WLTP

Comparison of WLTP unified database distributions and WLTC rev2 distributions

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Overview

- The comparison includes the following aspects
  - Different acceleration classification systems (km/h/s versus m/s²),
  - Consideration of idling phases,
  - Consideration of negative accelerations,
  - Discussion of database for extra high speed part,
- Further discussion point
  - Selection approach for short trips,
- The following figures show the comparison of acceleration distributions of the unified WLTP database and WLTC rev2 for the different speed parts. The distributions of the unified WLTP database were delivered by JARI, they contain also the idling phases.

Comparison of acc distributions, low

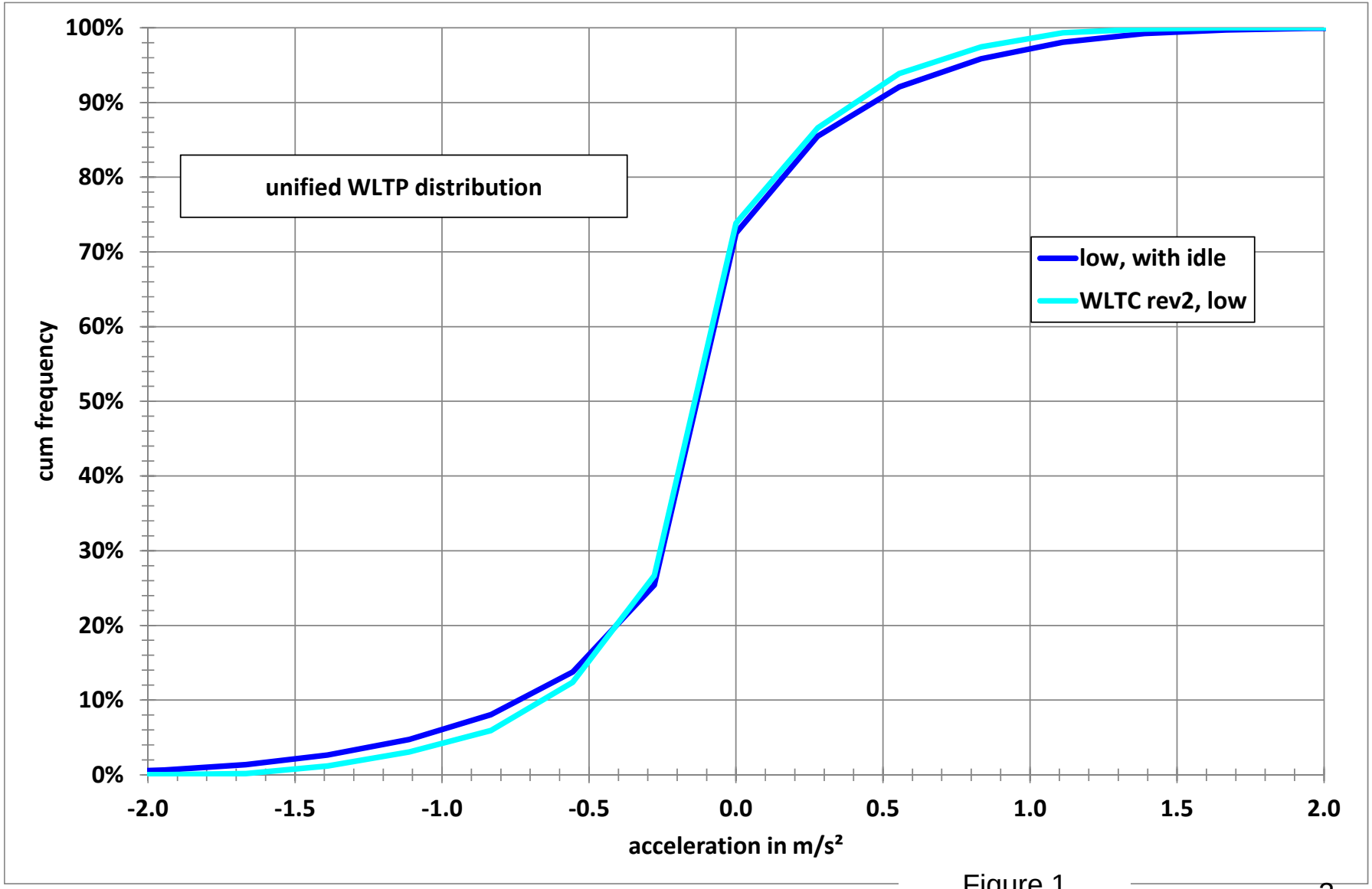

Figure 1

Comparison of acc distributions, medium

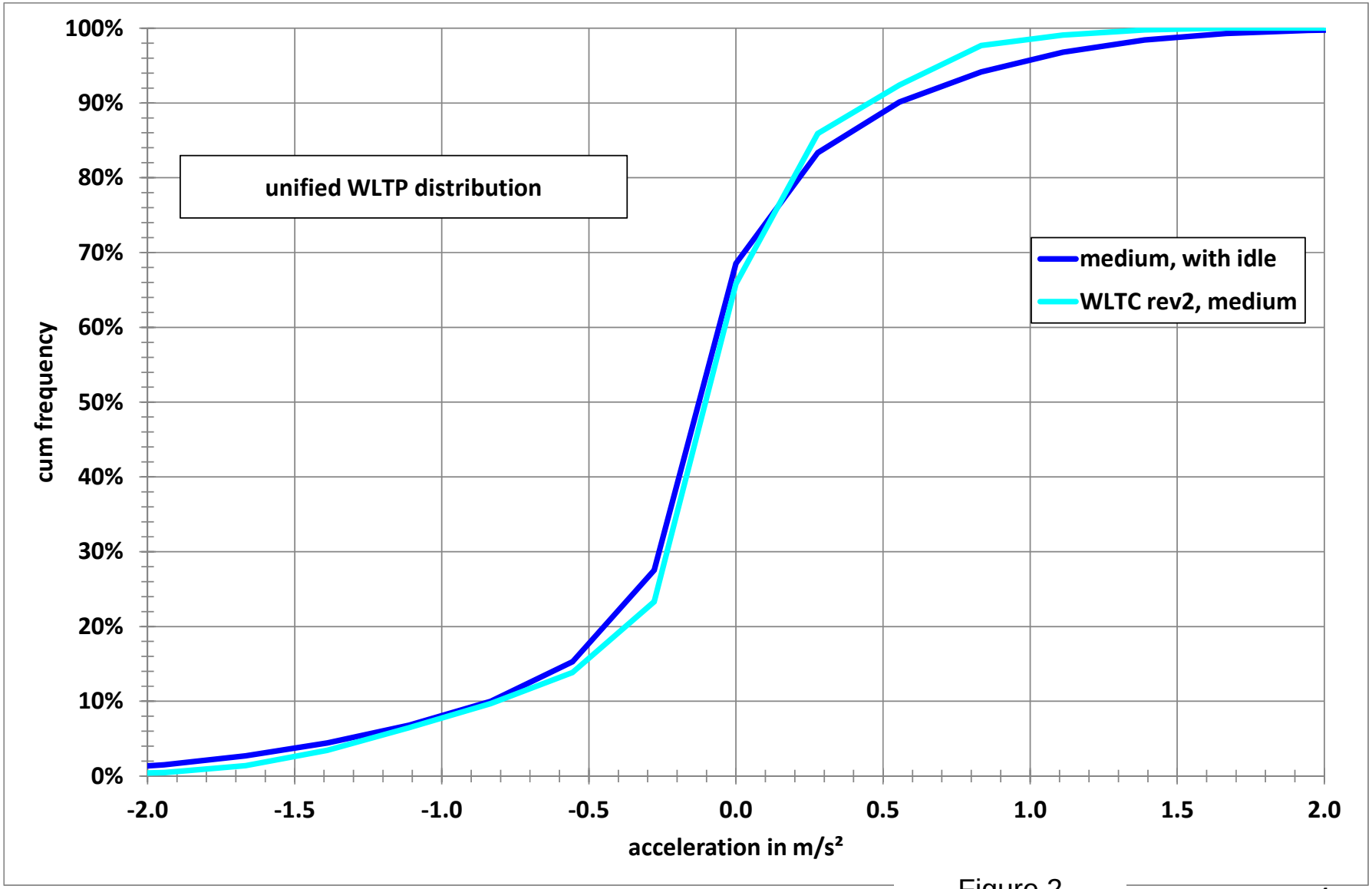

Figure 2

Comparison of acc distributions, high

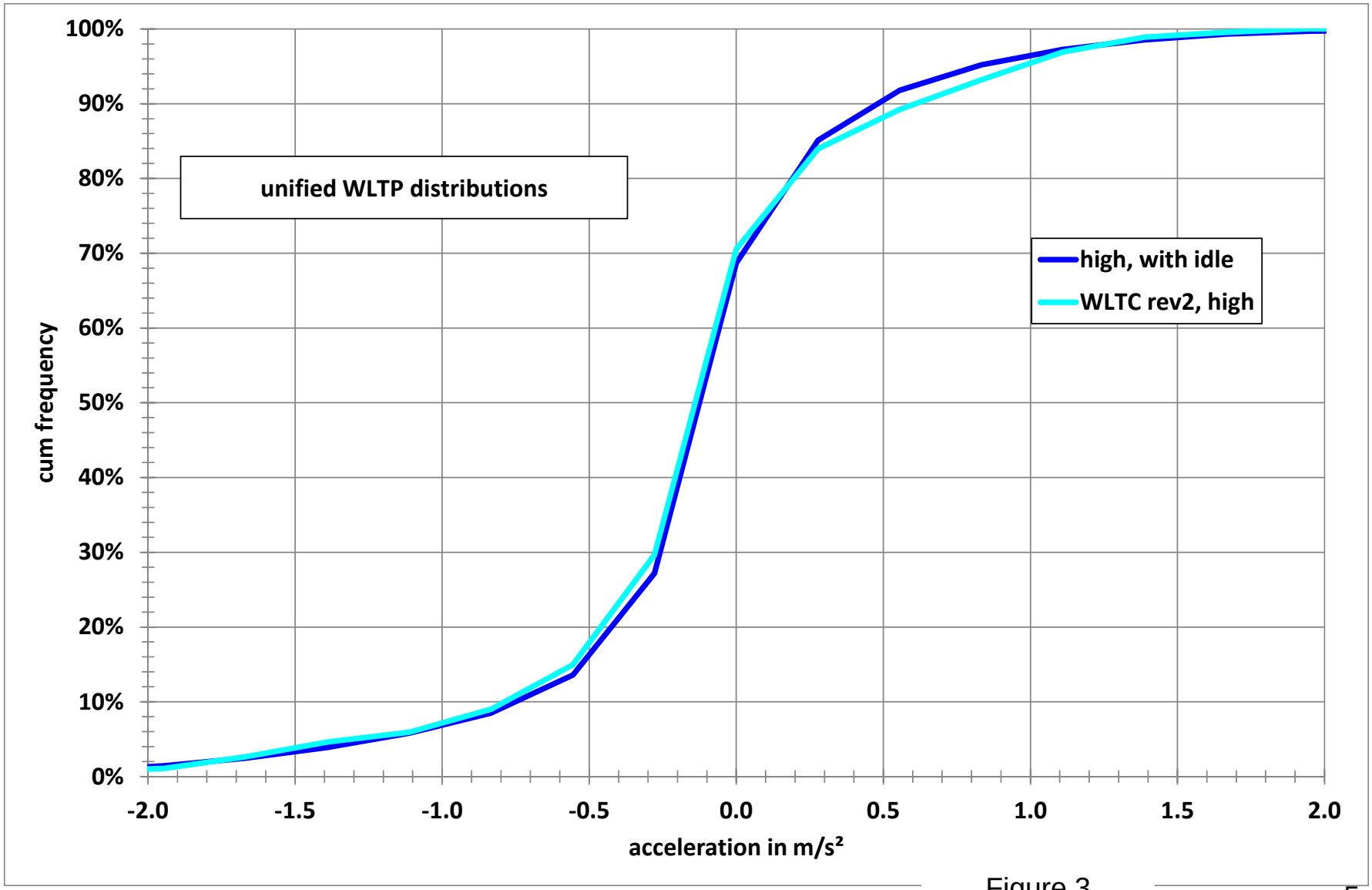

Figure 3

Comparison of acc distributions, extra high

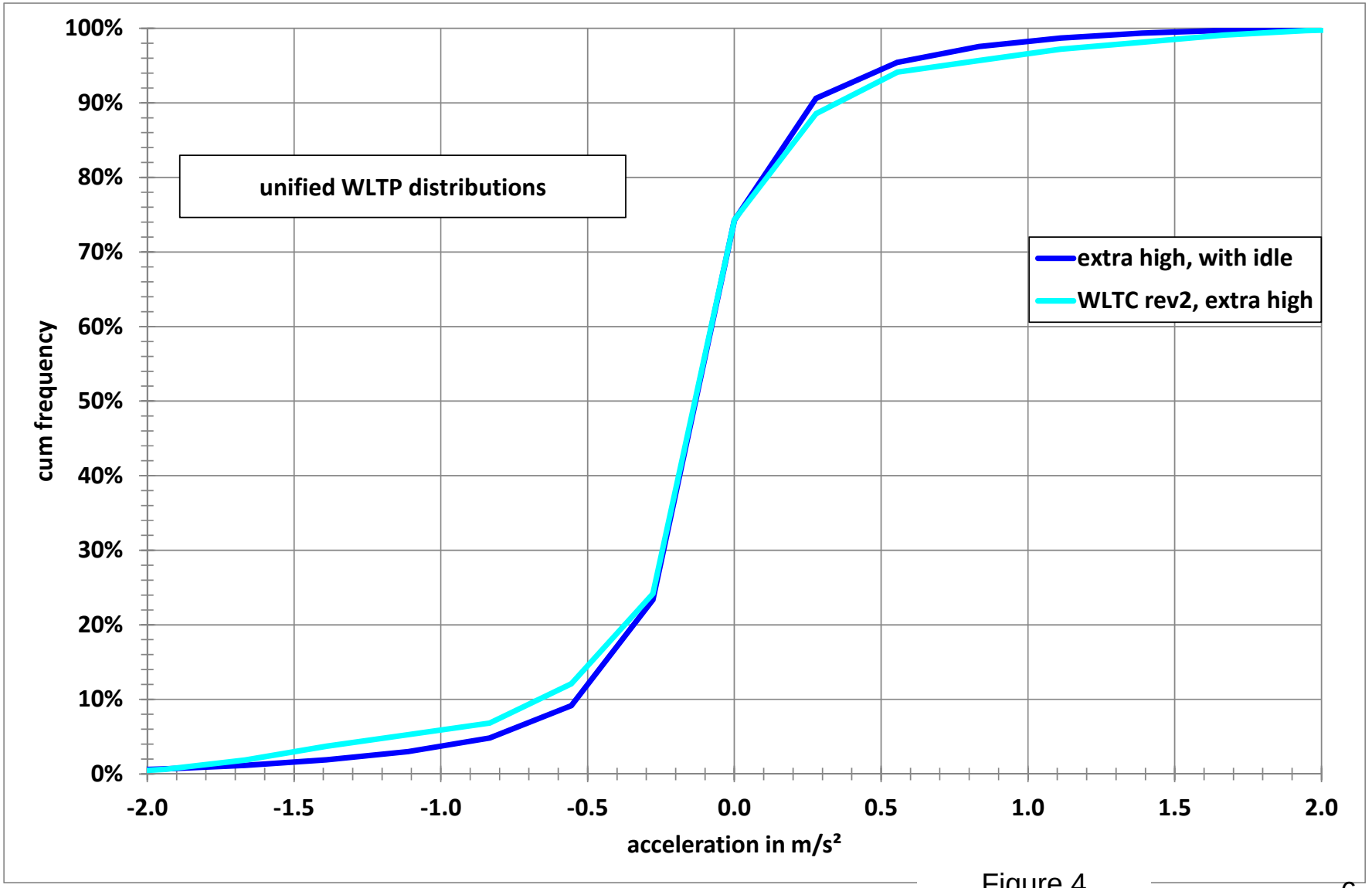

Figure 4

Observations, remarks, questions

- Only 30% of the operation time or even less is related to positive accelerations.
- Where is the justification to include the idling phases in the distributions and the least square calculation?
- The WLTC rev2 distributions for the low and the medium speed parts show lower dynamics in the positive acceleration sections than the database distributions.
- For the high and extra high speed parts it is the opposite, but less pronounced.
- Deviations to lower dynamics have the same influence on the least square sum as deviations of the same order to higher dynamics.
- This led to the differences shown in the comparison.

Observations, remarks, questions

- **This situation is unsatisfactory, especially because the acceleration phases determine the major parts of the CO2 and NOx emissions in real traffic.**
- **Figure 5 shows results of PEMS measurements performed with 3 different EURO 4 Diesel vehicles in Stuttgart within a project sponsored by LUBW.**
- **The routes driven were related to the low speed part. The idling and deceleration phases determine about 10% of CO2 and NOx emissions each, the by far most important phase is the acceleration phase.**
- **In this context, the situation will not be improved enough, if the idling phases are disregarded for the analysis (see figures 6 and 7).**

PEMS measurement results in real traffic

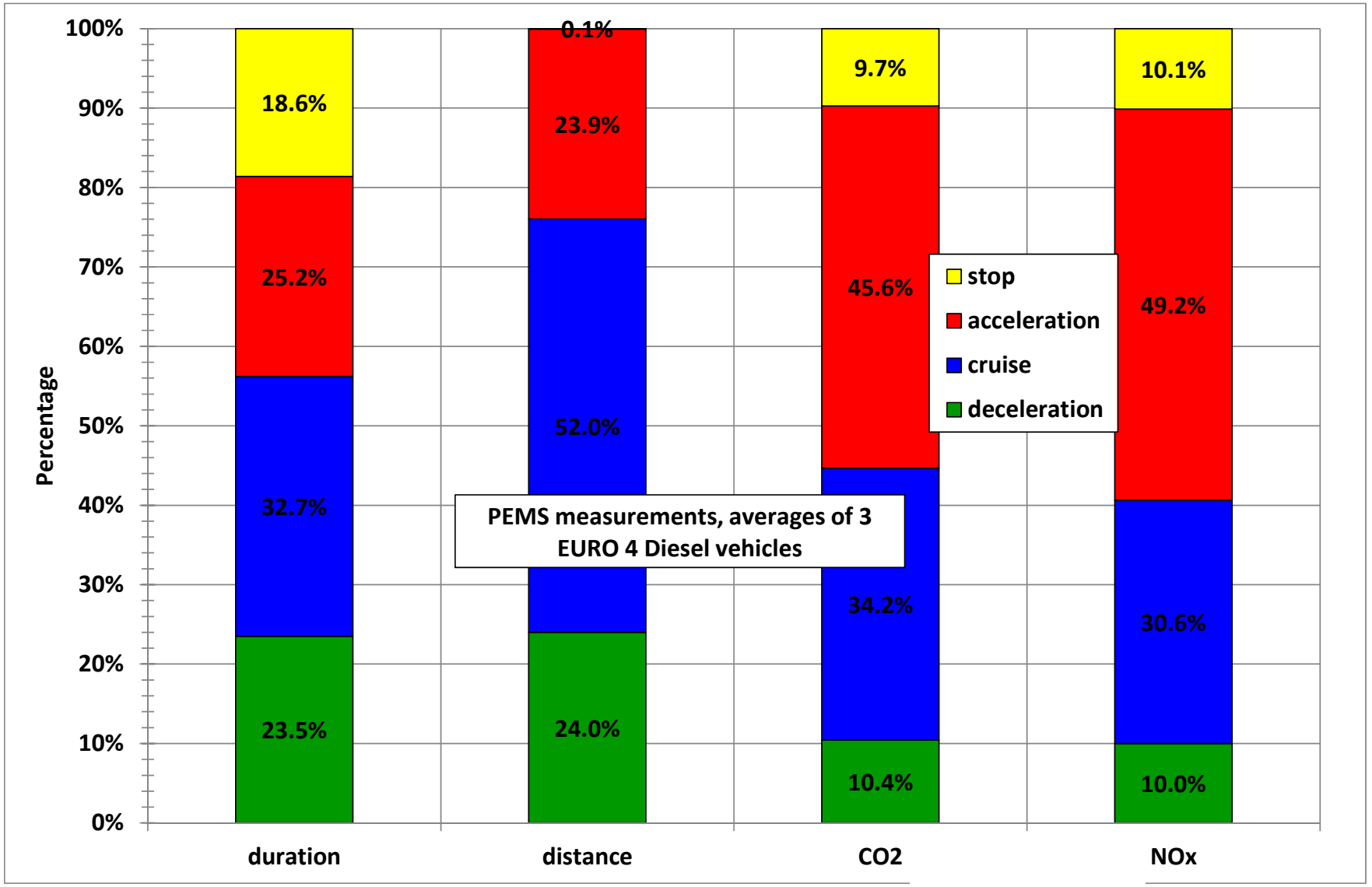

Figure 5

Comparison of acc distributions, low

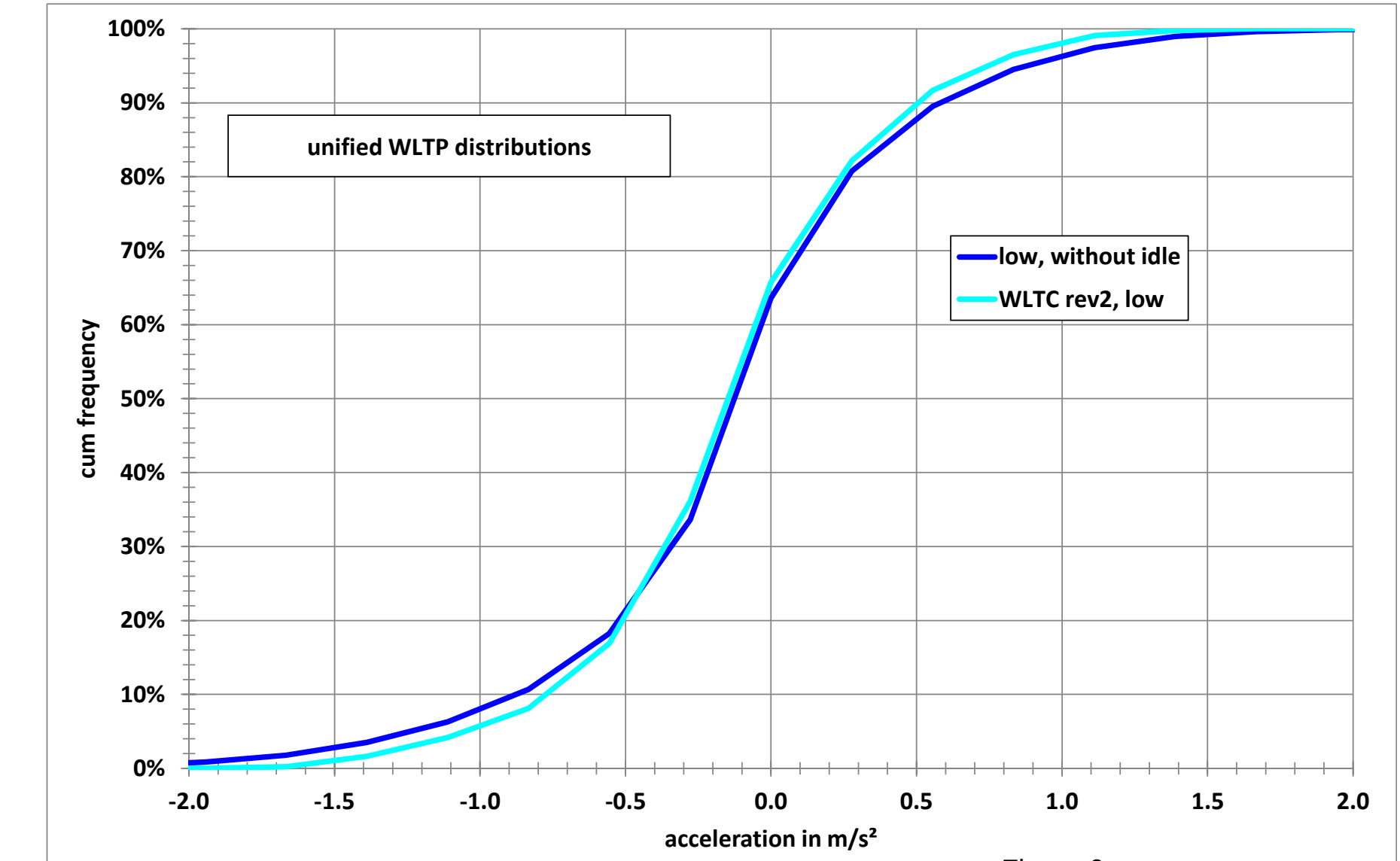

Figure 6

Comparison of acc distributions, medium

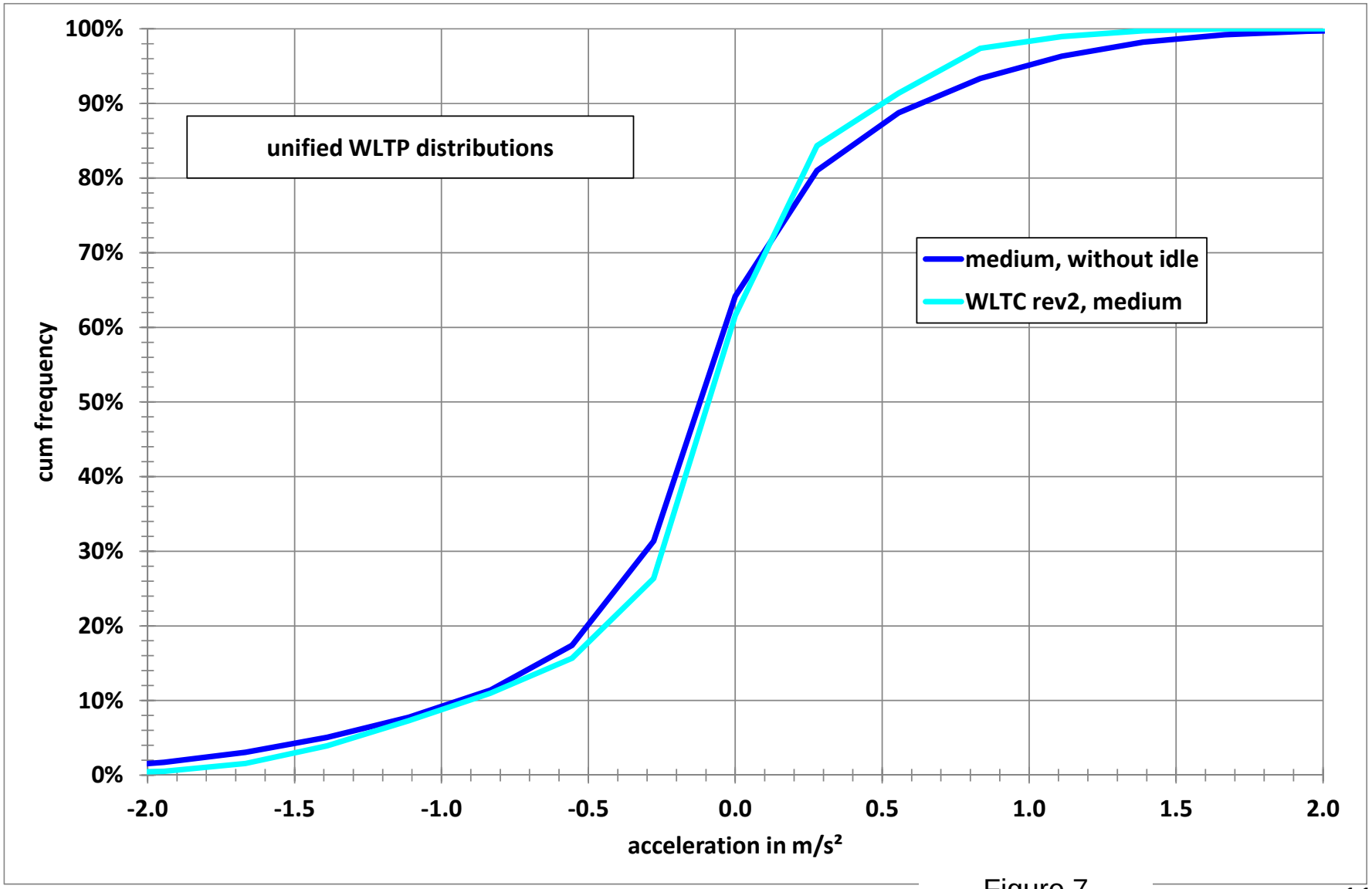

Figure 7

Comparison of acc distributions, medium

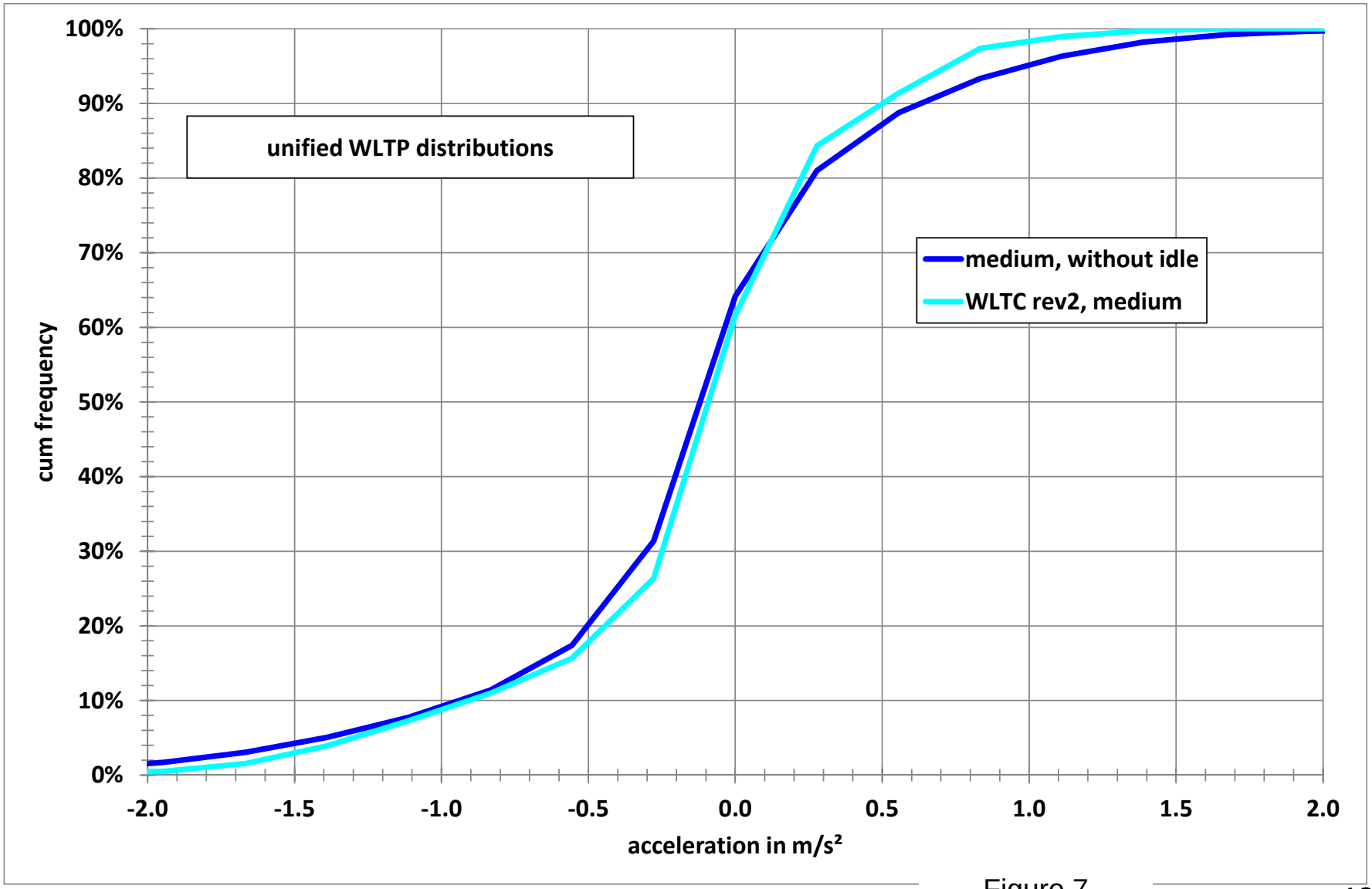

Figure 7

Observations, remarks, questions

- **The development approach should be related to the positive acceleration section instead.**
- **When focussing on this section the lower dynamics of the WLTC rev2 in comparison to the database distributions for low and medium speeds becomes more obvious (see figures 8 and 9).**
- **But the different acceleration classification systems used by JARI and JRC/Steven become important within this context, especially for the high and extra high speed parts (see figure 10).**

Comparison of acc distributions, low

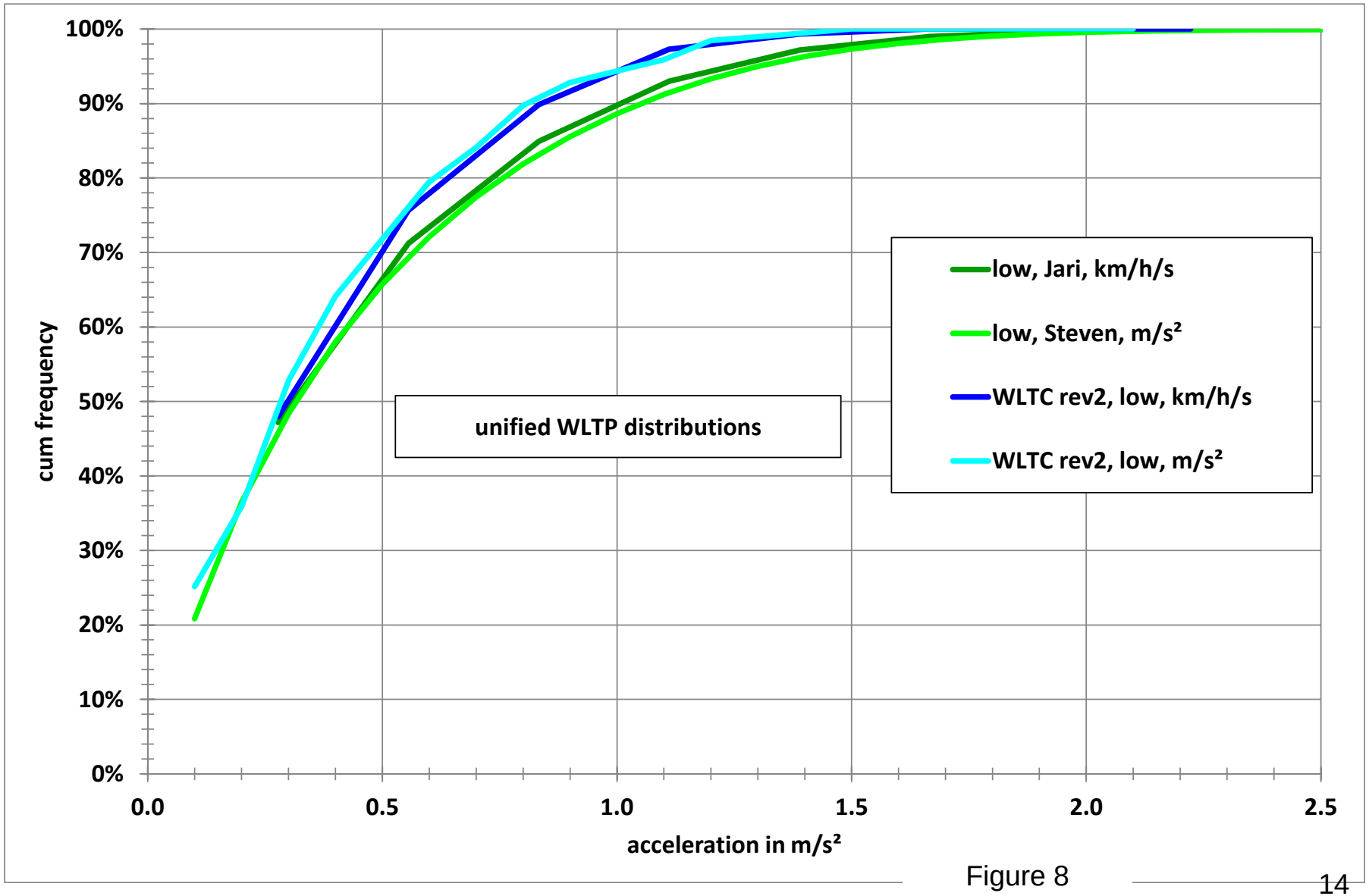

Figure 8

Comparison of acc distributions, medium

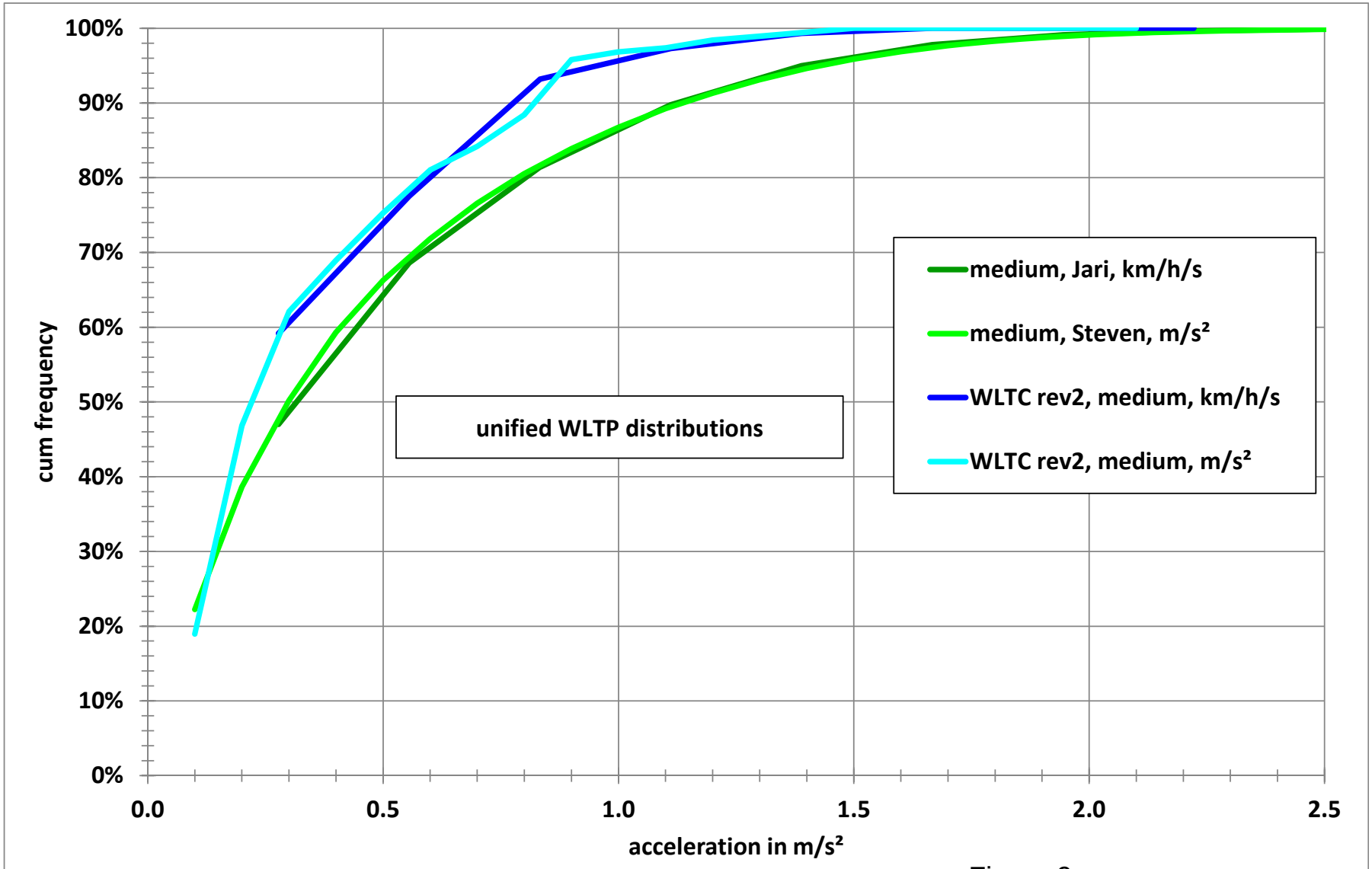

Figure 9

Comparison of acc distributions, high and extra high

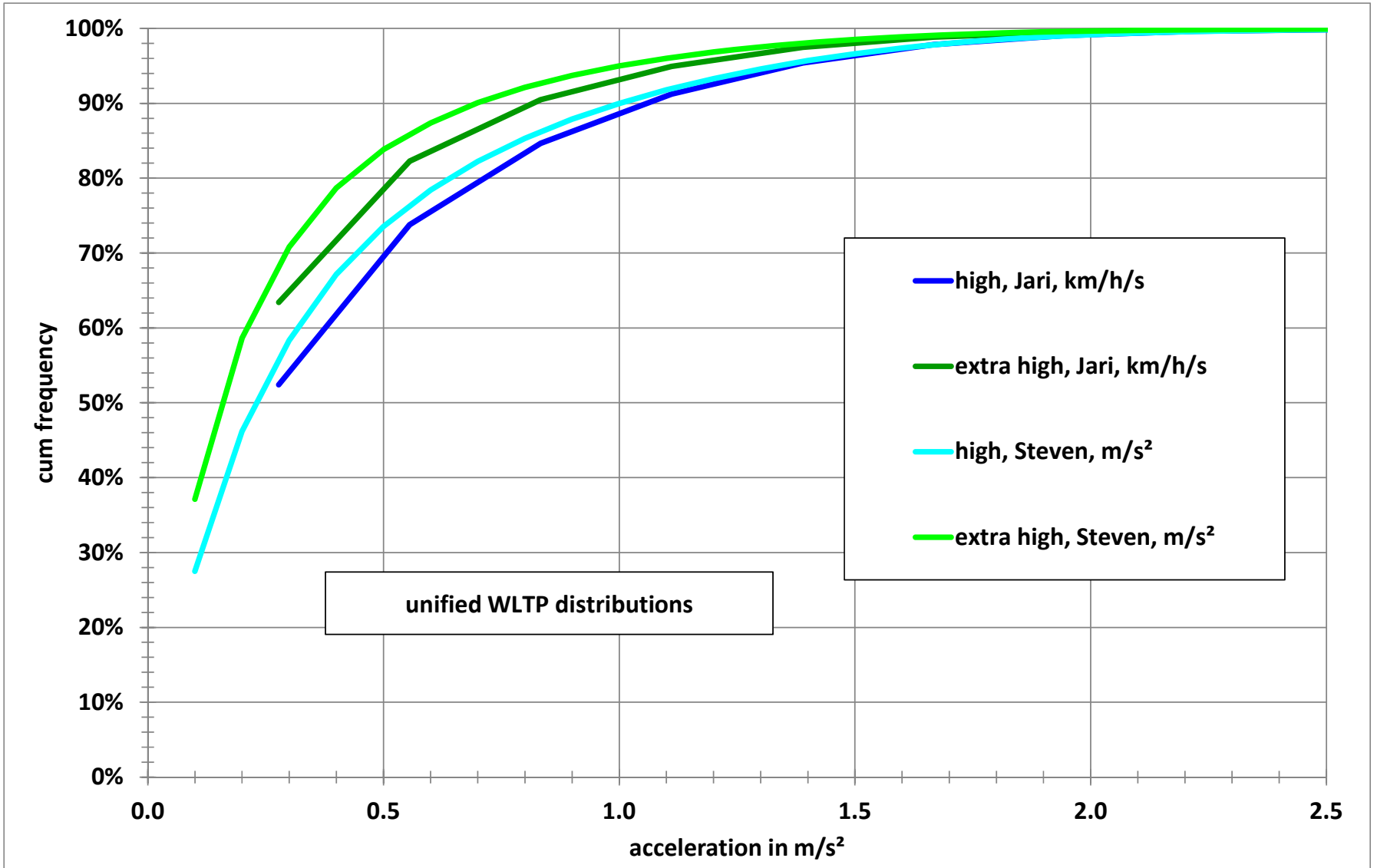

Figure 10

Further analysis

- In order to further check these observations additional analysis work was performed by developing regional cycles for the EU and the US. The key parameters of these cycles are tabled in Annex A.
- Figures 11 to 14 show the results for the positive acceleration sections and the different speed parts.
- First of all it needs to be mentioned that the distributions for the unified WLTP database and the EU regional database are pretty close together, while the distributions of the regional US database show higher dynamics for the low and medium speed parts and less pronounced for the high speed part. The distributions for the extra high speed parts are almost identical.
- The corresponding distributions for the candidate cycles show different trends.

Comparison between regions, low

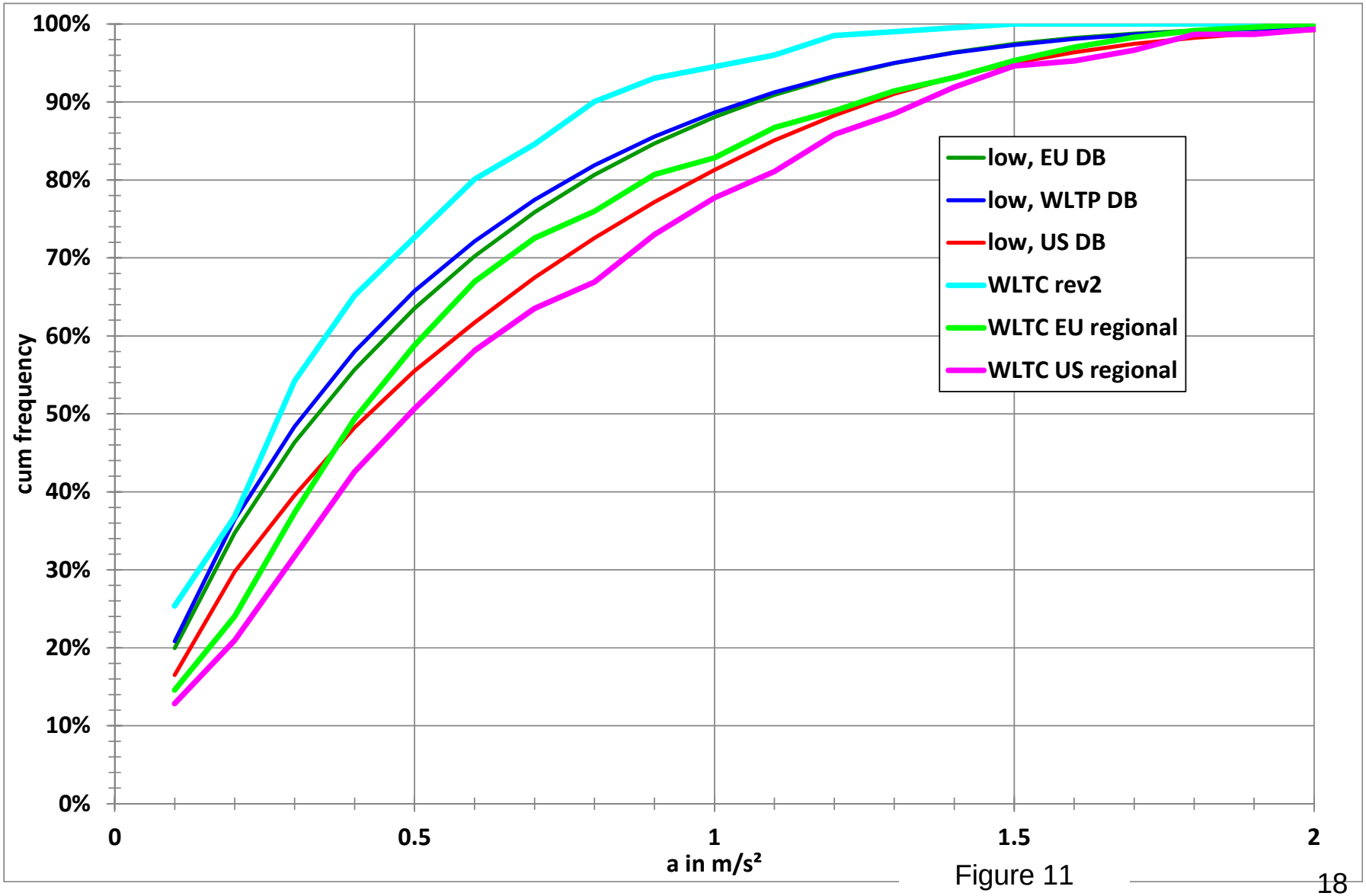

Figure 11

Comparison between regions, medium

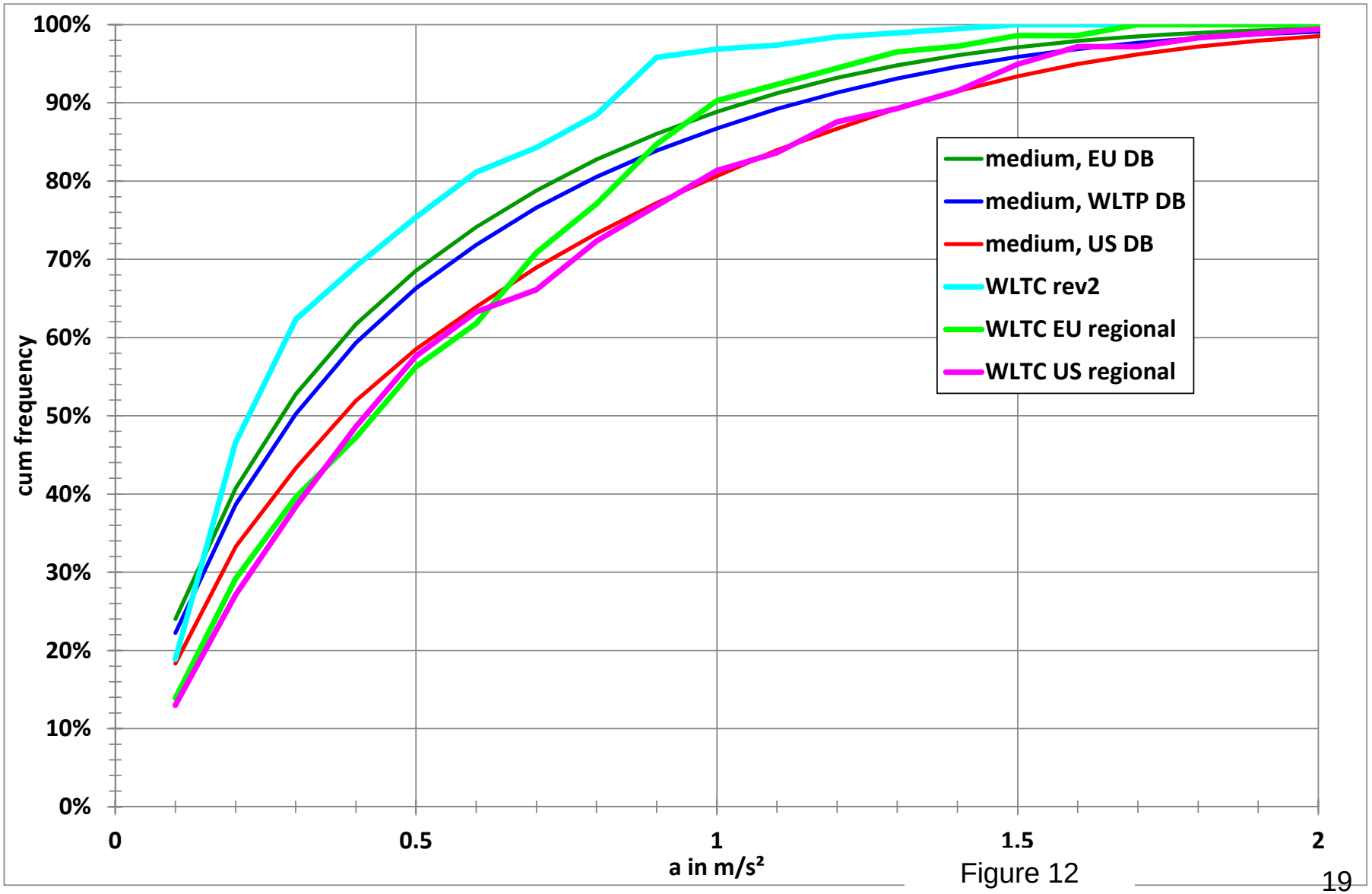

Figure 12

Comparison between regions, high

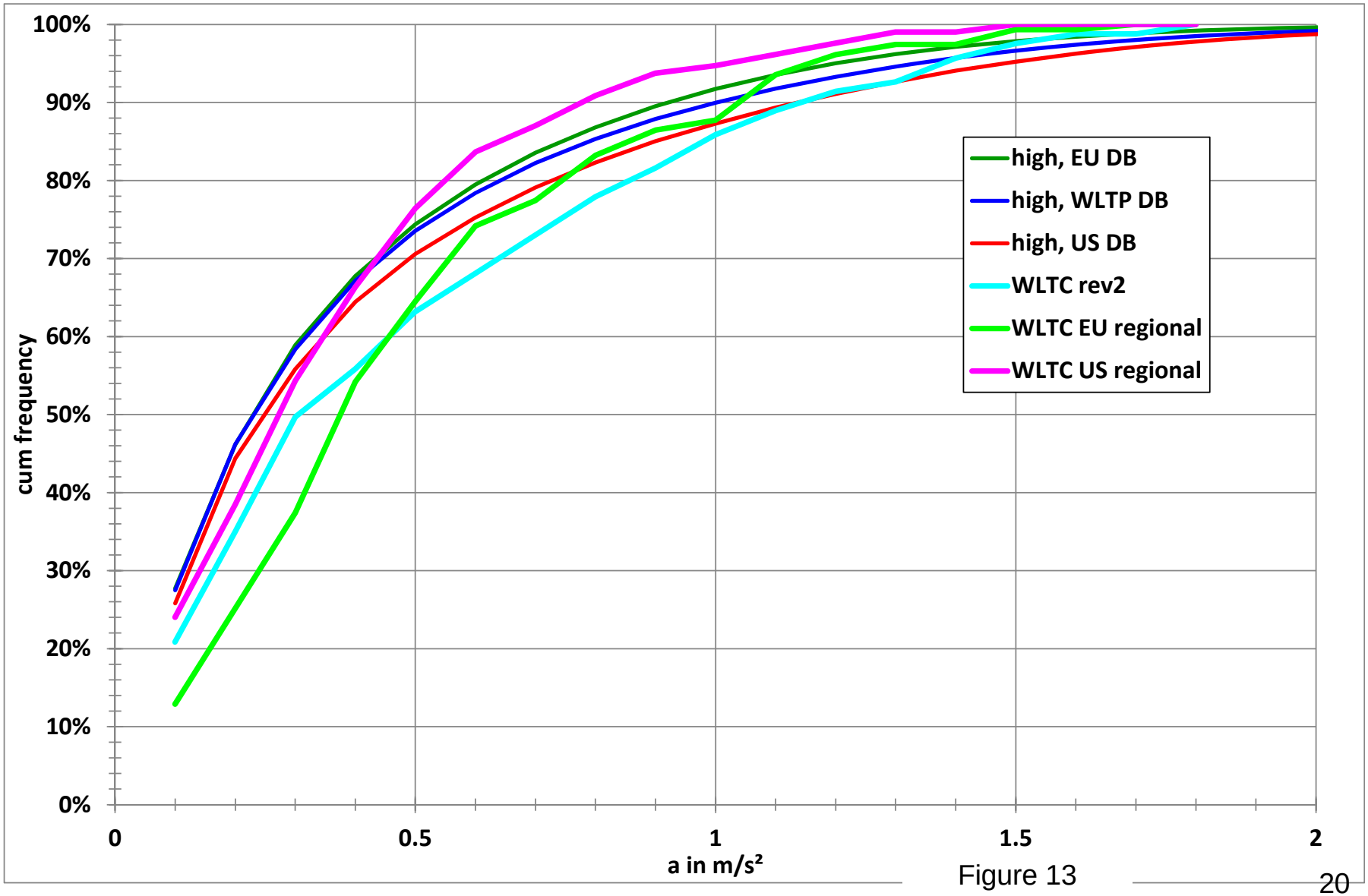

Figure 13

Comparison between regions, extra high

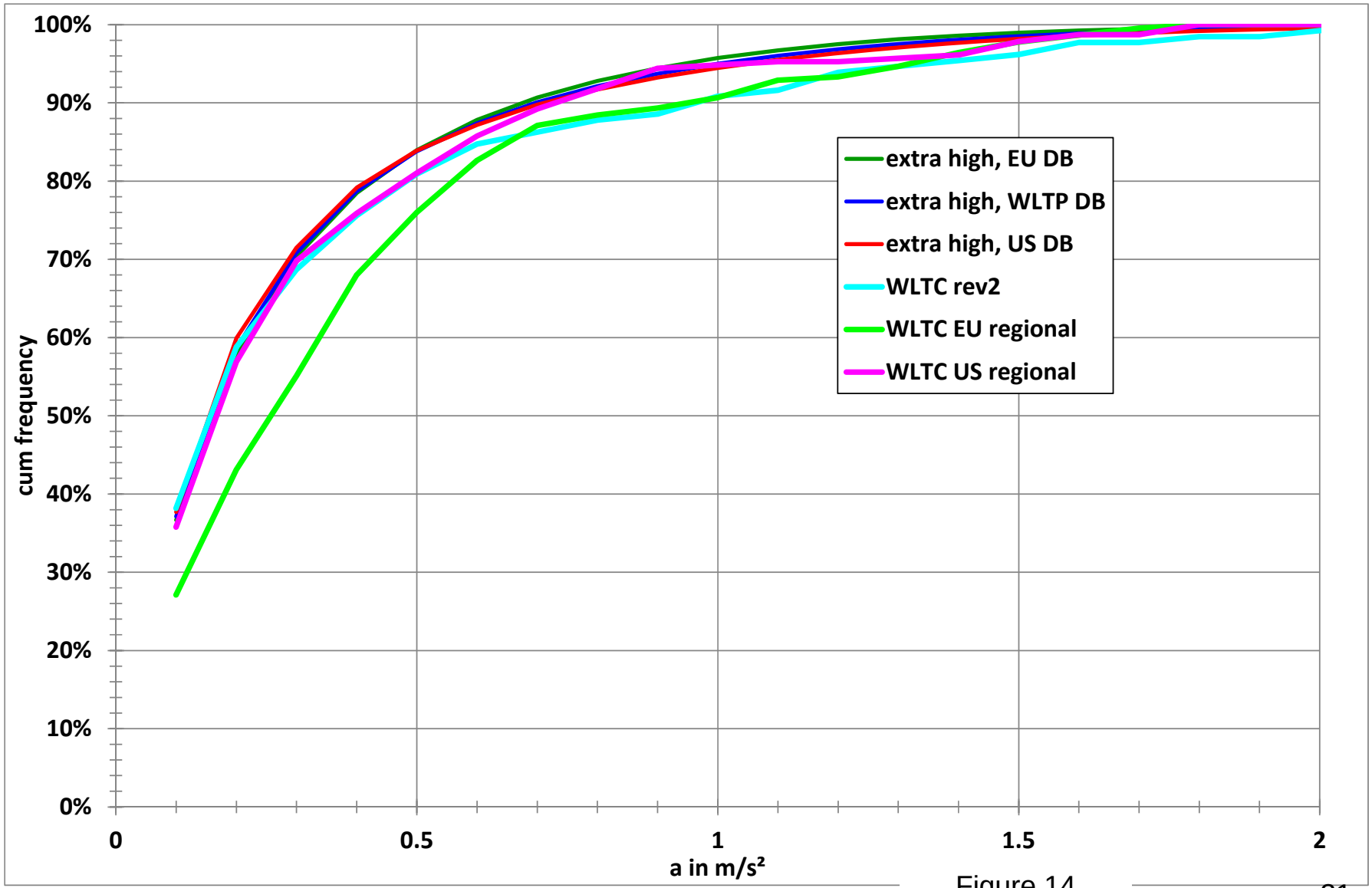

Figure 14

Observations, remarks, questions

- **In case of the low speed part the WLTC rev2 is less dynamic, the regional candidates are more dynamic compared to the database distributions.**
- **The results for the medium speed part show a different picture: WLTC rev2 once again less dynamic, EU regional in the lower acceleration area more dynamic, in the higher acceleration area good coincidence, US regional with an overall very good fit to the database.**
- **High speed part: WLTC rev2 and EU regional in the lower acceleration area more dynamic, in the higher acceleration area good coincidence, US regional less dynamic than the database.**
- **Extra high speed part: WLTC rev2 more dynamic in the middle, EU regional more dynamic and the US regional with a good fit to the corresponding database.**

Application of a modified approach

- These results underline the need for an alternative development approach.
- In a further step the cycle development approach was modified in that way that the v, a distributions were limited to positive accelerations only. An alternative cycle was then developed based on these distributions.
- Comparisons of the resulting acceleration distributions with the database distributions are shown in figures 15 to 18.
- In these figures two versions of the alternative cycle are shown: “original” and “modified”.
- “Modified” means, that the following modifications were applied to the original ST:
  - No decelerations within a ST below 10 km/h,
  - Accelerations were limited to +/- 2 m/s².

Comparison for pos. acc, low

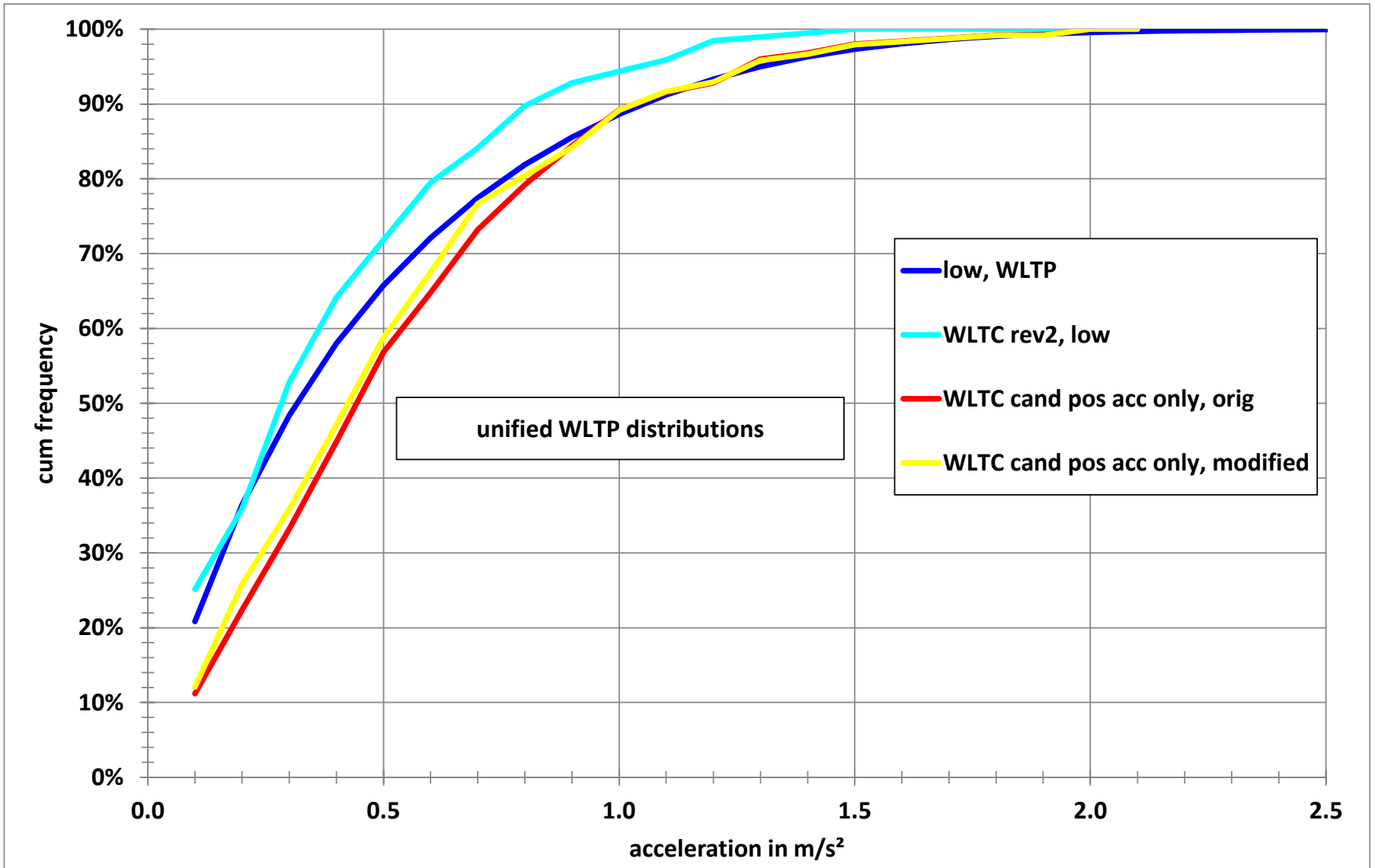

Figure 15

Comparison for pos. acc, medium

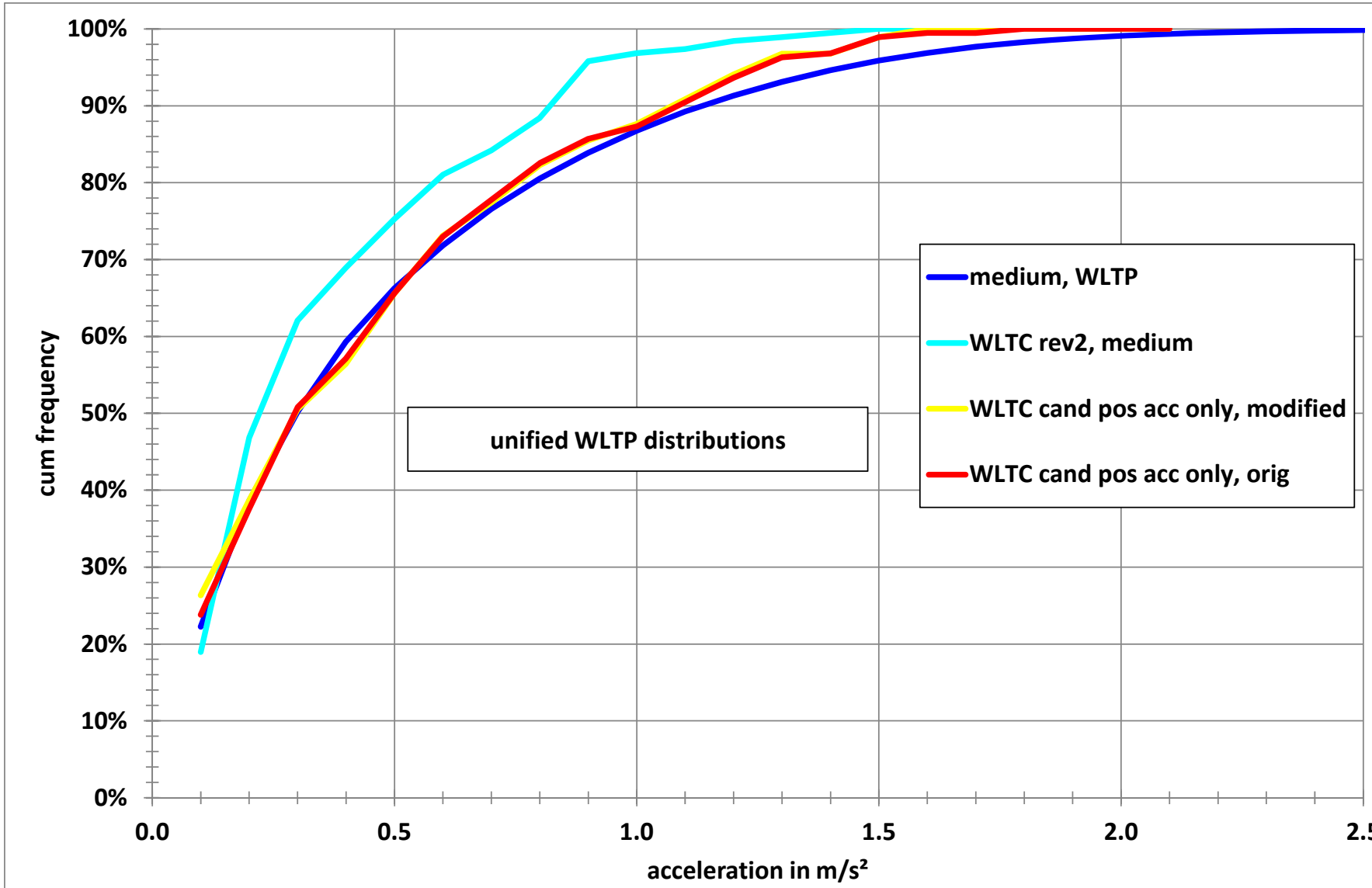

Figure 16

Comparison for pos. acc, high

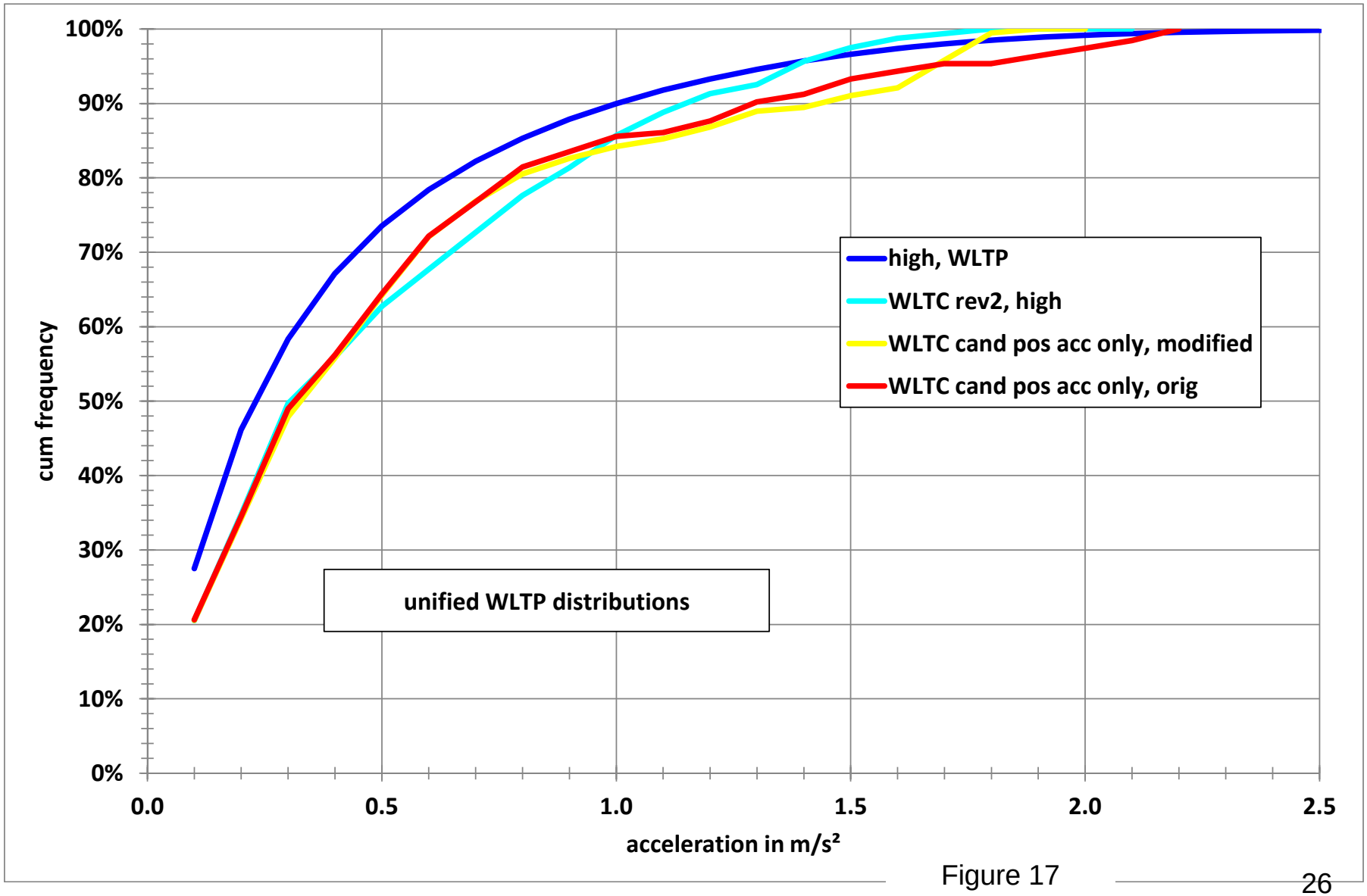

Figure 17

Comparison for pos. acc, extra high

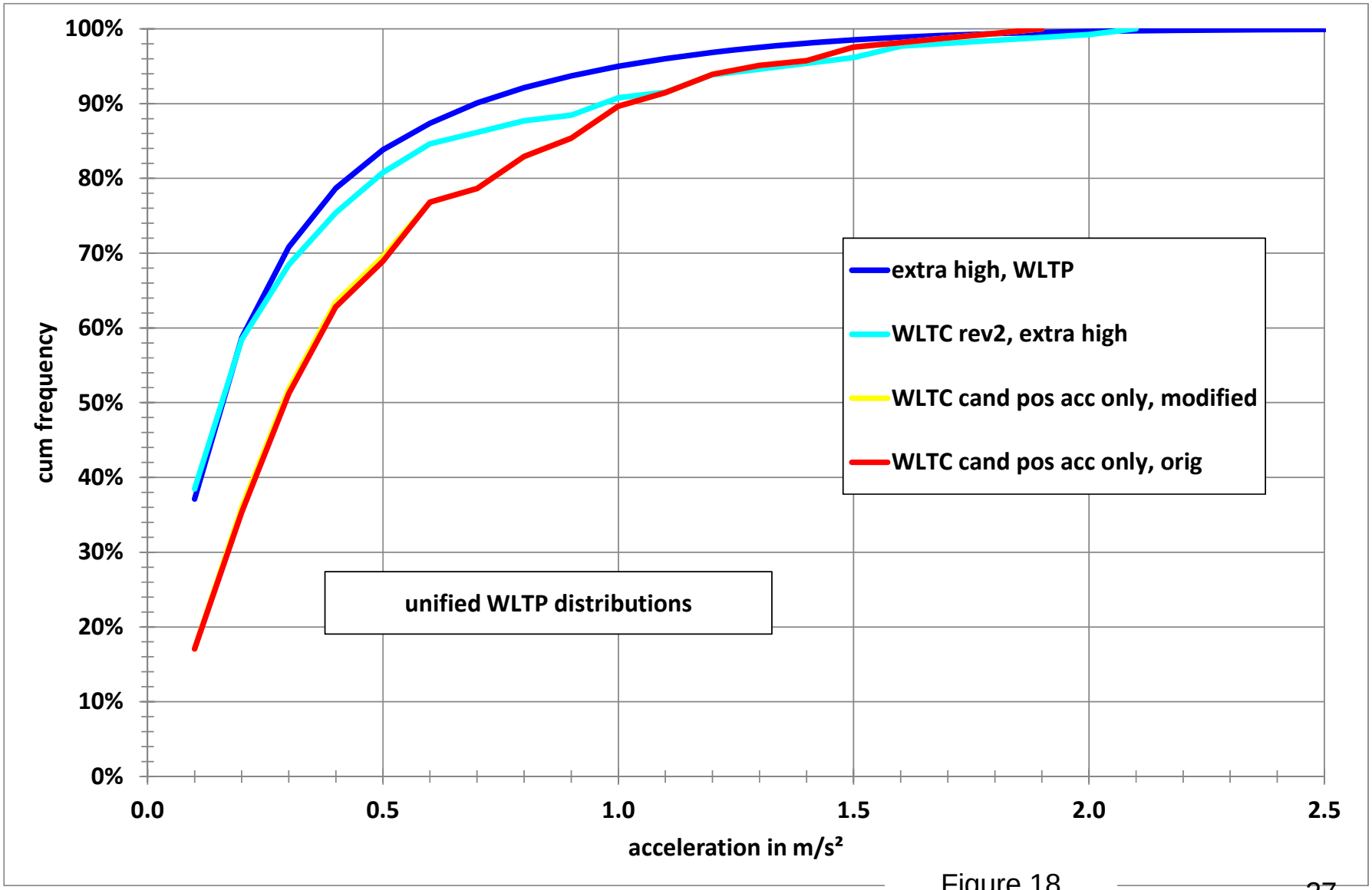

Figure 18

Application of a modified approach

- These modifications do not deteriorate the cycle dynamics but improve the driveability significantly.
- The acceleration distributions of the modified approach (consideration of only positive accelerations) for the low and medium parts fit significantly better to the database distributions than the WLTC rev2 distributions.
- For the high speed part the modified approach results in slightly higher dynamics than the WLTC rev2.
- The acceleration distribution of the modified approach are significantly more dynamic than the WLTC rev2 distribution and the corresponding database distribution.
- But as already stated in a previous presentation, alternative assessment criteria should be used for the extra high speed part, because - due to the time limitations – this part cannot cover the whole driving condition range of the database.

Conclusions, recommendations

- **The cycle development approach should be modified in that way that negative accelerations should be disregarded.**
- **The classification steps for the acceleration distributions should be smaller than 1 km/h/s (at least 0,5 km/h/s). A change to the m/s² unit and 0,1 m/s² steps would be even more preferable.**
- **It is highly recommended to include the v, v*a_pos distributions in the analysis and development process.**
- **It is recommended to modify the short trips in order to avoid driveability problems:**
  - **No decelerations within a ST below 10 km/h,**
  - **Limit accelerations to +/- 2 m/s².**

Conclusions, recommendations

- It is recommended to apply the original approach for the determination of the different short trip durations for the low speed part.
- This approach was already applied to the idling phases duration determination for WLTC rev2 in order to avoid too long idling phases.
- The same argument is also valid for the short trips. It would ease a better balance between the short trips and avoid too short ST.

Annex A, Key cycle parameter

- **The key cycle parameter for the WLTC rev2 and the EU and US regional candidate cycles are listed in the following tables.**

Comparison of key cycle parameter

speed class	duration in s			v_ave in km/h		
	WLTC rev2	EU cand	US cand	WLTC rev2	EU cand	US cand
low	589	620	375	18.2	20.3	20.1
medium	433	323	419	41.6	39.9	42.3
high	455	369	416	55.5	56.1	58.6
extra high	323	488	590	86.0	90.4	87.8

speed class	p_stop			number of ST		
	WLTC rev2	EU cand	US cand	WLTC rev2	EU cand	US cand
low	25.3%	19.0%	25.3%	5	6	5
medium	11.1%	8.6%	15.3%	1	1	3
high	6.6%	4.3%	6.7%	1	1	1
extra high	2.2%	1.4%	2.2%	1	1	1

Table 1

Comparison of key cycle parameter

speed class	a_max in m/s²			a_pos_ave in m/s²		
	WLTC rev2	EU cand	US cand	WLTC rev2	EU cand	US cand
low	1.47	1.65	2.10	0.47	0.49	0.61
medium	1.50	1.64	2.05	0.42	0.39	0.56
high	1.82	1.73	1.46	0.58	0.45	0.37
extra high	2.06	1.76	1.82	0.47	0.37	0.29

speed class	v*a_pos_ave in m²/s³			RPA in kWs(kg*km)		
	WLTC rev2	EU cand	US cand	WLTC rev2	EU cand	US cand
low	2.81	3.35	4.35	0.157	0.224	0.331
medium	4.38	4.51	6.53	0.148	0.166	0.256
high	6.73	5.45	5.60	0.138	0.187	0.181
extra high	9.22	7.82	5.98	0.117	0.157	0.118

Table 2