#### Cautionary statement

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# Radeon Software

**Terry Makedon** Director of Software Strategy and UX

Under embargo until June 29, 2016 at 9 a.m. EST



# Radeon Software

**GPUOpen enables developers through open source** 

Laser focused on delivering the best GPU user experience

Jnder embargo until June 29, 2016 at 9 a.m. ES

AMDA RADEON

#### GPUOpen

- AMD's initiative to enable developers through open source
- 14 major updates in the last 30 days\*
- 41 developer blogs in last 4 months\*
- 61 SDK/Samples/Libraries/Tools posted since launch Jan 26 2016
- We are the first IHV to release an SPIR-V extension the intermediate shader language used in Vulkan™ (we released support for GCN instructions)

\*Status as of May 28

AMD internal research and internal, projections submit to change

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## Open source effects, SDKs and libraries

#### New Effects

- ShadowFX (DX12)
- GeometryFX improvements (DX11)
- TressFX 3.1 (DX11)

#### New Libraries / SDK / Samples

- Multithreaded Rendering (DX12)
- Out of order rasterization (Vulkan)
- FireRays (Vulkan and OCL)
- ▶ CrossFire<sup>™</sup> API (DX11)



TressFX Viewer v3.0





#### Open sourcing tools for developers

- Compressonator for Textures
- GPUPerfAPI Analysis
- CodeXL 2.0
  - Profile, debug and analyze performance/power across CPU and GPU graphics and compute
  - **•** Efficiencies DX 12 CPU and GPU timelines



Enabling improved performance with more open source tools



### Radeon Support for OpenVX<sup>TM</sup>

- **OpenVX™** is an open standard for cross platform acceleration of computer vision applications & algorithms
  - ▶ Radeon support for OpenVX<sup>TM</sup> Open source API support
  - RunVX Efficient Runtime tool
  - Graph optimizer Automatic optimization



Radeon support for OpenVX ™is a fully open source stack designed for speed and accuracy



## So... what about virtual reality?

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### Virtual Reality Adoption

#### **Second Generation**

Headsets



Future statements, subject to change Under embargo until June 29, 2016 at 9 a.m. EST.

AMDA RADEON

#### LiquidVR<sup>™</sup> – New Features

- TrueAudio Next
- Compute Unit Reservation
- Quick Response Queue
- Variable Rate Shading
- ▶ DirectX<sup>®</sup>12 and Vulkan<sup>™</sup>





#### TrueAudio Next

- Real Time GPU Audio Physics Processing
  - Ray Tracing + Convolution for many audio sources
  - Scalable
  - Low latency
- Asynchronous Compute
  - Executes concurrently with other graphics & compute tasks
  - Uses queues with customized scheduling
- Open source library will be available on GPUOpen.com
- Optimized for superior VR experiences



Immersive audio in real time



#### Compute Unit Reservation

- Dedicate a number of CUs for a specific task queue
- Immediate execution with a fixed resource budget
- Works with any type of shader (graphics or compute)

CU	CU		
CU		CU CU	CU
CU		CU CU	CU
		CU	CU
		CU	
		CU	
	CU	CU	

Audio

Graphics



#### Quick Response Queue

- Solving VR time-critical task execution
  - Frames that take too long to render result in "judder" that destroys sense presence
- Quick Response Queue (QRQ)
  - More precise control of timing
  - Leverages asynchronous compute
  - Lower latency
- Asynchronous Time Warp on Oculus Rift uses QRQ to avoid dropped frames



Based on AMD internal engineering data and analysis

#### Variable Rate Shading

- Multi-viewport processing API
  - Assign viewport ID to each polygon
  - Independent resolution/quality settings for each viewport
- Used to implement foveated rendering
  - High resolution for frame center
  - Reduced resolution for periphery
  - Eye tracking support





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#### LiquidVR™ and DirectX®12

- DirectX®12 is ideal for VR development
  - Increased draw call throughput
  - Low CPU overhead
  - Native support for asynchronous compute and multi-GPU
  - Low-level GPU hardware access
- Supported by Oculus SDK and Basemark VR Score benchmark
- LiquidVR® DirectX®12 samples and documentation will be available at GPUOpen.com





# Radeon Software

GPUOpen enables developers through open source

Laser focused on delivering the best GPU user experience

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AMDA RADEON

# Experiences Stability

AMDA RADEON



For many years we did monthly WHQL driver updates.

Users thought it was too much.







# Then for a few years we toned down our release frequency.

Users thought it was too little.





#### **CURRENT PLAN**

6 full WHQL certified recommended drivers a year as many optional or game specific drivers as needed

(target all of them to be WHQL)

\*As of May 28 Under embargo until June 29, 2016 at 9 a.m. EST.

AMDA RADEON

#### Game-Day 0 supported with Radeon Software Crimson Edition



Crimson 16.1

Crimson 16.2

Crimson 16.2.1

Crimson 16.3

Crimson 16.4.1



#### Game-Day 0 supported with Radeon Software Crimson Edition



RSCE <u>16.5.1</u>

RSCE 16.5.2

RSCE 16.5.3

RSCE 16.5.3



#### User overall satisfaction



September 2014 – May 2016 Source: Internal AMD Data

4.4/5 Approval Rating



AMDA | RADEON

#### Radeon Software Beta Program

- Launched last month
- Users can email for information
  - RadeonSoftwareBeta@amd.com
- Fully integrated with our QA department and run by our lead beta tester of over 15 years

# Experiences Performance





## Paving the way with Vulkan<sup>™</sup>

Radeon Software 16.5.3



AMDA RADEON

## Performance leadership in DirectX® 12 games

Radeon Software 16.5.2 vs. Nvidia 365.10











	UP TO	UP TO	UPTO	UP TO	UP TO
Radeon™ Fury X vs. GTX 980Ti	21% <sup>11</sup>	23% <sup>12</sup>	18% <sup>13</sup>	2% <sup>14</sup>	0% <sup>15</sup>
Radeon™ R9 390 vs. GTX 970	57% <sup>16</sup>	81% <sup>17</sup>	40% <sup>18</sup>	19% <sup>19</sup>	13% <sup>20</sup>
Radeon™ R9 380 vs. GTX 960	9% <sup>21</sup>	70% <sup>22</sup>	39% <sup>23</sup>	12% <sup>24</sup>	38% <sup>25</sup>

\*Test results are not average and may vary Under embargo until June 29, 2016 at 9 a.m. EST.

AMDZ | RADEON

#### Smooth gaming experience on Radeon Software

Milliseconds per frame

 Radeon Software offers smooth MGPU DX12 titles

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 Low variance in frame times results in a better gaming experience <sup>10</sup>



Time



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# Experiences Features

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#### MultiGPU

- Scaling and high FPS don't improve experience above playable frame rate
- ▶ CrossFire<sup>™</sup> API (DX11) is on GPUOpen





## AFR frame pacing

- Support for DX12 planned support in a future Radeon Software driver update
- Insert delay on the GPU before each present to the display



RADEON

# Microsoft

Chas Boyd Principal Program Manager Windows Graphics



## Polaris support for Linux<sup>®</sup> distributions

- All Open Driver (all open source components)
  Currently upstreaming
- PRO Driver (Mix of open and closed components)
  - Supported for DOTA 2 Vulkan on Day 1 of release
  - **Bundled with SteamOS Beta 2.8 Enabling Vulkan support**





#### XConnect<sup>™</sup> software features

- **Safe Unplug** available now!
- ▶ Display through XConnect<sup>™</sup> planned for a future release





### Radeon Settings

- 9 new Crimson features
  - ▶ Crossfire<sup>™</sup> Global Control
  - ► HDMI<sup>™</sup> Scaling Control
  - Color Temperature Control
  - Power Efficiency Global Control
  - Display Scaling Per-Application
  - > 2 Display Quick Eyefinity Support
  - Quick OS Launcher
  - UI Language Selector







## Introducing Radeon WattMan\*

Take complete control of your GPU Available at launch for Radeon™ RX400 Series GPUs

\*Formerly known as AMD OverDrive Under embargo until June 29, 2016 at 9 a.m. EST.

formerly AMD OverDrive<sup>™</sup> AMDA RADEON



#### AMD Over Drive<sup>TM</sup>

Years of our users overclocking

Now we're going to redefine that experience with Radeon WattMan



### The new redefined overclocking experience

- Simple GPU and Memory Control
- Power Limit Control
- New features
  - Dynamic GPU Frequency Curve
  - Voltage Control Curve
  - Acoustic Limit Control
  - Advanced Temperature Control
  - Advanced Fan Control
  - Histogram Interface
  - Crash Recovery Mechanism



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#### New dynamic GPU frequency curve

With the new dynamic GPU Frequency curve, you can take direct control your GPU clock, adjusting frequency and voltage per state.

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7 customizable states on Polaris





#### New histogram interface

Record per-application data with only that application open. Easily track peak and average activity, clocks, temperature and fan speed.

5 trackable data-points





#### Hialgo acquisition

- Lays groundwork for gaming innovations
- **Chill:** Power saving
  - Enforced FPS limit only when movement is low
- Boost: Dynamic Image Quality Control
  - Delivers higher FPS during high action; improving smoothness and reduces lag





R

#### Summary

#### **SOFTWARE RELEASES**

- > 13 New releases for 2016, including 4 WHQL releases
- 15+ games supported and optimized (performance and quality)

#### FEATURES

- New API and SDK Support
  - ▶ Vulkan<sup>™</sup> API, DirectX<sup>®</sup> 12 Quick Response Queue, Oculus Rift<sup>™</sup> SDK
- New Product Support
  - Polaris 10, Polaris 11, Oculus Rift<sup>™</sup>, HTC Vive<sup>™</sup>, AMD XConnect<sup>™</sup> technology, AMD Radeon<sup>™</sup> Pro Duo graphics
- ▶ New Features Introduced for Radeon<sup>™</sup> Settings
  - Radeon WattMan, Global AMD Crossfire<sup>™</sup> control, HDMI<sup>™</sup> Scaling, Color Temperature Controls, Per-Game Display Scaling, Language Menu, Two Display Eyefinity, AMD Crossfire<sup>™</sup> Status Indicator, Updated Social Links based on Region, Power Efficiency Toggle

#### STABILITY

- Over 140 fixes and customer end user issues resolved in the last 6 months
- 4.4 User Satisfaction currently

#### PERFORMANCE

Sample Crimson improvements comparing 15.11 to 16.5.3





## RADEON° SOFTWARE

Enabling the Polaris Experience

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#### Radeon Software – Footnotes

AMD's product warranty does not cover damages caused by overclocking, even when overclocking is enabled via AMD hardware and/or software.

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Quantum Break<sup>TM</sup>, Hitman<sup>TM</sup>, Ashes of the Singularity<sup>TM</sup>, Gears of War: Ultimate Edition<sup>TM</sup>, Forza Motorsport 6: Apex and all other product names, logos, and brands are property of their respective owners. All company, product and brand names used in this presentation are for identification purposes only. Use of these names, logos, and brands does not imply endorsement.

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Slide 28: Testing conducted by AMD Performance Labs as of May 19, 2016 on two AMD Radeon<sup>TM</sup> R9 Fury X graphics cards in AMD Crossfire technology mode, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Ashes of the Singularity<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. Test results are not average and may vary.

<sup>1</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Doom<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X and Vulkan API scored 122.2 and with OGL API scored 97.8, which is 25% faster performance for Radeon R9 Fury X with Vulkan API. Test results are not average and may vary. RS-48

<sup>2</sup> Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> R9 Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game The Talos Principle<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X and Vulkan API scored 222.4 and with OGL API scored 109.5, which is 103% faster performance for Radeon R9 Fury X with Vulkan API. Test results are not average and may vary. RS-50

<sup>3</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Dota2<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X and Vulkan API scored 173.4 and with OGL API scored 136.5, which is 27% faster performance for Radeon R9 Fury X with Vulkan API. Test results are not average and may vary. RS-49

<sup>4</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Doom<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 and Vulkan API scored 113.2 and with OGL API scored 108.8, which is 4% faster performance for Radeon R9 390 with Vulkan API. Test results are not average and may vary. RS-51

<sup>5</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> R9 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game The Talos Principle<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 and Vulkan API scored 218.1 and with OGL API scored 116.2, which is 88% faster performance for Radeon R9 390 with Vulkan API. Test results are not average and may vary. RS-53

<sup>6</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Dota2<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 and Vulkan API scored 171.7 and with OGL API scored 139.1, which is 23% faster performance for Radeon R9 390 with Vulkan API. Test results are not average and may vary. RS-52

<sup>7</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Doom<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 X and Vulkan API scored 52.9 and with OGL API scored 44.0, which is 20% faster performance for Radeon R9 380 with Vulkan API. Test results are not average and may vary. RS-54

<sup>8</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game The Talos Principle<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 X and Vulkan API scored 170.5 and with OGL API scored 93.0, which is 83% faster performance for Radeon R9 380 with Vulkan API. Test results are not average and may vary. RS-56

<sup>9</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> R9 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and Windows 10 x64 using the game Dota2<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 X and Vulkan API scored 138.4 and with OGL API scored 119.8, which is 16% faster performance for Radeon R9 380 with Vulkan API. Test results are not average and may vary. RS-55



#### Radeon Software – Footnotes

11 Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon™ Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Quantum Break™. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X scored 40.95 and NVidia GTX980Ti with NV 365.10 driver scored 33.98, which is 21% faster performance for Radeon R9 Fury X. Test results are not average and may vary. RS-34

12Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon™ Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Hitman™. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X scored 43.86 and NVidia GTX980Ti with NV 365.10 driver scored 35.61, which is 23% faster performance for Radeon R9 Fury X. Test results are not average and may vary. RS-35

13 Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon™ Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Ashes of the Singularity™. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X scored 42.302 and NVidia GTX980Ti with NV 365.10 driver scored 35.954, which is 18% faster performance for Radeon R9 Fury X. Test results are not average and may vary. RS-36

14Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon™ Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Gears of War: Ultimate Edition™. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X scored 37.74 and NVidia GTX980Ti with NV 365.10 driver scored 36.86, which is 2% faster performance for Radeon R9 Fury X. Test results are not average and may vary. RS-37

15 Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> Fury X graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Forza Motorsport 6: Apex<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 Fury X scored 62.05 and NVidia GTX980Ti with NV 365.10 driver scored 62.34, which is 0% faster performance for Radeon R9 Fury X. Tests are not average and may vary.

16Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Quantum Break<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 scored 32.83 and NVidia GTX970 with NV 365.10 driver scored 20.89, which is 57% faster performance for Radeon R9 390. Test results are not average and may vary. RS-38

17Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Forza Motorsport 6: Apex<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 scored 50.96 and NVidia GTX970 with NV 365.10 driver scored 44.96, which is 13% faster performance for Radeon R9 390. Test results are not average and may vary. RS-39

18Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Hitman<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 scored 34.05 and NVidia GTX970 with NV 365.10 driver scored 18.86, which is 81% faster performance for Radeon R9 390. Test results are not average and may vary. RS-40

20Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 390 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Gears of War: Ultimate Edition<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 390 scored 29.26 and NVidia GTX970 with NV 365.10 driver scored 24.59, which is 19% faster performance for Radeon R9 390. Test results are not average and may vary. RS-42

AMDA RADEON

#### Radeon Software – Footnotes

<sup>21</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Quantum Break<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 scored 61.85 and NVidia GTX960 PNY with NV 365.10 driver scored 56.49, which is 9% faster performance for Radeon R9 380. Test results are not average and may vary. RS-43

<sup>22</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Forza Motorsport 6: Apex<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 3840x2160, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 scored 44.76 and NVidia GTX960 PNY with NV 365.10 driver scored 32.47, which is 38% faster performance for Radeon R9 380. Test results are not average and may vary. RS-44

<sup>23</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>TM</sup> 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Hitman<sup>TM</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 scored 39.55 and NVidia GTX960 PNY with NV 365.10 driver scored 23.3, which is 70% faster performance for Radeon R9 380. Test results are not average and may vary. RS-45

<sup>24</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Ashes of the Singularity<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 2560x1440, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 scored 33.24 and NVidia GTX960 PNY with NV 365.10 driver scored 23.881, which is 39% faster performance for Radeon R9 380. Test results are not average and may vary. RS-46

<sup>25</sup>Testing conducted by AMD Performance Labs as of May 19, 2016 on the AMD Radeon<sup>™</sup> 380 graphics card, on a test system comprising Intel i7 5960X CPU, 16GB DDR4-2666 Mhz system memory, Radeon Software Crimson Edition driver 16.5.2 and NV 365.10 driver and Windows 10 x64 using the game Gears of War: Ultimate Edition<sup>™</sup>. PC manufacturers may vary configurations, yielding different results. At 1920x1080, Radeon Software Crimson Edition 16.5.2 with Radeon R9 380 scored 53.97 and NVidia GTX960 PNY with NV 365.10 driver scored 48.23, which is 12% faster performance for Radeon R9 380. Test results are not average and may vary. RS-47

