Mariner 2 and the CSIRO Parkes Telescope

Fifty Years of International Collaboration

John Sarkissian | Operations Scientist

26 October 2012

CSIRO Astronomy and Space Science
www.csiro.au

The CSIRO Parkes Radio Telescope

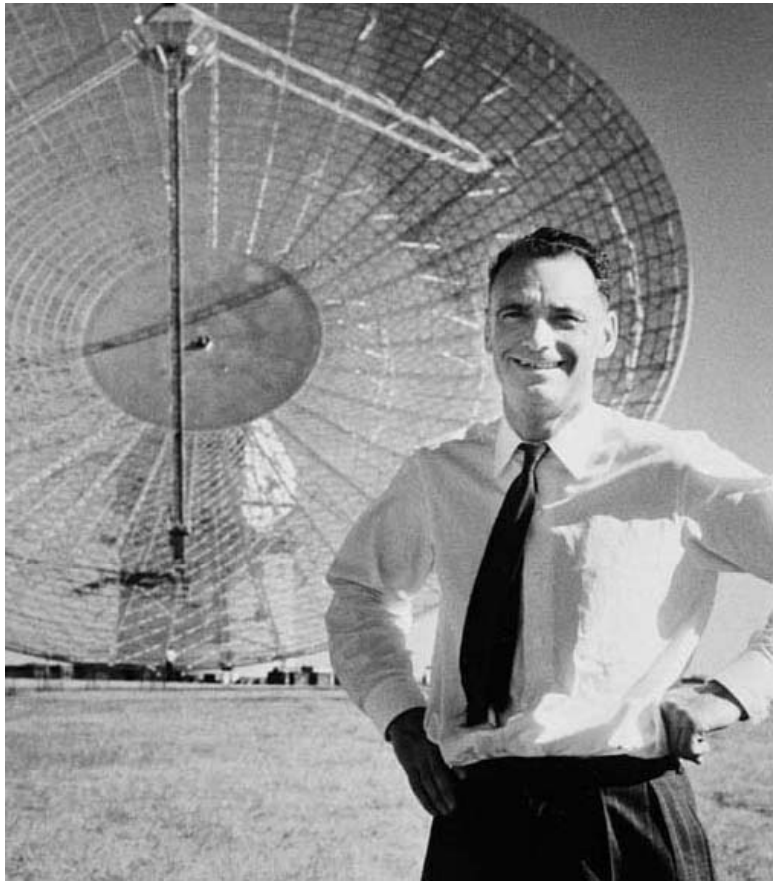
One of the world's great research instruments

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Space Missions

1. Mariner 2 – 1962
2. Mariner 4 – 1965
3. Apollo Missions – 1969-72
4. Voyager 2 Uranus – 1986
5. Halley's Comet (Giotto) – 1986
6. Voyager 2 Neptune – 1989
7. Galileo Jupiter – 1996-97
8. ACP (Mars) – 2003-04
9. Huygens – 2005
10. Curiosity – 2012

The CSIRO Parkes Telescope



Conceived by Edward "Taffy" Bowen in 1954.

The best all round instrument was a large, fully-steerable dish antenna

Funding the Project

1. $250,000 from the Carnegie Corporation
2. $250,000 from the Rockefellar Foundation
3. Matching Funds from Australian Government
4. $55,000 Australian Private Donations
5. Additional funds from the Australian Government and Rockefellar Foundation

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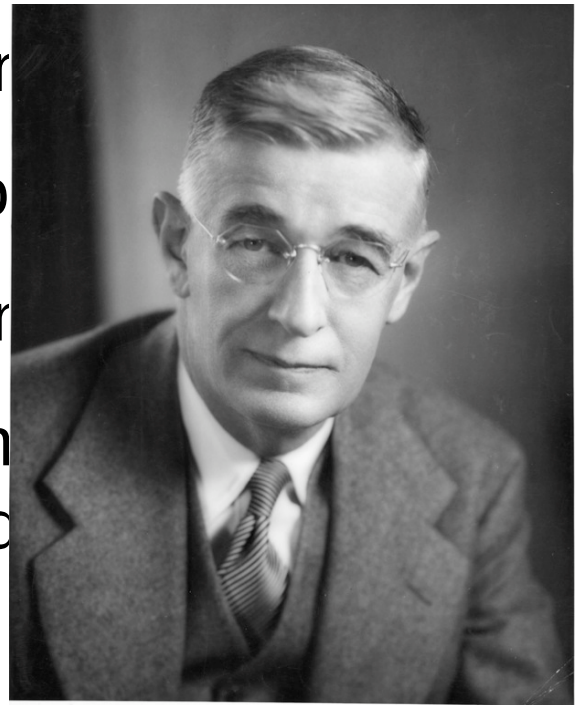

Vannevar Bush

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Dean Rusk

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Richard Casey

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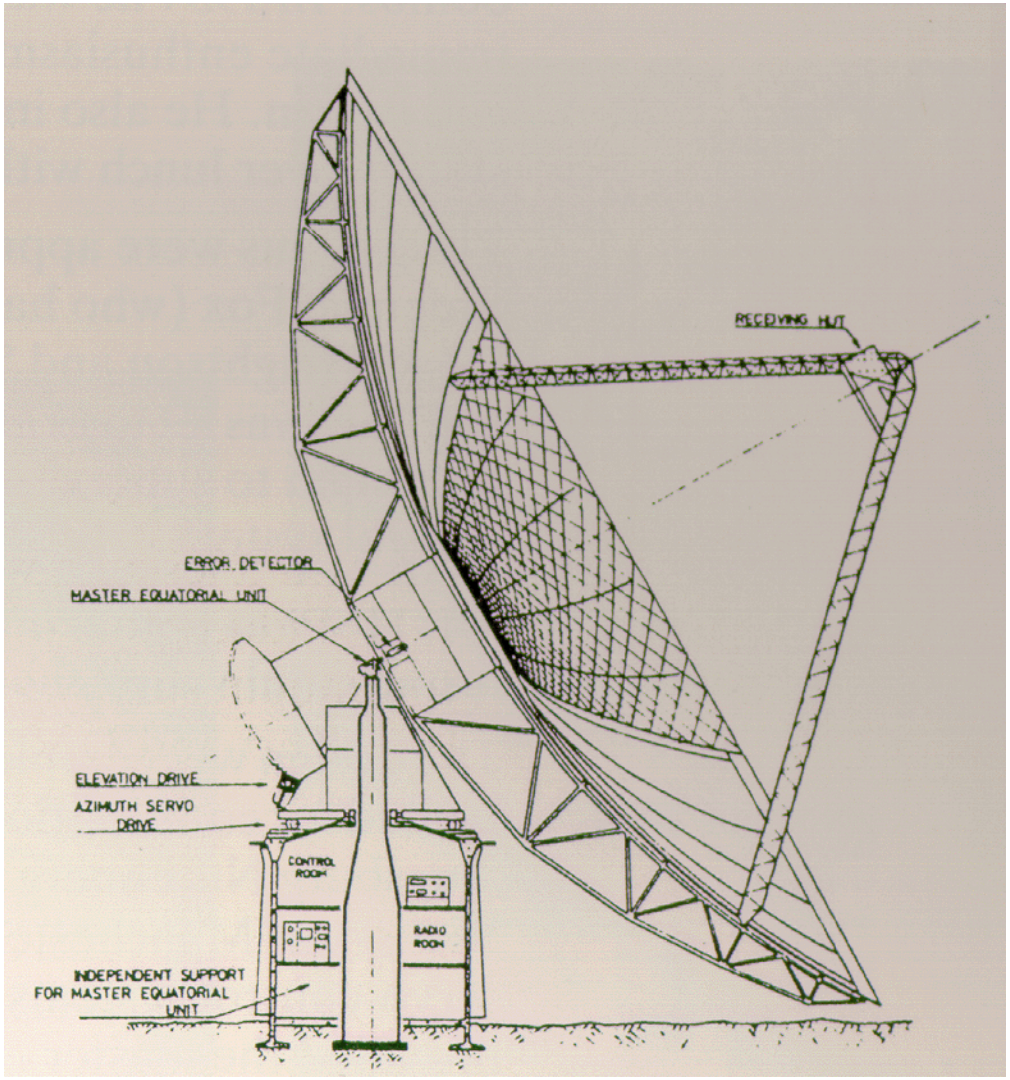
$1,420,000

Design by Freeman Fox & Partners



CSIRO Engineer, **Harry Minnett**, supervised the design and drive system from 1956-59

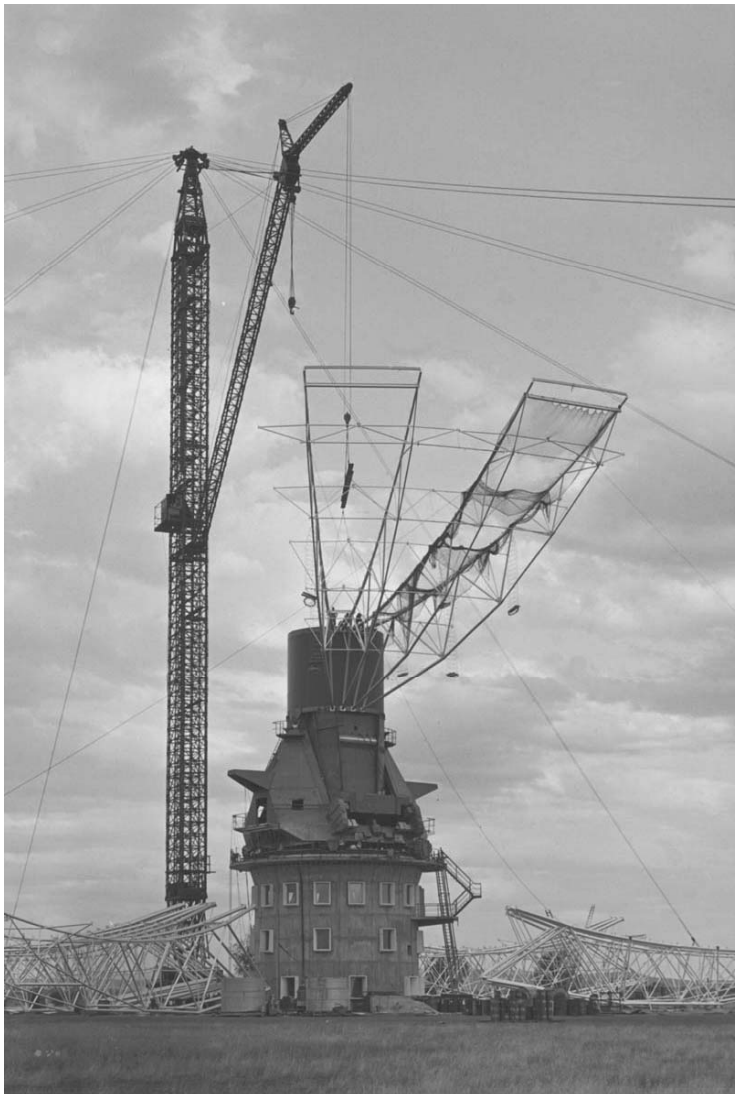
Construction: 1959-61

Parkes was chosen as the site because of the ***lack of radio interference***

Construction: 1959-61

MAN of West Germany were the main constructors

Construction: 1959-61



Construction: 1959-61

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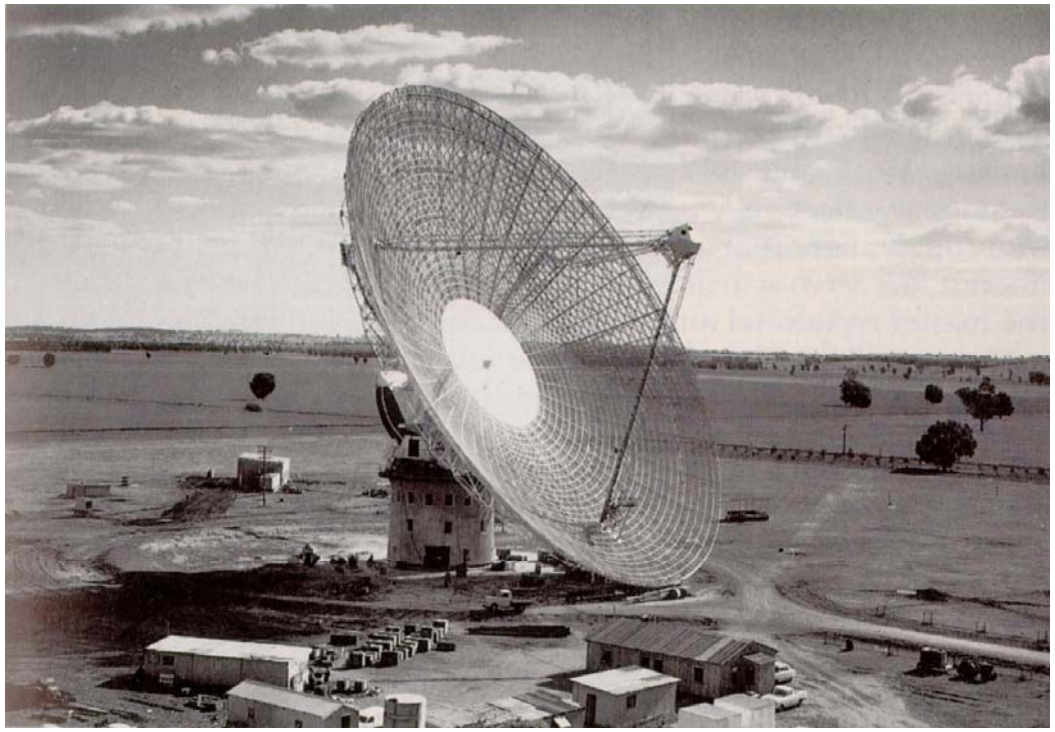
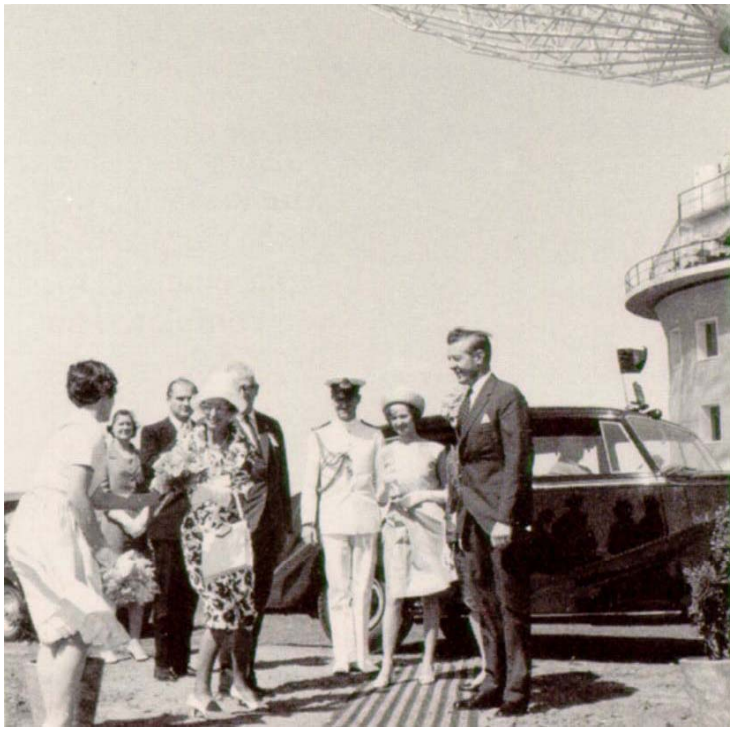


First Tip of the Dish
October 1961



Official Opening
31 October 1961

John Bolton Appointed the First Director

Space Missions

PIONEER 4

6 March 1959

Flew past the Moon at a record distance of 654,860 km

NASA/JPL could not communicate with it

The JPL Large Aperture Antennas

JPL needed largest possible antenna

1. 6–12 dB improvement over existing 26 metre array, that is, 60 – 80 metre class antennae

2. Optimum performance at 2200 MHz (surface accuracy)

3. Pointing accuracy of 1.2 minutes of arc

4. Slew rates of ~10°/min

The JPL Large Aperture Antennas

JPL needed largest possible antenna

These requirements matched Parkes very closely

A Proposal

From 1959-61 : Cooperative Space Exploration Program proposed

Occasional use of Parkes for data acquisition of a short term nature where an extremely strong and reliable signal was required

Letter from Edmond Buckley, NASA Assistant Director, Space Flight Operations to E.G. Bowen – dated 29 June 1960

NASA Research Grant: NsG-240-62

William Pickering invited the CSIRO to participate in the feasibility studies and specification reviews of the JPL large aperture antennas

Harry Minnett appointed Officer-in-Charge of advanced antenna design to head the CSIRO study

NASA Research Grant: NsG-240-62

Determine detailed performance parameters of the Parkes Telescope as regards:

a) structural behaviour

b) characteristics of the drive system

c) radio frequency performance

d) vibration characteristics

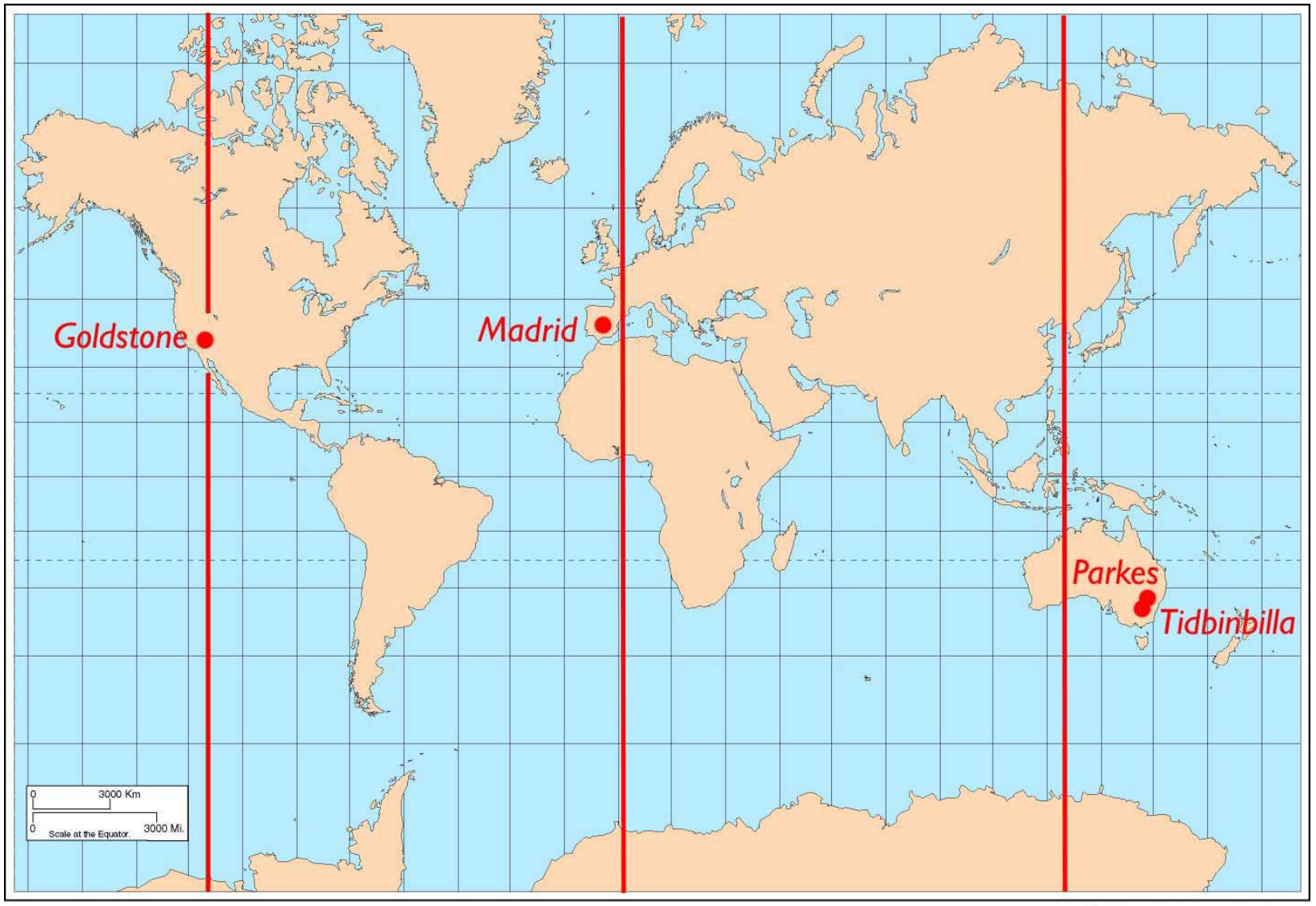
e) measurements of dish shape in the zenith and tilted positions

NASA Research Grant: NsG-240-62

This information was considered to be of critical importance in the design and construction of the JPL antennas

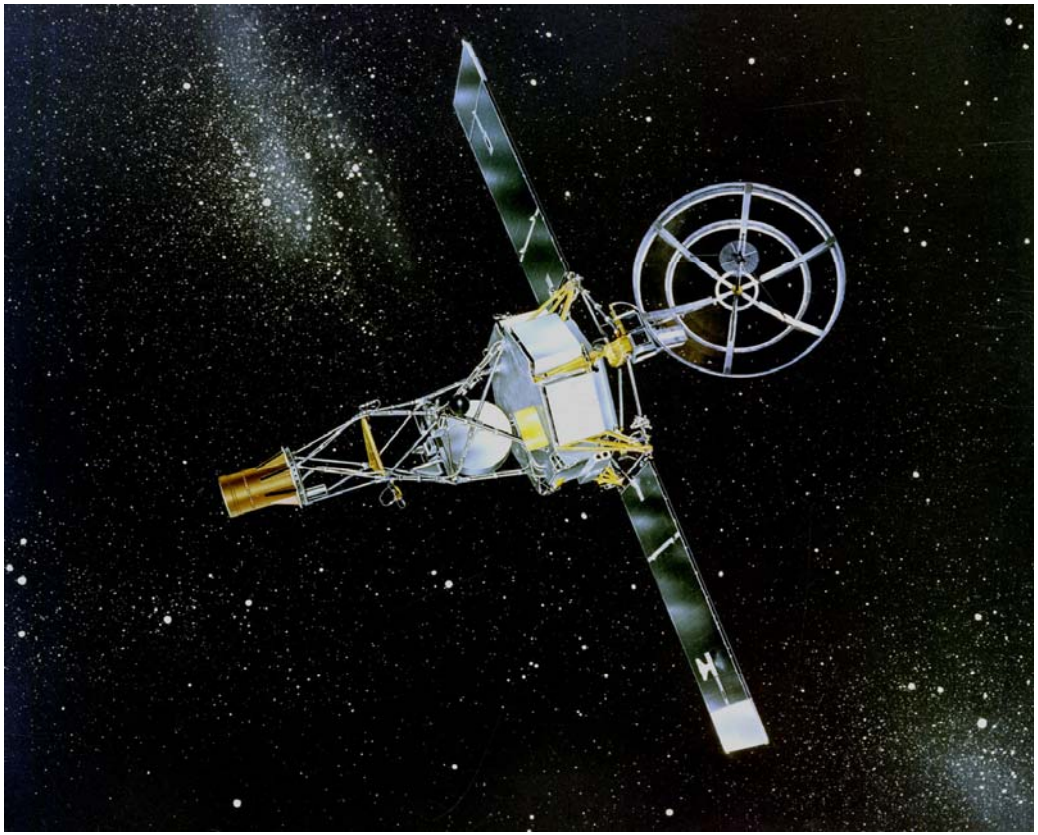
Bruce Rule, Bill Merrick, Eb Rechtin

The DSN


Goldstone
Madrid
Parkes
Tidbinbilla
0
3000 Km
0
Scale at the Equator
3000 Mi.

Mariner 2

First interplanetary space probe



Flew by Venus on 14 December 1962

Flew within 34,762 km of the surface

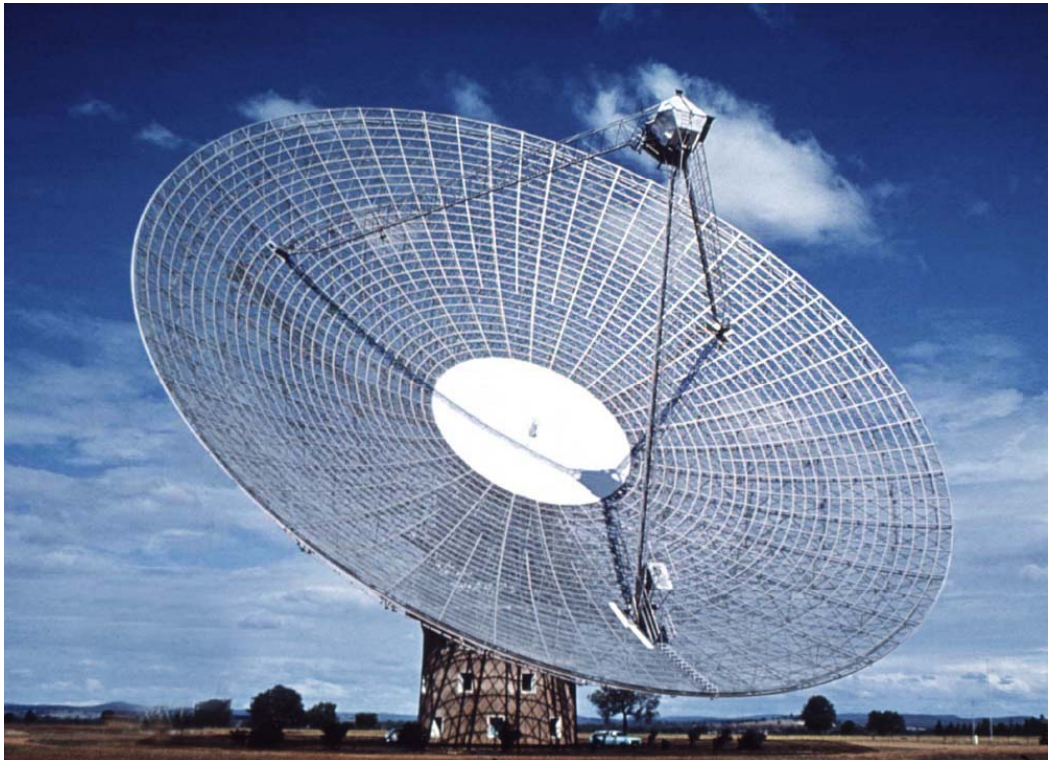
Mariner 2

A simple experiment measuring

1. Spacecraft position
2. Signal level
3. Doppler frequency

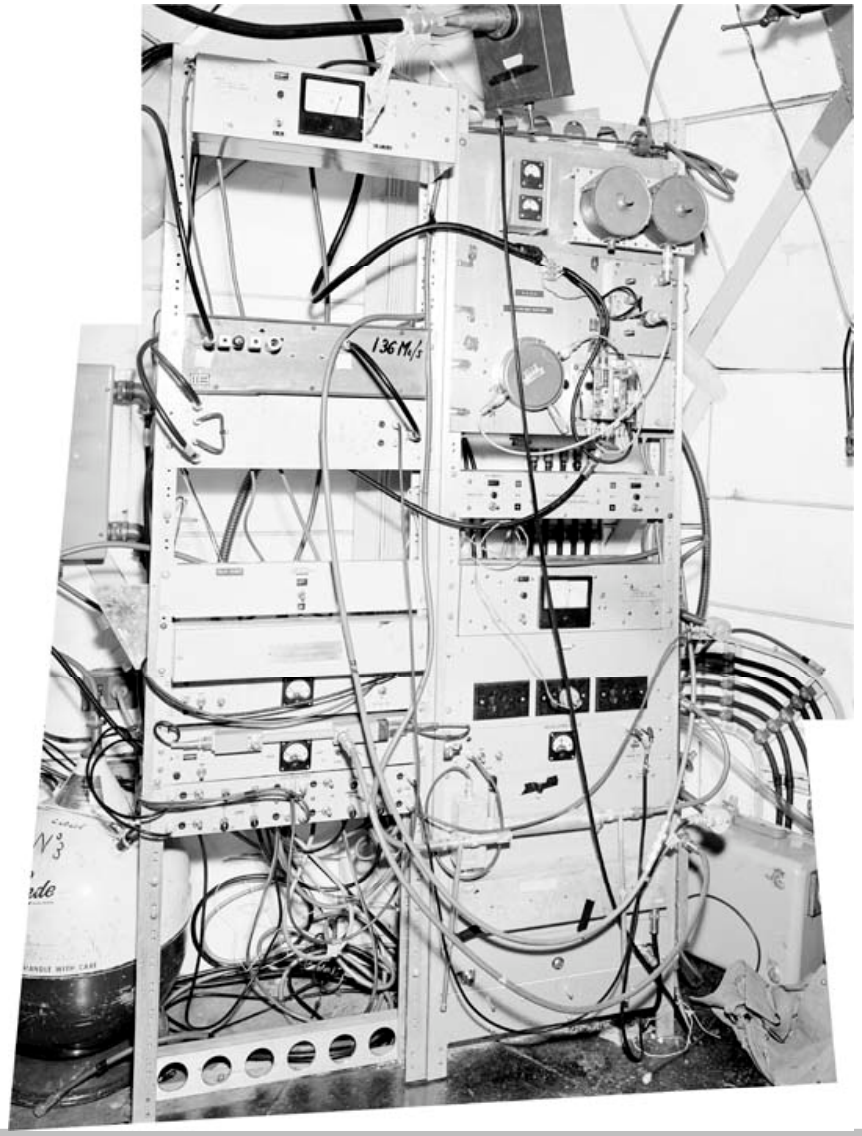
Establish the technique and measure the performance of a 64-metre antenna

Mariner 2



Tracked it for two weeks from
20 December 1962 to 3 January 1963

Mariner 2



960 MHz (L-band)
transportable
phase-lock receiver

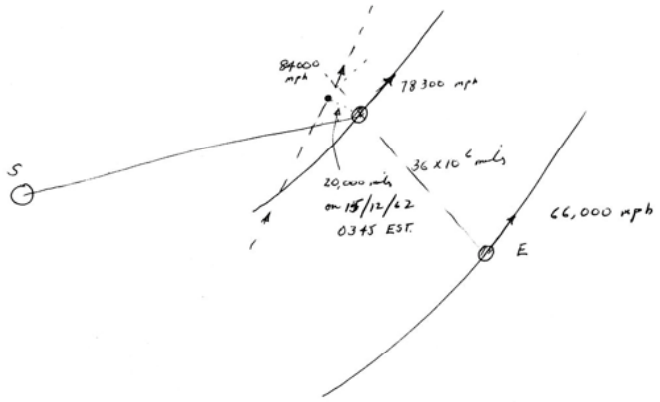
20 Hz gate
tuned manually

The Ancient Mariner

Mariner 2

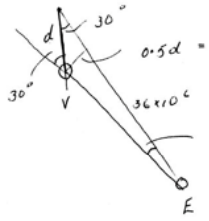
Harry Minnett's hand calculations

Probe co-ordinates



Probe passes Venus ~ 6000 mph

0545 EST on 17/12/62 — 50^m late probe will have moved d. 300,000 mls past Venus.



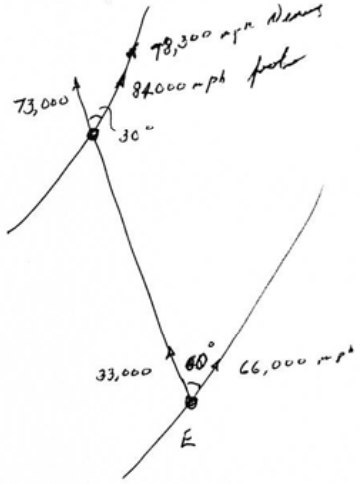
$0.5d = 150{,}000$ mls

$\Delta RA = \pm \frac{1.5 \times 10^5}{36 \times 10^6} \times 2 \times 10^6$

$= \frac{3 \times 10^{10}}{36 \times 10^6} = 8.3 \times 10^2$ "

$= 55^s$ of time.

Doppler shift



Relative velocity = 40,000 mph or more

= 11·1 mps

Doppler shift $= -\frac{11 \cdot 1}{186{,}000} \times 960 \times 10^6$

$= -57{,}400$ c/s.

Needed both Position AND Frequency

Mariner 2

FOLLOWING MESSAGE RECEIVED FROM JET PROPULSION LABORATORIES PASADENA
FOR MR. H MINNETT.

PP ADLADE
DE JETLAB
P 191820Z
TO ADLADE/H MINNETT
BT
PLEASE CONFIRM AS SOON AS FEASIBLE, RECEIPT OF THE FOLLOWING
PREDICTIONS AND THAT THEY WERE RECEIVED IN USEABLE CONDITION. ALSO
INDICATE FOR WHICH DAYS PREDICTIONS WERE RECEIVED.
PREDICTIONS FOR DAYS 353 THROUGH 003 FOLLOW.

FOLLOWING ARE PARKES PREDICTIONS
STATION ID IS SYNONOMOUS WITH PARKES
VCO FREQUENCY 0009100 CPS
BEGINNING RANGE 63747124 KM

	GMT	HA	DEC	C1	CC3	C3	DAY
4	000000	010316	345586	5452	0000	0000	353
4	001500	014072	345584	5454	0000	0000	353
4	003000	017828	345582	5457	0000	0000	353
4	004500	021584	345580	5459	0000	0000	353
4	010000	025341	345578	5462	0000	0000	353
4	011500	029097	345575	5464	0000	0000	353
4	013000	032854	345573	5467	0000	0000	353
4	014500	036610	345571	5469	0000	0000	353
4	020000	040367	345568	5471	0000	0000	353
4	021500	044124	345566	5473	0000	0000	353
4	023000	047881	345563	5475	0000	0000	353
4	024500	051638	345560	5477	0000	0000	353
4	030000	055395	345557	5478	0000	0000	353
4	031500	059153	345554	5480	0000	0000	353
4	033000	062911	345550	5481	0000	0000	353
4	034500	066670	345546	5482	0000	0000	353
4	040000	070430	345541	5484	0000	0000	353
4	041500	074192	345536	5484	0000	0000	353
4	043000	077955	345529	5485	0000	0000	353
4	044500	081705	345530	5486	0000	0000	353
4	050000	085482	345514	5486	0000	0000	353
4	051500	089272	345490	5486	0000	0000	353
4	053000	093085	345450	5486	0000	0000	353
4	054500	096959	345369	5486	0000	0000	353
4	164500	261498	345228	5415	0000	5906	353
4	170000	265423	345340	5414	0000	5908	353
4	171500	269252	345387	5414	0000	5911	353
4	173000	273048	345411	5415	0000	5914	353
4	174500	276830	345426	5415	0000	5917	353
4	180000	280603	345435	5415	0000	5920	353
4	181500	284347	345428	5416	0000	5923	353

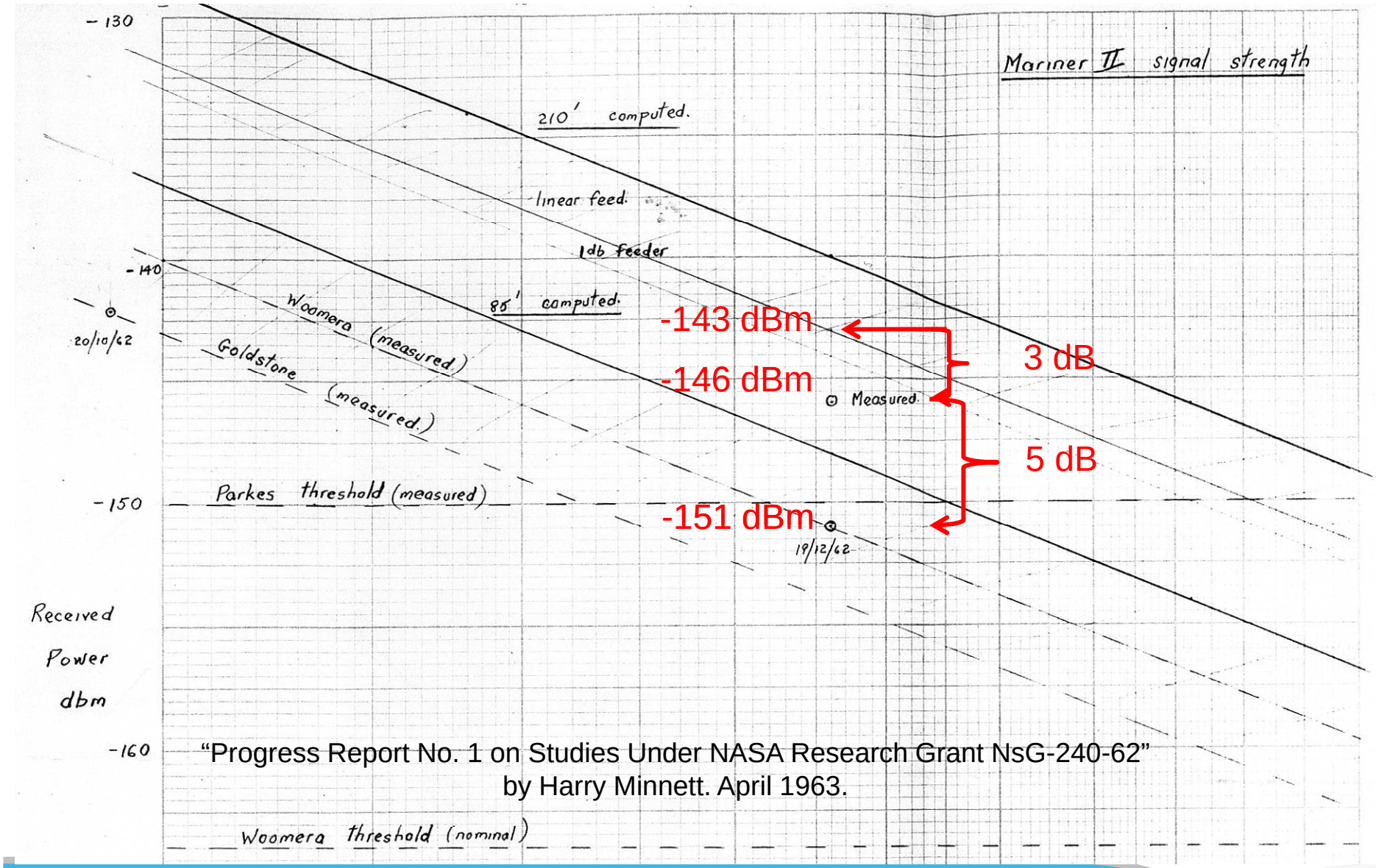
19/12/62

Harry Minnett requested predicts from Woomera DSIF

19 December GMT

(20 December AEST)

Mariner 2



"Progress Report No. 1 on Studies Under NASA Research Grant NsG-240-62"
by Harry Minnett. April 1963.

Parkes: The Model for the 64m DSN Antennas

Goldstone eventually commissioned in May 1966

Mariner 4

By Mariner 4, the Goldstone
64-metre dish was still
one year from completion

Parkes was approached to provide a
64-metre capability to act as a
backup for the DSN

Mariner 4

22 images returned of Martian surface

Parkes provided a ***3dB improvement*** over the existing DSN array

Parkes data combined with others to produce improved images of Martian surface

Mariner 4

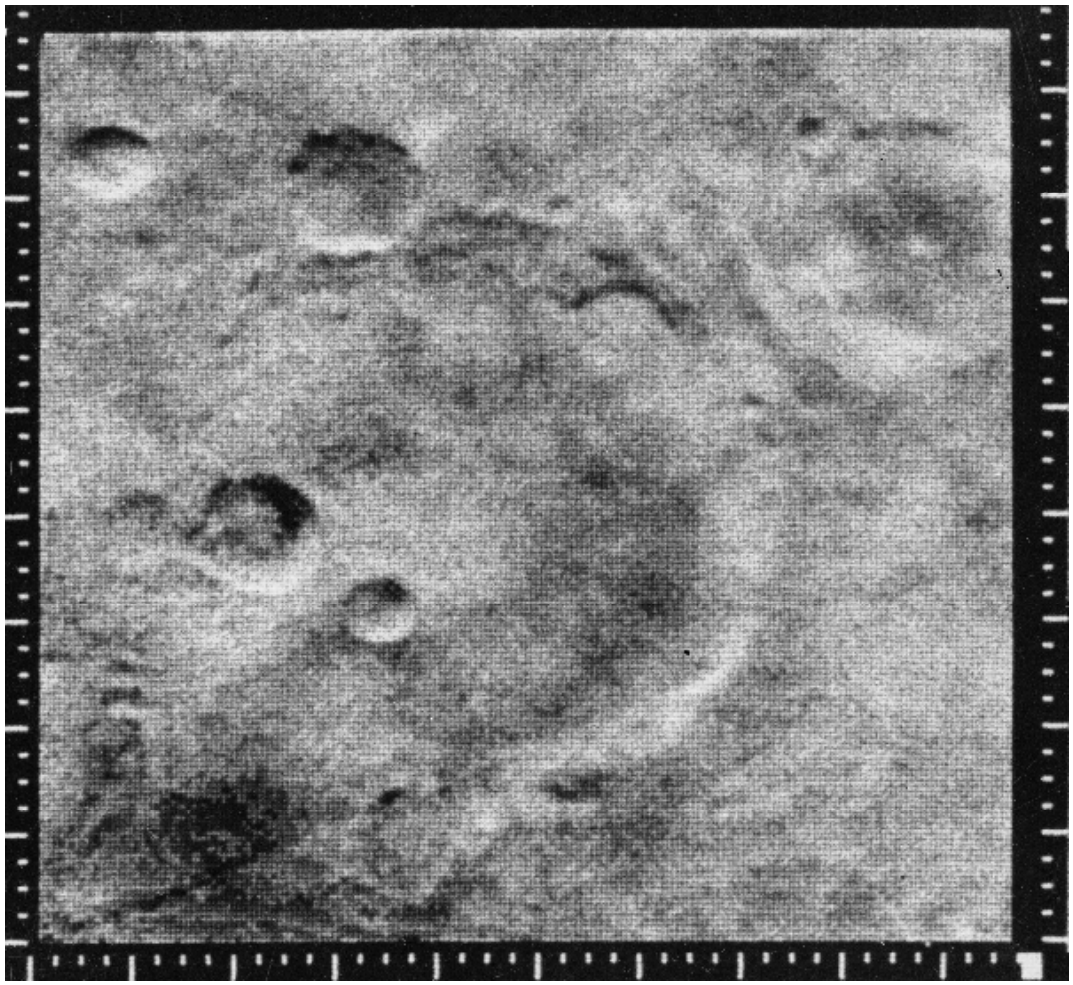
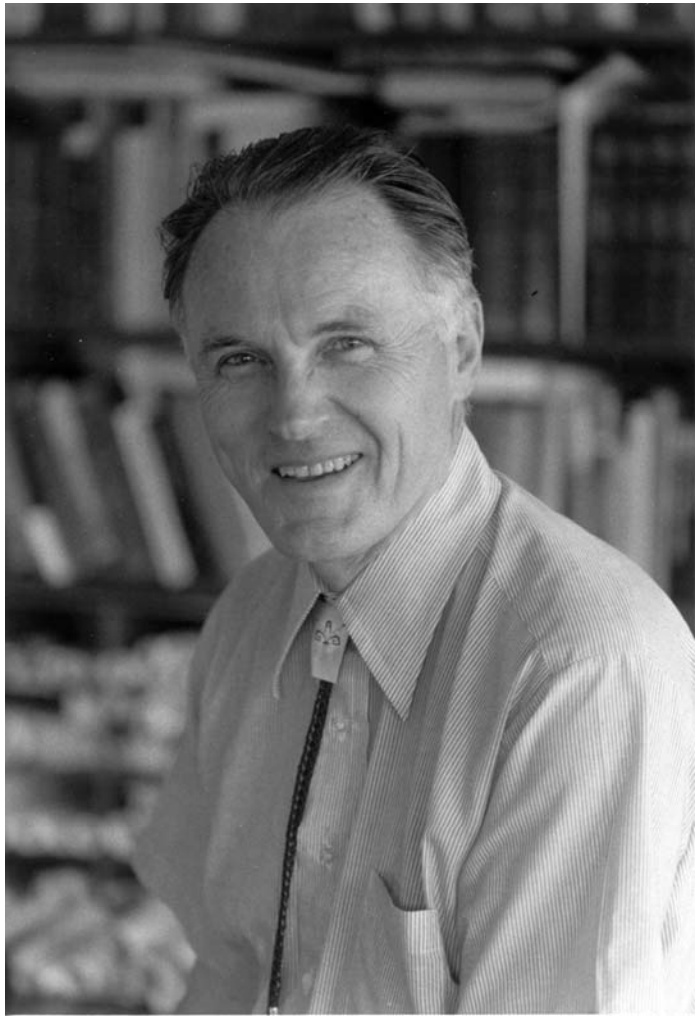


Image 11 was the best

Astronomers were disappointed!

Apollo 11 – An Invitation to Dinner



In October 1968, John Bolton was invited to dinner at the home of Bob Leighton.

He was asked to make Parkes available for the Apollo 11 mission

Apollo 11 – A TV spectacular

600 million people

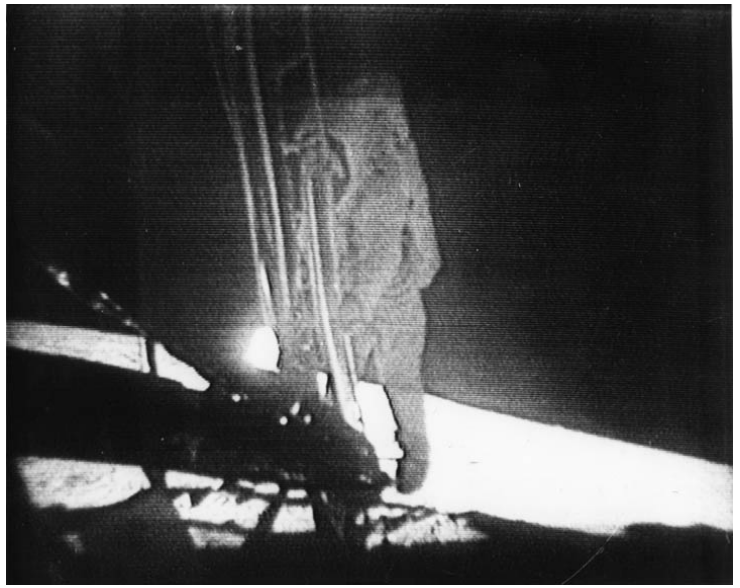
(1/6th of mankind)

Apollo 11 – TV Broadcast

Time	Video Transmission
00:00	TV on: Picture is from GDS (upside down)
00:31	Picture is reversed
01:39	Picture switched to HSK
02:20	Armstrong steps onto the Moon
04:42	Picture back to GDS (negative)
05:36	Picture switched to HSK
06:49	Picture back to GDS
08:51	Parkes Main Beam picture

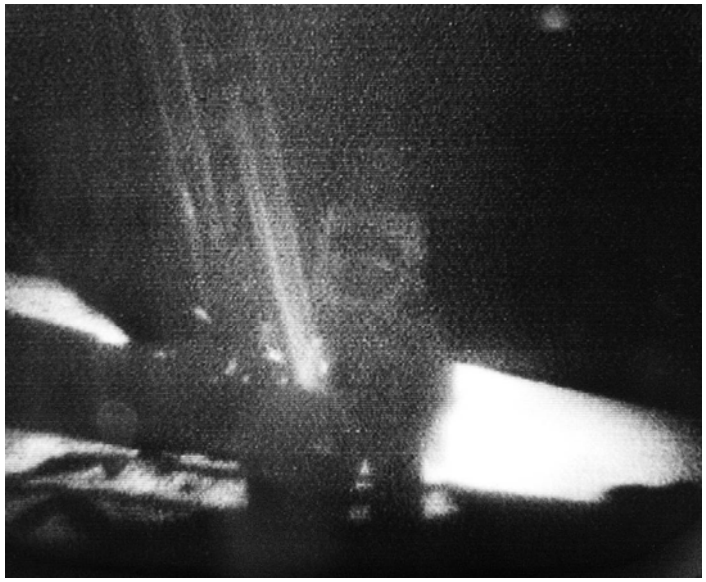
Apollo 11 – Comparison #1

GDS
Armstrong

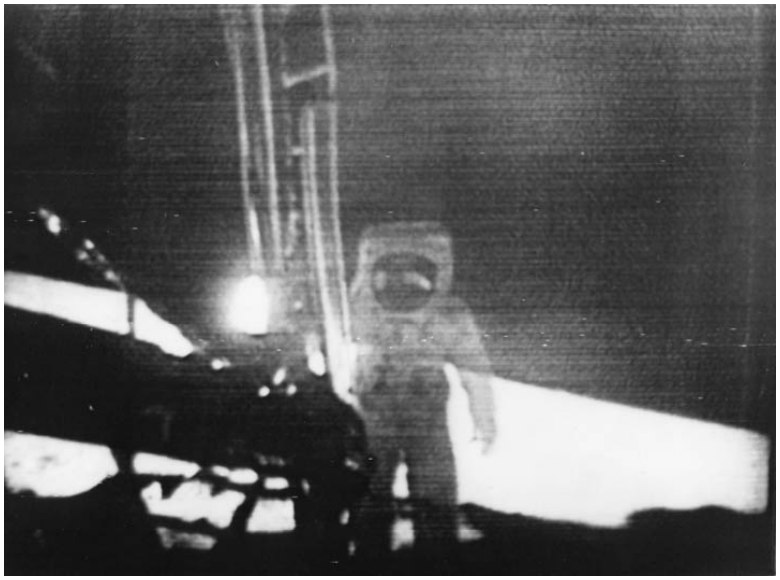


PKS
Aldrin

Apollo 11 – Comparison #2

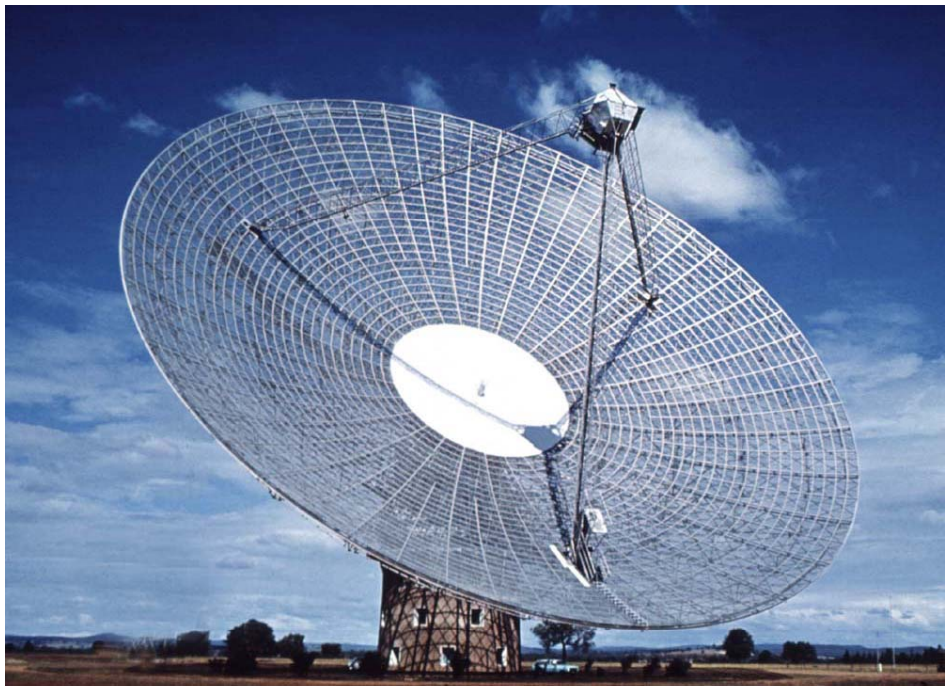


HSK
Armstrong



PKS
Aldrin

Mutually Beneficial Partnership



Whenever Parkes supports NASA space missions, CSIRO gets a better radio telescope and in return NASA has a more capable antenna for the next mission.

Conclusion

“ … the Parkes Telescope is like a trusted friend, ‘always there when we need a hand’. The relationship between the CSIRO and NASA is very much like that between the United States and Australia, as friends that share common values and dreams.”

His Excellency, J. Thomas Shieffer,

United States Ambassador to Australia

Official Launch of the Mars Tracks

Friday, 31 October 2003.

Epilogue

On 27 August 1962, Mariner 2, the first interplanetary spacecraft, was launched to Venus.

When New Horizons arrives at Pluto in July 2015

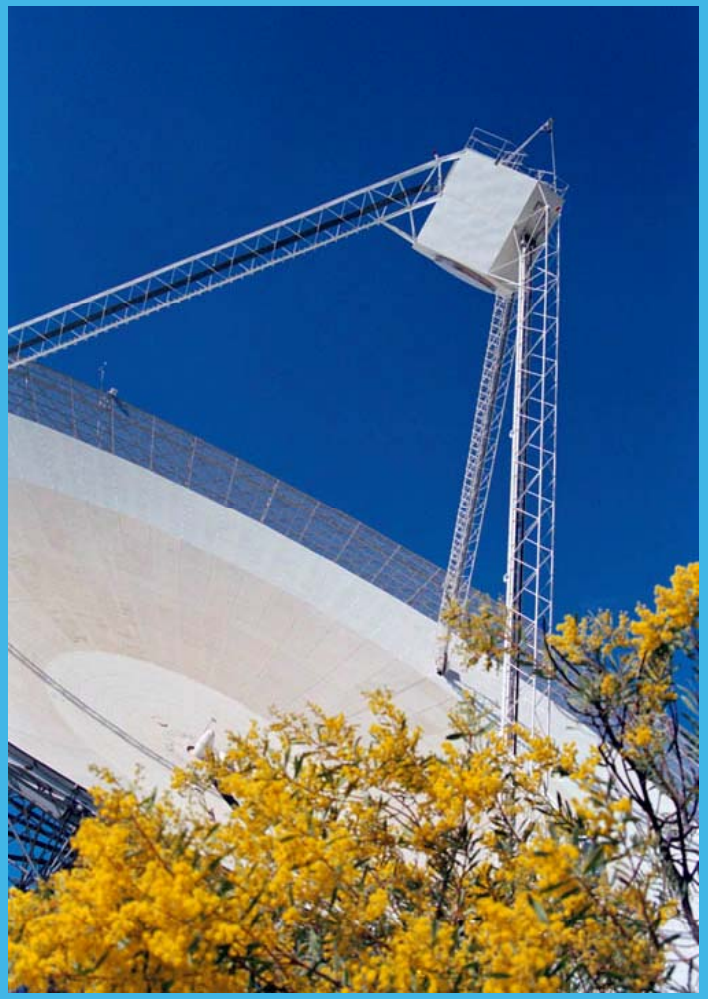
In the space of a single human life-time the entire Solar System would have been explored.

Wow !

Thank you

CASS Parkes Radio Telescope
John Sarkissian
Operations Scientist

t +61 2 6861-1769
e John.Sarkissian@csiro.au
w www.parkes.atnf.csiro.au/people/sar049/



Apollo 11 – TV Decision Flow

PKS

Sydney Video

HSK

Australian
Selection

GDS

International Broadcast

Houston TV

Apollo 11 – TV Broadcast

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Honeysuckle Creek

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Parkes

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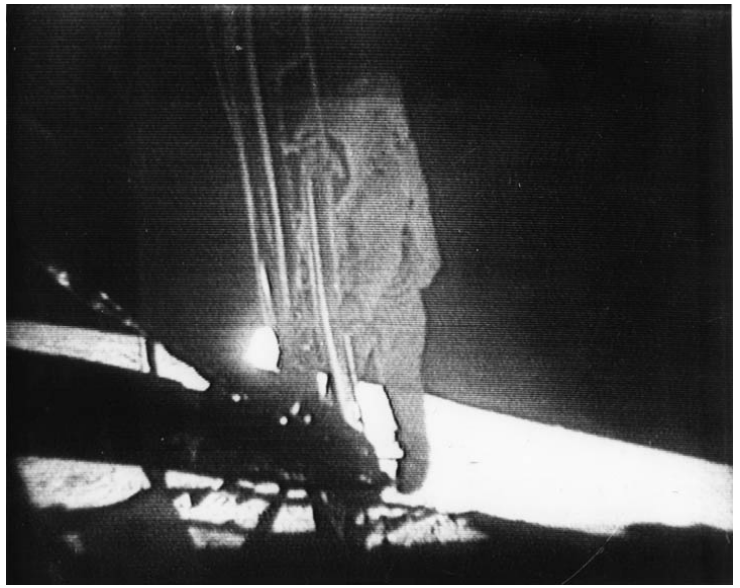
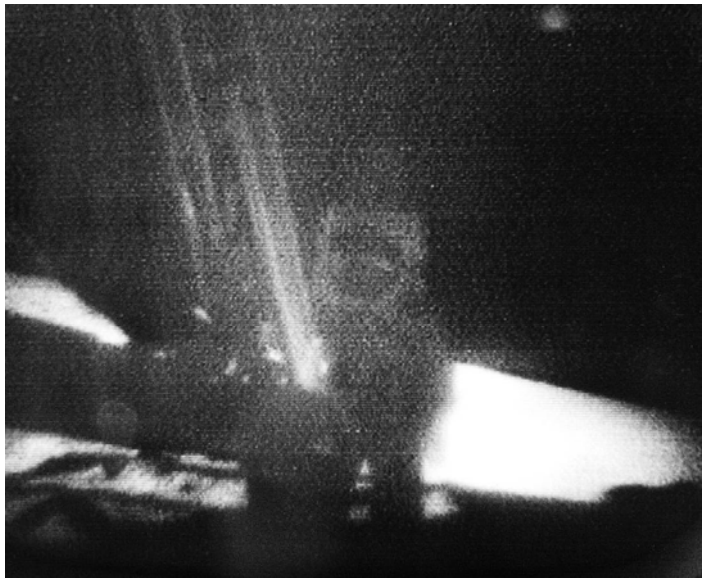
Armstrong

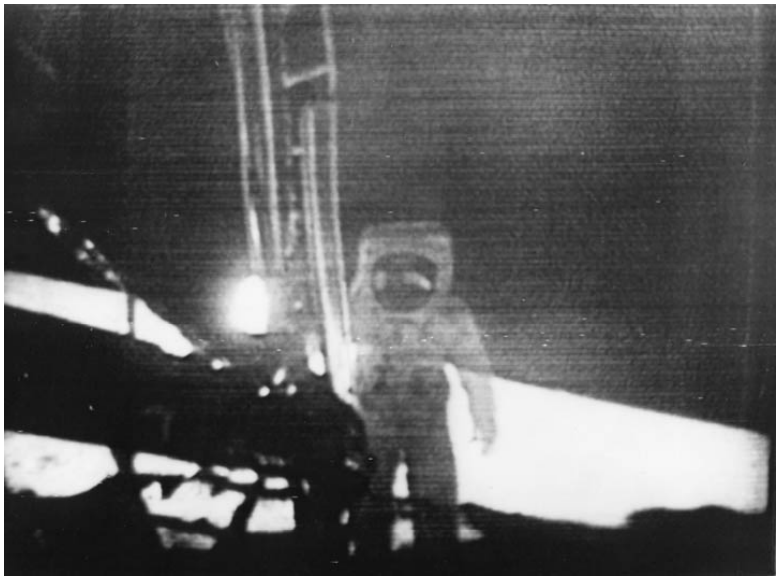


PKS
Aldrin

Apollo 11 – Comparison #2



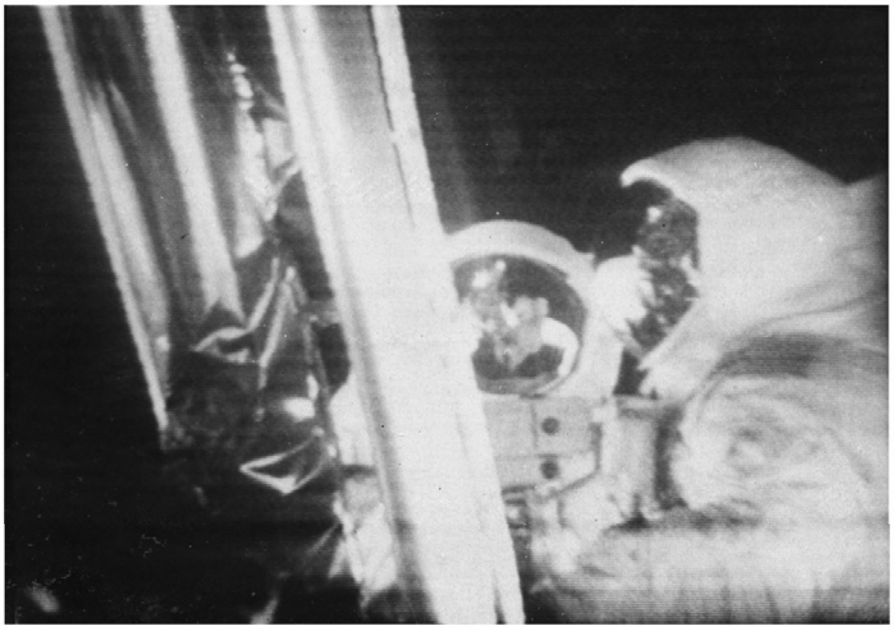
HSK
Armstrong



PKS
Aldrin

Apollo 11 – Comparison #3

Parkes scan-converted video



Polaroid of SSTV from Sydney Video

SSTV pictures were superior to the scan-converted images!

A Search for the Apollo 11 Tapes

Where are these tapes?

Stan Lebar (ex-Westinghouse)

Dick Nafzger (GSFC)

Bill Wood (ex-Goldstone)

Colin Mackellar (HSK web site)

John Sarkissian (CSIRO)

The Restored Apollo 11 Video

"This restored video is a valuable contribution to space exploration and space communication history"

- Neil Armstrong

Curiosity

5 August: A Double Rainbow Over The DISH

Curiosity – Landing on 6 August

The landing occured at 3:31 PM (AEST)

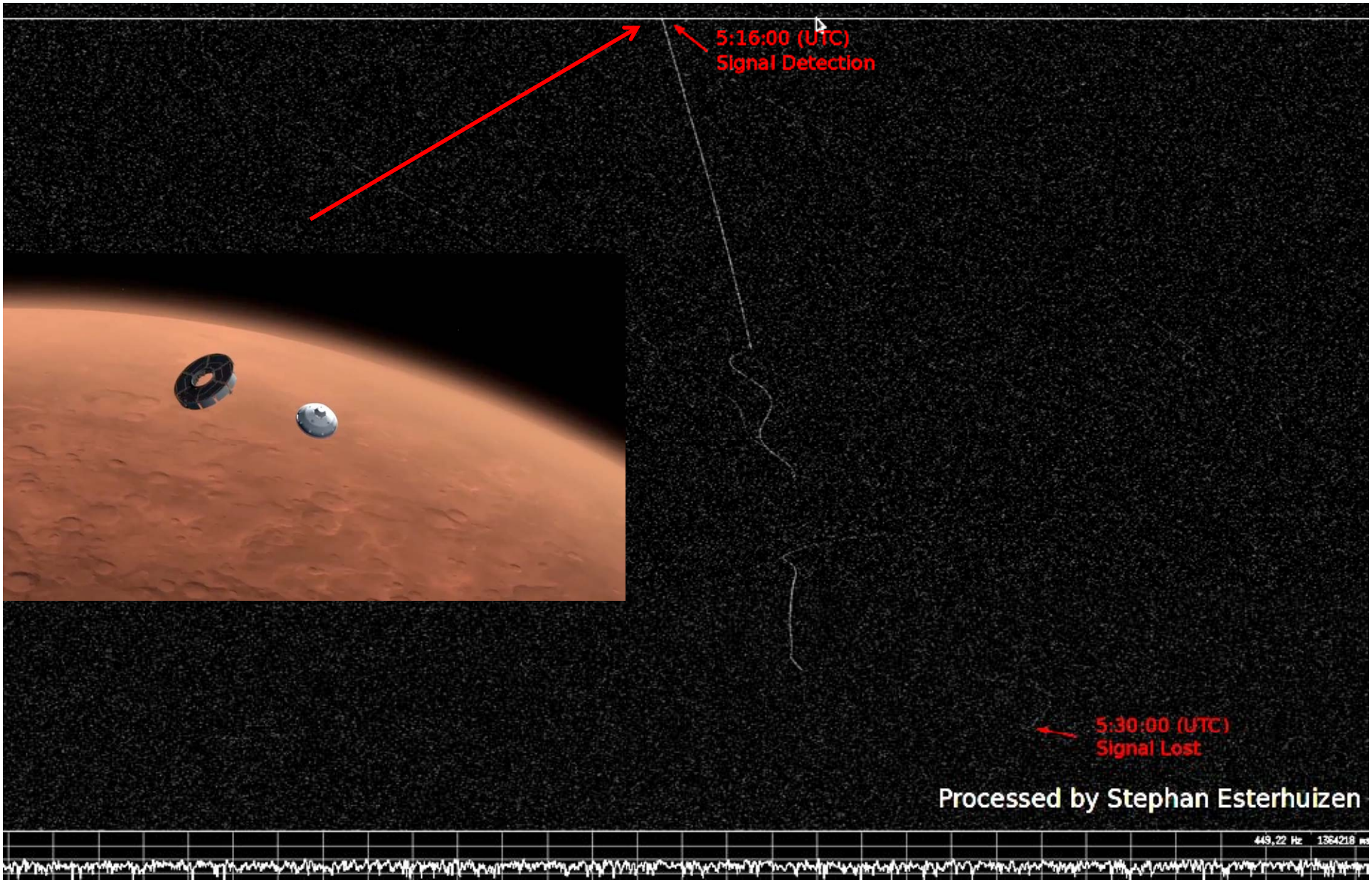
The EDL lasted 7 minutes

UHF Telemetry at 401.5 MHz

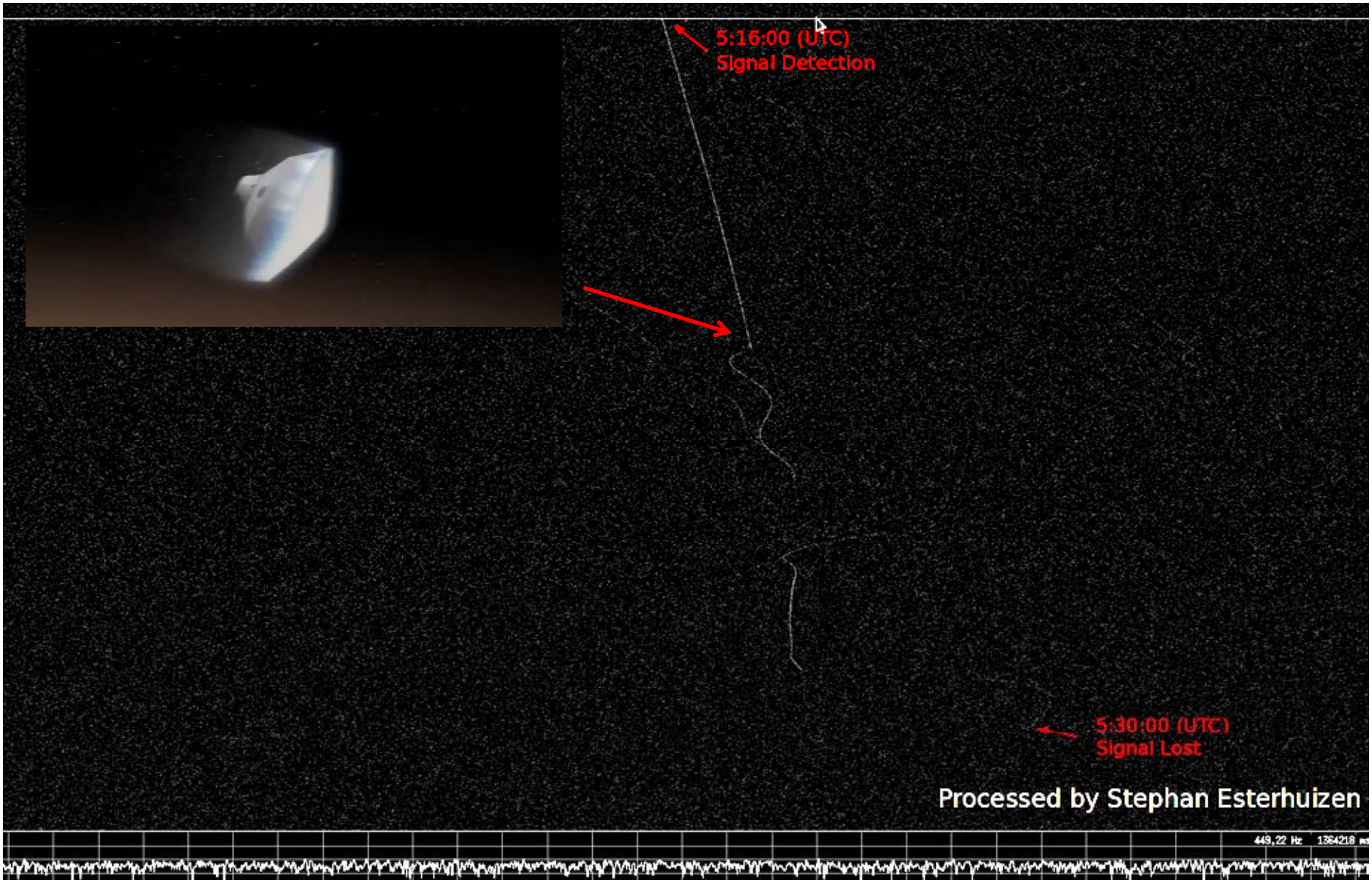
At each critical phase the
UHF signal was Doppler shifted

Curiosity – Landing on 6 August

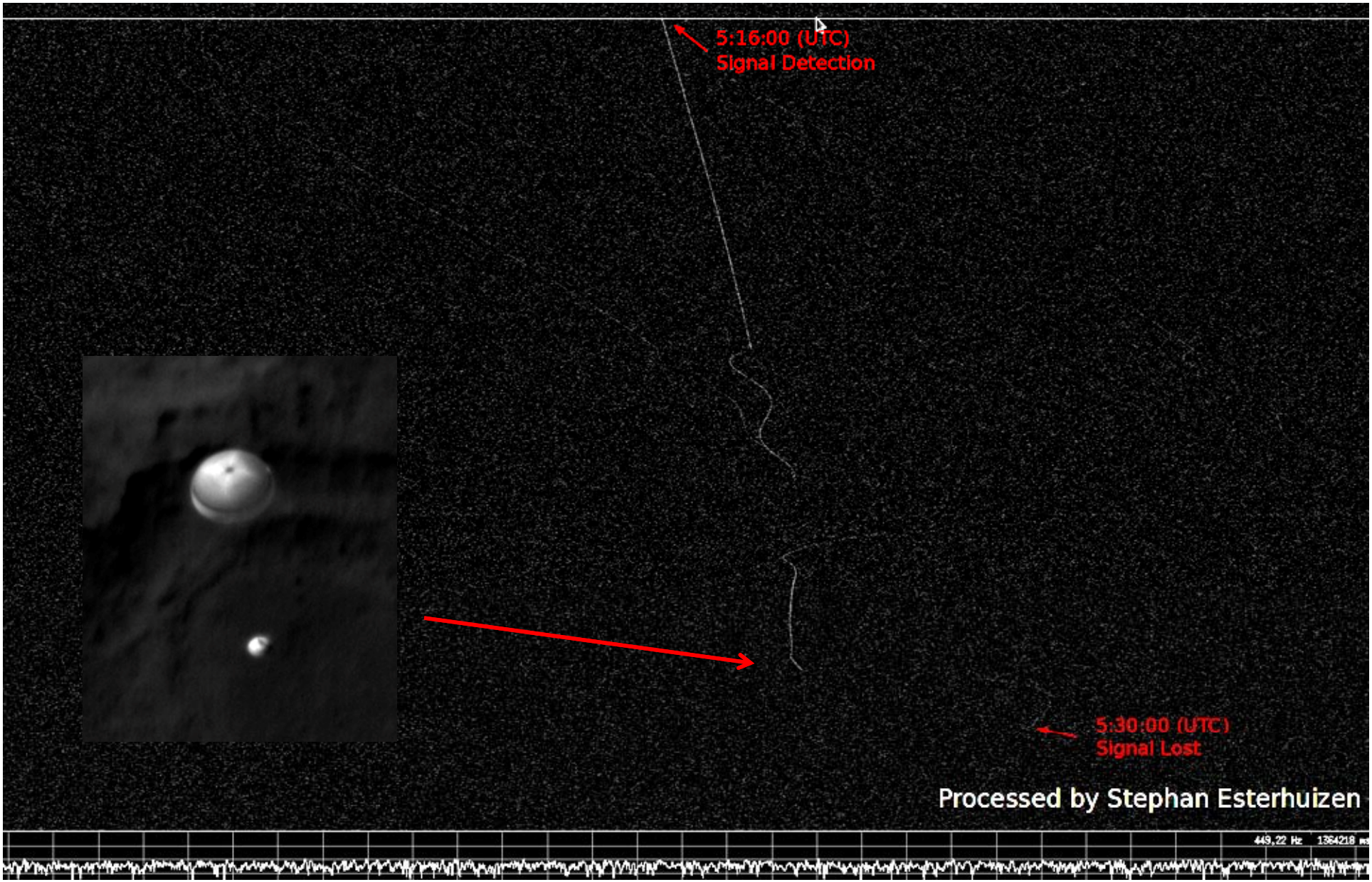
What did we see – Doppler Variations



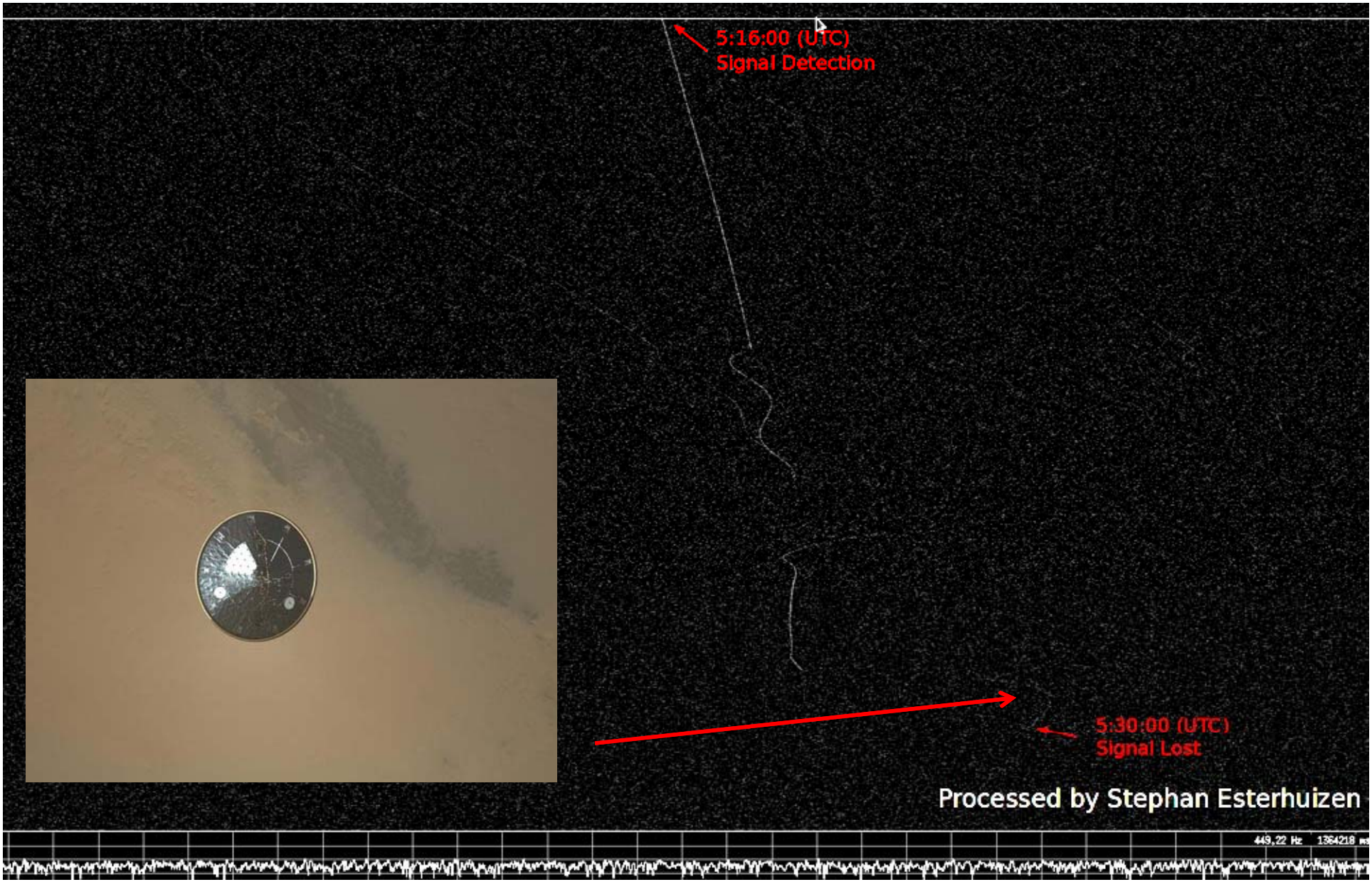
What did we see? – Doppler Variations



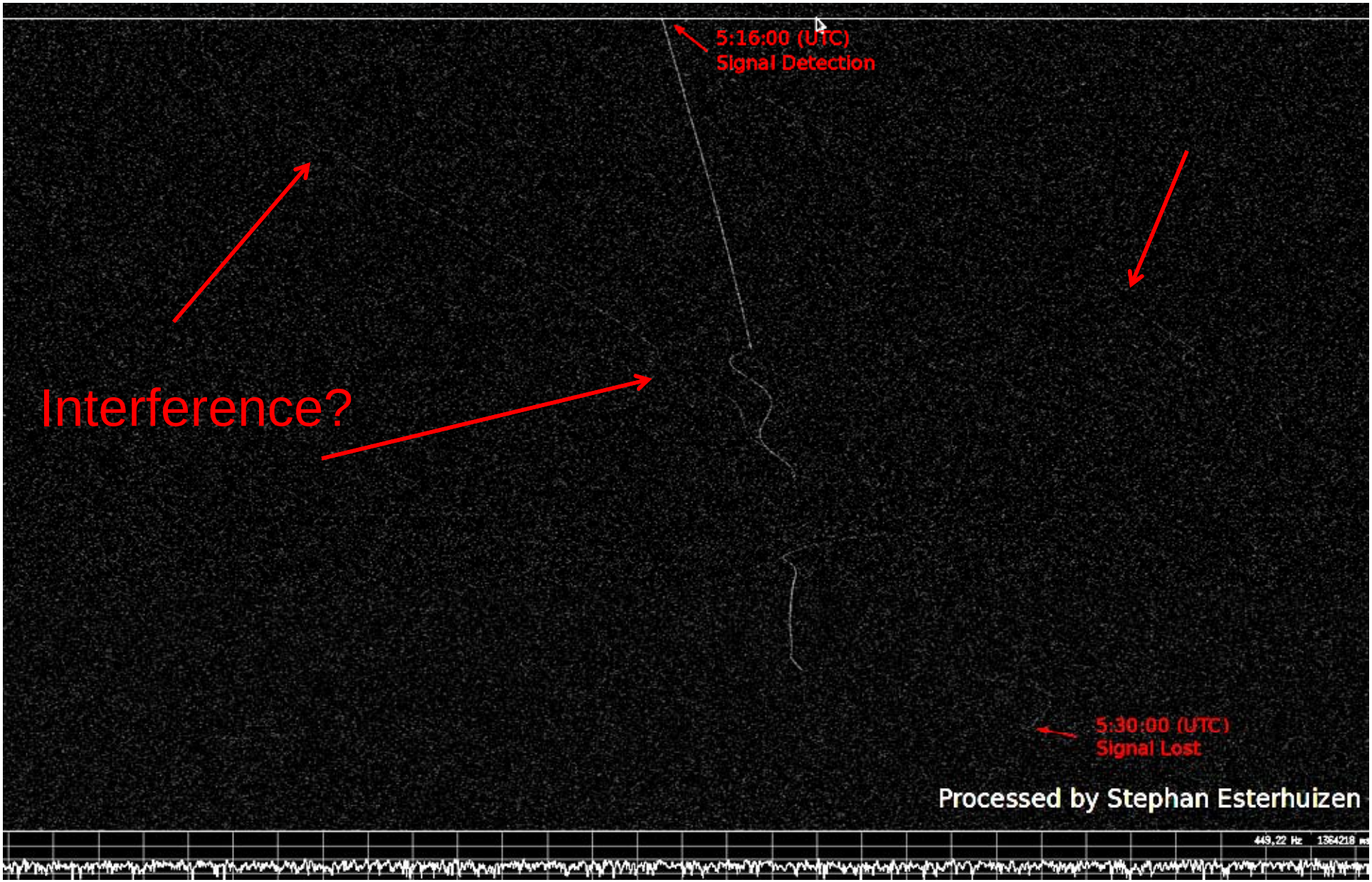
What did we see? – Doppler Variations



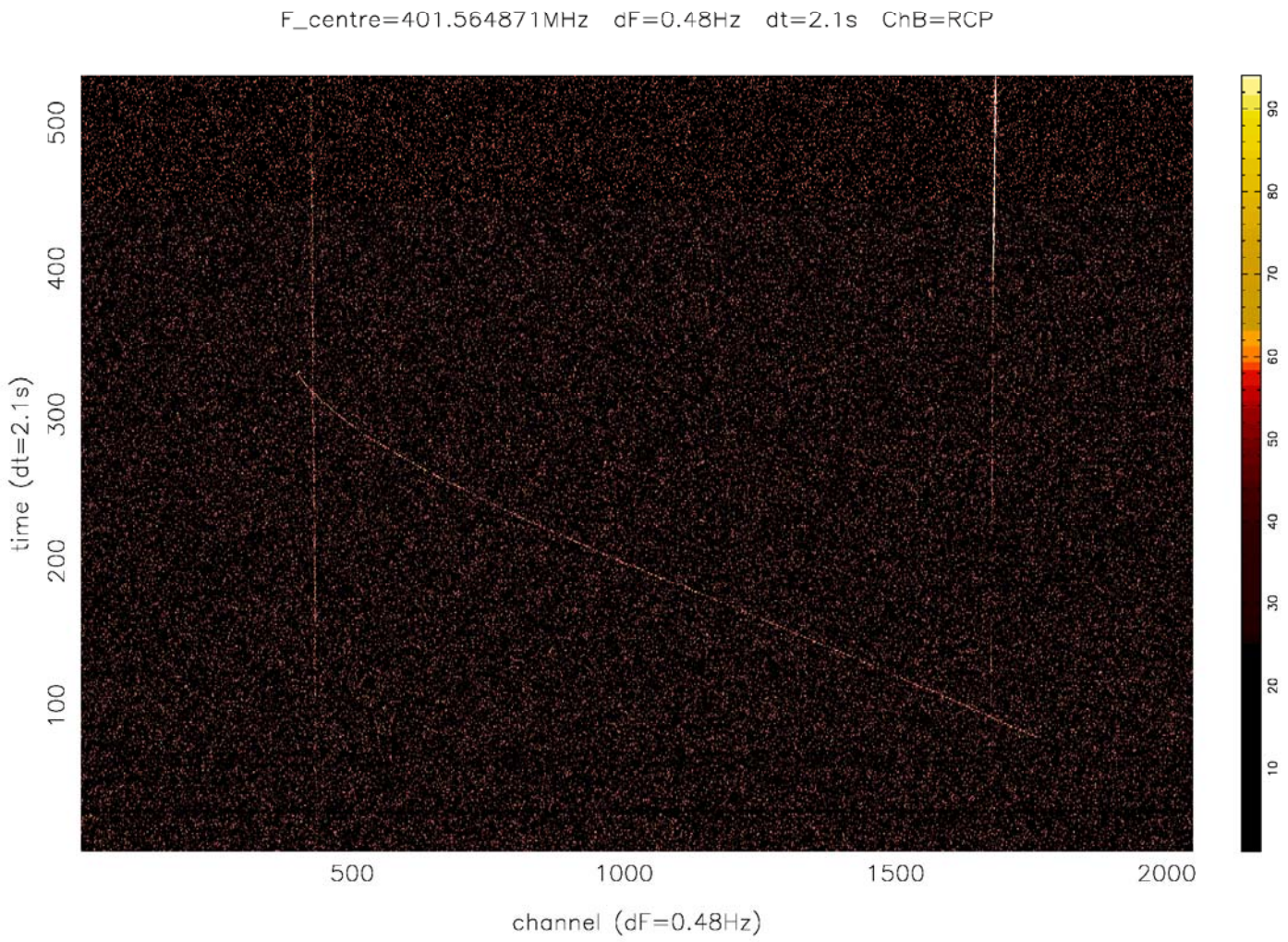
What did we see? – Doppler Variations



What did we see? – Doppler Variations

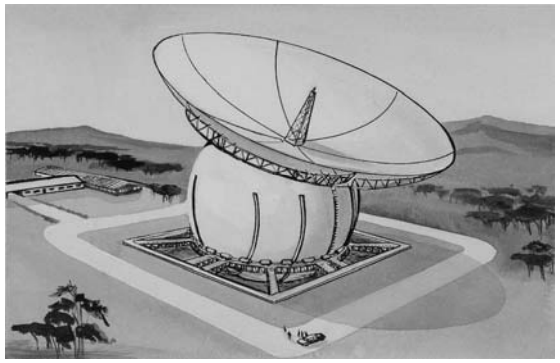


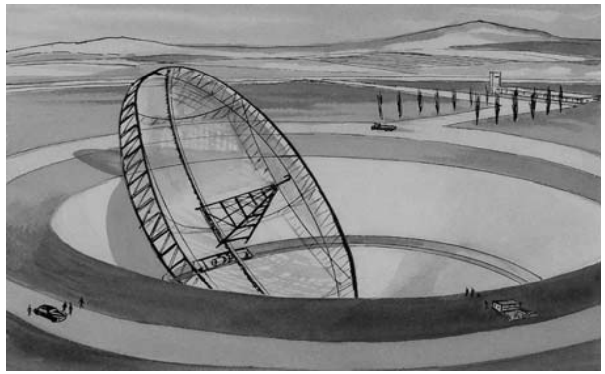
MSL Signal (sky frequency)

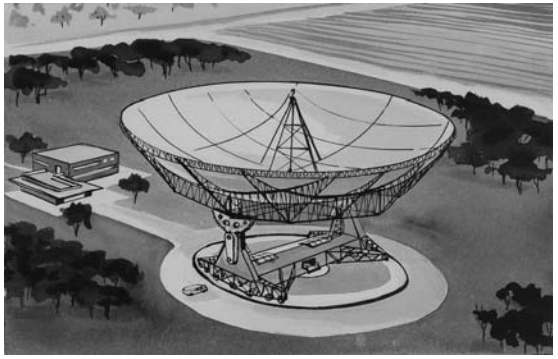


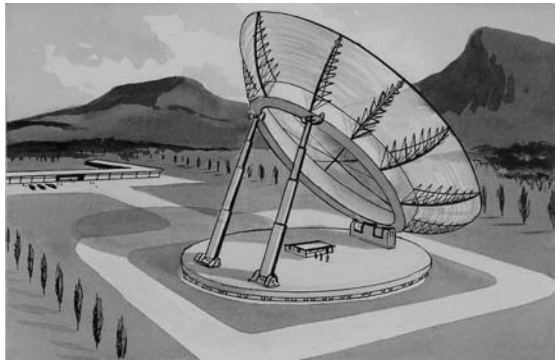
Celebrations

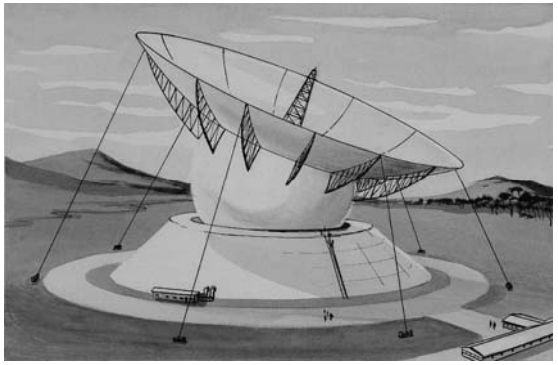
Early Concepts



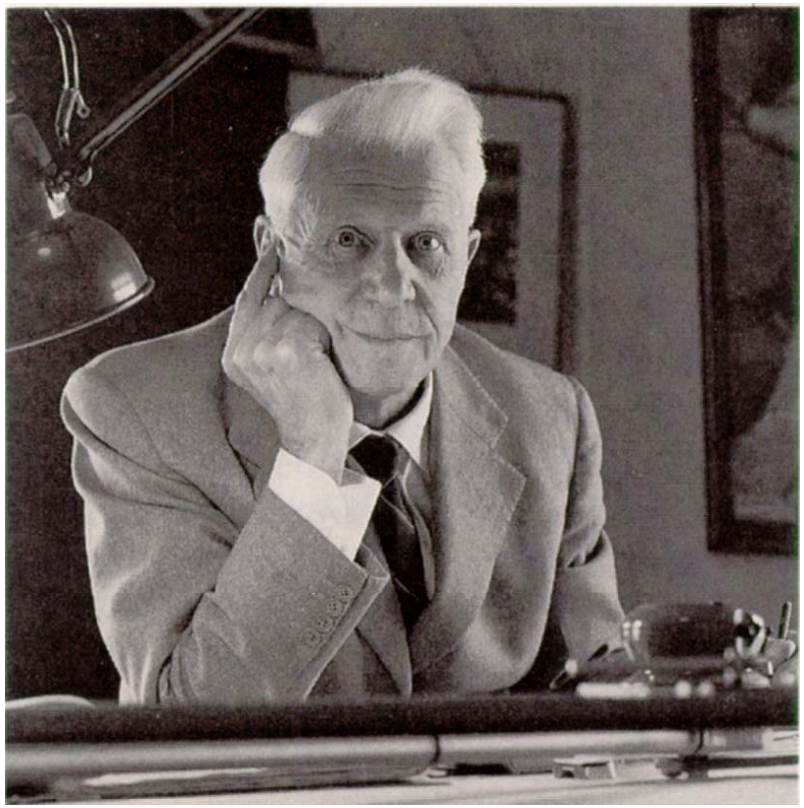








Barnes Wallis



Chief Engineer of Metropolitan-Vickers