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# "Telemetry Band C & S Capabilities Integrated for Test Range Activities"

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INTA as Governmental Center and Public Research Establishment specialized in the aerospace field; it is in charge of 2 important roles in Spain. Certification accoding to Regulation for Defense Airworthiness Royal Decrete 866/2015 and test means for aeronautical programs declared as "defense strategic".

"El Arenosillo" test range (INTA/CEDEA) has been for fifty years the Official test Range for Spanish Ministry of Defense, in order to support all development, certification and qualification programs for Military and Civil Aircrafts. Manned & unmanned aircrafts and their systems integration. INTA has been supporting as Government Furnished Facilities (GFF´s) tests for Certification, Qualification and Development flight test activities.

According to the needs that have been requested by Industry and Government, INTA/CEDEA had implemented a new autotracking system for Band C and S in 2015. In a very short time (only 15 minutes), it is possible to swap from one band to the other with a modular structure. It means to save costs in order to complaint all types of exercises. Additionally, this new autotracking capability has been fully integrated at INTA/CEDEA. It means that it coexists with 3 RADAR´s systems and 4 optronic systems. It lets to coordinate and optimize test activities sharing information from one system to the rest.

Aim of current abstract is to show the way this telemetry system has been integrated coexisting with additional system and providing its own test information for tracking capabilities as main data source to slave rest of sensors. In addition, when this new system is working in slave mode in order to catch aerial vehicle and provide telemetry data for flight test activities.

**Key words:** "Auto-tracking", "test range instrumentation", "unmanned vehicles", "certification airworthiness tests" and "Band S & C".

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## 1. Introduction.

National Institute for Aerospace Technology (INTA), founded in 1942, is a public research establishment attached to Spanish Ministry of Defence (MoD), hence, a governmental organization. Which is under direct Government decisions from State Secretary of Defense.

INTA activites on research trascend the scope of military applications to benefit, through new developments and applications, the most varied areas of activity. Currently, INTA personnel is based in technologists and researchers of the highest level in their areas of competence, while equipping itself with major infrastructures in the form of installations, facilities and laboratories for research, development, measurement and testing, all of them, pioneers in Europe and frequently used by national and international organizations.

INTA carries through its research activities in a highly cooperative environment, in collaboration with other partners in many international programs, participating also in most of international aeronautic and space forums. This interantionalization of activities is one of the most significative features of INTA. Summarizing INTA profile in figures, human resources working in INTA and its associated sites consist of more than 1.600 people with facilities situated at several different locations in Spain, each one with a definite purpose.

Aim of current paper in to show the way telemetry capabilities have been integrated at one of its test centers, Arenosillo Test Range (INTA/CEDEA), recently in 2015. These facilities located in the south of Spain, have been supporting activities for aeronautical Military and Civil Aircrafts, certification for solar energy systems and atmospheric studies. In fact, since 1962 supporting Research & Development (R&D) processes for any kind of activities, specially Aeronautical and Scientific programs can be counted among their main activities.

INTA/CEDEA is considered one of the most capable Test Ranges in Europe to support tests for Certification, Qualification and Research & Development activities. Manned and unmanned Aeronautical and ground systems can be validated and tested at its facilities. Additionally, training activities for National and Foreign military corps are one of the most relevant activities. National, foreign, governmental and industrial organizations have been performing experimental activities at INTA/CEDEA facilities since 1962. It means that taking into account this wide catalogue of possibilities, it is necessary to be supported by a high-specialized instrumentation.

INTA/CEDEA added values are based on three important pillars:

- Wide safety test area.
- High specialized instrumentation.
- Stable & suitable weather conditions for test activities.

INTA/CEDEA, joined to Centro de Investigación Aerotransportada de Rozas (INTA/CIAR), second INTA Test Centre in north of Spain, is involved in an ambitious expansion program to increase operational capabilities, specially focused in Unmanned Aerial Vehicles (UAVs). This new concept for next future will be supported by new instrumentation capabilities, specially increasing telemetry possibilities. It has been designed as an expansion from current INTA/CEDEA (Experimental Test Center) experience and capabilities. Based on it, some main ways have been implemented to define its main strategy. Ambitious expansion projects based on 40 years experience on the following activities:

- Certification/Qualification activities to integrate systems on aerial platforms.
- Operations of aerial unmanned vehicles and its improvement designs.
- Trayectographic systems.
- Supporting industries and National & Foreign Government forces.

## 2. INTA/CEDEA Autotracking Telemetry Capabilities.

Taking into account current needs to manage data, it was decided to integrate a new Band C auto-tracking system antenna at INTA/CEDEA test range instrumentation systems. However, it was decide to keep also Band S capabilities. Compromise solution decided has been to install a new system with both capabilities, taking into account that autotracking was not previously available at Test Range facilities for Band S. It was supported to integrate.

The solution decided was a 1.8m parabolic S&C Band Tracking System. It is installed at a high performance pedestal with a processor to manage its behaviour linked via fiber optic to the

Antenna Control Unit (ACU) located in the telemetry control room.

System consists of the following major elements:

- A high-performance pedestal driven by one brushless motor per axis. An Elevation over Azimuth pedestal design.
- A 1.8m carbon fiber parabolic reflector.
- 2 feeds: 1 S-Band tracking feed and 1 C-Band. Both tracking feeds with common backend.
- 1 Digital high-performance servo controllers closing the motor control loop.
- A real-time pedestal controller located at the servo enclosure at the pedestal.
- Fiber Optic Ethernet link between the pedestal and the ACU.

This system, previously described, is not INTA design. It has been provided by an external supplier.

Figure 1. Antenna instalation at CEDEA Test Range Facilities.

This system has following innovation concepts from typical telemetry equipment:

- To reduce S & C Band feed. It is designed with a common backend, permanently mounted on the antenna, that includes the amplifiers and the hybrid, to generate the right handed circular polarization (RHCP) & left handed circular polarization (LHCP).
- It means that antena user has the capability to install 2 different radomes that can be easily interchanged to meet the specific mission band of operation: S or C Band. It takes onbly 15 minutes.
  - This enables to minimize feed's cross section, minimize the Radio Frequency (RF) switching and thus increase the resulting G/T.
  - Reduce the filter complexity by requiring a simple but efficient narrow bandpass filter thus reducing the filter loss which in turn increases the overall G/T.
  - Feed RF output is provided on a fiber optic interface.
    - A transceiver that digitizes the RF signal in a manner suitable for Fiber Optic transport.
    - The transceiver has the added feature of giving the option to the user to re-generate the RF in the control room in the original band (S or C) or to an intermediate band (from C to S-Band or C- to L-Band for example) or to IF (70 MHz, 100MHz,…). This means that S-Band receivers can work with the C-Band feed. Furthermore, since the output can also be produced at IF (70MHz) there is no need for any receivers.

The pedestal includes a one brushless motor drive per axis design complemented with digital absolute angle encoders position feedback for each axis (typically from Heidenhain Corp.). The Elevation motor and feed are cable-wrapped to the Azimuth axis.

## 3. Advantage of a modular feed.

Feed design takes a competitive ventage than most conventional telemetry tracking feeds. Nomally, for an efficient dualband feed design, in order to get both added capability, impacts on more filtering, more RF components and a bigger housing. Final consequence means a reduction for the overall efficiency of the feed. To circumvent this limitation a modular feed solution has been adopted by supplier. This design splits the band dependent components and the band independent components. By doing so, a

common backend includes the Low Noise Amplifier (LNAs) and hybrids. Band independent components, as well as the motor for the nutating horn of the front end. The backend is permanently fixed to the antenna by the spars and feed ring. Individual front ends, one per band, configures final structure. These will be mounted on to the backend with the help of self-locating push-on coaxial RF connections and a quick release clamp.
This innovative approach allows to minimize the RF losses as fewer RF components are required and more efficient RF filtering can happen. Due to the effincy to design/acquire a high Q narrow bandpass filter with very low loss than incorporate a complex multiple bandpass filter. As conclusion, this modular approach reduces the size (length & cross-section) and weight of the feed. It reduces also the RF blockage. All this put together means that for the same reflector size the resulting G/T increases considerably.

This feed modular approach has the following advantages:

- Cost reduction for both capabilities at only 1 equipment. Cheaper to produce two band specific feeds than an all encompassing feed.
- Increased RF efficiency: less RF components, targeted filtering, size reduction.
- Better filtering of unwanted signals
- Backend structure is permanently fixed to the antenna. From operational point of view it takes the advantage that no need to realign the RF when changing front redomes.

## 4. INTA/CEDEA equipment instrumentation.

From instrumentation point of view, INTA/CEDEA is able to support multiple test scenarios due to its flexible structure, based on a redundant instrumentation system. A net of sensors implemented by optronic systems, RADAR´s, IR cameras, telemetry (described previously), and tracking systems are able to accommodate for each test scenario, fulfilling multiple test requirements as: some aerial platforms, some targets (aerial and maritime) and whatever system to check, qualify or certify. Mentioned structure can accommodate, for test requirements, trying to optimize all involves means, with a main aim: "to support and secure each operation test in a safe way".

Figure 2. RADAR Tracking at INTA/CEDEA.

In addition, mentioned structure is able to track and to link data between whatever aerial vehicles, instrumentation and aerial/ground development equipment. It means that INTA/CEDEA is able to support test for aerial vehicles, targets, aerial and ground systems and command unmanned aerial, ground and maritime systems. All systems at the same time or stand alone for each one.

A consequence and added value provided by this instrumentation structure drives to following opportunities:

- To manage in advance "Test Procedure and scheduled Programme" accommodating test means for each requirement, in a flexible way.
- To reschedule in real time, once test has begun, and accommodate to changes based on on-going test results.
- To evaluate in real time data information by telemetry.

Functional principle for all these equipments are based:

- For optronic systems: infrared (IR) & optical (OT) contrast. Also RADAR doppler (RDP).
- For tradicional monopulse tracking RADAR sytems.

Architecture instrumentation net is done by:

- 4 optronic platforms with IR, OT & RDP payloads.
- 3 Tracking RADARs.
- 1 Telemetry antenna for S & C Bands.

Figure 3. Optronic System at INTA/CEDEA Test Range.

## 5. Telemetry contribution to Test Range instrumentation.

Taking into account this instrumentation scenario, new telemetry system has been integrated taking into account information from rest of systems, (optronic and RADAR´s). It means that:

- For a high speed aerial platform. Optronic systems are able to catch from the beginning of its movement. Its high performance in terms of speed and high instrumentation payload weight (up to 1.000kg).
- For slow flying systems, all instruments (optronic, RADARs and Telemetry) are able to catch from the beginning.

From operational point of view, this architecture is able to slave rest of systems to a master equipment. In real time, is possible to update this configuration. It lets in case that for example, master loses its tracking, to recover swapping master-slave configuration. All systems are able to work according to this philosophy, including new telemetry system. In fact, contribution from this new equipment has increased test range reliability from tracking point of view.

Master equipment provide its relative polar coordinates from its own position. All of them are geo-reference located. Polar coordinates are provide by their own azimuth and elevation angles. Additionally range is provided and fix the aerial vehicle. This information, combined with its geo-reference position, is managed in order to provide the new relative position between slave equipment and system to track.

Information from telemetry system has 1 advantage. GPS position is possible to receive from aerial vehicle. It means that is possible to cross check this information and pedestal angular position. GPS position is used also to feed tracking data net. New telemetry system contribution has 1 disadvantage: only radial information is possible to extract from its pedestal. However for near vehicles is not a constraint. For aerial platforms coming far away, this radial information is so important. In these conditions, only telemetry system is able to track. GPS information allows to slave all tracking devices based on these kind of data. In case that no GPS is available, this radial information let to focus in "waiting position" all the systems. Once its functional principle is able to catch, device will be working in tracking mode if it is needed.

This configuration is described in figure 2.

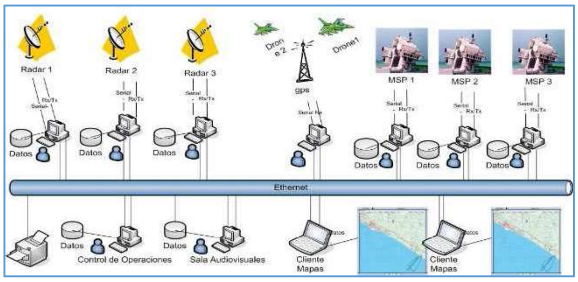


Figure 4. INTA/CEDEA tracking data management.

## 6. Telemetry antenna integration at test range infrastructure.

As it has been mentioned, antenna has implemented and ACU to manage different control options. There are six different operational modes: manual, search, stand by, tracking, acquire and slave. For last one is possible to get the information from: Ethernet, Serial and P-Track.

This same philosophy has been implemented for all equipment's: RADAR´s, optronic and for sure telemetry. It is possible also to charge an expected simulation trajectory. In case that tracking will be loose, it will operate in order to recover vehicle auto-tracking.

To integrate autotracking anetnna at Test Range instrumentation is necessary a new application at the ACU. It lets to know the field of the frame that sends all sensors to the control station. Once realized the application, thereby it enslaves ACU, therefore if the ACU lost the

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target, thanks to this new application, operator can know the position of the target and to get again auto tracking capabilities. Due to its high tracking range capability, telemetry antena is able to provide, as commented, GPS data and radial tracking information. Normally this last topic has more added value.

Following milestones describes the process to integrate at Test Range Control Center (TRCC). TRCCS is responsible of coordination, monitoring and recording whatever operational mission being conducted at the center. A data acquisition system is in charge to collect a set of physical signals and to digitizalize. This set of information is processed and it drives data transmision between all and each of the sensors forming the test center: RADAR´s, Optronic and Telemetry. It lets different devices the capacity to interactuate among themselves.

The TRCCS communicates with the sensors through coded frames bi-phase PCM signal synchronised. Thank the advance of new technology, benefiting from the Ethernet network and developed in the majority of teams. The Ethernet network has a transmission capacity of information, speed and reliability. The servers, where the positions of the aerial vehicles are received, is recorded in the system and is able to send the position of a sensor to all other sensors.

Current application can receive up to five mobile vehicle positions at the same time. In the new system also will be necessary software implementing that the operator is able to pass the position to any sensor regardless of your manual or automatic monitoring.

In order to keep the antenna in slave mode, new application for ACU, need to know protocol information that arrives to it. Information passed is (X, Y, Z), absolute coordinates gotten from relative coordinates from each sensor and its own georeferenced sensor location. ACU is responsible for adapting the frame X, Y, Z, such that the antenna can recognize the vehicle position.

## 7. Conclusions.

According to the acquisition of a new telemetry system for INTA/CEDEA Test Range, its tracking capabilities has been increased. INTA/CEDEA has been traditionally a trajectography center, with all its devices, RADARs and Optronic integrated at a Ethernet data system communication, working between sensors communications at a swapping Master & Slave mode.

This new antenna for Band S & C has been integrated in order to keep this operational protocol between sensors in real time.
In order to reduce costs and keep performances for both Bands, a system based on a modular feed has been implemented.

It lets Arenosillo Test Range to increase its tracking capabilities, but also its particular flexible structure. It means that these devices have the added value to be able to adapt for multiple flight test scenarios.

Figure 5. Tiger HAD for Certification and Qualification Tests at INTA/CEDEA.

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