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Executive summary:

This quality management plan covers the quality planning, quality assurance activities and quality control activities that will result in a high-quality product that meets customer expectations. The teams that play a crucial role in the product quality management are project manager, hardware design team, software and data team, customer support team, supply chain & production team, and quality team. Their key activities to contribute the product quality are also identified. The specific quality goals and objectives are defined. The standards, criteria and key performance indicators to meet these goals are specified, quantitatively whenever possible. A list of required documentation for quality management is stated, including the quality information they include and their document management plan. Inspection and testing methods were defined, outlining the requirements and pass/fail criteria. Detailed procedure on how defects and issues will be managed are outlined, including the use of commercial software for defect management.

Document Changes Log:

Issue	**Reason/Main changes**	**Date issued**
-01	First issue	18/03/24
-02	Use a table to outline the inspection/testing methods and requirements	07/04/24
-03	Remove content to ensure that the quality management plan is more product specific than broader project perspective.	20/04/24

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Distribution: Entire project team and supply chain partners

Product Quality Management Plan LocaVision

1. Introduction

1.1 Scope

This quality management plan covers quality planning, quality assurance activities and quality control activities that will result in a high-quality product that meets customer expectations. This plan considers the entire product lifecycle, from market research and conceptual design to mass production and continuous improvement post-launch. The quality management of LocaVision is based on the culture and mindset of all sub-teams within the project team. All sub-teams within the project contribute collectively, making this product quality management a total quality management system.

The project manager will oversee all the operations of the project and ensure there is effective collaboration among different sub-teams so that the product's quality is high and continuously improved. The hardware design team produces a high-performing design that meets all the customer expectations. The customer support team will resolve issues quickly and collect customer feedback. The software and data team will contribute with high-performing, up-to-date and user-friendly software systems and ethical handling of data. The supply chain and production team will secure beneficial contracts with reliable and sustainable suppliers while resolving supply chain issues to ensure a high-quality product is delivered on time. The quality team will visit LocaVision's suppliers in frequent rotations, playing an active role in quality management and conforming to specifications in upstream manufacturing processes.

1.2 Objectives

The product quality management plan aims to make a total quality management system that conducts quality planning and specifies quality assurance and control activities. This will help LocaVision efficiently meet customer expectations on time, the first time, and all the time. The product will have a long-term competitive advantage, sustainable success, and continuous improvement in quality rather than short-term profitability.

1.3 Definitions and Acronyms

Artificial Intelligence (AI) is a technology that enables computers and machines to simulate the intelligence of living things and problem-solving capabilities.

Augmented Reality (AR) is an interactive technology that enhances the real-world experience with computer-generated perceptual visuals.

Quality Management Plan (QMP) documents necessary information required to effectively manage product quality.

Quality Management System (QMS) is a collection of processes that focuses on quality management.

Key Performance Indicators (KPIs) are metrics that quantitatively measure success against targets.

Failure Mode and Effect Analysis (FMEA) is a technique to determine the modes under which a system or product might fail and what effect the identified failures would have on the system's performance, safety, and environment.

Lean Production (LP) principles that aim to minimise waste and lead time in the production line [1].

General Data Protection Regulation (GDPR) is a regulation of information privacy in the European Union.

CE marking is the approval to show products meet European Union safety, health and environmental requirements.

Restriction of Hazardous Substances (RoHS) directive is a restriction of certain hazardous substances in electrical and electronic equipment by the European Union [2].

The International Organization for Standardization (ISO) prepares and publishes international standards and guidelines for ease of use for end-users and the common market.

National Institute of Science and Technology (NIST) is an agency of the United States to promote innovation and industrial competitiveness [3].

International Electrotechnical Commission (IEC) is an international standards organisation that prepares and publishes standards for all electrical, electronic and related technologies [4].

Institute of Electrical and Electronics Engineers (IEEE) is an American professional association for electrical engineering, electronic engineering and related technologies [5].

Ingress Protection (IP) code indicates how well a device is protected against water and dust.

2. Quality Summary

2.1 Quality Objectives

The specific quality goals for the product are as follows:

- Achieve a seamless integration of AI, AR, location-aware features and relevant contextual information to provide enhanced user experience.
- Build and continuously improve the software in terms of functionality, performance, robustness, and user-friendliness.
- Design hardware that is functional, durable, safe and aesthetic
- Manufacture and assemble hardware that matches design specifications
- Strictly protect data privacy and security of the users
- Ensure the customer expectation of the product is aligned with the product's actual performance and specifications.
- Decrease the cost of nonconformance to product quality (such as cost of scrap, rework, replacement, warranty repairs, damaged reputation)
- Focus on long-term commitment to quality rather than short-term profitability.
- Achieve consistent quality and specifications in the design and manufacturing of different subteams.
- Resolve issues and enquires from customers quickly and effectively
- Ensure the product adheres to all the laws and regulations, obtaining approval from various regulatory bodies.
- Ensure the product follows relevant national/international standards and guidelines for good practices.
- Ensure the project adheres to schedule

2.2 Deliverable Quality Standards

The standards and criteria to evaluate the product deliverables are as follows:

- STP Ltd and all LocaVision's suppliers are certified with ISO 9001:2015. LocaVision's quality team will work with suppliers to ensure the components supplied and all their production processes comply with ISO 9000 standards and guidelines [6].
- The sunglasses frame provided by Mazzucchelli 1849 must comply with the fundamental requirements of ISO 12870:2016 [7]. The physical and mechanical properties must comply with ISO 18526-3:2020 [8].
- Hardware follows guidelines of ISO 9241-210:2019 on ergonomics, usability and accessibility of interactive systems, including wearables [9].
- Design follows guidelines of ISO technical report 25060:2023. It follows guidelines on systematic human-centred design for interactive systems.
- Ensure compliance with the Data Protection Act 2018 and the GDPR.
- Ensure compliance with General Product Safety Regulations 2005, Electromagnetic Compatibility Regulations and RoHS directive. Obtain CE approval.
- Batteries and energy management systems follow IEC 62133 safety requirements [10] and IEC 61960 performance requirements [11] on lithium-ion batteries
- Ensure compliance with IEEE 802.11 standard for wireless local area network technology [12].
- Follow the guidelines of the NIST Cybersecurity Framework and NIST guidance for wearable electronic products.
- Follow the AI ethical guidelines of Partnership on AI
- Follow the web content accessibility guidelines of ISO 40500:2012 [13]
- Follow international software quality standard ISO/IEC 25000:2014 [14]
- Upon sale, include a comprehensive, accessible multilingual user manual and technical documentation.
- Hardware manufacturing follows LP guidelines to minimise waste and lead time in the production line.
- Follow the right-to-repair legislation 2021 by having a third-party company stock and manage spare parts
- Ensure the design, marketing, legal production, and supplier delivery adheres to schedule.

2.3 Quality Metrics and KPIs

The KPI to measure the outcome metric is the defect rate of finished products. The target is 0.05%.

Four KPIs are used to measure the process performance metric – process potential (Cp), capability index (Cpk), mean time to detect (MTTD) and mean time to repair (MTTR).

Process potential (Cp) and capability index (Cpk) both describe the ability to meet specifications. Process potential (Cp) measures the spread relative to the specification limits. Capability index (Cpk) measures both the spread and mean relative to the specification limits. Both process potential (Cp) and capability index (Cpk) are targeted at 2.

MTTD is the average time to detect a defect from the moment the defect was first introduced in a component or code. MTTR is the average time to fix a defect once it has been detected. The target MTTD is one week and MTTR is 3 days.

The KPI that measures cost metric is the cost of quality as the percentage of project earnings. In a good QMS, more money is spent on quality assurance and control activities. Still, the cost of nonconformance to product quality (such as the cost of scrap, rework, replacement, warranty repairs, and damaged reputation) is heavily reduced. So, the cost metric is lower for a good QMS. The target cost of quality is less than 4% of project earnings.

Five KPIs measure customer support metrics – customer satisfaction rate, net promotor score (NPS), customer complaint rate, warranty-claim rate, and non-automated response time to enquiries. The target customer satisfaction rate is 90%. The target net promotor score (NPS) is 60%. The target customer complaint rate is less than 1%. The target warranty-claim rate is less than 2%. The target non-automated response time to enquiries is 1 hour.

Two KPIs measure supplier quality metrics – defect rate of components supplied and timely delivery of tasks. Supplier quality metrics can be beneficial in supplier selection and contract negotiations. The defect rate of components arriving from any supplier is aimed to be less than 0.5%.

The KPI that measures the metric of inspection tests is the rate of escaped defects, which are defective products that reach the end-users. The rate of escaped defects is aimed to be 0%.

The KPI for the durability of the product will be IP ratings and height of drop tests. The IP rating of the product will be IP53. The product will survive a drop from 2 metres high.

The KPI for product reliability is a warranty and free repair period. There will be a 1-year period.

2.4 Quality Documentation

Quality Documentation Type	Quality Information Provided	Document Management Plan
Product Quality Management Plan	- Quality planning, quality assurance and quality control information of the product and its production processes	Created by Quality Manager in 09/2024 Reviewed by the leads of all the sub-teams within the project in 09/2024 Approved by Project Manager in 10/2024 Review cycle: Quarterly Changes tracked using OneDrive
Product Requirements	- List of requirements and objectives which the product aims to achieve. - Test methods for the requirements and objectives.	Created by Project Manager in 09/2024 Reviewed by the leads of all the subteams within the project in 09/2024 Approved by the Chief Executive Officer in 10/2024 Review cycle: Monthly Changes tracked using OneDrive
Project Risk Register	- Potential risks that can affect product quality and their mitigations	Created by Assistant Project Manager in 09/2024 Reviewed by the leads of all the subteams within the project in 09/2024 Approved by Project Manager in 10/2024 Review cycle: Monthly Changes tracked using OneDrive
Configuration Identification and Control Documentation	- Specifications of a component - Drawings of a component - Prototypes of a component (if any) - Changes made and their dates	Created by a member of the technical team relevant to the component at the date the component was first designed Reviewed by another member of the same technical team Approved by the lead of the technical team Review cycle: whenever there is a change in the component information Changes tracked using OneDrive
Documentation for Formal Design Review	- Functionality of the concept - Feasibility of the concept - Compliance with requirements - Potential risks - Design assumptions - Design calculations	Created by relevant design lead on the first day of formal design review Reviewed by all members of the relevant design team Approved by the project manager

	- Completeness of design - Compliance with specifications - Intellectual property rights - Manufacturability - Tests on early-produced items on their efficacy - Design check and input from external technical experts hired from engineering consultancies	Review cycle: whenever another design review is done Changes tracked using OneDrive or Git if it is code
Quality Audit	- Verification of the quality management processes implemented - Verification of compliance with quality standards and meeting the KPIs	Created by the quality manager on the first day of the audit Reviewed by the leads of all the subteams within the project Approved by the project manager on the last day of the audit Review cycle: whenever another audit is done Changes tracked using OneDrive
Supplier Audit (second-party audit)	- Monitoring of supplier's ability to maintain the quality of components supplied - Monitoring the supplier's ability to deliver services on time - Monitoring the cost	Created by a member of the supply chain & production team in 09/2023 Reviewed by the supply chain & production manager Approved by the project manager Review cycle: Yearly Changes tracked using OneDrive
Inspection and Testing Documentation	- Date and owner of an inspection - Inspection and testing methods - Inspection and testing requirements - Pass/fail criteria - Configuration identity or production batch number - Inspection and testing results	Created by the owner of the inspection on the day the inspection is first planned Reviewed by another member of the quality team Approved by the quality manager Review cycle: Whenever information about the inspection needs to be traced Changes tracked using OneDrive
Issue and Defect Management Documentation	- Configuration identity or unique serial number of the defective component/product - Details of issue/defect - Categories and priorities of the issues/defects - Owner and status of the issue/defect - Cause of the issue/defect - Corrective actions implemented - Lessons learnt - Preventive actions implemented	Created by the owner of the issue/defect Reviewed by another member of the quality team Approved by the quality manager Review cycle: Whenever information about the issue/defect needs to be traced Changes tracked using OneDrive
Standard Operating Procedures (SOP) Documents	- SOP of manufacturing processes - SOP of inspection and testing methods - Issue/defect fixing SOP - Customer service SOP	Created by the relevant technical lead at the start of the project Reviewed by project manager Approved by the Chief Technical Officer Review cycle: Monthly Changes tracked using OneDrive
FMEA Document	- Relevant parts or functions of the component - All the possible failure modes and causes - Probability and detectability of each failure mode - Effects and severity of each failure mode - Priority of each risk - Plan to circumvent each failure mode, mitigate the effects of each failure mode, and take contingent action in case the failure occurred	Created by a member of the quality team on the first day of design Reviewed by the members of the relevant technical team Approved by the quality manager Review cycle: Monthly Changes tracked using OneDrive

Control Charts	- Consistency, trends, spread and variations in the production processes - Process potential (Cp) and capability index (Cpk) - Exponentially-weighted moving average (EWMA)	Created by a member of the quality team on the first day of production Reviewed by the members of the relevant technical team Approved by the quality manager Review cycle: Monthly Changes tracked using OneDrive
Pareto Charts Documentation	- Different causes of defects and how much each contributes to total defects - Most vital causes of defects	Created by the quality manager Reviewed by the members of the relevant technical team Approved by the project manager Review cycle: Monthly Changes tracked using OneDrive

3. New Product Quality Control

3.1 Inspection and Testing

For all the tests and inspections, test procedures, requirements, and pass/fail criteria will be clearly defined. Measured results will be used to generate KPIs, control charts and Pareto charts. Reports will be written, which include configuration identity, detailed inspection results, and the date and owner of the inspection. The configuration identity of every component, material or code inspected will be documented for tracking and tracing purposes.

The table below shows the inspection methods and pass/fail criteria for the essential requirements.

Key Requirements	**Inspection Methods**	**Pass Criteria**
Functionality of sunglasses frame	Manual testing was conducted on all finished products.	See if the frames, adjustable features and opening/closing work properly.
External dimensions and absence of damage in the sunglasses frame	Automated coordinate measuring machines (CMM) or digital callipers will measure dimensions. The absence of damages will be inspected visually, using magnification tools if necessary. Test on all finished products.	Dimensions are correct within the specified tolerances.
IP53 and 2m drop durability	Spray water from a nozzle at various angles up to 60° from the vertical. Put the product into a dust chamber and inspect for minimal ingress of dust. Drop the finished product from a height of 2m. Test on 1 product of every batch.	The water must not have any adverse effect on the performance. Dust must not interfere with the operation of the product. The drop must not have any adverse effect on the performance.
Electrical safety	Supply the nominal electrical current and voltage and inspect for any risks of electric shock or fire. Conduct circuit integration and continuity tests. Temperature test using thermal cameras when the product is executing tasks with high loads. Test on all finished products.	No risk of electric shock or fire. No open circuits. All components are fully and correctly integrated. The temperature measured must be within the required temperature range.
Electromagnetic compatibility	Follow the test procedures in the Electromagnetic Compatibility Regulations [15] Test on all finished products.	Emitted electromagnetic radiation is below the upper limits specified in Electromagnetic Compatibility Regulations.
Performance of logic circuit	Executes the automated self-test program in the logic circuit Test on all finished products	Executes the test successfully with expected speed and outputs, without any errors or faults.
Functionality of AR feature, camera, microphone, speaker, and GPS module	Manually test if all those features work. Test on all finished products	All those features must work.
Performance of camera and AR	Test the camera resolution with image processing software Test the AR rendering speed by assessing the frame rate, latency, and stability in various simulated environments. Test on a sample size of 10%	The camera resolution and AR rendering speed must be as specified
User experience	Beta testing by 100 people outside the project team, and they will rate their experience out of 10.	Average rating must be 9

Software performance	Conduct load testing to see how the software performs under high workloads. Conduct latency tests to inspect AI processing times.	Ensure the latency remains consistent and within the targeted response time. Ensure the software can handle the high workloads without lagging.

3.2 Issue and Defect Tracking

Every component, material or code in the production line has a configuration identity. Every finished product has its unique serial number alongside the production batch number.

We will use JIRA Work Management, which is a commercial management software that can be used for centralised issue/defect tracking and management. As JIRA is integrated with Git and our software team uses Git for version control, our software team will also be able to utilise JIRA effectively.

Each issue or defect will be logged onto the system as soon as it is detected at inspection or reported by the customer support team. Each log will include details of the issue and the configuration identity of the component, material or code where the issue lies. The configuration identity can be used to trace if there are any issues in the upstream production line. If it is a customer-reported issue, the serial number and production batch number of the product will be noted. The serial number can be used to trace the production process and manufacturing history.

Categories will be assigned to the defects/issues. Each defect/issue will be prioritised based on how severely it impacts the product functionality or customer experience. Defective components will be retrieved and returned to the supplier.

The issue will be assigned ownership to a member of the relevant team who has the expertise and capacity to manage and resolve it. The status of every issue will be regularly updated and documented in JIRA. If it is a customer-reported issue, timely and transparent updates will be given to the customer, with the expected time for the issue to be resolved.

Root-cause analysis will be conducted to systematically analyse the underlying cause of the issue/defect. The issue/defect will be fixed. There will be predefined procedures and workflows to resolve issues. If the time and resources needed to fix an issue/defect outweigh the potential benefits of resolution, a waiver or deviation may be sought. If a waiver or deviation is not possible, the component will be disposed of.

If the investigation of the issue indicates that there is a problem not only in this specific item but also in the whole production batch, the entire production batch may be retrieved. Suppose retrieval of the whole production batch is not beneficial. In that case, announcements will be sent to all customers who have purchased from this production batch, apologising and offering guidelines on how to report any issues, avoid the issues and self-fix the issue. Compensation will be given to the customers, regardless of whether we are legally liable or not. This enhances customer satisfaction.

Once an issue is resolved, another member of the relevant team will inspect and verify the resolution of the problem. If it is a customer-reported issue, a closure email will be sent out, apologising for the inconvenience and recommending how to prevent the issue in the future. A customer feedback survey will also be sent to obtain criticism and determine what needs to be improved.

Detailed documentation will be kept for future reference and traceability. The defects/issues and their causes will be analysed. Actions will be taken to prevent similar defects/issues and continuously improve product/project quality.

References

[1] https://www.leanproduction.com/

[2] https://www.gov.uk/guidance/rohs-compliance-and-guidance

[3] https://www.nist.gov/

[4] https://www.iec.ch/homepage

[5] https://www.ieee.org/

[6] https://www.iso.org/standard/62085.html

[7] https://www.iso.org/standard/68526.html

[8] https://www.iso.org/standard/62785.html

[9] https://www.iso.org/standard/77520.html

[10] https://webstore.iec.ch/publication/32662

[11] https://webstore.iec.ch/publication/27451

[12] https://www.ieee802.org/11/

[13] https://www.iso.org/standard/58625.html

[14] https://www.iso.org/standard/64764.html

[15] https://www.vicom.com.au/page/217/emc-emi-testing-what-is-electromagnetic-compatibility-testing-