**2021 NOAA/AOML/HRD Hurricane Field Program - APHEX**

# MATURE STAGE EXPERIMENT
## *Flight Pattern Description*

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**Experiment/Module:** Surface Wind and Wave Validation Module

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**Requirements:** Categories 2–5

**Mature Stage Science Objective(s) Addressed:**

1) Test new (or improved) technologies with the potential to fill gaps, both spatially and temporally, in the existing suite of airborne measurements in mature hurricanes. These measurements include improved three-dimensional representation of the hurricane wind field, more spatially dense thermodynamic sampling of the boundary layer, and more accurate measurements of ocean surface winds [*APHEX Goal 2*]

**P-3 Pattern #1: Dropsonde Overflights (One P-3)**

**What to Target:** Surface wind speeds ≥ 100 kts, most likely in the eyewall

**When to Target:** This module can be flown during any pass through the storm center.

**Pattern:** This module can be flown with any of the standard in-storm flight patterns. The module consists of flying inbound, releasing a dropsonde, or rapid sequence of 3 dropsondes, targeting the surface wind speed maximum, entering the eye and then flying outbound ~30–40° azimuthally downwind of the inbound leg to overfly the splash location of the dropsonde. It may be necessary to adjust the azimuthal separation of the inbound and outbound legs to account for eye size, storm strength, and flight altitude. Another option is to wait for the dropsonde(s) to splash, determine the splash location(s), and overfly the exact splash location(s).

**Flight altitude:** 8–12 kft radar altitude

**Leg length or radii:** Any

**Estimated in-pattern flight duration:** ~10–15 min. The time separation between releasing the dropsonde and the outbound pass over the estimated splash location should be as close as possible to the time it takes for the dropsonde(s) to fall to the surface (~5-6 min) or the time it takes to obtain the dropsonde(s) splash locations(s) (~10–15 min).

**Expendable distribution:** Release a dropsonde targeting the surface wind speed maximum on the inbound leg. If possible, release 3 dropsondes in rapid succession through a tight gradient to increase the chances of observing the surface wind speed maximum with a dropsonde. An AXBT is not required, but could provide helpful SST data if available.

**Instrumentation Notes:** Use standard SFMR set-up. Important to maintain as constant of a roll angle, pitch angle, and altitude as possible. If available, the WSRA, UMASS SFMR, and/or IWRAP should be operating normally.

**P-3 Pattern #2: Dropsonde Overflights (Two P-3s)**

**What to Target:** Surface wind speeds ≥ 100 kts, most likely in the eyewall

**When to Target:** This module can be flown during any mission using both P-3s and during any pass through the storm center.

**Pattern:** This module can be flown with any of the standard in-storm flight patterns. The module consists of one P-3 (preferably the P-3 with the WSRA) flying inbound and releasing a dropsonde targeting the surface wind speed maximum or a sequence of 3 dropsondes released in rapid succession to increase the odds of observing the surface wind speed maximum. The second P-3 (preferably the P-3 with IWRAP) will fly inbound ~30–40° azimuthally downwind of the first P-3 and approximately 5-6 min later (or the closest temporal spacing possible for safe operations) to overfly the splash location of the dropsonde(s). The two aircraft can be at different altitudes. It may be necessary to adjust the azimuthal separation of the two P-3s to account for eye size, storm strength, and flight altitude or to identify the actual splash location of the dropsonde(s).

**Flight altitude:** 8–12 kft radar altitude

**Leg length or radii:** Any

**Estimated in-pattern flight duration:** ~10–15 min. The time separation between the two P-3s should be as close as possible to the time it takes for the dropsonde to fall to the surface (~5-6 min) or the time it takes to obtain the dropsonde(s) splash locations(s) (~10–15 min) while maintaining safety of flight.

**Expendable distribution:** The first P-3 will release a dropsonde targeting the surface wind speed maximum on the inbound leg. If possible, release 3 dropsondes in rapid succession through a tight gradient to increase the chances of observing the surface wind speed maximum with a dropsonde. An AXBT is not required, but could provide helpful SST data if available.

**Instrumentation Notes:** Use standard SFMR set-up. Important to maintain as constant of a roll angle, pitch angle, and altitude as possible. If available, the WSRA, UMASS SFMR, and/or IWRAP should be operating normally.

**P-3 Pattern #3: SFMR High-Incidence Angle**

**What to Target:** Regions of wind speeds ≥ 15 m $s^{-1}$ with homogenous rain rates (or no rain) and wind direction (e.g., not in eye). Avoid regions with large wind speed or rain rate gradients.

**When to Target:** This module can be flown at any point during the flight while in the storm. If the WSRA is on the plane collecting surface wave data, then the preference is to fly this module at night or when the sun is low in the sky.

**Pattern:** This module can be flown with any of the traditional in-storm flight patterns. The module consists of flying at least 3 consecutive circles at a given roll angle (Figure 1). Roll angles to be sampled are 15°, 30°, and 45°. If time allows, it is preferable to fly 5 consecutive circles at 45°. Best to begin circles by turning upwind for station keeping.

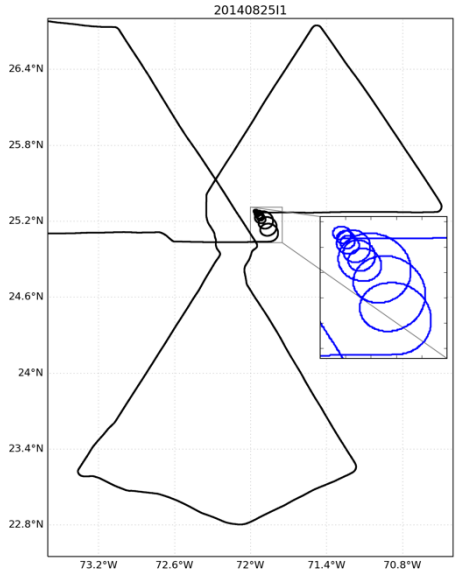


**Figure 1:** Example flight path (black) with SFMR high-incidence angle module. The inset zoomed in portion with the blue track displays the SFMR module in more detail.

**Flight altitude:** 8–12 kft radar altitude

**Leg length or radii:** Any

**Estimated in-pattern flight duration:** 3 circles at 15° takes ~17 min., 3 circles at 30° takes ~7 min., and 3 (5) circles at 45° takes ~4.5 (~7) min. for a total time of ~28.5 (~31) min. If time is a concern, remove 15° circles for a total time of ~11.5 min for 3 circles each at 30° and 45° or ~14 min for 3 circles at 30° and 5 circles at 45°.

**Expendable distribution:** Release a dropsonde/AXBT combo at the beginning of the module. If no AXBTs are available, this module can still be flown while only releasing a dropsonde at the beginning of the module.

**Instrumentation Notes:** Use standard SFMR set-up. Important to maintain as constant of a roll angle, pitch angle, altitude, and rain rate as possible. Ideal to fly this module while the WSRA is also operating and gathering surface wave data. However, any data collected is useful as long as there is a dropsonde for comparison.

## P-3 Pattern #4: SAR Overflights

**What to Target:** In-storm data collection coincident with synthetic aperture radar (SAR) data acquisition

**When to Target:** SAR satellite, Sentinel-1 A & B and RadarSAT-2, image acquisitions for ascending passes occur near 1800 local time and descending acquisitions occur near 0600 local time. Minimizing

the time difference between SAR image acquisition and aircraft data collection is desirable. However, as much as 6 to 8 hours difference between aircraft and SAR is tolerable. Ideal is between +/- 3 hours.

**Pattern:** This module can be flown with any of the standard in-storm flight patterns. Ascending SAR acquisitions are eastward of the sub-satellite point approximately 230 to 600 km (125 to 325 nm). Descending SAR acquisitions are westward of the sub-satellite point approximately 230 to 600 km (125 to 325 nm). SAR image acquisitions will be requested when the swath is forecast to intersect the storm. There will usually be a 24-to-48-hour notice. There are no particular SAR image "sweet spots" to consider.

**Flight altitude:** 8–12 kft radar altitude

**Leg length or radii:** Any

**Estimated in-pattern flight duration:** No additional time.

**Expendable distribution:** Normal dropsonde collection is sufficient for comparison to the SAR instruments. No additional requests.

**Instrumentation Notes:** Use standard instrumentation set-up. If available, the WSRA, IWRAP, and/or Doppler Wind Lidar should be operating normally.

### P-3 Pattern #5: High Seas

**What to Target:** Regions with significant wave heights of 8 ft and greater.

**When to Target:** Begin data collection when approaching significant wave heights of 8 ft on first inbound pass and continue data collection when significant wave heights are ≥ 8 ft.

**Pattern:** This module can be flown with any of the standard in-storm flight patterns. This pattern consists of extending standard flight legs, when necessary, to obtain WSRA significant wave height measurements in all regions with significant wave heights ≥ 8 ft. PIs will advise LPS prior to and during flight on the extent of waves with significant wave heights ≥ 8 ft.

**Flight altitude:** 8–12 kft radar altitude

**Leg length or radii:** Out to radius of significant wave heights ≥ 8 ft.

**Estimated in-pattern flight duration:** Data collection will occur during the entire flight. Extension of legs could add 30-60 min to a flight.

**Expendable distribution:** No expendables required.

**Instrumentation Notes:** Use standard WSRA set-up. Important to maintain 8-12 kft radar altitude for WSRA data collection.

**P-3 Pattern #6: Wave Buoy Overflights**

**What to Target:** Wave buoys within the storm environment.

**When to Target:** Any time during the flight when passing near (within 50 km) or over a wave buoy.

**Pattern:** This module can be flown with any of the standard in-storm flight patterns. This pattern consists of flying straight and level for 250 seconds (4 minutes and 10 seconds) on the approach to the buoy. If time allows, make a 90° turn (either direction) upon reaching the buoy and continue flying straight and level for an additional 250 seconds away from the buoy.

**Flight altitude:** 8–12 kft radar altitude

**Leg length or radii:** ~60 km

**Estimated in-pattern flight duration:** Approximately 8.5 mins for entire pattern with 90° turn at buoy.

**Expendable distribution:** No expendables required.

**Instrumentation Notes:** Use standard WSRA set-up. Important to maintain 8-12 kft radar altitude for WSRA data collection.