



Skylanders SuperChargers One Game, 22 Platforms

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Device Breakdown

- 6 consoles (Xbox 360, PS3, WiiU, Xbox One, PS4, and Apple TV)
- 9 tablets (iPad mini and beyond)
- 7 phones (iPhone 5 and beyond)



Main Challenges

- Memory
 - 512MB to 8GB
- Computing Power
 - 2 cores to 8 cores
- Verification
 - 300+ characters, story levels, racing, online, and more...

Other Challenges

- Input
 - Gamepad, touch screen, remote control, etc...
- Media
 - DVD, Blu-ray, Solid State, etc...
- 1st Party Requirements
 - Disc eject, loss of network, iconography, etc...



Talk Overview

- Goals
- Scalable Technology
- Working with Budgets
- Verification
- Teams
- Postmortem



Talk Overview

- **Goals**
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Experience Goals

- Core experience on all devices
- Expectations met on all devices



Developer Goals

- Minimize custom work
- Content creators control quality



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What is Scalable Technology?

- Easy
- Invisible
- Directed



Vicarious Visions™
ALCHEMY™

Device Classes

- Gen8 Console
 - Xbox One and PS4
- Gen7 Console
 - WiiU, Xbox 360, and PS3
- iOS High
 - Apple TV, iPad Air+, iPad mini 2+, and iPhone 5s+
- iOS Low
 - iPad mini+



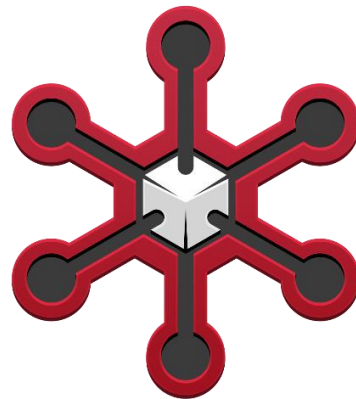
WYSIWYG



Emulation: Gen8 Console

Types of Technology

- Automatic
 - 80% of the way
 - Can opt out
- Directed
 - Improve quality using context



Automatic: Rendering Features

	Render Style	Dynamic Lighting & Shadows	Materials Features	Post Processing	Anti-Aliasing
iOS Low	Forward	None	Simplified	Low	None
iOS High	Forward	Partial	Standard	Low	MSAA
Gen7	Deferred	Standard	Standard	Medium	FXAA Medium
Gen8	Deferred	Advanced	Advanced	High	FXAA High



Gen8

Automatic: Texture Resampling

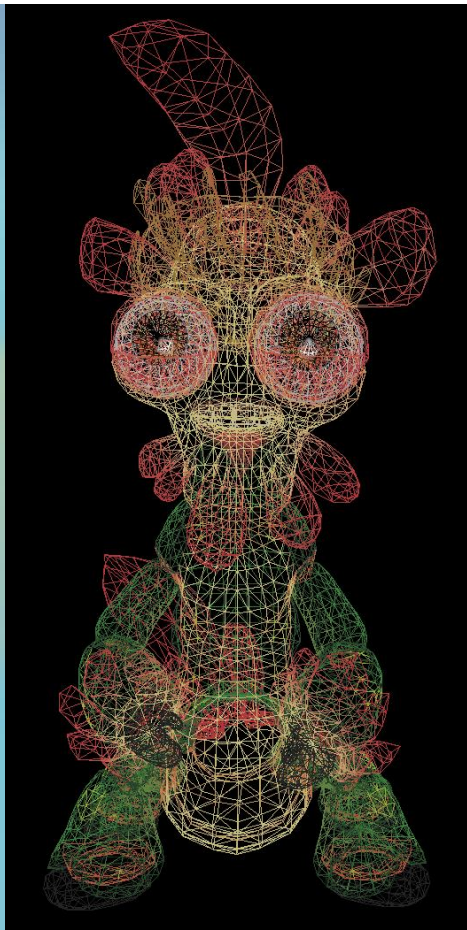
- Target 1080p
- Exclude 16k pixels
- Could opt-out

	Clamp	3D/VFX	UI
iOS Low	1024x1024	75%	50%
iOS High	1024x1024	50%	0%
Gen7	1024x1024	50%	33%
Gen8	2048x2048	0%	0%

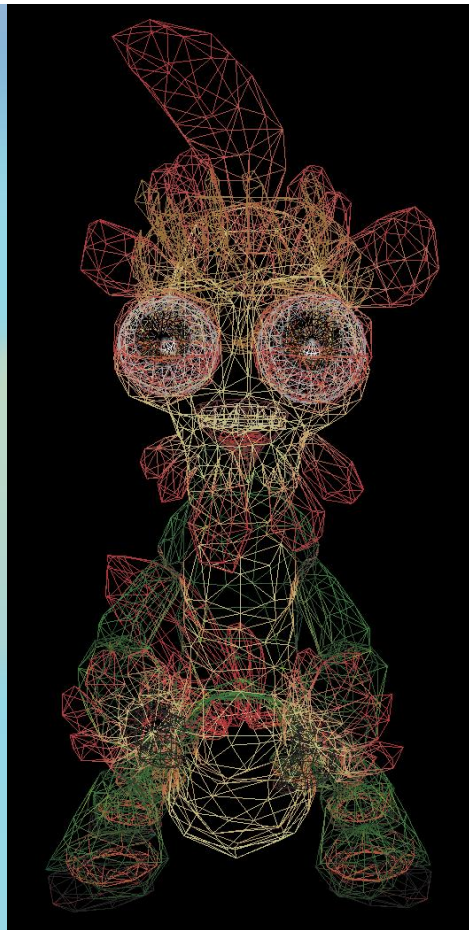
Automatic: Geometry Decimation

- Error tolerance
- Less on characters

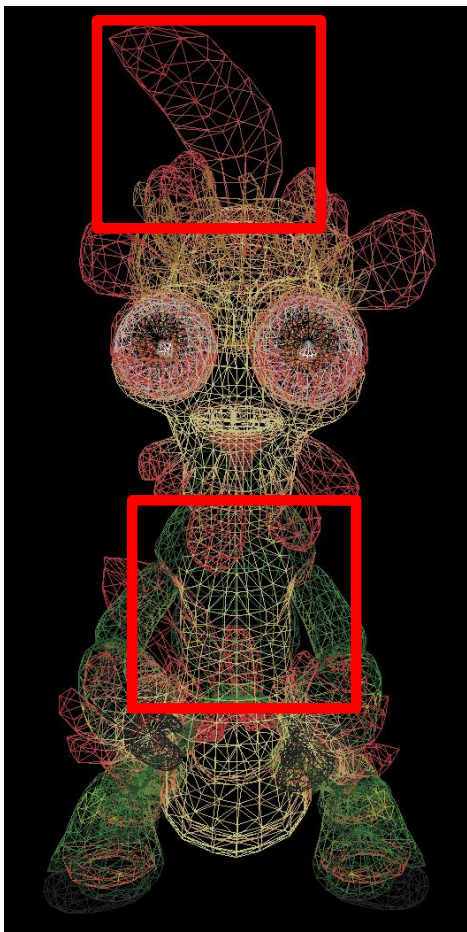
	Error Tolerance
iOS Low	High
iOS High	Medium
Gen7	Low
Gen8	None



Gen 8



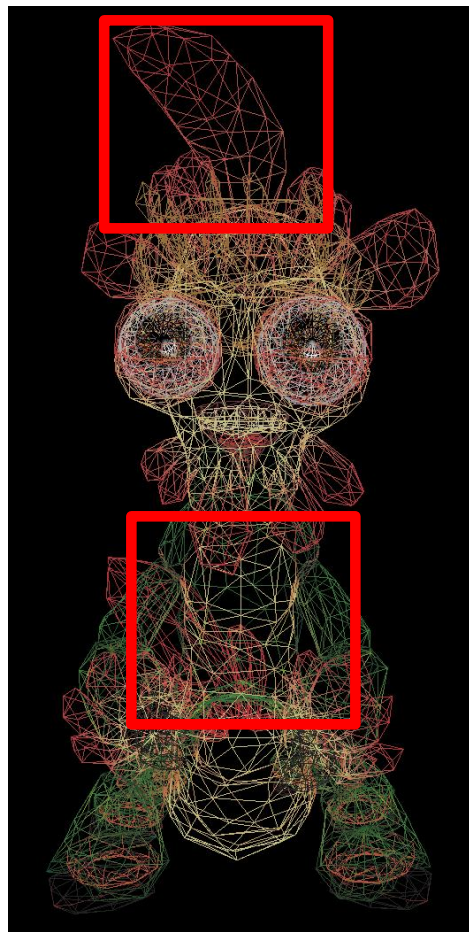
iOS Low



Gen 8

← Low →

← High →



iOS Low

Geometry Decimation: Opt Out



Automatic: Audio Features

	Reverb	Flanger	Equalizer	Compressor	Echo	Sample Rate Clamp
iOS Low	None	None	Simplified	Simplified	None	24khz
iOS High	None	None	Standard	Standard	Standard	24khz
Gen7	Advanced	Advanced	Advanced	Advanced	Standard	None
Gen8	Advanced	Advanced	Advanced	Advanced	Standard	None

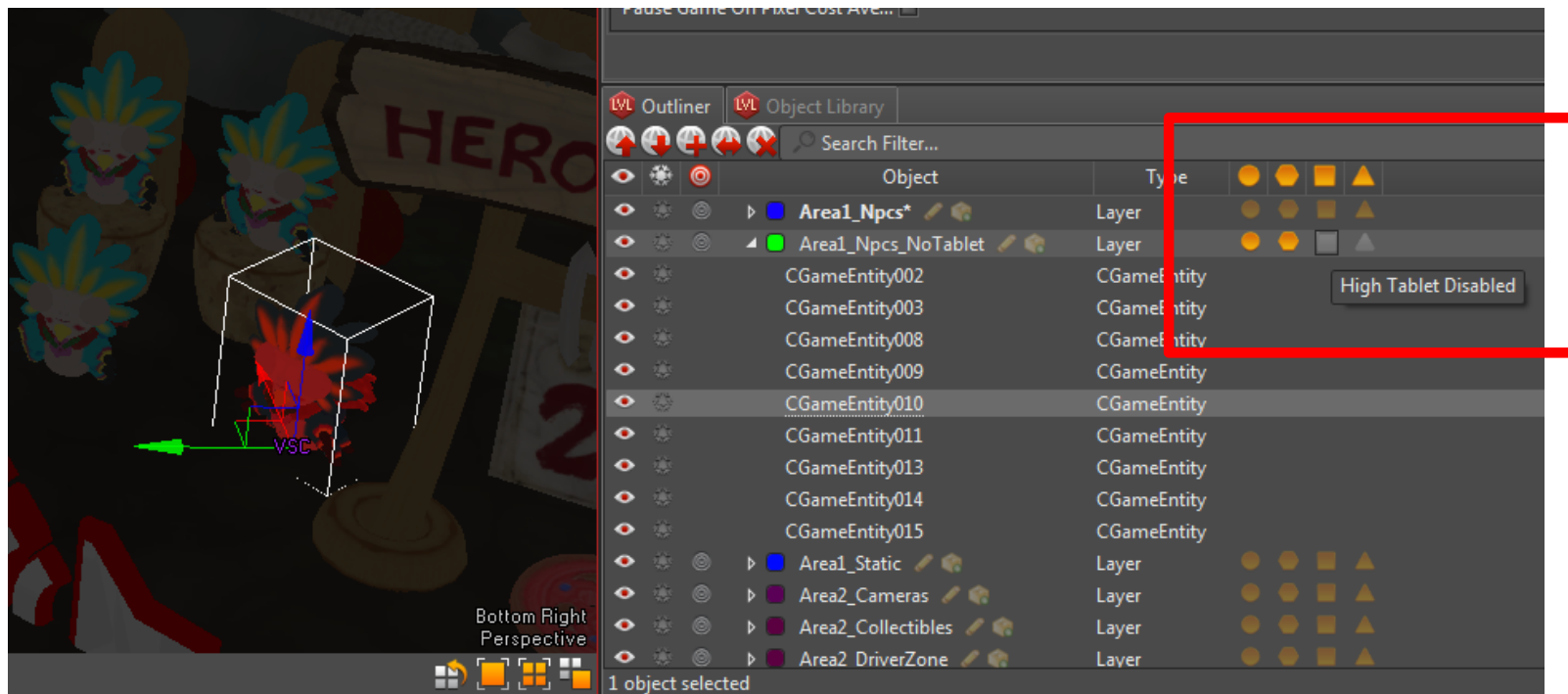
*Also supported per device options

Directed Scalability

- Toggles
 - X thing on Y platform
- Importance
 - Cull low priority



Directed: Entity Layers





Gen 8

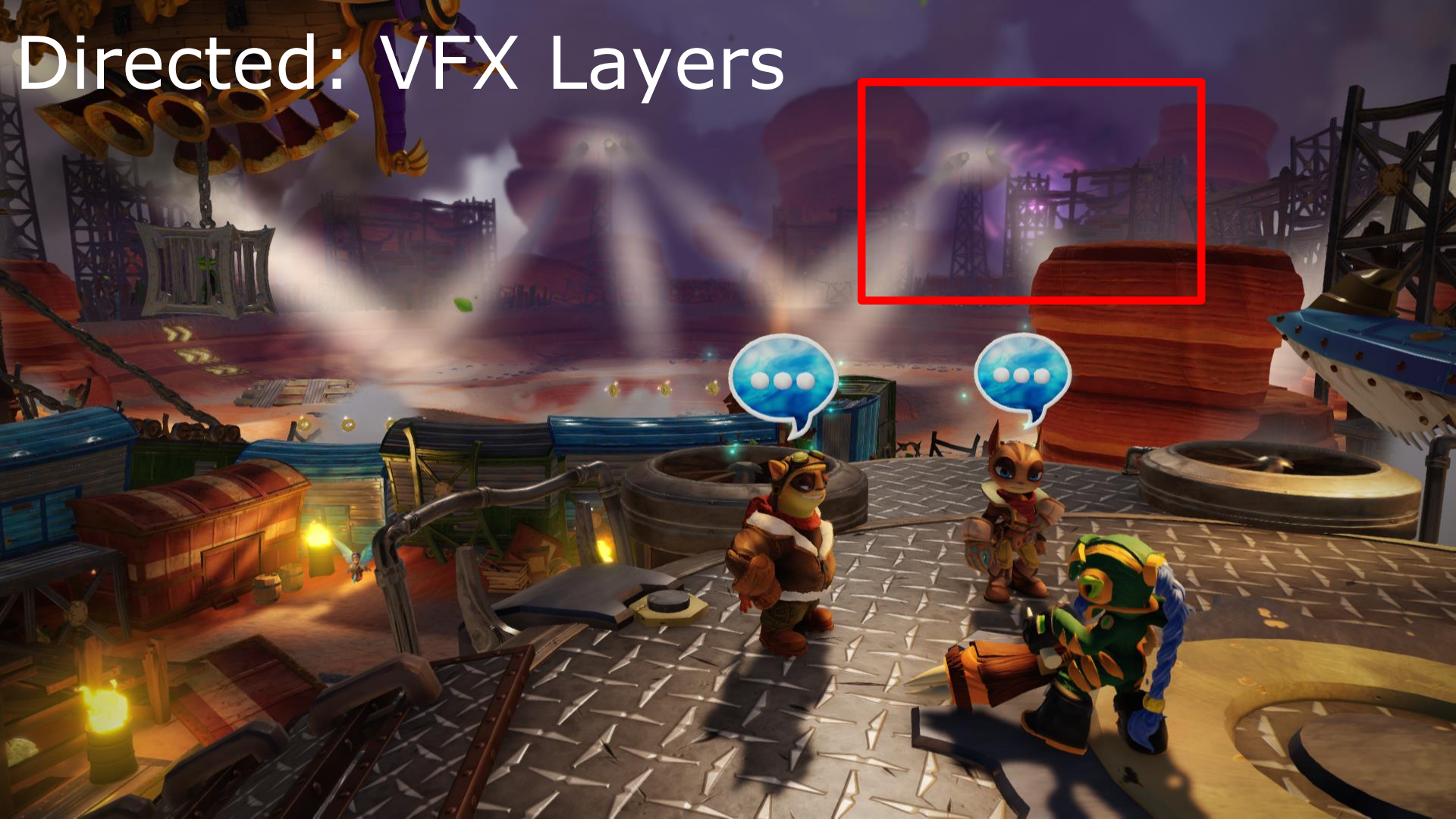


iOS

Directed: VFX Layers



Directed: VFX Layers



Directed: VFX Layers

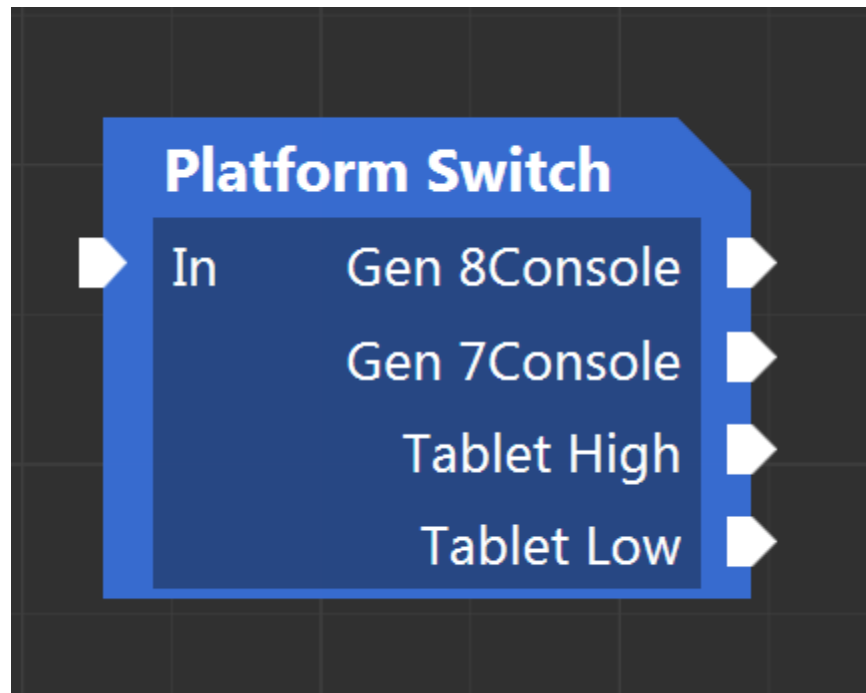


Gen 8



iOS

Directed: Visual Scripting Node





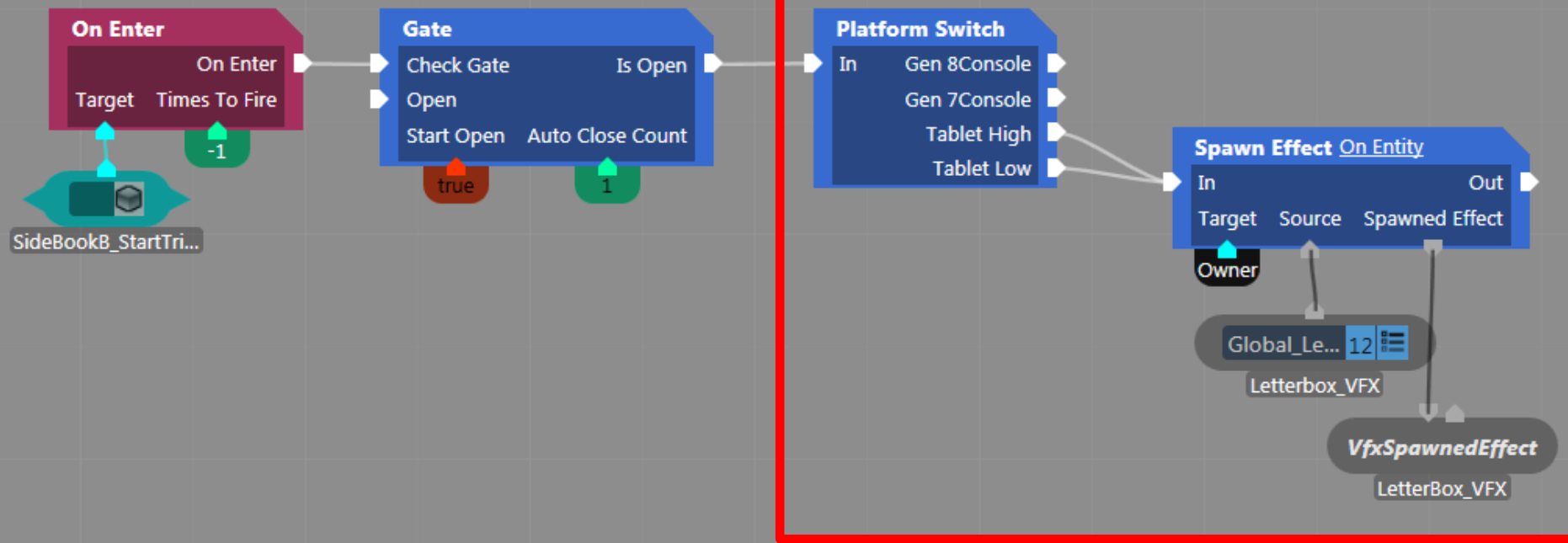
忍



PRESS  TO SKIP



General: Book Enter & Exit



Directed: Importance Authoring

- Assign importance values
- Remove less valuable things



Directed: Importance Visibility



Directed: Importance Visibility



Directed: Importance Visibility



Directed: Importance Visibility



Talk Overview

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- **Working with Budgets**
- Verification
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- Postmortem



Good Content Budgets

- Specific
- Actionable
- Realistic
- Stable
- Relative



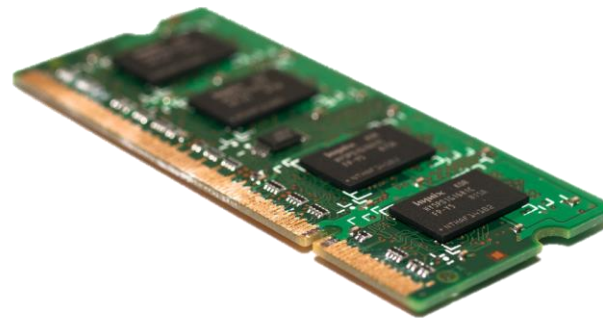
Memory

- 2 Types
 - Main memory
 - Scripts, UI, audio, etc...
 - VRAM
 - Models, textures, etc...
- PS3 exceptions
 - SPU utilization



Main Memory Budgets

- Similar across devices
- Broke some rules
 - Not stable
 - Not actionable
 - Lots of assets in one pool
 - Validated at runtime
 - Required engineering



VRAM Budgets

- Different per device
- Followed most rules
 - Stable
 - Actionable
 - Verified during build
 - Good tools
 - Free of engineers (mostly)

	iOS Low	Gen7	Gen8
permanent	33.5	40.5	110
character	7	8	23
characterElement	0.9	1.6	5
vehicle	6.9	10	21
streamedUI	6.3	4.21	12
map	160	140	450
hat	0.15	0.3	1

Budgets in MBs

Reports: Daily Levels

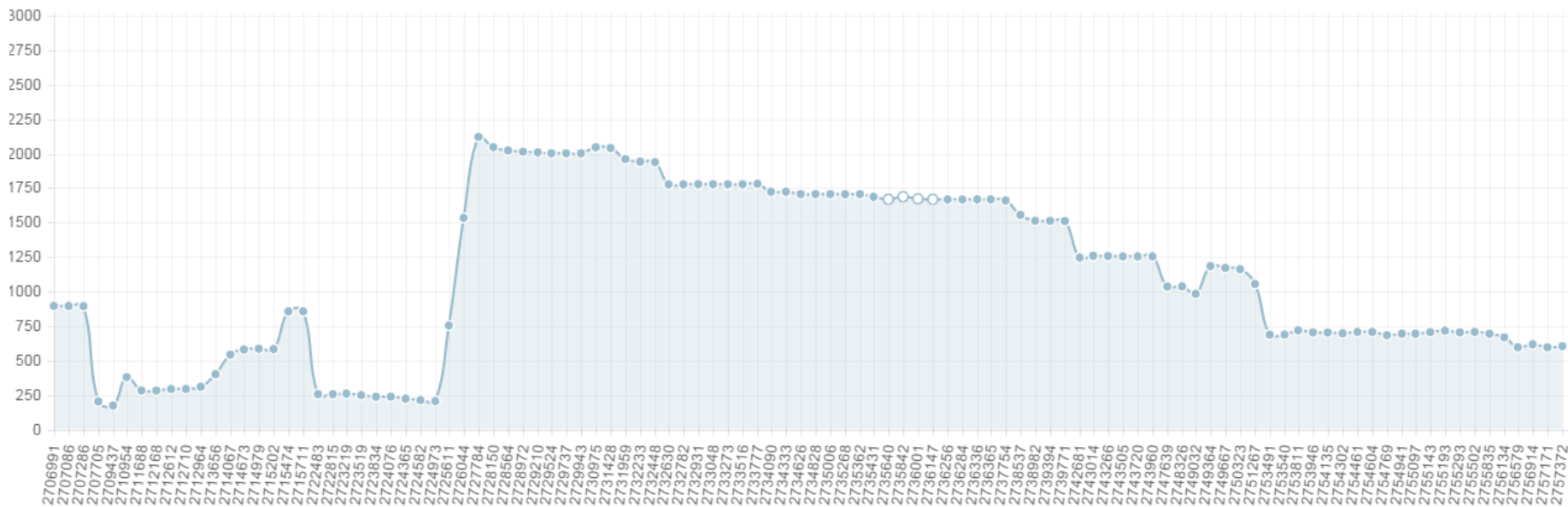
Level	Free At Peak KB	Increase KB
Sky3	856.42	-251.84
z_Deathzone	974.38	45.78
z_Magiczone	1066.90	-6.12
Nat1	1074.78	-26.97
Dark1	1244.35	-81.31
z_Techzone	1253.71	4.22
Sky1	1365.31	-47.59
z_Lightzone	1497.09	34.92
z_Earthzone	1595.92	-360.23
Nat3	1684.99	-79.17
z_Firezone	1697.69	-1.69
z_Airzone	1820.79	-9.00
Sky2	1823.93	-77.36
z_LifeZone	1846.96	21.99
z_Darkzone	1901.04	25.14
z_Waterzone	2155.59	30.77

Main Memory

Level	Usage MB	Increase MB	Remaining
Nat1	139.74	-0.09	0.98
Sky1	137.80	-0.01	2.92
Sky3	137.16	-0.67	3.56
Intro1	136.22	-0.32	4.50
Quest2	133.90	-0.08	6.82
Final1	130.63	-0.30	10.09
Quest3	130.33	-0.16	10.39
Academy	126.97	-0.32	3.75
Nat2	125.78	-0.08	14.94
Dark1	120.43	-0.21	20.29
Nat3	114.12	-0.16	26.60
Sky2	111.54	0.00	29.18
Quest1	96.44	-0.19	44.28
Mag1	93.50	-2.28	47.22
Final2	30.69	0.00	110.03
Intro	12.66	0.00	128.06

VRAM

Reports: Memory vs Changelists



Summary VRAM Reports

	A	B	C	D
1	Name	Total	Texture	Model
2	Nat1Report	139.9158	89.4604	50.4553
3	Sky1Report	137.6145	89.9648	47.6497
4	Sky3Report	137.2639	94.7876	42.4763
5	Intro1Report	136.4117	85.4395	50.9722
6	Quest2Report	134.2717	108.437	25.8347
7	Quest3Report	130.0168	100.3643	29.6526
8	Final1Report	129.9099	86.0986	43.8112
9	AcademyReport	127.3535	85.7944	41.559
10	Nat2Report	126.1361	79.3403	46.7958

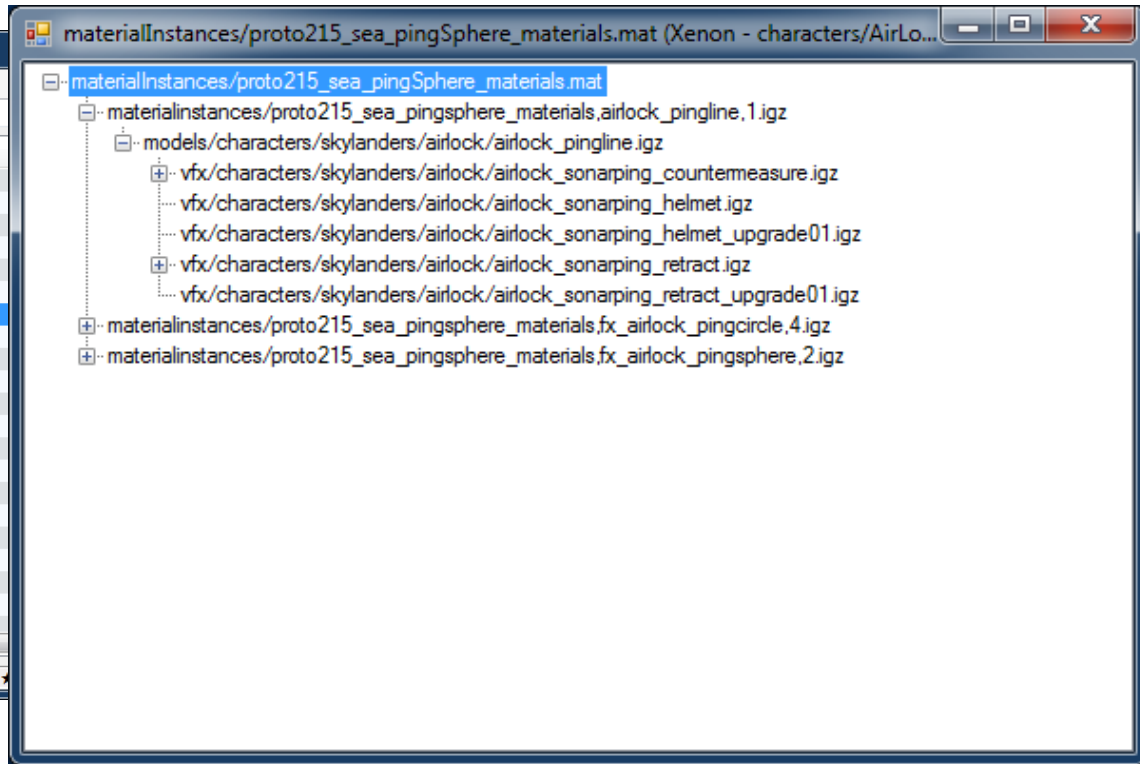
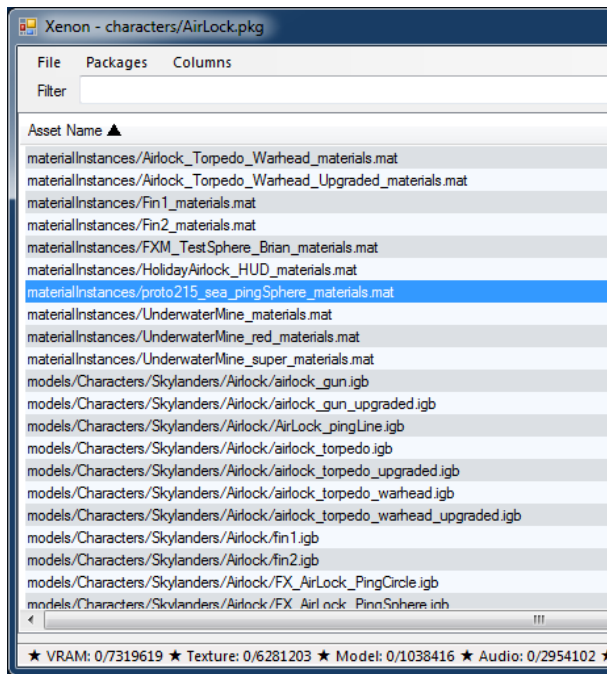
Maps

Detailed VRAM Reports

	A	B	C	D
1	File	Total (MB)	Texture	Model
53	normalmap,textures@!levels!nat1!nat1_welcomesign01_n`tga,110.igz	0.375	393216	0
54	normalmap,textures@!levels!nat1!nat1_woodenbucket_n`tga,111.igz	0.375	393216	0
55	normalmap,textures@!levels!nat1!nat1_woodpaintchip01_n`tga,111.igz	0.375	393216	0
56	normalmap,textures@!levels!quest1!q1_woodtile01_n`tga,111.igz	0.375	393216	0
57	normalmap,textures@!trees!flower_cattailhotdog01_n`tga,111.igz	0.375	393216	0
58	Temporary/BuildServer/xenon/Output/models/levelassets/edc_props/statics/edc_tt_houselow.igz	0.3741	0	392232
59	Temporary/BuildServer/xenon/Output/models/levelassets/nat1/statics/nat1_woodenbucket.igz	0.3629	0	380504
60	Temporary/BuildServer/xenon/Output/loosetextures/cookies/causticstyle32half.igz	0.3516	368640	0
61	Temporary/BuildServer/xenon/Output/models/levelassets/edc_props/statics/edc_troubletakerhouse_flowerset02.igz	0.3513	0	368336
62	Temporary/BuildServer/xenon/Output/actors/npc/flynn.igz	0.3414	0	357976
63	colormap,textures@!ui!resultscreen!star_land_dark`tga,011.igz	0.3359	352256	0
64	colormap,textures@!ui!resultscreen!star_land_lit`tga,011.igz	0.3359	352256	0
65	colormap,textures@!ui!resultscreen!star_sea_lit`tga,011.igz	0.3359	352256	0
66	colormap,textures@!ui!resultscreen!star_sea_unlit`tga,011.igz	0.3359	352256	0
67	colormap,textures@!ui!resultscreen!star_sky_lit`tga,011.igz	0.3359	352256	0
68	colormap,textures@!ui!resultscreen!star_sky_unlit`tga,011.igz	0.3359	352256	0

Maps

Package/Dependency Viewer



Performance

- Baseline analysis
 - Typical gameplay
 - Reference character
- Lead to budgets
 - Triangles, draw calls, vfx count, etc...

	Time (ms)
Render	9.9
Entity	10.5
Sound	0.9
Vfx	3.8
UI	1.2
Other	2.2
Total	28.5

CPU

Example Art Budgets

	Draw Calls	Triangles	VFX Spawns
iOS Low	300	350,000	150
iOS High	600	700,000	150
Gen7	1,500	1,500,000	150
Gen8	2,500	2,500,000	N/A

Tools: Pass Stats

	pass calls	tris (skinned)
=====		
shadows	891	1677034 (351121)
gbuffer	1007	1082642 (152150)
vfx	211	33691 (0)
vfx2	211	33691 (0)
obscuredDepth	11	19837 (19837)
obscuredColor	11	19837 (19837)
litDecalPass_Clone	71	19377 (0)
hud	22	12046 (0)
distortionPass_Clone	89	3741 (0)
waterPass_Clone	2	2410 (0)
waterBackFaces	2	2410 (0)
main	6	2040 (0)
fading_Clone	6	2040 (0)
skybox_far	2	430 (0)
skybox_far_low_resolution	2	430 (0)
gbufferIce_Clone	1	304 (0)
iceDepth	1	304 (0)
decalPass_Clone	8	96 (0)
pointLights	30	30 (0)
hero1ScreenSpaceShadows	1	12 (0)
composeScene	1	2 (0)
velocityNeighborMax	1	1 (0)

Tools: Model Stats

Draw Calls: 2346.43 / 2428.00

Triangles: 2802683.75 / 2899803.00

Vfx Count: 79.40 / 82.00

igb count calls tris (skinned)

```
=====
sky3_track01_v2      1    296  848224 (    0)
tree sharp02        7     26  171041 (    0)
sky3_portaldoor_t01  6     72  153672 (    0)
rangedbone          3     72  127712 ( 127712)
flynn                1     52  114724 ( 114724)
calicheap            1     44  102884 ( 102884)
sky3_bombgate01      1     25   97065 (   97065)
sky3_destructible_a  11     58   93032 (    0)
=====
```

Tools: Model Stats

	A	B	C	D	E	F	G	H	
1	model filename	count	igb draw calls	gbuffer draw calls	shadow draw calls	total draw calls	total tris	gbuffer tris	shac
2	sky3_track01_v2	1	183	60	236	296	848224	178048	
3	tree_sharp02	7	2	14	12	26	171041	92099	
4	sky3_portaldoor_t01	6	8	48	24	72	153672	78492	
5	rangedbone	3	9	27	45	72	127712	47892	
6	flynn	1	13	13	39	52	114724	28681	
7	calicheap	1	11	11	33	44	102884	25721	
8	sky3_bombgate01	1	5	5	20	25	97065	19413	
9	sky3_destructible_a	11	2	22	36	58	93032	35288	
10	sky3_island02	16	4	48	48	112	69280	32512	
11	driverstealthelf	1	6	6	0	24	68404	17101	
12	tree_sharp03	1	2	2	8	10	66025	13205	
13	sky3_destructible_b	21	1	21	28	49	58016	24864	
14	tree_sharp01	3	2	6	0	6	42027	42027	
15	sky3_tire01	2	6	12	12	24	41440	20720	
16	sky3_track01_flip	1	36	0	10	10	40784	0	
17	sky3_island04	10	6	40	24	84	39120	21000	

Tools: Vfx Stats

148 Playing Vfx. Update: 3.08 JQ Flush 0.76

Spawned Updated RCSpawn RCUpdate

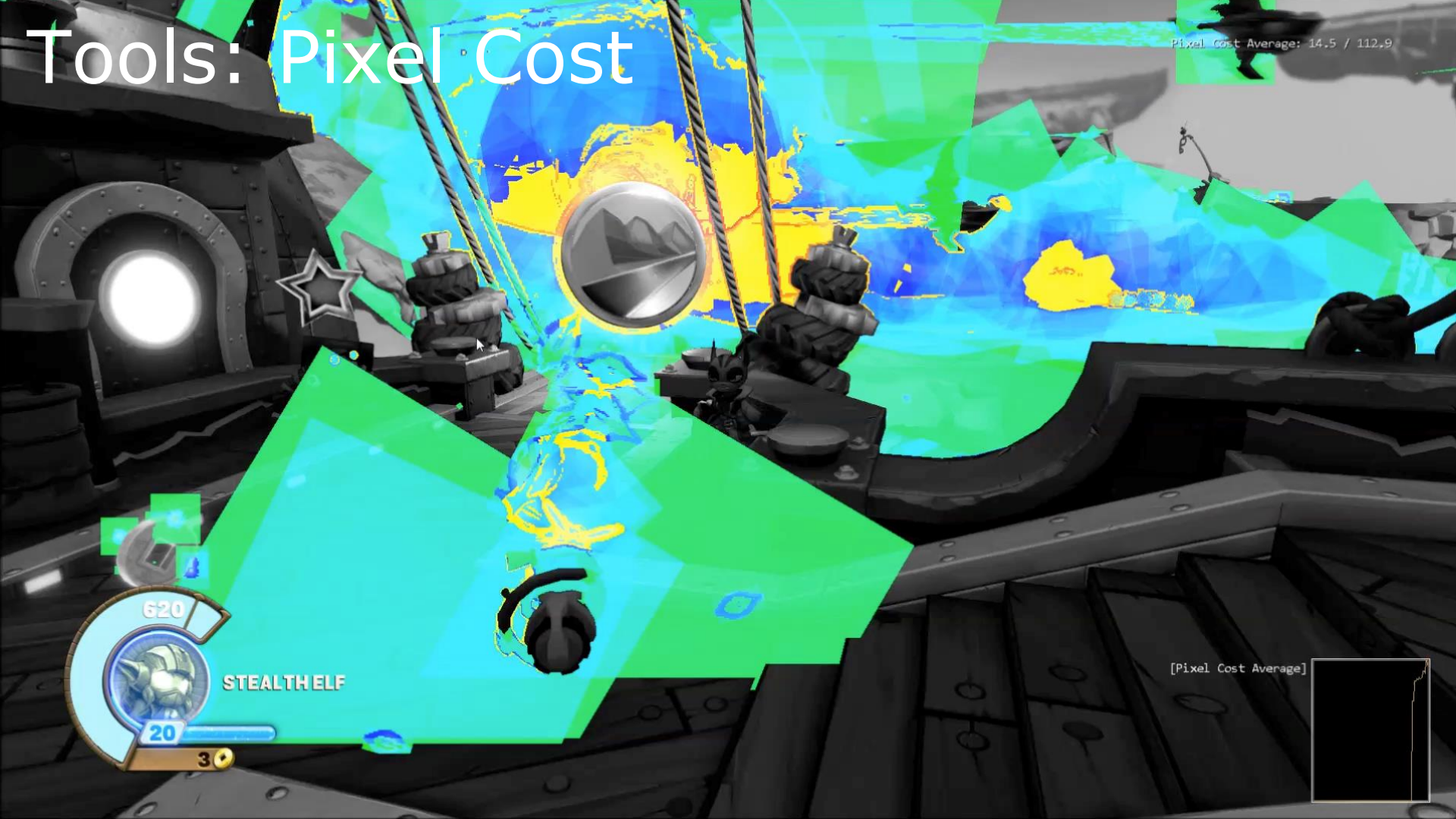
91	1091								
0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	[x3]	APL_BoostPadIdleSM		
0/ 1	1/ 3	0/ 0	0/ 0	0/ 0	0/ 0	[x1]	Body_Aviator_AirplaneBullet		
0/ 1	2/ 2	0/ 0	0/ 0	0/ 0	0/ 0	[x2]	EpicTreasureChest_Idle		
2/ 11	32/ 47	0/ 0	0/ 0	0/ 0	0/ 0	[x13]	FighterDark_ExhaustTrail		
0/ 7	1/ 11	0/ 0	0/ 0	0/ 0	0/ 0	[x1]	FighterElite_Death		
0/ 4	8/ 50	0/ 0	0/ 0	0/ 0	0/ 0	[x1]	FighterElite_Death_child		
11/ 64	110/500	0/ 0	0/ 0	0/ 0	0/ 0	[x19]	FlyerHazard_GroundSpark		
2/ 4	27/ 52	0/ 0	0/ 0	0/ 0	0/ 0	[x3]	FlyerHazard_TellVFX		
0/ 4	11/ 12	0/ 0	0/ 0	0/ 0	0/ 0	[x2]	global_hot_idle		
0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	[x3]	Intro1_AirShipLandLinear_Idle		
1/ 9	43/ 50	0/ 0	0/ 0	0/ 0	0/ 0	[x3]	Intro1_AirShipSmall_Idle		
1/ 8	38/ 39	0/ 0	0/ 0	0/ 0	0/ 0	[x3]	Intro1_EscapePod_EngineTrail		
0/ 0	8/ 8	0/ 0	0/ 0	0/ 0	0/ 0	[x8]	Intro1_HoverJet_01		
15/ 34	246/261	0/ 0	0/ 0	0/ 0	0/ 0	[x8]	Intro1_HoverJet_01_Child		
0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	[x11]	Intro1_SeaFaucetFlow		
0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	[x1]	Intro1_SkyHole_Master_AirSection		
0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	[x23]	Intro1_TankerTintLight		
0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	[x1]	Intro1_TubeEntranceLight		
1/ 3	12/ 15	0/ 0	0/ 0	0/ 0	0/ 0	[x1]	LevelSpecific		

Normalized Meta Budgets

- Approximate cost of “something”
- Normalized to 100% per device class
- Examples
 - Pixel cost
 - Entity



Tools: Pixel Cost



Pixel Cost Average: 14.5 / 112.9

620

STEALTH ELF

20

3

[Pixel Cost Average]



Tools: Entity Cost



[illegible]

Level Performance Process

- Data is recorded by QA
 - 2 consoles per day
- Engineering processed data
 - Validates budgets and sends reports
- QA writes issues
- Developers fix issues



Performance Heat mapping

Viewer
61 fps

Tab... Visibility... Render... Visual Data... Heatmap

aspen64 sky1

Metric	Level	Platform
behavior	sky1	aspen64
cputime	sky1	aspen64
draws	sky1	aspen64
droppedFrame	sky1	aspen64
entity	sky1	aspen64
gputime	sky1	aspen64
gui	sky1	aspen64
logic	sky1	aspen64
other	sky1	aspen64
physics	sky1	aspen64
render	sky1	aspen64
sound	sky1	aspen64
totalTime	sky1	aspen64
tris	sky1	aspen64
vfxCount	sky1	aspen64
vfxflush	sky1	aspen64
vfx	sky1	aspen64

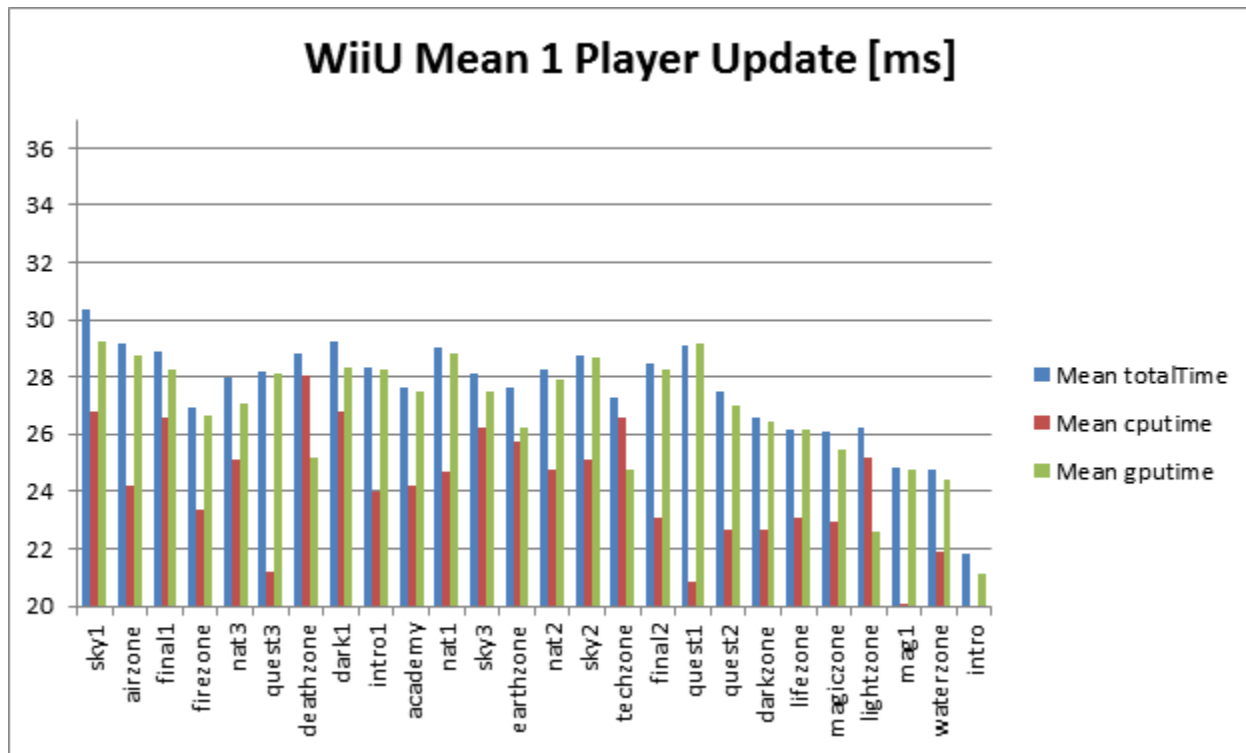
Clear heatmap

Outliner

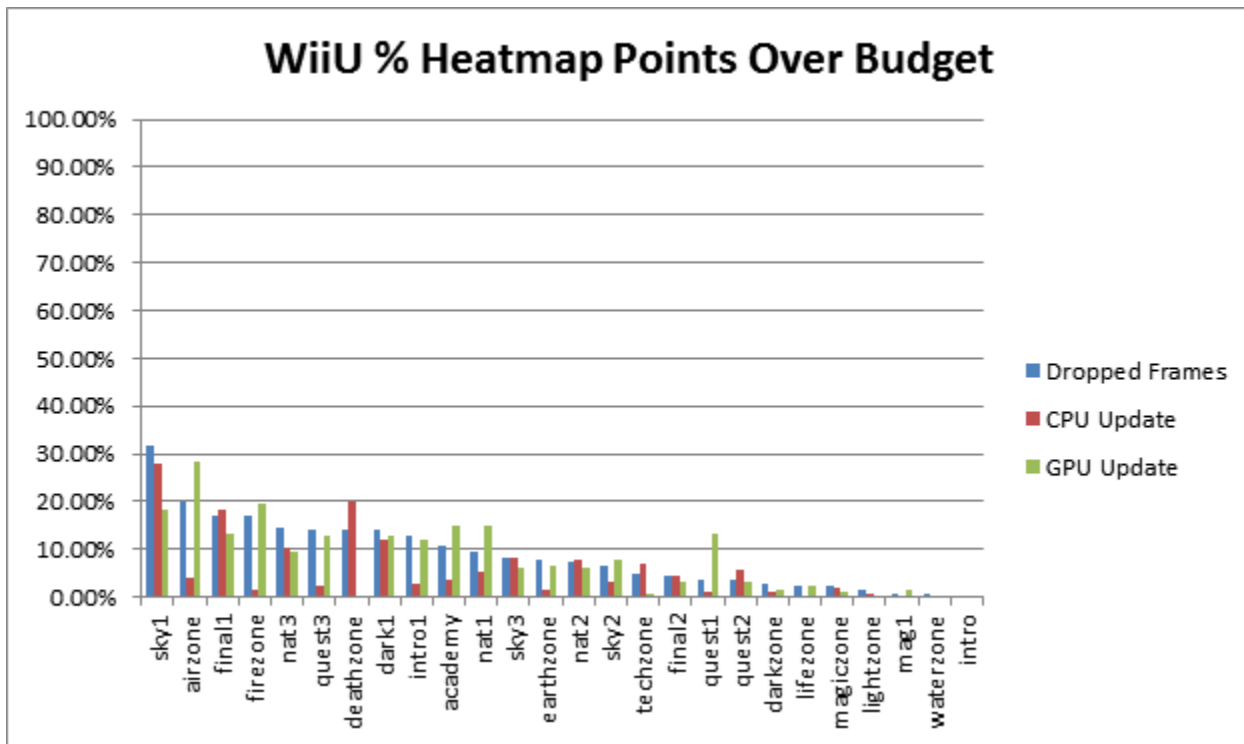
Object Library

Search Filter...	
Object	Type
Floor	Group
LandMasses	Group
Mountains	Group
Rocks	Group
Stairs	Group
ArtMountain223	CStaticEntity
ArtMountain224	CStaticEntity
Bridge61	CStaticEntity
Design_Core_Platform_83	CStaticEntity
Design_Core_Platform_137	CStaticEntity
Design_Core_Platform_147	CStaticEntity
Design_Core_Platform_148	CStaticEntity

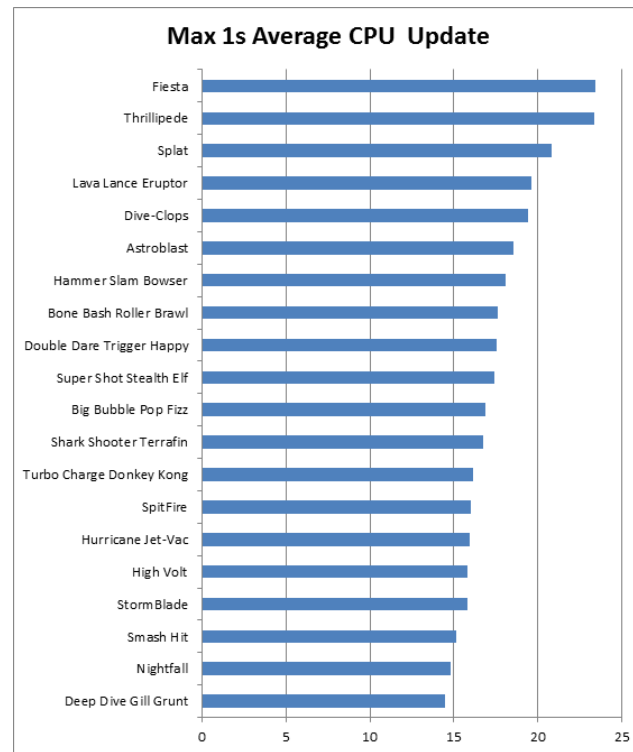
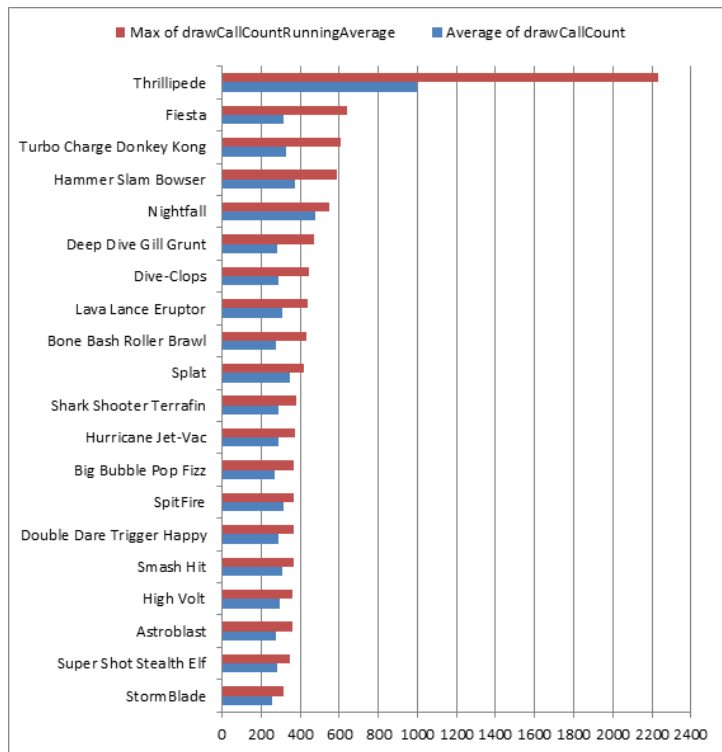
Reports: Update Time



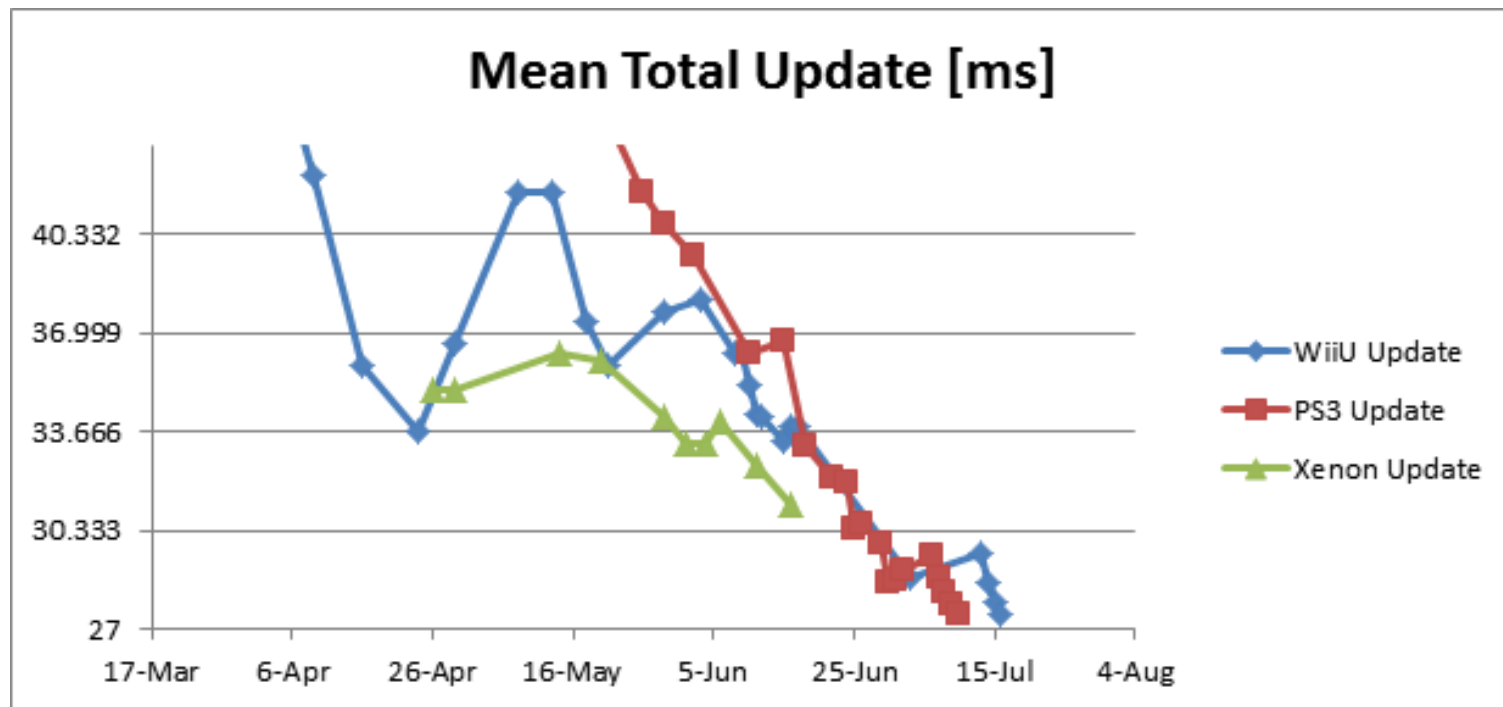
Reports: Over Budget Frames



Reports: Characters



Reports: Trends



Other Considerations

- Context
 - High draw calls with low design logic
 - Complex boss with few minions
- Training and documentation
- Platform Station



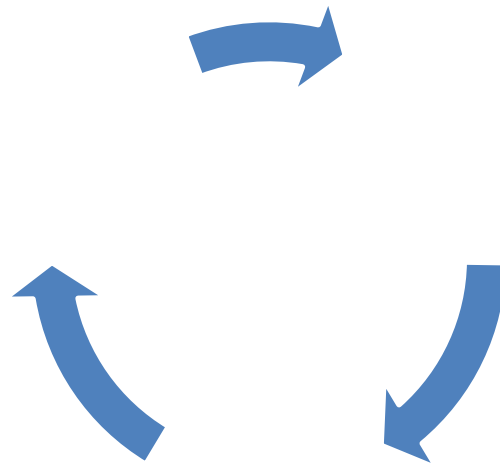
Talk Overview

- Goals
- Scalable Technology
- Working with Budgets
- **Verification**
- Teams
- Postmortem



Verification Cycle

- Devs make changes
- Build system creates and tests builds
- QA tests builds and writes bugs

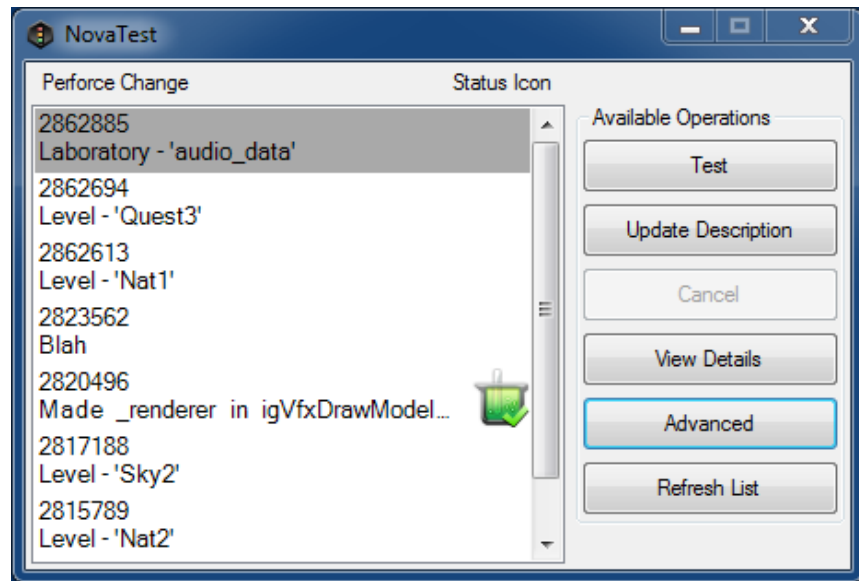


Dev Policy for Scalability

1. Test changes in game
2. Trigger pre-submission testing (10 min)
3. Submit
4. Status set to "On the hook"
5. Wait for dev build with changes (30 min)
6. Status set to "Off the hook"

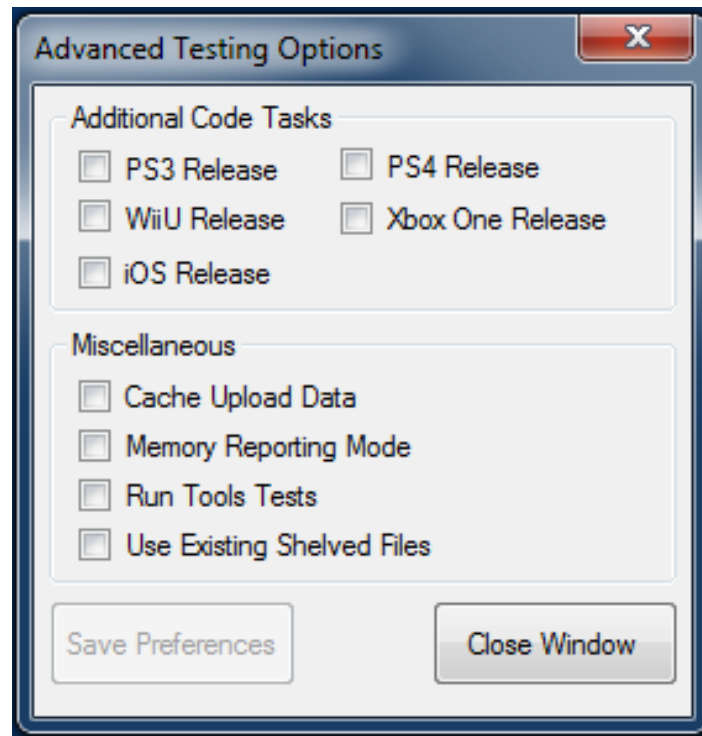
Pre-submission testing

- Basic testing
 - Compile
 - Verify memory
- Bug management
 - Reviews
 - Database integration



Pre-submission testing

- Advanced Testing
 - More devices
 - Memory validation



Build Generation

- Main build
 - Basic validation
- Device builds
 - Testing
 - Builds for QA, Marketing, Kid testing, etc...

:: pulse 2.7 ::		
browse server agents administration		
• Supernova		
• Nova Project Template		8 projects building
▲ skylanders-main	build 5777	:: 🔄
● supernova-code-analysis	build 19260	:: 🔄
▲ supernova-code-aspen	build 10099	:: success
● supernova-copy-alchemy.tool-to-automatedrelease		this project has never been built
● supernova-copy-alchemy.tool-to-release		this project has never been built
● supernova-copy-alchemy.tool-to-releasecandidate		this project has never been built
● supernova-data-aspen	build 2206	:: 🔄
▲ supernova-live-ops-main	build 279	:: ⚠️ warnings
▲ supernova-localization	build 385	:: ⚠️ warnings
● supernova-long	build 10905	:: 🔄
● supernova-long-cafe	build 16022	:: failure
● supernova-long-durango	build 9797	:: ⚠️ warnings
▲ supernova-long-ps3	build 12059	:: ⚠️ warnings
● supernova-long-ps4	build 6790	:: 🔄
● supernova-long-win	build 13630	:: failure
▲ supernova-main	build 31357	:: 🔄

Automated Testing

- APIs
 - I/O, Memory, VFX
- Features
 - Rendering, race mode
- Content
 - Levels, characters, vehicles



Hardware

- 41 pre-submission machines
- 31 build machines
- 38 devkits
 - 3 PS3, 3 PS4, 3 WiiU, 2 XB1, 25 XB360, 2 iPad

QA

- Local [30 PPL]
 - Developer support
 - Performance
 - SKU Parity
 - Build Verification Testing (BVTs)
- External [~130 PPL]
 - Additional testing and 1st Party Support



Build Verification Tests (BVTs)

- Consistent testing
- Examples
 - Level progression
 - Character upgrades
 - Collectibles
 - Hats
- Reports to Production

Level	Status	Notes	BLOCKER Bug ID	OTHER Bug ID
Intro	PASS		-	-
Intro 1	PASS		-	-
Sky 1	PASS		-	-
Sky 2	PASS		-	-
Sky 3	PASS		-	-
Quest 1	PASS	CRITICAL - Occasional crash during fights	-	SNV-49141 SNV-52128
Magic 1	FAIL	BLOCKER: Collision misaligned or non-existent on level geometry	SNV-71079	-
Nat 1	PASS		-	-

Technology for QA

- Build retrieval
- Easy deployment
- Efficiency gains
 - Add gold
 - XP multiplier
 - Skip movies

QATool	Bug	Entity	Net	Map
Smoke	>			
Options	>			
Character	>	Add 100 Gold		
Vehicle	>	Add 1000 Gold		
		Add 10000 Gold		

QATool	Bug	Entity	Net	Map	Save	Cutscene
Smoke	>					
Options	>	XP Multiplier			< 1.00 >	
Character	>	KidTestMode				()
Vehicle	>	Allow Skipping Cutscenes				()
		Show Toy Info				()

Talk Overview

- Goals
- Scalable Technology
- Working with Budgets
- Verification
- **Teams**
- Postmortem



Device Agnostic [80% PPL]

- Content focused teams [3-10 PPL]
 - Characters, vehicles, levels, etc...
- Work with budgets
 - No device hardware



Cross-device

- UX team [3-5 PPL]
 - 1st Party Requirements
- Feature teams [5-7 PPL]
 - Online & Rendering
- Optimization team [6 PPL]
 - Memory/performance optimization and management



Device Specific

- iOS team [3-5 PPL]
 - Custom UI
 - In app purchasing
 - Touch controls
 - Streaming assets from cloud



Support

- Build team [2-3 PPL]
 - Build maintenance
 - Build delivery
 - Developer support



Talk Overview

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What worked?

- Platform emulation
- Most developers ignored devices
- Budgets
- Content creators understood scalability

What's next?

- Less device classes
- Early budgets
- More importance authoring
 - Scripting
- More procedural systems
 - VFX



What's next?

- Offline memory analysis
- Faster submission process
- More automated testing





Thank You