D3.4 Planning and delivery of training activities – Phase 2

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Abstract:	The current deliverable is the first report addressing the requirements of Task 3.3 and Task 3.4, 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.

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List of acronyms and abbreviations

EU	European Union
WP	Work Package
GUI	Graphical User Interface
IT	Information and Technology
IoT	Internet of Things
GIS	Geographic Information System
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UI	User Interface
GFFFV	Ground Forest Fire Fighting Using Vehicles
NGO	Non Governmental Organization
SMURD	Romanian Mobile Emergency Service for Reanimation and Extrication
AR/VR	Augmented Reality / Virtual Reality

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Table of Contents

1. EXECUTIVE SUMMARY 16

2. SCOPE OF THE DOCUMENT 17
2.1 BACKGROUND 17
2.2 SCOPE AND AIM OF THE DOCUMENT 17
2.3 DOCUMENT STRUCTURE 17
2.4 RELATION WITH OTHER DELIVERABLES 18

3. BACKGROUND FOR WILDFIRE RESPONSE TRAINING – METHODOLOGIES, PROCEDURES AND PROTOCOLS 19
3.1. TRAINING NEEDS STEMMING FROM WILDFIRE SPECIFICS 19
3.2. TRAINING PARTICIPANTS 28
3.3. TRAINING EQUIPMENT 29

4. CREATING THE TRAINING FRAMEWORK FOR WILDFIRE DETECTION AND RESPONSE IN SILVANUS 32
4.1. SILVANUS APPROACH ON SYSTEMATIC METHODOLOGY FOR THE PREPARATION AND PRE-PLANNING ACTIVITIES FOR WILDFIRE RESPONSE 32
4.2. DATA AND INFORMATION AS CRUCIAL RESOURCES IN PRE-PLANNING AND PREPARATION ACTIVITIES FOR WILDFIRE RESPONSE 37
4.3. TRAINING OBJECTIVES 40
4.4. TRAINING FORMS AND METHODS 50
4.5. TRAINING MATERIALS 56

5. 'SILVANUS HANDBOOK ON SYSTEMATIC METHODOLOGY FOR THE PREPARATION AND PRE-PLANNING ACTIVITIES FOR WILDFIRE RESPONSE' 71
5.1. THE IDEA OF THE HANDBOOK 71
5.2. METHODOLOGY 71
5.3. STRUCTURE OF THE CONTENT 72
5.4. TECHNICAL INFORMATION AND STATUS 73

6. GUIDELINE BOOK ON 'NEW TECHNOLOGIES IN ENHANCING TRAINING FOR FIRE SERVICE IN WILDFIRE RESPONSE. THE SILVANUS APPROACH' 73
6.1. THE IDEA OF THE BOOK 73
6.2. METHODOLOGY 74
6.3. STRUCTURE OF THE CONTENT 74
6.4. TECHNICAL INFORMATION AND STATUS 76

7. INTEGRATION OF THE AR/VR CONTENT FOR TRAINING IN THE ROMANIAN PILOT. DEVELOPMENT OF SPECIFIC VR CONTENT FOR THE FRENCH PILOT 77
7.1 OVERVIEW 77
7.2 COMPLIANCE WITH THE OPERATIONAL SCENARIOS. INTEGRATION OF THE DIGITAL CONTENT IN THE AR/VR TRAINING TOOLKIT 82
MODELLING THE ENVIRONMENT AND SIMULATIONS IN VR 83

8. CONCLUSIONS 127

REFERENCES 128

ANNEX 1 132

ANNEX 2 133

Index of Tables

Table 1. Training needs 19
Table 2. Training objectives and scope for early detection and communication of the hazard..... 41
Table 3. Training objectives and scope for immediate disposal of wildfire responders..... 43
Table 4. Training objectives and scope for effective getting of the resources to the wildfire scene 44
Table 5. Training objectives and scope for comprehensive recognition of hazard situation (from ground and air) 45
Table 6. Training objectives and scope for firefighting tactics 47
Table 7. Training objectives and scope for cooperation between entities fighting the fire..... 48
Table 8. Training forms and methods for early detection and communication of the hazard..... 51
Table 9. Training forms and methods for immediate disposal of wildfire responders..... 51
Table 10. Training forms and methods for effective getting of the resources to the wildfire scene 52
Table 11. Training forms and methods for comprehensive recognition of hazard situation (from ground and air) 53
Table 12. Training forms and methods for firefighting tactics 53
Table 13. Training forms and methods for cooperation between entities fighting the fire..... 54

Index of Figures

Figure 1. Phases of wildfire management 32
Figure 2. General illustration of the SILVANUS approach 33
Figure 3. Preparation and pre-planning activities for wildfire response in the SILVANUS approach 34
Figure 4. The systematic methodology for the preparation and pre-planning activities to be carried out upon the ignition of forest fires 36
Figure 5. Romanian pilot location 79
Figure 6. French pilot location 80
Figure 7. Real intervention on the field (1) 81
Figure 8. Real intervention on the field (2) 81
Figure 9. Using the robot during the intervention 81
Figure 10. Environment grounds implementation in Rodna Mountains, Romania 84
Figure 11. Environment grounds implementation in St Sylvestre, France 85
Figure 12. Flora in Rodna Mountains, Romania 85
Figure 13. Flora in St Sylvestre, France 86
Figure 14. Fire simulation in Rodna Mountains, Romania 86
Figure 15. Rain simulation in Rodna Mountains, Romania 87
Figure 16. Environmental buildings in the French Pilot 87
Figure 17. Romanian firefighter 88
Figure 18. Romanian forest ranger 88
Figure 19. French firefighter (1) 89
Figure 20. French firefighter (2) 89
Figure 21. Romanian Emergency medical doctor (SMURD) 90
Figure 22. French Emergency medical doctor 90
Figure 23. Equipment – Fire Axe 91
Figure 24. Equipment – Firefighting Shovel 91
Figure 25. Equipment – Fire house nozzle 92
Figure 26. Equipment – Rubber Flap Flame-Retardant Fire Beater 92
Figure 27. Equipment – Crowbar 93
Figure 28. Equipment – Hatchet 93
Figure 29. Equipment – Fire extinguisher 94
Figure 30. Equipment – Water barrel 94
Figure 31. Equipment – Binoculars 95
Figure 32. Equipment – Boots 95
Figure 33. Equipment – CCTV camera 96
Figure 34. Equipment – Hammer 96
Figure 35. Equipment – Metallic tin 97
Figure 36. Equipment – Coordinator logbook 97
Figure 37. Equipment – Dagger 98
Figure 38. Equipment – Digital camera 98
Figure 39. Equipment – Drone 99
Figure 40. Equipment – Drone battery pack 99
Figure 41. Equipment – Drone camera 100
Figure 42. Equipment – Drone case Drone 100

Figure 43. Equipment – Drone Propellers 101
Figure 44. Equipment – Drone Remote Controller 101
Figure 45. Equipment – Chainsaw 102
Figure 46. Equipment – Numbered card 102
Figure 47. Equipment – Compass 103
Figure 48. Equipment – Fire behaviour analysis kit 103
Figure 49. Equipment – Fire blanket 104
Figure 50. Equipment – Fire ground light 104
Figure 51. Equipment – Fire hose wrench 105
Figure 52. Equipment – Fire truck, French pilot 105
Figure 53. Equipment – Fire truck, Romanian pilot 106
Figure 54. Equipment – 4X4 Duster (interior), Romanian pilot 106
Figure 55. Equipment – Flare gun 107
Figure 56. Equipment – Frequency scanner 107
Figure 57. Equipment – Fire hose 108
Figure 58. Equipment – Portable generator 108
Figure 59. Equipment – Glass jar 109
Figure 60. Equipment – Gloves 109
Figure 61. Equipment – Helmet 110
Figure 62. Equipment – Hydraulic cutter 110
Figure 63. Equipment – Hydraulic Jaw 111
Figure 64. Equipment – Laptop opened 112
Figure 65. Equipment – Backpack sprayer 112
Figure 66. Equipment – Medical Kit box 113
Figure 67. Equipment – Safety vest 113
Figure 68. Equipment – Mobile phone 114
Figure 69. Equipment - Fireman's rake 114
Figure 70. Equipment - Monitoring sensor 115
Figure 71. Equipment - Portable light 115
Figure 72. Equipment – Radio 116
Figure 73. Barrels 116
Figure 74. Report template 117
Figure 75. Rescue Toolkit box 117
Figure 76. Water transfer pump 118
Figure 77. Fire fighting robot 118
Figure 78. Tent 119
Figure 79. SMURD flag 119
Figure 80. Folding ladder 120
Figure 81. Survival kit 120
Figure 82. Folding stretcher 121
Figure 83. Thermal imaging camera 121
Figure 84. Thermometer 122
Figure 85. Toolbox 122
Figure 86. Whiteboard 123

Figure 87. Wind Meter 123
Figure 88. Breathing Apparatus 124
Figure 89. UI integration – Maps 125
Figure 90. UI integration – Drones information 125
Figure 91. Crew & Equipment – Live Communication and Alerts 126
Figure 92. UI integration – Crew & Equipment: Alerts 126

1. Executive summary

The current deliverable is the last report of WP3 activities, corresponding to task *T.3.3 – Preparation and pre-planning activities for wildfire response* and *Task 3.4 – AR/VR content curation for training firefighters*, dedicated to specific activities of training and preparation for wildfire response. A substantial part of the deliverable is dedicated to the specific background for wildfire response training in SILVANUS, comprising the theoretical and methodological approaches specific to training, operations and exercises for wildfire response and fire fighting.

This document serves as a basis for understanding the methodology, tools and execution of training activities specific to preparedness and prevention of wildfires, considering the real needs and demands of the Pilots.

Like in deliverable D3.2, a particular section is dedicated within the deliverable to the innovative approaches and tools for implementing the training activities in SILVANUS, which depicts the integration of AR/VR content to meet the professional training requirements of end-users.

2. Scope of the document

2.1 Background

This deliverable addresses the requirements of Task 3.3 and Task 3.4, which encompasses the most relevant aspects concerning the planning and delivery of training activities within the SILVANUS project.
Task 3.3 captures the significant prospects about the professional training of personnel involved in preparation and pre-planning activities for wildfire response and highlights the specific methodology of planning and delivery of training activities. Task 3.4 is focused on the innovative technologies applied in the first responders training in SILVANUS, comprising the design of the AR/VR solution in close consultation with the practitioners to deliver training for tackling the forest fires.
The deliverable describes how the training framework is built in SILVANUS, from theoretical, methodological and practical perspectives, emphasizing also the innovative technological approaches specific to training of fire fighters.

2.2 Scope and aim of the document

This deliverable was built on the ground of D3.2, aiming to create a logical and comprehensible structure that meets the requirements of Task 3.3 and Task 3.4. The content of deliverable D3.2 was revised, updated and enriched with new information and details about implementing the specific activities for planning and delivery of training activities.
The deliverable is drafted in such a way as to ensure a uniform view of planning and delivery of training activities, from theoretical, methodological and practical perspectives, based on compliance with the Pilots' own operational scenarios and the feedback received from them during the implementation of the SILVANUS platform components.

2.3 Document structure

The document is structured as follows:
Section 1. Executive summary: Presents the most relevant aspects of the deliverable in the context of the project implementation.

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

Section 3. Background for wildfire response training – methodologies, procedures and protocols: Presents significant aspects concerning the theoretical and methodological approaches specific to training, operations and exercises for wildfire response and firefighting.

Section 4. Creating the training framework for wildfire detection and response in SILVANUS: Depicts the specific of training framework (objectives, activities, resources, implementation, validation (KPIs), general description of the technologies used, ...) developed within SILVANUS.

Section 5. SILVANUS Handbook on Systematic Methodology for the Preparation and Pre-planning Activities for Wildfire Response: Presents the specific methodology for the Preparation and Pre-planning activities for wildfire response, as a comprehensive and consistent handbook.

Section 6. Guideline book on 'New technologies in enhancing training for fire service in wildfire response. The SILVANUS approach': Presents the technologies and innovative techniques and protocols used for implementing the training activities in SILVANUS within a comprehensive and consistent guideline.

Section 7. Integration of the AR/VR content for training in the Romanian Pilot. Development of specific VR content for French Pilot: Presents significant aspects regarding the VR training experience for the first responders in the Romanian and French Pilots.

Section 8. Conclusions: Presents the conclusions and final findings about the implementation of the SILVANUS training framework for wildfire response.

Annex 1: Detailed list of the content in 'SILVANUS Handbook on Systematic Methodology for the Preparation and Pre-planning Activities for Wildfire Response'.

Annex 2: Detailed list of the content in the book 'New technologies in enhancing training for fire service in wildfire response. The SILVANUS approach'.

2.4 Relation with other deliverables

The specific work from Task 3.3 and Task 3.4 is correlated with the outcomes from WP2 and is closely related to the activity of WP4 and WP5. The results obtained in both tasks have been considered in the specific integration process from WP8. Moreover, the results obtained in WP9 and the feed-back collected from the end-users in the Pilots are important input for the implementation of the training framework and the AR/VR Training toolkit.

Some of the research results presented in D3.4 state a content of two project-related books: Gromek P., *New technologies in enhancing training for fire service in wildfire response The SILVANUS approach*, Fire University, Warsaw 2024 (after review and in the production process), and *The SILVANUS Handbook on Systematic Methodology for the Preparation and Pre-planning Activities for Wildfire Response*, P. Gromek, A. Szajewska (eds.), Fire University, Warsaw 2025 (under review). The books are to be widely disseminated in the open access formula during the project and after it ends.

3. Background for wildfire response training – methodologies, procedures and protocols

This section aims to present the most relevant aspects regarding the theoretical and methodological approaches specific to training, operations and exercises for wildfire response and firefighting. Significant work has been dedicated to revise, update and improve the content of deliverable D3.2 concerning the methodological approach for training (needs, procedures, protocols and scenarios).

3.1. Training needs stemming from wildfire specifics

Wildfires pose one of the most serious threats to the natural environment and human safety. They are often the result of a combination of natural factors such as drought, high temperatures, and strong winds, as well as anthropogenic factors like careless campfires, discarded cigarette butts, or deliberate arson. In today's world, due to climate change and increasing anthropogenic pressures, the threat of forest fires is becoming increasingly pressing. Therefore, there is a need for proper preparation and training of individuals responsible for managing and combating forest fires. Considering that training can also prevent fires, training needs have become very important due to the growing risk of these disasters and their potential impacts on the environment and human safety (Pimlot et al., 2014; Szajewska, 2018; CIFFC, 2022; Casartelli, Mysiak, 2023). Based on this, the training needs are identified and listed in Table 1.

Table 1. Training needs

No.	The need	Description of the need
1	Safety principles	All individuals present in the forests should be familiar with the safety rules.
2	Prevention	A key aspect of training is education regarding wildfire prevention. It includes informing local communities about the risks associated with campfires, uncontrolled burning of grass, as well as promoting conscious use of the forested areas.
3	Monitoring and detection	People responsible for forest management and firefighting must be trained in monitoring the state of the fuels and detecting fire threats. To achieve this, satellite technologies, smoke detectors, and early warning systems can be utilised.
4	Intervention	Training in wildfire intervention should include learning various firefighting techniques, crisis management, and collaboration with other emergency services. Depending on the terrain and weather conditions, training in mountain and aerial rescue may also be necessary.
5	Fire Suppression	Training in firefighting is essential for rescue units and individuals responsible for workplace safety. It includes learning how to operate various types of extinguishers, techniques for extinguishing different types of fires, firefighting tactics, and proper situation assessment to avoid endangering human lives.
6	Protection from toxic substances	During firefighting in the forests, there is a risk of exposure to toxic substances such as smoke and fumes. Therefore, individuals participating in firefighting operations must be trained in the use of

No.	The need	Description of the need
		appropriate personal protective equipment and procedures for dealing with exposure to harmful substances.
7	Technologies and innovations	The development of technology can significantly impact the effectiveness of wildfire management and suppression efforts. Therefore, training should include learning how to operate modern equipment such as UAVs, satellites, and fire monitoring systems.
8	International cooperation	Wildfires do not stop at national borders, hence international cooperation in training and experience exchange is crucial. International organisations can play a key role in coordinating efforts and supporting countries in combating wildfires (e.g. Union Civil Protection Mechanism).
9	Social Education	It is crucial to ensure that training is accessible to a wide range of people. In addition to firefighting and forestry services, training should involve local communities. Social education and prevention play a key role in minimising the risk of wildfires, so there should be a strong emphasis on informing the public about hazards and proper safety procedures. Increasing public awareness of the risks associated with wildfires is essential for effective prevention. Therefore, training should not only target those directly involved in firefighting but also local communities, tourists, and political decision-makers.
10	Evacuation	Training on evacuation and securing property should be provided to local communities in the event of a fire. People should be trained in evacuation procedures, knowledge of escape routes, and how to behave in panic situations. These training sessions may include fire drills and demonstrating the appropriate actions in case of a real threat.

Source: own work on the basis of (Pimlot et al., 2014; Szajewska, 2018; CIFFC, 2022; Casartelli, Mysiak, 2023).

Training needs related to wildfires encompass both educating local communities and professional emergency services. Communities require knowledge about prevention, swift responses, and safe practices during evacuation in case of a wildfire threat. Training for emergency services should focus on refining firefighting techniques, crisis management, and intersectoral collaboration. Additionally, learning to use modern monitoring technologies and tools is crucial to enhance the effectiveness of preventive and intervention actions. Below are the thematic scopes for specific training sessions derived from real needs.

Safety rules

Safety rules in the forest should be known and followed by all individuals who spend time in the forested areas. This includes both individuals working there and those visiting the forests for recreational purposes. Safety rules should be taught to young citizens as part of preschool education by educators. Safety rules should also be posted on signs at forest entrances.

Training on wildfire prevention

The training program on prevention actions should provide participants with the knowledge, skills, and tools necessary to minimize the risk of wildfires and to react quickly in case of danger. Below are the topics that may be included in the training program (Pimlot et al., 2014; Szajewska, 2018; CIFFC, 2022; Casartelli, Mysiak, 2023):

1) Hazard identification: This topic should begin with discussing the main factors contributing to wildfires, such as weather conditions, human activity, forest condition, and species composition. Participants should be trained to recognize potential hazards and factors increasing the risk of fire.
2) Prevention and education: This topic should include elements of prevention, including education on proper behaviour in the forests, safety rules during campfires, prohibition of grass burning, and the consequences of smoking. Participants should be aware of the consequences of their actions and ways to minimize the risk of fire. Legal consequences for violations should be emphasized according to the laws of the country.
3) Monitoring and detection of threats: This topic should cover the use of monitoring techniques to assess forest conditions and detect fire hazards, including early warning systems, UAV observation, and satellite technologies. Participants should be trained to identify alarm signals and respond quickly to them.
4) Planning of preventive actions: This topic should include elements of planning preventive actions, such as working with hazard maps, discussing protected zones, terrain marking methods, and familiarization with topography and firebreak locations.
5) Safety and evacuation procedures: Participants should be trained in safety rules during preventive actions and evacuation in case of a fire threat. The program should include information on proper attire and equipment, alarm procedures, reporting fires, and evacuation procedures.
6) Social cooperation: A key element of the training program should be teaching social cooperation in forest fire prevention. Participants should be encouraged to actively participate in local social initiatives aimed at promoting safe forest use and supporting forest and rescue services.
7) Schedule of subsequent trainings: The training program should provide for regular updates and enhancements of knowledge and skills to adapt to changing weather, technological, and social conditions. Participants should be encouraged to continue learning and actively participate in local prevention initiatives.

By preparing a training program on wildfire prevention in this way, it can effectively increase public awareness of fire hazards and the skills needed to deal with them, ultimately contributing to reducing the number of fires and minimizing their impacts.

Training on wildfire detection and monitoring

A training program on wildfire detection and monitoring should be constructed comprehensively, encompassing theoretical lectures, practical exercises, and field simulations. The main objective of such a program is to train participants in effective methods of monitoring forest conditions and detecting fire hazards to enable quick response and minimise the impacts of fires. Following training forms and topics should be taken into account:

1) Theoretical lectures:
   a) Discussion of basic threats associated with forest fires and factors influencing their occurrence and development.
   b) Presentation of various methods for monitoring forest conditions, including the use of satellites, Unmanned Aerial Vehicles (UAVs), and other electronic technologies.

c) Operation of observation towers equipped with visual observation systems.
d) Explanation of the operation principles of early warning systems and interpretation of fire-related data.

2) Practical exercises:
   a) Demonstration of the practical operation of various monitoring technologies, including calibration and equipment setup.
   b) Exercises on interpreting monitoring data and responding quickly to alarm signals.
   c) Simulations of fire situations and attempts to detect fires in various terrain conditions
   d) Organization of field simulations allowing for the practical application of acquired knowledge and skills in realistic conditions.
   e) Fire detection using UAVs and other technologies in forest environments.
   f) Collaboration with other rescue services and participation in simulated firefighting actions.
3) Reporting and coordination procedures:
   a) Exercises utilizing various communication channels (radio, telephone, teleinformatics network).
   b) Training in documenting detected fire hazards and reporting data to relevant authorities.
   c) Exercises in coordinating actions between different rescue units and crisis management authorities.
4) Occupational health and safety (OHS):
   a) Introduction of participants to occupational health and safety principles in the field, including appropriate attire, equipment, and emergency procedures.
   b) Discussion of ethical and legal aspects of work related to monitoring and fire detection, including compliance with privacy and data protection principles.

The training program on wildfire detection and monitoring should be flexible and tailored to the needs and capabilities of the participants, while ensuring comprehensive preparation for effective fire risk management in forest environments. Regular updates and enhancements to the program are also crucial considering the rapidly changing technologies and terrain conditions.

Training on intervention and firefighting

The main objective of training on intervention in wildfires is to prepare participants for comprehensive action in fire hazard situations, including action planning, team coordination, crisis management, and effective firefighting. The main goal of firefighting training is to impart practical skills related to extinguishing fires, such as the use of various tools and firefighting techniques, handling firefighting equipment, and safe firefighting practices. While the thematic scope of both types of training is related, the main emphasis is placed on different topics. Training on intervention should include:

1) Theoretical lectures:
   a) Discussion of basic issues related to wildfires, including types of fires, factors influencing their development, and the consequences of fires for the natural environment and people.
   b) Presentation of various firefighting methods, including extinguishing agents, firefighting techniques, and tools used for firefighting.
2) Firefighting techniques:

a) Practical exercises on using different methods and techniques for firefighting in the forests, including the use of water, foam, powder extinguishers, aerosols, or other extinguishing agents.
b) Learning the proper operation and use of firefighting equipment, including fire hoses, handheld extinguishers, blowers, firefighting axes, and other rescue tools.

3) Firefighting tactics:
   a) Discussion of principles for planning firefighting actions, including situation assessment, threat identification, resource allocation, and selection of appropriate firefighting methods and techniques.
   b) Coordination exercises in firefighting teams, including role division, cooperation with other rescue units, and communication in crisis situations.
4) Safety and emergency procedures:
   a) ABC of safety principles.
   b) Introduction of participants to workplace safety principles during firefighting in the forests, including appropriate attire and equipment, emergency procedures, and securing the incident site.
   c) Training on alarm procedures, fire reporting, and response to emergencies and accidents.
5) Teamwork:
   a) Teamwork exercises during firefighting in the forests, including role division, cooperation with other rescue units, and coordination of actions in firefighting teams.
6) Crisis management:
   a) Discussion of crisis management procedures in wildfire situations, including organising actions, resource allocation, team coordination, and communication in crisis situations.
   b) Practical exercises in intervention action planning, including developing action strategies, risk assessment, and preparation of evacuation plans.
7) Social education:
   a) Discussion on the importance of social education in wildfire prevention and promotion of social awareness of fire hazards and the need for effective responses.
8) Schedule of subsequent trainings:
   a) Providing participants with the opportunity to continue training by providing educational materials, organising regular field exercises, and participating in skill-enhancing courses in firefighting and crisis management.

Protection against toxic substances

Training on protection against toxic substances in the context of wildfires must take into account specific hazards and procedures related to exposure to toxins during firefighting intervention. Below are topics that can be included in such training:

1) Definitions and classifications of toxic substances that firefighters may encounter during firefighting interventions in the forest.
2) Routes of exposure to toxins during wildfires and types of toxic effects.
3) Most common toxic substances released during wildfires, such as carbon monoxide, nitrogen oxides, aldehydes, chlorine compounds, volatile organic compounds.
4) Impact of fire smoke on human health, symptoms of poisoning, and long-term effects of exposure.
5) Risk assessment related to exposure to fire smoke and toxic substances.

6) Personal protective equipment used during firefighting interventions in the forests, such as dust masks, filtering masks, protective clothing.
7) Procedures in case of exposure to toxic substances during firefighting intervention in the forests.
8) Alarm procedures, first aid, and evacuation in case of contact with toxic substances.
9) Planning and conducting evacuation from the fire site in case of danger from toxic substances.
10) Personnel decontamination procedures after firefighting intervention, including removing contaminants from clothing and equipment.
11) Principles of safe firefighting in conditions of exposure to toxic substances.
12) Prevention of poisoning and minimisation of exposure risk through proper use of personal protective equipment and avoidance of exposure to fire smoke.
13) Field exercises and simulations of firefighting actions in realistic conditions, taking into account exposure to fire smoke and toxic substances.
14) Practical exercises involving protective equipment and procedures in case of exposure to toxins.

Including these topics in training will better prepare firefighters to operate in challenging fire conditions, minimising the risk of exposure to toxic substances and ensuring effective protection of the health and lives of rescuers.

Technology and innovation

Training on technology and innovation should focus on utilising modern tools and technologies for preventing, monitoring, combating, and managing wildfires. Here are some example topics that could be included in such a training:

1) Forest fire monitoring systems:
   a) Utilising satellites, UAVs (Unmanned Aerial Vehicles), and electronic sensor systems to monitor the forested areas for fire outbreaks.
   b) Early warning detection technologies: analysis of spectroscopic images, thermal sensors, networks of ground sensors.
2) Modelling and forecasting of fires:
   a) Using mathematical models and computer simulations to forecast the spread of wildfires.
   b) Predictive algorithms for fire hazards based on atmospheric conditions, terrain topography, and vegetation type.
3) Communication and crisis management systems:
   a) Using GIS (Geographic Information Systems) for managing wildfire data and coordinating intervention actions.
   b) Communication platforms and mobile applications for quickly disseminating information about fires, evacuations, and safety.
4) Modern firefighting technologies:
   a) Innovative methods for extinguishing wildfires, such as using UAVs for monitoring or helicopters with water sprinkling systems.
   b) Utilising automatic monitoring systems for the forested areas and responding to fire outbreaks.
5) Simulation program operation:
   a) Virtual training in crisis management and firefighting interventions for wildfires, enabling realistic simulations of different fire scenarios.

b) Using VR (Virtual Reality) and AR (Augmented Reality) technologies for practical training in extinguishing forest fires.
c) Simulations of total forest fires in simulation programs.

6) Social education and awareness of risks:
   a) Utilising social media, streaming platforms, and mobile applications for social education about wildfire risks and prevention methods.
   b) Information and educational campaigns using interactive multimedia, 360-degree videos, and simulation games.
7) Modern data analysis methods:
   a) Analysing data from sensors, detectors, and monitoring systems to identify trends, patterns, and factors influencing the risk of wildfires.
   b) Using machine learning algorithms to analyse large datasets related to wildfires and develop predictive fire risk models.
8) Utilisation of thermal imaging:
   c) Familiarisation with the physical properties of infrared observations.
   d) Operation and optimal use of thermal imaging cameras in various situations.

Trainings of this kind should be organised to keep up with the acquisition of new technologies so that they can be implemented into daily use as quickly as possible. A common mistake made by decision-makers is to save expensive modern equipment for fear of damage. As a result, the personnel trained to operate it is scarce, and the equipment is not utilised to its full extent.

International Cooperation

Training on international cooperation should aim to prepare participants for effective collaboration and coordination in preventing, monitoring, combating, and managing wildfires on an international scale. Training sessions may cover various areas of cooperation. Below are potential areas of international cooperation activities for which training should be conducted concurrently:

1) Dominant trends in wildfires:
   a) Assessment of the scale and frequency of wildfires worldwide.
   b) Identification of the main factors influencing the occurrence of wildfires on different continents.
2) International regulations concerning wildfires:
   a) Review of international agreements, conventions, and agreements concerning the protection of the forests from fires.
   b) Analysis of the role of various international organisations in coordinating actions related to wildfires.
3) Common standards and protocols:
   a) Development of common operating standards and intervention protocols for firefighting activities in different countries.
   b) Discussion of best practices in preparation, response, and management of wildfires at the international level.
4) Technologies and tools for monitoring wildfires:
   a) Overview of modern technologies, such as satellite monitoring systems, UAVs, ground sensors, used for monitoring wildfires on a global scale.

   b) Discussion of the potential use of fire monitoring data for joint analysis and forecasting of hazards.
5) National and regional cooperation:
   a) Analysis of models of international and regional cooperation in combating wildfires.
   b) Case studies of successful joint actions and initiatives in the field of fire risk management.
6) International education and training:
   a) Familiarisation with educational and training programs related to wildfires conducted in different countries.
   b) Discussion of educational strategies and informational campaigns aimed at raising public awareness of fire hazards.
7) Communication and information exchange:
   a) Familiarisation with communication tools and platforms used for exchanging information about wildfires between individual countries.
   b) Discussion on effective communication strategies in the event of international fire crises.
8) International exercises and simulations:
   a) Organisation of international exercises and simulations aimed at preparing for joint action in crisis situations.
   b) Utilisation of simulations to identify areas requiring further improvement and development of international cooperation.
9) Data management and risk analysis:
   a) Discussion of methods for collecting, processing, and analysing wildfire data at the international level.
   b) Use of risk analysis to identify areas most vulnerable to fires and to plan preventive actions.
10) Review of international support measures:
   a) Presentation of options for financial and logistical international support in the event of wildfires.
   b) Discussion of procedures and mechanisms of operation of international organisations in providing assistance to countries affected by wildfires.

Trainings should be conducted in an interactive manner, incorporating discussions, case studies, and practical exercises to enable participants to apply the acquired knowledge and skills effectively. It is also important to emphasize the significance of international cooperation.

Training on social education

Training on social education in the context of wildfires aims to raise general awareness about fire hazards and promote attitudes and behaviours conducive to preventing fires and responding appropriately in case of their occurrence. Topics may encompass various aspects related to wildfire protection and can be addressed to different social groups:

1) Analysis of the causes and effects of wildfires.
2) Discussion of factors increasing the risk of fires.
3) Emphasizing the importance of community involvement in preventive actions.
4) Strategies promoting active community participation in fire prevention.
5) Link between wildfires and environmental conservation.
6) Promotion of actions conducive to sustainable forest use.

7) Principles of safe use of the forested areas: grilling, campfires, camping.
8) Guidelines for avoiding behaviours that could lead to fires.
9) Identification of warning signs indicating the possibility of a wildfire.
10) Training in rapid and effective response in case of a fire.
11) Informing the community about action plans in case of a wildfire.
12) Building public trust in the actions taken by rescue services.
13) Explanation of alarm and evacuation procedures in case of a wildfire.
14) Education on available crisis communication methods and their importance.
15) Planning and implementation of educational campaigns on wildfires.
16) Utilisation of social media, posters, radio and television spots to promote safe practices.
17) Promoting cooperation among different social sectors in social education on wildfires.
18) Building interaction between local authorities, non-governmental organisations, the private sector, and the local community.
19) Methods for assessing the impact of educational activities on social awareness and behaviour change.
20) Monitoring the effectiveness of social campaigns and adjusting strategies based on evaluation results.

It is important for the training to focus not only on imparting information but also on developing practical skills and motivating participants to actively engage in actions for safety and security in the forest.

Evacuation

Training on evacuation should focus on preparing participants for the quick and safe departure from areas threatened by wildfires and teaching them appropriate procedures and behaviours in crisis situations. Training topics may include the following thematic areas:

1) Assessment of the risk associated with wildfires: atmospheric factors, terrain topography, type of vegetation.
2) Identification of potential hazards during evacuation.
3) Evacuation plans for areas threatened by wildfires.
4) Evacuation routes to assembly points.
5) Discussion of procedures for alerting the community about the wildfire threat.
6) Explanation of different warning and alert systems, such as sirens, SMS notification systems, radio alerts.
7) Training on how to react to a wildfire alarm (remaining calm, organising evacuation quickly).
8) Discussion on procedures for contacting emergency services and providing information about the situation on-site.
9) Instruction on safe evacuation techniques in the forested terrain: avoiding steep slopes, crossing streams, navigating around fires.
10) Education on identifying safe shelter locations in the event of rapid-fire spread (safety zones).
11) Tips for packing essential items for evacuation: documents, medications, water, and food supplies.
12) Training on preparing for evacuation in conditions of limited visibility caused by smoke.
13) Organisation of the evacuation of disabled persons and children.
14) Procedures for special care for disabled persons and children during evacuation.
15) Discussion of available transportation options for people with mobility impairments.

16) Communication during evacuation.
17) Guidance on maintaining communication with other family members and emergency services during evacuation.
18) Training on using mobile phones and other communication means in crisis situations.
19) Organisation of evacuation simulations in forested terrain or using virtual simulators.
20) Practical exercises on safely navigating in wildfire conditions and making decisions in crisis situations.
21) Training on securing households (home sprinkler systems, equipping with ladders, etc.).

Trainings should be tailored differently depending on the area in which they are to be conducted, taking into account local conditions. The thematic scope should be adapted to the training recipients (different for residents living in the forested areas than for those living in cities).

3.2. Training participants

Training programs related to wildfires should be tailored to various social and professional groups that may influence fire prevention, management, and suppression efforts. Below are the groups that should be covered by different training programs:

1) **Emergency services:** Firefighters, mountain rescue teams, forestry workers, and other units responsible for firefighting should undergo regular training in firefighting techniques, crisis management, and collaboration with other emergency services.
2) **Forestry workers:** Individuals working in forestry, including foresters, forest rangers, forestry administration staff, and volunteers, should be trained in fire prevention, forest monitoring, and emergency response procedures in case of a fire.
3) **Local communities:** Residents of nearby the forested areas, including farmers, livestock breeders, and property owners, should be educated about the risks associated with wildfires and appropriate safety procedures and evacuation.
4) **Tourists and vacationers**: Individuals visiting the forests for recreational purposes should be informed about safety rules and the consequences of careless behaviour that can lead to wildfires.
5) **Officials**: Individuals responsible for formulating environmental protection and crisis management policies, including local and regional officials, should be aware of the need to invest in fire prevention and intervention related to wildfires.
6) **Forest industry:** Companies operating in the forestry sector play a significant role in forest management and efforts to minimise fire risk. Training for business representatives and the forestry industry can focus on sustainable forest management strategies, the use of fire prevention technologies, and risk management associated with activities in the forested areas.

All these mentioned social groups have real training needs regarding wildfires, which can be met through appropriately tailored educational and training programs, taking into account the specific nature of their activities and the latest scientific and technological developments in crisis management and environmental protection. All these groups have their unique needs and challenges related to fire hazards, so it is important to adjust training programs to the specifics of their activities and consider diverse perspectives and experiences in managing these events.

Not any training needs to be organised by entities with the appropriate knowledge base, experts, and high qualifications. Basic fire safety training should be conducted as early as preschool and should be included in the educational program for children. Social education training can be conducted by NGOs and educational institutions. Specialised training, especially regarding intervention and firefighting, should be conducted by organisations with experts. Below there is a list of potential entities that can organise training:

1) **Environmental protection agencies:** Government agencies responsible for environmental protection often organise wildfire training because they are key entities in crisis management and preventive actions.
2) **Fire brigade:** Firefighting units, both at the local and regional or national levels, often organise training for their employees and for local communities in wildfire management (particularly in wildfire response).
3) **Non-governmental organisations:** Local NGOs, environmental protection associations, or community groups may engage in organising wildfire training, especially if they operate in areas threatened by this phenomenon.
4) **Educational and scientific institutions:** Universities, colleges, and scientific institutions often conduct research and organise training in ecology, environmental protection, and crisis management, including wildfires.
5) **Training companies:** Training companies specialising in fire safety can offer equipment and software services to clients from the public, private, and NGO sectors.
6) **International organisations:** International organisations such as the United Nations, the International Union for Conservation of Nature, the World Meteorological Organisation or Union Civil Protection Mechanism, may organise wildfire training for their members and partners from different countries.
7) **Forest industry companies:** Companies operating in the forestry sector, including forest management, timber industry, or commercial enterprises, may organise forest fire training for their employees and for local communities in the areas they manage.

These entities can organise various types of training, from informational sessions and practical workshops to evacuation simulations and field exercises, to impart the knowledge and skills needed for effective wild fire management.

3.3. Training equipment

During the implementation of a firefighting training program, a variety of equipment is used to assist participants in practical skill enhancement and simulating real-life situations. Depending on whether the training is field-based or theoretical, various tools can be utilised for its conduct. One of them is computer simulation.

Advanced computer simulation systems allow for simulating wildfires as well as intervention and crisis management actions. Participants can practice various scenarios and make decisions in conditions similar to the real ones. Popular programs include the **Wildfire Simulator**, which is a simulation tool that allows for simulating wildfire spread in various terrain and weather conditions. It is used for firefighter training, fire dynamics research, and planning preventive actions. Another example is the **FARSITE** software

developed by the USDA Forest Service. It is an advanced computer tool that enables simulation of fire spread over large forested areas and assesses its impact on the environment. FARSITE is used for firefighting planning, fire behaviour prediction, and risk analysis. Most simulation programs are based on fuel models, predicting burning time based on maps with specific fuel types for the region. However, since fuel types vary significantly in different regions, there is a legitimate concern that the adequacy of simulated fires may vary greatly from actual fires. It is worth noting that the adequacy of simulating total fire is higher than simulating surface fires, which are less predictable (Szajewska, 2018; Szajewska, 2024).

Simulating fires has the advantage over controlled burning in that it does not generate any costs to obtain knowledge about fire spread or unnecessary risk. Trained personnel can gain a general idea of fire development and various firefighting tactics. However, the degree of adaptation of fuel models to a given region and the adequacy of the simulation to the real situation are significant drawbacks. Model limitations mean the program cannot simulate realistic fire perimeters (Zinger et al., 2020). Other examples of simulation programs include **FLAMMAP** (Flame Length and Spread Model) and **Prometheus**. All these simulators are used to improve firefighting and fire risk management skills (Szajewska, 2018; Szajewska, 2024).

In addition to fire development simulators, there are also fire simulators that generate a subjective image for the observer through computer animation. These simulators generate various terrain conditions and types of fires, allowing for diversified training. Such training moderately reflects realistic conditions of a real fire, providing a preliminary insight into the situation for the trainee. Firefighter Training Software and Firefighting Simulator are examples that can utilise virtual reality (VR) animations for firefighter training:

1) **Firefighter Training Software:** Some versions of Firefighter Training Software offer the possibility of using virtual reality to conduct fire simulations and interactive exercises. Users can use VR devices, such as VR goggles, to immerse themselves in fire situations and practice their skills in realistic virtual scenarios.
2) **Firefighting Simulator:** Firefighting Simulator is dedicated software for fire simulation designed for use in virtual reality. It allows firefighters to practice firefighting exercises in a three-dimensional virtual environment, enabling realistic and immersive training in safe conditions.

In the both cases, the use of virtual reality allows firefighters to better prepare for real fire situations through practice in a controlled environment, where they can improve their firefighting skills, coordinate rescue actions, and make decisions under high-stress conditions.

Imaging systems are increasingly being utilised with UAVs. UAVs are equipped with visible light cameras as well as thermal imaging cameras. These sensors can be used for monitoring and observing wildfires from the air, as well as for locating people and animal habitats. During training sessions, they can be used to simulate aerial monitoring activities and coordinate rescue efforts. For heavier UAVs in the EU, pilots are required to have the appropriate category qualifications for operation. Specialised training courses for UAV operation are conducted for this purpose, culminating in the issuance of a certificate for the specific category. Most UAV flights are conducted within line of sight between the pilot and the UAV. Typical applications include (Feltynowski, Zawistowski, 2018; Szajewska, 2020; Fellner, 2023):

1) **Fire monitoring:** UAVs can be utilised to monitor wildfires, buildings, or industrial areas. With thermal and visual cameras, firefighters can obtain a realistic aerial view on the situation, enabling a better understanding of the size and dynamics of the fire.

2) **Search and rescue:** UAVs can assist in the search for missing or trapped individuals in hard-to-reach areas, which is particularly important during evacuations or rescue operations.
3) **Terrain monitoring:** By conducting flights over the terrain, UAVs can provide information about terrain conditions, topography, evacuation routes, or water sources, which are crucial for effective crisis management.
4) **Support in rescue planning:** Images and data collected by UAVs can be used to plan rescue strategies, including the location of firefighting points, evacuation routes, and optimal access routes for rescue vehicles, as well as observations of fire development.

There is currently a strong need for training in the use of UAVs in rescue operations. The reason for such high interest is the speed of response. UAVs can be quickly deployed into the air, providing a rapid aerial view of the situation. Until recently, bird's-eye-view imagery was only possible through aerial photography. Another reason is the availability of technology that was previously reserved for the military sector. UAVs are essential tools in firefighting training, allowing for skill enhancement, better situational understanding, and effective planning and coordination of rescue operations.

In addition to modern technology, exercises utilise equipment available in fire departments such as:

a) radio communication systems (radios),
b) firefighting off-road vehicles,
c) quads,
d) piston pumps,
e) fire extinguishers,
f) ropes, lances,
g) fire hoses,
h) axes and chainsaws for tree removal,
i) water transfer pumps,
j) water containers,
k) robots,
l) detectors,
m) telecommunication devices.

The mentioned equipment items are often used during wildfire extinguishing exercises and assist firefighters in effective rescue operations in the forests. They constitute the everyday tools of a firefighter, so regular training and practicing with this equipment are important to ensure high efficiency and safety during real interventions. The choice of specific training equipment depends on the training objectives, available resources, and the nature of the situation. It is important for the equipment to be properly adapted to training needs and to allow for realistic simulations and practical exercises that contribute to the effective improvement of participants' skills.

4. Creating the training framework for wildfire detection and response in SILVANUS

This section presents the most relevant aspects regarding the specific of training framework (objectives, activities, resources, materials, equipment, technologies, validation (KPIs)) implemented in SILVANUS project. The content is based on the elements for organizing the training in SILVANUS presented in detail in deliverable D3.2; the methodological and practical aspects were revised, updated and improved in the following descriptions.

4.1. SILVANUS approach on systematic methodology for the preparation and pre-planning activities for wildfire response

SILVANUS project gives steps significantly forward for preparation and pre-planning activities for wildfire response. The project "(…) envisages to deliver an environmentally sustainable and climate resilient forest management platform through innovative capabilities to prevent and combat against the ignition and spread of forest fires" and it is to "(…) cater to the demands of efficient resource utilisation and provide protection against threats of wildfires encountered globally" (SILVANUS, 2021). The project establishes synergies between three essential dimensions of wildfire management determinants: (a) environmental issues, (b) technologies, and (c) social science knowledge. It is to enhance the ability of wildfire management authorities to monitor resources of the forests, evaluate biodiversity, collect information about accurate fire risk indicators and promote safety standards, regulations and good practices among citizens (the users of the forests and other stakeholders). The project novelty stems from development and integration of (a) advanced semantic technologies, (b) knowledge of forest administration, and (c) resource utilisation. The platform is to establish a big-data processing framework for analysis of heterogeneous data sources (earth observation resources, climate models, weather data, etc.) and making on-board computation processes to obtain common situational picture for all entities involved in wildfire management processes. To achieve this goal, the project allows for integration of multiple sensors connected by effective and robust communication network. The project technological layer is comprised by ground and air solutions, and their practical use gives input to effective reconstruction and recovery of forests after a wildfire (SILVANUS, 2021).

The SILVANUS project covers all phases of wildfire management. Thus, it refers also to preparation and pre-planning activities. The phases are illustrated in Figure 1.

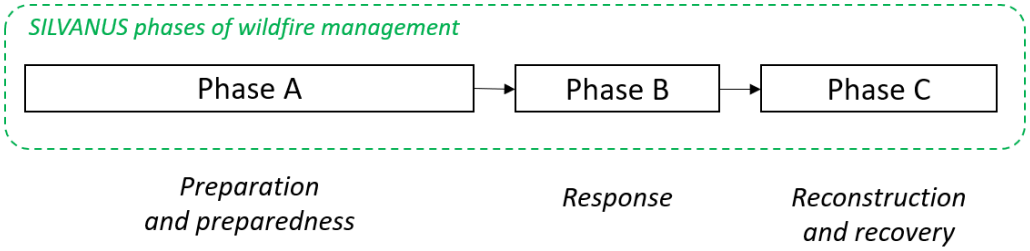

Figure 1. Phases of wildfire management
Source: own study.

Phase A is dedicated to the preparation and preparedness, including preparation and pre-planning activities for wildfire response. This is the initial phase of wildfire management. As a rule, relevant activities are conducted before fire materialisation. Special attention is put on deployment of multiple sensors,

computational tools, decision support systems, and the edge technologies to shape situational picture and to be ready for the picture modifications while a danger occurs. Very important issue is to effectively prepare wildfire responders to notify the hazard as well as to use skills, equipment and infrastructure they have to operate in disaster conditions. Phase B starts when a wildfire breaks out. It is related to performance of technological interventions developed and deployed for the early-stage detection of wildfire ignition. This means direct use of multiple technologies in making situational awareness and supporting wildfire responders. And phase C regards to reconstruction and recovery processes. It is about post fire rehabilitation of land. Forest resources state a key point in reconstruction and recovery processes. All technologies deployed are to monitor these processes as well as to give information valuable from the perspective of effective rehabilitation.

The general use of multiple technologies in the SILVANUS approach is presented in Figure 2.

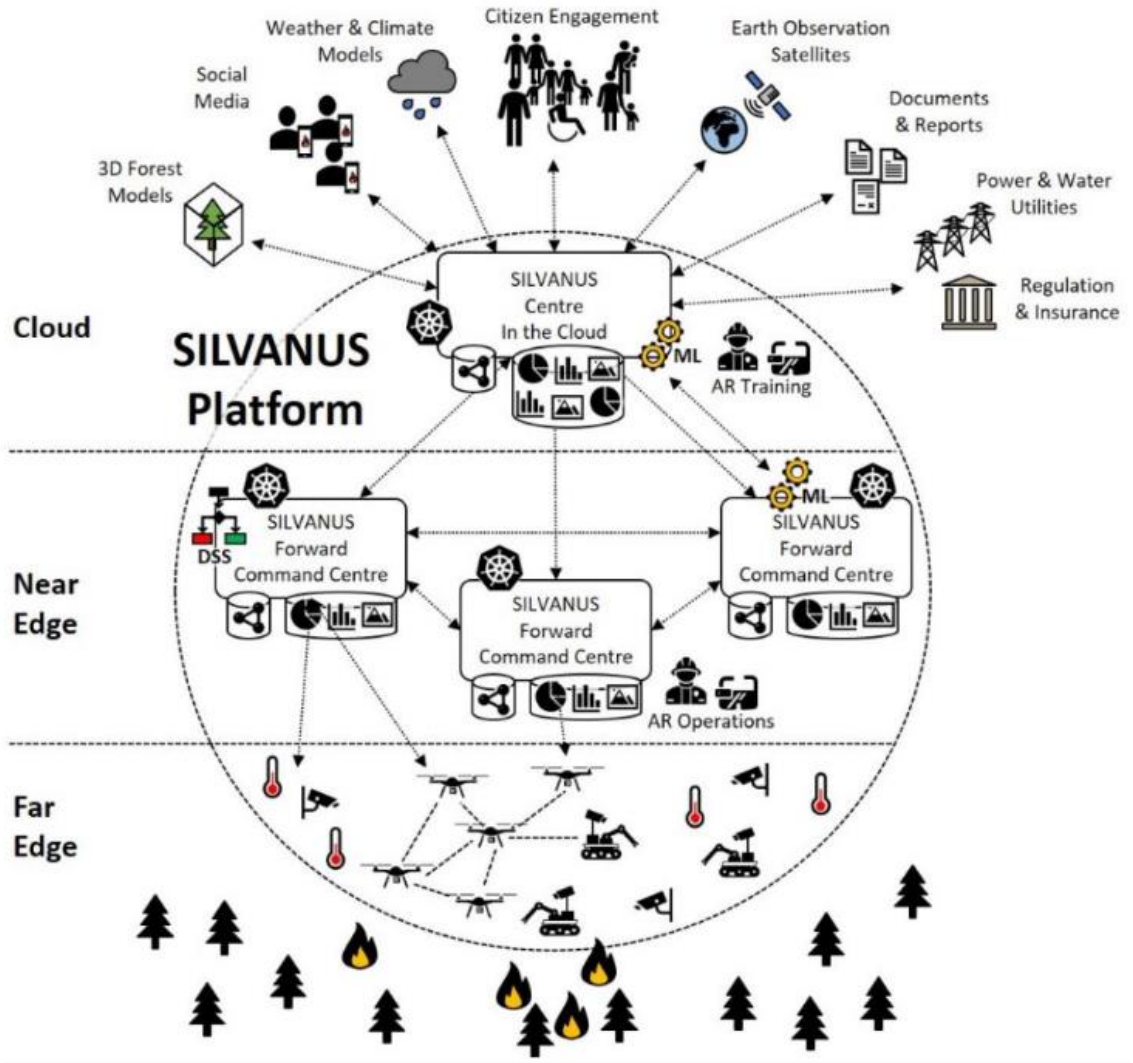

Figure 2. General illustration of the SILVANUS approach
Source: (Mojir et al., 2023).

The use of technologies is common for all wildfire management phases and divided into cloud implementation, near edge implementation and far edge implementation. It means that some of

technological functionalities to support preparation and pre-planning activities require to be used directly on the wildfire scene (for example robots, drones), some of them can be deployed in safety distance (command centres, etc.), and the rest are implementable to the cloud (i.a. decision support systems). Such kind of approach makes the preparation and pre-planning activities flexible and adjustable to current situational picture and operational needs of wildfire responders.

It is worth highlighting that SILVANUS project pays special attention on preparation and pre-planning activities for wildfire response. Task 3.3 in the project concerns directly this issue. The task objective is to propose a systematic methodology for the preparation and pre-planning activities to be carried out upon the ignition of forest fires. Consequently, the activities are ascribed directly into the general project idea and cross-cut many other project tasks. It is schematically presented in Figure 3.

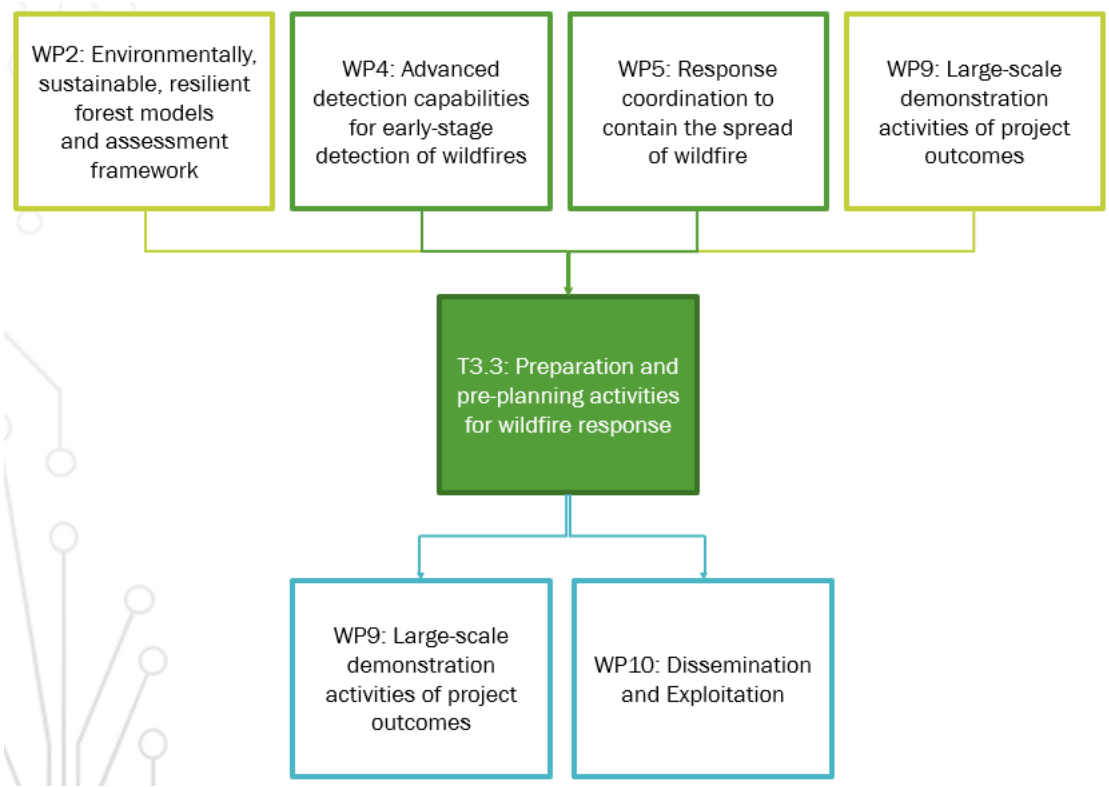

Figure 3. Preparation and pre-planning activities for wildfire response in the SILVANUS approach
Source: (SILVANUS T3.3, 2022).

Connections between T3.3 and other work packages of the project determine the way in which preparation and pre-planning activities are designed and conducted. The activities base on wide information framework on environmentally, sustainable, resilient forest models and assessment. They regard to advanced detection capabilities for early-stage detection of wildfires and reflect response coordination to contain the spread of wildfire. The very important point is to make them useful for stakeholders, including end-users of SILVANUS technologies. This justifies the close relation of preparation and pre-planning activities to project pilots and demonstrations, just like verification of relevant conditions and ideas in dissemination and exploitation processes. All of these to make a set of chances to confront T3.3 results to stakeholders (especially firefighters and other wildfire responders).

As regards to phase A of wildfire management and the project objectives, T3.3 is to give input to enhancement of wildfire prevention and management tactics methodologies and procedures using the progressive ICT tools, training handbook for fire fighters on the safety regulations for the deployment of technologies, development of a semantic framework to formalise the stakeholder involvement in sustainable forest management, as well as to define training activities designed to improve safety and preparedness of firefighters in combating wildfire. This emphasizes that essential issue of preparation and pre-planning activities for wildfire response due to the SILVANUS approach is a training.

In association to T3.3 results, the systematic methodology for the preparation and pre-planning activities to be carried out upon the ignition of forest fires bases on the following assumptions:

1. Training is the only kind of activity able to effectively transfer the wide spectrum of wildfire-related information to relevant responders and, simultaneously, to implement new technologies and ensure safety of trainees (in accordance to wildfire specifics).
2. The methodology should express fundamental educational issues such as:
   a) training content (data, information, skills),
   b) training objectives,
   c) training forms and methods,
   d) training materials.
3. The methodology needs to consider all technologies developed in the SILVANUS project and give guidelines on how to use them in training processes.
4. The use of technologies should be reflected in reference training protocols to make them operational and adjustable to multiple training needs.
5. Facing requirements of end-users' forces to ensure that training protocols must reflect overall process of wildfire response.

As far as these assumptions are concerned, the systematic methodology for the preparation and pre-planning activities to be carried out upon the ignition of forest fires can be presented in the step-by-step formula illustrated in Figure 4.

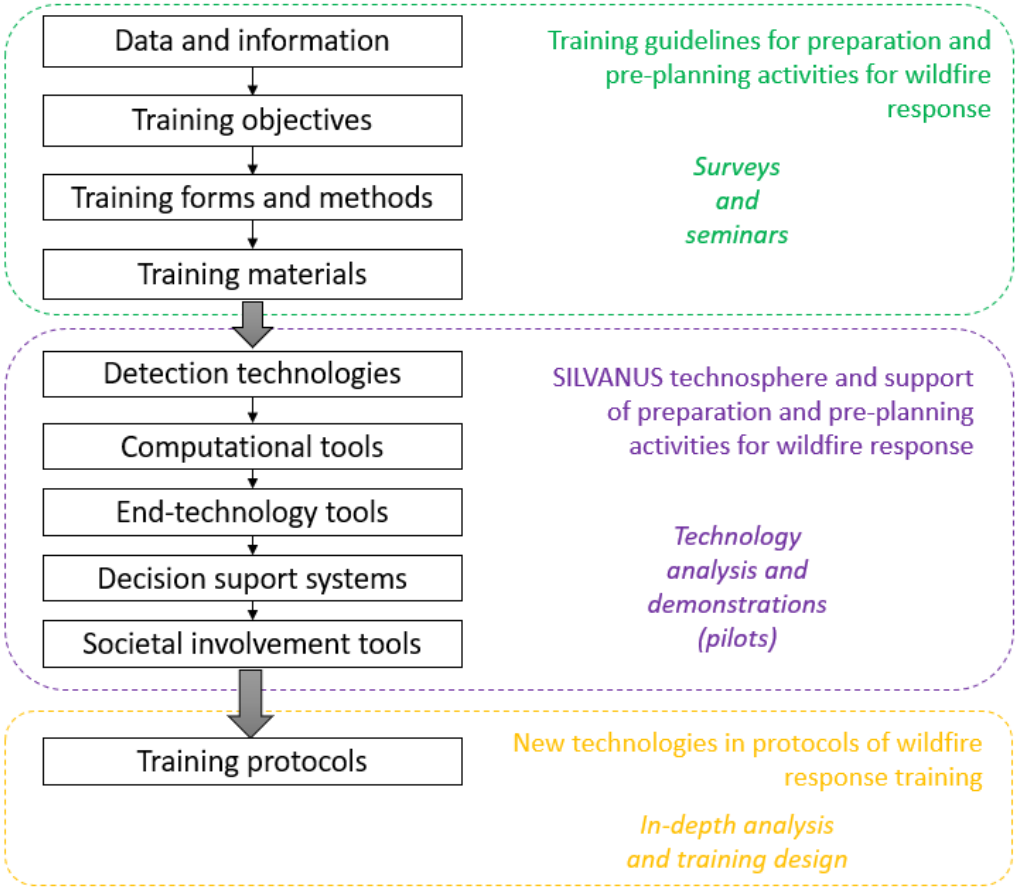

Figure 4. The systematic methodology for the preparation and pre-planning activities to be carried out upon the ignition of forest fires

Source: own study.

Collection of training guidelines for preparation and pre-planning activities for wildfire response requires to involve experts who are able to concretise what, when, where, for who and how should be done when plan and conduct the training. The reference forms of their involvement are surveys and seminars. The surveys make a chance for unhindered reflection of own ideas and insights. The seminars can play a significant role in operationalisation of information collected and in-depth analysis of survey results. Relevant results should be detail information about data and information (as crucial resources in pre-planning and preparation activities for wildfire response), training objectives, training forms and methods, and training materials.

Technology analysis and demonstrations (pilots) are reference ways to investigate and validate new solutions and tools to support pre-planning and preparation activities for wildfire response. As regards to the SILVANUS project, detection technologies, computational tools, end-technology tools, decision support system and citizen engagement tools should be taken into account. All of them should be analysed not only from the viewpoint of direct deployment to wildfire response but also from the perspective of training processes. This allows making background for comprehensive use of the tools and solutions before and during the response, as well as ensures effective manual and maintenance preparedness of wildfire responders.

Reference training protocols are said to be the final outcome of the methodology. To ensure their rationality and operationality, there is the need to reflect particular phases of the wildfire response, namely (a) early detection and communication of the hazard, (b) immediate disposal of wildfire responders, (c) effective getting of the resources to the wildfire scene, (d) comprehensive recognition of hazard situation, (e) firefighting tactics, and (f) cooperation between entities fighting the fire. This should be done in a line of in-depth analysis and training design to reflect specifics of wildfire phenomenon and response, assumptions for training related to preparation and pre-planning activities for wildfire response, training guidelines and training Technosphere.

Resuming, training seems to be the most universal and appropriate form of preparation and pre-planning activities for wildfire response when considering wildfire specifics, the response process, common use of modern technologies, and focusing of effectiveness. Training guidelines for preparation and pre-planning activities for wildfire response should be determined by data and information presented as well as training objectives, forms and methods, and materials. Special attention should be put on new technologies to support wildfire responders. Their analysis must consider training rigors and possibilities. The final outcome of the methodology is constituted by a set of training protocols that uniquely connect operational needs related to a wildfire and new technologies into the training framework.

The SILVANUS methodology states relatively universal framework for entities involved into preparation and pre-planning activities for wildfire response. It may be tailored to current expectations and needs. Specific results of its implementation are presented in this monograph.

4.2. 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 (a) early detection and communication of the hazard, (b) immediate disposal of wildfire responders, (c) effective getting of the resources to the wildfire scene, (d) comprehensive recognition of hazard situation (from ground and air), (e) firefighting tactics, and (f) cooperation between entities fighting the fire. Basing on literature analysis (paying special attention on operational procedures, research papers, good practices), focus group meetings, 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), 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 (platform X, Facebook), temperature detectors, pyrotechnic cartridges, etc.
    2) Exact location of hazard.
    3) Number of wildfire sources/hot-spots.
    4) Area of the danger zone (covering a range of flames and smoke, and site of the fire).

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 wildfire manifestations and cascading 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 and limitations of the use of aerial means that cannot fly in the presence of extreme wildfires.
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 defence 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 and limitations of the use of aerial means that cannot fly in the presence of extreme wildfires.
7) Location of reliable water supply points.
8) Location of reliable extinguishing points.
9) Location of reliable fire defence 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 to observe fire symptoms (a smoke, flames, a glow) from above of the trees (in visible light, infrared).
9) Information from satellite services (Landsat, Copernicus, Sentinel etc.)
10) Landform.
11) Presence of wildfire manifestations and cascading 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 defence lines – if existing. Location of potential defence 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.
14) Fire characteristics and behaviour (e.g., fire line intensity, rate of spread, spotting activity, and distance).

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.
12) Fire characteristics and behaviour (e.g., fire line intensity, rate of spread, spotting activity, and distance.

It is worth highlighting that some of data and information are required for more than only one phase of the wildfire response. Continuity of information flows gains in importance to be sure that situational picture is updated and every wildfire responder bases on the same operational assumptions.

4.3. Training objectives

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 mean general educational directions to be followed during preparation and pre-planning activities in wildfire response. They are closely related to the training scope as the scope is a kind of derivative of the objectives.

Training objectives and scope were specified within the first survey sent to all partners from Task 3.3 in the SILVANUS project as well as 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 main goal of the survey method was to identify objectives and scope of training for fire services, forest services, UAV operators and public administration representatives involved in wildfire response. Responders were informed that 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 was paid on the use of modern technologies (including AR/VR) as well as best organisational, equipment and tactical solutions.

Table 2 presents results of the process of collecting information about training objectives and scope regarding to early detection and communication of the hazard.

Table 2. Training objectives and scope for early detection and communication of the hazard

No.	Objectives of the training	Scope of the training
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.	Scheme and description of country early detection system. Specific detection procedure for fire service from ground and/or from air.
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.	Scheme and description of country early detection system. Specific detection procedure for forest service from ground and/or from air.
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.	Scheme and description of country early detection system. Specific operational procedure to support the system by UAV operators from air.
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.	Scheme and description of country early detection system. Specific operational procedure to use/manage the system by public administration.
5	To acquaint wildfire responders with the system of transmitting information about the occurring hazard.	Scheme and description of the system for communicating information on the occurring hazard.
6	To prepare wildfire responders to effective crisis communication procedures (formal communication between the responders).	Crisis communication procedures (formal communication between the responders) during wildfire (especially during first stage of the hazard development).
7	To prepare wildfire responders (especially decision makers) for effective risk communication procedures (formal communication with the public).	Risk communication procedures (formal communication with the public) during wildfire (especially during first stage of the hazard development).
8	To familiarise wildfire responders with specification of early detection of hazard.	Physical, chemical and biological issues determining wildfire and its detection (including weather conditions, fire scene conditions).
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').	Mechanism of generating 'false-positives' in early detection systems and operational ways to verify them.
10	To practically exercise a use of detection tools in field conditions by wildfire responders (especially UAV operators, fire services and forest services).	Manual and practical issues related to use of particular detection tools by UAV operators, fire services and forest services).

No.	Objectives of the training	Scope of the training
11	To acquaint wildfire responders with early detection system <<Fire detect>> to be able to use it in practice and to follow detection procedures.	The video detection system <<OiB-Fire Detect/Stribor>> is covering the coastal part of Croatia. 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	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.	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.

Source: own elaboration based on (SILVANUS D3.2, 2023).

Training should ensure that wildfire responders and wildfire managers are familiarised with early detection systems that operate due to wildfire risk. It means both organisational systems (that provide inter-agency and multi-entity risk communication and crisis communication) and technical systems (in the meaning of particular technology solutions). They could be country-specific and some of them may be EU-level solutions. Both cases should be taken into consideration to prepare trainees for operation in a familiar common detection framework when necessary. It is crucial also for wildfire responders from abroad (for example when dispatching rescue capacities or getting support from neighbouring countries). The main idea is to ensure that a trainee is sure that hazard-related information is actual, complete and reflect real safety and security determinants.

Table 3 presents results of the process of collecting information about training objectives and scope regarding to immediate disposal of wildfire responders.

Table 3. Training objectives and scope for immediate disposal of wildfire responders

No.	Objectives of the training	Scope of the training
1	To present organizational disposal system for wildfire responders.	Organisational structure, objectives and disposal mechanisms for wildfire responders.
2	To present technical disposal system for wildfire responders and use its chosen functionalities.	General specification and functionalities of disposal system.
3	To familiarize with information exchange between wildfire responders regarding to immediate disposal to action.	Structure of information exchange (including reliable information sources, information from citizens and decision makers).
4	To present information necessary to make decision about disposal of wildfire responders to the action.	Information to be collected to make decision about disposal of wildfire responders to the action.
5	To acquaint wildfire responders with the system of optimising the selection of rescue forces' potential.	Description of the system for selecting the potential of rescue units to extinguish a forest fire.
6	To acquaint wildfire responders with the minimum necessary equipment with vehicles, equipment and extinguishing agents for extinguishing forest fires.	Description of the selection system for equipment with vehicles, equipment and extinguishing agents for extinguishing forest fires.
7	To present alternatives for ”typical” wildfire responders (fire service, forest service) to be used in case of emergency.	Analysis of alternatives for "typical” 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	To connect immediate disposal of wildfire responders with crisis communication mechanisms in public administration bodies.	Crisis communication mechanisms in public administration bodies respecting immediate disposal of wildfire responders.
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.	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

No.	Objectives of the training	Scope of the training
		GIS-system and is fulfilled by Croatian firefighters.

Source: own elaboration based on (SILVANUS D3.2, 2023).

The need of familiarisation with organisational and technical solutions in the training for wildfire response is noticed also when talking about immediate disposal of wildfire responders. As a rule, the disposal must be immediate and concern resources that are quantitatively and qualitatively accurate to handle with a disaster (wildfire and relevant secondary threats). Apart from local resources, external supporters should be taken into account (for example firefighting troops from abroad). This determines processes of information exchange and gives rise to the need of resources optimisation. Training should realise that resources are limited. They must be dislocated and used rationally. Reserves should be appointed as well. Special attention should be put on entities that may support "classical" wildfire responders (such as fire services and forest services) during their operations and state operational alternatives and equivalents. Case studies from different countries may give inspirations on how to improve disposal of wildfire responders in other places.

Table 4 presents results of the process of collecting information about training objectives and scope regarding to effective getting of the resources to the wildfire scene.

Table 4. Training objectives and scope for effective getting of the resources to the wildfire scene

No.	Objectives of the training	Scope of the training
1	To acquaint wildfire responders with the system of fire commuting.	Description of the fire roads organization system in forest areas. Signed of access roads.
2	To present IT solutions allowing visualizing road network for the needs of getting of the resources to the wildfire scene.	IT solutions allowing visualizing road network for the needs of getting of the resources to the wildfire scene (e.g., GIS).
3	To exercise practical use of mobile IT solutions allowing visualizing road network for the needs of getting of the resources to the wildfire scene.	Mobile IT solutions allowing visualizing road network for the needs of getting of the resources to the wildfire scene (e.g., GIS).
4	To teach how to optimise arrival routes to the wildfire scene from the perspective of ground resources (e.g. fire engines).	Use of maps (paper ones and GIS) to optimise arrival routes to the wildfire scene from the perspective of ground resources.
5	To teach how to optimise arrival routes to the wildfire scene from the perspective of air resources (e.g., UAVs, firefighting planes).	Use of maps (paper ones and GIS) to optimise arrival routes to the wildfire scene from the perspective of air resources.
6	To present how to support ground resources by air resources to effective getting to the wildfire scene.	Supporting procedures and good practices in common use of maps (paper ones and GIS).
7	To familiarise with practical opportunities to use citizens involvement (e.g., social	Social media tools allowing identifying 'bottle necks', communication impediments and alternative arrival routes to the wildfire scene.

No.	Objectives of the training	Scope of the training
	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.	Description of the water supply organization system in forest areas. Signed of access water supply points.
9	To acquaint wildfire responders with the forest infrastructure organisation system.	Description of the organization of forest infrastructure related to fire protection. Requirements. Signs. The location of the infrastructure.
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.	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 system and 16 hours for GIS-system and is fulfilled by Croatian firefighters.

Source: own elaboration based on (SILVANUS D3.2, 2023).

As a rule, getting of the resources to the wildfire scene is the matter of field commanders who lead these resources into the action. However, common access to different information sources (for example GIS) may be inspiring for dispatchers, action staff members, emergency management teams, disaster management teams, crisis management teams and other entities to support commanders when they choose the optimal arrival way in the given circumstances and conditions. This is the next valuable direction for training of wildfire response. IT dashboards, GIS, satellite tools, and UAVs may be helpful to express supporting potential in this case. However, the forests are challenging from the viewpoint of terrain conditions. Consequently, trainees should be additionally prepared to handle on their own (without technology support) when approaching to the action on the basis of classical topographical techniques and skills (for example on “how to read the forests”).

Table 5 presents results of the process of collecting information about training objectives and scope regarding to comprehensive recognition of hazard situation (from ground and air).

Table 5. Training objectives and scope for comprehensive recognition of hazard situation (from ground and air)

No.	Objectives of the training	Scope of the training
1	To familiarise with organisation of reconnaissance system.	Description of the reconnaissance system organisation.

No.	Objectives of the training	Scope of the training
2	To present and exercise the reconnaissance system by ground patrols.	Description of the reconnaissance system by ground patrols. Practical reconnaissance by ground patrols.
3	To present and exercise the reconnaissance system by aerial patrols.	Description of the reconnaissance system by aerial patrols. Practical reconnaissance by aerial patrols.
4	To describe and exercise the communication system among ground patrols.	Description of the communication system among ground patrols. Use it in the field conditions.
5	To describe and exercise the communication system among aerial patrols.	Description of the communication system among aerial patrols. Use it in the field conditions.
6	To describe and exercise integrated communication system (among ground patrols and aerial patrols).	Description of integrated communication system (among ground patrols and aerial patrols). Use it in the field conditions.
7	To acquaint wildfire responders with supporting the reconnaissance systems by observation points.	Supporting mechanisms for the reconnaissance systems with the use of observation points.
8	To use of modern technologies for effective communication with commander during the reconnaissance.	Exercises with modern technologies for effective communication with commander during the reconnaissance in the field conditions.
9	To use of alternative means for effective communication with commander during the reconnaissance.	Exercises with alternative solutions for effective communication with commander during the reconnaissance in the field conditions.
10	To familiarise with reliable ways to check the information correctness.	Ways to check the information correctness basing on cooperation with other wildfire responders and citizens.
11	To exercise the use of technological tools for the reconnaissance.	Practical use of technological tools for the reconnaissance (e.g., UAVs, thermovision, GIS, visual cameras, satellite images).

Source: own elaboration based on (SILVANUS D3.2, 2023).

Comprehensive recognition of hazard situation (from ground and air) should be conducted by effective reconnaissance activities. This requires to familiarise trainees with reconnaissance organisation, means and manners, as well as to prepare them to handle with the recognition in conditions of communication limits and lacks of information. Wide range of technological solutions may be used referring to this wildfire response phase. They should be equivalent and give the same situational picture. Furthermore, trainee must be ready to verify existing and collect additional information with the use of improvised measures, also with cooperation to other wildfire responders. All these issues must ensure situational picture which fully reflects real wildfire conditions.

Table 6 presents results of the process of collecting information about training objectives and scope regarding to firefighting tactics.

Table 6. Training objectives and scope for firefighting tactics

No.	Objectives of the training	Scope of the training
1	To acquaint with manners to locate ground resources (mainly fire engines and water support lines).	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).	Manners to locate aerial resources (mainly AUVs) considering maps, transportation network and area to analyse from air.
3	To familiarise with the firefighting area' organisation.	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 familiarise with the operational system of aircraft extinguishing.	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.	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.	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 defence from the wildfire.	Basic structures of hose lines for extinguishing defence from the wildfire, regarding to different (qualitatively and/or quantitatively) ground resources.
8	To familiarise with water supply tactics in different ground conditions.	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 and coordination with other organisations.	For professional fire-fighters: to get acquainted with basic wildland suppression tactics and equipment. Fire direct and indirect attack, depending on the fire line intensity.

No.	Objectives of the training	Scope of the training
10	Extinguishing wildfires and transport with helicopter.	For volunteer fire-fighters: to get acquainted with basic wildland suppression tactics and equipment and transport with helicopter.
11	To collect information about fire characteristics and behaviour to formulate the tactics of the response.	Information concerning fire line intensity, rate of spread, spotting activity, distance.

Source: own elaboration based on (SILVANUS D3.2, 2023).

Firefighting tactics is the essential issue when talking about wildfire response. All previous phases are to prepare and make foundations for the response. Trainee needs to know elements of the tactics regarding to proper location of resources (to reduce operational risks), manners for organisation of firefighting scene, structures of hose lines to provide extinguishing action in the attack or in the defence, water supply, and logistics in the forested areas. Special attention should be put on effective cooperation between ground troops and aerial vehicles to maximise their synergistic effect of extinguishing action. There is also the needed to form skill of improvising and adjusting the tactics to dynamic wildfire environment and conditions. In other words, training should deliver not only information puzzles but also ready-to-implement and verified manners on how to connect them into effective firefighting action.
Table 7 presents results of the process of collecting information about training objectives and scope regarding to cooperation between entities fighting the fire.

Table 7. Training objectives and scope for cooperation between entities fighting the fire

No.	Objectives of the training	Scope of the training
1	To acquaint wildfire responders with the cooperation system of entities fighting the fire.	Description of the firefighting coordination system. Cooperating institutions.
2	To present alternatives for 'typical' wildfire responders (fire service, forest service) to be used in case of emergency.	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	To prepare wildfire responders (especially decision makers) for effective risk communication procedures (formal communication with the public).	Risk communication procedures (formal communication with the public) during wildfire (especially during first stage of the hazard development).
4	To acquaint wildfire responders with the system of transmitting information about the hazard development (e.g., cascading effect).	Scheme and description of the system for communicating information on the hazard development (e.g., cascading effect).
5	To prepare wildfire responders to effective crisis communication procedures (formal communication between the responders).	Crisis communication procedures (formal communication between the responders)

No.	Objectives of the training	Scope of the training
		during wildfire (especially during first stage and next stages of the hazard development).
6	To show how to use technologies and equipment to optimise the use of human resources on the wildfire scene.	Alternatives for use of human resources (e.g., firefighters, aerial patrols) considering UAVs, stationary extinguishing points, fire barriers etc.
7	To prepare wildfire responders to conduct their activities taking into consideration safety procedures.	Occupational health and safety procedures for wildfire responders and their practical implementation during large scale field exercises.
8	To teach how to identify mutual operational needs among entities fighting the wildfire.	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	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.	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.
11	To collect and share information about fire characteristics and behaviour to formulate the tactics of the response.	Information concerning fire line intensity, rate of spread, spotting activity, distance as well as particular tactics of entities involved in a wildfire response.

Source: own elaboration based on (SILVANUS D3.2, 2023).

Cooperation allows maximising a synergy effect of wildfire response. On the other hand, fire service and forest service may be insufficient to face the hazard analysed in the conditions of a disaster and/or co-existing hazards. Trainees need to be familiar with cooperation possibilities, standards and requirements

to plan and conduct common efforts in an effective way. Thus, training should be directed on system approach on the cooperation, initiating alternative resources and conducting multi-entity communication (crisis communication and risk communication). It concerns also safety procedures and the use of new technologies as not all entities may be preliminarily and equally prepared for it as "classical" wildfire responders.

As far as training objectives are concerned, their analysis allows to form training scope or elements of the scope. They need to be adjusted to current training needs and expectations. Moreover, some of the research results seem to cross-cut two and more phases of wildfire response. They are, for example, shaping situational awareness, crisis communication and the use of new technologies. It means that preparation and pre-planning activities for wildfire response in the form of training can be optimised, concern one or more response phases and consider the use of multiple technologies. Training organiser can match these elements to ensure effective training curricula and training protocols.

4.4. Training forms and methods

Training forms and methods mean specific ways to achieve all training objectives and cover entire training scope. At the highest level of generality, they should ensure effective transfer of knowledge and development of skills during a training. In addition, they need to be formulated in detail to frame specific methodological directions for the training. Training forms are general educational frameworks to organise the training. In turns training methods are specific ways to proceed the learning process. Some of the methods are specific for relevant forms. Special attention should be put on high-effectiveness forms and methods to maximise educational effect in the given time of training (Gromek, 2021).

Training forms and methods were specified within the second survey sent to all partners from Task 3.3 in the SILVANUS project, 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 main objective of the survey method was to identify training forms and methods for fire services, forest services, UAV operators and public administration representatives involved in wildfire response. Responders were informed that the forms and methods should have allowed 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. In addition, special attention should have been paid on the use of modern technologies (including AR/VR) as well as best educational and training solutions. The training should have reflected specification (scope, technologies, stakeholders involved, detail issues etc.) of wildfire-determined case studies. It should also have been opened 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.
Table 8 presents results of the process of collecting information about training forms and methods regarding to early detection and communication of the hazard.

Table 8. Training forms and methods for early detection and communication of the hazard

No.	Training form and/or method	Objective of the form and/or method use
1	Lecture	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	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-side observation	

Source: own elaboration based on (SILVANUS D3.2, 2023).

Training forms and methods used to prepare trainees for early detection and communication of the hazard need to ensure their familiarisation with general situational picture before a hazard occurs, and practical operational issues related to early warning systems. As a rule, the warning is early when the system operator notifies a hazard immediately after its materialisation. Practical abilities are crucial in this case. (lecture, discussion, talk) should be used to present and analyse the situational picture and the system functionalities. Nevertheless, special attention needs to be put on simulations, manual trainings and observations to develop and consolidate practical skills. E-leaning formula can be implemented as a supplement method – never as the solely one.

Table 9 presents results of the process of collecting information about training forms and methods regarding to immediate disposal of wildfire responders.

Table 9. Training forms and methods for immediate disposal of wildfire responders

No.	Training form and/or method	Objective of the form and/or method use
1	Lecture	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.
2	Presentation	
3	Talk	
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	

No.	Training form and/or method	Objective of the form and/or method use
11	E-learning system	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).

Source: own elaboration based on (SILVANUS D3.2, 2023).

Immediate disposal of wildfire responders requires to use exercise-related forms and methods to teach on how to optimise resources of wildfire responders to be dispatched, and how to communicate the optimisation result to the responders. Training should also allow to make conditions to identify safe routes, water reservoirs, fire shelters and other elements that determine the disposal to proceed it in an optimal manner. Case studies, table top exercises, decision trainings and practical exercises are especially valuable to check different disposal conditions and circumstances, and discuss them. Also, in this case e-leaning formula cannot be the solely one when considering training forms and methods. It may be very useful to make a training background and to state a platform for training materials.
Table 10 presents results of the process of collecting information about training forms and methods regarding to effective getting of the resources to the wildfire scene.

Table 10. Training forms and methods for effective getting of the resources to the wildfire scene

No.	Training form and/or method	Objective of the form and/or method use
1	Lecture	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. 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.
2	Presentation	
3	Talk	
4	Simulation (including computer simulation)	
5	Classical problem method	
6	Case study	
7	Table top exercises	
8	Decision training	
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	

Source: own elaboration based on (SILVANUS D3.2, 2023).

Effective getting of the resources to the wildfire scene requires preparing drivers, commanders and dispatchers to optimally plan arrival routes. Thus, essential knowledge about terrain conditions, routes, water reservoirs, potential fire defence lines, and biodiversity is needed. It may be transferred with the use

of classical teaching methods (for example lecture, presentation, talk) as well as by providing high-effectiveness formulas (table top exercises, decision training, etc.). When a fire service has its own disposal system, it is valuable to implement it to training process and adjust to wildfire scenarios. Decision-making problems should be considered as well. They could cover arrival problems that are typical (to appoint the optimal arrival route) and/or untypical (to urgently modify arrival route doe to hazard development) for wildfire responders.

Table 11 presents results of the process of collecting information about training forms and methods regarding to comprehensive recognition of hazard situation (from ground and air).

Table 11. Training forms and methods for comprehensive recognition of hazard situation (from ground and air)

No.	Training form and/or method	Objective of the form and/or method use
1	Lecture	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.
2	Presentation	
3	Talk	
4	Discussion	
5	Simulation (including computer simulation)	
6	Classical problem method	
7	Case study	
8	Wildfire history study	
9	Practical exercises	
10	Field exercises	
11	E-learning system	

Source: own elaboration based on (SILVANUS D3.2, 2023).

Comprehensive recognition of hazard situation (from ground and air) is to state situational picture necessary to formulate firefighting tactics and shape effective coordination between wildfire responders. This is why training should ensure a wide spectrum of forms and methods to develop reconnaissance and analytical skills, with strong support of multiple sources of information (sensors, detectors, decision support systems, drones, robots, communication systems, etc.). The good practice is to start training with the use of classical teaching methods (lecture, talk, presentation) to prepare for the essential part of the training process. E-learning may be used to support this process. The essential part should be practical exercises and/or field exercises to develop specific skills and test new knowledge in quasi-real or real conditions in the forests.

Table 12 presents results of the process of collecting information about training forms and methods regarding to firefighting tactics.

Table 12. Training forms and methods for firefighting tactics

No.	Training form and/or method	Objective of the form and/or method use
1	Lecture	1. To increase knowledge on first stage tactics formulation, division of hazard scene on
2	Presentation	
3	Talk	

No.	Training form and/or method	Objective of the form and/or method use
4	Discussion	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.
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)	

Source: own elaboration based on (SILVANUS D3.2, 2023).

Firefighting is the core issue of wildfire response. The conditions of the forests and specifics of wildfire phenomenon significantly regulate expectations from relevant training. Effective practice is required to prepare wildfire responders for operation directly to put out the fire. First part of training can be focused on theoretical information, standards and good practices on firefighting tactics, with special place for case studies and discussion on practical problems and making complex tactical decisions. But the main training part needs to be organised in exercise formula. It is important to be aware about duration and practical constrains of particular tactical activities. Training firefighting tactics generates also possibilities to use engines and equipment of wildfire responders to check them in quasi-real or real conditions of the response in the forests.

Table 13 presents results of the process of collecting information about training forms and methods regarding to cooperation between entities fighting the fire.

Table 13. Training forms and methods for cooperation between entities fighting the fire

No.	Training form and/or method	Objective of the form and/or method use
1	Presentation	1. Promote acquaintance with the firefighting procedures. 2. To promote communication and co-joint operational effectiveness. 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.
2	Debriefing	
3	Talk	
4	Discussion	
5	Classical problem method	
6	Case study	
7	Brainstorming	
8	Didactic games	
9	Table top exercises	
10	Decision training	
11	Practical exercises	
12	Field exercises	

No.	Training form and/or method	Objective of the form and/or method use
13	E-learning system	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.
14	Education for << Air-force guidance >> (4 day education and training for leaders of fire-fighting intervention).	

Source: own elaboration based on (SILVANUS D3.2, 2023).

Cooperation between entities fighting the fire is challenging from the viewpoint of a training. It requires tailoring training forms and methods for different users, and doing it in an integrated way. Nonetheless, wide catalogue of training forms and methods is valid in this case. The simple ones (presentation, talk, discussion) should be used to make theoretical background for the cooperation and to establish the cooperation structure (to be sure that every entity is aware of its tasks and duties). The more complex forms and methods are valuable to develop cooperation skills via solving complex decision-making problems and making common efforts to face a wildfire. Field exercises are very welcome in this case. Union Civil Protection Mechanism is the good example on how to organise such kind of a training in a way to maximise educational effect at international scale.

In addition, there is a need to adjust training duration to particular forms and methods. From practical point of view and to ensure flexibility for training organisers, it is suggested to consider following reference durations to achieve relevant aims:

a. 2-3 hours: presentation of early warning, data collection and communication solutions – for example to increase knowledge on the physical landscape (orography, vegetation, biodiversity, human occupation).
b. 6-8 hours: – familiarizing with procedures, good practices, technological solutions, etc. – for example to present modern technological solutions (hardware, software, satellite techniques) for ground and air reconnaissance.
c. 12 hours: organization of field-exercises to practically use new technologies, response strategies and cooperation issues – for example to organise practical exercise on training ground with aerial means (airplanes, UAV).
d. 20 hours: comprehensive training for voluntary responders responsible for supporting at the wildfire scene (e.g. volunteer firefighters) – for example to get acquainted with basic wildland suppression tactics and equipment and transport with helicopter.
e. 30 hours: comprehensive training for professional responders responsible for commanding at the wildfire scene (e.g. professional forest services, professional firefighters) – for example to get acquainted with basic wildland suppression tactics and equipment, fire direct and indirect attack, depending on the fire line intensity.

Trainings should be organised by institutions and organizations experienced in high-effective education of fire professionals (for example forest fire education centres, firefighting units, universities – including organizers and consortia under umbrella of the European Union and the United Nations) with strong support of technology providers (relevant for equipment used during the trainings).

Training target groups are basically entities that respond to wildfire directly and indirectly. Direct response on a wildfire refers to firefighting units of forest services, voluntary firefighters, professional firefighters, soldiers, etc. Indirect response on a wildfire concerns UAVs operators and UGVs operators (for example to make a reconnaissance from, respectively, air and ground), public administration (for example to coordinate an entire domain of response operation), police (for example to secure access roads and support in evacuation), critical infrastructure operators (to be better prepared for protection of the infrastructure against wildfire and its manifestations), forest owners (to be informed about wildfire protection means and manners), technology providers (to evaluate their solutions and open for operational needs and expectations of wildfire management) as well as citizens and their groups involved in the response (for example owners of plows and other heavy equipment to make ground defence lines).

4.5. Training materials

Training materials mean all information sources useful in the transfer of knowledge and development of skills related to training for wildfire response. The materials should be adjusted to training forms and methods as well as need to cover as much of training scope as possible. To make them operational, training materials should be shared with training attendees before, during and after training. E-learning platform is said to be a valuable form to share the materials. Furthermore, materials' content needs to be tailored to cognitive abilities of trainees to ensure that they are able to collect all necessary information immediately and effectively.

Training forms and methods were specified within the second survey sent to all partners from Task 3.3 in the SILVANUS project, and discussed during the Third International Scientific Seminar on Preparation and Pre-Planning Activities for Wildfire Response "Training Materials" (15 December 2022). The main objective of the survey method was to identify and discuss training materials for the needs of fire services, forest services, UAV operators and public administration representatives involved in wildfire response. Responders were informed that 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 have been paid on correspondence with modern technologies, high quality content, reflecting of state-of-the-art as well as best educational and training solutions as well as on entire spectrum of multiple training materials (i.e.): 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.

As focuses on training materials dedicated to training on early detection and communication of the hazard, the following materials are presented and synthetically described:

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) Categorisation 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.

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 determine 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 ensuring effective long-distance communication tools.
   d) Field testing allows to check the solutions in practice and facilitates 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.

Training on immediate disposal of wildfire responders can be supported by the use of the following materials:

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) Decision support systems may be used for automatic or semi-automatic (with human operation) disposal of wildfires resources on the action scene.
   b) Decision 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.

Effective getting of the resources to the wildfire scene is very specific topic of a training. It may be trained with the use of the following training materials:

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 analyze a network of fire trails in forest.
d) Fire trails in forest may play a role of quasi-natural defense 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 defense 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.

When considering comprehensive recognition of hazard situation (from ground and air), the following training materials are said to be valuable sources of information for the training needs:

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 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 Defense (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 checking 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 utilise 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.

As regards to firefighting tactics, several sources of information are commonly accessible and may serve for training participants in preparation and pre-planning activities for wildfire response. They are the following training materials:

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 other 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 firespread, 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 fire fighting 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.

The next set of training materials refers to cooperation between entities fighting the fire. The following sources of information may be used to support training organisers and attendees in this context:

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 reconnaissance 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 and 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: To improve skills and competencies of people, To improve the quality of, and access to continuing vocational training, Developing relevant and innovative e-learning content, The 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. An organisational dimension of a community is a good reference to design effective societal cooperation.

During the research, the need to establish the general category of training materials occurred. This means sources of information that may be used regarding to different phases of wildfire response due to current needs and expectations. The following items are enumerated in this category of training materials:

1) Majlingova, A., Kucikova, D., Kropil, R., Hancko D. (2022). Wildland fire patterns and fire-fighting tactics in Central European Countries. Zvolen: Technical University in Zvolen:
    a) Dynamics of wildfires determines firefighting tactics and disaster management conditions.
    b) Fire consequences may generate the necessity to involve multiple responders to make common efforts to face the fire and relevant secondary threats.
    c) Wide spectrum of firefighting tactics which may be tailored to (i.a.) current phase of wildfire development and terrain conditions.
    d) ICT and geoinformation technologies find their application in responding to wildfires.

2) Restas, A. (2022). Drone swarm technology as a competitive alternative to traditional aerial firefighting. In. *Advances in Forest Fire Research*, Viegas, D. X., Ribeiro, L.M. (eds). University of Coimbra: Coimbra, pp. 1612-1615:
    a) Drones are very perspective alternatives for classical aerial vehicles while put out a wildfire.
    b) Swarm formula is the next significant step in the common use of drones for wildfire response purposes.
    c) The use of drones requires specific calculation methods to ensure sufficient amount of extinguishing medium for wildfire response.
    d) Proper coordination between drone operators and other wildfire response actors is crucial from extinguishing efficiency and safety resons.
3) 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 characterise 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.
4) 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.
5) 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.
6) Mojir, K. Y., Olson, N., Balogh, Z., Maceviciute, E., Gatial, E. (2023). Citizen Engagement in wildfire management: needs, challenges, methods and framework. Yousefi Mojir et al. Citizen Engagement in wildfire management. *WiPe Paper – Track 10: Volunteers in Crisis Management/Emergency Response. Proceedings of the 20th ISCRAM Conference* – Omaha, Nebraska, USA May 2023, J. Radianti, I. Dokas, N. LaLone, D. Khazanchi, eds. https://idl.iscram.org/files/mojir/2023/2564_Mojir_etal2023.pdf:
    a) New technologies give new possibilities in support of wildfire management, including wildfire response.
    b) New media and personal devices increase citizen potential accordingly to engagement in wildfire management, including wildfire response. Several engagement patterns are elaborated and tested.
    c) ICT platform is a kind of perspective solution to integrate multiple technologies for wildfire response.
    d) Sensors, communication devices, robots and drones are good examples on how to use new technologies in wildfire response.

7) 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 solutions 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.
8) Innovation in Crisis Management, Fonio, C., Widera, A., Zwęgliński, T. (eds). Routledge:
    a) Trials state valuable forms of connected training and technology evaluation.
    b) Trainings and trials need to base of precisely identifies needs of practitioners to reflect real operational needs and expectations.
    c) New technologies are crucial to effectively shape situational picture and enhance situational awareness when talking about emergencies, disasters and crisis situations (including these triggered by a wildfire).
    d) Trials and trainings should base on methodologies to reflect state-of-the-art and best educational and evaluation practices.
9) 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).
10) Heikkila, T. V., Gronqvist, R., Jurvelius, M. (2010). Wildland Fire Management. Handbook for Trainers. Rome: Food and Agriculture Organization of the United Nations:
    a) Background and justification for intensified wildfire activities.
    b) Baseline data for wildfire control.
    c) Organisation of wildfire control.
    d) Fire prevention.
    e) Wildfire behaviour.
    f) Pre-suppression activities.
    g) Equipment.
    h) Suppression tactics and techniques.
11) Teie, W. C. (2018). *Firefighter's Handbook On Wildland Firefighting Strategy, Tactics and Safety*. 4th Edition. Stillwater: Oklahoma State University:
    a) Fireline safety.
    b) Fire weather
    c) Topography and fuels.
    d) Wildfire behaviour.
    e) Fireline construction
    f) Use of water and fire.
    g) Use of Firefighting Resources.

h) Initial attack: strategies and tactics.
i) Wildland/Urban firefighting: strategies and tactics.
j) Incident command system.
k) Firefighting realities.
l) Map reading.
m) Fire prevention.
n) Hazardous materials recognition.
o) Use and care of hand tools.

It is worth highlighting that training materials identified during the research state just the reference for the materials collected and shared for the purposes of multiple kinds of training for wildfire response. As a rule, any training is specific and requires specific materials for trainers and participants. Consequently, different forms of training materials should be taken into account. There is a reference list of these forms to be considered when plan and perform the training:

1) books,
2) research papers,
3) leaflets,
4) legal acts,
5) procedures,
6) guidelines,
7) operational manuals,
8) standards,
9) simulation results,
10) case studies,
11) action analysis,
12) reports from exercises,
13) reports from trials and technology pilots,
14) statistics,
15) maps and pictures,
16) technology demonstrators,
17) videos.

Every training should be optimised from the perspective of training materials prepared for and shared among participants. Time necessary for familiarisation with the materials needs to be relatively short but long enough to collect information crucial for achievement of training goals. It may be challenging when new technologies are considered but necessary to maximise educational effect of training. If relatively complex material is expected, e-learning preliminary course (organised before the core training part) can facilitate the process of information sharing and knowledge development.

5. 'SILVANUS Handbook on Systematic Methodology for the Preparation and Pre-planning Activities for Wildfire Response'

5.1. The idea of the handbook

The idea of the handbook is to present systematic methodology that allows to make an overview on preparation and pre-planning activities for wildfire response with strong relation to the use of new technologies. It is focused on presentation of the specifics of wildfire phenomenon and response, the specifics and general guidelines for the training related to preparation and pre-planning activities for wildfire response, the SILVANUS technosphere and support of these activities, as well as on ascribing new technologies in protocols of wildfire response training.

The book is to present the first part of information collected during realisation of T3.3 in the SILVANUS project. The task was focused on preparation and pre-planning activities for wildfire response. Technology and organisational analysis was carried out also during realisation of T3.4 (on AR/VR content curation for training firefighters), T3.5 (on citizen engagement programme for preventing wildfires) and T3.6 (on mobile application for citizen engagement).

Main beneficiaries of the new knowledge are decision makers from public administration, public fire services and forest services who are responsible for preparation and pre-planning activities for wildfire response. The book may be useful also for training organisers, technology providers and trainees to present general view on the training approach and facilitate to prepare training materials.

5.2. Methodology

The research problem was to answer the following question: What systematic methodology does allow to prepare and pre-plan activities for wildfire response?. It reflected relevant research objective that was to elaborate the systematic methodology to prepare and pre-plan activities for wildfire response. It was assumed that the systematic methodology should be in a line of the specifics of wildfire phenomenon and response, the specifics and methodological basics of a such of a training, and consider modern technologies. From operational point of view, it needs to be reflected in training protocols.

Research procedure required to use in-depth analysis of literature (data bases, legal acts, guidelines, procedures, case studies, and descriptions of good practices), carry out three survey sessions involving SILVANUS partners, organise three international scientific seminars on preparation and pre-planning activities for wildfire response (on 'Objectives and Scope of the Training', 29 June 2022; 'Training Forms and Methods', 29 September 2022, and 'Training Materials', 15 December 2022), and proceed comprehensive technology analysis. Particular results were discussed during IV International Scientific Seminar on Preparation and Pre-Planning Activities for Wildfire Response on 'Training guidelines on data and information flows between wildfire responders' and 'Guidelines on effective curricula for training related to preparation and pre-planning activities for wildfire response' (30 March 2023). Technology analysis were proceeded theoretically and practically (during SILVANUS pilots organised in 2023). These research methods allowed to effectively collect information, analyse it, shape new knowledge, discuss research results and transform them into the form of this research monograph.

5.3. Structure of the content

Chapter 1 frames background to make in-depth analysis on preparation and pre-planning activities for wildfire response. It regards specifics of a wildfire, paying special attention on its phenomenon and response. Definition and causes of a wildfire are described. Conditions for the origin and development of this hazard are presented. Information on wildfire types facilitates understanding of typical hazard conditions and development patterns. Process of wildfire response covers all types of wildfires and reflects typical kind of activities to be conducted to face the hazard analysed.

Chapter 2 focuses on training related to preparation and pre-planning activities for wildfire response. The training is said to be universal and organisationally flexible way to cover these activities in a line of specifics of wildfire phenomenon and response, the specifics and methodological basics of a training, and modern technologies accessible to wildfire responders. Training needs were presented. They concretise a connection line between wildfire phenomenon and response, and training curriculum. To operationalise training assumptions, relevant participants and equipment were described.

Chapter 3 regards training guidelines for preparation and pre-planning activities for wildfire response. SILVANUS approach on systematic methodology for the preparation and pre-planning activities for wildfire response was defined. It reflects the 'step-by-step' formula to collect information necessary to elaborate training curriculum in a replicable and rational way. In addition, data and information as crucial resources in pre-planning and preparation activities for wildfire response were analysed. Focusing on training objectives, forms and methods, and materials allowed to precise concrete methodological issues that are 'ready-to-use' when prepare and pre-plan for wildfire response in the form of a training.

Chapter 4 is strongly technology-related. Results of in-depth analysis of SILVANUS technosphere to support preparation and pre-planning activities for wildfire response were collected and discussed. The focus was on detection technologies, computational tools, end-technology tools, functionalities of decision support system, and societal involvement tools. Every solution was described in order to present its general idea, approach on how it works, relationships to particular phases of wildfire management, specific relationship to preparation and pre-planning activities for wildfire response, and training guidelines to simultaneously use of the technology and maximise educational effect.

Chapter 5 served to transfer information collected into a form that is practical for training organisers and technology providers. This allowed to determine training protocols. To reflect the 'step-by-step' formula, particular phases of wildfire response were taken into account: early detection and communication of a hazard, immediate disposal of wildfire responders, effective getting of the resources to the wildfire scene, comprehensive recognition of hazard situation, firefighting tactics, and cooperation between entities fighting a fire. In case of every response phase, its general approach, operational needs, technology functionalities desired, SILVANUS technologies recommended (with indicating purposes of their deployment into training processes), recommendation of connecting particular technologies to particulate technology functionalities, and exemplary training protocol were described. This delivers practical information on how to organise effective training with the use of new technologies.

Detail list of the content is presented in Annex 1.

5.4. Technical information and status

Title: The SILVANUS Handbook on Systematic Methodology for the Preparation and Pre-planning Activities for Wildfire Response.

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Research editors: Pawel Gromek, Anna Szajewska.

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Publishing House: Fire University, Slowackiego 52/54 Street, 01629 Warsaw (Poland).

Status: under review (it is planned to be published during first months of 2025).

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Number of figures: 49.

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Formula: open access (due to internal politics of the publishing house, the book file in '.pdf' format will be available for open dissemination after 3 months from publication; all forms of dissemination will be allowed, including digital repository of Fire University, ResearchGate and Academia.edu).

6. Guideline book on 'New technologies in enhancing training for fire service in wildfire response. The SILVANUS approach'

6.1. The idea of the book

The idea of the handbook is to present detail guidelines on how to effectively organise and conduct training for fire service and other firefighting entities in wildfire response with the use of new technologies. It describes technology-determined training for firefighters to enhance preparation and pre-planning activities for wildfire response and focuses on particular SILVANUS technologies. Information on these technologies are integrated to information on operational protocol on the technology use in the training, enhancement possibilities for both the training and the technology, and safety issues of the technology deployment in the training.

The book is to present the second part of information collected during realisation of T3.3 in the SILVANUS project. The task was focused on preparation and pre-planning activities for wildfire response. In-depth technology and organisational analysis was carried out also during realisation of T3.4 (on AR/VR content

curation for training firefighters), T3.5 (on citizen engagement programme for preventing wildfires) and T3.6 (on mobile application for citizen engagement).

Main beneficiaries of the new knowledge are training organisers, technology providers and trainees for it gives detail organisational and educational guidelines on how to conduct effective training. The book may be useful also for decision makers from public administration, public fire services and forest services who are responsible for preparation and pre-planning activities for wildfire response, to present detail view on the training approach and facilitate to prepare proper conditions for effective training.

6.2. Methodology

The research objective was to elaborate a comprehensive approach to use new technologies in enhancing training for fire service in wildfire response. The research problem was formulated in the following question: What approach does allow to effectively and comprehensively implement new technologies in enhancing training for fire service in wildfire response?. As regards to the research hypothesis, it was assumed that the effective and comprehensive implementation of new technologies in enhancing training for fire service in wildfire response requires to consider the technologies' specifics (so called 'technologies in the nutshell'), operational protocols on how to use the technologies in the training, as well as reflect two essential viewpoints of the enhancement (the perspective of firefighters and the point of view of technology providers), and personal safety issues.

The monograph is comprised by research results obtained exclusively by author while participating in the international research and development project entitled 'Integrated Technological and Information Platform for wildfire Management' (SILVANUS). The research bases on analysis of information collected on the webpage and public deliverables of the project (https://silvanus-project.eu/), literature review (https://www.sciencedirect.com/), analysis of training standards in Poland and other countries, participatory observations carried out during the project pilots in Slovak Republic (23-26.04.2023), Indonesia (06-11.10.2023) and Australia (14-16.10.2023), and consultations with firefighters who organise, conduct and participate in firefighting actions in wildfire response nationally and internationally (regarding to the Union Civil Protection Mechanism).

6.3. Structure of the content

Chapter 1 presents the general background for the research. It concerns technology-determined training for firefighters to enhance preparation and pre-planning activities for wildfire response. Special attention is put on specifics of the response. Relevant definitions are discussed and types are presented. Author illustrates division of the wildfire scene into several specific parts to make references for organisation of the scene. Wildfire response is presented in the wide context. Firefighting action, protection from smoke, environment protection, crisis communication, evacuation, property preparation and critical infrastructure protections constitute the response domain. Central placement of firefighting action is highlighted. In addition, SILVANUS approach on training in preparation and pre-planning activities for wildfire response is discussed. General project approach gives effective framework for implementation of new technologies to training processes and enables to connect three essential training perspectives: technology, organisation, and societal involvement. The project delivers 24 technological tools and solutions with potential to be deployed to wildfire management. Author focuses on 17 tools and solutions with the highest usefulness in the context of wildfire response. General implementation guidelines are presented as well.

Chapter 2 regards to reference detection technologies in enhancement of the preparation and pre-planning activities for wildfire response due to training of firefighters. They are fire detection using IoT devices, fire detection at the Edge, and fire detection based on social sensing. Internet is confirmed to be a great medium to collect, share and disseminate information necessary to detect a fire in the woods. It may connect responders and people in danger, also with the use of multiple detectors, sensors, and mobile applications (including social media). It is important to make the information reliable and to reduce false positives. Research results prove that many solutions and tools find their application in the first phase of fire response and are able to support firefighters when detecting and communicating the hazard.

Chapter 3 focuses on enhancement of the preparation and pre-planning activities for wildfire response with the use of reference computational tools due to training of firefighters. The tools are valuable to transform data collected in the woods into information useful for firefighters when they plan and conduct wildfire response activities. They are the biodiversity profile mobile app (Woode), fire danger risk assessment, and fire spread forecast. They provide the information necessary for situational awareness and allow for the simulation of fire conditions to check the hazard situation in the near future. The tools make calculations to get information crucial for firefighters to plan wildfire response, respecting location of responders and their resources, and operational priorities based on fire probability and risk. In this way, the results of the calculations can feed into other technological solutions, for example decision support systems.

Chapter 4 concerns enhancement of the preparation and pre-planning activities for wildfire response with the use of reference operational end-technology tools due to training of firefighters. End-technology tools mean all equipment, sensors and hardware that are at the first line of the response, as a rule directly in the danger zone. They support firefighters in their activities at the scene. They are UAV (drones), UGV (robots), Forward Command Centre, and MESH-in-the-Sky (the kind of mesh technology that is comprised by a set of elements that give commonly enhanced communication abilities). The first two are universal platforms for other technological tools and solutions. The centre increases communicational and coordination potential of the response. And the last one is a kind of communication network that provides access to information despite of hard terrain conditions and other constrains. It is especially important in the woods, where firefighters need to make simultaneously effective reconnaissance, conduct firefighting action, consider secondary threats, monitor the hazard situation, and cooperate with other wildfire responders.

Chapter 5 refers to enhancement of the preparation and pre-planning activities for wildfire response with the use of decision support systems due to training of firefighters. The systems are said to state information environment in which proper, actual, quick and rational decisions can be made. SILVANUS project delivers four solutions that can effectively support wildfire response conducted by firefighters. They are Multilingual Forest Fire Alert System, Resource Allocation of Response Teams, Priority Resource Allocation based on Forest Fire Probability, and Evacuation Route Planning. The technologies use data fusion, machine learning, deep learning, and simulations to suggest alternative decisions on the topics expressed in their names. Firefighters can be informed about fire locations, probabilities and fire risk to deploy resources in places where they are mostly needed or where they could be needed. In turns, evacuation planning is helpful when analyse overall response to the wildfire, arrival routes, and emergency routes (for people in danger, including firefighters).

Chapter 6 is about enhancement of the preparation and pre-planning activities for wildfire response with the use of reference societal involvement tools due to training of firefighters. The important role of citizens and fire service personnel is highlighted. Their preparation for wildfire response is essential to make the response effective. New technologies may facilitate to achieve this objective. Three reference technologies are described. They are augmented reality / virtual reality training for firefighters, citizen engagement application, and IT Dashboard. This demonstrates the complexity of solutions and tools that can ensure close collaboration between fire services and other stakeholders and increase the level of preparedness for a wide range of users.

Every chapter is structured to present the technology in the nutshell, relevant operational protocol, enhancement possibilities, and safety issues. This exemplifies the morphological analysis (each technology is and allows for complex and comprehensive research). Consequently, general context of the technology use is described, just like, respectively, the way on how to use it during a training, what are advantages and implementation risks related to the technology, as well as what factors may determine personal safety of trainees and how to face them.

Detail list of the content is presented in Annex 2.

6.4. Technical information and status

Title: New technologies in enhancing training for fire service in wildfire response. The SILVANUS approach.

Author: Pawel Gromek.

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7. Integration of the AR/VR content for training in the Romanian Pilot. Development of specific VR content for the French Pilot

This section, representing the demonstrator part of the report, presents the AR/VR solution for training developed in SILVANUS, comprising the major components and their specific capabilities (key features).
Addressing the requirements of Task 3.3 and Task 3.4, namely, introduction of the new protocols developed in the project with the existing practices adopted by the first responders across different geographical regions and the use of AR/VR technology in training exercises for first responders to wildfires, this part depicts an overview about the pilots which implement the AR/VR solution for training and the particular developments of the VR simulator for the Romanian Pilot and French Pilot.

The major objectives of implementing a VR training solution are:

- Enhance the skills of first responders, by learning and practicing appropriate operational scenarios in a realistic environment that simulates a wildfire intervention.
- Provide a secure and immersive environment for interactive training for wildfire response, missions and rescue scenarios.
- Preparing those who respond to wildfires to effectively communicate during times of disaster in the virtual training environments.

In the VR training environment, 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.

Two Pilots have been chosen to implement the AR/VR solution, namely the Romanian Pilot and French Pilot. Each location provides unique characteristics where various types of scenarios can be simulated.

For both Pilots, meetings with the end-users (firefighting experts, forest rangers, trainers, local authorities) have been organized to gather relevant information about the operations, procedures, protocols and demands. Relevant data regarding the specifics of the location and field interventions were also provided during the tabletop exercises organized in pilots.
Moreover, a series of workshops have been arranged with the interested Pilots to decide which scenarios could be implemented in the VR simulator, comprising details about the environment and visual representations. During these meetings, have been collected detailed written, audio and multimedia materials, and the specific requirements to understand the end-users needs, preferences and expectations.

7.1 Overview

The AR/VR Training toolkit (AR/VR solution) provides the first responders relevant information in real-time about the event (wildfire), status and environment, to speed up decision-making in case of major incidents and critical situations.
The simulator focuses on managing fire hazards in the specific regions (“Rodna” Mountains National Park in Romania and Municipality of St Sylvestre, Limoges, in France), integrating roles such as Firefighter, Coordinator, Drone Pilot, Forest Ranger and Emergency medical personnel.

The AR/VR Training toolkit developed in SILVANUS allows trainers to simulate operative and safety procedures, define hazards on multiple environment areas, develop specific content and use virtual avatars to add more realism to various scenes. The solution acts both as a player (VR simulator) and as an authoring tool, enabling the users to experience training programs and create also training scenarios in VR environment, based on their specific needs.

The training will improve the competences and optimal response capabilities to critical and emergency situations of first responders, having a strong social impact on the community and the environment.

As presented hereinbefore, two Pilots have been chosen to implement the AR/VR Training toolkit and applying its capabilities, namely the Romanian Pilot and French Pilot.

Each Pilot provides unique characteristics of the location and environment, where various types of scenarios can be simulated, as they are reproduced in the Pilot descriptions below.

The implementation of various training scenarios has been compliant with four major demands of the Pilots, namely:

- **Incident Simulation** - Users can engage in various simulated operational scenarios like wildfires, flash fires and hazardous material incidents. Each scenario is designed to train users and test their knowledge and skills.
- **Realistic Challenges** - Simulated interventions include unpredictable fire behavior, different environmental conditions, limited visibility, and coordination issues among team members.
- **Developing the educational content** – Integration of educational content about fire safety, emergency procedures, and environmental protection.
- **Wildlife and Conservation** – Provide information about local fauna and flora, and the importance of preserving the forest ecosystem during fire management.

Romanian Pilot

The Romanian Pilot is implemented in Rodna Mountains National Park (Figure 5).
One of the main attractions of the pilot area is represented by the hiking trails and camping areas, so human negligence is an important factor to consider in the prevention and mitigation of forest fires.Most forest fires occur in this area during spring time (March and April), followed by the summer months July and August. These periods also coincide with the increased influx of tourist on the hiking trails and camping sites. In this context, both the specific activities of prevention and monitoring of the area, as well as the efficiency of interventions in case of fires in the region, are of major importance.

Figure 5. Romanian pilot location

In the stage of Prevention and Preparedness, ones of the main objectives of the Romanian Pilot are the development of AR/VR training component and training of firefighters and forest rangers for specific operational scenarios.
The AR/VR Training toolkit aims to provide a realistic and immersive training experience for firefighters, forest rangers and emergency response teams.
The solution focuses on managing fire hazards in the region, integrating roles such as Drone Pilot, Firefighter, Coordinator/Commander, Forest Ranger and Emergency medical personnel.
The VR Simulator recreates the forested landscape of Rodna Mounatins region, including accurate topographical features, vegetation types and particular environmental conditions.

French Pilot

The French Pilot is organized in the Municipality of St Sylvestre, Limoges, France. The location of the Pilot is very close to SEVESO, a French company with activity in the explosives field, being considered a major risk in the forested area of St Sylvestre.
The French Pilot is organised around the topic of Forest fire with industrial accident in highly explosive plant, a challenge related to the production of smoke cloud and explosive.

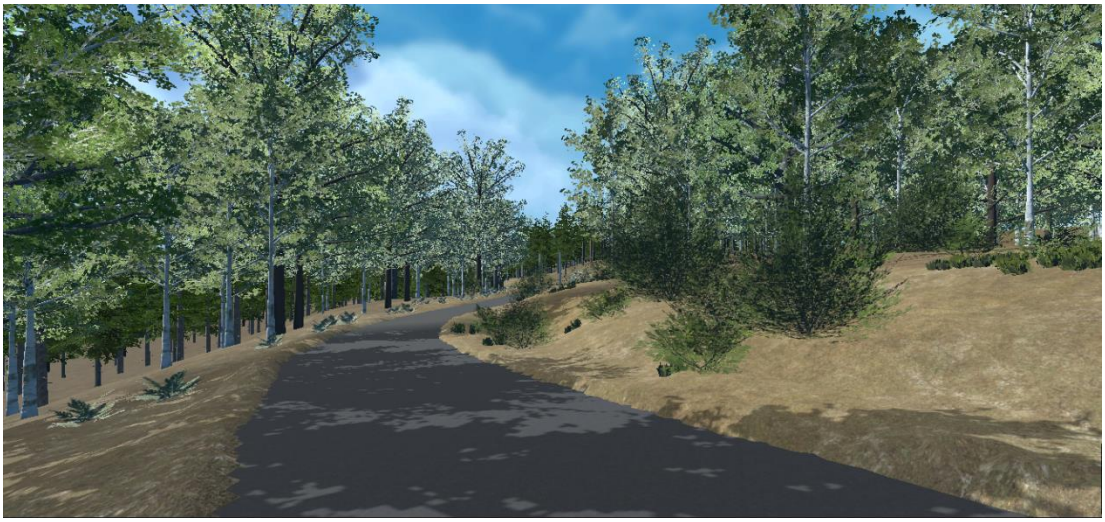

Figure 6. French pilot location

PUI, the coordinator of the Pilot, has organized a workshop in 2023 and a table-top exercise where several practical tests have been performed:

- Using drone for mapping and detection
- Using a drone with AR and smart glasses
- Detection of forest fire by sensors and camera
- Using a robot for extinction of the fire
- Firefighters intervention for extinction of the fire
- Treating the fire border with new tools
- Information in real time on social media (citizens engagement)
- Testing the SILVANUS tools and applications for citizens and municipalities.

Moreover, the pilot's coordinator and the involved firefighting team participated in the technical meetings for the implementation of the AR/VR Training toolkit, providing materials, photos and details about the environment, and the description of operational scenarios for the simulation.
Relevant information regarding the operation mode of the firefighters in case of fire was provided following the simulation of a real fire situation, described below.
To protect the forest and for security reasons (the vicinity of the real SEVESO company), a fire was to put in a container with potato starch.

Figure 7. Real intervention on the field (1)

The results were very efficient with smoke and fire in the container; the detection of the fire and smoke was possible.

The intervention was carried out according to the following scenario:

- Waiting for the detection of the fire by the sensors.
- Mobilize the first responders and firefighters with 3 fire trucks, with the goal to fight the fire with a pick-up, pump and new tools, and with the fire trucks and the robot.
- Monitor the information on the social media.

Figure 8. Real intervention on the field (2)

Figure 9. Using the robot during the intervention

Two simulations have been organized:

- One simulation in the forest with the deployment of firefighters and the robot, and support of the drones
- One simulation with the firefighters, where new tools were used: pipe carrying rack, tool GORGUI, pick-up with a high-pressure pump (40 bars).

7.2 Compliance with the operational scenarios. Integration of the digital content in the AR/VR Training toolkit

This section depicts relevant aspects regarding the VR training experience for the first responders in the Romanian and French Pilots.

The virtual environment is designed to provide a secure and regulated framework in which the first responders can practice a variety of firefighting tactics, procedures and techniques.

The goal of AR/VR Training toolkit (AR/VR solution) is to provide the first responders an interactive training virtual reality simulator to learn and practice appropriate crisis communication methods.

The AR/VR solution allows the development of multiple training programs in a virtual environment and simulates specific interventions or missions according to operational scenarios. Starting from the on-field specific requirements, comprehensive and accurate simulations of the behavior of wildfires 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.

Following the same way of approaching and structuring information like in deliverable D3.2, different sections are dedicated in this chapter for *defining the environment* and *identifying the particularities of implementing VR content* in the pilots interested in the application of AR/VR solution.

The components of the environment are structured like *ground elements, flora and fauna, avatars, specialized equipment, fog, smoke, rain, vehicles, tools, aerial monitoring elements (drones), robots, fire trucks, buildings* and *overview maps*.

One section is dedicated to the major roles defined, with details about the following categories:

Firefighter

- **Role:** Navigate to the fire scene using a firetruck and extinguish the fire.
- **Features:** Realistic fire truck controls, water spraying mechanics, and interaction with different types of fire equipment (hoses, extinguishers). The firefighter must also follow protocols for safety and efficiency.

Coordinator / Commander

- **Role:** Supervise the overall operation and make strategic decisions during the intervention.
- **Features:** A command center interface with maps, team status updates, and communication tools to coordinate the other roles. The coordinator gives orders, allocates resources, and tracks the progress of the intervention / operation.

Forest Ranger

- **Role:** Assist firefighters on the field by providing local information and support in the fire extinguishing.
- **Features:** Navigation tools, fire management skills, and interaction with the natural environment to assist in extinguishing the fire and protecting wildlife.

Drone Pilot

- **Role:** Monitor the forest area for people, fauna and fire hazards using a virtual drone.
- **Features:** Live video feed from the drone, thermal imaging, and real-time hazard detection. The pilot can mark areas of interest and provide information to the team.

Emergency personnel

- **Role:** Provide help in emergency situations, in rescue procedures.
- **Features:** Provide support in rescue operations for victims, performing first aid procedures and emergency medical interventions on the field.

Modelling the environment and simulations in VR

The implementation of the AR/VR Training toolkit in SILVANUS has two major objectives:

- Recreating the real environment for operations / interventions in VR.
- Simulating specific interventions or missions according to operational scenarios.

The AR/VR solution reflects accurately the ground features, flora and fauna to provide a true-to-life experience, as described hereinafter in section *Environment modelling*. Various textures of the ground and dynamic environmental elements like changing weather and seasonal variations improve the immersion.
The terrain and flora impact the operations by creating obstacles (e.g., rocky areas or dense undergrowth) and influence the fire behaviour (e.g., different types of vegetation burn at different rates). Moreover, different vegetation types and terrain features influence visibility, access routes and firefighting strategies and tactics. By incorporating the environmental details, users can experience a realistic environment in VR that mirrors the specific characteristics of the forested areas in the Romanian and French Pilots.
Scenario-based training in VR is an efficient method for educating the first responders by offering a secure and safe environment in which they can practice and refine their abilities.

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 do. The scenarios can also be built to be interactive, allowing users to make decisions and seeing the results of those actions in real time.
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 Commander, Drone operator, a forest ranger, firefighter or Emergency medical doctor. These roles correspond to the avatars defined in the AR/VR solution.
Specific elements for the scenario-based training are presented hereinafter in section *Integration of the digital content in the AR/VR Training toolkit*.

Environment modelling

The first step in the environment modelling is to collect the necessary data, which may include satellite imagery, topographical maps, weather forecasts, specific data about the forested area 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.

A significant effort was dedicated to modelling the environmental elements corresponding to the *terrain particularities, weather conditions and specific flora* of the forested areas in the two Pilots, as presented in the following.

Terrain particularities

In the following, suggestive images for the environment grounds and terrain particularities implemented in VR are depicted.

Figure 10. Environment grounds implementation in Rodna Mountains, Romania

Figure 11. Environment grounds implementation in St Sylvestre, France

Flora

In the following, suggestive images for particularities of flora implemented in VR are presented.

Figure 12. Flora in Rodna Mountains, Romania

Figure 13. Flora in St Sylvestre, France

Weather conditions and environmental simulations

In the following, suggestive representations of the weather conditions and environmental fire simulations are depicted for both Pilots.

Fire simulation, smoke simulation and rain simulation

The VR simulator implements advanced fire simulation and environmental conditions to replicate the challenges of reduced visibility often encountered during real-world incidents, as presented in the following images.

- Fire / Burnt tree

Figure 14. Fire simulation in Rodna Mountains, Romania

- Rain simulation

Figure 15. Rain simulation in Rodna Mountains, Romania

Environmental buildings

In the following, suggestive representation of the environmental buildings is depicted for the French Pilot.

Figure 16. Environmental buildings in the French Pilot

Integration of the digital content in the AR/VR Training toolkit

Challenging work was dedicated to the modelling of *firefighting equipment*, the integration of *digital content* in AR/VR Training toolkit, as well as the *incorporation of real-time data into the simulation* to model changes of the wildfire and firefighting efforts.

Specific elements of the digital content rigorously implemented in AR/VR solution are depicted in the following.

Avatars / Roles

Below, some suggestive images are shown, representing the developed Avatars for different roles in both Pilots.

Figure 17. Romanian firefighter

Figure 18. Romanian forest ranger

Figure 19. French firefighter (1)

Figure 20. French firefighter (2)

Figure 21. Romanian Emergency medical doctor (SMURD)

Figure 22. French Emergency medical doctor

Equipment

Virtual reality (VR) can provide to firefighters the capability to learn about the essential pieces of gear needed to battle forest or vegetation fires in an engaging and interactive manner. The virtual equipment is modelled to closely mimic real-life equipment, and firefighters will be provided extensive instructions on how to operate it.

In order to extinguish the simulated fire, the trainees must select the appropriate gear and use it in the appropriate manner. Specific tutorials are developed to provide trainees the necessary information about the equipment and specific procedures / protocols to be applied.

The equipment is crucial for the first responders' safety and allows firefighters to intervene and work effectively in places where the environmental conditions are compromised.

Specific operational equipment rigorously represented in the SILVANUS AR/VR solution is depicted in the following figures. Some equipment is dedicated for the Coordinator role, implying specific operations and guidance (laptops, whiteboards, notebooks, GPS monitoring, etc.).

- Fire Axe

Figure 23. Equipment – Fire Axe

- Firefighting Shovel

Figure 24. Equipment – Firefighting Shovel

- Fire house nozzle

Figure 25. Equipment – Fire house nozzle

- Rubber Flap Flame-Retardant Fire Beater

Figure 26. Equipment – Rubber Flap Flame-Retardant Fire Beater

- Crowbar

Figure 27. Equipment – Crowbar

- Hatchet

Figure 28. Equipment – Hatchet

- Fire extinguisher

Figure 29. Equipment – Fire extinguisher

- Water barrel

Figure 30. Equipment – Water barrel

- Binoculars

Figure 31. Equipment – Binoculars

- Boots

Figure 32. Equipment – Boots

- CCTV camera

Figure 33. Equipment – CCTV camera

- Hammer

Figure 34. Equipment – Hammer

- Metallic tin

Figure 35. Equipment – Metallic tin

- Coordinator logbook

Figure 36. Equipment – Coordinator logbook

- Dagger

Figure 37. Equipment – Dagger

- Digital camera

Figure 38. Equipment – Digital camera

- Drone

Figure 39. Equipment – Drone

- Drone Battery pack

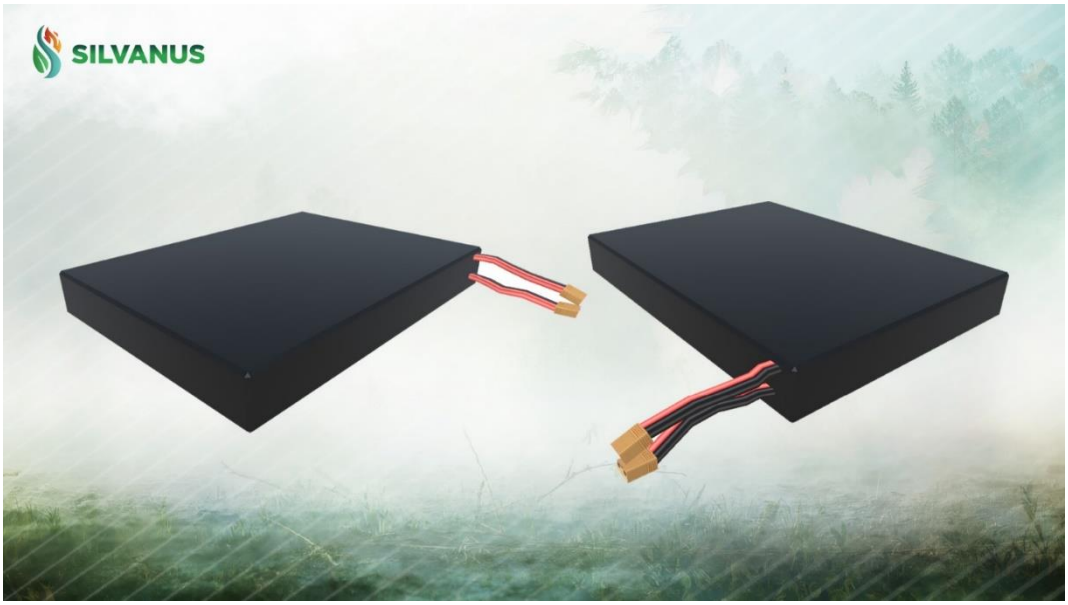

Figure 40. Equipment – Drone battery pack

- Drone Camera

Figure 41. Equipment – Drone camera

- Drone case Drone

Figure 42. Equipment – Drone case Drone

- Drone Propellers

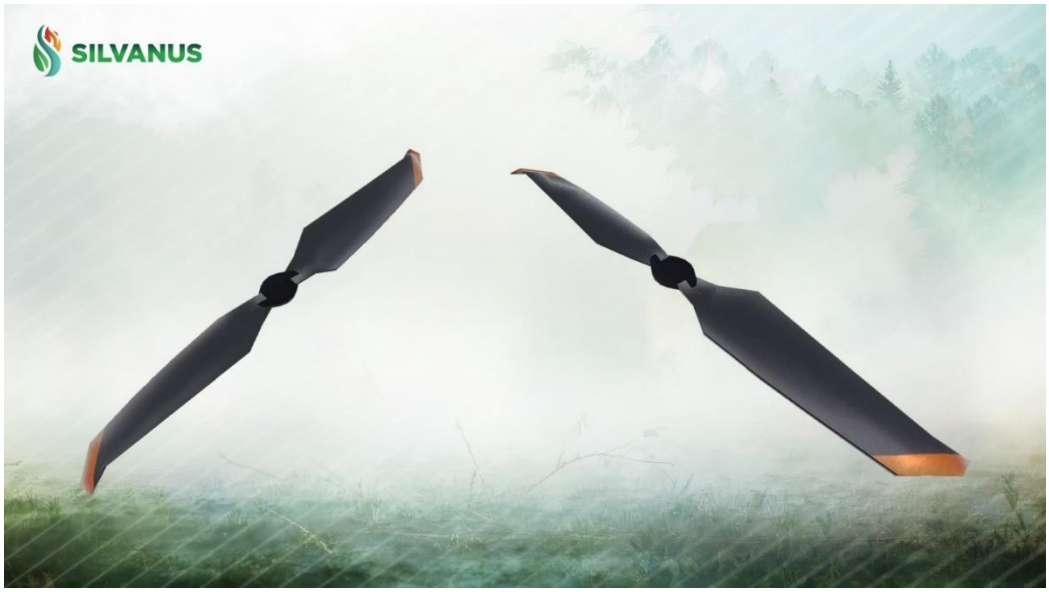

Figure 43. Equipment – Drone Propellers

- Drone Remote Controller

Figure 44. Equipment – Drone Remote Controller

- Chainsaw

Figure 45. Equipment – Chainsaw

- Numbered card

Figure 46. Equipment – Numbered card

- Compass

Figure 47. Equipment – Compass

- Fire behaviour analysis kit

Figure 48. Equipment – Fire behaviour analysis kit

- Fire blanket

Figure 49. Equipment – Fire blanket

- Fire ground light

Figure 50. Equipment – Fire ground light

- Fire hose wrench

Figure 51. Equipment – Fire hose wrench

- Vehicles Created for Firefighters role - Fire truck

Figure 52. Equipment – Fire truck, French pilot

Figure 53. Equipment – Fire truck, Romanian pilot

- Vehicles Created for Forest rangers role – Vehicle for intervention

Figure 54. Equipment – 4X4 Duster (interior), Romanian pilot

- Flare gun

Figure 55. Equipment – Flare gun

- Frequency scanner

Figure 56. Equipment – Frequency scanner

- Fire hose

Figure 57. Equipment – Fire hose

- Portable generator

Figure 58. Equipment – Portable generator

- Glass jar

Figure 59. Equipment – Glass jar

- Gloves

Figure 60. Equipment – Gloves

- Helmet

Figure 61. Equipment – Helmet

- Hydraulic Cutter

Figure 62. Equipment – Hydraulic cutter

- Hidraulic Jaw

Figure 63. Equipment – Hydraulic Jaw

- Laptop opened

Figure 64. Equipment – Laptop opened

- Backpack sprayer

Figure 65. Equipment – Backpack sprayer

- Medical Kit box

Figure 66. Equipment – Medical Kit box

- Safety vest

Figure 67. Equipment – Safety vest

- Mobile phone

Figure 68. Equipment – Mobile phone

- Fireman's rake

Figure 69. Equipment - Fireman's rake

- Monitoring sensor

Figure 70. Equipment - Monitoring sensor

- Portable light

Figure 71. Equipment - Portable light

- Radio

Figure 72. Equipment – Radio

- Barrels

Figure 73. Barrels

- Report template

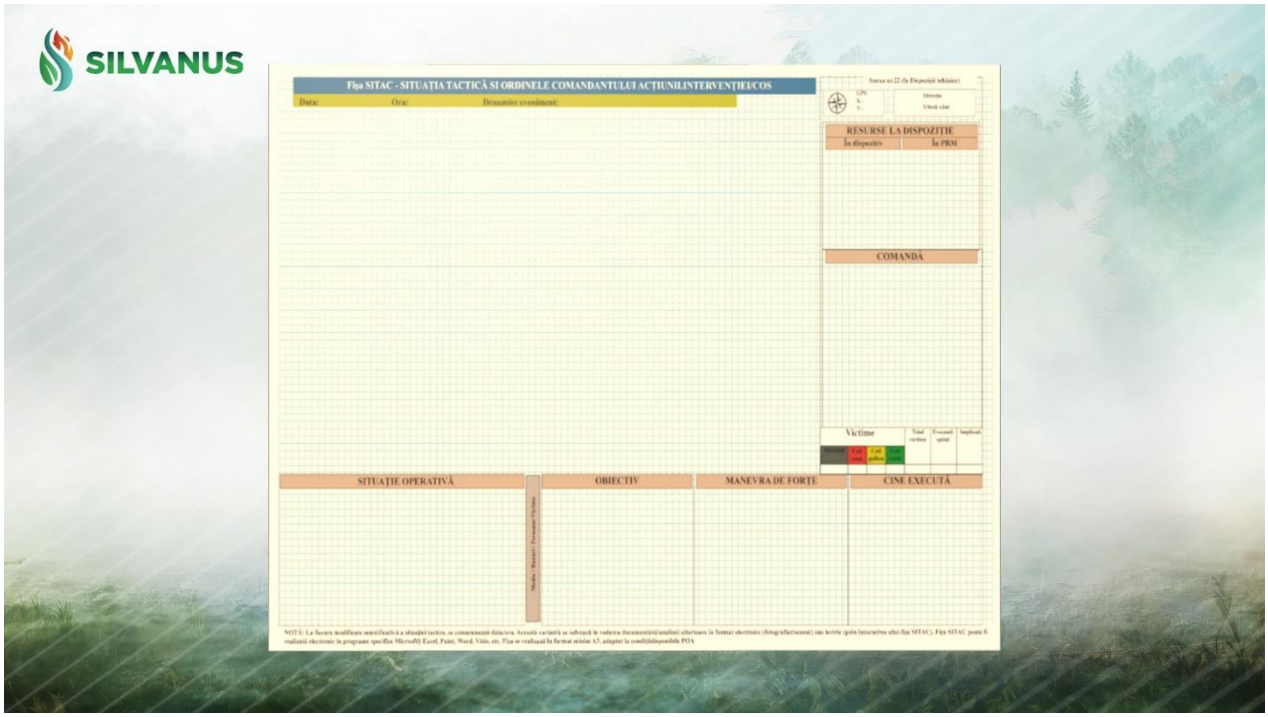

Figure 74. Report template

- Rescue Toolkit box

Figure 75. Rescue Toolkit box

- Water transfer pump

Figure 76. Water transfer pump

- Fire fighting robot

Figure 77. Fire fighting robot

- Tent

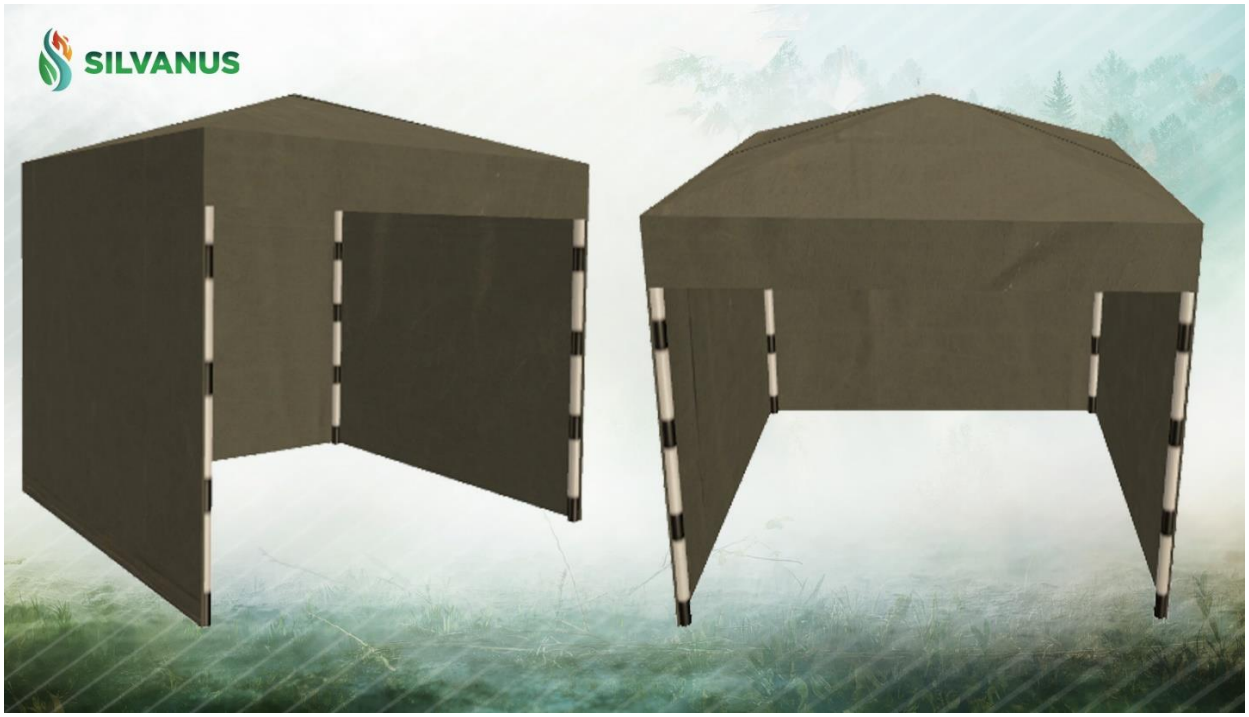

Figure 78. Tent

- SMURD flag

Figure 79. SMURD flag

- Folding ladder

Figure 80. Folding ladder

- Survival kit

Figure 81. Survival kit

- Folding stretcher

Figure 82. Folding stretcher

- Thermal imaging camera

Figure 83. Thermal imaging camera

- Thermometer

Figure 84. Thermometer

- Toolbox

Figure 85. Toolbox

- Whiteboard

Figure 86. Whiteboard

- Wind Meter

Figure 87. Wind Meter

- Breathing Apparatus

Figure 88. Breathing Apparatus

Integration of GUI in the AR/VR Training toolkit

The integration of Graphical User Interface (GUI), represented in the form of a dashboard of the AR/VR solution, is depicted in the following images (Figures 89, 90, 91 and 92), capturing the main features, such as the Maps, Drones view, Crew & Equipment and Alerts.

This integrated vision of the information from the field, with elements of environment modelling and simulated actions, aims to display the current firefighting action status, such as the location and progress of firefighters and equipment, and the status of the wildfire.

- Maps

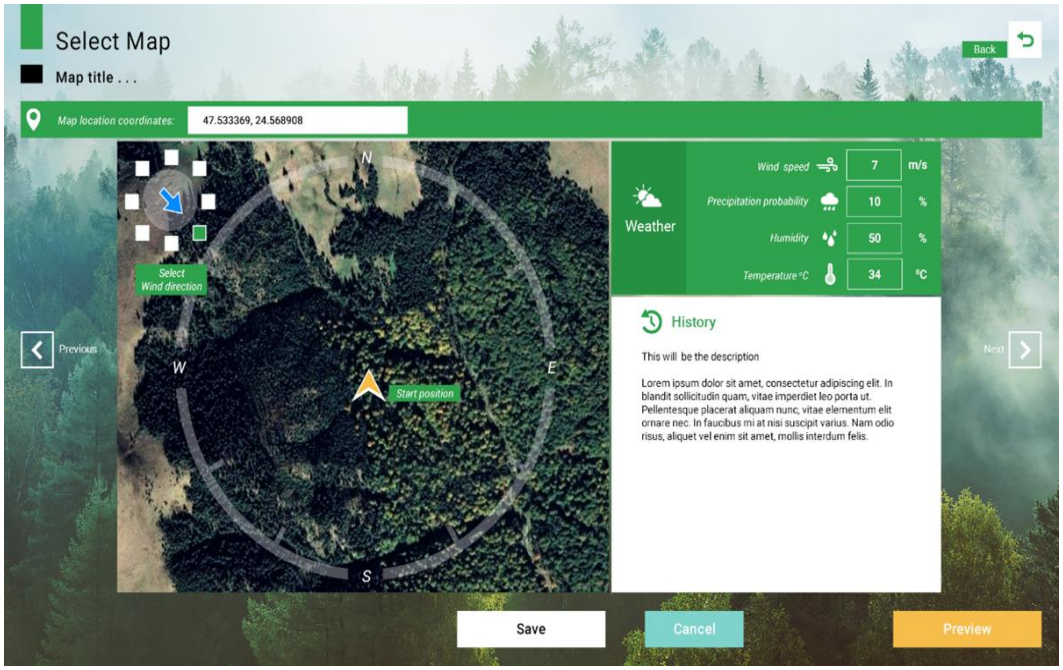

Figure 89. UI integration – Maps

- Drones view

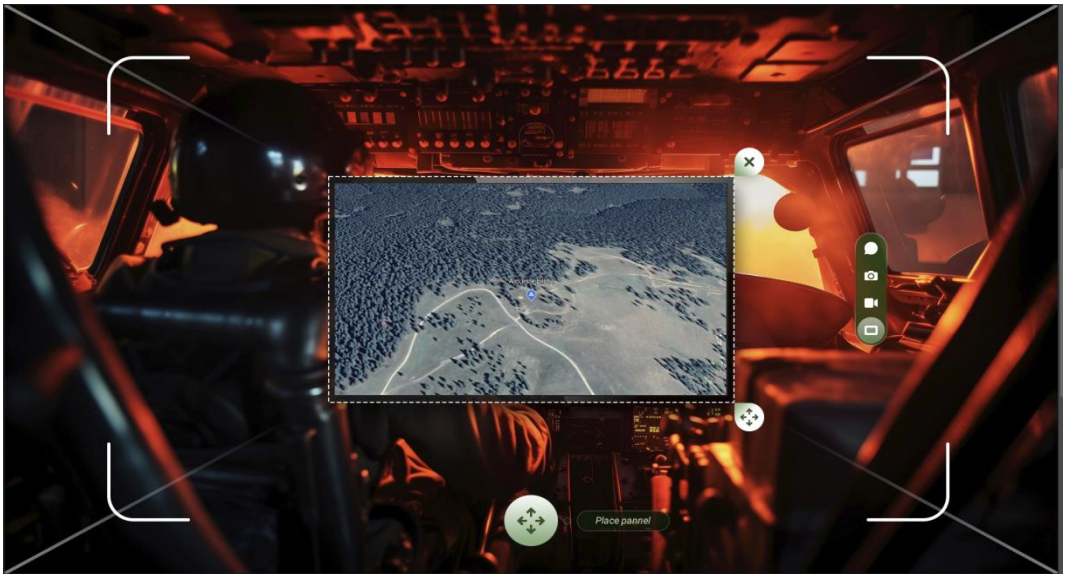

Figure 90. UI integration – Drones information

- Crew & Equipment – Live Communication and Alerts

Figure 91. Crew & Equipment – Live Communication and Alerts

Figure 92. UI integration – Crew & Equipment: Alerts

8. Conclusions

The deliverable presents the most relevant aspects and findings concerning the planning and delivery of training activities in SILVANUS.

The deliverable was built on the ground of D3.2, aiming to create a logical and comprehensible structure that meets the requirements of Task 3.3 and Task 3.4.

A uniform approach was applied for collecting information about the training methodology and implementation of the appropriate training approaches and techniques in SILVANUS, capturing the technical specifications, the functionalities and the operational view.

A particular section is dedicated to the innovative approaches and modern technologies for implementing the training activities in SILVANUS. Moreover, the integration of AR/VR content to meet the training requirements of end-users is presented, comprising details about the implementation of the AR/VR Training toolkit in two Pilots of SILVANUS, with representative results described in the demonstrator part of the report.

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Annex 1

Detailed list of the content in 'The SILVANUS Handbook on Systematic Methodology for the Preparation and Pre-planning Activities for Wildfire Response'

List of contents 3
Introduction 5
Chapter 1. Wildfire – the phenomenon and the response 10
1.1. Definition and causes of a wildfire 10
1.2. Conditions for the origin and development of a wildfire 19
1.3. Types of wildfires 28
1.4. Process of wildfire response 30
Chapter 2. Training related to preparation and pre-planning activities for wildfire response 37
2.1. Training needs stemming from wildfire specifics 37
2.2. Training participants 47
2.3. Training equipment 49
Chapter 3. Training guidelines for preparation and pre-planning activities for wildfire response 53
3.1. SILVANUS approach on systematic methodology for the preparation and pre-planning activities for wildfire response 53
3.2. Data and information as crucial resources in pre-planning and preparation activities for wildfire response 58
3.3. Training objectives 62
3.4. Training forms and methods 73
3.5. Training materials 80
Chapter 4. SILVANUS technosphere and support of preparation and pre-planning activities for wildfire response 99
4.1. Detection technologies 99
4.2. Computational tools 106
4.3. End-technology tools 114
4.4. Functionalities of decision support system 127
4.5. Societal involvement tools 140
Chapter 5. New technologies in protocols of wildfire response training 149
5.1. Early detection and communication of the hazard 149
5.2. Immediate disposal of wildfire responders 153
5.3. Effective getting of the resources to the wildfire scene 156
5.4. Comprehensive recognition of hazard situation 160
5.5. Firefighting tactics 165
5.6. Cooperation between entities fighting the fire 171
Conclusion 176
References 179
List of Tables 185
List of Figures 187

Annex 2

Detailed list of the content in the book 'New technologies in enhancing training for fire service in wildfire response. The SILVANUS approach'

List of contents 3
Introduction 7
Chapter 1. Technology-determined training for firefighters to enhance preparation and pre-planning activities for wildfire response 12
1.1. Specifics of wildfire response 12
1.2. SILVANUS approach on training in preparation and pre-planning activities for wildfire response 18
1.3. General implementation of new technologies for the training purposes 23
Chapter 2. Reference detection technologies in enhancement of the preparation and pre-planning activities for wildfire response due to training of firefighters 28
2.1. Fire detection using IoT devices 28
2.1.1. The technology in the nutshell 28
2.1.2. Operational protocol of the technology use 31
2.1.3. Enhancement possibilities 37
2.1.4. Safety issues for the deployment of the technology 38
2.2. Fire detection at the Edge 41
2.2.1. The technology in the nutshell 41
2.2.2. Operational protocol of the technology use 43
2.2.3. Enhancement possibilities 46
2.2.4. Safety issues for the deployment of the technology 48
2.3. Fire detection based on social sensing 50
2.3.1. The technology in the nutshell 50
2.3.2. Operational protocol 53
2.3.3. Enhancement possibilities 57
2.3.4. Safety issues for the deployment of the technology 58
Chapter 3. Enhancement of the preparation and pre-planning activities for wildfire response with the use of reference computational tools due to training of firefighters 61
3.1. Biodiversity profile mobile app (Woode) 61
3.1.1. The technology in the nutshell 61
3.1.2. Operational protocol 62
3.1.3. Enhancement possibilities 64
3.1.4. Safety issues for the deployment of the technology 66
3.2. Fire danger risk assessment 69
3.2.1. The technology in the nutshell 69
3.2.2. Operational protocol 72
3.2.3. Enhancement possibilities 74
3.2.4. Safety issues for the deployment of the technology 75
3.3. Fire spread forecast 77

3.3.1. The technology in the nutshell 77
3.3.2. Operational protocol 80
3.3.3. Enhancement possibilities 82
3.3.4. Safety issues for the deployment of the technology 84
Chapter 4. Enhancement of the preparation and pre-planning activities for wildfire response with the use of reference operational end-technology tools due to training of firefighters 87
4.1. Fire monitoring using UAVs (drones) 87
4.1.1. The technology in the nutshell 87
4.1.2. Operational protocol 91
4.1.3. Enhancement possibilities 95
4.1.4. Safety issues for the deployment of the technology 97
4.2. The use of UGVs (robots) 101
4.2.1. The technology in the nutshell 101
4.2.2. Operational protocol 103
4.2.3. Enhancement possibilities 106
4.2.4. Safety issues for the deployment of the technology 108
4.3. Forward Command Centre 112
4.3.1. The technology in the nutshell 112
4.3.2. Operational protocol 115
4.3.3. Enhancement possibilities 119
4.3.4. Safety issues for the deployment of the technology 122
4.4. MESH-in-the-Sky 126
4.4.1. The technology in the nutshell 126
4.4.2. Operational protocol 129
4.4.3. Enhancement possibilities 132
4.4.4. Safety issues for the deployment of the technology 134
Chapter 5. Enhancement of the preparation and pre-planning activities for wildfire response with the use of decision support systems due to training of firefighters 139
5.1. Multilingual Forest Fire Alert System (DSS-MFAS) 139
5.1.1. The technology in the nutshell 139
5.1.2. Operational protocol 141
5.1.3. Enhancement possibilities 143
5.1.4. Safety issues for the deployment of the technology 145
5.2. Resource Allocation of Response Teams (DSS-RART) 147
5.2.1. The technology in the nutshell 147
5.2.2. Operational protocol 150
5.2.3. Enhancement possibilities 152
5.1.4. Safety issues for the deployment of the technology 154
5.3. Priority Resource Allocation based on Forest Fire Probability (DSS-PRA) 156
5.3.1. The technology in the nutshell 156
5.3.2. Operational protocol 160
5.3.3. Enhancement possibilities 163
5.3.4. Safety issues for the deployment of the technology 165
5.4. Evacuation Route Planning (DSS-ERP) 166

5.4.1. The technology in the nutshell 166
5.4.2. Operational protocol 169
5.4.3. Enhancement possibilities 172
5.4.4. Safety issues for the deployment of the technology 174
Chapter 6. Enhancement of the preparation and pre-planning activities for wildfire response with the use of reference societal involvement tools due to training of firefighters 177
6.1. Augmented reality / virtual reality training for firefighters 177
6.1.1. The technology in the nutshell 177
6.1.2. Operational protocol 179
6.1.3. Enhancement possibilities 182
6.1.4. Safety issues for the deployment of the technology 184
6.2. Citizen engagement application 186
6.2.1. The technology in the nutshell 186
6.2.2. Operational protocol 190
6.2.3. Enhancement possibilities 194
6.2.4. Safety issues for the deployment of the technology 195
6.3. IT Dashboard 197
6.3.1. The technology in the nutshell 197
6.3.2. Operational protocol 199
6.3.3. Enhancement possibilities 203
6.3.4. Safety issues for the deployment of the technology 205
Conclusion 207
References 211
List of tables 218
List of figures 220