BREVE STORIA DELLA NAVIGAZIONE AEREA

napulevola.it

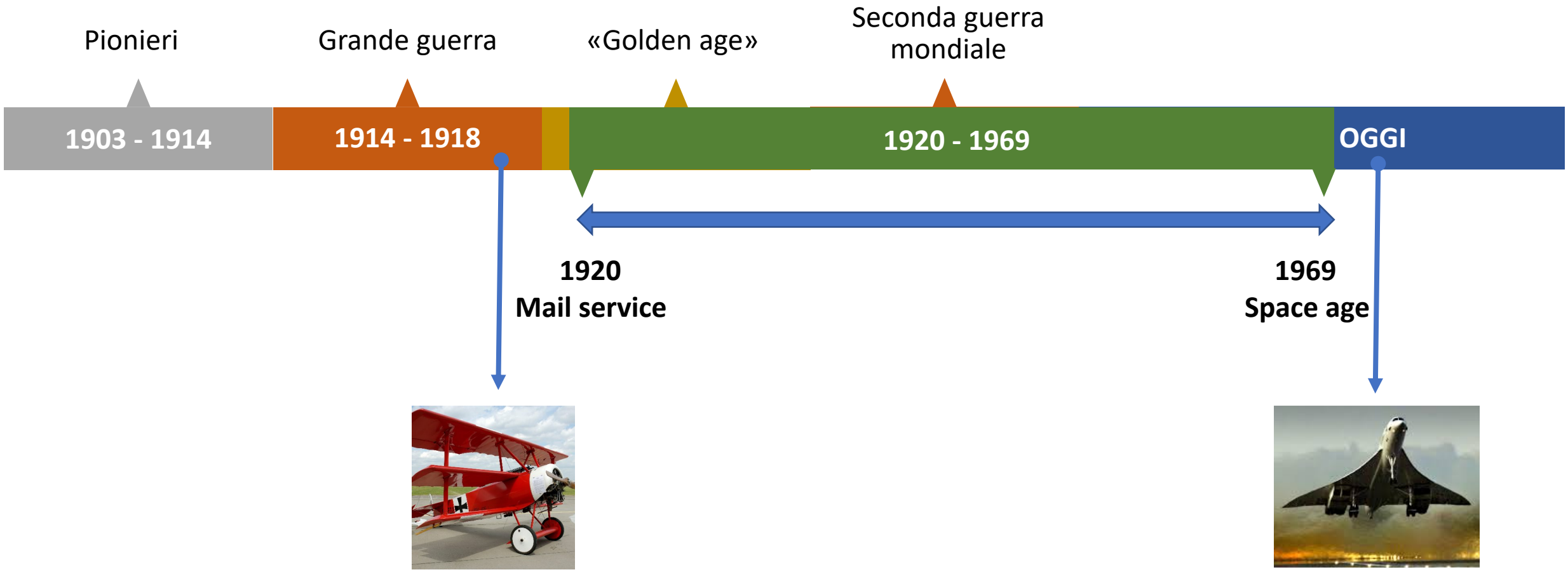
ANDREA - NPV1208

INTRODUZIONE

- Programma lezioni
  - Breve storia della navigazione aerea
  - VFR *Navigation* Basics 1 (Andrea)
  - VFR *Navigation* Basics 2 (Gianni)
  - VFR *Navigation* Basics 3 (Andrea)
  - VFR *Flight Planning* (congiunta)

- Lezione odierna

TIMELINE


Pionieri
Grande guerra
«Golden age»
Seconda guerra mondiale
1903 - 1914
1914 - 1918
1920 - 1969
OGGI
1920
Mail service
1969
Space age

PROBLEMATICHE DELLA NAVIGAZIONE AEREA

- Dove siamo
- Come arrivare a destinazione

- Alta velocità
- Non ci si può fermare
- Condizioni meteorologiche
- Condizioni ambientali nel cockpit
- Limiti di spazio e di peso
- Operazioni a *single-pilot*
- Navigazione in combattimento

As all experienced navigators know, it is extremely easy to get lost.” — Philip Van Horn Weems, Air Navigation, 1931

NAVIGAZIONE OSSERVATA (PILOTING)

ANTICHITA’ - OGGI

DESCRIZIONE:

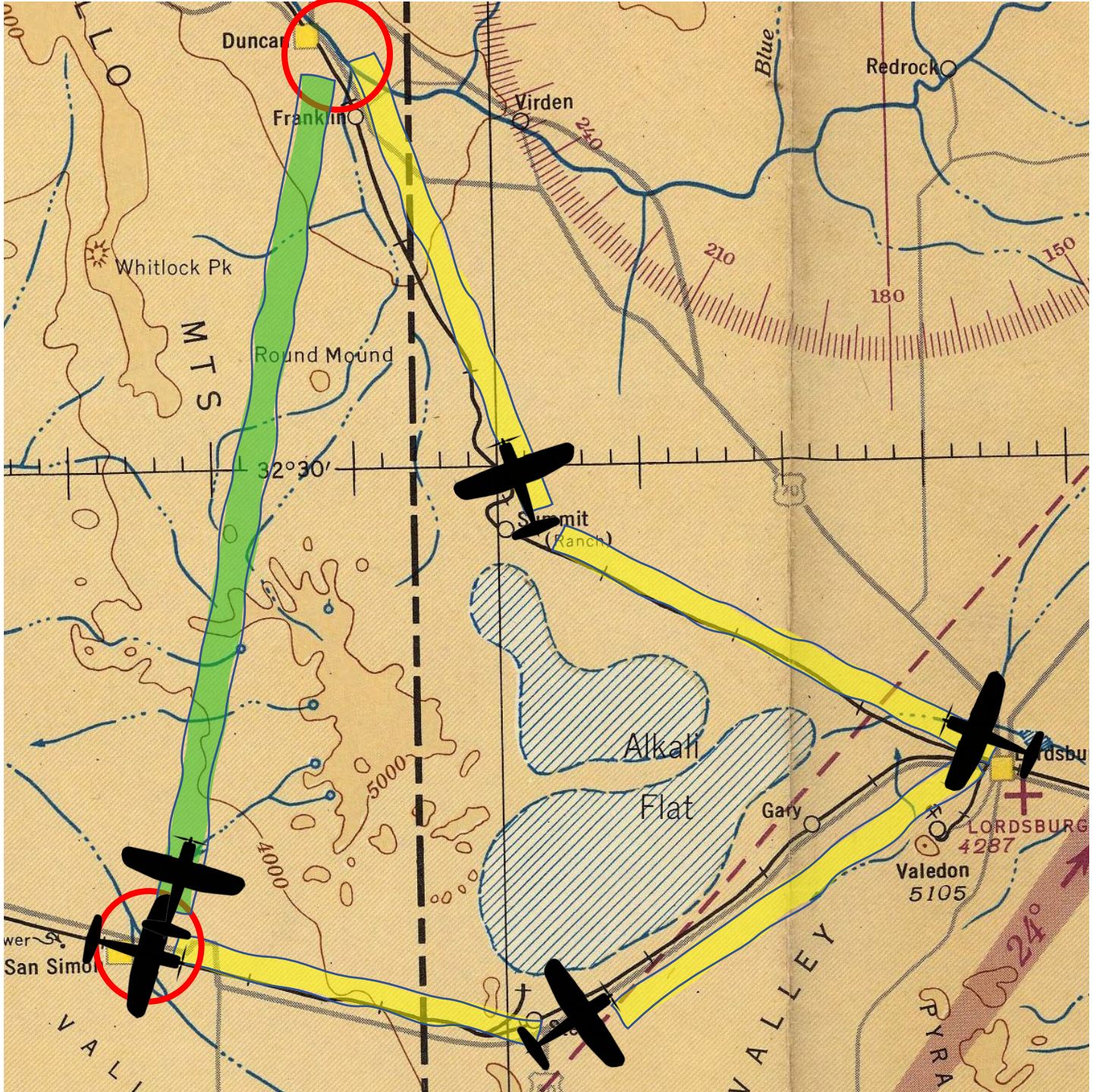
- Navigare seguendo solo punti di riferimento visivi

VANTAGGI:

- Semplicità
- Equipaggiamento minimo

SVANTAGGI:

- Richiede un ottima visibilità
- Difficile o impossibile volare di notte
- Facilità di perdersi
- Rotta inefficiente
- Non possibile in mare aperto, deserti, etc…




REYNOLDS


59B


EL PASO

AEROVIE LUMINOSE

1923 - 2017

DESCRIZIONE:

- Metodo di navigazione a vista per mezzo di fari luminosi dislocati lungo la rotta

VANTAGGI:

- Permette di navigare a vista di notte

SVANTAGGI:

- Non efficace quanto un sistema di navigazione strumentale
- Difficile implementazione e costosa manutenzione

TRANSCONTINENTAL AIRWAY

All’inizio degli anni ‘20, il tenente Donald L. Bruner (USAF), si propone di risolvere il problema della navigazione notturna dei voli postali.

Nel 1921, Jack Knight compie il primo volo postale notturno dal Nebraska all’Illinois con l’aiuto di falò disposti lungo la rotta.

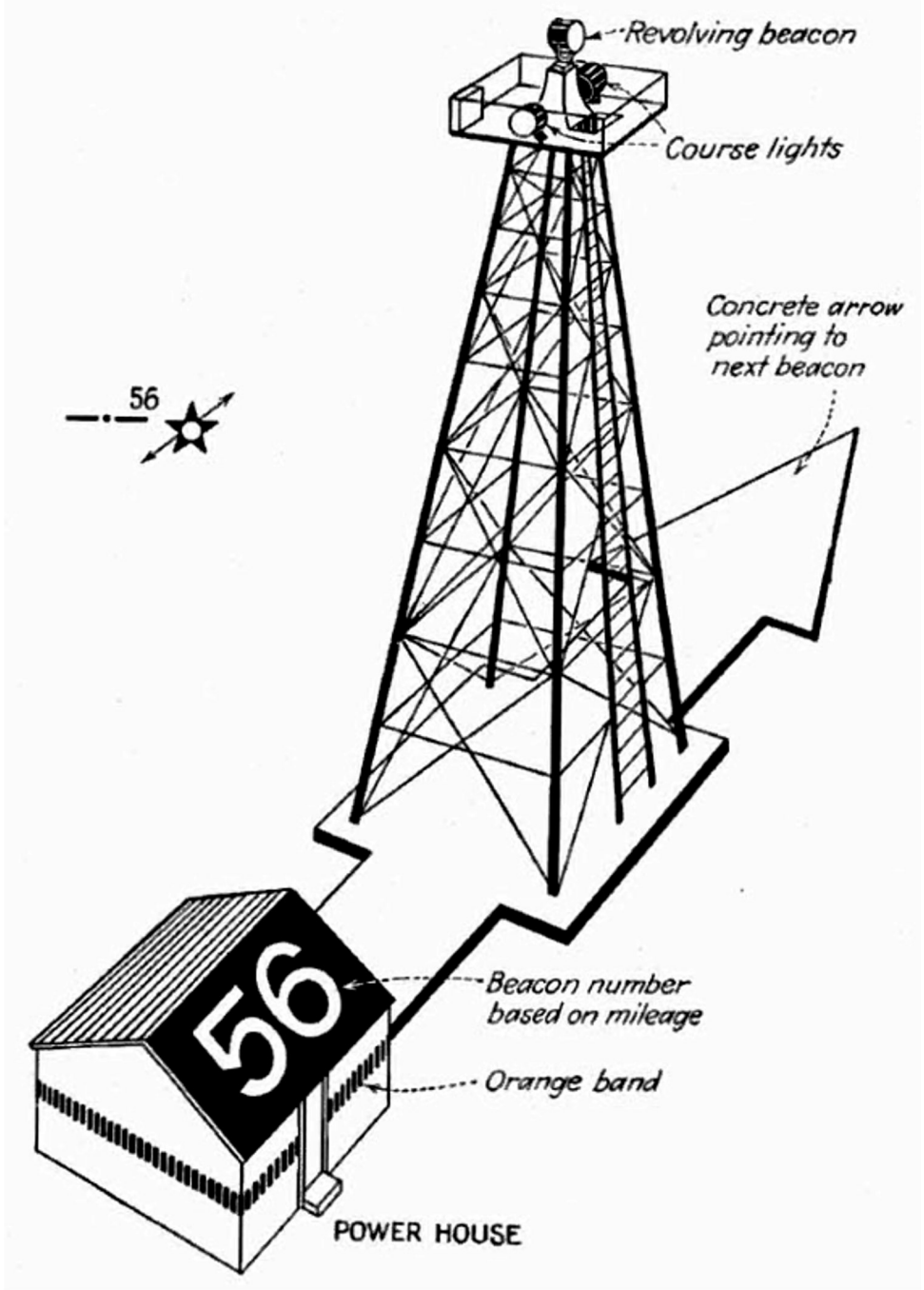
Nel 1923 il tenente Bruner, perfeziona la sua idea di un aerovia luminosa a fari rotanti (*beacons*) con il nome di TAS – *Transcontinental Airway System*

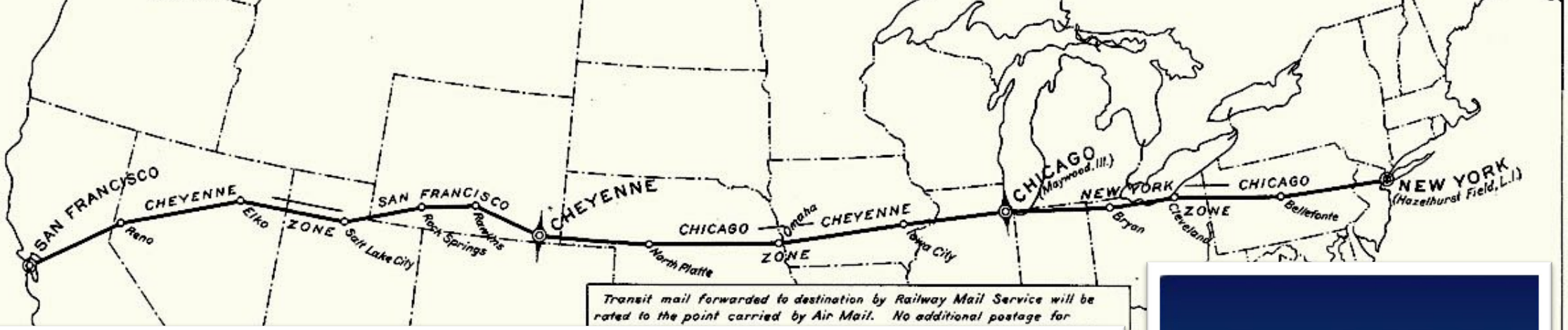
Nel 1933, 1500 beacons e 29,000 km di aerovie luminose erano in funzione negli Stati Uniti.

Benché il sistema andò in disuso negli anni ’70, lo stato del Montana ha mantenuto un aerovia di *beacons* fino al 2017

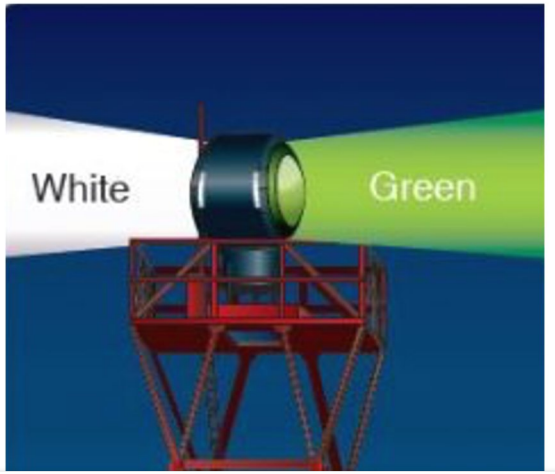
Jack Knight (1893 -1945)


L-A-A
© cibolahistory.org


Revolving beacon
Course lights
Concrete arrow pointing to next beacon
56
56
Beacon number based on mileage
Orange band
POWER HOUSE



Transit mail forwarded to destination by Railway Mail Service will be rated to the point carried by Air Mail. No additional postage for



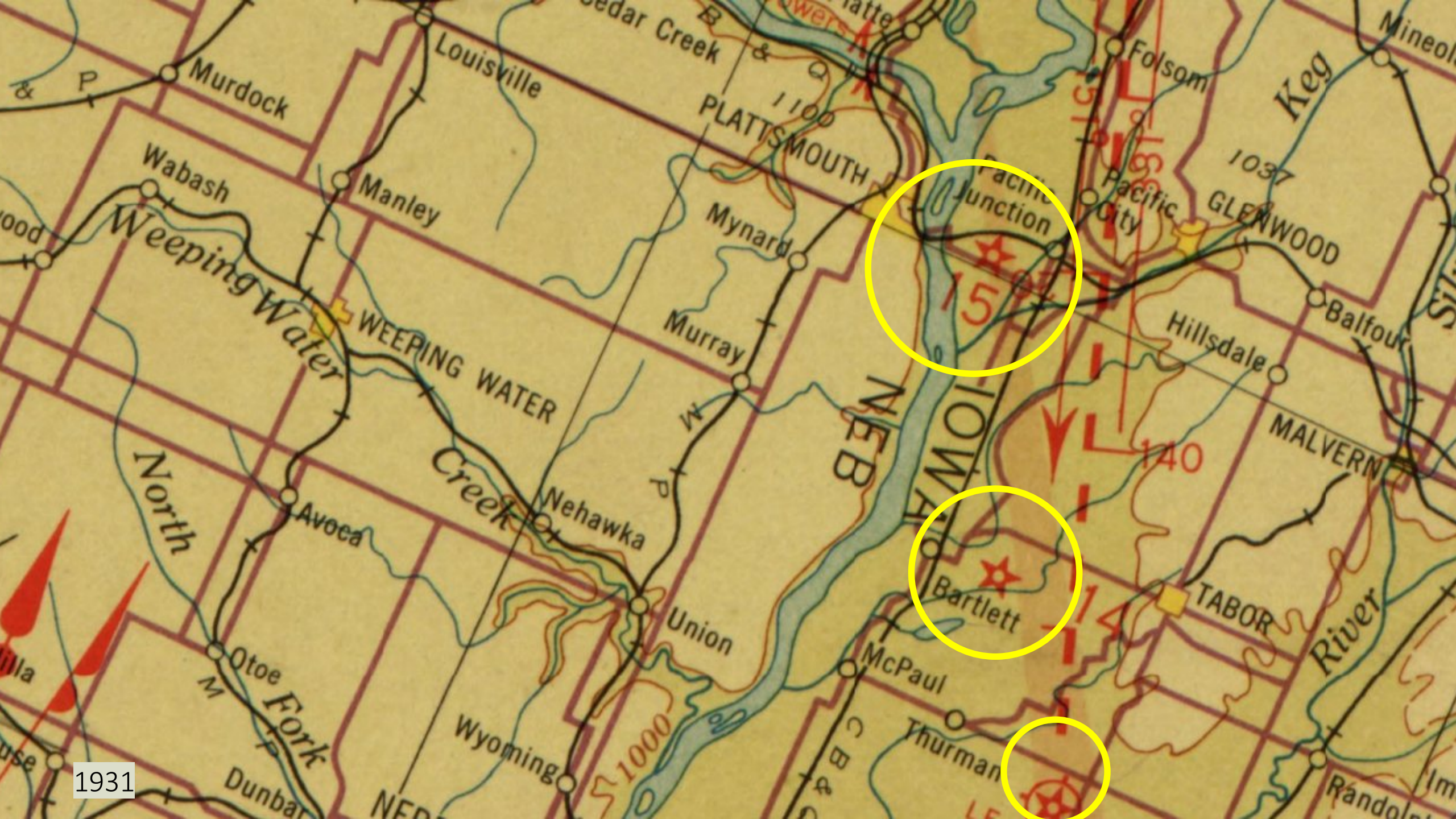
Cheyenne	16	16	16	16	8	8	8	8		8	8	8	8	8	8	
Rawlins	24	24	24	24	16	16	16	16	8		8	8	8	8	8	
Rock Springs	24	24	24	24	16	16	16	16	8	8		8	8	8	8	
Salt Lake City	24	24	24	24	16	16	16	16	8	8	8		8	8	8	
Elko	24	24	24	24	16	16	16	16	8	8	8	8		8	8	
Reno	24	24	24	24	16	16	16	16	8	8	8	8	8		8	
San Francisco	24	24	24	24	16	16	16	16	8	8	8	8	8	8		

At such cities as show an arrival late in the day by the Air Mail Schedule the use of special delivery stamps in addition to the zone postage will insure delivery on the date of receipt.

Postage eight cents an ounce, or fraction thereof, for each zone, or part of zone, in which mail is carried by plane. Transit mail forwarded to destination by Railway Mail Service will be rated to point carried by Air Mail Service.

Colorado	Cheyenne	Montana	Salt Lake	Bryan)
Idaho	Salt Lake	Nebraska (Except North Platte)	Omaha	Oregon
Illinois	Chicago			South Dakota
Indiana	Cleveland	Nevada (Except Elko)	Salt Lake	Utah
Iowa (Except Iowa City)	Chicago			Wisconsin
Kansas	Chicago	(Except Reno-Carson City-Tonopah-Goldfield-Virginia City)	Reno	Wyoming (Except Rawlins-Rock Spgs)
Michigan	Cleveland			Trans-Pacific, Foreign
Minnesota	Chicago			

Offices not located on the Air Mail Route may dispatch by rail to connect there[with]. For example: Philadelphia may dispatch to Los Angeles: by rail to New York or Cleveland, thence by air to San Francisco; thence by rail to Los Angeles. Denver may dispatch to Los Angeles or Philadelphia: by rail from Denver to Cheyen[ne] by air to San Francisco or New York; by train San Francisco to Los Angeles, or New Yo[rk] to Philadelphia.


Louisville
Murdock
Wabash
Manley
Mynard
PLATTSMOUTH
Pacific Junction
Folsom
Pacific City
GLENWOOD
Weeping Water
WEEPING WATER
Murray
Hillsdale
Balfour
MALVERN
Avoca
Nehawka
North Creek
Union
Bartlett
TABOR
McPaul
Thurman
Wyoming
Otoe
Fork
River
Keg
IOWA
NEB
1931

NAVIGAZIONE STIMATA (DEAD RECKONING)

1300 - OGGI

DESCRIZIONE:

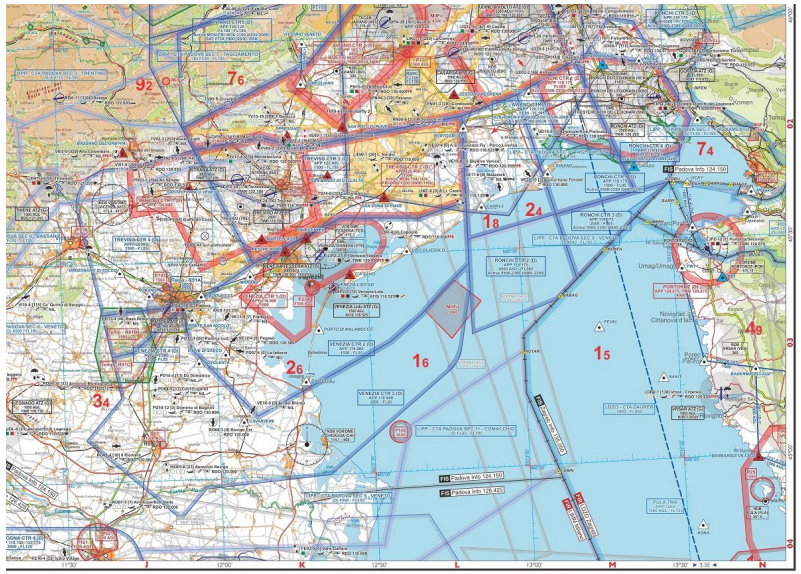
- Metodo di navigazione con il quale, dato un punto certo di partenza, è possibile stimare matematicamente le posizioni successive

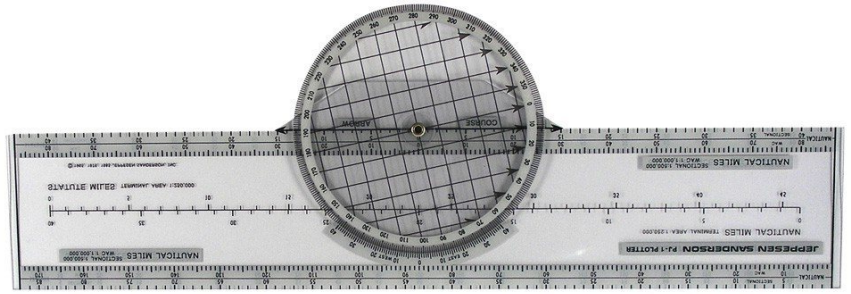
VANTAGGI:

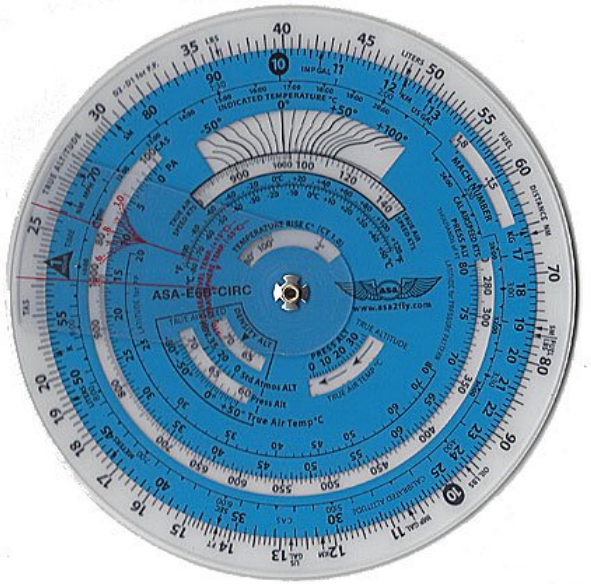
- Permette di navigare in mancanza di riferimenti visivi o altri riferimenti di posizione
- È molto efficace se usata insieme ad altre tecniche di navigazione

SVANTAGGI:

- Imprecisa sulle lunghe distanze
- È difficile fare calcoli in volo, soprattutto da *single-pilot*
- Richiede un esecuzione accurata

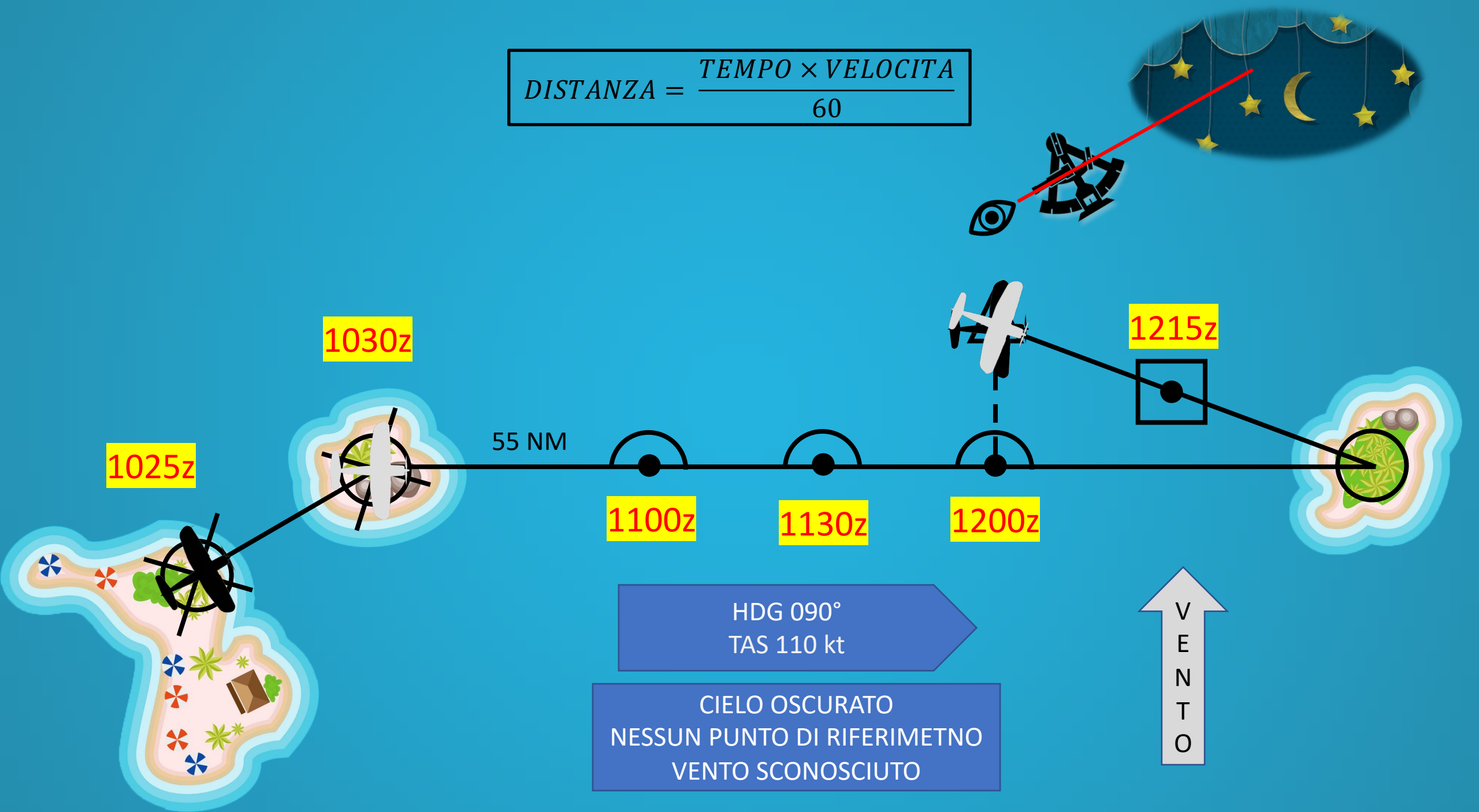







VACUUM
PUSH
HDG

$$DISTANZA = \frac{TEMPO \times VELOCITA}{60}$$



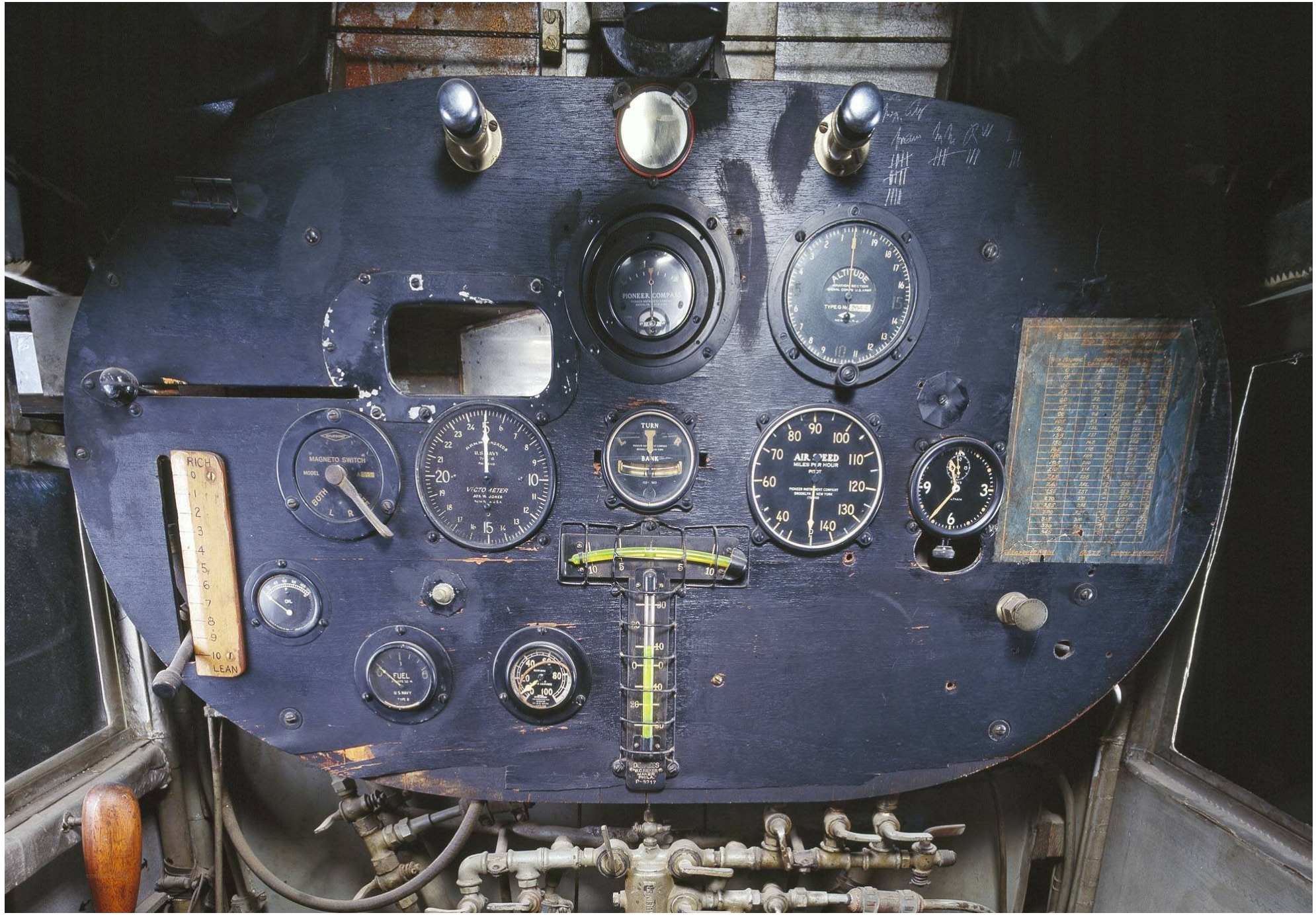
CHARLES A. LINDBERGH

1902 - 1974

Nel 1927 Charles Lindbergh compie la prima transvolata del nord atlantico in solitaria

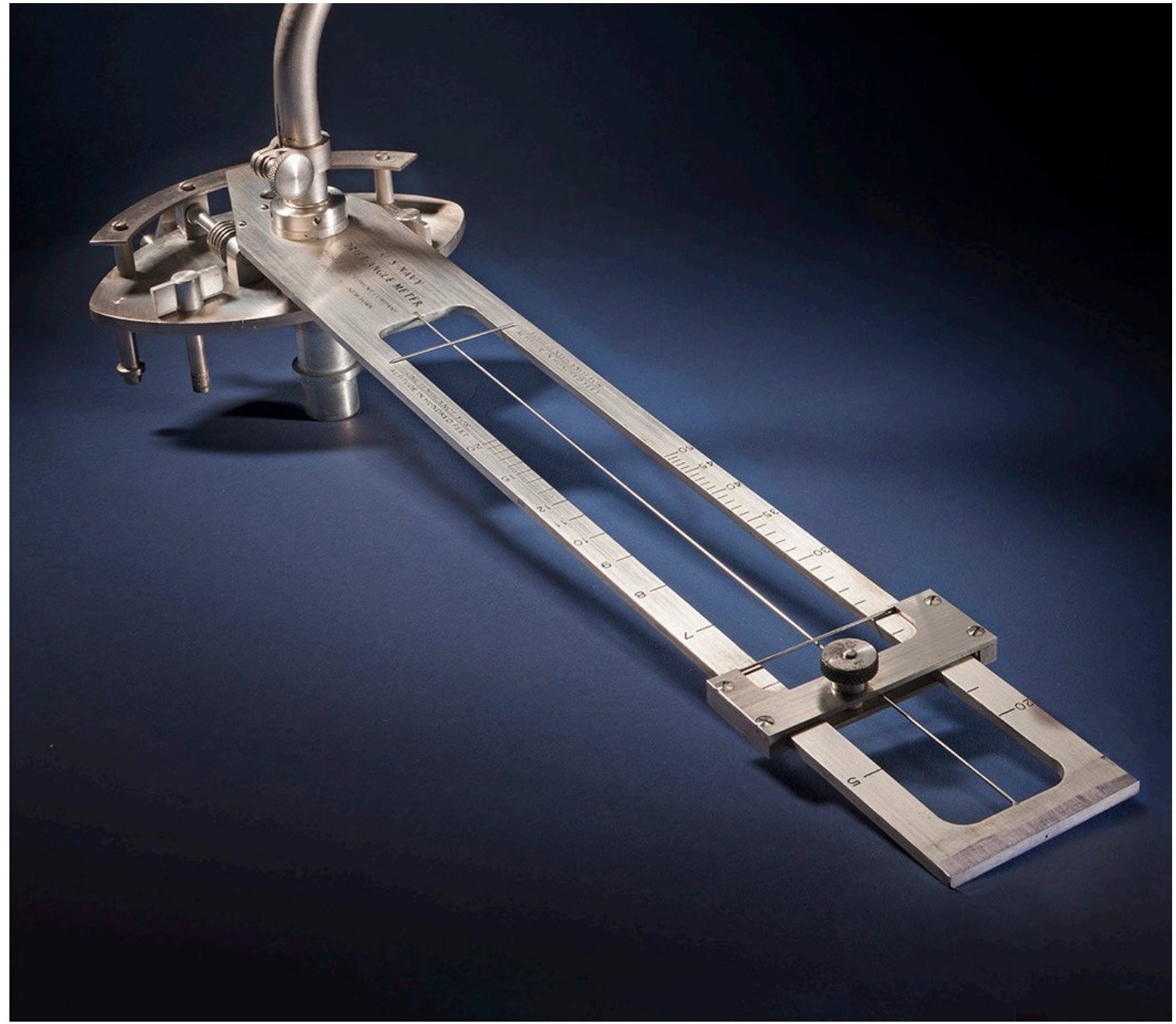
IL VOLO È QUASI TUTTO
IN DEAD RECKONING


ROTTA
ORTODROMICA
33 ORE E MEZZA


PIONEER COMPASS
ALTITUDE
MAGNETO SWITCH
BOTH
L
R
RICH
LEAN
VICTO METER
TURN
BANK
AIR SPEED
MILES PER HOUR
FUEL


SPARE BRUSHES
USE ONLY WHEN THOSE
INSTALLED ARE WORN OUT
PIONEER COMPASS


SPARE BRUSHES
USE ONLY WHEN THOSE
INSTALLED ARE WORN OUT
PIONEER COMPASS
PIONEER COMPASS




RICH
0
1
2
3
4
5
6
7

NAVIGAZIONE ASTRONOMICA

ANTICHITA’ - OGGI

DESCRIZIONE:

- Tipo di navigazione effettuata con l’ausilio di astri visibili

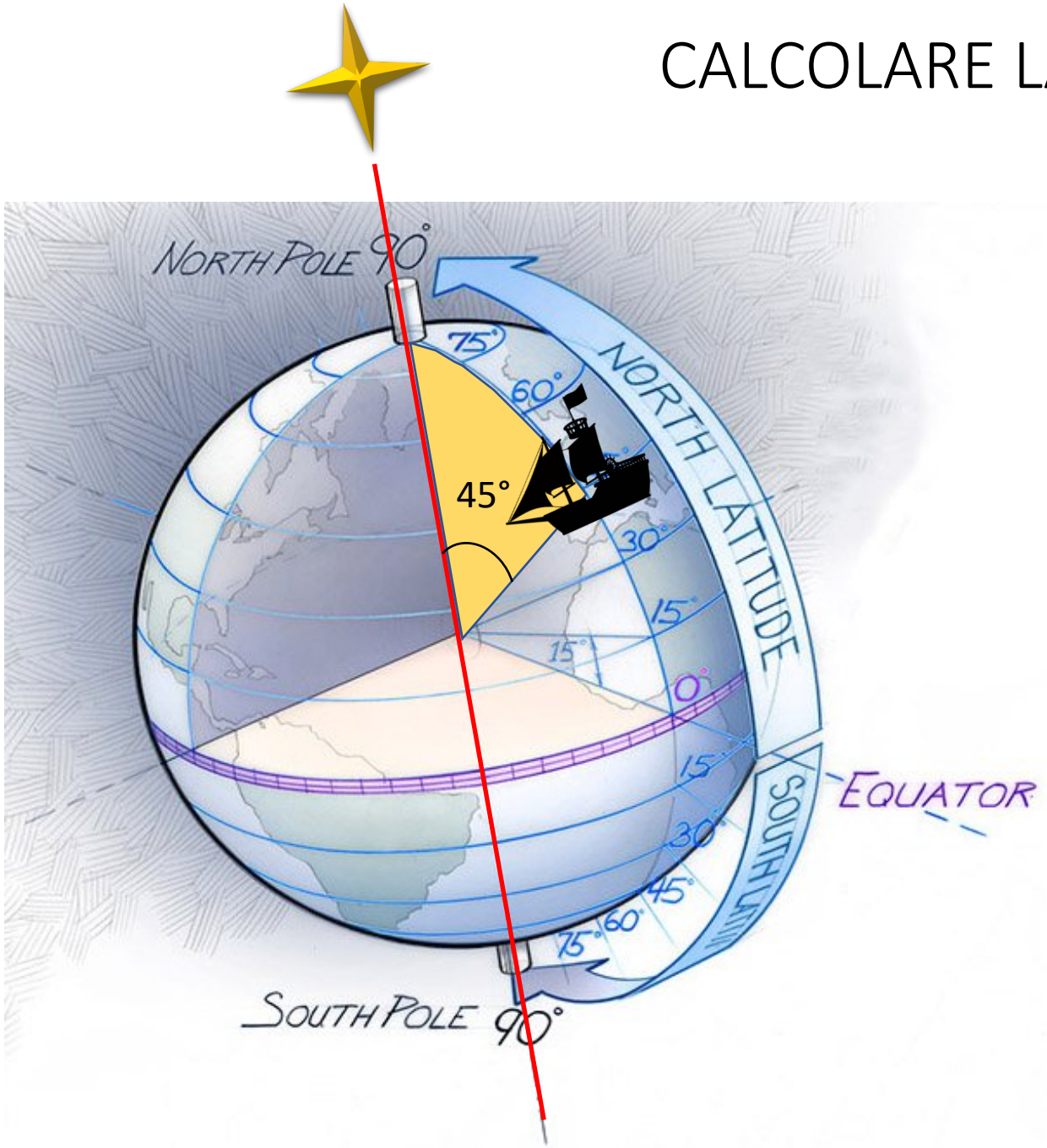
VANTAGGI:

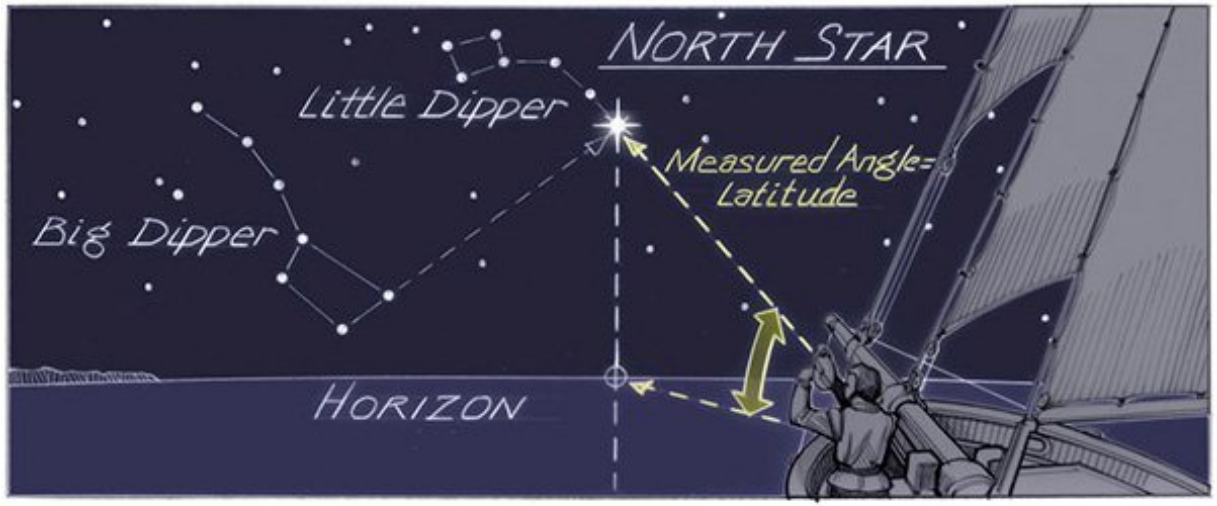
- Completamente autonoma ed indipendente da sistemi esterni
- Accurata se ben fatta

SVANTAGGI:

- Può essere complessa
- Difficile da effettuare in volo senza un navigatore.
- Il cielo deve essere visibile

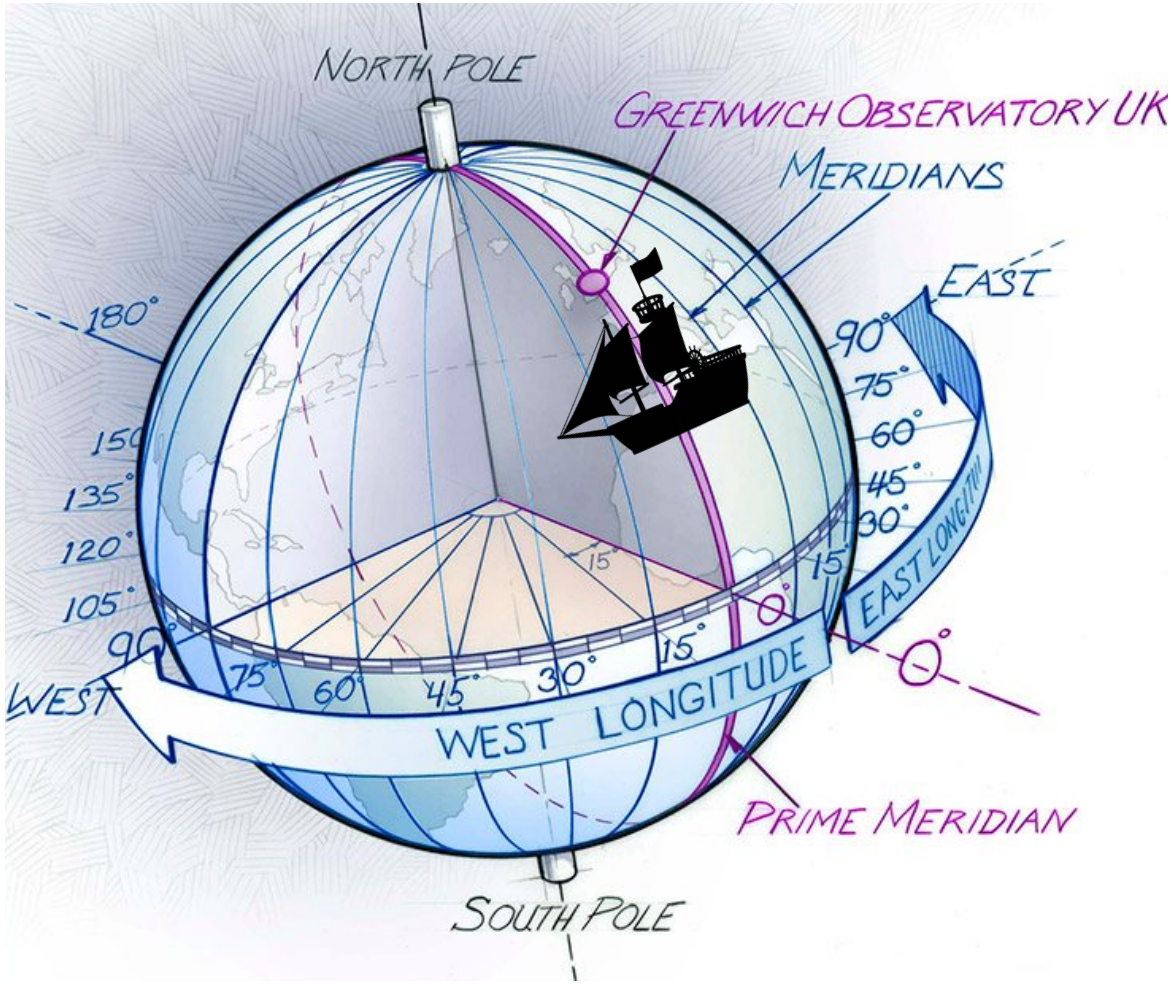
CALCOLARE LA LATITUDINE

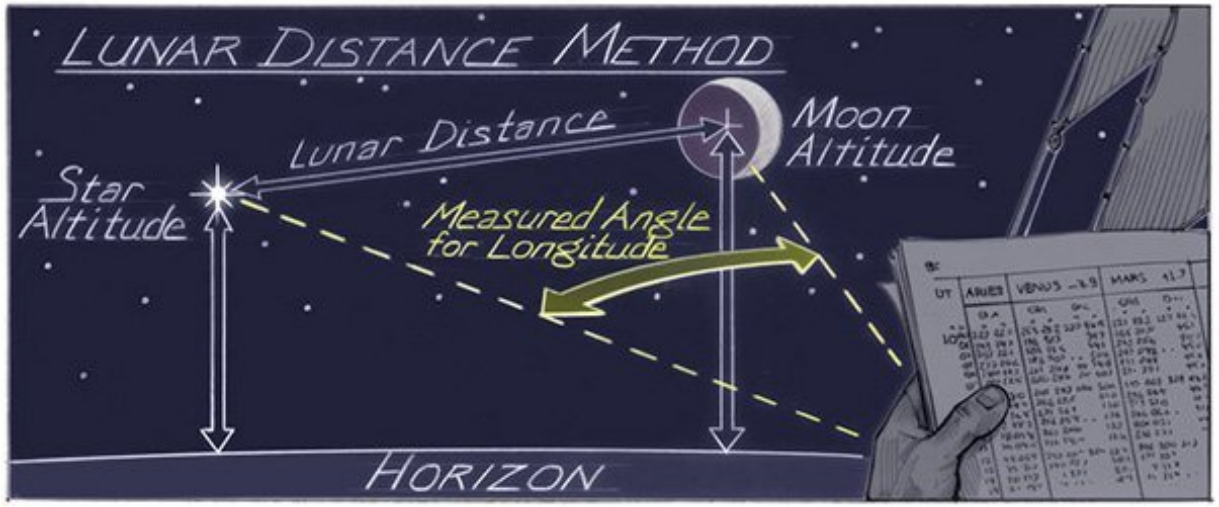




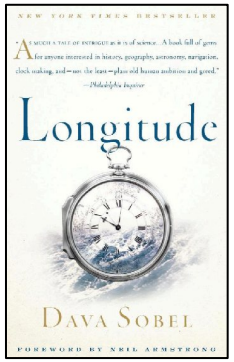
CALCOLARE LA LATITUDINE È RELATIVAMENTE SEMPLICE.

CALCOLARE LA LONGITUDINE





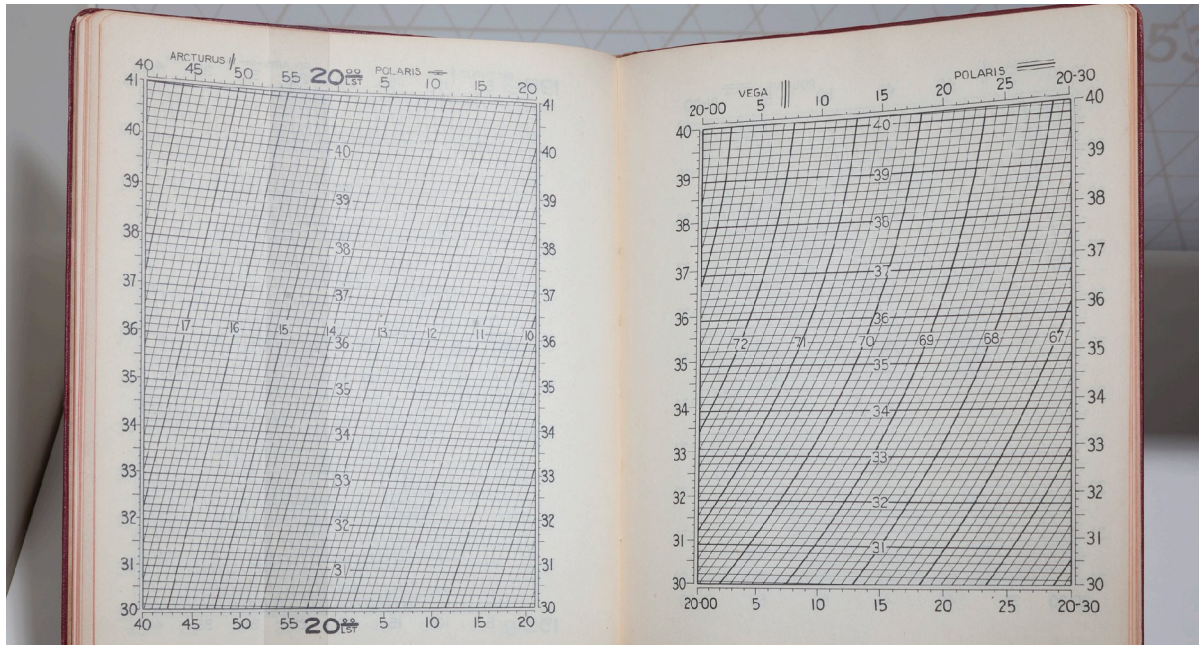
PRIMA DELLA METÀ DEL 1700, CALCOLARE CON PRECISIONE LA LONGITUDINE ERA MOLTO DIFFICILE.

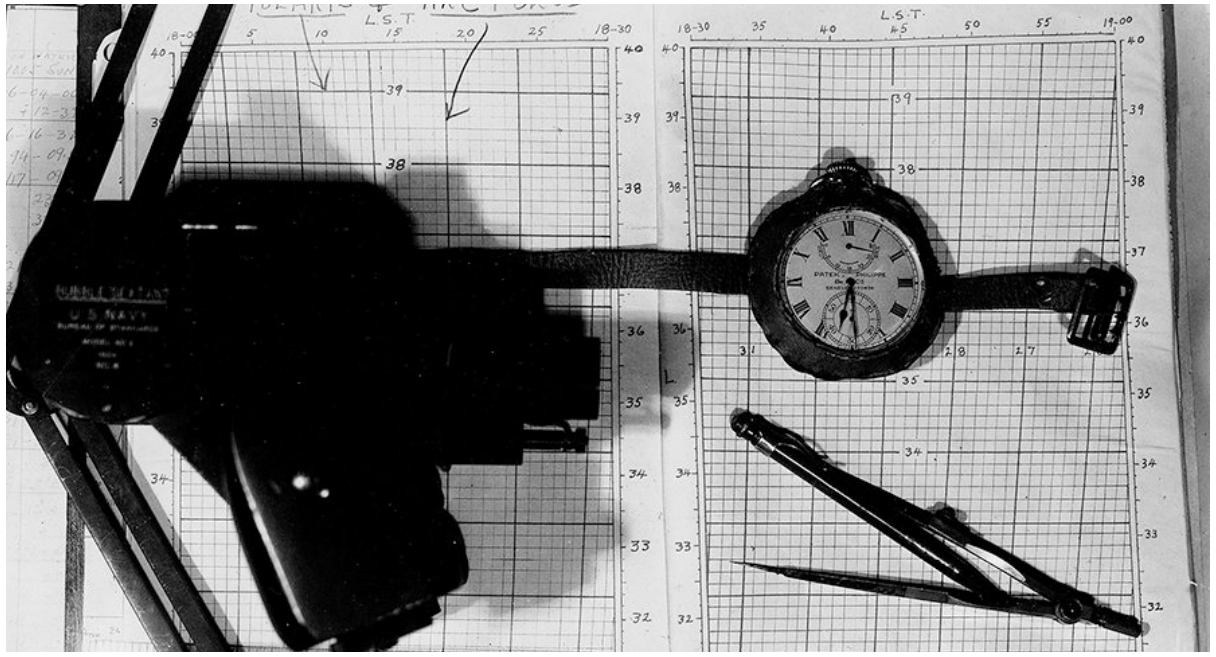


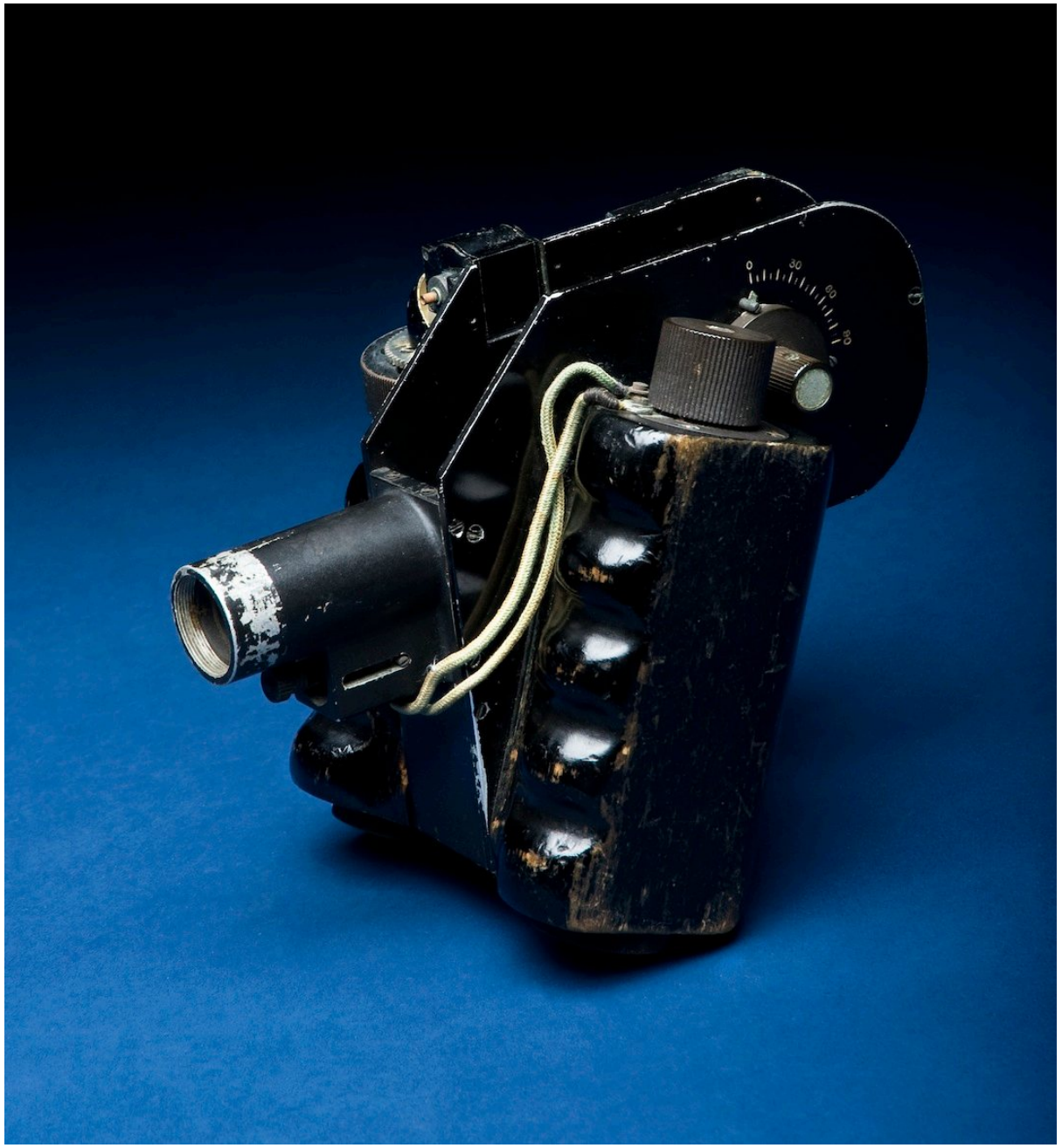
Longitude, Dava Sobel, 2007

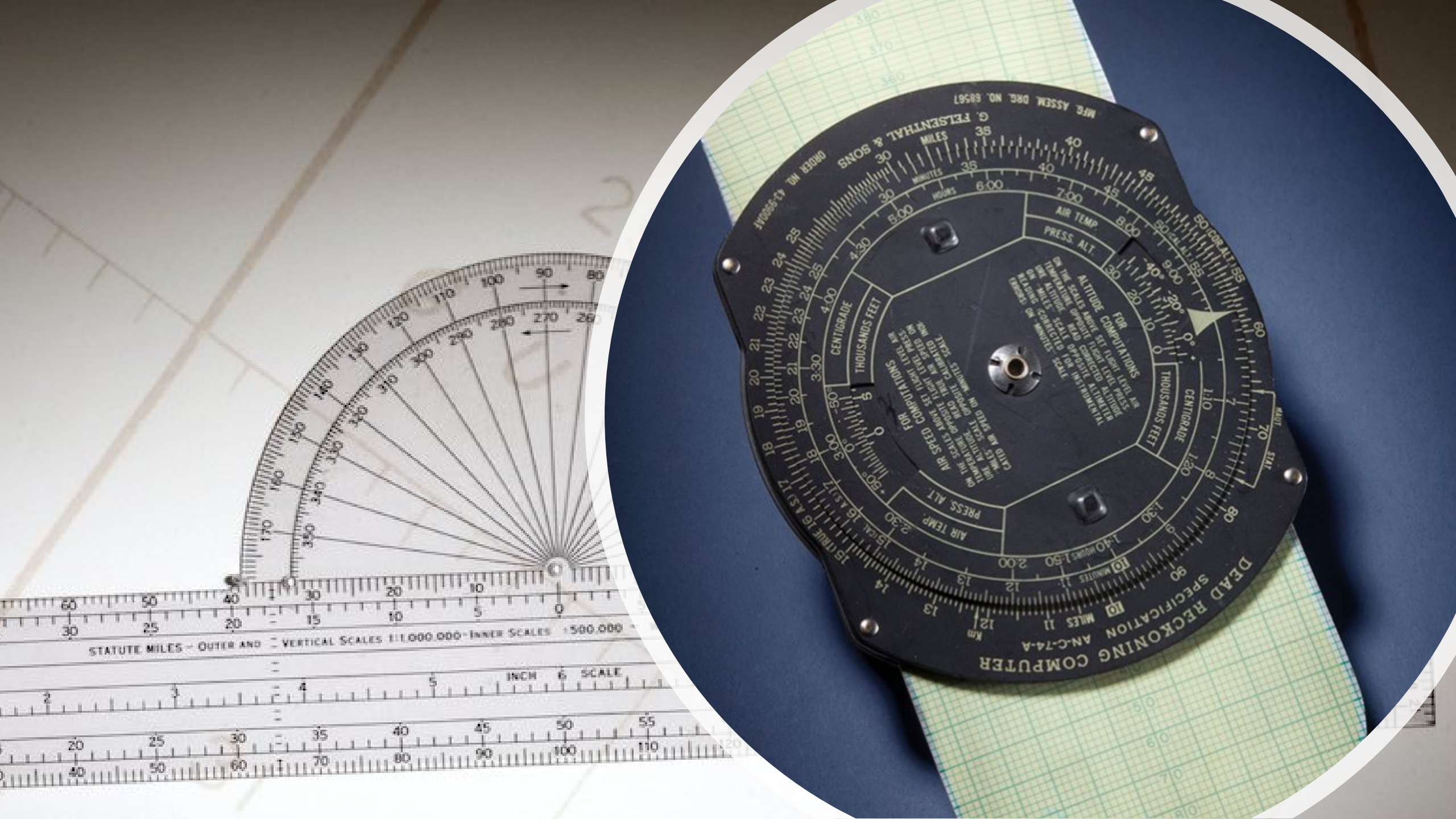
PHILIP VAN HORN WEEMS

1889 - 1979


ARCTURUS
POLARIS
VEGA
POLARIS


L.S.T.
L.S.T.




DEAD RECKONING COMPUTER
SPECIFICATION AN-C-74-A
G. FELSENTHAL & SONS
AIR TEMP.
PRESS. ALT.
CENTIGRADE
THOUSANDS FEET
STATUTE MILES - OUTER AND VERTICAL Scales 1:1,000,000 - Inner Scales 1:500,000
INCH & SCALE

Anne Morrow (1906 -2001)

Teaching "Lindy" Navigation

Why the World's Greatest Pilot Is Learning from a Tutor the A B C's of the Science of Finding His Way

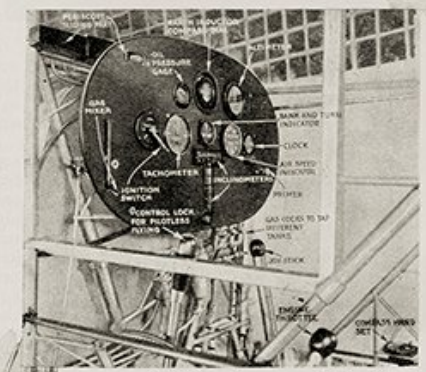
By BOYDEN SPARKES

Lindbergh's tutor in the science of navigation, Lieutenant Commander Philip V. W. Weems, U.S.N., demonstrates the simplest method of taking bearings, using a sextant and the wrist watch seen on his left arm.

LINDBERGH, it was announced recently, has an instructor who is teaching him navigation. To most people this seemed as silly as if President Coolidge had engaged someone to teach him political economy; or as if Pershing had begun to study under a drill sergeant.

Americans had thought of Lindbergh as the world's greatest aerial navigator. So he is, if by navigator you mean one skilled in finding his way; but mariners have a more precise understanding of the word. As a matter of fact, Lindbergh himself has explained that he knew nothing of celestial navigation when he flew from New York to Paris. Commander Byrd is a navigator. Lindbergh is a pilot skilled in following a course by dead reckoning. Any cadet at Annapolis knew more than Lindbergh about navigation, until the Colonel began his studies.

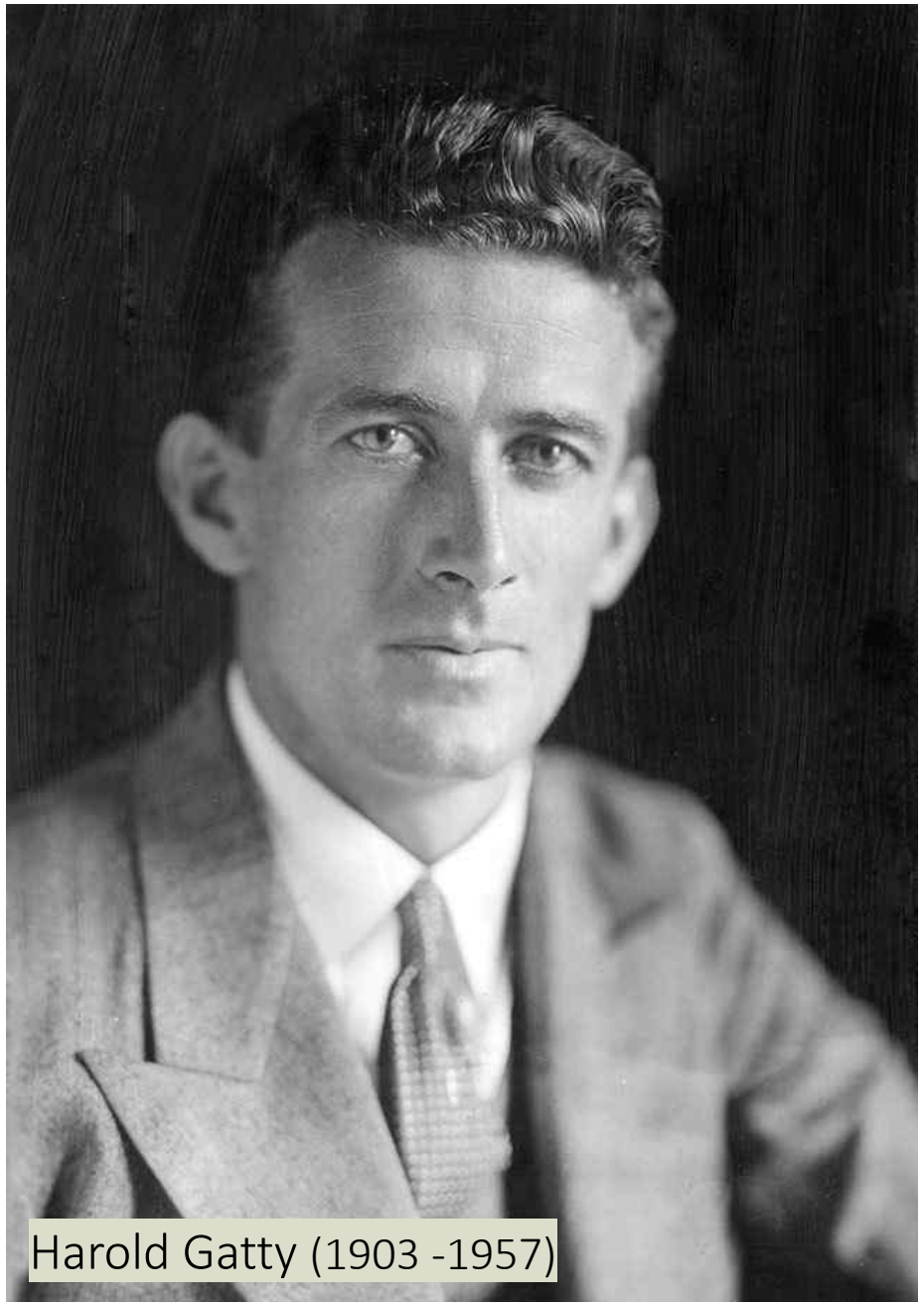
To understand this suppose you and Lindbergh and Byrd were motoring across the great American desert at night and lost your way at about the time your car broke down. Lindbergh, given all the instruments necessary for position finding, would be helpless to tell you where you were; but Byrd, given those same instruments, could tell precisely your position by sun or stars, and then, on a map, plot a course to the nearest service station. By the time this is published, though, Lindbergh probably will have learned enough of navigation to locate his position exactly anywhere.



With these instruments Colonel Lindbergh piloted the *Spirit of St. Louis* across the ocean and on his famous tours of the United States and Latin America by dead reckoning. With them he never lost his way; but, as this article shows, knowledge of navigation and the use of navigational instruments are necessary for greater accuracy in aviation.

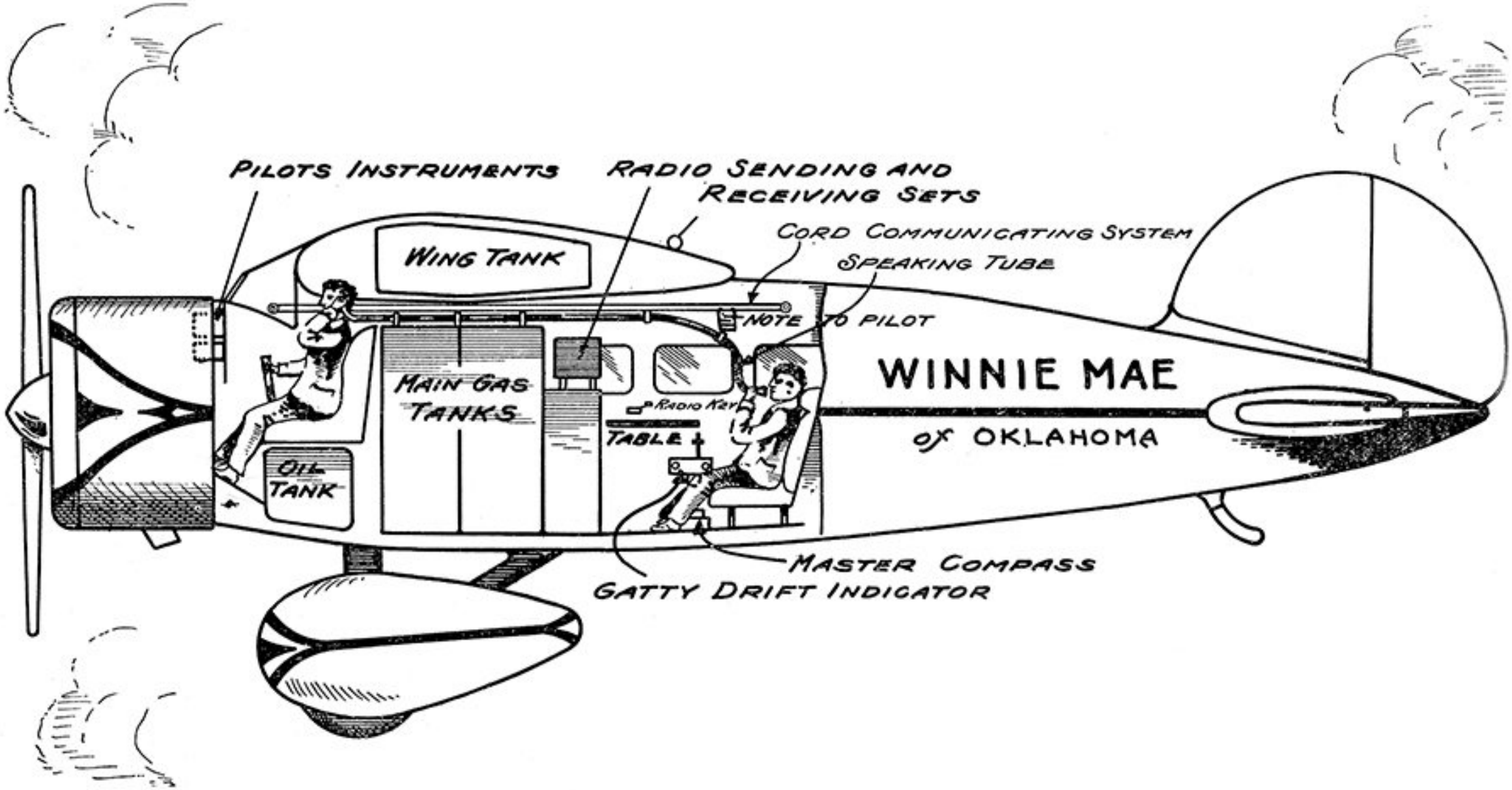
Lindbergh to San Diego, Commander Weems told the trans-Atlantic flyer that he had perfected what he believes is a "foolproof" set of navigation instruments for flyers. By ordinary methods it requires from fifteen minutes to half an hour to plot a position; that is, to find, by means of navigational instruments, where you are. Weems' simplified method reduces this time to forty seconds on a starlit night, or two minutes by day.

An air mail flyer is a pilot, not a navigator. A pilot is essentially a person familiar with a given course and able to find his way by landmarks. Normally an aviator flying cross-country is provided with a map of the region below him. Favored by good weather, he flies along a corridor about eighty miles wide, the side limits being formed by his ability to see. His map may show a railroad running parallel to his course. Dimly, far to one side, he sees the smoke of a locomotive. There is his railroad! He swings in that direction and



Harold Gatty (1903 -1957)

Wiley Post (1903 -1935)


PILOTS INSTRUMENTS
RADIO SENDING AND RECEIVING SETS
CORD COMMUNICATING SYSTEM
SPEAKING TUBE
WING TANK
NOTE TO PILOT
MAIN GAS TANKS
RADIO KEY
TABLE
OIL TANK
WINNIE MAE
of OKLAHOMA
MASTER COMPASS
GATTY DRIFT INDICATOR

Popular Mechanics

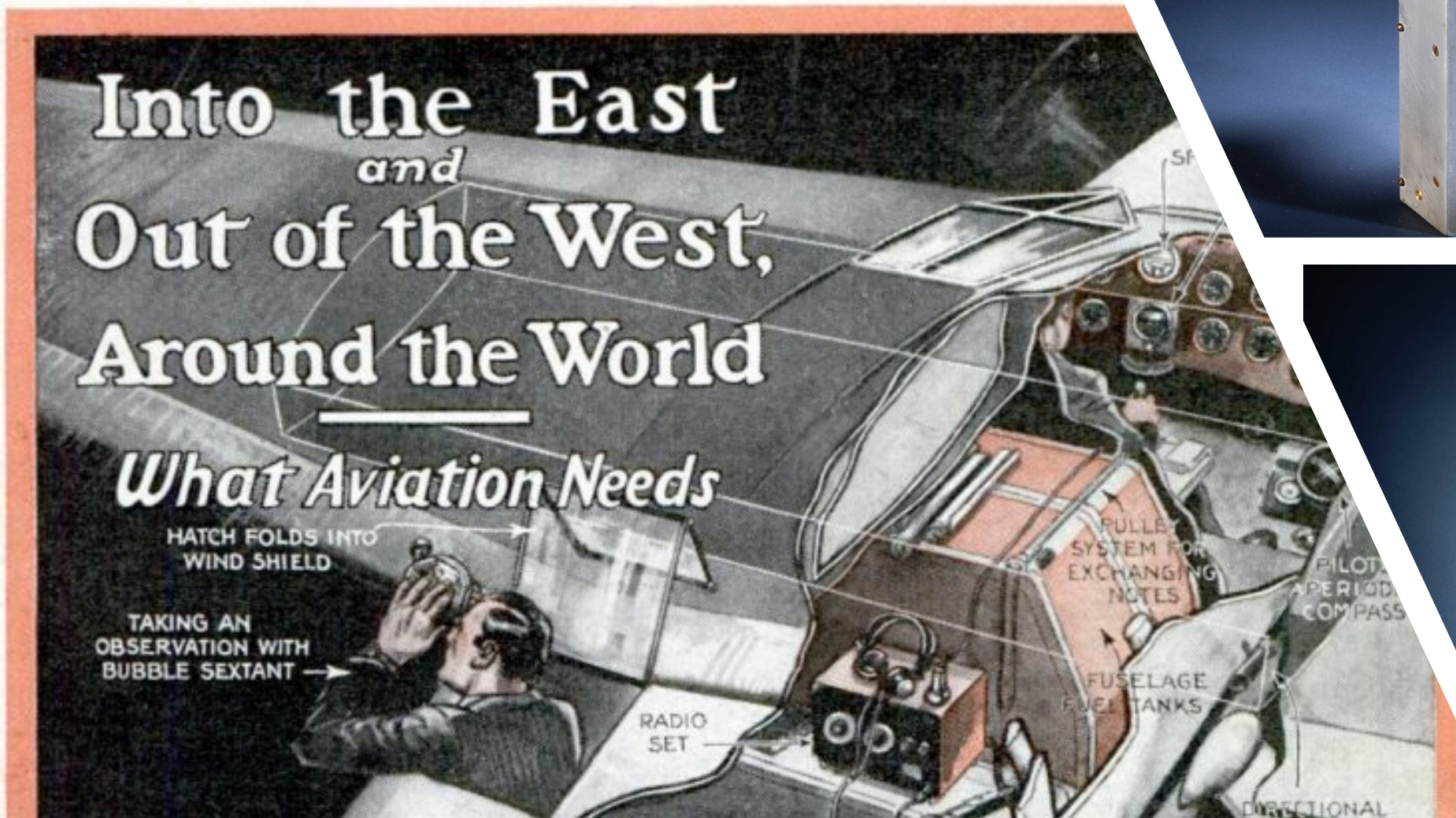
REGISTERED IN U. S. PATENT OFFICE

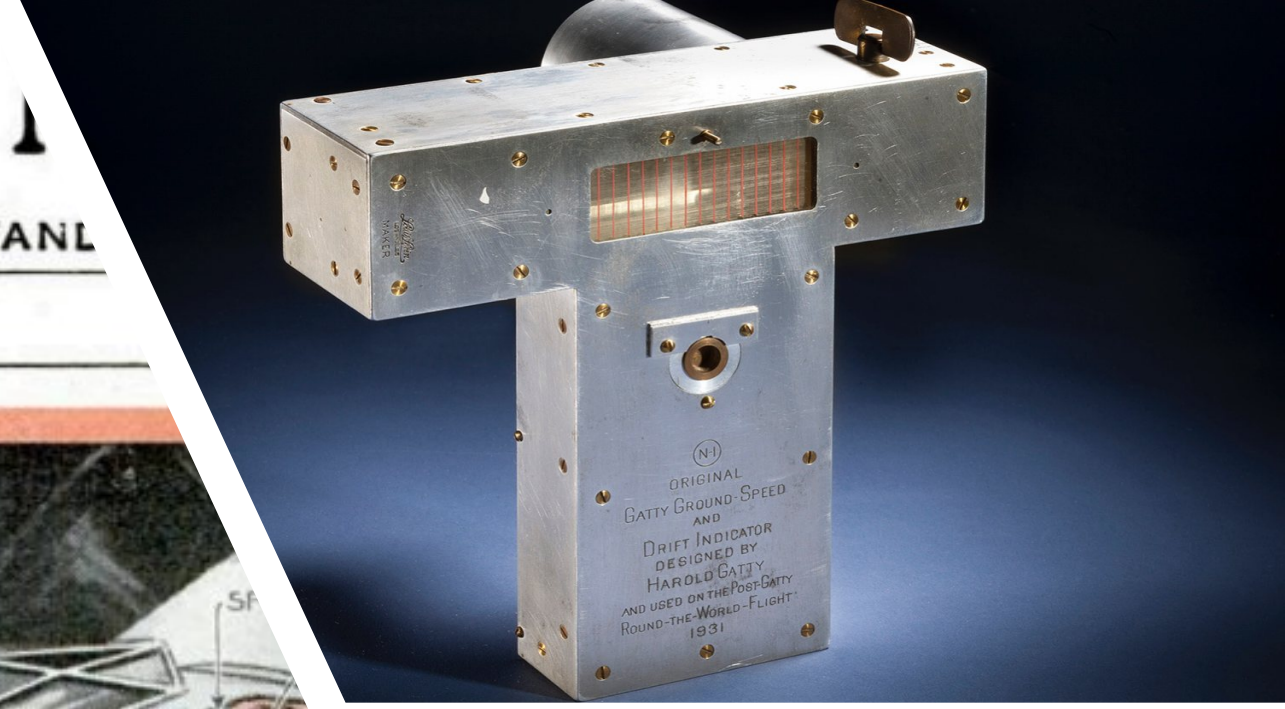
WRITTEN SO YOU CAN UNDERSTAND

Vol. 56 SEPTEMBER, 1931

Into the East and Out of the West, Around the World

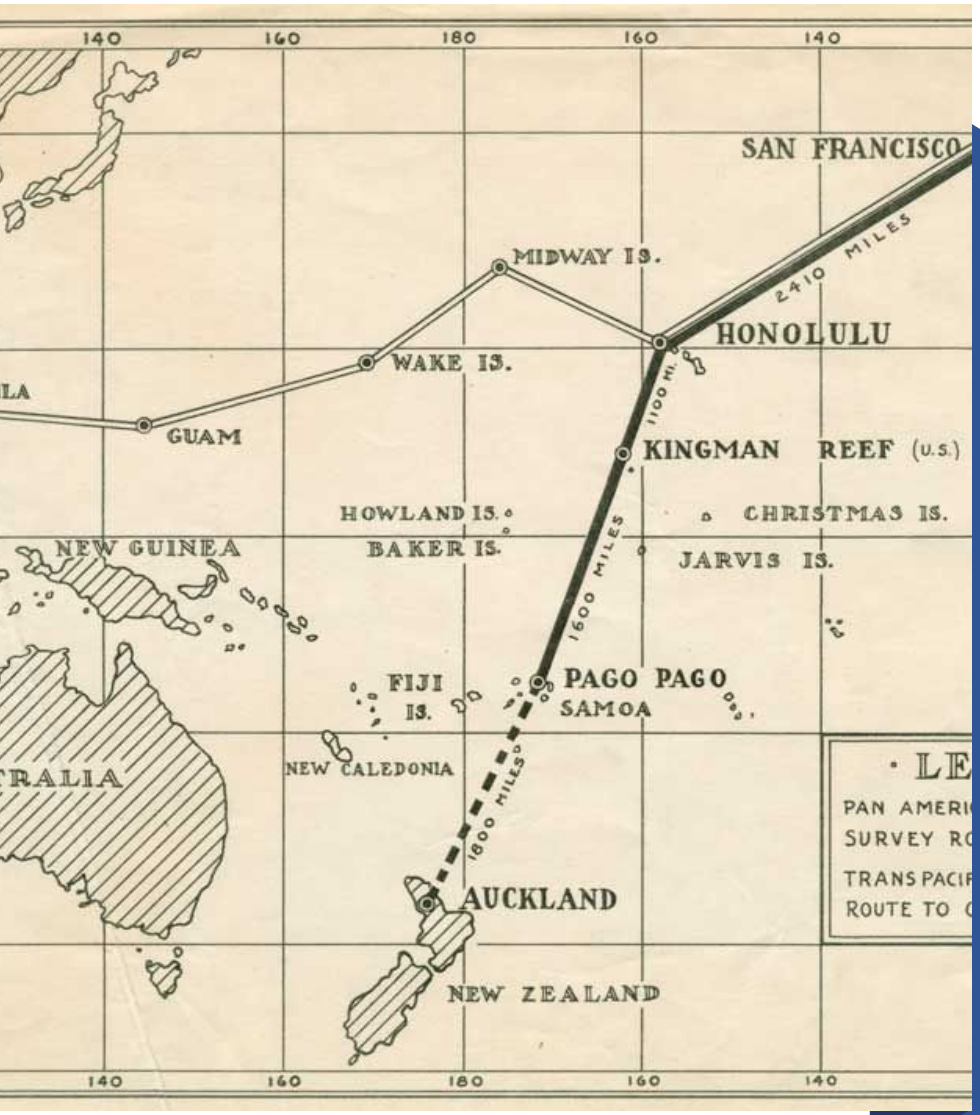
What Aviation Needs



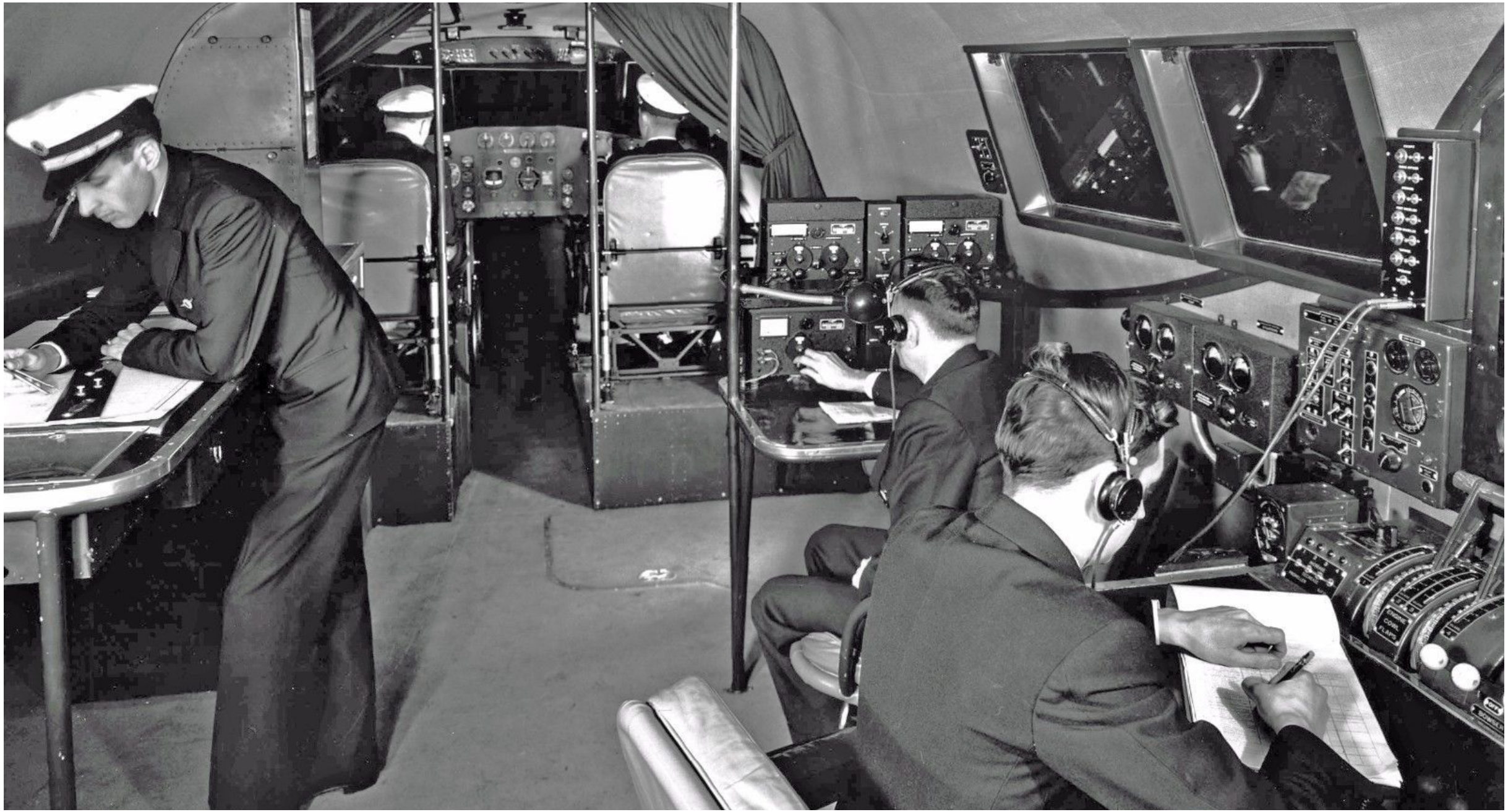


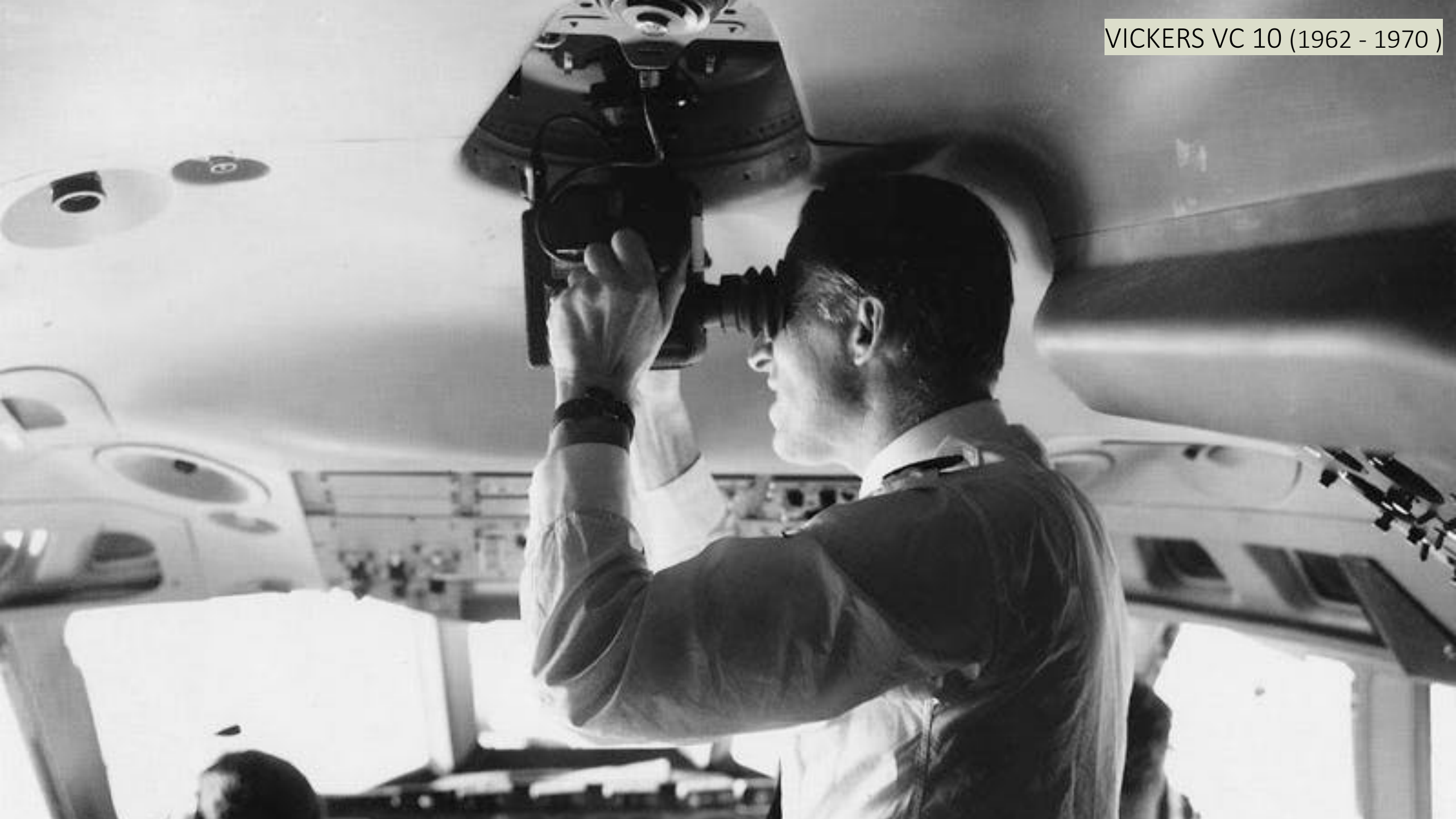
Fred Noonan (1893 -1937)

Amelia Earhart (1897 -1937)

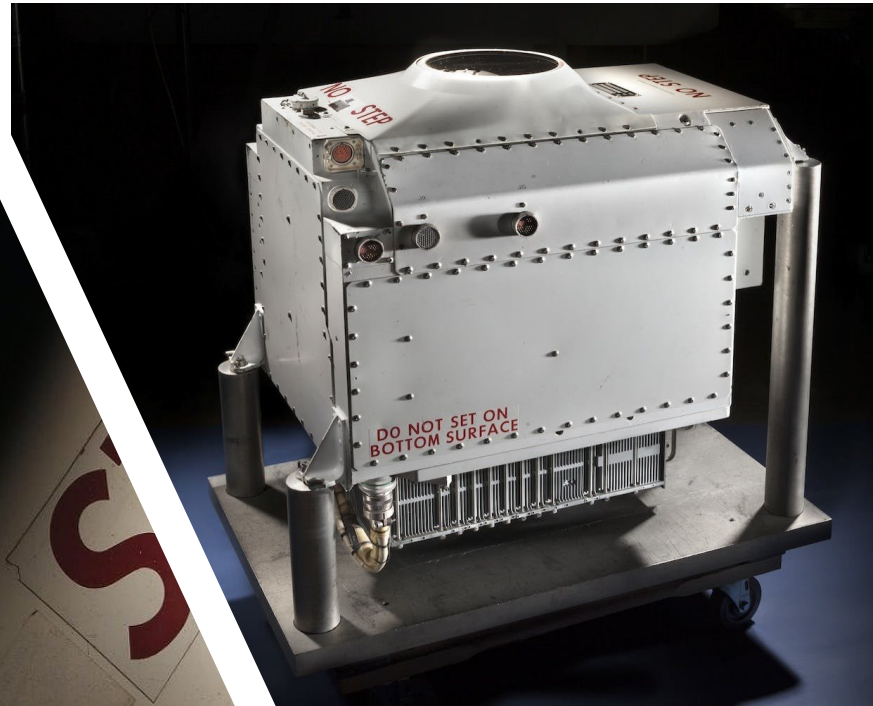


Boeing 314 “CLIPPER” (1939 -1948)





VICKERS VC 10 (1962 - 1970)



LOCKHEED SR-71 “BLACKBIRD” (1964 - 1998)

LA MISURAZIONE DEL TEMPO

- La storia della navigazione e la storia della misurazione del tempo sono strettamente correlate.

- Per lungo tempo non è stato possibile determinare con precisione la propria posizione in mare aperto per mancanza di un orologio accurato ed affidabile.

- Nel 1759, John Harrison, progetta e costruisce un orologio in grado di mantenere l'ora esatta durante lunghe navigazioni in mare aperto. Il problema della longitudine è risolto.

- Con il metodo di Weems, un errore di 30 secondi genera un errore di posizione di quasi 10 nm

- Nel GPS, un errore di 30 nanosecondi genera un errore di posizione di 30 m

- Oggi come allora non è possibile navigare senza una precisa misurazione del tempo.

"Strange to say, keeping the watches running correctly is one of the most difficult matters in navigation."

P. V. H. Weems, Air Navigation, 1931

IL MITO DELL'OROLOGIO DELL'AVIATORE

BLERIOT
ZENITH
1909

WEEMS
LOGINES
1927

LUFTHWAFFE
BEOBACHTUNGS-
UHREN 1941

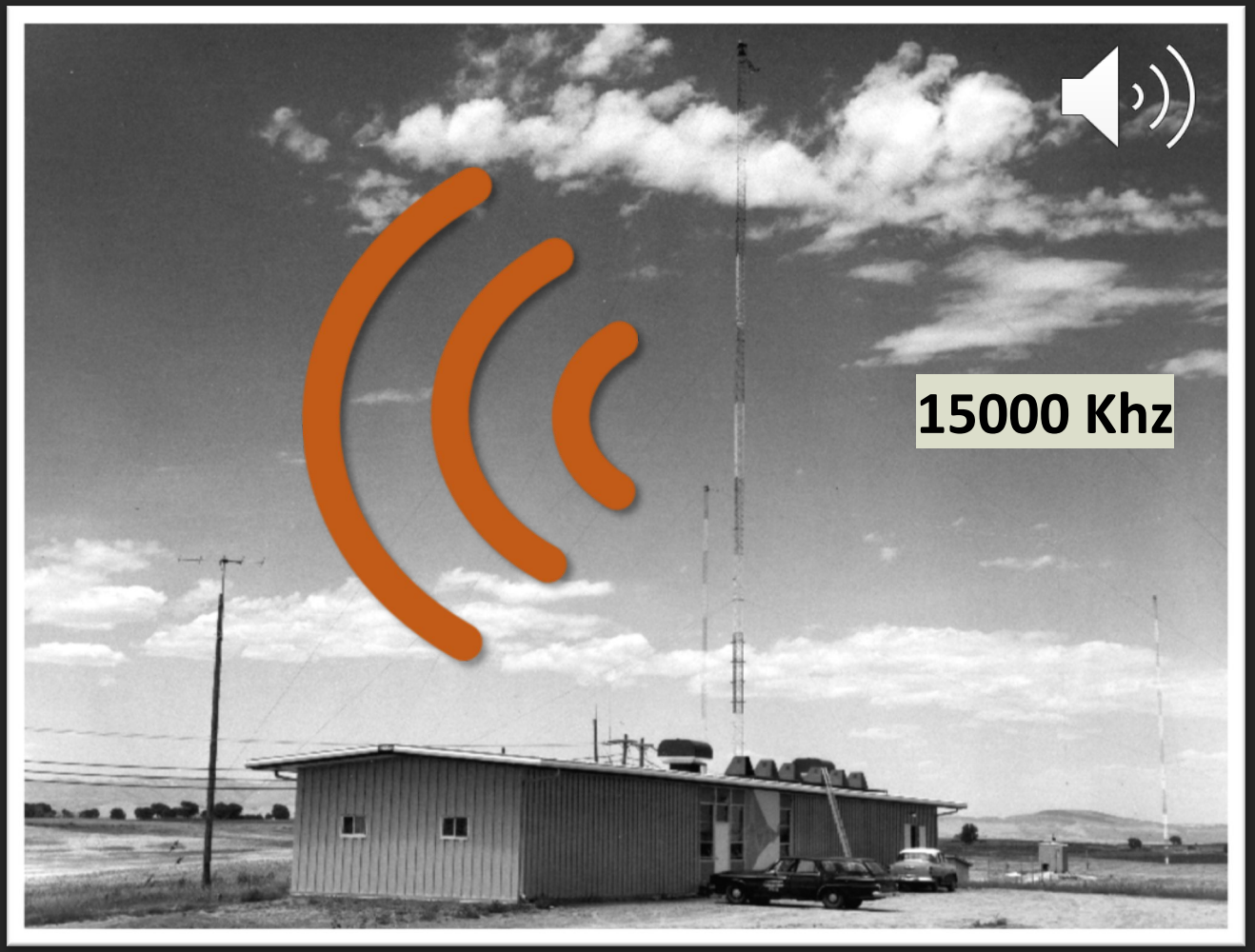
LINDBERGH HOUR ANGLE
LOGINES
1931

1957

OMEGA SPEEDMASTER

$$\Delta v = \int_{t_0}^{t_1} \frac{|T(t)|}{m(t)}\, dt$$

WWV Fort Collins Colorado



(STATICS) (SECONDS BEATS)

AT THE TONE 15 HOURS 1 MINUTE COORDINATED UNIVERSAL TIME…. MINUTE TONE

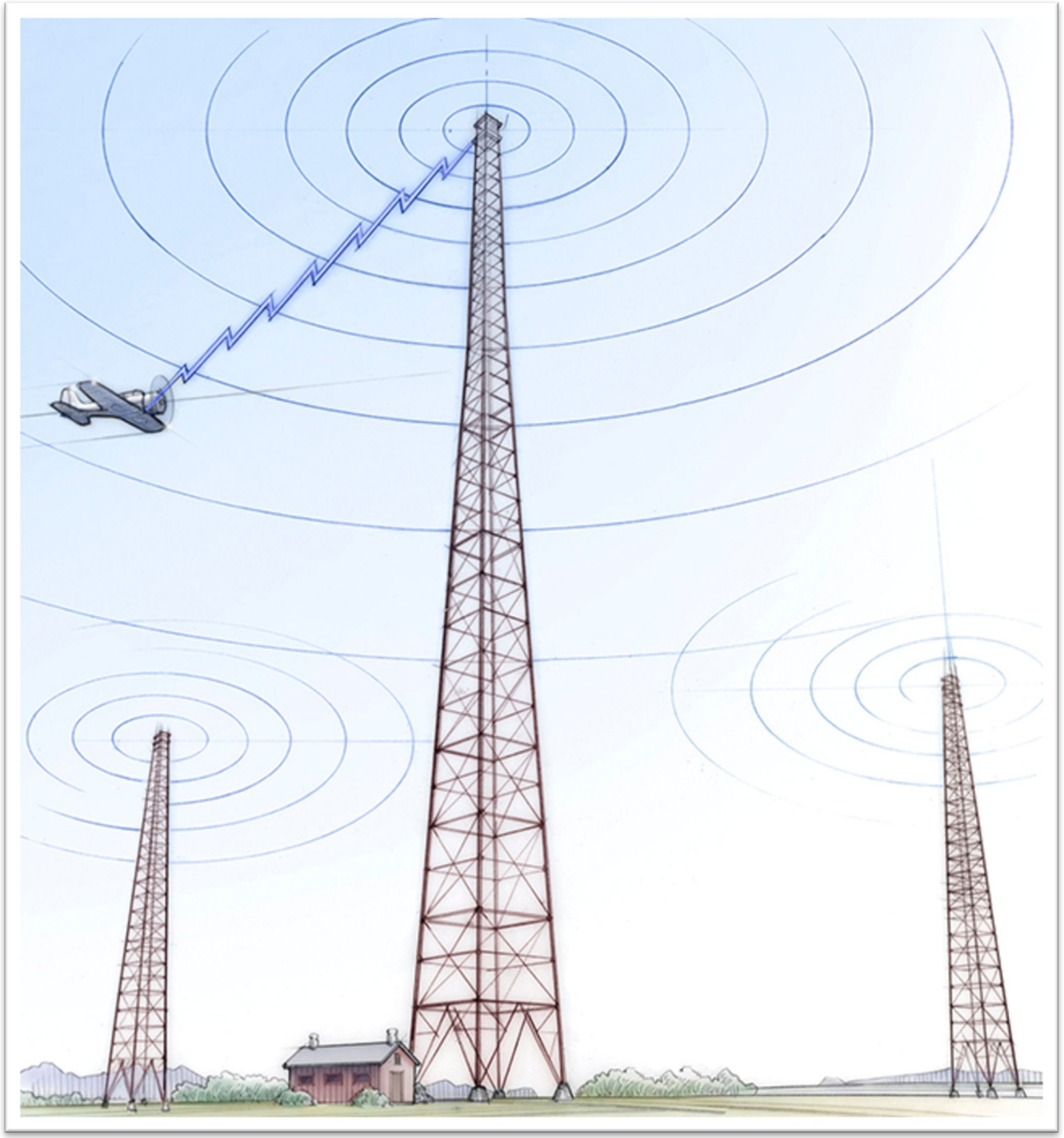
SECONDS TONE

RADIO NAVIGAZIONE

Metodo per determinare la posizione o la rotta tramite la ricezione di segnali elettromagnetici

Lt. James H. Doolitte

Prima navigazione strumentale.
Settembre 1929

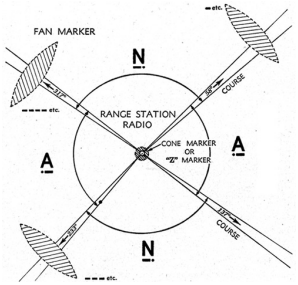


EVOLUZIONE DEI SISTEMI DI RADIO NAVIGAZIONE

1907

DIRECTION FINDER

1928



LF
RADIO RANGE

1933

NDB

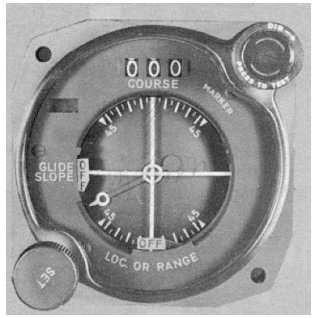
1942

LORAN-A

1946

VOR

1949



ILS

DIRECTION FINDER

1907 - OGGI

DESCRIZIONE:

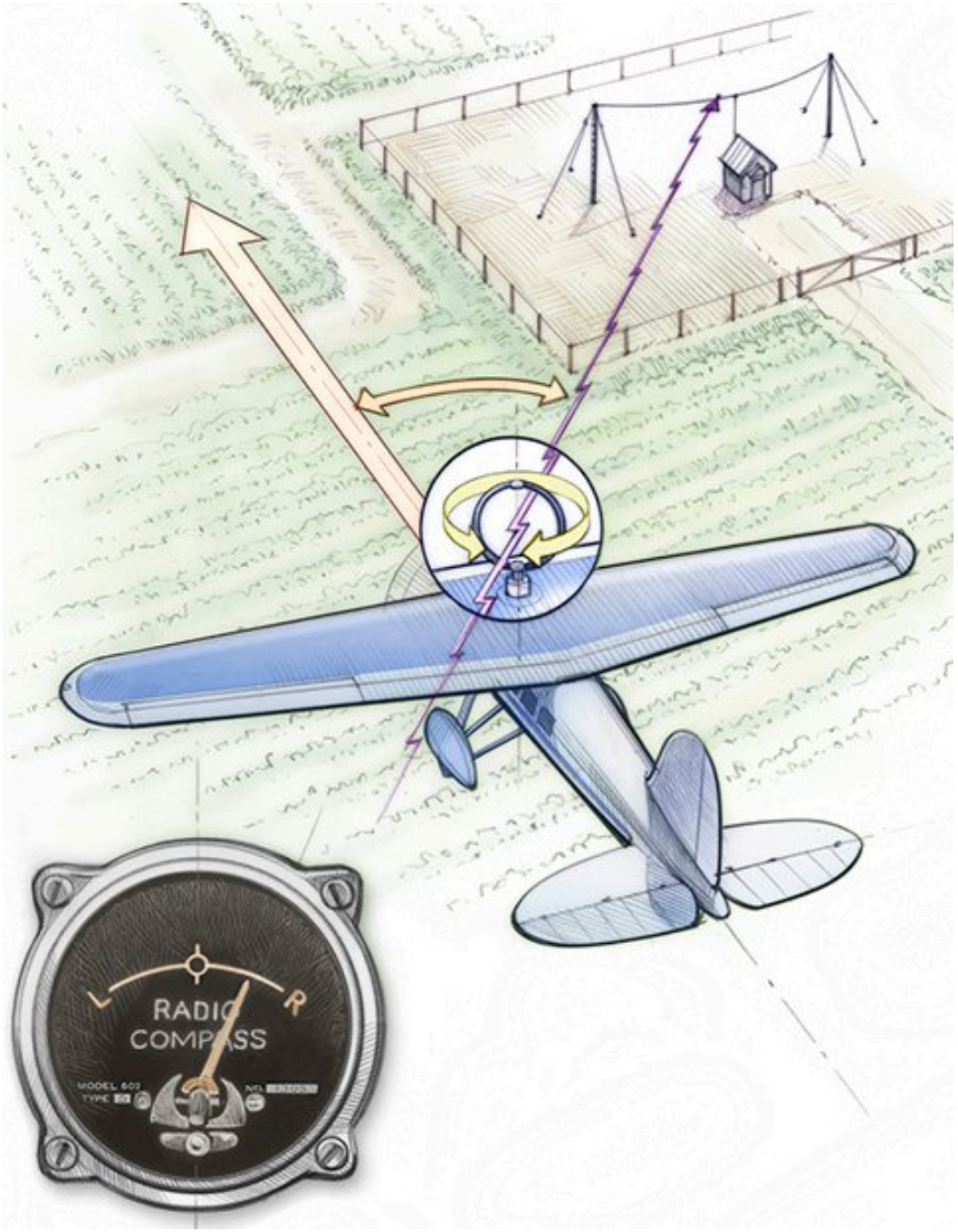
- Metodo per determinare la provenienza di un segnale radio

VANTAGGI:

- Molto semplice
- Permette di localizzare la provenienza di un qualsiasi segnale radio di terra
- Molto utile in guerra

SVANTAGGI:

- Soggetto ad interferenze
- Non permette una radionavigazione accurata

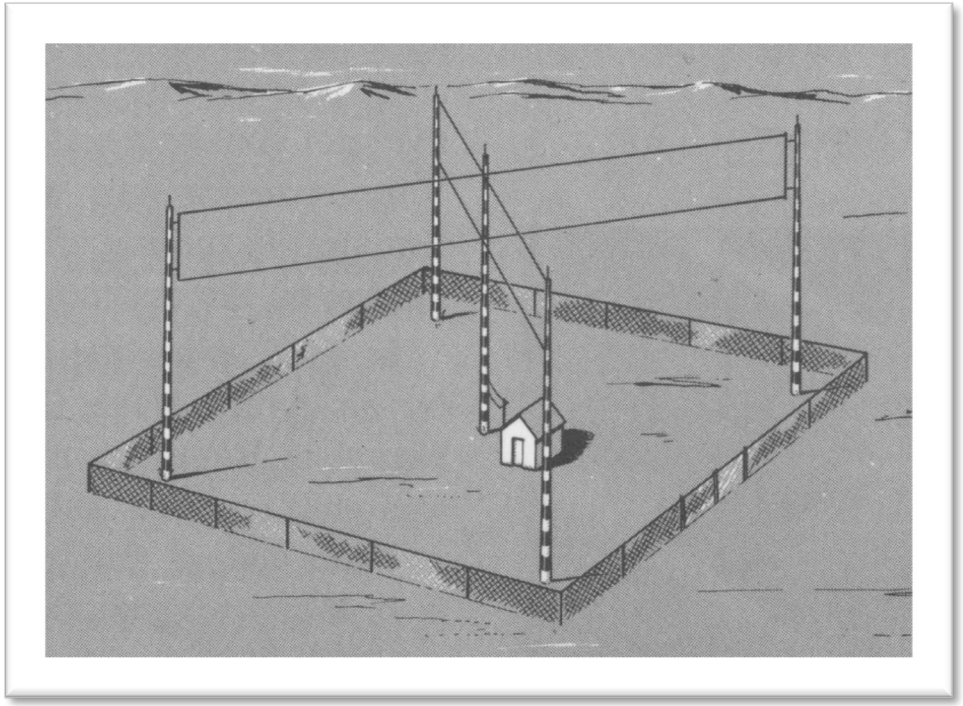


LOW FREQUENCY RADIO RANGE

1928 – ANNI 50

DESCRIZIONE:

- Sistema di radionavigazione tramite la trasmissione di segnali morse.

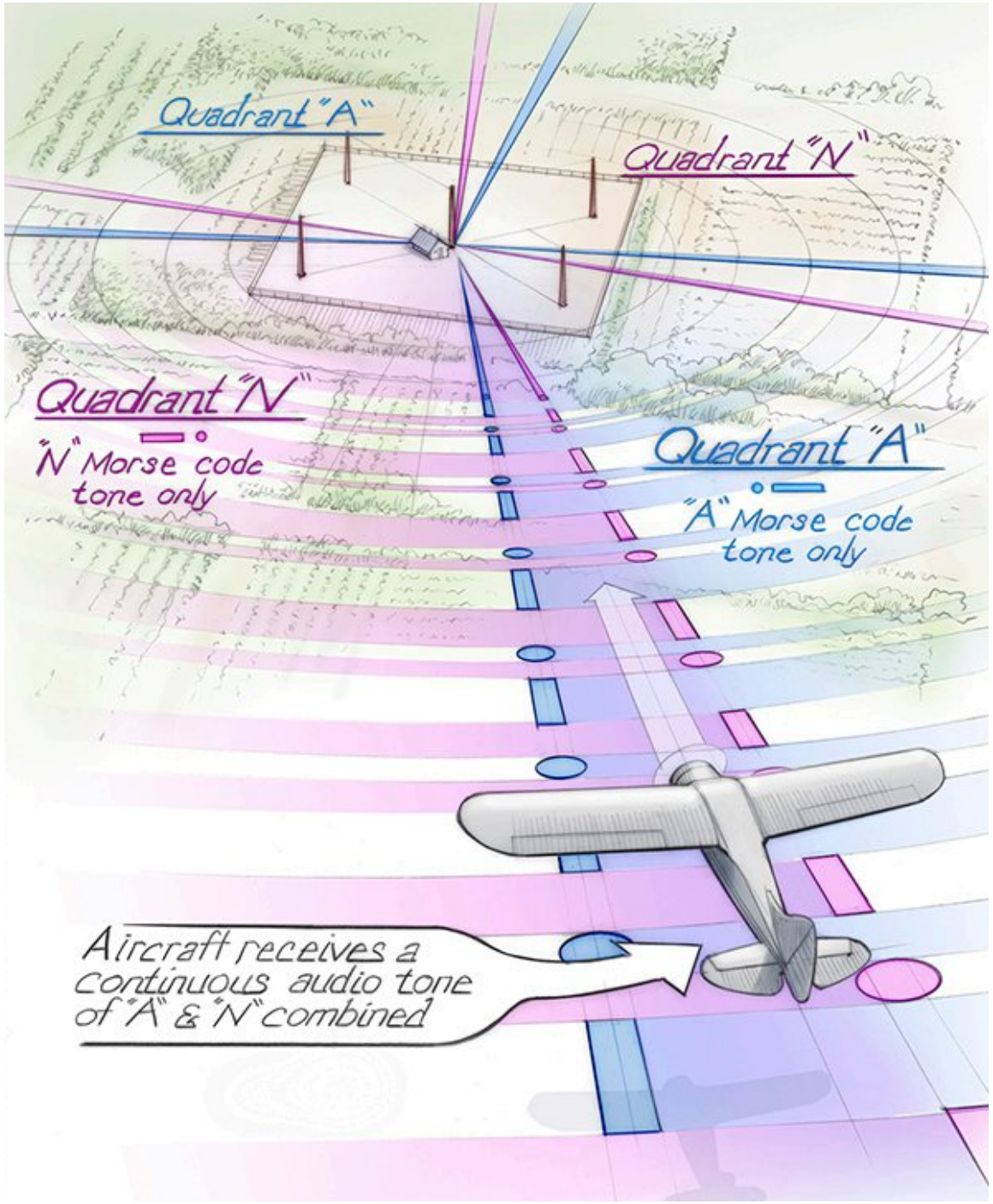


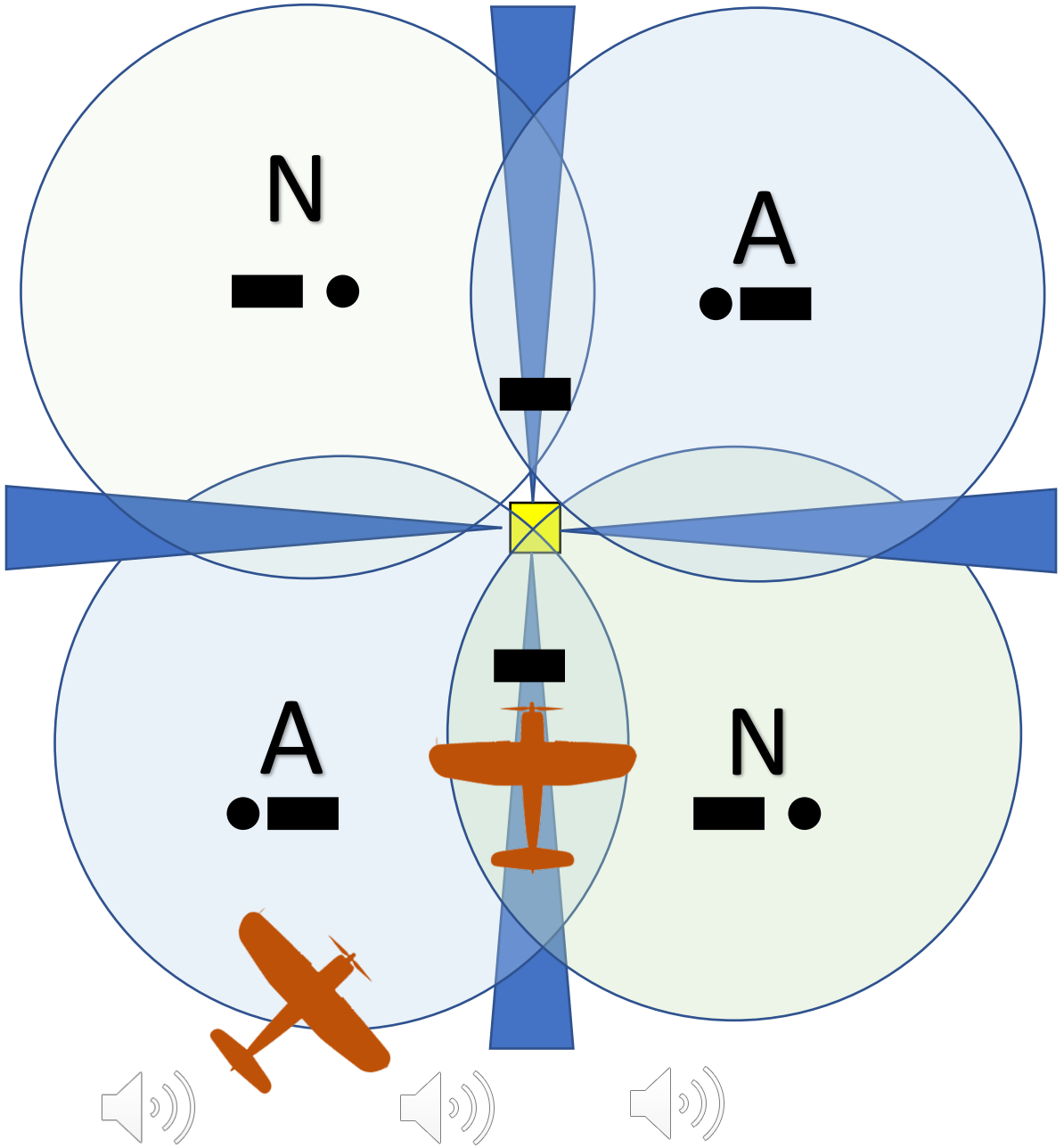
VANTAGGI:

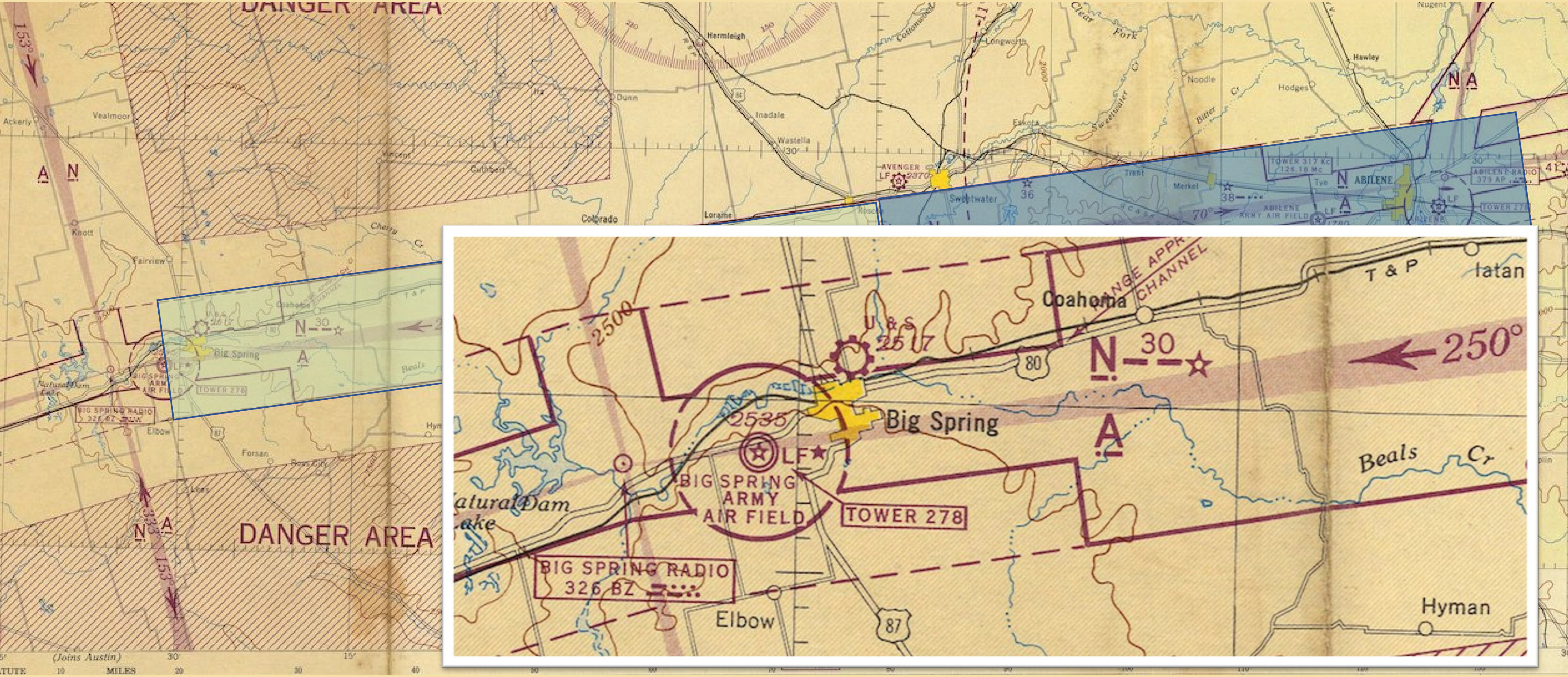
- Permette una navigazione esclusivamente strumentale
- Richiede un semplice ricevitore CW a bordo
- Facile da implementare

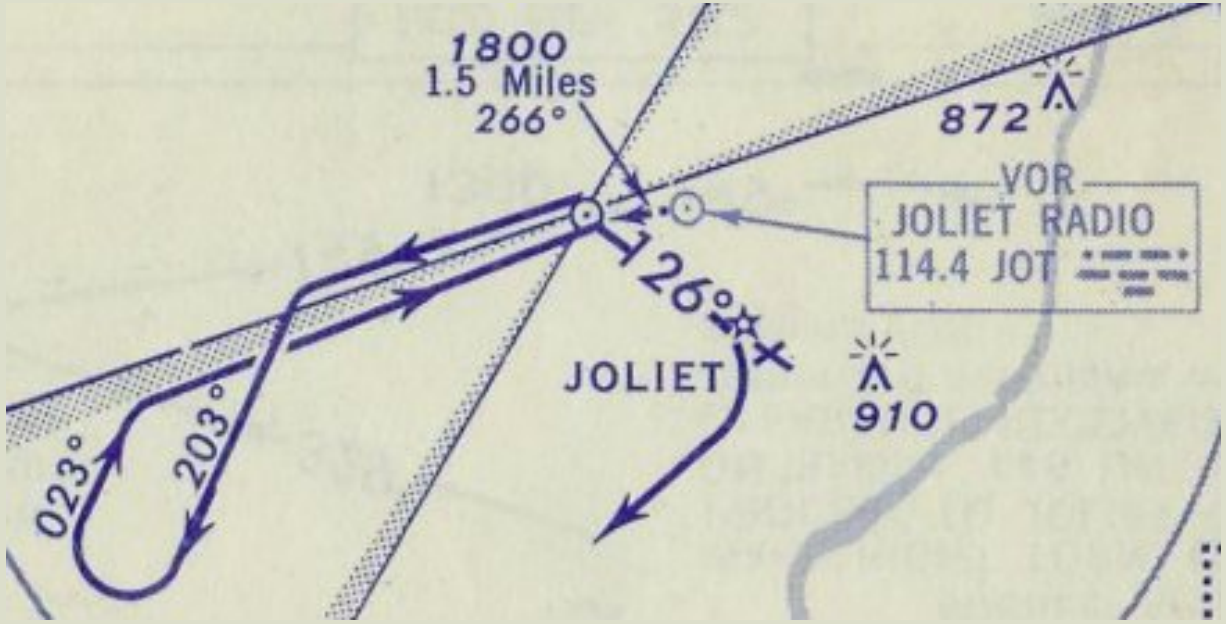
SVANTAGGI:

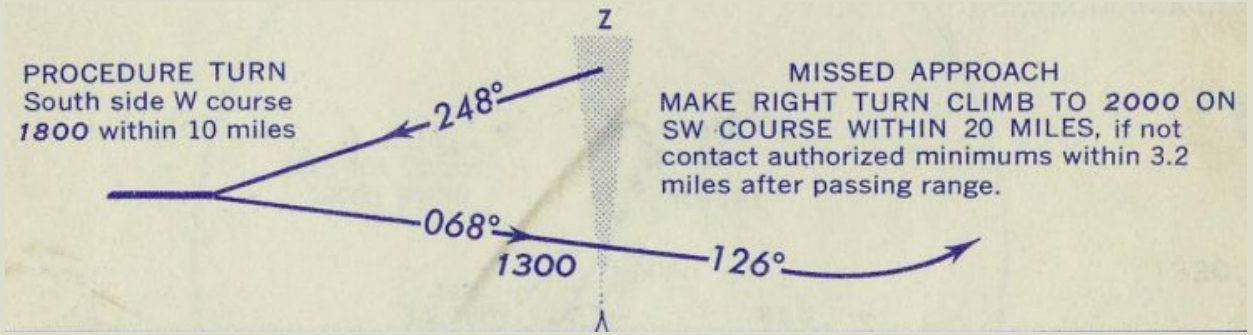
- Solo quattro «radiali»
- Molto soggetta ad interferenze
- Posizione ambigua, nessuna informazione di distanza
- Difficile da monitorare in caso di malfunzionamenti


Quadrant "A"
Quadrant "N"
Quadrant "N"
"N" Morse code tone only
Quadrant "A"
"A" Morse code tone only
Aircraft receives a continuous audio tone of "A" & "N" combined


N
A
A
N


DANGER AREA
Hermleigh
Dunn
Inadale
Wastella
AVENGER
Sweetwater
Colorado
Loraine
Longworth
Noodle
Hodges
Hawley
Nugent
Merkel
Trent
Tye
ABILENE
ABILENE ARMY AIR FIELD
TOWER 317 Kc 126.18 Mc
Ackerly
Vealmoor
Knott
Fairview
Elbow
Forsan
DANGER AREA
(Joins Austin)
Coahoma
T & P
Iatan
RANGE APPROACH CHANNEL
2500
U&S 2517
80
N 30
250°
A
Big Spring
2535
LF
BIG SPRING ARMY AIR FIELD
TOWER 278
Natural Dam Lake
BIG SPRING RADIO 326 BZ
Elbow
87
Beals Cr
Hyman



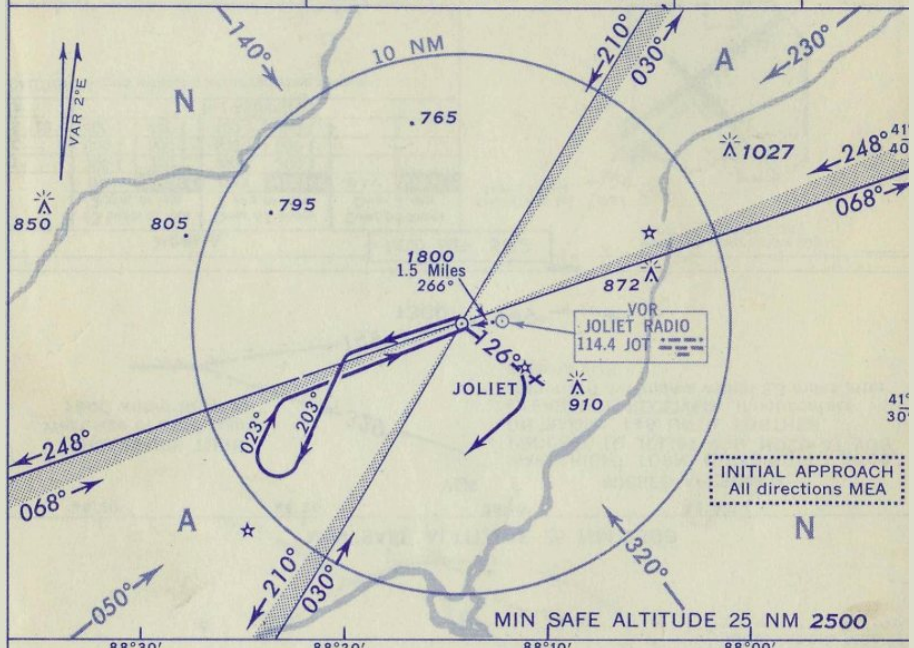


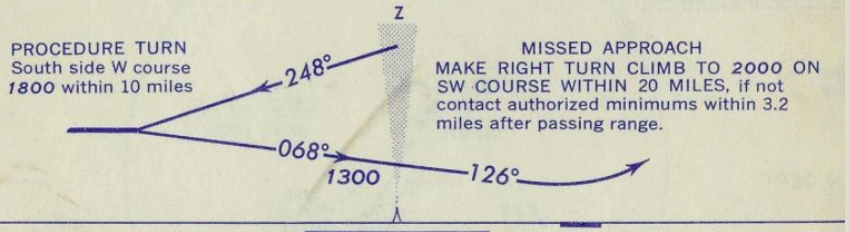
INST APCH PRO (CAA)

U.S. DEPARTMENT OF COMMERCE
PUBLISHED BY COAST AND GEODETIC SURVEY

Consult Radio Facility Charts for latest informatio

NO APPROACH CONTROL	JOLIET RADIO 257 JOT 122.2 126.7 135.0 135.9 255.4	NO TOWER	NO RADAR





MINIMA — FIELD ELEV 582

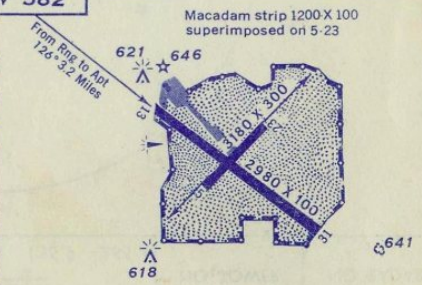
	65 knots or less 2 eng or less		Over 65 knots 2 eng or less		Over 65 knots Over 2 eng	
	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
T	300-1	300-1	300-1	300-1		
C	600-1	600-1	600-1	600-1		
S 13	400-1	400-1	400-1	400-1		
A	Not Authorized					

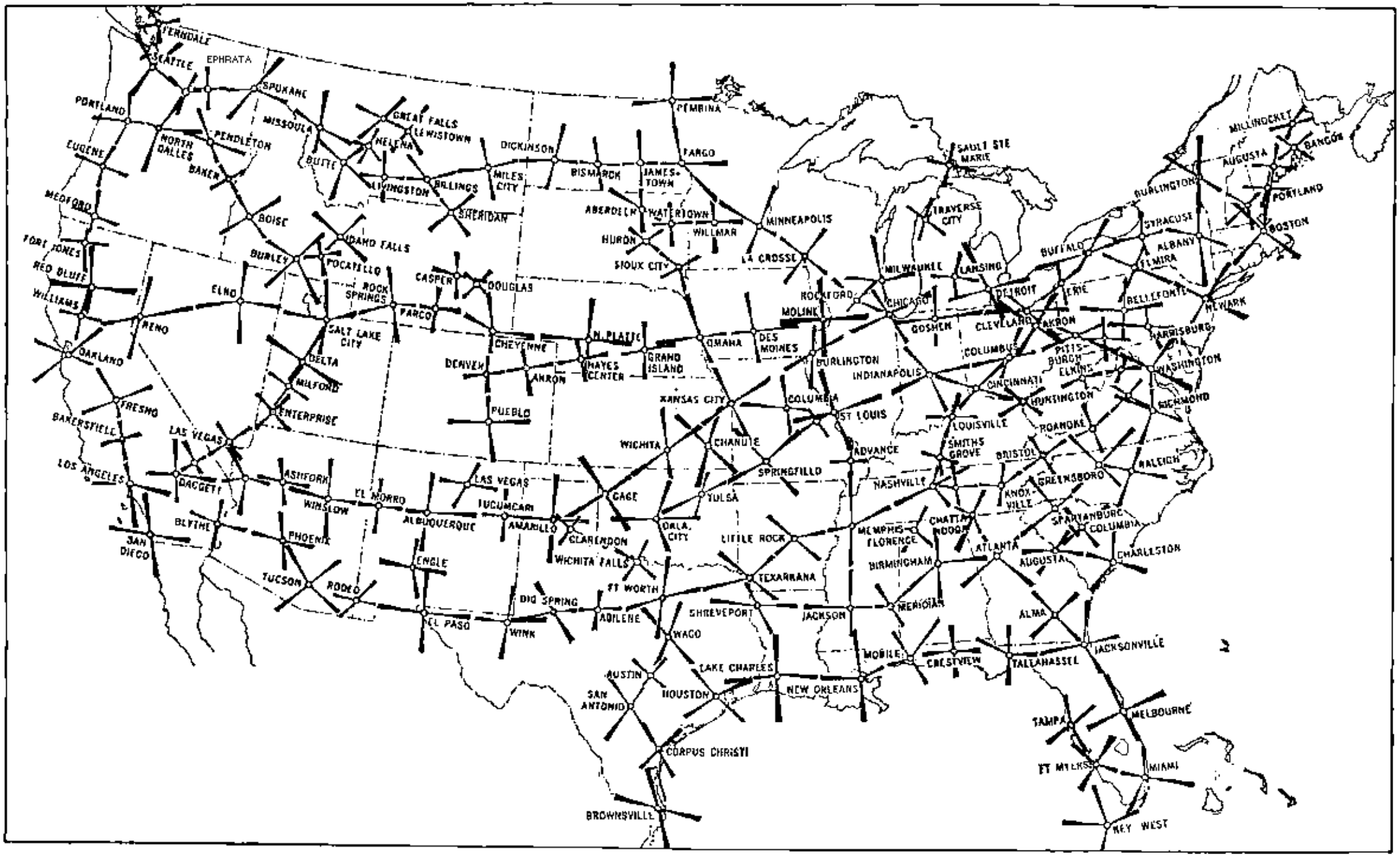
CAUTION: Airport without weather reporting services.

FACILITY TO AERODROME: 126° 3.2 NM

TIME FROM FACILITY TO MISSED APPROACH

KNOTS	90	100	110	130	150
MIN: SEC	2:07	1:55	1:45	1:29	1:17



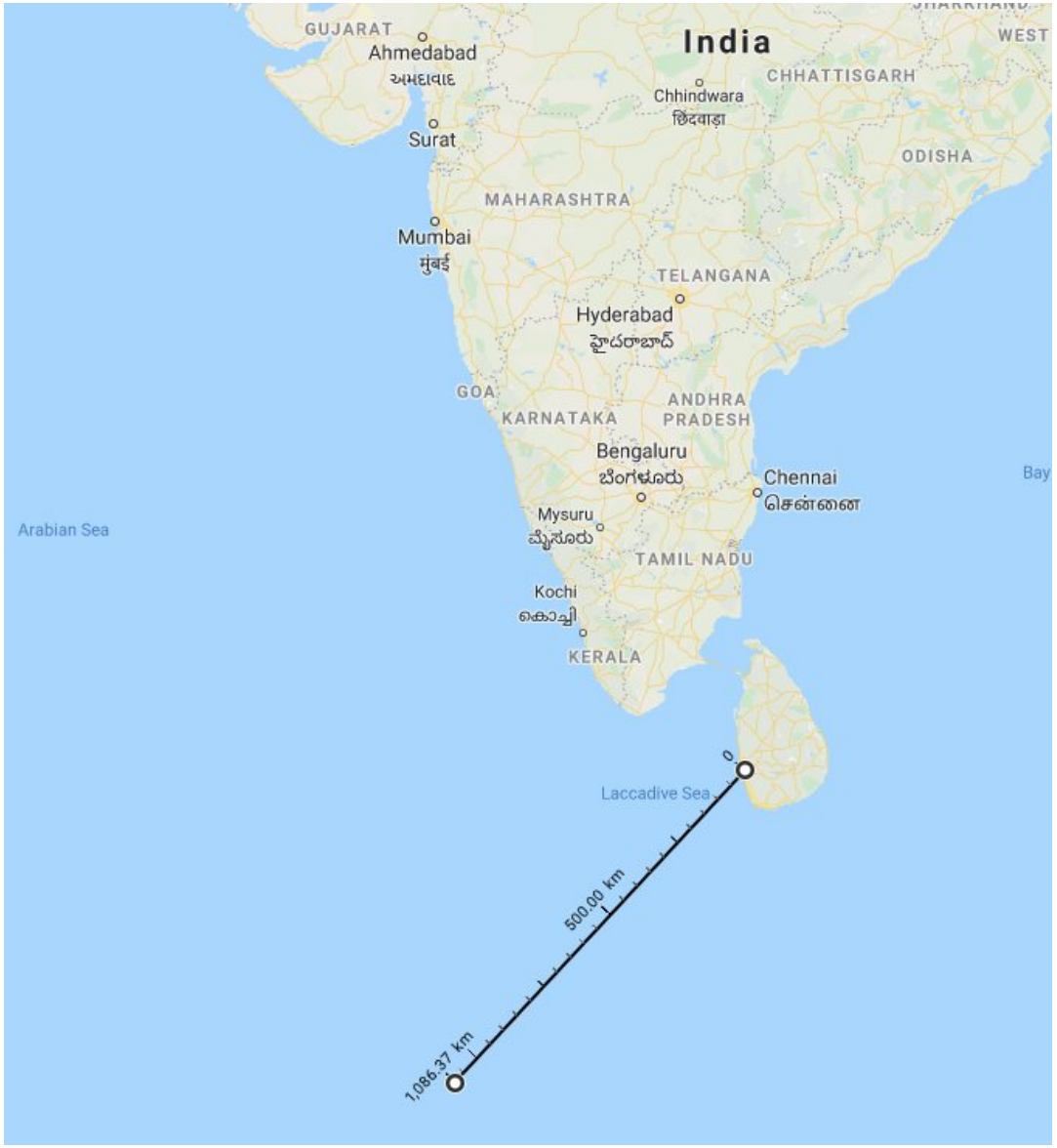

FERNDALE
SEATTLE
EPHRATA
SPOKANE
PORTLAND
EUGENE
NORTH BALLES
PENDLETON
BAKER
MISSOULA
BUTTE
GREAT FALLS
LEWISTOWN
HELENA
LIVINGSTON
BILLINGS
SHERIDAN
MILES CITY
DICKINSON
BISMARCK
JAMES-TOWN
FARGO
PEMBINA
MEDFORD
BOISE
BURLEY
IDAHO FALLS
POCATELLO
FORT JONES
RED BLUFF
WILLIAMS
ELKO
ROCK SPRINGS
CASPER
DOUGLAS
PARCO
RENO
SALT LAKE CITY
OAKLAND
DELTA
MILFORD
ENTERPRISE
FRESNO
BAKERSFIELD
LAS VEGAS
LOS ANGELES
DAGGETT
ASHFORK
WINSLOW
EL MORRO
BLYTHE
PHOENIX
SAN DIEGO
TUCSON
RODEO
ENGLE
EL PASO
DENVER
CHEYENNE
N. PLATTE
HAYES CENTER
GRAND ISLAND
AKRON
PUEBLO
LAS VEGAS
TUCUMCARI
ALBUQUERQUE
AMARILLO
CLARENDON
WICHITA FALLS
GAGE
ABERDEEN
WATERTOWN
WILLMAR
HURON
SIOUX CITY
MINNEAPOLIS
LA CROSSE
OMAHA
DES MOINES
KANSAS CITY
WICHITA
CHANUTE
SPRINGFIELD
YULSA
ORLA. CITY
FT WORTH
DIG SPRING
ABILENE
WINK
SAULT STE MARIE
TRAVERSE CITY
MILWAUKEE
LANSING
ROCKFORD
CHICAGO
MOLINE
GOSHEN
DETROIT
ERIE
CLEVELAND
AKRON
BURLINGTON
INDIANAPOLIS
COLUMBUS
CINCINNATI
COLUMBIA
ST LOUIS
LOUISVILLE
SMITHS GROVE
ADVANCE
NASHVILLE
BRISTOL
KNOX-VILLE
CHATTA-NOOGA
MEMPHIS
FLORENCE
BIRMINGHAM
LITTLE ROCK
TEXARKANA
SHREVEPORT
MERIDIAN
JACKSON
WACO
AUSTIN
SAN ANTONIO
HOUSTON
LAKE CHARLES
NEW ORLEANS
MOBILE
CRESTVIEW
ATLANTA
AUGUSTA
SPARTANBURG
COLUMBIA
CHARLESTON
ALMA
TALLAHASSEE
JACKSONVILLE
TAMPA
MELBOURNE
FT MYERS
MIAMI
KEY WEST
CORPUS CHRISTI
BROWNSVILLE
BUFFALO
SYRACUSE
ALBANY
ELMIRA
BELLEFONTE
HARRISBURG
PITTS-BURGH
ELKINS
WASHINGTON
NEWARK
HUNTINGTON
ROANOKE
RICHMOND
RALEIGH
GREENSBORO
MILLINOCKET
AUGUSTA
BANGOR
PORTLAND
BOSTON
BURLINGTON

DOUGLAS DC-3

HAWKER SIDDELEY HS-748


AERODROME BOOKLET
G - ORAL


Asia
International Boundary
AUSTRALIA - Independent State
Capital City
Major City
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
INDIA
Arabian Sea
Bay of Bengal
Colombo
SRI LANKA
MALDIVES
PAKISTAN
AFGHANISTAN
IRAN
IRAQ
SAUDI ARABIA
EGYPT
SUDAN
ETHIOPIA
SOMALIA
TURKEY
UKRAINE
BELARUS
JAPAN
NORTH KOREA
SOUTH KOREA
BURMA
THAILAND
LAOS
VIETNAM
PHILIPPINES
INDONESIA
PAPUA NEW GUINEA
AUSTRALIA


India
GUJARAT
Ahmedabad
Surat
Chhindwara
CHHATTISGARH
ODISHA
MAHARASHTRA
Mumbai
TELANGANA
Hyderabad
GOA
KARNATAKA
ANDHRA PRADESH
Bengaluru
Chennai
Mysuru
TAMIL NADU
Kochi
KERALA
Arabian Sea
Laccadive Sea
500.00 km
1,086.37 km

1030z

KAT VOR

1100z

1115z

50 nm

30°

60°

25 nm

50 nm

1130z

~ 100 nm

~ 40 nm

MLE NDB

Monsone di sud-ovest

1 IN 60 RULE

TK ERR = (50 nm * 30 °) / 60 = 25nm

CA = (25 *60) / 50 = 30 ° + 30 ° = 60 °

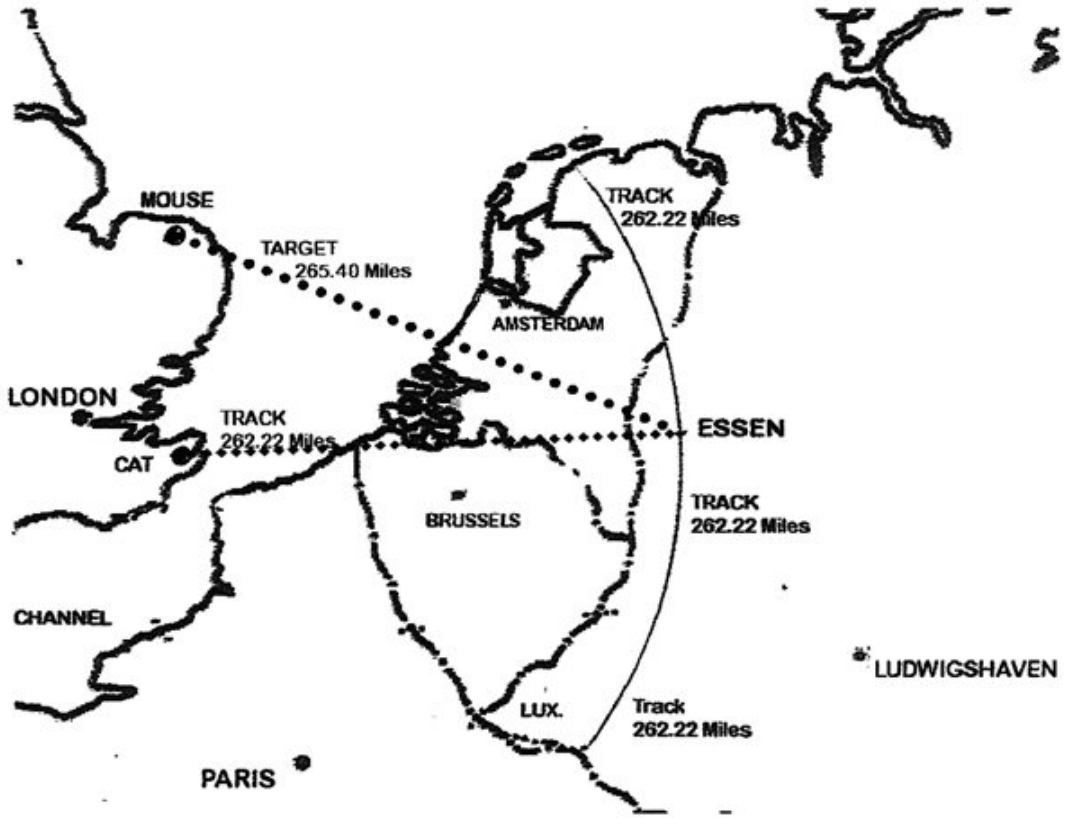

34
33
32
2
3
4
-26
-35
BIA
FI27
CI27
53
VOBL
27
5500
15
10
15
BL557
BL558
BL559
7000
185KT
MAN +4.0°
55' 28"
VOR1
BIA
VOR2
M

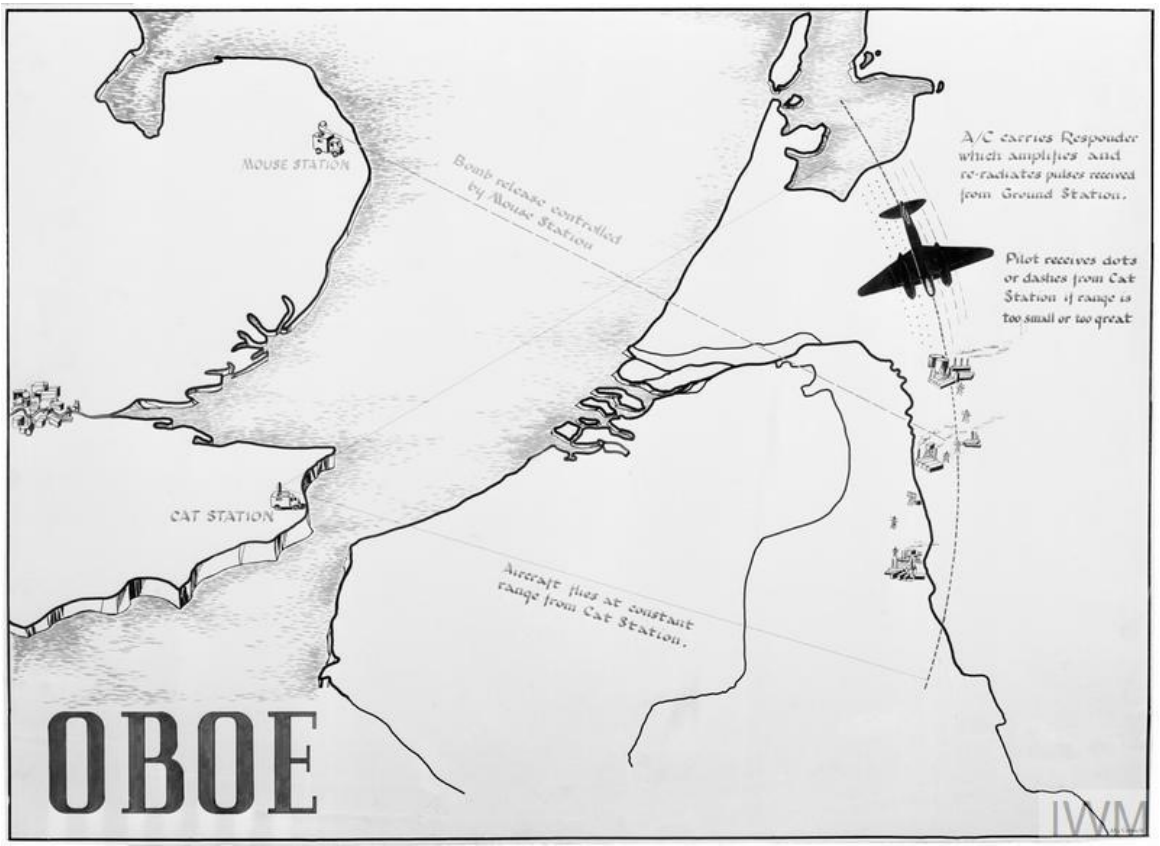
SISTEMI LONG RANGE

OBOE

GEE-H

DECCA





LORAN

1943 – 2010 (?)

DESCRIZIONE

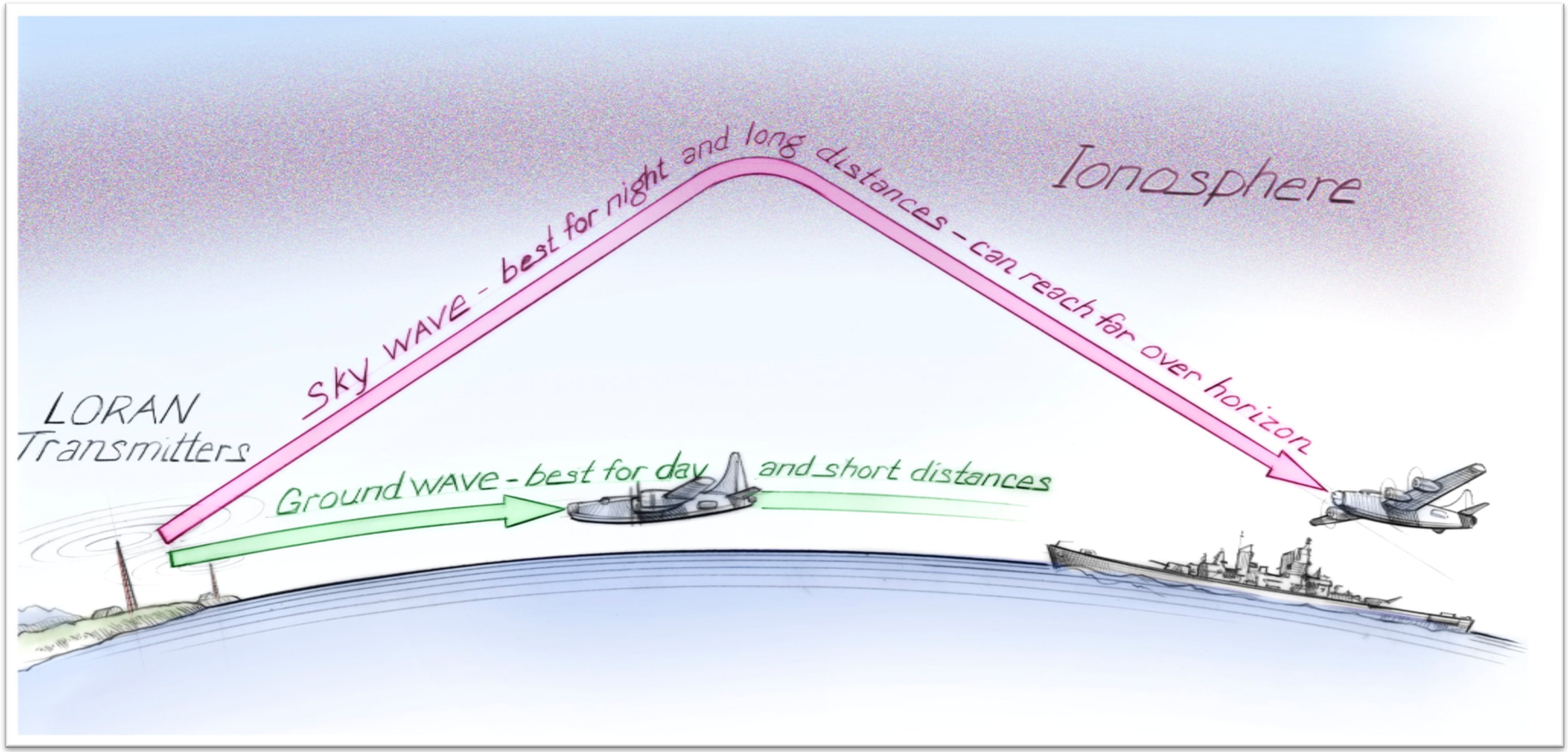
Sistema di navigazione iperbolico ad onde corte per navigazioni a lungo raggio

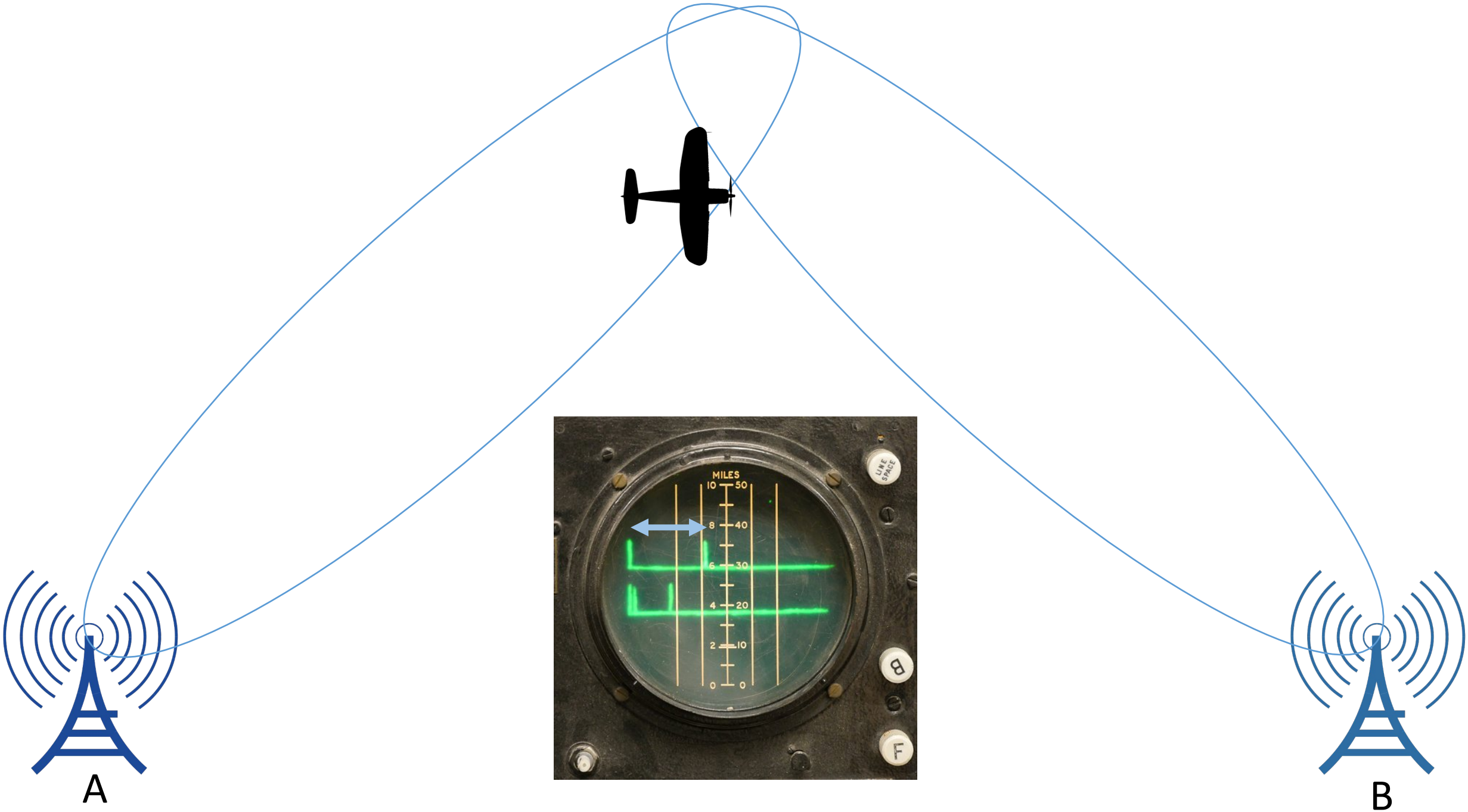
VANTAGGI:

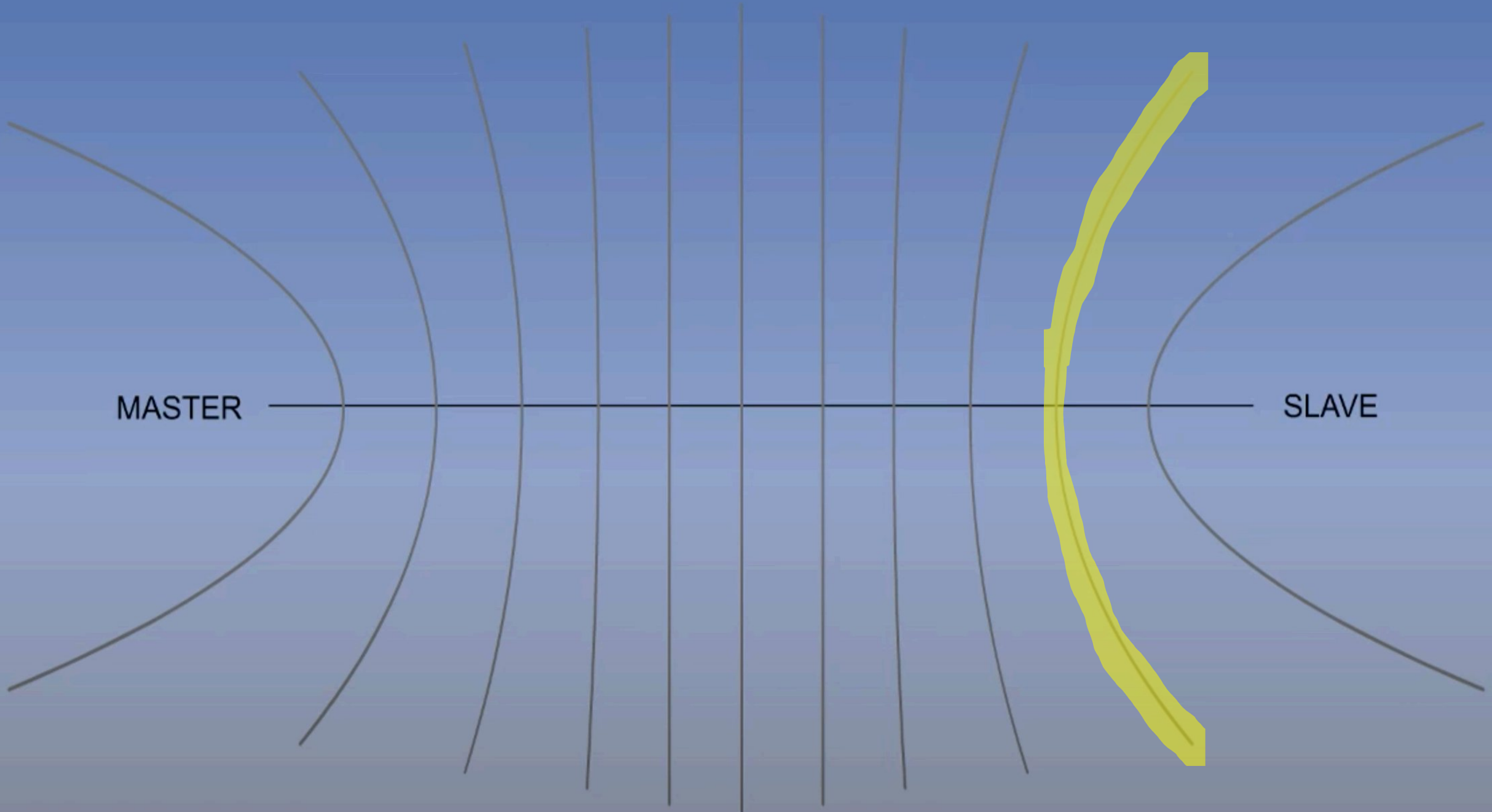
- Sistema a lungo raggio
- Molto preciso
- Resistente ad interferenze

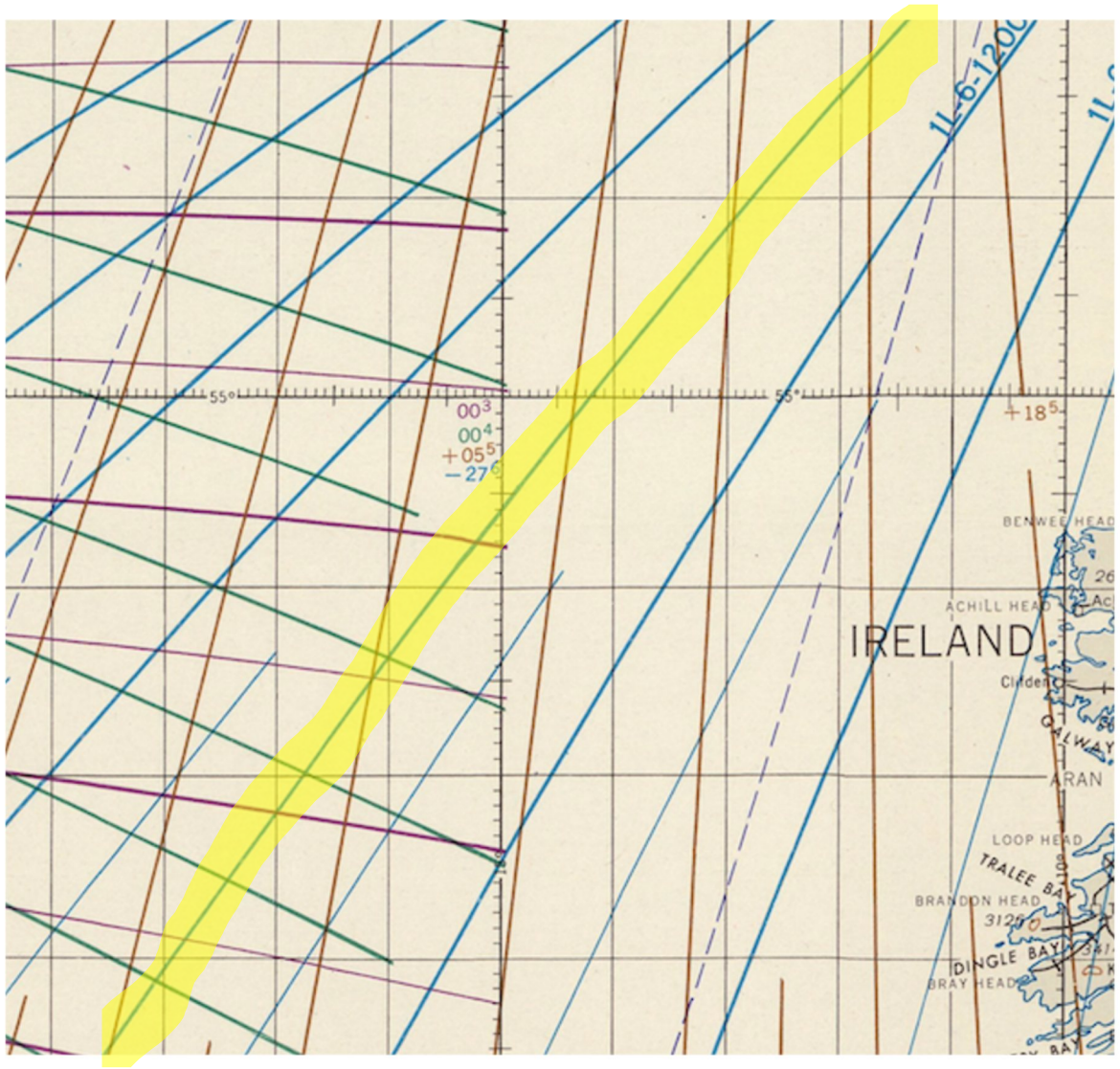
SVANTAGGI:

- Copertura non globale
- Dipendente dalla ionosfera
- Meno preciso del GPS


Ionosphere
Sky wave - best for night and long distances - can reach far over horizon
LORAN Transmitters
Ground wave - best for day and short distances


MILES
10
50
8
40
6
30
4
20
2
10
0
0
LINE SPACE
B
F
A
B


MASTER
SLAVE


IL-6-1200
IL-6-1300
IL-6-1400
IL-6-1500
IL-6-1600
IL-6-1700
IL-6-1800
IL-6-2100
IL-6-2300
IL-5-5395 EXT.
IL-6-1000
IL-6-1100
IL-5-4900
IL-5-5100
IL-5-4000
IL-5-4100
IL-5-4200
IL-5-4300
IL-5-4400
IL-5-4500
IL-5-4600
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IL-5-4800
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IL-5-3800
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IL-4-6200
IL-4-6300
IL-4-6400
IL-3-2800
IL-3-2900
IL-3-3000
IL-3-3100
IL-3-3200
IL-3-3300
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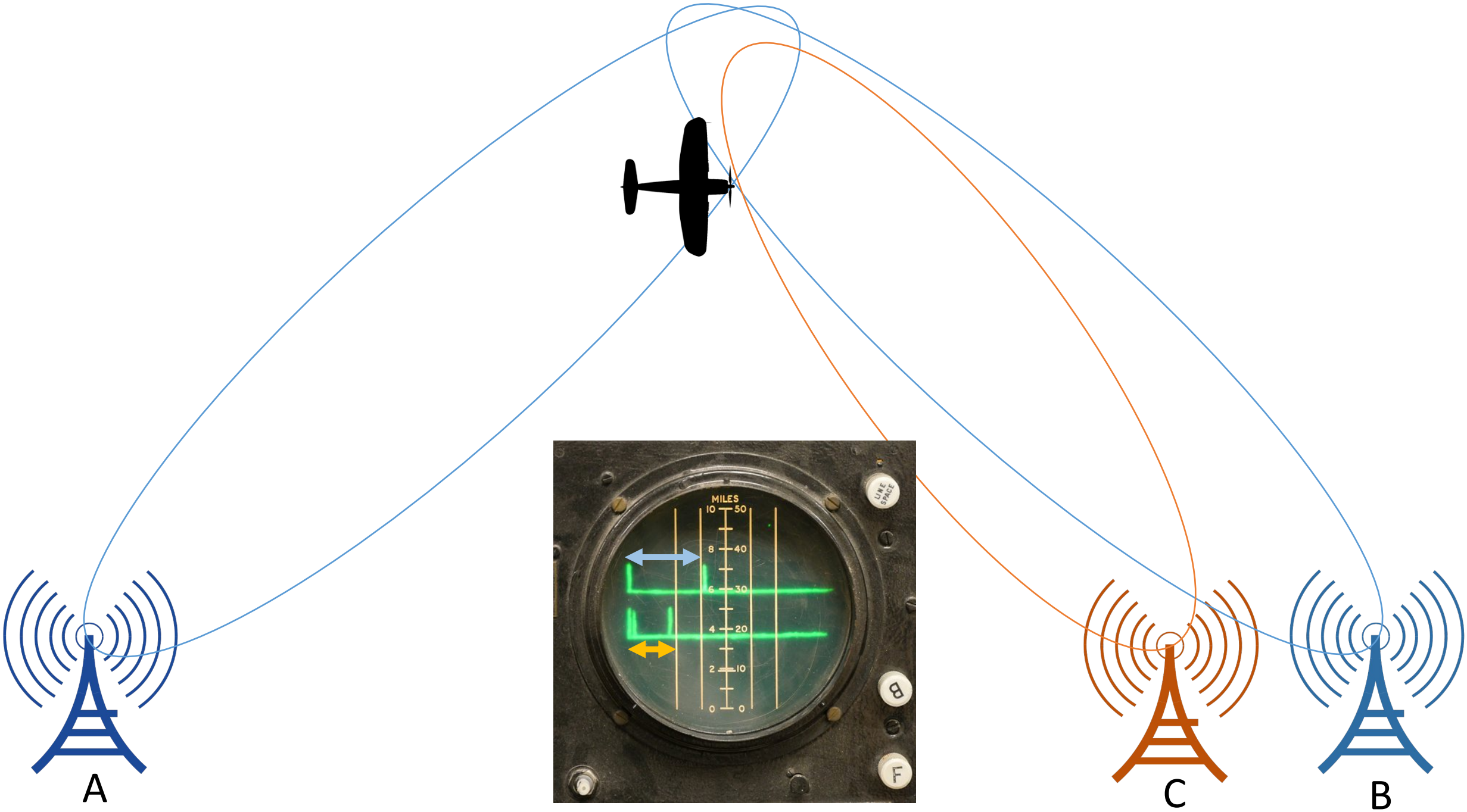
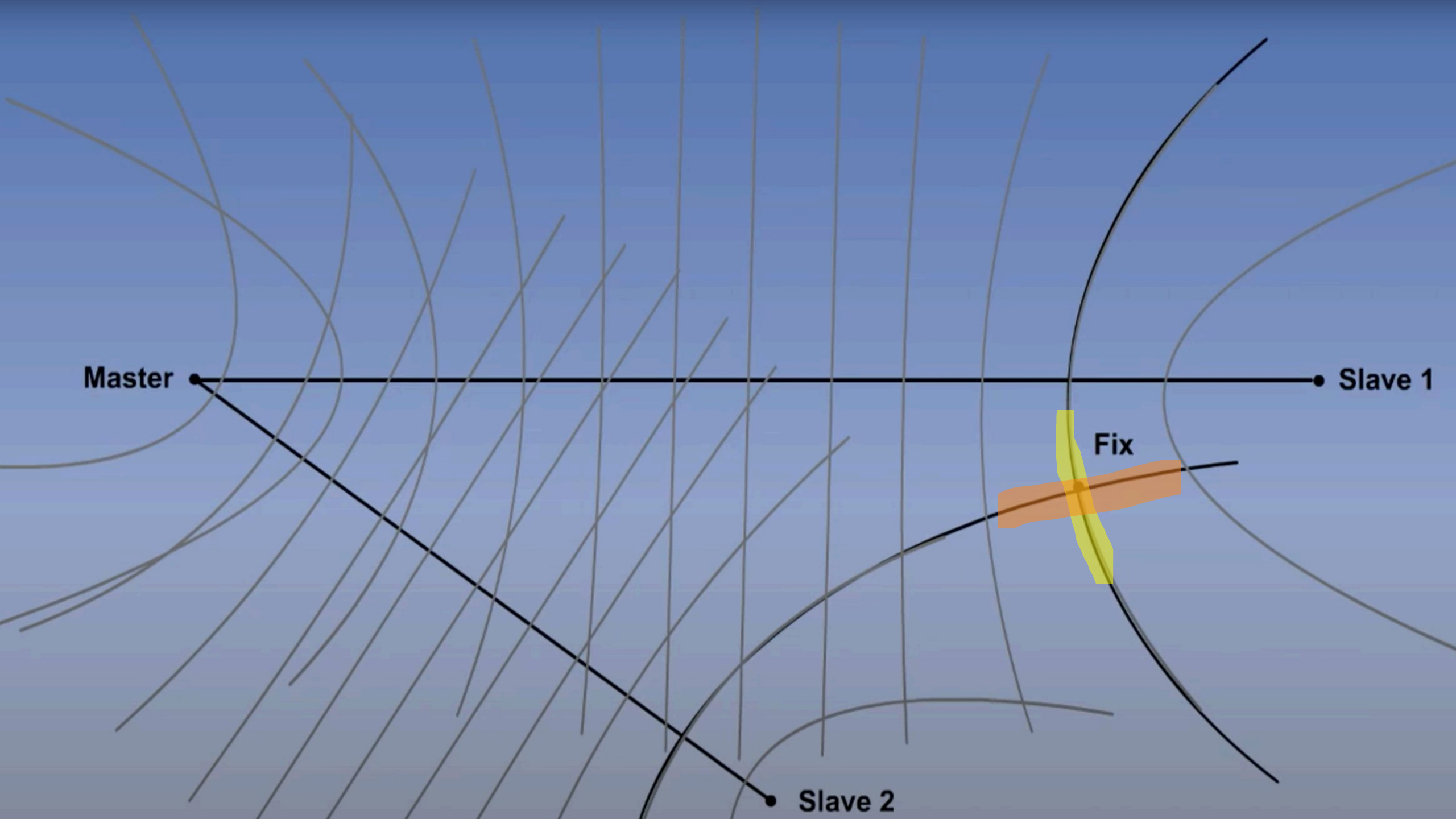
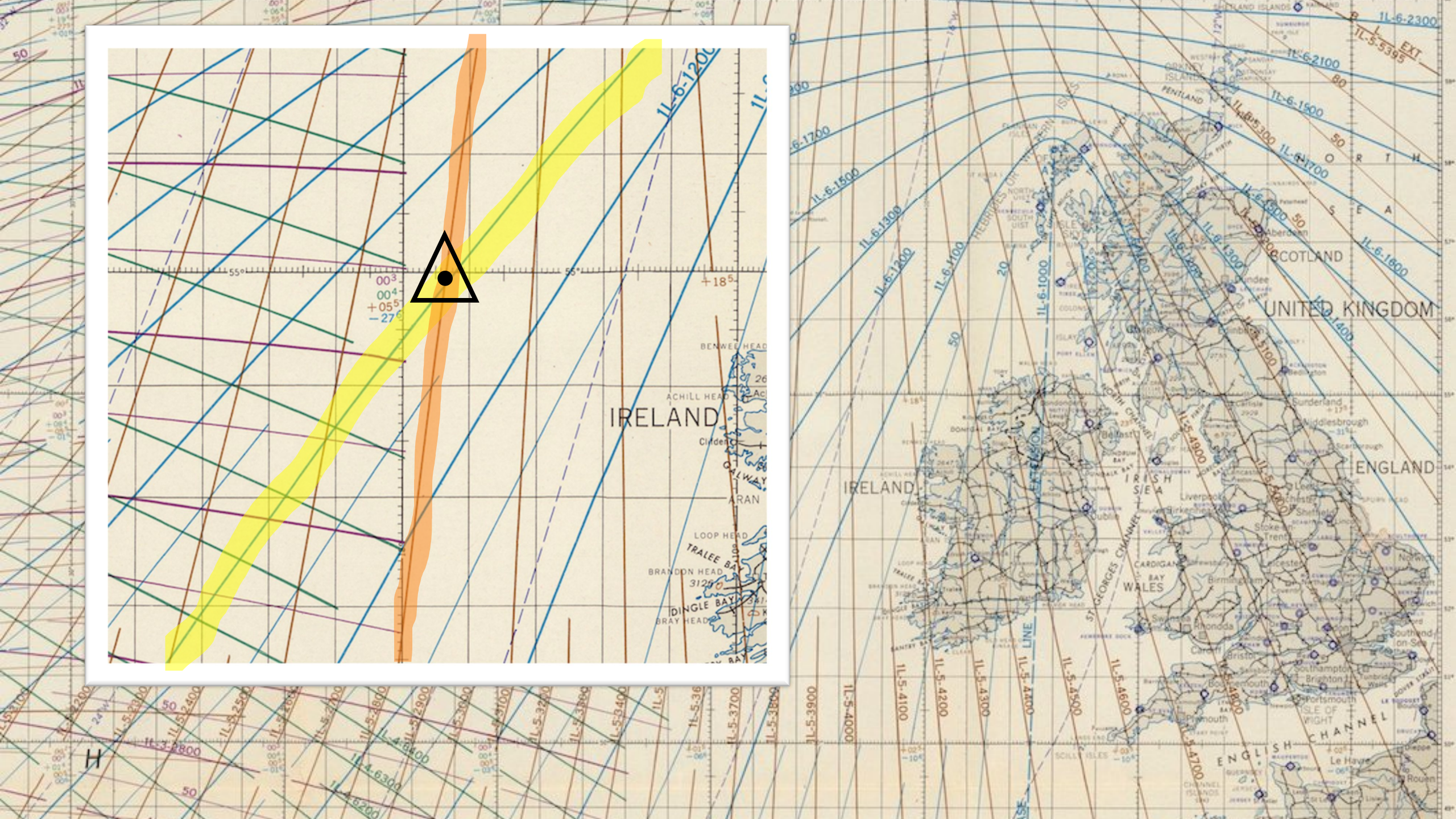
IL-5-4100
IL-5-4200
IL-5-4300
IL-5-4400
IL-5-4500
IL-5-4600
IL-5-4700
IL-5-4800
IRELAND
SCOTLAND
UNITED KINGDOM
ENGLAND
WALES
NORTH SEA
IRISH SEA
ENGLISH CHANNEL
ST GEORGES CHANNEL
HEBRIDES
ISLE OF WIGHT
ACHILL HEAD
BENWEE HEAD
ARAN
LOOP HEAD
TRALEE BAY
BRANDON HEAD
DINGLE BAY
BRAY HEAD
GALWAY
Aberdeen
Dundee
Edinburgh
Glasgow
Belfast
Dublin
Liverpool
Manchester
Sheffield
Leeds
Sunderland
Middlesbrough
Carlisle
Birmingham
Bristol
Cardiff
Swansea
Southampton
Portsmouth
Plymouth
Brighton
Le Havre
Rouen
CARDIGAN BAY
PENTLAND
H


MILES
10 50
8 40
6 30
4 20
2 10
0 0
LINE SPACE
B
F
A
C
B


Master
Slave 1
Fix
Slave 2


IRELAND
ACHILL HEAD
ARAN
LOOP HEAD
TRALEE BAY
BRANDON HEAD
DINGLE BAY
BRAY HEAD
IL-6-1200
IL-6-2300
IL-6-2100
IL-6-1500
IL-6-1700
IL-6-1300
IL-6-1100
IL-6-1000
IL-6-1400
IL-6-1800
IL-5-5395 EXT.
IL-5-5300
IL-5-5100
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IL-5-4200
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IL-5-3100
IL-5-2800
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IL-5-2600
IL-5-2500
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IL-5-2300
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IL-3-1300
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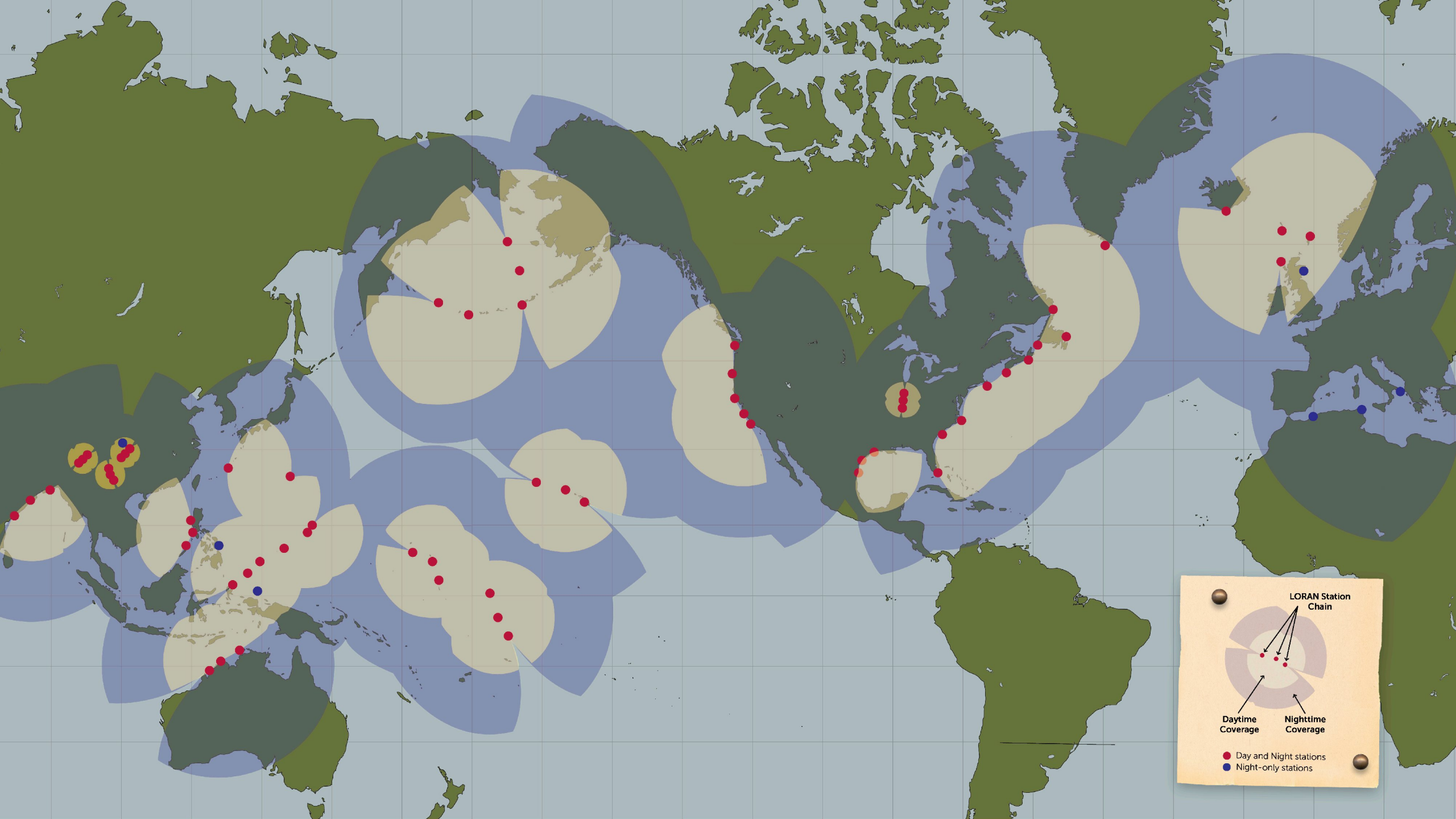
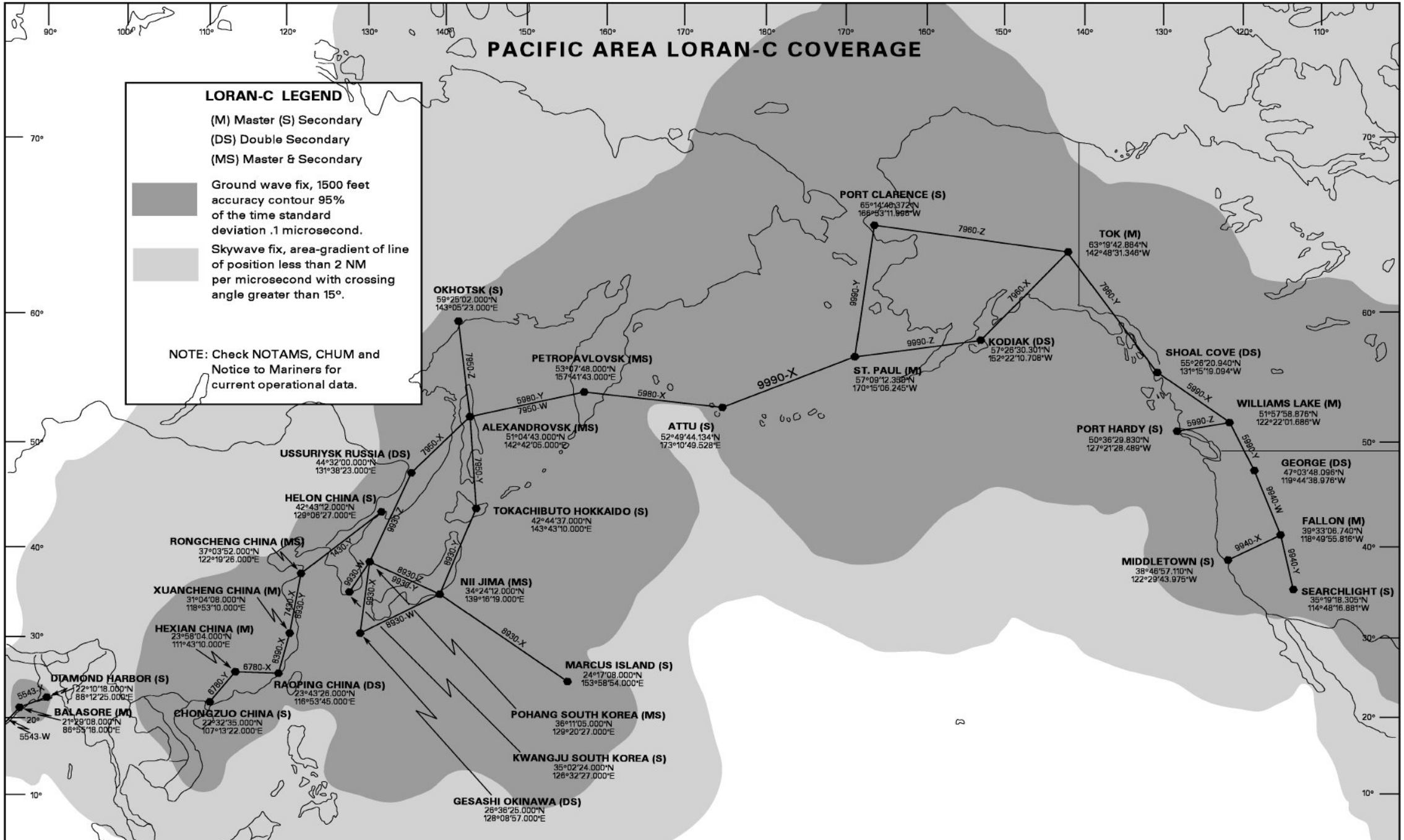
IL-1-300
IL-1-200
IL-1-100
IL-1-000
IL-0-3800
IL-0-3700
IL-0-3600
IL-0-3500
IL-0-3400
IL-0-3300
IL-0-3200
IL-0-3100
IL-0-3000
IL-0-2900
IL-0-2800
IL-0-2700
IL-0-2600
IL-0-2500
IL-0-2400
IL-0-2300
IL-0-2200
IL-0-2100
IL-0-2000
IL-0-1900
IL-0-1800
IL-0-1700
IL-0-1600
IL-0-1500
IL-0-1400
IL-0-1300
IL-0-1200
IL-0-1100
IL-0-1000
IL-0-900
IL-0-800
IL-0-700
IL-0-600
IL-0-500
IL-0-400
IL-0-300
IL-0-200
IL-0-100
IL-0-000
SCOTLAND
UNITED KINGDOM
ENGLAND
IRELAND
WALES
IRISH SEA
ST GEORGES CHANNEL
ENGLISH CHANNEL
ISLE OF WIGHT
NORTH SEA
HEBRIDES
PENTLAND
ORKNEY
SHETLAND ISLANDS
Aberdeen
Dundee
Edinburgh
Glasgow
Belfast
Dublin
Liverpool
Manchester
Sheffield
Leeds
Sunderland
Middlesbrough
Carlisle
Birmingham
Bristol
Cardiff
Swansea
Southampton
Portsmouth
Plymouth
Brighton
Le Havre
Rouen
Cherbourg
Stoke-on-Trent
Norwich
Southend-on-Sea
CARDIGAN BAY
55°
50
20
80
H


TEXAS INSTRUMENTS
9100
DIM
PAR
ENR
APR
PULL OFF
L/L
TD
CRS/D
R/RAD
R/B
XT/GT
2ND
ETE
GMT
N/E
S/W
S/ETA
7
8
9
REF
MARK
CORR
MVAR
WPT
4
5
6
OFST
MON
SEL
MODE
FR/TO
1
2
3
ACK
GRI
CLR
ENT
0
+/-
BACK


MASTER STATION A
SLAVE STATION B
SLAVE STATION C
67.4 Nautical Miles
121°
9 67.4 NM
FR 4 121 DEG
DIM
PAR
ENR
APR
PULL OFF
L/L
TD
CRS/D
R/RAD
R/B
XT/GT
2ND
ETE
GMT
N/E
S/W
S/ETA
7
8
9
REF
MARK
CORR
MVAR
WPT
4
5
6
OFST
MON
SEL
MODE
FR/TO
1
2
3
ACK
GRI
CLR
ENT
0
+/-
BACK


LORAN Station Chain
Daytime Coverage
Nighttime Coverage
Day and Night stations
Night-only stations


PACIFIC AREA LORAN-C COVERAGE
LORAN-C LEGEND
(M) Master (S) Secondary
(DS) Double Secondary
(MS) Master & Secondary
Ground wave fix, 1500 feet accuracy contour 95% of the time standard deviation .1 microsecond.
Skywave fix, area-gradient of line of position less than 2 NM per microsecond with crossing angle greater than 15°.
NOTE: Check NOTAMS, CHUM and Notice to Mariners for current operational data.
PORT CLARENCE (S)
65°14'40.372"N
166°53'11.998"W
TOK (M)
63°19'42.884"N
142°48'31.346"W
OKHOTSK (S)
59°25'02.000"N
143°05'23.000"E
KODIAK (DS)
57°26'30.301"N
152°22'10.708"W
PETROPAVLOVSK (MS)
53°07'48.000"N
157°41'43.000"E
ST. PAUL (M)
57°09'12.330"N
170°15'06.245"W
SHOAL COVE (DS)
55°26'20.940"N
131°15'19.094"W
ALEXANDROVSK (MS)
51°04'43.000"N
142°42'05.000"E
ATTU (S)
52°49'44.134"N
173°10'49.528"E
WILLIAMS LAKE (M)
51°57'58.876"N
122°22'01.686"W
PORT HARDY (S)
50°36'29.830"N
127°21'28.489"W
USSURIYSK RUSSIA (DS)
44°32'00.000"N
131°38'23.000"E
GEORGE (DS)
47°03'48.096"N
119°44'38.976"W
HELON CHINA (S)
42°43'12.000"N
129°06'27.000"E
TOKACHIBUTO HOKKAIDO (S)
42°44'37.000"N
143°43'10.000"E
FALLON (M)
39°33'06.740"N
118°49'55.816"W
RONGCHENG CHINA (MS)
37°03'52.000"N
122°19'26.000"E
MIDDLETOWN (S)
38°46'57.110"N
122°29'43.975"W
NII JIMA (MS)
34°24'12.000"N
139°16'19.000"E
XUANCHENG CHINA (M)
31°04'08.000"N
118°53'10.000"E
SEARCHLIGHT (S)
35°19'18.305"N
114°48'16.881"W
HEXIAN CHINA (M)
23°58'04.000"N
111°43'10.000"E
MARCUS ISLAND (S)
24°17'08.000"N
153°58'54.000"E
DIAMOND HARBOR (S)
22°10'18.000"N
88°12'25.000"E
RAOPING CHINA (DS)
23°43'26.000"N
116°53'45.000"E
BALASORE (M)
21°29'08.000"N
86°55'18.000"E
CHONGZUO CHINA (S)
22°32'35.000"N
107°13'22.000"E
POHANG SOUTH KOREA (MS)
36°11'05.000"N
129°20'27.000"E
KWANGJU SOUTH KOREA (S)
35°02'24.000"N
126°32'27.000"E
GESASHI OKINAWA (DS)
26°36'25.000"N
128°08'57.000"E

ATLANTIC AREA LORAN-C COVERAGE

LORAN-C LEGEND

(M) Master (S) Secondary
(DS) Double Secondary
(MS) Master & Secondary

Ground wave fix, 1500 feet accuracy contour 95% of the time standard deviation .1 microsecond.

Skywave fix, area-gradient of line of position less than 2 NM per microsecond with crossing angle greater than 15°.

NOTE: Check NOTAMS, CHUM and Notice to Mariners for current operational data.

JAN MAYEN IS. NORWAY (DS)
70°54'53.000"N
08°43'59.000"W

BERLEVAG NORWAY (S)
70°59'30.000"N
29°13'00.000"E

BO NORWAY (MS)
68°38'06.000"N
14°27'47.000"E

EJDE FAROE IS. DENMARK (M)
62°17'59.000"N
07°04'27.000"W

VAERLANDET NORWAY (DS)
61°17'53.000"N
04°41'49.000"E

PETROZAVODSK (S)
61°44'32.4"N
33°41'40.4"E

BRYANSK (M)
53°07'50.6"N
34°54'44.8"E

SYLT (MS)
54°48'00.000"N
08°18'00.000"E

SYZRAN (S)
53°17'17.6"N
48°06'53.4"E

SLONIM (S)
53°07'55.2"N
25°28'46.0"E

SIMFEROAOL (S)
44°53'20.6"N
33°52'32.1"E

LESSAY (MS)
49°09'00.000"N
01°30'00.000"E

SOUSTONS (S)
43°44'00.000"N
01°23'00.000"E

FOX HARBOR (MS)
52°22'35.252"N
55°42'27.852"W

COMFORT COVE (M)
49°19'54.000"N
54°51'43.000"W

CAPE RACE (DS)
46°46'32.286"N
53°10'27.806"W

BAUDETTE (S)
48°35'49.947"N
94°33'17.915"W

CARIBOU (MS)
46°48'27.305"N
67°55'37.159"W

SENECA (MS)
42°42'50.716"N
76°49'33.308"W

NANTUCKET (DS)
41°15'12.048"N
69°58'38.636"W

DANA (MS)
39°51'07.658"N
87°29'11.586"W

CAROLINA BEACH (DS)
34°03'46.206"N
77°54'46.100"W

GRANGEVILLE (S)
30°43'33.149"N
90°49'43.046"W

MALONE (MS)
30°59'38.870"N
85°10'08.751"W

JUPITER (S)
27°01'58.528"N
80°06'52.975"W

RAYMONDVILLE (S)
26°31'55.141"N
97°49'59.539"W

ASH SHAYKH HUMAYD (DS)
28°09'16.000"N
34°45'41.000"E

AFIF (MS)
23°48'37.000"N
42°51'18.000"E

SALWA (DS)
24°50'02.000"N
50°34'13.000"E

AL KHAMASIN (MS)
20°28'02.000"N
44°34'53.000"E

AL MUWASSAM (DS)
16°25'56.000"N
42°48'05.000"E

INERTIAL NAVIGATION

1960– OGGI

DESCRIZIONE:

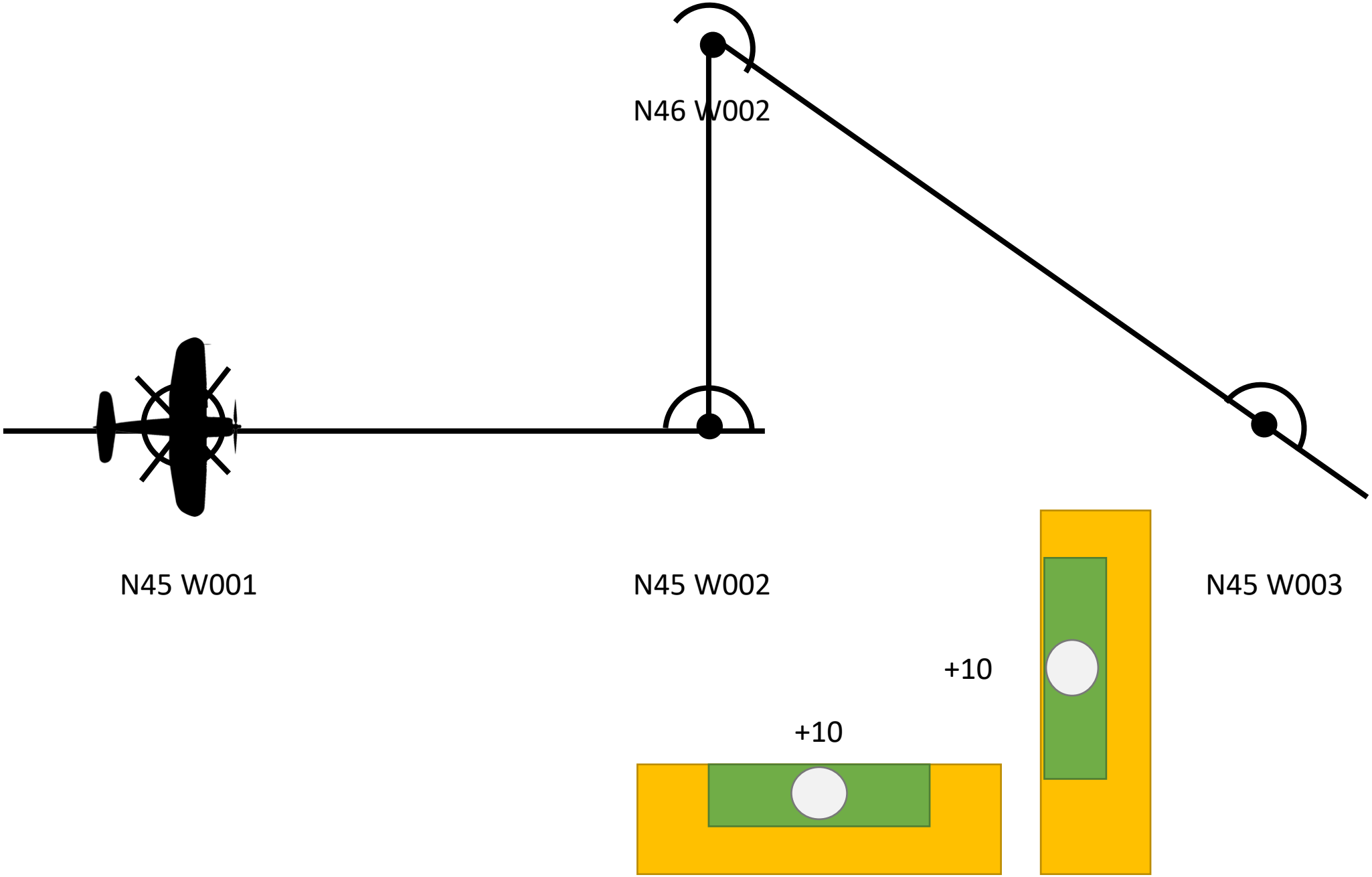
- Dispositivo di navigazione che calcola posizione, velocità ed accelerazione di un veicolo senza riferimenti o input esterni

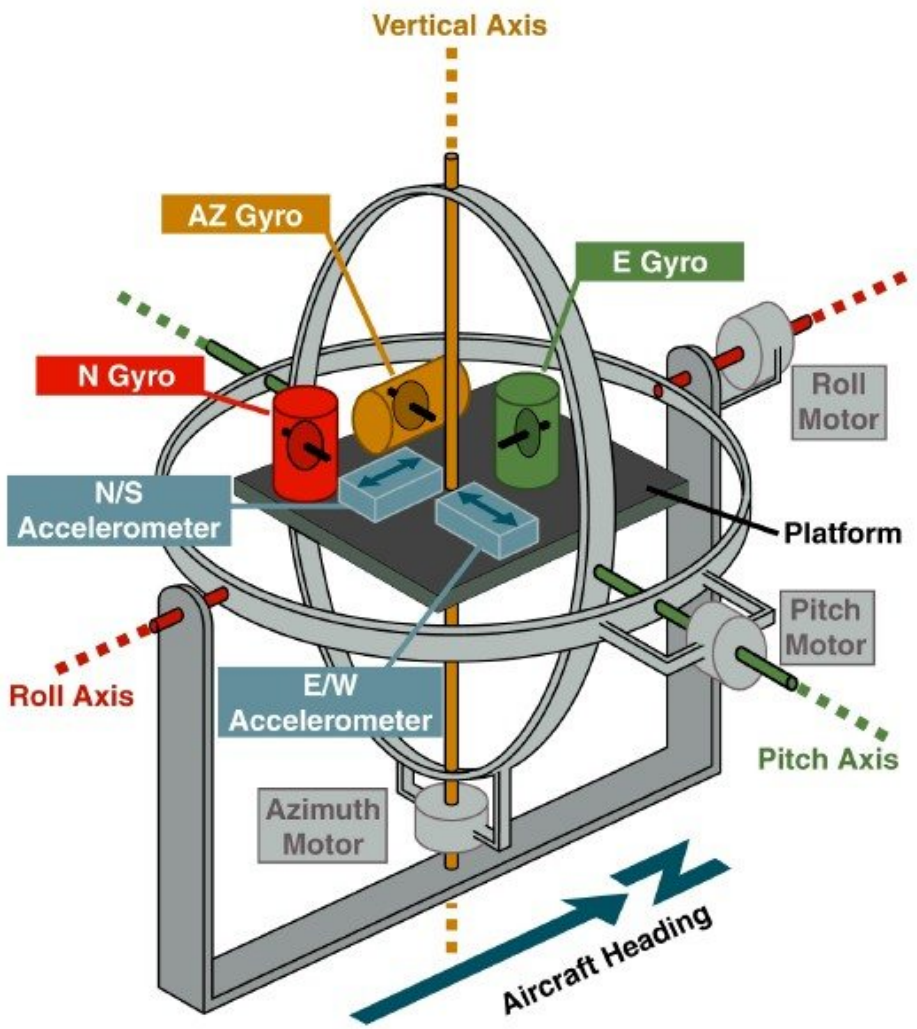
VANTAGGI:

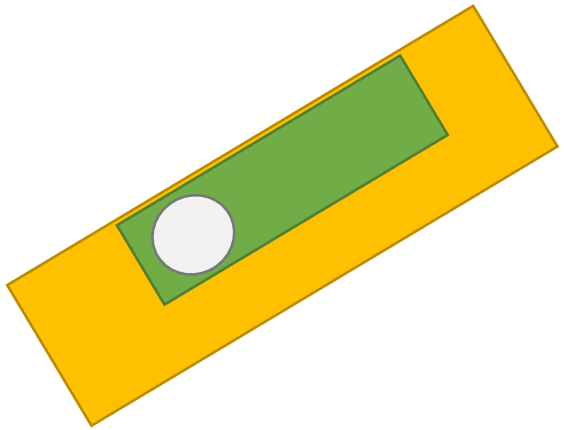
- Sistema indipendente
- Non richiede input esterni
- Permette di navigare in zone molto remote o dove la bussola magnetica non funziona

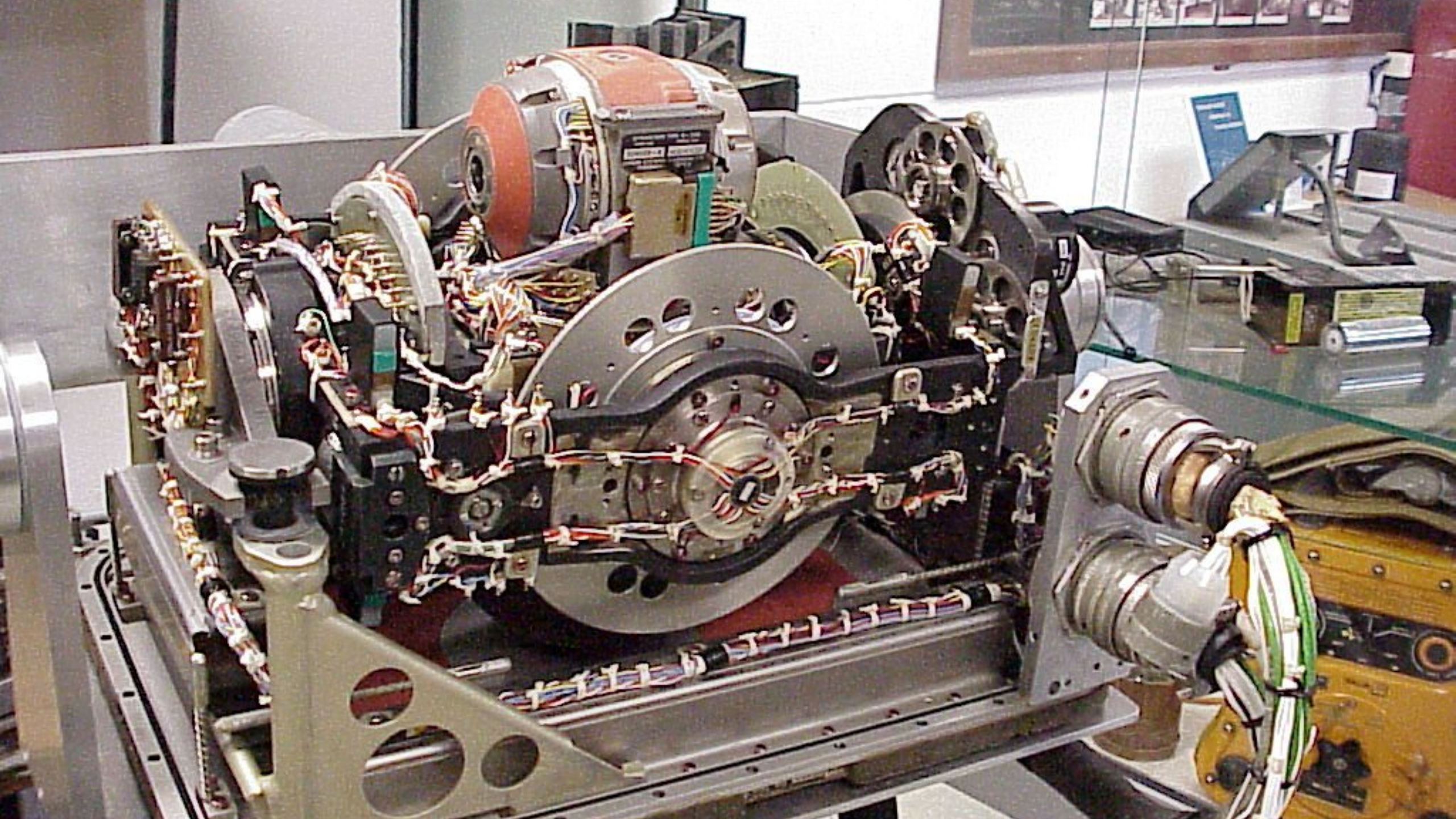
SVANTAGGI:

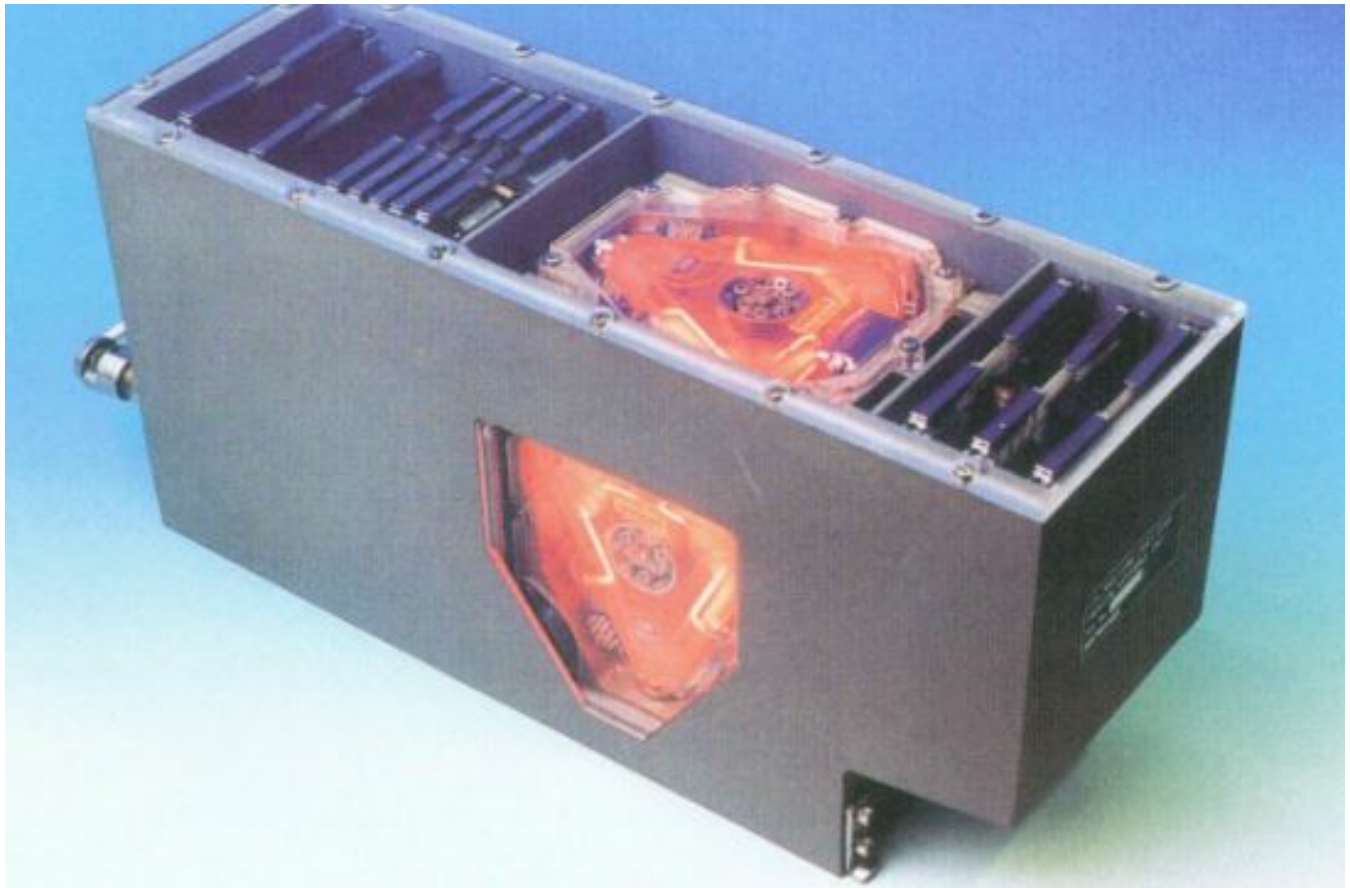
- Inaccurato sulle lunghe distanze
- Non si può allineare ai poli

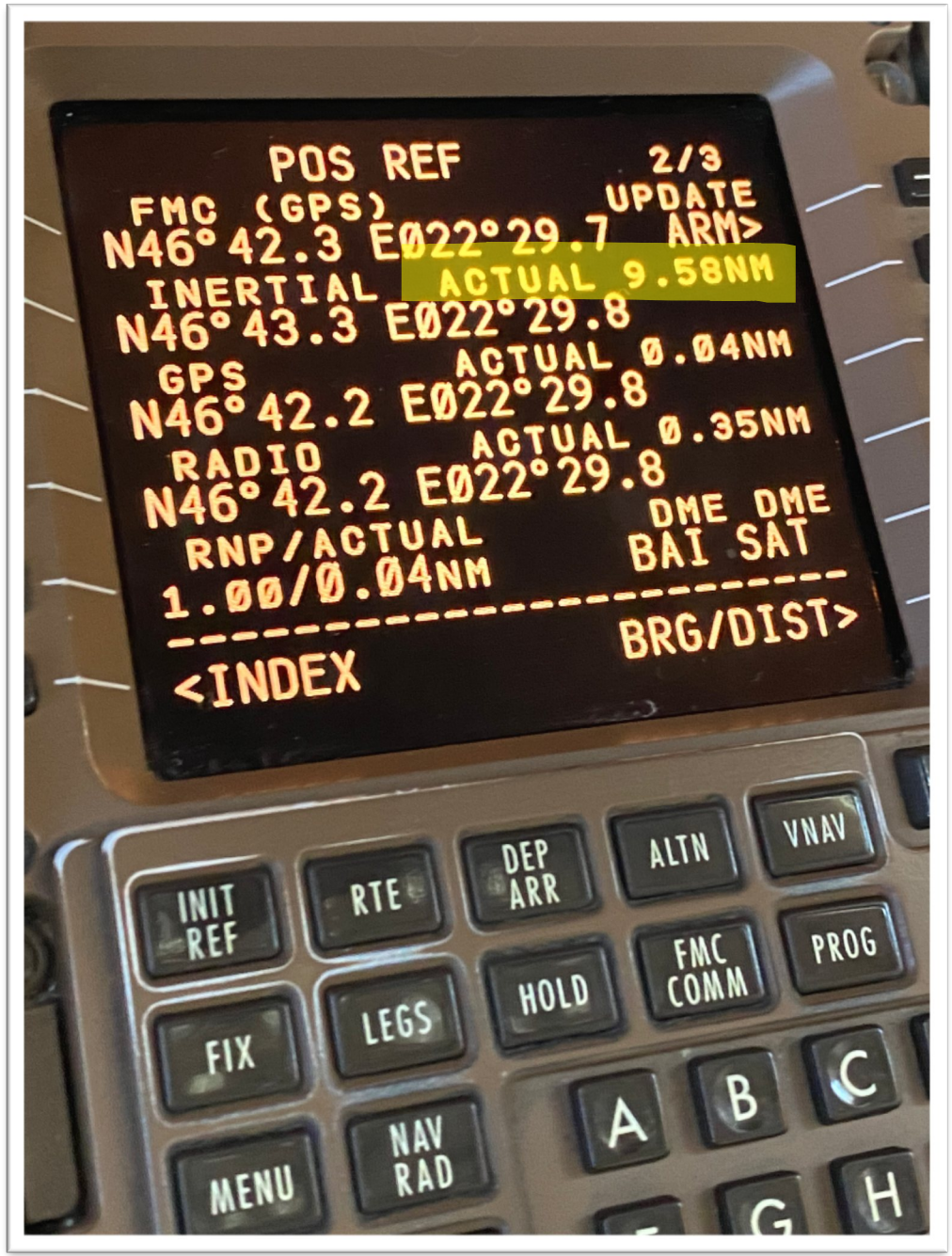

N46 W002
N45 W001
N45 W002
N45 W003
+10
+10


Vertical Axis
AZ Gyro
E Gyro
N Gyro
Roll Motor
N/S Accelerometer
Platform
Pitch Motor
Roll Axis
E/W Accelerometer
Pitch Axis
Azimuth Motor
Aircraft Heading








POS REF 2/3
FMC (GPS) UPDATE
N46°42.3 E022°29.7 ARM>
INERTIAL ACTUAL 9.58NM
N46°43.3 E022°29.8
GPS ACTUAL 0.04NM
N46°42.2 E022°29.8
RADIO ACTUAL 0.35NM
N46°42.2 E022°29.8
RNP/ACTUAL DME DME
1.00/0.04NM BAI SAT
BRG/DIST>
<INDEX
INIT REF
RTE
DEP ARR
ALTN
VNAV
FIX
LEGS
HOLD
FMC COMM
PROG
MENU
NAV RAD
A
B
C
G
H