

# ORBITAL NAVIGATION SYSTEMS



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PRESENT AND FUTURE TENDS



# CONTENT

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## WHAT IS COVERED

A BRIEF HISTORY OF SYSTEMS

PRESENT SYSTEMS IN USE

PROBLEMS WITH SATELLITE SYSTEMS

PLANNED IMPROVEMENTS

CONCLUSION



# CONTENT

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## 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

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START SPUTNIK LAUNCHED 1957

## USSR SYSTEMS

PARUS

6 SV MILITARY SYSTEM

TSIKADA

4 SV CIVILIAN SYSTEM

GLONASS

SIMILAR TO NAVSTAR GPS



# A BRIEF HISTORY

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## 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

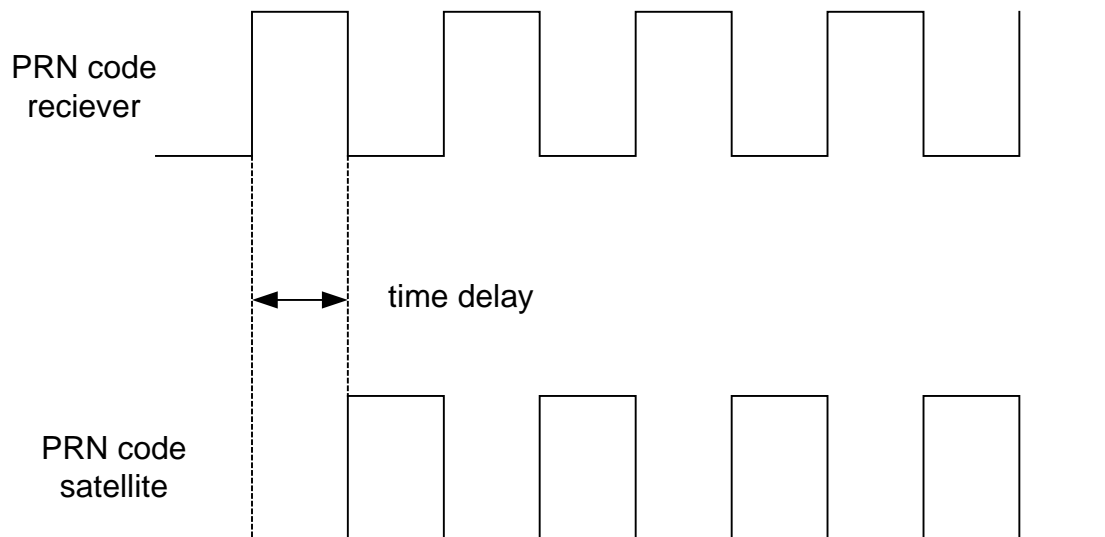
COMPLETE 1994- SA OFF 2000



# PRESENT SYSTEMS

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TIME DELAY MEASUREMENT  
USES PRN CODE TO DERIVE RANGE

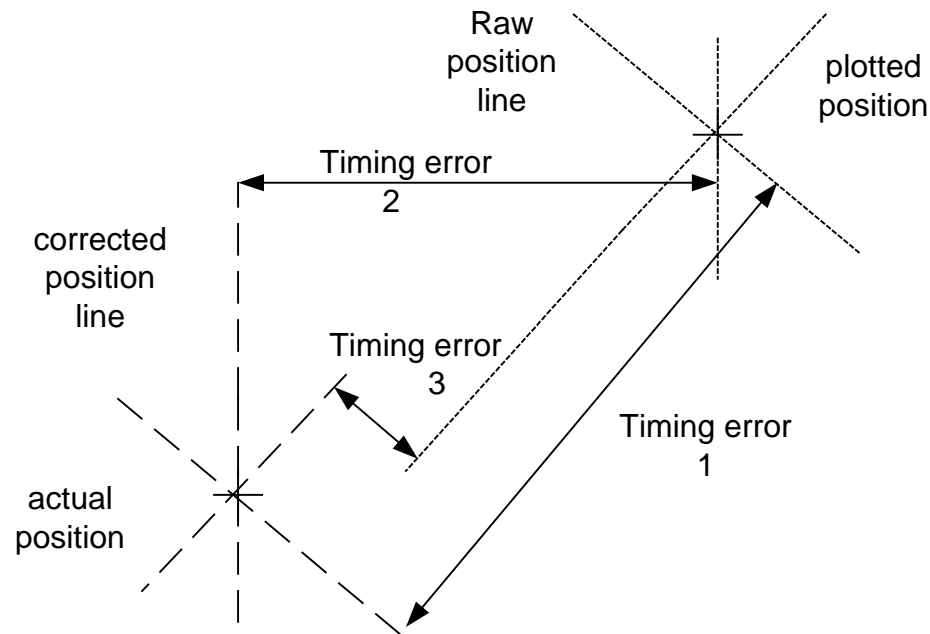


CARRIER PHASE DIFFERENCE MEASUREMENT

# PRESENT SYSTEMS

## DIFFERENTIAL GPS – DGPS

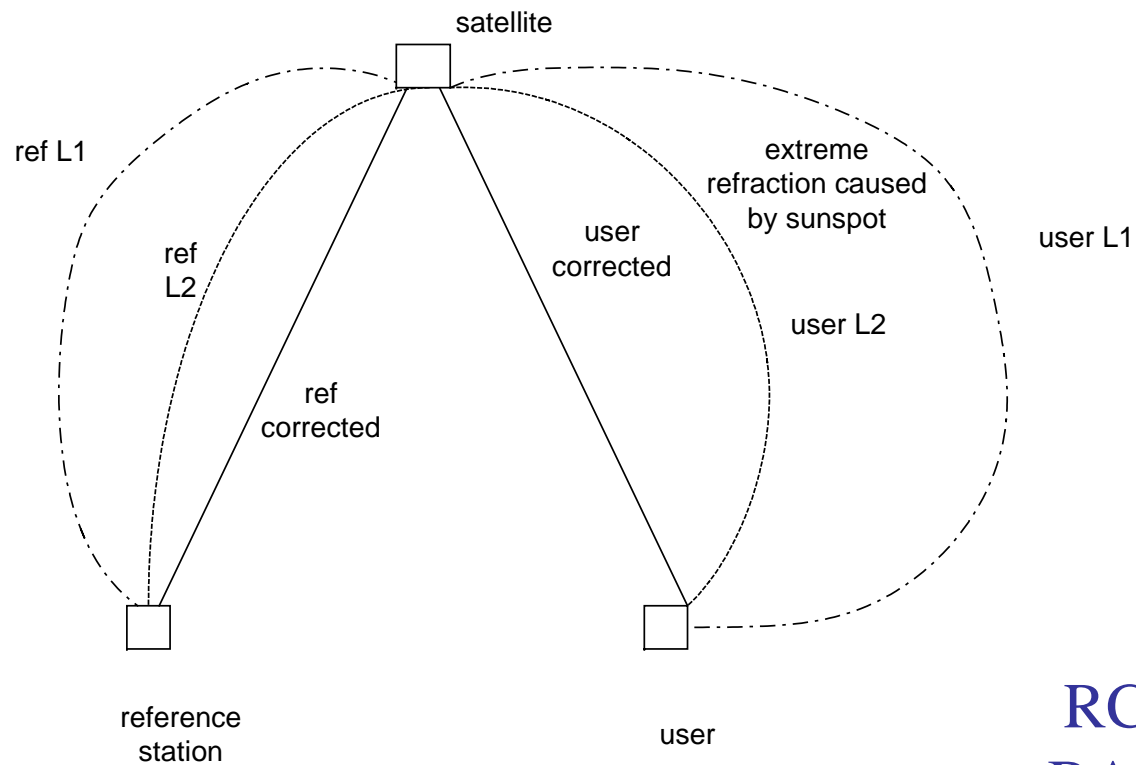
### TIME DELAY MEASUREMENT, ERROR CORRECTION



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

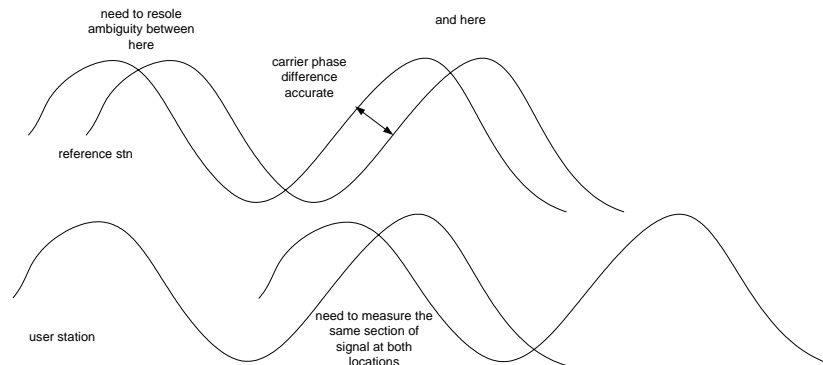




# PRESENT SYSTEMS

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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

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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

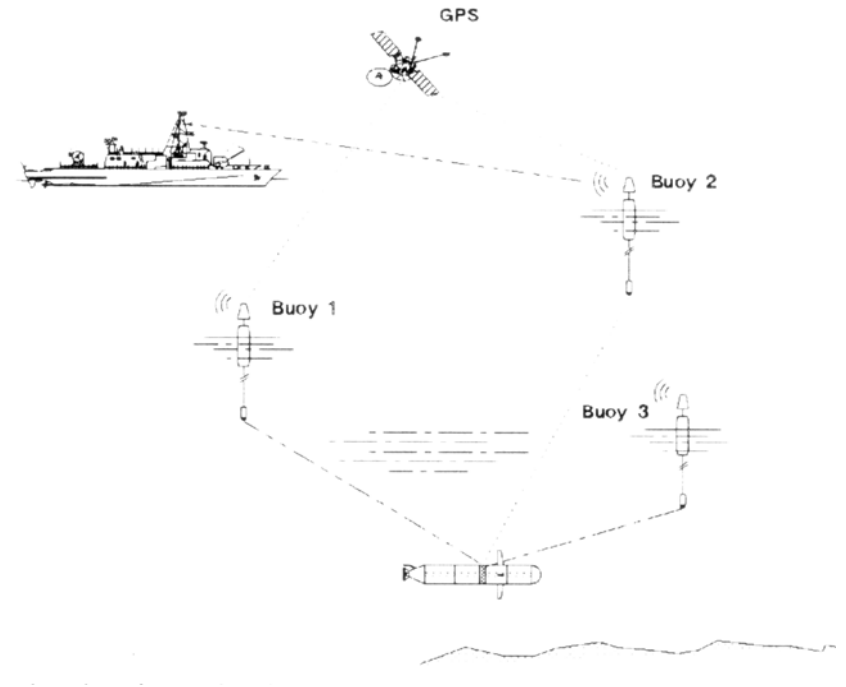


DVL drift less than 3m/hour

# 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

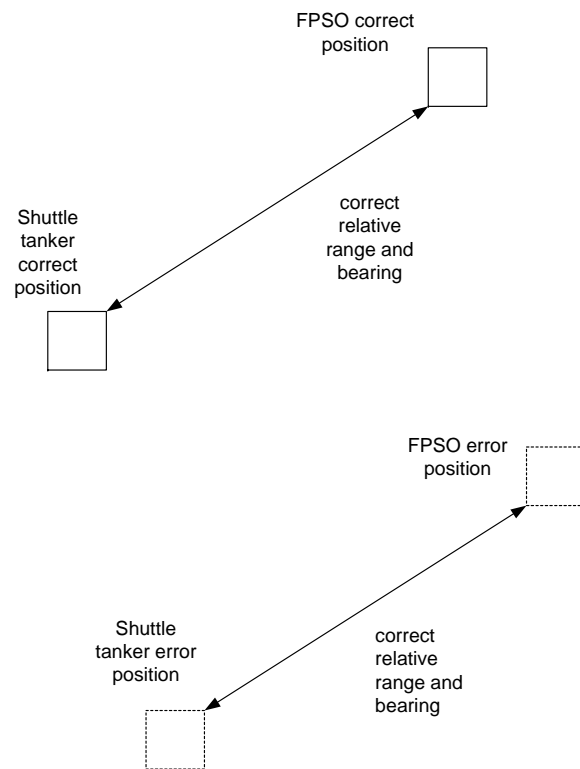




# PRESENT SYSTEMS

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## DARPS- DIFFERENTIAL ABSOLUTE RELATIVE POSITIONING



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



# PROBLEMS

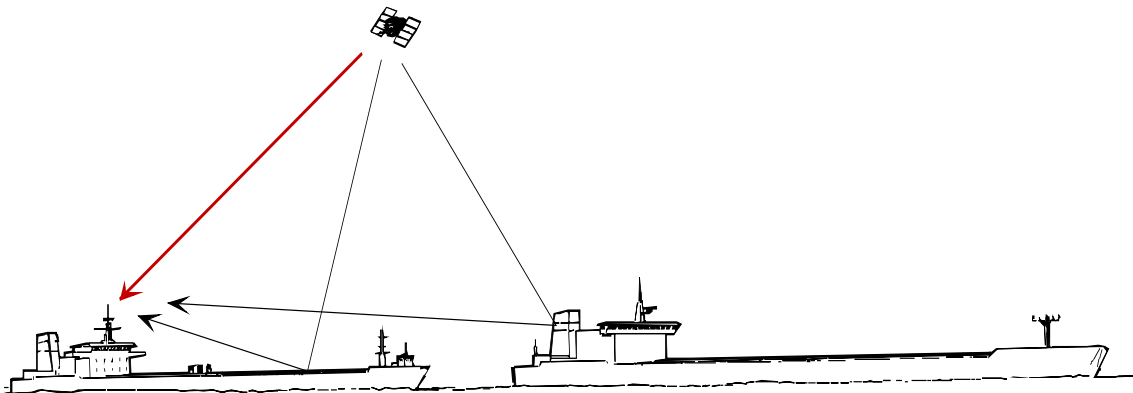
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## ATMOSPHERIC INTERFERENCE

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

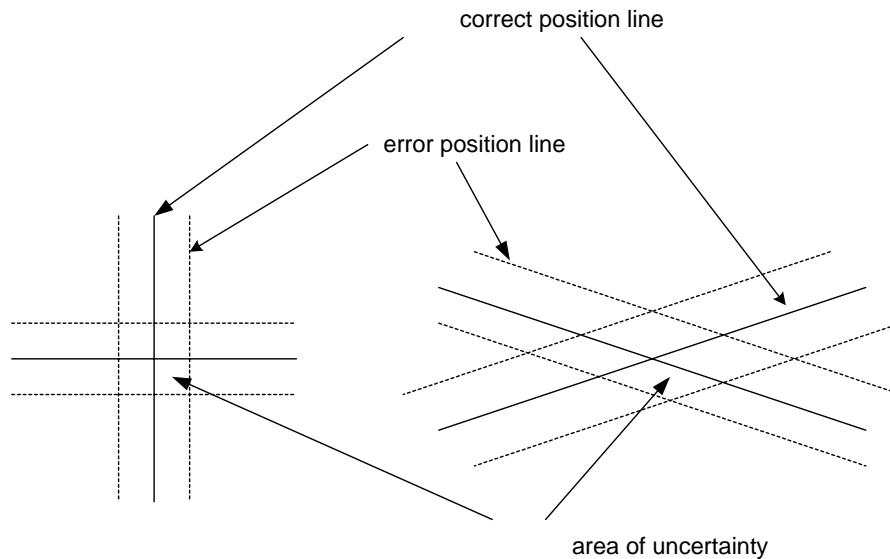
CAN BE DETECTED  
ANTENNA DESIGN  
SIGNAL PROCESSING



# PROBLEMS

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## POOR CONSTELLATIONS



TOO FEW SATELLITES  
OBSTRUCTIONS  
DOP AN INDICATOR





# PROBLEMS

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## 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

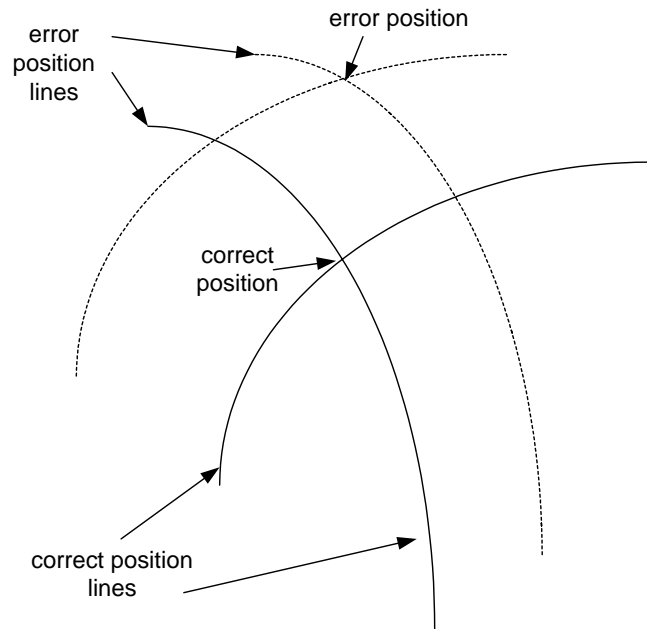
BACK UP TO 11

FAILURE STATUS NOT KNOWN

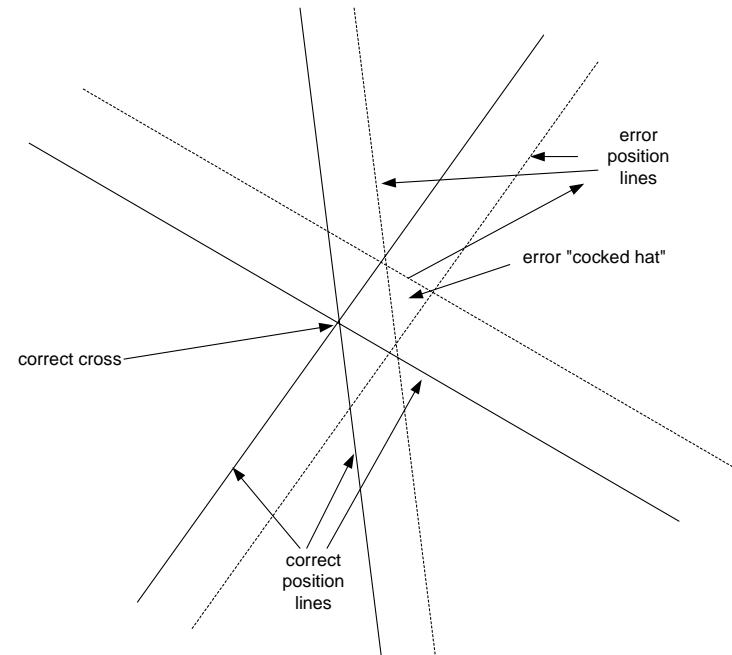


# PROBLEMS

## CLOCK ERRORS



CLOCK ERRORS CAUSE ERROR



THIRD SAT ALLOWS  
CALCULATION



# PROBLEMS

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## HUMAN ERROR

MANY CAUSES AT USER END  
AUDITS  
PROCEDURES  
ERGONOMICS  
DESIGN CAN REDUCE

CONTROL SEGMENT  
NUMBERS NOT AVAILABLE  
FOUND WITH EXTERNAL  
MONITORING



# PROBLEMS

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## SECURITY CONCERNS

SYSTEMS MILITARY

PROTECTED AGAINST JAMMING

CAN BE DEGRADED

OVERLAYS CAN CAUSE INTERFERENCE



# PLANNED IMPROVEMENTS

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## 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

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## 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

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## 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

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## 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

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## 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

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## 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

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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

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COMBINED SYSTEMS

MORE REALISTIC AS GLONASS IMPROVES

24 CHANNEL GPS/GLONASS AVAILABLE

TRIPLE SYSTEM PROPOSED FOR GPS/GLONASS/GALILEO



# CONCLUSION

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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

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QUESTIONS?