DEFINITION OF A QUALITY MONITORING SYSTEM FOR LPT DELIVERED SERVICE:
ROLE OF AUTOMATIC PASSENGER COUNTING APPLICATIONS

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Outline

- INTRODUCTION
- APC TOOLS AND TECHNOLOGIES
- ACCURACY IN APC
- COMPARISON OF DIFFERENT APC SOLUTIONS FOR LPT (LOCAL PUBLIC TRANSPORT) QUALITY MONITORING
- CONCLUSIONS
# LPT monitoring policies in Italy

<table>
<thead>
<tr>
<th>Document/Standard</th>
<th>Description</th>
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<tr>
<td><strong>D.Lgs. 422/97</strong></td>
<td>Provision of functions and tasks in the area of LPT for local and regional authorities</td>
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<td><strong>EN 13816:2002</strong> <strong>EN 15140:2006</strong></td>
<td>Service Quality (SQ) measurement for Public Passenger Transport (PPT)</td>
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<td><strong>DPCM dell’11.03.2013</strong></td>
<td>Concept of <em>load factor</em> for the allocation of LPT economical resources</td>
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<td><strong>MIT Decree n. 255/16</strong></td>
<td>Electronic ticketing standards in Italy</td>
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<td><strong>ASSTRA transport association guidelines</strong></td>
<td>Guidelines for the application of the UNI EN 13816 standard</td>
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</table>
PPT Service Quality measurement \[1\]

UNI EN 13816: The Quality Loop

**Customer view**
- Service quality sought
- Service quality perceived

**Service provider view**
- Service quality targeted
- Service quality delivered

**Measurement of the satisfaction**
- CSS: Customer Satisfaction Surveys

**Service Beneficiaries**
- Customers and the community

**Measurement of the performance**
- MSS: Mystery Shopping Surveys
- DPM: Direct Performance Measures

**Service partners**
- Operator, Authorities, Police, Road department, ...

UNI EN 15140: delivered SQ measurement examples

\[1\] EN 13816 European Standard, 2002.
Archimate language main features \[2\]

What does Archimate provide?

- A **language** with concepts to describe architectures
- A **framework** to organize these concepts
- A **graphical notation** for representing elements and relationships
- An **open standard** maintained by The Open Group global consortium

Archimate language main features [2]

Core Framework Layers:

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<th>Layers</th>
<th>Passive Structure</th>
<th>Behaviour</th>
<th>Active Structure</th>
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<td>Technology</td>
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Aspects

APC system classification \[3\]

The modalities to count the people on tramways, buses and trains can be classified into the two following categories:

1. Counting \textit{irrespective} on the ticket:
   
   a. Monitoring of \textit{single individuals}, usually by technologies on board the vehicle;
   
   b. Monitoring of the \textit{overall load} on the means of transport, with technologies applied to the suspensions or on the ground (rare).

2. Counting \textit{related} to the ticket (e.g. by people check-in and check-out monitoring)

Detection and counting passengers at doors \[3\]

**Active I-R**

**Passive I-R**

**Active and Passive I-R**

**Treadle mats**

**Computer (Stereo) Vision**

Estimation of the vehicle load [3]

WIM Station

Load cells and Electro-pneumatic valve/sensors

Counting related to the ticket(s)

Cards / Electronic tickets to monitor mobility services and the crowding level, according to the tracked travels

Check in

Check out

Anti theft system?

Data fusion and merging
Computer Stereo Vision Archi model
Archi model of Video Content Analysis
4 Error definitions [4]

**Number of passengers**

\[
N_{\text{manual\ passengers}}^{\text{manual}} = \frac{M_{in} + M_{out}}{2} \\
N_{\text{passengers}}^{\text{APC}} = \frac{I_{in} + I_{out}}{2}
\]

**Passenger error**

\[
E_{\text{pass}} = \frac{N_{\text{APC \ passengers}}^{\text{APC}}}{N_{\text{manual \ passengers}}^{\text{manual}}} \times 100\%
\]

**Balanced entering/exiting pass. error**

\[
E_{\text{passin}} = \frac{I_{\text{in}}}{M_{\text{in}}} \times 100\% \\
E_{\text{passout}} = \frac{I_{\text{out}}}{M_{\text{out}}} \times 100\%
\]

**Unbalanced error**

\[
E_{\text{unbalanced}} = \frac{\left( \sum_{k=1}^{n} a_k c_k + \sum_{k=1}^{n} b_k d_k \right)}{(M_{\text{in}} + M_{\text{out}})} \times 100\%
\]

APC systems might provide data with errors. The counted number of boarded passengers might be different from the counted number of passengers alighted.

A statistical procedure can be applied to correct APC data. The error is spread over stops proportionally to the traffic load that insists on each of them.

The statistically corrected APC data set will fit better the real counts.

Statistical corrected APC data: Example [4]

The model shows APC systems contribution in evaluating LPT Service Quality and consequently in improving the user's travel experience.
LPT SQ monitoring and Infomobility systems

Infomobility

APC data
On Board APC Systems
WIM Station

Infomobility

APC data
Load cells and Electro-pneumatic valves
Conclusions

- Public transport monitoring policies in Italy have been reviewed
- The most common APC systems on the market have been analyzed, focusing on the most cutting-edge technologies
- Every APC system does not work without faults, therefore APC raw data should undergo a statistical processing and detailed analysis
- ArchiMate models have been proposed to outline the general architecture of a LPT monitoring system
- APC systems contribute in evaluating LPT Service Quality and consequently in improving the user's travel experience
- On-site tests planned for Winter 2017