SAvE

Systems for UAV Advanced Alternative Energy

A: Aero
S: Space
S: System
E: Engineering
T: Team

AleniaAeronautica
Una Società Finmeccanica

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THE SAvE PROGRAM: A TECHNICAL CHALLENGE, AN INTERESTING OPPORTUNITY FOR EDUCATION

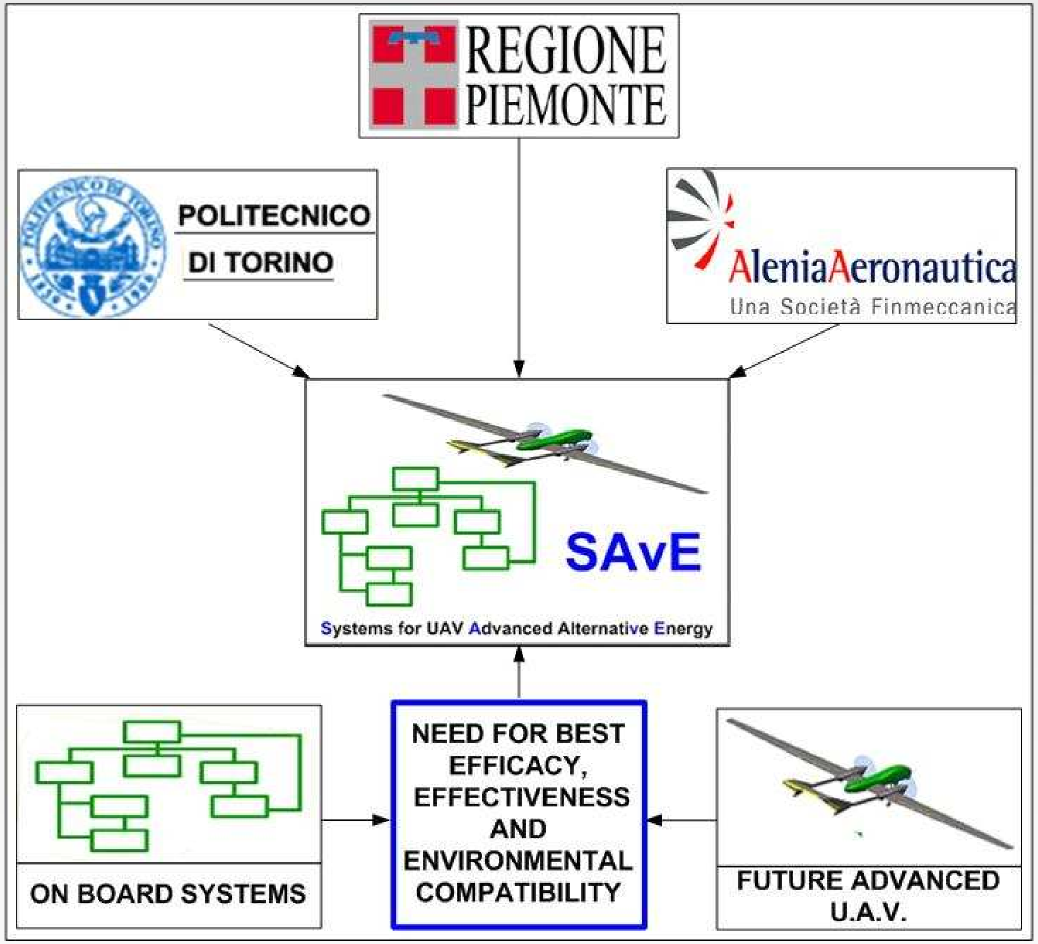
* POLITECNICO di TORINO, **ALENIA AERONAUTICA

EWADE on the Web

www.AircraftDesign.org

Sevilla, May 13th, 2009

Partners, topics and goals of SAvE (Systems for UAV Alternative Energy) research program



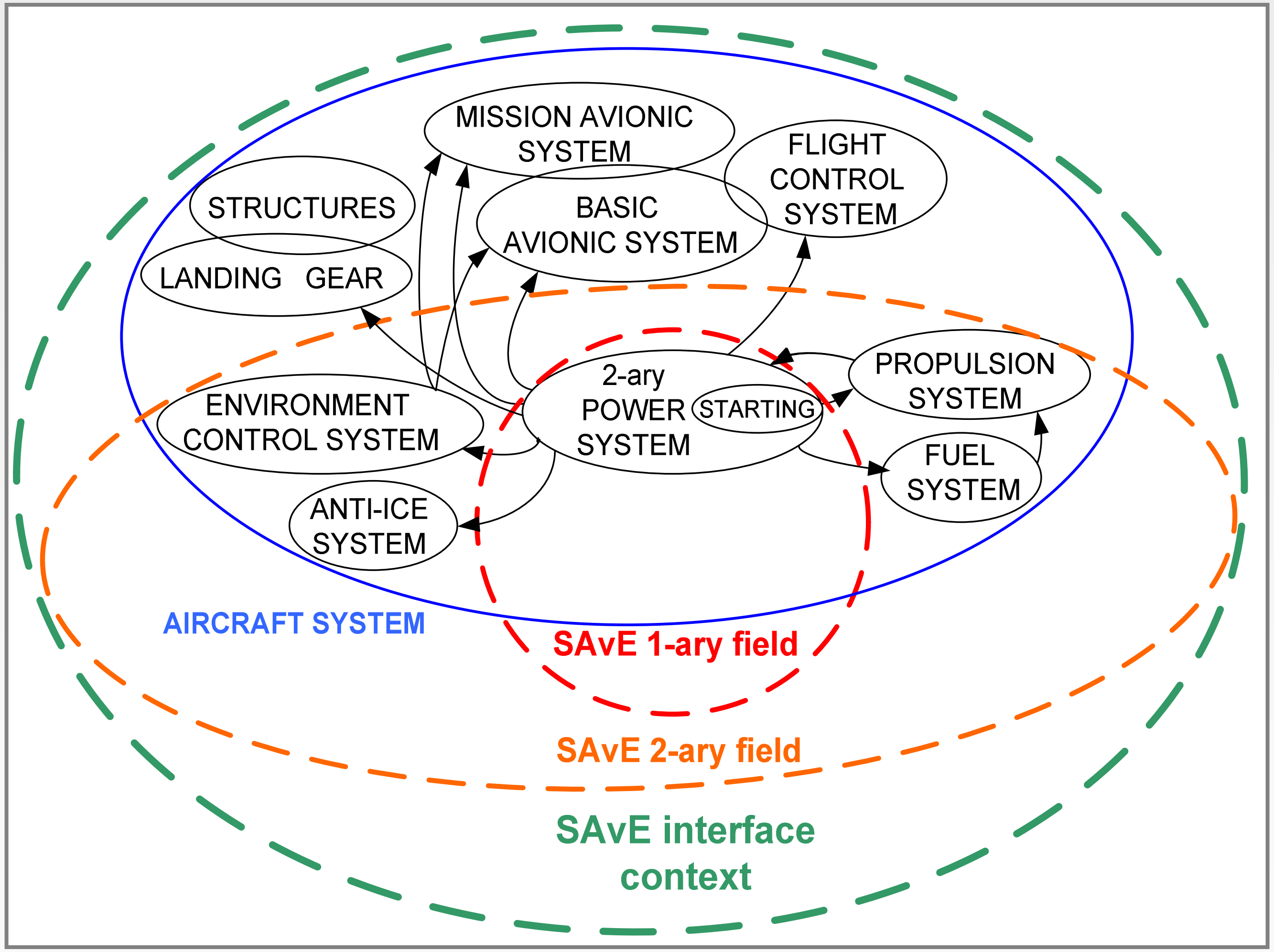
MALE and HALE UAVs are particularly critical from the energetic standpoint, because they have to meet the requirement of flying continuously, for many hours at high altitude. New efficient solutions have therefore to be elaborated both for the Propulsive Power and the Secondary Power

Alenia Aeronautica "Sky-X"

Alenia Aeronautica "Sky-Y"

Main field of study of SAvE, 2-ary field of interest and interface context

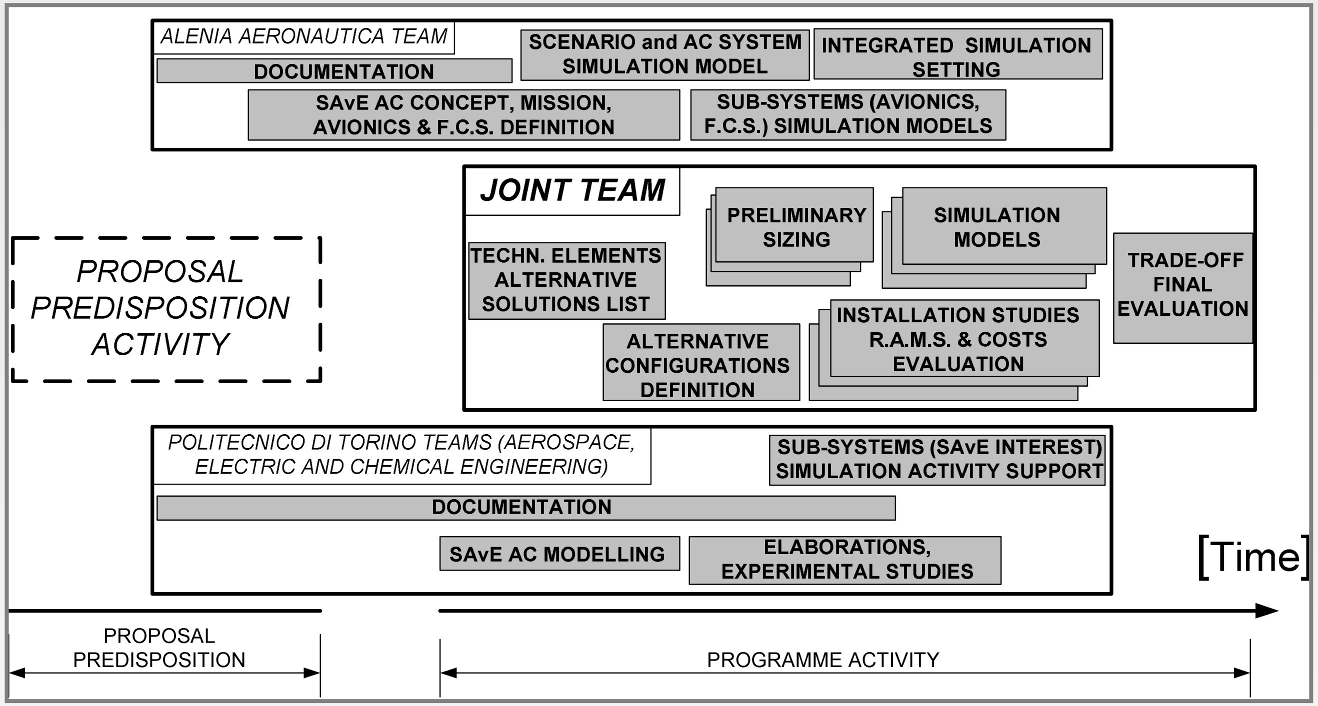
The Secondary Power System, applying the all-electric philosophy, is the primary field of research of the SAvE project. However, Propulsion, Fuel, Anti-Ice and Environment Control System are also considered, because of their close connection with the Secondary Power System. Eventually the Aircraft Configuration, the Structural Layout, the Landing Gear, the Avionic System (both basic and mission) and the Flight Control System are not studied within the SAvE program, but they represent the interface context for the other systems, thus being a source of requirements and constraints.



Joint Team and Technological Incubator

The schedule of the SAvE Program follows the classic design approach: after the definition of alternative configurations and their preliminary sizing, both functional and physical simulation models can be developed. All these research activities are carried out by the Joint Team: a team of young researchers of three different Departments of Politecnico di Torino, tutored and supervised by people from Alenia Aeronautica and Politecnico di Torino.

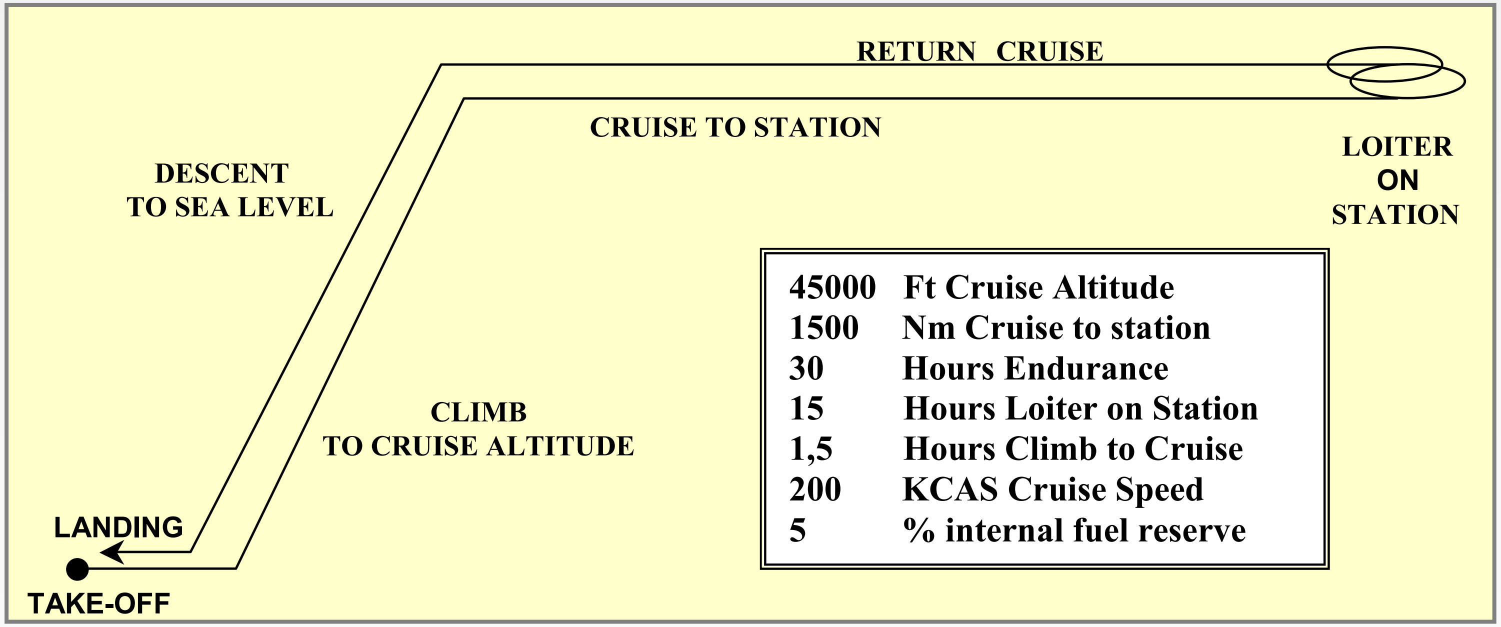
The Technological Incubator is an integrated environment, located inside the Industry (Alenia Aeronautica), where the Joint Team, is steadily involved into and works on the Project.

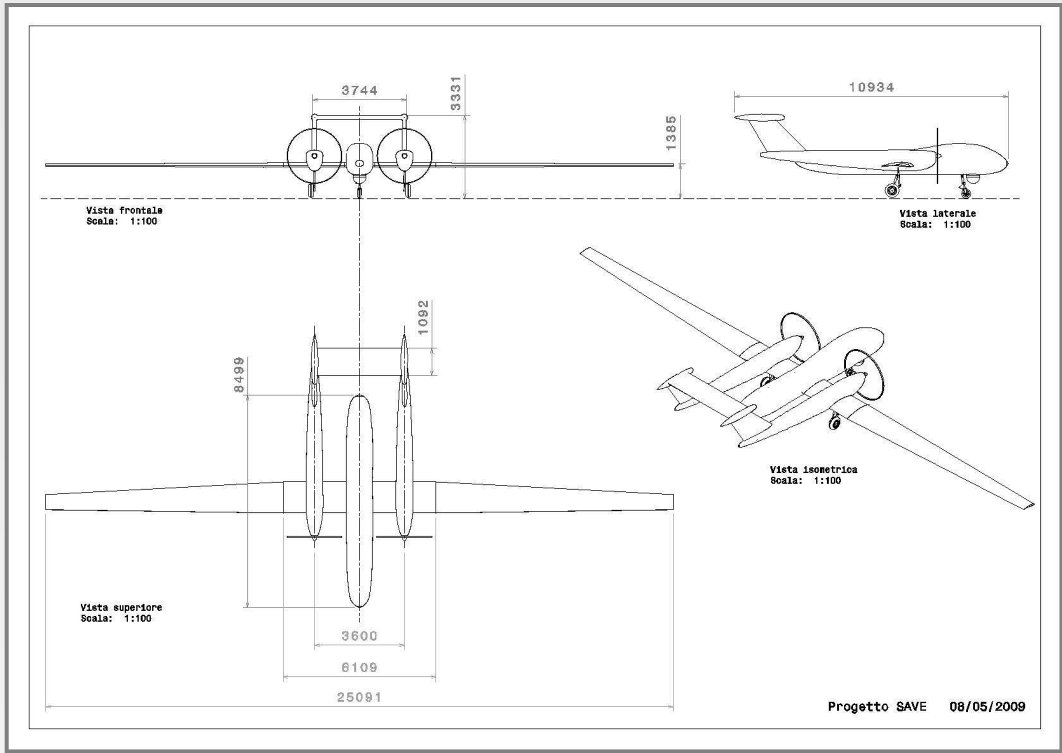


Mission profile

The following segments constitute the mission profile:

- *Take-off.*
- *Acceleration to maximum continuous climb speed.*
- *Climb to operating altitude of 45000 ft in maximum continuous rate.*
- *Cruise to station 1500 NM.*
- *Loiter on station 15 Hours.*
- *Return cruise 1500 NM.*
- *Descent to sea level.*
- *Landing.*

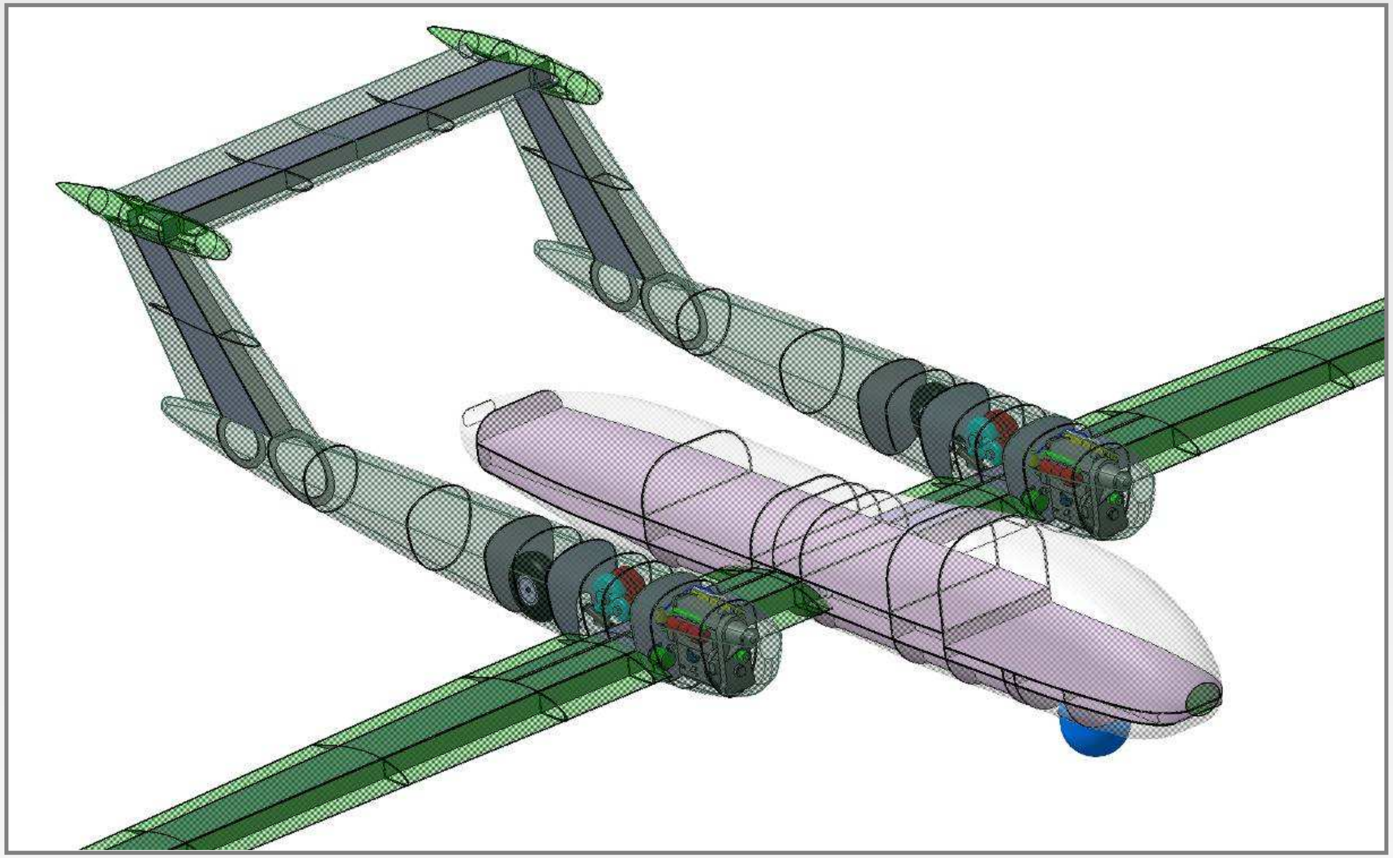


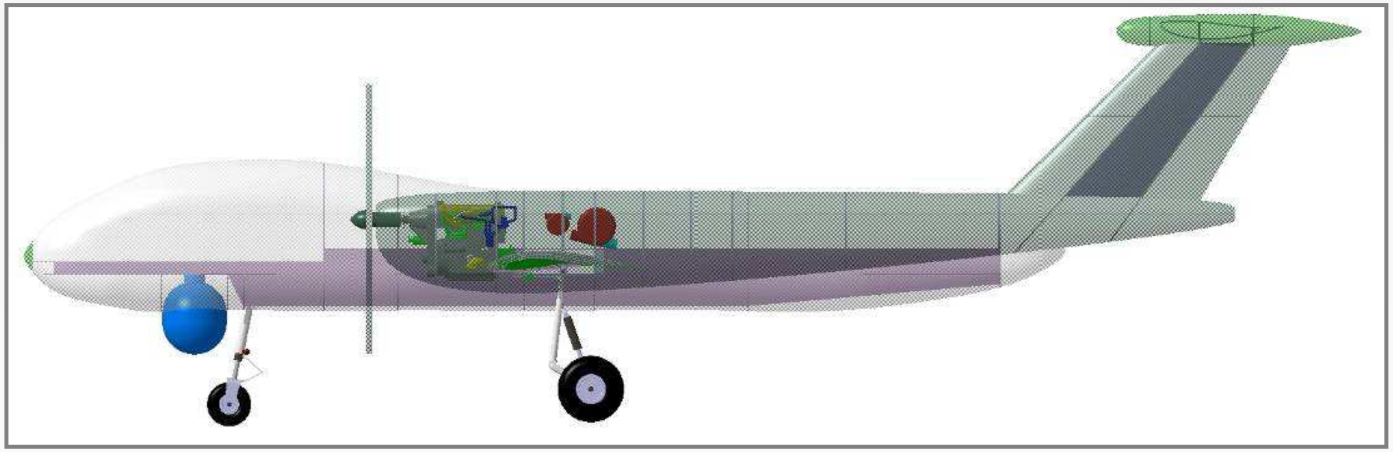


Reference aircraft/1

Dimensions	
Length:	11.47 m
Wing Span:	25.00 m
Wing Area:	25.00 sqm
Aspect Ratio:	25
Weights	
O.E.W.:	2213 kg
Fuel Weight:	1200 kg
M.T.O.G.W.:	3763 kg
Performances	
Endurance:	30 h
Radius:	2500 NM
Operational Altitude, Z:	15000 m
Time of climb:	1,5 h
Cruise speed:	200 KCAS
TO and Landing lengths:	1800 m
Power	
230 HP (Z $\leq$ 10000 m)	

Reference aircraft/2





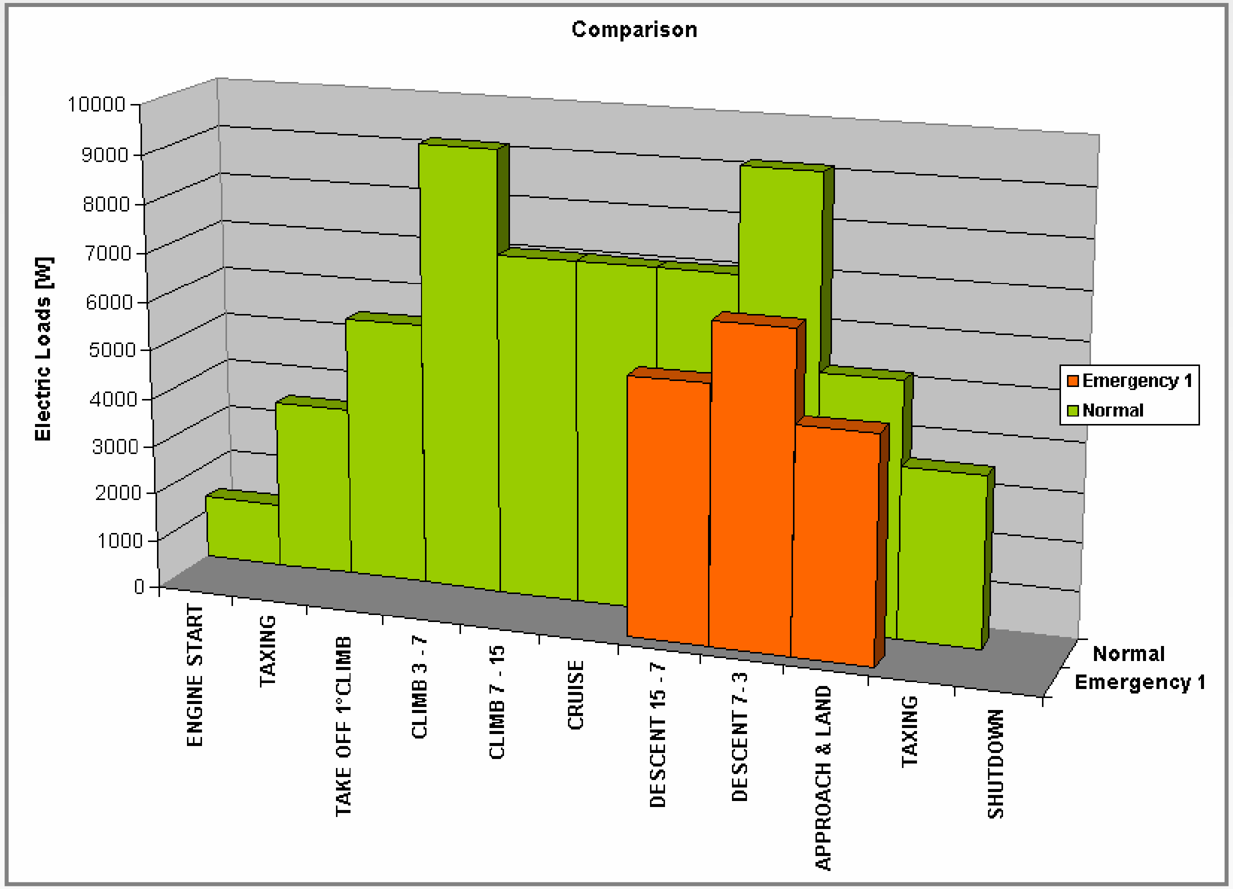
Mission avionics equipment

– Radar SAR.
– EO/IR Electro Optical Infra Red Sensor.
– IR Video-camera for landing.
– WBDL/LOS-ADT Wide Band DataLink/Line Of Sight-Air Data Terminal.
– WBDL/SAT-ADT Wide Band DataLink/Satellite Air Data Terminal.
– Datalink Computer.

Electric loads per each mission phase for different modes of operations

Taking into account the different mission phases of the reference mission profile and the various avionics equipments used in each mission phase, depending on the considered mode of operation, the electrical loads per each mission phase can be estimated.

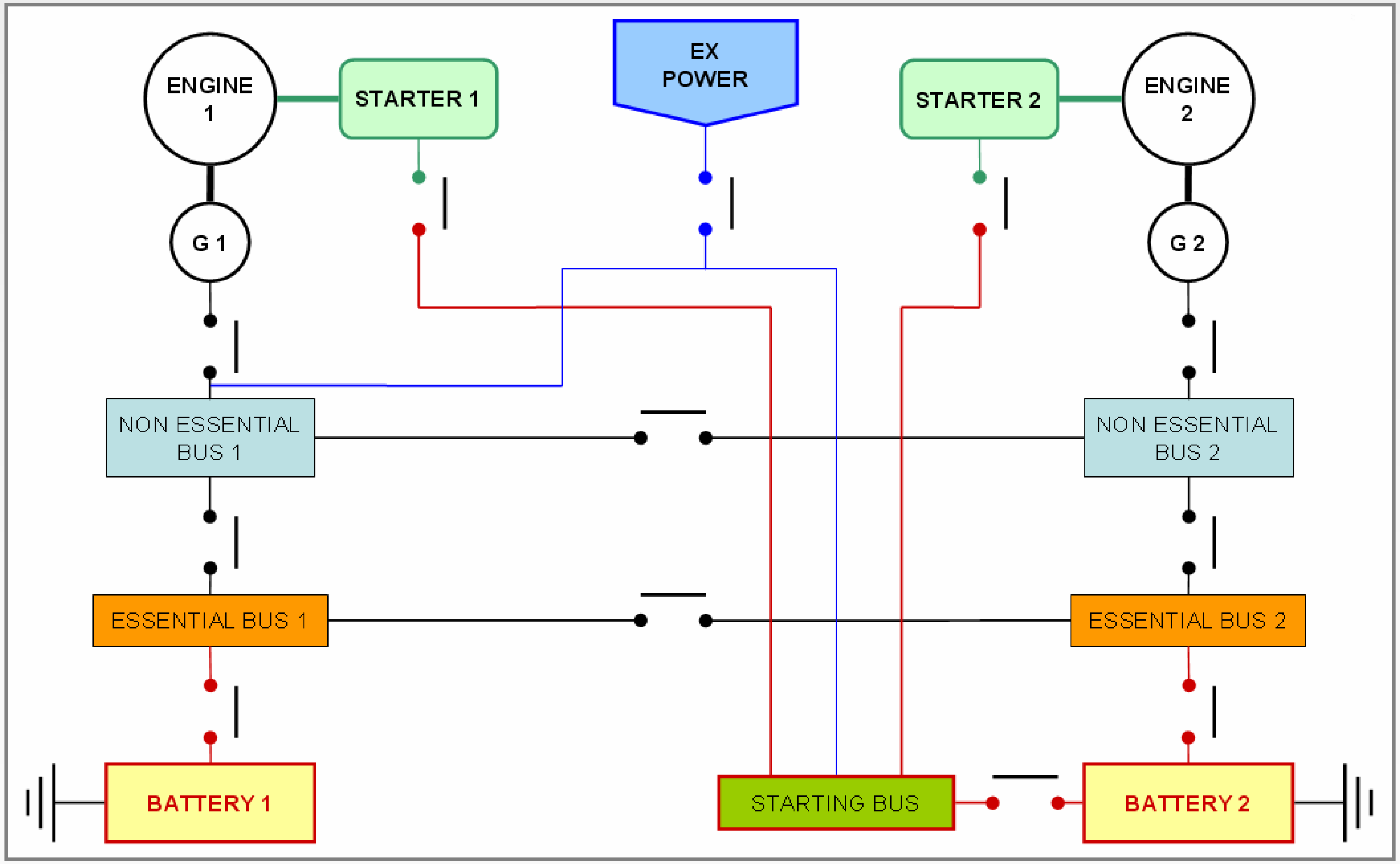
Two modes of operation have been considered: the normal and the emergency mode. In the normal mode of operation the planned mission is regularly performed, whereas in the emergency mode the planned mission is aborted and the aircraft starts immediately the descent.



Electrical power system conventional configuration/1

The trade-off analysis between different traditional configurations has led to the four buses electric power system configuration. Two buses out of four are named “essential”, while the remaining two buses are named “non essential”. As the name implies, all electrical loads, that are necessary during the emergency mode of operation when both engines are cut off, are connected to the essential buses.

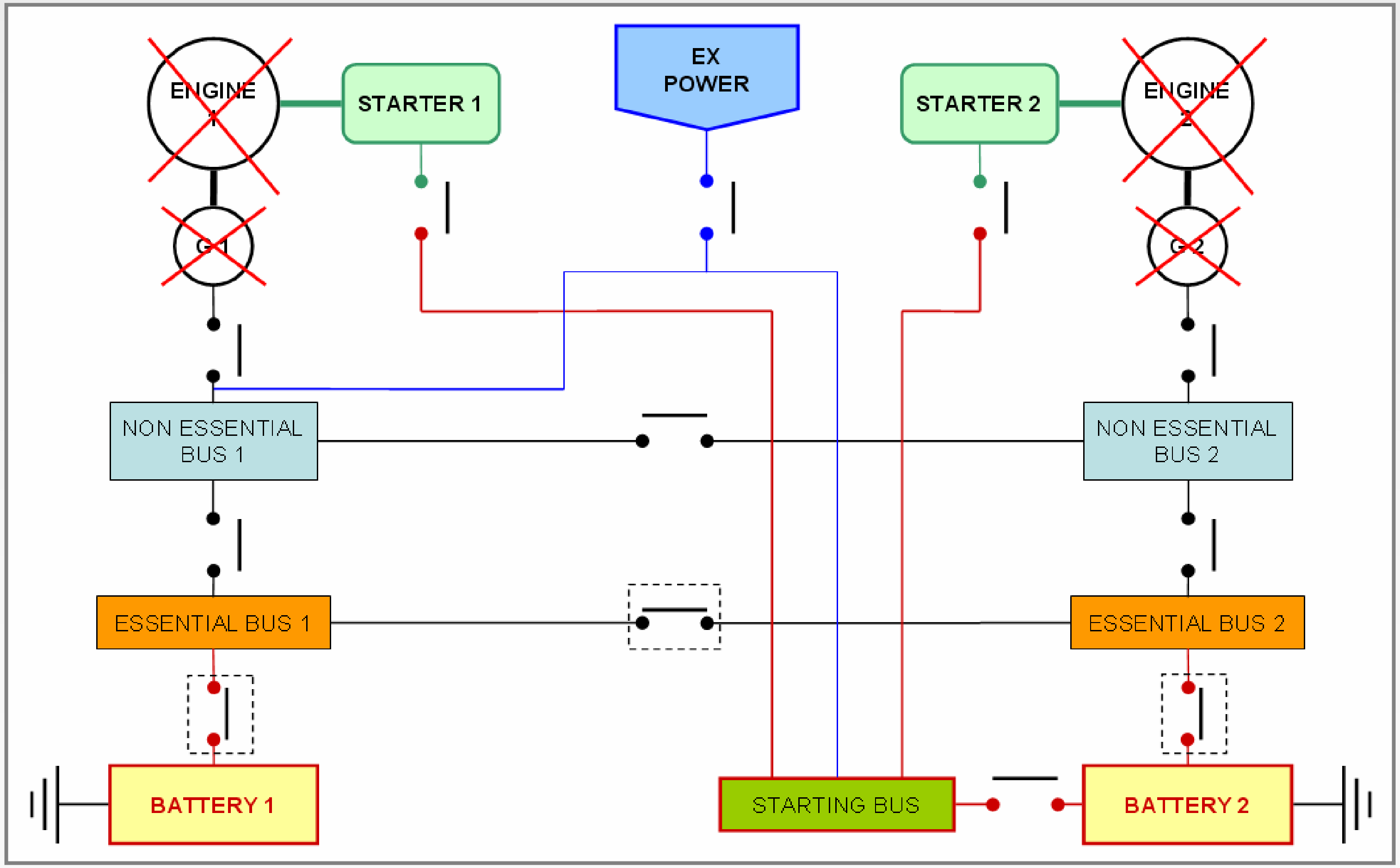
*The figure shows the electric power system block diagram. There are two battery packages and one starting bus to supply the two starters with electrical power. The starters in their turn start the two engines up, that supply 9*2 kW as maximum electrical power and that drive two DC generators.*



Electrical power system conventional configuration/2

In the emergency mode of operation, i.e. when both separated circuits have failures either in the engine or in the DC generator, the battery packages supply only the essential buses with the needed electric power.

In this condition, the aircraft starts immediately the descent and the peak power request (about 7 kW) occurs between 7000 m and 3000 m when the anti-icing system could be switched on.



Conventional configuration 3D digital mock-up/1

NiCd battery packages have been chosen as state-of-the-art for the conventional configuration and the following constraints have to be considered when accomplishing the installation study and the 3D modeling:

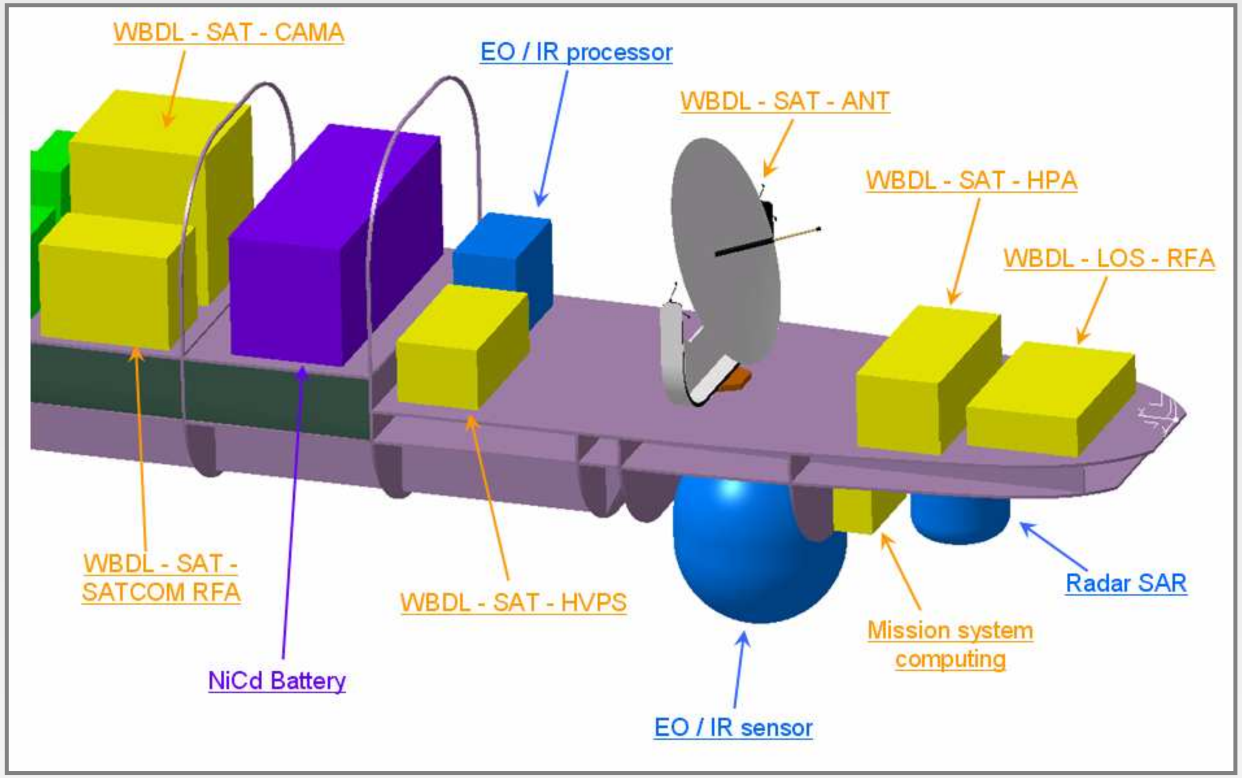
1. the center of gravity position has to lay between 10% and 30% of mean aerodynamic chord of the aircraft.

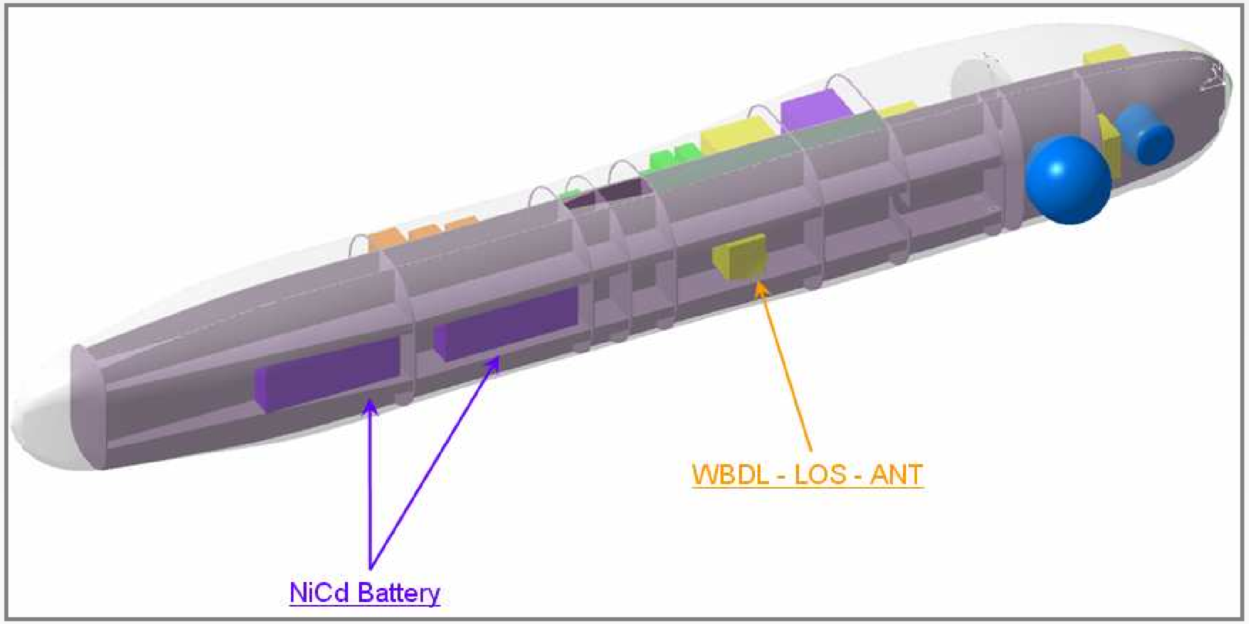
2. Some components have to be located close one to the other to allow mutual links.

3. The WBDL SAT antenna has to be placed in the front part of the aircraft and it needs a wide space all around to turn freely.

4. The inertial systems have to be located near the centre of gravity for assuring best performance.

Significant result of the 3D digital mock-up is a preliminary weight estimation of both the avionics system and the NiCd battery packages, which have turned out to weight respectively about 390 kg and 900 kg (0,5 m^3 of volume and about 8,5 kW of power). This solution has therefore been discarded, as not feasible.



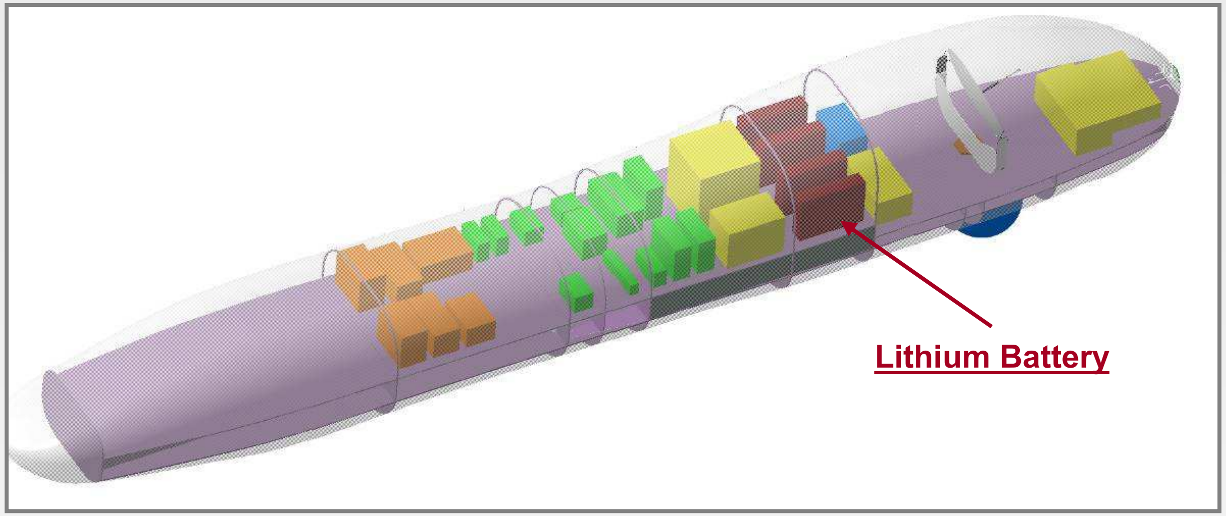


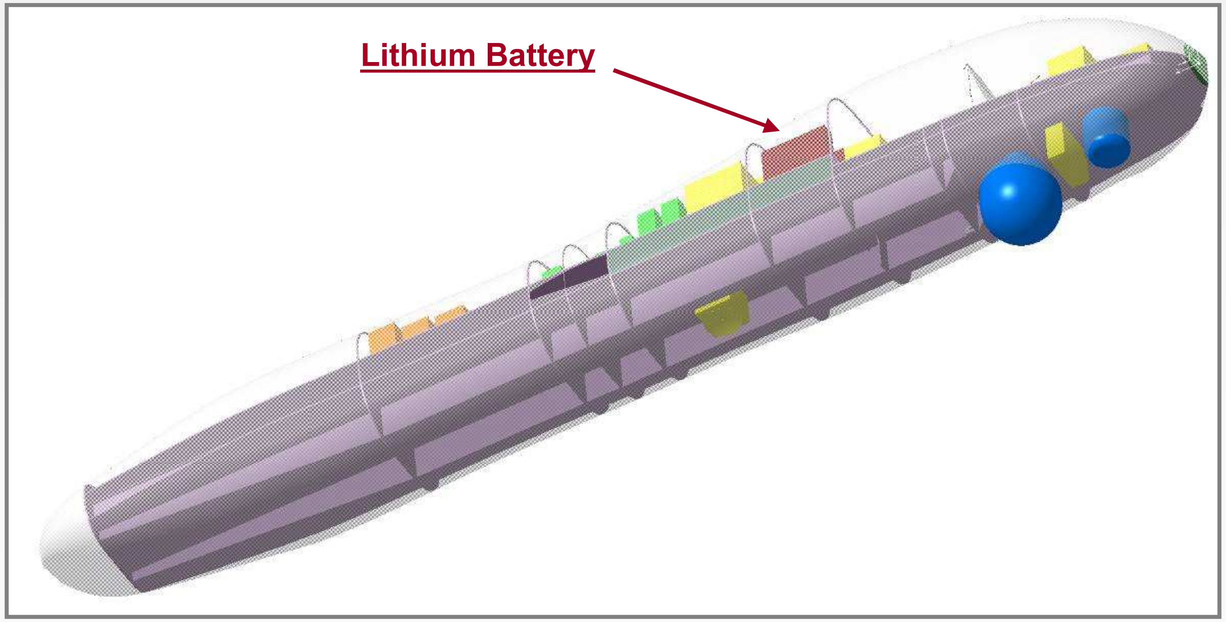
Conventional configuration 3D digital mock-up/2

In order to decrease weights and volumes, lithium battery packages are considered as alternative solution.

From the installation analysis point of view, the only change with respect to the previous case is represented by the location of the lithium battery packages, which are the red boxes in the 3D digital mock-up, shown in the figures beside.

The advantage of this solution in terms of both weight and volume is tremendous: the battery packages weight now 120 kg and have a volume of about 0,06 m^3.

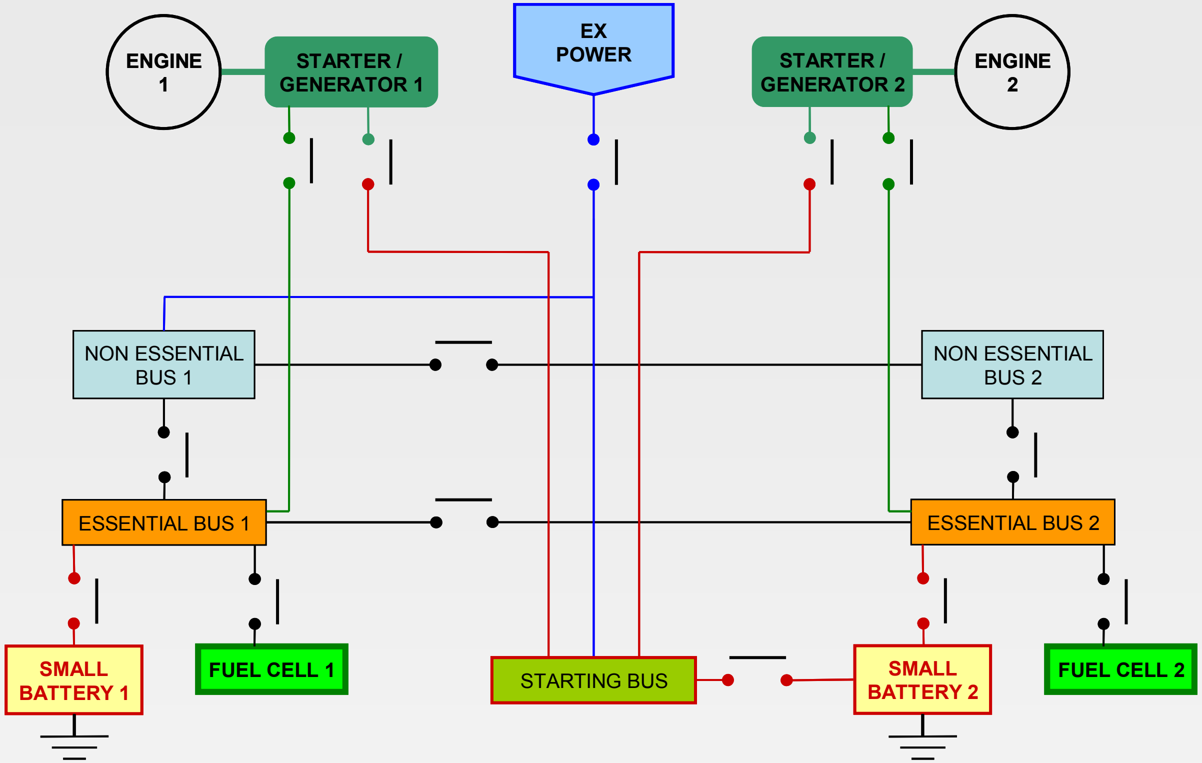




Non conventional configuration

A certain number of different concepts of alternative configuration of the electrical power system has already been defined. They will be sized and further investigated in the next months of the research project.

The picture beside shows two of the most interesting non conventional configurations: the "Only Fuel Cells" and the "Hybrid Fuel Cells" configurations. The components and the architecture are the same for both configurations but the sizing of the various equipments and their modes of operations are different.



Only fuel cells configuration	Hybrid fuel cells configuration
Engine starting: ▪ Small battery-starting bus-starter or starter/generator. ▪ External power source.	**Engine starting:** ▪ Small battery-starting bus-starter or starter/generator. ▪ External power source.
Normal operations: ▪The fuel cells supply all electric loads with their requested power. ▪ The fuel cells work at 100% of their maximum power. ▪ The small batteries are charged by the fuel cells and are useful to reply at the peak powers.	**Normal operations**: ▪ The fuel cells and the generators or starter/generators supply all electric loads with their requested power. ▪ The fuel cells and the generators or starter/generators work at 50% of their maximum power. ▪ The small batteries are charged by the fuel cells and are useful to reply at the peak powers.
Fuel cells failures: ▪ The generators or starter/generators supply both essential buses. Both non essential buses are cut off.	**Fuel cells failures**: ▪ The generators or starter/generators supply both essential buses, working at 100% of their maximum power. Both non essential buses are cut off.
Engines or generators failures: ▪ The fuel cells supply both essential buses. Both non essential buses are cut off.	**Engines or generators failures**: ▪ The fuel cells supply both essential buses. Both non essential buses are cut off.

Conclusions

SAvE research project started at the end of 2007.

Since the very beginning of the program, some important results have already been achieved but there are still some fundamental steps that have to be taken:

- ❑ *the **Joint Team** was constituted and various researchers, having different cultural background and coming both from the Industry and the University, started **working together in an "integrated" environment, called "Technological Incubator"**, where the practical experience of the industrial word could really meet the more theoretical approach of the academia;*
- ❑ *some **students**, working at their final year projects, also collaborate with the researchers of the Joint Team with the possibility of becoming part of the Joint Team itself in the future as researchers or PhD students;*
- ❑ *the research program proceeds accordingly to the **traditional design process** but it makes use of the most **innovative tools for design**, that allow to perform physical and functional simulations to reach a higher level of detail in the earliest phase of the design;*
- ❑ *the Joint Team is still working at the definition of the **non conventional configurations for the electric power system**;*
- ❑ *the Joint Team is still working at the implementation of **highly integrated simulation environment**.*
- ❑ *SAvE research project is **synergic to another wider program** (also funded by Regione Piemonte): **SMAT f1**. So we think that our Technological Incubator will last long.*

The authors wish to thank all people of the Joint Team and all people from Alenia Aeronautica and Politecnico di Torino involved in the research project.