



# An open assessment tool for standardized performance measures of long combination vehicles

Bengt Jacobson (Chalmers),  
Sogol Kharrazi (VTI),  
Niklas Fröjd (Volvo GTT),  
Toheed Ghandriz (Volvo Technology & Chalmers), and  
Omar Bagdadi (Swedish Transport Agency)



Project behind this research:

# *Performance Based Standards II,* 2018-2021



- The project is one of many projects which have led to that Sweden will allow HCT (34.5 m, 74 ton) from 2023-12-01.
- The “OpenPBS” is an assessment tool which was developed in one of the project’s work packages.

Project partners:



---

**An open assessment tool for standardized performance measures of long combination vehicles**

by Bengt Jacobson, Sogol Kharrazi, Niklas Fröjd, Toheed Ghandriz, and Omar Bagdadi

2023-10-12 16:18, Slide 2

# Lastbils kalkylatorn (LBK), in use since 2017, for {25.25 m, 74 ton}

TRANSPORT STYRELSEN

## Lastbils kalkylator

Fordon **Tekniska data** Last Resultat

Steg 1 av 4

Första fordonet

Dragbil

Registreringsnummer (valfritt)

**URL312**

Fordonstyp

Dragbil

Andra fordonet

Link

Registreringsnummer (valfritt)

**DXB170**

Fordonstyp

Link

Tredje fordonet

Påhängsvagn

Registreringsnummer (valfritt)

**RCS736**

Fordonstyp

Påhängsvagn

Nästa

TRANSPORT STYRELSEN

## Lastbils kalkylator

Fordon **Tekniska data** Last Resultat

Steg 3 av 4

Dragbil

Axeltryck

Axel 1 **7** ton

Axel 2 **7** ton

Axel 3 **7** ton

Link ...and load heights per unit

Lasthöjd **4** m

Axeltryck

Axel 4 **7** ton

Bakre kopplingstryck 15,6 ton

Beräkna

## Beräkningsresultat

✓ Kombinationen uppfyller gränsvärdena

Kombination	PBS measure	Required Gränsvärde	Calculated Beräknat värde
Sidostabilitet	<b>SRT</b>	≥ 3.5 m/s <sup>2</sup>	3.5 ✓
Dämpning	<b>YD</b>	≥ 0.15	0.46 ✓
Bakåtförstärkning	<b>RWA</b>	≤ 2.4	1.2 ✓
Spåravvikelse	<b>HSTO</b>	≤ 0.40 m	0.14 ✓
Backtagning	<b>GA</b>	≥ 1.0 %	2.5 ✓

User gives registration numbers

User gives vertical loads per axle















...and load heights per unit

Present version of LBK handles only up to 25.25 m and 2 articulation points, and some PBS measures are missing.

An open assessment tool for standardized performance measures of long combination vehicles

by Bengt Jacobson, Sogol Kharrazi, Niklas Fröjd, Toheed Ghandriz, and Omar Bagdadi

# Motivation to HCT and PBS and Open assessment tool

	startability		Swept path		Rearward amplif. High speed off-tracking
	gradeability		Steer tyre friction demand		Yaw damping
	Acceleration capacity		Static rollover threshold		Handling quality
	Overtaking provision		Directional stability while braking		Cross-wind sensitivity
	Tracking ability Straight path		Ride quality		

*picture from HAN (Joop Pauwelussen)*

**PBS**

**HCT/LCV**



**Transport  
efficiency,  
including CO<sub>2</sub>**

*Some sort of  
agreement of how  
to assess PBS  
(such as the LBK  
and/or the  
OpenPBS tool)*

# OpenPBS is modelled for arbitrary number of units and 16 PBS measures



TECHNOLOGY  
CONVERGENCE 2023

Main motivation	PBS measure		Measure
	Name	Abbreviation	
Transport efficiency	Startability	SA	Uphill grade
Transport efficiency	Gradeability	GA	Uphill grade
Transport efficiency	Acceleration Capability	AC	Time
Safety	Braking Stability in a Turn	BST	Braking distance
Safety, yaw stability	Rearward Amplification	RWA	Yaw Velocity amplification from first to last unit
Safety	Yaw Damping	YD	Yaw Angle damping over oscillations on worst unit
Safety	High Speed Transient Off Tracking	HSTO	Off-tracking between first and last axle in ISO lane change

Safety	High Speed Steady State Off Tracking	HSSO	Off-tracking between first and last axle
Safety, roll-over	Load Transfer Ratio	LTR	Off-tracking between first and last axle
Safety, roll-over	Steady state Rollover Threshold	SRT	Lateral acceleration
Transport efficiency	Low Speed Swept Path	LSSP	Path width between wheels outer edges
Transport efficiency	Tracking Ability on a Straight Path	TASP	Off-tracking between first and last axle
Transport efficiency	Frontal Swing	FS	First unit front body reaching distance outside defined path
Transport efficiency	Tail Swing	TS	Last unit rear body reaching distance outside defined path
Transport efficiency	Friction demand on Steering Tyres	FDST	#Force in ground plane under steered axles
Transport efficiency	Friction demand on Drive Tyres	FDDT	#Force in ground plane under driven axles

**An open assessment tool for standardized performance measures of long combination vehicles**

by Bengt Jacobson, Sogol Kharrazi, Niklas Fröjd, Toheed Ghandriz, and Omar Bagdadi

2023-10-12 16:18, Slide 5

# Envisioned solution and top level requirements on an open PBS tool



## What does “open” mean?

- Readable
- Understandable
- Free of charge

## Requirements:

- PBSs **independent** of Vehicles (A-double, B-double, ...)
- Vehicles specifications (“parameters”) **independent** of Vehicle models (“equations”)
- **Standard** format for dynamic models
- Dynamic models deducted from well-established **physical laws** (to facilitate additions which can handle future novel technologies such as propulsion on trailing units)

## Design decisions:

The tool (model library) was structured in:

- **Manoeuvres**, each incl. definitions of one or some **PBS measures**
- **Vehicle specifications** (vehicle parameters)
- **Vehicle models** (equations)

The tool was written in the standardized (and simulation tool independent!) format for dynamic models: **Modelica**

# Two “front-ends”

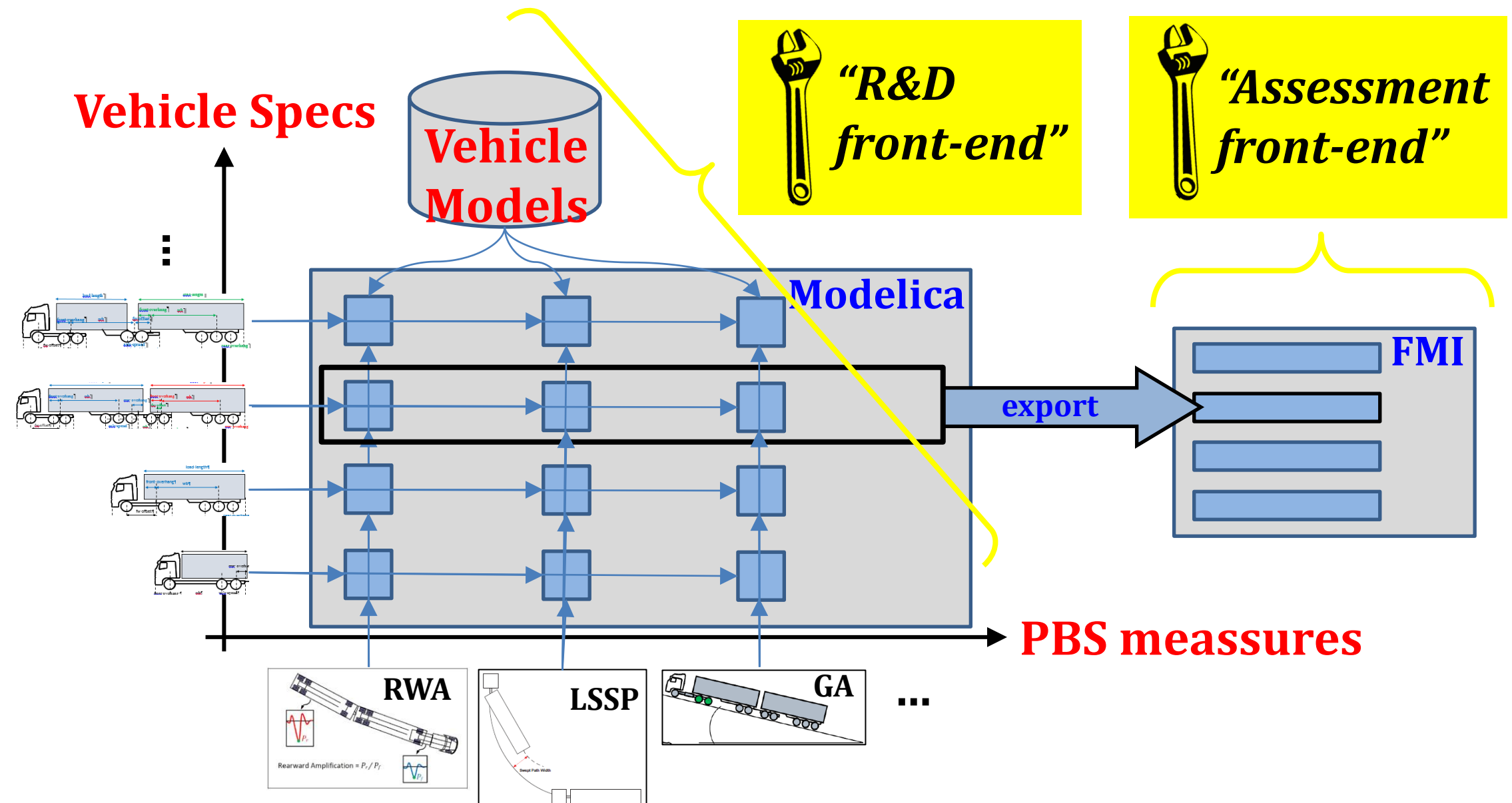
## For whom could the tool be useful?

Our vision: World-wide: Transport operators, Drivers, Vehicle manufacturers, Police, Authorities

## Who use LBK today?

Limited to Sweden. Transport operators, to some extent Police, Authorities, Truck manufacturers, and Trailer manufacturers

Now, the different use cases require different “front-ends”.



# What will happen to OpenPBS?



- The research project is now concluded.
- A functioning OpenPBS tool is delivered (and made available open on the web).
  - It is waiting on computer/web solutions set ups to find out if it can be the base of a next generation of LBK in Sweden
  - It is also occasionally used in new research projects for novel technology, such as propulsion on trailing units.
- So: No strong effort on maintenance or updates is in place. We welcome anyone who wants to try it or develop further...

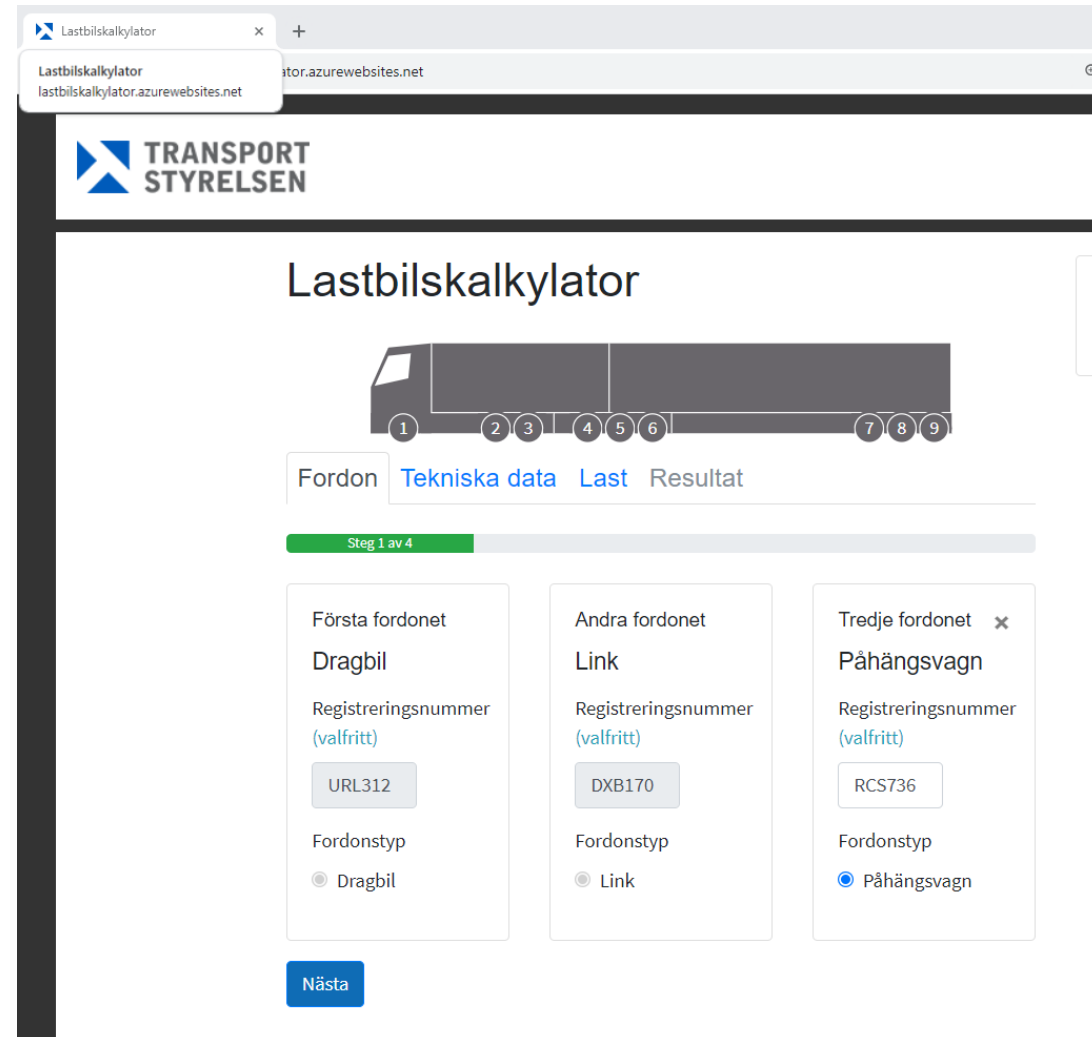


# Thanks for your attention

Bengt Jacobson (Chalmers),  
Sogol Kharrazi (VTI),  
Niklas Fröjd (Volvo GTT),  
Toheed Ghandriz (Volvo Technology & Chalmers), and  
Omar Bagdadi (Swedish Transport Agency)



# Prepared question 1 (Question to audience!)



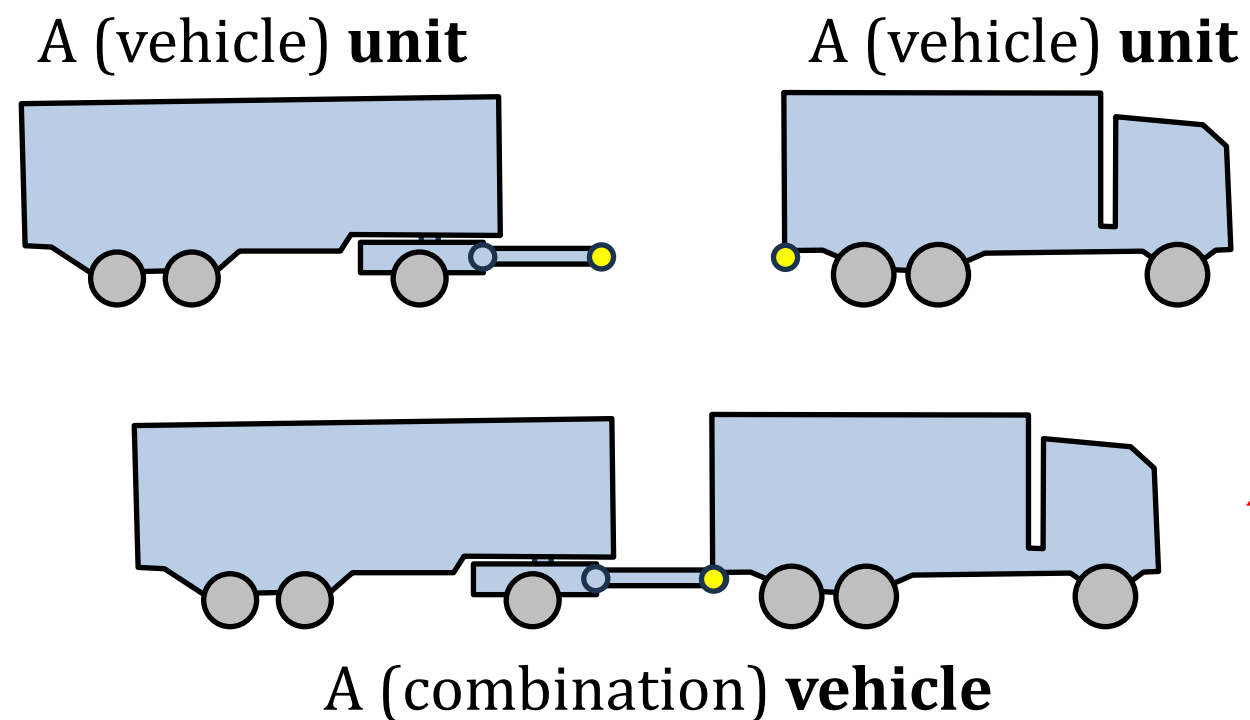
The screenshot shows a web browser window with the URL `lastbils kalkylator.azurewebsites.net`. The page header features the logo for "TRANSPORT STYRELSEN". The main heading is "Lastbils kalkylator". Below the heading is a truck icon with numbered axles (1-9). There are four tabs: "Fordon", "Tekniska data", "Last", and "Resultat". A progress bar indicates "Steg 1 av 4". The form is divided into three columns for "Första fordonet", "Andra fordonet", and "Tredje fordonet". Each column has a dropdown for vehicle type, a text input for registration number, and a dropdown for vehicle type. The "Första fordonet" is a "Dragbil" with registration number "URL312". The "Andra fordonet" is a "Link" with registration number "DXB170". The "Tredje fordonet" is a "Påhängsvagn" with registration number "RCS736". A "Nästa" button is at the bottom left.

Q: Are there other examples of similar “digital services” as Lastbils kalkylatorn in other countries? Experiences?

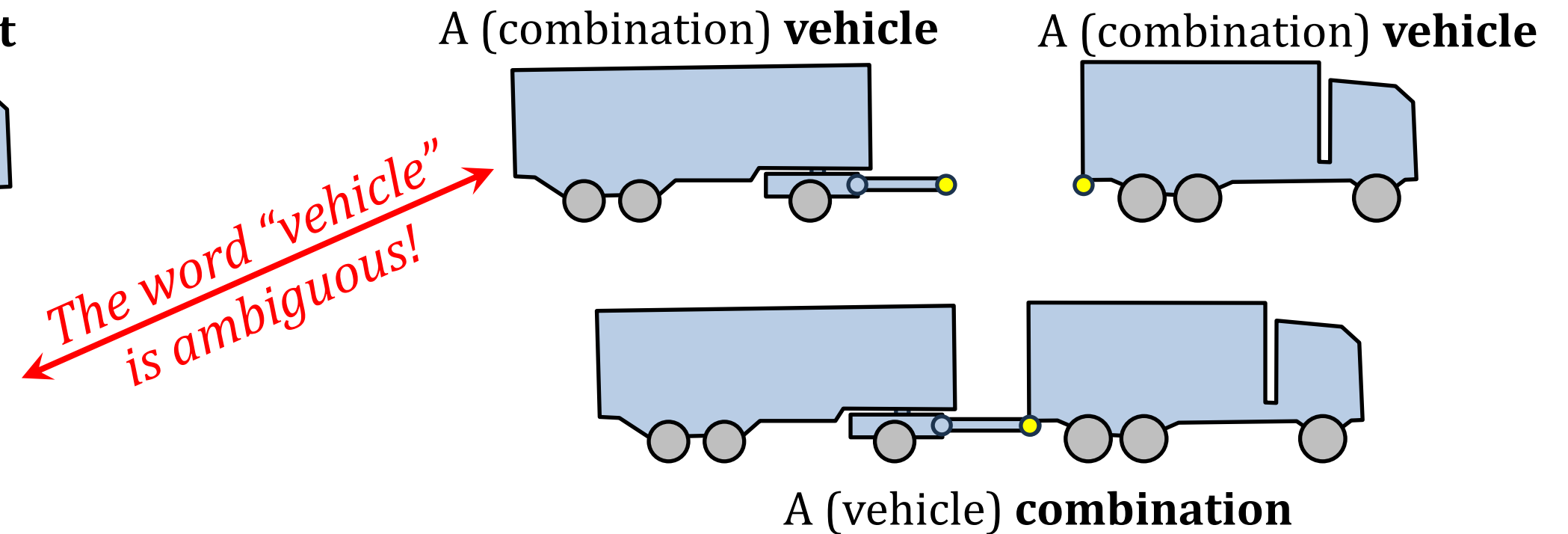
# Prepared question 2

(Question to audience!)

## Alternative 1



## Alternative 2



*The word "vehicle" is ambiguous!*

**Q: Which alternative do you use?**