Future Secure and Accessible Rail Stations

Grant Agreement no.: NUMBER 777636 — IP/ITD/CCA — IP1, IP3
Project Start Date: 01/09/2017
Project End Date: 31/08/2019

DELIVERABLE D7.2
Project Final Conference Report

Work Package: WP 7
Dissemination Level: PU
Status: F2
Leader beneficiary: UNEW
Due date of deliverable: 31/12/2019
Actual submission date: 15/09/2020
Prepared by: Emmanuel Matsika [UNEW]
Contributors: Emmanuel Matsika [UNEW]
               Umberto Battista [STAM]
Verified by: Emmanuel Matsika [UNEW]
The FAIR Stations project consortium

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<tr>
<th>No</th>
<th>Partner organisation</th>
<th>Short Name</th>
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<td>STAM SRL</td>
<td>STAM</td>
<td>Italy</td>
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<tr>
<td>2</td>
<td>UNIVERSITY OF NEWCASTLE UPON TYNE</td>
<td>UNEW</td>
<td>United Kingdom</td>
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<td>3</td>
<td>METRO DE MADRID SA</td>
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<td>UNION INTERNATIONALE DES TRANSPORTS PUBLICS</td>
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Executive Summary

The objective of the project was to develop solutions for improved user flows within the station and platform-train interface (PTI), considering key design factors such as security, safety, baggage handling, ticketing, design for accessibility, information & signage, and station environment management.

STAM of Italy successfully coordinated FAIR Stations Consortium which was composed of leading European companies, operators, associations, and universities engaged in the field of Research, Technology, and Innovation. During its lifetime, FAIR Stations worked successfully with two complementary Shift2Rail projects: PIVOT and IN2STEMPO.

In order to disseminate the project outcomes, and receive final feedback from stakeholders, FAIR Stations project organised a very successful final conference in Brussels on 11th December 2019. The conference agenda covered the following outputs of the FAIR Stations project:

- User Needs and Expectations
- Benchmark on Station Design and Accessibility
- Focus on crowd flow management
- Focus on PTI solutions
- Demonstrators presentations:
  - Crowd modelling
  - Platform-based solution for PTI
  - Future station

A very interested and interactive audience attended, with participants coming from researchers, academicians, policy makers, transport operators, infrastructure managers, passenger interest groups, disability organisations and consultants. Their feedback through question and answers provided a good basis for recommendations to future research.

The key outputs of the project were:

- Crowd flow models, validated through enabling technologies for crowd management and analysis, that include specific users’ behaviour and in particular persons with reduced mobility.
- Proof-of-Concept prototype of a platform-based fully automated universal independent boarding and alighting system, integrating advanced detection technologies.
- Station design algorithm flow chart for station design optimisation. The aim is to maximise safety, security, station capacity and crowd flow. On the other hand, minimise the train dwell time and cost.

Although the exploitable outputs were initially targeted at TRL3, the actual outputs (crowd flow models and solution for the PTI) represent TRL4/5. It is therefore recommended that future projects move these outs to TRL7/8, with the expectation that they can be commercialised in the near future.
List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>3D</td>
<td>Three dimensional</td>
</tr>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>DoF</td>
<td>Degree of Freedom</td>
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<td>JU</td>
<td>Joint Undertaking</td>
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<td>PO</td>
<td>Project Officer</td>
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<td>PRM</td>
<td>Persons with Reduced Mobility</td>
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<td>S2R</td>
<td>Shift2Rail</td>
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<tr>
<td>TRL</td>
<td>Technology Readiness Level</td>
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<td>TSI</td>
<td>Technical Standards on Interoperability</td>
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<td>WP</td>
<td>Work package</td>
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1. INTRODUCTION

FAIR Stations (Future Secure and Accessible Rail Stations) was a project co-financed by the Shift2Rail initiative of the European Commission and ran from September 2017 to December 2019. The objective of the project was to develop solutions for improved user flows within the station and platform train interface, considering key design factors such as security, safety, baggage handling, ticketing, design for accessibility, information & signage, and station environment management.

The FAIR Stations Consortium was coordinated by STAM, Italy, and composed of leading European companies, associations and universities engaged in the field of Research, Technology, and Innovation. Figure 1 shows the consortium members.

In order to disseminate the project outcomes, and receive final feedback from stakeholders, FAIR Stations project organised the final conference in Brussels on 11th December 2019. The conference agenda (in Appendix 1) covered the following outputs of the FAIR Stations project:

- User Needs and Expectations
- Benchmark on Station Design and Accessibility
- Focus on crowd flow management
- Focus on PTI solutions
- Demonstrators presentations:
  - Crowd modelling
  - Platform-based solution for PTI
  - Future station

To start with, the project coordinator, Umberto Battista from STAM (Figure 2), welcomed the participants to the event. He then provided a brief introduction of the FAIR Stations project before introducing the Shift2Rail JU Project Officer, Mr. Sebastian Denis (Figure 3) to officially open the conference.
In his opening presentation, Mr Sebastian Denis explained where FAIR Stations sits in the TD1.6 and TD3.11 S2R Innovation Programmes. These were the common factors between the complementary projects PIVOT and IN2STEMPO. Overall, he expressed satisfaction with the outputs of FAIR Stations project, considering that it was targeted at TRL3. He expected that next steps should bring project’s concepts to higher TRL, future research work may be considered for example under Horizon Europe programme.
Soon after, the project coordinator made a more detailed introductory overview of the FAIR Stations project. He reiterated where the project sits in the S2R JU programme. Elaborated further was the information on the project funding, consortium, and the links to the complementary projects PIVOT and IN2STEMPO. The project objectives, methodology, design factors, outputs and impact were also explained. Finally, the next steps were presented, with a new project PIVOT-2 and continued IN2STEMPO projects, that will consider the outcomes of FAIR Stations for further development up to TRL6.
2. ATTENDANCE

There was a total of 37 participants, of which 13 were project consortium members (see Appendix 2). Participants came from researchers, academicians, policy makers, train manufacturers, transport operators, infrastructure managers, passenger interest groups, disability organisations and consultants (Figure 4).

Figure 4 Conference Participants.
3. TECHNICAL PRESENTATIONS

This section summarises the technical outcomes of FAIR Stations project as presented by various partners.

3.1. User Needs and Expectations

This presentation covered outcomes of WP2 as summed up in Deliverable D2.1 “User Needs and Expectations of the General Public and PRMs” (Lemmerer et al, 2018). Takeru Shabayama and Helmut Lemmerer of VUT (Figure 5) made the presentation. They covered the current state of station users, and the evolving activities which are inherently driving the design of future stations. Results of the general public survey and a socio-technical study of PRM users were presented.

![Figure 5 Presenters Takeru Shabayama (left) and Helmut Lemmerer (right).](image)

The objectives of WP2 were to investigate on the following:

- User needs and expectations of the general public
- User needs and expectations for PRMs
- Requirements for baggage handling

A survey of over 5000 general public users revealed that about 51% of them had mobility impairment and would therefore be classified as PRMs. Investigation of legal and normative requirements on European level reveals a myriad of shortcomings.

The project also conducted telephone interviews and online survey for the following stakeholders: railway undertakings at national and urban levels, infrastructure managers, interest groups representing passengers, national authority, rail consultants and associations. The results of the interview showed that accessibility of the station and safety & security are the most important factors.

From the PRM socio-technical studies (focus group discussion, observational trips, PRM questionnaires and stakeholder questionnaires), it has emerged that:

- The most cardinal design factors are information & signage, safety, HFE & accessibility and PTI.
- PRMs feel that design for accessibility is not done with all PRMs groups in mind.
- The most highly impacted PRM groups are wheelchair users and the blind.
- Crowd flow was identified as an overarching concern, particularly during peak times.
- PRMs are more likely to need help in the station than boarding even less when alighting.
- Most stakeholders would be supportive in the implementation of station designs that promote accessibility.
3.2. Benchmark on Station Design and Accessibility

The topic on benchmarking station design and accessibility was presented by Corentin Wauters (UITP), Antonio De Santiago Laporte (MDM) and Emmanuel Matsika (UNEW) (Figure 6). The presented (which covered work conducted under WP3) included review/analysis of past stations and any relevant past projects. It also developed a catalogue of station assets. Results of a gap analysis were also presented.

Figure 6 Presenters Corentin Wauters (top left), Antonio De Santiago Laporte (top right) and Emmanuel Matsika (bottom).

WP3 had two main objectives namely:

- To collect and analyse data and information from past research and studies.
- Using a gap analysis, to identify and categorise factors that drive design of future stations.

The first objective was addressed through Deliverable D3.1 “Benchmarking of Current Railway Stations and Accessibility” (Kuzmina et al, 2019). Data was collected and analysed and information from past research and studies and identified the state-of-the-art of the knowledge. The areas covered included multi-modal and multi-functional high-capacity rail stations that provide for proper crowd flow, accessibility, and inherently secure; and, secondly, to develop a catalogue of key design features of typical train stations on European railway networks, and identify their categories.
The second objective was achieved through Deliverable D3.2 “Design Factors for Future Railway Stations” (Matsika et al, 2019). A gap analysis was conducted for the nine FAIR Stations design factors. During the gap analysis, a comparison was made between what should be best practice in Future Stations against the current benchmark. This deduces the gap and provides an indication of the ease with which such gaps can be closed. The summation of the two gives an indication of the relative opportunity for implementation in future stations. Information & signage has a large gap, yet has a high implementation opportunity, short implementation period and high impact. Information & signage has the highest impact for audio and visual solutions, followed by safety, PTI and ticketing. Audio and visual solutions are easy or very easy to implement, have high implementation opportunity, and a short implementation period of 1-3 years. This applies to both retrofitting and new builds.

3.3. Focus on crowd flow management

This presentation was made by Mony Khosravi (STAM) and Enrico Barelli (SIIT) (Figure 7). It covers the WP4 activities (Crowd Flow Analysis). To perform the modelling and analysis, the MDM Chamartin station was applied. Heat maps were used to understand crowd flows. The model can also simulate behaviour of PRMs, which is a first in the EU. The practical activities could not be achieved without the use of video analytics. So, the presentation explained the various types of cameras - traditional, Artificial Intelligence (AI) and 3D. For the FAIR Stations project, AI and 3D were chosen. The crowd model was well validated using video analytics based on the MDM data.

The objectives of WP4 were as follows:

- To study the crowd flow in large stations and describe the main behaviours and characteristics in the movement of people.
- To develop the modelling of multiple people flows in large stations and the ways to manage crowds particularly in emergency situations which are causing evacuation.
Identify available enabling technologies for crowd management and analyse people’s movement in stations.

Validation of the crowd flow model.

The presentations covered outputs from Deliverable D4.1 “Crowd flow and multiple people flows modelling in large stations” (Battista et al, 2019) and Deliverable D4.2 Enabling Technologies for Crowd Management Analysis (Naso Rappis et al, 2019).

Particular attention was paid to PRMs that usually face more difficulties than people without any physical problem. In the first part of this work, the milestones achieved through this analysis include the following:

- Built a model that realistically simulates the movement and behaviour of people in critical infrastructures.
- Identified and critically analysed weaknesses in the infrastructure.
- Proposed solutions and alternatives to reduce and/or mitigate problems in the infrastructure.
- Identified new solutions (active or passive) for crowd management.
- Identified critical issues during emergency scenarios.
- Provided a model suitable for future developments.

The second part focussed on evaluating different technologies (i.e. different types of 3D-cameras as well as different video processing solutions) and identifying the ones that can provide valuable improvements in system efficiency and reliability. The most significant improvement is enabled by two completely different innovations:

- Deep Learning based video processing algorithms, able to detect people and count them autonomously after a proper training phase.
- Three dimensional cameras that, exploiting the depth information (i.e. the distance of a point from the camera) can detect the presence of people in a more reliable way.

The combination of these technologies in a unique system represents a significant improvement for the crowd monitoring and management.

### 3.4. Focus on PTI solutions

Mony Khosravi from STAM (Figure 7) and Egon Carusi from SIIT (Figure 8) made the presentations. The former explained the mechanical system, while the latter focussed on the detection and motion control systems that enabled the automation of the integrated solution for the PTI. Constraints which provided the limiting scope for the design were explained. Afterward, 3 conceptual designs were developed (FlexiRamp, Allway and FlexiHump). The final design adopted was Flexy2Ramp, a 4 DoFs derivative of FlexiRamp. It is applicable for both long distance (with narrower door with steps) and short distance (with wider door without steps). In addition, it can compensate horizontal and vertical gaps for all types of platforms.

The sensor system incorporates quick positioning of the boarding mechanism without jeopardising safety. It is a relatively simple, yet robust design (for easier certification). A LiDAR sensor detects the train and the door position. The control system then applies sensor-based collision detection for deployment of the extendable blade that closes the PTI gap.
These results formed the outcomes of WP5, whose objective was to apply an iterative process in the design for safety/security and inclusion of PRMs. A systems approach where the station design, PTI and door access will be designed as an integrated system optimised for smooth passenger flow and the station with enhanced security for improved safety and customer satisfaction.

The main benefits of the automated boarding system are:

- Fully automated, and is therefore efficient with deployment.
- Reduces train dwell time.
- Significantly increases the train dwell time.
- Improves PTI safety.
- Based on Design for all or universal design since everyone (the general public and PRMs) can use it as part of the PTI solution. Staff with catering trolleys and other devices also benefit from this.

Full details of these outcomes can be found in Deliverables D5.1 “Platform based solutions for PTI” (Khosravi and Battista, 2018), D5.2 “Train access door system and service benchmark” (Lemmerer et al, 2019) and D5.3 “Door-Platform Alignment POC Demonstrator and System Integration” (Matsika et al, 2019).
4. **DEMONSTRATORS**

FAIR Stations project developed two key exploitable outputs:

- Crowd flow model that includes persons with reduced mobility.
- Engineering design of a platform-based fully automated universal independent boarding and alighting system.

This section presents these outcomes, and a video demonstrator.

4.1. Crowd modelling

The video demonstration was made by Mony Khosravi from STAM (in Figure 7), based on the fundamentals of the presentation in Section 3.3. It provided an animation of the behaviour of the general public and PRMs under normal and emergency conditions. One of the emergency cases demonstrated was when there was a bomb attack.

4.2. Platform-based solution for PTI

In this presentation made by Mony Khosravi from STAM (in Figure 7), two video presentations were made. Both were based on the fundamentals of the presentation in Section 3.4. The first video was an animation of the mechanical actuation of the PTI system using a 3D CAD modelling SW. On the other hand, the second was playback of a video recording of the operation of the prototype currently fitted at SIIT workshop in Genoa. Both videos were able to demonstrate that it:

- Is a fully automated system.
- Can be applied to different types of trains and platforms.
- Decreases train dwell time.
- Is a universal solution for the general public and PRMs.

4.3. Future station

Presented by Javier Garcia Salas from APF (Figure 9). In this virtual demonstration of an ideal future rail station, the following major components were integrated:

- the station design,
- the platform-based system for the PTI,
- the crowd model simulations.
A video was shown that depicts the ideal future rail station that embodies the FAIR Stations project design factors: Information and signage, Safety HFE & Design for accessibility (PRMs), Platform Train Interface (PTI), Design for Emergencies, Security, Ticketing, Baggage handling and Station Environment Management. It also shows the application of the four design characteristics (audio, visual, physical, and virtual solutions).
# 5. COMMENTS AND DISCUSSION

In this section, a collection of questions/comments and answers are provided (Table 1). These also provided the basis for what ended up being a very lively and fruitful discussion.

Table 1 Questions and Comments from Participants.

<table>
<thead>
<tr>
<th>Question/Comments</th>
<th>Answer</th>
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<tbody>
<tr>
<td><strong>User Needs and Preferences</strong></td>
<td></td>
</tr>
<tr>
<td>Why didn’t you use the WHO definition of disability?</td>
<td>In the transport sector, and for the purposes of mobility across all modes, the EU has developed a definition that is able to cover the disabled and other mobility impaired travellers under one term, PRMs.</td>
</tr>
<tr>
<td>Why didn’t participants of the observational trips book in advance?</td>
<td>In order to design stations of the future, it was necessary for the participants not to pre-book. In future, PRMs should be more independent when travelling.</td>
</tr>
<tr>
<td>What is the difference between safety and security?</td>
<td>Notwithstanding that these terms are interchangeable in other languages (e.g. French), in FAIR Stations, safety relates to failure of a component or system due to its design or material. On the other hand, security related to anthropometrically failure, which is a crime.</td>
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**Focus on crowd flow management**

<table>
<thead>
<tr>
<th>Question/Comments</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did validation include PRMs?</td>
<td>No, however, future projects should include more scenarios.</td>
</tr>
<tr>
<td>How do you account for the way in which PRMs evacuate, since they cannot use a lift in case of fire?</td>
<td>This scenario will be included in future projects.</td>
</tr>
<tr>
<td>Can you simulate panic or say someone piggybacking?</td>
<td>This can be added since the option ‘help’ already exists in the model.</td>
</tr>
<tr>
<td>Comment: It is hard to model human behaviour, and sometimes PRMs are helped first due to their condition.</td>
<td>This is true. That is why where possible historic data is used to improve the accuracy of the model.</td>
</tr>
</tbody>
</table>

**Focus on PTI solutions**

<table>
<thead>
<tr>
<th>Question/Comments</th>
<th>Answer</th>
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<tbody>
<tr>
<td>The system may interfere with the flow of the general public.</td>
<td>The system is designed for both the general public and PRMs.</td>
</tr>
<tr>
<td>How does it compensate for the different train lengths and stopping positions?</td>
<td>The system has a capability to compensate +/- 2m along the platform, which is sufficient to address this concern.</td>
</tr>
<tr>
<td>Did you consider suitability for all the different types and dimensions of wheelchairs?</td>
<td>Yes, the system covers all types of transportable wheelchairs are stipulated in the TSI PRM 2014.</td>
</tr>
</tbody>
</table>
| Why do you need to pre-book the system? PRMs seek independence, and not pre booking. | • This is not a usual type of booking, where you seek a space allocation. It is informing the system this a PRM is due, which allows them to be aware if there are other users due too.  
• Being the first time, it would be applied in the world, this is a precautionary safety measure.  
• It provides a gradual learning curve since a systems approach has been used to include Train Operating Companies and Infrastructure Managers. |
| Why do we need this system when new stations are solving this problem? | • There are currently over 30,000 stations affected by PTI challenges in Europe. It would be a long way before they are retrofitted to resolve the problems as it would require billions of Euros.  
• This solution provides safer PTIs in the interim. It also resolves crowd flow challenges. |
6. SUMMARY OF THE PROJECT AND FINAL WORDS

As part of the conclusions and closure, the project coordinator, Umberto Battista, and the project technical manager, Emmanuel Matsika, made the final remarks. One area that was highlighted was dissemination, explaining that the project increased its reach and visibility through 10 major conferences and workshops during its 2-year life. Dissemination materials developed included, project website, leaflet, banner, poster, project newsletters, FAIR Stations project video and 3D virtual demonstrator video. The FAIR Stations project outcomes were summed up in the following key messages:

- About **50% of station users** identify themselves as PRMs in a broader sense.
- Currently PRMs are experiencing **prolonged travel time** up to 200%.
- **Information and signage** still show a large gap, yet have high implementation opportunity.
- EU needs a **long-term strategy** to implement **physical solutions**, especially for retrofitting.
- Advanced **crowd modelling** techniques are a powerful tool to understand **user behaviour**, also considering PRMs.
- **AI-based** enabling technologies for **crowd analytics** should be considered when **designing CCTV systems**.
- Flexy2Ramp enables **autonomous boarding of PRMs**, by automatically **filling the PTI gap**, without obstructing other users.
- Flexy2Ramp could **significantly decrease** the train **dwell time**, especially for regional and long-distance trains.

In its final message, the project thanked the participants for attending, and the S2R JU for their financial support. The coordinator also paid special tribute to the project team for successfully delivering the project outcomes. Thereafter, the conference was officially closed.
7. CONCLUSIONS AND RECOMMENDATIONS

The well-attended FAIR Stations project final conference was successfully held with a total of 37 participants. They represented stakeholders from researchers, academicians, policy makers, train manufacturers, transport operators, infrastructure managers, passenger interest groups, disability organisations and consultants. Officially opened by the Project Officer, the conference saw technical presentations from the research and work conducted during the project life. A very interested and interactive audience attended, with participants coming from researchers, academicians, policy makers, transport operators, infrastructure managers, passenger interest groups, disability organisations and consultants.

The key outputs of the project were:

- Crowd flow models, validated through enabling technologies for crowd management and analysis, that include specific users’ behaviour and in particular persons with reduced mobility.
- Proof-of-Concept prototype of a platform-based fully automated universal independent boarding and alighting system, integrating advanced detection technologies.
- Station design algorithm flow chart for station design optimisation. The aim is to maximise safety, security, station capacity and crowd flow. On the other hand, minimise the train dwell time and cost.

Although the exploitable outputs were initially targeted at TRL3, the actual outputs (crowd flow and boarding system) represent TRL4/5. It is therefore recommended that future projects move these outs to TRL7/8, with the expectation that they can be commercialised in the near future.
REFERENCES


## APPENDIX 1 CONFERENCE AGENDA

### FAIR Stations “Future Secure and Accessible Rail Stations”

**Final Conference**

**Brussels, 11th December 2019**

**Venue:** NH Collection Brussels Centre

*Boulevard Adolphe Max, 7*

*1000 Brussels (Belgium)*

*Meeting Room: Brugges*

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Speakers</th>
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<tbody>
<tr>
<td>9:00 - 10:00</td>
<td>Registration</td>
<td></td>
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<tr>
<td>10:00 - 10:05</td>
<td>Welcome</td>
<td>U. Battista, STAM</td>
</tr>
<tr>
<td>10:05 - 10:15</td>
<td>Introduction by Shift2Rail</td>
<td>S. Denis, S2R JU</td>
</tr>
<tr>
<td>10:15 - 10:30</td>
<td>FAIR Stations project overview</td>
<td>U. Battista, STAM</td>
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<tr>
<td>10:30 - 11:00</td>
<td>User needs and expectations</td>
<td>T. Shibayama, VUT</td>
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<td></td>
<td></td>
<td>H. Lemmerer, VUT</td>
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<tr>
<td>11:00 - 11:30</td>
<td>Coffee break</td>
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<tr>
<td>11:30 - 12:00</td>
<td>Benchmark on station design and accessibility</td>
<td>C. Wauters, UITP</td>
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<td></td>
<td></td>
<td>A. De Santiago Laporte, MDM</td>
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<td></td>
<td></td>
<td>E. Matsika, UNEW</td>
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<tr>
<td>12:00 - 12:30</td>
<td>Focus on crowd flow management</td>
<td>M. Khosravi, STAM</td>
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<td></td>
<td>E. Bareli, SIIT</td>
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<td>12:30 - 13:00</td>
<td>Focus on PTI solutions</td>
<td>M. Khosravi, STAM</td>
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<td>13:00 - 14:00</td>
<td>Lunch</td>
<td></td>
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<tr>
<td>14:00 - 14:30</td>
<td>Demonstrators presentation</td>
<td>M. Khosravi, STAM</td>
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<tr>
<td></td>
<td>- Crowd modelling</td>
<td></td>
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<tr>
<td></td>
<td>- Platform-based solution for PTI</td>
<td>Javier García Salas, APF</td>
</tr>
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<td>- Future station</td>
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<tr>
<td>14:30 - 15:30</td>
<td>Comments and discussion</td>
<td>Stakeholders</td>
</tr>
</tbody>
</table>

*This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 777638.*
15.30 - 16.00 Conclusions and closure

E. Matsika, UNEW
U. Battista, STAM

Contacts: Corentin Wauters (UITP)  
corentin.wauters@uitp.org  
+32 26636665

Umberto Battista (STAM)  
u.battista@stamtech.com  
+39 3456589384