Going around in Cycles

by **Gavin Miller**

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Cycles… not an exciting subject, but something that you only should ignore at your own peril. These days, it seems that all of the manufacturers delight in devising new and complicated ways for us to track the airworthiness life of the various helicopter bits that go round-and-round and up-and-down. Now, I don't want to seem ungrateful, after all, they are just trying to give us more accurate ways to squeeze the maximum, safe, useful life out of these expensive parts. Right? But, how is one to keep track of all these weird and wonderful cycle counts so that no maintenance or airworthiness life items get missed?

The common term "cycle" came to be, I suppose, in the fixed-wing world. Generally speaking, it means you start the engines, taxi, takeoff, climb, pressurize the cabin, cruise for awhile, descend, land, taxi, and shut down the engines. Obviously, some parts and systems are more prone to needing attention or replacement based on the number of times they have gone through the cycle, rather than on how many hours they have flown (landing gear and turbine wheels are good examples). As such, the airframe manufacturers established airworthiness life and inspection limitations whose repetitive interval is measured in cycles, not flying hours. Limitation intervals on the structure of the wings and fuselage are often tracked in cycles. They may go by the name "landings" or even "flights", but the theory is the same.

Helicopters

Helicopters get a little more complicated. Repetitive cycle stress on the fuselage or wings caused by landings or pressurization cycles are obviously not so much of a concern, but some ships – such as Sikorskys – still have structural limits on the landing gear to worry about. This means that pilots may need to keep track of how many hours they fly, and how many landings they perform. And, of course, the maintenance control system needs to keep track of how many hours are on some parts, and how many landings are on others. Just to keep it interesting, maintenance planners also need to track how many days it's been since some maintenance actions were performed. Fire bottle squib replacement and hydrostatic tests are a common example. Some parts – like the Main Rotor Hub TT straps on older model Bells – have a life in hours and months.

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Dynamic Components

Helicopters have another thing to worry about that doesn't affect most fixed-wing aircraft – dynamic components. There are countless bits of metal in rotor hubs, drive shafts, and gearboxes all trying to fatigue themselves into failure. The majority of these are tracked in simple flight hours, but some components are stressed by other types of cycles, the most notable being significant power changes.

When a helicopter is put through a significant power cycle, such as taking off or lifting an external load, many powertrain parts undergo stress. A few manufacturers define these cycles and use them to specify retirement lives or overhaul intervals. For instance, some Eurocopter transmission parts have a life in cycles (landing, sling load, or water drop). Bell also treats each takeoff or lift as a fatigue cycle, and gives many of its main rotor masts and trunnions a life in RINs (Retirement Index Number).

Often, lifts and landings are one and the same (e.g., in most corporate and EMS work). In other cases (fighting forest fires, heli-logging, or performing other external load work), the difference between the two can become significant. On these helicopters, pilots must keep track of lifts and landings. For the maintenance staff, it can get downright ugly because the number of RINs accumulated for each takeoff or lift is not uniform. The main rotor trunnion and mast on the Bell LongRanger series accumulate one RIN for each landing and lift, but when the same parts are installed in a 206L-4, each event counts as two RINs.

On the Bell 212, each event counts as five RINs unless the aircraft is lifting logs, in which case, each event is 10 RINs. On the 205, the mast and trunnion accumulate RINs at a different rate, and logging lifts affect the trunnion adversely, but not the mast. For 212 operators involved in any kind of repeated heavy lifting, they must multiply the hours accumulated on the main rotor yoke by anywhere from 1.5 to 9.0 if they perform more than five events per hour, and log-

■ *(left)* **The main rotor trunnion and mast on the Bell LongRanger series accumulate one RIN for each landing and lift, but when the same parts are installed in a 206L-4, each event counts as two RINs.**

■ *(right)* **Turbomeca decided that speed and/or temperature cycles that the engine experiences affect each of the components differently.**

ging lifts count as two events. To keep track of all this in real time so that retirement lives don't get overrun requires both good records from the pilots, and either a huge supply of pencils and erasers in the maintenance department, or good software!

Sikorsky also defines RHL (Repetitive Heavy Lift) cycles for the S-61, and specifies the overhaul life of some drivetrain components accordingly. The S-76 may have components like the vent blower, the air conditioner, or combustion heaters that have inspection or overhaul intervals expressed in hours of operation. Traditionally, these have been tracked on an hour meter connected to the power circuit of the affected component. Technicians would then take a reading on these meters at regular maintenance events, and check to see if limits had been exceeded. This was both time consuming and not very reliable.

Another common example of this type of scheduled maintenance tracking is "hoist cycles", for helicopters equipped with a rescue hoist. The overhaul interval of the hoist, and the airworthiness life of the cable, is likely expressed in hoist cycles. External cargo hooks may also have an inspection or overhaul interval expressed in "hook releases." On certain Eurocopter models, they even go so far as to specify that releases under load (i.e., with the load not planted firmly on the ground when released), count as three normal releases. The better computerized maintenance tracking systems, such as WinAir from AV-Base Systems Inc., now allow the user to record daily usage in all the various hours and cycles. This allows for forecasts based on average utilization so that this type of maintenance can not only be better planned for, but so less of it gets missed. But, it does mean that the list of things the pilot has to record is getting longer... and the worst is yet to come.

Engines

Many turbine engine parts are also more sensitive to power cycles than to operating hours.

A turbine wheel that has gone from 70 degrees to 700, and from zero RPM to over 20,000, all in the space of about 30 seconds, has been tortured to a far greater degree than if it had been pulling the aircraft merrily along at 10,000 feet, for three hours. So, the engine manufacturers are in on the act too, with many rotating components having their useful life expressed in cycles. The ubiquitous Rolls-Royce 250 series engines are relatively simple to deal with – a start is one cycle, and most rotating parts have a life in cycles and hours. This brings up another issue that the fixed-wing folk don't usually have to worry about. Helicopters often land without shutting down the engine(s). If we want to get the maximum life out of the engine parts, we had better not count each landing as an engine cycle. This means you can add engine starts, or cycles, to the list of things our overworked pilot has to count.

Unfortunately, other companies, like Honeywell, Pratt & Whitney Canada (P&WC), and Turbomeca don't make counts as easy as Rolls-Royce. They have all decided that the speed

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** WARNING ** If math makes you dizzy, make sure you are seated before reading any further!

For the Bell212/412, the maintenance control system should track maintenance intervals in the following cycles, if you want to see "live" time remaining to all retirements and other maintenance events:

Dan Megna Photo

- Flight Hours
- Days/Months/Years
- Hoist Cycles
- RINs = (Landings + Lifts + (2 x Logging Lifts))
- #1 2A0E1F Cycles = #1 Starts + ((Landings – #1 Starts) / 2)
- #1 3A0E1F Cycles = #1 Starts + ((Landings – #1 Starts) / 3)
- #1 12A0E1F Cycles = #1 Starts + ((Landings – #1 Starts) / 12)
- #1 4A1E1F Cycles = #1 Starts + ((Landings – #1 Starts) / 4) + (#1 OEI x 1)
- #1 32A1.5E1.9F Cycles = (#1 Starts + ((Landings – #1 Starts) / 32) + (#1 OEI x 1.5)) x 1.9
- #1 10A3E1F Cycles = #1 Starts + ((Landings – #1 Starts) / 10) + (#1 OEI x 3)
- #1 2A0E3F Cycles = (#1 Starts + ((Landings – #1 Starts) / 2)) x 3
- #1 4A15E0.9F Cycles = (#1 Starts + ((Landings – #1 Starts) / 4) + (#1 OEI x 15)) x 0.9
- #1 10A3E4F Cycles = (#1 Starts + ((Landings – #1 Starts) / 10) + (#1 OEI x 3)) x 4
- #2 2A0E1F Cycles = #2 Starts + ((Landings – #2 Starts) / 2)
- #2 3A0E1F Cycles = #2 Starts + ((Landings – #2 Starts) / 3)
- #2 12A0E1F Cycles = #2 Starts + ((Landings – #2 Starts) / 12)
- #2 4A1E1F Cycles = #2 Starts + ((Landings – #2 Starts) / 4) + (#2 OEI x 1)
- #2 32A1.5E1.9F Cycles = (#2 Starts + ((Landings – #2 Starts) / 32) + (#2 OEI x 1.5)) x 1.9
- #2 10A3E1F Cycles = #2 Starts + ((Landings – #2 Starts) / 10) + (#2 OEI x 3)
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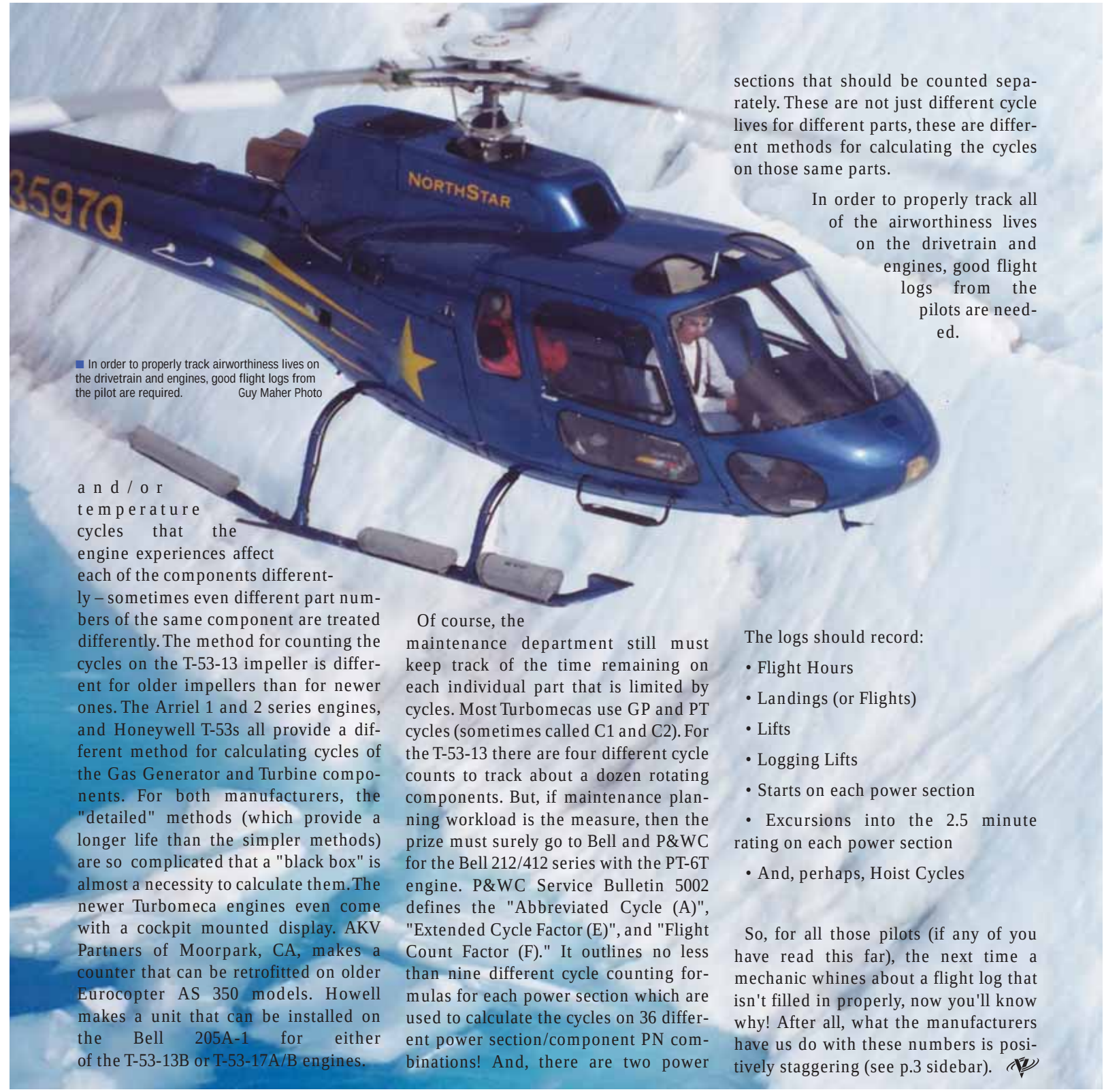
- #2 10A3E4F Cycles = (#2 Starts + ((Landings – #2 Starts) / 10) + (#2 OEI x 3)) x 4

There are 22 different cycle types above. Tracking all of the airworthiness limitations that use these cycles is no simple task, but it can – and should – be done. WinAir is the only software we are aware of that will do all of these calculations automatically and in real time.



■ In order to properly track airworthiness lives on the drivetrain and engines, good flight logs from the pilot are required. Guy Maher Photo

and/or temperature cycles that the engine experiences affect each of the components differently – sometimes even different part numbers of the same component are treated differently. The method for counting the cycles on the T-53-13 impeller is different for older impellers than for newer ones. The Arriel 1 and 2 series engines, and Honeywell T-53s all provide a different method for calculating cycles of the Gas Generator and Turbine components. For both manufacturers, the "detailed" methods (which provide a longer life than the simpler methods) are so complicated that a "black box" is almost a necessity to calculate them. The newer Turbomeca engines even come with a cockpit mounted display. AKV Partners of Moorpark, CA, makes a counter that can be retrofitted on older Eurocopter AS 350 models. Howell makes a unit that can be installed on the Bell 205A-1 for either of the T-53-13B or T-53-17A/B engines.

Of course, the maintenance department still must keep track of the time remaining on each individual part that is limited by cycles. Most Turbomecas use GP and PT cycles (sometimes called C1 and C2). For the T-53-13 there are four different cycle counts to track about a dozen rotating components. But, if maintenance planning workload is the measure, then the prize must surely go to Bell and P&WC for the Bell 212/412 series with the PT-6T engine. P&WC Service Bulletin 5002 defines the "Abbreviated Cycle (A)", "Extended Cycle Factor (E)", and "Flight Count Factor (F)." It outlines no less than nine different cycle counting formulas for each power section which are used to calculate the cycles on 36 different power section/component PN combinations! And, there are two power sections that should be counted separately. These are not just different cycle lives for different parts, these are different methods for calculating the cycles on those same parts.

In order to properly track all of the airworthiness lives on the drivetrain and engines, good flight logs from the pilots are needed.

The logs should record:

- Flight Hours
- Landings (or Flights)
- Lifts
- Logging Lifts
- Starts on each power section
- Excursions into the 2.5 minute rating on each power section
- And, perhaps, Hoist Cycles

So, for all those pilots (if any of you have read this far), the next time a mechanic whines about a flight log that isn't filled in properly, now you'll know why! After all, what the manufacturers have us do with these numbers is positively staggering (see p.3 sidebar).