Alien21
ATC units, Transponder, how communicate

It's finally the time to analyze how they work Air Traffic Controllers, how it work a Transponder, and basic theory about how to do a radio communication.

ATC units

Air Traffic Control is a job splitted for every flight phase: each controller have several specific responsabilities and duties for its specific phase, and it work following standard procedures for work between its adiacent facilities, and if necessary, use specific procedures under coordination. In any case, all controllers provide some Air Traffic Services. ATS service are:

- Air Traffic Control (ATC) with the purpose to avoid collisions, and maintain an efficient traffic flow. This service is provided on taxiways, runways, and in the airspace in the immediate proximity of the aerodrome, between inbound descending and outbound departing traffic inside a CTR (Control Zone) or inside a TMA (Terminal Maneuvring Area) if there are more airports, inside a Control Area (CTA) or inside airways during route or cruise phase.
- Flight information service (FIS) with purpost to provide information and any suggest for a secure air navigation. The best example could be METAR service

- Alerting Service, with the purpose to assist any plane under emergency and activate SAR operation (Search And Rescue)

As you can imagine, there are different ATC units, a system developed for a better organization for ATS services. Basically we can say that there are 3 units: Control Tower, Approach and Area Control Center, but it could be possible that there are more different units:

Let's start from Delivery: it's indicated with the suffix _DEL while we fly online, its job is to verify the flight plan, IFR or VFR, and cleared the flight plan (in Italy VFR doesn't receive an explicit clearance, just last QNH, and trasponder code after they had decleared the flight intentions). Flight plan clearance contain departure procedure, a omnidirectional deparure in substitution if available for the departure airport, takeoff runway, initial climb and trasponder code. Delivery is an ATC unit available only in major airports. When the pilot has confirmed with readback the clearance and declare to be ready for pushback and start, it release the flight to Ground. Anyway, in consideration that is one of his responsibility assign departure procedures (to be clear, the procedure to follow when airborne), if necessary for air traffic management, it will assign the clearance after a coordination with Approach/Departure controller and it will advise Ground and Tower, if the pilot request different or specific procedures. It provide only ATC service, few times FIS service and never Alert Service (it could inform however pilots on frequency about possible delays)

Next ATC unit is called Ground. It control all grounded flights, on every apron, taxiways, but not on runways. It release all traffic to to the Tower when they reach runway holding points and it will assume traffics from Tower unit after they vacate the runway.

It receive traffics from Delivery when they declare that are ready for pushback and/or startup engines. The job of this unit is to authorize all flights for pushback and startup (operation which is usually assigned only for IFR flights, because this clearance is connected with indicated departure time on flight plan, and it clear any flight to the airways network, this because all ATC's have in real life a coordination system for the air route traffic management), assign a taxiway instruction for the runway if departing, and for the gate if landed. It provide ATC service and FIS too, but never or under very extreme circumstances, Alerting service.

PS: In North America, inside major airports, it could be possible find with suffix _GND some units, called Ramp. However these aren't real ATC units: something similar is present also in Europe, but only in North Amerca they're contacted from the pilots before an aircraft join the Apron area, and after the radio contact they assign the gate number. Usually are flight operation managers of the same airline, and for this reason, they aren't called for pushback operation.

Last unit which operate without radar from the aerodrome control tower, is the <mark>Tower</mark>. Indicated with suffix _TWR, it control runway management and it could be sometimes, the only unit available for some controlled airports, because Ground and Delivery are units created with the purpose to help this specific facility. It control all flights on a takeoff/landing runway, it control VFR flights in the immediate proximity of the aerodrome (traffic pattern and traffics which would join the pattern). It provide ATC service, and in case the airspace under its responsibility is classified as C or D, it provide in addition to conventional FIS services (like METAR), also traffic informations with purpose to avoid collions. Is responsible for Alerting service in that airspace

First ATC unit which doesn't operate under "unaided eye", but with Radar support, is the ==Approach==. This unit is responsible for any flight inside the airspace of its competence, an airspace created in the proximity of one or more aerodrome with purpose to control the climb and descend phase. Is responsible also for any transiting VFR flight which is inside his airspace, after that they had receive the clearance (it could be explicit, or implicit like it happen in Italy). It provide informations about IFR landing procedure, barometric altimetry, appropriate traffic separation, it release traffics to the Tower when closer to their destination (usually IFR when they're on final on the localizer and the VFR when they reach a VFR report point for that aerodrome), and it exchange flights with the ACC when these leave/join his airspace.

Approach provide ATC service and FIS services in agreement with the classification of its airspace, and Alerting and SAR service. In some cases, the same area can be shared between more Approach controllers to allow a better traffic management, or between an Approach ATC and a ==Departure== ATC, which are indicated with suffix _APP and _DEP.

Some of these units can however, in agreement with local AIP, operate without radar service. In these situations it will be provided a procedural control, which are common for regional airports.

And finally, we have the ATC facilities which operate and provice their service from an Area Control Center.
Center controller provide traffic management during the cruise phase, and receive/release any traffic with other ACC or other APP units if a traffic is descending or climbing. Is the most complex ATC unit, because responsible for these service:

It provide STAR procedure information (for the arrival), provide traffic separation between any flight inside its airspace, it assign shortcut if possible or flight re-routing if necessary, and it apply any flight rescriction if necessary. Like APP it provide ATC and FIS service in agreement with airspace classification under its responsibility, and Alerting service. While you're flying online these units are indicated with suffix _CTR

Because this type of ATC units is the most complex facility type, sometimes a CTR can split its airspace in more sectors, also with different flight levels control zone layers. In addition, an ACC can host a unit for uncontrolled airspaces, which can be contacted under pilot discrection. The Flight Service Station, indicated with suffix _FSS, doesn't provide ATC service, just only information service which can assist any flight and Alerting service. Also if there units can be equipped with radar system, they doesn't use radar antenna's for operation purposes, but only for monitoring purpose.

Transponder

There are 2 option if you would be identified on the radar. The simplest mode available for an ATC, is the primary radar, which detect the aircraft position in correlation to the distance from the antenna, but it doesn't provide any other data. An aircraft which is detected only with a primary radar track, to be fully identified need always to execute a maneuver after has receive the ATC instruction which allow the controller to identify that track, and provide constaintly-updated data about altitude if this value it change.

Transponder help ATC during the identification phase with a different system. Is basically an electric device which after has

received a radio impulse (data interrogation), it provide to answer to the radar antenna which will provide to execute these data's on the screen.

There are different Transponder. Mode A it provide only the Transponder code for the identification. Mode C, if interrogated from any secondary radar, it will send trasponder squawk code, and altitude data from the barometric altimeter.
Last, but not least, Mode S (because Selective), in addition to the same data shared on Mode C, it provide more data excange, including different data like Callsign, this with the purpose to facilitate the identification. This is the most common Mode applied.

To allow data exchange, secondary radar send a 1030 Khz impulse to any transponder, which will provide to reply with another impulse in 1090 Khz. The delay between antenna's location and transponder is a factor which help the antenna to determine any aircraft position.

Transponder it have different operative mode. OFF, which doesn't need any word to explain how it work; STBY it activate the transponder but not for operative purpose, is basically a mode used for testing potential failures; ON it activate A mode, ALT it will provide to send altitude data and activate Mode C or S; and finally there are 2 different but very similar mode, which are available only for aircraft equipped with TCAS (basically on liners, but also some General Aviation planes can be equipped). Mode TA and TA/RA mode, which mean Traffic Advisory and Traffic Advisory/Resolution Advisory, both will provide to the pilot Traffic information if will be present other traffic in the immediate proximity of our planes, but only the second mode will provide

instruction in case of imminent collision predicted for a conflict resolution.

Transponder have also a special mode, called IDENT, which can help the controllers for identification purpose sending a special signal. This mode it must be activated exclusively under ATC request.

Transponder codes use only numbers from 0 to 7, and they have 4 octals digit numbers, with lowest value available 0000 and highest value available 7777, with a total number of 4096 codes available. Isn't possible insert 8 and 9 inside transponder code.

Code assignement is provided with several Letter of Agreement between any ACC which share the borders with that specific ACC. Also Towers have, in agreement with their ACC, specific codes, but for some situations or special flights there are specific squawk codes.

Code 7700, 7600 and 7500 are Emergency code. Code 7700 is available in case of Mayday, and it must be used only with this purpose, not for a generic equipment failure or Pan pan, except specific request from ATC. Once landed, the code must be changed to 2000 or deactivated, when emergency is terminated.

7600 Code can be used for total radio failures. If a pilot receive a communication and completed the readback, but the ATC has repeated again the communication, it could mean a possible transmitting failure, and it could be possible that later, the ATC will ask an IDENT impulse for acknowledge purpose. In that case partially radio falure will be confirmed and isn't necessary change trasponder code, excepted if requested from ATC unit. Is MANDATORY use this code only for emergency purpose, not for

ignoring intentionally an ATC while you're flying online.

Last special code is 7500, used for illegal act on board. This code can be used also for indicate HIJACKING act (not diversion to alternate airport), and for this reason is forbedden on any network use this code.

Code 7777 is a code for test purpose.

VFR flights have 3 specific codes. 1200 is VFR code applied in USA and Canada Airspaces, 7000 is the standard code in European airspace, and 2000 the recommended code from ICAO. However, last regulation published in 2018 in Europe airspace, indicate code 2000 as mandatory if under ATS service. Reg EU 1185/2016 and SERA GM (Guidance Material) 13005:

Except in the cases described in (a) above, the pilot shall: (1) select codes as instructed by the ATS unit; or (2) in the absence of ATS instructions related to code setting, select code 2000 or another code as prescribed by the competent authority; or (3) when not receiving air traffic services, select code 7000 in order to improve the detection of suitably equipped aircraft unless otherwise prescribed by the competent authority

Last code, for ADS-B aircraft equipped, is squawk 1000. This code can be used with this benefit for multiple planes on same airspace. ADS-B have their 24 bit unique code which provide a faster identification process. This system is the same which is applied from some plane tracker websites like Flightradar24 or Flightaware. A benefit but also a problem for this system is the lack of interrogation process, because the data are sended

constantly to anyone (Broadcast). For this reason, several military aircraft aren't equipped with this system.

If you're flying online, transponder activation must be completed via the client. Just open the client, click over Mode C, but for some payware planes it could be activated also directly from radio panel.

Now that we know transponder modes and which ATC units are available, let's see the basic theory around communications.

Radio Communications

As ICAO indicate, an ATC clearance allow a plane to proceed under specific conditions as indicated from ATC unit. In addition as published on Doc 4444 PANS-ATM ICAO:

Note 1.— For convenience, the term "air traffic control clearance" is frequently abbreviated to "clearance" when used in appropriate contexts.

Note 2.— The abbreviated term "clearance" may be prefixed by the words "taxi", "take-off", "departure", "en-route", "approach" or "landing" to indicate the particular portion of flight to which the air traffic control clearance relates.

Clearances are issues only to allow an expedite traffic management and guaranteed separations, and are based on know traffic situations from ATC which affect safety for planes operation. These conditions include airborne planes, airplanes on manoeuvring area (which doesn't include apron and maintaining

area, like movement area, but this detail will be analyzed in another document), veichles on manoeuvring area and not permanent obstacles installed on manoeuvring area.

An ATC clearance will never authorize a pilot to violate any regulation and compromize safety operations, in any case the pilot in command will be always responsible in case of safety infrindgements. In case is necessary execute another procedure, the pilot must report to the ATC the desired procedure to obtain the clearance, also if this changement could be subject to delays (a different runway for departure could be a reason for delays if weather conditions allow this request)

There is a big difference between clearance and instruction. Clearance allow us to do as pilot, something; an Instruction is a request to do something immediately without delays. In addition, for the first option will be always present in the phraseology the word "cleared", while inside an instruction will be possible find imperative moods, like climb, descend, turn, stop, follow....

Never use words which could cause misunderstanings, a communication must be done always, from pilot and ATC's, clear and must simple as possible.

Sometimes, there are communications which aren't clearances and instructions, as we can imagine if we're looking the previous documents and chapters, like ATC suggestion or flight informations, which doesn't required readback. In addition, sometimes ATC's use word "expect". This word indicate something which you will perform, but that it wasn't still cleared,

like a STAR or a runway approach. Is a word that a lot of flight simmers will misunderstand. If a pilot will not receive later the clearance to perform that specific procedure indicated, the appropriate action will be to perform the holding pattern until further communications from controllers. There are a lot of communications which require readback, usually these communications are route clearance or flight plan clearance, instructions and/or clearance for takeoff and landings, taxi on ground to gates or holding points, but also runway in use, barometric altimeter settings, SSR code, level/altitude authorized form an ATC, direction and speed.

As you can understand there are a lot of informations, but is impossible a detailed analysis for a document which introduce this argument. Next documents will provide to give you more details about each situation.

Source

ICAO Annex 2 Rules of Air, Chapter 1; ICAO Doc 4444 - Air Traffic Management, Chapter 8.5 and 6.3; ICAO Annex 11 Air Traffic Services Chapter 3.7