Why Do Pilots (and everyone else) Sometimes Forget to Perform Critical Tasks?

By Key Dismukes

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Have you ever told a friend you would meet them someplace but forgot to go when the time came? Has a business meeting ever slipped your mind? Have you ever forgotten to take out the trash before collection day? Have you ever gone to the store to buy some particular item and come home with lots of things but not the item you went for? Have you ever forgotten someone's birthday or your own anniversary?

In everyday life these memory lapses are annoying, sometimes embarrassing, but if what we need to remember is very important, a matter of life and death, there is no way we could forget, right?

Well, no.

In August 2008 an airline crew prepared their MD-82 for departure from Madrid. They set the cockpit up for departure and ran their checklists appropriately, but when they got to the runway they discovered an equipment problem and had to go back to the gate. After the mechanics fixed the problem, the crew taxied back to the runway, again setting the cockpit up for departure. They advanced the throttles for takeoff, and when they reached the appropriate speed rotated the aircraft, which staggered into the air and then crashed, killing 153 people.

The accident investigation team discovered that when the crew first taxied out they had set all the cockpit controls correctly, but going back to the gate required them to raise the wing flaps. Then, when they taxied back to the runway the second time, they forgot to reset the flaps and missed this item on the checklist. On large aircraft, flaps must be set to takeoff position to generate enough lift to climb away from the runway. Normally, if pilots advance the throttles for takeoff with flaps not set, the takeoff configuration warning system alerts them so they can abort the takeoff, but on this occasion the warning system failed to operate, and the pilots continued the takeoff roll.

I have known several sailplane pilots who were injured or killed because they overlooked hooking up a control connection. But pilots are not the only ones who sometimes forget to perform critical actions. Air traffic controllers sometimes forget to issue clearances, and on rare occasion this has caused accidents. In aircraft maintenance the single most common error is forgetting some normal procedural step when re-assembling equipment after maintenance or inspection.

Why do pilots, air traffic controllers, mechanics, surgeons, and other highly experienced professionals sometimes forget to perform routine, fairly simple procedural tasks? Is it because they are incompetent or lazy – or something else? My research team and I spent several years trying to answer this question, focusing on aviation. Without going into technical detail I will give you a high level summary of the conclusions we reached, drawing also on the findings of many other research teams.

What I'm talking about is a relatively new field of cognitive science called *prospective memory*: Remembering to do things we intend to but must defer until a later time.

It quickly became clear that everyone occasionally forgets to do things, no matter how simple the task is, no matter how often they have performed the task previously, no matter how skillful they are at their work, no matter how conscientious they are. So why do we forget and what can we do to prevent these memory lapses?

We found that people forget to do things in several prototypical situations, which I will illustrate with examples from soaring.

The first prototypical situation occurs when we intend to do something we do not normally do as part of our habitual routine.

Let's say it is a beautiful soaring day and you are cruising along at 15,000 ft in the mountains. You hear a beeping sound from your electronic oxygen regulator telling you its 9 volt battery is dying. You are prepared for this situation, keeping a spare battery in the side pocket, so you pull the spare out, put it in the regulator, making a mental note to yourself to replace the spare battery after you land. Will you remember to do that? Maybe – but maybe not. Why would you forget? To answer that question we need to look at how we *do* remember our deferred intentions on those occasions we actually succeed.

Humans have a vast store of information, almost unlimited, in *long-term*

memory. That's where everything you know resides. But at any one moment only a tiny sliver of that information is activated and immediately available to conscious manipulation in what is called *working memory*. When you made that mental note to yourself to replace the spare battery, that thought was momentarily held in working memory – but it is not practical to hold such a thought continuously in your awareness while you continue all the mental activities necessary to fly your sailplane. The deferred intention fades from your current awareness and working memory, but it is not lost from your brain – rather it is now held in long-term memory, where it can be retrieved when needed. So now the question is: what allows us to retrieve from long-term memory that deferred intention to replace the spare battery a few hours later when we get back on the ground? And why do we sometimes forget?

The research shows that to retrieve the deferred intention back into awareness at the right time, we must notice something relevant; some cue must remind us, a cue that is in some way related to the intention. Most often this cue is something we see or hear in the environment. The best cues are those that are highly salient or conspicuous, that grab our attention and are closely related in memory to the subject of the intention. For example, when you are taking your large ship batteries out for recharging, that is a kind of cue – one kind of battery is related in memory to other kinds of batteries. Or you may hear another pilot talking about needing to put oxygen in her bottle. That is a more indirect cue: oxygen is related to oxygen regulator, oxygen regulator is related to regulator battery. It is less effective but it might work. But do you see how haphazard this process is? You remember to replace the spare regulator battery because you happen to be pulling out ship batteries or you happen to hear someone talking about oxygen?

The example of the battery is fairly trivial, but the principle applies to any situation in which we need to remember to do something later that we don't normally do as a matter of habit. Let's say you are diving fast between thermals and notice a slight fluttery vibration from the back of the sailplane. You think to yourself you should have your A&P take a look at the tailplane before you fly again, but then get busy with finding lift, setting up a pattern, landing, and putting away the sailplane. Will you remember to talk with your A&P? Maybe, but maybe not until the next time you are diving between thermals, when the flutter returns.

The bottom line is that our brains are not well constructed to be very reliable in remembering to do things we do not do habitually. We will probably eventually remember that spare battery for the regulator but we may not remember at a time when we are in a position to do something about it. Later in this paper I suggest practical ways we can protect ourselves against these kinds of memory lapses.

Forgetting habitual tasks

When we looked at airline accidents in which pilots forget to perform some essential task, we found that most of the things they forgot were routine operational procedural steps, rather than unique actions they were trying to remember to do. These were fairly simple tasks that they had executed thousands of times without difficulty on previous flights – things like setting flaps, extending the landing gear, turning on hydraulic boost pumps, or reading items on a checklist.

These habitual tasks tend to be forgotten in several prototypical situations. Before I describe those situations, some background about how our brains process information when we are performing familiar tasks will help. Basically, the brain/mind has two fundamental ways of processing information: *executive* and *automatic*.[1] Executive processes, which are associated with attention, working memory, and deliberate thought, are slow and effortful. They operate serially – one step at a time – and can handle only a very small amount of information at any given moment. Executive processing is required whenever we are learning new skills, dealing with novel or difficult situations, planning future activities, or solving problems.

If we had to rely exclusively on executive processing, we truly could not walk and chew gum at the same time. The things we have to do in everyday life, not to mention flying, would

[1] Other terminology is sometimes used, but this works best for our purposes here.

quickly overwhelm the narrow-band executive system. Fortunately, this is where automatic processing comes in. The automatic mode develops over time from practicing specific tasks repeatedly in a consistent manner. Automatic processing is fast and efficient and requires little mental effort, and in *most* situations it is robust and reliable.

Think back to when you were first learning to drive a car or fly an airplane; you probably experienced high workload, trying to remember what to do next, where to look, and how to operate the controls to get the result you wanted. You were having to use executive processing exclusively. But as you gained experience, everything got easier, you didn't have to think so hard about what to do next, your mental workload went down dramatically. But the tasks had not changed at all; what changed was that your brain learned to perform and integrate the tasks with automatic processing.

Here is a grossly oversimplified sketch of what happens when we perform a highly practiced task:

A ⇨ B ⇨ C ⇨ D ⇨ E…

We habitually perform each step of the task in a fixed sequence; performing step A triggers step B, performing step B triggers step C, and so on down the line. An example from soaring is taking your sailplane out of its trailer and rigging it for flight. Presumably you follow a consistent sequence in rigging your glider, though that sequence may vary a bit from one pilot to another. If you did not follow a habitual sequence you would have to spend an awful lot of time trying to remember what to do next after each step.

When you are performing a highly practiced task you are using what is known as procedural memory, which is the basis of automatic processing. Normally procedural memory/automatic processing is extremely robust and reliable, even under conditions of fatigue, stress, and injury. But it can be disrupted in several ways I am going to talk about now.

Habitual execution of a set of procedural steps becomes much less reliable if, for some reason, we try to execute the steps out of their habitual order. For example, you probably have a set sequence of actions you perform when you set up your landing pattern. For me the procedure is to check *wind*, check for conflicting *aircraft*, lower *gear*, check *spoilers*, and check for *obstacles* in the field, and I use the mnemonic WAGSO as a mental checklist.

But what happens when one day you are squeaking back home low? Ten miles out the glide computer and your Mark II calibrated eyeballs tell you that you may or may not make it, depending on whether you hit sink on the way. Three miles out you realize you can make it and heave a sigh of relief. You don't have enough altitude for a full pattern but you can set up a base leg to final, no sweat. You turn final, carefully nailing your airspeed, flair at just the right place, and then hear that awful sound of fiberglass grinding off the belly.

What happened? How could you have forgotten to lower the landing gear, a simple task you have performed without difficulty on a thousand previous flights? What happened is that of necessity you skipped the downwind leg, step A, which normally automatically triggers your brain to perform the sequence of steps to get the sailplane ready for landing. Also you may have been focusing all of your attention and working memory on whether you could make the field, preventing you from using your executive processing to check that automatic processing was in fact completing all tasks.

Please do not misunderstand. This example is not an argument that we must always fly a complete pattern, no matter how low we are. What I am saying is that when you are in this kind of situation, in which your normal routine is disrupted, consider it a big red flag. Be especially deliberate about running checklists and asking if anything is out of order or if you are forgetting something.

Interruptions are another way in which our highly practiced procedures can be disrupted. Many older sailplanes do not have automatic control hookups, and failing to connect a control can have fatal consequences. Let's say that you have just mounted the horizontal stab on your A model ASW 20 and are tightening the bolt when the guy rigging next to you asks if he will clear your wingtip as he pushes back. You walk over to the wingtips to make sure they clear, then walk back to the back of your ship.

Will you remember to hook the pushrod up to the elevator? Probably, but is probably good enough when it is a matter of life and death? Let's look again at this simplistic schematic of the chain of events when we are executing a practiced procedure. In this case let's say that C is tightening the bolt on the horizontal stab and D is hooking up the elevator. Normally, tightening the bolt is the trigger that automatically prompts you to retrieve the next step from procedural memory: hooking up the elevator. But when you were interrupted to walk away, you created a time gap, so tightening the bolt is less effective as a trigger, and there is no obvious visual cue that the elevator pushrod is not connected.

A ⇨ B ⇨ C…
INTERRUPTION…D?…

I'm not saying you will forget, but the probability has just gone up significantly.

Another way we can get in trouble with a habitual procedure is when we decide to defer a step in the procedure out of its normal place unto a later time. Let's say that you have pulled your sailplane fuselage out of the trailer and are getting ready to rig it when you remember that when you de-rigged the previous week you left the safety pins for the l'Hotellier connectors in the front of the trailer. Rather than stopping to walk back to the front of the trailer you decide to go ahead and

rig and then get the safety pins when you have to go back to get the tail dolly anyway. What have you done here? Let's say that inserting the safety pins is step D, which you normally perform after you hook up the pushrods behind the cockpit, step C. You have moved step D, inserting the safety pins, out of your normal sequence:

A ⇨ B ⇨ C ⇨ E ⇨ F...D

Doing this prevents hooking up the pushrods (step C) from automatically triggering you to remember to insert the safety pins (step D). Will you remember later to get the safety pins and put them in? Maybe – maybe not.

The last example involves substituting an atypical procedural step for the normal, habitual one. Let's say that at the gliderport at which you frequently fly sailplanes you normally land on a grass runway paralleling a paved runway. Today, however, a notice on the bulletin board says the ground is very soft from rain, so land on the paved runway. After you come back to the gliderport from several hours of flying will you remember? Maybe, especially if you see other sailplanes landing on the pavement. But if you are the first one back, with no visible cue to remind you, you are vulnerable to reverting to habit.

Countermeasures

I can't emphasize enough that no matter how skillful you are and how conscientious, and how important or easy the task is and how many times you have done it correctly before, you, like all of us, are vulnerable to occasionally having one of these memory lapses. Fortunately, there are things we can do to substantially reduce our vulnerability once we acknowledge that we are vulnerable.

If a task is vitally important, if possible, avoid deferring it. If, when you are pulling your fuselage out of the trailer, you notice that the cotter pin for the clevis pin holding a rudder cable to your rudder is missing, don't defer dealing with it until you have finished rigging!

Of course, in many situations we have to defer things we intend to do. In this case it helps greatly to create a reminder cue that we will notice at the right time. The best reminder cues are distinctive, salient, unusual, and/or block further action, such as putting an empty Styrofoam cup over the throttles of an airplane to remind you that there is something you must do before you take off. In the example of the oxygen regulator battery, instead of putting the dead battery in the cockpit side pocket, put it in your shirt pocket, where you are more likely to notice it after you land. When practical, writing a note to yourself is great, but that note won't help unless you put it where you will see it when you need it.

Form what are called *implementation plans*. Explicitly identify where and when you intend to perform the deferred task; mentally note exactly where you will be and what you will be doing when you intend to perform that task. Visualize yourself performing that task.

Checklists are of course a crucial tool to prevent forgetting things that are part of our normal procedure, but checklists are not perfect. Pilots sometimes miss items on checklists and forget to resume checklists they have had to suspend before completion. When designing your own checklist, keep it as short as possible and put the killer items at the top. For normal checklists I prefer to use the airline method of flow, then check. I perform each item from memory in a set sequence, then use the checklist (which can be a mnemonic) for the killer items. Make sure the print is large and the checklist is easily accessible. Execute the checklist in a slow, deliberate manner, and point to each item checked.

Whenever you are interrupted – and you will be – pause before addressing the interruption to form an implementation plan. Create a reminder cue if practical. For example, if your checklist is interrupted, hold it in your hand instead of putting it down.

When multitasking, performing a procedural step out of sequence, or substituting an atypical procedural step, treat the situation as a big red flag. Form an implementation plan and create reminder cues. Enlist other people to help you remember.

Above all avoid rushing, regardless of time pressure. Rushing at best saves a few seconds, and it increases our vulnerability to these and other types of errors enormously.

Further reading:

Dismukes, R. K. (2012). "Prospective memory in workplace and everyday situations." *Current Directions in Psychological Science*. 21(4) 215-220.

Loukopoulos, L.D., Dismukes, R. K., and Barshi, I. (2009). *The Multitasking Myth: Handling Complexity in Real-World Operations*. Aldershot, U.K.: Ashgate.