D3.2 Planning and delivery of training activities – Phase 1

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101037247

Project Acronym	SILVANUS
Grant Agreement number	101037247 (H2020-LC-GD-2020-3)
Project Full Title	Integrated Technological and Information Platform for Wildfire Management
Funding Scheme	IA – Innovation Action

DELIVERABLE INFORMATION

Deliverable Number:	D3.2
Deliverable Name:	SILVANUS Planning and delivery of training activities – Phase 1
Dissemination level:	PUBLIC
Type of Document:	R/OTH
Contractual date of delivery:	31/03/2023 (M18)
Date of submission:	31/03/2023
Deliverable Leader:	SIMAVI
Status:	Final
Version number:	0.5
WP Leader/ Task Leader:	WP3 – SIMAVI; T3.3 - SGSP
Keywords:	Training, operational scenarios, interventions, survey, tactics, strategy, firefighting, wildfire, critical infrastructure, situational awareness, AR/VR content
Abstract:	The current deliverable is the first report addressing the requirements of Task 3.3, which presents the most relevant aspects regarding the planning and delivery of training activities within SILVANUS project. The deliverable is drafted in such a way as to ensure a unitary vision of the preparation and pre-planning activities for wildfire response, from theoretical, methodological and practical perspectives, highlighting also the innovative technological approaches specific to this stage of project implementation.

Deliverable Leader:	SIMAVI
Lead Author(s):	Pawel Gromek, Bogdan Gornea, Simona Bica, Robert Dobran
Reviewers:	

Document History			
Version	Date	Contributor(s)	Description
V0.1	15.02.2023	SIMAVI	Table of contents / Initial outline
V0.1 (4)	March 2023	SIMAVI	Final Table of contents
V0.2	17.02.2023	SGSP	First contribution for Chapter 4 and Chapter 5
V0.3	20.03.2023	KEMEA	Updated contribution for Chapter 4 and Chapter 5
V0.4	22.03.2023 – 27.03.2023	SGSP, SIMAVI, ASFOR	Contributions for Executive summary, Chapter 2, Chapter 3, Chapter 4, Chapter 5, Chapter 6, Chapter 7, Chapter 8
V0.5	29.03.2023	SIMAVI	Final version

List of Contributors

Partner	Author(s)
SIMAVI	Bogdan Gornea, Simona Bica, Robert Dobran, Razvan Purcarea
SGSP	Pawel Gromek, Anna Szajewska, Anna Prędecka
KEMEA	Georgios Sakkas, Nikolaos Iliopoulos, Georgios Loizos
ASFOR	Ciprian Musca, Mircea Segarceanu
UASVG	Mario Starčević, Željko Cebin
EDP	Luisa Serra, Ricardo Lucas
ITTI	Damian Puchalski
MH State Fire Service	Grzegorz Borowiec

List of acronyms and abbreviations

EU	European Union
DoA	Description of Action
WP	Work Package
UI	User Interface
IT	Information and Technology
GIS	Geographic Information System
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
GFFFV	Ground Forest Fire Fighting Using Vehicles
DSU	Department for Emergency Situations
IGSU	General Inspectorate for Emergency Situations
AR/VR	Augmented Reality / Virtual Reality

List of beneficiaries

No	Partner Name	Short name	Country
1	UNIVERSITA TELEMATICA PEGASO	PEGASO	Italy
2	ZANASI ALESSANDRO SRL	Z&P	Italy
3	NET COMPANY -INTRASOFT SA	INTRA	Luxembourg
4	THALES	TRT	France
5	FINCONS SPA	FINC	Italy
6	ATOS IT SOLUTIONS AND SERVICES IBERIA SL	ATOS IT	Spain
6.1	ATOS SPAIN SA	ATOS SA	Spain
7	EMC INFORMATION SYSTEMS INTERNATIONAL	DELL	Ireland
8	SOFTWARE IMAGINATION & VISION SRL	SIMAVI	Romania
9	CNET CENTRE FOR NEW ENERGY TECHNOLOGIES SA	EDP	Portugal
10	ADP VALOR SERVICOS AMBIENTAIS SA	ADP	Portugal
11	TERRAPRIMA - SERVICOS AMBIENTAIS SOCIEDADE UNIPESSOAL LDA	TP	Portugal
12	3MON, s. r. o.	3MON	Slovakia
13	CATALINK LIMITED	CTL	Cyprus
14	SYNTHESIS CENTER FOR RESEARCH AND EDUCATION LIMITED	SYNC	Cyprus
15	EXPERT SYSTEM SPA	EAI	Italy
16	ITTI SP ZOO	ITTI	Poland
17	VENAKA TRELEAF GbR	VTG	Germany
18	MASSIVE DYNAMIC SWEDEN AB	MDS	Sweden
19	FONDAZIONE CENTRO EURO-MEDITERRANEOSUI CAMBIAMENTI CLIMATICI	CMCC F	Italy
20	EXUS SOFTWARE MONOPROSOPI ETAIRIA PERIORISMENIS EVTHINIS	EXUS	Greece
21	RINIGARD DOO ZA USLUGE	RINI	Croatia
22	Micro Digital d.o.o.	MD	Croatia
23	POLITECHNIKA WARSZAWSKA	WUT	Poland
24	HOEGSKOLAN I BORAS	HB	Sweden
25	GEOPONIKO PANEPISTIMION ATHINON	AUA	Greece
26	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	CERTH	Greece
27	PANEPISTIMIO THESSALIAS	UTH	Greece

No	Partner Name	Short name	Country
28	ASSOCIACAO DO INSTITUTO SUPERIOR TECNICO PARA A INVESTIGACAO E DESENVOLVIMENTO	IST	Portugal
29	VELEUCILISTE VELIKA GORICA	UASVG	Croatia
30	USTAV INFORMATIKY, SLOVENSKA AKADEMIA VIED	UISAV	Slovakia
31	POMPIERS DE L'URGENCE INTERNATIONALE	PUI	France
32	THE MAIN SCHOOL OF FIRE SERVICE	SGSP	Poland
33	ASSET – AGENZIA NAZIONALE REGIONALE STRATEGICA PER LO SVILUPPO DEL TERRITORIO	ASSET	Italy
34	LETS ITALIA SRLS	LETS	Italy
35	PARCO NATURALE REGIONALE DI TEPILORA	PNRT	Italy
36	FUNDATIA PENTRU SMURD	SMURD	Romania
37	ASFOR- ROMANIAN FORESTRY ASSOCIATION	ASFOR	Romania
38	KENTRO MELETON ASFALEIAS	KEMEA	Greece
39	ELLINIKI OMADA DIASOSIS SOMATEIO	HRT	Greece
40	ARISTOTELIO PANEPISTIMIO THESSALONIKIS	AHEPA	Greece
41	OSPEDALE ISRAELITICO	OIR	Italy
42	PERIFEREIA STEREAS ELLADAS	PSTE	Greece
43	HASICSKY ZACHRANNY SBOR MORAVSKOSLEZSKEHO KRAJE	FRB MSR	Czechia
44	HRVATSKA VATROGASNA ZAJEDNICA	HVZ	Croatia
45	TECHNICKA UNIVERZITA VO ZVOLENE	TUZVO	Slovakia
46	OBCIANSKE ZDRUZENIE PLAMEN BADIN	PLAMEN	Slovakia
47	YAYASAN AMIKOM YOGYAKARTAY	AMIKOM	Indonesia
48	COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION	CSIRO	Australia
50	FUNDACAO COORDENACAO DE PROJETOS PESQUISAS E ESTUDOS TECNOLOGICOS COPPETEC	COPPETEC	Brazil

Table of Contents

Index of Tables

1 Executive summary

The current deliverable is the first report of WP3 activities, corresponding to task *T.3.3 – Preparation and pre-planning activities for wildfire response*, dedicated to specific activities of training and preparation for wildfire response. The document presents the joint work of the SILVANUS partners regarding the planning and delivery of training activities at this stage of the project implementation. The document serves as a basis for a common vocabulary and understanding of the specific methodology, tools and execution of training activities in this stage of implementing the requirements of Task 3.3, taking into consideration the needs and requirements of the pilots.

Within the deliverable, a uniform approach is proposed to describe the specific activities for planning and preparing the wildfire response, based on surveys for collecting relevant data and information about: i) training objectives and scope, ii) training forms and methods and iii) training materials.

A particular section is dedicated within the deliverable to the innovative approaches and tools for implementing the training activities in SILVANUS, which presents the integration of AR/VR content to meet the professional training requirements of end-users. Moreover, the deliverable addresses the role of fire ignition modelling in the training of first responders and preparation of wildfire response, as specified in task *T3.2 – Forest fire ignition models*.

2 Scope of the document

2.1 Background

The specific work of Task 3.3 is found in the activities of WP3, whose main objective is to develop tools, methodologies, and technologies to promote the culture of deterrence and prevention against wildfires.
Task 3.3 captures the relevant aspects of the professional training of personnel involved in preparation and pre-planning activities for wildfire response and emphasizes the specific methodology of planning and delivery of training activities. In this context, a significant effort was put on choosing the most appropriate methods of collecting and processing information and creating an execution plan (implementation stage) that meets the pilots' requirements.
Various methods of gathering relevant data and information have been used, namely: literature analysis (paying special attention on operational procedures, research papers, good practices), focus groups, consultation with environment engineering specialists and representative of managing directors and professional staff. The actual implementation of the preparation and pre-planning activities for wildfire response is based on the methodology described in *Section 5* of the deliverable.

2.2 Scope and aim of the document

The current deliverable addresses the requirements of *T.3.3 – Preparation and pre-planning activities for wildfire response*, which presents the most relevant aspects regarding the activities of training and preparation for wildfire response specific to this stage of project implementation. The report aims to build a logical and comprehensible structure that meets the requirements of Task 3.3; this structure will be updated and enriched with new information and details of implementing the specific activities for planning and delivery of training activities in the next deliverable D3.4.
The deliverable describes the methodologic approach specific to the current stage of project implementation to fulfil the objectives of the task, namely:

- To propose a systematic methodology for the preparation and pre-planning activities to be carried out upon the ignition of forest fires
- To provide a training methodology that will include the operational knowledge of technologies developed in WP4 and WP5 for the deployment of timely interventions against the spread of wildfires
- To formalise the new protocols developed in the project with the existing practices adopted by the first responders across different geographical regions

The deliverable is drafted in such a way as to ensure a uniform vision of planning and delivery of training activities, from theoretical, methodological and practical perspectives, highlighting also the innovative technological approaches specific to this stage of project implementation. Relevant aspects regarding the fire ignition models corelated with the pre-planning and preparation activities for wildfire response are also addressed within the document.

2.3 Document structure

This document is structured in 8 major sections:

Section 1. Executive summary: Presents a brief presentation of the deliverable in the context of the project implementation.

Section 2. Scope of the document: Presents a summary regarding the background, the scope of the deliverable, its structure and relation to other tasks and deliverables.

Section 3. Context and specificity: Presents significant aspects regarding the preparation and pre-planning activities for wildfire response in the field to which SILVANUS belongs, trends, challenges and regulations, stakeholders' involvement and role of innovation.

Section 4. End-user requirements for training activities: Presents relevant aspects regarding the end-users' requirements resulting from the specific activities of Task 3.3, dedicated to defining the objectives and goal of the training in SILVANUS and determining the significant data and information for pre-planning and preparation activities for wildfire response.

Section 5. Methodological approach for training and preparation for wildfire response: Presents significant aspects about the methodology applied in this stage of implementing the planning and delivery of training activities.

Section 6. Innovative approaches for implementing the training activities (integration of AR/VR content) in SILVANUS: Presents new innovative approaches for implementing the training activities delivered to the fire fighters along with the specification of AR/VR content.

Section 7. Fire ignition models related to training and preparation for wildfire response: Presents the modelling activity corresponding to Task 3.2 correlated with the training methodology and preparation of wildfire response.

Section 8. Concluding remarks and next steps: Presents the conclusions about the current status of implementing the requirements of Task 3.3 and further steps to follow during the deployment of the project.

2.4 Relation with other deliverables

The specific work from Task 3.3 is correlated with the activities and outcomes from WP2, Task 3.4, WP4 and WP5. Task T3.2 takes some of its data from the Task T2.5. One of the goals in Task T2.5 is statistical analysis of the data gathered from a multitude of pilot sites (e.g., Slovakia, Greece).

Thus, the deliverable D3.2 presents the preliminary aspects regarding the integration of AR/VR content in the planning and delivery of training activities, which will be addressed in detail further in deliverable D3.4. The implementation of the training activities corresponding to Task 3.3 is closely related to the activity of WP4 and WP5, emphasizing the elements presented below.

Relation with WP4: Collecting information from heterogeneous sources for early-stage detection of wildfires needs to reflect requirements for data and information as crucial resources in pre-planning and preparation activities for wildfire response. Thus, the information collected should be ranged into particular phases of the response in terms of pre-planning and preparation activities and state informational support for wildfire responders due to early detection and communication of the hazard, immediate disposal of wildfire responders, comprehensive recognition of hazard situation (from ground and air), effective getting of the resources to the wildfire scene, firefighting tactics (including ensuring continuous access to water) and cooperation between entities fighting the fire. This implies data collection, aggregation and pre-processing of earth observations (T4.1), tailored weather/climate models output for forest fire threat risk assessment

(T4.2), data collection, aggregation and pre-processing of in-situ devices (T4.3), social media sensing (T4.4), UGV monitoring for wildfire behaviour (T4.5) and UAV remote sensing and identification of wildfire (T4.6).
Relation with WP5: Response coordination, based on information about the spread of wildfire, should be reflected in training assumptions which must consider the coordination in the most effective way. The training requirements depicted in *Section 4* address two important activities from WP5: (i) situational awareness on fire danger index built on the base of Big-data Analytics framework should allow to indicate areas with the highest priority for sending firefighting resources to action in a line of the resources optimization (T5.1) and (ii) results from information fusion need to be easily accessible for wildfire managers (public administration, disaster management teams, etc.) and responders (forest services, fire services, armed forces) (T5.2). Moreover, the training methodology applied in SILVANUS must reflect and consider the monitoring elements during trainings and exercises (T5.3). The same requirement is noticed in case of data toolkit for decision support system (T5.4) as all entities involved in decision making processes must be able to use the toolkit in a training program before to use it in operational conditions.

3 Context and specificity

SILVANUS is a complex and challenging project incorporating cutting-edge technologies and methodological approaches which addresses a business field with specific requirements and interdisciplinary characteristics. The environment to which it is addressed is facing challenges in terms of preparation and pre-planning activities for wildfire response, technology and innovation requirements and proposal of regulations in the field.

This section aims to capture significant aspects regarding the preparation and pre-planning activities for wildfire response in the field to which SILVANUS belongs, trends, challenges and regulations, methodologies and implementation of training programs, stakeholders' involvement and role of innovation.

3.1 Methodologies for training and operations

The current methods employed for the preparation and pre-planning activities for wildfire response are provided by the national legislation with regards to the prevention of forest fires through awareness raising and specific procedures for fire fighters' intervention which include logistics preparedness and ensuring an efficient operational intervention process in case of needed intervention. While the existing methods do provide a certain degree of proactivity regarding prevention and a rigorous procedure for intervention in case of occurrence of a wildfire, they need to be updated to include and integrate multidisciplinary technologies and knowledge towards a holistic fire management strategy that aims to dramatically improve response times in such events.

The main goal of the training is to test and validate the use of various methods, materials and novel technologies (AR/VR content) in exercises for fire-fighters who will also be trained on the usage of SILVANUS platform in identifying threat levels, deploying resources to mitigate the fire ignition and finally to create a culture of prevention against wildfires.

In the following, some procedural steps to deploy the training and test the provided technologies / tools are described:

- Acknowledge the existing early detection system
- Analyse the wildfire responders and their equipment for extinguishing forest fires and present alternatives for 'classical' wildfire responders (fire service, forest service) to be used in case of emergency
- Be aware of the resources needed in the case of fire ignition and how the technology can optimize the arrival routes to them.
- Test the use of multiple recognition tools and procedures of hazard situation, getting information from different sources, checking the information correctness, effective communication with commander, alternative recognition ways (UAVs, thermovision, GIS, visual cameras, satellite images)
- Analyse the fire fighters' tactics to locate the ground and aerial resources, to communicate with the aircraft administration system, etc.
- Analyse the cooperation between the entities fighting the fire and to present alternatives for "classical" wildfire responders (fire service, forest service) to be used in case of emergency.

3.2 Specificity of the domain / requirements

The capture of the specific elements in the field we are addressing plays a major role in creating the strategy for planning and delivery of training activities.

Significant effort is put on gathering, processing and organizing the remarkable amount of information and data, coming from theoretical, methodological, practical and operational sources. The training programs and the curricula are adapted to the specific activity of the professionals involved in the stage of preparation and pre-planning activities for wildfire response and represent crucial requirements to prepare the fire-fighters and other stakeholders for a scenario in which a fire ignition takes place.

Within the project, the partners from the Pilots will work closely to prepare the first responders for the exercise and will provide the authorizations and free access to the location. A good coordination between the structures involved in this process is expected.

3.3 Technological approach / innovative technologies, techniques and procedures/protocols

The training will focus on the integration of novel tools, techniques and smart technologies in forest fire prevention and intervention, with the aims of:

- Reducing human negligence forest fire incidence by utilizing state-of-the art technological prevention measures
- Improving response time and operational capacity of the fire-fighters
- Utilizing AR/VR technology in training exercises for fire-fighters
- Introducing the new protocols developed in the project with the existing practices adopted by the first responders across different geographical regions.

Special attention should be paid on use of the modern technologies as well as of the best educational and training solutions and methods like: presentation, talk, discussion, work with printed materials, simulation (including computer simulation), classical solving problems method, case study, table top exercises, decision training, practical exercise, field exercise, e-learning systems, etc.

3.4 Critical infrastructure and situational awareness

Critical infrastructure and situational awareness play a very important role in developing the training strategy and take into account the precise determination of relevant parameters on the field.

As the pre-planning data was gathered, consisting of information about the location of the hazard, the area of danger zone, vegetation types, forest conditions, presence of derivative threats, road conditions (communication network, accessibility of roads), physical access to the fire zone, permission for UAV flights, extinguishing points, the location of reliable fire defence lines, mobile water supply points, mass evacuation conditions, a common operational picture, the training activities could be deployed without any critical issues.

3.5 Regulations

Considering the specificity of the field in which there are components that belong to some sectors of major importance, with implications on life, health and the environment, the regulations and the application of the legislation in force play an essential role. The training strategy and continuous training programs in the field of preparation and pre-planning activities for wildfire response are part of the national legislation of each European state.

As example, at the national level in Romania it is approved and applied for the management of forest fires, the National Concept of response in case of forest fires no. 93152 / 20.08.2018.

This act specifies details on the overall mission, operational priorities, coordination and response, authorities' missions, use of DSU coordination structures, management of interventions, etc.

At the same time, for the implied operational services, at IGSU level is issued the Guide on the technique and tactics of firefighting - ISU 04 which includes a dedicated chapter - Extinguishing fires of dry vegetation and forests.

3.6 Involvement of public bodies

Public bodies having a role in protecting the forest heritage and the environment are actively involved in specific activities of preparation and pre-planning activities for wildfire response and support the implementation of modern methods and innovative technological solutions for the digitalization of the first responders' training and operational activities.

As example, in Romania, the National Directorate of Forests - Romsilva, through the forestry directorates, and the territorial inspectorates of forestry and hunting regime, the private forestry schools within their area of activity, will permanently carry out instructive-educational actions regarding the forest fires prevention measures.

These specific actions can be achieved by:

a) Raising public awareness of the destructive action of fire and the fragile nature of the forest against the fires

b) Raising the individual consciousness on the civic responsibility of each citizen for saving and preserving the forest patrimony, collaborating with the forestry bodies in the actions of prevention and extinguishing of forest fires

c) Knowing and applying by the population of the norms of protection of the forests against fires, the engagement in the preventive actions and the operative announcement of the fire's ignition and the effective participation in their extinction

d) Promoting relations with all local administrative and public bodies and other organizations in order to achieve effective measures to prevent and extinguish forest fires.

3.7 Scientific approach and literature review

New technologies and innovative methodologies are increasingly being applied in the planning and delivery of training activities, based on scientific principles and results of research in the educational field. That is why specialized literature is extremely important for the development of training programs and their implementation plans.

In this regard, a wide presentation of the literature review and training materials applied in this stage of implementing the requirements of Task 3.3 is included hereinafter, in *Section 5. Methodological approach for training and preparation for wildfire response*.

4 End-user requirements for training activities

This section presents relevant aspects regarding the end-users' requirements resulting from the specific activities of Task 3.3, dedicated to defining the objectives and goal of the training in SILVANUS and determining the essential categories of data and information for pre-planning and preparation activities for wildfire response. Significant effort has been put on collecting, processing and organizing the remarkable amount of information and data, coming from theoretical, methodological, practical and operational sources. The relevant information presented in this section is the result of applying the methodology and a rigorous execution plan described in *Section 5. Methodological approach for training and preparation for wildfire response*.

4.1 Data and information as crucial resources in pre-planning and preparation activities for wildfire response

Data and information are crucial resources in pre-planning and preparation activities. This regards all phases of these activities which may be grouped into 1) early detection and communication of the hazard;

2) immediate disposal of wildfire responders; 3) effective getting of the resources to the wildfire scene; 4) comprehensive recognition of hazard situation (from ground and air); 5) firefighting tactics; 6) cooperation between entities fighting the fire. Collecting information about these resources has been based on literature analysis (paying special attention on operational procedures, research papers, good practices), focus group meetings of SGSP team members, consultation with environment engineering specialists and consultation with the chief of GFFFV (Ground Forest Fire Fighting Using Vehicles) group from the Main Headquarters of the State Fire Service (Poland).
Consequently, relevant data sets and information required for the needs of pre-planning and preparation activities for wildfire response are listed below:

1. ***Regarding to early detection and communication of the hazard:***
    1) Access to early detection system (name of the system, its functionalities, data accessible, reliability): particle detectors (PM10, PM2.5), GSM localizers, crowd sourcing (Twitter, Facebook), temperature detectors, pyrotechnic cartridges, etc.
    2) Exact location of hazard.
    3) Number of wildfire sources/hot-spots.
    4) Area of the danger zone.
    5) Weather conditions (Wind Force and direction, insolation, Temperature and Relative Humidity Relationships, Atmospheric Stability, Lapse Rates, Large Scale Circulation, Air Masses and Fronts, General Winds, Convective Winds {Land & Sea Breezes, Whirlwinds, Slope and Valley Winds}, Thunderstorms and Clouds).
    6) Vegetation type (for example: pine, spruce, 20-year-old forest, 50-year-old forest). Adaptation of a suitable fuel model.
    7) Forest conditions (type of combustible material, litter moisture).
    8) Presence of derivative threats (for example: smoke, critical infrastructure objects, limited visibility).

2. ***Regarding to immediate disposal of wildfire responders:***
    1) Quality and quantity of wildfire responders in disposal.
    2) Quality and quantity of equipment to fight wildfire (including specialized devices, UAVs).
    3) Road conditions (communication network, accessibility of roads).
    4) Physical access to fire zone.
    5) Permission for UAVs flights.
    6) Aircraft flight ceiling.
    7) Schedule of water supply flights.
    8) Location of reliable water supply points.
    9) Accessibility of water in conditions required (amount of water, efficiency of water supply source, current conditions of the water source): lakes, rivers, hydrants etc.
    10) Location of reliable extinguishing points.
    11) Location of reliable fire defense lines.
    12) Location of mobile water supply points.
    13) Possibility of additional supply of water.

3. ***Regarding to the effective getting of the resources to the wildfire scene:***

1) Road conditions (communication network, accessibility of roads).
2) Suggested access roads.
3) Access roads for tanks.
4) Physical access to fire zone.
5) Permission for UAVs flights.
6) Aircraft flight ceiling.
7) Location of reliable water supply points.
8) Location of reliable extinguishing points.
9) Location of reliable fire defense lines.
10) Location of mobile water supply points.
11) Mass evacuation conditions (evacuation routes, traffic jams, traffic management, detours).
12) Landform.

4. ***Regarding the comprehensive recognition of hazard situation (from ground and air):***
    1) Access to field communication system (name of the system, its functionalities, data accessible, reliability): radiotelephones, satellite phones, etc.
    2) Communication structure (everyone knows when, how and to whom to communicate).
    3) Geo-localization of people in danger zone (firefighters, outsiders).
    4) Number and location of fire sources/hot spots.
    5) Current range of danger zone.
    6) First prediction of wildfire development (incl. fire front size, fire line intensity, direction, speed).
    7) Adequacy of emergency resources arrived.
    8) Information from fire warning towers (in visible light, infrared).
    9) Information from satellite services (Landsat, Copernicus, Sentinel etc.)
    10) Landform.
    11) Presence of derivative threats (for example: smoke, critical infrastructure objects, limited visibility).
    12) Results of verification of preliminary information.
    13) Firefighting action status.

5. ***Regarding to firefighting tactics:***
    1) Location and structure of fire defense lines – if existing. Location of potential defense lines to build ad-hoc.
    2) Needs related to quality and quantity of extinguishing agents.
    3) Quality and quantity of extinguishing agents accessible.
    4) Possibility to use salt water, fire retardants agents, firefighting foams (due to environment protection).
    5) Current accessibility of equipment required.
    6) Alternativeness of equipment.
    7) Terrain height differences for the needs of water supply organization.
    8) Access to international emergency mechanisms (e. g. Union Civil Protection Mechanism modules and rescEU capacities, bilateral).
    9) Access to other security entities (for example: armed forces, board guard, police).

10) Prediction of wildfire development.
11) Fire engines tracking and visualization system.
12) Firefighting aerial means tracking and visualization system.
13) Acquisition of updated meteorological data in the fire area.

6. ***Regarding to cooperation between entities fighting the fire:***
    1) Access to international emergency mechanisms (e. g. Union Civil Protection Mechanism modules and rescEU capacities, bilateral).
    2) Access to other security entities (for example: armed forces, board guard, police) and to the National Emergency Health Centre (for ambulances, Hospitals, etc).
    3) Access to field communication system (name of the system, its functionalities, data accessible, reliability): radiotelephones, satellite phones, etc.
    4) Communication structure (everyone knows when, how and to whom to communicate).
    5) Geo-localization of people in danger zone (firefighters, outsiders).
    6) Prediction of wildfire development, mainly through fire spread simulation models.
    7) Common operational picture (staff knows who is working where).
    8) Command structure – who is in charge, who is coordinating.
    9) Available radio frequencies for foreign teams.
    10) Forest fire management plans are followed.
    11) Demarcation of aircrafts water intake area and prohibition of approaching by civilians.

4.2 Training objectives and scope

Training objectives mean directions of the training realisation. Objectives should be verifiable during the training. In turns, scope means information shared and/or gained during the training regarding relevant objective. The objectives and the scope should be formulated in detail to frame specific expectations for the training.

Training objectives and scope were specified within the first survey (Survey 1) sent to all partners from Task 3.3 and discussed during the First International Scientific Seminar on Preparation and Pre-Planning Activities for Wildfire Response "Objectives and Scope of the Training" (29 June 2022). The results and findings of this particular stage of implementing Task 3.3 are presented in the following table.

Table 1. Training objectives and scope

Phases of wildfire response	Objectives* of the training	Scope** of the training
1. Early detection and communication of the hazard *Technical detection, auto-detection, detection from ground, detection from air, conformation of the detection result, providing information about hazard to responders and the*	1. To acquaint fire services with early detection system in a country they represent to be able to use it in practice and to follow detection procedures. 2. To acquaint forest services with early detection system in a country they represent to be able to use it in practice and to follow detection procedures.	1. Scheme and description of country early detection system. Specific detection procedure for fire service from ground and/or from air. 2. Scheme and description of country early detection system. Specific detection procedure for forest service from ground and/or from air.

Phases of wildfire response	Objectives* of the training	Scope** of the training
public, crisis communication, etc.	3. To acquaint UAV operators with early detection system in a country they represent to be able to support it in practice and to follow detection procedures. 4. To acquaint public administration bodies with early detection system in a country they represent to be able to use/manage it in practice and to follow detection procedures. 5. To acquaint wildfire responders with the system of transmitting information about the occurring hazard. 6. To prepare wildfire responders to effective crisis communication procedures (formal communication between the responders). 7. To prepare wildfire responders (especially decision makers) for effective risk communication procedures (formal communication with the public). 8. To familiarise wildfire responders with specification of early detection of hazard. 9. To familiarise wildfire responders with the need and solutions (technical ones and procedural ones) to confirm wildfire detection positives (due to a risk of 'false-positives'). 10. To manually exercise a use of detection tools in field conditions by wildfire responders (especially UAV operators, fire services and forest services). 11. To acquaint wildfire responders with early detection system <<Fire detect>> to be able to use it in practice and to follow detection procedures.	3. Scheme and description of country early detection system. Specific operational procedure to support the system by UAV operators from air. 4. Scheme and description of country early detection system. Specific operational procedure to use/manage the system by public administration. 5. Scheme and description of the system for communicating information on the occurring hazard. 6. Crisis communication procedures (formal communication between the responders) during wildfire (especially during first stage of the hazard development). 7. Risk communication procedures (formal communication with the public) during wildfire (especially during first stage of the hazard development). 8. Physical, chemical and biological issues determining wildfire and its detection (including weather conditions, fire scene conditions). 9. Mechanism of generating 'false-positives' in early detection systems and operational ways to verify them. 10. Manual and practical issues related to use of particular detection tools by UAV operators, fire services and forest services). 11. The video detection system <<OiB-Fire Detect/Stribor>> is covering the coastal part of Croatia.

Phases of wildfire response	Objectives* of the training	Scope** of the training
	12. To acquaint wildfire responders with the SILVANUS dashboard/UI composed of selected tools and services for early detection of wildfires. NOTE: UI training objectives can be applied also to other phases of wildfire response (i.e., phases 2-6), depending on the tools and services integrated in the SILVANUS UI.	The signal and the management of the cameras is connected to the fire-fighting alarm centers. By signal or by colour the system warns the operator on possible ignition of fires and specific detection procedure for fire-fighting operators in fire-fighting alarm centers. The education includes use of fire-propagator (system of prediction of spreading of wildland fires). The education lasts 8 hours and is fulfilled by the public company "Odašiljači i veze-transmitters and connections" and the University in Split- Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture. 12. Usage, modes and tools incorporated into the SILVANUS dashboard, capabilities for configuration and customization of views, description of UI menu and notifications, management of information provided via the dashboard. NOTE: UI training scope can be applied also to other phases of wildfire response (i.e., phases 2-6), depending on the tools and services integrated in the SILVANUS UI.
2. Immediate disposal of wildfire responders *Initiating organisation of response, disposal of services, information exchange, resource optimisation, etc.*	1. To present organizational disposal system for wildfire responders. 2. To present technical disposal system for wildfire responders and use its chosen functionalities. 3. To familiarize with information exchange between wildfire responders regarding to immediate disposal to action. 4. To present information necessary to make decision about disposal of wildfire responders to the action.	1. Organisational structure, objectives and disposal mechanisms for wildfire responders. 2. General specification and functionalities of disposal system. 3. Structure of information exchange (including reliable information sources, information from citizens and decision makers). 4. Information to be collected to make decision about disposal of wildfire responders to the action.

Phases of wildfire response	Objectives* of the training	Scope** of the training
	5. To acquaint wildfire responders with the system of optimizing the selection of rescue forces' potential. 6. To acquaint wildfire responders with the minimum equipment with vehicles, equipment and extinguishing agents for extinguishing forest fires. 7. To present alternatives for ‘classical’ wildfire responders (fire service, forest service) to be used in case of emergency. 8. To connect immediate disposal of wildfire responders with crisis communication mechanisms in public administration bodies 9. To acquaint wildfire responders with Fire management system <<Upravljanje vatrogasnim intervencijama- Fire Management System>> to be able to use it in practice and to follow alarm, surveillance, Geoinformation and recording procedures.	5. Description of the system for selecting the potential of rescue units to extinguish a forest fire. 6. Description of the selection system for equipment with vehicles, equipment and extinguishing agents for extinguishing forest fires. 7. Analysis of alternatives for ‘classical’ wildfire responders (fire service, forest service) to be used in case of emergency (e.g., when the responders may turn out inadequate or are located far away from the wildfire scene), considering UAV operators, NGOs, entrepreneurs etc. 8. Crisis communication mechanisms in public administration bodies respecting immediate disposal of wildfire responders. 9. The Fire management system <<Upravljanje vatrogasnim intervencijama- Fire Management System>>is free on disposal to all fire-fighting units in Croatia. It is a web-application connected with the GIS – system <<GISCLOUD>>. The system defines procedures for fire-fighting operators in fire-fighting alarm centers. The education includes use of alarm system, fire management system, surveillance system (vehicles and fire-fighters) and GIS system. The training lasts 8 hours for alarm and surveillance system and 16 hours for GIS-system and is fulfilled by HVZ.
3. Effective getting of the resources to the wildfire scene *Road network and its limitations, arrival routes optimisation, arrival respecting wildfire spreading, access to water*	1. To acquaint wildfire responders with the system of fire commuting. 2. To present IT solutions allowing to visualize road network for the needs of getting of the resources to the wildfire scene.	1. Description of the fire roads organization system in forest areas. Signed of access roads. 2. IT solutions allowing to visualize road network for the needs of getting of the resources to the wildfire scene (e.g., GIS).

Phases of wildfire response	Objectives* of the training	Scope** of the training
and infrastructure needed, etc.	3. To exercise practical use of mobile IT solutions allowing to visualize road network for the needs of getting of the resources to the wildfire scene. 4. To teach how to optimize arrival routes to the wildfire scene from the perspective of ground resources (e.g. fire engines). 5. To teach how to optimize arrival routes to the wildfire scene from the perspective of air resources (e.g., UAVs, firefighting planes). 6. To present how to support ground resources by air resources to effective getting to the wildfire scene. 7. To familiarize with practical opportunities to use citizens involvement (e.g., social media) to increase effectiveness of getting to the wildfire scene. 8. To acquaint wildfire responders with the system of organizing water supply for firefighting purposes in forests. 9. To acquaint wildfire responders with the forest infrastructure organization system. 10. To acquaint wildfire responders with Fire management system <<Upravljanje vatrogasnim intervencijama- Fire Management System>> to be able to use it in practice and to follow alarm, surveillance, Geoinformation and recording procedures.	3. Mobile IT solutions allowing to visualize road network for the needs of getting of the resources to the wildfire scene (e.g., GIS). 4. Use of maps (paper ones and GIS) to optimize arrival routes to the wildfire scene from the perspective of ground resources. 5. Use of maps (paper ones and GIS) to optimize arrival routes to the wildfire scene from the perspective of air resources. 6. Supporting procedures and good practices in common use of maps (paper ones and GIS). 7. Social media tools allowing identifying 'bottle necks', communication impediments and alternative arrival routes to the wildfire scene. 8. Description of the water supply organization system in forest areas. Signed of access water supply points. 9. Description of the organization of forest infrastructure related to fire protection. Requirements. Signs. The location of the infrastructure. 10. The Fire management system <<Upravljanje vatrogasnim intervencijama- Fire Management System>>is free on disposal to all fire-fighting units in Croatia. It is a web-application connected with the GIS – system <<GISCLOUD>>. The system defines procedures for fire-fighting operators in fire-fighting alarm centers. The training includes use of alarm system, fire management system, surveillance system (vehicles and fire-fighters) and GIS system. The training lasts 8 hours for alarm and surveillance

Phases of wildfire response	Objectives* of the training	Scope** of the training
		system and 16 hours for GIS-system and is fulfilled by HVZ.
4. Comprehensive recognition of hazard situation (from ground and air) *Use of multiple recognition tools and procedures, getting information from different sources, checking the information correctness, effective communication with commander, alternative recognition ways, etc.*	1. To familiarize with organization of reconnaissance system. 2. To present and exercise the reconnaissance system by ground patrols. 3. To present and exercise the reconnaissance system by aerial patrols. 4. To describe and exercise the communication system among ground patrols. 5. To describe and exercise the communication system among aerial patrols. 6. To describe and exercise integrated communication system (among ground patrols and aerial patrols). 7. To acquaint wildfire responders with supporting the reconnaissance systems by observation points. 8. To use of modern technologies for effective communication with commander during the reconnaissance. 9. To use of alternative means for effective communication with commander during the reconnaissance. 10. To familiarize with reliable ways to check the information correctness. 11. To exercise the use of technological tools for the reconnaissance.	1. Description of the reconnaissance system organization. 2. Description of the reconnaissance system by ground patrols. Practical reconnaissance by ground patrols. 3. Description of the reconnaissance system by aerial patrols. Practical reconnaissance by aerial patrols. 4. Description of the communication system among ground patrols. Use it in the field conditions. 5. Description of the communication system among aerial patrols. Use it in the field conditions. 6. Description of integrated communication system (among ground patrols and aerial patrols). Use it in the field conditions 7. Supporting mechanisms for the reconnaissance systems with the use of observation points. 8. Exercises with modern technologies for effective communication with commander during the reconnaissance in the field conditions. 9. Exercises with alternative solutions for effective communication with commander during the reconnaissance in the field conditions. 10. Ways to check the information correctness basing on cooperation with other wildfire responders and citizens. 11. Practical use of technological tools for the reconnaissance (e.g., UAVs, thermovision, GIS, visual cameras, satellite images).

Phases of wildfire response	Objectives* of the training	Scope** of the training
5. Firefighting tactics *First stage tactics formulation, division of hazard scene on oper ational areas, optimal use of resources, reflecting forest environment (chances and threats), implementation of best operational practices*	1. To acquaint with manners to locate ground resources (mainly fire engines and water support lines).	1. Manners to locate ground resources (mainly fire engines and water support lines) considering maps, transportation network and sources of water supply.
	2. To acquaint with manners to locate aerial resources (mainly AUVs).	2. Manners to locate aerial resources (mainly AUVs) considering maps, transportation network and area to analyze from air.
	3. To familiarize with the firefighting area' organization.	3. Description of the cooperation system between the fire brigade, local administration and forest service. Operational areas, optimal use of resources. Command structure. Coordination of firefighting activities.
	4. To familiarize with the operational system of aircraft extinguishing.	4. Description of the aircrafts administration system. Principles of cooperation during the firefighting operation with the use of airplanes. (Landing field - technical facilities, water supply. Communication with aircraft). Operational use of fire-fighting aircraft. Coordination of aviation activities.
	5. To acquaint with the operating system of using drones.	5. Description of the drone use system during firefighting actions.
	6. To present and exercise basic structures of hose lines for extinguishing attack to the wildfire.	6. Basic structures of hose lines for extinguishing attack to the wildfire, regarding to different (qualitatively and/or quantitatively) ground resources.
	7. To present and exercise basic structures of hose lines for extinguishing defense from the wildfire.	7. Basic structures of hose lines for extinguishing defense from the wildfire, regarding to different (qualitatively and/or quantitatively) ground resources.
	8. To familiarize with water supply tactics in different ground conditions.	8. Multiple water supply tactics in different ground conditions and different resources accessible (e.g., fire engines, water main lines, motor pumps, water tanks).
	9. Extinguishing and landing craft on forest fires: use of tactics, equipment	9. For professional fire-fighters: to get acquainted with basic wildland

Phases of wildfire response	Objectives* of the training	Scope** of the training
	and coordination with other organizations 10. Extinguishing wildland fires and transport with helicopter	suppression tactics and equipment. Fire direct and indirect attack, depending on the fire line intensity. This training lasts 30 hours and is fulfilled by HVZ. 10. For volunteer fire-fighters: to get acquainted with basic wildland suppression tactics and equipment and transport with helicopter. This training lasts 20 hours and is fulfilled by HVZ.
6. Cooperation between entities fighting the fire *Effective risk and crisis communication, optimisation of use of resources, hazard monitoring issues, alternativeness of entities, mutual-securing of entities, etc.*	1. To acquaint wildfire responders with the cooperation system of entities fighting the fire. 2. To present alternatives for 'classical' wildfire responders (fire service, forest service) to be used in case of emergency. 3. To prepare wildfire responders (especially decision makers) for effective risk communication procedures (formal communication with the public). 4. To acquaint wildfire responders with the system of transmitting information about the hazard development (e.g., cascading effect). 5. To prepare wildfire responders to effective crisis communication procedures (formal communication between the responders). 6. To show how to use technologies and equipment to optimize the use of human resources on the wildfire scene. 7. To prepare wildfire responders to conduct their activities taking into consideration safety procedures.	1. Description of the firefighting coordination system. Cooperating institutions. 2. Analysis of alternatives for 'classical' wildfire responders (fire service, forest service) to be used in case of emergency (e.g., when the responders may turn out inadequate or are located far away from the wildfire scene), considering UAV operators, NGOs, entrepreneurs etc. 3. Risk communication procedures (formal communication with the public) during wildfire (especially during first stage of the hazard development). 4. Scheme and description of the system for communicating information on the hazard development (e.g., cascading effect). 5. Crisis communication procedures (formal communication between the responders) during wildfire (especially during first stage and next stages of the hazard development). 6. Alternatives for use of human resources (e.g., firefighters, aerial patrols) considering AUVs, stationary extinguishing points, fire barriers etc. 7. OSH procedures for wildfire responders and their practical implementation during large scale field exercises.

Phases of wildfire response	Objectives* of the training	Scope** of the training
	8. To teach how to identify mutual operational needs among entities fighting the wildfire	8. Mutual operational needs among entities fighting the wildfire, paying special attention to particular kinds of the entities (fire service, forest service, aircraft pilots and UAVs operators) as well as particular phases of wildfire response (early detection and communication of the hazard, immediate disposal of wildfire responders, effective getting of the resources to the wildfire scene, comprehensive recognition of hazard situation (from ground and air), firefighting tactics, cooperation between entities fighting the fire).
	9. Air-force guidance: principles of guidance of air-forces	9. For fire-fighting commanders: education for principles and way of communication with fire-fighting air forces. This training lasts 40 hours and is fulfilled by HVZ.
	10. To learn how to cooperate with firefighters from other countries (in case of receiving international assistance through Union Civil Protection Mechanism - UCPM, in bilateral basis etc.) and provide high level of Host Nation Support (based on EU Host Nation Support Guidelines) to the incoming modules.	11. Participation in international missions, exercises (i.e., EU MODEX), exchange of experts programme (i.e., pre-positioning of firefighters programme of UCPM) and UCPM training courses in order to enhance interoperability (to speak the same language) in civil protection operations.

5 Methodological approaches for training and preparation for wildfire response

This section presents the relevant aspects concerning the specific methodology applied for planning and delivery of training activities, in the context of preparation and pre-planning activities for wildfire response.
A rigorous implementation plan has been proposed by SGSP and a specific pathway has been followed in this stage of implementing Task 3.3, comprising: i) methods for collecting and processing information, ii) training forms and methods, iii) Execution Plan, iv) training materials and v) events.

5.1 Methods for collecting and processing information

Within SILVANUS project, the planning and delivery of training activities are approached from three perspectives: i) defining the training objectives and scope; ii) determining the training forms and methods and iii) using the most appropriate training materials.
To collect the most relevant information about the above-mentioned prospects, three specific surveys (presented in *Appendix 1, Appendix 2* and *Appendix 3*) have been drafted and submitted to the partners involved in Task 3.3.
The collection process of surveys has been directly related to T3.3 proceeding and has been carried out according to ***T3.3 Execution Plan***.
The plan assumed following periods for gathering relevant information:
Stage 2. Training Guidelines for Preparation and Pre-planning Activities for Wildfire Response

a. M8-M9: collecting information from T3.3 partners about training objectives and scope (Survey 1)
b. M9: presentation of information collection results by each partner and open discussion during international open online research seminar concerning the training objectives and scope
c. M10-M12: collecting information from T3.3 partners about training forms and methods (Survey 2)
d. M12: presentation of information collection results by each partner and open discussion during international open online research seminar concerning the training forms and methods
e. M13-M15: collecting information from T3.3 partners about training materials (Survey 3)
f. M15: presentation of information collection results by each partner and open discussion during international open online research seminar concerning the training materials
g. M16-M18: preparation of the guidelines and input to D3.2 (excerpt from the guidelines)
h. M18: release of D3.2, release of the guidelines, international open online research seminar to present the guidelines.

The surveys have been sent to the T3.3 partners to fill them before organizing relevant seminars. The results collected were consulted also with internal SGSP experts before the seminars, as follows:

- Lt. Col. Anna Prędecka, PhD Eng. (SGSP) – expertise in biological conditions of forests due to wildfires and environment pollution
- Anna Szajewska, PhD Eng. (SGSP) – expertise in forest fire protection
- Maj. Marcin Łapicz, PhD (SGSP) – expertise in firefighting due to wildfire
- Lt. Col. Grzegorz Borowiec (Main Headquarters of the State Fire Service) – expertise in firefighting due to wildfire, deputy chief of Polish GFFFV module in Sweden (2018), chief of Polish GFFFV module in France (2022).

Then the results have been presented within the three seminars with different topics, organized in the following periods:

a. **First International Scientific Seminar** on Preparation and Pre-Planning Activities for Wildfire Response *Objectives and Scope of the Training*, 29 June 2022.
b. **Second International Scientific Seminar** on Preparation and Pre-Planning Activities for Wildfire Response *Training Forms and Methods. Data and information as crucial resources in pre-planning and preparation activities for wildfire response*, 29 September 2022.
c. **Third International Scientific Seminar** on Preparation and Pre-Planning Activities for Wildfire Response *Specification of wildfire response training – from particular entities to cooperation. General requirements for training materials*, 15 December 2022.

The surveys were related generally to all pilots within SILVANUS project. It means no direct relation has been to particular pilots but general relation to all of them. From the perspective of the responses, two major information sources were considered useful in the context of existing methodologies:

1. The Trial Guidance Methodology, Project Driver+, https://www.driver-project.eu/wp-content/uploads/2020/02/TGM-handbook-FINAL.pdf.
2. Gromek, P. (2021), "Strategic training and exercises for critical infrastructure protection and resilience: A transition from lessons learned to effective curricula", International Journal of Disaster Risk Reduction, 65, p. 102647.

However, in this stage of implementing Task 3.3 are still generally described and need to be adjusted to specifics of the pilots when drafting the deliverable D3.4. In accordance to Task 3.3 we assumed to update the methodology during the second stage of the task realisation, in parallel with the pilots evaluation.

The seminars have been dedicated especially to the T3.3 partners and SILVANUS external stakeholders. However, SGSP made them open to public, giving the opportunity to everyone to participate. They were free of charge and stated platform to present the results and discussed them in a large assembly. After the seminars, the results were evaluated into a report and uploaded to SILVANUS file box in Ms Teams (Microsoft Teams) platform. The evaluation relied on summarizing the results with respect to the seminars' discussions. As the objectives and requirements were formulated in a final form directly in the surveys, there was no special need to extract them.

5.2 Training forms and methods

The forms and methods should be formulated in detail to frame specific expectations for the training. They should closely correspond to the training objectives as well.

Training forms and methods were specified within the second survey (Survey 2) sent to all partners from Task 3.3 and discussed during the Second International Scientific Seminar on Preparation and Pre-Planning Activities for Wildfire Response "Training Forms and Methods" (29 September 2022). The results and findings of this particular stage of implementing Task 3.3 are presented in the following table.

Table 2. Training forms and methods

Phases of wildfire response	Training form and/or method	Objective of the form and/or method use
1. Early detection and communication of the hazard *Technical detection, auto-detection, detection from ground, detection from air, conformation of the detection result, providing information about hazard to responders and the public, crisis communication, etc.*	1. Lecture. 2. Presentation. 3. Talk. 4. Work with materials printed. 5. Simulation (including computer simulation). 6. E-learning system. 7. Manual training of use of early detection systems (e.g., 'Fire detect' and 'Fire propagator Stribor' – 5 days long training). 8. On-site observation.	1. To increase knowledge on the physical landscape (orography, vegetation, biodiversity, human occupation). 2. To present local early detection systems and their basic functionalities. 3. To provide operational guidelines on how to address media, citizens, firefighters, municipalities, authorities, etc. 4. To get acquainted with the systems. 5. To present functionalities of national early detection systems in practice and practical handling with the system. 6. To acquaint with the system of transmitting information about the hazard to responders, public (including crisis communication).
2. Immediate disposal of wildfire responders *Initiating organisation of response, disposal of services, information exchange, resource optimisation, etc.*	1. Presentation. 2. Talk. 3. Discussion. 4. Work with materials printed. 5. Simulation (including computer simulation). 6. Classical problem method. 7. Case study. 8. Table top exercises. 9. Decision training. 10. Practical exercise. 11. E-learning system.	1. To provide the fastest and the most efficient deployment of firefighting, namely by identifying safe routes, water reservoirs, fire shelters, etc. 2. To present functionalities of national alarm, surveillance (tracking) and GIS system and practical handling with the system. 3. To use of system on its own. 4. To present the system of disposing of rescuers. 5. To acquaint with the local system of cooperation between forest managers and fire services during forest fires. 6. To present of new technological solutions enabling the most effective disposal of rescuers to a fire (as well tracking rescuers, GIS).
3. Effective getting of the resources to the wildfire scene *Road neatwork and its limitations, arrival routes optimisation, arrival respecting wildfire spreading, access to water*	1. Lecture. 2. Presentation. 3. Talk. 4. Discussion. 5. Simulation (including computer simulation). 6. Classical problem method.	1. To increase knowledge on road networks and access to danger zone. 2. To increase knowledge on access to water sources. 3. To increase knowledge on human occupation.

Phases of wildfire response	Training form and/or method	Objective of the form and/or method use
and infrastructure needed, etc.	7. Case study. 8. Table top exercises. 9. E-learning system. 10. Use of 'Fire propagator' – the fire management system unites the activities regarding disposal of firefighting resources, road network, access to water, infrastructure and wildfire-spreading.	4. To develop methodologies that enable biodiversity and wildlife protection. 5. To present functionalities of national alarm, surveillance (tracking) and GIS system and practical handling with the system. 6. To acquaint with new technologies enabling efficient and fast. 7. To acquire knowledge about forest infrastructure, access to water, communication between rescuers.
4. Comprehensive recognition of hazard situation (from ground and air) *Use of multiple recognition tools and procedures, getting information from different sources, checking the information correctness, effective communication with commander, alternative recognition ways, etc.*	1. Lecture. 2. Presentation. 3. Talk. 4. Discussion. 5. Simulation (including computer simulation). 6. Classical problem method. 7. Case study. 8. Wild fire history study. 9. Practical exercises. 10. Field exercises. 11. E-learning system.	1. To increase knowledge and proficiency on tools and procedures. 2. To present modern technological solutions (hardware, software, satellite techniques) for ground and air reconnaissance. 3. To check organisational procedures in practice.
5. Firefighting tactics *First stage tactics formulation, division of hazard scene on operational areas, optimal use of resources, reflecting forest environment (chances and threats), implementation of best operational practices*	1. Lecture. 2. Presentation. 3. Talk. 4. Discussion. 5. Debriefing. 6. Classical problem method. 7. Case study. 8. Table top exercises. 9. Decision training. 10. Practical exercises. 11. Field exercises. 12. E-learning system. 13. Education for << Extinguishing and landing (assault) on forest fires >>, 3.5 day education and training for professional fire-fighters (30 hours), 2.5 day education for volunteer fire-fighters (20 hours).	1. To increase knowledge on first stage tactics formulation, division of hazard scene on operational areas, optimal use of resources, reflecting forest environment. 2. To get acquainted with wildland suppression tactics and equipment. 3. To present and practical use of wildland firefighting equipment. 4. To desant (landing) with helicopter. 5. Compliance with health and safety rules in the field.
6. Cooperation between entities fighting the fire *Effective risk and crisis communication,*	1. Presentation. 2. Debriefing. 3. Talk. 4. Discussion. 5. Classical problem method.	1. Promote acquaintance with the firefighting procedures. 2. To promote communication and co-joint operational effectiveness.

Phases of wildfire response	Training form and/or method	Objective of the form and/or method use
optimisation of use of resources, hazard monitoring issues, alternativeness of entities, mutual-securing of entities, etc.	6. Case study. 7. Brainstorming. 8. Didactic games. 9. Table top exercises. 10. Decision training. 11. Practical exercises. 12. Field exercises. 13. E-learning system. 14. Education for << Air-force guidance >> (4 day education and training for leaders of fire-fighting intervention).	3. To get acquainted with wildland suppression tactics and guidance of aircrafts. 4. To present wildland fire-fighting tactics with air forces (Canadair, air tractor and helicopter). 5. To organise practical exercise with aerial means. 6. To organise practical exercise on training ground with aerial means (airplanes, UAV). 7. Participation in the UCPM training Programme, EU MODEX exercises, Exchange of experts Programme

5.3 Training materials

The training should reflect specification (scope, technologies, stakeholders involved, detail issues etc.) of case studies described in SILVANUS Grant Agreement. It should also be open for entire spectrum of multiple training materials (i.a.): books, handbooks, monographs, papers, articles, prevention programs, operational procedures, cooperation standards, operational manuals (including these dedicated for use of special equipment), multimedia, presentations, leaflets, etc. The materials should be formulated in detail to frame specific expectations for the training.

Valuable training materials were specified within the third survey (Survey 3) sent to all partners from Task 3.3 and discussed during the Third International Scientific Seminar on Preparation and Pre-Planning Activities for Wildfire Response "Training Materials" (15 December 2022).

The results and findings of this particular stage of implementing Task 3.3 are presented in the following table.

Table 3. Training materials

Phases of wildfire response	Training materials
1. Early detection and communication of the hazard *Technical detection, auto-detection, detection from ground, detection from air, conformation of the detection result, providing information about hazard to responders and the*	1. Slavkovikj, V., Verstockt, S., Van Hoecke, S., Van de Walle, R. (2014) 'Review of wildfire detection using social media', Fire Safety Journal, 68, pp. 109-118, https://doi.org/10.1016/j.firesaf.2014.05.021: a. Categorization of wildfire risk management systems (to indicate the wide context). b. Current status of social media in wildfire risk management (to present general operational potential). c. Disaster management methods using social media information (examples of use). d. Crowdsourcing applications.

public, crisis communication, etc.	e. Social media disaster management systems (a system for Social Media Alert and Response to Threats to Citizens, Tweeter, Global Disaster Alert and Coordination System GDACS). f. Social media data management – the sensing process (central coordination unit is required). g. Wildfire social sensor platform (IT solutions). 2. Jazebi, S., de León, F., Nelson, A. (2020) 'Review of Wildfire Management Techniques – Part I: Causes, Prevention, Detection, Suppression, and Data Analytics', IEEE Transactions on Power Delivery, 35(1), pp. 430-439, doi: https://ieeexplore.ieee.org/document/8768218: a. Main beneficiaries (wildfire prevention): power system engineers, electrical engineering academicians and suppliers of electrical apparatus. b. Following issues important from early detection point of view: prediction and prevention means, detection methods, monitoring and surveillance techniques, suppression methods, allocation and mapping algorithms. c. Damages and negative effects that a wildfire can cause to critical infrastructure. d. It is valuable to present multiple wildfires causes scenarios. 3. Bushnaq, O. M., Chaaban, A., Al-Naffouri, T. Y. (2021) 'The Role of UAV-IoT Networks in Future Wildfire Detection', IEEE Internet of Things Journal, 8 (23) , p. 16984-16999, doi: https://ieeexplore.ieee.org/document/9424181: a. Presentation of multiple ways to detect wildfire (satellite imaging, remote camera-based sensing, unmanned aerial vehicles assisted Internet of Things (UAV-IoT) networks). b. Awareness about detection alternatives is crucial from operational viewpoint (in terms of detection continuity as some detectors may be damaged or out of order). c. Limited system cost budgets determines final solutions implemented. d. Technical issues during the training need to be adjusted to cognitive potential of trainees and practical training objectives. 4. Boulton, C. A., Shotton, H., Williams, H. T. P. (2016) 'Using Social Media to Detect and Locate Wildfires', AAAI Publications, Tenth International AAAI Conference on Web and Social Media, https://ojs.aaai.org/index.php/ICWSM/article/view/14850: a. Following social media investigated: Instagram, Twitter, MODIS, FPA. b. The more social media sources the more possibilities to detect the hazard. c. Social media give quicker hazard detection that classical warning calls to public services. d. New media means new detection possibilities – how to keep up?

	5. Bouguettaya, A., Zarzour, H., Taberkit, A. M., Kechida, A. (2022) 'A review on early wildfire detection from unmanned aerial vehicles using deep learning-based computer vision algorithms", Signal Processing, 190, p. 108309, https://doi.org/10.1016/j.sigpro.2021.108309: a. UAV technology and deep learning-based computer vision algorithms are connected for early wildfire detection. b. UAV technology and deep learning-based computer vision algorithms connection requires a comprehensive system (data acquisition system, data processing, data transmission/receiving system, data processing on ground and concerned authorities). c. UAVs from forest services, fire services and private owners. d. Unification of operational standards or elaboration of common standards are required. 6. OIV Fire Detect AI (Intelligent system for early fire detection) https://hvz.gov.hr/UserDocsImages/EU%20projekti/OIV%20Fire%20Detect%20AI.pdf: a. Technological connection of video solutions, cloud computing and visualization tools. b. National level of implementation. c. Involvement of international entities (for example European Civil Protection Mechanism units, firefighting units) requires to ensure access for these entities. 7. Barmpoutis, P., Papaioannou, P., Dimitropoulos, K., Grammalidis, N. A, (2020) 'Review on Early Forest Fire Detection Systems Using Optical Remote Sensing', Sensors, 20, p. 6442, https://doi.org/10.3390/s20226442: a. Optical Remote Sensing technologies in early detection of wildfire (flame and smoke detection). b. Terrestrial, airborne and satellite-based systems are worth to be enumerated. c. Awareness of strengths and weaknesses is crucial to use concrete solutions in practice. d. Sensors: visible, infrared, multispectral. e. Methods: machine learning, deep learning. f. Training should regard solutions used by trainees. g. Visualisation of the technology approach may be important to understand it. 8. San-Miguel-Ayanz, J. et al., 'Comprehensive Monitoring of Wildfires in Europe: The European Forest Fire Information System (EFFIS), https://ec.europa.eu/environment/forests/pdf/InTech.pdf: a. Monitoring may serve for early detection purposes due to wildfire risk calculation. b. Comprehensive risk-based monitoring requires comprehensive approach to collect information (forest fire events, fire detection, burnt area maps, land

	cover damage assessment, emission assessment, potential soil erosion estimates, vegetation regeneration, danger forecast). c. The information must be at acceptable level of quality. d. The more countries involved the more comprehensive information may be collected. e. International level of the solutions is required. 9. Dampage, U., Bandaranayake, L., Wanasinghe, R. et al. (2022) 'Forest fire detection system using wireless sensor networks and machine learning', Scientific Reports, 12(46), https://doi.org/10.1038/s41598-021-03882-9: a. Wireless sensor networks and machine learning as directions for development of wildfire detection. b. Awareness about different (alternative) communication channels and communication tools is worth to be considered. c. Wireless sensor networks require to ensure effective long-distance communication tools. d. Field testing allows to check the solutions in practice and facilitate end-users to know new technological solutions. e. Machine learning support decision making processes but does not take responsibility for safety and security from end-users. 10. Alkhatib, A. A. A. (2014) 'A Review on Forest Fire Detection Techniques', International Journal of Distributed Sensor Networks, 10(3), https://doi.org/10.1155/2014/597368: a. Field trainings with detection tools may serve to examine them in operational conditions (it is important for technology providers with potentially positive influence on sharing relevant tools for the examination purposes). b. Multiple techniques are worth to be highlighted: – fire weather forecasts and estimates of fuel and moisture, – watch towers, – optical smoke detection, – lightning detectors which detect the coordinates of the strike, – infrared cameras/detectors, – spotter planes, – mobile/smart phone calls becoming increasingly common for detecting fires early, – education of house owners and tourists, – satellite systems, – digital cameras, – spectrometers. c. The techniques need to be chosen respecting training objectives and operational needs

	11. Wildland Fire Incident Management Field Guide. 2013. National Wildfire Coordinating Group, https://www.nifc.gov/nicc/logistics/references/Wildland%20Fire%20Incident%20Management%20Field%20Guide.pdf: a. Early detection and communication are derivatives of wildland fire safety culture (awareness about the culture determinants may simplify increasing the detection and communication effectiveness and is to be designed during training processes). b. Access to media is crucial to early warning and mass communication of the hazard. c. Early warning and communication (scope of information collected to warn and to communicate the hazard) should be considered in order to preliminary tactics and initial attack planning. 12. Guide to Wildland Fire Origin and Cause Determination. 2016. National Wildfire Coordinating Group, https://www.nwcg.gov/sites/default/files/publications/pms412.pdf: a. Investigation of post-fire scene as a potential condition for warning about additional fire sources and a cascading effect of the hazard development. b. Elaboration of on-side (field) ad hoc warning signals (warning flares, radio correspondence announcements, gesture messages, morse code) and procedures may increase firefighters' safety as well as may state the warning processes to match the hazard dynamism.
2. Immediate disposal of wildfire responders *Initiating organisation of response, disposal of services, information exchange, resource optimisation, etc.*	1. National Wildfire Coordinating Group (NWCG). 1993. S-290: Intermediate wildland fire behavior. NFES 2378. National Interagency Fire Center. Boise, Idaho, https://training.nwcg.gov/dl/s290/s-290-student-workbook-all.pdf: a. Disposal of particular equipment must reflect weather and topography. b. Disposal destination (the danger zone or near-danger zone) must consider hazard development (including heat radiation, smoke, cascading effect) and natural defence lines (roads, rivers, mountains, intersecting drainage, slope etc.). c. In case of huge wildfires, marking a place for concentration of the resources is a good operational practice. d. An ability of calculation of fire zone is valuable at this stage of wildfire response. 2. National Wildfire Coordinating Group (NWCG). 2006. Fireline handbook, appendix B, fire behavior. NFES 2165. National Interagency Fire Center. Boise, Idaho, https://www.nwcg.gov/sites/default/files/products/appendixB.pdf: a. Dispatcher should correctly interpret information about fire behaviour. b. An ability of calculation of safety zone is valuable at this stage of wildfire response.

	c. Preparation of worksheets may facilitate estimation of resources amount and localization of the destination point (points, area) at this early stage of the response. 3. State plan for engagement of firefighting forces (only in Croatian) https://hvz.gov.hr/UserDocsImages/dokumenti/Program%20aktivnosti/Dr%C5%BCavni%20plan%20anga%C5%BEiranja%202022%20i%20O%20Plan.zip: a. Considering of different wildfire locations allows for preparation on effective and immediate disposal of wildfire responders. b. Crisis communication procedures should reflect operational communication procedures of wildfire responders (including radio code names, radio technical specification, etc.). c. Dispatcher must be familiar with wildfire response structures (entities' organizational structures and a general structure of the response). d. Immediate disposal of wildfire responders should base of specified information expressing following issues: what?, who?, where?, how?, how many/how much?, why?, what for?. 4. Wollstein, K., O'Connor, C., Gear, J., Hoagland, R. (2022) 'Minimize the bad days: Wildland fire response and suppression success', Rangelands, 44(3), pp. 187-193, https://doi.org/10.1016/j.rala.2021.12.006: a. Immediate disposal of wildfire responders should reflect a preliminary tactics on the first attack on the hazard (basically this ought to be considered in operational procedures). b. Dispatcher should be familiar with local public-private partnerships determining overall wildfire response potential (for example plane owners, helicopter owners, off-road vehicles owners, UAV pilots). c. Knowledge about landownerships is necessary to optimize response on the wildfire affecting both public and private forests (information about the danger zone, direct access to the danger zone, cooperation with forest owners and their forest services). 5. Martell, D. L. (2015) 'A Review of Recent Forest and Wildland Fire Management Decision Support Systems Research', Current Forestry Reports, 1, pp. 128–137, https://doi.org/10.1007/s40725-015-0011-y: a. Decission support systems may be used for automatic or semi-automatic (with human operation) disposal of wildfires resources on the action scene. b. Decission support systems may optimize a demand of the response resources due to operational procedures. c. Immediate disposal should serve for the initial attack on the fire in a timely and cost-effective manner. d. The disposal must ascribe into strategic crisis (disaster) management priorities as wildfire requires often not only extinguishing actions but also organization

	of evacuation, preparation of infrastructure (including protection of critical infrastructure and ensuring its operability in wildfire conditions). e. Use of decision support systems requires awareness of their functional and technical issues in the scope reasonable from user point of view. 6. Calkin, D. E., Cohen, J. D., Finney, M. A., Thompson, M. P. (2013) 'How risk management can prevent future wildfire disasters in the wildland-urban interface, PNAS, 111(2), pp. 746-751, https://doi.org/10.1073/pnas.1315088111: a. Immediate disposal of wildfire responders should reflect a specification of area in danger (wildland, urban, wildland-urban). b. The disposal should respect previous operational experiences to optimize the use of wildfire response resources. c. Wildfire responders need to be directed to areas of the optimized wildfire risk - this means a necessity to balance between the fire risk (to fight the fire in areas where it is the most serious challenge), operational risk (to ensure the response continuity) and work risk of the responders (to save life and health of the responders). 7. Wildland Fire Incident Management Field Guide, https://www.nifc.gov/nicc/logistics/references/Wildland%20Fire%20Incident%20Management%20Field%20Guide.pdf: a. The responders designed for concrete hazard zone must be equipped matching personal safety requirements. b. Immediate disposal of wildfire responders should also be connected to initiation of emergency (disaster, crisis) management team when huge wildfire occurs. c. There should be a wildfire organizational point collecting information about disposal of all multiple wildfire responders (from different services and other entities).
3. Effective getting of the resources to the wildfire scene *Road network and its limitations, arrival routes optimisation, arrival respecting wildfire spreading, access to water and infrastructure needed, etc.*	1. Gkotsis, I., Petsioti, P., Eftychidis, G., Terzi, M., Kolios, P. (2021) 'Multiple Drone Platform for Emergency Response Missions' In: Akhgar, B., Kavallieros, D., Sdongos, E. (eds) Technology Development for Security Practitioners. Security Informatics and Law Enforcement. Springer, Cham. https://doi.org/10.1007/978-3-030-69460-9_29: a. Information about location of resources getting to the wildfire scene must be accessible at the level of command-and-control unit. b. Transportation means should ensure conditions for safe transport of specialised equipment. c. Arrival roads should be dealt with as potential evacuation roads for wildfire responders in case of emergency (for example when unexpected development of the fire occurs increasing risk for the responders to an unacceptable level).

	d. There is a need to optimize arrival roads when they are simultaneously evacuation roads for citizens. 2. State plan for engagement of firefighting forces (only in Croatian) https://hvz.gov.hr/UserDocsImages/dokumenti/Program%20aktivnosti/Dr%C5%BCavni%20plan%20anga%C5%BEiranja%202022%20i%20O%20Plan.zip: a. Considering of different wildfire locations allows for preparation on effective and immediate arrival roads. b. Crisis communication processes may serve for the needs of the arrival optimization (including multi-direction communication between different entities indicating desirable and undesirable directions and roads). c. Effective getting of the resources to the wildfire scene should base of specified information expressing following issues: what?, who?, where?, how?, how many/how much?, why?, what for?. 3. NSW RFS Fire Trail Standards, https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0009/69552/Fire-Trail-Standards-V1.1.pdf: a. There is a need to be familiar with fire trail standards (for example width, carrying capacity, turnarounds) to be able to choose proper ways in the forest to get effectively to the destination in the context of firefighting trucks and equipment conditions (size, transport means and manners, weight, etc.). b. Fire trail should be properly marked and the marks must be known to wildfire responders. c. Access to maps is crucial to analyse a network of fire trails in forest. d. Fire trails in forest may play a role of quasi-natural defence lines with influence on arrival and evacuation destinations and routes. e. Fire trucks have to be technologically adequate to forest conditions to be able to get to the destination point. 4. NSW Rural Fire Service Fire Trail Design, Construction and Maintenance Manual, https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0009/97569/Fire-Trail-Design-Construction-and-Maintenance-Manual-FINAL_reducedsize.pdf: a. Trails are often related to drainage. Knowledge about this kind of connection may be useful in planning of defence lines in the forest with influence on arrival routes and directions. b. Driver should be aware of different ways to construct a trail to be prepared for use it during arrival to the fire scene. c. Driver should be aware of a corridor width, a formation width, a longitudinal drainage and a carriageway width as basic trail parameters crucial for effective getting to the fire scene.

	5. Holuša, J., Koreň, M., Berčák, R., Resnerová, K., Trombik, J., Vaněk, J., Szczygieł, R., Chromek, I. (2021) 'A simple model indicates that there are sufficient water supply points for fighting forest fires in the Czech Republic', International Journal of Wildland Fire, 30, pp. 428-439, https://doi.org/10.1071/WF20103: a. Driver and commander should know location of water supply points. The points may be potential stops on the arrival roads to be used when necessary. b. Location of water supply points should be taken into consideration when planning arrival roads and entire transport network for the needs of wildfire response. c. Access to maps is crucial to analyze location of water supply points and to make operational analysis with their use. d. Geospatial information systems are useful in marking arrival roads regarding to water supply points and in general. e. Fire trucks must be prepared for use of water supply points, when necessary, also during arrival to the fire scene. 6. Stergiadou, A. (2014) 'Prevention and suppression of forest-fires by using the road network and water tanks', Fresenius Environmental Bulletin, 23(11), pp. 2755-2761: https://www.researchgate.net/publication/279321072_Prevention_and_suppression_of_forest-fires_by_using_the_road_network_and_water_tanks: a. Fire trucks must be prepared for use of different water supply points, when necessary, also during arrival to the fire scene (for example rainwater tanks, water ponds, fire hydrants, forest rivers, water basins). b. Road network is often matched to places of water supply. This consequently may be used for optimization of the arrival roads. c. Access to maps is crucial to analyse location of water supply points and to make operational analysis with their use. d. Geospatial information systems are useful in marking arrival roads regarding to water supply points and in general. e. Practical knowledge about water supply sources is necessary to effectively use them during arrival to the wildfire scene. f. Proper traffic management may lower traffic density on the arrival roads.
4. Comprehensive recognition of hazard situation (from ground and air) *Use of multiple recognition tools and procedures, getting information from different sources, checking the information*	1. National Wildfire Coordinating Group (NWCG). 1981. S-390: Fire behavior. National Interagency Fire Center. Boise, Idaho, https://training.nwcg.gov/dl/s290/s-290-student-workbook-all.pdf: a. Wildfire behaviour "(…) is shaped by its physical environment. Fire spread rates, fire intensity, and other characteristics of fire behaviour respond to the unique and ever-changing combination of the fire environmental components". The components are weather, topography and fuels. b. The components are ever-changing so the recognition must be ongoing and repeated. c. Recognition respecting fire environmental components should consider topographic, fuels, basic weather processes, temperature and humidity

correctness, effective communication with commander, alternative recognition ways, etc.	relationships, atmospheric stability, wind systems and ways to observe the weather. d. Wildfire responders should keep in mind conditions of extreme wildfire behaviour to be prepared on their identification and evaluation of firefighting tactics. e. Comprehensive recognition of hazard situation is to preliminarily point out danger zone and safety zone. 2. National Wildfire Coordinating Group (NWCG). 2004. Fireline handbook. NFES 0065. National Interagency Fire Center. Boise, Idaho, https://www.nwcg.gov/sites/default/files/products/appendixB.pdf: a. Preparation to comprehensive recognition of hazard situation should regard previous experiences and case studies to operationalize theoretical issues by showing their practical dimension. b. Knowledge about c. Tables are effective sources of information ready-to-use when recognizing the hazard situation (for example 'wildfire area estimations for point source fires as a function of wind speed'). d. Charts are also valuable in the recognition processes (for example 'relation between flame height and a diameter at breast height'). e. There is a need to adjust fire behaviour theory to operational needs of wildfire responders (as not everything is crucial from operational viewpoint). 3. Materials (manuals) of Air Forces of the Ministry of Defence (MoD). a. Some issues valuable for comprehensive recognition of hazard situation (from ground and air) are described in materials of wildfire response entities. They may be ready-to-use manuals to be adjusted to particular kind of situation. b. Use of the materials requires to check whether they are classified and it is forbidden to share them among different stakeholders. 4. Kinaneva, D., Hristov, G., Raychev, J., Zahariev, P. (2019) 'Early Forest Fire Detection Using Drones and Artificial Intelligence, 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), pp. 1060-1065, https://ieeexplore.ieee.org/document/8756696: a. Comprehensive recognition means the recognition from all possible ways. In case of wildfire this may be done from the ground and from the air. b. UAV technologies state modern directions of development for the recognition means and manners. c. "The UAVs also utilize the benefits from Artificial Intelligence (AI) and are equipped with on-board processing capabilities". d. Different scenarios are required to evaluate UAV use in wildfire circumstances. e. Effectiveness of UAV use for the recognition purposes depends on operator and receiver of information collected (for example fire service commander).

	5. Viegas, C., Chehreh, B., Andrade, J. et al. (2022) 'Tethered UAV with Combined Multi-rotor and Water Jet Propulsion for Forest Fire Fighting', Journal of Intelligent Robotic Systems, 104, p. 21, https://doi.org/10.1007/s10846-021-01532-w: a. In general, the recognition with the use of UAV may serve for terrain mapping, vegetation mapping, fire detection and monitoring, gathering data for a human decisionmaker, assisting search and rescue operations and burnt area mapping. b. In particular, UAV may be used for firefighting purposes during the first stage of the wildfire development, also simultaneously to the recognition.
5. Firefighting tactics *First stage tactics formulation, division of hazard scene on operational areas, optimal use of resources, reflecting forest environment (chances and threats), implementation of best operational practices*	1. Firefighter's Handbook On Wildland Firefighting Strategy, Tactics and Safety, 4th Edition. ISBN: 978-0-87939-676-3, https://www.ifsta.org/shop/firefighters-handbook-wildland-firefighting-strategy-tactics-and-safety-4th-edition/36712: a. The main idea is to 1) recognize situation, 2) adjust available possibilities to the situation, 3) be prepared for situational changes. b. Firefighting line is understood as an integral element of the action. It is comprised in firefighters, equipment and operational possibilities. c. Firefighter safety is a crucial issue to be taken into consideration when planning firefighting tactics (place of operation, personal protection equipment, operational procedures). d. Effectiveness of firefighting tactics is in effectiveness of firefighters who plan an initial attack, construct firefighting lines, prepare defence lines, use water supply points, make incident command system, etc. e. The tactics must reflect fire behaviour and risk of cascading effect materialisation. f. Close cooperation of on-ground teams with air resources is very important from the perspectives of the action effectiveness and safety. 2. Wildland Fire Suppression Tactics Reference Guide 1996. National Wildfire Coordinating Group. Standard Firefighting Orders. https://www.nwcg.gov/publications/pms110-18: a. Graphical visualisation makes easier to understand standards firefighting orders. b. Graphical visualisation makes easier to understand watch out situations. c. Logical connection of the tactics descriptions is important to remember them by responders (step-by-step formula is reliable when possible. d. The tactics must concern both operational issues (how to put out the fire?) and personal safety issues (what to do and what not to do to go back home in a one non-baked piece?). 3. Szabo, N., Vatrogasna taktika. - Zagreb: IPROZ, 2001. (Book in Croatian):

	a. Good practices and experiences from countries relatively often affected by wildfires may be reference to elaborate firefighting tactics in another countries. b. It is worth to analyse tactics from many countries to find out common issues, operations, tasks, aspects, etc. and to highlight them during trainings to increase chances for better understanding and cooperation in the future. c. International trainings may state platform for building cooperation potential and skills in tactics formulation. 4. Control Measure. Consider appropriate wildfire suppression tactics and develop and implement a tactical plan, https://www.ukfrs.com/guidance/search/consider-appropriate-wildfire-suppression-tactics-and-develop-and-implement: a. Tactics should concern a direct attack (a flank attack, a head attack, a tail attack), an indirect attack, an aerial attack and a combination of some, or all, of the above. b. There is a need to understand a common language describing wildfire scene (a head, a spot fire, a finger, a right flank, a tail, a left flank, an island, a pocket). c. The tactics is a derivative of current and predicted fire behaviour and fire spread, scene of operations and terrain, reduced visibility and resources available. d. List of reference tactics for different wildfire conditions is useful from practical viewpoint. 5. Strategy and Tactics, https://www.ifsta.org/sites/default/files/GC_Ch_4.pdf: a. There is a need to understand a common language describing wildfire scene (a head, a spot fire, a finger, a right flank, a tail, a left flank, an island, a pocket). b. The tactics may be presented in an incident action plan. c. Strategies for direct attack and indirect attack should be visualised. d. Anchor point is "(…) a barrier to -fire spread where the control action begins" and "Starting fireline construction from an anchor point is critical to firefighter safety". This is why anchor points are elements of the tactics. e. Line construction with mechanized equipment is reliable (when possible due to situational conditions). 6. Types and Strategies of Forest Fire Fighting, https://www.waldwissen.net/en/forestry/forest-protection/forest-fires/strategies-of-forest-fire-fighting: a. Strategies for firefighting should be focused on "(…) prevention of damage to people, property and assets. In addition, it significantly contributes to environmental protection. Fundamentally, the protection and safety of the operational fire fighting force is of prime importance. Necessary firefighting measures, which could put the rescue personnel in danger, should be limited as much as possible".

	b. Operational headquarters (a stationary one or a mobile one) is a good organizational practice to effectively coordinate wildfire response. c. Firefighting tactics should include ongoing reconnaissance related to protection of people, protection of animals, protection of structures (buildings, streets, utility lines, etc.) and protection of endangered or fast burning vegetation. d. Special attention should be paid on ammunition contaminated lands when wildfire occurs. This often requires close cooperation to armed forces and crisis management entities.
6. Cooperation between entities fighting the fire *Effective risk and crisis communication, optimisation of use of resources, hazard monitoring issues, alternativeness of entities, mutual-securing of entities, etc.*	1. ISO 22300:2021 Security and resilience – Vocabulary, https://www.iso.org/standard/77008.html: a. There is a need to be familiar with common vocabulary concerning security and resilience when talking about cooperation between entities fighting the wildfire. b. Organisational standards may be references in shaping a common language for the needs of multi-entity cooperation. c. A special attention should be paid on ISO223… family of the standards as they seem to penetrate many organizational issues of security (also security in wildfire conditions, including continuity management regardless of wildfire – see ISO 22301). 2. Multilingual handbook for fire terms across European borders during forest fire fighting. https://ctif.org/library/multilingual-handbook-fire-terms-across-european-borders-during-forest-fire-fighting: a. Common organizational and operational language is crucial from the perspective of cooperation. b. Visualization of common language terms is needed. c. Multilingual materials state a kind of bridge to common understanding of firefighting entities from different countries. d. Cross-border cooperation and international emergency mechanisms (for example UCPM) are basic platforms for elaborate the cooperation standards and to increase the cooperation potential. e. The cooperation should concern common references for reconaisence and tactics. f. Cooperation between entities fighting the fire must base on understanding of mutual operational potential (including equipment) and expectations. 3. European glossary for wildfires and forest fires. https://ctif.org/library/european-glossary-wildfires-and-forest-fires: a. Creating proper conditions for cooperation between entities fighting the fire should respect terminology on wildfire environment, suppression operations as well as preparation, prevention ad recovery. b. International projects may serve for the needs of the cooperation design before wildfire occurs.

	c. Wildfire cooperators should be familiar at least with terminology used in a region where they operate (for example in Europe). 4. Euro Fire Multi Lingual Training Tool for Forest Fires, Wild Fires and Vegetation Fires. https://ctif.org/training-and-tools/euro-fire-multi-lingual-training-tool-forest-fires-wild-fires-and-vegetation: a. Competency based training system is an effective tool to increase the cooperation potential. b. Competency based training system (Eurofire project) was focused on following objectives: i) Improve skills and competencies of people, ii) Improve the quality of, and access to continuing vocational training, iii) Developing relevant and innovative e-learning content, iv) Promotion of social dialogue in vocational training. These indicate directions to strengthen the cooperation also outside the project formula. c. The project formula is a proper way to prepare multi-lingual materials for the purposes of the cooperation design and improvement. 5. Firefighting intervention management UVI (software tool, available only in Croatian):https://hvz.gov.hr/istaknute-teme/informatizacija/sustav upravljanje-vatrogasnim-intervencijama/101: a. A valuable way to improve cooperation between entities fighting the fire is to connect efforts of the main executors (fire service) and the main managers (public administration). b. An improvement of the cooperation may be a derivative of a firefighting action standardisation, information unification and distribution, a unified reporting, a common use of IT support tools. c. The cooperation is built on common knowledge base about response resources, hazardous materials and the resources location with connection to warning system and vehicle tracking system. 6. Paveglio, T. B., Abrams, J., Ellison, A. (2016) 'Developing Fire Adapted Communities: The importance of Interactions Among Elements of Local Context', Society & Natural Resources, 29(10), pp. 1246-1261, http://dx.doi.org/10.1080/08941920.2015.1132351: a. The cooperation should consider also citizens. b. Societal perception of hazard must be calculated into overall wildfire risk (risk perception is an integral element of the risk). c. Every community has unique social and societal profile which may be used to increase the cooperation potential. 7. Paveglio, T.B., Edgeley, C.M. (2020) 'Fire Adapted Community' In: Manzello, S.L. (eds) Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires. Springer, Cham. https://doi.org/10.1007/978-3-319-52090-2_114:

	a. "A fire adapted community (FAC) is comprised of residents, land management professionals, local politicians, emergency managers, and fire professionals who collaborate effectively to plan for, respond to, and recover from the evolving risks that fires pose to humans within or outside of the Wildland Urban Interface". b. The cooperation should consider first of all citizens. c. Every community has unique social and societal profile which may be used to increase the cooperation potential. d. An organisational dimension of a community is a good reference to design effective societal cooperation.
7. General category**	1. Stefanou, N., Kazantzidou-Firtinidou, D., Sakkas, G., Theodoridis, G., Rousakis, V. (2022) 'Training and exercises for Critical Infrastructure – A Hellenic computer-assisted exercise use case analysis', International Journal of Disaster Risk Reduction, 69, p. 102729, https://doi.org/10.1016/j.ijdrr.2021.102729: a. Computer-assisted exercises characterizes high educational potential. b. Computer-assisted tools must match operational needs of wildfire response. c. Training materials may cover all phases of the training, namely identification and analysis of needs, training planning, training conduct, training evaluation, assessment and lessons learnt. 2. Be Prepared for a Wildfire, https://community.fema.gov/ProtectiveActions/s/article/Wildfire: a. Webpages of leading international security institutions serve as valuable information sources and may be used for wildfire response training. b. Hazard information sheet contains basic set of information to supplement the training content. c. Information about additional information sources may give participants more possibilities to gain their knowledge, also after the training. 3. Wildfire. Response Planning (Evacuation), https://community.fema.gov/ProtectiveActions/s/article/Wildfire-Response-Planning-Evacuation: a. Local fire evacuation plan is a good example of solution which may stay with training participants after the training, reminding crucial training issues. 4. Gromek, P. (2021) 'Strategic training and exercises for critical infrastructure protection and resilience: A transition from lessons learned to effective curricula', International Journal of Disaster Risk Reduction, 65, p. 102647, https://doi.org/10.1016/j.ijdrr.2021.102647: a. Training may base on general decision-making process comprising in analysis of decision-making process, decision problem formulation, formulating alternative solutions to the decision problem, analysis of the alternatives, choosing a reference solution to the decision problem, implementation of the solution and relevant evaluation.

	b. Training materials should contain background information, real information and templates. c. The materials should match issues related to trainers, trainees and equipment, commonly constituting effective training curricula. 5. The Trial Guidance Methodology, Project Driver+, https://www.driver-project.eu/wp-content/uploads/2020/02/TGM-handbook-FINAL.pdf: a. Complex materials should be properly described to increase chances for understanding by a reader (for example a bird's-eye view on the material, idea/approach description, summary). b. Graphical layer is a key issue of attractive material. c. Step-by-step approach is crucial in training of adults (training reason and objectives).

6 Innovative approaches for implementing the training activities (integration of AR/VR content) in SILVANUS

6.1 Introduction

6.1 Introduction

Responders to wildfires are entrusted with the responsibility of managing the hazardous and frequently unforeseen circumstances that come with putting out wildfires. It is absolutely necessary for these responders to have a solid foundation in efficient crisis communication protocols if they are to be able to carry out their duties efficiently. This chapter focuses on using novel technologies such as AR/VR technologies with the goal of preparing those who respond to wildfires to effectively communicate during times of disaster.

The purpose of VR Training is to give those who respond to wildfires access to an interactive training virtual reality simulator so as to learn and practice appropriate crisis communication methods. Responders will be able to practice their skills in a secure and managed environment thanks to the VR Training Simulator, which will be designed to create a realistic and immersive environment that simulates a wildfire scenario.

Conventional training methods frequently entail classroom lectures or field exercises, both of which may not adequately reflect the intricacies and dangers of forest fires. Realistic simulations of fire behavior provide an alternative to traditional teaching approaches. Firefighters can gain a better understanding of how fires spread and evolve, as well as how to respond to changing conditions, with the assistance of realistic simulations of fire behavior.

The VR Simulator partners employ computer modelling techniques to generate accurate representations of forest fires in order to incorporate realistic simulations of fire behavior into the game. The simulations have the capability of being constructed to recreate several types of fires, such as ground fires, surface fires, and crown fires, along with parameters that can take into consideration a variety of factors that influence the fire behavior, including wind, geography, and vegetation.

The development of effective virtual reality (VR) training programs for firefighters in the forest requires the inclusion of realistic simulations of the behavior of fires. Developers are able to create virtual settings that accurately replicate the complexity and unpredictability of wildfires by making use of advanced technology and reliable data.

In order to incorporate this into the VR training program, we started by generating several situations that firefighters may face while responding to wildfires. These scenarios may involve a range of different wildfires, a variety of climatic and topographical circumstances, and a variety of terrain types. This way, firefighters can be trained to adapt to and respond appropriately to any situation they may encounter in the field.

The simulations are designed to include a realistic representation of the behavior of fire, which should include aspects such as the strength of the fire, its pace of spread, and the intensity of the fireline.

Firefighters are able to learn to forecast how a fire would behave and make judgments based on this information if certain aspects are appropriately represented.

The virtual environment is designed to provide a secure and regulated setting in which firefighters can practice a variety of firefighting strategies and techniques. Virtual reality allows firemen to train in a simulated setting without endangering themselves physically or causing any harm to the surrounding environment. This can also allow opportunity for firemen to experiment with new methods and strategies without the fear of failing.

Additionally, the simulations are designed in such a way as to provide firemen the opportunity to experience the results of their own actions. For instance, if a firefighter decides to construct a fireline in a particular spot, the simulation can demonstrate how the fire reacts to this activity by showing how the fireline is affected. Because of this, firefighters are able to witness the results of their judgments and learn from their errors.

In general, starting from the on-field requirements, comprehensive and accurate simulations of the behavior of fires will become a necessary component of any VR training program designed for firefighters. Firefighters can be trained to adapt to and respond to any situation they may encounter in the field by authentically replicating the complexity and unpredictability of wildfires.

6.2 Interactive equipment tutorials

Virtual reality (VR) can provide a way for firefighters to learn about the essential pieces of gear needed to battle forest or vegetation fires in an engaging and interactive manner. Interacting with similar hardware and getting a feel for how the tools operate first hand is a much more effective learning method for firefighters than simply reading a manual or viewing a video on the subject.

Our goal is to develop immersive experiences that provide trainees the opportunity to explore and interact with a variety of firefighting equipment. In order to include interactive equipment, we plan on adding step-by-step instructions prior to starting an actual simulation. The virtual equipment will be modelled to closely mimic real-life equipment, and firefighters will be provided extensive instructions on how to operate. To guarantee that trainees are able to become proficient with the use of the equipment, the interactive equipment lessons are designed to be both interesting and straightforward to use.

A technique that is based on simulation is one method that can be used to build interactive equipment tutorials. Participants in the training program may be given a variety of scenarios that call for them to use particular pieces of equipment. In order to extinguish the simulated fire, the trainees must select the appropriate gear and use it in the appropriate manner. The user can receive feedback from the simulator, which will assist them in gaining an understanding of what they did properly or badly, as well as how to make improvements. This can be especially helpful for machinery that is only used infrequently or that has very unique operating procedures.

Gamification is yet another way that can be taken to integrate equipment lessons. The use of gamification in the training helps content become interesting and inspiring for the learners. We have the opportunity to design interactive serious-games that need trainees to make use of particular tools in order to achieve pre-planned goals. For instance, a game could mandate that the firefighter make use of a particular extinguisher in order to cut a way through the woods or cut down a tree to construct a barrier against the spread of fire. Real-time feedback on the trainee's performance, including things like accuracy, the amount of time it took to accomplish the assignment, and efficiency, might also be provided by the game.

We plan to employ a combination of interactive step-by-step lessons and cutscene animations, in addition to the methods that have been described above. For example, trainees could first see an animation on how to use a tool before being given the opportunity to use the tool themselves in a simulated setting. This gives them a better understanding of how the tool should be used. This strategy might prove to be very helpful for specialized equipment that calls for particular safety regulations.

Trainees can build confidence and competency in handling firefighting equipment when immersive, engaging, and realistic training experiences are created for them. This can ultimately lead to more effective and safer firefighting.

6.3 Multiplayer Scenarios

Fighting forest fires typically requires the cooperation of multiple individuals, and training should reflect this reality. The virtual reality simulator with multiplayer support can give firefighters the chance to hone their teamwork skills in a variety of settings and roles through participation in multiplayer scenarios.

One of our aims is to incorporate multiplayer scenarios into a virtual reality (VR) simulator by enabling several users to take part in the simulation and collaborate with one another to achieve their goals or complete their responsibilities. Many different approaches can be taken to achieve this goal, including the following:

Through the usage of a network connection, users of a networked virtual reality system are able to connect to the same virtual environment simultaneously. Firefighters would also need to ensure that they have a reliable internet connection in order to use the VR simulators in multiplayer mode.

Asynchronous Multiplayer: This method has users working on different activities or goals at different times, with their progress being saved and shared with other users. Because of this, users are able to practice their skills on their own before they collaborate with other people, which can be beneficial for training purposes.

As a virtual reality simulator for forest fire training, we plan on starting with some examples of possible multiplayer scenarios such as:

Grouping several fire fighters into teams to collaborate in putting out a simulated blaze in the woods, with each player taking on a distinct duty within the team (e.g., hose operator, lookout, drone pilot). Another example can require learners to take on the role of first responders battling a simulated forest fire. In order to accomplish this mission, each participant utilizes their own set of abilities and pieces of equipment.
Another example can present a group of firefighters who are putting out a forest fire using a method called controlled burning; each member of the team is in charge of a different facet of the operation (e.g., setting up fire breaks, monitoring wind conditions, controlling the burn).

Other examples can present putting out fires using another method which involves cutting down trees to isolate the fire spread.

This way learners are able to practice working together in a simulated environment that closely mimics real-world scenarios thanks to the incorporation of multiplayer technology. We aim on improving their coordination and teamwork when they are faced with emergency situations.

6.4 Hazard identification and risk assessment

Following the methodology objectives described in the previous chapters, we plan on creating content to allow firefighters learn about the various types of hazards they encounter during real forest fire events, such as falling trees or unstable terrain. This helps firefighters better prepare for the dangers they may face. They can gain a better grasp of the hazards involved and how to mitigate those risks with the help of this information.

To do so, the VR scenarios will be built to include potential dangers such as steep terrain, indeterminate weather conditions, hazards, poor vision owing to smoke, and the possibility of the fire rapidly spreading.

Firefighters should be able to discover potential dangers and evaluate the risks that are connected with each danger. We can start with a simple scenario in which a fire has broken out close to another group of trees. In this scenario, the user is required to recognize the potential hazards, which may include ponds, dry vegetation, boulders, wood logs and evaluate the risks that are associated with each hazard. For instance, the user may be asked to determine the likelihood that the fire will spread to the group of trees.

We plan on supplying information and tools to assist first responders in mitigating the risks connected with dangers that have been identified. For instance, the application can include information on the safest routes for responders to follow, the equipment that is required to address the hazards, as well as the appropriate processes for resolving the hazards.

During virtual firefighting operations, the simulator will be designed to integrate capabilities that make it possible to identify potential dangers in real time and to evaluate the associated risks. This could involve presenting the trainees with unexpected dangers or changes during the scenarios, such as an abrupt change in the direction the wind is blowing, and encouraging the user to recognize the dangers and assess the risks associated with taking any action before taking any action at all.

Creating virtual environments in which trainees are able to recognize and evaluate a variety of hazards and risks is one method for incorporating hazard identification and risk assessment into virtual reality (VR) simulators. This method is one of several ways that this can be accomplished. The trainee might, for instance, be shown a picture from a virtual forest in which they are asked to recognize and evaluate several sorts of hazards and risks that are linked with forest fires. Some examples of these include steep slopes, dense foliage, and strong winds. The learner may also be expected to evaluate the potential for the fire to spread to neighbouring vegetation or areas in some of the scenarios that can be included in the virtual environment.

We plan to incorporate hazard identification and risk assessment tools into the virtual reality simulator. The simulation will be able to provide immediate feedback to the trainee regarding the correctness of their assessment and make recommendations regarding how they can improve their skills.

The training can be made to feel more realistic by having the virtual reality setting contain a range of climatic and lighting variables, as well as differences in topography and vegetation. In order to provide a fuller knowledge of the dangers connected with forest fires, the environment can also contain several types of fire behaviour. We can make use of the probability patterns studied in the task T3.2.

A scoring system that measures the trainee's ability to appropriately detect and assess dangers and risks is planned to be incorporated as a method for determining whether or not the training was successful. The system will be designed to provide reports with a breakdown of the trainee's strengths and weaknesses, which can be utilized to better tailor the training to meet the requirements of the trainers.

6.5 Training in effective communication:

It is challenging to practice effective communication in a classroom or field context, despite the fact that it is essential for an emergency response to a forest fire. We can replicate in VR a variety of communication contexts, such as information sharing with other members of a team or collaborating with representatives from other organizations (Medics, Forest rangers).

We can simulate a variety of communication scenarios that are frequently encountered during forest fire incidents. These scenarios include radio communication, communication between different firefighting units, and communication with external sources (Command center in our case). Because of this, fire fighters would be able to hone their communication skills in a setting that is both secure and supervised.

6.6 Interactive role-playing

The virtual reality program can provide firefighters with the opportunity to play a variety of roles in a simulated environment, such as that of a Drone operator, a forest ranger, fire fighter or incident commander. Because of this, trainees would have the opportunity to experience other roles and practice communicating effectively in a variety of positions and settings.

6.7 Training that is provided in multiple languages

The simulator can deliver training in multiple languages, enabling first responders from a variety of countries to get instruction in a language that is most natural to them. This would be especially helpful for foreign teams that might have to collaborate during times of emergency, such as when there is a forest fire.

Training with specific communication equipment ensures that fire fighters are familiar with communication gear they will need to use during a real emergency and that they are able to use it efficiently.

In general, including communication training into our software can create a safe and realistic environment in which firefighters can practice their communication skills and increase their efficacy during forest fire events.

6.8 Training for dealing with stress and making decisions

The response to forest fires can be extremely stressful, and judgments that are made under these conditions can have severe repercussions. Virtual reality (VR) technology can provide a platform for firefighters to practice skills related to decision-making and stress management in a safe setting, which can assist prepare them for circumstances that they may face in the real world.

It is possible to construct the scenarios so that they include unforeseen occurrences and dangers that call for judgments to be made rapidly and accurately in order to reduce potential for harm and protect both responders and the environment.

Responders may be put through a variety of stressful situations and be under a time crunch while they are participating in the training to better prepare them for the reality of dealing with wildfires. They can also be given tools and resources to help manage stress and make good decisions, such as checklists and decision trees.

The training can be improved by including real-time feedback and coaching, which will assist respondents in recognizing and addressing flaws in decision-making, as well as reinforcing positive behaviors and the ability to make sound judgments.
Another way to accomplished this is through the use of virtual trainers or by integrating debriefings in which the participants discuss the mental processes and decision-making techniques that they utilized.

We will discuss about training activities on dealing with stress and making decisions to complement the training that firefighters receive for the difficult and high-pressure scenarios they face in real life. Stress can lead to cognitive and emotional impairment, which in turn can lead to poor decision-making abilities and slower reaction times. As a result, the virtual reality simulator ought to concentrate on giving the trainees tools to deal with stress and assisting them in making the appropriate choices in a timely manner.

In order to incorporate stress management and decision-making training it is possible to construct scenarios that imitate high-pressure circumstances. Some scenarios will be developed in such a way as to test the firefighters' capacity to handle stress and to make sound decisions even when they are under extreme time constraints. The scenarios can also be made more difficult by include unforeseen occurrences, such as the deterioration of equipment or a change in the weather.

Many methods, such as the addition of loud background noise, time constraints, and restricted resources, have been considered to be utilized in order to make the virtual reality app simulate an atmosphere that is stressful. The scenarios can be crafted in such a way as to impart a sense of time pressure and significance upon the activities at hand, so compelling the firemen to make decisions in a prompt and efficient manner.

The simulator can equip the firefighters with skills to regulate their emotions, such as exercises that involve deep breathing, visualization methods, and positive self-talk. These features help the firefighters manage stress and make the best judgments possible.

Moreover, feedback and coaching can be incorporated to assist the trainees in thinking critically about their decision-making process and gaining valuable insight from their errors. The feedback should highlight the strengths and limitations of the firefighters' decision-making skills, and it can be supplied in real time or after the scenario has been completed.

In general, training for dealing with stress and making decisions might be a useful addition to simulator, which can assist firefighters in getting ready for the difficulties they might encounter when fighting actual forest fires. The scenarios might test the firefighters' capacity to deal with stress and arrive at the correct judgments in a timely manner. At the same time, the simulator should provide trainees with tools to deal with stress and assist them in arriving at the correct decisions successfully.

Finally, the training can include practices that promote mindfulness and self-awareness in order to assist first responders in managing stress and enhancing their capacity to make reasonable decisions even when they are under extreme time constraints. These may include breathing exercises, techniques for visualization, and other stress-management tactics that can be performed in the virtual world and then implemented in real-life circumstances with wildfires.

6.9 Instruction in cultural sensitivity and participation with the community

It is essential for firemen to have an awareness of, and a connection to, the communities that they are tasked with protecting because forest fires can have substantial repercussions for the inhabitants of those towns. Virtual reality (VR) simulators from WP3 can give firefighters the opportunity to learn about people from other cultures and interact with members of the community in a digital context.

Making use of a wide variety of cultural perspectives: Virtual reality (VR) training scenarios can be designed to reflect a variety of cultural contexts, which can assist in raising awareness among trainees regarding cultural differences that may manifest in the course of their work in the real world. For instance, scenarios can be crafted to reflect a variety of languages, cultural conventions, and mentalities towards the handling of emergency situations.

Exercises in role-playing can be used to model real-life scenarios in which cultural competence is necessary for effective communication and community engagement. Trainees can be assigned roles that are representative of a variety of cultural backgrounds, and they can be encouraged to interact with one another so that they can improve their ability to communicate effectively.

Simulations of community engagement can be designed to mirror actual community engagement scenarios from the real world so that trainees can practice their engagement skills in those environments. For instance, virtual reality (VR) scenarios can be constructed to imitate community meetings at which response strategies for wildfires are discussed. This provides trainees with the opportunity to practice how to effectively communicate with people of the community.

Case studies and interactive scenarios are used to provide trainees better understanding of the ways in which cultural differences can have an effect on the way emergency response efforts are carried out. These scenarios can be used to replicate different situations in which cultural differences may develop, and trainees can be encouraged to reflect on how their actions could affect the situation.

6.10 Gamification

We plan to incorporating aspects of gaming into the training in order to boost engagement and motivation among participants. For instance, implementing a point system or leader boards to foster friendly competition among trainees; or incorporating mini-games into the training to reinforce crucial concepts; these are just a few examples of how these can be implemented.

By including components of games into the training module, gamification can be brought into our simulators. For instance, developing a setting similar to a video game that confers points of merit upon trainees in recognition of their successful completion of a variety of challenges, accomplishment of predetermined goals, and advancement through tiers. This strategy can serve to both motivate learners to participate in the training module and assist them in more effectively retaining the information that they have acquired.

Gamification can also be used to replicate a variety of settings, giving firefighters the opportunity to exercise their ability to make decisions and solve problems in a setting that is both safe and under their instructor's supervision. Trainees can improve their capacity for critical thinking and be more prepared for the challenges they will face in the real world by using this strategy.

Using game features such as points, badges, and leader boards is another approach to incorporate gamification into forest fire training. This can be done in a number of different ways. Trainees can be motivated to accomplish various activities and engage with the training module by utilizing these game elements. The usage of leader boards can also encourage a sense of healthy competitiveness among firefighters, which in turn motivates them to do better in terms of both their scores and their overall performance.

In addition, the simulators can offer trainees an experience that is both immersive and participatory, an experience that can be made even more engaging by employing gamification techniques. Learners, for instance, can be placed in a setting similar to that of a virtual forest fire and be tasked with completing a variety of activities, such as locating and putting out flames, determining the severity of dangers, and recognizing hazards. Firefighters can have an experience that is both more engaging and more likely to stick in their memories if they make use of gamification features such as prizes, points, and feedback in their educational endeavours.

6.11 Adaptive Learning

Can be implemented by making use of algorithms in order to customise the training depending on the individual strengths and shortcomings of each trainee. For instance, the simulator will monitor the progress of the trainee and change the instructions based on the firefighter's current degree of expertise.

The simulator will keep track of the trainee's progress and makes use of this information to modify the simulator content, degree of difficulty, and rate of progression.

The first thing that has been take in consideration was to integrate adaptive learning. This was used along with the contribution from the previous chapters to determine the learning goals and results that are defined or extracted from the previous methodology. The virtual reality (VR) system can then be designed to track the trainees progress and performance throughout the training, using data analytics and algorithms to adjust activities based on the user's strengths and weaknesses.

For instance, if a user has trouble distinguishing between the various kinds of forest fires, the VR system can deliver further hints on the subject matter until the user performs in such a way that they have mastered it. On the other hand, if a user is particularly skilled in specific areas, the system is able to ramp up the level of difficulty of the activities in order to present the user with a more complex challenge to maintain their interest.

It is essential to have a powerful data analytics system that is able to monitor the performance of users and provide insights into their individual educational requirements in order to successfully deploy adaptive learning. It is important that the VR system be developed with flexibility in mind from the beginning, so that it is simple to make changes and updates to the activities and material depending on the data that is collected from users and analyzed.

Overall, integrating adaptive learning can help to enhance the efficacy and efficiency of the training, ensuring that each firefighter receives a personalized and effective learning experience.

6.12 Collaborative training

One of the main things we considered was to make it possible for several trainees to take part in the same virtual reality situation at the same time. This encourages collaboration and communication among participants. Trainees, for instance, could be given the duty of cooperating with one another to put out a simulated fire while simultaneously talking with one another in order to coordinate their efforts.

This can be accomplished through the employment of a variety of different methods to enable up to 4 users to connect to the same virtual environment at the same time.

Firefighters are able to cooperate with one another in order to accomplish particular goals during collaborative training, such as putting out a simulated fire, creating a fire corridor or saving colleagues from harm when fire gets out of control. Trainees are able to engage with the virtual environment by using hand gestures, but they can also speak with one another using live voice chat.

It is essential to make sure that every user is assigned a certain task to do and that they are aware of the responsibilities that come along with that task in order for collaborative training to be successful. This targets clear communication and teamwork.

A simulated emergency response scenario in which up to 4 users are tasked with responding to a simulated wildfire is one example of collaborative training that may be carried out in virtual reality (VR). Each user is assigned a distinct function, such as a firefighter, a team leader, a drone operator (for mapping) or a medical member, and they are required to collaborate in order to put out the fire, recognize potential dangers, and communicate with other groups.

In this particular instance, firefighters are able to converse with one another via voice chat, and they also have access to a variety of virtual tools that allow them to interact with the environment, such as radios, maps, and water hoses, chainsaws etc. Trainees are able to obtain feedback on their performance, which can assist them in becoming more proficient over the course of time.

6.13 Scenario-Based Training

We target Scenario-Based Training to develop virtual reality (VR) experiences that are true to life in order to better prepare trainees for real-life events. For instance, replicating a wildfire in a particular geographical region (in our case we replicate 4 different regions), complete with varying climatic conditions and topographical factors that may have an effect on the efforts to put out the fire.

Scenario-Based Training can be included into forest fire training in VR by choosing scenarios that enable wildfire responders to practice their abilities in simulated real-life circumstances. This allows responders to get more hands-on experience with their training. These scenarios can be constructed to represent a variety of flames, weather conditions, and terrain features, as well as other factors that may influence how firefighting operations are carried out.

Training firefighters on how to behave appropriately in a variety of scenarios through the use of scenario-based training is an efficient method. It entails choosing to build a simulated environment that imitates real-world settings and circumstances that the individual may find themselves in at some point in their life. When it comes to training for fighting forest fires in VR, scenario-based training can be used to mimic the many kinds of forest fires that can occur and the necessary response that must be taken in order to control and put out the fires.

The incorporation of scenario-based training into the scenarios can be accomplished in a number of ways, one of which is by having the student complete a series of varying situations that have been pre-created. In each scenario, the trainee should be confronted with a unique set of obstacles and variables that they must traverse in order to effectively complete the assignment. The learner may be asked to demonstrate that they have mastered the abilities taught in earlier scenarios while the scenarios themselves may get increasingly more difficult.

As an example, we can add step-by-step tutorial scenarios, the trainee might be asked to use a fire extinguisher to put out a relatively minor blaze. There would be a variety of obstacles to overcome in this case, such as the fire being in a position that is difficult to access or the fire being close to another tree. The firefighter is responsible for overcoming these obstacles and putting out the fire while following to all of the safety regulations

In a harder training scenario, the trainee would be expected to put out a more serious blaze that calls for the deployment of more firefighting tools and apparatus, such as water hoses. The scenario could bring a variety of obstacles, such as the fire being located close to a forest area, in which case the trainee would need to communicate with other responders and establish the steps needed for isolating the initial fire.

The scenarios can be structured in such a way as to incorporate several training techniques, such as the identification of hazards, the evaluation of risks, the making of decisions, and the communication of those decisions. Each scenario can provide the trainees with quick feedback on their performance. Also, the firefighters should be given time to analyze their actions and make improvements before moving on to the next scenario.

The VR simulator can be used to generate not only situations, but also design environments that respond in different ways depending on what the firefighter does. For instance, if the trainee is unable to put out a fire in a timely manner, the flames may spread to other areas, forcing the trainee to alter their strategy and work in conjunction with the other people who are responding to the emergency.

Responders to forest fires are able to learn vital experience and abilities in an environment that is both safe and under their control if scenario-based training is integrated into VR. The utilization of virtual reality (VR) technology can produce an experience that is more immersive and engaging, which in turn can assist trainees in remembering material and applying it to real-world scenarios.

In order for the training program to be able to effectively build situations, the first step is to determine the precise abilities that wildfire responders need to master. After these skills have been uncovered, the scenarios can be constructed to put these skills to the test and provide them additional practice. For instance, a scenario can demand responders to immediately identify potential hazards and risks in a wildfire situation, analyze the situation, and make judgments on how to proceed with the issue.

The scenarios can be built to be customizable, which provides the opportunity for responders to practice reacting to a variety of various problems and sorts of situations. To ensure that firefighters are appropriately challenged and continue to develop their skills, adaptive learning techniques, such as adjusting the difficulty level of the scenario based on the user's performance, can also be incorporated.

The use of realistic visual and aural elements, such as fire and smoke effects, sound effects, and weather conditions, allows for the creation of scenarios that are truer to life. The scenarios can also be built to be interactive, allowing users to make decisions and seeing the results of those actions in real time. This adds another layer of depth to the experience

The incorporation of feedback mechanisms into the training program is something that may be done in order to make certain that the situations are useful. This can include providing feedback on the user's performance during the scenario, as well as providing feedback on how the scenario relates to real-life firefighting situations. Alternatively, this can also include providing feedback on how the scenario relates to other types of emergency situations.

In general, scenario-based training in virtual reality (VR) can be an efficient method for educating wildfire responders by offering a secure and managed environment in which they can practice and refine their abilities.

6.14 Haptic feedback

Using haptic feedback technology as part of the training simulator can recreate the sensations of fighting a fire physically. For instance, trainers could spray water via a hose while using haptic controllers to imitate the water movement and pressure of the hose's spray nozzle.

By presenting users with physical sensations that replicate real-world circumstances, it can serve to enhance the realism of the training experience and make it feel more like the actual world. The following examples identify of how haptic feedback can be included into VR training:

It is possible to incorporate haptic feedback into the firefighter joysticks that are utilized in the virtual reality (VR) training environment. The use of haptic feedback can imitate the weight, texture, and vibration of fire extinguishers.

Trainees will have a more realistic and immersive experience as a result of the haptic feedback's ability to replicate weather conditions like as wind, rain, and thunder.

Fire effects: The haptic feedback may imitate the smoke or intensity of the fire. This provides users with a sense of the environment they are in and enables them to have a greater understanding of the dangers they face.

The haptic feedback can imitate the actual obstacles that firefighters may face, such as rocky terrain or fallen trees. This assists users in navigating their way through these obstacles and enables them to respond more efficiently to the fire.

In general, including haptic feedback into forest fire training in virtual reality can give users a more immersive and realistic training experience, which in turn can help them improve their skills and their ability to make decisions while they are actually out in the field.

6.15 Multi-Sensory Training

Including participation from several senses in the training to increase the level of realism and utility provided by the experience. For instance, the simulator can include modules that can communicate to scent machines to imitate the smell of smoking, or heat lamps to imitate the feeling of being really hot.

For instance, in addition to visual and auditory signals, haptic feedback mentioned above can be utilized to imitate the feeling of heat from a fire, vibrations from equipment, or the weight of firefighting instruments. This can be accomplished by using a force-feedback device. In a similar manner, smoke or the smell of burning wood can be imitated with the use of aroma generators.

Although it may be more challenging to incorporate other sensory inputs, there are still methods available to create a more multimodal experience. For instance, including real-world artifacts in the training, such as clothing or apparatus used in firefighting, might give a tactile component to the instruction. The incorporation of ambient sound elements, such as birds chirping or leaves rustling, can also contribute to the overall immersive experience and make the environment more lifelike.

6.16 Data Analytics

Gathering data from firefighters can be used to assess their progress and enhance the training. For instance, by tracking the response times, accuracy, and other metrics of trainees, trainers can identify areas in which there is room for development and alter their instruction accordingly.

The training program can be improved so that it better prepares the trainees for scenarios that they will encounter in the real world if the learners' actions and decisions are monitored and analyzed.

The integration of data analytics can be accomplished in a number of ways, one of which is to gather data on the performance of trainees in a variety of scenarios and then utilize this data to identify areas of strength and weakness. Information pertaining to reaction times, decision-making procedures, and the efficacy of communication can fall under this category. After that, the data can be evaluated to discover patterns and trends, which can serve as a source of guidance for the creation of new training modules in the future.

Using data analytics as a means to customise the learning experience for each individual student is yet another strategy. By the collection of data on the trainees' performance and preferences, the virtual reality training software is able to adjust to the trainees' specific requirements and offer individualized feedback and direction. This can be helpful in ensuring that each student has a customized training experience that makes the most of their potential for learning.

Data analytics can be utilized to track and analyze ambient and weather factors in the virtual reality training scenarios in addition to being used to track and analyze performance data. This can serve to imitate realistic settings that trainees may experience out in the field, and educate them to make informed judgments in a number of environments that present a variety of unique challenges.

In general, incorporating data analytics can provide helpful insights and improve the effectiveness of the training program, ultimately contributing to better preparing wildfire responders for situations that they may encounter in the real world.

6.17 Virtual Coaching

For instance, an experienced fireman might observe a trainee's progress and provide comments and direction while the learner navigates the virtual reality (VR) training environment through the use of a headset.

The trainees can receive feedback, guidance, and assistance in real time from the virtual coach, which is based on how well they are performing the assigned tasks.

For instance, in a scenario in which trainees are tasked with putting out a wildfire using firefighting equipment and extinguishing agents, the virtual coach can provide instruction on the appropriate use of equipment and extinguishing agents, as well as safety standards that must be adhered to. The trainer is also able to provide comments on the performance of the trainees, which may include areas in which the trainees excelled and areas in which they still have room for development.

In a simulated setting, trainees can also benefit from the use of virtual coaching, which can assist them in developing their ability to make sound decisions. The virtual coach has the ability to present the trainees with a variety of scenarios and then ask them to make judgments based on the information that has been presented. The trainer is thus in a position to offer feedback on the trainees' decision-making process, which may include the logic behind the trainees' selections as well as areas in which they may improve.

In general, the incorporation of virtual coaching into forest fire training conducted in VR has the potential to offer trainees a more individualized and interactive learning experience. This, in turn, can improve the trainees' knowledge, skills, and confidence when it comes to dealing with actual fires.

6.18 Applying the operational methodology defined in Section 5 on phases of implementation

1) Data Collection

The first step is to collect the necessary data, which may include satellite imagery, topographical maps, weather forecasts, and other relevant information. This data should be compiled and organized in a format that can be easily accessed and used in the VR environment.

2) Creating the 3D Models

Using the collected data, 3D models of the environment are created in a 3D modelling software like Blender or 3D Studio Max then moved to Unity. This will allow for the exact location of hazards, wildfire sources, and danger zones to be plotted accurately in the VR environment.

3) Hazard Location

Once the 3D models are created, the exact location of hazards can be identified and marked in the VR environment. This can be done by placing markers or labels in the VR environment at the locations where hazards have been identified.

4) Wildfire Sources

In order to determine the number of wildfire sources/hot-spots, satellite or drones' imagery can be used to identify areas with a high risk of fire. These areas can then be marked in the VR environment as wildfire sources/hot-spots.

5) Danger Zones

The area of the danger zone can be identified by analyzing the topographical data and identifying areas that are at a higher risk of being affected by the wildfire. This information can then be used to create a boundary or a perimeter around the danger zone in the VR environment.

6) Testing and Validation

Once the above steps are completed, the VR environment can be tested and validated to ensure that it accurately represents the actual hazard, wildfire sources, and danger zones. This step can also involve user testing to ensure that the VR environment is intuitive and easy to use.

7) Refinement

Based on the results of the testing and validation, any necessary refinements can be made to the VR environment to improve its accuracy and usability.

8) Weather Conditions

- Gather weather data such as wind force and direction, insolation, temperature, and relative humidity relationships, atmospheric stability, lapse rates, large scale circulation, air masses and fronts, convective winds (land breezes, whirlwinds, slope and valley winds), thunderstorms, and clouds.
- Use this data to create a weather simulation system that accurately reflects the current weather conditions in the area.
- Integrate the weather simulation into the VR environment, allowing users to experience the effects of the weather on the wildfire.

9) Vegetation Type and Fuel Model

- Gather data on the vegetation types in the area and create a vegetation map that accurately reflects the different types of vegetation.
- Use this data to create a fuel model that accurately reflects the combustibility of each type of vegetation.
- Integrate the vegetation map and fuel model into the VR environment, allowing users to see the different types of vegetation and how they contribute to the wildfire.

10) Forest Conditions

- Gather data on the type of combustible material and moisture in the area.
- Use this data to create a forest condition model that accurately reflects the current conditions of the forest.
- Integrate the forest condition model into the VR environment, allowing users to see how the condition of the forest affects the wildfire.

11) Presence of Derivative Threats

- Gather data on any other threats in the area, such as critical infrastructure objects, limited visibility due to smoke, etc.
- Use this data to create a threat model that accurately reflects the presence of these threats in the area.
- Integrate the threat model into the VR environment, allowing users to see how these threats affect the wildfire.

12) Quality and Quantity of Wildfire Responders

- Gather data on the quality and quantity of wildfire responders in the area.
- Use this data to create a responder model that accurately reflects the current capabilities of the responders.
- Integrate the responder model into the VR environment, allowing users to see the impact of the responders on the wildfire.

13) Quality and Quantity of Equipment

- Gather data on the quality and quantity of equipment to fight wildfires, including specialized devices and UAVs.
- Use this data to create an equipment model that accurately reflects the current capabilities of the equipment.
- Integrate the equipment model into the VR environment, allowing firefighters to see the impact of the equipment on the wildfire.

14) Road conditions

- Gather information on the road network in the area, including the type and condition of the roads.
- Develop a database of these roads and their characteristics, such as their accessibility, capacity, and distance from the fire zone.
- Create a system that can display this information in the VR simulation, such as an overlay on the map or markers in the environment.

15) Suggested access roads

- Based on the road network and the location of the fire, suggest the best access routes for firefighters and equipment.
- Develop a system that can display this information in the VR simulation, such as an overlay on the map or markers in the environment.

16) Firefighting action status

- Develop a system that can display the current firefighting action status, such as the location and progress of firefighters and equipment, and the status of the fire itself.
- Incorporate real-time data into the simulation to model changes in the fire and firefighting efforts.
- Create a system that can display this information in the VR simulation, such as an overlay on the map or markers in the environment.

17) Firefighting action status

- Create a dynamic system that tracks the status of firefighting actions in real-time, including the number of personnel on the ground, their locations, and the equipment they are using.
- Use animations or visualizations to show the progress of firefighting efforts and any changes in the situation, such as new fires starting or existing fires spreading.

18) Quality and quantity of extinguishing agents accessible

- Create an inventory system that tracks the types and quantities of extinguishing agents available at different locations.
- Develop visualizations that show the locations of different types of extinguishing agents and the amounts available in real-time.

19) Possibility to use salt water, fire retardants agents, firefighting foams

- Incorporate environmental regulations and restrictions into the system to determine which types of extinguishing agents can be used in different areas.
- Create a database of available extinguishing agents and their properties, including their effectiveness and potential environmental impact.
- Use visualizations to show which types of extinguishing agents are available in different locations and how they can be used safely.

20) Current accessibility of equipment required

- Develop a system that tracks the locations of equipment required for firefighting, such as hoses, pumps, and vehicles.
- Use visualizations to show the locations of equipment and their status in real-time.

21) Alternativeness of equipment

- Create a database of alternative equipment that can be used for firefighting in case the required equipment is not available.
- Develop visualizations that show the locations of alternative equipment and how they can be used.

22) Terrain height differences for the needs of water supply organization

- Use topographical maps and terrain data to determine the height differences between different areas and the accessibility of water sources.
- Create visualizations that show the topography of the area and the location of water sources and how they can be accessed.

23) Prediction of wildfire development

- Use weather data and fire prediction algorithms to illustrate how a wildfire is likely to spread and develop.
- Create visualizations that show the predicted spread of the wildfire and the areas that are likely to be affected.

24) Firefighting aerial means tracking and visualization system

- Develop a system that tracks the location and status of firefighting aerial means, such as drones.
- Use visualizations to show the location of aerial means and their status in real-time.

25) Communication structure

- Develop a communication system that enables all parties involved in firefighting to communicate effectively and efficiently.
- Use visualizations to show the communication network and the status of communication channels.

26) Command structure

- Develop a command structure that determines who is in charge and who is responsible for coordinating firefighting efforts.
- Use visualizations to show the command structure and the roles and responsibilities of different personnel.

6 ARVR Simulators for firefighters

Introduction

The purpose of a VR simulator is to create an immersive, interactive environment that allows firefighters to experience and manipulate virtual objects in a realistic way. It has to provide a safe, controlled environment where firefighters can practice responding to various emergency situations. The simulator allows firefighters to experience realistic scenarios that mimic real-life situations, without exposing them to actual danger.

The VR simulator is equipped with a range of features that can simulate fire and smoke spreadbut also a various environmental factors, such as heat and humidity. This allows firefighters to prepare for different conditions they might encounter on the job.

The VR simulator offers several benefits over traditional training methods. It allows firefighters to practice responding to a wider range of emergency situations, including those that might be too dangerous or impractical to simulate in real life. It also allows firefighters to practice their skills in a repeatable and consistent environment, which could lead to better training outcomes.

Architecture

In this section we cover the hardware and software requirements for the VR simulator, including the types of devices and sensors needed. An overall overall system architecture design is still in progress but at this point we can include how the components of the system interact with each other.

The next version of this deliverable D3.4 will provide a data flow diagram to help visualize the data flow throughout the system once the communication is established with the rest of the components.

Technical requirements

The VR client is designed to be compatible with several VR headsets from the Oculus and Meta ecosystem such as Meta Quest, Meta Quest Pro, Meta Quest 2, Oculus Quest 1 and 2. It is compatible with Oulus and Meta Quest OS systems and hardware configurations.

The simulator embeds a login system (will describe later the benefits related to progress tracking and user metrics) and will function as a client application. Depending on the role that the user is assigned the application will enable several functionalities and tools.
One of the main requirements is to be compatible with commercial VR headsets. Our answer was to adopt Meta Quest 2 headsets since, at the time being, they offer one of the best deals in terms of quality vs price. The Meta manufacturer is providing security upgrades and has a solid ecosystem for providing VR solutions to the market, along with departments that provide technical assistance.
Since this is the first version of the deliverable, we have chosen the META Quest 2 headsets. We plan on updating the headset once the manufacturer releases an improved version of the hardware.
The headsets will be considered as minimum requirements since the trend is to have new improved devices once every 2-3 years. The software developed in this WP will be compatible with the future versions since the development of the application will be done using native language.

Figure 1 Meta Quest 2 (128 GB version)

The commercial package includes:

- one headset Meta Quest 2 with 128 GB of storage,
- two controllers with joysticks and touch areas,
- batteries,
- a USB 3.0 type C cable,
- a 15-watt power adapter.

The following features and components must be considered as minimum requirements:

- Panel Type: Fast-Switch LCD Display1832x1920 per eye
- Supported Refresh Rate: 60Hz – 120Hz
- USB Connector: 1x USB-C
- Tracking: Inside out, 6DOF
- Audio: 3D positional audio, integrated in headset, in-strap
- CPU: Qualcomm® Snapdragon XR2
- GPU: Qualcomm® Adreno™ 650 GPU
- Memory: 6GB LPDDR4X
- Lens Distance: Adjustable
- Input: 6DOF assured by 4 cameras, 2 controllers with accelerometer and gyroscopes
- Connectivity: Bluetooth5, Wi-Fi6

Adjusting your headset fit and view

1. To make minor adjustment to the lenses by shifting them to the left and then to the right until they click into the position that provides the best view of what is presented on the screen.The next step is to adjust the straps on the side. To accomplish this, you will need to shift the two sliders that are located on either side of the top strap.
2. To relax the side straps, slide the tabs toward the top strap in the direction of the top strap. You may vary the tension of the side straps by moving the sliders away from the top strap.

- To relax the side straps, slide the tabs toward the top strap in the direction of the top strap. You may vary the tension of the side straps by moving the sliders away from the top strap.
- Reposition the top strap so that it is between the sliders after adjusting the sliders. This ensures that the headset's two sides are balanced and that the top strap is centered on your head while you wear it.
- It's vital to remember that you'll need to remove the headset from your head to adjust the side straps with the sliders.

4. If you already use glasses, make sure the glasses spacer is properly inserted. When you're ready, slide the headset on from the front to the back of the headband.After you have placed the headset on your head, remove it so you can make any extra adjustments to the side straps that may be necessary.
5. After you've adjusted the side straps to your liking, put the headset back on your head and adjust the top strap. You may modify the fit of your Meta Quest 2 by disconnecting the top strap and then reattaching it in the preferred position. This ensures that the display is not obscured and that the image is clear.
6. Gently slide the arms on each side of your Meta Quest 2 up and down to change the angle of the headset against your face to fine-tune the fit and clarity. This will give you the opportunity to make any necessary changes. After you've adjusted your headset, you may complete the setup by following the directions in both Virtual Reality and the Meta Quest mobile app.

For more detailed information regarding the initial setup please access the official manufacturer link: https://www.meta.com/help/quest/articles/getting-started/getting-started-with-quest-2/#initial-setup

2.2 Other requirements

Software Prerequisites

The VR software must use the Quest operating system, which is based on Android 10.

The software is installed within the VR OS. Unity3D is used in the development and it serves as the rendering engine. The two controllers included in the Meta Quest package serve as inputs.

Compatibility of the System

The VR app should be compatible with the following devices: Meta Quest 2, as well as earlier Oculus Quest headsets (1 &2). Under development phase, Windows versions with simulators will be used aswell to test the functionality and interactions.

Graphical Options:

The VR app will provide options for modifying the program's visual settings, such as detail level, anti-aliasing, and texture quality. This allows the program to be optimized for different hardware combinations and improves the app's performance and visual quality.

Input Techniques:

The VR app makes use of the two motion controllers included in the package, but it also supports keyboard and mouse connections via a Bluetooth connection. The development will rely on the joysticks included in the Meta Quest2 package.

GPU Performance metrics:

The rendering target imposed by the development team is to be able to run at 60fps with a maximum latency of 44ms. This is very important since it prevents users to reduce motion sickness.

Methods for Rendering:

The simulator is designed to use forward rendering, but delayed rendering is taken in consideration aswell. To improve graphics, Shadow mapping and post-processing effects will be used during the development phase. This enables us to maximize quality perceived by the user and achieve the required aesthetics.

Audio Preferences:

The VR simulator is able to control and make us of audio settings like volume, sound effects, and music. Spatial audio is used in the development to enhance the immersion and atmosphere during the training sessions

Prerequisites for Networking:

The Simulator needs an active internet connection. It can connect wirelessly using the included Wi-Fi6 embedded card. This allow developers to integrate multiplayer and social features while giving users a seamless and better experience.

Tools for Development:

The rendering engine used is Unity3D, the programming language used will be mainly C#. For the voice we have in plan on using SoundSynth framework or the PUN Photon Voice SDK. For interactions we use the official Oculus integration SDK and XRTK SDK.

Storage necessities:

To minimize memory constraints, the VR app should be limited to a total of 40GB for all 4 scenarios.

Software Calibration:
The VR simulator will include content customizations such as tools to change users IPD (interpupillary distance), height, or orientation. This can help firefighters have a more natural and comfortable experience while avoiding motion sickness.

Haptics Assistance:
With the controllers, the VR software will use haptics such as vibration or force feedback. This can help to improve the app's realism and immersion while also providing more precise and intuitive feedback to the user.

Integration with Cloud systems:
The simulator will use cloud systems or platforms for storing files and multimedia data. This can assist minimize device load and enable more scalable and flexible data management or processing options.

Support for multiple players:
Simulator is developed to support multiplayer and a minimum network bandwidth of 50mbit/sec should be considered as baseline to ensure an optimal connection with up to four concurrent users. This ensures that the multiplayer feature is reliable and playable for all users, as well as that lag or other performance concerns are avoided.

Compliance of development guidelines:
Development rules and guidelines from Meta are followed by developers to ensure future compatibilities with the headsets and OS.

3.1 Project structure

The project is divided in multiple scenes, one for each pilot since it serves a different purpose. Interfaces are used as prefabs (menu screens, settings)

This allows us to modularize the project and make it easier to manage and maintain. We use Unity's scene management system to switch between scenes,

Figure 2 Project scenes (so far)

We have started developing the virtual environment for the Romanian Pilot. We went on-site to get aerial shots, images, videos, drone recordings to create a multimedia database. The resources were used by the development team and a first version of the environment has been created:

Figure 3 Rodnei's mountain scene environment sample

Figure 4 Rodnei's mountain scene environment with units

Figure 5 Rodnei's mountain scene environment with units

Figure 6 Environment and surroundings

Figure 7 Environment and surroundings

The images presented are providing an example of integration. The 3D resources are still under development but they are arranged to showcase the look and feel of the VR experience.

Since the Simulator allows different roles to be chosen (Firefighter, Drone Operator, Medic, Forest ranger) the corresponding units have been modelled:

Figure 7 Romanian firefighters suit

Figure 7 Romanian firefighters suit

Figure 7 Romanian firefighters equipment

Figure 7 Romanian firetruck with equipment

Figure 7 Romanian forest rangers

Figure 7 Romanian SMURD responders (Medical team)

Figure 7 Romanian SMURD vehicles

Once the hardware and software requirements have been defined, the next step is to design the overall system architecture for the VR simulator. This involves defining the various components of the system and how they will interact with each other.

User Interface/experience (UI/UX)

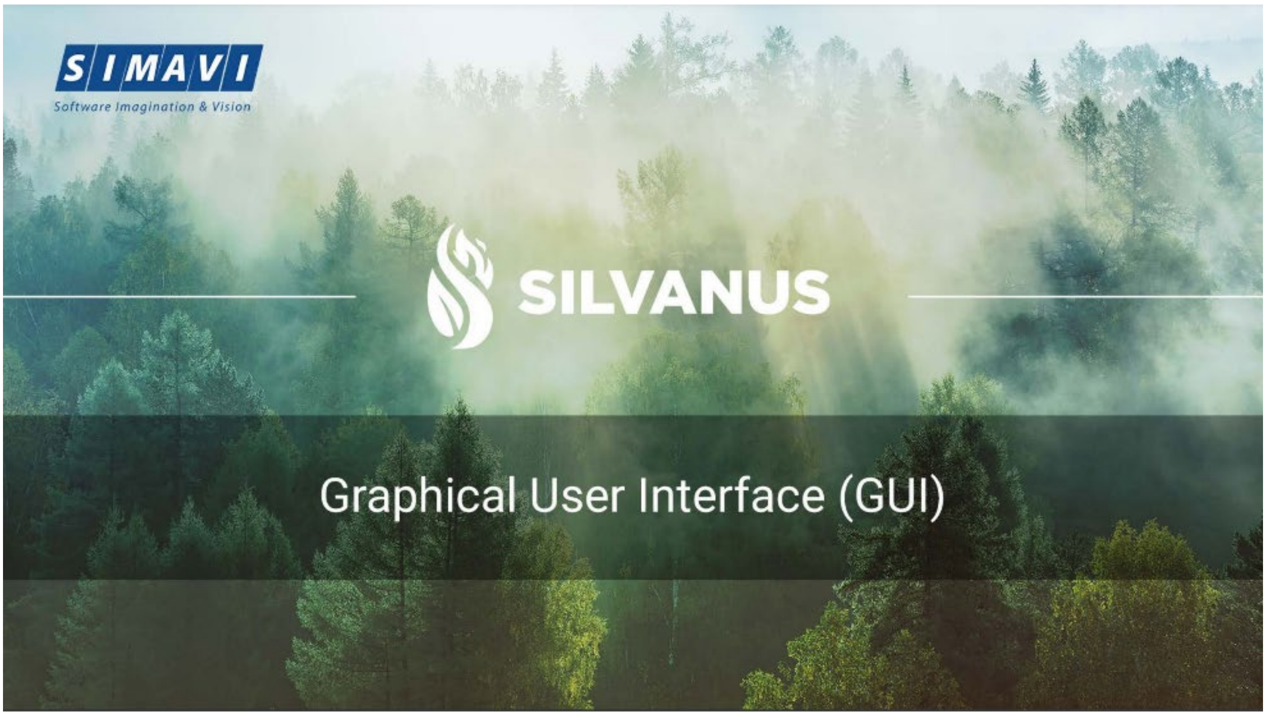
The user interface (UI) is a critical component of a VR simulator, as it is the means by which firefighters interact with and control the simulator. The UI needs to be intuitive and easy to use so that firefighters can focus on the training exercises and emergency scenarios.

One of the primary functions of the UI in a VR simulator for firefighters is to provide access to the various tools, equipment, and information needed to fight fires effectively. This may include access to radios, thermal imaging cameras, hoses, extinguishers, and other firefighting equipment. The UI may also display information on the status of the fire, such as its size, location, and rate of spread, as well as information on the building layout and potential hazards.

Another role of the UI is to provide real-time feedback on performance. The UI may display performance metrics such as response time, accuracy in identifying and addressing hazards, and the effectiveness of firefighting tactics. This feedback can help firefighters improve their skills and make more informed decisions in future training exercises and real-world emergency situations.

The UI in a VR simulator for firefighters may also play a role in facilitating communication and coordination between team members. The UI may include features such as voice communication, minimaps of the environment that displays the location of team members and any hazards or obstacles they may encounter.

This is why we started by developing the guidelines for the UI:



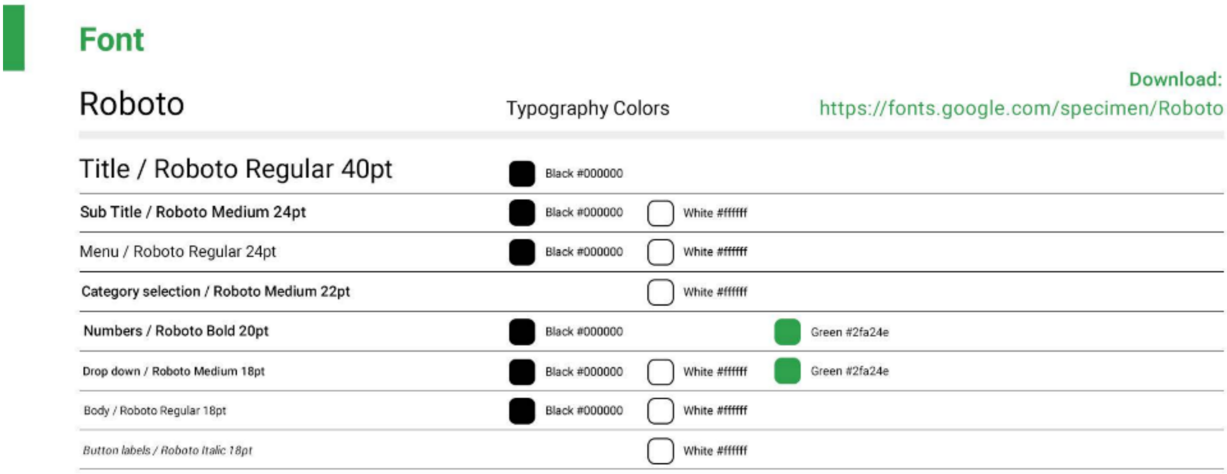


Figure 1 Fonts Specifications

Colors can also be used to reinforce the branding of the Silvanus project that the interface represents. Consistent use of colors can help create a strong brand identity. Colors can be used to create contrast and help differentiate between different elements of the interface. This can make it easier for firefighters to navigate the interface and find what they are looking for.
Colors are used to provide feedback to users. For example, changing the color of a button when it is clicked can provide visual confirmation that the action has been completed.
In the project we implemented the following color codes to assure consistency:

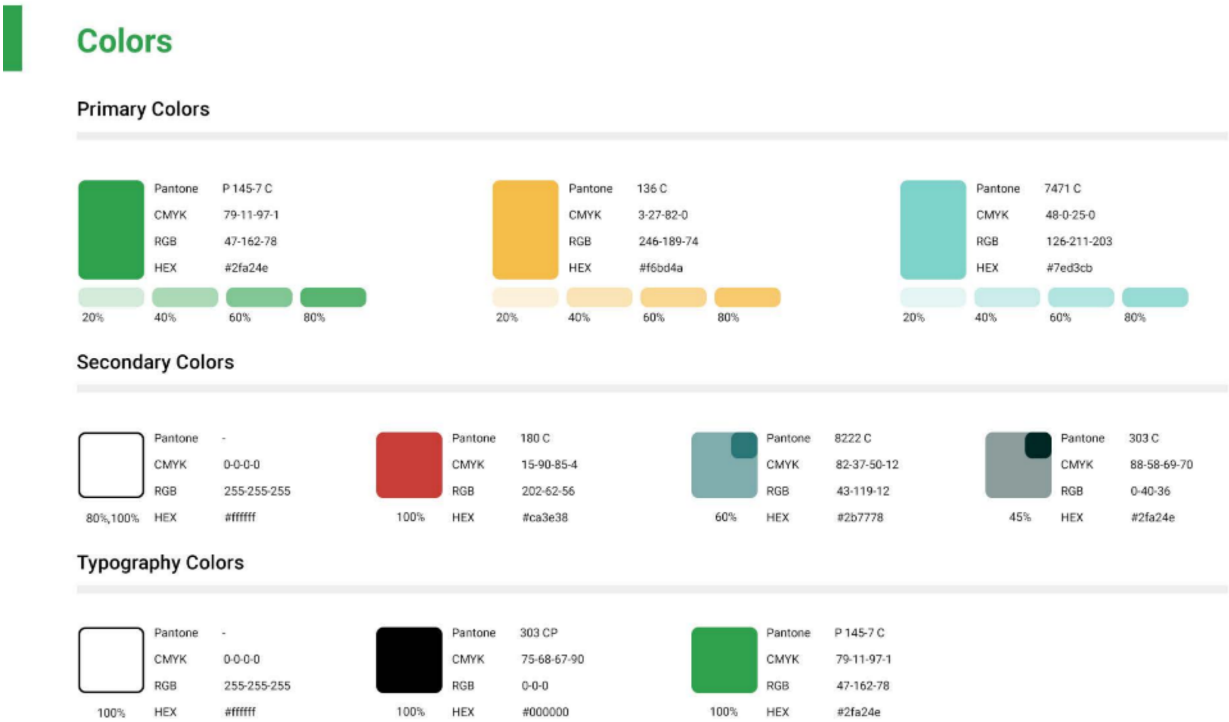


Figure 2 Color guidelines

UI components:

Button styles are an essential aspect of a GUI specification document because they help to establish a consistent look and feel for the interface. Consistent button styles make it easier for users to understand the function of each button and navigate the interface more efficiently.

Button styles can also convey important information to the firefigthers through their design. For example, a button that is brightly colored and prominently displayed might indicate a primary action or an urgent task, while a less prominent button with a more subdued color might indicate a secondary action or a less critical task.

We defined the following Button styles:

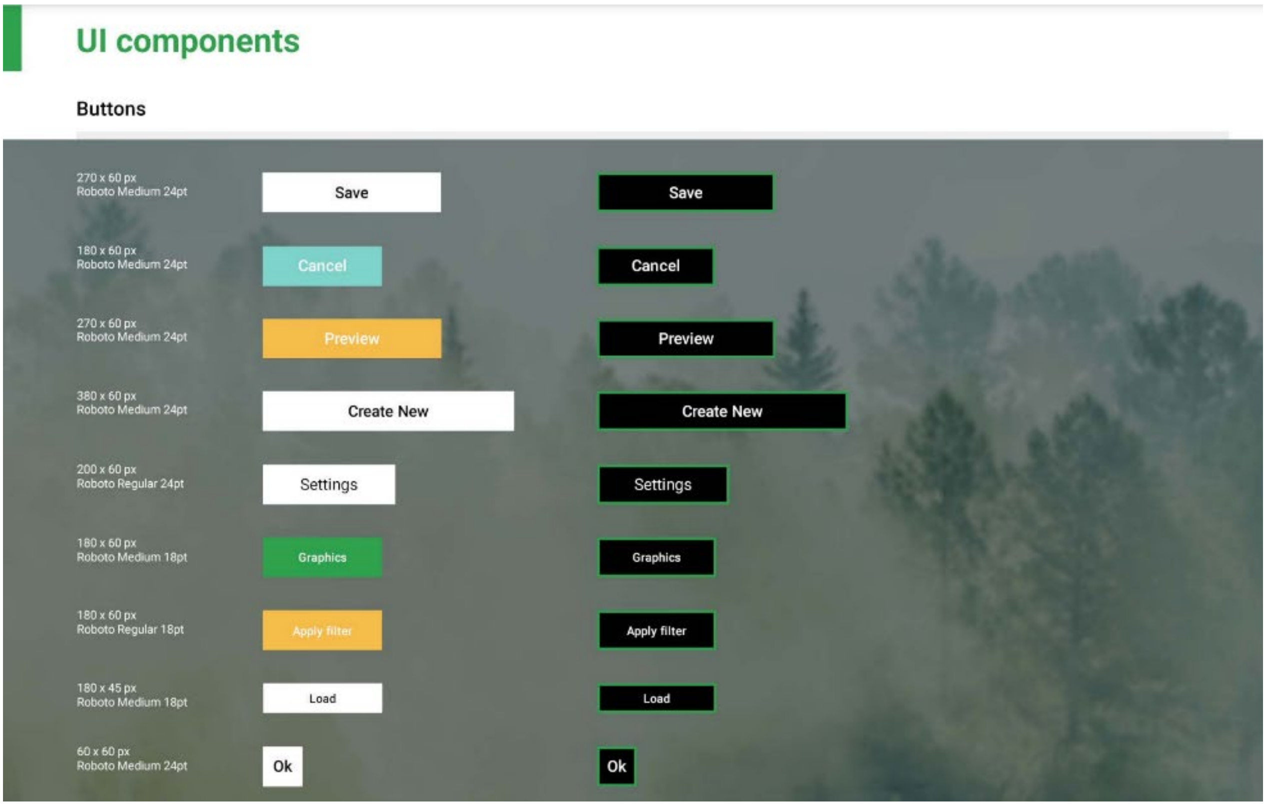


Figure 3 Buttons Specifications part 1

Figure 4 Button styles part 2

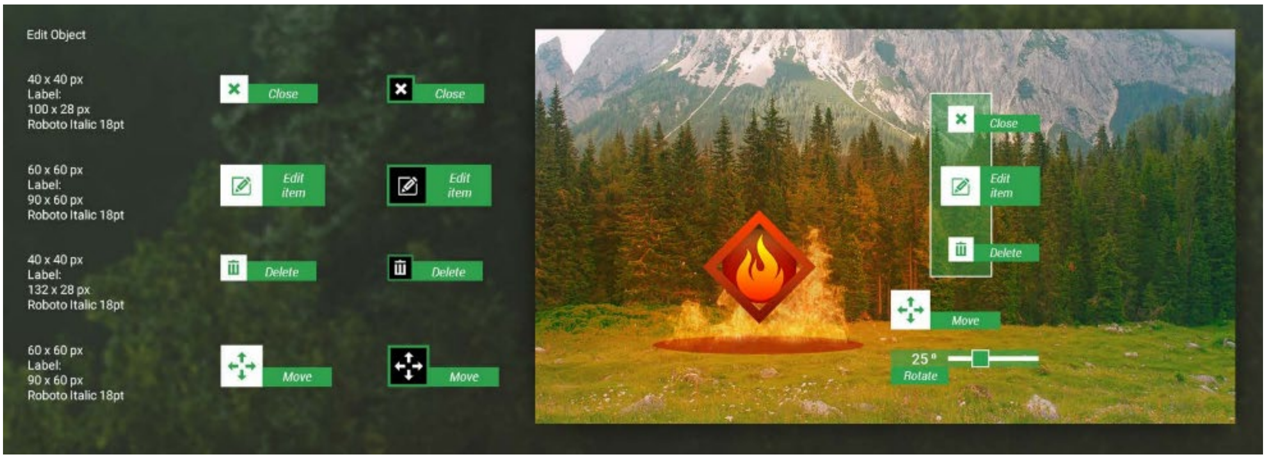


Figure 5 Button styles part 3

Icons are important in a GUI specification document because they can convey information quickly and efficiently without the need for text. They can help users understand the purpose or function of a button or feature at a glance, which can improve the user experience and make the interface more intuitive.

Icons can also make the GUI more visually appealing and easier to navigate. For example, using icons to represent different types of tools or equipment in a firefighting simulation can help users quickly identify and select the appropriate tool for a given situation. Additionally, using icons in place of text can reduce clutter and save space in the interface, making it easier for users to focus on the task at hand.

However, it's important to ensure that the icons used in the GUI are clear and easily recognizable. Icons that are too abstract or poorly designed can actually create confusion and hinder the user experience. Therefore, it's important to follow the same specifications as follows:

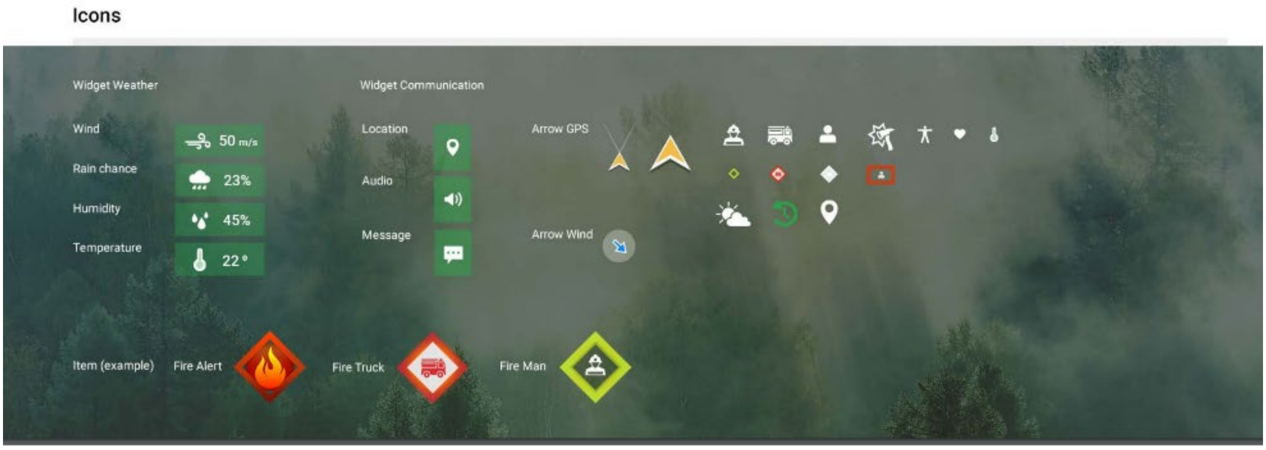


Figure 6 Icons specifications

Carousels specifications were defined because they provide an effective way to showcase multiple pieces of content or information in a limited amount of space. A carousel allows users to navigate through a set of images or content by clicking on buttons or swiping left or right.

Carousels are in our case because they can display different scenarios or training exercises that firefighters may encounter in the field. They can also be used to provide additional information or resources, such as safety guidelines or equipment manuals.

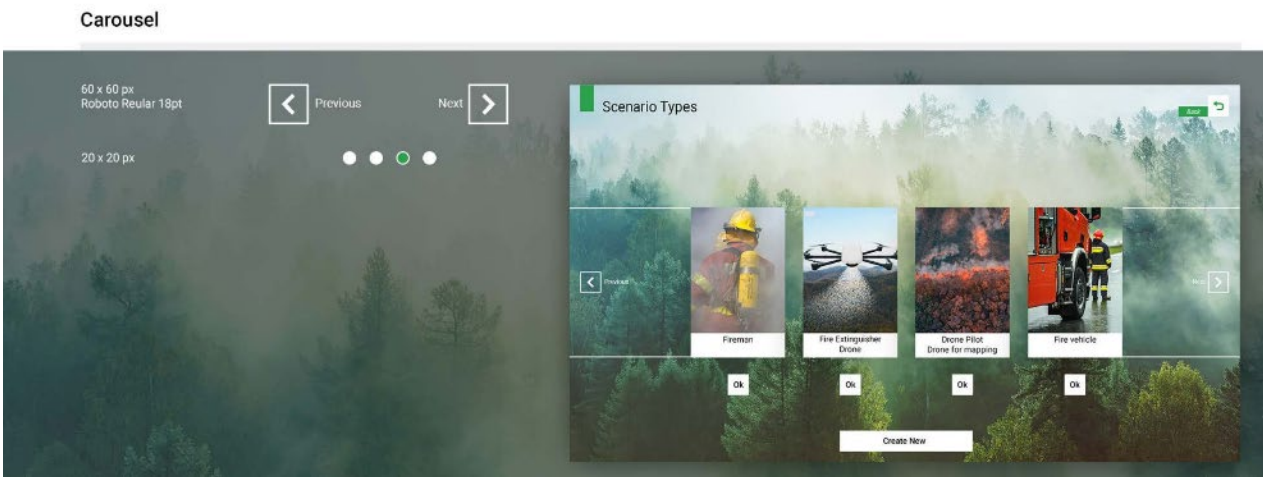


Figure 7 Carousel specifications

Dropdowns are important since they allow users to select one option from a list of many options. They are particularly useful when there are a large number of options that would otherwise clutter up the interface if they were all visible at once. By using a dropdown, users can quickly find the option they need without having to scroll through a long list.

In addition, drop-down lists can help to improve the usability of an interface by reducing the number of clicks required to select an option. For example, instead of having to navigate to a separate page or dialog box to select an option, users can simply select it from the dropdown menu on the current page. We considered defining the following specs:

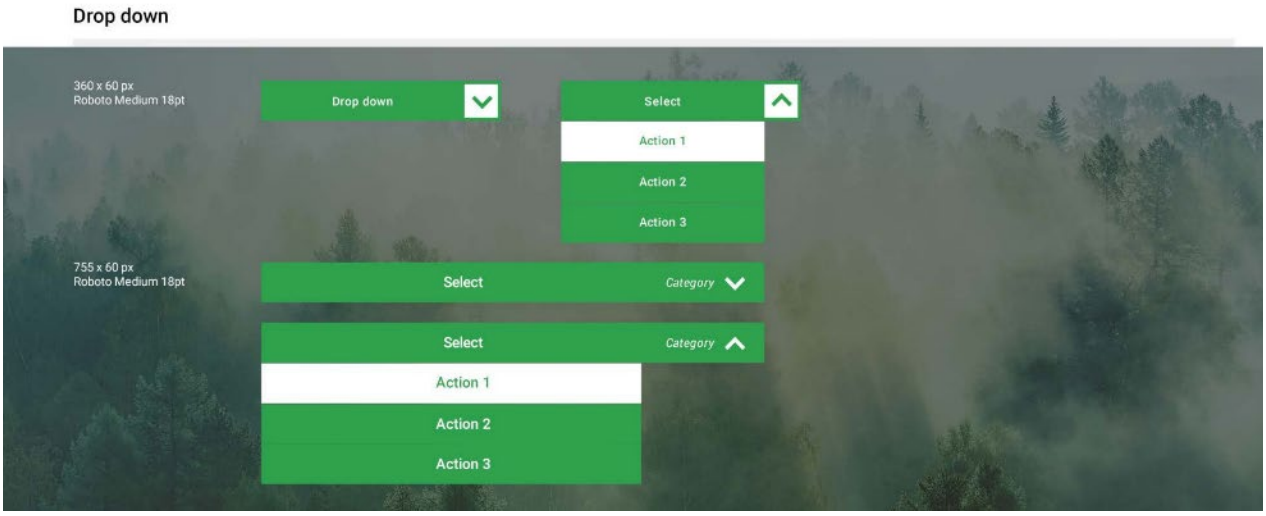


Figure 8 Drop-down lists

Sliders allow users to easily input and adjust numerical values. Sliders are commonly used in settings where precise adjustments are required, such as adjusting the level of graphics or volume of a system. They are also used where users can adjust image parameters such as brightness, contrast, or saturation. By dragging a slider handle, users can quickly and intuitively adjust the value of the parameter, without having to type in a numerical value. The sliders are also used when adjusting environment parameters.

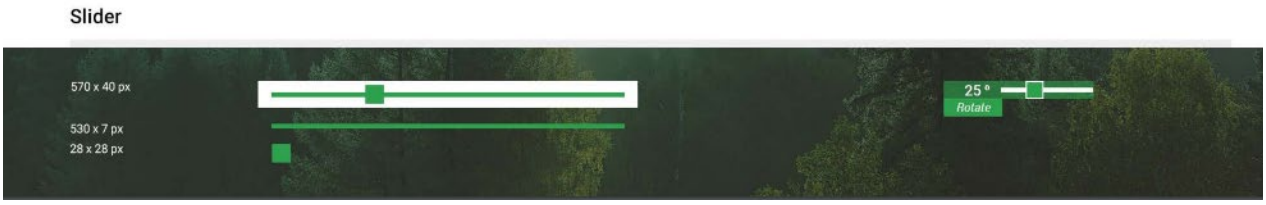


Figure 9 Sliders Specifications

Checkboxes and radio buttons allow users to select options or make choices in a visual and interactive way. Checkboxes are used to select one or more options from a list of choices, while radio buttons are used to select only one option from a list.

These elements are particularly useful when designing forms or settings pages, where users need to select from multiple options. Using checkboxes and radio buttons helps to simplify the user interface and make it more intuitive, as users can easily see all the available options and select the ones that apply to them.

In addition, checkboxes and radio buttons are often used in combination with labels to provide clear descriptions of each option. This helps to ensure that users understand what they are selecting and can make informed choices. The settings we defined for using the components:

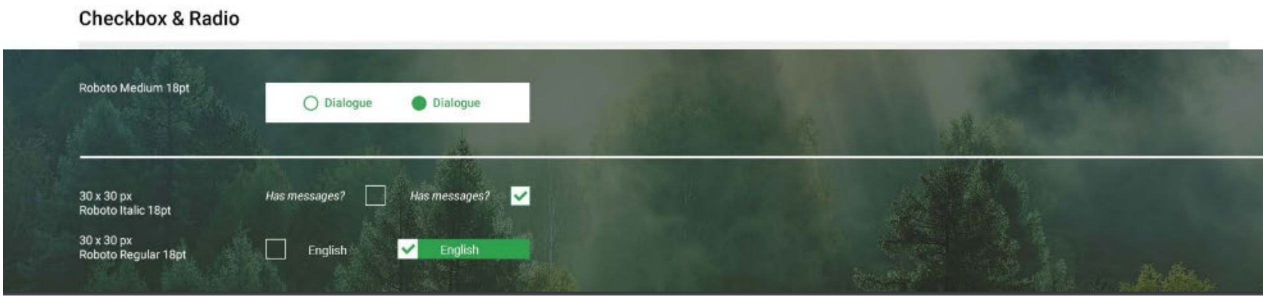


Figure 10 Checkboxes and Radio buttons specs

To ensure that the design and functionality of the interface are clearly communicated to the development team, as well as end-users, graphical examples of integrations have been designed and included.

By exemplifying the integration of the GUI we can avoid any misunderstandings or confusion that might arise from written descriptions alone. Graphical examples can help to speed up the development process by providing developers with a clear reference point for how each element of the interface should look and behave. This can help to minimize the need for back-and-forth communication between the development team and other partners, as well as reducing the likelihood of errors or misunderstandings during development.

Figure 11 Loading screen proposal

Figure 12 Login screen proposal

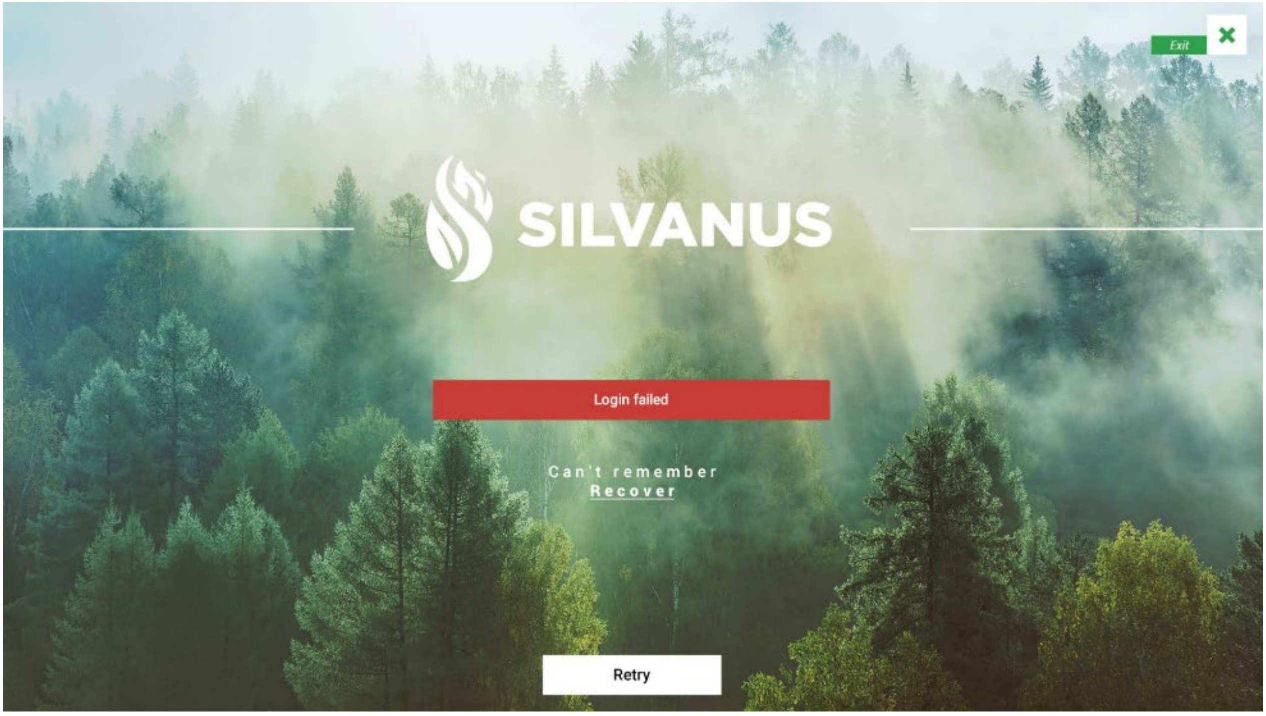


Figure 13 Failed login screen proposal

Figure 14 Register screen proposal

Figure 15 Main menu screen proposal

Figure 16 Main menu buttons

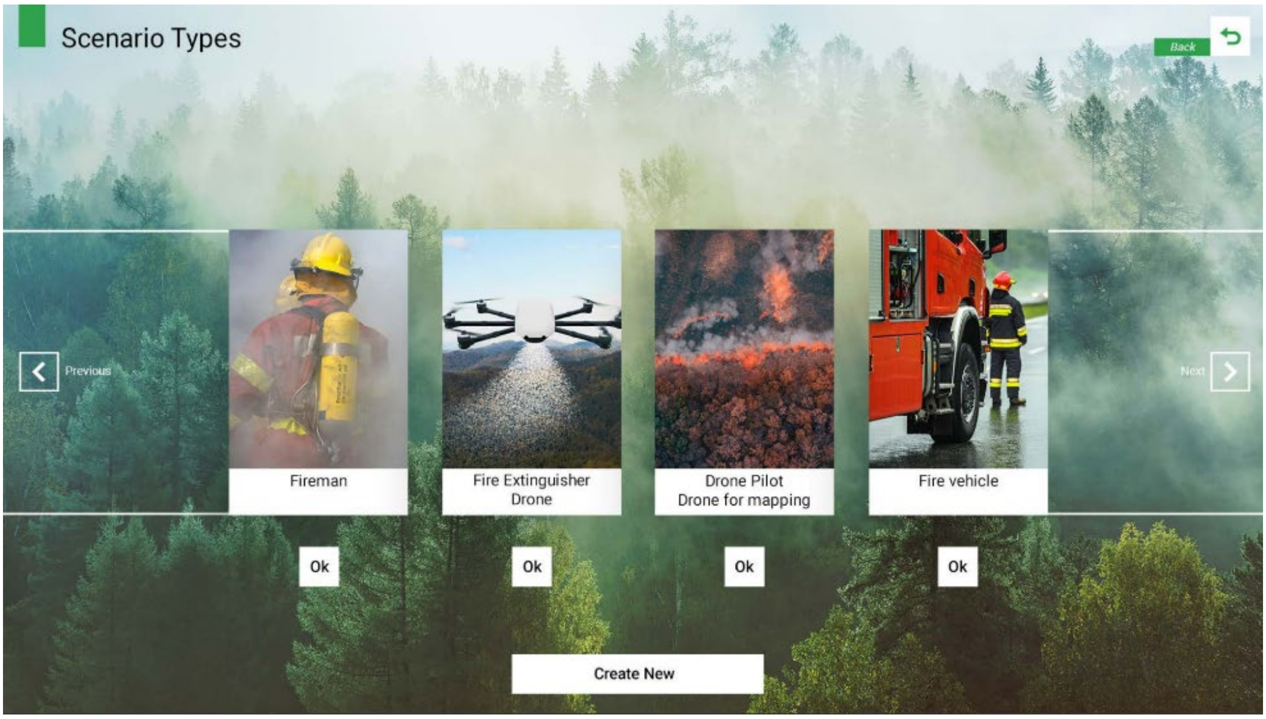


Figure 17 Scenario selector screen proposal

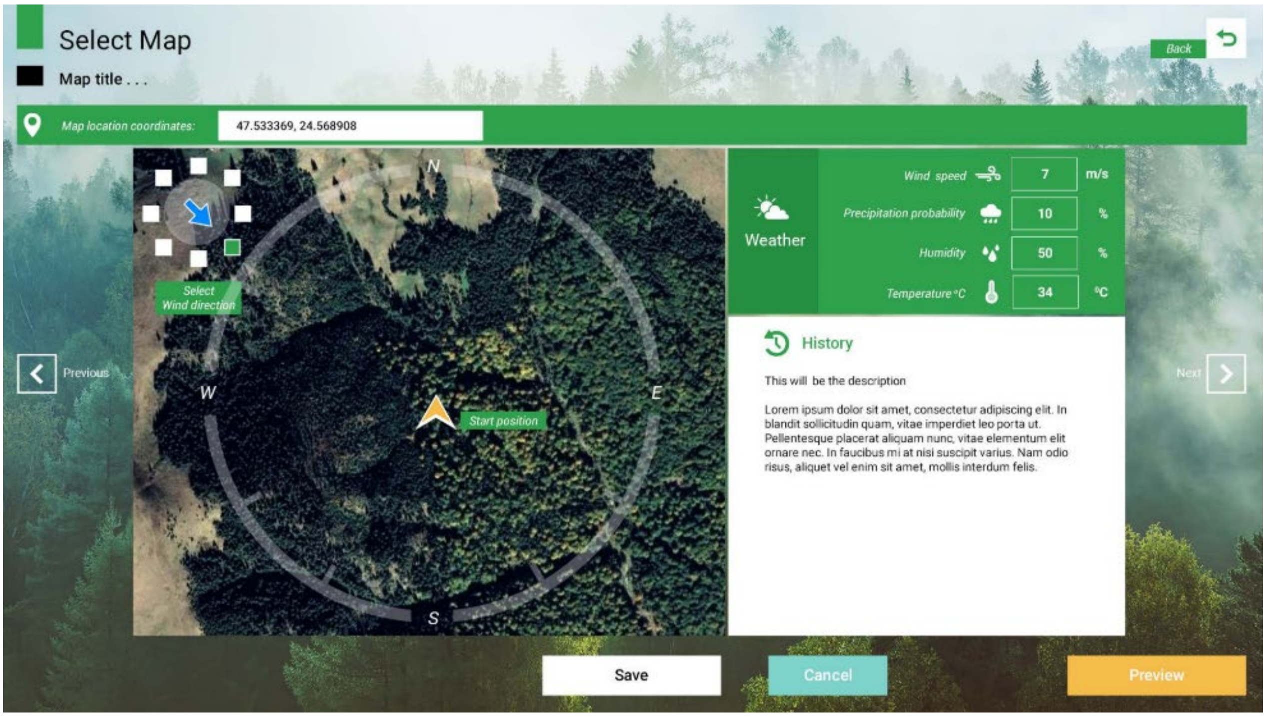


Figure 18 Environment customization screen proposal

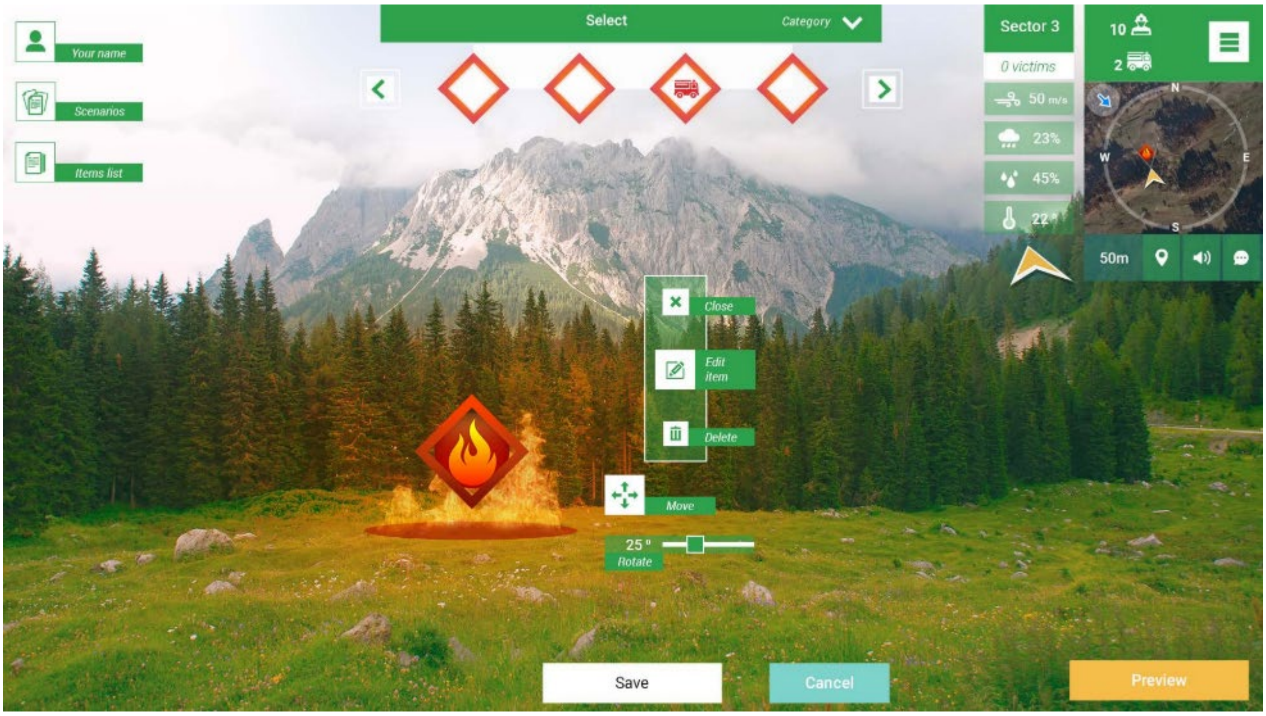


Figure 19 Authoring tool screen proposal

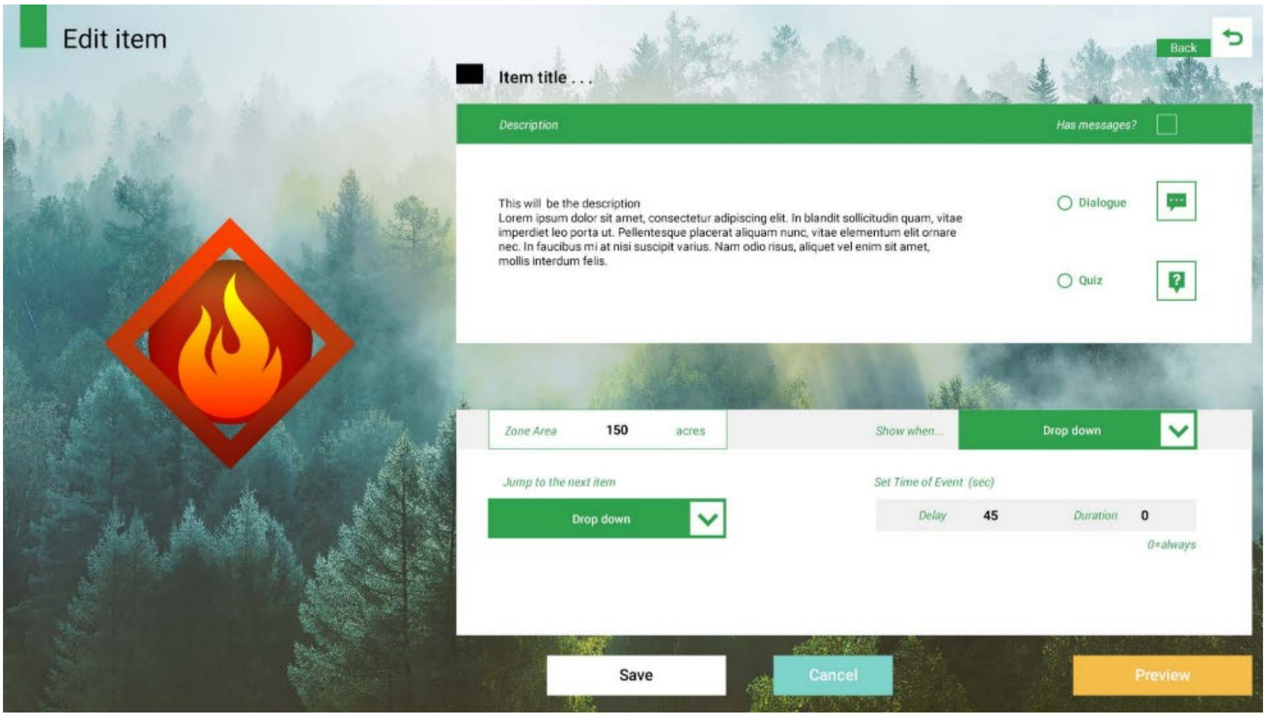


Figure 20 Object properties screen proposal

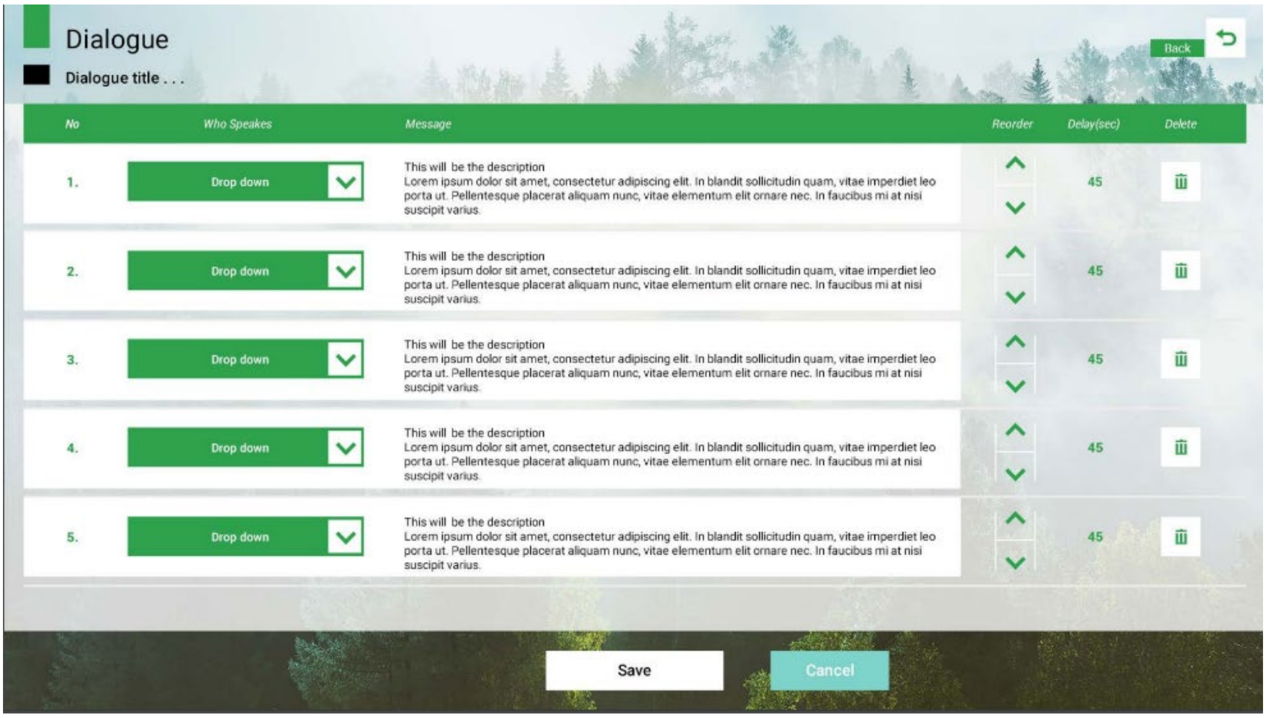


Figure 21 Dialogue editor screen proposal

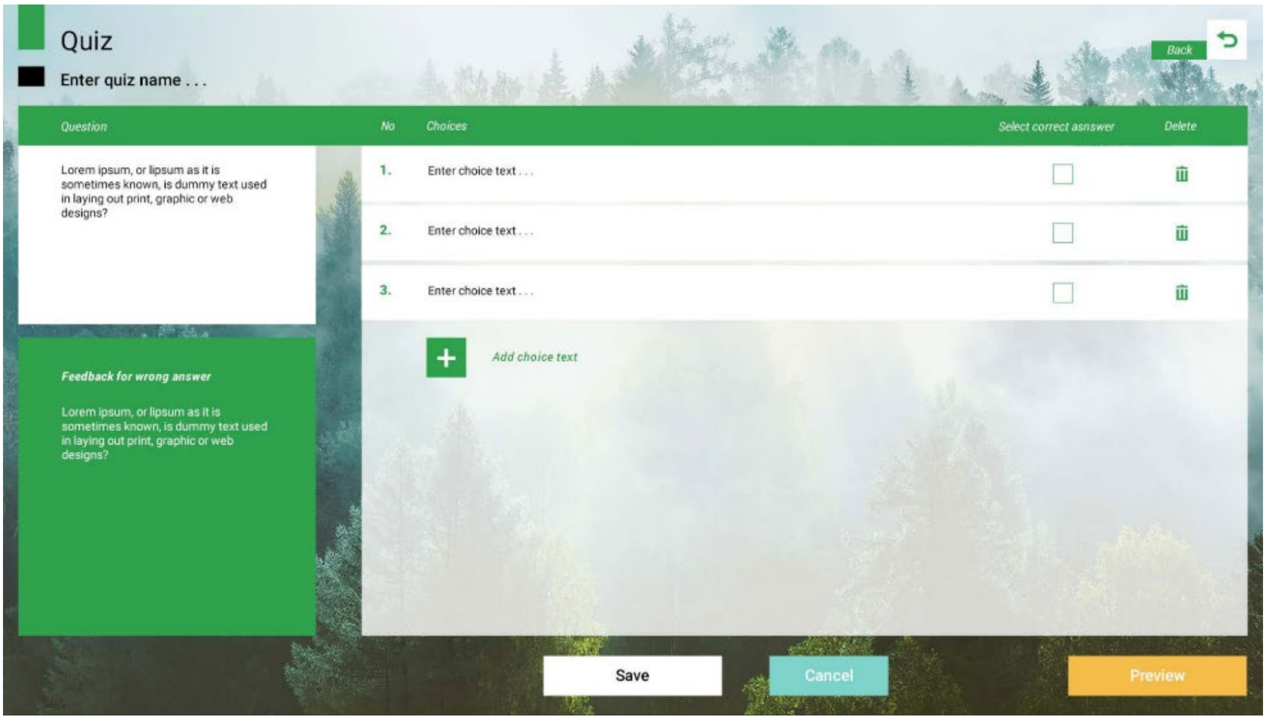


Figure 22 Quiz editor screen proposal

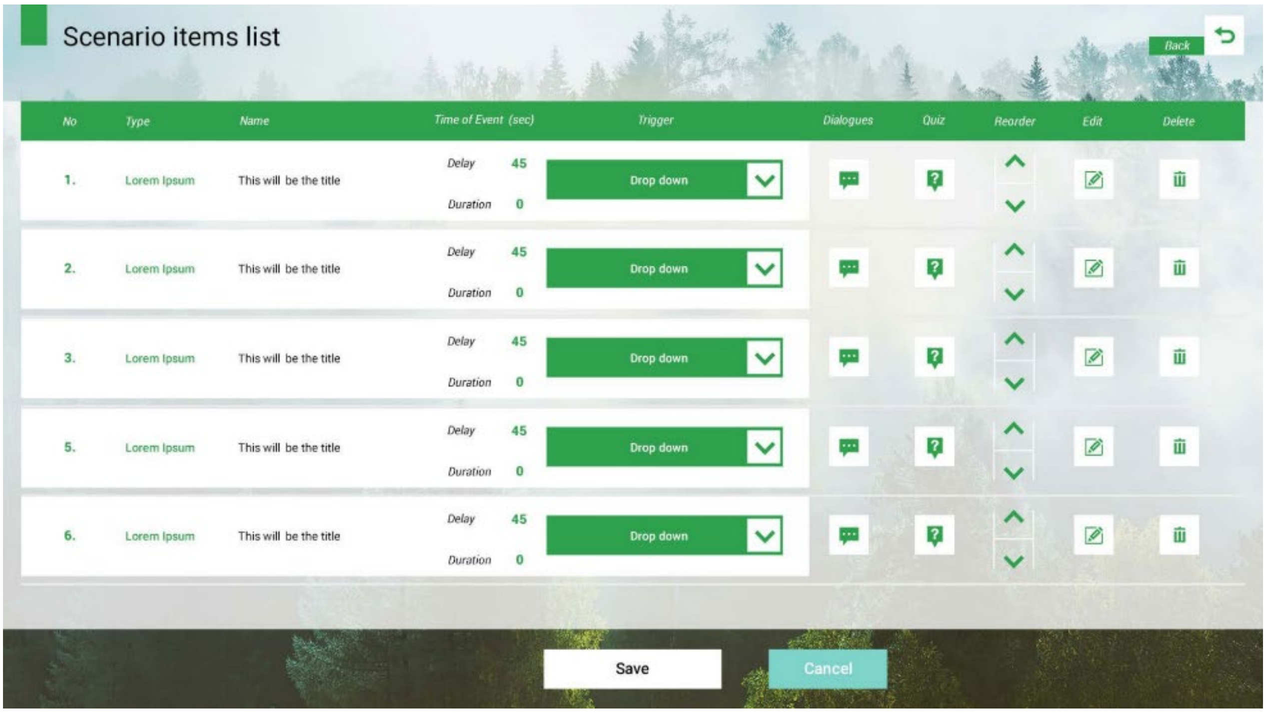


Figure 23 Scenario items screen proposal

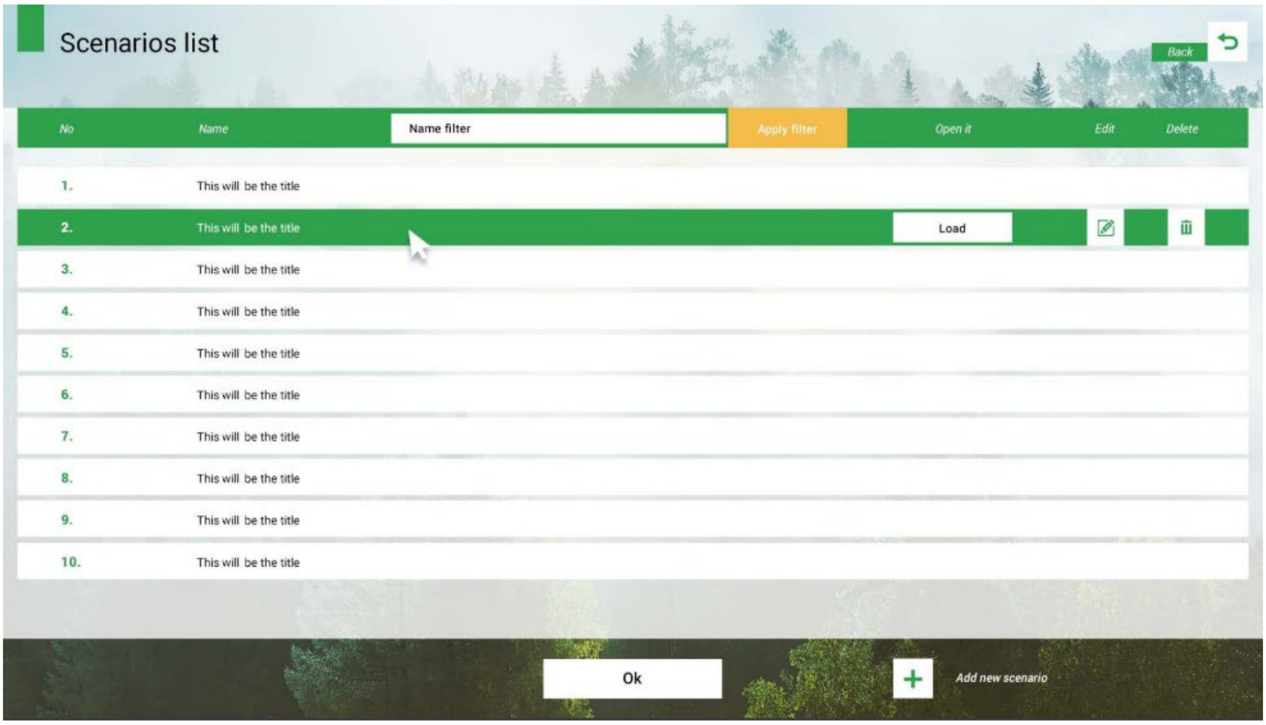


Figure 24 Scenario list screen proposal

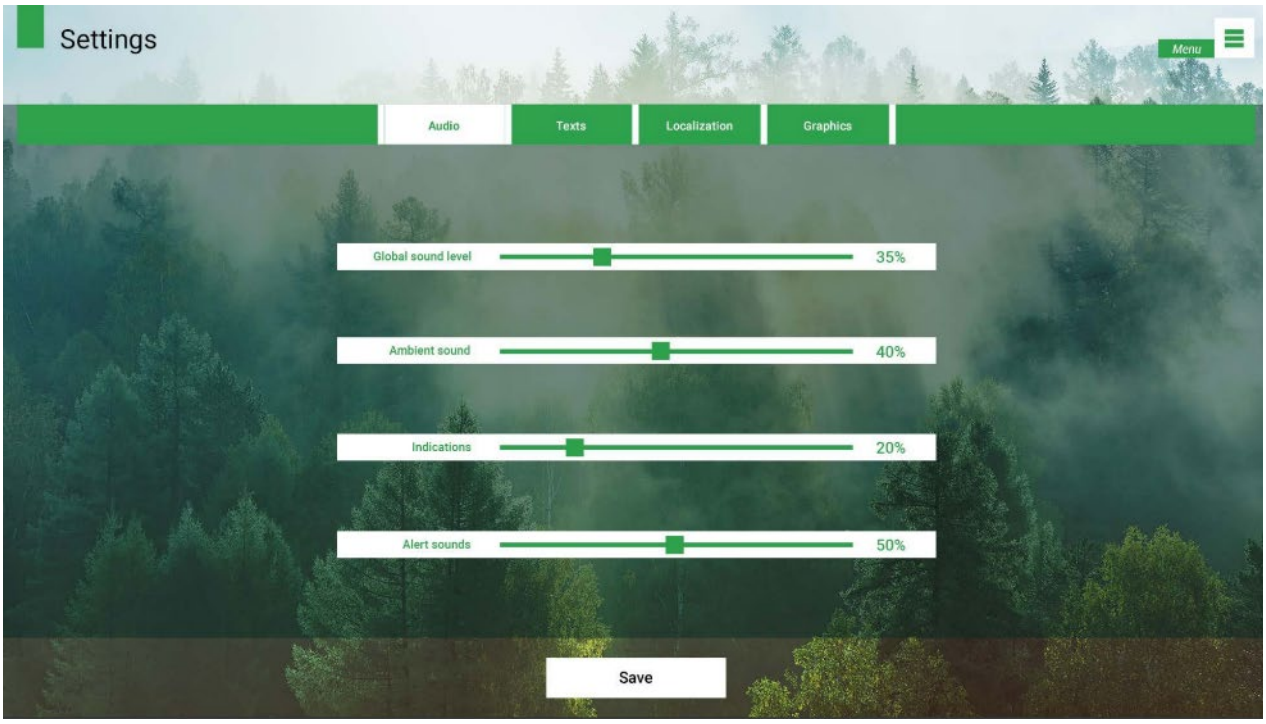


Figure 25 Audio Settings screen proposal

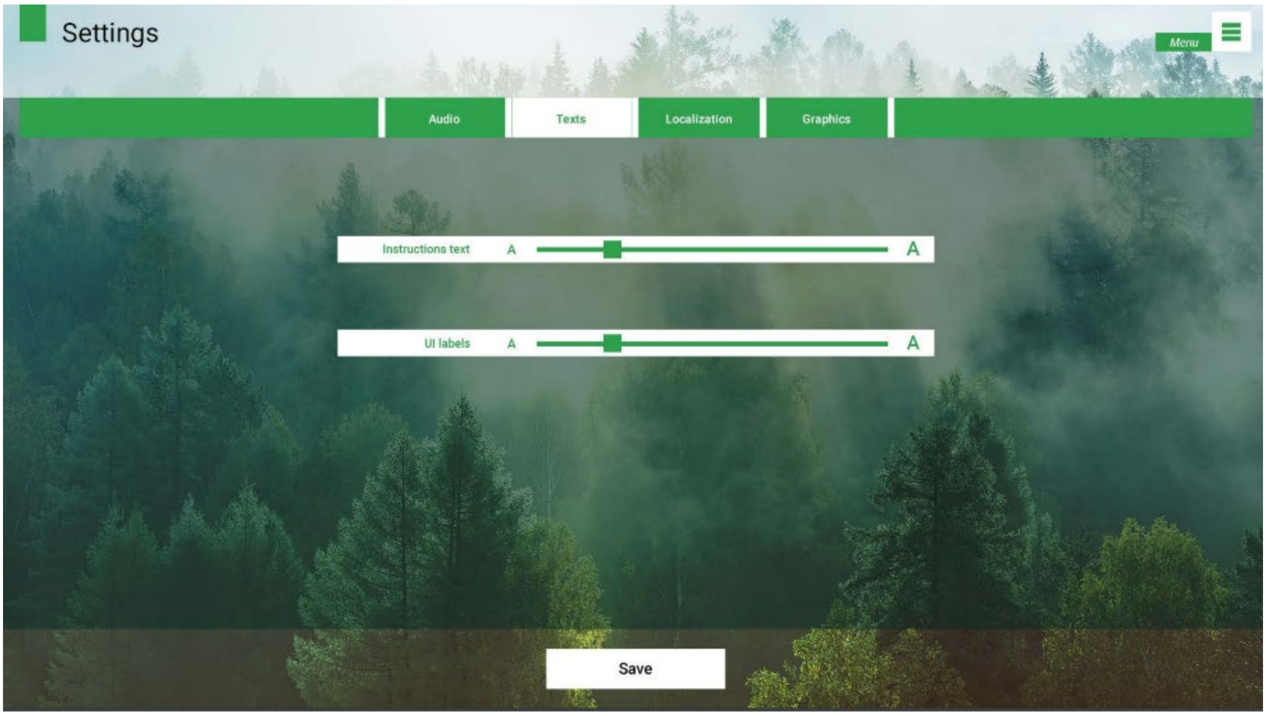


Figure 26 Text adjustment screen proposal

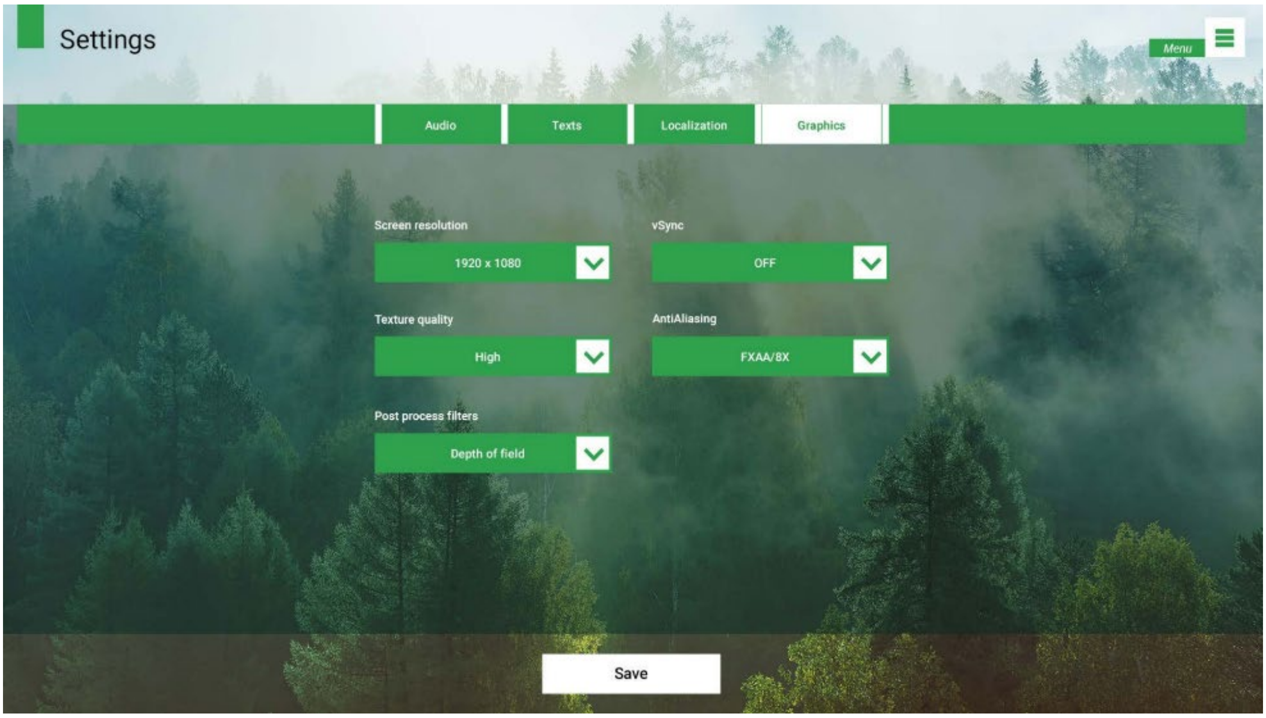


Figure 27 Graphics quality screen proposal

Development methodology

This section would describe the development methodology used for creating the VR simulator. It would cover the agile development approach and provide an overview of the requirements gathering, design, development, testing, deployment, and maintenance phases.

Agile development approach:

Agile development is an iterative and flexible approach to software development that emphasizes collaboration, feedback, and continuous improvement. We are using Kanban and Scrum for the programming and graphics team but all methodologies focus on delivering working software in small, incremental iterations.

We work in short sprints of two weeks during which we plan, develop, test, and deliver a working increment of the simulator. At the end of each sprint, we review the progress and present them to the partners in the WP meetings.

Requirements gathering and analysis:
The first step was to gather and analyze the requirements for the simulator. We went on field to gather information with ASFOR partner. It is important to identify their needs and priorities, and to develop a shared understanding of what the simulators should do.
The requirements gathering and analysis phase for firefighter training might involved conducting interviews with firefighters and training officers to understand their training needs and preferences.

Design and prototyping:
Once the requirements have been gathered and analyzed, the next step was to design the simlator and begin creating a prototype. This involves developing detailed designs for the user interface, game engine, physics engine, and other components of the system, and creating a working prototype that can be tested and refined based on user feedback.
We developed detailed wireframes and mockups of the user interface, and started modelling the initial 3D models of equipment and environment, and prototyping basic game mechanics for interacting with objects in the virtual environment.

Development and testing:
Once the prototype has reached an acceptable state, the next step was beginning developing the simulator core. This involves writing code, developing 3D models and textures, and integrating the various components of the system into a working whole.
Throughout the development process, test were performed regularly to ensure that it is functioning as intended. (testing individual components such as the game engine or physics engine, as well as testing the system as a whole to ensure that it is meeting the requirements)

During the development and testing phase for a Simulator detailed 3D models of equipment and environments are done, integrating realistic physics simulations for fire and smoke, and creating interactive scenarios that allow firefighters to practice skills such as search and rescue or ventilation. User testing has been planned with firefighters to ensure that the simulator is providing a realistic and effective training experience.

Deployment and maintenance:
Once the development and testing phases are complete, the final step is to deploy the simulator and make it available to firefighters. This means installing the system on the VR headsets.

Implementation
This section would cover the technical details of developing the VR simulator using Unity3D. It would describe the code structure and organization, scene design and modeling, integration with hardware and software components, and user interface design.

Overview of the Unity3D development environment:

Unity3D is a popular game engine that is widely used for developing virtual reality applications. It provides a range of tools and features that make it easy to create immersive and interactive VR experiences. The Unity3D development environment consists of a number of different components, including the Unity editor, scripting tools, asset store, and various third-party plugins.

Code structure and organization:

When developing our simulator using Unity3D, it is important to ensure that the code is well-organized and structured. This helps to make the code more maintainable and easier to extend. We use object-oriented programming (OOP) principles to structure the code into classes and modules.

Scene design and modeling:

Creating an effective and realistic VR simulator requires careful scene design and modeling. This involves creating 3D models of the environment, objects, and characters that will be used in the simulator. Unity3D provides a range of tools for creating and manipulating 3D models, including the ability to import models from external sources such as 3D modeling software. We used external resources for the modelling process (3D Studio Max and Blender for 3D modelling and Photoshop and Substance painter for texture creation).

Integration with hardware and software components:

In order to create a fully functional VR simulator, we developed on the hardware described in the requirements. The simulator is designed to nteract with motion sensors, controllers and other input devices. Unity3D provides a range of plugins and APIs for integrating with different hardware and software components.

User interface design:

The user interface (UI) design is an important aspect of developing a VR simulator, as it directly impacts the user experience. Unity3D itself provides a range of tools for creating UI elements such as buttons, menus, and HUDs (heads-up displays) but they are not enough. The UI design has been carefully planned and tested to ensure that it is intuitive and easy to use. The UI includes a menu for selecting different training scenarios, buttons for interacting with objects in the scene, and a HUD for displaying important information such as time remaining in the training session.

Functionalities of the simulator

This section describes the various functionalities of the VR simulator.

Firefighting Scenarios:

The VR simulator is designed to provide a range of firefighting scenarios that can be customized to meet specific training requirements. Scenarios are designed to simulate fires in different areas, not limited to what the on-site pilot will unfold. It includes various levels of complexity and danger. The scenarios are adjustable to simulate different weather conditions, such as high winds or rain.

Fire simulation:

Is necessary to provide a realistic and immersive training environment for firefighters, allowing them to practice responding to various fire scenarios without putting themselves in danger.

The fire simulation is created using physics-based algorithms that simulate the behavior of fire in different scenarios. This includes factors such as the type of fuel, oxygen levels, and temperature. The simulation takes into account the size of the fire, the intensity of the flames, and the speed at which it is spreading. This level of detail is essential for providing firefighters with an accurate representation of a fire scenario, which they can then use to train and develop their skills.

Figure 28 Forest fire

The fire visualization component is responsible for rendering the fire simulation in a way that is visually realistic and engaging for the user. This is done using particle effects, lighting, and textures. By providing an immersive visual experience, the firefighter can better understand the behavior of the fire and react appropriately to different situations.

Figure 29 Forest fire hazard

Even if the fire spread is not calculated in realtime (due to hardware limitations) the fire simulation would take into account the fuel source, the amount of oxygen available and the heat generated. As the fire grows in intensity, the simulation would enhance the spread of the fire throughout the forest, accounting for the trees involved. The fire visualization component would render the flames and smoke with particle effects and lighting.

Virtual Firefighting Tools and Equipment:

One of the key features of the VR simulator for firefighter training is the ability to simulate a range of firefighting tools and equipment in a virtual environment. This allows firefighters to practice using these tools and equipment in a safe and controlled environment, where they can learn how to use them effectively and efficiently.

The VR simulator includes a range of virtual firefighting tools and equipment, such as axes, hoses, nozzles, ladders, firetrucks and more. These tools and equipment are designed to behave and function as they would in real life, allowing firefighters to practice using them in a realistic and immersive environment:

Fire Extinguishers:
The VR simulator provides virtual fire extinguishers that can be used to simulate the process of extinguishing a fire. Different types of fire extinguishers such as water, foam, and CO_2 can be used based on the type of fire.

Figure 30 Fire extinguishers

Hose Operations:
The VR simulator allows the trainee to practice using a hose to extinguish a fire. The simulator provides a realistic representation of the water, flow rate, and spray pattern of a water hose.

Breathing Apparatus: The VR simulator simulates the use of a breathing apparatus that firefighters use in hazardous environments. The trainee can learn how to put on and operate the breathing apparatus as well as navigate through smoke-filled environments.

Figure 31 Breathing mask

Figure 32 Air tank

Axes and Halligan Bars:
The VR simulator provides virtual axes and halligan bars that can be used to break obstacles during the operations.

Figure 33 Various tools used by firefighters

Ladders:

The VR simulator simulates the use of ladders for rescue and firefighting operations. The trainee can practice extending, raising, and positioning ladders in a realistic environment.

Figure 34 Ladders for firefighters

Personal Protective Equipment (PPE):
The VR simulator includes virtual PPE such as helmets, boots, gloves, and turnout gear that the trainee can wear during firefighting operations.

Figure 35 Firefigthers PPE

Communication Devices:
The VR simulator includes virtual communication devices such as radios and walkie-talkies that can be used to communicate with other firefighters and dispatchers.

The virtual firefighting tools and equipment can be used in conjunction with the fire simulation and visualization features of the VR simulator, allowing firefighters to practice responding to a range of fire scenarios with a variety of tools and equipment. This can help improve their skills and confidence when responding to real-life firefighting situations.

In addition to traditional firefighting tools and equipment, the VR simulator can also simulate the use of cutting-edge technologies such as drones.
There is actually a role designed for drone operation. The role of the drone operator is to to gather information about the fire incident and assist with search and rescue operations in hazardous environments.

Overall, the Virtual Firefighting Tools and Equipment functionality of the VR simulator provides firefighters with a safe and effective way to practice using a range of firefighting tools and equipment in a realistic and immersive environment. This can help improve their skills, confidence, and preparedness when responding to real-life firefighting situations.

Communication and Coordination

The VR simulator provides training in communication and coordination skills that are essential for firefighting operations. Firefighters can practice communicating effectively with each other using virtual communication devices and can practice coordinating their actions during firefighting operations.

The simulator incorporates live audio communication features to help improve cooperation and coordination skills, such as realistic radio communication, team collaboration.

The virtual communication tools enable trainees to use radios and headsets to communicate with their team members during a fire simulation. The communication system is designed to mimic real-world scenarios, and trainees must use clear and concise language to convey information effectively. This feature helps firefighters to develop their communication skills and learn how to relay critical information quickly and accurately, minimizing errors that could lead to potential safety hazards.

The VR simulator also includes collaboration tools that enable firefighters to work together seamlessly to address the situation. Trainees can work together to perform tasks such as advancing a hose line or conducting search and rescue missions. These features help foster teamwork and build camaraderie among trainees, which is essential in the firefighting profession.

In addition, the simulator includes features that help trainees develop their leadership skills. Trainees can take on different roles, such as incident commander, to learn how to manage an emergency response effectively. These roles provide trainees with the opportunity to practice decision-making, delegation, and other leadership skills.

Hazard Recognition and Response

The VR simulator provides training in hazard recognition and response skills that are essential for firefighting operations. Firefighters can practice identifying and responding to potential hazards, such as smoke and heat, and can practice making quick decisions in high-pressure situations.

This functionality aims to enhance the situational awareness of firefighters, and train them to quickly identify potential hazards and respond appropriately. In the simulator, firefighters are presented with a range of scenarios that include various hazards such as fire, smoke, explosions, and collapsing trees.

The hazard recognition and response training feature includes a number of tools and techniques that firefighters can use to identify and respond to potential hazards. The simulator provides virtual sensors and detectors that can be used to monitor conditions such as temperature, smoke density, and gas concentration. These sensors can help firefighters quickly identify potential hazards and take appropriate action.

Another important aspect of hazard recognition and response training is developing the ability to communicate effectively with other members of the firefighting team. The VR simulator will provide step-by-step training on how to use radios and other communication devices to maintain contact with other team members, as well as how to relay critical information such as the location of potential hazards and the status of trapped victims.

By providing realistic hazard recognition and response training, the VR simulator can help firefighters develop the skills and confidence they need to respond effectively to real-life emergencies. With this training, firefighters can minimize risks to themselves and others, and improve their overall effectiveness in the field.

Situational Awareness

Simulator is designed to provide training in situational awareness skills that are essential for firefighting operations. Firefighters can practice monitoring their surroundings and identifying potential hazards and can practice maintaining situational awareness even in high-pressure situations.

It involves understanding the environment, identifying potential hazards, and being aware of one's own capabilities and limitations. In the VR simulator, situational awareness is achieved through the use of realistic visual and auditory cues, as well as other sensory feedback, such as vibrations in the haptic controllers.

We will simulate reduced visibility, making it difficult to see potential hazards. The simulator may also produce sounds that replicate the noises heard in a real fire, such as the sound of flames or the collapse of trees. By experiencing these realistic sensory cues, firefighters can develop their situational awareness skills and learn to quickly identify potential hazards.
With this technology, firefighters can look around and get a complete picture of their surroundings, which can help them identify potential hazards that may be out of their line of sight.

Critical Decision Making:

The VR simulator provides training in critical decision making skills that are essential for firefighting operations. Firefighters can practice making quick and informed decisions in high-pressure situations and can practice evaluating different options and selecting the best course of action.

The simulator includes various scenarios with different levels of complexity and risk, and trainees are presented with various challenges that require them to make quick and accurate decisions.

One of the key features of the simulator is the use of artificial intelligence to generate realistic fire behavior, which is based on various factors such as fuel type, ventilation, and fire size. Trainees must use their knowledge of fire behavior to make critical decisions such as where to approach a burning tree, how to navigate through smoke-filled areas, and when to call for backup.

Trainees are required to communicate with their team members, report on their progress and the situation at hand, and make decisions that take into account the safety and wellbeing of everyone involved.

To further enhance the development of critical decision-making skills, the simulator also includes a debriefing system that provides trainees with feedback on their performance. After each scenario, trainees are able to review their actions and decisions, receive feedback on areas for improvement, and reflect on how they could have made better decisions.

Real-time Feedback and Performance Metrics:
Real-time feedback and performance metrics help firefighters track their progress and improve their skills. The simulator will be able to collect feedback on a firefighter's response time, decision-making skills, and communication skills. This feedback can then be used to improve future training sessions and identify areas for improvement.

Real-time feedback and performance metrics are crucial elements in any training program, and the VR simulator for firefighters developed in Unity3D is no exception. In order to effectively train firefighters and evaluate their progress, the simulator provides real-time feedback and performance metrics.

The real-time feedback system provides immediate responses to the actions of the firefighter, allowing them to adjust their approach in real-time based on the feedback received. This helps to improve their decision-making skills and situational awareness.

In addition, performance metrics are used to evaluate the firefighter's performance during the simulation. These metrics are tracked throughout the simulation and can be viewed by a trainer or the firefighter at the end of the session. Metrics can include factors such as the time taken to complete the simulation, the number of correct responses, and the efficiency of the firefighter's actions.

The real-time feedback and performance metrics system allows for a comprehensive evaluation of the firefighter's skills and abilities during the simulation. The trainer can use this information to identify areas where the firefighter needs improvement and adjust the training accordingly.

Accessibility:
The VR simulator must be accessible to firefighters regardless of their location or time constraints. Firefighters can access the simulator from their own vr devices, and can train at any time that is convenient for them. This accessibility increases the frequency and effectiveness of training sessions and ultimately leads to better-prepared firefighters.

In this context, accessibility refers to how easy it is for firefighters of different physical abilities to use the simulator.

An aspect of accessibility is designing the user interface in a way that is easy to use and understand for all firefighters. This includes considerations such as font size, color contrast, and audio cues for those with hearing impairments. The user interface should also be designed with clear instructions and feedback to ensure that all firefighters can use the simulator effectively.

Cost-effective Training

The VR simulator provides a cost-effective alternative to traditional training methods. Since we are specialized in eLearning solutions we understand that traditional training methods can require expensive equipment, such as fire trucks and firefighting gear, and can require time-consuming travel to training facilities. The VR simulator eliminates these costs and allows firefighters to train from their own devices, ultimately saving time and money.

Cost-effective training is a crucial factor in any organization's decision to adopt new training methods. Traditional training methods often involve large capital investments in terms of equipment, space, and personnel. However, VR training eliminates these expenses by providing a platform where trainees can receive immersive training that simulates real-life scenarios at a fraction of the cost of traditional training methods.

Moreover, VR training provides the opportunity for repetitive training, which can be difficult and expensive to achieve in traditional training methods. Trainees can repeat scenarios as many times as necessary to gain proficiency, without incurring additional costs. This is particularly useful for hazardous scenarios that are difficult to replicate in real life.

Another benefit of VR training is that it reduces the cost of travel associated with traditional training methods. Trainees can access VR training from anywhere with an internet connection, eliminating the need to travel to a specific location for training. This is particularly beneficial for fire departments in rural areas, which may have limited access to training facilities.

Furthermore, VR training can be easily updated to reflect changes in procedures, equipment, or regulations. Traditional training methods require the production and distribution of new training materials, which can be time-consuming and costly. VR training allows for quick and easy updates to be made, ensuring that trainees are always receiving the most up-to-date training.

Scalability:

The VR simulator is scalable and can be customized to meet the specific training needs of different firefighting organizations. Small rural fire department as in the Romanian pilot may have different training needs than a large urban fire department. The VR simulator can be customized to provide training that is relevant and effective for each fire department.

The simulator can be customized to include different scenarios and levels of difficulty to meet the needs of various skill levels and experience levels. This allows new firefighters to learn the basics in a safe and controlled environment, while more experienced firefighters can use the simulator to practice more complex techniques and strategies.

In addition, the VR simulator can be easily accessed from anywhere with an internet connection, allowing firefighters to train remotely and reducing the need for expensive travel and logistical arrangements. This scalability also allows multiple firefighters to train simultaneously in the same virtual environment, providing a more realistic training experience and fostering teamwork and collaboration.

Simulator Modules

This section would describe the different modules of the VR simulator, including the fire behavior module, firefighting module, navigation module, communication module, and scenario module. Each module would be described in detail, including how it contributes to the overall functionality of the VR simulator.

Fire behavior module

The Fire behavior module is a component in the VR simulator for firefighters that simulates realistic fire behavior. This module uses computational fluid dynamics (CFD) to model the flow of smoke, heat, and gases within a simulated environment. This simulation takes into account various factors such as the size and shape of the space, the type and quantity of fuel present, and the ventilation available.

The Fire behavior module can simulate the various stages of a fire including the ignition, growth, and decay stages. It can also simulate the different types of fires that firefighters might encounter such as structural fires, wildland fires, or industrial fires.

The module can also take into account the impact of firefighter actions on fire behavior. For example, if a firefighter opens a door or window, it can change the flow of air and impact fire behavior. Similarly, if a firefighter uses a fire extinguisher or hose, it can impact the spread of the fire.

The Fire behavior module can provide firefighters with a more realistic training experience by simulating real-world scenarios that they may encounter. It can also be used to help firefighters understand the underlying physics and dynamics of fire behavior, which can improve their decision-making skills in the field.

Firefighting module

A firefighting module is a key feature of VR simulators for firefighters, providing trainees with an opportunity to practice essential firefighting skills in a realistic and safe environment. This module often includes a variety of scenarios that require the use of firefighting equipment and tactics.

One key aspect of the firefighting module is the inclusion of interactive fire behavior, which we discussed earlier. Trainees can observe and respond to changes in fire behavior as they occur, allowing them to develop critical decision-making skills and situational awareness.

The firefighting module may also include simulations of various types of fires, such as structural, wildland, or vehicle fires, each requiring specific techniques and equipment to be used. Trainees can practice techniques such search and rescue, hose line deployment, and nozzle operation.

The firefighting module also includes virtual firefighting equipment, that respond realistically to user input. Trainees can practice using this equipment in various scenarios to develop muscle memory and improve their response times.

Finally, the firefighting module may also include virtual teammates, such as other firefighters or incident commanders, with whom trainees must communicate and coordinate their actions. This allows trainees to practice teamwork and communication skills that are essential to firefighting operations.

Scenario module

Allows firefigthers to move through and explore the virtual environment. This module is crucial for firefighters to practice and hone their navigation skills, as well as learn to navigate new or unfamiliar environments.

The navigation module typically includes a variety of features to enhance the user experience, such as:

- Movement options: Users can choose from different movement options such as teleportation, smooth locomotion, or a combination of both.
- Map and compass: The module includes a map and compass to help users orient themselves and navigate through the environment.
- Points of interest: The module may include various points of interest such as exits, hazards, or areas where additional resources are available.
- Object manipulation: Users can interact with objects in the environment to gain access to new areas or move obstacles out of the way.
- Realistic environment: The virtual environment is designed to be as realistic as possible, with accurate lighting, sound, and physical characteristics.

7 Fire ignition models related to training and preparation of wildfire response

7.1 Introduction

In the SILVANUS project, task T3.2 is responsible for developing fire ignition models which will be a key asset for the preparation of the response against wildfires. The task pursues three main outcomes: analysing frequency and probability of fire occurrence in the SILVANUS pilots, determine which factors most influence fire occurrence and create an easy visualization tool for the results for a greater reach. Predicting in advance the risk zones of fire can be a tremendous advantage in preparation for wildfires. Moreover, understanding the factors leading to forest fire ignition can be very important for preventing fires from happening in the first place or limiting the extent of the damage caused by fires. Thus, Task T3.2 is developing tools to statistically model forest fire ignition and help with pre-planning activities in an intuitive and visual way.

7.2 Negative Binomial Hurdle Model

Fire occurrence is a relatively infrequent event but with an enormous impact when it happens. For this reason, classical statistical distributions do not usually fit the data in a satisfactory way. However, there are distributions specifically designed to overcome challenges of this nature. One family of such distributions are the hurdle models, and one member of the family is the Negative Binomial Hurdle Model that has been selected for the SILVANUS project.

A hurdle model is a statistical model that consists of two parts: a classifier that is designed to deal with the zero values that are over-represented in the data source and a part to deal with the non-zero positive values. For the Negative Binomial Hurdle, a truncated negative binomial distribution is used to deal with the non-zero positive values. For the SILVANUS project, a Naïve Bayes classifier has been selected to deal with the zero values.

Several methods of classification have been tried before deciding on the Naïve Bayes classifier since it performed the best on the available data. Different classifiers might be used in the future if they perform better whenever more data is received.

A Naïve Bayes classifier is a relatively simple example of a classifier based on the Bayesian statistics approach. They are also an example of a supervised machine learning algorithm since a special target variable is always present in the data model. In the case of the current task, the target variable is 0 if a fire did not occur and 1 if a fire did occur in the relevant timeframe.

The negative binomial regression is a type of distribution designed to deal with "count" variables i.e., positive integer variables. Each entry that enters the regression part has a "count" variable associated with it that measures how many times an event happened in that entry. For the case of the SILVANUS project, the "count" variables consist of the number of fires in a certain area in a period of time, 1 month to be more precise.

A previous study concerning the regions of Sardinia, Apulia and Catalonia has been made to examine fire occurrence in these regions using a Negative Binomial Hurdle Model. In the SILVANUS project, one of the aims is to use the same methods to examine fire occurrence in the pilot regions. However, the significant

differences in the particularities of the regions, the biggest of which is the size of the region, lead to important changes in the methodology.
Knowing probable location of fire occurrence is vital for preparation of the response against wildfires. The model developed in task T3.2 will fulfil this need by providing information on fire probability and fire frequency in each region of the pilot sites. Authorities of the pilot sites involved in the project will be informed the risk regions from their pilots and will be able to concentrate response to these area in any way they see fit.

7.3 Dataset and variable analysis

One of the main outcomes of the task relates to examining the correlation between some factors and fire occurrence. Collaboration with relevant authorities in Romania, the available data from the different pilots involved in the SILVANUS project, general literature review and the example of a previous similar study has led to the selection of several variables to use in the statistical modelling.

All the data used for the analysis originates either from Task T2.5 in the SILVANUS project who works directly with the pilot sites, from the pilot sites themselves or from open-source data sources like the Copernicus programme. Considering what data comes from Task T2.5, the model will only examine data from the years 2012-2021. Task T2.5 is responsible for cataloguing fire occurrence in the pilot sites with some data such as location, time, cause being the main focus. This data must be supplemented with information about the climatic factors involved, the topography of the terrain, landscape, anthropic etc. which originate from other sources. All data related to a fire occurrence is then aggregated.
The data is then manipulated to fit in standard template in CSV format and fed to the Python implementation of the model. At the moment, manual manipulation of the data is needed but work is being done to automate the process using an intermediary backend. A common data model is being developed but the constant influx of new data in different formats and with different available fields changes the model quite frequently.
All the data is split in entries, each entry being only for one region and one specific time period. For time, a period of one month allows each entry to have enough occurrences to model a proper negative binomial distribution, but the data also seems to fit the classifier to achieve good results.
For the region part, the Slovakian pilot was split in 16 regions, which are as follows: Detva, Hriňová, Podkriváň, Zvolenská Slatina, Stožok, Vígľaš, Kriváň, Dúbravy, Stará Huta, Korytárky, Klokoč, Slatinské Lazy, Detvianska Huta, Horný Tisovník, Látky, Očová. For the Greek pilot, 3 regions were identified: D. Istiaias – Aidipsou, D. Mantoudiou - Limnis – Agias Annas si D. Dirfyon – Messapion. A further refinement of the regions will be necessary for the Greek pilot since each region contains too many incidents. The current version of the region selection is done based on the closest municipality.

For climatic variables, the most important data to gather consists of temperature, level and frequency of precipitations and lack thereof in the form of number of dry days. All this information is gathered from open-source data sources after determining the appropriate meteorological station after consulting maps or information from the pilot sites.
However, climatic data does not vary significantly between different regions of the same pilot site due to the relatively small size of the sites. Thus, this data is more relevant for differentiating between different pilot sites rather than determining which zone in one site is more prone to fire ignition.

For topographic variables, altitude and slope are the selected variables. This data will be extracted from topographical maps of the pilot sites or from open-source data available.
One of the more important aims for the task is examining the impact of the anthropic element on fire ignition. Some data such as population, population density, distance from major urban settlements, distance from roads will be used. This data is gathered from online sources as well as from maps provided in the SILVANUS project. The anthropic data is crucial for the statistical analysis since the previous study has identified these variables as significantly correlated with fire occurrence.

Landscape data is very relevant as well. Since the SILVANUS project concerns itself with forest fires in particular and the pilot sites are in heavily forested areas in some cases, differentiation based on type of vegetation was chosen as the main landscape drivers in the data. For each region of the pilot sites, percentages for each type of vegetation are calculated and input in the CSV files following the template.

Maybe the most crucial data variables are related to the cause of forest fire ignition. Variables to model diverse fire occurrence causes like human negligence, power faults, arson and external weather conditions. From examining the data provided in task T2.5, the preliminary analysis shows the main cause of fire ignition to be human negligence, in particular from cigarettes, lighters and matchsticks. This result enforces the idea that anthropic factors are crucial for examining fire ignition and should influence preparation for wildfires.

Examining the correlation of all the variables described so far with the occurrence of fire ignition is a key element of the task within the SILVANUS project. The purpose of the analysis is to determine risk factors of fire ignition and consider what actions can be taken to ameliorate the risk whenever possible.
The dataset assembles all the previously mentioned variables in 2 CSV files, one for the classification part and one for the regression part. In both cases, there is a target column at the end, the fire occurrence for the classification and the number of fires for the regression.

As is standard practice for algorithms of this type, the dataset is split in training and testing data. Training data is data that the model uses to “learn” the pattern and is used to determine the parameters of the model. The testing data is used to check whether the models perform correctly and to prevent overfitting. Overfitting is a phenomenon in algorithms when the algorithm fits it parameters too well on the training data and is unable to perform properly on data that it did not have in the training data.

Currently, the prediction accuracy of classification hovers at 0.8878 on the training data and 0.8879 on the test data. The results being close on the training and testing data shows the model is not overfitting and the results are real. This result is expected to improve once data concerning other pilots is added since at the moment the statistical model is only based on data from the Greek and Slovakian pilots, but the value it currently has is considered satisfactory given the relatively low amount of data used (only data from 2012-2021 in two pilot sites in Greece and Slovakia). Other indicators such as AUC, RMSE, and the Pearson correlation coefficient will be used to further quantify the success of the statistical analysis.

There is not much that can be done on a local level concerning climatic or topographic factors, but knowing about the danger is still helpful in prevention or rapid responses to fire occurrence. Information about factors relating to vegetation can be used in the long term. Information about the human element can be crucial in dissemination campaigns or other policy designed to influence human behaviour relating to fire occurrence.

7.3 Visualization of results

The last key aspect of the task is the dissemination of the information discovered during the project. For this, a web-based platform will be developed to share some of the outputs. The key output for dissemination will be two maps for each of the pilot sites, one for probability of fire occurrence and one for frequency.

Examining long lists of fire probability can be cumbersome so the solution from the SILVANUS project improves accessibility of key information from both a speed and ease of access way. Viewing a map where key regions are highlighted saves time in situations that may be urgent.

The maps can be used for training purpose since the approach will be intuitive. Colouring will be consistent with standards so a viewer can easily discern the problem zones and determine the most efficient way of approaching the problem.

8. Concluding remarks and next steps

The deliverable presents the most relevant aspects and findings concerning the planning and delivery of training activities, at this stage of the project implementation. Significant work has been dedicated to collecting, processing and organizing the great amount of information and data, coming from theoretical, methodological, practical and operational sources.

Within the deliverable, a unitary approach has been proposed to depict the specific activities for planning and preparing the wildfire response, based on surveys for collecting relevant data and information about: i) training objectives and scope, ii) training forms and methods and iii) training materials.

A particular section is dedicated to the innovative approaches and modern technologies for implementing the training activities in SILVANUS, which describes the integration of AR/VR content to meet the training requirements of end-users. Moreover, the deliverable addresses the role of fire models in the training of first responders and preparation of wildfire response, as required in task *T3.2 – Forest fire ignition models*.

The deliverable D3.2 presents the preliminary aspects regarding the methodology of implementing the planning and delivery of training activities, which will be addressed in detail further in deliverable D3.4.

The current report proposes a logical and comprehensible structure that meets the requirements of Task 3.3; this structure will be updated and enriched with new information and findings about the preparation and pre-planning activities for wildfire response in the above-mentioned deliverable.

References

- D'Este, M., Ganga, A., Elia, M. et al. Modeling fire ignition probability and frequency using Hurdle models: a cross-regional study in Southern Europe. Ecol Process 9, 54 (2020). https://doi.org/10.1186/s13717-020-00263-4
- Neussner, O. (2021). Early warning alerts for extreme natural hazard events: A review of worldwide practices. International Journal of Disaster Risk Reduction, 60, 102295. https://doi.org/10.1016/j.ijdrr.2021.102295
- Gromek, P. (2021), "Strategic training and exercises for critical infrastructure protection and resilience: A transition from lessons learned to effective curricula", International Journal of Disaster Risk Reduction. https://scholar.google.pl/
- Deliverable D2.1 - Existing Sustainable Forest Management Services and Formalization of Functional requirements

APPENDIX 1: First Survey dedicated to preparation and pre-planning activities for wildfire response

Project Acronym	SILVANUS
Project Full Title	Integrated Technological and Information Platform for wildfire Management
Work Package	WP3 Culture of deterrence and prevention against wildfires
Task	T3.3 Preparation and pre-planning activities for wildfire response
Institution completing the survey	...
Person(s) who represents(-) institution completing the survey	1. ... 2. ...

Survey 1
Objectives and scope of training

Introduction (training assumptions)	The main objective of the survey method is to identify objectives and scope of training for fire services, forest services, UAV operators and public administration representatives involved in wildfire response. The training scope should cover operations to be carried out during first period after wildfire ignition, ascribing into early detection and communication of the hazard, immediate disposal of wildfire responders, comprehensive recognition of hazard situation (from ground and air), effective getting of the resources to the wildfire scene, firefighting tactics (including ensuring continuous access to water) and cooperation between entities fighting the fire. Special attention should be paid on use of modern technologies (including AR/VR) as well as best organisational, equipment and tactical solutions. The training should reflect specification (scope, technologies, stakeholders involved, detail issues etc.) of case studies described in SILVANUS Grant Agreement.

Complete the following table of information concerning objectives and scope of training corresponding to assumptions mentioned in the Introduction.

Phases of wildfire response	Objectives* of the training	Scope** of the training
1. Early detection and communication of the hazard *Technical detection, auto-detection, detection from*	… *Example:* *1. To acquaint wildfire responders with early detection system <<Name of the system>>*	… *Example:* *1. Scheme and description of early detection system <<Name of the system>>. General detection procedure with the use*

Phases of wildfire response	Objectives* of the training	Scope** of the training
ground, detection from air, conformation of the detection result, providing information about hazard to responders and the public, crisis communication, etc.	*to be able to use it in practice and to follow detection procedures.* *2. Next objective…*	*of the system. Specific detection procedure for fire service. Specific detection procedure for forest service.* *2. Next scope description…*
2. Immediate disposal of wildfire responders *Initiating organisation of response, disposal of services, information exchange, resource optimisation, etc.*	…	…
3. Effective getting of the resources to the wildfire scene *Road neatwork and its limitations, arrival routes optimisation, arrival respecting wildfire spreading, access to water and infrastructure needed, etc.*	…	…
4. Comprehensive recognition of hazard situation (from ground and air) *Use of multiple recognition tools and procedures, getting information from different sources, checking the information correctness, effective communication with commander, alternative recognition ways, etc.*	…	…
5. Firefighting tactics *First stage tactics formulation, division of hazard scene on operational areas, optimal use of resources, reflecting forest environment (chances and threats), implementation of best operational practices*	…	…

Phases of wildfire response	**Objectives* of the training**	**Scope** of the training**
6. Cooperation between entities fighting the fire *Effective risk and crisis communication, optimisation of use of resources, hazard monitoring issues, alternativeness of entities, mutual-securing of entities, etc.*	…	…

* Objective means direction of the training realisation. Objective should be verifiable during the training.

** Scope means information shared and/or gained during the training regarding relevant objective.

General remark: The objectives and the scope should be formulated in detail to frame specific expectations for the training.

Thank you for support in T3.3 realisation!

APPENDIX 2: Second Survey dedicated to preparation and pre-planning activities for wildfire response

Project Acronym	SILVANUS
Project Full Title	Integrated Technological and Information Platform for wildfire Management
Work Package	WP3 Culture of deterrence and prevention against wildfires
Task	T3.3 Preparation and pre-planning activities for wildfire response
Institution completing the survey	...
Person(s) who represents(-) institution completing the survey	1. ... 2. ...

Survey 2
Training forms and methods

Introduction (training assumptions)	The main objective of the survey method is to identify training forms and methods for fire services, forest services, UAV operators and public administration representatives involved in wildfire response. The forms and methods should allow to reflect operations to be carried out during first period after wildfire ignition, ascribing into early detection and communication of the hazard, immediate disposal of wildfire responders, comprehensive recognition of hazard situation (from ground and air), effective getting of the resources to the wildfire scene, firefighting tactics (including ensuring continuous access to water) and cooperation between entities fighting the fire. Special attention should be paid on use of modern technologies (including AR/VR) as well as best educational and training solutions. The training should reflect specification (scope, technologies, stakeholders involved, detail issues etc.) of case studies described in SILVANUS Grant Agreement. It should also be open for entire spectrum of multiple training forms and methods (i.a.): lecture, discussion, presentation, problem solving method, table top exercises, field exercises, field demonstrations, demonstrations with equipment, computer simulation, AR/VR simulation, work with handbook, brainstorming, decision training, multimedia decision training.

	The very desirable is to indicate specific training solutions (e.g. programs) with their names.

Complete the following table of information concerning training forms and methods corresponding to assumptions mentioned in the Introduction.

Phases of wildfire response	**Training form and/or method**	**Objective of the form and/or method use**
1. Early detection and communication of the hazard *Technical detection, auto-detection, detection from ground, detection from air, conformation of the detection result, providing information about hazard to responders and the public, crisis communication, etc.*	… *Example:* *1. Lecture.* *2. Presentation.* *3. Next form/method…*	… *Example:* *1. To present local early detection systems and its basic functionalities .* *2. To present functionalities of local early detection systems in practice.* *3. Next objective…*
2. Immediate disposal of wildfire responders *Initiating organisation of response, disposal of services, information exchange, resource optimisation, etc.*	…	…
3. Effective getting of the resources to the wildfire scene *Road neatwork and its limitations, arrival routes optimisation, arrival respecting wildfire spreading, access to water and infrastructure needed, etc.*	…	…
4. Comprehensive recognition of hazard situation (from ground and air) *Use of multiple recognition tools and procedures, getting information from different sources, checking the information*	…	…

Phases of wildfire response	Training form and/or method	Objective of the form and/or method use
correctness, effective communication with commander, alternative recognition ways, etc.		
5. Firefighting tactics *First stage tactics formulation, division of hazard scene on operational areas, optimal use of resources, reflecting forest environment (chances and threats), implementation of best operational practices*	…	…
6. Cooperation between entities fighting the fire *Effective risk and crisis communication, optimisation of use of resources, hazard monitoring issues, alternativeness of entities, mutual-securing of entities, etc.*	…	…

* Objective means direction of the training realisation. Objective should be verifiable during the training.
General remark: The forms and methods should be formulated in detail to frame specific expectations for the training. Additional information on objectives of their use will allow to connect particular forms and methods with the results of Survey 1.

Thank you for support in T3.3 realisation!

APPENDIX 3: Third Survey dedicated to preparation and pre-planning activities for wildfire response

Project Acronym	SILVANUS
Project Full Title	Integrated Technological and Information Platform for wildfire Management
Work Package	WP3 Culture of deterrence and prevention against wildfires
Task	T3.3 Preparation and pre-planning activities for wildfire response
Institution completing the survey	...
Person(s) who represents(-) institution completing the survey	1. ... 2. ...

Survey 3
Training materials

Introduction (training assumptions)	The main objective of the survey method is to identify and discuss training materials for the needs of fire services, forest services, UAV operators and public administration representatives involved in wildfire response. The materials should consider operations to be carried out during first period after wildfire ignition, ascribing into early detection and communication of the hazard, immediate disposal of wildfire responders, comprehensive recognition of hazard situation (from ground and air), effective getting of the resources to the wildfire scene, firefighting tactics (including ensuring continuous access to water) and cooperation between entities fighting the fire. Special attention should be paid on correspondence with modern technologies, high quality content, reflecting of state-of-the-art as well as best educational and training solutions. The training should reflect specification (scope, technologies, stakeholders involved, detail issues etc.) of case studies described in SILVANUS Grant Agreement. It should also be open for entire spectrum of multiple training materials (i.a.): books, handbooks, monographs, papers, articles, prevention programs, operational procedures, cooperation standards, operational manuals (including these dedicated for use of special equipment), multimedia, presentations, leaflets, etc.

	The very desirable is to indicate specific training materials with their names, ISBN, ISSN, doi, www links, etc. (when possible) to clearly identify them and their sources.

Complete the following table of information concerning training materials corresponding to assumptions mentioned in the Introduction.

Phases of wildfire response	**Training materials**
1. Early detection and communication of the hazard *Technical detection, auto-detection, detection from ground, detection from air, conformation of the detection result, providing information about hazard to responders and the public, crisis communication, etc.*	… *Examples:* *1. Bouguettaya, A., Zarzour, H., Taberkit, A. M., Kechida, A. 2022, A review on early wildfire detection from unmanned aerial vehicles using deep learning-based computer vision algorithms. Signal Processing 190, 108309. https://doi.org/10.1016/j.sigpro.2021.108309.* *2. Wildland Fire Incident Management Field Guide. 2013. National Wildfire Coordinating Group. https://www.nifc.gov/nicc/logistics/references/Wildland%20Fire%20Incident%20Management%20Field%20Guide.pdf.* *3. Guide to Wildland Fire Origin and Cause Determination. 2016. National Wildfire Coordinating Group. https://www.nwcg.gov/sites/default/files/publications/pms412.pdf.*
2. Immediate disposal of wildfire responders *Initiating organisation of response, disposal of services, information exchange, resource optimisation, etc.*	…
3. Effective getting of the resources to the wildfire scene *Road neatwork and its limitations, arrival routes optimisation, arrival respecting wildfire spreading, access to water and infrastructure needed, etc.*	…
4. Comprehensive	…

Phases of wildfire response	**Training materials**
recognition of hazard situation (from ground and air) *Use of multiple recognition tools and procedures, getting information from different sources, checking the information correctness, effective communication with commander, alternative recognition ways, etc.*	
5. Firefighting tactics *First stage tactics formulation, division of hazard scene on operational areas, optimal use of resources, reflecting forest environment (chances and threats), implementation of best operational practices*	…
6. Cooperation between entities fighting the fire *Effective risk and crisis communication, optimisation of use of resources, hazard monitoring issues, alternativeness of entities, mutual-securing of entities, etc.*	…

* Objective means direction of the training realisation. Objective should be verifiable during the training.

General remark: The materials should be formulated in detail to frame specific expectations for the training. Additional information on objectives of their use will allow to connect particular materials with the results of Survey 1 and Survey 2.

Thank you for support in T3.3 realisation!