MATERIALX

LUCASFILM Ltd

SUBSTANCE by Adobe

AUTODESK.

Eric Bourque
Director of Engineering
AUTODESK.

Jonathan Stone
Sr Software Engineer
ADG
LUCASFILM Ltd

Iliyan Georgiev
Principal Developer
AUTODESK.

Davide Pesare
Head of Labs
SUBSTANCE by Adobe

David Larsson
Sr Software Engineer
SUBSTANCE by Adobe

Nikola Milošević
Principal Product Designer
AUTODESK.

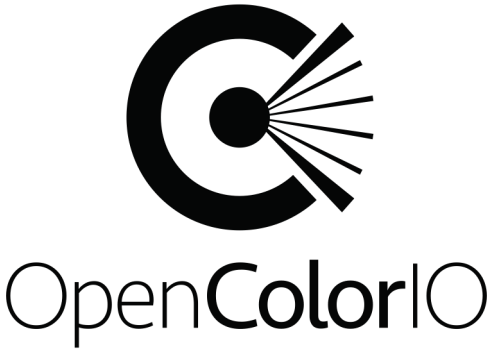
MATERIALX

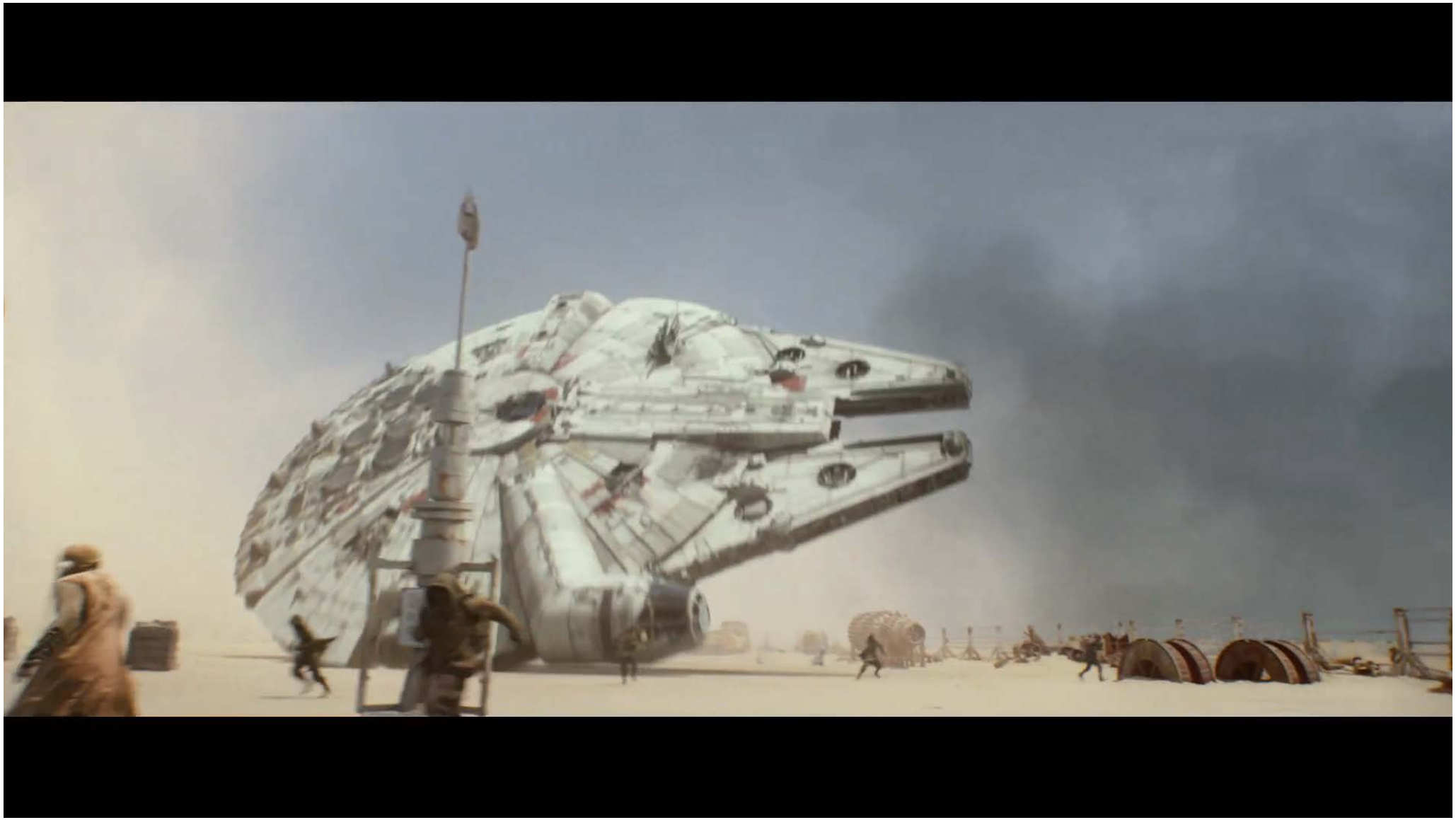
Safe Harbor Statement

Autodesk and Adobe may make statements regarding future events and/or statements regarding planned or future development efforts for our existing or new products and services. We wish to caution you that such statements reflect our current expectations, estimates and assumptions based on factors currently known to us and that actual events or results could differ materially. Also, these statements are not intended to be a promise or guarantee of future delivery of products, services or features but merely reflect our current plans, which may change. Purchasing decisions should not be made based upon reliance on these statements. The statements made in this presentation are being made as of the time and date of its live presentation. Autodesk and Adobe do not assume any obligation to update any statements made to reflect events that occur or circumstances that exist after the date of this presentation.

MaterialX: Origins at Lucasfilm

Open-Source Data Formats





MaterialX Initiative

- Rich material description, node-based and color space-aware

MaterialX Initiative

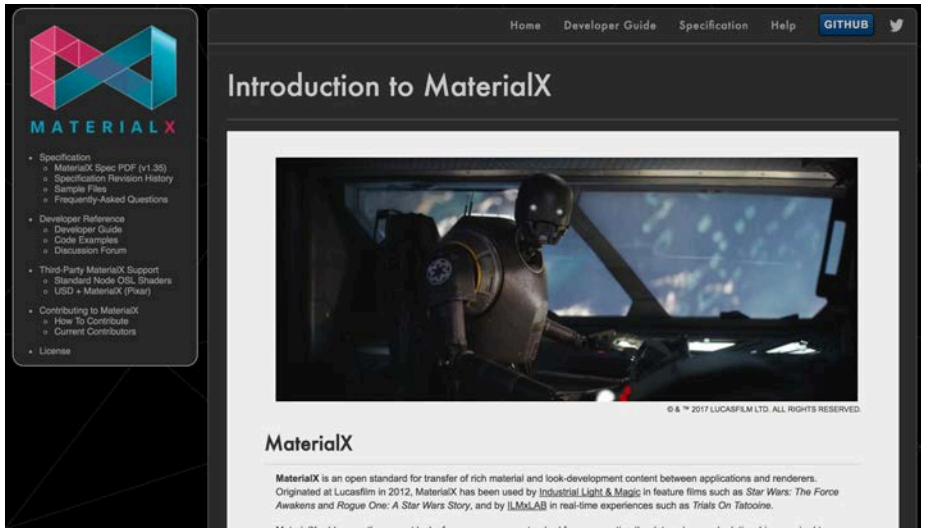
- Rich material description, node-based and color space-aware
- First significant usage on *Star Wars: The Force Awakens* in 2015

MaterialX Initiative

- Rich material description, node-based and color space-aware
- First significant usage on *Star Wars: The Force Awakens* in 2015
- Open standard published in 2016

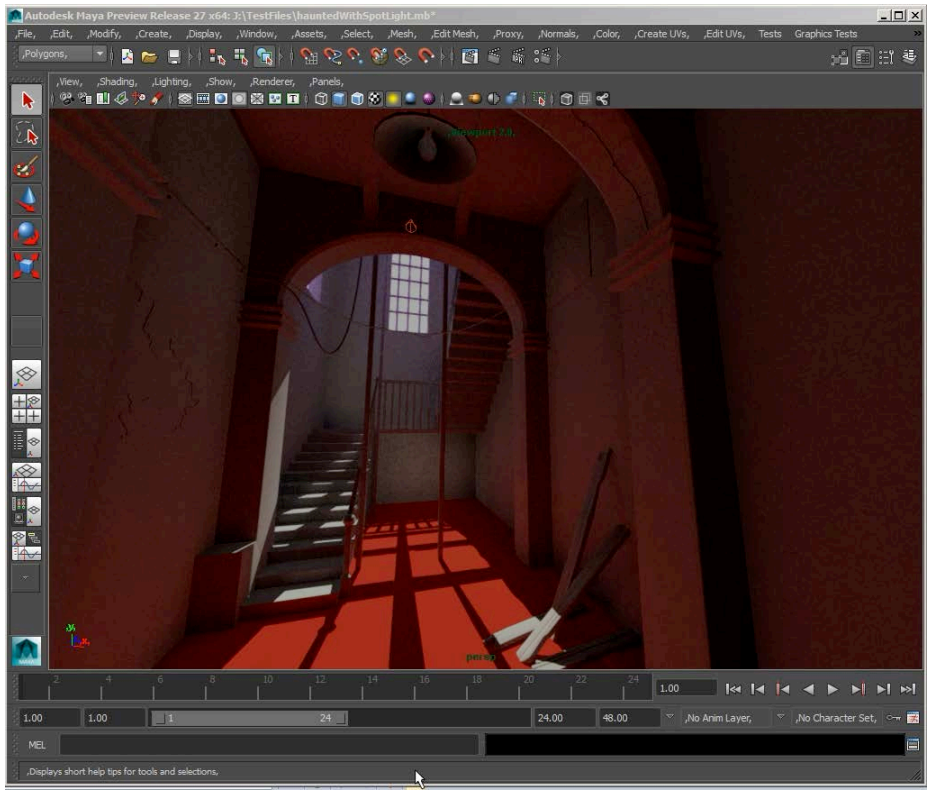
MaterialX Initiative

- Rich material description, node-based and color space-aware
- First significant usage on *Star Wars: The Force Awakens* in 2015
- Open standard published in 2016
- Open-source codebase released in 2017



Early Interest at Autodesk

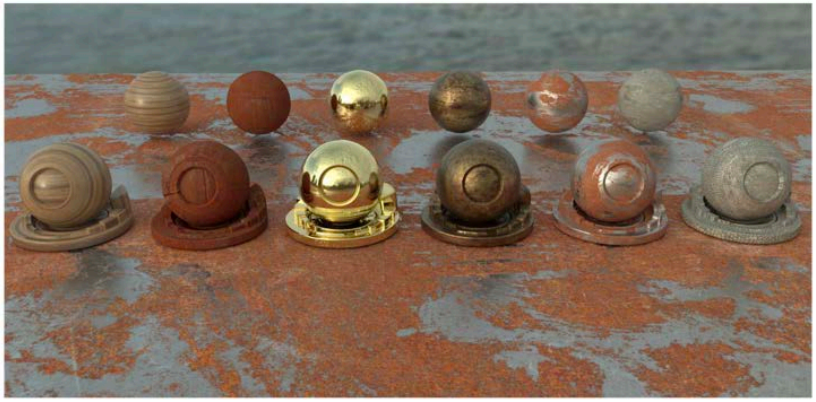
- Consistent looks across Autodesk DCCs
  - multiple renderers in a single DCC
  - physics as ground truth
- Abstract Material Graph (AMG)
- abcMaterial, MaterialX
- Worked together with Lucasfilm to help build an open industry standard



ShaderX Collaboration

- A partnership between Lucasfilm and Autodesk beginning in June of 2016
- Inheriting the best of both MaterialX and Abstract Material Graphs
- Autodesk begins developing two key extensions to MaterialX

ShaderX: A shader generation extension to MaterialX

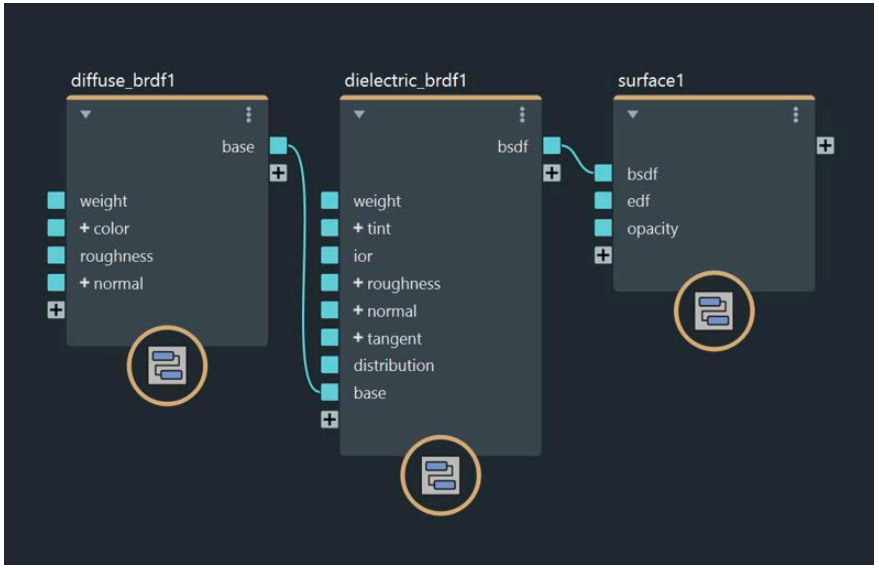


Niklas Harrysson
niklas.harrysson@autodesk.com

Document Draft
2019-02-07

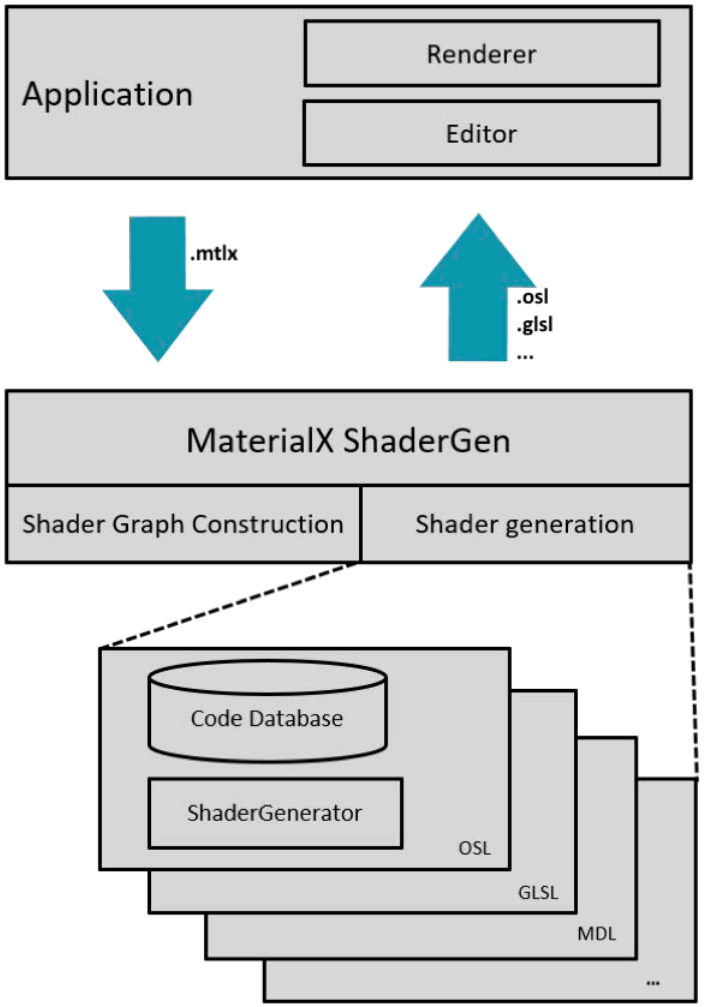
Physically-Based Shading Nodes

- The first new feature is a standard set of physically-based shading nodes
- In addition to patterns, the underlying physically-based shaders can now be portably captured
- MaterialX ships with shading graphs for Standard Surface and USD Preview Surface



Shader Code Generation

- The second new feature is a framework for shader code generation
- Automatic conversion of a MaterialX document to domain-specific shading code for rendering
- MaterialX ships with support for OSL and GLSL, with additional languages planned



MaterialX Viewer

- Leverages MaterialX shader generation in combination with the open NanoGUI framework
- Provides a ground truth reference for renders of MaterialX content
- Provides a reference for integration of MaterialX shader code generation into other applications

Open @ Autodesk

- Autodesk is a strong supporter of Open Source software
- Our customers' pipelines are heterogeneous
- Founding member of the ASWF
  - providing funding and technical expertise
  - helping drive strategic direction

Open @ Autodesk

- Actively contributing to many existing projects
  - OCIO v2
  - MaterialX
  - USD
- Have open sourced our own projects:
  - AnimX
  - ShaderX
  - sitoa
  - Standard Surface

Standard Surface v1.0.1

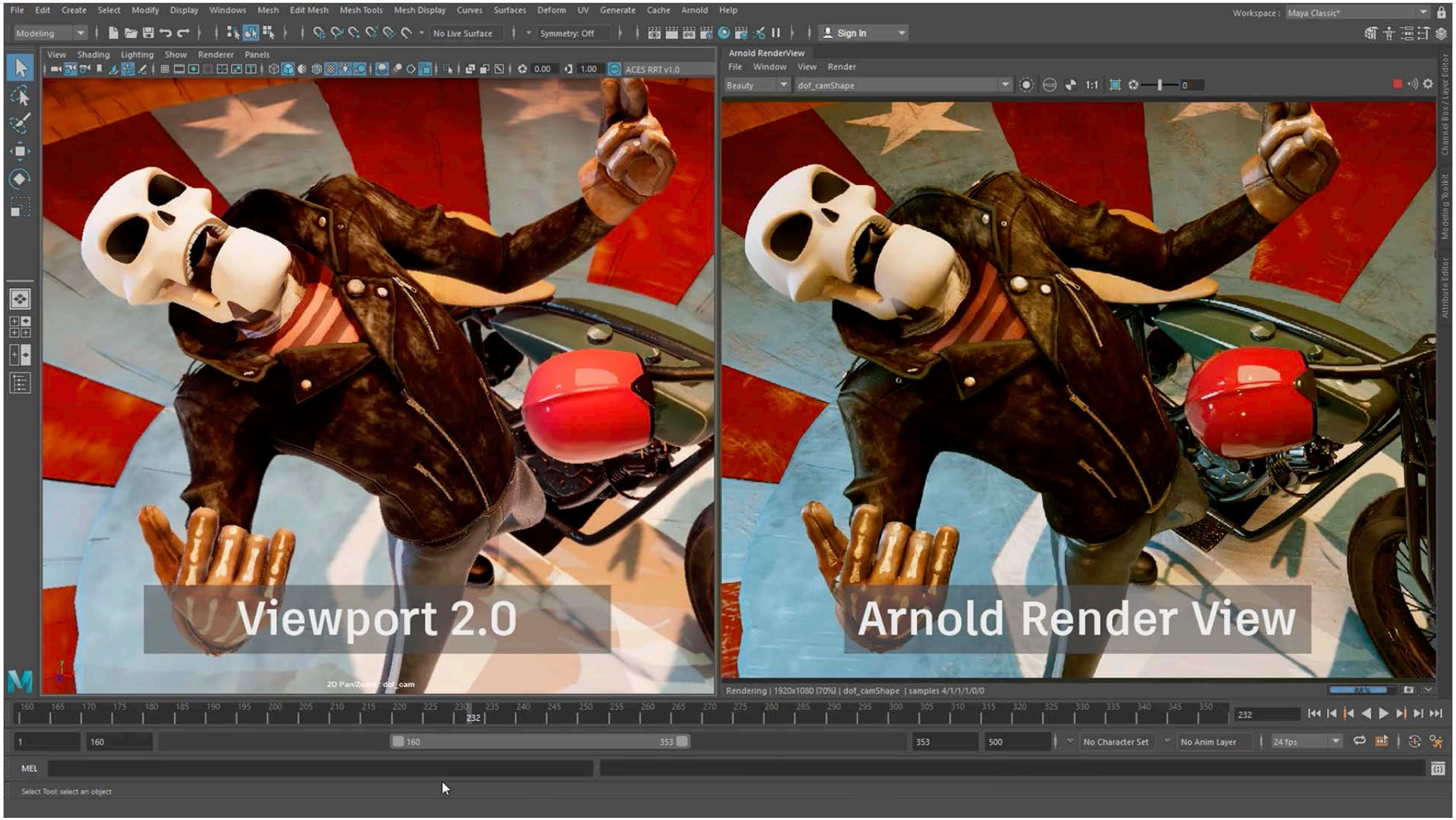
An open spec by Autodesk

What is Standard Surface?

- Open uber-shader specification
- Artist-friendly parameters
- Production proven
- Supported in Autodesk products

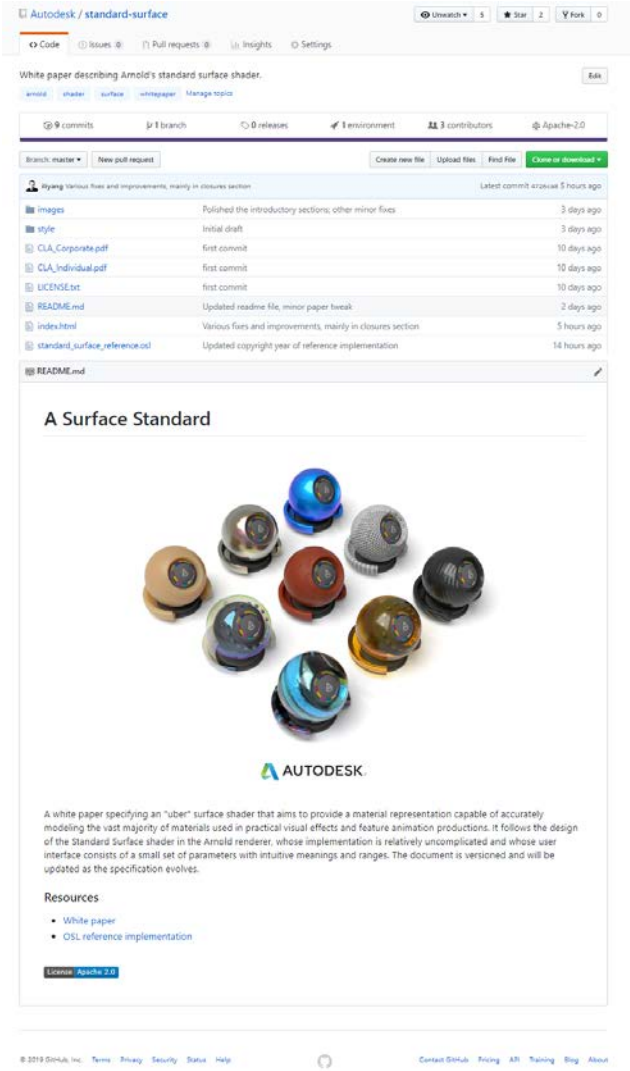
Goals

- Compactly represent most materials
  - Modern set of scattering lobes
- Easy to use
  - Minimal set of intuitive parameters
- Simplification for
  - partial representations
  - real-time applications


Viewport 2.0
Arnold Render View

Whitepaper

- Available now
  autodesk.github.io/standard-surface
- Open source (Apache License 2.0)
  github.com/autodesk/standard-surface
- Reference implementation
  - MaterialX
  - OSL



Inspiration

Physically Based Shader Design in Arnold

by Anders Langlands

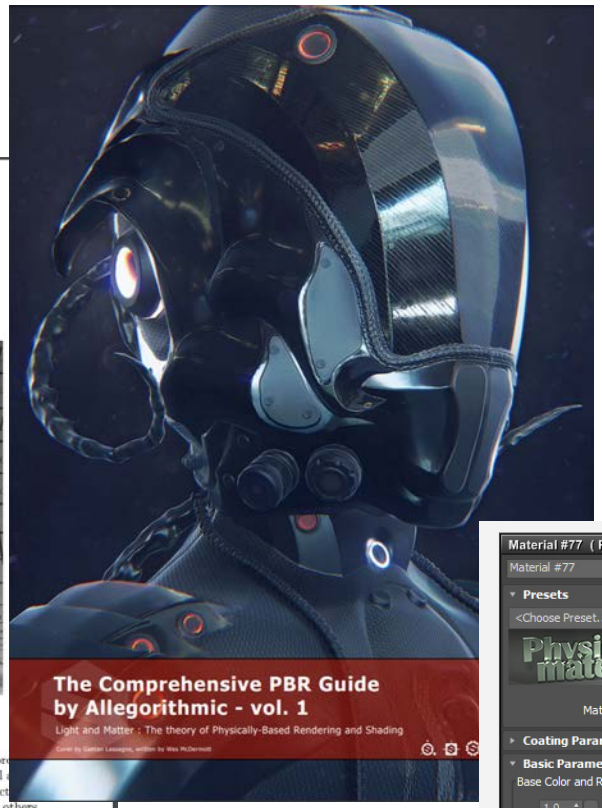
Introduction

alShaders is an open-source, production shader library for Arnold. It was created as a hobby pr
both as a learning exercise for the author to get to grips with the Arnold SDK, as well as to fill
in the Arnold toolset, since no production-quality library existed that was available or fully funct
across all of the DCC applications supported by Arnold. It was made open source in order that others
might learn from it and hopefully contribute to its development. Since its inception in 2012, it has
seen action in many studios around the world and across a wide variety of work.

In this document, we will examine what constitutes a production shader library and examine the design choices that shaped the form alShaders would take. As we will see, many of those choices follow naturally from the design of the renderer itself, so we will also take a brief look at the design of Arnold. We will primarily focus on the design of the surface shader, alSurface, examining the way it is structured in order to create a simple-to-use, physically plausible shader. We will cover the outputs it generates and how they are intended to be used within a visual effects pipeline. We will also look at some of the tricks employed to reduce noise and render faster, even if it sometimes means breaking physical correctness.

Finally, we will see what other choices could have been made in its design, along with potential areas for improvement in the future, including potentially fruitful research avenues based on recent work within the graphics community.

1



Physically-Based Shading at Disney

by Brent Burley, Walt Disney Animation Studios

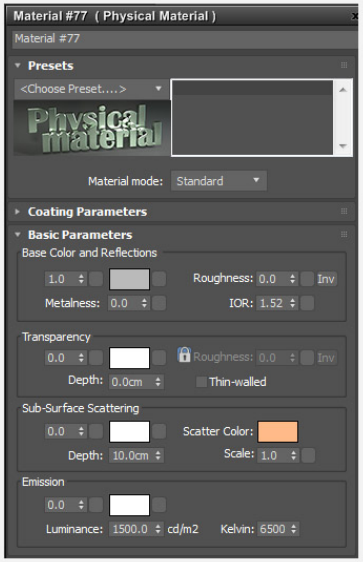
[Revised Aug 31, 2012. Corrected normalization factor in Equation 4.]

1 Introduction

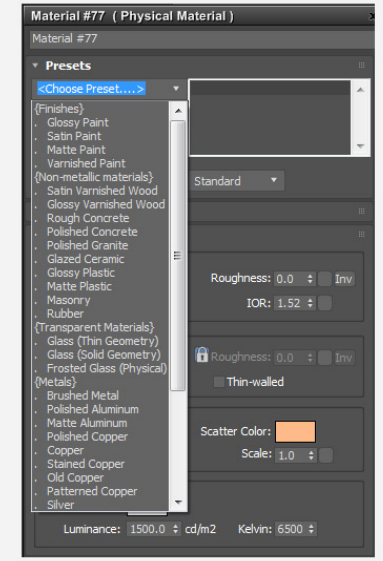
Following our success with physically-based hair shading on Tangled [27], we began considering physically-based shading models for a broader range of materials. With the physically-based hair model, we were able to achieve a great degree of visual richness while maintaining artistic control. However, it proved challenging to integrate the lighting of the hair with the rest of the scene which had still used traditional "ad-hoc" shading models and punctual lights. For subsequent films we wanted to increase the richness of all of our materials while making lighting responses more consistent between materials and environments and also wanted to improve artist productivity through the use of simplified controls.

When we began our investigation it wasn't obvious which models to use or even how physically-based we wanted to be. Should we be perfectly energy conserving? Should we favor physical parameters like index-of-refraction?

For diffuse, Lambert seemed to be the accepted norm, while specular seemed to get most of the attention in the literature. Some models such as Ashikhmin-Shirley (2000) [3] aimed to be intuitive

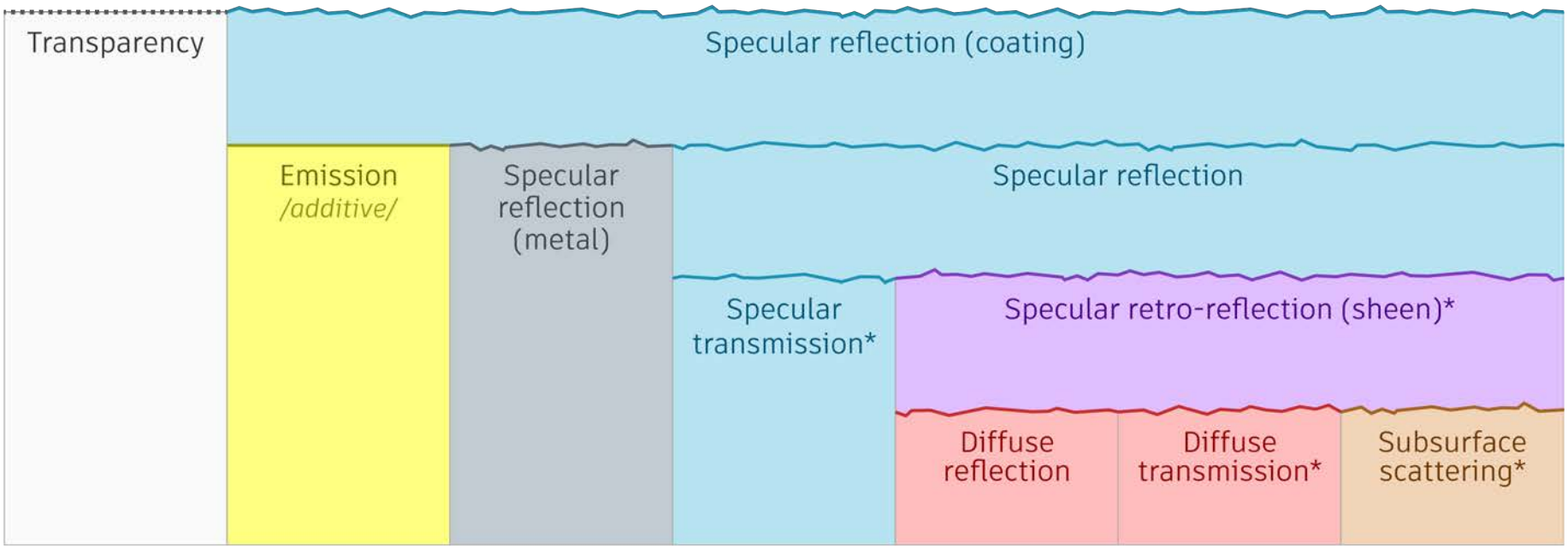


Physical Material UI

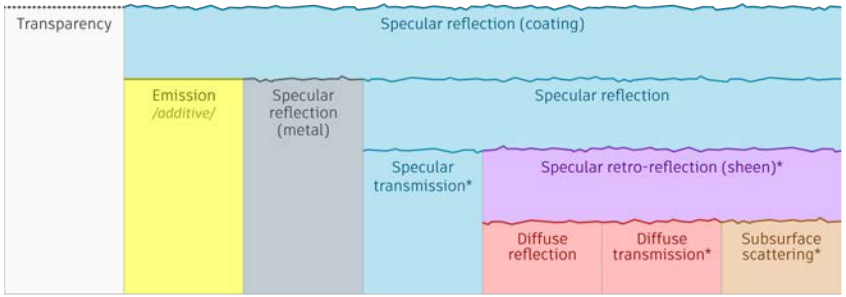


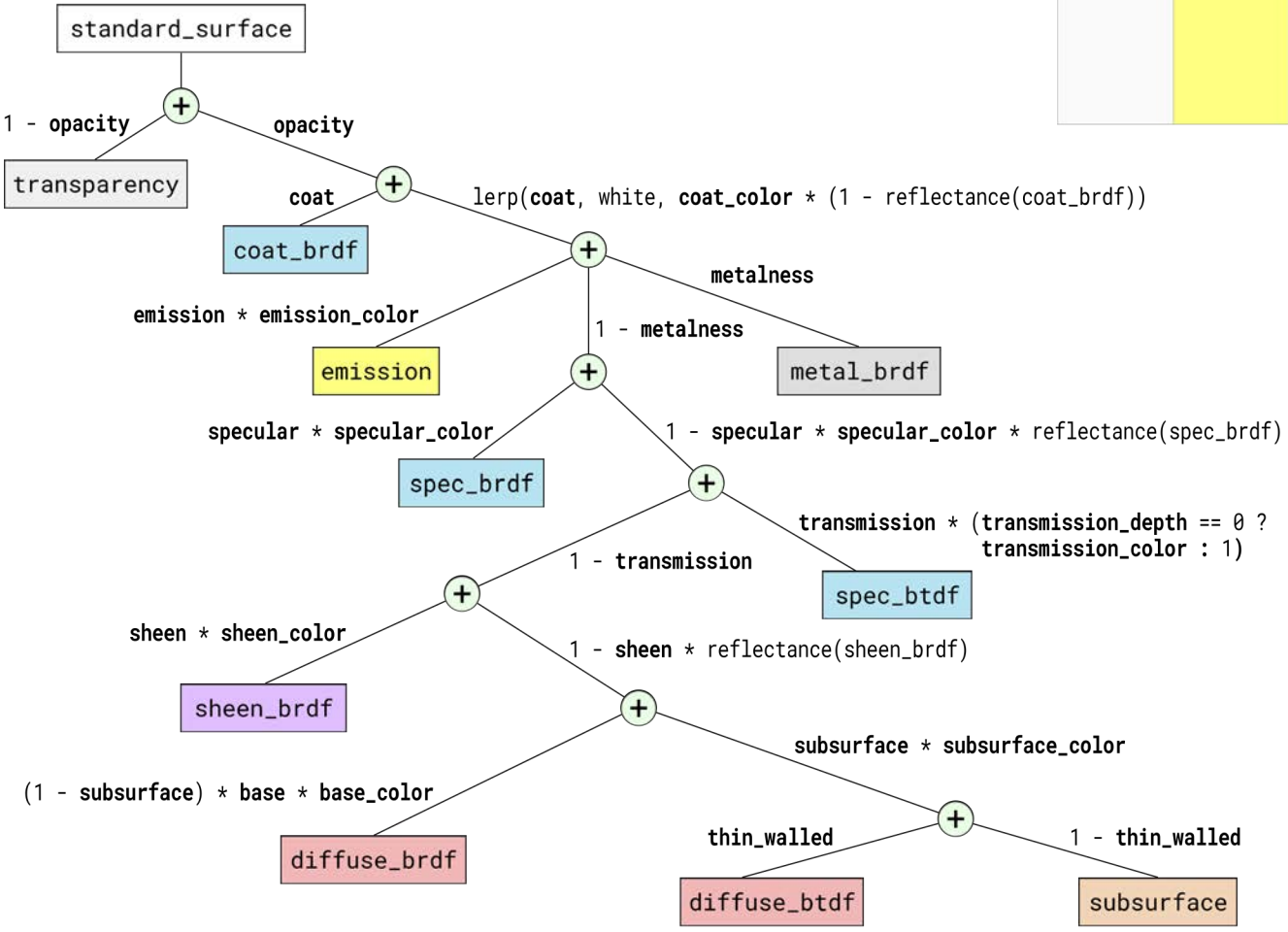
Material Preset List

Layered Mixture Model

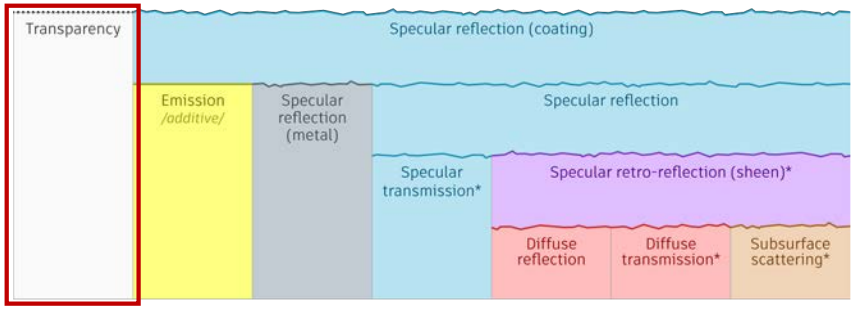


Closure representation

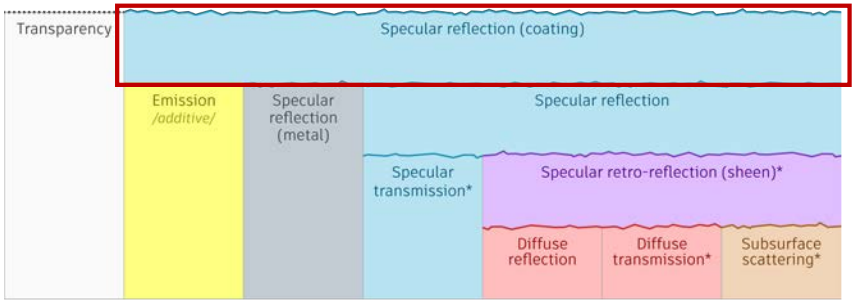




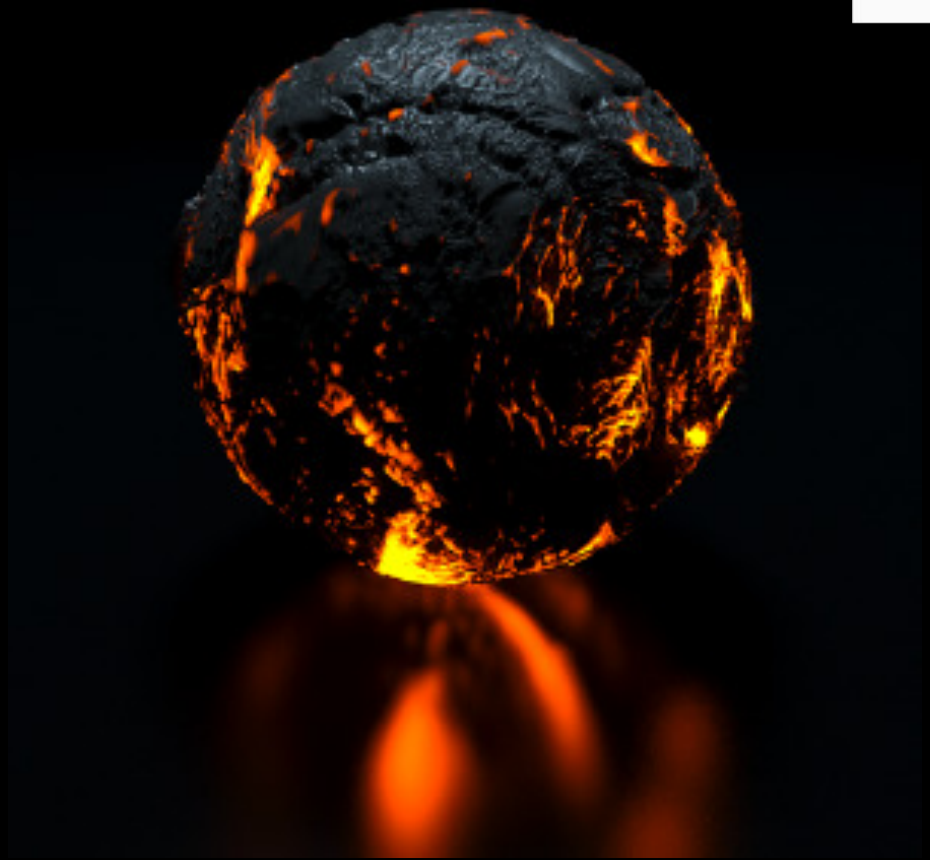
Transparency

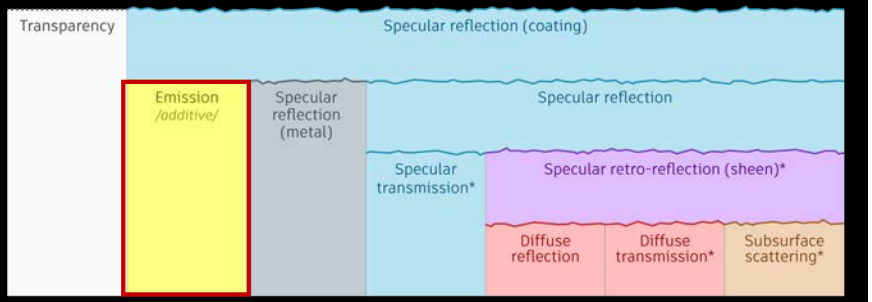


Coat

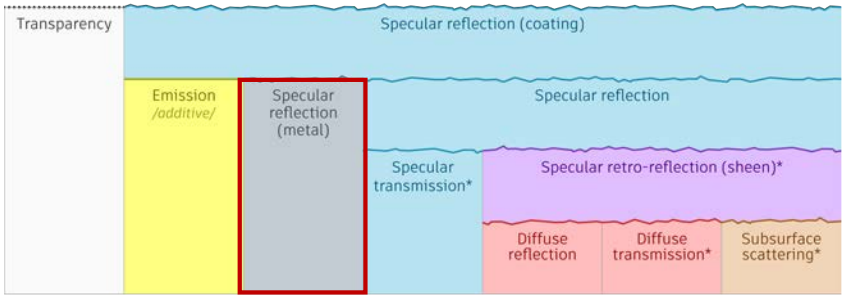

Transparency
Specular reflection (coating)
Emission
/additive/
Specular reflection (metal)
Specular reflection
Specular transmission*
Specular retro-reflection (sheen)*
Diffuse reflection
Diffuse transmission*
Subsurface scattering*

Emission

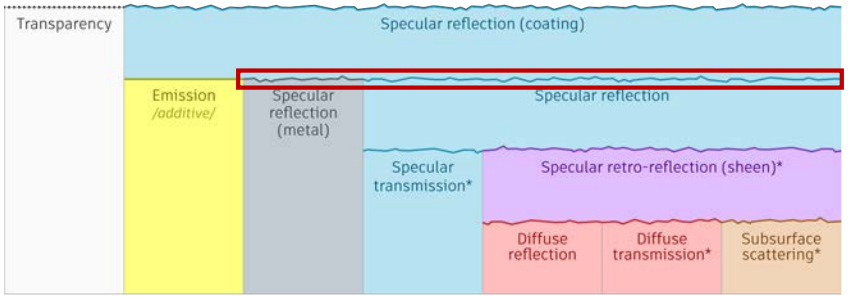



Transparency
Specular reflection (coating)
Emission
/additive/
Specular reflection (metal)
Specular reflection
Specular transmission*
Specular retro-reflection (sheen)*
Diffuse reflection
Diffuse transmission*
Subsurface scattering*

Metal

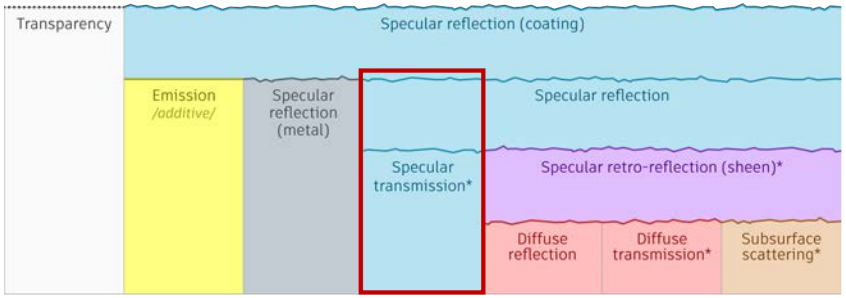

Transparency
Specular reflection (coating)
Emission
/additive/
Specular reflection (metal)
Specular reflection
Specular transmission*
Specular retro-reflection (sheen)*
Diffuse reflection
Diffuse transmission*
Subsurface scattering*

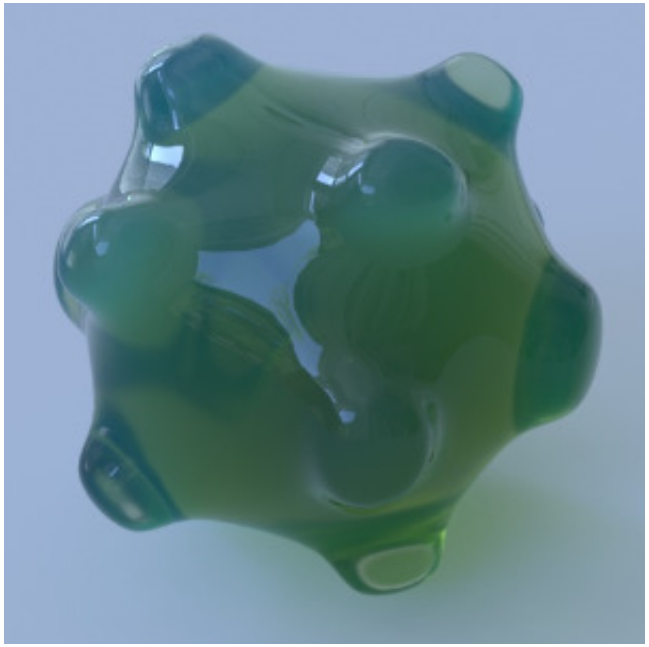
Thin film


Transparency
Specular reflection (coating)
Emission
/additive/
Specular reflection (metal)
Specular reflection
Specular transmission*
Specular retro-reflection (sheen)*
Diffuse reflection
Diffuse transmission*
Subsurface scattering*

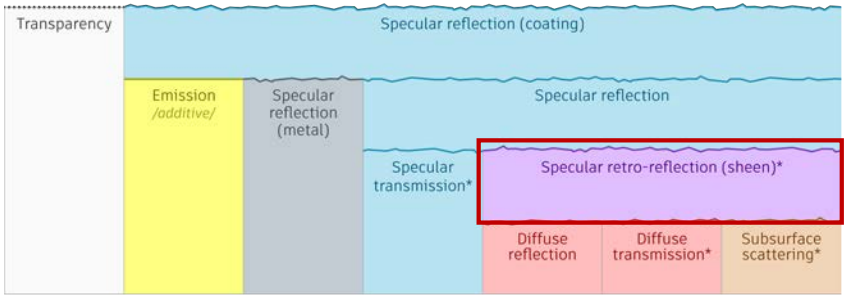

ARNOL

Specular reflection & transmission

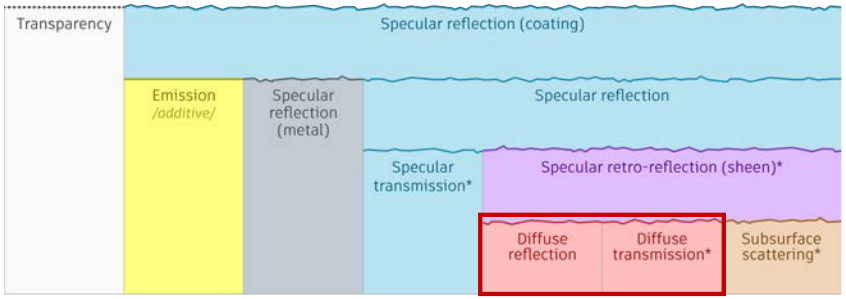


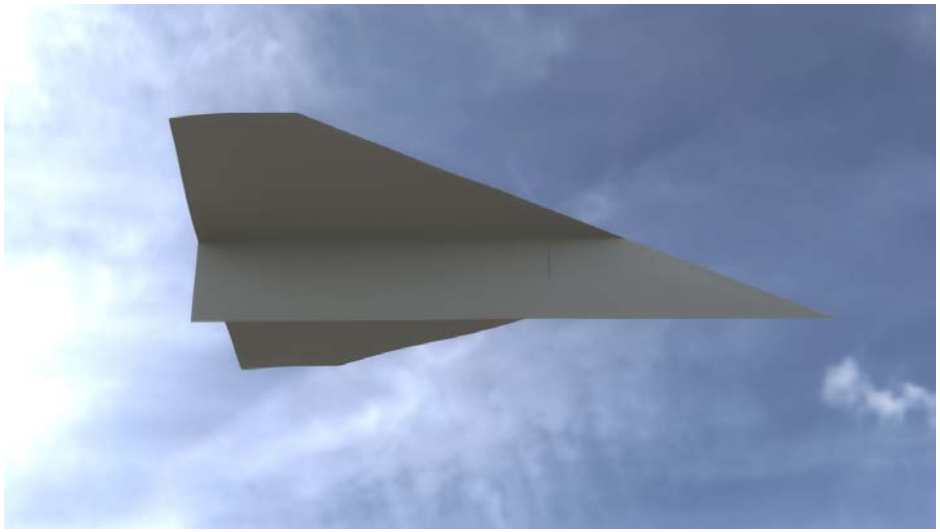


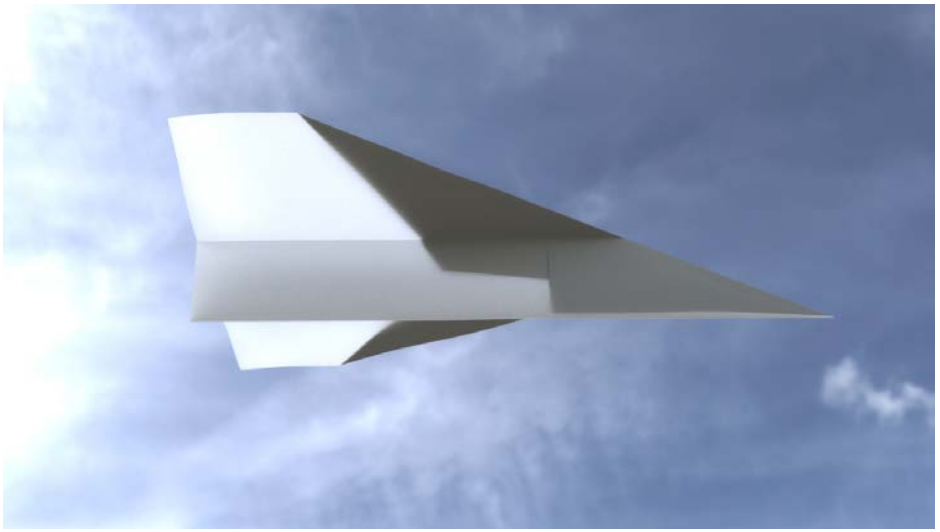
Sheen


Transparency
Specular reflection (coating)
Emission
/additive/
Specular reflection (metal)
Specular reflection
Specular transmission*
Specular retro-reflection (sheen)*
Diffuse reflection
Diffuse transmission*
Subsurface scattering*

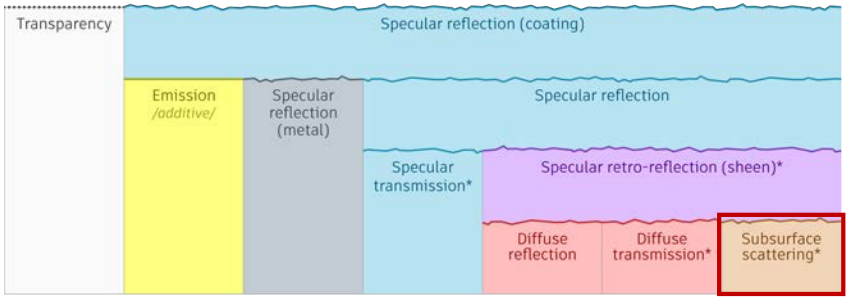
Diffuse reflection & transmission







Subsurface scattering



Future work

- Reciprocity
- Improved layering model

Contribute!

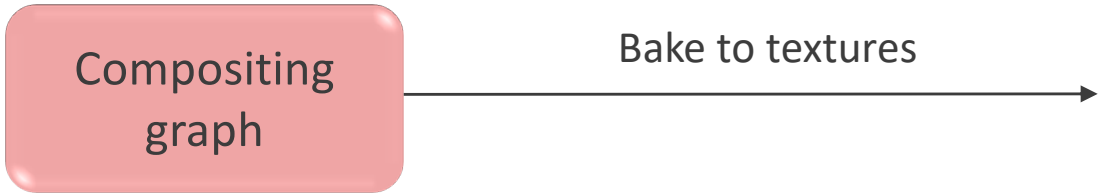
Join the conversation!

github.com/autodesk/standard-surface

Why we need a new standard Uber Shader

Substance Materials in a nutshell

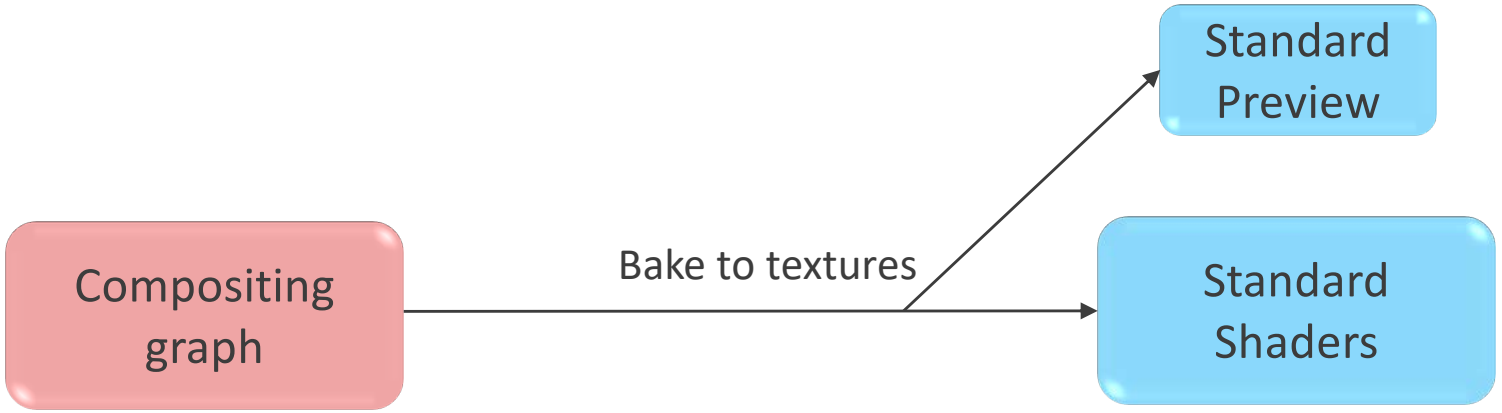
- Procedural packages, from a comp graph
- Typically bake **specific textures** before render
  - e.g. albedo, roughness, height, etc...



SUBSTANCE by Adobe

Maximize Portability

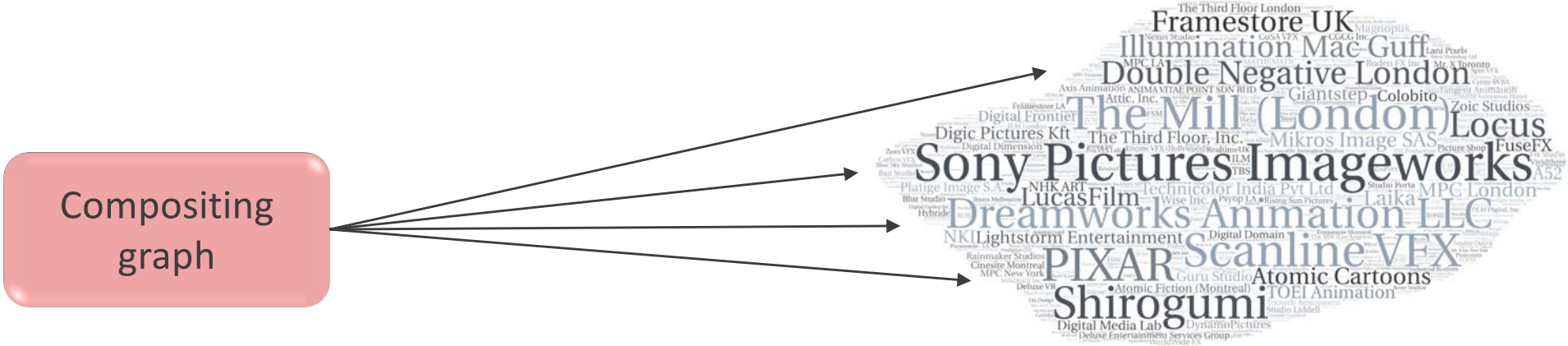
- Rely on standard Uber-Shaders
  - Know how to approximate for speed



SUBSTANCE by Adobe

Maximize Portability

- Conversion to other shading models is known
  - Easy to adopt and port (even when lossy)



SUBSTANCE by Adobe

Two production strategies for Surfaces

- **"Playmobil"**: **Uber Shaders**
  often good for 90% assets. More common and makes exchange easier

- **Lego**: **Lobe combining**
  more powerful, covers final 10% of LookDev challenges

Can work with either

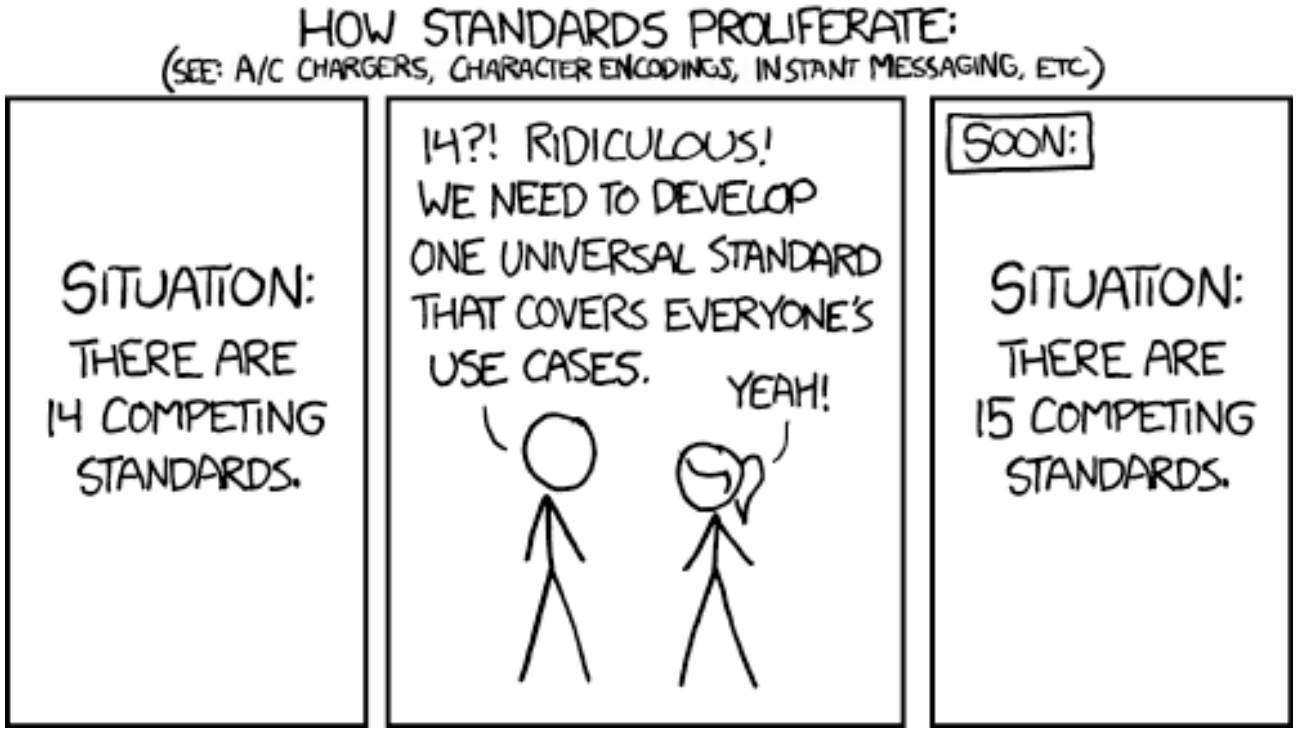
- Thanks to the **ShaderX** addition, MaterialX now supports the Lego approach
- With packaging and subgraphs, it can support well
  Playmobil approaches too

SUBSTANCE by Adobe

We like the portability of UberShaders

- Our baseline shading models don't cover cases that are now common
  - Too many semi-documented extended variants for advanced lobes

- We were considering drafting our own updated standard


HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)
SITUATION: THERE ARE 14 COMPETING STANDARDS.
14?! RIDICULOUS! WE NEED TO DEVELOP ONE UNIVERSAL STANDARD THAT COVERS EVERYONE'S USE CASES.
YEAH!
SOON:
SITUATION: THERE ARE 15 COMPETING STANDARDS.

Standards are hard

- UberShaders **need** strong standards to be successful for exchange purposes
- **Need** very good documentation
- One standard is better than none

SUBSTANCE
by Adobe

Standards are hard

- UberShaders **need** strong standards to be successful for exchange purposes
- **Need** very good documentation
- One standard is better than none
- One standard is also better than too many
  - Must have very good reasons to create a new one
- Takes time to gather support from other vendors and studios
  - If only we could find someone to collaborate right from the start…

SUBSTANCE
by Adobe

Let’s collaborate on a standard

- Last Siggraph, Autodesk included us on a draft whitepaper for a Standard Surface
- Perfect timing to start a collaboration

SUBSTANCE by Adobe

We like Standard Surface

- Good balance:
  - More complete feature set
  - Not overcomplicated
  - Considers simplifications for preview purposes
- Well documented, well thought through
  - Crucial to adopt it partially, or evolve towards it
- First serious effort to make a collaborative BXDF UberShader
  - Included in the discussion top experts in the field

SUBSTANCE by Adobe

We like Standard Surface

- We are interested in growing some of our existing materials towards it
  - Would like to fully embrace it natively
  - That is not the state currently
- We still must be able to export to most models

SUBSTANCE by Adobe

Implemented for Substance Designer

SUBSTANCE
by Adobe

Implemented for Substance Designer

SUBSTANCE by Adobe

Contribute

- Please follow and participate to this project on GitHub!

SUBSTANCE
by Adobe

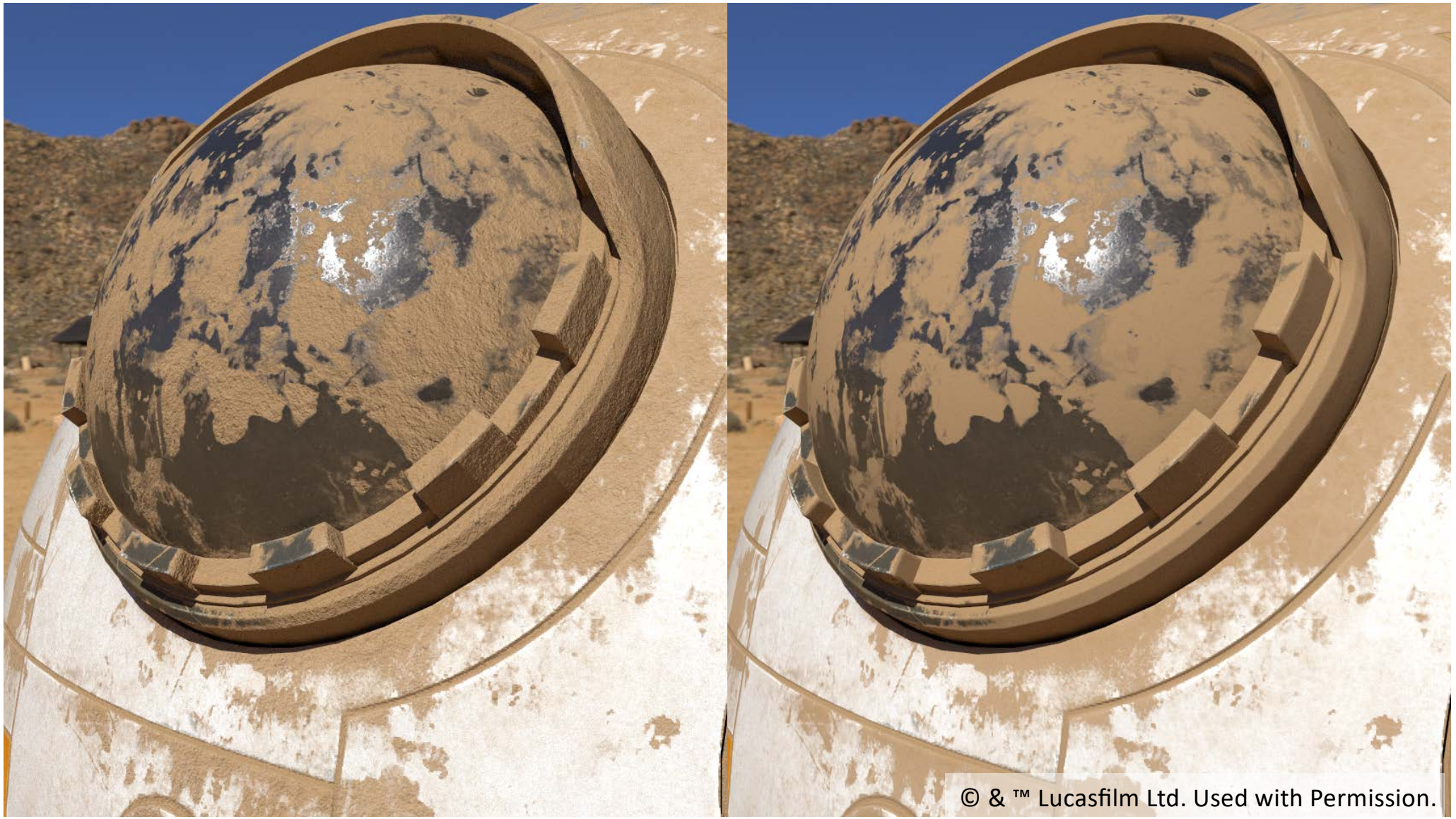
MaterialX Prototype in Substance Designer

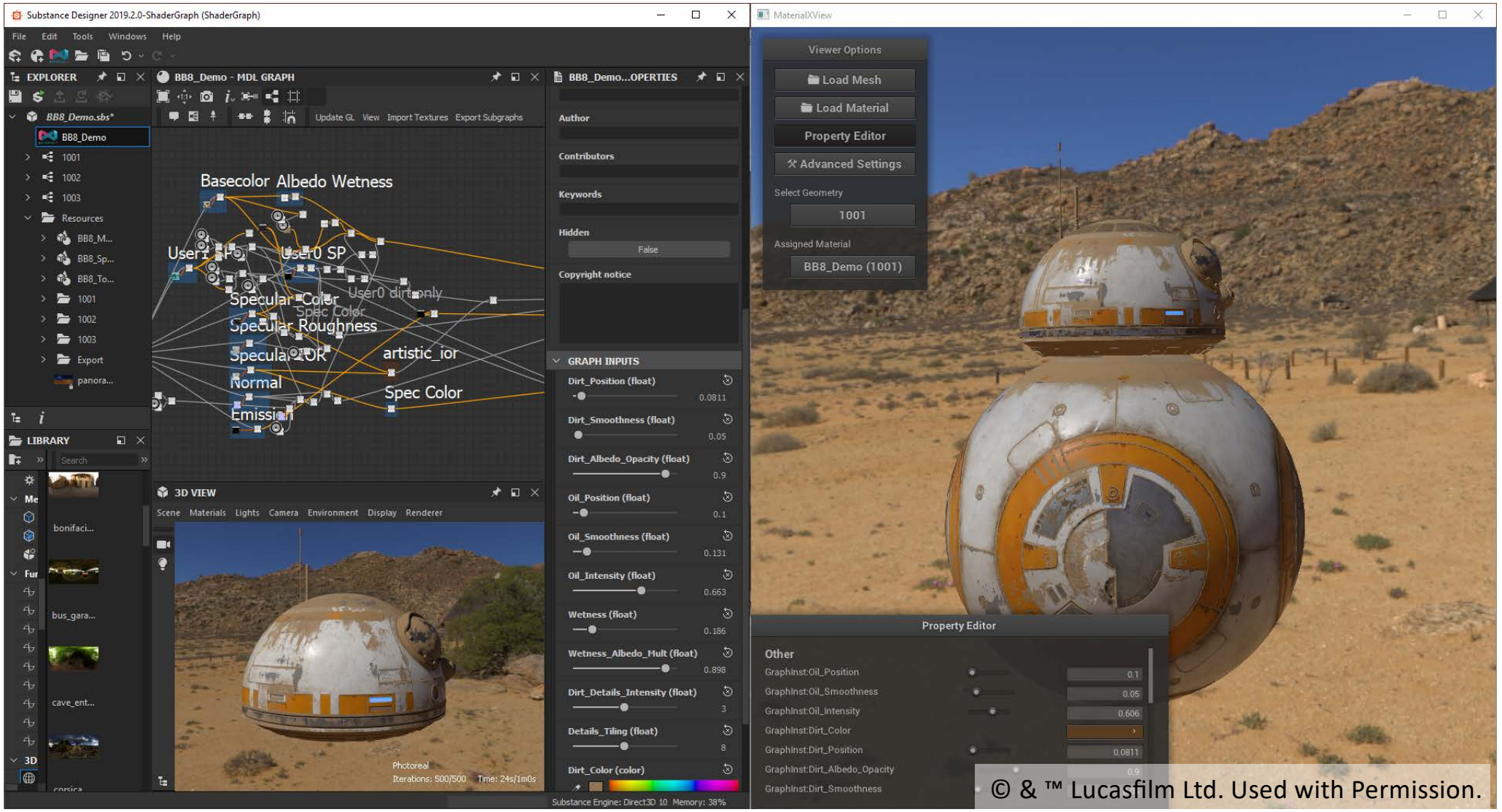
David Larsson

Autodesk Vision Series

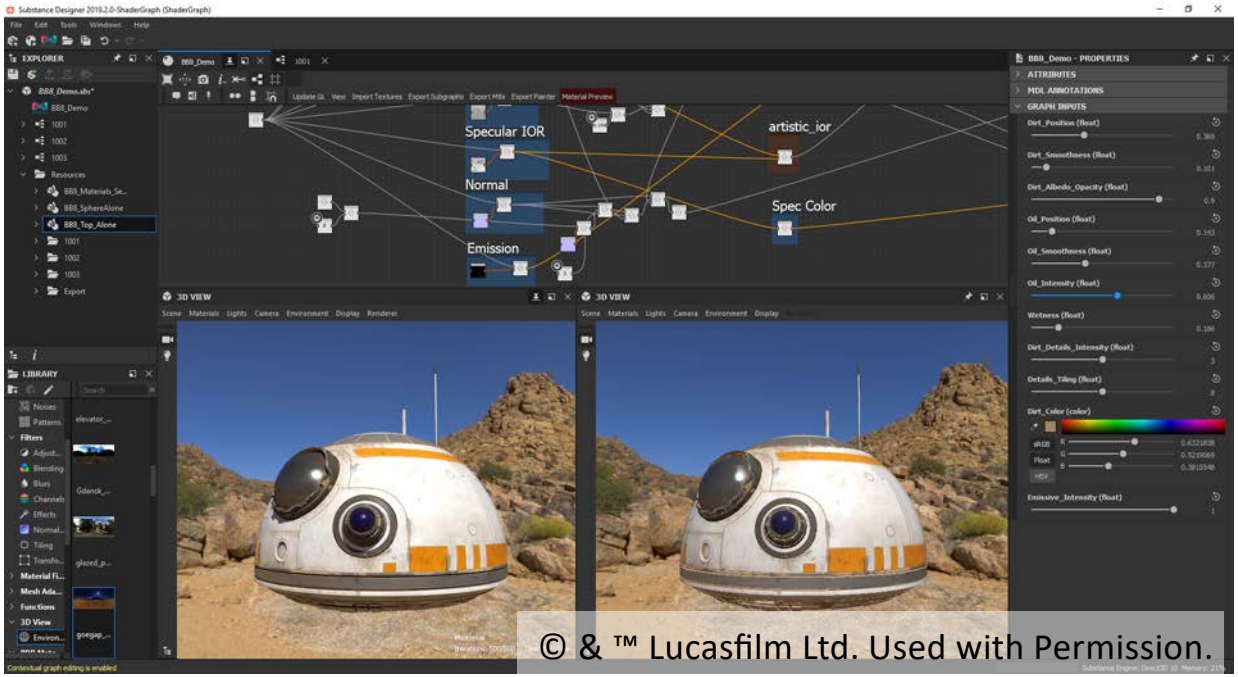
Making and sharing Materials

Shaders




Substance Designer 2019.2.0-ShaderGraph (ShaderGraph)
File Edit Tools Windows Help
EXPLORER
BB8_Demo.sbs*
BB8_Demo
1001
1002
1003
Resources
Export
LIBRARY
BB8_Demo - MDL GRAPH
Update GL View Import Textures Export Subgraphs
Basecolor Albedo Wetness
User1 SP
User0 SP
Specular Color
Spec Color
User0 dirt only
Specular Roughness
Specular IOR
artistic_ior
Normal
Spec Color
Emission
3D VIEW
Scene Materials Lights Camera Environment Display Renderer
Photoreal
Iterations: 500/500 Time: 24s/1m0s
BB8_Demo...OPERTIES
Author
Contributors
Keywords
Hidden
False
Copyright notice
GRAPH INPUTS
Dirt_Position (float) 0.0811
Dirt_Smoothness (float) 0.05
Dirt_Albedo_Opacity (float) 0.9
Oil_Position (float) 0.1
Oil_Smoothness (float) 0.131
Oil_Intensity (float) 0.663
Wetness (float) 0.186
Wetness_Albedo_Mult (float) 0.898
Dirt_Details_Intensity (float) 3
Details_Tiling (float) 8
Dirt_Color (color)
Substance Engine: Direct3D 10 Memory: 38%
MaterialXView
Viewer Options
Load Mesh
Load Material
Property Editor
Advanced Settings
Select Geometry
1001
Assigned Material
BB8_Demo (1001)
Property Editor
Other
GraphInst:Oil_Position 0.1
GraphInst:Oil_Smoothness 0.05
GraphInst:Oil_Intensity 0.606
GraphInst:Dirt_Color
GraphInst:Dirt_Position 0.0811
GraphInst:Dirt_Albedo_Opacity
GraphInst:Dirt_Smoothness
© & ™ Lucasfilm Ltd. Used with Permission.

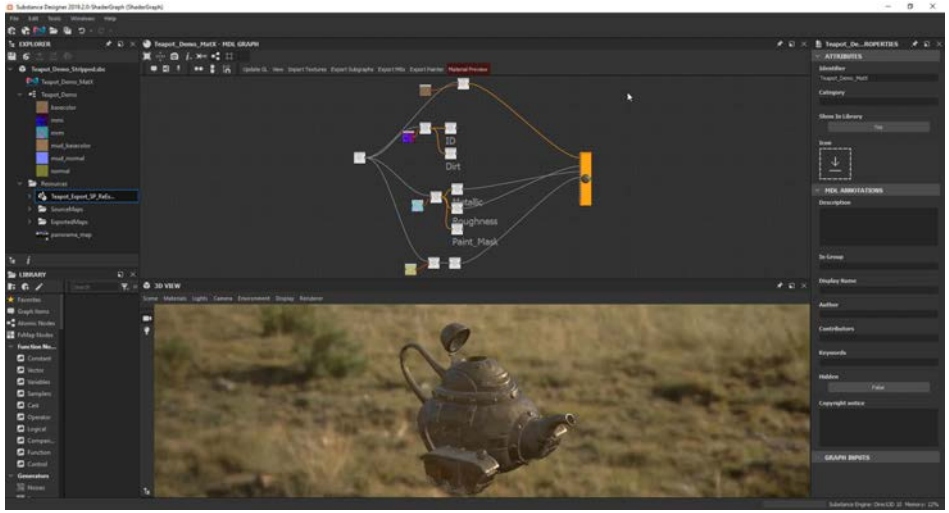
MaterialX Prototype in Substance Designer



SUBSTANCE by Adobe

Demo

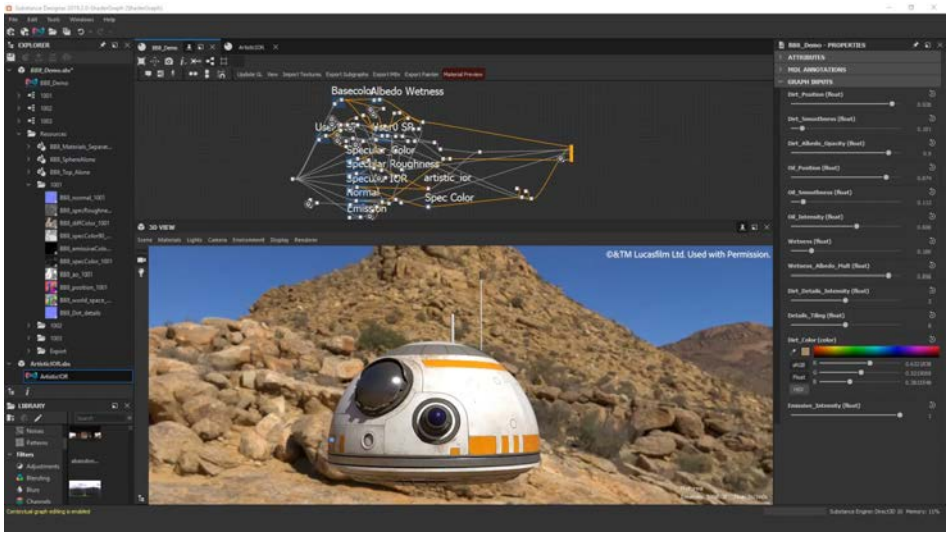
MaterialX Editor in Substance Designer



SUBSTANCE
by Adobe

Demo

Droid material setup in Designer



SUBSTANCE
by Adobe

Demo

Droid material setup in Designer

SUBSTANCE by Adobe

Demo

Droid washing in Substance Painter

SUBSTANCE
by Adobe

Maya / Arnold Demo

Questions?

LUCASFILM Ltd

SUBSTANCE by Adobe

AUTODESK