SERIOUS INCIDENT

Aircraft Type and Registration:	BAE Systems (Operations) Ltd ATP, SE-MHF	
No & Type of Engines:	2 Pratt & Whitney Canada PW126 turboprop engines	
Year of Manufacture:	1989 (s/n 2013)	
Date & Time (UTC):	14 December 2017 at 0606 hrs	
Location:	On approach to East Midlands Airport	
Type of Flight:	Commercial Air Transport (Cargo)	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	29 years	
Commander's Flying Experience:	2,089 hours (of which 1,854 were on type) Last 90 days - 82 hours Last 28 days - 29 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was conducting an ILS approach to Runway 27 at East Midlands Airport (EMA). At around 800 ft agl (approximately 670 ft aal) the co-pilot attempted to disconnect the autopilot but it did not appear to disconnect. The crew made several further attempts to disconnect the autopilot before initiating a go-around at 230 ft aal. An uneventful, manually flown, circuit and landing was completed afterwards.

Although the crew perceived that the autopilot disconnected while the aircraft was climbing during the go-around, recorded flight data indicated that it disconnected at approximately 425 ft aal during the approach.

No defects or abnormalities were identified with any units associated with the autopilot.

Following this incident (and two earlier similar events), the manufacturer decided to review the Emergency Checklist to see whether it should be amended to address the condition where crews are unable to disengage an autopilot.

History of the flight

First sector

The crew reported for duty at EMA at 2250 hrs on 13 December 2017 for a cargo flight to Belfast Aldergrove Airport (BFS) scheduled to depart at 0020 hrs. The co-pilot had been

called from a standby duty commencing at 1200 hrs on 13 December. The aircraft required de-icing and the departure was delayed. De-icing started at 0228 hrs, the aircraft took off from EMA at 0301 hrs and landed at BFS at 0406 hrs.

Second sector

The aircraft departed from BFS at 0503 hrs for the return sector to EMA; the co-pilot was designated as the pilot flying (PF). The crew reported that the weather conditions en route were mainly clear and, although the aircraft may have passed through some light cloud, they did not encounter any sustained icing conditions. The weather conditions at EMA had improved; the arrival ATIS recorded at 0549 hrs indicated Runway 27 in use, runway surface wet, surface wind from 230° at 11 kt, visibility more than 10 km and few cloud at 1,700 ft.

The crew briefed for an ILS approach to Runway 27. It was anticipated that the approach would be conducted in visual conditions and, in accordance with the operator's Standard Operating Procedures (SOPs), was planned to be stable by a minimum of 500 ft agl.

On the ILS approach, with autopilot 2 (AP2) engaged, the aircraft descended through 1,000 ft in a normal (gear down, flaps 15°) but not yet stable configuration. The co-pilot decided to disconnect the autopilot earlier than usual to take advantage of the manual handling opportunity. He recalled using the control wheel autopilot disconnect button at between 1,000 ft and 800 ft agl[1], but the autopilot remained engaged. He then tried using the control wheel trim switch, which should also have disconnected the autopilot, but that was similarly ineffective. He commented aloud that he couldn't disconnect the autopilot but the commander interpreted the comment as confirmation that he was disconnecting it and acknowledged the comment, not having realised that the autopilot was still engaged.

As the aircraft approached 500 ft agl (approximately 425 ft aal), when it was required to be stable, the commander became concerned that the aircraft was not yet configured for landing and prompted the co-pilot to make the landing flap selection. Landing flaps (20°) were selected and the co-pilot again advised the commander that he was unable to disconnect the autopilot. The commander tried the autopilot disconnect switch on her control wheel but the autopilot appeared to remain engaged and she called for a go-around. The co-pilot, concerned about how to go around while working against the autopilot, recalled information he learned after a previous incident on one of the operator's aircraft[2] and used the synchronisation (sync) switch on his control wheel[3] (Figure 1). As he pressed the switch he felt a 'release' of control wheel pressure which enabled him to take control and pitch to a nose up attitude for the go-around.

Footnote

1 Referenced to radio altitude (RA).
2 AAIB investigation to BAe ATP, G-BUUR '*Go-around due to autopilot issue and subsequent elevator control problems, on approach to Guernsey Airport, 26 January 2016'.* Available at: https://www.gov.uk/aaib-reports/aaib-investigation-to-bae-atp-g-buur.[accessed October 2018].
3 The sync switch de-energises the elevator, elevator trim and aileron clutches.

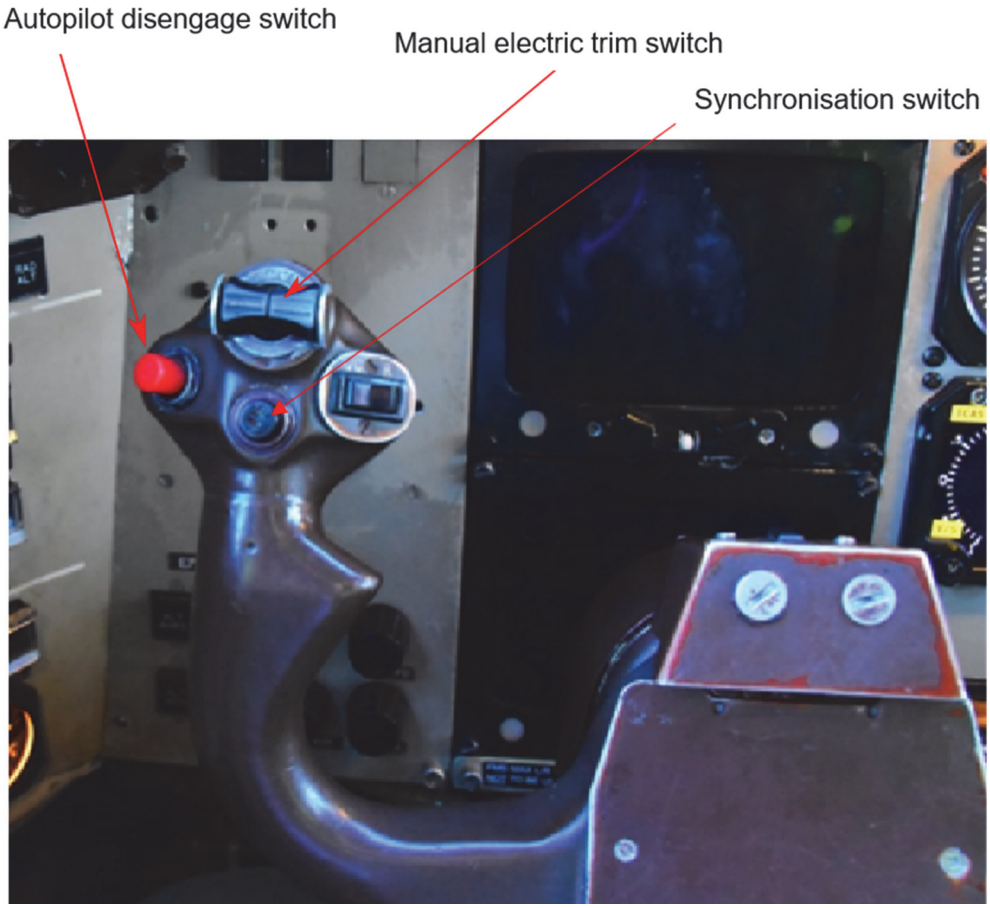

Figure 1

Control wheel switches (captain's control wheel)

The flight data showed that flap 20° was selected at 350 ft aal and that a go-around was initiated at 230 ft aal. During the go-around both pilots noticed that AP 2 was no longer indicating as engaged on the Primary Flying Display (PFD), although neither of them had heard an autopilot disconnect audio warning. The co-pilot continued to fly the aircraft manually and completed an otherwise uneventful circuit, approach and landing at EMA.

Pilot information

The commander started flying the BAe ATP in October 2011 as a co-pilot and completed command upgrade training in October 2016.

The co-pilot had a total of 2,500 hours flying experience, which included 700 hours on type. He had flown 65 hours in the preceding 90 days, 20 hours in the preceding 28 days. His previous duty, on 12 December 2017, was also a standby duty at 1200 hrs, from which he was called for a 1400 hrs report and went off duty at 2139 hrs.

Following his flight on 13/14 December he was scheduled to change aircraft fleet; he commented that because of this he had chosen to disconnect the autopilot earlier than usual and fly manually, his normal practice being to disconnect it at around 400 ft agl.

Post incident crew comment and analysis

The crew reviewed the event after the flight and realised that there had been a mis-communication between them concerning the autopilot status. The co-pilot believed he had informed the commander there was a problem with the autopilot disconnection, but the commander had received a different message and did not realise. In hindsight, the co-pilot thought that he may have been questioning rather than assertive when stating there was a problem. The misunderstanding was resolved when the commander became concerned that the approach might not be stable by the required 500 ft agl and started to prompt the co-pilot to complete the pre-landing actions.

The co-pilot noted afterwards that he had been confused by not being able to disconnect the autopilot and by an apparent lack of concern from the commander. He reported that for a while he was focussed on repeatedly trying to disconnect the autopilot and became absorbed by the problem. Although he anticipated he would have to go around, he was not sure how to achieve this. Then, when the commander prompted him for the before-landing actions, and realising that the approach should by now be stable, he again voiced his inability to disconnect the autopilot. The commander called for a go-around and the co-pilot, recalling having practised using the sync switch in training after the previous event in one of the operator's aircraft[4], pressed and held the sync switch and gained control to carry out the go-around.

Recorded information

SE-MHF was equipped with a 30 minute duration, tape-based, Cockpit Voice Recorder (CVR) and a tape-based Flight Data Recorder (FDR) with a capacity of 25 hours. Both of these devices were removed from the aircraft and successfully downloaded at the AAIB.

The CVR contained a discussion of the event between the flight crew after the aircraft had landed, but coverage of the actual event had been overwritten due to the elapsed time since the initial approach.

The FDR data for SE-MHF's approach and go-around, is shown below in Figure 2.

The data showed that AP2 was engaged with the aircraft in a gradual descent approaching 2,000 ft amsl as it aligned with the inbound course for Runway 27 at EMA. Flap 7 was selected with the airspeed reducing towards 154 kt and engine torque at 27.5% and 32.5% for engines 1 and 2 respectively. SE-MHF's pitch attitude then decreased, and a descent was started[5]. Engine power remained unchanged and, after a temporary increase in airspeed as the aircraft began to descend, Flap 15 was selected. SE-MHF's airspeed then began to reduce, reaching a minimum of 107 kt at 500 ft aal recorded after a period of 113 seconds. During this time, as the airspeed reduced, both the elevators and the pitch trim provided increasing nose-up inputs. An additional 13-14% of torque

Footnote

[4] AAIB investigation to BAe ATP, G-BUUR Guernsey Airport, 26 January 2016. Available at: https://assets.publishing.service.gov.uk/media/57ac5f91e5274a0f5200007e/BAe_ATP_G-BUUR_09-16.pdf [accessed October 2018].

[5] SE-MHF was flying an ILS approach with the autopilot coupled, the descent would be consistent with capturing the glideslope.

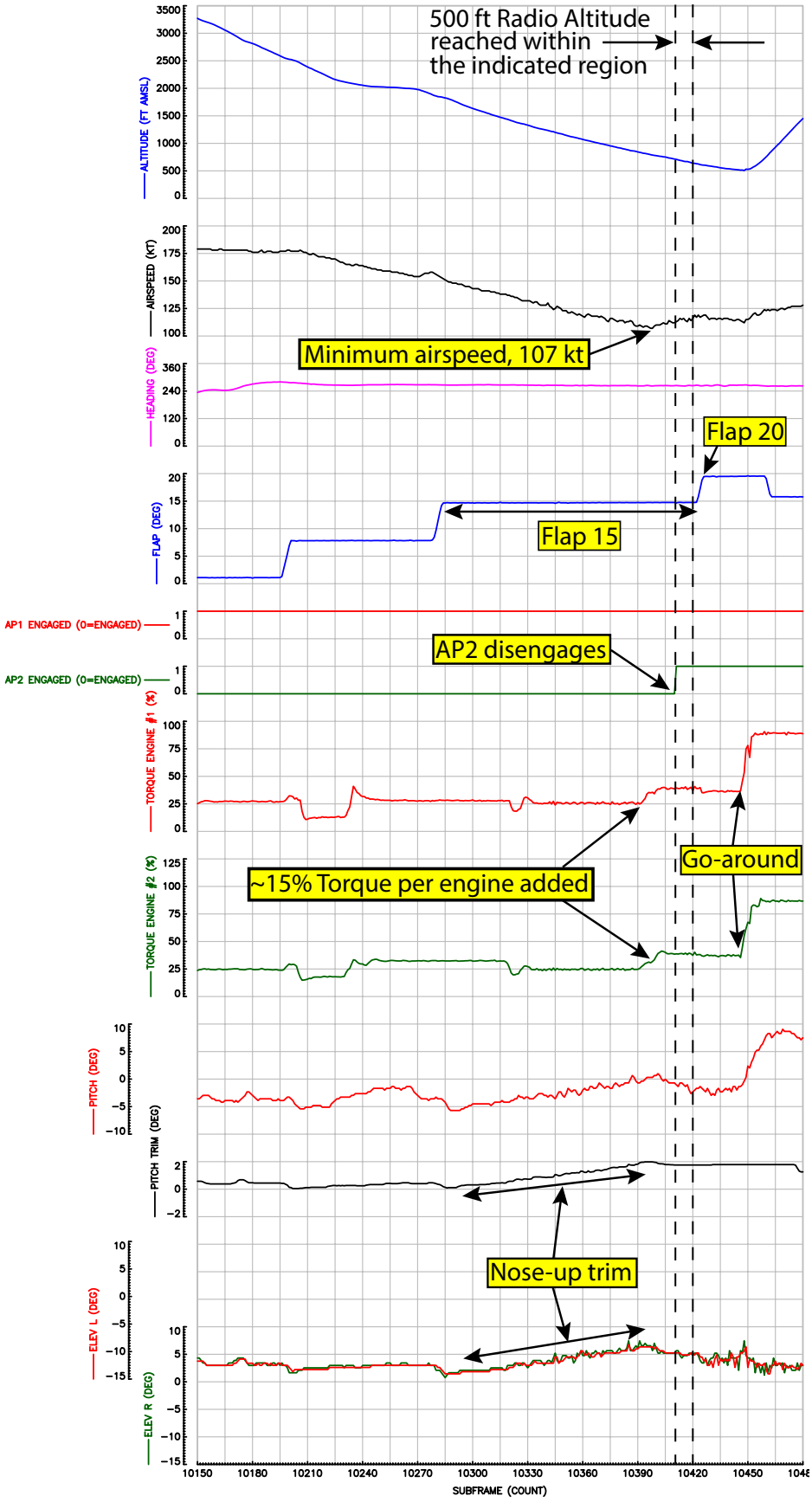

Figure 2

The initial approach and go-around at East Midlands Airport

per engine was applied just prior to the point of minimum airspeed and, subsequently, the airspeed increased to 113 kt. The data then shows that AP 2 disengaged[6] at 425 ft aal (approximately 500 ft radio altitude (RA)) and, thereafter, that the airspeed stabilised around 117 kt. The increase in airspeed of SE-MHF was accompanied by a corresponding decrease in aircraft pitch, but after AP2 disengaged no further pitch trim activity was seen in the data. Flap 20 was selected at 350 ft aal and a go-around was initiated at 230 ft aal.

Aircraft information

The aircraft has a common autopilot controller which, through dual circuits, interfaces with either the No 1 or No 2 autopilot system. A 'fly through' facility is available whereby an autopilot servo motor can be overridden by means of a slipping clutch. This requires a force in excess of 50 lb on the control column but does not disengage the autopilot, and any opposing force must be sustained. A spring-loaded sync switch located on each pilot control wheel, when held pressed, de-clutches the pitch, pitch trim and roll servo motors allowing the pilot to adjust the aircraft attitude without disengaging the autopilot.

Autopilot engagement/disengagement

An autopilot is engaged by the selection of an autopilot switch on the autopilot controller (Figure 3). The indication on the controller is an AP/YD[7] annunciation and illumination of a SYS 1/SYS 2 light. If No 1 autopilot is engaged, AP1 is shown in green on the left (Captain's) PFD and in white on the right (First Officer's) PFD. The situation is reversed when the First Officer is controlling the aircraft using No 2 autopilot (AP2 is shown in green on the right PFD and white on the left).

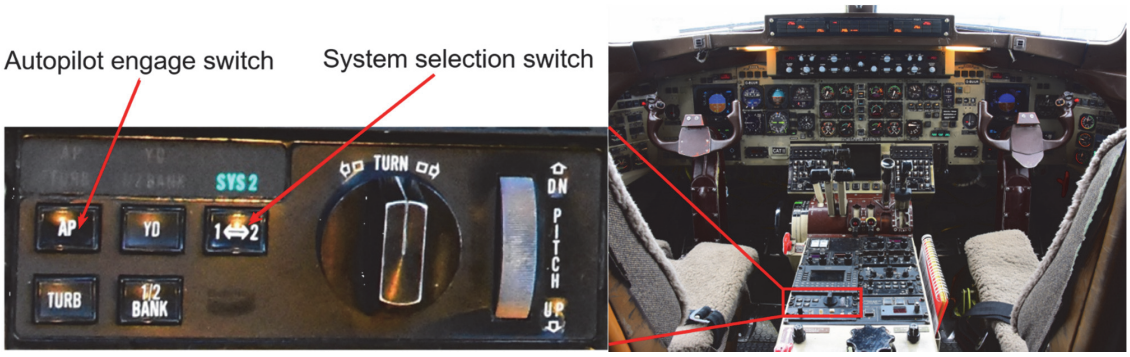

Figure 3
Autopilot controller

Footnote

[6] FDR installation on SE-MHF recorded the engagement status of each autopilot but did not record the inputs to the autoflight system that are used to trigger disengagement of the autopilot(s).
[7] Autopilot/Yaw Damper.

There are multiple methods by which an autopilot can be disengaged, shown in Table 1:

Action	Location
Activation of autopilot disconnect button	Pilot control wheels
Activation of either electric trim switch	Pilot control wheels
Activation of either Go around button	Power levers
Operation of A/P System 1-2 select switch	Centre console
Circuit breakers AP No.1 flight controller and No.2 flight controller	Left and Right side distribution panel respectively

Table 1

Methods for autopilot disengagement

When an autopilot disengages automatically, the AP/YD annunciations on the autopilot controller are removed and the AP1/AP2 indications on the PFDs are replaced with a red AP/FD[8] indication. At the same time, a continuous audio 'cavalry charge' multiple tone is provided to each pilot's headset and the cockpit speakers if they are selected ON. The tone can be cancelled by pressing either of the AP disengage switches.

When an autopilot is disconnected manually, AP/YD annunciations on the autopilot controller are removed and the AP1/AP2 indications disappear from the PFDs. A one second 'cavalry charge' audio tone is generated. There are no indications if the autopilot is already disengaged and further attempts are made to disconnect.

Landing data

The calculated landing weight was 16,778 kg, with the centre of gravity within the allowable range. The manufacturer's operating publications provide speed data for landing with flaps 20° or 29° and it is recommended the landing flap setting is selected before 250 ft aal. The approach speeds for a flap 20° landing are referenced to V_{AT} 20° (98 kt for 17,000 kg); speed data are provided on a landing card.

Emergency procedures

The Emergency & Abnormal Checklist does not provide a procedure for an autopilot which does not disengage.

Aircraft examination

Based on the details of the incident, the aircraft manufacturer recommended a package of tests to verify the serviceability of the aircraft's autoflight system which were completed by the operator's engineers at EMA. The only defect identified during these tests was that the No 1 autopilot computer failed to disengage within the required time during the autopilot disconnect test. As a result, the possibility was considered that the No 1 autopilot, although

Footnote

[8] Autopilot/Flight Director.

not the active autopilot during the incident, could have affected the behaviour of the No 2 autopilot. The aircraft manufacturer carried out an analysis of the data transfer within the autoflight system which confirmed that there is no data exchange between the autopilot computers.

All the avionics associated with the auto flight system were removed and replaced. The units removed from the aircraft were transported to the AAIB for further tests. Both autopilot computers, the autopilot control panel, both Flight Director mode control panels, the tone generator and the signal summing unit were tested by the Original Equipment Manufacturers (OEM), under AAIB supervision. No defects or abnormalities were identified with any of the units.

The operator confirmed that there were no further defects relating to the aircraft's autoflight system reported between its return to service and the end of the investigation.

Airfield information

The aerodrome elevation at EMA is 306 ft and the threshold elevation of Runway 27 is 282 ft. The terrain under the approach path to Runway 27 rises gradually from the east towards the aerodrome. The effect is that RA on approach does not correspond to the height of an aircraft above the runway threshold. This is shown in Table 2.

Distance from threshold Runway 27 (nm)	Altitude (amsl ft)	Radio Altitude (RA ft)	Above threshold elevation (ft)
3	1,290	1,152	1,008
2	970	815	688
1.4	780	620	500
1	650	450	368

Table 2

Effect of ground surface on radio altitude (RA)

Human factors

On 12 December 2017, the co-pilot finished his duty at 2139 hrs; he reported that after this he achieved a normal night's sleep. On 13 December, he was called from a 1200 hrs standby duty and reported that he did not sleep after being called. He also said that, at times, he felt very tired during the flight. The commander did not report feeling unduly tired during the flight. The incident occurred at 0606 hrs on 14 December.

The EASA Guidance Material for Flight Time Limitations at '*GM1 CS FTL.1.225(b)(2) Standby*' includes the following reference:

> *'AWAKE TIME -- Scientific research shows that continuous awake time in excess of 18 hours can reduce the alertness and should be avoided.'*

Alertness and performance are affected by two neurobiological processes: homeostatic sleep drive and circadian rhythms. The homeostatic sleep drive is a biological pressure for sleep. It is low shortly after waking and builds over the time a person is awake until it becomes difficult or impossible to resist sleep[9]. Homeostatic sleep drive starts to be evident as sleepiness or performance deficits after approximately 16 hours[10].

Circadian rhythm modulates many physiological and neurobehavioural human functions, including alertness and sleep patterns. The lowest point of this rhythm, on average, in people who are entrained in a stable 24-hour light and dark cycle is between 0300 and 0600[9]. The extent to which individuals suffer from performance deficits caused by a lack of sleep is highly variable[11].

The effects of sleepiness on performance include: increased periods of not responding or delayed responding on attention-based tasks; slowed information processing; increased reaction time; reduced accuracy of short term memory[12]; difficulties in problems solving; and perseveration[9,13].

Organisational information

The operator's stabilised approach policy is stated in their Operations Manual:

> *'The intention of the stabilised approach is that all flights shall be stabilised when passing 1000' AAL unless in VMC conditions where 500' AAL applies, otherwise a go-around shall be performed. It should be noted that radio altitude (RA) is used to give an approximation of height above the airfield without the potential confusion of referring to different barometric altitudes during the approach.'*

and

> *'There may be instances where the radio altitude varies greatly from height above the airfield – such as approaches made over the sea. In these cases, crew should take this into account in order to adhere to the intentions of the stabilised approach.'*

Footnote

[9] Mallis, M.M., Banks, S. and Dinges, D.F. (2010). Aircrew Fatigue, Sleep Need and Circadian Rhythymicity. In E. Salas and D. Maurino (Eds*.) Human Factors In Aviation*, *2nd Edition*, Academic Press: Amsterdam 401-436.

[10] Van Dongen, H.P.A, Maislin, G., Mullington, J.M. and Dinges, D.F. (2003). The Cumulative Cost of Additional Wakefulness: Dose-Response Effects on Neurobehavioral Functions and Sleep Physiology From Chronic Sleep Restriction and Total Sleep Deprivation. *Sleep,* 26 (2), 117-126.

[11] Van Dongen, H.P.A, Maislin, G. and Dinges, D.F. (2004). Dealing with inter-individual differences in the temporal dynamics of fatigue and performance: Importance and techniques. *Aviation, Space, and Environmental Medicine,* 75 (3), A147-A154.

[12] Dinges, D.F. (1995). On overview of sleepiness and accidents. *Journal of Sleep Research,* 4, Suppl. 2, 4-14.

[13] Tendency to repeat or prolong an action, thought, or utterance after the stimulus that prompted it has ceased.

The stabilised approach criteria for an approach in visual conditions are shown in Table 3.

Criteria	RA (ft)
On the correct flight path	500
Landing gear	1,000
Landing Checks	500
Rate of Descent - Maximum 1000 fpm	1,000
Landing flaps	500
IAS 150 kt or less, but not less than VAT / Vref,	500
VAT / Vref to VAT / Vref + 20 kt	500
Power setting appropriate for the landing configuration	500

Table 3

Criteria for stabilised approach in visual conditions

Other information

Previous similar events

Two previous events are recorded where flight crew have reported an inability to disconnect the autopilot on the ATP aircraft. The first was 27 May 1991:

> *'The commander of an ATP, G-BTPJ, stated that in the early stages of an approach the autopilot failed to disengage using any of the usual means. The crew eventually disengaged the system by pulling the autopilot circuit breaker. A fault was later found on the co-pilot's electric trim switch and there is no record of the problem recurring.'*

The second event was on 26 January 2016 and concerned ATP registration G-BUUR[14]. On this occasion no technical explanation for the event was found. Following the event, the operator (the same operator as for this event) issued '*Flying Staff Instruction No 175 Autopilot Disconnect*'. A pre-flight test was prescribed and, in the event of a failure to disconnect the autopilot on approach, a procedure for carrying out a go-around was provided:

> *1. Prior to every flight, the normal method of autopilot disconnect must be verified as operational.*
>
> *2. Should the autopilot not disconnect whilst carrying out an approach, an immediate 'go around' must be carried out using the following actions:*
>
> - *The autopilot must be overpowered using moderate force (but as much as is required) in order to gain manual control of the flight path.*

Footnote

[14] AAIB investigation to BAe ATP, G-BUUR Guernsey Airport, 26 January 2016. Available at: https://assets.publishing.service.gov.uk/media/57ac5f91e5274a0f5200007e/BAe_ATP_G-BUUR_09-16.pdf [accessed October 2018].

- *Crew can expect an 'SCS' caption immediately when overpowering the autopilot.*
- *The autopilot should disengage resulting in an 'ELEVATOR ENGAGE' caption on the SCS panel, but either pilot will have control of the aircraft as required.*
- *If the autopilot does not disengage, moderate force will be required to manually fly the aircraft.*

The co-pilot advised that during his recurrent simulator training an alternative method of managing an engaged autopilot had been practised, by using the sync switch.

The operator did not advise the AAIB of any changes to procedures following this latest event. However, the manufacturer decided to review the Emergency Checklist to see whether an additional item should be incorporated to address the condition where crews are unable to disengage an autopilot.

Analysis

At the time of the approach at EMA, it is likely the crew were operating at a low point of their circadian rhythm which could have adversely affected their alertness. Additionally, the co-pilot had been awake in excess of 18 hours which might have reduced his capacity for attention-based tasks. However, the crew were both accustomed to operating night duties.

The co-pilot thought that his first attempt to disconnect the autopilot was at between 1,000 and 800 ft. The operator's procedure is for heights below 1,000 ft to be referenced from the radio altimeter, thus, providing this reference was being used, the initial attempt to disconnect would have been at between 2.5 nm and 2 nm on the approach. If the co-pilot was still using the pressure altimeter as a reference, then the aircraft would have been about 1 nm closer to the runway. In either case, there was an opportunity to resolve the discrepancy at this early stage but the communication was ineffective and it was missed.

It was only as the aircraft was approaching 500 ft RA, the height by which the approach was required to be stable, that the commander became concerned and started to prompt the co-pilot. The misunderstanding between the crew about the difficulty in disconnecting the AP was then resolved. Thus, the requirement for a stable approach was an effective barrier, alerting the crew to the situation and preventing the incident from becoming more serious.

Once aware of the problem the commander tried to disconnect the AP and also concluded that it would not disengage. When an AP is already disengaged, there are no new indications when there is an additional attempt to disconnect it. It is therefore possible that repeated attempts were perceived as unsuccessful because there was no associated feedback. In the confusion, the aircraft continued to descend below the stabilised approach height of 500 ft RA before go-around action was taken. As the RA was indicating height over the lower terrain to the east for the runway, the aircraft actually descended to 230 ft aal before

a go-around was initiated. The crew perception was that the AP disconnected at some time when the aircraft was climbing during the go-around, whereas the flight data indicated that it disconnected during the approach at approximately 425 ft aal.

No defects or abnormalities were identified with any units associated with the autopilot.

Conclusion

The crew reported that the autopilot would not disengage when commanded during the approach despite repeated attempts, but the recorded flight data indicated that it disengaged at around 500 ft RA (approximately 425 ft aal). It is possible that one or both pilots was affected by fatigue which affected intra-crew communication and their perception of the status of the autopilot. However, a similarity with a previous event suggested there may be something about the characteristics of the autopilot disconnect feedback which can result in uncertainty as to its status.

If an autopilot does remain engaged, there is a risk that an approach will be continued below minima, possibly resulting in unintended ground contact through crew distraction or a late, or ineffective go-around. There have been three reported events where the flight crew have not been able to disengage the autopilot but there is no Emergency Checklist procedure available for this condition.

Safety action

As a result of this serious incident, and the two similar preceding events, the manufacturer decided to review the Emergency Checklist to see whether an additional item should be incorporated to address the condition where crews are unable to disengage an autopilot.

Bulletin correction

Prior to publication information was received from the aircraft manufacturer resulting in Table 1 and the following paragraph being amended.

The online version of the report was amended prior to publication on 13 December 2018.

Full details of the correction can be found on the AAIB website [https://www.gov.uk/aaib-reports/aaib-investigation-to-bae-systems-operations-ltd-atp-se-mhf] and in AAIB Bulletin 1/2019.