الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Accident

- Final Report -

AAIS Case Nº AIFN/0006/2020

Collision with Ground Support Vehicle during Parking

Operator:	Sigma Airlines
Make and Model:	Airbus A300B4-203F
Nationality and Registration:	Republic of Kazakhstan, UP-A3003
Place of Occurrence:	Sharjah International Airport, Sharjah
State of Occurrence:	The United Arab Emirates
Date of Occurrence:	28 February 2020

This Investigation was conducted by the Air Accident Investigation Sector of the United Arab Emirates pursuant to Civil Aviation Law No. 20 of 1991, in compliance with Air Accident and Incident Investigation Regulation, and in conformance with the provisions of Annex 13 to the Convention on International Civil Aviation.

This Investigation was conducted independently and without prejudice. The sole objective of the investigation is to prevent future aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The Air Accident Investigation Sector issued this Final Report in accordance with national and international standards and best practices. Consultation with applicable stakeholders, and consideration of their comments, took place prior to the publication of this Report.

The Final Report is publicly available at:

http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx

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Accident Brief

AAIS Report No.:	AIFN/0006/2020
Operator:	Sigma Airlines
Aircraft Type and Registration:	Airbus A300B4-203F, UP-A3003
MSN:	141
Number and Type of Engines:	Two, General Electric CF6-50C2
Date and Time (UTC):	28 February 2020, at 1522
Location:	Sharjah International Airport, Sharjah, the United Arab Emirates
Type of Flight:	Commercial Freight
Persons Onboard:	Five
Fatalities:	Zero

Investigation Process

The occurrence involved an Airbus A300B4-203F aircraft, registration UP-A3003, and was notified to the Air Accident Investigation Sector of the United Arab Emirates (AAIS) by a phone call to the Duty Investigator Hotline Number +971 50 641 4667.

The AAIS opened an investigation in line with the Annex 13 obligations, the United Arab Emirates being the State of Occurrence, and appointed an investigator-in-charge and members from the AAIS for the various investigation areas.

After the on-site Investigation, the occurrence was classified as 'Accident' due to the substantial damage to the Aircraft.

The AAIS notified the Aviation Accidents Investigation Department of the Republic of Kazakhstan, being the authority of the State of Registry and the Operator. The Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile of France (BEA), being the authority of the State of Aircraft Manufacture and Design, and the National Transportation Safety Board of the United States (NTSB), being the authority of the State of Engine Manufacture.

Accredited representatives were designated and were assisted by advisers from Airbus and the European Union Aviation Safety Agency (EASA).

Notes:

[1] Whenever the following words in this Report are mentioned with the first letter capitalized, it shall mean:

- (Accident). This investigated accident
- (Aircraft). The aircraft involved in this accident
- (Commander). The commander of the flight of the subject accident
- (Copilot). The copilot of the flight of the subject accident

- (Flight Engineer). The flight engineer of the flight of the subject accident
- (Investigation). The investigation into this accident
- (Operator). Sigma Airlines
- (Report). This Final Report.

2 Unless otherwise mentioned, times in this Report are Coordinated Universal Time (UTC), United Arab Emirates local time minus 4 hours.

3 Photos and figures used in this Report are taken from different sources and are adjusted from the original for the sole purpose of improving clarity of the Report. Modifications to images are limited to cropping, magnification, or insertion of text boxes, arrows, or lines.

Abbreviations and Definitions

AAIS	Air Accident Investigation Sector of the United Arab Emirates
ATC	Air traffic control
BEA	The Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile of France
CAVOK	Ceiling and visibility ok
CVR	Cockpit voice recorder
FDR	Flight data recorder
ECAM	Electronic centralized aircraft monitor
FCOM	Flight crew operating manual
GCAA	General Civil Aviation Authority of the United Arab Emirates
HSSJ	Juba Airport, South Sudan
NOSIG	No significant change (METAR information)
NTSB	The National Transportation Safety Board of the United States
OMSJ	Sharjah International Airport, the United Arab Emirates
QRH	Quick reference handbook
SAS	Sharjah Aviation Services (Sharjah ground handling agent)
TR	Temporary revision to manual
UAE	The United Arab Emirates
UTC	Coordinated universal time

Synopsis

On 28 February 2020, at 1515 UTC, an Airbus A300B4-203F freighter Aircraft, registered as UP-A3003, landed at Sharjah International Airport (OMSJ), the United Arab Emirates, after a return flight from Juba Airport (HSSJ), South Sudan. There were five crewmembers onboard comprising the Commander, the Copilot and the Flight Engineer on the flight deck, together with a loadmaster and an aircraft maintenance engineer who were seated in the galley area.

The departure from Juba Airport and flight were uneventful until the Aircraft descended due to moderate turbulence, when the fluid level in the yellow hydraulic system rapidly decreased and the HYDRAU light illuminated on the master warning panel, followed by an autopilot disconnect. The flight crew executed the checklist items for the hydraulic system loss from the *quick reference handbook (QRH)* and continued the flight with the autopilot disconnected. Air traffic control or ground staff at the destination airport were not informed about the hydraulic system issue.

According to the Commander, the descent, approach, landing, and taxiing to the cargo apron were uneventful, and the brakes functioned normally. He followed the marshaller's signals and stopped the Aircraft in front of the cargo hangar. The Commander stated that once the Aircraft came to a stop, he maintained manual brakes, the crew started the parking checklist, and the Copilot prepared to shut the engines down. When the Commander looked up, he realized that the Aircraft was moving forward. He repeatedly applied manual brakes and set the parking brake, but the Aircraft did not stop. He stated that he then steered to the left to avoid the cargo hangar in front of the Aircraft until the left engine collided with a tug that was parked in the equipment area.

There were no injuries because of the Accident. The Aircraft's left engine, pylon and wing attachment were substantially damaged. The tug was damaged.

The Investigation identified that the loss of the yellow hydraulic system was a result of a fractured high-pressure filter housing, which was located in a part of the hydraulic system that did not directly affect the function of the parking brake. However, for reasons that the investigation could not determine, a secondary failure also depressurized the system accumulators and disabled the parking brake function. This resulted in the Aircraft moving forward by engine idle thrust.

The Commander's decision to select the parking brake without sufficient yellow hydraulic system pressure, and before the Aircraft nose wheels were chocked, was a contributing factor to the Accident.

The marshaller was not prepared to chock the Aircraft after it arrived at the parking bay and was unable to react timely to stop the movement of the Aircraft.

The Investigation also identified that Airbus became aware that the design of the high-pressure filter head was, apart from inadequate attachment bolts, another contributor to fractures developing at the head flange. Airbus issued a service bulletin for the replacement of the attachment bolts, and communicated the filter head design issue to operators in technical documents and during a technical symposium.

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1. Factual Information

1.1 History of the Flight

On 28 February 2020, at 0450 UTC, an Airbus A300B4-203F freighter Aircraft, registration UP-A3003, departed Sharjah International Airport (OMSJ), the United Arab Emirates, for Juba Airport (HSSJ), South Sudan. There were five crewmembers onboard comprising the Commander, the Copilot, and the Flight Engineer on the flight deck, together with a loadmaster and an aircraft maintenance engineer who were seated in the galley area. The flight was uneventful and the Aircraft landed at HSSJ at 0845.

Prior to departure, the Commander and the maintenance engineer completed the transit check. When the Commander noticed oil dripping from the lower fuselage, the maintenance engineer advised that the oil was most likely a residue from the green hydraulic system tank that was replaced four days earlier. The maintenance engineer informed the Commander that the Aircraft would be cleaned on arrival at OMSJ.

The Aircraft departed HSSJ at 1020 after 1 hour 35 minutes on the ground. The flight crew stated that the departure and the cruise were uneventful. Approximately 3 hours 50 minutes into the flight, the Commander requested a flight level change due to moderate turbulence. Immediately after initiating the descent, the Flight Engineer reported that the fluid level in the yellow hydraulic system rapidly decreased. The HYDRAU light illuminated on the master warning panel and the autopilot disconnected.

The Commander stated in his interview that the checklist items for the hydraulic system loss from the *quick reference handbook (QRH)* were followed, and the flight was continued with autopilot disconnected. The Commander was the pilot flying.

In the interviews, the flight crewmembers stated that while a briefing was conducted prior to descent, this briefing identified a possible extended landing distance but did not include a thorough analysis of other operational limitations due to the lost yellow hydraulic system.

The flight crew did not inform air traffic control (ATC) or ground staff at OMSJ about the hydraulic system loss. The Aircraft landed at 1515 on runway 30 and exited via the high-speed taxiway Bravo 7.

The Commander stated that the descent, approach, landing and taxiing to the cargo apron were uneventful, and that the manual brakes functioned normally. The Aircraft stopped at the assigned A300 position mark on parking stand 57, in front of the cargo hangar.

Figure 1. Aircraft taxiing, stopping and beginning to roll forwards

The Commander stated that once the Aircraft came to a stop, he maintained manual brakes. While the crew started the parking checklist, the Copilot prepared to shut the engines down. When the Commander looked up, he realized that the Aircraft was moving forward. He stated that he repeatedly applied manual brakes and set the parking brake but the Aircraft did not stop. He steered the Aircraft to the left to avoid the cargo area in front and collided with a tug, which was parked in the equipment area.

Figure 2. Ground staff noticed Aircraft movements, Aircraft turning, and impact with tug

Footage obtained from the apron surveillance camera (figures 1 and 2)[1] showed that the Aircraft stopped on the parking mark for a few seconds and then moved forward. The Aircraft turned left until its left engine impacted the tug. The Aircraft came to a stop with the nose landing gear on the service road, approximately 36 meters beyond the A300 position mark.

Data obtained from the flight data recorder (FDR) confirmed that the engines were operating at idle thrust when the Aircraft was moving forward until it collided with the tow tug. The flight crew then shut both engines down and the Commander pulled the left engine fire handle to reduce the likelihood of a fire emerging because of the collision.

1.2 Injuries to Persons

There were no injuries to persons because of this Accident.

1.3 Damage to Aircraft

The Aircraft sustained substantial damage to the left engine pylon and wing attachment. Hydraulic oil and other fluids were observed leaking from the damaged engine. (Figure 3)

1.4 Other Damage

The tow tug, parked 19.5 meters from the parking stop line in the equipment storage area, was damaged by the collision with the engine. (Figure 4)

[1] The time stamp of the apron surveillance camera, as shown in figures 1 and 2, was not aligned with UTC or local time and was used for reference only

The fluid spilled on the ground from the engine and the lower fuselage were cleaned up.

Figure 3. Damage to the left engine

Figure 4. Left engine impact with the tug

1.5 Personnel Information

Table 1 illustrates the flight crew information, current at the time of the Accident.

Table 1. Flight crew information

	Commander	Copilot	Flight Engineer
Age	49	55	35
Type of license	Air Transport Pilot License (A)	Commercial Pilot License (A)	Flight Engineer License
Valid until Medical expiry	6 August 2020	10 October 2020	4 April 2020
Rating	A-300	A-300	A-300
Total flying time (hours)	5,309	3,550	373
Total on this type (hours)	4,879	1,150	213
Total hours on type last 90 days	184	158	89
Total hours on type last 28 days	148	158	89
Total hours in last 7 days	21	21	21
Total hours in last 24 hours	9:45[2]	9:45[2]	9:45[2]
Last Safety & Emergency Procedures training	2 November 2019	10 October 2019	10 October 2019
Last line check	14 November 2019	23 March 2019	24 January 2020
Medical class	1	1	2
Valid to	6 August 2020	10 October 2020	4 April 2020
Medical limitation	Nil	Nil	Nil

[2] The flight crew operated 9:45 hours on the 28 February 2020 from OMSJ to HSSJ and returned to OMSJ, where the Accident occurred

The flight crewmembers stated in the interview that they were well-rested prior to the first sector from OMSJ, and that they were not fatigued during the return flight or at the time of the Accident.

1.6 Aircraft Information

The Aircraft was an Airbus A300B4-203F, which is a twin-engine, wide-body, medium-to-long-range aircraft. It was manufactured in 1981.

It was powered by two General Electric CF6-50 turbofan engines. The flight deck was designed to seat three flight crewmembers, including flight engineer.

The Aircraft was configured for freight and was equipped with seating to accommodate four persons in the front galley area.

The fuselage had a diameter of 5.64 meters, a length of 53.61 meters, a wingspan of 44.84 meters, and a height of 16.61 meters. (Figure 5)

The maximum takeoff-weight was 165,000 kg, including a maximum payload of 37,495 kg.

Airbus fleet data suggested that about 30 Airbus A300B2/B4 were in service at the time of the Accident.

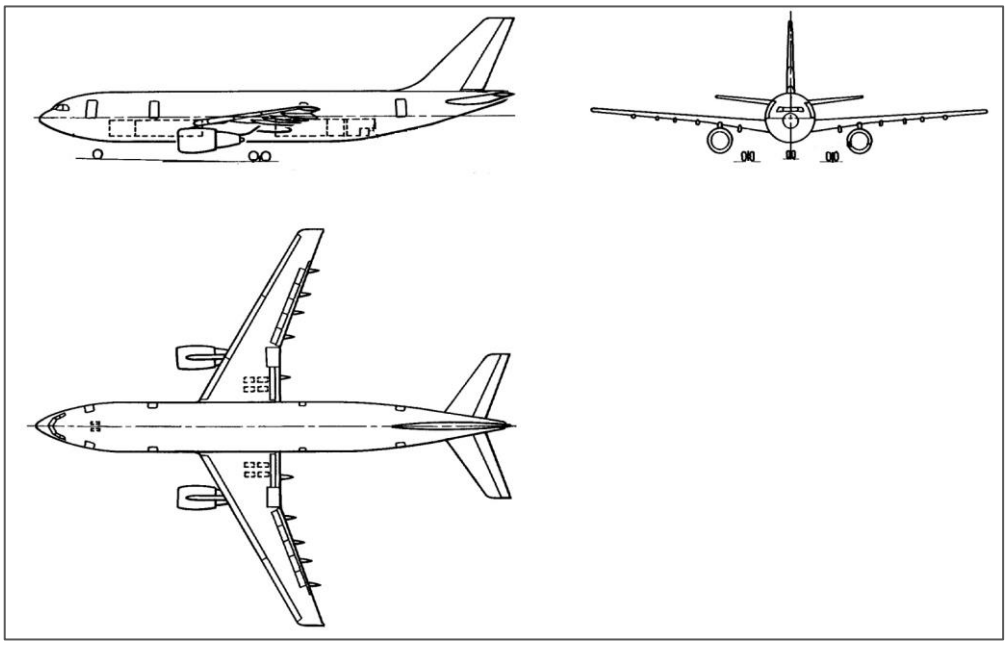

Figure 5. Airbus A300 [Source: Airbus]

1.6.1 Aircraft data

Table 2 illustrates the Aircraft data at the time of the Accident.

Table 2. Aircraft data		
Manufacturer		Airbus
Model		A300B4-203F
Manufacture Serial Number		141
Date of manufacture		19 May 1981
Nationality and registration		The Republic of Kazakhstan, UP-A3003
Name of the Owner		Air Speed Charter FZE
Name of the Operator		Sigma Airlines
Certificate of Airworthiness		
	Number: Issue date:	1190 16 July 2019
Certificate of Registration		
	Number: Issue date:	1190 15 July 2019
Total hours since new		51,941
Total cycles since new		29,441
Last major inspection and date		C4-Check on 30 March 2017
Total hours since last inspection		108 hours (A5-Check on 31 January 2020)
Total cycles since last inspection		43 cycles (A5-Check on 31 January 2020)
Maximum take-off weight		165,000 kg
Maximum landing weight		134,000 kg
Maximum zero fuel weight		126,000 kg
Zero weight		80,234 kg

1.6.2 Engines

The Aircraft was equipped with two General Electric CF6-50C2 engines, which are high by-pass turbofan engines with a by-pass ratio of 4.24 to 4.4. The engines provide axial airflow and consist of a dual rotor system with an annular combustion chamber.

Table 3 illustrates the engine data at the time of the Accident.

Table 3. Engine data		
Engine manufacturer: General Electric		
	No.1 engine (left)	**No.2 engine (right)**
Model	CF6-50C2	CF6-50C2
Serial number	528154	455433

Date installed	24 March 2019	11 April 2017
Total hours since new	46,781	67,846
Total cycles since new	19,210	30,429
Total cycles since last inspection	137	555

1.6.3 Airbus A300 hydraulic system

The Airbus A300 aircraft is equipped with three hydraulic systems, which operate simultaneously. Each of the green, yellow and blue hydraulic system is supplied from its respective hydraulic reservoir. The systems are independent and there is no provision for transfer of hydraulic fluid between the systems.

Two engine-driven hydraulic pumps on each engine provide a system pressure of 3,000 psi. The two hydraulic pumps on the left engine provide pressure to the green and blue system, while the two hydraulic pumps on the right engine provide pressure to the green and yellow systems.

The fail-safe design of the hydraulic system includes check valves at some safety critical locations to prevent the complete loss of the hydraulic system in case of fluid leaks.

1.6.4 Hydraulic system indications

Quantity indicators on the flight engineer's panel display the hydraulic fluid level in the respective hydraulic system reservoir. The green arc indicates the usable range of the reservoir content under normal operation. The upper small green arc indicates the normal fluid level range on the ground with the reservoir pneumatically pressurized and the hydraulic system depressurized. The yellow arc indicates an abnormally low fluid level in the reservoir. When an indicator drops below the red dot, as pointed out in figure 6, the electronic centralized aircraft monitor (ECAM) master caution lights illuminate on the left and right main instrument panels.

1.6.5 Airbus A300 brake system

Figure 6. The Aircraft's hydraulic system indications after collision with the tug

The Airbus A300 brake system consists of a 'Normal' system powered by the green hydraulic system; and an 'Alternate', 'Emergency' and 'Parking Brake' systems powered by the yellow hydraulic system.

The 'Normal' brake system includes the antiskid system and is electrically controlled by a brake pedal transmitter, which is mechanically linked to the flight crew's brake pedals. With the

brake system selected to 'Normal' and without any brake pedal depression, the yellow hydraulic system provides pressure to the 'Alternate' and 'Emergency' brake systems.

The 'Alternate' brake system includes an antiskid system and is automatically selected when the green hydraulic pressure fails, the green system is not in operation, or when it is manually selected. The 'Alternate' brake system is mechanically controlled by 'footmotors', which are linked to the brake pedals.

The 'Emergency' brake system utilises the same hydraulic lines as the 'Alternative' brake system, and is automatically selected when both the green and yellow systems fail. Two accumulators in the yellow system, charged by an AC electric pump, will provide sufficient hydraulic fluid for seven brake applications. If the antiskid system is selected 'Off', the 'Emergency' brake system will be pressurized by the normal yellow system, backed-up by the accumulators.

As illustrated in figure 7[3], the 'Parking Brake' system is supplied with a pressure of 3,000 psi from the yellow hydraulic pumps or, when the pumps are not used, the yellow system accumulators to provide 'Parking Brake' pressure for about 10 hours.

When the parking brake handle is selected 'On', the parking brake selector valve closes and maintains pressure on the brakes. This does not require the deflection of the brake pedals by the flight crew.

The selection of the 'Parking Brake' automatically de-activates the 'Normal' or 'Alternative' brake systems to prevent a double pressurization of the 'Normal' and 'Alternative' braking pistons on the brake units.

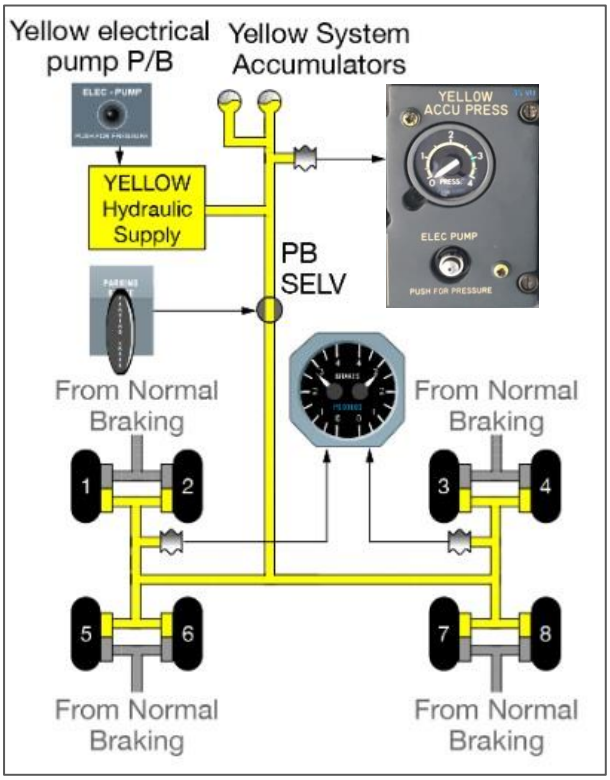

Figure 7. Parking Brake system with the Aircraft's pressure indicator image inserted
[Source: Airbus/AAIS]

A yellow hydraulic system pressure indicator, labelled "YELLOW ACCU PRESS", is located on the center overhead panel of the flight deck. In case of the loss of the yellow hydraulic system, the parking brake system operates through the accumulators which are hydraulically isolated by safety and check valves.

The Aircraft's cockpit indicator, as illustrated in figure 7, is scaled from 0 to 4,000 psi, indicating a green 'normal operation' range from about 3,000 psi. A dual brake pressure indicator was located in the cockpit center panel and displays the available brake pressure from the yellow

[3] Figure 7 of the yellow hydraulic system omits the location of the high-pressure filter and check valves located in the yellow hydraulic system supply line

hydraulic system for the left and right sides. There was no brake pressure indicator for the green hydraulic system.

1.6.6 Hydraulic system automatic selector valve

When the parking brake handle is selected, the parking brake selector supplies yellow system accumulator pressure to the automatic selector valve. This will close the emergency anti-skid return line and maintain the parking brake pressure of 1,595 psi supplied by the accumulator to the eight main landing gear brakes.

1.6.7 Hydraulic system maintenance

On 24 February 2020, an entry in the *Aircraft Flight/Maintenance Log* was made recording that the green hydraulic tank had a leakage. The hydraulic tank was subsequently replaced and replenished with 26 quarts[4] of hydraulic fluid.

On 27 February 2020, the yellow hydraulic system was routinely replenished with ten quarts of hydraulic fluid. This was four flights prior to the complete loss of the system on 28 February 2020.

1.6.8 Yellow hydraulic system failure

The flight crewmembers stated in their interviews that the yellow hydraulic system failed during flight level change in the Muscat flight information region.

An inspection of the Aircraft during the on-site investigation phase identified that the yellow hydraulic system high-pressure filter housing, located in the lower fuselage, had fractured and leaked hydraulic fluid. (Figure 8)

The filter head was identified as part number P6952, serial number 1602. It was installed during Aircraft manufacture in May 1981 and accumulated 51,941 hours and 29,441 flights in service.

Figure 8. Hydraulic filter housing fracture

1.7 Meteorological Information

The prevailing meteorological conditions were not a factor in this Accident.

The meteorological conditions at the time of the Accident were normal with ceiling and visibility OK (CAVOK). The QNH was 1014 Hectopascal. The wind was recorded with a speed of 6 knots from a direction of 300 degrees.

The METAR for the period 1500 to 1530 at Sharjah International Airport read:

METAR OMSJ 281500Z 30006KT CAVOK 22/16 Q1014 NOSIG

[4] A ‘quart’ is defined as a quarter of a US gallon and equals 0.946 liters.

METAR OMSJ 281530Z 31005KT CAVOK 21/16 Q1014 NOSIG

Sunset at Sharjah International Airport on 28 February 2020 was at 1419 UTC.

1.8 Aids to Navigation

The Investigation concluded that none of the ground-based navigation aids, onboard navigation aids, and aerodrome visual ground aids and their serviceability were a factor in this Accident.

1.9 Communications

The cockpit voice recorder (CVR) data was successfully downloaded in Abu Dhabi Flight Recorders Laboratory, the Air Accident Investigation Sector of the United Arab Emirates (AAIS). ATC recordings were also provided to the Investigation.

The quality of the CVR recording was poor and provided the Investigation with limited audible flight crew conversations.

In the interviews, the flight crewmembers stated that a briefing was conducted prior to descent. This briefing identified a possible extended landing distance but did not include a thorough analysis of other operational limitations due to the lost yellow hydraulic system.

ATC recordings showed that essential communication with the flight crew was established. The Commander stated in the interviews that, due to the workload, neither ATC nor the ground operations staff at the destination airport were informed of the hydraulic failure, or any consequential operational limitations.

1.10 Aerodrome Information

Sharjah International Airport is located in Sharjah, the United Arab Emirates, 13 km south-east of Sharjah city. The airport has two runways: 12 and 30, with runway lengths of 4,060 meters and 4,057 meters, respectively. A cargo apron with parking bays for freight aircraft is separated from the airline operation gates in front of the terminal.

1.10.1 Cargo apron parking bay 57

The Investigation requested information on the marking compliance, lighting conditions and slope of the cargo apron in general, and in particular for parking bay 57, where the Accident occurred.

Figure 9. Aircraft landing and taxi route to parking bay 57

The apron markings and the slope of 0.28% at parking bay 57 were found to be compliant with the *Civil Aviation Regulations* of the United Arab Emirates. However, an aerodrome compliance audit conducted by the General Civil Aviation Authority of the United Arab Emirates (GCAA) in January 2020 found that the lighting intensity at bay 57 were not compliant with *Civil Aviation*

Regulation CAR Part IX, Appendix 9, 9.24 – *Apron Floodlighting*. At the time of the Accident, there was no record that this non-compliance had been rectified.

Paragraph 9.24.4 reads:

> "The average illuminance shall be at least the following:
> a) Aircraft stand:
> i) horizontal illuminance - 20 lux with a uniformity ratio (average to minimum) of not more than 4 to 1; and
> ii) vertical illuminance - 20 lux at a height of 2 m above the apron in relevant directions.
> b) Other apron areas:
> horizontal illuminance - 50 per cent of the average illuminance on the aircraft stands with a uniformity ratio (average to minimum) of not more than 4 to 1."

Figure 10 illustrates the apron lighting readings at parking bay 57 during the compliance audit. It identified that horizontal readings were as low as 2.7 lux.

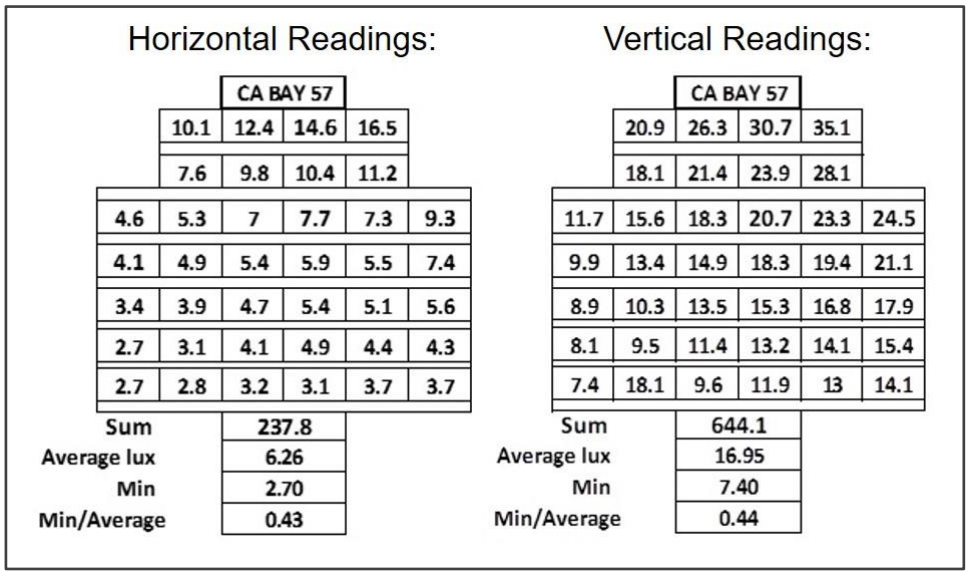

Figure 10. Parking bay 57 lighting test results [Source: Sharjah International Airport]

1.11 Flight Recorders

The Aircraft was equipped FDR and CVR. Both recorders were removed from the Aircraft and sent to Abu Dhabi Flight Recorders Laboratory, where the data was downloaded.

1.11.1 Flight data recording

The Aircraft was fitted with a Honeywell magnetic tape FDR, part number 980-4120-GTUS, which recorded 139 parameters over 24 hours.

The recorded parameters were limited to general information such as airspeed, heading, altitude, landing gear status, engine data, and some other parameters. This limitation prohibited a detailed data analysis of the occurrence, and in particular the hydraulic system failure and braking issues during parking.

The FDR recording, together with the apron surveillance camera, confirmed that the Aircraft stopped for five seconds at the A300 parking position. Eleven seconds later it began to

move forward, until it veered to the left. The Aircraft collided with the tug 27 seconds after it started moving from the parking position.

Both engines were at idle thrust during taxiing, parking, during Aircraft movement after the initial stop, and when the left engine impacted the tow tug. Approximately 12 seconds after collision, at 1522, both engines were shut down.

1.11.2 Cockpit voice recording

The download of the magnetic tape Fairchild CVR, part number 93A100-30, provided two recording files, a 8K 32 minutes and a 16K 45 minutes audio files. Both recordings were heavily distorted, which inhibited clear identification of the crewmember's communication.

The recording of the cockpit area microphone was inaudible, and one crewmember channel recorded ambient audio from the aerodrome traffic information service throughout the recording.

These technical anomalies prevented an analysis of the flight crew communication during the flight, landing, taxiing, and parking.

1.12 Wreckage and Impact Information

The Aircraft's left engine impacted the tow tug. The engine nose cowl was substantially damaged and the engine fan blades exhibited signs of rubbing with the outer shroud. The fan could not be rotated during the post-Accident inspection.

The left engine pylon and wing attachment, fan case, hydraulic and fuel lines, and the engine gearbox were damaged during impact.

1.13 Medical and Pathological Information

The flight crewmembers were subjected to post-Accident blood tests for alcohol and other psychoactive substances that could have degraded their performance.

The Copilot declared taking prescription medication, which was detected in the toxicology report. The results were provided to the Aeromedical Practitioner of the GCAA.

The Commander's and the Flight Engineer's toxicology reports did not indicate any alcohol or other psychoactive substances.

1.14 Fire

There was no evidence of fire.

1.15 Survival Aspects

None of the occupants or ground staff was injured.

1.16 Tests and Research

1.16.1 Post-Accident hydraulic system troubleshooting

The Airbus A300 yellow hydraulic system was designed to the fail-safe principles, which prevent a complete loss of hydraulic system pressure and content in case of a high-pressure filter failure, similar to the failure experienced during this Accident. This included an in-line check valve,

which prevents the loss of hydraulic system fluid and accumulator pressure to the remaining yellow hydraulic system.

When the Aircraft was repaired after the Accident, extensive tests of the yellow hydraulic system were conducted in accordance with the Airbus A300 *Fault Isolation Manual* and with the support from Airbus' technical advisor. These tests were accomplished after the replacement of the filter and after the yellow hydraulic system was restored, which included system drainage, replenishment, and bleeding. The cause of the yellow hydraulic system pressure and quantity loss beyond the check valve could not be determined by the Investigation.

The Aircraft then returned to service based on nominal operational tests. After some time in operation, the automatic selector valve was replaced for further investigation purposes.

The green hydraulic system, which was found nearly depleted on the day when the Investigation team had access to the Aircraft, was repaired in accordance with the *Aircraft Maintenance Manual*.

A subsequent functional test revealed that the loss of hydraulic fluid from the green hydraulic system was most likely the result of the damage to system components located at the left engine, caused by the collision with the tug.

1.16.2 Test of the automatic selector valve

The events of the yellow hydraulic system loss and the manual braking issues as reported by the flight crew, required further investigation into the hydraulic system. Consequently, the automatic selector valve was removed and sent to the manufacturer's facility for testing and further examination to determine if the valve contributed to the loss of the parking brake function.

The examination plan included an external visual inspection and functional check as per an agreed inspection plan, internal leakage tests, and a disassembly and internal inspection of the valve parts.

The examination report concluded that the automatic selector valve conformed with all executed tests and did not reveal any findings with potential functional impact.

1.17 Organizational and Management Information

1.17.1 The Operator

Sigma Airlines was founded on 1 June 2017 and was granted an air operator certificate (AOC) number KZ-01/001, issued by the Aviation Administration of Kazakhstan. The AOC authorized Sigma Airlines to provide commercial domestic and international airfreight operations.

The Operator had two offices in Almaty, Kazakhstan, and in Ajman, the United Arab Emirates. The fleet of four aircraft consisted of two Ilyushin IL-76TD, one Ilyushin IL-76TD-90, and one Airbus A300B4-203F.

The aircraft were based in Kazakhstan and Jordan and provided chartered air freight services to Africa, the Middle East, South America, Antarctica, and the Arctic.

1.17.2 Airbus A300 parking procedure

The Airbus A300 *flight crew operating manual (FCOM)* described the parking procedure and the individual flight crewmember actions as follows:

Commander:

"PARKING BRAKE

- Check the ACCU PRESS. In case of low accumulator pressure, chocks are required before engines shutdown.
- Set parking brake handle.
- Observe pressure and PARKING BRK ON lt on MWP.

Note: Parking brake must stay on as long as engines are running."

Copilot:

"MASTER WARNING PANEL

- It is recommended to depress TO INHI to avoid all audio warnings during shutdown.

Commander:

GROUND CONTACT

- Establish ground communication.

Flight Engineer:

APU BLEED

- Set APU BLEED sel to AUTO and check m.i. in line.

Commander:

ENGINES

- Set FUEL LEVERS to OFF and check fuel flow reads zero."

These procedures are followed by confirmation that the cabin is de-pressurized, the external and beacon lights are turned off, seat belt signs are off, and the aircraft is prepared for parking.

The last item in the *FCOM* parking procedure is the *Parking Challenge/Response* checklist[5] read by the copilot; and responded by the commander, the copilot and flight engineer accordingly. (Figure 11)

The *FCOM* described the sequence of actions after the aircraft has come to a complete stop at the parking position. It is displayed as:

CM2	PARKING
1	Engines ..... OFF
3	ΔP (DIFF PRESS) ..... CHECKED ZERO
1	Exterior lights ..... (AS REQD) ----
1	Signs ..... (AS REQD) ----
3	Fuel pumps ..... (AS REQD) ----
1	Parking brake/chocks ..... SET
2	Parking checklist ..... COMPLETED

Figure 11. *FCOM* parking checklist [Source: Airbus]

[5] The *FCOM* parking checklist describes the commander as crewmember 1 (CM1), the copilot as crewmember 2 (CM2) and the flight engineer as crewmember 3 (CM3) to assign the relevant tasks/challenge responses

1.17.3 Operator's briefing procedure

Sigma Airlines' *Operations Manual* Section 1.19 – *Briefings*, described in sub-section 1.19.4 the approach briefing as follows.

> "Before the start of an instrument approach, the PF [pilot flying] should brief the PNF [pilot not flying] of his intentions in conducting the approach. Both pilots should review the approach procedure.
> All pertinent approach information, including minimums and missed approach procedures, should be reviewed and alternate courses of action considered.
> As a guide, the approach briefing should include at least the following:
> - weather and NOTAMS at destination and alternate, as applicable;
> - type of approach and the validity of the charts to be used;
> - navigation and communication frequencies to be used;
> - minimum safe sector altitudes for that airport;
> - approach procedure including courses and heading;
> - vertical profile including all minimum altitudes, crossing altitudes and approach minimums;
> - speed restrictions;
> - determination of the Missed Approach Point (MAP) and the missed approach procedure;
> - other related crew actions such as tuning of radios, setting of course information, or other special requirements;
> - taxi routing to parking;
> - any appropriate information related to a non-normal procedure."

The *Operations Manual*, Section 1.82 – *Parking*, described the steps for parking the aircraft. It required the commander to check the yellow system accumulator pressure to ensure that yellow system braking pressure is available prior to setting the parking brake.

It stated:

> "In case of low accumulator pressure, chocks are required before engines shutdown.
> -Set parking brake handle.
> -Observe pressure and PARKING BRK ON lt on MWP.
> Note: Parking brake must stay on as long as engines are running."

Once communication with ground staff is established, the commander shuts down the engines and shall:

> "Check chocks in place and release parking brake to improve cooling.
> Note: It is recommended not to set parking brake handle while brake hot warning is activated."

The copilot then continues with the *Parking* checklist, which is aligned with the steps in from *FCOM Parking* checklist.

1.18 Additional Information

1.18.1 The Commander's statement

The flight crewmembers provided written statements and were interviewed by the Investigation.

The Commander stated that he was alerted of the loss of the yellow hydraulic system by the Flight Engineer once they entered the Muscat flight information region. A warning on the master warning panel followed, together with the disengagement of the Autopilot 2, Yaw Damper

2 and the Pitch Feel 2 system. He continued to fly the Aircraft manually and commanded the "Hydraulic System Yellow Lost" checklist from the *QRH*.

He stated that: "When we completed the QRH checklist the Aircraft was stable, but due to [the] workload we missed the point to report to ATC about hydraulic system lost (one of three)."

According to the Commander, the descent, approach, landing, braking and taxiing to the parking bay were without problems. Once the Aircraft arrived at parking bay 57, the marshaller signaled that the Aircraft had come to a complete stop. The Commander reported that the Aircraft "Stopped for 3-5 seconds but then suddenly started to move again. The brake pedals [were] not released yet, the parking brake was not set yet and the engines [were] running."

The Commander stated that: "I was trying to push pedals [a] few times but [with] no effect, then I tried to apply parking brake. I checked yellow system emergency reservoir on overhead panel and it was showing ¼ of full. I tried to switch to alternative antiskid braking system and again, and again to push brake pedals but no effect."

The Commander was aware of people working in the hangar straight ahead and decided to stop the Aircraft by colliding with a tow tug, which was parked left of the parking bay. He stated in the interview that he was not fatigued during the flight or at the time of the Accident.

1.18.2 Apron surveillance camera recording

The Investigation observed footage from the cargo apron camera. It showed the Aircraft following the marshaller's guidance along the lead-in line to parking bay 57 and stopping at the Airbus A300 parking mark.

The engines were both operating and the hazard light was 'on'. Wheel chocks were not placed after the Aircraft stopped.

After the Aircraft stopped for approximately three seconds, it was observed to slowly move forwards. This went unnoticed, because the marshaller was not paying attention to the Aircraft. After ten seconds, he became aware that the Aircraft was moving towards the cargo hangar and tried to get the flight crew's attention.

Twelve seconds after the Aircraft started to move, the nose wheel steered to the left until the Aircraft collided with the tow tug approximately 13 seconds later.

The recording showed that the marshaller did not prepare for the placement of wheel chocks at the nose or main landing gear.

1.18.3 Airbus temporary revision to A300 *FCOM*

As a result of the Accident, Airbus published a temporary revision (TR) to the *FCOM*. *TR No. 231-1* was issued to enhance the use of the parking brake in the normal procedures and added a warning in the Normal Procedures 'Parking' to release the parking brake in case of parking brake failure in order to restore manual braking using the brake pedals. (Figure 12)

The warning reads:

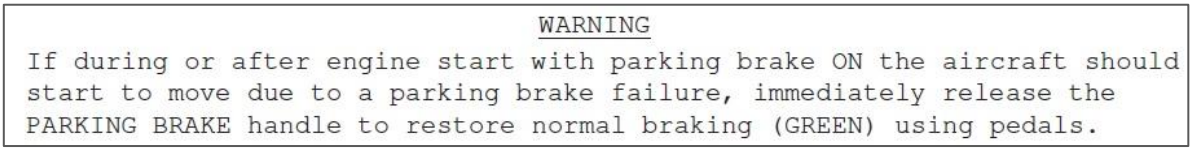

Figure 12. *FCOM* temporary revision warning [Source: Airbus]

1.18.4 Airbus *Safe Aircraft Parking* article

Airbus published an article in their *Safety first* magazine[6] in January 2020, describing a parking event in which an Airbus A320 rolled forward after the brake pedals were released while the parking brake was selected 'on'.

The article described parking brake designs of various Airbus types, including the A300, and analyzed events of unintended aircraft movements. The article concluded with flight crew recommendations for safe aircraft parking.

The article discussed the issue of inadvertent aircraft movements after setting the parking brake. It reads:

> "On A300 and A310 aircraft, the parking brake handle must be set back to OFF to recover normal pedal braking to stop the aircraft."

In regards to wheel chock placement, Airbus recommended to place a set of wheel chocks on one of the nose landing gear wheels as soon as the aircraft comes to a stop and while the engines may still be on idle thrust. Once the engines are shut down, the chocks could be placed on the main landing gear wheels as documented.

The article concluded with the following recommendation:

> "To ensure that an aircraft remains safe and stationary when using the parking brake, flight crew or maintenance personnel must first ensure that sufficient accumulator pressure is available using the BRAKES and ACCU pressure indicator before setting the brake handle to ON. If the indicator is in the green band, they can set the parking brake to ON and confirm using the pressure indicator that sufficient pressure is applied to the brakes. If not, they must wait until chocks are correctly placed at the wheels before releasing the brake pedals and switching off the engines or disconnecting from the towing vehicle. Maintenance must be alerted about the issue to troubleshoot and rectify."

1.18.5 Airbus *Service Bulletin SB A300-29-098*

Airbus published *SB A300-29-098* in May 1991, after operators' reports of ruptured high-pressure filter heads of the blue hydraulic system.

The service bulletin stated that it was identified in the laboratory that the existing filter housing attachment bolts could not provide sufficient tightening torque due to their design, which resulted in inadvertent movement of the filter housing. This movement resulted in fractured filter heads on some aircraft.

The service bulletin required the operators to replace the existing attachment bolts of the three high-pressure hydraulic filter housings with bolts that have a shorter smooth section which provided an adequate tightening torque on the filter head.

The Aircraft modification records showed that *SB A300-29-098* had been incorporated on 10 September 1991, when the Aircraft had accumulated 26,504 hours and 13,381 flights.

The intent of this service bulletin was also applicable to other Airbus aircraft types with the same high-pressure filter fitted. Service bulletins *SB A300-29-2031* and *SB A300-29-6023*

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[6] *Safety first* Magazine 29th Edition, January 2020, Safe Aircraft Parking, Airbus Product Safety department.

were issued for the A310 and A300-600 fleet respectively, and required the replacement of the high-pressure filter head attachment bolts.

1.18.6 High-pressure filter head design

An Airbus *Technical Follow-Up* document[7], first issued on 1 August 1986 and last updated on 1 May 1994, identified that together with the issue of high-pressure filter head attachment bolts, as described in *SB A300-29-098*, the curve radius of the filter head design was also a contributor to developing fractures along the flange.

The document reads:

> "Several cases of damaged high pressure filter head have been reported to Airbus. Some of these incidents coincided with broken fixing screws, some other are cracks located on the flange just below the clogging indicator boss. Some breakages originate from insufficient tightening of the filter head on the manifold. This is due to the unthreaded part of the screw contacting the threads on the manifold before the screw has tightened down on the filter head. Insufficient curve radius at the flange level is also a contributor to head breakage."

As a result, the filter assembly manufacturer increased the curve radius on filter heads with part number P6952 and serial numbers starting at 3267, and filter head part number P6955 with serial numbers starting at 3258. The new filter assemblies were installed on A300-600 and A310 aircraft from the late 1980's.

A replacement of filter heads already installed on aircraft was not discussed in the *Technical Follow-Up* document, which was last updated on 1 May 1994. The document status is 'Closed' with a last internal publication date of 5 December 2015.

A service information letter, SIL29-032, initially dated 22 August 1986, and last revised on 6 November 2007, provided to operators a summary of the latest information on addressing hydraulic leaks on A300, A310 and A300-600 aircraft.

The SIL states that:

> "*Filter HP Head (All aircraft):* Cases of damaged high-pressure filter heads were reported to Airbus (broken fixing screws, cracks located on the flange just below the clogging indicator boss). Some leaks were due to insufficient tightening of the filter head on the manifold because of the fixing screws. Insufficient curve radius at the flange level is also a contributor to head crack.
>
> Airbus developed a modification that replaces the fixing screws by a new standard. Subject screws were introduced with Airbus SB 29-0098, 29-6023 and 29-2031. The vendor Sofrance has increased the filter head flange curve radius. This improvement concerns filters PN 6955 starting at S/N 3258 and PN P6952 starting at S/N 3267. For more details, please refer to closed TFU 29.11.42.002."

In-Service Information 29.00.00002 originally dated 22 August 1986 and last published on 18 April 2019, titled 'Preventing External Hydraulic Leaks', replaced *SIL 29-032* and repeats the statement from the SIL above.

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7 Airbus *Technical Follow-Up TFU 29.11.42.00.*

Airbus delivered a presentation titled ‘Hydraulic Leaks – A300/A310/A300-600’ during the Airbus Technical Symposium in June 2001.

The presenter’s information with regards to the high pressure filter heads include the following statement:

> “Cases of damaged HP filter heads were reported to Airbus Industrie. We introduced new fixing screws which allow a better tightening of the HP filter bowl head in the High Pressure Manifolds. The filter manufacturer also introduced the filter head flange radius, which was also a contributor to the filter head leaks. For more details concerning leaks at the HP filters, you can refer to TFU 29.11.42.002.”

The relevant Airbus *illustrated parts catalogue* did not provide information to the operators that the design of the high-pressure filter head had changed after serial numbers 3267 and 3258 respectively. This information was made available via technical documents and other communication with operators.

1.18.7 Aircraft brake system developments

The original brake system design of the ‘Normal’ and ‘Parking’ brake systems of Airbus A300 aircraft did not require depressing the brake pedals to set the parking brake to ‘on’. It also inhibits the pedal braking when the parking brake handle is pulled, and recovers the pedal braking by releasing the parking brake to ‘off’.

However, after Airbus received reports from operators about problems with aircraft moving after the parking brake had been set to ‘on’, Airbus studied the possibility to modify the interaction of the ‘Normal’ and ‘Parking’ brake systems on the A300, A310 and A300-600 aircraft.

Airbus developed modifications as a result of this study which introduced a pressure switch to alert the flight crew of insufficient braking pressure, and a time delay which allowed the use of the brake pedals after a short delay after the parking brake was selected ‘on’.

While these modifications were documented in service bulletins, the changes were introduced as production modifications during aircraft manufacture.

Airbus analysed the likelihood for double pressurization on brake units in case of a failure of either of these system alterations, and their potential impact on take-off performance due to residual braking. It was concluded that the potential for this occurrence with the existing carbon brakes was unlikely, but that regular checks were necessary to ensure that failures could be detected. It was also identified that the flight crew should avoid pressing brake pedals when selecting the parking brake to ‘on’ or when it is in the ‘on’ position.

Airbus concluded that:

> “Taking into account complementary operational scenarios and different aircraft configurations, led to the conclusion that the currently defined modifications would be difficult and too constraining for Operators to implement on A300B and A310 aircraft, even fitted with carbon brakes.”

As a result, Airbus cancelled the changes introduced by service bulletin *SB A300-32-0432* (mod 12089) for the A300 aircraft, and *SB A310-32-2116* and *SB A300-32-6078* (mod 12088 and 12403) for A310 and A300-600 aircraft. The cancellation of production modifications was covered by mandatory service bulletin *SB A300-32-6100*.

1.18.8 Marshalling hand signals

Sharjah Aviation Services (SAS "ground handling agent") *Ground Operations Manual* chapter 4.8.4 - *Marshalling Hand Signals (For Aircraft)*, provided to staff the marshalling procedures and hand signals for aircraft movements.

Footage from the apron camera showed that the marshaller applied these hand signals for the arrival of the Aircraft at the parking bay. However, the hand signal 'Set Brakes' was not in conformance with the hand signal procedure, and it could not be established if the flight crew confirmed the setting of the parking brake with the 'thumbs-up'.

The marshaller did not signal 'Chocks Inserted' to the flight crew before he left his position in front of the Aircraft.

1.18.9 Wheel chock placement

SAS *Ground Operations Manual* Section 4.7 - *Aircraft Chocking*, provided the procedure for the equipment agent and described that when the aircraft comes to a complete stop, wheel chocks are to be immediately placed forward and aft of the nose gear wheels.

The procedures described that "This is the first action to take place around the aircraft, and shall be completed before any other activity may take place."

Before approaching the main landing gear, the engines have to be shut down and the anti-collision lights switched off. The main wheels are then chocked according to the applicable normal chock placement diagram and the flight crew notified.

The Investigation reviewed the apron camera recording and could not identify preparation or any attempt, by the marshaller or other ground staff, to chock the Aircraft's nose or main wheels when the Aircraft arrived or came to a stop.

1.19 Useful or Effective Investigation Techniques

This Investigation was conducted in accordance with the United Arab Emirates *Civil Aviation Law* No. 20 of 1991, and *Air Accident and Incident Investigation Regulation* of the United Arab Emirates (AAIR). It was conducted in adherence with the AAIS-approved policies and procedures, and in accordance with the Standards and Recommended Practices of *Annex 13* to the Chicago Convention.

2. Analysis

2.1 General

The Investigation reviewed all available evidence for the purpose of identifying the causes and contributing factors of the Accident. The limited number of parameters recorded by the flight data recorder and the quality issues of the recorded audio from the cockpit voice recorder resulted in minimal factual evidence from the aircraft systems and flight crew communication. In the absence of this data, the Investigation relied on the flight crew statements and other sources for the determination of the cause and the contributing factors that led to the Accident.

2.2 Loss of Braking during Parking

The Commander stated that the landing and taxiing to the parking position were uneventful and that the 'Manual' brake was functioning normally. This was observed by the Investigation through watching the apron camera. The brake and steering functions are operated by the green hydraulic system.

According to the Commander, when the Aircraft began to roll forward after it came to an initial stop, the normal brakes were still applied. The engines were at idle.

According to the *flight crew operating manual (FCOM)*, the parking procedure required the application of manual brakes, check for sufficient accumulator pressure for the parking brake, setting the parking brake, checking the brake pressure indicator, and observing that the PARKING BRK ON light illuminates on the master warning panel.

The available accumulator pressure for the parking brake is indicated for the flight crew in the overhead panel. The Commander stated that the pressure was indicated as sufficient with one quarter available. According to the accumulator pressure indicator, a normal operation indication is at three quarters. An indication of one quarter would have required the use of the electrical pump to increase the accumulator pressure when the engines were shut down. The fracture of the high-pressure filter head relieved the system pressure in the part of the yellow system that is isolated from the parking brake function. The accumulators were expected to maintain system pressure for the braking function. For reasons that could not be determined, this pressure was lost.

The parking procedure required the Commander to request aircraft chocks when the accumulator pressure is low, before the engines are shut down.

The Investigation concludes that the Aircraft's steering and braking systems operated normally during taxiing and arriving at the parking position, when these functions were powered by the green hydraulic system. When the Aircraft arrived at the parking position, it is likely that the parking brake was set, which transferred the braking system from manual braking powered by the green hydraulic system to the parking brake powered by the yellow hydraulic system as per the A300 brake system design. The parking brake did not function normally because of the undetermined loss of the accumulator pressure.

2.3 Yellow and Green Hydraulic System Depletion

The Airbus A300 hydraulic system was designed to the fail-safe principles. The system features check valves in critical locations in order to prevent a complete loss of hydraulic pressure, should the system encounter leaks similar to the Accident circumstances.

The post-Accident system checks did not reveal the cause for the complete pressure loss of the yellow hydraulic system which prevented the parking brake to function. The automatic selector valve was removed and tested at the manufacturer's facility, where no fault was found.

The ability to steer the Aircraft to the parking position, brake on the A300 line, and steer the Aircraft to the left after it resumed its movement, indicated a functional green hydraulic system throughout the occurrence. The post-Accident functional checks of the green hydraulic system, after repairs were completed, indicated that the hydraulic fluid loss, as indicated on the flight engineer panel after the Accident, was most likely a result of system components damage caused by the collision with the tug.

Based on these checks and the system examination, the Investigation concludes that the fractured high-pressure filter head in combination with an undetermined failure of the accumulator part of the yellow hydraulic system caused the system failure. The Investigation could not determine the cause for the complete depletion of the yellow hydraulic system and the consequent failure of the parking brake.

2.4 Flight Crew Performance

The Commander stated in the interviews that when he was alerted of the yellow hydraulic system loss and the autopilot disconnected, he continued to fly the Aircraft manually. The Commander requested the *Hydraulic System Yellow Lost* checklist from the *quick reference handbook*, which was then completed. The Commander stated that due to his increased workload he did not inform air traffic control or the ground staff at the destination airport of the hydraulic loss and its limitations on the Aircraft operation. The marshaller and ground support staff were therefore not aware of the potential braking issues at the parking position. This also prevented a runway inspection after landing to ensure that leaked hydraulic fluid did not pose a threat to other aircraft.

Appropriate application of workload management practices and good communication between flight crewmembers after the loss of the hydraulic system and again during the approach briefing, had allowed the sharing of all relevant information and the distribution of critical tasks, including the communication with air traffic control and ground staff.

The Operator's *Operations Manual*, Section 1.19 – *Briefings*, required the Commander as the pilot flying to brief the Copilot before the start of the instrument approach. Both pilots should review the approach procedure with all pertinent information. According to these procedures, the approach briefing should also include "other special requirements", "taxi routing to parking", and "appropriate information related to a non-normal procedure".

The Investigation determined that the Operator's approach procedures provided sufficient check items to remind the Commander and the other flight crewmembers of the potential problems during landing, taxiing or parking. Had this been communicated to ground staff, the supply of wheel chocks prior to releasing the manual brakes would have prevented the Aircraft from uncontrolled movement after parking.

2.5 Aircraft Condition prior to Departure from Juba Airport

The transit check at Juba Airport identified oil dripping from the lower fuselage. The Commander accepted the maintenance engineer's explanation that oil was most likely residue from the green hydraulic system tank replacement four days earlier. The Aircraft's hydraulic system did not indicate any issues during the previous flight and with the assurance that the

Aircraft would be cleaned on arrival in Sharjah, the Commander determined that the Aircraft was serviceable.

The Investigation could not determine where the oil residue had originated from. However, the Investigation finds that the explanation provided by the maintenance engineer during the transit check plausible because no abnormal system indications during the previous flight had been reported.

2.6 High-pressure Filter Head Design and Failures

The design of the high-pressure hydraulic filter head with its small curve radius, and the use of inappropriate mounting bolts, were identified by Airbus as contributing to developing fractures along the mounting flange. The problem with the inappropriate mounting bolts was rectified by the issue of service bulletin *SB A300-29-098* and a revised *illustrated parts catalogue*. The curve radius issue was addressed by the filter assembly manufacturer by a design change in the manufacturing process and became effective in the production of the units. While this ensured that future filter assemblies were addressed, the already installed units on operational aircraft were not systematically surveyed and replaced. Airbus' *Technical Follow-Up* document was last updated in May 1994.

The relevant Airbus *illustrated parts catalogue* did not provide information to the operators that a newly-designed high-pressure filter head was available to reduce the likelihood of developing fractures at the mounting flange. This information was made available via technical documents and other communication with operators.

The filter head assembly was installed on the Aircraft with pre-modification attachment bolts for 26,504 hours and 13,381 flights in the ten years until the service bulletin was incorporated.

Based on the information provided in Airbus' technical documents to the operators, the Investigation concludes that Airbus addressed both known causes for the filter head fracturing with different priorities. While Airbus addressed the issue with the inappropriate attachment bolts in a service bulletin, the design changes to the filter head were covered in a *Technical Follow-Up* document, and mentioned in a service information letter, an in-service information, and during an Airbus symposium that summarized general A300, A310 and A300-600 hydraulic leak issues.

2.7 Sharjah Airport Parking Bay 57

During an airport compliance audit of Sharjah International Airport, conducted by the General Civil Aviation Authority of the United Arab Emirates (GCAA) in January 2020, it was identified that the lighting conditions at the cargo apron, and specifically at parking bay 57, were not in accordance with the *Civil Aviation Regulations* CAR Part IX, Appendix 9, 9.24 – *Apron Floodlighting*.

These conditions had not been rectified at the time of the Accident on 28 February 2020.

While the Investigation does not have evidence to suggest that the lighting conditions were a factor in the Accident, adequate apron lighting contributes to a safer work environment and prevents workplace accidents.

It is of concern that Sharjah International Airport had not immediately rectified this situation when presented with the non-compliance finding by the GCAA.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes, and contributing factors were made with respect to this Accident. These shall not be read as apportioning blame or liability to any particular organization or individual.

- **Findings.** Are statements of all significant conditions, events or circumstances in this Accident. The findings are significant steps in this Accident sequence but they are not always causal or indicate deficiencies.
- **Causes.** Are actions, omissions, events, conditions, or a combination thereof, which led to this Accident.
- **Contributing factors.** Are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the Accident occurring, or mitigated the severity of the consequences of the Accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 Findings relevant to the Aircraft

(a) The Aircraft was certified, equipped, and maintained in accordance with the requirements of the civil aviation regulations of the Republic of Kazakhstan.

(b) The Aircraft was manufactured on 19 May 1981 as serial number 141 and had accumulated total of 52,941 hours and 29,441 flights.

(c) The yellow hydraulic system high-pressure filter head was fitted during manufacture and had accumulated 52,941 hours and 29,441 flights prior to fracturing.

(d) The yellow hydraulic system high-pressure filter head bolts had been replaced in accordance with service bulletin *SB A300-29-098* on 10 September 1991, when the Aircraft had accumulated 26,504 hours and 13,381 flights.

(e) The yellow hydraulic system failed during descent, approximately 3 hours 50 minutes into the flight to Sharjah International Airport.

(f) The loss of the yellow hydraulic system fluid resulted in the illumination of the HYDRAU light on the master warning panel, and the autopilot to disconnect.

(g) The post-Accident checks and testing indicated that the yellow hydraulic system automatic selector valve was serviceable at the time of the Accident.

(h) An undetermined failure in the accumulator part of the yellow hydraulic system, in combination with the filter head fracture, caused the depletion of the yellow hydraulic system and the failure of the parking brake.

3.2.2 Findings relevant to the flight crew

(a) The flight crewmembers were licensed and qualified for the flight in accordance with the requirements of civil aviation regulations of the Republic of Kazakhstan.

(b) The flight crewmembers were well-rested prior to the flight.

(c) The Commander was the pilot flying and the Copilot was the pilot monitoring. The Flight Engineer completed his duties in his role as per company procedures.

(d) The Commander conducted a limited approach briefing with the flight crew which did not address the possible aircraft performance limitations caused by the yellow hydraulic system loss.

(e) The Commander did not share the Aircraft's operational limitation with the ground staff, and relied on the yellow brake pressure when selecting the parking brake.

(f) The Commander did not request wheel chocks.

(g) The Commander did not inform air traffic control about the hydraulic system problems.

3.2.3 Other Findings

(a) Sharjah International Airport did not comply with *Civil Aviation Regulation* CAR Part IX, Appendix 9, 9.24 – *Apron Floodlighting*, pertaining to lighting intensity at cargo bay 57, which were identified during compliance audit conducted by the General Civil Aviation Authority of the United Arab Emirates (GCAA) in January 2020.

(b) The Marshaller's hand signal 'Set Brakes' was not in conformance with the hand signal procedure.

(c) The Marshaller did not signal 'Chocks Inserted' to the flight crew.

(d) The Marshaller did not prepare for the placement of the wheel chocks prior to the Aircraft arrival at the parking bay.

3.3 Causes

The Air Accident Investigation Sector of the United Arab Emirates determines that the causes of the Aircraft collision with a parking tow tug and the consequent substantial damage were:

(a) The uncontrolled movement of the Aircraft by engine idle thrust beyond the parking stop line.

(b) The Aircraft could not be maintained at rest after the initial stop because the selected parking brake was not operational due to a leak from a fracture in the yellow hydraulic system high-pressure filter head, and a failure of the accumulator system of the parking brake that could not be determined during the Investigation.

(c) The Aircraft could not be stopped by manual braking because that the 'Manual' brake was disabled after the flight crew selected the 'Parking' brake without prior confirmation that adequate parking pressure was available.

3.4 Contributing Factors to the Accident

The Investigation identified that the following were contributing factors to the Accident:

(a) Airbus had identified the design of the high-pressure filter head as one of two contributors to fractures developing at the head flange, but did not address this issue with equal priority.

(b) The marshaller was not prepared to place wheel chocks on the Aircraft's arrival at the parking bay and was therefore unable to react timely to obstruct the movement of the Aircraft.

4. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the conclusions listed in section 3 of this Report; the Air Accident Investigation Sector of the United Arab Emirates (AAIS) expects that all safety issues identified by the Investigation are addressed by the receiving States and organizations.

4.2 Safety Actions Taken

4.2.1 Safety actions taken by Sigma Airlines

As a result of the Accident and the initial findings, the Operator introduced an aircraft system refresher training for all flight crew and a crew resource management training to all crew members.

Additionally, simulator sessions were scheduled to expose flight crew to different aircraft system failures and to train and practice adequate responses.

4.2.2 Safety actions taken by Airbus

As a result of the Accident, Airbus issued a temporary revision to the *flight crew operating manual (FCOM)* to enhance the 'Normal Procedure' for the use of the parking brake, and to add a 'warning' to immediately release the parking brake handle to restore the green system pressure for manual braking in case of aircraft movement due to a parking brake failure.

4.3 Final Report Safety Recommendations

4.3.1 Airbus

Airbus had identified the issue of the high-pressure filter head fracturing in 1986 and issued a *Technical Follow-Up* to evaluate this problem. It was identified that the filter head mounting bolts were inadequate to apply the required tightening torque and that, according to the *Technical Follow-Up*, the small head flange curve radius was a contributor to the fracturing. As a result, service bulletin *SB A300-29-0098* was issued for the Airbus A300 models in which the mounting bolts issue was resolved. The issue with the filter head curve radius was not addressed with equal priority.

The Air Accident Investigation Sector recommends that Airbus:

SR31/2021

Identify aircraft fitted with suspected filter heads, to take appropriate action for the prevention of future filter head cracking as a result of the filter head design.

4.3.2 Sigma Airlines

Considering the actions taken by Sigma Airlines, the Air Accident Investigation Sector recommends that Sigma Airlines:

SR32/2021

Assess the newly introduced aircraft system training for flight crew to ensure that they enhance their system knowledge to assist in their decision making when faced with unexpected operational situations.

4.3.3 Sharjah International Airport

An aerodrome compliance audit conducted in January 2020 by the GCAA found that the lighting intensity at bay 57 was non-compliant with *Civil Aviation Regulation* CAR Part IX, Appendix 9, 9.24 – *Apron Floodlighting*.

The Air Accident Investigation Sector recommends that Sharjah International Airport:

SR33/2021

Rectify the lighting conditions at cargo bay 57 to comply with *Civil Aviation Regulation* CAR Part IX, Appendix 9, 9.24 – *Apron Floodlighting*.

This Final Report is issued by:

The Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates
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5. Appendices

Appendix A: Marshalling Hand Signals – Page 1

4.8.4.9 Dispatch Aircraft

Perform a standard military salute with right hand and/ or wand to dispatch the aircraft. Maintain eye contact with the flight crew until the aircraft has begun to taxi.

4.8.4.10 Fire

Fire–Move right hand in an exaggerated figure of eight (8), or a fanning type motion, from the shoulder to the knee, while at the same time pointing with the left-hand wand to the area of the fire.

4.8.4.11 Set Brakes

Raise hand just above shoulder height with open palm. Ensuring eye contact with the flight crew, close hand into a fist. DO NOT move until receipt of thumbs up acknowledgment from the flight crew.

Appendix A: Marshalling Hand Signals – Page 2

4.8.4.12 Release Brakes

Raise hand just above shoulder height with hand closed in a fist. Ensuring eye contact with the flight crew, open palm. DO NOT move until receipt of thumbs up acknowledgment from the flight crew.

4.8.4.13 Chocks Inserted

With arms and wands fully extended above head, move wands inward in a "jabbing" motion until the wands touch.