

S9949: A new PBR Material serving Mobile, Web, Real-time Engines and Raytracing



3DEXPERIENCE®

Jan Meseth (3DS)
Marc Ellens (X-Rite)
Pierre Maheut (Allegorithmic)
Jan Jordan (NVIDIA)

Motivation

Enterprise Visualization – Diverse Requirements

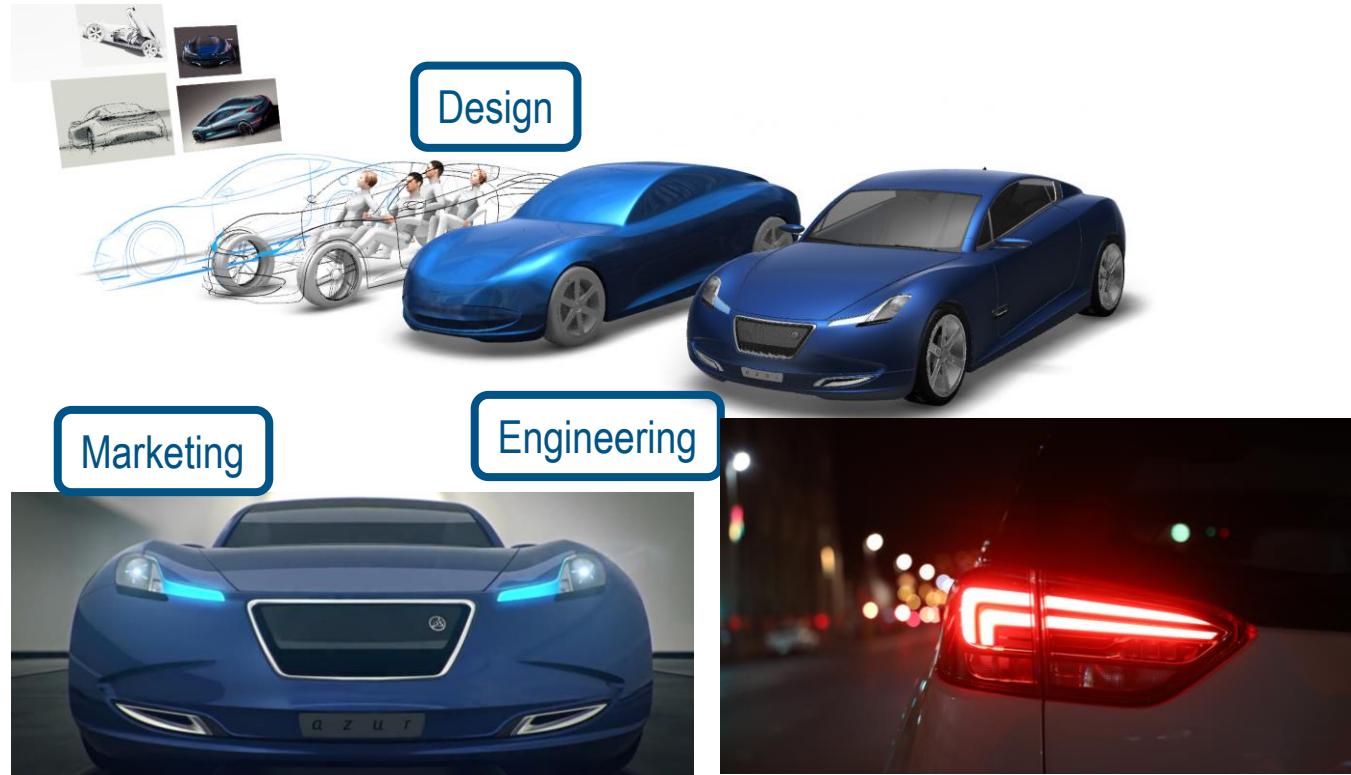
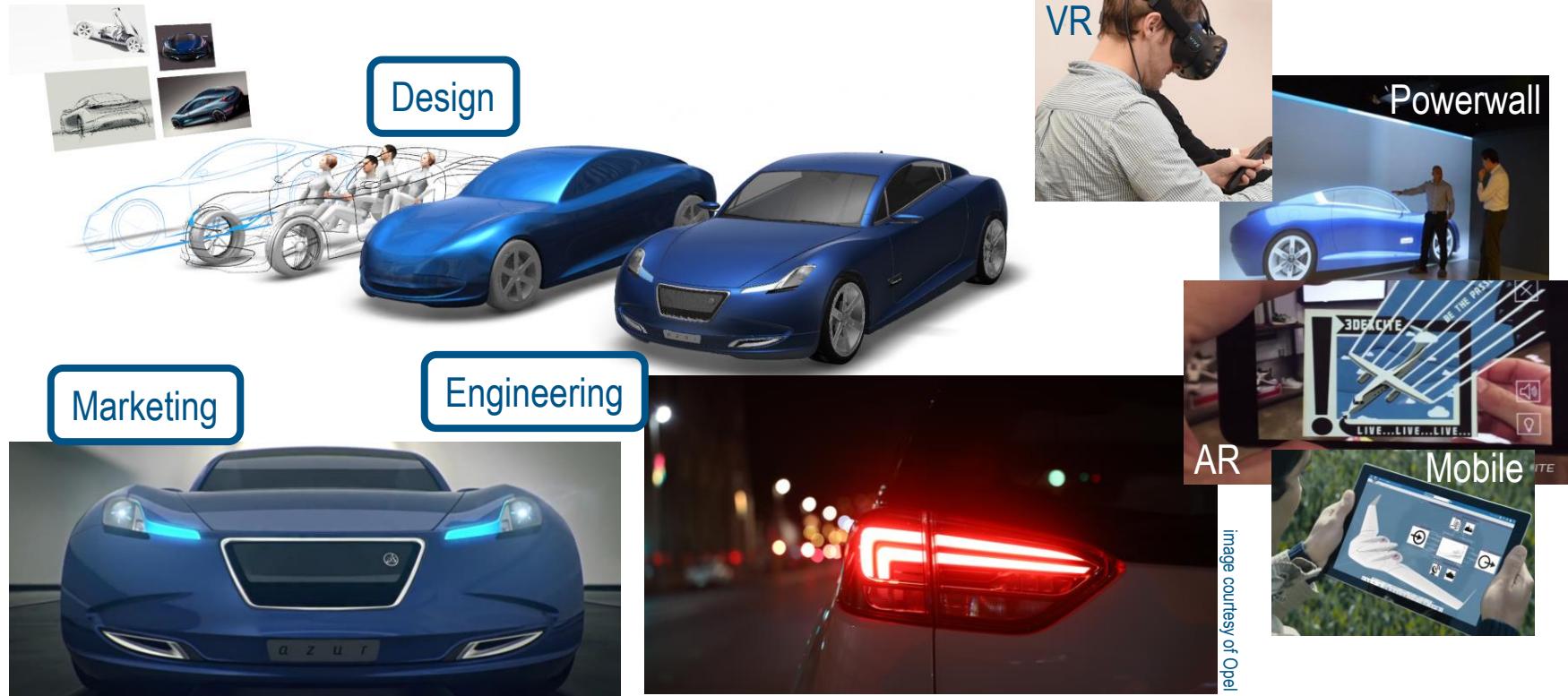


image courtesy of Opel

Enterprise Visualization – Diverse Requirements



Enterprise Visualization – Diverse Requirements

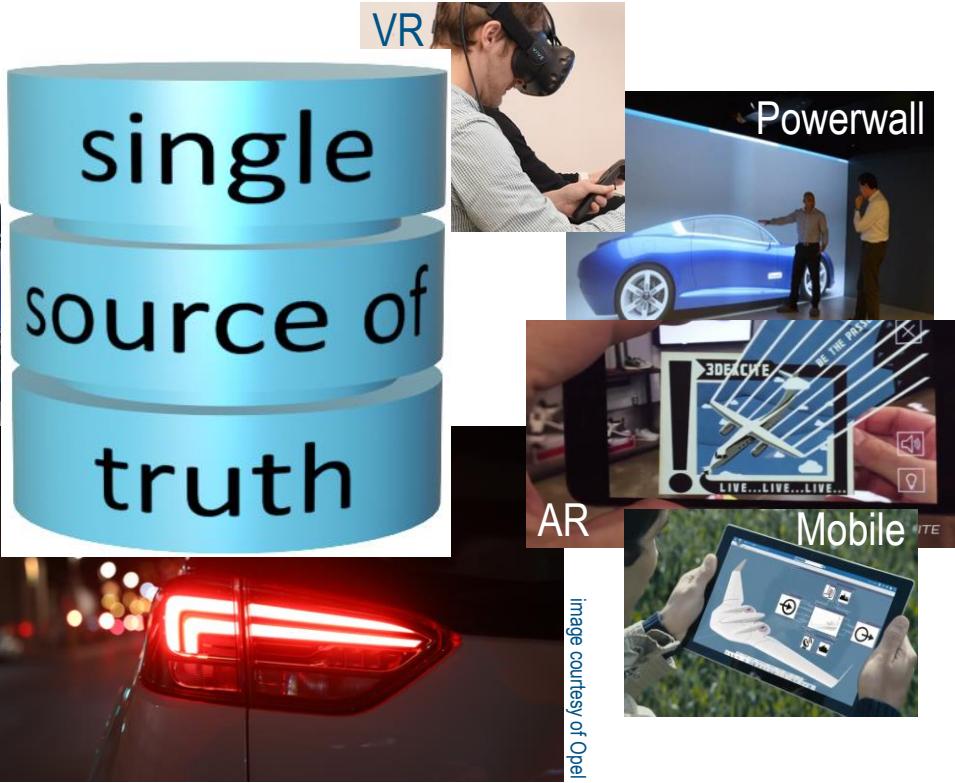


image courtesy of Opel

GGX PBR

- ▶ Different proposals
 - ▷ Disney Principled BRDF
 - ▷ Unreal 4 PBR Material
 - ▷ ...
- ▶ Widely adopted
- ▶ Very performant
- ▶ Not all relevant effects covered

Physically-Based Shading at Disney

by Brent Burley, Walt Disney Animation Studios

/Revised: Aug 21, 2019. Corrected normalization factor in Equation 1.1.

Real Shading in Unreal Engine 4

by Brian Karis, Epic Games

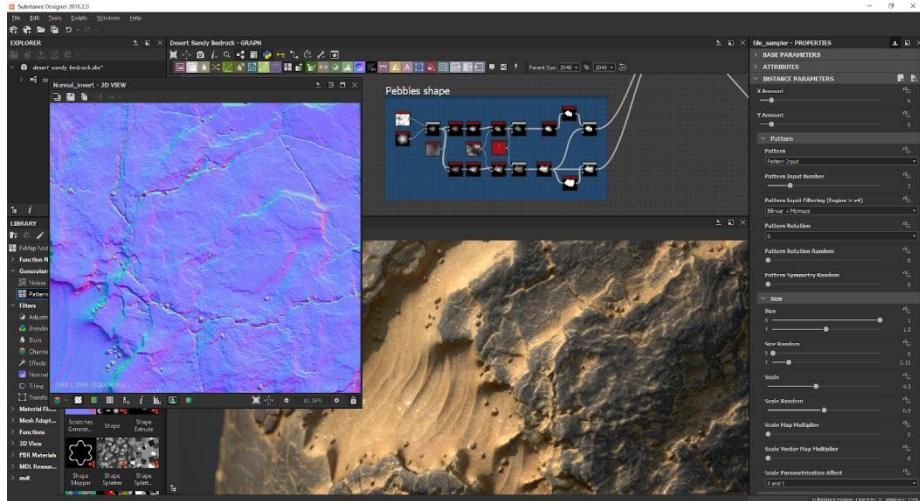


Figure 1: UE4: Infiltrator demo

ysically-based shading were proved to be more intuitive and faster to implement than traditional methods. The results are visually more appealing and realistic.

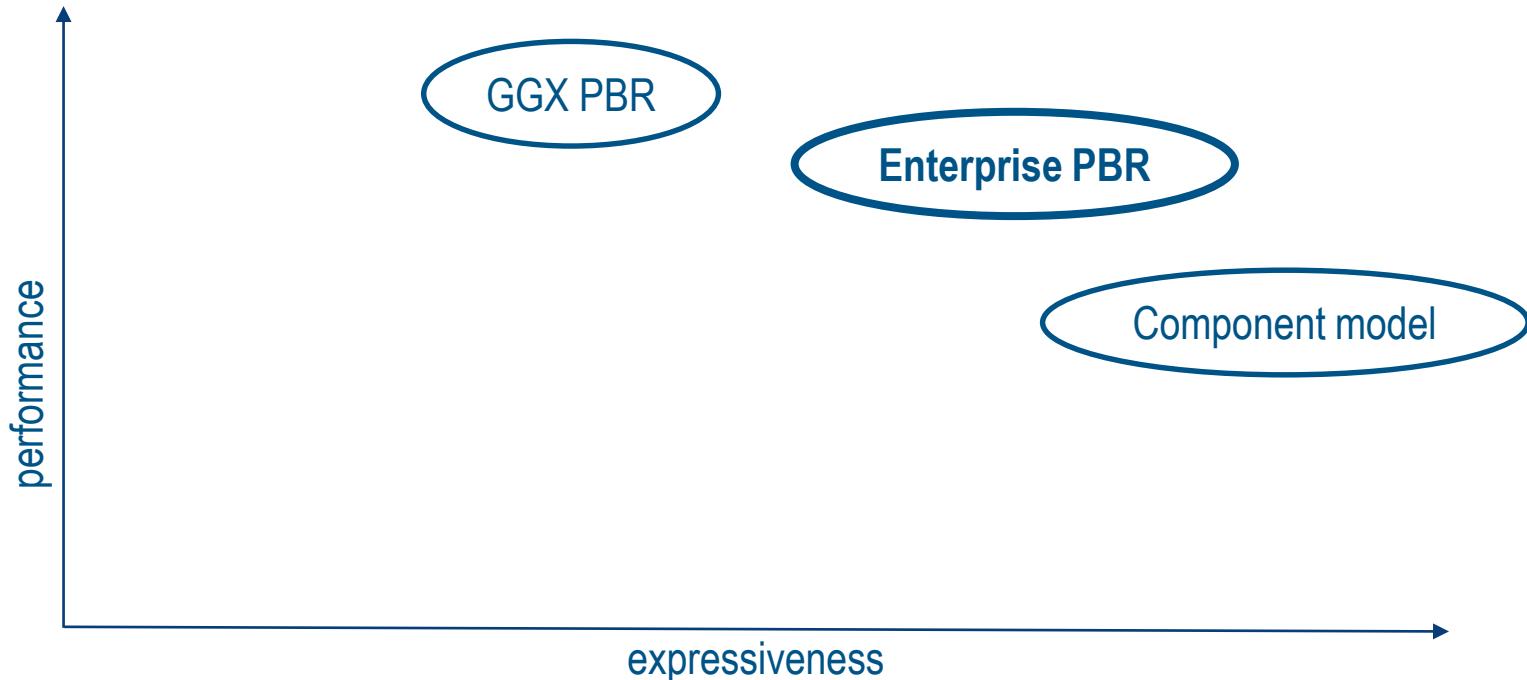
Component Models

- ▶ Many proposals
 - ▷ MDL (Material Definition Language)
 - ▷ OSL (Open Shading Language)
 - ▷ ...
- ▶ Widely adopted
- ▶ Very expressive
- ▶ Hard to implement efficiently



New Proposal: Enterprise PBR

- Great expressiveness at great performance



Proposed Appearance Model

Enterprise PBR

► Design Goals

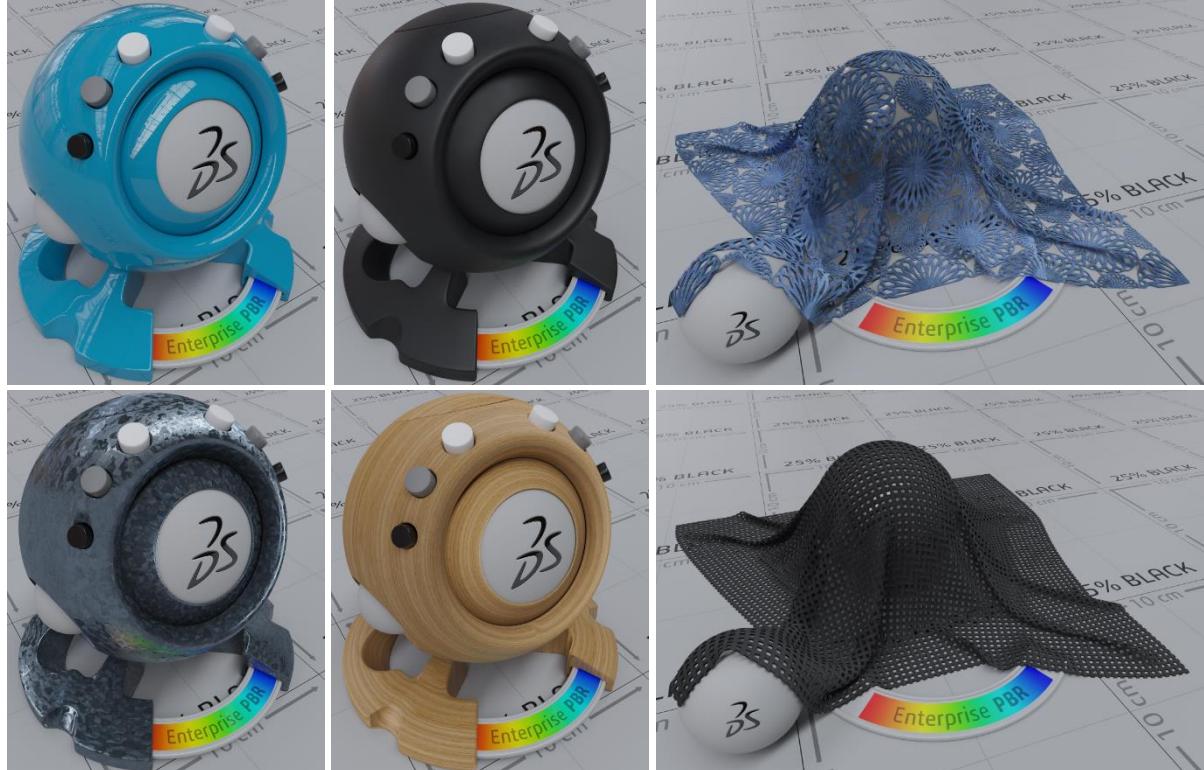
- ▷ Expressiveness – model most common materials
- ▷ Performance – AR / VR / mobile
- ▷ Ease of use – few intuitive parameters
- ▷ Fitness for Global Illumination

► Inspired by existing GGX models

Enterprise PBR – Base Layer

- ▶ Albedo *
- ▶ Metallic *
- ▶ Roughness *
- ▶ Anisotropy *
- ▶ Normal Map *
- ▶ Transparency
- ▶ Cutout Opacity *
- ▶ Sheen *
- ▶ Specular *
- ▶ Specular Tint *
- ▶ **Not:** Sheen Tint

* Supported in popular GGX PBR



Enterprise PBR – Coating Layer

- ▶ Clearcoat *
- ▶ Clearcoat Roughness *

▶ Not:

- ▷ Clearcoat IOR
- ▷ Tinting
- ▷ Thin Film



* Supported in popular GGX PBR

Enterprise PBR – Flakes Layer

- ▶ Flake Color
- ▶ Flake Density
- ▶ Flake Roughness
- ▶ Flake Size

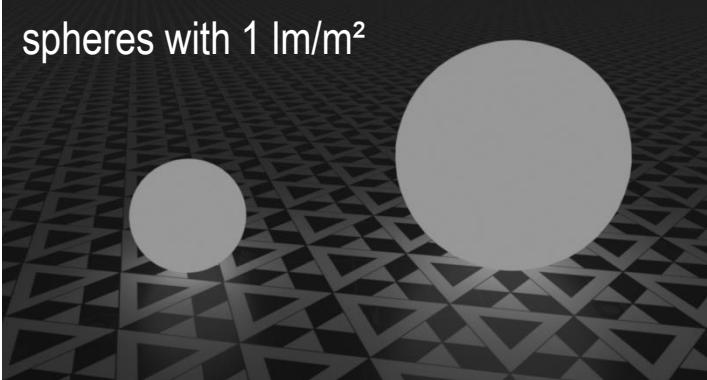
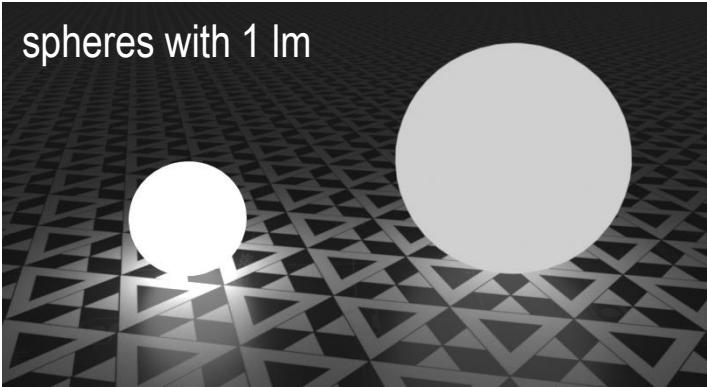
- ▶ **Not:**
 - ▷ Differentiation Flip vs. Flop
 - ▷ Roughness of individual flakes



* Supported in popular GGX PBR

Enterprise PBR – Emission Layer

- ▶ Emission color * (normalized or not)
- ▶ Emission value (in lm/m² or lm)
- ▶ Not:
 - ▷ Goniometric profile

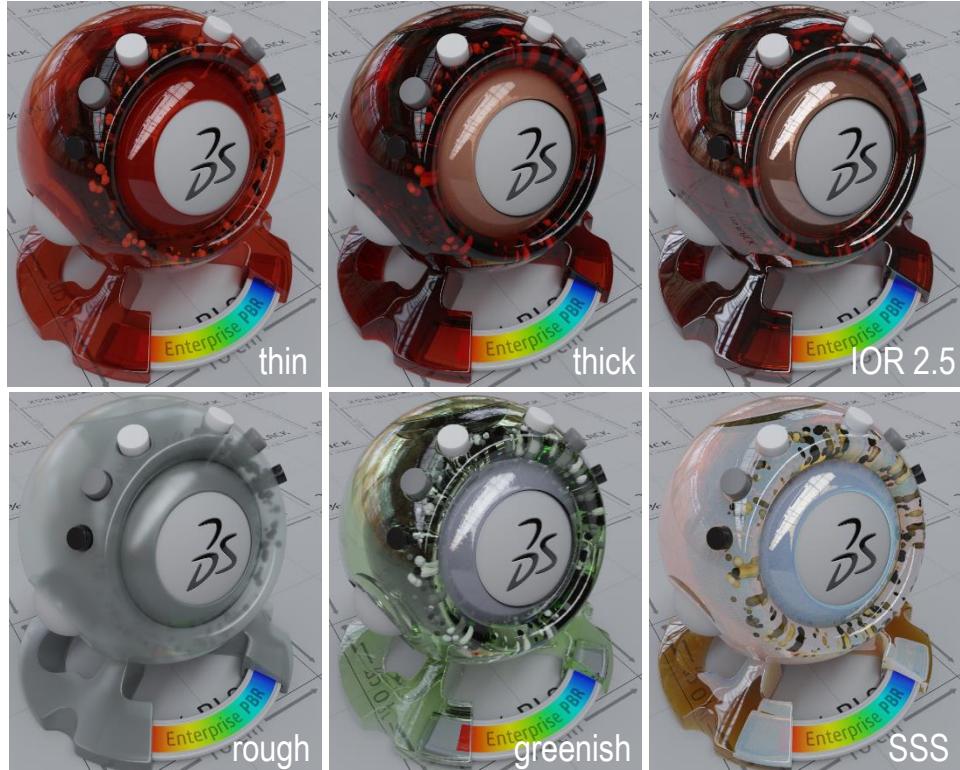


* Supported in popular GGX PBR

Enterprise PBR – Volume Layer

- ▶ Thin Walled
- ▶ IOR
- ▶ Attenuation Color
- ▶ Attenuation Distance
- ▶ Subsurface Color *

- ▶ Not:
 - ▷ Phase Function

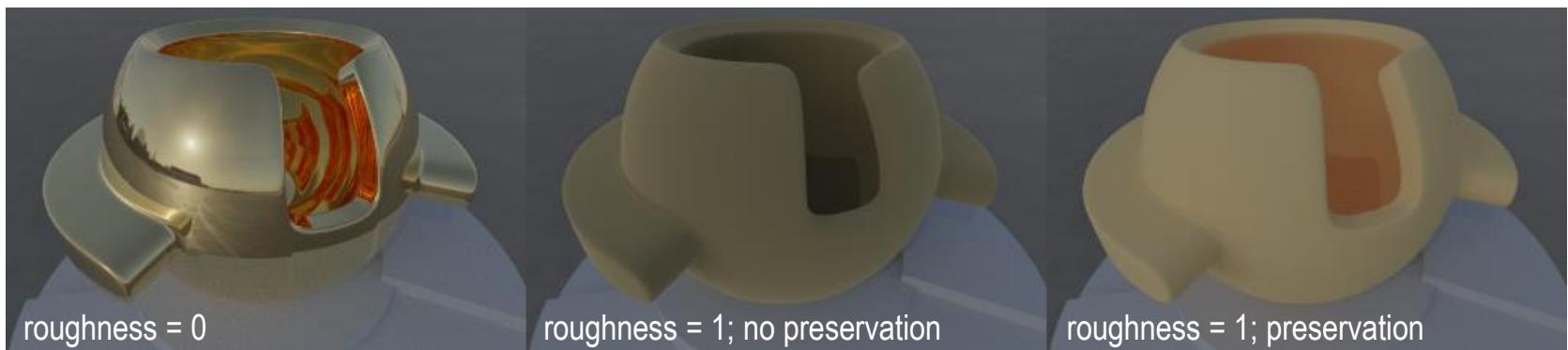


* Supported in popular GGX PBR

Energy Preservation

- ▶ Previous PBR models: energy conservation
- ▶ Enterprise PBR: also energy preservation / multi-scattering
- ▶ Solutions:
 - ▷ Lookup table
 - ▷ Approximation via closed formula

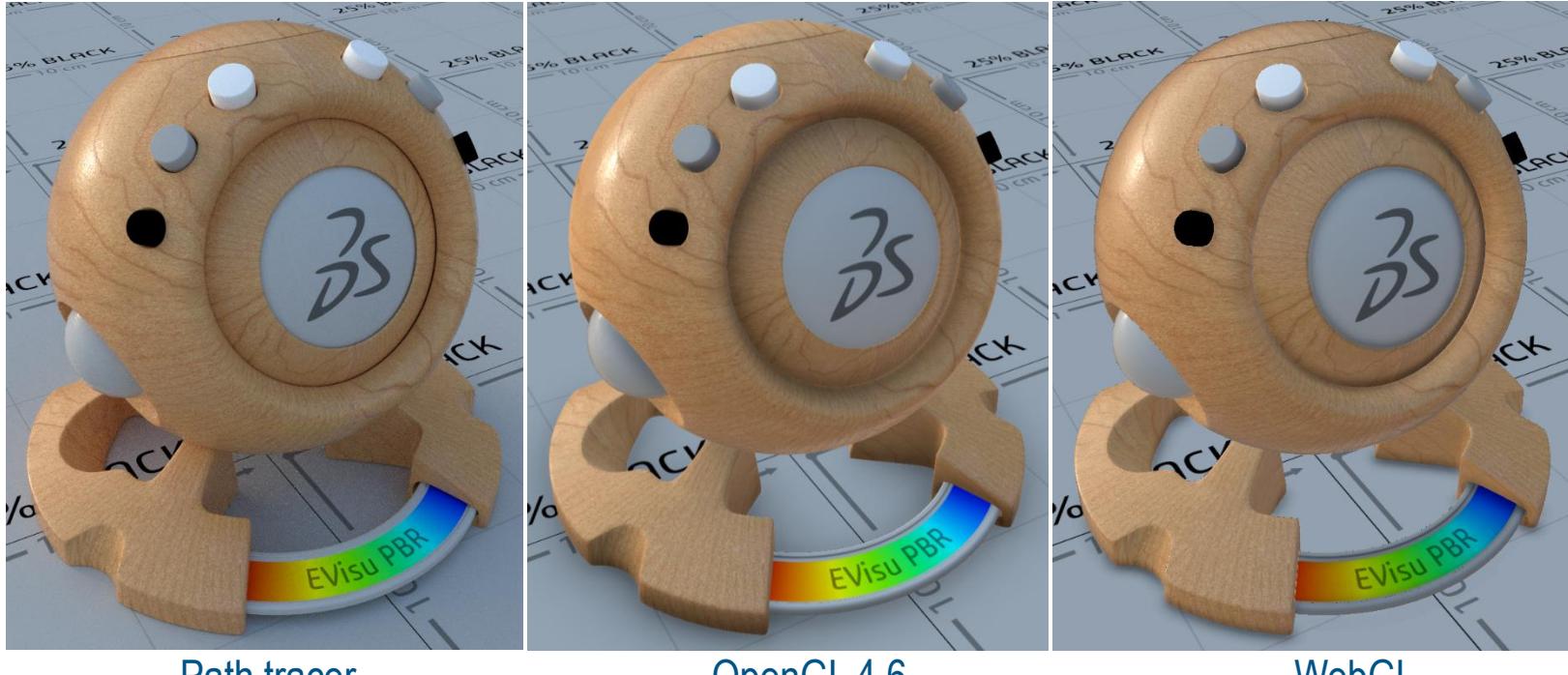
$$C_r(\mathbf{v}, \mathbf{l}) = \underbrace{\frac{(1 - E_m(\mathbf{v} \cdot \mathbf{n}))(1 - E_m(\mathbf{l} \cdot \mathbf{n}))}{\pi(1 - E_{m,avg})}}_{\text{Multiple scattering GGX}} \underbrace{\frac{F_{m,avg}^2 E_{m,avg}}{1 - F_{m,avg}(1 - E_{m,avg})}}_{\text{Multiple scattering Fresnel}}$$



A close-up photograph of a blue industrial machine component, likely a pump or valve. The word "Enterprise" is printed in a stylized font above "PDI". There are four hexagonal bolt holes on the surface. A black metal plate is attached to the left side. A coiled black hose is visible at the top left. The background is blurred.

Implementation in 3DS engines

Consistency between Renderers

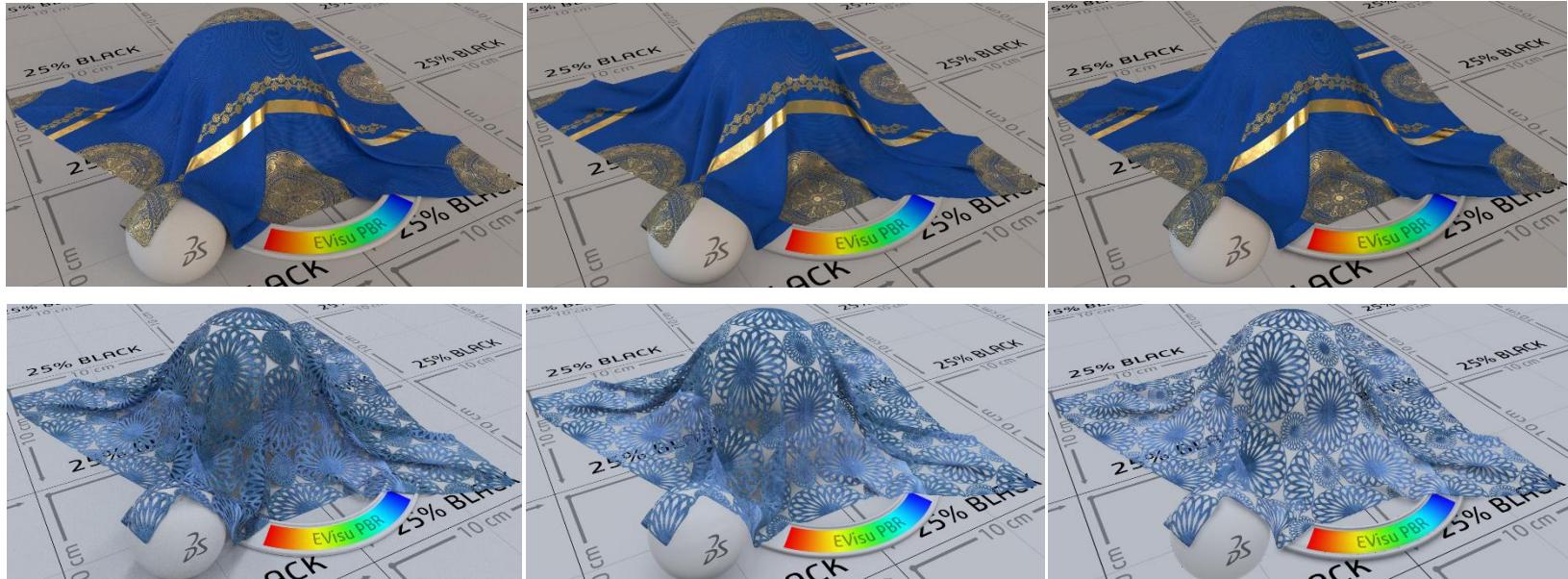


Path tracer

OpenGL 4.6

WebGL

Consistency between Renderers



Path tracer

OpenGL 4.6

WebGL

Consistency in different Engines

Path tracer (GI)



OpenGL 4.6 (OGL)



WebGL (Web)



in collaboration with

COVIVIO

Consistency in different Engines (with baking)



in collaboration with
COVIVIO

DS DASSAULT SYSTEMES | The 3DEXPERIENCE® Company

Enterprise PBR – Github project

► Published on Github

<https://github.com/DassaultSystemes-Technology/EnterprisePBRShadingModel>

▷ Specification

▷ User Guide

▷ Images

▷ Format Example (based on glTF 2.0)

► Target:

Evolve into widely used standard

README.md

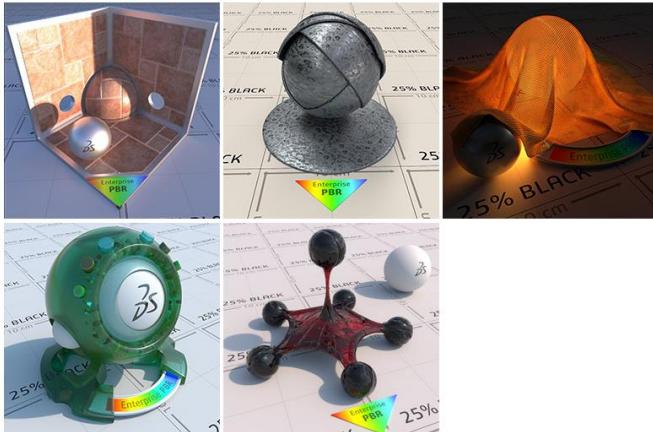
Enterprise PBR Shading Model

License CC BY-SA 4.0

The Dassault Systèmes Enterprise PBR Shading Model (DSPBR) is an easy-to-use, renderer-independent PBR material for a large variety of industries and use-cases, ranging from high-performance VR applications to high-quality GI renderings.

- Specification
- User Guide

Raytraced Examples



Ecosystem

Creating and Using Enterprise PBR

INTRODUCTION

WHO WE ARE



INTRODUCTION

METHODS TO GENERATE DIGITAL MATERIALS

TOTAL APPEARANCE CAPTURE

IS THE DIGITIZATION OF MATERIALS

WITH TRUE, FULL

APPEARANCE MEASUREMENT.

ARTISTIC PROCESSES

ARBITRARY RESULTS DEPENDING ON ARTISTIC SKILLS OF OPERATOR
TYPICALLY OPTIMISED FOR A SPECIFIC SCENE

TEXTURE
SCANNER

PLAUSIBLE COLOR
DECLINING ACCURACY WITH
INCREASING MATERIAL COMPLEXITY

FULL
APPEARANCE
MEASUREMENT

PHYSICALLY
CORRECT AS
BASED ON
MEASUREMENTS

HIGH ACCURACY
EVEN FOR
COMPLEX
MATERIALS

SCENE
INDEPENDENT



Accuracy

COMMUNICATE

THE APPEARANCE EXCHANGE FILE FORMAT



THE AxF FILE IS THE **DIGITAL TWIN** OF A PHYSICAL MATERIAL SAMPLE COMPRISING, FULL APPEARANCE MEASUREMENT INFORMATION PLUS METADATA.

AxF



AxF MATERIAL FORMATS

MEASURED MATERIALS

SVBRDF

Ward

GGX

EP-GGX (Dassault Systems)

CarPaint (BTF/BRDF Hybrid)

Translucent Plastic

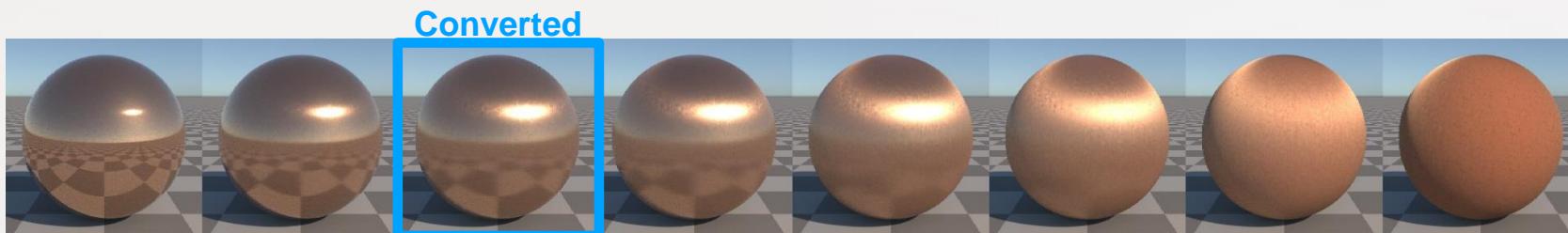


x-rite PANTONE®

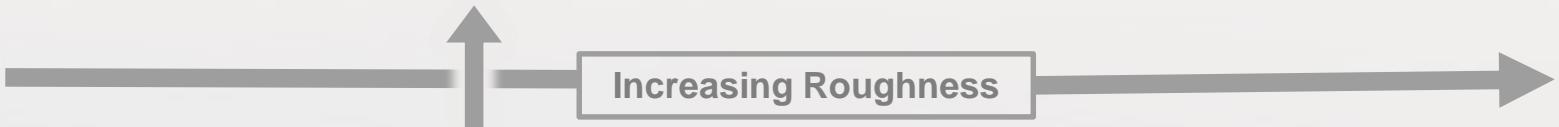
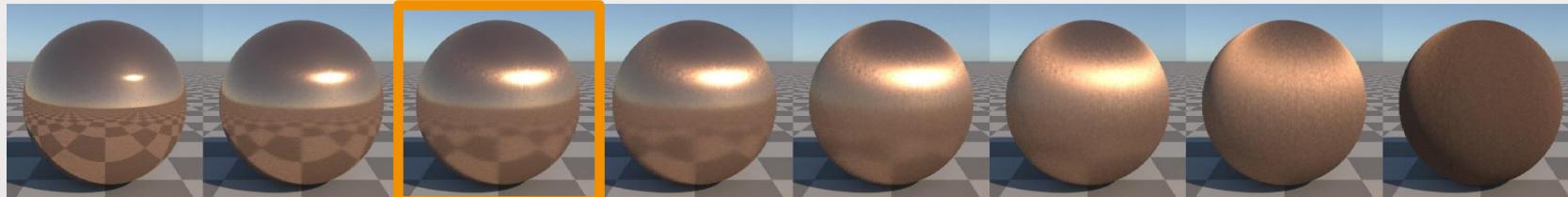
EP-GGX in AxF 1.7

DEFAULT SVBRDF MATERIAL MODEL

EP-GGX
AxF 1.7



GGX
AxF 1.5



CAPTURE

THE TAC7 SCANNER



EDIT AND MANAGE

THE PANTORA DIGITAL MATERIAL HUB



x-rite PANTONE®

VISUALIZE

THE VIRTUAL LIGHT BOOTH





SUBSTANCE

THE INDUSTRY STANDARD
FOR MATERIAL AUTHORIZING AND 3D TEXTURING

SUBSTANCE PARAMETRIC MATERIAL



A COMPREHENSIVE TOOLSET



A COMPREHENSIVE TOOLSET





SUBSTANCE
SOURCE

Substance Source x +

https://source.allegorithmic.com/assets

terrazo x 199 pts My Assets

SUBSTANCE SOURCE

New Assets 20

Updated Assets 2

Free Assets 12

All Categories 1725

Ceramic 39

Concrete - Asphalt 71

Fabric 372

Ground 73

Leather 200

Marble - Granite 20

Metal 203

Organic 58

Paint 66

Paper 14

Plaster 20

Plastic - Rubber 264

Stone 124

Terracotta 42

Translucent 21

Wood 138

All Categories

Materials size 🔍 🔍

WINTER'S NEW ARRIVALS IN THE SUBSTANCE SOURCE WARDROBE!

Art by Rohan Mahon

NEW

Synthetic Fleece SBSAR

NEW

Synthetic Fabric Twill Weave SBSAR & SBS

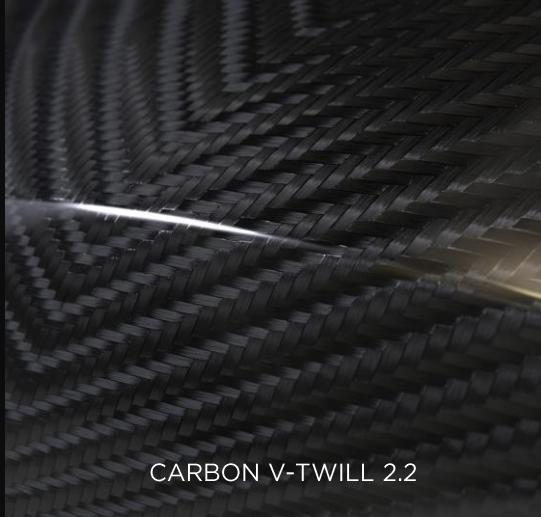
NEW

Synthetic Fabric Double Knit SBSAR & SBS

NEW

Synthetic Fabric Knit SBSAR & SBS

The screenshot shows the Substance Source website interface. On the left, a sidebar lists various material categories with their counts: Ceramic (39), Concrete - Asphalt (71), Fabric (372), Ground (73), Leather (200), Marble - Granite (20), Metal (203), Organic (58), Paint (66), Paper (14), Plaster (20), Plastic - Rubber (264), Stone (124), Terracotta (42), Translucent (21), and Wood (138). The 'Fabric' category is currently selected, indicated by a blue background. Below the sidebar, there's a section titled 'All Categories' showing four new synthetic fabric materials: 'Synthetic Fleece' (SBSAR), 'Synthetic Fabric Twill Weave' (SBSAR & SBS), 'Synthetic Fabric Double Knit' (SBSAR & SBS), and 'Synthetic Fabric Knit' (SBSAR & SBS). Each material is represented by a 3D render of a textured cap. The main content area features a large banner with the Substance Source logo and the text 'WINTER'S NEW ARRIVALS IN THE SUBSTANCE SOURCE WARDROBE!'. The banner also includes a credit line 'Art by Rohan Mahon'. The top right corner of the browser window shows the user has 199 points and is logged into their account.



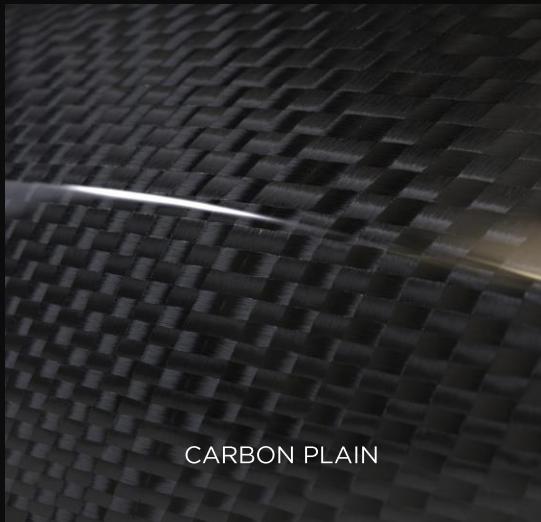
CARBON V-TWILL 2.2



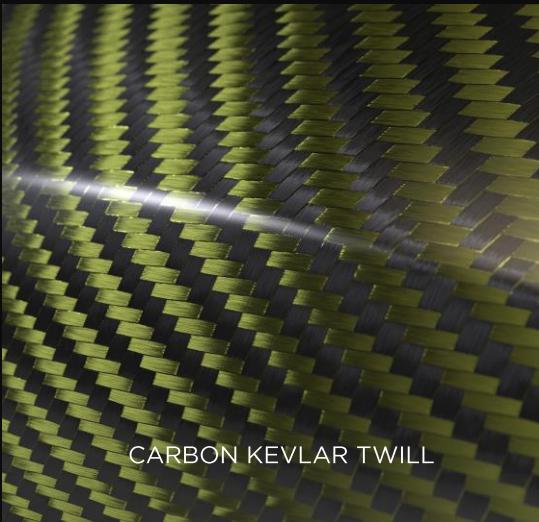
CARBON V-TWILL 1.1



CARBON ANODIZED TWILL



CARBON PLAIN

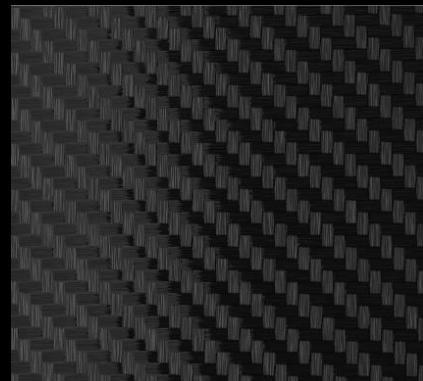
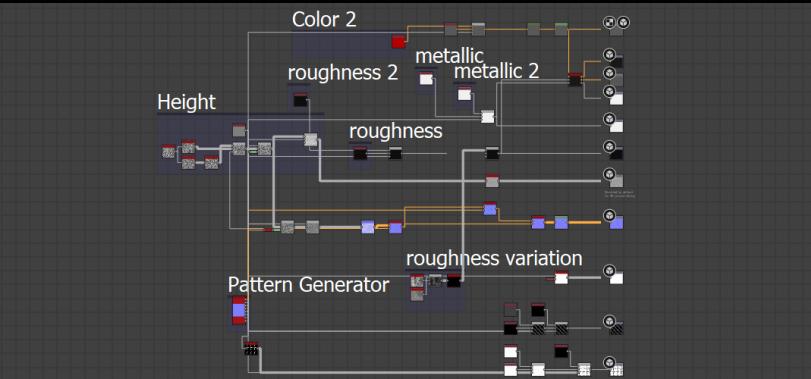


CARBON KEVLAR TWILL

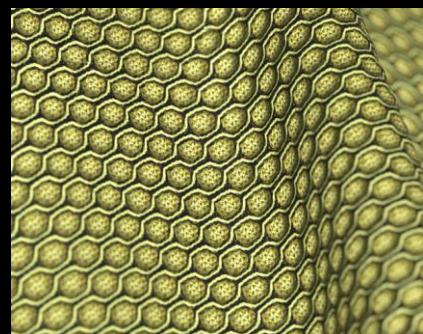
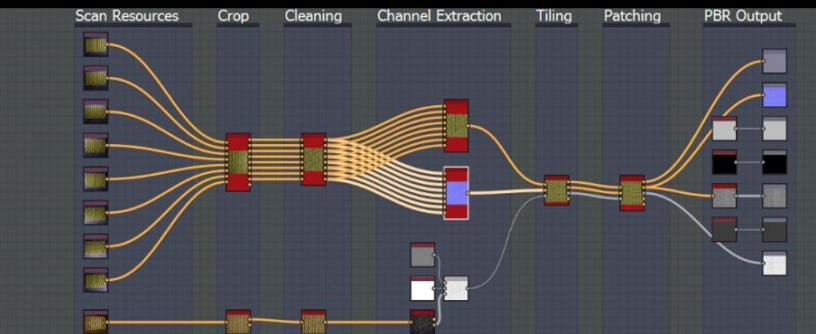


CARBON ANODIZED TWILL 2.2

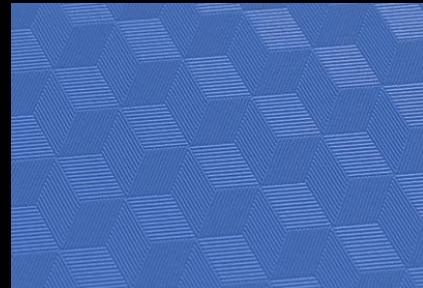
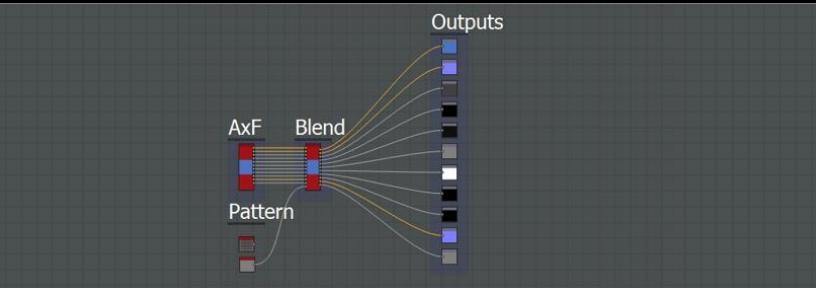
Procedural



Scan Based



Hybrid



Substance Designer 2018.3.3

File Edit Tools Scripts Windows Help

3D View Library Explorer

Scene Materials Lights Camera Environment Display Renderer

carbon_fiber_twill_weave - GRAPH

Parent Size: 4096 4096

Color 2
Height
roughness 2
metallic 2
roughness
roughness variation
Pattern Generator

Height - 2D VIEW

Iterations: 1000/1000 Time: 12s/1m0s

carbon_fiber_twill_weave - PROPERTIES

BASE PARAMETERS

ATTRIBUTES

INPUT PARAMETERS (Preview)

- select preset -

Fiber Intensity 0.2

Tile 40

Pattern Amount Y 1

Pattern Rotation 0.25

Pattern Gap X 0.1

Y 0.001

Pattern Weave 1

Pattern Deformation Intensity 0

Two Color False

Color sRGB H 0 S 0 V 127

Float

HSV

Roughness 0.03

Roughness Variation 0

Metallic 1

Opacity False

Add Anisotropy to Normal False

Contextual graph editing is enabled

Substance Engine: Direct3D 10 Memory: 7%

```
graph TD; Height --> RG[roughness 2]; Height --> MG[metallic 2]; Height --> RV[roughness variation]; Height --> PG[Pattern Generator]; Height --> C2[Color 2]; RG --> M2[metallic 2]; RG --> RV; RG --> PG; MG --> M2; MG --> PG; RV --> PG; C2 --> PG; PG --> Out[Output]
```



MDL and Enterprise PBR bridging worlds

Jan Jordan

Software Product Manager MDL

March 18, GTC San Jose 2019



The NVIDIA Material Definition Language (MDL)

- is technology developed by NVIDIA
- to define **physically-based** materials
- for physically-based rendering solutions.
- Materials are defined by combining elemental building Blocks (BSDF)

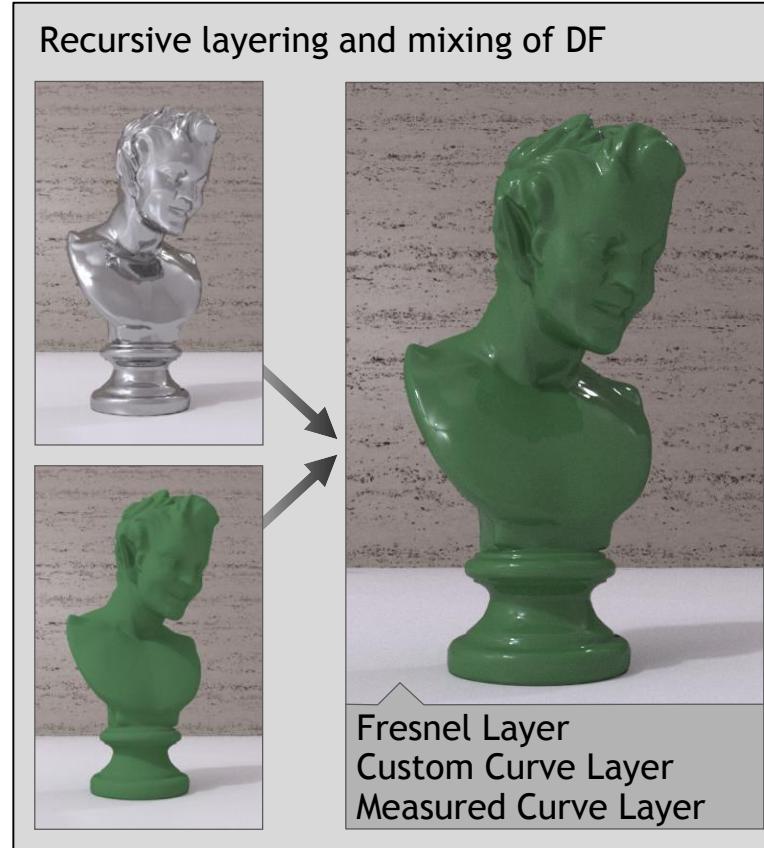
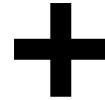
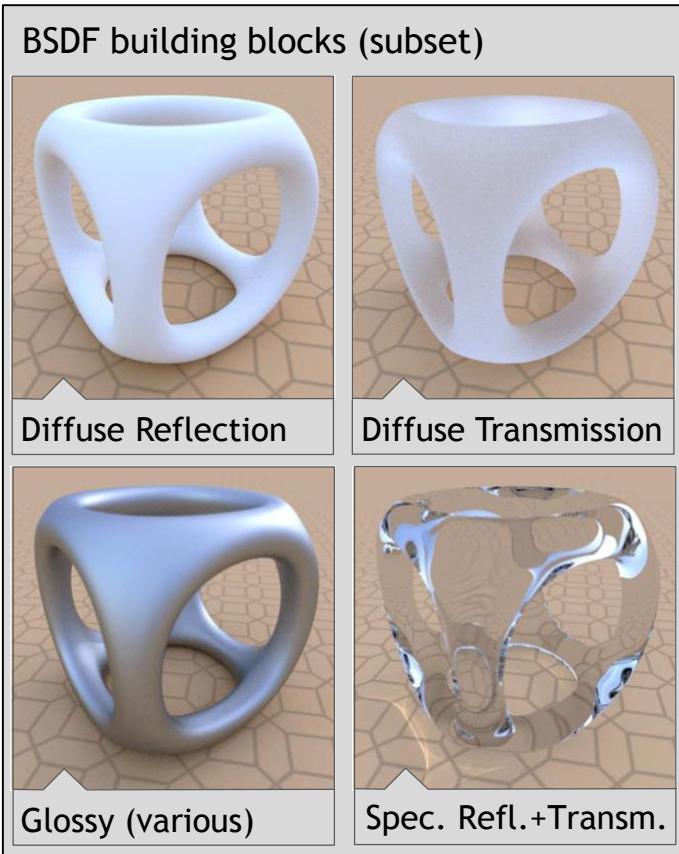
More info:

S9346 Sharing Physically Based Materials between
Renderers with MDL (<https://on-demand-gtc.gputechconf.com/>)

www.nvidia.com/mdl



MDL Materials: combinations of (X)DF



Complex example

www.mdlhandbook.com



4 anisotropic glossy highlights + translucency



MDL vs. Enterprise PBR

When to use MDL

- if your users often have exotic requirements for materials
- if you want to give users choice about material interfaces and features
- if flexibility in content creation is key

When to use Ubershaders

- if your users are ok with you choosing a material interface for them
- if you need performance guarantees (VR, Games)
- if most work is using a similar set of materials

Bridging worlds: going there...



Implementing Ubershaders in MDL

Fixed Material Model

Simple BSDF structure

One texture per parameter

Implementation

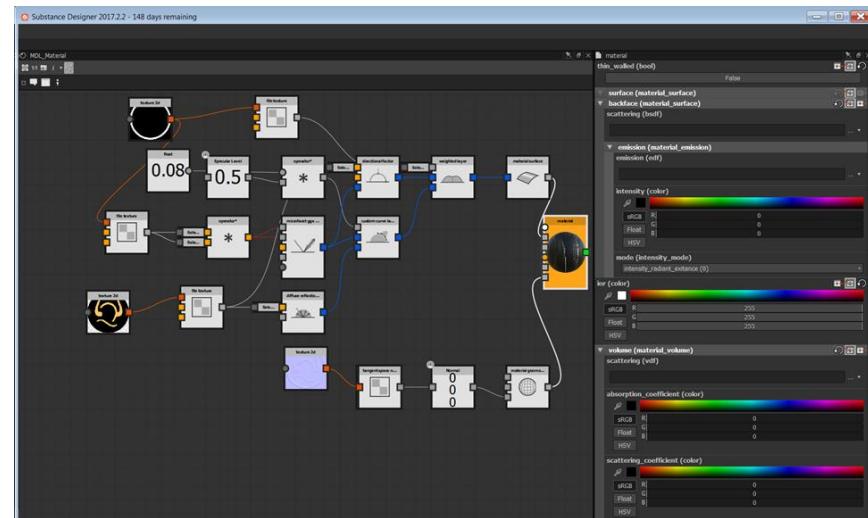
MDL Material

Complex BSDF layering

Complex procedurals

MDL is powerful enough to implement common physically based Ubershaders.

Sharing of content is reduced to sharing of parameter values and textures.



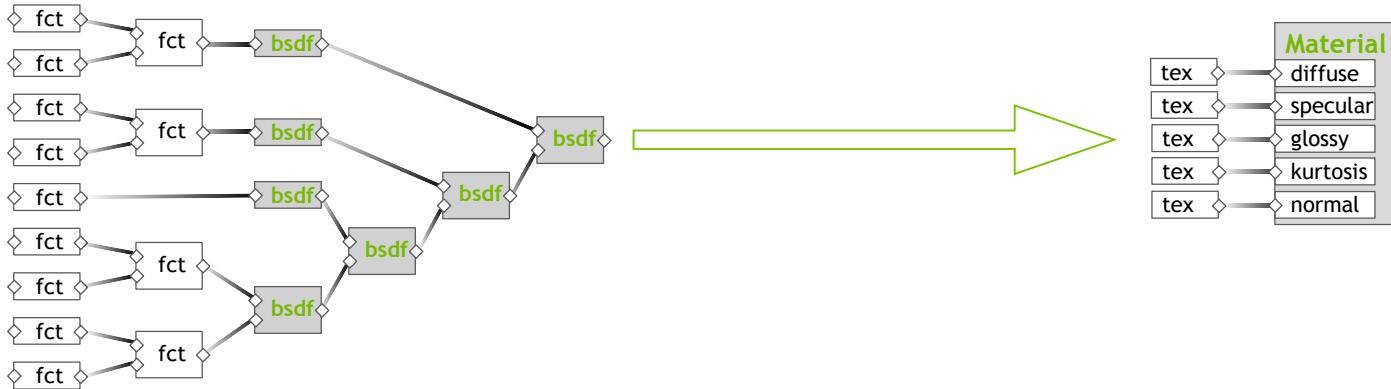
Bridging worlds: ...and coming back



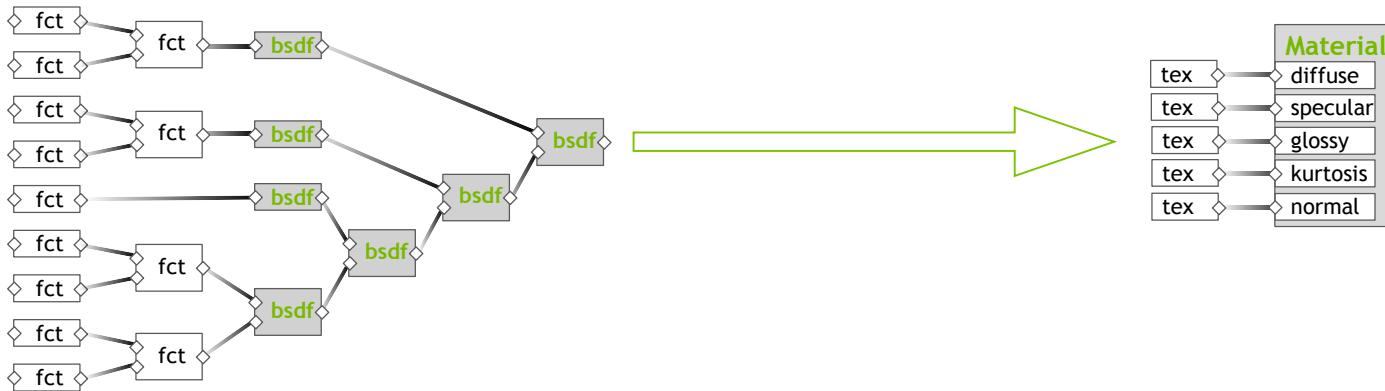
Distillation to Fixed Material Model



Distillation to Fixed Material Model

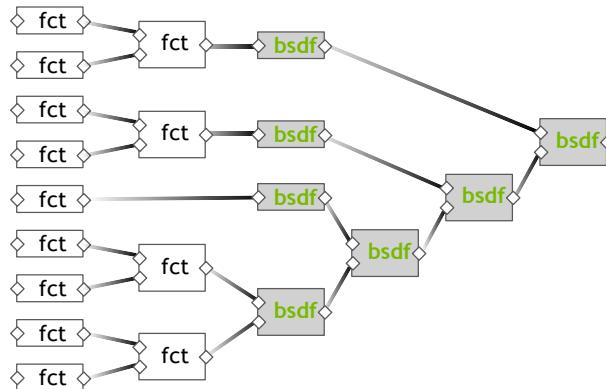


Distillation to Fixed Material Model

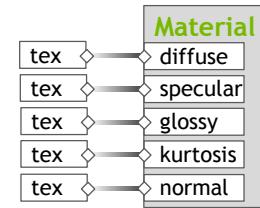


Approximate render result:
Some materials will look quite different

Distillation to Fixed Material Model



Fast projection of material instances: Realtime editing



Approximate render result:
Some materials will look quite different

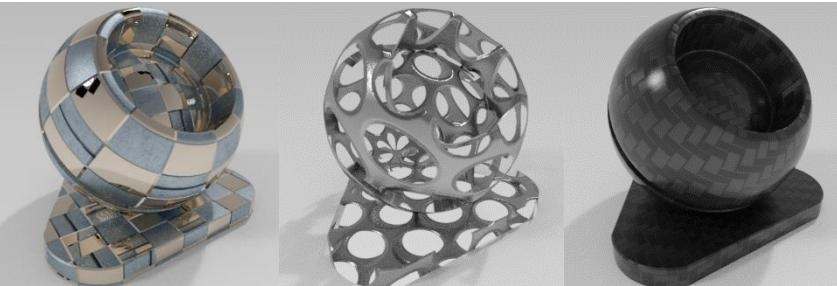
MDL Distilling

Released as part of Iray/MDL SDK

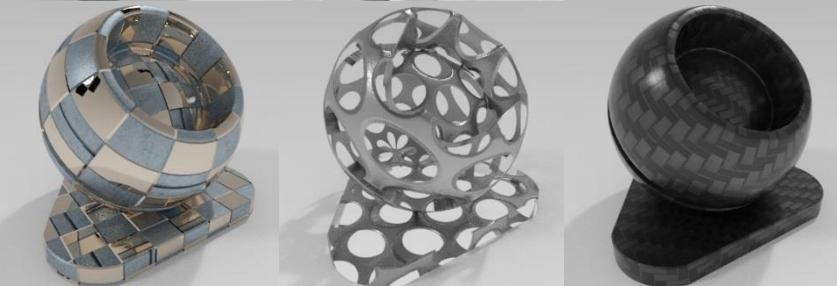
Multiple distilling targets (diffuse only, diffuse_glossy, UE4)

GLSL rendering sample using Distilling and baking

MDL



UE4

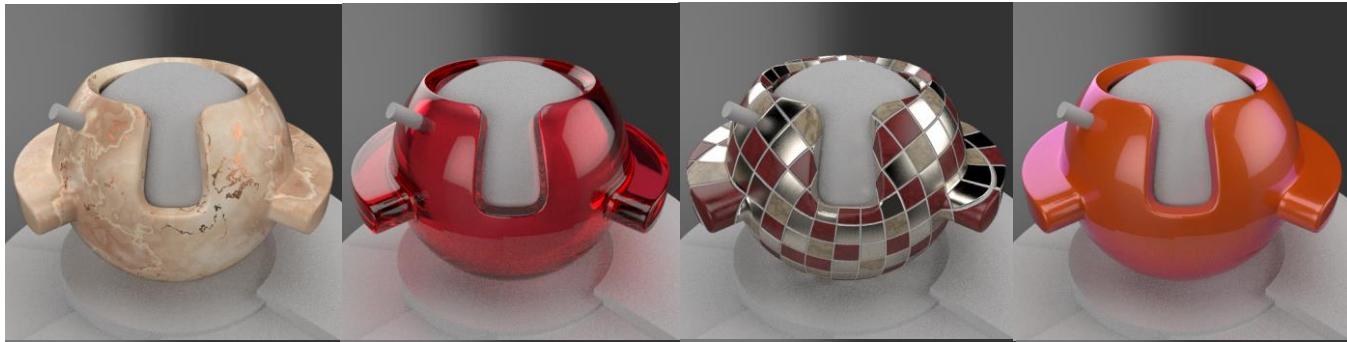


MDL Distilling

Released as part of Iray/MDL SDK

New with MDL SDK 2019: transmissive_pbr (Enterprise PBR semantic)

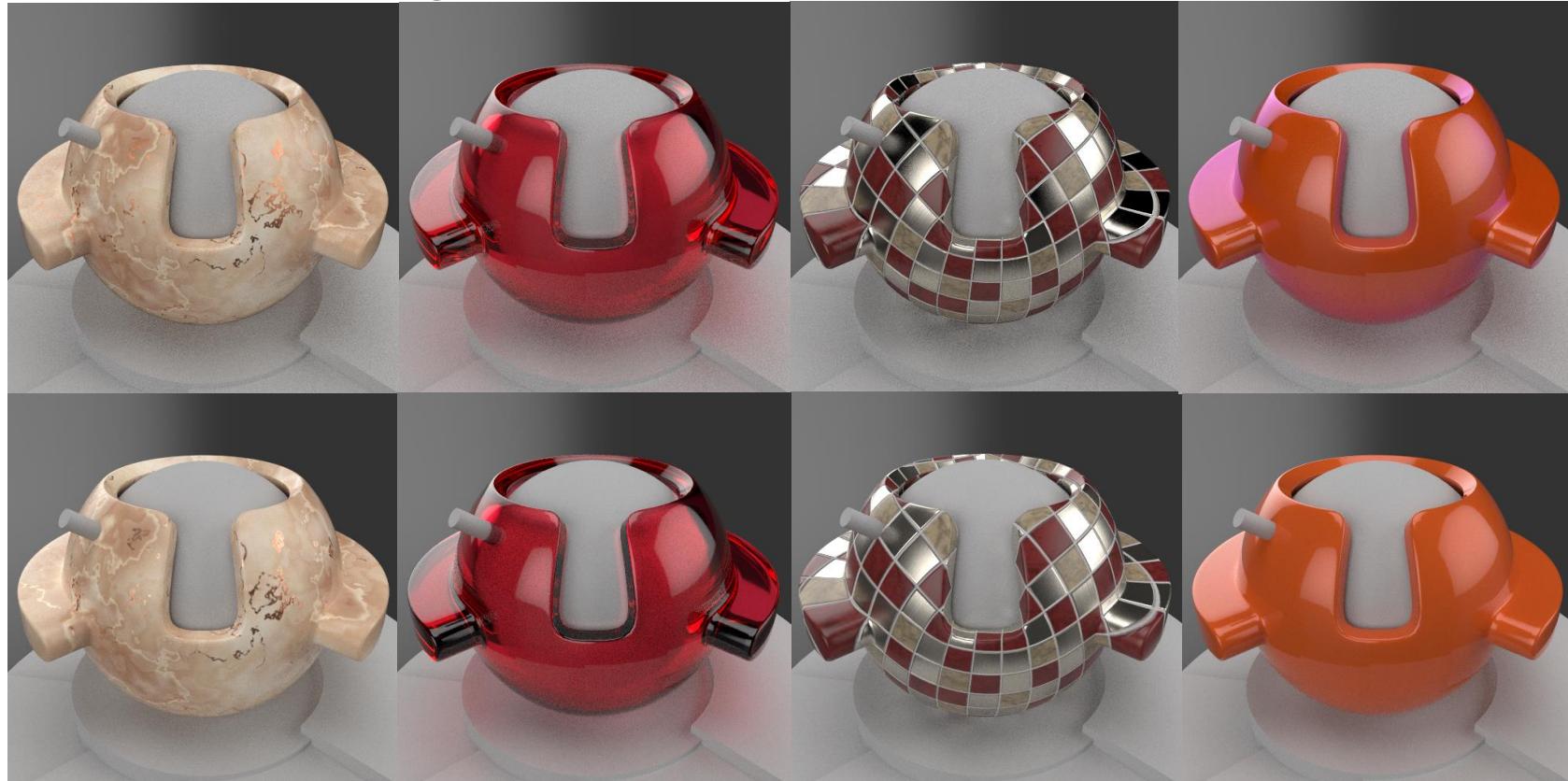
Original:
Iray MDL



Projection:
Stellar Physically
Correct with
Enterprise PBR

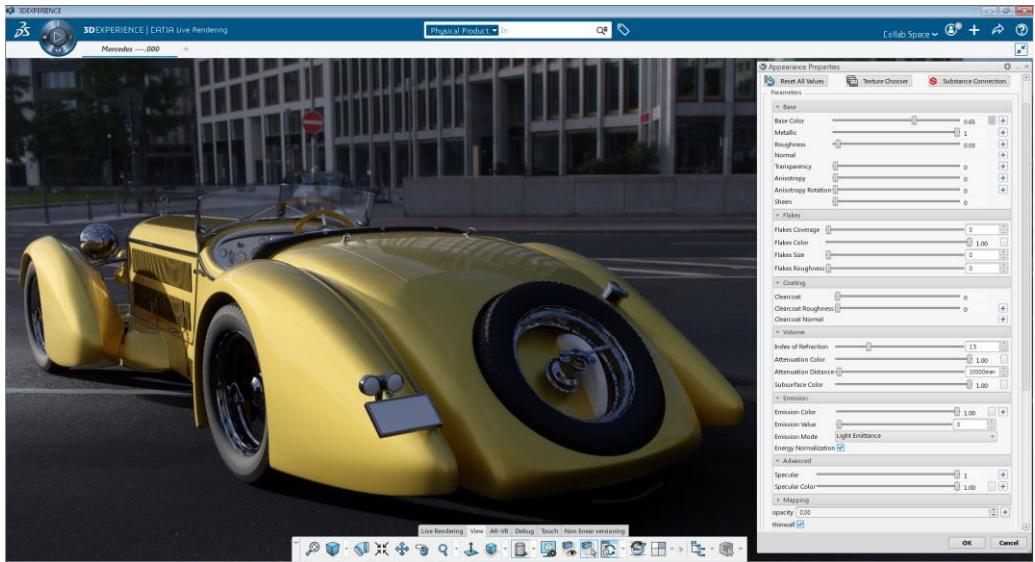


MDL Distilling



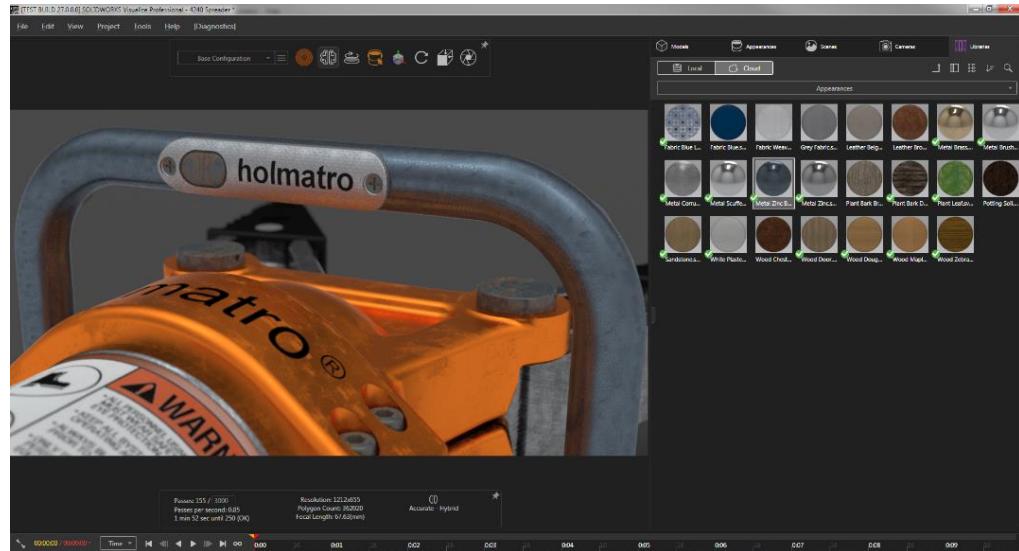
Enterprise PBR in 3DEXPERIENCE Platform

- ▶ 3DEXPERIENCE platform
 - ▷ BUSINESS EXPERIENCE platform
 - ▷ “Framework” for 3DS apps
 - ▷ Support Substance archives
 - ▷ Predefined content roles
- ▶ Enterprise PBR enables
 - ▷ High fidelity appearance representations
 - ▷ Lossless import



Enterprise PBR in SOLIDWORKS Visualize

- ▶ SOLIDWORKS Visualize
 - ▷ Quick and easy creation of professional, photo-quality images, animations & other interactive 3D content
- ▶ Enterprise PBR enables
 - ▷ High fidelity appearance representations
 - ▷ Lossless im-/export



Enterprise PBR in 3DEXCITE DELTAGEN Suite

► 3DEXCITE DELTAGEN

- ▷ Bring CAD-Data to life
 - ▶ Real-time 3D rendering
 - ▶ Interactive Storytelling
 - ▶ Immersive marketing

► Enterprise PBR enables

- ▷ High fidelity appearance representations
- ▷ Lossless im-/export



Questions & Answers



