MANCHESTER 1824

A short history of Space VLBI

Richard Schilizzi

18 April 2012

This is a tale of two missions

This is a tale of two missions

VSOP - HALCA

This is a tale of two missions

VSOP - HALCA

Hisashi
abayashi

The three Samurai

Masaki
Morimoto

Minoru
Oda

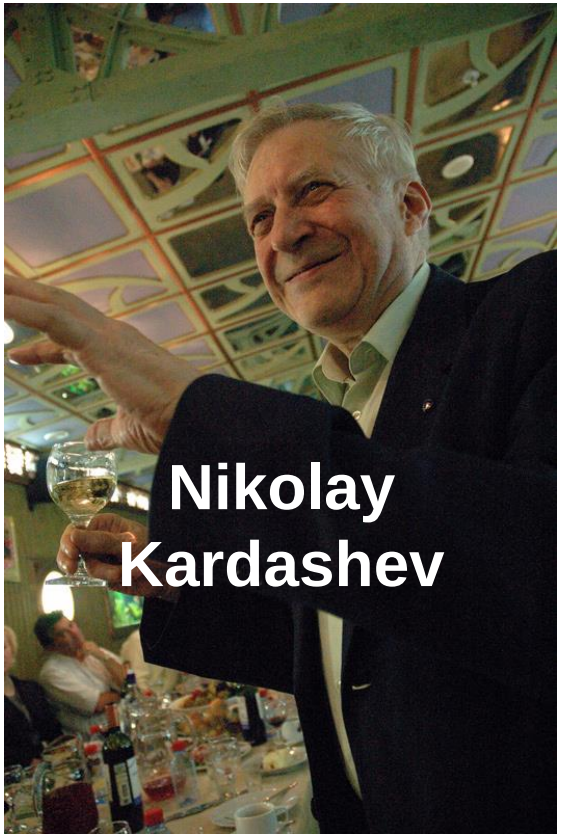
This is a tale of two missions

VSOP - HALCA

The three Samurai

and

RadioAstron



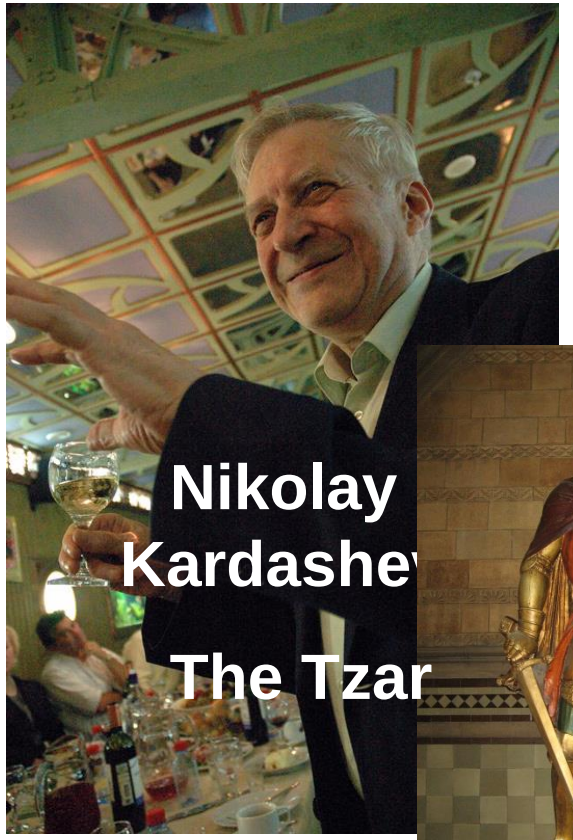
This is a tale of two missions

VSOP - HALCA

The three Samurai

and

RadioAstron



MANCHESTER 1824

This is not only a tale of two missions but what went before, and in between

It was not a linear process

Stage 1:The very early days of space VLBI: 1977 - 1982

Stage 1:The very early days of space VLBI: 1977 - 1982

JET PROPULSION LABORATORY

ENGINEERING MEMORANDUM

315-16

11 February 1977

TO: R. A. Preston

FROM:

SUBJECT: VLBI with an Earth-Orbiting Antenna

ABSTRACT:

Satellite-borne VLBI terminals could be used to provide maps of compact celestial radio sources with finer resolution, less ambiguity, and more efficiency than earth-bound VLBI techniques. These maps and their time variability would help unravel the physical processes that govern some of the most enigmatic classes of celestial objects. Hence, VLBI should be one of the principle justifications for placing a large parabolic antenna in earth orbit. This memorandum explores the advantages, technical problems, and scientific goals associated with earth-orbiting VLBI.

RAP:tg

Stage 1:The very early days of space VLBI: 1977 - 1982

INVESTIGATION AND TECHNICAL PLAN

Volume 1

Of a Proposal to the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

for a

VERY LONG BASELINE INTERFEROMETER STATION ON 1981-1983 SPACELAB MISSION

This joint proposal is submitted by the

CENTER FOR SPACE RESEARCH OF THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
and

GODDARD SPACE FLIGHT CENTER

and the
JET PROPULSION LABORATORY OF THE
CALIFORNIA INSTITUTE OF TECHNOLOGY

DR BERNARD F. BURKE

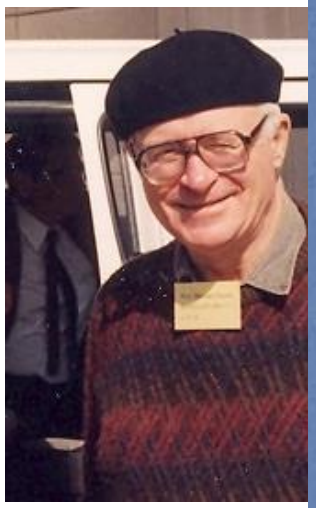
MIT, 26-335
Cambridge, Mass. 02139
617-253-2572

15 NOVEMBER 1978

AO-OSS-2-78

15 November 1978

Stage 1:The very early days of space VLBI: 1977 - 1982



Final Report

Mission Definition Study for a VLBI Station

Utilizing the Space Shuttle

NAS-5-25543

Professor Bernard F. Burke October 12, 1982

CENTER FOR SPACE RESEARCH

ASSACHUSETTS INSTITUTE OF TECHNOLOGY

617-253-2572

15 November 1978

An important side-show - satellite-linked VLBI

1977

Real-Time, Very-Long-Baseline Interferometry Based on the Use of a Communications Satellite

Abstract. *The Hermes satellite, a joint Canadian-American program, has been used to provide a communication channel between radio telescopes in West Virginia and Ontario, for very-long-baseline interferometry (VLBI). This system makes possible instantaneous correlation of the data as well as a sensitivity substantially better than that of earlier VLBI systems, by virtue of a broader observational bandwidth. With the use of a geostationary communications satellite it is possible to eliminate the tape recorders and the most troublesome part of the postobservational data processing. A further possibility is the development of a phase-coherent interferometer.*

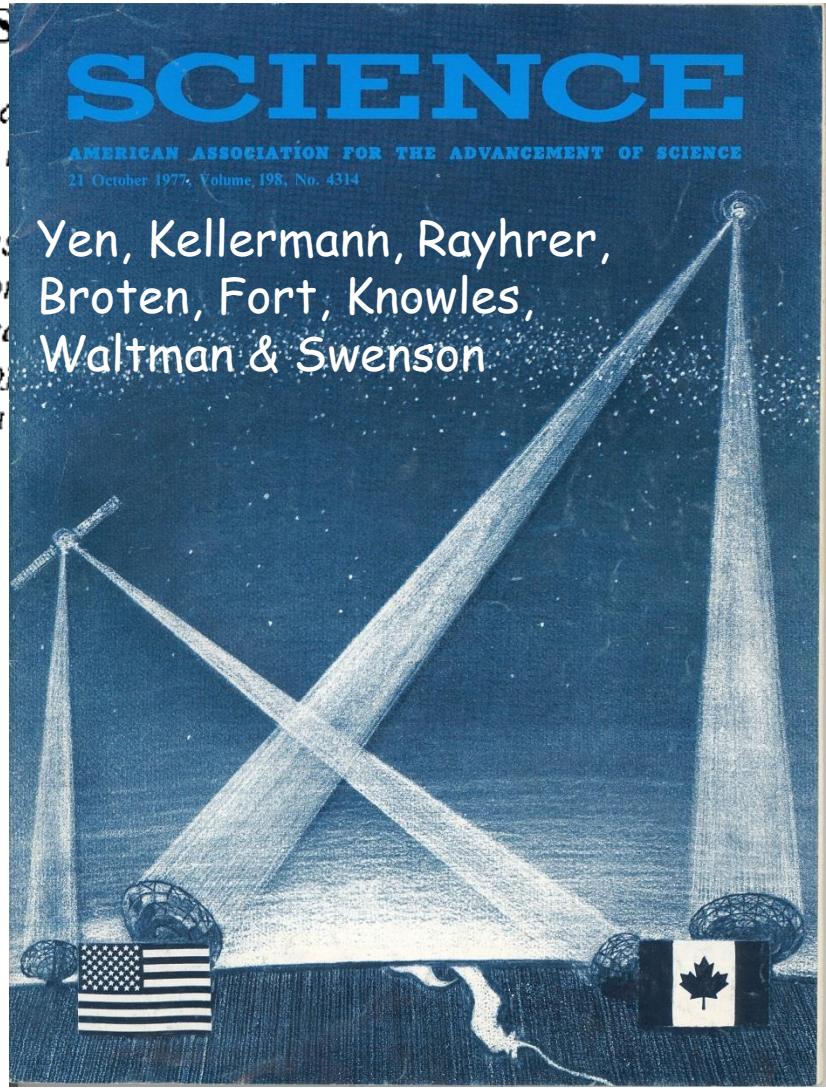
An important side-show - satellite-linked VLBI

1977

Real-Time, Very-Long-Baseline Interferometry

Based on the Use of a Communications S

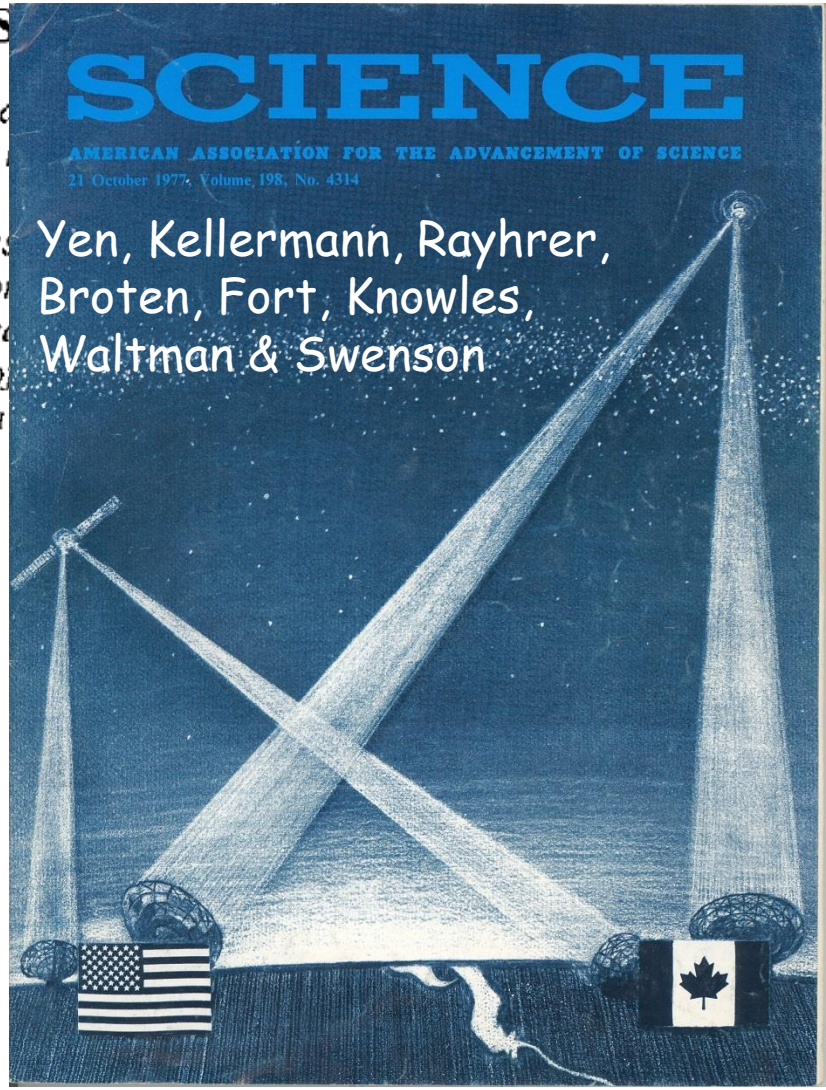
Abstract. *The Hermes satellite, a joint Canadi*
used to provide a communication channel between
and Ontario, for very-long-baseline interferometry
sible instantaneous correlation of the data as well a
than that of earlier VLBI systems, by virtue of a b
With the use of a geostationary communications s
the tape recorders and the most troublesome part o
cessing. A further possibility is the development of a



An important side-show - satellite-linked VLBI

1977 **Real-Time, Very-Long-Baseline Interferometry Based on the Use of a Communications S**

Abstract. *The Hermes satellite, a joint Canadi*
used to provide a communication channel between
and Ontario, for very-long-baseline interferometry
sible instantaneous correlation of the data as well a
than that of earlier VLBI systems, by virtue of a b
With the use of a geostationary communications s
the tape recorders and the most troublesome part o
cessing. A further possibility is the development of a



1978: ESA Feasibility Study of satellite-linked VLBI (Schilizzi et al)

1981: ESA Phase A study of satellite-linked VLBI using L-SAT (Schilizzi et al)

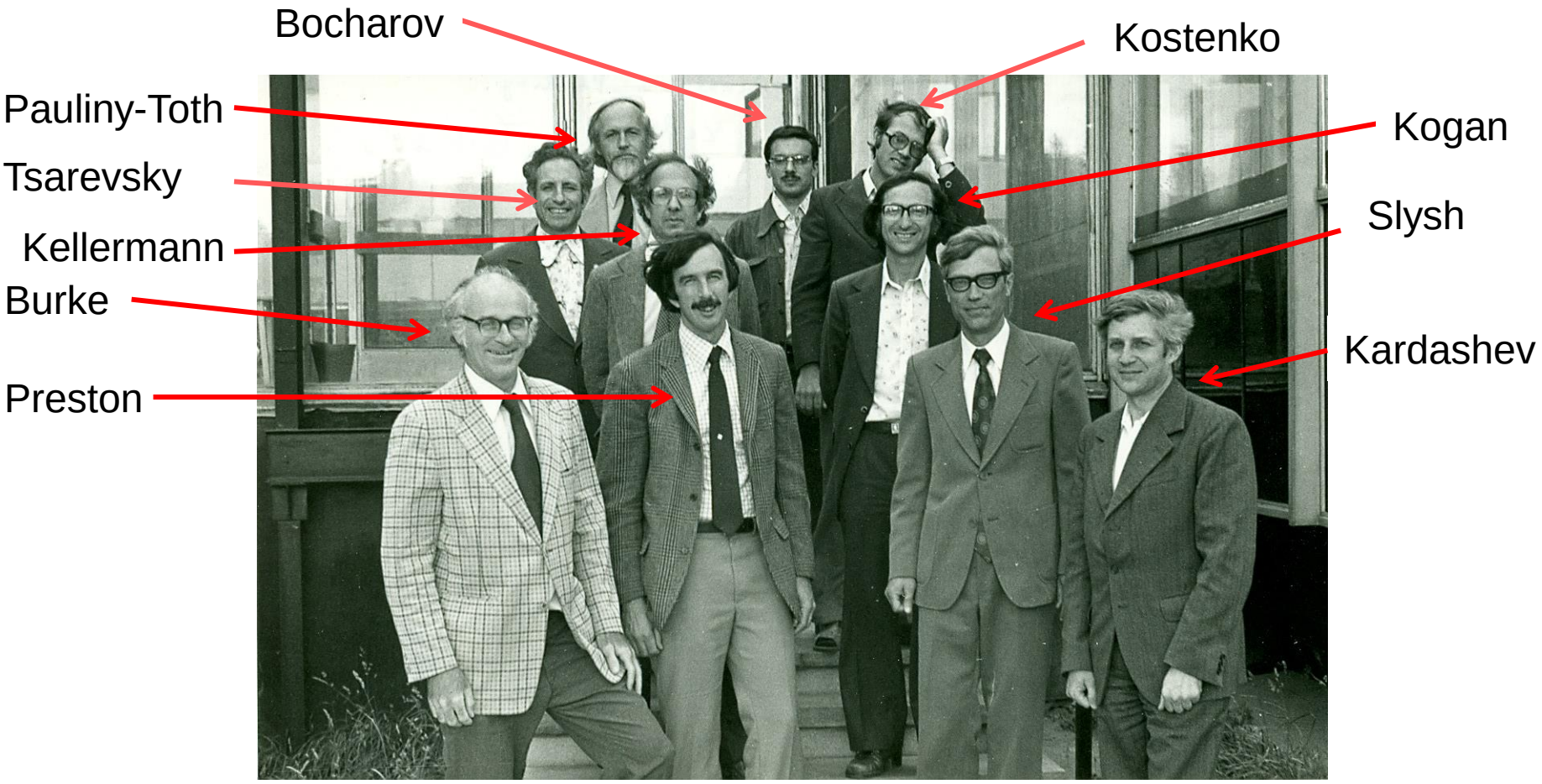
1982: Phase transfer via ESA's Orbital Test Satellite by van Ardenne et al

Stage 1:The very early days of space VLBI: 1977 - 1982

KRT-10 deployed on Salyut-6 in 1979

Stage 1:The very early days of space VLBI: 1977 - 1982

MPIfR-Soviet Academy of Sciences discussions on VLBI in August 1979



But the détente didn't last, at least at the geo-political level….

Stage 1:The very early days of space VLBI: 1977 - 1982

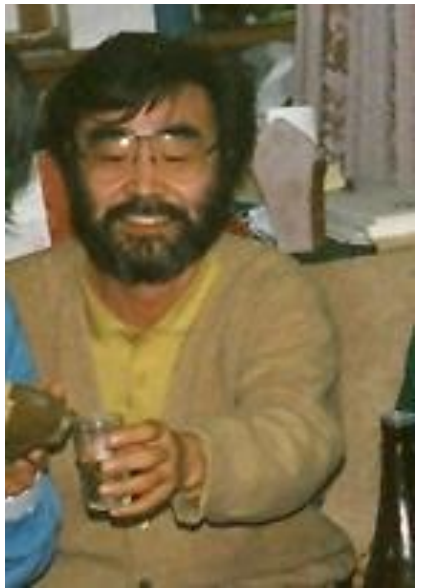
SPACE VLBI

H. HIRABAYASHI, Y. CHIKADA, M. INOUE, M. MORIMOTO

Nobeyama Radio Observatory*, Tokyo Astronomical Observatory,
University of Tokyo, Nobeyama, Minamisaku-gun
Nagano-Ken 384-13, Japan

(Submitted to Space Station Symposium Tokyo)

Oct. 1982



Large diameter antenna on US Space Station

Stage 2: 1983-1988

esa
european space agency

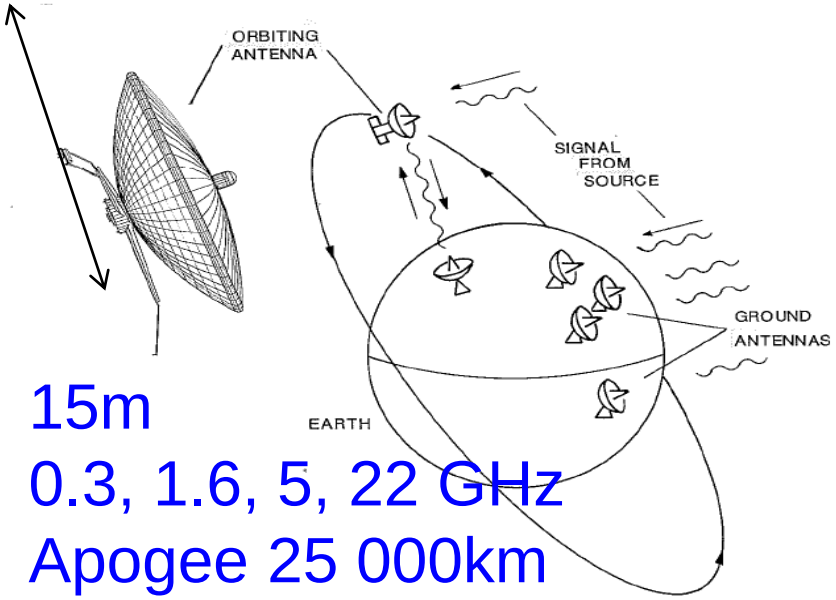
SCI(85)5
NOVEMBER 1985

QUASAT

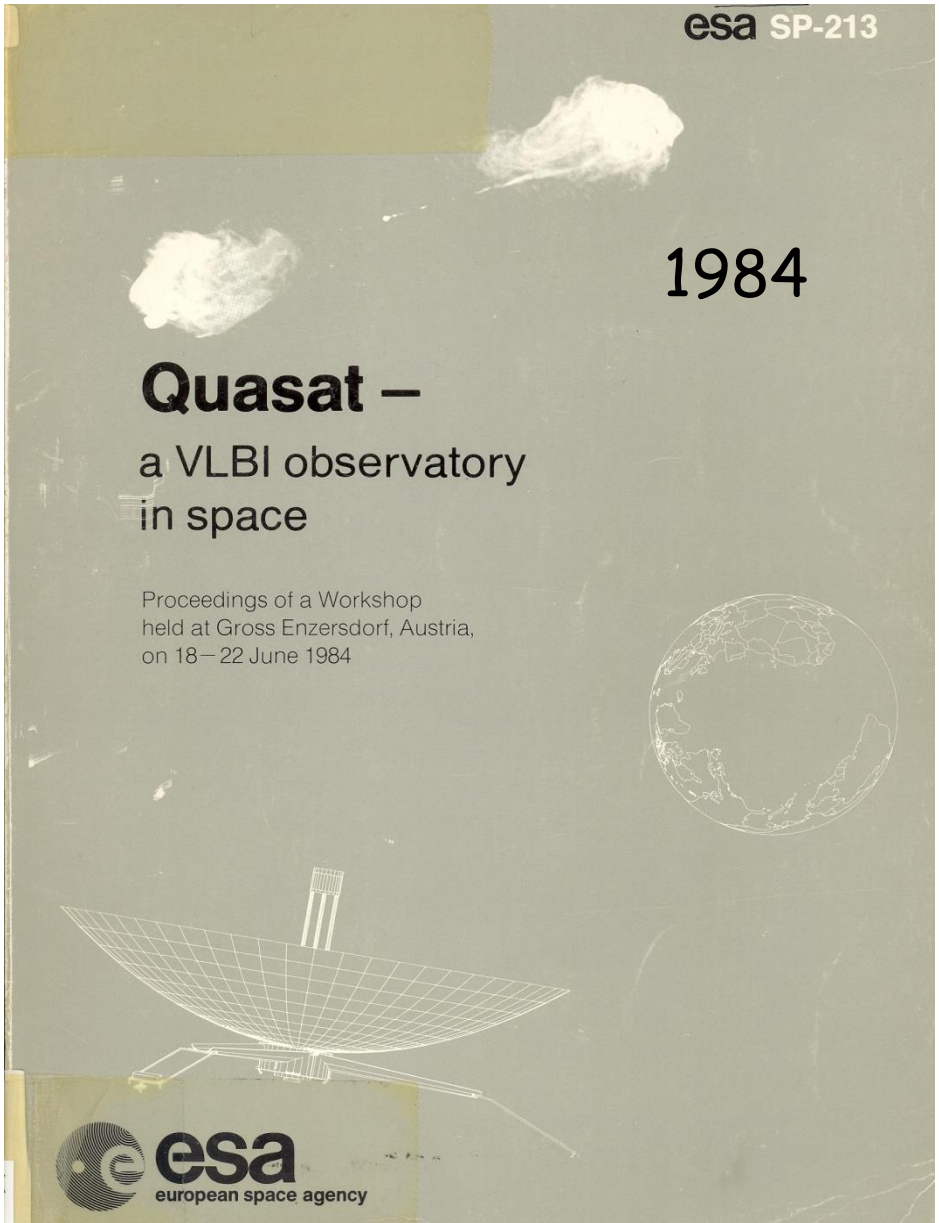
A SPACE VLBI SATELLITE

1983-1985

ASSESSMENT STUDY



15m
0.3, 1.6, 5, 22 GHz
Apogee 25 000km



MANCHESTER 1824

1984: QUASAT Workshop

CONTENTS

1984: QUASAT Workshop

Some prospects for space VLBI by R.Z Sagdeev

“Basic concepts of space very longbase radio interferometry are discussed. Two perspective ground-space interferometer projects are considered: with low-orbit space telescope (very complete coverage of uv-plane) and with high orbit space telescope (very good angular resolution).”

1984: QUASAT Workshop

CONTENTS

1984: QUASAT Workshop

Space VLBI Studies in Japan
by M. Morimoto

"The other is a joint study group in Institute for Space and Astronomical Science (ISAS), RRL and NRO, to study a possibility of having a small antenna in space to do VLBI experiments."

High-level coordination began to take place in 1984

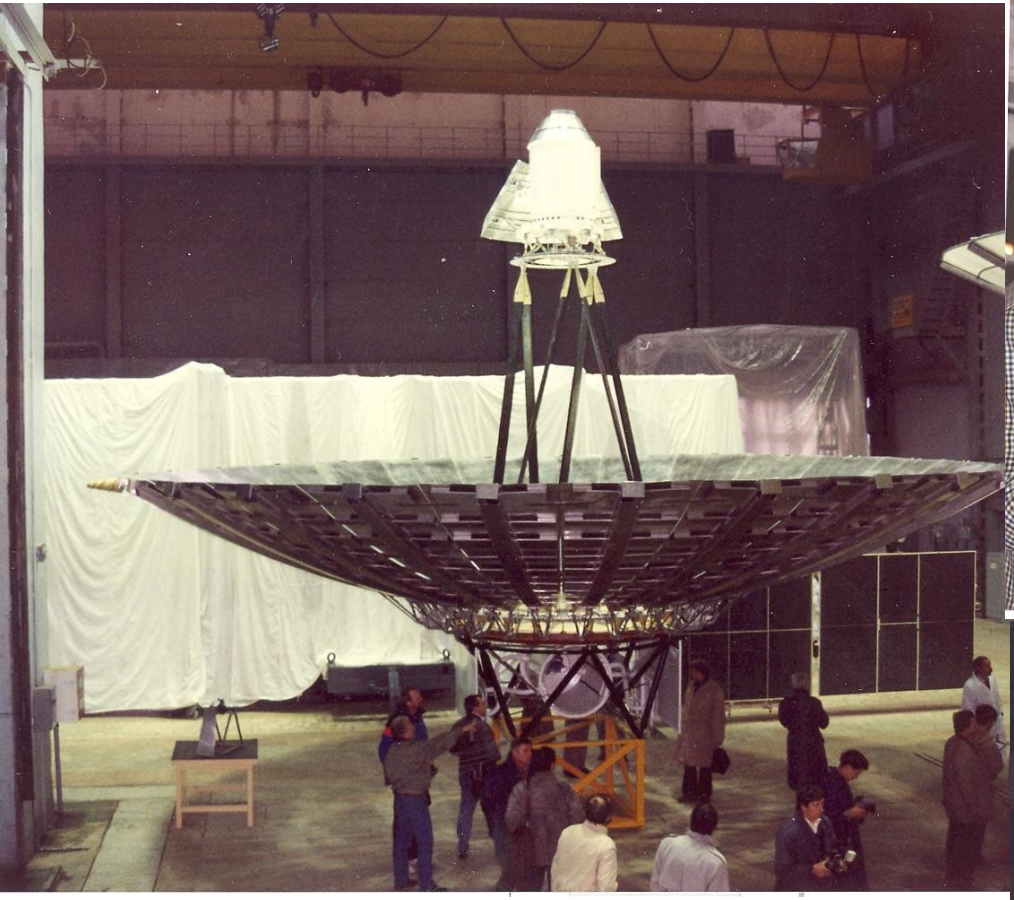
- COSPAR Ad-hoc Committee on Space VLBI

  -served as a body to coordinate the three different efforts until the mission-specific International Scientific Committees were formed

- Inter-(Space) Agency Consultative Group

  - Panel 1 on Space VLBI

RadioAstron was approved in 1985



10m diameter, 0.3, 1.6, 5, 22 GHz, apogee 200 000km, (later changed to 100 000 km and then back to 350 000 km)

MANCHESTER 1824

Phase A Study
1986-1988

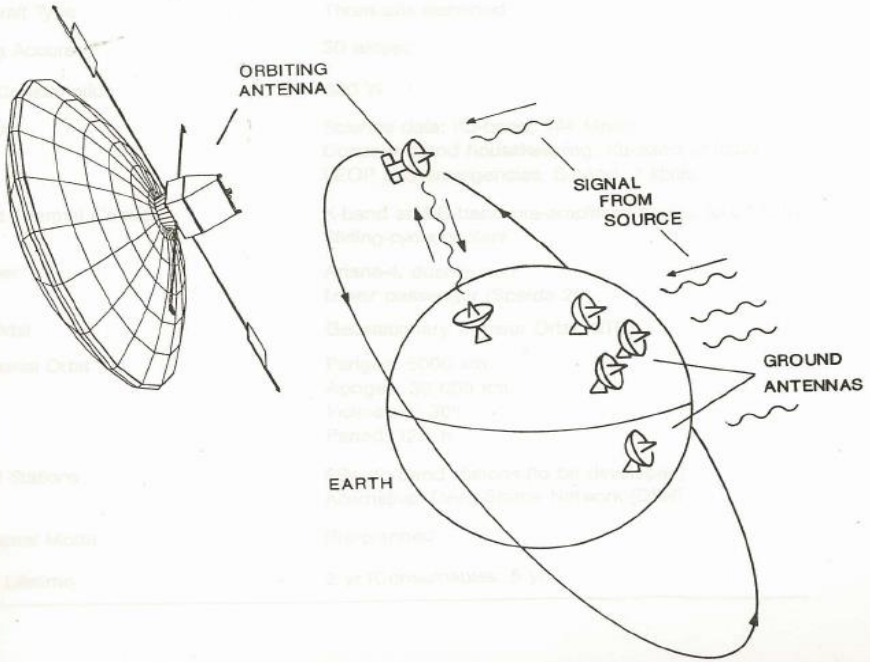
esa european space agency agence spatiale européenne

SCI(88)4
October 1988

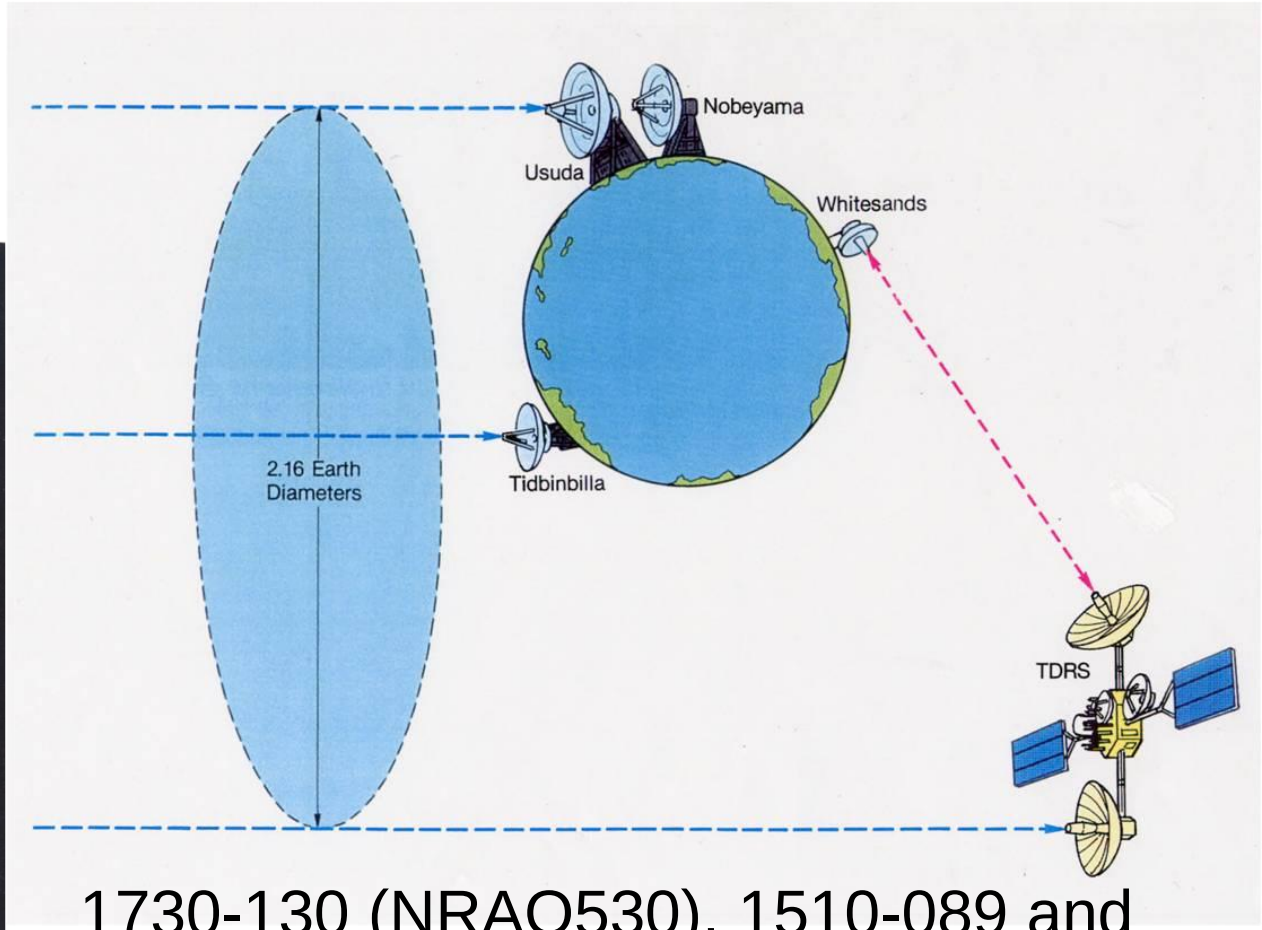
QUASAT

A SPACE VLBI SATELLITE

REPORT ON THE PHASE A STUDY



First space VLBI fringes with TDRSS in1986



1730-130 (NRAO530), 1510-089 and 1741-038, detected at 2.3 GHz

Cultural exchanges took place

October Revolution Parade in Leningrad, November 1988

There's a story behind this poster….

So what happened in the end?

QUASAT was shot down by ESA in October 1988 and finally died in 1989 (lost out to Cassini-Huygens)

VSOP was approved by ISAS in December 1988

- 8m diameter 1.6, 5, 22 GHz; apogee 21 600 km

Working closely with the Soviet Union on RadioAstron still didn't have the seal of approval from you know who…

So the QUASAT team all took an oath of allegiance to the Three Samurai…..

while continuing to work with The Tzar, participating in advisory committee meetings and building receivers

MANCHESTER 1824

Stage 3: 1988 – 2012

VSOP and RadioAstron

RISC and VISC

RISC - April 1988
in Dwingeloo

VISC - November 1992
in Sagamihara

There were risks in being a RISC member

The bus crash
Pushchino to Moscow Road,
November 1991

The Ground Segment

Global VLBI Working Group

Proposed in the Capitol Bar in Socorro in 1990 by Ron Ekers, Roy Booth and Paul Vandenbout, chair: Roy Booth

Global VLBI Working Group

Proposed in the Capitol Bar in Socorro in 1990 by Ron Ekers, Roy Booth and Paul Vandenbout, chair: Roy Booth

The GVWG was established in 1990 as a Working Group of Commission J at the URSI General Assembly in Prague, and recognized in 1991 at the IAU General Assembly in Buenos Aires as a Division X Working Group. The mandate of the GVWG, its membership and chair, are reviewed at Commission J business sessions during URSI General Assemblies.

The current mandate of the GVWG comprises the following tasks:

1. To develop a concept for an International VLBI Network, comprising existing or future national and regional networks.
2. To promote compatibility of technology in VLBI instrumentation.
3. To serve as a liaison between ground-based observatories and national or international space agencies, for coordination of participation by ground radio telescopes in Space VLBI missions.

The GVWG carries out its tasks in conjunction with the organizations concerned, and presents summaries of its activities to URSI Commission J and IAU Division X at their respective General Assemblies.

Global VLBI Working Group

3. To serve as a liaison between ground-based observatories and national or international space agencies, for coordination of participation by ground radio telescopes in Space VLBI missions.

The Ground Segment

Global VLBI Working Group

Onsala, October 1993

VSOP space segment

Technical development was advised by

the chief cook,

9 assistant cooks, and

one bottle-washer

MANCHESTER 1824

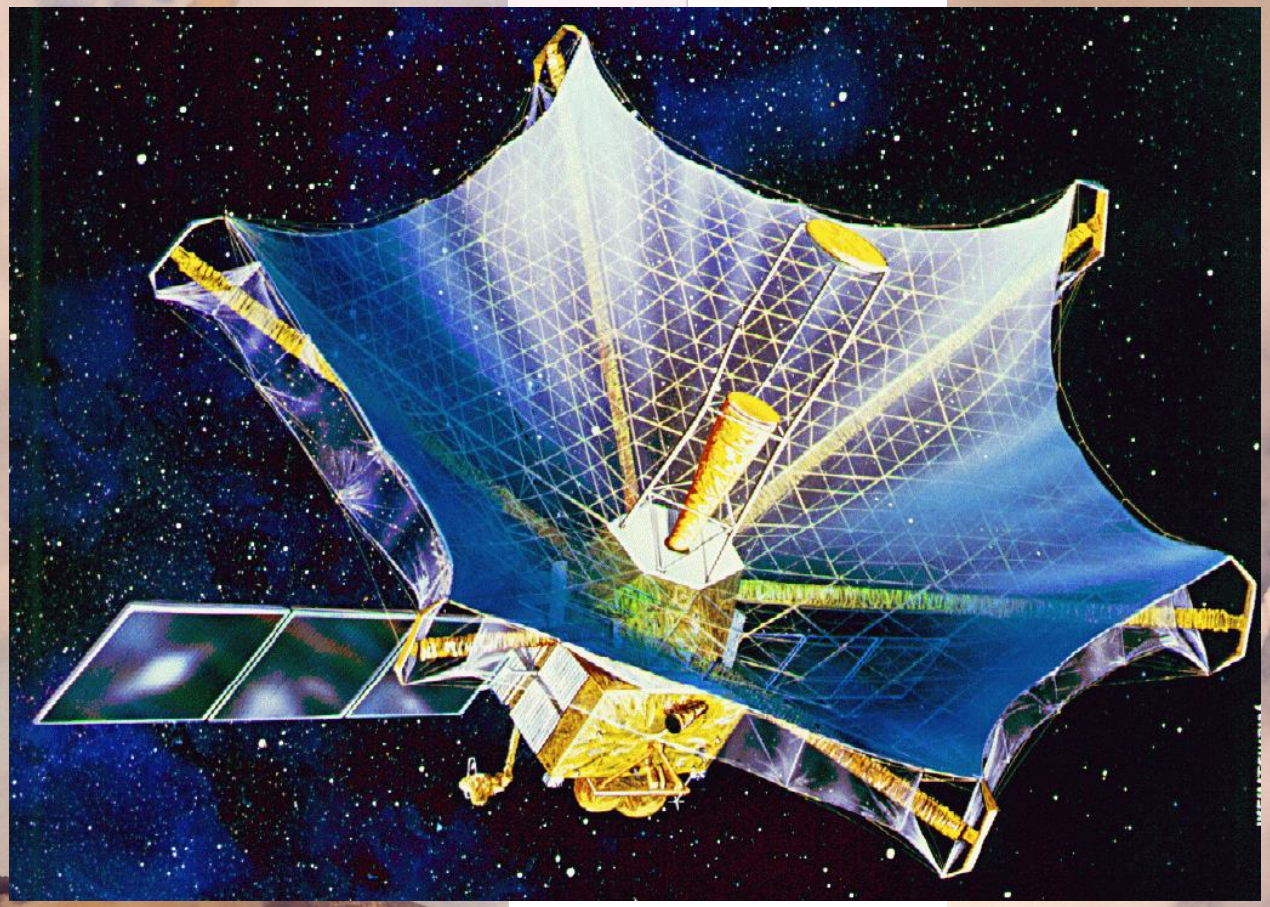
Not to forget a bit of help from friends with connections…

Launch in February 1997

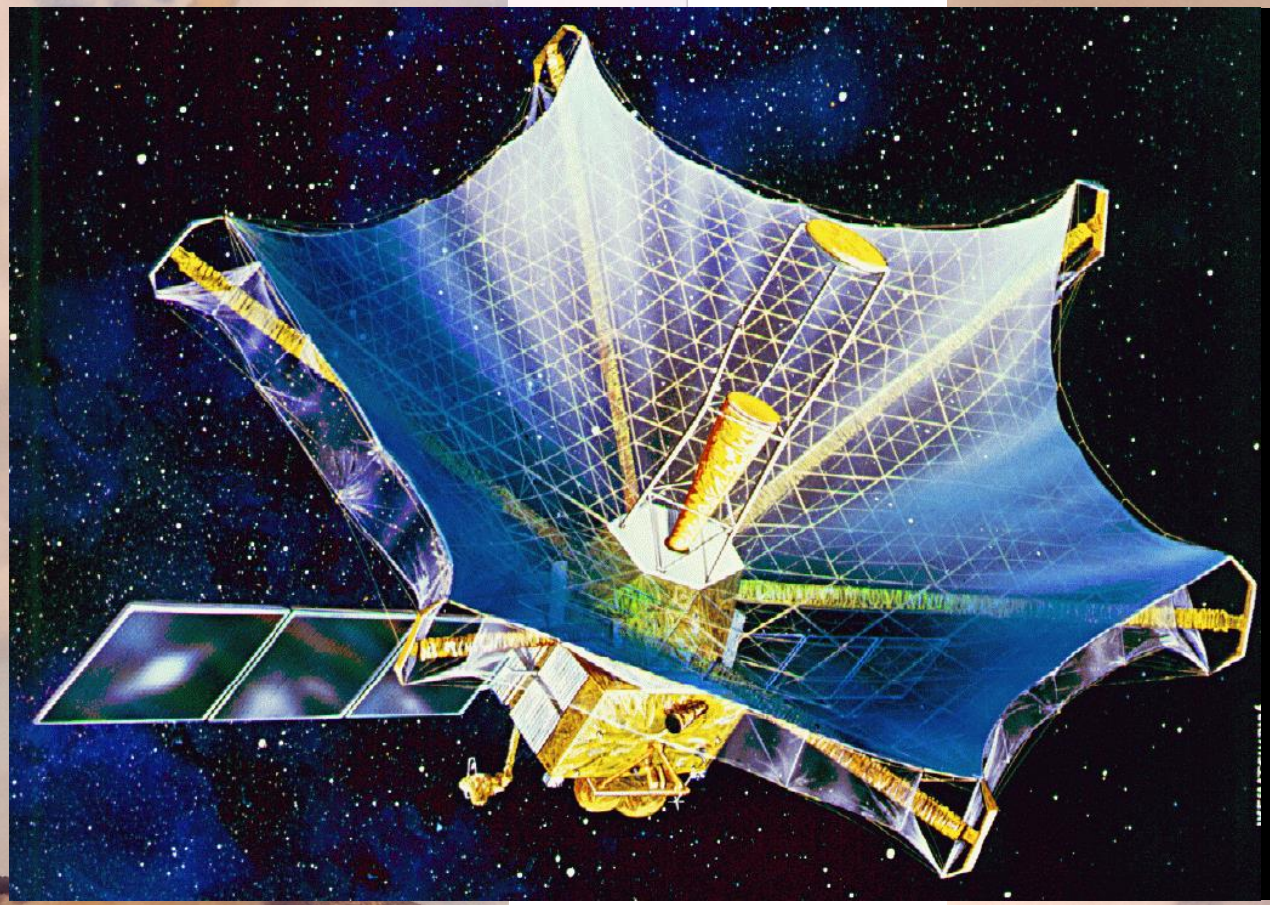
Launch in February 1997

Launch in February 1997

Launch in February 1997



Launch in February 1997



operational until Nov 2005

MANCHESTER 1824

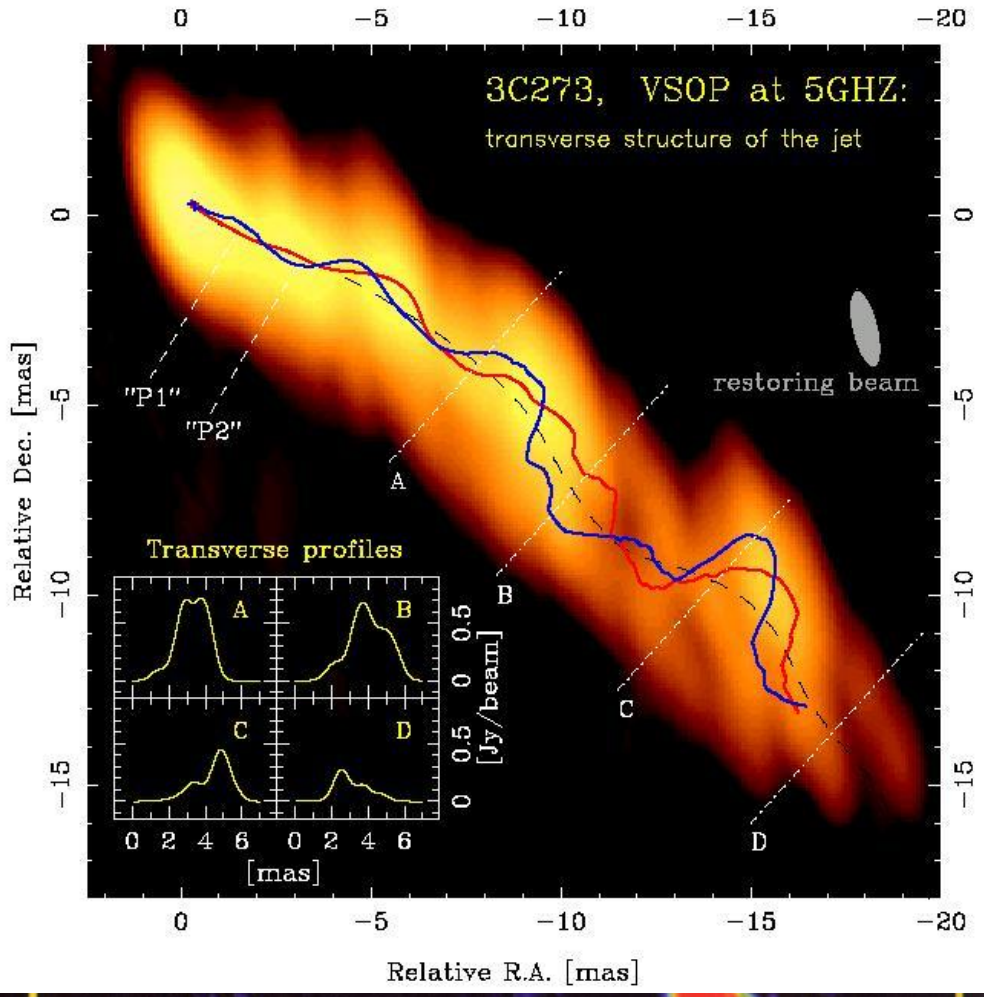
"V" for Victory or VSOP or …

MANCHESTER 1824

Quasar 3C273
3 billion ly away

Central Core is Zoomed by VSOP

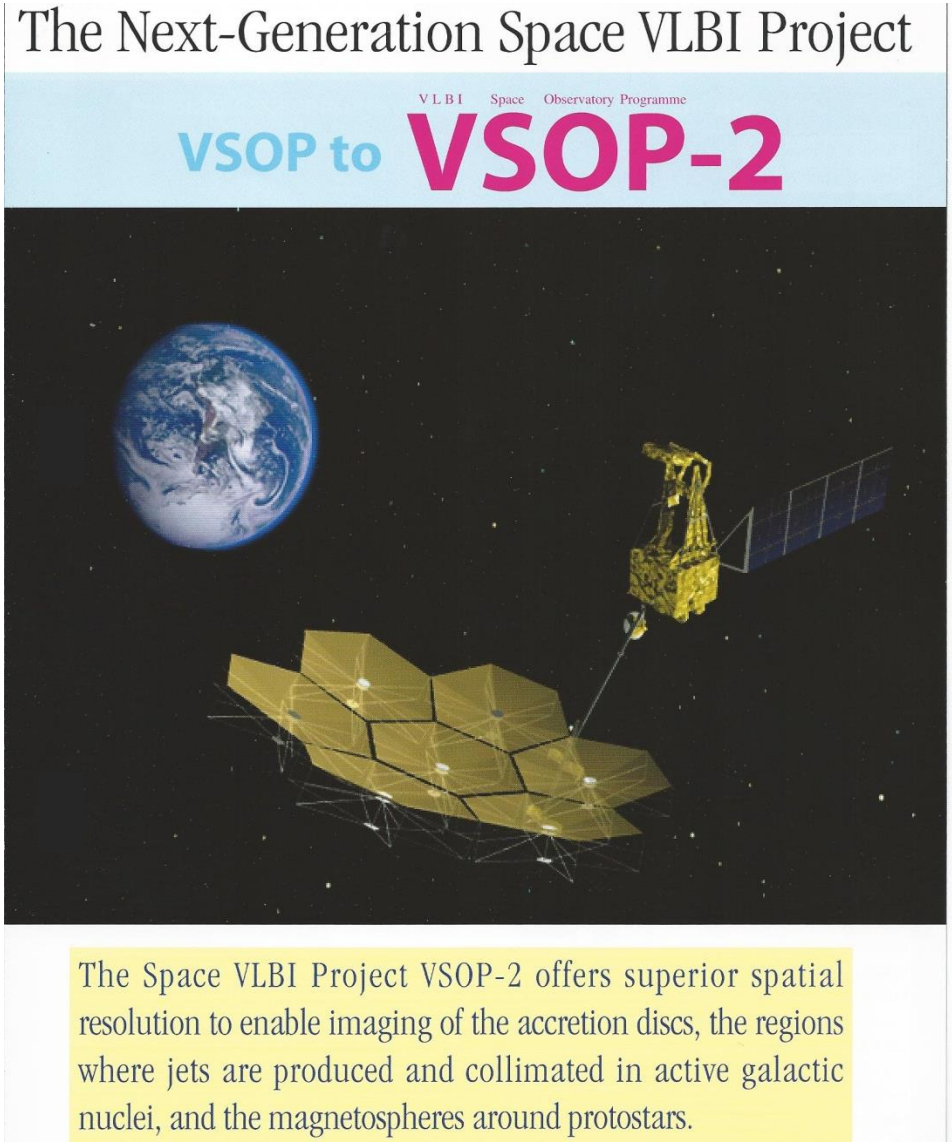
Optical: Pseudo-color;
Radio: Contour



VSOP image of 3C273 by Lobanov et al

Hubble Space telescope (left) and MERLIN (right) images of the Quasar 3C273

And to follow up…



9m diameter
8, 22, 43 GHz
25000 km apogee

And to follow up…

9m diameter
8, 22, 43 GHz
25000 km apogee

Approved in 2007 by JAXA as ASTRO-G, but ran into technical problems and was cancelled in 2011

In the meantime, Nikolay and his team carried on…

getting all the help he could…

Prime Minister Putin

MANCHESTER 1824

Ready to go to Baikonur

And finally the launch in July 2011

And finally the launch in July 2011

MANCHESTER
1824

And the rest is history…..

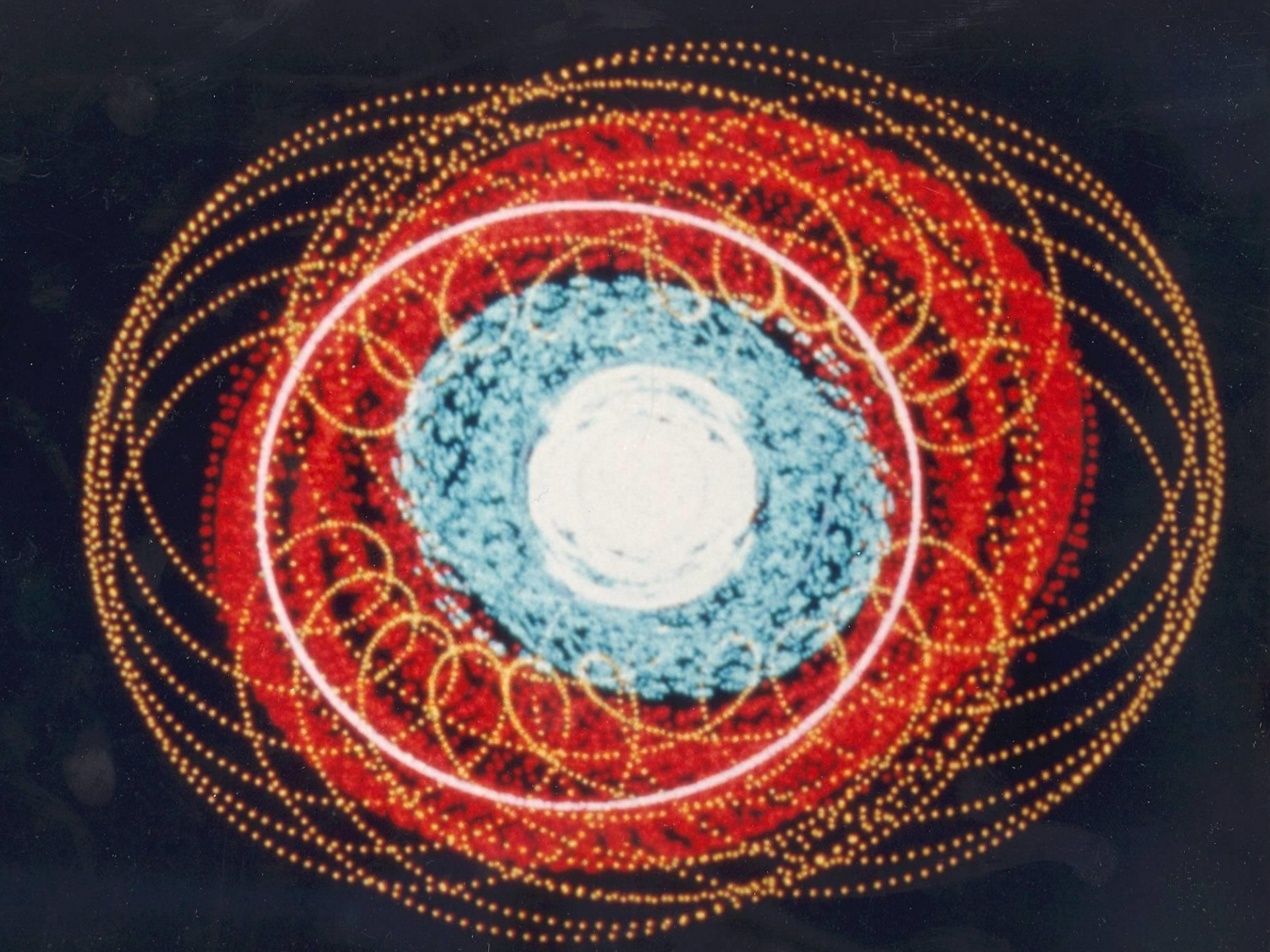
MANCHESTER 1824

Dual-satellite space VLBI

In the mid-1980s, the QUASAT team realised that it was impossible to combine superb uv-coverage with a substantial jump in angular resolution compared to ground-based VLBI.

So why not combine forces and simultaneously fly two satellites in complementary orbits, and achieve "perfect" uv coverage out to 60 000 km?

QUASAT + RadioAstron or
QUASAT + Japanese satellite



EVN 6cm receiver for Radioastron

Kardashev and Setti signing the agreement in 1986

EVN 6cm receiver for Radioastron

Kardashev and Setti signing the agreement in 1986

Although it was built in Dwingeloo and Bonn, tested at ESTEC, and delivered to Moscow, it did not fly on RADIOASTRON.

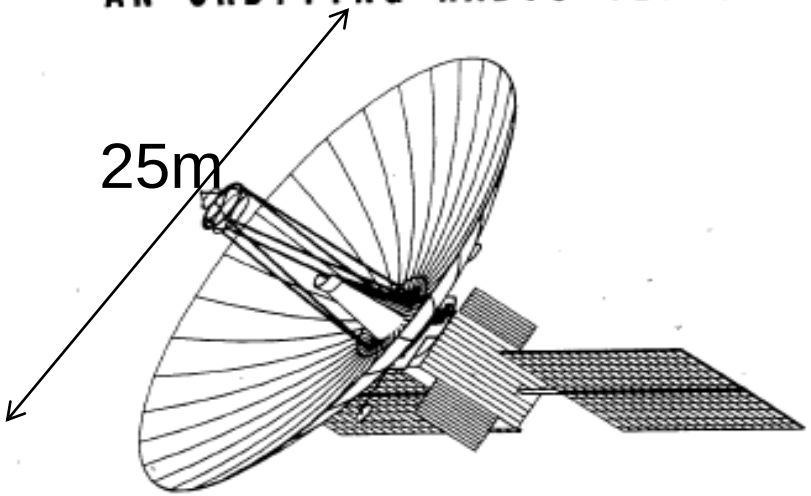
But that's another story…..

Last gasps from ESA and NASA

1989-1991

I V S

AN ORBITING RADIO TELESCOPE



REPORT ON THE ASSESSMENT STUDY

V. Altunin, B. Anderson, J.W.M. Baars, A. Baudry, R.S. Booth, B.E. Chertock, J. Cornelissen, Yu.S. Dekisov, L.I. Gurvits, K.S. Karbadnev, Yu.P. Kolyano, T. Kuiper, G. Pelbratt, R.A. Preston, R.T. Schilizzi, V.I. Slysh, G. Tofani, S. Volonte, P.N. Wilkinson, T.L. Wilson

January 1991

SCI(91)2

Last gasps from ESA and NASA

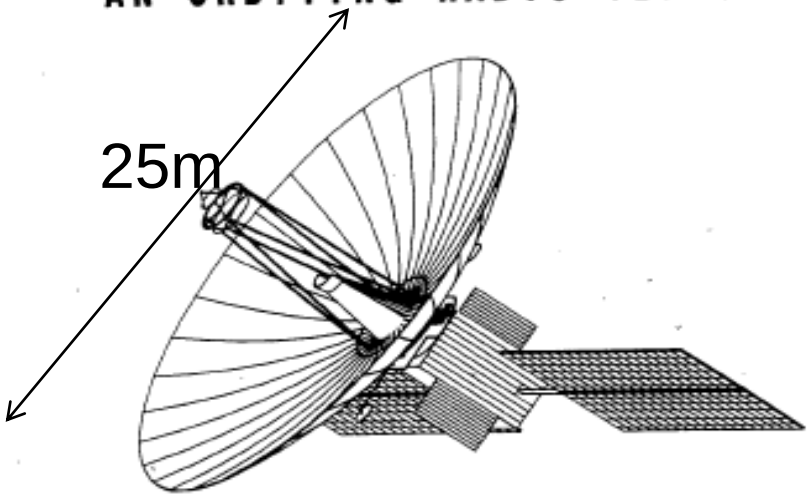
esa european space agency

ASC

1989-1991

I V S

AN ORBITING RADIO TELESCOPE

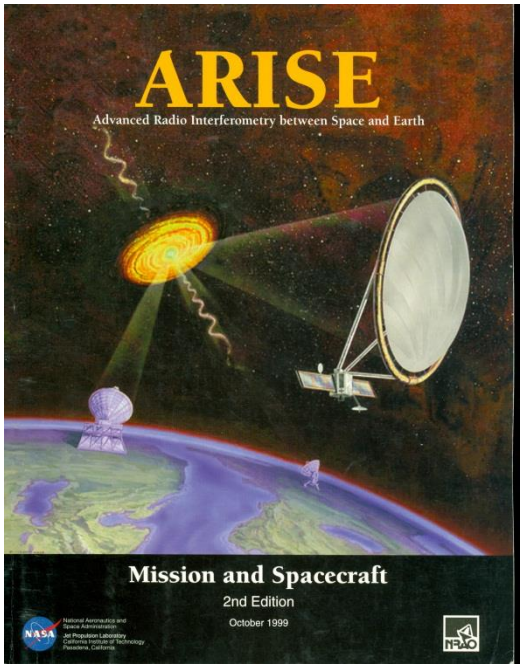


REPORT ON THE ASSESSMENT STUDY

V. Altunin, B. Anderson, J.W.M. Baars, A. Baudry, R.S. Booth, B.E. Chertock, J. Cornelissen, Yu.S. Dekisov, L.I. Gurvits, N.S. Kardashev, Ya.P. Koltanko, T. Kuiper, G. Pelbratt, R.A. Preston, R.T. Schilizzi, V.I. Slysh, G. Tofani, S. Volonte, P.N. Wilkinson, T.L. Wilson

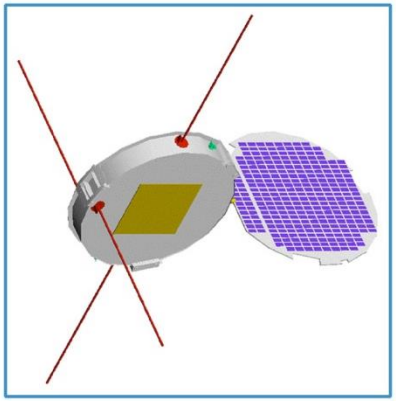
JANUARY 1991

SCI(91)2



ALFA (~2002)

Antenna :	100 km array of 16 spacecraft
Frequency Bands (MHz):	0.03 - 30 (tunable)
Resolution (arcseconds):	10,000 - 10
Sensitivity:	several Jy



IVS precursor

The nominal spec: 100 t - to LEO
18 t - GEO;
32 t - Lunar track;
28 t - Venus or Mars track.

Demonstrated in flight was only the first value (LEO). Quite a monster actually.