The EVN, JIVE and SKA through the decades – history, people and politics

Richard Schilizzi
University of Manchester

EVN Seminar, 24 October 2024

The EVN, JIVE and SKA through the decades – history, people and politics

Richard Schilizzi
University of Manchester

EVN Seminar, 24 October 2024

Caveats

The only thing we learn from history is that we learn nothing from history

Georg Wilhelm Fredrich Hegel (1770 -1831)

Caveats

The only thing we learn from history is that we learn nothing from history

Georg Wilhelm Fredrich Hegel (1770 -1831)

Human memory is a leaky storage device

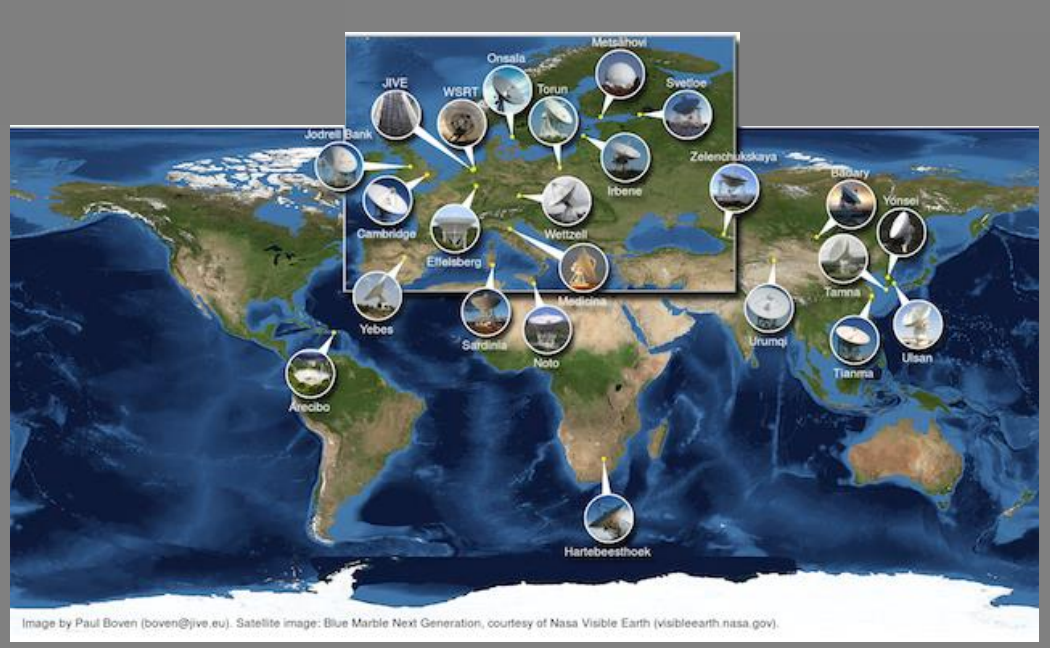
Big Science, Big Collaborations

EUROPEAN VLBI NETWORK

JIVE
Joint Institute for VLBI ERIC

SKA-mid SKA-Low

Big Science, Big Collaborations



EUROPEAN VLBI NETWORK

1975 first ideas
1980 EVN established

JIVE
Joint Institute for VLBI ERIC

1980 first ideas
1993 JIVE established
2014 JIV-ERIC

SKA-mid

SKA-Low

Big Science, Big Collaborations

EUROPEAN VLBI NETWORK

1975 first ideas
1980 EVN established

JIVE
Joint Institute for VLBI ERIC

1980 first ideas
1993 JIVE established
2014 JIV-ERIC

SKA-mid SKA-Low

1980s, 1990 first ideas
1993 URSI Large Telescope WG
1999 first Steering Committee
2011 SKAO established as UK company
2021 Inter-Governmental Organisation

Big Science, Big Collaborations

EUROPEAN VLBI NETWORK

JIVE
Joint Institute for VLBI ERIC

SKA-mid SKA-Low

Science driven, bottom-up projects that have successfully evolved into pillars of European and global radio astronomy

A brief history of Very Long Baseline Interferometry

1960s
- first VLBI observations, in Canada and USA
- first US-Europe (Sweden) observations

1970s
- first 2-station European observations
- first discussions of European VLBI
- US VLBI Network Users Group formed
- first 3-station European VLBI observations
- first real-time VLBI via a geostationary satellite

1980s
- European VLBI Network formed
- European VLBI Consortium formed

1990s
- Joint Institute for VLBI in Europe (JIVE) established
- US VLB Array began operations
- Japanese space VLBI telescope, VSOP-HALCA, launched
- European VLBI Data Processor at JIVE began operations

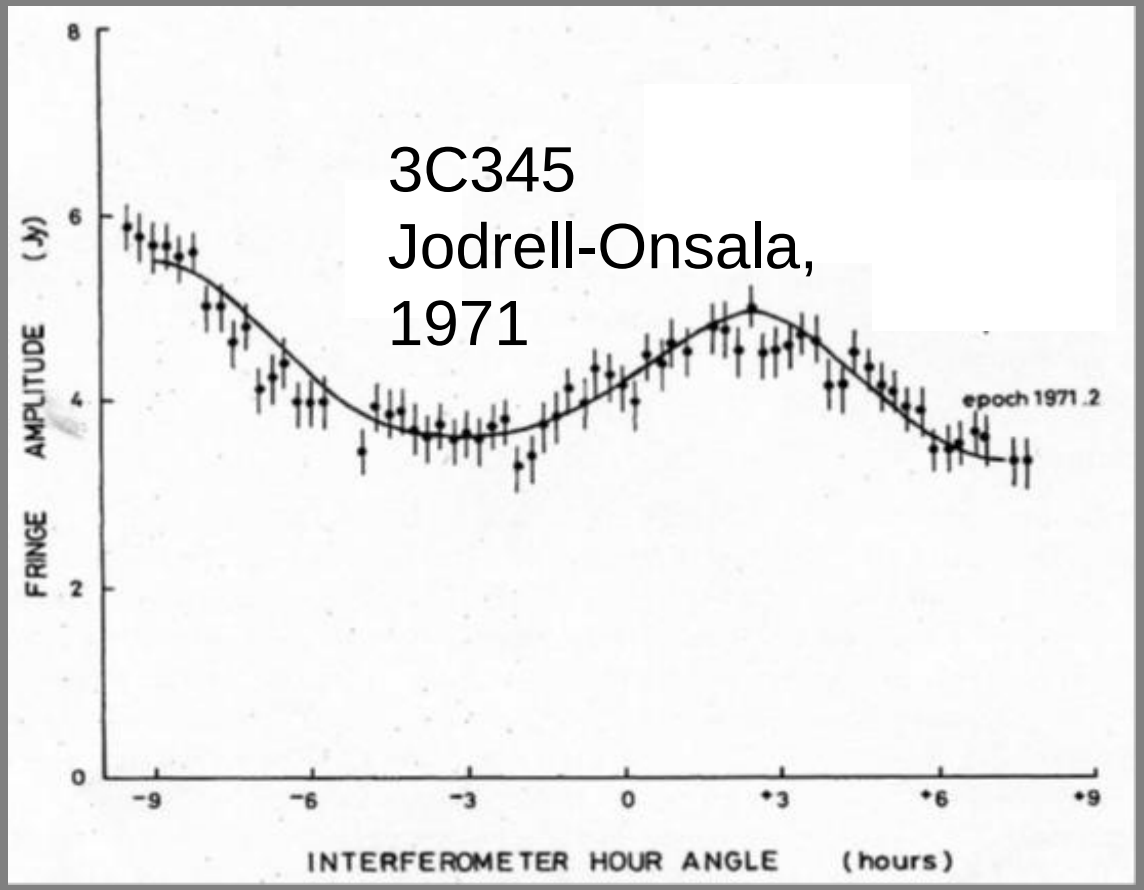
2000s
- first real-time VLBI via fibre, in the EVN

2010s
- Russian space VLBI telescope, RadioAstron, launched
- JIVE becomes a European legal entity (ERIC)

European VLBI in the 1970s

1971 First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson

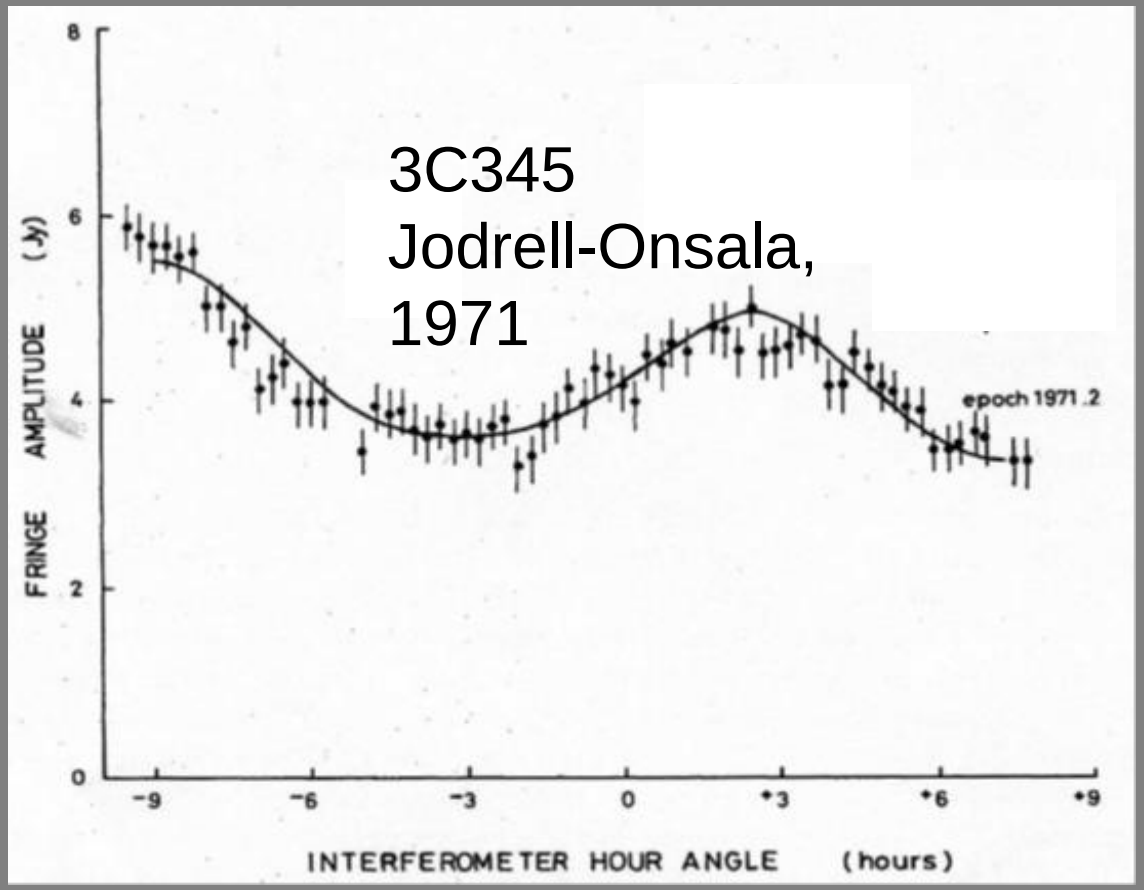
published in Fort, 1971, Ph.D. thesis and Stannard et al, 1980



European VLBI in the 1970s

1971 First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson

published in Fort, 1971, Ph.D. thesis and Stannard et al, 1980



European VLBI in the 1970s

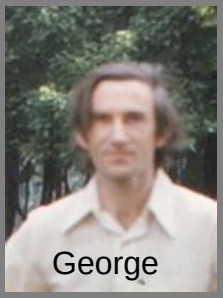
1971 First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson

1975 (April) Coffee table discussion at MPIfR - Roy Booth (JBO), Ivan Pauliny-Toth (MPIfR), Eugen Preuss (MPIfR), George Miley (Leiden)


Roy


Ivan


Eugen


George

(Sept) MPIfR- First meeting of interested astronomers from Germany, Italy, NL, Sweden, UK

European VLBI in the 1970s

1977 Sept Jodrell Bank- 4th informal meeting of interested astronomers and engineers from Germany, Italy, NL, Soviet Union, Sweden, UK, USA

European VLBI in the 1970s

1976 First 3-station European observations, Onsala-Dwingeloo-Effelsberg, Oct 1975, on 3C236

left to right:

Baudewijn Baud
RTS
George Miley

Astron. Astrophys. 77, 1–6 (1979)

ASTRONOMY AND ASTROPHYSICS

High Resolution Observations of the Compact Central Component in the Giant Radio Source 3 C 236

R. T. Schilizzi[1], G. K. Miley[2], A. van Ardenne[1], B. Baud[2,*], L. Bååth[3], B. O. Rönnäng[3], and I. I. K. Pauliny-Toth[4]

[1] Netherlands Foundation for Radio Astronomy, Radiosterrenwacht, Dwingeloo, The Netherlands
[2] Sterrewacht, Huygens Laboratorium, Leiden, The Netherlands
[3] Onsala Space Observatory, Onsala, Sweden
[4] Max Planck Institut für Radioastronomie, Auf dem Hügel 69, D-5300 Bonn 1, Federal Republic of Germany

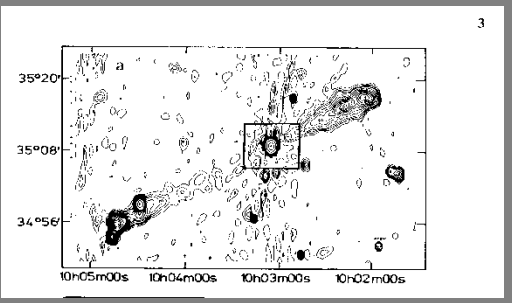
Received October 16, 1978

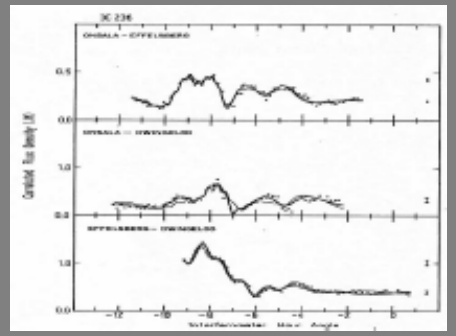
ODE EXPERIMENT

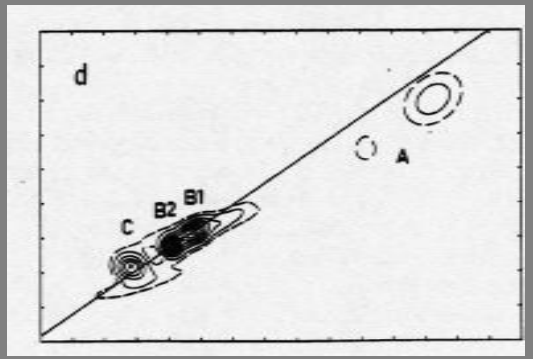
OCTOBER 1, 2

[A] CONTINUUM. F = 1610. MHz. BW = 2. MHz. STATION B = EFFELSBERG, C =

SOURCE	SCAN #	START B	START C	START A	STOP	TAPES B	TAPES C	TAPES A	SCAN TIMES B-C	SCAN TIMES A-C	SCAN TIMES A-B
3C273	275-1530	15 02 32	14 59 55	15 00 00	15 30	MPI-151	MPI-76	050-1	27½	30	27½
3C315	-1600	15 36 45	15 35 55	15 33 10	16 00	"	"	"	23½	24	23½
4C39.25	276-0230	02 02 00	02 00 00	02 01 00	02 30	MPI-041	MPI-018	050-7	28	29	28
A00235	-0300	02 35 00	02 38 06	02 35 18	03 00	"	"	"	22	22	25
3C22	-0330	03 04 30	03 08 40	03 03 07	03 30	"	"	"	25½	25½	25½
3C84	-0400	03 35 00	03 35 15	03 33 15	04 00	"	"	"	25	25	25
3C263	-0430	04 07 06	04 08 05	04 06 20	04 30	MPI-042	MPI-019	050-8	22	22	23
4C39.25	-0500	04 40 15	04 34 33	04 32 15	05 00	"	"	"	20	25½	20
3C236	-0600	05 02 30	05 04 11	05 01 14	06 00	"	"	"	56	56	57½
"	-0700	06 06 10	06 07 46	06 05 42	07 00	MPI-043	MPI-025	050-9	52½	52½	54
"	-0800	07 02 10	07 02 33	07 00 27	08 00	"	"	"	57½	57½	58
"	-0900	08 05 00	08 08 25	08 05 18	09 00	MPI-053	MPI-012	050-10	51½	51½	55
"	-1000	09 00 00	09 03 39	09 00 25	10 00	"	"	"	57½	57½	59½
"	-1100	10 06 30	10 09 29	10 05 00	11 00	MPI-055	MPI-013	050-11	50½	50½	53½
"	-1200	11 00 00	11 03 44	11 00 48	12 00	"	"	"	56½	56½	59½
"	-1300	12 05 30	12 07 00	12 06 07	13 00	MPI-056	MPI-014	050-12	53	53	54







European VLBI in the 1970s

1971	First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson
1975	April Coffee table discussion at MPIfR - Roy Booth (JBO), Ivan Pauliny-Toth (MPIfR), Eugen Preuss (MPIfR), George Miley (Leiden)
	Sept MPIfR- First meeting of interested astronomers from Germany, Italy, NL, Sweden , UK
1976	First 3-station European observations, Onsala-Dwingeloo-Effelsberg (ODE), on 3C236
1978	ESA Feasibility Study of satellite-linked VLBI using L-SAT

European VLBI in the 1970s

1971	First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson
1975	April Coffee table discussion at MPIfR - Roy Booth (JBO), Ivan Pauliny-Toth (MPIfR), Eugen Preuss (MPIfR), George Miley (Leiden)
	Sept MPIfR- First meeting of interested astronomers from Germany, Italy, NL, Sweden , UK
1976	First 3-station European observations, Onsala-Dwingeloo-Effelsberg (ODE), on 3C236
1978	ESA Feasibility Study of satellite-linked VLBI using L-SAT

Satellite-linked VLBI

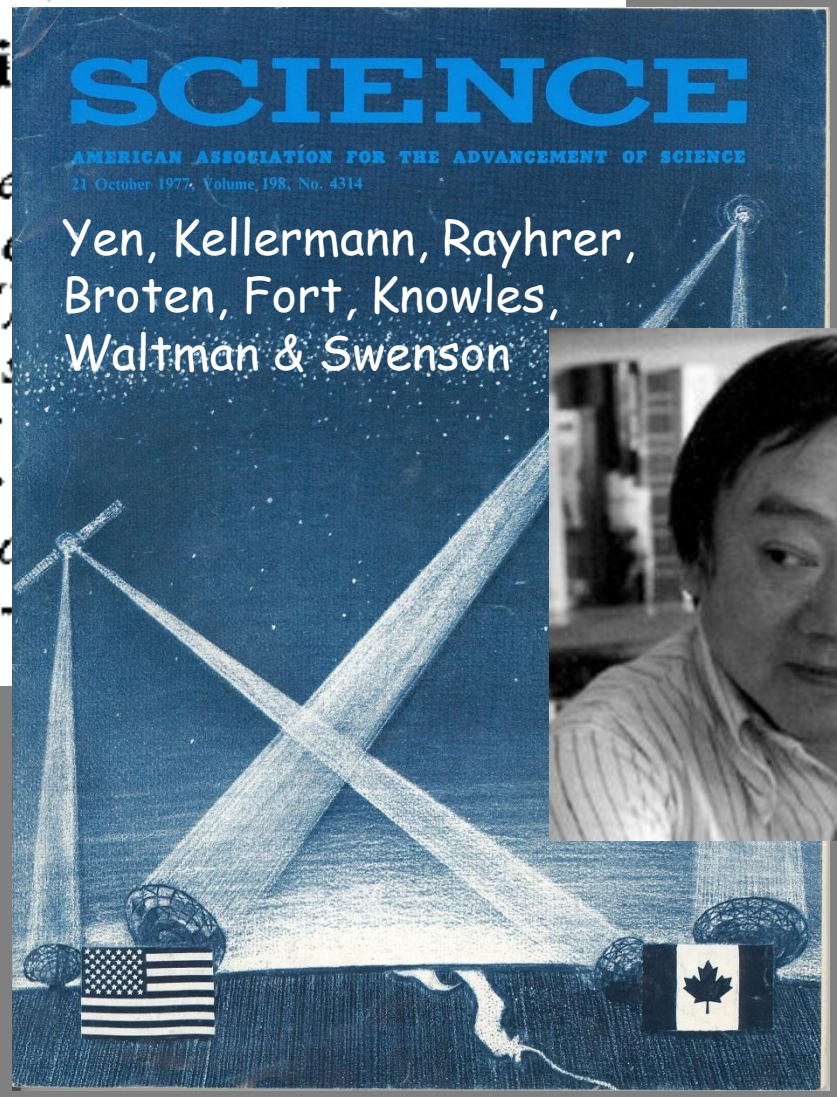
Real-Time, Very-Long-Baseline Interferometry Based on the Use of a Communications Satellite

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.*

Satellite-linked VLBI

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

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



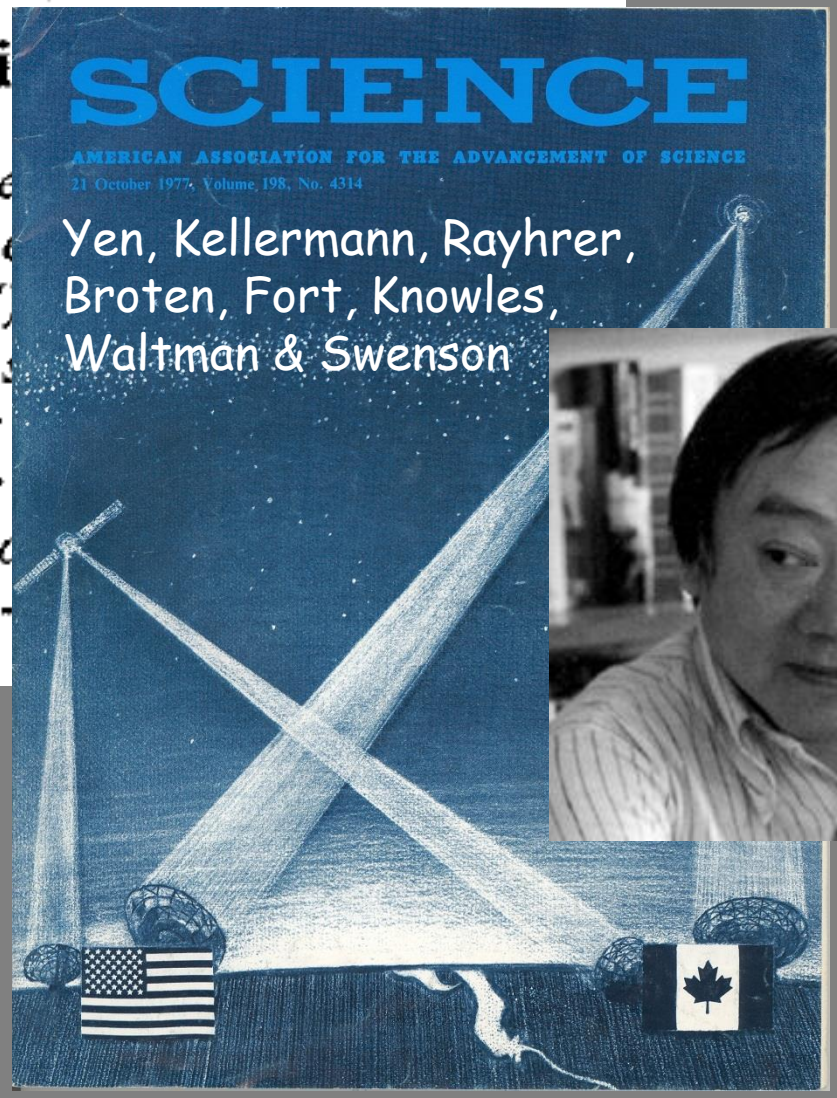
Yen, Kellermann, Rayhrer, Broten, Fort, Knowles, Waltman & Swenson

Satellite-linked VLBI

Real-Time, Very-Long-Baseline Interferometry

Based on the Use of a Communications Satelli

Abstract. *The Hermes satellite, a joint Canadian-Ame*
used to provide a communication channel between radio t
and Ontario, for very-long-baseline interferometry (VLBI)
sible instantaneous correlation of the data as well as a sen
than that of earlier VLBI systems, by virtue of a broader
With the use of a geostationary communications satellite
the tape recorders and the most troublesome part of the pr
cessing. A further possibility is the development of a phase-



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

European VLBI in the 1970s

1971 First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson

1975 April Coffee table discussion at MPIfR - Roy Booth (JBO), Ivan Pauliny-Toth (MPIfR), Eugen Preuss (MPIfR), George Miley (Leiden)

Sept MPIfR- First meeting of interested astronomers from Germany, Italy, N

1976 First 3-station European observations, Onsala-Dwingeloo-Effelsberg (ODE)

1978 ESA Feasibility Study of satellite-linked VLBI using L-SAT initiated

1978 MPIfR 3-station Mk2 correlator began operation (2 MHz)

1979 MPIfR decision to purchase 3-station Mk3 correlator from Haystack (56MHz)

European VLBI in the 1970s

1971 First intra-European observations (Jodrell-Onsala) – Dave Fort, Bryan Anderson

1975 April Coffee table discussion at MPIfR - Roy Booth (JBO), Ivan Pauliny-Toth (MPIfR), Eugen Preuss (MPIfR), George Miley (Leiden)

Sept MPIfR- First meeting of interested astronomers from Germany, Italy, N

1976 First 3-station European observations, Onsala-Dwingeloo-Effelsberg (ODE)

1978 ESA Feasibility Study of satellite-linked VLBI using L-SAT initiated

1978 MPIfR 3-station Mk2 correlator began operation (2 MHz)

1979 MPIfR decision to purchase 3-station Mk3 correlator from Haystack (56MHz)

European VLBI in the 1980s

1980 EVN established (annual meetings of Directors) and
EVN Program Committee established (Ivan Pauliny-Toth, 1st chair)

1980-2 discussed new generation wide-band *real-time* correlator for Satellite-linked VLBI
L-SAT use too expensive for EVN → demise of satellite-linked VLBI

1983 proposal by Setti et al to EC for expansion of MPIfR Mk3 correlator.
Not successful


EVN Directors meeting
Noto, 1988


15th EVNPC meeting
Onsala,1984

European VLBI in the 1980s

1980 EVN established (annual meetings of Directors) and
EVN Program Committee established (Ivan Pauliny-Toth, 1st chair)

1980-2 discussed new generation wide-band *real-time* correlator for Satellite-linked VLBI
L-SAT use too expensive for EVN → demise of satellite-linked VLBI

1983 proposal by Setti et al to EC for expansion of MPIfR Mk3 correlator.
Not successful

1983-5 discussed alternative proposals for large data processors
- upgrade 3-station Mk3 processor at MPIfR to 8 stations (€5 M)
- develop new generation (12 station) user-friendly data processor at NFRA in Dwingeloo (€7.5 M)

1984 European Consortium for VLBI established (5 members, 4 associates).
- Consortium agrees to seek funding for new generation processor in Dwingeloo.
- MPIfR Directors decided to upgrade their 3-station correlator to 5-stations


EVN Directors meeting
Noto, 1988


15th EVNPC meeting
Onsala,1984

First formal meeting of the European Consortium in Bonn, in February 1985

1980

1980-2

1983

1983-5

First formal meeting of the European Consortium in Bonn, in February 1985

1980

1980-2

1983

1983-5

1988 Consortium proposal to EC for 1st phase of a 20-station correlator (17.8 M€). Also unsuccessful, but…

First formal meeting of the European Consortium in Bonn, in February 1985

1980

1980-2

1983

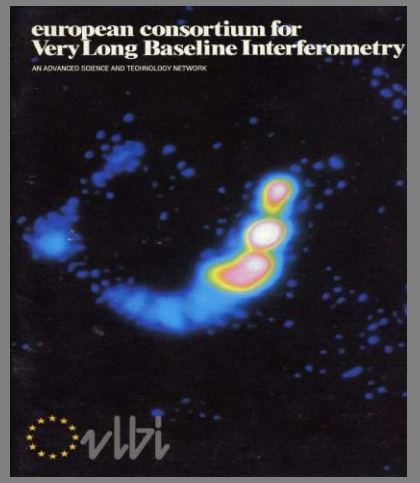
1983-5

1988 Consortium proposal to EC for 1st phase of a 20-station correlator (17.8 M€). Also unsuccessful, but…

Behind the scenes…

1983-6 Discussions with President of the European Science Foundation and EC D-G Research

Consortium proposal to EC in Brussels (12 stations). Circulated to European Science Ministries.



1987-9 EC Framework Programme (FP1) approved

Consortium Board discusses “science” program and future strategy with D-G Research

NL Science Minister (Deetman) discusses VLBI with his French counterpart (Curien).

Initiated ESF report on VLBI priority within ground-based astronomy

1990-1 ESF Review Panel gave strong support to processor

NL Ministry led pressure on Brussels for EC funding of pure research facilities like VLBI in FP3

Funding at last!

1992 1 M€ from EC (Access to Large Scale Facilities, for the EVN)

- 5.5 M€ from Ministry of Education and Science in NL
- 0.3 M€ from CNRS in France
- 0.55 M€ from the Swedish Wallenberg Foundation

1993 Joint Institute for VLBI in Europe (JIVE) formally established as a Foundation in the Netherlands. Roy Booth 1st chair of the Board

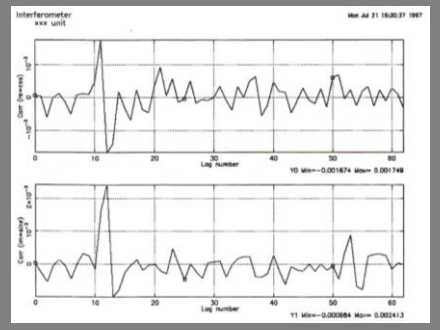
1993-8 Design, prototyping, and construction of 16 station MkIV processor by international consortium (8.7 M€ including manpower). Part of the EVN upgrade.

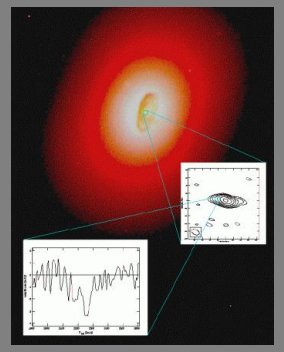
Official opening of EVN Data Processor at JIVE

October 1998

Official opening of EVN Data Processor at JIVE

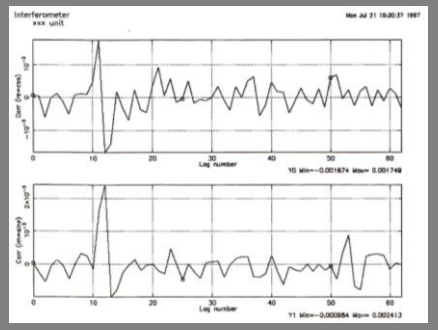
October 1998

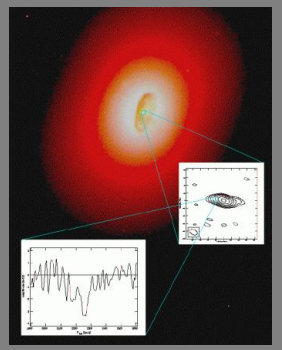


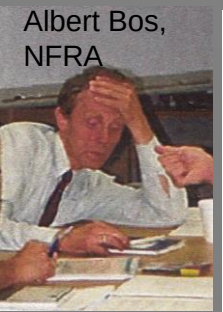


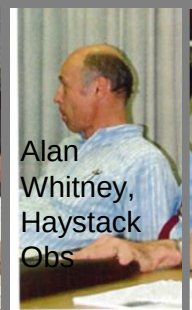
Official opening of EVN Data Processor at JIVE

October 1998






Albert Bos, NFRA

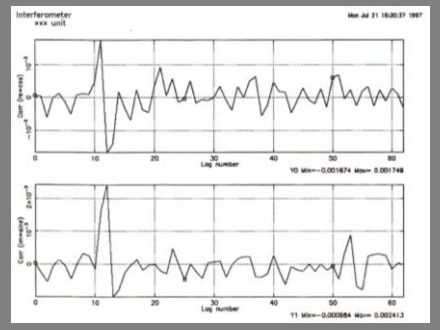

Alan Whitney, Haystack Obs

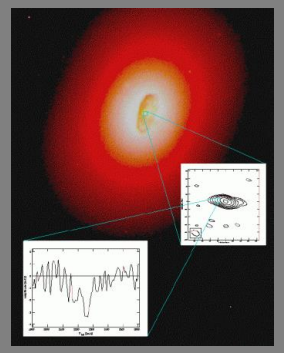

Sergei Pogrebenko, JIVE

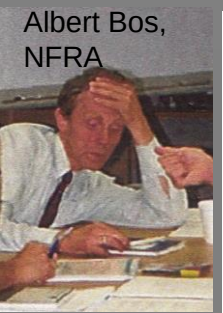

Bryan Anderson, Jodrell

Official opening of EVN Data Processor at JIVE

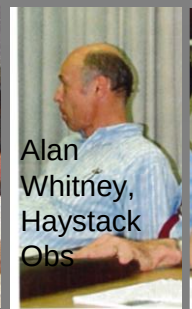
October 1998





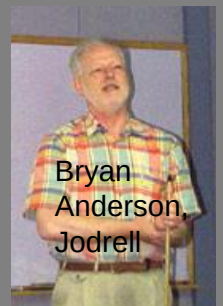


Albert Bos, NFRA



Alan Whitney, Haystack Obs

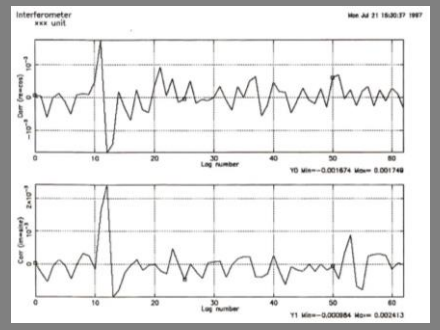
Sergei Pogrebenko, JIVE

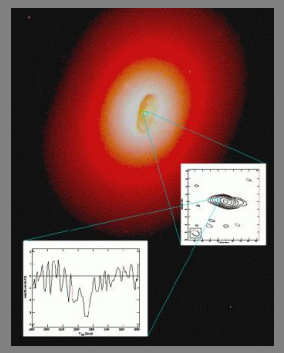


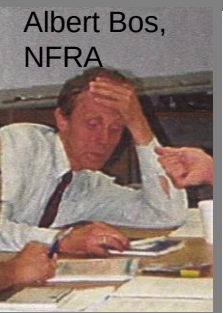
Bryan Anderson, Jodrell

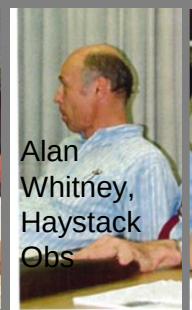
Official opening of EVN Data Processor at JIVE

October 1998






Albert Bos, NFRA


Alan Whitney, Haystack Obs


Sergei Pogrebenko, JIVE


Bryan Anderson, Jodrell

JIVE and the EVN, post-1998

- Radio astronomy and the EC
- e-EVN
- JIV-ERIC


1993-2002


2003-2006


2007-2017


2018-2022


2023 →

JIVE Directors

Radio astronomy funding via the EC 1989-2020

FP2-FP4 - Science stimulation, access to large scale facilities, research & technical development, cooperation with Hungary and Poland, 1989-1999 (8.2 M€)

RadioNet – Trans-National Access, Joint Research Activities, and Networking Activities a strong cohering force in European radio astronomy, 2000-2020 (42 M€)

EXPReS, NEXPReS - e-EVN development, 2005-2014 (7.4 M€)

Other programs (including SKA Design Study SKADS, 2004-9) ≥ 24 M€

TOTAL ≥ 81 M€

RadioNet

RadioNet

EXPReS

RadioNet

NEXPReS
Novel EXplorations Pushing Robust e-VLBI Services

RadioNet

RadioNet

JUMPING JIVE

RADIO BLOCKS

OPTICON RadioNet Pilot

Aeneas

Astéricis
Astronomy ESFRI & Research Infrastructure Cluster

ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

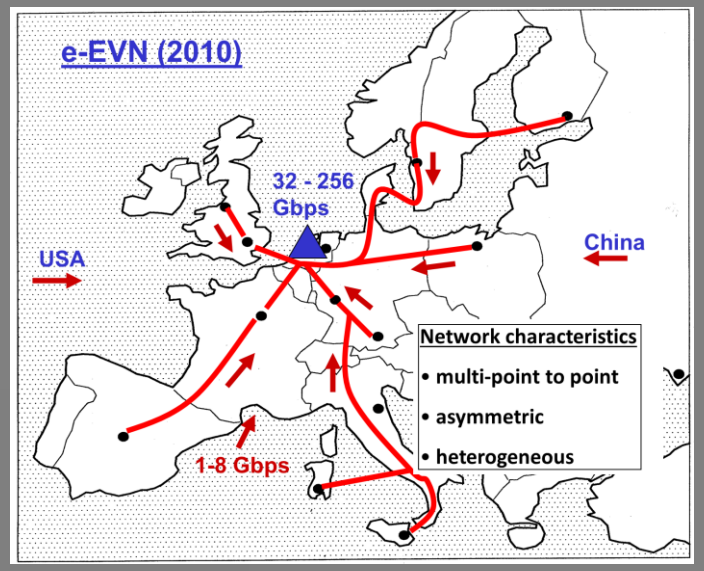
RadioNet Coordinators 2000→

FP5-1 **FP6** **FP7-2** **FP5-2**
H2020 **FP7-1**
ORP

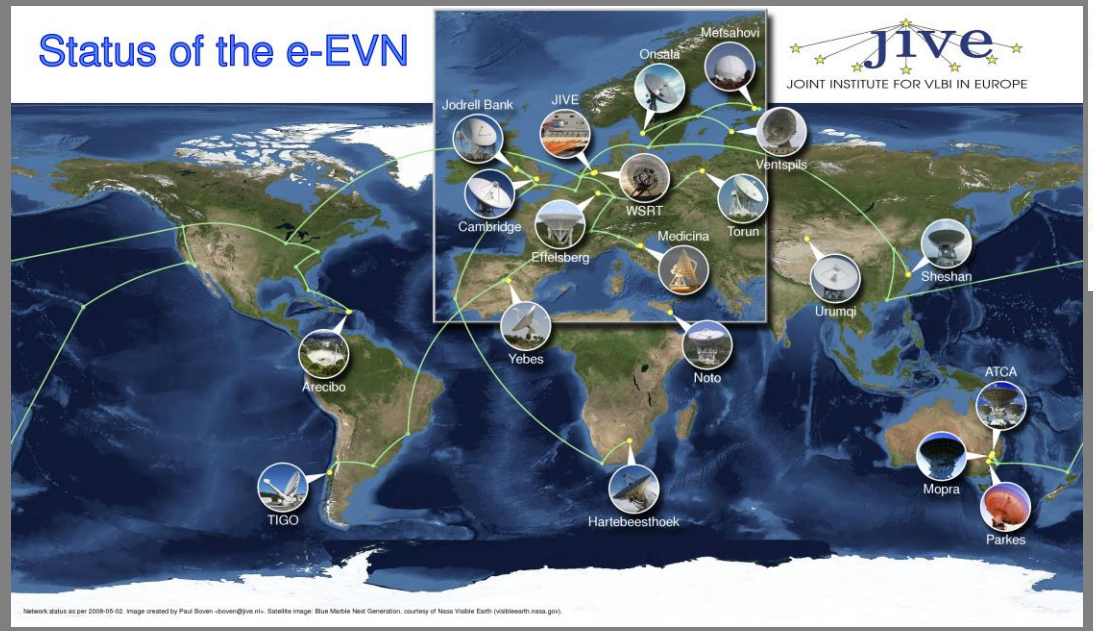
e-EVN

2000-2002	Concept presentations to NRENs, EC, European Science Foundation, CERN,…
2002	Test of concept
2005	EXPReS, e-EVN operational, Coordinator: Mike Garrett
2009	NEXPReS, Coordinator: Huib van Langevelde

Concept (2001)



operational



NEXPReS
Novel EXplorations Pushing Robust e-VLBI Services

In parallel, space VLBI 1982-1991

Orbiting VLBI telescope

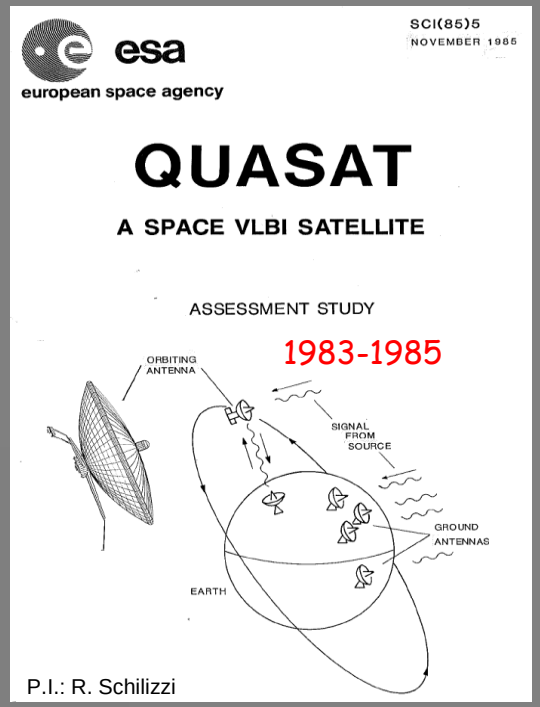
1982 QUASAT, ESA-NASA VLBI mission initiated at a VLBI meeting in Toulouse, France

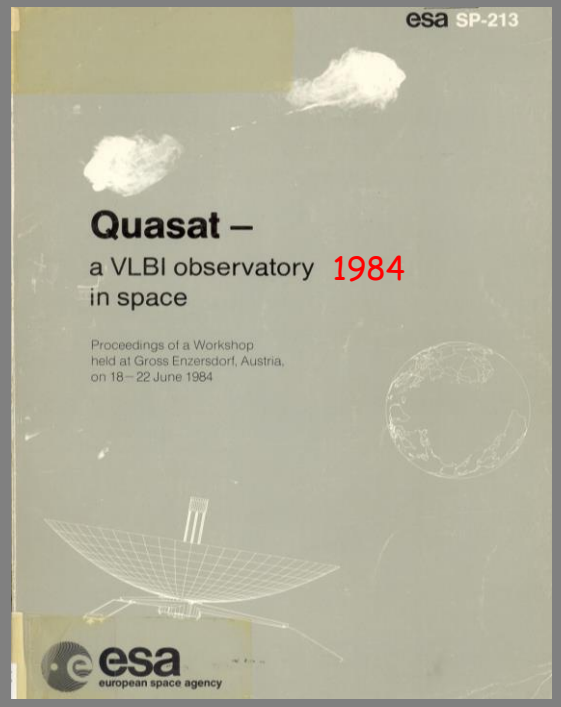
1983-5 Assessment Study

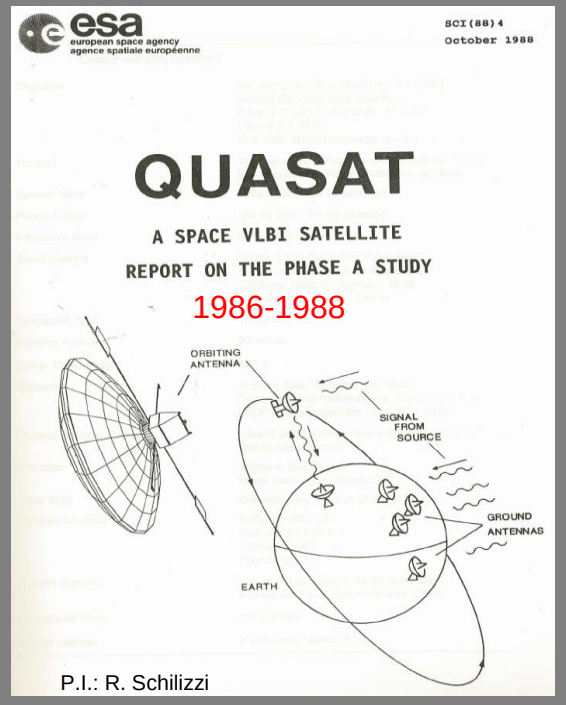
1984 ESA conference at Gross Enzersdorf, Austria

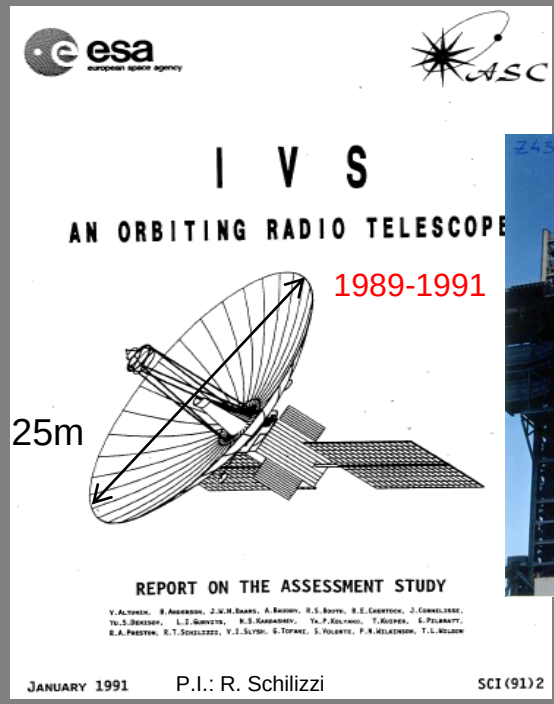
1986-8 Phase A Study

1989 International VLBI Satellite, ESA-Astro Space Center Russia









In parallel, space VLBI 1982-1991

Orbiting VLBI telescope

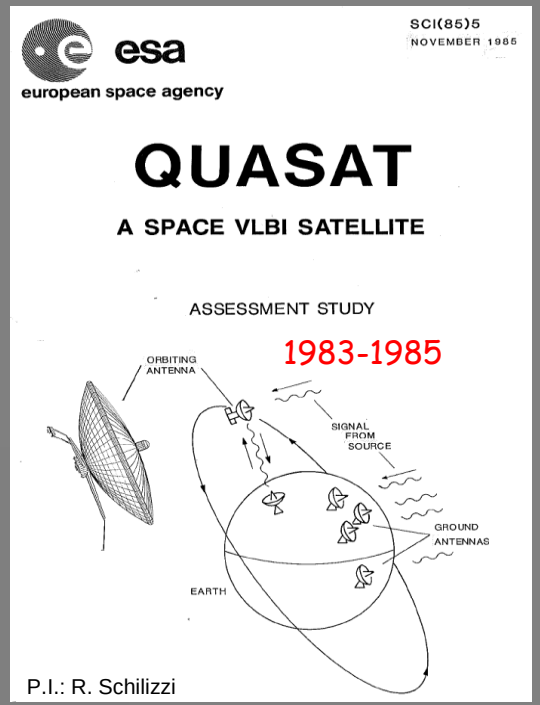
1982 QUASAT, ESA-NASA VLBI mission initiated at a VLBI meeting in Toulouse, France

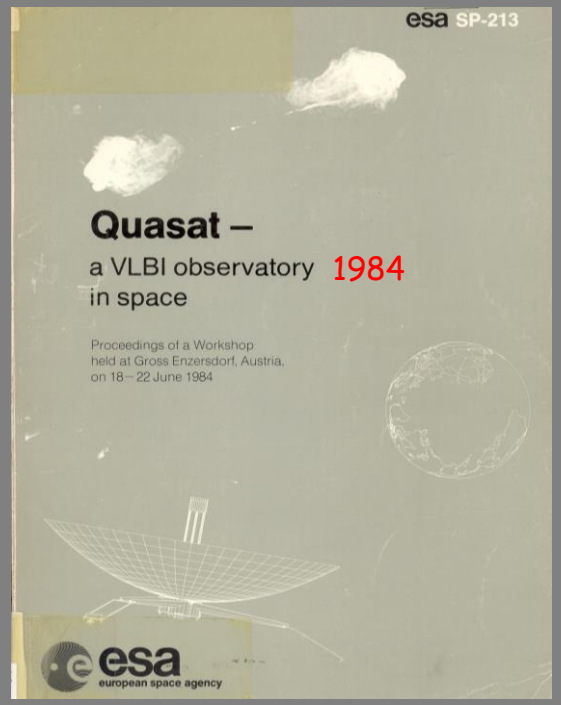
1983-5 Assessment Study

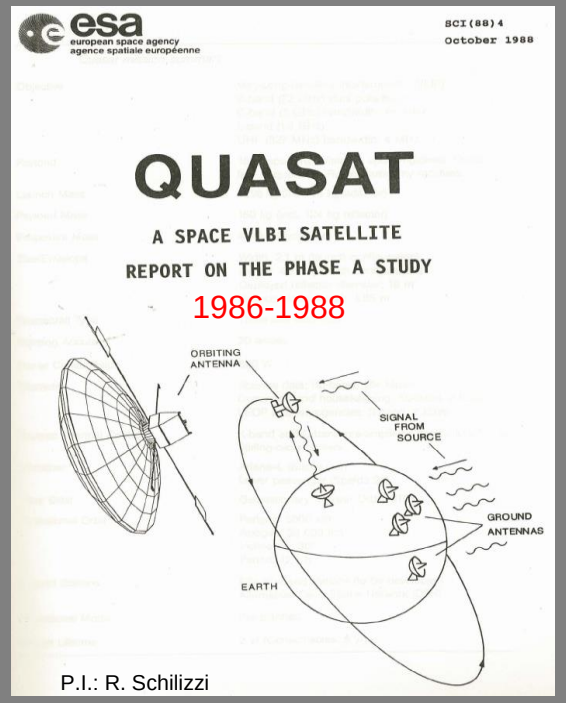
1984 ESA conference at Gross Enzersdorf, Austria

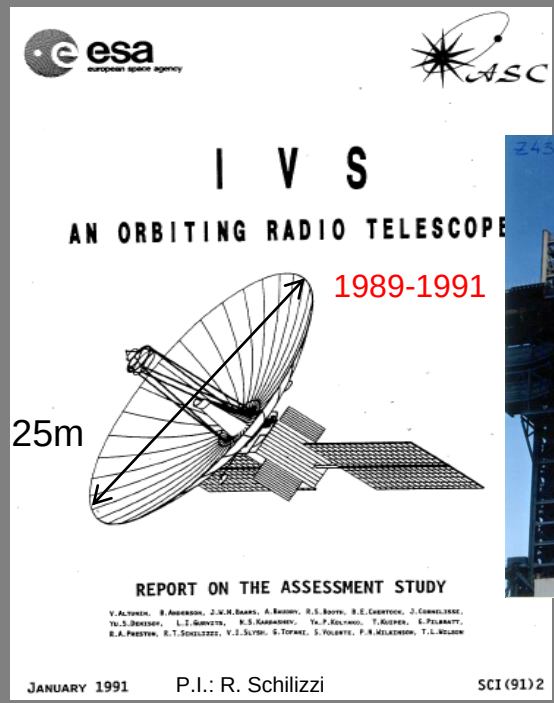
1986-8 Phase A Study Too expensive, not selected

1989 International VLBI Satellite, ESA-Astro Space Center Russia









In parallel, space VLBI 1982-1991

Orbiting VLBI telescope

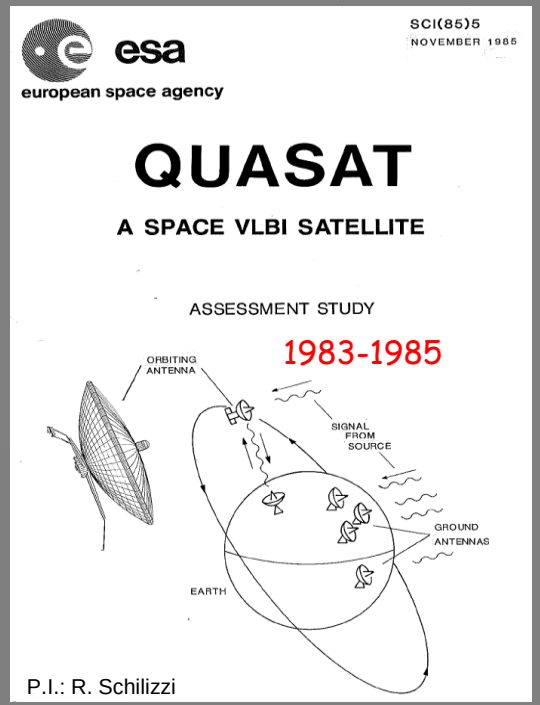
1982 QUASAT, ESA-NASA VLBI mission initiated at a VLBI meeting in Toulouse, France

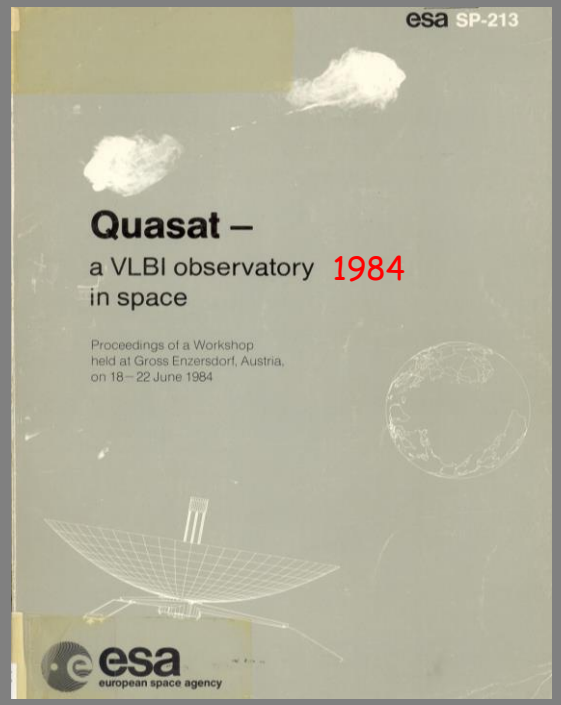
1983-5 Assessment Study

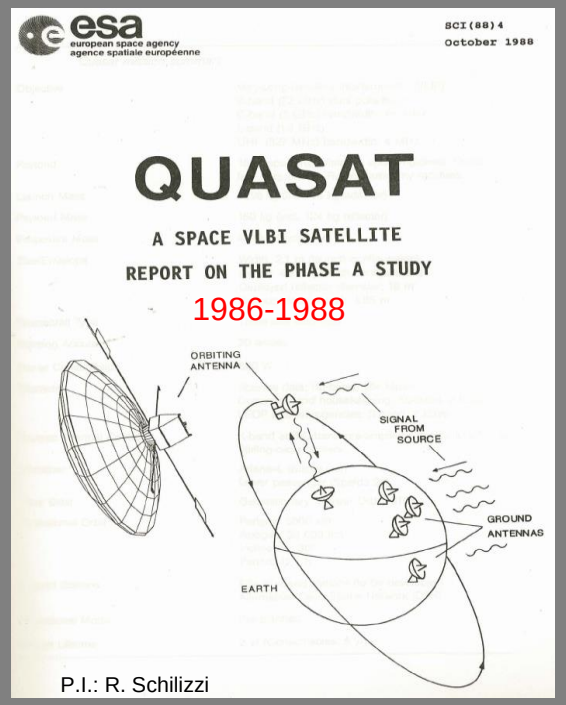
1984 ESA conference at Gross Enzersdorf, Austria

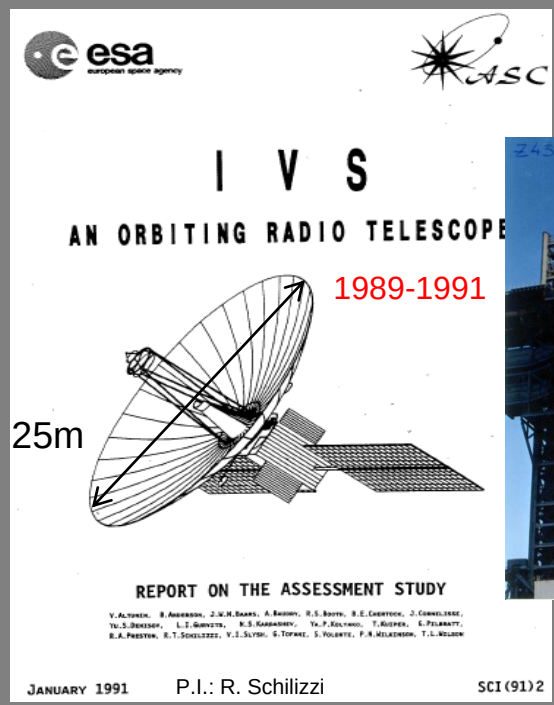
1986-8 Phase A Study Too expensive, not selected

1989 International VLBI Satellite, ESA-Astro Space Center Russia Not selected, Russian funding too risky



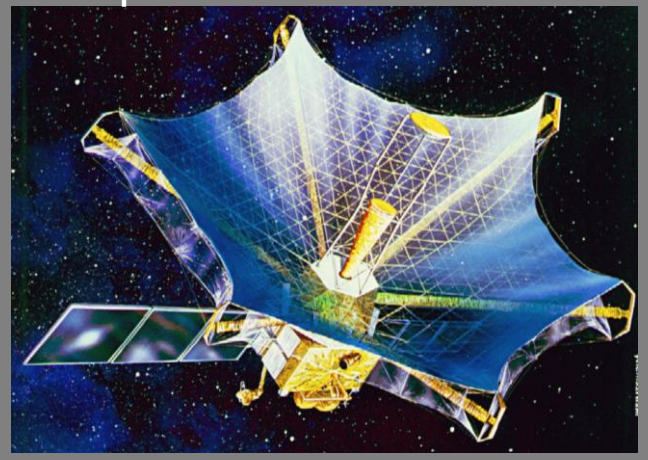






VSOP and RadioAstron carried on

VSOP-HALCA
Operational 1997-2005




Hisashi Hirabayashi

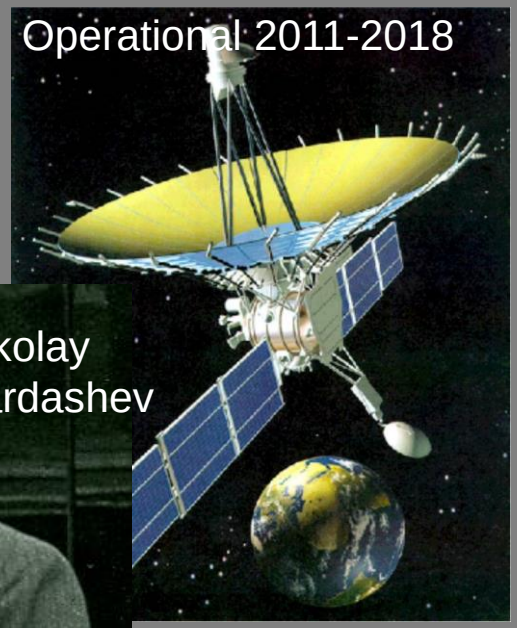

Masaki Morimoto


Minoru Oda


Global VLBI Working Group
Onsala, May1993
Roy Booth, chair

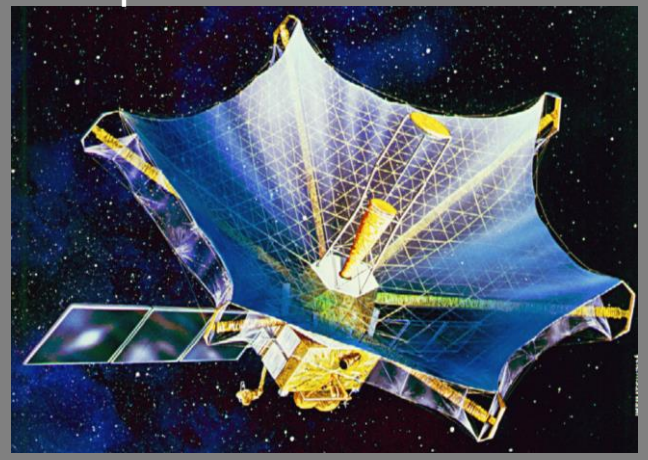

Nikolay Kardashev

RadioAstron
Operational 2011-2018



VSOP and RadioAstron carried on

VSOP-HALCA
Operational 1997-2005



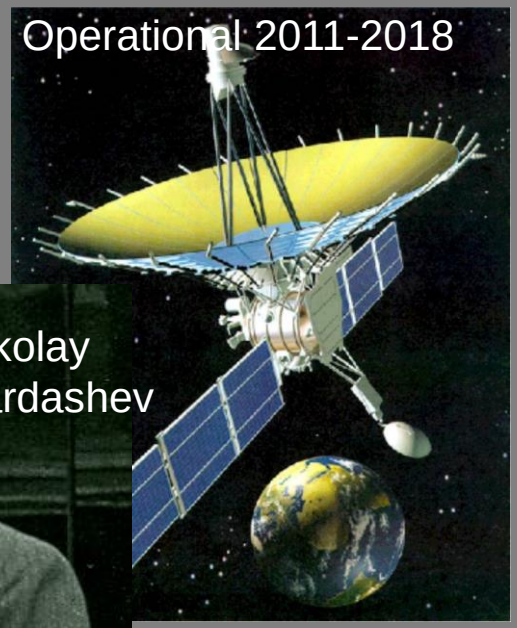

Hisashi Hirabayashi


Masaki Morimoto


Minoru Oda


Global VLBI Working Group
Onsala, May1993
Roy Booth, chair

RadioAstron
Operational 2011-2018




Nikolay Kardashev

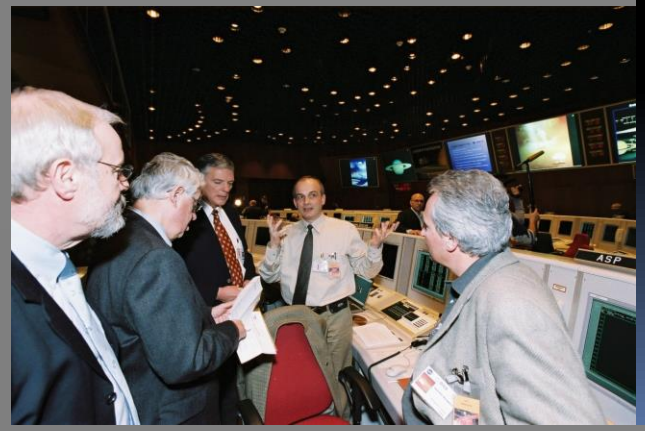
1986-1994
EVN 6 cm receiver
built in Dwingeloo and Bonn, tested at ESTEC, and delivered to Moscow. It did not fly on RADIOASTRON

Cassini-Huygens and VLBI, 2005

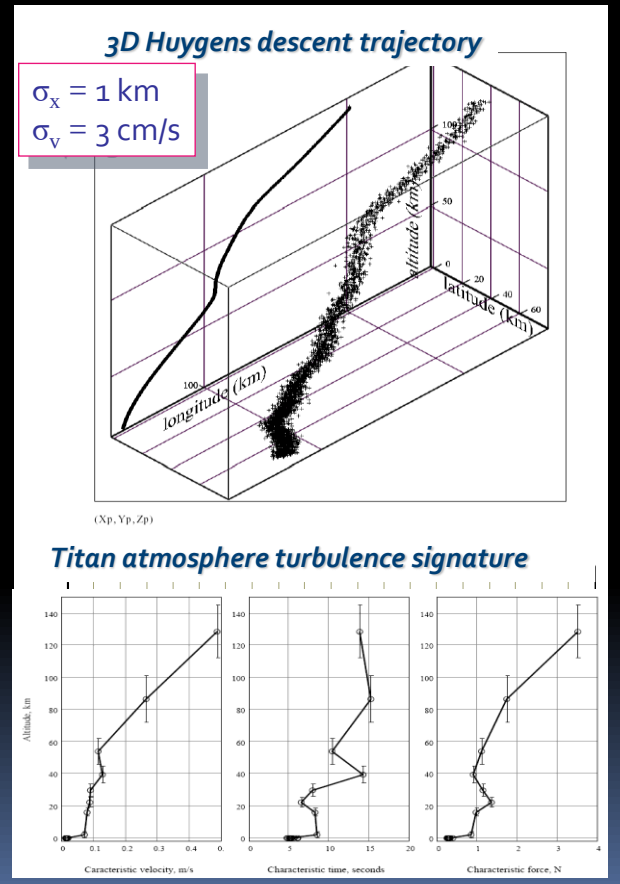
Huygens VLBI heritage: 20 photons/dish/s

- Ad hoc use of the Huygens “uplink” carrier signal at 2040 MHz
- Utilised 17 Earth-based radio telescopes
- Achieved 1 km accuracy of Probe’s descent trajectory determination
- Assisted in achieving one of main science goals – vertical wind profile

Titan, 14 January 2005



P.I.: Leonid Gurvits

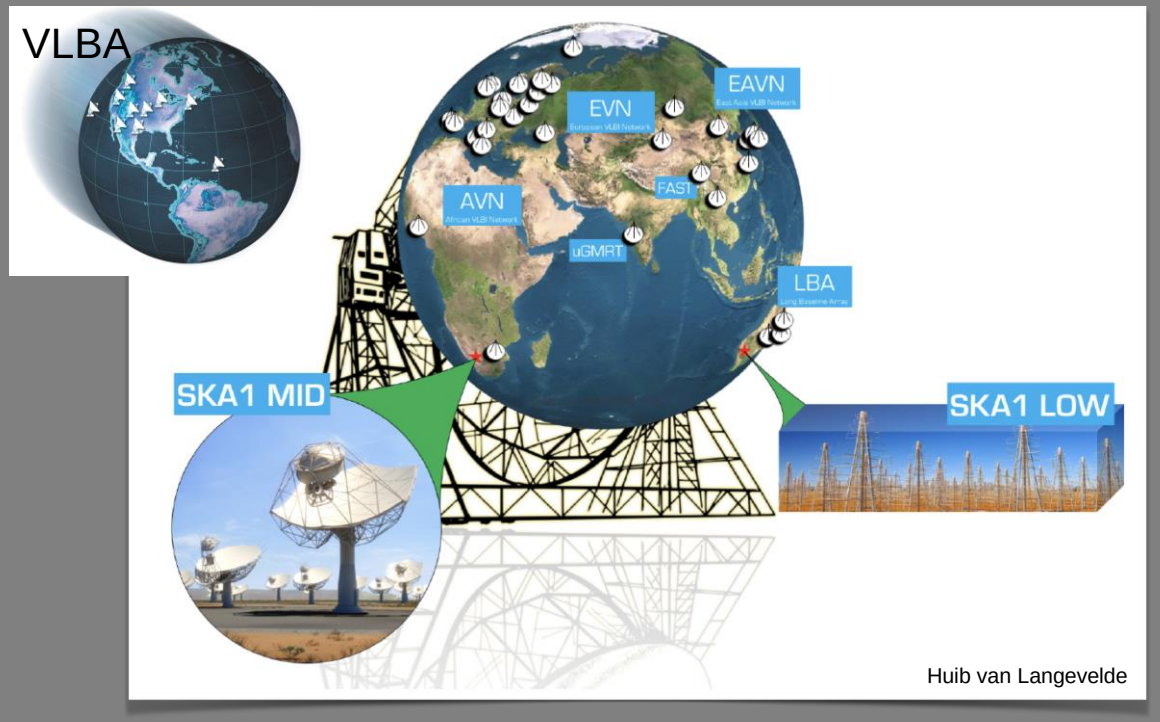


JIVE → European Research Infrastructure Consortium

- JIVE was inaugurated as an ERIC on 21 April 2015

Signing the end of JIVE Foundation. 2016

VLBI → SKA



EVN

12 countries

20+ telescopes

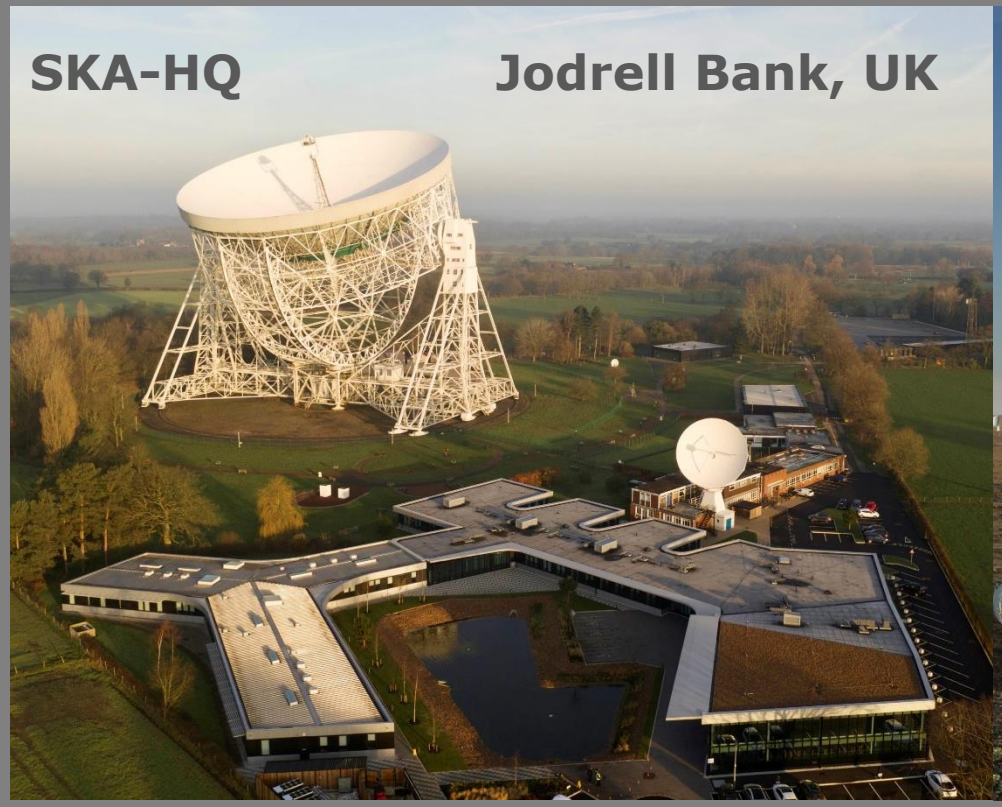
Global VLBI

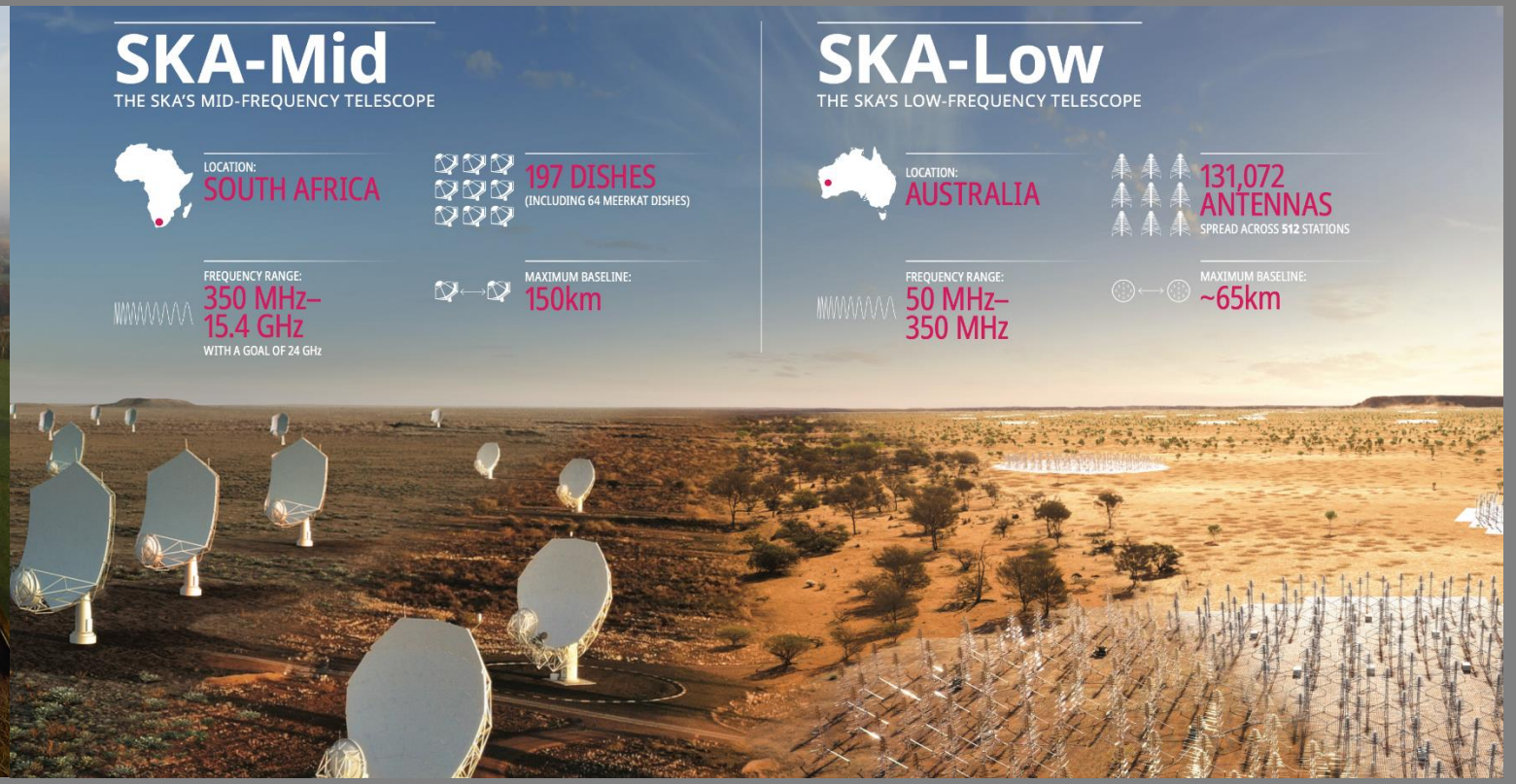
17 countries

40+ telescopes

- culture of successful international collaboration
- set the scene for SKA development in the 1990s
- many of the people who grew up in that culture played, and still play, leading roles in the SKA.

What is being built?
One Observatory, Two Telescopes, Three Sites – a grand vision





- Construction cost: ~€1.3 B (2021)
- early science in 2026/27; operational in 2029/2030;
- 50+ year lifetime; ~700 PB/yr science data
- A huge engineering and scientific effort involving 100s of people

SKA MID (South Africa) Construction Update

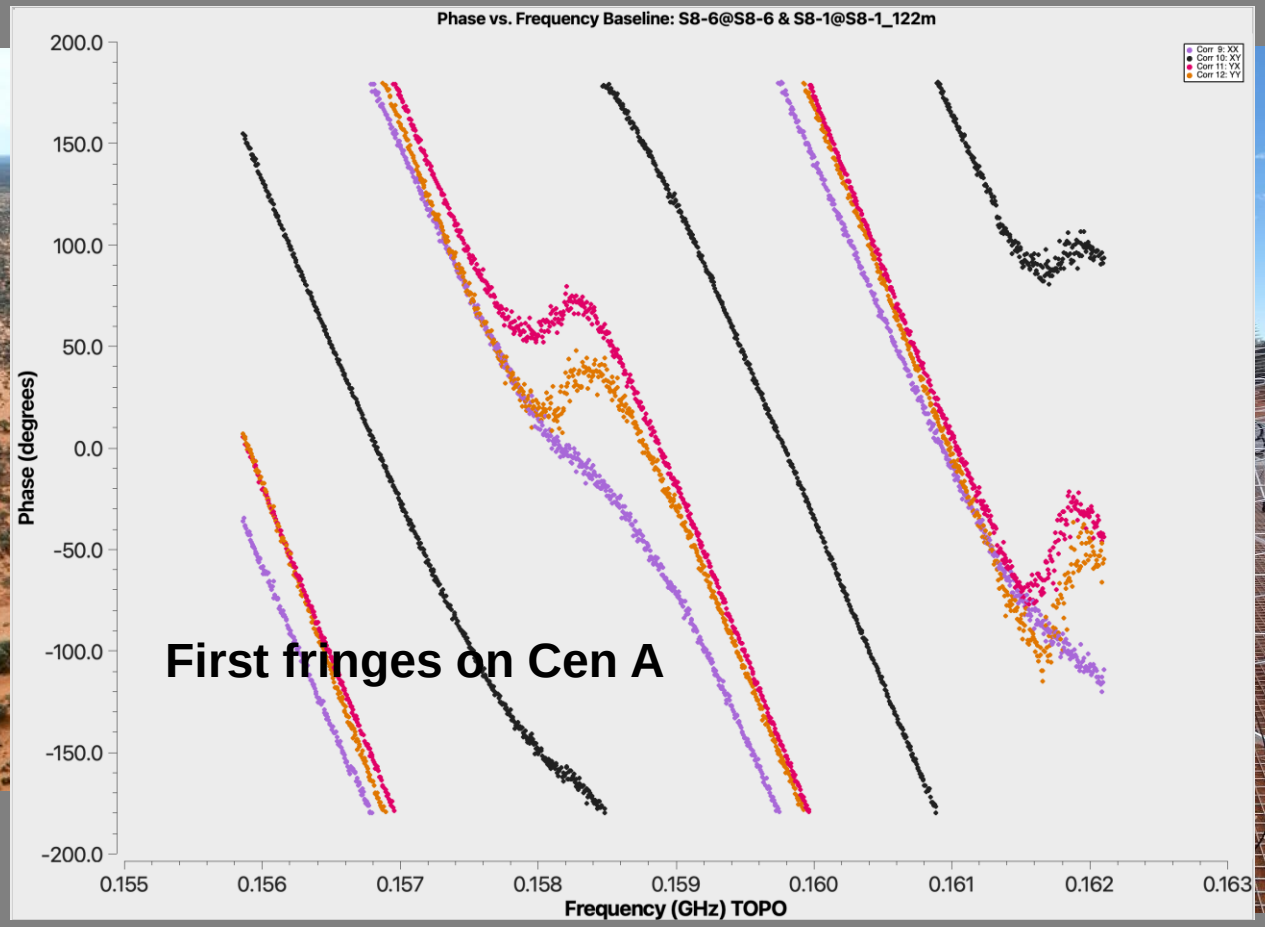
Dishes #1, #2 & #3 on site, Dish #1 near completion.

Dish #4 fully assembled in China, used as a test bed.

Next two dishes in transit to South Africa.

SKA-Low Cluster S8: Station Assembly

SKA-Low Cluster S8: Station Assembly



SKA Observatory

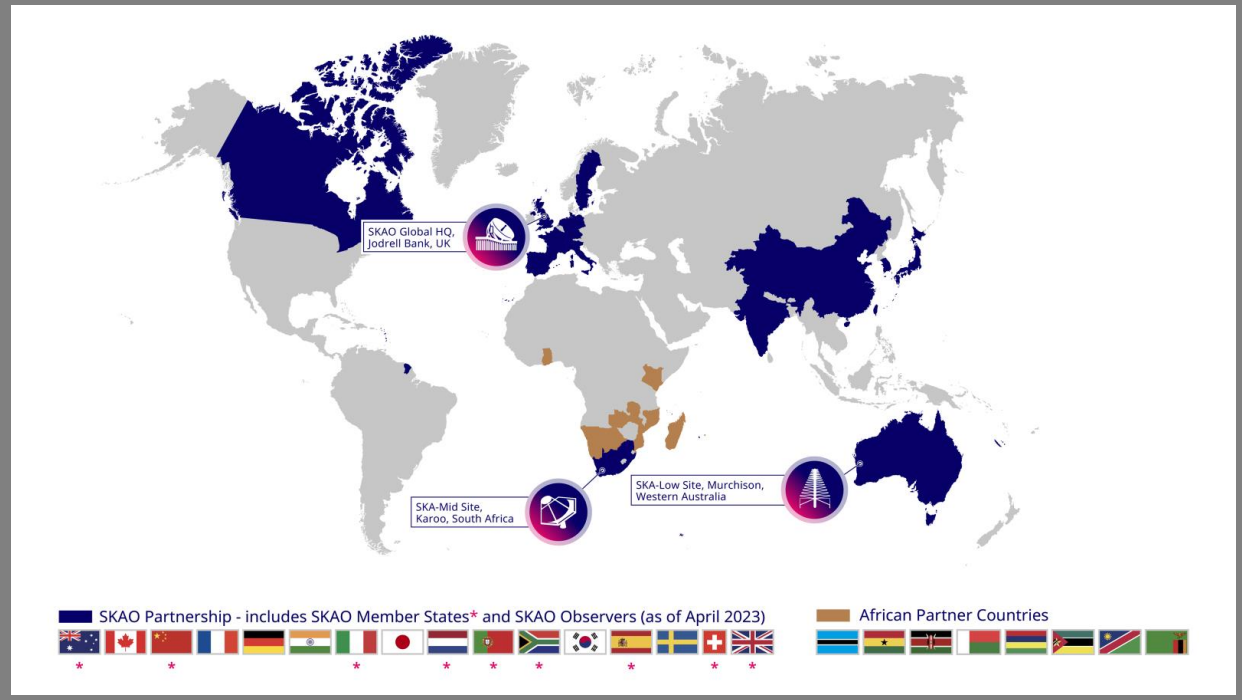
Members (11):
Australia, Canada, China, India, Italy, Netherlands, Portugal, South Africa, Spain, Switzerland, UK

Accession stage:
France, Germany

Awaiting government decisions:
South Korea, Sweden

Early stages:
Japan

In conversations with 9 other governments



SKA Observatory

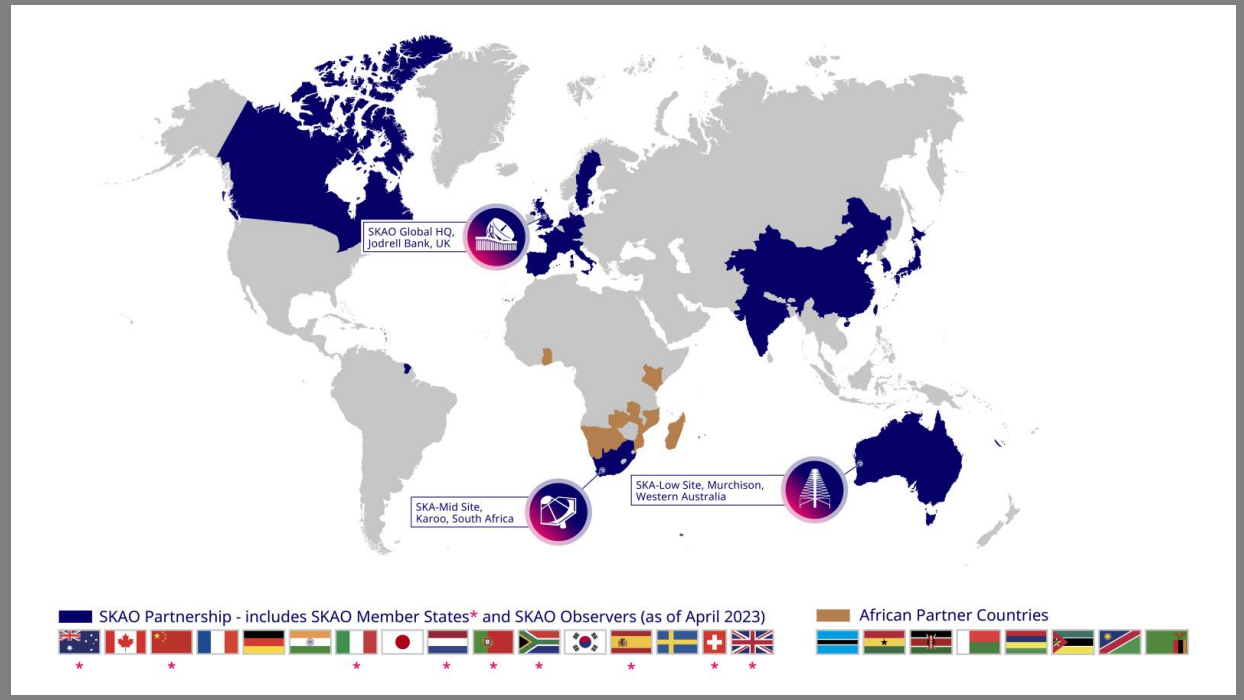
Members (11):
Australia, Canada, China, India, Italy, Netherlands, Portugal, South Africa, Spain, Switzerland, UK

Accession stage:
France, Germany

Awaiting government decisions:
South Korea, Sweden

Early stages:
Japan

In conversations with 9 other governments



Note there is no dominant national partner, but the 3 hosts contribute the most to the construction costs

So how did this grand vision become reality?

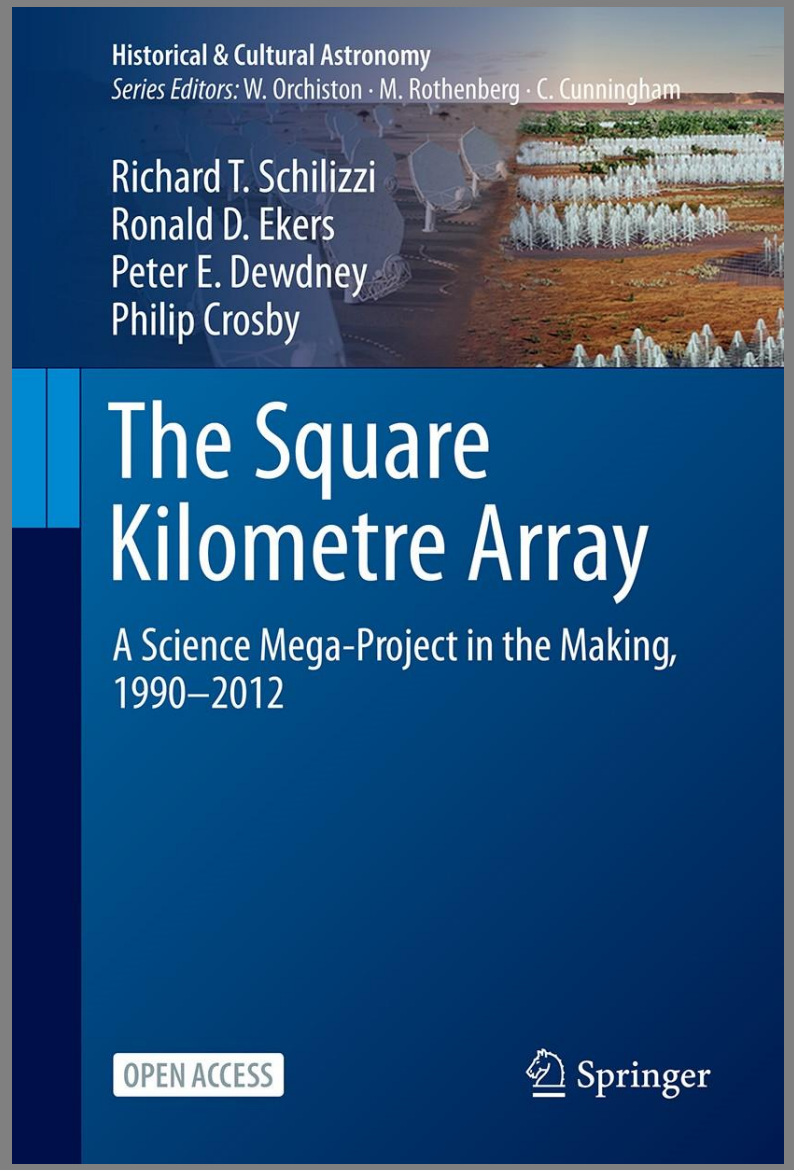
So how did this grand vision become reality?

You can read all about it in this best-seller!

https://link.springer.com/book/10.1007/978-3-031-51374-9

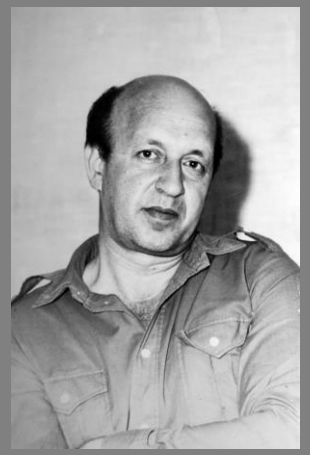
Open Access

and Amazon



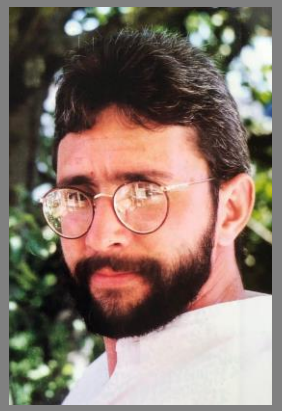
The originators of the SKA idea

Govind Swarup
India, ~1980



Yuri Pariiskii
Soviet Union, 1960

Peter Wilkinson
UK, 1984



Robert Braun Ger de Bruyn Jan Noordam
1985-1989, The Netherlands

Photos circa 1990

The “lightbulb” moment

1990: Visions merged, more or less by chance over coffee, at a Conference in Albuquerque, NM on recent results in radio astronomy and future developments – October 1990

The "lightbulb" moment

1990: Visions merged, more or less by chance over coffee, at a Conference in Albuquerque, NM on recent results in radio astronomy and future developments – October 1990

Radio Interferometry: Theory, Techniques and Applications,
IAU Coll. 131, ASP Conference Series, Vol. 19, 1991,
T.J. Cornwell and R.A. Perley (eds.)

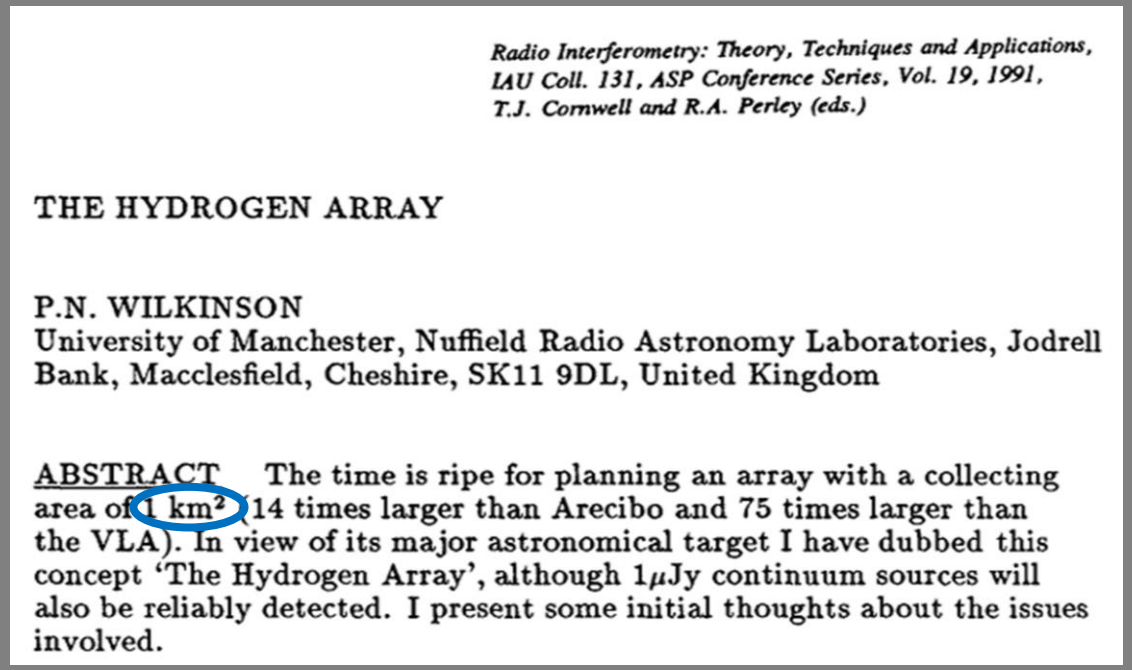
THE HYDROGEN ARRAY

P.N. WILKINSON
University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire, SK11 9DL, United Kingdom

ABSTRACT The time is ripe for planning an array with a collecting area of 1 km² (14 times larger than Arecibo and 75 times larger than the VLA). In view of its major astronomical target I have dubbed this concept 'The Hydrogen Array', although 1μJy continuum sources will also be reliably detected. I present some initial thoughts about the issues involved.

The "lightbulb" moment

1990: Visions merged, more or less by chance over coffee, at a Conference in Albuquerque, NM on recent results in radio astronomy and future developments – October 1990



Radio Interferometry: Theory, Techniques and Applications,
IAU Coll. 131, ASP Conference Series, Vol. 19, 1991,
T.J. Cornwell and R.A. Perley (eds.)

THE HYDROGEN ARRAY

P.N. WILKINSON
University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire, SK11 9DL, United Kingdom

ABSTRACT The time is ripe for planning an array with a collecting area of 1 km² (14 times larger than Arecibo and 75 times larger than the VLA). In view of its major astronomical target I have dubbed this concept 'The Hydrogen Array', although 1μJy continuum sources will also be reliably detected. I present some initial thoughts about the issues involved.

1993: Resolution passed at the General Assembly of the International Union for Radio Science (URSI) to establish a Large Telescope Working Group (LTWG, Chair, Robert Braun)

Australia, Canada, China, France, Germany, India, NL, Russia, UK, USA

SKA was **BORN GLOBAL**

LTWG vision for the SKA (1993)

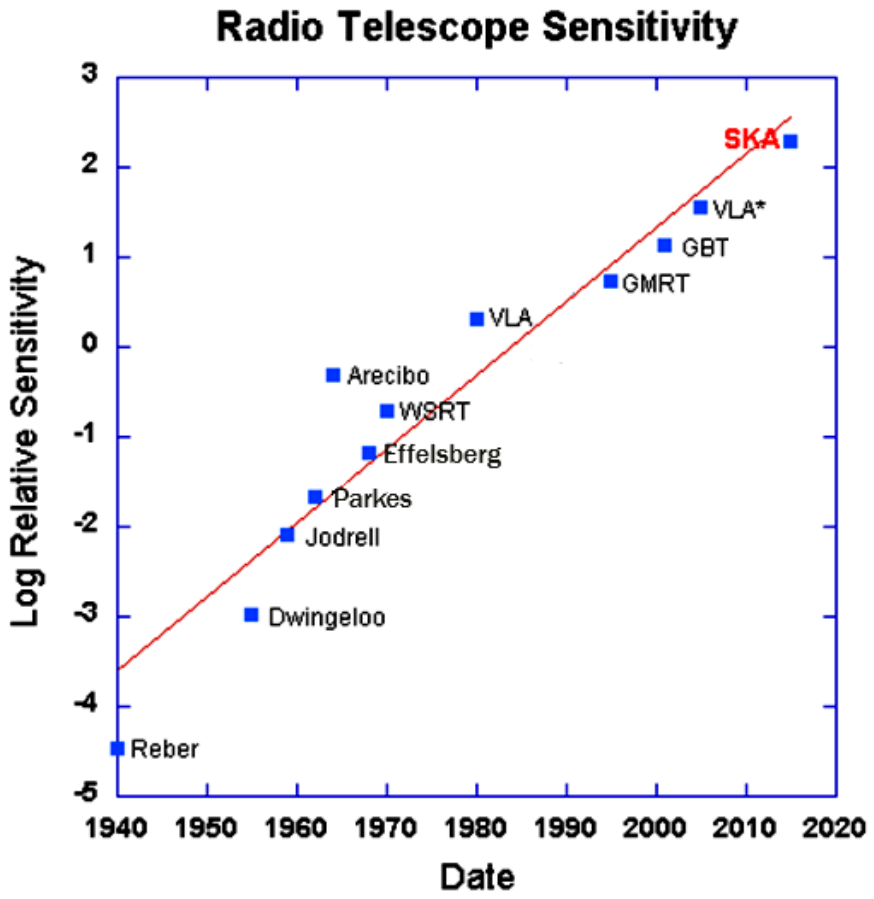
LTWG meeting, China, 1995

- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.

LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

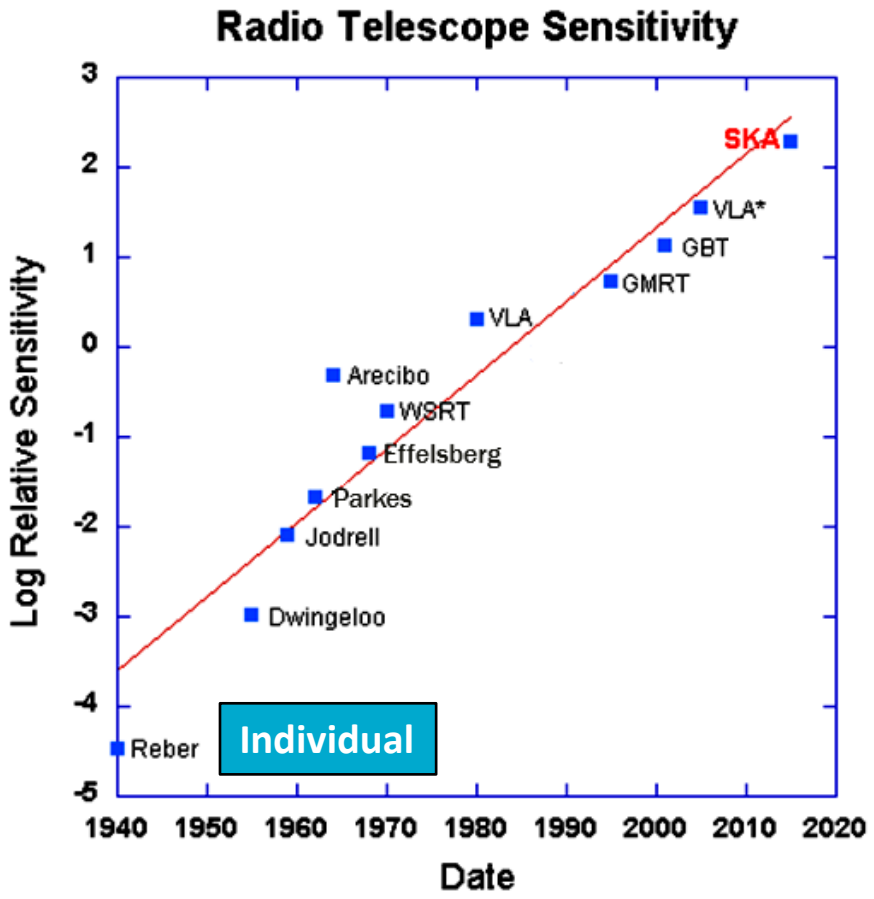
- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

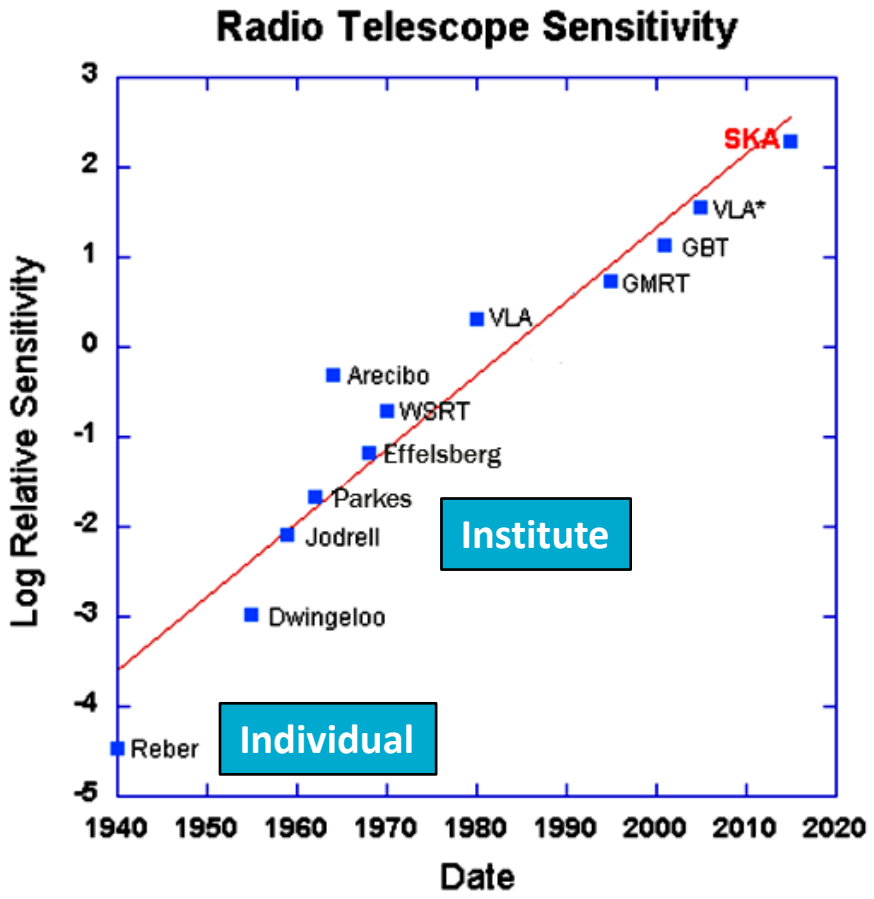
- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

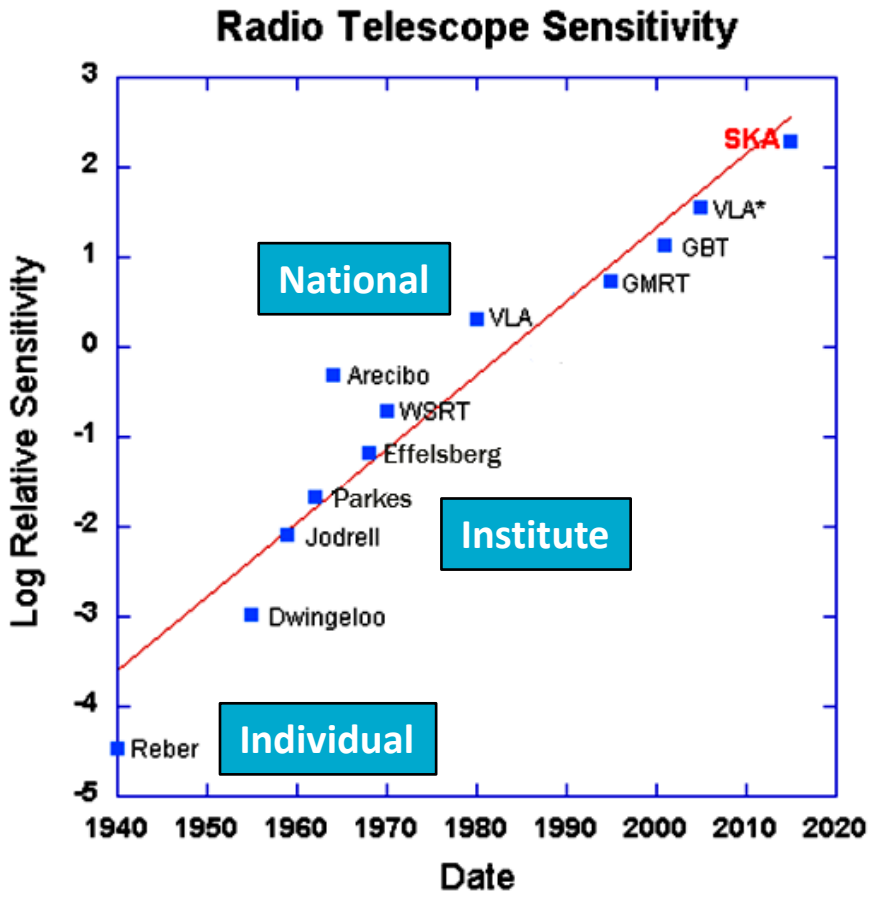
- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

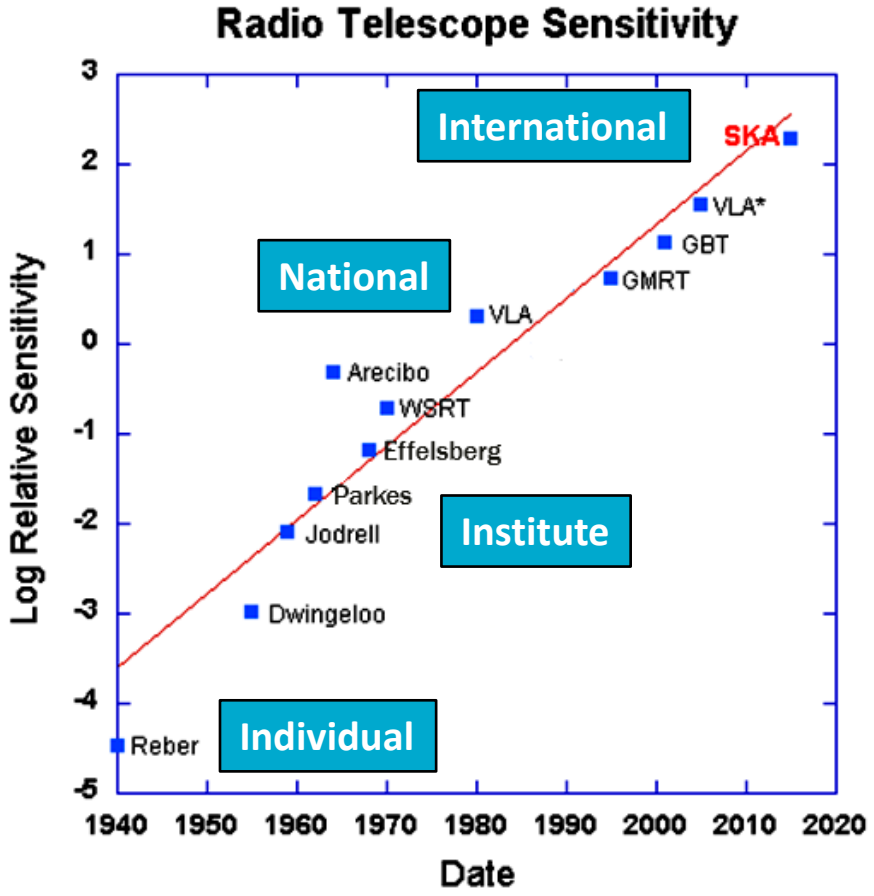
- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

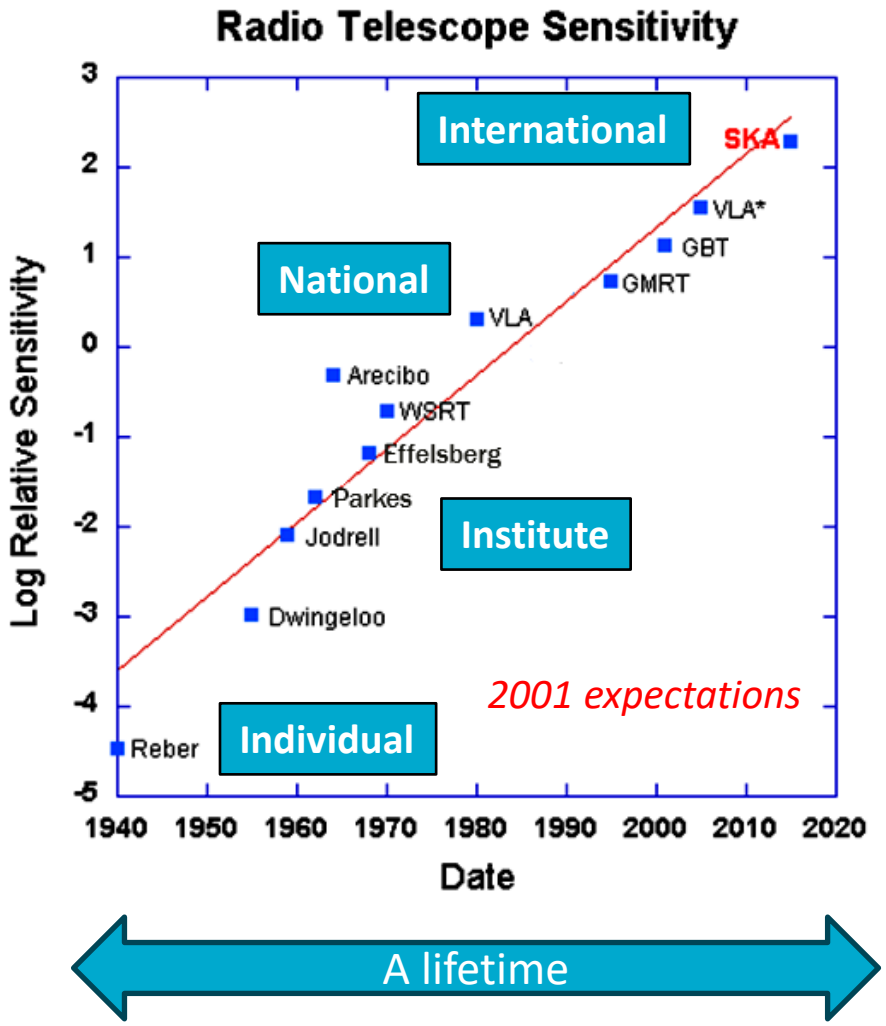
- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

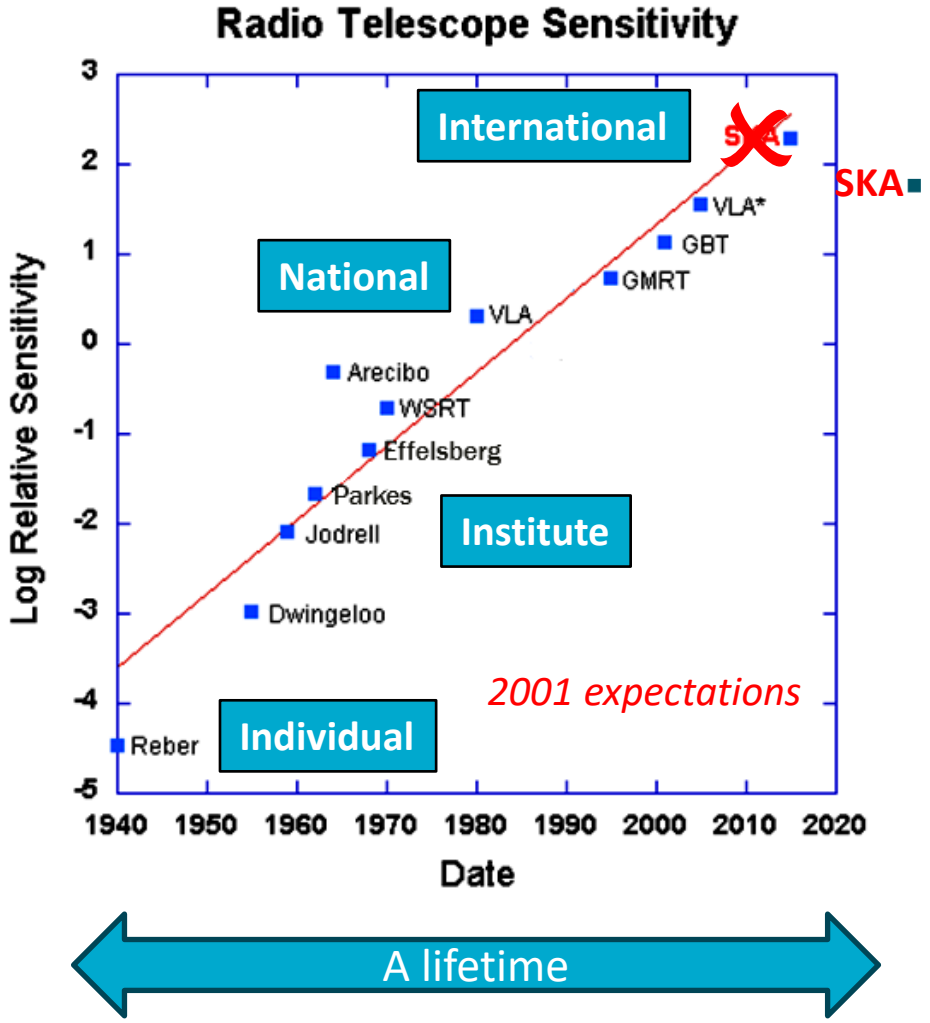
- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



LTWG vision for the SKA (1993)

LTWG meeting, China, 1995

- angular resolution better than the Hubble Space Telescope (< 0.1”)
- field of view significantly larger than the full moon (~ 1 square degree)
- and all at a sensitivity about 100 times the VLA.



Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality

Technology R&D

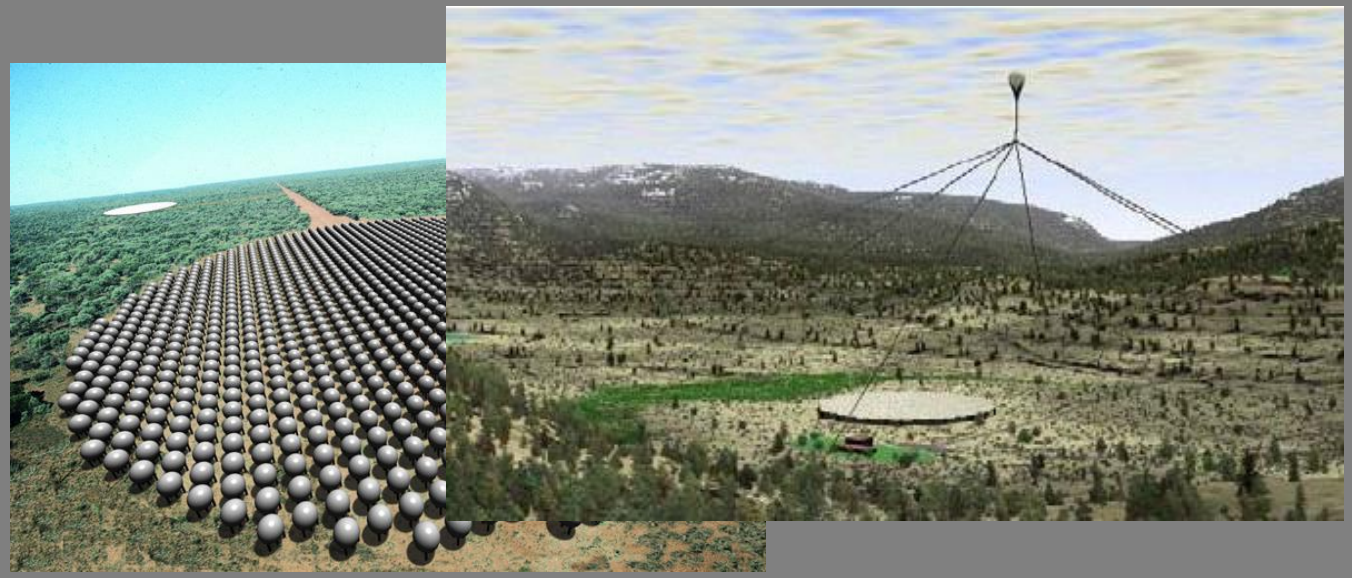
Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality

Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality



Technology R&D

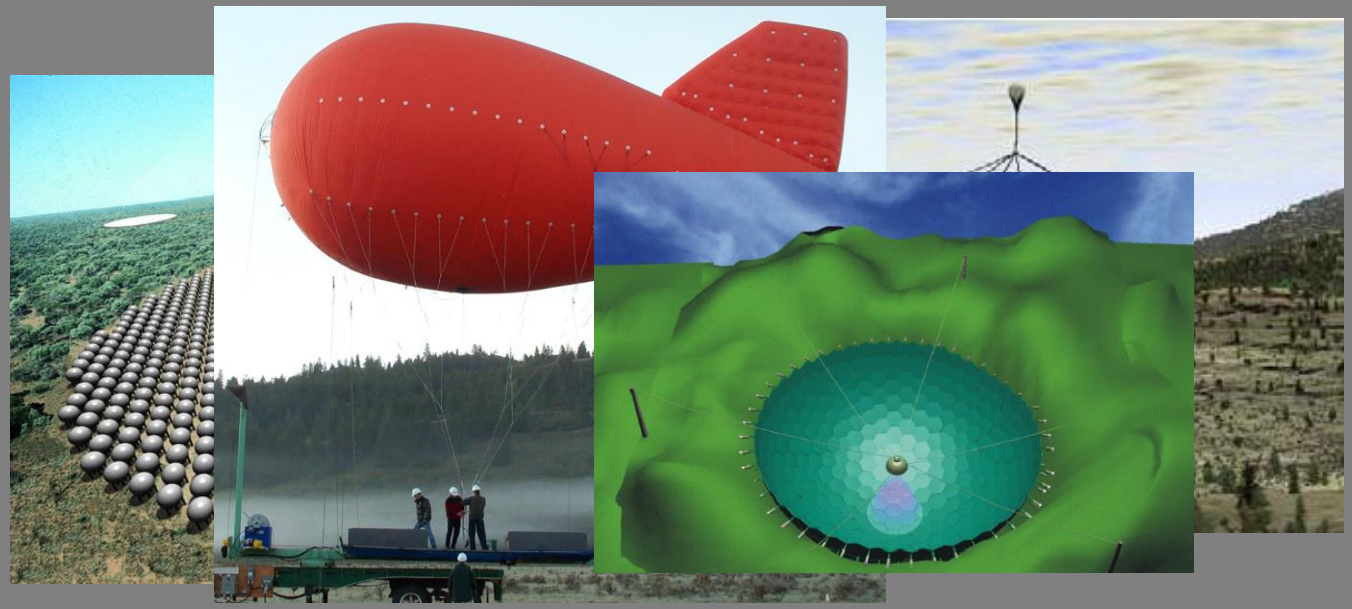
Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality

Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

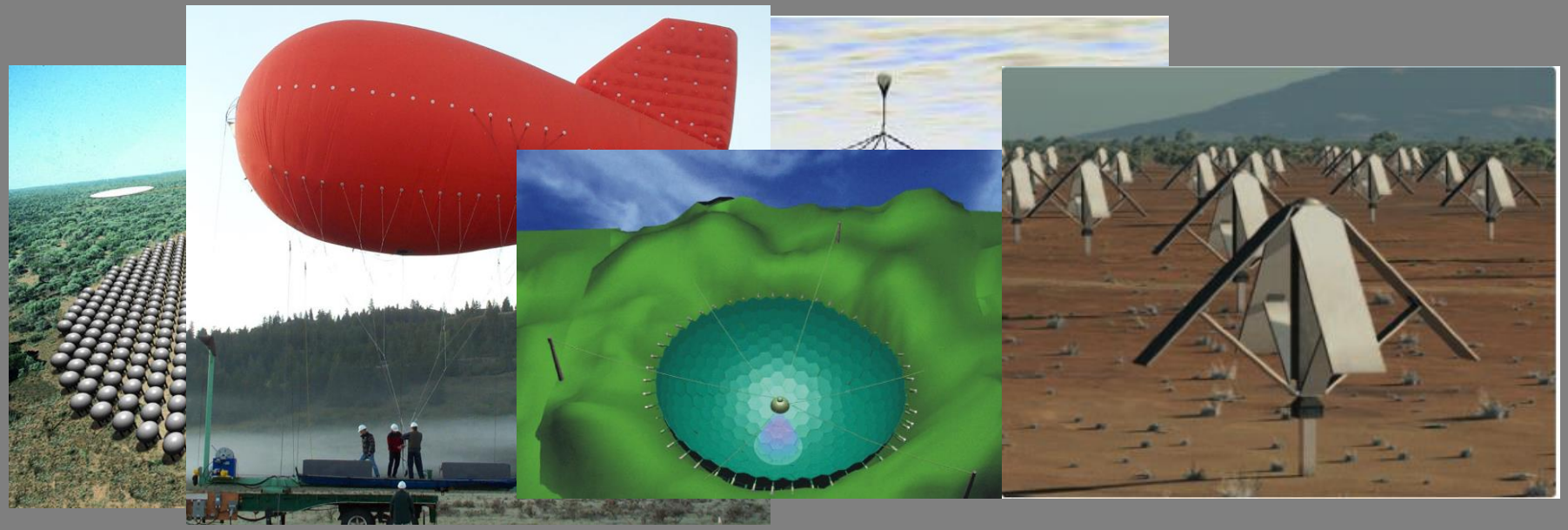
National technology innovations through the 1990s – 2000s, but eventually innovation met reality



Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

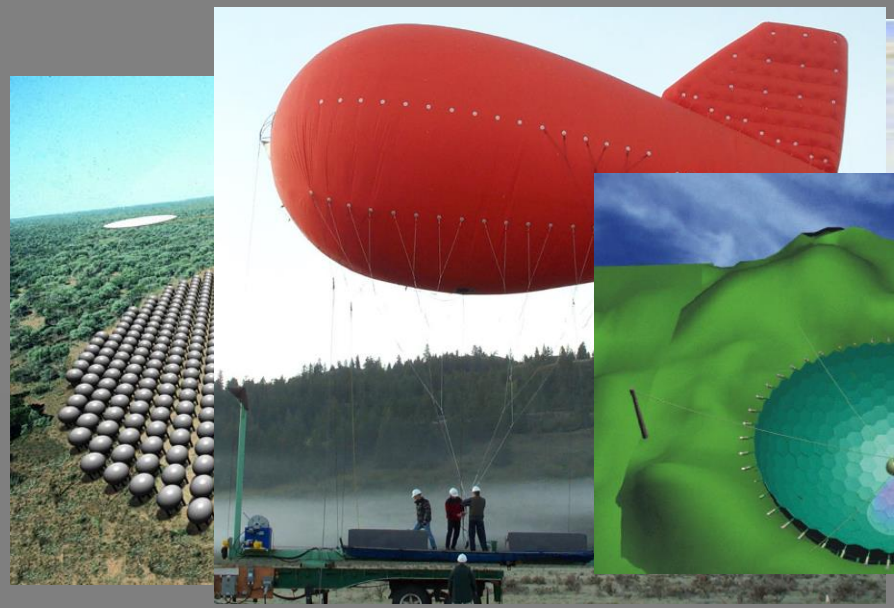
National technology innovations through the 1990s – 2000s, but eventually innovation met reality

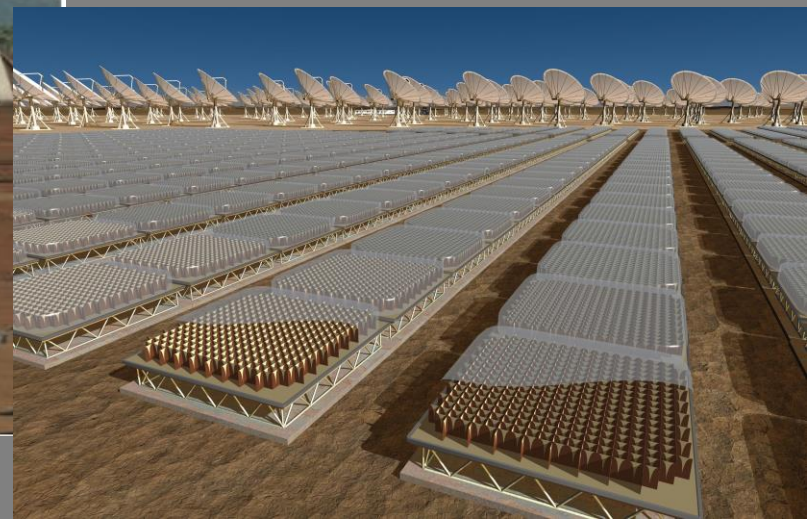


Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality

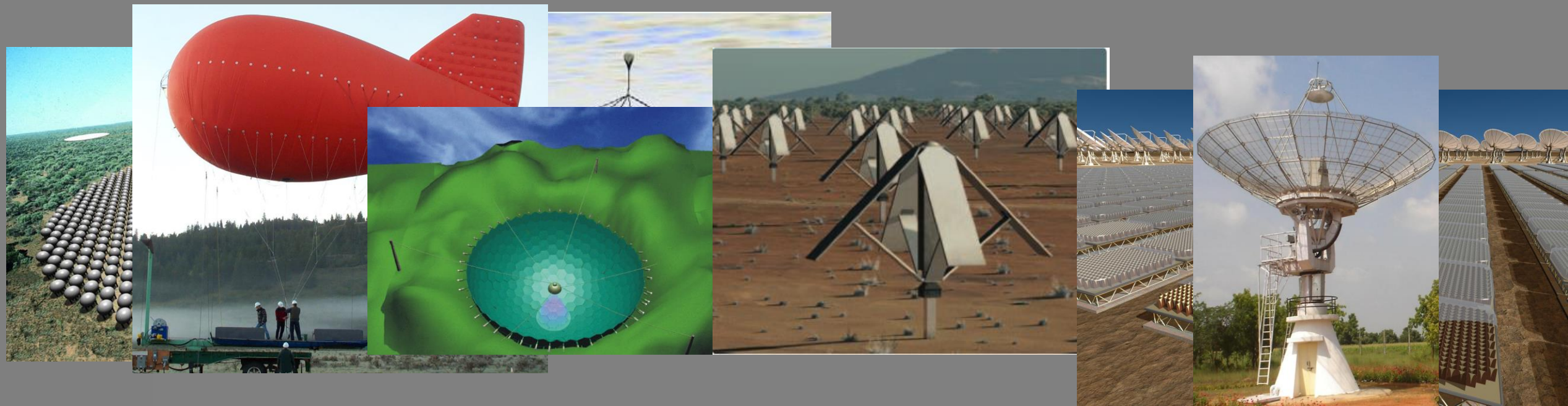




Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

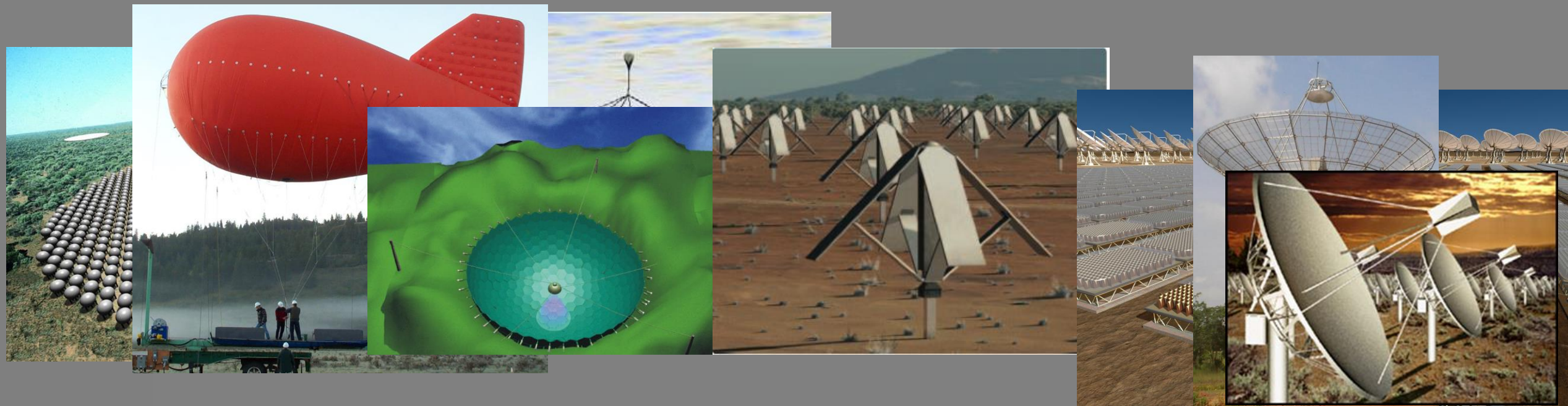
National technology innovations through the 1990s – 2000s, but eventually innovation met reality



Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

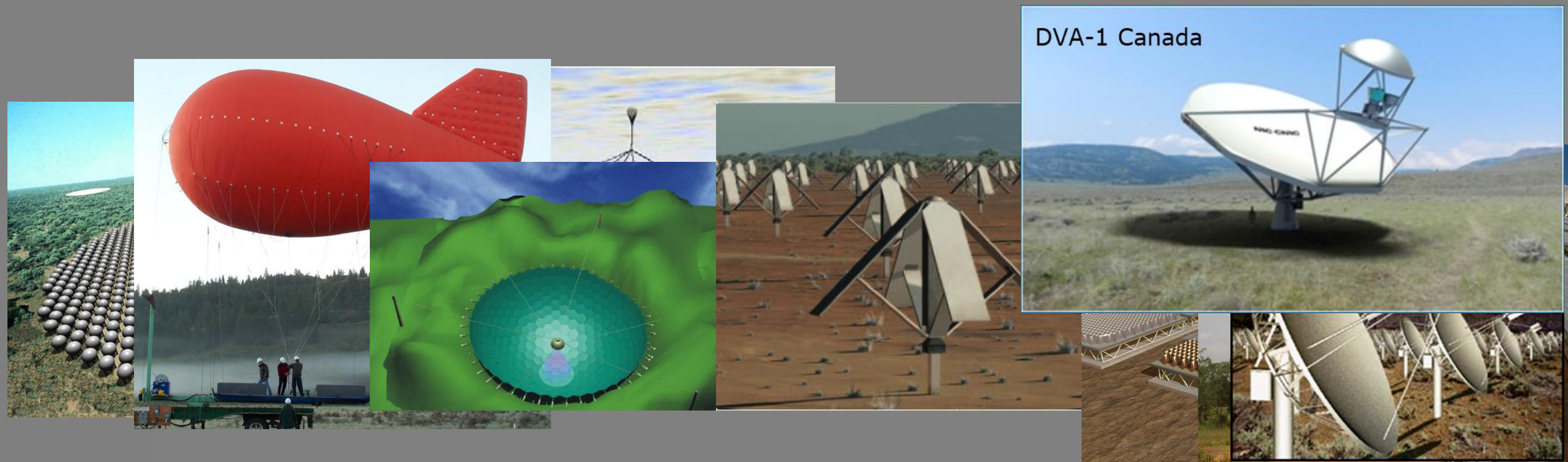
National technology innovations through the 1990s – 2000s, but eventually innovation met reality



Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

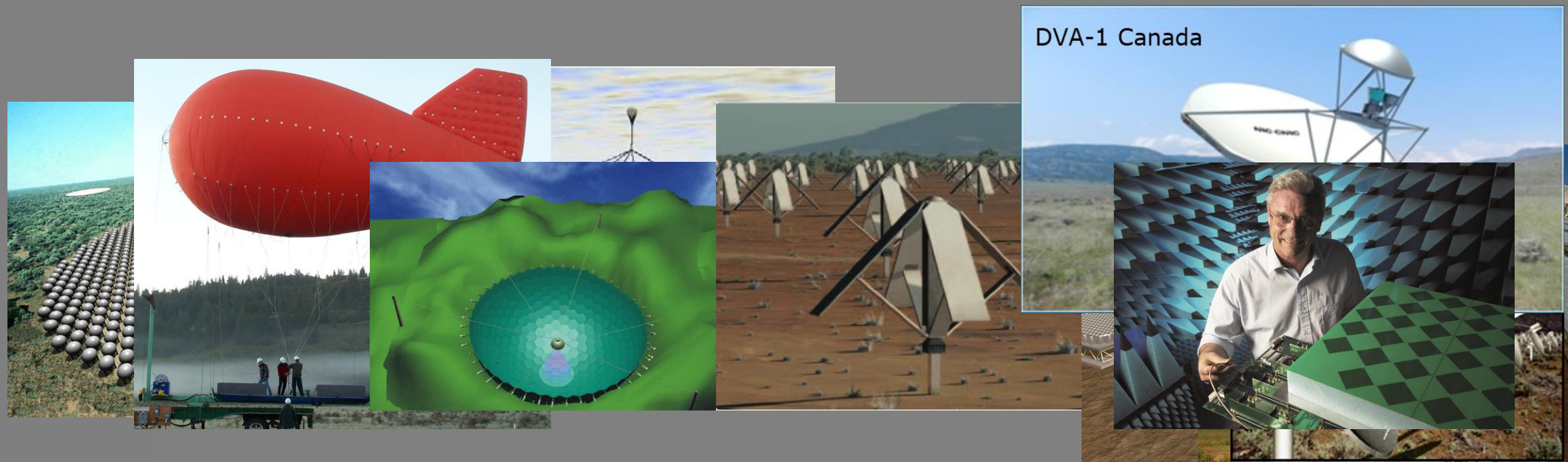
National technology innovations through the 1990s – 2000s, but eventually innovation met reality



Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality



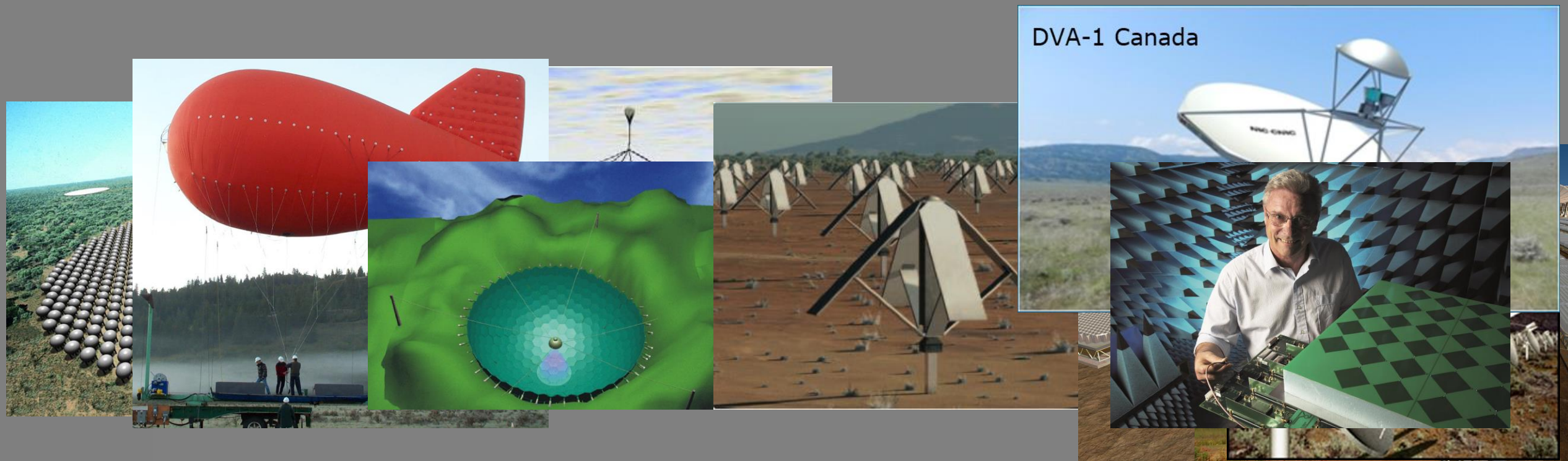
Technology R&D

Achieving the factor of 100 in sensitivity was not straightforward

National technology innovations through the 1990s – 2000s, but eventually innovation met reality

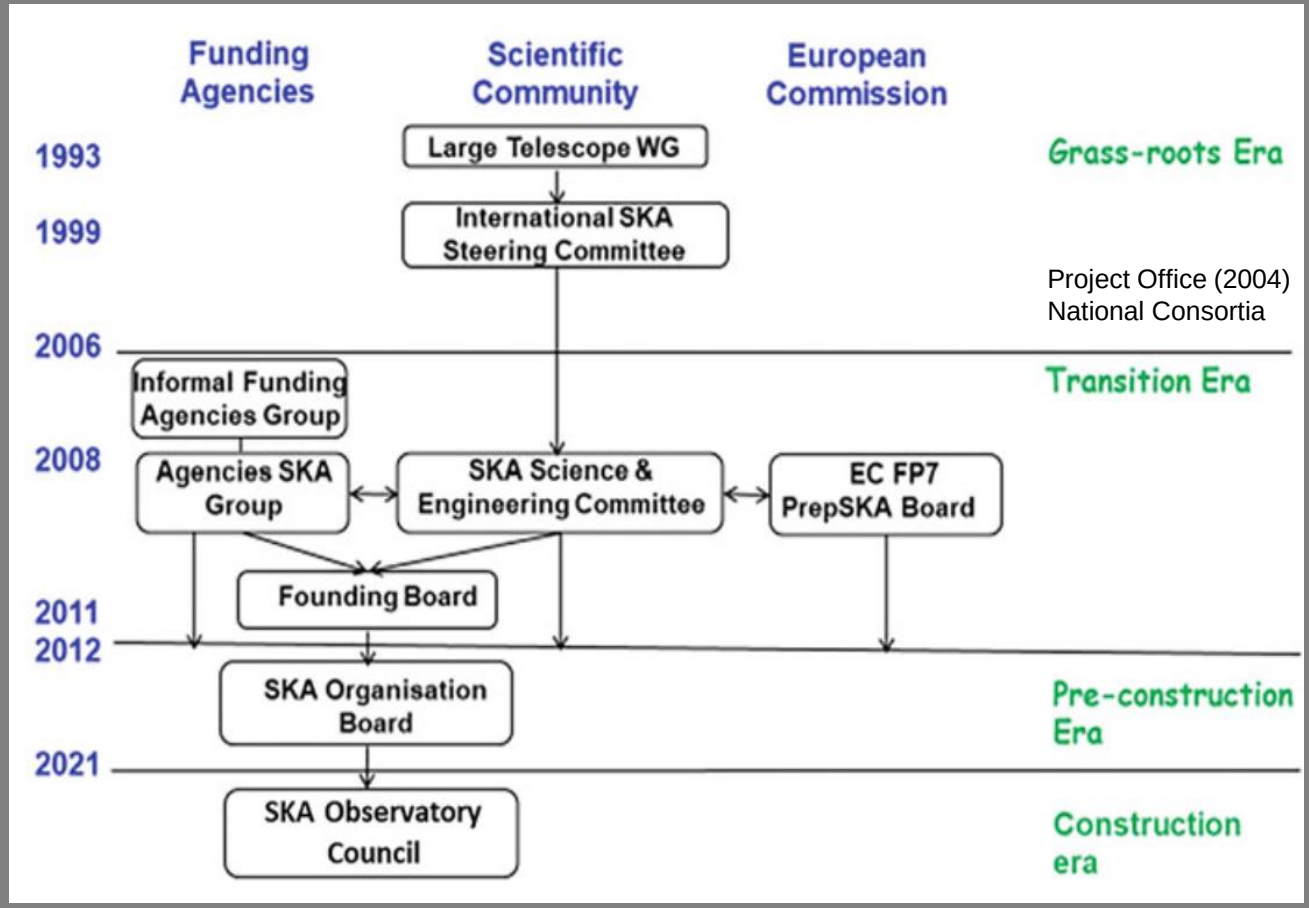
Big collaborations followed - SKADS (2004, dense AAs), PrepSKA (2007, Europe-led),
Technical Development Program (dishes, US-led)

Technology down-selects in 2005, 2010 (SKA1), 2015 → SKA-Mid and SKA-Low



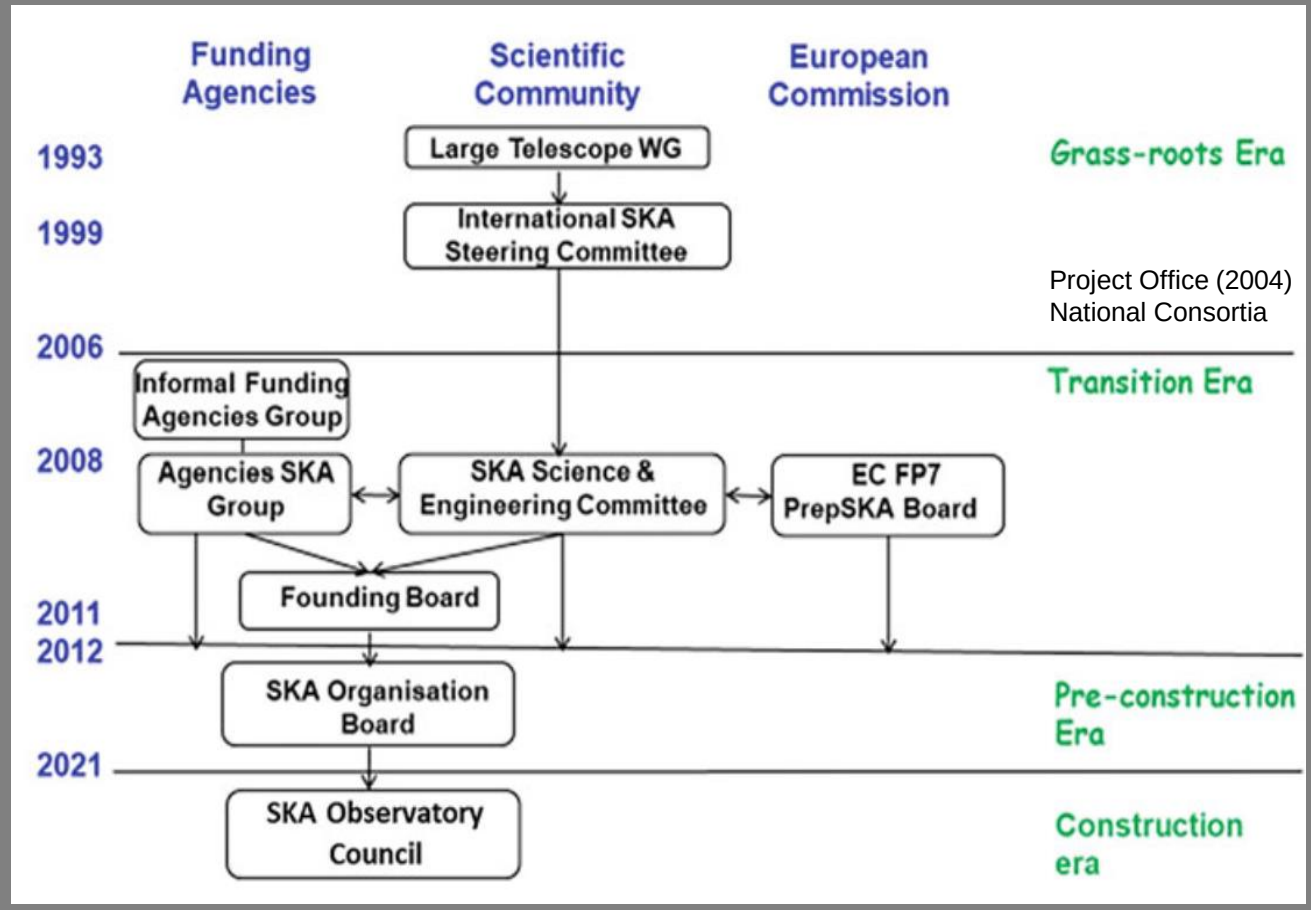
Global (mega-)science facilities like the SKA are complex

- Multiple nations, multiple players
  - different national funding cycles and different cultural approaches to science and decision-making
- Research organisations
  - large and small, institutes and universities
- Industrial organisations
  - large and small
- Governments, Funding Agencies, and EC
  - scientific community is no longer in sole control
- Expensive



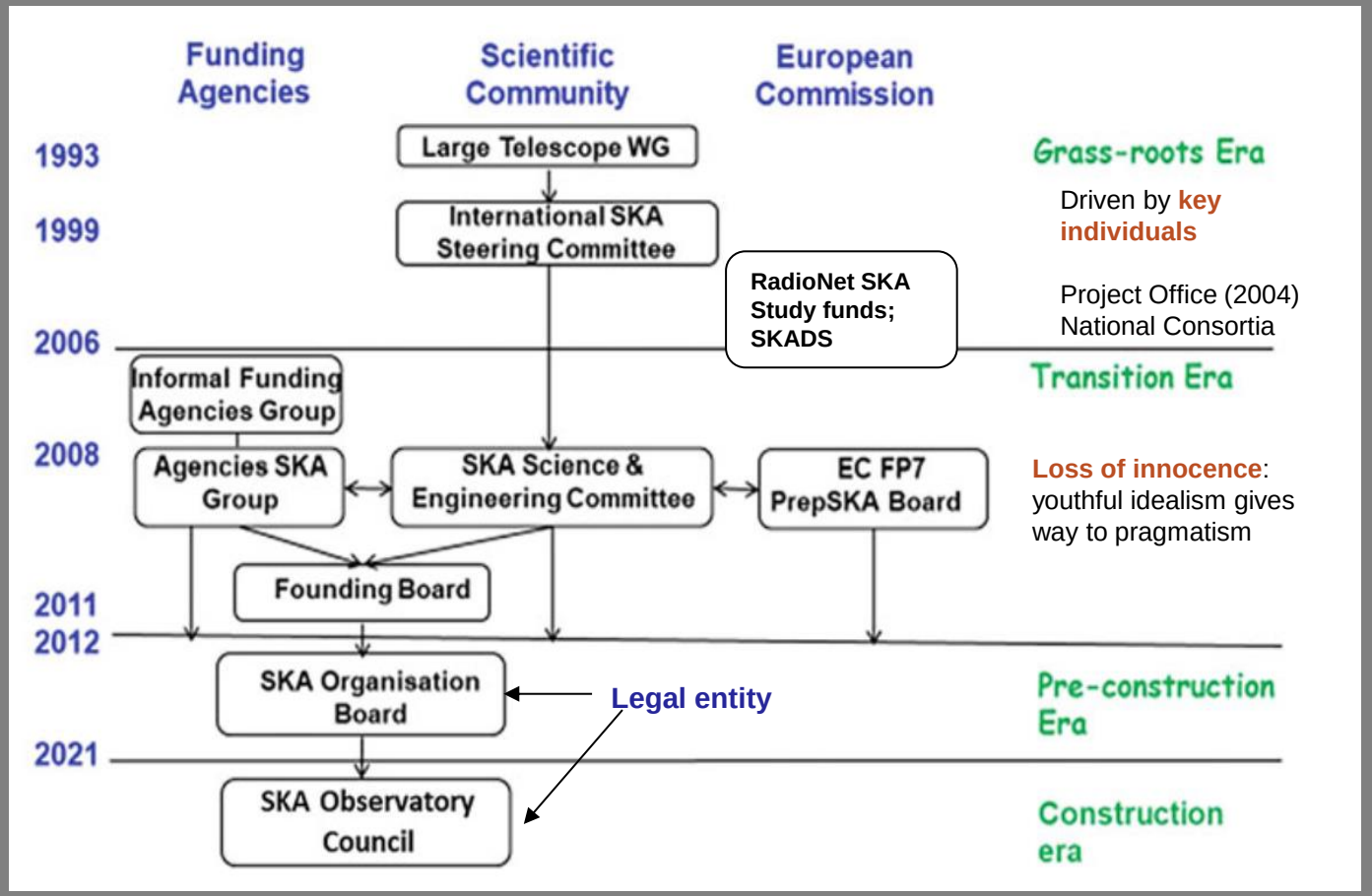
Global (mega-)science facilities like the SKA are complex

- Multiple nations, multiple players
  - different national funding cycles and different cultural approaches to science and decision-making
- Research organisations
  - large and small, institutes and universities
- Industrial organisations
  - large and small
- Governments, Funding Agencies, and EC
  - scientific community is no longer in sole control
- Expensive



The glue for SKA:
the over-riding grand vision of building the world's largest radio telescope, but it's still amazing it worked at all, particularly with no dominant partner!

Governance

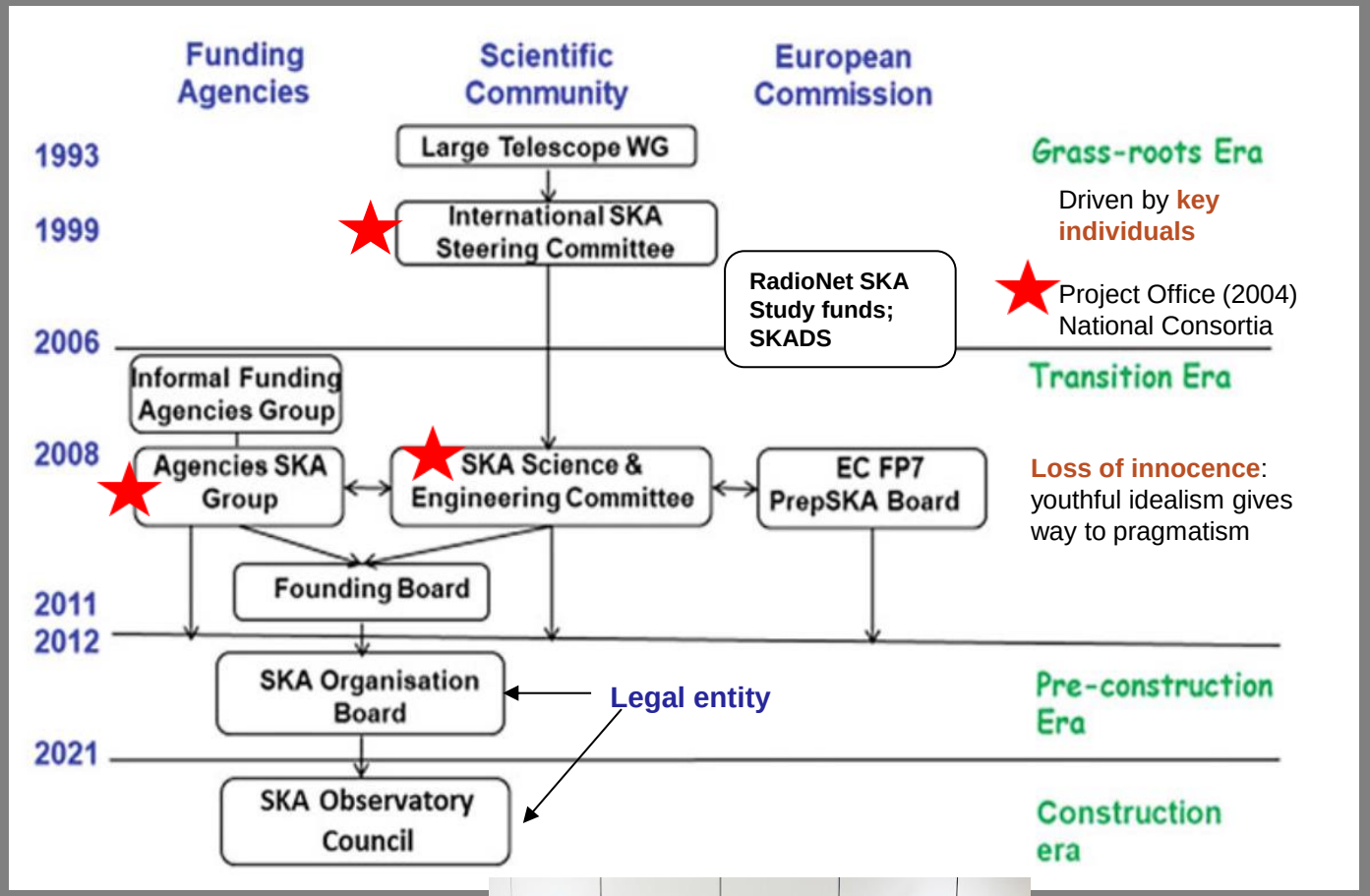

Funding Agencies
Scientific Community
European Commission
1993
1999
2006
2008
2011
2012
2021
Large Telescope WG
International SKA Steering Committee
RadioNet SKA Study funds; SKADS
Informal Funding Agencies Group
Agencies SKA Group
SKA Science & Engineering Committee
EC FP7 PrepSKA Board
Founding Board
SKA Organisation Board
Legal entity
SKA Observatory Council
Grass-roots Era
Driven by key individuals
Project Office (2004)
National Consortia
Transition Era
Loss of innocence: youthful idealism gives way to pragmatism
Pre-construction Era
Construction era

Governance


ISSC
2000
18 members representing 11 countries
6 European, 6 USA, 2 Canada,
2 Australia, 1 China, 1 India, 2 at-large


SSEC, 2009


Agencies SKA Group)
+ SSEC Exec, 2010


Funding Agencies
Scientific Community
European Commission
1993
Large Telescope WG
Grass-roots Era
Driven by key individuals
1999
International SKA Steering Committee
RadioNet SKA Study funds; SKADS
Project Office (2004)
National Consortia
2006
Transition Era
Informal Funding Agencies Group
2008
Agencies SKA Group
SKA Science & Engineering Committee
EC FP7 PrepSKA Board
Loss of innocence: youthful idealism gives way to pragmatism
Founding Board
2011
2012
SKA Organisation Board
Legal entity
Pre-construction Era
2021
SKA Observatory Council
Construction era

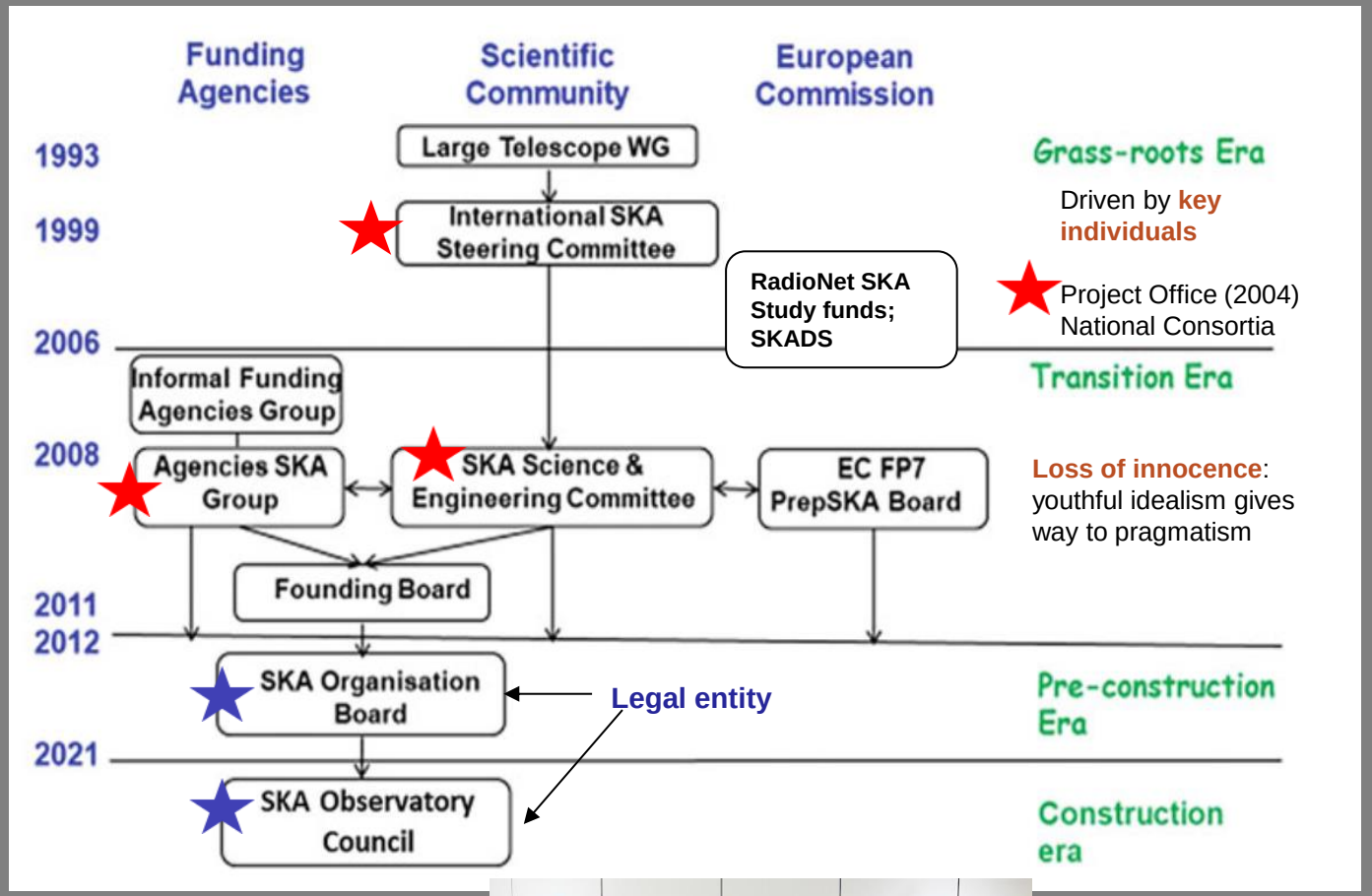

SKA Program Development Office, 2011

Governance


ISSC
2000
18 members representing 11 countries
6 European, 6 USA, 2 Canada,
2 Australia, 1 China, 1 India, 2 at-large


SSEC, 2009


Agencies SKA Group)
+ SSEC Exec, 2010


Funding Agencies
Scientific Community
European Commission
1993
Large Telescope WG
Grass-roots Era
Driven by key individuals
1999
International SKA Steering Committee
RadioNet SKA Study funds; SKADS
Project Office (2004)
National Consortia
2006
Transition Era
Informal Funding Agencies Group
2008
Agencies SKA Group
SKA Science & Engineering Committee
EC FP7 PrepSKA Board
Loss of innocence: youthful idealism gives way to pragmatism
Founding Board
2011
2012
SKA Organisation Board
Legal entity
Pre-construction Era
2021
SKA Observatory Council
Construction era


SKA Program Development Office, 2011


SKA Organisation Board, 2011

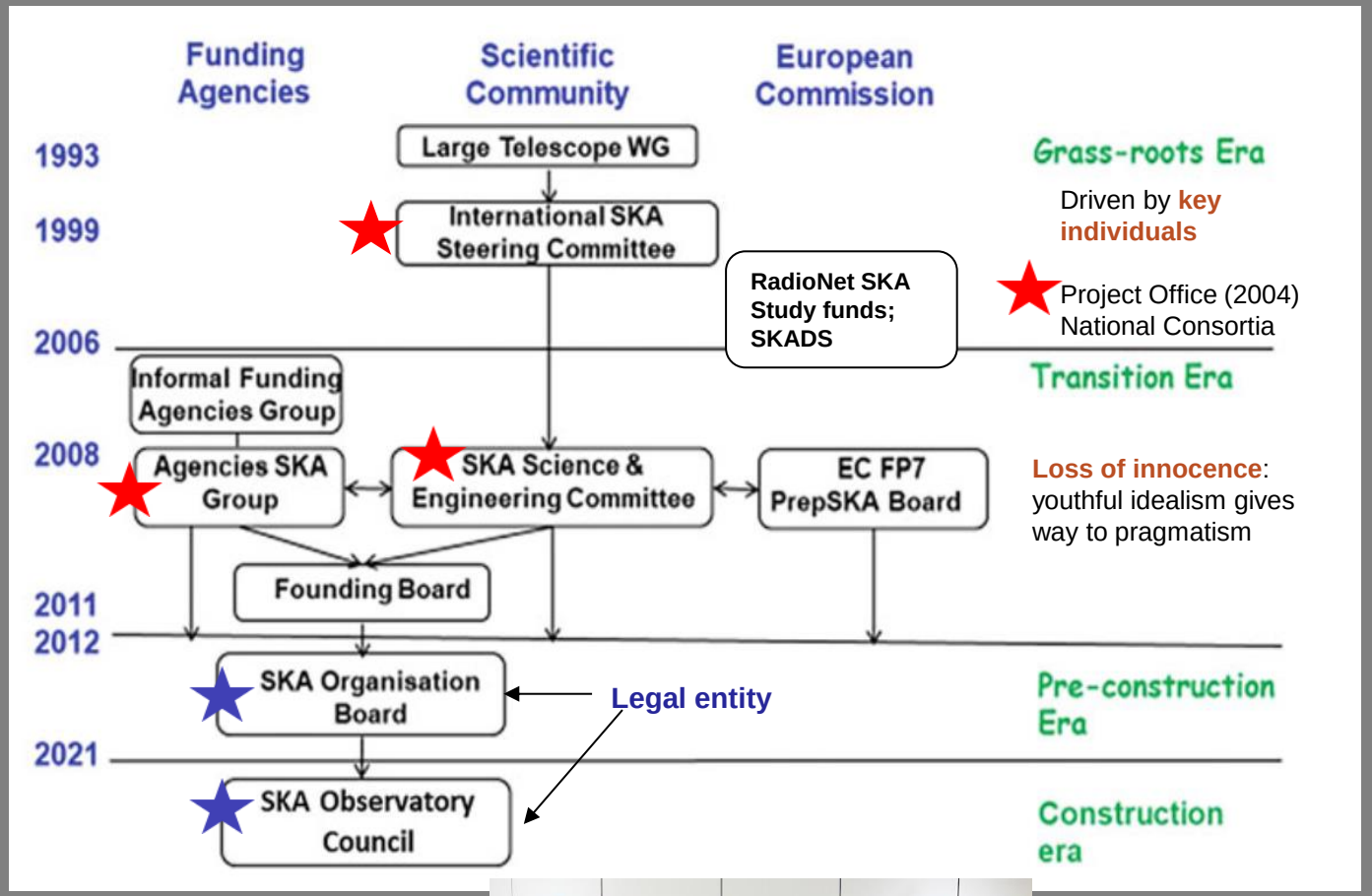

SKA Observatory Convention Signing by State representatives 2019

Governance


ISSC
2000
18 members representing 11 countries
6 European, 6 USA, 2 Canada,
2 Australia, 1 China, 1 India, 2 at-large


SSEC, 2009


Agencies SKA Group)
+ SSEC Exec, 2010


Funding Agencies
Scientific Community
European Commission
1993
Large Telescope WG
Grass-roots Era
Driven by key individuals
1999
International SKA Steering Committee
RadioNet SKA Study funds; SKADS
Project Office (2004)
National Consortia
2006
Transition Era
Informal Funding Agencies Group
2008
Agencies SKA Group
SKA Science & Engineering Committee
EC FP7 PrepSKA Board
Loss of innocence: youthful idealism gives way to pragmatism
Founding Board
2011
2012
SKA Organisation Board
Legal entity
Pre-construction Era
2021
SKA Observatory Council
Construction era


SKA Program Development Office, 2011


SKA Directors
Michiel van Haarlem 2011-12
Phil Diamond 2012→
Richard Schilizzi 2003-11


SKA Organisation Board, 2011


SKA Observatory Convention Signing by State representatives 2019

It wasn't all plain sailing – challenges 2006-2012

1) Funding approval - Needed to get on the Funding Agency/government roadmaps

Europe: European Strategy Forum for Research Infrastructures, 2006 → EC Preparatory Studies (PrepSKA, 2007), ASTRONET (2007-8)

USA: 2010 Decadal Survey

And we needed "luck". Being there in time for the first round of EC Preparatory Studies

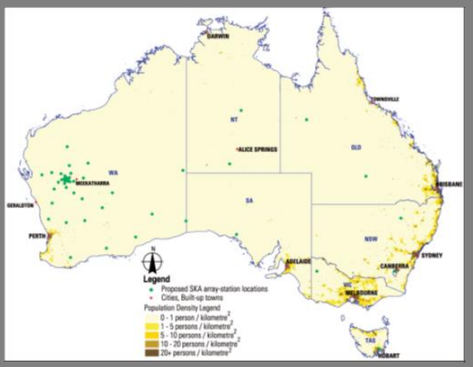
2) Site selection – tense and political, under Funding Agency control from 2010

3) Engineering design – major effort to manage the generation and implementation of a design for a telescope on the scale and cost of the SKA.

No-one had been involved in a project of this scale and cost before.

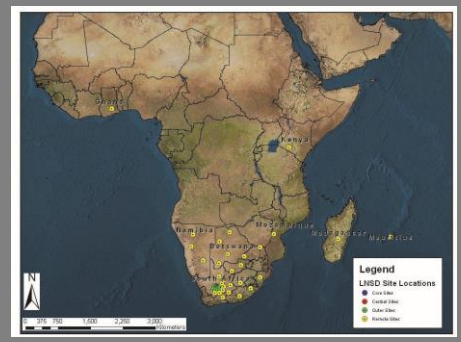
4) Governance - What form of governance → stable environment. No home environment for SKA, had to be invented

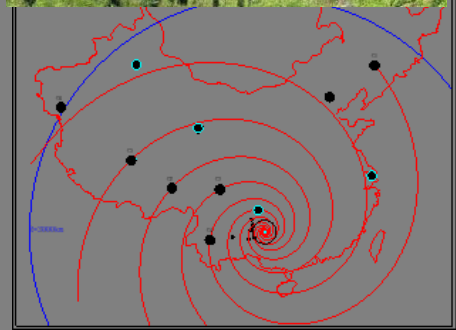
Site selection and decision timeline



2002 open request to global radio astronomy community for Expressions of Interest in siting SKA → 5 candidates

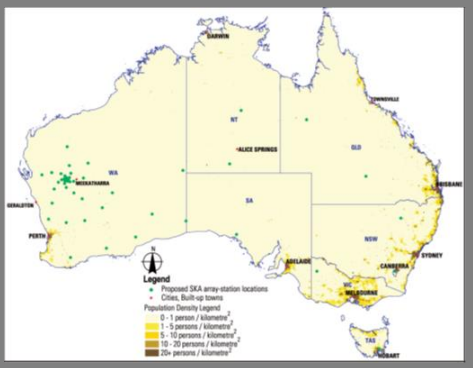
2006 site short-listing: Australia-NZ and Southern Africa





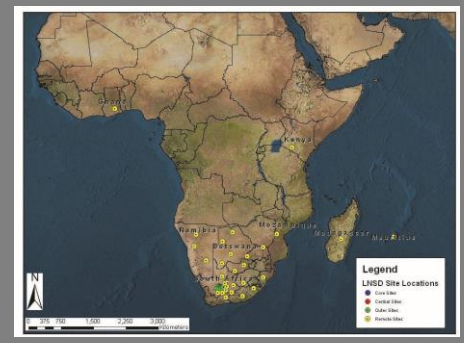
Site photos by Rob Millenaar

Site selection and decision timeline



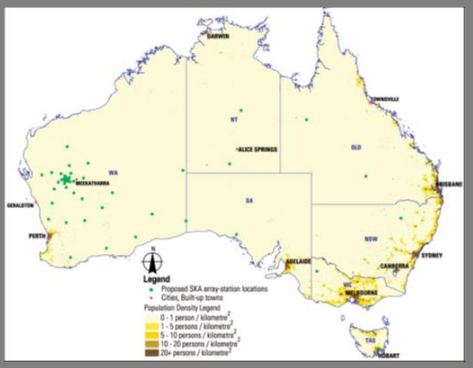
2002 open request to global radio astronomy community for Expressions of Interest in siting SKA → 5 candidates

2006 site short-listing: Australia-NZ and Southern Africa



Site photos by Rob Millenaar

Site selection and decision timeline



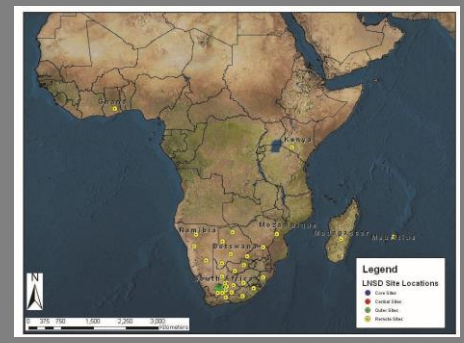
2002 open request to global radio astronomy community for Expressions of Interest in siting SKA → 5 candidates

2006 site short-listing: Australia-NZ and Southern Africa

2008 site characterisation begins

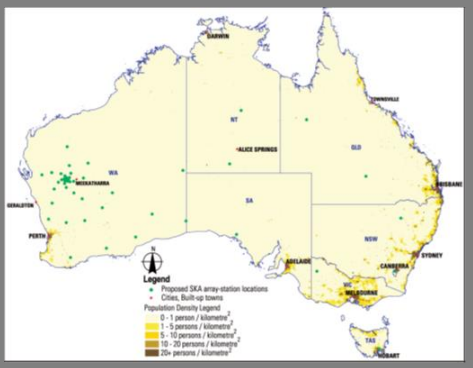
2010 Funding Agencies assumed control of the site selection process

2010-12 proposal evaluation and site decision by SKAO Board



Site photos by Rob Millenaar

Site selection and decision timeline



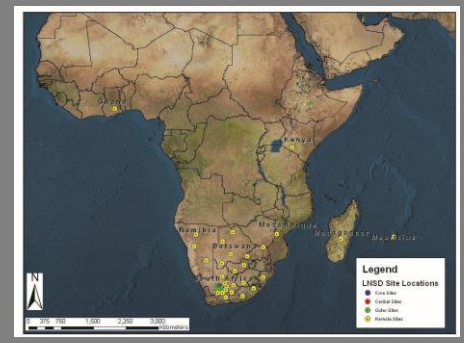
2002 open request to global radio astronomy community for Expressions of Interest in siting SKA → 5 candidates

2006 site short-listing: Australia-NZ and Southern Africa

2008 site characterisation begins

2010 Funding Agencies assumed control of the site selection process

2010-12 proposal evaluation and site decision by SKAO Board

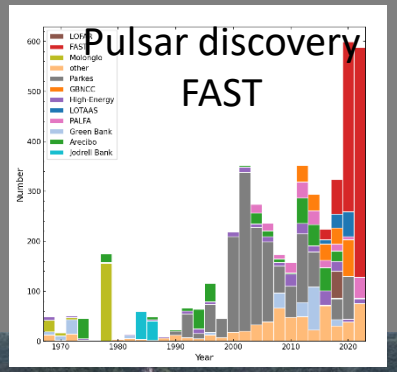


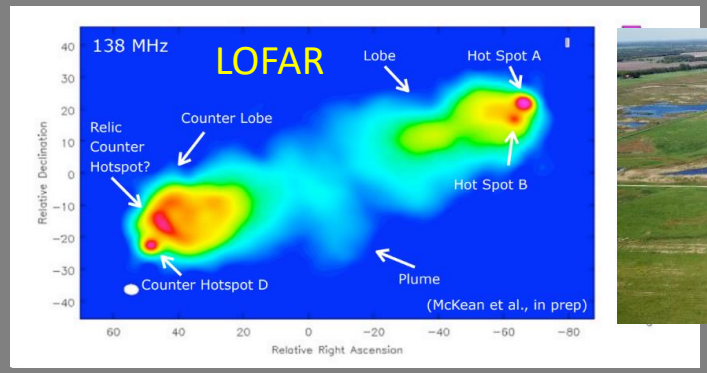
Full array	Mid-freq dish array	SA
	Low freq AA	ANZ
	Mid freq AA	SA or ANZ
Phase 1	Mid-freq dish array	SA
	Low freq AA	AU
	Survey	AU

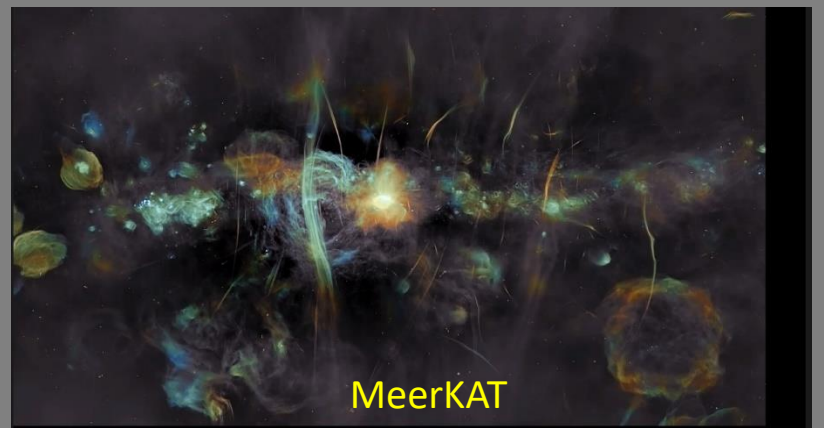
Site photos by Rob Millenaar

The SKA is already a success

- Precursor and Pathfinder discovery science
- The drivers of innovation







I didn’t tell you about…

- The individual national stories about how and why they got involved in the SKA
- Our over-optimism about timescales and costs, at all stages of the project
- Why the US is no longer involved the SKA
- The details of the final site decision

I didn’t tell you about…

- The individual national stories about how and why they got involved in the SKA
- Our over-optimism about timescales and costs, at all stages of the project
- Why the US is no longer involved the SKA
- The details of the final site decision

See the book

Acknowledgements

Richard Porcas “A history of the EVN: 30 years of fringes”
10th EVN Symposium, 2010
Proceedings of Science
https://pos.sissa.it/125/011/pdf

Photos, figures, slides, other information
Phil Diamond
Ron Ekers
Mike Garrett
Leonid Gurvits
Huib van Langevelde
George Miley
Richard Porcas
Giancarlo Setti
Laura Wolz

MANCHESTER
1824

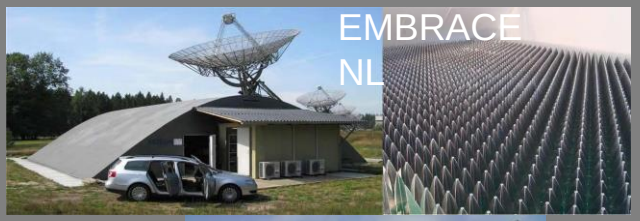
The end

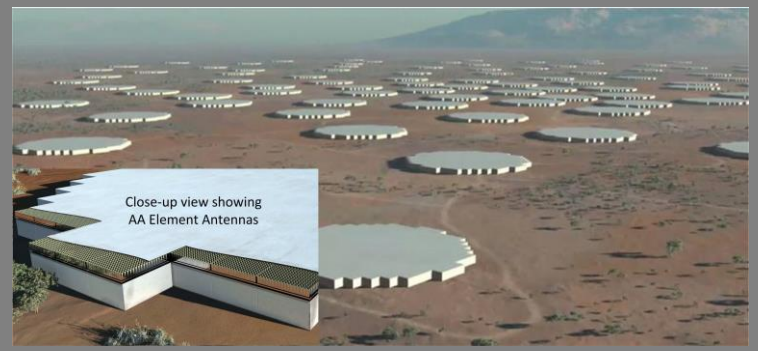
SKADS

EC-FP4 Program, 2004-2009, 10.5 M€
Coordinator: Arnold van Ardenne

Dense aperture arrays

SKADS → PrepSKA Aperture Array Verification Program
→ SKAO Advanced Instrumentation Program





What makes a successful international scientific collaboration?

- Top quality science
  - convinces the community and funding agencies, and provides the “why” for the collaboration
- Mutual advantage for the individual parties (science, engineering, industry engagement, nations…)
  - Optimising mutual advantage means understanding and respecting the agendas of the people you deal with before you start
- Simple governance and management
- Good internal and external communication
- A satisfied community

Challenges for global science projects like the EVN & JIVE and SKA

In the various countries involved, there are different

- funding cycles
- prior investment histories
- scientific interests
- levels of technology development
- decision-making cultures
- social cultures

Challenges for global science projects like the EVN & JIVE and SKA

In the various countries involved, there are different

- funding cycles
- prior investment histories
- scientific interests
- levels of technology development
- decision-making cultures
- social cultures

You need to find mutually beneficial ways around these challenges if there is no dominant partner calling the shots.

And you need luck… particularly with the funding

Science & politics in Europe

1950s-1960s

Post-World War II, western Europe began to construct cross-border collaboration agreements to bind former adversaries together

- 1952 European Coal and Steel Community (ECSC)
- 1957 European Economic Community (EEC), European Atomic Energy Community (Euratom), each with its own Executive Commission
- 1965 Merger Treaty merged executive structures and budgets of ECSC, EEC, and Euratom into a single Commission of the European Communities = European Commission.
- Pan-European Research Infrastructures established as Treaty Organisations like UNO
  - CERN (1954), ESO (1962)

National radio observatories - Dwingeloo, Jodrell Bank 250-foot, Stockert, Onsala Space Observatory…

1970s

European Space Agency (ESA, 1975)

More national radio observatories – Effelsberg, Westerbork, Metsahovi,… EVN idea born

1980s

EC Framework Programs for international collaboration begin (1987) – primarily high energy Physics

More national radio telescopes - Torun, Wettzell, Medicina, Seshan, Noto,…

Science & politics in Europe. II

1990s

European Union (1993)

Framework Programs, 3, 4 and 5

JIVE (1993); SKA concept → URSI WG 1993

2000s

European Research Area (ERA, 2000)

ESFRI (European Strategy Forum for Research Infrastructures, 2002)

Framework Programs 5, 6 and 7

RadioNet (Infrastructure Cooperation Network, 2000)

ASTRONET (2005)

2010s

European Research Infrastructure Consortia (ERIC. 2009)

ERIC #10: JIV-ERIC (2014)

Framework programs → Horizon2020 (2014)

SKA becomes a legal entity

2020s

Horizon Europe

Increasing Europeanisation