



Australian Government
Australian Transport Safety Bureau

ATSB

AO-2023-001 Sea World mid-air survivability assessment

Presented by

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Survivability

- VH-XH9
 - Flyable/completely survivable
 - Minor to serious injuries
- VH-XKQ
 - Catastrophic damage/beyond considered survivable
 - 4 fatalities, 3 survivors (serious/life changing injuries)

Survivability assessment

- Focus on XKQ
- Importance of video
 - 3 internal mobile phones XKQ
 - 2 internal mobile phones XH9
 - 6 CCTV
 - 1 external mobile phone

VH-XKQ ground impact



VH-XKQ Impact video analysis



VH-XKQ Impact video analysis

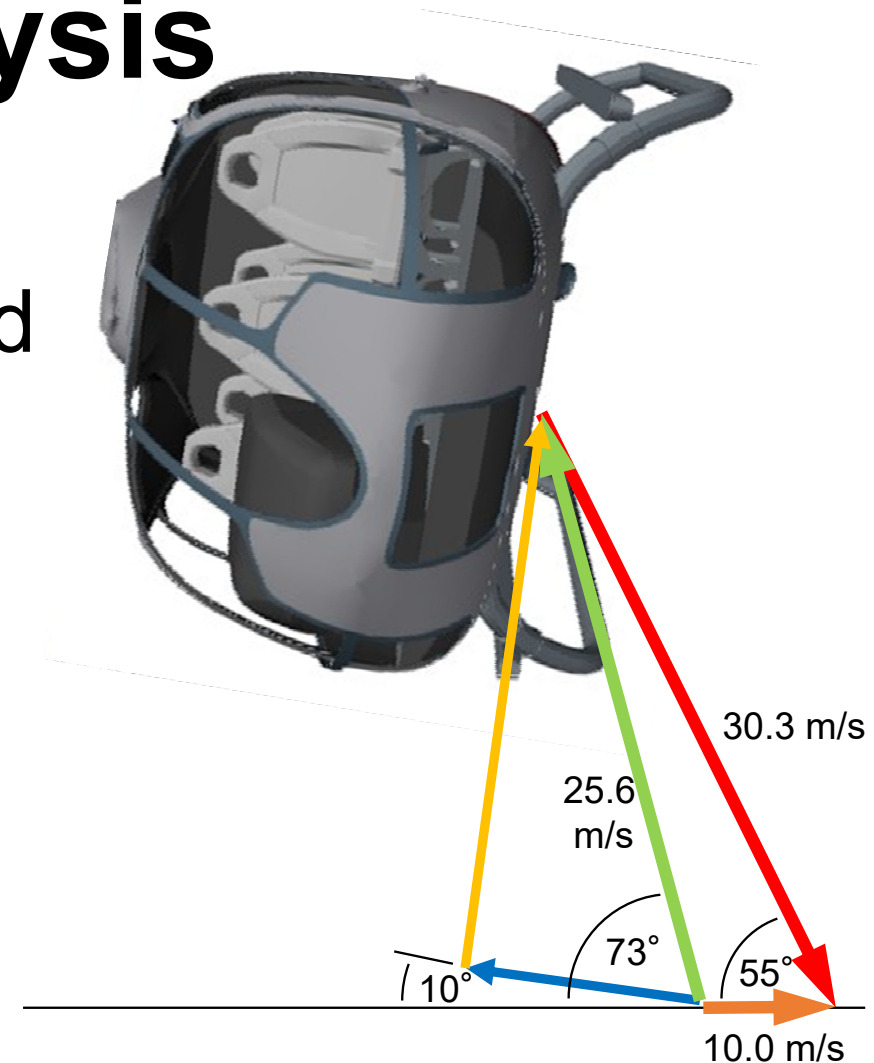
	SeaWorld CCTV (25 fps)	GCSCN CCTV (25 fps)
Resolution	0.085 m/pix	0.026 m/pix
Analysis length	11 frames	8 frames
Vertical speed	24.3 m/s	24.8 m/s
Horizontal speed (across the screen)	14.2 m/s	17.5 m/s
Apparent angle of impact	60°	75°
Travel angle out of plane	34°	67°
Impact velocity	30.2 m/s	30.3 m/s
Angle of impact	55°	55°

VH-XKQ orientation at impact

- Rolled right 75° - 80° (increasing at ~120 deg/s)
- Yawed 10° right - given the vertical orientation, 10° downwards - rotating left (upwards) at 60 deg/s)
- Little to no forward motion
- Impact mostly parallel to gently rising sand bank.

Ground impact analysis

- Inbound vector known
- Outbound vector guestimated
- Reaction vector calculated
- Resolved to body axis
 - 11.6 m/s vertical
 - 22.8 m/s lateral
- Average acceleration
 - 14.8 g vertical
 - 29.0 g lateral

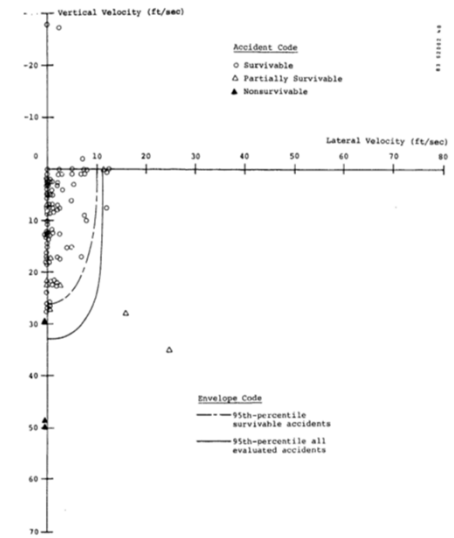
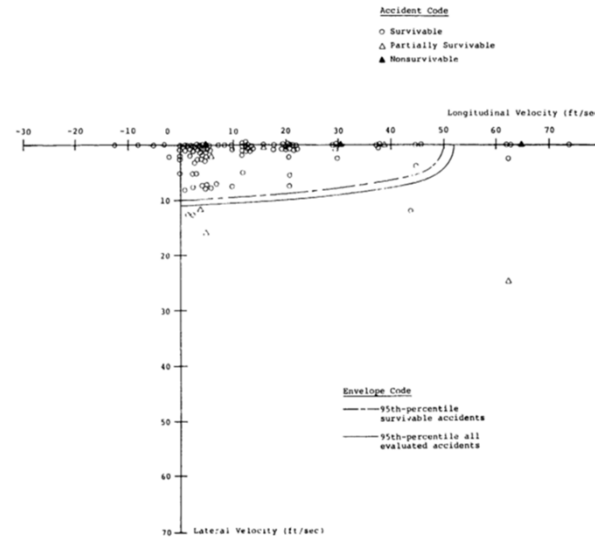
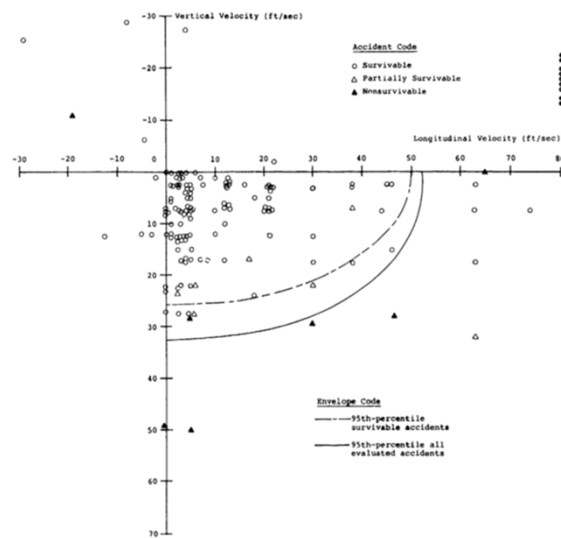


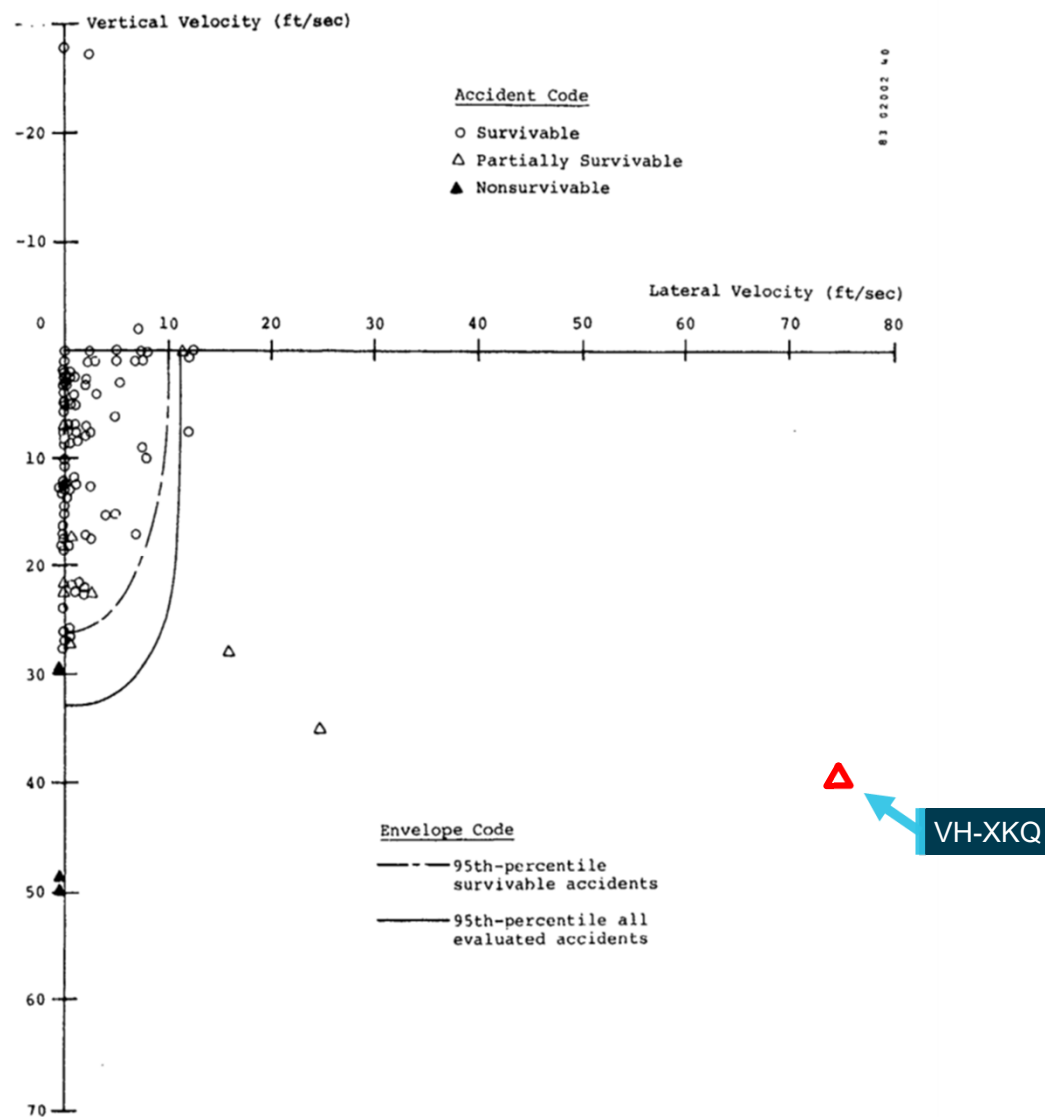
Reference material

- DOT/FAA/CT-85/11 Analysis of Rotorcraft Crash Dynamics for Development of Improved Crashworthiness Design Criteria – Coltman et.al, 1985
 - Review all civilian helicopter accidents for 1974-78 (the most recent five-year period available), and where possible, determine the aircraft velocity and attitude at impact.
 - “The magnitude of these parameters was very difficult to estimate from the accident description and damage photographs.”

Reference material

- Coltman, et al (1985) *'Analysis of rotorcraft crash dynamics for development of improved crashworthiness design criteria'*





Occupant Equipment



Equipment performance

- Dynamic loading averaged 32 g (> 80ms), peak 50 - 60 g (well in excess of the 8g static certification load case)
- The seats were canted (parallelogrammed) substantially to the right.
- The seat legs were mostly undeformed.
- All seat legs remained attached to the seat tracks.
- All seat tracks remained attached to the floor (front row) or plinth (second row).



Equipment performance

- Seat legs and integrated track slots rolled right with the seat track permanently set.
- The seat buckets stroked on one side.
- The composite seat buckets mostly intact and undeformed.
- Seat pan and seat back cushions in place and undamaged.
- The cabin ceiling had compressed onto the seats.



Restraint performance

- One occupant submarined and flailed outside of the cabin (SI) – identified high buckle position pre-flight. Removed from wreckage without undoing safety harness.
- One occupant's shoulder harness released, and they flailed outside the cabin (fatal).
- Another occupant submarined (SI - no injuries below chest height) – identified high buckle position pre-flight.
- One occupant released and found external under the fuselage/engine bay (SI). Did not have a high buckle position pre-flight.
- Three remaining fatally injured – no evidence of inappropriate safety harness use

Safety briefing

- Inconsistent and incomplete briefing material
 - Safety briefing video
 - Safety briefing card



Operational errors

- Poor occupant restraint
- Equipment incompatibility



Safety harness malfunction

- All XKQ harnesses disassembled
 - No faults found
 - Unintended actuation

Five survival factor findings

- Other factors that increased risk
 - **Safety briefing system inconsistent and incorrect**
 - Restraint system effectiveness compromised due to incorrect positioning and loose lap belts. Additionally, belts released or partially released
 - Restraints incorrectly fitted by ground crew
 - **No procedures for lifejackets with seatbelts**
 - Lack of research with combined wearing of lifejackets with multipoint seatbelts

Outcomes

- Five findings related to survivability
 - Operational in nature
 - Restraint releases weren't understood
- 2x Safety Advisory Notices
 - Instructions required for lifejackets with seatbelts
 - Research required for proper use of lifejacket with multipoint harnesses

Response



Questions?

