Faster to the desired seat

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DLR

About

- Introduction
- State of the Art
  - Seat reservation
  - Passenger change
- Problem description
- Solution and Modelling
- Simulation results
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State of the Art
Seat reservation

Image Sources: eurail.com, simpleusability.com

State of the Art
Passenger change

Image sources: focus.de, telanganatoday.com

State of the Art
Passenger change

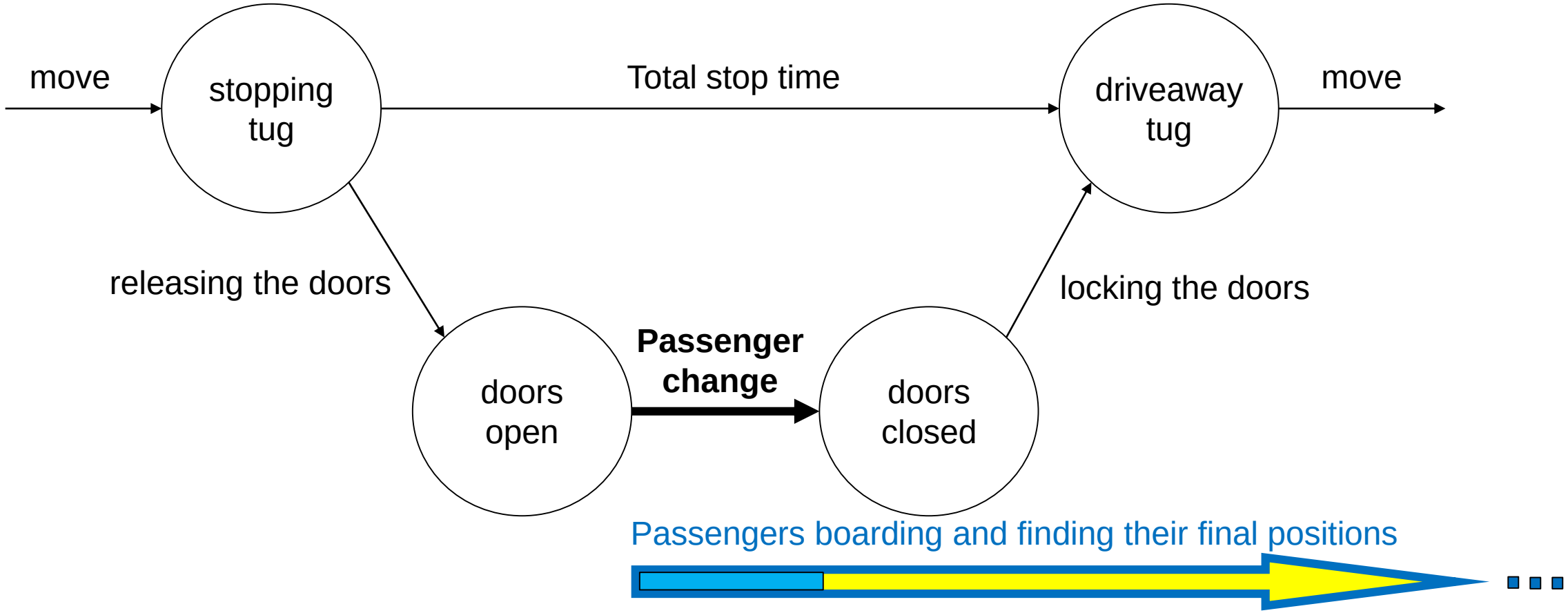
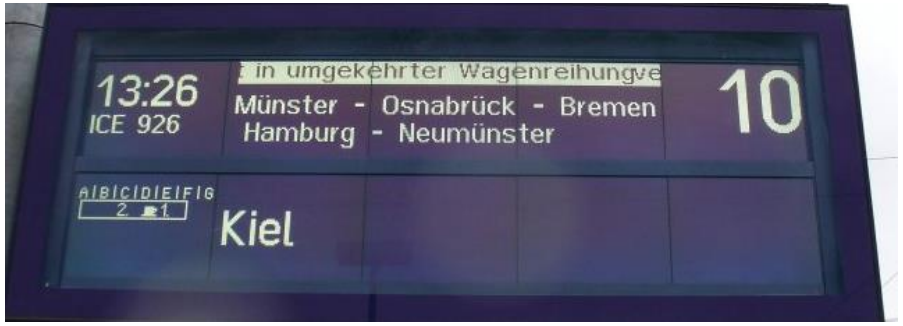
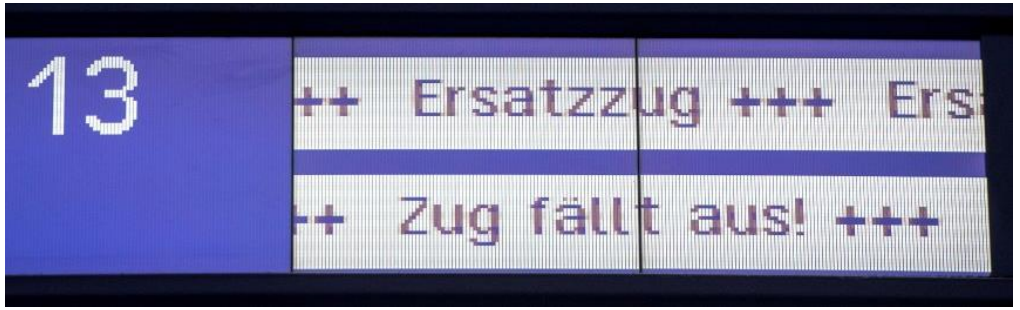


Image source: self sketched in accordance with Weidmann 1995

Problem description (1)



„supply of the coaches in reverse order“



Provision of a spare train (with different coach/seat numbering

Unknown reservation status

Image sources: ice-treff.de, Spiegel Online, faz.net, Inside Bahn

Problem description (2)

Halt	Datum	Zeit	Gleis	Produkte	Reservierung
Braunschweig Hbf Hannover Hbf	14.10. 14.10.	ab 09:51 an 10:25	6 11	IC 2432	1 Sitzplatz, Wg. 5, Pl. 163, 1 Gang, Großraum, Nichtraucher oben, Handy, Res.Nr. 8053 1004 0256 60
Hannover Hbf Hamburg Hbf	14.10. 14.10.	ab 10:37 an 11:56	8 12	ICE 394	1 Sitzplatz, Wg. 14, Pl. 53, 1 Gang, Großraum, Nichtraucher, Handy, Res.Nr. 8053 1004 9502 64

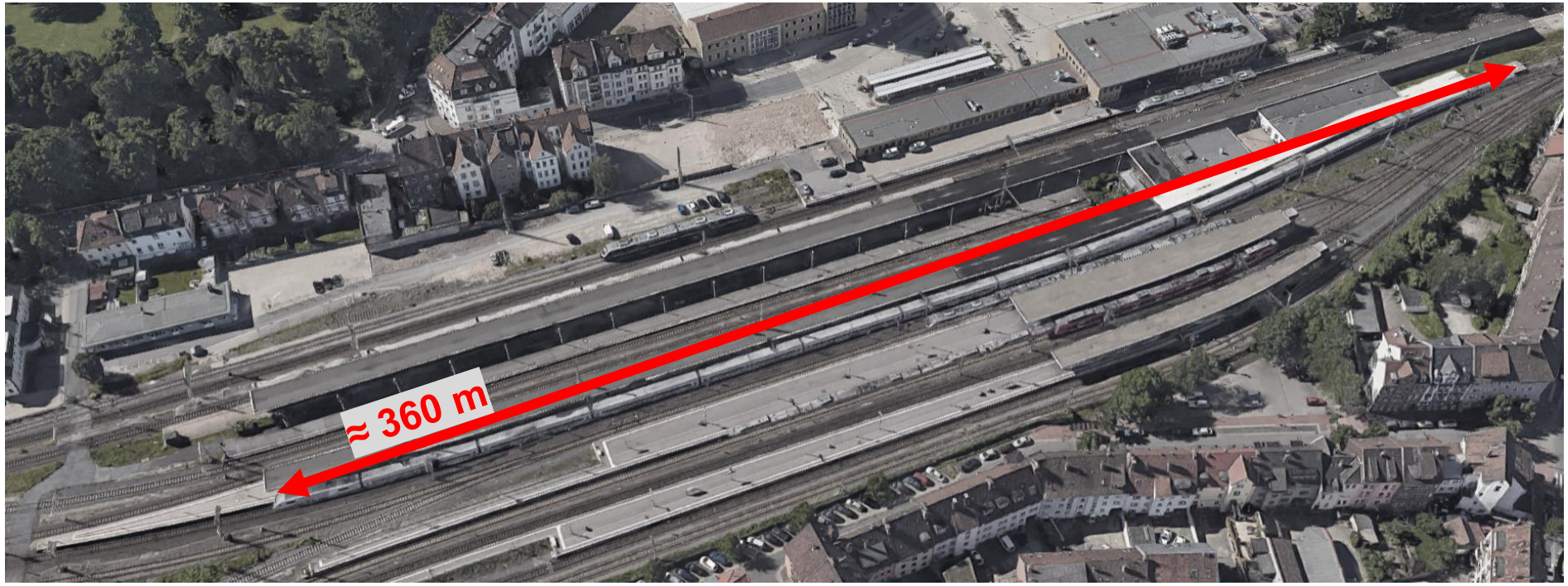


Image sources: bahnreise-wiki.de, Google Maps

Problem description (3)

Passenger change: well researched and established from an operational point of view
this considers only the areas close to doors (neither train nor platform)
→ the process of finding a seat (/standing place) concerns the passenger concretely
more than a comfort issue!

Finding an entrance: carriage position indicators (see example below)
platform section marking (e.g. A to G)
carriage markings (car designators)

:

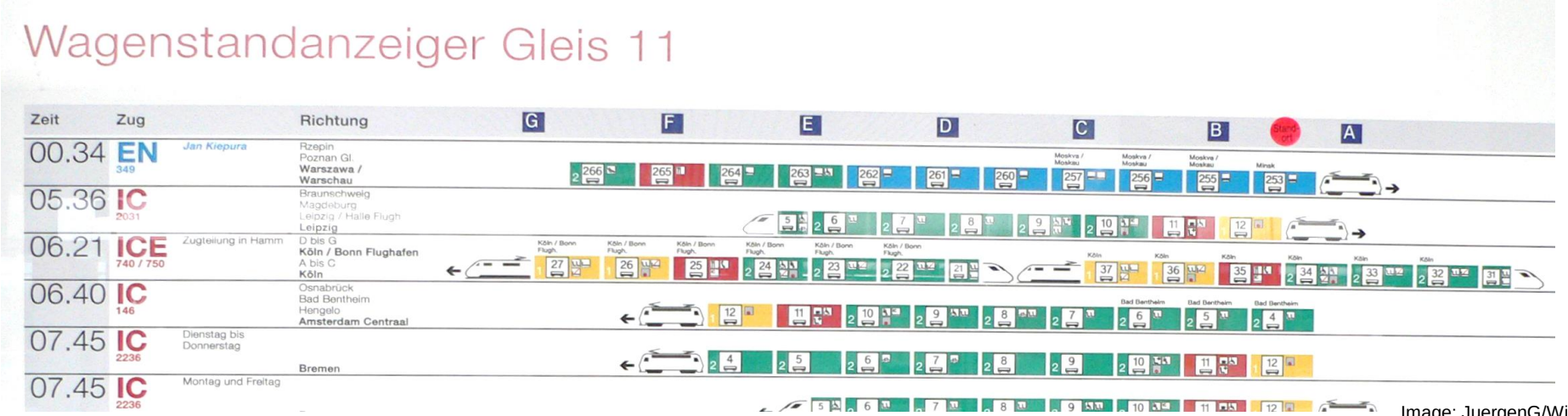
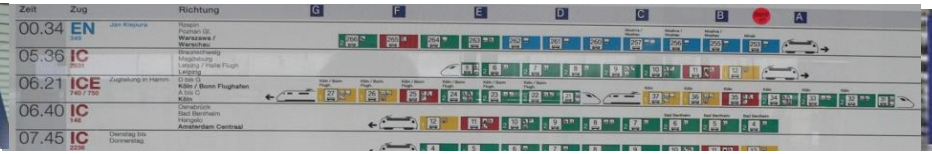


Image: JuergenG/Wikipedia, CC BY-SA 3.0

Solution

- **instead of helping the passenger to understand the system**

- **the system is given the ability to respond to the passenger**

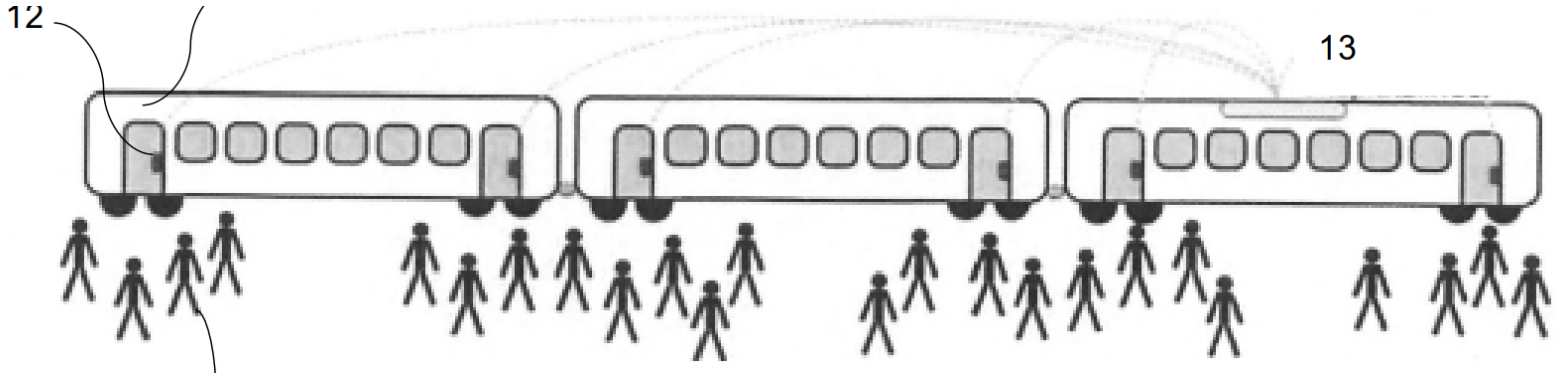
- the passenger enters the train **wherever he wants**
  - where she is just standing
  - where he suspects his seat
  - where she uses a service facility on the platform (bench, poster, smoking area, kiosk, etc.)
  - where he is talking to someone
  - where she arrived with another train before (e.g. opposite)

- the system accepts rebellious behaviour and offers a suitable seat close to the chosen entry

Image sources (bahn-sparpreise.de, bahnbilder.de, Wikipedia, DB AG

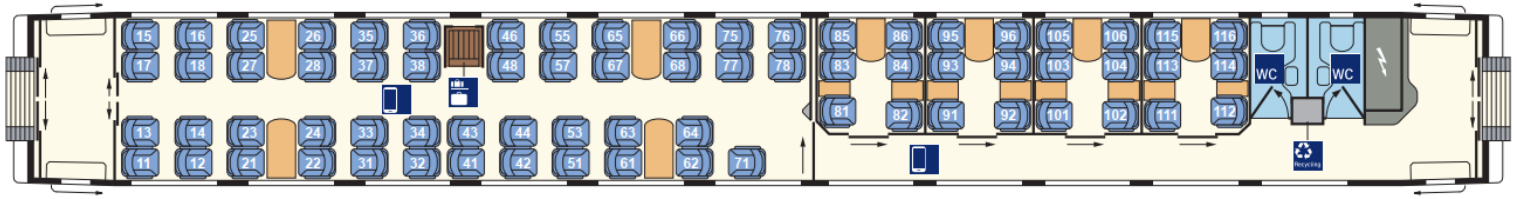
Solution
Advantages

- free choice of entry for the passenger
- flexible reallocation of the reservation depending on the selected entry
- allocation of seats on sections of the route (not possible so far), also multiple (not possible at all)
- compatibility with status quo possible
- the possibility of spontaneous reservations increases the incentive to purchase reservations
- the use of train occupancy indicators at the platform makes sense now (unusual in Germany)



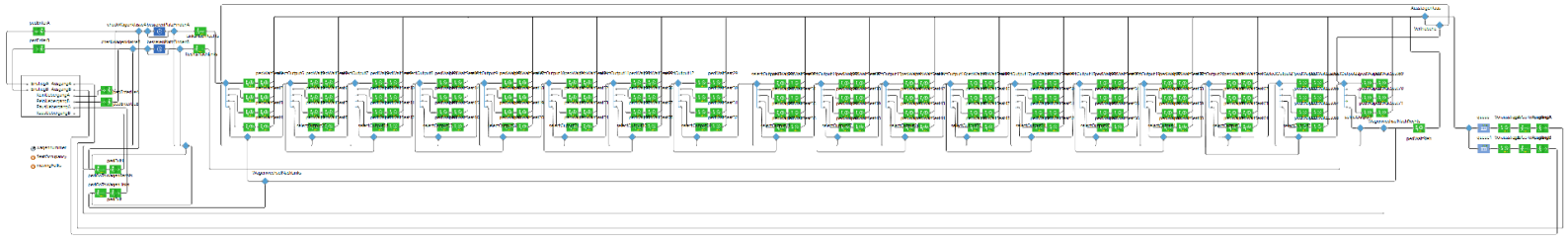
Modelling

- selection: class 401/801-804 („ICE 1“) trainset as 12+2 configuration with total length of approx. 358 m
- redesign from 2003, service carriage as carriage 9 as 1st class (incl. conference compartment)
- 203/497 seats (1st/2nd carriage class)
- 2nd class: carriages 1 - 7
- dining carriage (on-board bistro modeled as a replacement standing place area, seating area for passenger change irrelevant)
- 1st class: carriages 9, 11, 12, 14



- modelling with Anylogic and Passenger Library/Social Force Modell
- modular modelling of the different parts of the train (carriages 1-7, 8, 9, 11-14) and platform
- passenger generation and seat reservation with JAVA in Anylogic
- pre-filling the train before actual passenger change with "Disembarking passengers" and "Maintaining in train passengers", depending on the scenario
- reservation starting from the dining car, but this also applies to the “pre-filling”, therefore wide spread of reservations and free seats for the passenger change

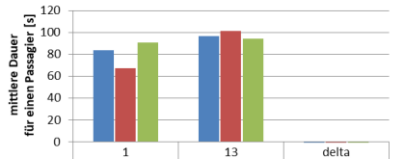
Scenario parameters



- 16 + 6 Scenarios

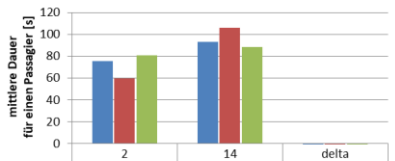
- Parameter variation concerns
  - quantities of "Disembarking passengers", "Maintaining in train passengers" and "Entering passengers"
  - scenarios 1…16 in total 100%
  - scenarios 1.25….5.75 based on S1 and S5 with lower demand 25%/50%/75%)
  - reservation rate (30% or 70%)
  - reservation exchange rate (90% or 0%)
- Constants
  - platform discipline (75%)
  - modeling parameters of the seat search (e.g. probability of searching for a free seat in the next car)

Results: Average values, single event "entry time to seat"



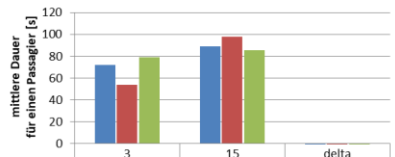
	1	13	delta
MW Einsteigedauer [s]	83,50	96,46	-13,4%
MW Einsteigedauer mit Reservierung [s]	67,38	101,10	-33,3%
MW Einsteigedauer ohne Reservierung [s]	91,03	94,30	-3,5%

Szenario ID



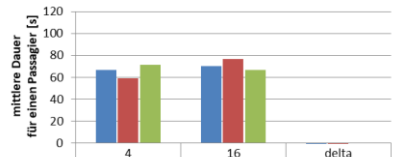
	2	14	delta
MW Einsteigedauer [s]	75,27	93,24	-19,3%
MW Einsteigedauer mit Reservierung [s]	59,75	106,01	-43,6%
MW Einsteigedauer ohne Reservierung [s]	81,09	88,49	-8,4%

Szenario ID



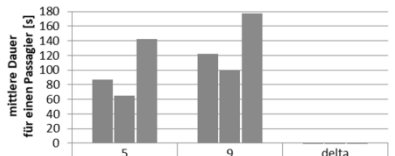
	3	15	delta
MW Einsteigedauer [s]	71,85	89,19	-19,4%
MW Einsteigedauer mit Reservierung [s]	54,10	98,01	-44,8%
MW Einsteigedauer ohne Reservierung [s]	79,33	85,46	-7,2%

Szenario ID



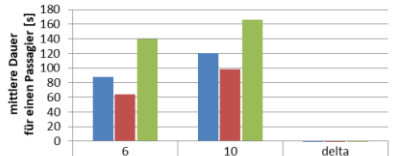
	4	16	delta
MW Einsteigedauer [s]	67,00	70,08	-4,4%
MW Einsteigedauer mit Reservierung [s]	58,92	76,55	-23,0%
MW Einsteigedauer ohne Reservierung [s]	71,24	66,69	6,8%

Szenario ID



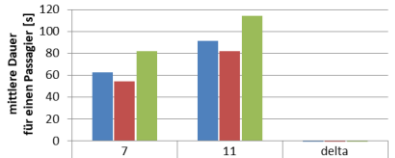
	5	9	delta
MW Einsteigedauer [s]	86,90	122,01	-28,8%
MW Einsteigedauer mit Reservierung [s]	65,07	100,05	-35,0%
MW Einsteigedauer ohne Reservierung [s]	142,25	177,71	-20,0%

Szenario ID



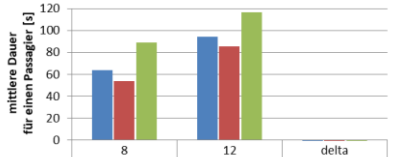
	6	10	delta
MW Einsteigedauer [s]	88,21	120,15	-26,6%
MW Einsteigedauer mit Reservierung [s]	64,11	98,71	-35,1%
MW Einsteigedauer ohne Reservierung [s]	139,76	165,98	-15,8%

Szenario ID



	7	11	delta
MW Einsteigedauer [s]	62,79	91,65	-31,5%
MW Einsteigedauer mit Reservierung [s]	54,47	81,84	-33,4%
MW Einsteigedauer ohne Reservierung [s]	81,98	114,29	-28,3%

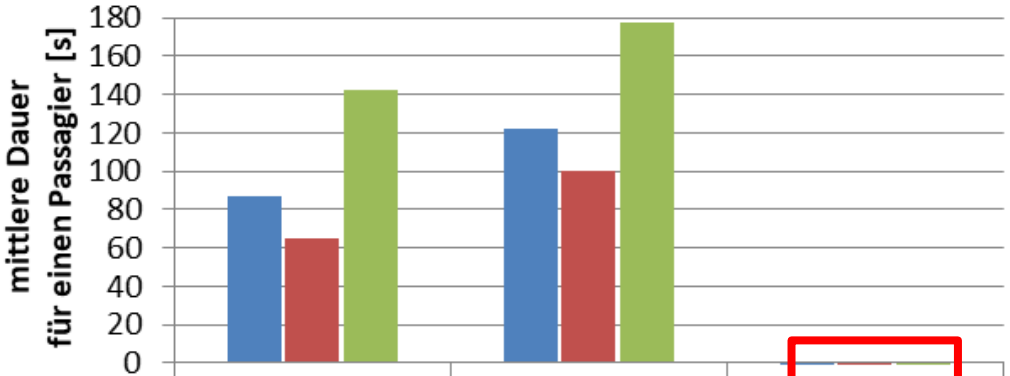
Szenario ID



	8	12	delta
MW Einsteigedauer [s]	63,65	94,18	-32,4%
MW Einsteigedauer mit Reservierung [s]	53,64	85,32	-37,1%
MW Einsteigedauer ohne Reservierung [s]	89,14	116,75	-23,6%

Szenario ID

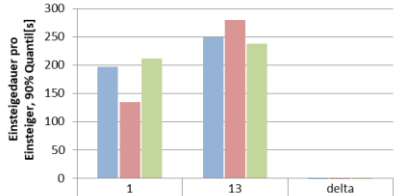
leerer Zug, 70% Reservierungsquote, 100% Einsteiger, mit [5] bzw. ohne [9] Sitzplatztausch



	5	9	delta
MW Einsteigedauer [s]	86,90	122,01	-28,8%
MW Einsteigedauer mit Reservierung [s]	65,07	100,05	-35,0%
MW Einsteigedauer ohne Reservierung [s]	142,25	177,71	-20,0%

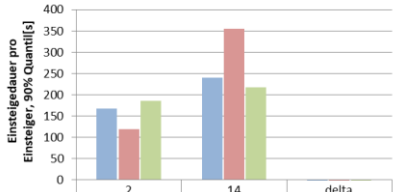
Szenario ID

Results: 90% percentile, single event "entry time to seat"



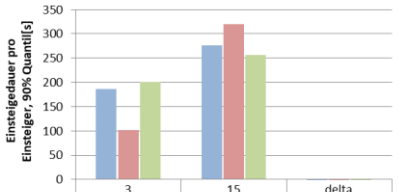
	1	13	delta
Einsteigedauer alle 90% Quantil	197,22	249,06	-20,8%
Einsteigedauer mit Reservierung 90% Quantil	134,16	279,90	-52,1%
Einsteigedauer ohne Reservierung 90% Quantil	211,80	238,20	-11,1%

Szenario ID



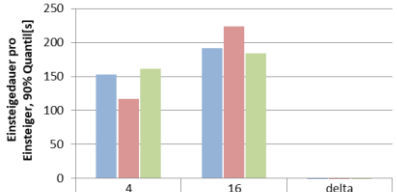
	2	14	delta
Einsteigedauer alle 90% Quantil	168,03	239,94	-30,0%
Einsteigedauer mit Reservierung 90% Quantil	118,80	354,84	-66,5%
Einsteigedauer ohne Reservierung 90% Quantil	185,40	217,38	-14,7%

Szenario ID



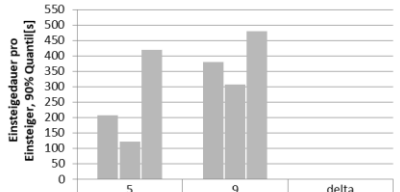
	3	15	delta
Einsteigedauer alle 90% Quantil	186,00	275,55	-32,5%
Einsteigedauer mit Reservierung 90% Quantil	101,94	319,53	-68,1%
Einsteigedauer ohne Reservierung 90% Quantil	201,30	256,38	-21,5%

Szenario ID



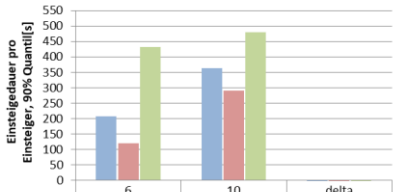
	4	16	delta
Einsteigedauer alle 90% Quantil	152,91	192,00	-20,4%
Einsteigedauer mit Reservierung 90% Quantil	117,39	223,80	-47,5%
Einsteigedauer ohne Reservierung 90% Quantil	161,46	183,78	-12,1%

Szenario ID



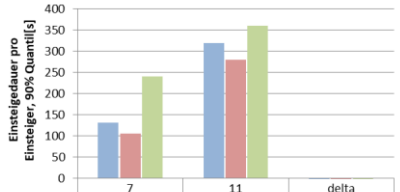
	5	9	delta
Einsteigedauer alle 90% Quantil	207,36	379,56	-45,4%
Einsteigedauer mit Reservierung 90% Quantil	121,35	306,30	-60,4%
Einsteigedauer ohne Reservierung 90% Quantil	419,52	479,58	-12,5%

Szenario ID



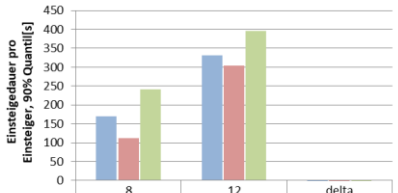
	6	10	delta
Einsteigedauer alle 90% Quantil	207,72	362,82	-42,7%
Einsteigedauer mit Reservierung 90% Quantil	120,90	291,15	-58,5%
Einsteigedauer ohne Reservierung 90% Quantil	431,88	479,52	-9,9%

Szenario ID



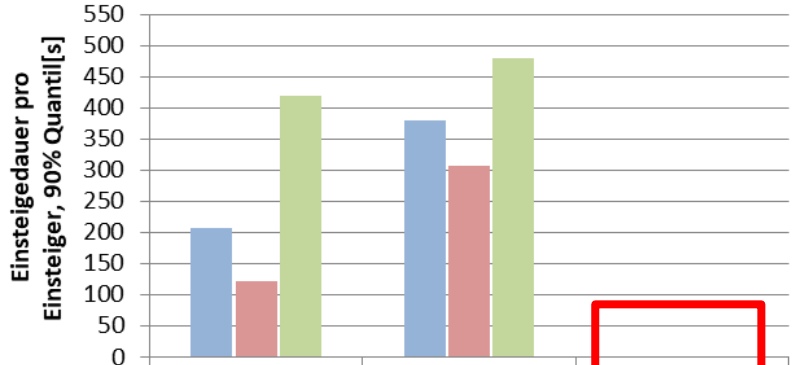
	7	11	delta
Einsteigedauer alle 90% Quantil	131,10	317,88	-58,8%
Einsteigedauer mit Reservierung 90% Quantil	105,51	278,70	-62,1%
Einsteigedauer ohne Reservierung 90% Quantil	240,12	358,83	-33,1%

Szenario ID



	8	12	delta
Einsteigedauer alle 90% Quantil	170,04	331,20	-48,7%
Einsteigedauer mit Reservierung 90% Quantil	111,15	304,80	-63,5%
Einsteigedauer ohne Reservierung 90% Quantil	241,44	395,94	-39,0%

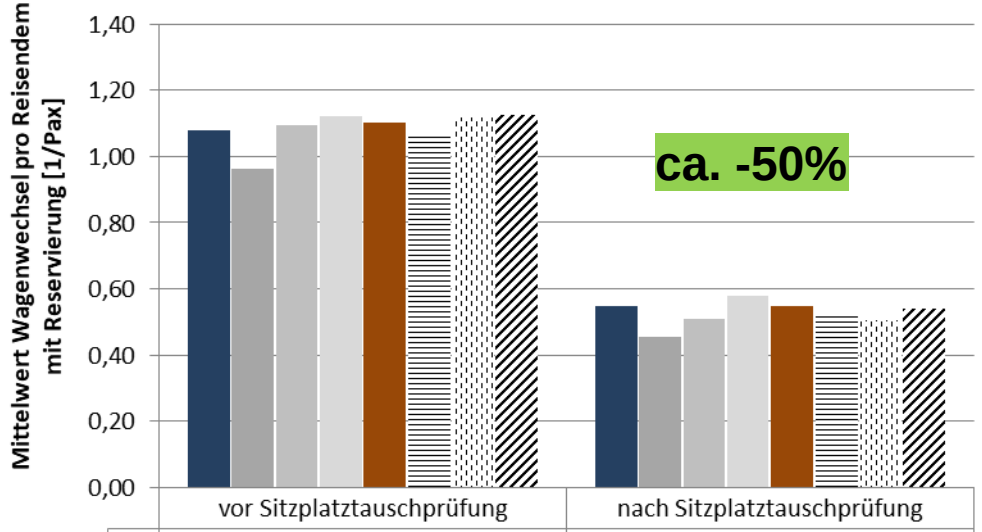
Szenario ID



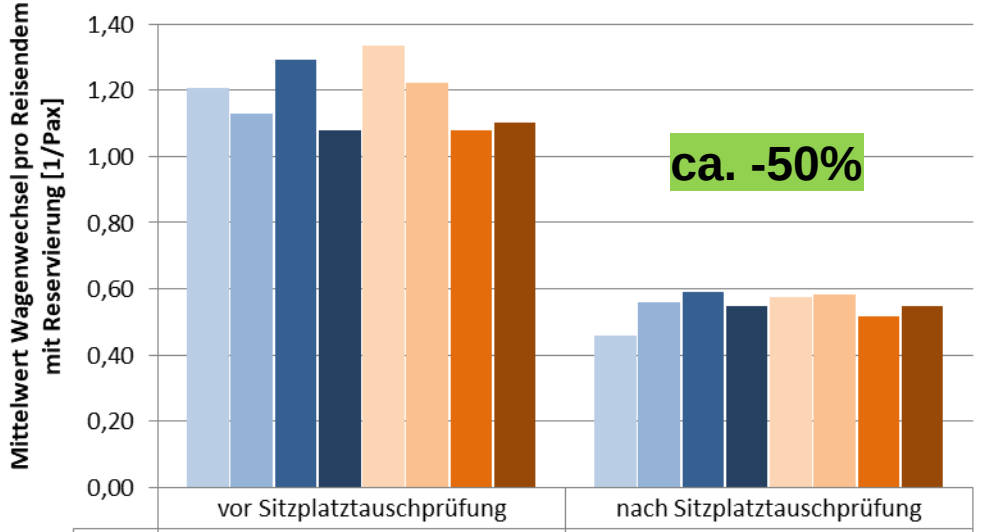
	5	9	delta
Einsteigedauer alle 90% Quantil	207,36	379,56	-45,4%
Einsteigedauer mit Reservierung 90% Quantil	121,35	306,30	-60,4%
Einsteigedauer ohne Reservierung 90% Quantil	419,52	479,58	-12,5%

Szenario ID

Results: Reduction of the required carriage changes (passengers with reservation)



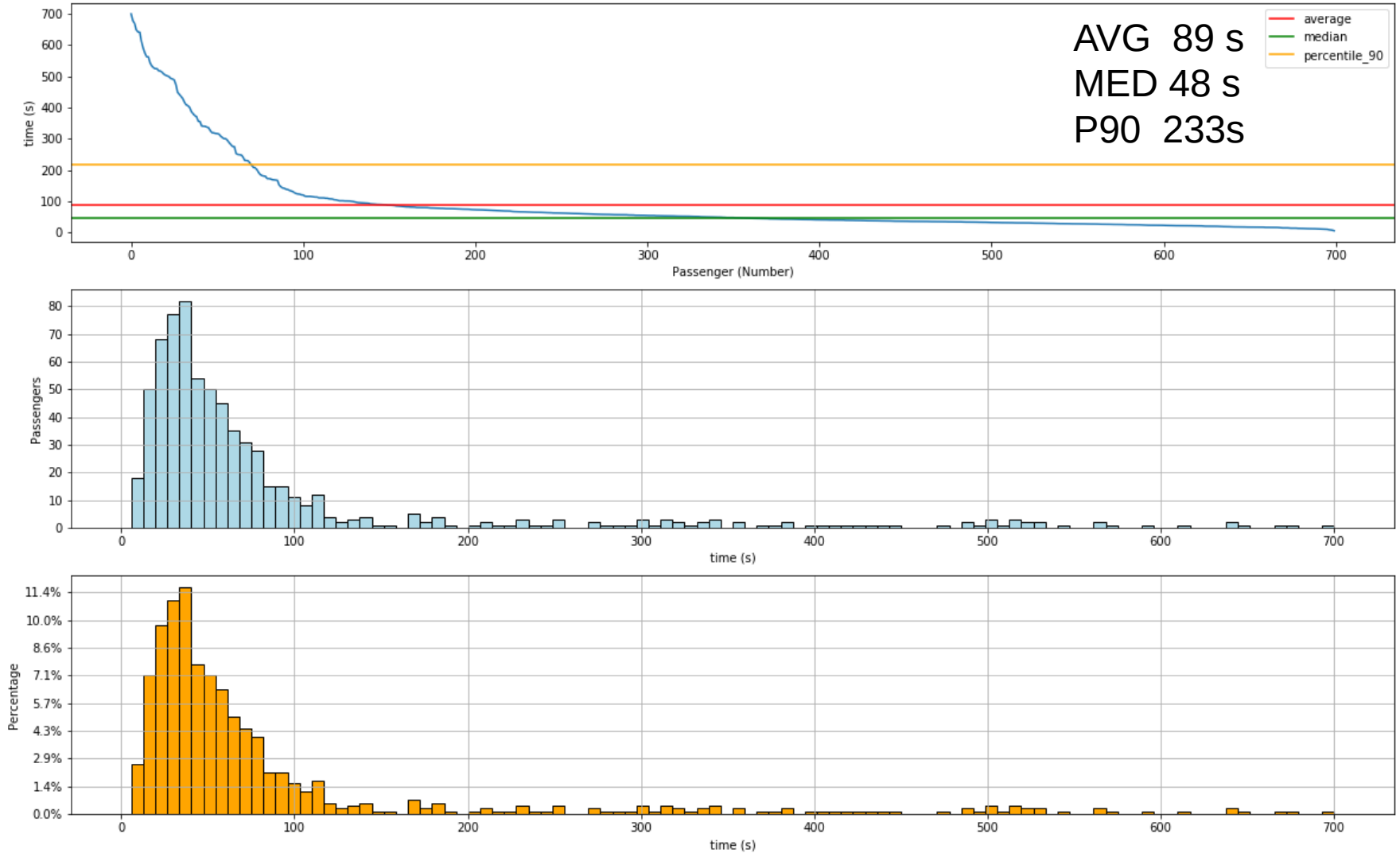
	vor Sitzplatztauschprüfung	nach Sitzplatztauschprüfung
1	1,08	0,55
2	0,96	0,45
3	1,10	0,51
4	1,12	0,58
5	1,10	0,55
6	1,07	0,52
7	1,12	0,51
8	1,13	0,54



	vor Sitzplatztauschprüfung	nach Sitzplatztauschprüfung
1.25	1,21	0,46
1.50	1,13	0,56
1.75	1,29	0,59
1	1,08	0,55
5.25	1,33	0,58
5.50	1,22	0,58
5.75	1,08	0,52
5	1,10	0,55

vor Sitzplatztausch:	**Buchung vs. Einstieg**
nach Sitzplatztausch:	**Actual vs. Einstieg**
Tauschteilnehmerquote:	**90%**
Bahnsteigdisziplin:	**75%**

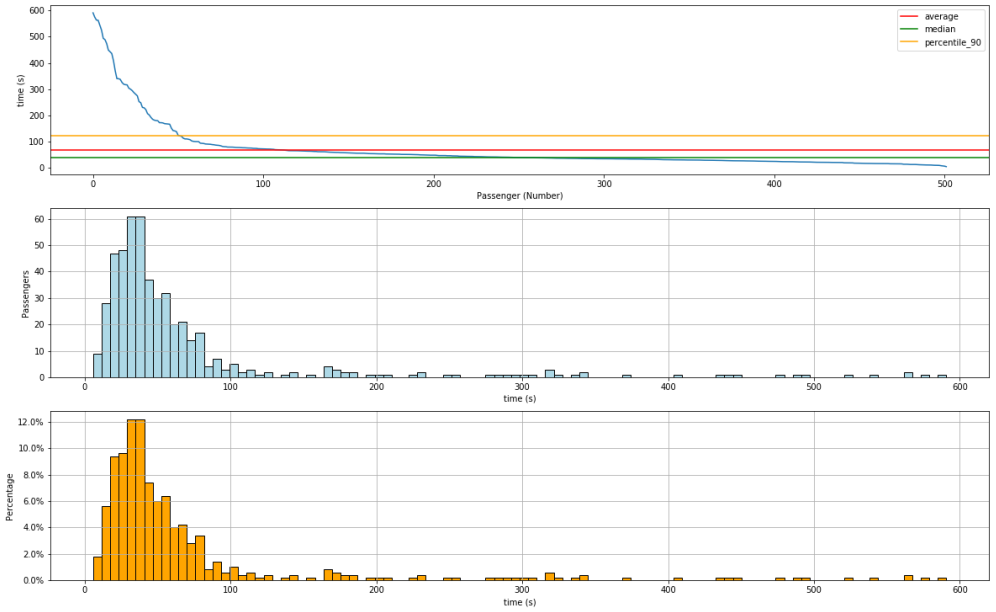
Results: Total durations



Simulation run 5. 1,
all "Entering passengers"

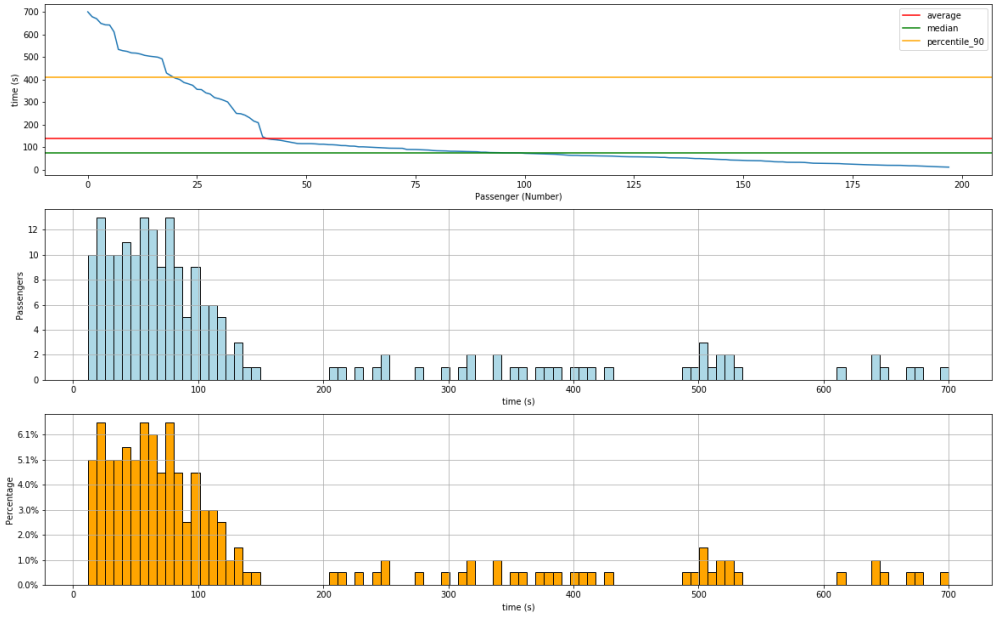
Results: Total durations

"Entering passengers" with reservation



AVG 69 s
MED 41 s
P90 124s

"Entering passengers" without reservation



AVG 138 s
MED 75 s
P90 409 s

Simulation run 5.1, left: with r., right: without r.

Conclusion

Total duration to find a seat ALL (90% percentile):

223 vs. 327 seconds

-32%
on average scenarios 1-8 vs. 9-16 *

Total duration to find a seat
with reservation (90% percentile):

116 vs. 295 seconds

-60%
on average scenarios 1-8 vs. 9-16 *

Required carriage changes per passenger (ALL):

0,65 vs. 0,90

-28%
on average scenarios 1-8 vs. 9-16 *

Required carriage changes with reservation
per passenger:

0,53 vs. 1,09

-51%
on average scenarios 1-8 (after/before exchange search)

* note different output distributions!

```
1  System.out.println("I am happy to answer your questions!");
2
3      while (questions > 0) {
4          question_string = voice.readLine();
5          String answer = answer_question(question_string);
6          System.out.println(answer);
7
8          questions--;
9      }
10
11 System.out.println("Thank you for your attention.");
12 /**
13 * Erik Grunewald
14 * German Aerospace Center
15 * erik.grunewald@dlr.de
16 * 0049-531-3045
```