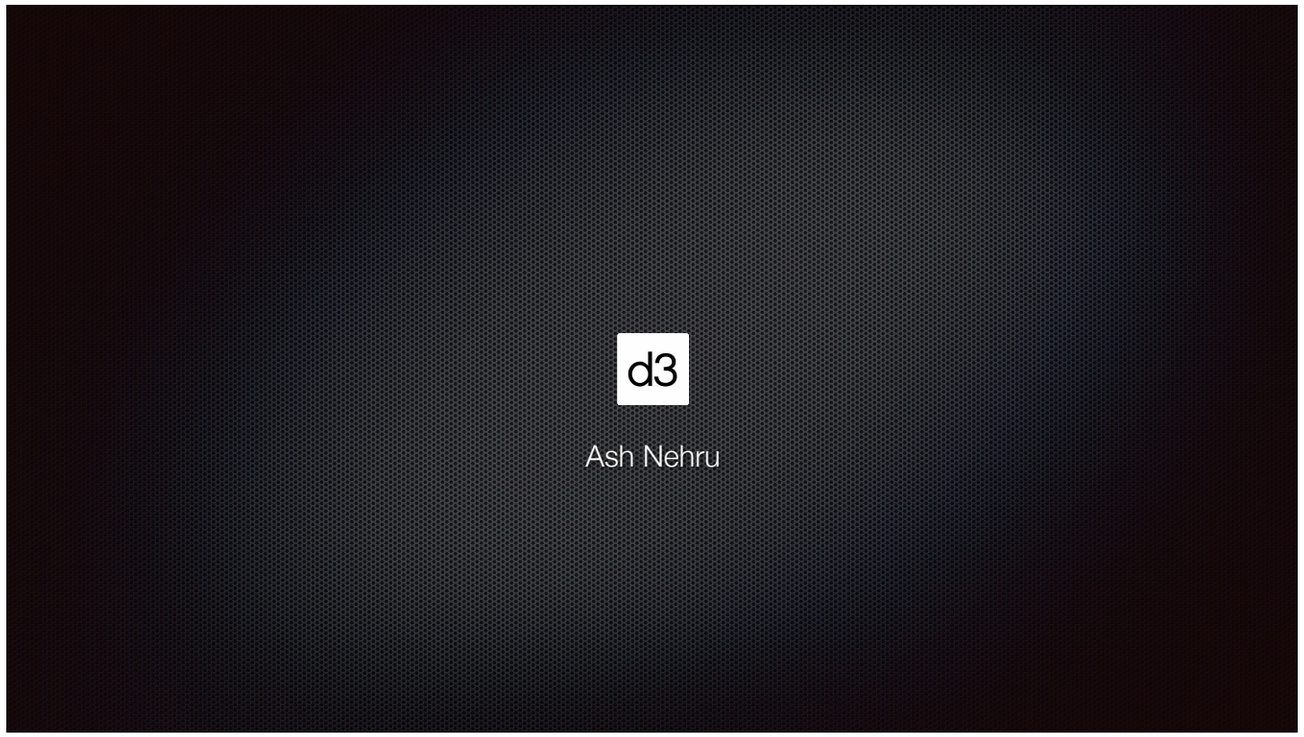
“there’s no business like show business”

projection mapping at scale



thanks for the invite, I’m ash etc.

outline

1. Where we are now
2. Where we're going
3. What we're going to need

talk overview - three sections
1) what projection mapping is today { 10 minutes }
2) where it's going { 10 minutes }
3) implications for hardware { 10 minutes }

1. Where we are now

“what is projection mapping ?”

we’re familiar with both of these upcoming technologies but they’re not quite here yet

Augmented Reality

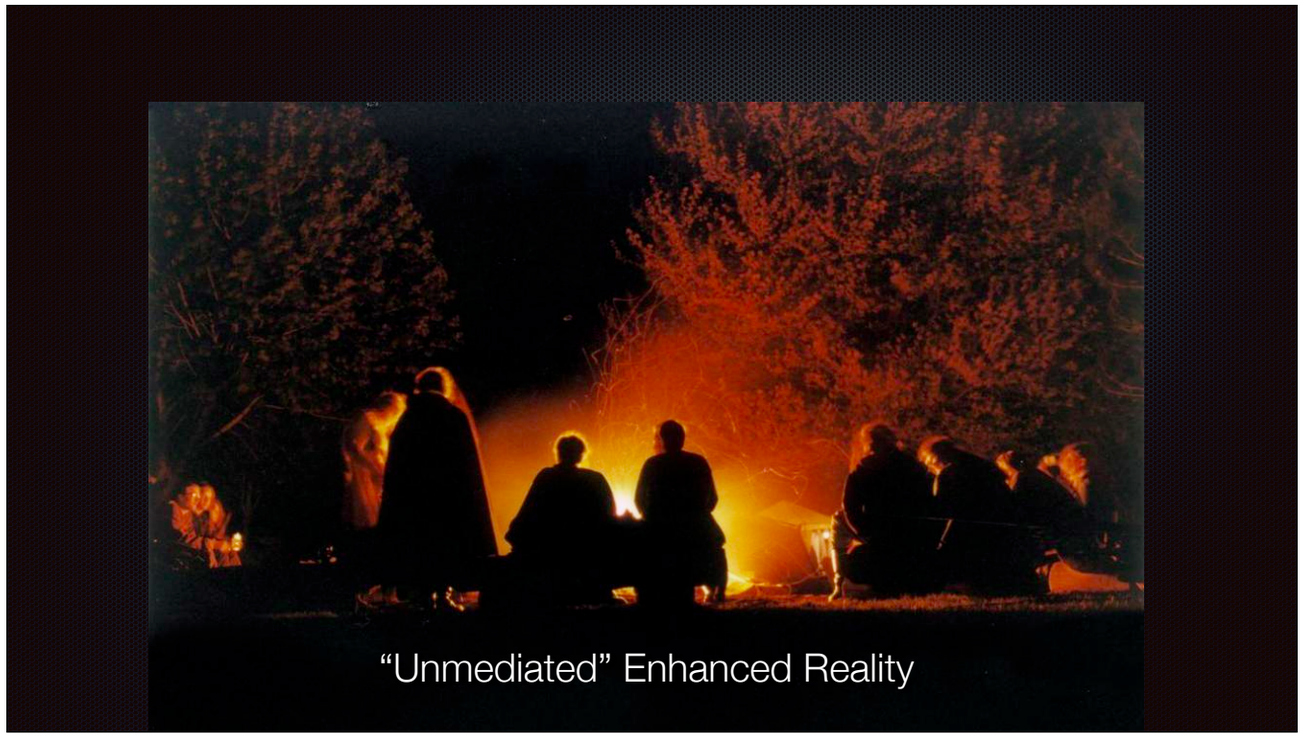
we’re familiar with both of these upcoming technologies but they’re not quite here yet

Augmented Reality

Virtual Reality

we’re familiar with both of these upcoming technologies but they’re not quite here yet

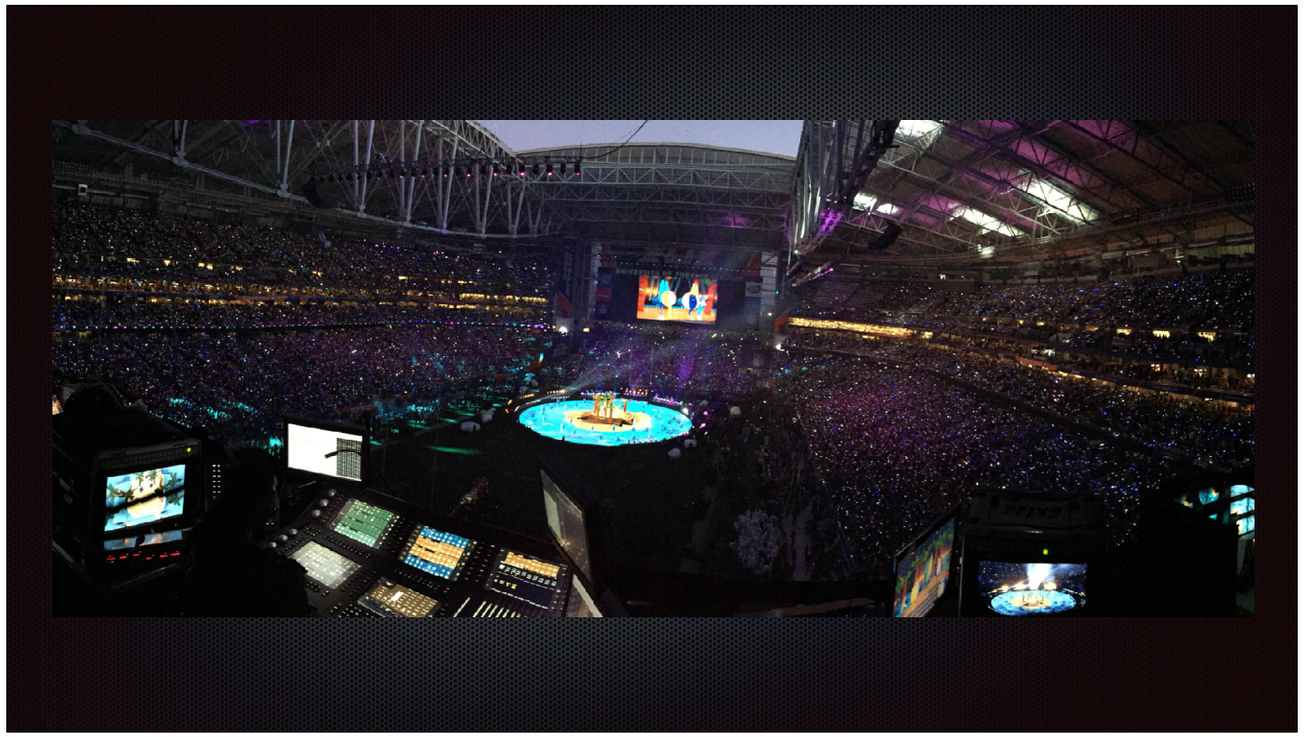
we’re more interested in gatherings of people, with unmediated experience



we’re more interested in gatherings of people, with unmediated experience

concerts, live music

theater, opera, highbrow, lowbrow, -> interested in creating



sports, spectacle

courtesy Lightborne Productions

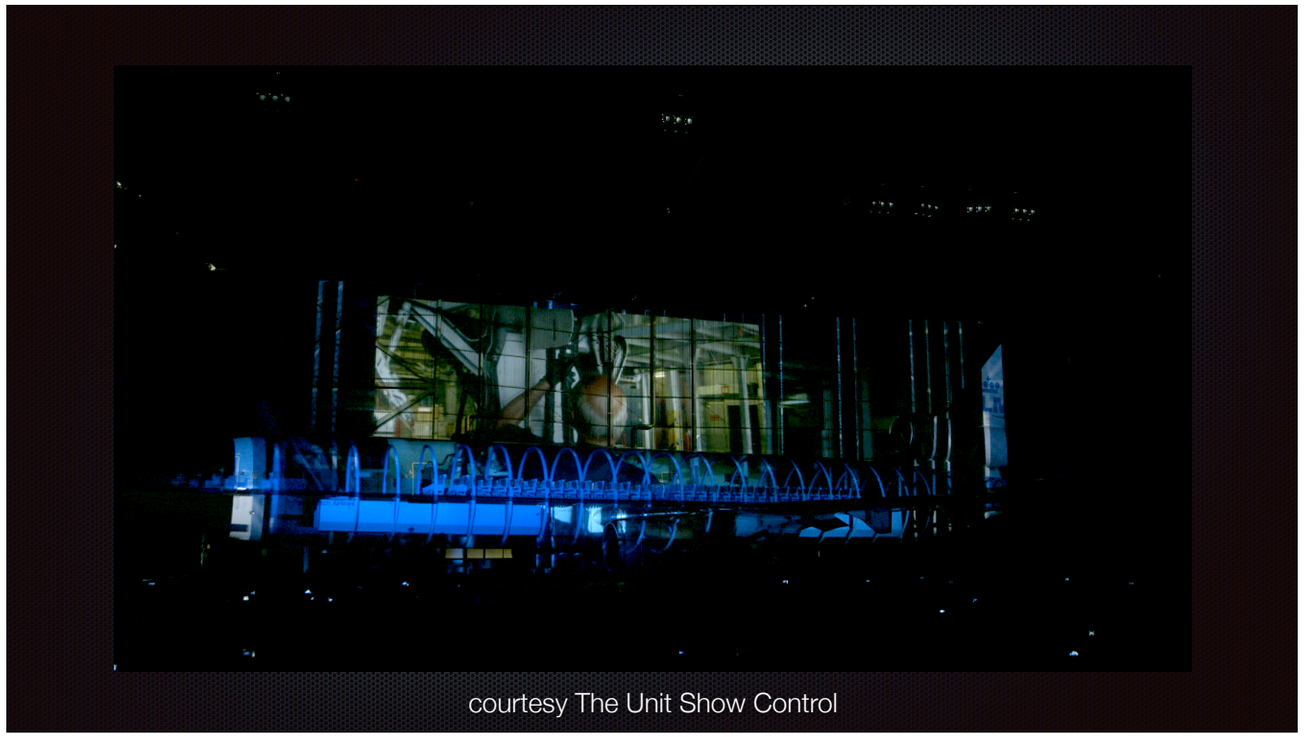
{ placeholder for video }
video is at https://www.youtube.com/watch?v=Rj28BVM_1tE }

courtesy Lightborne Productions

{ placeholder for video }
video is at https://www.youtube.com/watch?v=Rj28BVM_1tE }

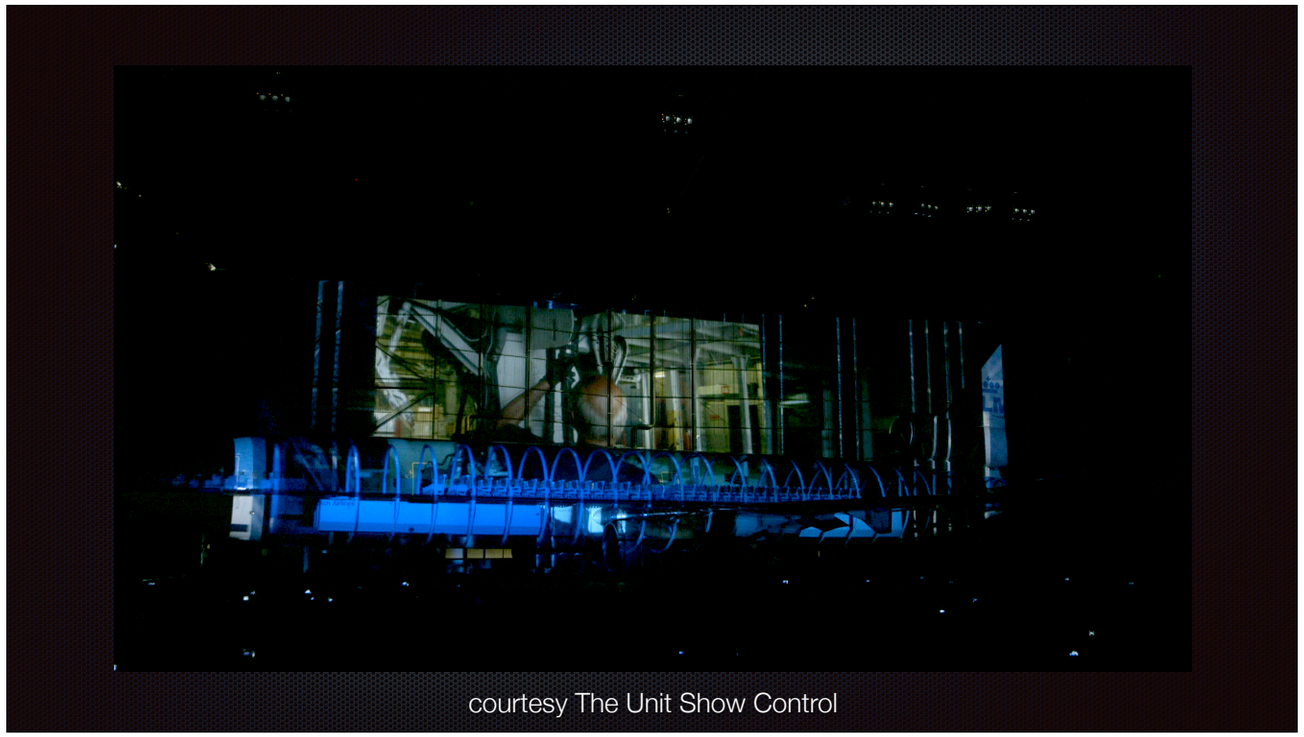
courtesy Drive Productions

courtesy Drive Productions



courtesy The Unit Show Control

at most complex, the idea of ‘texture mapping reality’ – projecting any skin we like onto real objects (large or small) (video).



courtesy The Unit Show Control

at most complex, the idea of ‘texture mapping reality’ – projecting any skin we like onto real objects (large or small) (video).

courtesy Creative Technology Ltd

bigger, bigger, bigger...

courtesy Creative Technology Ltd

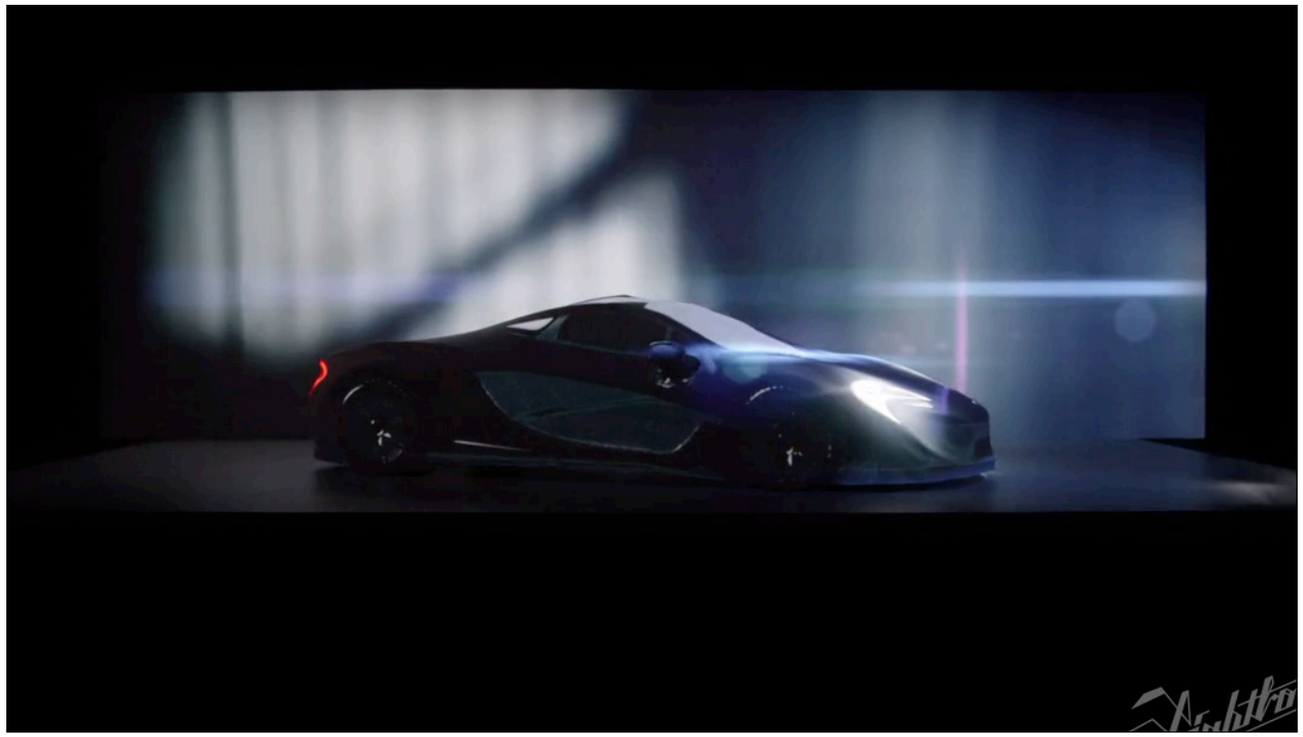
bigger, bigger, bigger...

courtesy Lightborne Productions

courtesy Lightborne Productions

“so what are we doing ?”

in a nutshell, it’s really pretty simple :



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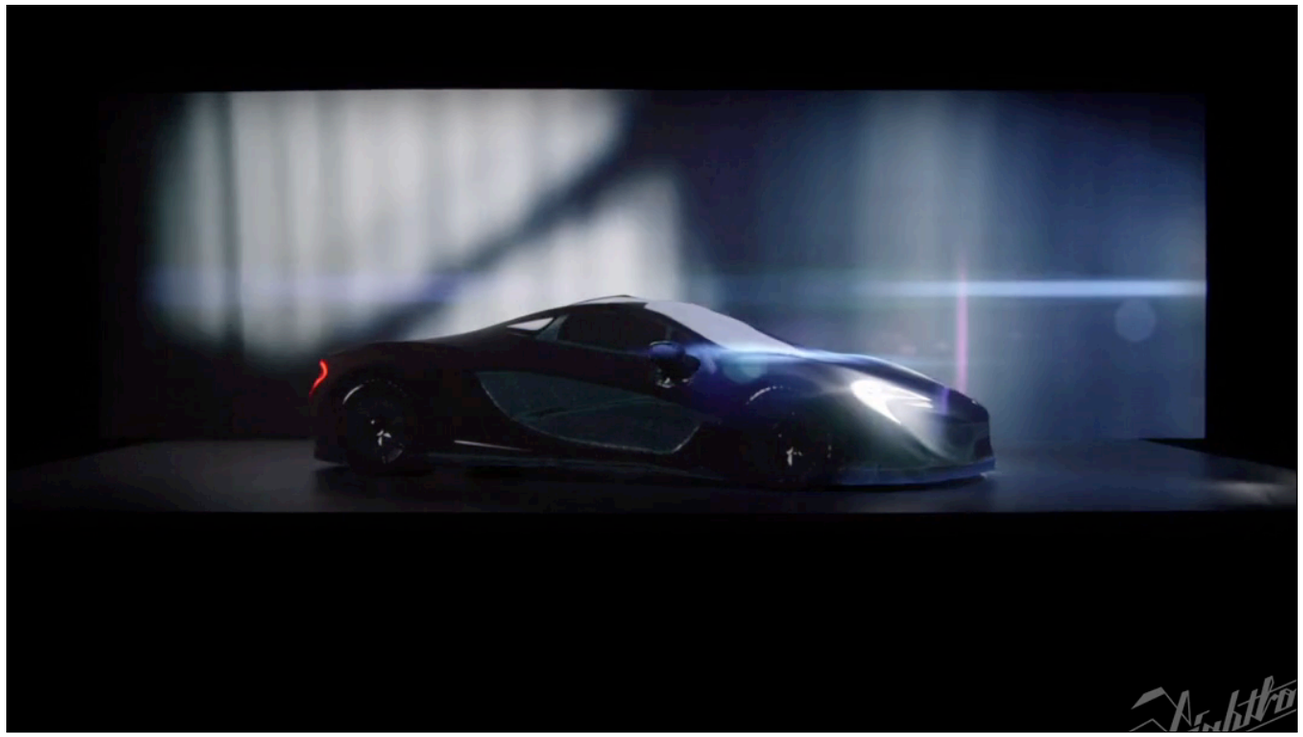

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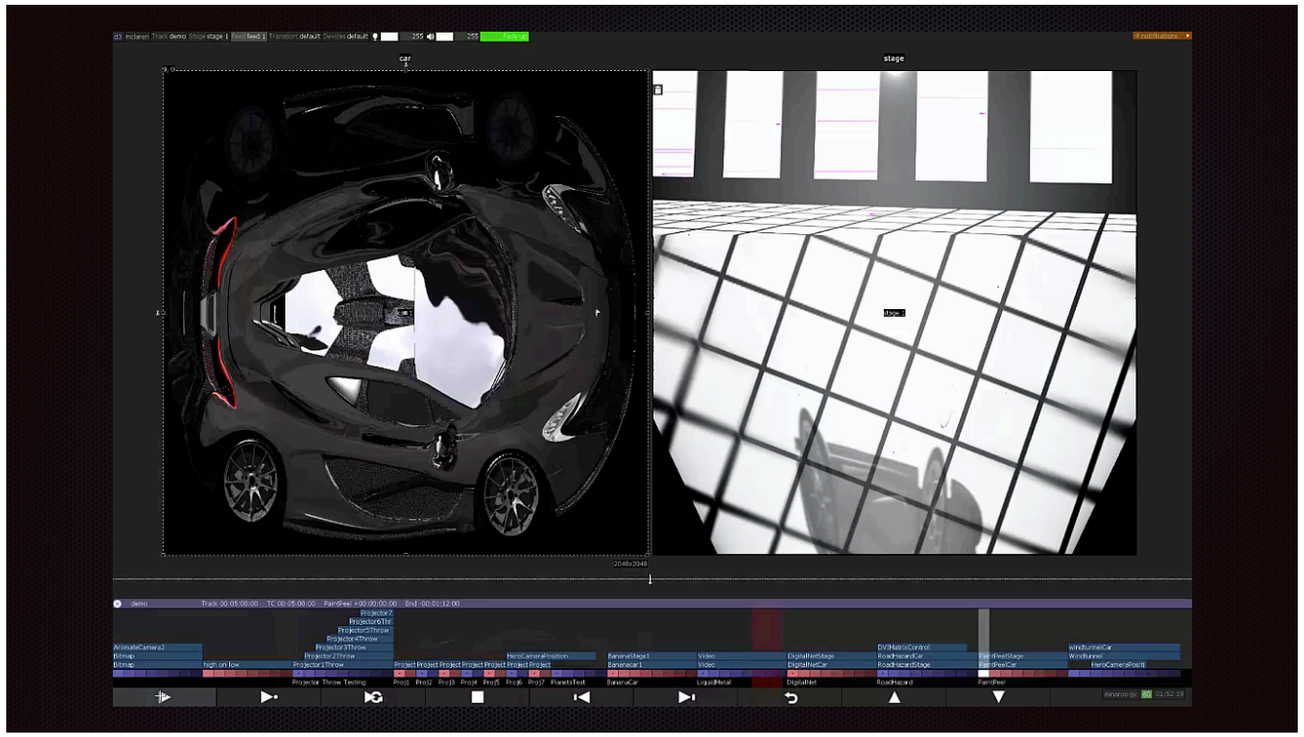
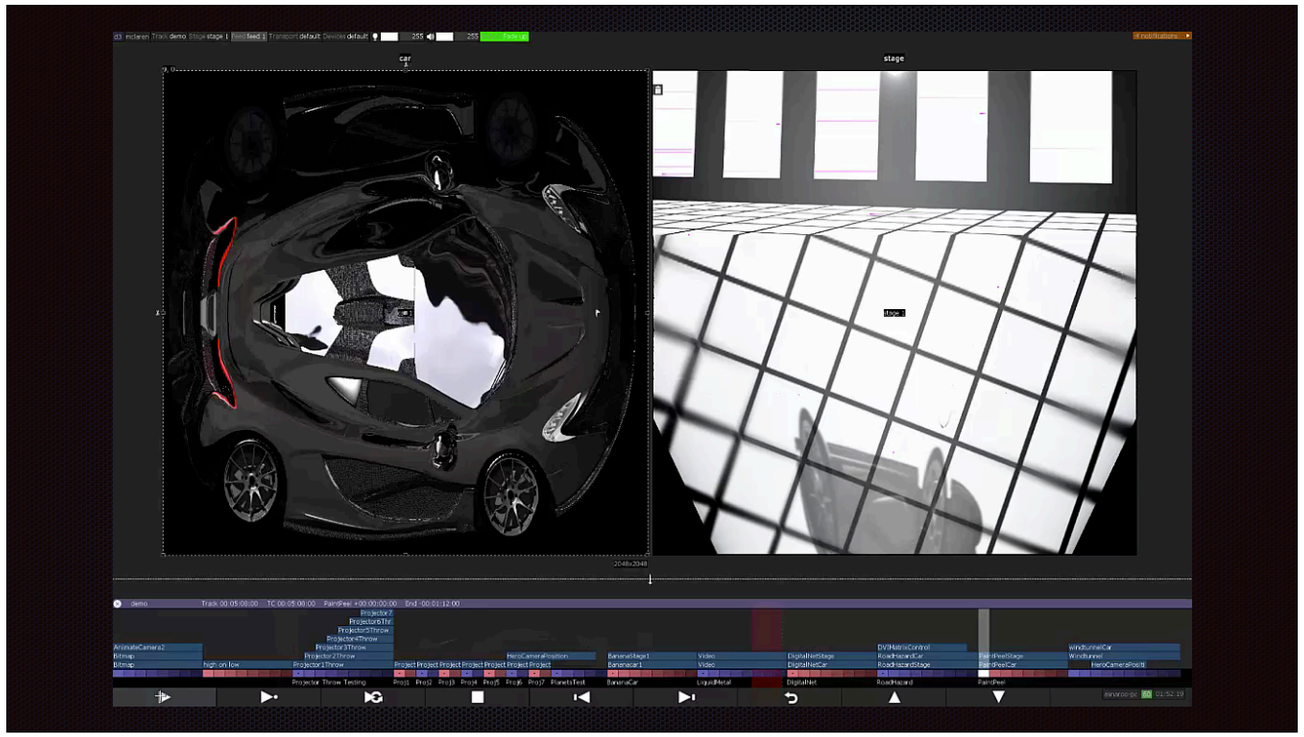


playing large video files



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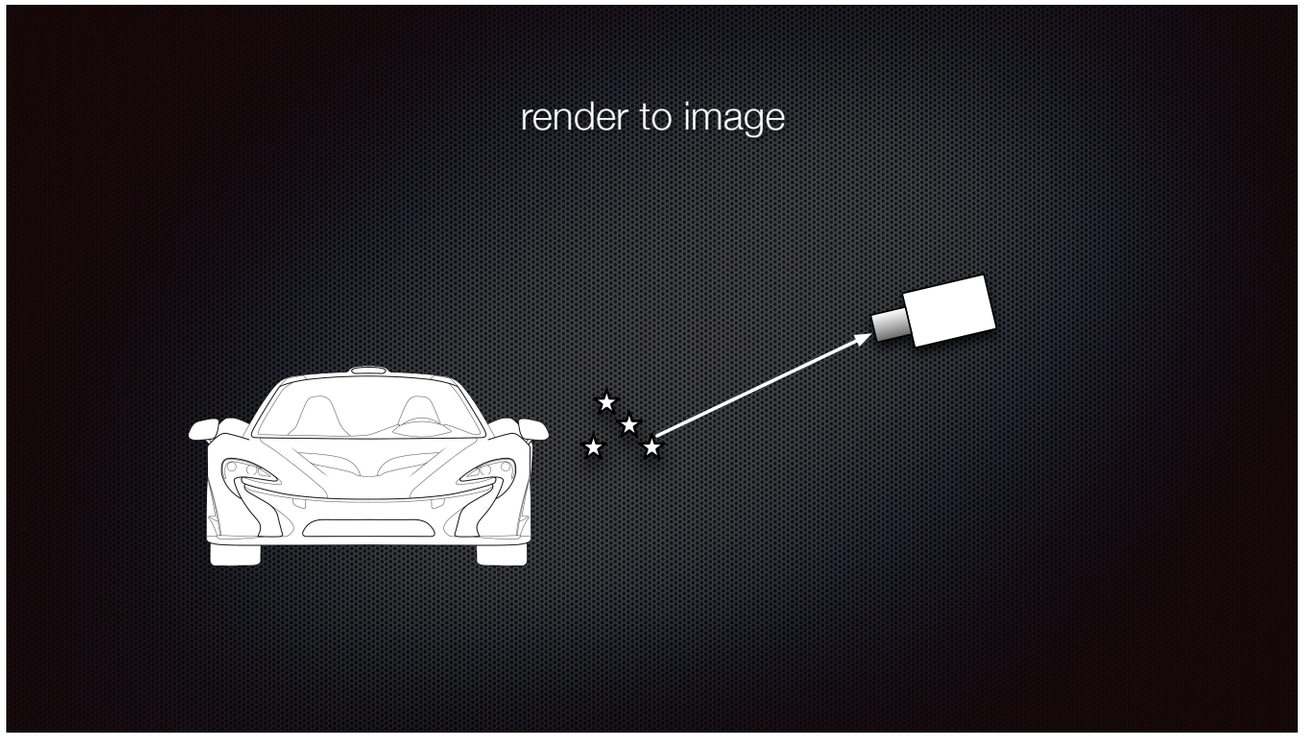
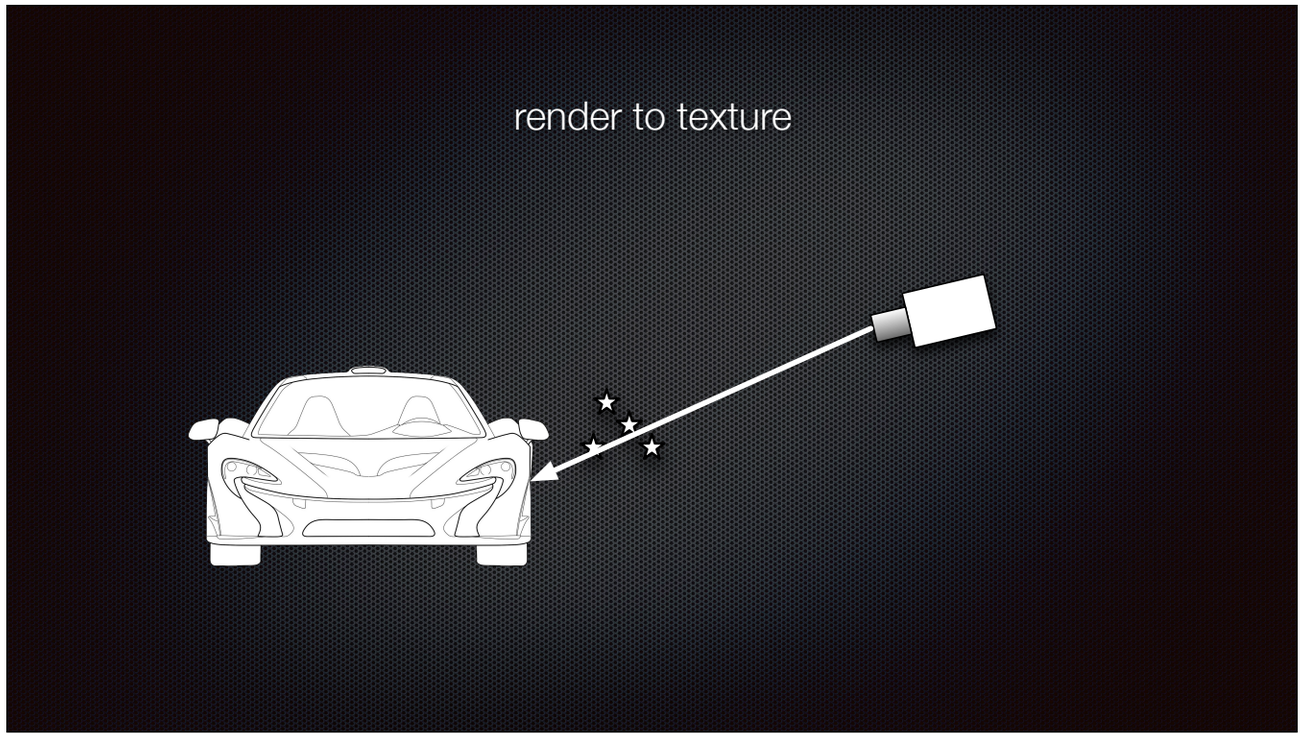


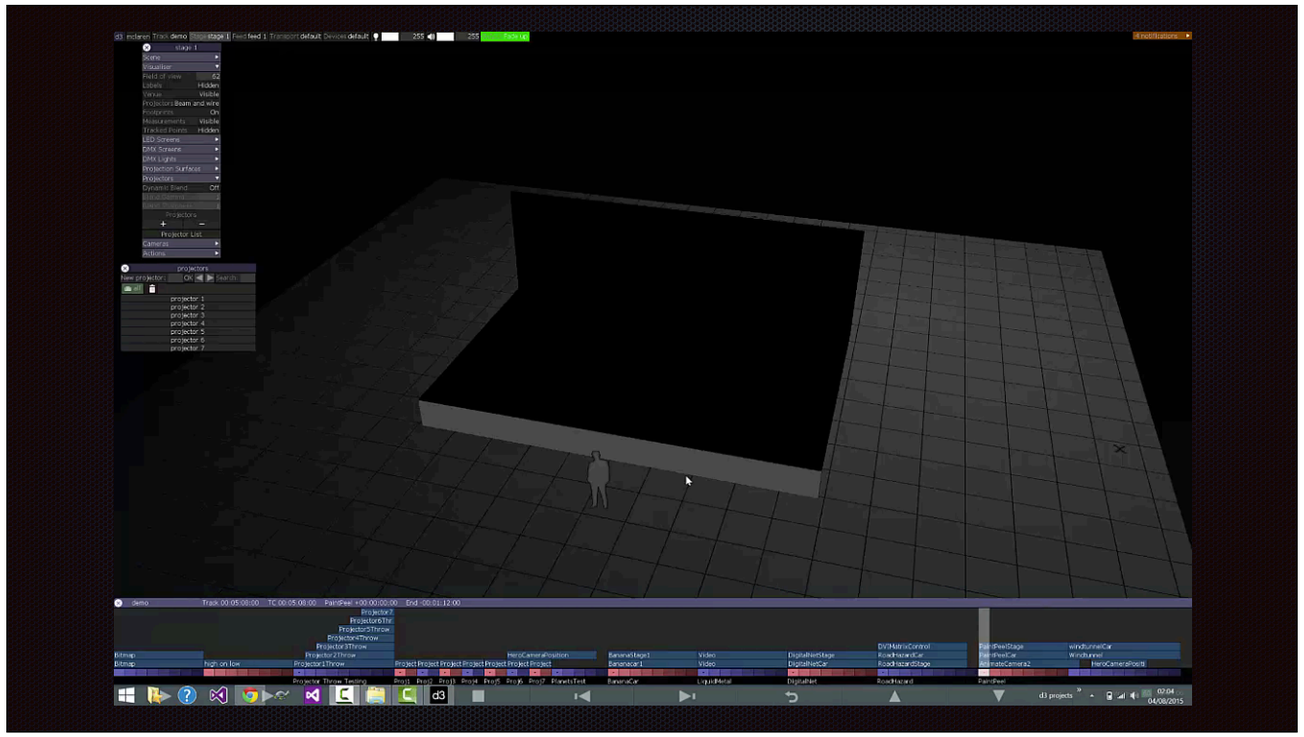
reverse texture mapping



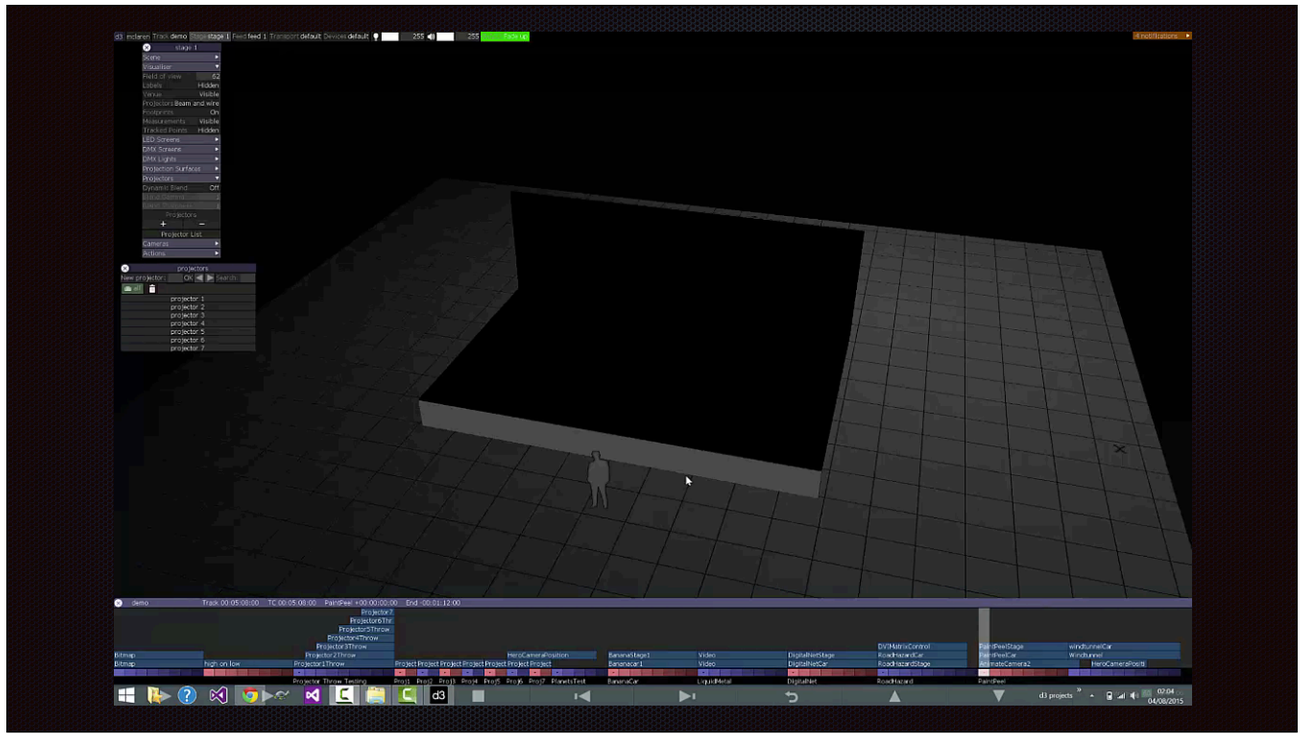
reverse texture mapping

viewing them in 3D

viewing them in 3D



planning projector layout, previewing quality and overlaps



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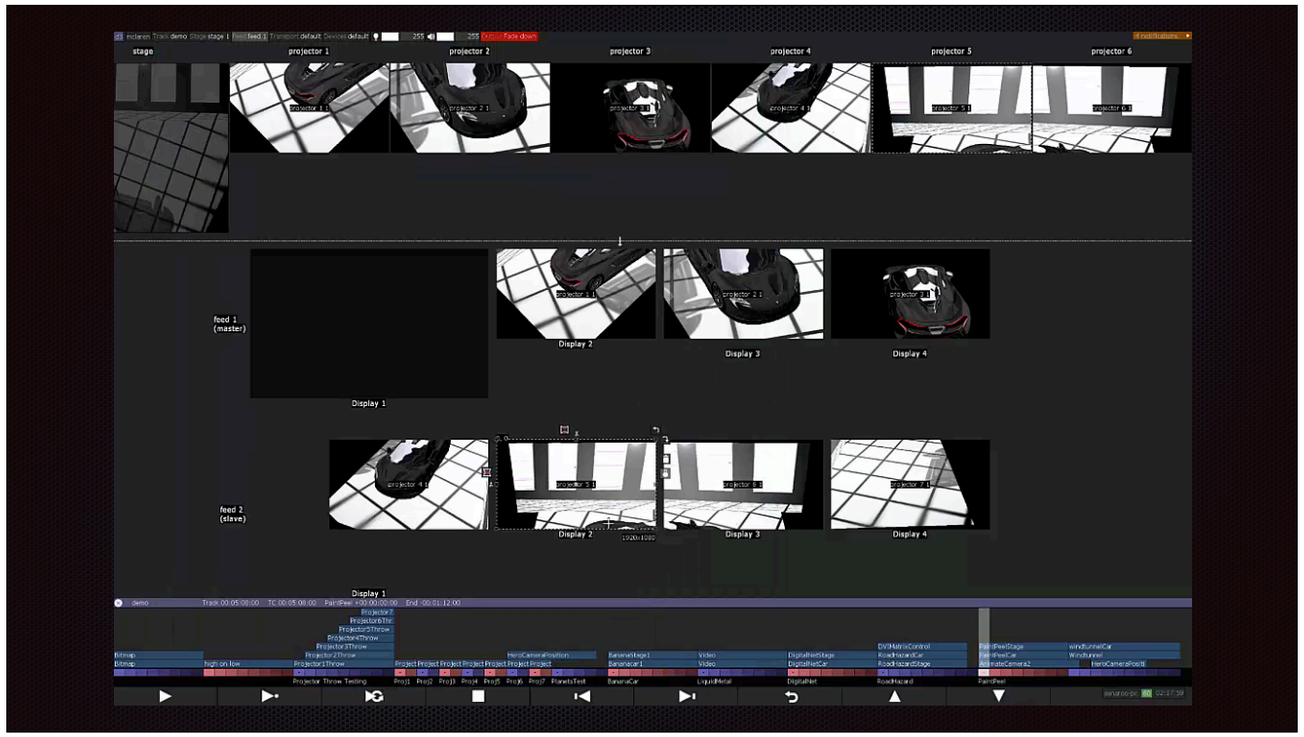
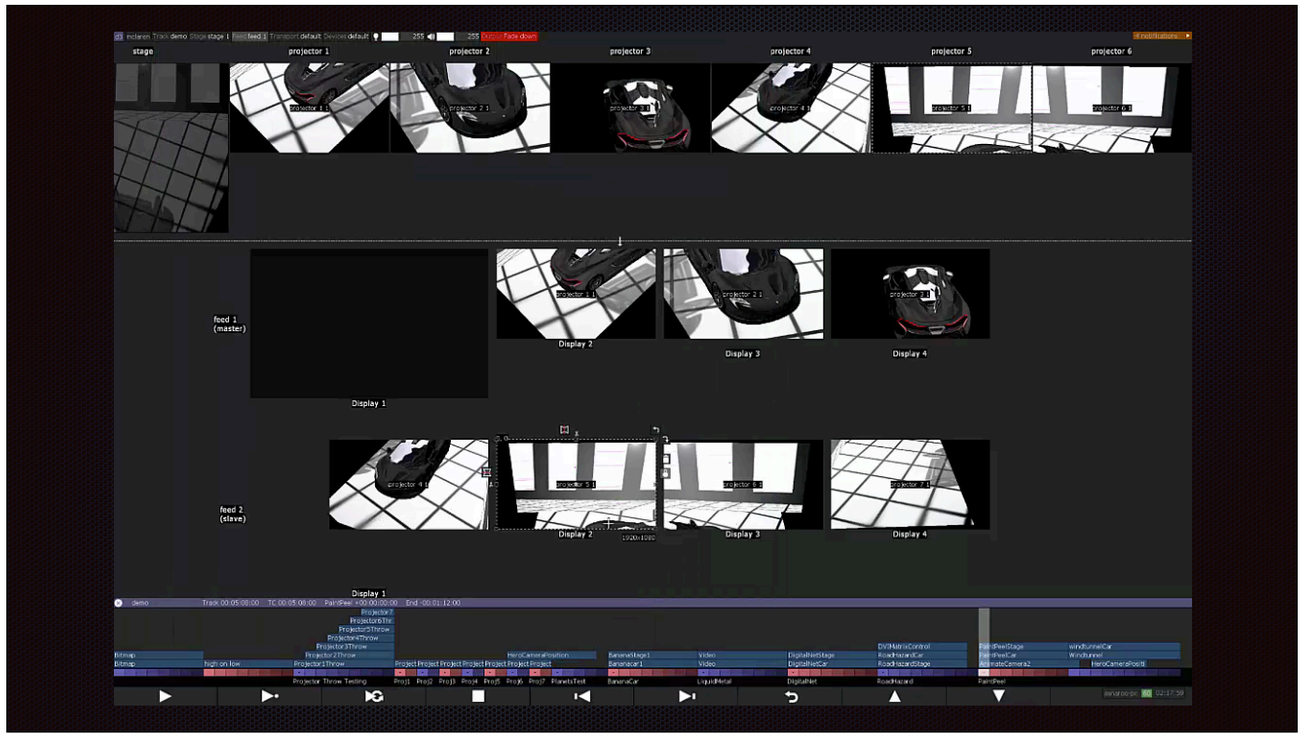


management of multiple machines and projectors / distribution



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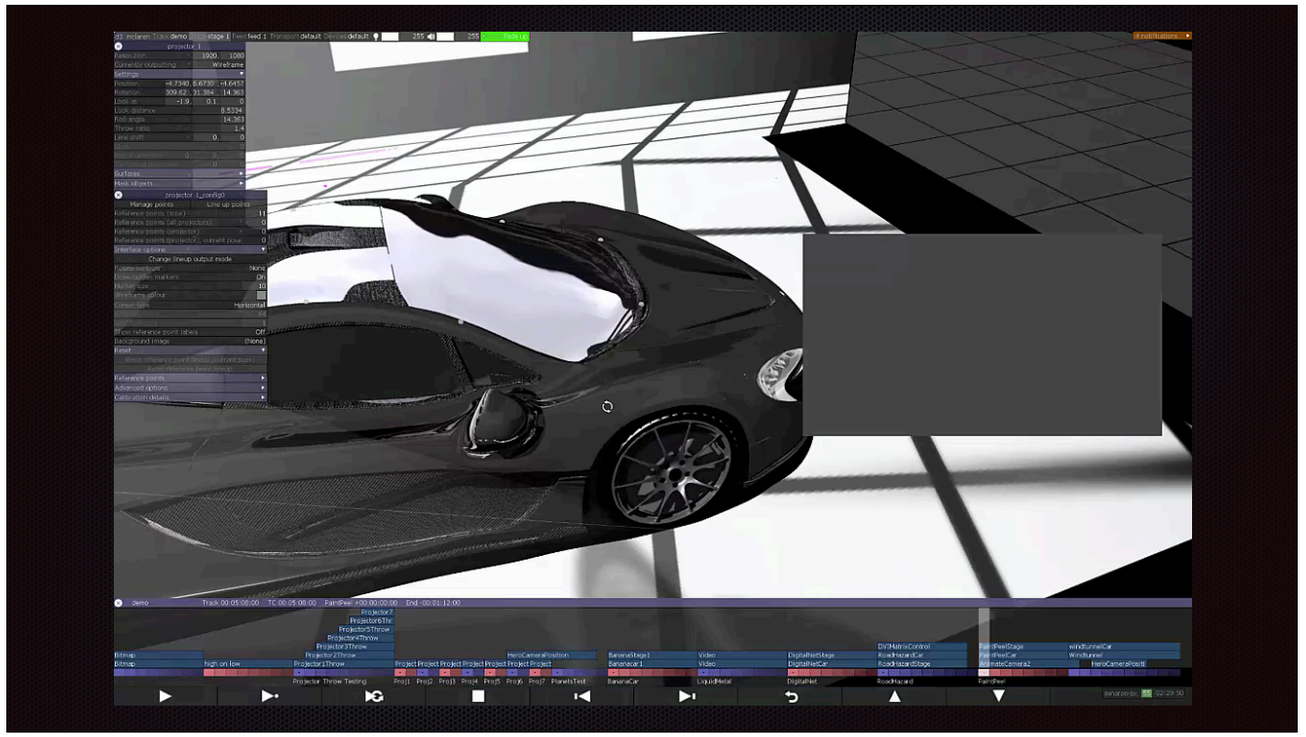
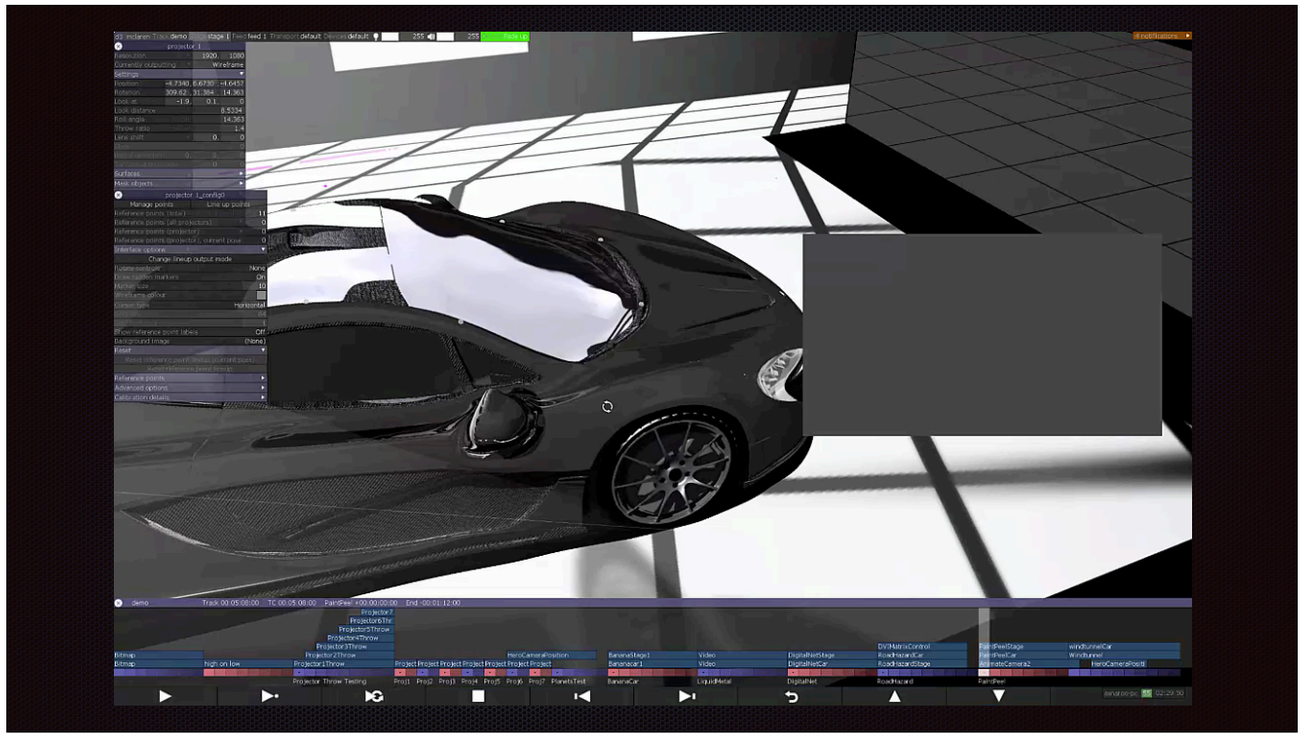


projector calibration to match the virtual projectors to the real ones



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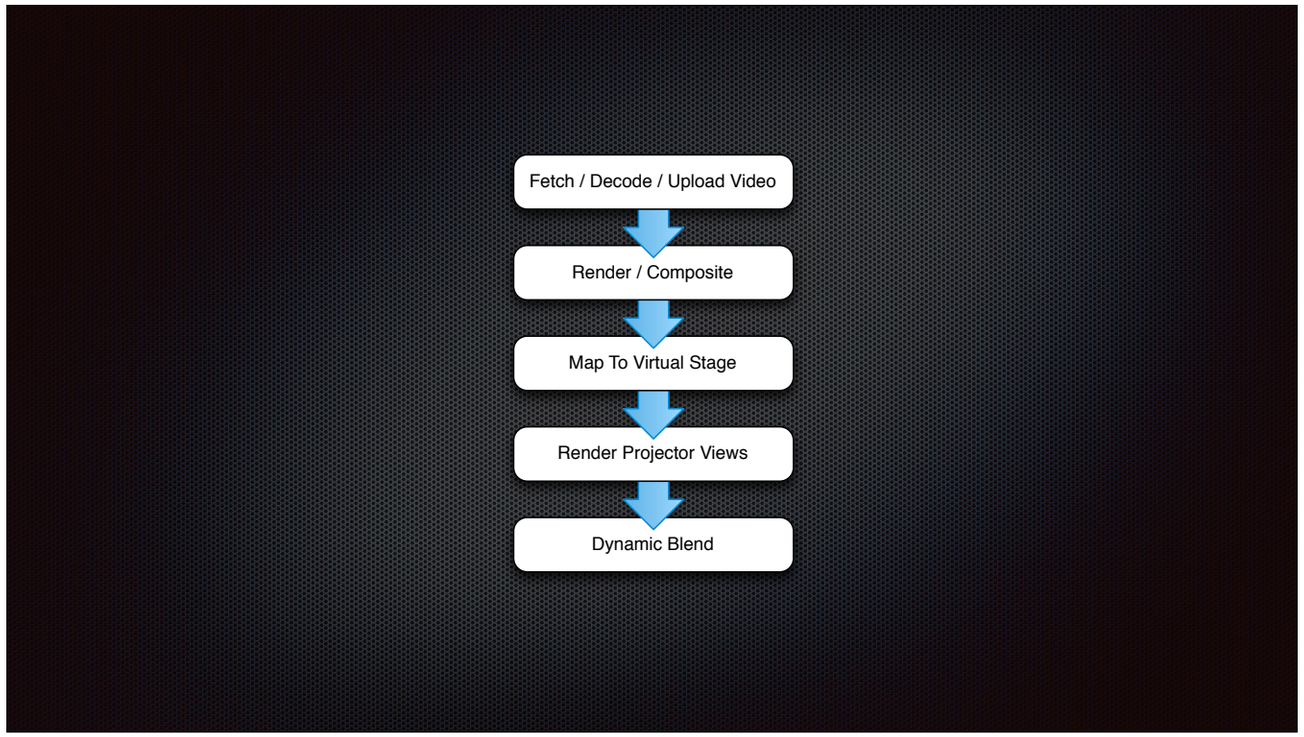

render pipeline - this is what’s going on every frame

media server >>

“...show business...”

deadlines do not slip. the show will happen at the specified time and date.
you may or may not be a part of it, but the audience will arrive and the show will go on.

Rule Number One : “The Show Must Go On”

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Consequences

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  - modifications become harder
  - modifications become more dangerous
  - the customer will ask for more modifications

deadlines do not slip. the show will happen at the specified time and date.
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Once you have wheels up, you cannot screw up. Everyone is watching. Has to work or that’s the end for you.

Rule Number Two : “No Second Chances”

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Consequences

Consequences

- crashing is not an option ! extreme exception safety

Consequences

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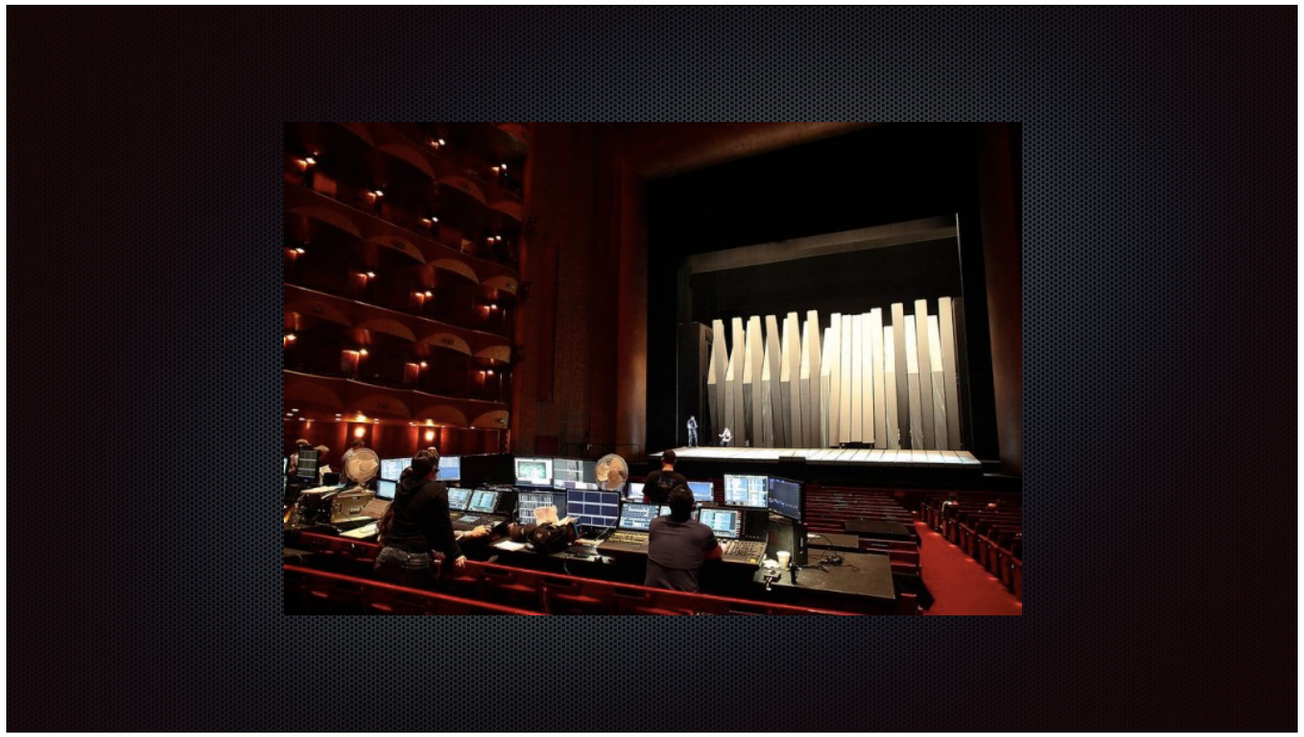
- always start / always continue / soldier on
- use simple designs (eg. NASA rules)
- avoid threading if at all possible **
- understudy / fault tolerance is a must



You are not the only part of the production. Lighting, scenic, automation, lasers, choreography, rehearsal, all have to have their time on stage. You don’t get very much time to get your shit together. Also, all eyes are on you !

Rule Number Three : “Hurry Up”

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Consequences

Consequences

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Consequences

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Consequences

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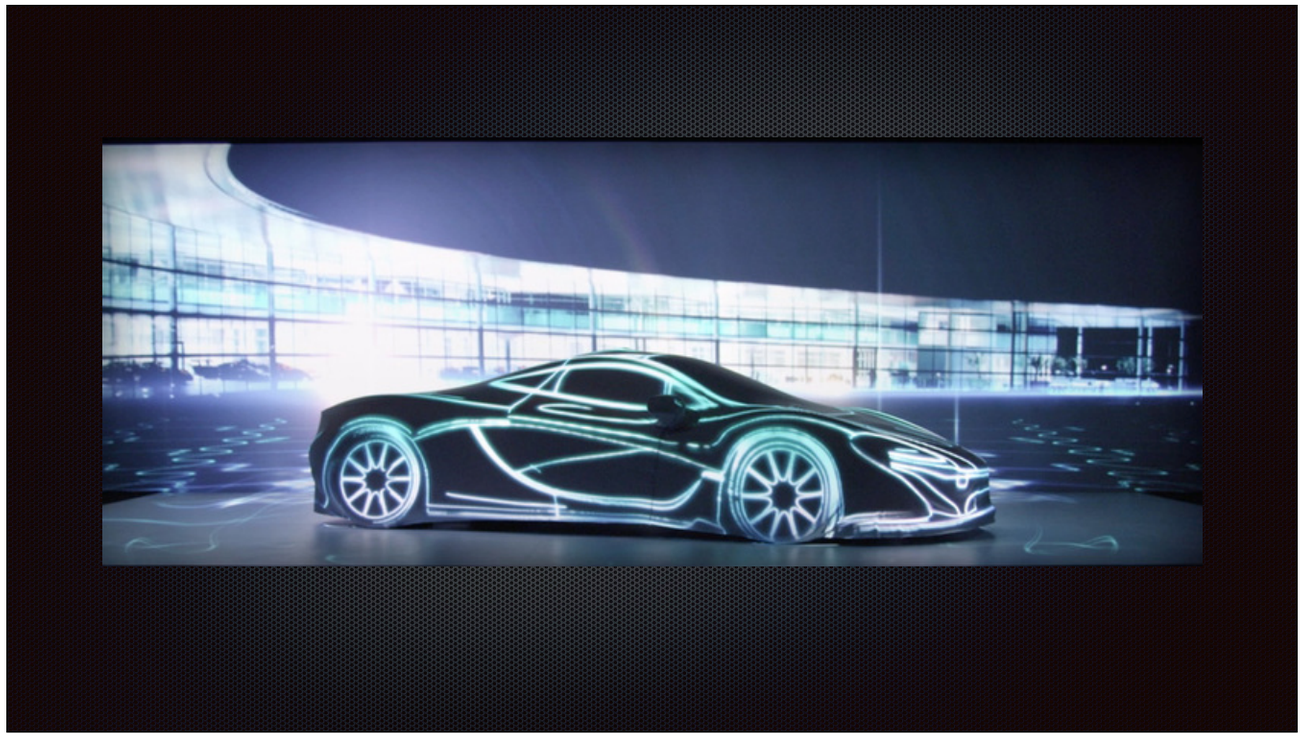
- enable parallel / collaborative workflows
- go for simplest ways of achieving task
- avoid ultimate flexibility - there won’t be time
- a visualiser is essential for progress



Nobody wants to see what you showed last year. Always have to do something new !
Oh, and it has to work, see rule two. Example: dynamic blend was refined on Marvel Universe.

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Oh, and it has to work, see rule two. Example: dynamic blend was refined on Marvel Universe.

Consequences

Consequences

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Consequences

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- need to find customers with nerves of steel

Consequences

- have to do R&D on actual shows
- need to find customers with nerves of steel
- need a fine instinct for risk calculation

“so what do we mean by ‘scale’ ?”

‘scale’ means:

This needs to be a series of entertaining images, one per point - blat through them fast.

‘scale’ means:

large / complex physical surfaces

This needs to be a series of entertaining images, one per point - blat through them fast.

‘scale’ means:

large / complex physical surfaces
large number of projectors / signals

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physically challenging environment
lots of people watching
highly compressed schedules

This needs to be a series of entertaining images, one per point - blat through them fast.

example: superbowl 2015

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football pitch : 50 meters across

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football pitch : 50 meters across
80 projectors, 40 separate signals

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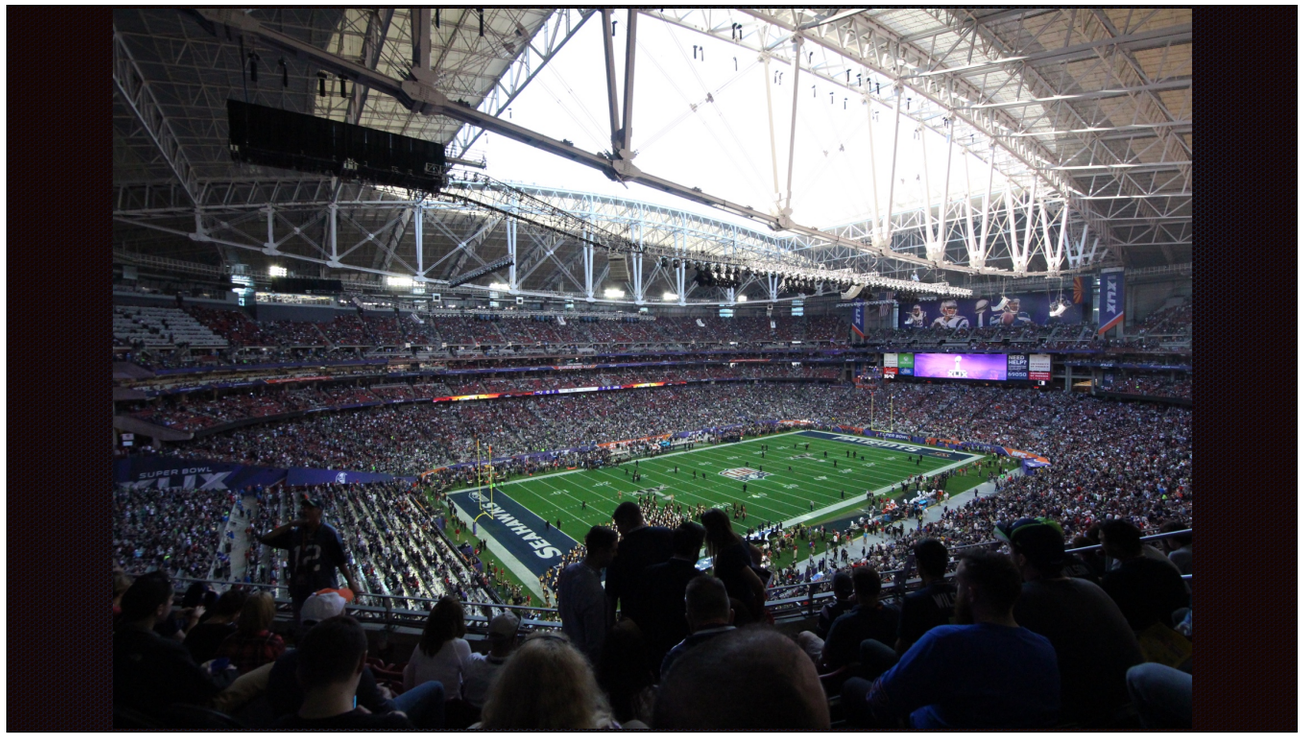
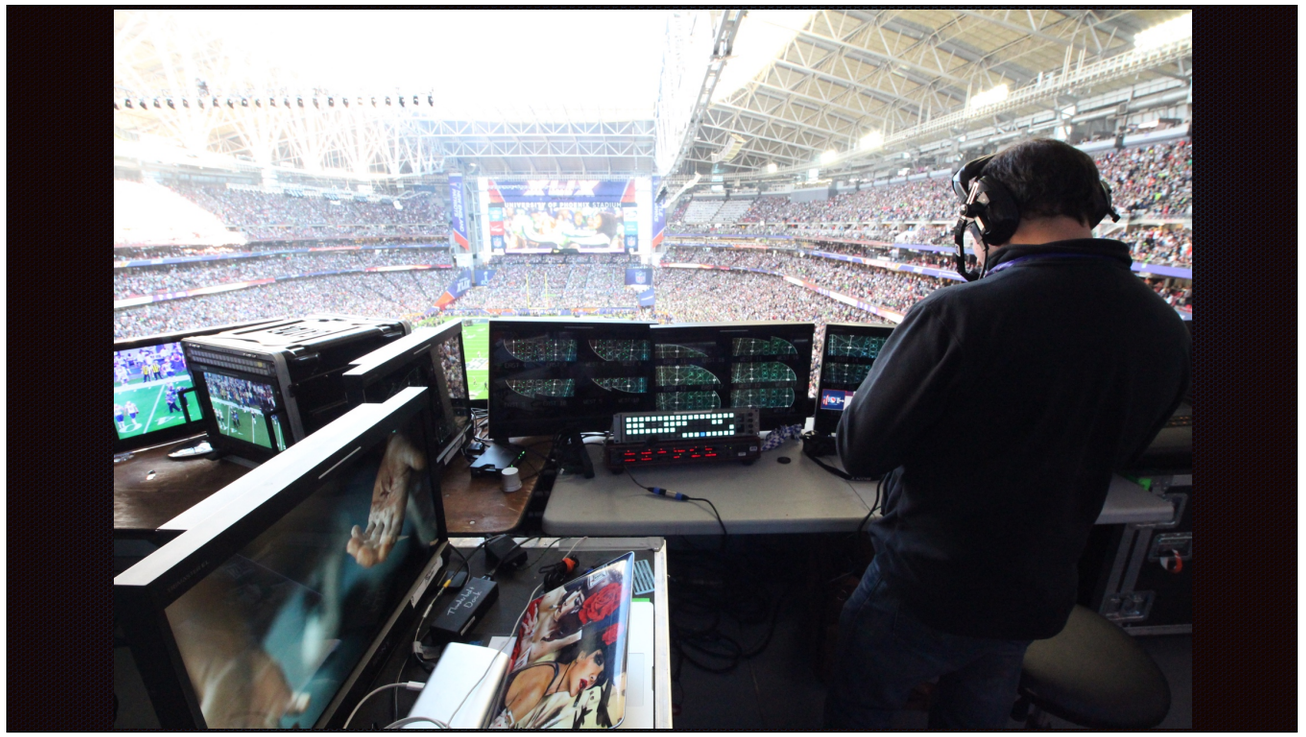
80,000 people in the stadium, 150M viewers
five-day lineup window
seven minutes available for last-minute touchups


ARIZONA


SUPER BOWL
SEAHAWKS



example: hoover dam

example: hoover dam

hoover dam : 220 meters across

example: hoover dam

hoover dam : 220 meters across
60 projectors

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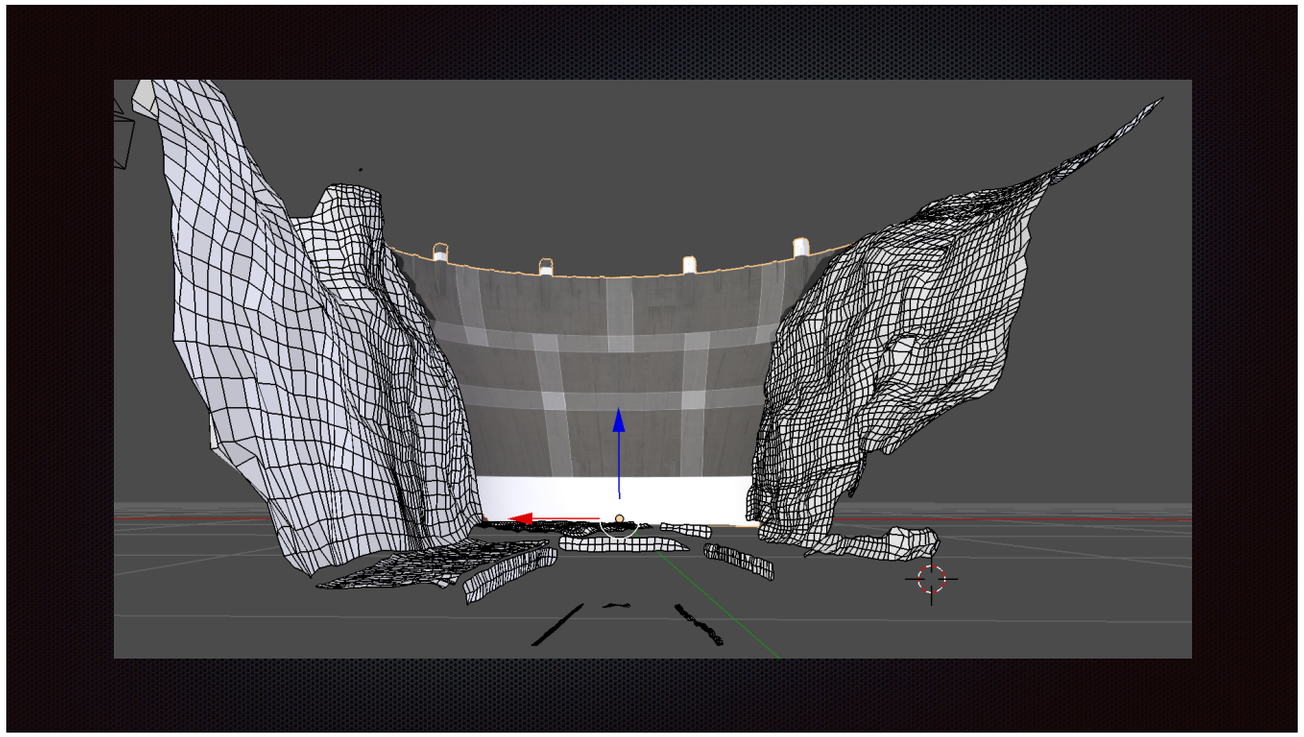
four-day setup

example: hoover dam

hoover dam : 220 meters across
60 projectors
3600 by 3400 pixel canvas
four-day setup
outdoors, wind, rain, cold, sunshine



a quick look at hardware:

a very quick dive into how we do things today, to motivate how I’d like to see things change in the future

basically : a computer playing video onto a monitor

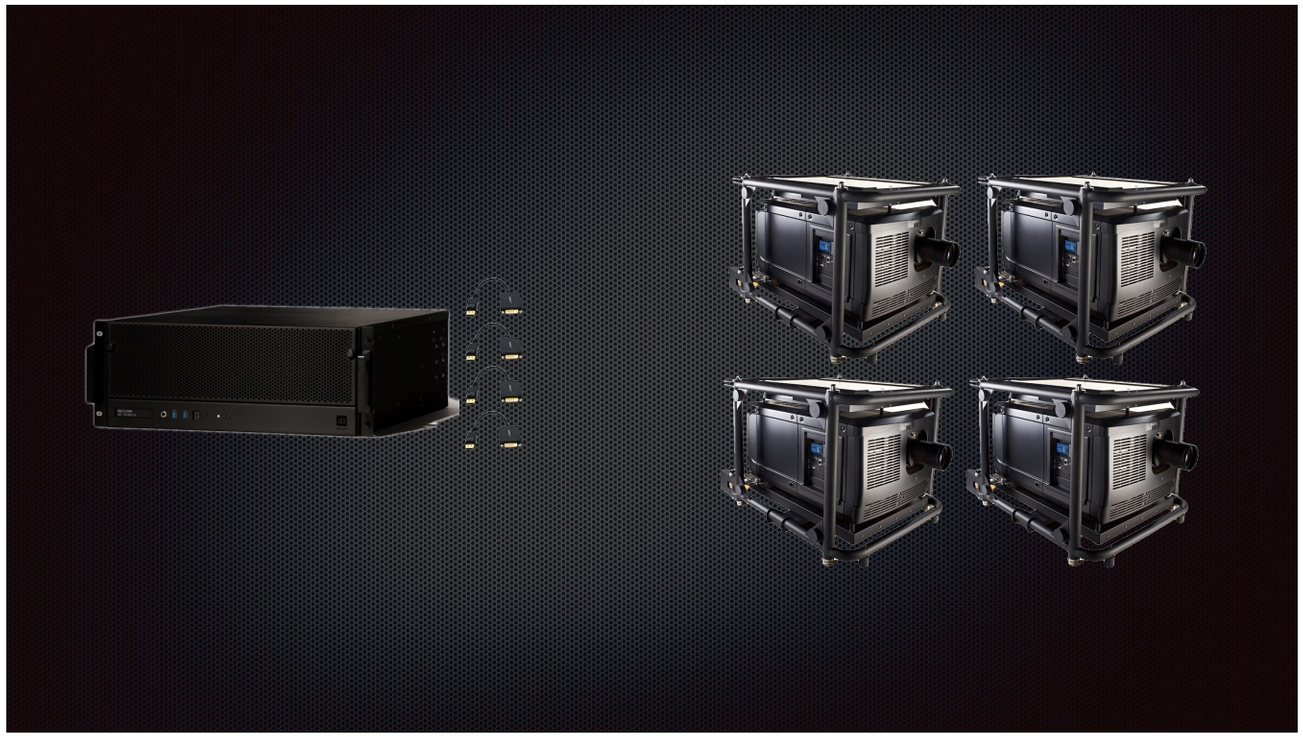
except it’s not a monitor, it’s a projector

not a home projector, but a big one - this one is 40K lumens as compared to 1500, weighs a ton, has its own config software, the size of a small car

not just a computer - a media server. (disclosure - we make one)

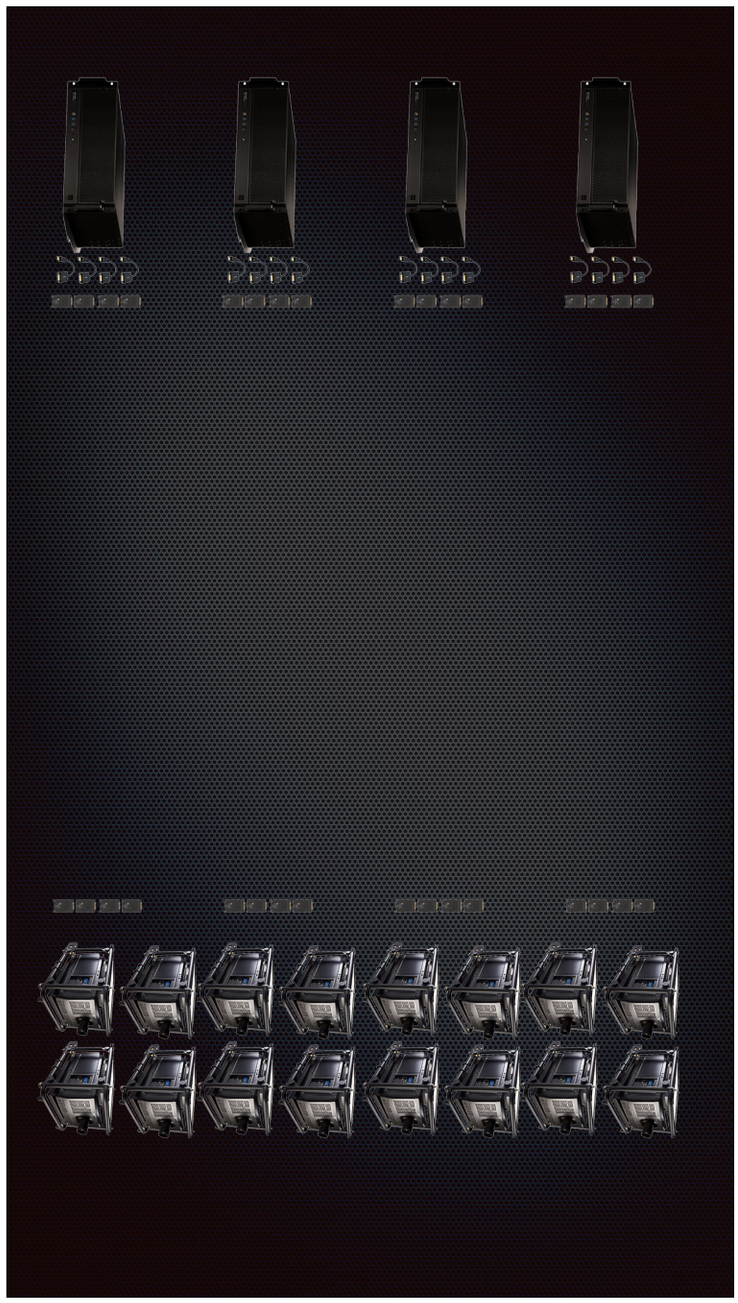
four physical DisplayPort outputs, so we can drive up to four 4K projectors

except those projectors don’t speak DP, they speak either DVI or SDI; so we have to convert
(and accept lower resolution limits)



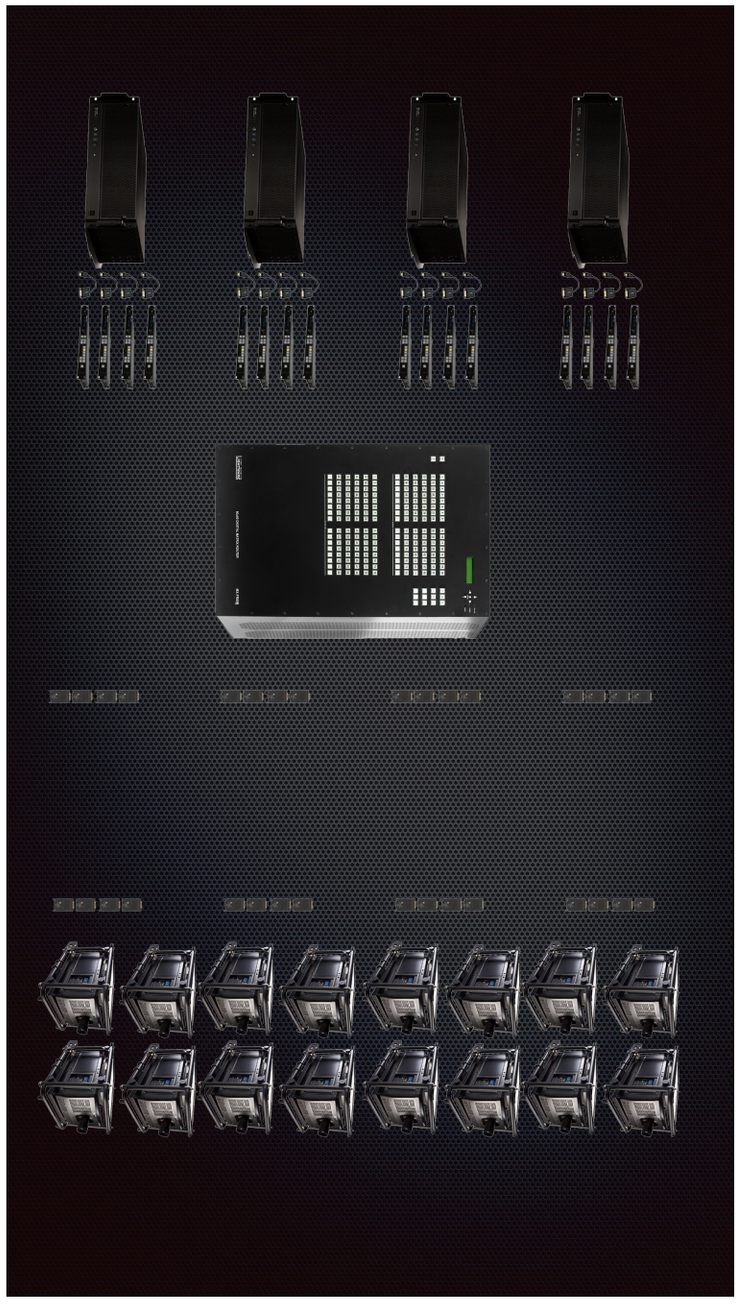
let’s multiply this up a little bit : 4 servers, 16 projectors, a medium sized show

the projectors are miles away from the servers, so we need to get our signals there:
we use fiber transmission.



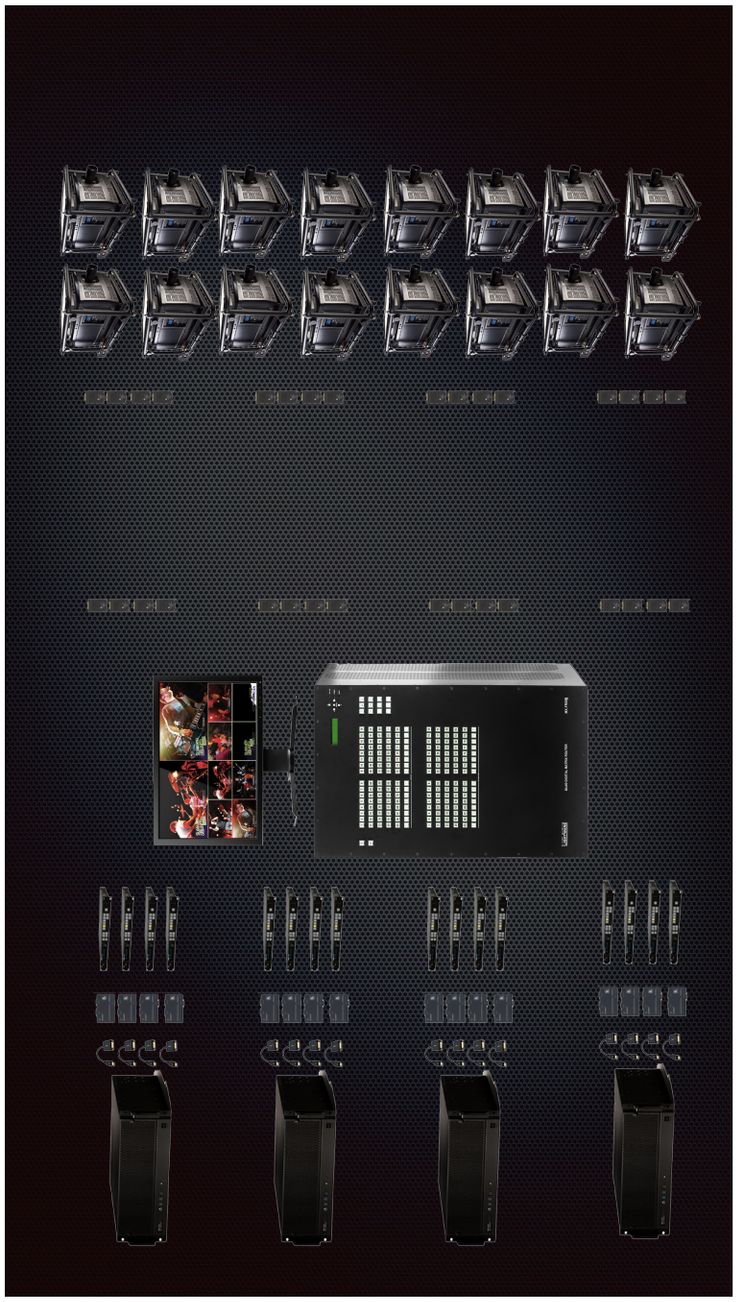
For some reason, when people make shows for television, they specify broadcast signal standards:
SDI (Serial Digital Interface), a ‘video’ protocol... so we have to convert

“the show must go on” - if a machine goes down, we have to cope. So we use crossbar matrix devices.
This one is an 80x80 DVI matrix made by Lightware, cost $x0000.



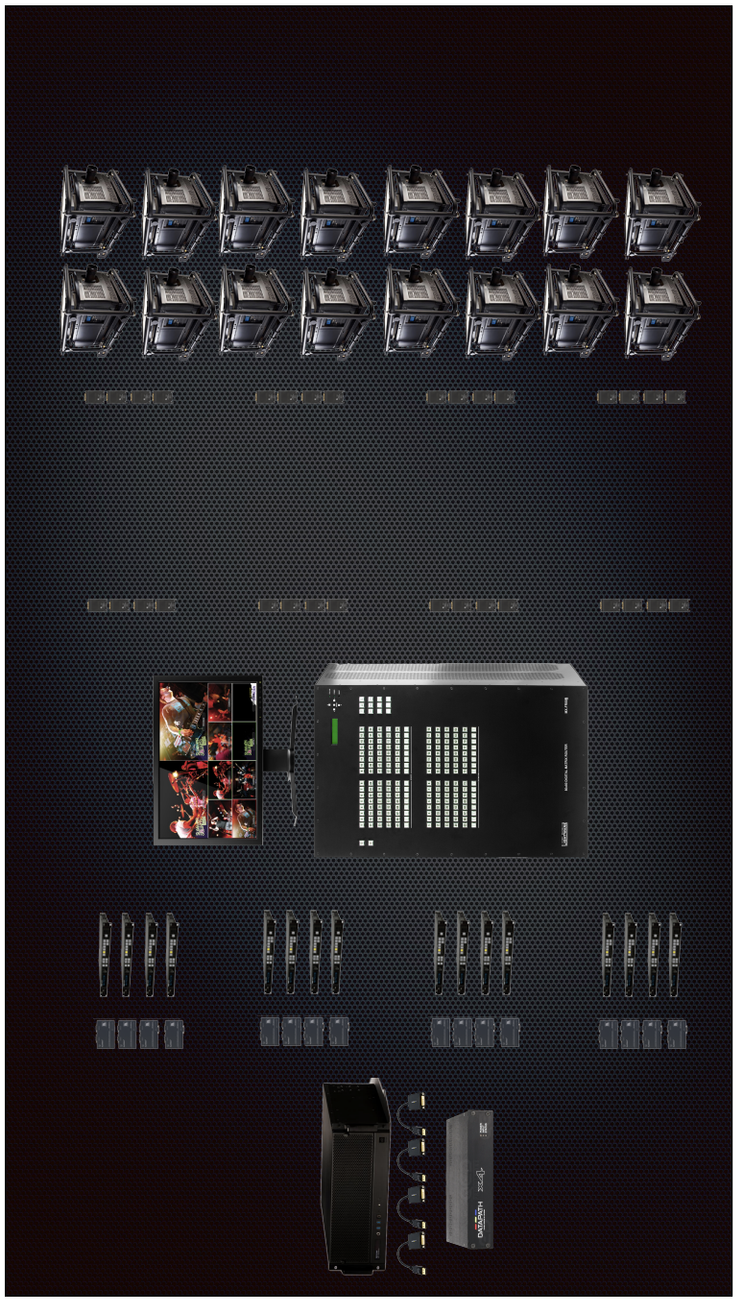
Need to see what the actual outputs of each machine are doing; so we need a multiview.

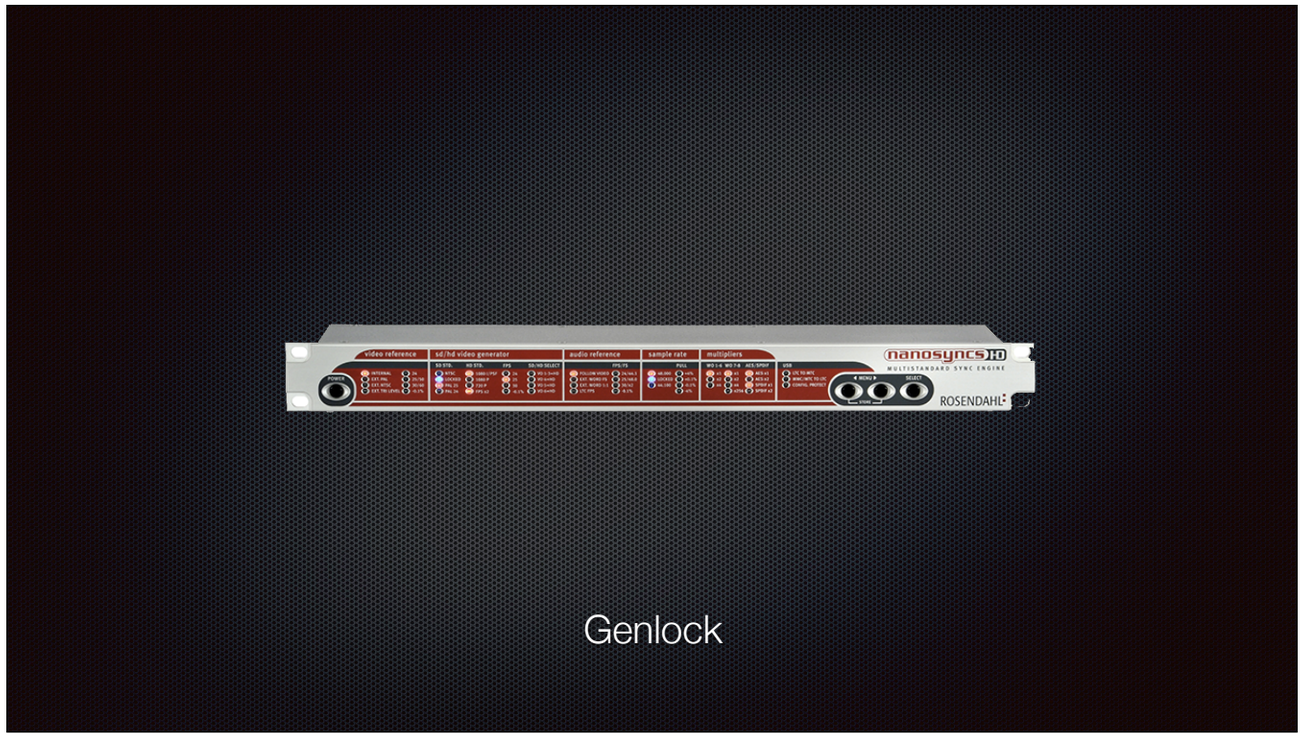
and to get the signals in, we need to duplicate each output, so we need a DVI distribution amp (DA)



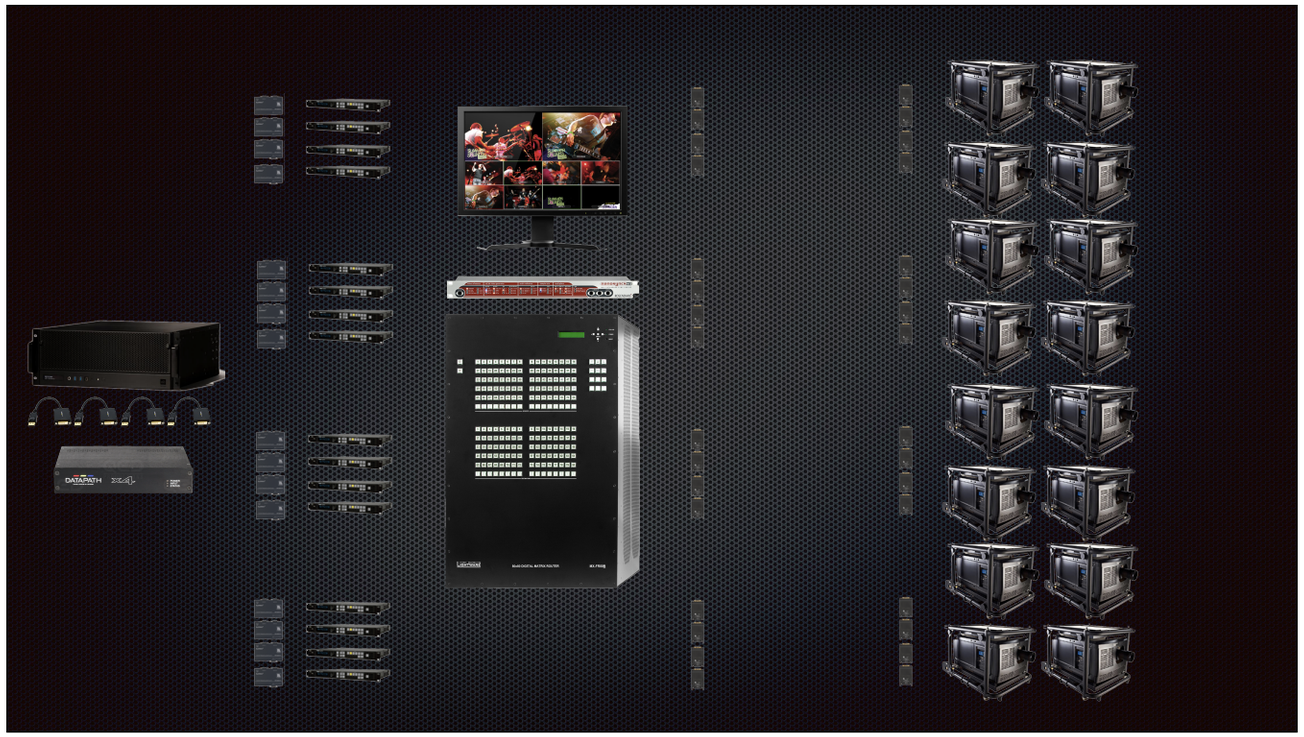
Four-way DVI splitter

Then these guys came out and realised that you can fit four 1280x720 feeds into a single 2560x1440.
so you need four times less servers (at the cost of another two frames of latency).
Thanks, DataPath.





then of course you have to genlock all signals together, and it helps if you sync to your television cameras,
so you need a nanosync to make sure we get a good genlock signal



et voila - a 16-projector show driven off one server.

and here’s one we made earlier. whole thing gets built in a week and torn down after the show.
the guys who build and maintain these systems are insane.

Superbowl 2015

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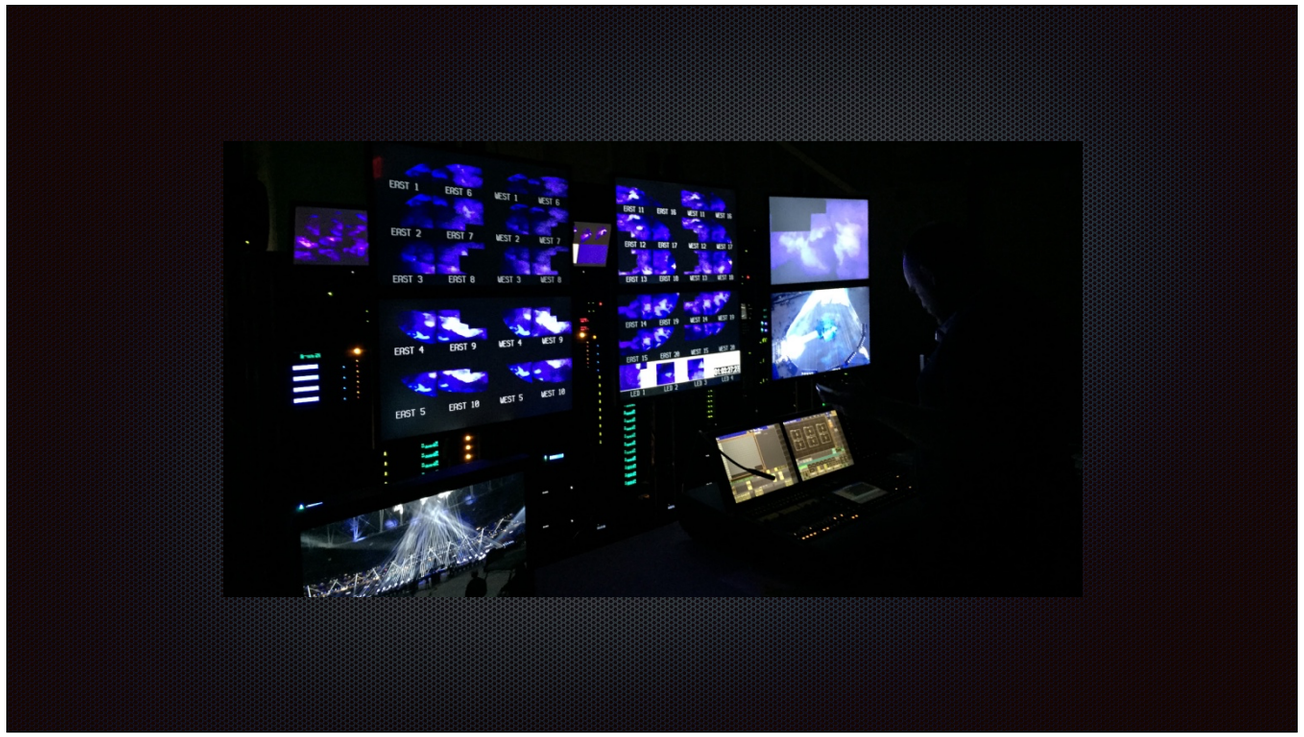
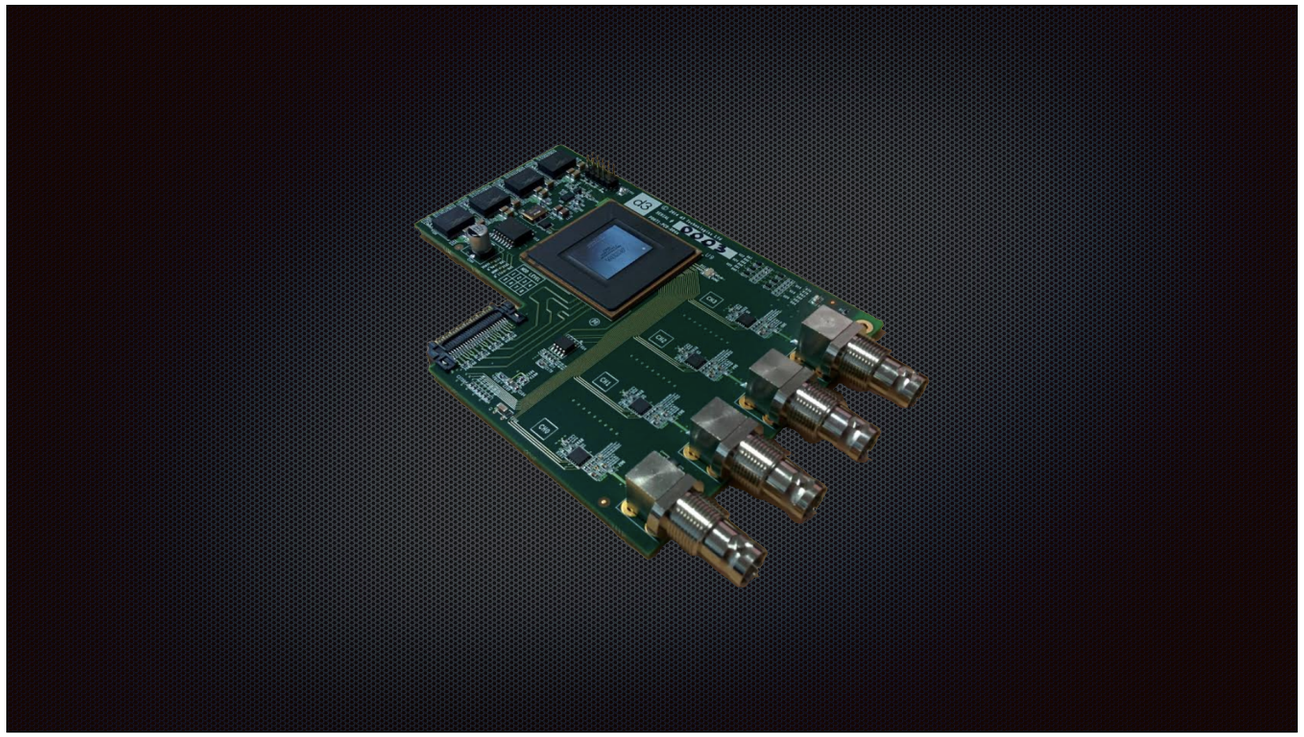


the view from the cockpit

Superbowl 2015

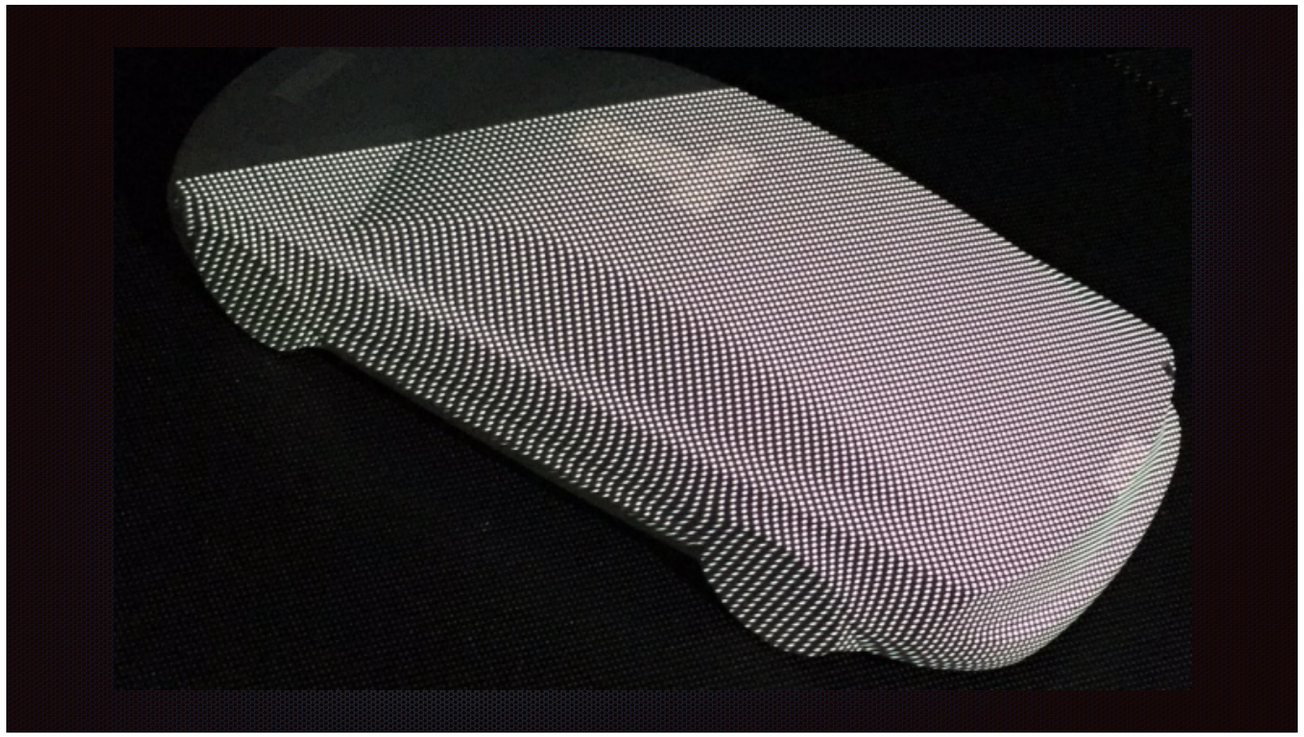
the view from the cockpit

2. Where we’re going

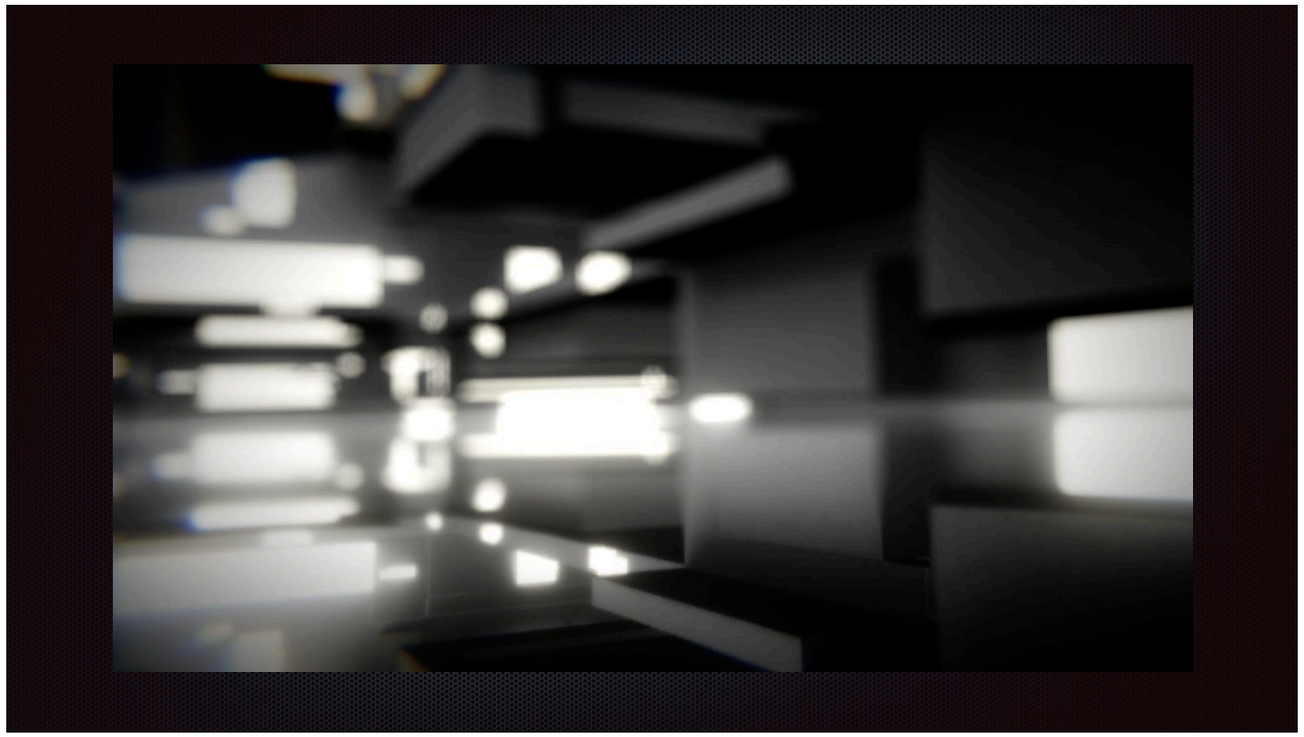


trying to get more and more outputs out of one machine, to reduce the size of the rack
downstream FPGAs split a 4K output into quad HD outputs, and convert to SDI with zero latency
reducing the complexity of the system

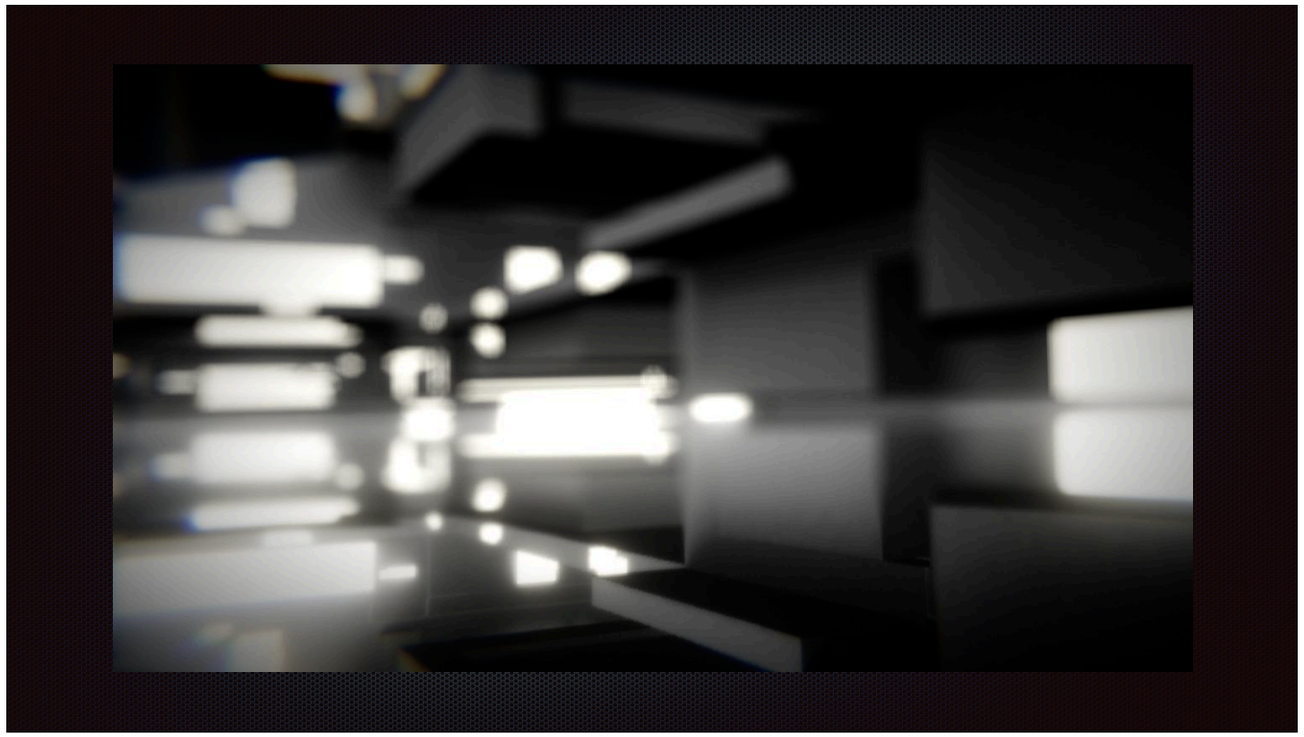
the first rack we built with the new output cards - 16 DVI outputs per machine
(but only a single GPU per machine) - this is 100 physical outputs



using networks of low-cost, easy-to-use iPhones coupled with structured pattern emission,
capture point clouds of objects to conform meshes to, and derive precise projector poses.
handle lighting changes, people moving through the scene, etc.



generative content = ‘video’ files that contain executables, shaders, etc, and generate their output live
(can be rendered on coprocessor GPUs and DMAd to the main GPU)



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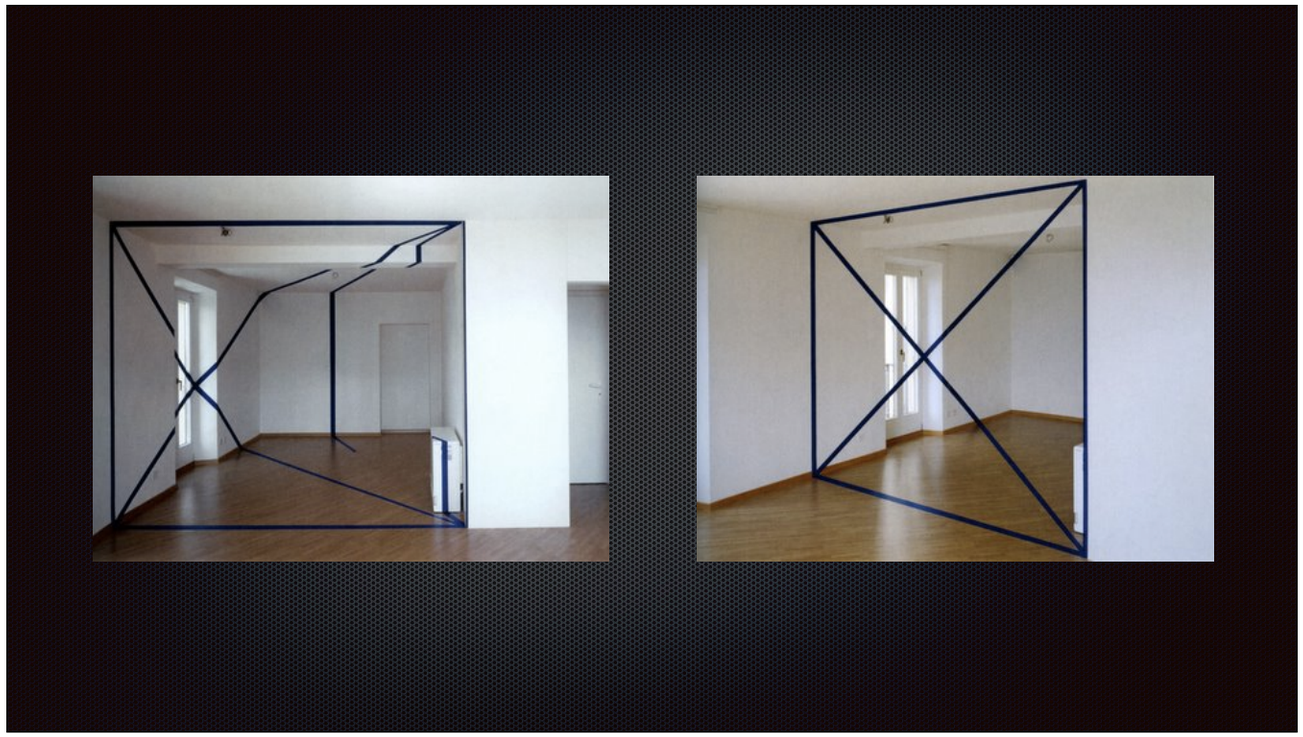
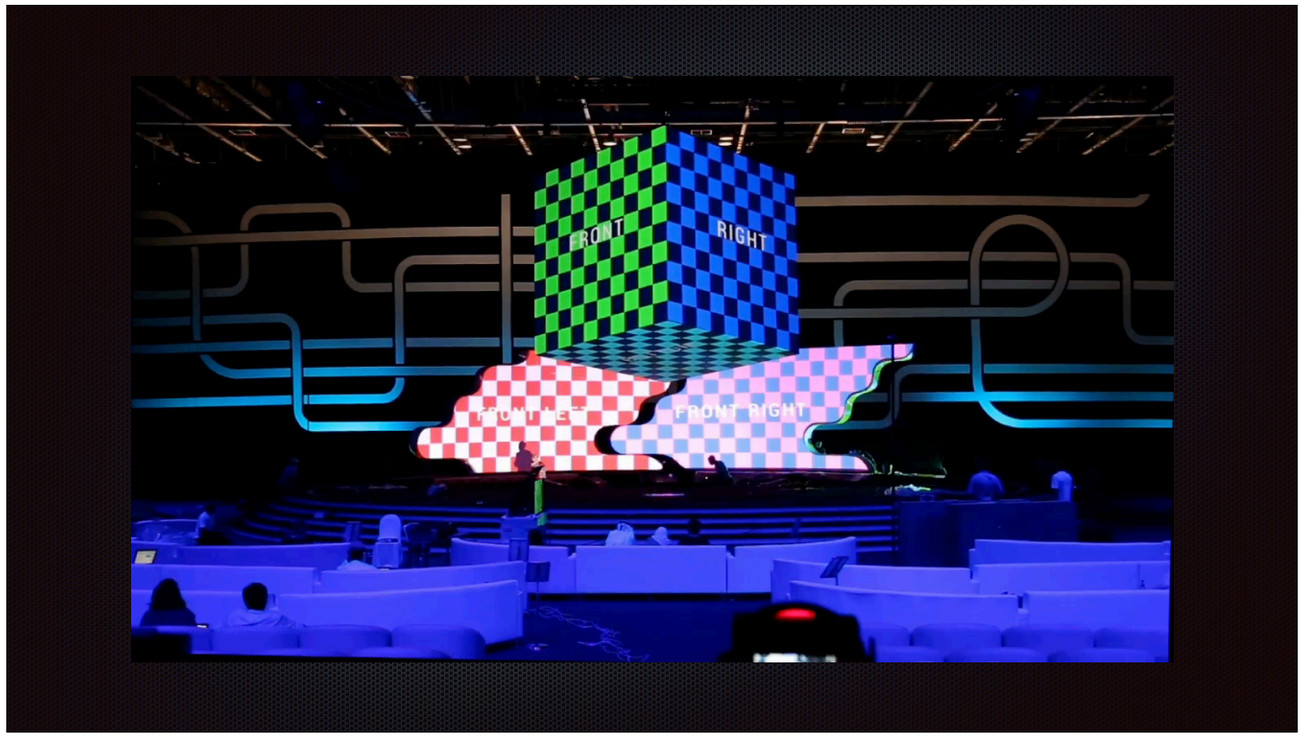
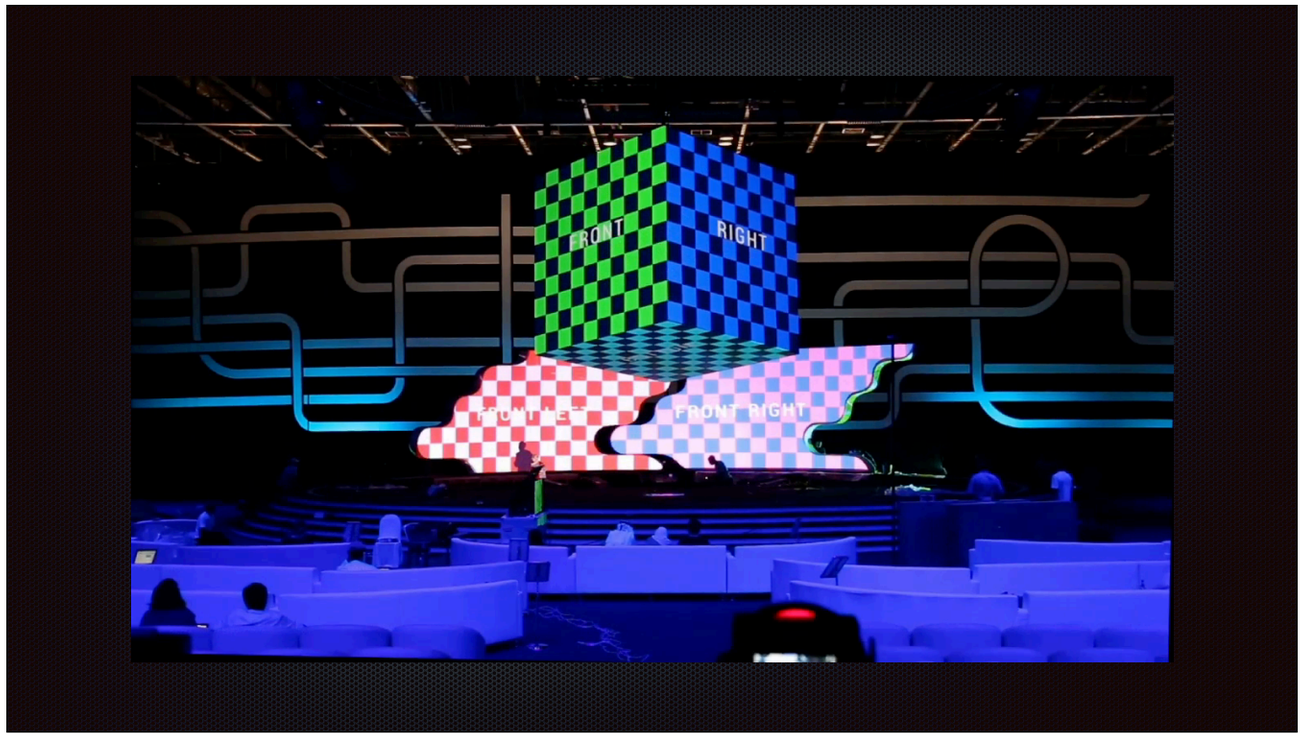


coupled with camera position feedback, create live ‘in camera’ effects that look properly 3D
{ placeholder for video }



moving objects / dynamic blending



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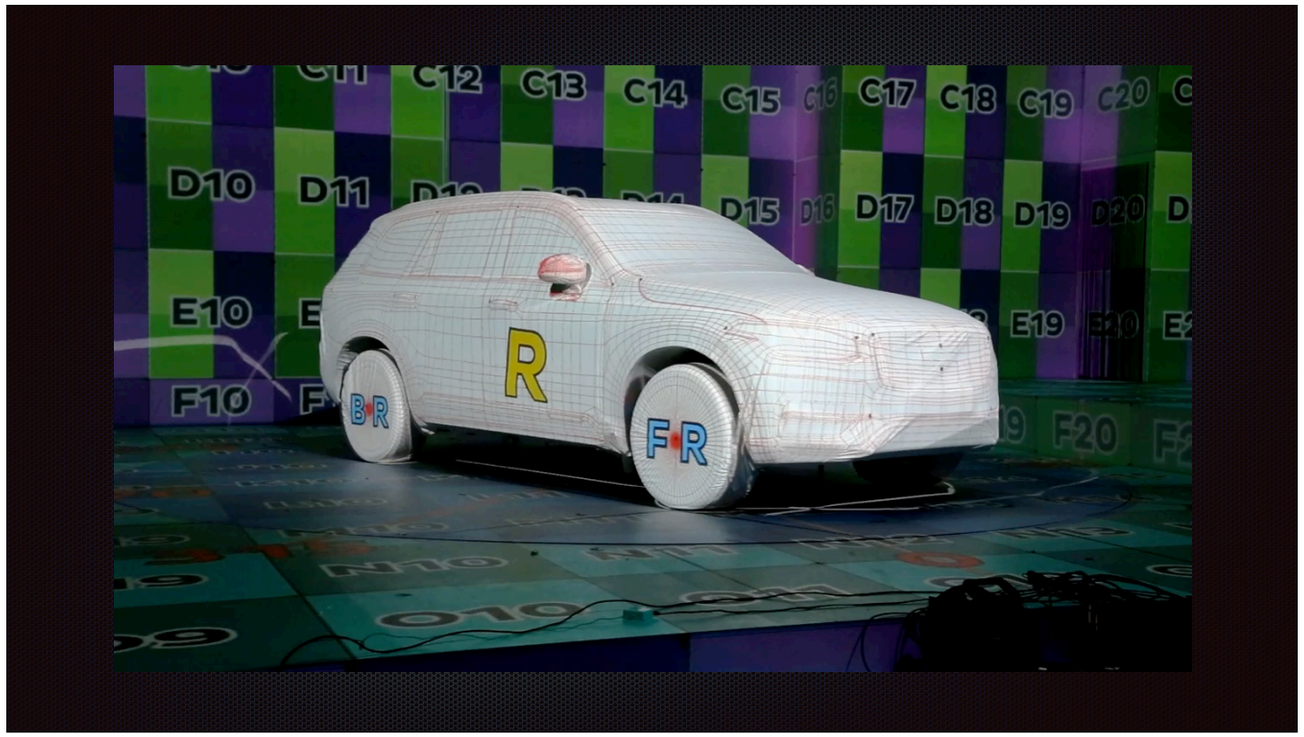
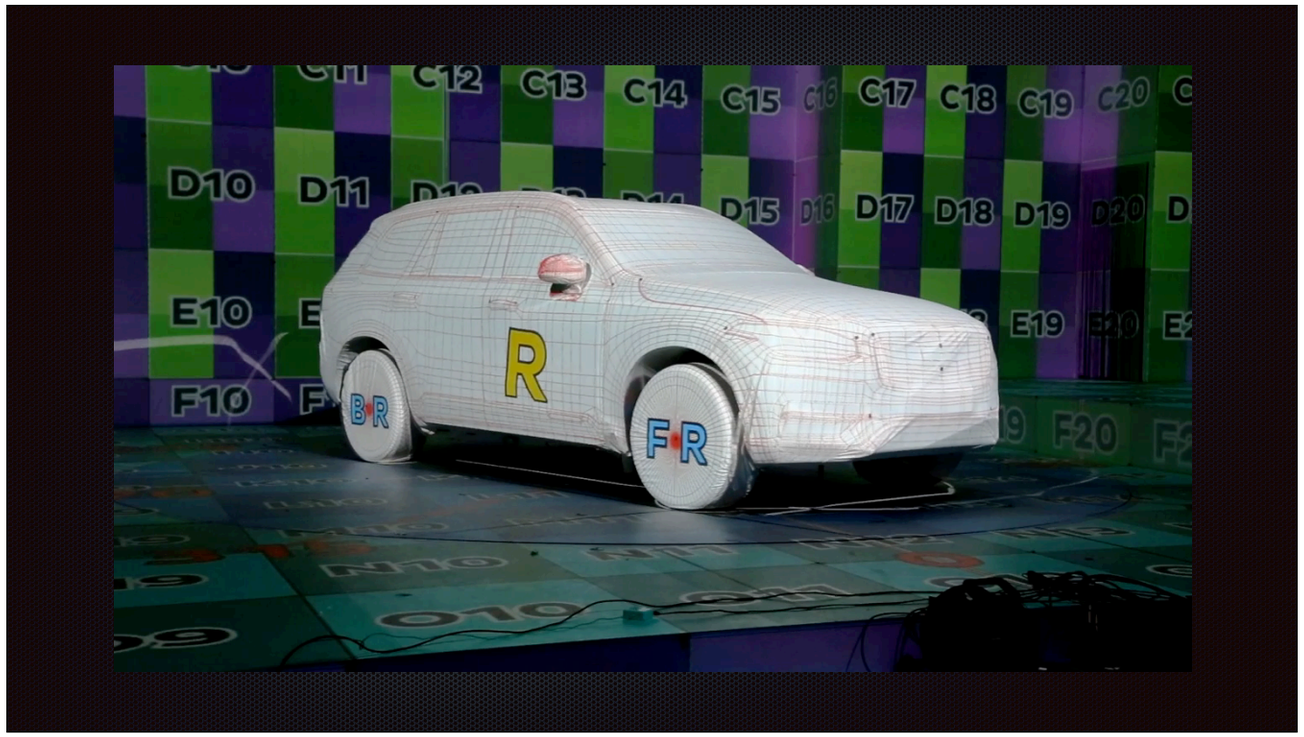


and we’re starting to be able to do this with moving objects and moving projectors.
(video)



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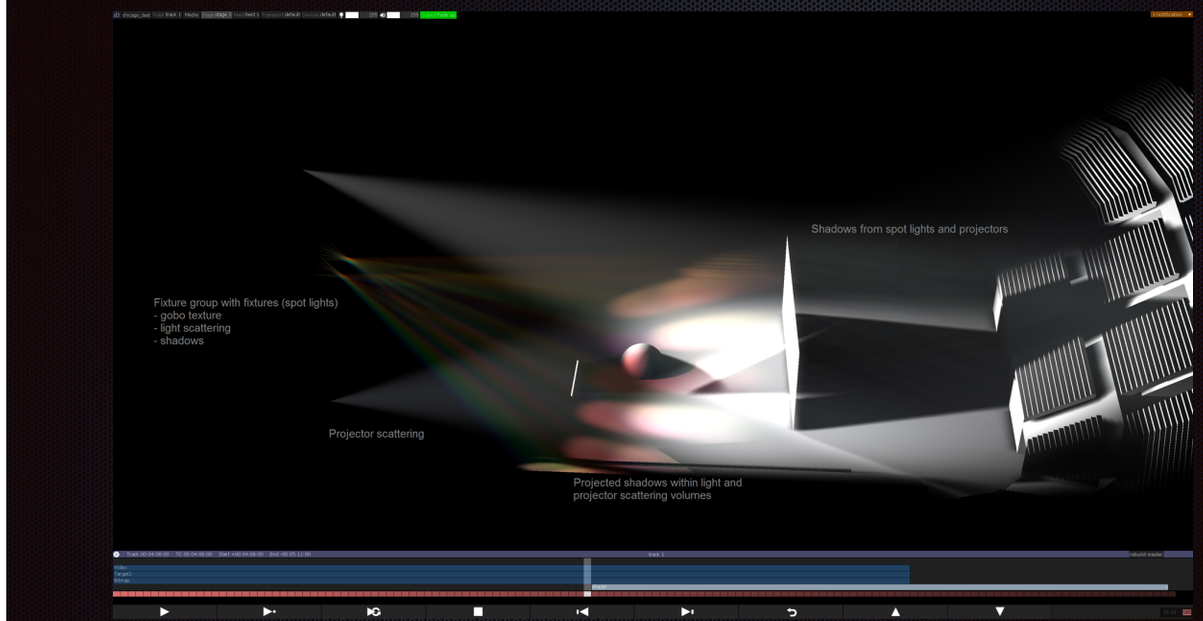
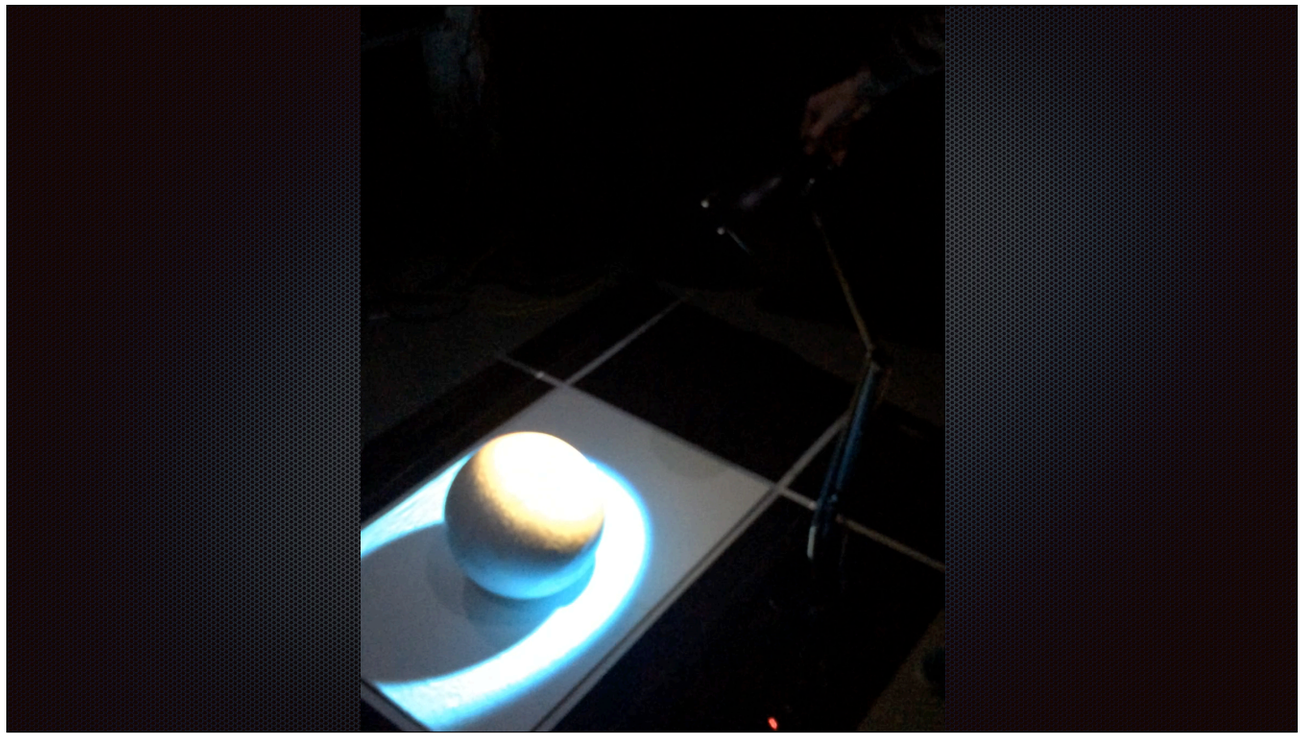
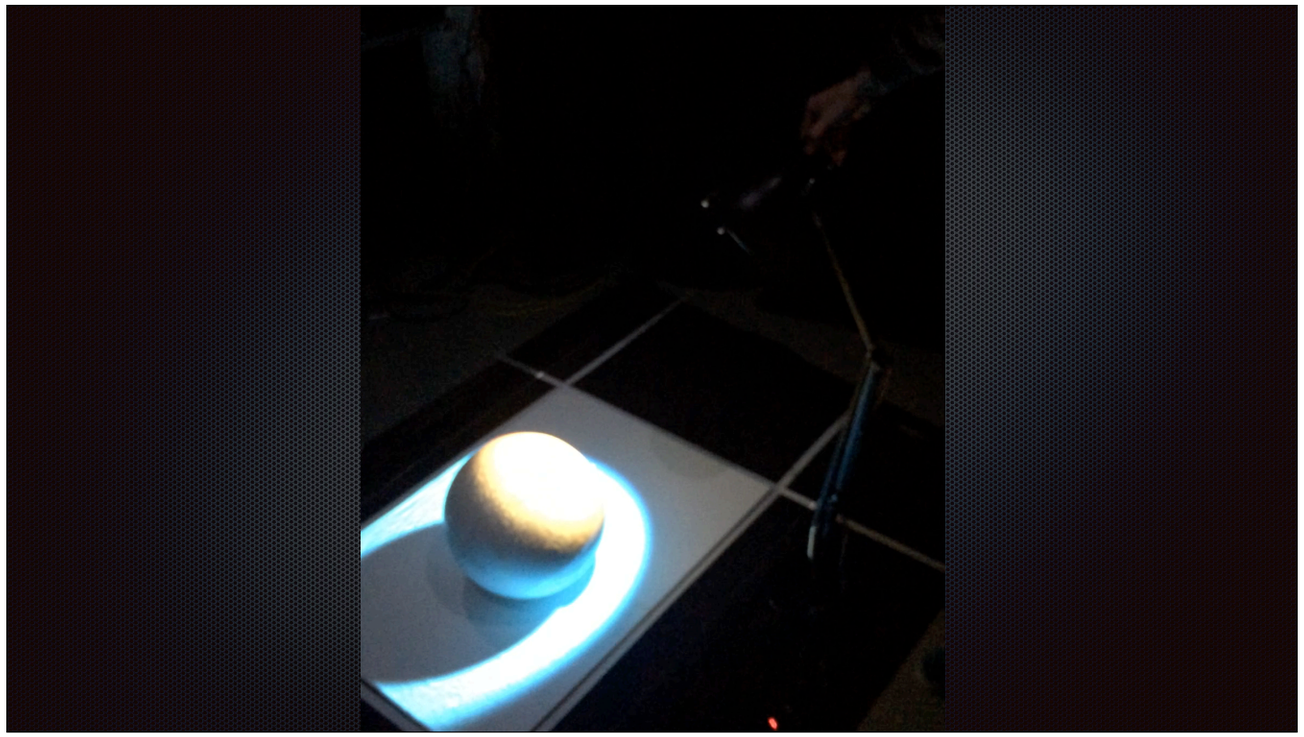


better visualisation of lighting and projection



using infrared-emitting marker LEDs and IR tracking cameras, triangulate the positions of objects in real time, and project content onto them; also from moving projectors.
{ placeholder for video }



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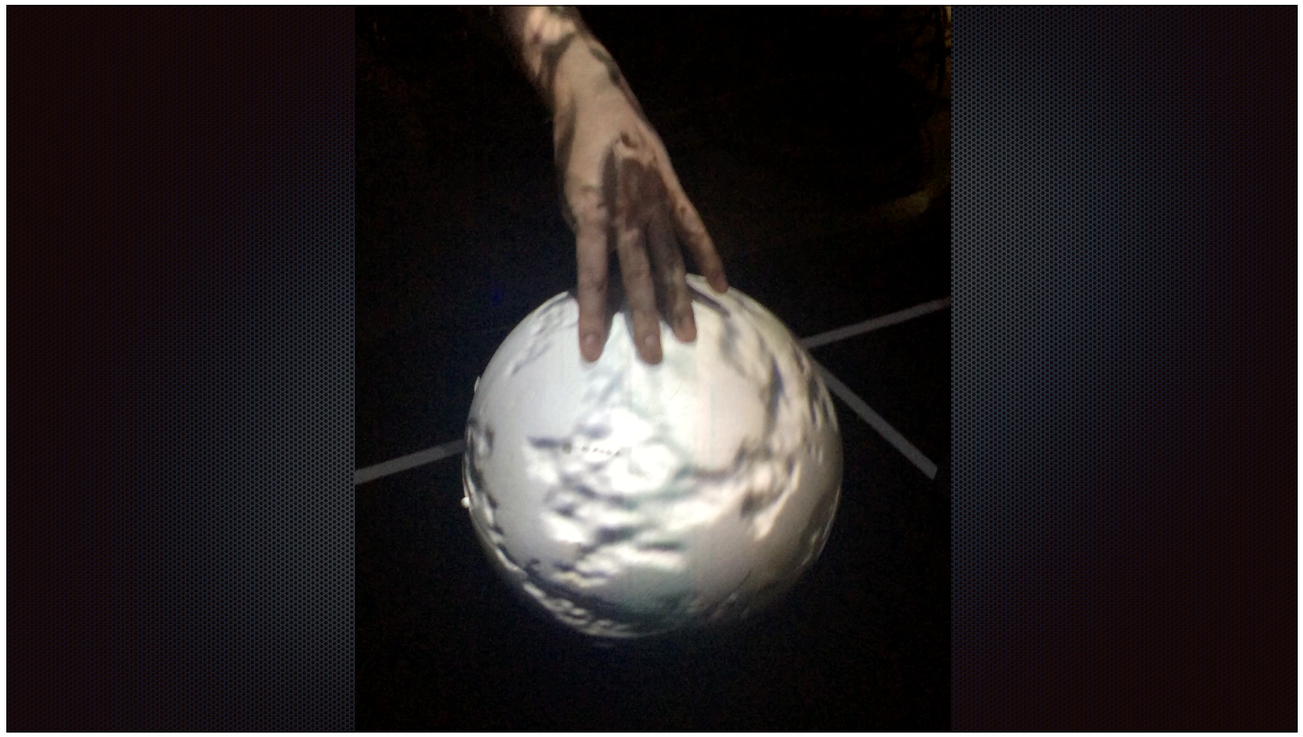

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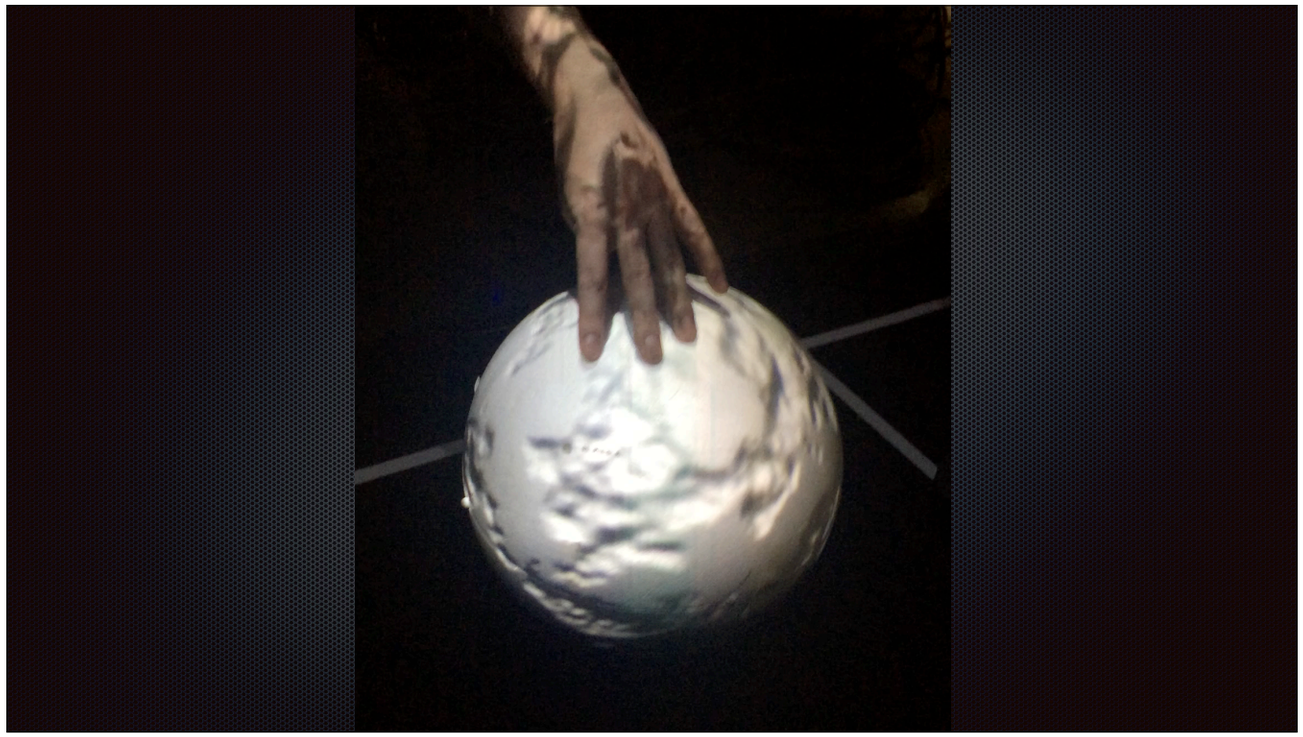
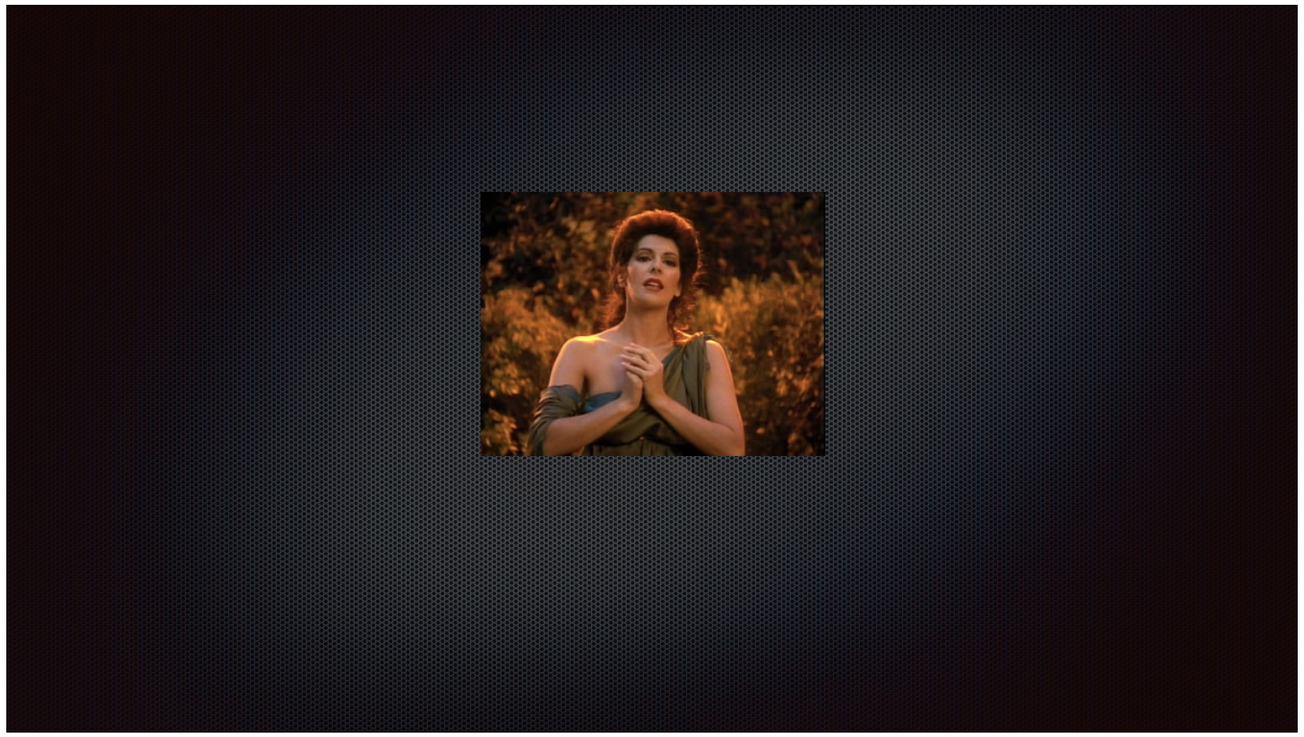


using infrared-emitting marker LEDs and IR tracking cameras, triangulate the positions of objects in real time, and project content onto them; also from moving projectors.
{ placeholder for video }

ultimately, would be nice to be able to capture without invasive markers;
i.e. reproject different ‘skins’ onto people / faces – research projects exist { video }
completely re-light scenes in real time, in camera

so where is this all leading ?

so what happens if we increase the numbers of everything ...



so where does this all tend towards ? ...

“the holodeck”

so where does this all tend towards ? ...

3. What we'll need

GPU limitations 2015

GPU limitations 2015

- number of outputs 4-6

GPU limitations 2015

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- canvas size 16K pixels

GPU limitations 2015

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- canvas size 16K pixels
- upload / decode bandwidth 8x 4K

GPU limitations 2015

• number of outputs	4-6
• canvas size	16K pixels
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• latency	48 msec

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• fault tolerance	no
• monitored	no

GPU without limitations

GPU without limitations

- number of outputs 200+

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- canvas size 128K pixels

GPU without limitations

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- upload / decode bandwidth 800x 4K

GPU without limitations

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- upload / decode bandwidth 800x 4K
- latency 4ms

GPU without limitations

• number of outputs	200+
• canvas size	128K pixels
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• latency	4ms
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• modularity	1x

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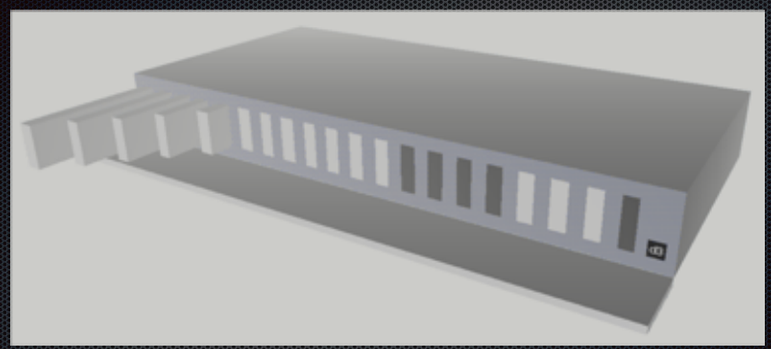

“switchblade”

idea of a modular GPU – you slot in as many units as you need outputs (perfect modularity)

“switchblade” concept

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- modular microcluster architecture

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- slot-in ‘blades’ carrying SSD, CPU, GPU and FPGA

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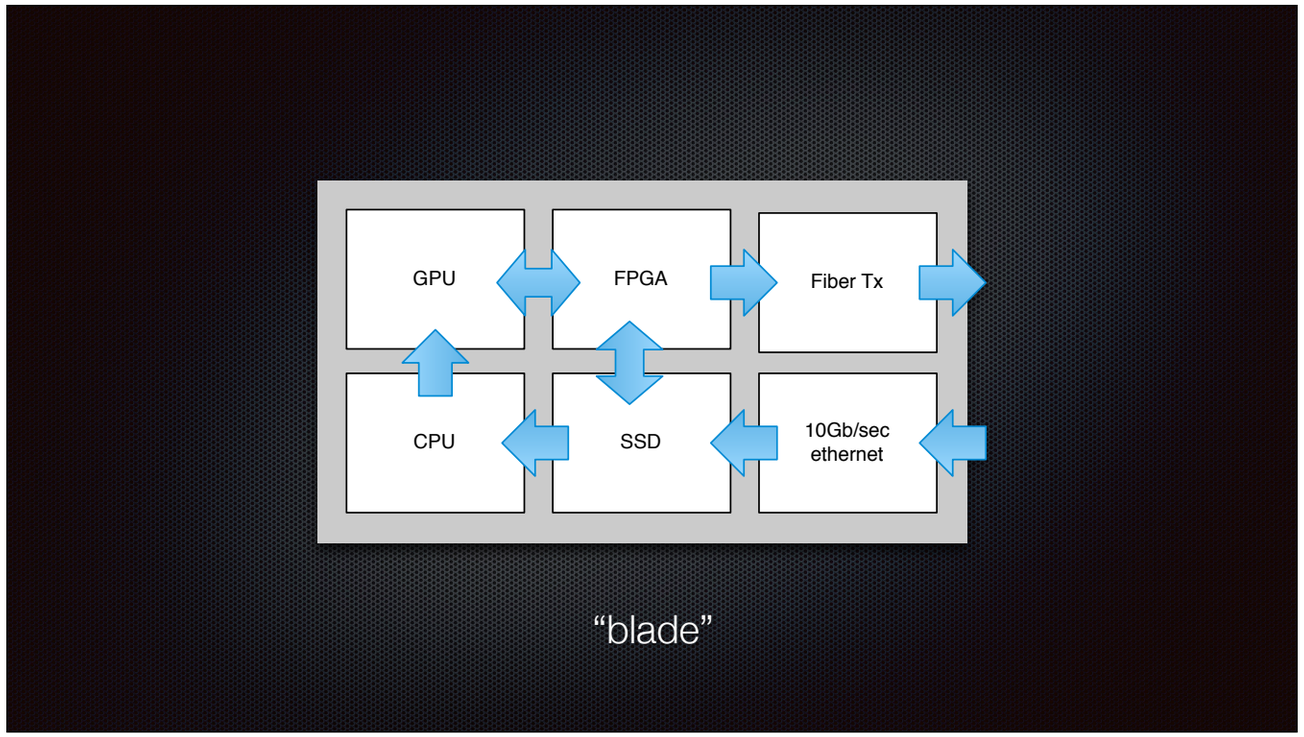
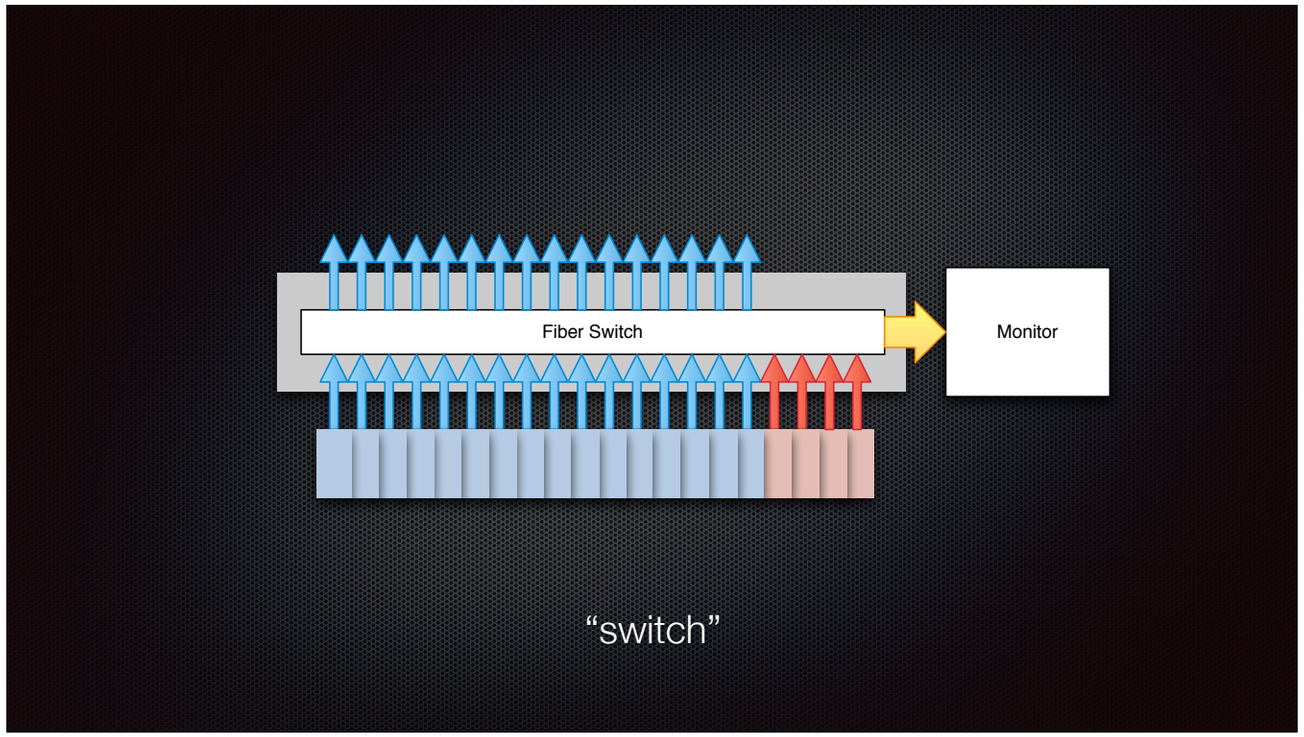
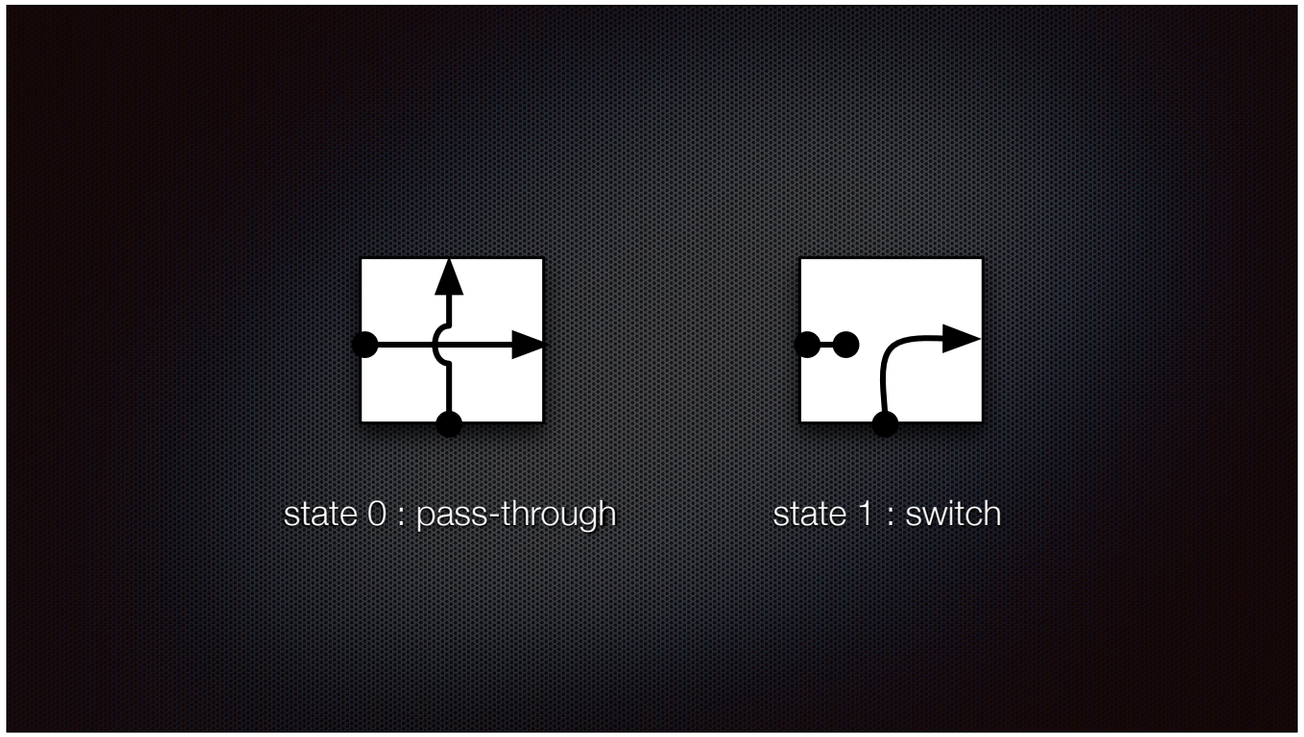
- tile-based texture management architecture
- ‘net GPU’ programming model (eg. Chromium)



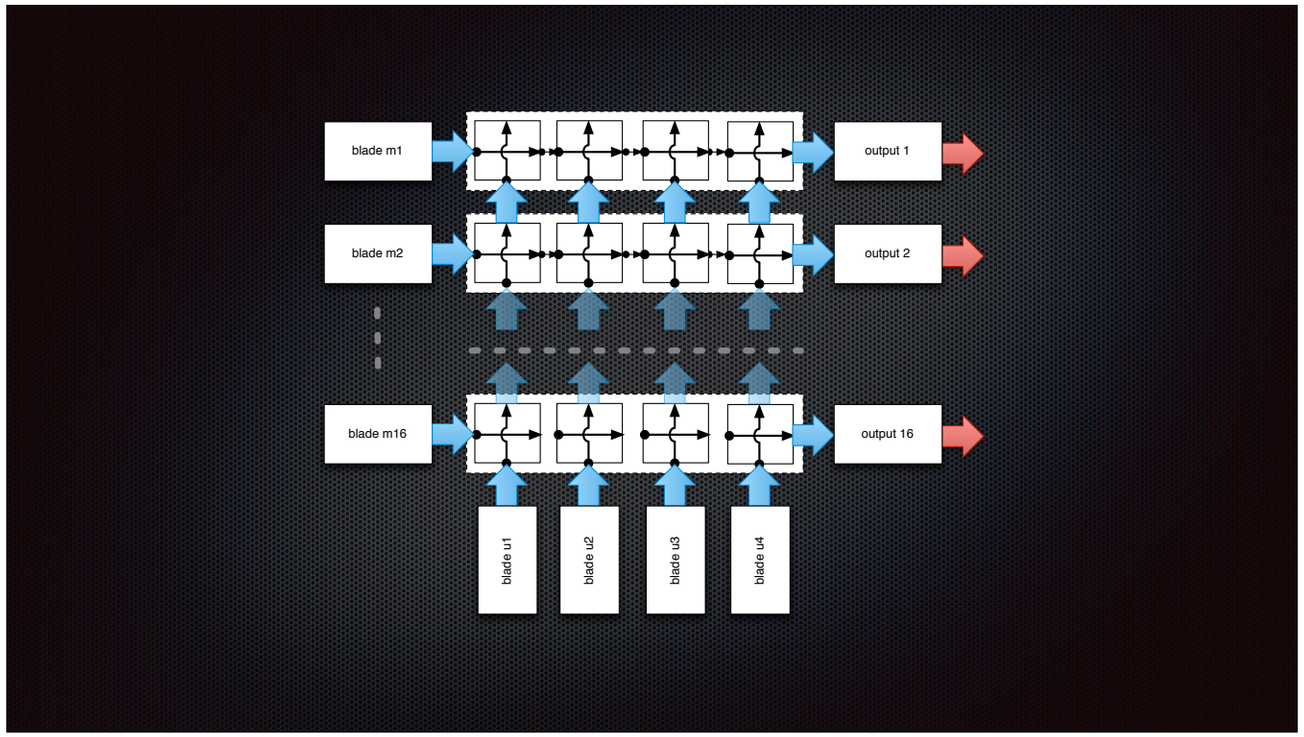
blade concept. have to be able to genlock over ethernet... about the size of an iphone.



switch is much simpler than a full crossbar, as it only has to switch each output to receive from the corresponding input, or one of the understudies. As a bonus, generates a multiview.

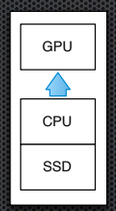


the switch is really super simple; it’s just an Nx4 crossbar



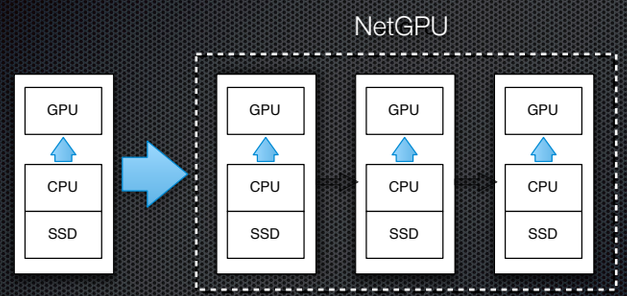
because it either passes through, or substitutes one of the understudies.

Fantasy GPU programming model

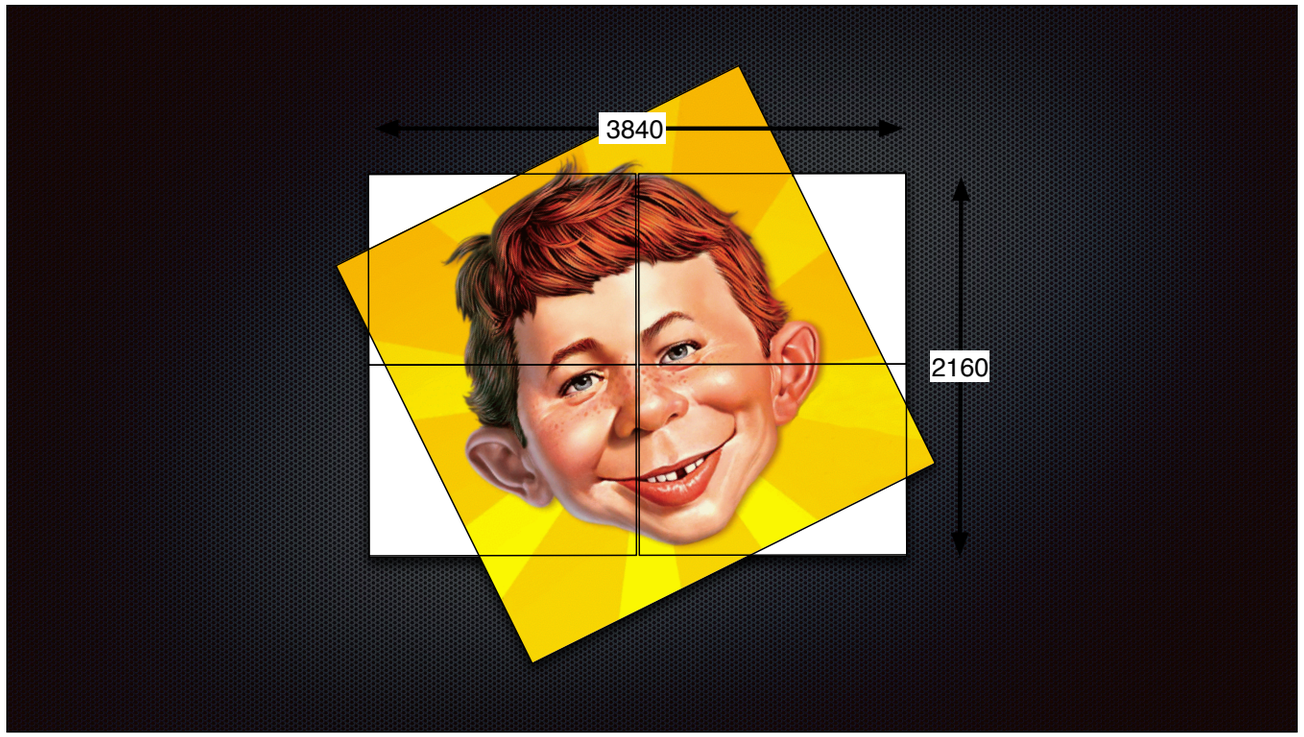


familiar with this model

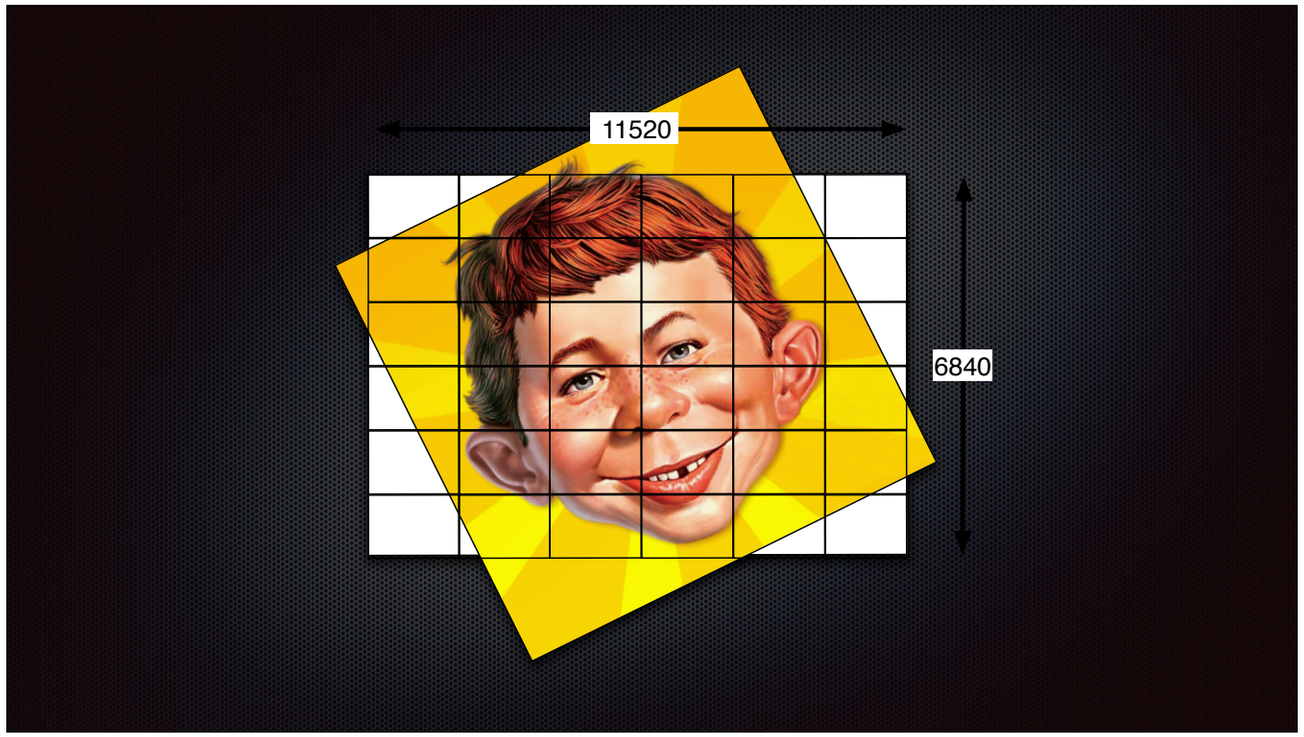
Fantasy GPU programming model



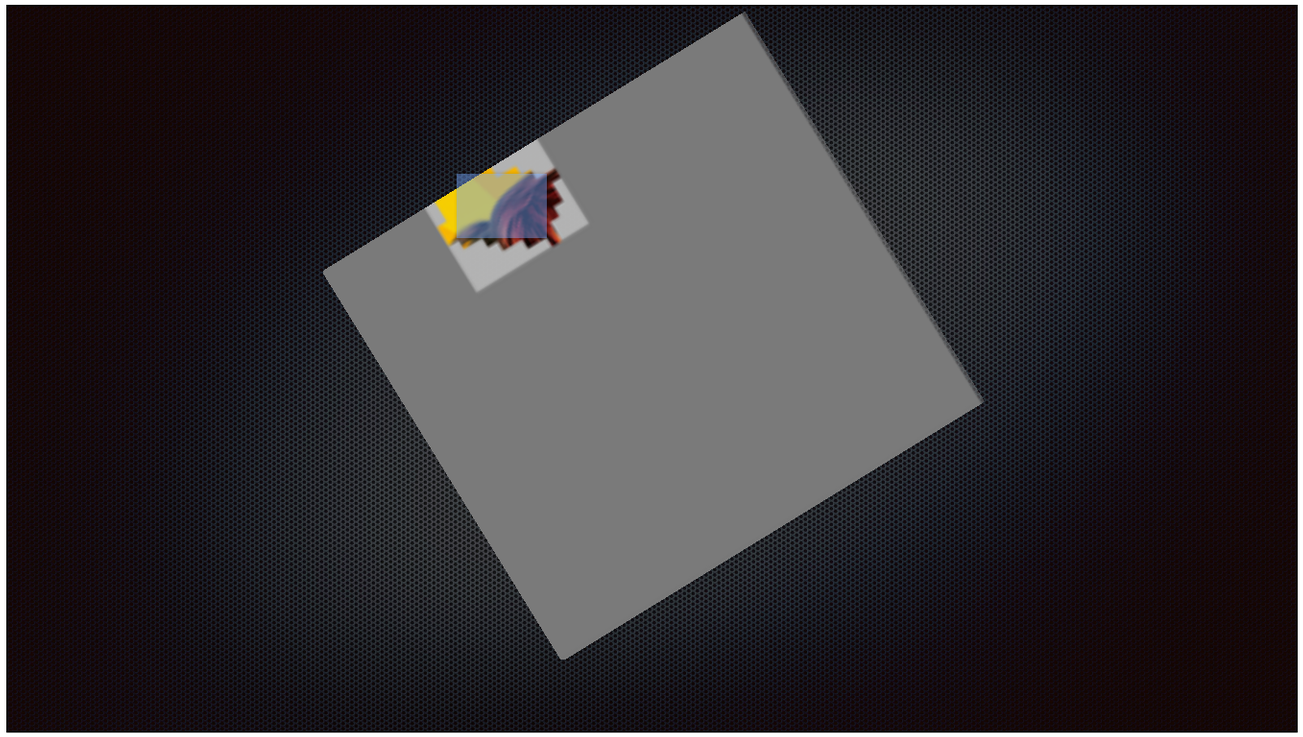
what we really need is this model



task : spinning a single bitmap across four outputs on a single machine : easy



as bitmaps get bigger, becomes less easy. 9 machines, 36 heads.



so let’s split up that texture into tiles, and load only the tiles that we actually need for that output.
but we need something to help us with coverage analysis; and predictively caching tiles across the node SSDs

Fantasy GPU programming model

project chromium, sadly hasn’t been active since 2008. need to embrace and extend it with some new concepts..
partial residency, coverage analysis, GPGPU workloads

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Fantasy GPU programming model

+ ?

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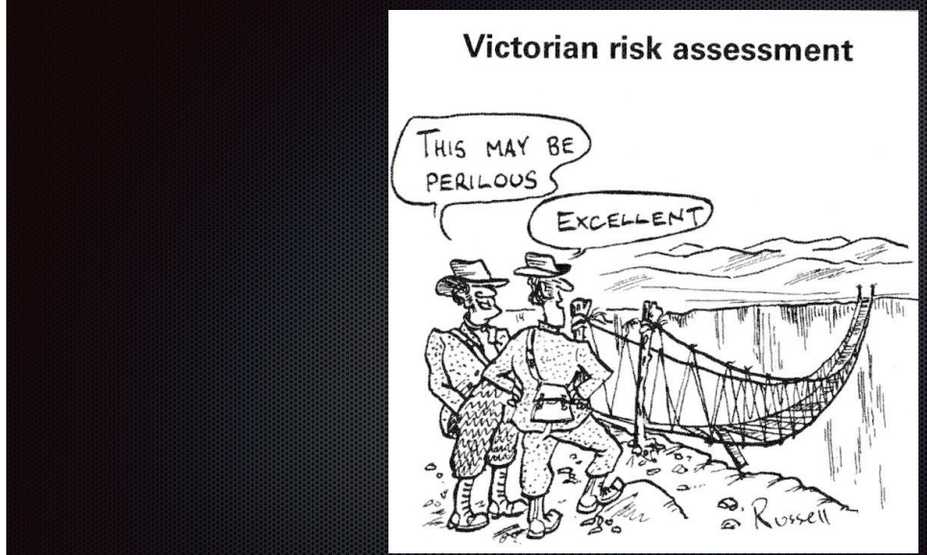

we really want to make this vision a reality, and we want to enlist your help.

thank you

thank you

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