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# PJ.14-W2-101 “SWIM TI Green Profile for Ground/Ground Civ-Mil Information Sharing” TRL6 Contextual Note

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# PJ.14-W2 I-CNSS

SESAR TECHNOLOGICAL SOLUTION PJ.14-W2-101 TRL6 TVALR

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## Abstract

This TRL6 Contextual Note (CN) provides the SESAR technological solution description for industrialisation consideration.

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# 1 Purpose

Please read this disclaimer[1].

This Contextual Note provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR technological solution in terms of scope, main operational and performance benefits, relevant system impacts.

When the technological solution is at TRL6 level, it contains as well additional activities to be conducted during the industrialization phase or as part of deployment.

This document introduces the technological solution data pack comprising the SESAR3 JU deliverables (for TRL6, these data are proposed to support industrialization/deployment).

[1] The opinions expressed herein reflect the author’s view only. Under no circumstances shall the SESAR3 Joint Undertaking be responsible for any use that may be made of the information contained herein.



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# 2 Improvements in Air Traffic Management (ATM)

The objective of the PJ.14-W2-101 SESAR technological solution (SWIM-TI[2] Green Profile (GP) for Ground/Ground (G/G) civil-military information sharing) is to support, at SWIM-TI profile level, the full scope civil-military coordination/cooperation relying on SWIM-Enabled Applications (SEAs). PJ.14-W2-101 is the continuation of SESAR 2020 Wave 1 PJ.17-03.

GP corresponds to a middleware exclusively intending to support SWIM-based exchanges between civil ATM applications and military related applications. In the pre-SWIM context, data-oriented civil-military exchanges mainly flow from civil to military applications; the SWIM deployment will stimulate bidirectional exchanges.

Military applications (systems) can be located in a military unclassified sub-domain or in a military classified sub-domain, typically for Air Defence (AD). In the second case, the bidirectional data flow should go through an Information Exchange Gateway (IEG) that connects both sub-domains in order to reach the military SWIM-TI node hosting GP, which is located in the military unclassified sub-domain and connected to the civil Internet Protocol (IP) infrastructure network.

This coordination/cooperation may rely on existing SESAR 1 / SESAR 2020 SWIM services together with SWIM services to be defined outside the R&D[3] scope. Operational needs, associated with these SWIM services in the scope of this coordination/cooperation, cannot be fully identified by the end of SESAR 2020 Wave 2; PJ.14-W2-101 has to anticipate as much as possible future needs (e.g. needs forecast for the 2025-2035 period).

GP aims at filling the gap between existing standardized G/G SWIM profiles and what is needed to fully support SWIM-based civil-military coordination/cooperation, especially in terms of (cyber) security, resilience, interoperability and indirectly safety (support of operational use cases providing more safety to the European ATM).

In order to be taken into account by GP R&D as baseline, existing G/G SWIM-TI profiles have to be at minimum in the early industrialization stage, so standardized or equivalent. This is the case for the Yellow Profile (YP) defined by the EUROCONTROL SWIM-TI YP 1.1 specification with a Full Operational Capability (FOC) by end-2025 as stated in Common Project One (CP1). The Blue Profile (BP) is out of the scope of CP1, it is not yet standardized.

During TRL2 workshops, military representatives acknowledged that existing G/G SWIM-TI profiles are sufficient for some civil-military exchanges.

Operational use cases, for which the military estimate that the Quality of Service (QoS) provided by standardized G/G SWIM-TI profiles is not sufficient, are related, at execution time, to air policing

[2] System-Wide Information Management - Technical Infrastructure

[3] Research & Development



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(priority flights requiring tactical control), the consumption at the military side of civil flight data (early use of the SWIM-TI for this key capability before BP is operational), the support of Search And rescue operations etc. At planning time, operational use cases correspond to the submission to the Network Manager (NM) of military sensitive flight plans (OAT[4], GAT[5], mixed GAT/OAT) then their distribution by NM to relevant civil/military Air Traffic Control (ATC) systems. The management of (sensitive) Mission Trajectories (MTs) and Dynamic Airspace Configurations (DAC) are likely to necessitate the support of GP.

Military specific operational expectations will require additional capabilities at the SWIM-TI level (GP level) so new technical requirements that will fill the above gap. In order to improve security, resilience and interoperability, the solution decided in TRL6 to drop TRL4-chosen declining technologies and to replace/extend them by newly standardized cutting-edge technologies on the rising deployment slope together with an already significant share in terms of operational use in websites at a worldwide scope.

Main Operational Environments (OEs) applicable to this technological solution are: en-route, terminal airspace and network.

Main concerned systems at the civil side are en-route/approach ATC systems and NM ones while at the military side, mainly consider systems such as en-route/approach military ATC, Wing Operations Centre (WOC) and AD.

PJ.14-W2-101 targets military extensions/restrictions to the EUROCONTROL SWIM TI YP 1.1 specification in Wave 2 (TRL6) addressing non-high-critical exchanges. Post PJ.14-W2-101, safety-critical exchanges (BP scope) will require additional R&D once BP is standardized.

[4] Operational Air Traffic

[5] General Air Traffic





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# 3 Performance Operational Improvement Steps (POIs) & System Enablers (SYS ENs)

SYS ENs and POIs for this technological solution were handled with Data Set 19 (DS19), there is no change on this scope with DS22 (DS23 draft).

**This technological solution is associated to its dedicated POI-0014-IS** aiming at gathering all SYS ENs relevant to the solution, so assigning per SYS EN Ownership (Develop or Use) and Compulsory (Required or Optional) attributes.

**The only relevant SYS EN for the solution (develop/required) is SWIM-INFR-07** scoping evolutions/restrictions based on the EUROCONTROL SWIM TI YP 1.1 specification in order to support the full extent of civil-military SWIM-based non high-critical exchanges. This SYS EN is fully covered by PJ.14-W2-101, it introduces the Functional Decomposition (FD) associated to the Green Profile Technical System (GP TS), corresponding Functional Blocks (FBs) and associated Functions. It also introduces the System Ports of GP TS (technical facet).



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# 4 Background and validation process

### *Wave 1 (PJ.17-03)*

**No validation activities were associated with the TRL2 phase.**

**The technological solution performed technical validation in TRL4.**

The TRL4 technical validation was performed at laboratory level, the goal being to "verify" all technical requirements defined in the TRL4 technical specification and associated with technical validation objectives.

TRL4 technical validation objectives were grouped in the same way than GP TRL4 technical requirements, so interoperability, quality of service and behaviour. Each technical validation objective was possibly associated to one or more key aspects (security, resilience, data sensitivity and performance).

The TRL4 technical validation was structured through three exercises (a different partner in charge of each exercise). The target was not that each technical validation exercise covered all technical validation objectives (therefore all TRL4 technical requirements – no focus on YP requirements which are assumed already validated because belonging to a de facto standard) but to cover all of them through the 3 exercises.

**This way of proceeding provided highly consolidated results at solution level, aggregating contributions of independent exercises (different prototypes/platforms).**

### *Wave 2 (PJ.14-W2-101)*

**The technological solution performed technical validation in TRL6.**

A unique exercise, performed by THALES AIR SYS, aimed at covering all technological objectives consisting of a subset dedicated to complementary objectives addressing "verification" of TRL4 updated technical requirements or new TRL6 technical requirements and of another subset dedicated to close-to-real environment validation of GP (GP integrated at the ATM level).

Therefore, this TRL6 exercise was structured in two chronological phases:

- **Phase 1**: Laboratory testing for TRL6 complementary verification of technical requirements,
- **Phase 2**: Real Time Simulation (RTS) in a close-to-real environment.

The RTS platform (phase 2) implemented the following GP-enabled environment:

- **Civil domain**: A real civil ATC system (THALES AIR SYS product) and a THALES AIR SYS tool simulating the NM system in charge of validating/distributing flight plans.
- **Military domain**: A real military ATC/AD system (THALES AIR SYS product) and a dedicated THALES AIR SYS tool emulating the submission by a Wing Operations Centre (WOC) of military flight plans. (No IEG present in this domain since this was not the purpose of the validation)
- **A main GP node implementation** (one node at the military side, another node at the civil side) **and a GP limited implementation** (update ("greening") at the civil side of the pre-existing NM system tool initially relying on YP).



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**While phase 1 enabled the verification of key technical requirements used in phase 2 (synergy), phase 2, thanks to test scenarios based on key solution scenarios identified in TRL6 TVALR, demonstrated the added value of GP at the operational level.**



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# 5 Results and performance achievements

Results and performance achievements are expressed at TRL4 and TRL6 levels, thus reflecting laboratory-level results corresponding to the verification of technical requirements structured through technological validation objectives together with RTS / close-to-real environment validation results associated with ad hoc technological validation objectives (TRL6 only).

PJ.17-03/PJ.14-W2-101 mainly target, in the context of a future GP extension/restriction of the EUROCONTROL SWIM TI YP 1.1 specification, to provide more security/resilience, the support of the transfer of military sensitive data to the civil side and, when required, the right level of performance (capacity) without forgetting more safety depending on the nature of supported SWIM services.

The GP targeted high level benefit (Wave 1 + Wave 2) is to support G/G SWIM-based civil-military exchanges on the full operational scope compared to YP not fitting all related operational use cases.

In this context, **main GP characteristics confirmed by TRL4/TRL6 exercises are summarized as follows**:

- Support of "out of the box" interoperability between SWIM-TI GP nodes (two THALES AIR SYS different implementations of GP in TRL6);
- Definition of highly integrated bindings (set of interoperability capabilities) to connect SWIM services (consumer and provider sides), a binding encompassing four topics: a SEA service interface, an IP network interface, a protocol stack and security. Bindings:
    - Contribute to the above "out of the box" interoperability;
    - Rely on different key technologies (Advanced Message Queuing Protocol (AMQP 1.0), Hypertext Transfer Protocol (HTTP/1.1 and HTTP/3) and Transport Layer Security (TLS 1.3)), so offer different levels of security for AMQP and HTTP bindings.
- Introduction of time/space/synchronization decoupling between SEAs based on the use of the asynchronous fire & forget message exchange pattern (AMQP bindings) associated with a message queue capability allowing flexible deployment options;
- Introduction of elementary resilience capabilities aiming at addressing specific disruptions as soon as detected to possibly annihilate them before they have real impacts or to minimize their impacts;
- Introduction of the concept of "resilience binding" (i.e. HTTP/3 binding) that can be used, for example, at SWIM service level when Transmission Control Protocol (TCP) related bindings are not (sufficiently) operational;
- Compatibility of the simple (and advanced) AMQP binding with capacity performance expectations regarding key SWIM services from an operational point of view.

Though not validated in TRL6 because this is a deployment issue, **the definition in TRL6 of a set of external technical requirements targeting the Public Key Infrastructure (PKI) will increase security and resilience at SWIM-TI level** (beyond GP but in synergy with GP).

The TRL6 qualitative high level economic appraisal (HLEA) underlined that **GP has a significant positive impact on the "civil-military cooperation and coordination" Key Performance Area (KPA) and other key KPAs** such as security, interoperability or safety, without negative impact on other GP-related KPAs. Compared to above benefits, **the GP deployment cost is minor** due to GP being an YP extension/restriction.

# 6 Recommendations and additional activities

The EUROCONTROL SWIM TI YP 1.1 specification is the baseline for first YP deployments (initial SWIM whose Full Operational Capability (FOC) is end-2025), including for the military (i.e. for SWIM services for which YP is sufficient). GP (its YP-MIL facet) is built on top of YP, its Initial Operational Capability (IOC) will occur later than YP FOC.

Section 5.2.1 of the TRL6 TVALR provides **recommendations for the GP industrialization phase (possibly the deployment one, special highlight in this case) summarized and completed as follows**:

- Extend the scope of GP (European ATM community decision)
    - While it is still assumed that GP will not be used between military applications (unless they communicate through the civil IP infrastructure), the TRL6 validation demonstrated that GP is necessary in at least one use case[6] between civil applications.
- Complement the safety assessment (operational stakeholders during early industrialization)
    - GP, as defined in TRL6, contributes to safety through its intrinsic integrity and resilience capabilities in the scope of interoperability.
    - Main safety considerations are associated to SWIM services (corresponding SEAs) related to execution time. Identified SWIM services needing GP and matching this filter are potential ones, so to be confirmed by concerned operational stakeholders so that they perform the necessary safety assessment to possibly allocate complementary safety requirements to GP.
        - This is especially important for SWIM services for which the incomplete TRL6 safety assessment process identified that post R&D safety activities are needed.
- Improve the security assessment (rolling process until GP is operational / during operations)
    - Security improvement is a continuous process, R&D security assessment mainly focused on interoperability based in a Confidentiality / Integrity / Availability (CIA) initial assessment. In order to harden security in the scope of interoperability, considering GP as an industrial concrete product (as part of a SWIM node) in a real world deployment will add additional requirements. Some of them could, at some point, be considered as belonging to the interoperability scope, so be part of GP.
    - Security in not only a GP matter, it is a system of systems matter at minimum on the SWIM-TI scope. For example, GP external technical requirement on PKI REQ-14.101-

[6] Distribution to civil en-route/approach ATC systems of validated sensitive flight plans by the IFPS (Integrated initial Flight Plan Processing System is a NM system).

If the sensitive flight plan submitter is a civil entity (such as a FOC – here for Flight Operations Centre), then using GP for flight plan validation submission to IFPS should also use GP to protect flight plan data between these two civil entities.



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TS-EXTR-0001 deals with the need for crypto agility to face the threat of Quantum Computing and underlines that NIST (US National Institute of Standards and Technology) has launched in 2016 its Post-Quantum Cryptography Project[7].

- In the scope of this project, in July 2022, NIST has selected[8] the Falcon algorithm (co-developed by Thales together with academic and industrial partners from France, Switzerland, Canada and the US) along with two other algorithms (Crystals-Dilithium and Sphincs+) for digital signatures used for identity authentication, and the Crystals-Kyber algorithm for general encryption used to protect information exchanged across a (public) network.
- These algorithms should be included in the NIST's post-quantum cryptography standards[9] expected to be fully defined by 2024.
- It is likely that, at some point in the future, GP and other SWIM profiles, together with the SWIM Common PKI, will rely on algorithms introduced by such post-quantum computing standards.

- Improve the resilience approach (intrinsic, interoperability and with local SEA)
  - As for security, which has a connection with resilience, resilience improvement is a continuous process.
  - Resilience at GP level is addressed as a set of elementary capabilities to face a large scope of possible disruptions. The GP philosophy is to prevent when possible and to provide alternate ways to continue operating for its "client SEAs" (SEAs using GP) when a disruption occurs.
  - GP intrinsic resilience improvements may be added without merging with the YP core specification (GP is an YP extension/restriction) while GP interoperability resilience improvements should be merged as much as possible with the YP core specification to benefit quicker to the SWIM community because YP use will be wider than GP use in this community.
  - Regarding GP resilience in coordination with SEAs through their SWIM services (possibly involving peers), such as switching to a resilience binding (i.e. HTTP/3) when the usual binding is not able to provide its expected QoS, TRL6 assessed capabilities and possible improvements are outside of the scope of GP technical requirements

[7] Excerpts from https://csrc.nist.gov/Projects/Post-Quantum-Cryptography:

- "The goal of post-quantum cryptography (also called quantum-resistant cryptography) is to develop cryptographic systems that are secure against both quantum and classical computers, and can interoperate with existing communications protocols and networks."
- "Some engineers even predict that, within the next twenty or so years, sufficiently large quantum computers will be built to break essentially all public key schemes currently in use."

[8] See https://www.nist.gov/news-events/news/2022/07/nist-announces-first-four-quantum-resistant-cryptographic-algorithms

[9] If they are not broken in the meantime as the Sike algorithm has been (finalist in the Post-Quantum Cryptography Project competition).



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unless the use of some resilience schemes is of interest for a significant community of stakeholders (envisage to add them to GP).

- Assess the PKI dimension (external requirements on PKI) as soon as necessary
    - As above explained for security (also true for resilience), the overall QoS provided by GP is also a matter of the system of systems scale. In order to provide its QoS, GP has to cooperate with a PKI compliant with the subset of GP external requirements on PKI, subset not validated in TRL6 (solution expert judgments).
    - While the deployment phase is the ultimate phase to interface GP with the target PKI in line with GP PKI external requirements, better start during the industrialization phase the consolidation of such requirements (other expert judgments) and the assessment of the adequacy of such external requirements with the SWIM Common PKI, possibly alternate PKIs best fitting military (GP) SWIM nodes.
- Take advantage of HTTP/3 maturing and combined technologies
    - The introduction in TRL6 of the HTTP/3 technology, encompassing the QUIC technology, is a technological breakthrough favoured by their fast adoption in the worldwide IT community.
    - Stakeholders of SEAs willing to rely on GP should take advantage of HTTP/3 combined technologies (e.g. SSE – Server-Sent Events) to improve the capabilities offered by the HTTP/3 binding.
    - Another nice move could be to complement GP with an Advanced HTTP/3 binding encompassing message level security based on S/MIME 4.0 (Secure / Multipurpose Internet Mail Extensions), technology already part of Advanced AMQP 1.0 and Advanced Raw HTPP bindings.
- Consolidate the expected QoS at IP infrastructure level when relevant
    - Section 6 of TRL6 TS/IRS Part I introduces three performance assumptions on QoS of the GP underlying civil IP infrastructure in order to help satisfying GP QoS: they are related to the consumption of flight data possible SWIM service but could help for other possible GP-enabled SWIM services such as QRA Tracks.
    - Once a GP deployment is planned, addressing this facet is necessary across the overall civil IP infrastructure from an end-to-end viewpoint between all concerned SEAs.

Section 5.2.2 of the TRL6 TVALR dealing with recommendations for updating ATM Master Plan Level 2 (planning and architecture view) underlines that IOC for GP (YP-MIL) is end-2029 based on SWIM-INFR-07, which seems very late (NM could reach GP IOC by end-2025, which looks like pointless if alone). **Revising this GP IOC to get an earlier forecast seems wise in order to satisfy rising operational needs in the scope of SWIM-based civil-military cooperation and coordination**. (Such revision could be initialized at the very end of GP TRL6 activities)



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# 7 Actors impacted by the SESAR technological solution

The European ATM Architecture (EATMA) defines roles rather than actors. A Capability Configuration (CC), as defined in EATMA, is deployed by a stakeholder; it encompasses relevant actors and TSs such as a GP SWIM-TI profile TS as part of a SWIM node[10].

Identifying impacted actors is not suitable in the case of GP due to the theoretical wide range of addressed SWIM services. The stakeholder level of granularity is more convenient, especially if corresponding impacted CCs are identified.

**Stakeholders involved in the SWIM-TI G/G infrastructure are directly impacted if their scopes encompass civil-military interoperability relying on GP**. Only stakeholders involved in the SWIM Identity Management CC (PKI) may be concerned because the current EATMA content (DS23 Draft, EATMA V16.0 Draft) associates SWIM profile TSs to CCs belonging to operational-level stakeholders

**Operational-level stakeholders needing to use SWIM services relying on GP are indirectly impacted** (add a GP TS in relevant CCs, develop new GP related SWIM services, train concerned actors etc.), they correspond at minimum to:

- Air Navigation Service Providers (ANSPs)
    - Civil/military ATS Approach Service Providers ➔ CC: Civil/military Approach Area Control Centre (ACC)
    - Civil/military ATS En-Route Service Providers ➔ CC: Civil/military En-Route ACC
- Civil/state Airspace Users (AUs)
    - Military Wing Operations Centre ➔ CC: State AU Operations Centre (encompassing a State AU WOC TS)
    - [In case the GP scope is extended to civil-civil exchanges – Use case of a civil sensitive flight plan] Civil Flight Operations Centre ➔ CC: Civil AU Operations Centre (encompassing a Civil AU Flight Operations Centre (FOC) TS)
- Network Manager (NM) ➔ CC: Regional Air Traffic Flow and Capacity Management (ATFCM[11])

Military authorities in charge of deploying and managing Air Defence (AD) centres ("external CCs" are no more part of the EATMA content in Wave 2) complete the list of most-impacted operational-level stakeholders.

[10] A SWIM(-TI) node is a logical entity which, in the context of this CN, aggregates one or more SWIM(-TI) profiles, thus hiding real world deployment considerations.

[11] Today, the ATFCM technical system of the Regional ATFCM CC corresponds to IFPS (see section 6).



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# 8 Impact on aircraft system

This technological solution being dedicated to SWIM-based G/G civil-military coordination/cooperation, no impact on aircraft systems.



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# 9 Impact on ground systems

**Civil G/G SWIM-TI nodes**, that are used to coordinate/cooperate with the military SWIM-enabled applications, **will be impacted in case GP extensions/restrictions are needed**.

**It is assumed that military SWIM-TI nodes will have to support GP**, except in case some military SWIM-TI nodes will be dedicated to pure YP (no BP yet), e.g. Aeronautical Information Management (AIM) data and Meteorological (MET) data can be exchanged on top of YP. The “pure YP” configuration is unlikely considering that, at a country level, the military will probably deploy one up to two SWIM-TI nodes (second one for resilience / load balancing).

**It is granted that some civil/military systems hosting the SWIM services / SWIM-enabled applications will be impacted by this technological solution**:

- Relevant existing SWIM services: e.g. use of new GP bindings corresponding to a military dedicated quality of service supported by GP;
- Relevant SWIM-enabled applications: e.g. use of new SWIM services satisfying civil/military coordination/cooperation needs and running on top of GP because it cannot run on top of YP.

# 10 Regulatory framework considerations

As an YP extension/restriction, GP should not have extra regulatory framework considerations compared to YP.



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# 11 Standardization framework considerations

GP is defined as an extension/restriction of YP. Currently, the EUROCONTROL SWIM-TI YP 1.1 specification is the de facto standard used to deploy YP in the scope of CP1.

EUROCONTROL, as responsible for the YP specification, makes this de facto standard evolve based on stakeholder’s input. EUROCONTROL plans a continuous evolution of this specification.

Provided that the solution TRL6 gate is passed during early Q4 2022, the plan is to push, from mid Q4 2022 onwards, the solution TRL6 Data Pack at the entry of the YP specification continuous evolution process through EUROCONTROL, which is also a solution partner.



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# 12 Technological solution Data Pack

The TRL6 Data Pack for this technological solution includes the following documents:

- **SESAR 2020 PJ.14-W2-101 TRL6 TS/IRS Part I – D8.1.120 Edition 01.01.00**. This document focuses on R&D finalized GP technical requirements together with architectural aspects from different viewpoints.
- **SESAR 2020 PJ.14-W2-101 TRL6 TS/IRS Part II – D8.1.120 Edition 01.01.00**. This document corresponds to the Safety Assessment Report (SAR) in a context of lack of safety requirement input from the operational level. The assessment scope, so assessment outcomes, are partial compared to what is expected in TRL6; this document clearly provides such statement and related rationale.
- **SESAR 2020 PJ.14-W2-101 TRL6 TVALR – D8.1.400 Edition 01.02.00**. This document presents the consolidated technological validation results with GP integrated in a close-to-operational environment, includes a qualitative high level economic appraisal (as replacement for the Cost Benefit Analysis for Technological solution (CBAT)) and compiles recommendations for the next steps (post R&D).
- **SESAR 2020 PJ.14-W2-101 TRL6 CBAT – D8.1.500 Edition 01.00.00**. This CBAT document is an empty shell, it refers to Appendix C of the TRL6 TVALR (see above) corresponding to the TRL6 HLEA replacing this TRL6 CBAT.



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