# Flight planning

**Break out group summary**
**EUREC⁴A Planning Workshop, Paris 24-26 Sep 2019**

This is a very condensed summary of discussions around flight planning for the ATR-42, HALO, Twin Otter, WP-3D aircraft as well as the Boréal and Latitude drones. This summary focuses mainly on the research aircraft. The Boréal drone is planning to coordinate flights with the ATR-42. The Latitude drone will be operated from the Ron Brown and is planning on coordinating flights with the WP-3D.

More extensive information about the flight planning for EUREC$^4$A are collected in the slides from the workshop. This summary is structured to address the main three subjects scheduling, aircraft patterns, and aircraft coordination.

## 1 Schedules

All aircraft will arrive at Barbados before 18. Jan 2020. The first possible day for local research flights is the 20. Jan 2020. The last day for local research flights is the 14. Feb 2020.

Due to crew regulations, flights for most of the aircraft are scheduled for every second day with one additional day off every week. This results in three flights per week. The actual flight days will be decided based on the needs of the airport operations at Barbados in terms of parking capacity.

To capture the diurnal cycle of clouds and precipitation, three different take-off times are planned for HALO and ATR-42: early (take-off before sunrise), daytime, and late (landing after sunset). Twin Otter will try to work the same schedule as HALO and ATR-42, and probably also fly on days in between. The WP-3D is planning for roughly the same schedule with the possibility of one week of night flights and also possibly flying on the days between the flight days of the other aircraft. ATR-42 and Twin Otter plan on going back to BGI for refuelling during flight days. There are some constraints for this, as commercial air traffic has precedence.

Tradeoffs between capturing the diurnal cycle with HALO and loosing measurements from visible instruments are still discussed. One solution could be to do 2-hour staggering (take-off 6, 8, 10 LT or 7, 9, 11 LT) instead of 4-hour staggering (take-off 4, 8, 12 LT). Another solution could be longer HALO flights (10-11 hours instead of 9 hours). This could maximise the daytime flight time of HALO for visible instruments and still ensure capturing part of the diurnal cycle during early morning hours.

Open topics:

- HALO flights longer than 9 hours?
  → *check crew times*
- Flight days?
  → *wait for answer from BGI airport about parking capacity*
- Take-off times?
  → *wait for answer from BGI airport about refuelling capacity and runway construction work*

## 2 Patterns

All aircraft groups have defined flight patterns to achieve their scientific goals. These patterns are outlined below. The general location of the aircraft operation areas are shown in Fig. 1.

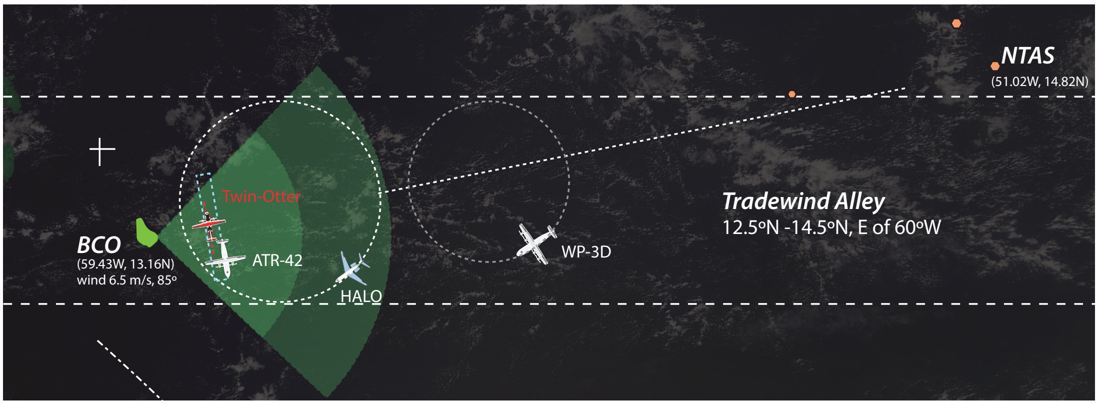


Figure 1: Schematic of aircraft positions.

- **ATR-42** Plans for the ATR-42 include three patterns: (i) a rectangle flown just above cloud base, (ii) perpendicular turbulence legs in sub-cloud layer, (iii) cloud layer legs with possible roll (Fig. 2). Ideally, all three patterns will be flown in every flight.
- **HALO** HALO will combine different pattern in each flight: (i) divergence circles at 9 km with dropsondes (Fig. 3), (ii) one context in the direction of the NTAS buoy (Fig. 1), (iii) low leg (ca. 5 km) towards BGI with BCO overpass.
- **Twin Otter** The Twin Otter will focus on one layer for each flight: (i) detrainment layer, (ii) cloud layer, (iii) sub-cloud layer (Fig. 4). The aircraft will mostly target individual clouds. If the Twin Otter would fly during nighttime, targeting clouds and flights in the sub-cloud layer will not be possible.
- **WP-3D** The WP-3D will mostly operate a bit upstream of the other aircraft towards the NTAS buoy. Plans are to combine all planned patterns in each flight: (i) long legs with dropsondes, (ii) 1.5° circles with dropsondes, (iii) stepped profiling between 3 km and sub-cloud layer, (iv) lawnmower grid at cloud base (Fig. 5).
- **Boréal and Latitude** Both drones will focus their observations on the sub-cloud layer. They will fly legs and profiles at altitudes from 40 to 2500 m (Fig. 6). The flights will be coordinated

with the other aircraft. The Boréal drone will be coordinating flights with the ATR-42, the Latitude will be coordinating with the WP-3D.

Open topics:

- Definition of cloud base/LCL and other levels?
  → *working group will work on definitions and plans for implementation during the campaign*

# 3 Coordination

To benefit from measurements from multiple aircraft, several patterns are planned for coordination (Tab. 1). It is envisioned that all objectives listed in Table 1 can be targeted in every flight. To this end, the necessary patterns will be combined for each aircraft as far as possible.

Table 1: Scientific objectives and aircraft coordination patterns to achieve those.

| | HALO | ATR-42 | Twin Otter | WP-3D |
|---|---|---|---|---|
| Massflux (cloud base to detrainment)<br>→ *"Common area" for HALO/ATR-42/TO (HAT)* | ✓ | ✓ | ✓ | |
| Boundary layer turbulence<br>→ *ATR-42/TO same track, different levels* | | ✓ | ✓ | |
| Diurnal cycle (statistics)<br>→ *Shifted HAT schedules + WP-3D night flights* | ✓ | ✓ | ✓ | ✓ |
| Warm rain processes<br>→ *TO at different levels, coordinated with ATR-42 radar/lidar (following or offset)* | | ✓ | ✓ | |
| Mesoscale organization<br>→ *Leg along BCO-NTAS / super-curtain* | ✓ | | ✓ | ✓ |
| Calibartion / validation<br>→ *"Super-curtain" after take-off* | ✓ | ✓ | ✓ | ✓ |
| → *Coinciding circle* | ✓ | | | ✓ |

The two main coordination patterns are the common HAT area and the super curtain. The common HAT area will be located in the western part of the HALO circle. This will ensure collocated measurements of HALO, ATR-42, and Twin Otter (HAT). Here, all three aircraft will sample roughly the same airmass each time they pass this area. It has been discussed if flattening of the HALO circle on the western part would be beneficial. This could ensure an even closer overlap of the three aircraft and help with deconflicting dropsondes from HALO and the other two aircraft. Further discussion is needed on this topic.

For the super curtain, the aircraft will fly in line after take-off. If one or multiple ships are in the area, they should also be located along this line. These measurements will give the chance for instrument intercomparisons. This pattern is done as often as possible. But, if for some reason one aircraft is delayed during take-off, the others will not wait but continue with their planned flights.

The fact that HALO will be dropping sondes roughly every four minutes while other aircraft are flying underneath is a source for uncertainty. This has to be worked out with aircraft operations and the ATC. Also, the communication between the different aircraft and possibly ships has to be worked out. This is addressed in the "logistics group".

Open topics:

- Flattening of HALO circle in the west?
  → *explore benefits and drawbacks of the different scenarios*
- Feasibility of patterns from aircraft operations point of view?
  → *check back with the different aircraft operations divisions*
- Deconfliction of dropsondes and ATR-42, Twin Otter?
  → *check back with the different aircraft operations divisions and ATC*

## 4 Figures

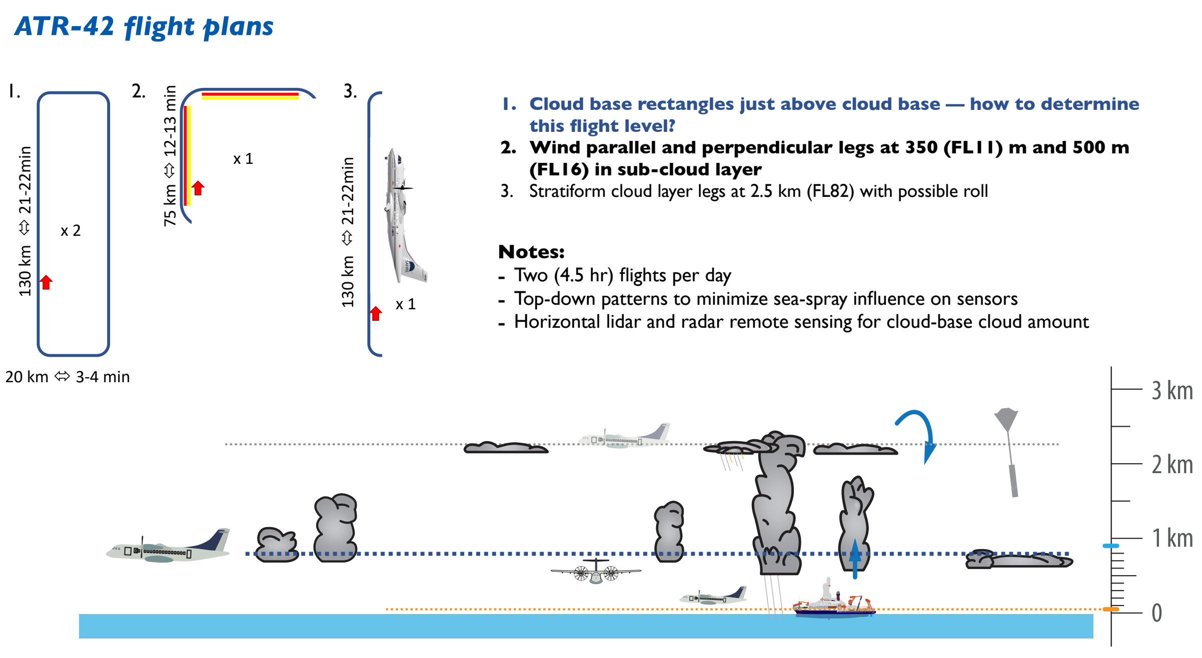


Figure 2: Schematic of ATR-42 pattern (slide prepared by Sandrine and Bjorn).

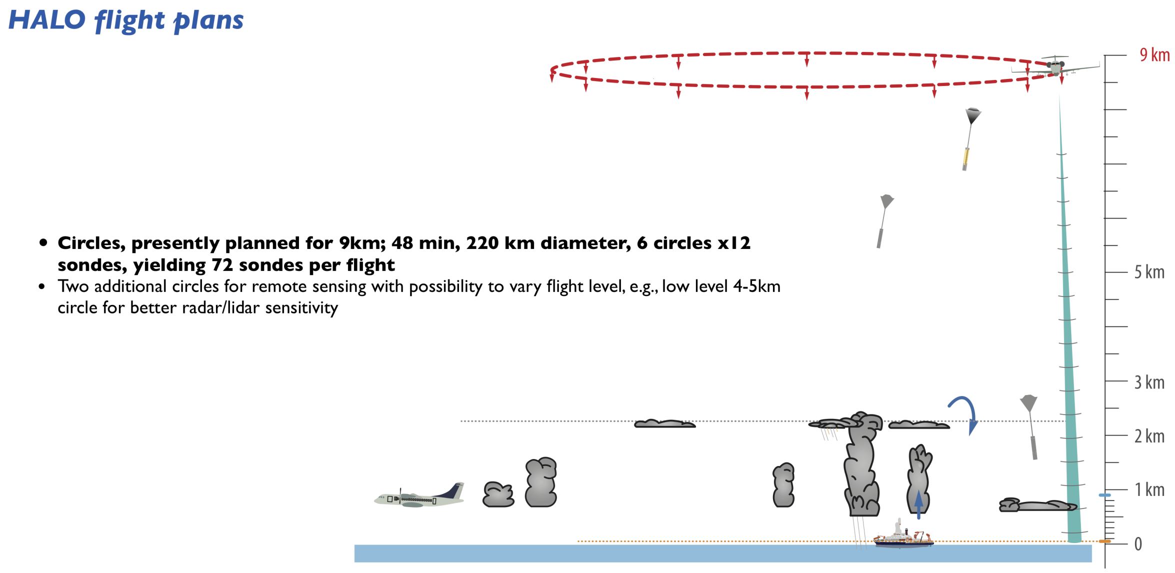


Figure 3: Schematic of HALO pattern (slide prepared by Sandrine and Bjorn).

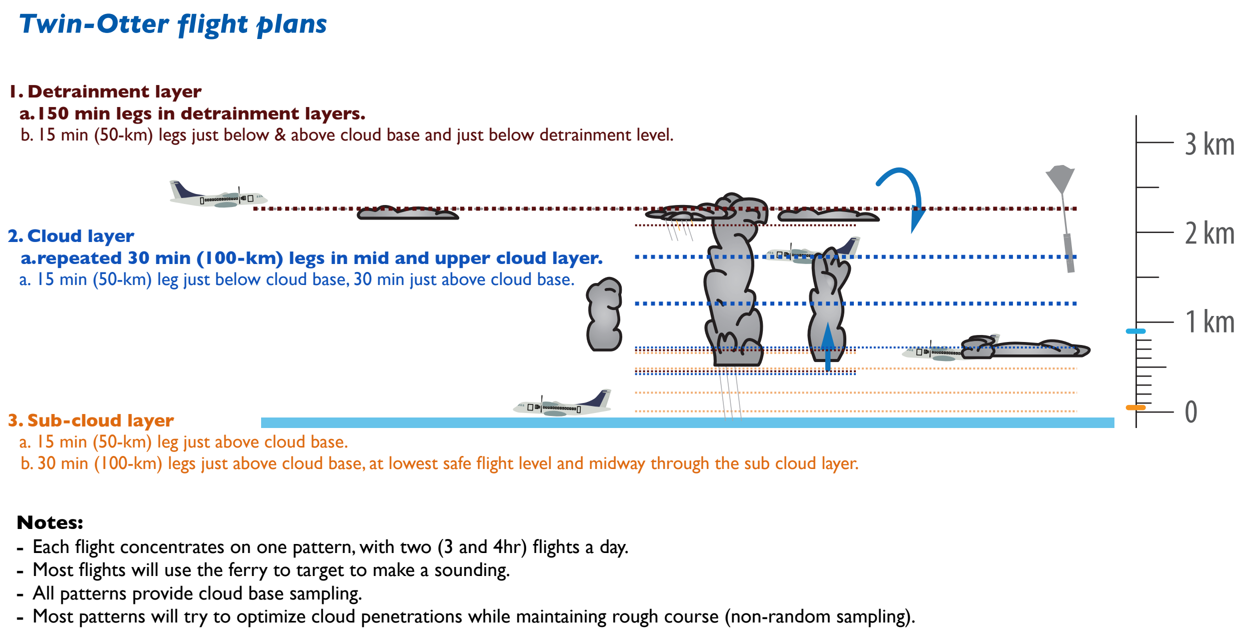


Figure 4: Schematic of Twin Otter pattern (slide prepared by Sandrine and Bjorn).

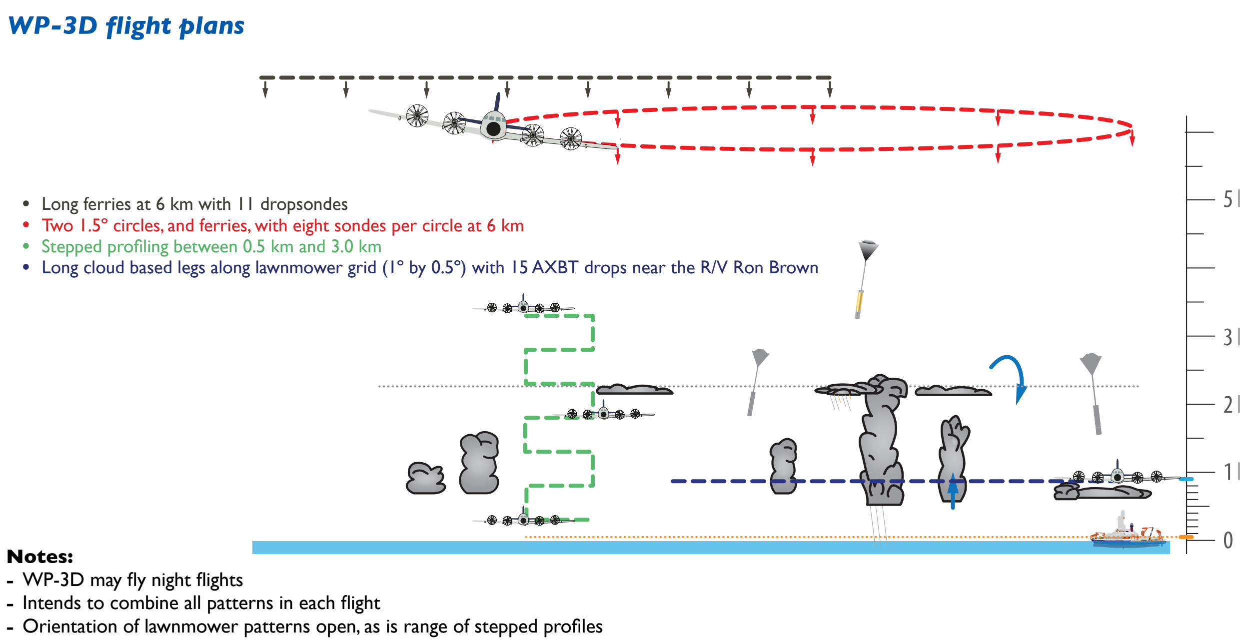


Figure 5: Schematic of WP-3D pattern (slide prepared by Sandrine and Bjorn).

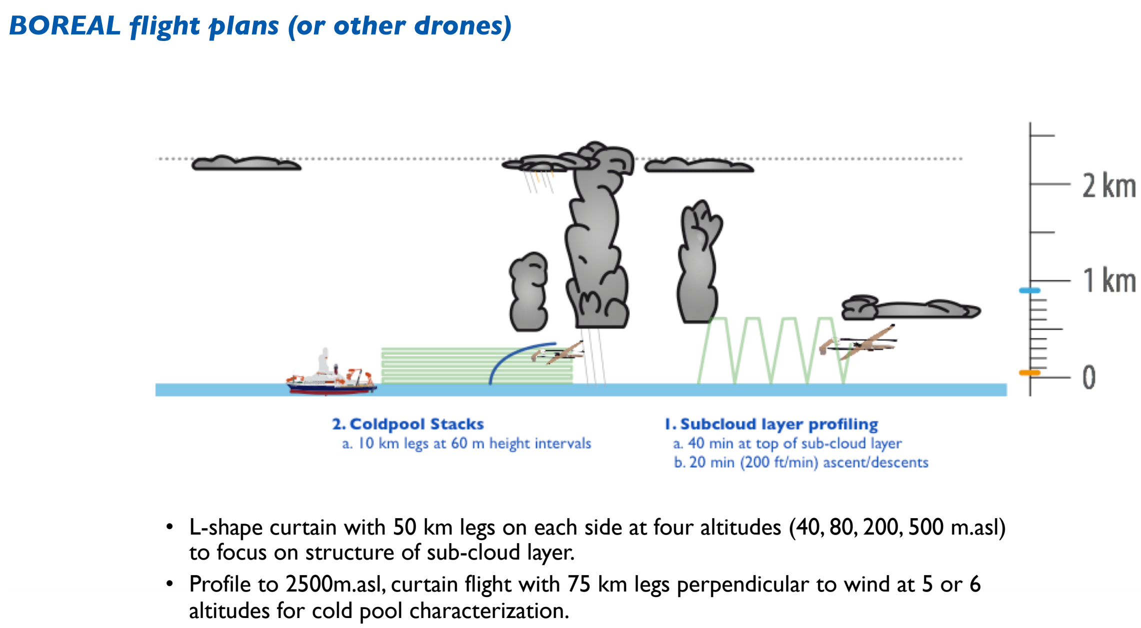


Figure 6: Schematic of WP-3D pattern (sketch prepared by Sandrine and Bjorn).