



Verification of detection range (55 m for L3)

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Verification of detection range(55m)

- Before making a decision about sensor requirement which covers minimum distance and minimum operation speed, **we need to make sure that min. detection range(55m for L3) is a logically calculated value.**
 - As we know, we have been discussing ‘sensor detection range’ for 3 times of ACSF meetings.
 - Despite the number of meetings with much discussion and elapsed time, the conclusion (55m for L3) is little confusing.
 - Therefore, ROK would like to provide this document for summarization of flow of ACSF meeting proceedings so far.
 - Let’s review it now.

The previous history

ACSF-12-09 by UK and Secretary (page 5)	ACSF-13-15 by OICA&CLEPA (page 6)																				
<p>Radar reflection performance of the vehicle Vehicle integration Tolerance and ageing of components Environmental conditions (rain, snow, dirt etc.)</p> <p>Physics:</p> <p>Typical* Radar Cross Section values:</p> <table border="1"> <tr> <td>Passenger car:</td> <td>~ 10 dBm²</td> </tr> <tr> <td>Motorcycle:</td> <td>~ 5 dBm²</td> </tr> <tr> <td>(Pedestrian:</td> <td>~ 1 dBm²)</td> </tr> </table> <p>*: Reflection value may vary due to design of the vehicle („stealth design“)</p>	Passenger car:	~ 10 dBm ²	Motorcycle:	~ 5 dBm ²	(Pedestrian:	~ 1 dBm ²)	<p>Sensor range Proposal: Type Approval</p> <table border="1"> <tr> <td>Value (best) incl simple bumper</td> <td>70 m</td> </tr> <tr> <td>-10% for test</td> <td>63 m</td> </tr> <tr> <td>ageing</td> <td>3dB (acc. Developm. 4.5 dB)</td> </tr> <tr> <td>Environment</td> <td>4dB (acc. Developm. 5 dB)</td> </tr> <tr> <td>Bumper</td> <td>- dB</td> </tr> <tr> <td>Sum</td> <td>7dB -34%</td> </tr> <tr> <td></td> <td>41,58 m</td> </tr> </table> <p>Basis: 63m, but for M1 vehicles!</p> <p>Asumption: Difference in detection range L3 vs. M1 is 15%</p> <p>Calculated Sensor range for L3 vehicle: 63m - 15% = 54m</p> <p>C1-system can be approved, if an object (e.g. M1 vehicle) is detected in a sensor range of > 63m</p>	Value (best) incl simple bumper	70 m	-10% for test	63 m	ageing	3dB (acc. Developm. 4.5 dB)	Environment	4dB (acc. Developm. 5 dB)	Bumper	- dB	Sum	7dB -34%		41,58 m
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<p>ACSF-14-04 paragraph 5.6.5.8.1</p>																					
<p>The ACSF Category [C1] shall be able to detect vehicles approaching from the rear in an adjacent lane up to a distance as specified below:</p> <ul style="list-style-type: none"> • 63m for a regular high volume series production passenger car of category M1 AA saloon, • 55m for a regular high volume series production vehicle of category L3, other than sub-category L3-A1. <p>JUSTIFICATION: See ACSF-13-15</p>																					



Logical Verification

Question

Q. What's the base Assumption(Difference in Detection range L3 vs. M1 = 15%) ?

Consider the base assumption in two ways.

First, If the difference was not based on RCS, there should be reasonable grounds.

Second, If the difference was just based on RCS... the result is abnormal when reviewed.
variable

This below is basic radar equation.

$$\mathbf{1} \quad R_{\max} = \sqrt[4]{\frac{P_S \cdot G^2 \cdot \lambda^2 \cdot \sigma}{P_{E_{\min}} \cdot (4\pi)^3}}$$

R_{\max} = Detection range [m], σ = Radar Cross section of Target [m^2]

P_S = transmitted power [W], G = antenna gain, λ = wave length
 $P_{E_{\min}}$ = received power

constant

If we replace constant terms with K, this can be simplified as $R_{\max} = K * \sigma^{0.25}$

2

→ Detection range \propto (RCS of Target) $^{0.25}$

※ Unit of Detection range = [m] , Unit of RCS = [m^2]



Logical Verification

Question (Continued)

→ Calculate Detection range of M1 & L3 with equation and values in following table.

Radar Equation	RCS value of L3, M1
1 Detection range[m] $\propto (RCS [m^2])^{0.25}$	L3 : $5dBm^2$, M1: $10dBm^2$

▶ 1st Step (Unit conversion of RCS ($dBm^2 \rightarrow m^2$))

- The difference of RCS[dBm^2] between L3 and M1 : $5dBm^2$

2 $\rightarrow 10 \log \left(\frac{L3 \text{ RCS}[m^2]}{M1 \text{ RCS}[m^2]} \right) = -5$ **3** $\rightarrow \text{RCS}[m^2] \text{ of L3} \approx 0.3162 * \text{RCS}[m^2] \text{ of M1}$

▶ 2nd Step (Put this RCS in a Radar Equation)

4 \rightarrow Detection range of L3 = $(0.3162)^{0.25} * \text{Detection range of M1} \approx 0.75 * \text{Detection range of M1}$

\rightarrow So, the difference in Detection range L3 vs. M1 is **25%**, not 15%

※ If the RCS of M1 and L3 were $10m^2$ and $5m^2$, 15% is correct according to $(0.5)^{0.25} \approx 0.84$



Suggestion

The illogical sentence should not be accepted in this Regulation.

Even if lots of discussions have been made, especially the wrong calculation results, we have to reconsider by giving the following options

< Solution A >

Srear : 55m → 48m(25% ↓ against 63m for M1)

< Solution B >

Remain Srear as 55m but, **agree with 7dBm^2 of L3 RCS**

**Solution A ? Solution B ?
Else(i.e. No the further discussion) ?**