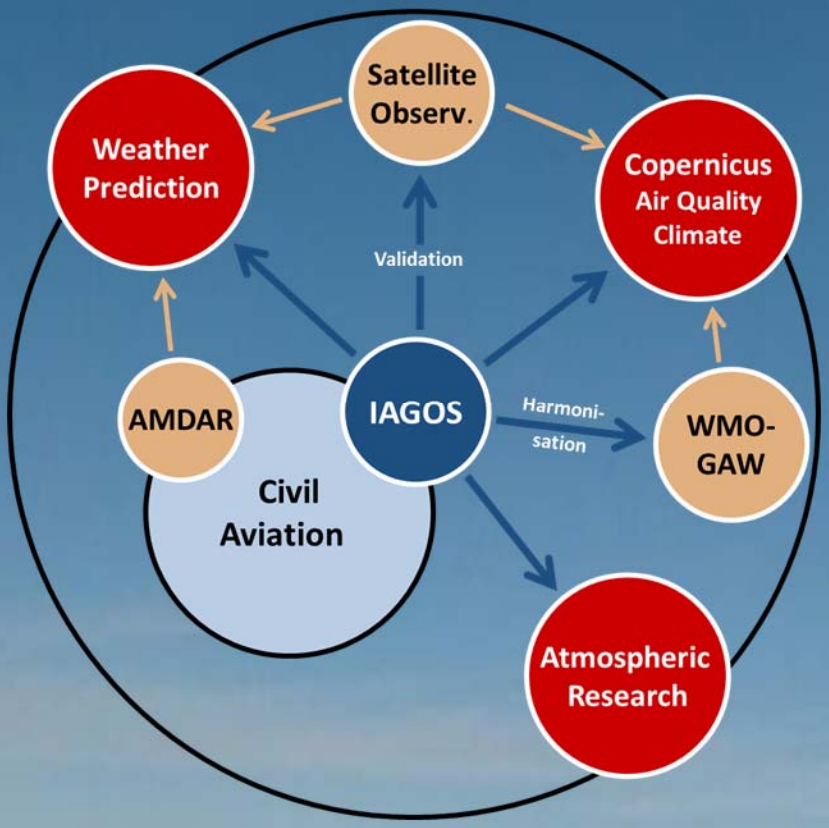
In-Service Aircraft for a Global Observing System — Association Internationale Sans But Lucratif

IAGOS-AISBL



Implementation Plan 2018

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Contents

Members of IAGOS-AISBL

Acronym	*Member*	*Country*
FZJ	Forschungszentrum Jülich GmbH	Germany
CNRS	Centre National de la Recherche Scientifique	France
MPG	Max-Planck Gesellschaft zur Förderung der Wissenschaften e.V.	Germany
MF	Météo France	France
UMAN	University of Manchester	U.K.
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V.	Germany
TROPOS	Leibniz-Institut für Troposphärenforschung e.V.	Germany
KIT	Karlsruher Institut für Technologie	Germany

Note: MPG is contributing to IAGOS with two of its institutes:

MPI-C: Max-Planck Institute for Chemistry, Mainz

MPI-BGC Max-Planck Institute for Biogeochemistry, Jena

Technical Setup

IAGOS combines the expertise of two successful European research projects, MOZAIC and CARIBIC. The complementary methodology developed in these projects is continued in IAGOS in order to fully exploit the advantages of both approaches.

As detailed below, IAGOS-CORE provides continuous data of key constituents with quasi global coverage from many aircraft, whereas IAGOS-CARIBIC provides additional information for a deeper scientific understanding from one aircraft.

IAGOS CORE

The ultimate goal of IAGOS is to equip 20 long-range aircraft of internationally operating airlines with IAGOS-CORE equipment for continuous deployment. In order to reach this goal, several conditions must be fulfilled:

1. Aeronautic Certification of the IAGOS equipment for installation aboard commercial long-range aircraft (Supplemental Type Certificate, STC)
2. Acquisition of the necessary equipment with EASA Form 1
3. Cooperation contracts with suitable airlines
4. Cooperation contracts with aeronautic companies for continued airworthiness
5. Logistics for maintenance and quality assurance

For each aircraft modification, the following components are required (see Fig. 1):

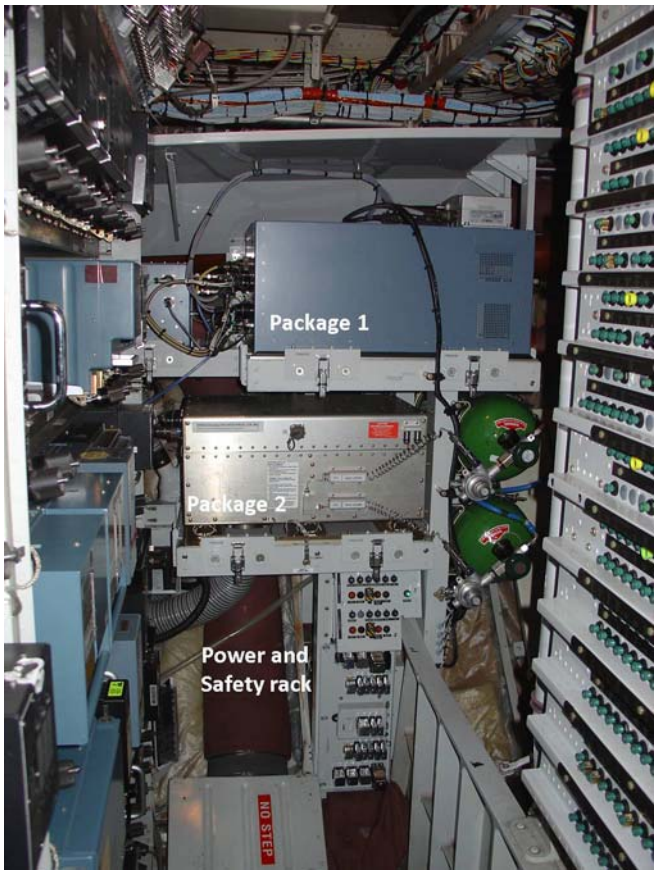

Fig. 1: IAGOS-CORE rack with instruments (P1, H2O, BCP and P2a) installed in an Airbus A340-300 operated by Lufthansa (left) and outside view of the IAGOS-CORE Inlet Plate (top).

1. IAGOS-CORE modification kit, comprising the mechanical, electrical and safety provisions for installation of the instruments and a special inlet plate with the probes for connecting the different instruments to ambient air.
2. Engineering support by the airline's maintenance department and by the design organisation in charge of the IAGOS STC.
3. Scientific instruments
    I. Package 1 (denoted P1), which contains the central data acquisition and transmission as well as the instruments for measuring ozone (O_3) and carbon monoxide (CO).
    II. Water vapour sensor (H_2O)
    III. Backscatter Cloud Probe (BCP)
    IV. Package 2 in one of five possible options:
        a. Instrument for the measurement of total odd nitrogen, denoted NO_y (P2a)
        b. Instrument for the measurement of nitrogen oxides, denoted NO_x (P2b)
        c. Instrument for the measurement of aerosol number density (P2c)
        d. Instrument for the measurement of greenhouse gases, i.e. CO_2, CH_4, CO and H_2O (P2d)
        e. Instrument for the measurement of aerosol extinction and NO_2 (P2e, in preparation)
    V. Unit for data transmission in real real-time via a satellite link to the WMO Information system (RTTU)

Each instrument must be approved for installation on commercial aircraft by Supplemental Type Certificate and must be manufactured by a company with EASA Part 21 approval. For maintenance of the equipment, companies with EASA Part 145 approval are required.

The EASA-STC for installation of the IAGOS-CORE rack with P1, H2O, and BCP was obtained in 2011 for A340 aircraft and in 2013 for A330 aircraft. The EASA-STC has been approved by the authorities of Taiwan Hong Kong and USA.

The installation of P2a and P2b was certified in 2011 for Lufthansa aircraft. The EASA-STC for installation of P2d has been obtained in December 2016 for all aircraft equipped with the IAGOS-CORE rack. STC application for P2a-c is in progress. The first P2d unit was installed in November 2017 on Lufthansa D-AIKO.

All instruments have been successfully operated on different research aircraft during scientific campaigns.

The RTTU has been installed on the first IAGOS-CORE aircraft (D-AIGT) in February 2017.

IAGOS has established a Technical Operations Group (TOG) for coordination of aircraft installations, instrument operations, certification issues and maintenance of the equipment. This group oversees the IAGOS Maintenance Centre lead by Enviscope.

IAGOS-CARIBIC

One AIRBUS A340-600 operated by Lufthansa carries provisions for operation of the IAGOS-CARIBIC Flying Laboratory, a modified cargo container (see Fig. 2) with (actually) 19 state-of-the art instruments for in-situ and remote sensing measurements and provisions for

the collection of whole air and aerosol samples. The latter are analysed in different European laboratories for a more detailed view of the atmospheric composition during the flights. The aircraft carries a complex inlet probe (see Fig. 2), which is connected to the instruments inside the container. Operation of the CARIBIC container is typically once a month, with 4 consecutive long-haul flights. IAGOS-CARIBIC is operated and coordinated by KIT (Germany), with further 11 partners from 5 European countries (11) and the US (1).

The instruments deployed in CARIBIC are designed for in-situ measurements of ozone, water vapour, cloud water/ice, carbon monoxide, carbon dioxide, methane, water isotopologues, nitrogen oxides, volatile organic compounds, and aerosol properties including number concentration, size, elemental composition, soot, and biogenic particles. Also a slot for IAGOS-core package-2 instruments is provided. The whole air samples are analysed (after flight) using different gas chromatographic systems for a large suite of organic compounds and fluorocarbons. The elemental composition of the aerosol samples is analysed using ion beam thermography.

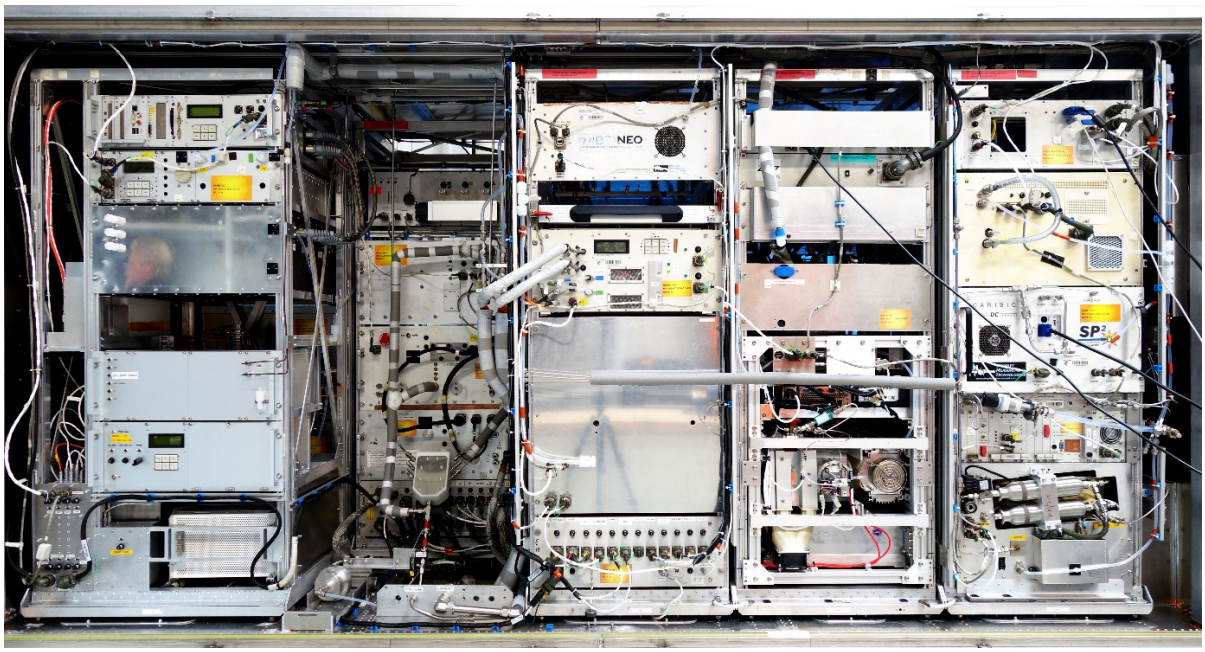

Fig. 2: Cargo container equipped with CARIBIC instruments (top) and the CARIBIC inlet mounted below the aircraft (left).

Planning

IAGOS-CORE

Fig. 3 gives an overview of the planning for aircraft installations (black bars) and the acquisition of the necessary hardware by the Members of IAGOS-AISBL.

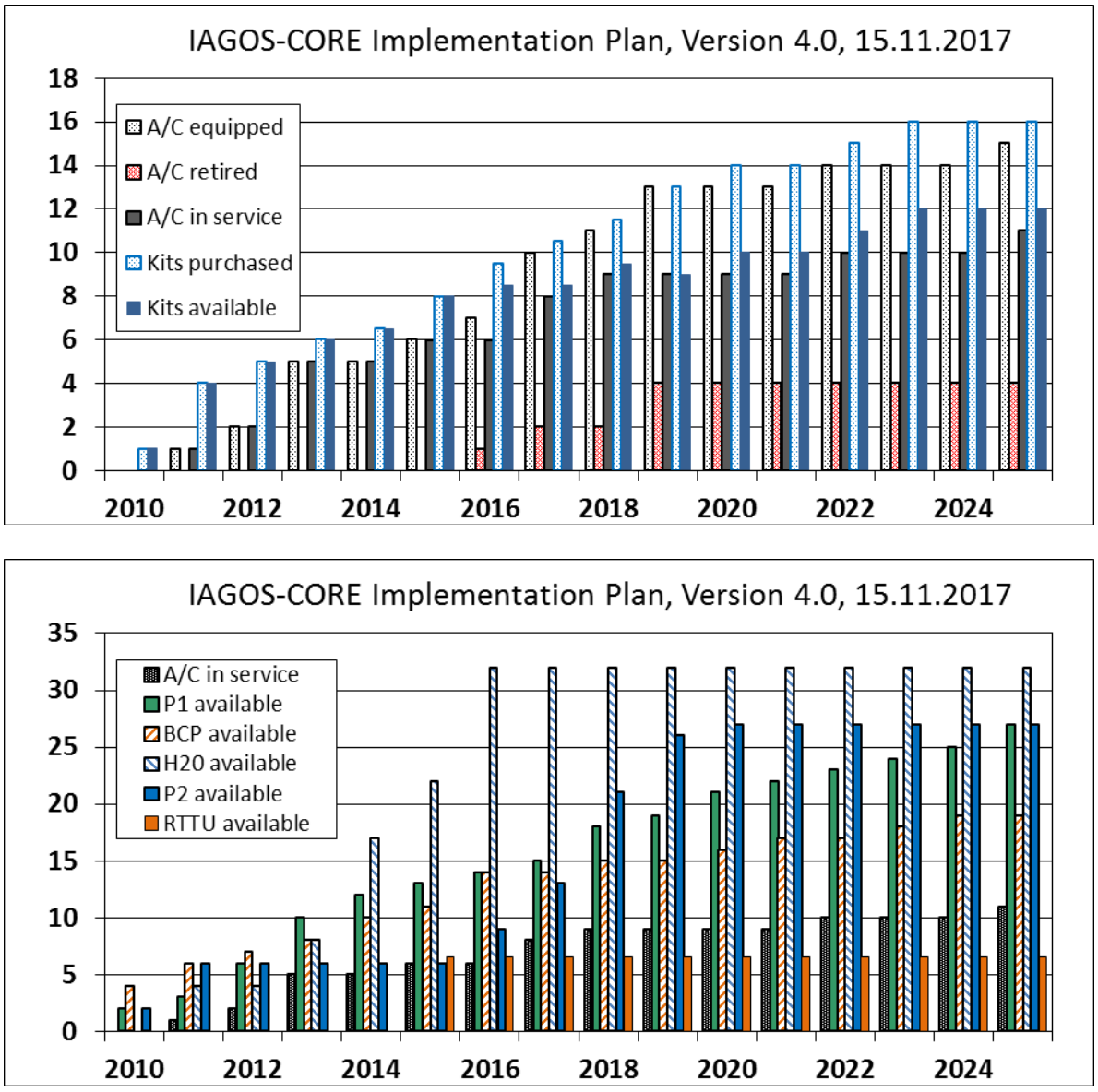

Fig. 3: Planning of aircraft installations and acquisition of hardware for IAGOS-CORE

The detailed planning, including the responsible Members, is listed in Table 1. The planning is annually revised and depends to some extent on the availability of financial resources, which are granted on an annual basis for the Members CNRS, MF and UMAN. Detailed planning also depends on the availability of suitable aircraft for integration. In order to avoid interference with airline operations, integration is usually done during a scheduled layover (C- or D-check) of the aircraft.

For the year 2018, only one new installation of IAGOS-CORE equipment is foreseen on an A330 aircraft operated by Finnair (priority 1) and Iberia (priority 2).

Table 1: Planning for Aircraft installations and acquisition of hardware by the different Members involved in IAGOS-CORE, based upon current resources estimates.

IAGOS-CORE																	
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Aircraft installations	**0**	**1**	**1**	**3**	**0**	**1**	**1**	**3**	**1**	**2**	**0**	**0**	**1**	**0**	**0**	**1**	**15**
FZJ		0.5		1		1	1	1	1	1							6.5
CNRS				1				2		1			1			1	6
NCU			1														1
co-funding by EC		0.5		1													1.5
IAGOS Kits total	**1**	**3**	**1**	**1**	**0.5**	**1.5**	**1.5**	**1**	**1**	**1.5**	**1**	**0**	**1**	**1**	**0**	**0**	**16**
FZJ		2		1	0.5	0.5	0.5	1	1	1.5							8
CNRS		1				1	1				1		1	1			6
co-funding by EC	1		1														2
Package 1 total	**2**	**1**	**3**	**4**	**2**	**1**	**1**	**1**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**27**
P1 by CNRS		1	3	4	2	1	1	1	3	1	2	1	1	1	1	2	25
co-funding by EC	2																2
H2O total	**0**	**4**	**0**	**4**	**9**	**5**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**32**
H2O by FZJ		4		4	9	5	10										32
BCP Total	**4**	**2**	**1**	**1**	**2**	**1**	**3**	**0**	**1**	**0**	**1**	**1**	**0**	**1**	**1**	**0**	**19**
BCP by CNRS					1												1
BCP by FZJ	1	2			1		3										7
BCP by UMAN	3		1	1		1			1		1	1		1	1		11
Package 2 total	**2**	**4**	**0**	**0**	**0**	**0**	**3**	**4**	**8**	**5**	**1**	**0**	**0**	**0**	**0**	**0**	**27**
P2a/b by FZJ	2	2					2	2	2								10
P2c by FZJ		1					1	2	2	2							8
P2d by MPG		1						0	3	2							6
P2e by FZJ									1	1	1						3
RTTU	**0**	**0**	**0**	**0**	**0**	**6.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6.5**
MeteoFrance						1.5											1.5
co-funding by EC						5											5

Numbers in black: according to long-term estimation

Numbers in red: funding yet to be secured

IAGOS-CARIBIC

Planning for CARIBIC concerns the continuous improvement of instruments and container infrastructure, and the development of new instruments. Implementation of new or improved instruments requires a revision and re-certification of the container. As shown in Table 2, such a revision with the installation of 5 new instruments and 3 newly built-up instruments has been accomplished in 2016/2017. The two instruments for CO_2 and CH_4 were substituted by a single instrument (Picarro CRDS) and the Hg instrument was removed in 2016. Certification of the modification is in expected for mid-November 2017. Thereafter, operation is planned to start again.

Planning for the future also concerns the preparation of a changeover to a new aircraft in 2019, including the construction of a new inlet system and recertification of the container, including the potential integration of new instruments. Thereafter instrument updates are expected each ~3 years.

Table 2: Planning schedule for IAGOS-CARIBIC

	Year	≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Infrastructure	**Member**												
Container upgrade	KIT / MPI-C	1		1			1						
Inlet exchange	KIT / MPI-C	1					1						
A/C changeover	KIT / DLH						1						
Instrumentation													
O3	KIT	1											
H2Otot	KIT	1											
H2Ogas	KIT	1											
CO	MPI-C	1											
CO2	MPI-C	1			-1								
CH4	KIT	1			-1								
CH4/CO2	KIT / MPI-BGC			1									
H2O isotopes	KIT	1		i									
NOx/NOy	DLR	1											
Hg	MPI-C	1			-1								
Aerosol (CPCs)	TROPOS	1											
Aerosol (OPSS-1)	TROPOS	1											
Aerosol (OPSS-2)	TROPOS						1						
INP sampler	TROPOS						(1)						
Soot photometer	MPI-C	1											
VOCs (PTRMS)	KIT	1		i									
SO2, CH2O, ... (DOAS)	Uni HD	1		i									
Sampler	MPI-C	1											
NMHC GC-system	MPI-C	1	1										
HCs	Uni UEA	1											
Aerosol samples	Uni Lund	1					-1						
Aerosol (mini-AMS)	MPI-C / TROPOS			1									
WIPS (bioaerosol)	MPI-C			1									
N2O5, NO3, NO2, O3	Cork / NOAA / KIT			1									
Slot for CORE P2	KIT / FZJ			1									

Notes:
1: implemented
-1: removed
(1): tentative
i: improved

Revision and Status:

Version	***Published***	***EB approval***	***GA approval***	***Remarks***
02	24.10.2017	23.10.2017	15.11.2017	Final version

IAGOS-AISBL

Enterprise number:	**545.953.612**
Register:	**Brussels**
Address:	**Rue du Trône 98, B-1050 Bruxelles**
Chief Executive:	**Dr. Valerie Thouret**
President :	**Prof. Dr. Jean-Marie Flaud**
Contact :	**info@iagos.org**