

# MERIDIAN

MARS EXPLORATION ROVER  
TELECOM PREDICTION

MATT CONLEN    CHELLY JIN    SARA STALLA

PI: VICKIE SCARFFE-BARRETT

SOLS 4833 - 4833

GTP

EMP

128



CLEAR

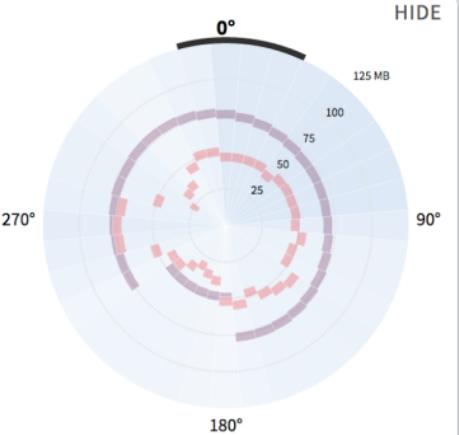
OVERPASS

SEND

YPR 123, 21, 1

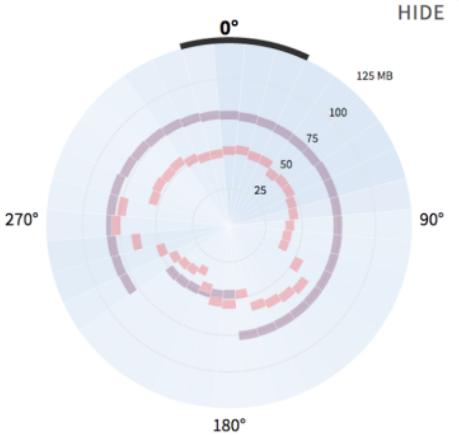
## ODY 45761

139 11:25 2017  
4743 17:00 SOL



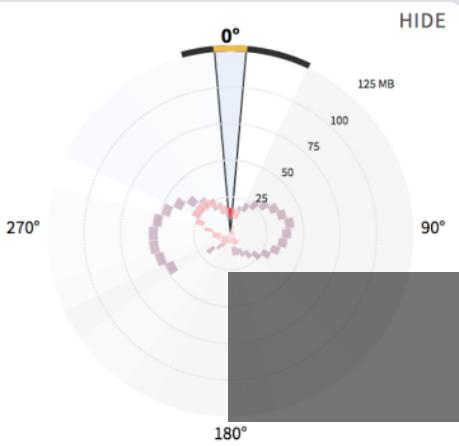
## ODY 45231

139 11:25 2017  
4743 17:00 SOL



## MRO 56921

139 11:25 2017  
4743 17:00 SOL



# MERIDIAN

0 ..... 130 MB

4.7 14.5 16.39

56921  
350°

4.9 13.58 14.53

0°

20

15

10

5

0

-5

-10

-15

-20

-25

-30

-35

-40

-45

-50

-55

-60

-65

45761  
350°

0°

10°

20°

14.3

50.04 74.09

45231

9.1

12.1

12.1

12.1

14.3

50.66 77.19

46.68 75.99

46.68 74.45

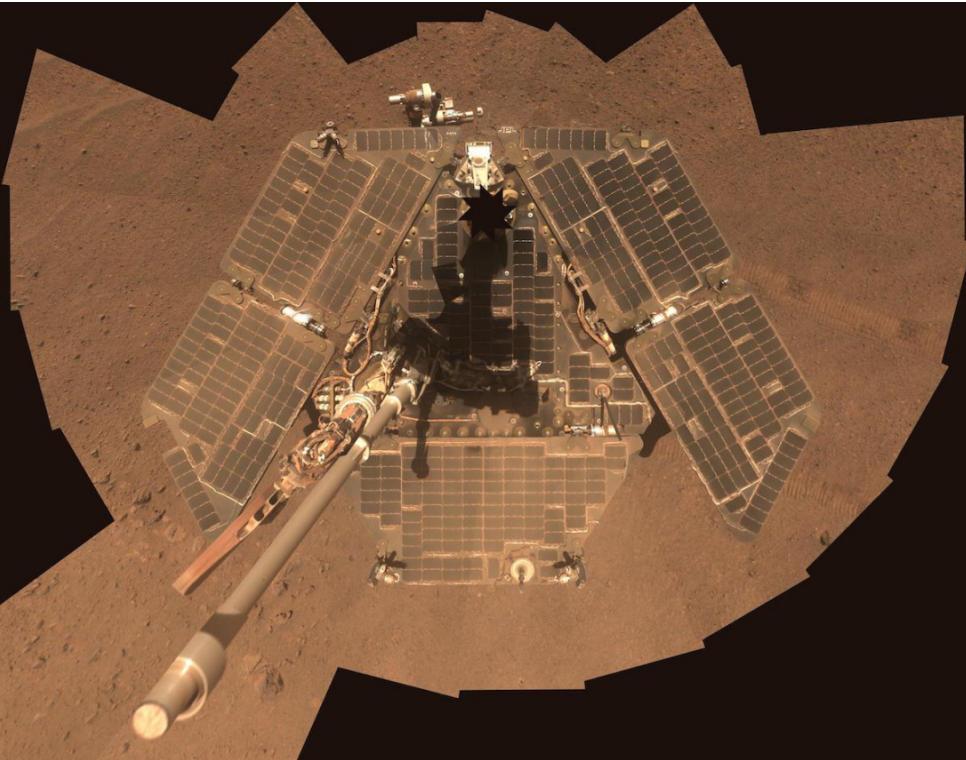
46.68 72.87

50.04 74.09

# Mars Exploration Rover (MER) **OPPORTUNITY**

Launched in 2003,  
on Mars since 2004

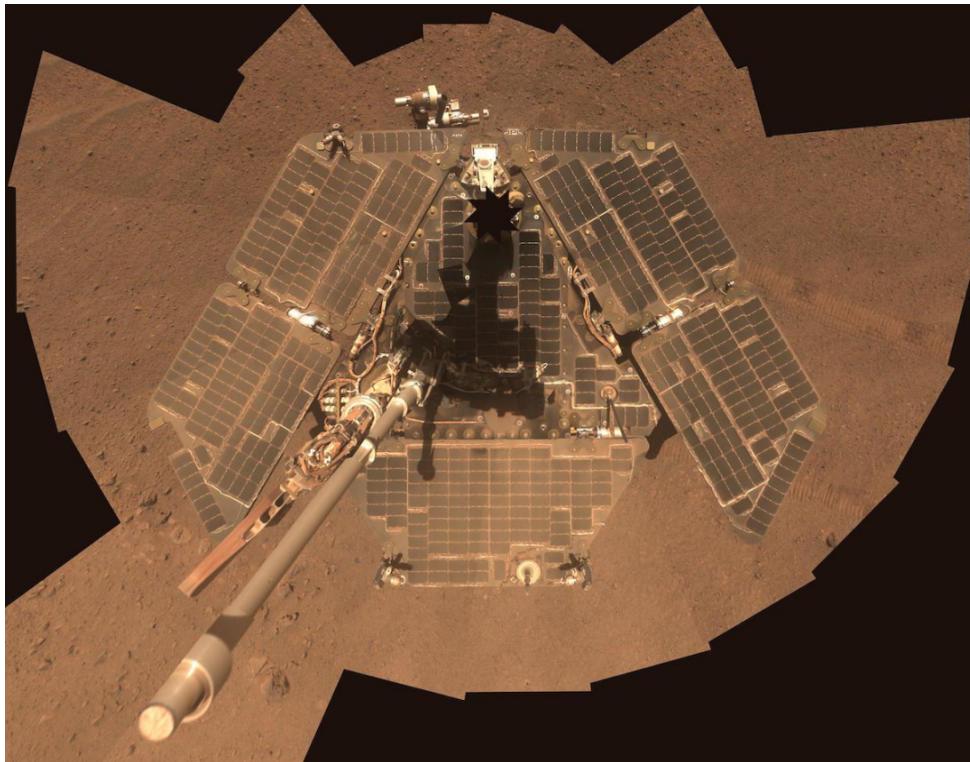
Several cameras  
onboard spectrometer  
microscopic imager



Mission was meant to last 90 days,  
certain tools not developed for long  
term management

## **ROVER LIMITATIONS**

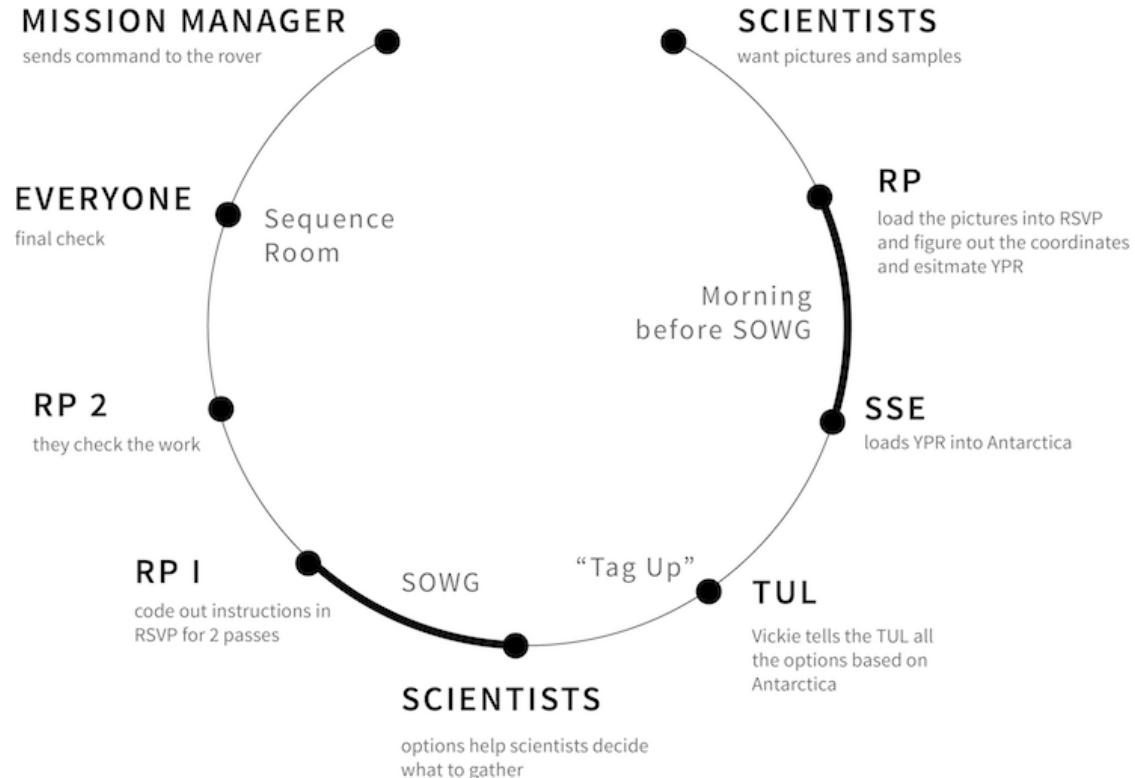
steering, driving, memory is wiped  
every night

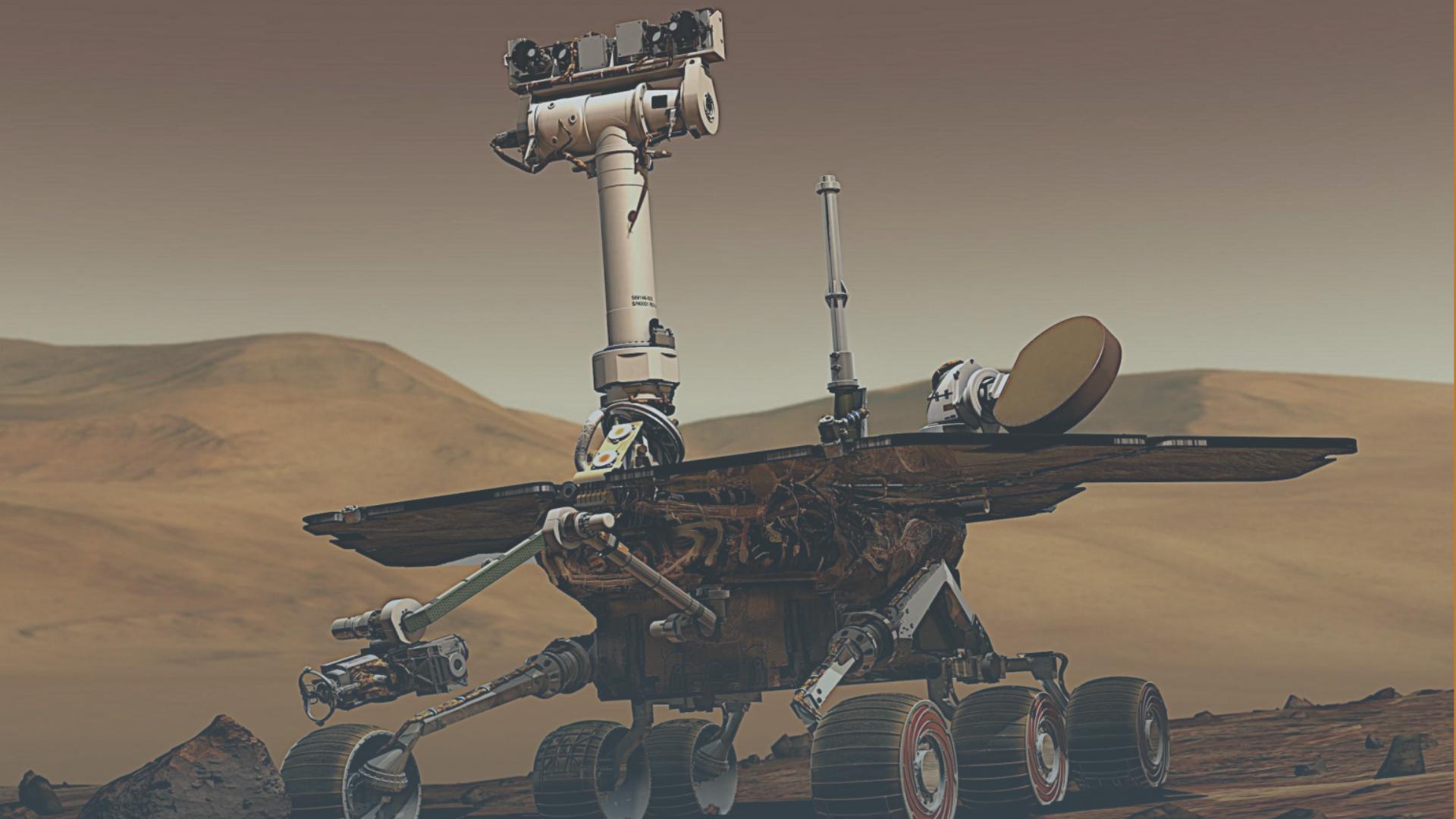


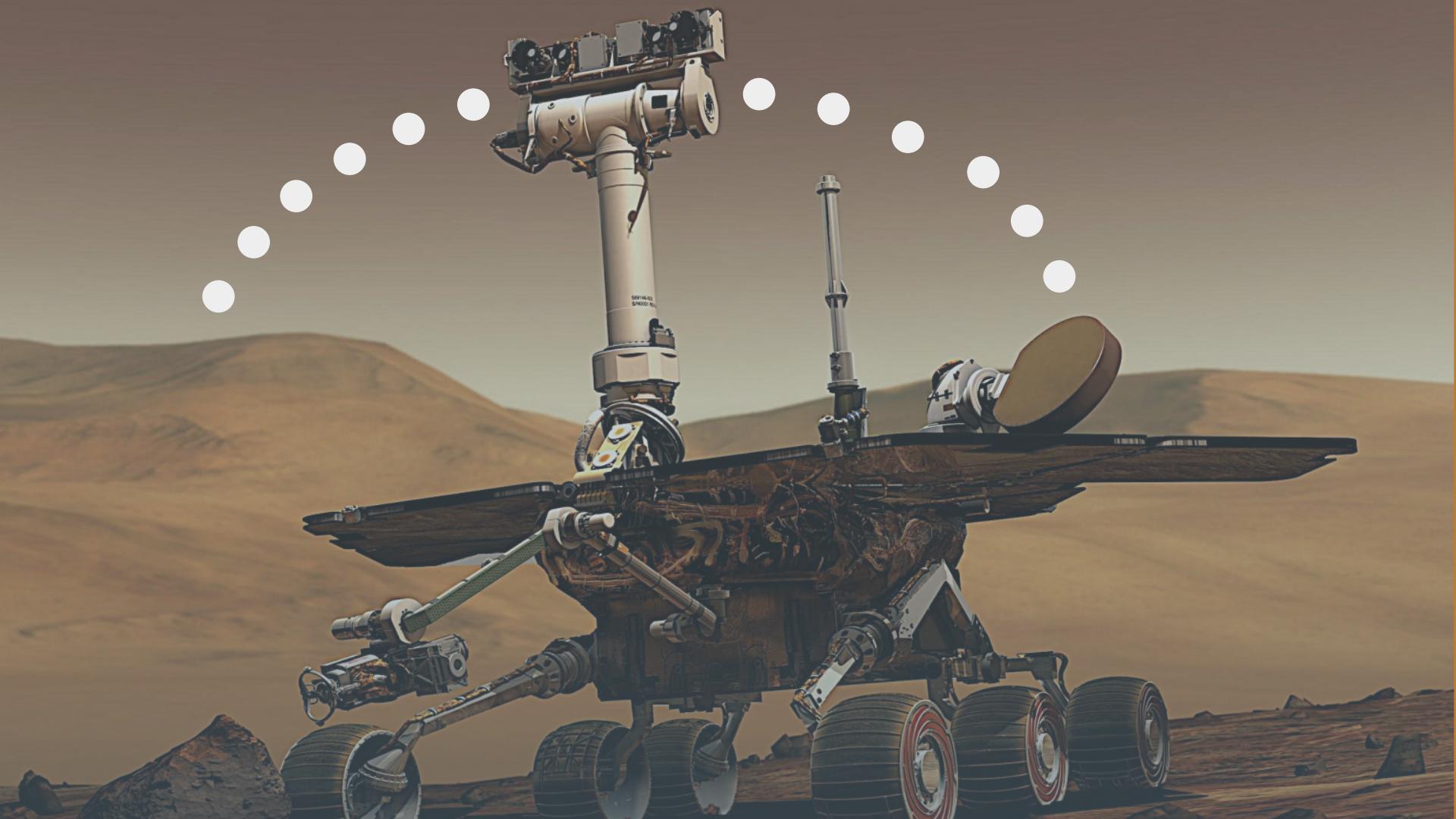
# PROBLEM STATEMENT

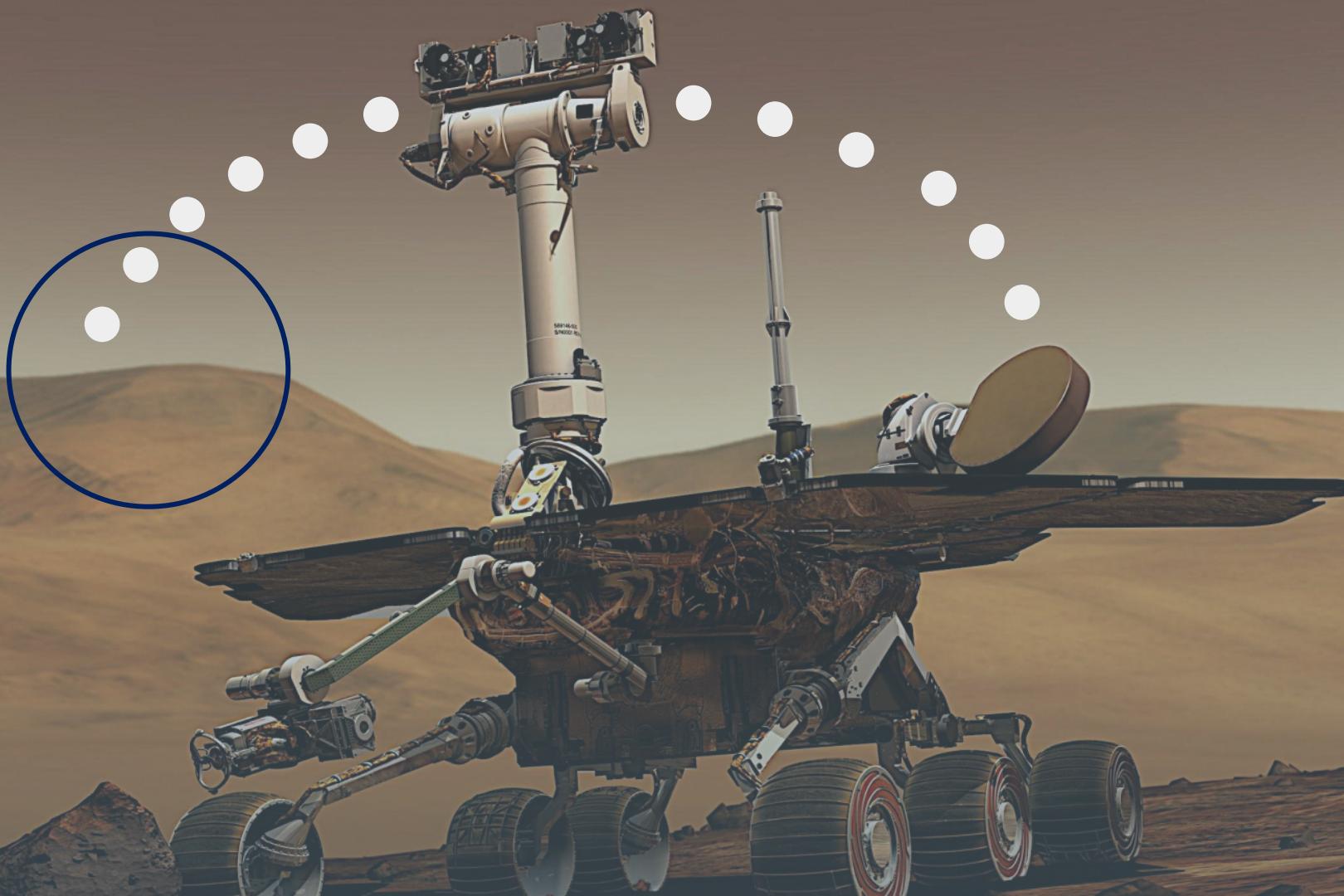
Spacecraft Systems Engineers (SSEs) need to predict how much data can be transferred from the rover to an overpassing satellite in order to:

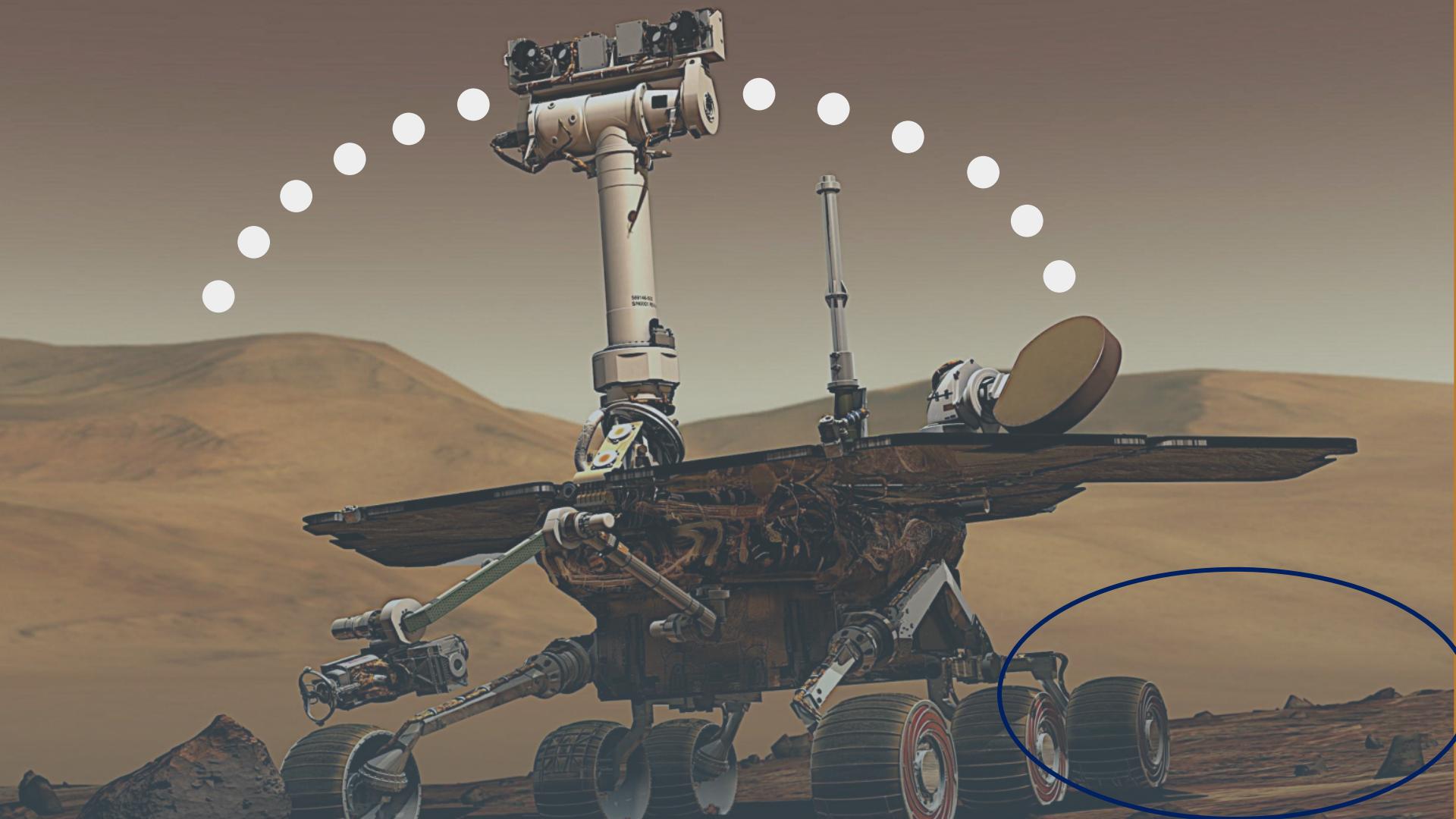
- 01     Provide scientists with an estimate of available data transfer
- 02     Recommend the heading at which a rover should end its path to achieve a high level of data transfer.

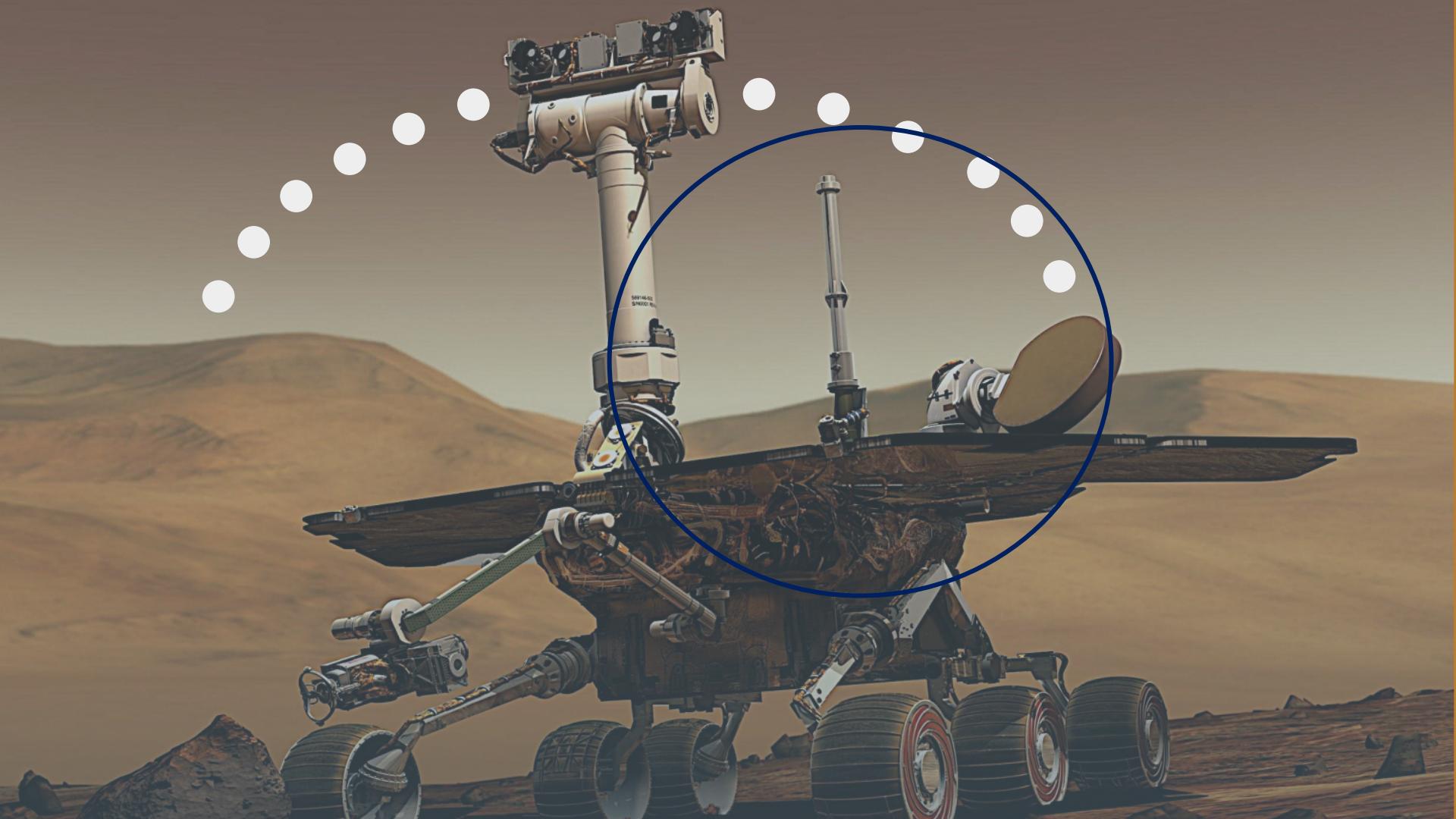






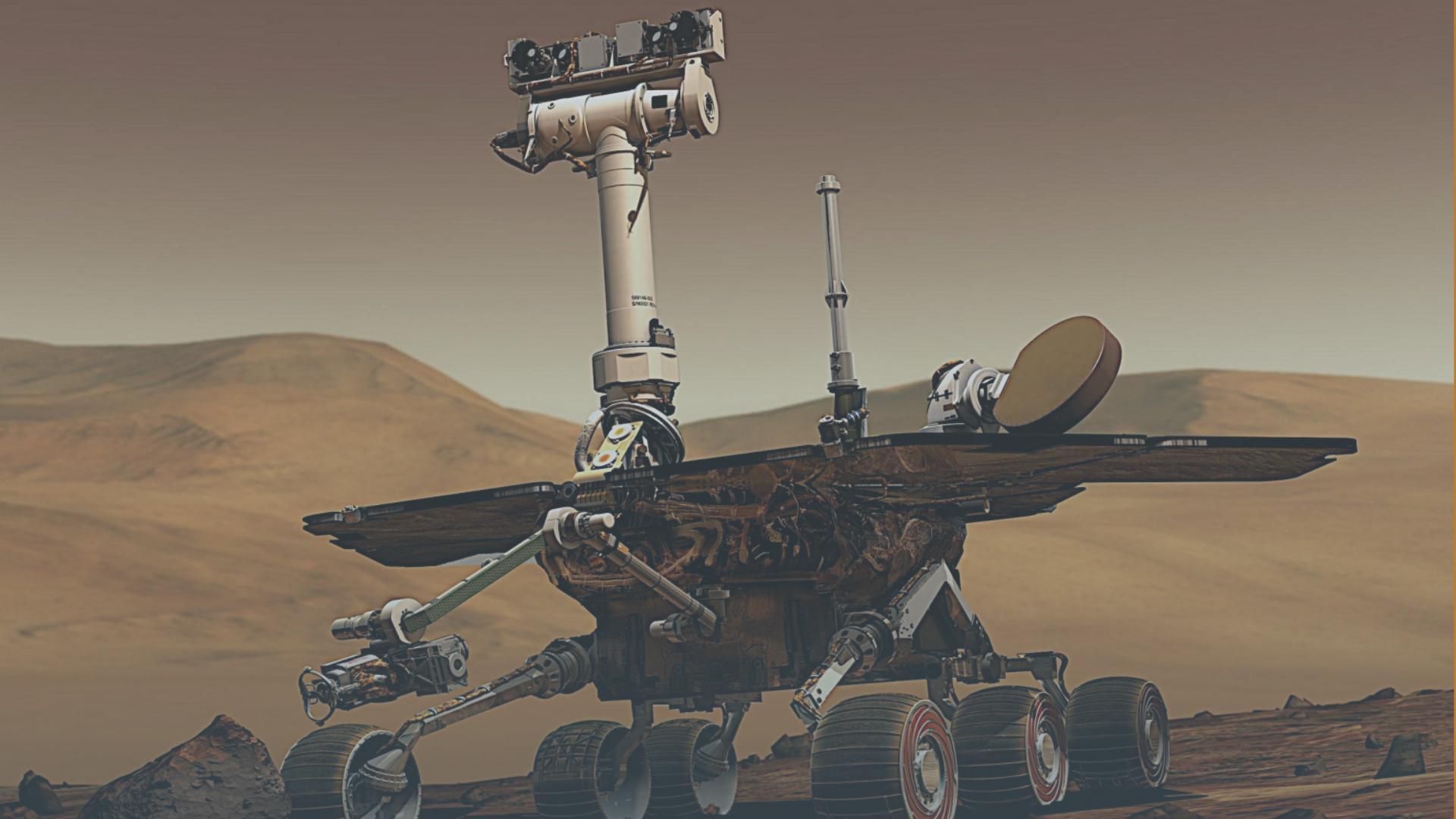






## WHEN MAKING DECISIONS ABOUT DATA TRANSFER, **SSEs MUST CONSIDER**

- |    |   |    |   |
|----|---|----|---|
| 01 | The ability of the rover<br>to link with the orbiter<br><i><u>Link Margin</u></i> | 02 | The total amount of<br>data that can be<br>transferred<br><i><u>GTP EMP</u></i> |
|----|---|----|---|



*“Currently our method of evaluating our heading choices is to open all of the plots, on different computers or windows, and to examine each one, moving them around the screen to compare next to each other.*

***Sometimes we will even print out some of the plots and hold layered paper up to the light to compare them together.”***

\* \* \* W A R N I N G \* \* \*  
You are connected to a Jet Propulsion Laboratory machine

Property of the  
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This computer is funded by the United States Government and operated by the California Institute of Technology in support of ongoing U.S. Government programs and activities. If you are not authorized access to this system, disconnect now. Users of this system have no expectation of privacy. By continuing, you consent to your keystrokes and data content being monitored.

Unauthorized Access is a violation of U. S. Federal Law.

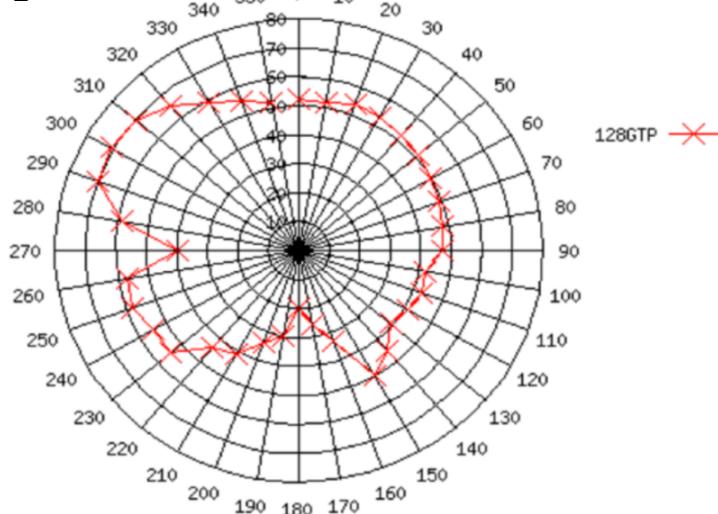
\* \* \* W A R N I N G \* \* \*  
You are connected to a Jet Propulsion Laboratory machine

Property of the  
UNITED STATES GOVERNMENT

This computer is funded by the United States Government and operated by the California Institute of Technology in support of ongoing U.S. Government programs and activities. If you are not authorized access to this system, disconnect now. Users of this system have no expectation of privacy. By continuing, you consent to your keystrokes and data content being monitored.

Unauthorized Access is a violation of U. S. Federal Law.

. /ANTARCTICA.pl

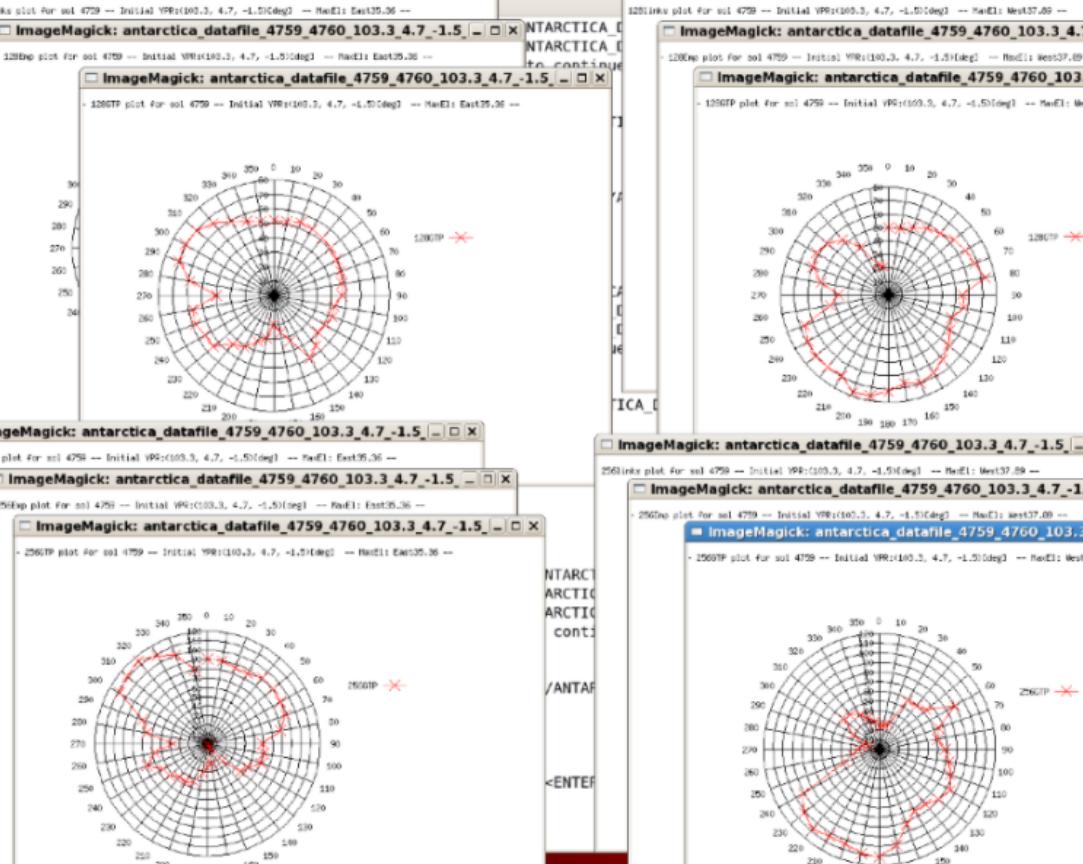
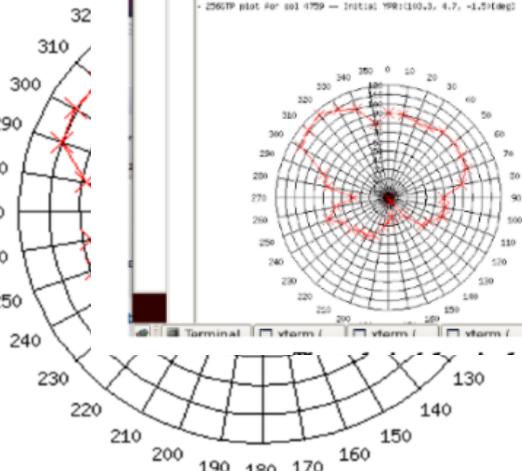


**./ANTARCTICA.pl**

You are conn

This computer is funded  
by the California Institute of  
Technology. It is a research  
program and acts as a public  
service system, disconnec  
tions of privacy. Etc.

Unauthorized



Predicts for 47591 ODY\_MRB\_2017\_165\_01  
yaw = 350.00, pitch = -3.24, roll = -3.72  
Startran: 2017-165T04:21:29 (UTC) SOL  
4759 17:26:58 (LST)  
Pass is East, with a max el of 35.36 (deg)

## GTP Predicts\*\*\*\*\*

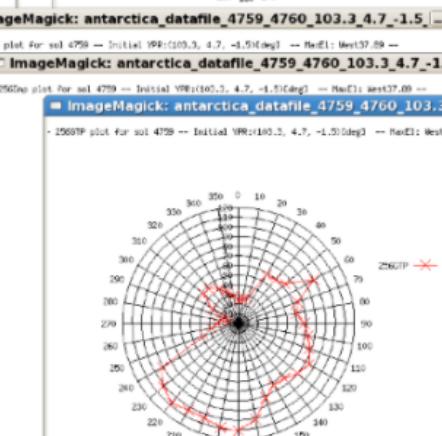
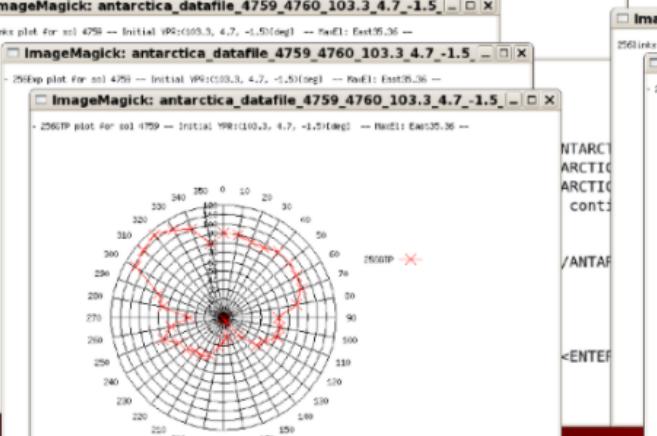
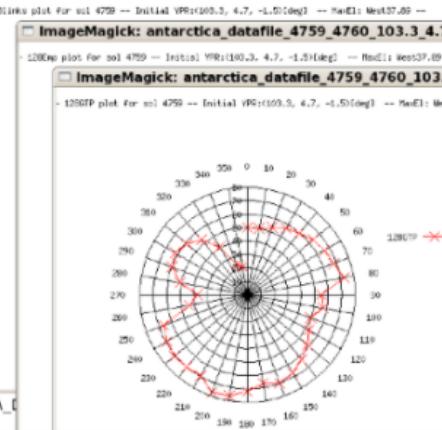
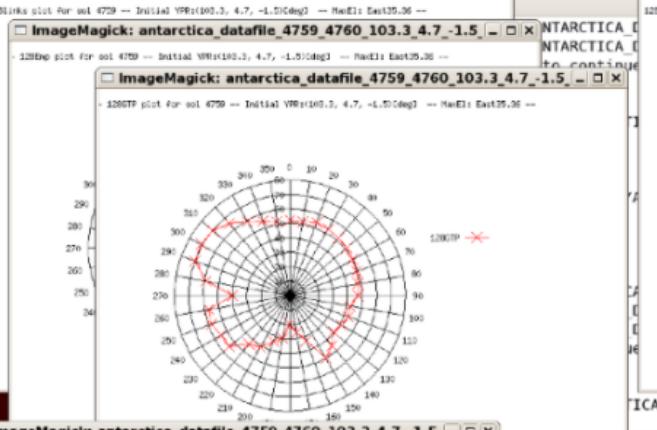
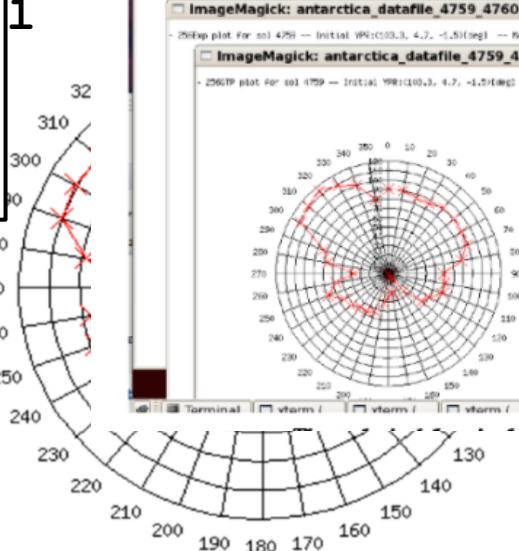
128k DV: 52.64 (Mbits) Link (dB): 12.83 \*\*\*  
256k DV: 80.46 (Mbits) Link (dB): 8.932

### Empirical Predicts\*\*\*

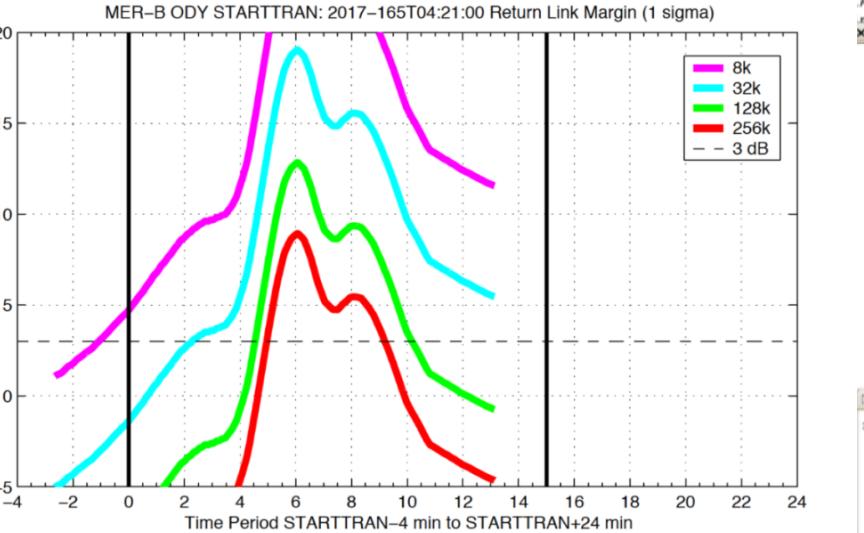
128k DV: 92.45 (Mbits) \*\*\*  
256k DV: 119.33 (Mbits)

Historically, for this yaw the 128k Empirical predicts have been more accurate.

Historically, for this yaw the 256k Empirical predicts have been more accurate.





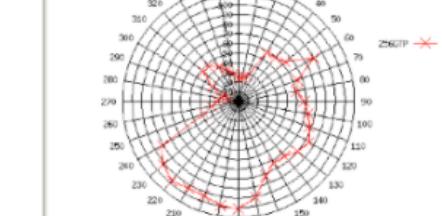
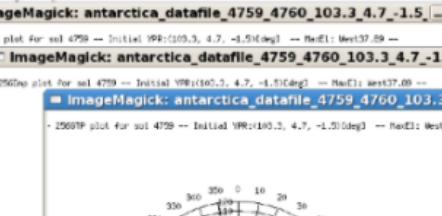
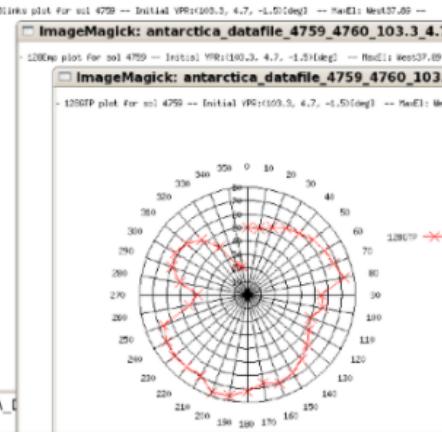


dicts for 47591 ODY\_MRB\_2017\_165\_01  
v = 350.00, pitch = -3.24, roll = -3.72  
rtran: 2017-165T04:21:29 (UTC) SOL  
59 17:26:58 (LST)  
ss is East, with a max el of 35.36 (deg)

P Predicts\*\*\*\*\*  
3k DV: 52.64 (Mbits) Link (dB): 12.83 \*\*\*  
6k DV: 80.46 (Mbits) Link (dB): 8.932

Empirical Predicts\*\*\*  
8k DV: 92.45 (Mbits) \*\*\*  
6k DV: 119.33 (Mbits)

Historically, for this view the 128k Empirical



Predicts for 47591 ODY MRB 201

Y Predicts for 47E01 QRY\_MBB

## Predicts for 17001 GBT - MRB

Predicts for 4759 | UDY\_MF  
252.26 ± 0.00 - 0.01

Predicts for 47591 ODY

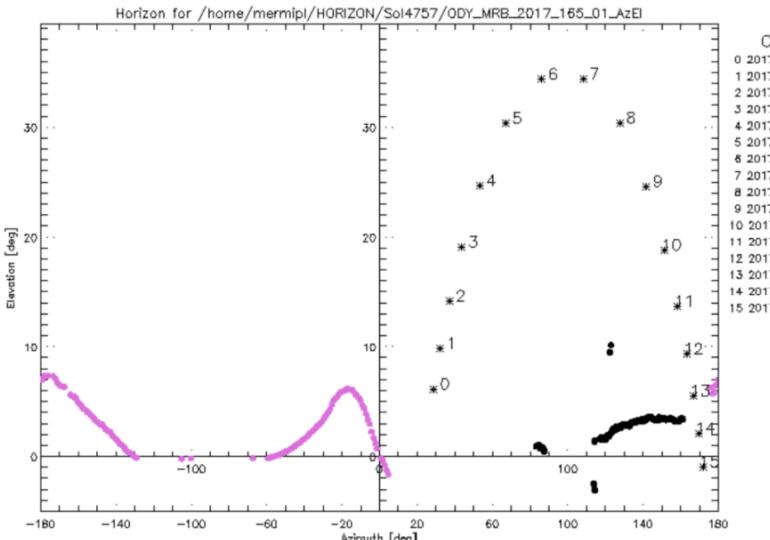
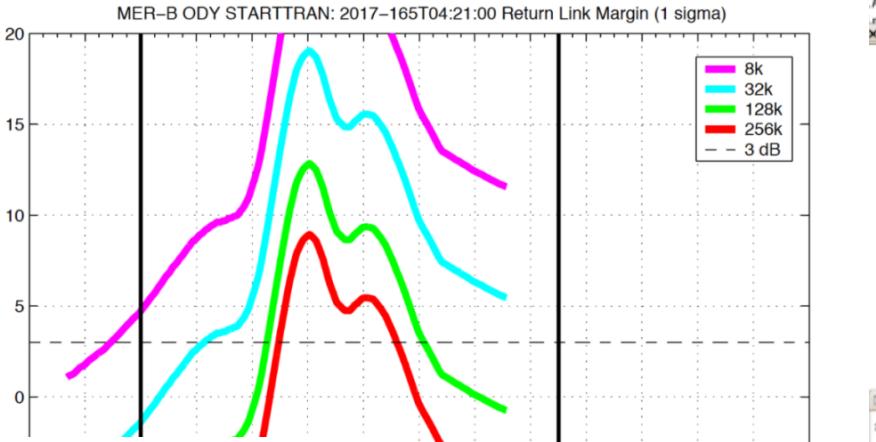
P 47 va

Pa St Predicts for 47591

G 47 ya Predicts for 47

12 G Page 1 Predicts f

目 25 12 47 Sta v3



er Times  
-14T04:21:29.000  
-14T04:22:29.000 **N-4 min to STARTTRAN+24 min**

1470424:29:000 VRB\_2017\_165\_01  
1470425:29:000  
1470426:29:000 !4, roll = -3.72  
1470427:29:000  
1470428:29:000 :29 (UTC) SOL

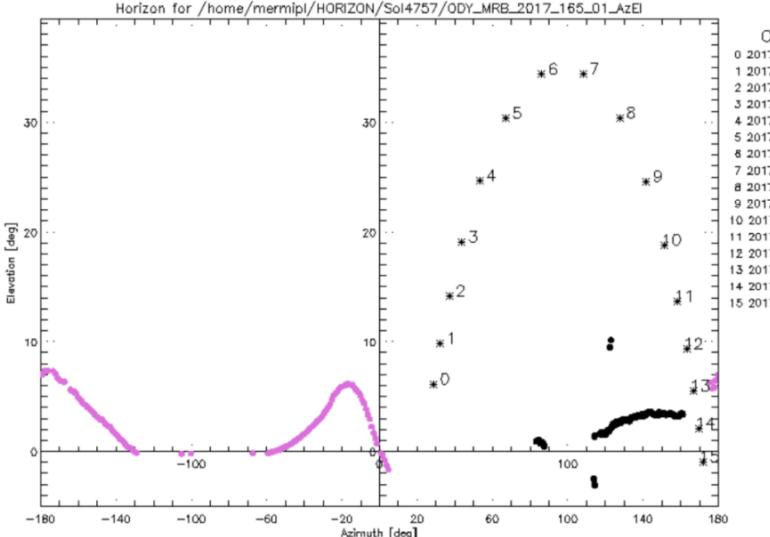
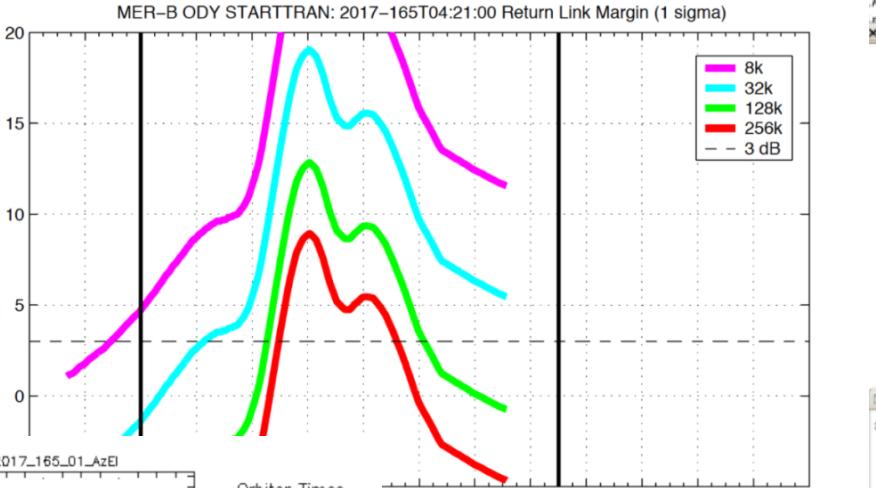
-14T04:30:29.000  
-14T04:31:29.000  
-14T04:32:29.000  
-14T04:33:29.000

-14T04:34:29.000  
-14T04:35:29.000  
-14T04:36:29.000

ink (dB): 12.83 \*\*\*

**pr<sub>1</sub> M<sub>1</sub>**] Historically, for this view the 128k Empirical

Predicts for 47591 ODY MRB 201



MRB\_2017\_165\_01  
14, roll = -3.72  
29 (UTC) SOL

MRB\_2017\_165\_01  
4, roll = -3.72  
:29 (UTC) SOL

06-14T04:28:29.000 :29 (UTC) SOL

06-14T04:30:29,000

06-14T04:31:29.000

06-14T04:32:29.000 1 of 35 36 (deg)

06-14T04:34:29.0

06-14T04:35:29.0

06-14T04:36:29.0

• 1

10. The following table summarizes the results of the study.

- 1 -

For more information about the study, please contact Dr. Michael J. Hwang at (310) 794-3000 or via email at [mhwang@ucla.edu](mailto:mhwang@ucla.edu).

For more information about the study, please contact Dr. Michael J. Hwang at (310) 206-6500 or via email at [mhwang@ucla.edu](mailto:mhwang@ucla.edu).

[View Details](#)

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\*

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[Historically, for this view the 128k Empirical]

22

## WHAT ARE THE PROBLEMS WITH THE CURRENT APPROACH

01

TIME CONSUMING

02

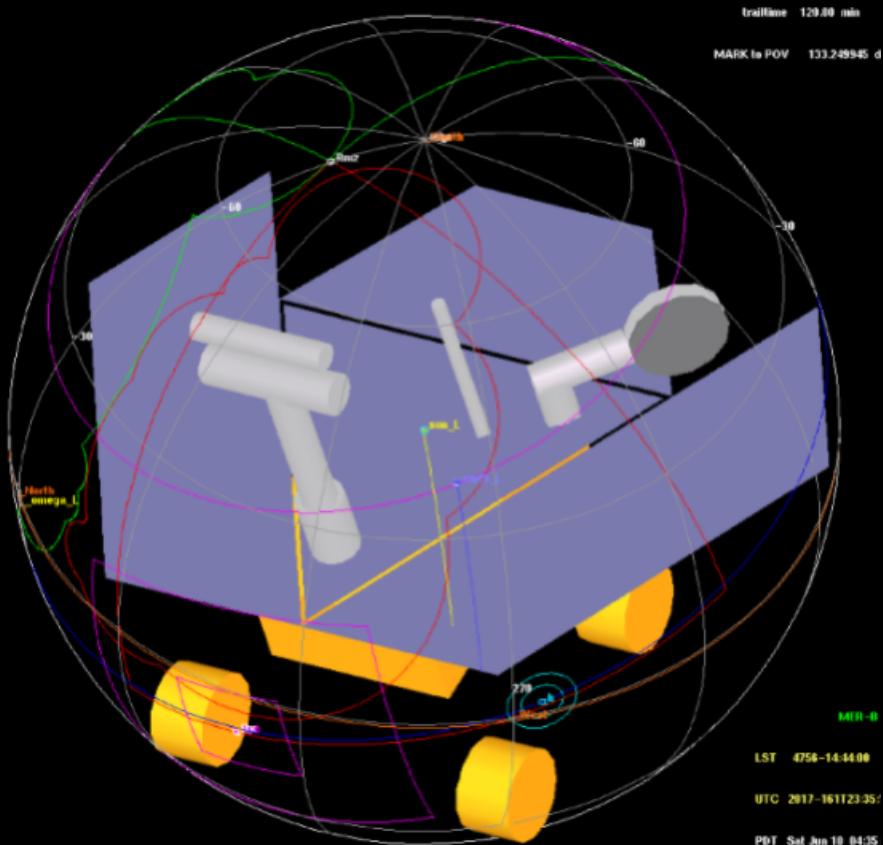
DECENTRALIZED

03

HARD TO COMMUNICATE

**WHAT ARE THE PROBLEMS  
WITH THE CURRENT APPROACH**

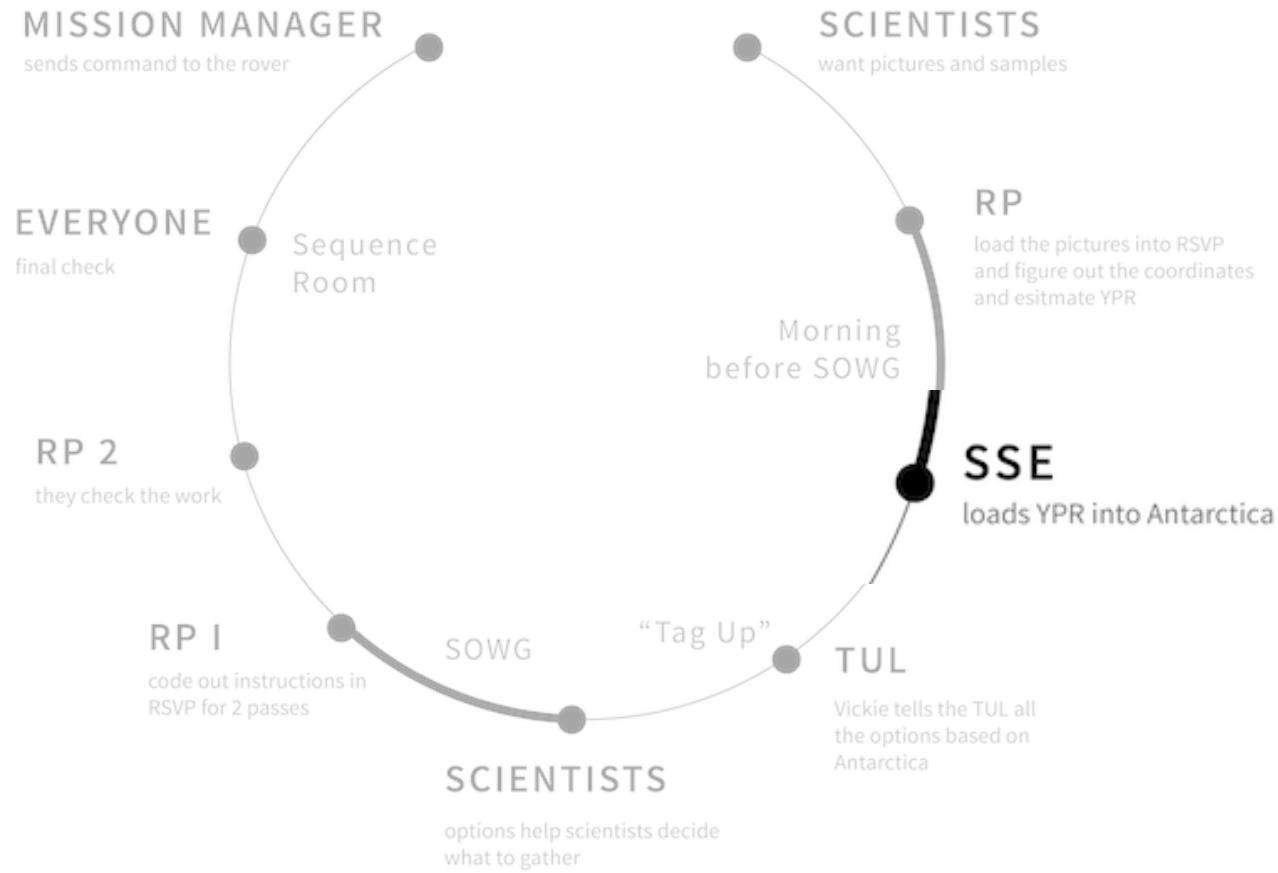
**SERIOUS REPERCUSSIONS FOR MISTAKES**



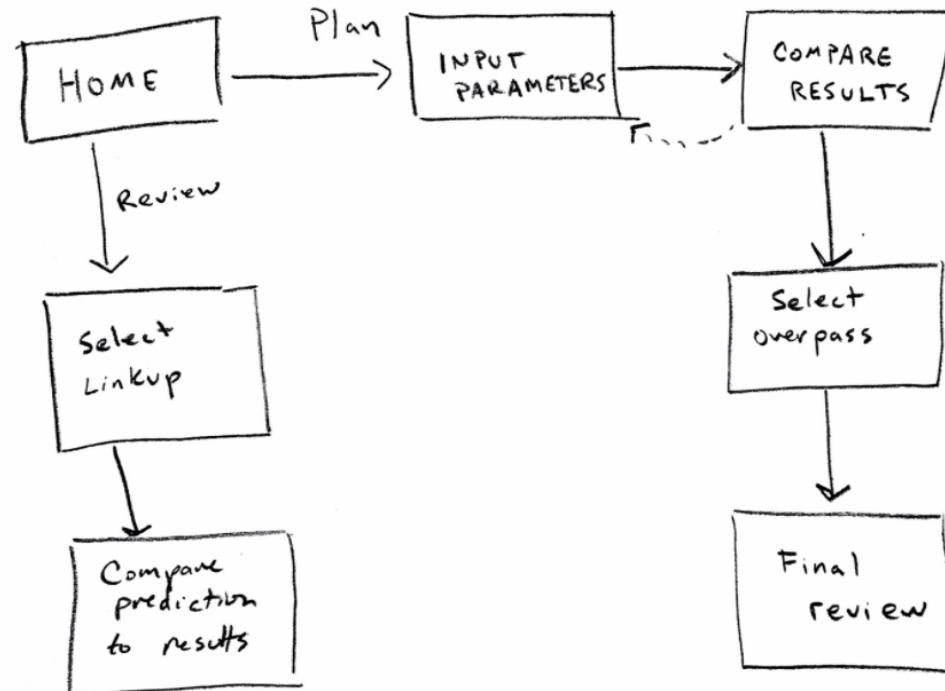
# PROBLEM STATEMENT

Spacecraft Systems Engineers (SSEs) need to predict how much data can be transferred from the rover to an overpassing satellite in order to:

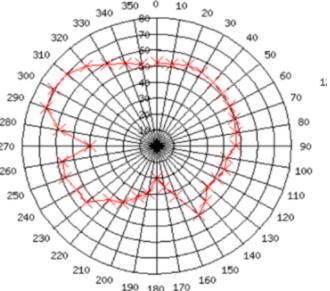
- 01     Provide scientists with an estimate of available data transfer
- 02     Recommend the heading at which a rover should end its path to achieve a high level of data transfer.



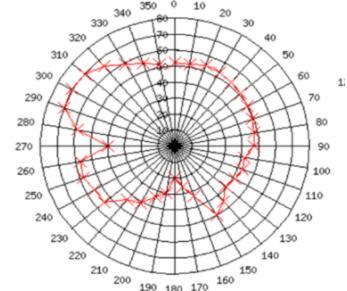
# SYSTEM WORKFLOW



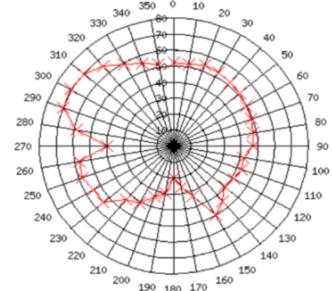
# REDESIGNING THE PLOTS



GTP

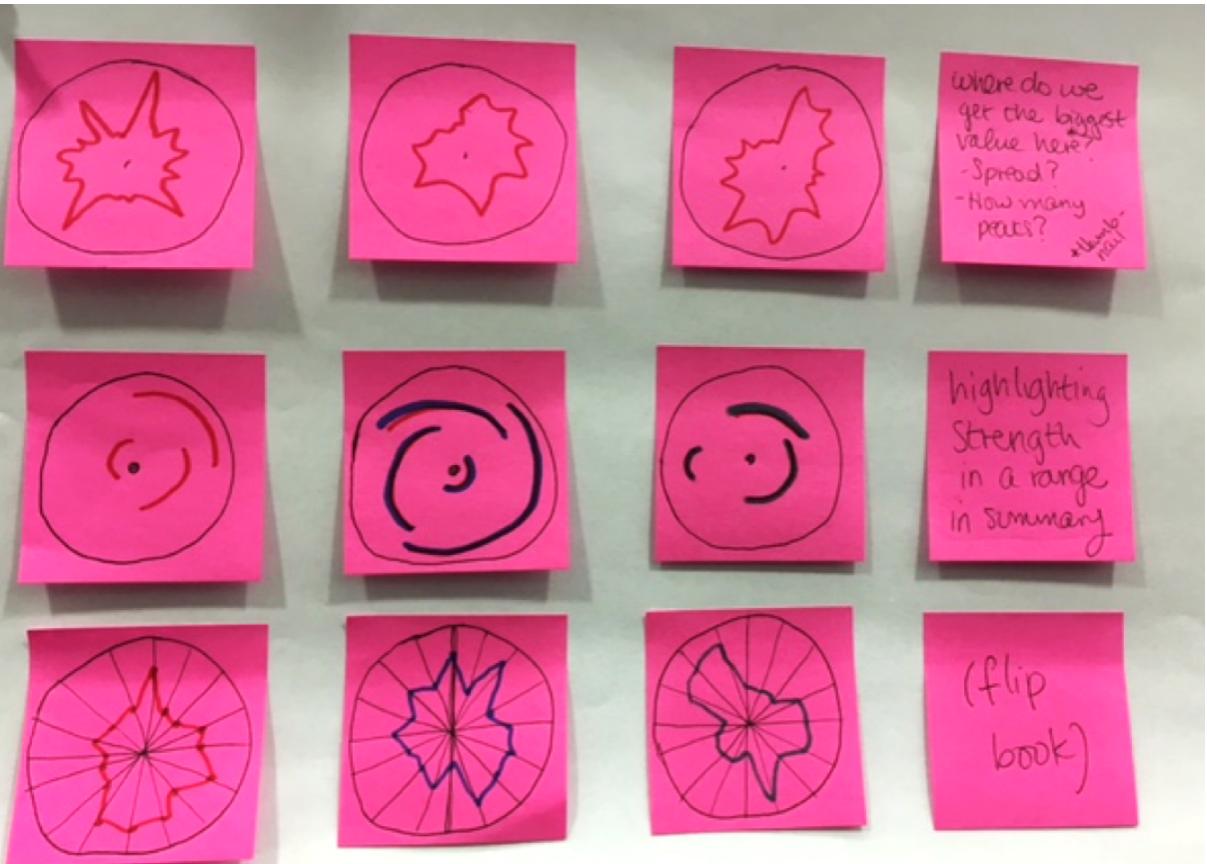


EMP



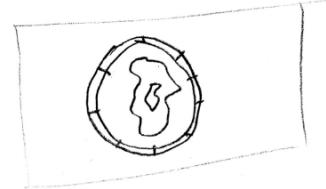
LINK  
MARGIN

# REDESIGNING THE PLOTS

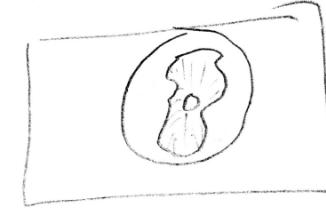


Small Overview  
Chart Ideas

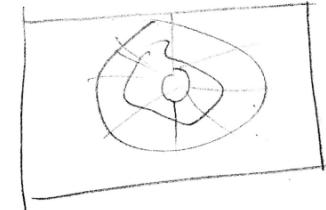
Color only around ring



Color clipped by lines



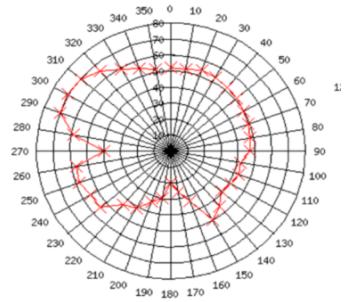
Softer coloring



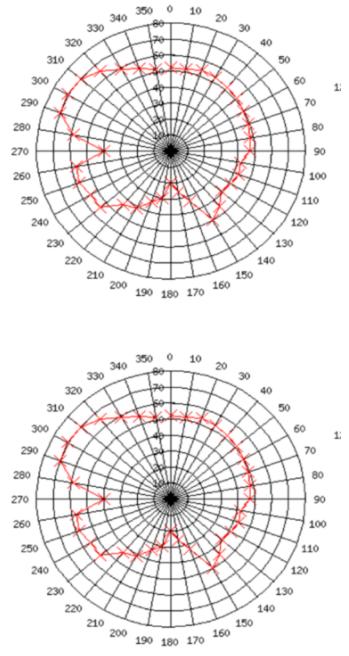
Cut outer or opacity fade



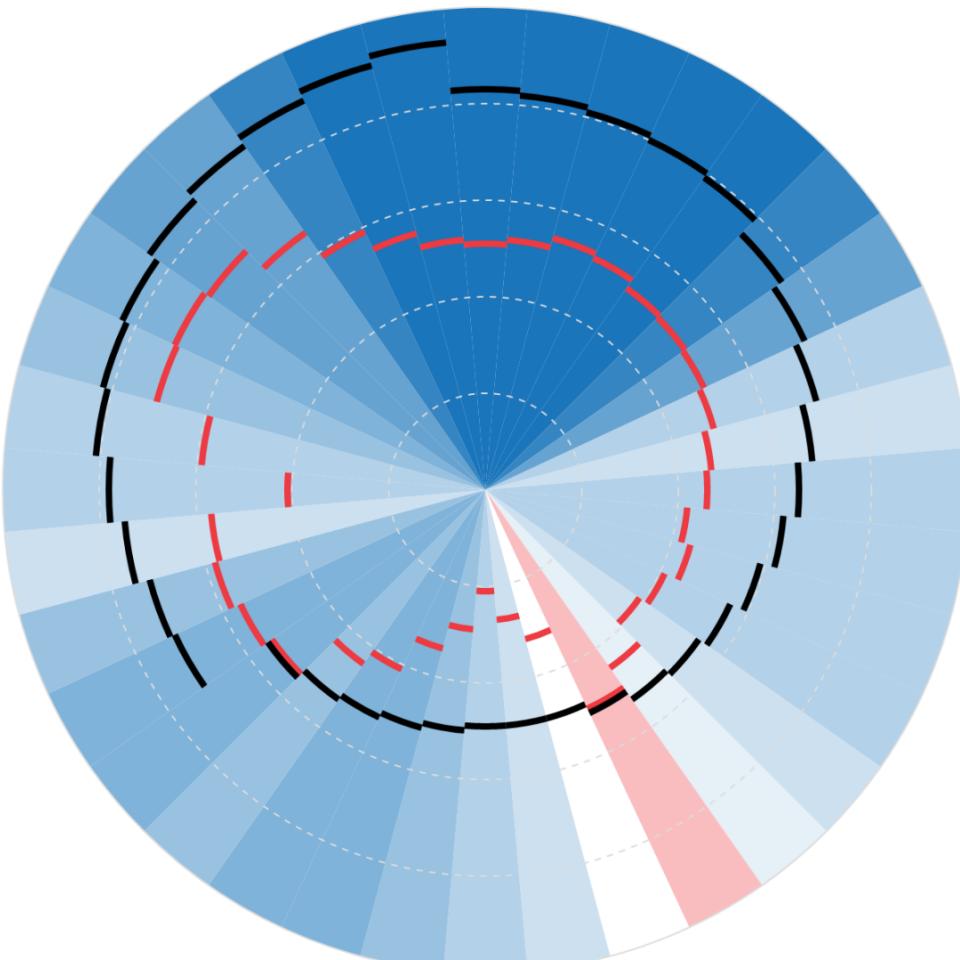
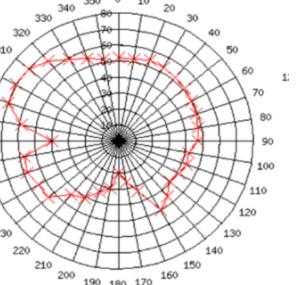
**GTP**

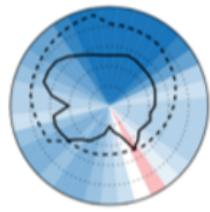


**EMP**



**LINK  
MARGIN**





A



B



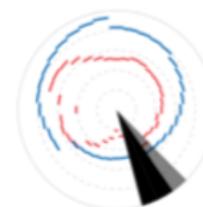
C



D



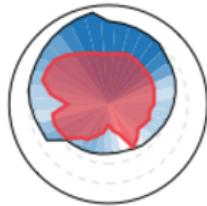
E



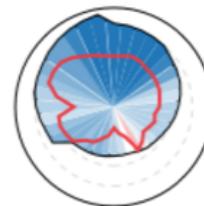
F



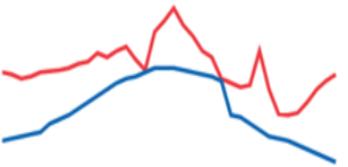
G



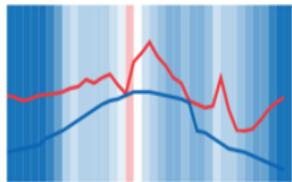
H



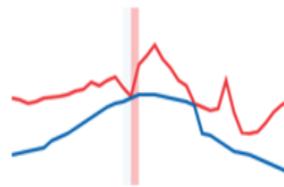
I



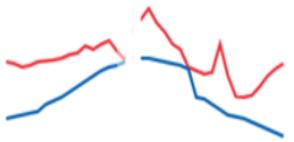
J



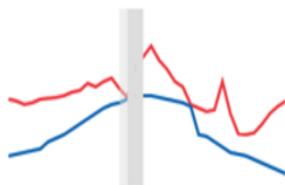
K



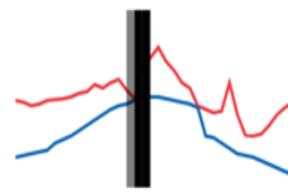
L



M

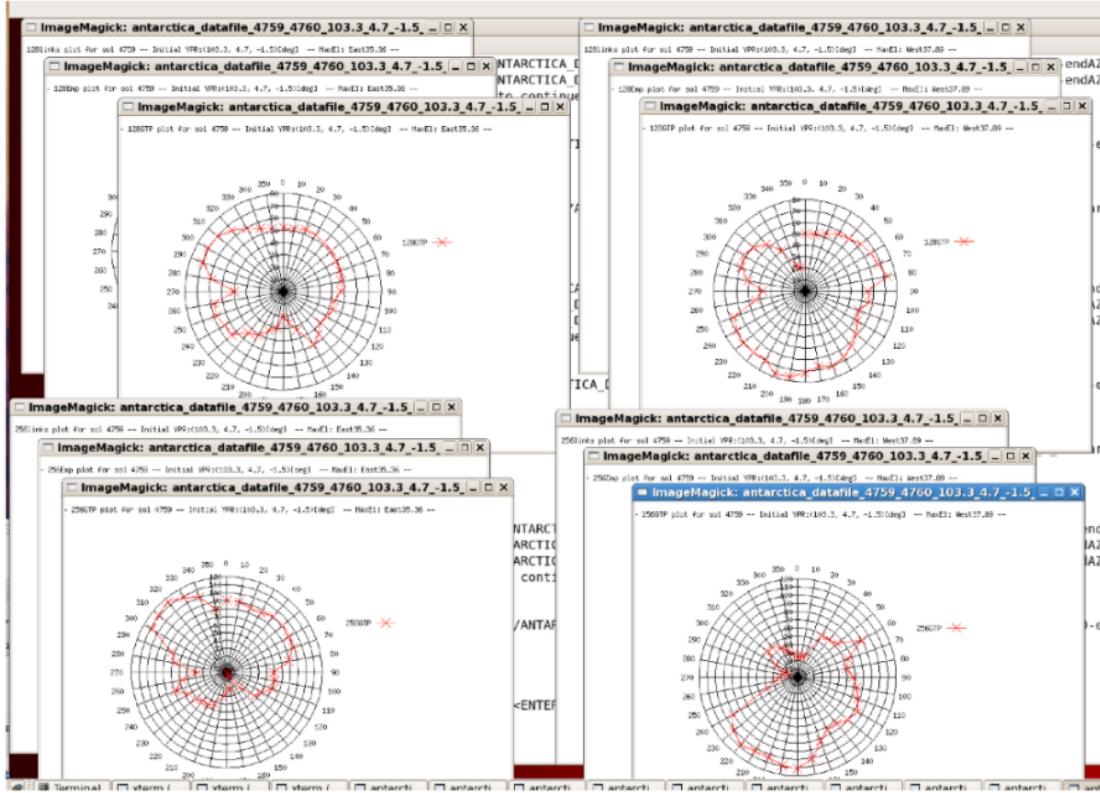


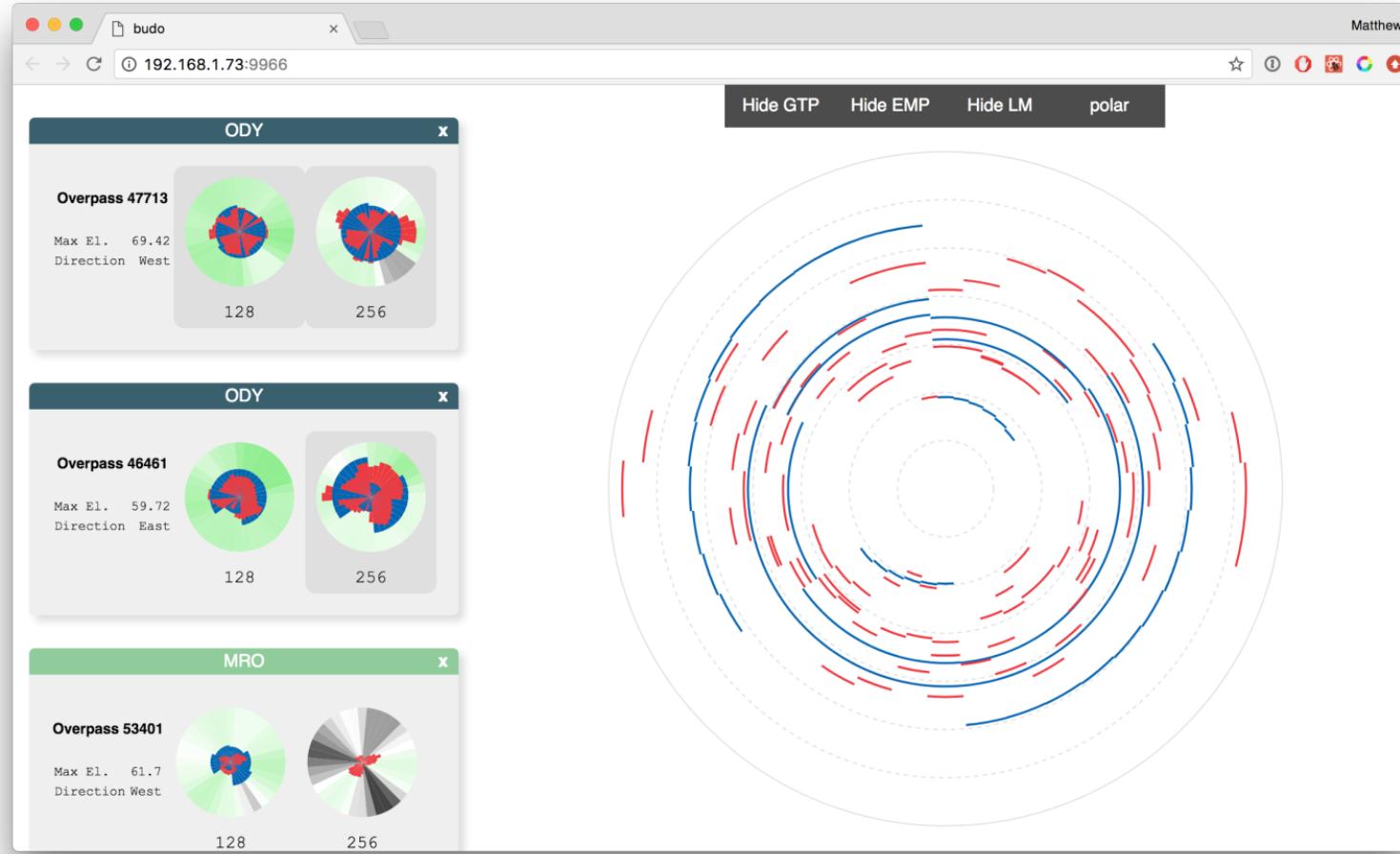
N

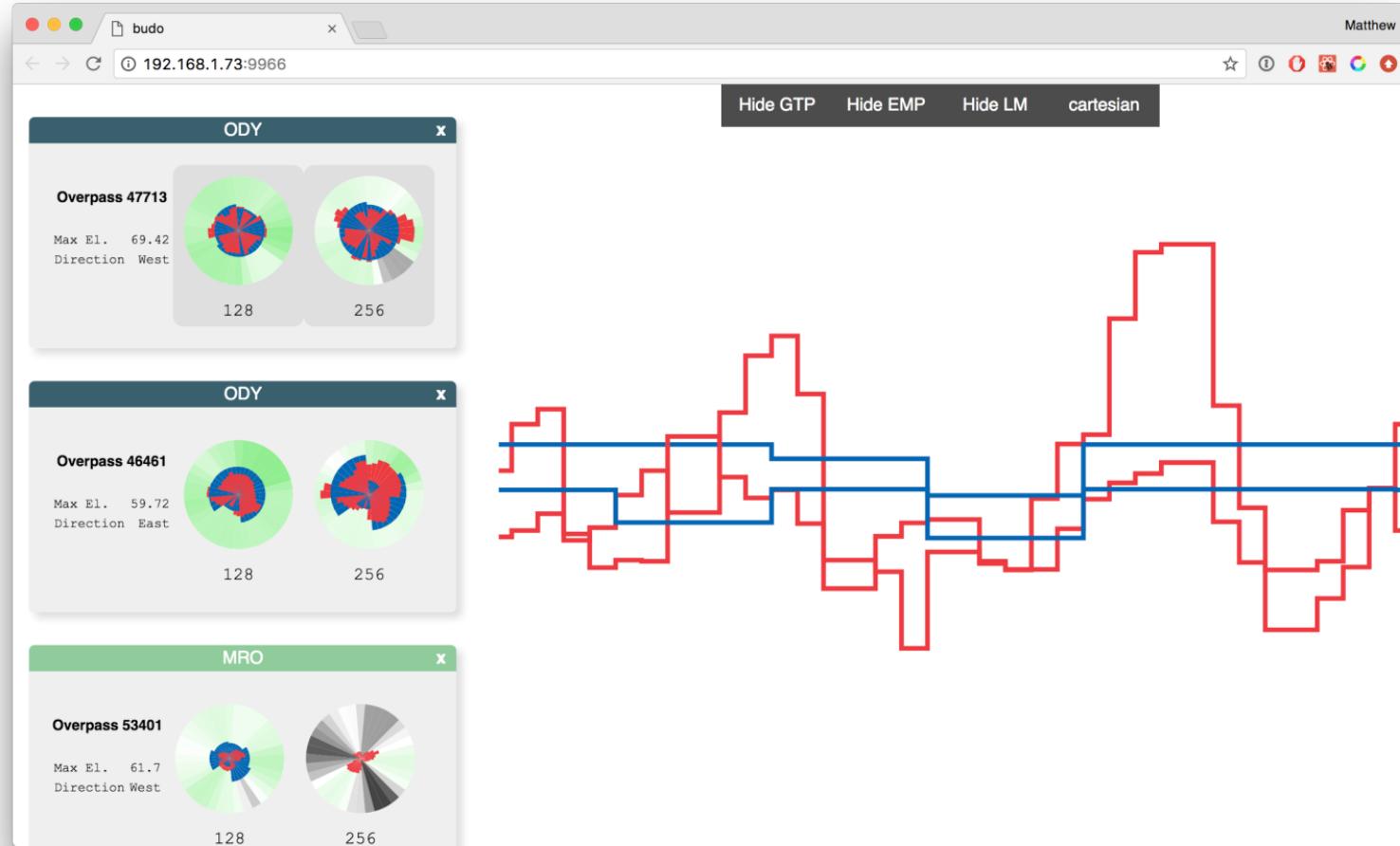


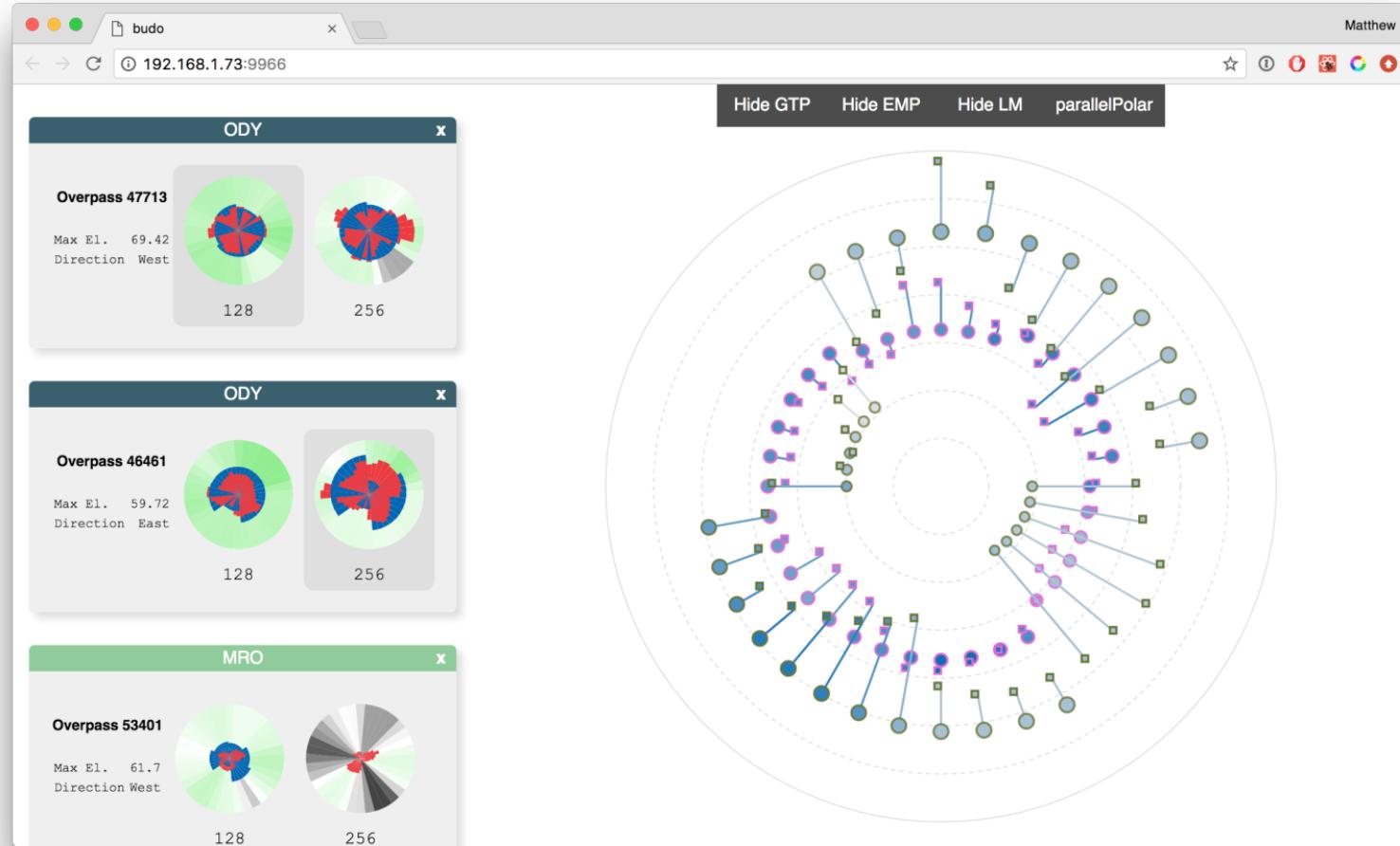
O

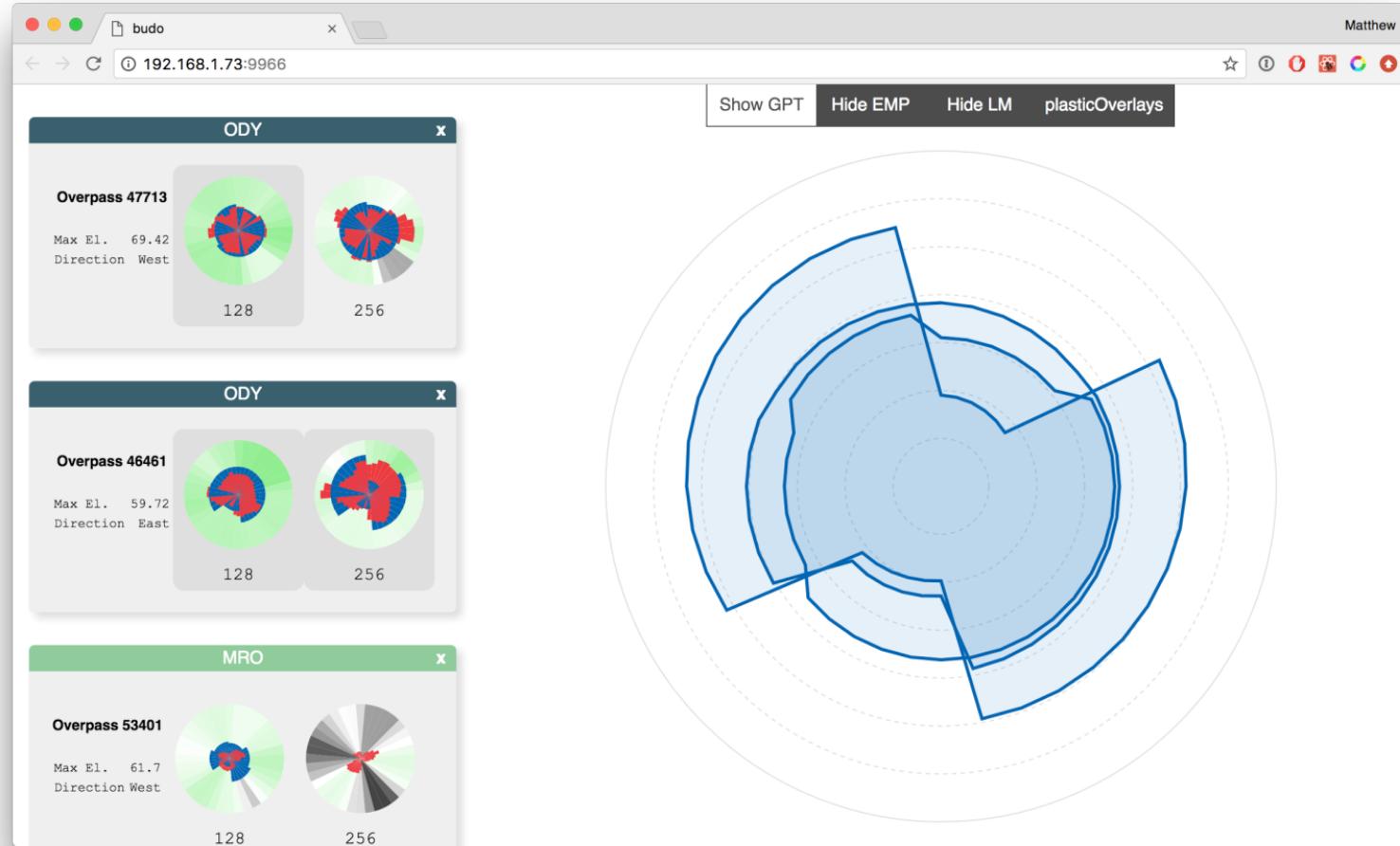
# BUT, WE STILL HAVE TO WORK WITH THIS

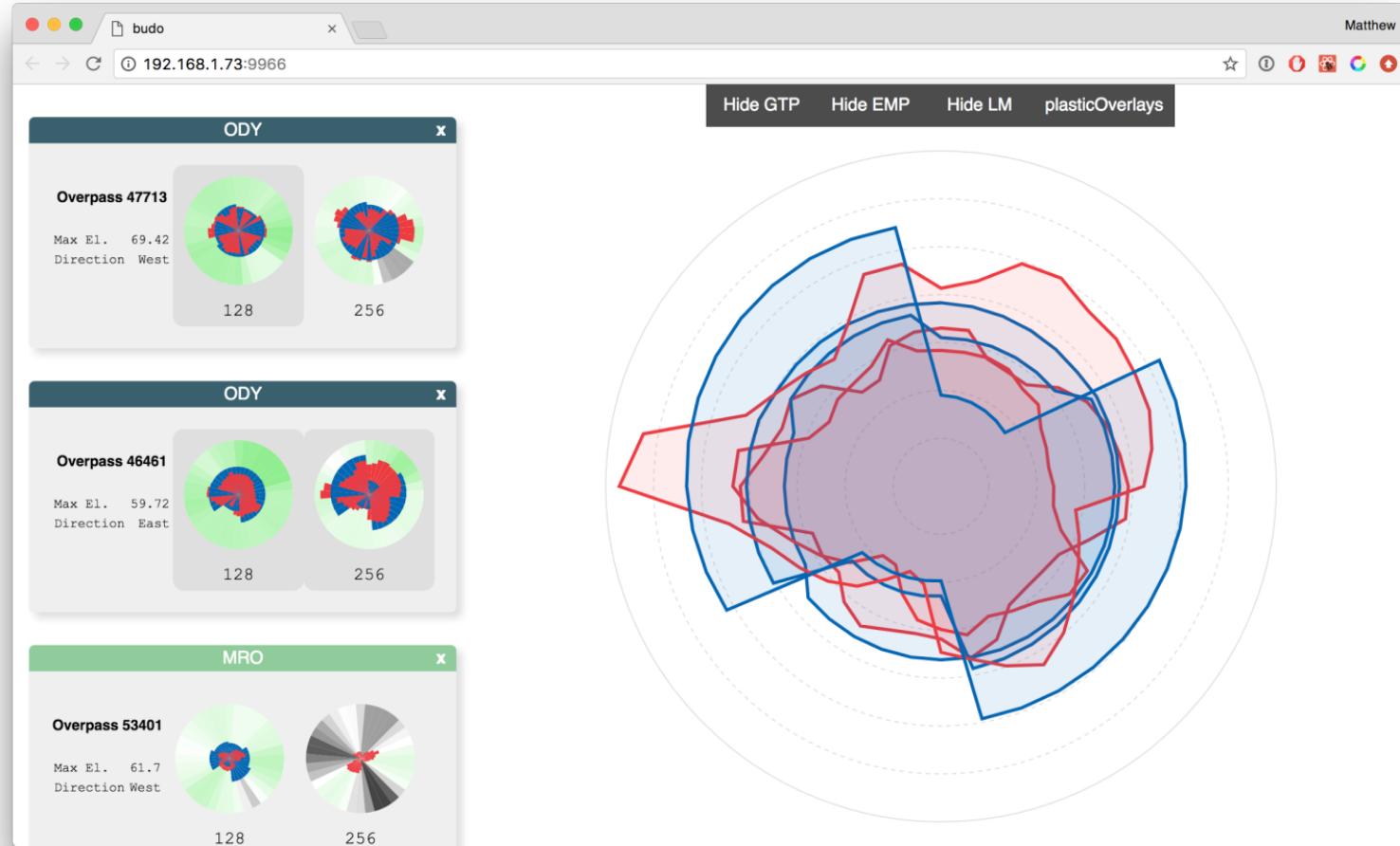


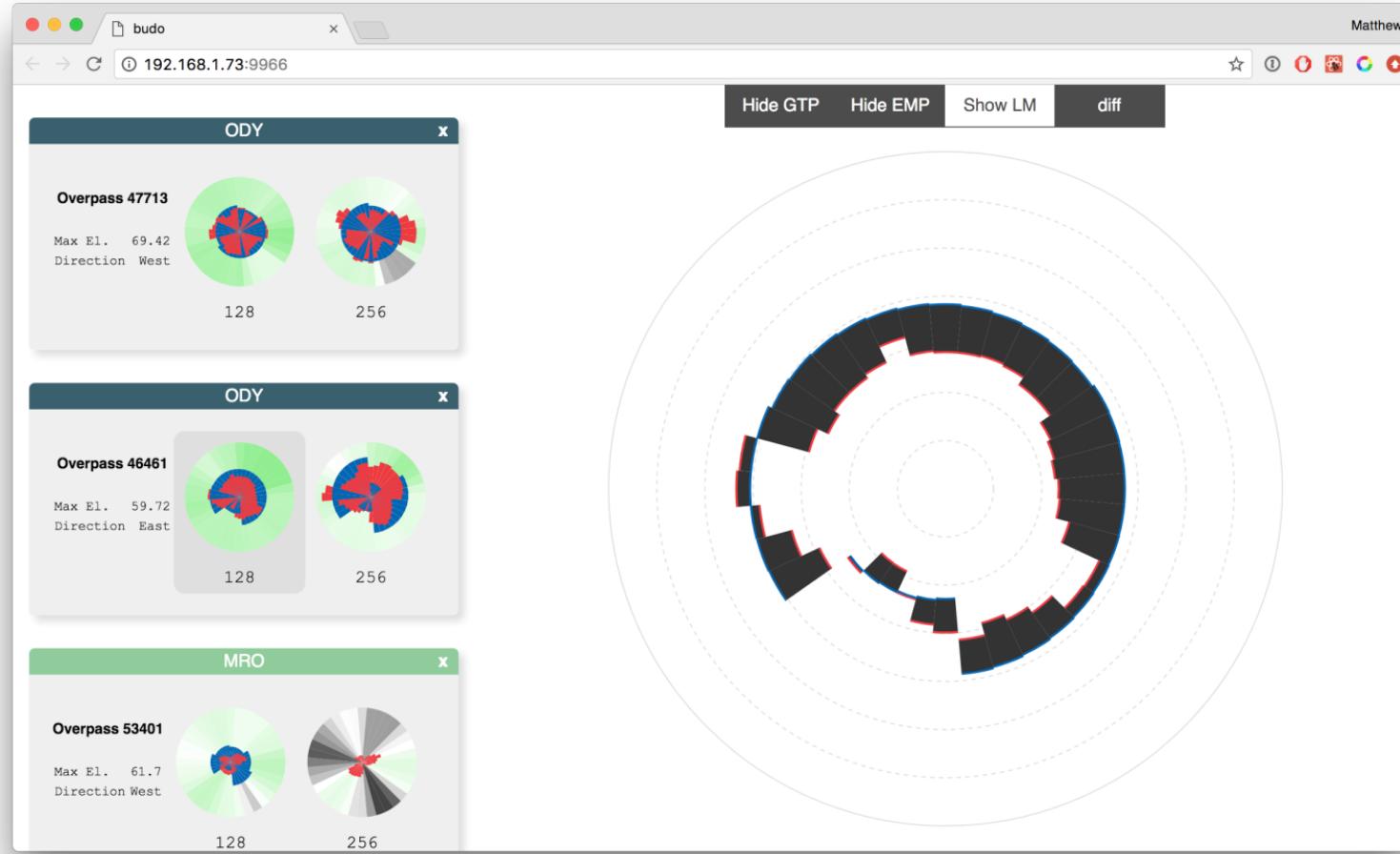


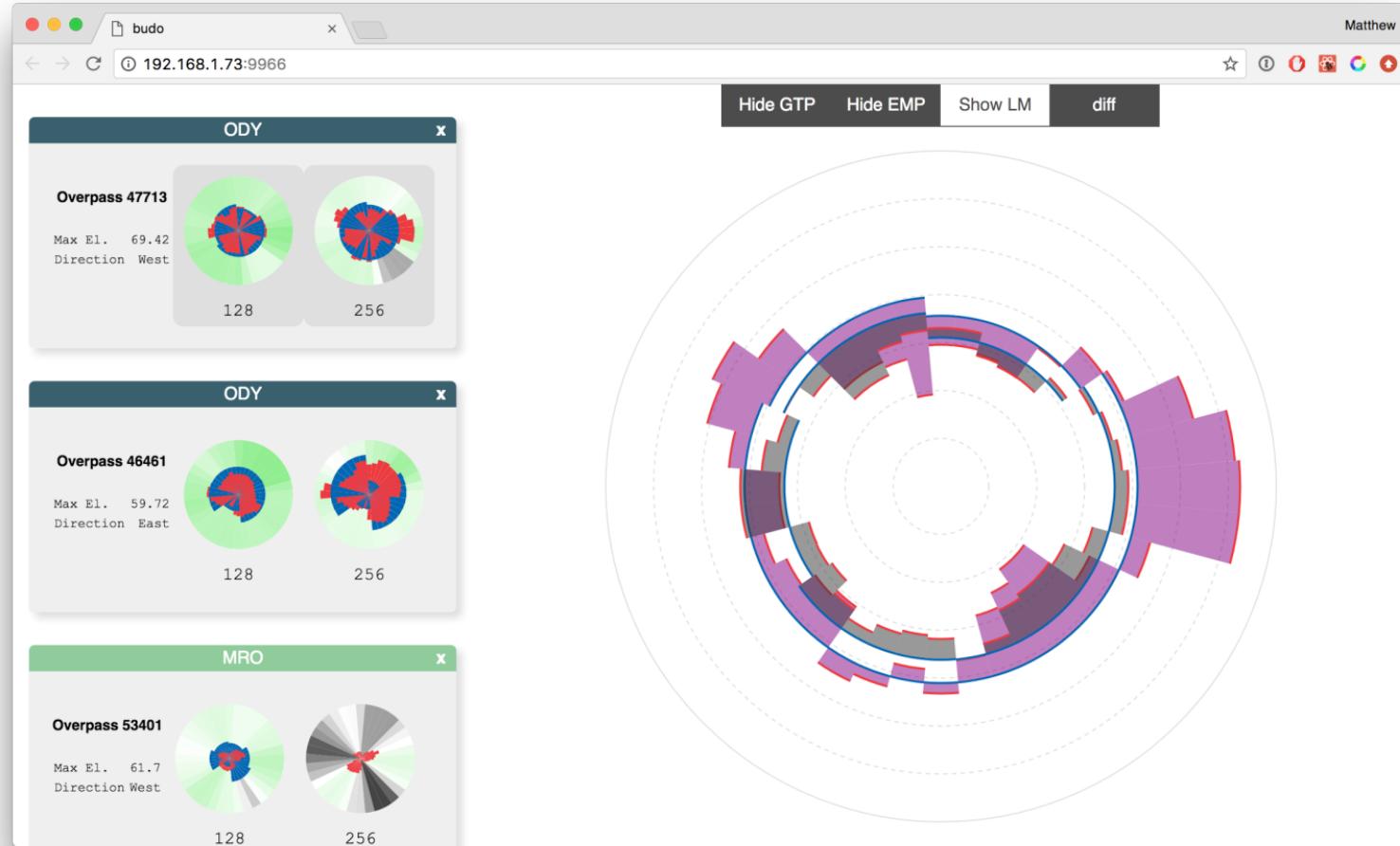


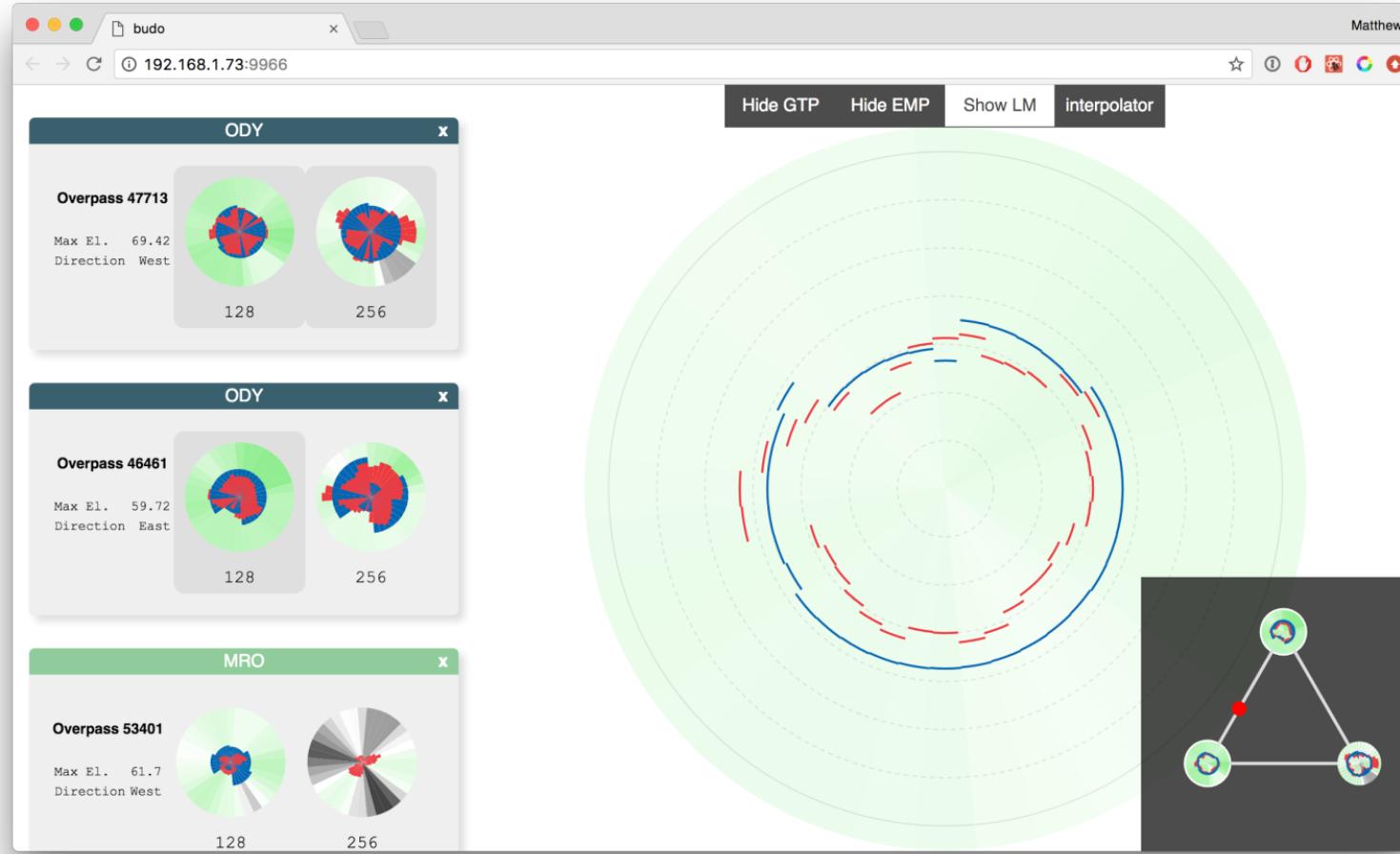


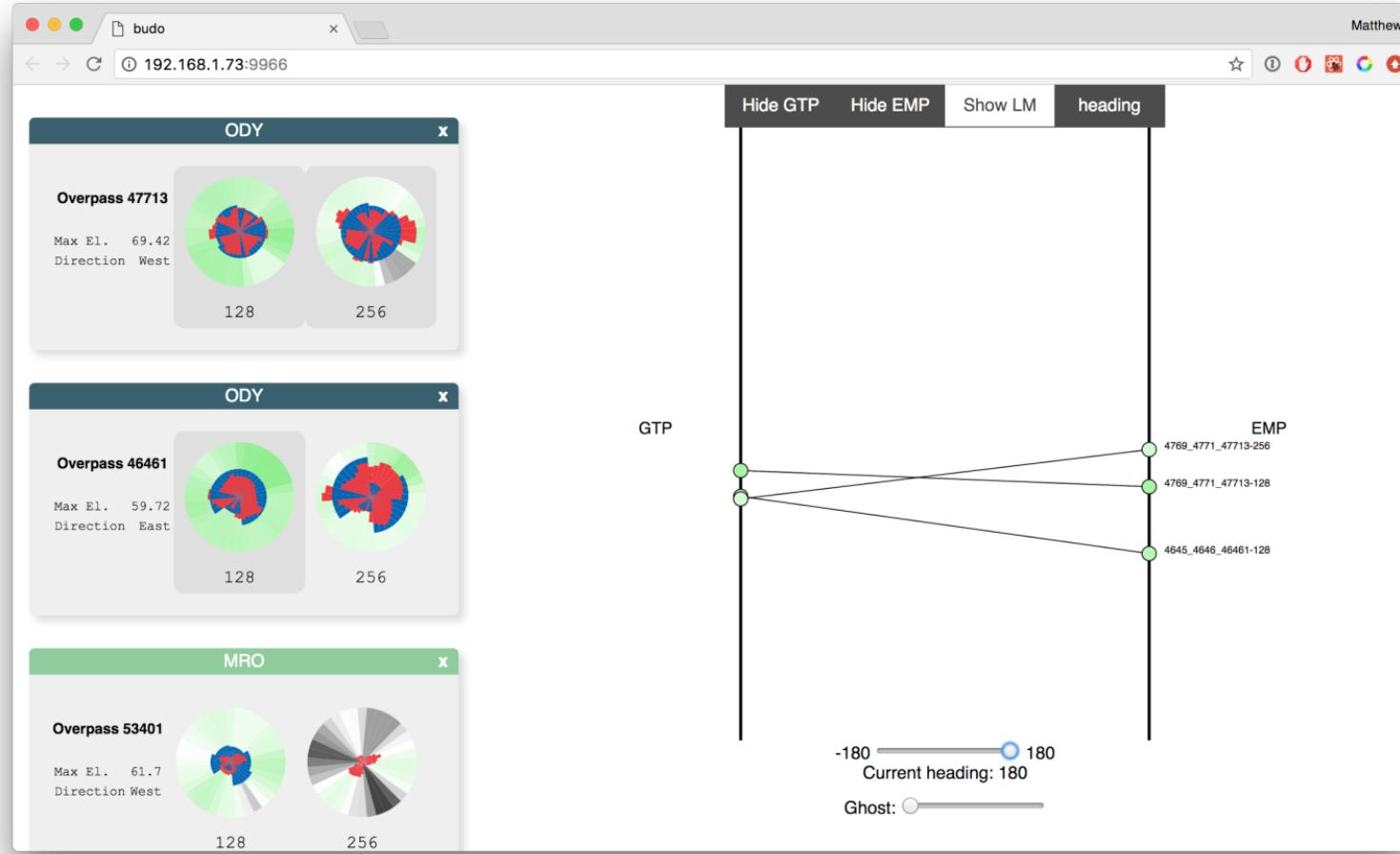


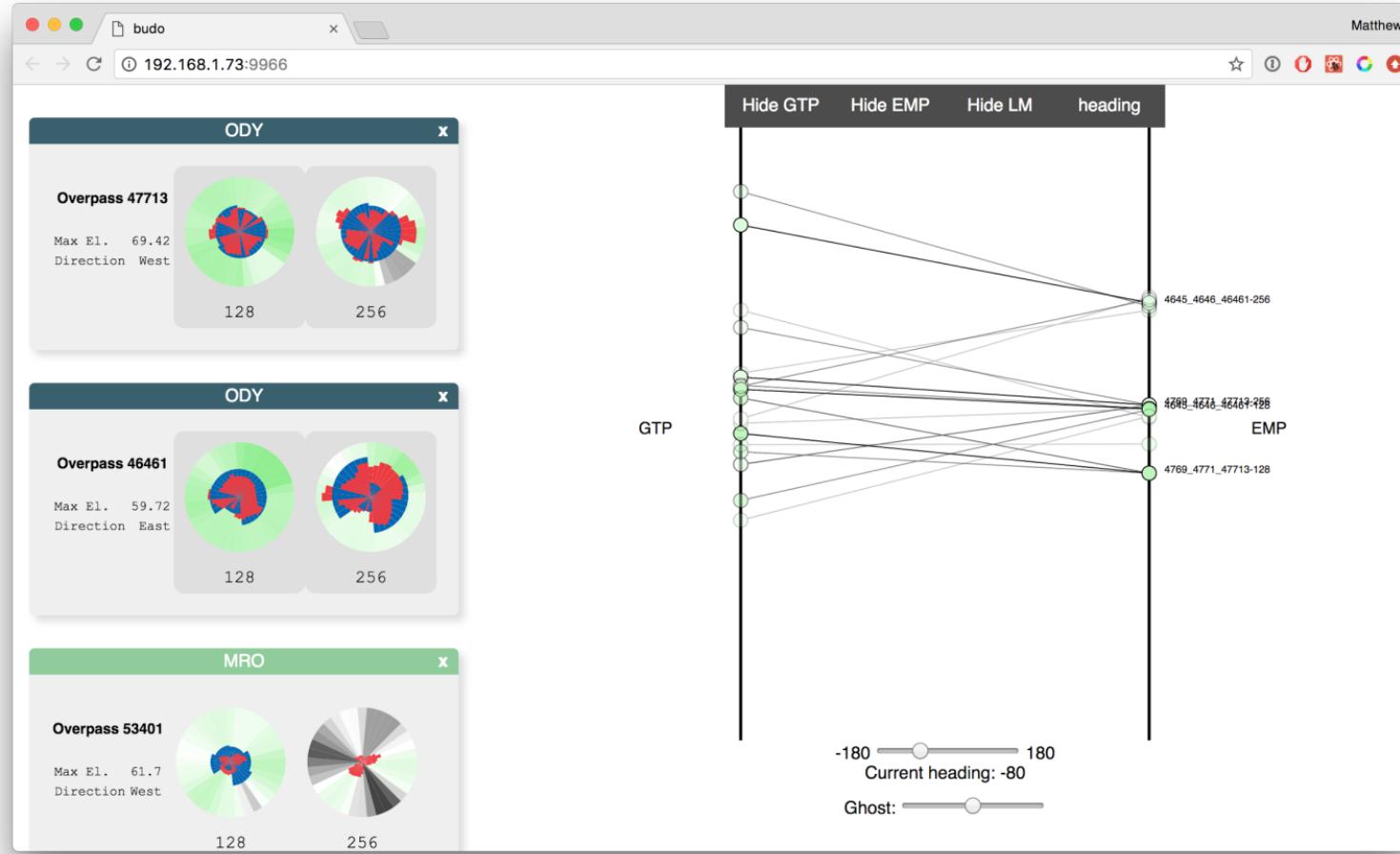












Hide GTP Hide EMP Show LM heading

GTP

EMP

-180 180  
Current heading: -20

Ghost:

# PAPER PROTOTYPING

Show data rates: 8 32 128 256      View: Cards Polar

Show Predictors: EMP GTP LM

ODY

Overpass A  
67° W

ODY

Overpass B  
33° W

MRO

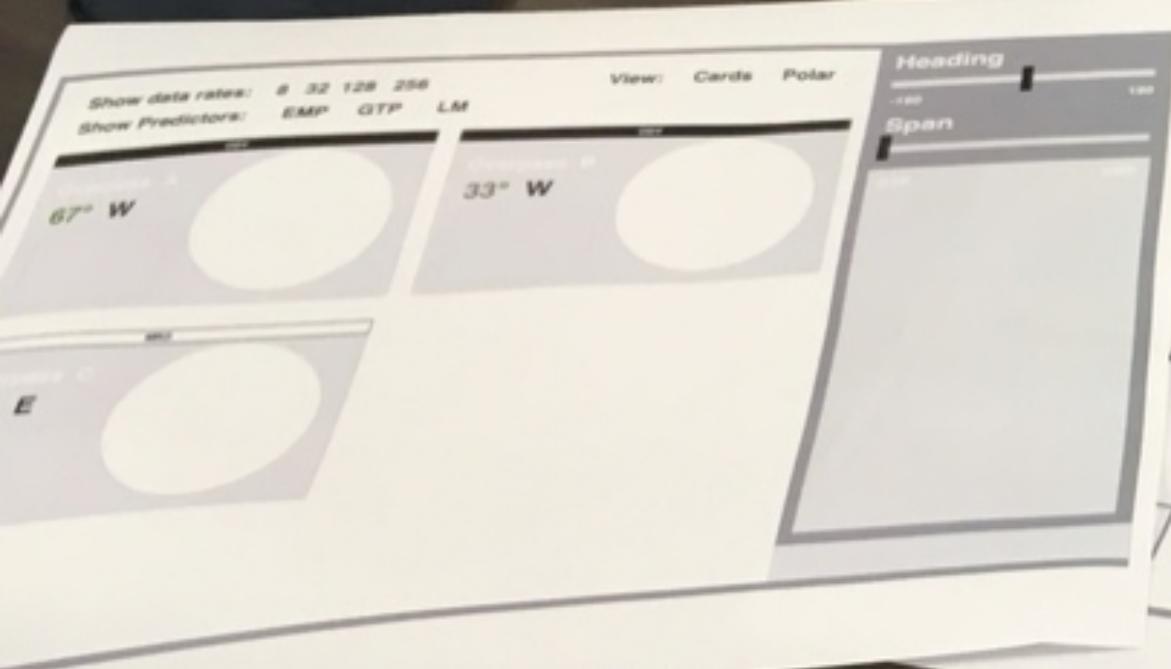
Overpass C  
85° E

Heading

-180 180

Span

GTP EMP

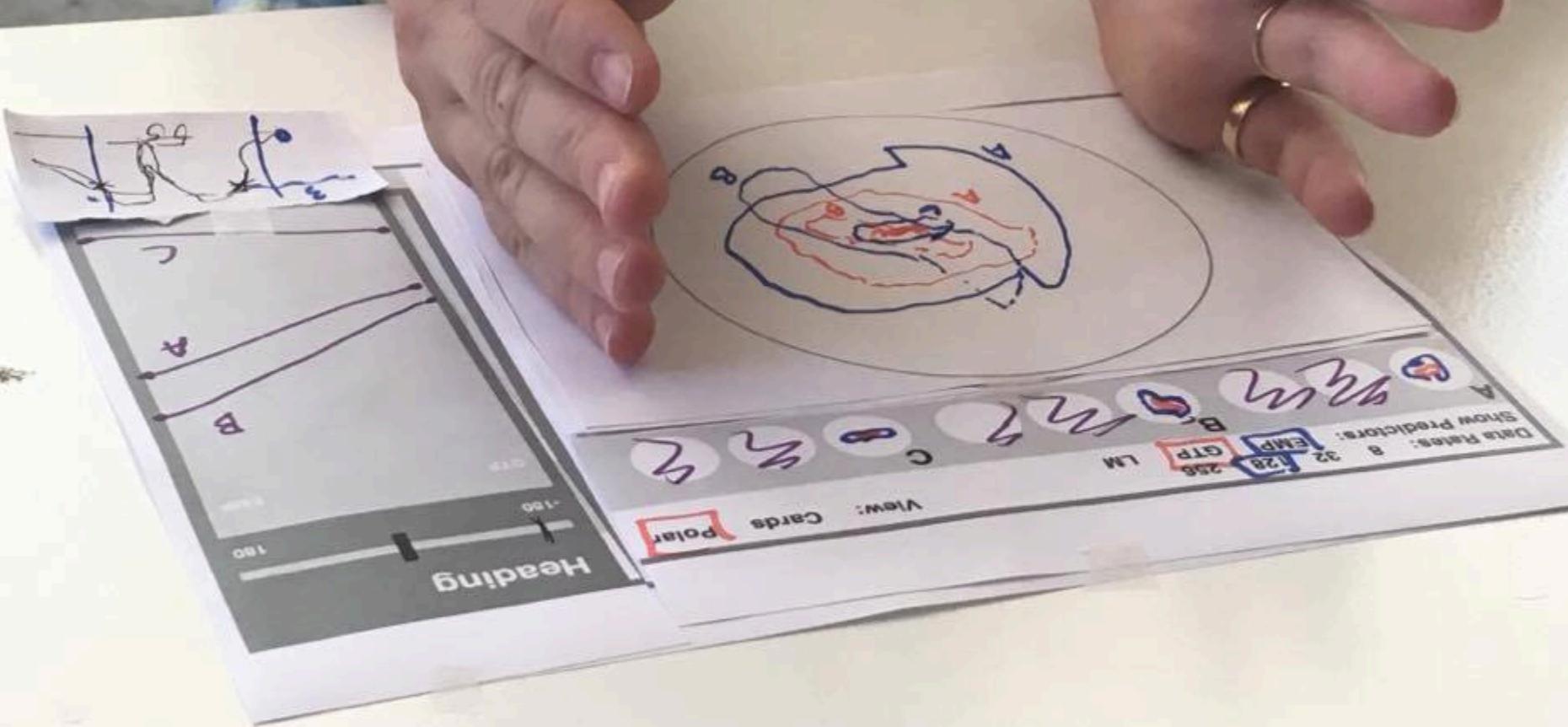


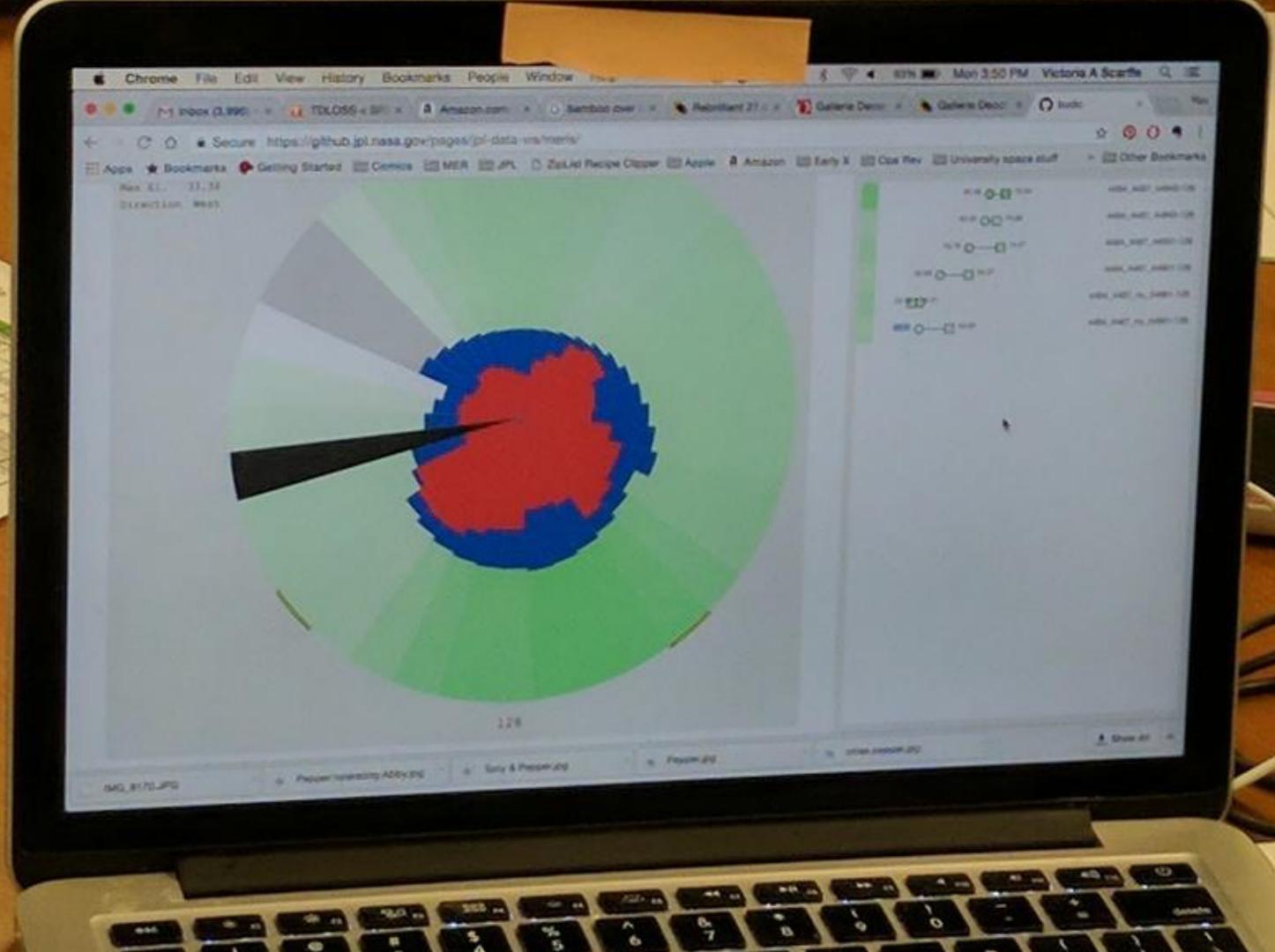
ome! Enter the information below to  
telemetry estimates.

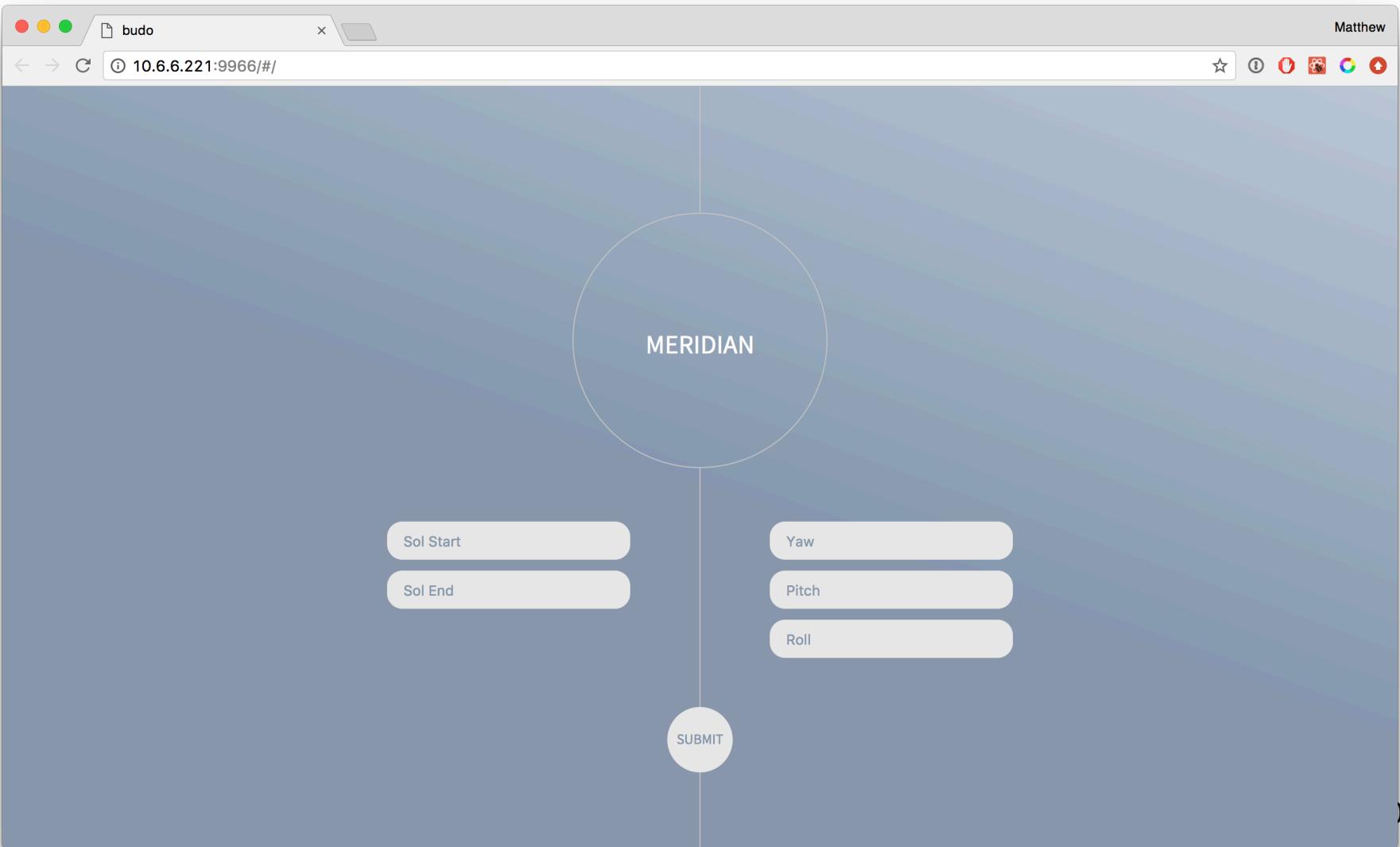
ading: 0

A

Data Rates:  
Show Predictors:







## **OUR SOLUTION**

- 01 A centralized web interface
- 02 Organized, hierarchical info
- 03 Easy to download and send to colleagues
- 04 Plan in place to deploy with MER team

# TECH

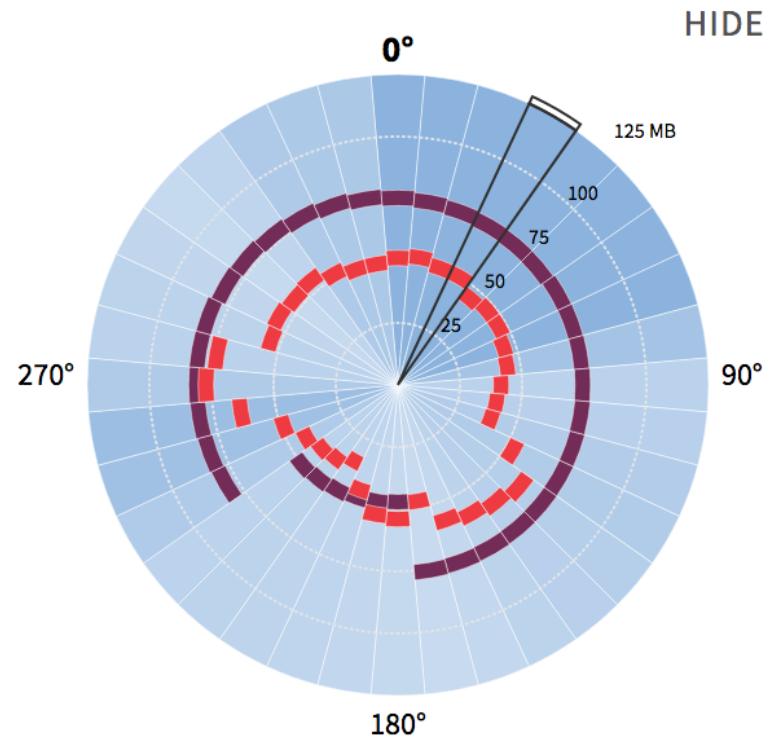
**Budo** development server

**Flexbox** for layout

**D3** for scales, calculations, colors

**React** for state & view management

Developed reusable components



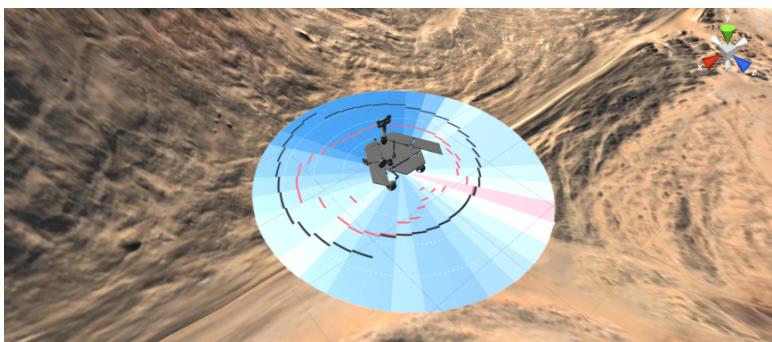
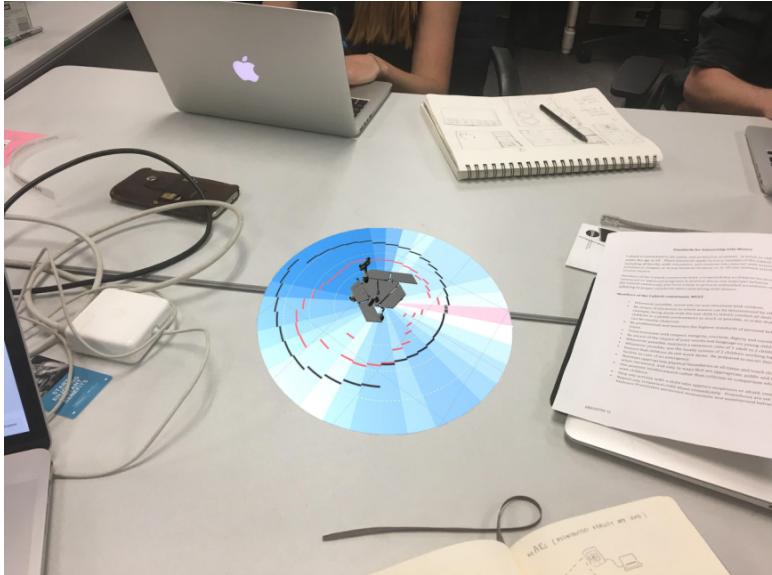
# FUTURE WORK

Integration into other systems *Quill, 2020, etc*

Integration of the rover itself in terrain mask

Mobile

3D environment



# THANK YOU

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