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Design of Security Screw for Telecommunication Division Box as an Efforts to Prevent Network Theft

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ABSTRACT

The rapid growth of the telecommunications sector under globalization has intensified competition among service providers, particularly in meeting demands for high-speed and reliable connectivity. Along with this development, safeguarding infrastructure has emerged as a critical concern. Distribution boxes represent vulnerable components within telecommunications networks and are frequently targeted for equipment and cable theft. Such incidents lead to financial losses, service interruptions, and erosion of customer confidence. This study proposes the design of a security screw to enhance system security, employing a design thinking (DT) approach that encompasses the stages of empathize, define, ideate, prototype, and test. Insights obtained from interviews and HMW-based brainstorming informed the development of a product design referred to as the tri-hole Screw. The proposed screw employs a customized head design to deter unauthorized removal using commonly available tools. The experimental results demonstrate that the proposed screw design cannot be rotated using conventional Phillips and flat-head screwdrivers, as well as improvised tools. The measured torque resistance ranged from 2.21 to 2.24 Nm, indicating the effectiveness of the design in enhancing resistance against unauthorized access.

1. INTRODUCTION

The telecommunications industry is developing rapidly and is fueling competition among service providers. Telecommunication providers are not only required to provide high-quality services but also to maintain infrastructure security to ensure uninterrupted service [1]. The biggest challenge is the theft of equipment or cables from distribution boxes. Distribution boxes are crucial points in telecommunications network distribution, connecting the main cable to the customer's network. Illegal access to distribution boxes can potentially lead to theft of copper cables, network equipment, or even sabotage, which can seriously impact service continuity [2]. Furthermore, the development of threats to telecommunications infrastructure is not only in the form of theft of physical assets, such as copper cables, but also in the form of network theft through illegal access to distribution boxes. This method is known as illegal tapping or interception of communication transmissions, which is the tapping or illegal connection to a telecommunications network without permission [3]. This practice can cause greater losses than material theft because it has the potential to cause customer data leakage, service theft, and even a decrease in service quality.

Network theft cases in Indonesia are increasing as the demand for high-speed internet services increases. Several operators have reported significant losses due to unauthorized access to distribution boxes, which not only disrupts service performance but also damages the company's reputation [4]. This is important to accurately evaluate possible risks to infrastructure and facilities that may involve the bypass of locks and locking hardware [5].

This situation necessitates the need for physical protection through the use of security screws with special heads that are difficult to open using standard screwdrivers. Security screws have unique heads that increase their resistance to wear and pressure while also making them far more difficult to remove. The security screws that currently exist include: torx screws, one-way screws, spanner screws, button head screws, countersunk screws, flanged button head screws, hex socket cap screws, and pan head screws [6]. To maintain access and network security, the Indonesian telecommunications industry is seeking to design a unique security screw. For this reason, data and information related to existing security screws are needed, as well as discussions to design security screws that are suitable for the telecommunications industry. One of the methods used to design products is the design thinking (DT) framework.

DT helps customer to identify their issues and offer data for improvement ideas, which designers can use to create new products. DT provides a method for creativity and problem-solving, also garnered a lot of attention from academics and practitioners. The core principle behind the DT process is to keep learning and refining initial concepts [7]. Currently, the method has been used in learning media design, motorcycle workshop design, application design, project design, and product design [7-11]. This shows that DT is not limited to just one type of design but can be applied to all types. Therefore, this research aims to design a security screw to improve the security system of the telecommunications industry in Indonesia.

2. LITERATURE REVIEW

2.1 Telecommunications infrastructure

Due to its capacity to transmit data quickly, receive it instantly, and even cross national borders, telecommunications are a human communication platform that offers advantages over other communication platforms. The efficiency and productivity of the community as a whole will undoubtedly be impacted by a strong telecommunications infrastructure [12]. At the vanguard of the technological revolution is telecommunications infrastructure, which is an essential part of "new infrastructure." While "new infrastructure," fueled by technology innovation, is becoming more and more important in the new economy, exemplified by the digital economy, traditional infrastructure construction has seen declining marginal utility and returns over time [13]. Due to the diminishing returns on telecommunications investments, it is expected that the majority of income in developing nations will come from investments in telecommunications infrastructure. From the standpoint of government policy, the data offer compelling evidence that the development of economic growth depends on the provision of an effective telecommunications infrastructure [14].

Numerous attackers with malevolent intent and no justification may launch assaults against telecommunications infrastructure. In certain instances, their acts can be motivated by a desire to produce unlawful gains or complete communication failure. There are four classifications of attacks on telecommunications infrastructure, namely; a) terror attacks; b) technological threats; c) criminal attacks; and d) general threats [15].

(1) Terror attacks are any type of attack has the potential to seriously impair network services. One is a consequence of armed conflicts. As a purposeful military tactic, particularly by terrorists, certain military confrontations result in the physical damage of telecommunications infrastructure. This is accurate in areas where there has been or continues to be a military war of some kind.

(2) Technological threats are referring to dangers posed by the technologies themselves. The corporate clientele of telecom firms is primarily linked to these threats. The threat or attack may occasionally result in significant financial losses.

(3) Criminal attacks are the players' actions involve using a variety of deceptive techniques to commit conventional frauds. Both the telecom providers and their clients are at risk from these kinds of attacks. Criminal attacks fall into two categories: computer-related attacks and telecommunication cable splicing, PABX hacking, etc. Unauthorised access to a telecommunications network can be obtained via splicing into telecommunications cable. Making illicit relationships is the primary goal of such behaviour. Because of this, protecting these connections from unwanted and unauthorised tampering is very expensive and almost impossible. Because it is so easily abused, thieves mechanically splice into the wiring so they may connect and make free calls, which leads to a huge cost for a subscriber whose line was regrettably and illegally utilised. Private Branch Exchange (PABX) hacking is also a risky illegal activity. Contemporary branch exchanges are specialised private-use communication devices with a wide range of uses. The administration of this technology necessitates skilled service professionals, and it permits remote administrator access over the telephone network. This is made easy by the fact that many administrators either use an insufficient password or stick with the default password that was pre-set by the supplier. An act committed by an experienced computer user is known as computer crime. In contrast to terror strikes, this crime entails the theft of a person's or company's private information rather than the actual destruction of infrastructure. Sometimes, the player involved in this behaviour is called a hacker.

(4) General threats are players like special government agencies are involved in this. It is a type of nation-state-sponsored hactivism. For example, the Government agencies are actively attacking telecommunication operators' infrastructure and applications to enable clandestine monitoring. APT stands for Very Advanced Persistent Threats. APT allows skilled actors to conduct covert surveillance and remain hidden for extended periods of time. Phone lines, internet chat, mobile phone data, and other communication channels are among those targeted for covert surveillance. Cyberattacks may be used for covert surveillance between countries. In several instances, a cyberattack from one country has stopped the leaders of another from using their mobile devices to communicate.

Physical security breaches such as cable or device theft significantly impact telecommunications service. However, by causing large revenue losses and interruptions to the electrical supply, cable theft and vandalism have exacerbated the industry's issues. Vandalism and cable theft have grown to be serious issues for the power sector in emerging nations. The literature describes their impact on the social and economic structure of the country. Cable theft and vandalism not only damage energy utility suppliers but also consumers, who ultimately have to pay higher rates to compensate for these losses. From a socioeconomic perspective, theft and vandalism of copper cables have resulted in disruptions to telecommunications networks, accidents, electrical shock deaths, and burn injuries from maintaining and repairing damaged substations and copper cables [16]. Therefore, service providers must adopt multi-layered protection, including both digital and physical protection.

2.2 Security screws

Security screws are a mechanical solution for enhancing the physical security of a device or infrastructure. Security screws are designed with heads that require specialized tools for installation and removal. This design significantly increases the difficulty for unauthorized parties to open or gain unauthorized access to protected devices. Some common types of security screws used in various industrial sectors include the snake-eye or spanner type, and the pin-in Torx. Each type has unique characteristics in the shape of the screw head. For example, a snake-eye or spanner screw has two small holes resembling the eyes of a snake, so it can only be turned with tools that have two parallel pins. Another variant, the pin-in

Torx, button head screws, countersunk screws, flanged button head screws, and hex socket cap screws, see Figure 1.

Figure 1. Type of security screws

In practice, the use of security screws has been proven to be able to prevent theft and sabotage, because the perpetrator must have access to special tools that are rarely freely available [17, 18]. Therefore, security screws are widely applied to important infrastructure such as electrical systems, transportation, electronic equipment, and telecommunications networks. The application of security screws in the context of telecommunications distribution boxes not only functions as a physical barrier, but also as a form of psychological deterrence, where the perpetrator will think twice before trying to open the box illegally.

2.3 Design thinking framework

DT is an approach that prioritizes user needs, utilizing tools from design to drive innovation and integrate solutions effectively. Combine user's needs with suitable technology to create a cohesive solution and a reliable product due to its ability to deliver effective results [19]. The user centered DT based approach promotes the successful integration of technology into society and aids in the creation of more usable prototypes [20].

DT has the potential to be a useful framework for implementing DT in school education because it can enhance learners' experiences, develop competencies in the design and creation of technological solutions to solve problems, help students be creative and highly motivated so they can propose and develop practical and innovative designs, and have positive results on design outcomes, learning objectives, and student achievement. Based on the types and causes of misunderstandings, context specificity, and the abilities, competencies, and needs of learners, DT offers educators an organized and formal path that enables them to select the most appropriate approach for recognizing and removing student misconceptions [21-23]. From the standpoint of creativity, DT can combine motivation with creative abilities to produce future human resources that are capable of serving society more successfully. From the perspective of innovation, it is a design methodology that involves developing connections between stakeholders and decision makers in order to continuously improve ideas toward novel paths [24, 25].

The literature has suggested a variety of DT process topologies, ranging from three to six phases. Nonetheless, the fundamental concept of the many process models is the same. Only a finer subdivision is displayed by models with additional phases. Every DT procedure can be divided into three primary parts. These are (1) gathering information about the issue, (2) coming up with ideas, and (3) putting those ideas to the test [26]. The advancement of DT from a conceptual cognitive-strategic paradigm to a practical methodological approach led to the emergence of several influential frameworks aimed at systematically guiding innovation activities. Five stages that are widely used in DT were popularized by Kelly through a human-centered approach, iterative problem-solving and initial stages of experimentation to answer complex challenges [27]. The five stages consist of emphasize, define, ideate, prototype, and test. The emphasize stage aims to develop an understanding of user needs. This understanding involves using qualitative and ethnographic research methods to observe users in their environment from their experiences and perspectives [28].

Based on the data obtained during the empathy phase, we developed user personas and articulated key points of view that collectively represent the aspects most relevant to users. By employing tools such as empathy maps, insights from individual interviews were synthesized to generate a comprehensive understanding of the target population [29]. In the define phase, all previously obtained insights are rigorously synthesized and systematically evaluated to determine their relative importance. This stage aims to establish a coherent and shared knowledge framework, culminating in the formulation of a well-defined point of view (POV) that explicitly specifies the target user and provides a substantiated rationale for the significance of the identified issue to the user [29]. During the ideation phase, an extensive range of novel concepts and potential solutions is systematically generated and examined. This phase serves as a critical mechanism for fostering creativity while simultaneously supplying the foundational inputs required for prototype development and the subsequent translation of innovative outcomes into user-oriented applications [28, 30]. In the prototyping phase, which follows ideation, conceptual propositions are translated into tangible representations, enabling design teams to rapidly identify shortcomings and generate new insights through iterative exploration. Subsequently, the testing phase is dedicated to the systematic evaluation and continuous refinement of these prototypes, with the objective of converging on an optimal solution that effectively addresses the defined problem [30].

3. METHODOLOGY

This study adopts the DT framework, which is structured into five sequential stages. The first stage, Empathize, employs empathy mapping to systematically analyze the rising incidence of device and cable theft within telecommunications distribution boxes, a phenomenon that has led to service interruptions and substantial financial losses for network operators. Within the DT framework, data collection is conducted using a mixed-methods strategy that combines semi-structured interviews, questionnaire-based surveys, systematic field observations, and immersive contextual inquiry. These methods are employed to capture users' experiences, behaviors, and needs, thereby supporting the empathize stage and informing subsequent phases of the design process [29]. The outcomes of this empathy mapping process are illustrated in Figure 2, which is described in the following section:

(1) Says: The Says quadrant captures explicit statements

and verbal expressions articulated by users during data collection activities.

(2) Thinks: The Thinks quadrant represents users' implicit thoughts, beliefs, and cognitive considerations inferred from interviews and contextual observations.

(3) Does: The Does quadrant documents observable actions and behavioral patterns exhibited by users in real or simulated environments.

(4) Feels: The Feels quadrant reflects users' emotional responses and affective states associated with their experiences and interactions within the studied context.

At this stage, interview is carried out with the telecommunications companies to find out what they need, think and feel. The study then proceed to the subsequent phase, referred to as the define stage.

"Says"	"Does"
"Thinks"	"Feels"

Figure 2. Empathy mapping

The define stage aims to synthesize insights generated during the Empathize phase in order to formulate a clear and user-centered problem definition. This stage plays a critical role in problem framing, where qualitative user data are transformed into structured insights that reflect real user needs and contextual constraints, thereby providing a solid foundation for the ideation process [31]. An interactive qualitative approach enables to examine the applicability of theoretical frameworks within complex real-world contexts that often deviate from simplified or idealized theoretical assumptions [32]. Qualitative insights were generated through structured brainstorming activities, which facilitated the formulation of a POV by clarifying the core problem to be addressed. The POV statement encapsulates the design intent by identifying the most relevant problem to be addressed during the ideation phase. It is developed through the reframing of the design challenge into a clear and actionable problem definition. The formulation of a POV integrates synthesized user insights, identified user needs, and contextual understanding derived from the Empathize stage of the research [33].

Once the design challenge has been articulated through a POV statement, the research proceeds to the ideation phase by formulating problem-oriented inquiry statements. These inquiries are commonly expressed as "How Might We" (HMW) questions, which function as structured prompts to translate defined user needs into opportunities for systematic idea generation. Such questions facilitate exploratory thinking and support the development of potential solutions in a focused ideation process [33].

The ideation phase in the DT process involves generating a wide range of solution concepts based on insights gained from earlier stages, particularly the empathize and define phases. This stage emphasizes divergent thinking to explore multiple potential directions before converging on the most promising ideas. The goal during ideation is not to immediately decide on a final solution but to encourage creativity, uncover latent opportunities, and expand the range of possible options. By integrating diverse perspectives from stakeholders and multidisciplinary team members, the ideation phase enhances the robustness and relevance of subsequent design outputs. Ultimately, the most promising ideas identified in this phase serve as the foundation for developing prototypes and further refinement in later stages of the research process [34, 35].

The prototype phase involves transforming the most promising ideas generated during the ideation stage into tangible representations that can be evaluated. This phase emphasizes rapid, low-fidelity experimentation to externalize concepts and make them actionable. The primary objective of prototyping is not to deliver a finalized solution, but to facilitate early exploration of design assumptions, usability issues, and technical feasibility [36]. The prototype developed in this study is presented as a mock-up representation. The final phase of this research involves the testing stage.

The test stage involves systematic evaluation of the developed prototypes through direct engagement with end-users and relevant stakeholders (telecommunication's company). This phase aims to evaluate the effectiveness, usability, and user acceptance of the proposed solution through an iterative trial-and-error approach, followed by statistical validation using Welch t-test. The methodological process flow is illustrated in Figure 3.

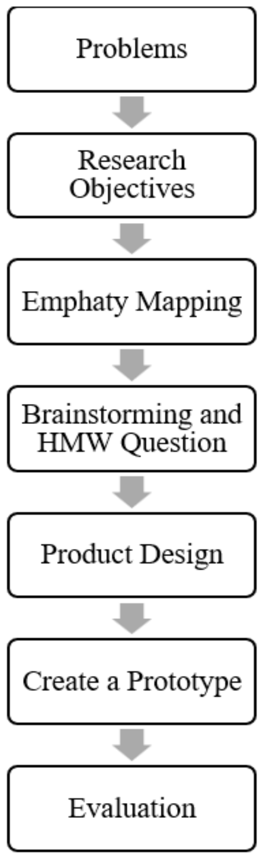

Figure 3. Research process flow

4. RESULT AND DISCUSSION

Before initiating the empathize stage of the DT process, the screw illustrated in Figure 1 was utilized as a baseline reference to inform the conceptual development of the proposed product. The comparative analysis of screw types presented in Table 1 is derived from internationally recognized standards (ISO 10664; ISO 4762; ISO 898-1) and supported by Shigley's Mechanical Engineering Design and the Machinery's Handbook, which provide comprehensive insights into torque capacity, mechanical performance, and application characteristics of fastening systems [37-41].

A comparative assessment of the six screw types indicates distinct performance characteristics in terms of functional role, security level, torque capacity, and application domain. Snake-eye screws primarily serve as tamper-resistant fasteners, offering a moderate level of security but limited torque capability, making them suitable for public infrastructure and panel applications. Torx screws, on the other hand, are engineered to deliver high torque transfer with reduced cam-out, and are therefore widely applied in automotive and industrial systems, although their security level remains moderate due to the availability of compatible tools.

In contrast, button head and countersunk screws are not intended for security purposes; instead, they are designed to improve surface profile and structural integration, providing moderate torque performance in general mechanical assemblies. Flanged button head screws enhance load distribution and vibration resistance due to the integrated flange, making them suitable for dynamic environments. Meanwhile, hex socket cap screws exhibit superior mechanical strength and high torque capacity, rendering them ideal for heavy-duty and precision engineering applications, despite offering minimal resistance against unauthorized access.

Based on the comparative evaluation results, the snake-eye screw was selected as the reference configuration in this study, particularly for the M4 size, due to its representative performance characteristics and suitability for benchmarking against the proposed design. This choice was driven by its inherent tamper-resistant characteristics, aligning with the primary objective of the proposed design, which is to reduce the risk of cable and network component theft in distribution box systems.

Subsequently, the findings derived from field technician interviews and observational activities conducted during the empathize stage are systematically summarized in Table 2.

Table 1. Comparative summary of screw types

Screw Type	Primary Function	Security Level	Torque Capacity	Typical Application
Snake-eye	Tamper resistance	Moderate	Low	Public panels, utility enclosures
Torx	High torque transmission	Moderate	High	Automotive, industrial machinery
Button head	Low-profile fastening	Low	Moderate	Casings, light mechanical parts
Counter Sunk	Flush surface integration	Low	Moderate	Structural panels, assemblies
Flanged button head	Load distribution	Low	Moderate	Vibrating systems, automotive
Hex socket cap	High-strength fastening	Low	Very High	Heavy machinery, precision part

Table 2. Empathy mapping of distribution box vandalism issues

No	Empathy Mapping	Interview Result
1	Says	The findings demonstrate that the majority of break-in incidents were executed using commonly available hand tools, such as Phillips and flat-head screwdrivers and pliers. This indicates that the existing screw-based locking mechanism offers limited mechanical resistance and can be easily compromised. Consequently, the conventional fastening system is considered insufficient to provide adequate protection against unauthorized access.
2	Feels	From an affective perspective, field technicians and network operators reported a persistent sense of insecurity, primarily due to frequent service disruption reports resulting from cable theft and deliberate tampering of distribution boxes. This recurring operational vulnerability has intensified the perceived urgency for a more specialized mechanical security system that is not easily duplicated or bypassed by unauthorized individuals. These findings underscore the necessity of redesigning the protective mechanism to enhance resistance against intentional interference while simultaneously restoring operator confidence in infrastructure reliability.
3	Does	At present, the company’s response to customer complaints related to network theft primarily involves repairing the affected distribution box and restoring it to a secure operational condition. This corrective approach focuses on post-incident recovery rather than preventive intervention, indicating that mitigation efforts remain largely reactive in nature.
4	Thinks	Based on these considerations, the company articulated several key requirements for an enhanced security solution. 1. The mechanism must be resistant to manipulation using conventional tools such as Phillips and flat-head screwdrivers or pliers. 2. The system should remain operable through authorized company-issued tools, ensuring that access is restricted exclusively to certified technicians. 3. The proposed solution should not necessitate substantial modifications to the existing distribution box design, thereby preserving structural compatibility and minimizing implementation costs.

The outcomes of the brainstorming sessions, which involved network operators, field technicians, and middle management representatives, led to the formulation of a clear POV derived from Table 2. The collective insight emphasized the necessity of developing a security screw with a specialized head configuration that cannot be disengaged using standard screwdrivers. Such a design is expected to mitigate unauthorized access to distribution boxes while maintaining operational efficiency during authorized maintenance activities.

By applying the HMW questioning technique, three key design inquiries were formulated to address the identified security challenges:

(1) How might a screw head be engineered so that it can only be disengaged using a dedicated proprietary tool?
(2) How might the proposed configuration ensure sufficient mechanical strength and resistance against vandalism or forced manipulation?
(3) How might the geometric profile of the screw head be optimized to prevent removal using alternative or improvised tools?

These guiding questions served as a structured foundation for the subsequent ideation phase, directing the development of a technically robust and security-oriented fastening solution.

During the ideation phase, several alternative security screw head configurations were generated. These included: (1) a single central recess design (pin-in type), (2) a dual-hole parallel configuration (spanner-type screw), and (3) a symmetric three-hole pattern arranged in a triangular geometry.

Following structured discussion and technical evaluation, the three-hole screw configuration was selected as the primary design concept. This decision was based on several considerations. First, the geometry is inherently incompatible with conventional screwdrivers, such as Phillips and flat-head types. Second, it requires a dedicated driver equipped with three precisely aligned pins, thereby restricting access to authorized personnel. Third, the triangular distribution of contact points allows a more uniform torsional load transfer, enhancing mechanical stability during fastening and removal. Additionally, the configuration presents greater resistance to improvised manipulation using commonly available tools.

The three-hole design was therefore assessed as offering a higher level of security, particularly because the corresponding removal tool is not widely available in the commercial market. This characteristic significantly reduces the likelihood of opportunistic tampering while maintaining functional accessibility for certified technicians.

The outcomes of the ideation stage were subsequently translated into a prototype development phase, where the selected concept was engineered into a functional security screw. The screw head was designed with three symmetrically arranged recesses positioned at 120° intervals to ensure geometric balance and uniform torque distribution. Such symmetric load transfer is essential to reduce localized stress concentration and improve mechanical reliability during fastening operations [40].

The diameter and depth of each recess were carefully calibrated to enable engagement exclusively with a dedicated three-pin driver, thereby eliminating compatibility with conventional screwdrivers. Security fasteners employing proprietary geometries have been shown to significantly reduce opportunistic tampering by limiting tool accessibility [42].

Stainless steel was selected as the primary material due to its favorable strength-to-weight ratio and intrinsic corrosion resistance, which enhance durability in outdoor telecommunication infrastructure exposed to varying environmental conditions [43].

Furthermore, the threaded section of the screw was manufactured in accordance with millimeter-based metric fastening standards currently applied in telecommunications distribution boxes to ensure dimensional compatibility and seamless integration without structural redesign [44].

Collectively, these design considerations demonstrate that the prototype not only fulfills the identified security requirements but also aligns with established mechanical design principles and material engineering standards. The prototype of the proposed tri-hole security screw is illustrated in Figure 4 and Figure 5.

In addition to developing the tri-hole screw, this study also designed a dedicated tool for installation and removal. The specialized three-pin screwdriver developed for this purpose is presented in Figure 6.

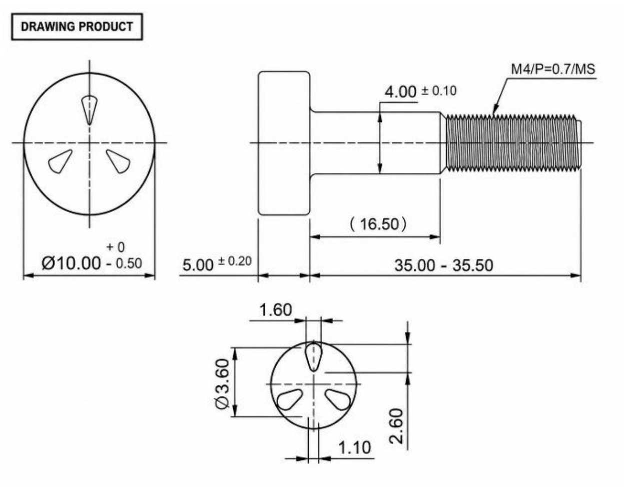

Figure 4. Screw tri-hole design

Figure 5. Tri-hole screw

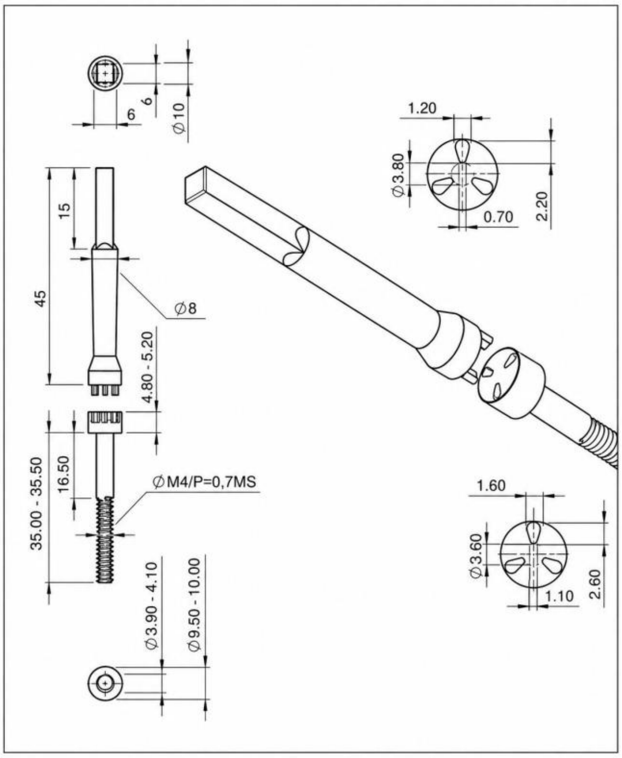

Figure 6. Screwdriver design for tri-hole screw

The developed tri-hole screw was experimentally evaluated on the distribution box using a trial-and-error approach, and the resulting performance outcomes are presented in Table 3. The implementation of the tri-hole screw on the distribution box is shown in Figure 7.

The testing results indicate that the screw could not be rotated using conventional Phillips or flat-head screwdrivers, nor with improvised tools. Furthermore, installation and removal using the dedicated three-pin driver were performed efficiently, without causing delays or operational constraints for technicians.

Table 3. Trial and error result

No	Screwdriver Type	Result	Observation
1	Flathead	Failed to open	No engagement with holes
2	Philips	Failed to open	No contact points
3	Pozidriv	Failed to open	Misalignment of tip
4	Torx	Failed to open	Shape mismatch
5	Hex (Allen)	Failed to open	No insertion possible
6	Robertson (square)	Failed to open	No geometric fit
7	Tri-wing	Failed to open	Incompatible profile
8	Spanner (snake-eye)	Failed to open	Only two contact points
9	Security Torx	Failed to open	Central pin interference
10	Clutch	Failed to open	No alignment
11	Torq-set	Failed to open	Offset geometry mismatch
12	Tri-point	Failed to open	Three-point mismatch
13	Modify Screwdriver	Failed to open	Insufficient grip

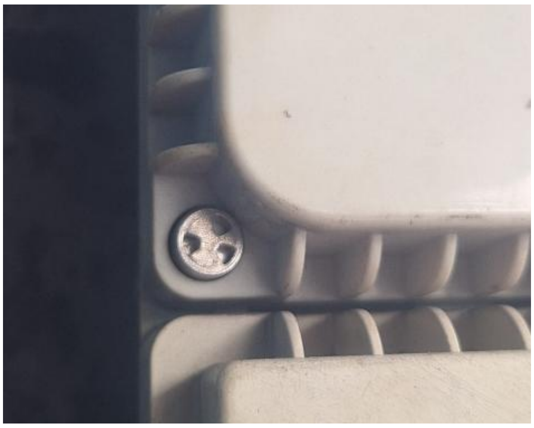

Figure 7. Application of the tri-hole screw on the distribution box

The primary function of the proposed screw extends beyond mechanical fastening to act as a deterrent against criminal activity. When potential offenders encounter an unconventional screw head geometry, they are confronted with increased effort and the need for specialized tools, thereby prolonging access attempts and elevating the perceived risk of detection. Such an effect is consistent with the Crime Prevention Through Environmental Design (CPTED) framework, which posits that thoughtful design modifications can reduce criminal opportunities by increasing the effort required to commit a crime and the likelihood of apprehension [45].

Beyond the qualitative trial-and-error evaluation of tool compatibility, the torque resistance of the snake-eye and tri-hole screws was quantitatively assessed using a digital torque tester. Each screw type was tested with a sample size of ten specimens. The resulting torque data were then subjected to Welch's t-test to evaluate the presence of a statistically significant difference in mean torque resistance between the two screw configurations. The test results are presented in Table 4.

Table 4. The results of the torque resistance

No	Snake-Eye (SE) Screw	Tri-Hole (TH) Screw
1	1.99	2.20
2	1.77	2.23
3	1.85	2.24
4	1.92	2.23
5	1.75	2.22
6	1.83	2.23
7	1.88	2.21
8	1.93	2.23
9	1.97	2.21
10	1.90	2.23

The mean and standard deviation for each sample were computed using Eqs. (1) and (2). The resulting statistical values for each sample are presented as follows:

$$\mu = \sum_{i=1}^{n} \frac{xi}{n} \quad (1)$$

$$s = \sqrt{\frac{\sum_{i=1}^{n}(xi-\mu)^2}{n-1}} \quad (2)$$

$$\mu SE = 1.88 \text{ N.m}, sSE = 0.0796$$

$$\mu TH = 2.22 \text{ N.m}, sTH = 0.0125$$

The t-statistic was subsequently calculated using Eq. (3) and evaluated against the critical value from the t-distribution, where the degrees of freedom were determined using Eq. (4).

$$t = \frac{\mu 1 - \mu 2}{\sqrt{\frac{s1^2}{n1} + \frac{s2^2}{n2}}} \quad (3)$$

$$df = \frac{\left(\frac{s1^2}{n1} + \frac{s2^2}{n2}\right)^2}{\frac{\left(\frac{s1^2}{n1}\right)^2}{n1-1} + \frac{\left(\frac{s2^2}{n2}\right)^2}{n2-1}} \quad (4)$$

$$t - statistic = \pm 13.4957, df = 9$$

$$t - table = 2.262157$$

At the 95% confidence level, the calculated t-statistic exceeds the corresponding critical value, confirming the presence of a statistically significant difference in mean torque resistance between the snake-eye and tri-hole screws. A comparative analysis between the snake-eye and tri-hole screw configurations is presented in Table 5.

The comparison presented in Table 5 highlights the fundamental differences between snake-eye and the proposed tri-hole screw in terms of geometric configuration, mechanical performance, and security characteristics. The tri-hole design demonstrates superior torque resistance due to its three-point contact mechanism, which enables a more uniform distribution of applied forces, as supported by established mechanical design principles [40]. In contrast, the snake-eye screw relies on a two-point engagement system, making it more susceptible to slippage and tool manipulation.

Table 5. Main comparison between snake-eye and tri-hole

No	Aspect	Snake-Eye	Tri-Hole Screw
1	Material	Stainless steel	Stainless steel
2	Number of holes	2-holes (180° configuration)	3-holes (120° configuration)
3	Driving tool	2-pin (spanner) driver	3-pin custom driver
4	Difficulty of removal	Moderate (can be manipulated using improvised tools)	Higher (geometrically incompatible with conventional tools)
5	Torque resistance	1.75–1.99 N.m (two-point contact)	2.21–2.24 N.m (three-point force distribution)

In addition to its enhanced security performance, the tri-hole screw design also offers ergonomic advantages, particularly for field technicians. The use of a dedicated three-pin driver facilitates more stable torque transmission and reduces the likelihood of tool slippage compared to conventional single- or dual-contact configurations. Furthermore, the improved contact distribution between the driver and the screw head enhances rotational control while minimizing localized stress concentrations during operation.

5. CONCLUSION

This study proposed a tamper-resistant fastening mechanism in the form of a tri-hole security screw developed through stakeholder interviews and structured brainstorming activities. The screw head was designed with three evenly spaced recesses positioned at 120° intervals to achieve geometric balance and controlled torque transmission.

The findings indicate that the proposed screw design effectively resists removal using conventional Phillips and flat-head screwdrivers, as well as improvised tools commonly associated with unauthorized access attempts. Furthermore, the measured torque resistance, ranging from 2.21 to 2.24 Nm, confirms the mechanical robustness of the design. These results demonstrate the potential of the proposed configuration to enhance security in applications such as distribution boxes and other outdoor enclosures.

The novelty of this research lies in the development of a security screw specifically designed to enhance the physical protection of telecommunication distribution infrastructure while maintaining usability for technicians. From a practical standpoint, the proposed solution offers a feasible approach for network operators to reduce infrastructure tampering, minimize service disruptions, and improve asset protection.

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