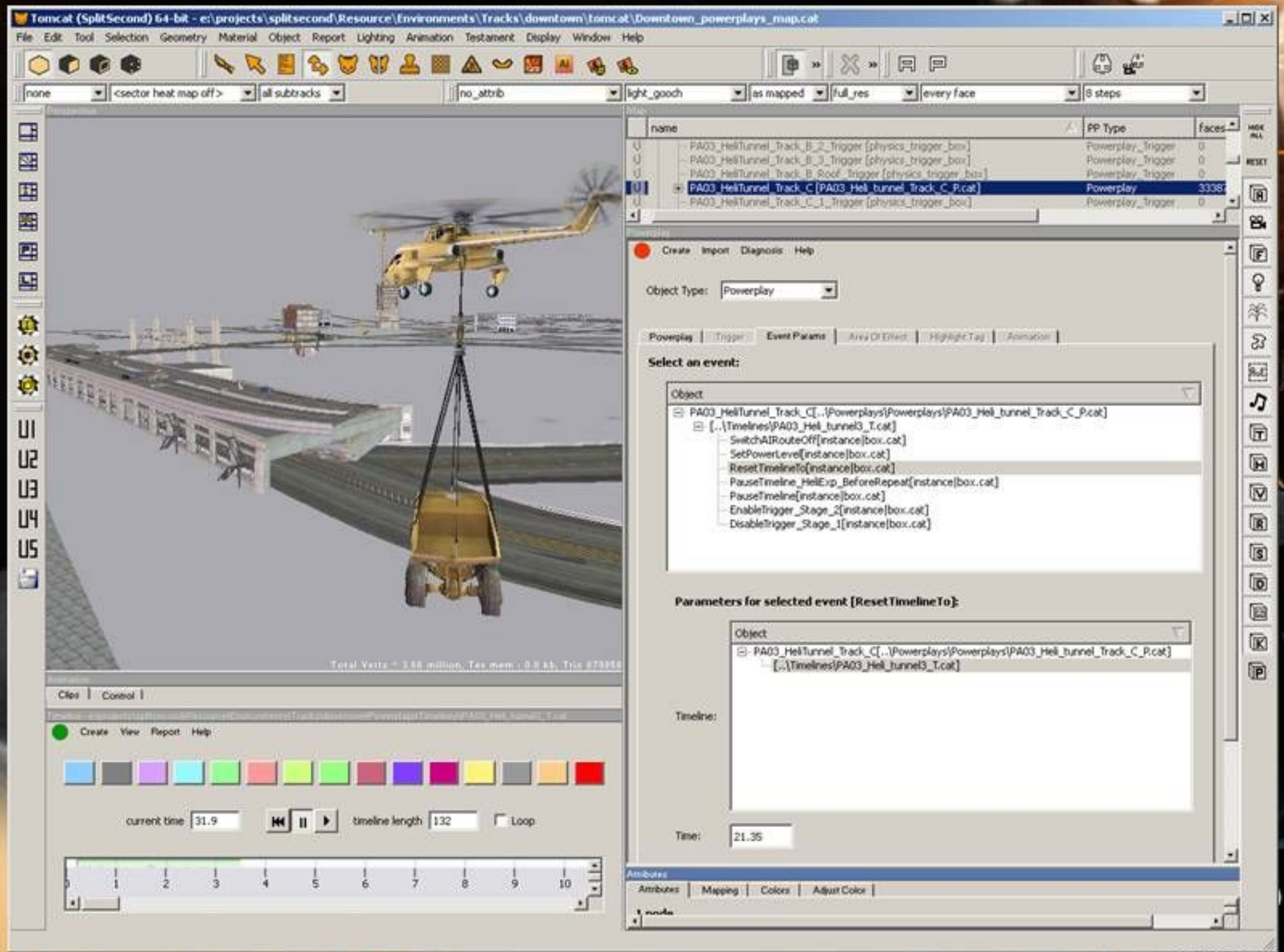
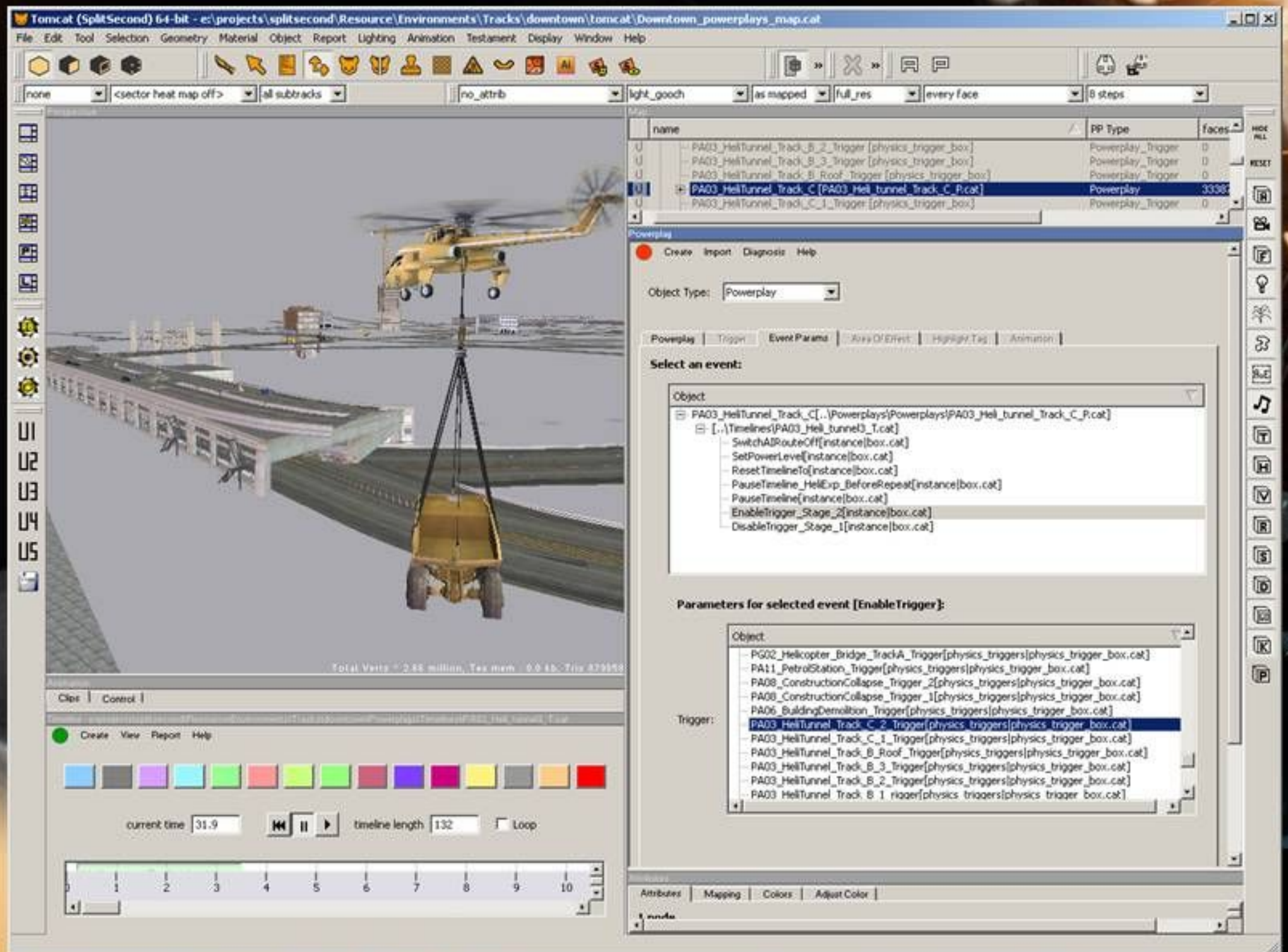
Multi-Stage Powerplays

- Progressive destruction
  - Pause event to ‘stop’ playback
  - Disable current trigger
  - Enable subsequent trigger
  - Continues playback from previous time point
- Idle animations for ambient motion
  - Multiple clips
    - Idle_XXX and Action_XXX name convention
  - Blends to first frame of next animation clip

Event Parameters



Event Parameters



Area-of-Effects

- Runtime explosive forces
  - Triggers shockwave/physical impulse
  - Affects vehicle handling
  - Assigned attributes which impact game state
    - Cause crash state
    - Camera shake
    - Controller rumble
    - Track damage
    - Post-processing effects

Visual F/X

- Provided eye-candy
  - Degree of realism and visual polish
  - Give “Hollywood” look-and-feel
- Particles
  - Emitters placed on timeline
  - Optionally attached to bones
- Debris cannon
  - Pool of dynamic rigid bodies launched at a given velocity/trajectory

Part III

- Rapid iteration
- Troubleshooting
- Performance
- Usability

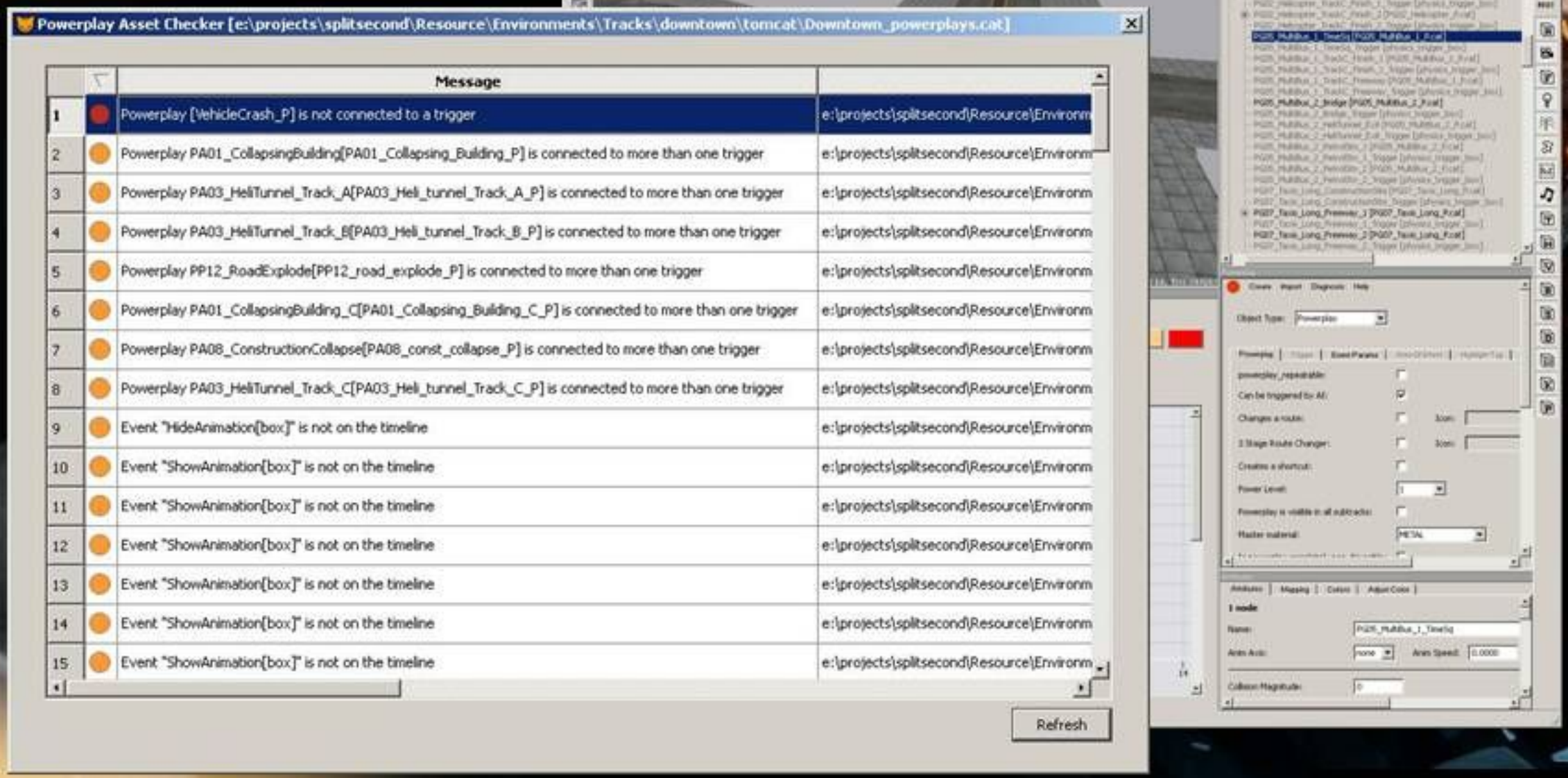
Live Update

- Streamlined iteration time
- Avoided need to rebuild assets when making small changes
  - Placing instances
  - Tweaking animation speeds
- Supported for Animation, Timeline and Powerplay instances

Powerplay Asset Checker

- Performed validation of common errors
- Red/green status indicator
  - Prominent display
- Helped identify problems before databuild
- Presented list of offending instances with error messages

Powerplay Asset Checker



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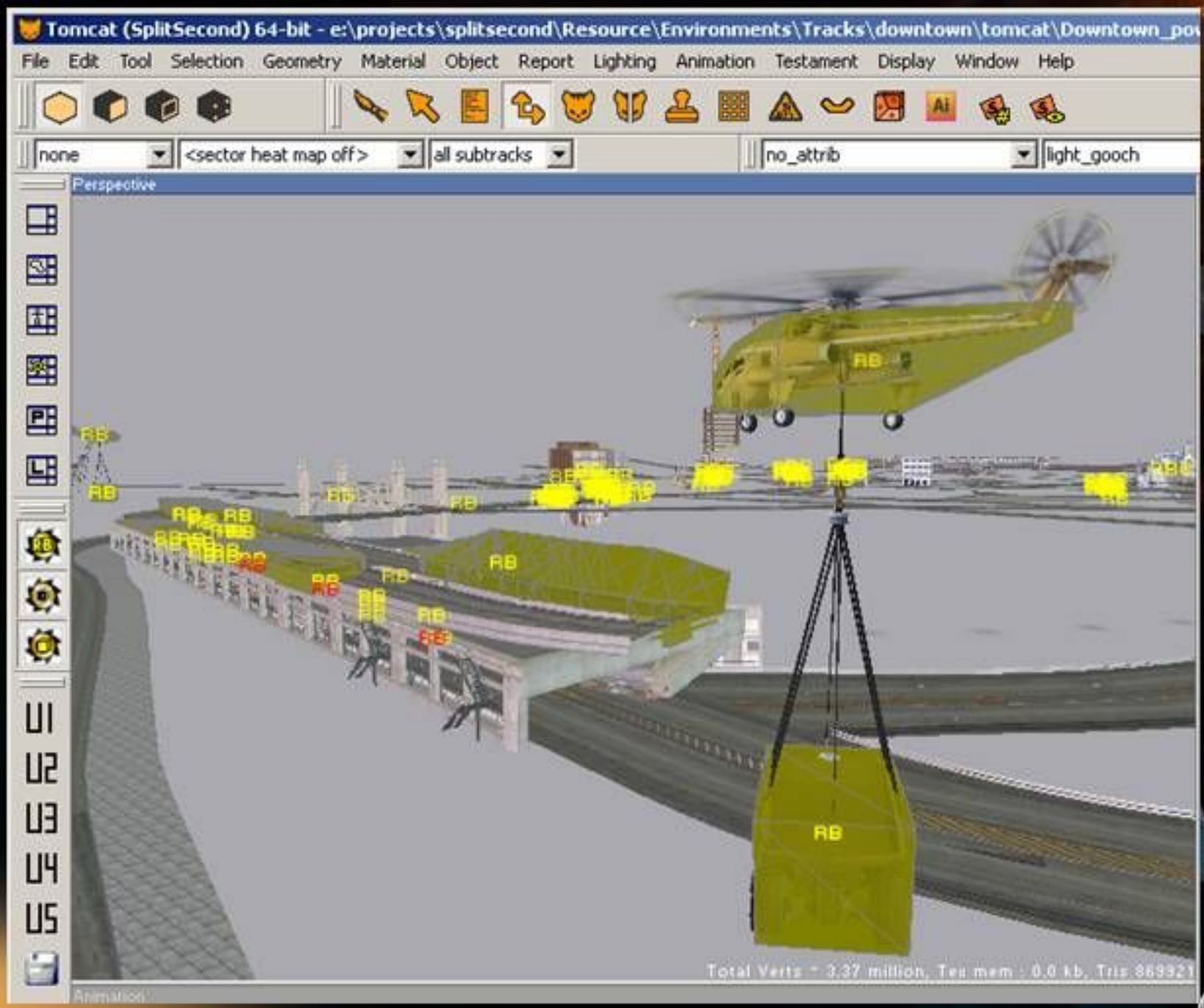
Rigid Body Rendering



Performance

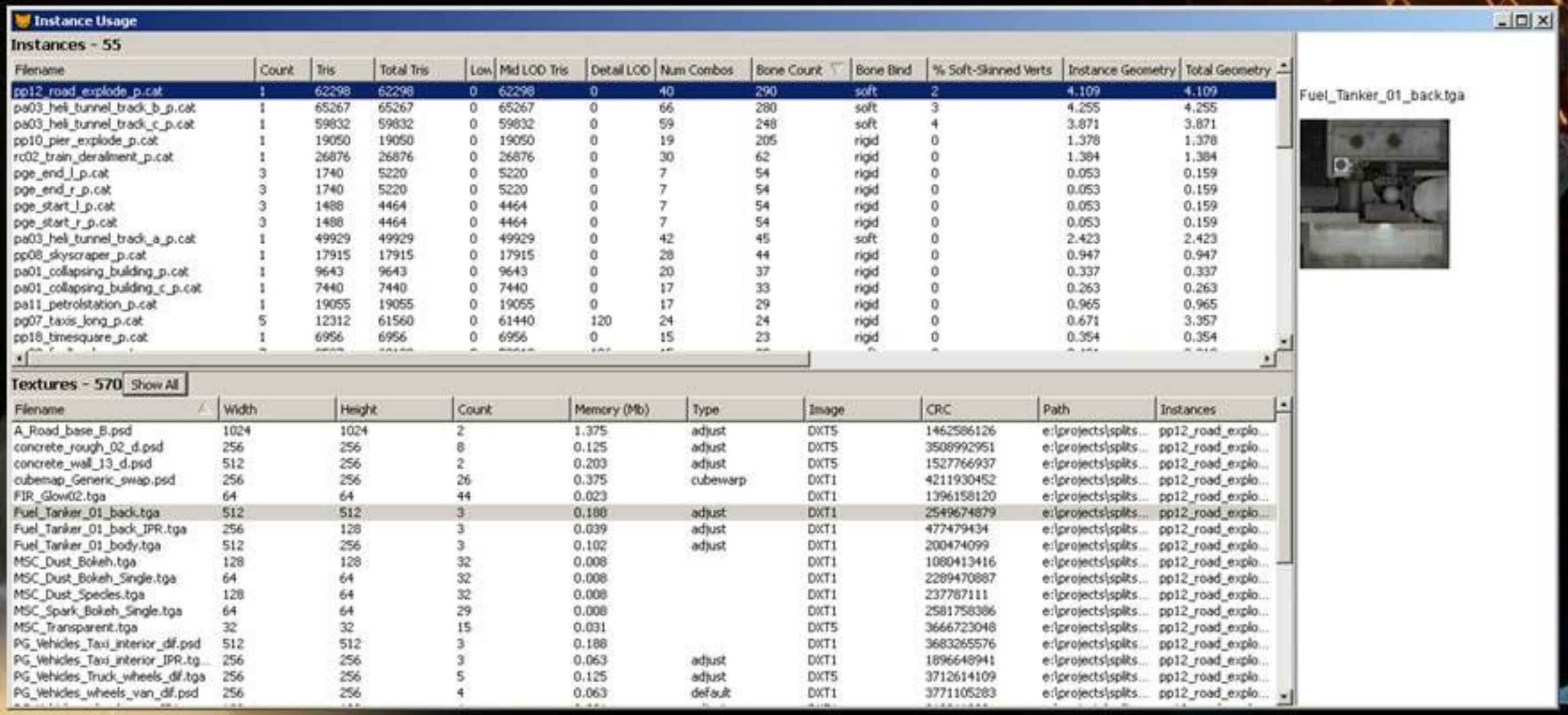
- Skeletal animation
  - vertex textures for matrix-palette skinning gave us good performance for rigs w/ high bone counts
  - Industrial-strength compression
- Model swapping to reduce skinning overhead
- Rigid Bodies
  - Key-framed motion does not require synchronization during online play
  - List shapes help reduce number of collision bones

Asset Reporting

- Analyze performance of animated instances
  - Geometry
    - Number of bound verts (Rigid/soft skinned)
  - Material
  - Animation
    - Bone counts
  - Collision
    - Number of rigid bodies
    - Collision shape density

Powerplay Report

- Can drill down into Timelines



Rigid Body Report

- Number of rigid bodies and collision shapes
- Convex hull/mesh shape density
- Can drill down into Timelines

Rigid Body Usage

Instances - 17

Filename	Count	Total Rigid Bodies	Rigid Bodies	Animated	Animate	Collision Shapes	Convex Hulls	Mesh Shapes	Anir	Convex Hull Verts	Mesh Verts
pa03_heli_tunnel_track_c_p.cat	1	27	27	21	0	27	27	0	0	334	0
pa03_heli_tunnel_track_b_p.cat	1	26	26	26	0	26	23	3	0	289	248
pp09_crn_girder_drp_p.cat	2	30	15	15	0	15	15	0	0	118	0
pg07_taxis_long_p.cat	5	60	12	12	0	12	12	0	0	465	0
pg07_taxis_p.cat	1	12	12	12	0	12	12	0	0	478	0
pa11_petrolstation_p.cat	1	10	10	10	0	10	10	0	0	404	0
pp12_road_explode_p.cat	1	10	10	9	1	10	10	0	0	141	0
pg07_vans_p.cat	1	9	9	9	0	9	9	0	0	261	0
pa01_collapsing_building_p.cat	1	5	5	5	0	21	16	0	0	168	0
pa03_heli_tunnel_track_a_p.cat	1	5	5	5	0	5	2	3	0	16	248
pp08_skyscraper_p.cat	1	5	5	2	3	5	4	1	0	36	16
pp18_timesquare_p.cat	1	4	4	4	0	4	4	0	0	69	0
pa01_collapsing_building_c_p.cat	1	3	3	3	0	14	11	0	0	108	0
pp18_building_explode_corner_p.cat	2	6	3	3	0	3	0	3	0	0	212
rc02_train_derailment_p.cat	1	3	3	3	0	3	3	0	0	45	0
pg05_multibus_2_p.cat	4	4	1	1	0	1	0	1	0	0	61
pp18_building_explode_roof_p.cat	1	1	1	1	0	1	1	0	0	18	0

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Usability

- Usability issues
  - Cross-discipline communication
    - Informal catch-ups
  - Time-and-motion studies
    - One-Button Export
    - Powerplay wizard
    - Asset Validation

Conclusion

- Do more with less tech
  - Empower the content creators
- Author assets in stages
  - Well-defined workflow
- Keep tech flexible
  - Adapt to changing requirements
- Build user-friendly tools
  - Identify and automate tedious tasks

Questions?

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