"FLYING THE BEAM"

NAVIGATION BY AIR & SPACE

BY: WAYNE HANSEN (KC1MCW)

& MARK RUDD (KC1LOM)

GUEST SPEAKERS

Wayne Hansen, left (STARS KC1MCW)

Mark A. Rudd (NCRC KC1LOM)

Fall 2019 Field Trip: Newport State Airport
Spoiler Alert: Morse Code Beacon is “UUU”

FLYING THE BEAM (SUMMERY)

1)WWII NAVAID Technology

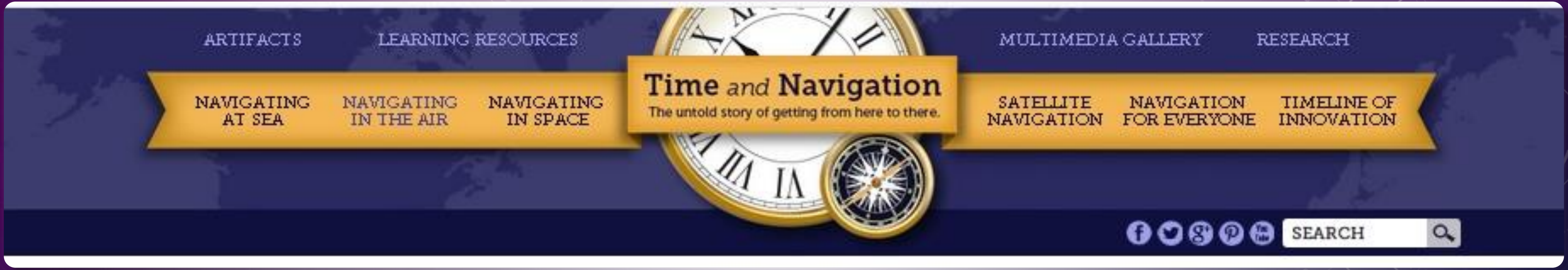
2)Four Course Marker Beacon

3)Current NAVAID Technology

4)Apollo Navigation

FLYING THE BEAM

1) WWII TECHNOLOGY



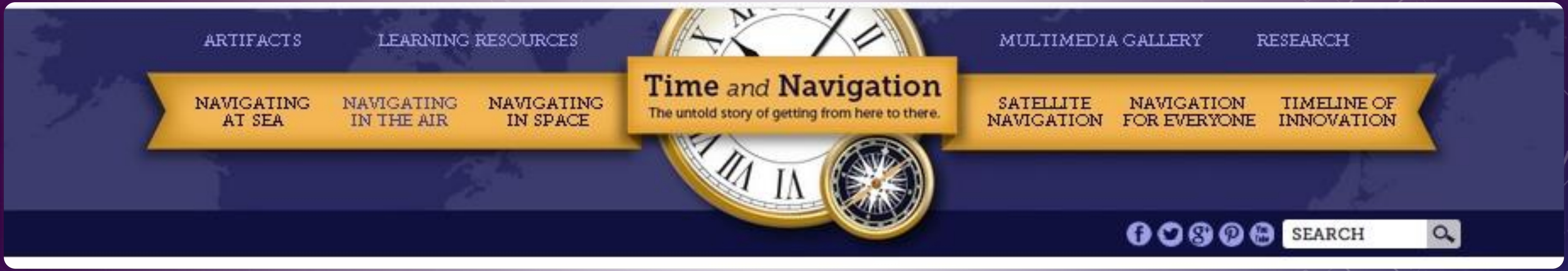
FLYING THE BEAM

AIR & SPACE MUSEUM

Smithsonian

National Air and Space Museum
National Museum of American History

https://timeandnavigation.si.edu/navigating-air



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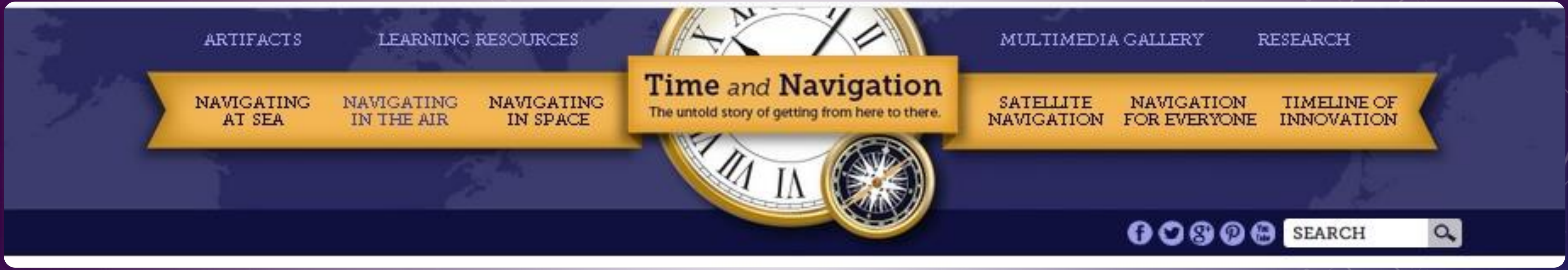
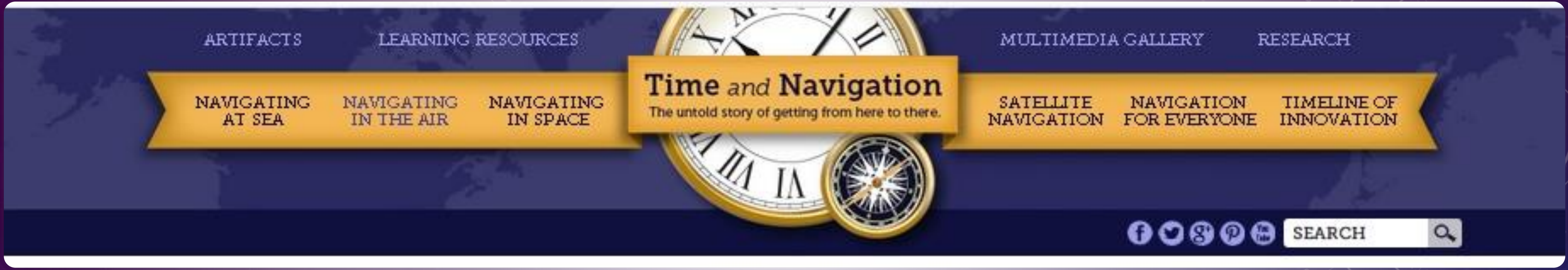


FLYING THE BEAM

Commercial Radio Stations used.

https://timeandnavigation.si.edu/navigating-air/challenges/overcoming-challenges/radio-navigation

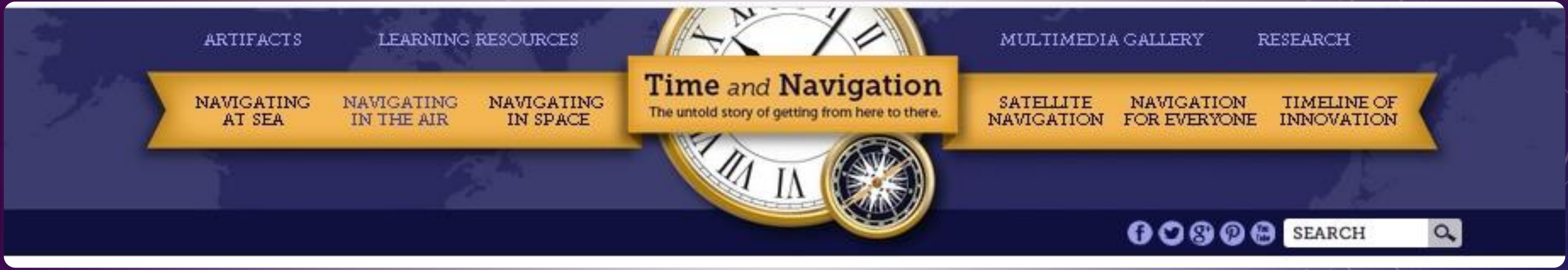


FLYING THE BEAM

Positioned the square antenna “loop” manually to home in on commercial broadcast radio stations.

https://timeandnavigation.si.edu/navigating-air/challenges/overcoming-challenges/radio-navigation

Time and Navigation



THE TIME - PLACE CONNECTION

To know where you are, you need a reliable clock.

- ➢ DIST = T x V

One WWII Navigator depended to much on time alone.

- ➢ Thought arrival to home base was too soon.
- ➢ Suspected Beacon was Enemy Decoy
- ➢ Not trusting instruments sent crew into Sahara Desert

AN 5740 Master Navigation Chronometer

Time and Navigation

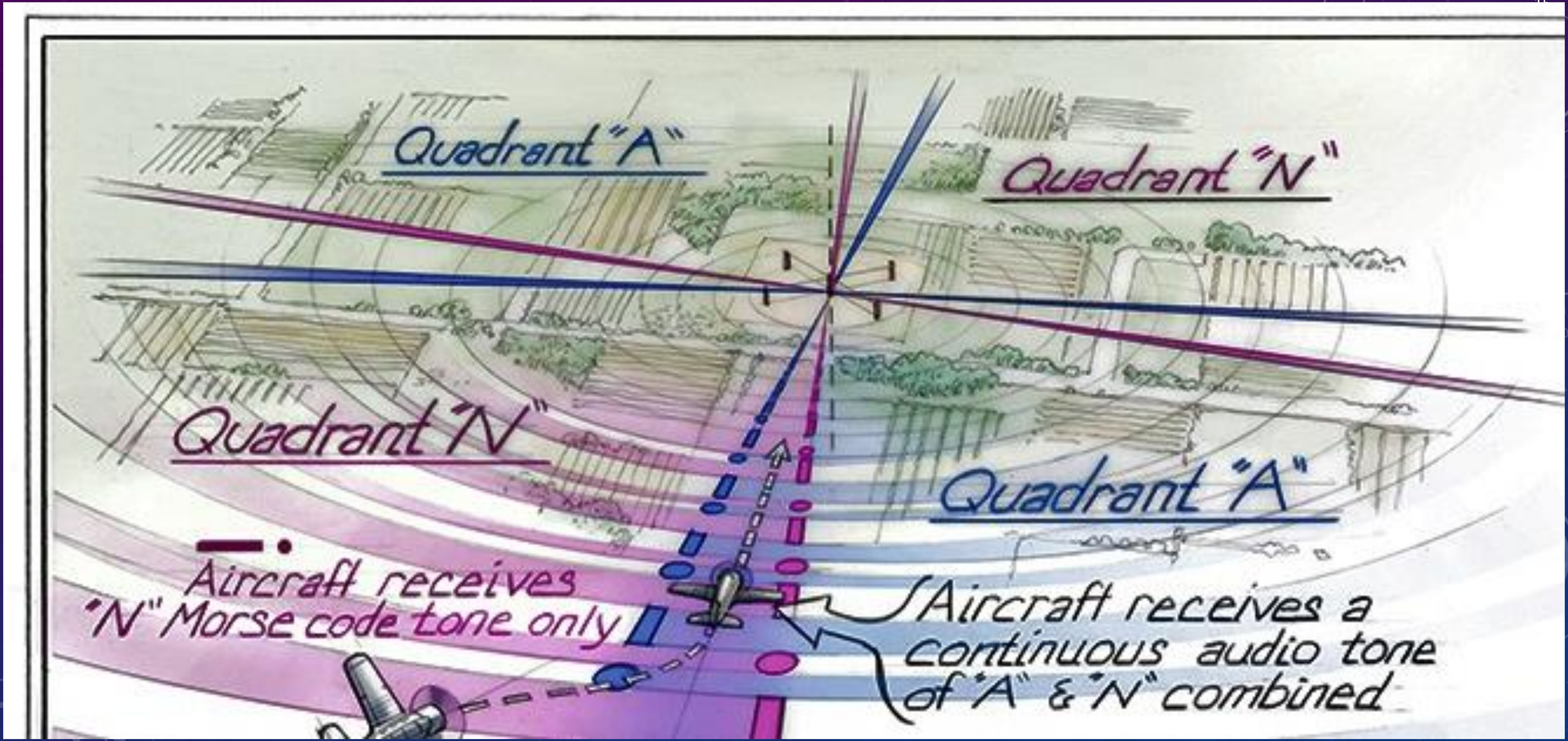
FLYING THE BEAM

2) **FOUR COURSE MARKER BEACON**

FLYING THE BEAM
2) Four Course Marker Beacon

Pilots hoped to hear a steady tone on the radio that meant they were on course. If they drifted off course to either side, they would hear different sounds – a Morse code “A” or “N.”[13]

Four Course Marker Beacon



N

A

FLYING THE BEAM

3) CURRENT NAVAID TECHNOLOGY

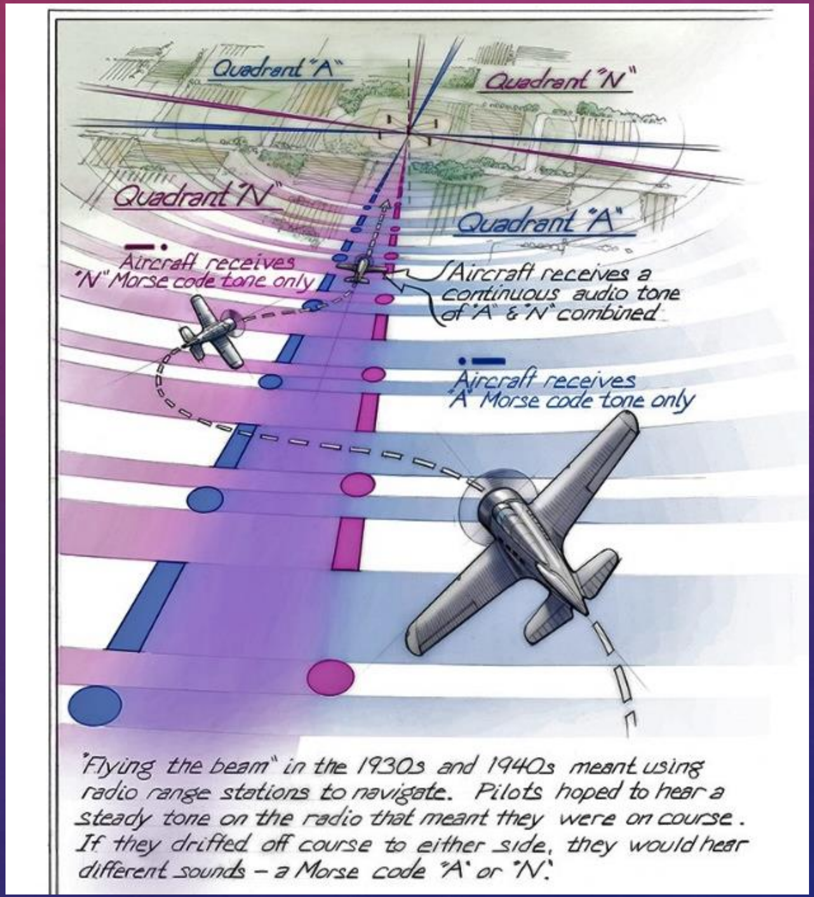
NAVAID BEACONS (THEN AND NOW)

A • —

N — •

4 COURSE BEACON

Morse Code A & N



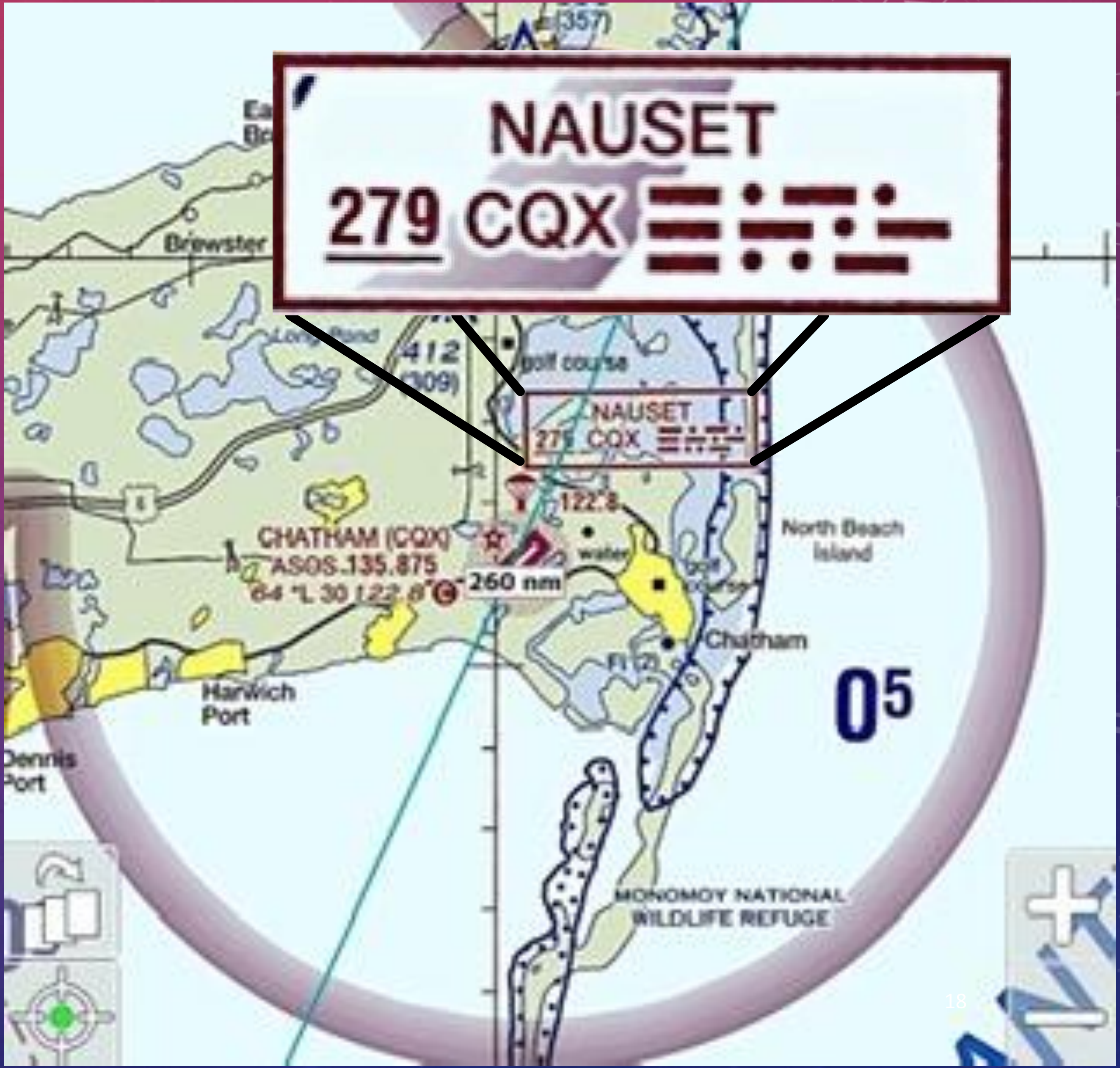
TODAY'S BEACON

Morse Code Next Slide

NAUSET/CHATHAM BEACON

MORSE CODE IDENTIFIER

CQX



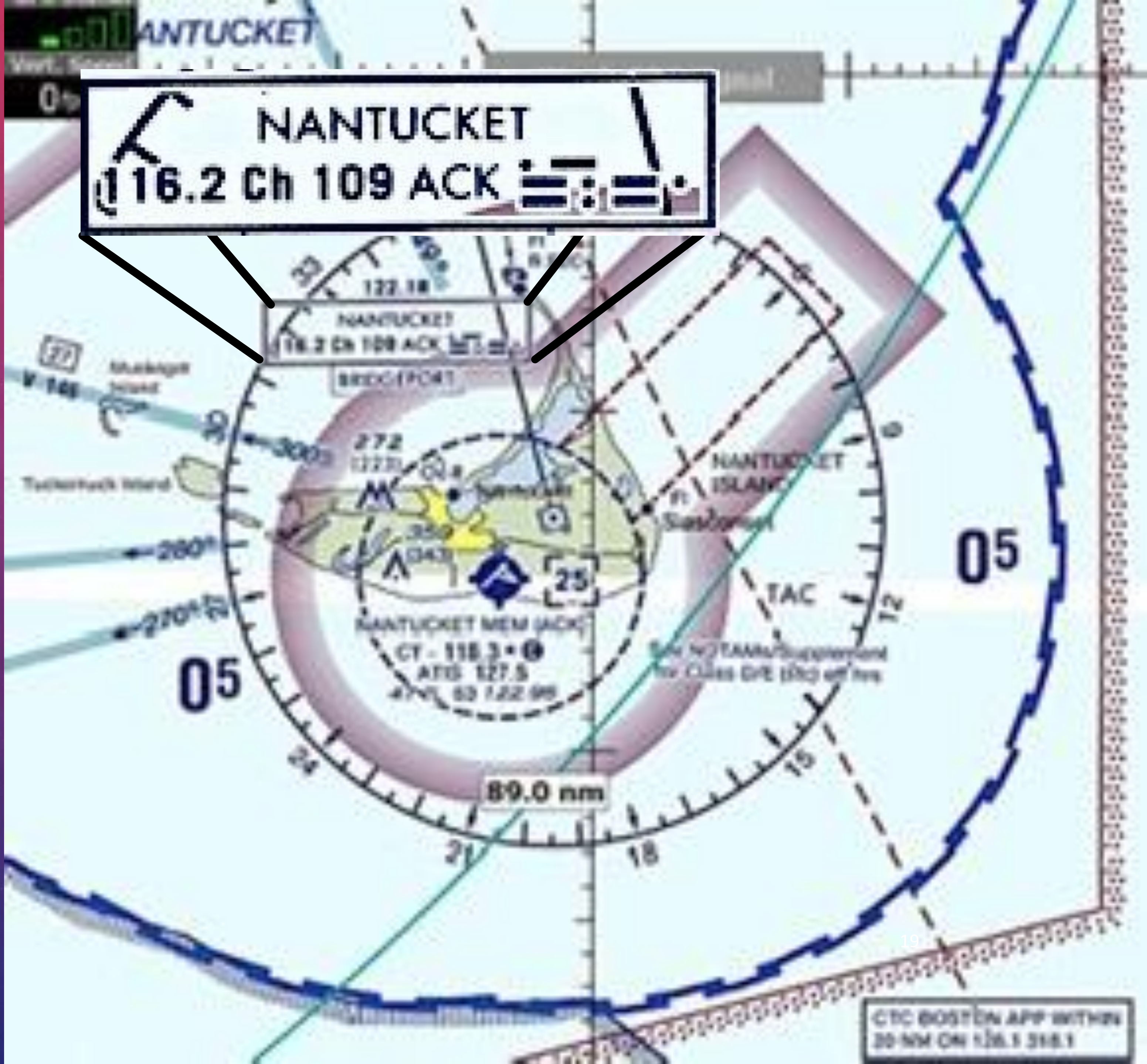
- Chatham (Cape Cod) VFR Chart
- Note the Beacon starting with: **CQ**

“COMPASS ROSE” OF A TYPICAL VOR STATION

VOR AT NANTUCKET ISLAND

ACK

[MAY NEED TO REDUCE VOLUME.]



VHF OMNI-DIRECTIONAL RANGE (VOR)

VHF OMNI-DIRECTIONAL RANGE (VOR)

On-board VOR display with CDI

[Ground Plane for reflection?]

Course Deviation Indicator (CDI)

DVOR (Doppler VOR) ground station, collocated with DME.

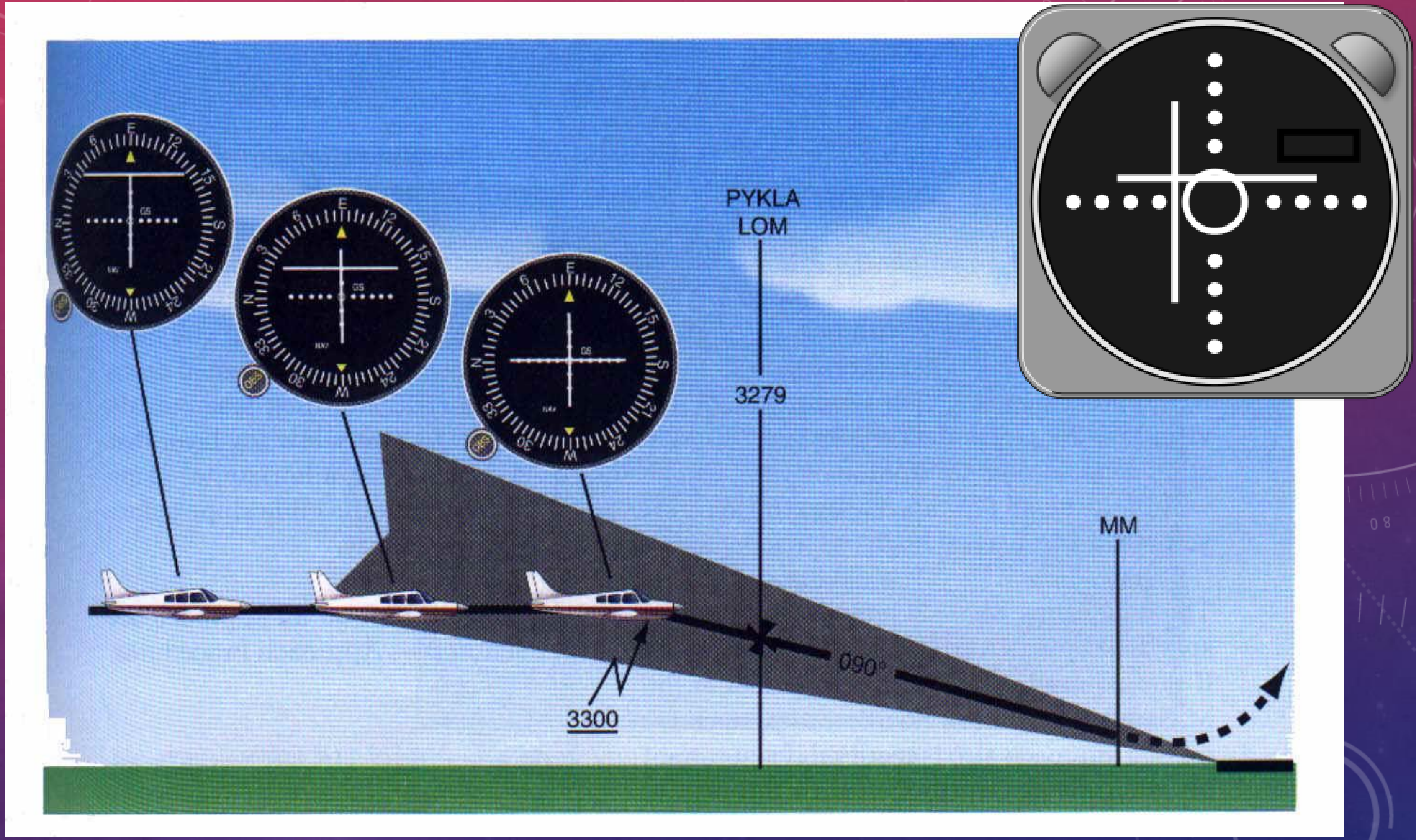
https://en.wikipedia.org/wiki/VHF_omnidirectional_range

INSTRUMENT LANDING SYSTEM (ILS)

Good for Poor Visibility

Establishes Glide Slope

[Look up radio specs for Radio Club]



INSTRUMENT LANDING SYSTEM (ILS)

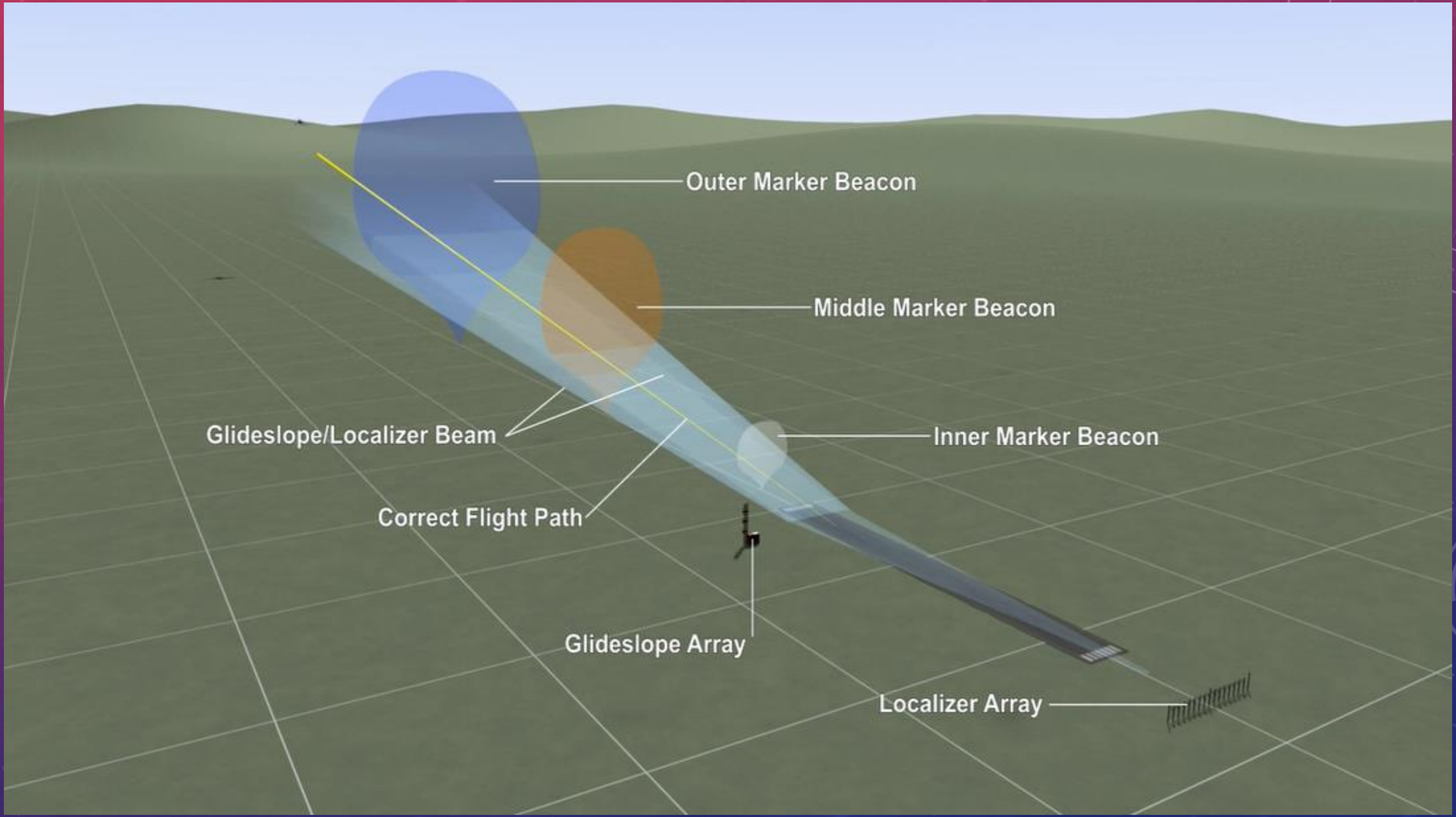
Omni Bearing Selector (OBS)

Course Deviation Indicator (CDI)

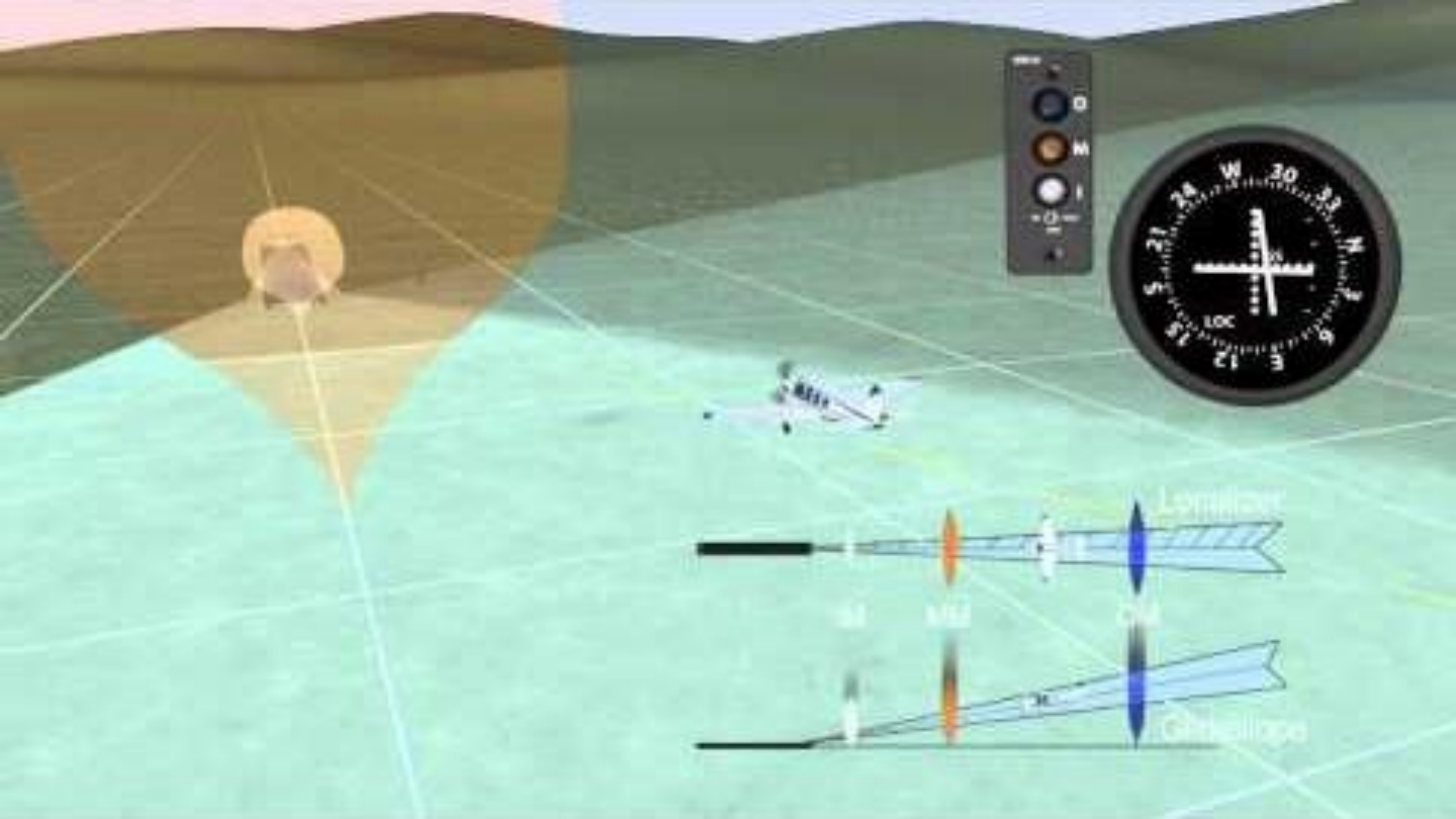
Localizer (Antenna)

GLIDE-SLOPE ANTENNA

(2:05) VIDEO SIMULATION -- LANDING USING ILS

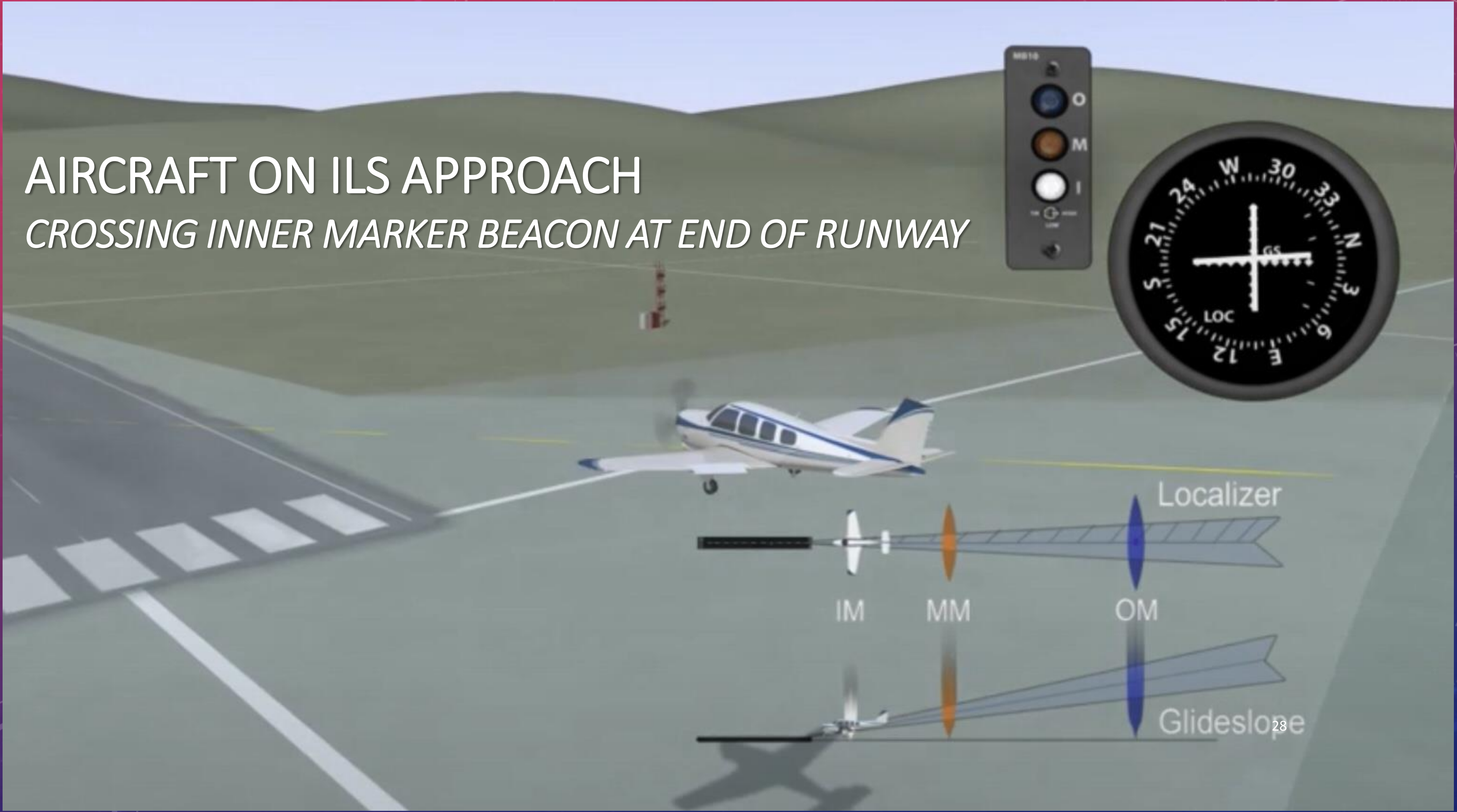


https://youtu.be/KVtEfDcNMO8

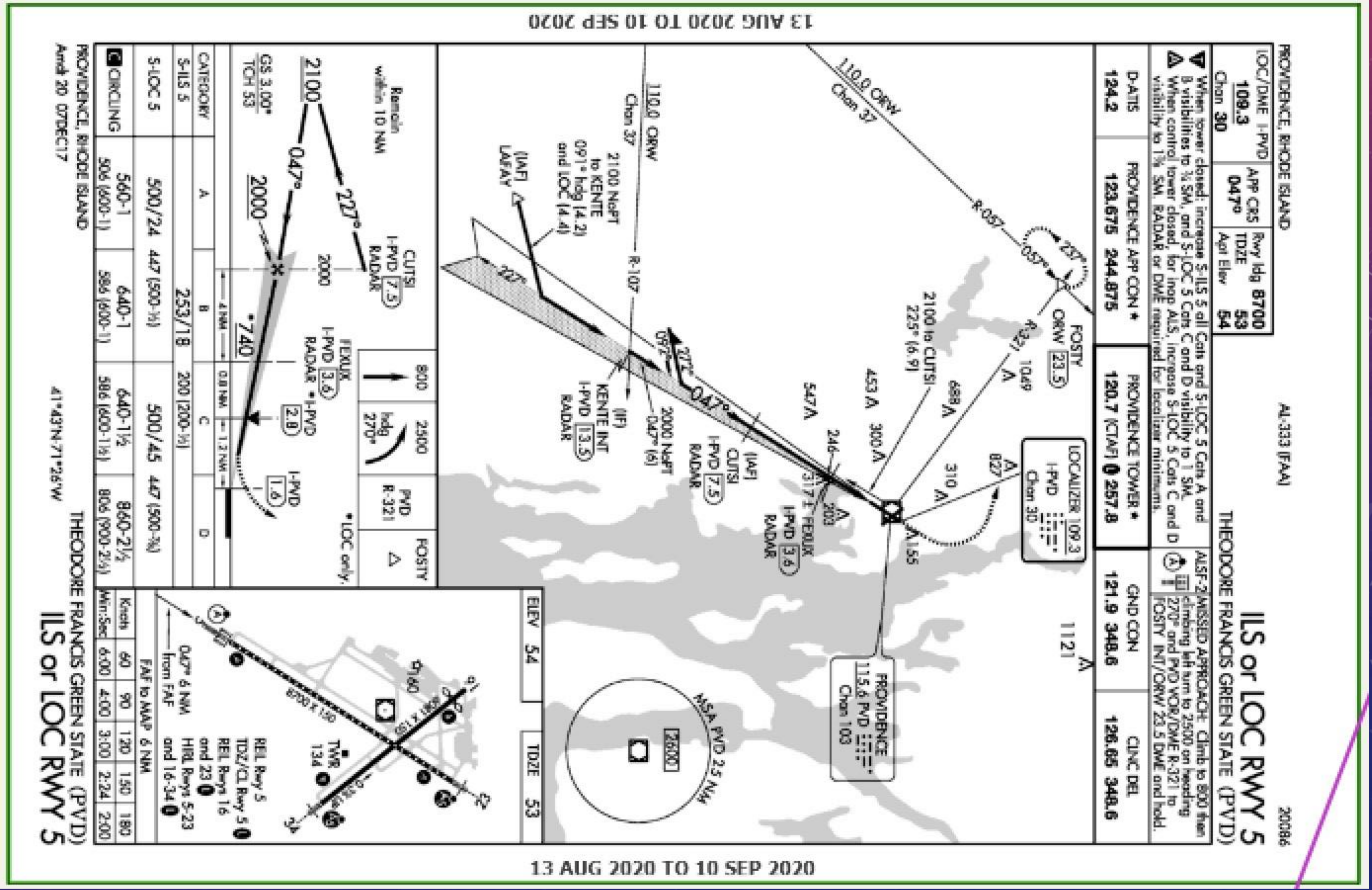

O
M
I
W
30
33
N
3
6
E
12
15
S
21
24
LOC
Localizer
Glideslope

AIRCRAFT ON ILS APPROACH

CROSSING INNER MARKER BEACON AT END OF RUNWAY



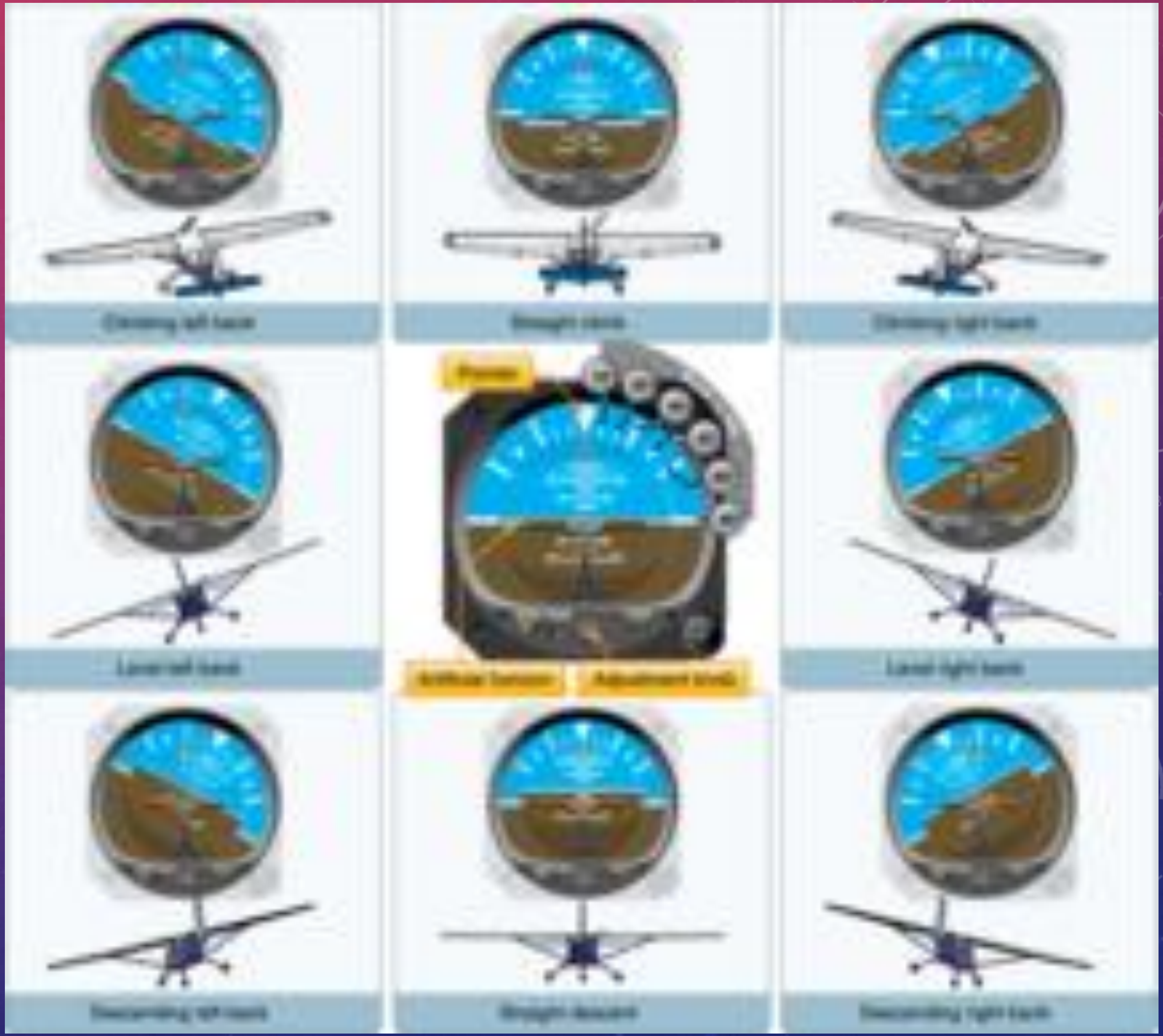
PVD-ILS APPROACH PLATE



ADDITIONAL SLIDES

3) CURRENT NAVAID TECHNOLOGY

HORIZON INSTRUMENT



HORIZON + HEADING INSTRUMENT

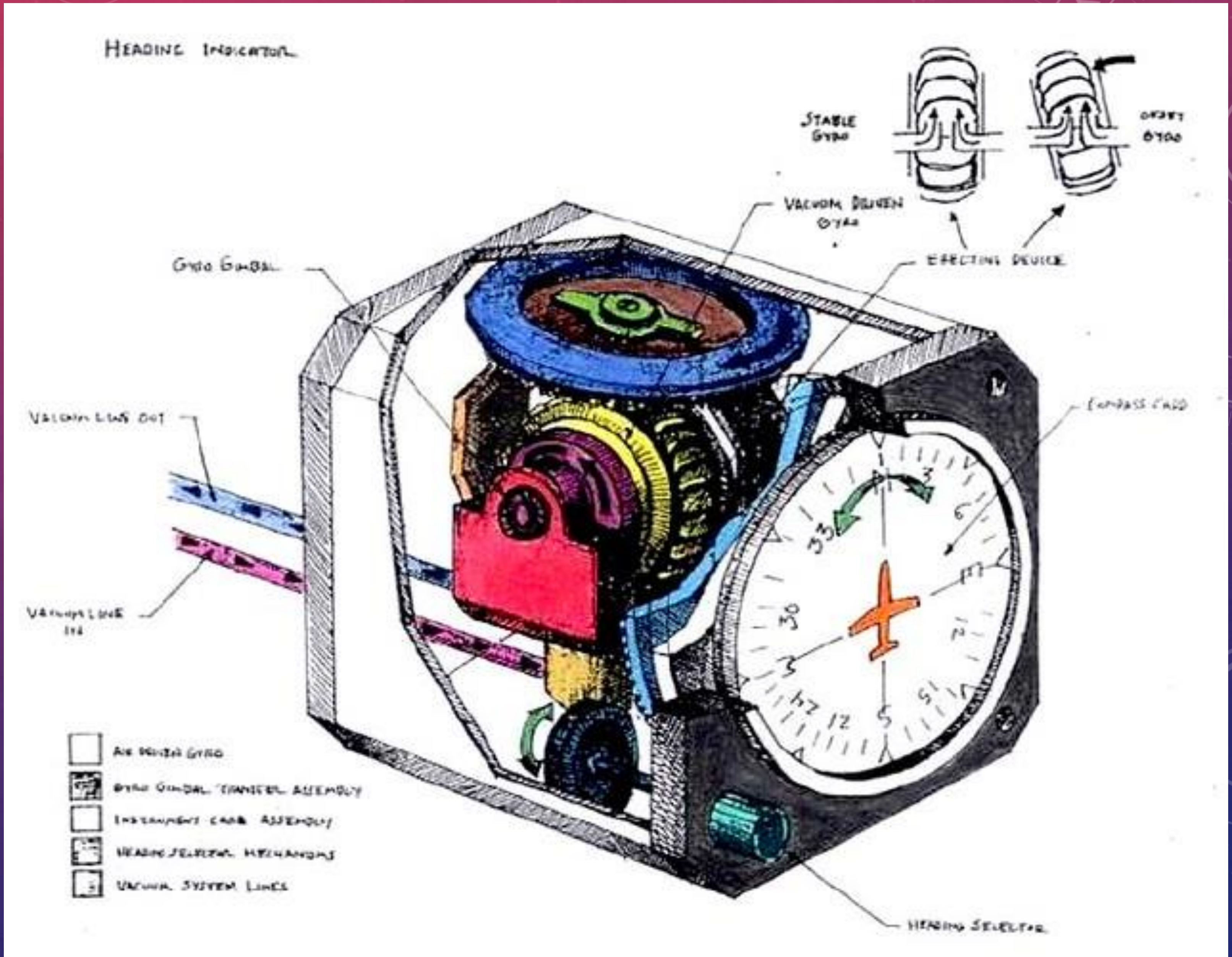
Roll Angle

Pitch Angle

Heading

Magnetic

HEADING INDICATOR

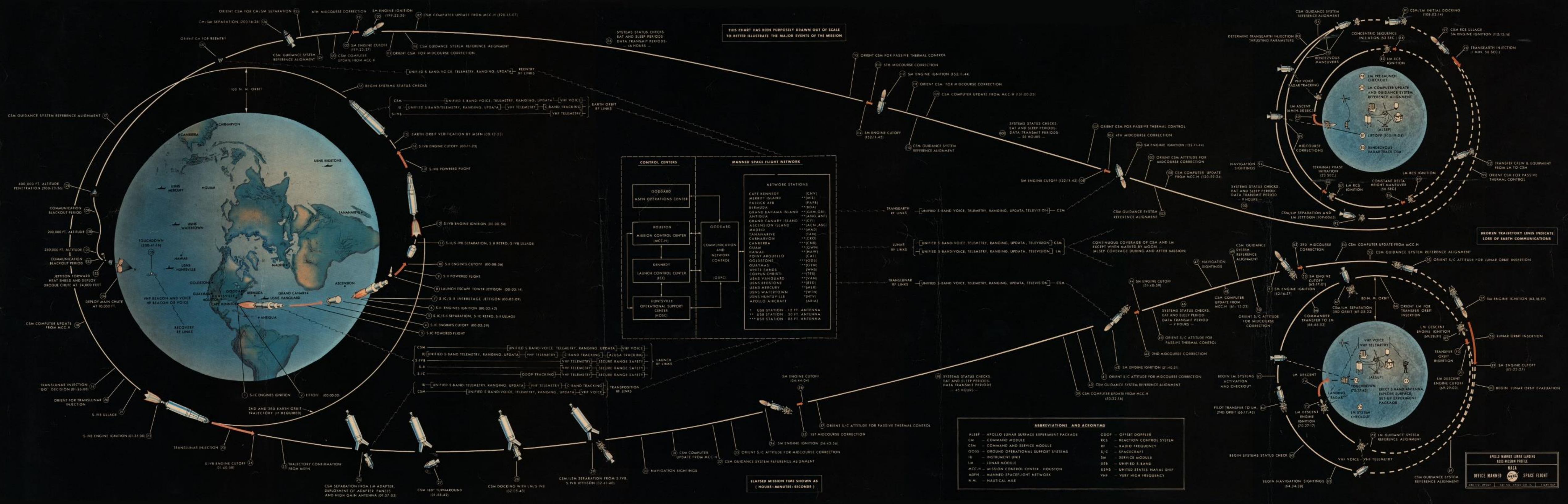


FLYING THE BEAM

4) APOLLO NAVIGATION

APOLLO MISSION FLIGHT PLAN (1967)

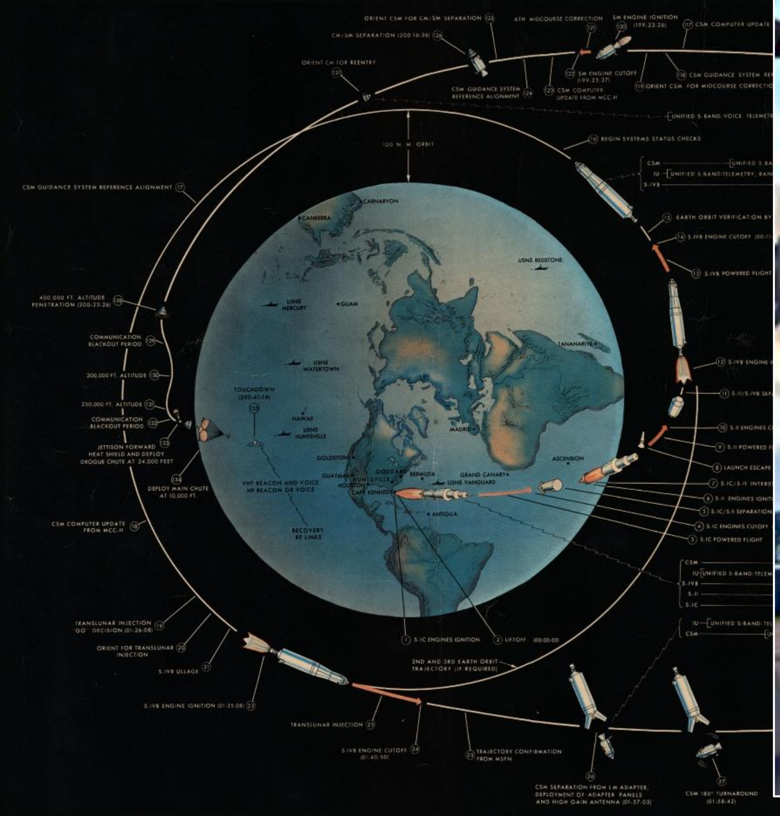
(DEEP SPACE COMMUNICATIONS + TELEMETRY + GUIDO)

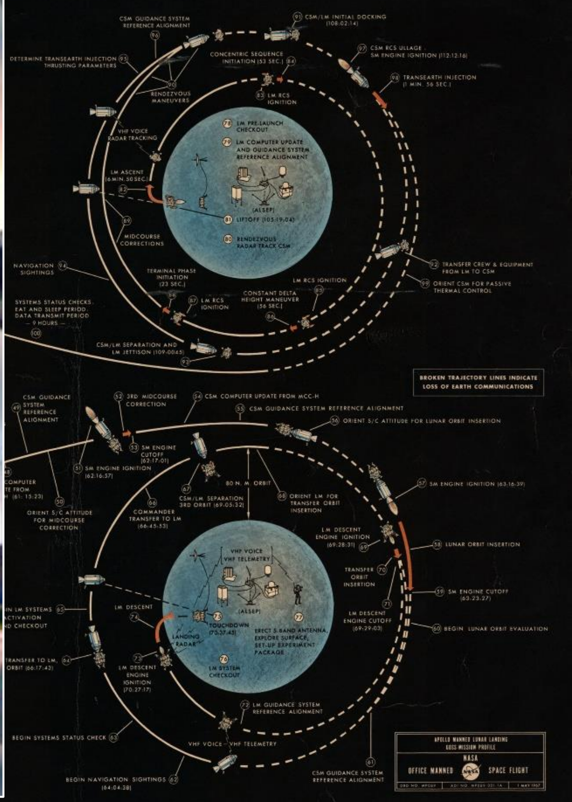


https://**moon.nasa.gov**/resources/348/apollo-mission-flight-plan-1967/

APOLLO MISSION FLIGHT PLAN – STARTED WITH:

FLEET OF 'CALCULATORS, LIKE IN "HIDDEN FIGURES" 2016

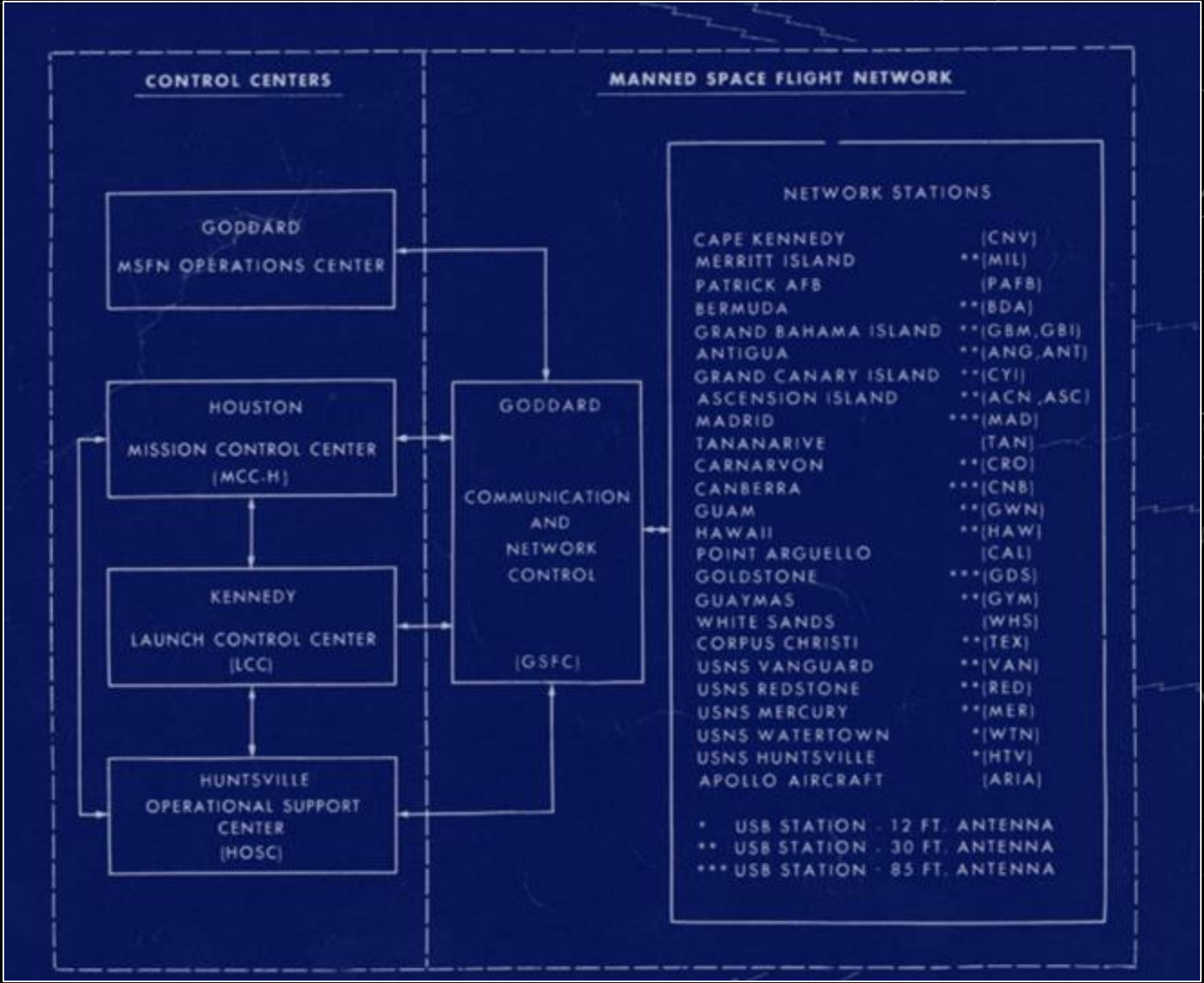




https://**moon.nasa.gov**/resources/348/apollo-mission-flight-plan-1967/

THREE CENTERS

1) CONTROL CENTERS
   - LAUNCH CONTROL
   - HOUSTON CONTROL
2) COMM +NETWORK
3) MANNED SPACE FLIGHT NETWORK (MSFN)
   - APOLLO S-BAND

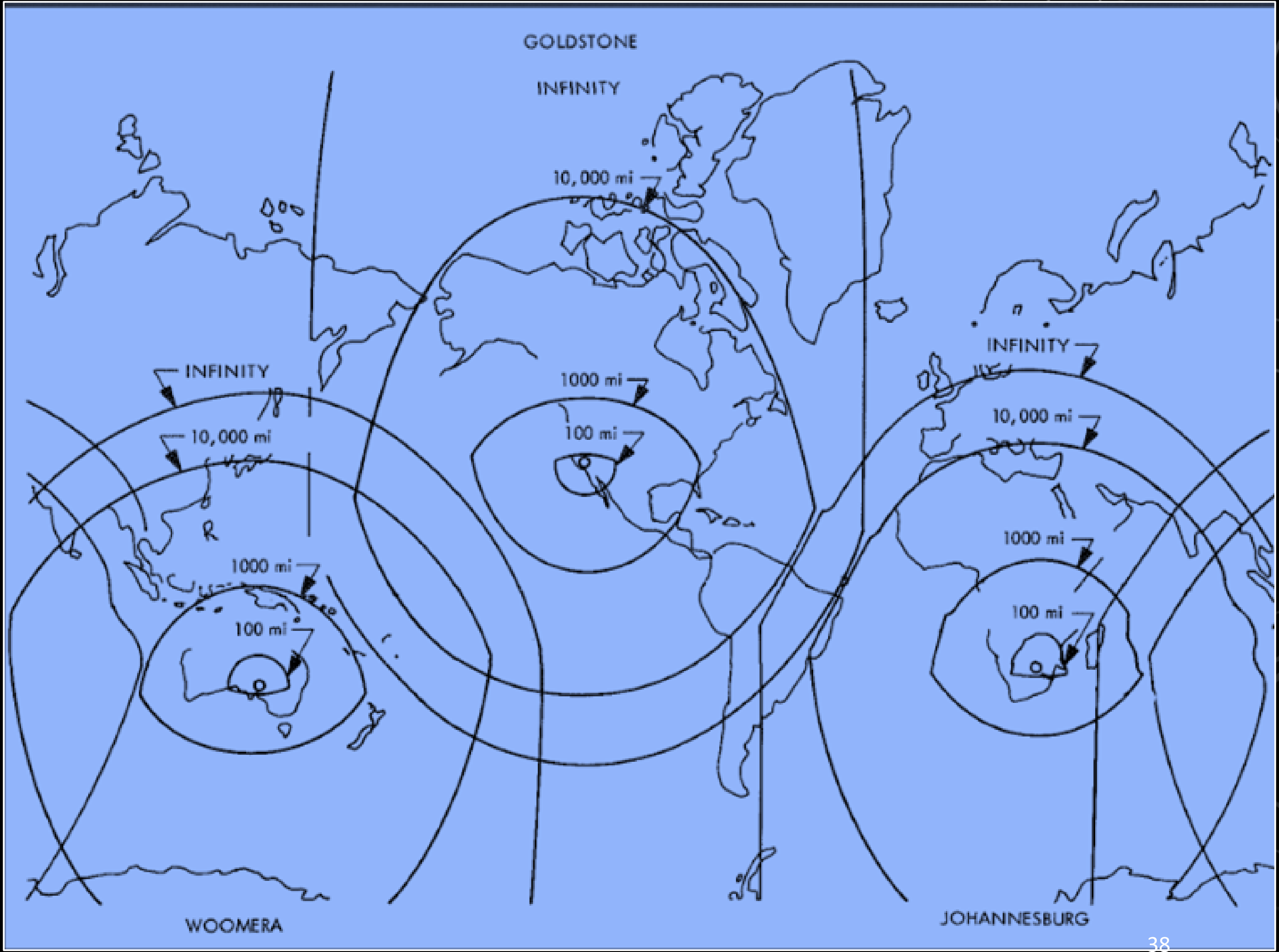


DEEP SPACE NETWORK (DSN)

Coverage of Original Three 85-ft Antennas for Apollo

Part of:

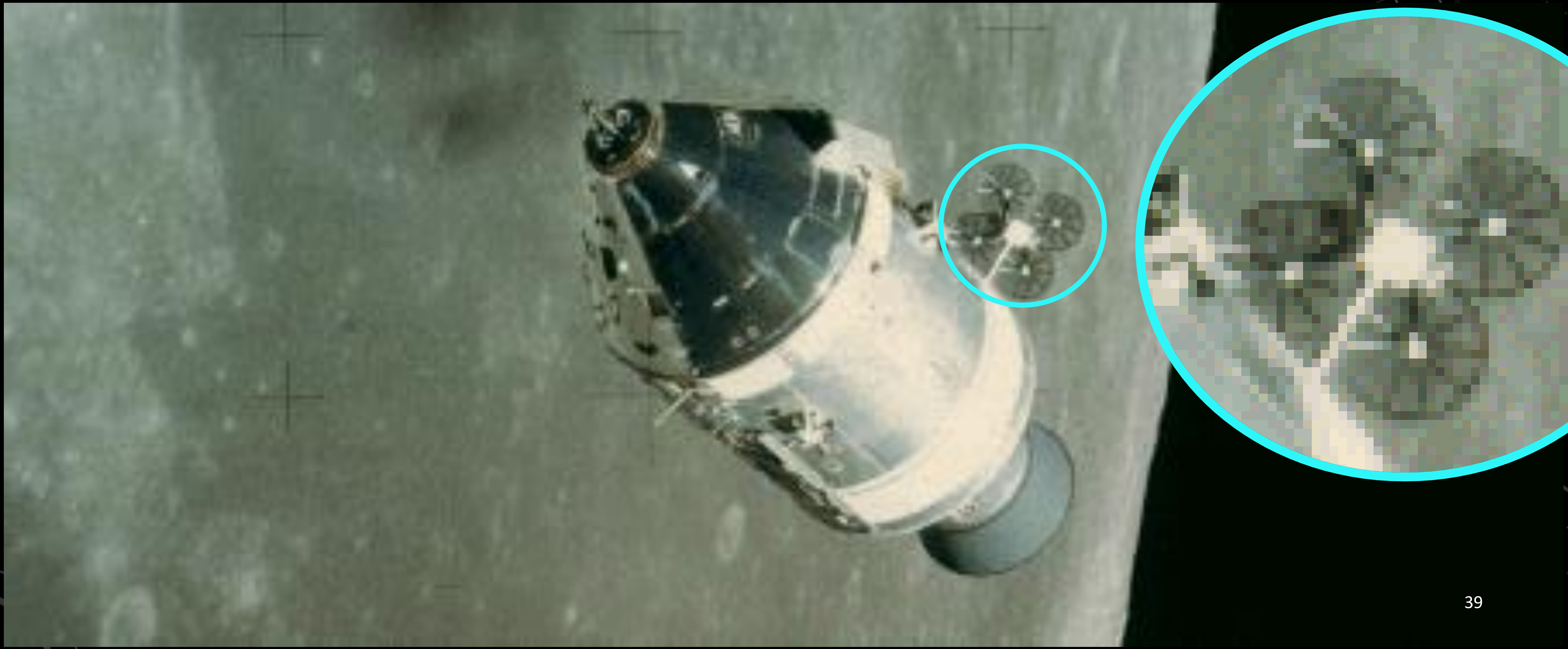
Manned Space Flight Network (MSFN)



https://**ntrs.nasa.gov**/archive/nasa/casi.ntrs.nasa.gov/19710009001.pdf

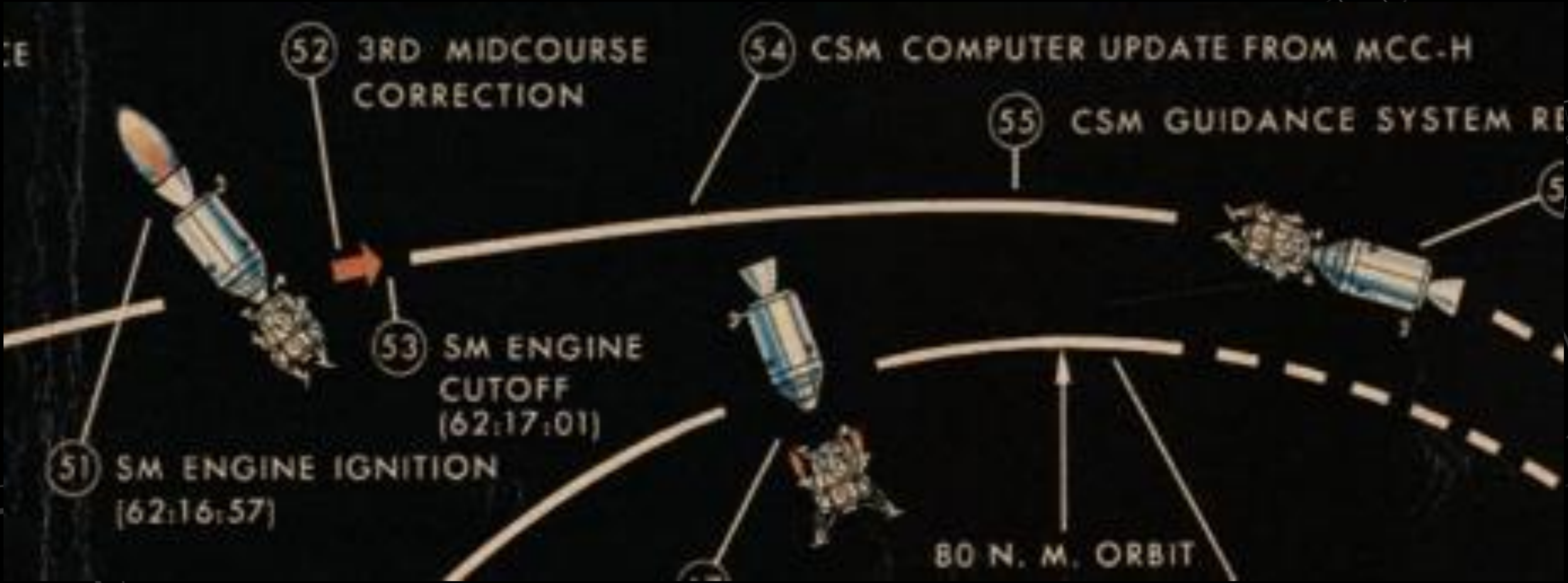
SM S-BAND HIGH GAIN ANTENNA

COMM + TELEMETRY/DATA + RELAY-STATION



https://www.**lpi.usra.edu/lunar**/missions/apollo/apollo_16/images/c_s_modules_lg.gif

TRANSLUNAR EXAMPLE OF TRANSMISSIONS
(S-BAND: *VOICE, TELEMETRY, RANGING, UP-DATA, TV*)



‘(5:10) HOW APOLLO FLT COMPUTERS GOT TO THE MOON AND BACK’

Britannica HTTPS://WWW.BRITANNICA.COM/SCIENCE/APOLLO-SPACE-PROGRAM

ABORT GUIDANCE COMP
CRITICAL DESIGN

RECOVER FROM CRASHES

PRIORITIES OPS:
-MISSION CRITICAL
-ABORT TOP PRIORITY
-DROPS NONCRITICAL

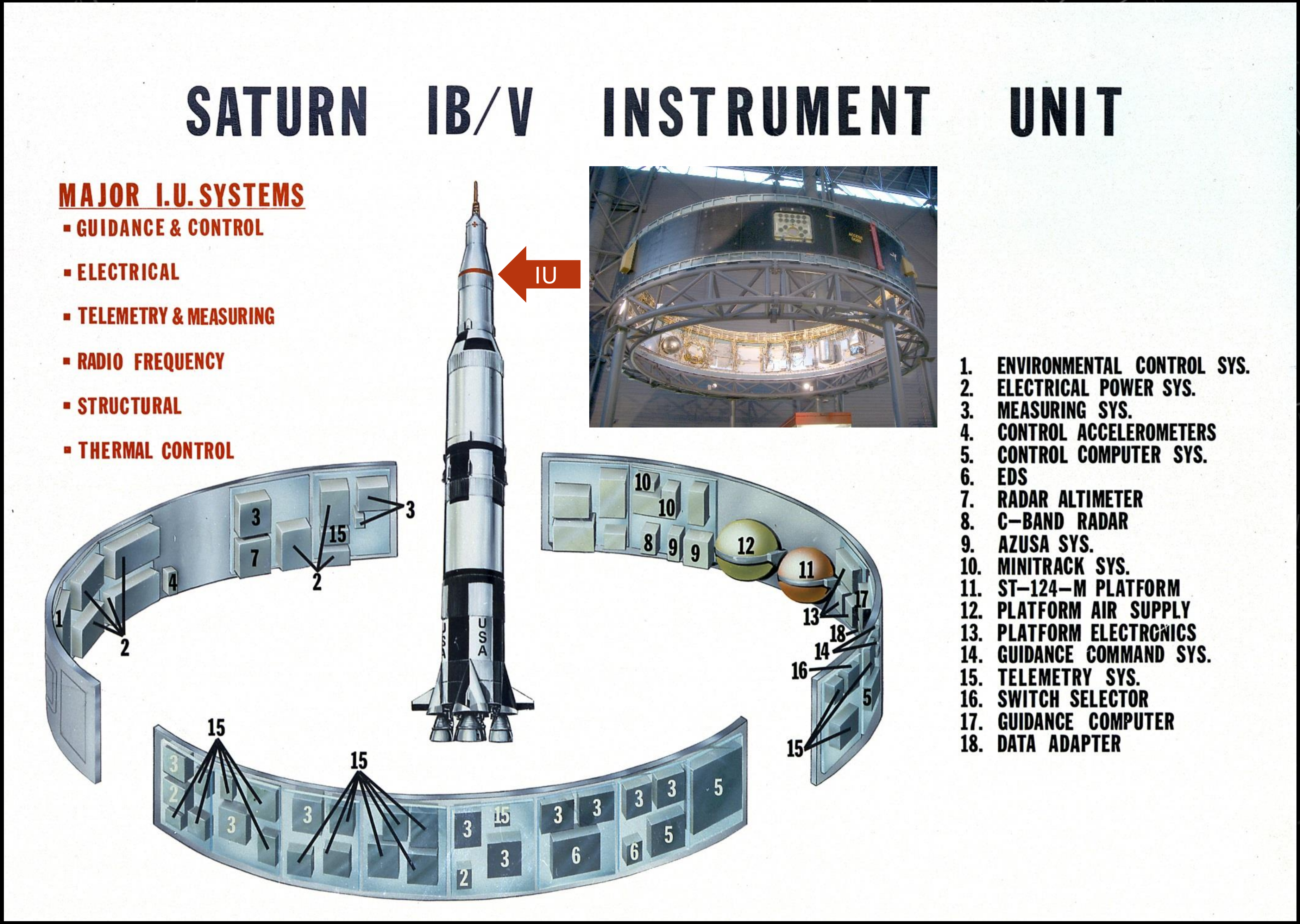
A SMART PHONE CAN’T DO THAT!


CURIOUS
DROID
BRIGHTNESS
ERROR RESET
VERB
NOUN
53
53
CLEAR
VERB
NOUN
00000
03323
00004
+
7
8
–
4
5
0
1
2
3

MOST INSTRUMENTS WERE <u>NOT</u> COMPUTERS BUT RADIO GEAR

SATURN'S INSTRUMENT UNIT, HANDLED:

- ✓ GUIDANCE & CONTROL
- ✓ ELECTRICAL
- ✓ TELEMETRY & MEASUREMENTS
- ✓ 'C-BAND RADAR'
- ✓ Etc.

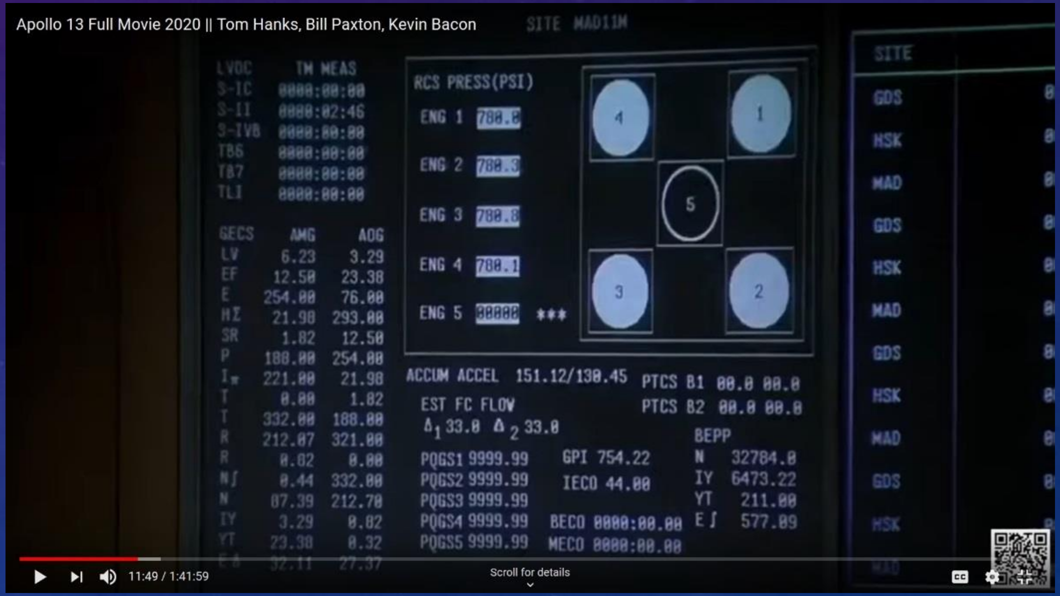


https://en.wikipedia.org/wiki/Saturn_V_instrument_unit

INSTRUMENT RING AT IT'S BEST
(AN EXAMPLE FROM APOLLO 13'S FAILURE OF ENGINE FIVE)

Real Time Measurements & Telemetry

"Burn extra long on the 4 good engines."



SOME
OLD SCHOOL
COMPARISONS

Contrasts between:

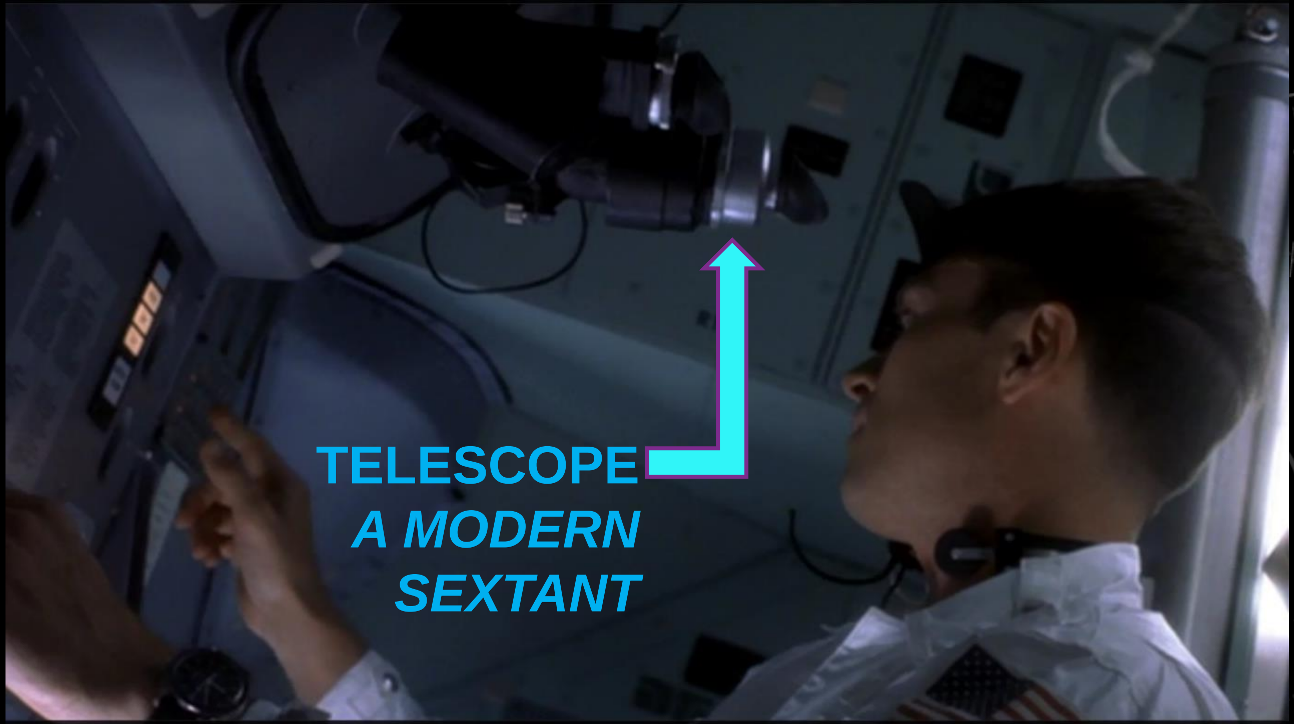
- ➢ 1940s Technology (WWII) &
- ➢ 1960s Technology (Apollo)

❖ Note the Advancements!

NAVIGATION (SOME COMPARISONS)

- **SEXTANT – North Star**

- **OLD SCHOOL, BY THE STARS**

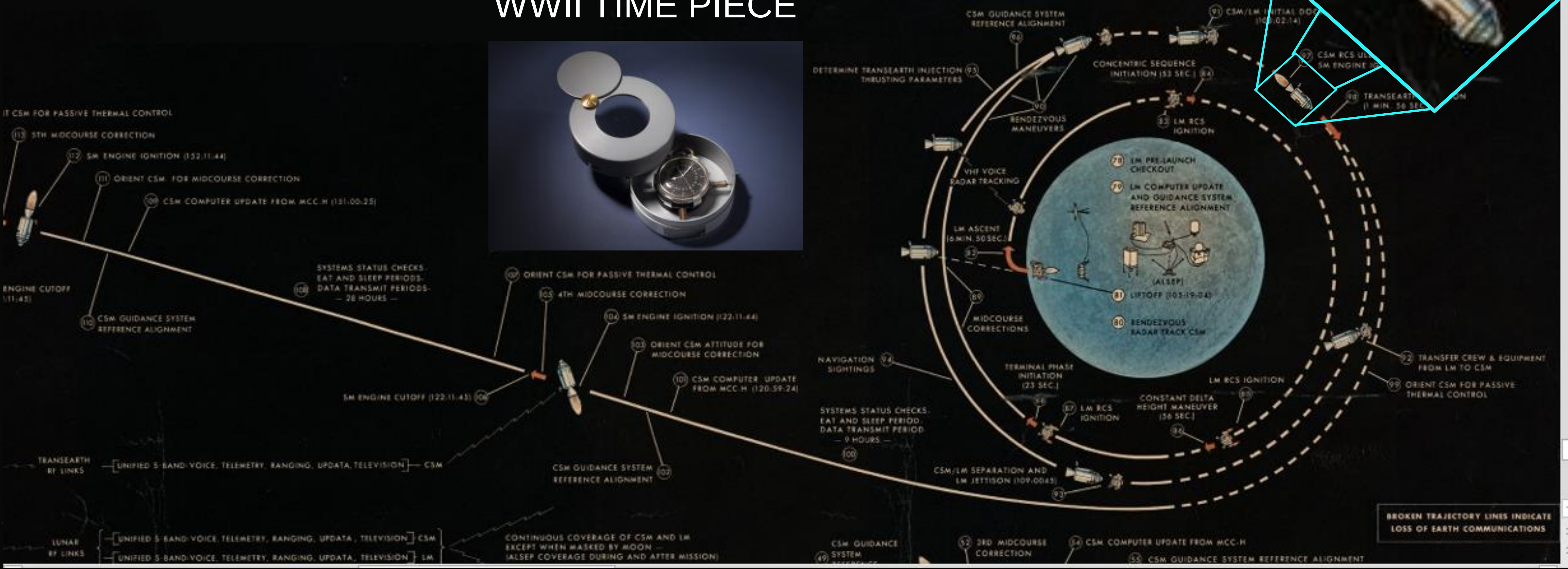


CALIBRATED GUIDANCE COMPUTER

NAVIGATIONAL TIMING IS EVERYTHING

(*SYNC TIMING FOR FINAL BURN DURING LOSS OF SIGNAL*)

WWII TIME PIECE



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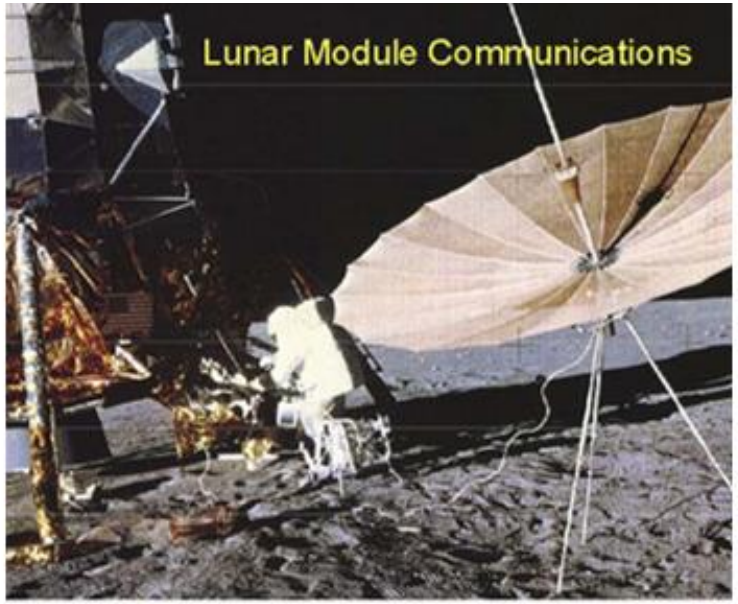
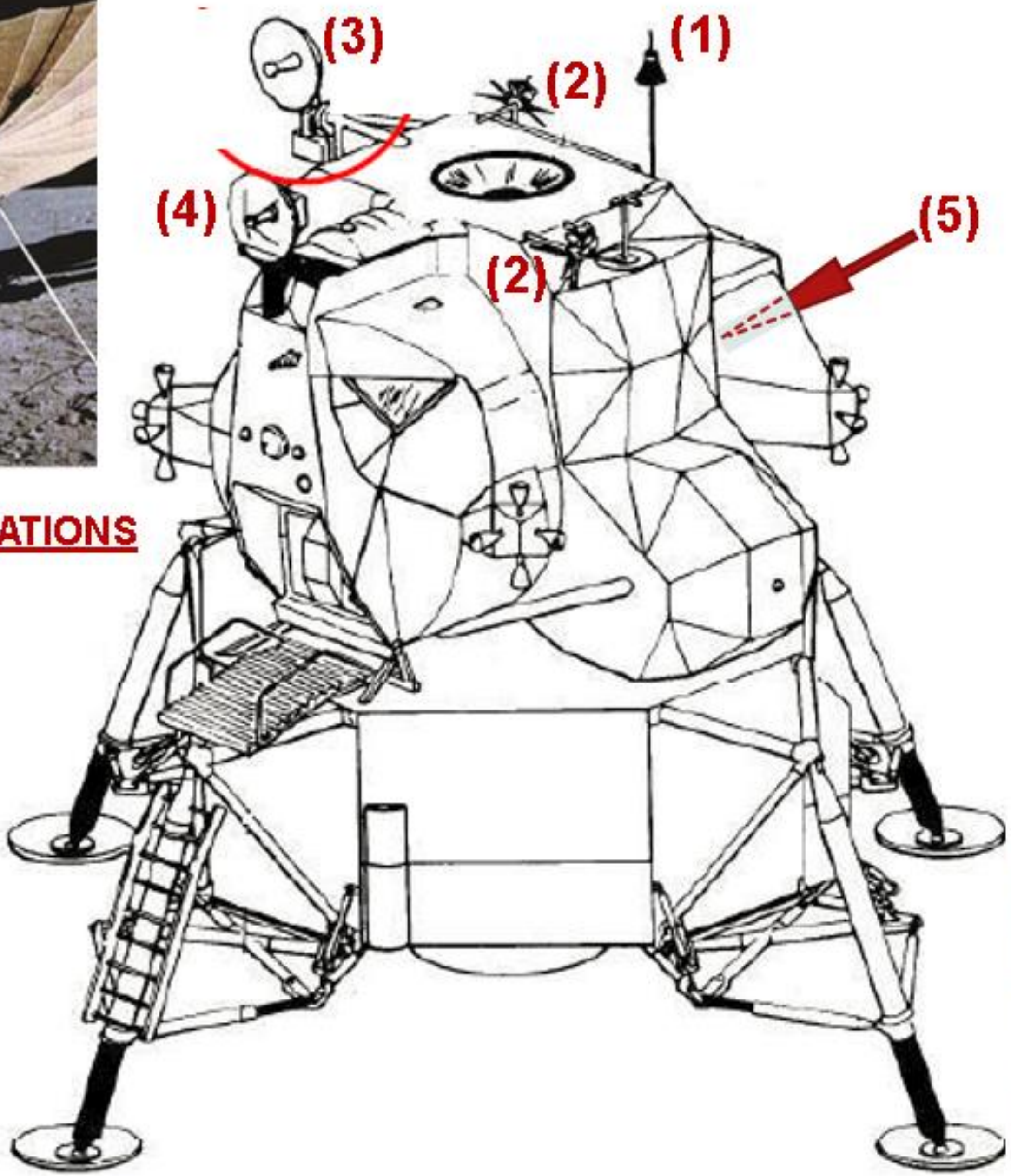
Comm + Guido for Lunar Landing

https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20090015392.pdf



Lunar Module Communications - NTRS - NASA

- (1) EVA Dipole Antenna
- (2) VHF Antennas (2)
- (3) S Band Steerable
- (4) S Band Inflight (Forward)
- (5) S Band Inflight (Aft)
- (6) S Band Erectable



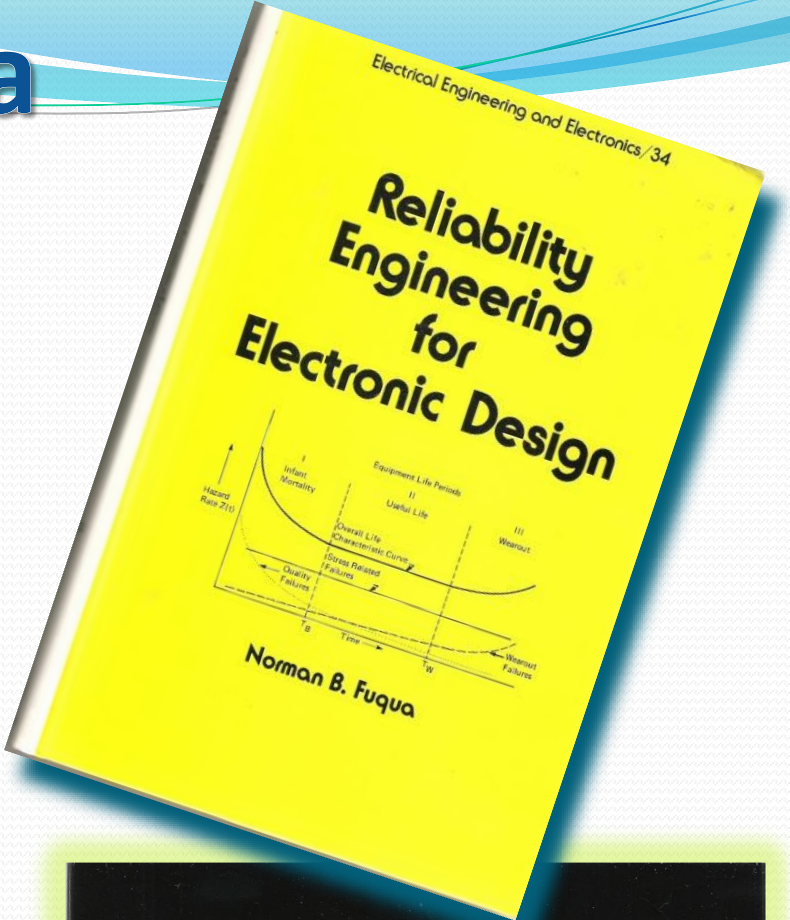
(6)

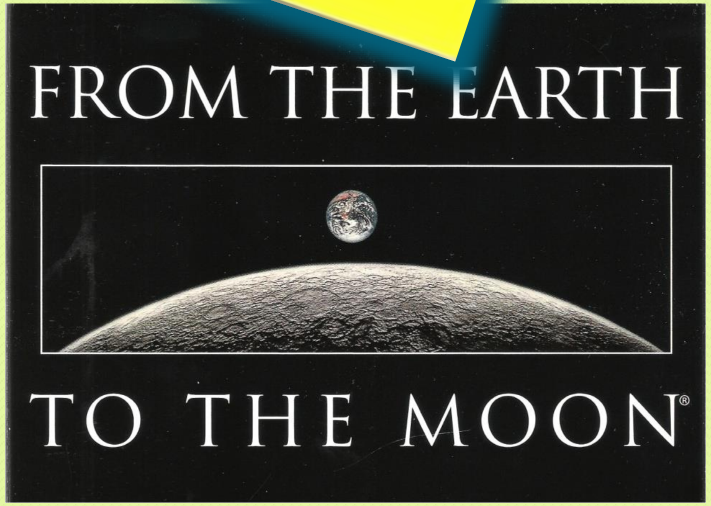
Guest Speaker: Norman Fuqua

Engineering Experience w/ Apollo Program

- Since the Apollo Moon mission:
  - A. Norman Fuqua Developed and taught an internationally recognized training course on electronic reliability design,
  - B. Authored the book titled:

    "Reliability Engineering for Electronic Design"
- Play-by-play commentary, using::
  "From the Earth to the Moon."

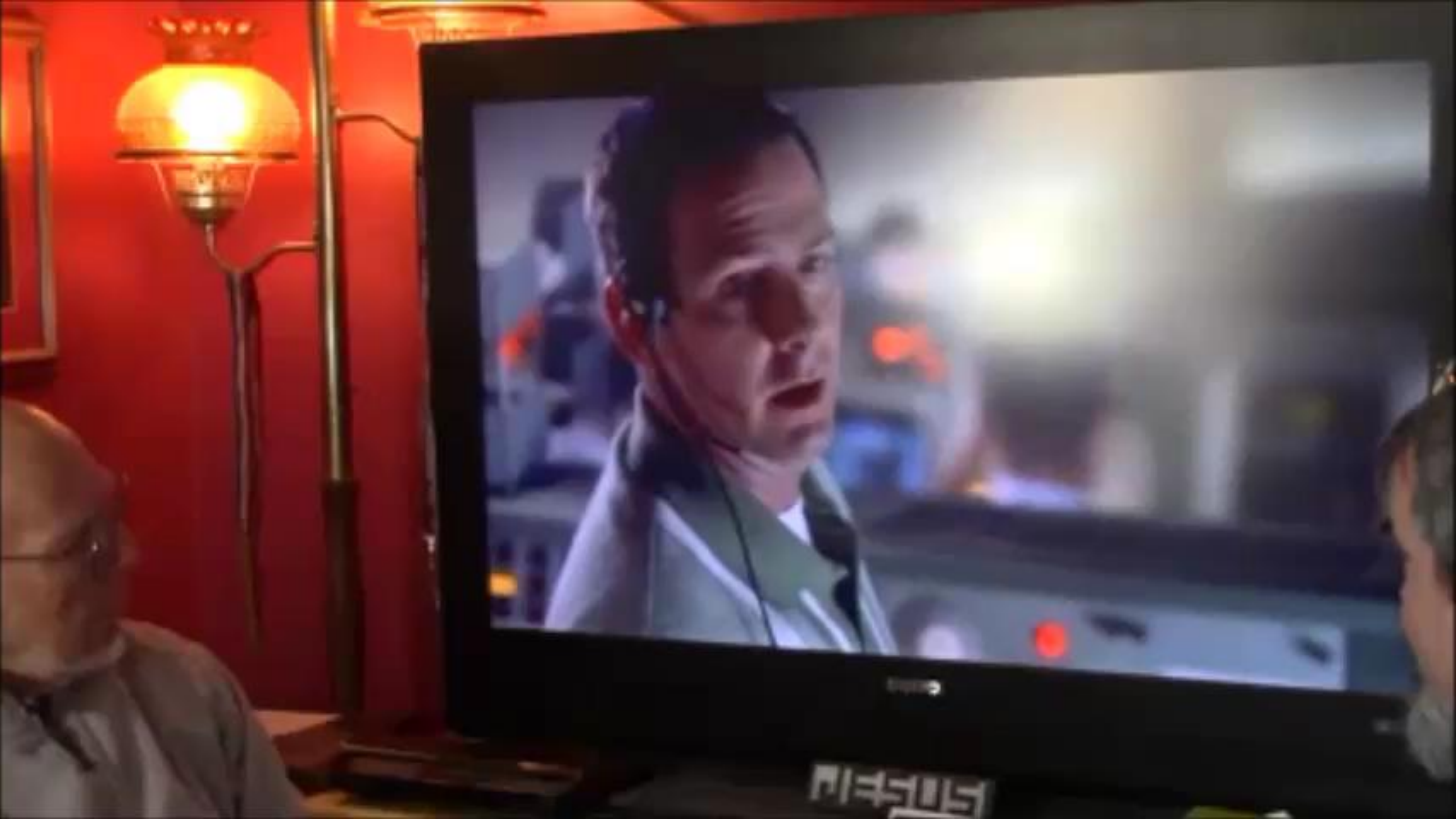


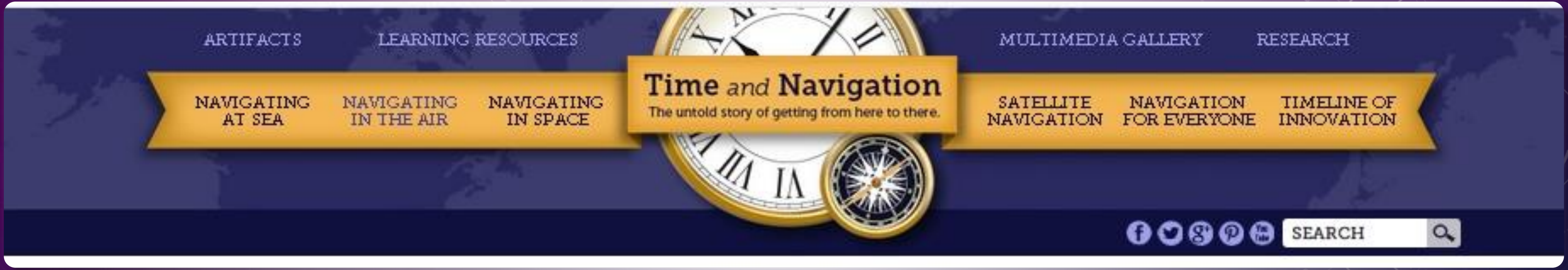


ADVERTISEMENT USED FOR
KING'S CO-OP + NEWPORT'S MET

HERE'S A COMMENTARY ON "FROM THE EARTH TO THE MOON." *ENJOY THE RADIO CHATTER.*

FILENAME: (10-14) First Landing - 2016 Interview w Norm Fuqua – FINAL'





FLYING THE BEAM

ADDITIONAL SLIDES

4) APOLLO NAVIGATION

Armstrong training in the lunar module simulator

RADIO NAVAIDS + COMMUNICATIONS

(REFERENCING APOLLO 11 VIDEO)

USE IF OUT OF TIME

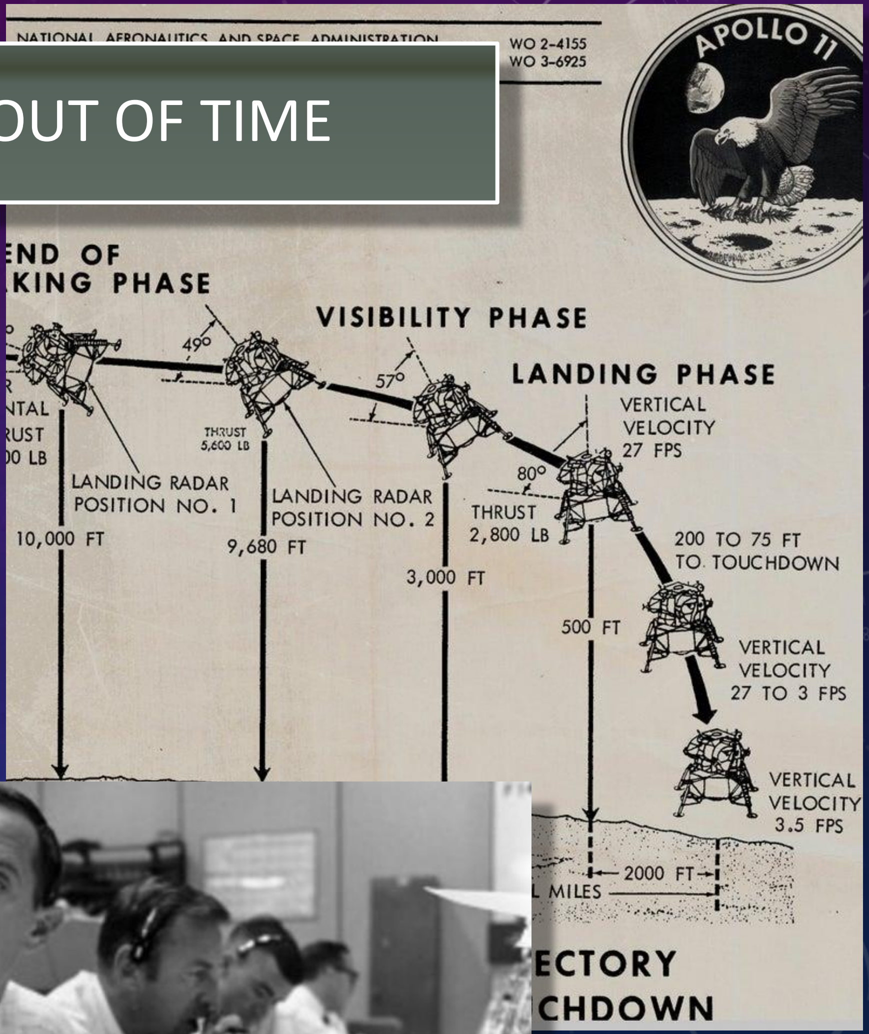
“Fly by Wire”

Landing Radar Updates

- Telemetry for “Fly by Wire”

Guidance Computer Updates

- Guidance Fail. Go Manual
- “1202” Program Alarm
  - Could have aborted landing
  - Guidance couldn’t keep up
  - Armstrong went manual
  - The rest is history



Capcom Charlie Duke, and backup crewmembers

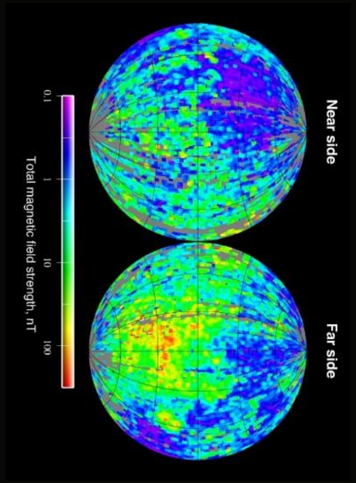
COMPASS NAVIGATION – COMPARE + CONTRAST

EARTH'S USABLE NORTH. *MOON'S UNUSABLE NORTH*

Compass North used for Millenia

Magnetic Field: weak and Erratic

- Weak Field 5 to 50;
- CRUST, NOT CORE
- **No compass**

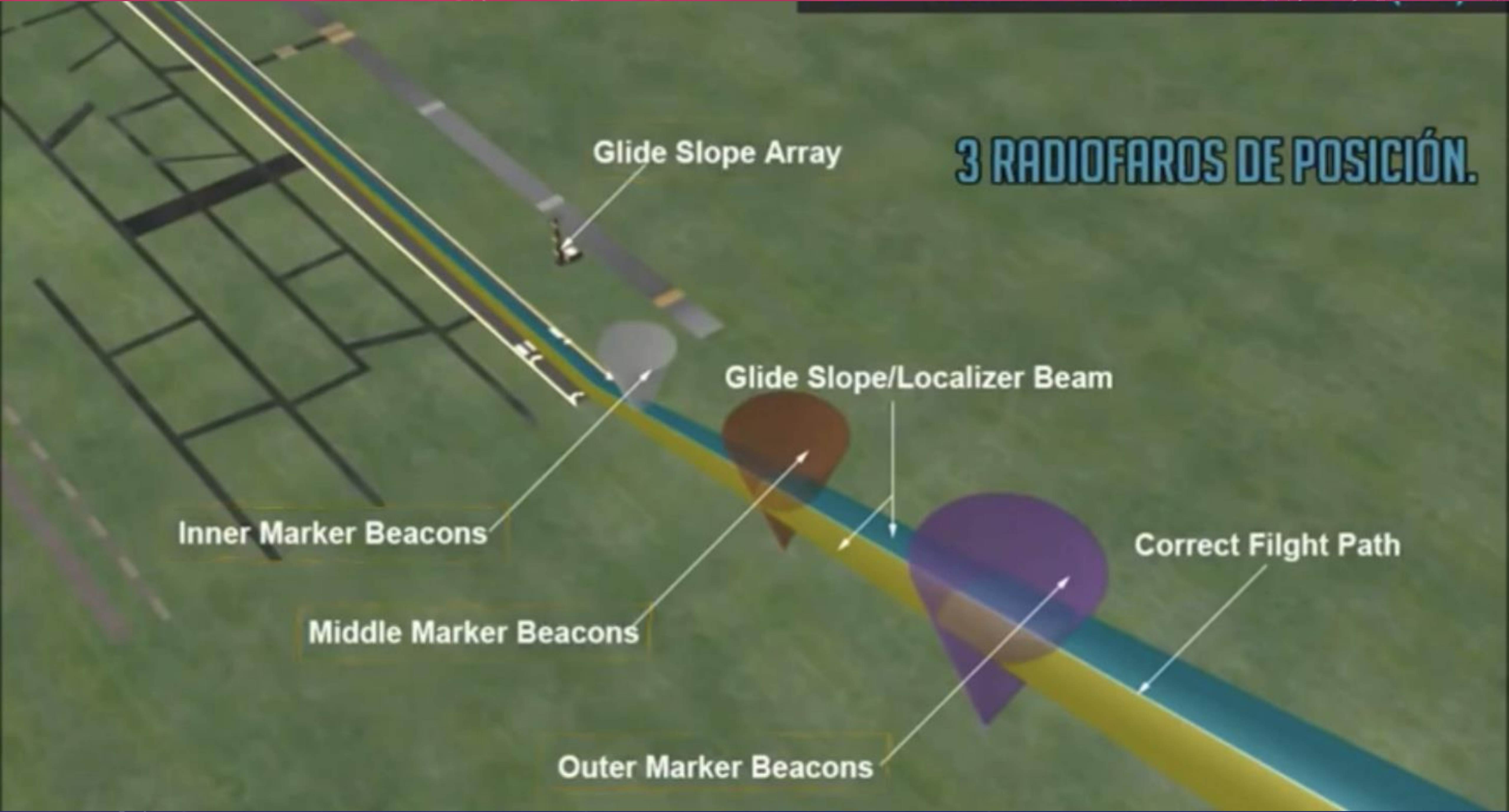


https://**moon.nasa.gov**/resources/348/apollo-mission-flight-plan-1967/

ADDITIONAL SLIDES

CONTINUED

3 RADIOFAROS DE POSICIÓN.



ADDITIONAL SLIDES

SUPPLEMENTAL

REFERENCE MATERIAL

ARTWORK CREDIT: https://www.**nasa.gov**/specials/apollo50th/

RUDD'S FAVORITE SOURCE: ***FROM THE EARTH TO THE MOON*** *DOCUMENTARY, PRODUCED BY TOM HANKS*

ARTWORK CREDIT: https://www.**nasa.gov**/specials/apollo50th/

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https://ntrs.nasa.gov/ **Lunar Module Comm PDF**

IMAGE GALLERIES FROM NASA.GOV

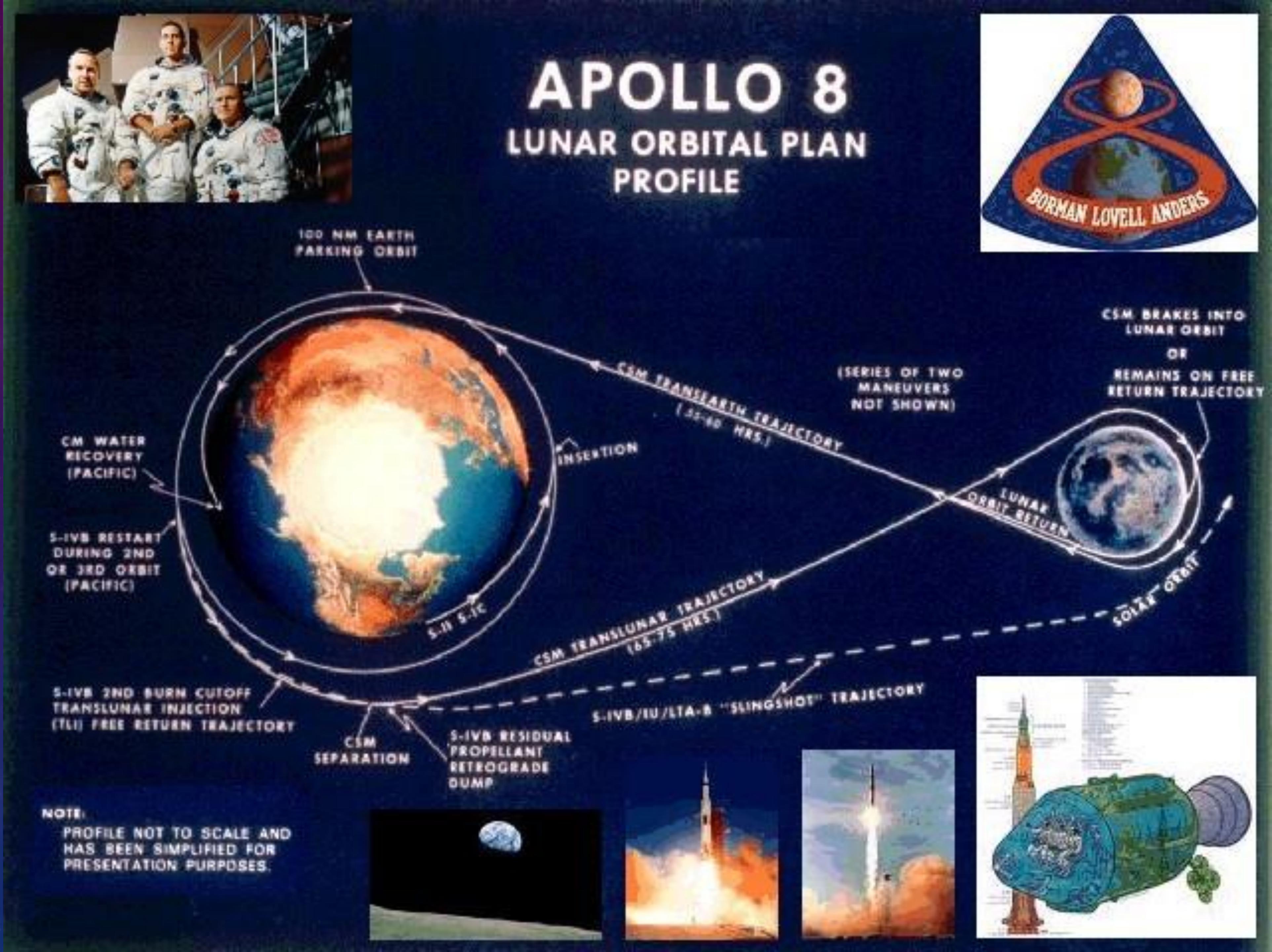
https://www.**nasa.gov**/multimedia/**imagegallery**/index.html

MORE ADDITIONAL SLIDES

DATA PATH

From Earth Network

To Lunar Module

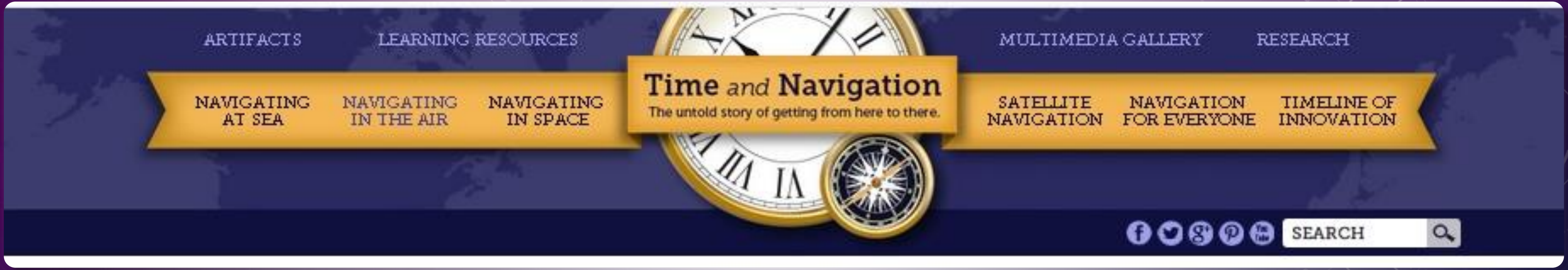


Cockpit-lunar-module-Apollo-mockup Used

67-

https://airandspace.si.edu/collection-objects/cockpit-lunar-module-apollo-mockup/nasm_A19760015000

Smithsonian
National Air and Space Museum



FLYING THE BEAM

AIR & SPACE MUSEUM

https://timeandnavigation.si.edu/navigating-air