Apron Lighting Evaluation

Mai Yeung | Senior Associate - Airports

IESALC

24 October 2013



Beca

BECA Consultants

Agenda for today

- A. Background
- B. Apron lighting standards
- C. Apron lighting designs
- D. Current evaluation practice and challenges
- E. Opportunities for improvement
- F. LED apron floodlights development

Background

- Inconsistent design process
- Inconsistent lighting levels measuring procedures
- Incorrect interpretation of results (MOS V1.5 May 2010)
- Leading to confusion
- Discrepancy between design and installation
- Dissatisfied clients

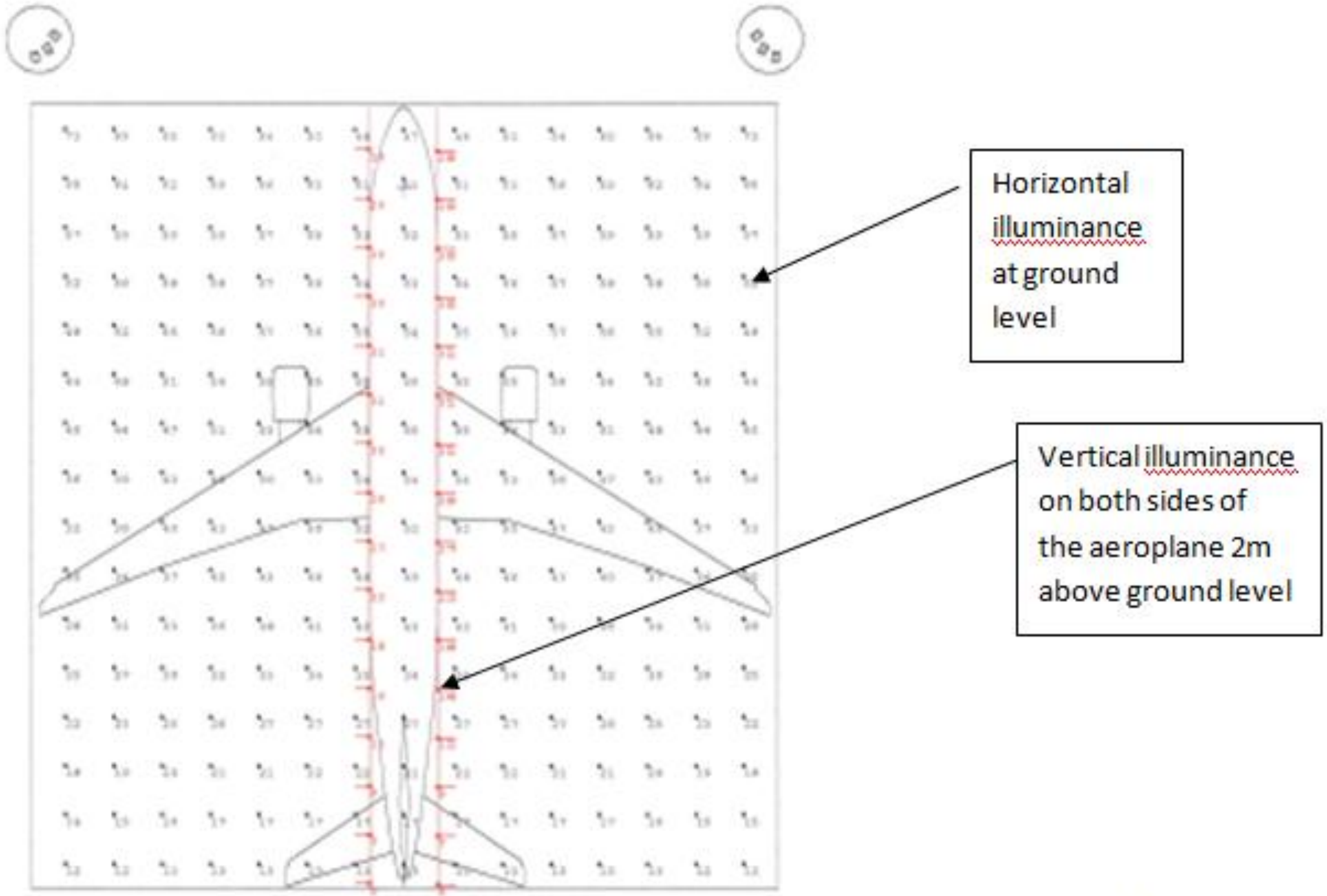
Standards

- Governing Standards
  - MOS 139 Chapter 9 (derived from ICAO)
  - AS/NZS 3827.1 – Lighting System performance – Accuracies and tolerances Part 1: Overview and general recommendations
  - AS/NZS 3000 – Wiring Rules
- Relevant Standards
  - AS 1680.5 – Outdoor Workplace Lighting
  - European Standard EN 12464 -2 – Lighting of work places – Part 2: Outdoor work places
  - AS 2560.1 – Sports Lighting General Principles
  - CIBSE SLL Code of Lighting 2012
  - CIE 67- Guide for the Photometric Specification and Measurement of Sports Lighting Installations

Civil Aviation Safety Authority (CASA) Manual Of Standards (MOS) 139 Chapter 9

- At apron used by large aircraft
  - Aircraft parking position
    - Horizontal ave illuminance: 20 lux, U < 4
    - Vertical ave illuminance: 20 lux at 2m high in the relevant parking direction, parallel to the aeroplane centreline
  - At other apron areas: 50% of the horizontal illuminance shown above and U < 4
- At apron used by smaller aircraft ≤ Code 3C
  - Aircraft parking position
    - Horizontal ave illuminance: 5 lux, U < 4
    - Vertical ave illuminance: 5 lux at 2m high in the relevant parking direction, parallel to the aeroplane centreline
  - At other apron areas: 1 lux at apron extremities or 2 lux with no taxiway lights

Interpretation of MOS 139



Beca

MOS 139 Chapter 9 (cont'd)

- *9.16.4.9 Each minimum illuminance value mentioned in this Section is maintained illuminance below which the actual value must not fall*
- *9.16.4.10 Each floodlight design must meet a target value which allows for a depreciation and maintenance factor that is appropriate for the particular floodlight system*

Design Tools and Parameters

- Computer software
  - Industry accepted software e.g. AGI32
- Lamp selection – determines the luminous flux
- Fitting selection – governs luminous flux distribution – no light above horizontal
- IES format – common input format used for most software
- Maintenance factor or light loss factor – consult airport maintenance team to confirm cleaning cycle
- Light loss factor (LLF) – combining lamp lumen depreciation and maintenance practice

Calculation Inputs

- Lighting Software must be validated
- Photometric data of chosen fittings are accurate
- Lamp lumen outputs are appropriately specified
- Aircraft parking area defined
- Position of high masts determined and coordinated with civil pavement, aerobridges, GSE parking
- Calculation grid size determined
- Aiming angles are optimised
- Mounting orientation or position defined

Calculation grid size determination

- Governing Standards do not have guidance on grid size
- AS 1680.5 2012 Appendix B B2.2
  - *“ An orthogonal grid of points shall cover the area of the general outdoor task. The points shall be spaced at no greater than the lesser of 5m or 0.3H, where H is the mounting height of the luminaries. The ratio grid spacing on each axis shall not be greater than 1.25.”*
- AS 2560.1 2002 Appendix B B2.3
  - *“For outdoor sports areas which are smaller than those covered in Figure 1 of CIE 67, the number of grid points shall be not less than 20 or the number of points obtained by the use of a grid spacing of not more than 2m, whichever is the greater.”*

Beca

Calculation grid size determination (cont'd)

- EN 12464 – Section 4.3.3 and SLL Code of Lighting
  - *Illumination Grid define the maximum grid size as determined by:*
    - $p = 0.2 \times 5^{\log d}$
    - *Where*
      - *d = longer dimension of the area in m if the ratio of the longer to the shorter side is less than 2, otherwise d is the shorter dimension of the area*
      - *p = maximum grid cell size in m*
  - *p should be less or equal to 10*

Example: grid size determination

- A330 – 200/300 apron, aircraft parking position 60 x 64m, 30m high mast
  - Maximum grid size using AS 2560.1 is 2m
  - Maximum grid size using EN 12464-2 formula is 3.6m
  - Maximum grid size using AS 1680.5 is 5m

Beca

Examples of results using different grid size

- Typical A330-200/300 aircraft parking apron
- Commonly used HPS floodlights
- High masts located at both sides of apron

Calculation grid size	Average horizontal lux	Average vertical lux
2 x 2m	40.93	22.47
3.6 x 3.6m	41.12	22.32
5 x 5m	40.67	22.00
10 x 10m	39.47	21.43

Beca

What affects lumen outputs

- Lamp lumen depreciation
- Lamps interaction with control gear
- Supply voltage variations
- Dirt or dust on the lamp
- Ambient temperature in the fixture
- Quality assurance of the lamp manufacturers

Light Loss Factor or Maintenance Factor

- Light loss factor = Lumen depreciation factor x Luminaire Maintenance Factor (LMF)
- Consult lamp manufacturer for lumen depreciation factor for the chosen lamp
- LMF – depends on cleaning cycle and pullution of environment, SLL Code of Lighting suggested values

Table 18.5 LMF values for outdoor use

Cleaning interval / months	Luminaire maintenance factor								
	IP2X minimum (a)			IP5X minimum (a)			IP6X minimum (a)		
	High pollution (b)	Medium pollution (c)	Low pollution (d)	High pollution (b)	Medium pollution (c)	Low pollution (d)	High pollution (b)	Medium pollution (c)	Low pollution (d)
12	0.53	0.62	0.82	0.89	0.90	0.92	0.91	0.92	0.93
18	0.48	0.58	0.80	0.87	0.88	0.91	0.90	0.91	0.92
24	0.45	0.56	0.79	0.84	0.86	0.90	0.88	0.89	0.91
36	0.42	0.53	0.78	0.76	0.82	0.88	0.83	0.87	0.90

Measurement of apron lighting

- AS/NZS 3827.1 defines the accuracies and tolerances of measurement
  - Section 9.5.2 Sources of uncertainty states *"Any meaningful measurement has to be based on the premise that the grid used for measurement and the grid used for the design are comparable (See Clause 7.3.2). If this does not occur, the measurements will be meaningless, since no estimate of uncertainly can be assigned to this source of error."*

Industry practice

- Designers use random grid size in calculations
- Incorrect assumptions on light loss factor
- Grid size used in measurement during commissioning and maintenance different to the grid size in calculations
- Voltage at light source not recorded
- Lamp lumen depreciation cycle not recorded
- Luminaires cleaning cycle and method not recorded

Beca

Challenges of measuring apron lighting

- Limited window due to operation constraints
- Survey of measuring grid takes a long time
- Calculation grid size unknown to the contractor doing the site measurements
- Waiting time for the lamps to stablise
- MOS does not make reference to creditable lighting standards for measuring procedures
- Open to interpretations by contractors or airport operators

Current survey practice

- Use of concrete pavement joints as point of measurement
- Survey one line at apron extremities and eyeballing the rest
- 10m grid is commonly used
- Do not reflect design grid cell sizes
- Do not reflect calculation grid points
- Current survey methods are crude and inaccurate

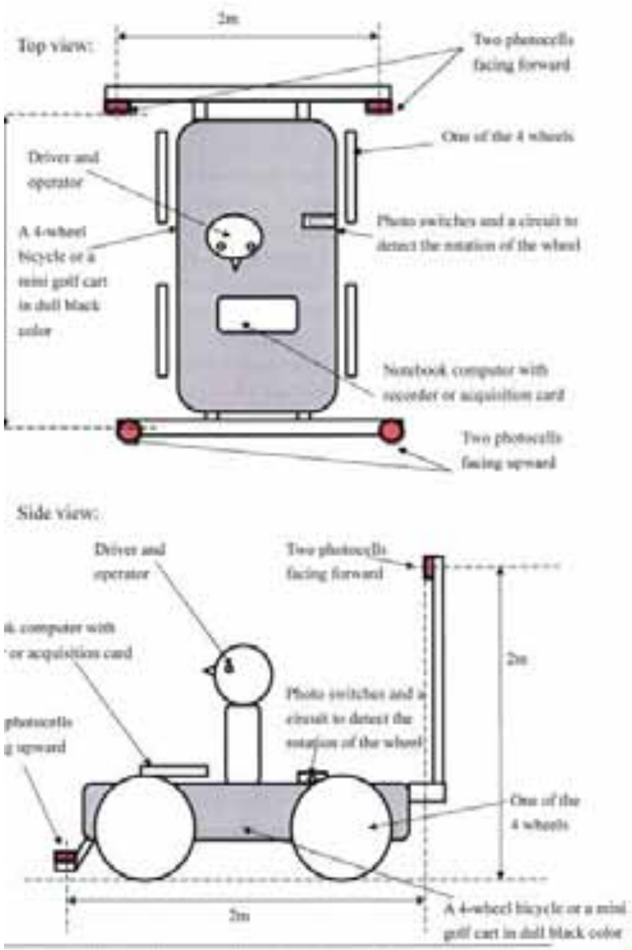
Interpretation of measurements

- Compliant – no further work required
- Non-compliant - Conversions to design conditions
  - Supply voltage variations correction
  - Calculation & measurement grid size review
  - Check aiming angles
  - Check control gear
  - Maintenance cycle correction
    - Clean fitting
    - Lamp replacement
    - Review maintenance strategy

Beca

What has been used overseas?

- Developed by Professor Edward Lo and used at Hong Kong International Airport (first used in 1997, last used in 2009)
  - Manual grid survey
  - Light sensors
  - Photo switch
  - Data acquisition card
  - Notebook computer
  - Golf cart
  - Light meters for vertical lighting level face the lights



What are the drivers for accurate survey?

- Compliant measurements (AS 3827.1)
- Accurate results to compare with the design intent
- Repeatability – for maintenance purpose, lighting levels can be measured at the same point
- Asset management – better understanding of asset performance
- Sustainability – efficient re-measurement

Beca

Opportunities of GPS based survey

- Proven technology
- Repeatability
- Improved accuracy
- Improved apron availability
- Standardise industry practice for light measurement
- Applicable to other exterior lighting installations operated by Councils

Beca

LED Apron Floodlights

- Driven by carbon footprint reduction initiative
- Driven by perceived long life and energy efficiency than HIDs
- Handful of luminaires on the market
- Lack of design standards, operation standards, installation standards and maintenance standards
- First European airport installation completed in 2011
- Australian airports started to consider LED technology now
- Melbourne Airport trialling a few fittings
- Brisbane Airport keeps a close eye on European airport trials
- Sydney Airport starts looking at options

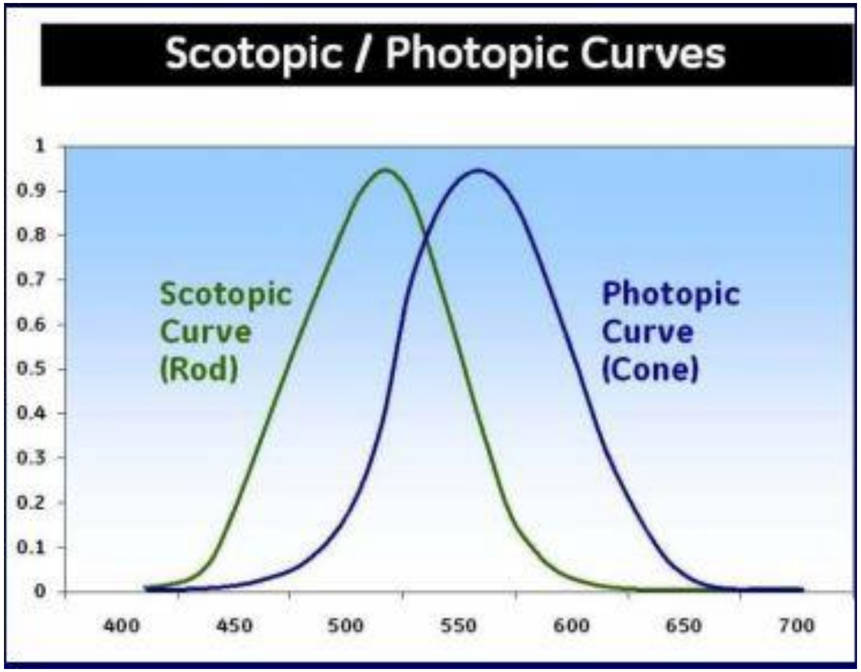
LED luminaire evaluation

- Photometric performance
  - Source of LED chips
  - Reflector or refractor design
  - Efficacy – lumen / watt
  - Glare control
  - Certified IES files
  - Colour temperature, ≤ 4000K
- Construction
  - Heat management
  - Glass front visor
  - Maintenance
- Cost
  - Capital cost
  - Spare part cost
- Maintenance
  - Company profile
  - Technical support from agent
  - Warranty
  - Definition of unserviceability
- Evaluation matrix
  - weighting and scoring
  - Stakeholders workshop

Beca

Impact of Colour Temperature

- Rods and cones share the responsibility of seeing
- Rods respond better at night
- Cones respond better during daytime
- Pupil size reduces with increased colour temperature
- High colour temperature leads to more rods are activated, resulting in area appears brighter



European Installation example

Beca

LED luminaire evaluation – Cont'd

- Photometric performance
  - Source of LED chips
  - Reflector or refractor design
  - Efficacy – lumen / watt
  - Glare control
  - Certified IES files
  - Colour temperature, ≤ 4000K
- Construction
  - Heat management
  - Glass front visor
  - Maintenance
- Cost
  - Capital cost
  - Spare part cost
- Maintenance
  - Company profile
  - Technical support from agent
  - Warranty
  - Definition of unserviceability
- Evaluation matrix
  - weighting and scoring
  - Stakeholders workshop

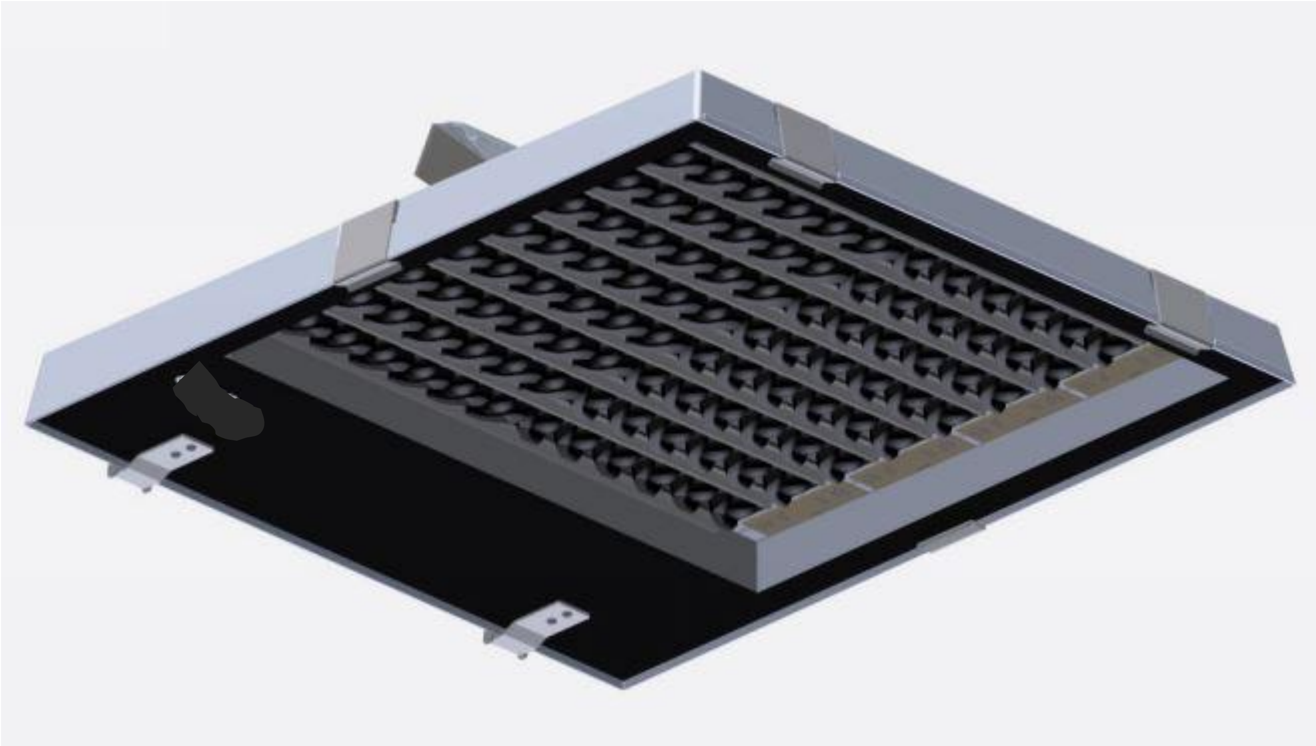
LED luminaire evaluation – Cont'd

- Photometric performance
  - Source of LED chips
  - Reflector or refractor design
  - Efficacy – lumen / watt
  - Glare control
  - Certified IES files
  - Colour temperature, ≤ 4000K
- Construction
  - Heat management
  - Glass front visor
  - Maintenance
- Cost
  - Capital cost
  - Spare part cost
- Maintenance
  - Company profile
  - Technical support from agent
  - Warranty
  - Definition of unserviceability
- Evaluation matrix
  - weighting and scoring
  - Stakeholders workshop

LED luminaire evaluation – Cont'd

- Photometric performance
  - Source of LED chips
  - Reflector or refractor design
  - Efficacy – lumen / watt
  - Glare control
  - Certified IES files
  - Colour temperature, ≤ 4000K
- Construction
  - Heat management
  - Glass front visor
  - Maintenance
- Cost
  - Capital cost
  - Spare part cost
- Maintenance
  - Company profile
  - Technical support from agent
  - Warranty
  - Definition of unserviceability
- Evaluation matrix
  - weighting and scoring
  - Stakeholders workshop

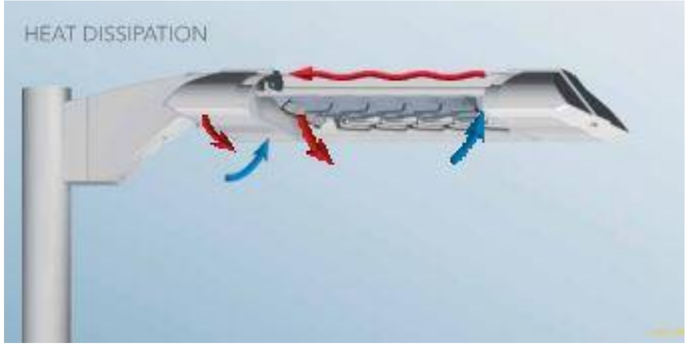
First European Fitting

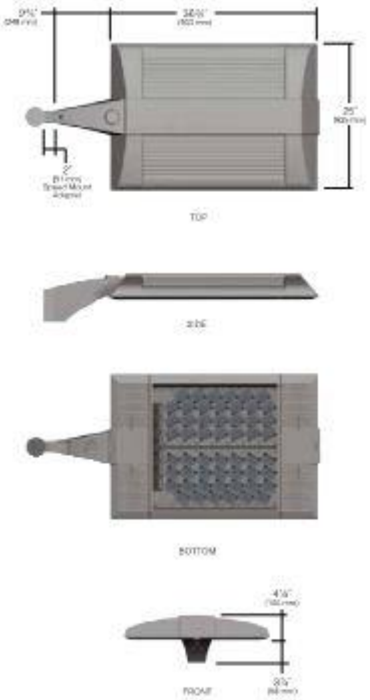


Beca

Another European Fitting

Example of US Fitting





Beca

Another US Fitting

Questions

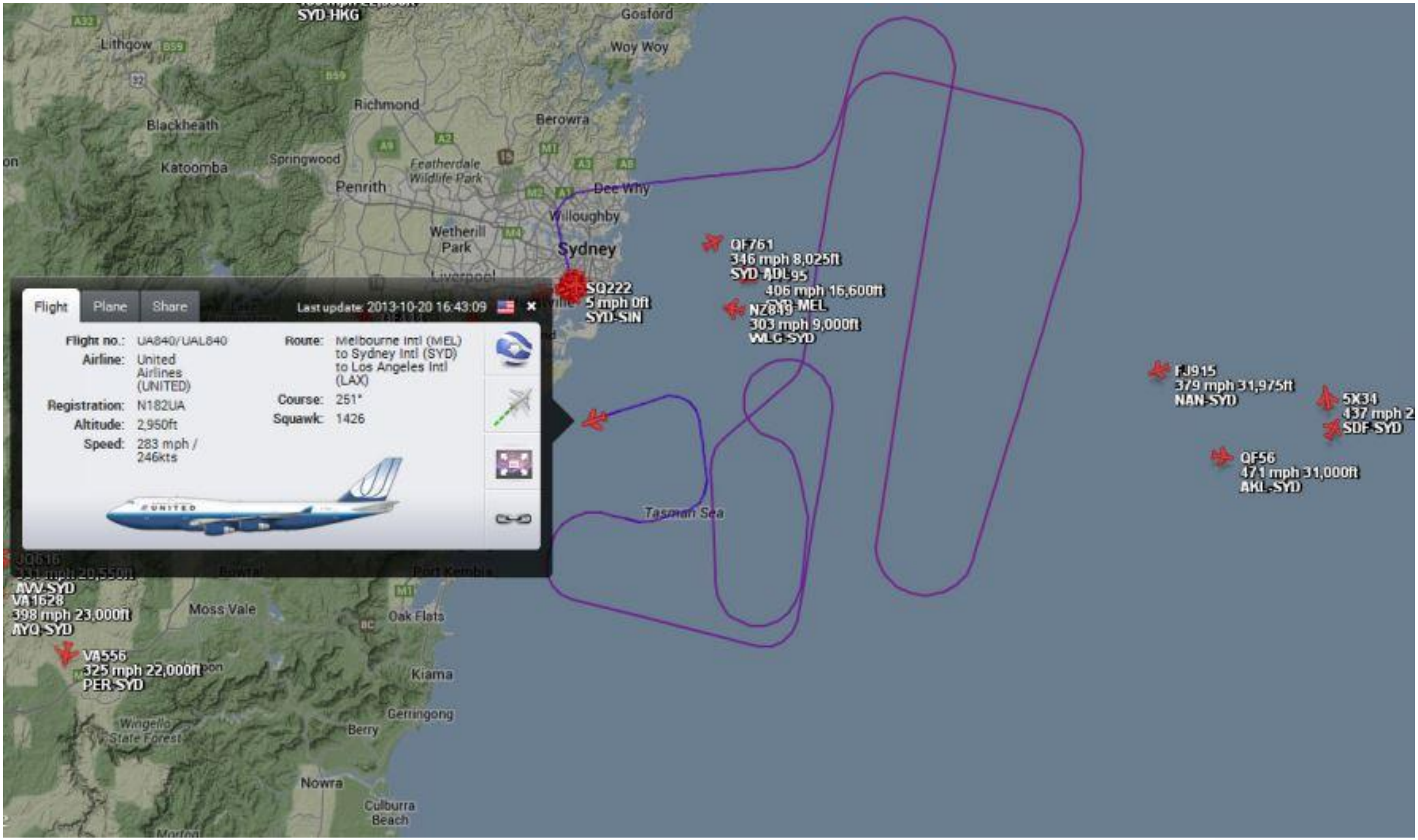
What happened to UA840 on Sunday?

- Two blown tyres on take off
- Landing gear failed to retract
- Forced to return to Sydney Airport

Response from Sydney Airport

- Runway 34L was closed after UA840 took off (debris on runway)
- Two large planes on final approach forced to abort landing with steep climb
- Departing planes waited in the queue for 45 minutes
- UA840 is the only plane allowed to land on Rwy 34L 2 hours later
- Most international flights were diverted to Newcastle Airport – 100 km north of Sydney

Where did UA840 go?



UA840 – returning to Gate 60 at Sydney Airport

Beca

The incident….

- 100 minutes of dumping fuel over Tasman Sea
- Passengers practising brace position and familiarising emergency evacuation procedures
- Captain and cabin crew calmed passengers
- 10 minutes before touch down – captain advised no need to go to brace position
- Fire trucks were standing by
- UA840 landed safely
- Taxiied to outside runway strip
- Then it was towed to gate
- Passengers got off via aerobridge

- UA840 was cancelled