An Evacuation Model For High Speed Trains

UNIVERSIDAD DE CANTABRIA

GIDAI

Prof. J. A. Capote ; Dr. D. Alvear; Dr. M. Lázaro; Dr. O. Abreu and A. Cuesta

GIDAI - UNIVERSITY OF CANTABRIA

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PRESENTATION OVERVIEW

1. Introduction
2. Description of the model
3. Verification Tests
4. Conclusions

1–INTRODUCTION

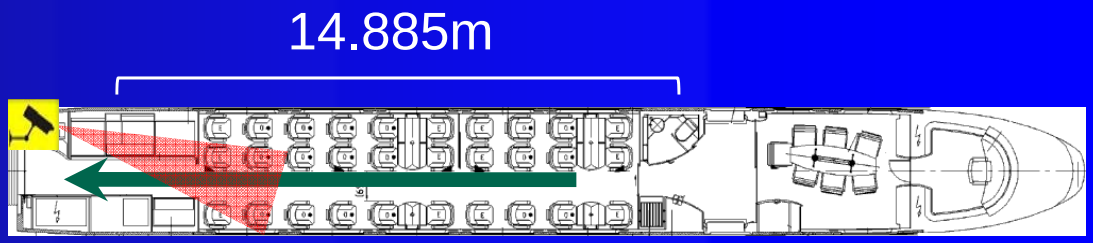
- There are No **SPECIFIC** models for Passenger Trains.

- High Speed Trains (evacuation characteristics):

  - **Variety of potential scenarios.**
  - **Vehicles can be in motion.**
  - **Passengers alertness.**
  - **Passengers are seated in separate coaches.**
  - **Few crew members.**
  - **Simple geometries and narrow spaces.**

1–INTRODUCTION

- **Passengers actions** before and during evacuation movements may have a **great impact** in evacuation process.



20 passengers
Evacuation Time = 79s
Aisle blocked = **30.30 %** of total time

Unannounced Evacuation Drill

1–INTRODUCTION

How do We Simulate Behaviours that Interrupt The Continuous Movement?

Uncertainty
Who , What, Where and How long?

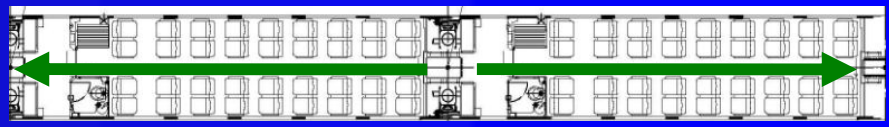
Stochastic Approach → Assigned by Model

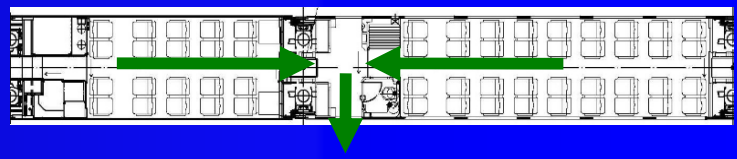
Application for Simple Goemetries (Trains) where actions of passengers are limited in suchs a restricted space

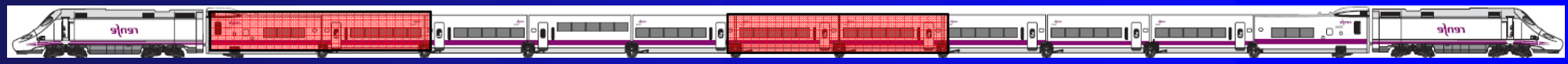
2-DESCRIPTION OF THE MODEL

SINGLE-EXIT SCENARIOS

•three types of Trains







MODELING METHOD

Microscopic Approach which incorporates the probability of passengers performing actions in addition to their movement towards the exit*

Object - oriented model developed with Microsoft Visual C# 2008 over .NET Framework 3.5 SP1 platform

* Kuligowsky

2-DESCRIPTION OF THE MODEL

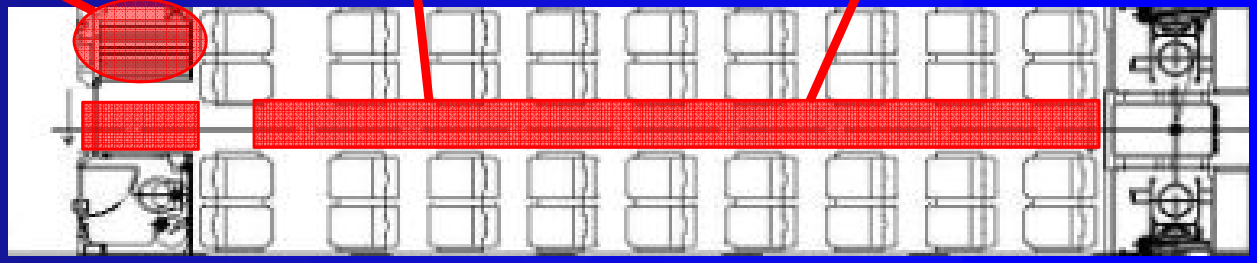
PASSENGERS MOVEMENT AND BEHAVIOUR

Locations where potential behavioural actions may interrupt continuous evacuation movements

Lugagge Compartment

Collecting belongins from overhead bagagge rack

Waiting for others



Exit steps

0	0	0	0	12	23	21	11	21	11	21	11	21	11	21	11	21	11	21	11	21	11	0	0	0
0	0	0	0	12	22	20	11	20	11	20	11	20	11	20	11	20	11	20	11	20	11	0	0	0
42	41	33	33	32	31	31	32	31	32	31	32	31	32	31	32	31	32	31	32	31	32	31	31	31
43	43	0	0	12	22	20	11	20	11	20	11	20	11	20	11	20	11	20	11	20	11	0	0	0
44	0	0	0	12	23	21	11	21	11	21	11	21	11	21	11	21	11	21	11	21	11	0	0	0

2-DESCRIPTION OF THE MODEL

Stochastic Parameters

- Unimpeded walking speed: W_s (m/s). — Distribution
- Personal response time: T_{pr} (s). — Distribution
- Probability of occurrence for T_1. — Distribution
- Time to prepare: T_1 (s) – the time spent by a passenger blocking the aisle.
- Probability of occurrence for T_2. — Distribution
- Time to pick up baggage: T_2 (s) – the time spent blocking the aisle in front of the luggage compartment.
- Personal exit flow: T_3 (s) – the time to negotiate the exit steps. — Distribution

each passenger: each run

2-DESCRIPTION OF THE MODEL

Evacuation drills conducted by RENFE Operadora (Spanish Railroad Administration)

Announced Evacuation Drill

Deference Behaviour

Passengers Actions:

- Collect belongings
- Put on jacket
- Waiting for others

2-DESCRIPTION OF THE MODEL

Experiments conducted at University of Cantabria.
22 participants performing the following actions:

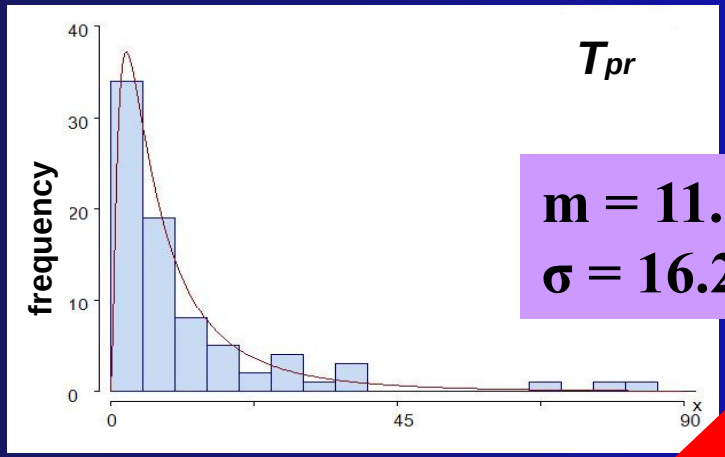
- (*Tpr*) Personal response time:
  1) Reading,
  2) Listening to music in earphones and
  3) Using a laptop.
- (*T1*) Time to prepare:
  1) Putting on jacket and
  2) Collecting hand bag from overhead baggage rack.
- (*T2*) Time at luggage compartment:
  1) Collecting a large suitcase and
  2) Collecting a small suitcase.
- (*T3*) Personal time to negotiate exit steps:
  1) Normally,
  2) Carrying a large suitcase and
  3) Carrying a small suitcase.
- (Ws) Unimpeded walking speeds in the aisle

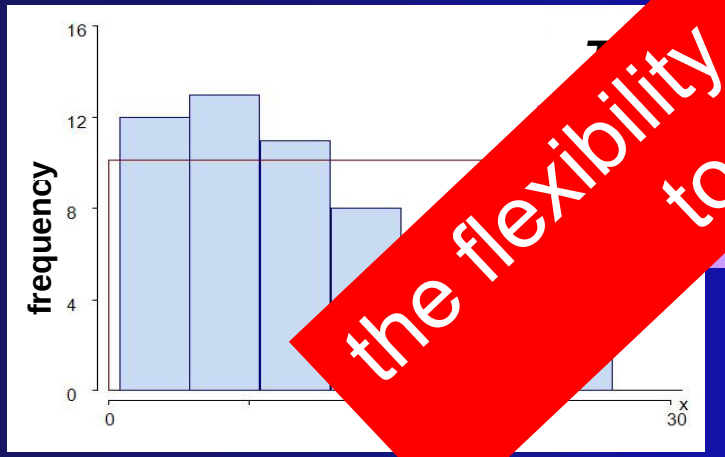
2-DESCRIPTION OF THE MODEL

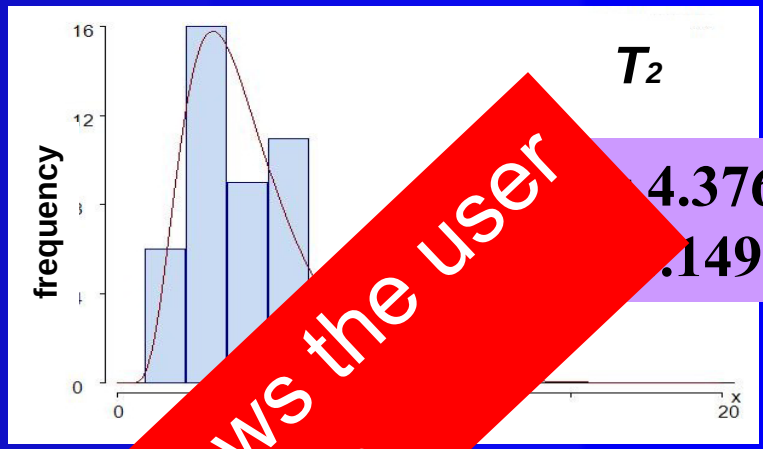
Fit for Distributions TESTS used:

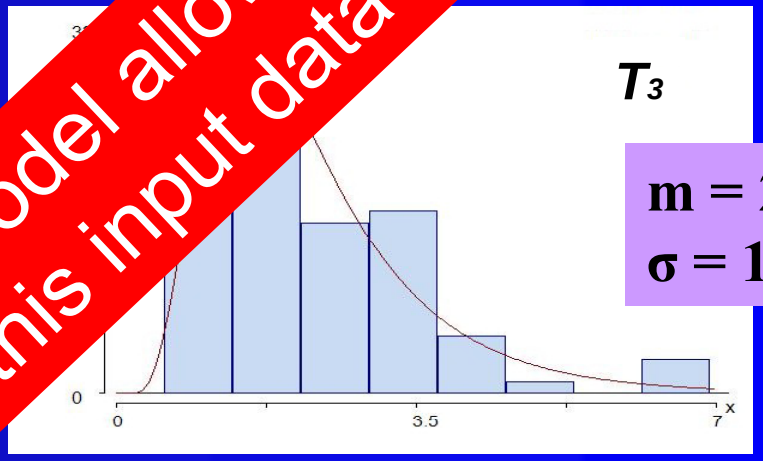
- D' Agostino's K-square normality test (samples > 25).
- The Anderson-Darling normality test (samples < 25).
- Hypothetical log-normal test applying the normality test.
- The Anderson-Darling uniformity test.

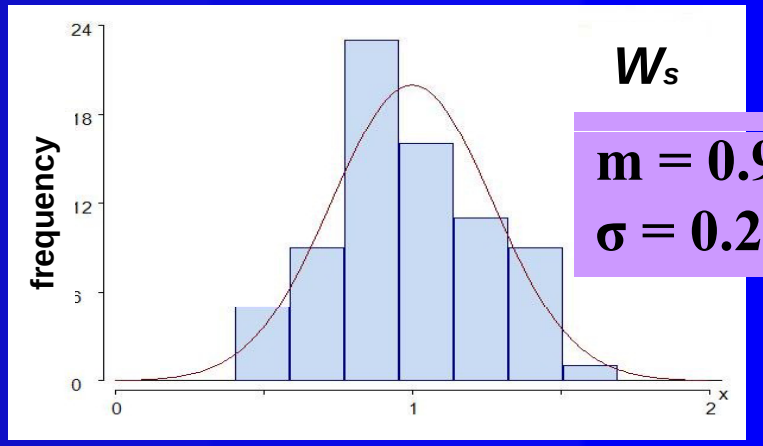
Samples of data were combined according to the Mann-Whitney non-parametric test











the flexibility of the model allows the user to modify this input data

2-DESCRIPTION OF THE MODEL

Advantages

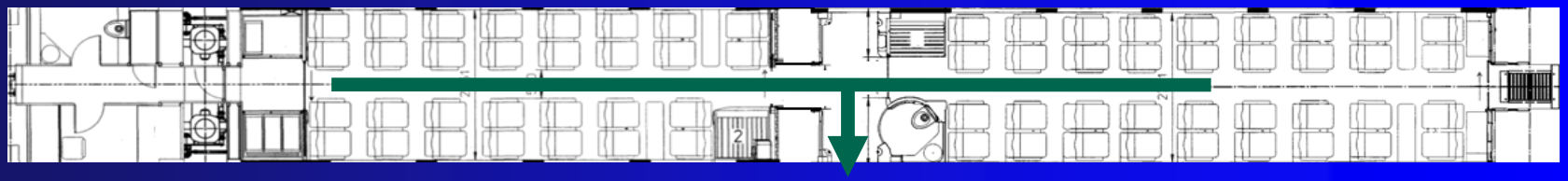
1. Quick and easy to set up
2. It is possible to represent how different human behavoiur affects evacuation times
3. We can simulate thousands of potential outcomes in less than 20 seconds (results in Real-Time)

Demostration

3-VERIFICATION TESTS

Test 1

Single-exit Scenario (door 0.813 wide)
50 passengers
Train S 102



No Pre-evacuation Time; Fixed Walking Speed of 1 m/s

Model (flow inputs)	Time (s)
STEPS (NFPA fare/gate)	69
PathFinder (SFPE)	74.90
Pathfinder (steering)	53
FDS+Evac	68

Proposed Model (flow inputs T_3)	Time (s)
"no interaction" flow is set to zero	55.90
(SFPE)	74.90
(NFPA door/gate)	79.90

3-VERIFICATION TESTS

Test 2

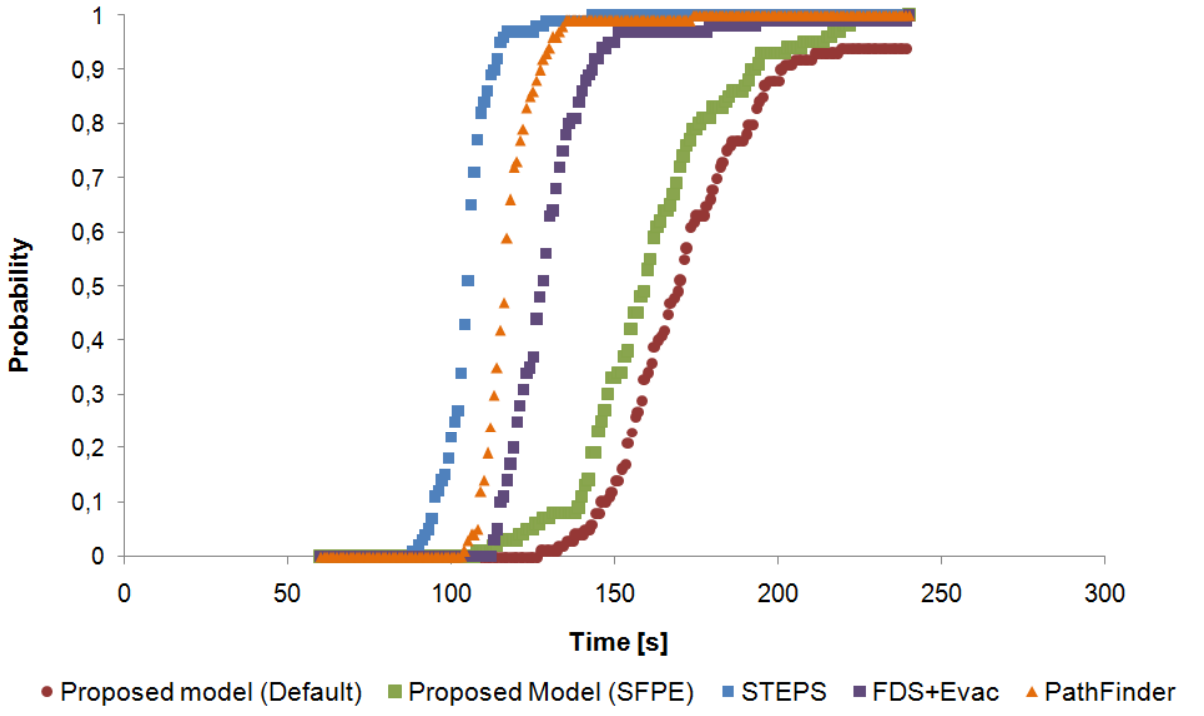
Microsoft Visual Studio 2008. NET Framework 3.5 SP1. 1000 random values for T_{pr}, T_1 and T_2 taking into account the probabilities of occurrence, P_{T1} and P_{T2}

T_{pr}
T_1
T_2
→ Pre-evacuation time → Log-normal Distribution
Mean = 54.18s
SD= 47.08s

100 runs by each model

Model	Mean (s)	SD (s)
STEPS	105.25	7.69
PathFinder	117.74	8.62
FDS+Evac	130.40	17.52
Proposed model (Default)	177.74	38.10
Proposed model (SFPE)	162.47	24.91

Worse cases with P_{T1} *(0.7-0.9)* *and* P_{T2} *(0.07-0.3)*



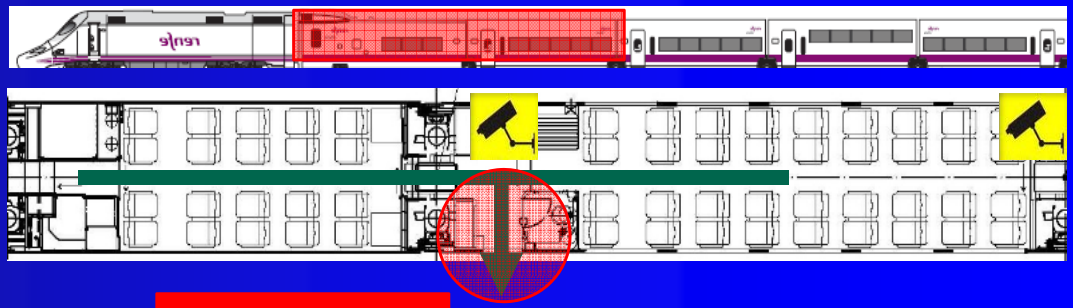
3-VERIFICATION TESTS

Test 3

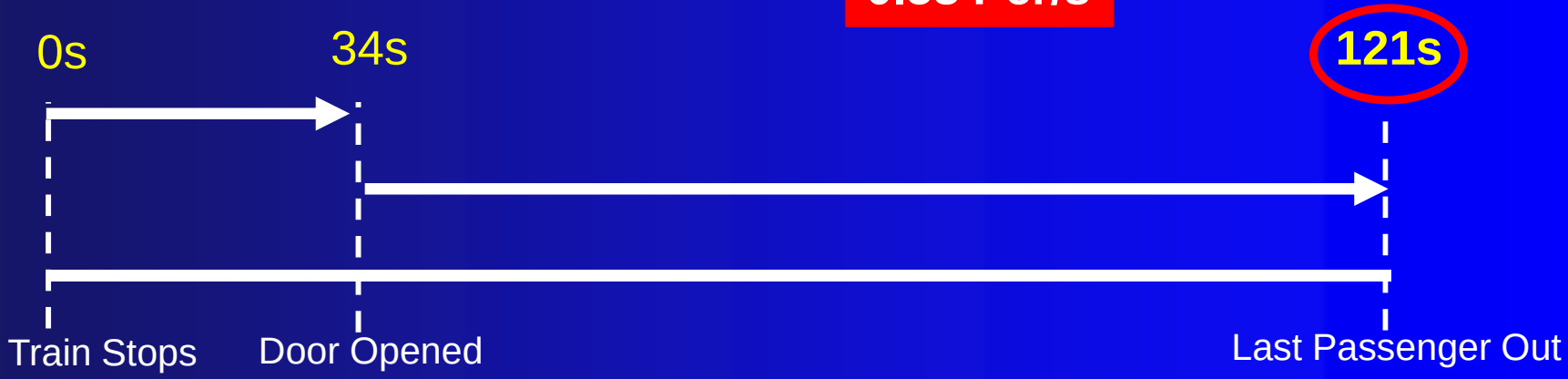
Announced Evacuation Drill

Nº Passengers = 40

Train S 130



0.58 Per/s



Proposed Model	Mean (s)	SD (s)	Min. (s)	Max. (s)	Percentile 95 % (s)
Simulation of Drill: *Pt1* =0.3-0.5; Flow = 0.58 per/s	120.35	12.97	104.20	169.90	152.239
Default :*Pt1* = 0.3-0.5; Flow =0.44 per/s	137.16	12.62	117.50	178.30	171.23
Default: *Pt1*= 0.7-0.9; Flow = 0.44 pers/s	168.75	23.09	122.80	274.40	223.55

CONCLUSIONS

1. People actions and decisions may have a relevant influence on the evacuation process (this is particularly important inside trains, where the space is limited). Therefore, more parameters related to human behaviour in trains should be considered.
2. The proposed model is an alternative approach to solve the problem of predicting additional behaviours of passengers during the evacuation process, and their impact on egress calculations.
3. Results from Test 1 showed that the basic components of model work adequately. Results from Test 2 showed a wider range of possible evacuation times (this is expected for a stochastic model). Furthermore, in Test 3 the predicted evacuation times from proposed model were very close to the observed results from an evacuation drill.

FUTURE WORKS

The current version of the proposed model has limitations that need to be addressed. Future research will include:

- Simulation of evacuations in a wider range of scenarios (railway tunnels, evacuation to track level, etc.) and different evacuation procedures.
- Improve more features.
- More data collection in order to increase the statistical samples and quantify more behavioural parameters.
- Further validation of the model.

Thanks

CONTACT DATA

Prof. Dr. Jorge A. Capote Abreu (capotej@unican.es)
Dr. Daniel Alvear Portilla (alveard@unican.es)
Dr. Orlando Abreu (abreuo@unican.es)
Dr. Mariano Lázaro (Lazarom@unican.es)
D. Arturo Cuesta (cuestaar@unican.es)

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Dpt. de Transportes y Tecnología de P… Procesos

UNIVERSITY O… TABRIA

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Postal Addres…

GIDA… …ety – Research and Technology
E.T.S. …os Industriales y Telecomunicación
Ave. L… Castros, s/n
39005 SANTANDER (Cantabria). SPAIN
Tel. +34 942-20.1826 Fax: +34 942-20.1873