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ALARP: the tolerability of risk,
and Proportionality
Two case studies:

Queenstown night operations
Port Villa Runway

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Queenstown Night Operations

History



- 1961: first regular service by Mt Cook DC3s
- 1969: new sealed runway, HS-748 operations begin
- 1989: first jet operations BAe 146
- 1995: runway extensions completed:
- 1996: Trans-Tasman B737 operations begin
- 2003: RNP-AR approaches developed
- 2014: Night operations FSC approved by CAA
- 2015: New \$17M terminal opened, 1.4M passengers per year
- 2016: Infrastructure work and start of night operations 0600-2200

ZQN Night Operations Overview



History

- Night Operations was considered many times before 2012. Final study by CAA NZ concluded that it was not safe without major airport infrastructure improvements – recommended deeper study.
- In 2012, QAC contracted Navigatus to coordinate industry and develop a Safety Case to determine the risk and requirements for safe Night Ops. This Foundation Safety Case (FSC) was a two-year risk assessment by Air NZ, Qantas, Jetstar, QAC and Airways. Collaboration with CAA and CASA.
- FSC a benchmarked risk-based approach. In May 14 Director of Civil Aviation approved in principle that ZQN Night Operations could be completed safely if 65 risk ‘Controls’ were established.
- Each stakeholder would need to submit an Operator Safety Case (OSC) to CAA showing how the will comply with the FSC and establish individual airline capability for safe operations.

ZQN Night Operations Overview



Operational Challenges

- Terrain

ZQN Night Operations Overview



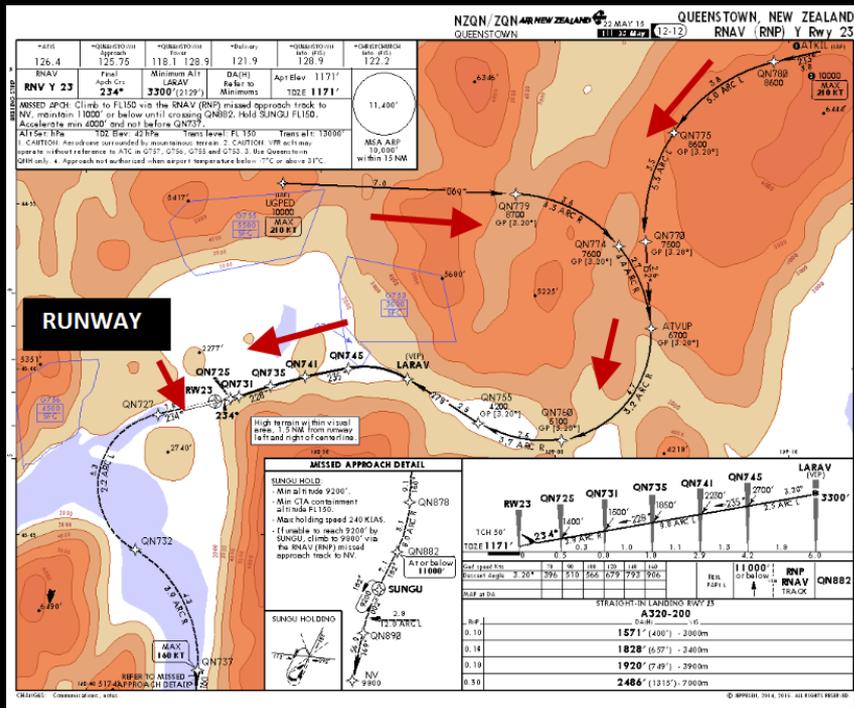
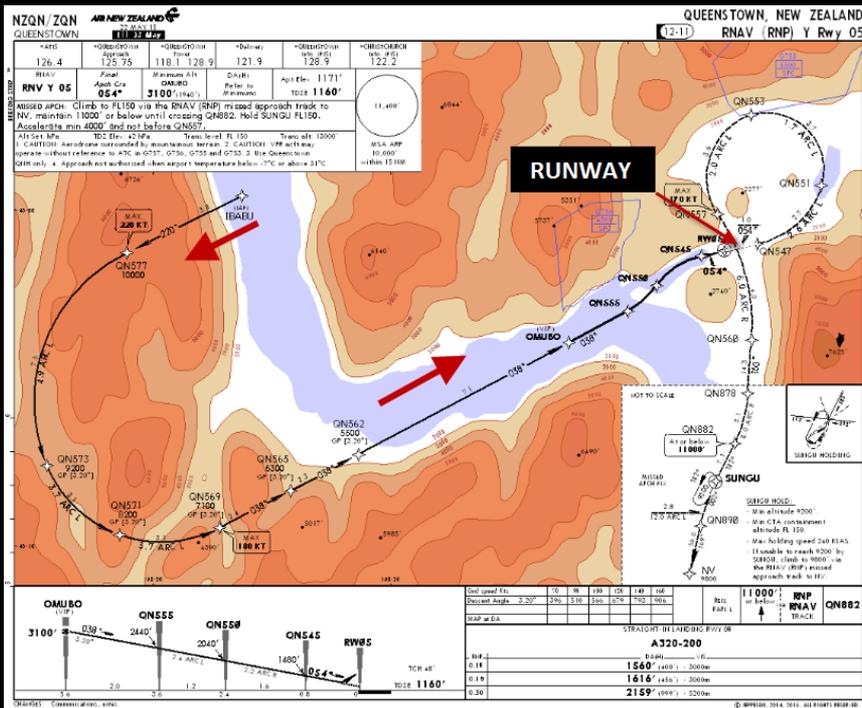
Operational Challenges - Terrain



ZQN Night Operations Overview



Operational Challenges - Terrain



ZQN Night Operations Overview



Operational Challenges

- Terrain
- Weather

ZQN Night Operations Overview



Operational Challenges – Weather and Topography

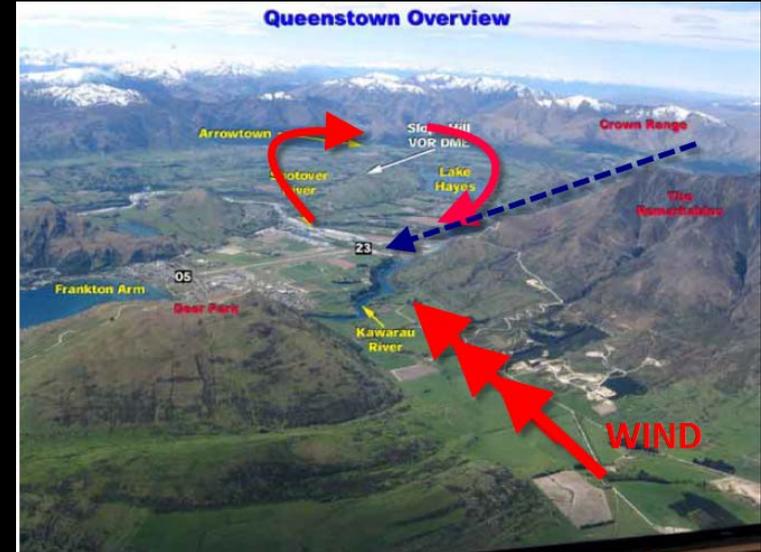
- Alpine climate: high precipitation rates, diurnal and seasonal temp range. Harsh for ground and air.
- Variable weather due to terrain; cloud base building up against terrain; hill fog; orographic wind effects; turbulence; local precipitation and wind changes (different by the minute!)
- Latitude – cold temperatures. Only approach in the world where the aircraft is configured for landing at 10,000' so exposed to airframe icing for long periods.
- No ground weather radar to see weather coming up the valley (at night)

ZQN Night Operations Overview



Operational Challenges – Weather - Wind

- Terrain induced turbulence - Windshear
- Tailwinds at both ends of runway
- Tailwinds quickly followed by extreme crosswind



ZQN Night Operations Overview



Operational Challenges

- Terrain
- Weather
- Approach and Runway

ZQN Night Operations Overview



Operational Challenges – Approach and Runway

- RNAV GPS (RNP) approach is good ...but it's not a precision approach. Curved approach due to terrain.
- The ZQN approach is the only RNAV (RNP) approach in the world where the aircraft is not aligned with the runway at Decision Altitude (400' AGL).
- No vertical guidance onto the runway
- All combined with turbulence, tailwinds and extreme crosswinds
- Short and narrow runway currently (100m shorter than WLG and 30m wide vs 45m normally)
- Icing (airframe icing on approach and on the runway itself)
- ZQN has a reputation amongst pilots for being a challenging airfield

ZQN Night Operations Overview



Operational Challenges

- Terrain
- Weather
- Approach and Runway
- Airline Operational Challenges

ZQN Night Operations Overview



Operational Challenges – Airline Operational Challenges

- Relatively isolated.
- Complex approach requiring special qualification of systems and pilots
- Takes 20-25 mins to do a full missed approach and landing (climb to 11,000')
- Short runway: can only accept 1-2 knots max tailwindbut sometimes there is tailwinds at both ends
- Windshear events are regular occurrences

Two safety cases: FOUNDATION SC and OPERATOR SC

Foundation Safety Case



ALARP – As Low as Reasonably Practicable: assessing **the tolerability of risk**

A fundamental principle of risk management where we do not necessarily seek to eliminate risk, but to reduce risk to a tolerable point above which the cost of risk management exceeds the benefits.

The principal objective of the FSC was to set out how the risks of night operations at Queenstown can be **tolerable and achieve an Acceptable Level of Safety** - **ALOS**.

A safety case does not require nor preclude any particular approach to managing risk—it requires only that threats and hazards are managed to reduce risk **below a defined level**. The Queenstown night operations safety case achieved this by defining specific elements required in the infrastructure and operational regime.

Defining 'Acceptable Risk'



Although various accident probability criteria appear in a number of aviation standards, and these are used to inform design decisions, CAA (as with most state regulators) has not defined an overall 'acceptable level of safety'.

The UK CAA defines the probability of any *individual hazard or probability combination* being unacceptable if it exceeds 1×10^{-9} per flight hour (1 in 100 million)

Eurocontrol Safety Regulator Requirement Number 4 sets the mark at 1.55×10^{-8} per flight hour (a 1 in 64,516,129 chance), but neither of these measures help set an acceptable benchmark for an *entire operation*. The per-flight-hour analysis also 'dilutes' the overall risk profile by averaging risk across the high and low-risk phases of flight.

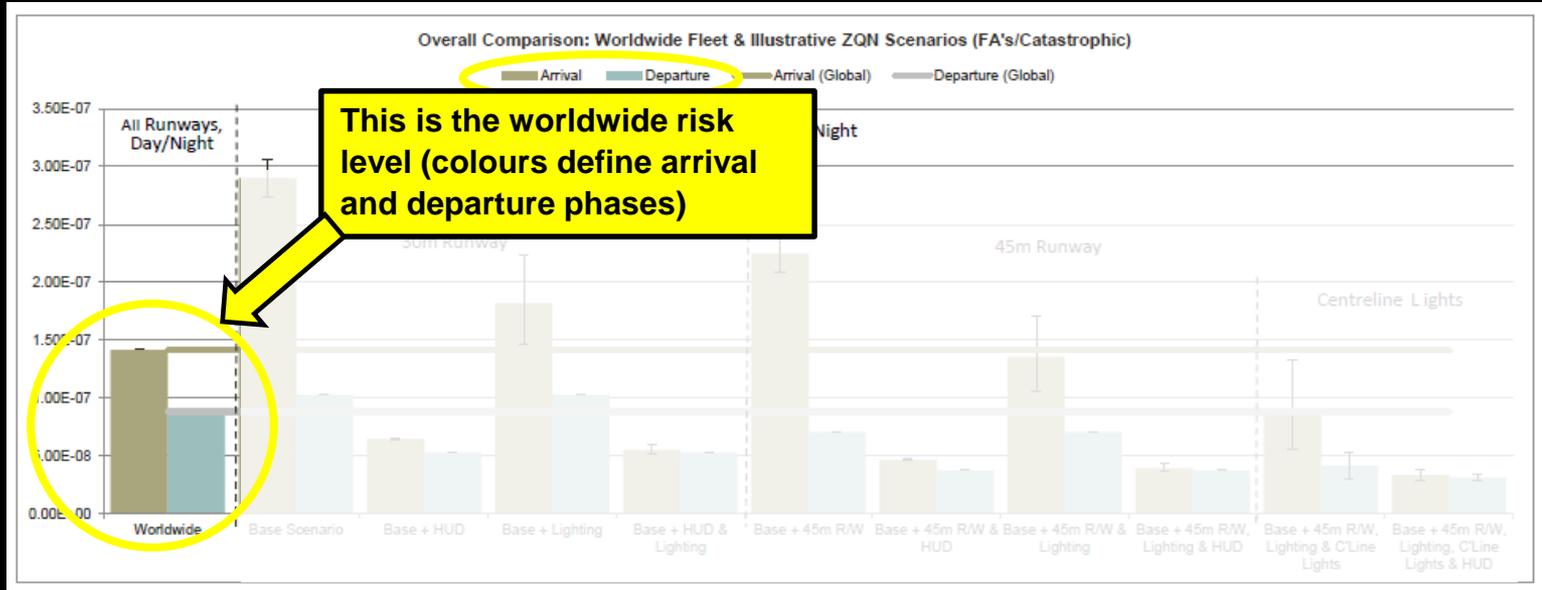
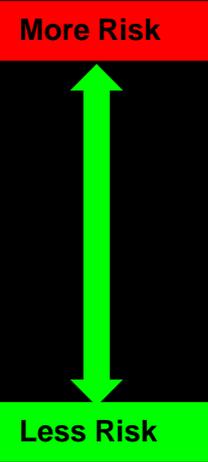
Defining 'Acceptable Risk'



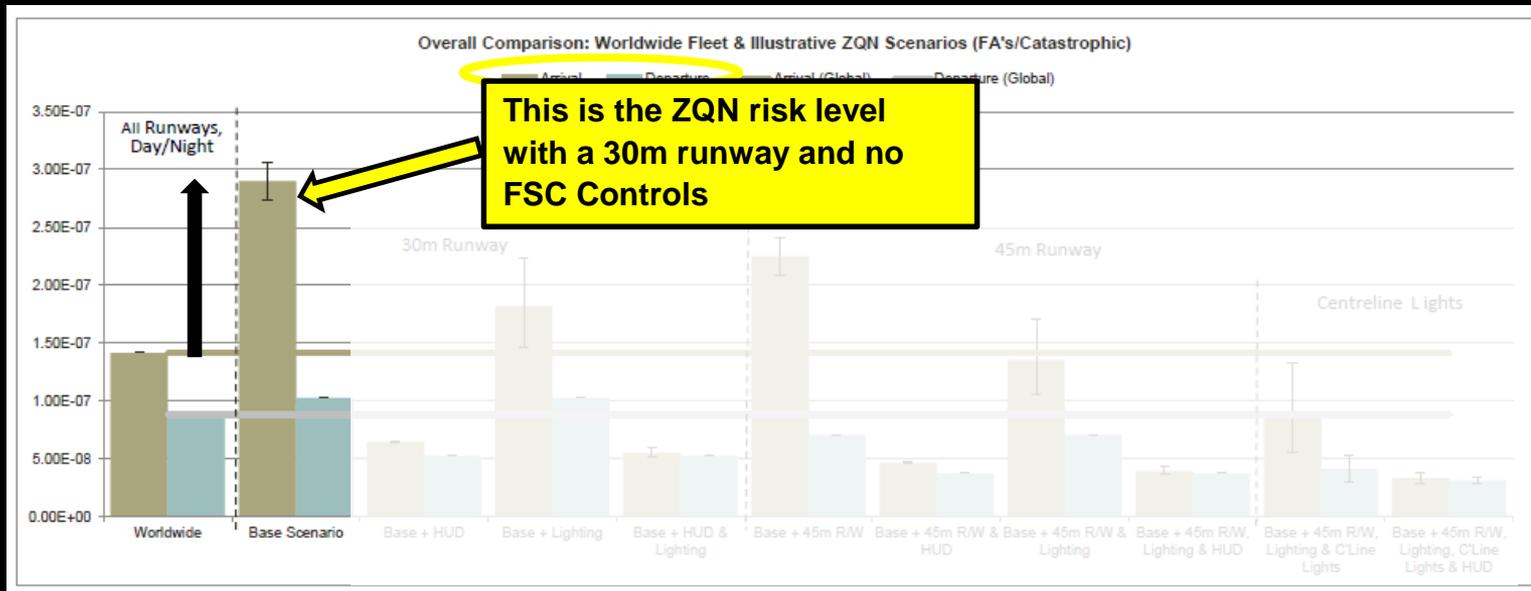
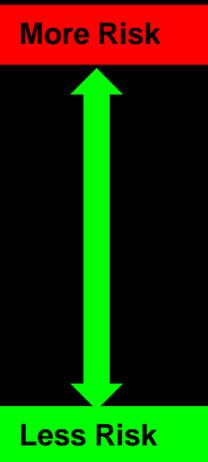
In order to overcome this lack of an absolute standard for acceptable risk, **detailed analysis of global accident rates was undertaken.**

This global analysis was based on Boeing research and modified to be applicable to the **directly relevant phases of flight.** It produced a **probability profile** for both the arrival and departure that in turn formed a benchmark for the risk analysis.

Defining 'Acceptable Risk'



Defining 'Acceptable Risk'



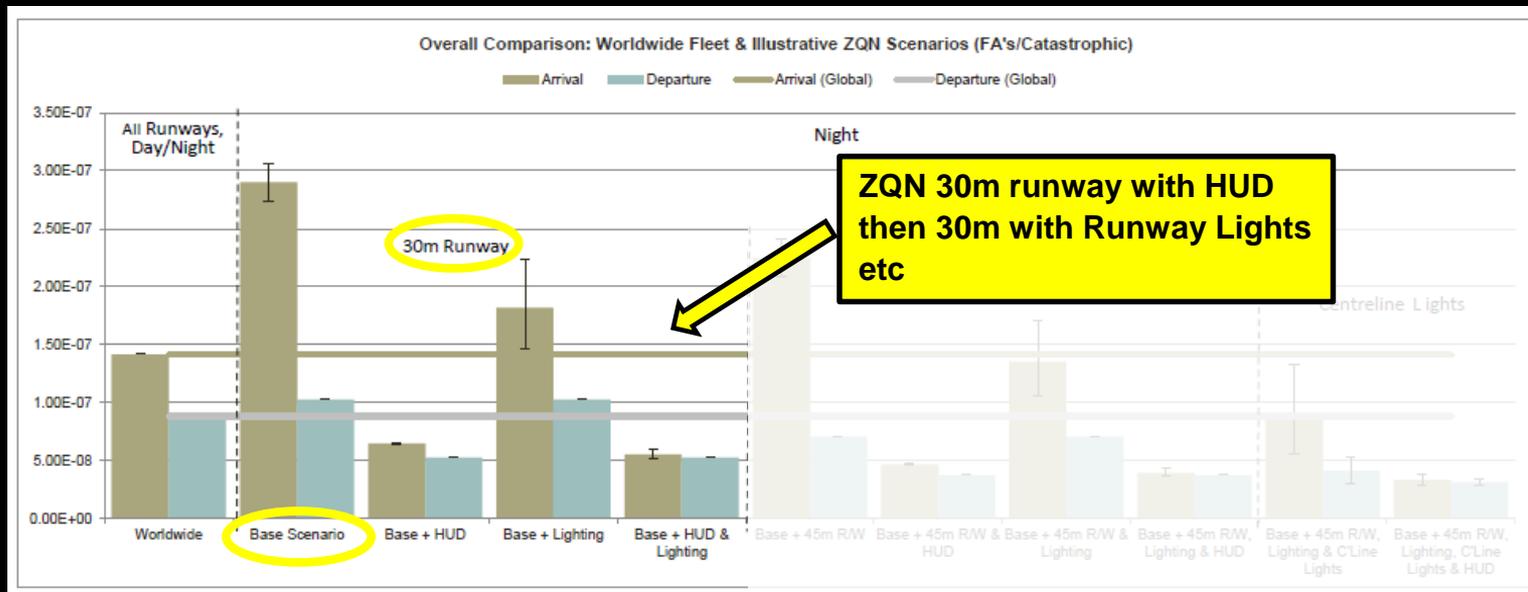
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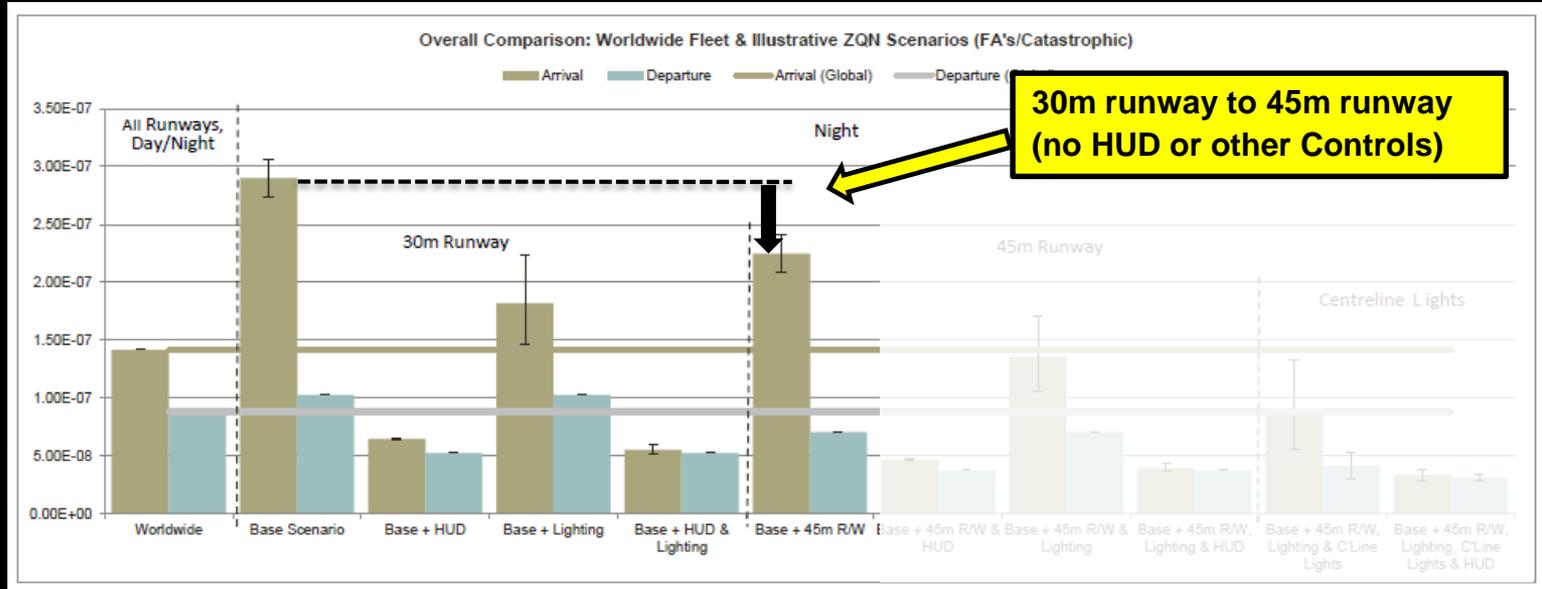
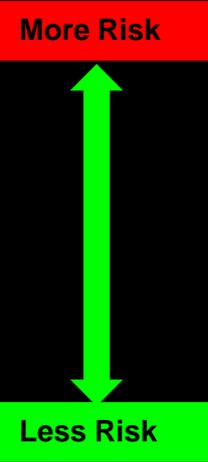
More Risk



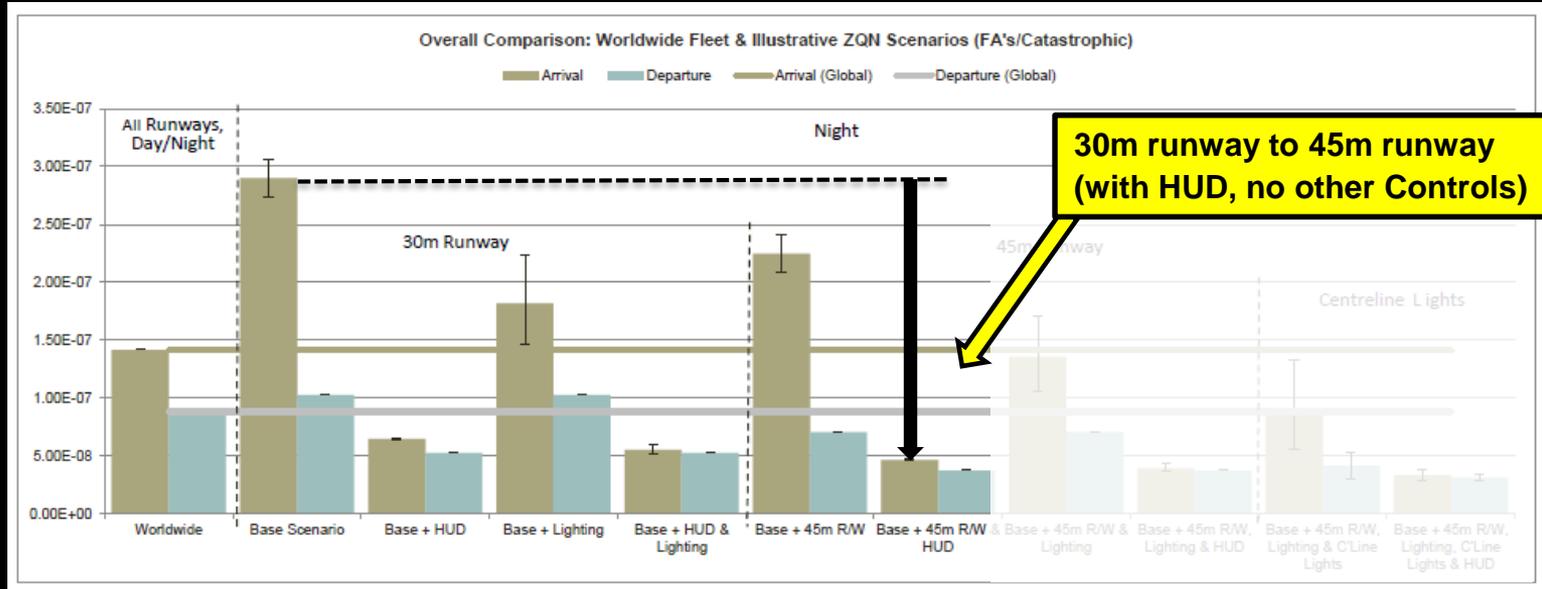
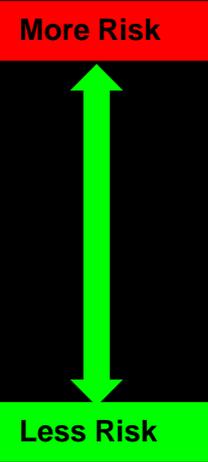
Less Risk



Defining 'Acceptable Risk'



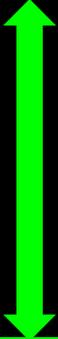
Defining 'Acceptable Risk'



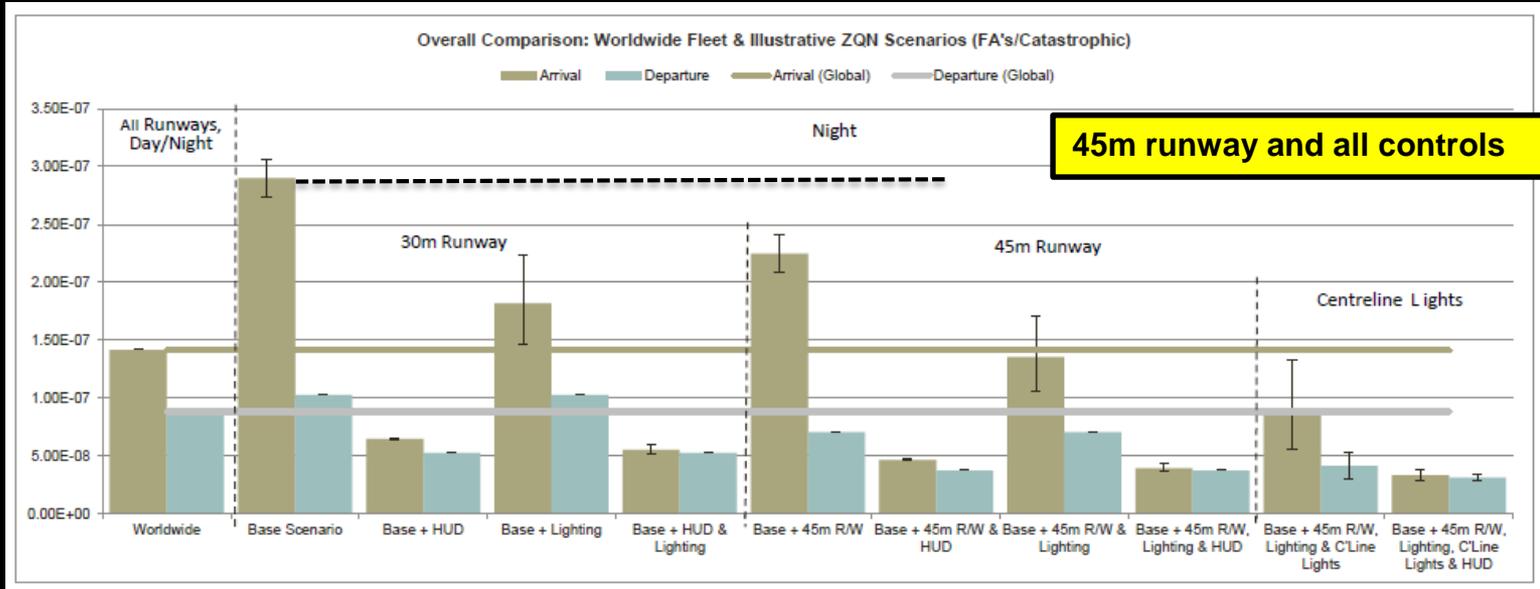
Defining 'Acceptable Risk'



More Risk



Less Risk



Assessing the Level of Risk

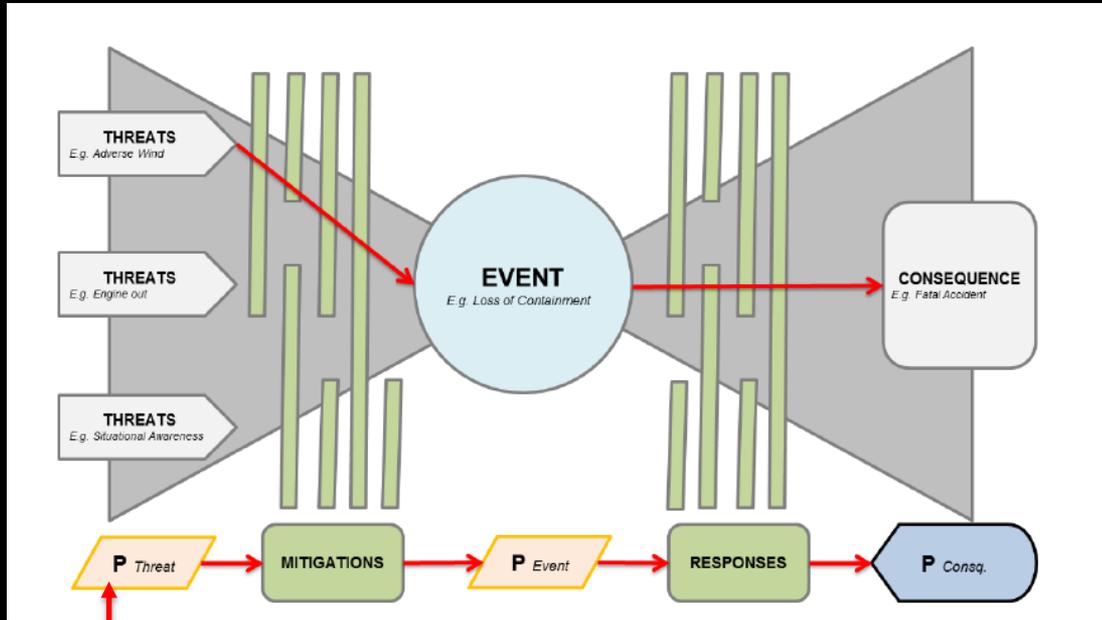


The FSC used the Bow Tie model of Risk Assessment

The major benefit of the Bow Tie model is the ability to assess each individual element of risk—the ‘disaggregation of risks to their constituent parts’. This fine level of ‘granularity’ results in a more accurate risk calculation. The model’s primary focus, however, is on ensuring there are *“sufficient barriers or controls for each failure pathway.”*



The Bow Tie Model–Structure



Threats are hazards or circumstances which can lead to the defined event (see below). Each threat has a series of raw probability inputs which, when combined, produce the 'raw' (unmitigated) chance of a catastrophic event.

The model is designed to be read from left to right and illustrates the layered approach to risk analysis applied in the FSC.



Bow Tie Example—Modified Probability



The key figure for quantifying the safety of the operation is the modified probability, as this represents the conditions under which we will be operating.

Threat Presence	Raw Event	Raw Consequence	Raw Probability
1.89E-01	5.00E-01	2.00E-03	1.89E-04

Threat Evaluation			
Threat Presence	Modified Event	Modified Consequence	Modified Probability
1.89E-01	5.66E-09	2.00E-05	2.14E-14

Modified probability is the probability that that threat will cause a catastrophic consequence *when all of the analysed mitigations and responses are put in place.*



Assessing the Level of Risk



Therefore the aim of the exercise was *to mitigate the identified risks to identify where and of what form of mitigations could be used:*

- *fixed solutions (infrastructure);*
- *procedures and standards (standard daytime, modified daytime and specific night-time), and;*
- *enhanced good practice and professional judgement (as developed by for example HF training and additional simulator scenarios)*

FSC Controls



The Output of the FSC specified 65 'controls' which must be complied with before night operations could occur. Some of the controls are applicable to the airport, some to Airways Corp. and the remainder to the individual airline operators.

Airways

- No GA night operations, extra ATC training, slot-time control, MLAT monitoring etc.

Airport

- 45 m runway, grooved with extra lighting package, obstacle lighting, bird control, decontamination etc.

Operators

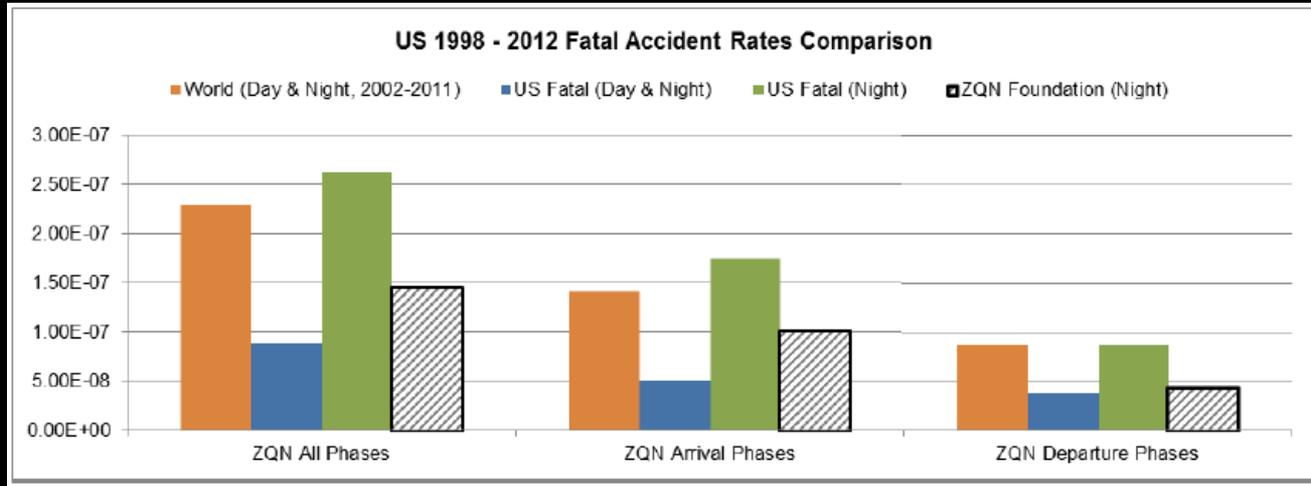
- Existing approved RNP operator into ZQN. Automation policies, enhanced procedures, trials flights, training and equipment etc.



Findings of the FSC



After assessing each and every threat/risk and probability in each phase it was found it that night time operations at Queenstown are possible to a level of safety on a par with that achieved by US civil transport operations at night.



Each of these requirements has the further benefit of enhancing the safety of day-time operations.



Questions?

Proportionality



Port Villa runway, Vanuatu

The costs associated with establishing an Acceptable Level of Safety would be grossly disproportionate to the benefits of one weekly flight.



The situation



- Air NZ learned that the condition of the runway at Port Villa had over time become degraded
- Obtained an engineer report on the condition of the runway surface
- A decision was made to avoid the hazard - service was suspended
- No criteria for acceptability of risk
- Precautionary – the benefit of doubt went toward safety
- A professionally subjective decision
- Probability was unknown
- Uncertain

The consequences



- When Air NZ suspended the service, Qantas and Virgin followed
- Air Vanuatu and Fiji Airways continued
- Temporary repairs were quickly completed

Proactive vs Reactive



Queenstown

- Proactive
- Objective
- Assessed
- Measured
- Controlled , regulated
- Tolerable
- Acceptable
- Proportionate
- ALARP ALOS

Port Villa

- Gradual
- Reactive
- Subjective
- No criteria for acceptability
- Uncertain
- Precautionary
- Not regulated



Questions?