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0.2.0 20-03-2023	5.3.1.3 6.1.1.2 6.2, 6.2.1.1 6.4.4.1 6.4.4.2 6.4.1.5 6.4.4.9 6.4.5.1 7.4.1 7.4.2 Table 4 Table 7 Table 8	Implementing EECT#94 and EECT#95 comments: ● “ATO state” returned to be consistent with SS-125 (rejected former OCORA request to use “ATO status” to align with ETCS vocabulary) ● mistakes corrected: “brake effect” and “...brEff” abbreviation remain in few cases instead of correct “brake feedback” and “..brFB”. ● References added or corrected	UNISIG ATO WP
1.0.0 05-07-2023	None	Baseline 1 1st release	UNISIG ATO WP

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5 INTRODUCTION

5.1 Scope and purpose of the document

5.1.1.1 The scope of this document covers the signals exchanged between ATO-OB and Rolling stock in order to control traction, brakes and doors. Other functionalities (like passenger information system control) are not covered by this document.

5.1.1.2 The purpose of this document is to define a standardised ATO-OB / Rolling stock interface at application level to support ERTMS/ATO.

5.1.1.3 The scope of this document is the definition of the standardised set of data to transmit between the ATO-OB and Rolling stock to support ERTMS/ATO.

5.1.1.4 The high level requirements related to this interface are included in [Ref 1].

5.1.1.5 Requirements applicable to rolling stock regarding lower communications layers are specified in [Ref 8].

5.2 Applicable and reference documents

Ref. N°	Title	Reference
[Ref 1]	ERTMS/ATO System Requirement Specification	SUBSET-125
[Ref 3]	Information transmission in the train (train bus) - General dispositions	UIC 556
[Ref 4]	Glossary of Terms and Abbreviations	SUBSET-023
[Ref 5]	European Commission Regulation - TSI LOC&PAS	1302/2014
[Ref 6]	ERTMS/ATO GLOSSARY	13E154
[Ref 7]	SAE Truck and Bus Control Communications Network	SAE J1393 standard
[Ref 8]	CCS Consist Network Communication Layers	SUBSET-147
[Ref 9]	Technical Application Profile – Doors – FOC	CTA2-T1.2-T-BTD-069-03
[Ref 10]	Railway applications - Braking - Requirements for the brake system of trains hauled by locomotives	EN 14198
[Ref 11]	Railway applications - Braking systems of multiple unit trains	EN 16185

Table 1: Referenced Documents

5.3 Abbreviations and Definitions

5.3.1.1 For ATO abbreviations and definitions see ERTMS/ATO glossary [Ref 6].

5.3.1.2 For ETCS abbreviations and definitions see SUBSET-023 [Ref 4].

5.3.1.3 Definitions

1	train brake request / train brake feedback	the signals for train (indirect) brake control: request / feedback signals Note 1 These values indicate the pressure drop in the brake pipe as a percentage of maximum pressure drop for full service brake application. For suppressing the transient effects during brake application and releasing processes, the feedback variable refers to pressure in equalising reservoir of brake control valve. Note 2: the name “train brake” is used intentionally as its synonym “indirect brake” may be confused with “direct brake”, especially in verbal communication.
2	side selective door control	the doors on left and right sides of the train can be controlled independently – see [Ref 5] clause 4.2.5.5.6
3	Propulsion	Vehicle equipment related to traction and (optionally dynamic brake force generation). Note: in electric vehicle, the propulsion consists of traction converters and traction engines. In diesel vehicles, it consists of diesel engine(s) and transmission system(s) - gear-box(es) or traction generator(s), traction converter(s) and traction engine(s), according to vehicle type.
4	set (signal is set)	logical signal is in active (TRUE) level
5	reset (signal is reset)	logical signal is in inactive (FALSE) level

Table 2: Definitions

5.3.1.4 Abbreviations used in this document in the tables below:

1	Dir	Direction
2	Bool	Boolean (binary) signal
3	Bitset	A set of binary signals that are transmitted together
4	Num	Numeric signal (continuous value)
5	Enum	Enumerated (limited set of values)
6	Enum4, Enum8	Enumerated (limited set of values) - with indication of physical length of the variable (4-bit or 8-bit number)
7	MAXNUM, -MAXNUM	Maximum (positive respectively negative) displayable number within given data type (e.g. 255 for UINT8, +127 / -128 for INT8 etc.) Note: This formal value is used when defining special or spare values of the variable and the exact value itself is not important.

Table 3: Abbreviations

6 ATO-OB / ROLLING STOCK FUNCTIONAL INTERFACE SPECIFICATION

6.1 General

6.1.1.1 This chapter describes the functional requirements on all information, which is exchanged between ATO OB and Rolling stock via this Interface.

6.1.1.2 With reference to the ATO OB / Rolling stock Interface:

Input is defined as data flow from Rolling stock to ATO OB
Output is defined as data flow from ATO OB to Rolling stock

6.1.1.3 Rolling stock shall send all input signals to ATO continuously, independently of the ATO state as required in chapter 7 of this document.

6.1.1.4 Every project to which this specification is applied shall take the measures necessary to ensure that the risk of an incident occurring with ATO in operation is controlled

6.1.1.5 Other Rolling stock requirements are given in SS-125 [Ref 1] chapt. 6.3.1.

6.2 ATO state

6.2.1.1 The ATO state information is listed in Table 4:

	Signal	Dir	Type	Description	SS-125
1	ATO state	Out	Enum	Values NP,CO,NA,AV,RE,EG,DE,FA correspond to particular states of ATO-OB.	9

Table 4: The ATO state signal

6.2.1.2 Rolling stock requirement: The Rolling stock uses ATO state signal to decide which ATO-OB output signals from the list of ATO active functions will be followed (see table 8 “ATO-OB Active Functions table” of SS-125 [Ref 1])

6.3 Traction Control

6.3.1.1 The Traction control signals are listed in Table 5. The more detailed description of signals is in Appendix 1 of this Subset:

	Signal	Dir	Type	Description	SS-125
1	Relative traction / brake request *)	Out	Num	Percentage of traction/brake capability of the train. Range: 0 .. +100% (full traction) Note: negative values of this signal are used for brake control (see 6.4.2.1 and 6.4.3.1)	9.7 7.1.5.13 7.1.5.15 7.1.5.17
2	Traction request **)	Out	Bool	Supporting control signal for traction control	as above

3	Traction ready	In	Bool	All conditions for applying the traction are fulfilled - propulsion ready, brakes released (etc.).	as above
4	Train applicable conditions	In	Bool	All vehicle conditions for ATO-OB engagement are fulfilled	9.1.2.1 9.1.2.2
5	Traction applied ***)	In	Bool	Propulsion reports that traction is applied	7.1.5.4
6	T/B set value	In	Num	Current value of Rolling stock's traction/brake control signal +)	7.1.5.4

Table 5: The Traction / Dynamic brake control signals

*) equivalent to UIC 556 [Ref 3] signal *Traction target v*alue: telegram R1, octet 49 + 50, signal 4.23/1;
**) equivalent to UIC 556 [Ref 3] signals *Prepare for running*: telegram R1, octet 48, bits 2 + 3, signal 4.34/1;
***) corresponds to *Driveline engaged* signal according to [Ref 7]
+) see [Ref 3] App. A, ser. n. 4.23 and 4.24

6.3.1.2 Note: ATO-OB uses the above mentioned output signals to command the Rolling stock for realizing the ATO-OB's requests on traction capabilities of the train.

6.3.1.3 Note: ATO-OB uses the above mentioned ATO-OB's input signals to manage engagement and traction control.

6.3.1.4 Note: Signals from Table 5 lines 2 to 5 are described in detail in Appendix 1.

6.3.1.5 **Relative traction/brake request definition:** The interpretation of the requested value is related to a **speed independent maximum available force** value (further also "reference force"). (Table 12 / Fig. 1).

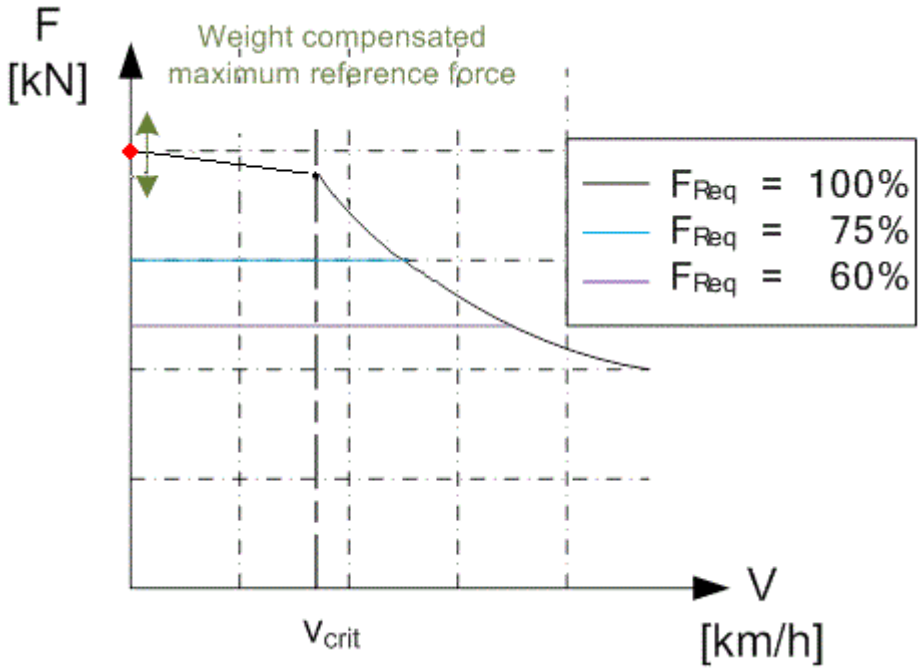


Figure 1: The interpretation of *Relative traction/brake request* signal in Traction

6.3.1.6 Rolling stock requirement:
For C-type trains:

- the payload compensation shall be performed by the vehicle itself by varying the reference force input to ATO-OB, e.g. lowering the value if the vehicle is empty;
- the reference force varies only over the current payload;

For both S-type and C-type trains:

- the Rolling stock shall calculate the requested force applied to the vehicle as the product of the reference force multiplied by the Relative traction/brake request value as commanded by the ATO-OB, but limited with the current available speed dependent force value.

6.3.1.7 Rolling stock requirement: The conversion of *Relative traction/brake request* signal to vehicle-specific control signals shall be done in Rolling stock (this requirement shall be also applicable on chapters 6.4.2 and 6.4.3 which describe the vehicle behaviour for negative values of this signal).

6.3.1.8 Rolling stock requirement: The input signals *Traction ready, Traction applied,* shall be summarized over the whole trainset. It means when at least one propulsion in the train reports this signal as TRUE, Rolling stock shall report it as TRUE to ATO-OB as well.

6.3.1.9 Rolling stock requirement: Rolling stock is allowed to request other conditions for ATO-OB engagement, all these conditions are included in *Train applicable conditions* signal. If Rolling stock does not request any additional condition, it shall set this signal to TRUE constantly.

6.4 Brake control

6.4.1 Train brake information (S-type and C-type trains)

6.4.1.1 The basic information about train brake status is listed in Table 6:

	Signal	Dir	Type	Description	SS-125
1	EB released	In	Bool	Emergency brake application is not indicated	9.1.1.1
2	Traction over brake enabled	In	Bool	Possibility to request the traction even if service brake is applied in accordance with second note of LOC&PAS TSI 1302/2014 4.2.4.4.2.	7.1.5.21
3	Traction over brake request	Out	Bool	Request for allowing traction even if service brake is applied (e.g. hill start managed by ATO-OB).	as above

Table 6: The pneumatic brake status information (S-type and C-type trains:)

6.4.1.2 Note: The *EB released* signal is used by ATO-OB to determine operational conditions (see [Ref 1] §9.1.1.1 b).

6.4.1.3 Rolling stock requirement: The *Traction over brake enabled* signal is mandatory if function needing such signal, for example “brake cleaning mode (e.g. snow brake)” or “hill start”, is included in Rolling stock.

6.4.1.4 Note: The *Traction over brake enabled* signal is used for informing ATO-OB about that ATO-OB is authorised to traction even if train brake is not completely released.

6.4.1.5 Note: If the Rolling stock indicates an applied train brake (“*Train brake feedback*” signal), ATO-OB shall be able to request for traction only if “*Traction over brake enabled*” signal is set.

6.4.1.6 Note: ATO-OB uses *Traction over brake request* signal to inform Rolling stock that ATO-OB intentionally wants to request the traction even if the train brake is still applied.

6.4.1.7 Rolling stock requirement: if ATO-OB requests for traction over brake using *Traction over brake request* signal, Rolling stock shall set the *Traction over brake enabled* signal if there are no conditions for rejecting this ATO-OB request.

6.4.2 Service Brake Control (C-type trains)

6.4.2.1 The Service brake control signals for C-type trains are listed in Table 7. The more detailed description of signals is in Appendix 1 of this Subset:

	Signal	Dir	Type	Description	SS-125
1	Relative traction / brake request *)	Out	Num	Percentage of brake capability of the train. Range: -100% (full service brake) .. 0 Note: positive values of this signal are used for traction control (see 6.3.1.1)	9.7 7.1.5.1 7.1.5.4
2	Brake request **)	Out	Bool	Supporting control signal for brake control	as above
3	Dynamic brake available	In	Bool	Availability of Dynamic brake	as above
4	Dynamic brake ready	In	Bool	All conditions for applying the dynamic brake are fulfilled. If this signal is active, then ATO-OB is allowed to request the dynamic brake.	as above
5	Dynamic brake applied ***)	In	Bool	Rolling stock reports that dynamic brake is applied.	as above
6	Brake applied	In	Bool	Rolling stock reports that dynamic, pneumatic (service) or blending brake is applied.	as above
7	Dynamic brake inhibition	Out	Bool	The use of dynamic brake (including brake blending) is not allowed	7.1.5.25

Table 7: The Brake control signals - C-type trains

6.4.2.2 *) equivalent to UIC 556 [Ref 3] signal *Traction target v*alue: telegram R1, octet 49 + 50, signal 4.23/1;
**) equivalent to UIC 556 [Ref 3] signals *Prepare for braking*: telegram R1, octet 48, bits 2 + 3, signal 4.34/1;
***) corresponds to *Driveline engaged* signal according to [Ref 7].

6.4.2.3 Note: ATO-OB uses the above mentioned output signals to command the Rolling stock for realizing the ATO-OB's requests on brake capabilities of the train.

6.4.2.4 Note: ATO-OB uses the above mentioned ATO-OB's input signals to manage the brake control.

6.4.2.5 Note: the feedback information on brake effect is given in *T/B set value* information.

6.4.2.6 Note: Signals from Table 7, lines 2 to 6, are further described in detail in Appendix 1.

6.4.2.7 Rolling stock requirement: The input signals *Dynamic brake available, Dynamic brake ready* and *Dynamic brake applied* shall be summarized over the whole train. It means when at least one propulsion in the train reports this signal as TRUE, Rolling stock shall report it as TRUE to ATO-OB as well (see 6.3.1.8).

6.4.2.8 Rolling stock requirement: In case of C-type trains, there is only one signal for common control of pneumatic and dynamic brakes. The -100% request shall be interpreted as a request on full service brake, whereby "full service brake" is referencing the maximum available service brake force, regardless by which type of brake (pneumatic, dynamic, both) it is realized. The maximum available service brake force is adapted by the rolling stock to the actual vehicle weight (assuming the payload is within the design criteria of the vehicle), if applicable.

6.4.2.9 Rolling stock requirement: if Rolling stock receives the *Dynamic brake inhibition* signal, it shall disable brake blending and shall not use dynamic brake at all.

6.4.3 Dynamic Brake Control (S-type trains)

6.4.3.1 The dynamic brake control signals for S-type trains are listed in Table 8. The more detailed description of signals is in Appendix 1 of this Subset:

	Signal	Dir	Type	Description	SS-125
1	Relative traction / brake request *)	Out	Num	Percentage of dynamic brake capability of the train. Range: -100% (full brake) .. 0 Note: positive values of this signal are used for traction control (see 6.3.1.1)	9.7 7.1.5.1 7.1.5.4
2	Dynamic brake request **)	Out	Bool	Supporting control signal for dynamic brake control	as above
3	Dynamic brake available	In	Bool	Availability of Dynamic brake	as above
4	Dynamic brake ready	In	Bool	All conditions for applying the dynamic brake are fulfilled. If this signal is active, then ATO-OB is allowed to request the dynamic brake.	as above
5	Dynamic brake applied ***)	In	Bool	Propulsion reports that dynamic brake is applied.	as above
6	Dynamic brake inhibition	Out	Bool	The use of dynamic brake (including brake blending) is not allowed	7.1.5.25

Table 8: The dynamic brake control signals - S-type trains:

6.4.3.2 *) equivalent to UIC 556 [Ref 3] signal *Traction target v*alue: telegram R1, octet 49 + 50, signal 4.23/1;
**) equivalent to UIC 556 [Ref 3] signals *Prepare for braking*: telegram R1, octet 48, bits 2 + 3, signal 4.34/1;
***) corresponds to *Driveline engaged* signal according to [Ref 7].

6.4.3.3 Note: ATO-OB uses the above mentioned output signals to command the Rolling stock for realizing the ATO-OB's requests on dynamic brake capabilities of the train.

6.4.3.4 Note: ATO-OB uses the above mentioned ATO-OB's input signals to manage dynamic brake control.

6.4.3.5 Note: signals from Table 8, lines 2 to 5, are described in detail in Appendix 1.

6.4.3.6 The definition of *Relative traction/brake request* signal in negative values is identical to its definition in positive values, only "braking force" instead of "tractive force" is used. Then, chapter 6.3.1.5, including Figure-1, shall be used accordingly for definition of dynamic brake control

6.4.3.7 Rolling stock requirement: The -100% request shall be interpreted as a request on full dynamic brake over the whole train.

6.4.3.8 Rolling stock requirement: The input signals *Dynamic brake available, Dynamic brake ready* and *Dynamic brake applied* shall be summarized over the whole trainset. It means when at least one propulsion in the train reports this signal as TRUE, Rolling stock shall report it as TRUE to ATO-OB as well (see 6.3.1.8).

6.4.3.9 Rolling stock requirement: if Rolling stock receives the *Dynamic brake inhibition* signal, it shall disable brake blending and shall not use dynamic brake at all.

6.4.4 Pneumatic Brake Control (S-type trains)

6.4.4.1 The control signals for pneumatic brake control are listed in Table 9:

	Signal	Dir	Type	Description	SS-125
1	Train brake request	Out	Num	Control signal for direct control of train (indirect) air brake Range: 0 ... 100% (full service brake) 0% represents the request on fully released train brake, 100% represents the request on full service train brake application	9.7 7.1.5.1 7.1.5.4 6.2.1.8
2	Locomotive brake request	Out	Num	Control signal for direct control of locomotive (direct) air brake. Range: 0 ... 100% (full direct brake - max. pressure in brake cylinder)	as above
3	Quick brake release request	Out	Bool	Supporting signal for quick brake release.	as above
4	Train brake feedback	In	Num	Feedback signal for train brake control.	as above
5	Locomotive brake feedback	In	Num	Feedback signal for locomotive brake control	as above
6	Train brake control specific values	In	Num	Specific values for train brake control: - Last Release Step (LAST REL)	as above

				- First Braking Step (FIRST BR) - Last Possible Braking Step (LAST POSS BR) - Minimum Change (MIN CHANG)	
7	Brake overcharging feedback	In	Bool	Brake overcharging is currently being applied	as above 7.1.5.15
8	Filling stroke feedback	In	Bool	Filling stroke is currently being applied	as above 7.1.5.15

Table 9: The pneumatic brakes control signals - S-type trains

6.4.4.2 *Train brake feedback* refers to the same variable that is controlled by *Train brake request* signal.

6.4.4.3 *Train brake control specific values* define the margins for train brake control, which come from the technical behaviour of train brake. ATO-OB shall follow these specific values for train brake control.

6.4.4.4 Detailed description of *Train brake control specific values* is in Appendix 2

6.4.4.5 The signals *Brake overcharging feedback* and *Filling stroke feedback* are used by ATO-OB for detection of which signal was used by train for Quick brake release command realization and for how long time these functions were applied.

6.4.4.6 Note: The use of Locomotive brake is application specific feature and is only applicable if the brake system architecture allows to control the Locomotive brake accordingly.

6.4.4.7 Rolling stock requirement: *Quick brake release request* is used usually within the long trains. Which concrete signal (overcharging (Angleicher) or high pressure filling stroke (Füllstoss)) will be used is to be decided in Rolling stock.

6.4.4.8 Rolling stock requirement: For suppressing the transient effects during brake application and releasing processes, the Train brake feedback variable shall refer to pressure in equalising reservoir of brake control valve. If the brake control system on the vehicle does not use equalising reservoir (which situation is not expected for S-type trains), the project-specific solution shall be used.

6.4.4.9 Rolling stock requirement: The value of *Train brake feedback* shall be set when service brake is applied (triggered by e.g. ATO-OB, ETCS-OB or Driver).

6.4.5 Holding brake control

6.4.5.1 The signals for **Holding brake control** are listed in Table 10:

	Signal	Dir	Type	Description	SS-125
1	Holding brake request	Out	Bool	Control signal for applying of Holding brake.	6.2.1.7
2	Holding brake applied	In	Bool	Feedback signal. The vehicle is prevented from moving by Holding brake	6.2.1.9 6.2.1.10 7.1.5.11

Table 10: The holding brake control signal

6.4.5.2 Rolling stock requirement: When ATO-OB is in EG state, shall apply the Holding brake on ATO-OB request only.

6.4.5.3 Rolling stock requirement: The releasing of Holding brake shall be done by Rolling stock according to its internal functions after Rolling stock's internal request on applying traction appears (regardless which is the source of this traction request - ATO-OB or Driver).

6.5 Doors control signals

6.5.1.1 The doors control signals are listed in Table 11:

	Signal	Dir	Type	Description	SS-125
1	Doors L/R release request	Out	Num	Request to release the doors for individual opening by passengers (side selective)	7.2.2.2
2	Doors L/R open request	Out	Num	Request to open the doors centrally; side selective.	7.2.2.2
3	Doors L/R close request	Out	Num	Request to close the doors centrally; side selective.	7.2.2.3
4	Doors status signals	In	Bitset	Feedback signal - the actual status of doors: doors control is available, all doors closed&locked (side selective)	6.3.3.3 8.2.4, 8.2.5.3, 9.1.2.1

Table 11: The doors control signals

6.5.1.2 All door control signals are defined according to [Ref 9].

6.5.1.3 The Rolling stock uses this information for doors control. The ATO-OB output signals are activated only if *Doors control available* information in *Doors status signal* is TRUE, otherwise the output signals are reset (filled by zeros).

6.5.1.4 The *Door status* signal coming from Rolling stock are indicating:

- Whether Rolling stock is able to receive doors control from ATO-OB ("*Doors control available*")
- Whether left doors are closed and locked ("*All left doors closed & locked*")
- Whether right doors are closed and locked ("*All right doors closed & locked*")

6.5.1.5 The left / right side refers to a forward movement with the active cabin.

6.5.1.6 Rolling stock requirement: *Doors release requests* and *Doors open / close request* shall be transmitted as counters (each one request increments the relevant counter) to avoid unclear states when ATO-OB is changing from EG to AV states.

6.5.1.7 Rolling stock requirement: After ATO-OB reset, these counters shall be filled with 0 (zero). Change of any counter from any number to zero shall be ignored by Rolling stock.

6.5.1.8 Rolling stock requirement: During standard operation, these counters shall step from MAXNUM to 1 (instead of 0). Rolling stock shall consider this step (from MAXNUM to 1) as one standard step.

6.6 Train and vehicle specific values

6.6.1.1 The signals regarding train and vehicle specific values are listed in Table 12:

	Signal	Dir	Type	Description	SS-125
1	Maximum train speed	In	Num	Current maximum allowed train speed respecting all existing technical constraints (e.g. failure of gearbox, of air suspension etc.). Does not include limits due to signalling or operational rules. The variable shall be transmitted if available in Rolling stock, otherwise the value must be entered by driver.	7.1.2.6
2	Maximum available tractive force (for the whole train)	In	Num	Includes both multiple traction and reduced traction capabilities (isolated bogie etc.). Tractive force at the wheels is meant.	7.1.5.4
3	Maximum available tractive output power (for the whole train)	In	Num	Includes both multiple traction and reduced traction capabilities (isolated bogie etc.)	as above
4	Currently available tractive force (for the whole train)	In	Num	Maximum tractive force (at the wheels) at current speed. Includes both multiple traction and reduced traction capabilities (isolated bogie etc.)	as above
5	Maximum available dynamic brake force (for the whole train)	In	Num	Includes both multiple traction and reduced dynamic brake capabilities (isolated bogie etc.). Brake force at the wheels is meant. Mandatory for S-type trains, optional for C-type trains.	as above
6	Maximum available dynamic brake power (for the whole train)	In	Num	Includes both multiple traction and reduced dynamic brake capabilities (isolated bogie etc.)	as above
7	Currently available dynamic brake force (for the whole train)	In	Num	Max. dynamic brake force (at the wheels) at current speed. Includes both multiple traction and reduced dynamic brake capabilities (isolated bogie etc.)	as above
8	Maximum available service brake force (for the whole train)	In	Num	For C-type trains only. Brake force at the wheels is meant. Note: this value describes the maximum achievable brake force for service braking regardless by which brake (dynamic, pneumatic or their combination) this force is induced.	as above
9	Train mass	In	Num	Current mass information on the entire train. The variable shall be provided by the Rolling stock if available. Otherwise, it shall be entered by the driver during ATO specific data entry.	as above
10	T/B lever position	In	Enum	Indication of traction / zero / brake position of TBL *)	6.2.1.11 6.2.1.12 8.2.9.1 8.2.9.2
11	Brake lever neutral position	In	Bool	Controllers of all other brakes (indirect, direct, magnetic...) are in neutral position.	6.2.1.11 8.2.9.1 9.1.2.1 9.12.1.1
12	Brake position	In	Bitset	Mandatory for S-type trains: G / P - freight train / P - pass. train / R, as well as EP brake information Note: R+Mg is not relevant for ATO.	7.1.2.8 7.1.5.3 7.13.1.1
13	Slip/slide information	In	Bool	Information on wheel slipping and sliding	7.5.1.2 7.5.1.3 7.7.1.6
14	Cab info	In	Bitset	Information on active cabin	8.2.4.1 10.1.2.1 10.1.6.1 10.2.2.9

15	Brake force of Holding Brake	In	Num	Brake force of Holding Brake	6.2.1.8
16	Currently available service brake force (for the whole train)	In	Num	For C-type trains only. Brake force at the wheels is meant. Note: this value describes the currently achievable brake force for service braking regardless by which brake (dynamic, pneumatic or their combination) this force is induced.	7.1.5.4
17	Direction controller	In	Enum	Direction controller position	9.1.2.1
18	Train in standstill	In	Bool	Logical information about train standstill - in accordance with [Ref 5] - 4.2.5.5.2 (5)	7.2.2.4 7.2.2.9 8.2.4.2

Table 12: Train and vehicle specific values

*) If 2 separate levers are used (traction lever, dynamic brake lever), then coding the brake position has priority over coding the traction position.

6.6.1.2 The variables *Maximum available tractive force, Maximum available tractive output power, Maximum available dynamic brake force, Maximum available dynamic brake power* and *Brake force of Holding Brake* contain current values valid for given train, respecting switched off propulsions, isolated bogies etc. It is not expected to change these values during train movement (with exclusion of variables depending on traction power system).

6.6.1.3 Rolling stock requirement: “Neutral position” of brake controllers shall be understood as “brake release position” for position-dependent controllers and “running position” for time-dependent ones. Neutral position of self-standing switch for brake isolation (if such switch exist) shall also be included in this signal

7 ATO-OB / ROLLING STOCK INTERFACE - CONNECTION AND PACKETS

7.1 Communication management

7.1.1.1 The Rolling stock and the ATO-OB shall exchange packets while the connection is established.

7.1.1.2 Both Rolling stock and ATO-OB shall distinguish between “connection active” and “connection not active” states.

7.1.1.3 The initial state shall be “connection active”.

7.1.1.4 Both Rolling stock and ATO-OB shall maintain for each packet a timeout value. Whenever a valid packet is received the receiver shall reset the specific packet timeout counter.

7.1.1.5 The connection shall be considered as “not active” if one of the timeout counters is triggered.

7.1.1.6 The state shall change from “connection not active” to “connection active” when for each specified process data valid packets are received.

7.1.1.7 The ATO-OB shall change to FA state if it considers the connection as “not active”.

7.1.1.8 Any packet received by the Rolling stock or the ATO-OB shall be ignored if it is considered as not valid.

7.1.1.9 A packet is considered as not valid if one of the following conditions is fulfilled:

a) Its number is not known;
b) Its timestamp is equal or older than a previously received packet with the same number;
c) Any variable uses spare values;
d) The computed length of the packet does not correspond to the one indicated in the corresponding variable.
e) The computed Checksum/CRC of the packet does not correspond to the one indicated in the corresponding packet

7.2 Definition of Packets

7.2.1 General

7.2.1.1 Packets are multiple variables grouped into a single unit, with a defined internal structure.

7.2.1.2 Due to limits of Ethernet communication, the total size of user data shall not exceed 1461 bytes.

7.2.1.3 To provide a sufficient protection from communication errors, CRC shall be used on application level.

7.2.1.4 The packet consists of a header, followed by the user data and terminated by a checksum (CRC). Following table describes the packet structure.

Header	7 bytes
User Data	0...1461 bytes
Checksum	4 bytes

Table 13: Packet Structure

7.2.2 Header

7.2.2.1 The following table defines the packet header.

Packet Header				
Item	**Variable Name**	**Description**	**Data Type**	**Resolution/Formula**
1	NID_PACKET	Packet identificator.	UINT8	range: 31 ... 60 other values: reserved Note: the range is selected with respect to other ATO-OB communications possibly sharing the same physical line to allow better diagnostics of the traffic.
2	L_PACKET	Length of Header + User Data length.	UINT16	**Minimum:** 7 **Maximum:** 1468 **Resolution:** 1 byte
3	T_TIMESTAMP	Timestamp in milliseconds since start-up. The timestamp will be set at the moment the telegram is issued.	UINT32	**Resolution:** 1 ms

Table 14: Packet Header

7.2.3 User Data

7.2.3.1 The definition of User Data is further in this document.

7.2.3.2 Spare bits and bytes in the User Data shall be set to 0.

7.2.4 Checksum

7.2.4.1 For error detection, the cyclic redundancy check mechanism CRC32, based on the IEEE 802.3 (Ethernet) specification, shall be used with the following parameters:

Parameter	Value
Name	CRC-32/BZIP2
Width	32 bits
Generator-Polynomial	0x{1}04C11DB7
Init	0xFFFFFFFF (-1)
RefIn	False
RefOut	False
Final XOR value (Inversion of CRC) Check value	0xFFFFFFFF (-1) 0xFC891918

Table 15: CRC Parameters

7.2.4.2 The byte order of the CRC is MSB first, LSB last.

7.2.4.3 The CRC value shall be computed over Header and User Data.

7.3 List of Packets

7.3.1.1 Following packets are used for communication between ATO-OB a Rolling stock (RST):

Packet Name	Packet identificator	Source	Sink	Transmitting cycle [ms] (max)	Data Class [Ref 8]	Timeout [ms]
ATO_RST_data	31	ATO	RST	50	Process Data	250
RST_ATO_data fast	32	RST	ATO	50	Process Data	250
RST_ATO_data slow	33	RST	ATO	500	Process Data	2500

Table 16: Packet summary

7.4 Packet Description

7.4.1 User data - ATO to RST packet 31

Offset	Bit	Variable Name	Signal / Description	Data Type	Resolution/Formula/Values	Table, Line
0		M_ATO_RTBRq	Relative traction / brake request	INT16	**Range:** -16384..0..+16384 = -100%..0%..+100% resolution 100 / 16384 % **Special values:** -32768 ...-16385: spare +16385 ...+32767: spare	Tab 5 Line 1 Tab 7/ Tab 8 Line 1
2		M_ATO_TraBrRq	Immediate train brake request	UINT8	**Range:** 0 ... 100 = 0% (brake released) ... 100% (full brake) resolution 1% **Special values:** 101 ... MAXNUM: spare	Tab 9 Line 1
3		M_ATO_LocoBrRq	Immediate locomotive brake request	UINT8	**Range:** 0 ... 100 = 0% (brake released) ... 100% (full brake) resolution 1% **Special values:** 101 ... MAXNUM : spare	Tab 9 Line 2
4	0..3	M_ATO_State	ATO state States of ATO_OB.	ENUM4	**Values:** 0...7 = {NP,CO,NA,AV,RE,EG,DE,FA} **Special values:** 8...15: spare	Tab 4 Line 1
	4..7	(spare)				
5		Q_ATO_SupTB	Supporting logical control signals for traction and brake control Included signals: Traction request, Dynamic brake request (S-type trains) / Brake request (C-type trains), Holding brake request, Quick brake release request, Dynamic brake inhibition, Traction over brake request	BITSET8	**Values**: bit 0 = TrRq bit 1 = DBRq (S-type) / BRq (C-type trains) bit 2 = HBRq bit 3 = QBRRq bit 4 = DBInh bit 5 = TOBRq **Special values:** bit 6,7 = spare	Tab 5 Line 2 Tab 7 / Tab 8 Line 2 Tab 10 Line 1 Tab 9 Line 3, Tab 8 Line 6 / Tab 7 Line 7 Tab 6 Line 3
6		M_ATO_DoorLrel	Doors release request - left doors,	UINT8	**Values:** 1...MAXNUM = sequential number of the command **Special value:** 0 = ATO OB was restarted	Tab 11 Line 1
7		M_ATO_DoorRrel	Doors release request - right doors	UINT8	see above	Tab 11 Line 1
8		M_ATO_DoorLOp	Doors open request - left doors	UINT8	see above	Tab 11 Line 2
9		M_ATO_DoorROp	Doors open request - right doors	UINT8	see above	Tab 11 Line 2

Offset	Bit	Variable Name	Signal / Description	Data Type	Resolution/Formula/Values	Table, Line
10		M_ATO_DoorLCl	Doors close request - left doors	UINT8	see above	Tab 11 Line 3
11		M_ATO_DoorRCl	Doors close request - right doors	UINT8	see above	Tab 11 Line 3

Table 17: ATO to RST packet 31

7.4.2 User data - RST to ATO packet 32 - fast data

Offset	Bit	Variable Name	signal / Description	Data Type	Resolution/Formula	Table, Line
0		M_RST_TBsetVal	T/B set value	INT16	**Range:** -16384..0..+16384 = -100%...0%...+100% resolution 100/16384 % **Special values:** -32767 ...-16385$_x$: spare +16385 ...+32767: spare -32768 ... unknown	Tab 5 Line 6
2		M_RST_TraBrFB	Train brake feedback	UINT8	**Range:** 0 ... 100 %, resolution 1% **Special values:** 101 ... MAXNUM - 1: spare MAXNUM: Unknown / Not used	Tab 9 Line 4
3		M_RST_LocoBrFB	Locomotive brake feedback	UINT8	**Range:** 0 ... 100 %, resolution 1% **Special values:** 101 ... MAXNUM - 1: spare MAXNUM: Unknown / Not used	Tab 9 Line 5
4		M_RST_FcurAva	Currently available tractive force	UINT16	**Range:** 0 ... 3000 kN, resolution 1 kN, **Special values:** 3001 ... MAXNUM - 1: spare MAXNUM: Unknown	Tab 12 Line 4
6		M_RST_FcurAvaDB	Currently available dynamic brake force	UINT16	**Range:** 0 ... 3000 kN, resolution 1 kN, **Special values:** 3001 ... MAXNUM - 1: spare MAXNUM: Unknown	Tab 12 Line 7
8		M_RST_FcurAvaSB	Currently available service brake force	UINT16	**Range:** 0 ... 3000 kN, resolution 1 kN, **Special values:** 3001 ... MAXNUM - 1: spare MAXNUM: Unknown	Tab 12 Line 16
10		Q_RST_DoorStat	Doors status signal	BITSET8	bit 0 = doors control available bit 1 = all left doors closed & locked bit 2 = all right doors closed & locked bit 3..7 = spare	Tab 11 Line 4

Offset	Bit	Variable Name	signal / Description	Data Type	Resolution/Formula	Table, Line
11		Q_RST_SupTB	Supporting logical control signals for traction and dynamic brake control. Included signals: Traction ready, Dynamic brake available, Dynamic brake ready, Train applicable conditions, Traction applied, Dynamic brake applied, Brake applied (C-type trains), TSI standstill	BITSET8	**Values**: bit 0 = TrRdy bit 1 = DBAva bit 2 = DBRdy bit 3 = ApplCond bit 4 = TrApp bit 5 = DBAppl bit 6 = BAppl (C-type) / spare (S-type) bit 7 = TSIstand	Tab 5 Line 3 Tab 7/ Tab 8 Line s 3, 4 Tab 5 Lines 4, 5 Tab 7/ Tab 8 Line 5 Tab 7 Line 6 Tab 12 Line 18
12		Q_RST_BrakeStat	Brake status - Supporting logical control signals for pneumatic brakes control Included signals: EB released, Holding Brake applied, Traction over brake enabled, Overcharging feedback, Filling stroke feedback	BITSET8	**Values**: bit 0 = EBrel bit 1 = HBapp bit 2..3 = TOBen 00 = no Traction Over Brake enabled 01 = brake cleaning mode / hill start 1x = spare bit 4 = OverchFB bit 5 = FilStrFB bit 6...7 = spare	Tab 6 Line 1 Tab 10 Line 2 Tab 6 Line 2 Tab 9 Lines 7, 8
13		M_RST_TBLpos	T/B lever position	ENUM8	**Values:** 0...2 = {zero position, traction position, braking position } **Special values:** 3 ... MAXNUM - 1 = spare MAXNUM = unknown (failure)	Tab 12 Line 10
14		M_RST_BLpos	Brake levers Neutral position	UINT8	**Values:** 0 = any of brake levers is out of neutral position 1 = all brake levers in zero positions **Special values** 2 ... MAXNUM - 1 spare MAXNUM: Unknown (failure)	Tab 12 Line 11
15		M_RST_SlipSlide	Slip/slide	BITSET8	**Values**: bit 0 = slipping bit 1 = sliding bit 2 .. 7 = spare	Tab 12 Line 13

Table 18: RST to ATO packet 32 - fast data

7.4.3 User data - RST to ATO packet 33 - slow data

Offset	Bit	Variable Name	signal / Description	Data Type	Resolution/Formula	Table, Line
0		V_RST_Vmax	Maximum train speed	UINT32	**Range:** 0 ... 166 667 mm/s (600 km/h), resolution 1mm/s **Special values:** 166 668 ... MAXNUM - 1: spare MAXNUM:Unknown	Tab 12 Line 1

Offset	Bit	Variable Name	signal / Description	Data Type	Resolution/Formula	Table, Line
4		M_RST_Fmax	Maximum available tractive force	UINT16	**Range:** 0 ... 3000 kN, resolution 1 kN, **Special values:** 3001 ... MAXNUM - 1: spare MAXNUM: Unknown	Tab 12 Line 2
6		M_RST_Pmax	Maximum available tractive output power	UINT16	**Range:** 0 ... 32 000 kW, resolution 1 kW, **Special values:** 32001 ... MAXNUM - 1: spare MAXNUM:Unknown	Tab 12 Line 3
8		M_RST_FmaxDB	Maximum available dynamic brake force	UINT16	**Range:** 0 ... 3000 kN, resolution 1 kN, **Special values:** 3001 ... MAXNUM - 1: spare MAXNUM:: Unknown	Tab 12 Line 5
10		M_RST_PmaxDB	Maximum available dynamic brake power	UINT16	**Range:** 0 ... 32 000 kW, resolution 1 kW, **Special values:** 32001 ... MAXNUM - 1: spare MAXNUM:: Unknown	Tab 12 Line 6
12		M_RST_FmaxSB	Maximum available service brake force	UINT16	**Range:** 0 ... 3000 kN, resolution 1 kN, **Special values:** 3001 ... MAXNUM - 1: spare MAXNUM:: Unknown / not used	Tab 12 Line 8
14		M_RST_TrnMass	Train mass	UINT16	**Range:** 0 ... 15 000 t, resolution 1 t **Special values:** 15001 ... MAXNUM - 1: spare MAXNUM:: Unknown	Tab 12 Line 9
16	0..3	Q_RST_BrPos	Brake position	ENUM4	**Values**: 0...3 = {G, P - freight train, P - passenger train, R} **Special values:** 4 ... 15: spare	Tab 12 Line 12
	4..7		EP-brake information	ENUM4	**Values:** 0...3 = {standard UIC brake, EP light brake, EP assist brake, EP direct brake} **Special values:** 4...15: spare	Tab 12 Line 12
17		M_RST_LastRel	Specific values for train brake control: Last Release Step	UINT8	**Range:** 0 ... 100 %, resolution 1% **Special values:** 101 ... MAXNUM - 1: spare MAXNUM: Not used	Tab 9 Line 6
18		M_RST_FirstBr	Specific values for train brake control: First Braking Step	UINT8	**Range:** 0 ... 100 %, resolution 1% **Special values:** 101 ... MAXNUM - 1: spare MAXNUM: Not used	Tab 9 Line 6
19		M_RST_LastPossBr	Specific values for train brake control: Last Possible Braking Step	UINT8	**Range:** 0 ... 100 %, resolution 1% **Special values:** 101 ... MAXNUM - 1: spare MAXNUM: Not used	Tab 9 Line 6

Offset	Bit	Variable Name	signal / Description	Data Type	Resolution/Formula	Table, Line
20		M_RST_MinChang	Specific values for train brake control: Minimum Change of train brake request	UINT8	**Range:** 0 ... 100 %, resolution 1% **Special values:** 101 ... MAXNUM - 1: spare MAXNUM: Not used	Tab 9 Line 6
21	0..3	M_RST_DirContr	Direction controller position	ENUM4	**Values:** 0...2 = {zero position, forward position, backward position } **Special values:** 3 ... MAXNUM - 1 = spare MAXNUM = unknown (failure)	Tab 12 Line 17
	4..7	M_RST_CabInfo	Active cabin information	BITSET4	**Values**: bit 4 = Cab1 active bit 5 = Cab2 active bit 6 .. 7 = spare	Tab 12 Line 14
22		M_RST_BrForceHB	Brake force of Holding brake	UINT16	**Range**: 1...1000 kN, resolution: 1 kN, **Special values**: 0... HB not available 1001...MAXNUM - 1: spare MAXNUM: unknown	Tab 12 Line 15

Table 19: RST to ATO packet 33 - slow data

APPENDIX 1: DETAILED DESCRIPTION OF THE SUPPORTING TRACTION/BRAKE SIGNALS

A1.1 Traction ready (TrRdy**)** **Applicable: Both S-type and C-type trains**

Propulsion is ready for applying traction. The signal includes all propulsion conditions for applying traction (e.g., no major failure, traction voltage present / Diesel engine is running, traction lock open etc.). The signal is set when all these conditions are met and reset when at least one condition is not met (according to Rolling stock logic).
In the following descriptions, we assume that the conditions for the generation of the Traction ready signal are met, unless explicitly stated other.
Traction ready remains set if *Traction request* (TrRq) and/or *Traction Applied* (TrApp) are set.

ATO-OB shall request Rolling stock to traction only if *Traction ready* is set.

If *Traction ready* signal disappears during traction is applied, ATO-OB shall stop requesting the traction (*Traction request* is removed) and train starts coasting or braking dynamically or pneumatically. ATO-OB keeps engaged. If *Traction ready* signal re-appears, ATO-OB shall resume in applying traction without any driver's command (if there is no other reason for driver's command, like disengaging in between).

Note: This signal means that the only reason why the vehicle is not applying traction is that applying traction is not requested by ATO-OB.

A1.2 Dynamic brake available (DBAva**)** **Applicable: Both S-type and C-type trains**

Dynamic brake is generally available on the train (is present and is not switched off by driver).

Unlike DBRdy which may dynamically disappear and reappear according to the current readiness of the dynamic brake (e.g. neutral sections) and serves for instant control, this signal gives general information if the ATO-OB can take into account the dynamic brake for speed profile computations (regardless that in some situations it may become temporarily unavailable) or not.

In case of dynamic brake failure, this signal is revoked by Rolling stock. The signal is not revoked due to a natural loss of dynamic brake effect at low speed

Note: DBAva may be used for an energy-optimized braking strategy (using less deceleration for a higher rate of recovered energy).

A1.3 Dynamic brake ready (DBRdy**)**: **Applicable: Both S-type and C-type trains**

Propulsion is ready to brake dynamically. The signal contains all conditions for dynamic braking (e.g., no major fault, traction voltage (if necessary), etc.). It is set when these conditions are met and reset when at least one condition is not met (according to Rolling stock logic).

In the following descriptions, we consider that the conditions for generating the DBRdy signal are fulfilled, unless explicitly stated other:
DBRdy remains set if Dynamic brake request (DBRq) and/or Dynamic brake applied (DBApp) are set.

DBRdy remains set also if Traction request (TrRq) and/or Traction applied (TrApp) are set.

The signal is revoked in case of dynamic brake failure and also in case of natural loss of dynamic brake effect at low speed

Note: This signal means that the only reason the vehicle is not dynamically braking is that it is not requested.
Note 2 (for S-type trains only): if DBRdy is not set, then ATO-OB requests a train air brake only.

A1.4 Traction request (TrRq) **Applicable: Both S-type and C-type trains**

ATO-OB wants to traction. The signal is set when ATO-OB intends to traction and Rolling stock reports TrRdy signal. The signal is reset when ATO-OB does not intend to traction. In project-specific cases (e.g. vehicles with contact elements in the traction circuit, e.g. contactors or mechanical clutches, that switch at each change from coasting to traction) this signal might be kept until ATO-OB requests braking.

A1.5 Dynamic brake request (DBRq) **Applicable: S-type trains**

ATO-OB wants to brake dynamically. The signal is set when ATO-OB intends to brake dynamically. In contrast to the traction request TrRq, there is no condition of active DBRdy signal. The signal is reset when ATO-OB does not intend to brake dynamically.

A1.6 Brake request (BRq) **Applicable: C-type trains**

ATO-OB wants to brake. The signal is set when ATO-OB intends to brake. The signal is reset when ATO-OB does not intend to brake.

A1.7 Traction applied (TrApp) **Applicable: Both S-type and C-type trains**

Confirmation that propulsion is realizing the traction. The signal is set when Rolling stock has accepted TrRq signal and it (Rolling stock) reaches the state when it can immediately follow the changes of RTBRq signal. The word "Immediately" should be understood as "only the regulation response, without any technological delays given be e.g. contactor switching or gearbox engaging". The signal is reset when condition above is no more met.

Project specific note: If Rolling stock uses a minimum threshold to realize any traction demand, this threshold needs to be exposed towards ATO-OB designer during the design phase of the project.

A1.8 Dynamic brake applied (DBApp) Applicable: Both S-type and C-type trains

Confirmation that propulsion is realizing the dynamic braking. This signal is set when Rolling stock has accepted DBRq signal and it (Rolling stock) reaches the state when it can immediately follow the changes of RTBRq signal. The word "Immediately" should be understood as "only the regulation response, without any technological delays given be e.g. contactor switching or gearbox engaging". The signal is reset when condition above is no more met.

If ATO-OB requests for dynamic brake and Rolling stock is realizing a brake blending due to any reason, this signal is revoked.

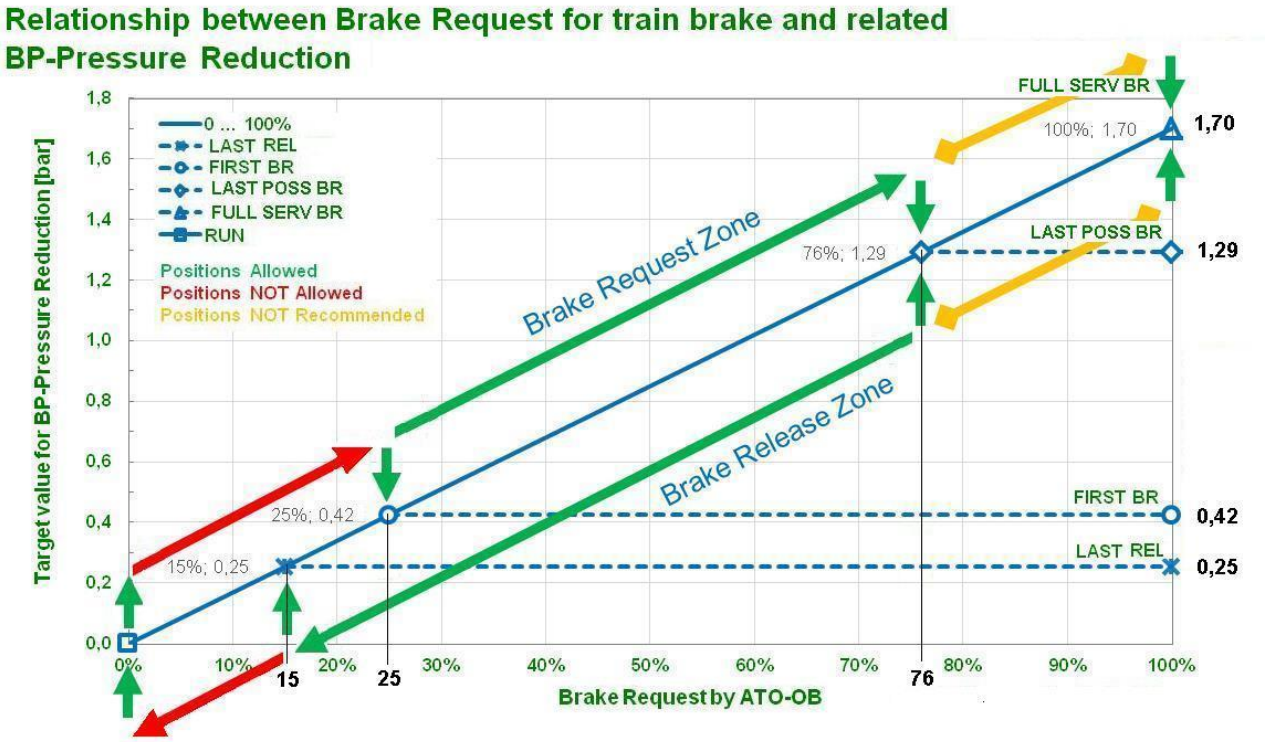
Project specific note: If Rolling stock is maintaining a minimum threshold to realize any dynamic brake demand, this threshold needs to be exposed towards ATO-OB designer during the design phase of the project.

A1.9 Brake applied (BApp) Applicable: C-type trains

Confirmation that train is braking, regardless which brake is used (this is the responsibility of Rolling stock).

Project specific note: If Rolling stock is maintaining a minimum threshold to realize any brake demand, this threshold needs to be exposed towards ATO-OB designer during the design phase of the project.

APPENDIX 2: DETAILED DESCRIPTION OF TRAIN BRAKE SPECIFIC VALUES



Value (% of Brake request)	Description	Related requirement	Remark	Position of DABC [3)]
RUN (0)	Running position	In accordance with EN 14198 [1)]: The target value for the pressure in the Brake pipe shall be the **Normal working pressure**	Nominal value is 5,00 bar bar with tolerance +/- 0,05 bar. Note: If tested under certain conditions, it shall be possible to adjust the pressure to a value between 4,95 and 5,05 bar.	Running
LAST REL (≈ 15)	Last Release Step	In accordance with EN14198 [1)]: Pressure in the Brake Pipe between **0,25**	Minimum value that can be requested by ATO-OB when decreasing the brake request from higher brake effect values	1A

		and 0,35 bar below the normal working pressure	Any brake request between RUN and LAST REL shall not be demanded by ATO-OB.	
FIRST BR (≈ 25)	First Braking Step	In accordance with EN 14198 [1]: Pressure reduction in the Brake Pipe between **0,4 and 0,5 bar** below the normal working pressure	Minimum value that can be requested by ATO-OB for first brake application after brake release. Coming from the value RUN, any brake request between RUN and FIRST BR shall not be demanded by ATO-OB.	1B
BR_RANGE (≈ 25 ... ≈ 75)	Control Range for ATO-OB	-	Any value between _LAST REL and LAST POSS BR (exception is the first braking step).	2 … 6
LAST POSS BR (≈ 75)	Last Possible Braking Step (before a Distributor Valve could reach the Brake Cylinder pressure of a full-service brake application).	In accordance with EN15335 [2]: Pressure reduction for full-service brake application between **1,4 and 1,6 bar** below the normal working pressure	Limit of linear behaviour of train brake, higher values should not be requested by ATO-OB excluding specific situations (e.g. instant failure of dynamic brake) This limit is defined to make sure that the pressure in the Brake Cylinder will be changed if ATO-OB increases the brake request to a higher value. Note: in principle this limit is not relevant during the operation of a train, but it was claimed by some operators after they made static tests. It could be discussed, if that is really a necessary requirement for ATO operation.	7
FULL SERV BR (100)	Full-Service brake application	In accordance with EN14198 [1]: Reduction of the pressure in the Brake Pipe between **1,6 and 1,8 bar** below the	Any brake request between LAST POSS BR and FULL SERV BR shall not be demanded by ATO-OB except of failure situations..	Full-Service

		normal working pressure		
MIN CHANG	Minimum change of brake request (that has response in brake effect).	In accordance with EN15335 [2]: Minimum pressure reduction in the Brake Pipe pressure which shall be followed by a change of the Brake cylinder pressure **0,1 bar**	If the requested change is smaller, it is not sure that the train brake will react accordingly	N/A

[1] EN 14198 Railway applications – Braking – Requirements for the brake system of trains hauled by locomotives (Annex E)

[2] EN 15355 Railway applications – Braking – Distributor valves and distributor-isolating devices

[3] Position-dependent Driver's Automatic Brake Controller in accordance with UIC612-0