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Test Plan, Test Design Specifications and Test Cases

Version 1

CENG 408

Innovative System Design and Development II

VR-Kitchen: Risk Management Platform for Gastronomy Practitioners

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1. INTRODUCTION

1.1 Version Control

Version No	Description of Changes	Date
1.0	First Version	April 15, 2025

1.2 Overview

This is the verification and validation test plan for the VRKitchen project. The system will be able to simulate the environment through the use of Virtual Reality (VR) technology, where users are able to learn how to manage ingredients, schedule kitchen operations, and react to various safety hazards with real-time AI-based feedback.

1.3 Scope

This document encapsulates the test plan, design specifications, and test cases for critical components of the VRKitchen platform. It covers interface interactions, cooking task execution, response to hazards, and AI-driven instruction checking.

1.4 Terminology

Acronym	Definition
GUI	Graphical User Interface
VR	Virtual Reality
AI	Artificial Intelligence
RAG	Retrieval-Augmented Generation
RM	Risk Management

2. FEATURES TO BE TESTED

A brief description of the main features to be tested is given in this section. A test design specification for every significant feature is appended at the end of the test plan document.

2.1 AI Guidance & Speech Interaction (AI)

This feature tests whether the AI system provides accurate, context-dependent instructions during cooking and in response to hazards. This includes testing of recipe step-by-step instructions, risk response instructions (e.g., fire control, allergen alerts), and general user inquiries via speech-to-text and text-to-speech. The tests ensure that the RAG-enabled system answers appropriately based on the user's actions and voice input — for instance, reading out the next recipe step when the user asks for a next step, detecting hazards, or warning against unsafe actions.

2.2 Graphical User Interface (GUI)

Includes testing VR scene objects built using Unity, for example, interactions with environments, scenes in a virtual kitchen, and interactions with objects such as opening cabinets, operating stoves, or placing/removing assets (e.g., pans, ingredients). This would allow having the VR user interface embedded directly within the immersive experience.

2.3 Risk Management Scenarios (RM)

Simulations are designed to test kitchen risk scenarios including fire incidents, liquid spills, and cross-contamination. This feature provides for the realistic triggering of hazards while users are guided toward the recognition of appropriate responses from RAG to hazards within the simulation.

3. FEATURES NOT TO BE TESTED

- **Multiplayer Interactions**

  Reason: Designed for individual training, VRKitchen has been set up as one-user training to enhance personal learning and risk assessment. Thus, the present version has no multiplayer capabilities (e.g., collab, competition, instructor-student mode) implemented and reserved for future development.

- **Admin Panel for Configuring Backend RAG**

  Reason: The RAG system's knowledge base is managed externally through AWS services and is not part of the end-user VR interface. As such, the admin tools used to modify backend content are considered out-of-scope for VR environment testing.

- **Mobile or Desktop Compatibility Outside Meta Quest 3**

  Reason: VRKitchen is optimized and tested exclusively for the Meta Quest 3 headset. Compatibility with other platforms (e.g., desktop VR or mobile emulation) is not part of the current deliverables and would require additional adaptation and testing in separate environments.

4. ITEM PASS/FAIL CRITERIA

The considered result is that a test case has passed as far as all of its expected results are concerned. If one expected effect does not occur and/or an error or exception occurs during its evaluation, the test case is considered to have failed.

4.1 Exit Criteria

- 100% of the test cases are executed
- 95% of all test cases passed
- All High and Medium priority test cases passed
- No unresolved critical or major bugs remain

5. REFERENCES

[1] TeamID_202319_SRS_Document
[2] TeamID_202319_SDD_Document

6. TEST DESIGN SPECIFICATIONS

6.1 AI Guidance & Speech Interaction (AI)

6.1.1 Subfeatures to be tested

6.1.1.1 Recipe Guidance (AI.REC):

Step-by-step instruction delivery using various methods including speech-to-text and RAG.
It includes verifying AI responses to commands such as 'next step', 'repeat', or 'skip step'.

6.1.1.2 Hazard Response (AI.HAZ):

Real-time alerts and instructions for hazards like fire or cross-contamination.
The system should deliver real-time verbal alerts and actionable instructions to help the user address the hazard safely.

6.1.1.3 General Query Handling (AI.QUE):

Responding to user-initiated questions or requests for help.
The system should interpret the question and provide accurate, helpful responses using the RAG-based knowledge base.

6.1.2 Test Cases

TC ID	Requirements	Priority	Scenario Description
AI.REC.01	3.2.2.7, 3.2.2.8	H	User says 'What’s the next step?' and the system correctly reads out the next recipe step.
AI.REC.02	3.2.2.7, 3.2.2.8	M	User asks 'Repeat that step', and the system replays the last instruction.
AI.REC.03	3.2.2.7, 3.2.2.8	M	User gives voice input during ongoing AI speech, and the system queues the new input properly.

AI.REC.04	3.2.2.7, 3.2.2.8	L	System receives unclear voice input and prompts the user for clarification.
AI.REC.05	3.2.2.7, 3.2.2.8	H	User sends a “Step Done” query step, and AI confirms before jumping ahead.

TC ID	Requirements	Priority	Scenario Description
AI.HAZ.01	3.2.2.7, 3.2.2.8	H	Fire starts in the kitchen, and the AI instructs the user to locate and use the extinguisher.
AI.HAZ.02	3.2.2.7, 3.2.2.8	H	Cross-contamination event occurs and the AI warns the user with corrective steps.

TC ID	Requirements	Priority	Scenario Description
AI.QUE.01	3.2.2.7, 3.2.2.8	M	User asks 'What is this tool used for?' and receives the correct explanation.
AI.QUE.02	3.2.2.7, 3.2.2.8	M	User says 'Help me', and the system offers safety instructions and suggestions.

6.2 Graphical User Interface (GUI)

6.2.1 Subfeatures to be tested

6.2.1.1 Scene Navigation (GUI.SCN):

Covers the ability of the user to freely move around different areas in the virtual kitchen environment.
Includes teleporting or walking between zones, triggering new views or areas, and ensuring environment boundaries are respected.

6.2.1.2 Object Interaction (GUI.OBJ):

Validates the user's ability to interact with various objects like stoves, cabinets, pans, and utensils in the Unity-based VR scene.
Includes grabbing, placing, activating, or combining items using VR controllers or hand tracking.

6.2.1.3 Kitchen Task Mechanics (GUI.TSK):

Covers the interaction logic for core cooking-related tasks such as slicing ingredients, placing items in cooking appliances (e.g., ovens, pans), and monitoring cooking states. This includes testing responsiveness during slicing, realistic object behavior when dropped into pots or onto counters, and visual or auditory cues indicating cooking progress or completion.

6.2.2 Test Cases

TC ID	Requirements	Priority	Scenario Description
GUI.SCN.01	3.2.2.1	H	User moves freely across different kitchen zones and scenes using teleport or analog movement.
GUI.SCN.02	3.2.2.1	M	Kitchen environment loads successfully and the user spawn point is positioned correctly.

TC ID	Requirements	Priority	Scenario Description
GUI.OBJ.01	3.2.2.1	H	User opens a cabinet door, retrieves a pan, and closes the door.
GUI.OBJ.02	3.2.2.1	H	User places a pan on the stove and activates the stove burner with a knob.
GUI.OBJ.03	3.2.2.1	M	User grabs a knife, cuts an ingredient, and drops the item in a pot.

TC ID	Requirements	Priority	Scenario Description
GUI.TSK.01	3.2.2.1	H	User slices a vegetable with a knife and sees the sliced parts separate accurately.
GUI.TSK.02	3.2.2.1	M	User places an ingredient into a pan and hears a sizzling sound indicating cooking.
GUI.TSK.03	3.2.2.1	M	Ingredients change visual state (e.g., color, texture) after being cooked for a set time.
GUI.TSK.04	3.2.2.1	L	Ingredient overcooks or burns if left in the cooking appliance too long.

6.3 Risk Management Scenarios (RM)

6.3.1 Subfeatures to be tested

6.3.1.1 Fire Hazards (RM.FIRE):

Simulates kitchen fire events (e.g., pan fire, oven flare-up) and tests whether the system alerts the user and provides appropriate instructions for fire response. This includes locating a fire extinguisher, using it properly, and receiving real-time AI feedback.

6.3.1.2 Object Interaction (GUI.OBJ):

Simulates scenarios where raw and cooked foods are handled improperly (e.g., using the same knife or cutting board) and evaluates whether the system detects the violation, provides warnings, and guides users through proper safety practices.

6.3.2 Test Cases

TC ID	Requirements	Priority	Scenario Description
RM.FIRE.01	3.2.2.2, 3.2.2.3, 3.2.2.4	H	User leaves a pan on high heat, and a fire starts. System provides a visual alert and AI instructs the user to use the extinguisher.
RM.FIRE.02	3.2.2.2, 3.2.2.3, 3.2.2.4	M	User uses the fire extinguisher with the instructions in real time given by the AI.
RM.FIRE.03	3.2.2.2, 3.2.2.3, 3.2.2.4	L	AI gives post-fire instructions, including checking other appliances and reporting the incident.

TC ID	Requirements	Priority	Scenario Description
RM.CONT.01	3.2.2.2, 3.2.2.3, 3.2.2.4	H	User uses the wrong surface for raw chicken and vegetables. System detects risk and triggers a contamination warning through AI.
RM.CONT.02	3.2.2.2, 3.2.2.3, 3.2.2.4	L	System highlights safe vs. unsafe ingredient zones when the user attempts to mix raw and cooked items.

7. Detailed Test Cases

7.1 AI.REC.01

TC_ID	AI.REC.01
Purpose	User says 'What's the next step?' and the system correctly reads out the next recipe step.
Requirements	3.2.2.7, 3.2.2.8
Priority	High
Estimated Time Needed	2 Minutes
Dependency	System must be in an active cooking session.
Setup	User starts a recipe and progresses through initial steps.
Procedure	[A01] User says 'What's the next step?'
	[V01] AI reads out or writes the next recipe step on the screen correctly.
Cleanup	Continue to the next recipe step.

7.2 AI.REC.02

TC_ID	AI.REC.02
Purpose	User asks 'Repeat that step', and the system replays the last instruction.
Requirements	3.2.2.7, 3.2.2.8
Priority	Medium
Estimated Time Needed	2 Minutes
Dependency	Previous step must have been read by AI.
Setup	User is in the mid-recipe session.
Procedure	[A01] User says 'Repeat that step'.
	[V01] AI repeats the last given instruction.
Cleanup	Proceed with the current recipe step.

7.3 AI.REC.03

TC_ID	AI.REC.03
Purpose	User gives voice input during ongoing AI speech, and the system queues the new input properly.
Requirements	3.2.2.7, 3.2.2.8
Priority	Medium
Estimated Time Needed	3 Minutes
Dependency	Ongoing AI narration, either speaking or writing on the screen.
Setup	AI is processing a query answer.
Procedure	[A01] User interrupts AI with a new command.
	[V01] System queues the new input and executes it after the current instruction.
Cleanup	Return to normal interaction flow.

7.4 AI.REC.04

TC_ID	AI.REC.04
Purpose	System receives unclear voice input and prompts the user for clarification.
Requirements	3.2.2.7, 3.2.2.8
Priority	Low
Estimated Time Needed	2 Minutes
Dependency	None.
Setup	User is mid-session and has access to the voice input.
Procedure	[A01] User says an unintelligible command.
	[V01] System prompts user to repeat or clarify.
Cleanup	Retry with correct input.

7.5 AI.REC.05

TC_ID	AI.REC.05
Purpose	User sends a “Step Done” query step, and AI confirms before jumping ahead.
Requirements	3.2.2.7, 3.2.2.8
Priority	High
Estimated Time Needed	2 Minutes
Dependency	Ongoing recipe flow.
Setup	User is midway through the recipe.
Procedure	[A01] User sends “Step Done” query to the RAG system.
	[V01] AI confirms and provides the next steps.
	[A02] User confirms and continues with the process.
	[V02] AI waits for another “Step Done” query.
Cleanup	Resume cooking instructions.

7.6 AI.HAZ.01

TC_ID	AI.HAZ.01
Purpose	Fire starts in the kitchen, and the AI instructs the user to locate and use the extinguisher.
Requirements	3.2.2.7, 3.2.2.8
Priority	High
Estimated Time Needed	3 Minutes
Dependency	Triggered or random fire event.
Setup	Simulate fire by overheating a pan or a random event
Procedure	[A01] Fire ignites.
	[V01] AI alerts users and gives step-by-step on fire extinguisher use.
Cleanup	Confirm fire extinguished, resume the session.

7.7 AI.HAZ.02

TC_ID	AI.HAZ.02
Purpose	Cross-contamination event occurs and the AI warns the user with corrective steps.
Requirements	3.2.2.7, 3.2.2.8
Priority	High
Estimated Time Needed	2 Minutes
Dependency	Trigger contamination condition.
Setup	Users use the wrong surface for certain meat types.
Procedure	[A01] Game detects cross-contamination and sends a query to the RAG.
	[V01] AI issues a warning and explains corrective action steps.
Cleanup	Sanitize equipment before proceeding.

7.8 AI.QUE.01

TC_ID	AI.QUE.01
Purpose	User asks 'What is this tool used for?' and receives the correct explanation.
Requirements	3.2.2.7, 3.2.2.8
Priority	Medium
Estimated Time Needed	2 Minutes
Dependency	None.
Setup	User sends a query by speaking.
Procedure	[A01] User says 'What is this tool used for?'.
	[V01] AI provides usage info.
Cleanup	User continues with the task.

7.9 AI.QUE.02

TC_ID	AI.QUE.02
Purpose	User says 'Help me', and the system offers safety instructions and suggestions.
Requirements	3.2.2.7, 3.2.2.8
Priority	Medium
Estimated Time Needed	2 Minutes
Dependency	Ongoing task or issue.
Setup	User is in the middle of any kitchen process.
Procedure	[A01] User says 'Help me'.
	[V01] AI offers relevant guidance or options.
Cleanup	User resumes interaction with AI support.

7.10 GUI.SCN.01

TC_ID	GUI.SCN.01
Purpose	User moves freely across different kitchen zones and scenes using teleport or analog movement.
Requirements	3.2.2.1
Priority	High
Estimated Time Needed	2 Minutes
Dependency	The VR movement system must be functional.
Setup	User is in an open kitchen environment/scene.
Procedure	[A01] User uses controller or teleport to move between zones.
	[V01] System moves user with no glitches or delays.
Cleanup	Reset user to initial spawn point.

7.11 GUI.SCN.02

TC_ID	GUI.SCN.02
Purpose	Kitchen environment loads successfully and the user spawn point is positioned correctly.
Requirements	3.2.2.1
Priority	Medium
Estimated Time Needed	1 Minute
Dependency	Scene loader and environment assets must be ready.
Setup	Application is launched.
Procedure	[A01] Start the simulation.
	[V01] Scene loads and the user appears in a valid starting location.
Cleanup	Close the simulation.

7.12 GUI.OBJ.01

TC_ID	GUI.OBJ.01
Purpose	User opens a cabinet door, retrieves a pan, and closes the door.
Requirements	3.2.2.1
Priority	High
Estimated Time Needed	2 Minutes
Dependency	Interactive cabinet and pan assets must be loaded.
Setup	User spawns near the cabinet.
Procedure	[A01] Open the cabinet door.
	[A02] Grab the pan.
	[A03] Close the door.
	[V01] All actions trigger animations and object behavior.
Cleanup	Return pan to original position.

7.13 GUI.OBJ.02

TC_ID	GUI.OBJ.02
Purpose	User places a pan on the stove and activates the stove burner with a knob.
Requirements	3.2.2.1
Priority	High
Estimated Time Needed	2 Minutes
Dependency	Stove and control knobs initialized.
Setup	User has access to a pan and stove area.
Procedure	[A01] Place the pan on the stove.
	[A02] Turn knob to activate the stove.
	[V01] Heat effect appears and pan stays stable.
Cleanup	Turn off the stove and remove the pan.

7.14 GUI.OBJ.03

TC_ID	GUI.OBJ.03
Purpose	User grabs a knife, cuts an ingredient, and drops the item in a pot.
Requirements	3.2.2.1
Priority	Medium
Estimated Time Needed	3 Minutes
Dependency	Knife, ingredients, and pot present in the scene.
Setup	User is near the chopping station.
Procedure	[A01] Grab the knife.
	[A02] Slice ingredient.
	[A03] Drop the sliced item into the pot.
	[V01] All actions visually and physically function correctly.
Cleanup	Reset sliced ingredients.

7.15 GUI.TSK.01

TC_ID	GUI.TSK.01
Purpose	User slices a vegetable with a knife and sees the sliced parts separate accurately.
Requirements	3.2.2.1
Priority	High
Estimated Time Needed	2 Minutes
Dependency	Slicing logic and mesh separation enabled.
Setup	User is at a chopping board with a vegetable.
Procedure	[A01] Grab a knife and slice the vegetables.
	[V01] Vegetables split into separate mesh pieces.
Cleanup	Remove or discard sliced pieces.

7.16 GUI.TSK.02

TC_ID	GUI.TSK.02
Purpose	User places an ingredient into a pan and hears a sizzling sound indicating cooking.
Requirements	3.2.2.1
Priority	Medium
Estimated Time Needed	2 Minutes
Dependency	Sound and interaction logic must be active.
Setup	User holds a raw ingredient and stands by the stove.
Procedure	[A01] Place ingredient in a heated pan.
	[V01] Sizzle audio triggers and cooking effect begins.
Cleanup	Remove cooked item from the pan.

7.17 GUI.TSK.03

TC_ID	GUI.TSK.03
Purpose	Ingredients change visual state (e.g., color, texture) after being cooked for a set time.
Requirements	3.2.2.1
Priority	Medium
Estimated Time Needed	3 Minutes
Dependency	Cooking timer logic and visual states must be implemented.
Setup	Ingredients placed in cooking appliances.
Procedure	[A01] Wait for cooking period.
	[V01] Ingredients texture changes to represent cooked state.
Cleanup	Move ingredients to the plating area.

7.18 GUI.TSK.04

TC_ID	GUI.TSK.04
Purpose	Ingredient overcooks or burns if left in the cooking appliance too long.
Requirements	3.2.2.1
Priority	Low
Estimated Time Needed	3 Minutes
Dependency	Burn state logic must be functional.
Setup	Ingredient placed in cooking appliances with no user interaction.
Procedure	[A01] Let cooking exceed the intended time.
	[V01] Ingredient darkens or smokes indicating burning.
Cleanup	Dispose of burned item.

7.19 RM.FIRE.01

TC_ID	RM.FIRE.01
Purpose	User leaves a pan on high heat, and a fire starts. System provides a visual alert and AI instructs the user to use the extinguisher.
Requirements	3.2.2.2, 3.2.2.3, 3.2.2.4
Priority	High
Estimated Time Needed	3 Minutes
Dependency	Fire trigger must be enabled in stove logic.
Setup	User is in the cooking scene and places the pan on high heat.
Procedure	[A01] Wait until fire is triggered.
	[V01] Visual fire appears.
	[V02] AI issues alert and guidance.
Cleanup	User uses extinguisher, system resets kitchen state.

7.20 RM.FIRE.02

TC_ID	RM.FIRE.02
Purpose	User uses the fire extinguisher with the instructions in real time given by the AI.
Requirements	3.2.2.2, 3.2.2.3, 3.2.2.4
Priority	Medium
Estimated Time Needed	3 Minutes
Dependency	Fire extinguisher logic must be interactive.
Setup	User is facing an active fire and holding the extinguisher.
Procedure	[A01] User holds the extinguisher.
	[V01] System gives “How to use” instructions.
Cleanup	AI confirms fire extinguished and scene resets.

7.21 RM.FIRE.03

TC_ID	RM.FIRE.03
Purpose	AI gives post-fire instructions, including checking other appliances and reporting the incident.
Requirements	3.2.2.2, 3.2.2.3, 3.2.2.4
Priority	Low
Estimated Time Needed	2 Minutes
Dependency	Fire must be extinguished successfully.
Setup	Fire scenario has just been completed.
Procedure	[A01] System checks nearby appliances.
	[V01] AI explains follow-up safety protocol.
Cleanup	Kitchen reset or continue to the next step.

7.22 RM.CONT.01

TC_ID	RM.CONT.01
Purpose	User uses the wrong surface for raw chicken and vegetables. System detects risk and triggers a contamination warning through AI.
Requirements	3.2.2.2, 3.2.2.3, 3.2.2.4
Priority	High
Estimated Time Needed	2 Minutes
Dependency	Contamination detection logic must be active.
Setup	User uses a cutting board for raw meat, then for vegetables.
Procedure	[A01] Observe misuse of surface
	[V01] System issues warning and displays sanitation prompt.
Cleanup	System suggests cleaning procedures or switching tools.

7.23 RM.CONT.02

TC_ID	RM.CONT.02
Purpose	System highlights safe vs. unsafe ingredient zones when the user attempts to mix raw and cooked items.
Requirements	3.2.2.2, 3.2.2.3, 3.2.2.4
Priority	Low
Estimated Time Needed	2 Minutes
Dependency	Scene must support zone highlighting.
Setup	User holds raw and cooked items near storage or prep surfaces.
Procedure	[A01] User attempts to mix raw and cooked zones.
	[V01] System displays colored feedback or blocks unsafe action.
Cleanup	Return ingredients to respective areas.