Lima eBus
Impact on Operations
Workshop Agenda

1. What is Process Flow Mapping?
2. Intro to Transit Bus Operations
4. Map Changes with eBus Operations (Interactive Discussion)
5. Operations Impact
   1. Scheduling (Blocks / Runs)
   2. Emergency Service
   3. Indoor vs. Outdoor Storage
   4. Seasonal Effects
   5. Peak vs. Off Peak Charging
   6. Safety & Maintenance
6. eBus Operations – Santiago, Chile
7. Session Wrap & Questions

Session 3
Impact on Operations
15:30pm to 17:00pm
Process Mapping

**Process Mapping:** planning and management tool use to outline work flow
- Series of process steps
- Interaction between steps and processes
- Decision making
- Allows for clear visual communication of processes
- Understand work flow and possible improvements
Typical Daily Bus Operations (Diesel)
How Daily Operations Change Going Electric?
Changes to Daily Operations (eBus)

New process steps:
1. Need for manual plug-in and plug-out of eBus charger as part of daily service
2. Possibility of on-route or midday charging introduced
Changes to Daily Operations (eBus)

Pre-trip Inspection
- Scope of inspection changes
  - Charging Station
  - eBus

<table>
<thead>
<tr>
<th>Component</th>
<th>Check For:</th>
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<tbody>
<tr>
<td>Electrical Harness/Wiring</td>
<td>Chaffing/Rubbing, Vibration and Potential Pinch Points</td>
</tr>
<tr>
<td>Battery Compartment</td>
<td>Enclosure Damage, Loose Terminal Connections, Leaks</td>
</tr>
<tr>
<td>Power Electronics</td>
<td>Abnormal Noise/Hum, Voltage, Current Readings</td>
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Maintenance Lanes
- Possibility of dedicated eBus maintenance lane
- Mixed fleet (i.e. diesel and eBus) maintenance lane based on propulsion type

Maintenance Activity
- Requirement for specialized eBus tools
- Mechanic training on High Voltage systems to repair eBus
- Time needed to put on PPE
Changes to Daily Operations (eBus)

**Revenue Service Operation**
- Operator training on eBus
- Emergency response training (i.e. power disconnect)
- Interaction with on-route charging infrastructure

**Post-trip Inspection**
- Same impact as pre-trip inspection

**Daily Service Line**
- No engine or transmission oil changes
- Fueling replaced with eBus charging
- Need for manual plug-in / plug-out of chargers
- Increased service line time due to charging

**Bus Parking**
- Park eBus in lanes designated with chargers
Operations Impact
Scheduling (Blocks/Runs)

- eBus operations can impact scheduling and transit planning

- eBuses assigned to blocks/runs dependent on operating range

- Consider scheduled and interlining issues of shared chargers
  - Delays can impact charger availability for eBuses
  - Time required to complete charge

- Transit service planning to cut blocks into smaller segments
Emergency Service

- Transit agencies which use bus fleet as emergency service (i.e. backup transit) can face challenges
  - eBus fleet in the middle of charge cycle may not be able to be deployed
  - TTC uses bus fleet as backup to subway service
Indoor vs. Outdoor Storage

- Time needed to pre-heat internal cabin temperature of eBus increases
- Introduce plug-in at depot to regulate battery temperature for parked eBuses
- Increased cost for electricity to plug-in heat eBuses parked outdoors
- Risk of ice buildup on charging ports and/or pantograph charger
- Lower efficiency on vehicle charging at temperatures below 0 °C
- Need to pre-heat battery before charging
- Increased maintenance cost 5 to 10% estimated

Not applicable to Lima’s Operating Climate
Seasonal Effects

- Extreme cold and hot weather can place additional demand on HVAC system
- Battery thermal management system has increased electrical load
- Decreased operating range may require reassignment of blocks/runs
- Cold accelerates battery degradation
- Cold can also cause changes in battery chemistry (i.e. cell crystallization)

Not applicable to Lima’s Operating Climate
Peak vs. Off Peak Charging

• Electricity rates ($/kWh) differ by time of day

• Off peak charging can reduce electricity costs but impact scheduling and fleet availability

• Peak shaving, midday charging and on-route charging can be used to shift energy demand
Maintenance & Safety Impact

• To be discussed further in Maintenance & Safety sessions
  • Impact to scope of preventative maintenance
  • Increased time for use of PPE and establishing work safe zones
  • Part availability and supply chain impact
  • Training and diagnostics
eBus Operations in Santiago, Chile
Thank you!

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