Up.Periscope
Product Requirements Document

Team Members:

Jessica Bernstein - Project Coordinator

Katy Smith - Customer Liaison and Scribe

Yvie Bodell - Documents Handler

Customer:

David Krinick

Document Number 01

Revisions Level	Date
E	12-14-2016

Authentication Block

TABLE OF CONTENTS

Revision History

Rev	Description	Date	Authorization
A	**Initial PRD**	10-26-2016	All
B	**PRD Revision 1**: Managed customer expectations to revise specifications. Prioritized specifications. Added section Team Roles, Design Options, and Display Options.	11-9-2016	All
C	**PRD Revision 2**: Added two mirror system to Design Options. Added section Comparison of Designs and We Are Not Responsible For.	11-30-2016	All
D	**PRD Revision 3:** Added Table of Contents. Updated formatting and organization. Created Schedule. Added captions to figures.	12-12-2016	All
E	**PRD Revision 4:** Added the rest of our citations. Edited budgetary constraints. Added financial information for large mirrors. Updated and revised all sections.	12-14-2016	All

Introduction

The Up.Periscope is a customer driven product. As such, its design inputs were derived from interactions with David Krinick. Our Project Coordinator is Jessica Bernstein, our Documents Handler is Yvie Bodell, and our customer liaison and scribe is Katy Smith. Our faculty adviser is Duncan Moore. We will be working with a mechanical engineering senior design team.

Vision

The goal of the Up.Periscope project is to create an aesthetically pleasing periscope that employs analogue methods. The periscope ought to allow multiple individuals at once to view the New Rochelle waterfront from approximately one mile away from the middle of the downtown area.

Environment

The periscope must operate under the following environmental conditions:

1. **Temperature**
   Expected to operate in adverse weather conditions
   0-100 °F (-18-33°C) – Operation range

2. **Relative Humidity**
   50%-90% humidity levels

Regulatory Issues

All regulatory issues will be determined by the city and will depend on obtaining a city permit.

Fitness for Use

The system will:

- Provide a clear image of the waterfront
- Accommodate optics less than 3 feet in diameter
- Rise at least 70 feet towards the top of most downtown buildings
- Require low maintenance with repairable optics and housing attachments
- Withstand adverse New York weather conditions
- Include no artificial light source
- Provide an image that is clearly visible from the ground
- Include an image display that is aesthetically pleasing

It is desirable that the system:

- Accommodates a viewfinder similar to a Hasselblad
- Accommodates a viewer rotated 90 degrees from the water
- Costs less than $10,000
- Is capable of providing a vertical or slightly tilted image to the viewer
- Contains optics that are less than 1 foot in diameter
- Generates a field of view that is approximately 8 degrees, or as close to the field of view of a human eye as possible
- Provides an image that includes enough detail to visualize water texture as well as the detail in the tree line of Long Island
- A mechanical engineering team will analyze the options for optical housings that can withstand weather conditions and will be long lasting

Design Options

Relay System

This system would encompass multiple positive lenses (4f relay) to relay the image down a 70ft tube.

Size of Lens (mm)	Focal Length (mm)	Number of Lenses	Calc FFOV (degrees)	Realistic FFOV (degrees)	Brightness /Losses	Cost/Lens	Cost	Size of Image (in)
75	200	53.3	21.24	10.62	34.04%	$185.50	$9,894.57	2.95
75	300	35.6	14.25	7.13	48.75%	$198.80	$7,069.33	2.95
75	400	26.7	10.71	5.36	58.34%	$198.80	$5,302.00	2.95
102.31	1524.73	7	3.84	1.92	86.82%	$945.00	$6,611.83	4.03
116	1524.73	7	4.36	2.18	86.82%	$1,035.00	$7,241.53	4.57
128.02	1900.24	5.6	3.86	1.93	89.28%	$985.00	$5,529.82	5.04
140	1900.24	5.6	4.22	2.11	89.28%	$1,075.50	$6,037.89	5.51

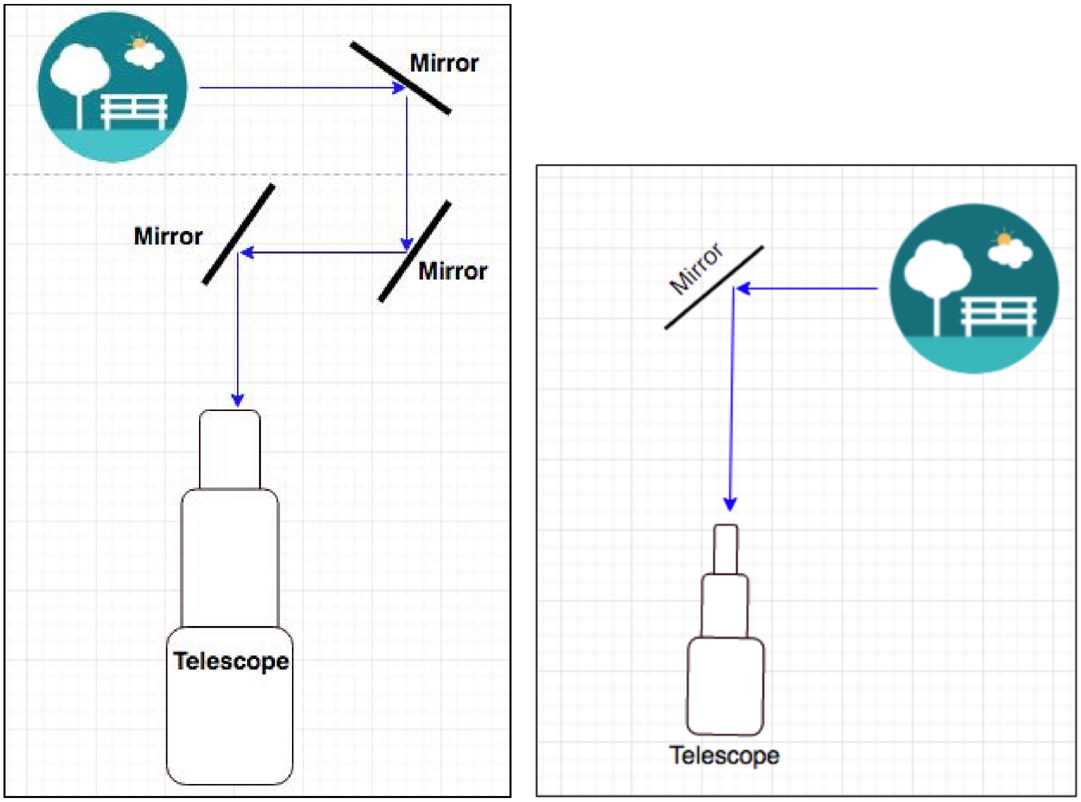
Table 1: Comparison of the benefits of various parameters of the relay system. This table also provides additional information about the specifics of the design options.

Initial concerns associated with the Relay System:

- Costs per lenses
- Diameter of lenses vs. number of lenses
- Diameter of lenses vs. field of view
- Image quality, specifically Petzval curvature
- Transmission losses due to large number of lenses
- Cost of coatings

Telescope with Mirror

This system would encompass a system of mirrors at the top to capture the field of view, which will then be seen by the viewer using a commercial telescope. The system of mirrors may have the capability to rotate and scan across the horizon by user control.



Figures 1 and 2: Figure 1 shown on the left depicts a telescope paired with multiple mirrors at the top of the system. Figure 2 on the right depicts the same concept but with a telescope paired with only a single mirror.

Initial Concerns with the Telescope System:

- Capturing acceptable field of view
- Rotating mirror capabilities
- Integrating desired display

Digital System

This system would encompass a digital camera at the top of the building with an LCD screen at ground level for viewing. Our customer is adamantly opposed to this option. However, it may be further explored depending on changes in customer preferences and received funding.

Initial Concerns with a Digital System:

- Customer adamantly desires an analogue system
- Restricts possibilities for project design because a digital design may not incorporate many optical components

Two Mirror "Shipping Container" System

This system would encompass two flat mirrors that ultimately allow the view of the water to be displayed at ground level for an easy viewing experience.

Figures 3 and 4: Representing a two mirror display system using large mirrors and a shipping crate as the holder. This system has been created in the past and Figures 3 and 4 above provide a good starting point for where we can take this design option in the future.

Figure 5: Showing how the image is displayed in the shipping crate container example of the two mirror system.

Height of Periscope (ft)	Mirror Diameter (ft)	FFOV (°)
70	8	6.541
70	6	4.908
70	4	3.273
70	2	1.637

Table 2: Highlights the diameter of the periscope versus the field of view for the two mirror periscope option.

Size of Mirror (ft)	Cost of Mirror
3x5	$360
3x6	$379
4x6	$895

Table 3: Cost analysis of glassless mirrors in varying sizes.

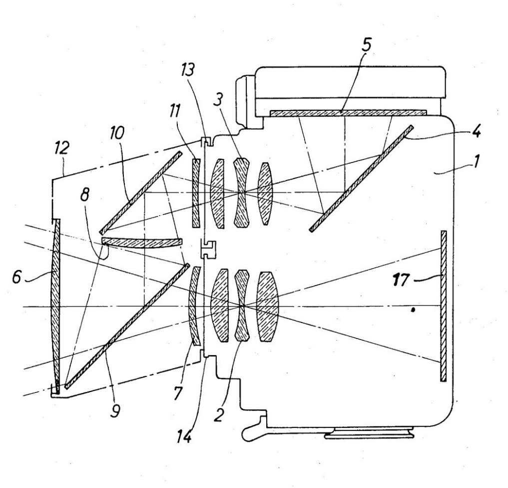
Initial Concerns with a Two Mirror System:

- Large in diameter
- Free standing system - will not be attached to a building
- Will not provide a magnified image
- Distortion will need to be considered and analyzed

Image Display Options

Image Projected on Ground Glass

This viewfinder would encompass a system similar to a Hasselblad viewfinder. The image would be projected onto a focusing screen, ground glass.



Figures 6 and 7: Figure 6 on the left represents the optical design of a two-lens reflex camera[1]. Figure 7 on the right depicts a hasselblad viewfinder projected onto ground glass.

Initial Concerns with a Ground Glass Projection:

- Brightness of image may be insufficient for outdoor ambient lighting conditions
- Size of image will be restricted by lighting conditions
- Quality of image will likely be very low

Eyepiece

This system would encompass a standard eyepiece for viewers to use at ground level.

Initial Concerns with an Eyepiece:

- Viewing experience is limited to only a single viewer
- Not customer's first choice due to the aforementioned single viewer drawback

Digital Display

This system would encompass an LCD display at ground level. This option would allow for a multiple person viewing experience.

Initial Concerns with a Digital Display:

- Customer adamantly desires an analogue system
- Will retract from the old school appearance of the system once it has been installed

Mirror Display

This system would encompass a mirror at ground level displaying the image. This option would allow for a multiple person viewing experience.

Initial Concerns with a Mirror Display:

- No magnification

Comparison of Designs

	Relay System	Two Mirrors	Telescope System with Adjustable Mirrors
FFOV	2-5 degrees	Approx. 6 degrees	Approx. 2 degrees
Diameter	5 inches	8 ft	2.5 ft
Size of Image	N/A	8 ft	N/A
Number of Viewers	One	Multiple	One
Quality of Image	Poor (tons of aberrations and losses)	No aberrations or losses	Minimal aberrations and losses
Magnification	Possible	None	50x or 167x
Costs	Mutiple lenses so higher costs - varies from $6-10k	Approx. $6000	Less than $2000

Table 4: Comparison of the three main design systems and their specifications.

	Relay System	Two Mirrors	Telescope System with Adjustable Mirrors
FFOV	Medium	Highest	Lowest
Diameter	Smallest	Largest	Medium
Size of Image	N/A	8 ft	N/A
Number of Viewers	One	Multiple	One
Quality of Image	Worst	Best	Medium
Magnification	Possible	None	50x or 167x
Costs	Highest	Medium	Lowest

Table 5: Provides the same information as Table 4. However, this layout is more simply highlights the most optimal and least desirable outcomes for each specification.

Not Responsible For

We are not responsible for the mechanical design of the housing for the optical system. We expect the mechanical engineering team to be responsible for all relevant environmental analysis and housing condition analysis.

Schedule

Plan for Spring Semester

January
- Begin coordinating with mechanical engineering team
- Test telescope and mirror design option using Professor Knox's telescope
- Work with customer on funding options and create documents to assist

February and March
- Research materials needed and get specific cost estimates
- Analyze large mirror distortion
- Use software to create image simulation for different design options
- Compare benefits of design options

April
- Create scaled down prototypes of different design options
- Choose best design option

May
- Complete final prototype if necessary

Citations

1. Faasch, Werner and Schade, Harry. Twin Lens Reflex Camera. Patent 2,963,950. 8 Jul. 1958.
2. Gardner, Danielle. "Hasselblad 500C Through the Viewfinder." *Flickr*. Yahoo!, 2014. Web. 14 Dec. 2016.
3. "40-Foot Cargo Container Turned into World's Tallest Periscope." *Weburbanist.com.* 2015 Sept. 17. Web.