Risk Management of Sulawesi Maluku Papua Submarine Cable System of 20-1000 Meter Water Depth Using Analytical Hierarchy Process (AHP)

Review of Integrative Business & Economics Research

Mohammad Andre Mutalibov
School of Business and Management, Institut Teknologi Bandung

Taufik Faturohman*
School of Business and Management, Institut Teknologi Bandung

ABSTRACT

The security and reliability of a submarine communication cable system is an important asset in the telecommunications sector. This research aims to find out what risks might occur to the submarine cable system at a shallow water depth of 20-1000 m (case: SMPCS, route with the most frequent faults), and to provide the best protection solutions to avoid these risks in the future. The conceptual framework used a Risk Management Process from ISO 31000, and Analytical Hierarchy Process as a tool to help in the decision making process. The result of risk assessment showed that fishing activity was the biggest risk contributor to the SMPCS at a depth of 20-1000 m. The risk management carried out focused on cable protection to avoid damage from fishing activities. The cable protection system studied is divided into 3 parts of water depth, namely 20-30 m, 31-150 m, and 151-2000 m. From the results of the determination using AHP, it was determined that the best submarine cable protection system at a depth of 20-30 m is Burial, then at a depth of 31-2000 m is a Higher Specification Cable (Double Armor / Rock Armor).

Keywords: Risk Management, Submarine Communication Cable System, Undersea Cable Protection

1. INTRODUCTION

Internet users in Indonesia are increasing every year. The Association of Indonesian Internet Service Providers (2020) stated that the population of Indonesia is 266.91 million and 196.71 million of whom are internet users in the second quarter of 2020 and continue to grow. To fulfill and satisfy its customer's demand, a telecommunications infrastructure is needed to provide telecommunications signals to the people of Indonesia in every region. The infrastructure is the Submarine Cable Communication System (SCCS). The Submarine Cable Communication System (see Figure 1) is a telecommunications infrastructure in the form of optical fiber located at sea, connecting telecommunications signals between islands, countries, and continents.

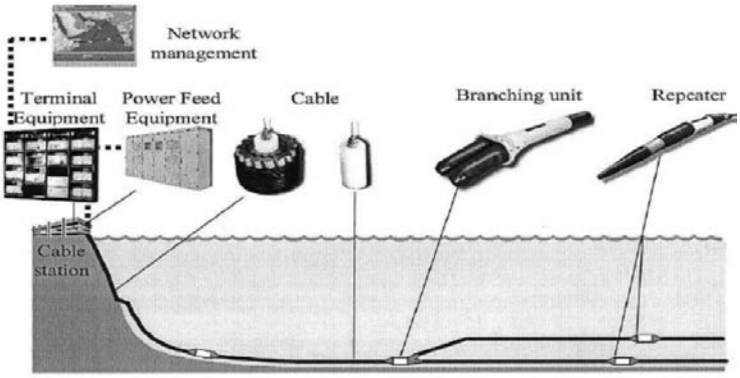

Figure 1. Submarine Communication Cable System (TelkomInfra 2019)

Submarine Communication Cable System has a bigger transmission capacity and smaller delay than Microwave and Satellite systems. To date, 99% of transoceanic data transmissions are traversed using undersea optical cables.

Submarine Communication Cable System Sulawesi Maluku Papua Cable System (SCCS SMPCS) is a telecommunications infrastructure that connects eastern Indonesia. This submarine cable system is very important for Indonesia because the eastern region has not yet received a remarkably advanced infrastructure and technology as in Indonesia's western region. Based on the company document report in 2019, there were 36 submarine cable faults, and SMPCS became the most significant contributor with 14 faults. This disruption causes blackouts on fixed and mobile broadband data services. Society, government, defense, and economic actors cannot transfer and receive large amounts of data because the telecommunications network in eastern Indonesia is backed up only using IP radio communication systems and satellites. TelkomInfra upholds the company's values and moral obligations, namely high reliability and high availability. Therefore, the reliability and availability of a submarine communication cable system are critical to be maintained.

2. LITERATURE REVIEW

2.1 Risk Management

ISO 31000 (2018) states that risk management is an activity that controls and directs a company based on risk. The risk management process includes identifying, assessing, and controlling risks that can harm the company in achieving its objectives. Risk itself is an event that can not be predicted or an uncertain event. Threats or risks can come from anywhere, such as human error, operational errors, financial conditions, legal and natural disasters that cannot be avoided. These threats or risks cannot be eliminated, but their impact and likelihood can be reduced using risk management. The proper and appropriate application of risk management can help a company make effective decisions and steps without being affected by threats or risks. The Risk Management Process (see Figure 2) consists of 3 main processes: establishing the Scope, Risk Assessment, and Risk Treatment. The purpose of establishing the scope is to provide limits or boundaries on the discussion in order to obtain an effective risk assessment and targeted risk treatment. Risk assessment is carried out to identify, analyze (measuring the impact and likelihood), evaluate threats or risks that can harm the company. Risk treatment is carried out to provide a mitigation plan to change these risks' impact and likelihood values.

In this research, the concept of risk management focused on the mitigation plan of SMPCS. This is because the risks have been identified and analyzed based on literature studies and company document reports.

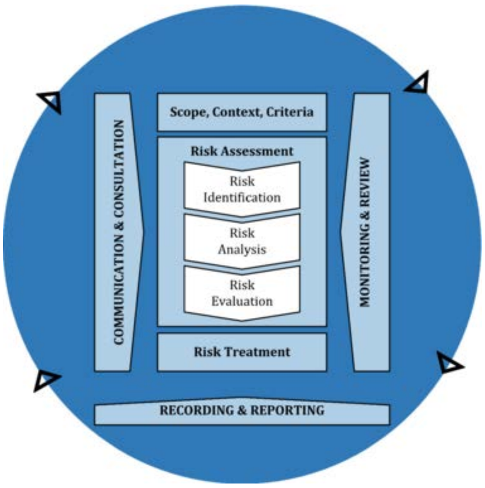

Figure 2. Risk Management Process (ISO 31000:2018)

2.2 Analytical Hierarchy Process

Saaty (1970) developed a structured method to analyzing complex decisions called the Analytical Hierarchy Process. The Analytical Hierarchy Process is used to make it easier to solve problems that have multiple alternatives and criteria. AHP does not provide the "correct" answer in answering a problem but instead provides the most "appropriate" answer in accordance with the goals and existing problems. Problem decomposition in AHP consists of 3 main hierarchical structures: decision-making goals, criteria of alternatives, and alternative solutions. AHP selection process diagram can be seen in Figure 3.

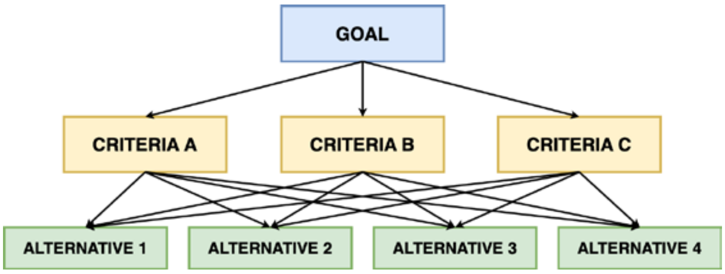

Figure 3. Analytical Hierarchy Process (Saaty 1970)

A quantitative assessment of criteria and alternatives is carried out using the *Pairwise Comparison* method to determine the best alternative solution. *Pairwise comparison* is a quantitative method that compares entities to find out which entity is more suitable or has more value, or is identical to other entities. The assessment using a pairwise comparison is filled out by experts who have been involved and experienced in the deployment and maintenance process of the SMPCS.

3. RESEARCH METHODOLOGY

This research aims to provide an alternative solution in the form of risk mitigation in the business issue that occurred at PT. Infrastruktur Telekomunikasi Indonesia. The company document reports shows that the cable damage of SMPCS always occurs every year. In order to understand the existing situation, a business issue and risk management study process is required in sequence in the SMPCS (see Figure 4).

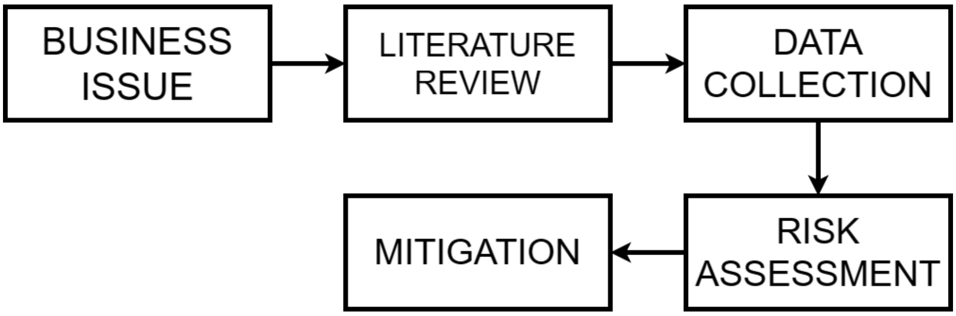

Figure 4. Research Diagram Flow

Understanding the business issue is done by conducting interviews and focus group discussions with experts who have been directly involved in the deployment and maintenance of SMPCS to find out the current business situation. The literature study in this research was conducted by studying academic journals and books related and relevant to the Submarine Cable Communication System and SMPCS itself. In addition, a study was also conducted on Risk Management ISO 31000 and the Analytical Hierarchy Process decision-making method to provide outputs in the form of effective and targeted risk mitigation.

The data collection is divided into two types: primary data collection and secondary data collection. The primary data collection carried out in this research aims to get a picture of the reality that occurs in the environmental conditions of the SMPCS. The primary data collection carried out is in the form of qualitative data collection. Qualitative data collection is carried out by conducting interviews and focus group discussions with experts who have been directly involved in the deployment and maintenance of SMPCS. Secondary data collection carried out in this research is by studying the company document reports, international submarine cable maps, and news articles relevant to the SMPCS.

After collecting related and relevant data on the SMPCS, a risk assement was carried out, referring to the study literature and data collection findings. Risk assessment is carried out to determine the threats or risks that causes cable breaks or damage to the SMPCS route, which always occurs every year.

After analyzing the results of the risk assessment, risk mitigation was carried out to control and reduce the impact and likelihood that occurred in the SMPCS. A decision is made using the Analytical Hierarchy Process method to get the output in the form of the best alternative solution.

4. BUSINESS SOLUTION

4.1 Context and Scope

This research discusses the risks of SMPCS in water depths of 20-1000 m and options to control the risks. The water depth of 20-1000 m is the water depth with the highest number of cable breaks among other water depths per 2019 (TelkomInfra Company Document Report). Risk Management in this research focuses on providing preventive efforts so that the risks that have often occurred in the SMPCS can be reduced.

4.2 Risk Assessment

Based on literature studies, company document reports, and validation from experts experienced in deploying and repairing SMPCS, it is determined that several risks can pose a threat to SMPCS (See Table 1). The SMPCS cable is located in the Arafura Sea, known as "the golden fishing ground," causing high maritime activity in the SMPCS cable area. This condition harms SMPCS cable operations due to the high risk of Fishing & Ship Anchor.

Table 1. Risk Identification

Risk Type	**Possible Risk**		**Description**	**Impact**
Nature	N1	Earthquake	Movement of the earth plates that causes ground shaking and destruction	Cable Break
	N2	Submarine Landslides	Mass sediment shifting from a shallow water to deep water	Cable Break and Missing
	N3	Bad Seabed Topography	Uneven seabed or steep slope	Cable bending, cable break, difficult for maintenance
Human Activity	H1	Fishing & Ship Anchor	Anchor dragging the cable	Damaging the armor and cable break
	H2	Floating Excavator	Dredging soil that hits the cable	Damaging the armor and cable break
	H3	Vandalism	Intentional cable destruction	Damaging the armor and cable break

Each of these risks was measured the level of impact and likelihood (See Figure 5), and it was found that the risk of H1 (Fishing & Ship Anchor) is the most dangerous and has the most significant potential to damage the SMPCS cable with Impact values of 5 and Likelihood of 5.

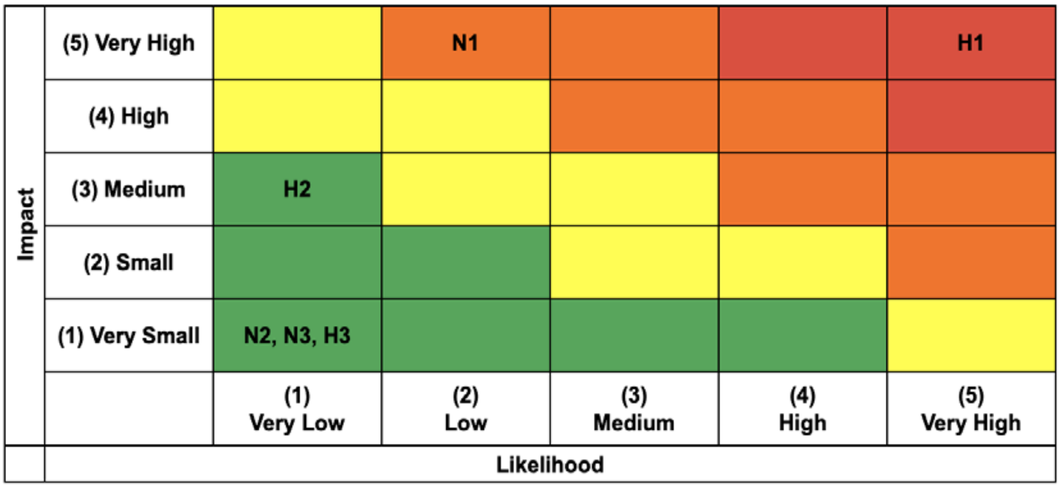

Figure 5. Risk Matrix

Referring to the findings of the Risk Assessment, then the Risk Treatment is carried out focusing on minimizing the impact that occurs due to the risk of H1 (Fishing & Ship Anchor). Risk Treatment is carried out by choosing the best cable protection system that is considered capable of reducing the impact of these risks.

4.3 Risk Treatment

In determining an alternative solution for submarine cable protection systems, PT. Infrastruktur Telekomunikasi Indonesia has several criteria that must be met by a submarine cable protection system (see Table 1). These four criteria become the company's reference in making decisions to protect the SMPCS.

Table 2. TelkomInfra's Criteria of Submarine Cable Protection System

No.	Criteria	Description
1	Cost	The price that must be issued refers to technology, materials, implementation, and reliability.
2	Reliability	The durability and strength of the cable protection system in the event of endangering submarine cables.
3	Implementation	Ease of implementation in the field
4	Maintenance	Ease of doing maintenance or repairs when an event occurs.

Water depth affects the implementation of several alternatives so that not all alternatives can work at a specific water depth. This problem exists because the deeper the water, the higher the water pressure. In addition, the underwater environmental conditions also make it impossible to implement several alternatives using current technology. Table 2 shows alternative cable protection systems according to the existing water depth.

Table 3. Cable Protection System Alternatives

Water Depth		
20-30 m	**31-150 m**	**151-1000 m**
Uraduct	Uraduct	Uraduct
Higher Spec Cable Replacement	Higher Spec Cable Replacement	Higher Spec Cable Replacement
Articulated Pipe	Burial	Reroute
Burial	Reroute	No Protection
Reroute	Cement bag	
Cement bag	Concrete Mattress	
Concrete Mattress	No Protection	
No Protection		

4.3.1 Cable Protection Alternatives Description

4.3.1.1 Uraduct

Uraduct is a casing protection system patented by the Swedish polymer technology company Trelleborg AB. Uraduct is designed to protect fiber optic cables, power cables, and more from impact and abrasion. Uraduct has become an alternative down cable protection system with a pretty good reputation.

Figure 6. Uraduct (Trelleborg.com)

4.3.1.2 Higher Specification Cable Replacement (Double Armor/Rock Armor)

Double Armor cable is a cable that has been UQJ qualified for underwater applications up to a water depth of 600 m using burial or surface laid methods. Double Armor has a cable breaking load of 400 kN. DA cable has a cable structure that is thoroughly water blocked, stainless steel central loose tube as fiber protection, and provided with mechanical protection that can withstand higher stress. *Rock Armor cables* can be applied to a water depth of 600 m. Rock Armor has a cable breaking load of 350 kN. RA cable is also structured in thorough water blocked, stainless steel loose tube, and galvanized steel wire armor.

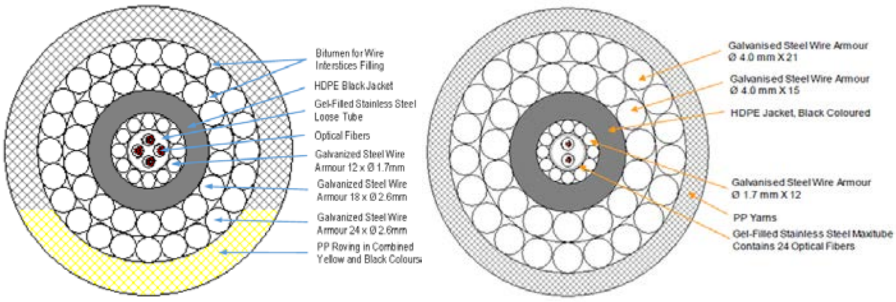

Figure 7. Left to right : Double Armor and Rock Armor (ccsi.co.id)

4.3.1.3 Articulated Pipe

The articulated pipe is a protection system made of cast iron with articulation in the form of a ball and socket. The articulated pipe protects the undersea optical cable from abrasion, rock-dumping and maintains the bend radius of marine optical cables.

Figure 8. Articulated Pipe (utscable.com)

4.3.1.4 Burial

The Burial method allows underwater communication cables to be buried/planted to a depth of 1-3 meters below the seabed. Burial is done to protect the cable from fishing activity, anchors, and other causes. The use of burial plow machines for submarine cable burial is widespread. The burial method is considered very safe by experts because the cable is under the seabed, so it is not exposed to threats such as fishing activity and anchors.

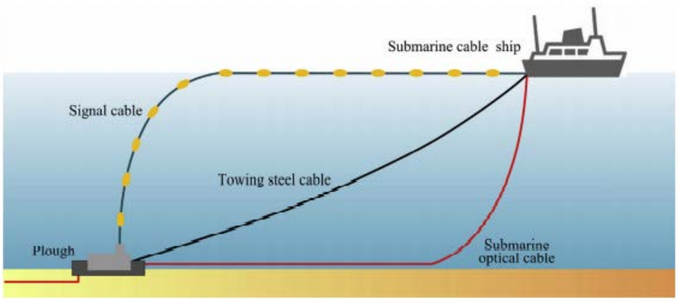

Figure 9. Burial Method (thestar.com)

4.3.1.5 Reroute

Reroute or relocation is a method by moving or re-deploying the cable to a safer place and far from marine activities. This alternative is quite promising but takes a lot of time, money and resources in its implementation.

4.3.1.6 Cement Bag

A *cement bag* is a protection system using a heavy-duty bag material filled with sand, mortar mix, or cement. The ease of cement bag implementation allows divers to work manually at a depth of <40 m.

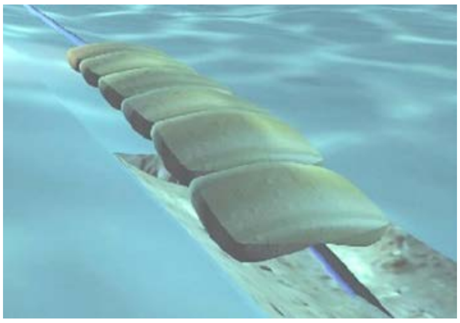

Figure 10. Cement Bag (Nexant Norway AS)

4.3.1.7 Concrete Mattress

This method is done by using a mattress or carpet made of concrete to cover the surface of the cable so that the cable is protected and does not hit directly with threats that can damage the durability of the cable. In addition, a concrete mattress can provide stability and protection from dropped objects such as anchors or ship wreckage.

Figure 11. Concrete Mattress (Subseaprotectionsystems.com)

4.3.1.8 No Protection

Submarine cables are left on the seabed without additional safeguards. This is quite risky because sea activities often occur at a depth of 20-1000 m, ranging from fishing activity, ship activity, to vandalism.

4.3.2 Mitigation

Risk control is carried out by preparing several alternatives in the form of a submarine cable protection system that can reduce the impact and likelihood of the risks. Decision-making regarding which alternative to choose is done using the Analytical Hierarchy Process or AHP method. AHP was carried out three times based on the water depth of the SMPCS. Figure 12 shows a diagram of the selection process of the SMPCS Protection System Hierarchy.

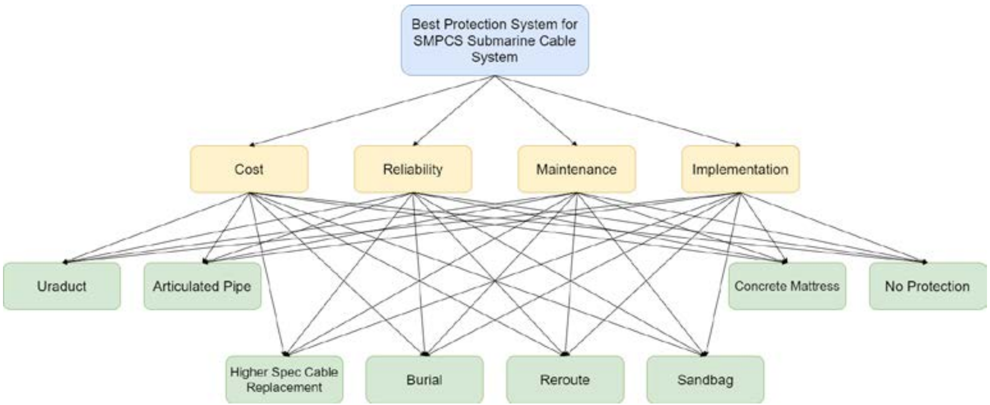

Figure 12. Analytical Hierarchy Process

In conducting an assessment to choose the best alternative solution in the SMPCS Protection System, a quantitative Pairwise Comparison assessment method is carried out. Experts carry out the pairwise Comparison quantitative assessment by comparing the existing criteria to determine the main priority criteria that must be met.

4.3.2.1 Criteria Pairwise Comparison

In determining alternative solutions that are effective and on target, criteria are needed as a reference in choosing these alternatives. It can be seen in Figure 13 that the Reliability criterion has the highest value among other criteria with a value of 0.536. Furthermore, the Reliability criteria will be the primary reference in the Pairwise Comparison assessment between alternatives based on the criteria.

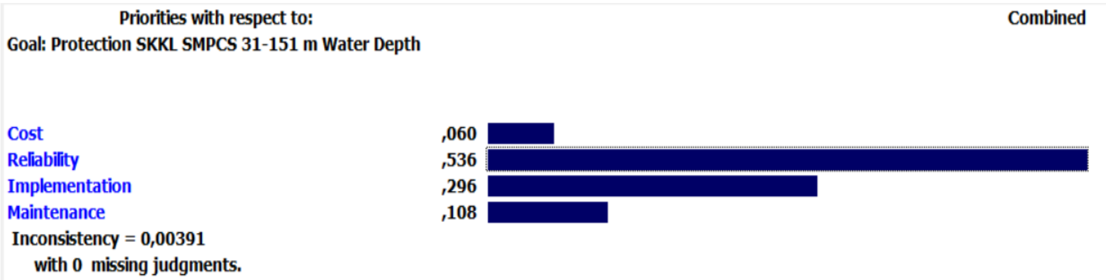

Figure 13. Result of Criteria Pairwise Comparison

4.3.2.2 Alternative Pairwise Comparison (20-30 m Water Depth)

a. Reliability Criteria

Based on the assessment by the experts (see Figure 14), the alternative with the highest level of reliability is a protection system using Burial with a value of 0.301. Articulated Pipe is a protection system with the second-highest level of reliability with a value of 0.223. While the alternative of Concrete Mattress is the third-highest protection system with a value of 0.152.

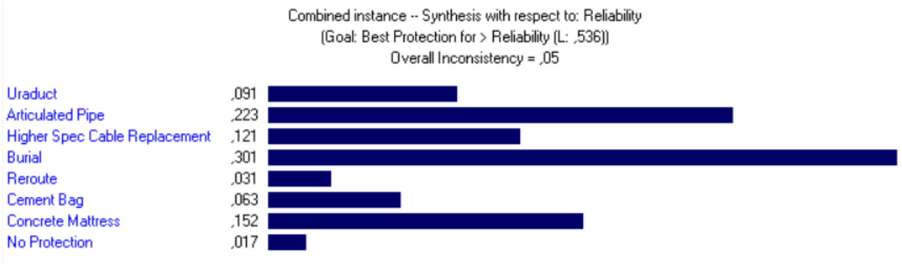

Figure 14. 20-30 m Water Depth Alternative Pairwise Comparison on Reliability Criteria

b. Implementation Criteria

Based on the assessment by the experts (see Figure 15), the alternative with the ease of implementation commensurate with the highest reliability is the Higher Specification Cable Replacement with a value of 0.256. Burial is a protection system with ease of implementation with the second-highest reliability with a value of 0.220. While the alternative Uraduct is a protection system with ease of implementation with the third-highest reliability with a value of 0.148.

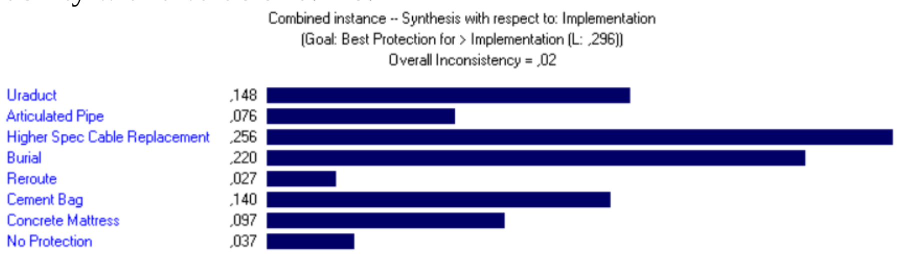

Figure 15. 20-30 m Water Depth Alternative Pairwise Comparison on Implementation Criteria

c. Maintenance Criteria

Based on the assessment by the experts (see Figure 16), the alternative with the ease of maintenance commensurate with the highest reliability is the Higher Specification Cable Replacement with a value of 0.254. Burial alternative is a protection system with ease of maintenance with the second-highest reliability with a value of 0.244. Meanwhile, alternative Uraduct is a protection system with ease of maintenance with the third-highest reliability with a value of 0.184.

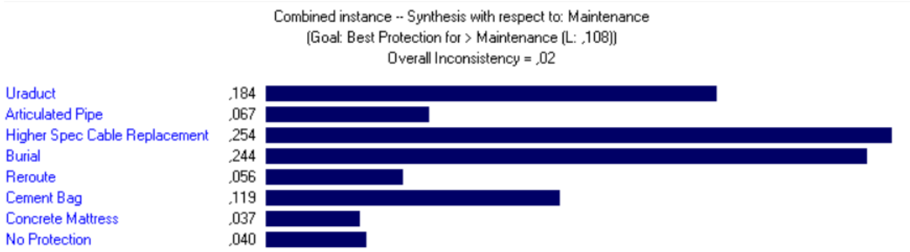

Figure 16. 20-30 m Water Depth Alternative Pairwise Comparison on Maintenance Criteria

d. Cost Criteria

Based on the assessment by the experts (see Figure 17), the alternative with the cost value commensurate with the highest reliability is Concrete Mattress, with a value of 0.233. The burial alternative is a protection system with the second-highest rank of cost commensurate to its reliability with a value of 0.220. Meanwhile, alternative Uraduct is a protection system with the third-highest cost compared to reliability with a value of 0.148.

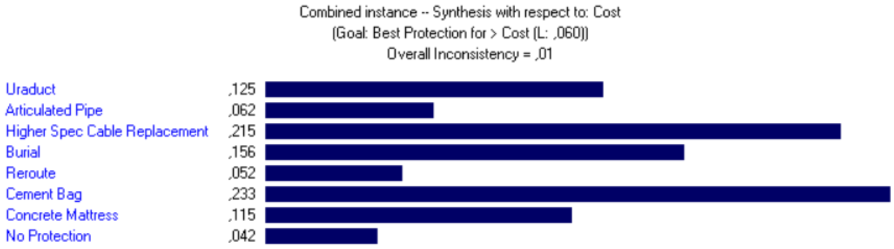

Figure 17. 20-30 m Water Depth Alternative Pairwise Comparison on Cost Criteria

4.3.2.3 Alternative Pairwise Comparison (31-150 m Water Depth)

a. Reliability Criteria

Based on the assessment by the experts (see Figure 18), the alternative with the highest level of reliability is a protection system using Burial with a value of 0.316. Alternative Uraduct is a protection system with the second-highest level of reliability with a value of 0.223. While the alternative Higher Spec Cable Replacement is the third-highest protection system with a value of 0.161.

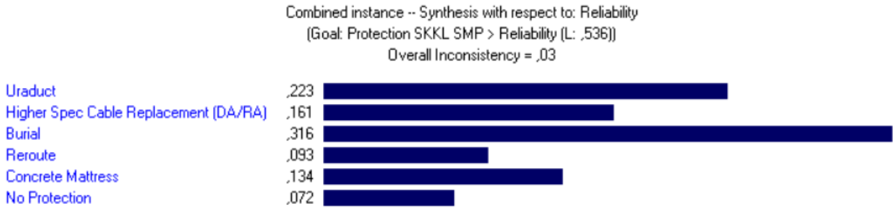

Figure 18. 31-150 m Water Depth Alternative Pairwise Comparison on Reliability Criteria

b. Implementation Criteria

Based on the assessment by the experts (see Figure 19), the alternative with the ease of implementation commensurate with the highest reliability is the Higher Specification Cable Replacement with a value of 0.300. No Protection is the second-highest ease of implementation with a value of 0.298. Meanwhile, the alternative Uraduct is the third-highest protection system with a value of 0.148.

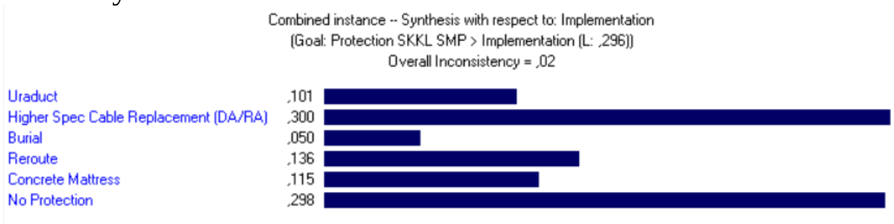

Figure 19. 31-150 m Water Depth Alternative Pairwise Comparison on Implementation Criteria

c. Maintenance Criteria

Based on the assessment by the experts (see Figure 20), the alternative with the ease of maintenance commensurate with the highest reliability is the Higher Specification Cable

Replacement with a value of 0.257. Reroute alternative is a protection system with the second highest ease of maintenance with a value of 0.250. While No Protection is a protection system with the third-highest ease of maintenance with a value of 0.235.

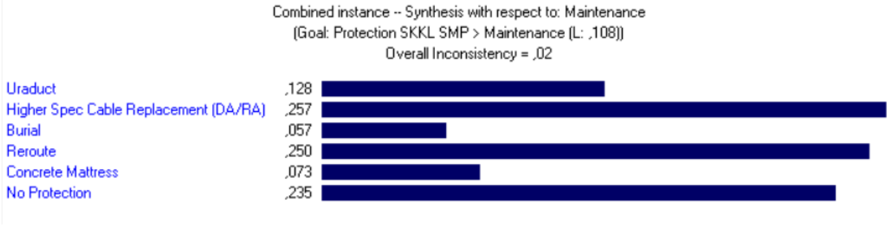

Figure 20. 31-150 m Water Depth Alternative Pairwise Comparison on Maintenance Criteria

d. Cost Criteria

Based on the assessment by the experts (see Figure 21), the alternative with the cost commensurate with the highest reliability is No Protection, with a value of 0.236. Alternative Concrete Mattress is a protection system with the second-highest rank of cost commensurate to its reliability with a value of 0.234. Meanwhile, alternative Uraduct is a protection system with the third-highest cost compared to reliability with a value of 0.190.

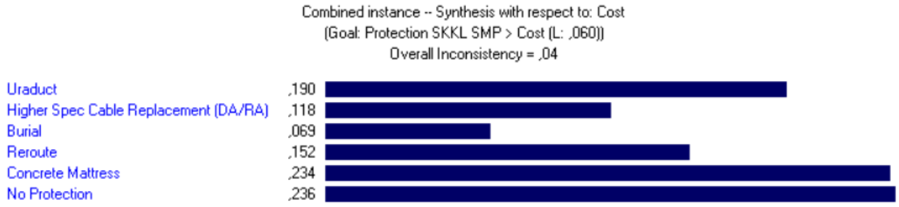

Figure 21. 31-150 m Water Depth Alternative Pairwise Comparison on Cost Criteria

4.3.2.3 Alternative Pairwise Comparison (151-1000 m Water Depth)

a. Reliability Criteria

Based on the assessment of experts (see Figure 22), the alternative with the highest level of reliability is to use Higher Spec Cable Replacement with a value of 0.405. The Uraduct alternative is a protection system with the second-highest level of reliability with a value of 0.311. While the Reroute alternative is the third-highest protection system with a value of 0.238.

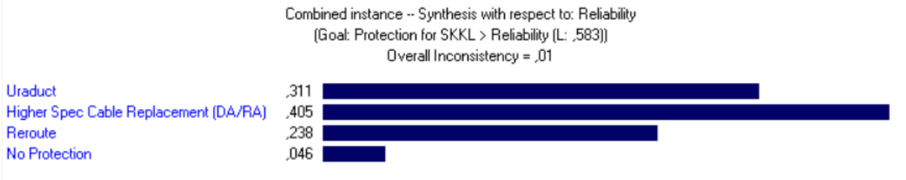

Figure 22. 151-1000 m Water Depth Alternative Pairwise Comparison on Reliability Criteria

b. Implementation Criteria

Based on the assessment by the experts (see Figure 23), the alternative with the ease of implementation commensurate with the highest reliability is No Protection, with a value of 0.351. Uraduct is a protection system with the second highest ease of implementation with a value of 0.229. While the Higher Spec Cable Replacement and Reroute alternatives have the same value, namely 0.148.

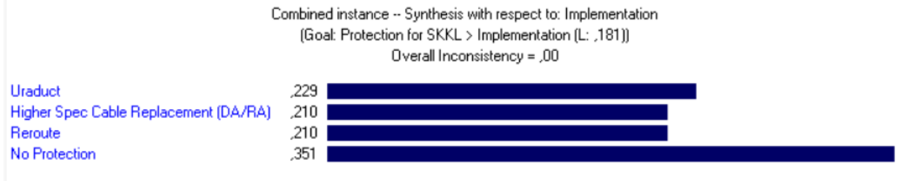

Figure 23. 151-1000 m Water Depth Alternative Pairwise Comparison on Implementation Criteria

c. Maintenance Criteria

Based on the assessment by the experts (see Figure 24), the alternative with the ease of maintenance commensurate with the highest reliability is the No Protection alternative with a value of 0.361. Reroute is an alternative with the second-highest ease of maintenance with a value of 0.302. Meanwhile, Higher Spec Cable Replacement is a protection system with the third-highest ease of maintenance with a value of 0.251.

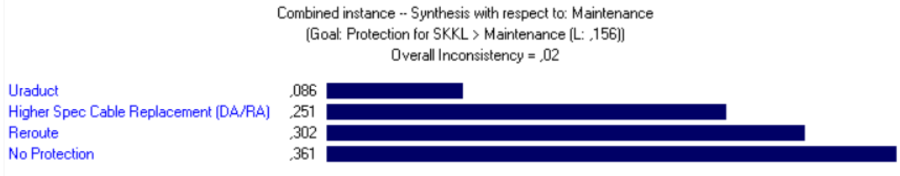

Figure 24. 151-1000 m Water Depth Alternative Pairwise Comparison on Maintenance Criteria

d. Cost Criteria

Based on the assessment by the experts (see Figure 25), the alternative with the cost commensurate with the highest reliability is No Protection, with a value of 0.435. Alternative Higher Spec Cable is a protection system with the second highest rank of cost commensurate to its reliability with a value of 0.358. Meanwhile, alternative Uraduct is a protection system with the third highest rank of cost commensurate to its reliability with a value of 0.146.

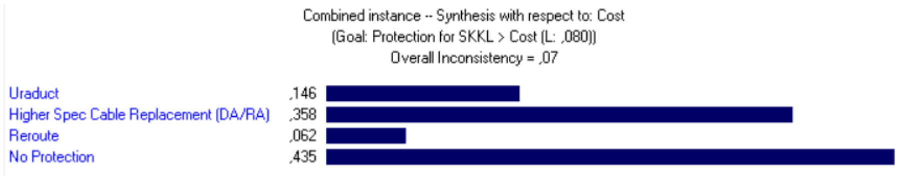

Figure 25. 151-1000 m Water Depth Alternative Pairwise Comparison on Cost Criteria

5. CONCLUSION

Based on the results of studies that have been carried out on SMPCS water depths of 20-1000 m, some conclusions can be drawn as follows:

1. SMPCS is one of the submarine cable communication systems that often experience disruption or damage every year.
2. Based on literature studies and company document reports, the most common risk in SMPCS at a water depth of 20-1000 m is Fishing Anchor that drags and breaks the cable.

3. Alternative solutions for the SMPCS protection system (see Table 4) are divided into three types of depth, namely (1) 20-30 m, the best alternative is Burial, (2) 31-150 m, the best alternative is Higher Specification Cable Replacement and (3) 151 -1000 m, the best alternative is Higher Specification Cable Replacement

Table 4. Summary of Best Alternative Solution

Rank	20-30 m	31-150 m	151-1000 m
1	**Burial (25.8%)**	**Higher Spec Cable (21.1%)**	**Higher Spec Cable (33.7%)**
2	Higher Spec Cable (19.7%)	Burial (18.7%)	Uraduct (24.5%)
3	Articulated Pipe (14.6%)	Uraduct (17.3%)	Reroute (23.1%)
4	Uraduct (12.3%)	No Protection (17.1%)	No Protection (18.8%)
5	Concrete Mattress (11.8%)	Reroute (13.0%)	
6	Cement Bag (10.6%)	Concrete Mattress (12.8%)	
7	Reroute (3.4%)		
8	No Protection (2.8%)		

REFERENCES

[1] Clark, B (2016), 'Undersea cables and the future of submarine competition', *Bulletin of the Atomic Scientists*, vol. 72, no. 4, pp. 234–237, viewed 15 March 2021, Taylor Francis Online database, doi:10.1080/00963402.2016.1195636

[2] Dou, T, Yao, YX, Zhang, Y & Tan, L (2017). '*Study on the protecting method of submarine cable'*, EPTC Power Transmission and Transformation Technology Conference, viewed 10 March 2021, ProQuest database.

[3] Hummelholm, A (2019). 'Undersea Optical Cable Network and Cyber Threats', European Conference on Cyber Warfare and Security, viewed 15 March 2021, ProQuest database.

[4] International Organization for Standardization in Switzerland (2018), *ISO 31000: Risk Management Principles and Guidelines*, Geneva, Switzerland.

[5] Libert, JF, & Waterworth, G (2016). *Undersea Fiber Communication Systems, 2nd end*, Elsevier USA, USA.

[6] Saaty, TL (2008). *Decision Making with The Analytical Hierarchy Process*. Pittsburgh: Int. J. Services Sciences, Vol 1, No. 1.

[7] Seung, HA, Dong, SK (2009), ‘Submarine Cable Installation and Protection Methods according as Characteristics of Ocean Environment’, trans, Journal of the Korean Society of Marine Environment & Safety, vol. 15, no. 1, pp. 25-32.
[8] Vargas, R. V. (2010). Using the analytic hierarchy process (ahp) to select and prioritize projects in a portfolio. Paper presented at PMI® Global Congress 2010—North America, Washington, DC. Newtown Square, PA: Project Management Institute.
[9] Shoki, M, Zakuan, N, Tajudin, M, Ahmad, A, Ishak, N, Ismail, K (2014), ‘A Framework for Risk Management Practices and Organizational Performance in Higher Education’, *Review of Integrative Business and Economics Research*, vol. 3, no.2, pp. 422-432.
[10] Starosielski, N 2015. *The Undersea Network*, Duke University Press, Durham.