THE UNIVERSITY OF SYDNEY

Institute of Transport & Logistics Studies

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Zero Emission Buses

Service Planning and Scheduling Considerations

PBA Transit Planning

Service Planning and Scheduling Considerations

Objectives

- Identify the key factors in planning and scheduling your services
- Begin to consider how they might impact your own plans
- "So what can we do now ?"

Context

- Electric Vehicles only
- Up to today's technology and EV maturity – things *are* changing rapidly
- Current governmental thinking - things *will* evolve rapidly

Context – What is the Body of Evidence ?

Case Studies

- ❖ Mature implementations in Asia Europe and North America
- ❖ Continued trials as technology improves

Australian Trials

- ❖ >24 months operating experience in local trails
- ❖ Many industry contributions and investments

Practical Experience

- ❖ Industry is gaining experience in developing plans and schedules, and in dealing with associated complexities

International Case Studies – Foothill Transit California

- Trialled **12 BEBs** and fully electrified route 291
- **Fast charged** at a mid-route charging station which fully charges a bus in **around 5 minutes**
- Foothill built a layover time into the schedule to allow enough time for charging
- Bus availability ranges from a high of **98% to a low of 62%**
- Mid-route lay-overs resulted in passengers become frustrated and reacting negatively

BEB parked at the charging station. A Government building houses the charging equipment is on the left.

Figure. Route 291 (as of January 2019); *BEB for Foothill Transit Proterra*

International Case Studies – Rapid Transit models

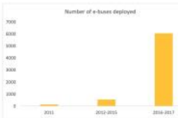
- **Connexxion (Netherlands)**
- 16 Routes, including 5 with 24/7 operations serving Amsterdam Airport Schiphol
- 30,000 km per day / 30 million boardings per annum
- 100 articulated EVs up to 228 by end of 2021
- 'Futuristic' BRT design with four doors
- Overnight slow charge supplemented by fast charging pantographs on-route
- 80 km range boost with fast 20 minute charge during layovers, with buses recharged over the day to maintain 24/7 coverage of 5 routes
- Very flat topographies

- **Hamburger Hochbahn (Germany)**
- 100% ZEB procurement since 2020, with 100 units procured in 2021 and 530 by 2025
- Dedicated and optimised EV depot in Alsterdorf with 96 charging points and 48 AC fast chargers, no on-route charging at the present time but may be introduced as fleet grows and depot exceed capacity
- High speeds and longer runs required for express services – inner city underground
- EV manufacturers must guarantee at least 200km range for rigids and 150km for articulated vehicles
- Close co-development between government and manufacturers (Mercedes, MAN)

International Case Studies – Shenzhen City China

- Shenzhen Bus Group (SZBG) deploys more than 6,000 electric buses:
  - 4,964 heavy-duty / more than 70 passengers capacity
  - 1,089 medium-duty (shorter than 10 meters) buses
- SZBG deploys over **1707 charging terminals at 104 stations** at terminals and depots
- Buses and infrastructure chosen to specifically **minimise impacts** on Operations and Scheduling – quick charge, long range, reliable, depot structures optimised for high capacity and quick turn-around
- SZGB have a **fully integrated operational platform** that can monitor and manage vehicle allocations and charging requirements dynamically during the day
- Over 8 years transition with **strong Governmental funding** and support right across the supply chain

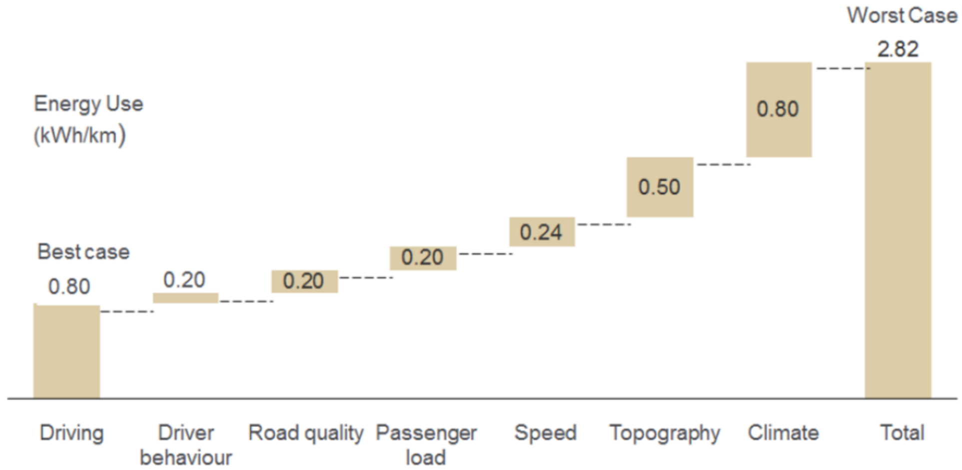
Dominant bus model BYD K8



Charging terminal with four chargers

Lessons Learned (which are rapidly becoming less relevant)

- EV buses have been better deployed on routes that are:
  - **Shorter** with regular charging options
  - **Flatter** so that batteries aren't discharged more quickly than expected
  - **Moderate temperatures** without a large fluctuation to maximise battery performance
  - **Lower passenger loads** (generally) to offset extra battery weight
  - **Low to moderate average speeds**, as vehicles perform better and batteries last longer
  - **Smoother speed patterns** & lower traffic light density across the journey, so that acceleration and braking is well managed
  - **Industry-wide cooperation** is required



These "generalities" *mostly* still apply

Key Scheduling Considerations

- Building and operating optimised Schedules will require consideration of:
  - Infrastructure
    - **Depot** capacity, layout, charging capability, hours of operation
    - **On-Route Infrastructure** including layover points, charging stations (?) and type of charging technology
  - Fleet
    - **Vehicle attributes** such as range, capacity, charge rate, length
    - **Fleet mix** as EVs increase in number and diesels decrease
    - **Vehicle allocation** to routes and depots
  - Service Plan
    - **Longer Route Service Plans & Timetables** may need to adapt to EV constraints
    - **Route Design** including total journey length, topography, speeds
    - **Vehicle Allocation** to specific blocks and linkage of blocks
  - Staffing
    - **Driver** skills and training
    - **EA** conditions such as shift length and break requirements

PBA Transit Planning

Key Scheduling and Planning Challenges for Operators

1: Rate of Charging Facility Implementations

- On-route charging could reduce dead running and PVR but is it feasible ?
- Assumption = The depot remains the primary (only) location where EVs are charged
- Depot upgrades a become core transition task

2: EV Fleet Acquisition and Allocation to Task

- The types of vehicle available now/soon is limited
- Retirements / acquisitions must be sensible
- Post-COVID patronage forecasts are less certain in the 0 - 2 year horizon

3: Rate EV Technology Change

- EV vehicles are improving every day (range, reliability)
- Current trials have provided more certainty for scheduling assumptions
- Previous on-road performance gaps between diesel and EV are rapidly decreasing

Most operators will have “mixed” fleets for some time which could increase the planning and scheduling task

What Does This Mean for Scheduling and Planning in 2022 ?

Scheduling becomes more "assumption" dependent (for the short-term future)

- Vehicle range and buffer
- Charge and discharge rates
- Until body of experience increases as trials expand

The Scheduling task needs to consider mixed vehicle types

- Differences in linking vehicle blocks and vehicle allocations
- Differences in assigning drivers to vehicles
- Yard layout and in-depot movements may require closer management

Skill and Experience before Automation

- Scheduling tools are introducing useful EV capability and automation
- Tools are only as good as they are configured and deployed
- Scheduling experience in a mixed-fleet environment will be important

Most operators will have "mixed" fleets for some time which could increase the planning and scheduling task

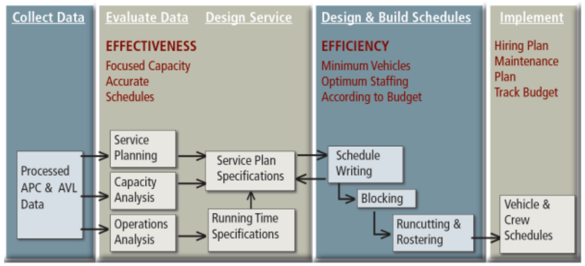
Practical Implications for Operators

1: Develop a Long-Term Plan

- <u>Manage your rate of change</u> to suit:
  - New technologies
  - Governmental investment
  - Your operational cost budgets

2: Develop a Medium-Term Plan

- Map your EV acquisition timeline, location, vehicle type, routes
- Identify Depot uplifts to support EVs
- Run scheduling & cost scenarios



3: Develop a Short-Term Plan

- Begin building the cross-functional skills and knowledge required
- Identify your “EV-friendly” routes and run trials

Questions and Observations