COPAL

COmmunity heavy-PAyload Long endurance Instrumented Aircraft for Tropospheric Research in Environmental and Geo-Sciences

WP3

Copal scientific survey

Results of the survey sent to the scientific community

<u>Deliverable D 3.1.1.</u>

The European needs for airborne experiments in the aerial platforms

by

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1 Introduction

This report contains, by way of summary, the results of the survey for user needs conducted among the European scientific community. The survey was collected to discover current and future needs related to projects, experiments and research, based and supported by airborne instrumentation.

Survey results will be used as a reference to define aircraft requirements for COPAL project and issue the relevant specifications.

The survey was sent to the key scientific groups conducting research in atmospherics and environmental science in Europe. These groups were selected based on personal knowledge of EUFAR members carrying out research activity in their country in this specific field. There were 778 scientists in the group, but only 48 (6, 2 %) answered the questionnaire. This lack of participation could be explained because it is more a technical survey than a scientific one, as the objective of the survey is to collect data for the specification of an aircraft.

2 Type of science

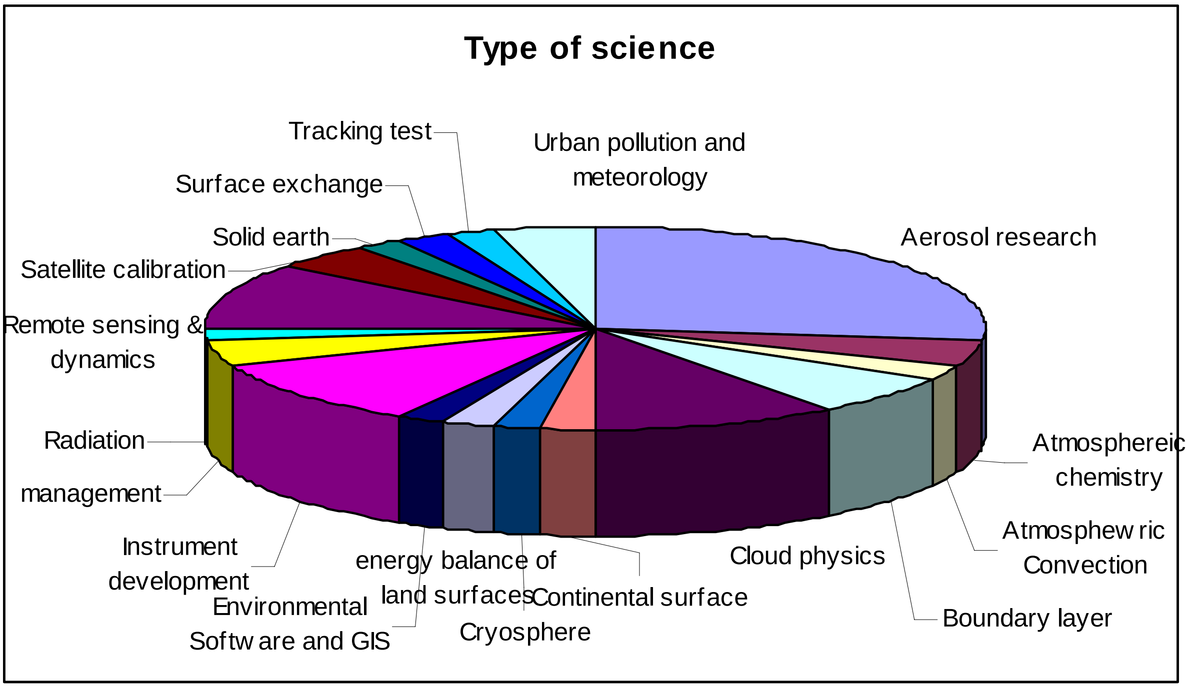
Scientists were able to choose between 14 different types of science for research, but they had also the possibility of adding a new one. The result shows that most of them decided to choose Earth sciences or environmental studies, what corroborates the relevance of COPAL objectives.

An HPLE aircraft would be then used specially in environmental and geo-science research, e.g. atmospheric chemistry, aerosols, climate, meteorology, biogeochemistry, polar research, oceanography, geography, ecology, glaciology, boundary layer studies, development and testing of remote sensing, etc… Firstly, the data acquired shows that the scientific fields with the highest demand in aerosol research. This could be explained because of the steadily increasing of interest in problems like the climate change. Environmental disasters such as storms, ozone depletion and oil pollution have raised the awareness of the public to environmental issues, making research in environment, climate and the atmosphere a topic of significant social and cultural importance. Analysis of the physical, chemical and biological processes within the atmosphere and at the Earth’s surface are crucial for research, because these processes maintain the conditions necessary for life on Earth. In the past decades, we have observed important changes in climate and in the composition of the atmosphere, which are expected to affect the well-being of humankind and the biosphere. The resulting concern about global change has stimulated much necessary research, including instrument/technique development, satellite and in-situ observations. Out of this research has grown an understanding of Earth as a system, involving physical, chemical, biological and human processes. This understanding is described in analytical and numerical models of increasing sophistication and complexity. These models in turn require observations for testing, validation and further development. There are also other three different type of science with an important demand: cloud physics, instrument development and remote sensing and dynamics. This kind of aircraft would have other uses like satellite calibration activities, boundary layer, aerospace scientific and long-term operational applications in general.

Another thing to point out is that although these are the highly demanded type of science (especially aerosol research) all the specified areas were of interest for scientists.

For that reason, it is important to note that the new platform must be flexible enough in its performance to enable it to be used extensively for all the specified Earth research disciplines and it should be available for remote sensing. Examples for such applications are remote sensing applications for Earth observation, particularly the coastal zone. (Remote sensing techniques are a major tool to provide information about coastal water quality, currents, sea state, ice extension, flooding, morphodynamics, land use etc). The new aircraft is expected to play a major role in the testing and validation of new remote sensing tools.

Type of science	Percentage of users interested
Atmospheric chemistry and climate research	**33,33**
a. Atmospheric chemistry	4,17
b. Aerosol research	27,08
c. Atmospheric Convection	2,08
Biogeochemistry and biosphere/atmosphere interactions	**27,08**
a. Cloud physics	10,42
b. Radiation	2,08
c. Continental surface	2,08
d. Cryosphere	2,08
e. Energy balance of land surfaces	2,08
f. Solid earth	2,08
g. Surface exchange	2,08
h. Urban pollution and meteorology	4,16
Instrument development	**10,42**
Satellite calibration	**7,74**
Boundary layer	**6,25**
Tracking test	**2,08**
Environmental Software and GIS	**2,08**
Remote sensing & dynamics	**10,417**
Others	**4,16**



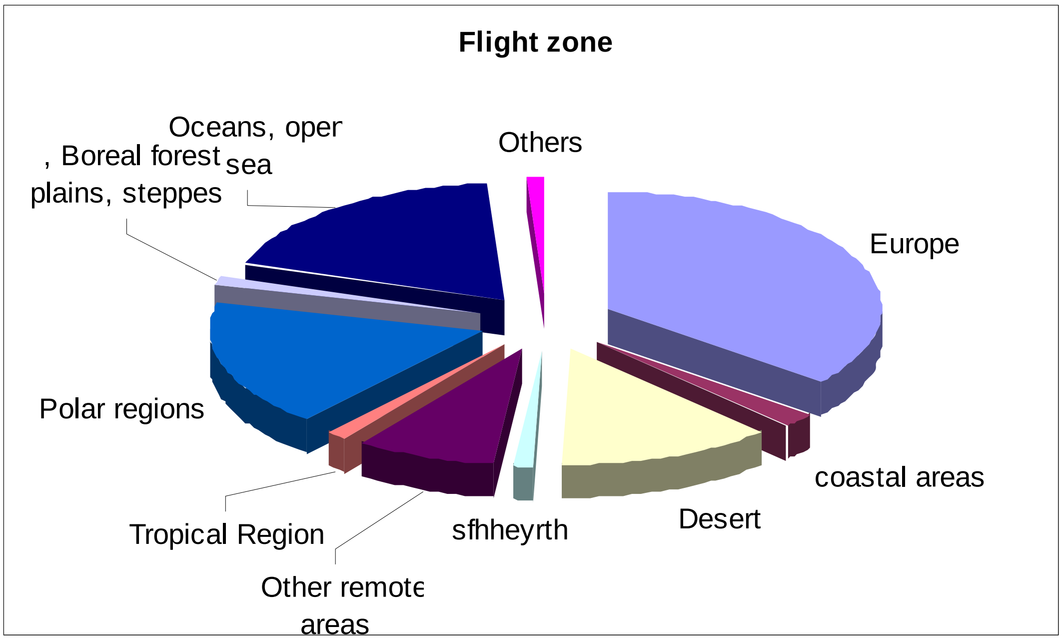
3 Required aircraft performance based on survey data

The scientific needs about aircraft performance should be defined with the analysis of some experiment requirements like the flight zone, range, minimum and maximum speed, altitude, number of scientific personal on board, earth station needs, and weight and maximum dimension of the scientific equipment to install on the aircraft. With the analysis of these data, it is possible to elaborate a preliminary specification of the aircraft performance.

- Flight zone:

The geographical zones for service are shown in the following table, giving the option to the scientists to extend these regions according to their needs.

Flight zone	
Europe	35,79
coastal areas	2,11
Desert	12,63
sfhheyrth	1,05
Other remote areas	8,42
Tropical Region	1,05
Polar regions	17,89
Boreal forest, plains, steppes	1,05
Océans, open sea	18,95
Others	1,05

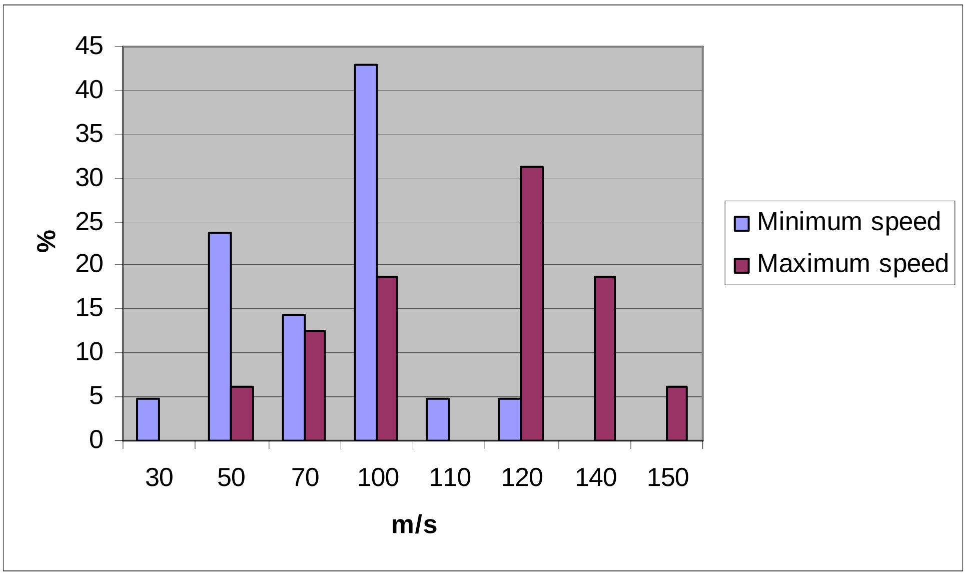


The flight zone for the experiment gives information about the required endurance for the new aircraft, and it is a part of the information needed to make a preliminary analysis about the possibility of multidisciplinary flight. The areas most demanded by the European scientific community are Europe, Oceans, the Polar Regions and deserts. As many scientists have chosen Europe, it could be an important zone for multidisciplinary flights, as it seems interesting for many of them. The interest in Polar Regions, oceans and deserts (almost 50%) establish an important requirement for the new aerial platform as it should have a very long endurance. The aircraft should be able to reach the selected area, carry out the experiment and coming back to the selected airport or base.

- Minimum and maximum speed:

The minimum speed required is also an important factor to select an aircraft for research, as many experiments need speeds of 50m/s or even less to take data accurately. The results are shown as follows:

Velocity (m/s)	**% Minimum speed:**	**% Maximum speed:**
30	4,76	0
50	23,81	6,25
70	14,29	12,5
100	42,86	18,75
110	4,76	0
120	4,7	31,25
140	0	18,75
150	0	6,25



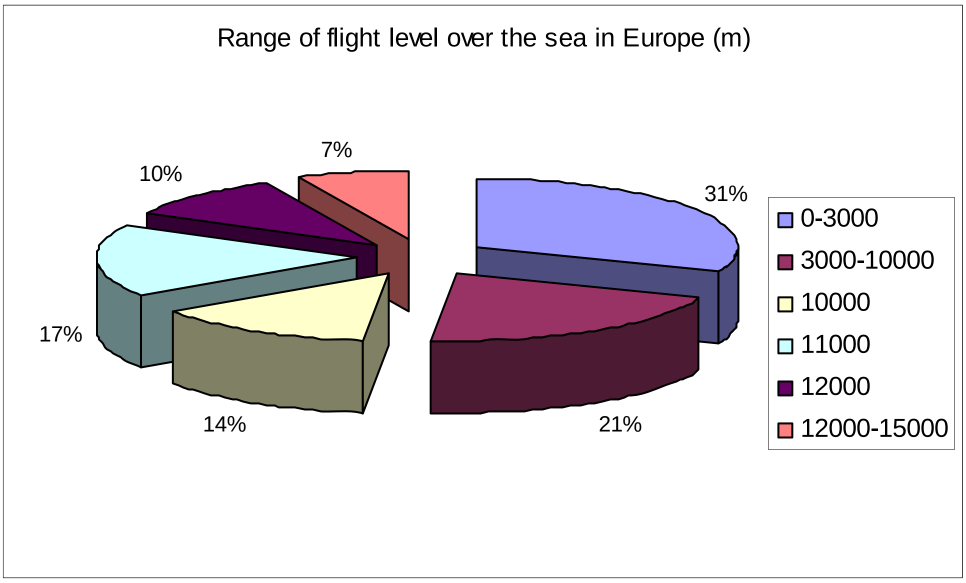
The survey reveals that it would be necessary to look for an aircraft capable of flying at a low speed. Almost half of the participants need a minimum speed of 100 m/s, and over 25% would need around 50 m/s. Mainly, the scientific users interested need low speed for instrument development and for remote sensing campaigns. This is not a difficult requirement to fulfill, as all the aircraft selected in COPAL project (previously identified A400M, C130, C295) could do it.
Regarding maximum speed, it could be really useful when making a "Ferry" flight to a remote area of the world (and this is a real requirement of the scientific community), because the quicker the aircraft reach the experiment zone, the less time the total campaign will take, reducing costs.

- Altitude:

Most of the informants need flights with altitudes from 0 to 11.000 m, but almost the 16% of the potential activities would need an aircraft with a ceiling superior to 11.000 m.

Altitude **(m)**	%
0-3000	31,03
3000-10000	20,69
10000	13,79
11000	17,24
12000	10,34
12000-15000	6,9

This is also an easy requirement to meet; taking into account that almost all the high payload and long endurance aircraft would be able to reach 11000m. As the objective of COPAL is to provide a new aerial platform for tropospheric studies, this kind of platform could satisfy this objective. Over 16% have selected higher altitudes, but these experiments could be carry out with other aerial platforms more adapted to stratospheric studies available in EUFAR, like HALO.

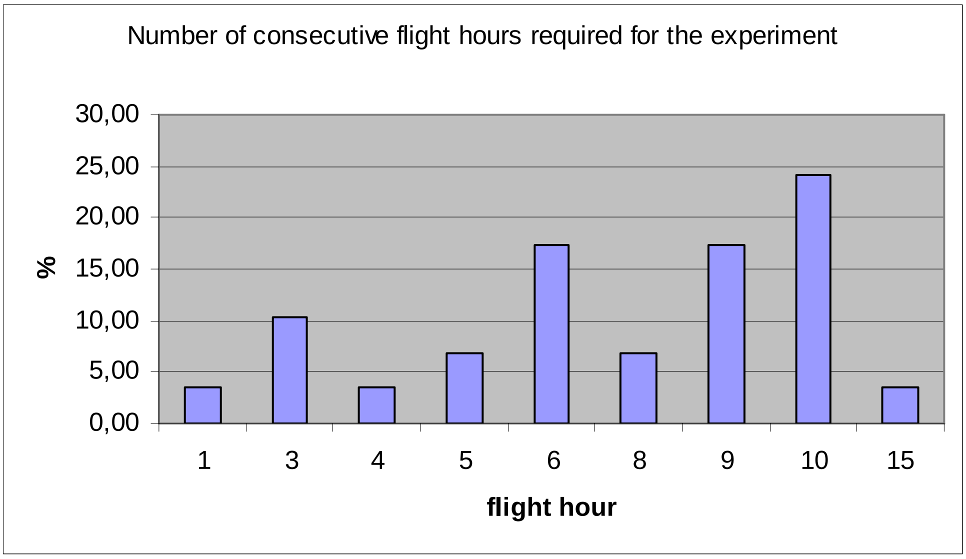


- Minimum flight hours per flight (endurance)

Scientists were also asked what endurance they need for experiments. Most of them need a endurance between 6 and 10 hours, so a long endurance aircraft will be needed.

Anyway, there is no point of establishing a requirement of an endurance higher than 10 hours, because although all the aircraft may be able to reach it, there would be other problems like the maximum consecutive hours for the crew to fly.

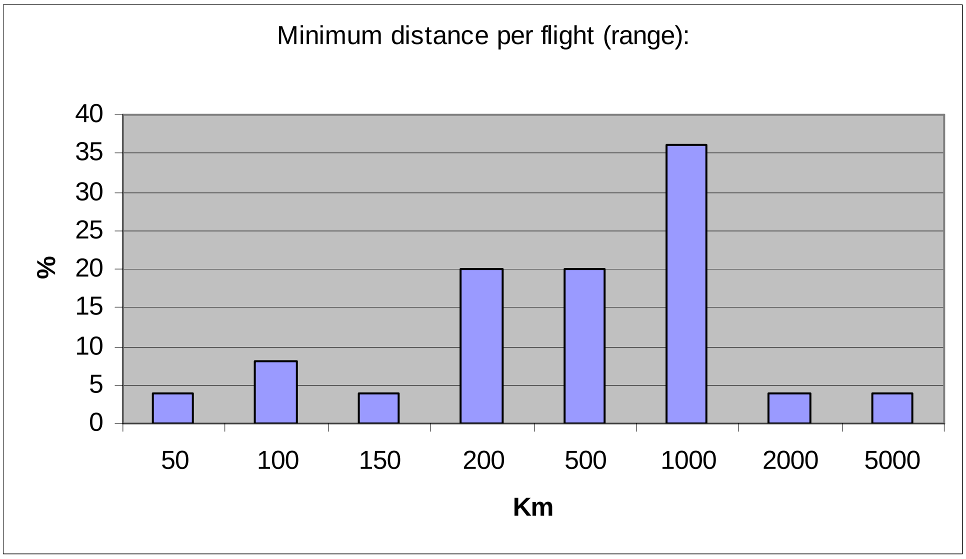
Number of consecutive flight hours required for the experiment	% required
1	3,45
3	10,34
4	3,45
5	6,90
6	17,24
8	6,90
9	17,24
10	24,14
15	3,45



- Minimum distance per flight (range)

The survey reveals that it would be necessary to look for an aircraft with a medium range, most of the scientist require a range between 200 and 1000 km.

Minimum distance per flight (range) Km	% required
50	4
100	8
150	4
200	20
500	20
1000	36
2000	4
5000	4

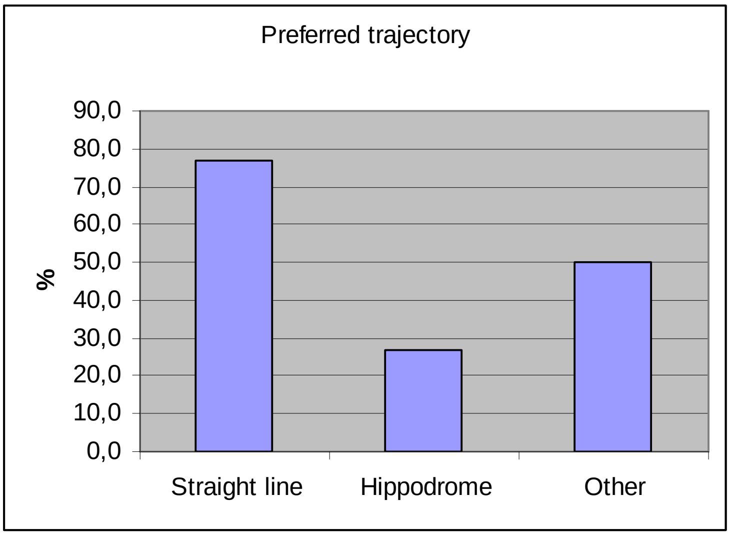


This is not a difficult requirement to fulfill, as all the aircraft contemplated in COPAL project would satisfy it.

- Preferred trajectory

Scientists were also asked what trajectory they need for experiments. The survey reveals that the preferred trajectory is a straight line.

	% required
Straight line	76,7
Hippodrome	26,7
Other	50,0

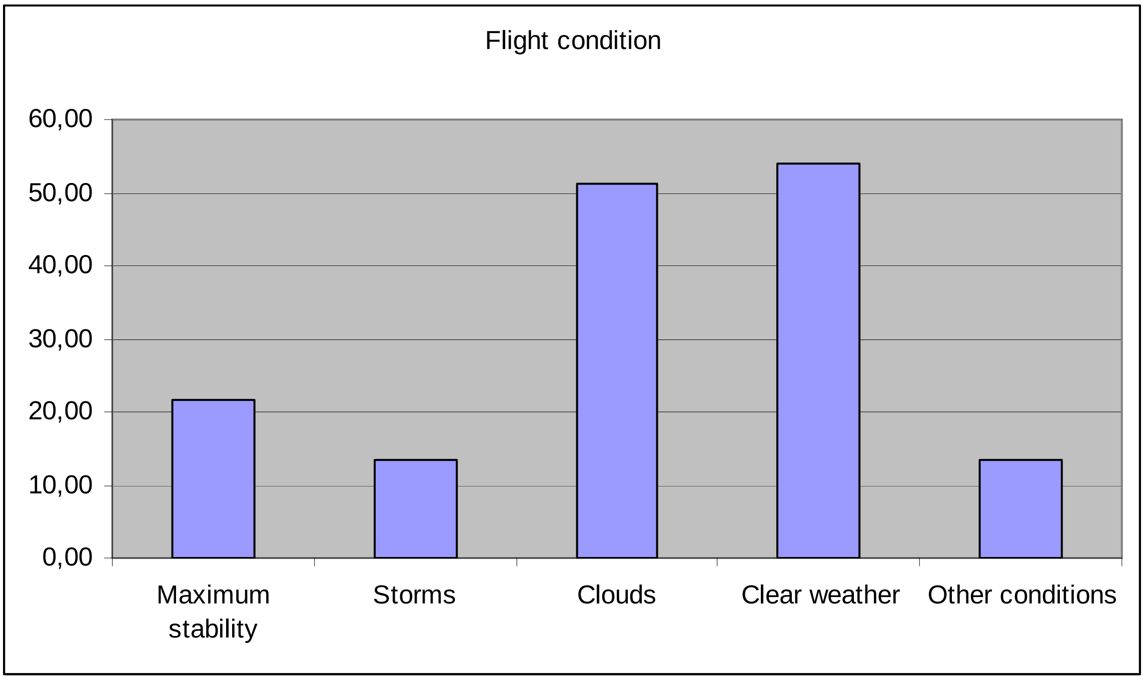


This common requirement could be an important advantage to organize multidisciplinary flights, as the requirement for a hippodrome or a vertical profile (almost half of the specified trajectories in “others” are vertical profiles). Over 25% of the scientists would need specific trajectories like profiles through clouds.

- Flight conditions needed

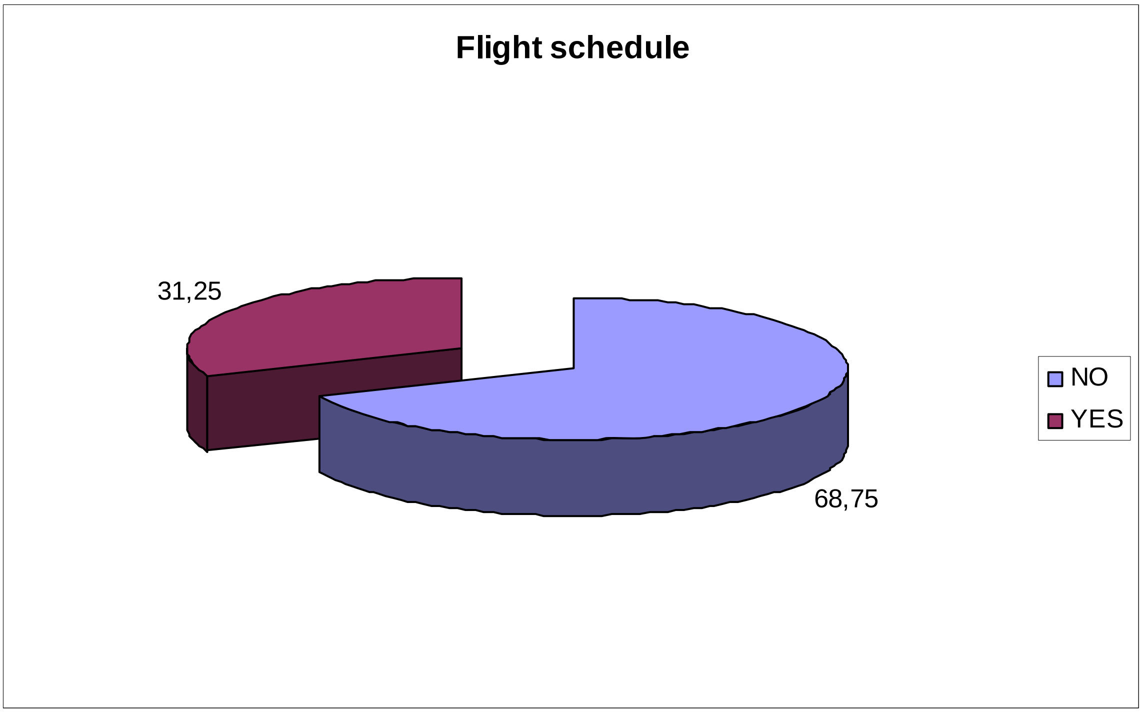
The survey also asked what conditions scientists need for experiments. The most requested conditions were clear weather and clouds, and in other conditions, the scientist required special Events (dust, Arctic haze), both strong and weak stability in the surface layer, or a pre-defined wind speed and direction. In order to organize multidisciplinary flights, clouds and clear weather would be the most required conditions.

Flight conditions needed	% required
Maximum stability	21,62
Storms	13,51
Clouds	51,35
Clear weather	54,05
Other	13,51

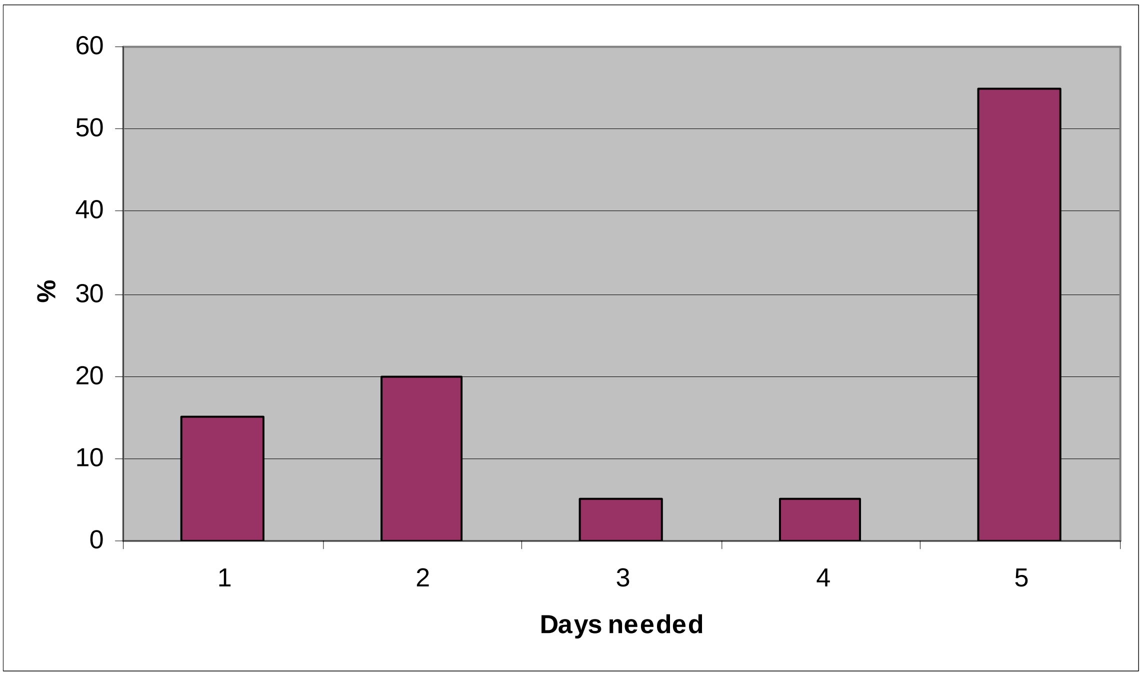


- Flight schedule

To organize the operations of aircraft in the future, it is necessary to know the lead-time with which we can program the experiment. The experiment can be scheduled various months in advance in 31,25 % of cases, and in 68,75% it needs special weather/ atmospheric conditions that cannot be predicted accurately

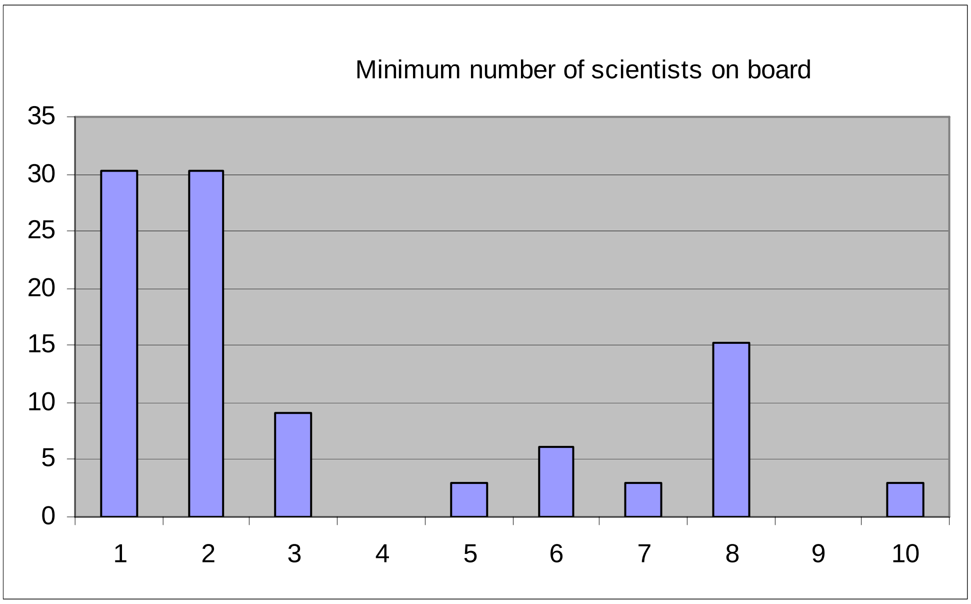


Most of the scientists need five days to make a prediction accurately:

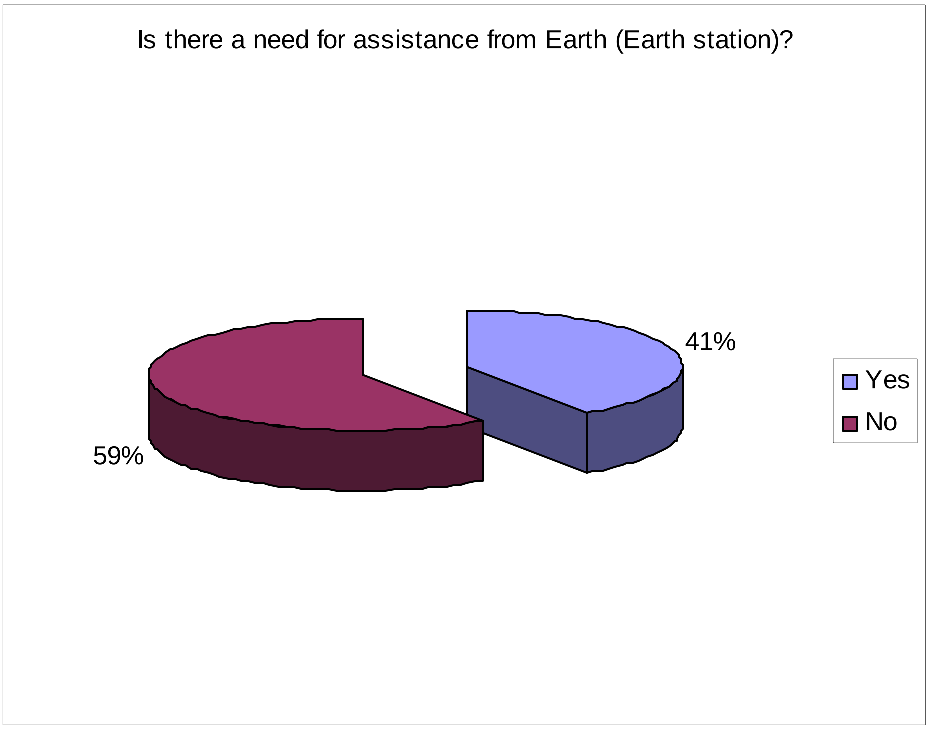


- Experiment data:

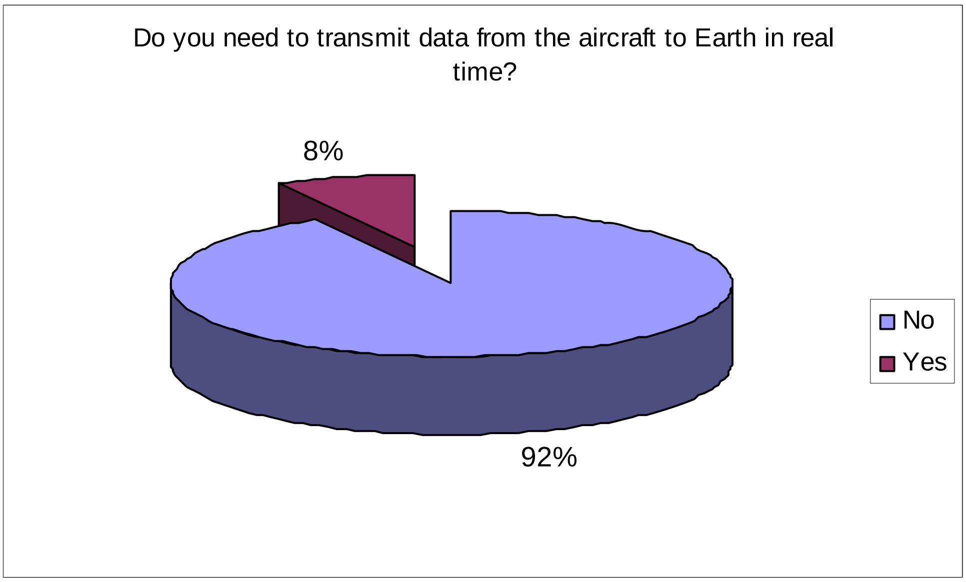
The minimum number of scientist on board oscillates between 1 and 10. The following table shows the distribution:



Ground assistance is needed in 41% of cases



And data transmission from the aircraft to Earth in real time is needed in 8% of cases:



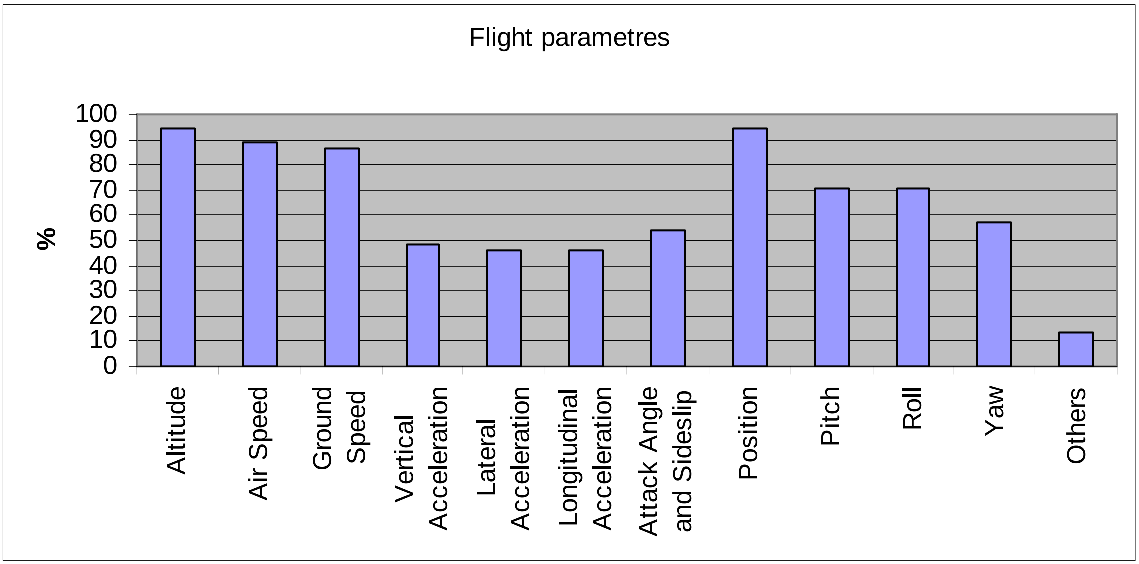
- Parameters to be measured:

To give the best support to scientists, they were asked about the data that they may need to acquire. Almost all of the suggested parameters were of interest for the scientific community.

Parameters to be measured	% Required
Temperature	88,57
Dew point	80,00
Static pressure	74,29
Liquid water content	62,86
Icing rate	34,29
Cloud droplet spectrum	57,14
Cloud particles	57,14
Heading	62,86
Condensation Nuclei	54,29
Small particles	65,71
O3	57,14
NO	34,29
NO2	37,14
SO2	34,29
CO	37,14
CO2	40,00
H2O	54,29
SF6	25,71
Others	37,14

Other data required were radiation, particle spectrum, AMS, aerosol chemistry (individual analysis and global analysis), optical depth (photometer), attenuated backscatter (LIDAR), methane, CH4, N2O, radon-222, CCN, PAN, VOC, aerosols, ice nuclei, an aircraft with a LIDAR, fluorescence… in general it depends on the individual task.

- Flight parameters:

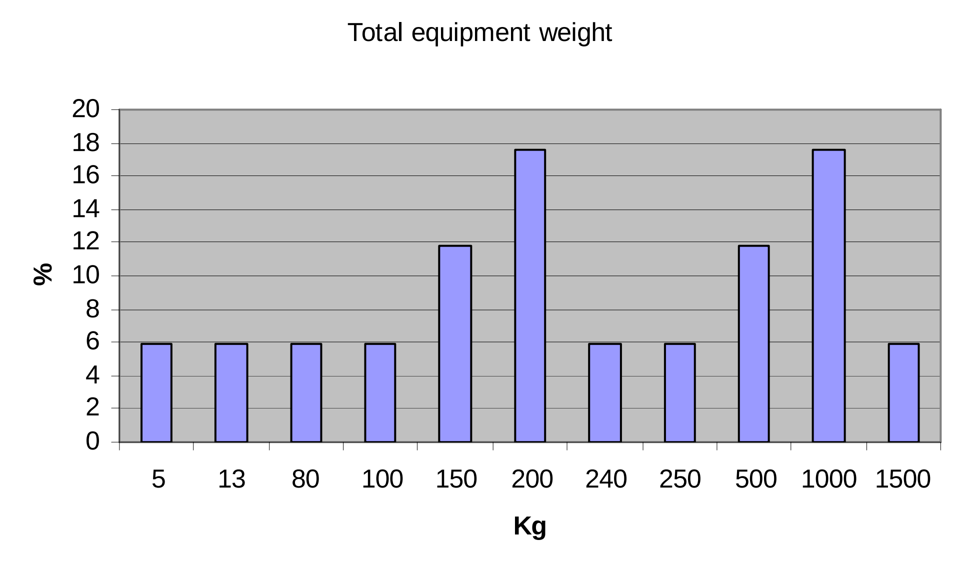


Other data required by the scientific community were vertical velocity, wind speed and direction, time, position, space, turbulence intensity, video recording (down and forward views) or time stamp from CAS must be given for data synchronization

- Payload weight and dimensions:

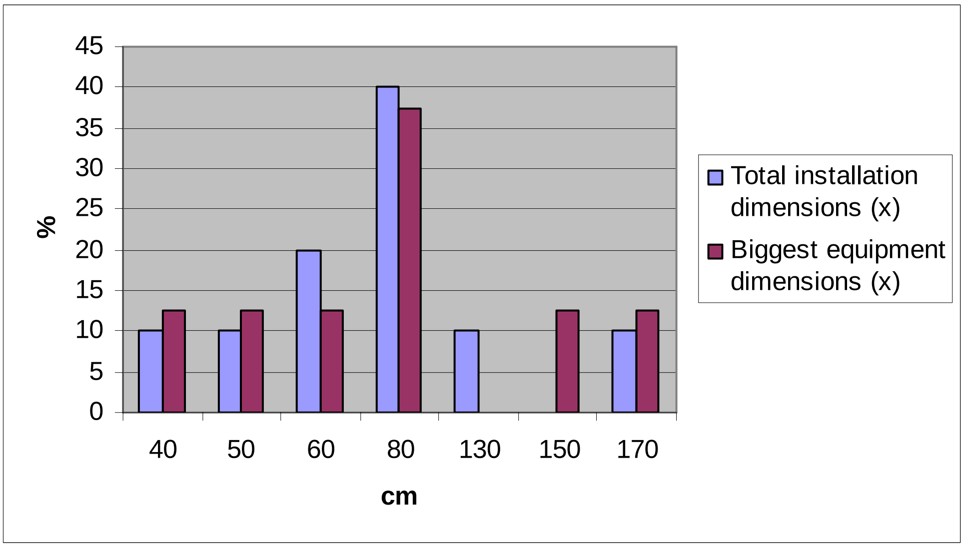
These questions are to ensure that the equipment could be introduced in the aircraft without problems, looking at the specified dimensions there should not be any problem in any aircraft eligible for COPAL project.

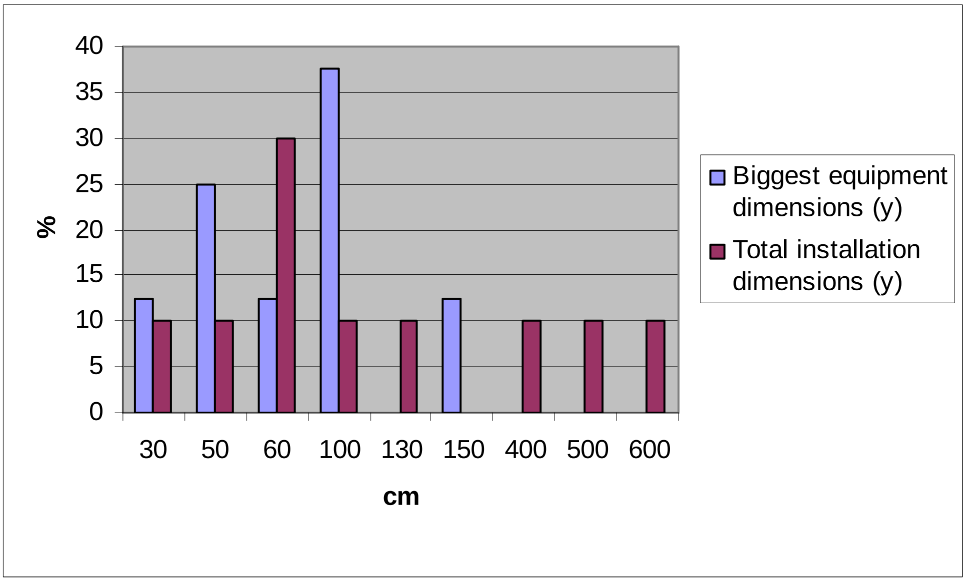
The results of the survey are showed in the following graphics:

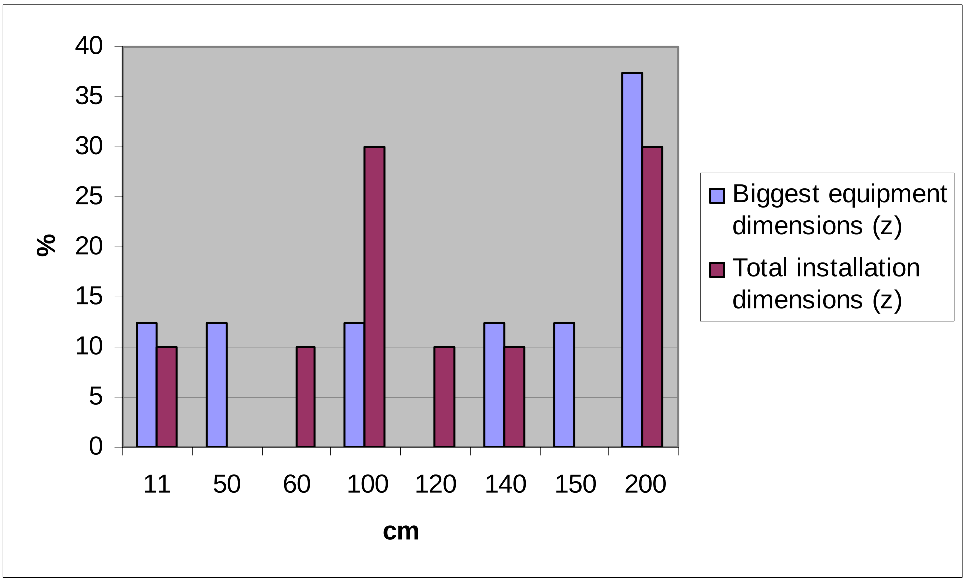


As this kind of platform represents a really good opportunity to make multidisciplinary flights, there is a special need for an aircraft with high payload. That would allow the new aerial platform to have several teams of scientists on board at the seem time.

The size of the cabin is determined by the following data:







- Installation method:

In order to correctly place the scientific equipment, the survey asked about the position that this equipment would occupy in the aircraft. This is more a technical feature than a scientific one, and only 27% of the participants answered it.

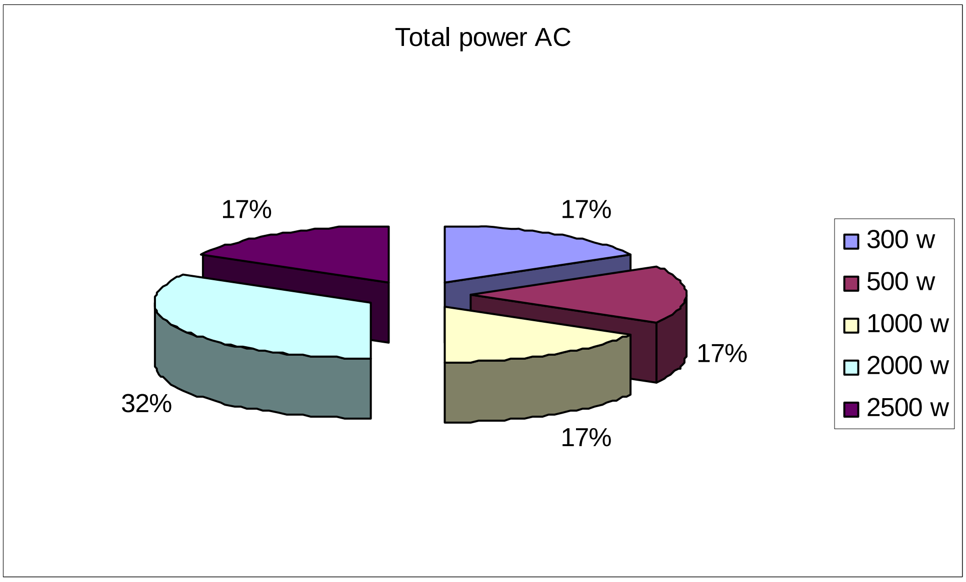
Required characteristics	% of the participants
Some parts can be installed in pods under the wings	30,8
Some parts can be installed in a nose probe	15,38
Has the equipment ever been certified in any aircraft?	61,54
Does the equipment need calibration before flight?	69,23
Indicate whether the equipment is passive or active	54,55 % (passive)

The lack of answer in "Installation method" makes it difficult to elaborate the requirements from these data, but it is clear that the new aircraft should have hard points under the wings to install pods as a nose probe at the front.

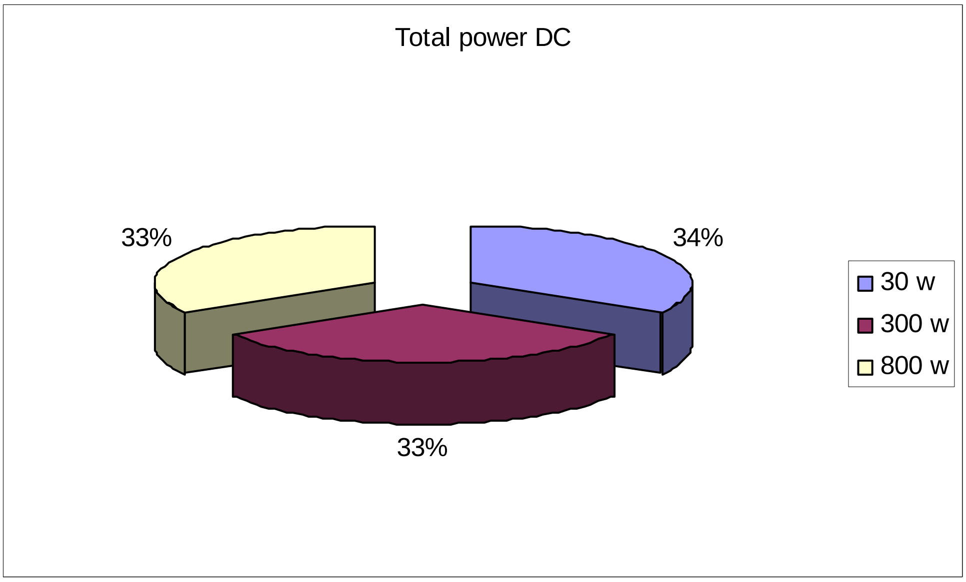
- Electrical consumption

This data is very important to supply electrical power equipment according to the characteristics of the equipment to be installed.

In AC, the voltage required was 220/240V (15% of the participants), and the total power is shown in the following figure:

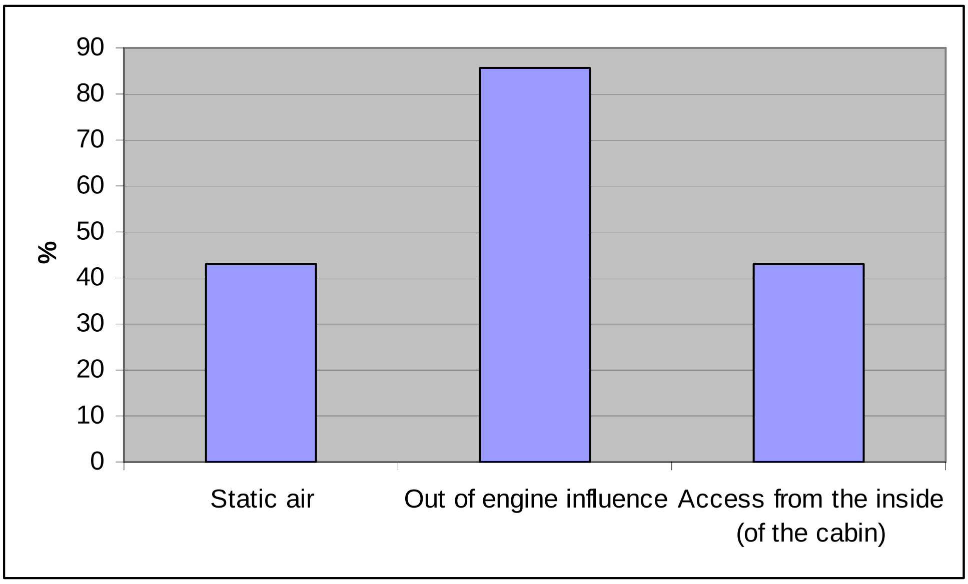


In CC, the voltage required was 12V (2% of the participants) and 28V (6% of the participants). The power needed is shown in the next figure:



- Aircraft modifications

Aircraft modifications include inlets opening and windows. Questions about inlets were only answered by 14,6% of the participants, most of them required them to be out of engine influence and only some of them would need access from the inside or inlets in static air.



Regarding to the openings and windows only 10% of the participants could answer it and the only requirement was to have openings in the floor and the roof of the aircraft.

4 Conclusion

The survey has offered the opportunity to the scientists to express their needs in airborne research, specifically their needs for a new aerial platform of high payload and long endurance.

One of the conclusions that the authors have been able to draw from the survey is that perhaps, due to the complexity of the aeronautical world, it is understandable that scientists are sometimes confused as to the limits in performance of any given aircraft, they prefer to express their scientists needs in terms of their equipment but not in terms of the aerial platform required, as for example an specific aircraft or its modifications for research.

According to results of the survey, the majority of scientists were interested in the field of atmospheric chemistry and climate research, in particular in aerosol research. Other sciences required were clouds physics, instruments development and remote sensing and dynamics.

Therefore the most suitable aircraft for this type of research would be one with the following characteristics:

- A flight speed that oscillates between 50 and 150 m/s
- Ceiling above 11.000m.
- More than 96% would be satisfied with an endurance of 10 hours.
- Range about 1000km would satisfy over 90% of the scientists.
- The preferred trajectory is an straight line, as more than 70% chose it
- The majority of the scientists need clear weather for their experiments or clouds.
- Almost 70% can not schedule the flight several months in advance. Most of them would need five days to exactly plan the experiment (because of weather conditions).
- Over 60% of the scientists would need only 1 or 2 operators on board.
- Over 60% would need ground assistance.
- Over 92% would not need to transmit data on real time from the aircraft to Earth.
- All the parameters expressed were interesting for the scientific community.
- The highest weight for the equipment to install would be 1500kg, and the average would be around 417kg each installation.
- The aircraft should have hard points under its wings to install pods
- The medium power required for a single experiment is over 500w, but in order to make multidisciplinary flights maximum power should be available for scientists.