

ORBITAL NAVIGATION SYSTEMS



PRESENT AND FUTURE TENDS



CONTENT

WHAT IS COVERED

A BRIEF HISTORY OF SYSTEMS

PRESENT SYSTEMS IN USE

PROBLEMS WITH SATELLITE SYSTEMS

PLANNED IMPROVEMENTS

CONCLUSION



CONTENT

WHAT IS NOT COVERED

SYSTEMS FOR SHORE USE

E.G. QZSS IN JAPAN, JOHN DEERE SYSTEM

SYSTEMS FOR AIRCRAFT

E.G. EGNOS, WAAS, MSAS, LAAS

MILITARY SYSTEMS – EXCEPT WHERE IT AFFECTS
CIVILIAN USE



A BRIEF HISTORY

START SPUTNIK LAUNCHED 1957

USSR SYSTEMS

PARUS

6 SV MILITARY SYSTEM

TSIKADA

4 SV CIVILIAN SYSTEM

GLONASS

SIMILAR TO NAVSTAR GPS



A BRIEF HISTORY

US SYSTEMS

TIMATION

EASILY JAMMED

621B

NEEDED GROUND SIGNALS TO OPERATE

TRANSIT

1962 TO 1996

POLAR ORBITS 4 TO 6 FIXES PER DAY

NAVSTAR

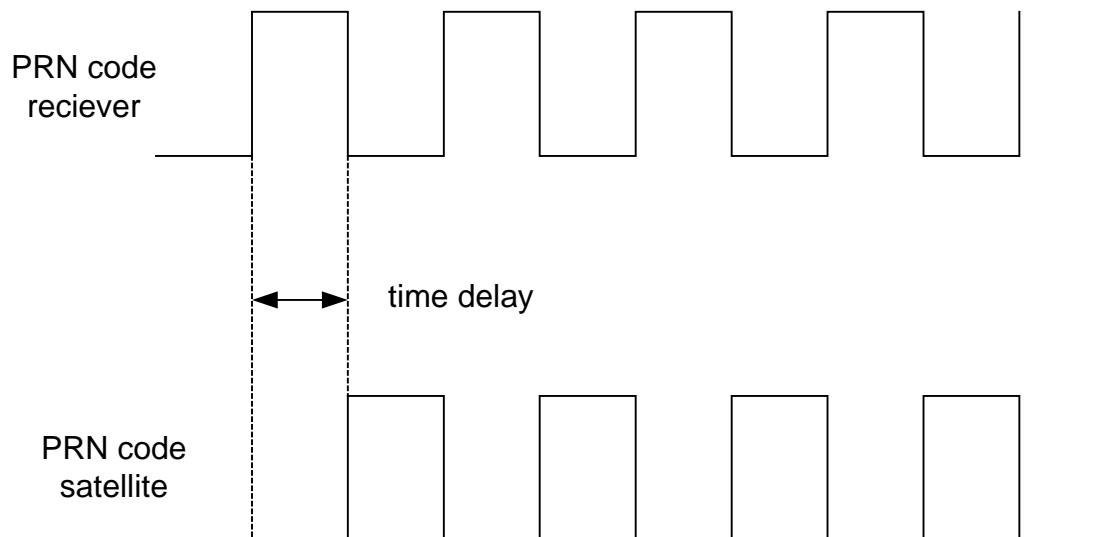
START 1973- FIRST SV 1978 -OPERATE 1989

COMPLETE 1994- SA OFF 2000



PRESENT SYSTEMS

TIME DELAY MEASUREMENT
USES PRN CODE TO DERIVE RANGE

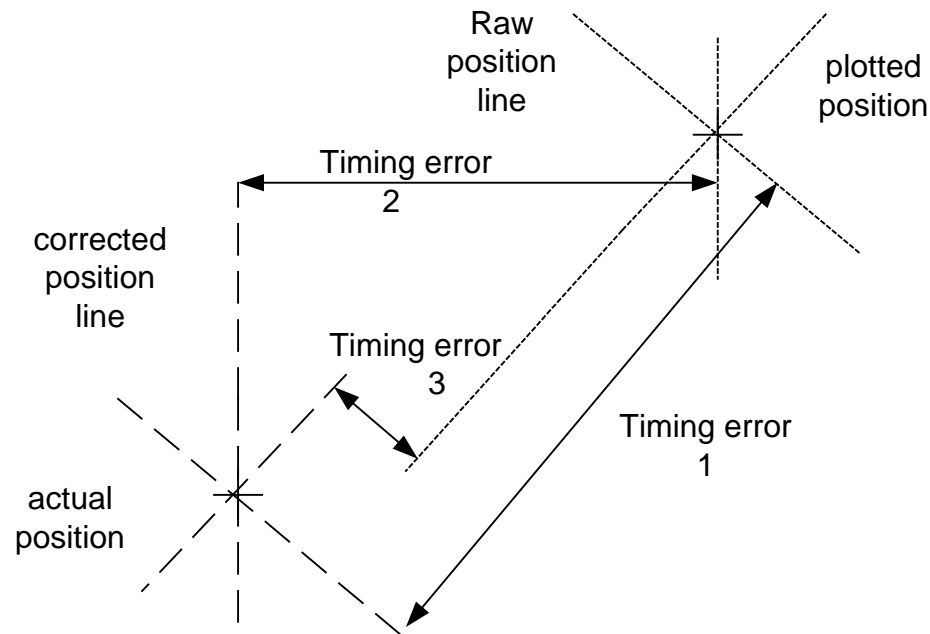


CARRIER PHASE DIFFERENCE MEASUREMENT

PRESENT SYSTEMS

DIFFERENTIAL GPS – DGPS

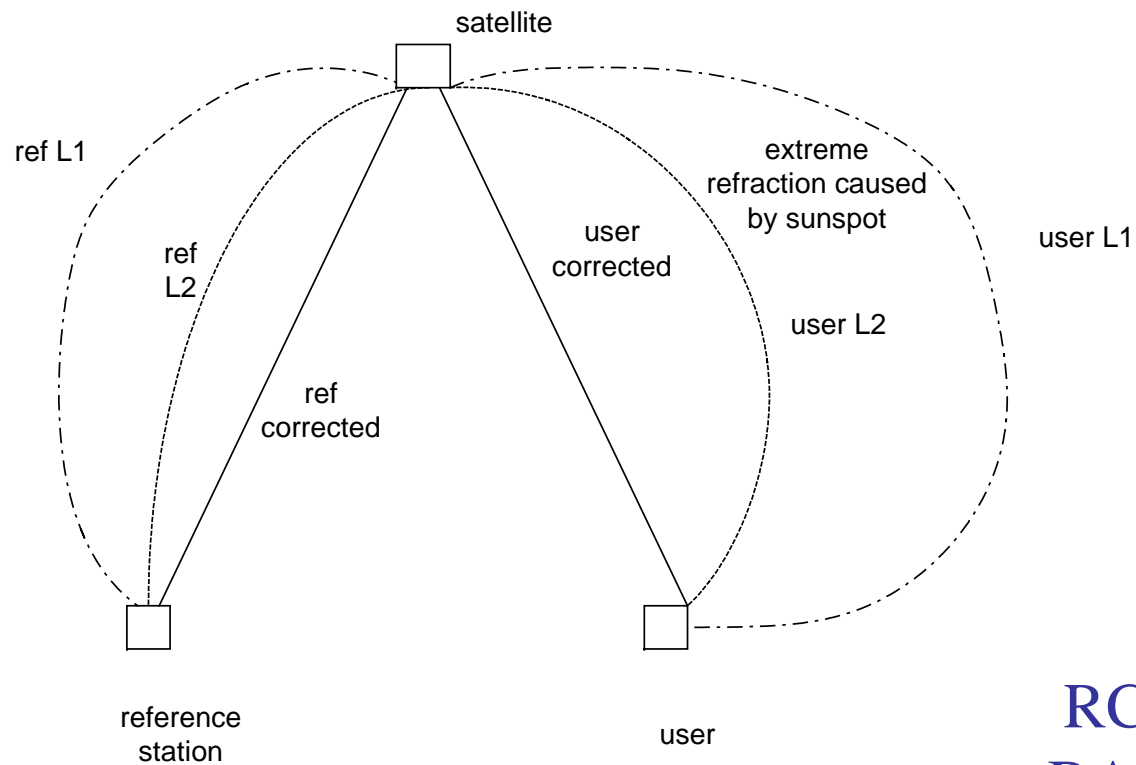
TIME DELAY MEASUREMENT, ERROR CORRECTION



NECESSARY WHEN SELECTIVE AVAILABILITY IN USE
STILL USED TO IMPROVE RELIABILITY
USERS HAVE THE OPTION TO USE RAW SIGNAL

PRESENT SYSTEMS

DUAL FREQUENCY SYSTEMS USES L1 15 MZ L2 12 MHZ

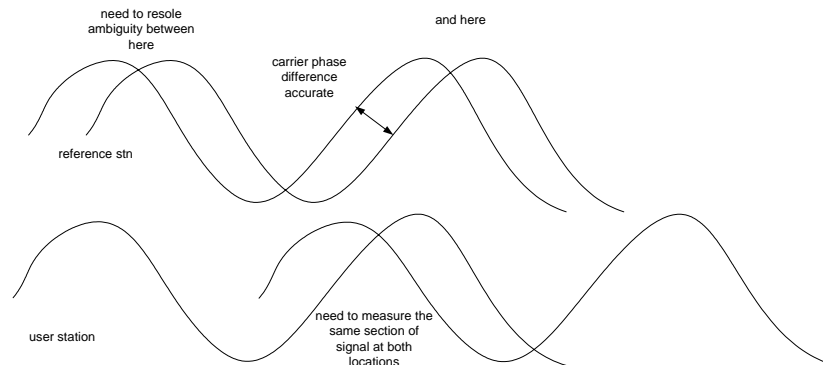


RCTM 15, 55
BASELINE 2000KM



PRESENT SYSTEMS

REAL TIME KINEMATIC
CARRIER PHASE DIFFERENCE MEASUREMENT
LANE IDENTITY NEEDS TO BE SOLVED



REQUIRES SPECIALISED ANTENNEA
REQUIRES SUBSCRIPTION
LIMITED TO VICINITY OF REFERENCE STATION

PRESENT SYSTEMS



Optimised Solutions

ERRORS SEGMENTED

REF STATIONS CLOCK AND ORBIT ERRORS

CORRECTIONS BROADCAST VESSEL

VESSEL USES DUAL FREQUENCY

MULTIPATH AND RECEIVER NOISE NEED TO BE RESOLVED

VBS STATIONS

VESSEL USES CORRECTIONS FROM MULTIPLE REF STATIONS

CORRECTIONS WEIGHTED VESSEL GETS SINGLE SET

NETWORK SYSTEMS

MANY SYSTEMS AVAILABLE

DIFFERENCES ALLOWED FOR

PRESENT SYSTEMS

GPS INERTIAL NAVIGATOR SYSTEM (INS) COMBINATION

COMMERCIAL INS CHEAPER THAN
MILITARY SYSTEMS
GPS/DGPS INPUT USED UNTIL
FAILURE SWITCHING TO INS
REDUCE'SDRIFT TO BETWEEN
2M PER MINUTE TO 3M PER HOUR

no log drift 2m/min

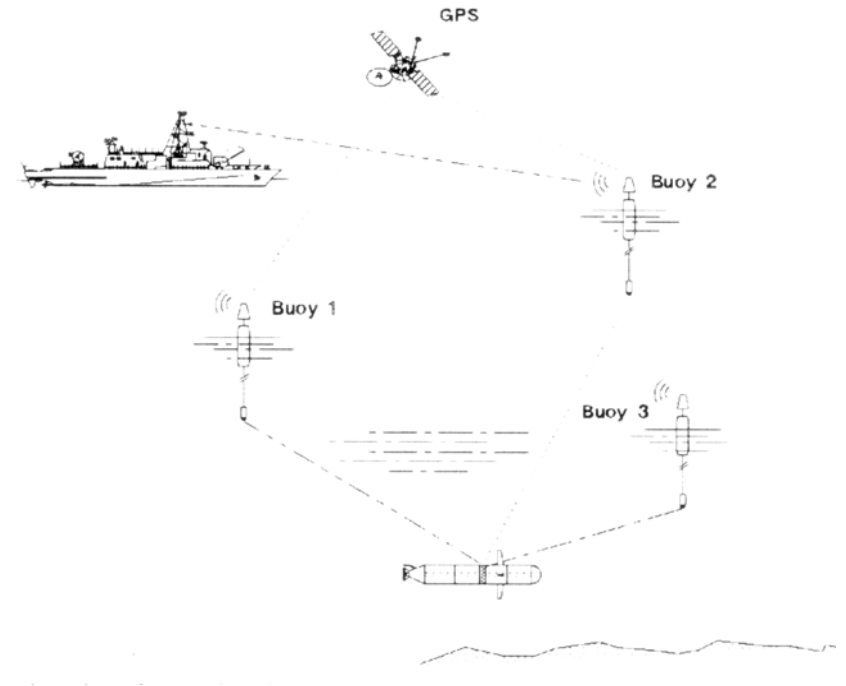


DVL drift less than 3m/hour

PRESENT SYSTEMS

GPS INTELLIGENT BEACON (GIB)

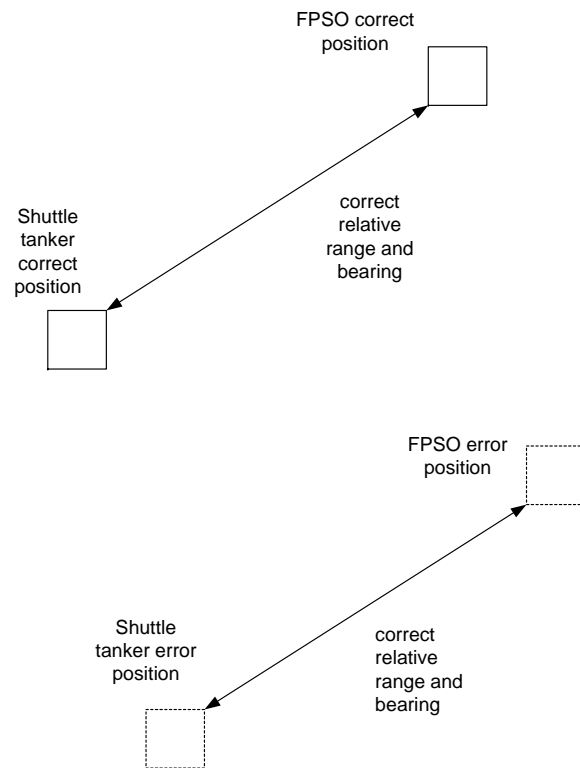
SURFACE BUOYS HAVE GPS AND
ACOUSTIC RECEIVER
SUBSEA VEHICLE TRANSMIT ACOUSTIC
SIGNAL
TIME DELAYS MEASURED AT BUOYS
BUOYS TRANSMIT POSITION AND TIME
DELAY
VESSEL WORKS OUT RANGE TO VEHICLE
FROM BUOY
VEHICLE POSITION CALCULATED





PRESENT SYSTEMS

DARPS- DIFFERENTIAL ABSOLUTE RELATIVE POSITIONING



SAT FIX FROM FPSO SENT TO
SHUTTLE TANKER
TANKER PLOTS POSITIONS
RELATIVE DISTANCES
ACCURATE



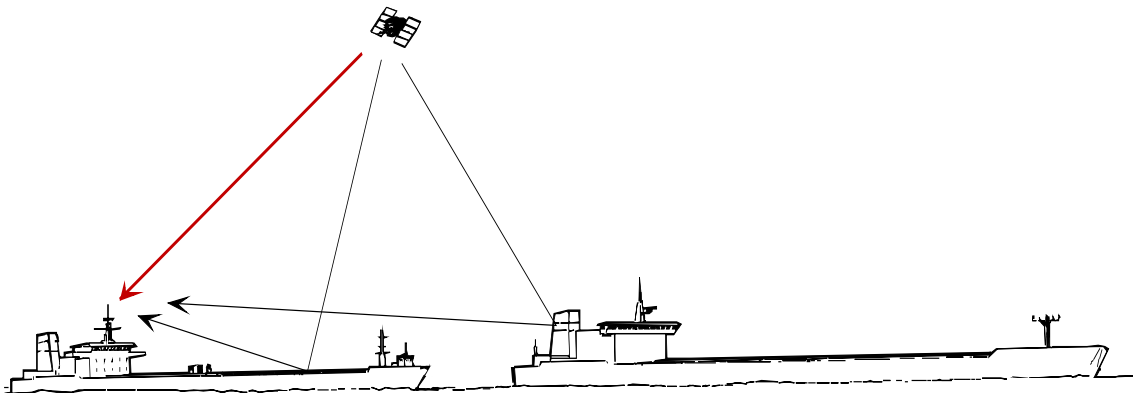
PROBLEMS

ATMOSPHERIC INTERFERENCE

RAY BENDING AFFECTS FIXING
CAN CAUSE DROP OUT
MODELLING NOT EFFECTIVE IN SEVERE CASES
NETWORKS AND DUAL FREQUENCY CAN REDUCE

PROBLEMS

MULTIPATH



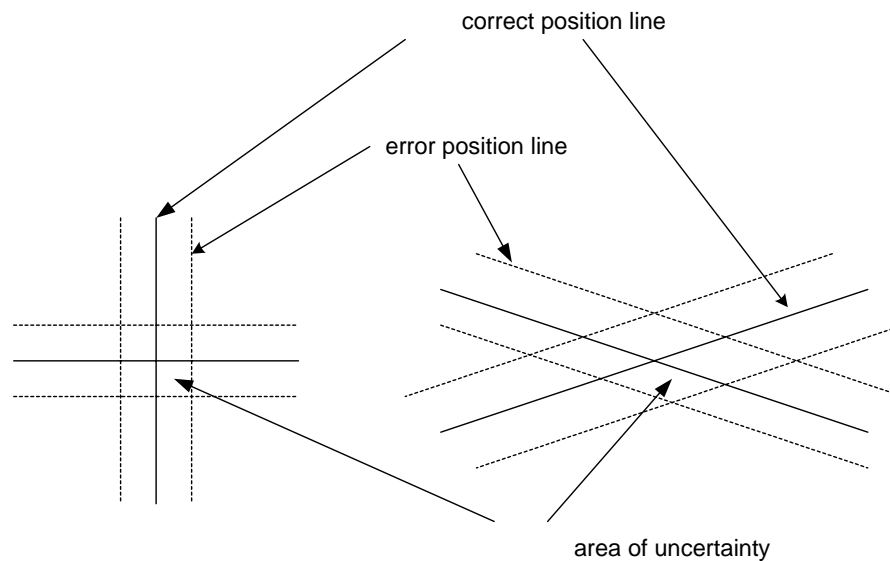
SIGNALS BOUNCE IN
CAUSE INTERFERENCE
CAN CAUSE DROPOUT

CAN BE DETECTED
ANTENNA DESIGN
SIGNAL PROCESSING



PROBLEMS

POOR CONSTELLATIONS



TOO FEW SATELLITES
OBSTRUCTIONS
DOP AN INDICATOR



PROBLEMS

OLD SATELLITES

GPS SATS IN USE

2 BLOCK II

16 BLOCK IIA

11 BLOCK IIR

7 NAV FAILURE

1 BUS FAILURE

4 ONE OF EACH

14 OLD SATS

GLONASS

3 YEAR LIFECYCLE

DOWN TO 6 OR 7

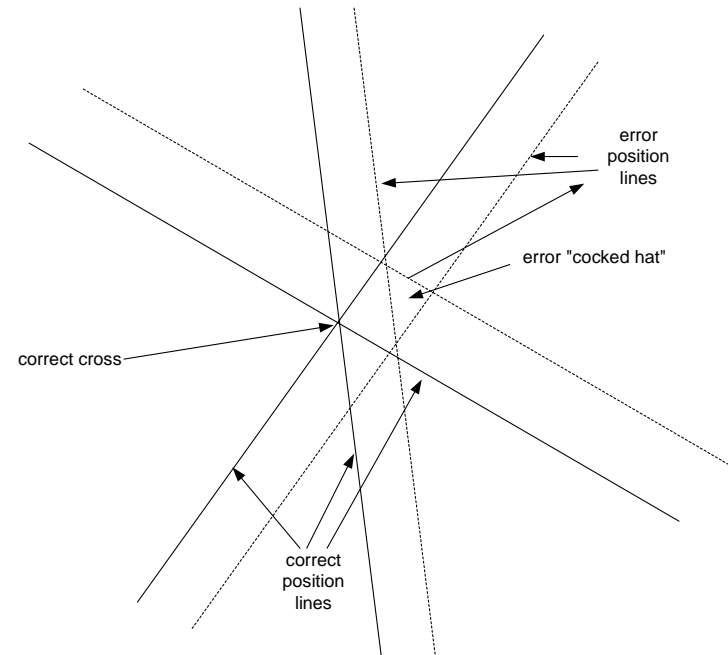
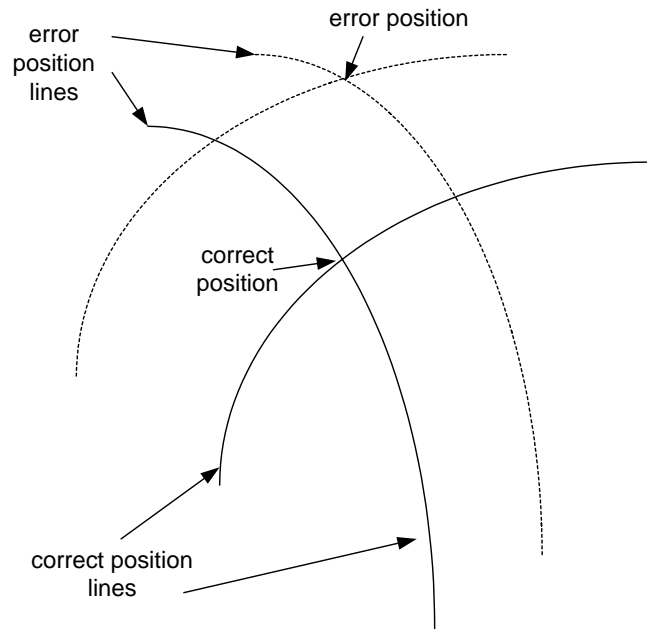
BACK UP TO 11

FAILURE STATUS NOT KNOWN



PROBLEMS

CLOCK ERRORS



CLOCK ERRORS CAUSE ERROR

THIRD SAT ALLOWS
CALCULATION



PROBLEMS

HUMAN ERROR

MANY CAUSES AT USER END
AUDITS
PROCEDURES
ERGONOMICS
DESIGN CAN REDUCE

CONTROL SEGMENT
NUMBERS NOT AVAILABLE
FOUND WITH EXTERNAL
MONITORING



PROBLEMS

SECURITY CONCERNS

SYSTEMS MILITARY

PROTECTED AGAINST JAMMING

CAN BE DEGRADED

OVERLAYS CAN CAUSE INTERFERENCE



PLANNED IMPROVEMENTS

GALILEO

GNSS SYSTEM PLANNED TO OPERATE BY 2008

OPERATION SIMILAR TO NAVSTAR

FIRST LAUNCH 2005 OPERATIONAL 2008

TEST SV 2005

4 SV AND VALIDATION EARTH AND SPACE SYSTEMS

2005 TO 2006

3 MEDIUM EARTH ORBITS



PLANNED IMPROVEMENTS

GALILEO

SYSTEM WILL INCLUDE 2 GROUND CONTROL CENTRES
5 S BAND AND 10 C BAND UPLINK STATIONS
30 SV 27 +3 SPARE
SYSTEM EXPECTED TO HAVE INTEGRITY MESSAGES
SAR FUNCTION BUILT IN
DISTRESS SIGNAL SENT TO RCC
DISTRESS STATION ALSO ADVISED OF STATUS



PLANNED IMPROVMENTS

GLONASS

NUMBER OF WORKING SATELLITES DROPPED TO 7
COVERAGE WAS NOT 24 HOURS IN CERTAIN AREAS

INVESTMENT HAS BEEN SECURED

LAUNCH PROGRAMME STARTED

11 SV IN CONSTELLATIONS 10 OPERATIONAL

PLAN FOR 18 BY 2007

OPERATING IN CO-OPERATION WITH INDIA

NEW SATELLITES LONGER LIFECYCLE



PLANNED IMPROVEMENTS

SATELLITES UPDATES

BLOCK IIR – M COMMENCE 2004-6 COMPLETE 2012

L2 CIVILIAN CODE OVERLAY ADDED

L1 AND L2 M-CODE OVERLAY ADDED

HIGHER POWER JAMMING RESISTANT

IMPROVED SIGNAL STRUCTURE

BLOCK IIF COMMENCE 2015 12 SV

IIR-M COMPATIBILITY

L5 HIGH POWER HIGH PRECISION CODE 1176MHZ

L1-L5 DUAL FREQUENCY ATMOSPHERIC CORRECTION

AIRCRAFT



PLANNED IMPROVEMENTS

M CODES

MAY 2000 SELECTIVE AVAILABILITY REMOVED

SELECTIVE DENIABILITY TO REPLACE

REQUIRES M CODE SUB CARRIERS

INSTALLED ON BLOCK IIR-M AND IIF SATELLITES

2 OVERLAYS EACH ON L1 AND L2



PLANNED IMPROVEMENTS

GPS 3 SYSTEMS

PLANNED START 2010

INCREASED ACCURACY

ASSURED AVAILABILITY

CONTROLLED INTEGRITY

SYSTEM SURVIVABILITY

NAV MESSAGES

RESPONSIVE OPERATIONS

3 NON RE-OCCURRING ORBITS

SAME SIGNAL STRUCTURE AS GALILEO



PLANNED IMPROVEMENTS

CHINESE BEIDOU SYSTEM

NOT A GLOBAL SYSTEM

USES 3 GEOSTATIONARY SATELLITES

SIMILAR TO GEOSTAR

IMPORTANT POINT IS DESIRE TO HAVE A GPS TYPE
SYSTEM



PLANNED IMPROVEMENTS

COMBINED SYSTEMS

MORE REALISTIC AS GLONASS IMPROVES

24 CHANNEL GPS/GLONASS AVAILABLE

TRIPLE SYSTEM PROPOSED FOR GPS/GLONASS/GALILEO



CONCLUSION

MOST WIDELY USED SYSTEM

USE WILL INCREASE

NEED TO RESOLVE INTERFERENCE ERRORS

NEW SYSTEMS MAY HELP RESOLVE PROBLEMS

CAN MAKE GNSS TRULY REDUNDANT



THANK YOU

QUESTIONS?