

# StaGeDiS project

## Starter/Generator Disconnect System for more S/G connected to main engines of more electrical aircraft.

### Background

*This project, named as StaGeDiS (electrical **Starter / Generator Disconnect System**) and developed by the consortium CT-Ingenieros and Indra Sistemas, has answered the topic-call of the “JTI-CS-2013-03-SGO-02-052” which is inside of the call16 of the FP7 of the European Commission*

*The StaGeDiS project has established a new conceptual designs for a dual-use over a starter/generator disconnect system.*

*In the scope of new generation aircrafts where it is required higher level of electrical power and leading to an increase in weight and volume of the electrical machines, it is important to compensate this increase of weight and volume by optimization of the aircraft systems. So, the generator shall be able to operate as an electric starter also, eliminating the need of pneumatic starter over the combustion engines (main engines and APU).*

*But in any case, due to safety reasons, the starter/generator requires a disconnection system to protect the machines and engine gearbox in case of a mechanical failure in one of them, especially in over the main engines, due to the catastrophic effect if all engines are damaged.*

*Most of current aircraft main engines are fitted with electrical generator and pneumatic starter. And the current safety disconnect system between generator and engine gearbox, where available, are mechanical fuses and/or clutching devices designed to transmit torque only in one rotating direction.*

*The electrical machine proposed in this CfP replaces the separated starter and generator machines by only one starter/generator (S/G) device which is able to work in two operational modes:*

- Mode 1: starter to start the aircraft engine,
- Mode 2: generator to give electrical energy to the aircraft.

*So, this disconnection system expected for this kind of new electrical machines shall be able to separate mechanically the gearbox from the starter/generator with the electrical machine operating whether as starter or generator according to initial requirements. Moreover, according to aeronautic requirement, the expected new disconnection devices shall comply with at least the same levels of performances, weight, dimensions, integration, safety, robustness, reliability, maintainability and operability that the current and legacy disconnection systems, and if possible to improve all or some of these requirements.*

*Along the project, different technologies and architectures have been studied, evaluated and compared in order to define a proper disconnection system. Criteria of compactness, weight reduction and conformity with harsh aeronautic engine environment were also taking into account, as very important part of these studies to ensure and maximize the compliance with those previous requirements.*

*And at the end of the project a deep compatibility study was performed to confirm these compliances under studies and simulations and also a preparation of a required test campaign was done to ensure its future verification under a potential prototype.*



## Objectives

The main objectives requested for this disconnection system were to be able to separate mechanically the gearbox from the starter/generator, with the electrical machine operating whether as starter or generator.

This system was expected to be commanded by an electrical pulse.

## Description of work

Both companies building the Consortium had experience in aeronautic system engineering. CT-Ingenieros working as consuler for several aircraft systems as APU, Bleed and hydraulic systems. And other hand, Indra has a vast experience in the design and manufacturing of aeronautic equipment's and systems, as electrical/electronic as mechanical ones.

Moreover, both companies have also a vast experience in other mechanical applications over ground and sea transports.

Then, due to this aeronautic experience (aeronautical requirements, current limitation and problems in this kind of system, potential improvements,...), due also to their global mechanical knowledge and finally, as not less important, due to the good previous relationship between both companies, it was decide to bet about this proposal, in order to find a challenge device capable to answer all these necessities.

To note that previously to the presentation of this project proposal, the consortium did a preliminary review of the state of the art over this kind of systems, in order to propose some first approach ideas of solutions for this proposal, to achieve the objectives requested for this project.

Once, that the project proposal was ranked by the independent experts committee, the project, was started and developed under an structure of eight work-packages. Six work packets were defined for technical aspects (RTD) in a sequential way, and two additional ones, were developed in parallel and along the project to cover the activities of dissemination & exploitation and the activities of coordination & project management.

So, a short description of the activities done under each of these WPs were:

### - First work package

This first working period was based in the analysis of the system requirements in order to further define the applicable technologies for the potential solutions.

It was very important in this first period to identify the existence of any preliminary show-stopper in the requirements. The resulted requirement specification of the analysis were reviewed, agreed and consolidated, in order to be used as input for the following working periods of the project.

### -Second work packages

The purpose of this working period was to define the potential solutions for the starter-generator disconnect system taking into account the requirements analyzed in the previous period.

A deep State Of the Art analysis (SoA) was done, as key aspect for the success of this period and the project in general. Existing mechanisms and active patents applicable to the potential solution were identified and analyzed. After this analysis, a certain number of potential solutions were outlined for the subsequent working periods. In a first moment, three potential solutions were pre-selected.

### - Third work package

Once the requirements were consolidated and these several possible solutions defined, the different criteria of selection were defined according to aerospace industry TRL methodology.

Moreover, during this phase, it was noted other opportunities not taken into account previously, so, two additional solutions were identified, treated and included in the criteria and pre-selection list.

### - Fourth work package

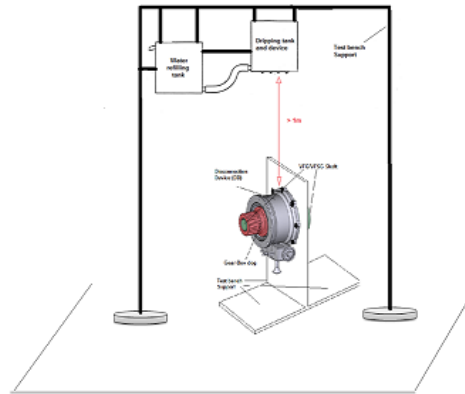
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#### - Fifth work package

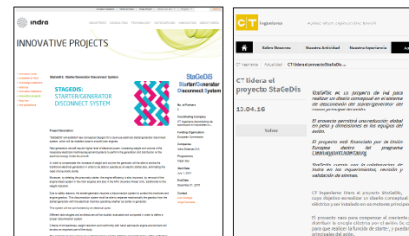
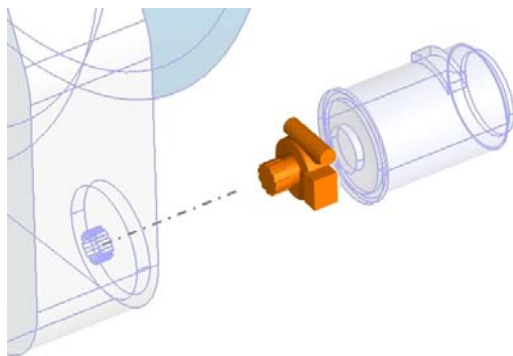
The selected design progressed through the Critical Design Review level (CDR). The conceptual design of the selected solution was developed to its final system design, equivalent to a readiness level of TRL3.

The system was dimensioned to fulfill the consolidated requirements. And when the detail design was available, several studies were performed to demonstrate the compatibility of the resulting design with mechanical, electrical, thermal and fluidic environment, leading in same case to several loops of adjustments in the design to optimize the final design and get the maximum compatibility level.



#### - Seventh work package

This WP was used to plan and report the dissemination and exploitation derivative activities from this project.



#### - Sixth work package

Following to the resulting system design, it was defined a verification and qualification tests plan to be applied in the future over a real prototype, including, functional and environmental applicable requirements, tests setup, tests sequence and tests procedures. As commented before, Project Management and Dissemination & Exploitation activities were performed in parallel to the technical development activities along the entire project timeline. So additionally to these technical WPs, two other transversal WPs were performed along the project.

#### - Eighth work package

This final WP was used to cover the activities of project management and consortium coordination over this project. To note that coordination activities not only included internal coordination of teams and partners of the consortium but also relationships and communication with the Topic Manager and with the CSJU.



At the end of the project, all these project information has been reported for its validation and acceptance.

## Results

As a result of the work done during the project, the main expected results in the development for the new disconnect device were:

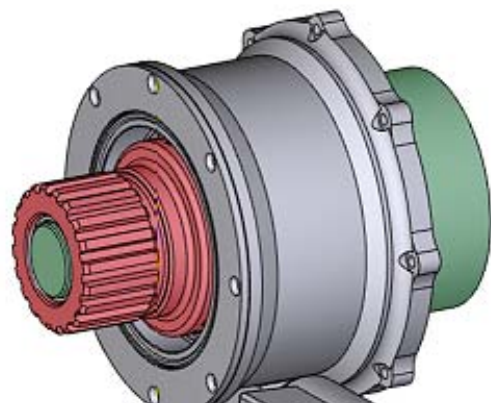
- An innovative disconnect system solution that fulfills all the requirements specified.
- A design that minimizes the risk of uncommanded disconnections and avoids accidental reconnections.
- A system compatible mechanically and environmentally.
- A system capable to operate in both directions of torque transmission.

And at the end of the project, the Consortium can confirm that all these objectives have been achieved and validated over the proposed solution and final design developed, as it can be confirmed through all the documents and deliverables performed by the Consortium and reviewed by the Topic Manager.

Moreover, some additional results and impact that have been achieved through this project and that are put in advance by the current proposed design are:

- Disconnection System with the capability to operate with different torque transmission directions and that makes the system suitable for forthcoming More Electrical (MEA) & Full Electrical Aircraft (FEA) architectures.
- Applicable in future MEA & FEA architectures for electric generators connected to power-plants, both propulsive and non-propulsive.
- Use as connection / disconnection system over bidirectional electrical machines, as starter / Generators.
- Improvement of the reliability and robustness against the current systems.

- Improvement of the aircraft operability by capability to perform system tests in advance to a failure. And also better accessibility and re-engagement of the system.
- Possibility to use this solution in an integrated equipment or isolated or remote application.
- Consolidation of the Consortium build by CT-Ingenieros and INDRA to perform additional project and apply the concept and lesson learnt over potential opportunities, and get synergies between both companies.
- To propose alternative to the current disconnection devices, and not only over new topologies with S/G but also in legacy architectures with generators only. It is important also to comment that most of the legacy solutions are based in American Patents, and this could be an alternative over the current monopoly in some of these solutions.
- Finally to comment that this solution could be applied to other markets, as general industry and ground transport if not applied yet. Perhaps similar solution could be already applied in these other markets, but the current solution presented in this project could improve aspect over the ones potentially available in other markets, due to the restricted and harsh requirements in this aeronautical application (reduction of weight and volume, lifetime and robustness, working performances under 32500rpm,...)



### **Project websites**

*It is important to highlight again that all these points has been achieved at the end of the StaGeDiS project.*

*And the idea is to get additional funding to develop a real prototype and to test it and in parallel to explore the possibility to apply this solution/concept over some projects and/or applications.*


<http://www.thectengineeringgroup.com/index.php/evento/ct-lidera-el-proyecto-stagedis/105>

<http://www.indracompany.com/en/sostenibilidad-e-innovacion/proyectos-innovacion/stagedis-startergenerator-disconnection-system>



# StaGeDiS project

Starter/Generator Disconnect System for more S/G connected to main engines of more electrical aircraft.

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### CT leads StaGeDiS project

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StaGeDiS is a Research and Development project that will produce a conceptual design for the starter/generator disconnect system in main aircraft engines. The project aims to achieve a global reduction in weight and dimensions of aircraft systems. The project is framed within the programme Clean Sky.

CT Ingenieros leads the project StaGeDiS, whose goal is to complete a conceptual design for a dual-use electrical starter/generator disconnect system to be installed in the main engines of an aircraft.

This project was created to compensate for the growing weight and volume of the necessary equipment that is needed to generate and distribute the electrical energy inside the aircraft. Following this line of thinking, the project works to evolve traditional generators so that they can operate as an electrical starter as well, and can eliminate the need for a pneumatic starter system.

Stagedis project analyzes, studies, and compares the different technology and architecture that can optimize this new system in the aircraft. In doing so, the project seeks solutions to achieve a global reduction in weight and dimensions, an increase in the reliability and security of the system, and approaches to make the system more easily maintainable—thus reducing maintenance time and costs. The selected solution will carry out a detailed design, complete with the appropriate definition and methodology for the verification and qualification tests.

The project relies on the collaboration and wide experience of Indra for the design of on-board equipment. The reason for this partnership is due to their comprehensive expertise in the definition of system requirements, system evaluation and system validation.

StaGeDiS, with expedient nº PT-641503, has been co-financed by the European Commission through "CleanSky Joint Undertaking" within the 7<sup>th</sup> Framework Programme of the European Union (FP7) 2007-2013.

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### StaGeDiS: Starter/Generator Disconnect System

## STAGEDIS: STARTER/GENERATOR DISCONNECT SYSTEM



**StaGeDiS Starter/Generator Disconnect System**

**No. of Partners**  
2

**Coordinating Company**  
CT Ingenieros Aeronáuticos de Automoción e Industrias S.L.

**Funding Organisation**  
European Commission

**Companies**  
Indra Sistemas S.A.

**Programmes**  
Clean Sky

**Start Date**  
July 1, 2010

**End Date**  
December 31, 2016

**Contact**  
Luis Verdugo  
Jorge Carmona

**Project Description**

"StaGeDiS" will establish new conceptual designs for a dual-use electrical starter-generator disconnect system, which will be installed close to aircraft main engines.

New generation aircraft requires higher level of electrical power, increasing weight and volume of the necessary electrical machines/equipment/systems to perform the generation and distribution on the electrical energy inside the aircraft.

In order to compensate this increase of weight and volume the generator will be able to evolve the traditional electrical generators in order to be able to operate as an electric starter also, eliminating the need of pneumatic starter.

Moreover, by deleting the pneumatic starter, the engine efficiency is also improved, by removal of the engine bleed system in the main engines and also in the APU (Auxiliary Power Unit) additionally to the weight reduction.

Due to safety reasons, the starter/generator requires a disconnection system to protect the machines and engine gears. This disconnection system shall be able to separate mechanically the gearbox from the starter/generator with the electrical machine operating whether as starter or generator.

This system will be commanded by an electrical pulse.

Different technologies and architectures will be studied, evaluated and compared in order to define a proper disconnection system.

Criteria of compactness, weight reduction and conformity with harsh aeronautic engine environment will be also an important part of this study.

The selected solution will require a detailed design and the definition and methodology of the verification and qualification tests.

## Project Summary

Acronym : [StaGeDiS](#)

Name of proposal: [Electrical Starter /generator Disconnect Systemt.](#)

Technical domain: [Power Generation](#)

Involved ITD: [ITD-SGO](#)

Grant Agreement number: [641503](#)

Instrument: [Clean Sky JU](#)

Total Cost: [565600€](#)

Clean Sky contribution: [282800€](#)

Call: [SP1-JTI-CS-2013-03\\_ITD-SGO-02-052](#)

Starting date: [01/07/2015](#)

Ending date: [31/12/2016](#)

Duration: [18 months](#)

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- Partner: [Indra Sistemas, S.L. \(INDRA\)](#)