Fluid atmospheres:
Adaptive interplay between natural and artificial light projection

by
Dan Li

B.A. at China Central Academy of Fine Arts, 2012

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Signature of Author: Signature redacted
Department of Architecture
January 14, 2016

Certified by: Signature redacted
Takehiko Nagakura, MArch, PhD
Associate Professor of Design and Computation
Thesis Supervisor

Accepted by: Signature redacted
Takehiko Nagakura, MArch, PhD
Chair of the Department Committee on Graduate Students

Thesis Committee

Takehiko Nagakura, MArch, PhD
Associate Professor of Design and Computation

Azra Aksamija, MArch
Class of 1922 Career Development Professor
Assistant Professor of Art, Culture and Technology

Skylar Tibbits, SMArchS
Research Scientist of Architecture

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Adaptive interplay between natural and artificial light projection

By
Dan Li
Submitted to the Department of Architecture on January 14, 2016
in partial fulfillment of the requirements for the degree of

Master of Architecture

ABSTRACT

Imagine. This is the same daily route you travel and the same space you pass through. And it is not. How do we create an adaptive and customized space with no materials at all? Can the generic be customized and specific at the same time? Given extra layers of "light", a compose-able architecture is yet to come. A building is a living, breathing space that is ever moving and rapidly morphing - its animus is time.

Take a closer look at the surfaces that enclose our space: there are screens with news, lectures, movie clips; there are windows, shadows and shade created by lights of all different kinds; there are colors and ornamentations that inform us of the history of our architectural lineage. Sunlight naturally creates an evolving atmosphere with the change in time and the seasons; now, with new technologies, we can create even more dynamic atmospheres with light that engage and collaborate with the sun.

Light exists in two forms: natural light and artificial light created from technology. Sunlight creates our everyday perception of the physical world, and thus, our ability to understand and live in the space around us. Nevertheless, "digital light" is becoming a larger and larger part of our lives, as we perceive and create information through the medium of a screen. However, "digital light" does not always need to be flat -- through projection mapping, we can create a three-dimensional light that leaves the 2D surface of the screen and is responsive to the environment of the physical world. Using this method, our perception of the physical space will not only change due to the passing of the sun, but also from our own agency in creating altered environments through designed projection systems.

This project creates a methodology and a toolkit to design dynamic spaces with natural and projection lighting that allows for customization and alterations of space. Through this system, the static building itself becomes the instrument that is played. This project also demonstrates these tools through investigating projections with light in the atrium of MIT Brain and Cognitive Sciences Complex building.

Thesis Supervisor: **Takehiko Nagakura, MArch, PhD**
Associate Professor of Design and Computation

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The first and deepest appreciation is to my advisor, Takehiko Nagakura, for offering me brilliant guidance and enormous help, from every aspects of the thesis. His enthusiastic attitude and generous heart will have forever influence on me.

I would like to thank Azra Aksamija, for her inspiring points of view on art projects and insightful feedback on my thesis argument;

Skylar Tibbits, who accurately teased out the good points from my chaos explorations and offered me witty comments when I was confusing.

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I appreciate the help from RPL, Cron, Facility, Administration and other departments.

Last but not the least, I want to say thank you to my parents. With their love, I grow up happily. This positive mind is the most important gift that I have received.

Fluid atmospheres:
Adaptive interplay between natural and artificial light projection

Foreword

Considering the development of lighting and projection technology, and the fact that human's dependence on natural light, the ambition of this thesis is to investigate possible workflows/ solutions to create more interactive and subtle interplay between natural and artificial light projection, within the current/ foreseeable level of technology development.

Thus, this thesis hopes to create a set of tools that can be used by different people, a workflow that suits the tools and their users, a catalog that instructs and inspires the users, and a demonstration/ design from the author.

This documentation of my thesis will be organized in five parts. The first part tells the background and general idea of my thesis topic. The second part is a summary of all the experiments that have been done, named as "toolbox". From this toolbox, the user can see the possibilities and potentials of using projection lights as a way to enrich the spatial experience in a space that has natural lights. The third part is the demonstration in a scaled model of the atrium of MIT Brain and Cognitive Sciences Complex building. This demonstration is presented as a spatial art project. The fourth part records the progress of creating this demonstration. The last part concludes what have been learned and forecasts the possible future of this tool.

There are three threads that will be followed along this thesis:

artistic: The first one is searching more subtle and engaging interplay between natural and artificial light projection.Where can we find new opportunities for a new spatial experience/narrative?

Along this line, the experiments and inspirations are the keys for seeking the "accidents", the "unknown".

technical: The second one tackles the "supply chain" from an artistic idea to the reality, which called "service design" in this thesis. It discusses the technical challenges, trouble shooting methods and logistics on the way to achieve the design goal.

How do we make better use of projection technology, along with the power of "internet of things", to achieve a new spatial experience? What will the workflow be? What are the current products? How to link these products efficiently? The transition from art/imagination to tech/realization will be examined with a very specific case in this thesis.

social: In addition, the social application and impact that is derivative from this "tookit" and the design demostration will also be discussed.

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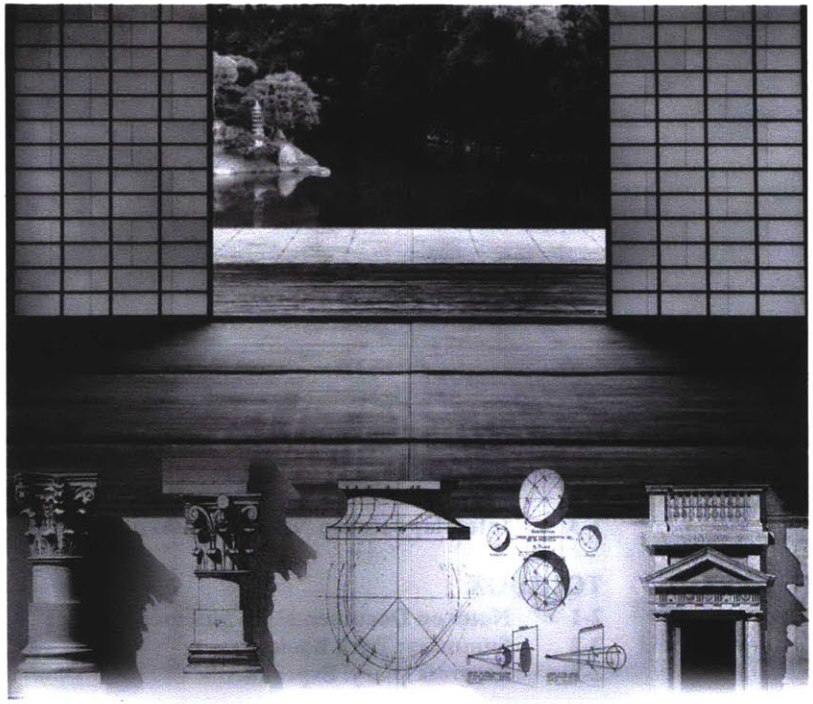
CHAPTER 1

CONTEXT OF THE TOPIC



FLUID ATMOSPHERES

Adaptive Interplay Between
Natural and Artificial Light Projection

CHAPTER 1

CONTEXT OF THE TOPIC

1-1 Precedents

1-1-1 Architectural Surfaces and Spatial Experiences
1-1-2 Shades and Shadows: Spatial Experiences Made from Natural Lights
1-1-3 Spatial Arts Made from Artificial Lights

1-2 Current Artificial Light Projection

1-2-1 Lights and Artificial Light Projection
1-2-2 Projectors
1-2-3 Projection Mapping Software Platforms
1-2-4 Projection Mapping Projects

1-3 Interplay between Natural and Artificial Lights

CHAPTER 1 CONTEXT OF THE TOPIC

1-1 Precedents

1-1-1 Architectural Surfaces and Spatial Experiences
1-1-2 Shades and Shadows: Spatial Experiences Made from Natural Lights
1-1-3 Spatial Arts Made from Artificial Lights

" Light enables us to see the world around us. It provides the means by which our sense of sight gleans the most direct information about the physical arrangement of the world and how it is changing. Indeed, the capacity of light to carry and convey information is perhaps its most important, and remarkable, characteristic."

Walmsley, I. (2015). Light: A very short introduction. Oxford University Press. P.1

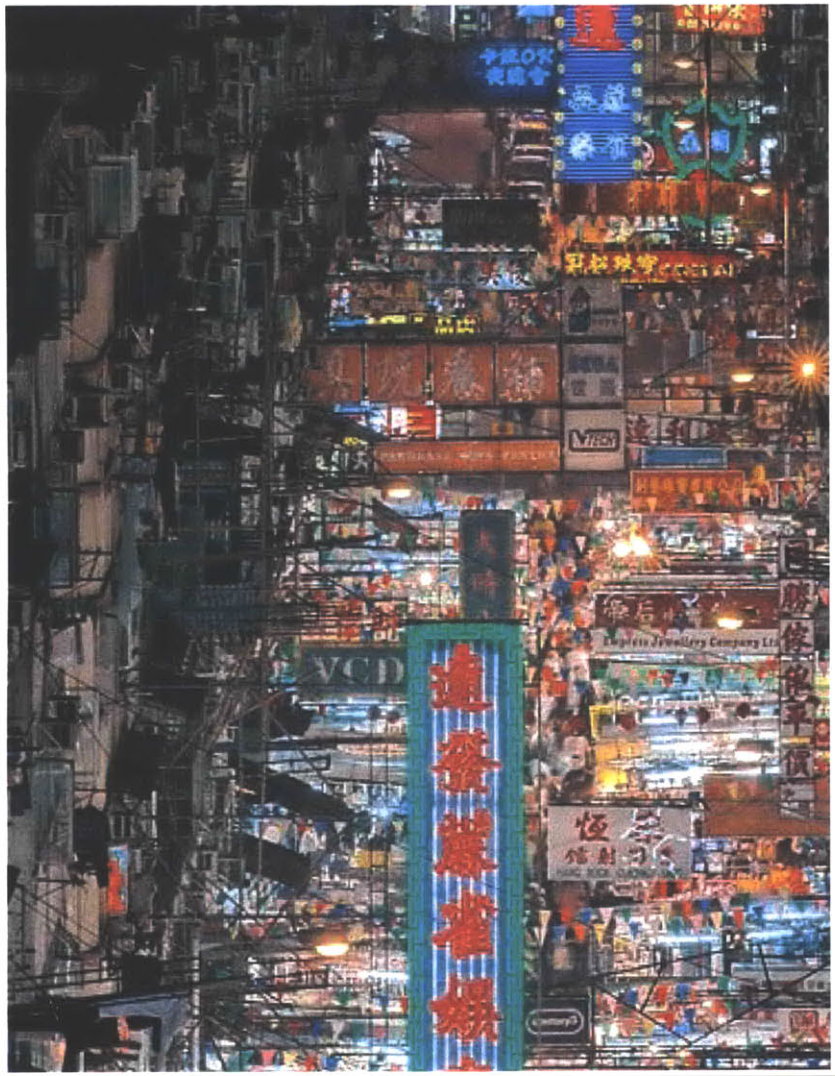
What we have perceived and remembered visually are under the premise of light. Aimed for creating more dynamic spatial experience, this thesis researches the precedents in order to understand different approaches of making the spaces.

In the first place, architectural surface has been discussed from many different viewpoints. With keywords, the first part of this chapter tries to collect and curate the historical materials of architectural surfaces among those discussions. The main purpose of this "curation" is to claim the important influence that architectural surfaces have on the spatial atmosphere and narrative.

The second part of this chapter seeks the interplay between objects and sunlight. Shades and shadows are the key information for our perception of three-dimensionality. Sculptures and the decorations on architectural elements have shown to us brilliant ideas of using sunlight to compose pleasant visual effect.

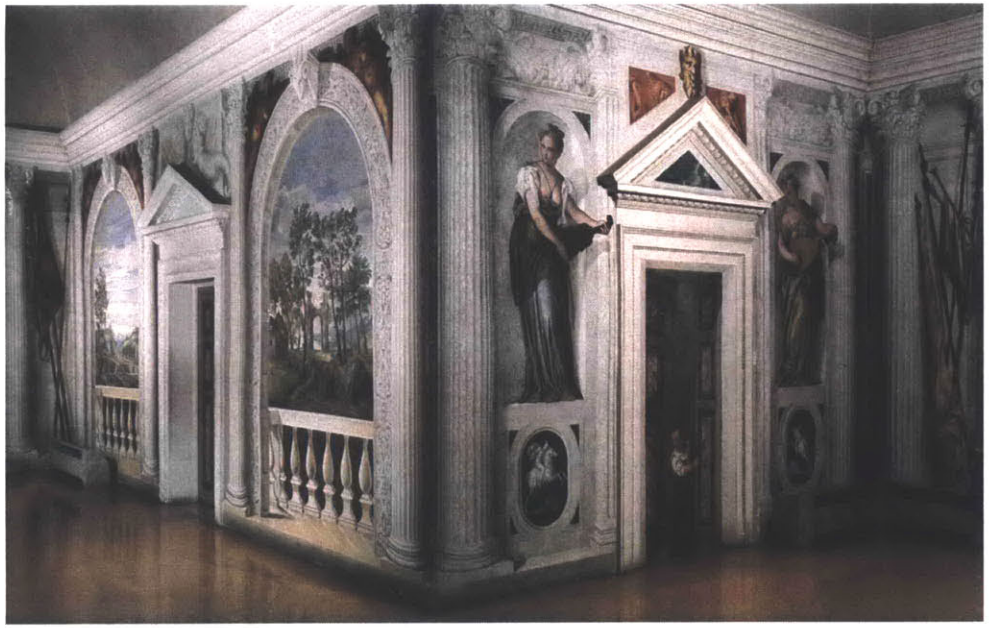
The third part looked through some examples of art projects. With the development of technology, the using of artificial lights in arts, especially those interacts people in spaces, i.e., atmospherically, become more and more popular.

CAPITALIZED ARCHITECTURAL SURFACES



Left: Temple Street is a street located in the areas of Jordan and Yau Ma Tei in Kowloon, Hong Kong. It is known for its night market and one of the busiest flea markets at night in the territory.

Above: The billboards in Times Square, NY.

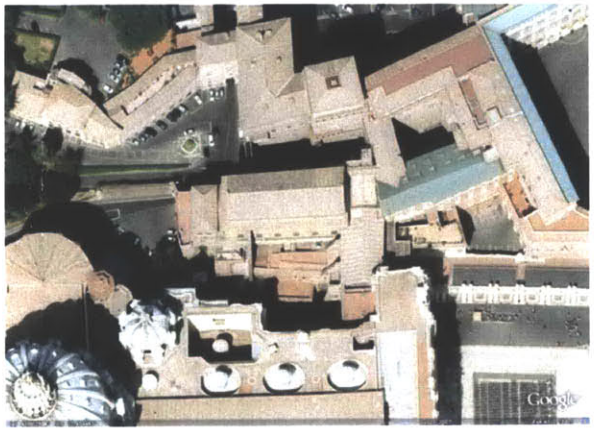


At the Villa Barbaro, the solid walls transform into a loggia, a painted representation drawing the natural surroundings into the central hall, or sala, with allegorical depictions of the seasons and scenes from contemporary villa life executed in 1561 by Paolo Veronese (1528–1588).

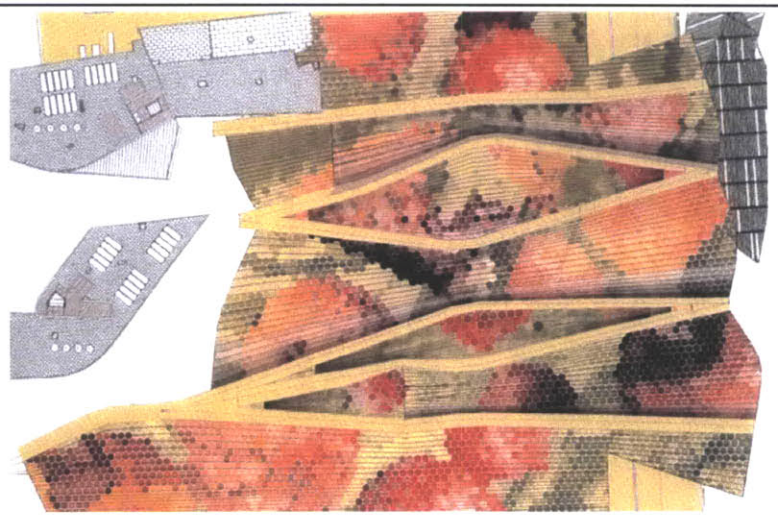
Villa Barbaro

Sistine Chapel

Here, I am trying to engage architecture more that just a surface of projection. By analyzing the Sistine Chapel as more than imagery, as a relation of structure/image, there are other attributes of architecture matter.

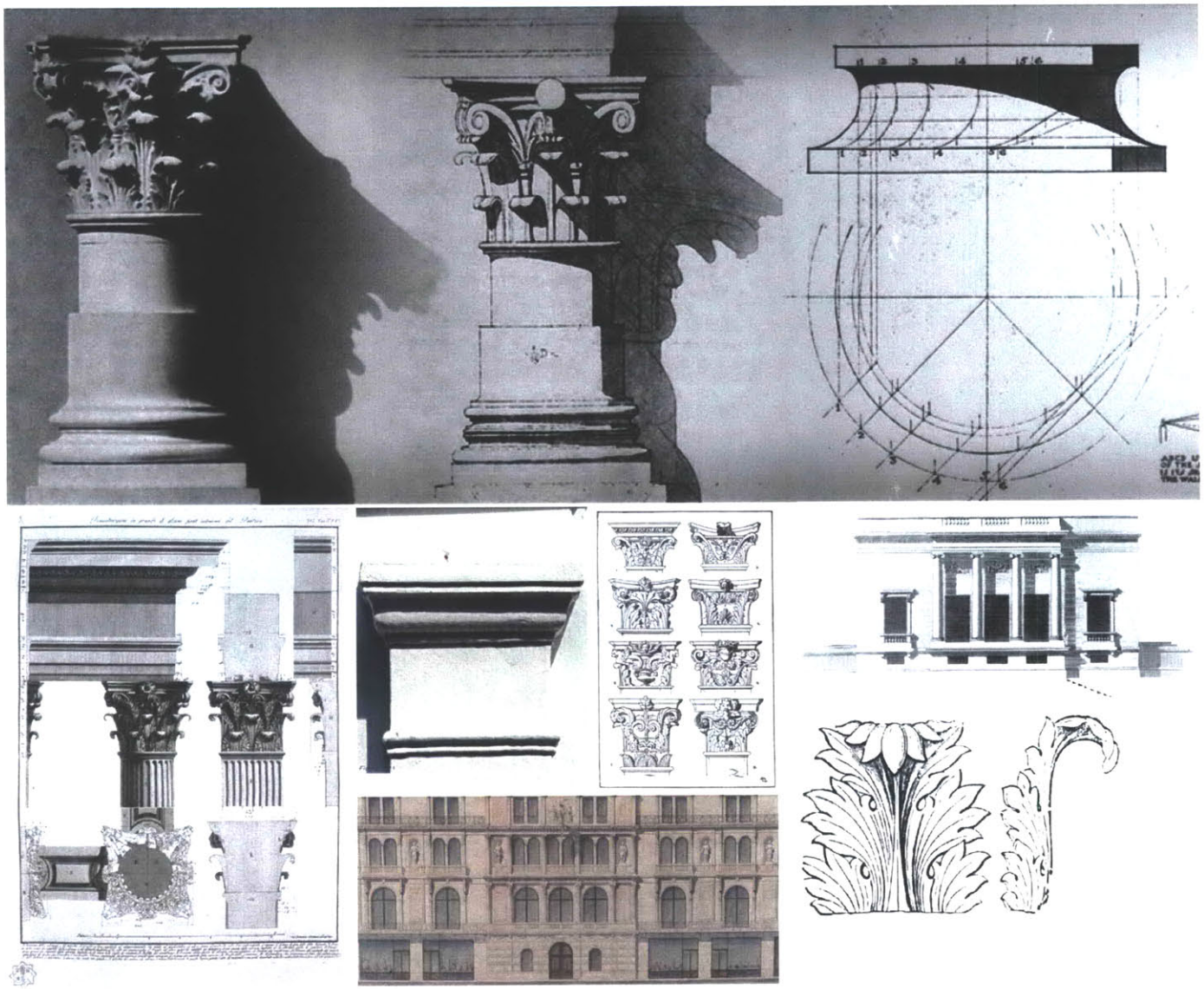


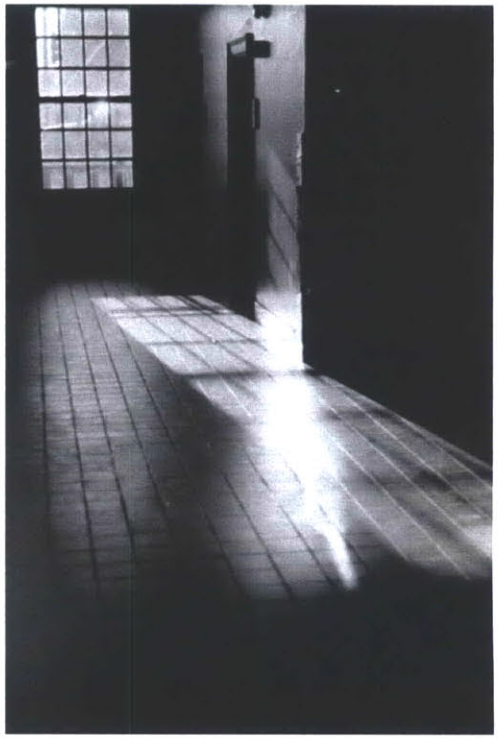
The narrative of bible story, which being represented as architectural decor here, can be considered as virtual reality. The relations between the structure of the roof and the mural composition is crucial for the examination of the "construction vitual" in reality.



Left: Social project in Danmark
Up: Market in Barcelona, Spain

1-1-2 Shades and Shadows: Spatial Experiences Made from Natural Lights





Shades and shadows are the key information for our perception of three-dimensionality. Sculptures and the decorations on architectural elements have shown to us brilliant ideas of using sunlight to compose pleasant visual effect.

"I constantly end up in discussions whether something's in the shade or shadow. Is there a clear definition of the difference between these two? Where I come from (Norway) we have a single word covering all forms of light blocking darkness."

--Øystein Sveum Moen

Both shade and shadow come from the same Old English word sceadu, "shade, shadow, darkness." The general definitions given for both words are almost identical in the OED:

shadow: I. Comparative darkness. 1. a. Comparative darkness, esp. that caused by interception of light; a tract of partial darkness produced by a body intercepting the direct rays of the sun or other luminary.

shade: I. Comparative darkness. 1 a. Partial or comparative darkness; absence of complete illumination; esp. the comparative darkness caused by a more or less opaque object intercepting the direct rays of the sun or other luminary.

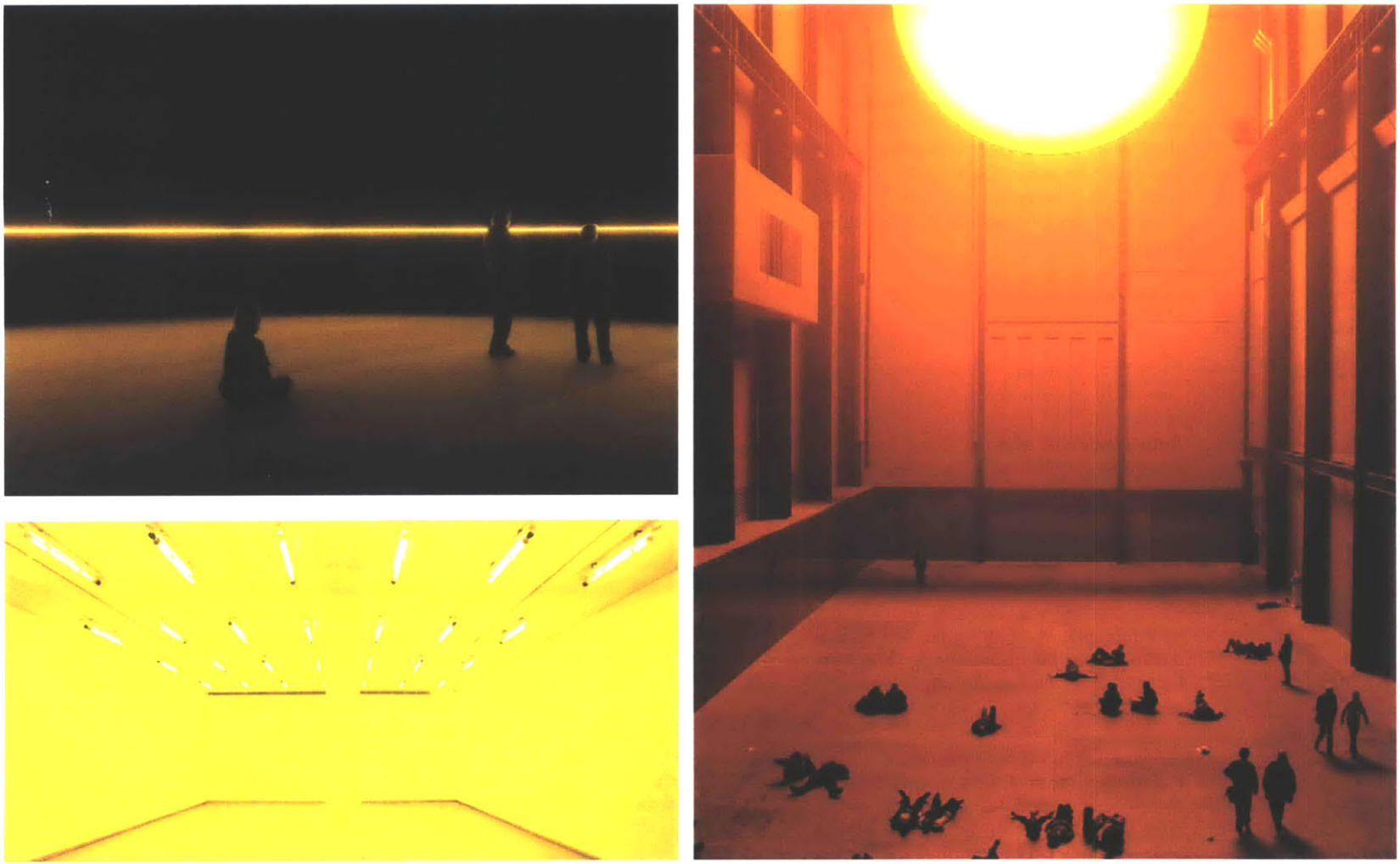
"...Materiality is not a question of the materials themselves but rather the substance of material relations..."
"Illuminating the modern surface condition, she notes how façades are becoming virtual screens and the art of projection is reinvented on gallery walls. ...In performing these critical operations on the surface, she articulates it as a site in which different forms of mediation, memory, and transformation can take place."

Bruno, G. (2014). Surface: Matters of aesthetics, materiality, and media. The University of Chicago Press.

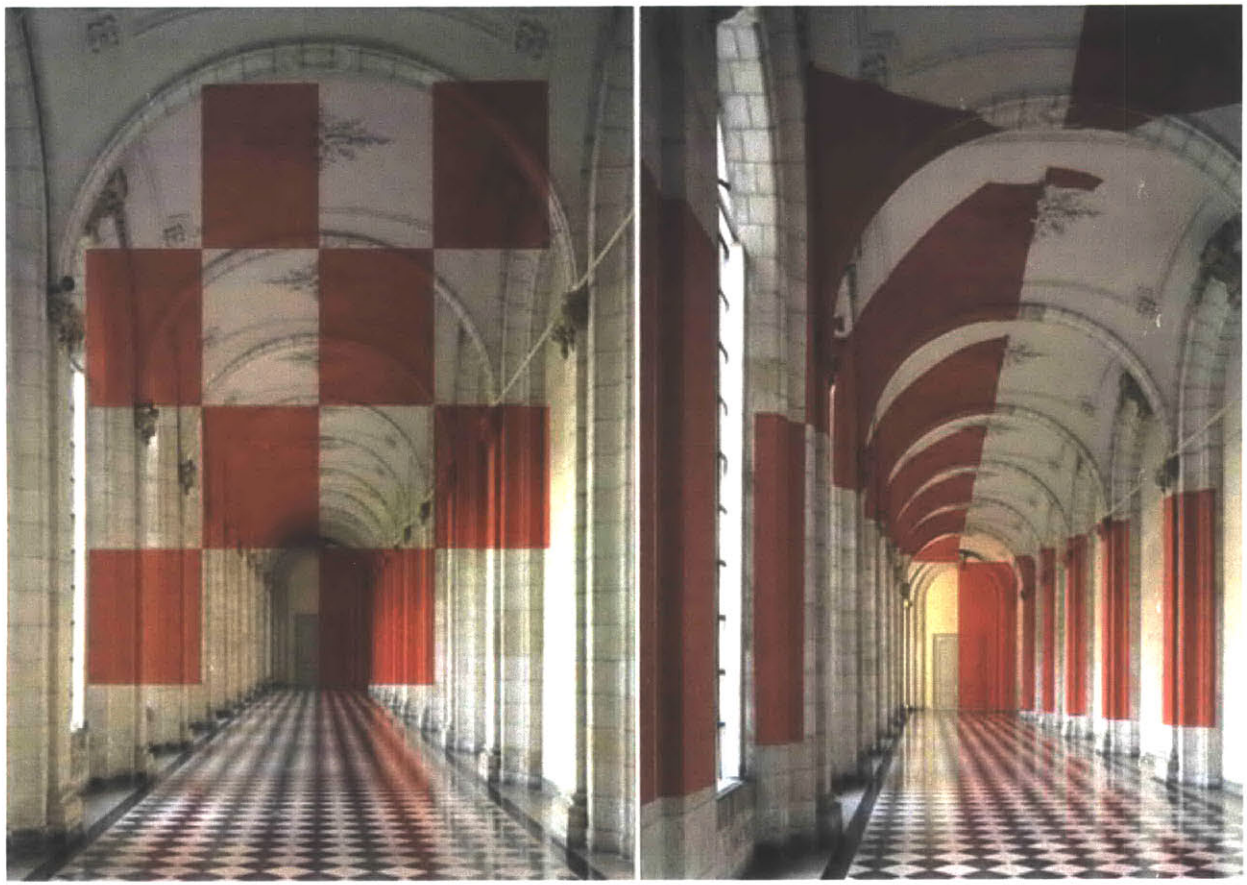
"Medium is the message means that what is important is not the content of the message itself, but the environment it is presented in. Taking the example of tribalization, what was printed did not matter to the shift to nationalization; what mattered was the affect of print on society. Likewise, what matters in retribalization is not what is shown on tv, presented on the internet, or played on the radio. It is the fact that the mediums themselves have shifted our focus from ourselves to our tribe (in this case, a global community) and from our ears to our eyes."

MacLuhan, M. (2005). The medium is the message. Corte Madera: Gingko Pr.

1-1-3 Spatial Arts Made from Artificial Lights



Art Projects by Olarfur E.



Contemporary artists and architects who are engaging digital technology to reimagine contemporary urbanism:

What are some emerging design questions from such precedents?

1-2 Current Artificial Light Projection

1-2-1 Lights and Artificial Light Projection

1-2-2 Projectors

From www.projectionscreen.net

1-2-3 Projection Mapping Software Platforms

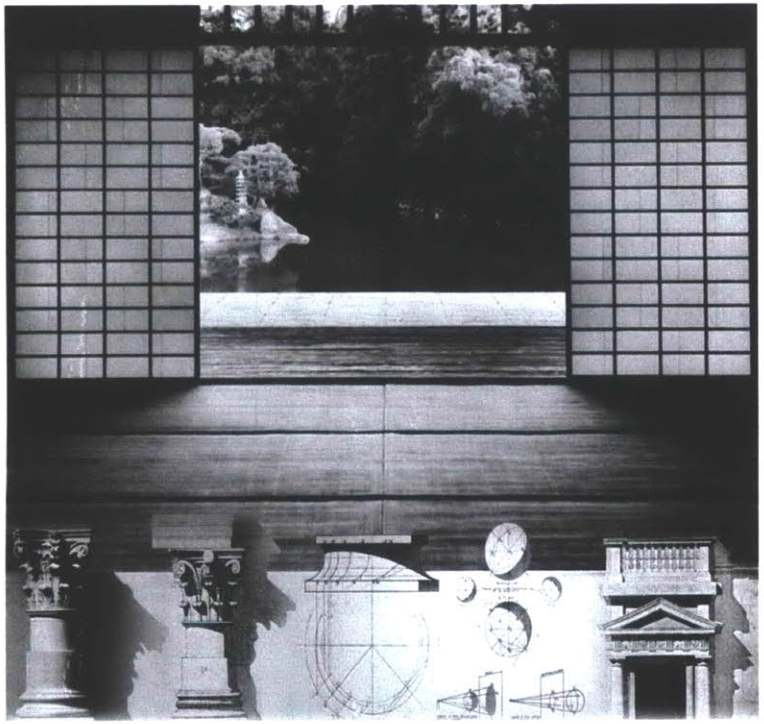
1-2-4 Projection Mapping Projects

http://www.staywellgroup.com/travel/sydney-australia/sydney-travel-guide

http://www.staywellgroup.com/travel/sydney-australia/sydney-travel-guide

The projection mapping arts right now remain to happen during night time.

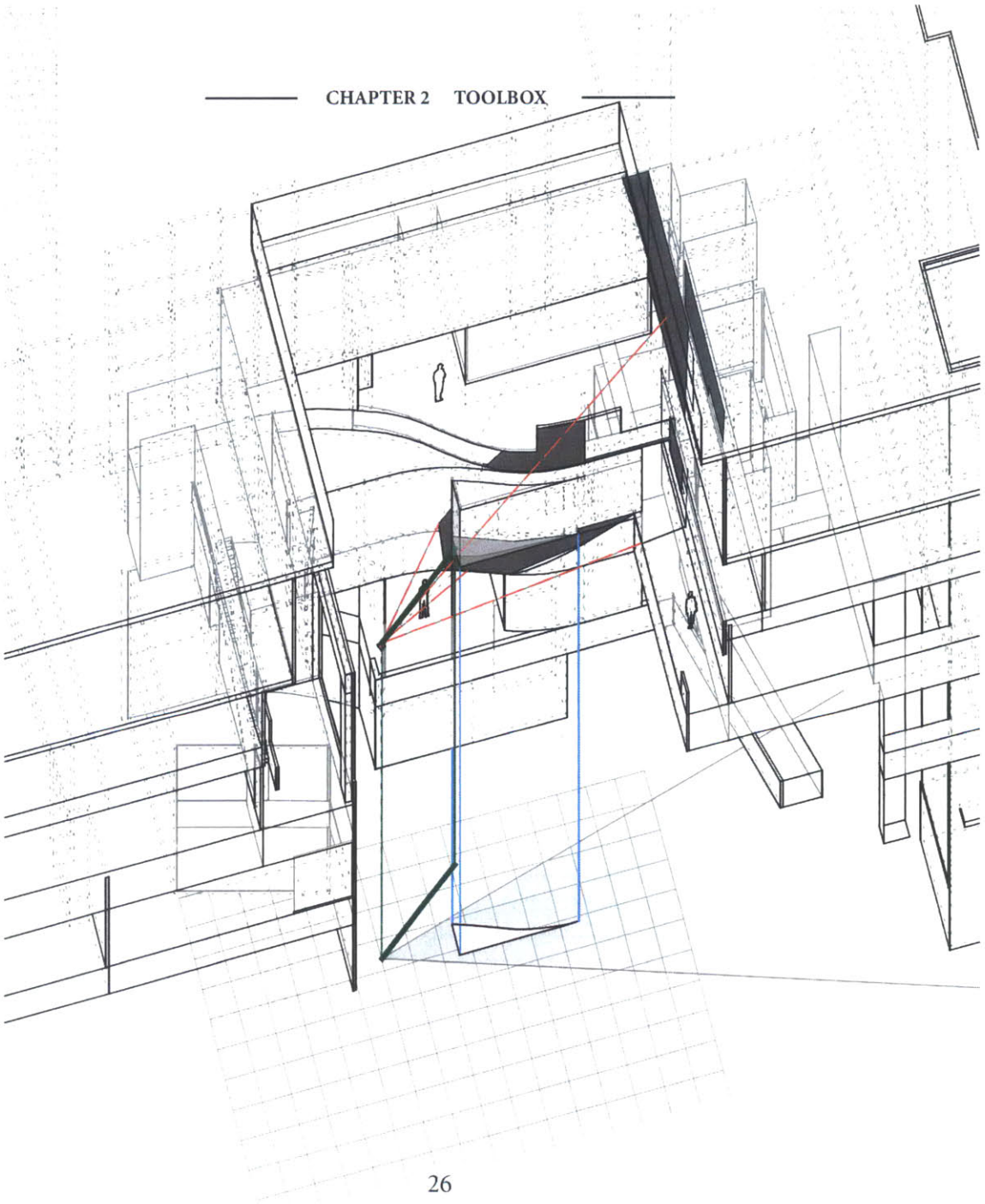
1-3 Interplay between Natural and Artificial Lights



Take a closer look at the surfaces that enclose our space: there are screens with news, lectures, movie clips; there are windows, shadows and shade created by lights of all different kinds; there are colors and ornamentations that inform us of the history of our architectural lineage. Sunlight naturally creates an evolving atmosphere with the change in time and the seasons; now, with new technologies, we can create even more dynamic atmospheres with light that engage and collaborate with the sun.

CHAPTER 2

TOOLBOX



CHAPTER 2

TOOLBOX

2-1 Notes on Documentation Methods

2-2 Summary: Trick Book

2-3 Progress Diary: Experiments

2-3-1 In the Corridor
2-3-2 In MIT Lobby 7
2-3-3 In the Atrium of MIT Brain and Cognitive Science Complex building
2-3-4 On the Models (stable lighting environments)

2-1 Notes on Documentation Methods

This chapter documented the projection-experiments with the projector Epson EX7235 Pro.

The documentation included the study of the projector, the summary of the experiments that can be used as inpirations for designing the space with projections, and the process diary.

In the trick box, there are three columns of pictures on each page. The first column included the photos of the space without projection; the second column of photos showed how it looks like with projection and the last column of pictures are the output images from the projectors.

There are two kinds of documentation methods in the Process Diary of Experiments. The first one is the common methods, which included the photos of the projection in the spaces. The second kind of documentation aimed for showing the relationship of light intensity in the space.

Epson EX7235 Pro, WXGA Widescreen HD, Wireless, 3000 Lumens Color Brightness, 3000 Lumens White Brightness, 3LCD Projector

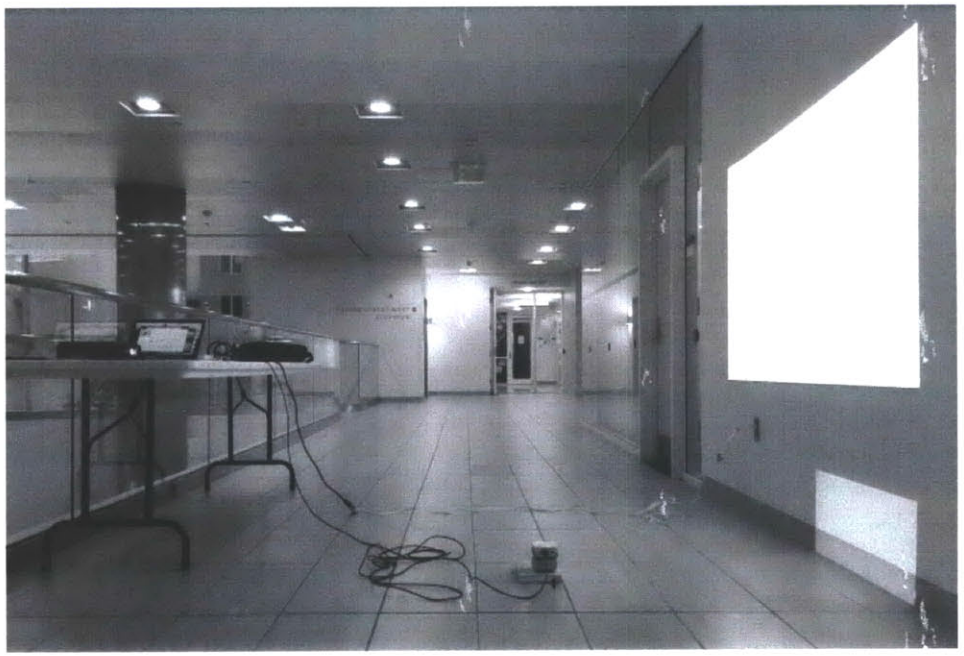
3x Brighter Colors, and reliable performance - 3LCD, 3-chip technology
One measurement of brightness is not enough - look for both high color brightness and high white brightness. The EX7235 Pro has: Color Brightness - 3000 lumens and White Brightness - 3000 lumens
Professional-grade projector - present like a pro with widescreen HD, WXGA resolution and advanced connectivity
Wireless connectivity - connect directly to your laptop with the included wireless LAN module
Project from your smartphone or tablet - leave your laptop at home; connect wirelessly, with the free Epson projection App

http://www.amazon.com/gp/product/B00M8XKA-MA?psc=1&redirect=true&ref_=oh_aui_detailpage_o05_s00

Study of the intensity of the projected lights:

// the brightness of the projector's bulb

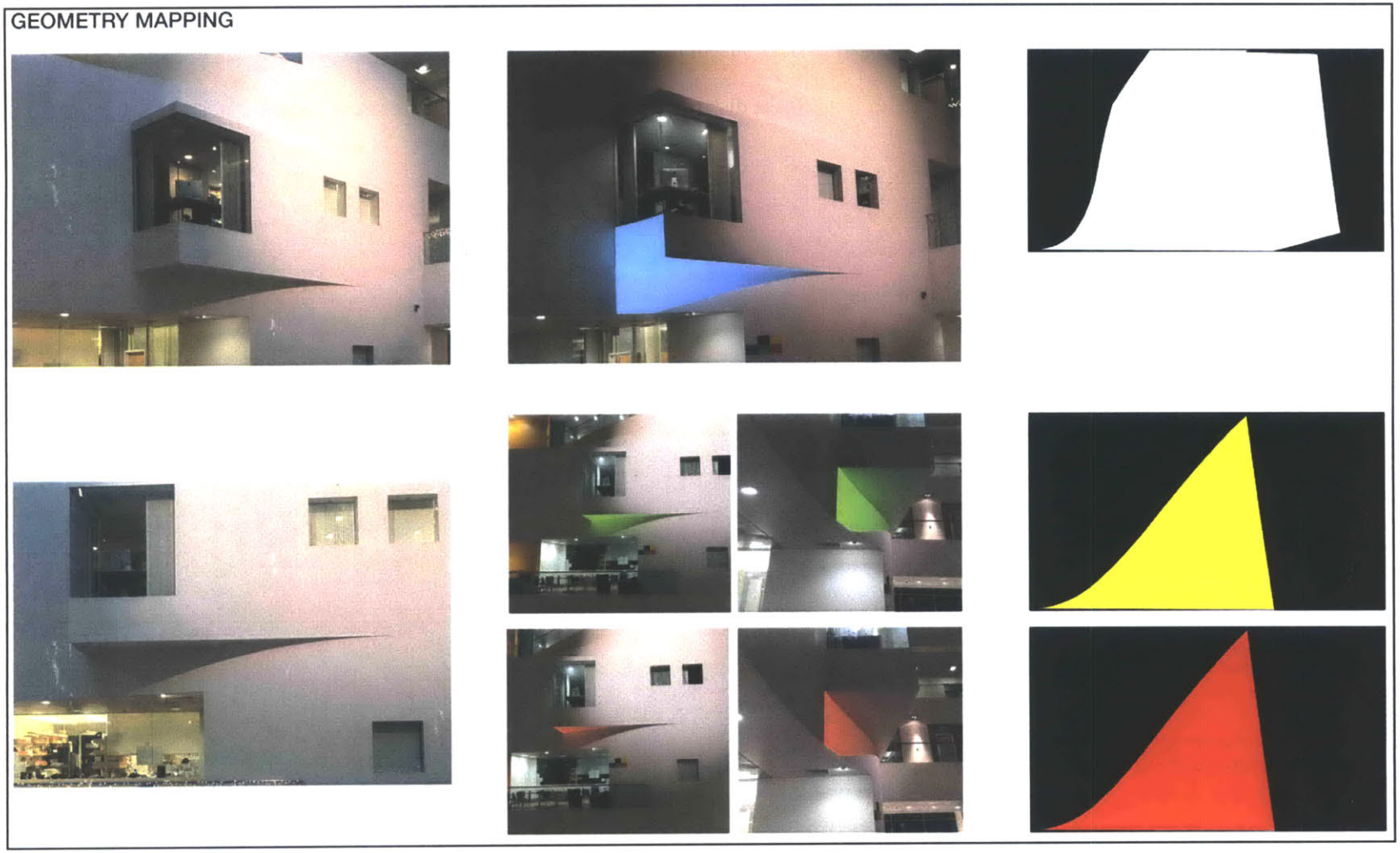
// the distance between the projector and its target surface



2-2 Summary: Trick Book

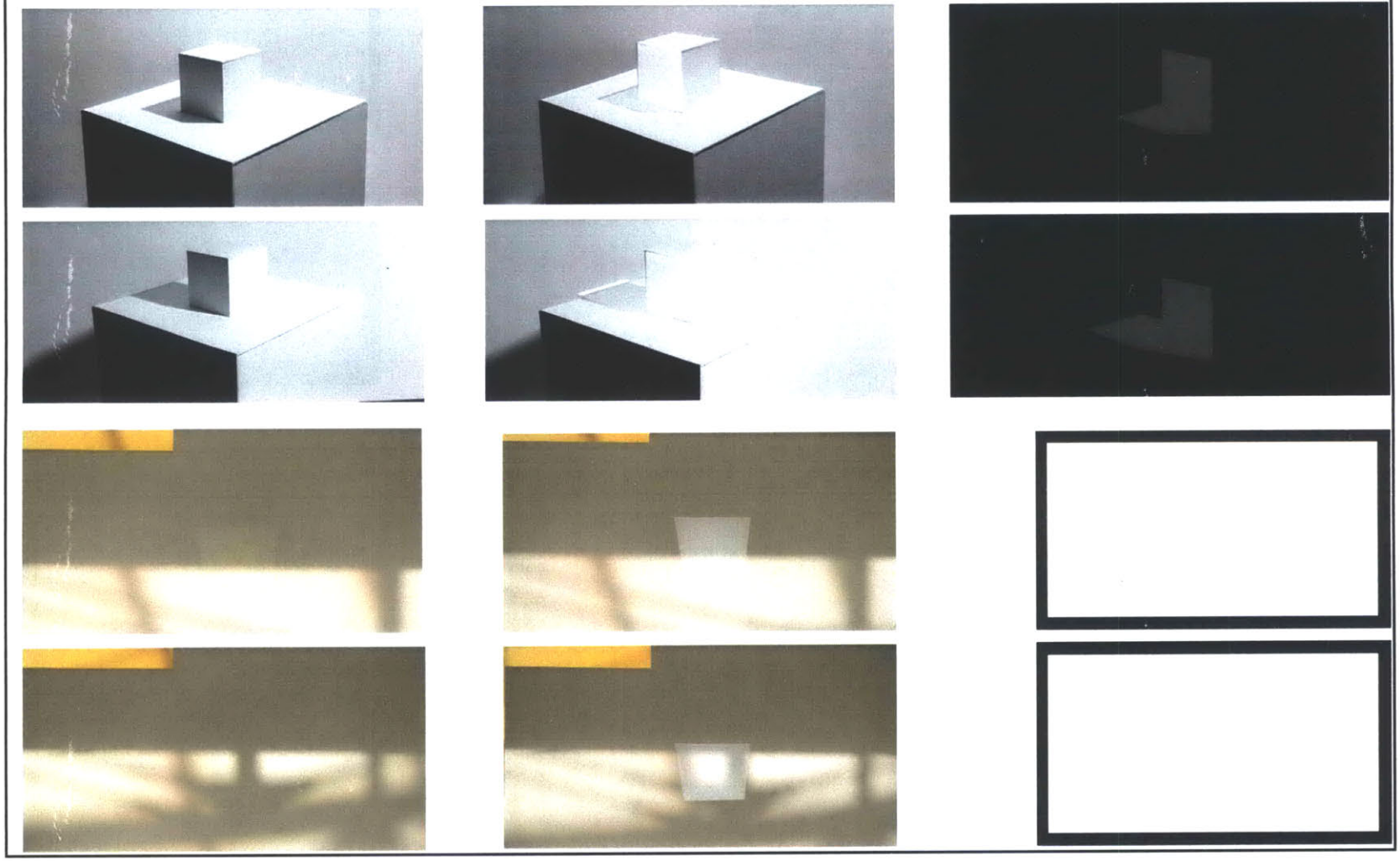
In the trick box, there are three columns of pictures on each page. The first column included the photos of the space without projection; the second column of photos showed how it looks like with projection and the last column of pictures are the output images from the projectors.

2-2-1



2-2-2

PLAY WITH SHADOW

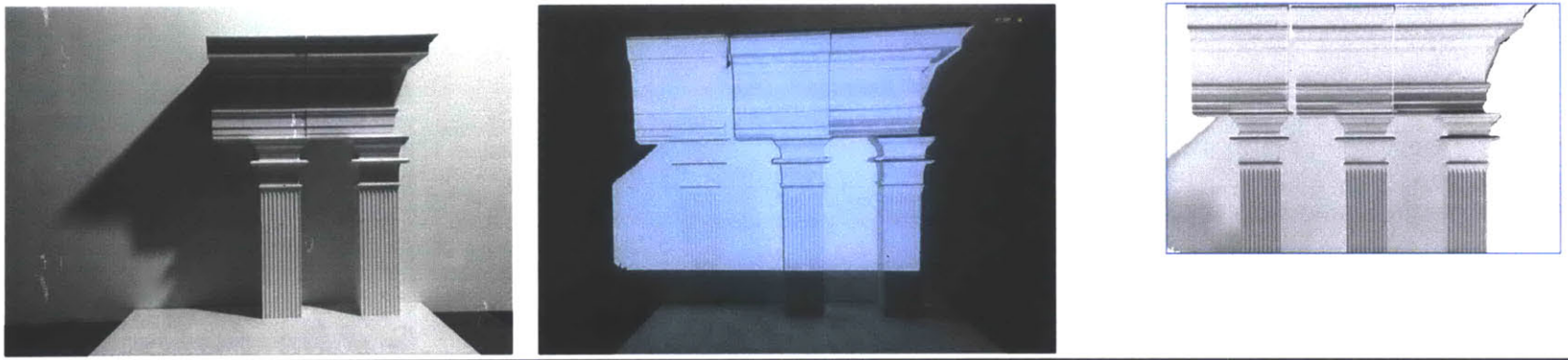


2-2-3

ARTIFICIAL LIGHTS

2-2-4

ADDING ELEMENTS



2-3 Progress Diary: Experiments

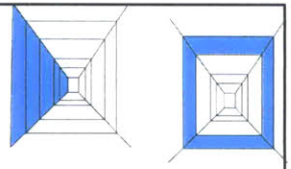
This part documented most of the experiments that I have conducted, in four categories. The main purposes of these experiments are exploration, as I have no idea what the space will feel like unless I test it on site.

2-3 Progress Diary: Experiments

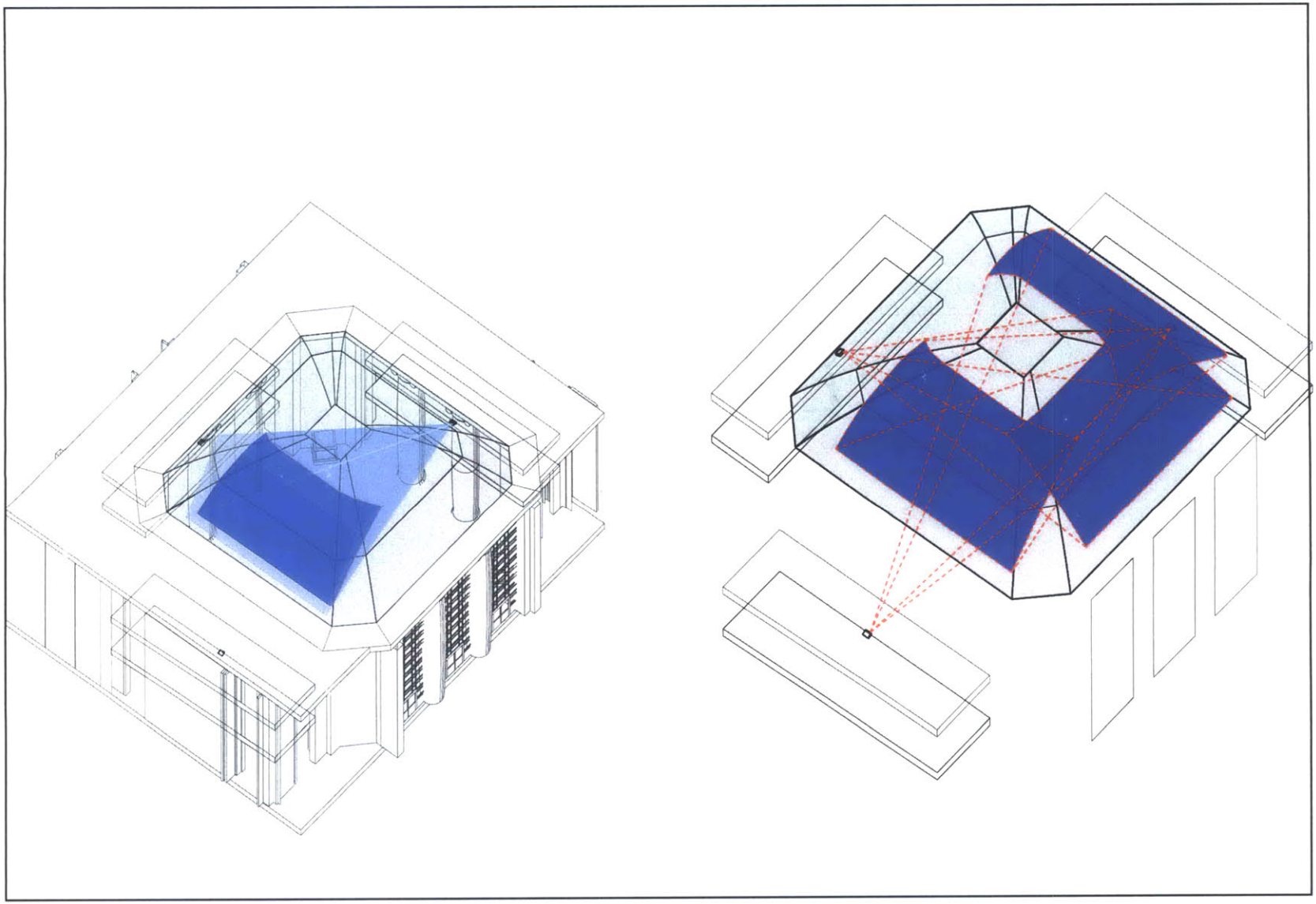
2-3-1 In the Corridor

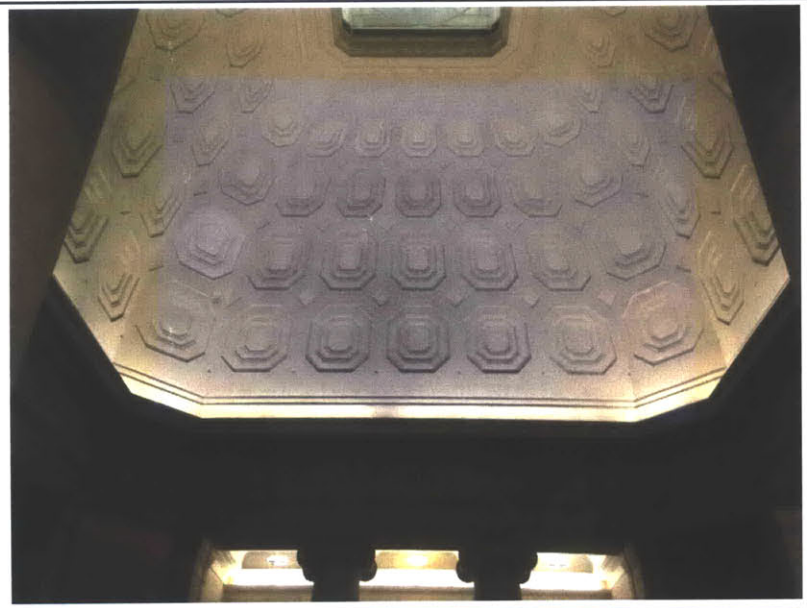
The projection creates three things here, which I found interesting:

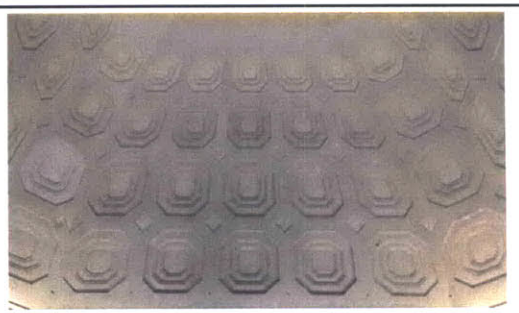
1) the projected image/information;
2) the reflection on the floor due to the materiality;
3) the ambient light around the ceiling and the other wall.

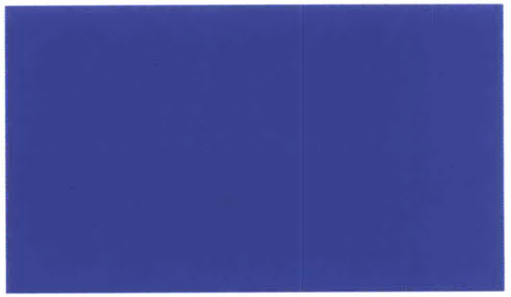


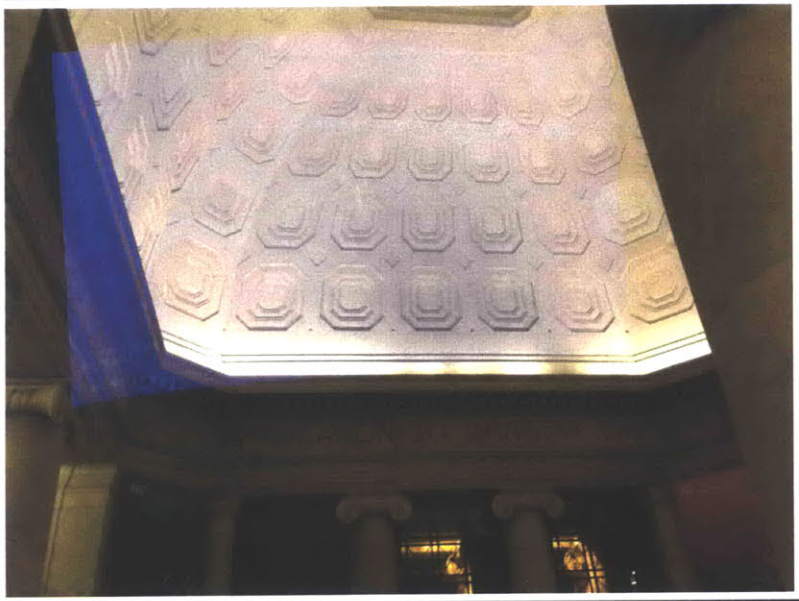
2-3-2 In MIT Lobby 7

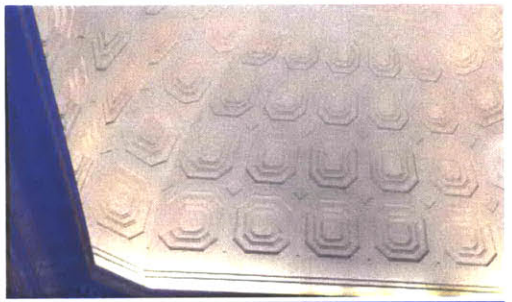


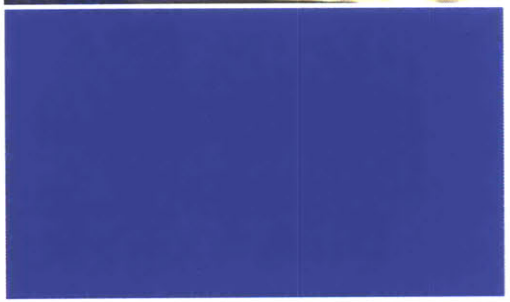




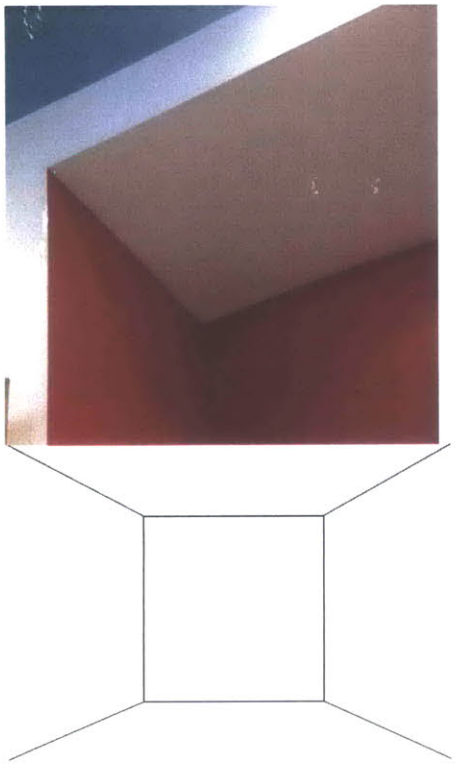


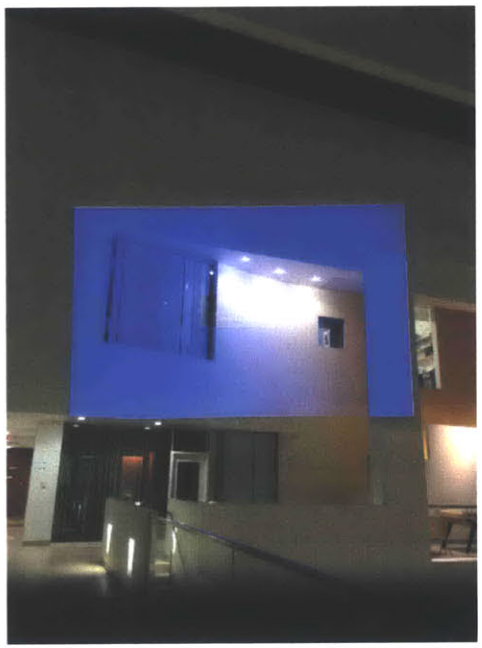


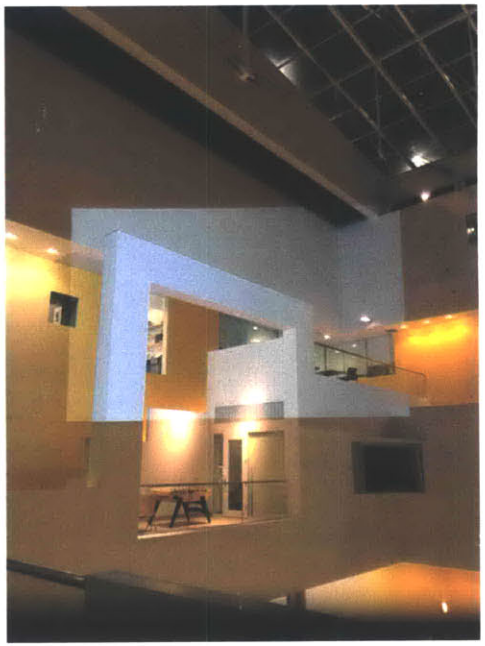




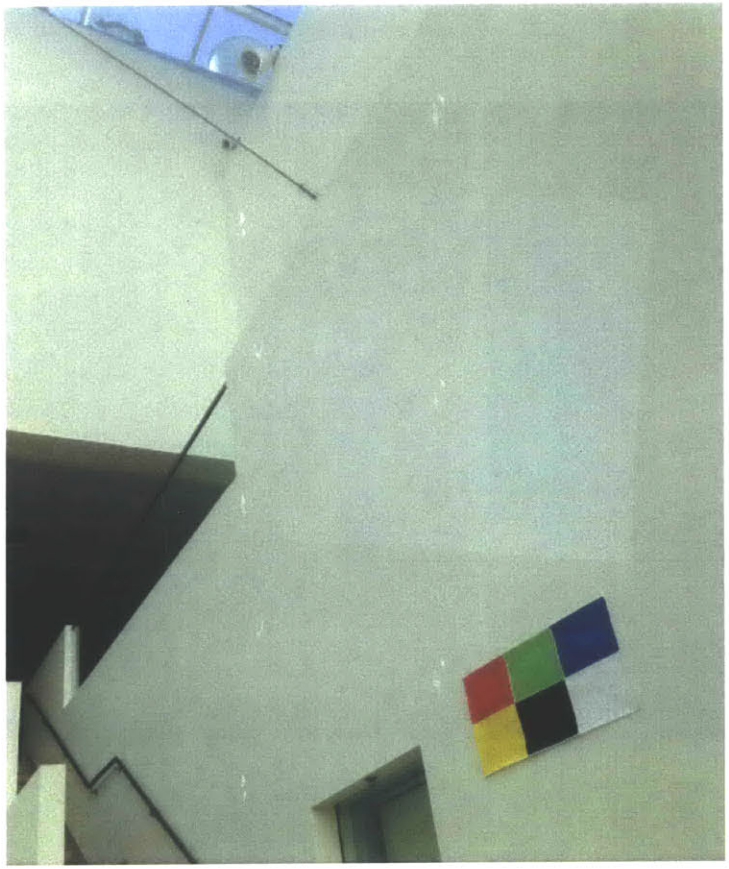
2-3-3 In the Atrium of MIT Brain and Cognitive Science Complex building





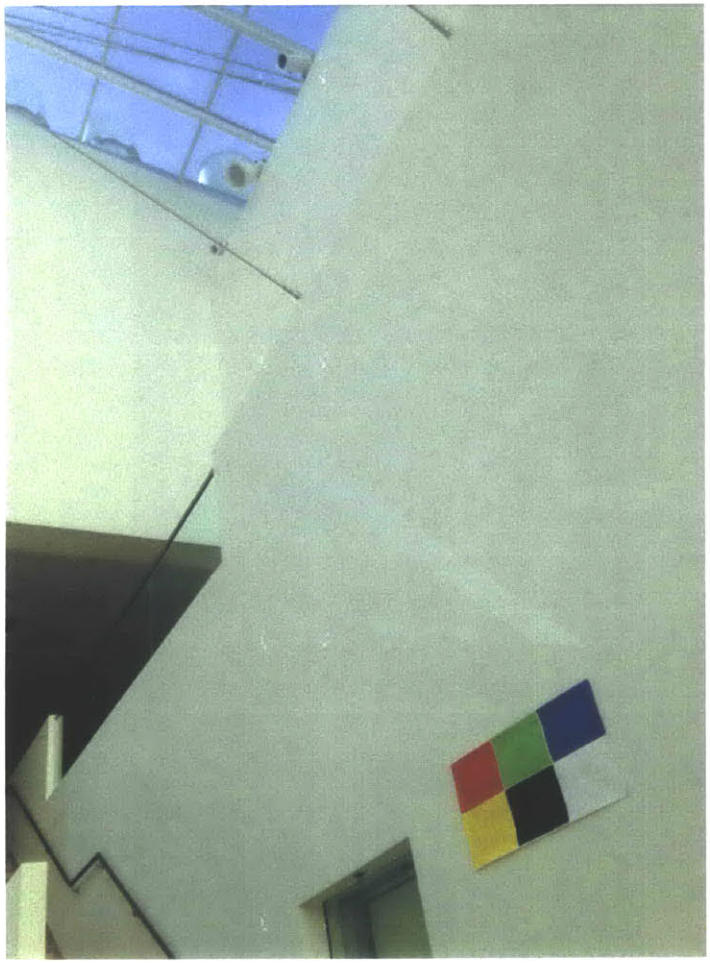


10am MIT Brain and Cognitive Complex

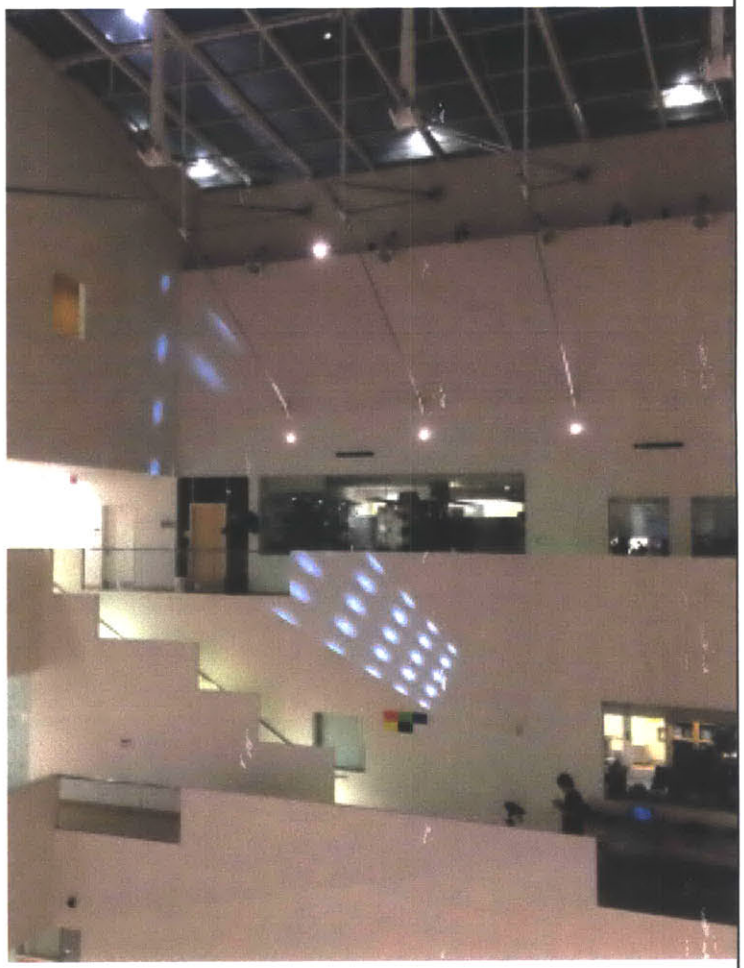


10pm MIT Brain and Cognitive Complex

10am MIT Brain and Cognitive Complex

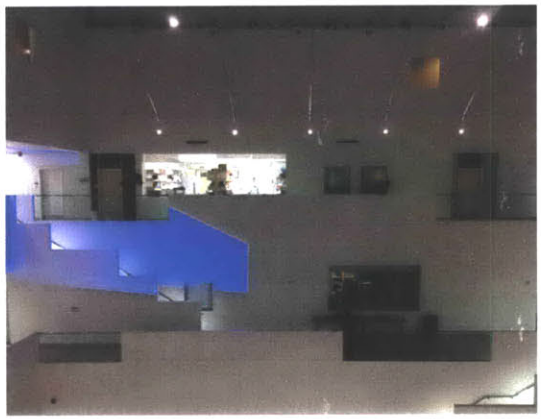


10pm MIT Brain and Cognitive Complex

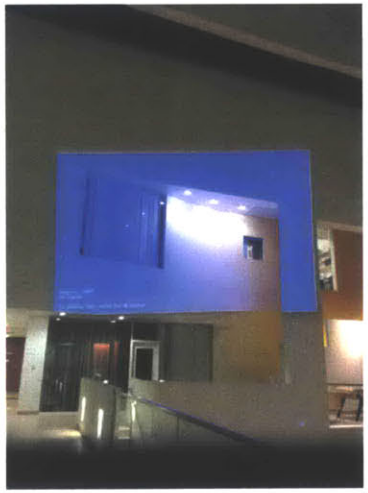


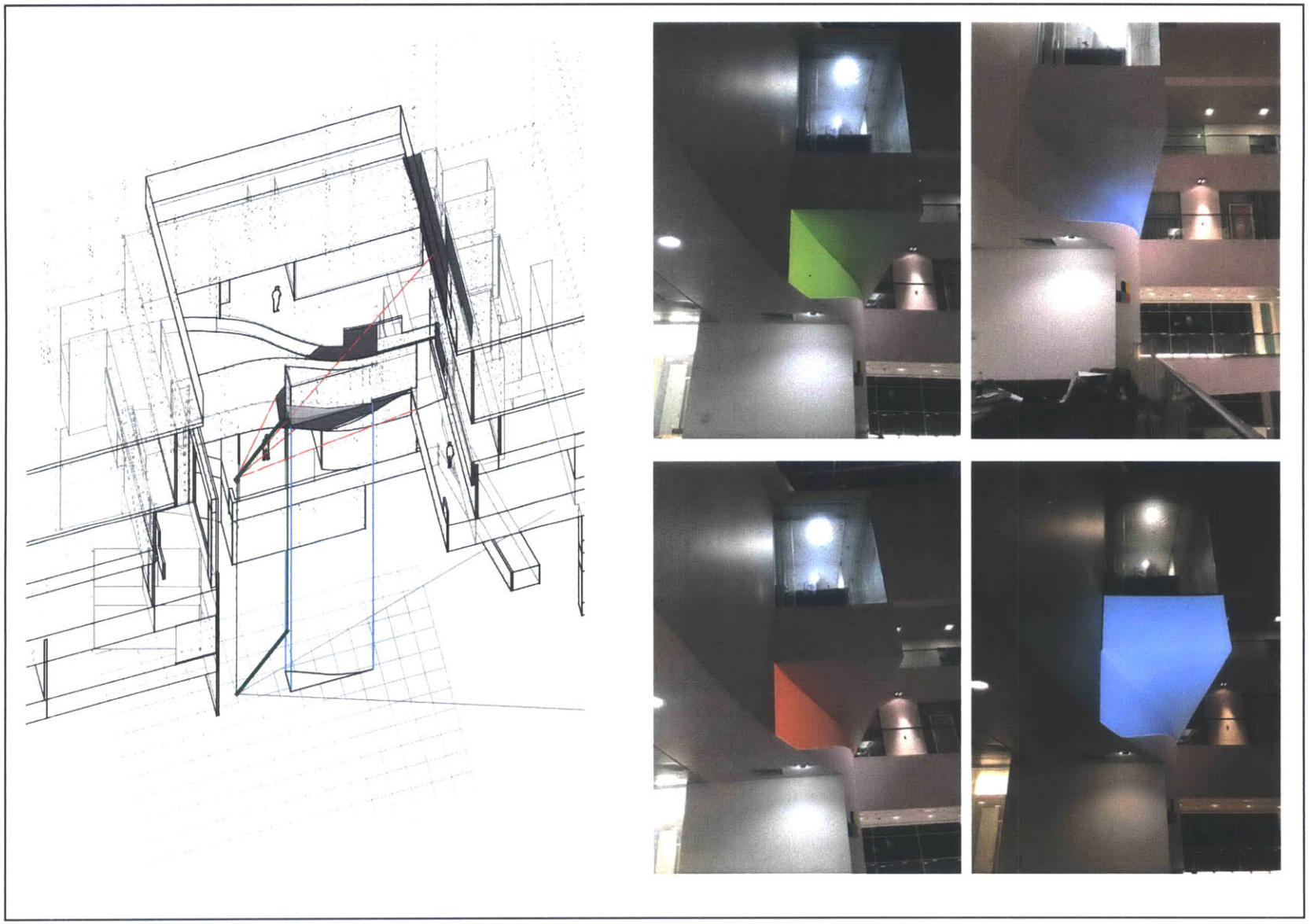
Projection from the Side

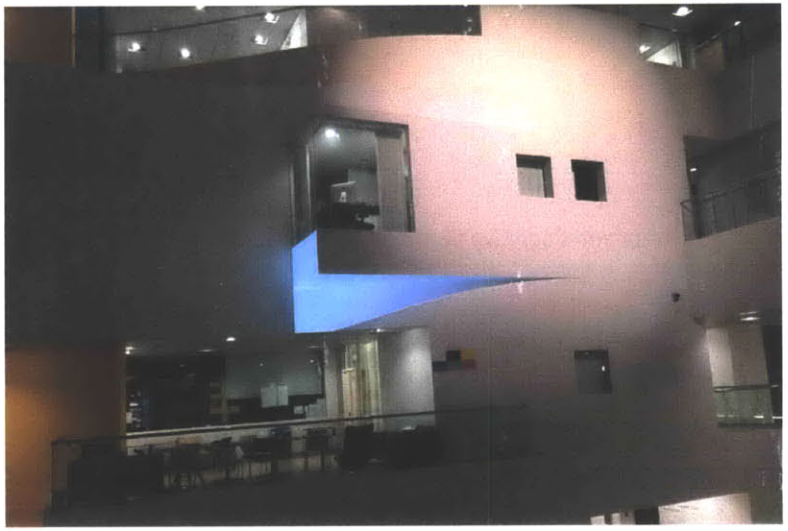
Projection with Different Angle

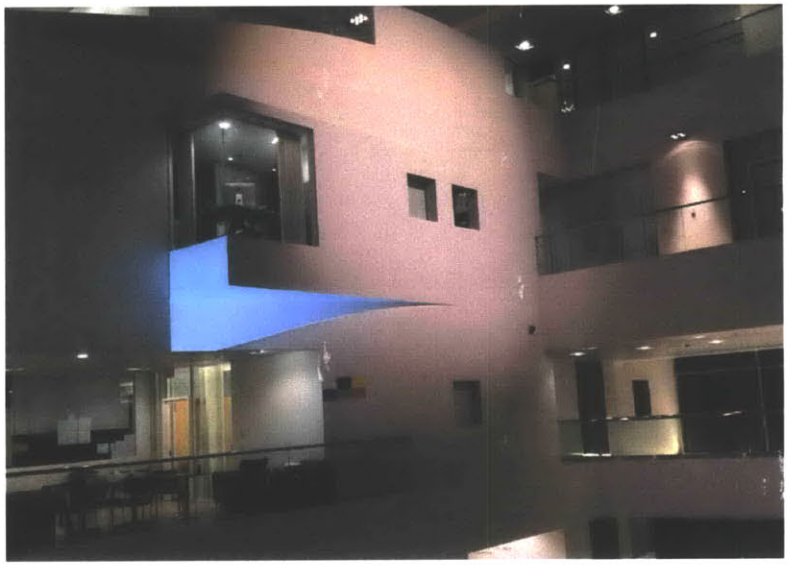


Perception of the color in complex lighting environment







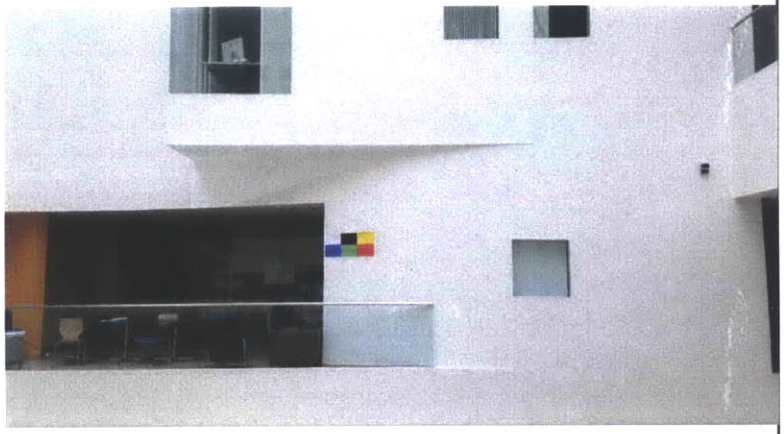


"Random" tests

on site

10pm MIT Brain and Cognitive Complex

8am MIT Brain and Cognitive Complex



"Random" tests

on site

10pm

MIT Brain and Cognitive Complex

8am

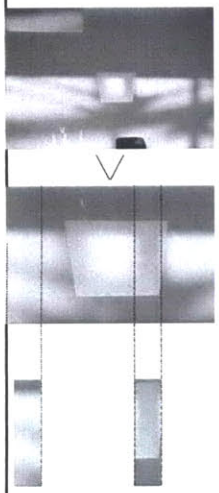
MIT Brain and Cognitive Complex

"Random" tests

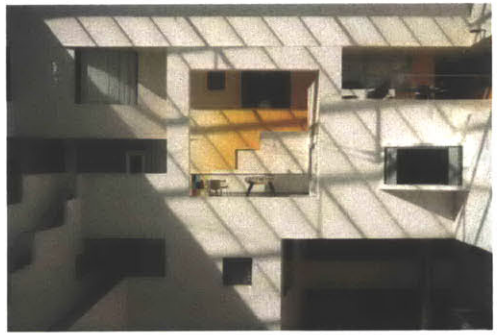
on site

As the sun moves, the shadow patterns changes.

There will be no identically patterns due to the time and season.



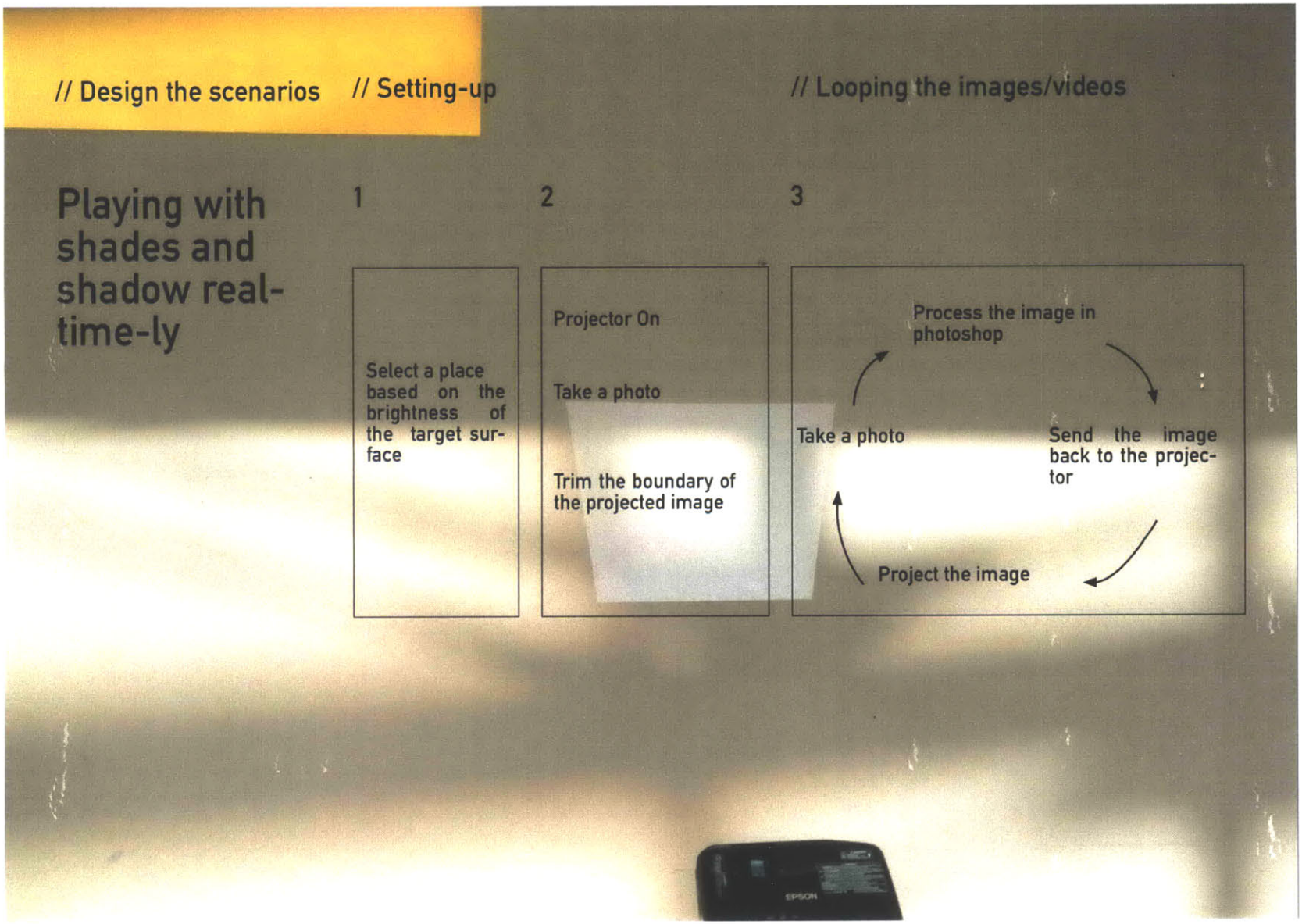
Using projection to make the shadow area brighter.



The three images to the left are taken at about the same time.

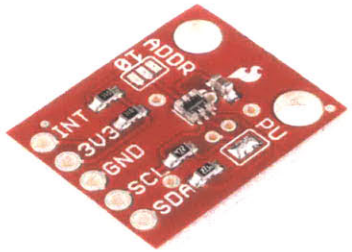
It shows the result with different projected images.

Workflow discussion

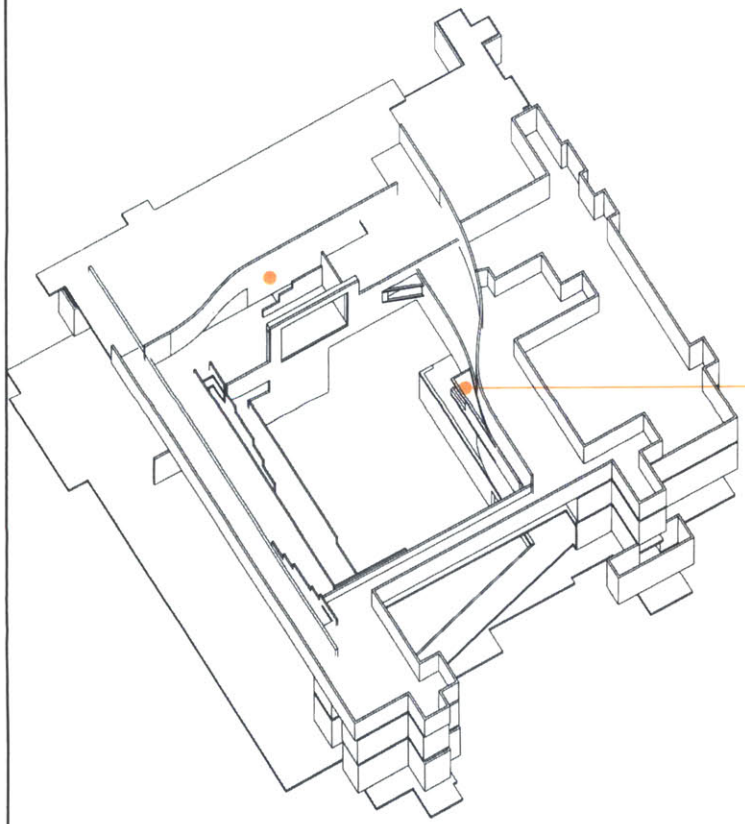


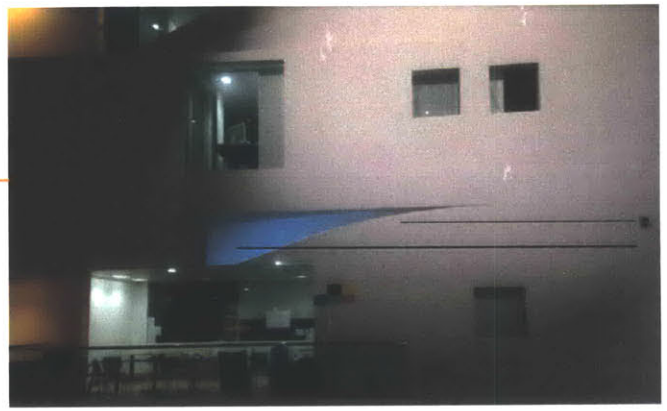
Following is a set of experiments to understand the light intensity relationship.

By taking photos and measuring the lux level with light sensor, the relationship between the "abstract numbers" and the perception of human's eyes can be established. The ambition of this set of documentation is to build a "data-base" for this relationship. This relationship is the translation between sensation and technology.

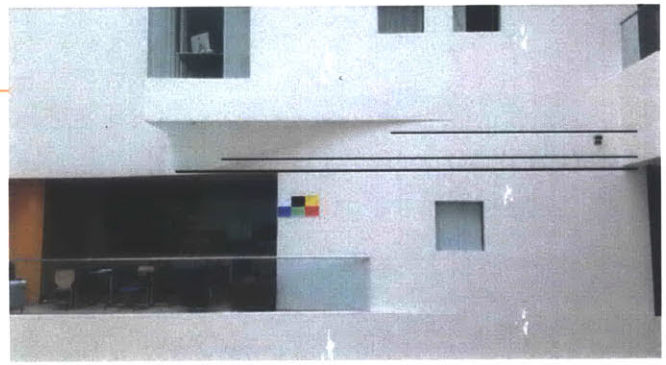


In the Atrium of MIT Brain and Cognitive Science Complex building

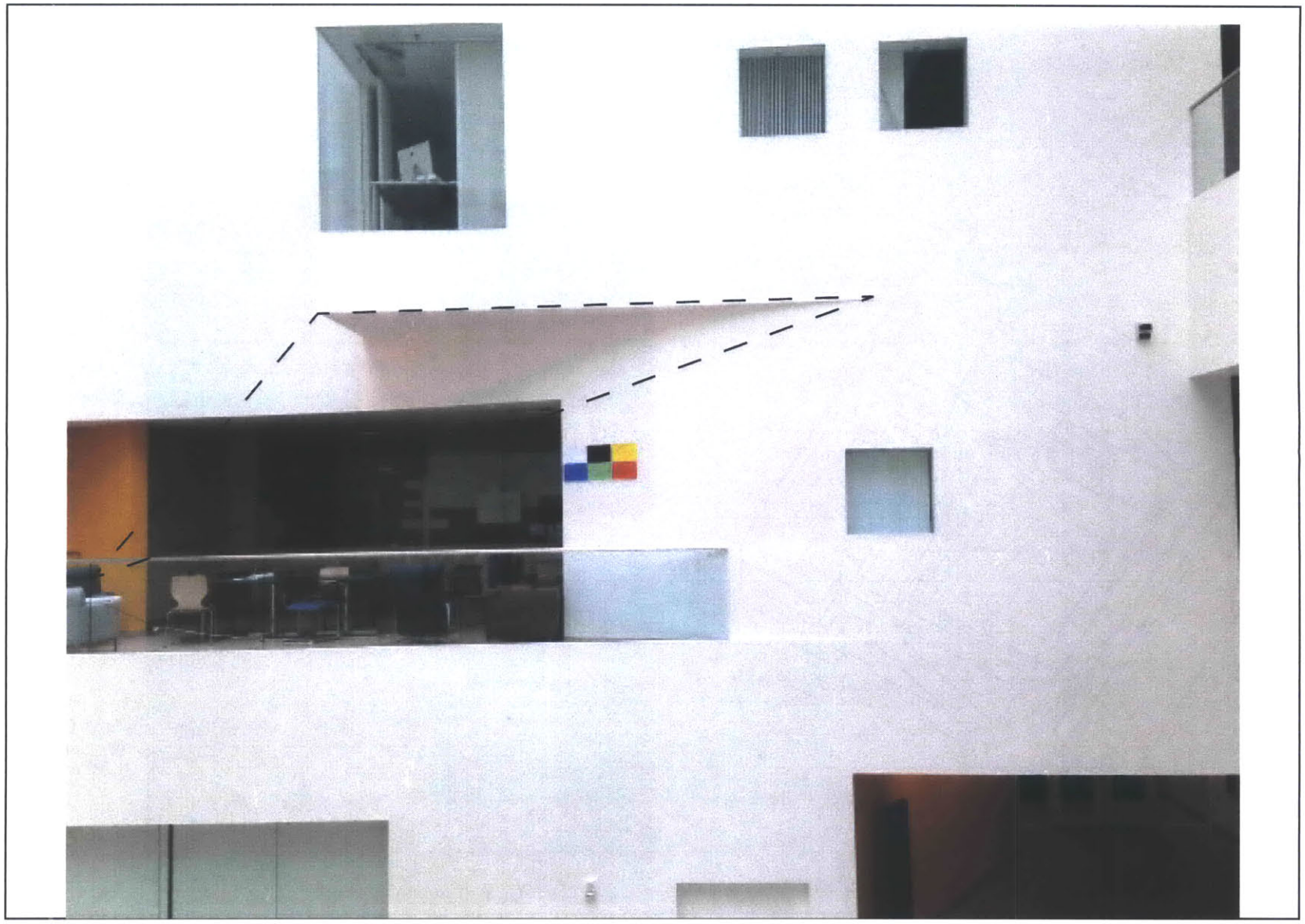




4,200 Lumen
25,000 Lumen



1,770 Lumen
970 Lumen
1,200 Lumen



PROJECTOR STUDY

/ Projected from front : far

photo: no projection

photo: with projection

PROJECTOR STUDY

/ Projected from front : close

photo: no projection

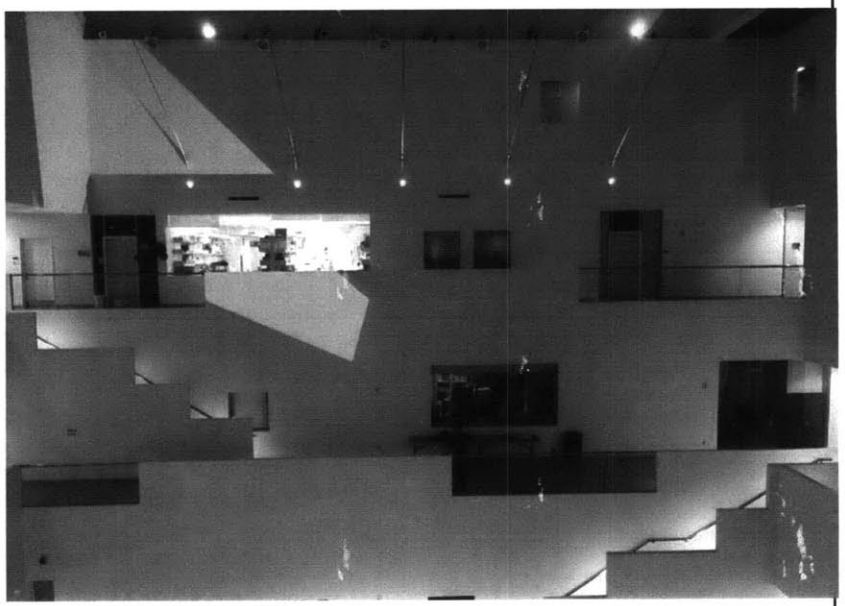
photo: with projection

PROJECTOR STUDY

/ Projected from side

photo: no projection

photo: with projection



PROJECTOR STUDY

/ Projected from side

photo: no projection

photo: with projection

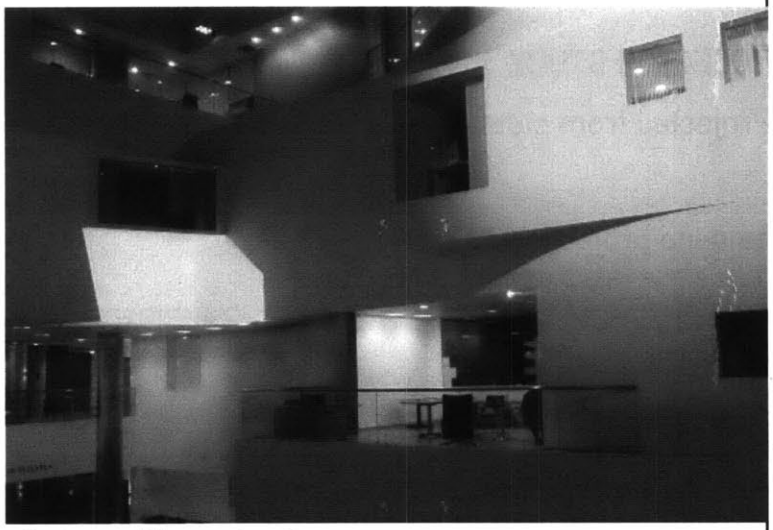


photo: with projection

PROJECTOR STUDY

/ Projected from side

photo: no projection

photo: with projection

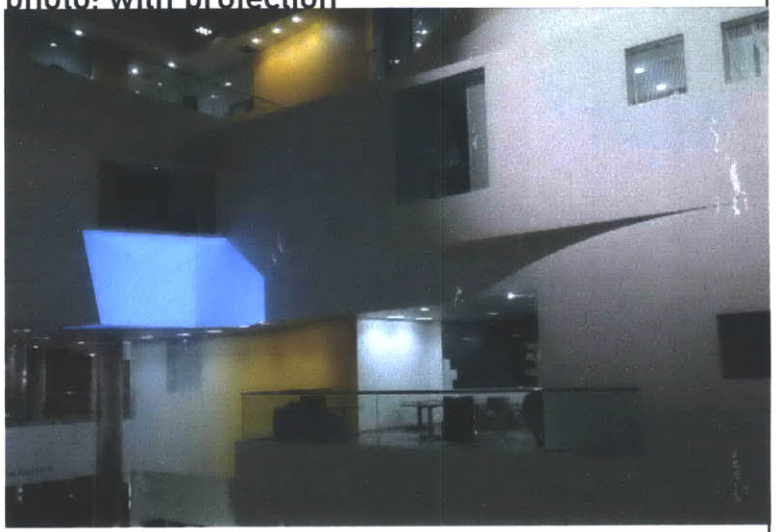
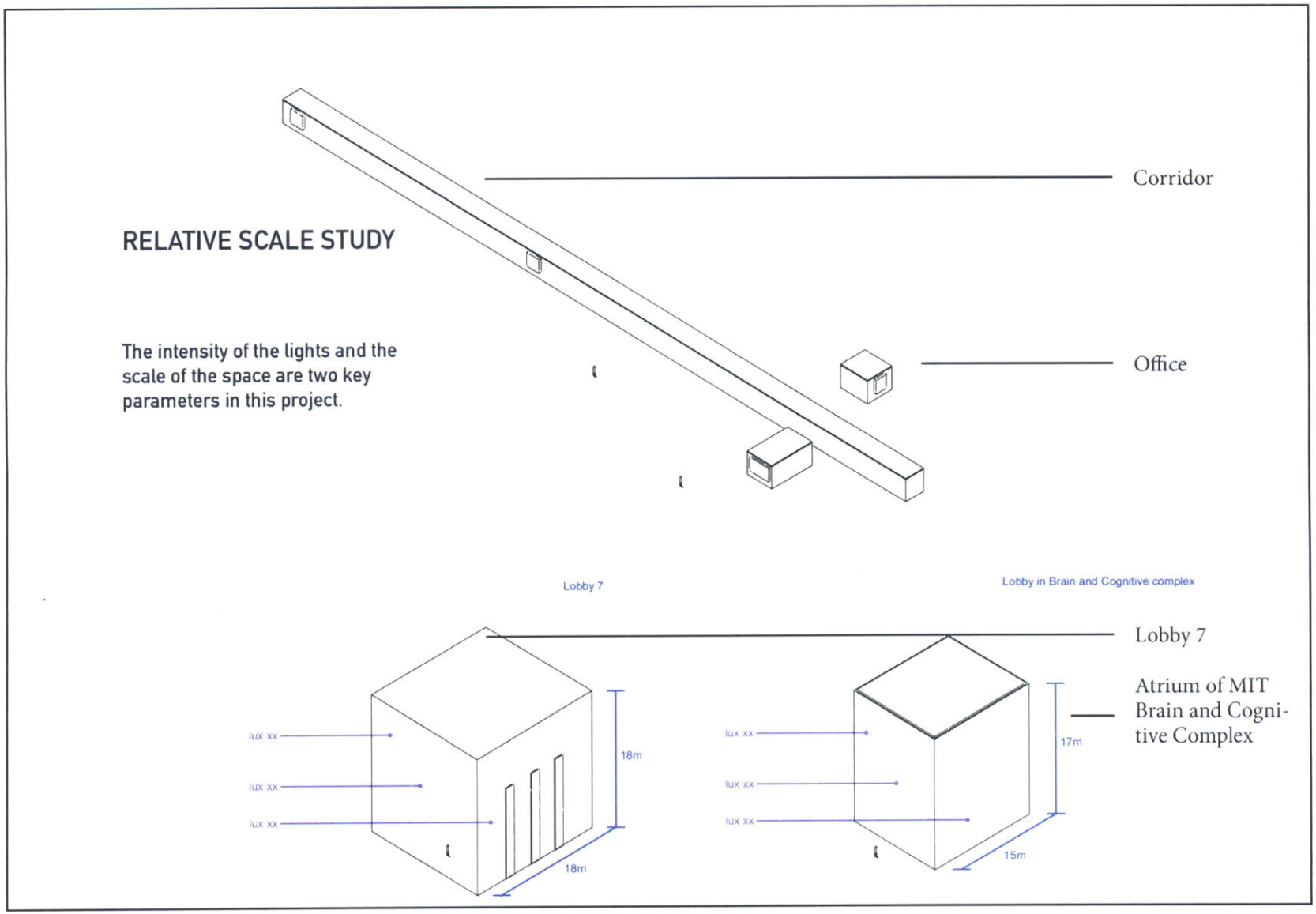


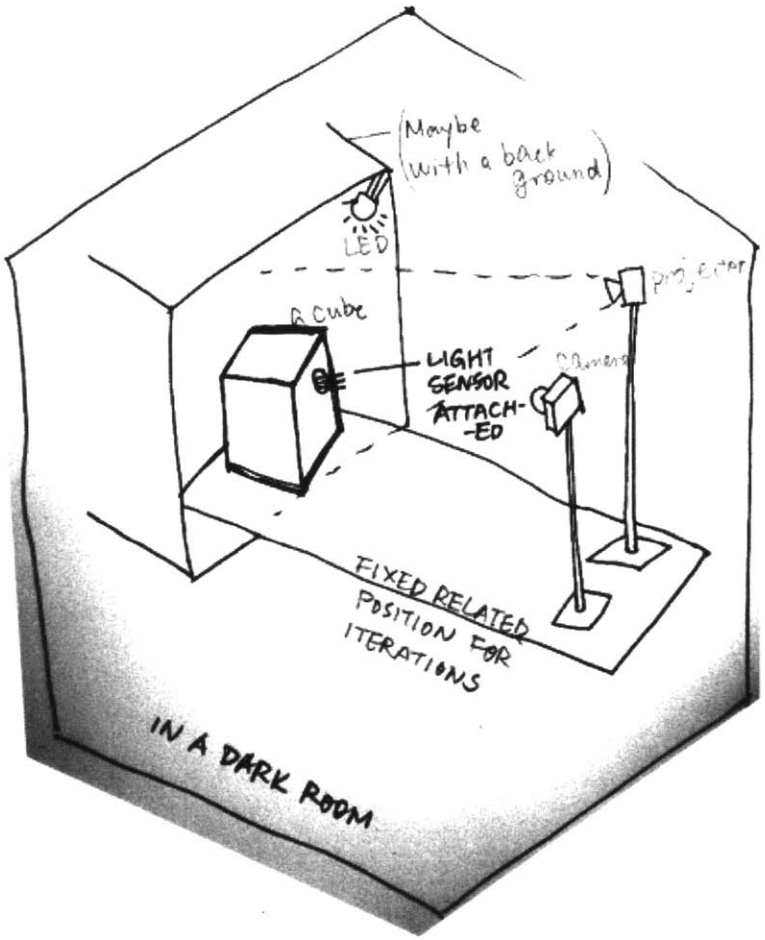
photo: with projection

Relative Scale Study

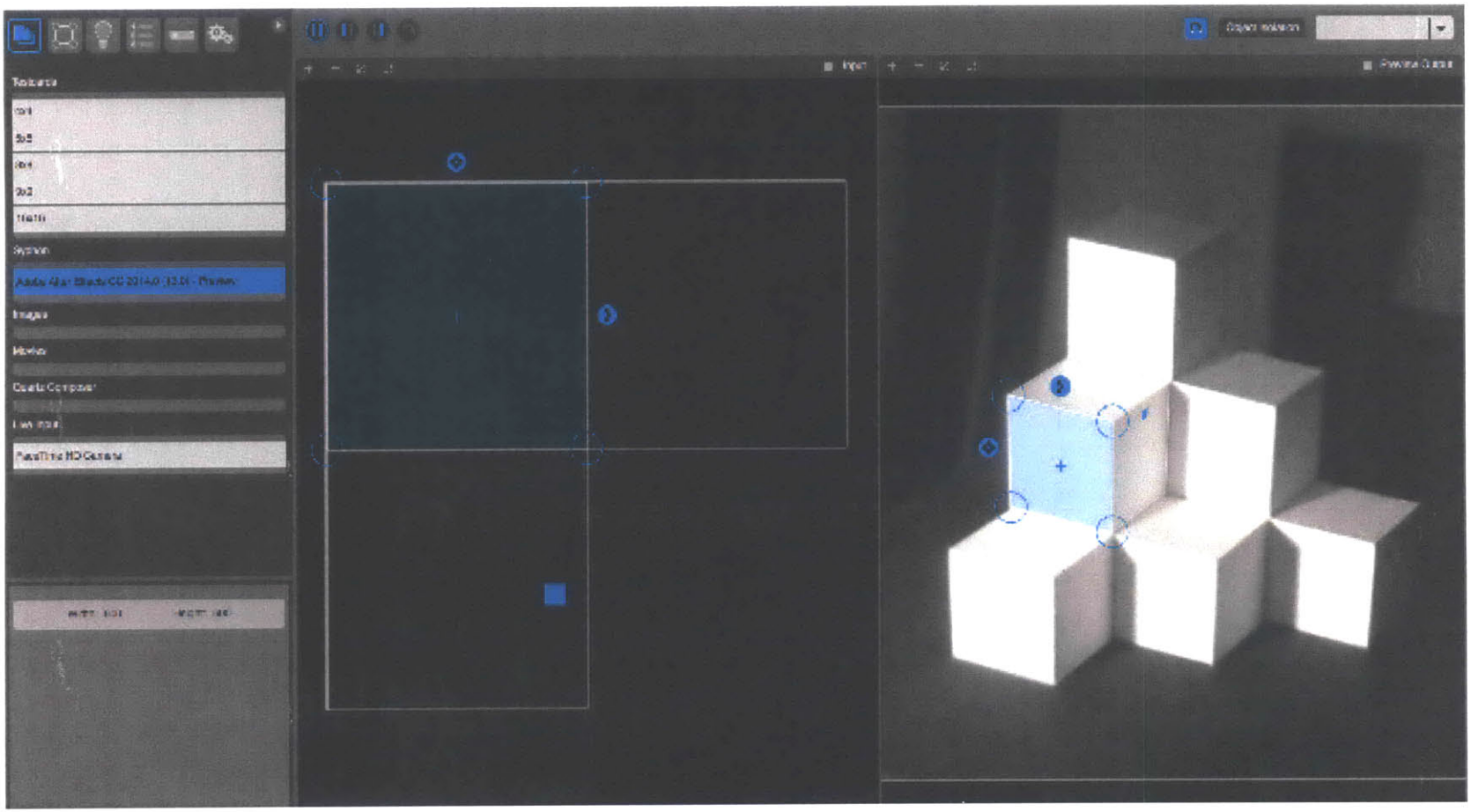


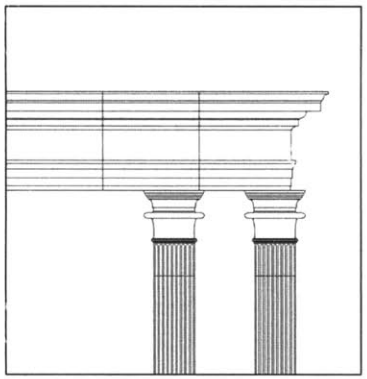
2-3 Progress Diary: Experiments

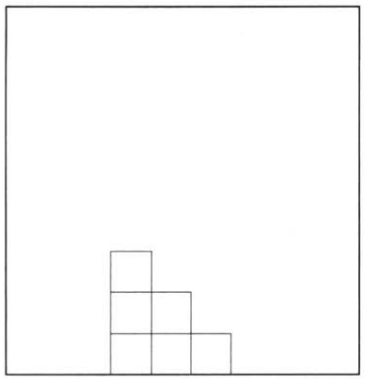
2-3-4 On the Models (stable lighting environments)

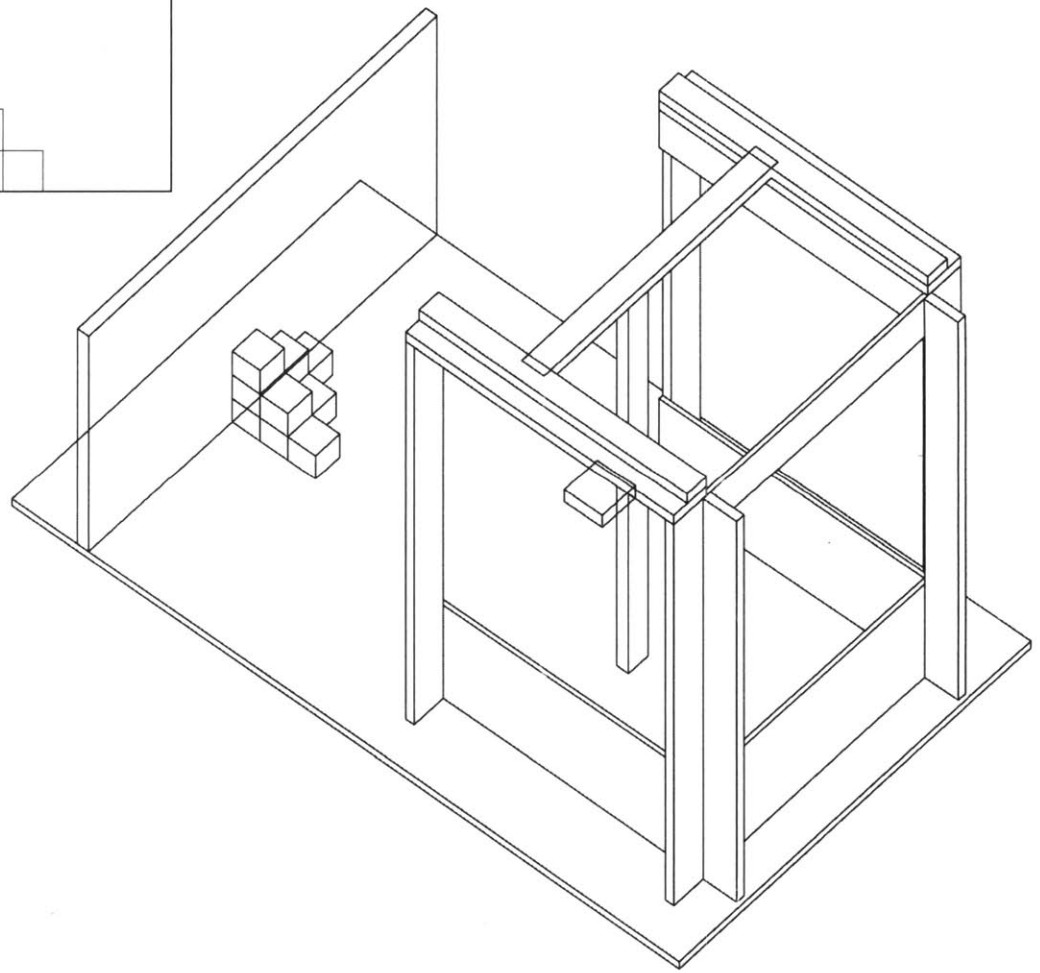


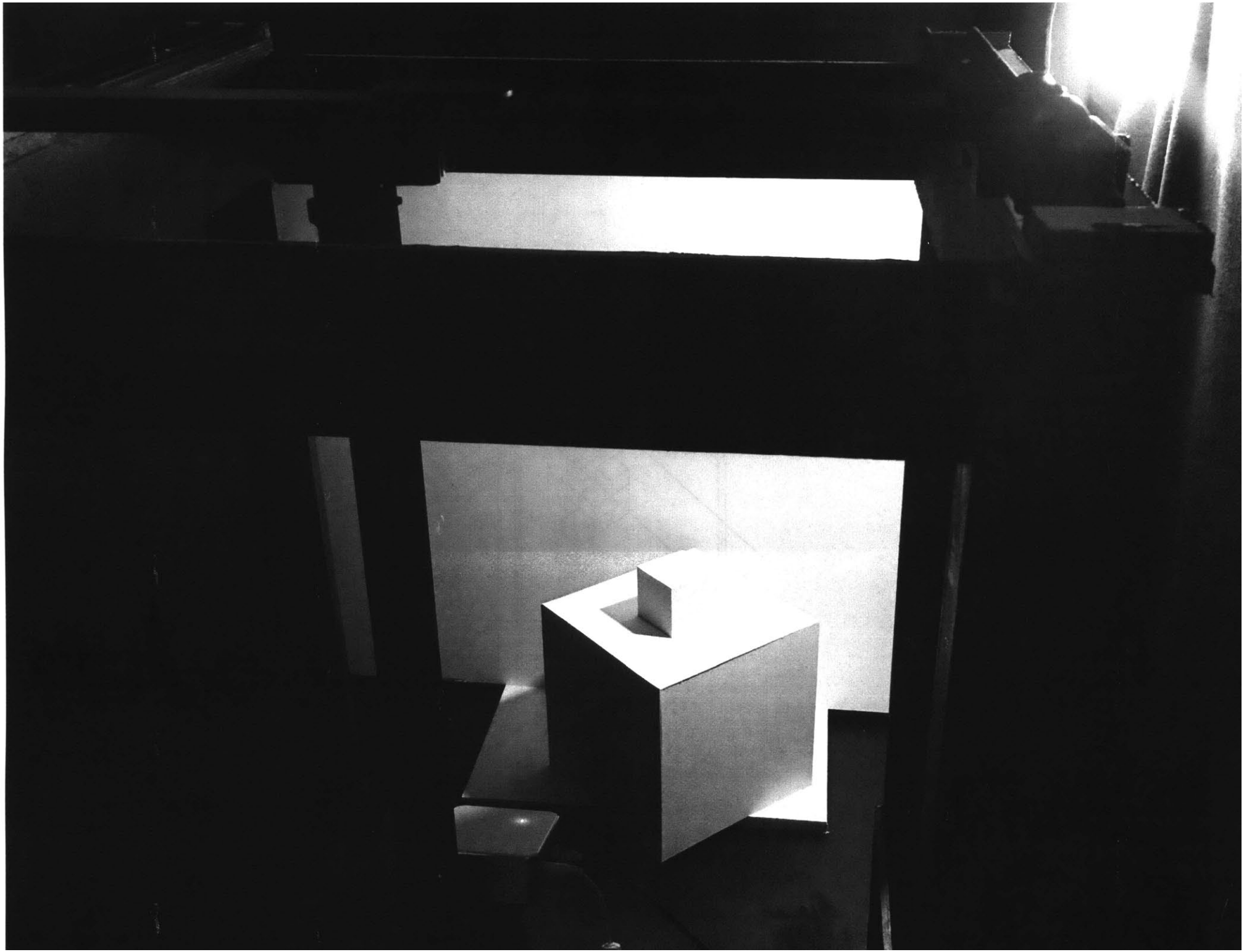
Small scale tests in an "ideal"/controlled environment











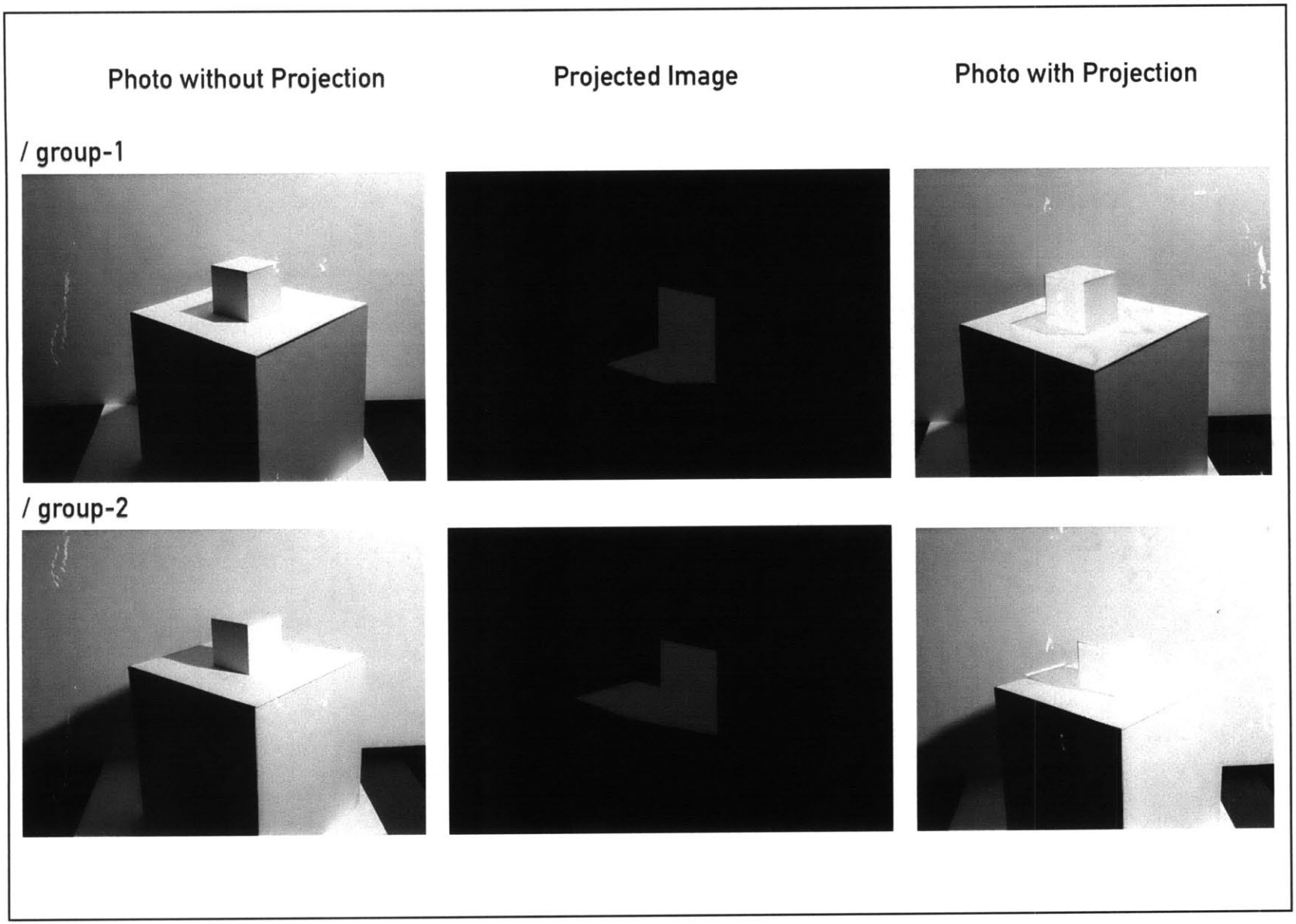
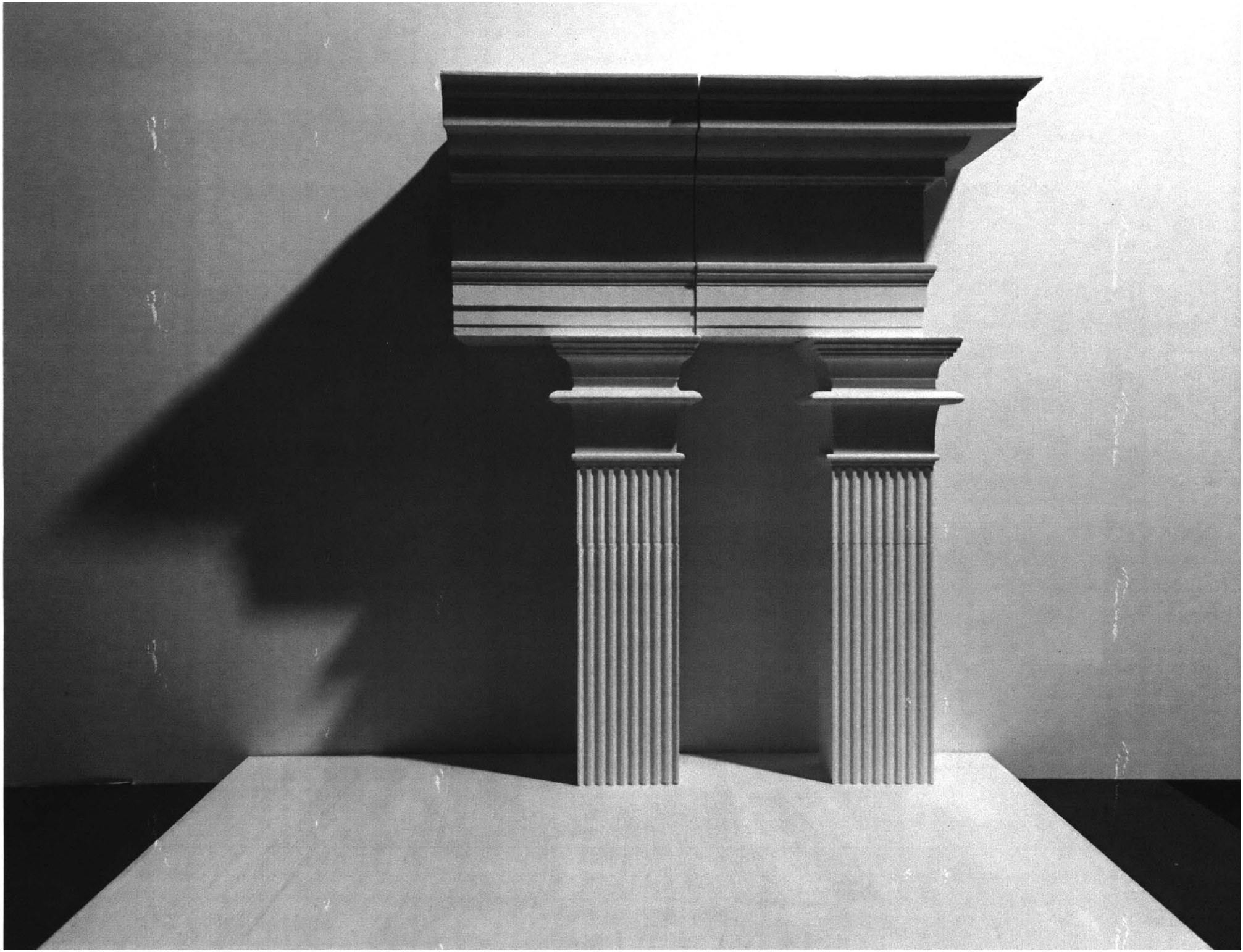
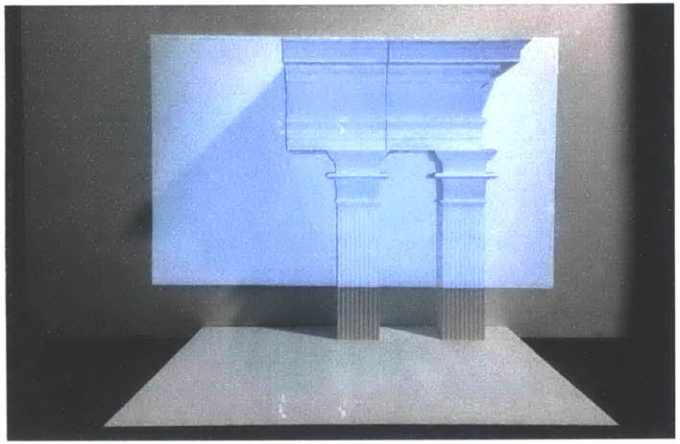


Photo without Projection
Projected Image
Photo with Projection
/ group-1
/ group-2

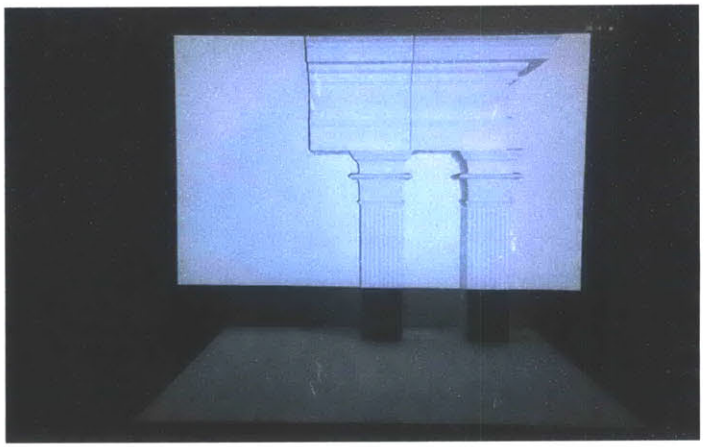


/ group-1

Projecting White Image with brighter ambient light

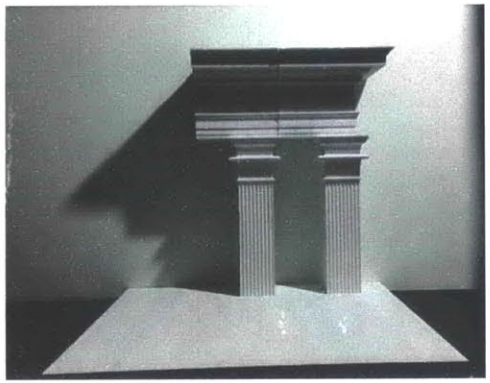


Projecting White Image with darker ambient light



/ group-2

Photo without Projection



Projected Image

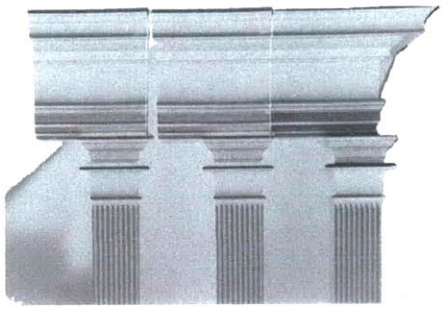
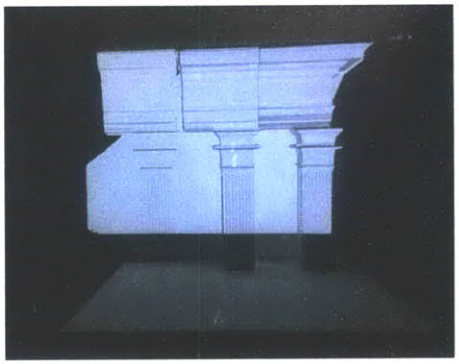
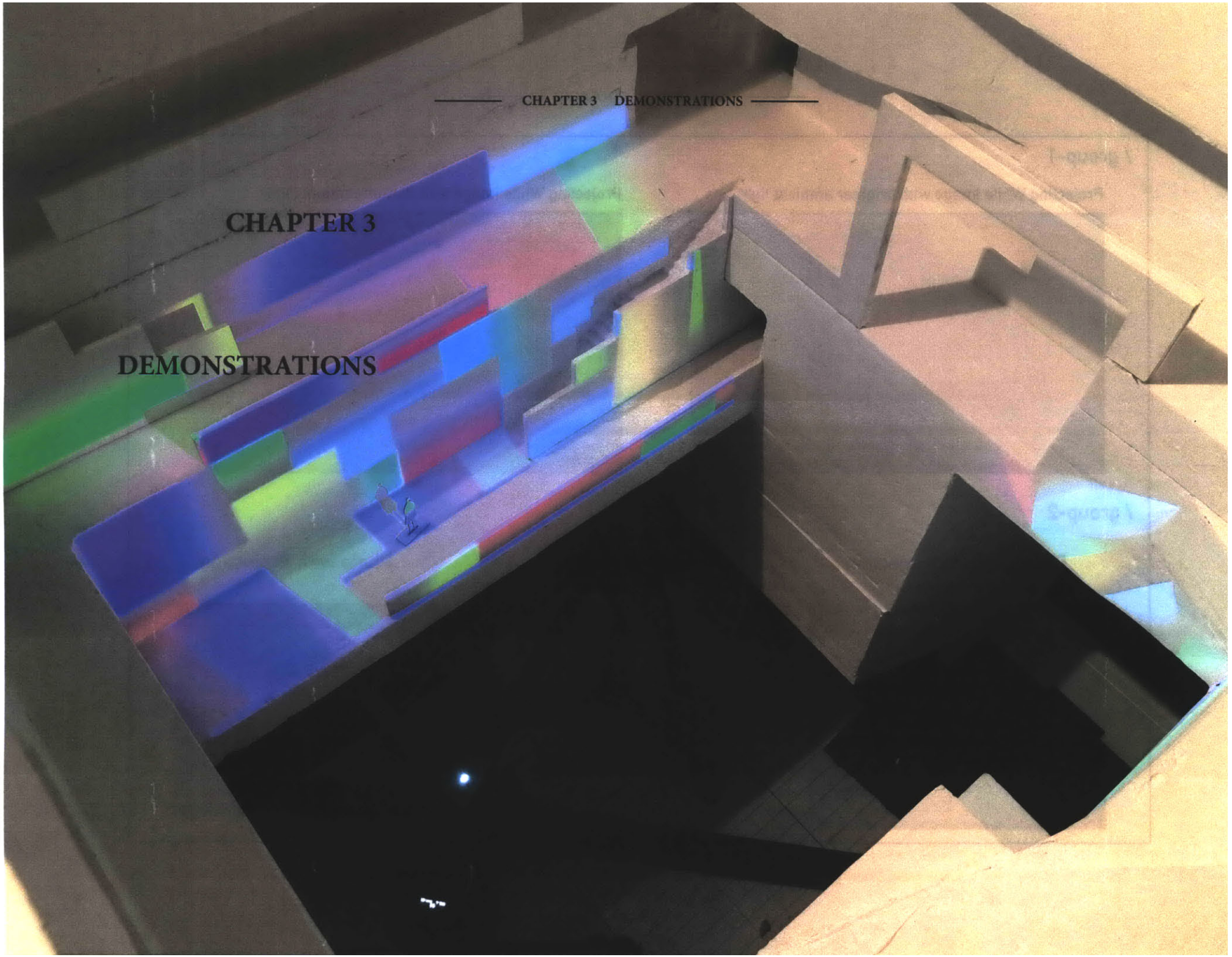


Photo with Projection



CHAPTER 3

DEMONSTRATIONS



CHAPTER 3

DEMONSTRATIONS

3-1 The Design of 1 to 30 Models and the Projections

3-1-1 Scale
3-1-2 Projectors
3-1-3 The sunlight
3-1-4 Remodeling and Fabrication

3-2 Technical Issues

3-2-1 Projectors as an android device
3-2-2 Logistics: image formatting and workflow
3-2-3 Sync between projectors: website as end controller

3-3 The System

3-4 The Projection Show

3-5 Notes on Design of the Projected Images/ Videos

3-1 The Design of 1 to 30 Models and the Projections

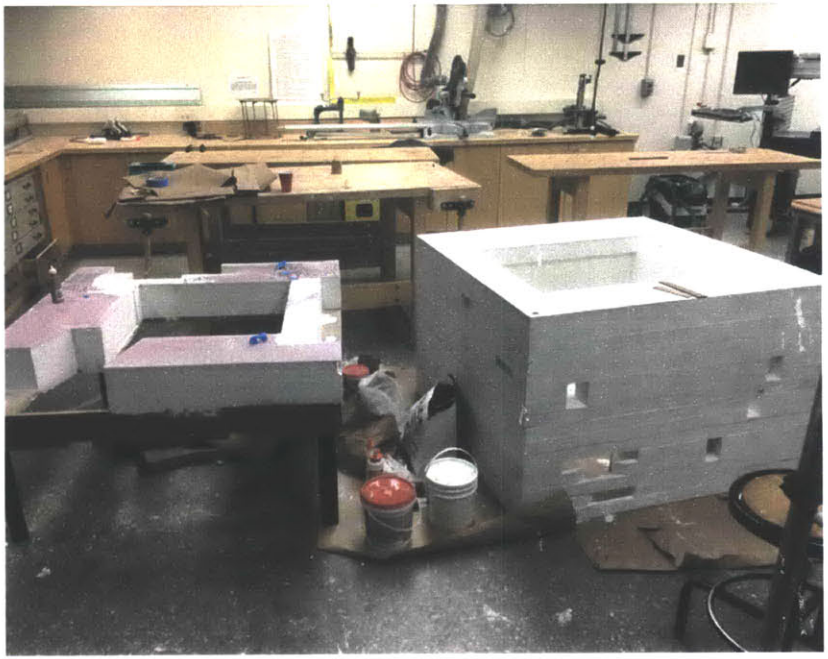
3-1-1 Scale (1:30)
3-1-2 Projectors

Ivation Pro3 Portable Rechargeable Smart DLP Projector - Streams via HDMI/MHL & USB connections, Wi-Fi, Bluetooth - Compatible with DLNA, Miracast, Airplay Wireless Mirroring for iOS & Android

3-1-3 The "sunlight"

Within this scaled model, the "sunlight" is replaced by a light bulb, which provides stable light condition for testing purpose.

3-1-4 Remodeling and Fabrication



3-2 Technical Issues

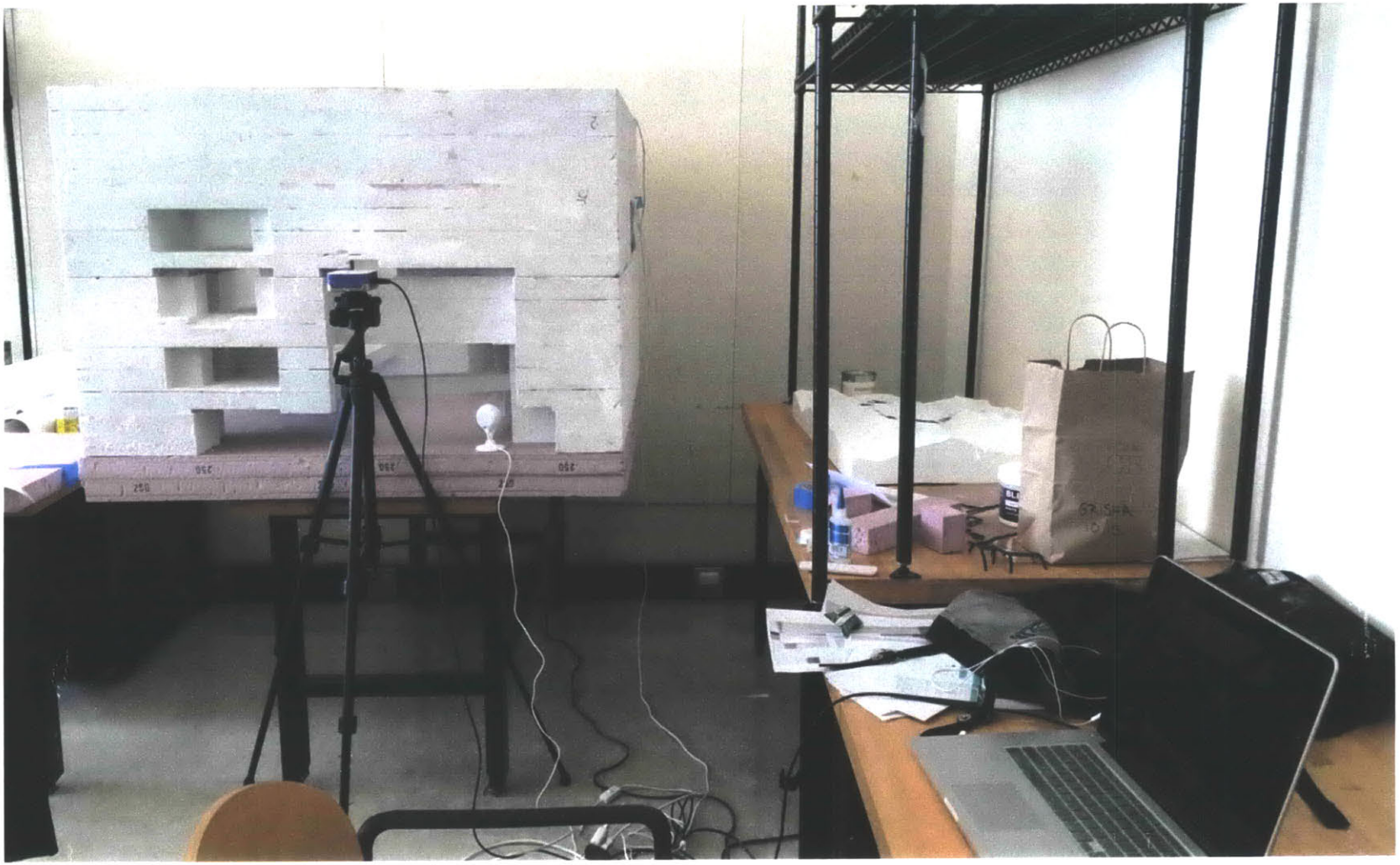
3-2-1 Projectors as an android device

Ivation Pro3 Portable Rechargeable Smart DLP Projector - Streams via HDMI/MHL & USB connections, Wi-Fi, Bluetooth - Compatible with DLNA, Miracast, Airplay Wireless Mirroring for iOS & Android

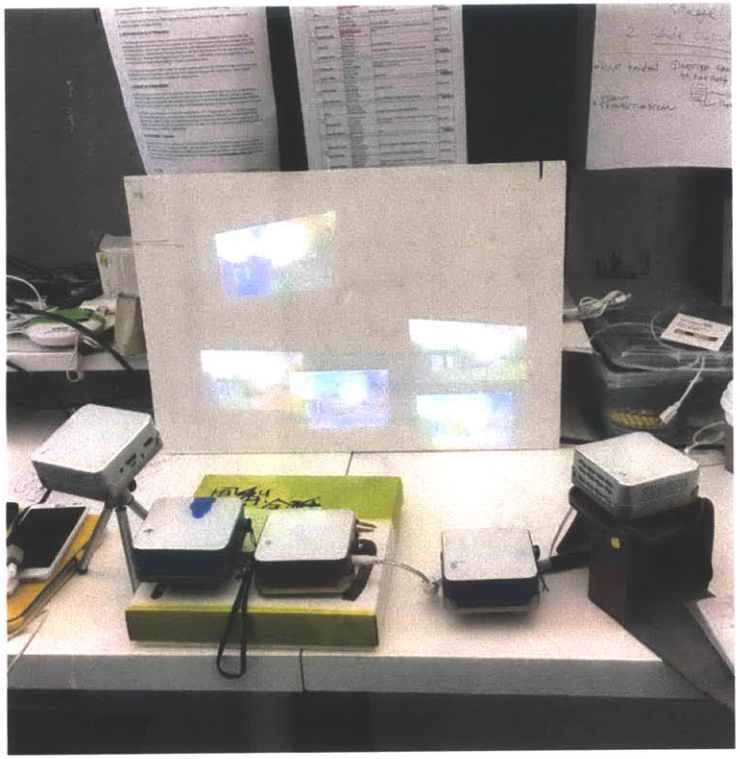
Seamlessly Streams & Projects All Your Videos, Photos, Slide Presentations & More
Supports USB, HDMI/MHL, Wi-Fi, Bluetooth, DLNA, & Wireless iOS/Android Mirroring
Self-Contained Setup w/Rechargeable Battery, Speaker & Remote/App Control
Built-in Android 4.4 OS with 4GB Storage Supports Apps for Added Functionality
Premium Leather Case with Easel Converts Into Platform to Set & Raise Projector

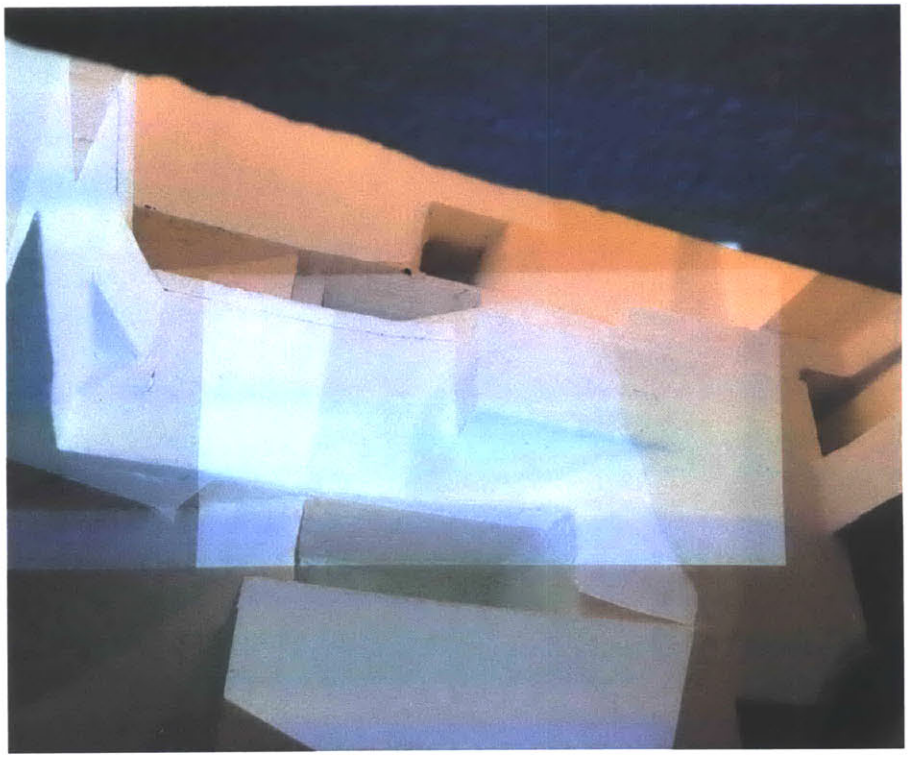
http://www.amazon.com/gp/product/B0141DTBD8?psc=1&redirect=true&ref_=oh_aui_detailpage_o05_s00

3-2-2 Logistics: image formatting and workflow

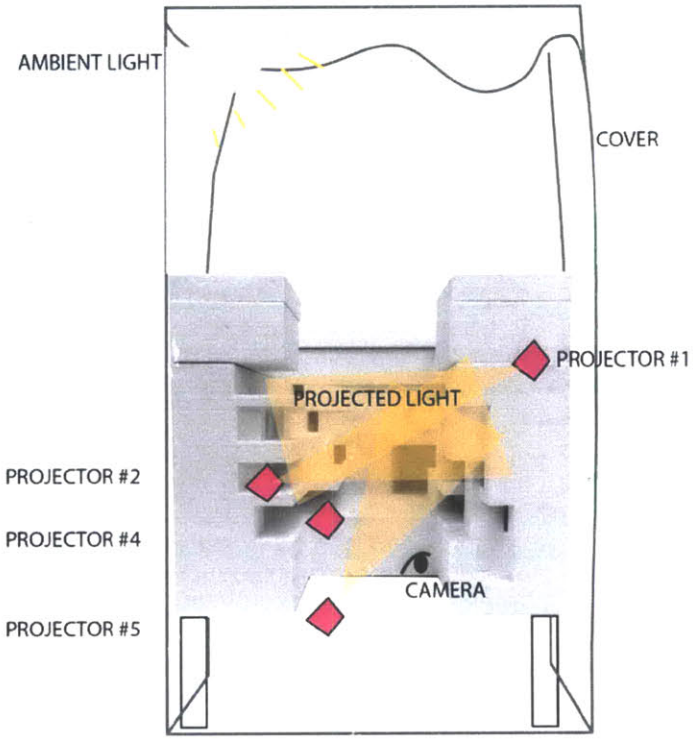


// Stage 1_Set Up the Projectors

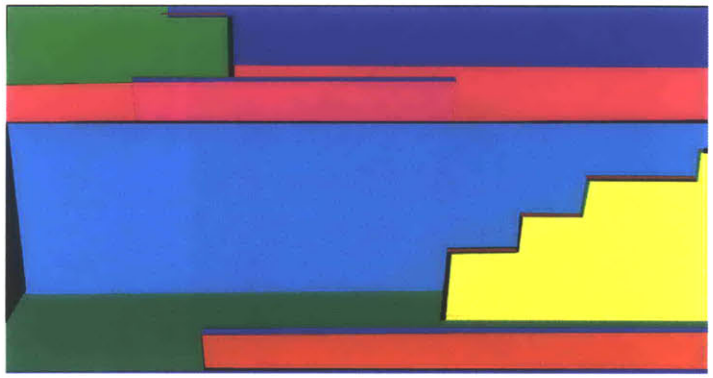


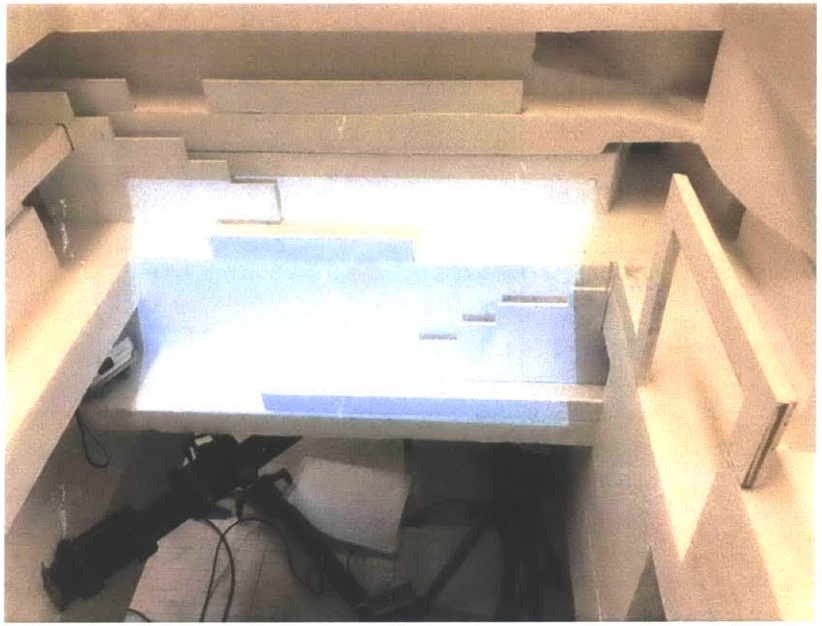


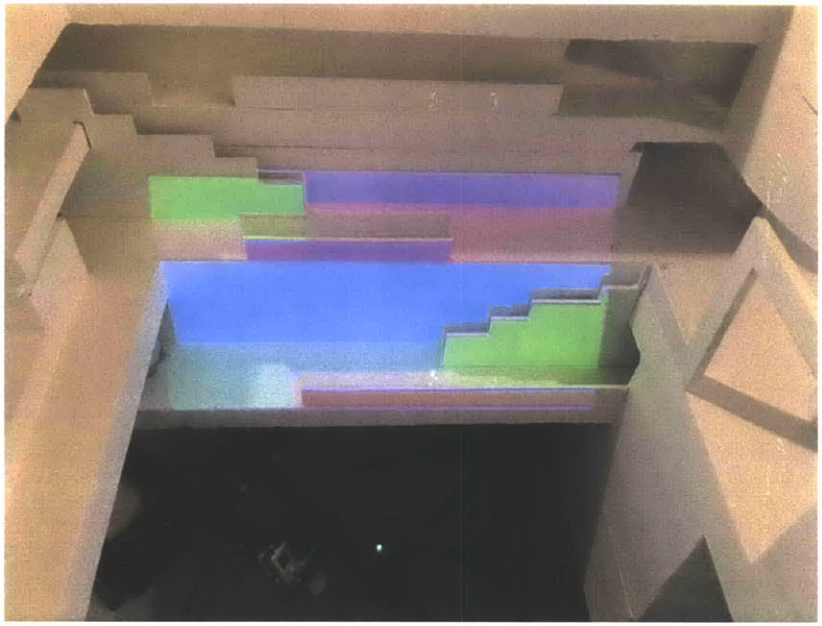
// Stage 2_Set Up the "Stage" Model and Fix the Projectos in Place



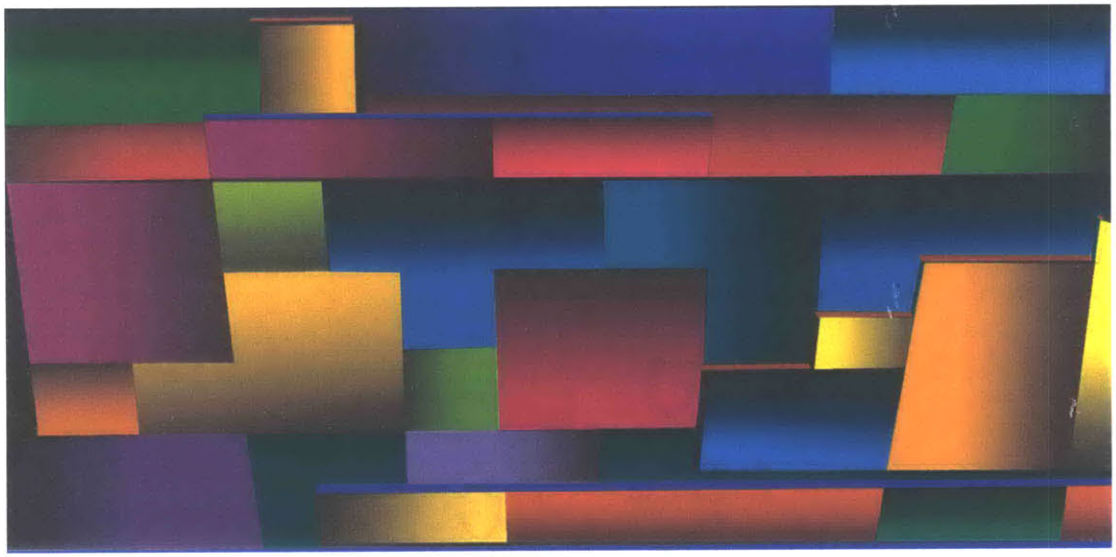
// Stage 3_Set Up the Templates (Here I am using Projector #1 as example)

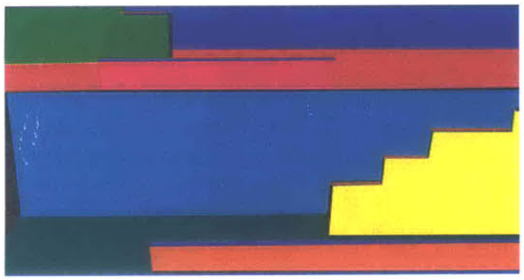


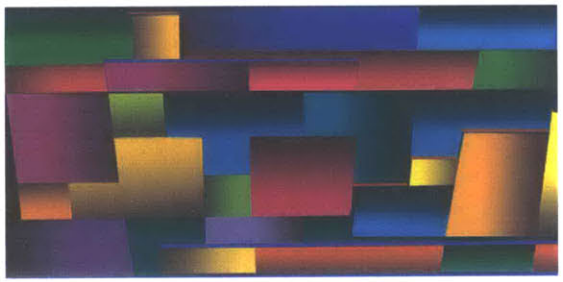




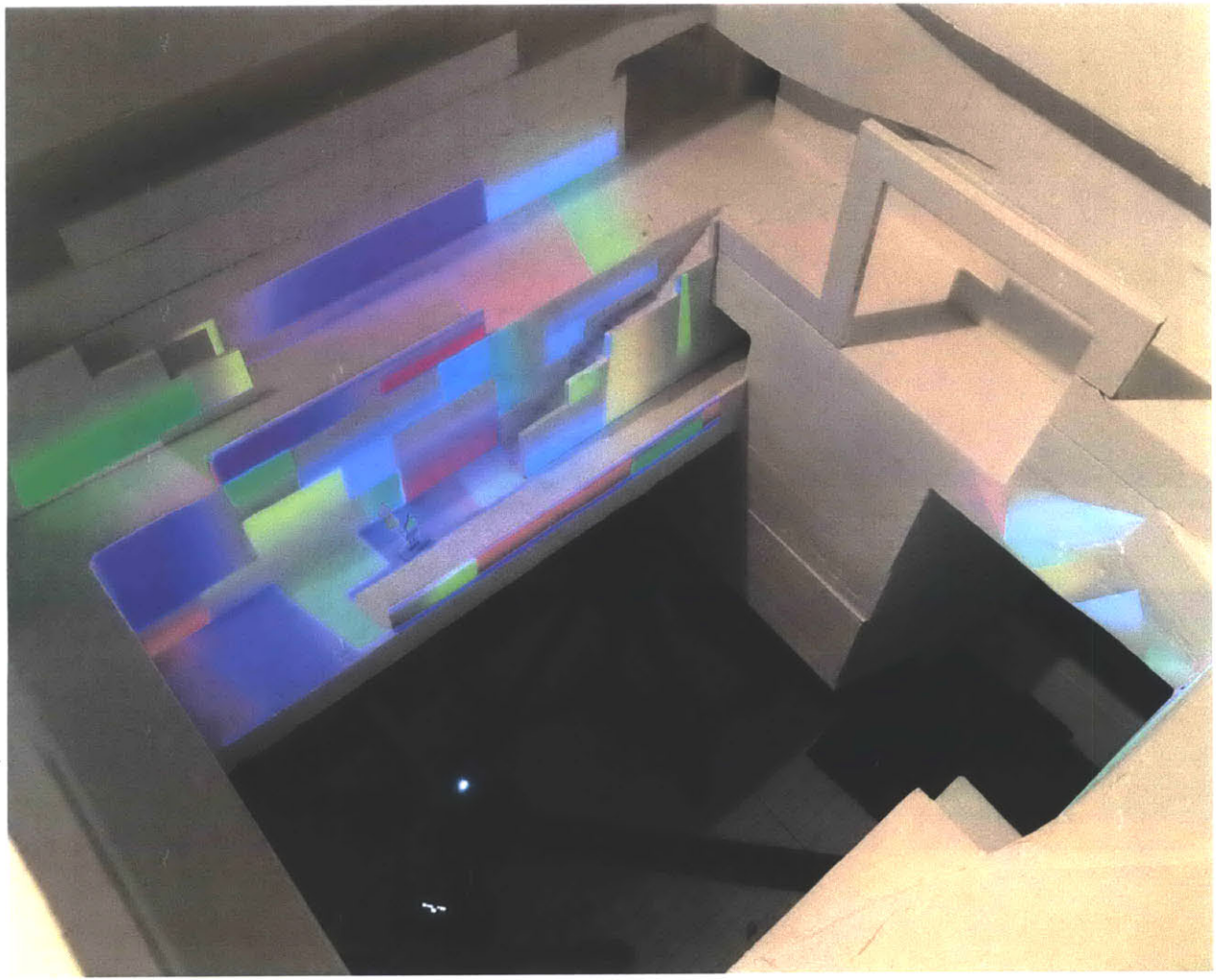
// Stage 4_Replace the template with designed image/video
and Upload to Projector #1



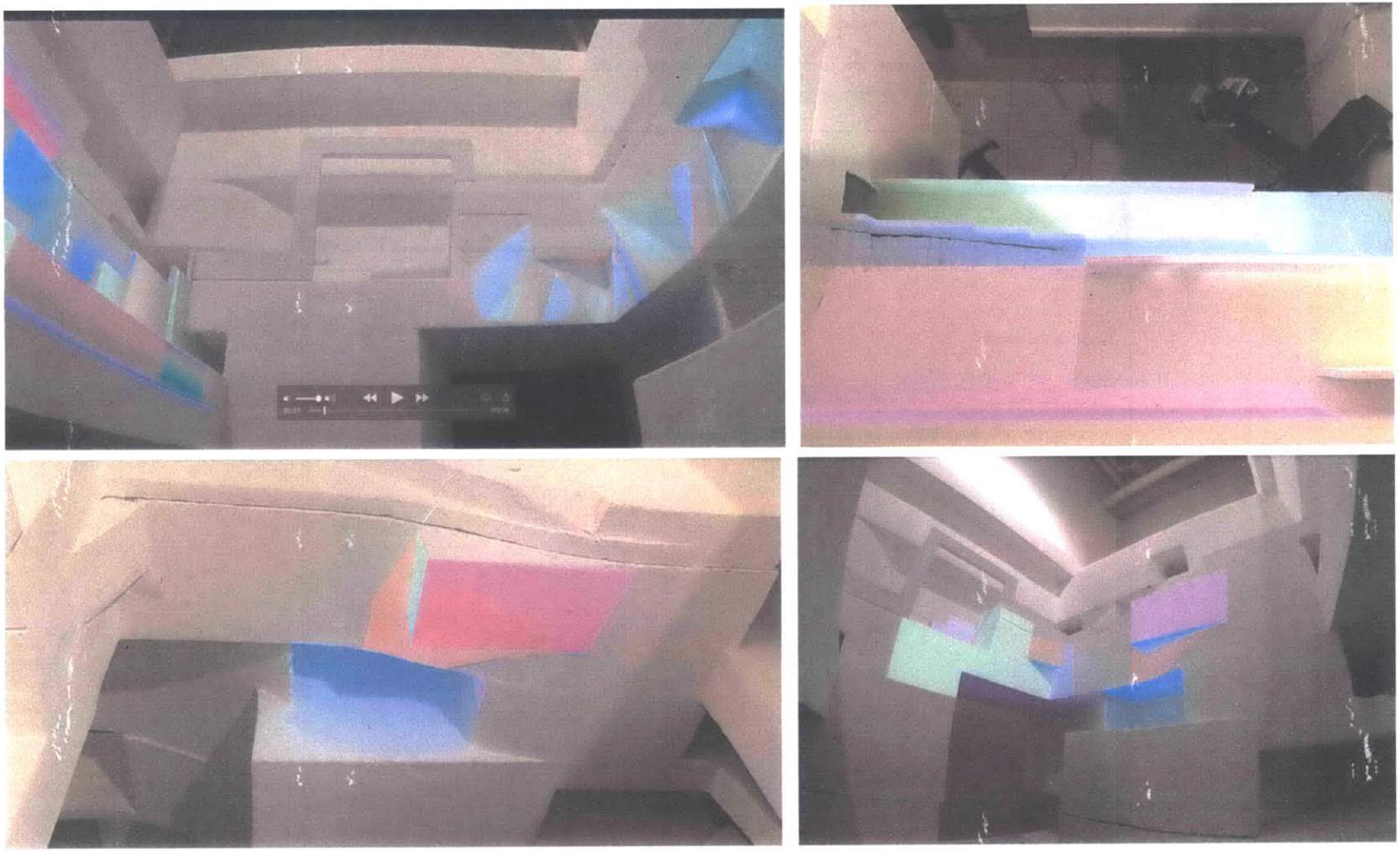




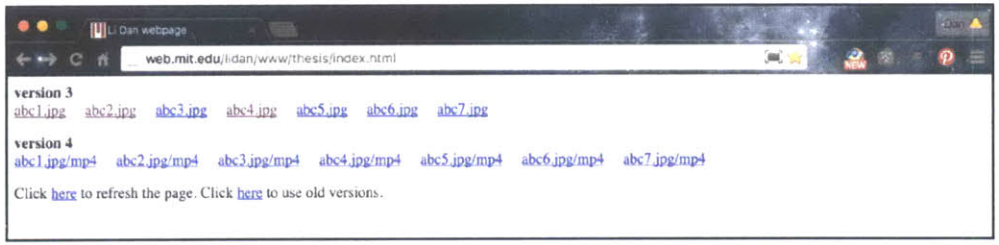
// Stage 5_Projecting and Documentation



From other viewpoints

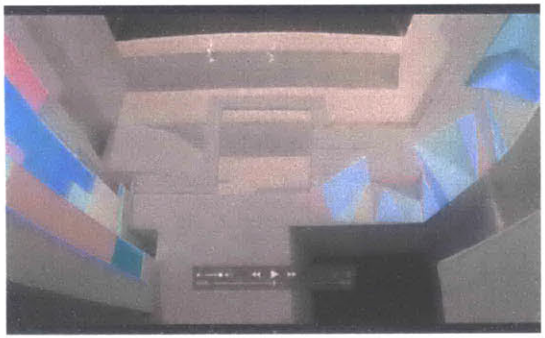


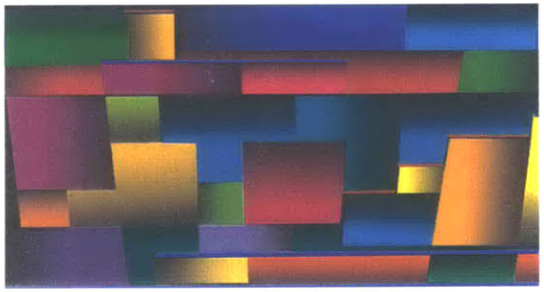
3-2-3 Sync between projectors: website as end controller

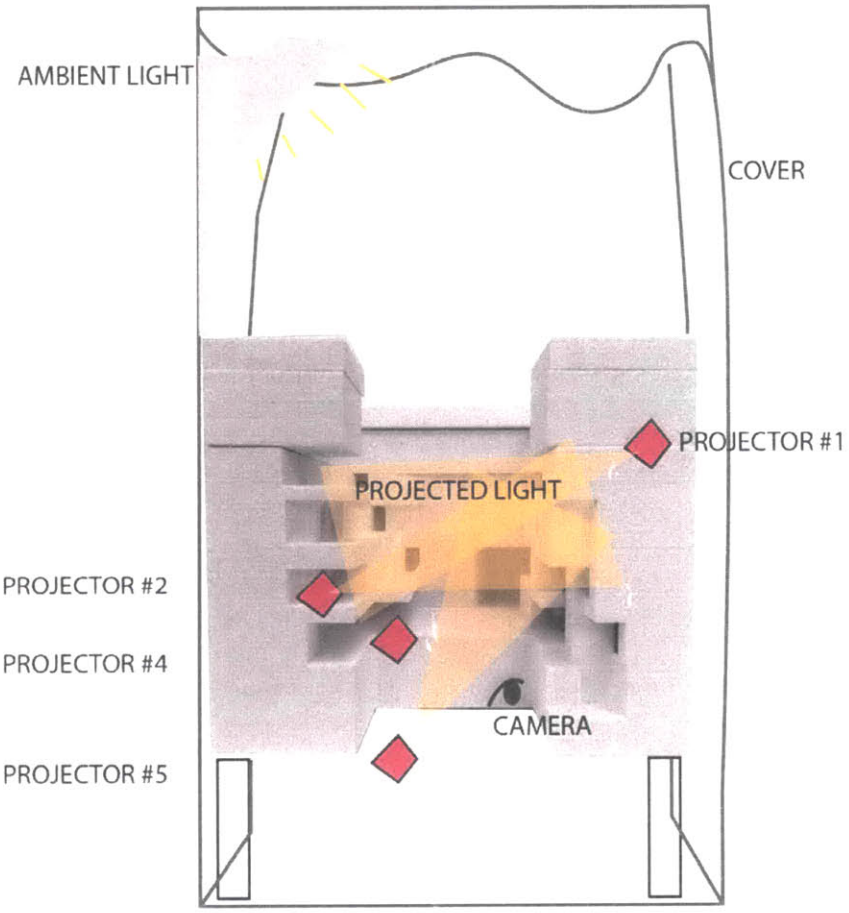


*Takehiko has helped me to build this Website.

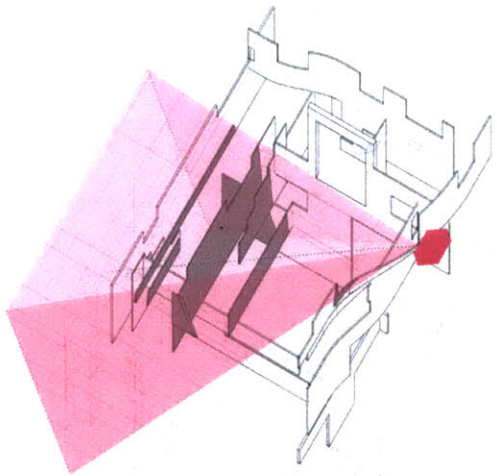
3-3 The System

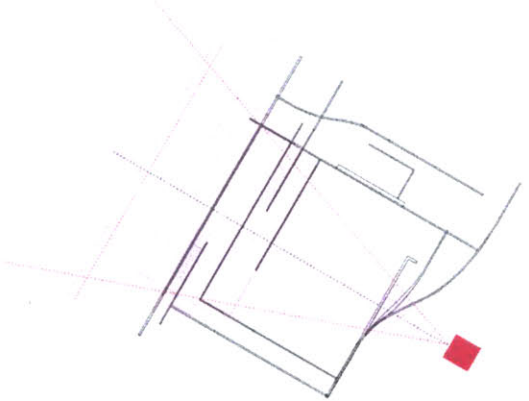






PROJECTOR #1





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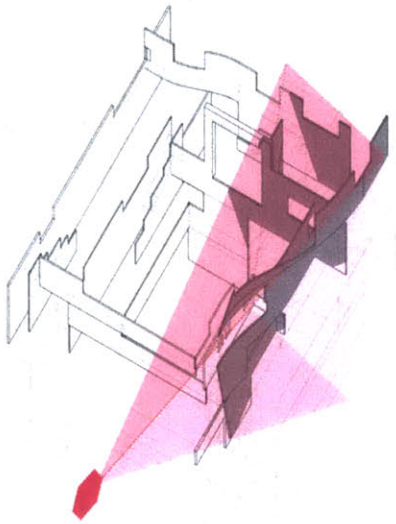

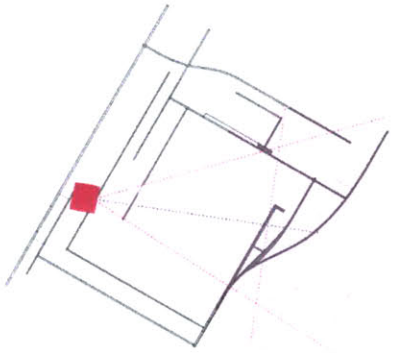

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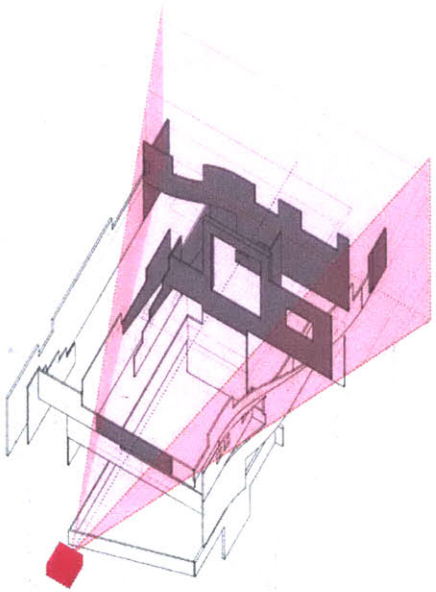
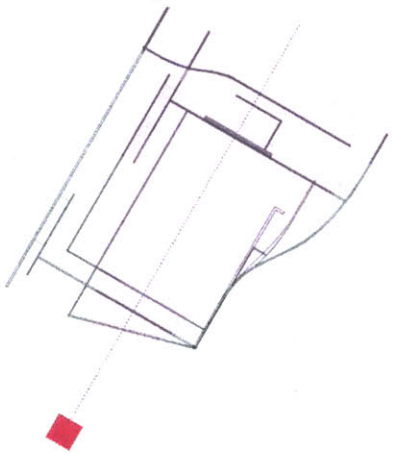
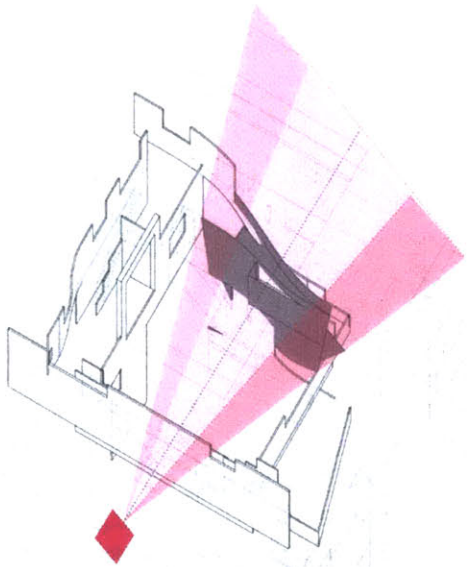
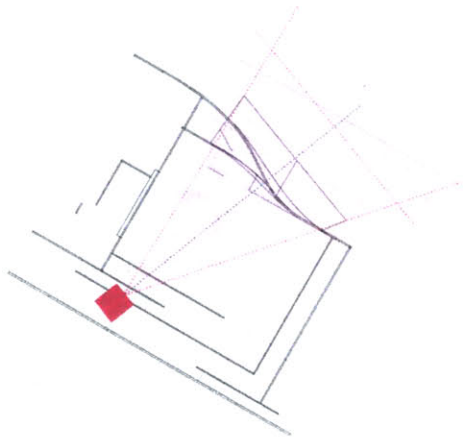


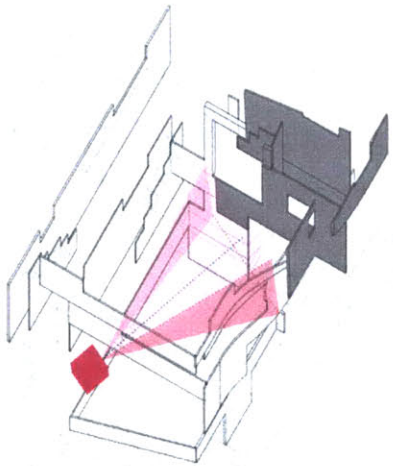


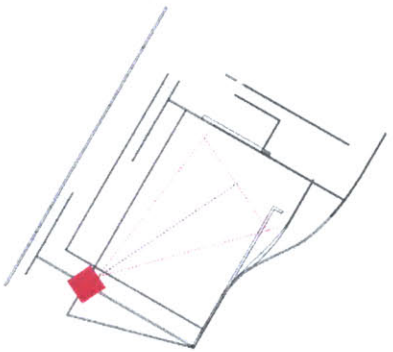




PROJECTOR #4

PROJECTOR #5





3-4 The Projection Show

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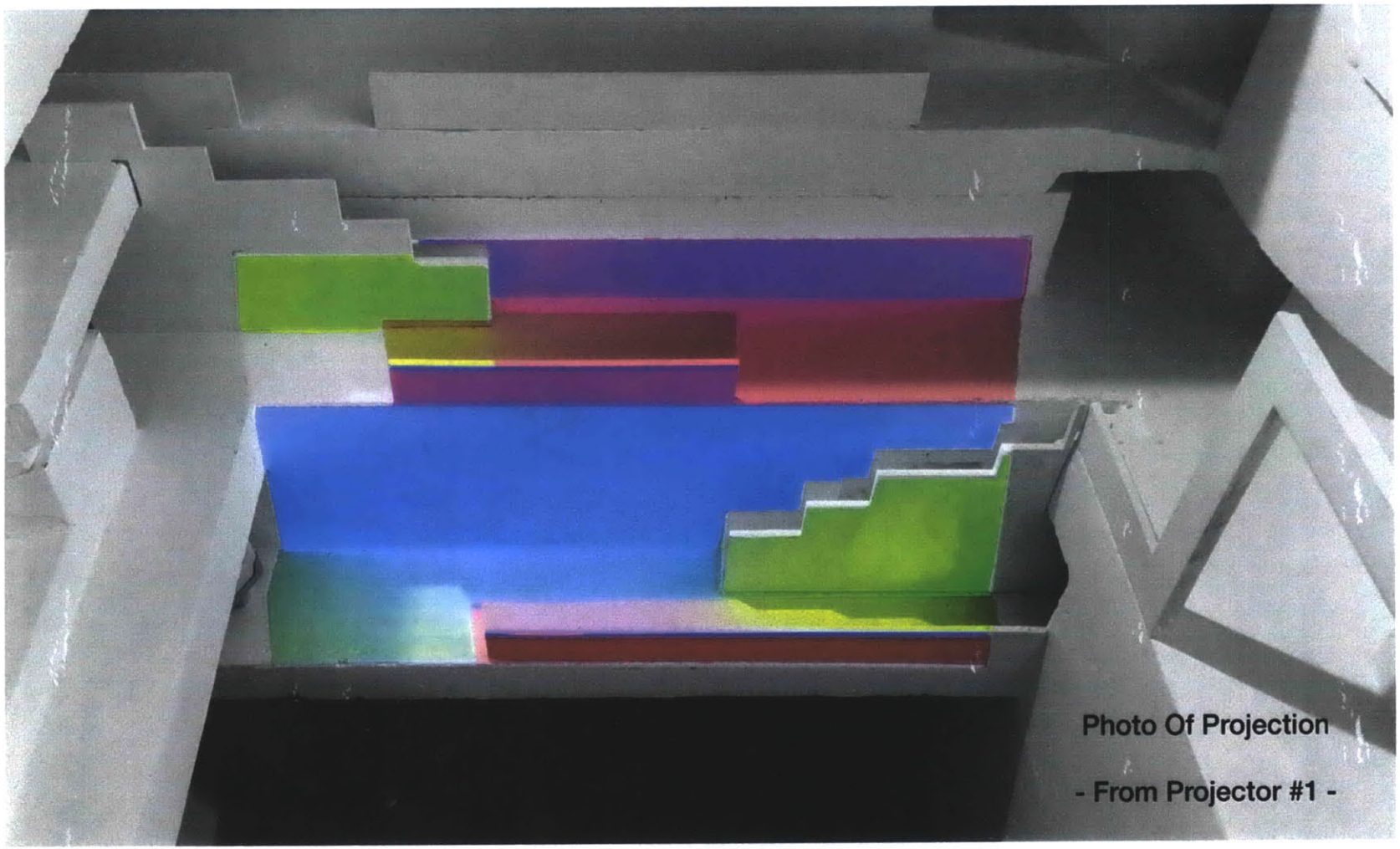


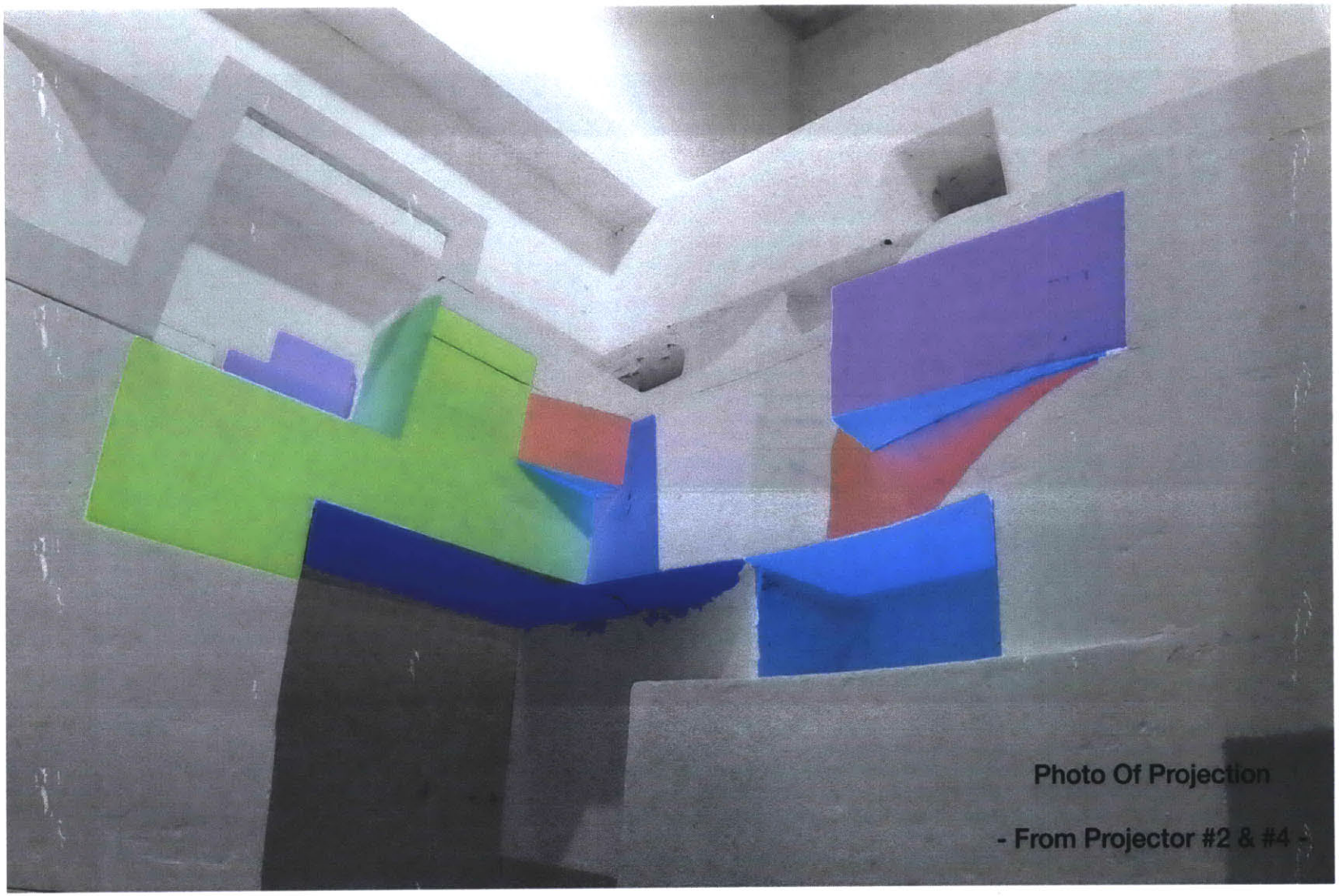


Photo Of Projection
- From Projector #2 & #4 -

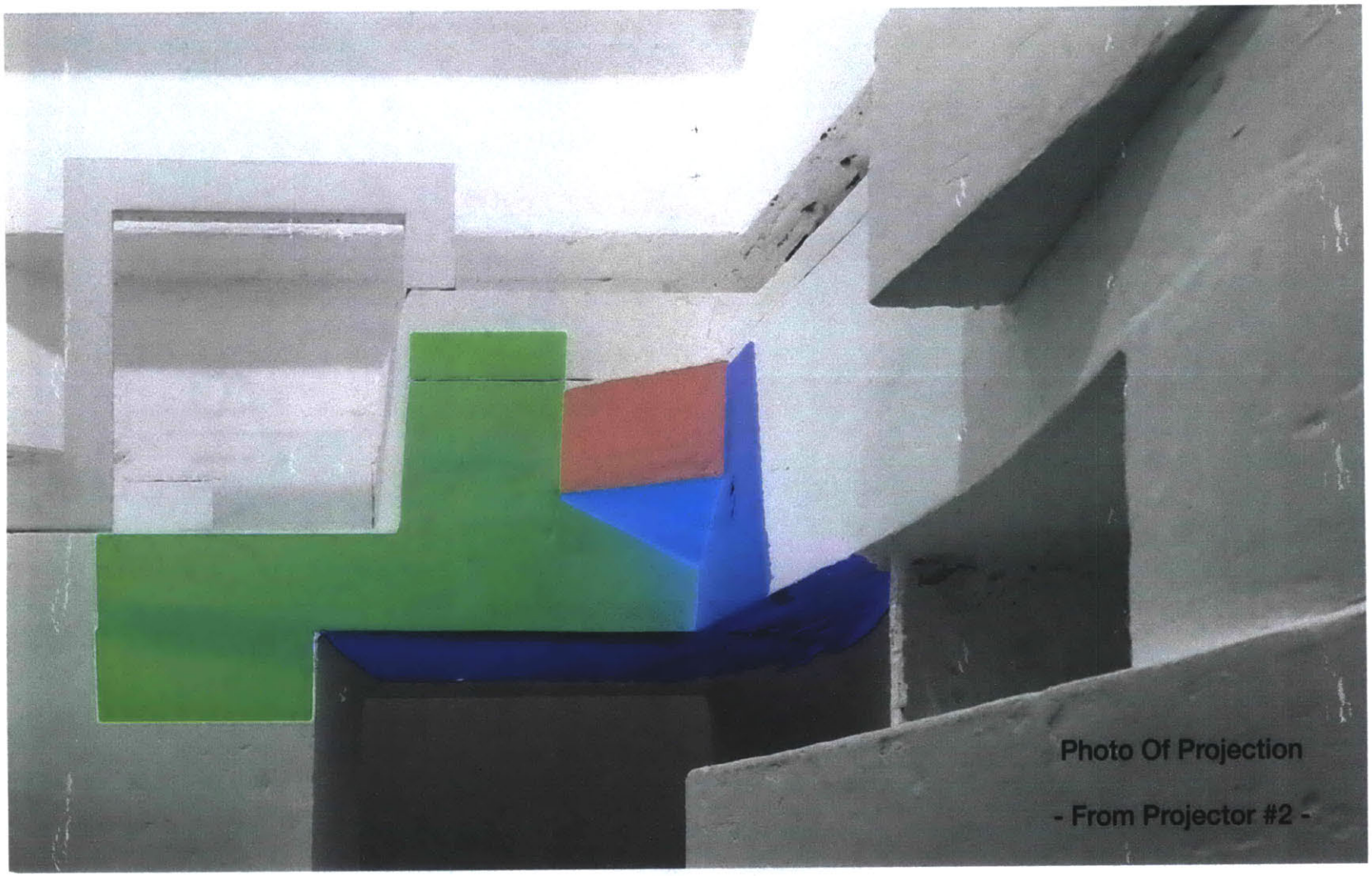
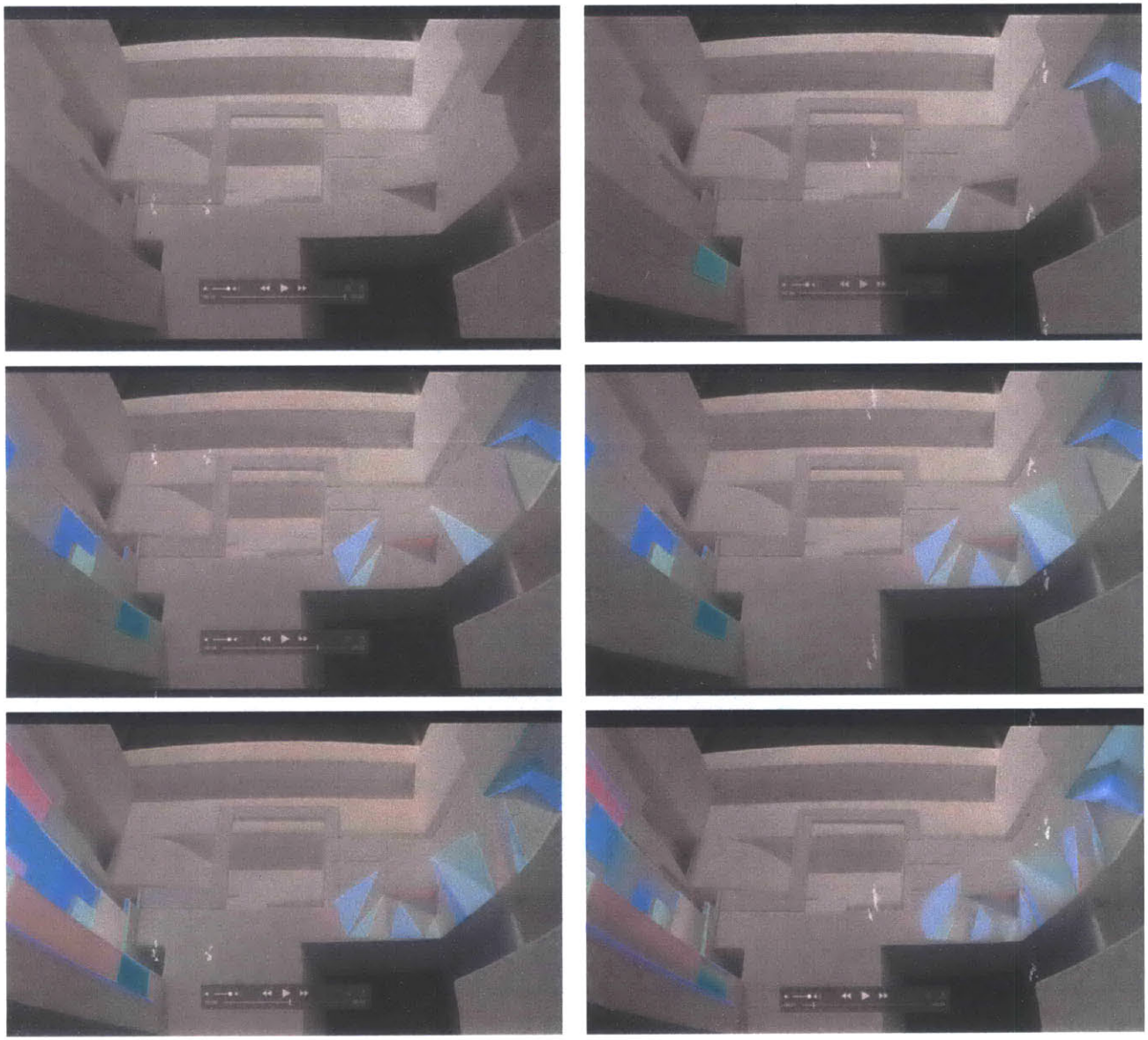


Photo Of Projection
- From Projector #2 -

Photo Of Projection
- From Projector #4 -

//2



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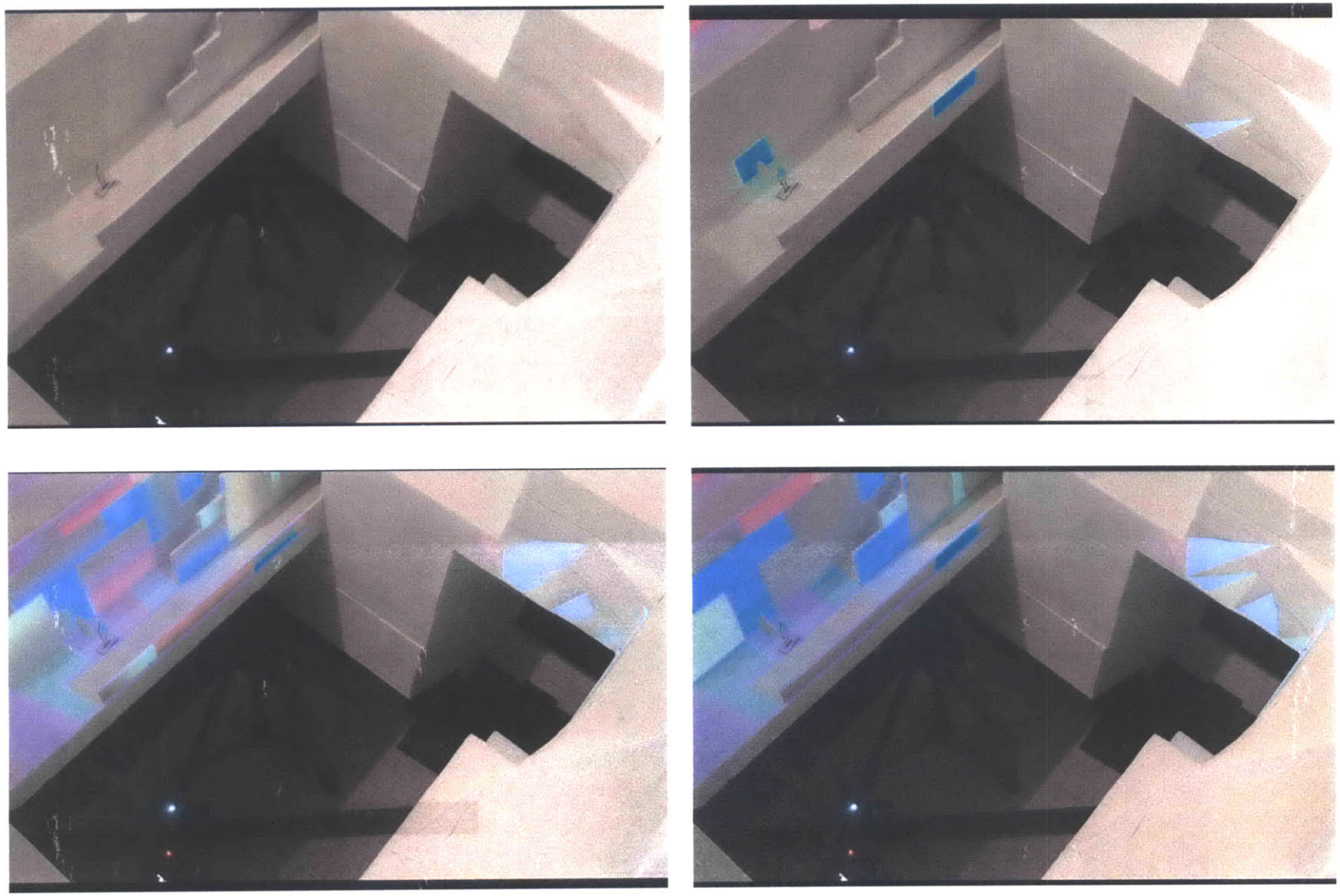

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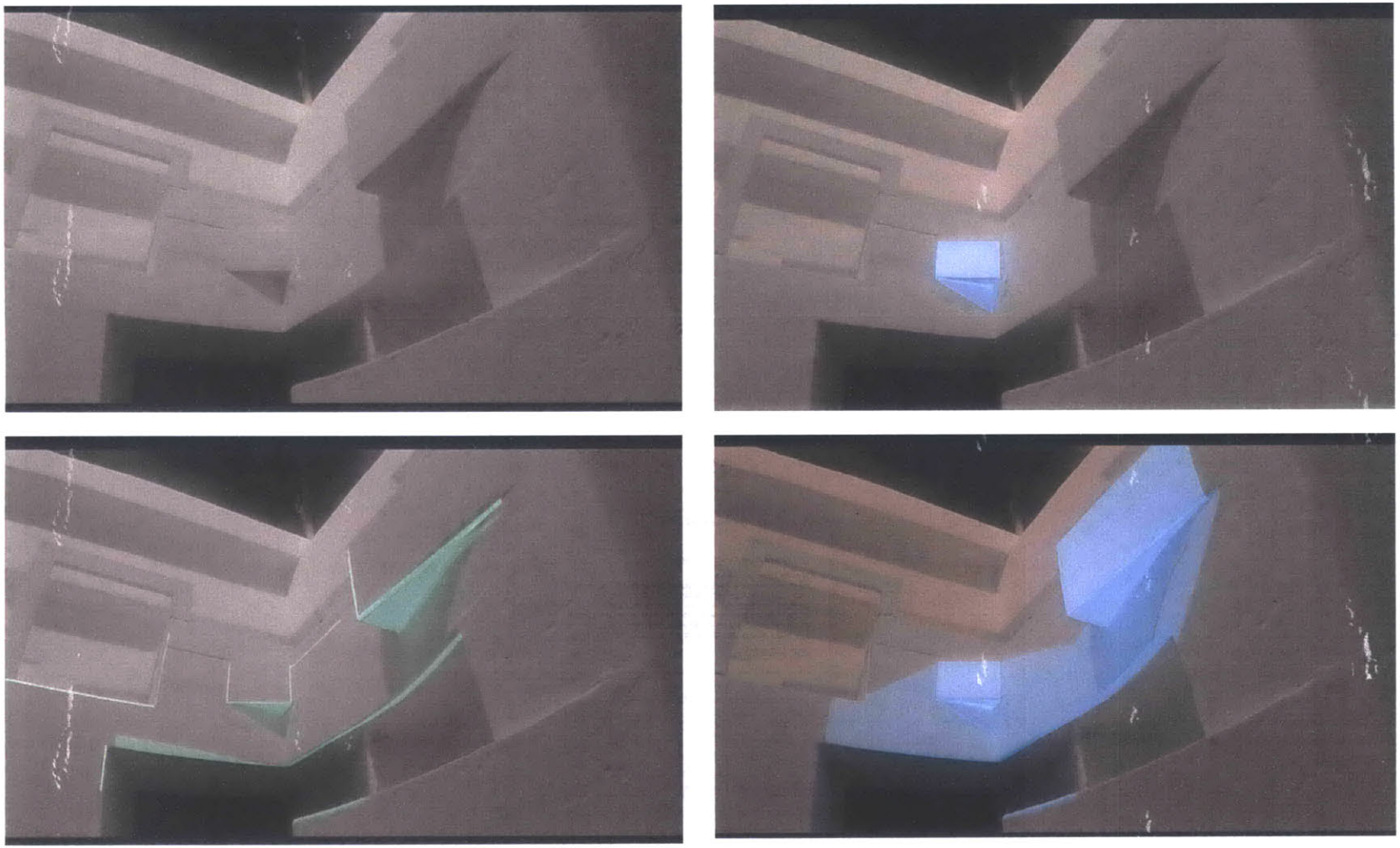
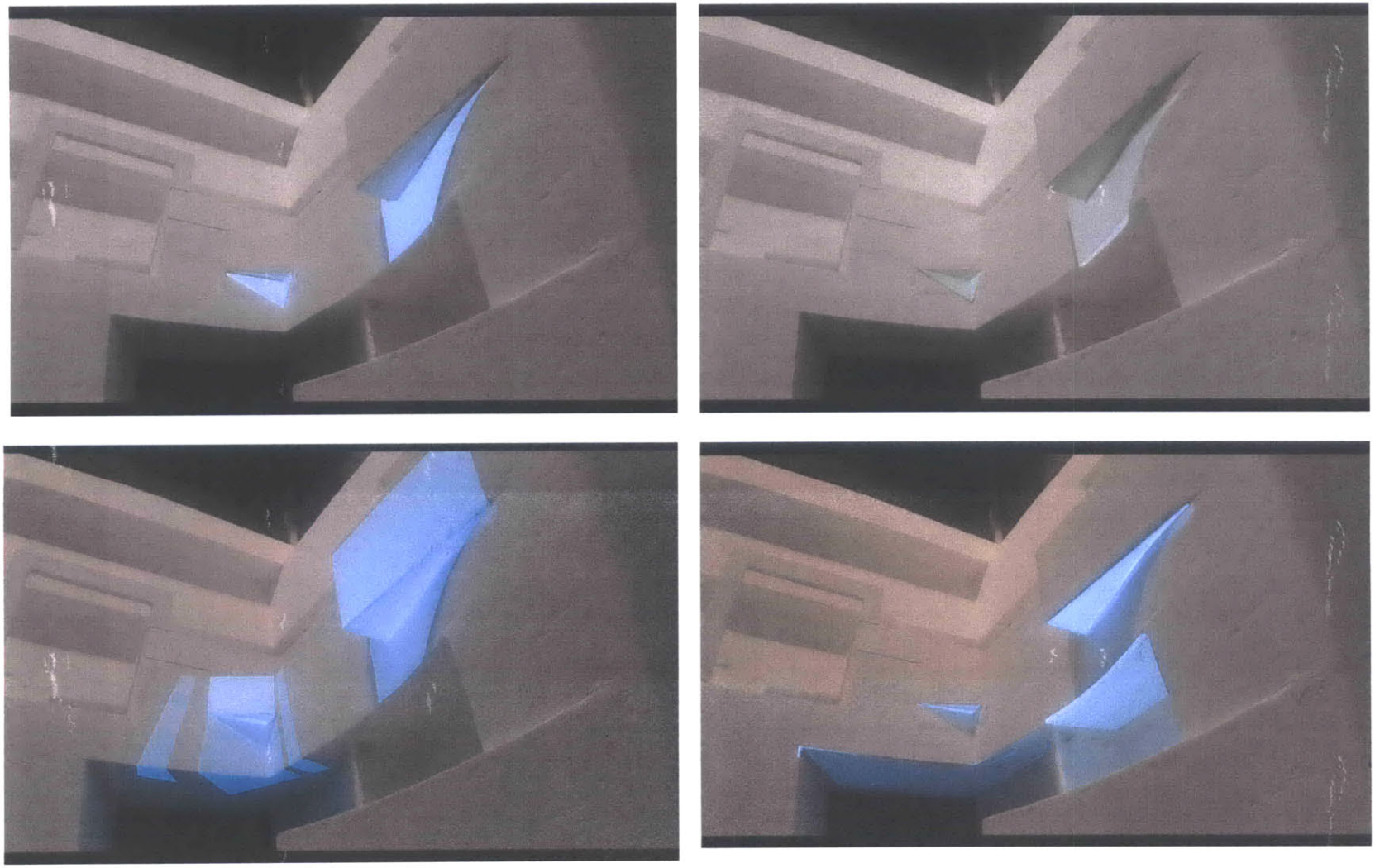
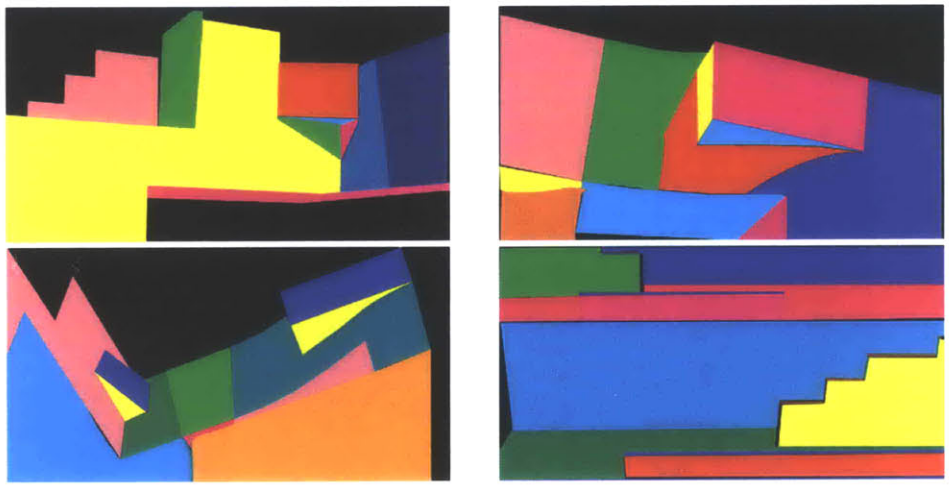




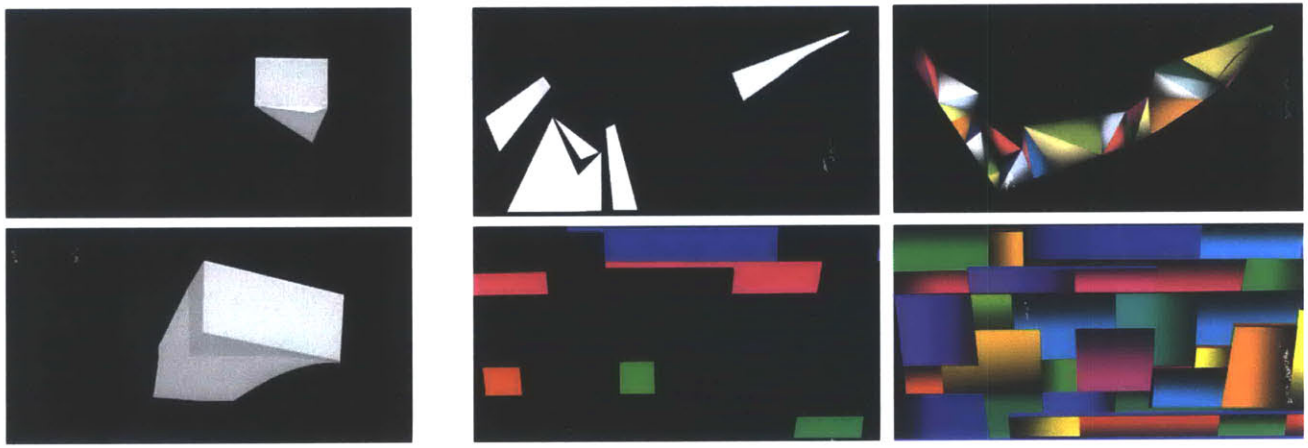
3-5 Design of the Projected Images/ Videos

Templates for Each Projectors



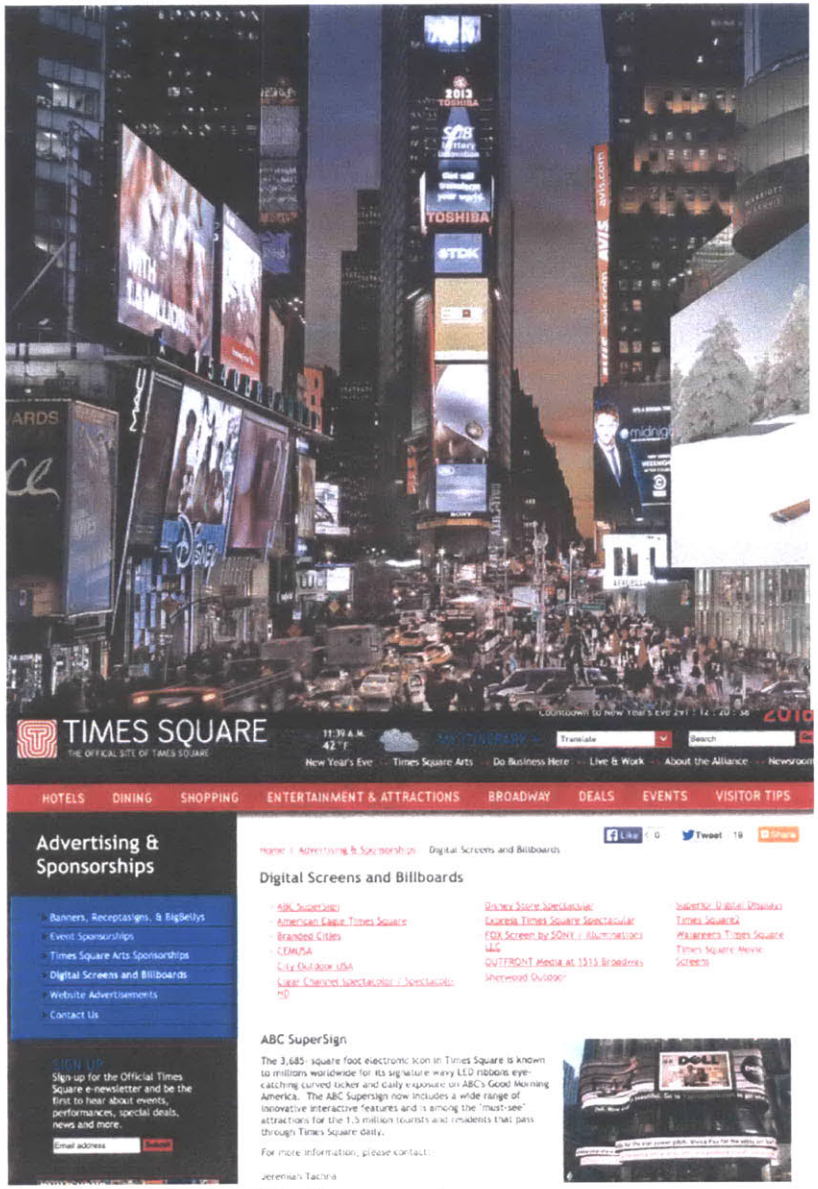
From Templates to Design:

Examples of Projected Images



CHAPTER 4

FURTHER DISCUSSION AND CONCLUSIONS



Above: The billboards in Times Square, NY. **http://timesquarenyc.org/**

CHAPTER 4

FURTHER DISCUSSION AND CONCLUSIONS

4-1 The Question of Agency: Who Has the Power to Use This Tool?

A toolkit will not produce anything without users. However, the question of who has the power to use this tool, especially in a public space, matters. One initial idea was to provide new opportunities for people to create spatial art projects. In this way, the social/ political voice will be "published", if there is any in the art project, in a more delicate and subtle way.

4-2 What Will You Choose to Project?

What we are consistently encounter everyday are series of scenes. It can be interior space that are holding a special event; It can also just be street corners or the dime corridor. No matter whether you are on your daily routine or are attending a special event, you always encounter a series of scenes. Probably you spend more time with that building facade outside the office window more than your significant other. Or the everlasting dime corridor where you talk with your colleagues knows most of the gossips. These micro environments are "the opportunities" to be programed with projection mapping.

4-3 To Be Continued

I will be exploring this topic in several directions: 1. the technology and usage development; 2. the recipient site of such projections which are subsequently transformed, augmented, etc., and 3. the potential of a paradigmatic change in design systems between the 2d and 3d.

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APPEDIX

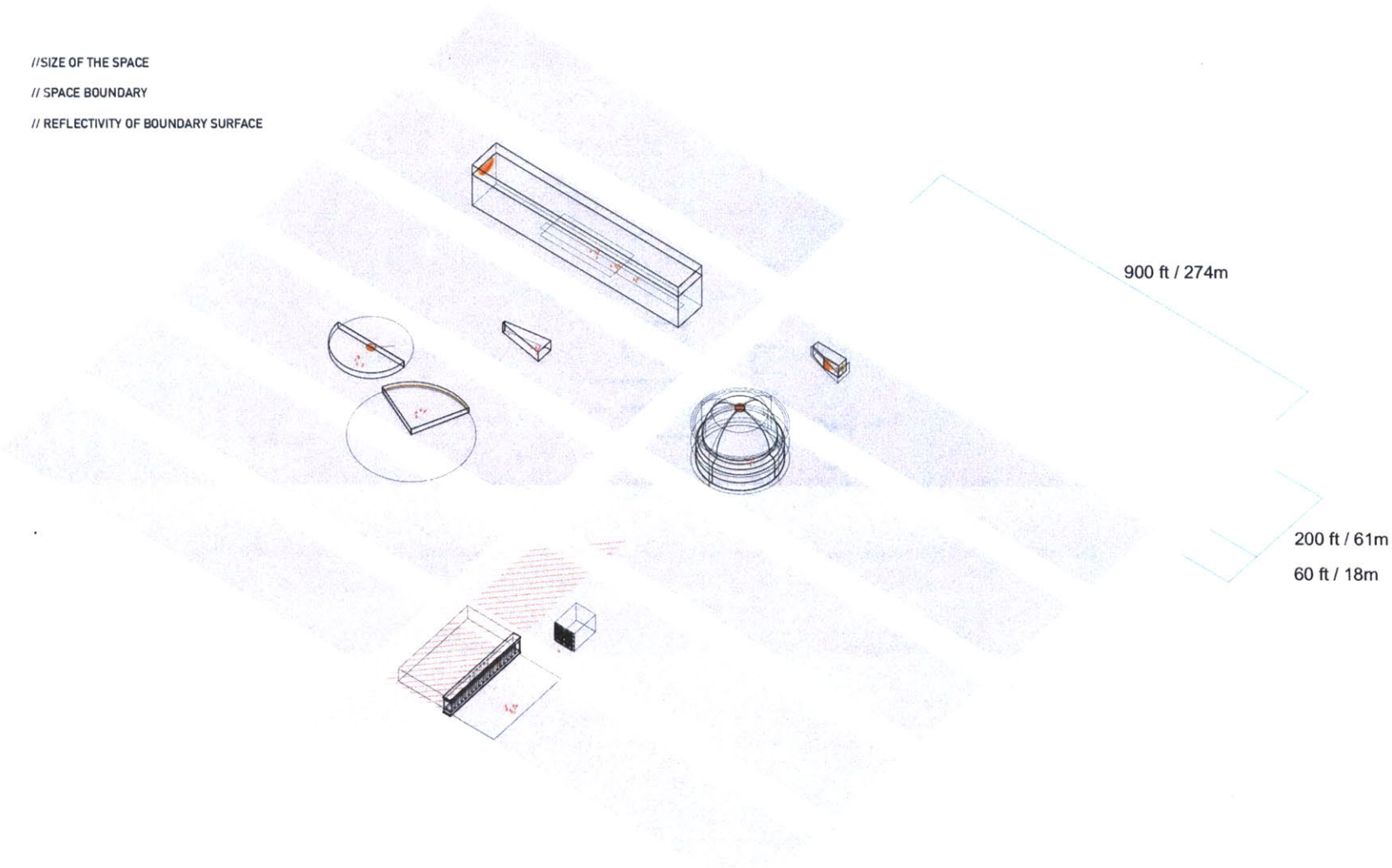
1- Precedents Research: Scale and Light Source

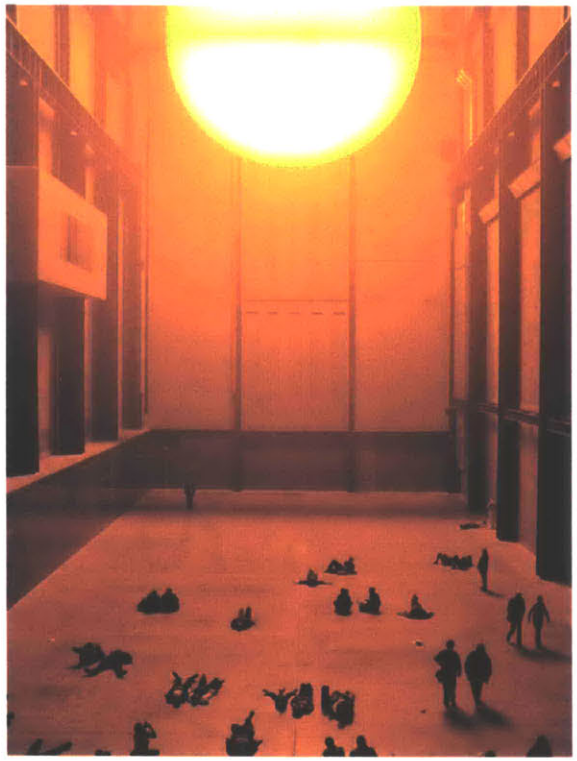
// VIEWERS' POSITION

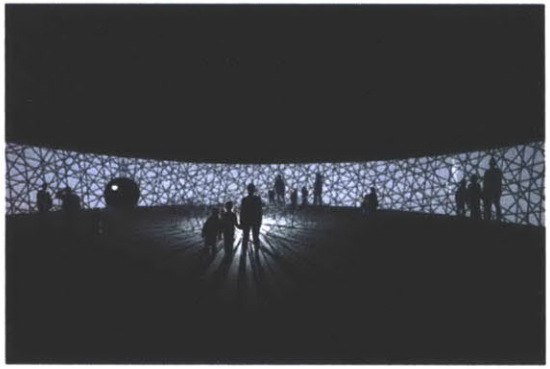
//SIZE OF THE SPACE

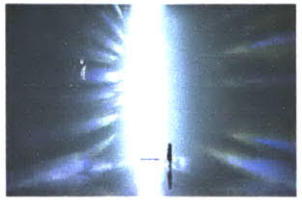
// SPACE BOUNDARY

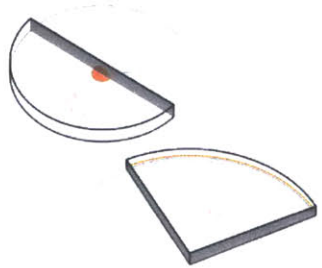
// REFLECTIVITY OF BOUNDARY SURFACE

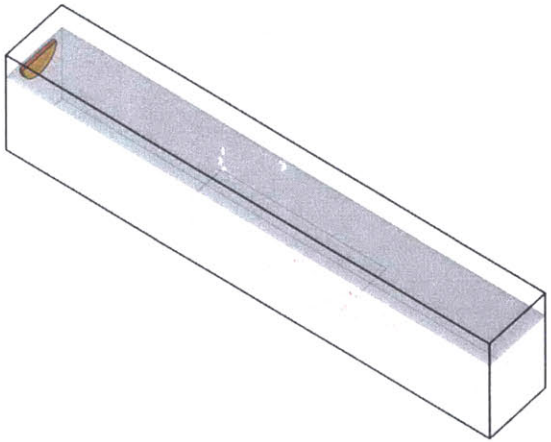


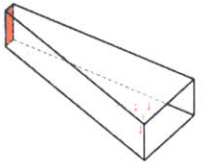




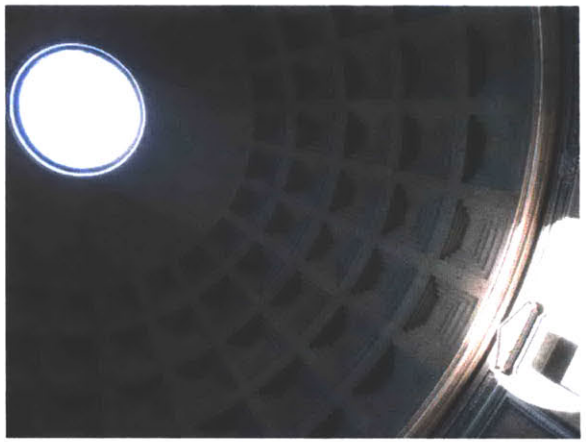


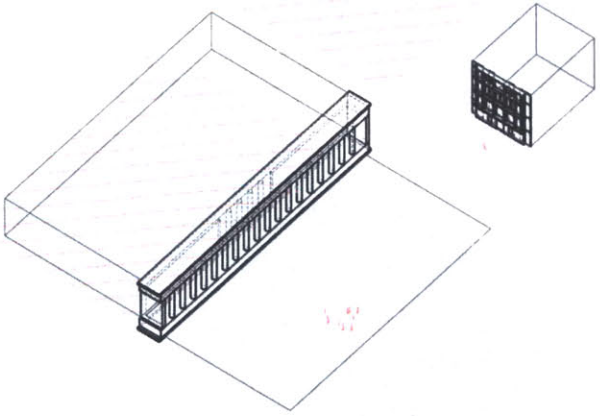


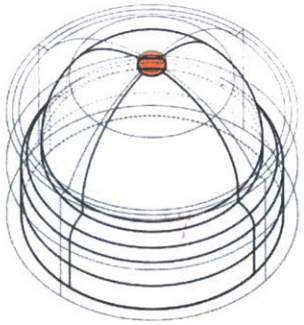


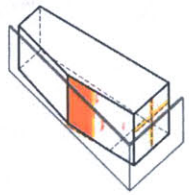


APPEDIX

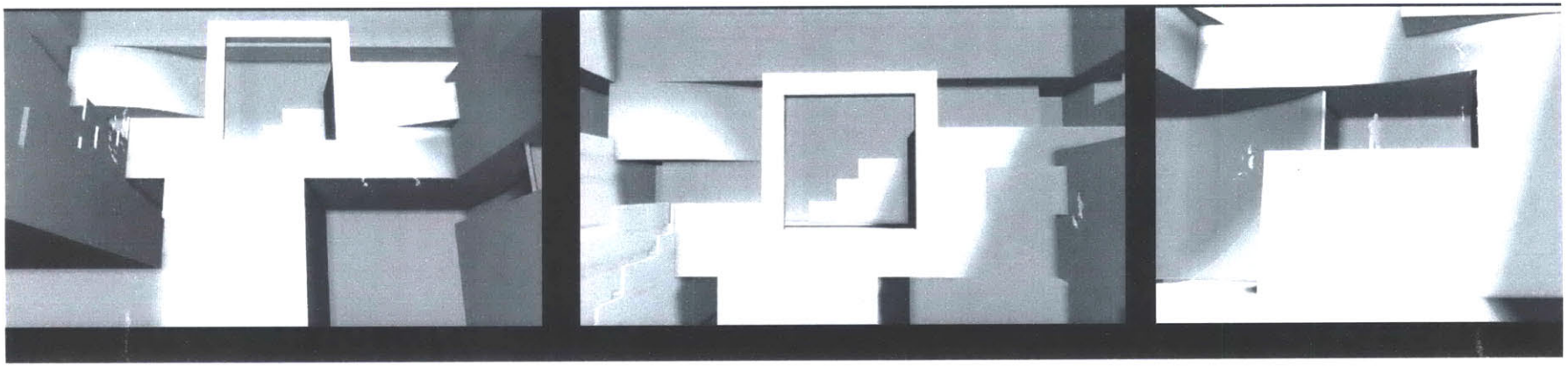


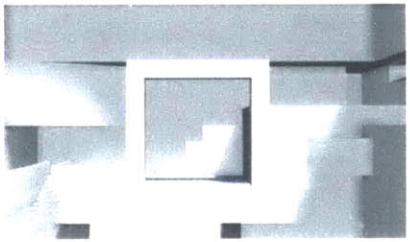


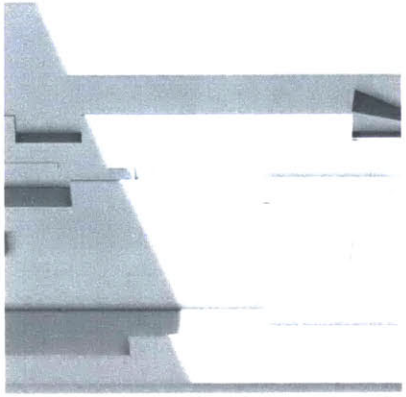


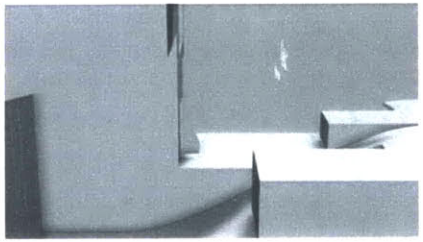


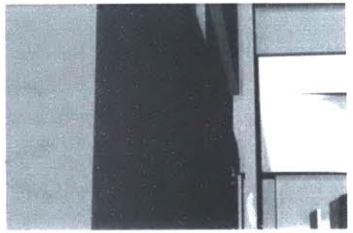
2- Testing Workflow with Rhino Rendering

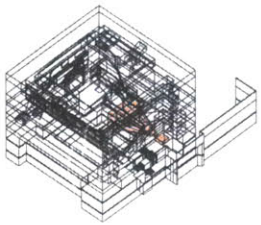












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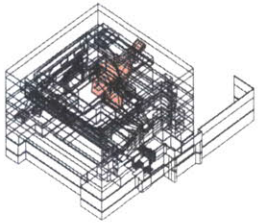

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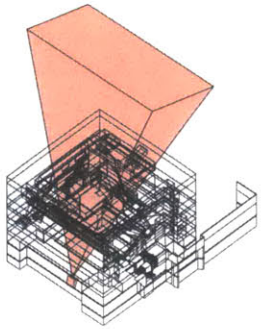

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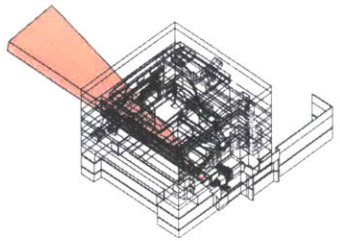

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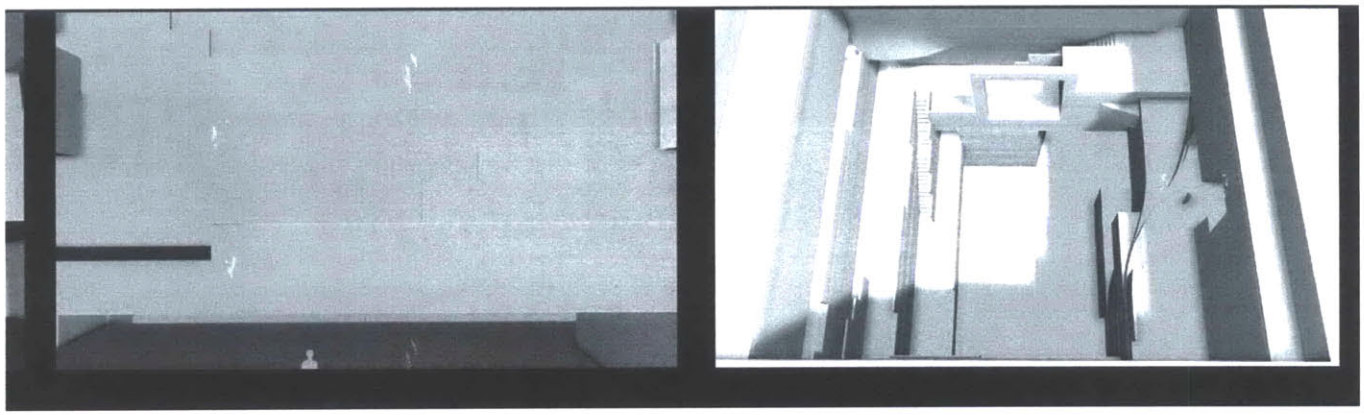
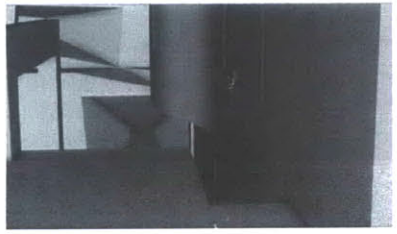
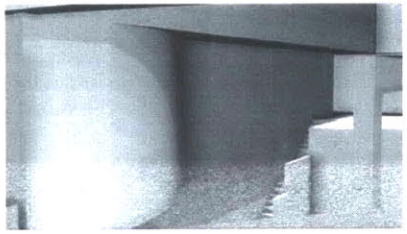
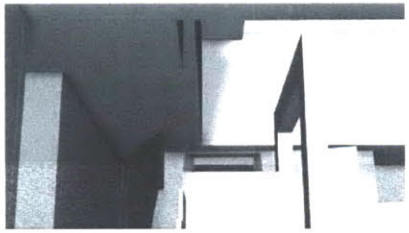
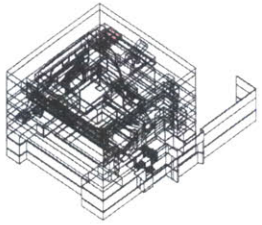


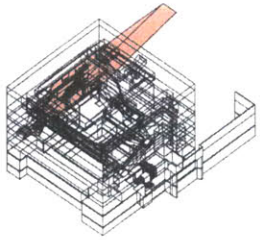




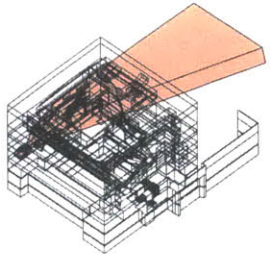




PROJECT #5

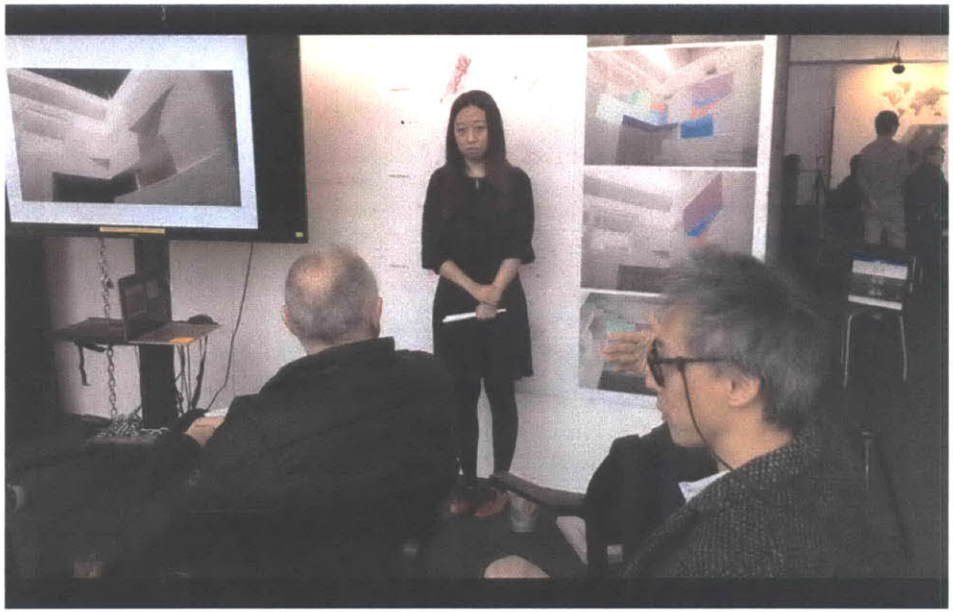


PROJECT #6



PROJECT #7

3- Final Presentation



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