Stochastic Analysis of Transit Route Segments’ Passenger Load Variation for Capacity & Quality of Service Assessment

Introduction
- This study uses weekday Automatic Fare Collection (AFC) data on a premium bus line in Brisbane, Australia
- Stochastic analysis is compared to peak hour factor (PHF) analysis for insight into passenger loading variability
- Hourly design load factor (e.g. 88th percentile) is found to be a useful method of modeling a segment’s passenger demand time-history across a study weekday, for capacity and QoS assessment
- Hourly coefficient of variation of load factor is found to be a useful QoS and operational assessment measure, particularly through its relationship with hourly average load factor, and with design load factor
- An assessment table based on hourly coefficient of variation of load factor is developed from the case study

Inbound Segments’ Passenger Load Factors’ Profiles
- Strong morning peak due to CBD work trips
- Crush load conditions (MSL > 1) on 07:25 service across inner segments MSD – SCH – COM – INT
- Softer evening peak with contra-peak direction demand from regional shopping center, inner urban connections

Quantile – Quantile Tests for Normality of Segments’ Hourly Load Factor Distributions
- Small sample sizes due to limited frequencies makes other normality testing difficult
- Line of equality comparison for morning peak hour strongly indicates normality
- No evidence of systematic bias particularly for most extreme quantiles
- Methodology does not use extreme tails so truncated normal distribution not necessary
Segments' PHF Time Histories (Clockface Hour)
- PHF correlates somewhat between consecutive segments
- Some irregular oscillation throughout day
- Low PHFs mainly during off-peak times when 15min frequencies can easily skew downward
- PHF important so operator can ensure highest contiguous 15 minutes of hour can be accommodated / managed
- PHF similar to a 15min peak’s average load – which may be used as a passenger load QoS standard

Segments' PHF Load Factors Time Histories as Percentiles
- PHF load factor varies irregularly between 75th and 95th percentiles across all segments
- Highlights conceptual difference between PHF and Hourly Design Percentile
- Hourly Design Percentile sensitive to both hourly average load factor and standard deviation of load factor

Load Factor of PHF Service Traversing Segment / During Study Hour \( H \)

\[
LF_{PHF,i,H} = \frac{\sum_{k=1}^{m} P_{k,i}}{m \max_{1 \leq k \leq m} (P_{k,i})}, \quad m < 4
\]

- Number of services
- Passengers on board each service

\[
LF_{PHF,i,H} = \frac{\sum_{k=1}^{m} P_{k,i}}{m \max_{1 \leq k \leq m} (P_{k,i})}, \quad 4 \leq m \leq 8
\]

- Number of services
- Passengers on board each service
- Maximum Schedule Load of each service

Normal Distribution Percentile of Load Factor of PHF Service Traversing Segment / During Study Hour \( H \)

\[
F(LF_{PHF,i,H}) = \Phi \left( \frac{LF_{PHF,i,H} - LF_{av,i,H}}{LF_{sd,i,H}} \right)
\]

- Average load factor across all \( m \) services
- Standard deviation of load factor over all \( m \) services

Acknowledgments
- Academic Strategic Research Alliance (ASTRA), Queensland Australia
- Queensland Department of Transport and Main Roads, TransLink Division, Australia
Segments’ Hourly Design Load Factor
- 88th percentile corresponds to 7th highest minute of hour – appropriate design state
- Each segment’s design profile envelops most of its load factors by service

Advantages of Methodology
- Requires only AFC data
- Can be used to identify along a route, in time and space, operational concerns such as pass-ups, bunching

Future Research
- Pursue application of stochastic approach to transit route across a number of consecutive study days
- To gain stronger insight into influences of day-of-week, seasonality, weather conditions on reliability