TRAINING COURSE

INTRODUCTION TO PSR SYSTEM

Primary Surveillance Radar Systems
ATM

Nº doc.: 0066605020000MA02
Edición: A Revisión: 1
Fecha: 09/03/2020

Warning of Confidentiality

Signature Sheet

	INDRA			
	Name	Signature	Date	Responsibility
Prepared	Jaime Herrero Gutiérrez			Systems Engineer
Revised	Carolina Rincón Gila			Systems Engineer
Approved	Crisanto Molina Blesa			Systems Engineer
Authorized	Crisanto Molina Blesa			Systems Engineer

Changes Record

DOCUMENT CHANGES RECORD				
EDITION	*REVISION*	*DATE*	*CHAPTER*	*REASON OF THE CHANGES*
A	0	18/04/2017	All	First Edition
A	1	09/03/2020	All	Second Edition

Acronyms

µsec	microsecond
3D	Tridimensional
AC	Alternating Current
ACP	Azimuth Change Pulse
ADC	Analog to Digital Converter
AGSU	Active Groups Selector Unit
AP	Anomalous Propagation
APG	Antenna and Pedestal Group
ARP	Azimuth Reset Pulse
ASR	Airport Surveillance Radar
ASTERIX	All Purpose STructured Eurocontrol suRveillance Information EXchange
ATC	Air Traffic Control
BIT	Built-in test
BW	Bandwidth

Acronyms

CBU	Control and Bite Unit
CCW	Counter Clockwise
CFAR	Constant False Alarm Ratio
CH	Channel
cm	Centimeter
CMS	Control and Monitor System
CNR	Control No Radar
COHO	COHerent Oscillator
COTS	Commercial-Of-The-Shelf
CPC	Central Processor Computer
CPI	Coherent Process Interval
CPIP	Coherent Process Interval Pair
CSC	Software Component
CW	Clockwise
dB	Decibel

Acronyms

dBc	Decibel (relative to carrier)
dBm	Decibel (relative to milliwatt)
DC	Direct Current
DDC	Digital Down Converter
DDPG	Digital Modulator Demodulator and Processor Group
DDS	Direct Digital Synthesis
DKA	Display & Keyboard Assembly
DP	Data Processing
DRCG	Dual Rotary Control Group
DRU	Digital Receiver Unit
DSP	Digital Signal Processor
DSU	Digital Synthesizer Unit
EMC	Electromagnetic Compatibility
EPG	Exciter and Processor Group

Acronyms

ESBB	Encoder Signals Bypass Board
FGG	Frequency Generator Group
FIR	Finite Impulse Response
FPGA	Field Programmable Gate Array
GPB	Generic Processor Board
GRPG	Generator. Receiver and Processor Group
h	Hour
HW	Hardware
Hz	Hertz
ICAO	International Civil Aviation Organization
IF	Intermediate Frequency
IFCSU	Intermediate Frequency Control and Switch Unit
kft	Kilofeet
kg	Kilogram
km	Kilometer

Acronyms

kVA	Kilovoltamper
kW	Kilowatt
LAN	Local Area Network
LNA	Low Noise Amplifier
LO	Local Oscillator
LOSDU	Local Oscillators Switching and Distribution Unit
LP	Long Pulse
LRU	Line Replaceable Unit
LVA	Large Vertical Aperture
m	Meter
MSSR	Monopulse Secondary Surveillance Radar
MTAC	Multi Turn Around Clutter
MTAT	Multi Turn Around Target
MTBCF	Mean Time Before Critical Failures

Acronyms

MTD	Moving Target Detector
MTI	Moving Target Indicator
MTTR	Mean Time To Repair
MWCG	MicroWave Control Group
MWCU	MicroWave Control Unit
MWG	Microwave Group
N/A	Not applicable
NLFM	Non Lineal Frequency Modulation
NM (nmi)	Nautical Miles
ns	Nanosecond
NTP	Network Time Protocol
NWS	National Weather Service
ºC	Celsius degree
ºF	Fahrenheit degree
PA	Power Amplifier

Acronyms

PC	Personal Computer
PLC	Programmable Logic Control
PPI	Plan Position Indicators
ppm	Parts per million
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PRT	Pulse Repetition Interval
psig	Pound per Square Inch Gage
PSR	Primary Surveillance Radar
PTCP	Pedestal Top Control Panel
PTIP	Pre-Transmit Interpulse Period
PW	Pulse width
RCS	Radar Cross Section
RF	Radiofrequency
RFCSU	Control and Switching unit

Acronyms

RGCU	Receiver Group Control Unit
RCS	Radar Cross Section
RJ	Rotary Joint
rms	root mean square
rpm	Revolution per minute
RX	Reception
RXG	Receiver Group
RXU	Receiver Unit
s	Second
SCBG	Synchronization Control and Bite Group
scfm	Standard Cubic Feet per Minute
SCR	Radar Communication System
SDCU	Signal Distribution Control Unit
SDG	Signal Distribution Group
SDRAM	Synchronous Dynamic Random Access Memory

Acronyms

SLG	Local Control System
SP	Signal Process/Short Pulse
SRG	Remote Control System
SRXU	S Band Receiver Unit
SSR	Secondary Surveillance Radar
STALO	STAble Oscillator
STC	Sensitivity Time Control
STCU	Sensitivity Time Control Unit
SW	Software
SYNU	Synchronization Unit
TAR	Terminal Area Radar
TGT	Target
TISMU	Test Injection and Stability Monitoring Unit
TMA	Terminal Maneouvering Radar
TRIP	Transmit-Receive Interpulse Period

Acronyms

TSU	Turning Signal Unit
TWS	Track While Scan
TXCU	Transmission Control Unit
TXG	Transmitter Group
TXGU	Transmission Generation Unit
TXGU	Transmitter Generation Group
UCS	Supervision and Control Unit
VSIPL	Vector. Signal. and Image Processing Library
VSWR	VoltageStanding Wave Ratio
W	Watt
WCD	Waveguide Compressor Dehydrator
WX	Weather
ZVF	Zero Velocity Filter

Index

Index

Preliminary Notions

1

- Primary Surveillance S-band radar which provides air surveillance, tracking activity and weather detection for all target (cooperative and non-cooperative) in short and medium ranges.
- Operation:
  - Two different Coherent Processing Intervals (CPIs) with two transmitted pulses (Long & Short Pulses). Each CPI burst is transmitted with a certain PRF.
  - Reception and pulse processing in order to visualize target and weather data.
- Design clues:
  - Power
  - Frequency
    → Range and Coverage
  - Resolution → Probability of Detection
  - False Alarms → MTAT/MTAC, Permanent Echoes, Angels, Rain, wind, ground clutter returns
  - Blind Speeds → CPI's PRF Variation

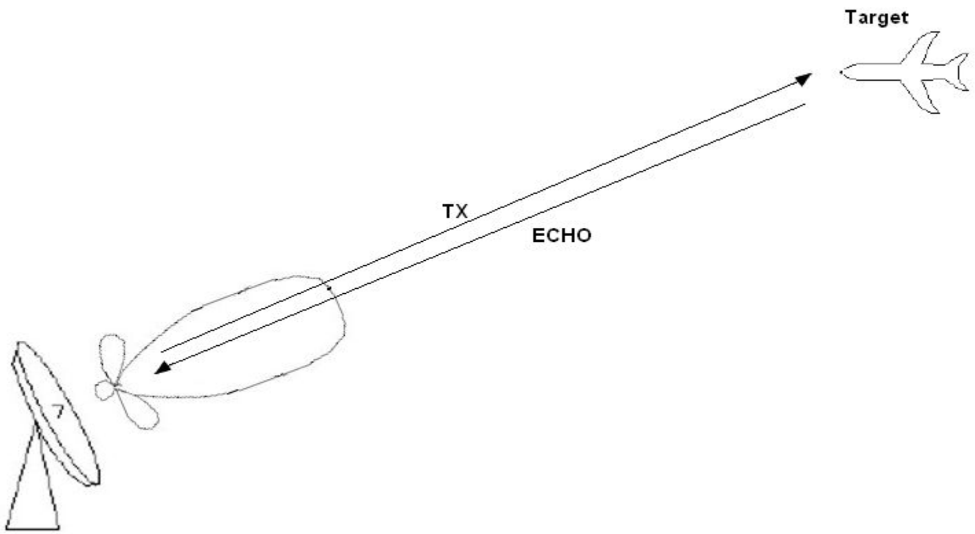
Radar and Operation Concepts

- Radio Detection and Ranging
- Maximum and Minimum Range Determination
- Doppler Concept
- MTD-IV Processing
- Blind Speeds
- Frequency Diversity
- Transmission Concepts
- State Diagram
- Stability

2

Radio Detection and Ranging

- BASIC CONCEPT
  - A primary radar operates by radiating electromagnetic energy and detecting the echo reflected by objects.
  - The electromagnetic energy travels at constant speed, approximately the speed of light.
  - By using an antenna that focused the energy (directional beam), direction can be determined.



Maximum and Minimum Range Determination

- MAXIMUM RANGE
  - Radar system range is not related linearly to transmitted power.
  - In order to improve range, transmitted power must be increased in the order of R^4.

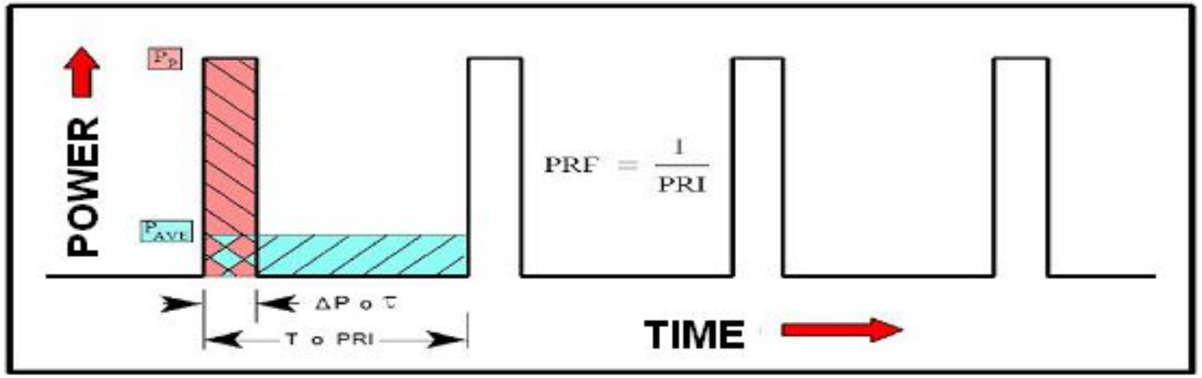
$$P_r = \frac{P_t G_t A_r \sigma}{(4\pi)^2 R^4} \rightarrow R = \sqrt[4]{\frac{P_t G_t A_r \sigma}{(4\pi)^2 P_r}} \rightarrow \begin{matrix} R = \alpha * \sqrt[4]{P_t} \\ P_t \Rightarrow R^4 \end{matrix}$$

  - There are two different possibilities to increase maximum range:
    - Transmitted power rising (Higher peak power).
    - Transmitted pulse length increasing (Higher average power).

- MINIMUM RANGE
  - Minimum range achieved depends on the transmitted pulse length among other factors.
  - While transmitting, receiving is not possible. This fact will limit the minimum range.

Maximum and Minimum Range Determination

- Maximum range improvement
  - In order to improve maximum range, transmitted average power is risen by means of expanding transmission time pulse.

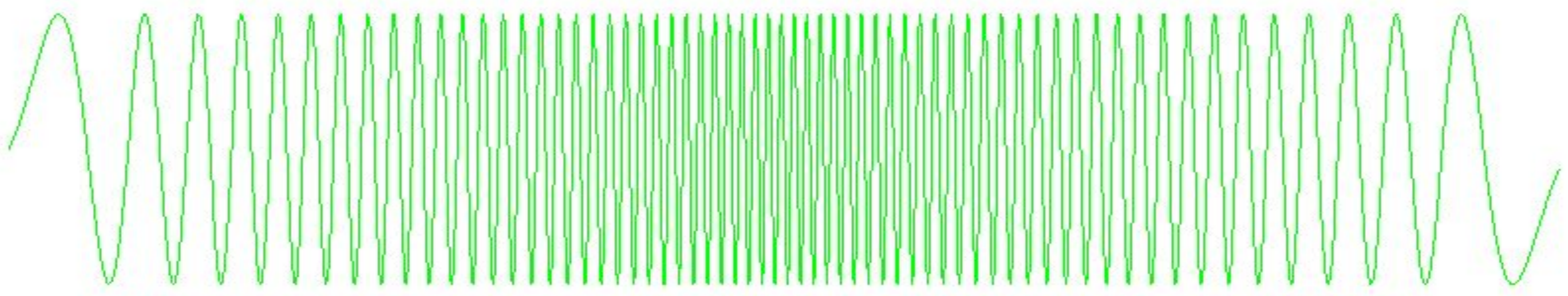


  - The disadvantages are a range resolution deterioration, besides minimum range will be affected.
  - Solutions:
    - 1.Pulse Compression.
    - 2.Short Pulse Transmission.

Maximum and Minimum Range Determination

Pulse Compression

- Range resolution is related to pulse duration:
  - Goal: a long pulse transmission to achieve a good range, processed as a short pulse to get the SP resolution.
- PULSE COMPRESSION:
  - This technique compresses the received long pulse signal into a short pulse.



Maximum and Minimum Range Determination

Pulse Compression

- NLFM (Non Linear Frequency Modulation)
  - The pulse compression technique allows to convert a long and low resolution pulse into a short pulse (narrower bandwidth). Such short pulse improves the range resolution with the same power.
  - The range resolution is related to the transmitted pulse width.

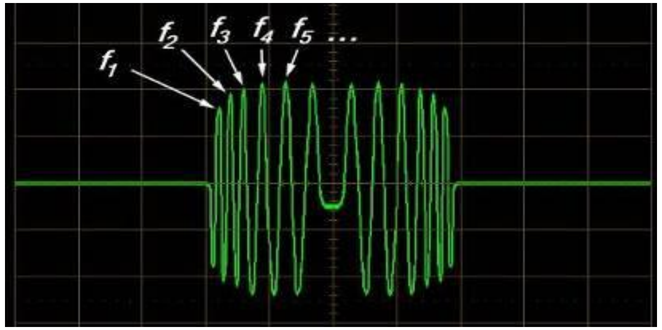
$$R_{RES} = \frac{c}{2 \cdot BW} \; ; \quad \textbf{PW = Pulse Width}$$

Ex: 15000 m to 100µs

  - In a pulse compression system a chirp signal is transmitted. This means that the transmitted long pulse is considered as a set of short pulses with different frequencies
  - In this case, the range resolution do not depends on its pulse width, it depends on the bandwidth of the transmitted signal.

The formula is:

$$R_{RES} = \frac{c \cdot PW}{2} \; ; \quad \textbf{BW = Band Width}$$



Maximum and Minimum Range Determination

Pulse Compression (Resolution)

- By means of this technique, resolution is a function of bandwidth, as seen before:

$$R_{RES} = \frac{c}{2 \cdot BW}$$

- PSR transmitted bandwidth is:1,942 MHz, achieving a minimum resolution of:

$$R_{RES} = \frac{3x10^{8}}{3.884x10^{6}} = 77{,}24$$ **meters**

- On the other hand, taking into account the windowed factor=1,33:

77,24*1,33= 102,73 m

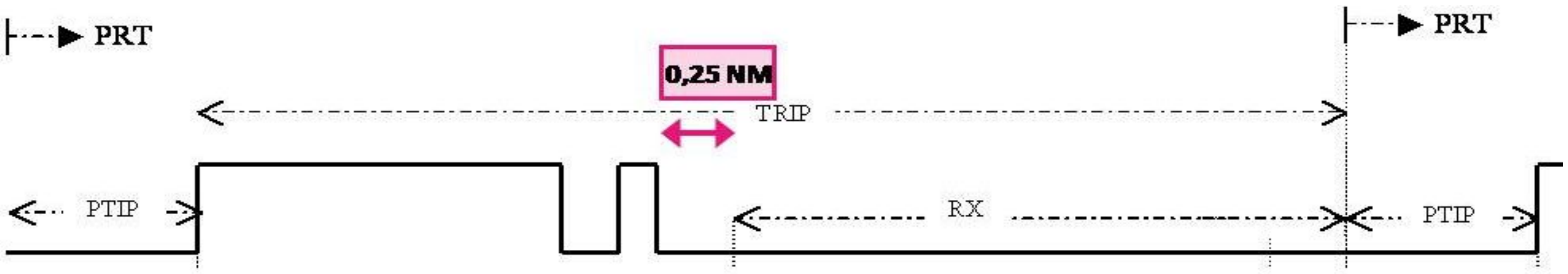
- Resolution will be:

Resolution= range+range/2= 102,73+(102,73/2)= 154,1 m

Maximum and Minimum Range Determination

Short Pulse Transmission

- **SHORT PULSE TRANSMISSION**:
    - By means of pulse compression, resolution can be improved. However, system minimum range can not. Minimum range would depend on pulse width (60 – 90 us).
    - Solution: transmitting a short pulse aprox. 1 us (nearby coverage).
    - This short pulse is a continuous waveform (non modulated).
    - Long pulse is used to further range (from the end of short pulse to the end of the coverage).

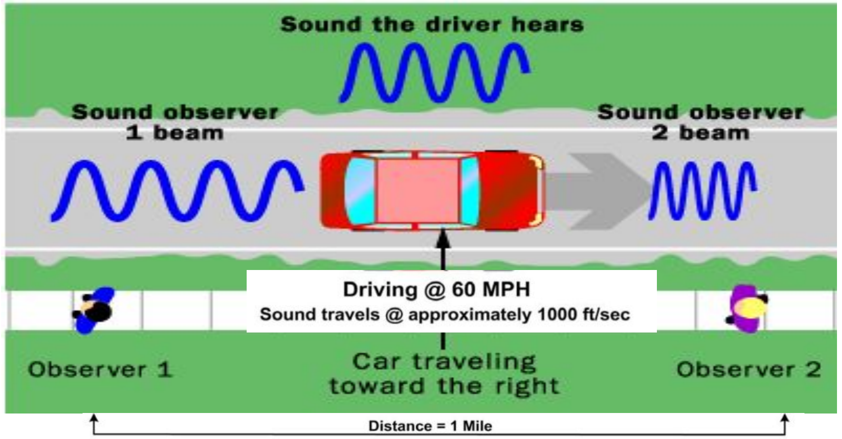


Doppler Concept
Introduction

- **Doppler Frequency:**
  - Changes in electromagnetic frequency that occurs when the source of the radiation and its observer move toward or away from each other.
  - Attending to the source radiation movement:
    - If the target is coming toward the observer, the frequency is higher.
    - If the target is moving away from the observer, the frequency is lower.
    - If the target is not moving, the frequency does not vary.
  - A clear example is the sound of a horn in a car, explained in the following slice.

Doppler Concept

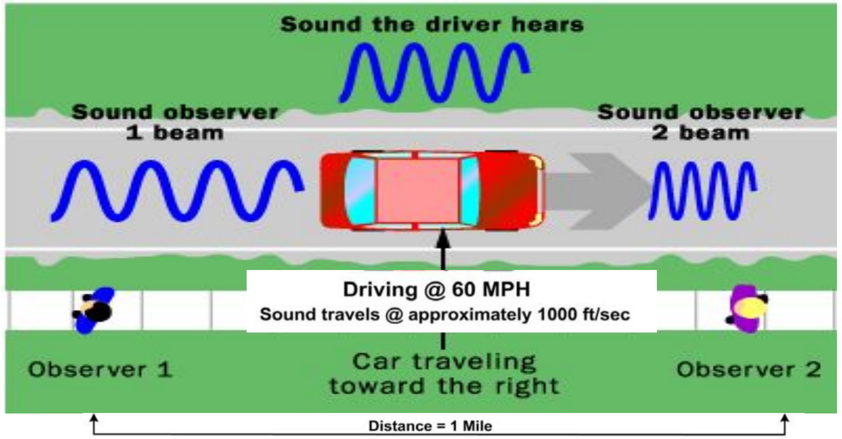
Introduction



- Sound is propagated at 1000 ft/s. (1 NM approx.. 6000 ft) □ 6 s/NM
- Driver starts to press the horn at **Observer-1** position and stops at **Observer-2**.
- The car spends 60 sec. in covering the distance from observer-1 to observer-2 (1 nm.).
- The sound spends 6 sec. in covering the distance between both observers (1 nm.).
- Observer-1 hears the horn since driver starts to press the horn till 6 seconds after driver stops pressing it (66 sec).

Doppler Concept

Introduction



- Observer-2 does not hear the horn sound till 6 seconds after the driver started to press it, however as far as driver stops pressing the horn, the observer stops to hear it (54 sec.).
- The driver hears the horn sound during exactly 60 sec.
- Horn frequency = 10 KHz → Transmission 10,000 cycles x 60 sec. = 6 x 105 cycles.

Driver = 6 x 10^5 cycles / 60 sec. = 10 KHz

Observer-1 = 6 x 10^5 cycles / 66 sec. = 9 KHz

Observer-2 = 6 x 10^5 cycles / 54 sec. = 11 KHz

- The signal is the same for both cases. The difference performs in frequency, the later the lower the frequency, the earlier the higher the frequency.

Doppler Concept

Radar Application

- Considering the relative movement of a target with respect a radar, the frequency from the echo varies as follows:
  - Higher frequency if target is coming toward the radar.
  - Same frequency if the range does not vary (circling the radar).
  - Lower frequency in case target is moving away from the radar.

- The change in frequency is measurable as Doppler shift and can be used to determine the radial velocity of the target.

- The PSR does not measure radial velocity of a target to calculate the targets speed. It uses Doppler shift to determine if there has been a change from pulse to pulse in a given range cell (stationary or moving target).

$$f_{Doppler} = 2 * V_{Target} * \cos\theta * \frac{f_{Transmitted}}{c}$$

Doppler Concept
Radar Application

- Calculation of Doppler shift:
  - Wavelength: **λ = C / Frequency**

    $\lambda = (3 \times 10^8 \text{ m/s}) / (2.7 \times 10^9 \text{ Hz})$
    $\lambda = 0.11$ m

    $\lambda = (3 \times 10^8 \text{ m/s}) / (2.9 \times 10^9 \text{ Hz})$
    $\lambda = 0.10$ m

  - Frequency of Doppler: **F*d*= (2 x Velocity of Target) / λ**

100knots	= (2 x 51.4 m/s) / 0.11 = 934 Hz	= (2 x 51.4 m/s) / 0.10 = 1028 Hz
300knots	= (2 x 154.3 m/s) / 0.11 = 2805 Hz	= (2 x 154.3 m/s) / 0.10 = 3086 Hz
500knots	= (2 x 257.2 m/s) / 0.11 = 4676 Hz	= (2 x 257.2 m/s) / 0.10 = 5144 Hz

Doppler Concept

Radar Application

- It is impossible to determine a Doppler change from one pulse echo returned from a target.

- A series of identical pulse returns must be analyzed over time to determine the Doppler phase change. This grouping of pulses is known as a **Coherent Processing Interval (CPI)**. The Indra PSR uses 2 different CPI: 8 pulse CPI and 6 pulse CPI.

- When coherent pulses are compared over a complete CPI, the magnitudes of the received signals will trace out the Doppler shift of the target.

- Moving targets will have different magnitudes because phase/amplitude of the received echo is changing.

- A stationary target will produce an echo in the same phase (and amplitude) over a series of pulses. The peaks are all the same amplitude, this “traces” a Doppler frequency of Zero for fixed targets.

MTD-IV Processing

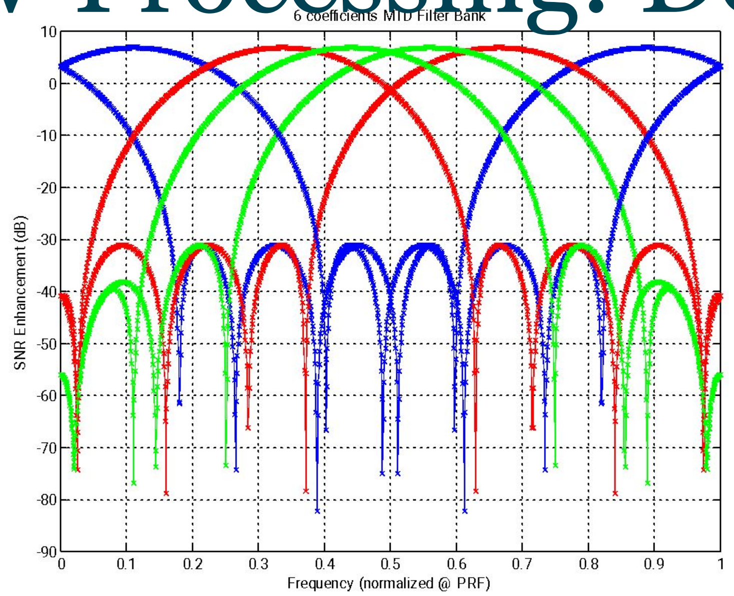
Doppler Speed

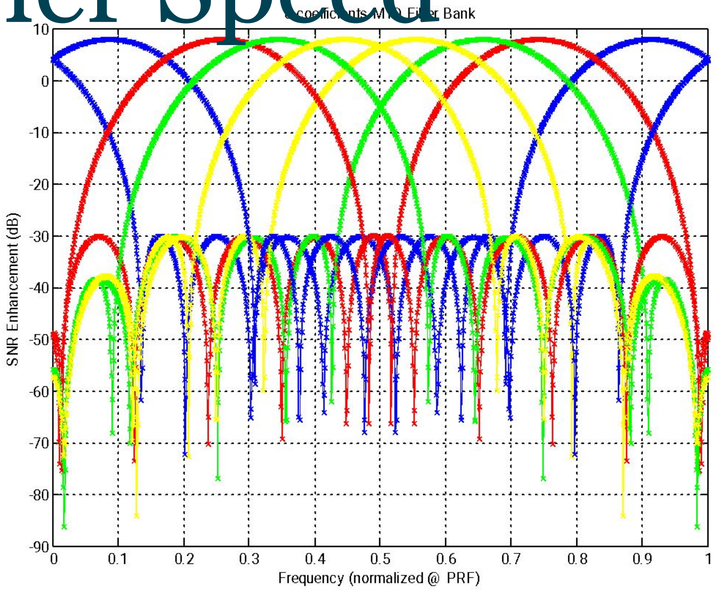
- Doppler processing:
  - MTD Filter bank.
  - High resolution for targets flying from 20 to 800 knots.

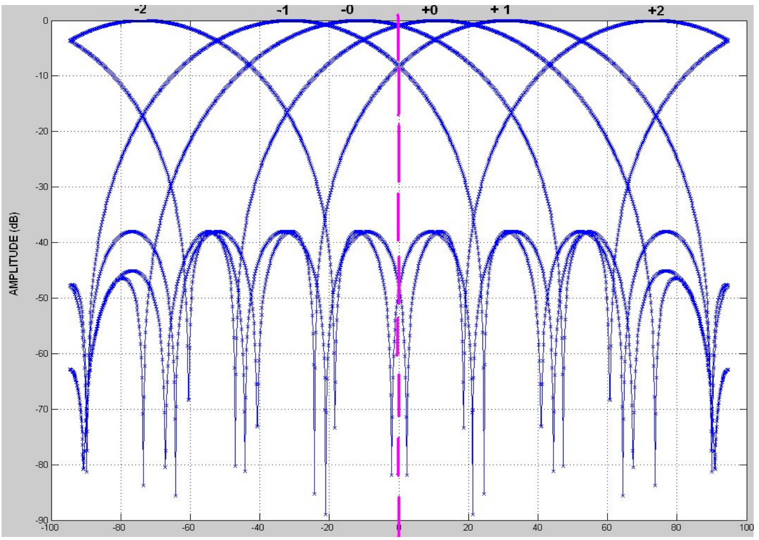
- MTD bank filter is made up of **8 and 6 FIR filters** (notice that 8 implies high PRF and 6 low PRF allows identical filters: improving resolution).

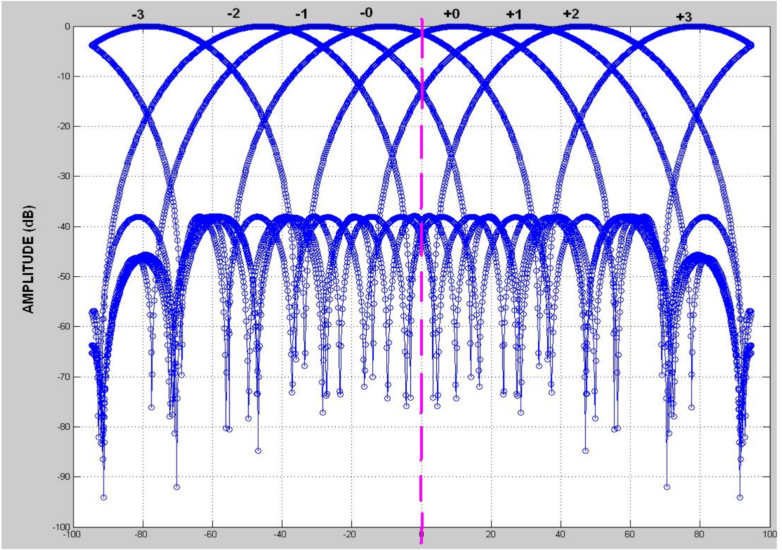
- Filtering characteristics:
  - One filter per pulse → Improves Doppler resolution. High reliability for bimodal clutter resolution.
  - Zero velocity filter (ZVF) → Tangential target detection/clutter synchronous map updating.
- The 8/6 bursts of every CPI are divided and processed by the 8/6 MTD Filters, obtaining 8/6 outputs based each on the 8/6 pulses.

MTD-IV Processing: Doppler Speed









MTD-IV Processing: Doppler Speed

PRF Concept

- The Pulse Repetition Frequency (PRF) is the number of transmitted pulses per second.
- Inverse parameter: PRI (Pulse Repetition Interval) or PRT (Pulse Repetition Time) is the time elapses between the beginning of one pulse and the next.
- The PRF establishes the maximum range and maximum non-ambiguous Doppler velocity.

$$R_{\max(unambiguous)} = \frac{c * PRT}{2} = \frac{c}{2PRF}$$

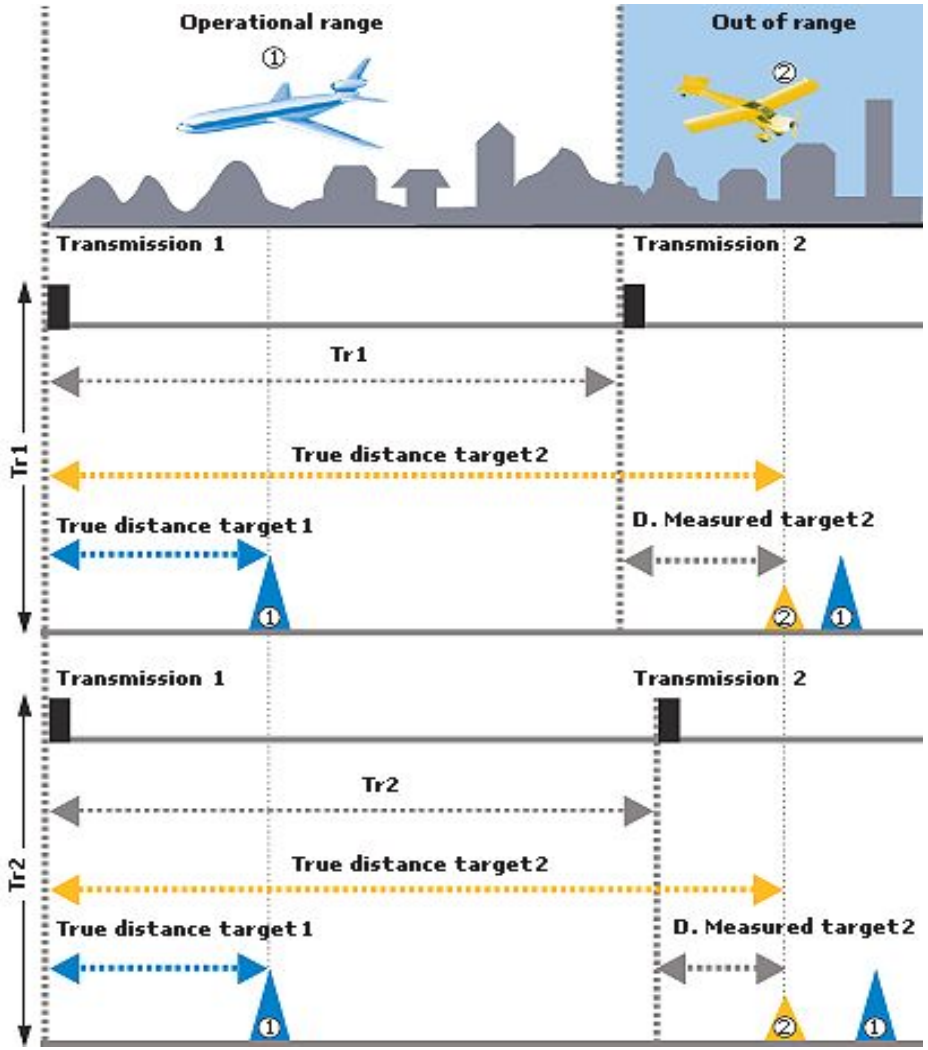
$$v_b = f_r \frac{\lambda}{2} = \frac{\lambda}{2t_r}$$

MTD-IV Processing

PRT Concept

- The PRT of the radar becomes important in maximum range determination because target return times that exceed the PRT of the radar system appear at incorrect locations (ranges) on the radar screen.

- Returns that appear at these incorrect ranges are referred to as AMBIGUOUS RETURNS or SECOND TIME AROUND ECHOES.



Blind Speeds

PROBLEM:

- If a target has a Doppler frequency which is a PRF exact multiple, consecutive echoes will appear at the same Doppler signal point □ eliminated because of being zero Doppler.

SOLUTION:

- Frequency diversity.
- PRF variation each CPI
  - □ Stagger 1.22 (60nmi) and 1.27 (80nmi). For both configuration the first blind speed is 800 knots.
  - □ PSR allows different PRFs pairs combination.

□ □ $v_b = f_r \frac{\lambda}{2} = \frac{\lambda}{2 t_r}$ Km

Ex. PRFb = 800 Hz □ PRFa = 1040Hz

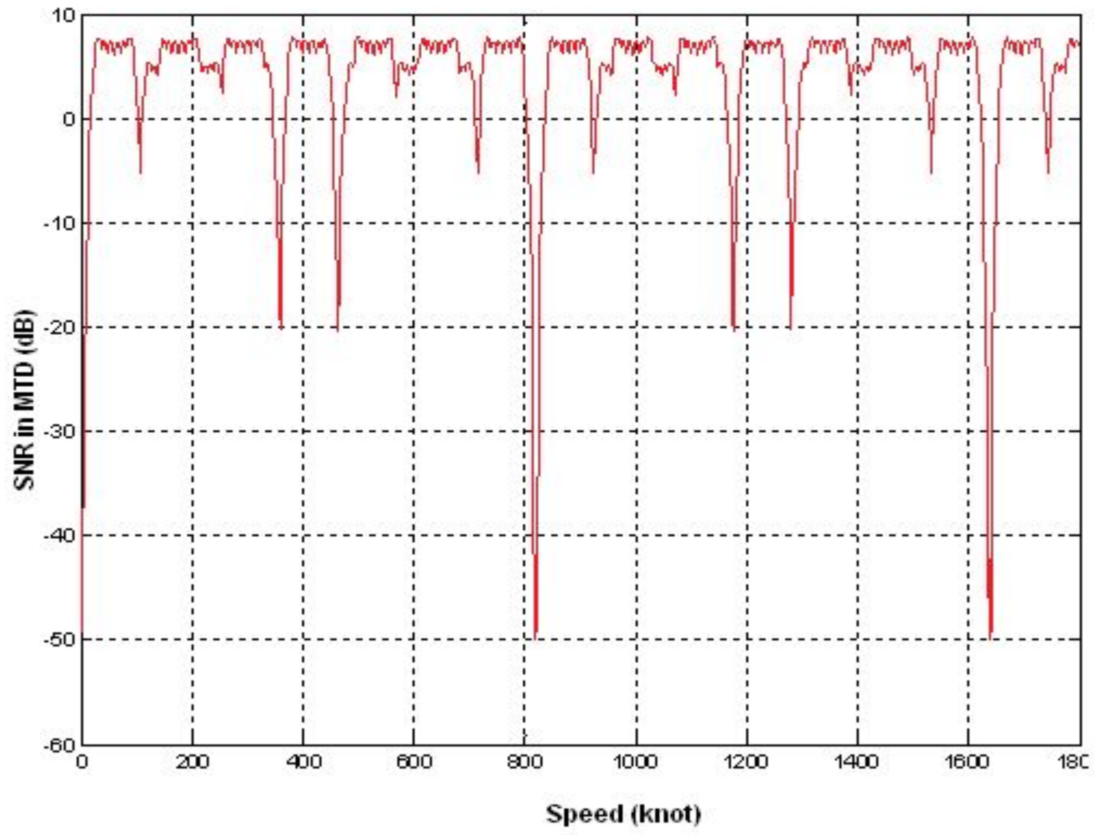
Vb=(0,29(800Hz))/2,7Ghz = 85,9 knots

Vb=(0,29(1040Hz))/2,7Ghz = 111,7 knots

$$V_b = \frac{0.29\, PRF(Hz)}{f(GHz)}$$

Blind Speeds

- MTD filters determines first blind speed.



Frequency Diversity

- This method is used in order to improve the probability of detection, caused by fluctuations in the amplitude of the received signal.
  - Consist of assigning different frequencies for each pulse (long and short), f1 and f2.

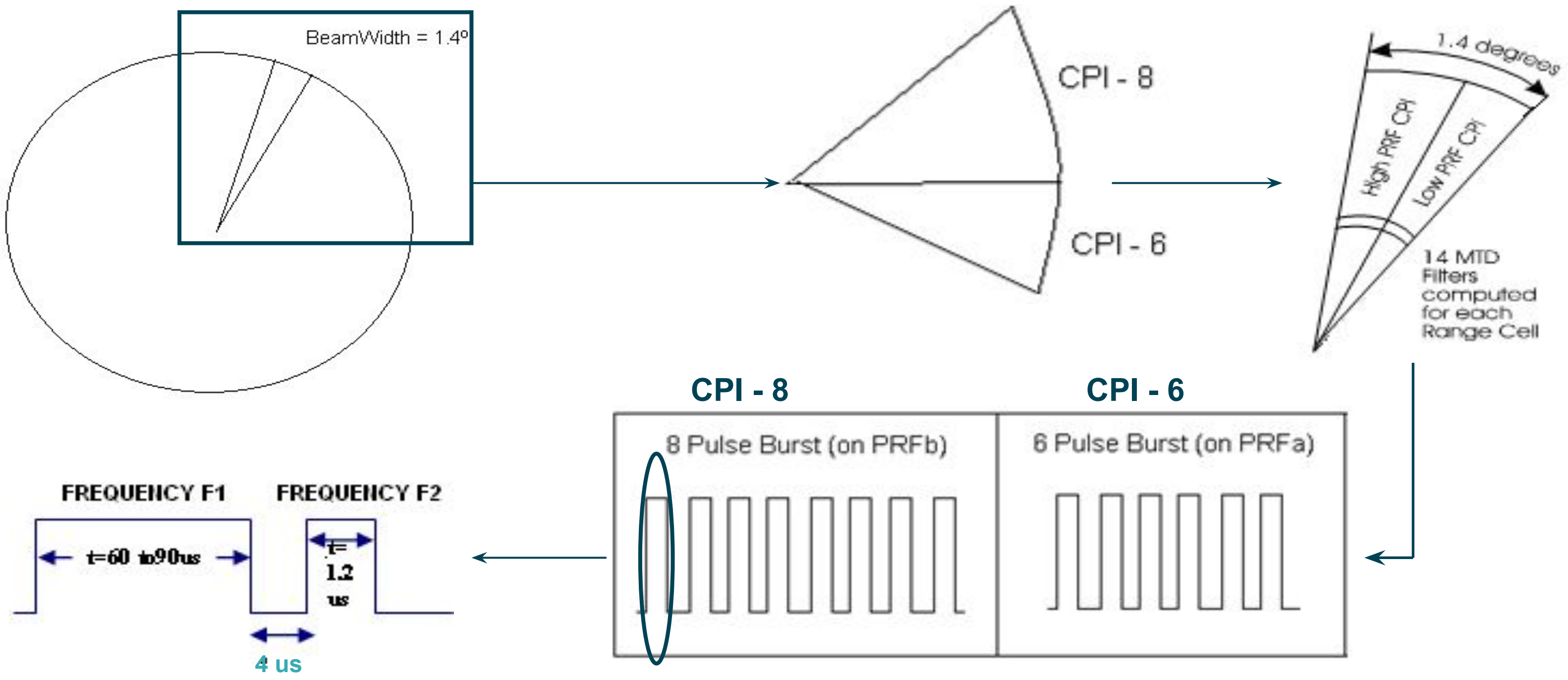
$$\left| f_1 - f_2 \right| = 75.7\ MHz$$

- Short pulse (SP) and long pulse (LP) uses different frequencies.
  - Both are processed independently.
  - Possible interference between pulses will be eliminated.

Transmission Concepts

CPIs + PRF + Frequency Diversity

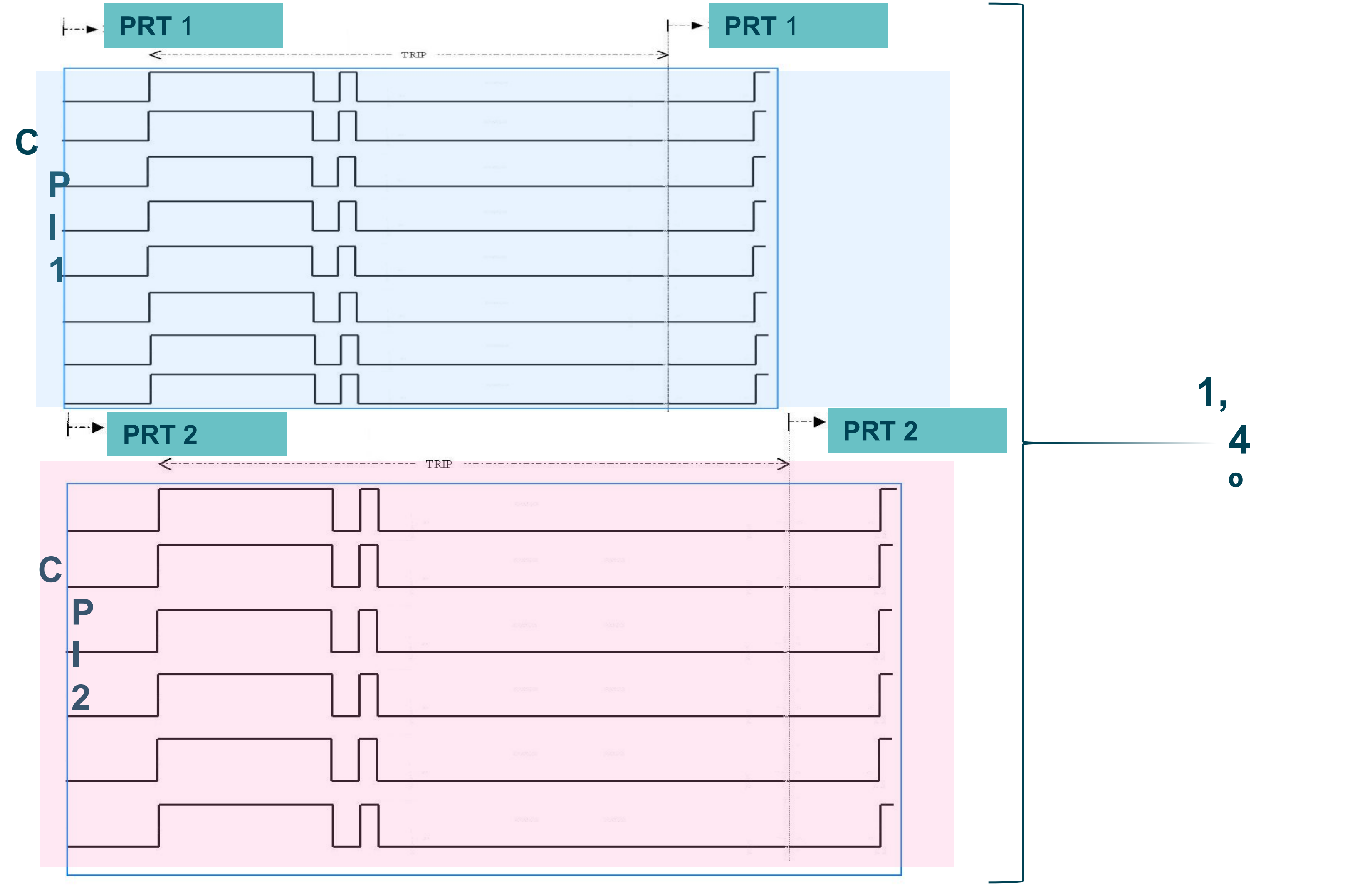
- Azimuth sectored: synchronous clutter maps improves superclutter visibility.



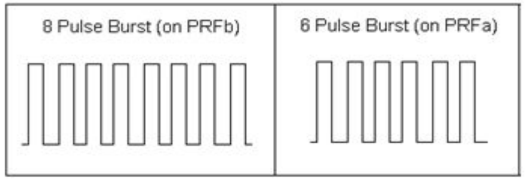
- Signal transmitted in 2 CPIs per beamwidth (1,4º) or 64 ACPs.
- 2 CPIs with different PRFs.
- Subsequent frequencies F1 and F2 (separated 75.7 MHz) for LP and SP.

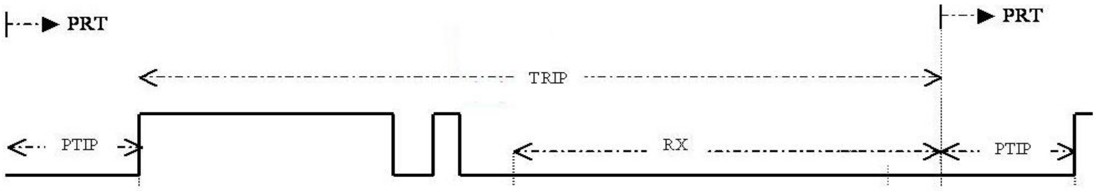
Transmission Concepts

CPIs + PRF + Frequency Diversity



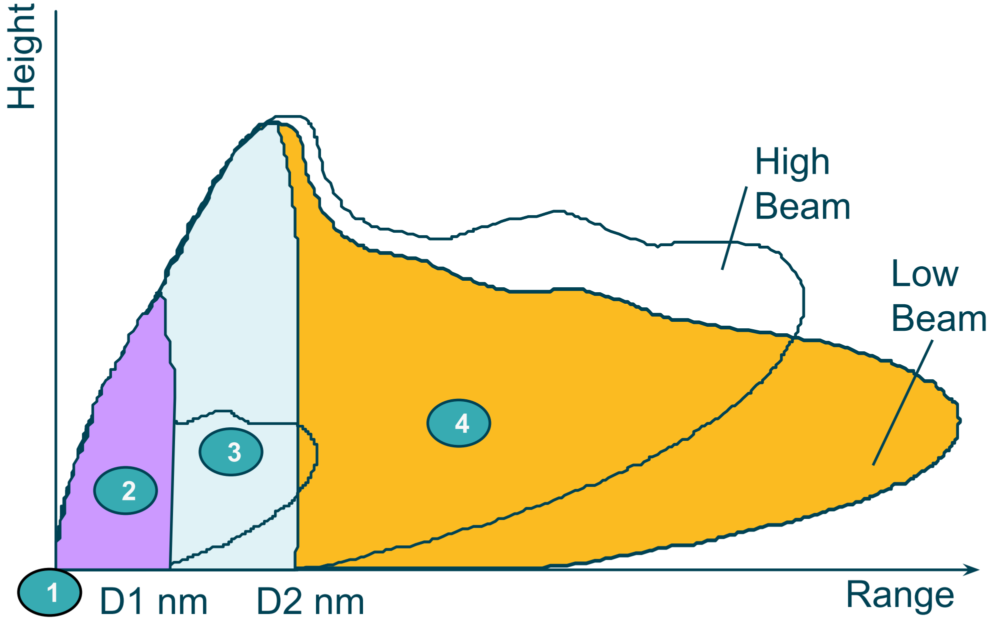
Transmission Concepts
CPIs + PRF + Frequency Diversity





- TRANSMITTED SIGNAL:
  - PTIP time elapses in synchronism generation.
  - TRIP time elapses in tx/rx.
  - Short pulse introduction Improves minimum range.
- PRFa < PRFb Eliminate second around echoes.
- Synchronous maps.
- MTD Processing.
- Polarization selection:
  - CIRCULAR (improves visibility in case of heavy rain clutter, for ex.).
  - LINEAR.

State Diagram



1 Long/Short Pulse transmission
2 Short Pulse , High Beam reception
3 Long Pulse, High Beam reception
4 Long Pulse, Low Beam reception

- STANDARD DIAGRAM:
  - According to range: Short or long pulse echo → maximum range or minimum instrumented range.
  - D1-D2: depends on long pulse length (configurable between 60 – 90us).
  - This is an example of a typical configuration, however it will be configured by sectors. According to each site (two states per pulse can be configured).
- Advantage, switching processing is performed by software, therefore any mechanical switch is used in order to select channels (seamless switching).

Stability

- STABILITY COHERENT RADAR
  - Outstanding measurement in radars which uses Doppler (instabilities can produce Doppler errors).
  - The transmitted signal is digitally generated by means of DDS (Direct Digital Synthesis) techniques.
  - Stable transmitter.
    - Is able to amplify the transmitted signal without affecting to stability. Three different points to check stability in CMS.
  - Very stable crystals (coherent oscillators) are used to generate the final frequencies for transmitted signals and also, the clocks (STALO y COHO).

Design Features

- Evolution
- Main Features
- Characteristic Summary

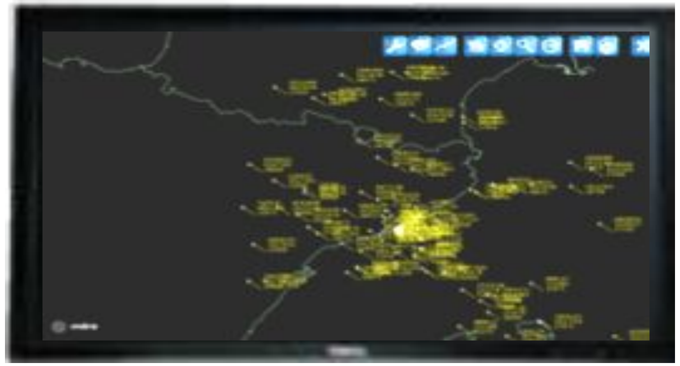
3

Evolution

- Collects features about Indra 3D radar (Lanza).
- Designed following the EUROCONTROL and ICAO Specifications.
- Includes additional redundancy levels (multiple combinations allowed). Reliability, availability and maintainability.
- High capacity to adapt the system on environment.
  - Friendly user interface and adaptation tools (graphical optimization).
  - Powerful integrated BITE.
- Full solid state transmitter.
  - Graceful degradation and hot repair.
- Dual beam antenna.
  - Seamless switching.

Main Features

- TAR and TMA applications.
- ASR system provides improvement levels of safety, integrity, maintainability and reliability to enhance the quality of service and overall safety of operation.
- Full solid-state technology.



- Operation as Stand-alone or co-mounted with a SSR radar.
- Westinghouse and Northrop Grumman heritage plus Indra military 3D PSR “Lanza” knowledge.

Characteristic Summary

System Performance

Frequency	2,7 to 2,9 GHz
Frequency diversity/agility	2 frequencies (LP/SP) 75,8 MHz freq diversity. Possible exchange of frequencies for subsequent CPIs or scans.
Peak Power	20 kW min for 10 PA configuration 25 kW min for 12 PA configuration
RF Blanking	Sectored in azimuth
Pulse width	Short Pulse: 1,2 us Long Pulse: 60 to 90 us
PRF	735 to 1300 Hz (configured in exploration modes map)
Sub-clutter Visibility	> 42 dB (distributed clutter)
Detection Range	60 NM , 80 NM or 100 NM
Stability	> 60 dB

Characteristic Summary

System Performance

Resolution	Range: 155 m (80%) LP 230 m (80%) SP Azimuth: 2,8º rms
Accuracy	Range: 50 m rms, typ 38 m Azimuth: 0,15º rms, typ 0,12º
MTBCF	> 45.000 hours
Availability	> 99,999%
MTTR	< 20 min.
Useful life cycle	15 years
Remote Control and Monitoring	Graphical Friendly-User Integrated PSR-MSSR Interface

Characteristic Summary

Antenna Performance

Beams	Low beam for transmission High and Low beams for reception
Gain	> 34 dB (Low beam) > 32,5 dB (High beam)
Azimuth Beamwidth	1,45º ± 0,05º
Elevation Beamwidth	> 4,6º (Low Beam) > 4,8º (High Beam) Cosecant squared to + 40º
Rotation speed	12/15 rpm
Polarization	Linear (vertical) Circular (right-handed)

Characteristic Summary

Receiver and Processor Performance

Noise Figure	< 2,35 dB
Sensitivity	- 108 dBm (Short Pulse) - 126 dBm (Long Pulse)
Dynamic Range	84 dB, before pulse compression
STC	2 RF and 1 digital
Processing Type	MTD-IV Doppler filter bank 6/8 (low/high PRF)
False Alarm Control	CFAR in each filter, Clutter Synchronous Map, Clear Day Map, Geo-censor Map, Threshold Adaptive Map, Interference/Suppression detect, MTAT, MTAC,AP detection
Weather Processing	US-NWS 6 levels detection Doppler filters for Ground clutter suppression
Processing Capacity	1500 plots/scan 1000 Tracks/scan
False Alarms	10 each scan (at the tracker output in normal clutter conditions)
ADC	14 bits @ 93.2144 MHz

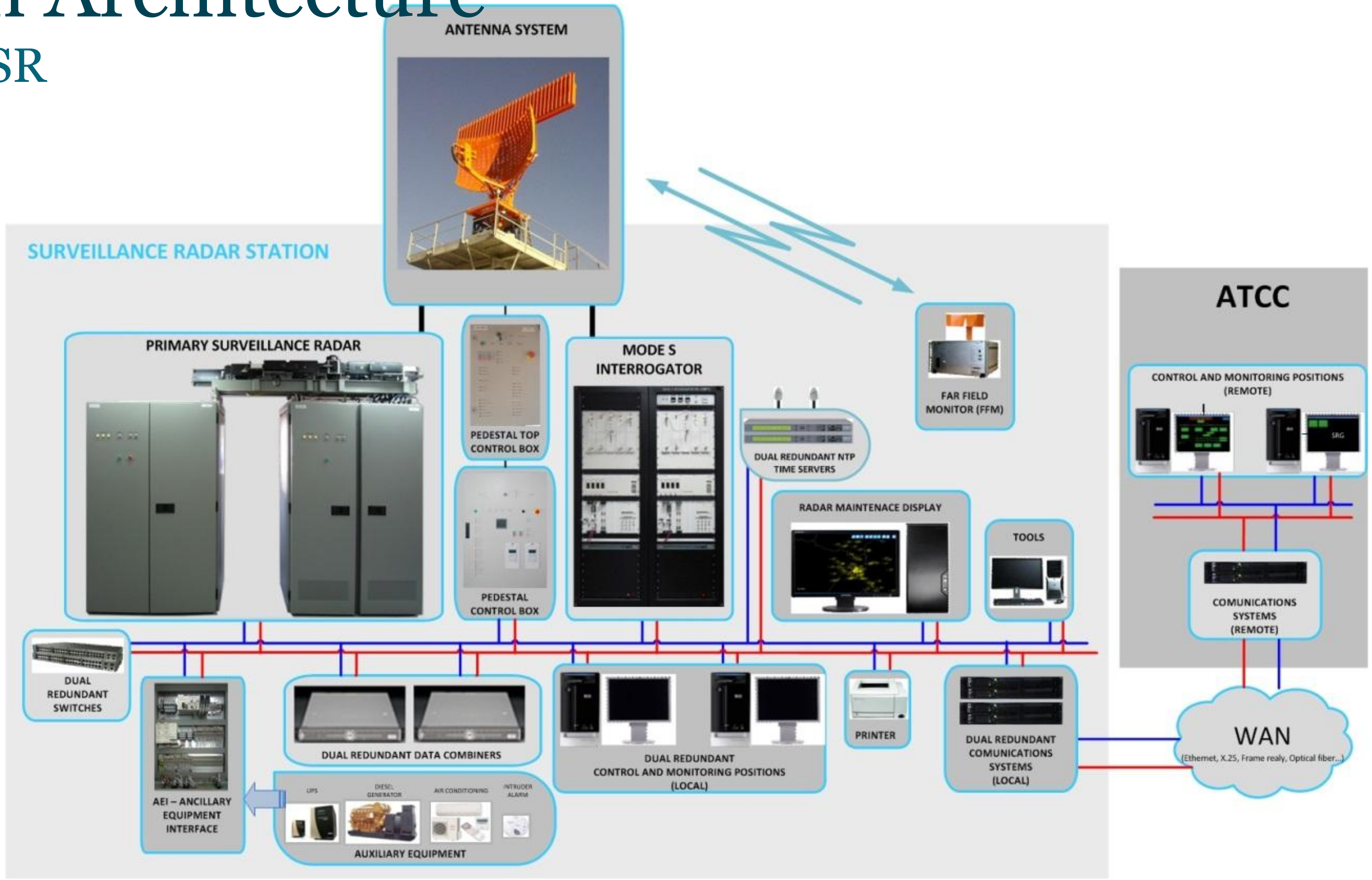
General Description

- System Architecture
- System Elements
- Functional Description
- Operation and Monitoring

4

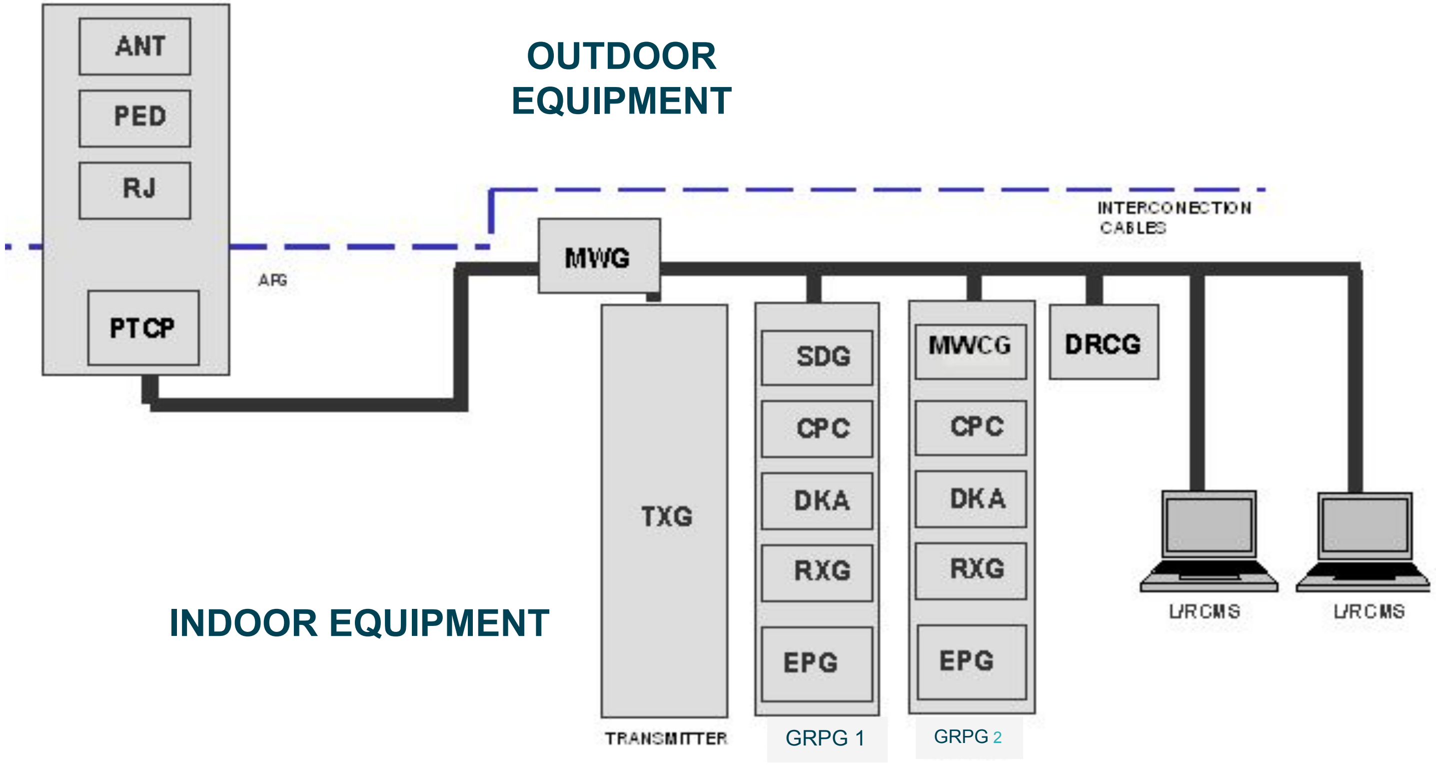
System Architecture

PSR + MSSR

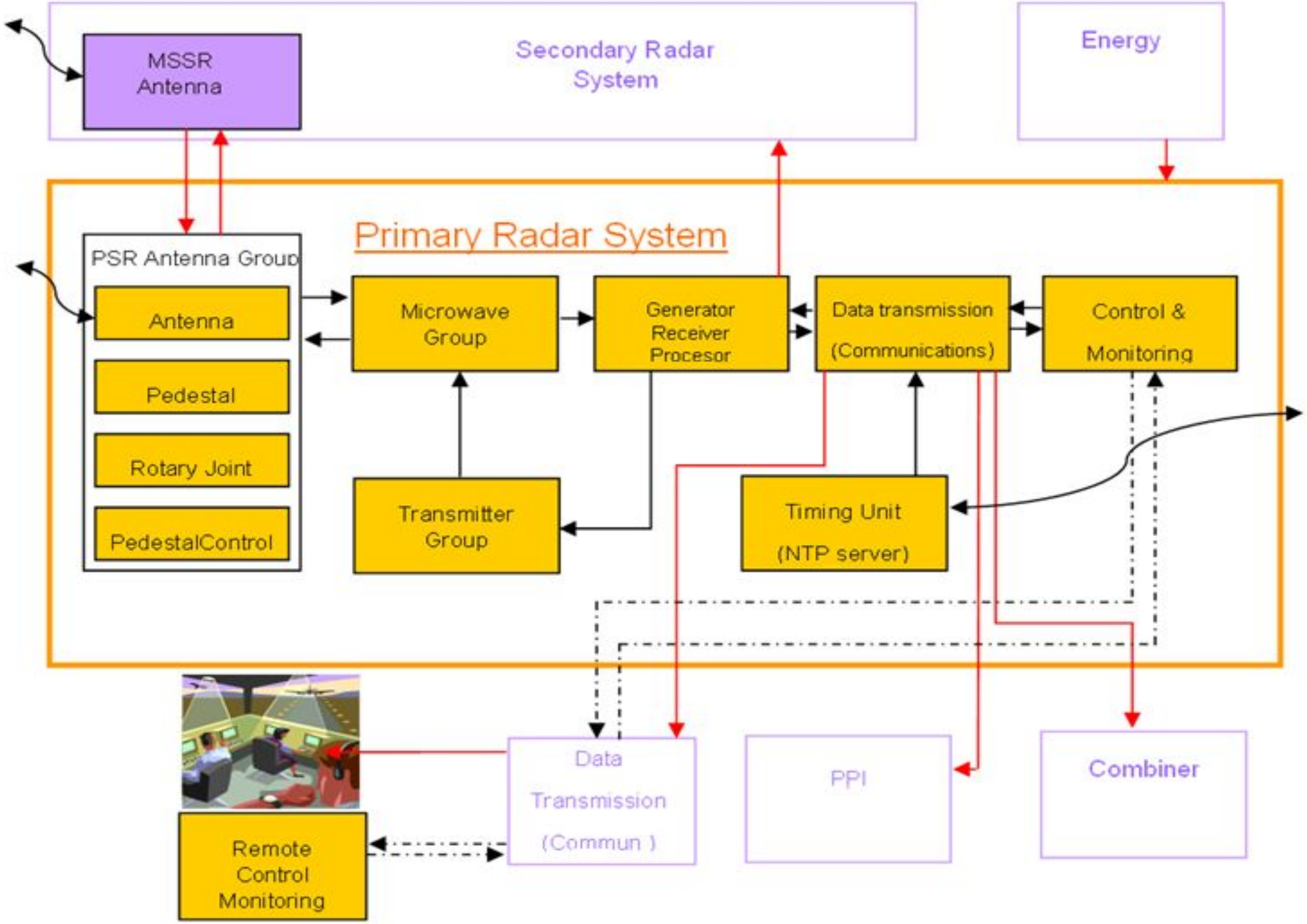


System Architecture

Block Diagram

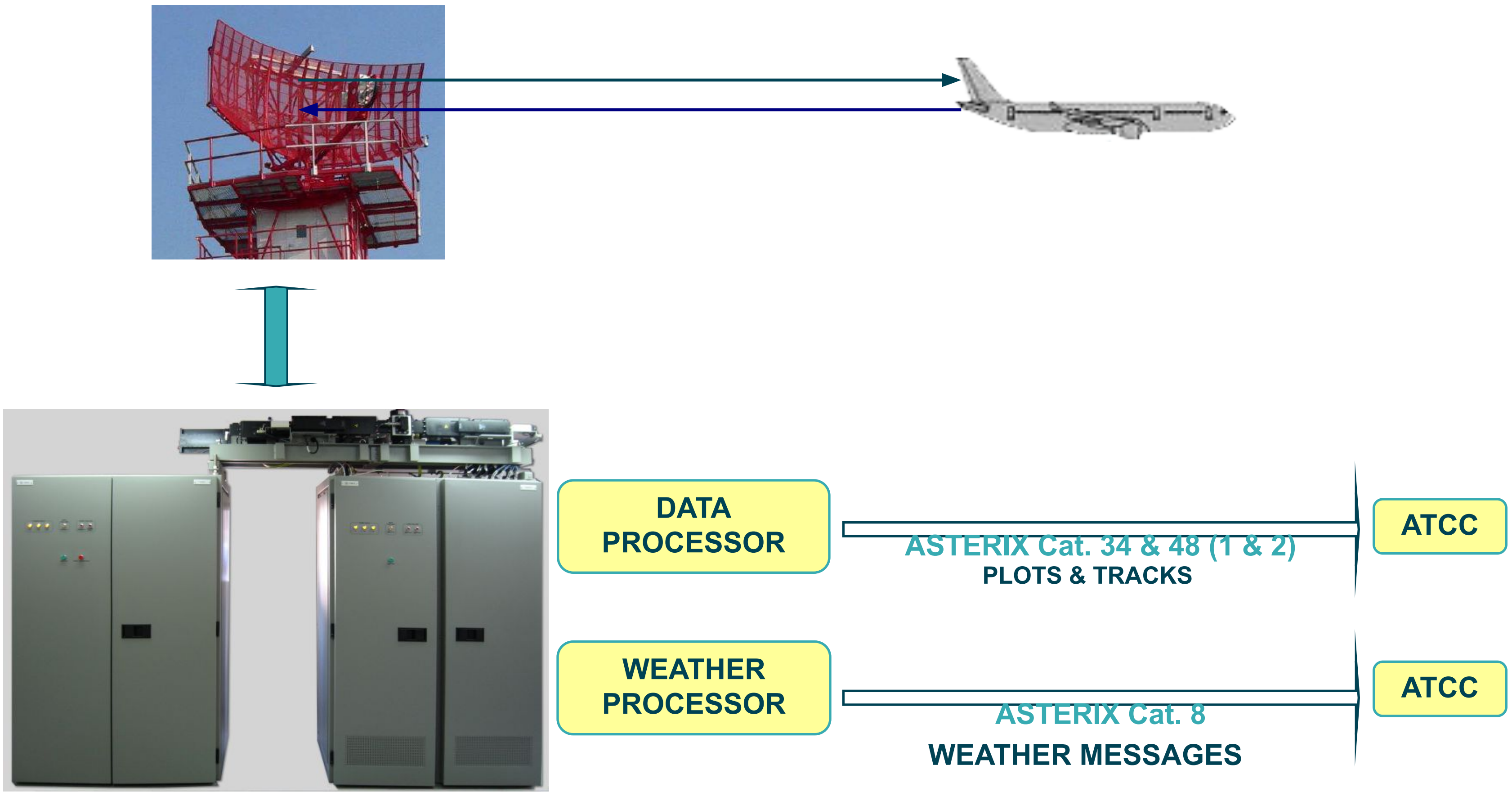


System Architecture: Interfaces

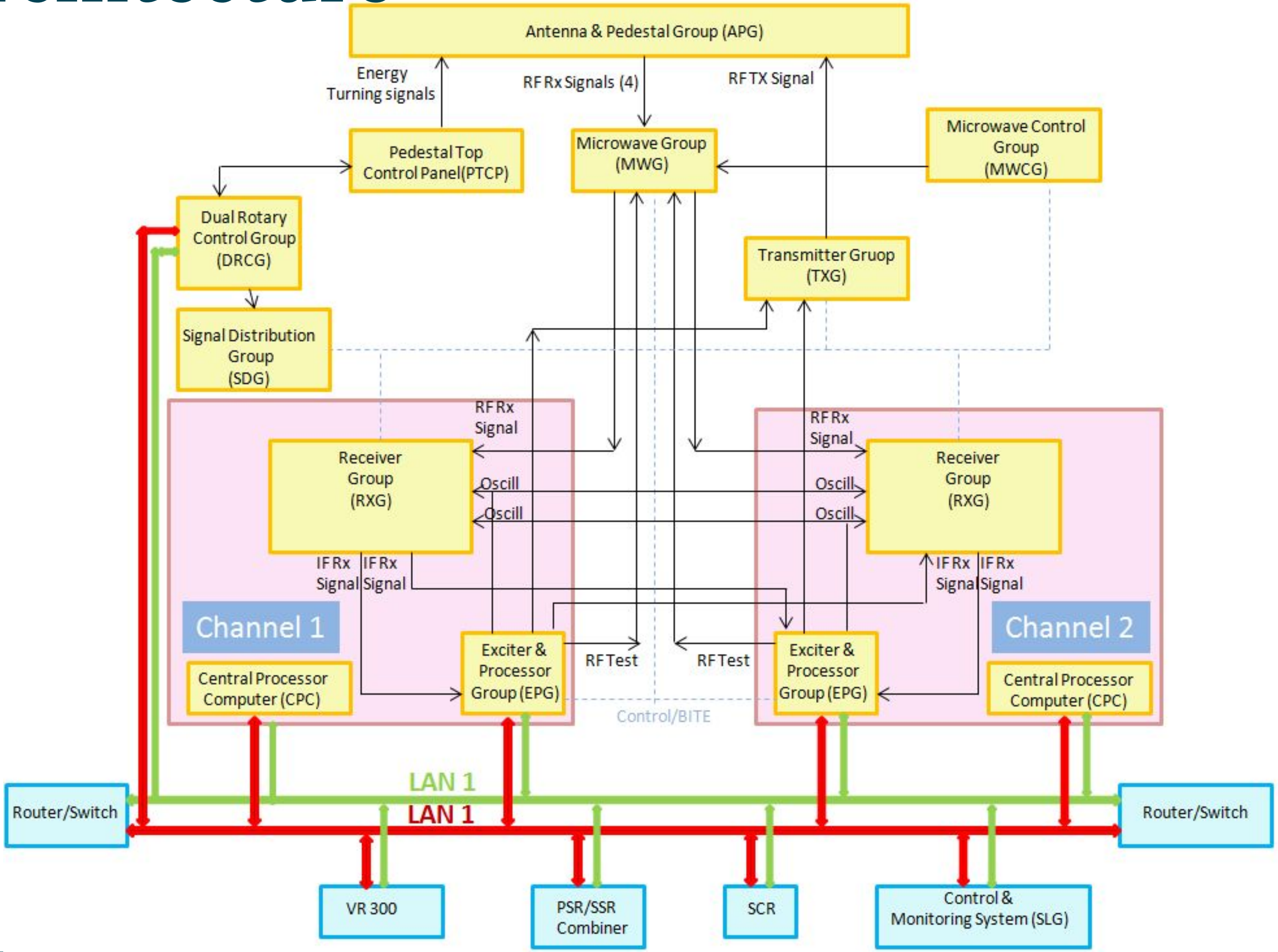


System Architecture

External Interfaces



System Architecture
Interfaces



System Architecture

Antenna and Pedestal Group (APG)

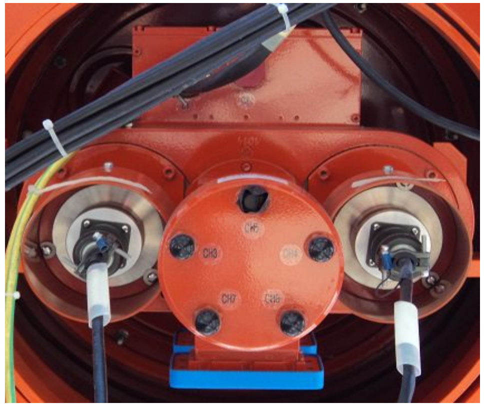
APG

System Architecture

Antenna and Pedestal Group (APG)

ANTENNA

ROTARY JOINT



PEDESTAL

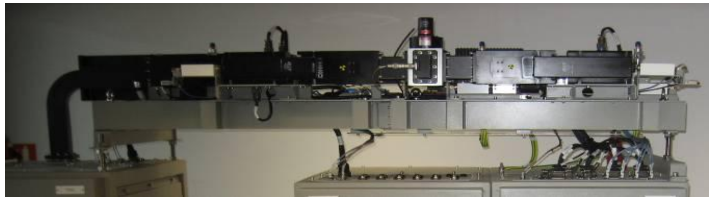
System Architecture

Dual Rotary Control Group (DRCG)

System Architecture

Transmitter, GRPG and MWG

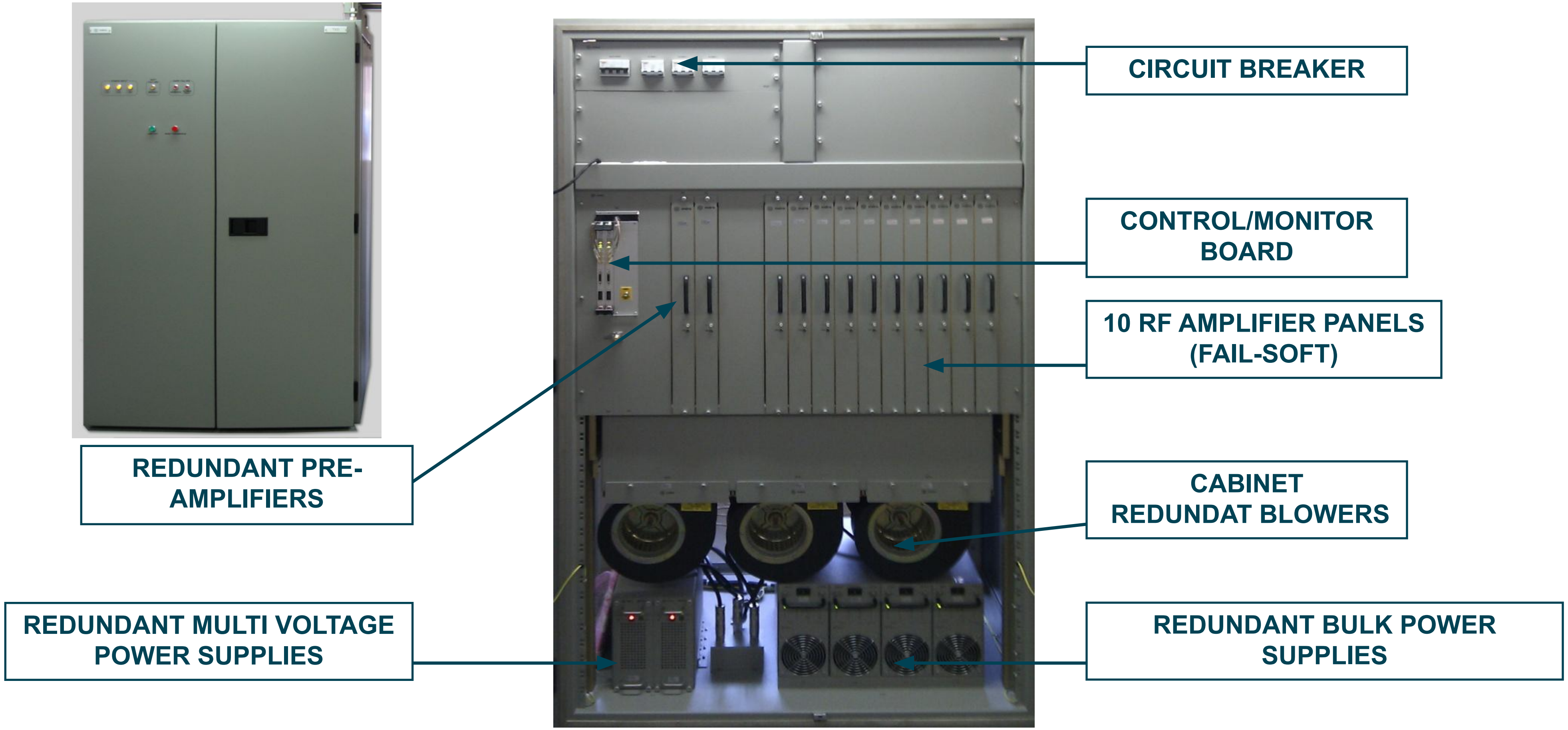
MICROWAVE GROUP



TRANSMITTER

GRPG

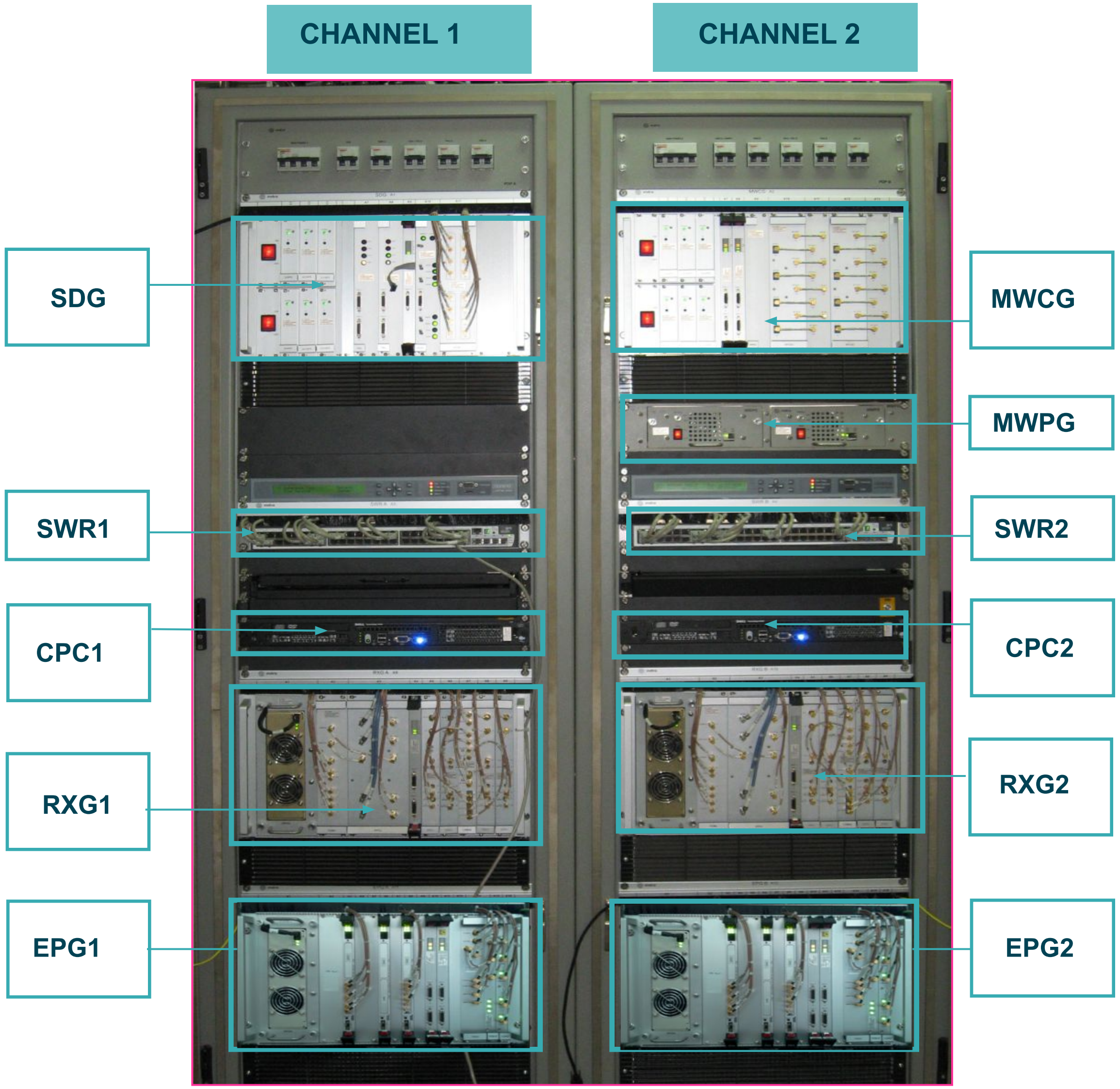
System Architecture
Transmitter



System Architecture

Dual Receiver Cabinet (GRPG)

SDG:	Signal Distribution Group.
MWCG:	Microwave Control Group.
CPC:	Central Processor Computer.
RXG:	Receiver Group.
EPG:	Exciter and Processor Group.
SWR:	Switch Router.
TTSU:	Temperature Sensor Unit.
MWPG:	MWG Polarizer and Input RF Switches Power Supply Group.



System Architecture

Microwave Group (MWG) and Compressor Dehydrator

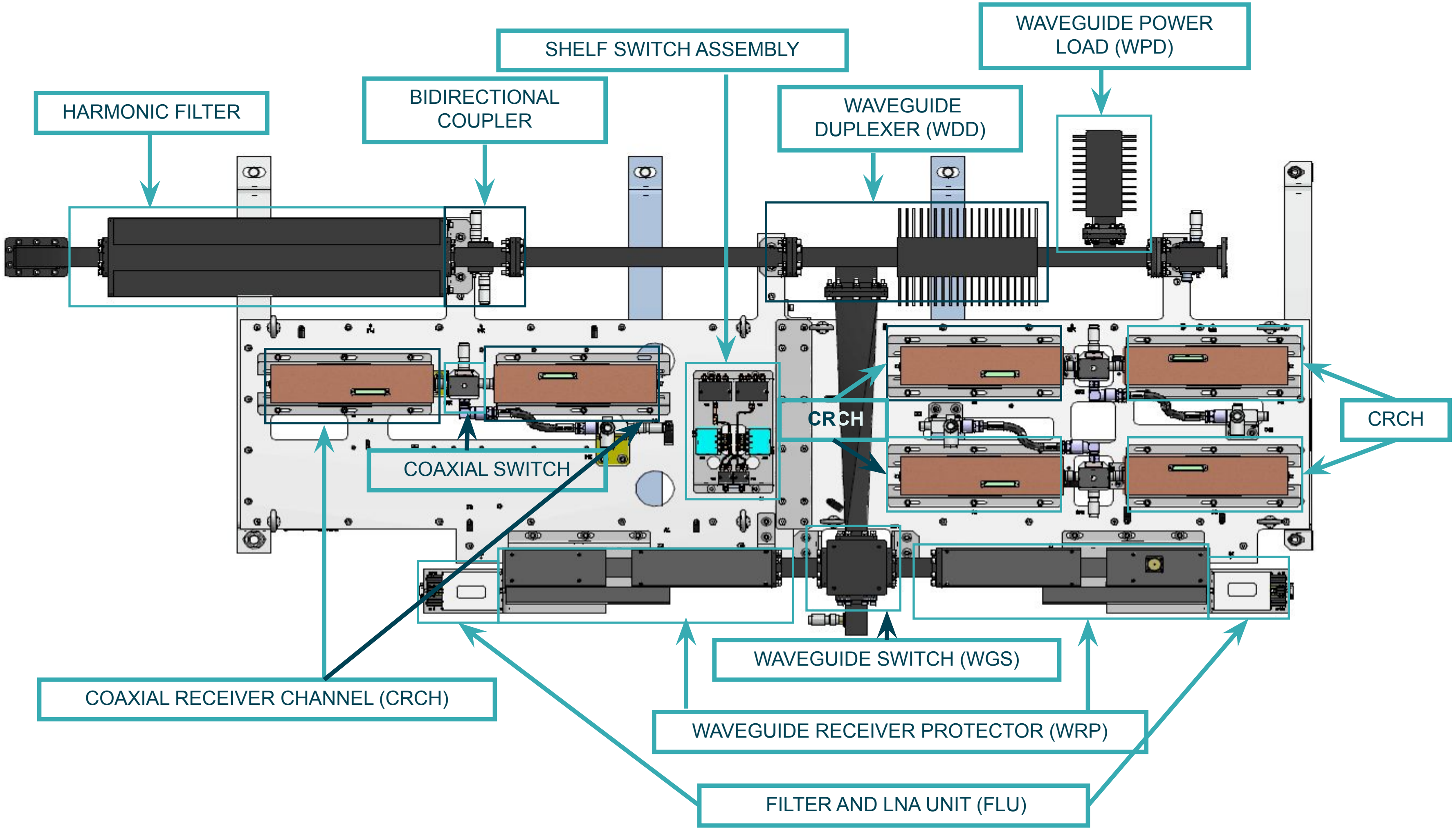
MWG

Compressor

Dehydrator

System Architecture

Channel Distribution for Microwave Group (MWG)



Functional Description

Antenna and Pedestal Group (APG)

- APG assembly performs RF signal radiation and reception with a specific power, directivity and coverage.

  - Antenna S-band reflector (until 40º in elevation).
    Two feedhorns.
    Polarizer.

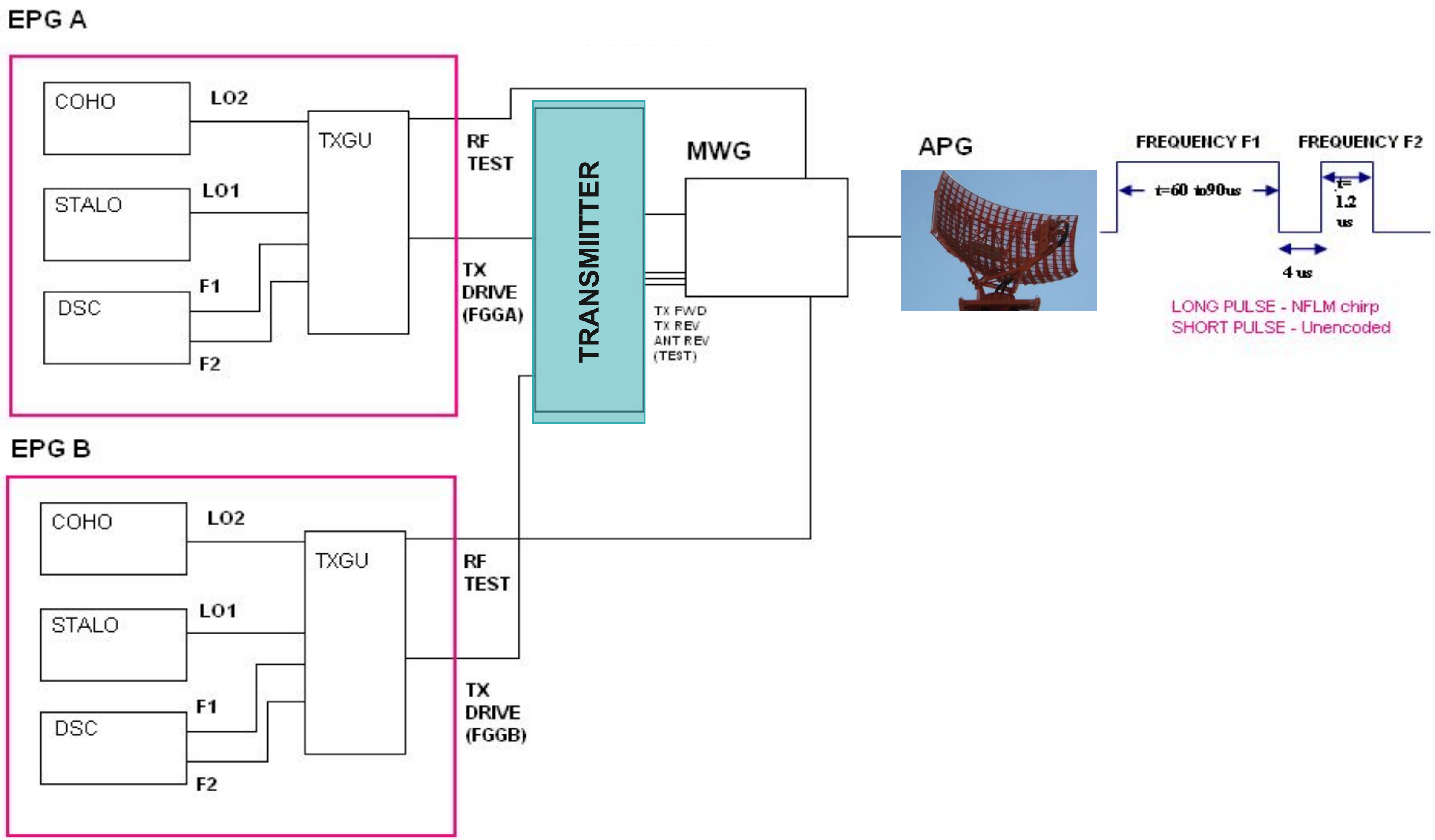
  - Pedestal Mechanical support and physical interface with antenna platform.
    Two motors which carry on the antenna turning.

  - Rotary Joint Two encoders.
    RF signal path between the antenna and the radar.
    Power supply and control signals pass though slip-rings (control and polarizer feed).

  - DRCG Control and monitoring of motors and all the elements of the APG.

Functional Description

Transmission Path Diagram



Functional Description

Transmission Path

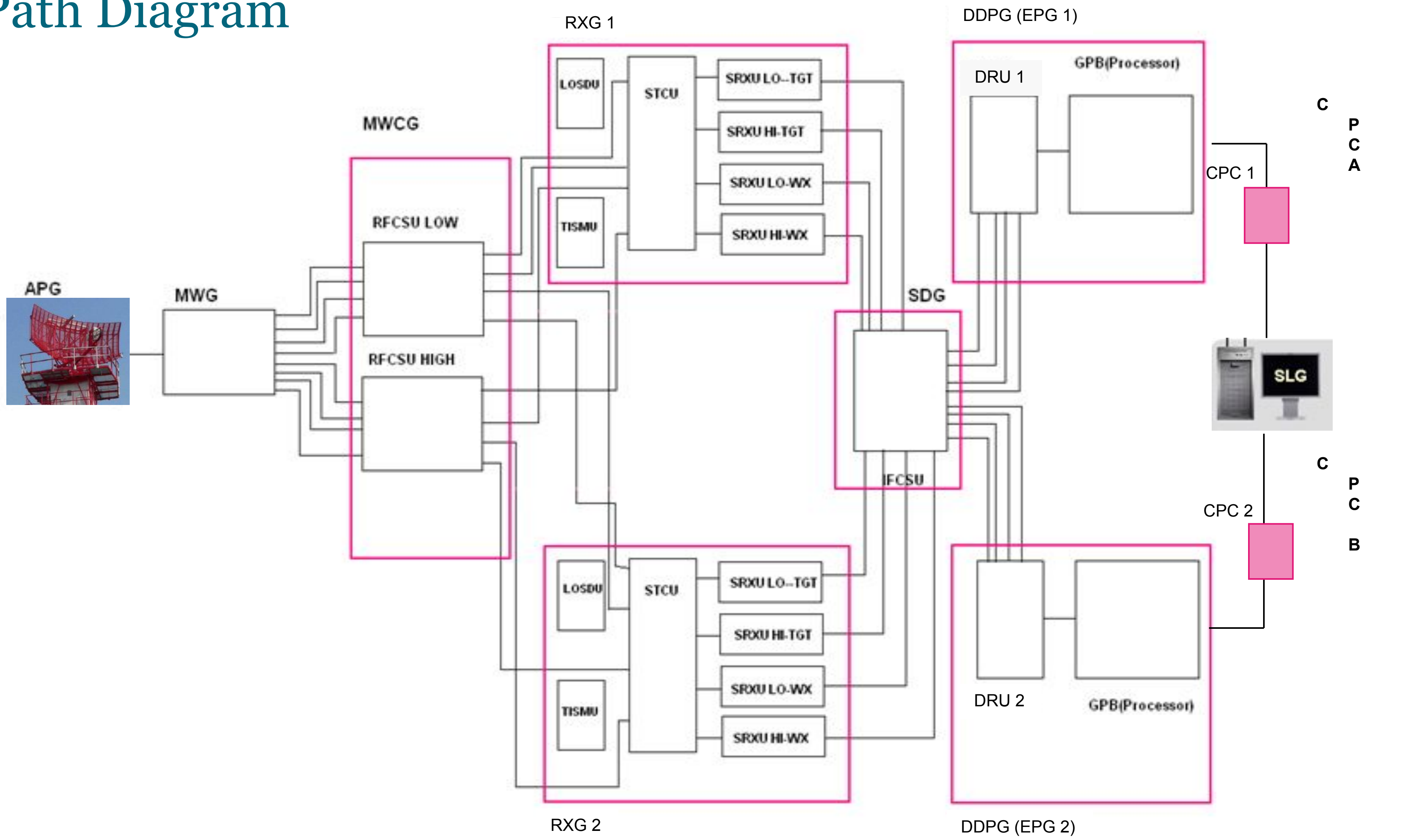
- EPG (Frequency Generation).
  - Oscillator signal generation (STALO y COHO).
  - Transmitted signal generation and up-conversion (TXGU).

- Solid state transmitter.
  - Peak Power: 22kW
  - Radiation of two pulses each transmission period.
  - Redundancy in order to provide high reliability and graceful degradation.
    - N+1 redundancy.
  - Signal samples in three different points stability checking.
  - BITE reports excess duty cycle, VSWR…
  - Control from SCP (EPG in the receiver) TXCU communication.

- MWG
  - Signal path from transmitter (**LOW-TGT**) to antenna.

Functional Description

Reception Path Diagram



Functional Description

Reception Path

- MWG (Microwave Group).
  - Receives echoes through antenna and route them toward the receiver (four independent paths).
    - HIGH-TGT.
    - LOW-TGT.
    - HIGH-WX.
    - LOW-WX.
- MWCG (Microwave Control Group).
  - Through two boards, RFCSU (High and Low) channel 1 or 2 for MWG or RXG are selected. Cross selection is possible.
  - The selection is controlled by MWCU.
- RXG (Receiver Group).
  - STCU, performs a certain attenuation level depending on the STC configuration map.
  - SRXU, carries out frequency filtering, down-conversion, amplification and output signal adjustment.
  - LOSDU, distributes LO1 and LO2 signals to SRXUs.

Functional Description

Reception Path

- EPG (DDPG: Digital Demodulator and Processor Group).
  - DRU, performs down-conversion to baseband and A/D conversion.
  - GPB, carries out signal and data processing.

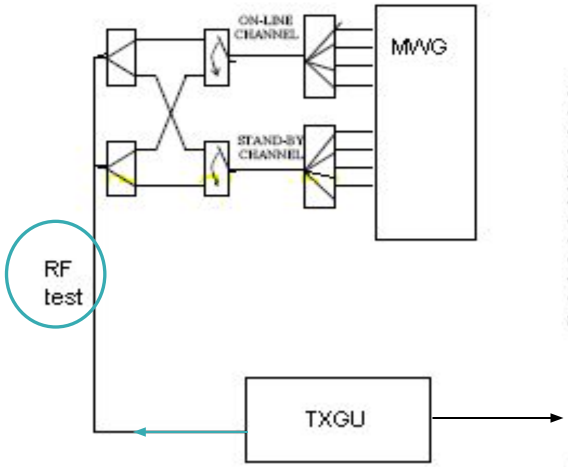
- EPG (SCBG: Synchronization, Control and BITE Group).
  - SYNU, system synchronism generation.
  - CBU, system control and BITE reception.

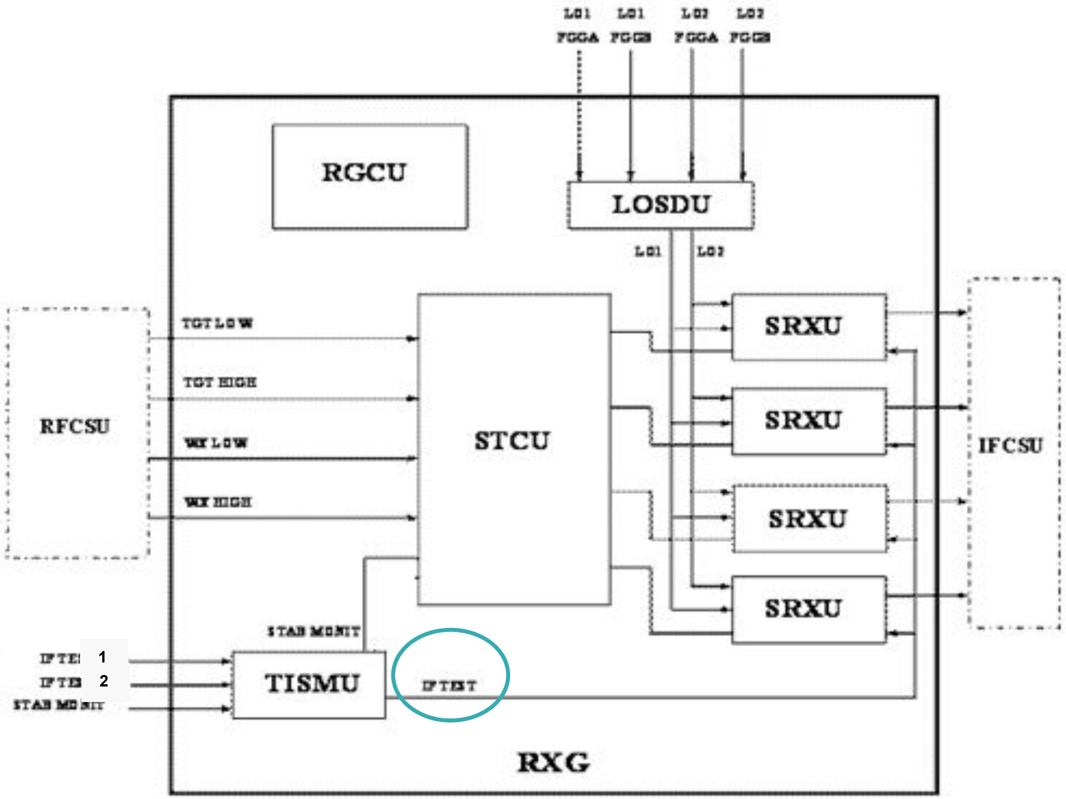
- SDG (Signal Distribution Group).
  - IFCSU, routes IF signals from SRXU to SCBG (base band demodulation and processing).
  - SDCU, collect SDG BITE signals. Redundancy control through CBU (Control and BITE Unit).
  - AGSU, selects operative groups if locally controlled.
  - TSU, conversion and distribution of ACP/ARP signals.

Functional Description

Test Signals

- RXG
  - IF test signal from TXGU □ TISMU □ SRXUs.
- MWG
  - RF test signal from TXGU□ MWG
- EPG
  - Digital test signals.



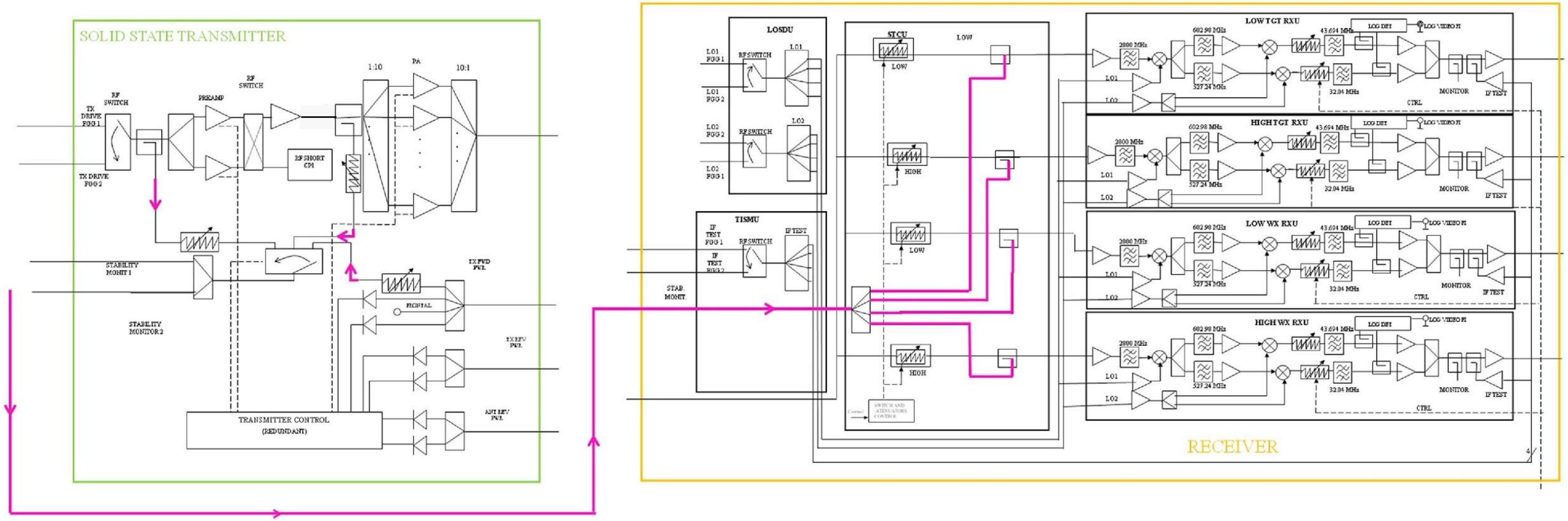


Functional Description

Stability Signals

- RXG

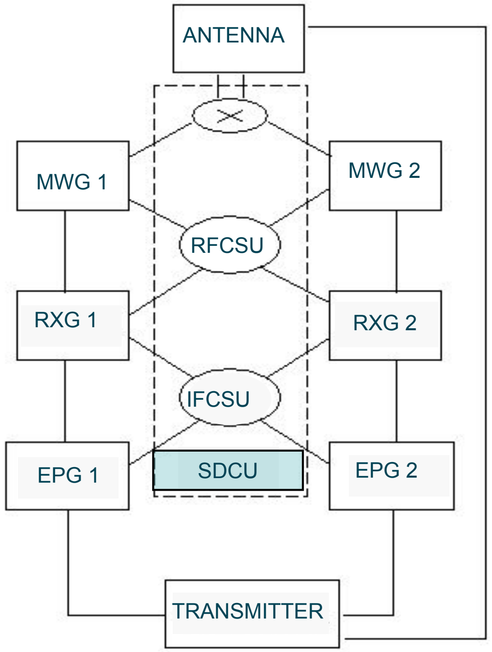
  - Stability control (three points of the transmitted signal are monitored) in TXG.
  - These samples are sent from TXG to TISMU and checked through STCU.

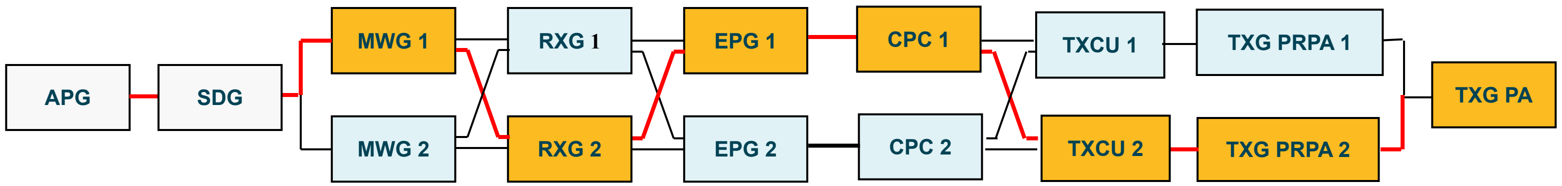


Functional Description

Control & Bite (SCBG in EPG). Redundant System

- Redundant dual channels for reception and signal processing.
- Automatic fault detection possible automatic channel switching.
- SCBG (System Control and Bite Group) receives status signals and sends control commands.
- SDG: (SDCU) redundancy control (operational/stand-by channels).
- SDG: Manual switching, local control (AGSU).
- High operation flexibility.





Functional Description

Main System Functions

- **System Controlling.**
  - Antenna (turning, polarization).
  - Transmitter (radiation on/off).
  - Possibility of switching in various points.
  - Operation mode (Main/Standby).
  - Reception map configuration (state map).
  - System stability measurement.
  - Noise figure system measurement.

- **Alarms / BITE.**

Functional Description

Main System Functions

- **Performance evaluation.**
  - Test target injection.
  - Permanent Echoes.

- **Signal processing.**
  - Pulse compression.
  - MTD filtering. CFAR techniques.
  - Clutter and clear day map generation.
  - STC map generation.
  - Range, azimuth and doppler estimation.
  - Weather signal processing.

- **Data processing.**
  - Azimuth detection correlation.
  - Track generation.
  - Weather data detection (weather map).

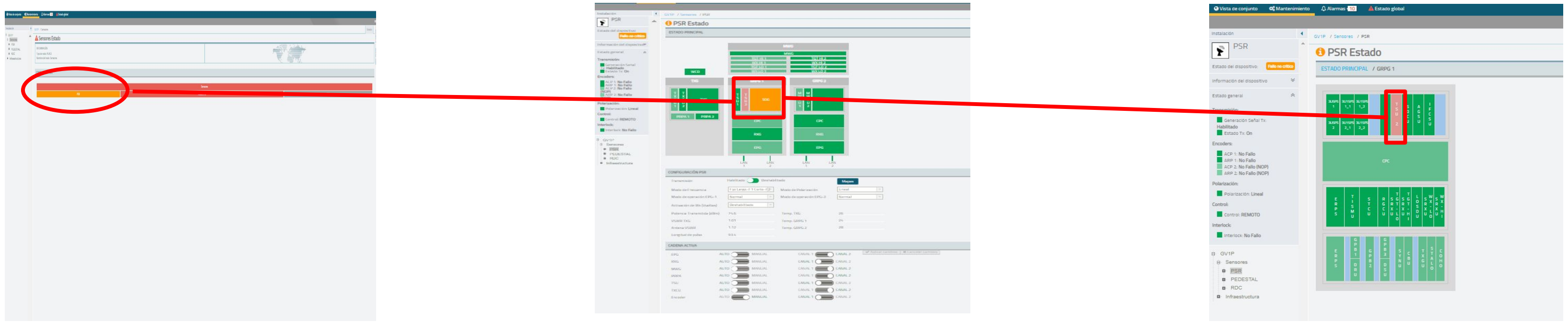
Operation and Monitoring

Control and Monitoring System Main Screen

Operation and Monitoring

Control & BITE

- Powerful BITE.
- Graphical report of failures in all levels of Control and Monitoring applications using text and colour coded status elements.



RMMS indication:
PSR Failure

UCS indication:
GRPG Failure

LRU indication:
Module failure

- All failures are reported and are monitored in both Local or Remote Control and Monitoring System (SLG or SRG).
- BITE is collected by the control board of each group and sent to the CBU(in control and BITE group in EPG).

At the core