A Unique Insight into National Mapping's Programs

Carl McMaster and Paul Wise

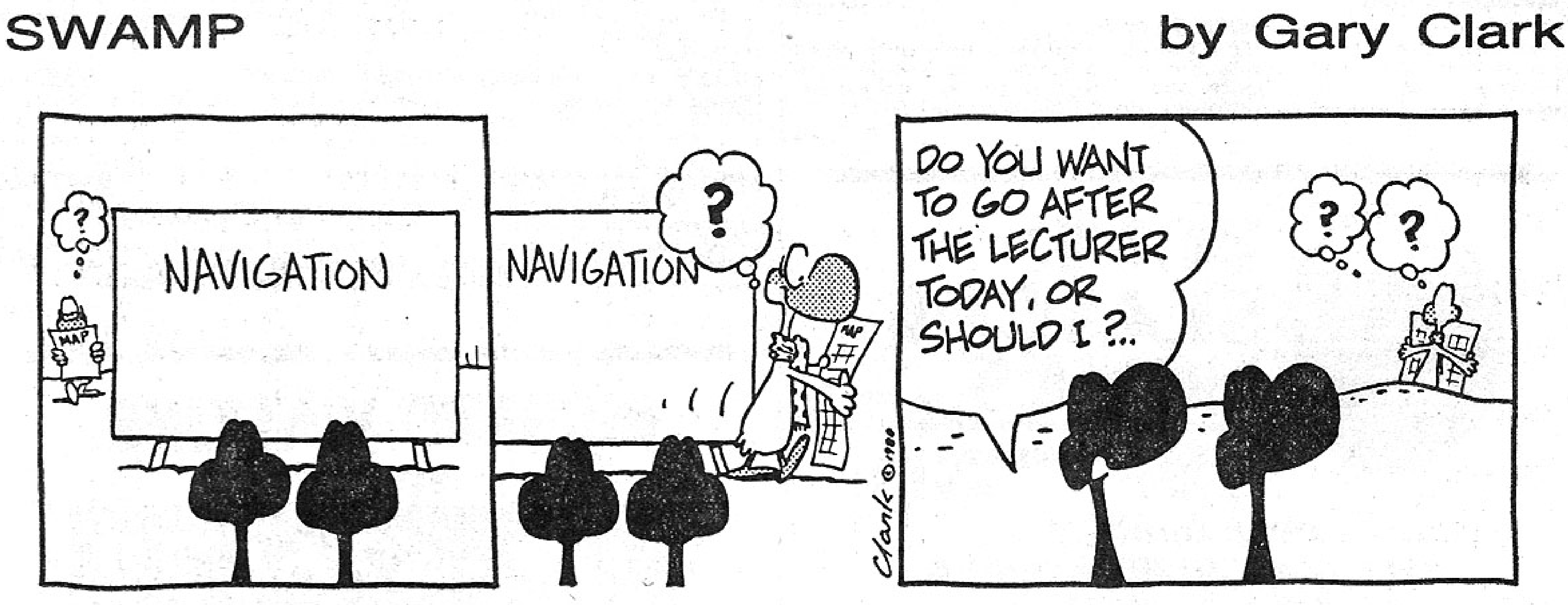
400 Years of Mapping Australia

Darwin, 23 - 25 August 2006

1960s – 1970s era

The Division of National Mapping (Natmap)

- Federal Government's civilian mapping agency
- Responsible for the majority of Australia's 1:250 000 scale and 1:100 000 scale mapping


SWAMP
by Gary Clark
NAVIGATION
?
MAP
NAVIGATION
?
MAP
DO YOU WANT TO GO AFTER THE LECTURER TODAY, OR SHOULD I ?..
?
?
Clark

In the 1960s

The national horizontal and vertical control networks:

- were sparse

- would need to be intensified (rapidly & accurately)

  - to suit aerial photography (primary data source)

  - for use in stereo-plotters (Wild B 8, Kern PG 2)

Our paper describes the technology and processes Natmap used to fulfil this task using:

1 - 'Natmap early days, map compilation from aerial photographs 1948 - 1970s', by Dave Hocking.

2 - ‘Division of National Mapping Aerodist Program' Technical Report. No 27, by Carl McMaster

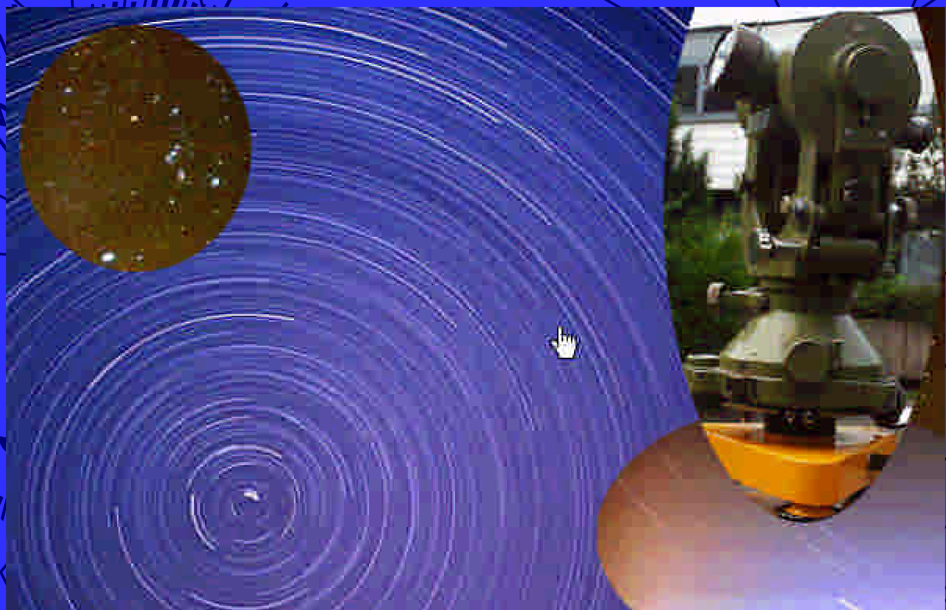
3 - ‘Laser Terrain Profiling’, Division of National Mapping Technical Report No. 26, by Paul Wise

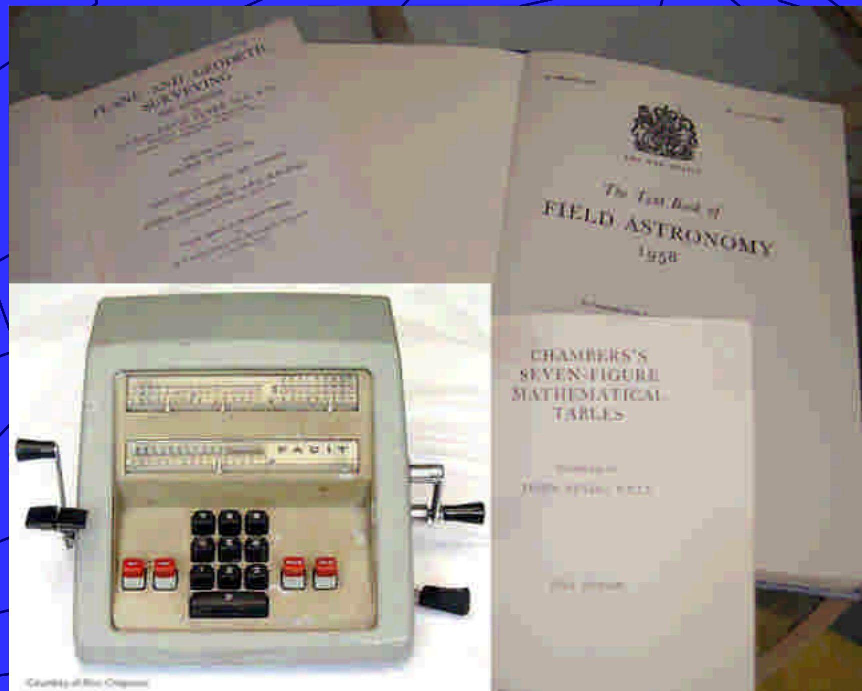
Remember that in the 1960s:

- the mobile phone

- computer

- positioning system





Aerial photography was:

- the foundation of all Natmap mapping

- acquired by Defence, Contractors and Natmap

- controlled by the best available
  horizontal and vertical information

(Courtesy Rapid Color, Inc.)

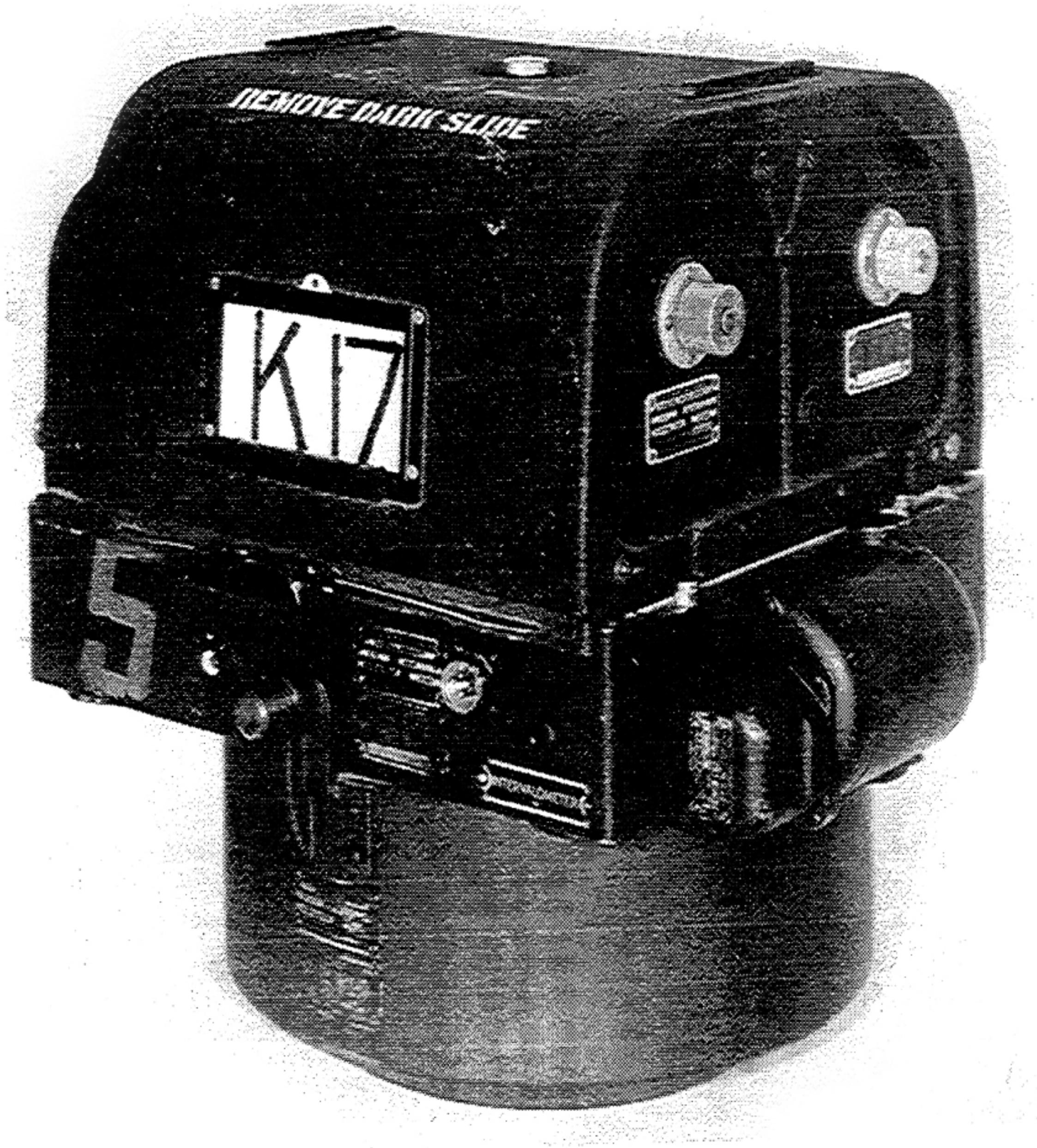
First of two eras of aerial photography

Late 1940s-early 1950s

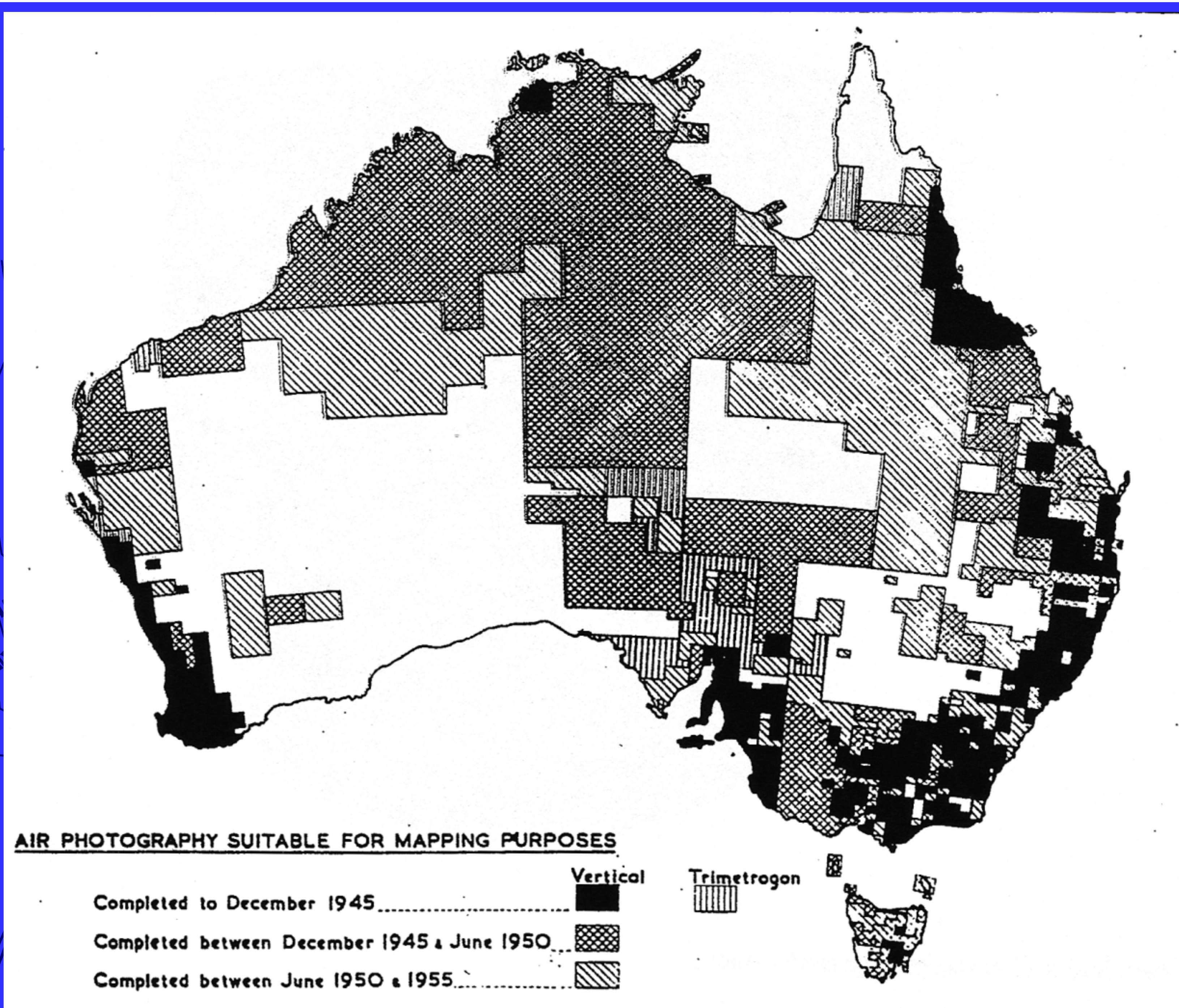
- 1:50 000 scale with Fairchild K17 camera

- Obtained from 25 000 feet by RAAF, 87 PR (Photo Reconnaissance) Squadron

- Base data for the 1:253 440 and 1:250 000 scale R502 map series


REMOVE DARK SLIDE
K17
5

To
1955


AIR PHOTOGRAPHY SUITABLE FOR MAPPING PURPOSES
Vertical
Trimetrogon
Completed to December 1945
Completed between December 1945 & June 1950
Completed between June 1950 & 1955

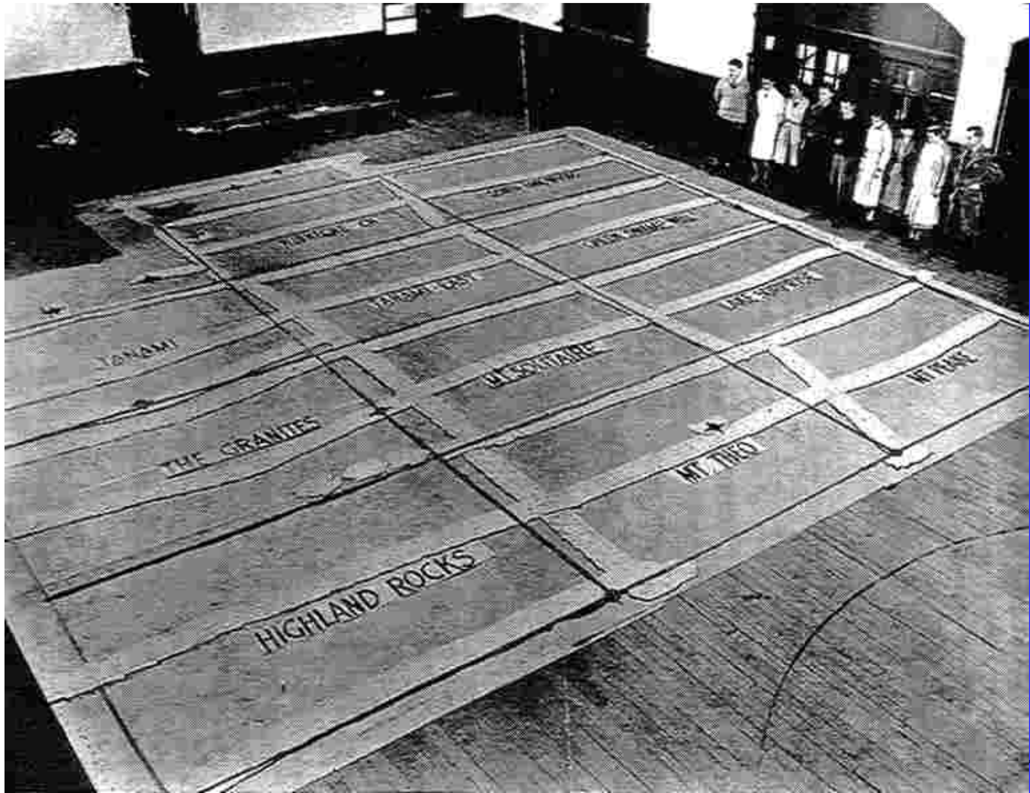
Photomaps

Photomaps at 1:253 440 or 4 miles to the inch scale:

- prepared from unrectified K17 aerial photographs

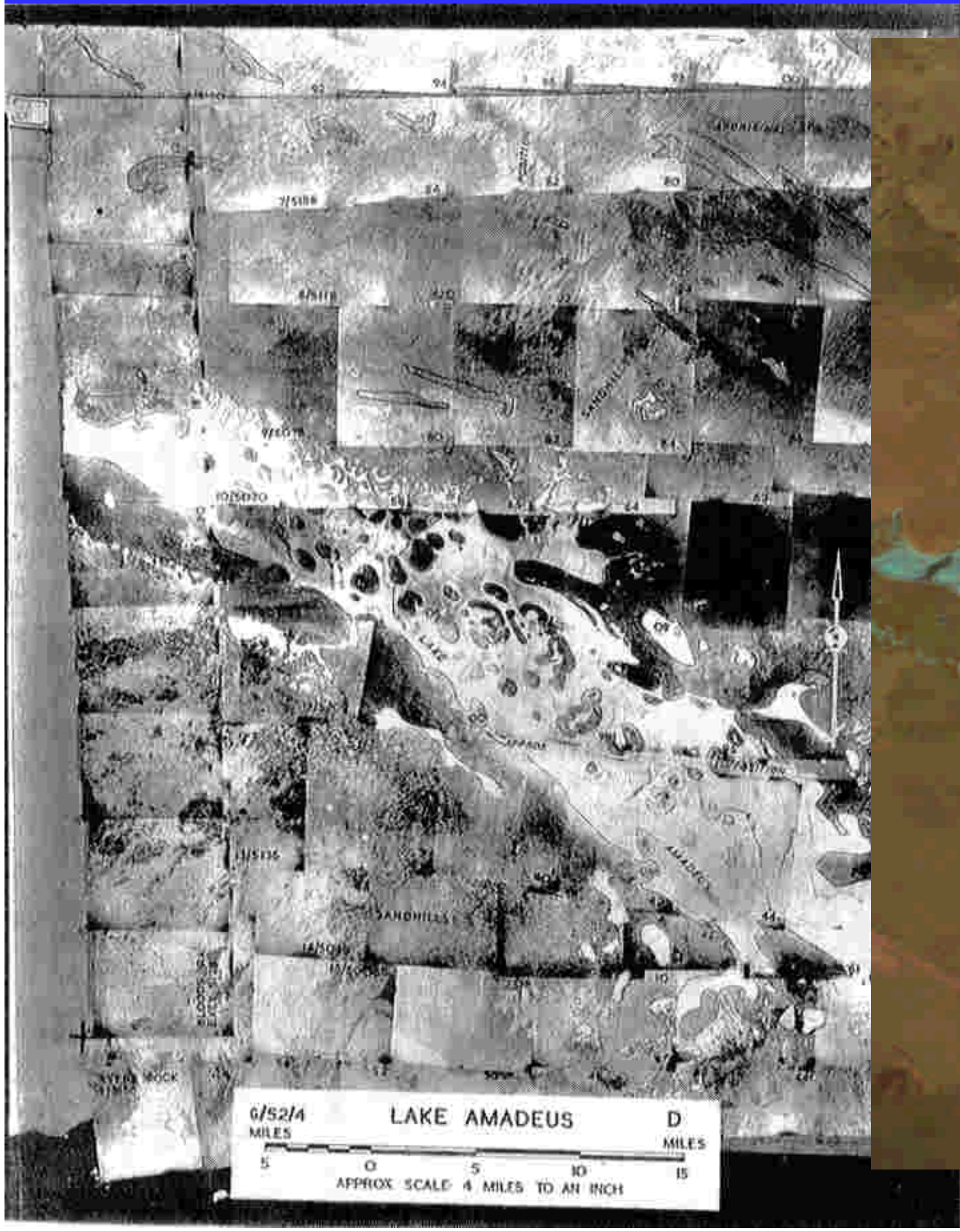
- controlled by slotted template generally based on astronomical fixations

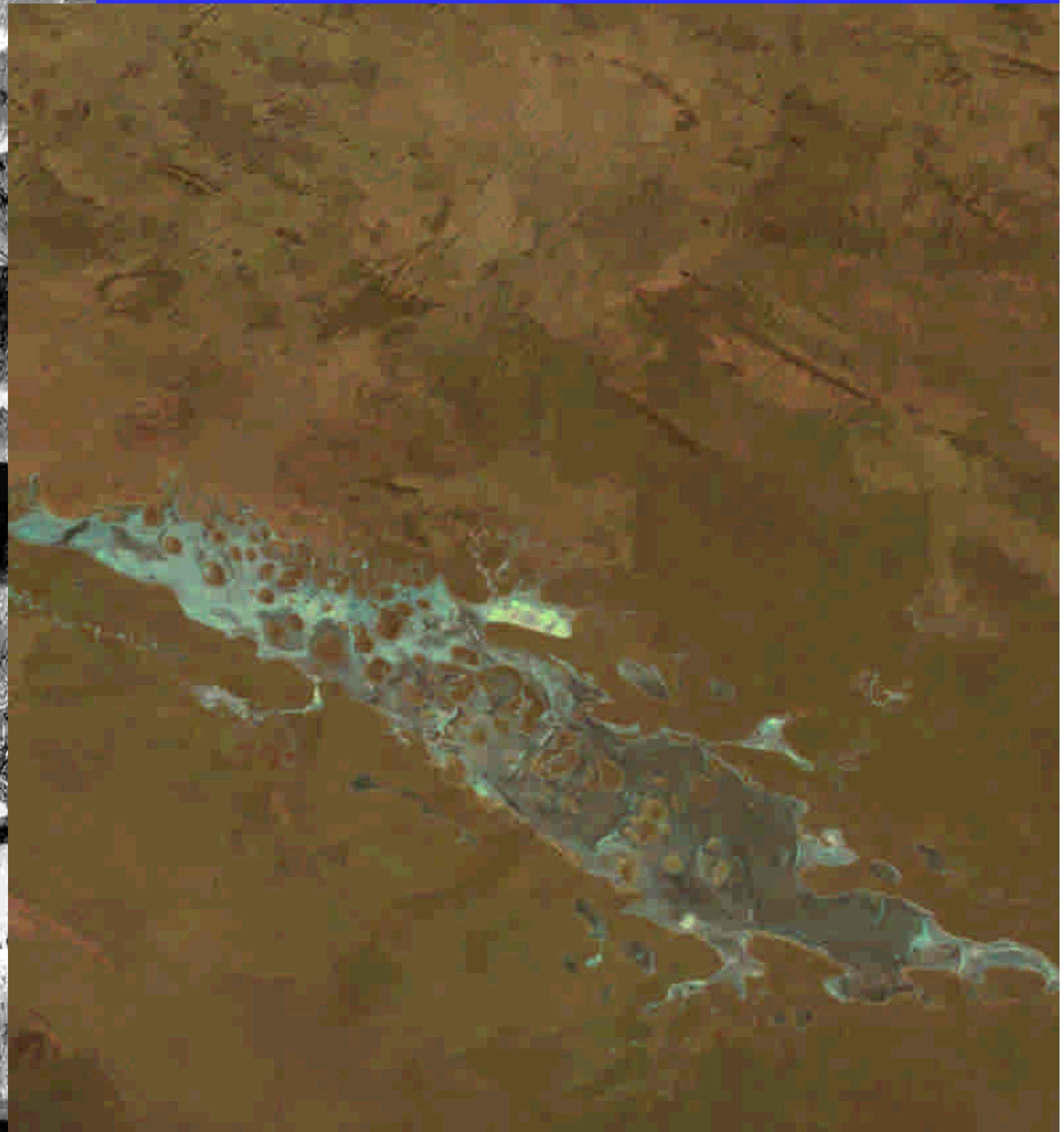
Compiling Photomaps



Photomap

Landsat ETM





Second era of aerial photography:

Early 1960s – 1970s

- 1:80 000 scale with Wild RC9 or RC10 camera

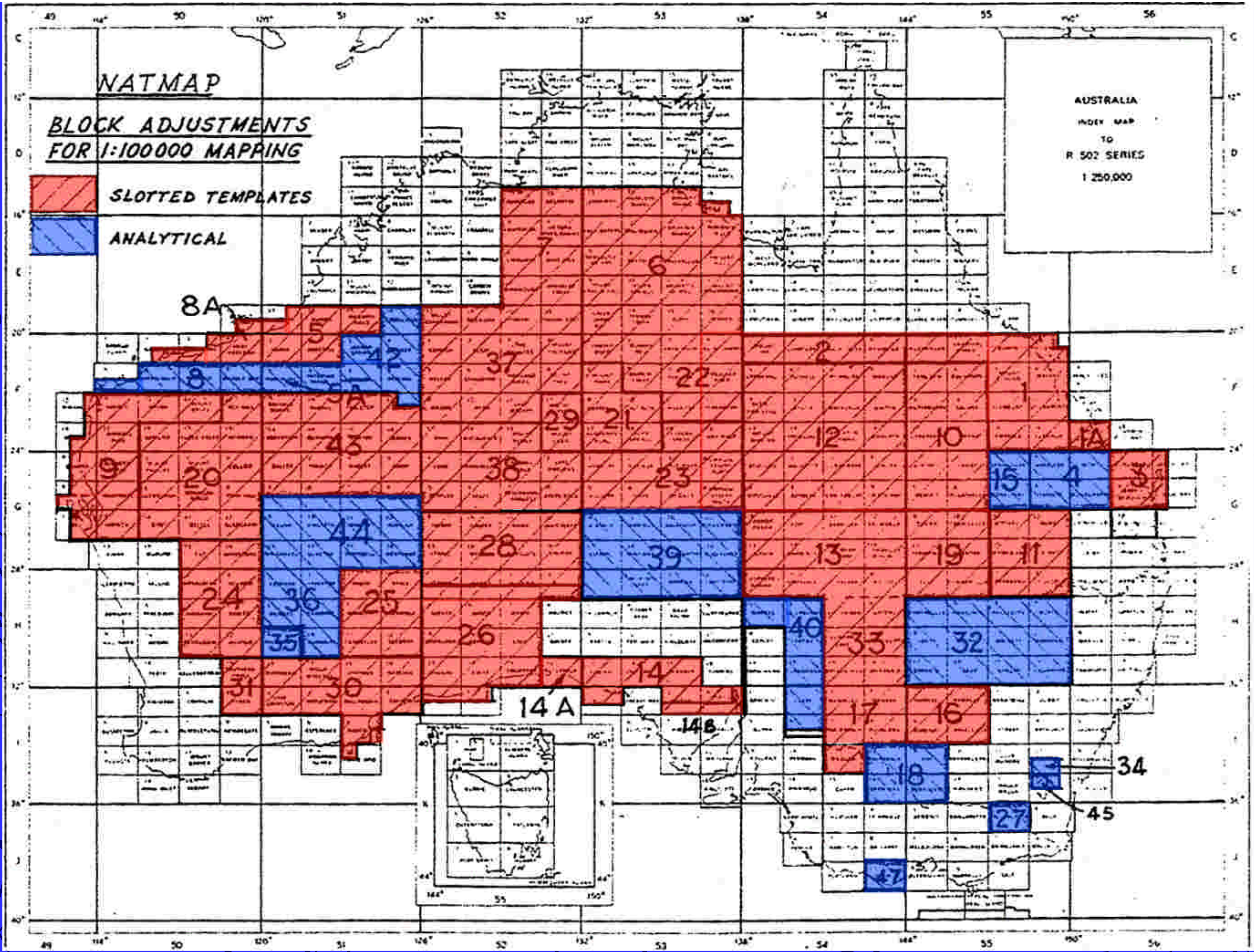
- Obtained from 25 000 feet by contractors / Natmap

- Base data for the 1:100 000 and 1:250 000 scale National Topographic Map Series

- Controlled by slotted template generally based on first & second order survey control

Wild
RC9 & 10
Cameras

On
Oxygen


NATMAP
BLOCK ADJUSTMENTS FOR 1:100000 MAPPING
SLOTTED TEMPLATES
ANALYTICAL
AUSTRALIA
INDEX MAP
TO
R 502 SERIES
1:250,000
8A
5
42
8
5A
7
6
37
22
2
1
29
21
12
10
1A
43
38
23
9
20
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33
32
35
31
30
14
14A
14B
17
16
18
34
45
27
47

Slotted Template Assembly (STA)

History

- Used by Natmap from 1948

- Typically a number of 1:250 000 scale map areas formed a STA “block”

- In 1970s in-house analytical aerotriangulation commenced

- By 1980s STA replaced by contract analytical aerotriangulation

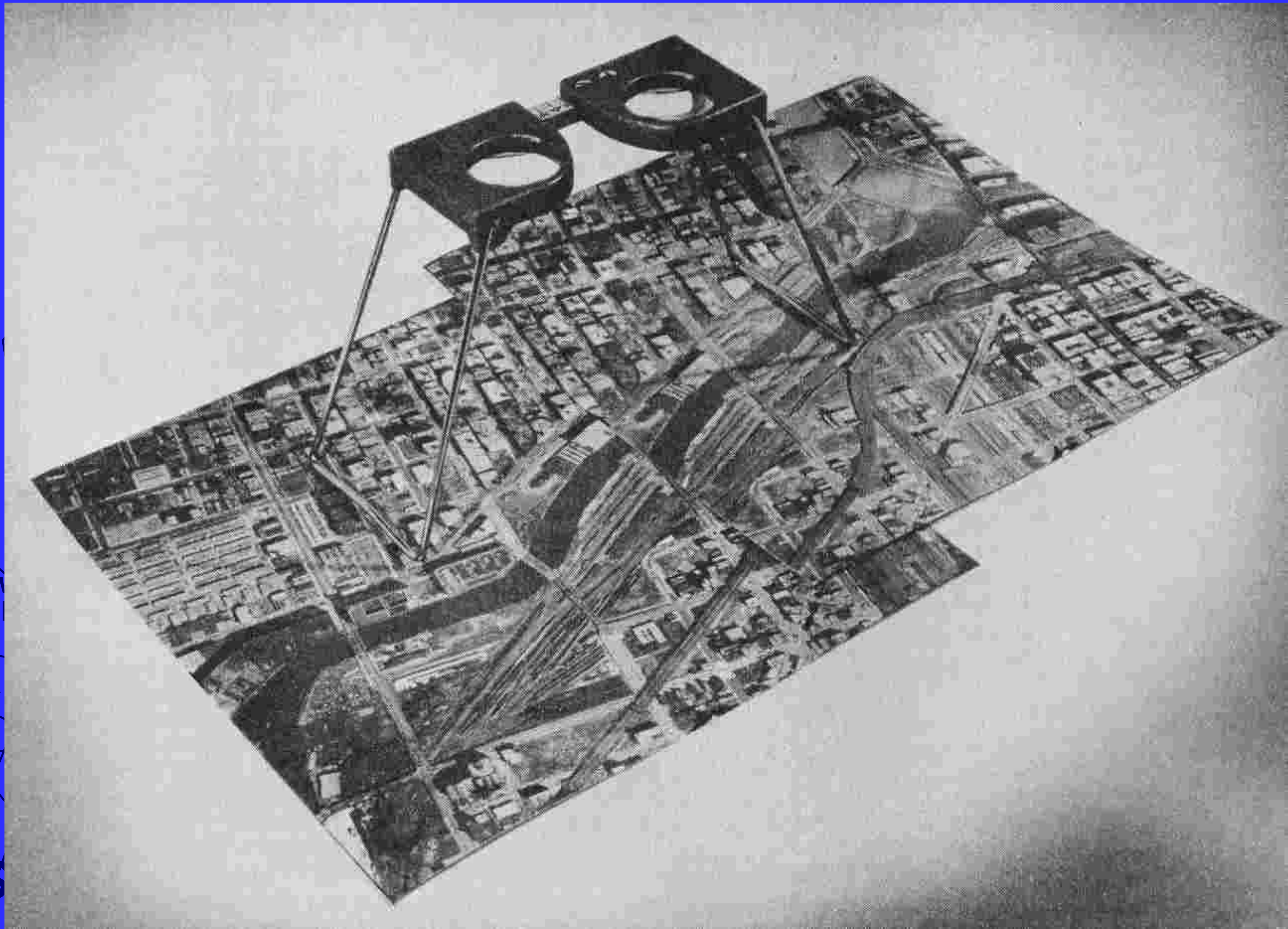
Slotted Template Assembly (STA)

Advantages

- Australia's inland undeveloped areas were relatively flat with slopes of less than 5 degrees

- Graphically determined horizontal control for each 1:80 000 scale stereo-model

- Gave direct transfer of minor horizontal control positions to compilation sheets



Example of a Stereo-model

Example

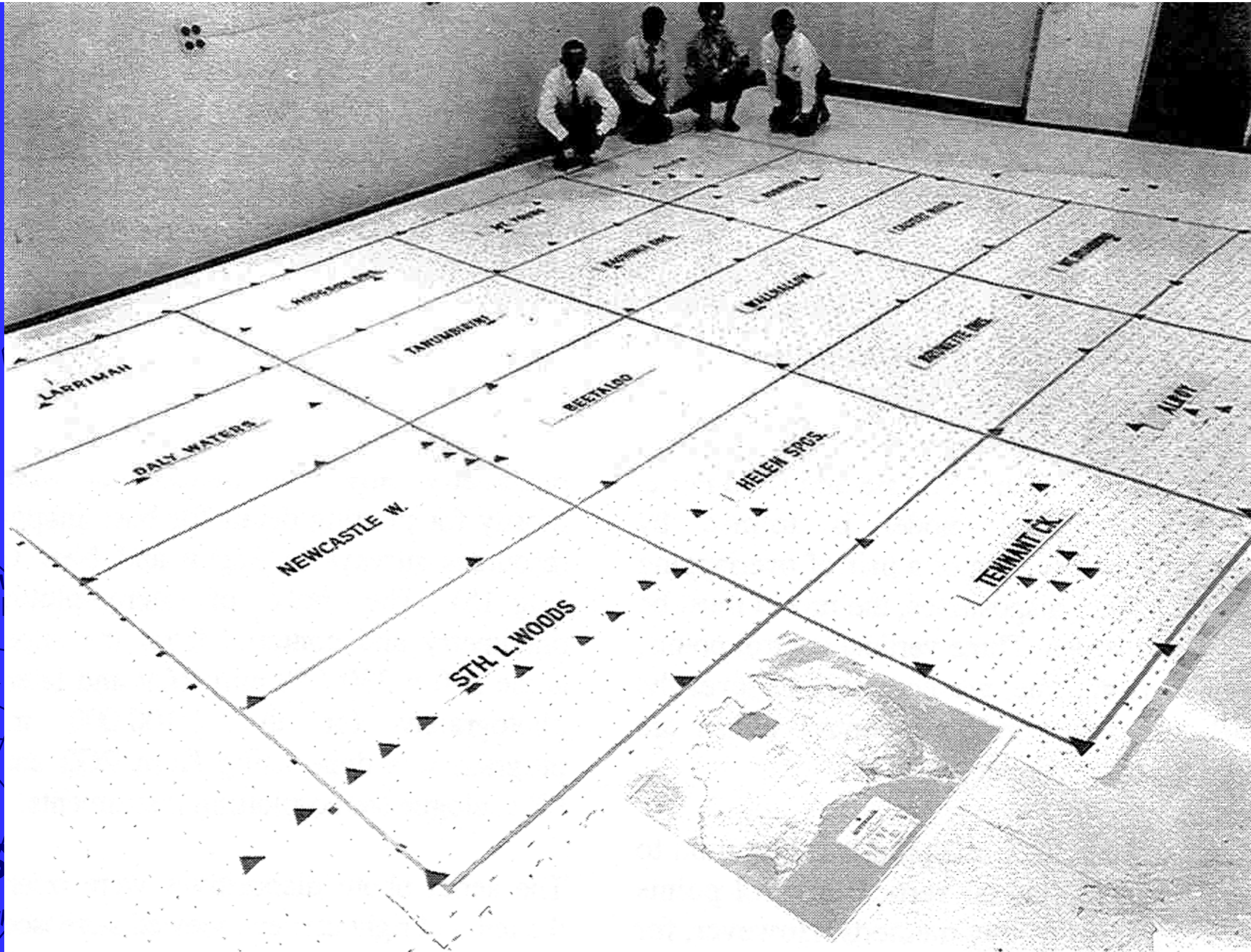
STA Block 6 in the Northern Territory

- Covered 19 x 1:250 000 scale map areas

- Comprised 3076 templates

- Used 6600 studs

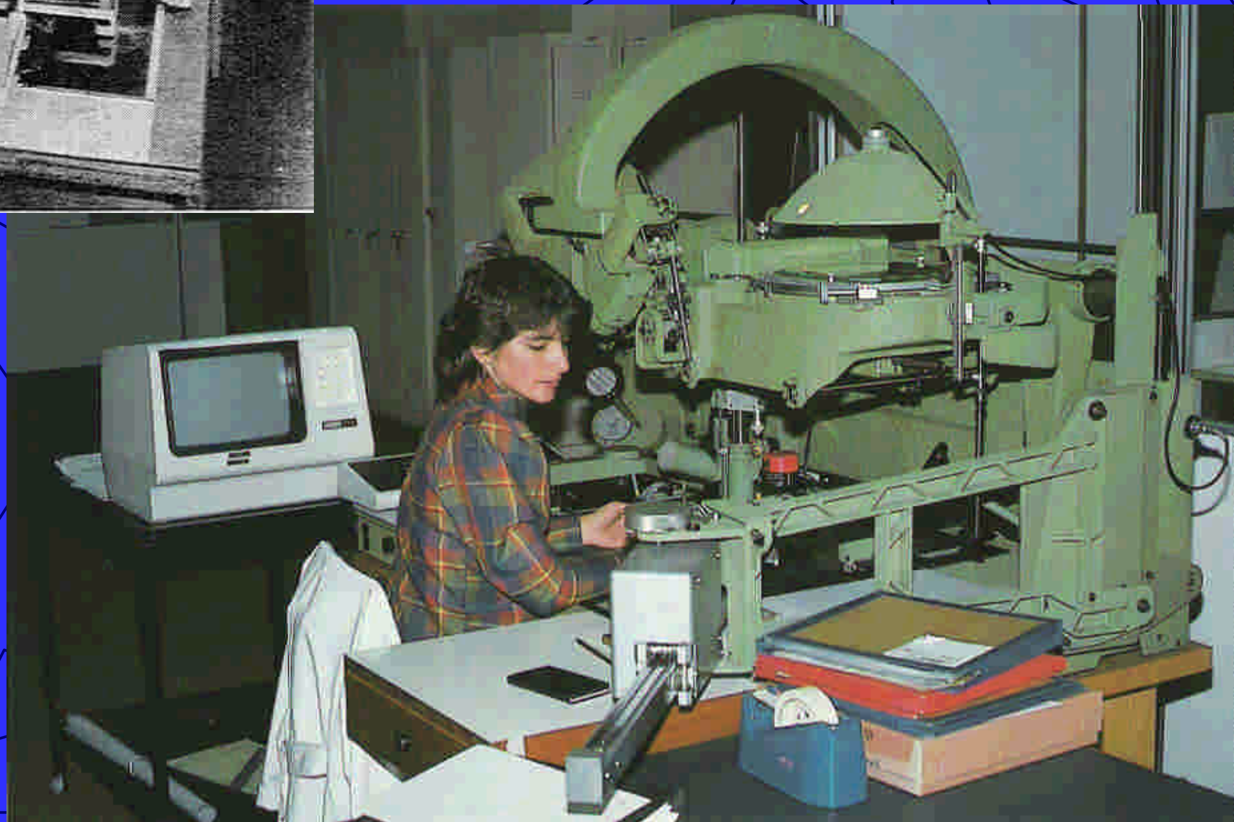
- Covered 315 000 sq.km.
  (approx combined area of the states of Victoria and Tasmania)


LARRIMAH
TANUMBIRINI
DALY WATERS
BEETALOO
NEWCASTLE W.
HELEN SPGS.
STH. L.WOODS
TENNANT CK.

Block 6 STA

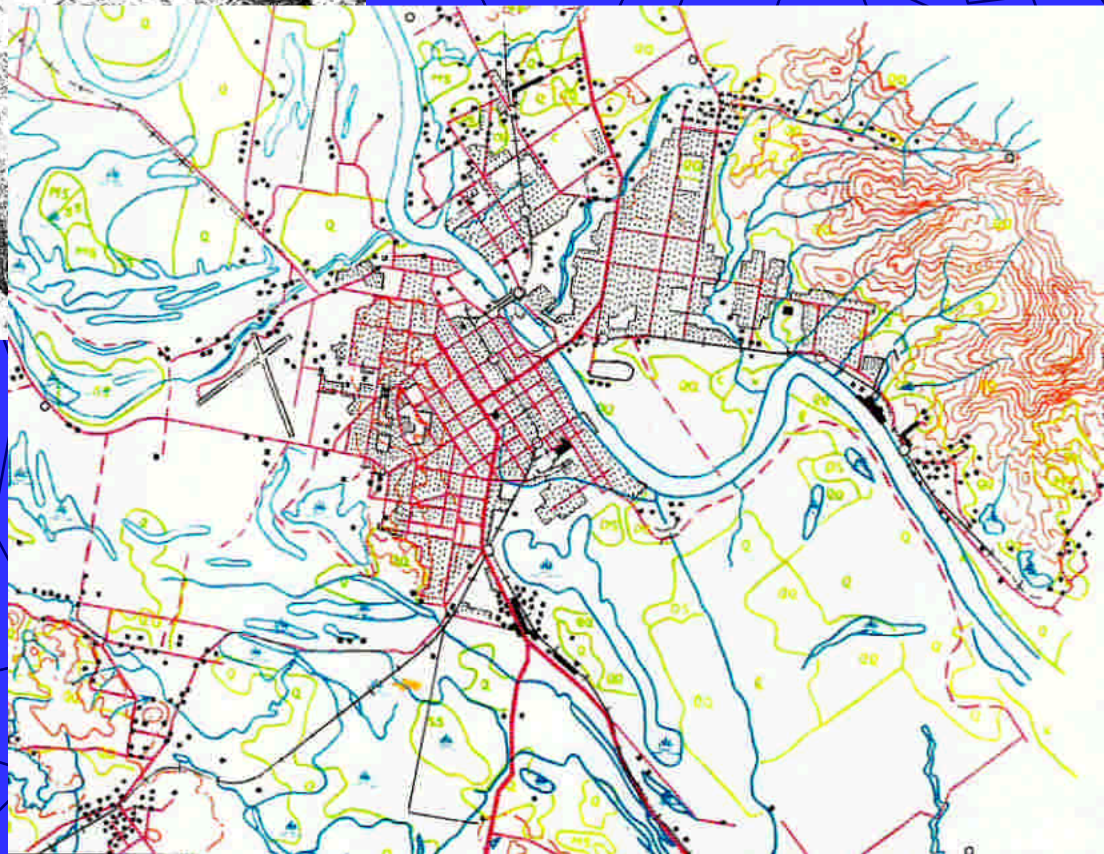
Stereoplotting

Stereotope



Wild B8

Stereo-model
to
Map compilation
via
stereoplotting



Until the 1960s

Horizontal control provided by:

- primary geodetic survey networks plus
    - astronomic observations &
    - identified survey marks

Vertical control provided by:

- 3rd order level traverses plus
    - barometric heighting

To accelerate the mapping program Natmap introduced:

- **Aerodist** – Airborne distance measuring

- **Airborne profiling** – APR – Airborne profile recorder
  LTP – Laser terrain profiler

While "data gathering" was "state of the art" majority of data "reduction" was manual

Although labour intensive allowed errors to be 'trapped' and 'isolated' as they occurred

Errors did not accumulate

Natmap Aerodist
1963 – 1974

- Provided horizontal control for 1:100,000 scale mapping over 50%+ of Australian mainland

and

- extended the survey network to Islands / Reefs off northern Australia

Before 1963

Sparse astronomical observations in-filled the geodetic survey network established by triangulation and EDM traversing

Astro obs accuracies (horizontal) ~ 30 metres

3rd order levelling and barometric heighting for vertical control

1:100 000 scale map program required horizontal control at:

- a minimum of 1 degree grid spacing

- an accuracy of ±3 m

Therefore needed to extend measuring range between non-intervisible points in flat areas of the continent

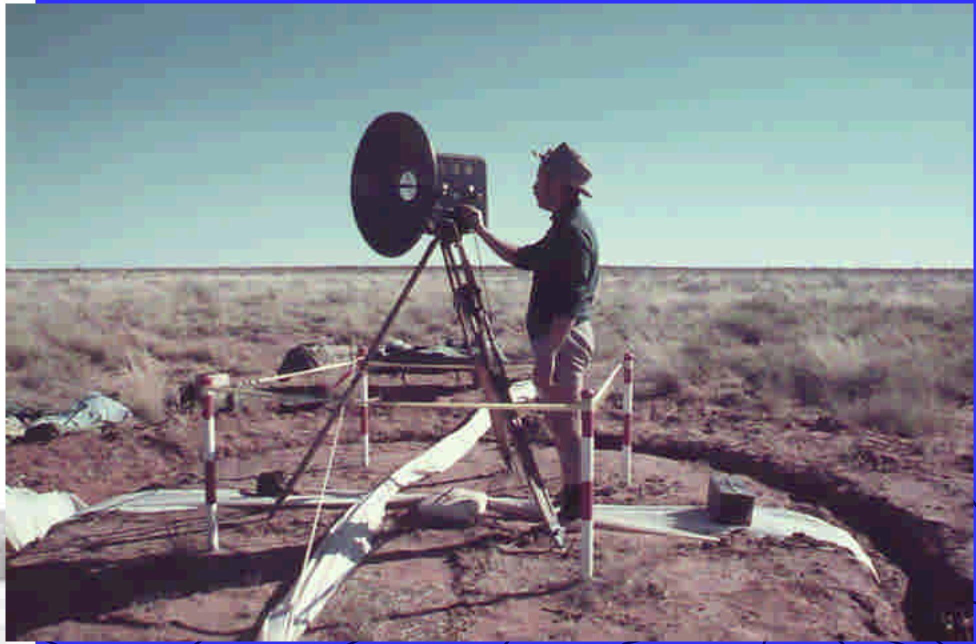
Thus Natmap purchasing approval in 1960 for an

Aerodist : airborne EDM (Tellurometer) system

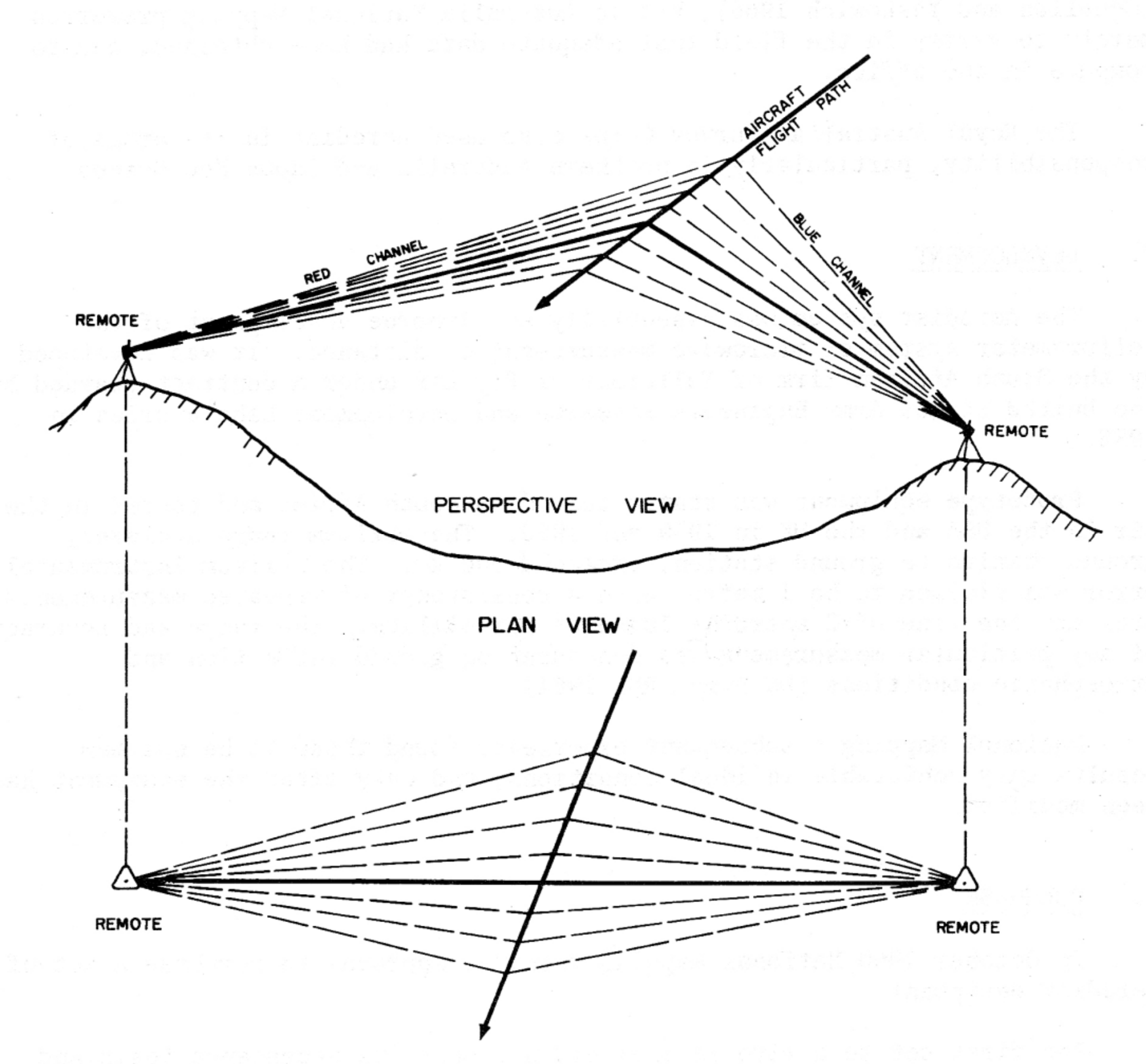
Original & later master antennae on Aero Commander aircraft

Master equipment rack in aircraft

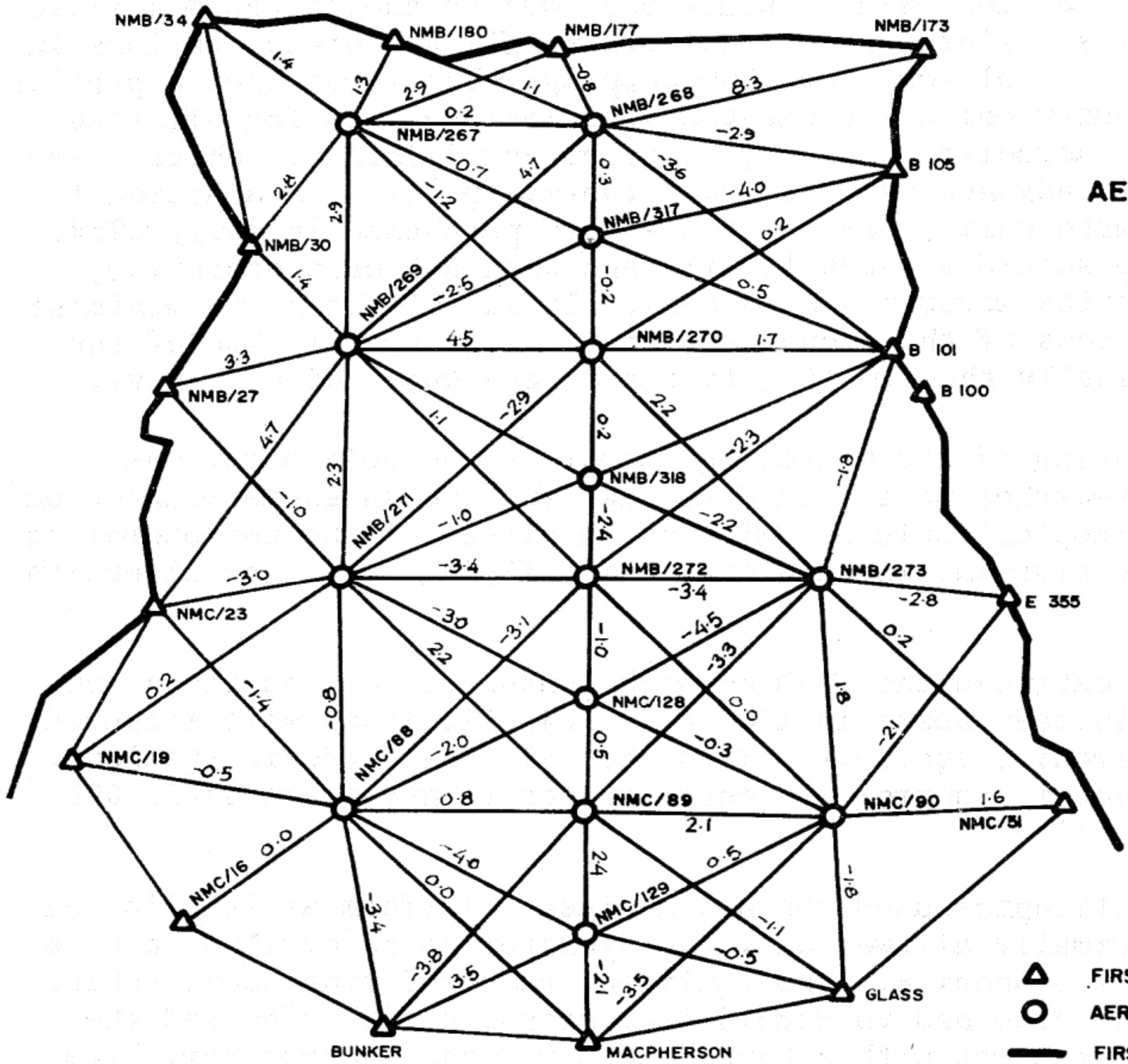
Remote operations



Aerodist line crossing

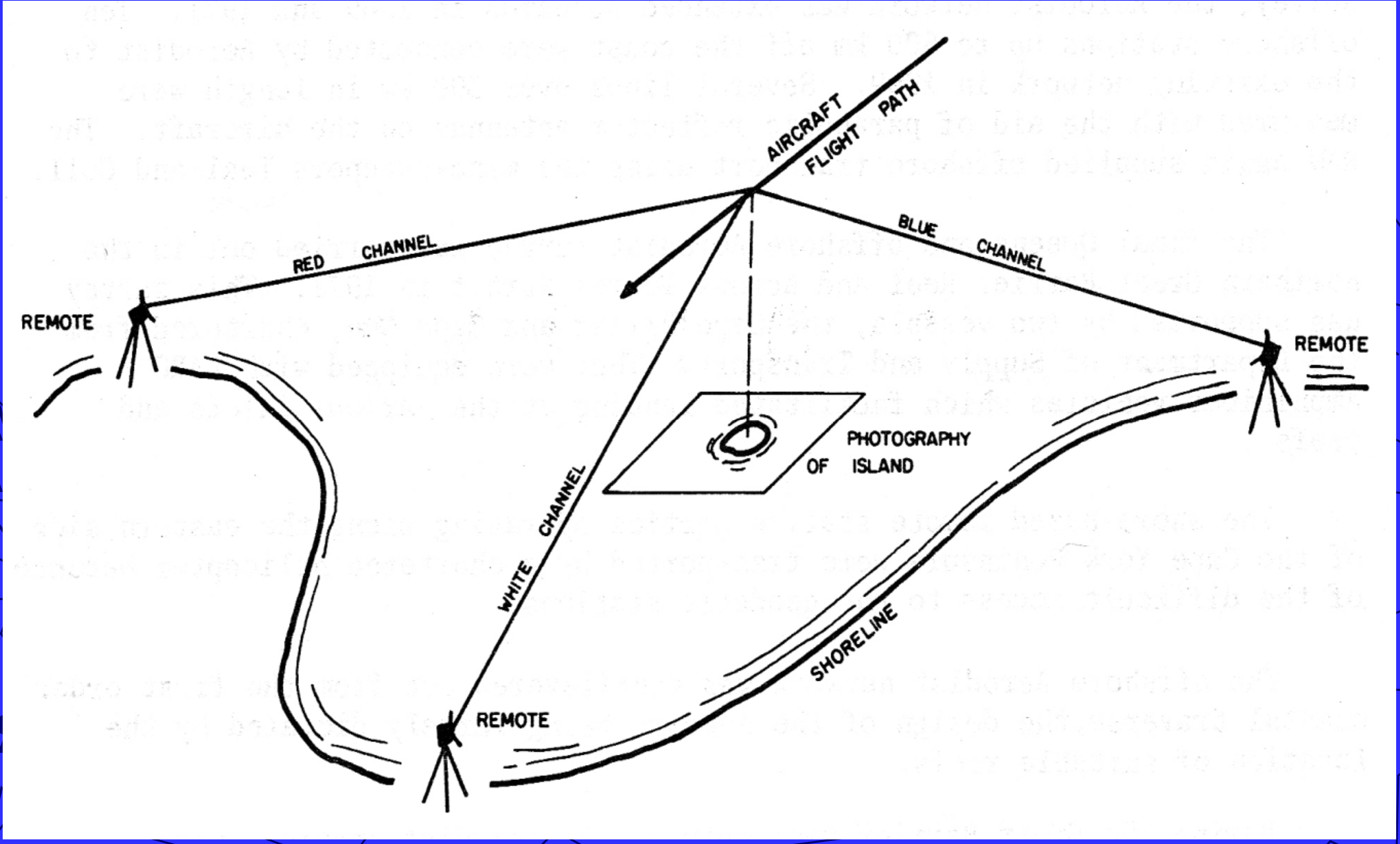


AERODIST BLOCK 15



△ FIRST ORDER STATION
○ AERODIST STATION
━ FIRST ORDER TRAVERSE
— AERODIST LINES
2·1 RESIDUALS IN METRES (OBSERVED — ADJUSTED)

Aerodist trilateration



Aerodist Field Operations

- Rapid and cost effective

- Key factors :

. planning vehicle movements

. Logistics (helicopter support)

. communications (base station – aircraft - remotes)

. electronic equipment maintenance in field

New Work Practices with Aerodist

- Survey skills + EDM operations and maintenance

- Electronic data processing for distance calculations

- Large scale block adjustments to fit perimeter geodetic control to provide AGD coordinates

- Software written in-house

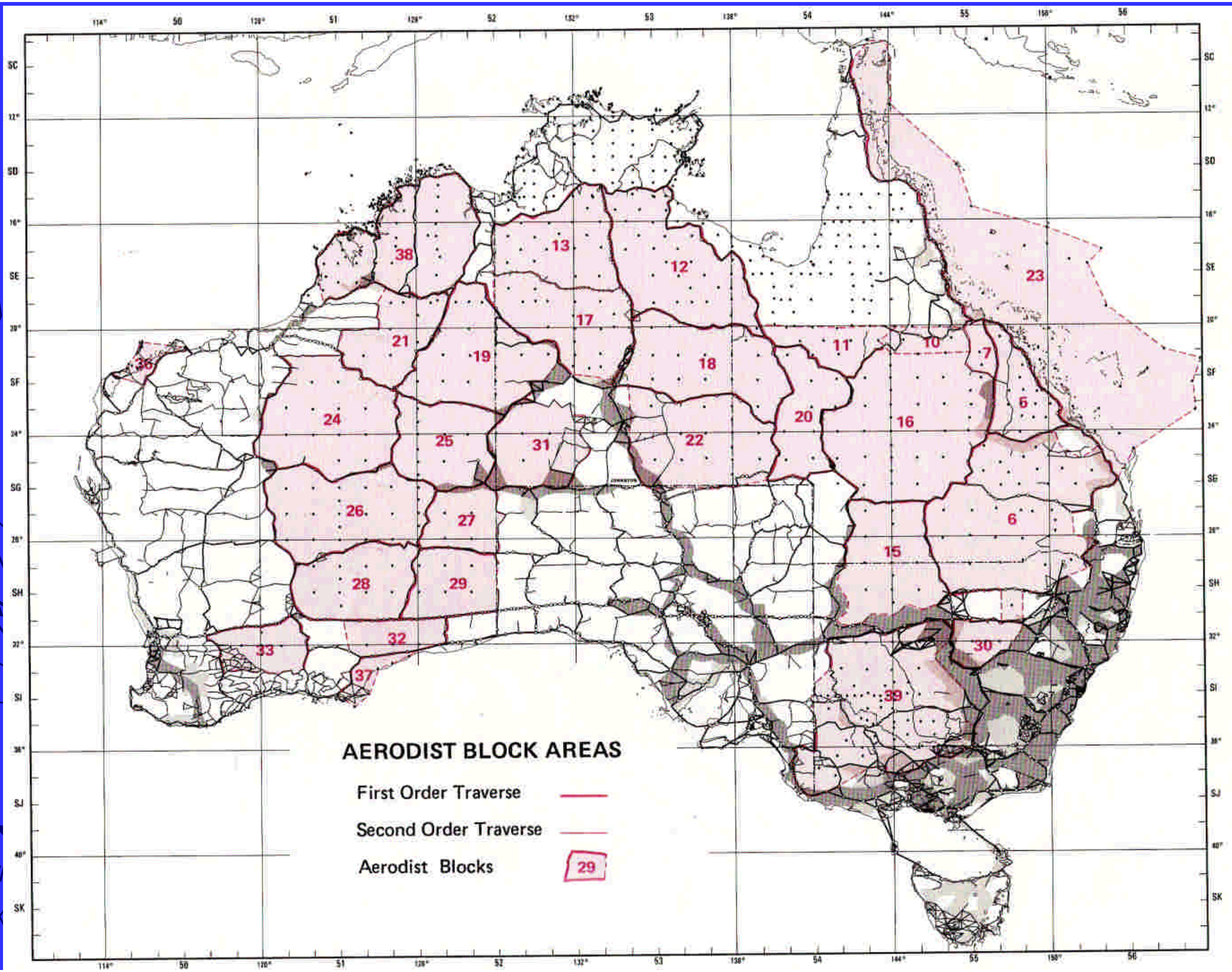
Aerodist History

- 1961/62 Trials, Testing, Training in Bell 47J helicopter (from 1965 Aero Commander high-wing aircraft)

- 1963 Ten man survey party measured 66 lines to fix 17 stations in 6 weeks in SE Queensland

- Annual field surveys with 517 lines in 1972 measured in 34 weeks in WA from the Great Sandy Desert to the Nullarbor

- Program completed in 1974 with over 3000 lines measured to fix 480 stations


AERODIST BLOCK AREAS
First Order Traverse
Second Order Traverse
Aerodist Blocks
29

Aerodist Accuracy

- Aerodist Varycord adjustments gave an average difference between observed and adjusted distances of 1.49 metres for a 100 km line

- For the twenty-nine adjustments average maximum residual 6.3 metres (0.06 mm at 1:100 000 scale)

- Subsequent Tellurometer traverses or JMR fixes at Aerodist stations verified Aerodist coordinates to better than 5 metres

Aerodist surveys


PERILS
FACED BY
THE
REMOTE
OPERATOR
by GBL

Laser Profiling
1970 – 1981

- 250 000 kilometres of laser profiling

- provided 1:100 000 scale vertical control over 30%+ of Australian mainland

and

- upgraded the vertical control over a further 20%

Before 1970

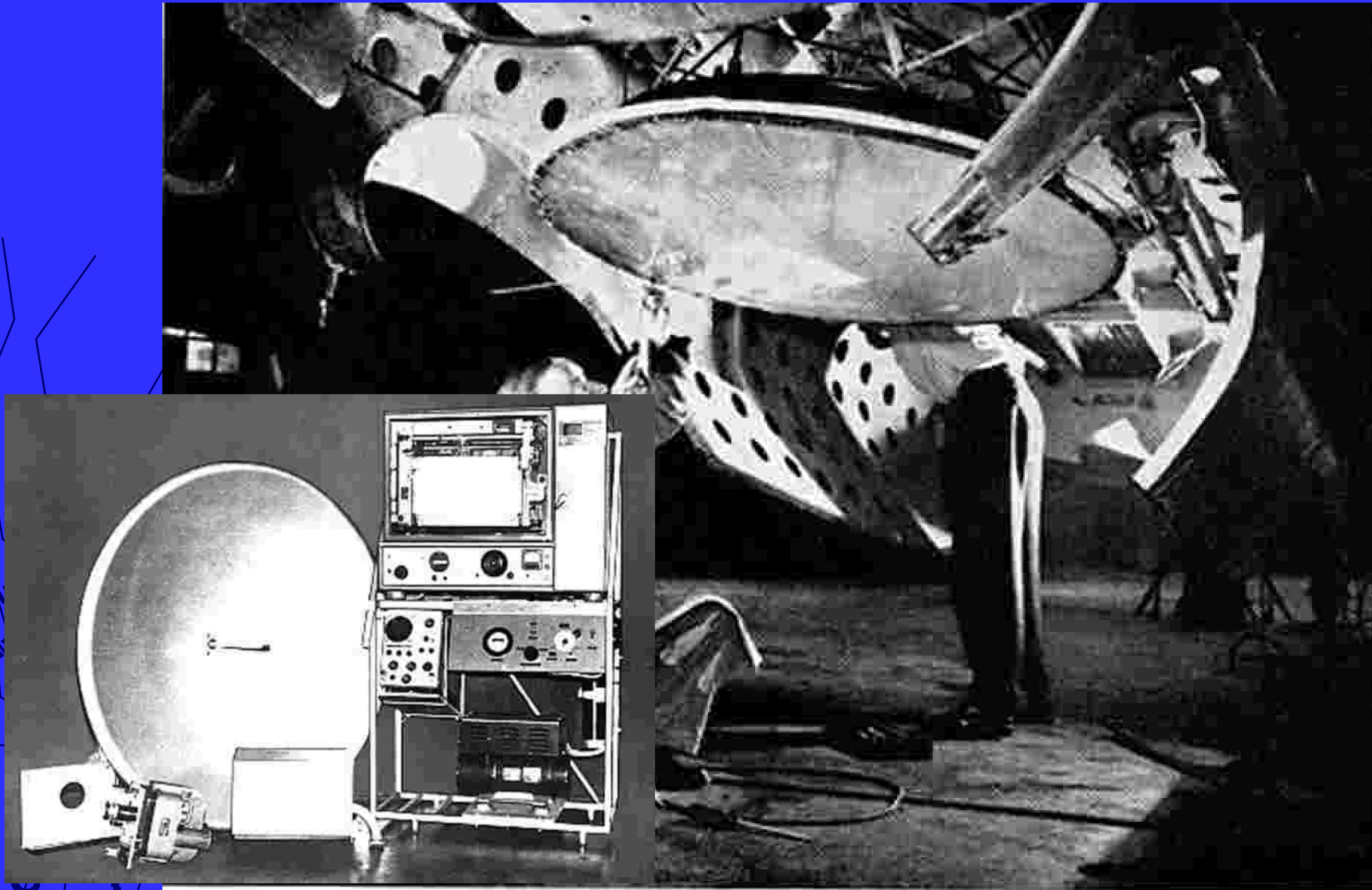
Vertical control initially provided by:

- 3rd order levelling
- barometric heighting

Subsequently:

- Radar based Airborne Profile Recording (APR)

New laser technology provided more accurate system



Fitting the "dish" receiver for an Airborne Profile Recorder into a Lockheed Hudson.

Airborne Profile Recorder (APR) System

Laser Terrain Profiler (LTP) Components

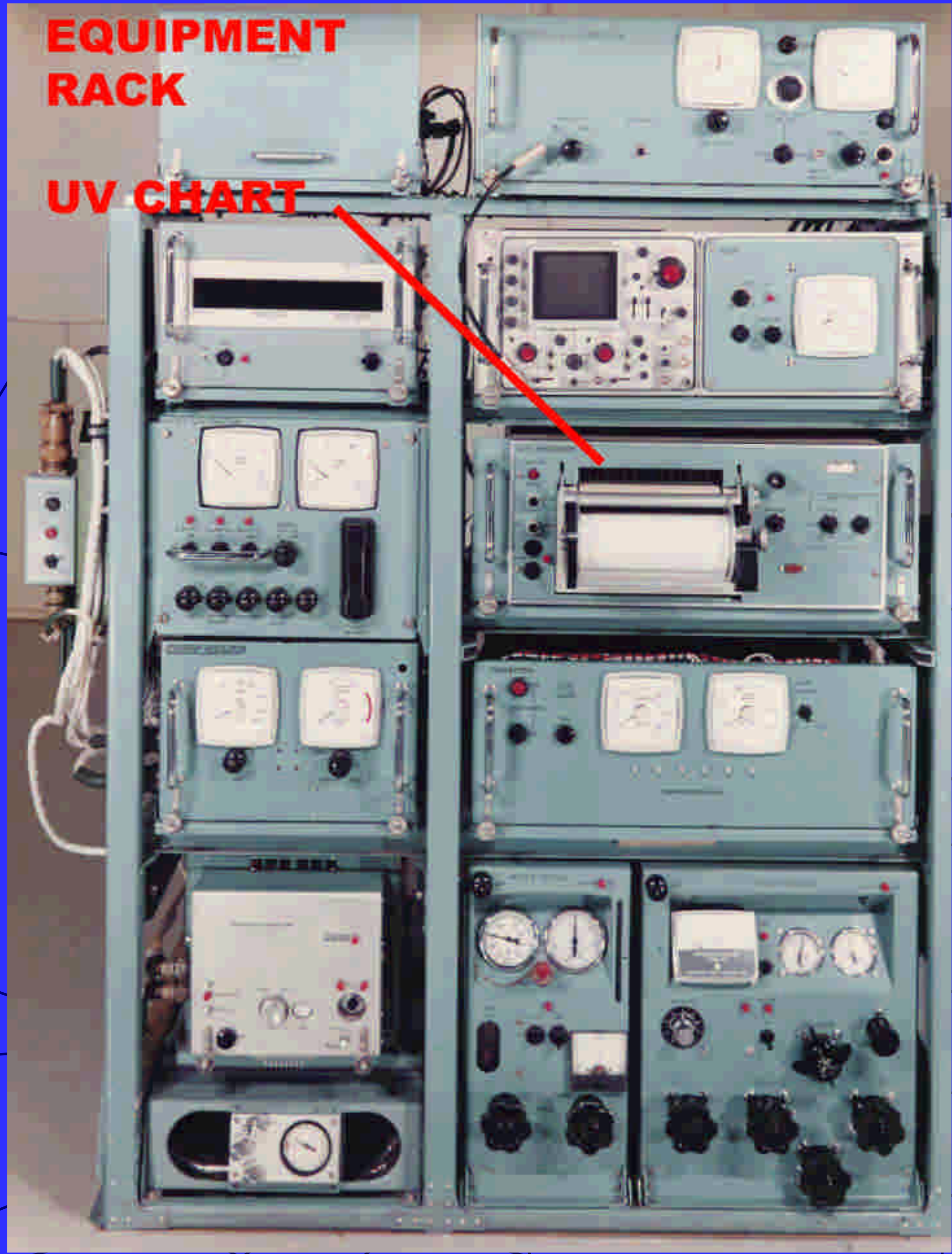
- Laser distance measuring system
  (laser emitter and receiver)

- Continuous-strip 70 mm camera to record the track

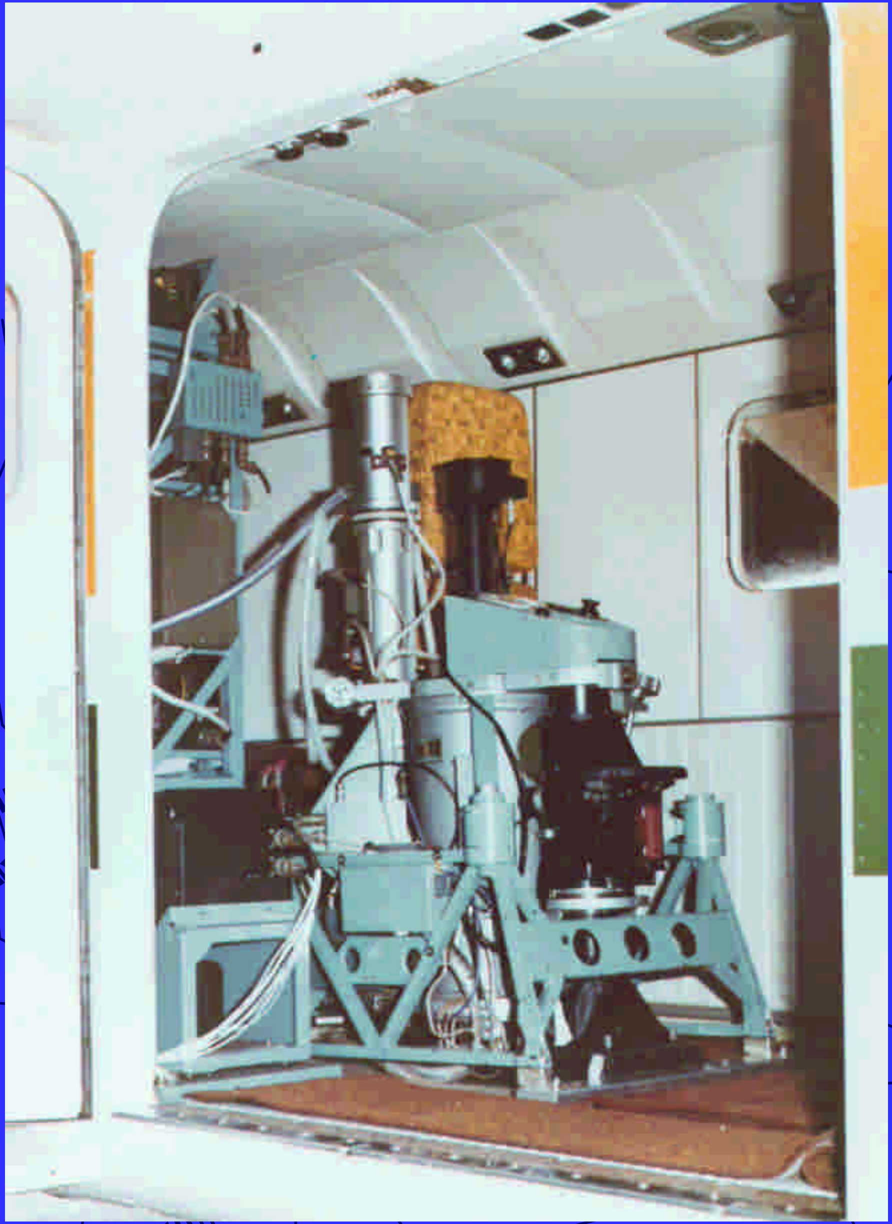
- Barometric reference unit to establish height datum

- Gyroscopes to sense the attitude of the aircraft

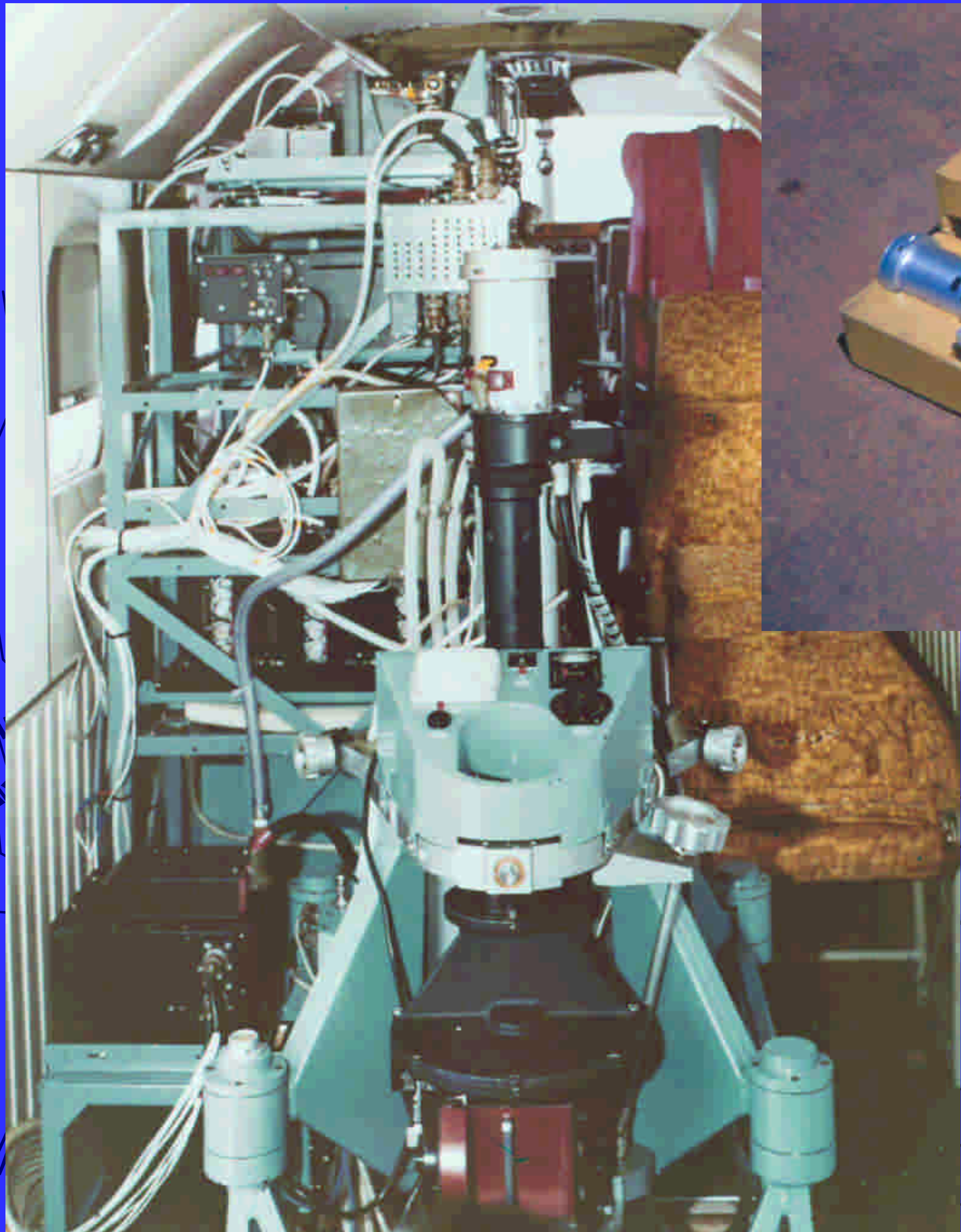
- Ultra-violet sensitive, paper recorder for data display



Laser Terrain Profiler (LTP) System



LTP System in NOMAD N22B



Laser removed for repair

&

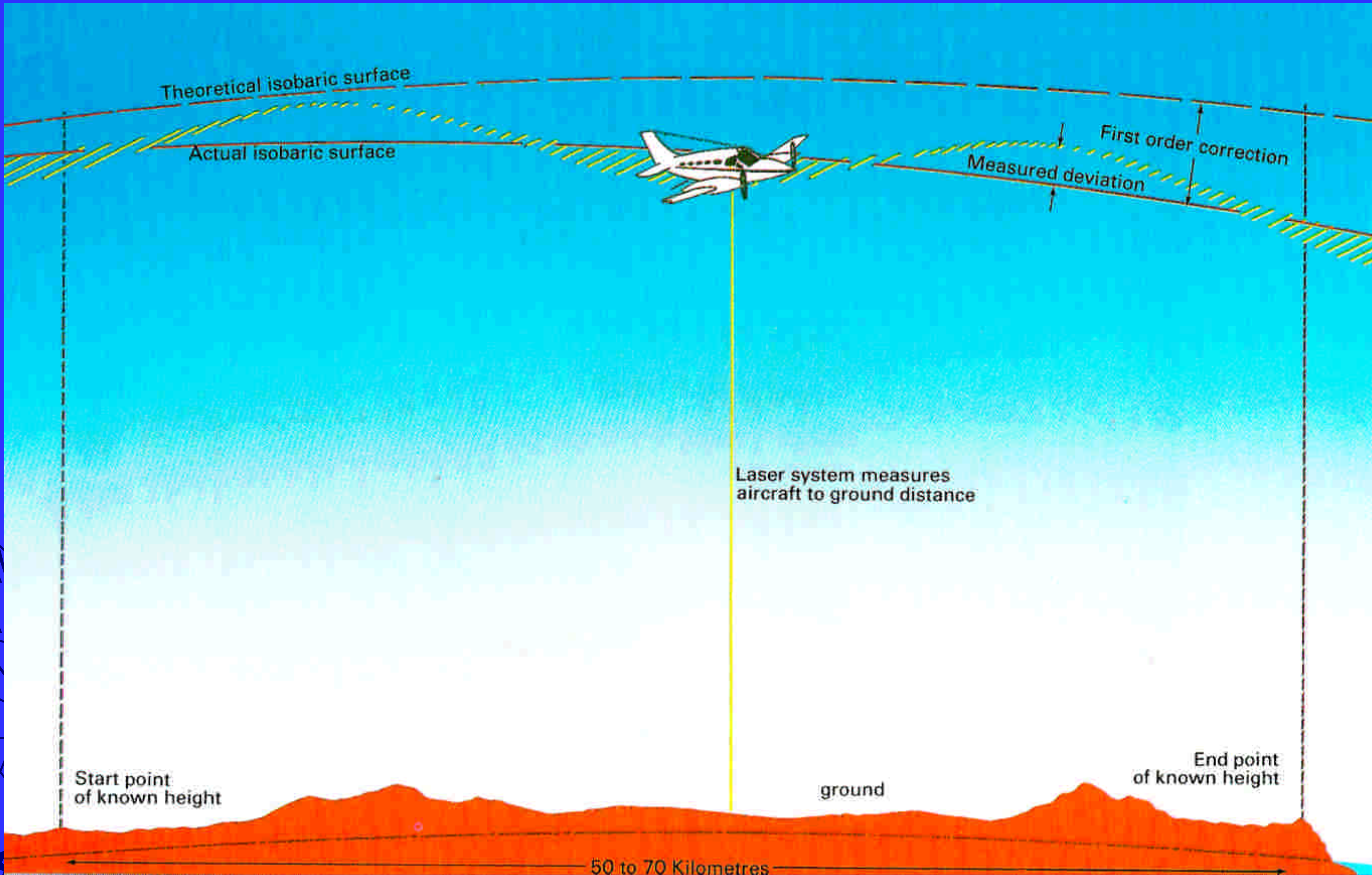
further view of LTP installation

Principle of airborne profiling

- Fly along a pressure surface, continuously measuring any deviation from that surface (Δd) and the distance between the ground and aircraft (d)

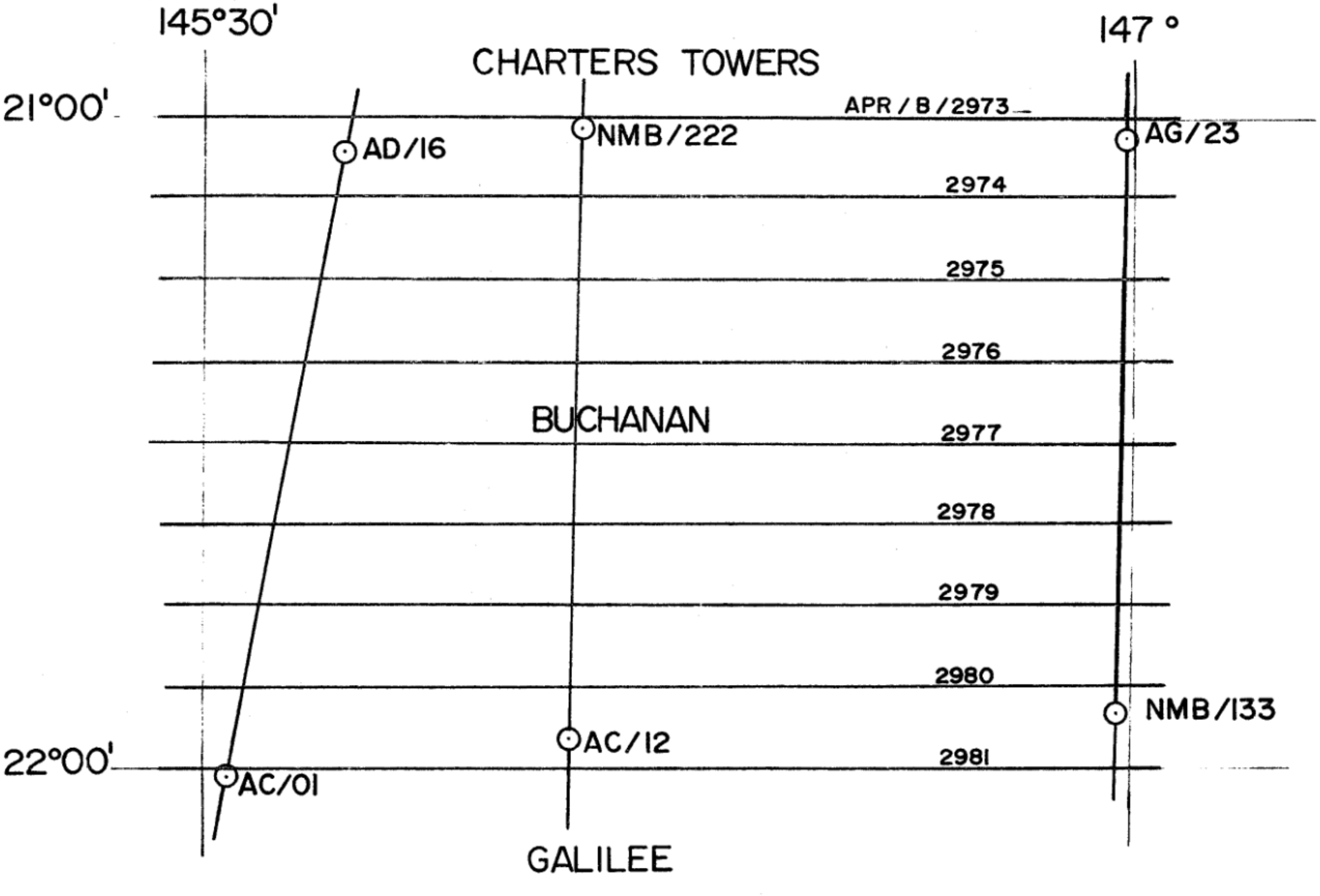
- Using points of known elevation at the start and finish of each flight line establish the flight height datum (h) and any misclose (Δh)

- The height of any intermediate point is the flight height datum less the sum of the other components (h – (Δh + d + Δd))



PRINCIPLE OF AIRBORNE PROFILING

LTP SURVEY BUCHANAN



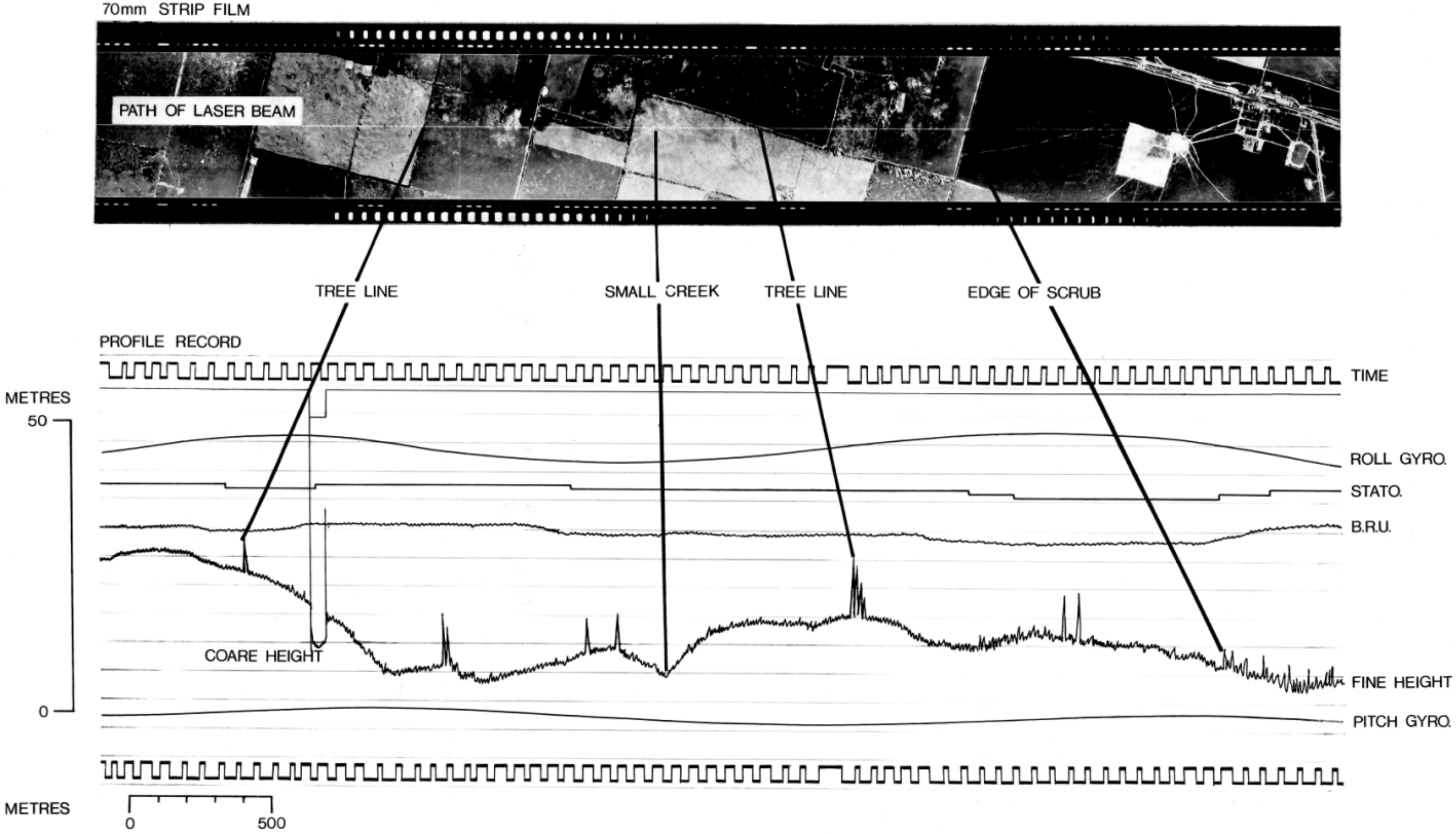
Heights for stereo-model control

For each stereo-model

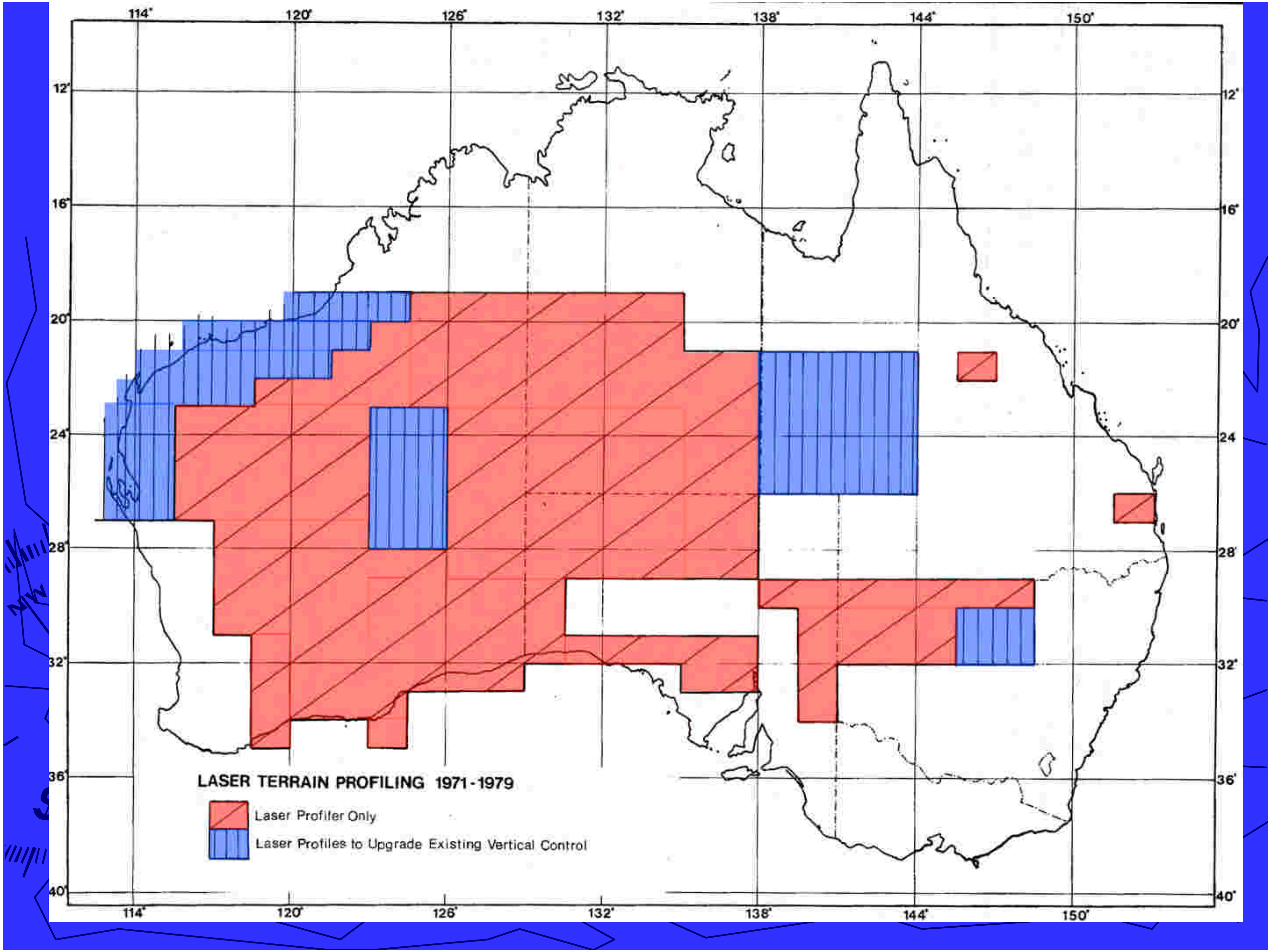
- common points of detail from 70 mm tracking camera film selected and annotated

- aligning the time code on the edge of the film with that on the paper roll recorder relate the two media

- the height of a point is calculated from data extracted from the paper record at the applicable time



Aligning paper record with film using timecode


114°
120°
126°
132°
138°
144°
150°
12°
16°
20°
24°
28°
32°
36°
40°
LASER TERRAIN PROFILING 1971-1979
Laser Profiler Only
Laser Profiles to Upgrade Existing Vertical Control

LTP Accuracy

- Laser accuracy ±0.3 m at all times

- Cumulative system errors decrease accuracy to ±3 m

- In practice, ±2m expected

- This is about the pointing accuracy of the photogrammetric plotters used on 1:80 000 scale photography, so the two systems are compatible

LTP surveys


Think we should turn the laser down a bit????
by GBL

Quote (17 December 1979)

(At the end of the laser profiling field program)

"Looking back it amazes me that the combination of:

(a) Weather including high and low clouds

(b) Aircraft unserviceability and pilot's hours

(c) Equipment including leaky lasers, modulator bubbles and electronic gremlins

(d) Personnel including lost navigators, operators jamming camera cassettes, technicians blowing capacitors,

compounded by turbulence, cross winds, hail, fuel drums, fuel pumps, refuelling difficulties and late nights and early mornings that any profiling was ever done at all".

Map Accuracy Natmap maps

Measured by:

- ‘completeness’ (fidelity of representation and description of the topographic features represented)

- ‘metric quality’ (the correct geographical positioning of the topographic features represented)

Completeness surveys:

- carried out by air and ground methods

Map Accuracy Natmap maps

Metric quality:

- Ascertained on a sampling basis

- A representative map selected from block of maps based on common horizontal & vertical control

- Positions of ‘check’ points independently established by ground survey & compared with the map coordinates

Map Accuracy Natmap maps

Conclusion:

- As far as it could be proved Natmap maps met the established map accuracy criteria of the time

IN CONCLUSION

The Aerodist and Laser heighting surveys enabled the successful completion of Natmap’s

1:100 000 and 1:250 000 mapping programmes

Far-sighted executive

Rapid adaptation by field personnel

Early adoption of EDP

The Authors gratefully acknowledge the following:

- the Australian Map Circle

- Mrs Iris Hocking allowing us to use Dave’s paper

- the Commonwealth of Australia, through Geoscience Australia for the use of the Natmap papers

- so as not to leave anyone out, all those who worked for or with Natmap, for their contribution to mapping

- for use of their imagery in this presentation – Messrs Ely, Ertok, Lawrence & Stuchbery