

Secondary Surveillance Radar

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Introduction

Problems that were recognized immediately from the birth of RADAR technology included the weakness of the return pulse and the lack of other information about the aircraft including whether it was friend or foe.

The original radar patent granted in April 1935 contained an idea for overcoming these problems by having a transmitter installed on the aircraft that would detect the primary pulse from the radar and be triggered into transmitting its own signal.

This would greatly increase the strength of the return signal, which could also contain information to Identify Friend from Foe (IFF).

The device on the aircraft is called a **transponder** (combination of transmitter and responder).

Transponder

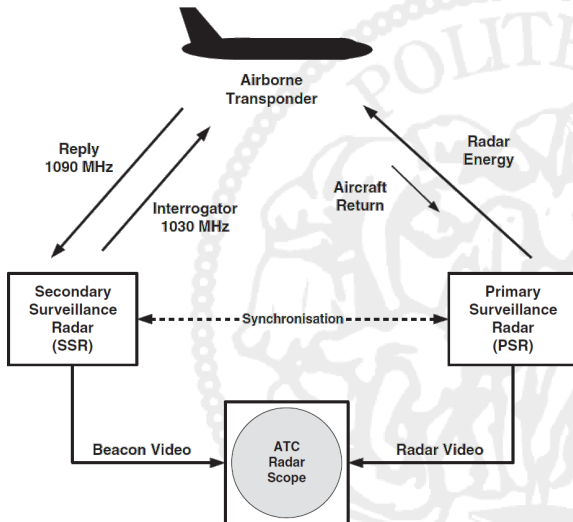
Originally, transponders responded with a signal that had the same frequency as the primary RADAR pulse but as RADAR frequencies changed, it became necessary to allocate a separate band for the service.

This was set at around 1000 MHz, and specifically:

- 1030 MHz for the interrogation (ground to air).
- 1090 MHz for the reply (air-to-ground).

The system is known as **Secondary Surveillance Radar (SSR)** or **Air Traffic Control Radar Beacon System (ATCRBS)**.

SSR



Transponder modes

Different operating versions (identified by their **Mode**) of the SSR have been developed in time.

They differ in the information packed in the payload of the A/C reply and in some operating capabilities.

Common to all modes reply:

- a 4 octal digit code (often referred to as *squawk*) assigned to the A/C by Air Traffic Control (ATC) on a per-flight basis.
- The *Ident* capability, i.e. whether the pilot is currently pushing the *Ident* unstable pushbutton on the panel or not.

With respect to Mode A, Mode C introduced the transmission of the A/C baro altitude, automatically retrieved by the transponder from on-board altimeter or Air Data Computer (ADC).

Squawk Codes

Notable transponder codes:

- 0000: shall never be used.
- 1200: code for generic Visual Flight Rules (VFR) flight in US and Canada.
- 7000: code for generic VFR flight in Europe.
- 7500: aircraft hijacking.
- 7600: radio failure.
- 7700: generic emergency.

Transponder modes

Mode S (where S stands for Select) introduces many innovations. For a start it brings-in the capability for interrogators to uniquely identify and address the transponder of a particular A/C. This is carried out by means of a unique 24-bit ID which is assigned to every single A/C at first registration time and follows the machine for its entire operating life.

Additionally, Mode S replies are not rigid in their payload content, but may be adjusted to include a wide variety of data depending on the interrogator's necessities.

Finally, a new air-to-air operation mode is added to the traditional ground-to-air. This permits A/C to A/C data communication over Mode S replies which is exploited by a number of systems, like TCAS and ADS-B.

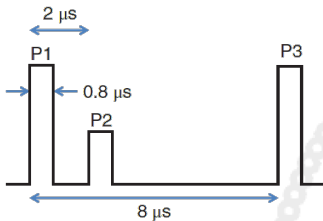
Transponder modes

MODE	INFO IN REPLY
A (ALPHA)	SQUAWK CODE + IDENT
C (CHARLIE)	SQUAWK CODE + IDENT + BARO ALTITUDE
S (SIERRA)	SQUAWK CODE + IDENT + A/C UNIQUE 24bit ID + SELECTABLE DATA

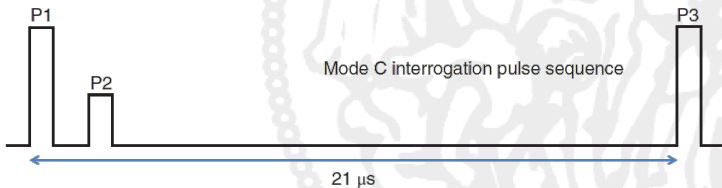
Mode S interrogations can be:

- legacy: all transponders reached by the interrogation will reply (like in Mode A and C).
- selective: only the Mode S transponder with the ID specified in the interrogation will process it and reply.
- broadcast: all transponders will receive and process the interrogation but none will reply.

INTERROGATION PULSES (MODE A and C)

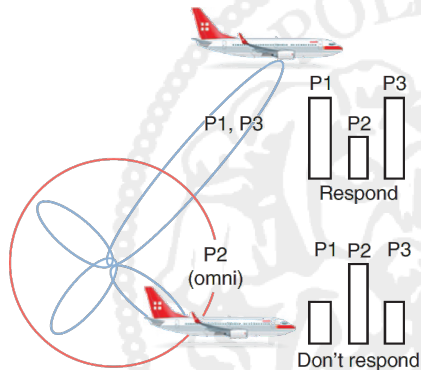


Mode A interrogation pulse sequence

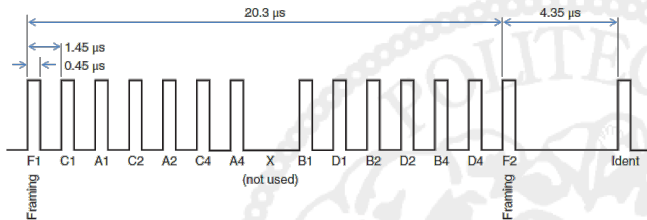


Mode C interrogation pulse sequence

INTERROGATION PULSES



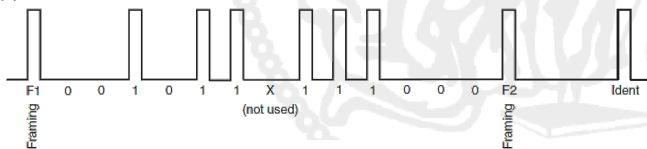
MODE A REPLY



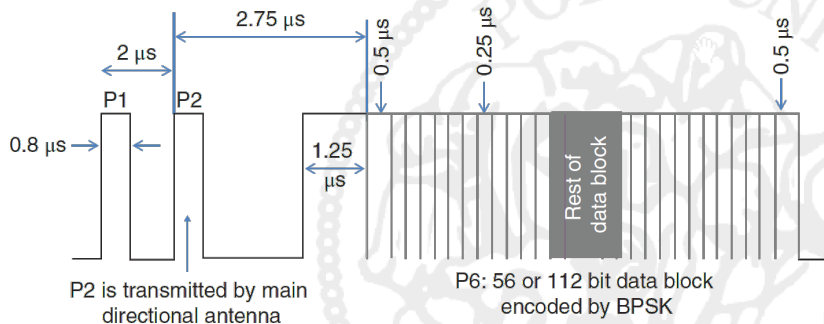
(b)

	4	2	1	
Transmitted code 4361	1	0	0	A
	0	1	1	B
	1	1	0	C
	0	0	1	D

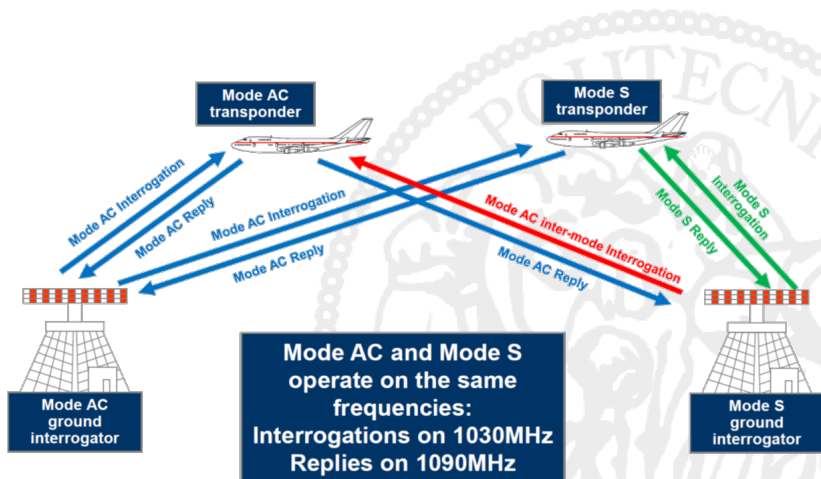
(c)



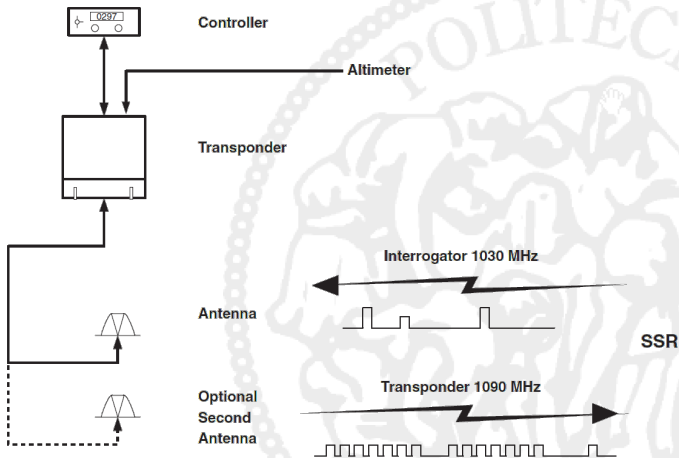
MODE S SELECTIVE INTERROGATION



MODE A, C and S INTEROPERABILITY



ON BOARD COMPONENTS



COCKPIT PANEL



List of Acronyms

ATCRBS	Air Traffic Control Radar Beacon System
ADC	Air Data Computer
ADS-B	Automatic Dependent Surveillance - Broadcast
ATCRBS	Air Traffic Control Radar Beacon System
ATC	Air Traffic Control
IFF	Identify Friend from Foe
SSR	Secondary Surveillance Radar
TCAS	Traffic Alert and Collision Avoidance System
VFR	Visual Flight Rules

