June 5, 2013

An Approach to Predicting Passenger Operation Performance from Commuter System Performance

SYSTRA

Outline

1. Introduction of the approach
   - What - To predict passenger operation performance (schedule conformance) from system reliability and availability
   - Why - to guide system requirement specification; To guide function areas of improvement
2. Theory basis of the approach
3. Four step approach
   - System reliability prediction
   - System function use frequency estimation
   - Probability estimate of function failure mitigation
   - Rollup calculation

Theory basis of the approach

The multiplication rule
Failures mitigated by method of operation

- Layered method of operation
  - PTC (ACSES, I-ITCS, I-ETMS, etc.)
  - Automatic Cab Signaling (ATC)
  - Signaled methods (CTC, ABS, manual interlocking, manual block control) with field interlocking
  - Non-signaled (Track warrant control, direct traffic control, etc.)

Failures affect passenger operation performance

- These are the failures in the first layer, in combination of (mitigation) failures in the underlying layer(s)

Four step approach

Strategy

Identify what function failures impact the operation performance, estimate the functional use frequency, analyze the available mitigation with probability of success, and roll up to the operation performance

- System reliability prediction
  - System element reliability data
    - Collected from field service data (Chi-Square method) – This formula matches the Chi-square distribution. This is not quite the Chi-squire test
    - Calculate with a method such as MIL HDBK 217
- System function use frequency estimation
  - Characterize operation scale – number of trains per hour in the system, at a wayside location (CP or Base Station), fraction of the system on each train, and the number of trains in depot, etc.
  - Identify operation impact functions
  - Estimate function use frequency
    - Use determined by system design, e.g., transponder reading depends on distribution of transponders
    - Use determined by system parameters, e.g., wayside status query frequency

Four step approach - continued

- Probability estimate of function failure mitigation
  - Identify operation mitigation with underlying layer(s) and manual procedures. Some examples follow:
    - Wayside status query function failure is mitigated with underlying signaling (Cab, CTC, ABS, etc.) that can operation the train to its destination without cause significant delay
    - Transponder reading function failure is mitigated with underlying signaling (Cab, CTC, ABS, etc.) that can operation the train to its destination without cause significant delay
  - Signaling system failure
    - In case of underlying signaling system failure, a manual backup operation can be used. The failure, however, may or may not be satisfactorily mitigated.
- Rollup
  - Identify operation mitigation with underlying layer(s) and manual procedures

Rollup calculation

$$\sum_{i=1}^{n}\left[\left(\sum_{C_j}\lambda_{ji}\right)\cdot P_{f_i}\cdot P_{m_i}\right]=\sum_{i=1}^{n}\left[\left(\sum_{C_j}\lambda_{ji}\cdot P_{f_i}\cdot P_{m_i}\right)\right]=\sum_{C_j}\sum_{i=1}^{n}\left(\lambda_{ji}\cdot P_{f_i}\cdot P_{m_i}\right)=$$
$$\sum_{C_j}\lambda_{ji}\sum_{i=1}^{n}P_{f_i}\cdot P_{m_i}$$

Thank You