

R66 N450MC, recorded data synchronization

Data was recovered from 3 separate devices in the accident aircraft– the Rolls-Royce engine EMU, the Garmin GTN 750, and the Garmin GDU 1060. The Garmin devices get clock/time information from GPS satellites, but the EMU does not. As such, there is no direct way to correlate the timing of the data sets from the EMU and the Garmin devices. Consequently, an attempt was made to correlate the data sets using other means.

The Garmin devices do not record any engine parameters that could be used for correlation, but they do record acceleration, roll and pitch data, which can be used to determine when the aircraft first lifts off of the ground – the aircraft will start to roll or pitch as it lifts off the ground, whereas prior to lift-off the pitch and roll values remain static.

The EMU records engine torque as one of its parameters. Assuming the aircraft weight and center of gravity are the same, the engine torque required to cause the aircraft to lift off the ground will be the same between two aircraft.

Synchronizing Garmin GPS and Rolls-Royce EMU on exemplar R66 at RHC factory

RHC has a representative R66 aircraft (R66 SN 1133) which has similar avionics to the accident aircraft (R66 SN 916). We used a stopwatch, which was started at a set time on the Garmin GTN 750 GPS, then started the aircraft, and after a few minute engine run, stopped the stopwatch when the fuel mixture was pulled to the 'off' position. The fuel mixture being pulled off creates a very distinct, sharp temperature drop which is visible on the MGT channel of the EMU data. Reviewing the Rolls-Royce EMU data following this run indicated that the difference between the two clocks was 3.2 seconds, so we used 3 seconds as our offset number (the dataset's maximum resolution is 1 second).

Having this time synchronization value allowed us to combine the data sets from the Garmin data and the Rolls-Royce EMU data for our test 'exemplar' aircraft, providing us a complete data set for an aircraft that was nearly identical to the accident aircraft that included both engine torque data, and pitch and roll data.

Simulating the accident aircraft's lift-offs with exemplar R66 at RHC factory

The RHC aircraft was loaded/ballasted to closely match the GW and CG of the accident aircraft. (See attached Weight and Balance spreadsheets), and a series of ten lift-offs were conducted at the RHC factory. There are variables in play – such as the speed and direction of the wind, variations in engine performance and gauge tolerance, etc. Most significantly, the manner in which the aircraft lifts off is variable - if the cyclic is held perfectly in the correct spot, the aircraft skids will leave the ground "all at the same time", and the torque at which this occurs will be higher. On the other hand, if the pilot is holding the cyclic off center as the collective is raised, the aircraft will rock forward or rearward or sideward, and this will occur at a lower collective (torque) setting. The manner in which the aircraft lifts off the ground will be reflected in the appearance of the pitch/roll versus time data.

Comparing the accident aircraft lift-offs to exemplar aircraft lift-offs

On the accident flight, aircraft SN 916 initially lifted off, repositioned on the ramp, and set back down, and stayed there with the engine running for around 4 minutes, then lifted off ("second lift-off") and departed the airport. As a result, there are two lift-offs that can be compared to the exemplar aircraft lift off data. The weight difference between the two lift-offs on the accident flight due to fuel burn would be insignificant.

The data from the 10 lift-offs on the exemplar aircraft, specifically the pitch and roll data, were compared to the lift-off pitch and roll data from the accident aircraft on the accident flight. There were several lift-offs on the exemplar R66 aircraft that looked very similar to the lift-offs of the accident aircraft, in terms of the pitch and roll value versus time as the aircraft lifted off.

For the lift-offs that looked similar between the exemplar and accident aircraft, a distinct point in time could be identified as the lift-off time in both sets of data – for the exemplar aircraft we could also get the torque value associated with this lift-off time. Once the lift-off point was identified on the accident aircraft data, we could read the time associated with the lift-off. We then went into the Rolls-Royce EMU data and found the torque value we obtained from the exemplar aircraft data, and found the time associated with that torque. Noting the time difference between these two clock times, we could use this number to synchronize the data sets. Looking at more than one lift-off in the exemplar aircraft provides slightly different time correction numbers, these numbers could be used to 'bracket' the probable time offset between the accident aircraft's Garmin and Rolls-Royce EMU data sets.

For example, lift-off number 7 on the exemplar aircraft can be compared to the second lift-off on the accident flight. Lift-off number 7 occurred at 09:21:38, and the EMU torque value at that point was 36.43%. On the accident aircraft's second lift-off, the time on the Garmin device was 19:57:19. The accident flight's EMU data indicated the matching torque value (36.43%) on the second lift-off occurred at 12:59:38.8. Discarding the hour column, the time difference between the two sets of data is 59:38.8 – 57:19 = 2 minutes and 19.8 seconds.

Lift-off number 8 on the exemplar aircraft also looked similar to the second lift-off on the accident flight. Using the same method, lift-off number 8 occurred at 09:22:33, and the EMU torque value at that point was 46.25%. The accident flight's EMU data indicated the torque value of 46.25% on the second lift-off occurred at 12:59:41.5. This results in a time difference between the two datasets of 59:41.5 – 57:19 = 2 minutes and 22.5 seconds.

[illegible]

DATE						
FLT NO SHIP COPY		WEIGHT (lbs)	LOCATION		MOMENT	
			STA	B.L.	LONG	LAT
DATE WEIGHED 30-Mar-22						
SER NO	R66 SN 1133	1433.2	107.80	-0.59	154492	-852
EQUIPMENT ADDED/REMOVED						
		0.0	80.0	-15.0	0	0
Add Unusable Fuel		0.0	113.9	-20.3	0	0
Station for eng oil (add weight if oil was not full)		0.00	127.0	-14.6	0	0
Remove 1.8 lb leveling plate - MOMENT ONLY		0.00	0.0	0.0	0	0
3.00 lb Tail Ballast Installed at Time of Weighing		0.00	325.4	4.5	0	0
Aux Fuel Tank installed at Time of Weighing (30 Lb)		0.00	101.0	1.5	0	0
CORRECTED EMPTY WEIGHT		1433.2	107.80	-0.59	154492	-852
FRONT LEFT SKID		0.0	69.0	-35.0	0	0
NOSE BATTERY		0.0	10.0	0.0	0	0
FWD FLOOR LEFT		0.0	29.5	-12.2	0	0
FWD FLOOR RIGHT		0.0	29.5	12.2	0	0
FWD BAGGAGE LEFT		0.0	42.0	-12.2	0	0
FWD BAGGAGE RIGHT		40.0	42.0	12.2	1680	488
REAR FLOOR LEFT		0.0	64.0	-15.0	0	0
REAR FLOOR RIGHT		20.0	64.0	15.0	1280	300
REAR BAGGAGE LEFT		0.0	82.0	-15.0	0	0
REAR BAGGAGE RIGHT		20.0	82.0	15.0	1640	300
FWD TAIL		0.0	220.5	0.0	0	0
AFT TAIL		0.0	244.5	0.0	0	0
BAGGAGE COMPARTMENT		35.0	107.0	0.0	3745	0
AUX FUEL	GAL: 0.0	0.0	100.9	-1.0	0	0
PILOT	Woolums	175.0	49.0	12.2	8575	2135
PASSENGER	Martin	187.0	49.0	-12.2	9163	-2281
LEFT REAR SEAT		0.0	80.0	-16.0	0	0
REAR CENTER SEAT		0.0	78.0	0.0	0	0
RIGHT REAR SEAT		0.0	80.0	16.0	0	0
TAKEOFF FUEL		GAL				
USABLE	55.0	368.5	102.7	-3.2	37839	-1171
TAKEOFF		2278.7	95.85	-0.47	218414	-1082
FLIGHT DURATION (HRS)		1.0				
LANDING FUEL		GAL				
Aux	0.0	0.0	100.9	-20.3	0	0
Main	55	368.5	102.7	-3.2	37839	-1171
Total	55.0	368.5	102.7	-3.2	37839	-1171
LAND		2278.7	95.85	-0.47	218413.6	-1082