Air Defence and Command and Control Systems

Origins to the cutting edge (1985-2023)

indra

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Building on decades of cooperation with the Spanish Ministry of Defence and the Spanish Air and Space Force, Indra has contributed over the course of its history to developments and constant technological upgrades of the air defence radars and air command and control systems used to monitor, control and defend sovereign national airspace. Indra has thus emerged as one of the world's leading companies in these advanced technological solutions, and Spanish air defence has become one of the most solid in the world.

The origins and developments of these systems leading to the state-of-the-art technology used to protect our skies are described in detail throughout this paper.

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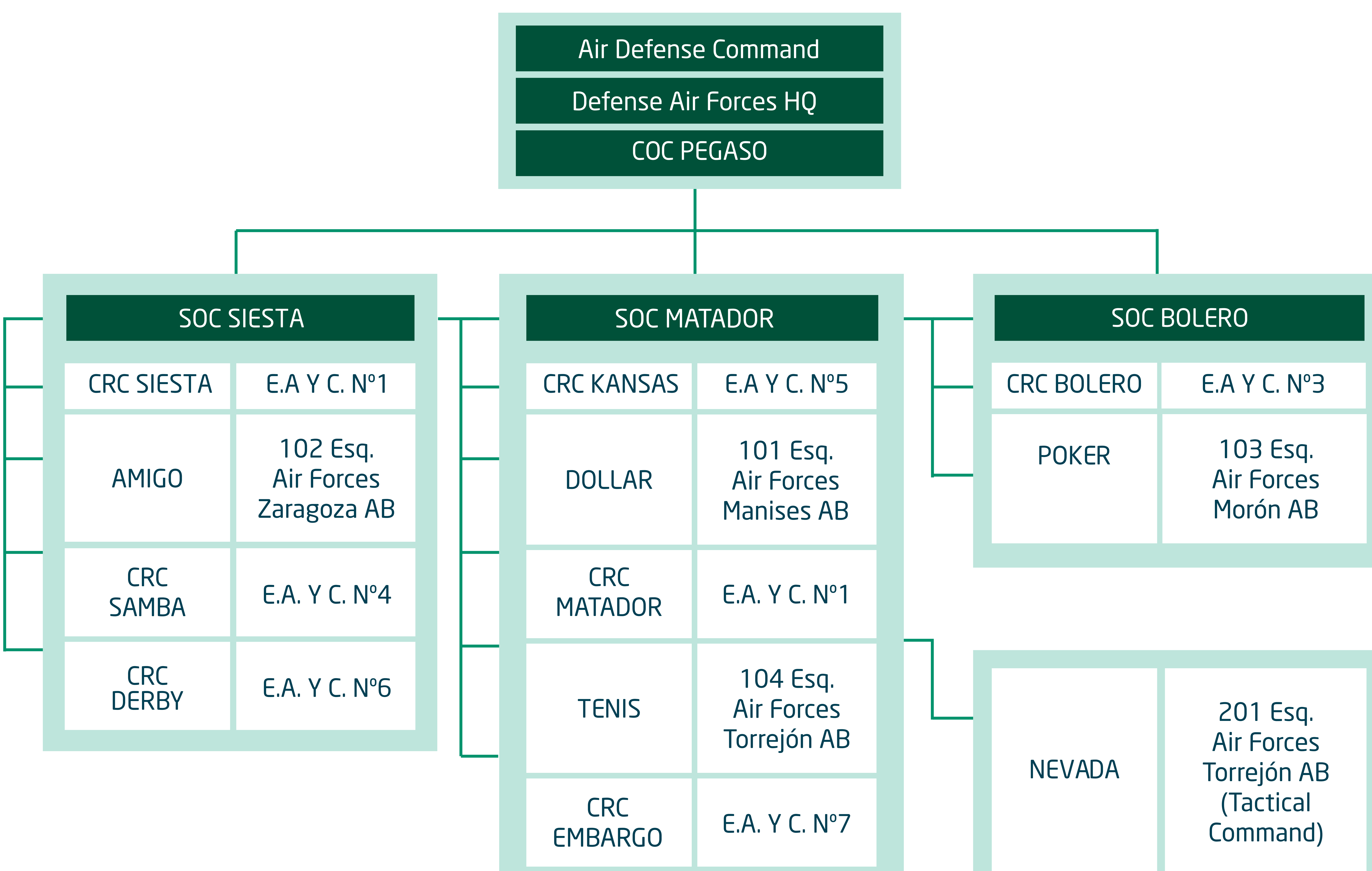
Background

The air doctrine of the 1960s, which was understood as a guide for planning operations and common air defence procedures, provided for independent command and control structures to plan, direct and conduct offensive, defensive and support air operations. This is how it was in the structure of the Spanish Air Defence Command and in most European countries, which had similar structures.

This was an Aircraft Warning and Control Network, directed from Combat Operations Centres (COCs) and in which operations were carried out from Sector Operations Centres (SOCs), which could have multiple associated Control and Reporting Centres (CRCs). SOCs and CRCs were necessarily sited next to surveillance and altitude radars (AN/FPS-20 and AN/FPS-6) so they could exploit their raw video and thus exercise surveillance and control of the airspace in their area of coverage. Inter-centre integration was limited to dedicated voice communications channels.



December 1964

The Aircraft Warning and Control Network, which until then had been operated jointly by the Spanish Air Force and USAF (United States Air Force) personnel, was transferred to the Spanish Government (Air Force Defence Command).

Since then, the Air Force has been bolstering the third level of maintenance, equipment and systems engineering, configuration control, together with an urgent and special supply channel, with highly qualified civilian technical assistance personnel.

A logistic support concept for the air defence system was thus implemented, which has proven to be highly effective and has achieved and maintains the highest levels of operational readiness. The company Servicios Técnicos de Electrónica SA (STESA), later EMAC and today part of Indra, participated in this achievement from 1 July 1965.

1974

Work began in 1974 on the **Combat Grande I** programme, the result of the **agreement between the Spanish and US governments** to improve the air defence system.

The contractor selected was COMCO Electronics, a joint venture formed by the US company Hughes Aircraft and the Spanish company Compañía de Electrónica y Comunicaciones (CECSA), also now part of Indra. In essence, the US company handled equipment design and software development and CECSA took charge of manufacturing a large number of subsystems, including more than 1,000 printed circuit boards and 60 equipment racks, along with installation and testing.

The planned investment in this first phase of the programme amounted to $50 million, with a proportion of 70% US and 30% Spanish. After the semi-automation process was completed, the new system was commissioned on 16 December 1977 and remained in service until it was decommissioned in 2004.

SOC Torrejón (1976)

The 70's

The second phase of the programme, **Combat Grande II**, began in the late 1970s with a view to improving radar coverage in northwest Spain and integrating surface-to-air missile (SAM) systems.

Computers Room COC/SOC Torrejón (1976)

The 80's

Upon completion of the Combat Grande II programme, the **Ministry of Defence Authorities decided to push for technological independence in the area of Air Command and Control**.

The first step was the renovation of the Canary Islands' obsolete air defence system. The **ALERCAN** programme thus spawned in the mid-1980s, replacing the Combat Grande IV programme. This system, dubbed SADAC, was developed by CESELSA (one of the founding companies of Indra), though it retained operational capabilities from the Torrejón COC/SOC, resulting from the Combat Grande programme. It was developed with the programming language ADA.

The ALERCAN programme covered the development and installation of new control consoles (CPR-95), together with the installation of a data extractor in the radars of the 21st Air Surveillance Squadron (EVA-21) at Pozo de las Nieves, Gran Canaria. The COC/SOC was also equipped with the capability to interface with anti-aircraft missile defence (SAM) systems.

EMACOT Air Defense Simulator (1993)

An identical system was installed in 1993 at the COC/SOC at the Torrejón air base as a backup for that system, and also at the then School of Transmissions at the Cuatro Vientos air base, today known as the School of Command and Control (EMACOT).

Lanza 3D Radar, from Lanzarote to the world

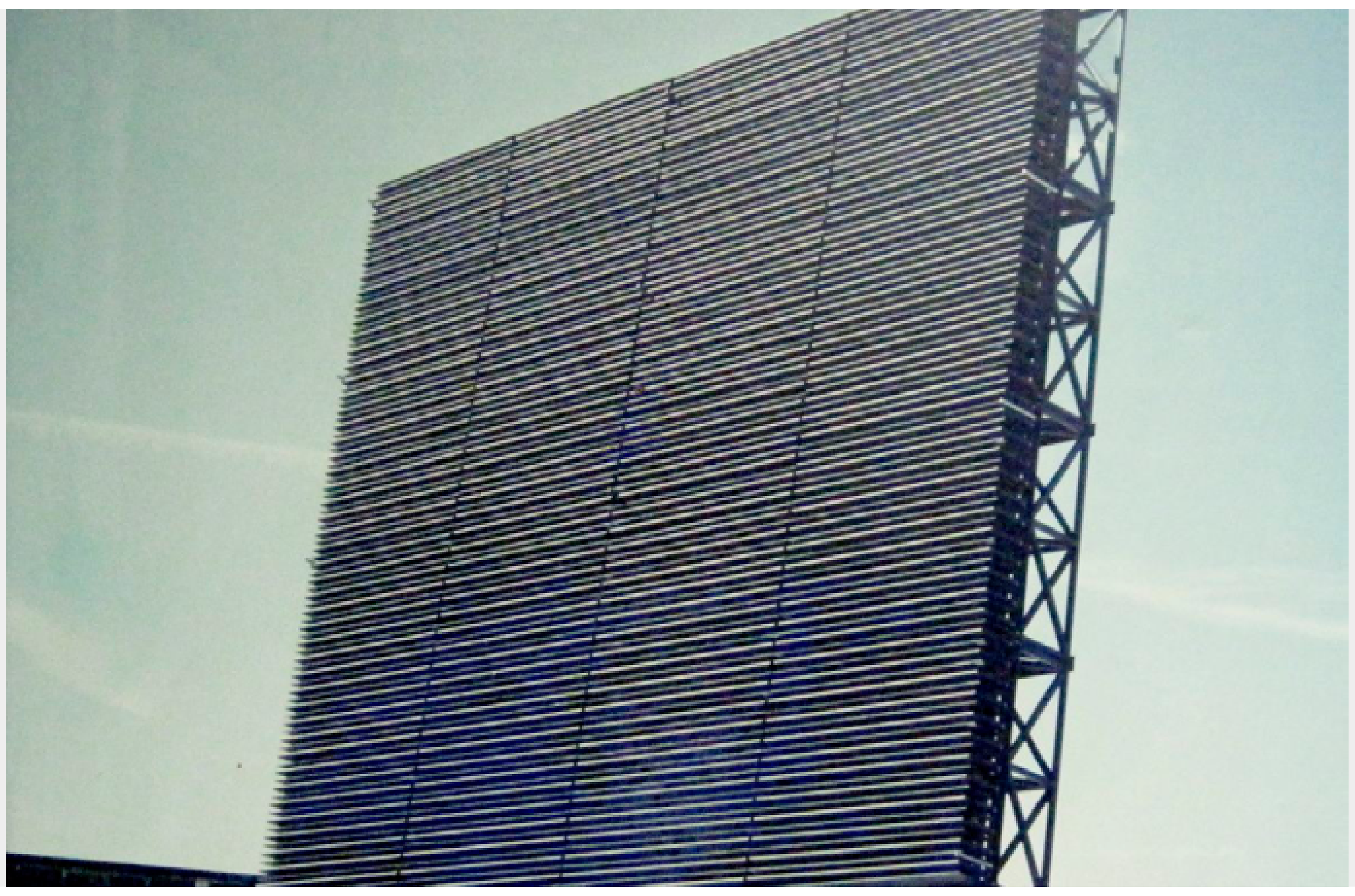
The Combat **Grande III** programmes to upgrade and modernise air defence command and control systems encompassed the **establishment of new long-range radar sites and the refurbishment of existing ones**.

On the Canary Islands, Combat Grande IV, later renamed ALERCAN, responded to the need to install a **24-hour long-range radar** to replace the mobile tactical equipment AN/TPS-43, which had been installed on the island of Lanzarote as an emergency solution.

The new radar was initially intended to be purchased on the international market. However, the technological capacity of Spanish industry in this field, demonstrated in the execution of the ALERCAN programme, in civil aviation programmes and in the maintenance of air defence system radars, led the Spanish Air Force to propose to the Ministry of Defence in November 1985 the **development in Spain of three-dimensional long-range radar equipment**. This proposal was supported by the feasibility study initiated in 1984 by the company CESELSA, now Indra, on its capability to **develop and manufacture a long-range three-dimensional radar**, in the context of the company's so-called Gaviota project.

The project called for the Air Force to draw up operational, technical and functional requirements, which was done between November 1985 and February 1986. In April 1986, the Ministry of Defence awarded CESELSA the contract to develop the first prototype. This is how a **private company such as CESELSA, committed itself to innovation, increasing national added value and making Spain a country capable of building radars** and other systems with its own technology with the same level of quality as the large multinational companies.

A highly complex project such as the development of the three-dimensional long-range radar required a joint company/air force effort. The project was initially planned in two phases. The first, in turn, had two stages: **the preliminary design and development of a laboratory model** with a five-row antenna out of the 48 contemplated in the operational prototype design. **The second phase consisted of the production of an operational prototype**. The programme was renamed **Lanza 3D Radar** because of its planned installation on Lanzarote.



3D Lanza (1989)

A deal was signed by the Ministries of Defence, Industry and CESELSA to finance the project. The company contributed 1.2 billion pesetas . However, to demonstrate that the company was capable of supplying all the radars, CESELSA opted to convert the laboratory model into a fully functional prototype, increasing the cost of development by nearly 2,000 million pesetas to meet the increased budget.

The Air Force validated the laboratory model in **1991**, a prerequisite for the award of the serial radars, but the contract for ten (10) radars was delayed by two factors: mainly due to budget cuts and new operational requirements arising from Spain's participation in the Atlantic Alliance.

3D Lanza (1991) CEAR Guadalajara

In parallel to the ALERCAN and Lanza programmes in Spain, NATO began to define a programme that basically involved the evolution of an air defence-only system into an Air Command and Control System (ACCS), which would also allow for the planning and conduct of both offensive and support air operations. The Air Force adopted NATO's new doctrine and requirements in 1989 and began **modernising its air defence** system through a new programme referred to as SIMCA (Air Command and Control System), the successor to Combat Grande. The integration into the NATO Command and Control Programme and the endorsement of its requirements led to an internal Air Force analysis of the introduction of these NATO Class I radar requirements into the Lanza 3D programme, with the greatest impact coming from the transportability requirement. Eventually, the Air Force took the decision in mid-1992 to apply NATO specifications to the contract for 10 Lanza 3D radars. This decision had an impact on the company's strategy to convert the operational prototype into a NATO Class I radar.

In October 1993, the Council of Ministers authorised the award of the contract for the acquisition and installation of ten mobile Lanza 3D radars and transportation systems for four units to CESELSA-INISEL S.A. (Indra). The first series unit, the second-generation Lanza 3D radar, was installed in 2001 in the 11th Air Surveillance Squadron in Alcalá de los Gazules, one of the squadrons newly created by the Air Force's SIMCA programme. Associated with the primary radar, these radars were equipped with the Monopulse Secondary Radar Interrogator IRS-20M, also developed by Indra.

New versions

Developments of the third-generation Lanza 3D long-range radar began in 2000 with the aim of maximising the use of COTS (Commercial Off-The-Shelf) components and open architecture, thereby simplifying maintenance and operation compared to the previous two generations. A new, more powerful processor was added to increase the ability to run more complex signal processing algorithms.

3D Lanza (2001)
Air Surveillance Squadron Nº 11
(Alcalá de los Gazules)

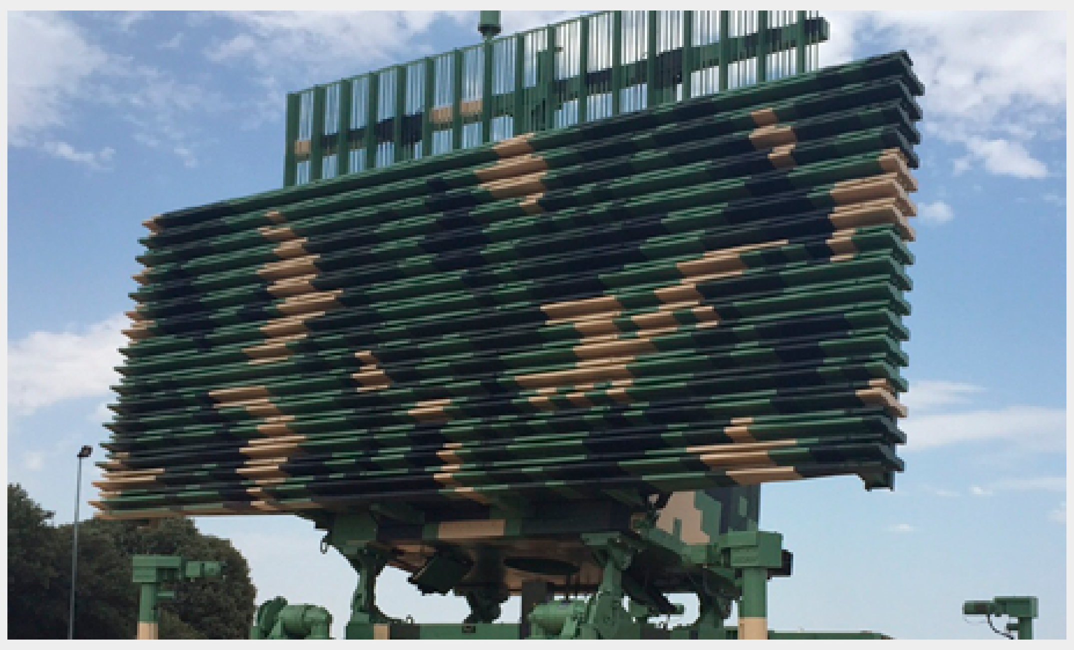
3D Lanza (2002)
(Transportable Configuration)

3D Lanza (2009) FADR

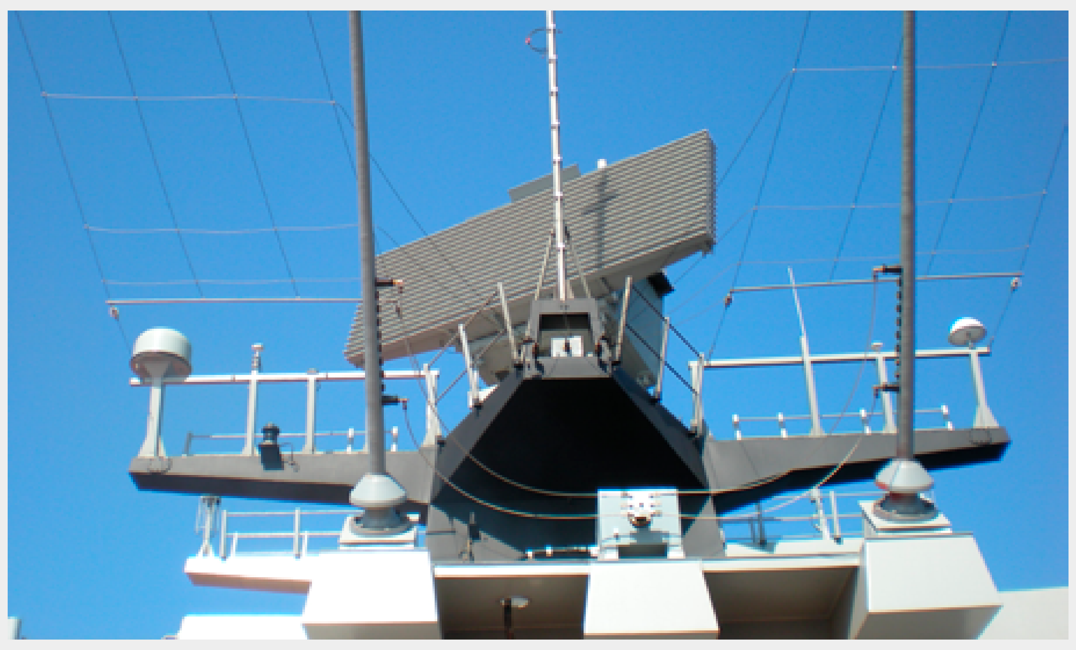
Additional members were subsequently added to the Lanza 3D family of radars. One example is **Lanza MRR, a medium-range tactical radar** with versions whose instrumented ranges reached 180 and 200 nautical miles (nm), and different gapfiller versions (instrumented range: 60/80 nm). The modernised, production version of this radar is currently known as the **LTR-20**.

A naval version of this radar (Lanza 3D-N) was also developed following an initial commission from the Spanish Navy. This radar is in operational service on the Spanish Navy's Juan Carlos I L61. Similarly based on this radar, the **PSR-3D** is in production as a dual-use radar for air defence and approach and en-route air traffic management. In this radar, military-specific capabilities such as frequency agility and Electronic Counter-CounterMeasures (ECCM) are not part of its base configuration, while others, such as redundancy of its main subsystems, have been added to meet ICAO requirements.

3D Lanza MMR (2008)



3D Lanza LTR-20 (2018)



3D Lanza Naval (2009) (L61 Juan Carlos the 1st, Spanish Navy)

The development of the mobile tactical version of the Lanza 3D long-range radar was initiated in 2012, taking into account both NATO requirements for deployable air defence radars and Air Force specific requirements. The development was carried out within a Public Innovative Procurement programme of the Spanish Ministry of Defence with the support of the Centre for the Development of Industrial Technology (CDTI).

The LTR-25 is part of the fourth generation of Indra's L-band 3D radar family and incorporates a major technological leap. The LTR-25 integrates electronic radar beam pointing; on-antenna data digitalisation; monopulse elevation and azimuth technique; anti-clutter capability; the latest signal processing technologies; short- and medium-range tactical ballistic missile detection and tracking capability; and a design that facilitates and reduces the cost of maintenance. It also incorporates the latest advances in Digital Beam Forming (DBF) and therefore falls into the **smart radar category**.

3D Lanza LTR-25 (2017) CEAR Guadalajara

In parallel to the LTR-25 primary radar, Indra developed the **IFF INT2000**, which **features the most advanced capabilities in this type of radar**, such as, in addition to the traditional modes, mode 5 (with AIMS certification, Air traffic radar control beacon system, MKXIIA Identification Friend or Foe (IFF) System, from the US DoD AIMS Program Office) and mode S.

The Lanza 3D radar exemplifies Spain's technological and industrial capabilities for protecting the interests of Defence and National Security. It currently operates in countries on five continents

State-of-the-art radar technology

The Lanza 3D family of radars is constantly undergoing further developments and refinements to become one of the most advanced radars on the market. Consequently, Spain now has its own technology that is strategic for its defence and sovereignty.

All this work has been key to making Indra one of the world's leading manufacturers of radars, applied not only to the defence sector, but also in the field of mobility and air traffic. The company has one of the largest radar factories in Europe in the Community of Madrid (CoM), spanning over 7,000 square metres and employing 200 specialised professionals.

The protection of European airspace, the survival of the Eurofighter and the ships of several navies, and even the protection of satellites in orbit depend on the company's mastery of this technology. With over four decades of experience in developing these systems, Indra has exported its radars to the five continents and is NATO's main supplier. It has also developed one of the most powerful radars in Europe and the world, capable of detecting objects in orbit more than 2,000 kilometres above the earth, and is responsible for protecting launches, satellites and the international space station.

Air Command and Control Centres

The 1990s ushered in a major doctrinal change in air operations and air defence systems, which became **air command and control systems** with the integration of capabilities for planning, directing and conducting offensive, defensive and support air operations.

At the level of real-time tactical control, **ARS entities, command, surveillance, identification and control centres** were created. The ARS, in either stationary or deployable (ARS-D) configuration, is capable of decentralised air defence execution and airspace control, including support to offensive air operations in its assigned area of responsibility. These activities are carried out through surveillance, identification, weapons control, airspace control and tactical data link management. The ARS comprises:

- **Air Control Centre (ACC)**, which manages the air battle in real time, performing air mission control of manned and unmanned aircraft and SAM systems. The ARS may also provide Air Traffic Control (ATC) services
- **RAP Production Centre (RPC)**, which produces and distributes a reliable air situation representation (RAP) and manages its subordinate surveillance assets
- **Sensor Fusion Post (SFP)**, which performs data fusion from assigned sensors to obtain local traces, remotely manage sensors and respond to anti-radiation missile threats and electronic countermeasures activity

IARS Zaragoza (2001)

Towards the end of the 1990s, the Air Force adopted the doctrinal concepts derived from NATO's ACCS programme, mentioned above, and took the decision, through the SIMCA programme, **to implement command and control centres with ARS functionalities**, also equipping them with a modern ground/air/ground communications management system. This decision took shape for the first time with the contracting of the newly created **IARS ("Interim ARS")** to the company Indra, to be installed at the Zaragoza air base, entering into service in 2001. This development was replicated in 2003 to replace the COC/SOC installed by the ALERCAN programme at Gando air base and then in 2005 to replace the COC/SOC at Torrejón air base, installed by the "Combat Grande" programme.

IARS Gando (2003)

IARS Torrejón (2005)

IARS Simulator EMACOT (2003)

In order to facilitate command and control training for intercept controllers and command and control operators, an ARS simulator was installed at the Air Force Command and Control School (EMACOT) at Cuatro Vientos air base.

Tactical data links

The new air operations doctrine resulted in an **operational employment concept based on the use of tactical data links** to ensure proper integration of the new air command and control entities with each other and with the various air platforms (fighters, AWACS, air-to-air refuelling, maritime patrol, etc.), naval and SAM systems. Therefore, in the early 2000s, Indra boosted the development of these capabilities.

The first steps were the **integration of Link11A into IARS entities**, in a native way, i.e. without requiring any buffering, which reduces operational capabilities (SSSB type, Ship Shore Ship Buffer) and allowing the use of all Link11A functions (maritime operations support, network management, remote media control, etc.).

The Link16 capability was a major challenge for the company, in collaboration with the Spanish Ministry of Defence. Three key areas were addressed: MIDS LVT terminals, Equipment Suite for the operation of these ground terminals and the integration of the Link16 capability of IARS entities.

With regard to MIDS (multifunctional information distribution system) terminals, the company is part of the **international MIDSCO consortium** (created by the United States, France, Italy, Germany and Spain) and has been involved from the outset in the **development of the MIDS LVT (Low Volume Terminal) specifications**. It has a 25% stake in the MIDS LVT EuroMIDS terminal. An Equipment Suite was also developed for installing MIDS LVT terminals on the ground.

In parallel, integration of Link16 capabilities in IARS entities entailed two phases. The first of these, known as **Basic RPC**, independent of the IARS, but **with the capacity to exchange RAP with it**, consisted of three subsets: the software processes that implement the bulk of the functionalities; the human-machine interface and, finally, the management of the MIDS LVT terminals. This first phase, including ES and MIDS LVT terminals in different Air Force radio/radar settlements, **entered service in 2006 in the three IARS entities in Spain**.

Deployable IARS (2007)

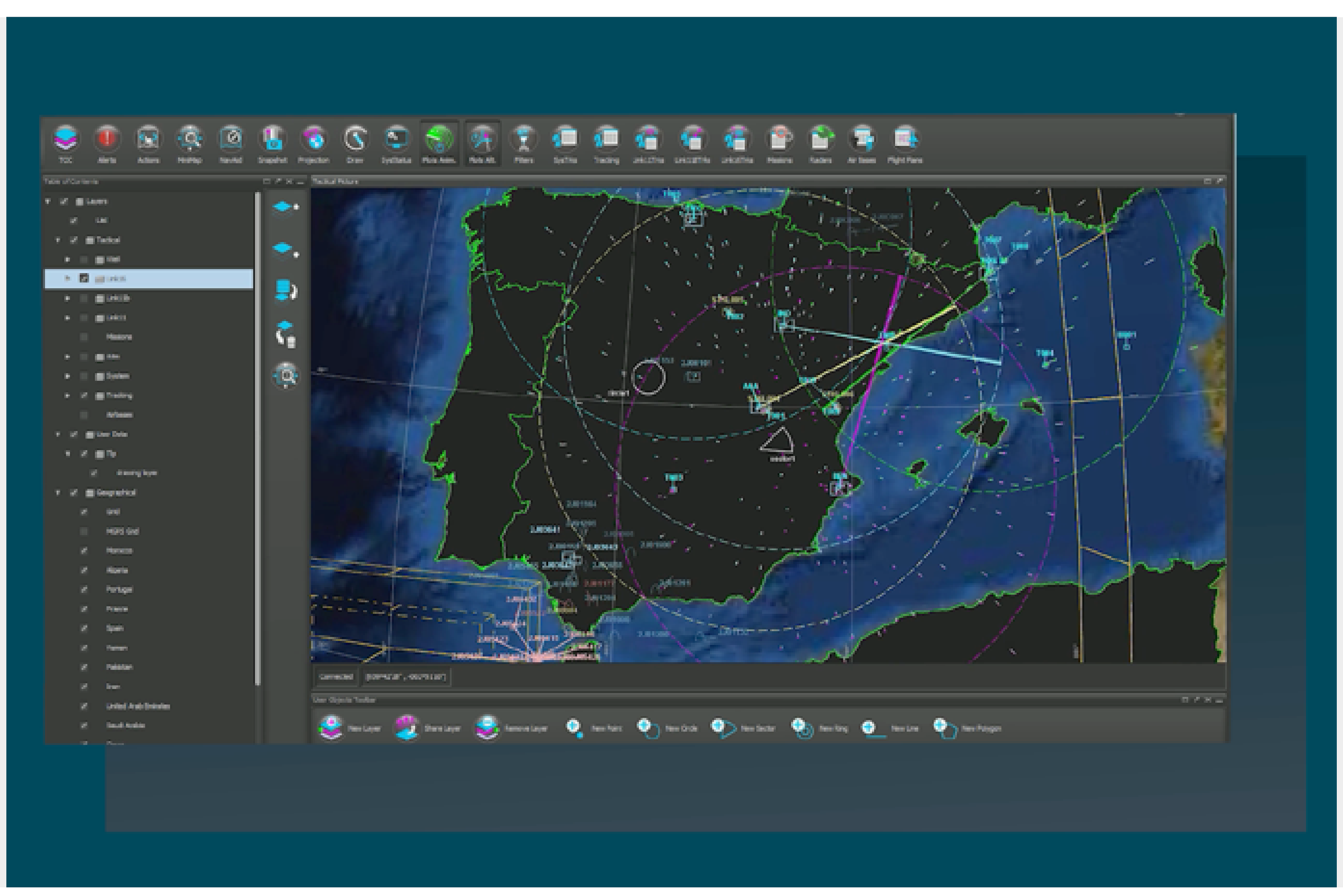
The **second phase**, which is still ongoing, consists of the **native integration of all Link16 functionalities**, including those related to Ballistic Missile Defence (BMD), **into the IARS entities**. This capability is described in more detail below, when discussing AirDef, the latest development of the AOC and ARS entities' venture.

In 2007, the Air Force's deployable command and control component was significantly enhanced with **Indra's supply of a deployable IARS**.

AirDef: Indra's next-generation system

The latest development in Air Operations Centre (AOC) planning and real-time execution (ARS) level command and control centres is the **AirDef system**, **designed by Indra to meet NATO ACCS functionalities** and ensure interoperability with NATO Air Command Structure CAOCs and its contribution to the NATO Integrated Air and Missile Defence System (NATINAMDS) with an essential and continuous mission, in times of peace, crisis and conflict, to safeguard and protect Alliance territory, populations and forces against any air or missile threat or attack.

In the planning phase, it can generate Air Tasking Orders (ATOs) and Airspace Control Orders (ACOs), and also export/import them via the ADatP-3 standard. In short, **it provides the required functionalities at the AOC level**.



AIRDEF (2018)

It is also **capable of providing the functionalities required for the ARS to fulfil its mission**, both in terms of sensor fusion, generation of the reliable Recognised Air Picture (RAP) and the control of air missions, and in all aspects related to operational security, including procedures and tools to neutralise and control cyberthreats. It also has the most advanced simulation functionalities.

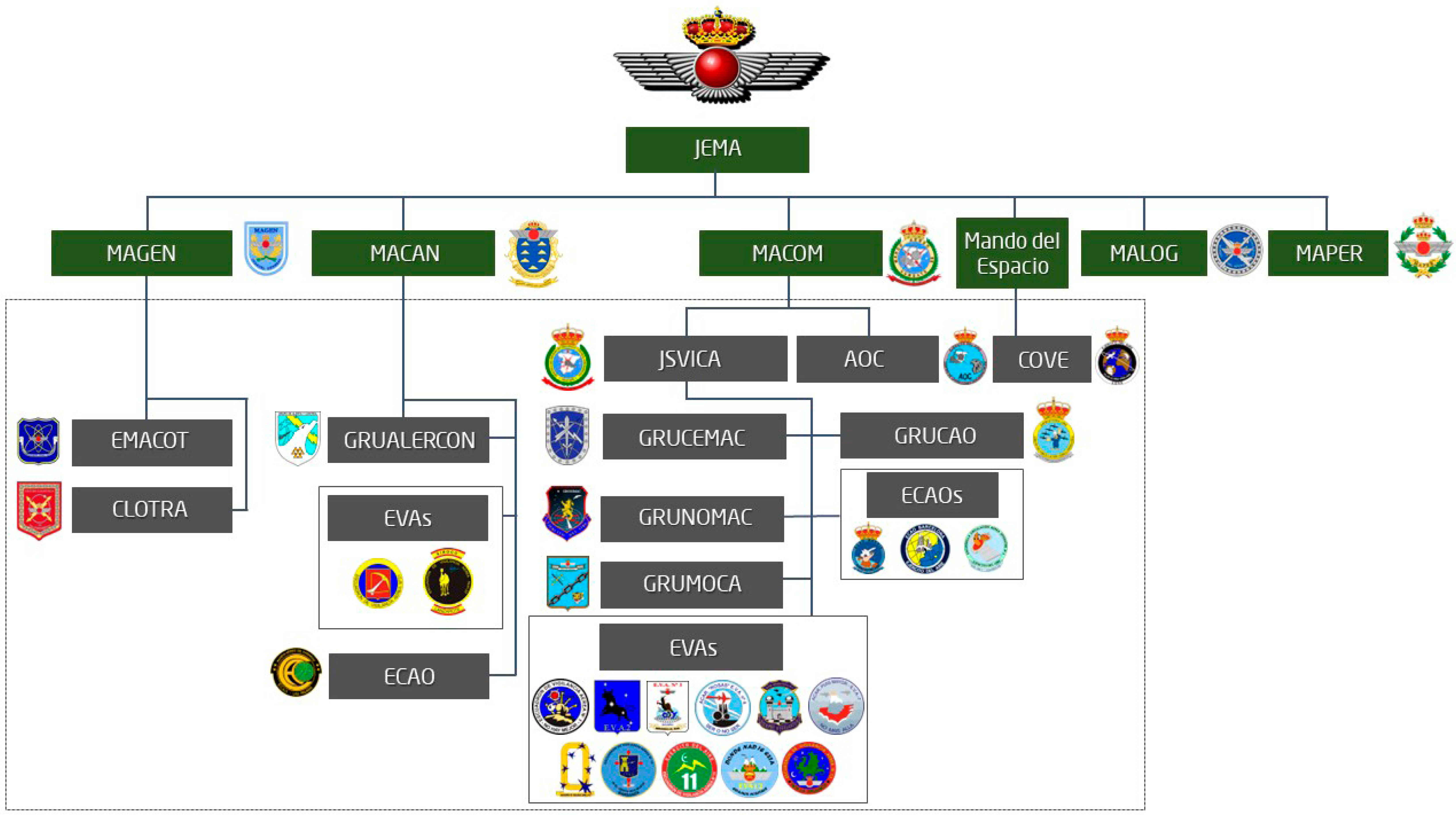
The AirDef system is capable of integrating all types of data, including information from a wide range of sensors, intelligence and civilian traffic. This information is integrated using standard protocols: ASTERIX, MIL-ASTERIX (AWCIES) and ADEXP. AirDef natively integrates the following tactical data links: Link 11, Link-22, Link 11B, Link 16, JREAP and VMF (under development).

The Ministry of Defence awarded Indra a contract in December 2022 **to modernise and update the command, surveillance, identification and control centres (ARS Systems)**, entities that contribute to the permanent mission of the Air Force and Air and Space to monitor and control national sovereign airspace.

With this project, the Ministry of Defence once again relies on Indra's solutions for its system, as it did at the end of the 1990s with the IARS system, which is currently in service at GRUCEMAC (Torrejón de Ardoz), GRUNOMAC (Zaragoza), GRUALERCAN (Gando, Gran Canaria) and the School of Command and Control (EMACOT).

The latest generation AirDef command and control system, together with Indra's Lanza 3D radars in the Air Surveillance Squadrons (EVAs), form the backbone of the surveillance and control of Spain's sovereign airspace.

With the implementation of AirDef in the Air Operations Centre (AOC) of the Aerospace Command (AC), missile defence can be managed by integrating TBM-capable sensors (Lanza 3D LRR and LTR-25) and tactical data links with missile weapon systems. AIRDEF will also provide the AOC with a NATO-interoperable tool to generate the ATOs and ACOs required for planning area operations.



Meeting Alliance requirements and becoming **one of the most advanced command and control systems in operation in NATO countries** opens up the possibility for other nations to adopt Indra's technology, in line with the Spanish Ministry of Defence's decision.

The new AirDef system has been designed to meet NATO's demanding air command and control requirements, thus enhancing its contribution to NATO's Integrated Air and Missile Defence System (NATINAMDS) and potential adoption by other NATO countries

Together with AIRDEF, the project includes the installation in the ARS of the **GAREX-300M** communications management and remote control system for ground/air radios, which introduces new software and hardware architectures with separate classified and unclassified (red/black) communications, and IP technology.

This new system is currently being implemented at the Combined Air Operations Centre (CAOC) of NATO's air command structure (CAOC) in Uedem, Germany.

This system is **the latest generation technical solution for voice communications systems (VCS) for air command and control centres**, which had as its antecedents those installed in the IARS entities of Zaragoza, Gando and Torrejón, as well as in the deployable IARS and later in the VCS of the ARS ACCS of Torrejón (the first Indra VCS included in the NATO inventory).

Leading technology on a global scale

In addition to further strengthening Spain's air defence and placing it at the forefront, the modernisation and upgrading of the command, surveillance, identification and control centres reinforces **Indra's position as one of the most advanced defence engineering technology companies in Europe and the world** and as a leader in digitalisation of the sector.

The Ministry of Defence's decision in the mid-1980s to have strategic autonomy in the radar and command and control areas has had a very positive impact on Indra's technological capabilities. From collaborating with US companies in the manufacture and installation of equipment for the first modernisation in the 1970s, it has moved on to a high degree of technological independence in areas such as radar, communications and command centres.

Indra is proud of our key contribution to this strategy, enabling us to achieve commercial successes in the radar and air command and control area in countries on five continents which, in addition to providing the necessary stability, have placed the company in a competitive position never before achieved, in which technological innovation and the ability to take risks has been the key factor.

Indra reserves the right to modify these specifications without prior notice

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