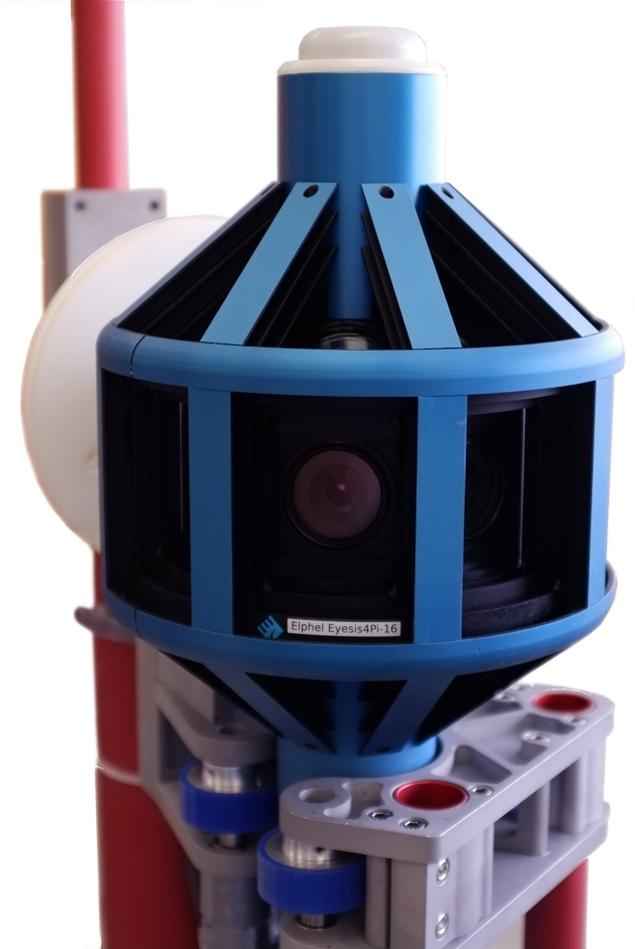
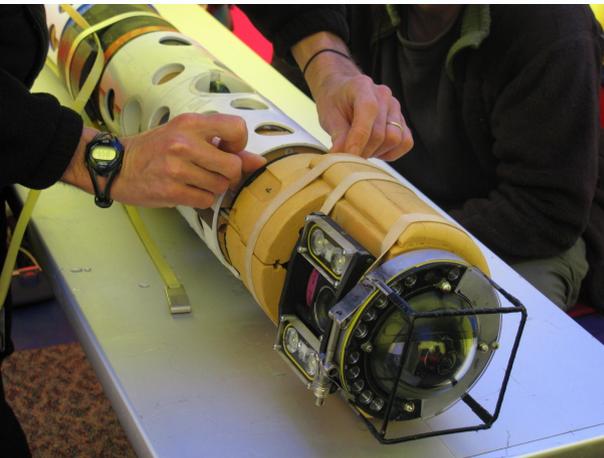


# Open Hardware Cameras



Olga Filippova  
Elphel, Inc. 1405 W. 2200 S. #205  
West Valley City, UT 84119

# Hardware: NC353L

## Tech specs:

*5 Megapixel CMOS Sensor*

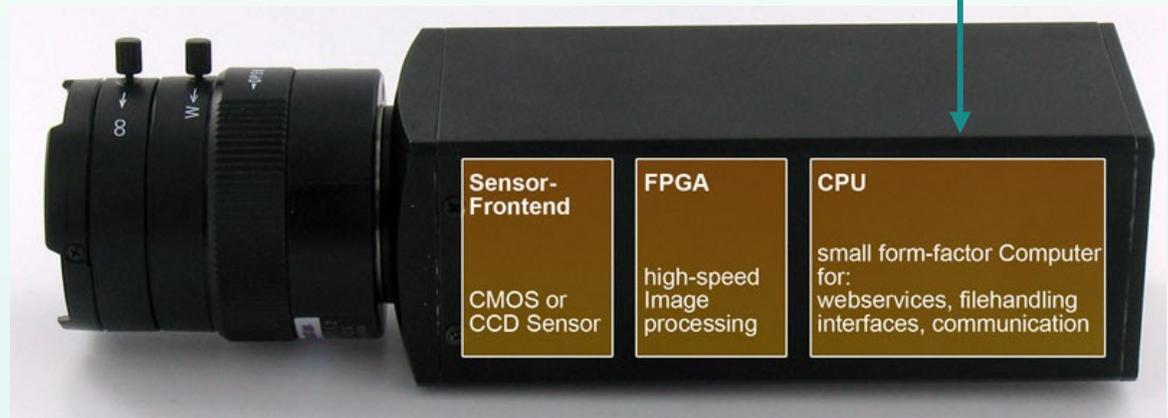
*Exchangeable Lens (c-mount)*

*75 Megapixels/second Throughput*

*FPGA with Image pipeline*

*Embedded Linux computer*

*(webserver, Ethernet, USB, SATA connections)*



# Applications: Document Scanning

## Elphel Model 323

35-mm format Kodak CCD image sensor

11 megapixels resolution (4008 x 2672)

2 fps framerate

Nikon F-mount



# Applications: Panoramic Imaging



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## Google Street View

From Wikipedia, the free encyclopedia  
(Redirected from [Streetview](#))



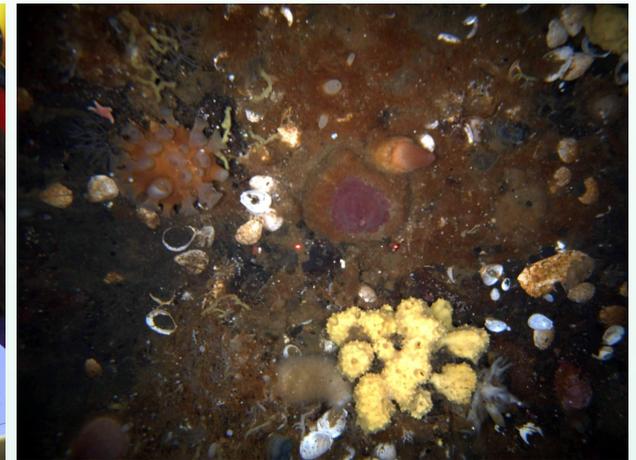
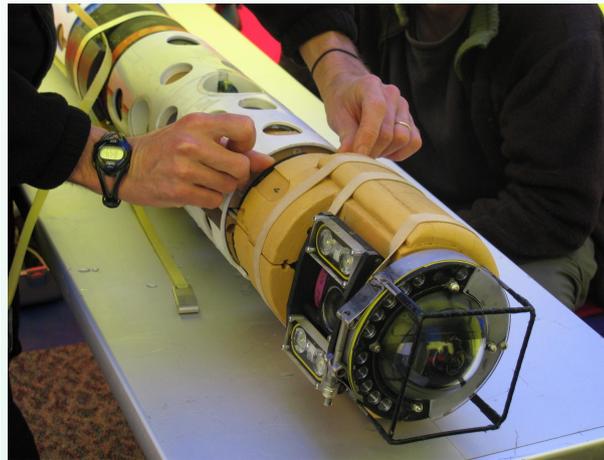
This article **may need to be updated**. Please update this article to reflect the [talk page](#) for more information.

**Google Street View** is a technology featured in [Google Maps](#) and [Google Earth](#) that provides [panoramic](#) views on May 25, 2007, originally only in several cities in the United States, and has since gradually expanded to include many more cities. Google Street View displays images taken from a fleet of specially adapted cars. Areas not accessible by car, like some mountainous areas, are sometimes covered by *Google Trikes* ([tricycles](#)) or a [snowmobile](#).<sup>[2]</sup> On each of these vehicles there are nine directional cameras for positioning and three laser range scanners for the measuring of up to 50 meters 180° in the front of the vehicle and Wi-Fi [hotspots](#).<sup>[3]</sup> Recently, 'high quality' images are based on [open source hardware](#) cameras from Elphel.



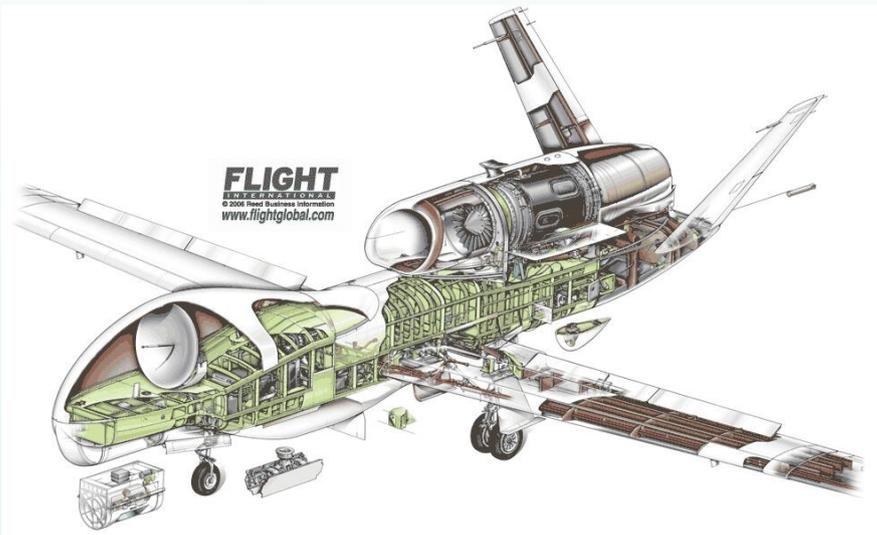
# Variety of Applications: SCINI - Antarctic Underwater Exploration Robot

Submersible Capable of under-Ice Navigation and Imaging

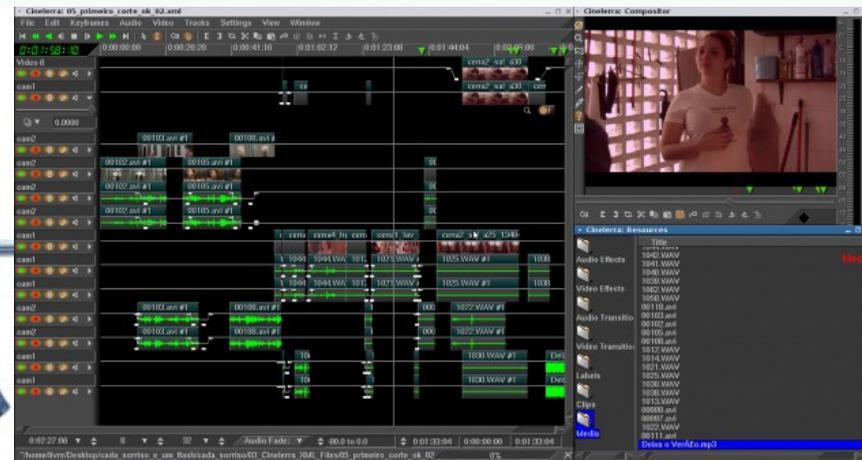


## Moss Landing Marine Lab

# Applications: NASA Global Hawk UAV Aerial Near Space Exploration



# Applications: Cinematography Apertus, Floresta Vermelha Project



# Triclop Camera

Depth of Field from 3D information

Sintel – Open Movie by Blender Foundation



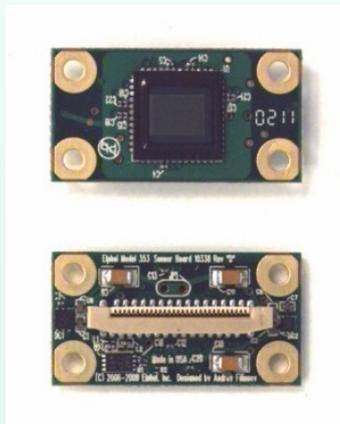
## Boards Overview



10353 System Board



10369 IO Board



✓ 10338 Sensor Board



✓ 10359 Multi Sensor Board

# Camera Configurations



Basic camera NC353



Stereo



IMU & GPS



HDD

`/* source is inside */`

Camera is reconfigurable and user/developer friendly.

Controlled through a web-based user interface.

- HTML, JavaScript, PHP
- C, C++
- Verilog HDL





## Elphel reconfigurable cameras

by apolto, elphel, geekjim, khlut, onearthplease, ...

Summary

Files

Support

Develop

Hosted Apps

Tracker

Mailing Lists

Software and HDL code for Elphel reconfigurable network cameras

Download Now!

elphel353-8.0.8.48.tar.gz (4.5 MB)



OR

View all files

article discussion edit history

### 10353

10353 processor board is the computer part of the Elphel 353/363 series cameras.

- It uses [ETRAX FS](#) processor running GNU/Linux (currently kernel 2.6.19) that has support for multiple hardware interfaces with the following of them used/connected in the Model 353:
  - 10/100 Ethernet
  - USB 1.1 (host)
  - IDE (ATA-6)
  - RS-232
- Teridian 78Q2123 is used as Ethernet PHY in the camera - it has Auto-MDI/X, so no more crossover cables are needed when connecting camera directly to a PC.
- 64MB of 32-bit white system SDRAM provide memory to run multiple applications in the camera. It is also used as a buffer for video/images and as a RAM-disk.
- 128MB of system flash memory work as a



10353 board, top view



10353 board, bottom view



Camera Processor Board 10353

To Sensor

DDR SDRAM 64MB (32Mx16)

IEEE802.3af PD

Aux Power 48/3.3VDC

www3.elphel.com

Code is available on

SourceForge.net

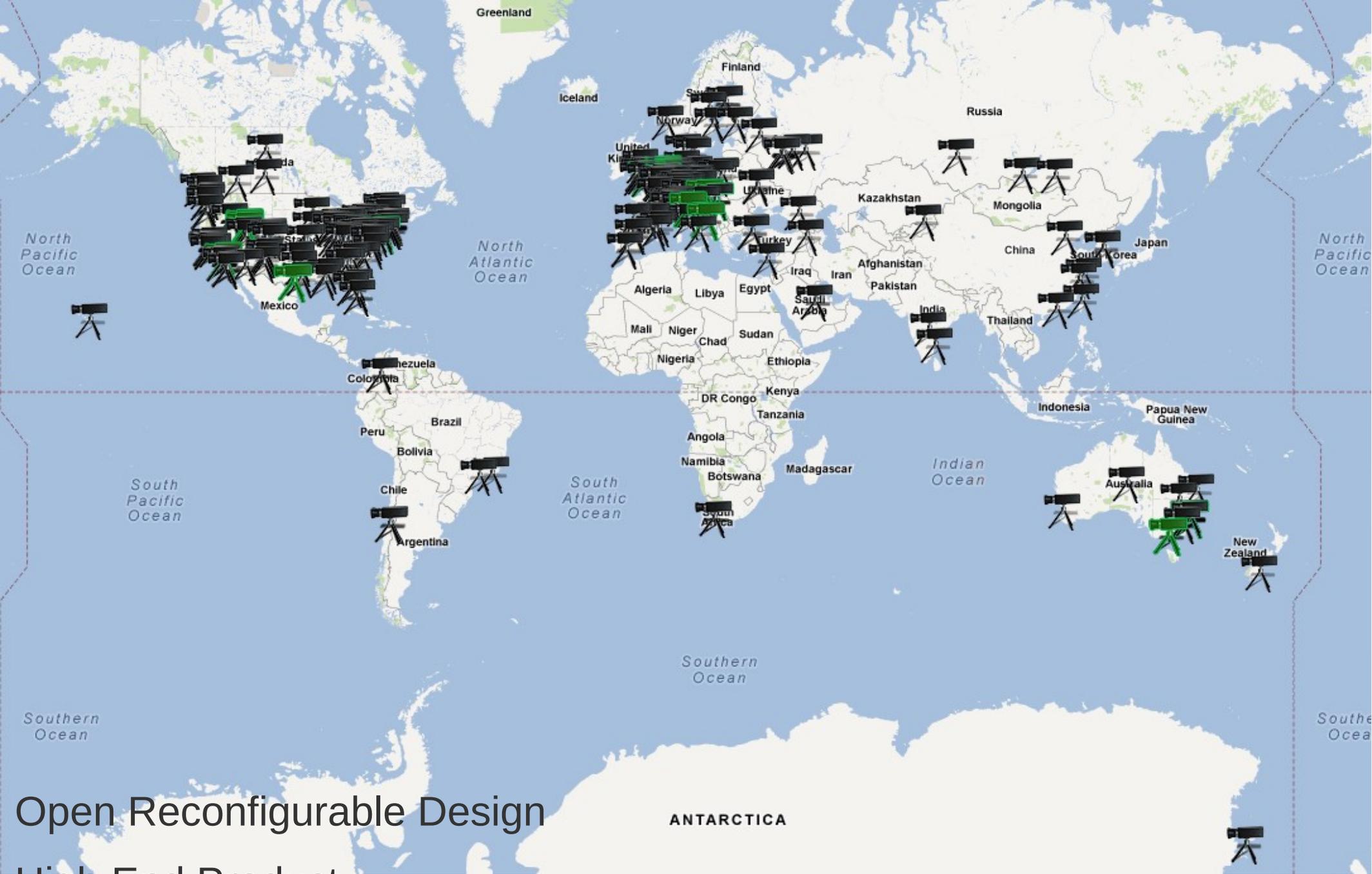
Schematics,

PCB layout & Documentation

wiki.elphel.com

## Licenses:

- *GNU GPL V3*
- *GNU Free Documentation License V1.3*
- *CERN Open Hardware License V1.1*



Open Reconfigurable Design  
 High End Product

Camera users around the world

# Eyesis 4 $\pi$ – Stereophotogrammetric Camera

**eyesis 4 $\pi$**   
stereophotogrammetric  
camera

number of sensors	coverage	total resolution	frame rate	GPS	IMU
26	4 $\pi$	80 MPx	5 FPS	5 Hz	3D position & orientation
					2400 smpl/sec

free software  
open hardware

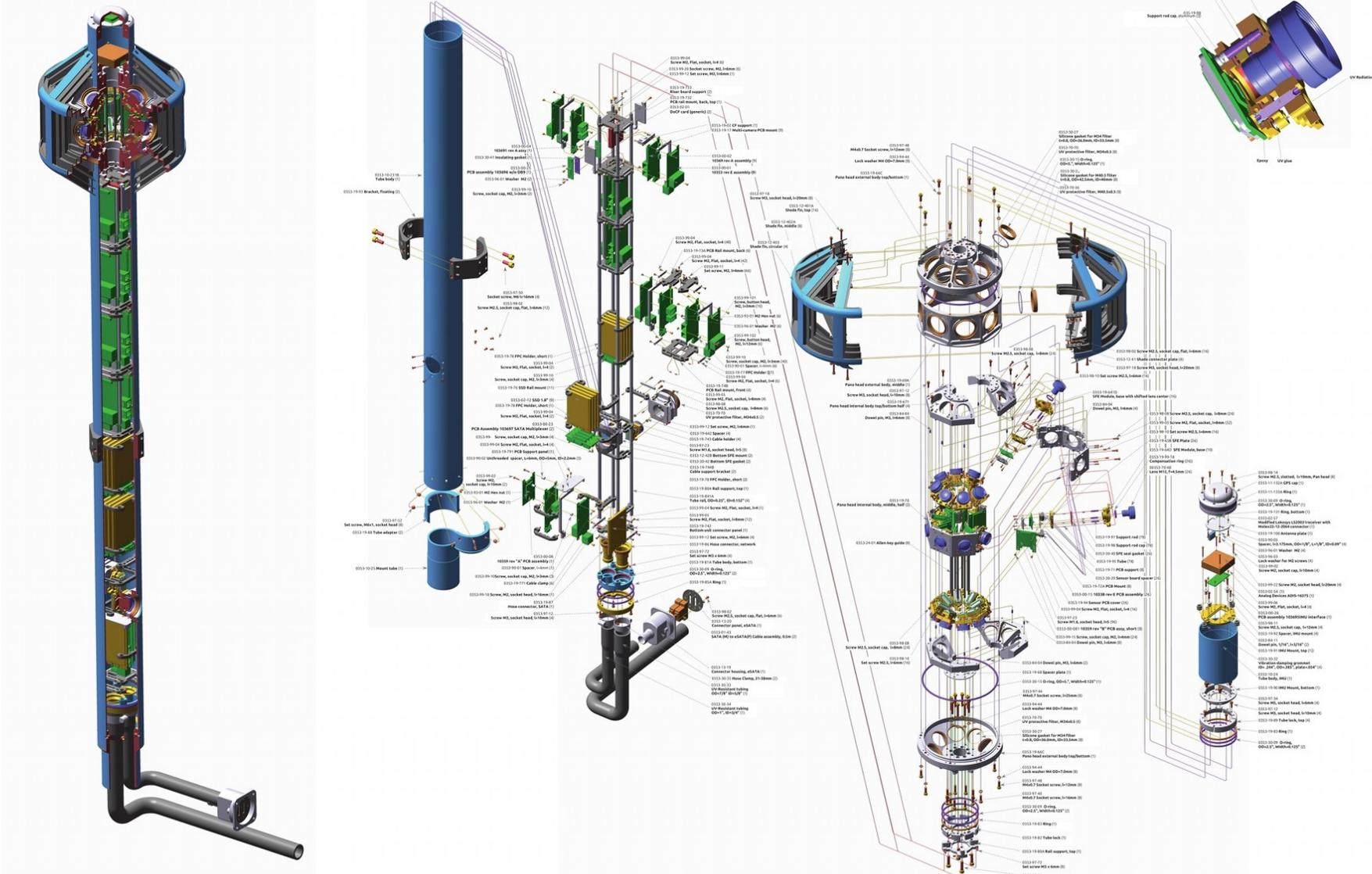
- Full Sphere Panoramic Camera
- High Resolution: 120 Mpix, total (64 Mpix - panorama)
- Images are synchronized with GPS and IMU
- Photogrammetry ready



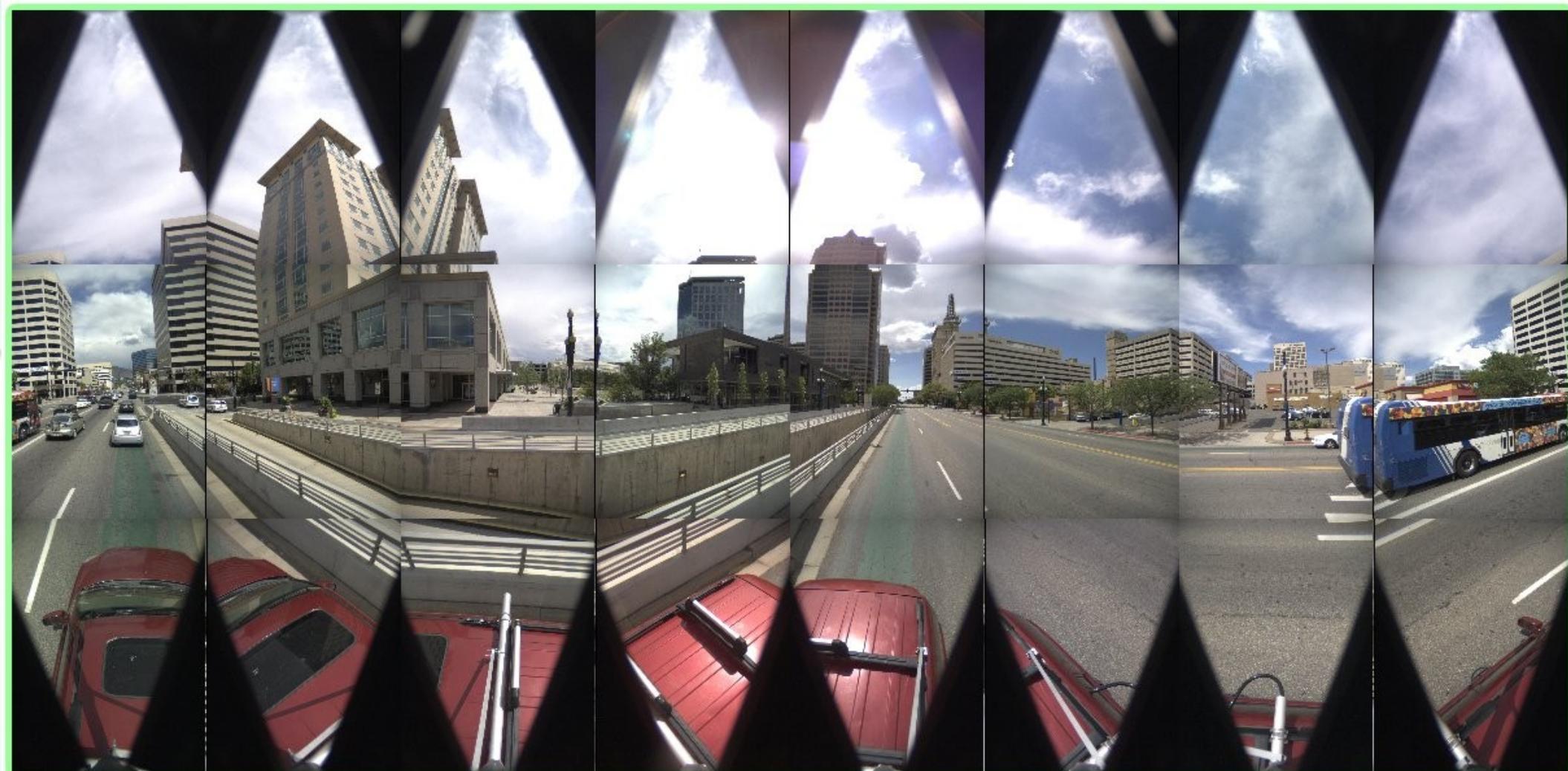
# Elphel at SIGGRAPH 2012

Calibrated camera for 3D reconstruction





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 Foundation with its Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the  
 license is included in the section entitled "GNU Free Documentation License".



[Full size preview](#)

Process files as JPEGs:

# Eyesis 4π – Footage Preview

20120731...

Image number

Image name: **1/1342928263\_838636\_1.jp4**

OR  image set(s)

Status: *Working.*

# Interface for Camera Controls

File Edit View History Bookmarks Tools Help

Elphel camera parts 0353-12... Eysis4Pi GUI

127.0.0.1/my/scripts/cookies/

Eysis Footage Pro... Programming MAC ... Panorama Viewer/E... Fiji

REC

STOP

Settings

Previews

Recording Camera Other Test

Switch format to

JPEG

JP4

Force recording in JP4 format



Compression quality:

+

98

-

HDR mode

on

off

Test pattern

on

off

Trigger period (1/fps),ms

2000

apply



Skip Frames Mask, (hex - 0x1ff)

0x1ff



HDRVexpos, (hex - 0x40000)

0x40000



AutoExp max, ms

50



AutoExp level, (0-255)

200



AutoExp fracpix, (hex - 0xdf7)

0xdf7



AutoExp frames ahead

1



Apply

uncheck all

White Balance:

Sunny

Cloudy

Fluorescent



2.82



2



2.45

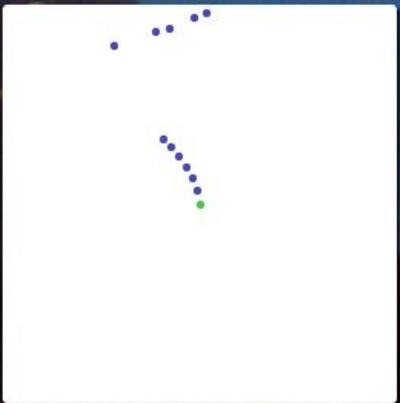
Apply

# Eyesis 4 $\pi$ – Panoramic Image

- Full Size(14268x7135), Equirectangular Projection
- WebGL Viewer



# WebGL Panorama Viewer /Editor



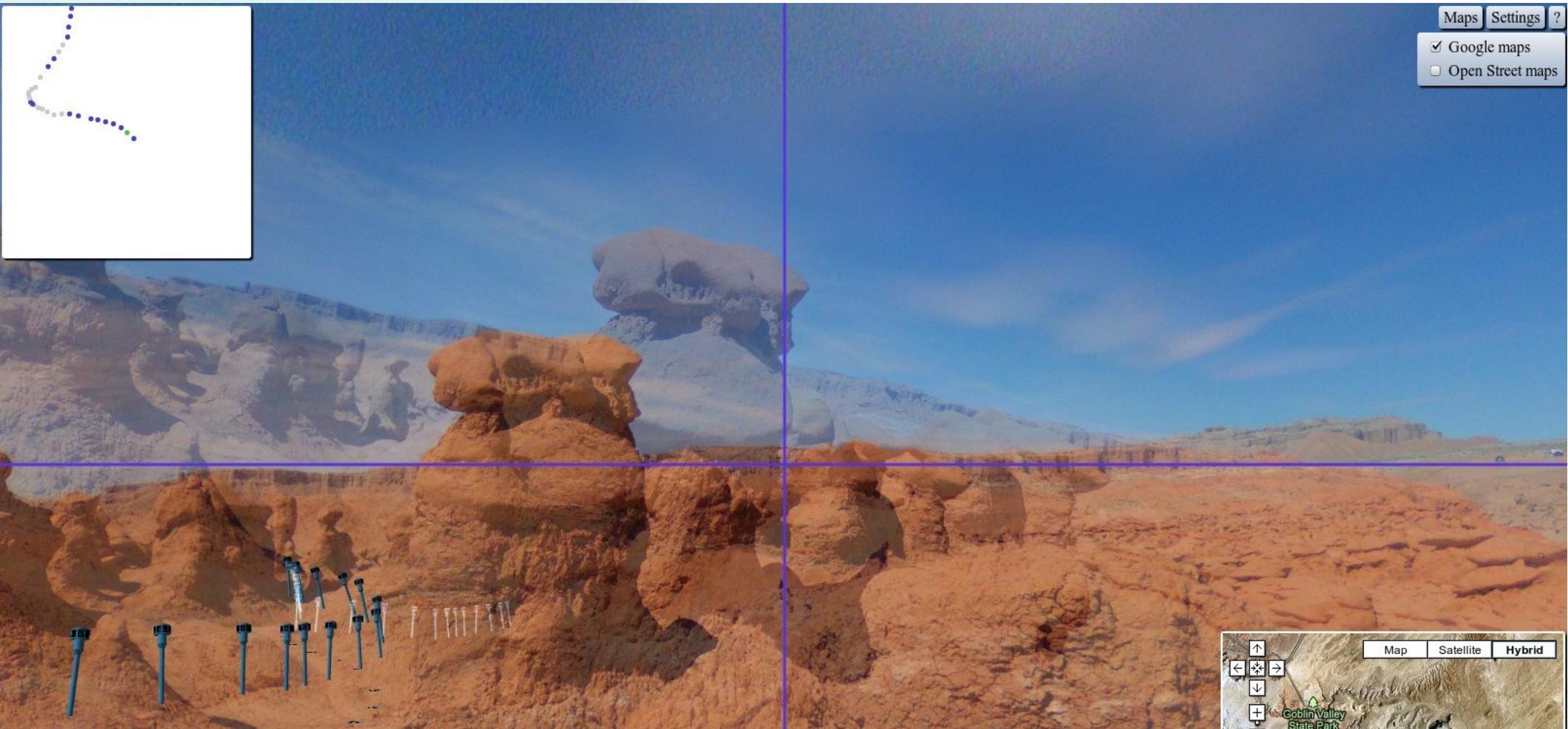
Longitude,° <input type="text" value="-110.698388"/>	Heading: <input type="text" value="217.68"/>	View azimuth: <input type="text" value="223.12"/>	Texture size: 14272x7136	<input checked="" type="checkbox"/> Show plan	Timestamp: 04/22/2011 17:06:08.46693 UTC
Latitude,° <input type="text" value="38.562246"/>	Tilt: <input type="text" value="-4.28"/>	View elevation: <input type="text" value="-0.48"/>	Maximal zoom: <input type="text" value="1"/>	<input checked="" type="checkbox"/> Show cameras	Sun Azimuth: <input type="text" value="122.05"/>
Altitude, m <input type="text" value="1429.72"/>	Roll: <input type="text" value="10.35"/>	<input checked="" type="checkbox"/> Ortho	Current zoom: <input type="text" value="0.525"/>	<input type="checkbox"/> Show labels	Sun Elevation: <input type="text" value="50.12"/>
Description: <input type="text" value="0: undefined"/>	Navigation: <input type="button" value="&lt;"/> <input type="button" value="&gt;"/>				

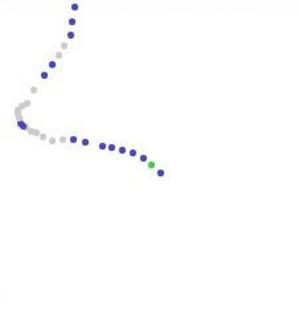
hide info [Permanent Link](#)



Maps Settings ?

Google maps  
 Open Street maps





Map Satellite Hybrid



Longitude, °	-110.698395	Heading:	223.85	View azimuth:	258.67	Texture size:	14272x7136	<input checked="" type="checkbox"/> Edit mode		<input type="button" value="Save to KML"/>		Timestamp:	04/22/2011 17:06:09.46693 UTC
Latitude, °	38.562236	Tilt:	-6.96	View elevation:	6	Maximal zoom:	8	<input checked="" type="checkbox"/> Show plan		<input type="checkbox"/> Vertical move	0.7	Sun Azimuth:	122.06
Altitude, m	1429.91	Roll:	-2.52	<input checked="" type="checkbox"/> Ortho		Current zoom:	0.525	<input checked="" type="checkbox"/> Show cameras		<input type="checkbox"/> Key points	<input type="checkbox"/> Visibility	Sun Elevation:	50.12
Description:	l: undefined		Navigation: < >		Keypoint <input checked="" type="checkbox"/> Open								

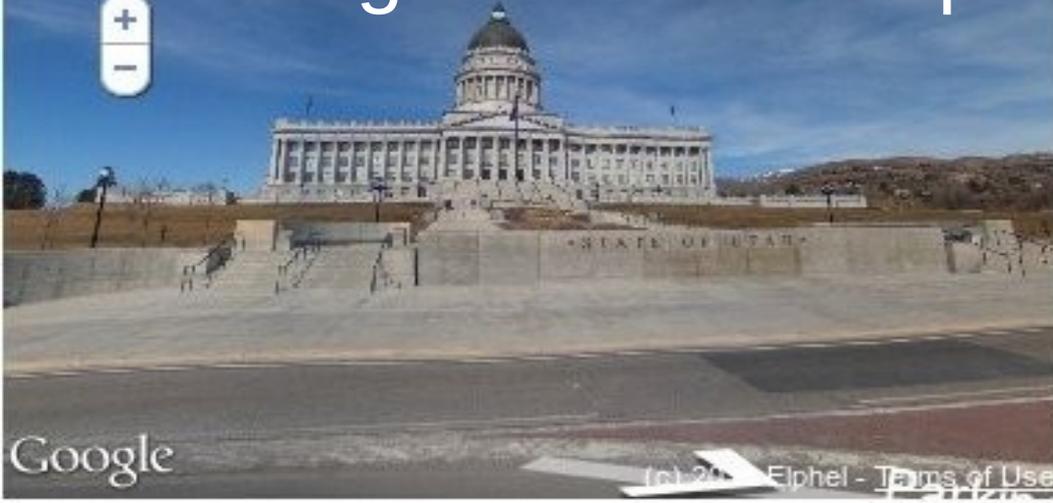
hide info [Permanent Link](#)

# WebGL Panorama Viewer / Editor

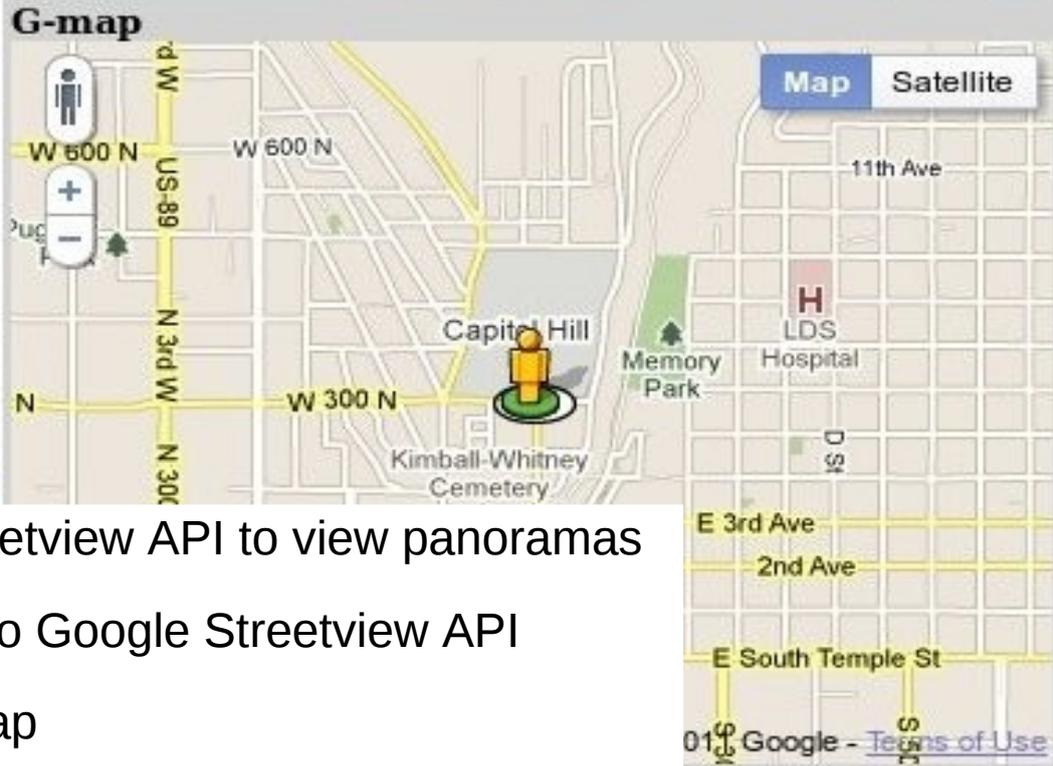
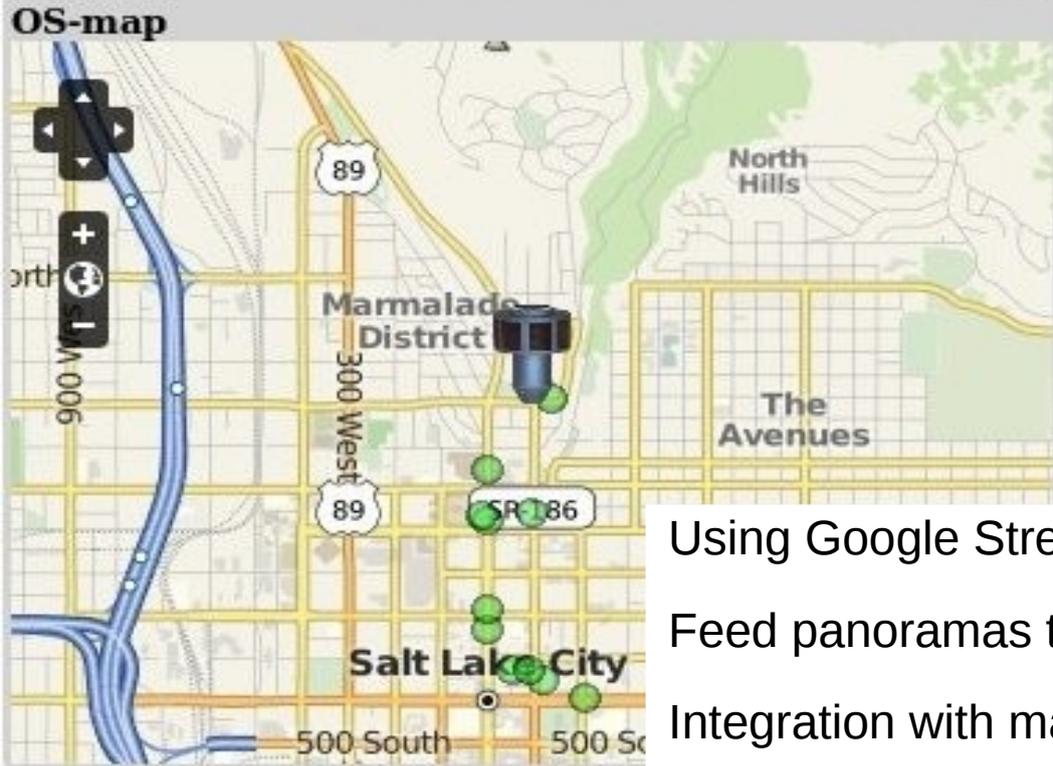


The Capitol  
Address is approximate

# Integration with Maps



Utah 186, Salt Lake City, Utah  
Address is approximate



Using Google Streetview API to view panoramas  
Feed panoramas to Google Streetview API  
Integration with map

# Post-processing

- Metadata extraction
- RAW conversion
- Aberration correction
- Distortion Correction
- Photogrammetry ready



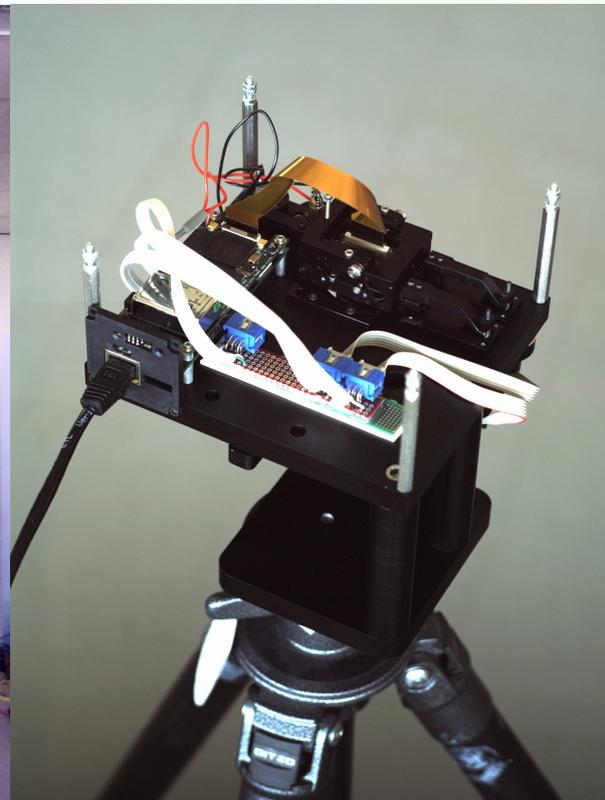
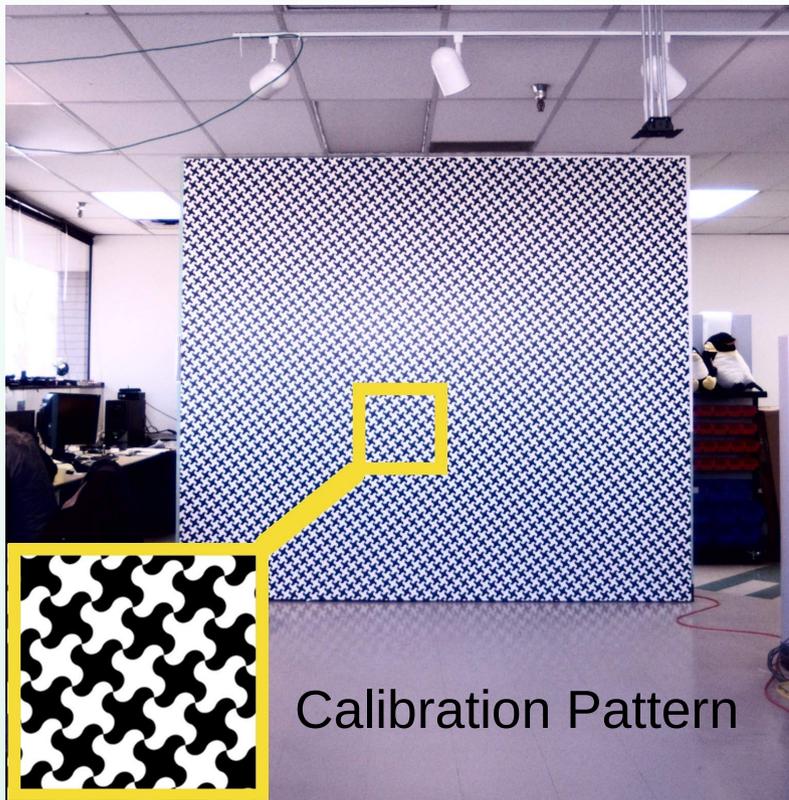
**original**



**enhanced**

# Focus and Alignment

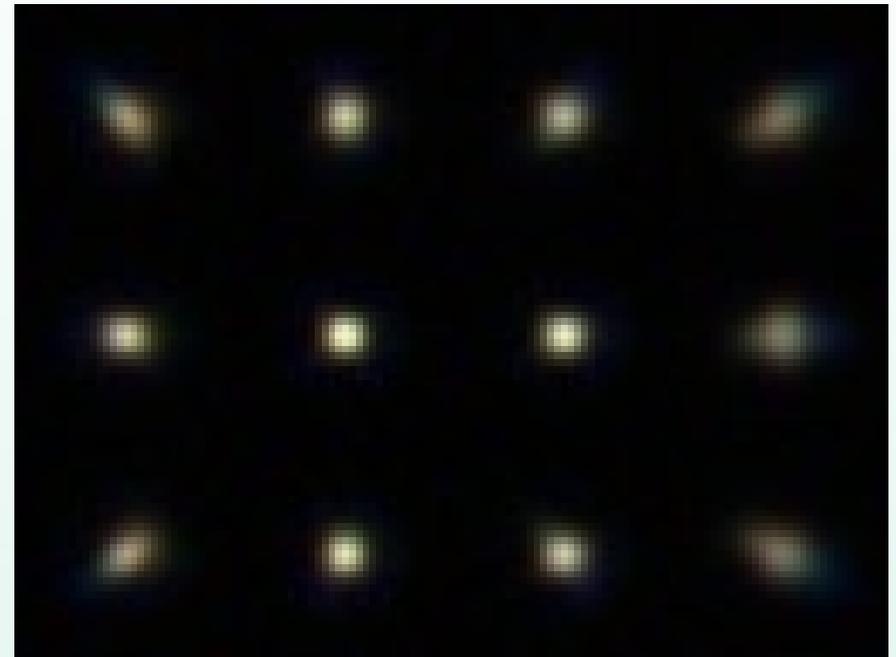
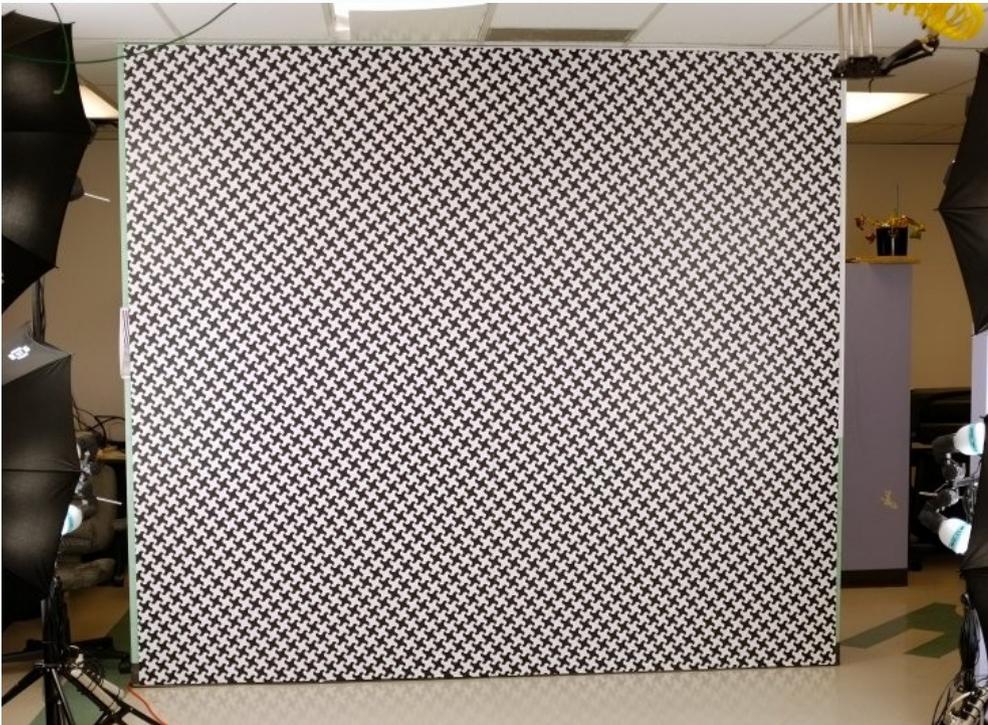
optical aberration measurement and correction developed for Eysis cameras



Lens is aligned and centered with sensor<sup>11</sup>

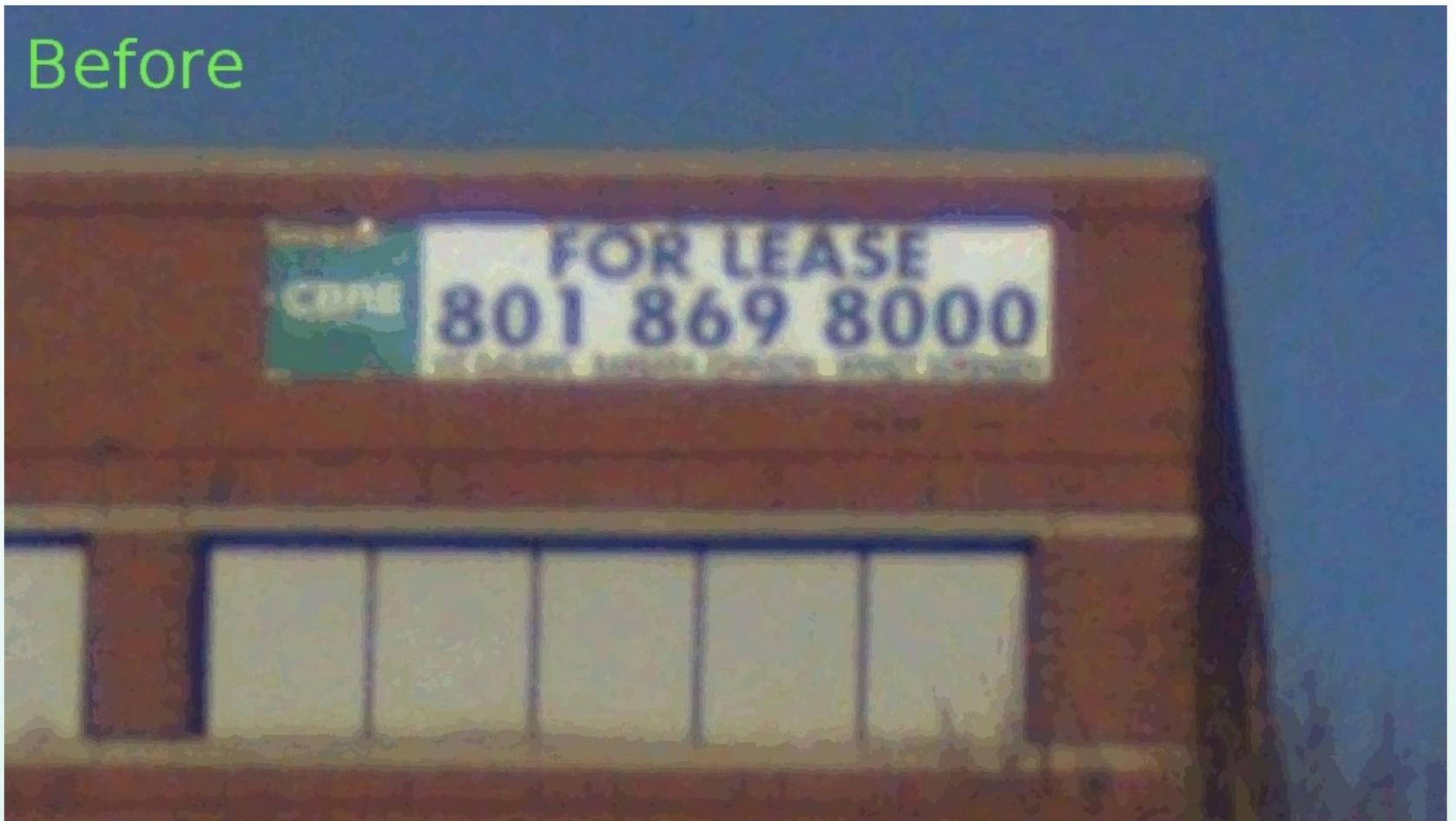
# Optical Aberrations of the Lens

Aberrations are more in the corners than in the center of the lens;  
Point Spread Function of one of 12 areas of the pattern.

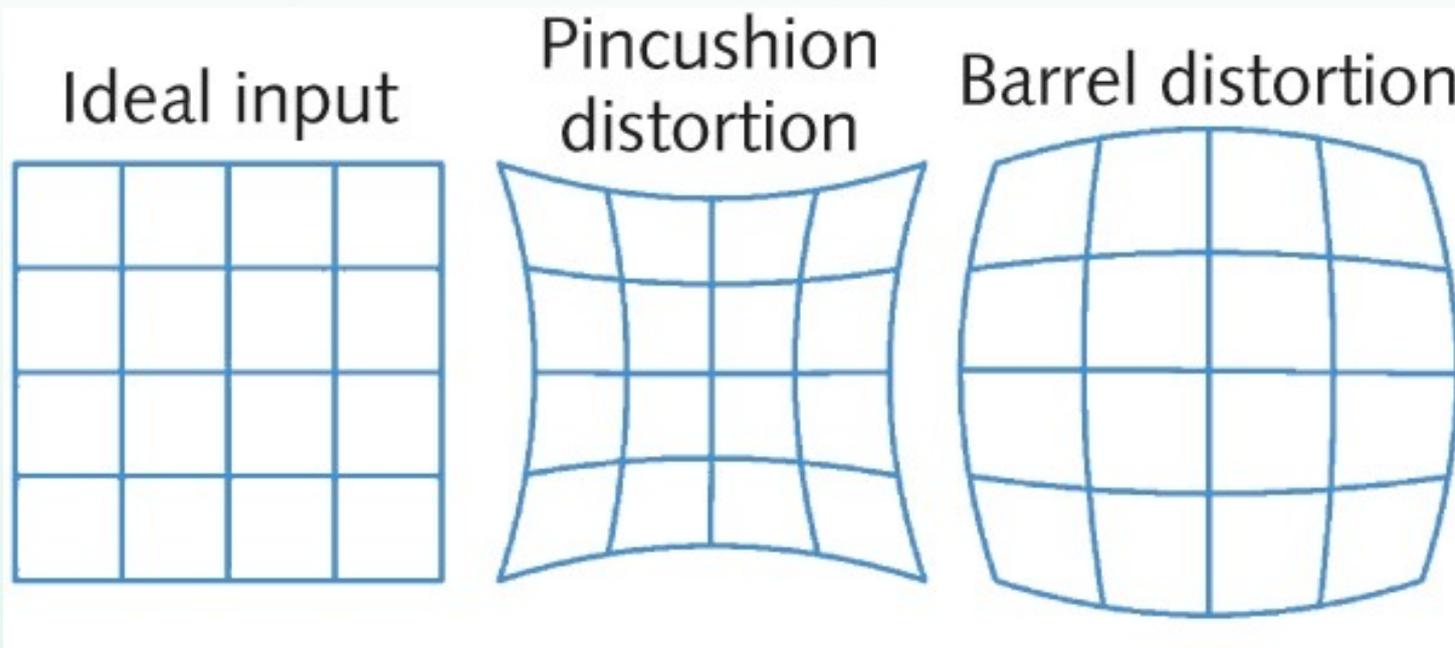


# Aberration Correction - Results

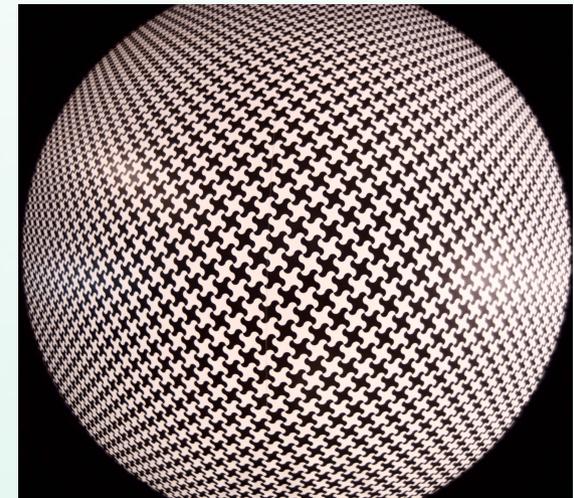
With 1/2.5" 5 megapixel sensor we achieved average sharpness improvement over the image area around 40% compared to the raw images, effectively doubling the resolved pixel count.



# Optical Distortions

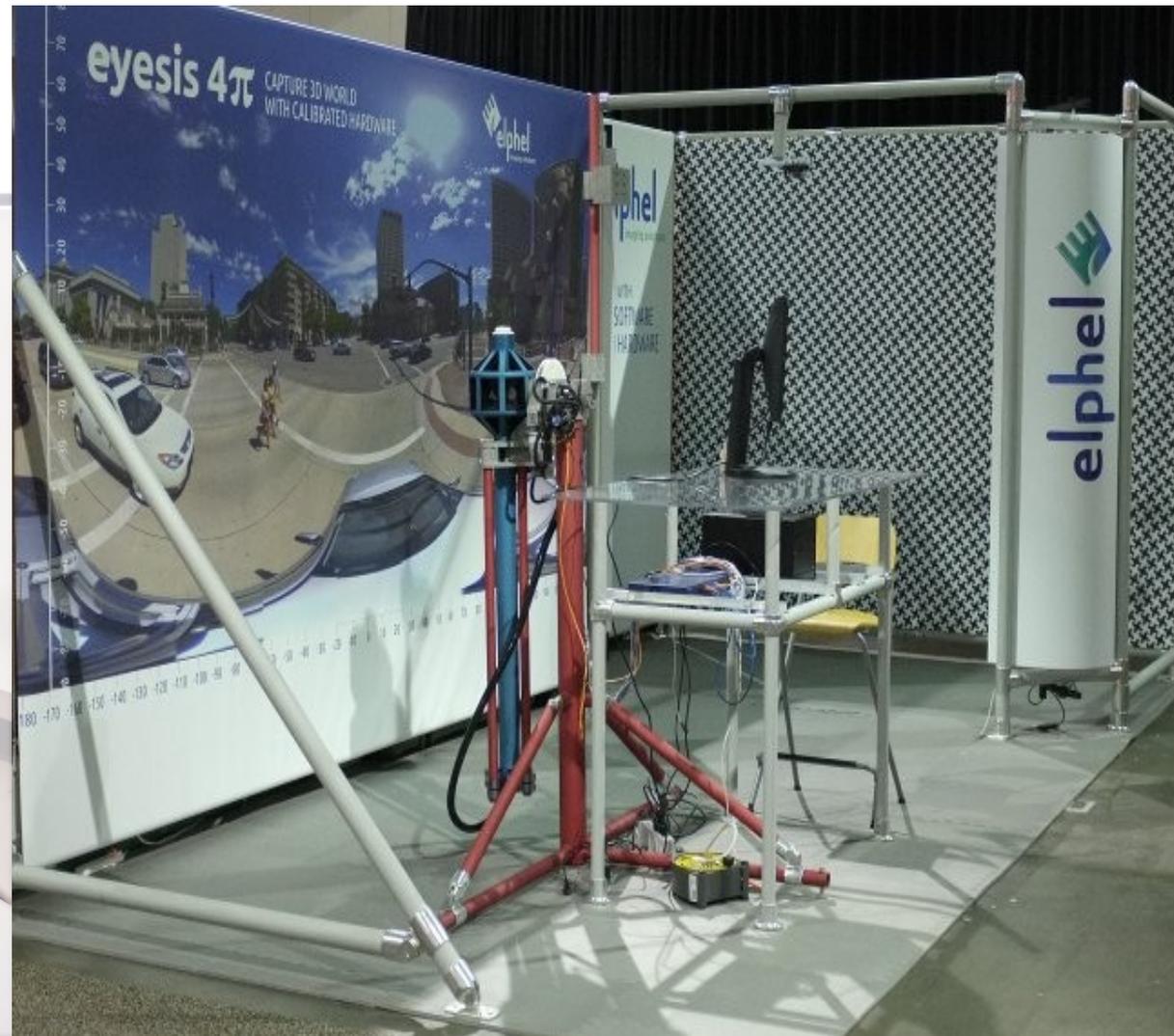


## Fish-eye lens distortion



# Calibration for Distortions

## Calibration Machine and Pattern

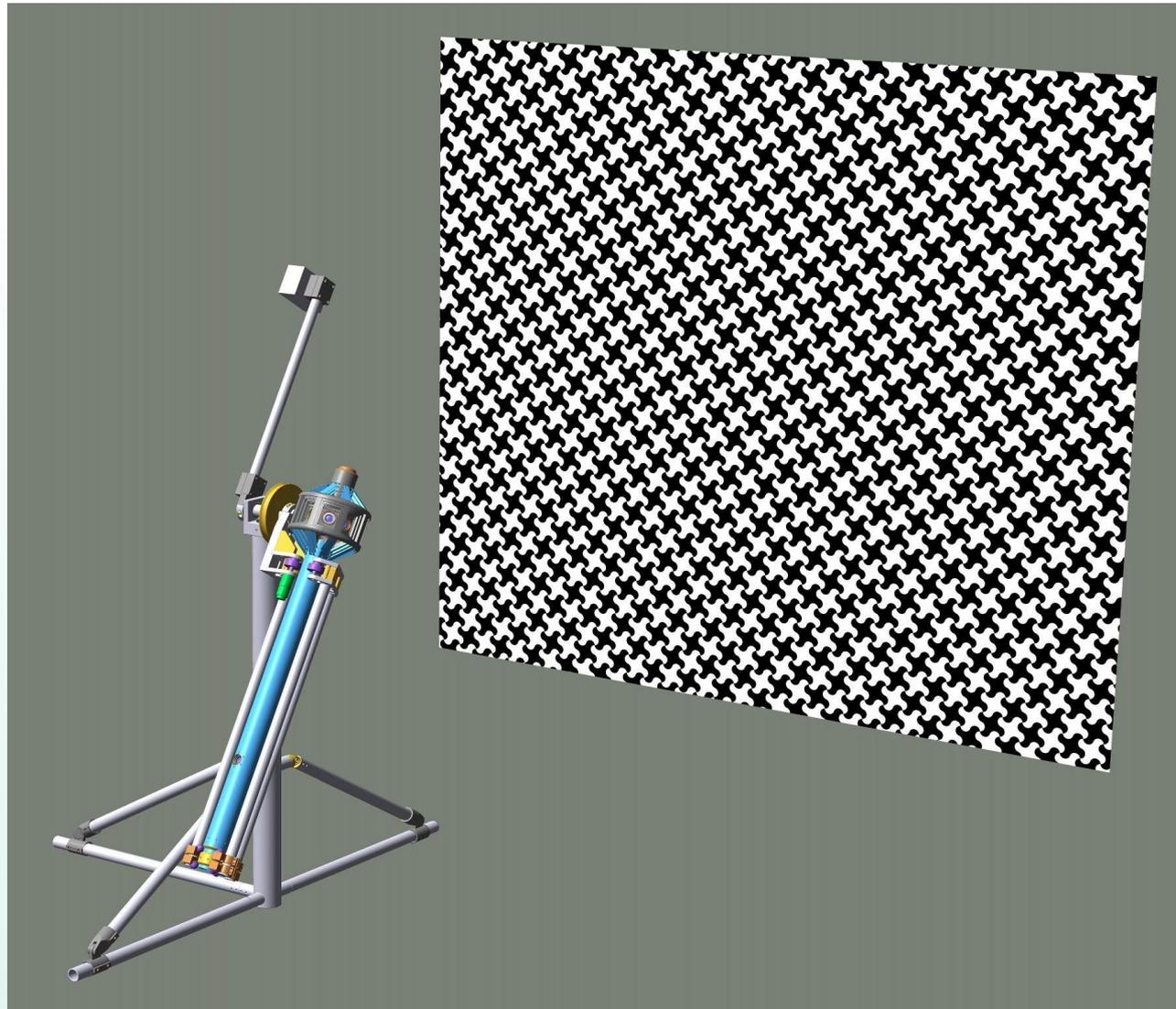


# Pixel Mapping with sub-pixel resolution

Camera as a measuring tool

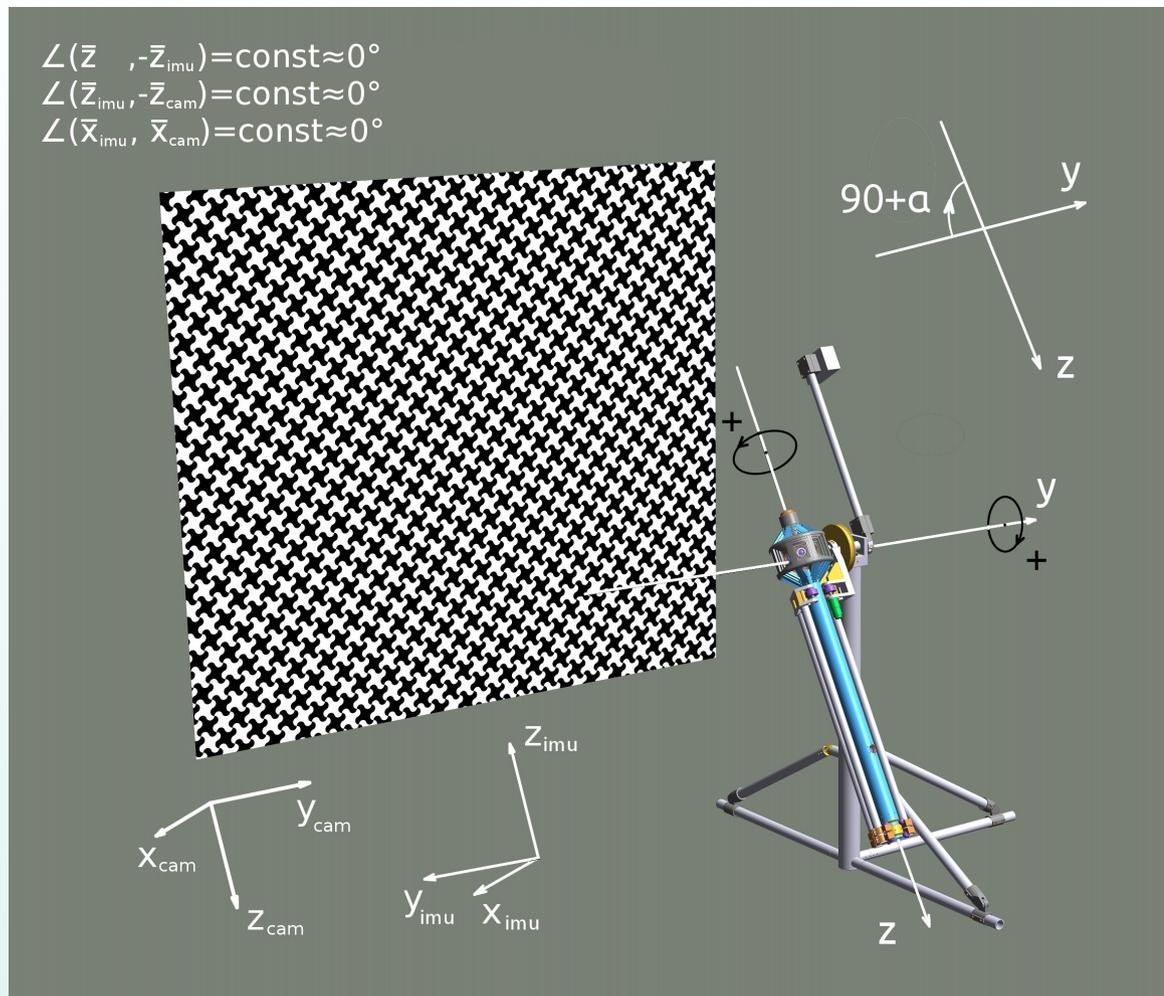
Photogrammetry

3D reconstruction



# Inertial Measurement Unit (IMU):

IMU calibration



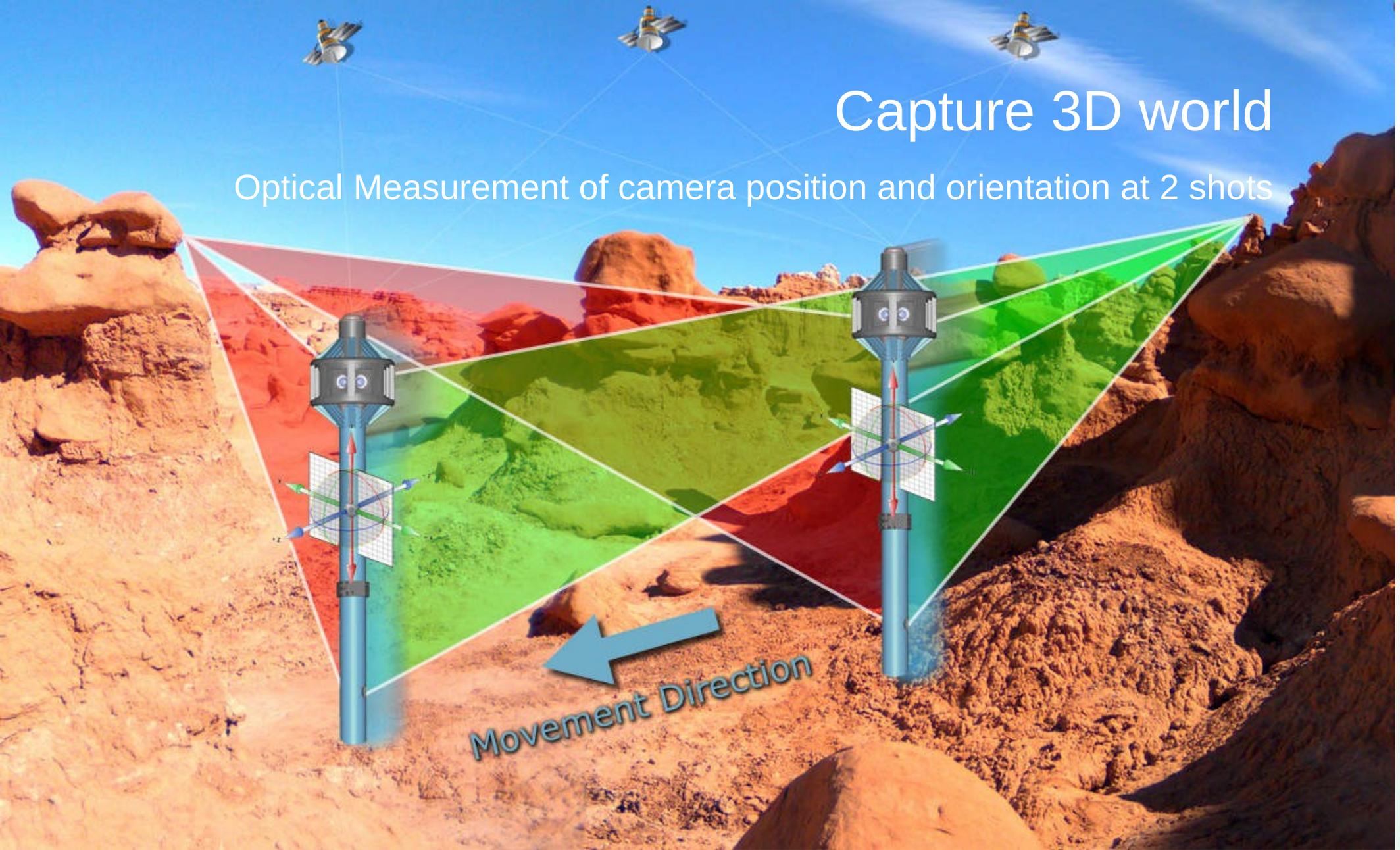
## Inertial Measurement Unit (IMU):

Compensate ERS (Electronic Rolling Shutter) distortion by recording position /orientation of camera several times within each frame



# Capture 3D world

Optical Measurement of camera position and orientation at 2 shots



HDR with moving camera,  
will be possible with textures on 3D mesh



## Eyesis $4\pi$ R&D

- Inertial Measurement Unit (IMU) :  
3D Position and Orientation  
Compensate for Rolling Shutter Distortion
- Photogrammetry
- 3D Reconstruction
- HDR with moving camera

# Internship at Elphel

## Programming:

- image processing for optics and cameras (Java, C/C++)
- Web applications (WebGL, PHP, Javascript, HTML)
- adapting camera for specific applications (PHP, Javascript, HTML, Java)
- IMU data processing: filtering, orientation (Java, C/C++)
- 3D reconstruction (Java, C/C++)
- FPGA programming (Verilog);

Experience working with electronics hardware

Electronics Design and Verification

Open house: October 10<sup>th</sup>, 18<sup>th</sup>  
12 – 2pm

1405 W 2200 S #205 WVC, UT 84119

[www.elphel.com](http://www.elphel.com)

Development Blog: <http://blog.elphel.com>

Documentation: [wiki.elphel.com](http://wiki.elphel.com)

Code: [SourceForge.net](http://SourceForge.net)

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