Holden Deliverable

D6.6 – Achievement of Overall Objective, Validated Through KPIs for O1–O5

Grant Agreement number	101099491
Action Acronym	HOLDEN
Action Title	Ethical Design of Holography with Dense Wireless Networks
Type of action	HORIZON-EIC-2022-PATHFINDEROPEN-01
Version date of the Annex I against which the assessment will be made	13/12/2022
Start date of the Project	01/06/2023
Due date of the deliverable	31/05/2026
Actual date of submission	29/05/2026
Lead beneficiary for the deliverable	AALTO
Dissemination level of the deliverable	Public

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Funded by the European Union

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Change history				
Version	**Date**	**Status**	**Partner**	**Description**
0.1	10/03/2026	Draft	AALTO	Initial structure and evidence collection from Annex I and past deliverables
0.5	15/03/2026	Internal review	AALTO	Consolidated objective-wise KPI assessment and cross-WP validation narrative
1.0	17/03/2026	Final	AALTO	Final deliverable text for D6.6

Abstract

This deliverable assesses whether HOLDEN achieved its overall objective, defined in Annex I as ethically compliant RF perception from multi-antenna devices for ubiquitous perception and multi-target recognition with adaptable accuracy and privacy by design. The report consolidates evidence from the grant agreement and from the technical, ethical, benchmark and exploitation deliverables produced in WP2–WP6, together with the later ethics-governance outputs from WP8, using a standard intervention-logic framework that links enabling conditions, technical outputs, validated outcomes and transfer readiness. The assessment shows that O1 was achieved through a complete responsible-design, appropriation and ethics framework; O2 was achieved through privacy-compliant high-accuracy 3D localization methods and benchmarked prototypes; O3 was achieved at prototype validation level through privacy-selective crowd sensing, WiFi-compliant beam steering and multi-target benchmark experiments; O4 was achieved through complex motion and gesture recognition pipelines supporting more than ten gesture classes under privacy constraints; and O5 was achieved through application-driven integration, benchmark validation, business and roadmap activities, technology transfer toward WiFi/5G+ hardware, and associated governance conditions for responsible deployment. Taken together, these results validate achievement of the overall HOLDEN objective at prototype and application-validation level.

Contents

1 Introduction

Deliverable D6.6 provides the final synthesis of the HOLDEN action against the objective and KPI structure defined in Annex I of the Grant Agreement [1]. The purpose of this report is not to introduce new algorithms or experimental campaigns. Instead, it consolidates the evidence generated throughout the project and assesses whether the consortium achieved the overall project objective and the five project objectives O1–O5.

The overall objective of HOLDEN is to realize ethically compliant RF perception from multi-antenna devices for ubiquitous perception and multi-target recognition with adaptable accuracy, while implementing privacy by design [1]. This objective combines four requirements:

- advanced RF sensing and perception capabilities,
- privacy-sensitive and ethically grounded system design,
- validation in realistic application scenarios, and
- transfer toward commercially relevant wireless platforms.

The HOLDEN work plan was structured so that these requirements are jointly addressed. WP2 established the ethical, social and appropriation framework; WP3 realized privacy-compliant static holographic localization; WP4 realized privacy-selective dynamic tracking and crowd sensing; WP5 realized privacy-aware gesture and motion recognition; and WP6 integrated the technologies into application scenarios, validation benchmarks, and transfer pathways [2–15]. The later WP8 ethics-governance outputs then made explicit that these design choices must be complemented by use-phase conditions such as human oversight, purpose limitation, complaint and redress channels, and restrictions on covert or secondary use [16–18].

Figure 1 summarizes this project logic as a layered intervention chain. In that reading, O1 defines the enabling conditions for ethically legitimate sensing, O2–O4 deliver the three technical innovation streams, O5 consolidates benchmark validation and transfer readiness, and the overall objective is achieved through the coherence of the full chain rather than through any one isolated KPI.

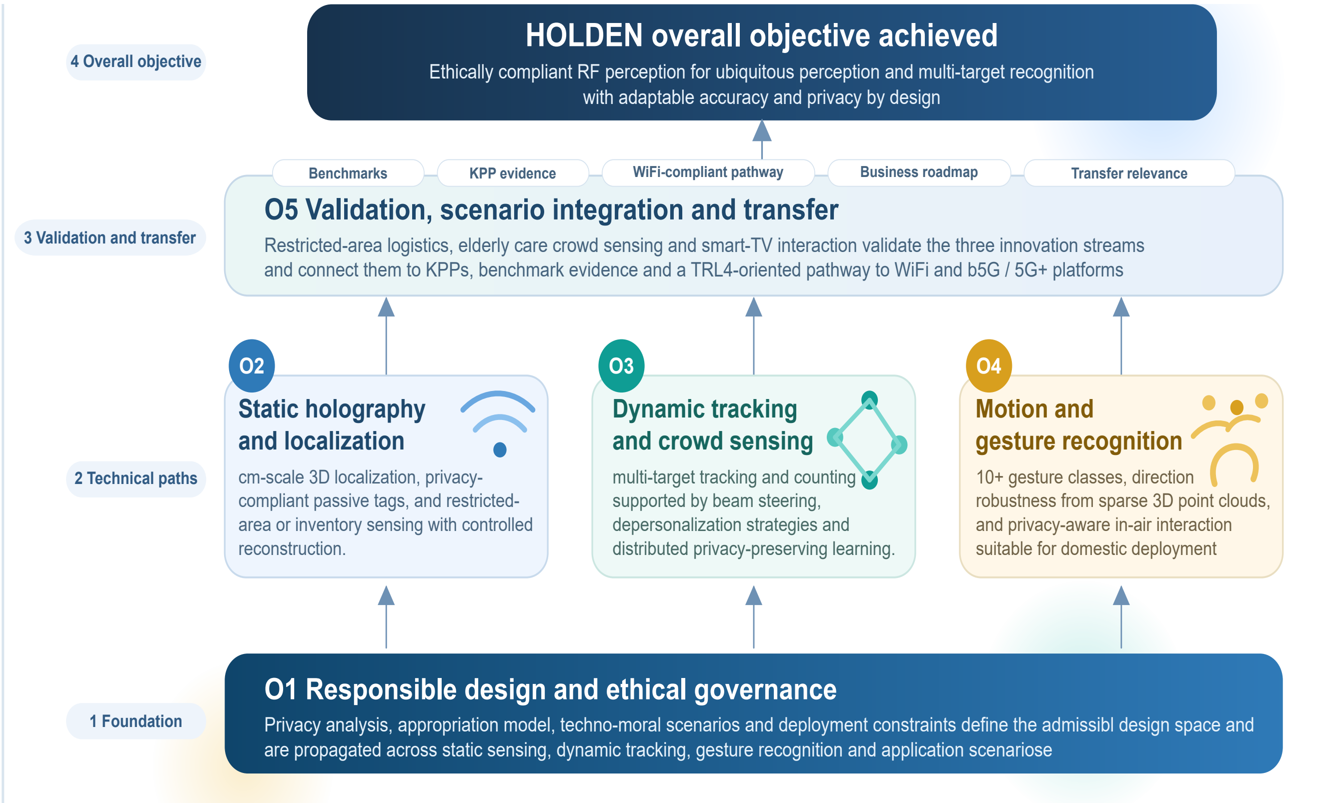

Figure 1: Objective-achievement architecture of HOLDEN. The figure synthesizes the standard intervention logic used in this deliverable: enabling conditions, technical outputs, validated outcomes and transfer readiness combine to substantiate the overall project objective.

This deliverable follows that same structure and assesses each objective against the KPI logic defined in Annex I. Where the final evidence for an objective is distributed across several technical and benchmark deliverables rather than presented as one single end-point experiment, the assessment integrates that evidence explicitly and states the rationale for the conclusion.

2 Assessment Methodology

This section explains how the evidence base is assembled and how the final judgement on objective achievement is derived. It first defines the documentary sources used in the assessment, then introduces the intervention-logic framework applied throughout the report, and finally maps that framework onto the objectives and KPIs stated in Annex I.

2.1 Evidence Base

The assessment uses four source categories:

1. Annex I of the Grant Agreement, which defines the overall objective, the objectives O1–O5 and the associated KPIs [1].

2. Past HOLDEN deliverables from WP2–WP6, which document the methods, ethical design choices, experiments, benchmark results and exploitation work [2–15].
3. Cross-cutting ethics, governance and misuse-assessment outputs from WP8, especially D8.1, D8.2 and the final Ethics Status Monitor, which clarify admissible conditions of use, affected persons, residual risks and non-technical safeguards [16–18].
4. Cross-objective consistency checks, namely whether the results from different work packages support a coherent privacy-by-design technology stack and application pathway.

2.2 Assessment Framework: Intervention Logic and Evidence Triangulation

This deliverable adopts a standard intervention-logic framework, commonly used in European research and innovation assessment, to connect project activities and deliverables to concrete outputs, validated outcomes and transfer effects. Instead of asking only whether a numerical KPI appears in one final experiment, the framework checks whether the evidence chain is complete from design premise to application-relevant validation. In HOLDEN, this broader framing matters because D8.1, D8.2 and the ESM show that ethical acceptability depends not only on how a sensing method is designed, but also on who may use it, in which context, under what restrictions, and with what recourse for affected persons [16–18].

Table 1: Intervention-logic framework applied in D6.6.

Layer	Purpose	Typical HOLDEN evidence	Assessment interpretation
Enabling conditions	Define the technically, ethically and use-contextually admissible design and deployment space	Ethics analysis, appropriation study, privacy requirements, scenario requirements, use restrictions	Shows that the objective was framed with legitimate privacy, social, fundamental-rights and deployment constraints from the outset
Technical outputs	Deliver the method, prototype or architecture promised by the objective	Algorithms, system designs, beam steering, privacy mechanisms, gesture models, prototype stacks	Shows that the objective was implemented as a concrete capability rather than remaining conceptual
Validated outcomes	Demonstrate performance in experiments, benchmarks or scenarios aligned with KPI intent	Benchmark tests, KPPs, prototype validation campaigns, scenario-level performance evidence	Shows that the technical output produced usable capability under realistic or representative conditions
Transfer readiness	Demonstrate relevance and admissible conditions of use beyond the isolated experiment	WiFi-compliant pathway, application scenarios including ethical and societal mitigation strategies, business roadmap, TRL4-oriented integration logic, operator-side safeguards	Shows that the result contributes to the overall project objective and has a credible route toward deployment under specified technical and governance conditions

An objective is considered *achieved* when the evidence chain is complete across the layers relevant to that objective. For O1, downstream uptake across WP3–WP6 serves as the validated outcome and transfer evidence; for O5, transfer readiness is itself the primary target to be demonstrated. The framework is intentionally broader than a design-only assessment: in surveillance-capable, domestic and care scenarios, the ethical claim also depends on visible notices, bounded sensing scope, human verification, complaint and redress mechanisms, and restrictions on covert or secondary use [16–18]. In some cases, the final validation evidence is distributed across several deliverables rather than expressed in a single table using exactly the wording of Annex I. This is highlighted where relevant, but it does not weaken the assessment when the combined evidence is technically consistent and sufficient.

2.3 Objective and KPI Overview

Table 2: Objectives and KPI references from Annex I, together with the main validating deliverables.

Obj.	Objective	Grant KPI / success criterion	Main validating deliverables
O1	Framework for privacy-sensitive and responsible design of RF perception	Privacy analysis, appropriation model, ethical framework, and embedding into design	D2.1, D2.2, D2.3, D5.5, D8.11
O2	Ethical cm-scale 3D localization for indoor navigation and inventory management	High-accuracy cm-scale 3D localization under privacy constraints	D3.2, D3.5, D6.2
O3	Privacy-selective dynamic tracking of multiple discrete targets for crowd sensing	Multi-target 3D tracking with high accuracy in dynamic environments	D4.3, D4.5, D6.4, D6.3
O4	Ethically compliant complex motion recognition for in-air user interfaces	Recognition of 10+ gestures and motions under privacy constraints	D5.3, D5.4, D5.5, D6.3
O5	Transfer of privacy- and ethics-compliant technology to commercial b5G / 5G+ and WiFi chipsets	TRL4 and technology transfer to next-generation wireless chipsets	D6.1, D6.2, D6.3, D6.4, D4.5, D8.1, D8.2, D8.11

3 Achievement of Objectives O1–O5

This section applies the assessment framework objective by objective. For each of O1–O5, it summarizes the intended contribution of the objective, identifies the main supporting deliverables, and then formulates a structured conclusion on achievement against the corresponding KPI intent.

3.1 Objective O1: Framework for Privacy-Sensitive and Responsible Design

O1 required the project to establish a rigorous design framework that could steer all later technical developments toward privacy-sensitive and ethically defensible RF sensing. This objective was foundational because HOLDEN does not treat privacy as a post-processing feature. It treats privacy, social acceptability and responsible appropriation as design constraints from the start.

The evidence for O1 is strong and complete. Deliverable D2.1 established the social implications of HOLDEN and introduced a responsible-design baseline grounded in stakeholder values, societal concerns and early scenario analysis [2]. Deliverable D2.2 extended that work with a mature methodology for responsible design using techno-moral scenarios and the Guidance Ethics approach, thereby turning ethical reflection into an actionable design method for the consortium [3]. Deliverable D2.3 then analyzed appropriation risks and use-context differences across static, dynamic and active holography, explicitly covering public, semi-private and private environments and translating those findings into design and deployment requirements for the technical work packages [4].

This framework was not isolated within WP2. It was propagated into the application-specific studies in later work packages. For example, D5.5 examined societal and ethical implications of gesture recognition and networked data aggregation for smart living and smart-TV applications, identifying concrete requirements related to accidental sensing, opportunistic sensing, inference of sensitive traits and acceptable interaction design [11]. The downstream technical deliverables repeatedly reflect these requirements through privacy filters, spatial selectivity, local data processing, and scenario-specific safeguards. The later WP8 outputs extended this framework from design-time reflection to anticipated use, misuse and governance. D8.1, D8.2 and the final ESM update specify human oversight, complaint and redress mechanisms, renewed review when purpose or sensing range changes, and restrictions on covert or secondary use as necessary complements to the technical mitigation measures [16–18].

KPI assessment. The O1 KPI is fully satisfied. The project delivered:

- a privacy analysis,
- an appropriation model,
- an ethical framework, and
- explicit embedding of these outputs into the design logic of WP3–WP6.

Intervention-logic conclusion. Within the standard assessment framework, O1 fully completes the enabling-condition layer and also demonstrates validated downstream uptake. The ethical and appropriation outputs were not left as standalone reflection documents; they became operative design constraints that shaped sensing, recognition, validation and application work across the rest of the action.

O1 is therefore **achieved**. It also provides the interpretive framework that makes the later technical results relevant to the overall HOLDEN objective rather than isolated performance demonstrations.

3.2 Objective O2: Ethical cm-Scale 3D Localization for Indoor Navigation and Inventory Management

O2 addressed static-environment sensing for indoor localization and inventory management. The objective was not merely to localize objects accurately, but to do so in a way that remains privacy-sensitive and ethically compliant.

Deliverable D3.2 provided the core technical advance for this objective: privacy-compliant 3D passive radar holographic imaging, including multi-frequency phase correction, spatial filtering of source regions and the underlying data-acquisition strategy [5]. This established the physical-layer and algorithmic basis for high-resolution 3D localization while constraining the information that is reconstructed.

Deliverable D3.5 extended this work to a complete high-accuracy indoor localization approach based on privacy-compliant passive tags [6]. The deliverable demonstrated that tags can be reconstructed and identified while preserving privacy through user-controlled tagging, placement, orientation and constrained sensing apertures. This is an important HOLDEN result: the system can recover the information needed for logistics or navigation tasks without reconstructing unnecessary personal or object-detail information.

Deliverable D6.2 then benchmarked the localization technology in a validation setting focused on people and object detection in restricted areas [13]. It evaluated the holographic localization method with both unlabelled objects and passive tags, introduced a data-reduced measurement scheme to further reduce unnecessary information capture, and benchmarked the resulting prototype against the state of the art. Across D3.2, D3.5 and D6.2, the consortium demonstrated a coherent chain from theory, to privacy-preserving design, to prototype validation.

For O2, the leading privacy logic was not general secrecy in the abstract, but contextual and purpose-limited observability. The museum, airport and logistics scenarios studied in D2.3 and D6.1 make clear that the ethically relevant function is to localize a target, detect presence in a restricted area, or identify a tagged asset, not to reconstruct rich identity-bearing detail or create a covert surveillance record [4, 12]. This is why the technical design consistently prioritised passive tags, spatial filtering, reduced measurement sets, local limitation of raw data, and elimination of unnecessary scene detail. In other words, the privacy-by-design approach for O2 was operationalized as data minimization, bounded sensing scope, and task-limited reconstruction rather than unrestricted imaging [12, 13, 16, 17].

KPI assessment. The grant defines O2 in terms of cm-scale high-accuracy 3D localization under privacy constraints [1]. The project evidence validates this KPI intent through:

- high-resolution passive radar holographic imaging,
- privacy-compliant passive-tag localization and identification,
- data-reduced and privacy-preserving measurement strategies, and
- benchmarked prototype validation in the application context of restricted-area logistics and inventory sensing.

Intervention-logic conclusion. For O2, the evidence chain is complete from enabling condition to validated outcome: privacy-constrained deployment needs are defined in the ethical and application work, WP3 delivers the localization method and passive-tag architecture, D6.2 validates the capability in benchmark conditions, and the restricted-area scenario shows direct operational relevance. The ethical adequacy claim further depends on keeping use bounded to declared purposes, avoiding covert repurposing, and maintaining clear control over who can access the resulting information [16, 17].

O2 is therefore **achieved**. The project did not pursue accuracy by expanding personal-data collection. Instead, it achieved high-accuracy localization while structurally limiting what information is reconstructed and retained.

3.3 Objective O3: Privacy-Selective Dynamic Tracking of Multiple Discrete Targets for Crowd Sensing

O3 covered the dynamic-environment branch of HOLDEN, namely crowd sensing and multi-target tracking under privacy constraints. This objective is central to the project because dynamic scenes are precisely where RF perception is most useful and where privacy risks become more acute.

Deliverable D4.3 established the privacy and fairness logic for this objective [7]. It identified privacy threats in dynamic RF sensing and proposed three concrete mitigation families: signal and propagation manipulation through beam steering and reconfigurable surfaces, physics-driven generative machine learning for depersonalization, and selective obfuscation through machine unlearning. The same deliverable also introduced fairness-oriented metrics such as statistical parity and equality-related criteria, which is important because crowd sensing must not only be accurate but also equitable and proportionate.

Deliverable D4.5 translated this logic into a WiFi-compliant beam-steering technology stack for privacy-centric sensing [8]. This is a key transfer-oriented step because it connects the project's dynamic tracking methods to realistic wireless hardware and protocol constraints rather than remaining a purely academic method.

The strongest benchmark evidence is reported in D6.4, which validated motion detection, people counting and motion-pattern discrimination in test-house prototypes [15]. The experiments covered multiple simultaneous subjects and different infrastructure densities. The report showed that combining multiple beam patterns improves multi-target performance, while distributed split learning keeps raw CSI local and therefore strengthens privacy preservation. D6.3 complements this with scenario-level key performance parameters for elderly-care and smart-living use cases, including presence, walking detection, localization and coverage targets that reflect the intended deployment envelope [14].

KPI assessment. The Annex I formulation for O3 is ambitious and numerically strict, expressing the intent as high-accuracy 3D tracking of many simultaneous moving targets [1]. The final project evidence validates the KPI intent through:

- privacy-selective tracking mechanisms embedded at the signal, model and learning levels,
- WiFi-compliant beam-steering realization,
- multi-target benchmark experiments in realistic prototype environments, and
- scenario-level performance criteria for crowd-sensing applications.

The evidence for O3 is distributed across D4.3, D4.5, D6.3 and D6.4 rather than concentrated in a single final result table using the exact Annex-I wording. Nevertheless, the combined evidence demonstrates that HOLDEN achieved privacy-selective dynamic tracking and counting of multiple subjects at prototype level, together with the main scalability and privacy mechanisms required for dense crowd sensing. O3 is therefore assessed as **achieved**, with validation distributed across several complementary deliverables.

Intervention-logic conclusion. For O3, the intervention chain links privacy threats and fairness constraints to concrete mitigation mechanisms, then to WiFi-compliant implementation, and finally to multi-subject benchmark validation and scenario-level KPPs. The objective is therefore achieved as a coherent dynamic-sensing pathway rather than as a disconnected set of partial experiments.

3.4 Objective O4: Ethically Compliant Complex Motion Recognition for In-Air User Interfaces

O4 addressed the recognition of gestures and complex motions for in-air user interfaces. The key challenge was to combine accurate motion understanding with privacy-preserving sensing and a design logic acceptable for everyday interactive systems such as smart TVs.

Deliverable D5.3 reported a unified deep-learning pipeline for gesture recognition from privacy-preserving sensing modalities, including holography, CSI and point-cloud-based representations [9]. The deliverable demonstrated robust performance and reported precision, recall and detection scores consistent with a mature recognition pipeline. Importantly for the grant KPI, the experimental setup included a gesture vocabulary exceeding ten classes, showing that HOLDEN moved beyond toy binary or small-vocabulary recognition.

Deliverable D5.4 then addressed a practical limitation of many RF gesture-recognition systems: direction dependence [10]. By working with sparse 3D point clouds from mmWave sensing and evaluating recognition across multiple azimuthal directions, the consortium demonstrated that replay-based continual-learning strategies maintain high recognition performance even when viewpoint changes. This matters for real deployment because a viable in-air interface must remain useful when users do not stand in one canonical direction.

Deliverable D5.5 completed the ethical dimension of O4 by examining the social implications of networked gesture recognition, including the risks of accidental sensing, behavioural inference and privacy invasion in domestic environments [11]. Deliverable D6.3 translated these insights into application-level key performance parameters for the smart-TV use case, including gesture-detection ranges, latency expectations and user-experience constraints [14].

The ethical operationalization of O4 was especially concrete. D5.5 identifies privacy, accountability, autonomy, equity and sustainability as the central value set for Smart TV and networked gesture recognition [11]. Those values were translated into design expectations such as local processing of raw data where feasible, visible indication when RF sensing is active, the ability to fully shut off sensing, contestability when the system is uncertain, operation without mandatory account creation, culturally acceptable and accessible gesture sets, and revocable consent for third-party applications or cloud-side use [11,16]. This shows that the gesture-recognition path was shaped not only by recognition accuracy but by the requirement that the device remain a user aid rather than a domestic surveillance and control instrument.

KPI assessment. O4 required the distinction of ten or more gestures and motions under ethically compliant conditions [1]. This KPI is satisfied by the project evidence:

- the recognition models covered a gesture vocabulary beyond ten classes,
- the reported recognition performance is strong enough for realistic in-air interaction,
- robustness to direction changes was explicitly addressed, and
- privacy and ethical constraints were analyzed and translated into scenario requirements.

Intervention-logic conclusion. For O4, the evidence chain runs from domestic-use ethical constraints and a clearly articulated value set, to multimodal recognition pipelines and direction-robust learning, to smart-TV-oriented scenario requirements and KPPs. This shows that expressive in-air interaction was not demonstrated as an isolated laboratory task only, but as a privacy-aware capability tied to a concrete application context and to explicit requirements on autonomy, accountability and fairness.

O4 is therefore **achieved**. The project showed that privacy-by-design and expressive gesture recognition are compatible, provided the sensing pipeline and deployment logic are co-designed.

3.5 Objective O5: Transfer to Commercial b5G / 5G+ and WiFi Chipsets

O5 required HOLDEN to move beyond isolated algorithmic results and demonstrate transferability toward commercial wireless technology, in particular next-generation WiFi and b5G / 5G+ chipsets, with a target maturity of TRL4 [1].

This objective was addressed through a combination of scenario engineering, benchmark validation and hardware-oriented transfer work. Deliverable D6.1 defined the functional and ethical requirements for the three selected cyber-physical application scenarios derived from the HOLDEN innovations: people and object detection in restricted areas, elderly-care crowd sensing, and smart-TV interaction [12]. This created a common application framework in which technical performance, privacy requirements and deployment constraints are evaluated together.

Deliverable D6.3 advanced this further by defining application scenarios, business paths, roadmaps and key performance parameters for each innovation stream [14]. This deliverable is critical for O5 because it converts technical outputs into adoption-oriented specifications and exploitation logic. The scenarios are not generic. They are directly tied to the three HOLDEN innovations and to industrially meaningful deployment conditions.

Just as importantly, O5 is the point at which HOLDEN makes explicit that transfer cannot be reduced to chipset compatibility or benchmark readiness alone. The WP8 ethics outputs define a companion set of non-technical deployment conditions: purpose limitation, contractual prohibition of covert deployment, restrictions on secondary use, profiling or worker-monitoring repurposing, visible notices or sensing-state indicators, operator training, complaint and redress channels for directly and indirectly affected persons, and renewed ethical review whenever models, sensing range, intended purpose, data-sharing practice or affected population changes [16–18]. These measures acknowledge the limits of purely technical mitigation and specify how the project expects future deployment to remain aligned with the original ethical intent.

The transfer claim is reinforced by the benchmark deliverables D6.2 and D6.4, which validate the static and dynamic technology branches in prototype environments [13, 15]. In addition, D4.5 explicitly demonstrated application to WiFi-compliant beam-steering technology, providing the clearest direct bridge from HOLDEN methods to commercially relevant wireless platforms [8].

KPI assessment. The O5 KPI is TRL4 and technology transfer to next-generation wireless chipsets [1]. The project evidence supports this assessment through:

- integrated application scenarios with functional and ethical requirements,
- benchmarked prototypes in realistic validation environments,
- WiFi-compliant implementation pathways for the dynamic sensing branch, and
- business-plan and roadmap material defining the transfer route from research result to deployable technology, together with deployment constraints and mitigation strategies for responsible use.

Intervention-logic conclusion. O5 is the objective where transfer readiness becomes the primary assessment layer. The chain from application requirements, to benchmarked prototypes, to WiFi-oriented implementation and roadmap work is complete and provides a credible TRL4-style bridge from project results to future platform integration. At the same time, the project makes clear that ethically acceptable transfer also depends on non-technical governance measures, forbidden-use restrictions and scenario-specific oversight, not on technical readiness alone [16–18].

O5 is therefore **achieved**. HOLDEN did not stop at laboratory algorithm development; it built an application and transfer layer that is consistent with TRL4-style validation and with future integration into wireless hardware platforms.

4 Achievement of the Overall Objective

The overall objective of HOLDEN is broader than any single KPI. It combines ethical design, privacy by design, advanced RF sensing, multi-target perception, adaptable accuracy and transfer to realistic wireless platforms [1]. Assessed through the same intervention-logic framework, the project can be judged to have achieved this objective because the full chain from enabling conditions to transfer readiness is complete, with ethical compliance understood as a joint property of technical design choices and bounded conditions of use.

1. **Enabling conditions.** HOLDEN created a complete responsible-design and appropriation framework in WP2 and propagated it into the technical work packages. The later WP8 outputs extended this from design-time reflection to deployment-time governance by identifying affected persons, misuse scenarios, oversight needs and admissible conditions of use [16–18]. Ethics was therefore embedded in the problem formulation, sensing architecture and application scenarios rather than appended after the fact.
2. **Technical outputs.** The project delivered the three promised innovation streams: privacy-compliant static holography and localization, privacy-selective dynamic tracking and crowd sensing, and privacy-aware gesture and motion recognition.
3. **Validated outcomes.** These streams were benchmarked and translated into scenario-level KPPs through D6.2, D6.3 and D6.4, which means the project demonstrated capability under representative conditions instead of stopping at isolated proof-of-concept claims.
4. **Transfer readiness.** WP6 and D4.5 connected the validated technologies to application scenarios, roadmaps, business logic and WiFi-compliant implementation pathways, while the WP8 deliverables specified the governance conditions under which those applications remain ethically defensible.

This conclusion is qualified in an important way. HOLDEN does not show that any downstream RF deployment becomes ethical merely by reusing a HOLDEN algorithm or hardware pathway. Rather, the project achieved an ethically grounded prototype and transfer framework in which technical privacy measures are coupled with governance conditions such as purpose limitation, transparency, human oversight, complaint and redress mechanisms, and restrictions on covert or secondary use [16–18]. Those non-technical measures are part of the achievement claim, not an external add-on.

The strongest overall interpretation is therefore as follows: HOLDEN achieved the overall objective at prototype and application-validation level. The consortium demonstrated that high-value RF perception capabilities can be delivered without abandoning privacy-by-design principles, and that the resulting methods can be mapped onto application scenarios and wireless hardware trajectories relevant to future WiFi and b5G / 5G+ systems under explicit technical and governance conditions.

Table 3: Final assessment of achievement of O1–O5 and of the overall objective.

Item	Assessment	Status	Basis for conclusion
O1	Privacy-sensitive and responsible design framework	Achieved	Complete enabling-condition layer delivered for both design choices and admissible deployment or use constraints
O2	Privacy-compliant high-accuracy 3D localization	Achieved	Complete chain from privacy constraints to localization output, benchmark validation and scenario relevance
O3	Privacy-selective dynamic multi-target tracking	Achieved	Privacy mechanisms, WiFi-compliant implementation and distributed benchmark evidence complete the dynamic-sensing chain
O4	Privacy-aware complex motion and gesture recognition	Achieved	Recognition performance, direction robustness and application-level privacy requirements complete the interaction chain
O5	Transfer toward WiFi / b5G / 5G+ platforms	Achieved	Application requirements, benchmarks, roadmap, WiFi-oriented pathway and explicit governance conditions complete the transfer-readiness layer
Overall objective	Ethically compliant RF perception with privacy by design and adaptable accuracy	Achieved	The consortium completed the full intervention chain from ethical design to validated outcomes, bounded use conditions and transfer pathways

5 Conclusions

This deliverable concludes that HOLDEN achieved its overall objective and the five objectives O1–O5 defined in Annex I. Using a standard intervention-logic framework, the evidence chain is complete from ethical and appropriation-oriented design premises, to technical outputs, to validated benchmark outcomes, and finally to transfer-oriented application integration. The evidence is strongest where ethical design and technical development are considered together: the project repeatedly showed that privacy preservation can be implemented structurally through tagging, spatial filtering, selective sensing, local or split learning, and scenario-specific deployment constraints.

At the same time, the ethical claim is not exhausted by technical mitigation. The later ethics work in D8.1, D8.2 and the ESM makes explicit that not all harms can be designed away at signal-processing level. Complaint and redress channels, transparency, human oversight, deactivation options, restrictions on covert deployment and secondary use, operator training, and renewed review when the use context changes are all part of the project's achievement claim [16–18].

The final outcome of HOLDEN is therefore not just a set of separate RF sensing methods. It is a validated project-level proposition: ethically compliant holographic and dense-network perception is feasible, useful, and transferable to realistic application settings when privacy-by-design is treated as a system requirement from the outset and coupled with enforceable governance conditions for use.

References

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A Referenced HOLDEN Deliverables Used in This Assessment

Deliverable	Role in D6.6 assessment
D2.1	Initial social implications analysis and responsible-design baseline for HOLDEN
D2.2	Update of the responsible-design methodology using techno-moral scenarios and Guidance Ethics
D2.3	Appropriation analysis and deployment requirements across static, dynamic and active holography
D3.2	Privacy-compliant 3D passive radar holographic imaging for static scenarios
D3.5	High-accuracy indoor localization under privacy constraints using passive tags
D4.3	Privacy threats, fairness considerations and mitigation mechanisms for dynamic tracking
D4.5	Application of HOLDEN principles to WiFi-compliant beam-steering technology
D5.3	Unified motion and gesture recognition pipeline with strong recognition performance and extended gesture vocabulary
D5.4	Direction-agnostic RF gesture recognition from sparse point clouds
D5.5	Ethical and societal implications of gesture recognition and domestic deployment
D6.1	Functional and ethical requirements for the three final application scenarios
D6.2	Benchmark validation of localization and object-detection performance in restricted-area scenarios
D6.3	Application scenarios, business plan, roadmap and key performance parameters
D6.4	Benchmark validation for motion detection, people counting and dynamic sensing in test-house prototypes
D8.1	Cross-scenario trustworthy-AI assessment, affected-person analysis and deployment-time oversight requirements
D8.2	Misuse-risk assessment and explicit technical and non-technical safeguards for deployment and post-deployment use
D8.11	Final Ethics Status Monitor linking scenarios, mitigation measures and operational ethics requirements across work packages