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ERTMS/ATO OPERATIONAL SCENARIOS

VERSIONS & MODIFICATIONS

Version No.	Date of distribution	Comments on the modification	Modified by
Draft A-1	22-05-2013	Initial draft for internal review by NR group	Glyn Roberts
Draft A-2	04-06-2013	Includes comments from CM/KC/ME/GR	Glyn Roberts
Draft A-3	12-06-2013	Includes further comments from CM/GR and modification to scenario titles. Will include a revised figure 2 and a revised table 1;	Glyn Roberts
Draft A-4	26-06-2013	Includes further modifications from CM/GR/KC and Normal Scenarios added to Appendix B	Glyn Roberts/Ken Chan
Issue 0.1	26-06-2013	Issued as first copy for review by EUG	Glyn Roberts
Issue 0.2	13-07-2013	Includes comments from EUG and other modifications including addition of Abnormal Scenarios and Degraded Scenarios.	Glyn Roberts/Ken Chan
Issue 0.3	14-08-2013	Further modifications and clarification of text and scenario content to combine Abnormal with Normal Scenarios and clarification to Degraded Scenarios. Issued for further review by EUG.	Glyn Roberts/Ken Chan/Carine Marin
Issue 1.0	22-08-2013	Official Issue	Glyn Roberts/Ken Chan/Carine Marin
Issue 1.1	06-09-2013	Modified to reflect comments received from EUG and internal review by GR & KC	Glyn Roberts/Carine Marin
Issue 1.2	16-09-13	Updated following update of Operating Principles and Requirements	Carine Marin
Issue 1.3	22-09-2014	Updated following EUG and UNISIG meetings	Carine Marin
Issue 1.4	09-05-2017	Updated to reflect current requirements suite	S Lawson / K Montgomery
Issue 1.5	11-06-2017	Updated to reflect EUG review	S Lawson / K Montgomery
Issue 1.6	29-08-2017	Updated to reflect EUG review	A McGrady
Issue 1.7	17-01-2020	Updated to reflect supplier review, EECT decisions and update of Operational Requirements	Fabian Kirschbauer
Issue 1.8	20-08-2020	Update to reflect various changes	Fabian Kirschbauer
Issue 1.9	2022-01-21	Update following name change AoE to ATO	Arvid Bäärnhielm
Issue 1.10	2022-02-18	Formatting and additional updates following name change AoE to ATO	Arvid Bäärnhielm
Issue 1.11	2022-03-23	Updated figure 1 following ATO-WP review.	Arvid Bäärnhielm
Issue 1.12	2023-06-23	Major update according to the context of GoA3/4	S2R ATO WP GoA 3/4 Users
2-	2023-12-14	Version for inclusion in the CCS TSI Application Guide.	Arvid Bäärnhielm

		The content is replicating version 1.11, which is the final version from S2R ATO WP GoA2 Workstream, aligning with the ATO specifications in the CCS TSI Appendix A.	

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1 INTRODUCTION

The European Railways are currently in the process of implementing ETCS. The railways have identified an opportunity to achieve improved capacity, on-time performance and make energy efficiency improvements through developing and implementing Automatic Train Operation (ATO). ATO is the sub-system which performs some or all of the functions of automatic speed regulation, accurate stopping, door opening and closing, performance level regulation, and other functions assigned to a train driver or train attendant.

2 SCOPE

This document specifies the ERTMS/ATO Operational Scenarios to be used to validate the ERTMS/ATO Operational Principles [RD2] and the ERTMS/ATO Operational Requirements [RD3]. This document defines the Normal and Degraded Operational Scenarios that will typically be enacted by command, control and management systems for ATO on any ETCS fitted railway.

The ERTMS/ATO Operational Scenarios are limited to GoA1 and GoA2 scenarios.

These ERTMS/ATO Operational Scenarios can enable the technical systems to be verified and tested and enable operating rules and procedures to be developed.

3 ERTMS/ATO SYSTEM OVERVIEW

The ERTMS/ATO system is based on two sub-systems: the ATP system (ETCS, see [RD6]) and the ATO system. Unlike ETCS the ATO system cannot operate in isolation; it can only drive the train automatically in areas where ETCS is guaranteeing the safe movement of the train. Both ETCS and ATO include on-board and trackside constituents. ETCS supervises the train ensuring that speed and movement limits are observed and the train proceeds only when it is allowed by the trackside to do so. The ATO on-board automatically drives trains, through control of traction and braking, including but not limited to accurate stopping at specified stopping positions using operational data provided by a traffic management system (TMS) and infrastructure data provided by trackside equipment.

The ATO trackside interfaces with the Traffic Management System which can automate normal signaller operations such as route setting and train regulation. ATO and TMS work together to maintain a train within a defined tolerance of the operational timetable whilst managing conflicts to ensure that overall train operation is optimised.

ATO is not a safety critical system and therefore any identified safety requirements as a result of the ATO operational requirements shall be assigned to other safety systems e.g. ETCS or Train Control Management Systems.

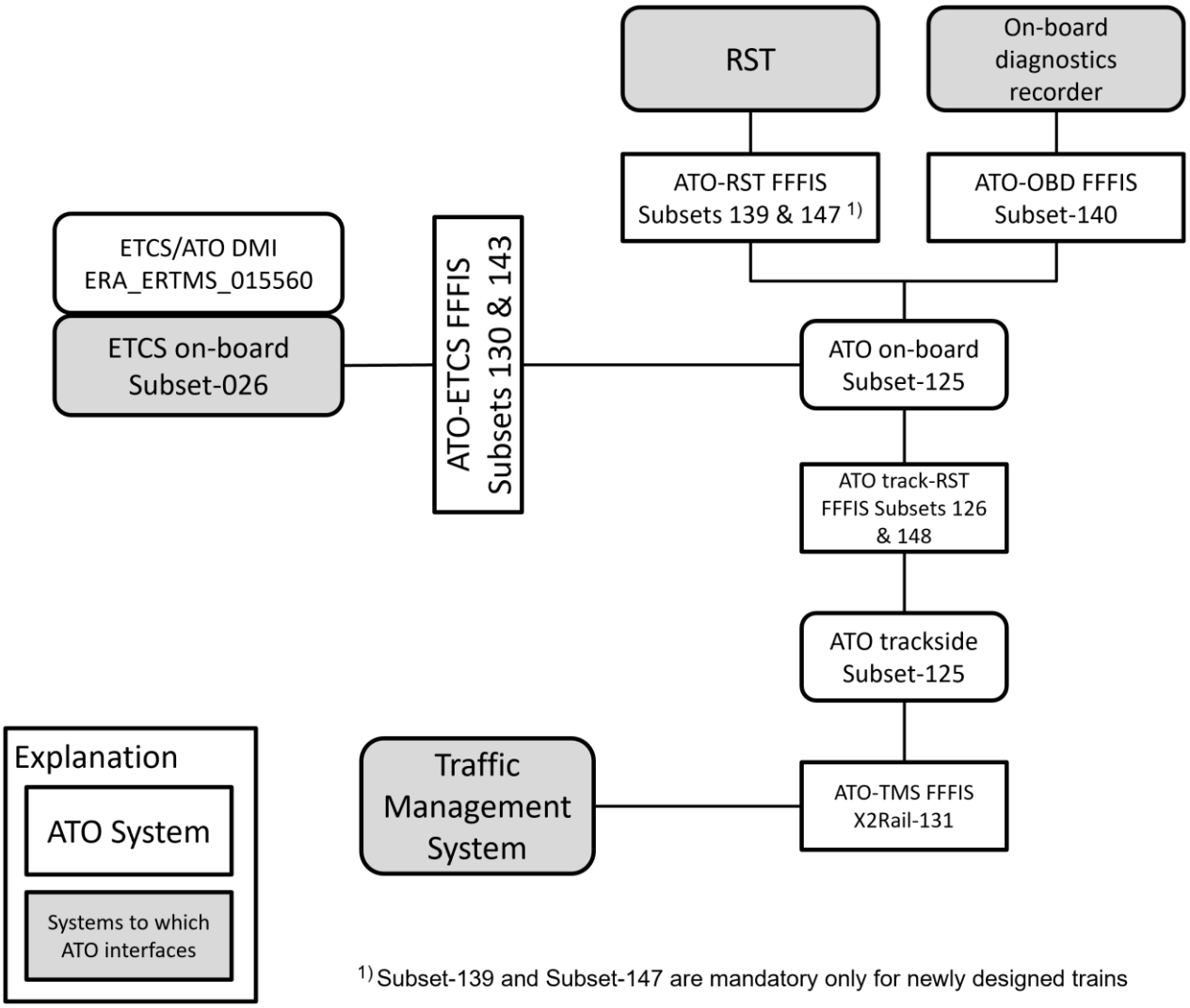
The table below provides an overview of the different Grades of Automation (GoA) that an ATO system can operate. GoA1 is covered in this document by requirements for C-DAS using the same principles as ATO in GoA2 upwards.

GoA	GoA Name	On-board Train Operator	Description
GoA1	**Non-automated train operation**	Train driver in the cab	The train is driven manually; but protected by automatic train protection (ATP). This GoA can also include providing advisory information to assist manual driving.
GoA2	**Semi-automated train operation**	Train driver in the cab	The train is driven automatically, stopping is automated but a driver in the cab is required to start automatic driving of the train, the driver can operate the doors (although this can also be done automatically), the driver is still in the cab to check the track ahead is clear and carry out other manual functions. The driver can take over in emergency or degraded situations.
GoA3	**Driverless train operation**	Train attendant on-board the train	The train is operated automatically including automatic departure, a train attendant has some operational tasks, e.g. operating the train doors (although this can also be done automatically) and can assume control in case of emergency or degraded situations.
GoA4	**Unattended train operation**	No staff on-board competent to operate the train	Unattended train operation; all functions of train operation are automatic with no staff on-board to assume control in case of emergencies or degraded situations.

Table 1 – Grades of Automation high level description

All the interoperable interfaces for the ATO system in GoA1&2 are shown in Figure 1. The figure does generally not show interfaces which are defined in other specifications like the ETCS track-train interface.

Note: The figure shows the standard architecture for ATO. This does not exclude the possibility to implement another architecture, as long as the specifications relevant for interoperability are respected. A different architecture could especially be used for the integration of ATO with existing ETCS on-boards or rolling stock.



1) Subset-139 and Subset-147 are mandatory only for newly designed trains

Figure 1 – ERTMS/ATO System Architecture for GoA2

When operating in GoA3/4 all the driver's functions (if not performed by a train attendant) will have to be replaced by an automated system. The identification of this full list of driver responsibilities is still an open Point as is the assignment of these automated functions to systems. See open point 1 & 2 in Annex A.

Note: The ATO specification is developed with ETCS as the ATP system. ATO in combination with a Class B ATP system is not in the scope of this specification. It is possible to re-use this specification for the development of ATO over Class B.

4 REFERENCES

The following documents have been used in the development of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including amendments) applies.

[RD1] ERTMS/ATO Glossary, EUG Reference: 13E154.

[RD2] ERTMS/ATO Operational Principles, EUG Reference: 12E108.

[RD3] ERTMS/ATO Operational Requirements, EUG Reference: 13E137.

[RD4] EN 62290-1:2006: Railway applications - Urban guided transport management and command/control systems, Part 1: System principles and fundamental concepts.

[RD5] EN 62290-2:2011: Railway applications - Urban guided transport management and command/control systems, Part 2: Functional requirements specification.

[RD6] The Control-Command and Signalling subsystem technical specification for interoperability as specified by the European Commission decision of 2012/88/EU and the amendment 2012/696/EU, published in the Official Journal of the European Union on the 10th November 2012.

[RD7] EUG 03E055: Functional Scenarios.

5 TERMS, DEFINITIONS AND ABBREVIATIONS

The terms, definitions and abbreviations used in this document are defined in [RD1].

NOTE: Where these Operational Scenarios refer to roles, the terminology used does not necessarily refer to the job title of the actor conducting the activity.

6 SCENARIOS

The scenarios have been developed based on a ‘Day-In-The-Life’ of an ATO Train.

The scenarios are limited to GoA1 and GoA2.

The scenario template is shown below in Figure 2 and includes a scenario ID, scenario title, operational objective for the scenario and any system preconditions required to start the scenario.

The scenario steps are cross-referenced with the requirements published in [RD3].

Applies to	**GoA1**		**GoA2**	
Scenario Objective				
Preconditions				

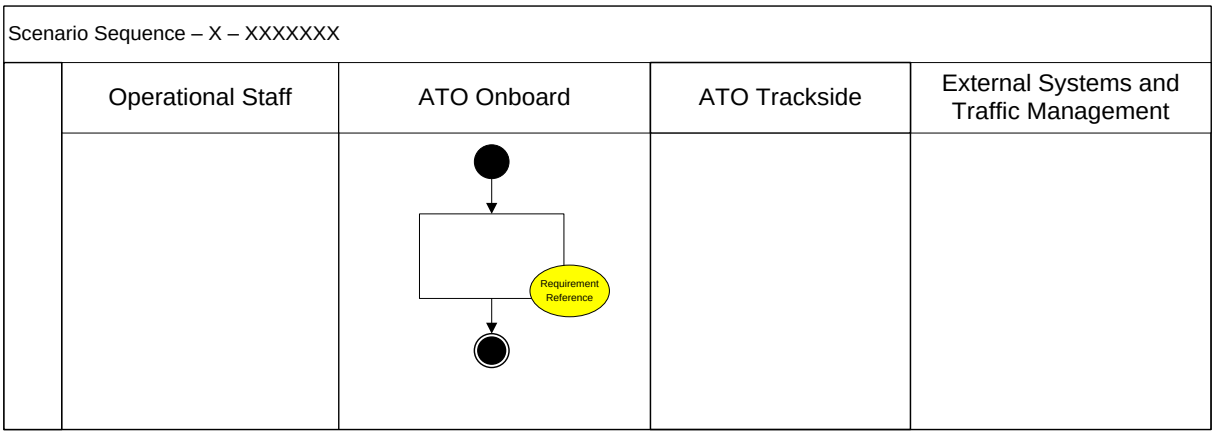


Figure 2 – ATO Operational Scenario Template

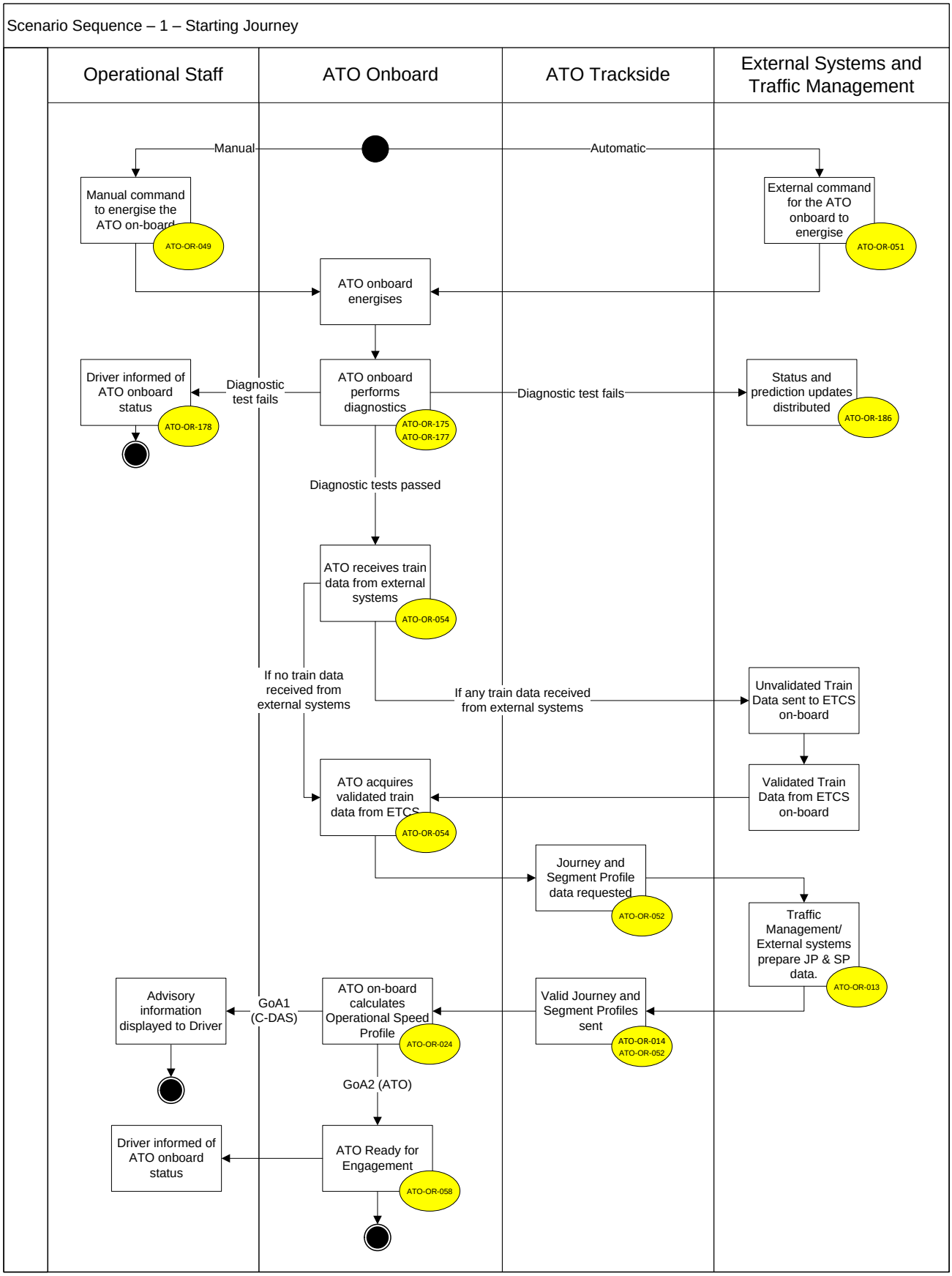
The ERTMS/ATO Operational Scenarios do not show the periodic/event driven reports sent by the ATO on-board to the trackside, this includes:

- ATO reporting of positioning (ATO-OR-025)
- ATO on-board reporting estimated time to next timing point (ATO-OR-032)
- ATO on-board reporting of its GoA (ATO-OR-102)
- ATO failure reporting (ATO-OR-186 & ATO-OR-187)

Note: Reporting of ATO diagnostic failures when energised are shown in Scenario 1.

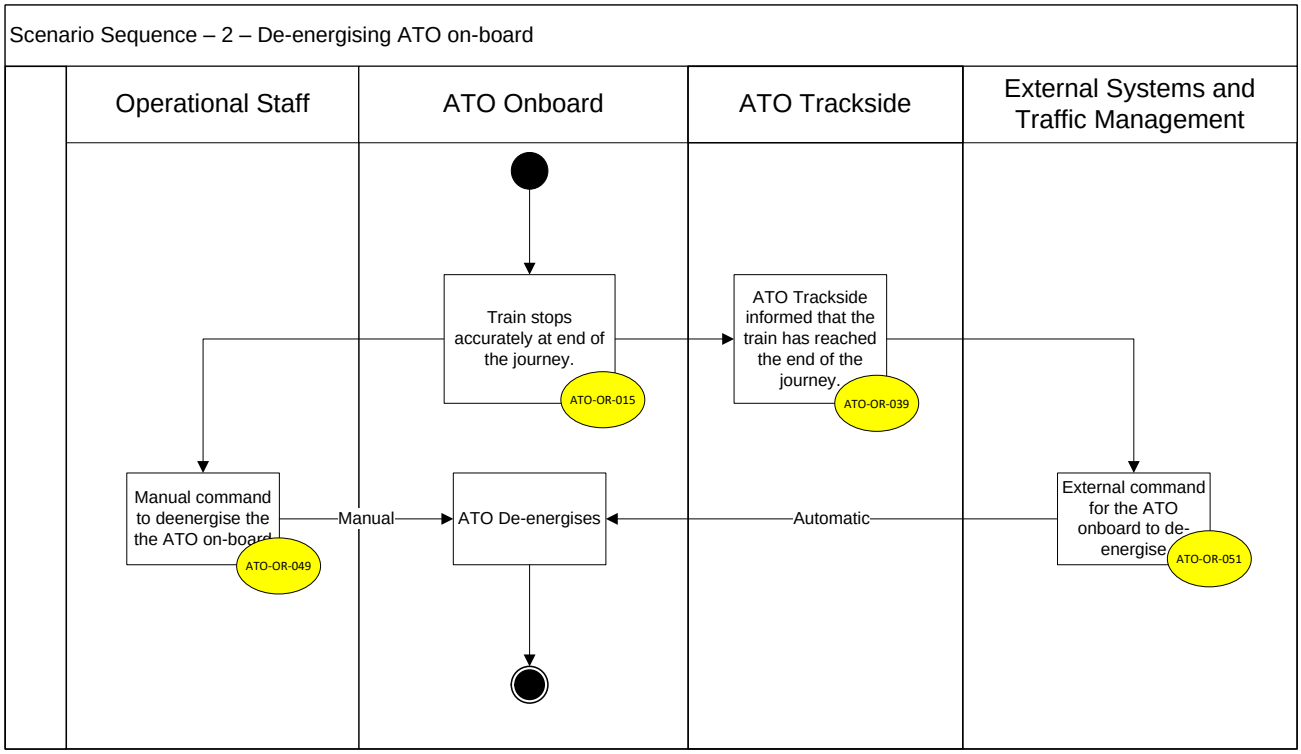
1 Starting Journey

Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required to energise an ATO on-board and assign an ATO train a Journey Profile.			
Preconditions	1. GoA1 (C-DAS) and GoA2 (ATO) are not inhibited. 2. The train is in an ATO area and a radio connection from ATO on-board to ATO trackside is established as soon as possible. 3. All vehicle and on-board systems are fully operational.			
Notes	1. If ATO-OB is energised, the necessary conditions are fulfilled and ETCS-OB is in FS mode only DAS information is available. If the same conditions as before apply but the ETCS-OB is in AD mode, the ATO functions are available. 2. If the ATO on-board is automatically energised, then the command will come from the rolling stock to the ATO on-board. The original command to the rolling stock can come from a remote system. 3. If the ATO on-board diagnostic tests fail, then the driver should still be able to drive manually (ATO-OR-185). 4. The ATO on-board can perform self-tests and diagnostics at any time during operation (ATO-OR-176) but this must not interfere with ATO operation (ATO-OR-181). 5. Although additional train data may be required for ATO e.g. train mass, the driver shall not have to enter any additional train data for ATO (ATO-OR-053) 6. The TMS may not create the SP and JP but the necessary data for SP and JP shall be sent to the ATO-TS. This is implementation specific.			


Scenario Sequence – 1 – Starting Journey
Operational Staff
ATO Onboard
ATO Trackside
External Systems and Traffic Management
Manual
Automatic
Manual command to energise the ATO on-board
ATO-OR-049
External command for the ATO onboard to energise
ATO-OR-051
ATO onboard energises
Driver informed of ATO onboard status
ATO-OR-178
Diagnostic test fails
ATO onboard performs diagnostics
ATO-OR-175
ATO-OR-177
Diagnostic test fails
Status and prediction updates distributed
ATO-OR-186
Diagnostic tests passed
ATO receives train data from external systems
ATO-OR-054
If no train data received from external systems
If any train data received from external systems
Unvalidated Train Data sent to ETCS on-board
Validated Train Data from ETCS on-board
ATO acquires validated train data from ETCS
ATO-OR-054
Journey and Segment Profile data requested
ATO-OR-052
Traffic Management/ External systems prepare JP & SP data.
ATO-OR-013
Advisory information displayed to Driver
GoA1 (C-DAS)
ATO on-board calculates Operational Speed Profile
ATO-OR-024
Valid Journey and Segment Profiles sent
ATO-OR-014
ATO-OR-052
GoA2 (ATO)
Driver informed of ATO onboard status
ATO Ready for Engagement
ATO-OR-058

2 De-energising ATO on-board

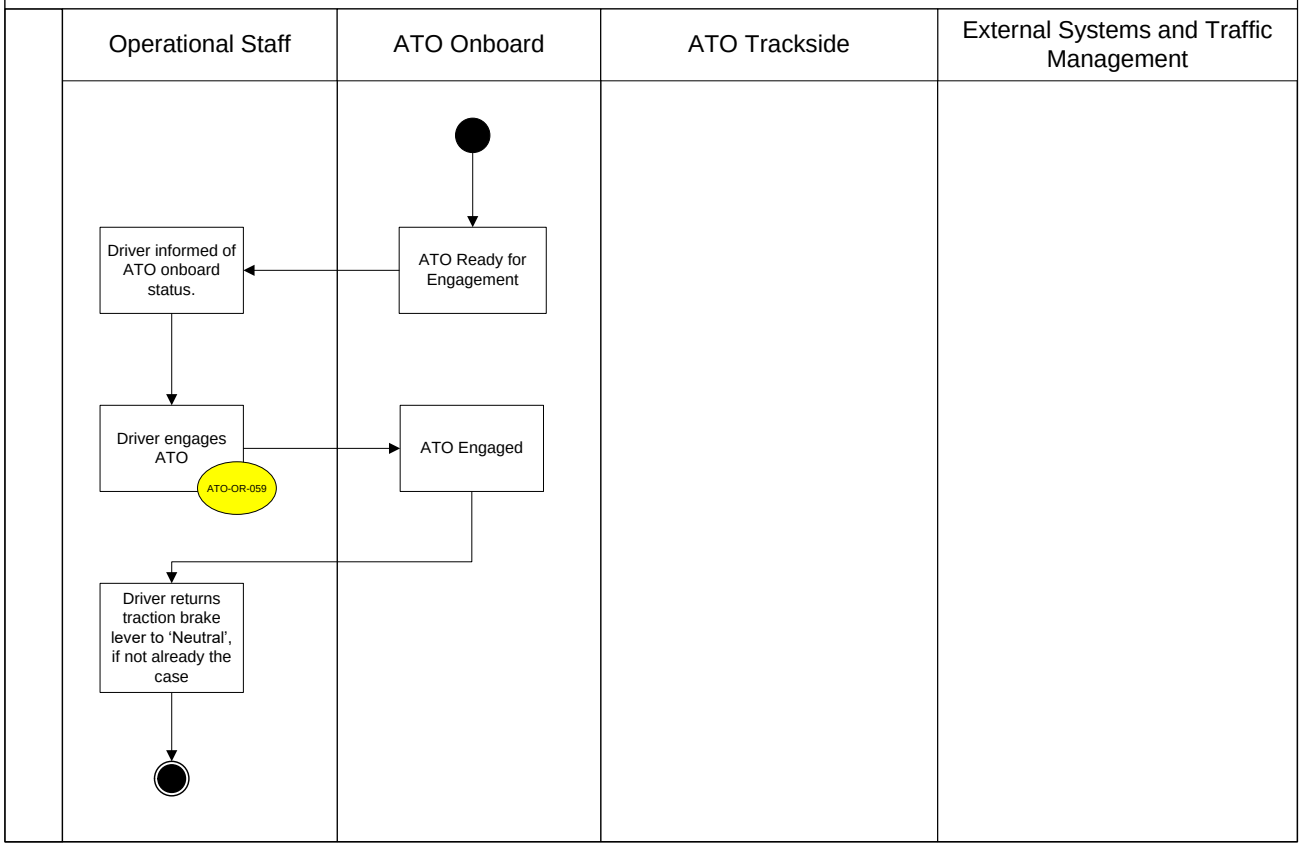
Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required at the end of an ATO train's journey.			
Preconditions	1. ATO is engaged. 2. All vehicle and on-board systems are functioning correctly.			
Notes	1. This scenario does not refer to a train leaving ATO and continuing its journey in GoA1. This is covered in scenario 6. 2. It is assumed when the train stops accurately all passengers have disembarked (or freight has been unloaded) and that train doors are closed and locked. 3. The current requirement suite allows de-energisation to take place anywhere. Operationally, this would only happen at a stand, at the end of the journey. 4. This scenario does not cover an ATO reset that can be commanded by the driver			



3 Planned GoA1 to GoA2 transition on the move

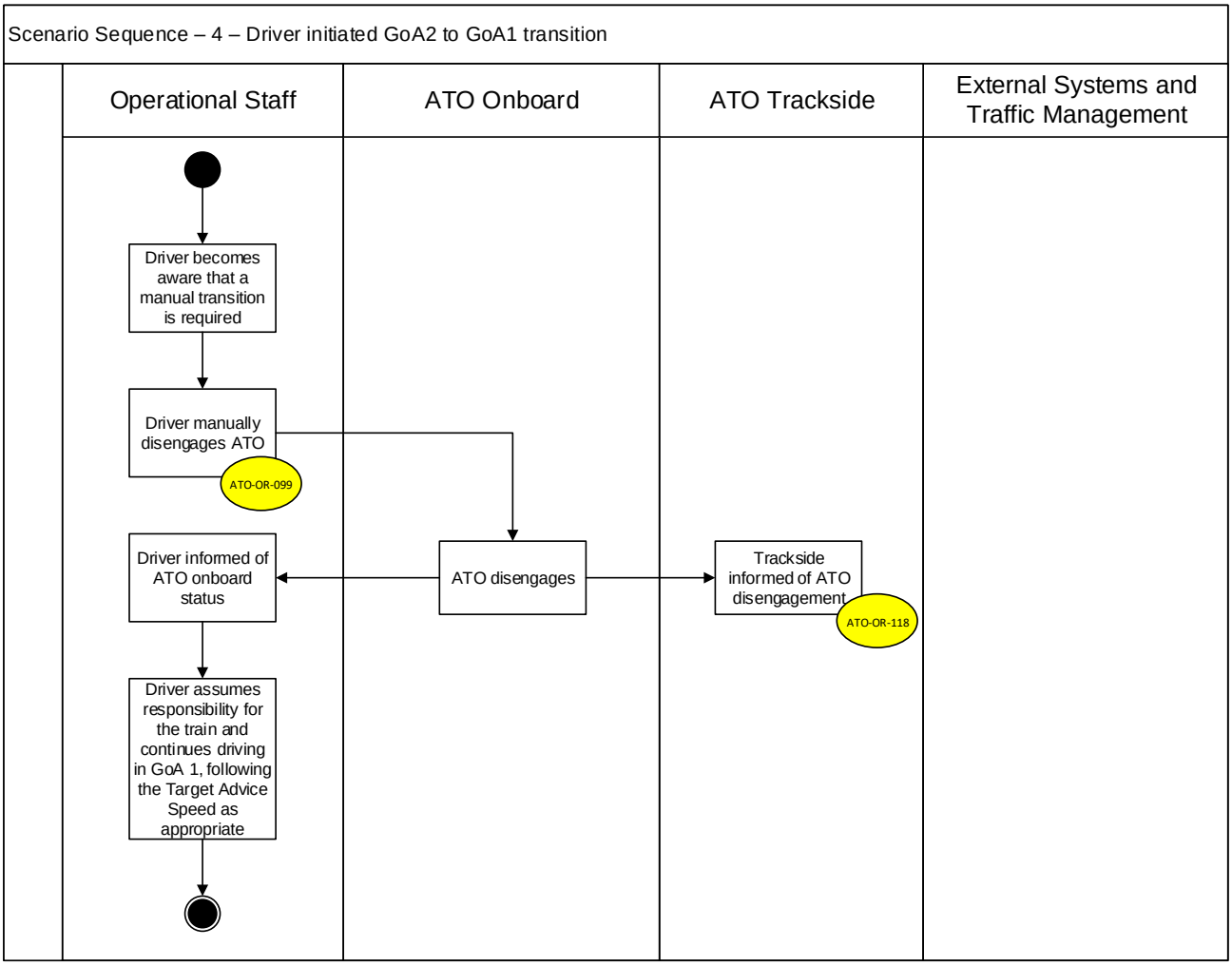
Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for a train to transition into GoA2 on the move.			
Preconditions	1. ATO engagement conditions have just been fulfilled (e.g. FS MA received by the ETCS on-board). 2. All vehicle and on-board systems are functioning correctly 3. GoA transitions are allowed on the move (ATO-OR-109 & ATO-OR-105).			
Notes	1. Transition to ATO at 0 km/h will happen at a stopping point, the flashing yellow button shall be pushed by the driver. 2. The location at which the transition from GoA1 to GoA2 happens is not dependent on there being a radio connection to the ATO trackside as long as a valid Journey Profile and Segment Profiles have been received by the ATO on-board and engagement conditions are fulfilled. 3. This scenario could also arise as part of normal movement in ETCS Level 1.			

Scenario Sequence – 3 – Planned GoA1 to GoA2 transition on the move



4 Driver-initiated GoA2 to GoA1 transition

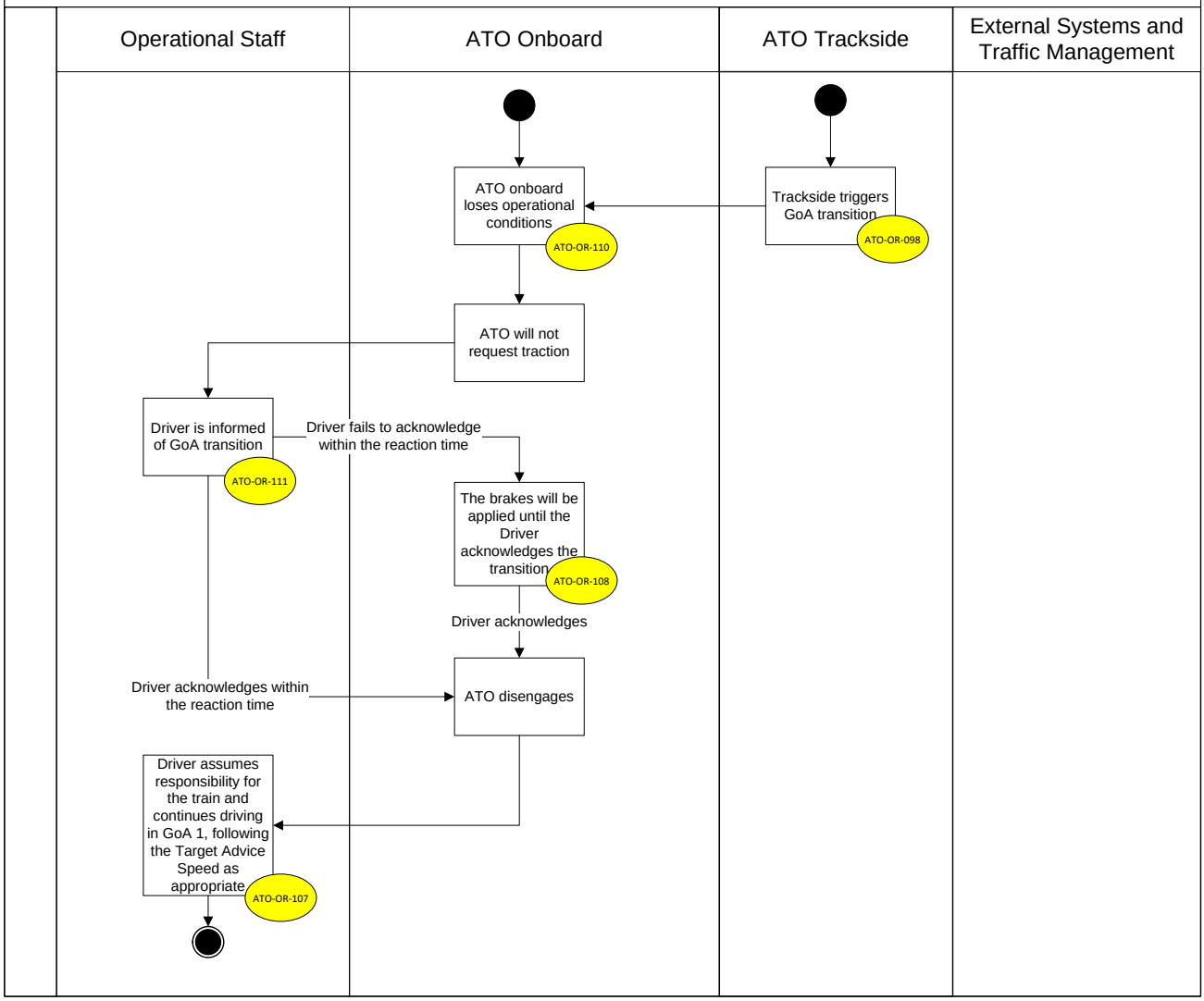
Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to transition from GoA2 to GoA1 when commanded by the driver.			
Preconditions	1. ATO is engaged			
Notes	1. This scenario could arise due to degraded conditions which do not invoke an automatic transition (e.g. driver detects obstacle on track) 2. This scenario could also arise as part of normal movement when operating ATO in ETCS Level 1 3. There may be a number of ways for the driver to disengage ATO depending on the application, they could brake the train using the brake lever (ATO-OR-101) or they could push a disengage ATO button or they could unselect ATO.			



5 Automatic GoA2 to GoA1 transition on the move

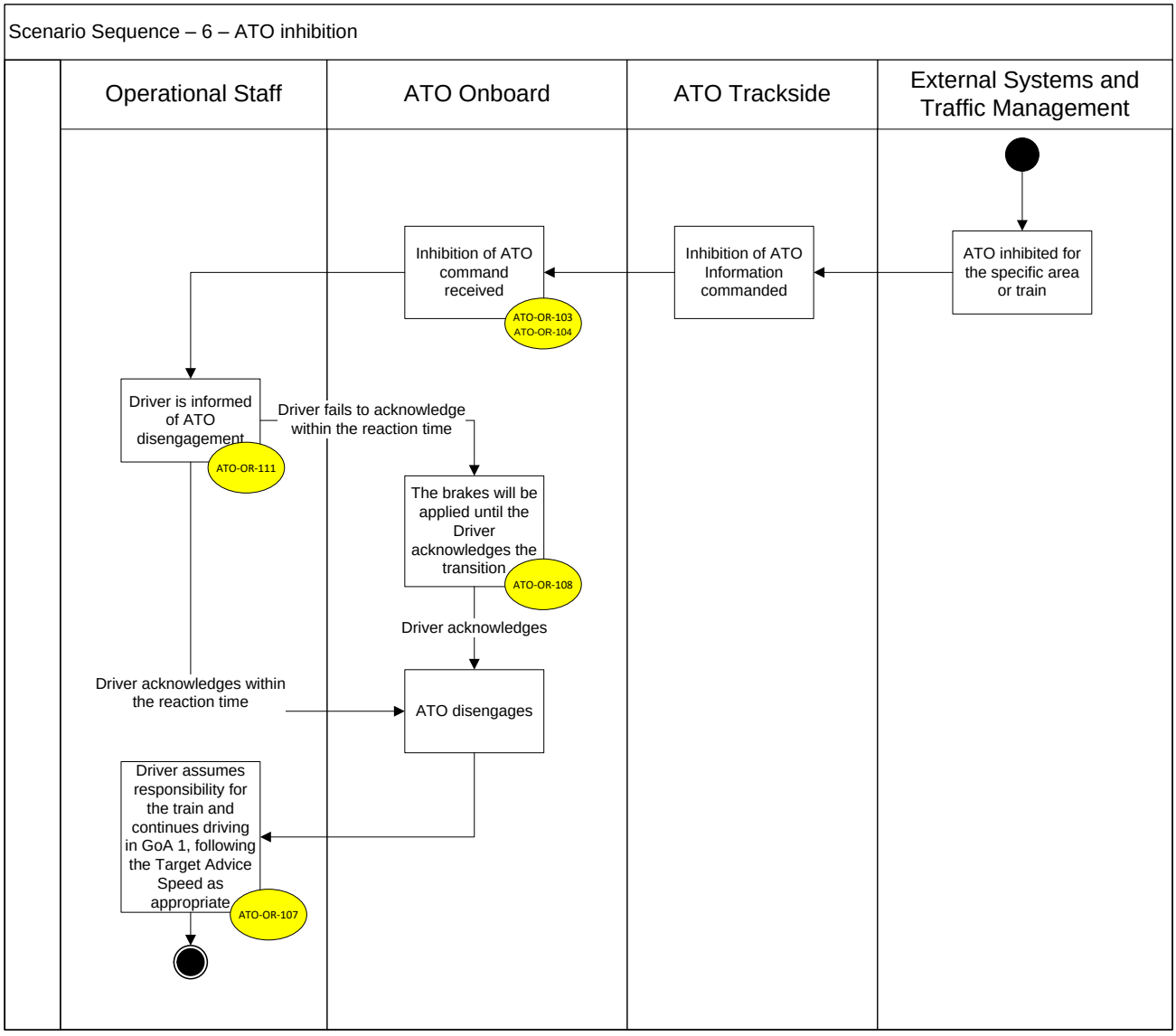
Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to transition automatically from GoA2 to GoA1.			
Preconditions	1. ATO is engaged 2. GoA transitions are allowed on the move (ATO-OR-109)			
Notes	1. This scenario could arise due to loss of operational conditions including no further JP information is to be provided by the trackside. 2. ATO cannot be engaged again until all engagement conditions are fulfilled (ATO-OR-112). 3. If the transition is due to the loss of engagement conditions, then if these engagement conditions are recovered within a certain time the ATO on-board can continue in automatic driving 4. Before the ATO disengages any on-going brake application from the ATO on-board shall be completed. 5. If there's an ATO trackside failure, the ATO- on-board should continue the operation to the end of the currently available JP. 6. If there's an ATO on-board failure the on-board shall start braking after reaction time until the driver acknowledges the ATO on-board failure by taking over control or deselecting ATO.			

Scenario Sequence – 5 – Automatic GoA2 to GoA1 transition on the move



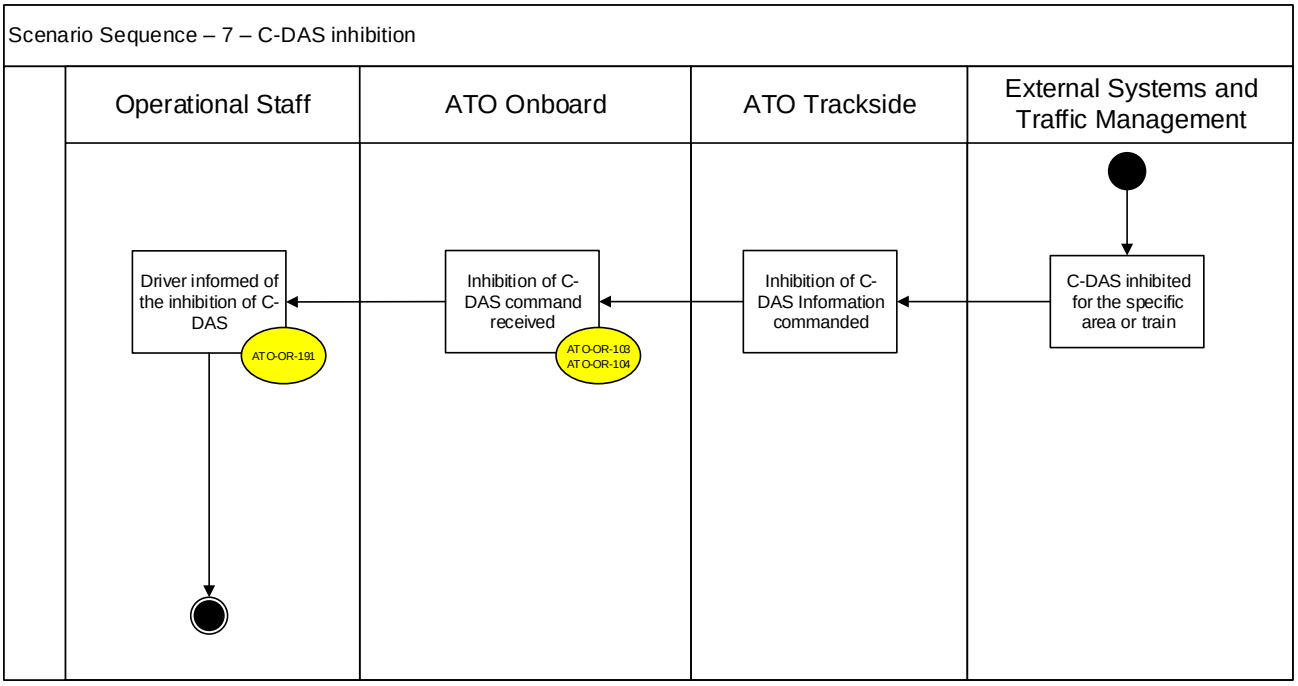
6 ATO inhibition

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required when it is necessary to suppress ATO in a given direction.			
Preconditions	1. ATO is in operation 2. All vehicle and on-board systems are functioning correctly			
Notes	1. When ATO is inhibited, the operational conditions are lost and scenario 5 applies.			



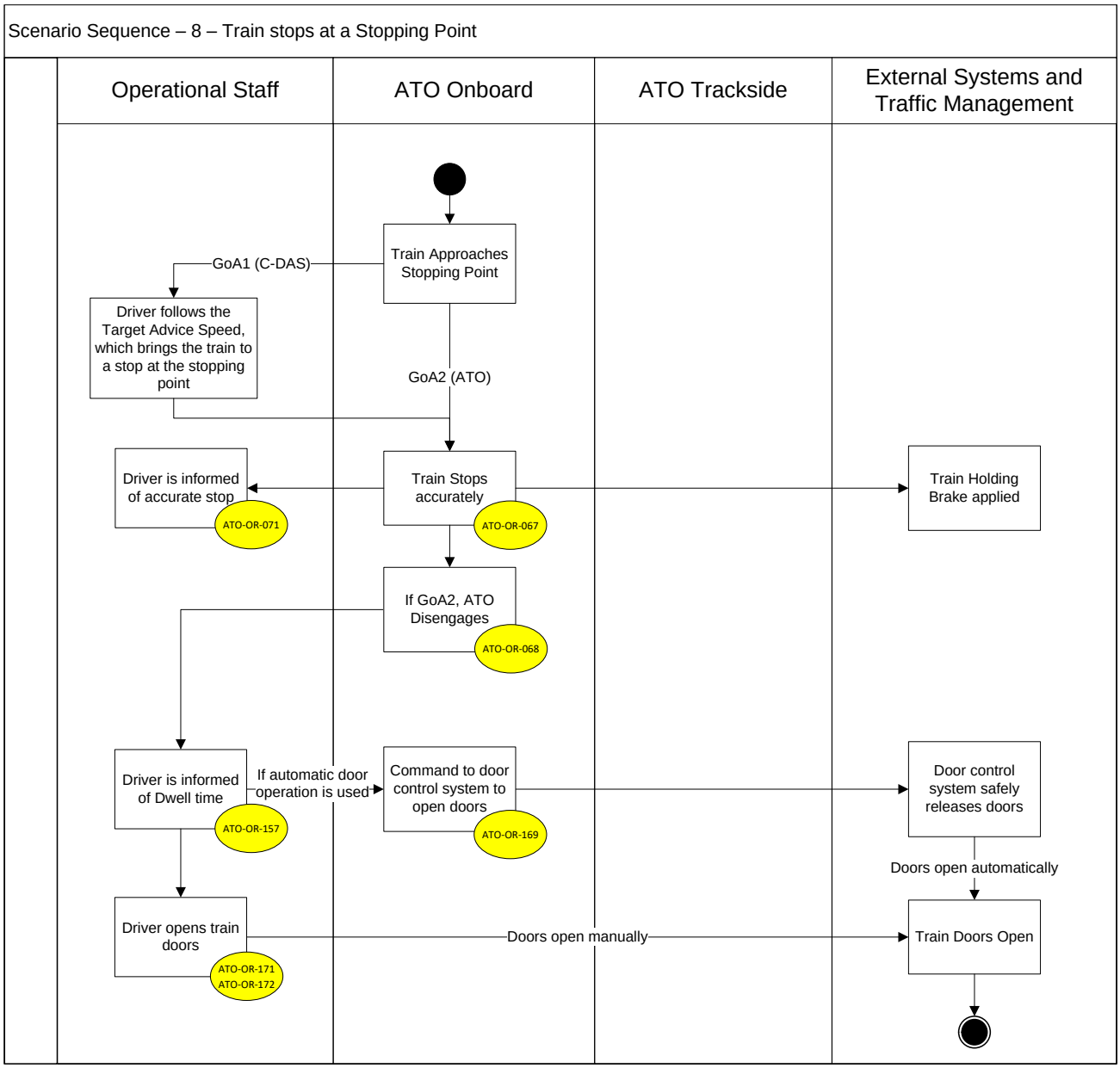
7 C-DAS inhibition

Applies to	**GoA1**	Yes	**GoA2**	No
Scenario Objective	This describes the operational activities required when it is necessary to suppress C-DAS in a given direction or for a given train.			
Preconditions	1. ATO is in operation 2. All vehicle and on-board systems are functioning correctly			
Notes	1. If C-DAS is unavailable, the train is still considered to be in GoA1 when be driven manually.			



8 Train stops at a Stopping Point

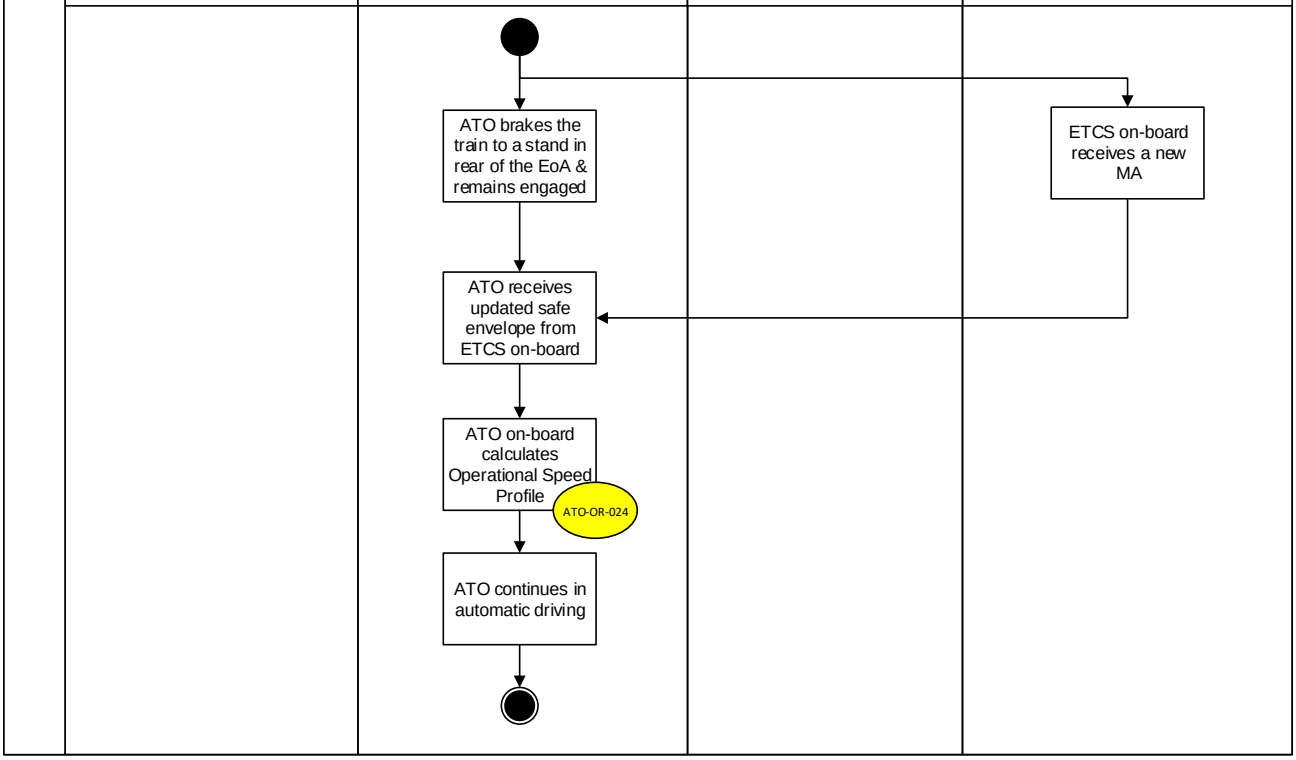
Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to stop at a stopping point.			
Preconditions	1. The Stopping Point is contained in the Journey Profile			
Notes	1. When a train is stopped by signalling and driving automatically in GoA2, it will drive until the EoA and stop, but will not disengage. When a movement authority is received on-board then the ATO will continue to drive automatically without any further command required from the driver. 2. The opening/release of the doors when the train has stopped accurately can be configured to be automatic or manual (ATO-OR-168).			



9 Train stopped by signalling

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities when a train is automatically driven and stopped by signalling. The train shall not disengage but continue when granted a new movement authority.			
Preconditions	1. Valid Journey Profiles and Segment Profiles have been received that cover the section beyond the current EoA.			
Notes	1. ATO will remain engaged (in GoA2) when the train is at a stand 2. Automatic driving will recommence once the MA is extended 3. GoA1 is not included as it is seen as standard driving			

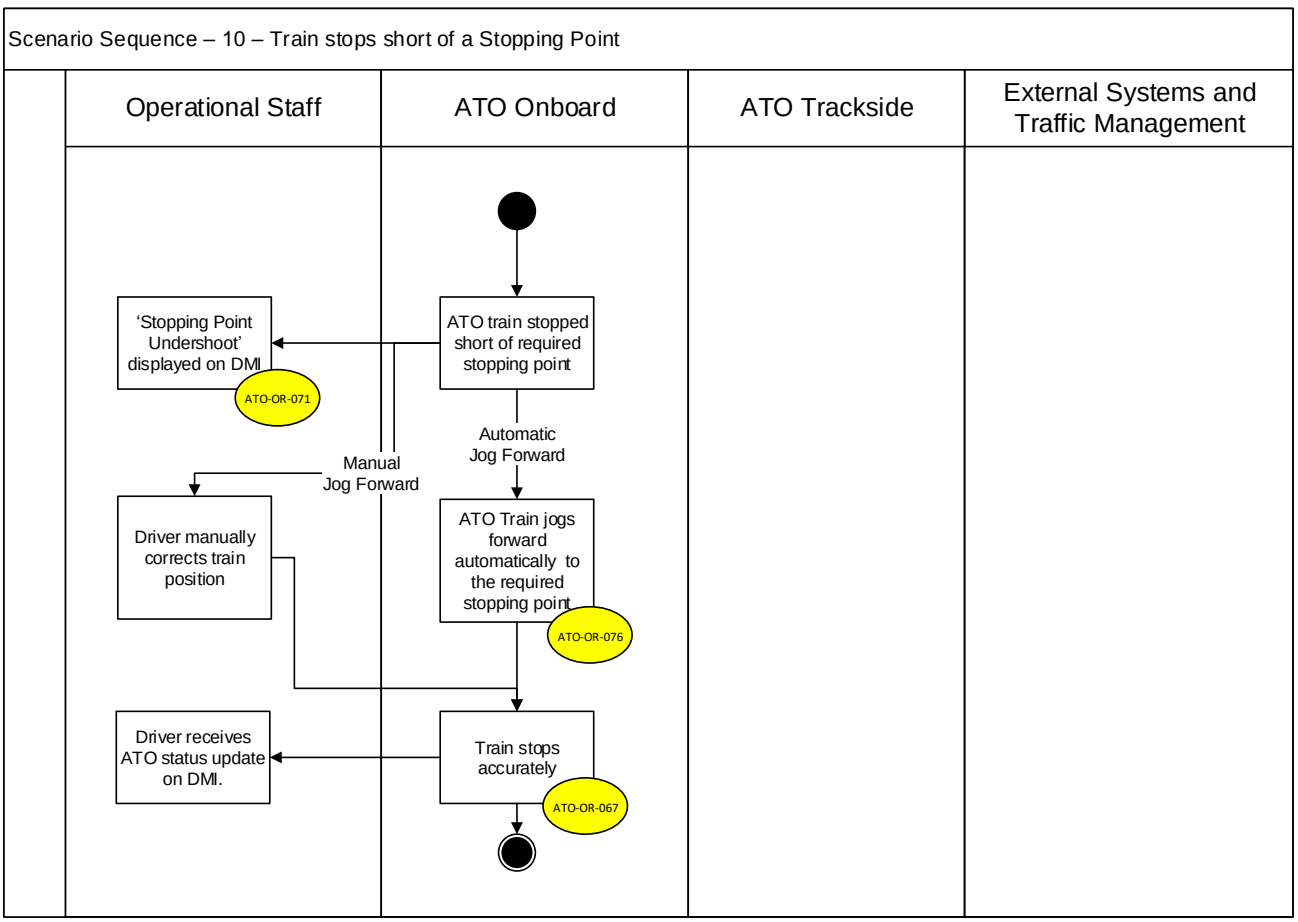
Scenario Sequence – 9 – Train stopped by signalling



10 Train stops short of a Stopping Point

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to jog forward after stopping short of a stopping point.			
Preconditions	1. ATO is engaged 2. The Stopping Point is contained within the Journey Profile			
Notes	1. Once the train has stopped accurately it will continue as in Scenario Sequence 8. 2. If there is no automatic jog forward then the ATO will disengage when it stops, even if inaccurately.			

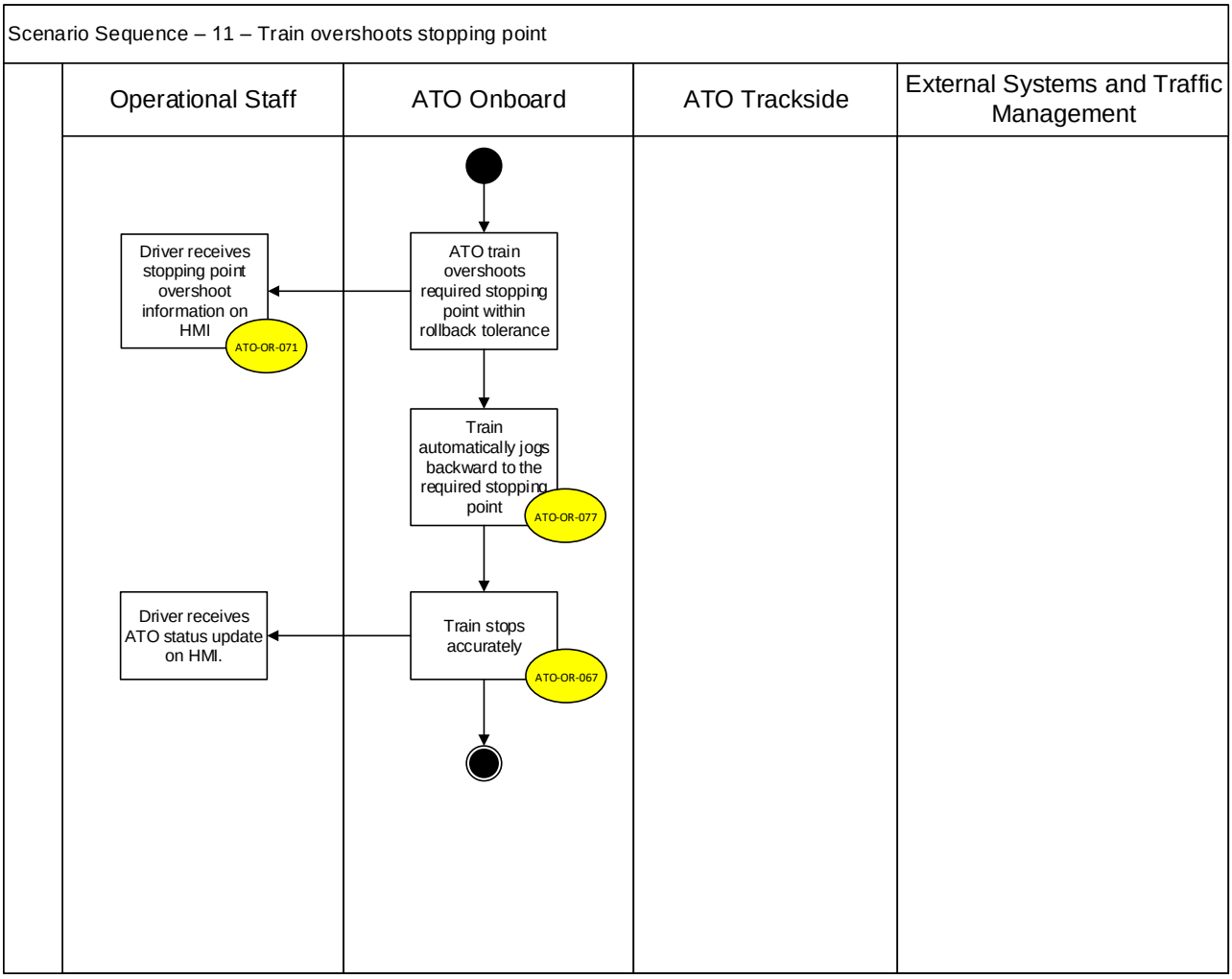
Scenario Sequence – 10 – Train stops short of a Stopping Point



11 Train overshoots Stopping Point

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required when an ATO train overshoots a stopping point.			
Preconditions	1. ATO is engaged 2. The Stopping Point is contained within the Journey Profile			
Notes	1. If the ATO overshoots the stopping point and brings the train to a stand beyond the rollback tolerance, then the driver will be informed and have to take manual action based on operational rules. (ATO-OR-078). 2. It is assumed in GoA1 (C-DAS) the driver will not overshoot the stopping point, if following the target speed advice. 3. In some cases manual jogging backwards may be allowed depending on the operational rules.			

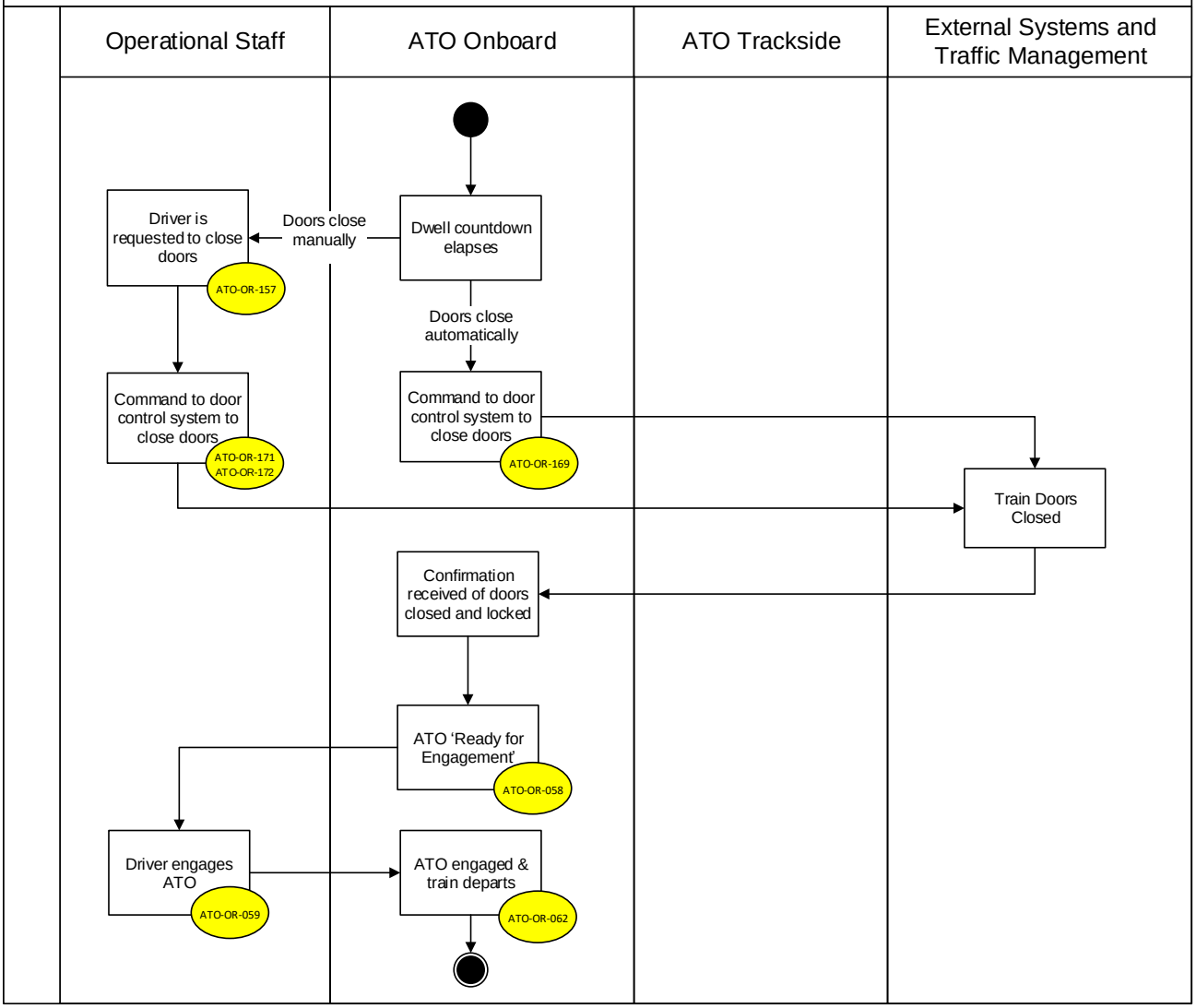
Scenario Sequence – 11 – Train overshoots stopping point



12 Train departs from a Stopping Point

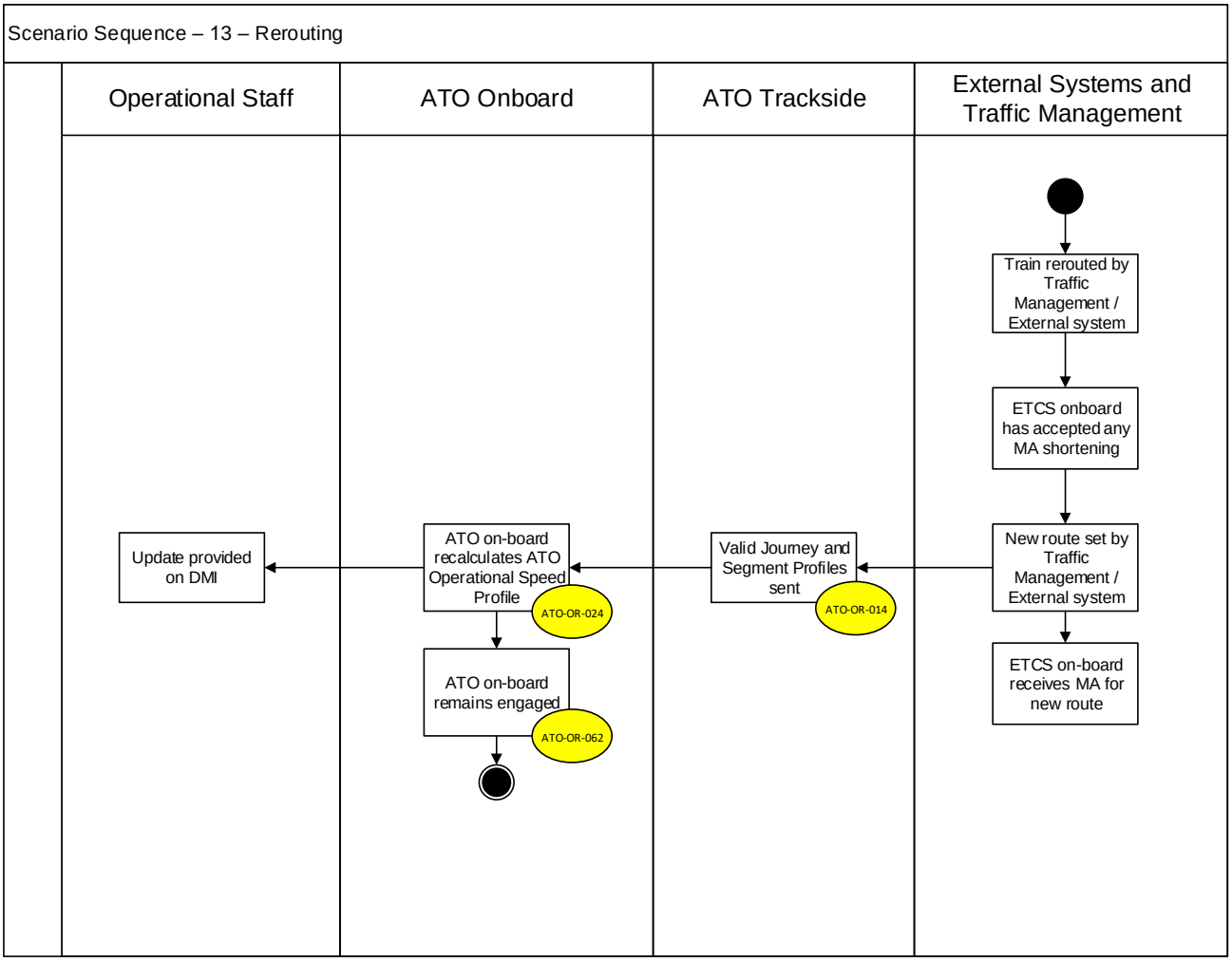
Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to depart from a station.			
Preconditions	1. ATO is not engaged 2. ATO Operational Conditions are fulfilled 3. Train is stationary at a stopping point and inside the stopping window			
Notes	1. Where an immediate departure is required, the trackside will send an updated Journey Profile, and the scenario sequence will remain the same as the scenario below (ATO-OR-084).			

Scenario Sequence – 12 – Train departs from a Stopping Point



13 Rerouting

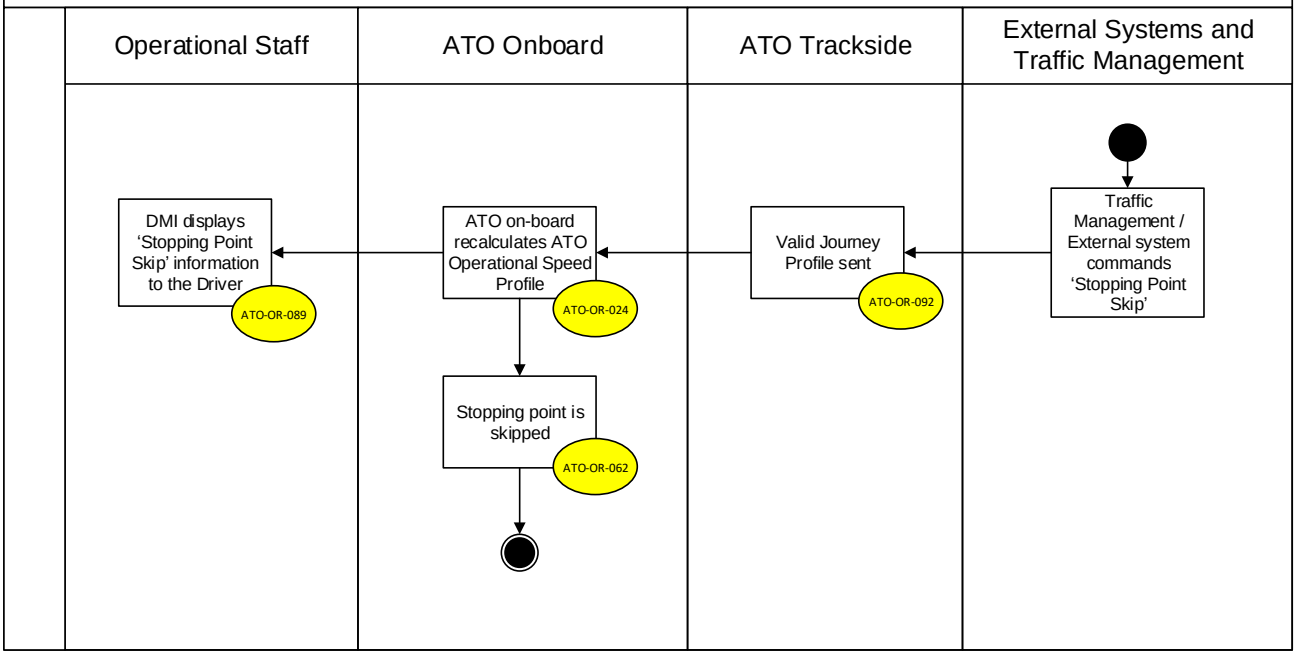
Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required to reroute an ATO train			
Preconditions	1. ATO is engaged 2. The train has a Movement Authority for Route A 3. The train is now required to run via Route B.			
Notes				



14 Trackside initiated ‘Stopping Point Skip’

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to skip a stopping point when commanded by the trackside.			
Preconditions	1. ATO is engaged 2. All vehicle and on-board systems are functioning correctly			
Notes	1. If the train comes to a stand in the platform to be skipped, the doors will not be opened automatically (ATO-OR-075) 2. To remove a ‘stopping point skip, an updated Journey Profile must be issued (ATO-OR-088).			

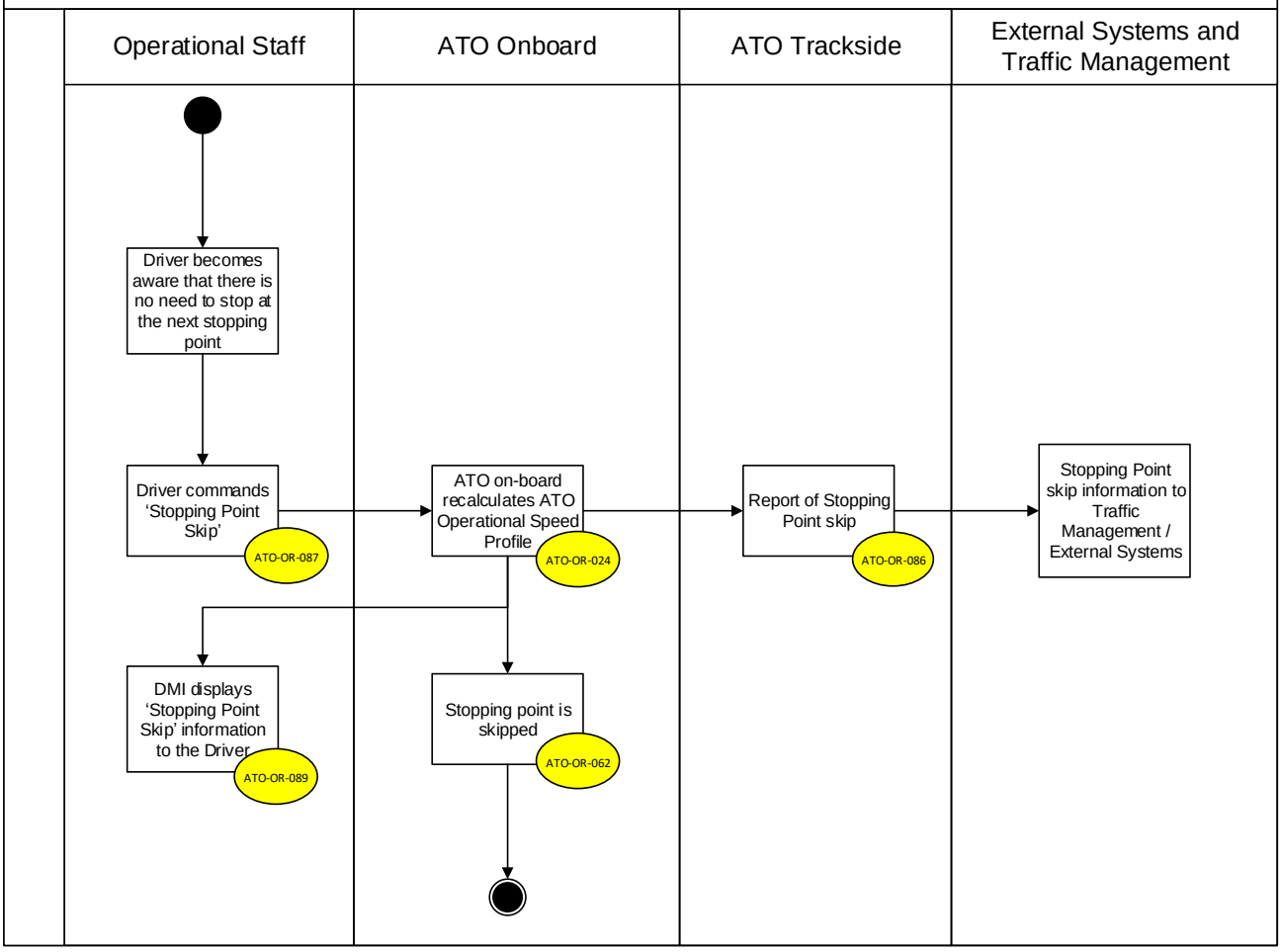
Scenario Sequence – 14 – Trackside initiated ‘Stopping Point Skip’



15 Driver initiated ‘Stopping Point Skip’

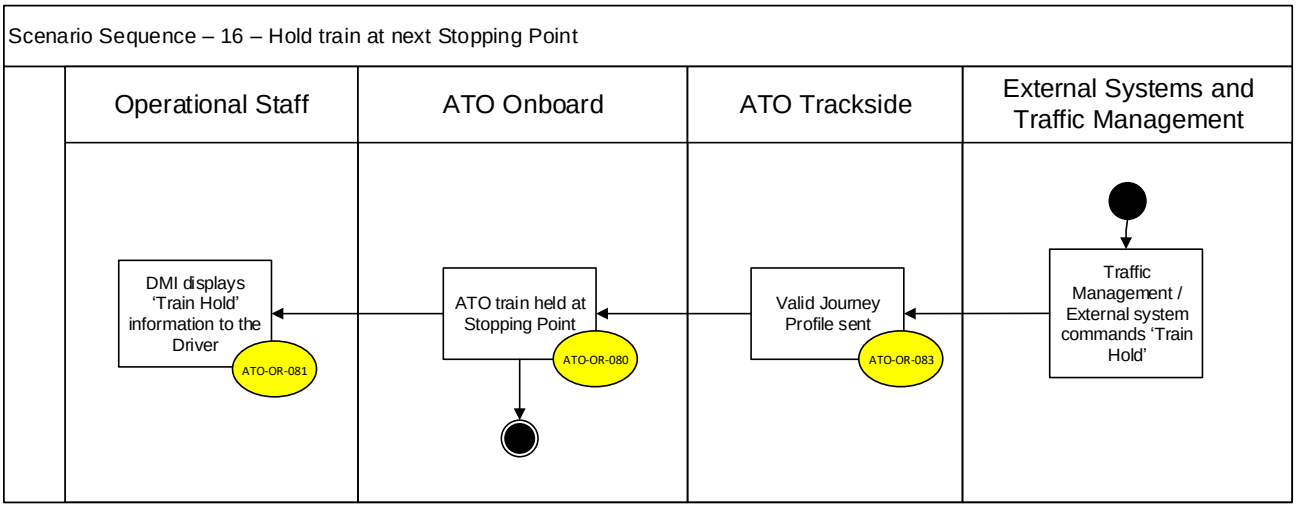
Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for an ATO train to skip a stopping point when commanded by the Driver.			
Preconditions	1. ATO is engaged 2. All vehicle and on-board systems are functioning correctly 3. ATO Operational conditions are fulfilled.			
Notes	1. If the train comes to a stand in the platform, the doors will not be opened automatically (ATO-OR-075). 2. The purpose of this scenario is to support energy efficiency, predominately in rural settings, where there are infrequent demands for loading and unloading. 3. A “Stopping Point Skip” initiated by the train driver shall only be revoked by the train driver (ATO-OR-091).			

Scenario Sequence – 15 – Driver initiated ‘Stopping Point Skip’



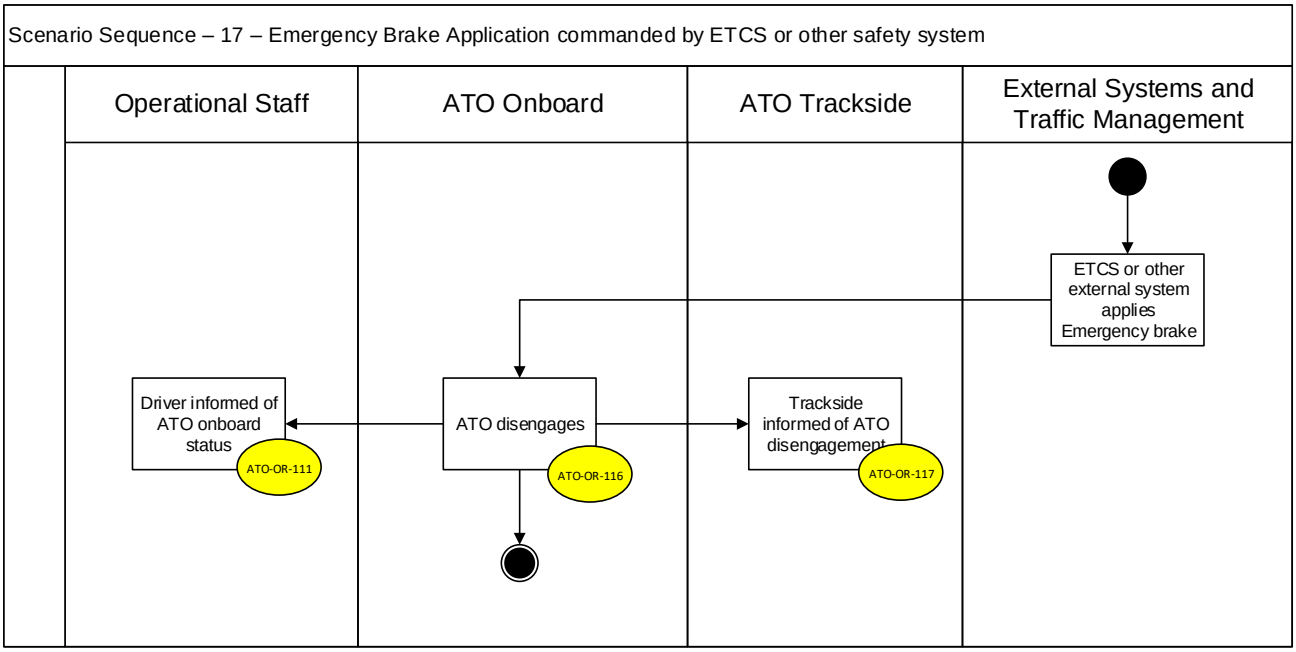
16 Hold train at next Stopping Point

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required to apply a train hold command.			
Preconditions	1. ATO is in operation 2. All vehicle and on-board systems are functioning correctly			
Notes	1. The train is held until a new Journey Profile is received.			



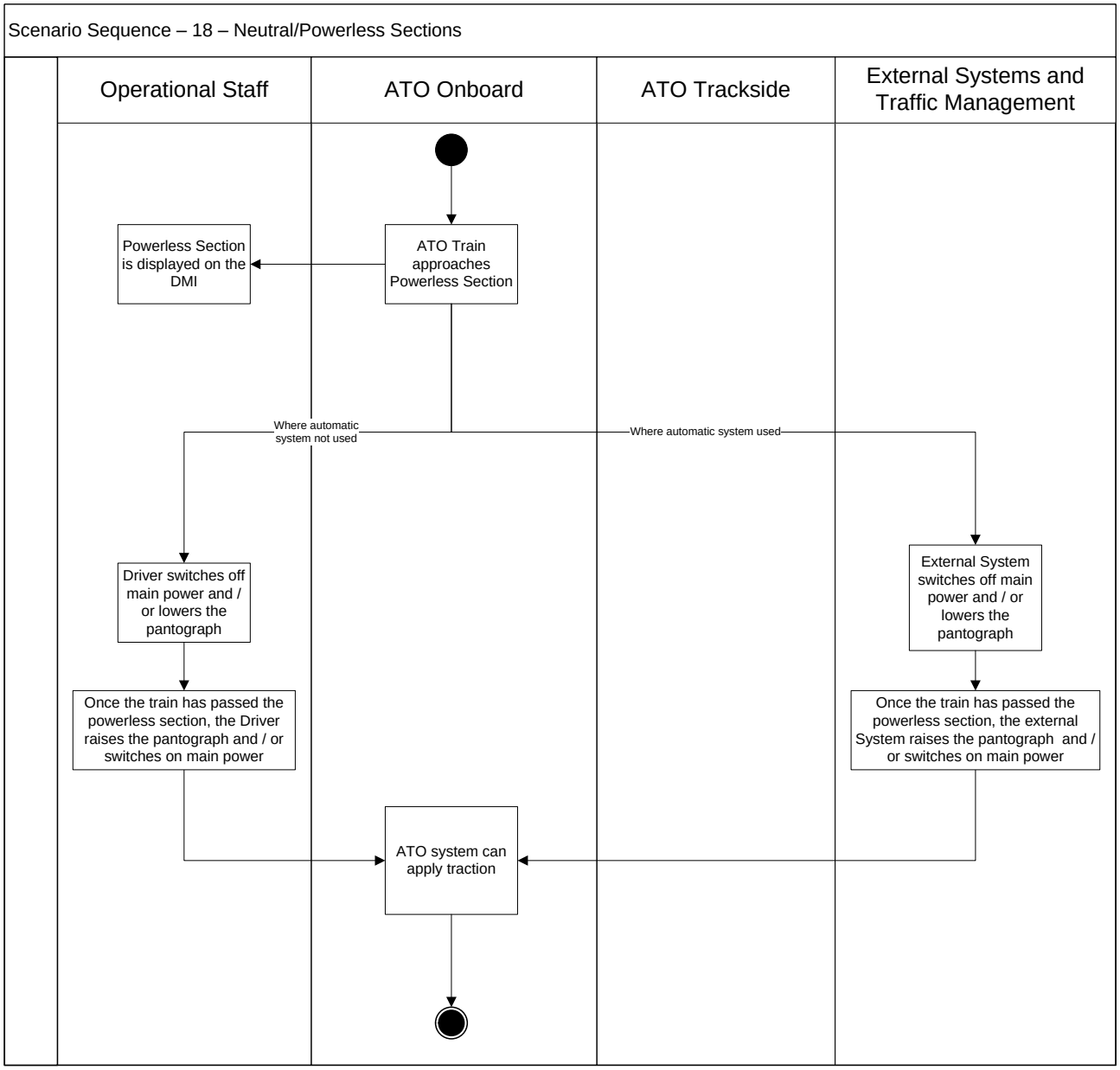
17 Emergency brake application commanded by ETCS or other safety system

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required when an ATO train receives an emergency brake application.			
Preconditions	1. ATO is engaged 2. All vehicle and on-board systems are functioning correctly			
Notes	1. ATO cannot be engaged again until all engagement conditions are fulfilled (ATO-OR-112).			



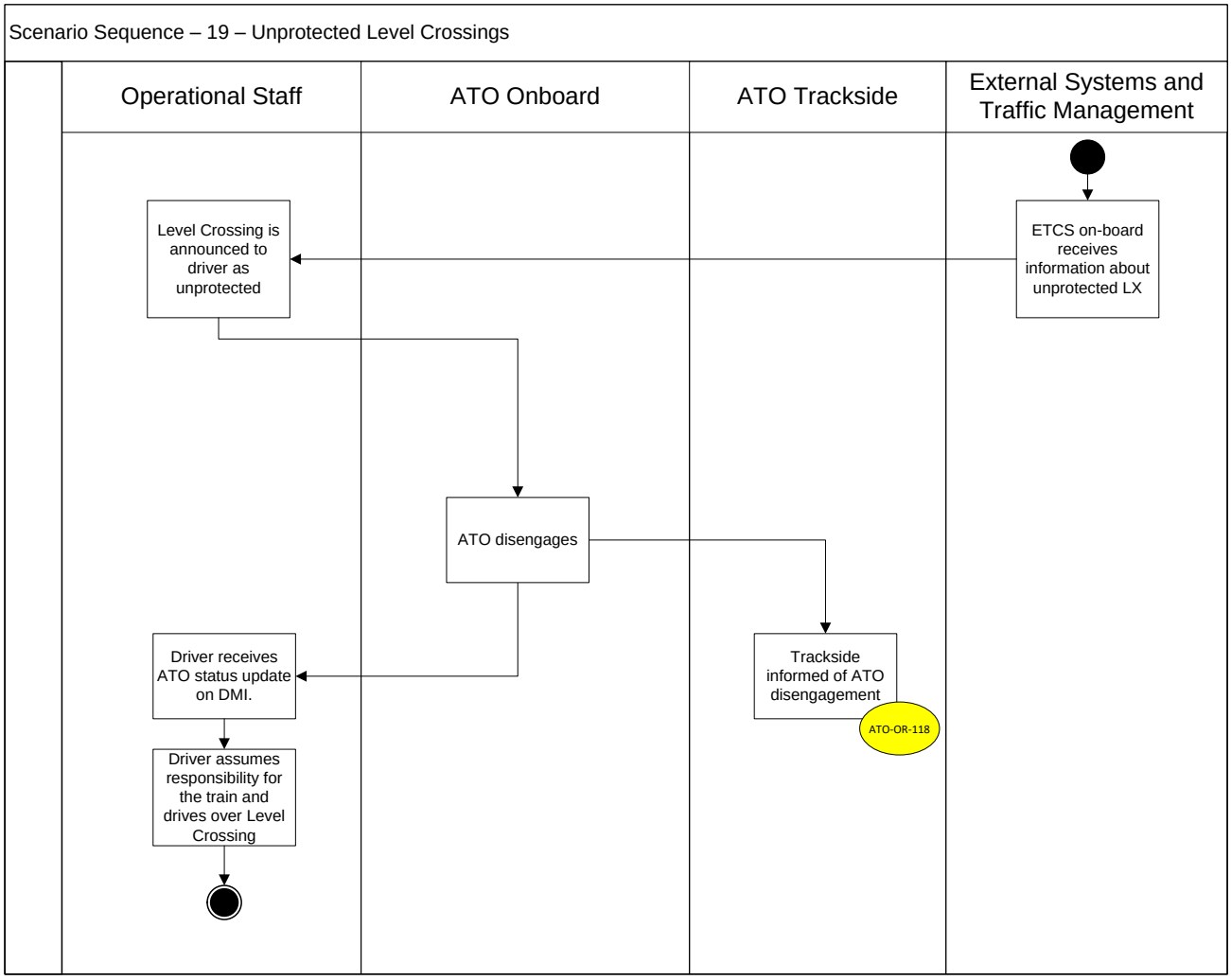
18 Neutral/Powerless Sections

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for a train to pass through a neutral section.			
Preconditions	1. ATO is engaged. 2. All vehicle and on-board systems are functioning correctly			
Notes	1. The ATO operational speed profile will be calculated taking into account that during the powerless section ATO cannot command power. Powerless sections are included in the Segment Profile. 2. ATO does not command the lowering/raising of pantographs or opening/closing of switches, this is done by external systems.			



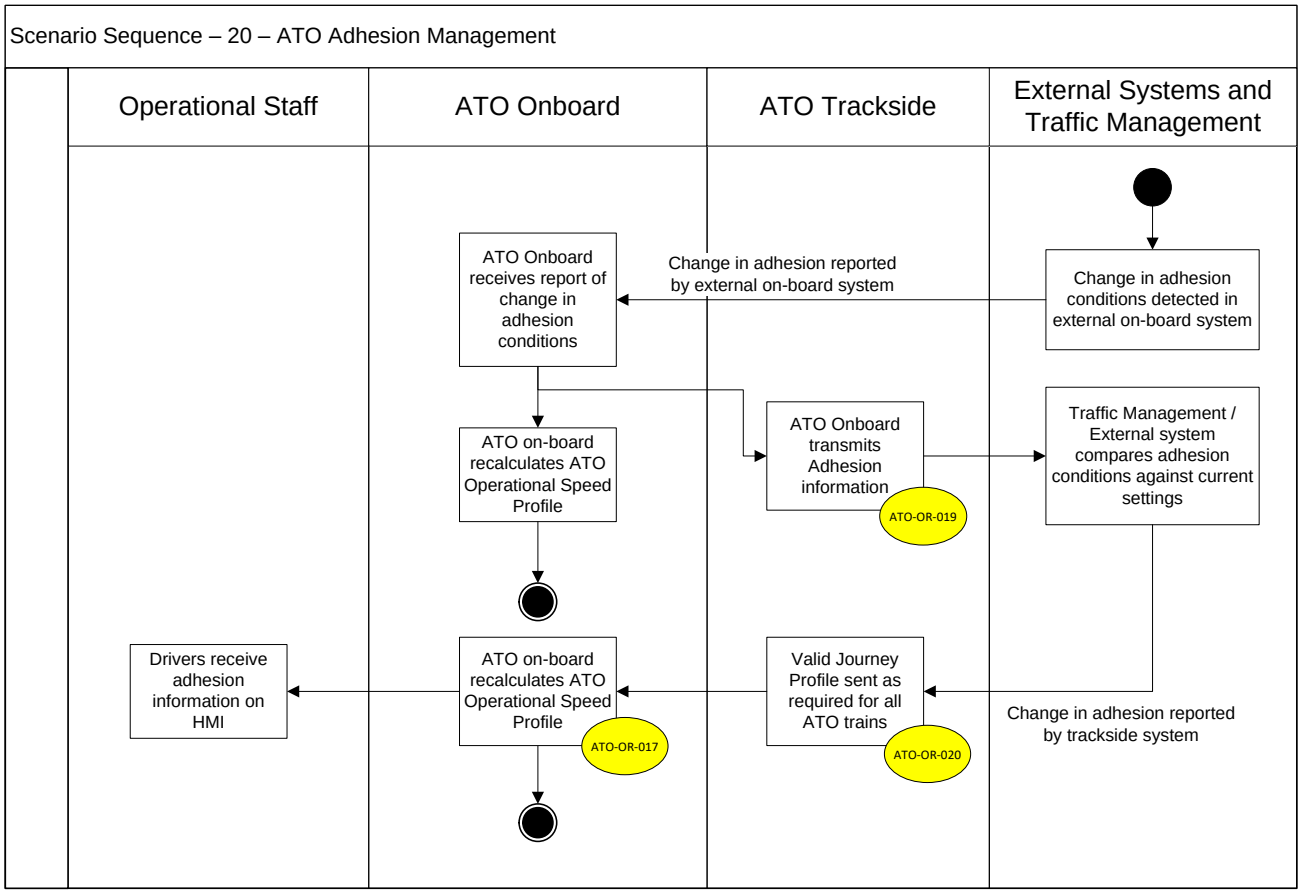
19 Unprotected level crossings

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for a train to pass over an unprotected level crossing.			
Preconditions	1. ATO is engaged 2. All vehicle and on-board systems are functioning correctly 3. The train is approaching an unprotected level crossing			
Notes	1. Unprotected level crossings can only be passed over by disengaging ATO and driving manually (ATO-OR-094) 2. Automatic driving will remain engaged without the need for any acknowledgement across protected level crossings (ATO-OR-093).			



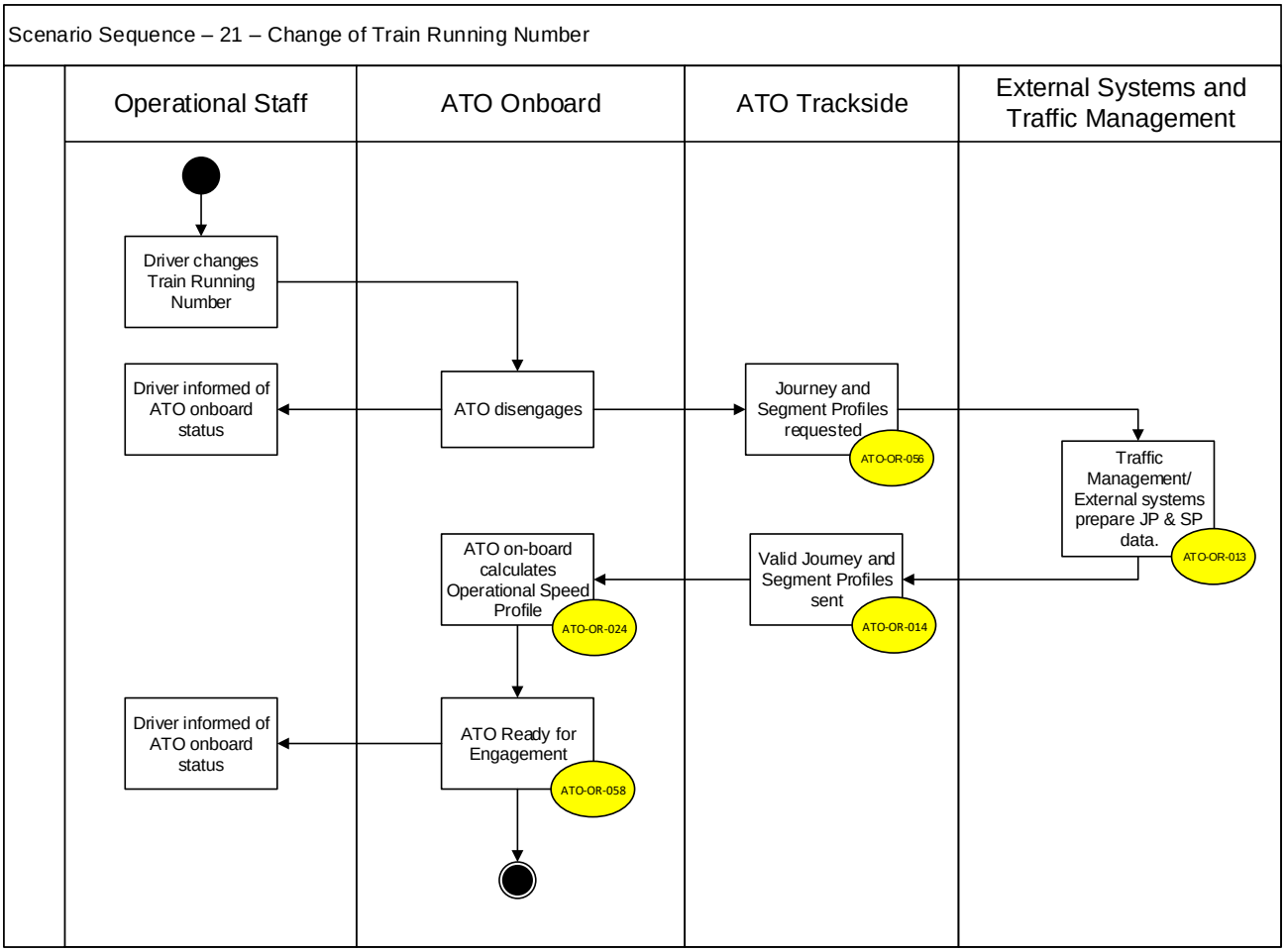
20 ATO adhesion management

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required for ATO trains to report requirements to change adhesion settings.			
Preconditions	1. ATO is in operation 2. All vehicle and on-board systems are functioning correctly			
Notes	1. Changes in adhesion conditions can be detected by different systems (WSP or ATO trackside). 2. ATO needs to work across a wide range of adhesion conditions (ATO-OR-016).			



21 Change of Train Running Number

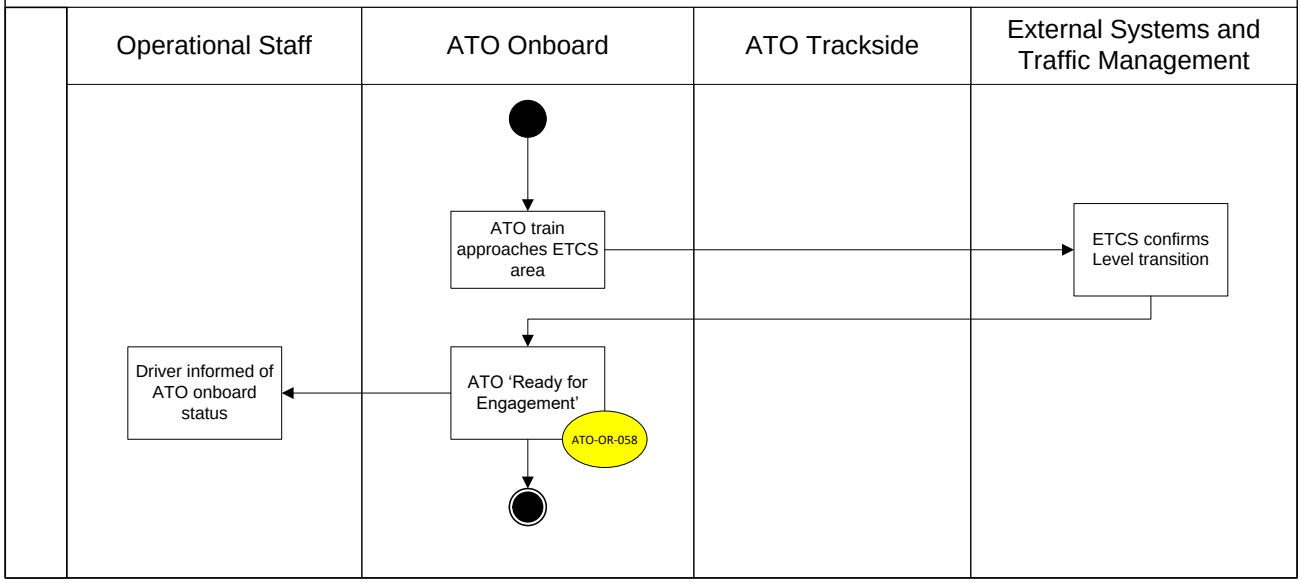
Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required when a Train Running Number is changed.			
Preconditions	1. ATO is in operation 2. New Journey Profiles and Segment Profiles consistent with the new TRN are available 3. All vehicle and on-board systems are functioning correctly			
Notes				



22 Transition from Class B area

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required when a Train is leaving a Class B system (Level NTC) and transitioning to ETCS			
Preconditions	1. ATO is functioning correctly in the Class B system but the operational conditions are not fulfilled as there is no ETCS. 2. All vehicle and on-board systems are functioning correctly			
Notes	1. It is assumed that all engagement conditions are fulfilled after passing the ETCS level transition.			

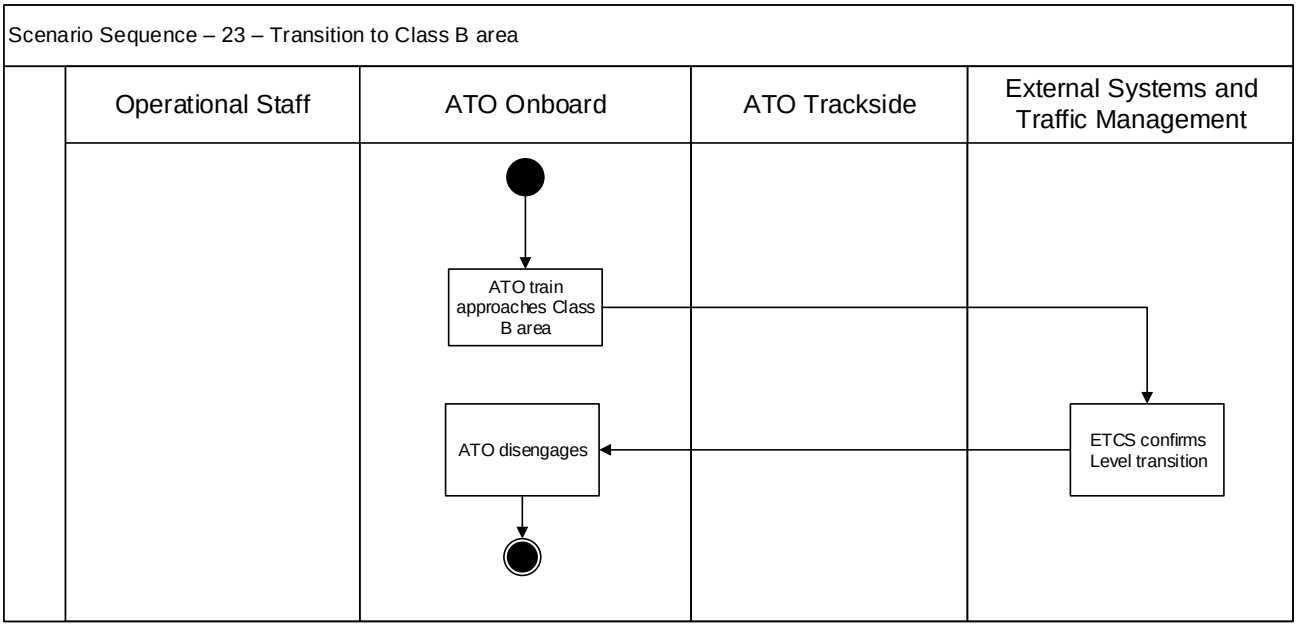
Scenario Sequence – 22 – Transition from Class B area

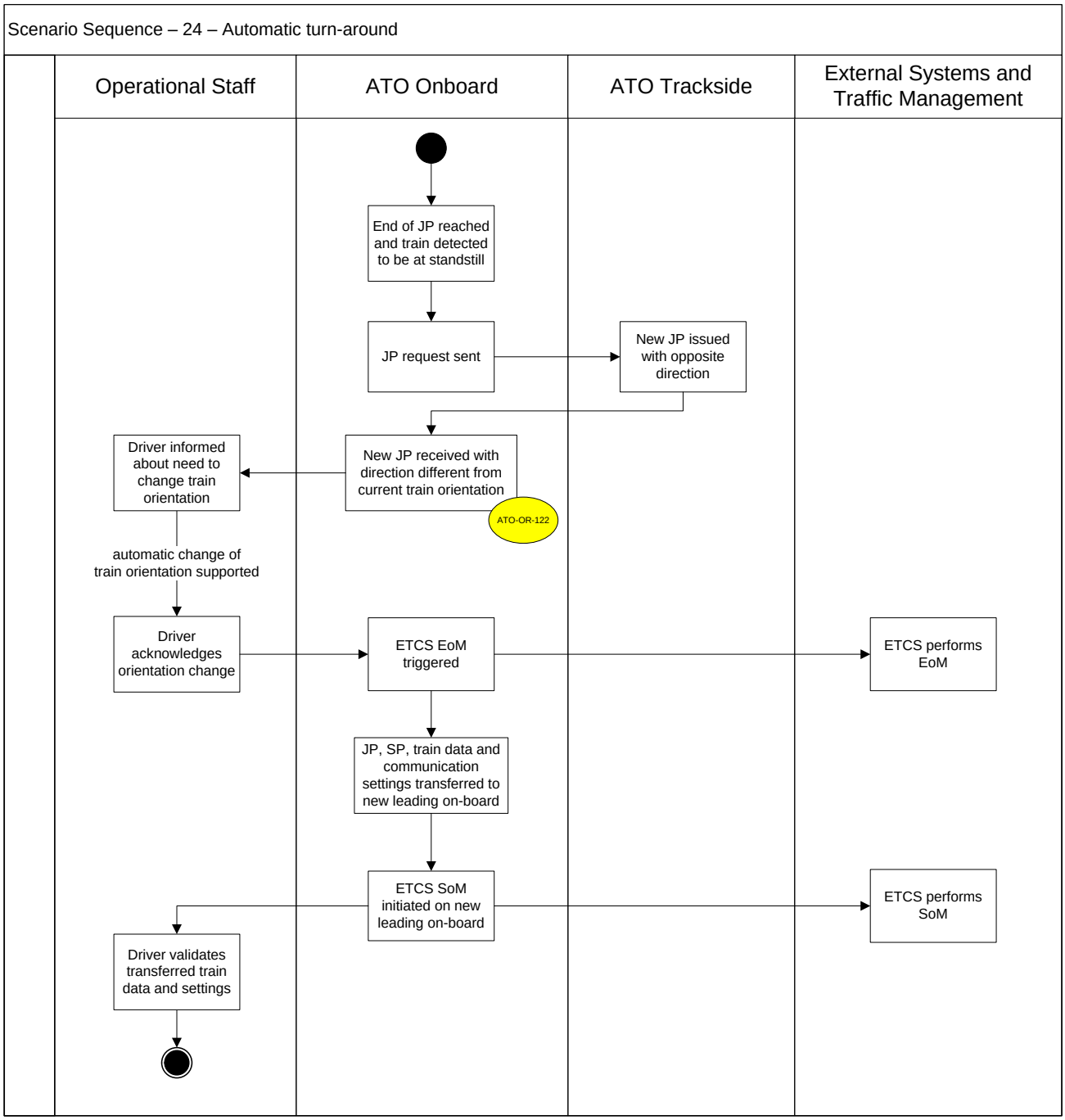


23 Transition to Class B area

Applies to	**GoA1**	No	**GoA2**	Yes
Scenario Objective	This describes the operational activities required when a Train is leaving ETCS and transitioning to a Class B system (Level NTC)			
Preconditions	1. ATO is engaged under the protection of ETCS. 2. All vehicle and on-board systems are functioning correctly			
Notes	1. It is assumed that the driver will acknowledge the transition to ETCS Level NTC.			

Scenario Sequence – 23 – Transition to Class B area



24 Automatic turn-around

Applies to	**GoA1**	Yes	**GoA2**	Yes
Scenario Objective	Change train orientation in ATO and ETCS to comply with new travel direction given in Journey Profile.			
Preconditions	1. ATO is at last Stopping Point of journey and has disengaged. 2. New Journey Profile demands travel in opposite direction.			
Notes	1. This scenario covers a stationary turn-around only.