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Fire Safety in Modern Smart Construction: Awareness and Attitudes

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FIRE SAFETY IN MODERN SMART CONSTRUCTION: AWARENESS AND ATTITUDES

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1. Foreword

Challenge of accepting the new thought patterns

Urbanisation, as a phenomenon, causes migration. Modern views regarding housing requirements also affect the need to transform the way we build things. The feeling of safety has always been a strong influencer on where people choose to live and especially the younger generation's attitude towards housing may be quite different than that of older ones. The construction business has to be able to concurrently adapt to these needs, rather than continue to produce conventional services and residences as always. As our operating environment changes, building technologies must also modernise.

In order for us to rapidly adapt to change, we must first consider what we already have and what can be utilised. Enhancing fire safety does not necessarily mean that we must set new requirements or install more technology. On the contrary, we should consider utilising existing technologies or services in novel ways. Through cooperation we must find ways to emphasise the role of fire safety, as all too often these days the topic remains in the background and is seen as an add-on part of construction.

Even now, there are increasingly more significant growth centres in Finland where, associated with urbanisation and novel town planning, trendy ideas on smart building, energy efficiency and adaptability are emerging. At the same time, the concept regarding smart building and its requirements is being contemplated. As needs are being assessed, consideration should be given to the fact that when living standards change so do people's behaviour along with the conditions in their environmental surroundings.

Compared to the rapid development of other building features, fire safety is often ignored and does not meet the current requirements. The end-users of buildings should be more involved in the planning process so that designers would know what they actually want and need. Town planning should be discussed as a development tool for larger entities instead of there being separate approaches. In addition to the requirements of individual building sites, urban planning should focus on the future needs of the operating environment. It is only too easy to stick to the old ways. The attitude "it has always been done this way" is still set in cement in the building industry. But the question is: do we still need to adhere to the old solutions if the outdated procedures no longer even meet the present needs, let alone future ones?

Do we have information on future construction needs from the standpoint of the parties involved or should building design aim to anticipate presently unknown requirements for the entire life cycle of a building? Even now, a smart

building consists of different premises with varied uses and, consequently, different risks. Thus, safety should be a comprehensive feature for all users, even those who have little knowledge of the building or its functions. When it comes to construction and town planning, sites should already now be prepared to answer unforeseeable future needs and requirements which arise from both the users and the operating environment. While present technology may provide some answers, we must always first recognise what and why something is needed.

Along with the advancing technology the challenge to understand technological entities increases. It is especially at the owner and operator level where the significance of comprehending the whole intensifies. Decision-makers in the technical sector should also develop their competence so as to meet the challenges of the changing operating environment. Clinging to the old ways of doing things ultimately leads to a situation where the changed methods and modern operating environment bring about yet new challenges.

Old habits die hard, but new ones might be better

Decision-makers in construction projects need more impartial and easily digestible information as well as explicit options that support their actions and help them recognise the significance of fire safety. Even now the building industry must meet the challenges of changing practices, including the issues associated with fire safety. At present, people often hold information to themselves and it does not reach all relevant parties, which hinders progress.

Old-fashioned attitudes alongside outdated practices and the rigid boundaries between subcontractors may be some of the factors slowing down development. Others difficulties are the broad scope of fire prevention technology and the harmonisation of different environmental requirements. For many, complicated building projects, multiple subcontracts and different system combinations lead to inefficient working, and particularly, decision-making. Because of this the parties involved often resort to old practices: new operating models are considered risky and the fractured implementation among different actors is feared to be uncontrollable. What is more, they would have to figure out, during the implementation phase, how to solve problems that may come up as well as find out who would have the required expertise and skills. Presently, in the worst case, the end user faces problems which stem from conflicts between outdated technology and the modern operating environment.

Modern systems are able to optimise system functions and equipment criteria in accordance with the user's needs and experiences for the life cycle of the building. Environmental conditions can be monitored, predicted and reacted to at the right time. It is often the case that problems and incompatibilities are only addressed after the technology has been introduced, which increases the costs of corrective actions. Also, the facts that other automation could be used for preventive fire safety and that the technology which is already in place could be used in new applications for improving safety are also often ignored.

The technical requirements for fire safety are on the rise and fire prevention systems must meet novel requirements and conditions. Forecasting, even in the short term, is difficult. However, the longer the focus, the easier it becomes to shape the future in the desired manner and to react, and adapt, to changes. In any case, the field of fire safety must significantly improve the manner in which it exchanges information as well as its competence so as to find anwers to the already existing challenges and to those which we are not yet able to foresee. In order to meet this need it is essential the required information is available.

This attitude survey implemented with the Fire Laboratory of Tampere University adds to the SPEK Talks publication series. The previous publication in the series was the abstract of Tuomas Pylkkänen's Master's Thesis: "Utilization of IoT (Internet of Things) technology in developing fire safety in buildings and in a smart environment", 2018 (https://edu.spek.fi/koulutus/wp-content/uploads/sites/2/2015/09/KeRy-Utilising-IoT-technology-in-developing-fire-safety-in-buildings-and-in-a-smart-environment.pdf). Building on both of these, during this year Tampere University will continue a follow-on research project: "Prospects for applying and using new technologies in fire safety". The Finnish National Rescue Association will participate in guiding this project.

Lauri Lehto Safety and Security Advisor, Fire Prevention technology - The Finnish National Rescue Association, SPEK

2. Starting points of the survey

In Finland, the built environment is facing the challenges of developing technologies and human behaviour. Fire prevention, too, must develop in accordance with these trends. The domestic construction business should promote such an attitude climate on fire safety and fire prevention that would be open to the prospects of new technical and functional innovations.

The novel definitions of the built environment, such as multipurpose premises, energy efficiency and the life-cycle approach, as well as the social and welfare challenges concerning the ageing population are issues that come with inherent problems and opportunities, and which must also be addressed from the viewpoint of fire safety and the fire safety experts. While smart fire safety solutions do exist, their widespread introduction is impeded by insufficient knowledge or negative attitudes, inadequate financial resources or poor technical viability – often all simultaneously.

Smart construction workshops talk about the abundance of available information and its prospects as an enabler of new kinds of functions, business and services. Why would we not also extend smart thinking to the field of fire safety?

The Master's Thesis of M.Sc. Tuomas Pylkkänen at the Lappeenranta University of Technology: "Utilization of IoT (Internet of Things) technology in developing fire safety in buildings and in a smart environment" was the most important reference and also to some extent a trigger for this survey (Pylkkänen 2018). The thesis raised awareness of the need to improve attitudes among the different parties of a building project. In addition to the property developer and the constructor, these parties also include experts, designers, consultants and the authorities. Pylkkänen indicates that one of the most pressing needs is to improve the interaction between the developer and the client in order to appropriately recognise fire safety and its significance during the life cycle of the building. (ibid 2018)

The study "Building service and safety systems in fire. The present and the future", carried out in 2007 at VTT Technical Research Centre of Finland, examined the then modern smoke alarms and fire detection equipment and systems as well as their integration with other building service and information systems (Hakkarainen 2007). It was stated that the new solutions provide a good base for functionality and safety-improving technologies. However, the management and utilisation of information can also be challenging, especially in connection with changes in the ownership and use of buildings.

Insurance Europe (2007), a European network within the insurance

business, published the article “Information for insurers on smart systems”. The article evaluates the concept of “smart systems”, the potential problems of these systems, specific safety concerns and their future prospects.

2.1 Goals

The survey aspired to establish how well the parties to modern building projects are aware of fire safety requirements and, on the other hand, of the utilisation of advanced technological and functional solutions. The expectations of the different parties regarding available information, training and development needs, among other things, were also surveyed. In particular, the project aimed to increase fire safety awareness among the decision-makers (developer, financier, owner) of building projects so that they would identify different options and alternatives and could evaluate their technical and financial impacts during the life cycle of the building. The results of the research project can be used as an instrument to steer future research and focus the technical solutions on meeting real-world challenges.

2.2 Research questions

The project was launched around the following two key questions:

1. How has fire safety been taken into consideration in upcoming smart and high-rise construction projects?
2. What are the key challenges in utilising the potential offered by new technologies?

The key questions were made more concrete with the help of speculative questions that also prepared the participants prior to the actual interviews:

1. How could the new technology best serve fire safety?
2. What impedes the introduction of new technologies in the field of fire safety?
3. Are all parties to large projects aware of the needs and possibilities for improving fire safety?
4. How can the decision-makers and implementers of projects be made aware of, and to understand, the possibilities and cost efficiency factors associated with fire safety?
5. What kind of information or instruments is needed to support fire safety designing and implementation in projects?
6. On whom, and how, should information be focused?
7. Could fire safety also be ‘merchandised’ as a service, as an alternative to individual technological solutions?

3. Implementation of the survey and materials

The survey was launched on the initiative of the Finnish National Rescue Association (SPEK), and was, for the most part, carried out by the Tampere University Fire Laboratory. Representing the commissioner, and working in the steering group of the project, were Safety Advisor Lauri Lehto and Research Manager Tuula Kekki. Secretary Milja Löyttyniemi participated in carring out the web survey, which was part of the project. Professor Mikko Malaska and Doctoral Student Anu Aaltonen represented Tampere University.

The project comprised of four work packages:

1. Collecting background and basic information, examining the supporting materials.
2. Regional semi-structured interviews, reaching out to key personnel in smart construction projects and the rescue services.
3. Evaluation of interview materials, implementation of the web survey.
4. Reporting and publishing the results, mapping the follow-on actions.

3.1 Semi-structured interviews

The first phase of the actual survey was carried out through regional interviews from 4.12.2018 to 11.1.2019 on five separate occasions in Tampere, Turku and Helsinki. These cities are presently implementing spearhead projects that represent new concepts in building and are active in the field of smart construction. Representatives of Smart City programmes, real estate development projects and rescue services were interviewed.

Since the interviewees were experts representing a diverse field of construction projects, who were not necessarily dealing with fire safety issues on a daily basis, the aim was to keep the interviews as unrestricted as possible so the participants would feel free to express their own views about the research topic. As an introduction to the interview, the participants had previously received a presentation briefly explaining the project, which was then also briefly discussed at the beginning of each interview. The ones that were invited to the interviews were also asked to spread the invitation further within their respective organisations and contact networks.

The events took shape as group interviews of 2–7 persons, in which the interviewees represented one or more reference group(s) from the sectors of fire safety. Open questions (appendix 1) on the challenges of the different topics were prepared to shape the interviews. Each question was supposed to be discussed at least with some level of precision. The interviews, however,

soon turned into fairly free-flowing discussions in which the commenting and dialogue were spontaneous and diverse. The interviewees were told that their anonymity would be preserved and that no single references or opinions would be reproduced in such a manner that they could be connected to any individual or organisation. This made the debate freer and helped the interviewees express even quite bold opinions.

The interviews addressed the present situation as well as problems and challenges associated with smart fire safety solutions. Regarding the future, the interviewees pondered not only the hindrances to development, but also their wishes, ideas and the possibilities. The topics were quite distinctly associated with, on the one hand, the implementation of large projects and, on the other hand, everyday life within the rescue services.

3.2 Structured web surveys

Based on the interview experiences, a web questionnaire was formulated in February, 2019. It was sent to a wider field of participants selected from, among others, SPEK's client register. The purpose of this web interview was to test and deepen the hypotheses which arose from the interview findings. In addition to multiple choice questions, the questionnaire included many essay questions, which made it possible for the respondents to propose their own fresh ideas and views.

The survey was sent to the interviewees, to experts that they recommended, plus a wider selection of recipients from SPEK's client register (participants of SPEK working groups or seminars who had given permission to be sent these kinds of requests). All the recipients were also welcomed to distribute the questionnaire link further.

The majority of the participants in both the interviews and the survey represented the rescue services. In addition, real estate developers and other parties to smart projects participated in the interviews. Responses to the questionnaire were also received from representatives of building control services or other oversight authorities, designers and those who gave insurance and risk management or security as their main area of responsibility.

The survey inquired about the respondents' work activities, which, typically, appeared to be associated with several sectors. Education and induction training were at the core of most respondents' reponsibilities, as were supervision and inspections. The most important themes in the work activities were fire safety regulations, structural fire safety and fire prevention technology.

4. Challenges and problems

4.1 Challenges to cooperation

The survey charted the level of competency in the respondent's own sector with regard to the different sectors of fire prevention technology and the functioning of cooperation with the project's other parties. This was not raised as a specific topic in the interviews.

Structural fire safety was found to be well mastered, but room for improvement was seen in real estate and regional development projects as only safety-related evaluations were fairly well known. In operational fire safety, structural issues are well known, but when it comes to user-level fire safety and technical support systems things could be better. The level of know-how associated with building automation system solutions and data security was not considered to be very high. The overall expertise in the development of fire safety regulations and standards was deemed as being very good.

As for the cooperation between the other project parties, the rescue services and oversight authorities are seen as being good partners. The developer and contractors received the poorest marks. In their view, inter-authority cooperation and the exchange of information is improving, even though regional differences also occur in interpreting regulations and requirements. The respondents wished interpretations and practices were harmonised. The rescue service's cooperation with the contractor was deemed problematic in the sense that the designer, most often, is an intermediary in the process. In the same vein, the interface with the contractor is weak; even information on major changes in plans and implementation does not always reach the authorities. The real estate developer is seen as the weakest link in cooperation. Smart security should be taken into consideration as the key element in design and subsequent solutions to the site's security features should be required. Regrettably, too often the economic views prevail and the solutions are selected on financial grounds: resources are being minimised by all, safety and life-cycle issues are pushed into subsidiary roles and in the end the final implementation becomes inadequate. "When you choose the cheapest option, you get what you did not want and might not even need". The end user's perspective and, especially, safety features for special groups are neglected.

The perceived problems in the planning process were that the designer is usually either unaware or ignorant of the premise's final use and of use-related risks. It is often the case in the planning phase that the purpose of the space or the actual end user is not known. Consequently, the user-related needs, such as the occupants' capacity for independent living, cannot be

taken into consideration. It was even mentioned as a detail in the survey that the designer might even promise the developer to include solutions that violate the code. This causes delays in projects and may even result in having to replace the designer.

Regarding designers, lacking expertise in smaller projects and a certain kind of inclination to setting a low bar was also mentioned (practical examples included a sophisticated high-end project in which the designer ignored the special instructions of the commissioner). Then again, the client might not properly appreciate the value of having a fire engineering consultant from the outset of a project. The reliability of performance-based fire design may become a problem when the design criteria and their use are not made sufficiently transparent for the supervising authority to be able to evaluate their validity.

It is regrettably common that the implementation does not conform to the original plan. Particularly worrisome reasons for this may include unprofessionalism, individual workers' whims, unscrupulous contractors or lacking supervision. On the other hand, the problem may also be caused by building-phase modifications or corrected flaws that are not recorded in the final documentation.

When it comes to practical cooperation the respondents complain about too few joint meetings. By increasing the number of meetings it would be possible to lighten the agenda and reduce the number of participants, and to target the right people with the right issues. Up-to-date information should be available and known to all parties.

One participant brilliantly summed up the challenges to cooperation: "We know too little about what the others have done and thought; the only focus is on one's own performance and in this process we forget the essential subject, the end user."

4.2 Challenges to adopting the attitudes

The challenges to this topic are associated with how fire safety is perceived as a part of a real estate or building project. Then again, clear shortcomings can be identified in the end user's fire safety awareness and actions after the project is completed and handed over to the owner.

Possibly the greatest challenge to adopting the attitudes is that proper fire safety emerges through negation: what price are we willing to pay for a fire that does not break out?

When asked about the greatest negative factors to considering fire safety

in projects, the main answer was that fire safety is not considered to be important enough. Among other things, it may be subordinate to the electric or HEPAC (Heating, Plumbing and Air Conditioning) subcontract, or it may be seen as an unavoidable nuisance and an extra expense. Design is distributed between separate consultants, the project is divided among different parties and subcontractors, thereby obscuring the management of fire safety solutions and comprehensive system entities. Furthermore, the fire branch itself has failed to establish good practices in accepting the emerging smart solutions.

Typically, fire safety technology is seen to be a small, separate detail, which is mostly approached from the standpoint of the requirements for the statutory, compulsory alarm and extinguishing systems. Even if the real estate developers and decision-makers were interested in the issue, they are not able to demand or address the relevant matters in the project's planning phase if the information is not readily available and direct cost benefits are not easily achieved.

The building's users may be completely unaware of the fire safety issues of their surroundings: how to act in an emergency (sounding an alert, reacting to an alarm, escape routes or gathering places) is not known nor practiced. This is particularly true for premises that are less familiar to the users, such as shopping centres or the open 'smart premises' designed by the City of Helsinki. In larger buildings the situation is more straightforward because the situation is being monitored and controlled by a control room familiar with the systems and procedures.

The poorest marks were given to the promotion of digital system possibilities and to the definition of the rights and responsibilities associated with data storage, usage and dissemination. Nor do most respondents feel that the management of large real estate entities and their control processes is well enough defined. The harmonisation of fire safety in different activities, as a whole, does not appear to have succeeded particularly well in any sector.

4.3 Information challenges

Part of the previous subject matter, challenges to adopting the attitudes, is also associated with how readily information is available and how easily it can be implemented into the relevant matter and needs.

As previously stated, actors in large projects not only need to recognise the significance of fire safety, they also need information which is readily available and adoptable as well as clear options that support decision-making. So as to make this available, fire consultants, automation designers and others that present options should be aware of the possibilities, requirements and cost

alternatives offered by fire safety solutions and new technological innovations. In practice, however, even experts often believe that fire safety has been taken care of when the premises are fitted with an automatic extinguishing system.

More information should also be provided to the contractors. Generally speaking, large projects manage fire safety issues quite well but the SME sector, which is responsible for the bulk of construction, is not as knowledgeable, not to mention the DIY house builders.

One of the greatest problems involves the exchange of information among separate systems (which is also partly a technical challenge, see the next subchapter). In nearly all of the interviews it was mentioned that the numerous technical systems in a building do not 'converse with each other', or have interfaces with each other. There are cases where the system's interconnecting operation test phase alone dragged on significantly, delaying the building's planned handover by several months. Once compatibility has been reached, the system may crash when a single component is being repaired, changed or updated. This is particularly harmful if extinguishing or alarm systems that require absolute reliability and must meet statutory requirements have been integrated with some other technology. This is why, at least for the moment, they are completely separated from such systems.

Even when a system functions technically correctly, the human factor may cause problems. Especially sensitive phases include handing the building over to the users, modernising or replacing systems, when the users or the real estate service provider change, and maintenance actions. If, in these cases, the proper information transfer is not secured, for example, by appropriate induction training and documentation, even a functioning system may be left unused. When it comes to maintenance actions, cause for concern includes whether, for example, sprinkler system maintenance is carried out in accordance with the maintenance programme or were there shortcomings. There are also examples of post-maintenance blunders such as forgetting to switch the system or its parts back to normal from the service mode.

4.4 Technical challenges

Not one case was mentioned where the desired system features would not have been technically feasible. Most technical challenges are associated with the previously discussed problems of compatibility and reliability, and with the dissemination of information – consultants or decision-makers may not be sufficiently informed on the potentials of the new solutions.

The planning phase of a large project may take years. Nowadays technology advances so rapidly that the solutions selected in a project's early

phase may already be obsolete before their implementation. Therefore, decisions associated with fire safety and other security-related solutions may be delayed until the end phase of the project, in which case they are left isolated from or are add-on parts to other systems.

In the interviews the representatives of the rescue services gave much thought to the challenges and possibilities of alarm and firefighting technology. Various systems, such as 3D indoor navigation and evacuation models, have been developed and even piloted. While most such systems are innovative and sophisticated, they are overly complicated to serve their purpose. During an alarm situation, the system must be straightforward and intuitive because then there is no time to learn or use complex features. Likewise, the information it generates should be extremely simple and visual. For example, fully outfitted firefighters cannot use tablets. Rather, the information provided to them should be projected onto their helmet visors, for example.

According to the rescue services interviewees, up to 98% of all automated alarms are false. Likewise, smoke alarms in flats cause ungrounded inspection visits when the the devices malfunction or their batteries die. On the one hand, it is hoped that technological solutions would improve the reliability of systems and equipment and, on the other hand, false alarm cancelling and reset procedures could be simpler than having to dispatch an entire fire unit to the scene.

Data security was also mentioned as a technical challenge. In the safety (and fire safety) sector, too, all kinds of data are available, such as CCTV surveillance data, but particularly grey areas are how and where the data are recorded and who is allowed to access and use it. So as to fully take advantage of technological solutions, harmonised and universally accepted practices should be created for issues associated with data security and the protection of individuals.

4.5 Challenges to cost awareness and life cycle

Challenges to adopting the attitudes, discussed in subchapter 4.2, are strongly associated with how much and on what terms we are prepared to pay for fire safety; is there the willingness to invest in not having to fight a fire.

The risk of a fire is deemed to be so low that in many cases decision-makers are unwilling to pay for any voluntary solutions that exceed the statutory minimum requirements. Even though good plans were made and their expenses were accepted at the project level, when the construction project advances and the command chain of subcontracts lengthens, the solutions are often reduced to the system contractor's 'the cheapest is the

best' alternative. Apart from the authorities' inespections (which normally focus on meeting the minimum statutory criteria) the solution's appropriateness and compliance with the plan is not necessarily monitored or inspected.

Even though a number of solutions could technically be implemented, it is difficult to evaluate their volume and cost impact. For instance, it would be possible to install sensors that record data during a fire, but how many such dwellings will eventually burn and what kind of financially viable information would this kind of investment yield?

4.6 Other observations about the challenges

Regarding regulations, it was stated that the development of technology outpaces the development of statutes and legislation. Neither do statutes always unambiguously steer construction solutions, and their interpretations may vary according to different authorities and districts. It is occasionally difficult to apply new, innovative solutions to existing regulations and to present permit and inspection practices. Occasionally, the authorities find features and solutions that deliberately contradict the building permit.

Concern was expressed about the fire safety of risk groups. High-risk occupants live in conventional flats although their capacity for independent living has not been evaluated. Council houses, particularly, may combine high-risk occupants with low structural and functional fire safety levels.

It is necessary to emphasise that the perceived problems and challenges apply equally to new construction and renovations.

5. Development needs and ideas

5.1 Comprehensive management

All parties to construction projects should improve their awareness and know-how in fire safety issues. This could be achieved through, e.g., training, practical examples, representative statistics and development initiatives. The respondents expressed the desire that legislation, established guidelines and harmonised practises would make a positive impact as well as the wish for allocating more resources to supervision and inspection. The presence of rescue authorities in preliminary planning meetings would be desirable.

Smart building solutions should be integrated into the overall project from the very beginning, rather than add them on separately near the completion of the project. The developer ought to consider smart safety as a key element of design, and demand consequent solutions for the site's safety features. The responsibilities should be defined and the implementation should be monitored better. The interviewees proposed that a 'fire safety engineer' be designated to, at least, larger sites to manage and monitor the implementation phase. This would be analogous to the already existing moisture and safety site engineers, for example. The required competencies could be developed and verified through training.

Fire safety, and safety thinking as a whole, should be better recognised and considered during the whole life cycle of a building or environment. One commentator reminds us: "Fire safety exists for the sake of the owner/operator: after all, they are the ones that will occupy the building for the next 30–60 years". Another respondent suggests: "The significance of maintenance, from the standpoint of functionality, would become more clear to project personnel if the crucial decisions were made in the early stages of the project and if they were involved in the planning and decision processes. For example, regarding system interfaces, the operators could be invited to participate in the planning process from the installation protocol phase onwards (selection of equipment, etc)."

The handover and commissioning of the building should be done comprehensively so that information about the systems, their operation and maintenance as well as the required cooperation would seamlessly transfer from the designers and constructors to the owners and operators. Induction training and proper documentation play key roles in this, as do straightforward and clear instructions as well as well-defined maintenance contracts, maintenance and service schedules and high-quality installation protocols. These together form an updating organism of system documentation, which should also include the interfaces between systems. Induction and documentation also ensure the transfer of information even

when contractual partners – owner, operator, service provider – change.

One option for comprehensive management might be to create a 'one-stop shop' where multiple services are offered for all fire safety solutions and systems, ranging from project planning to implementation all the way to maintenance, repairs and updates.

5.2 The attractiveness of fire safety solutions vs costs

The "carrot and stick" principle is often offered to tackle cost challenges. Binding measures could involve, for example, land use terms: fire safety issues could be included in the terms for land transfer or zoning regulations. The carrot could entail direct benefits from advanced fire safety solutions, such as getting more building rights or lower insurance premiums. Image marketing, too, could improve the product: if the buyer of a property is ready to pay for better fire safety (or updating the fire safety level for ageing occupants) the constructor could add this image benefit to the flat's price. This trend is already noticeable in ecological solutions, for instance.

At the present, many fire safety solutions, such as sprinkler systems in wood-framed houses, are still quite rarely used and, subsequently, are relatively expensive. If such solutions were taken more widely into use, the prices might also come down.

The interviewees reflected on the implementation of different options and their cost impacts. In the large urban projects that they represented fire safety is already at a high level. The project parties are ready to embrace new solutions and innovation, and substantial financial resources are allocated for the purpose. On the other hand, small improvements, such as in suburban renovation projects, came up where it would be possible to improve the fire safety of individual flats through safer cookers, smart smoke alarms and the IoT for home appliances. Even though such improvements are small on an individual scale, their volume is substantial and, hence, their impact on fire safety is significant.

5.3 Social actions

It is only too easy to propose more stringent legislation and statutes – that this or that "should be made obligatory" – but the interviewed legislators pointed out that the process for making statutory obligations binding is lengthy and laborious; it takes years. Hence, it is not the appropriate way to push through small improvements.

Social support actions regarding, e.g., high-risk occupant groups are of course recommendable. Still, a fire-safe residence should not be a benefit gained from 'shoddy living'. Nor should it only be available when the occupant's functional abilities are reduced, for instance, the consequence of injuries from fire. The safety of risk groups will improve when safe living is guaranteed for everyone.

5.4 Improving technical solutions

Most technical challenges are associated with compatibility and reliability problems, and with the dissemination of information – consultants and decision-makers are not sufficiently informed about the new solutions and their possibilities. This could be an opening for automation system and equipment manufacturers. On the other hand, an impartial expert might be required because manufacturers may rarely want to develop their compatibility with competing products.

In the interviews and web surveys alike, the rescue service representatives naturally emphasised improvements in their field:

- Small and inexpensive solutions such as cooker safety devices or smart smoke alarms (providing large impact in, e.g., suburban renovation projects)
- Reducing the amount of false automatic fire alarms and simplifying the alarm cancelling and reset procedures
- Solutions that make the actual firefighting easier (locating the source of fire, floor plan solutions and escape routes, locating the people for evacuation)

6. Summary: How to make the most of shared information

Throughout the entire survey, challenges concerning cooperation, information and data dissemination were recurrent themes. As there are no practices and methods that cover the life cycle of a building, the authorities, designers, maintenance personnel or users do not receive readily available and adoptable information. Furthermore, no representative examples on cost savings and benefits exist. Summed up, the development and integration of smart fire safety solutions into other building systems and their operating environment has been difficult.

There is plenty of expertise within the field but it does not necessarily transfer to the critical decision-making phases of projects. Fire safety, particularly in large projects, is fragmented into parts of various technical systems and is not valued as a feature affecting the whole building. Moreover, fire prevention technology is only rarely seen as a profitable investment since the risk of fire materialises so infrequently. This results in a situation where fire safety is seen as an add-on part of construction, from which cost cuts are easy to make. Technical solutions do exist and they can be developed, but the information does not easily reach the construction projects' decision-makers or designers in an easily digestible form.

Thought to be especially challenging were the service, operation and maintenance procedures of smart and basic systems alike during the different phases of a building's life cycle. Examples have come forward of how pertinent information does not transfer from one actor to another: if the owner, operator or system maintainer changes, indispensable information on building system operations may be forgotten or, in the worst case, the whole system or parts thereof may remain unused because of extinct information or competence. In an emergency the impacts may become catastrophic.

Fire prevention systems, at present, typically consist of components isolated from the building's other systems and mostly comprise static detector and extinguishing systems – rarely do they contain any smart applications. Then again, isolation is also the criterion for reliability: the statutory systems must be absolutely reliable and cannot fail due to faults or shortcomings in other systems. So long as the letter of the law is met, fire prevention technology does not often receive further attention.

Impediments to modernising the building sector at the moment include diverging opinions on the matter and old-fashioned attitudes which continue to make fire safety an add-on part of construction. Furthermore, the fire branch itself has failed to establish good practices in accepting the emerging

smart solutions and opportunities. On the flip side, maybe the information has not been provided in a way that is easily acquired, understood and adopted.

The trouble is that the financial prospects and life-cycle impacts of fire prevention technology cannot be realistically taken into consideration. Furthermore, an investment in fire safety is only too often seen as an extra expense. And yet, fire safety extends into the everyday use of a building and its continuity management. It is essential to make the projects' decision-makers appreciate and comprehend the possibilities and cost effectiveness factors of fire safety. Based on the survey responses, further development is also needed in measures for promoting fire safety or providing new service types, e.g., in the form of life cycle service packages. Hence, novel marketing concepts for the safety sector and, especially, fire safety, are needed to make every involved party aware of the importance of the topic. This could be, for instance, a concept for applying the good health service practices to fire safety or, alongside other services, a city could distinguish itself from other municipalities in safety issues and thereby improve its safety image.

From the commercial point of view business security and continuity management are paramount to companies and individuals alike. Furthermore, new solutions and trustworthy security features may improve the effectiveness of actions and anticipate behavioural changes. In any case, more emphasis must be placed on people. So as to gain all of the possible benefits from digitalisation, cloud services and the Internet of Things, communities must become sources of information and the needs on which to anticipate future progress must be brought forward.

We must think about how safety is visible to the occupant and how to engage the end user early enough in decision-making. Then, image marketing could improve the product and developers could more easily transfer this image benefit to themselves. Since this trend is already noticeable in, for example, ecological solutions, why would it not work in safety thinking? Occupants are probably willing to pay for safer homes and operating environments so long as they are given adequate opportunities and the means to have an influence. The feeling of safety is one of the most important features of where people choose to live. Neither experts nor the parties embarking on construction projects are sufficiently aware of the demands of modern living. Therefore, data on future trends should increasingly be provided to those involved.

The challenges to adopting new initiatives are strongly associated with how much, and on what terms, people are willing to pay for fire safety. Do we want to invest in a fire not breaking out? Apart from the authorities' inspections, the solution's appropriateness and compliance with the plan are not necessarily monitored or inspected any further. Even if real estate

developers and decision-makers were interested in the issue, they may not demand or address the relevant matters during the project's design phase if the information is not readily available and direct cost benefits cannot be achieved.

As presented above, we must find out what information or instruments we need to support fire safety designing and implementation in construction projects. Therefore, the work of experts must shift to disseminating information and improving attitudes. Follow-on research should analyse the root causes of outdated attitudes and evaluate whether these views have already become such paradoxes that they no longer reflect the importance they once had. Future research can generate long-term visions, at which time alternative scenarios can help bridge the dialogue and the exchange of information among different parties. Shared information and cooperation may create roadmaps for new procedures and practices, which might, after all, not prove to be as laborious as suspected beforehand.

7. Follow-on actions

This survey indicates that many diverse sectors need more research, development and education. The results, for their part, can steer R&D projects in more detail towards the desired sectors and suitable focus groups.

To make the technical solutions meet real-world challenges, the results of the survey will be utilised in a project which was already launched in the spring of 2019. The aim of the study is to investigate the possibilities of building automation and environmental sensor data: what data, and how the data, can be utilised to improve fire safety in buildings and premises and to support the rescue services.

The study will examine what information proactive fire detection, a situation picture during a fire and accident investigation, among other things, require. It will also investigate what types of phenomena can be measured with sensors, what kind of new sensor technology is entering the market and how the data collected from different sensors can be processed to generate the kind of fire-safety improving information that the users will understand and the services can utilise. Information on fire risks associated with smart construction will also be gathered. Attitudes on smart solutions will be improved by increasing awareness. This, in turn, will support and expedite the realisation of smart fire safety.

The research project will be carried out as a Master's Thesis at the Tampere University Fire Laboratory. Both the Fire Laboratory and SPEK will participate in coordinating and guiding the project.

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Appendix 1: Semi-structured interview questions

Key questions

- Is fire safety represented in project development?
- Which parties evaluate fire safety?
- Have IoT solutions for fire safety come up?
- What are the impediments for developing fire safety solutions?

Challenges to adopting the attitudes

1. For whom is safety intended?
2. Technology makes things possible, but what should be targeted? Do people consider fire prevention technology and systems important? Are they properly appreciated?
3. Do people know how to act in the new operating environment?
4. Are the people using the premises aware of safety issues? Does the required induction materialise in practice? If not, why?
5. Are safety and fire safety considered to be two distinct concepts and procurements? Why so?
6. Is fire safety as a single item too small to be taken into consideration?
7. Is the comprehension of the big picture, rather than costs, more of an impediment?
8. Would life cycle service packages and comprehensive management bring new options to the development of fire prevention?

Information challenges

1. Do all relevant parties have a comprehensive awareness of the present situation and of the potentials for development?
2. Is there enough exchange of information? Is there enough expertise?
3. What kind of new risks may there be in new construction and operating environments?
4. Would life cycle service packages and comprehensive management bring new options to the development of fire prevention?
5. Is fire safety as a single item too small to be taken into consideration?
6. Would a comprehensive safety solution be a key enabler for development?
7. Is the comprehension of the big picture, rather than costs, more of an impediment?
8. Should information be more readily available? To whom?
9. Who administers proposing/demanding/taking decisions on solutions?

Technical challenges

1. The total automation building concept. What demands does it place on fire prevention technology?

2. Is fire safety integrated with the building service and information systems' engineering?
3. Possibilities for jointly using the systems?

- Could fire prevention technology carry out building automation tasks (e.g. fire detection system=detection of heat, humidity, motion, CCTV monitoring)?
- What information could fire prevention technology provide to other automation systems?
- Have the available data been evaluated; how could they be utilised to improve fire safety?
- How about sensors and other systems, the IoT?

4. Could fire prevention technology neutralise potential risks in new operating environments?
5. Who assures quality? Where are the problems found during implementations or procurements?
6. Do present procurement practices meet the needs or the site's requirements?
7. Does data security materialise?
8. Could safety be implemented as a comprehensive package instead of separate systems and processes?

Cost awareness and life cycle

1. Is the goal and the value of the building site that is protected by the implementation properly recognised?
2. Properties' life cycle and investment ratio, how are they understood? Fire prevention technology safeguards business continuity and minimises potential damage, but is this properly taken into account?
3. In general, fire prevention technology costs amoun to 1–2% of the total construction cost. Is the price an impediment to better solutions?
4. In addition to service-based solutions, are financing options needed for system investments?
5. Is the added value to properties brought about by new solutions, such as energy efficiency, long-term systems or the improving image of sustainable development, taken into account?
6. Are fire safety and fire prevention system procurements considered in life-cycle thinking?

Appendix 2: FIRE INTELLIGENCE: Taking fire safety and attitudes into account in smart construction

Smart construction workshops talk about the abundance of available information and its prospects for being an enabler of new kinds of functions, businesses and services. Why would we not also extend smart thinking to the field of fire safety? The contemporary definitions of the built environment, such as multipurpose premises, energy efficiency, the life-cycle approach, along with those of the social and welfare branch, such as challenges posed by the ageing population, are issues that come with inherent problems and opportunities and that must also be addressed from the viewpoint of fire safety and the fire safety experts. While intelligent fire safety solutions do exist, their widespread introduction is impeded by insufficient knowledge or negative attitudes, lacking financial resources or poor technical viability – often all simultaneously.

This attitude survey is part of research conducted by the Finnish National Rescue Association (SPEK) and the Fire Laboratory of Tampere University. It examines the present situation and the future prospects for integrating fire safety solutions with other smart construction technologies. The results will steer future research and education and be used to meet emerging real-world questions.

In the first phase of the study we interviewed certain key personnel representing real estate development and the rescue services in large cities. A web survey for a larger group of experts was designed on the basis of the topics that came up in the inteviews.

You received this questionnaire because you have already participated in the first interviews of the study or because other interviewees mentioned your expertise. Your name might be included in the collaborative networks of SPEK or the Fire Laboratory of Tampere University, or we may have selected you on the basis of your position or field of expertise found on public internet pages. Any information you provide will remain anonymous and will be processed in such a manner that it cannot be connected to you, your organisation or a possible construction site you used as an example.

A BASIC QUESTIONS

Your area of responsibility/sector?

- ☐ Rescue services
- ☐ Building control services or other oversight authorities
- ☐ Design/planning and consulting
- ☐ Real estate and/or regional development
- ☐ Technical systems
- ☐ Other, what?

What are your work tasks? You may select several.

- ☐ Design/planning
- ☐ Legislation or standardisation
- ☐ Supervision and inspections
- ☐ Decision-making
- ☐ Education and induction training
- ☐ Fire safety regulations
- ☐ Real estate or development projects
- ☐ Structural fire safety
- ☐ Fire prevention technology
- ☐ Building automation solutions
- ☐ Operational fire safety
- ☐ Data security issues in networked system structures
- ☐ Developing fire safety regulations or standards
- ☐ Other, what?

In what region do you mainly operate?

- ☐ 01 Uusimaa
- ☐ 02 Southwest Finland (aka Finland Proper)
- ☐ 04 Satakunta
- ☐ 05 Tavastia Proper
- ☐ 06 Pirkanmaa
- ☐ 07 Päijänne Tavastia
- ☐ 08 Kymeenlaakso
- ☐ 09 South Karelia
- ☐ 10 Southern Savonia
- ☐ 11 Northern Savonia
- ☐ 12 North Karelia
- ☐ 13 Central Finland
- ☐ 14 South Ostrobothnia
- ☐ 15 Ostrobothnia

☐ 16 Central Ostrobothnia
☐ 17 North Ostrobothnia
☐ 18 Kainuu
☐ 19 Lapland
☐ 21 Åland Islands

B DIFFERENT PARTIES IN IMPLEMENTING FIRE SAFETY

What is your opinion about the level of expertise of different parties in projects that address the implementation of fire prevention technology? Is there sufficient knowledge in your sector?

Stuctural fire safety

The level of expertise in projects in your sector is sufficient 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree,5=no opinion

	1	2	3	4	5
Fire safety in buildings, in general, (fire classes, emergency exits, structures…)					
Technical fire safety solutions (extinguishing systems, smoke alarms, smoke extraction…)					

Fire safety in real estate or regional development projects

The level of expertise in projects in your sector is sufficient 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

	1	2	3	4	5
Decision-making (implementation, investments)					
Life-cycle planning					
Cost evaluations					
Safety evaluations					
Selection of technical systems					

Operational fire safety

The level of expertise in projects in your sector is sufficient 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

	1	2	3	4	5
Structural fire safety at the regional level					
Structural fire safety at the building project level					
User-based fire safety in residential buildings					
User-based fire safety in non-residential buildings					

Building automation solutions
The level of expertise in projects in your sector is sufficient 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

	1	2	3	4	5
Access control and security; HEPAC and electric engineering, monitoring and servicing…					

The level of expertise in projects in your sector is sufficient 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

	1	2	3	4	5
Data security in digital systems.					
Development of fire safety regulations or standards.					

Is there sufficient cooperation in your sector among the other parties of the project? 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

	1	2	3	4	5
Rescue services					
Design/consulting					
Developer					
Building control services or other oversight authorities					
Contractors					

The interviews in this survey established that cooperation and communication among the different parties (developer, subcontracting, monitoring) could be improved. How, in your opinion, could this be improved in collaboration with others?

Write short answers to the following questions. Please also justify your most important concern.

Strengths:
Who (party)

Weaknesses:
Who (party)

Things to improve:

Who (party)

Why are you of this opinion? You can explain your answer in more detail below:

C. TAKING FIRE SAFETY INTO CONSIDERATION

Do building projects and design sufficiently appreciate the significance of fire safety? What do you think of the following statements:
1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

	1	2	3	4	5
Fire safety has enough visibility in project planning.					
Fire safety solutions are comprehensively considered during the different stages of a project.					
New fire prevention solutions and options are presented in a wide-ranging manner.					
The properties and options of digital systems (system integration and joint use, data to be compiled) are sufficiently presented.					
The entities and networks responsible for fire safety are designated and known to all parties in the project.					
The rights and responsibilities associated with data storage, usage and dissemination are clearly defined.					
The comprehensive management process, in your opinion, is unambiguous.					

The harmonisation of fire safety is achieved well: 1=totally agree, 2=somewhat agree, 3=somewhat disagree, 4=totally disagree, 5=no opinion

In preventing accidents and in a proactive manner.	
In continuity management.	
In the actor's image-branding.	
In project planning.	

Open questions

Please provide short answers to the following questions.

What factors make it more difficult to take fire safety into account in projects?

How, in your opinion, would it be possible to improve fire safety awareness?

D PROBLEMS AND CHALLENGES

Where do you find shortcomings in the present situation? Which issues make it more difficult to introduce new fire safety solutions? Please evaluate the significance of each statement on a scale from 1 to 5. In addition, select the greatest problem for each theme.

Challenges to adopting the attitudes

1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Fire safety issues are not considered to be important or their significance is not acknowledged.

Fire safety issues are not recognised as part of a building's technical solutions.

Users do not think of fire safety as part of their operating environment.

Fire safety issues are not valued as a feature affecting the whole building. Rather, they are fragmented into parts of the technical systems.

Which one of these do you think is the most important one. Please provide a short justification.

Infomation challenges

1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Decision-makers in projects are not sufficiently informed of fire safety to support their decisions.

Designers are not sufficiently informed of new solutions and their possibilities.

The SME sector and/or DIY house builders are not sufficiently informed of fire safety issues.

The people using the premises are uninformed about fire safety systems and their operation.

Compatibility and reliability are not ensured during system updates, replacements or repairs.

Information about system operation is not transferred when users or service providers change.

Terminology is inconsistent even when experts communicate with each other (e.g. smoke/fire alarm/detector). When systems are updated, replaced or repaired, compatibility is not ensured and reliability is not verified.

Information about system operation is not transferred when users or service providers change.

Which one of these do you think is the most important one. Please provide a short justification.

Technical challenges

1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

There are no readily available or suitable solutions for the desired functions.
The technical solution is too complicated (e.g. for the rescue personnel during an alarm).
The new solution does not comply with the requirements of legislation.
There are information security problems in using the technical solution (hacking, data access rights, protection of privacy).
The system is not sufficiently reliable.
Systems are not mutually compatible.
System maintenance is ignored
or systems may be left in the
service mode.

Which one of these do you think is the most important one. Please provide a short justification.

Cost awareness and life cycle
1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

The risk of a fire is deemed to be so low that
decision-makers are unwilling to pay for
voluntary solutions.
Even if good plans were made, the contractor, in the end, will select the cheapest acceptable solution.
Fire safety investments do not achieve direct cost benefits.
Fire safety is not thought of as a part of a building's life-cycle thinking.
It is hard to properly determine the
share and volume of costs allocated
to fire safety solutions (e.g. what risk
groups will be protected and how
cumbersome can these solutions be)

Which one of these do you think is the most important one. Please provide a short justification.

You can justify your choices here. For example, you can give details on the context where you encountered the abovementioned problems.

Any other problems or challenges you have encountered:

E DEVELOPMENT NEEDS AND IDEAS

Do the hindrances to implementing fire safety concern technology, legislation, finances or attitudes? What is your opinion about how different the parties function and the need to improve their attitudes? What issues, in your opinion, impact the development of fire safety solutions? How much do the following issues affect the development of fire safety solutions? Please evaluate the significance of each statement on a scale from 1 to 5. In addition, select the most important measure for each theme.

Comprehensive management
1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Develop a 'one stop shop' service model for fire safety solutions that will include everything, ranging from planning to maintenance.
Fire safety is part of the comprehensive implementation of a building's technological and digital solutions (instead of only meeting the minimum requirements and installing individual systems).
Improve fire safety awareness and competency among project developers and decision-makers.
Improve fire safety competency among construction professionals (e.g. personal certifications for constructors, supervisors and operators)
Improve system reliability and compatibility.
Centralise monitoring and control.
Improve the supervision and monitoring of appropriate maintenance actions.

Which one of these do you think is the most important one. Please provide a short justification.

The attractiveness of fire safety solutions
1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Achieve cost benefits from voluntary fire safety solutions (e.g. lower insurance premiums, getting more building rights).
Steer investments through image marketing for fire safety (e.g. safety solutions for

home buyers).

Effective maintenance
1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Maintenance is proactive and effective,
which saves time and money.

Which one of these do you think is the most important one. Please provide a short justification.

Social actions
1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Tighten legislative requirements.
Make fire safety issues a part of land use processes (e.g. terms for land transfer).
Society should support fire safety solutions, e.g., in the living arrangements of high-risk groups.

Which one of these do you think is the most important one. Please provide a short justification.

Improving technical solutions
1=very important, 2= quite important, 3=not very important, 4=not at all important, 5=no opinion

Develop innovative solutions in large projects (halls and arenas, adventure parks, etc)
Develop small grassroots solutions (e.g. cooker safety devices or smart smoke alarms) and large volume items (suburban renovation projects, etc).
Improve technical solutions so that they become more user-friendly and visual.
Develop data collection and usage, taking into account issues associated with data security and the protection of privacy.
Develop solutions for the reduction of false automatic and smoke alarms, and more straightforward alarm cancelling and reset procedures.
Develop solutions that make firefighting easier (e.g. locating the source of a fire, floor plan solutions and evacuation routes, locating the people to be evacuated).

Which one of these do you think is the most important one. Please provide a short justification.

Are the following topics visibly and clearly defined? Do the parties to the project know each other's responsibilities? Could the practices be further improved?
Who is allowed to propose fire safety solutions and options? How, in your opinion,

could this be improved in collaboration with others?

Who selects the fire safety solutions and makes the other decisions? How, in your opinion, could this be improved in collaboration with others?

Who designs the fire safety solutions and systems; who comments on them? How, in your opinion, could this be improved in collaboration with others?

Who is responsible for the final selection, procurement and implementation of fire safety systems? How, in your opinion, could this be improved in collaboration with others?

Who is responsible for compatibility among individual systems? How, in your opinion, could this be improved in collaboration with others?

Who is responsible for the maintenance and monitoring of the systems in use? How, in your opinion, could this be improved in collaboration with others?

How is the introduction, documentation and induction of installed systems implemented? How, in your opinion, could this be improved in collaboration with others?

How is the continuity of system know-how (service and maintenance) and functional reliability (updates, repairs, new systems) organised throughout the life cycle of the building?

How is the systems' compliance with plans and quality assurance taken care of? If the implementation does not comply with the original plan, what is the reason for this?

Do you have any comments, ideas for improvement or need for more detail to the abovementioned thoughts? How would you like the other parties in your project to improve their competency and activities? What other issues should be included in future research projects? Do you have any good ideas for improving fire safety?

F HOW DID WE SUCCEED?

	Well	Fairly well	No opinion	Fairly poorly	Poorly
It was easy to provide answers to the survey					
The survey addressed issues that are important and relevant to my work					
The survey, in my opinion, addressed important issues					
I believe that the results of the survey will identify good topics for improving communication and training					
I believe that the results of the survey can raise important fire safety topics.					

Thank you for your time!

When our research project is completed we will send you the final report. We may also get in touch with you in the future with further questions regarding this topic. If you DO NOT wish to receive any mail from us in the future, please tick the appropriate box below.

We will send the final report to the same people who received the request from us to participate in the survey. If you received the link from someone else, you can get the report from the same person or organisation, or by e-mailing a separate request to anu.aaltonen@tuni.fi.

☐ I do not want to receive any more mail from SPEK or the Fire Laboratory of Tampere University. Please remove my name and contact information from your files.

6

SUOMEN PELASTUSALAN KESKUSJÄRJESTÖ SPEK PUHEENVUOROJA SPEK

This survey brought together different parties involved in fire safety in construction and real estate development. The discussions took place principally in cities which are implementing spearhead projects representing new concepts of building and which are also active in the field of smart construction. The survey and the follow-on research project aim to investigate whether the fire safety issues are sufficiently recognised in modern building projects and whether the project parties acknowledge the importance of fire safety development needs.

The survey results affirm the overall picture and notions concerning the development needs of fire safety and fire prevention, which turned out to be more about the shared information than individual technical solutions. The results could be used as an instrument to steer future research and education, and to focus technical solutions in accordance with the perceived needs and challenges.

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