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Australian Transport Safety Bureau

Runway undershoot involving Beechcraft 200, VH-FDO

Cairns Airport, Queensland, on 9 July 2020



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Addendum

Page	Change	Date

Safety summary

What happened

On 9 July 2020, at about 0005 Eastern Standard Time, a Beechcraft 200 aircraft, registered VH-FDO and operated by the Royal Flying Doctor Service, Queensland Section, was on approach to Cairns Airport, Queensland. On board the aeromedical flight were the pilot in command under supervision, supervisory pilot, flight nurse and two patients.

The Cairns runway 15 threshold was temporarily displaced due to runway works. During the approach, the flight crew sighted an airport safety officer's car with its headlights directed at what appeared to be a row of lights across the runway, illuminating the displaced threshold. The aircraft passed above the row of lights and touched down beyond it. However, the aircraft had landed short of the actual displaced threshold and struck an unseen temporary runway end light.

What the ATSB found

The ATSB found that the airport safety officer's car headlights were directed at reflective witches' hats that marked the works limit line, which was in front of the displaced threshold. To the flight crew, this appeared as a row of lights across the runway. As a result, the flight crew misidentified the aerodrome works limit line as the displaced runway threshold lights. The actual displaced threshold lights were also indistinguishable from the taxiway lights that remained illuminated during the approach. This resulted in a runway undershoot as the aircraft landed short of the displaced threshold.

The works and airport safety officers laid out the aerodrome works lighting, but did not ensure it was arranged such that the location of the displaced threshold was unambiguous to the flight crew. The requirement that lighting was not confusing to pilots was stipulated in the *Civil Aviation Safety Regulations Part 139 (Aerodromes) Manual of Standards*. However, the Cairns Airport procedures for temporary runway works lighting and markings were inconsistent and did not ensure they were laid out in accordance with the required standards.

What has been done as a result

After the incident, the following safety actions were taken by Cairns Airport for the remaining runway works:

- no vehicle headlights were to be directed towards the active runway
- the works limit line was marked by a single amber light on the side of the runway
- taxiway lights were only illuminated after an aircraft had landed
- witches' hats with reflective tape were not to be used
- the notice to airmen was amended to advise that taxiways were not available, and of temporary blue taxiway edge lighting
- green temporary displaced threshold lights were replaced with solar lighting that did not require electricians to wire.

Safety message

Aerodrome works can pose a hazard to aircraft, particularly where there are unusable portions of a runway and a displaced runway threshold. Aerodrome works markings and lighting must be unambiguous and laid out in accordance with relevant standards, to minimise the likelihood of confusion for flight crew and the potential for a runway undershoot or excursion.

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The occurrence

Tasked flight

On 8 July 2020, at about 1900 Eastern Standard Time,¹ a Beechcraft 200 aircraft, registered VH-FDO and operated by the Royal Flying Doctor Service (RFDS) Queensland Section, departed Cairns Airport, Queensland. The pilot in the left seat was in command under supervision (ICUS) of the supervisory pilot in the right seat. A flight nurse was also on board for the aeromedical flight, which collected one patient at each of Northern Peninsula and Kowanyama Airports, before returning to Cairns.

Cairns Airport was undergoing runway works, with the runway 15 threshold temporarily displaced 1,856 m. While the runway was closed at night during the works, a portion of the runway was available to the RFDS with prior notice. As such, when the aircraft departed Kowanyama at 2310, the pilot ICUS contacted air traffic control (ATC) to advise of their estimated arrival time in Cairns. The Cairns Tower controller subsequently radioed the duty airport safety officer (ASO) to let them know the aircraft was expected to arrive at 0013 (on 9 July).

When the controller switched on the runway and taxiway lights in anticipation of the arrival, the duty ASO reported driving in a southerly direction to make sure the green displaced threshold lights were visible. The duty ASO then drove to taxiway B3 and stopped at the holding point, angled about 45° down the runway, with the safety car headlights pointing at the works limit line (refer to section titled *Works limit lights and markers* and Figure 4). Closed-circuit television footage of the incident showed that the headlights were on high beam, however, the ASO thought they were on low beam at the time.

Arrival at Cairns

At about 0003, while on descent, the pilot ICUS contacted the Cairns Approach controller and advised that they had received the current automatic terminal information service.² This included that the landing distance available was 1,300 m and the instrument landing system (ILS)³ was not available. The Approach controller responded that they should expect the area navigation Z (RNAV-Z) approach to runway 15 with displaced threshold as per the notice to airmen (NOTAM).⁴

Two and a half minutes later, the controller cleared the flight crew to conduct the RNAV-Z approach. The flight crew then briefed for that approach, noting that there would be no precision approach path indicator⁵ or ILS guidance.

The RNAV-Z approach was programmed in the aircraft's flight director to fly a 3° profile to the minimum descent altitude,⁶ which was 860 ft. Continuing the 3° profile would take the aircraft to the actual runway threshold, therefore, the flight crew planned to fly a short level segment until the aircraft intercepted a visually-assessed position from which a 3° approach to the displaced threshold could be made.

¹ Eastern Standard Time (EST): Coordinated Universal Time (UTC) + 10 hours.

² Automatic terminal information service: The provision of current, routine information to arriving and departing aircraft by means of continuous and repetitive broadcasts during the hours when the unit responsible for the service is in operation.

³ Instrument landing system: A precision instrument approach system which normally consists of the following electronic components: VHF localiser, UHF glideslope, VHF marker beacons.

⁴ NOTAM: A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

⁵ Precision approach path indicator consists of four lights perpendicular to the runway abeam the touchdown point, which transition between red and white depending on the aircraft's approach slope.

⁶ Minimum descent altitude: A specified altitude in a 2D instrument approach operation or circling approach operation below which descent must not be made without the required visual reference.

When about 8 NM (15 km) prior to the runway threshold, the pilot ICUS extended the landing gear and selected the landing lights on. The Approach controller instructed the pilot to contact Cairns Tower, and at 0010:15, as the aircraft descended through about 1,900 ft, the Tower controller cleared the flight crew to land. At that time, the aircraft became clear of cloud and the pilot ICUS recalled seeing a large spotlight where the workers were operating at the closed end of the runway. When the aircraft descended to 860 ft, the flight crew had the runway in sight. The flight crew could also see the safety car with its headlights on, which appeared to be directed at a row of lights across the runway, depicting what they believed to be the displaced threshold.

At the time, the duty ASO observed that the reflective band on the witches' hats were lit up 'incredibly brightly' with 'a bright white light extending across the runway'.

The pilot ICUS reported selecting the autopilot off, flying a short level segment, and a 3° approach profile to what they assessed was the displaced threshold. The flight crew recalled that the aircraft passed over the displaced threshold at about 50 ft and touched down about two runway edge lights (120 m) beyond that, in accordance with normal procedures. However, at about 0018, the ASO observed the aircraft touch down short of the displaced threshold. The Airservices Australia radar data also showed that the aircraft landed at about the position of the temporary runway end lights, which were 60 m prior to the displaced threshold. The ASO reported not taking any further action that night, as there were no abnormal communications between the flight crew and the Tower controller. The flight crew taxied to the hangar and shut down the aircraft.

Post-flight inspections

Later that morning, at about 0500, an ASO reported that one of the temporary runway end lights was broken. The metal base had been pushed about 30 cm across the runway and the red light was shattered. No aircraft other than VH-FDO had landed the previous night.

The aircraft operator's senior base pilot was advised of the broken light by Cairns Airport personnel. The senior base pilot phoned the flight crew and asked whether the aircraft had struck anything the previous night, but neither was aware that it had. The supervisory pilot subsequently found a corresponding scuff mark on the right main landing gear tyre of VH-FDO. After some investigation, it was established that the flight crew had misidentified the works limit line as the displaced runway threshold and landed short of the displaced threshold. The aircraft tyre had struck the temporary runway end light, which was taped to be unidirectional to aircraft using runway 33 and was therefore not visible to flight crew when they landed on runway 15 (Figure 1).

Figure 1: Example of temporary runway end light – taped to be unidirectional



Source: Cairns Airport

Context

Personnel information

Pilot in command under supervision

The pilot ICUS held a Commercial Pilot Licence (Aeroplane), an instrument rating and a Class 1 Aviation Medical Certificate. The pilot had been an RFDS pilot for 12 months and had accrued 1,864 hours of aeronautical experience, of which 515 hours were in the Beechcraft 200- and 300-series (King Air) aircraft, and 55.4 hours at night. At the time of the incident, the pilot had been awake for 9 hours and on duty for 6 hours, with a self-assessed fatigue level⁷ of '3: okay, somewhat fresh'.

Supervisory pilot

The supervisory pilot had been an RFDS pilot for over 17 years and had accrued nearly 13,000 hours total flight time, of which 6,224 hours were in the King Air aircraft and about 3,000 hours were at night. This experience included routinely operating into remote airstrips, with the use of improvised runway lighting. At the time of the incident, the supervisory pilot had been awake for about 7 hours and on duty for 6 hours, with a self-assessed fatigue level of '2: very lively, responsive, but not at peak'.

Aerodrome information

Cairns Airport runway works

The first two stages of Cairns Airport runway works had been completed, which involved removing and re-laying the asphalt runway surface. Stage three commenced on the night of 8 July 2020 and involved grooving the newly-laid surface. For the duration of the works, the runway was closed at night other than for nominated aircraft. For those aircraft, a portion of the runway was available, with a temporarily displaced threshold.

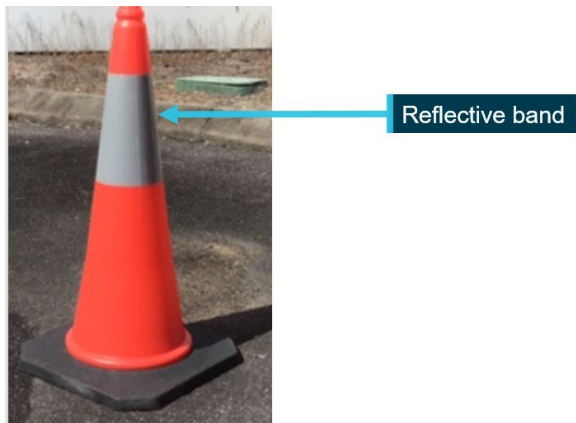
In preparation for commencement of the works that night, there were three ASOs, including one as the designated works safety officer (WSO) and one as the duty ASO. They were tasked with laying out the required aerodrome works lighting, and blanking out runway and taxiway lighting on the unusable portions of the aerodrome. The portable lighting they laid out was:

- five green lights either side of the runway to mark the displaced threshold
- runway end lights across the width of the runway that appeared red for aircraft landing on runway 33, but were taped with black tape so that they were not visible to pilots of aircraft arriving on runway 15
- reflective 'witches' hats (Figure 2) placed on the works limit line, with an orange flare torch placed between each pair of hats.

The WSO and ASOs commenced this task at about 2110. When completed, the WSO advised the Cairns Tower air traffic controller that the threshold was displaced as per the NOTAM (refer to section titled *Pre-flight planning*).

⁷ The ATSB and RFDS Queensland Section use the Samn-Perelli fatigue scale from 1 (Fully alert. Wide awake. Extremely peppy) to 7 (Completely exhausted. Unable to function effectively. Ready to drop).

Figure 2: Witches' hats used to mark the works limit line



Source: Cairns Airport

Regulations regarding aerodrome lighting

Regulations pertaining to aerodromes were specified in the Civil Aviation Safety Authority's (CASA) *Civil Aviation Safety Regulations 1998, Part 139 (Aerodromes)* and the associated *Manual of Standards (MOS)*. Much of that information was also published in the *Airservices Australia Aeronautical Information Publication, Part 3 – Aerodromes*. The following was specified in the MOS with regard to runway lighting and markings.

General guidance

It is important for pilot recognition and interpretation of aerodrome lighting systems, that standard configurations and colours be used. The pilot always views the aerodrome lighting systems in perspective, never in plan, and has to interpret the guidance provided, while travelling at high speed, often with only a limited segment of the lighting visible. As time will be limited to see and react to visual aids, particularly in the lower visibilities, simplicity of pattern, in addition to standardisation, is extremely important.

Displaced threshold lighting

Applicable to the Cairns runway width, five green lights either side of the runway depicted a temporarily displaced threshold.

Runway edge lighting

Due to the works in progress, runway 15 was a non-precision approach runway. As such, it was required to have runway edge lights along both sides of the full length of the runway available for use. At least six red runway end lights were required to be positioned across the runway, between these runway edge lights. The 60 m of the runway that was available for aircraft use prior to the displaced threshold was required to have runway edge lights showing red in the direction of approach. The ground crew had covered all edge lights prior to the displaced threshold.

Taxiway centreline lighting

The green taxiway centreline lights in the vicinity of the displaced threshold were required to not cause confusion with the green displaced runway threshold lights.

Extinguish closed portions

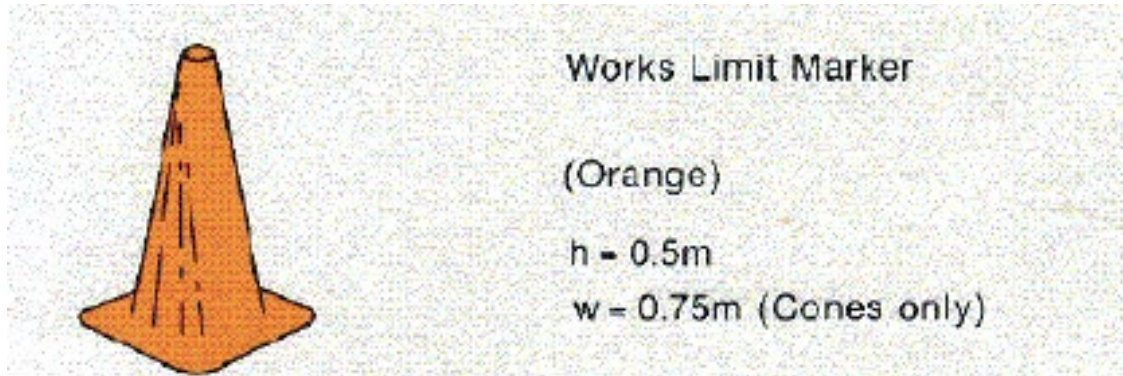
When all or part of a runway or taxiway is closed, all the associated aerodrome lighting must be extinguished. Additionally, the lighting was required to be electrically isolated or disabled, to prevent inadvertent activation of the lights. However, it was acceptable to cover lights with an opaque cover for short time periods provided the cover was firmly attached to the ground and could not be dislodged, and it did not pose a hazard to aircraft operations.

Works limit lights and markers

The works limit line, also known as the equipment limit line (ELL) delineates a safety barrier for workers. Portable amber, yellow or orange works limit lights were to be used to indicate the limits of the works area to the works personnel.

Daytime works limit markers were fluorescent orange PVC cones or witches' hats (Figure 3). These were to depict aerodrome works to the works personnel and not to convey information to pilots regarding the movement area.

Figure 3: Works limit marker



Source: CASA

Civil Aviation Safety Authority guidance

The stated purpose of CASA's [Advisory Circular 139-20\(0\)](#) – *Safe planning and conduct of aerodrome works* was '...to discuss the areas of safety concern and offer suggestions on how to minimise the hazard which may be created by aerodrome works'. The circular also noted that it was the aerodrome operator's responsibility to ensure aerodrome safety during aerodrome works. Of particular relevance to this incident, the circular included the following regarding the extinguishing of unnecessary lighting and the use of vehicle headlights:

10.6 Extinguish Unnecessary Lights – Aerodrome lighting must show only the usable aerodrome facilities. Where because of aerodrome works, a portion of the runway or taxiway is not usable, the lights on those portions of runway or taxiway must be extinguished so as not to create confusion. One method of extinguishing a light is to place masking tape over the light, another is the use of a bucket to cover the light.

11.3 If there are aircraft operations at night, the lights from vehicles engaged in night work must not cause confusion to pilots. Vehicle light fittings should be checked to ensure that the lights are not directed unduly upwards. Drivers must be told that as a matter of course, high beam is not to be used.

Method of working plan

The MOS required a method of working plan (MOWP) for the works to be conducted at Cairns Airport. The Cairns Airport MOWP included that, for stage three of the works, the runway would be closed nightly until 1 August 2020 for specified hours. The closure would be advised by NOTAM and applied to all aircraft operations except for RFDS King Air and other nominated aircraft. For these aircraft, the runway could be used with 30 minutes prior notice. The MOWP also included template text for the NOTAMs.

The MOWP stipulated that the designated WSO's responsibilities included ensuring:

- the safety of aircraft operations
- unserviceability markers and lighting were placed in accordance with the MOS.

The MOWP also stated that:

- works personnel were to remain behind the works area limit line marked by a row of orange witches' hats

- drivers must use low beam only on vehicle headlights.

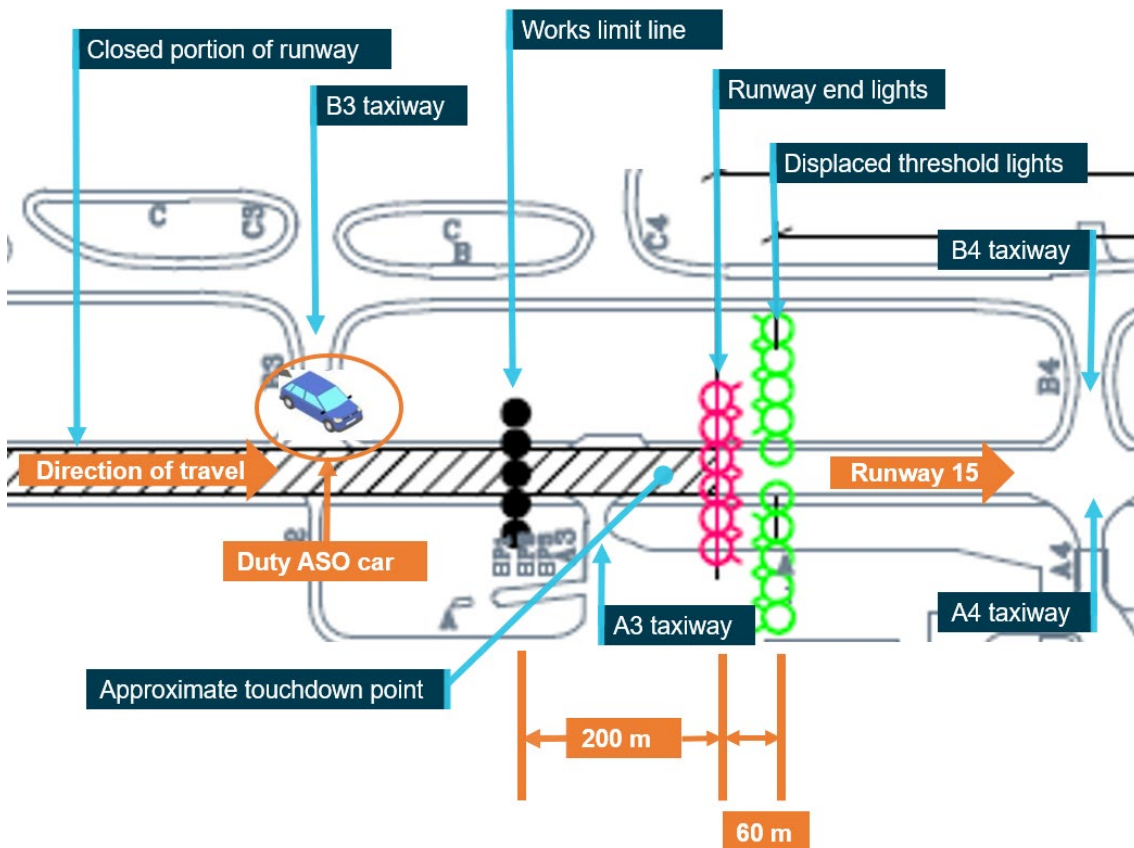
The RFDS operational procedures supplement to the MOWP documented the arrangement between Cairns Airport, RFDS and Cairns ATC, to allow for medical flights to continue during the scheduled runway works. Much of the information detailed in the supplement was provided to the flight crew in a notice to aircrew (NOTAC) (refer to section titled *Pre-flight planning*).

Runway works drawing

The drawing of the overlay for the runway 15 displaced threshold operations, an extract of which is depicted in Figure 4, was an annex to the MOWP. The drawing indicated that the displaced threshold was 1,856 m beyond the permanent runway 15 threshold, and the temporary runway end was 60 m prior to the displaced threshold. The works limit line was 200 m prior to the runway end and there was 260 m between the works limit line and the displaced threshold. The legend for the drawing described the following:

- equipment (works) limit line was orange witches' hats during daylight hours and flashing amber lights at night
- runway end lighting was at least six lights spaced evenly between the rows of runway edge lights
- displaced threshold lighting was five green lights either side of the runway, 2.5 m apart, with the innermost lights on each side omnidirectional and in line with the runway edge lights.

Figure 4: Extract of drawing depicting the displaced threshold and associated lighting



Source: Cairns Airport, annotated by the ATSB

Laying out the lights

Airport safety officers

Of the three ASOs assigned for the works on the incident night, one was designated the WSO and another the duty ASO. While the WSO was responsible for aerodrome safety according to the

MOWP, the three ASOs worked together to set up the runway lighting. The duty ASO was the most experienced, having worked at Cairns Airport for 34 years.

When the WSO collected the witches' hats from their storeroom, there were no MOS-compliant orange witches' hats available, only traffic cones with reflective bands (Figure 2). These were branded with 'ELL', which indicated to the WSO that they were appropriate for use. The WSO reported that an orange flare torch was placed between each pair of witches' hats on the works limit line.

Blacking out lights

Inset lights, recessed into the aerodrome surface, were blacked out with 400 x 400 mm carpet tiles and raised lights were covered with a vinyl sock. The ASO reported that they laid carpet tiles over the runway end lights, lead-on and lead-out lights for taxiways B2 and B3, holding point lights, and taxiway A2. They placed a vinyl sock over each of the runway edge lights between the displaced and permanent runway 15 threshold, and on the blue lights on the aircraft turning areas on the runway.

Taxiways A3, B3, A4 and B4 remained lit from the holding point, and taxiway A4 and 'some of' A3 (green) lead-in lights and temporary blue taxiway edge lighting parallel to the runway between A3 and A4 remained illuminated. In accordance with the NOTAM, the high intensity approach and runway lights, and the precision approach path indicator were not available and were therefore not selected on by the Cairns Tower air traffic controller. There was no reference to the closed taxiways in the NOTAM.

During stage two of the works, as the runway asphalt was progressively taken up and new surface laid, electricians isolated light circuits, removed and re-laid the cables, thereby extinguishing taxiway lights. This was not done for stage three. On the incident night, an electrician assisted with laying out the temporary displaced threshold lights and runway end lights. After the incident night, these were replaced with solar lights that did not require wiring.

Works safety officer tasks

The first task for the WSO each night was to attend the works contractors' 'toolbox' meeting as the representative for Cairns Airport. The WSO reported that, on the incident night, the contractors' toolbox meeting was scheduled to start at the time the WSO arrived at work. After attending the meeting, the WSO recalled then being pushed for time to get the runway set up. The WSO split the tasks to be completed with the two ASOs, so that one person did either side of the runway, and the third did the threshold and runway end lights. Despite the rush, the WSO and ASOs thought the displaced threshold and lighting was set up correctly. Subsequent to the incident night, the rostering was amended to allow more time between the start of shift and commencement of runway works for the WSO to set up and check the works lighting.

The WSO reported that their normal plan each night was to enter the runway to cover and lay out the lights at the commencement of the works hours. The WSO was responsible for ensuring the runway was set up according to the MOWP, drawing, associated emails, and the MOS, which were accessible on an iPad.

Once complete, the WSO advised the Cairns Tower controller, and the other ASOs resumed their normal duties. When the works contractors started work, the WSO was then responsible for monitoring the worksite, and escorting workers on and off the site.

Works checklist

Cairns Airport issued a works safety officer tasking list when stage one of the works commenced. The checklist detailed the items to be completed by the WSOs and ASOs at the start and end of each shift. The items were based on the car number and assigned role, however, car 18/34 was referenced, which was not in use for stage three. The WSO reported that they had used a

checklist when they first started the works, but not for stage three. The WSO checklist tasks for the start of shift that also applied to stage three included:

- attend the works toolbox meeting
- set up the works limit line
- request ATC deselect the lighting as required
- deploy the displaced threshold – carpet squares on inset lighting, cover runway lighting and tape lights as required
- confirm with ATC that the displaced threshold has been established and request selection of the runway lighting to confirm the visual aids are correct.

According to the checklists, the duty ASO was to conduct a runway inspection with the aerodrome ground lighting energised, prior to any RFDS movement and prior to the runway being opened after the works. The ASO was also required to check the NOTAMs for accuracy. There was no reference to covering taxiway lighting in the checklist.

Closed-circuit television footage

Closed-circuit television footage taken of the incident flight, showed that the taxiway lights were illuminated, including the A3 and B3 taxiways. The safety car headlights were on high beam and directed at the witches' hats (designating the works limit line), and the runway edge lights between the witches' hats and displaced threshold were not visible.

Lighting on a subsequent night

Several nights after the incident, the flight crew again flew into Cairns, using the runway 15 displaced threshold. The flight crew reported that, compared to the incident night, the displaced threshold was distinct and that, due to the absence of extraneous lighting, there was no confusion. Differences to the runway lighting arrangement included:

- the reflective witches' hats were absent and a single amber light to the side of the runway marked the works limit line
- no safety car headlights were directed at the runway
- taxiway lights were deselected until the aircraft landed such that the only green lights leading to/from and perpendicular to the runway were the displaced threshold lights
- there was no runway lighting prior to the displaced threshold (Figure 5).

Figure 5: Runway lighting for the runway 15 displaced threshold several nights after the incident



Source: Flight crew

Operational information

Pre-flight planning

The flight crew signed on at about 1800, were tasked for the flight and conducted the pre-flight planning. The pilot ICUS performed aircraft weight and balance, and fuel calculations, and discussed the implications of the NOTAMs and forecast weather with the supervisory pilot. The aircraft operator provided the NOTAMs to flight crew, transcribed as NOTACs.

Regarding stage three of the runway works, the NOTAC detailed the work periods when the displaced thresholds would be in place and that initially, the runway 15 threshold would be displaced 1,856 m, followed by displacement of the runway 33 threshold. While the runway 15 threshold was displaced, aircraft would be required to enter and exit the runway via taxiway A4 and backtrack the runway as required.

The NOTAC referenced the MOWP drawing (refer to the extract in Figure 4), detailed the runway lengths, and take-off and landing distances available. The NOTAC also stated that the localiser, glide path, precision approach path indicator and high intensity approach and runway lighting were not available. It stated that the temporary threshold would be lit by five green lights each side of the runway.

The flight crew received and reviewed the NOTAC and MOWP 2 days prior to the incident. Then, during the pre-flight briefing, they noted that it was the first night the runway threshold would be displaced for stage three works. They also identified that the ILS would not be available and that they expected to conduct the RNAV-Z approach to Cairns.

Flight crew interpretation of aerodrome works lighting

During the approach to Cairns, both flight crew assessed that the lit witches' hats looked like a row of lights indicating the displaced threshold, although both thought it odd that the safety car's

headlights were directed at the threshold. The flight crew also reported that the actual displaced threshold green lights placed either side of the runway merged with the green taxiway centreline lights. This resulted in multiple rows of green taxiway lights extending from both sides of the runway.

The pilot ICUS recalled aiming to land two runway edge lights beyond what they assessed was the displaced threshold. Therefore, the pilot ICUS thought that the runway edge lighting must have been on from between the works limit line and displaced threshold. However, closed-circuit television footage correlated with the ASO reports that those runway edge lights had been covered and were not visible. The lights the flight crew referenced as cues were therefore not runway edge lighting, but may have instead been temporary taxiway edge lighting on the western side of the runway.

Earlier that night, the flight crew had landed at Kowanyama and Bamaga Airports, which had lighting that created rectangular runways. The lit witches' hats, which they thought were lights across the runway, made the Cairns runway also look rectangular.

Aircraft landing lights

The aircraft had two landing lights and a third designated as a taxi light, all attached to the nose landing gear leg. It was standard practice to select all three lights on for landing (and take-off). The landing lights were high intensity discharge lights, which the pilot ICUS reported were only 'useful' from about 500 ft above the runway elevation. The aircraft fleet's landing lights were gradually being replaced with LED lights, but VH-FDO's had not yet been replaced.

Similar occurrences

A search of the ATSB's occurrence database for the 10 years prior to the incident identified 10 runway undershoot events involving a displaced threshold, all of which occurred during daylight hours. Nine of these were during runway works and one was with a permanently displaced threshold. None resulted in injuries.

Safety analysis

Introduction

Runway 15 at Cairns Airport, Queensland had a displaced threshold due to runway works. During landing on that runway at night, the aircraft touched down prior to the displaced threshold.

This analysis details the flight crew's interpretation of the aerodrome works lighting and the airport safety officers' actions in laying out the lighting. Although the works safety officer reported that the tasks to lay out the lighting were rushed, they were of the view that the aerodrome works lighting had been set up correctly. Additionally, Cairns Airport's planning and procedures for establishing the aerodrome works lighting will be considered.

Displaced threshold misidentification

It was the first night the flight crew had operated into Cairns with the temporarily displaced runway 15 threshold in place, and they had briefed for, and set up the approach accordingly. While on approach, the flight crew sighted the airport safety officer's car headlights directed at what appeared to be a row of lights.

The pilot in command under supervision and the supervisory pilot, who was highly experienced at operating at night, both misidentified the row of lights as the displaced threshold. Like the two previous runways they had landed on that night, the runway lighting appeared to form a perfect rectangle. Additionally, the five green displaced threshold lights placed either side of the runway, were indistinguishable from the green taxiway centreline lights and did not alter the flight crew's misperception of the threshold.

Although the pilot in command under supervision reported aiming to land the aircraft two runway edge lights beyond the displaced threshold, those lights were extinguished and it could not be determined what the pilot had referenced as runway edge lights. Nevertheless, due to the misidentification, a runway undershoot occurred. The radar data showed that the aircraft landed short of the displaced threshold, near the temporary runway end lights and beyond the works limit line. As a result, the aircraft's right main landing gear tyre contacted a temporary runway end light, which was blacked out and not visible to the flight crew.

Lighting requirements

The works safety officer was responsible for ensuring the aerodrome works lighting was in accordance with the *Manual of Standards Part 139 – Aerodromes* (MOS) and that it was unambiguous to pilots. The works safety officer was assisted by two other experienced airport safety officers in laying out the aerodrome works lighting. However, they did not identify that the witches' hats with reflective bands were contrary to the MOS and the method of working plan (MOWP) diagram.

Further, the use of the safety car headlights on high beam, as shown in the closed-circuit television footage, was contrary to the MOWP. The duty airport safety officer believed that it was the aircraft's landing lights (rather than the safety car headlights) that illuminated the reflective bands. However, the aircraft's lights were not effective from the height at which the flight crew had misidentified the works limit line as the displaced threshold.

Additionally, the MOS required that lights on unusable portions of the aerodrome were extinguished so as not to create confusion to pilots. In the two previous works stages, electricians had isolated and removed taxiway (and other) lights. However, this was not done for the third stage of works and the unusable taxiway lights were not blanked out. The lights remained illuminated on taxiways that were not available for use by the flight crew. Leaving the green taxiway centreline lighting illuminated perpendicular to the runway increased the likelihood of confusion with the green displaced threshold lighting.

Therefore, the combination of the safety car headlights lighting up the reflective witches' hats and the lit taxiways did not ensure that the displaced runway threshold was unambiguous to the flight crew.

Cairns Airport procedures

The MOWP stated that the works limit line was to be designated by orange witches' hats, which was not in accordance with the MOS for night-time works. In contrast, the MOWP diagram specified the use of amber flashing lights to designate the works limit line at night and witches' hats only for daytime works, which was in accordance with the MOS. The MOS also specified that red runway edge lights were required in the usable runway (60 m) prior to the displaced threshold, however, these were not included in the MOWP diagram or laid out.

Additionally, during previous works stages, the green taxiway lights were isolated and removed by electricians. Electricians would not be doing this for stage three, therefore the taxiway lights had to be extinguished to avoid potential confusion with the green displaced threshold lights. However, deselecting or covering the taxiway lights was not included in the MOWP.

Lastly, Cairns Airport had provided checklists to the works and airport safety officers detailing the tasks to be completed, but ground crew had not used the checklist for stage three. The checklist referenced tasks by car number, which required amendment to reflect the roles for stage three and did not include covering or extinguishing taxiway lighting. Use of an appropriate checklist would have assisted the airport safety officers with setting up the runway correctly, particularly as they were unaware prior to the incident that the lighting was ambiguous.

Therefore, it is important that procedures are in place to ensure runway works lighting and markings are in accordance with the standards. As it was, the Cairns Airport procedures were inconsistent, and did not assure the works lighting met the requirements, including that the lighting was unambiguous to pilots.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the runway undershoot involving Beechcraft 200, VH-FDO, at Cairns Airport, Queensland, on 9 July 2020.

Contributing factors

- The flight crew misidentified the aerodrome works limit line for the displaced runway threshold lights, resulting in a runway undershoot and collision with an unseen portable runway end light.
- The works and airport safety officers did not ensure the aerodrome works lighting was arranged such that the location of the displaced threshold was unambiguous to the flight crew.
- Cairns Airport procedures for temporary runway works lighting and markings were inconsistent and did not ensure lighting was not confusing to pilots.

Safety actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. All of the directly involved parties are invited to provide submissions to this draft report. As part of that process, each organisation is asked to communicate what safety actions, if any, they have carried out to reduce the risk associated with this type of occurrences in the future. The ATSB has so far been advised of the following proactive safety action in response to this occurrence.

Additional safety action by Cairns Airport

Following the incident, and for the duration of the remaining runway works, Cairns Airport took the below safety actions.

- No vehicle headlights were to be directed at the active runway during any aircraft operations on, or on approach to, the runway.
- The works limit line was marked by an amber solar-powered light only.
- Witches' hats with reflective tape were not to be used.
- Air traffic control was requested to only activate taxiway lights once an arriving aircraft had landed and to deactivate the taxiway lighting after an aircraft had departed.
- Green temporary displaced threshold lights were replaced with solar lighting that did not require electricians to wire.
- The notice to airmen was amended to advise that taxiways were not available, and of temporary blue taxiway edge lighting on taxiway A between A3 and A4.

General details

Occurrence details

Date and time:	9 July 2020 – 0015 EST	
Occurrence category:	Incident	
Primary occurrence type:	Runway undershoot	
Location:	Cairns Airport, Queensland	
	Latitude: 16° 53.1480' S	Longitude: 145° 45.3180' E

Aircraft details

Manufacturer and model:	Beechcraft 200	
Registration:	VH-FDO	
Operator:	Royal Flying Doctor Service of Australia (Queensland Section)	
Serial number:	BB-2020	
Type of operation:	Aerial work – EMS	
Activity:	Commercial air transport – Non-scheduled – Air ambulance	
Departure:	Kowanyama, Queensland	
Destination:	Cairns, Queensland	
Persons on board:	Crew – 3	Passengers – 2
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	None	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- flight crew
- operator
- Cairns Airport managers and airport safety officers
- Airservices Australia
- the Civil Aviation Safety Authority.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- the flight crew
- the operator
- Cairns Airport managers and airport safety officers
- Airservices Australia
- the Civil Aviation Safety Authority.

Any submissions from those parties will be reviewed and, where considered appropriate, the text of the draft report will be amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, international agreements.

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.