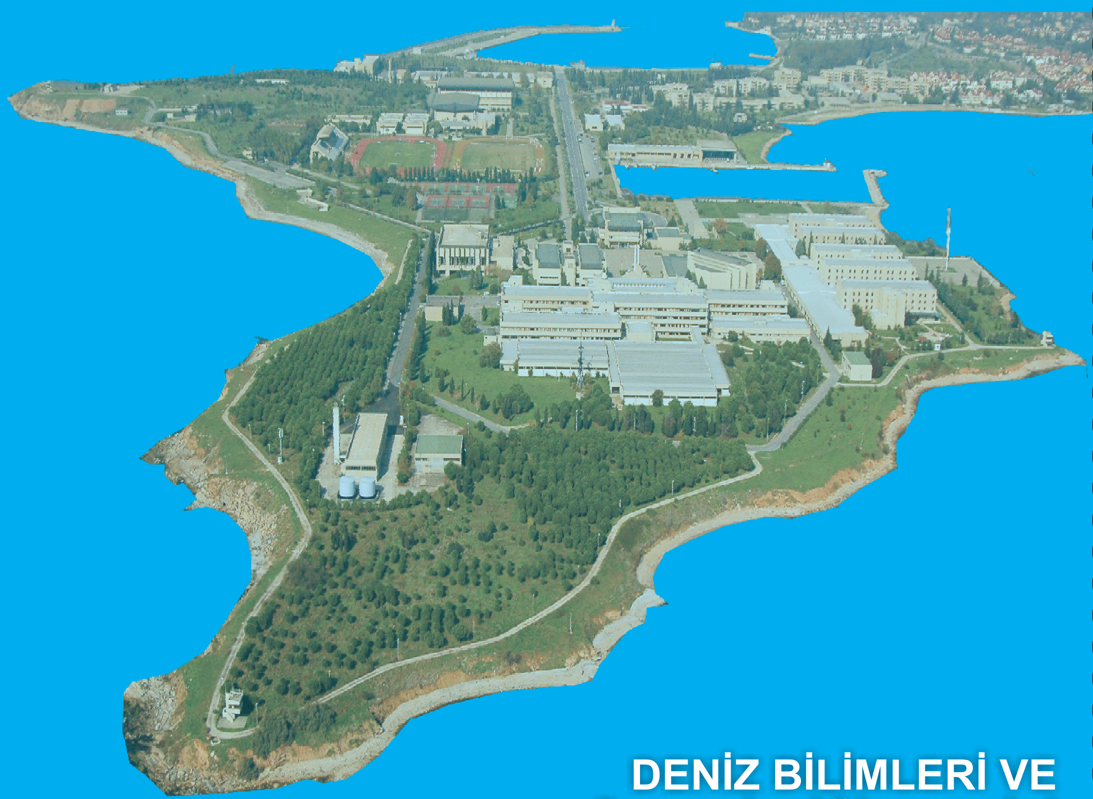
MİLLİ SAVUNMA ÜNİVERSİTESİ
BARBAROS DENİZ BİLİMLERİ
VE MÜHENDİSLİĞİ ENSTİTÜSÜ

JOURNAL OF NAVAL SCIENCES AND ENGINEERING

VOLUME:14 NUMBER:2 NOVEMBER 2018 ISSN:1304-2025



DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ

CİLT : 14 SAYI : 2 KASIM 2018

DENİZ HARP OKULU MATBAASI - İSTANBUL

Journal of Naval Sciences and Engineering

Barbaros Naval Sciences and Engineering Institute
Barbaros Deniz Bilimleri ve Mühendisliği Enstitüsü

Deniz Bilimleri ve Mühendisliği Dergisi

Volume/Cilt:14
Number/Sayı:2
November/2018

PRINTED BY/BASKI
Turkish Naval Academy Printing House/Deniz Harp Okulu Basımevi

CORRESPONDENCE AND COMMUNICATION ADDRESS/YAZIŞMA VE HABERLEŞME ADRESİ

Milli Savunma Üniversitesi
Barbaros Deniz Bilimleri ve Mühendisliği Enstitüsü
Deniz Harp Okulu Yerleşkesi
Tuzla/İSTANBUL/TÜRKİYE

Phone/Telefon : +90 216 395 26 30
Fax/Belgegeçer : +90 216 395 26 58
E-mail/E-posta : jnse@dho.edu.tr
Web : http://www.dergipark.gov.tr/jnse

NATIONAL DEFENSE UNIVERSITY
BARBAROS NAVAL SCIENCES AND ENGINEERING INSTITUTE
JOURNAL OF NAVAL SCIENCES AND ENGINEERING

MİLLİ SAVUNMA ÜNİVERSİTESİ
BARBAROS DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ ENSTİTÜSÜ
DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ

Volume/Cilt: 14 Number/Sayı: 2 November/Kasım 2018 ISSN: 1304-2025

Owner on Behalf of the Barbaros Naval Sciences and Engineering Institute
Barbaros Deniz Bilimleri ve Mühendisliği Enstitüsü Adına Sahibi ve Sorumlusu
Dr.Mehmet Bilge Kağan ÖNAÇAN

Journal of Naval Sciences and Engineering is a peer reviewed, international, inter-disciplinary journal in science and technology, which is published semi-annually in November and April since 2003. It publishes full research articles, review articles, technical notes, short communications, book reviews, letters to the editor and extended versions of conference papers. Topics of interest include the technological and scientific aspects of the following areas: **Computer Science and Engineering**, **Electrical and Electronics Engineering**, **Naval/Mechanical Engineering**, **Naval Architecture and Marine Engineering, Industrial Engineering and Basic/Social Sciences**. The journal aims to provide a scientific contribution to the increasing needs of Turkish Armed Forces. The papers in the journal are published in English.

Following Open Access Model of Publishing, Journal of Naval Sciences and Engineering presents a variety of scientific viewpoints. The authors are responsible for the scientific, contextual and linguistic aspects of the articles published in the journal. The views expressed or implied in this publication, unless otherwise noted, should not be interpreted as official positions of the Institution.

Our journal uses double-blind review, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process. The articles submitted to JNSE to be published are free of article submission, processing and publication charges. The accepted articles are published free-of-charge as online from the journal website and printed.

DATABASES INDEXING OUR JOURNAL / TARANDIĞIMIZ VERI TABANLARI

Open Academic Journals Index (OAJI) (13.03.2016)
Sobiad Citation Index (31.01.2018)
Scientific Indexing Services (SIS) (28.02.2018)
Arastirmax Scientific Publication Index (13.03.2018)
CiteFactor Academic Scientific Journals (14.05.2018)
Asian Digital Library (03.09.2018)
Idealonline (05.09.2018)
Directory of Open Access Journals (DOAJ) (09.10.2018)

Deniz Bilimleri ve Mühendisliği Dergisi; uluslararası düzeyde, hakemli, çok disiplinli, Nisan ve Kasım aylarında olmak üzere 2003 yılından bu yana yılda iki kez yayımlanan, bilim ve teknoloji dergisidir. Dergide; Bilgisayar, Makine, Gemi İnşa, Elektrik/Elektronik, Endüstri Mühendisliği ile Temel ve Sosyal Bilimler alanlarında bilimsel nitelikli araştırma makaleleri, derlemeler, teknik notlar, kitap incelemeleri, editöre mektuplar ile konferans ve toplantıların genişletilmiş raporlarına yer verilmektedir. Dergi, Türk Silahlı Kuvvetlerinin artan ihtiyaçlarına bilimsel katkı sağlamayı amaçlamaktadır. Dergide yer alan makaleler İngilizce olarak yayımlanmaktadır.

Açık erişimli yayın politikası izleyen Deniz Bilimleri ve Mühendisliği Dergisi değişik bilimsel bakış açılarını okuyucularına sunmaktadır. Dergide yayınlanan makalelerin bilim, içerik ve dil bakımından sorumluluğu yazarlarına aittir. Doğrudan veya dolaylı olarak ifade edilen görüşler kurumun resmi görüşleri olarak görülmemelidir.

Dergimiz, makale değerlendirme sürecinde çift-kör hakemlik sistemini kullanmaktadır. DBMD'ye yayımlanmak üzere gönderilen makaleler; makale gönderim, işlem ve yayın ücretinden muaftır. Kabul edilen makaleler, ücretsiz olarak basılı şekilde ve dergi web sayfasından çevrimiçi (on-line) olarak yayınlanmaktadır.

NATIONAL DEFENSE UNIVERSITY
BARBAROS NAVAL SCIENCES AND ENGINEERING INSTITUTE
JOURNAL OF NAVAL SCIENCES AND ENGINEERING

MİLLİ SAVUNMA ÜNİVERSİTESİ
BARBAROS DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ ENSTİTÜSÜ
DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ

Volume/Cilt: 14 Number/Sayı: 2 November/Kasım 2018 ISSN: 1304-2025

NATIONAL DEFENSE UNIVERSITY
BARBAROS NAVAL SCIENCES AND ENGINEERING INSTITUTE
JOURNAL OF NAVAL SCIENCES AND ENGINEERING

VOLUME: 14 NUMBER: 2 NOVEMBER 2018 ISSN: 1304-2025

CONTENTS / İÇİNDEKİLER

MİLLİ SAVUNMA ÜNİVERSİTESİ
BARBAROS DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ ENSTİTÜSÜ
DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ

CİLT: 14 SAYI: 2 KASIM 2018 ISSN: 1304-2025

Journal of Naval Sciences and Engineering
2018, Vol. 14, No.2, pp.71-90
Basic and Social Sciences/Temel ve Sosyal Bilimler

RESEARCH ARTICLE

THE MODEL OF PRICING OF SMALL SCALE LNG BUNKER TERMINAL IN TURKEY

Tansel ERKMEN[1]

[1]*International Logistics and Transportation, Piri Reis University, Tuzla, Istanbul, Turkey,*
terkmen@pirireis.edu.tr

Date of Receive: 08.06.2018 **Date of Acceptance: 14.11.2018**

ABSTRACT

Turkey has great potential in liquified gas bunkering industry. Early application of liquified gas terminal investments is high likely to generate substantial income for the shipping industry of Turkey and to its economy as a whole. The marine shipping industry is facing challenges to reduce engine exhaust emissions and greenhouse gases (GHGs) from their ships. LNG is a potential solution for meeting these requirements. Progress in the marine fuel industry has become critical to shipowners and cargo owners, since fuel consumption accounts for much of the total cost of travel and can be a significant part of total transport costs. LNG bunker in Northern Europe is advancing, however, worldwide lack of supply is undermining the spread of LNG bunkering. Therefore, providing security of supply in the Eastern Mediterranean could represent an important milestone towards LNG supply chain implementation.

Keywords: *LNG Terminal Price, Marine Fuel, Bunker Alternatives, Emission*

Tansel ERKMEN

TÜRKİYE'DE KÜÇÜK ÖLÇEKLİ LNG YAKIT TERMİNALİNİN FİYATLANDIRMA MODELİ

ÖZ

Türkiye'nin doğal gaz gemi yakıtı tedarikinde büyük bir potansiyeli var. Sıvılaştırılmış gaz terminali yatırımlarının erken uygulanmasının, Türkiye denizcilik sektörü ve bir bütün olarak Türkiye ekonomisi için önemli bir gelir yaratması mümkündür. Gemilerin neden olduğu egzoz emisyonlarının ve sera gazlarının azaltılması talepleri denizcilik sektörü üzerinde ciddi sıkıntı yaratmaktadır. Deniz yakıtı endüstrisindeki ilerlemeler, gemi sahipleri ve kargo sahipleri için kritik hale gelmiştir, çünkü yakıt tüketimi toplam seyahat masraflarının çoğunu oluşturmaktadır ve bu durum, tonaj maliyetlerinin önemli bir parçasıdır. LNG bu gereksinimleri karşılamak için potansiyel bir çözümdür. Kuzey Avrupa'da LNG yakıt tedariki çok hızla ilerlemektedir, ancak dünya çapında arz eksikliği LNG tedarik zinciri'nin yayılmasını engellemektedir. Bu nedenle, Doğu Akdeniz'de yakıt arz güvenliği sağlayacak terminal yatırımları, LNG tedarik zinciri uygulamasına yönelik büyük bir eksiği kapatmaya yardımcı olacaktır.

Anahtar Kelimeler: *LNG Terminal Fiyatı, Gemi yakıtı, Gemi yakıtı Alternatifler, Kirlilik*

1. INTRODUCTION

Increased environmental focus on the market today and the simultaneous need for the maritime industry to become more responsible for its environmental footprint is influencing the decisions that the shipment must make in terms of fuel type selection. “In the International Energy Outlook 2016 [8] reference case, transportation sector delivered energy consumption increases at an annual average rate of 1.4%, from 104 quadrillion British thermal units (Btu) in 2012 to 155 quadrillion Btu in 2040.” This amount is more than 50% higher than previously assumed and involves an annual CO2 (Carbon dioxide) emission of approximately 1100 million tones, equivalent to about 4% of global CO_2 emissions. “In addition, marine vessels emit large quantities of SO_2 (Sulfur dioxide), NO_x (nitrogen oxides) and soot PM10 (Particulate Matter), since the standard shipping fuel HFO (Heavy Fuel Oil) contains at present about 2.7% Sulfur, which is very high compared to other transport fuels. “Shipping emissions have been estimated to induce more than 60,000 premature deaths globally, of which about one third in Europe [2]". "Land based sources have achieved an enormous reduction in air pollution over the last decades. In contrast, shipping emissions have substantially increased over the same time span, along with the gradual growth of marine transport [7]". The combination of liquefied natural gas bunkering and natural gas combustion engines for ships has been presented as one of the three possible ways to comply with the standards established by the International Maritime Organization (IMO) regulating the control of dangerous pollutant in ship exhaust systems. The other two options are continued use of heavy fuel oil (HFO) with exhaust gas purifiers and combustion of low sulfur MGO (Marine Gasoil) / marine diesel MDO (Marine Diesel oil) diesel in ship propulsion systems. "The global LNG industry is approaching its 53th anniversary in 2017. It has proposed a huge amount of new LNG capacity of 400 million metric tons a year, which, if built, would be double 2025 [12]". The growing shortage and price of oil will favor the use of renewable fuels. For a ship, fuel may represent between 50% and 70% of the total ship ownership and ship management costs. Heavy fuel oil , marine diesel oil and marine gas oil are all conventional fuels. Ship-based fuels are a major part of oil consumption and all these fuels are high in the emission rate. The marine fuel oil market consumes about 300 million tons of diesel annually, and oil prices tend to follow price developments. LNG potential as bunker fuel to help reduce ship emissions is remarkable. "The use of natural gas produces the following NO_x, PM and CO_2 reduction of engine exhaust emissions; carbon emissions of about 25%, nearly 100% SO_x, 85% NO_x, 95% PM[13]".

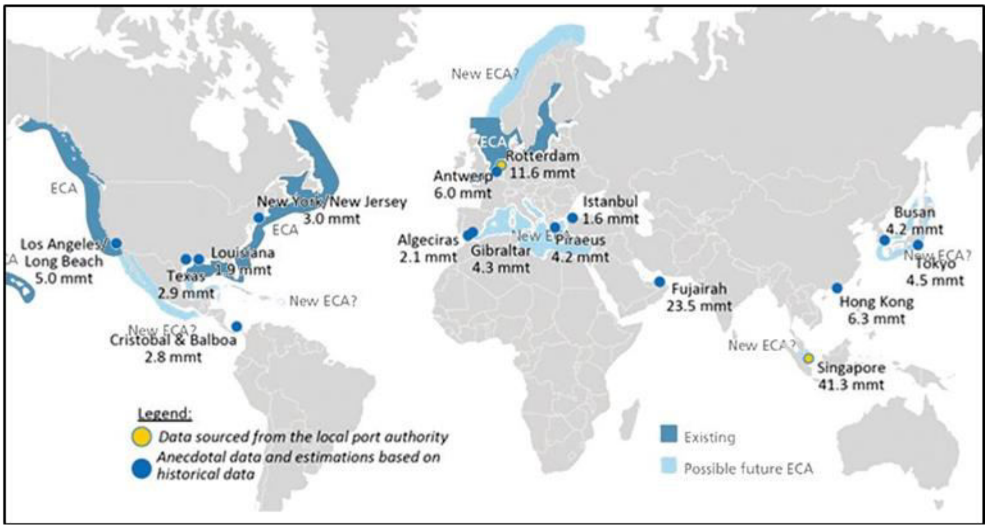


Figure 1. Emission Control Areas (ECA)
Source: DNV GL

In Emission Control Areas, Figure 1. Emission control areas (ECA) for Tier III and possible future ECA as indicated by DNV GL, sulphur limit in fuel used on board is 0.1%. The explanation of 'fuel oil used on board' includes use in main and auxiliary engines and boilers. In addition, there are new rules on ship energy efficiency for owners / operators and cards to be considered, where Liquefied Natural Gas (LNG) can play an important role. However, the main developments of liquefied LNG infrastructure must take place before it can be considered a viable alternative to conventional fuels. As the maritime industry considers alternatives to HFO, a part of the market will move to the MGO, partly to LNG and, where appropriate, liquid biofuels. "Transportation and handling of LNG a cargo on land and sea have been proven for many decades. With new emission regulations, the potential applications for LNG is expanding. Especially attractive for marine vessels travelling set routes such as ferries and tug boats. LNG as main propulsion fuel is no longer a new invention and the technology is already classified as proven. One of the main reasons for exploring LNG is its potential for environmental benefits. "International regulators, such as the International Maritime Organization (IMO) and the national environmental agencies in many countries, have issued rules and regulations that drastically reduce greenhouse gases and emissions from marine source [9]". Offshore ships typically spend 5% to 6% of their running time on SO_x Emission Control Areas. Therefore, ship owners should consider new fuels and / or technologies to develop the competitive advantage of short sea shipping.

2. LNG BUNKER CONSUMPTION

"LNG consumed as marine fuel will reach 1 million tones by 2020 and rapidly grow to 8.5 million tons by 2025 [5]". Europe and the United States will rely primarily on the national production of natural gas for the making of LNG as marine fuel. Asia Pacific will instead have to rely on LNG imports at fixed prices in the Asia-Pacific market. Several other LNG demand projections as marine fuels have been published and all vary in hypotheses; world activity and shipping and shipping activities, absolute fuel prices, relative Gross Domestic Product (GNP) and natural gas compared to the cost of supplying LNG as fuel, The cost of LNG supply infrastructures and the availability of LNG fuels.

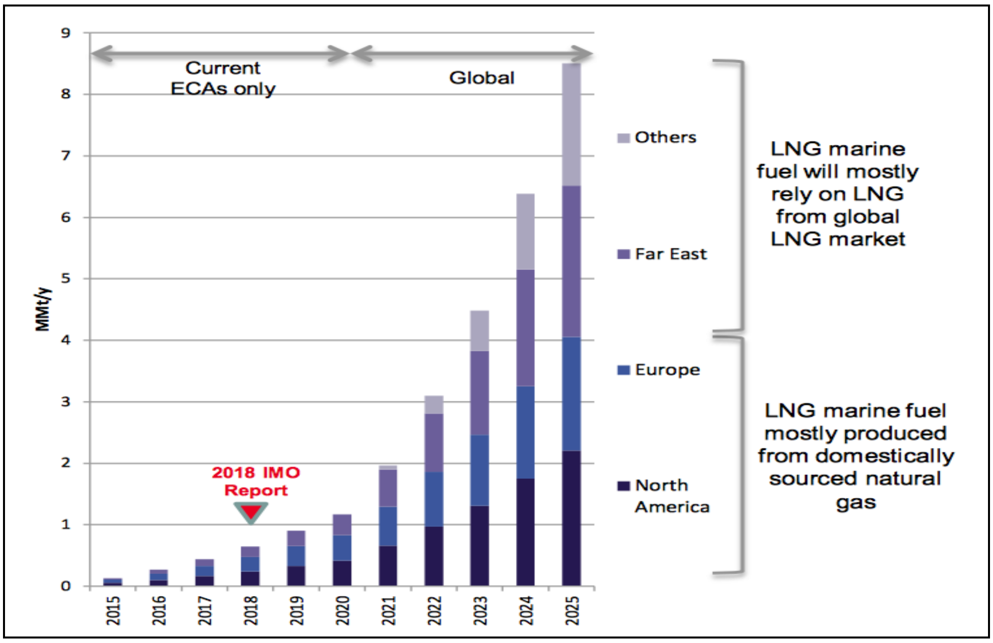


Figure 2. LNG Marine Fuel Consumption by Location
Source: IMO.org

Figure 2. shows that the use of liquefied natural gas as ship fuel has recently gained more attention in Europe, but also in Asia and the USA. "DNV GL recently published the Maritime Forecast to 2050 which analyses the impact of the changing global energy system on the shipping industry through to 2050. The report proposes that by 2050, "only 47% of energy for shipping will be from oil-based fuels. The share of gas in the fuel mix will rise to 32% [3]". The typical expectation is, from 0.7 to 66 million tons in 2025 depending on the scenario, from 8 to 33 million tons in 2020 according to the scenario, 65 million tons in 2030. Europe and the United States depend mainly on the national production of natural gas for the production of LNG for marine fuels. Asia Pacific will instead have to rely on LNG imports at fixed prices in the Asia-Pacific market. There have been several other LNG demand projections as marine fuels and all vary global business assumptions and subsequent shipping and naval activity, absolute fuel prices, relative GNP and natural gas relative to the oil price, activity Regulating specifically environmental issues, costs to equip conventional ships to use LNG as fuel, cost of LNG supply infrastructure and LNG fuel availability. LNG consumed as marine fuel will reach 1 million tones in 2020 and rapidly increase to 8.5 million tones in 2025. It is expected to meet this demand must be established more than 40 small scale LNG terminals across Sulphur Emission Control Areas (SECA) 2015, integrated by terminals of medium size, tankers and combustion vessels. From an economic and financial point of view, the following recommendations are offered:

- The reference price for LNG bunkering infrastructures should be based on an average internal rate of return on infrastructure investment below 12% to reach a competitive GNP price;
- Are coordinated investment efforts to avoid sub-optimization are needed to establish "least critical" level of LNG bunkering infrastructure to meet demand in 2015-2020;
- Business cases or plans for specific investment projects need to be developed, partly as a result of cluster work in ports or similar;
- Local or regional port clusters should underline the development of the local LNG market, including possible synergies with land demand;

- The European funding scheme is necessary for the development, construction and operation of LNG bunker vessels / barges at the initial stage of the market.

3. LNG BUNKERING UNCERTAINTIES

There are some uncertainties that affect the decisions of ship owners and bunker fuel suppliers in global LNG growth as marine fuels. Ship owners face three alternatives to comply with regulations with uncertain timing for global implementation. Regional Emission Control Areas (ECA) initiatives will lead to greater use of LNG. This has happened in Scandinavia and seems to be developing in the United States. However, the overall prospects remain slow and there will be a clear choice of fuel, because the ship owners will be able to opt for the flexibility in their navigation commands until finally the time and implementation of Annex VI is established. Given the considerable uncertainty about fuel differentials and fuel prices, a flexibility strategy will be crucial. “About 80% of total LNG sales are made through long-term LNG purchase and sale contracts; The rest is sold in spot and short term. The world market size for bunker fuel equivalent to about 70% of the global LNG market, a significant fuel LNG fuel change would require such an increase in LNG supply [10]”. Future fuel price estimates contain a large number of uncertainties. “However, the cost of infrastructure costs to transport LNG from end-user import terminals is important if LNG is a competitive fuel for shipping. In addition, the cost-benefit analysis of the supply chain LNG is characterized by great uncertainties that make companies more sensitive than the estimated return time. In addition, shorter retrieval times are generally required when uncertainties are greater [1]”. “It is expected that annual LNG demand will reach 8.5 million meters in 2020 and 14 million cubic meters in 2030 is expected to meet this demand needs to be established more than 40 small scale LNG terminals across SECA in 2016, Integrated From medium-sized terminals, tankers and tanks.” From an economic and financial point of view, the following recommendations are offered,

- The price of LNG infrastructure should be based on an average internal rate of return on infrastructure investments of less than 12% to obtain a competitive GNP price;

- Co-ordinated investment efforts are needed to avoid minimal optimization to establish a critical level of LNG infrastructure to meet demand in 2016-2020;
- Business cases or plans for specific investment projects need to be developed, partly as a result of working in port groups or similar;
- Regional port or similar businesses should insist on the development of the local LNG market, including potential synergies with land demand;
- A European funding scheme for the development, construction and operation of LNG vessels / barges is needed in the initial market launch."

4. LNG BUNKERING INVESTMENT MODELS & DECISION PROCESS

There are several ways of quantifying, presenting and analysing LNG investments for storage purposes; conceptual issues with regard to investment analysis and considerations of practical models in this respect. Three main mathematical models for retail LNG to bunkering is

- Asset/ Liability Models,
- Cash Flow LNG Bunkering Investment Approach
- Hub price + cost/profit elements; What matters most is your future and preferred risk management vision.

The investment strategy is the set of basic guidelines in which the investment function operates. The asset/liability area plays a key role in the development of general guidelines or investment strategy. The investment strategy for the LNG bunkering storage process begins with the development of the initial investment strategy. LNG Bunkering investment decision requires;

- Framework and decision-making processes
- Risk and measure of reward
- Use of cash flow or asset/liability model
- Evaluation of alternative difficulties to investment modelling,
- Investment vehicles and hedging opportunities
- Different tools available for coverage - both oil and gas
- Some also choose double fuel as a natural hedge
- It's important to work on contracts to fit your preferences
- Terms, prices, delivery terms and more

- Inland and supply chain requirements
- International standards (IMO, ECA, etc.)
- Other bunkering systems
- Duration and volume goals
- Requirements credit quality requirements
- Location requirements
- Liquidity constraints (short-term cash requirements)
- Parameters of the investment mix
- Cash flow characteristics (MGO versus LNG)
- Performance criteria (total performance, maximum performance).
- Asset / Liability LNG Bunkering Investment Approach; Asset/liability models are a common tool in developing the investment strategy. Asset and liability models are a key tool that investment decision makers can use to measure the parameters associated with investment risk. These include the duration and convexity, liquidity, and cash flow characteristics. Below are some useful tips for proper use of these models.
- Understand the strengths and weaknesses of the investment.
- Project cash flows, if properly adjusted. It gives us a general understanding of the characteristics of cash flow and investment risk. However, the cash flow model does not give us a good idea of credit risk.
- Therefore, you need to understand the strengths and weaknesses of your cash flow models and make sure you do not draw conclusions based on a weak model.
- To have a realistic cash flow model, you need to get the buy-in from the investment area in the investment hypotheses. If this is not achieved, it can mislead LNG investment needs in that region and make it virtually impossible to move from model results to supply.

Finally, avoid complications in the cash flow model. To understand what is really driving the results, you should keep it simple. A complicated pattern can confuse of the results.

4.1. Cash Flow LNG Bunkering Investment Approach

Cash Flow LNG bunkering investment model produces results in a number of interest rate scenarios. In general, measure the present value of legal incomes in each scenario. A risk measure could be the relationship between average and standard deviation. It is often useful to look at different worst scenarios. Usually it can be seen a model in the worst cases that indicate the riskiest environment for that particular responsibility.

4.2. Hub Price Cost /Profit Elements Approach

Cost/ Profit Elements model is the ability of a business to control its costs of goods sold (COGS), along with fixed costs, while revenue optimization contributes to profitability in generating profits. The investment evaluates three levels of profit margin. The first is the gross margin, which is equivalent to the regular gross profit divided by income. In this equation, the key elements of the cost are COGS. These are the costs for the manufacture or purchase of LNG fuel that you sell to generate revenue. Their gross margin shows how their ability to add value to the sale of goods and to pay reasonable prices on them. This is fundamental to the bottom line. In addition to COGS, operating costs also include fixed or general costs that are paid to operate independently of production or revenues. Maintaining operating costs is important to give the LNG fuel terminal an opportunity to use gross profit to cover costs and make money.

With converging prices and a more efficient market, market price definition influences are needs. In this case, it would be necessary to foresee the future bid and the demand for a forward price. In a conservative forecast, with a higher bid than long-term demand due to large projects, a long-term price reduction could occur. This is reflected in the low-priced scenario. The forward price between two parties is usually the difference between the spot price and the forward price. This long useful life for a forward contract poses any risk to the contract issuer. As a supplier, it is important that the forward price is also above the price of the balancing of the delivery costs, in order to make the contract profitable. The current spot price in National Balancing Point (NBP) is 11-12 USD / MMBtu. Meanwhile, the balance price when recording the transport to Milford Haven is 6.8 USD / MMBtu. Therefore, the forward price should be between these two figures. In the low-priced scenario, the price in Europe is 8 at the lowest level. Therefore, let us assume a forward price of 8.5 USD / MMBtu. “The LNG infrastructure price should generally be based on an average internal rate of return on infrastructure investments of less than 12% (corresponding to a recovery period of approximately 8 years) to obtain a competitive price of LNG, Co-ordinated investment efforts are needed to prevent under-optimization to establish a critical level of LNG infrastructure [14]". Business cases or plans for specific investment projects need to be developed, partly as a result of working in port groups or the like, Conglomerates of local or regional ports or similar should point to the development of the local LNG market, including possible synergies with land demand, The need for funds for the construction of the LNG terminal is established after taking into account the financial resources required for the implementation of the Project and the evaluation of the submitted national and international regulations. The model establishes that LNG Terminal revenue consists of three partitions;

- Fixed cost compensation includes all fixed costs of the LNG Terminal, its infrastructure and the connection necessary to ensure the operation of the LNG Terminal, including installation costs of the LNG terminal, its Infrastructure and connection to the LNG Terminal Y gas transport system is the carrying value of these activities;
- Regasification Rate Revenue; Revenue from fixed-cost compensation and return on investment is included in the security component. The safety component is collected, administered and delivered by the operator of the natural gas transport system under the conditions set by the national authorities.
- The Model provides for the pricing of services of an entity in natural gas liquefying business, which establishes the calculation of an additional natural gas supply safety component in addition to the upper limit of the natural gas transmission price. The need for funds for the construction of the LNG Terminal is established after taking into account the financial resources necessary for the implementation of the Project and evaluating the presented national and international regulations. The Model states that the revenue from the LNG terminal consists from two partitions:
- Revenue from fixed cost compensation includes all the fixed costs of the LNG Terminal, its infrastructure and connection that are necessary to ensure the operation of the LNG Terminal which includes installation costs of the LNG Terminal, its infrastructure and connection to the gas transmission system and is the carrying value of these assets;

- Revenue from Regasification tariff; The revenue from fixed cost compensation and the revenue from return on investment shall be included into the Safety Component. The Safety Component shall be collected, administered and disbursed by the transmission system operator for natural gas under the terms and conditions set by the national authorities.
- According to the Model, the Price security supplement (Mp, Sec) is calculated using the below mentioned formula:

F_{ACOST} = fixed annual cost of the LNG Terminal, its infrastructure which are calculated using the following formula:

$$F_{ACOST} = C_{Maint} + C_{Staff} + C_{Tax} + C_{Admin} + C_{M\&S} + C_{O} + C_{Term} + C_{DE}, \qquad (1)$$

thousand LTL, here

C_{Maint} = Maintenance, repair, technical management and operational costs,

C_{Staff} = Staff costs,

C_{Tax} = Tax costs,

C_{Admin} = Managerial costs,

$C_{M\&S}$ = Advertising and Trades costs,

C_{DE} = Depreciation (amortization) costs,

C_{O} = other fixed costs,

C_{Term} = Costs of the LNG Terminal,

ROI_{d} = Return on Investments in infrastructure part

$F^{ADM}_{ACOST\ (t+1)}$ = Forecast for expected tax expenses for the calendar year.

Q_{p} = Expected quantity of natural gas transmitted through gas transmission pipes, thousand m^3.

5. LNG BUNKERING RECOMMENDATIONS IN TURKEY

We believe that Turkey can be a driving force in the eastern Mediterranean region, and it should involve a number of activities such as research, development and concept design standards, and some early commercial applications, especially when we have very promising and Building Industry Well-structured naval. Turkish ship builders will gain a lot if they see LNG fuel demand on the shipping market quite quickly. The feasibility of LNG bunkering terminal projects, large-scale terminals, will cover the cost of construction in about 8 years, while small and medium-sized terminals will cover construction costs in approximately 12 years at current rates. This study will help future operators and ship owners in LNG bunkering business and waterfront facilities in Turkey. Of course, it will not be a single solution for ship owners to comply with the new rules. Some factors should be considered to make a decision; the type and age of the ship, its route, its secondary market, the financial strength of the owner, the competition between the ship owners, crew qualification, potential loss of loading), experience of LNG owners, availability of worldwide, regional and local products, etc.

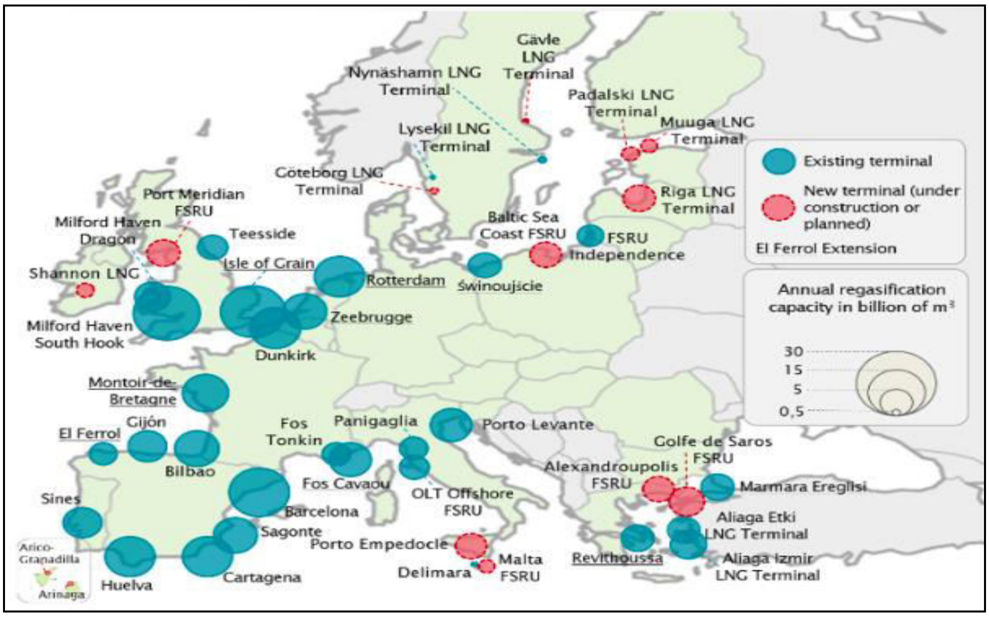


Figure 3. Existing LNG Terminal in Europe
Source: GIIGNL 2018 Annual Report

Figure 3. shows an overview of the large-scale LNG import terminals in Europe today, existing, under construction and planned and the services provided at Europe's existing LNG import terminals. "On the demand side, the LNG market is becoming more diverse and more complex, with a total of 40 countries now importing LNG. Most of the demand growth occurred in Asia, where LNG imports grew by 19.6 MT [6]". The transport sector is

the main contributor to oil demand in Turkey, almost 40% of the current budget deficit caused by oil costs. The ships will be impacted by the regulations and competition among ship owners is strong. This will create a new demand for shipbuilding. “Particularly ECA short-haul boats with fixed routes will develop a high percentage of new construction and RO-RO and a small percentage of new or existing oil tankers. Many land ships will also operate with LNG, which should increase the amount of LNG fuel available in the port to reach a certain scale. Obviously, this will create new opportunities for the naval industry. More than 1,000 new LNG vessels will be ordered over the next 20 years to comply with the new regulations [5]”. The starting point for LNG supply depends on the region and therefore from the availability of LNG or pipeline gas, import or export region, region extension and door density, etc. The requirement to start and build the entire supply chain is seen as a major obstacle to the development of LNG bunkers.

There are a limited number of supply points for LNG liquefied gas in the Mediterranean Sea, although LNG is already available in many places. Further logistics are needed to transport it to the port, keep and retain the ship. Each case must be considered separately, taking into account these characteristics. Turkey has great potential to meet these needs if it acts quickly and well planned. In the long run, some governments around the world have larger LNG plans in the maritime sector. For example, “The European Commission has launched an ambitious plan for the supply of 139 LNG landfill gas inland waterways and inland waterways for the period 2020-2025 [4]”. There is a steady increase in the number of ports that are studying to invest in LNG as fuel in Europe. The main change brought by Directive 2012/33/EU, namely the mandatory use of low sulphur marine fuels in the Baltic Sea and North Sea designated as Sulphur Oxides Emissions Control Areas (‘European SOx-ECAs’), took effect on 1 January 2015. Consequently, the Commission received Member States' first reporting on compliance with the new sulphur requirements in the European SOx-ECAs not earlier than 30 June 2016. The European Parliament and Council a more stable and aggregated overview of the level of enforcement at present-day. There are very few supply points for LPG liquefied gas, although LNG is already available in many places. Further logistics are needed to transport it to the port, keep and retain the ship. There are several advantages for the first engines in this industry of the shipping industry that provide for supplying or using LNGs as fuel.

The effectiveness of LNG liquidity markets depends on the ability of suppliers to optimize logistics and make it economically advantageous for customers to convert their LNG stock. High-intensity capital infrastructure is much more expensive than similar chains and, consequently, infrastructure costs represent much of the energy cost compared to competing energy carriers. In this relatively new market area there are important investments in the supply chain such as charging plants, small scale liquefaction plants, local terminals and storage facilities, distribution trolleys and ships, bunker barges, operators and security personnel for dealing with substances cryogenic.

5.1. LNG Terminals in Turkey

Turkey has two Liquefied Natural Gas (LNG) terminals, the Aliağa and the Marmara Ereğlisi. The Aliağa has a capacity of 25 mcm of gas transfer per day while Marmara Ereğlisi has 18 mcm. BOTAŞ plans to increase Marmara Ereğlisi LNG Terminal's daily capacity to 27 mcm by 2017. BOTAŞ aims to increase Turkey's energy supply security and diversify its gas sources, and with this aim, the company is working on expanding LNG storage and Floating Storage Regasification (FSRU) units.

Clearly, there will be only one solution for ship owners to comply with the new rules. Many factors have to be considered to determine the best solution; the type and age of the ship, its route, its secondary market, the financial strength of the owner, the competition between the ship owners, crew qualification, potential loss of Load space), experience of LNG owners, availability of global, regional and local products, etc. The transport sector is the most important contribution to oil demand in Turkey, almost 40% of the expenditure. The ships will be affected by the rules and the competition between ship owners is convincing. This will create a new question for shipbuilding. Particularly ECA short-haul boats with fixed routes will develop a high percentage of new construction and RO-RO and a small percentage of new or existing oil tankers. Many land ships will also operate with LNG, which should increase the amount of LNG available in the port to reach a certain scale. Clearly, this will create new opportunities for the naval industry. More than 1,000 new LNG vessels will be ordered over the next 20 years to comply with the new regulations. The starting point for LNG supply depends on the region and therefore from the availability of LNG or pipeline gas, import or export region, region extension and door density, etc.

5.2. The Major Obstacle of the Development of LNG Bunkers

The condition to start and build the entire supply chain is seen as a major obstacle to the development of LNG bunkers. There are very few supply points for LNG liquefied gas in the Mediterranean Sea, although LNG is already available in many places. Further logistics are needed to transport it to the port, preserve and preserve the ship. Each case must be considered separately, taking into account these characteristics. Turkey has great potential to meet these needs if it acts quickly and well planned. In the long run, some governments around the world have larger LNG plans in the maritime sector. For example, the European Commission has launched an ambitious plan for the supply of 139 LNG landfill gas inland waterways and inland waterways for the period 2020-2025 [4].

The Chinese central government, at the end of 2012, provided guidance on how the development of green ports would be part of its strategy to improve air quality under its twelfth five-year plan. Within the scope, ports will accelerate the use of natural gas to replace heavy fuel oil with ships. "Figure 3 shows that 68% of the bunker LNG infrastructure set is based in Europe primarily in the Scandinavian region according to Lloyd's register [11]". There is a steady increase in the number of ports reported that are studying LNG as fuel in Europe. The main focus was on ports in Northern Europe, guided by the 2015 deadline for the sulfur-dioxide monitoring zone (SECA). However, there are other ports that are implementing bunkering facilities, such as Rotterdam and Singapore, with further ports in Europe, North America and Asia. There are very few supply points for bunker LNG, even though LNG is already available in many places. The further logistics are required to transport it to the port, store and bunker the ship. There are several advantages to first movers in this segment of marine industry who plan to supply or utilize LNG as fuel. Among the reasons for being first investors to LNG bunkering facilities, include,

- Concerns about the potential supply shortages for ultra-low sulfur diesel in between 2015 - 2020

- A potential price spike due to high demand for ULSD and scrubber installation cost
- Environmental stewardship
- Low cost and abundant supply of natural gas.

The feasibility of many emission reduction technologies depends to a large extent on the different fuel prices and the relative differences. This fact, together with the general importance of fuel prices for the profitability of the maritime industry, makes it vital to monitor the fuel markets and monitor their developments. Analysis of oil and gas trends is expected to show that gas prices and oil and gas dissipation are a turning point that is likely to increase the availability of spot gas in Europe. "According to new standards, low sulfur fuel will be in high demand, which in turn will lead to greater demand for alternative fuels. The future of marine fuels seems to be a combination of fuel types combined with new propulsion technologies and adaptive fuel systems and / or emission systems. The maritime industry will face increasing demands for safety, security, environmental performance and efficiency beyond 2020 [12]". Fuel will remain expensive beyond 2020 and will drive demand for energy-efficient vessels. These will focus on optimum energy utilization and will be designed and managed with alternative fuels such as LNG, energy systems and lightweight construction. Anticipating a growing global demand for natural gas, the Turkish government should see LNG as a promising future for maritime industry. The infrastructure needed for LNG bunkering of ships in Turkish sea and inland ports using special LNG bunkering vessels needs to be explored further. To enable LNG bunkering in Turkish ports, the country needs to build a supply infrastructure before 2020. One quick and efficient method would be distributing LNG via ship to ship bunkering with small vessels LNG carriers, with short term LNG storage provided by port terminals. Finding storage terminal in port location will be challenging task to face with.

6. CONCLUSION

It should be known that great price differences in bunker fuels, and even more so with LNG, can be seen among different countries' fuel markets. Eventually, there will be an LNG bunkering procedure that follows the same pattern as that of heavy fuel oil, customers will expect a similarly convenient bunkering, including an acceptable time frame and guarantees for the safety of crew and passengers. This is the next challenge to develop a LNG storage system that includes all organizational, security and technical aspects and requirements. Stronger environmental standards requiring reduced $SO_{x,}$ NO_x and particulate emission levels are pushing the shipping industry to use cleaner energy sources. “Reducing technologies, such as recirculation of exhaust gases, scrubbers and catalytic reduction, can generally meet some of these standards. “LNG and biofuel blends will be exploited beyond 2020 By 2020, marine fuels will reach 1 million tones by 2020 and will rapidly increase to 8.5 million tones by 2025 [12]”. Europe and the US Will mainly be from the national production of natural gas for the production of LNG for marine fuel. Asia Pacific will instead have to rely on LNG imports at fixed prices in the Asia-Pacific market. The results of these expectations, LNG demand will rise to 8 to 33 million tons in 2020 and 65 million tons in 2030. Controlling emissions and low LNG prices should be the main engines for LNG development as fuel. Currently missing bunker infrastructures and the regulatory framework for such operations are the main challenge that needs to be tackled soon to make LNG a reliable option for owners in their decision on future ships. Since LNG marine fuel becomes more common, it is necessary to implement regulations and standards along with technical and procedural developments. LNG fuel standards are needed because they guarantee a level of safety and create common reasons for operators, thus facilitating the expansion of the LNG industry.

When deciding on a strategy to comply with emission laws, the important compromise is the cost of low sulfur fuel compared to the cost of a purification system. Regulations and profitability are the most significant reasons for investing in new technologies, while the installation and operation costs and maturity of the technology itself are the most important. Industry will continue to introduce the technological innovations and infrastructures needed to provide the growing LNG market, provided there is an advantage over the costs of using LNG compared to alternative fuels. In recent decades, market focus has focused on technical and commercial issues, but now that technical solutions exist and markets are growing, the industry is looking closely at strategic and regulatory issues. Because of its low cost compared to conventional marine fuels and its ecological nature, LNG is seen by the European Union as an attractive future fuel for ships.

REFERENCES

[1] Castillo, L. and Dorao, C.A. (2011). ***Decision-Making on Liquefied Natural Gas (LNG) Projects Using Game Theory***. Paris, July, 2011, pp.60-66.

[2] Corbett, J. J. Wang, C. Winebrake, J. J. Green, E. (2007). ***Allocation and Forecasting of Global Ship Emissions; Clean Air Task Force and Friends of the Earth International***. Boston, MA, January, 11, 2007, pp.1-26.

[3] Oudman, B. (2017). DNV GL, "Oil and Gas Forecast to 2050 Energy Transition Outlook 2017", Retrieved from https://www.igu.org/sites/default/files/6_Ben%20Oudman_DNV%20GL_Energy%20Transition%20Outlook%20-%20Forecast%20for%20oil%20and%20gas....pdf (Access Date: 08.05.2018).

[4] European Commission, (2013). "Annual Report", Retrieved from http://ec.europa.eu/ europeaid/index_en.htm. (Access Date: 01.05.2018).

[5] Gulf, H. (2015). "LNG Shipping News", Retrieved from www.offshoreenergytoday.com (Access Date: 15.04.2018).

[6] GIIGNL, (2018), "The International Group of Liquefied Natural Gas Importers", Retrieved from https://giignl.org/publications (Access Date: 25.05.2018).

[7] Hammingh, J.M.M. Aben, W.F. Blom, B.A. Jimmink, W.J. de Vries, and M. Visser. (2007). "MNP Report 500092004/2007 Effectiveness of International Emission Control Measures for North Sea Shipping on Dutch Air Quality". AH Bilthoven, 2007, pp.1-50.

[8] International Energy Outlook. (2016). DOE/EIA-0484(2016), "U.S. Energy Information Administration", Retrieved from https://www.eia.gov/outlooks/ ieo/ pdf/ 0484 (2016).pdf. (Access Date: 30.06.2016).

[9] IMO. (2016). "Emission Standards: International: IMO Marine Engine Regulations". Retrieved from https://www.dieselnet.com /standards/ inter/ imo. php (Access Date: 01.29.2016).

[10] International Energy Agency. (2011). "Are We Entering a Golden Age of Gas?", **World Energy Outlook**. Retrieved from www.eia.gov (Access Date:05.04.2018).

[11] Lloyd's Register. (2017). "Lloyd's Register LNG Bunkering Infrastructure Survey 2017", ***Lloyd's Register***. Retrieved from www.lr.org (Access Date: 09.05.2018).

[12] Melling, A.J. (2010). "Natural Gas Pricing and Its Future. Europe as the Battleground", ***2010 Carnegie Endowment for International Peace***, Washington, D.C.

[13] Stenersen, D. (2011). "Gas Fuelled Ships". ***Cimac***, pp.1–38.

[14] Wurster, R. Windorf, W. Zittel, W. and Müller. S. (2011). "LNG as an Alternative Fuel for the Operation of Ships and Heavy-Duty Vehicles", (March 2014), pp.1–94.

Journal of Naval Sciences and Engineering
2018, Vol. 14, No.2, pp.91-99
Basic and Social Sciences/Temel ve Sosyal Bilimler

RESEARCH ARTICLE

WIRE STRAND WITH COMPLEX SHAPED ELLIPTIC OUTER WIRES

Cengiz ERDÖNMEZ[1]

[1]*Basic Sciences, National Defense University, Tuzla, Istanbul, Turkey,*
cerdonmez@dho.edu.tr

Date of Receive: 07.11.2018 **Date of Acceptance: 20.11.2018**

ABSTRACT

The main advantage of wire ropes is their ability to operate under high tensile load and in this way to resist large axial loads. Different types of wire ropes are produced according to increase their strength over the traditional ones. For example compacted wire ropes are low stretch wire rigging which increase the breaking strength and stretch of the wire ropes compared to the traditional wire ropes. Outer wires are formed using a special process called compacting. In this article, a three-dimensional model of different external wire cross-section is examined. For this purpose, a (1+6) wire strand model designed by using elliptical cross-sectional outer wires are designed. Then finite element analysis results for stress, displacement and contact pressure are presented.

Keywords: *Wire Strand, Elliptical Wire Strand, Modeling Wire Rope, Elliptical Outer Wire Composition, Wire Strand Finite Element Analysis*

KOMPLEKS ŞEKİLLİ ELİPTİK DIŞ TELLER İLE TEL DEMET

ÖZ

Tel halatların ana avantajı, yüksek gerilme yükü altında çalışabilmeleri ve bu şekilde büyük eksenel yüklere karşı dayanıklılıklarıdır. Geleneksel olanlara göre mukavemetini arttırmak için farklı tel halat türleri üretilmektedir. Örneğin, sıkıştırılmış tel halatlar, geleneksel tel halatlara kıyasla tel halatların kopma mukavemetini ve gerilmesini arttıran düşük gerilimli tel halatlardır. Dış kablolar sıkıştırma denen özel bir işlem kullanılarak oluşturulur. Bu yazıda farklı bir dış tel kesitinin üç boyutlu modeli incelenmiştir. Bu amaçla eliptik kesitli dış teller kullanılarak tasarlanan bir (1 + 6) tel demet modeli tasarlanmıştır. Daha sonra sonlu elemanlar yöntemiyle elde edilen stres, uzama ve temas basıncına ait analiz sonuçları sunulmuştur.

Anahtar Kelimeler: *Tel Demet, Eliptik Tel Demet, Tel Halat Modelleme, Eliptik Dış Tel Kompozisyonu, Tel Demet Sonlu Eleman Analizi*

1. INTRODUCTION

Due to wire ropes capability to carry large tensile loads, wire ropes find different usage area in the industry and daily life such as lifting, mining, bridges, cranes, etc. Different configurations of the material, wire, and strand structure provide different benefits for the specific lifting application, including such as strength, flexibility, abrasion resistance, crushing resistance, fatigue resistance, corrosion resistance and rotation resistance. In the literature there are a number of studies on wire rope theory and its numerical analysis. Costello et.al. studied various aspects of wire ropes under specific conditions in his study [1]. Velinsky et.al. developed a theory to predict the static response of a wire rope with complex cross sections in [2]. A finite element model of a simple straight wire rope strand is presented by Nawrocki and Labrosse [3] which allows for the study of all the possible interwire motions. An accurate and general strand model using the FEM is presented by Jiang et.al. which accounts combined effects of tension, shear, bending, torsion, contact, friction and possible local plastic yielding when loaded in [4].

3-D wire rope modeling gives ability to conduct Finite Element Analysis over a wire rope under certain loading conditions. Thus, one can have deep information about the behavior of the wire rope under different scenarios. In the literature search there exists a number of paper about modeling wire ropes. A wire rope with an independent wire rope core (IWRC) model, which fully considers the double-helix configuration of individual wires considered by Elata et.al. in [5]. Parametric mathematical equations of single and double helical wires within an IWRC is represented in [6]. Modeling issues of nested helical structure based geometry for numerical analysis and the encountered problems and solution techniques are mentioned in [7]. Lately a geometric model of spiral one or two-layered oval nested wire strands (WS) are proposed by Stanova et.al. in [8].

During this literature search, it is observed that all kind of wire ropes are composed using circular cross sectional wires. Only the compacted forms are different because of the special process used to build them to reduce the gaps between wires. In this paper this procedure will be investigated and the reductions of gaps between wires are done using elliptic cross sectional wires.

2. WIRE ROPE MODELS

There are number of traditional type wire ropes are produced widely such as WS, IWRC, Warrington IWRC, Seale IWRC with different wire compositions are given in Figure 1. From this figure it can be seen that these traditional wire ropes are composed by using circular shaped wires.

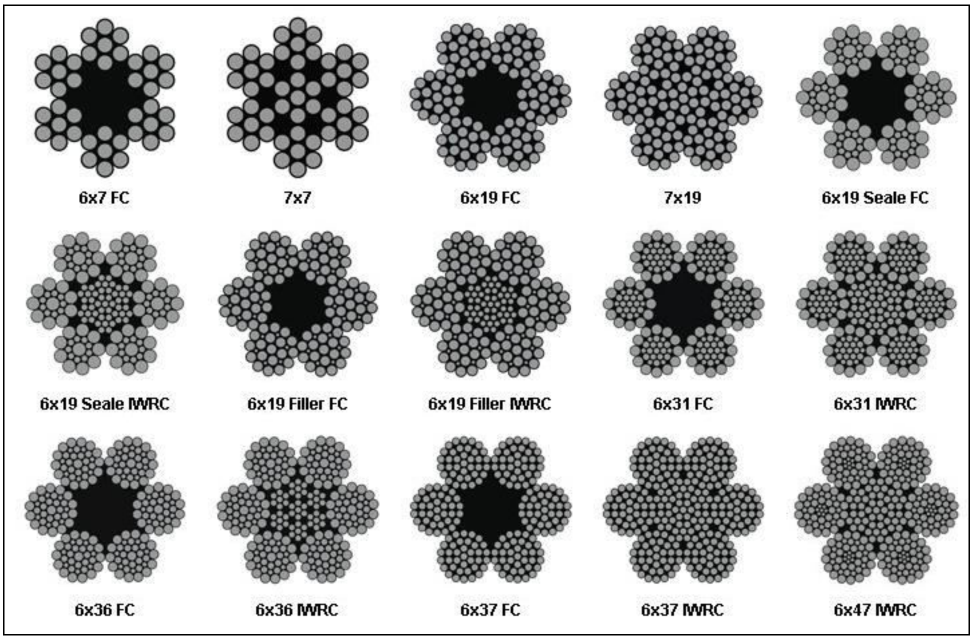


Figure 1. Different Types of Wire Ropes

But this issue is started to change with newborn wire rope compositions like compacted wire ropes. According to the producers of these type of wire ropes, compacted form is low stretch wire rigging, which features more than a 30% increase in breaking strength over traditional 1×19 wire, and 25% less stretch. A cross section of this kind of compacted wire rope is presented in Figure 2.

It is observed from the Figure 2 that these wires fill more space between wires by leaving fewer gaps. Compacted wire ropes are built by swaging process. Swaging is a metal forming process of reducing diameter of a rod or tube by forcing it into a die with the help of reciprocating blow. This process plastically deforms the metal and forces it to flow into die and acquire die cavity shape.

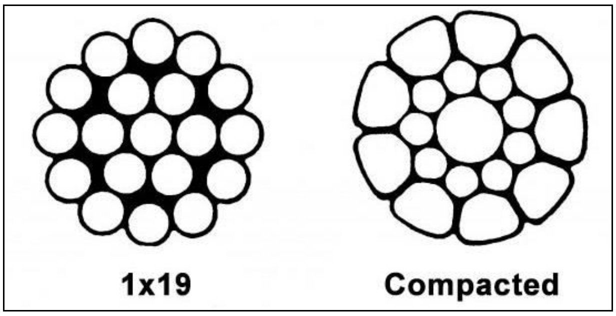


Figure 2. Traditional and Compacted Form of a 1x19 Wire Strand

There are some benefits of compacting on wire ropes such as cutting force is higher compared to the same rope diameter and have a long life. Since the outer shape of the rope is rectangular and extend the life inclusive of the drum reduces the frictional force.

Using the idea of reducing the gaps between wires in a wire strand for 3-D modeling, elliptical outer wires are taken into account in this paper. First of all the general model for the wire strand is created using elliptical helical wires around a single straight center wire. Then its finite element analysis is done.

3. CONSTRUCTION AND FINITE ELEMENT ANALYSIS OF THE ELLIPTICAL WIRE STRAND MODEL

Classical structure of wire strand consists of a (1+6) wire where outer circular wires are wound helically around the core circular wire. The proposed model is built using elliptical cross sectional wires instead of circular outer wires. This structure is modeled and meshed using parametrical mathematical equations using Matlab code. A circular cross section of a wire strand is shown in Figure 3-a, while Elliptical Wire Strands (EWS) cross-section is shown in Figure 3-b and EWS meshed model is given in Figure 3-c. Due to the shape of the EWS gap between the outer wires and the center wire is more closer than the circular wire strand. Finite Element Analysis (FEA) is done using the EWS model and the von-misses stress distribution over the strand is shown in Figure 4. During the analysis one end of the EWS is constraint with encastre boundary condition while the other end displaced in the z direction. The stress distribution along the wire strand shows the general characteristics of wire strand. Displacement distribution and contact pressure distribution over center and two outer elliptic wires are shown in Figure 5-a and Figure 5-b respectively. The contact pressure shows contact area along outer wires in Figure 5-b.

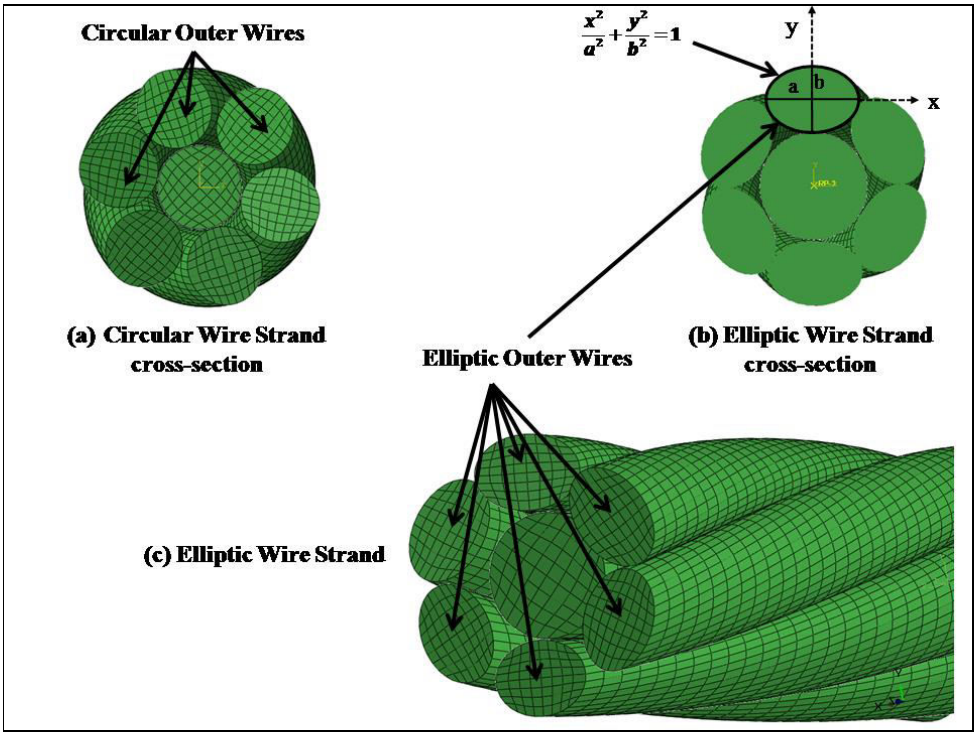


Figure 3. (a) (1+6) Circular Wire Strand, (b) (1+6) Elliptical Wire Strand Cross-Section, (c) (1+6) Elliptical Wire Strand Meshed Model

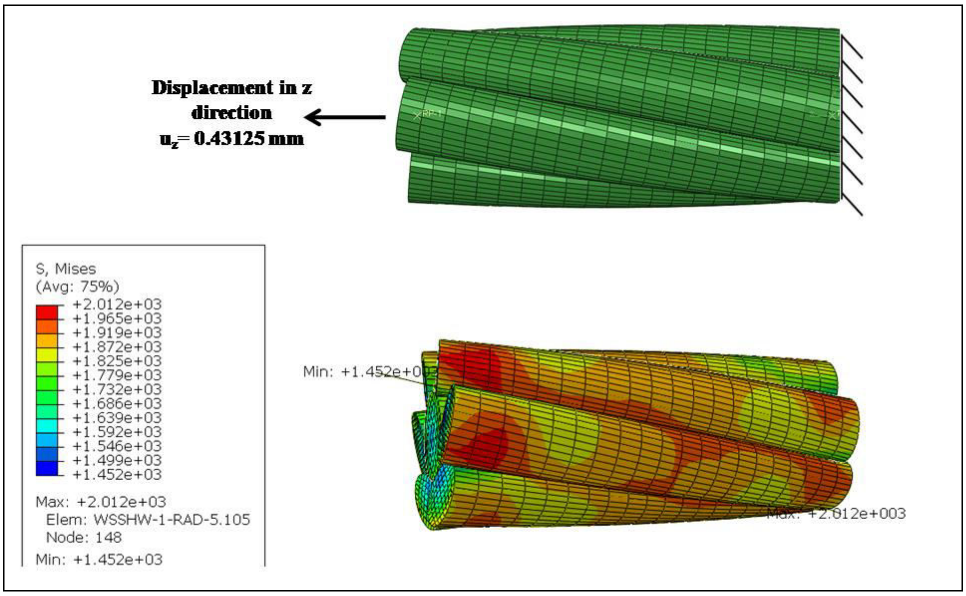


Figure 4. Von-Misses Stress Distribution over an Elliptical Wire Strand

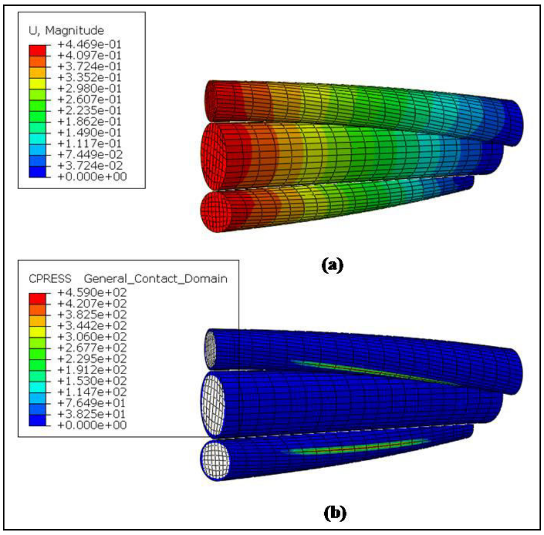


Figure 5. (a) Displacement Distribution on EWS, (b) Contact Force Along the EWS

4. CONCLUSION

Wire strands are modeled with using circular wires around a single straight wire in general. To build more compact wire strands with reduced gaps between center wire and outer wires, elliptical outer wires are used in this study. This structure is named as elliptic wire strand (EWS) and it is modeled and meshed using parametrical mathematical equations using Matlab code. The finite element analysis (FEA) of the proposed model is run and the results show the general behavior of the wire strands. The proposed study is going to be the generation for the other complex forms as future works.

REFERENCES

[1] Costello, G.A. (1990). ***Theory of Wire Rope***, Berl: Springer.

[2] Velinsky, S.A., Anderson, G.L., and Costello, G.A. (1984). "Wire Rope With Complex Cross Sections", ***Journal of Engineering Mechanics***, vol. 110, no. 3, pp.380-391.

[3] Nawrocki, A. and Labrosse M. (2000). "A Finite Element Model for Simple Straight Wire Rope Strands", ***Computers and Structures***, 77, 345-359.

[4] Jiang, W.G., Yao, M.S., and Walton, J.M. (1999). "A Concise Finite Element Model for Simple Straight Wire Rope Strand***",*** ***International Journal of Mechanical Sciences***, vol.41, pp.143-61.

[5] Elata, D., Eshkenazy, R., and Weiss, M.P. (2004). "The Mechanical Behavior of a Wire Rope with an Independent Wire Rope Core", ***International Journal of Solids and Structures***, 41, 1157–1172.

[6] Erdönmez, C., and İmrak, C.E. (2011). "A Finite Element Model for Independent Wire Rope Core with Double Helical Geometry Subjected to Axial Loads", ***SADHANA-Academy Proceedings in Engineering Sciences,*** vol.36, pp.995-1008. DOI: 10.1007/s12046-011-0053-1.

[7] Erdönmez, C., and İmrak, C.E. (2011). "Modeling Techniques of Nested Helical Structure Based Geometry for Numerical Analysis", ***Strojniški vestnik - Journal of Mechanical Engineering***, vol. 57,no.4, pp.283-292. DOI:10.5545/sv-jme.2009.006.

[8] Eva, S., Gabriel, F., Stanislav, K., Molnar, V., and Micheal, F. (2015). "Finite Element Analysis of Spiral Strands with Different Shapes Subjected to Axial Loads", ***Advances in Engineering Software***, vol.83, pp.45-58. DOI:10.1016/j.advengsoft.2015.01.004.

Journal of Naval Sciences and Engineering
2018, Vol. 14, No.2, pp.100-109
Basic and Social Sciences/Temel ve Sosyal Bilimler

RESEARCH ARTICLE

REFLECTIONS AND SUGGESTIONS ON CROSS-COUNTRY ELECTRONIC SERVICES FOR TRANSPORTATION, LOGISTICS AND FOOD SUPPLY CHAIN

Tunç MEDENİ[1]
Tolga MEDENİ[2]
Demet SOYLU[3]

[1]Ankara Yıldırım Beyazıt University, Ankara, Turkey,
tuncmedeni@gmail.com
[2]Ankara Yıldırım Beyazıt University, Ankara, Turkey,
tolgamedeni@gmail.com
[3]Ankara Yıldırım Beyazıt University, Ankara, Turkey,
bunchnoble@gmail.com

Date of Receive: 15.11.2018 **Date of Acceptance: 26.11.2018**

ABSTRACT

This paper aims to reflect on the increasing need for the electronic cross-country service provision, and provide certain solution suggestions to address related issues, benefiting from the experience and expertise of the coauthors. While the current state is being presented and suggestions are being provided, examples from transportation and logistics areas are given, with a particular focus on food supply chain and thus technology support in agriculture and livestock management activities. Accordingly, the paper is finalised with a specific suggestion on block-chain-based cross-country information system for livestock supply chain management. The resulting work is hoped to contribute to the development and provision of high quality, user-oriented electronic cross-country services.

Keywords: *Cross-Country Electronic Services, Information Systems for Farmers, Agriculture and Livestock Management, Block-Chain, E-Government*

ULAŞIM, LOJİSTİK, GIDA TEDARİK ZİNCİRİ ALANLARINDA ÜLKELER-ARASI ELEKTRONİK HİZMETLERE YÖNELİK DÜŞÜNCELER, ÖNERİLER

ÖZ

Bu çalışma, ortak yazarların tecrübe ve deneyimlerinden yararlanarak, ülkeler arası elektronik hizmet sunumuna yönelik artan ihtiyacı değerlendirmeyi ve ilgili hususlarda çözüm önerileri getirmeyi amaçlamaktadır. Mevcut durum ele alınırken ve öneriler getirilirken, ulaşım ve lojistik alanlarından örnekler verilmekte olup, yiyecek tedarik zinciri ve dolayısıyla tarım ve hayvancılık yönetimi aktivitelerinde teknoloji desteğine özel olarak odaklanılmaktadır. Buna dayalı olarak çalışma, bir blok-zinciri temelli, canlı hayvan tedarik zinciri yönetimi için önerilen ülkeler arası enformasyon sistemi önerisi ile sonuçlandırılmaktadır. Ortaya çıkan çalışmanın, yüksek kalitede, kullanıcı odaklı ülkeler-arası elektronik hizmetlerin geliştirilip sunulmasına katkıda bulunması ümit edilmektedir.

Anahtar Kelimeler: *Ülkeler-arası Elektronik Hizmetler, Tarım, Hayvancılık ve Çiftçiler İçin Bilgi Sistemleri, Blok-Zinciri, E-Devlet*

1. INTRODUCTION

In today's global world, it is no surprise that there is an increasing awareness and recognition of the need for cross-country electronic services. For instance, European Commission underlines the cross-country mobility for businesses and citizens, "as one of the main objectives of the EU eGovernment Action Plan 2016-2020" [1]. Here the key enablers, eID and eDocuments are of vital importance, especially eIDAS Regulation coming into full force (pp. 30-37). Accordingly, for instance, Europol's SIRIUS portal already responds to the goal of "establishing an online information and support portal at EU level to provide support to online investigations, including information on applicable rules and procedures." [2] (pp. 3-4)

However, there is still work to be done in order to diffuse the use of electronic cross-country services [1]. in all areas, based on a life-cycle or life event approach, similar to those adapted to national services. For instance, an example recently experienced by the coauthors could be given from the transportation area:

For a train travel between Poland and Germany in September 2018 tickets were bought using credit card at the Germany company website, before departing from home, Ankara, Turkey. A mail was received, acknowledging the completion of the online transaction. Meanwhile additional postal service charge was being paid to receive the tickets, as the system did not give the digital tickets. Before starting out the train trip from Warsaw Central Train Station, the counters of the relevant company were visited and it was confirmed that showing the mail version on the train would be enough for the ticket control. However, on the train the Polish officials did not accept these documents for already-bought tickets and forced to buy new tickets, behaving in a very impolite, humiliating and even threatening way in public space. Despite their pre-paid and pre-reserved/pre-bought seats, the coauthors were treated as if they did not do so, experiencing a very negative customer service that spoiled their trip. They were also told that on German border the crew would change and they would ask the help of the German team. But the German side on the train and in the arrival station were also not very useful, and as of this paper is written, the issue still remains unsolved, while a response being expected from the German company headquarters at least for the return of the initial ticket payments.

As far as the coauthors are concerned, this example is a very good case of how cross-cultural services could go terribly wrong. A number of solutions to address the related issues could be to enable the issuing of electronic tickets or other documents that are acceptable on both the departure and arrival country sides. Or the online system should at least give proper warnings to prevent such cases to happen in reality. Over all the companies should assume full responsibilities for the whole trip, rather than splitting them to be valid only for their sides until the border.

This paper, accordingly, aims to investigate further the related issues with respect to electronic cross-country service provision, and provide certain solution suggestions to address them. In accordance with the Journal theme, while transportation, logistics, and supply chain areas will be underlined, a specific attention will also be given to food supply chain and thus technology support in agricultural & livestock management activities.

2. INFORMATION SYSTEMS FOR AGRICULTURE AND LIVESTOCK MANAGEMENT, AND THEIR APPLICATIONS IN TURKEY AND EUROPE AS CROSS-COUNTRY ELECTRONIC SERVICES

Since the development of agriculture, most of the food needed to feed the population has been produced through industrialized agriculture. Although industrialized agriculture has been successful in producing large quantities of food, the future of food production is in jeopardy due to problems in agriculture. Two of the most major problems in agriculture are the loss of agricultural land and the decrease in the varieties of crops and livestock produced. This is mostly caused by the use of wrong farming methods which decrease the quality of community living in rural aspect. Second significant problem is low level of environmental, farming literacy of farmers and their lack of knowledge in farming technologies. In places where economy is mostly based on agriculture, it is crucial to meet the information needs of farmers and enable their farming capacity in accordance with developments, fluctuating innovations with Industry 4.0 and farming sectors becoming digital as well for national development [3]. Agricultural productivity and yield can basically be enhanced through information and technology [4].

Farmers and farmer groups are as vital as other stakeholders such as authorities in municipalities, businessmen, traders, non-governmental organizations, among others, in a rural community. Farmers have a capacity and power to control their environment. They all need and share information about politics, finance, market, technology and in relevant fields.

In their agricultural activities, farmers encounter problems such as unfertilized crops and products which leads to the negative fluctuations in the economy, dying plants due to the misuse of pesticides and wrong irrigation methods. Routinely-faced problems in the agricultural working field leads to the loss of motivation and efficiency in the professional-based daily activities of the farmers. Among different professional groups, farmers are one of the key groups who need agricultural information and information about recent farming technologies in everyday life.

As Turkey has been progressing well on national e-government systems ([5] based on [6]), "E-Government-Gateway (EGG) provides various services for Turkish farmers", for instance enabling them access to services of Ministry of Food, Agriculture and Livestock [7] (p. 21.) As a result of these services, for example, it is practically possible to access to the records of a cattle and check whether the information given in the "Feast of Sacrifice" market by the seller about the age of an animal is true or not.

Such information systems are designed for and effectively work at national scale. However, for cases where international transactions are involved it is hard to find and give examples of such systems. As one recent controversial case about animals imported from Brazil by Turkey before the 2018 "Feast of Sacrifice", there have been questions on "how the authorities allowed those 'infected animals' to enter the country", whereas the official rule is stated to be that "all animals imported into the country are quarantined at a specific site and tests are run on those animals for 21 days to make sure they do not have any diseases before they are allowed to be sold on the market." [8] While this case raises serious public concerns on food security and safety [9], issues on animal rights and the health conditions in the related logistics operations are also highlighted by different parties (for example, [10]).

Such issues and risks that emerge as part of international logistics and supply chain operations could be addressed and mitigated, benefiting from a cross-country information system. There are various examples of such systems. For instance, STORK/STORK 2.0 and e-SENS projects, in which Turkish institutions were also involved, developed an authentication and authorization, as well as information and document sharing system across different countries in Europe [11, 12]. In eSENS project, for instance, "a cross-border farmer from a German border area can authenticate himself/herself using his own e-ID to log in to the Dutch agricultural portal. He can access all digitally available services, such as applying for European agricultural subsidies, and can comply with agricultural regulations in such matters as the registration of cattle." (eSENS Agriculture Pilot, Figure 1, [13])

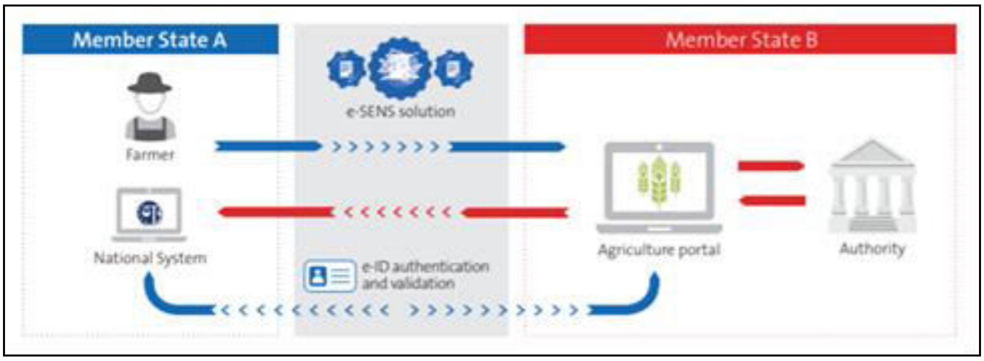


Figure 1. eSENS Agriculture Pilot Use Case Scenario (Source: [14])

3. A SUGGESTION FOR BLOCKCHAIN-BASED CROSS-COUNTRY INFORMATION SYSTEM FOR LIVESTOCK SUPPLY CHAIN MANAGEMENT

Based on the information provided above, combination of new technologies such as Internet of Things (IoT) applications and block-chain mechanisms / smart contracts could be utilized to support information systems for agriculture and livestock management. These could enable smarter and more secure and effective systems for such cross-country or intercontinental operations. For instance, health situation of animals on the transport ships could be monitored by a cloud IoT tool (please see, for example, [15]) as part of a business transaction determined by predefined smart contracts (Figure 2).

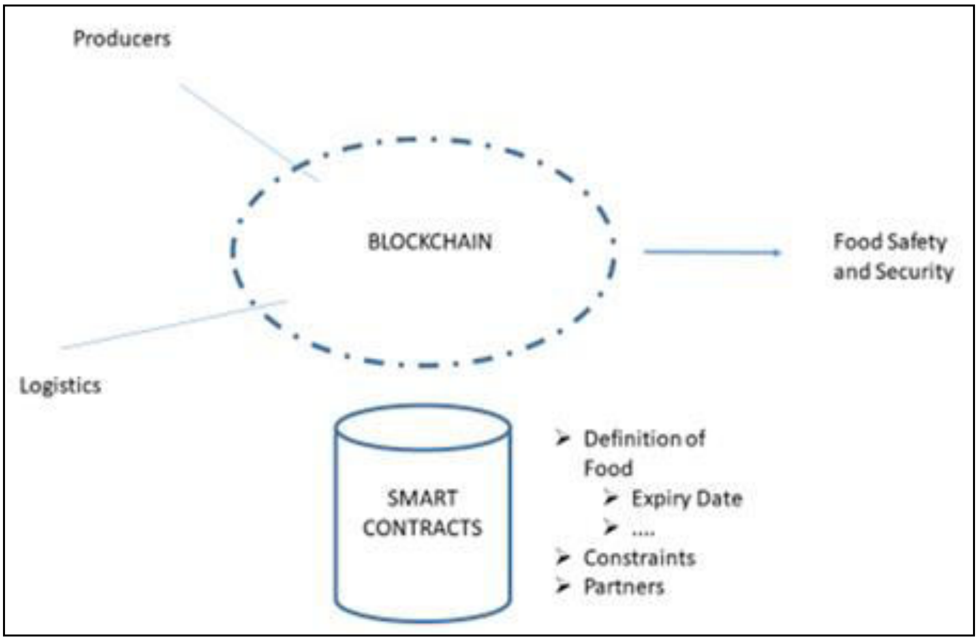


Figure 2. Block-Chain-Based Smart Contract Structure for Cross-Country Secure Live-Stock Supply Chain Management

Benefiting from such system, a specific constraint, for instance, could be not to have more than 1 sick animal during the transportation. If more ill animals are identified via health monitoring then the conditions of the contract are not met and the animals are not accepted. Such systemic solutions could prove to be very useful to address public trust, especially for travels that last more than the quarantine period, which also happen due to delays because of forced fares between ports that do not accept the ships with troublesome cargo. These could at least stop controversies on where and when responsibilities start and end.

Similarly, different contract terms could address other partners' and stakeholders' concerns and requirements. As a result a smooth, effective cross-country operation that addresses issues on food security and safety, as well as animal rights, among others, can be ensured.

The examples with respect to cross-country service provision in transportation and logistics areas could also be increased. Customs and other border transactions could also be added to these. Furthermore, examples could be expanded, considering other life areas and activities. Transactions of life and health insurance that arise when a citizen of a country visits another country where and when s/he experiences health problems could be given one example to the possible occurrences with respect to these different life events. Such scenarios could be studied by cross-country teams to provide reliable, working solutions to real life problems.

4. CONCLUSION

Cross-country services and transactions have become an inseparable part of socio-economic life, and information and communication services would play a significant part on developing and providing user-oriented, quality applications across borders that integrate online and offline business processes. Transportation and logistics, as well as food supply chain are among the key areas with respect to these online cross-country services. This paper has presented a current state analysis of and suggested solutions to the related issues, providing selected examples relevant to these areas. The analysis and suggestions come from coauthors' experience and expertise, and mainly provide a selective perspective at Turkey-level and its relations with EU and overseas. Still it is hoped that the information and ideas shared in this paper would be helpful for academicians and practitioners who would work on electronic cross-country service development in the future.

REFERENCES

[1] European Commission. (2017a). ***eGovernment Benchmark 2017: Taking Stock of User-Centric Design and Delivery of Digital Public Services In Europe.*** Retrieved from https://www.capgemini.com/wp-content/uploads/2017/11/2017-egovernment-benchmark_background_v7.pdf (Access Date: 15.10.2018).

[2] European Commission. (2017b). ***Improving Cross-Border Access to Electronic Evidence: Findings from the Expert Process and Suggested Way Forward.*** Retrieved from https://ec.europa.eu/home-affairs/sites/homeaffairs/files/docs/pages/20170522_non-paper_electronic_evidence_en.pdf (Access Date: 15.10.2018).

[3] Meitei, L.S., and Devi, T.P. (2009). "Farmers Information Needs In Rural Manipur: An Assessment". ***Annals of Library and Information Studies***. vol.56, pp.35-40.

[4] Opara, U.N. (2008). "Agricultural Information Sources Used By Farmers In Imo State, Nigera". *Information Development*. vol.24, no. 4, pp.289-295.

[5] E-devlet. (2018). ***2018 Birleşmiş Milletler e-Devlet Ölçümleme Raporu Yayınlandı***. Retrieved from http://www.edevlet.gov.tr/2018/07/21/2018-birlesmis-milletler-e-devlet-olcumleme-raporu-yayinlandi/ (Access Date: 14.11.2018).

[6] United Nations. (2018). ***United Nations E-Government Survey 2018: Gearing E-Government To Support Transformation Towards Sustainable And Resilient Societies.*** UN. Retrieved from https://publicadministration.un.org/egovkb/portals/egovkb/documents/un/2018-survey/e-government%20survey%202018_final%20for%20web.pdf (Access Date:15.10.2018).

[7] Soylu, D., Cevher, N., Schirone, M., and Medeni, T. (2016). "A Comparative Study of Information-Seeking Behavior and Digital Information Needs of Farmers in Turkey and Sweden". ***International Journal of E-Business and E-Government Studies***,

vol.8, no.2, 2016, ISSN:2146-0744 (Online) Retrieved from http://www.sobiad.org/ejournals/journal_ijebeg/arhieves/2016_1-2/DemetSoylu.pdf

[8] Görgülü, E. (2018). "Anthrax-Infected Cattle Imports from Brazil Worry Local Breeders in Ankara", ***Hürriyet***. Retrieved from http://www.hurriyetdailynews.com/anthrax-infected-cattle-imports-from-brazil-worry-local-breeders-in-ankara-136275 (Access Date: 14.11.2018).

[9] Saltık, A. (2018). "ODATV'de Şarbon Hakkında Söyleşi" Retrieved from http://ahmetsaltik.net/2018/09/30/odatvde-sarbon-hakkinda-soylesi/#comments (Access Date: 14.11.2018).

[10] HAKİM. (2018). "HAKİM: Talebimiz Hayvanların İyi Koşullarda Nakli Değil, Özgürlükleri" News by Pelin Denizli. Retrieved from https://m.bianet.org/bianet/saglik/200663-hakim-talebimiz-hayvanlarin-iyi-kosullarda-nakli-degil-ozgurlukleri (Access Date: 15.10.2018).

[11] European Commission. (2015). "The End of STORK 2.0: Major Achievements in Making Access to Mobility In EU Smarter" Retrieved from https://ec.europa.eu/digital-single-market/en/news/end-stork-20-major-achievements-making-access-mobility-eu-smarter (Access Date: 14.11.2018).

[12] eSENS. (2017a). "eSENS" Retrieved from https://www.esens.eu (Access Date: 14.11.2018).

[13] eSENS. (2017b). "E-Agriculture" Retrieved from https://www.esens.eu/content/e-agriculture (Access Date: 14.11.2018).

[14] eSENS. (2017c). "E- Agriculture Pilot" Retrieved from https://www.esens.eu/sites/default/files/fs_eagriculture.pdf (Access Date: 14.11.2018).

[15] Saravanan, K., and Saraniya, S. (2018). "Cloud IOT based novel livestock monitoring and identification system using UID", ***Sensor Review***, vol.38, no.1, pp.21-33. https://doi.org/10.1108/SR-08-2017-0152.

Journal of Naval Sciences and Engineering
2018, Vol. 14, No.2, pp.110-120
Basic and Social Sciences / Temel ve Sosyal Bilimler

RESEARCH ARTICLE

A COMPLEX DISCRETIZED 3D WIRE ROPE MODEL CREATION AND ITS NUMERICAL ANALYSIS: 6X25 FILLER IWRC

Cengiz ERDÖNMEZ[1]

[1]*Basic Sciences, National Defense University, Tuzla, Istanbul, Turkey,*
cerdonmez@dho.edu.tr

Date of Receive: 19.11.2018 **Date of Acceptance: 26.11.2018**

ABSTRACT

6x25 Filler IWRC type ropes belong to 6x19 rope class. It is widely used in 6x19 wire rope class in almost all industrial sectors. Filler type rope has good balance in both wear and fatigue resistance. Drilling lines, cranes, lifting devices, bridges, oil drilling rig, elevators etc. are some of the usage areas. 25 Filler wire strand (1-6-6f-12) consists of two layers of uniform-size wire around a center wire with the inner layer and small filler wires are laid in the holes of the inner layer. In this paper, three-dimensional meshed model of 6x25 Filler IWRC was created by using parametric equations. Using the proposed three-dimensional model, a finite element analysis is conducted by applying displacement boundary condition to one end and encastre boundary condition is applied to the other end of the wire rope. The results of the analysis show that the proposed model can be used in analysis studies under different loading conditions.

Keywords: *6x25 Filler IWRC, Filler Wire Strand, Meshed Model*

KOMPLEKS AYRIKLAŞTIRILMIŞ 3D TEL HALAT MODELİNİN OLUŞTURULMASI VE SAYISAL ANALİZİ: 6X25 FILLER IWRC

ÖZ

6x25 Filler IWRC tipi halatlar 6x19 halat sınıfına aittir. Neredeyse tüm endüstri sektöründe 6x19 tel halat sınıfında yaygın olarak kullanılmaktadır. Filler tipi halat hem aşınma direnci, hemde yorulma direnci açısından iyi bir dengeye sahiptir. Sondaj hatları, vinçler, kaldırma tertibatları, köprüler, petrol sondaj kuleleri, asansörler vb. alanlarda kullanılmaktadırlar. 25 Filler tel demeti (1-6-6f-12), merkez telin etrafına sarılı iki katmanlı tekdüze tellerden oluşturulmuş olup dolgu telleri bu iki katman arasındaki boşluklara yerleştirilmiştir. Bu yazıda, 6x25 Filler IWRC'nin üç boyutlu sayısal örgü modeli, parametrik denklemler kullanılarak oluşturulmuştur. Önerilen üçboyutlu halat modelinin bir ucuna enkastre diğer ucuna ise yer değiştirme sınır koşulları uygulanarak sonlu eleman analizi gerçekleştirilmiştir. Elde edilen analiz sonuçları, önerilen modelin farklı yükleme koşullarında yapılacak analiz çalışmalarında kullanılabileceğini göstermektedir.

Anahtar Kelimeler: *6x25 Filler IWRC, Filler Tel Demet, Sayısal Örgü Modeli*

1. INTRODUCTION

During last decades importance of wire rope usage is increased in wide variety of application area due to its flexible nature and advantages over traditional solutions. With the diversification of the areas of use, the rope manufacturers focus on research and development activities to produce ropes of different characteristics and types to meet the needs in these areas. There is a need to analyze new designs and productions in engineering field and to report their results. For this purpose, it is necessary to design and manufacture test equipments. In addition test samples needed for the analysis and to perform rope tests under different conditions. The time required to make the required tests, as soon as possible, number of staff needed and the creation of the samples is going to result high costs. In addition there can be difficulties in developing remedies for the problems that may arise during production. One of the best solutions is to use high performance computer technology. The existing high-processor PCs and advanced software allow for the three-dimensional modeling and analysis of such structures.

Researches on modeling and analysis of ropes have been investigated comprehensively. A generalized mathematical model that completely describes the geometry of the wires. The specific model for a 33-mm 6×19 Seale, independent wire rope core (IWRC) was presented by showing the paths and the geometric properties of the wires within the given models in [1]. An accurate wire strand (WS) model is generated using the finite element method (FEM) which accounts tension, shear, bending, torsion, contact, friction and possible local plastic yielding and compared the results with available theoretical and test results in [2]. The nested helical structure (NHS) for wire ropes using 3D solid modeling is presented where the mesh problems using CAD softwares are taken into account and a solution procedure is proposed for the solution in [3]. A new technique of modeling IWRC is presented and the numerical results of the IWRC model compared with the literature in [4]. The single-lay wire strands and double-lay wire ropes models are presented using CATIA 5 in [5]. The development of a finite element model for the numerical simulation of the multi-layered strand under tension are represented in [6]. A more difficult complex helical structures in three-dimensional form which is called triple helical structure is presented and then it is generalized to more complex form of n-tuple helical structures in [7]. The response of a multi-strand wire rope, which is called independent wire rope core (IWRC), subjected to axial tension and axial torque is represented and it is showed that the torsion stress of a double-helix wire can be neglected when the rope is subjected to axial tension while axial torsion is restrained in [8]. A beam finite element model (FEM) presented for efficient analysis of the mechanical behavior of a three layered 19-wire strand using two-noded elastic plastic beam elements in [9]. Three-dimensional modeling approach and finite element analysis of wire ropes are explained and wire-by-wire results are gathered by using the proposed modeling and analysis method under various loading conditions in [10]. In addition a lot of study conducted on the experimental analysis. The response of prestressing strands to axial tensile load is investigated both theoretically and experimentally in [11]. Calculation of irregularity of stress distribution between a core and wires of the steel rope in case of different rates of wire twisting is investigated in [12]. Theoretical and experimental determination of bending over sheave fatigue lifetimes of rotation resistant steel wire ropes has been conducted in [13]. Discard lifetimes of 6 × 36 Warrington-Seale steel wire ropes subjected to bending over sheave (BoS) fatigue have been determined theoretically and experimentally and presented in [14]. Characterize the mechanical behavior of the wire rope in service along with monitoring the evolution of its damage in order to facilitate the determination of the conditions of use reliably is presented in [15]. These experimental analysis can be supported and enhanced by the contributions of the numerical analysis results.

As a result of the literature review, it has been observed that finite element analysis (FEA) of the wire ropes are increased in last decade. Many studies have focused on modeling simple wire rope strands. Recently, more efforts have been focused on IWRC type rope models. Generalization of the rope structures to the n-tuple wire rope structures in focused in [7]. In addition, SEALE type rope model is included in a few studies. However, Filler type wire rope model is not mentioned. For this reason, in this article the design and analysis of a common type of 6x25 Filler type wire rope model is discussed.

2. FILLER IWRC WIRE ROPE STRUCTURE

Filler wire rope is one of the most used rope type in the industry. Most common identification of this class of wire ropes are known under the name of 6x19 class wire ropes. Beyond this class of wire ropes 6x25 Filler IWRC is analyzed in this paper. The core is an 7x7 IWRC which is surrounded by 6 Filler strand which is composed by using (1-6-6f-12) wires. In Figure 1 the general structure of the 6x19 Filler IWRC is presented.

The construction of the Filler IWRC, shown in Figure 1, done by using the parametric mathematical equations of both single and double helical wires as mentioned in the literature [1,3,4,7]. The wire radiuses are labeled as R1-R4 for IWRC in Figure 1. The core inner wire strand of the IWRC is composed by using a straight wire which is nested by 6 simple helical wires. But the outer strands of the IWRC includes both single and double helical wires. The single helix geometry centerline $\left(x_s, y_s, z_s\right)$ of the outer strand of the IWRC is obtained by the following formula,

$$x_s = r_s \cos(\theta_s), \;\; y_s = r_s \sin(\theta_s), \;\; z_s = r_s \tan(\alpha_s)\theta_s , \tag{1}$$

where r_s shows the radius of the center wire of the outer strand and α_s shows the helix angle of the outer strand. The outer strand single helical of the IWRC is surrounded by six double helical wires and its centerline $\left(x_d, y_d, z_d\right)$ is defined in parametric form as,

$$\begin{aligned} x_d &= x_s(\theta_s) + r_d \cos(\theta_d)\cos(\theta_s) - r_d \sin(\theta_d)\sin(\theta_s)\sin(\alpha_s), \\ y_d &= y_s(\theta_s) + r_d \cos(\theta_d)\sin(\theta_s) + r_d \sin(\theta_d)\cos(\theta_s)\sin(\alpha_s), \\ z_d &= z_s - r_d \sin(\theta_d)\cos(\alpha_s), \end{aligned} \tag{2}$$

where r_d shows the radius of the double helical wire and θ_d is the rotation angle of the double helical wire around the single helical wire. The relation between the rotation angles given in [7]. Using the Equations (1) and (2) centerlines of the single and double helical geometries can be obtained.

The next step is to construct the 25 wire Filler Strand and to wound it around the IWRC. The 25 wire Filler strand is composed by a single helical wire as a core and two lays of outer double helical wires. Wire radiuses for the Filler strand is labeled as R5-R8 in Figure 2. First layer has 6 double helical wires while the second layer has 12 double helical wires. There exists 6 double helical wires between the first and the second layers. Figure 2 shows one of the Filler strand which is wound helically around the IWRC. A sector of this Filler strand is defined in Figure 2. Two new important lengths to properly define the centerline of each double helical wires within the Filler IWRC is represented by r_7 and r_8 in this sector view. Using these lengths, r_7 and r_8, one can find the centerline of each double helical structure within the Filler strand in the similar way of double helical wires defined for IWRC in Equation 2. The wire radiuses and pitch lengths are given for the 6x25 Filler IWRC in Table 1.

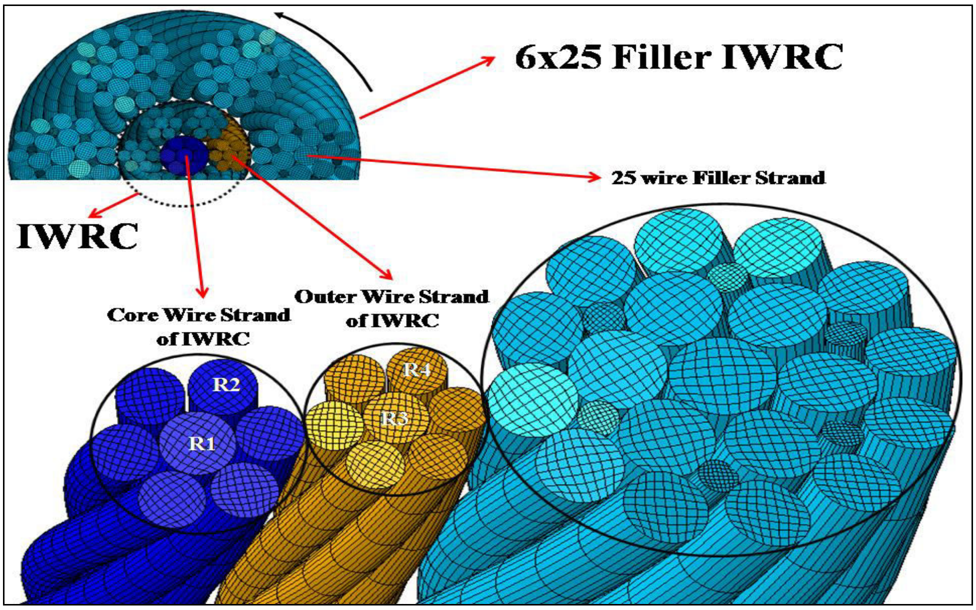


Figure 1. Composition of the 6X25 Filler IWRC Structure

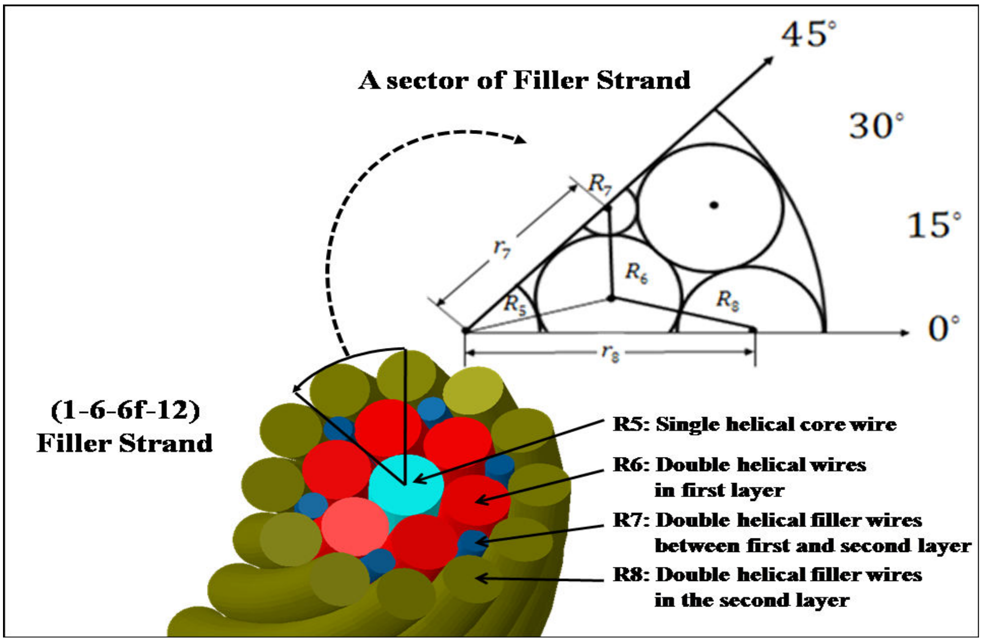


Figure 2. (1-6-6f-12) Wire Filler Strand Radiuses and a Sector of Filler Strand

Table 1. Wire Radiuses and Pitch Lengths for 6x26 Filler IWRC

Labels	Radiuses	Pitch lengths
R1	0.343*mm*	-
R2	0.305*mm*	35.74*mm*
R3	0.292*mm*	88.48*mm*
R4	0.267*mm*	35.82*mm*
R5	0.483*mm*	82.89*mm*
R6	0.445*mm*	33.07*mm*
R7	0.191*mm*	33.18*mm*
R8	0.406*mm*	45.88*mm*

3. THREE-DIMENSIONAL MESHED MODEL AND STRESS ANALYSIS

Using the Equations (1) and (2) double helical geometries are prescribed for each wire within the IWRCs and Filler Strands. It has been presented in [3] that the discretized meshed model of wire ropes are very difficult most of the time. For this reason a Matlab code is developed to model which uses the proposed parametrical equations to generate meshed model of each wire within 6x25 Filler IWRC. This code generates 199 wires which constructs the whole model of the 6x25 Filler IWRC in 3D and gives a text output. This output file can be imported by using Abaqus/CAE and the FEA is run on this 3D meshed model. The benefit of this code is that it only takes a few minute, depending on the length of the wire rope you need to generate, to produce the meshed model of the wire rope. So any changes on the wire radiuses or the helix angles can be re-meshed within a few minutes again.

The last step is the FEA of the proposed model of the 6x25 Filler IWRC. The numerical analysis of the proposed model is conducted using Abaqus/CAE. The length of the model is 20*mm*. Encastre boundary condition is applied to one end while the displacement boundary condition is applied to the other end. Only 0.43125*mm* displacement is applied for the analysis. In the proposed model total number of nodes, Total number of elements and number of linear hexahedral elements of type C3D8R are used as 360855, 272384 and 272384 respectively. Von-misses stress and strain distribution on the 6x25 Filler IWRC are represented in Figure 3 and Figure 4 respectively. The results are represented for selected strands and wires along the model to see the distributions over the wires inside the 6x25 Filler IWRC. From the Figure 4 and Figure 5 it can be observed that the stress and strain distributions along the wires on the model shows the general characteristics of the wire ropes. Meanwhile it can be obtained that the stress and strain values are increasing at the contact areas as expected. At the same time due to contact center wires of each strand becomes more important for the whole model.

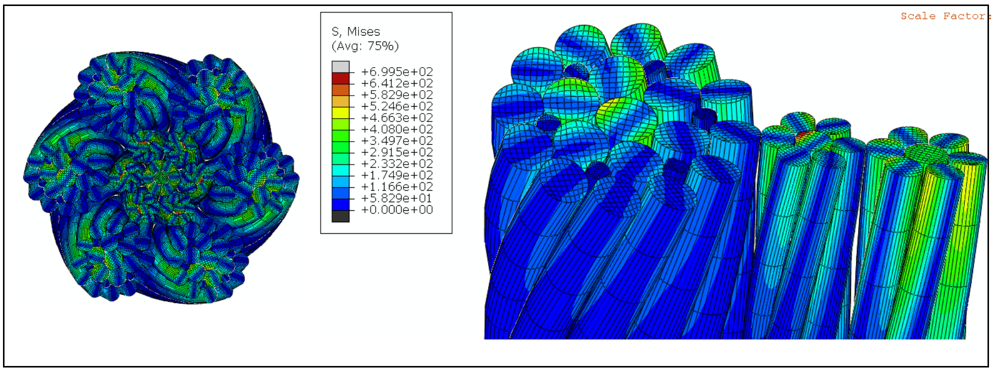


Figure 3. Von-Misses Stress Distribution Along Filler IWRC

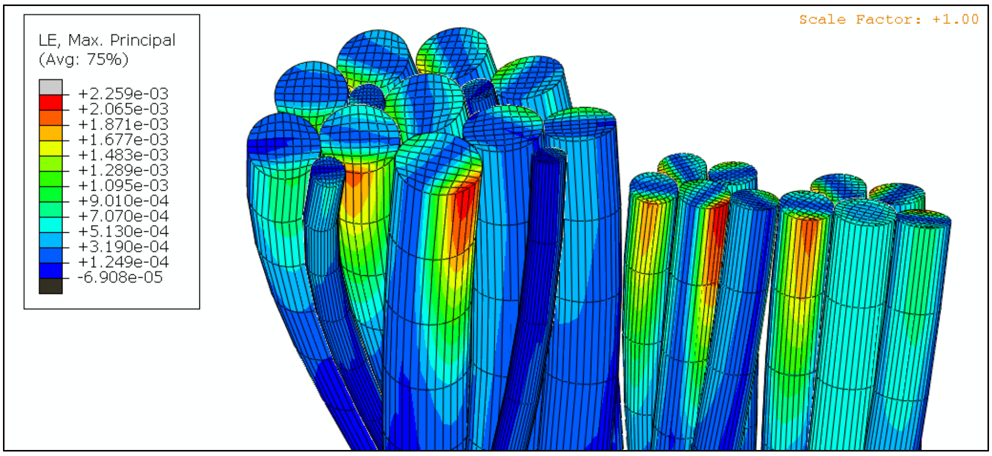


Figure 4. Logarithmic Strain Components Along Filler IWRC on Selected Wires

4. CONCLUSION

6x25 Filler IWRC is one of the most popular design along the class of 6x19 wire ropes in the industry. The most important issue that manufacturers work on is undoubtedly to produce more durable wire ropes which can work under the desired conditions. One of the way to achieve this is to do research and development on the design of wire ropes. Instead of expensive and long-term testing, it is possible to improve the products through numerical analysis studies in the industry. For this purpose three-dimensional modelling and analysis of 6x25 Filler IWRC ropes are discussed in this paper. The parametric mathematical model of the rope has been converted into a ready-made design by means of an intermediate program code written using Matlab. Then the finite element analysis of this meshed model performed under the displacement boundary conditions. The results show that the core wires of the strands are important for the rope and the elongation and stress distribution are increasing towards the center of each IWRCs and Filler strands. This study shows that the three-dimensional model of the 6x25 Filler IWRC can be build easily using the proposed Matlab code correctly and gives expected FEA results. It is thought that the present study will guide the other researchers to do more complicated analysis in the future.

REFERENCES

[1] Wang, R.C., Miscoe, A.J., and McKewan, W.M. (1998). "Model for the Structure of Round-Strand Wire Ropes", ***U.S. Department of Health and Human Services,*** Pittsburgh, PA, Publication No. 98-148, Report of Investigation RI 9644, September 1998.

[2] Jiang, W.G., Yao, M.S., and Walton, J.M. (1999). "A Concise Finite Element Model for Simple Straight Wire Rope Strand", ***International Journal of Mechanical Sciences***,vol.41, pp.143-61.

[3] Erdönmez, C., and İmrak, C.E. (2011). "Modeling Techniques of Nested Helical Structure Based Geometry for Numerical Analysis", ***Strojniški vestnik - Journal of Mechanical Engineering***, [S.l.], vol. 57, no.4, pp.283-292. ISSN 0039-2480.

[4] İmrak, C.E., and Erdönmez, C. (2010). "On the Problem of Wire Rope Model Generation with Axial Loading", ***Mathematical and Computational Applications***, vol.15, no.2, pp.259-268.

[5] Stanova, E., Fedorko, G., Fabian, M. and Kmet, S. (2011). "Computer Modelling of Wire Strands And Ropes Part I: Theory and Computer Implementation", ***Advances in Engineering Software***, vol.42, no.6, pp.305–315.

[6] Stanova, E., Fedorko, G., Fabian, M. and Kmet, S., (2011). "Computer Modelling of Wire Strands and Ropes Part II: Finite Element-Based Applications", ***Advances in Engineering Software***, vol.42, no.6, pp.322-331.

[7] Erdönmez, C. (2014). "N-Tuple Complex Helical Geometry Modeling Using Parametric Equations", ***Engineering with Computers***, vol:30, no.4, pp.715-726. DOI:10.1007/s00366-013-0319-9.

[8] Xiang, L., Wang, H.Y., Chen, Y., Guan, Y.J., Wang, Y.L., and Dai, L.H. (2015). "Modeling of Multi-Strand Wire Ropes Subjected To Axial Tension and Torsion Loads", ***International Journal of Solids and Structures***, vol.58, pp.233-246. ISSN 0020-7683.

[9] Yu, Chunlei, Jiang, W., Liu, C., and Cui, J. (2017). "A Beam Finite Element Model for Efficient Analysis of Wire Strands", ***International Journal of Performability Engineering***, vol.13, no.3, 315-322. 10.23940/ijpe.17.03.p7.315322.

[10] Erdönmez, C., and İmrak, C.E. (2011). "A Finite Element Model for Independent Wire Rope Core With Double Helical Geometry Subjected To Axial Loads", ***Sadhana***, 36(6), pp. 995-1008.

[11] Onur, Y.A. (2016). "Experimental and Theoretical Investigation of Prestressing Steel Strand Subjected to Tensile Load", ***International Journal of Mechanical Sciences***, vol.118, pp.91-100.

[12] Musikhin, V.A. (2016). "Determination of a Real Strain-stress State of the Steel-wire Rope Elements", ***Procedia Engineering***, vol.150, pp.1848-1852. ISSN 1877-7058.

[13] Onur, Y.A., İmrak, C.E. and Onur, T.Ö. (2017). "Investigation on Bending Over Sheave Fatigue Life Determination of Rotation Resistant Steel Wire Rope", ***Experimental Techniques***, 41(5), pp. 475-482.

[14] Onur, Y.A. and İmrak, C.E. (2017). "Discard Fatigue Life of Stranded Steel Wire Rope Subjected to Bending Over Sheave Fatigue", ***Mechanics & Industry***, 18 (2), 223.

[15] Mouradi,H., Barkany, A.E. and Biyaali, A.E. (2018). "Steel Wire Ropes Failure Analysis: Experimental Study", ***Engineering Failure Analysis***, vol.91, pp.234-242.

Journal of Naval Sciences and Engineering
2018, Vol. 14, No.2, pp.121-139
Industrial Engineering/Endüstri Mühendisliği

RESEARCH ARTICLE

AN INTEGRATED FAHP-FGP APPROACH FOR ROUTE SELECTION IN A DISRUPTED TRANSPORT NETWORK

Yaşanur KAYIKCI[1]

[1]Industrial Engineering, Turkish-German University, Beykoz, Istanbul, Turkey,
yasanur@tau.edu.tr

Date of Receive: 21.11.2018 **Date of Acceptance: 27.11.2018**

ABSTRACT

An efficient, effective and sustainable freight transport network is a crucial determinant for economic growth and development. This network needs to be structured as resilient as practicable and also quickly adoptable and adaptable to meet the needs of transport users and provide alternative optimal routes, if it is affected by disruptive events. This paper presents a route selection model which supports transport planners to decide rapidly on an optimal transport route in case of disruption in a multimodal freight transport network. An integrated method based on Fuzzy Analytic Hierarchy Process and Fuzzy Goal Programming is developed to support the decision of route selection.

Keywords: *Multimodal Transport, FAHP, FGP, Disruption, Decision Support*

KESİNTİYE UĞRAMIŞ KOMBİNE YÜK TAŞIMACILIĞI AĞI İÇİN BİR BÜTÜNLEŞİK FAHP-FGP ROTA SEÇİMİ YAKLAŞIMI

ÖZ

Ekonomik büyüme ve gelişme için verimli, etkin ve sürdürülebilir bir yük taşımacılığı ağı çok önemli bir belirleyicidir. Bu ağın, uygulanabilir olduğu kadar esnek olması ve yıkıcı olaylardan etkilenmesi halinde kombine yük taşımacılığı operatörleri ve nakliyeciler gibi ulaştırma kullanıcılarının ihtiyaçlarını karşılamak ve alternatif en uygun ulaşım hatlarını sağlamak için hızla benimsenmesi ve uyarlanabilmesi gerekmektedir. Bu çalışma, kombine yük taşımacılığı ağında meydana gelebilecek bir kesinti durumunda, en uygun taşımacılık güzergâhını hızlı bir şekilde seçmek için ulaşım planlayıcılarını destekleyen bir rota seçim modeli sunmaktadır. Bulanık Analitik Hiyerarşi Süreci ve Bulanık Hedef Programlamaya dayalı bütünleşmiş bir yöntem, rota seçim kararını desteklemek için geliştirilmiştir.

Anahtar Kelimeler: *Kombine Taşımacılık, FAHP, FGP, Kesintiye Uğrama, Karar Destek*

1. INTRODUCTION

A well-functioning transport system and infrastructure are important to the economic growth and development. A competitive and sustainable multimodal freight transport network is therefore necessary for companies to plan and execute both domestic and international transport operations. Multimodal transport offers an advanced platform for more efficient, effective and sustainable freight transport network [1] by enabling technical and economic advantages of long distance, high safety and speed of connection, large transport capacity and low costs/tariffs [2]. Multimodal transport is defined as a transport system which integrates at least two different transport modes in a transport chain [3]. A multimodal freight transport network includes different combinations of transport modes such as: rail-road, inland waterway- road, sea-road, sea-rail and so on. Any disruption within a transport network caused by natural disaster (hurricane, flood, tornado, earthquake), traffic condition (road constructions, accident, high traffic jams), weather condition (snow, ice, drifting, wind), technical problem (traffic signal control problem, system failure), wear and tear (road damage from trucks), political issues (changing policies, customs issues) or human factor (strike and lock-out) may affect the system reliability and efficiency and risk overheating [4,5]. These problems may occur at any level and affect all transport modes, furthermore, prevent the goods to be delivered to the final delivery point on-time. Therefore, it is an important goal for decision makers, mostly transport network planners or operators, to offer cost effective, swift, time efficient alternative freight routes for transport users in case of a disruption.

Based on this need, this study proposes an optimal route selection approach using an integrated Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Goal Programming (FGP) methods. FAHP is used to determine weights of each selection criteria, whereas FGP is used to calculate the optimal route in terms of weights of each goal. Finally, a real-world case is included in this study to present the practicality of the proposed approach. The numerical example is solved using LINGO 13.0 software package.

2. MULTIMODAL TRANSPORT NETWORK: RESEARCH FOCUS

Multimodal freight transport, also known in the literature as intermodal transport, combined transport or integrated transport chain, refers a multi-unit transport chain in which transport of goods are moved by the integration of at least two or more different transport modes among road, rail, sea, inland waterway, short-sea shipping and air based on a single multimodal freight transport contract. The goods are carried by using advanced and standardized transport units (mostly trailer, semi-trailer or container), which are received from a departure terminal (origin) in a country by right of Multimodal Transport Providers (MTPs) in transport means (e.g. vessel, train) to a delivery terminal (destination) for delivery in another country [6]. Until end of journey, transport goods are not handled and transport units do not change. Often an MTP or a consortium of MTPs (such as liner shipping provider and railway freight provider) is responsible for the performance of the complete haulage contract from Origin to Destination (O-D) [7].

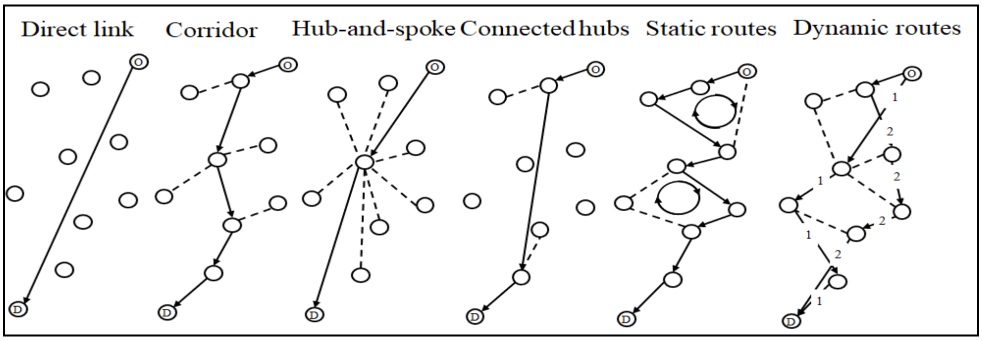


Figure 1. Six Transport Options from Origin to Destination in a Transport Network

There are different types of transport network seen in Figure 1. in order to define routing between O-D: direct link, corridor, hub-and-spoke, connected hubs, static routes, and dynamic routes [8], where the dotted lines refer operationally related routes in the freight transport network. In dynamic routes, two alternative routes are shown. In all other network configuration, the routing is predefined [8]. In the literature, freight consolidation systems are mostly designed as hub-and-spoke networks, with hub being a freight consolidation facility. Locations of hubs are determined and spoke nodes are allocated to these hubs [1]. The hub-and-spoke system is a process whereby the main legs (main-haulage) by carrier haulage between the ocean port and the hub are operated by rail or sea/inland waterways, meanwhile the initial leg (pre-haulage) and final legs (end-haulage) are usually operated by road [9] and these are often offered or arranged by an MTP or an MTP consortium. This concept is a typical illustration of the multimodal transport networks.

Because of its complex nature, multimodal transport networks are characterized by dynamically changing conditions and various modes of transport running on simultaneously. The objectives of relevant interest such as the minimization of cost, time, risk or maximization of service level, reliability, are conflicting goals. Thus, in general, there is no single optimal solution, but rather a set of optimal trade-off solutions, from which the decision maker must select either the most appropriate solution, or the best compromise solution. It is usually assumed that the route selection in multimodal transport network is a multi-goal multi-criteria decision problem which needs to consider both qualitative and quantitative factors evaluating potential routes. Many experts solve this problem based on the mathematical programming models [10] where often the quantitative factors are taken into considerations. In this study, an integrated FAHP and FGP is proposed as a solution methodology, as this method is suitable to process both qualitative and quantitative factors in route selection problem, using FAHP, decision makers can consistently integrate multi expert opinions and effectively determine appropriate weights. With the objective functions of FGP, decision makers can effectively set the upper and lower limits to find the optimal route for each condition.

3. RESEARCH METHODOLOGY

This study is integrated FAHP and FGP to find the optimal route for multimodal transport. A procedure is given in Figure 2. First, FAHP is used to obtain the relative weights of route selection criteria based on different freight conditions. It includes these steps: (1) determine the route selection problem, determine the possible routes (2) identify the selection criteria and construct the FAHP hierarchy, (3) perform the pairwise comparisons, decision makers are interviewed to obtain their opinions by using linguistic variables, (4) calculate weight for each criterion, (5) check consistency if it is not less than 0.10 then the expert is asked to revise his opinion until a consistency is met, (6) determine weights for main goals.

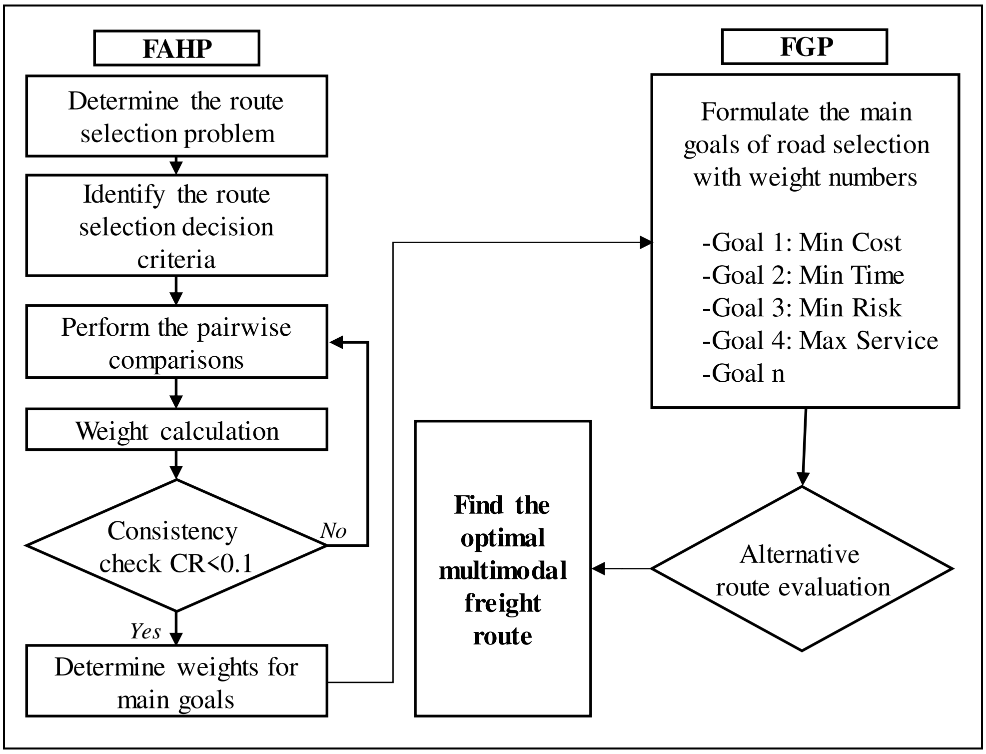


Figure 2. Proposed Route Selection Model by Integration of FAHP and FGP in a Multimodal Freight Transport Network

Second, FGP is utilized to process quantitative evaluation using weight numbers as coefficients of an objective function to determine the optimal route among given alternatives. It includes these steps: (1) Formulate the main goals of road selection with weight numbers that includes cost minimization, time minimization, risk minimization and service maximization. (2) solve FGP and evaluate the potential routes, (3) filter potential routes. Finally, one of these potential routes can be selected as optimal route.

3.1. The Fuzzy Analytic Hierarchy Process

The AHP model, firstly suggested by Saaty [11], is one of the commonly used Multi Criteria Decision Making (MCDM) methods. AHP can effectively address both qualitative and quantitative data to solve problem hierarchically. Therefore, the problem is completely broken down and the relevant sub-criteria are listed with respect to the hierarchical level in relation to the overall objective/goal to the sub-objectives. However, the conventional AHP method may not accurately reflect human judgment. For this reason, AHP with fuzzy extension, namely FAHP approach, using fuzzy set theory and hierarchical structure analysis has been proposed to solve MCDM problems. The basic concept of FAHP [12] is presented as follows:

Step 1: Development of hierarchical structure for the decision-making problem with an overall goal or objective at the top, criteria and sub-criteria at various levels and the decision alternatives at the bottom of the hierarchy.

Step 2: Construction of the fuzzy judgment matrix, $\tilde{M}(a_1 ij$), by using Triangular Fuzzy Numbers (TFNs) with pair-wise comparison as in Equation (1):

$$\tilde{M}(a_{ij}) = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} (1,1,1) & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \frac{1}{\tilde{a}_{12}} & (1,1,1) & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{\tilde{a}_{1n}} & \frac{1}{\tilde{a}_{2n}} & \cdots & (1,1,1) \end{bmatrix} \quad (1)$$

The judgment matrix $\tilde{M}$ is an $n \times n$ fuzzy matrix containing fuzzy numbers $\tilde{a}_{ij}$ (2):

$$\tilde{a}_{ij} = \begin{cases} 1,2,3,4,5,6,7, \quad or \\ 1^{-1}, 2^{-1}, 3^{-1}, 4^{-1}, 5^{-1}, 6^{-1}, 7^{-1}, if\ i \neq j \\ 1, \quad if\ i = j \end{cases} \quad (2)$$

Where $\tilde{a}_{ij} = \tilde{a}_{ij}^{-1}$, and all $\tilde{a}_{ij}$ are TFNs $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$.

Let $X = \{\{x_1, x_2, \dots, x_n\}$ be a set of objectives, whereas $G = \{g_1, g_2, \dots, g_m\}$ be a set of goals. According to the model of fuzzy extent analysis, each object is taken and extent analysis for each goal, g_i, is carried out respectively. Resulting in m extent analysis values for each object can be obtained with $\tilde{M}_{gi}^1, \tilde{M}_{gi}^2, \dots, \tilde{M}_{gi}^m,$ $i = 1,2, \dots, n$, where all the

$\widetilde{M}_{gi}^{j}(j = 1,2, \dots, m)$ are TFNs representing the performance of the object x_i by reference to each goal g_i.

Step 3: The value of fuzzy synthetic extent of the i th object for m goals is determined as:

$$S_i = \sum_{j=1}^{m} \widetilde{M}_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} \widetilde{M}_{gi}^{j}\right]^{-1} \quad (3)$$

To obtain $\sum_{j=1}^{m} \widetilde{M}_{gi}^{j}$ the fuzzy addition operation m extent analysis values for a particular matrix is applied such as

$$\sum_{j=1}^{m} \widetilde{M}_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (4)$$

And to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} \widetilde{M}_{gi}^{j}\right]^{-1}$, the fuzzy addition operation of $M_{gi}^{j}(j = 1,2, \dots, m)$ values is applied such as

$$\sum_{i=1}^{n}\sum_{j=1}^{m} \widetilde{M}_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \quad (5)$$

And then the inverse of the vector above is calculated, such as

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} \widetilde{M}_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (6)$$

The degree of possibility of $\widetilde{M}_1 \geq \widetilde{M}_2$ is defined as:

$$V(\widetilde{M}_1 \geq \widetilde{M}_2) = \sup_{y \geq x}\left[\min\left(\mu_{\widetilde{M}_1}(x), \mu_{\widetilde{M}_2}(y)\right)\right] \quad (7)$$

When a pair (x, y) exist such that $x \geq y$ and $\mu_{\widetilde{M}_1}(x) = \mu_{\widetilde{M}_2}(y)$, the equality equation $V(\widetilde{M}_1 \geq \widetilde{M}_2) = 1$. Since $\widetilde{M}_1 = (l_1, m_1, u_1)$ and $\widetilde{M}_2 = (l_2, m_2, u_2)$ are convex fuzzy numbers and can be presented like that:

$$V(\widetilde{M}_1 \geq \widetilde{M}_2) = 1 \; if \; m_1 \geq m_2 \tag{8}$$

$$V(\widetilde{M}_1 \geq \widetilde{M}_2) = \text{hgt}[\![(\widetilde{M}_1]\!] \cap \widetilde{M}_2) = \mu_{\widetilde{M}_1}(d) \tag{9}$$

Where, d is the ordinate of the highest intersection point D between $\mu_{\widetilde{M}_1}$ and $\mu_{\widetilde{M}_2}$, seen in Figure 3. When $\widetilde{M}_1$ and $\widetilde{M}_2$, the ordinate of D is given by the following equation:

$$V(\widetilde{M}_2 \geq \widetilde{M}_1) = \text{hgt}[\![(\widetilde{M}_1]\!] \cap \widetilde{M}_2) = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \tag{10}$$

To compare $\widetilde{M}_1$ and $\widetilde{M}_2$ both values of $V(\widetilde{M}_1 \geq \widetilde{M}_2)$ and $V(\widetilde{M}_2 \geq \widetilde{M}_1)$ are required.

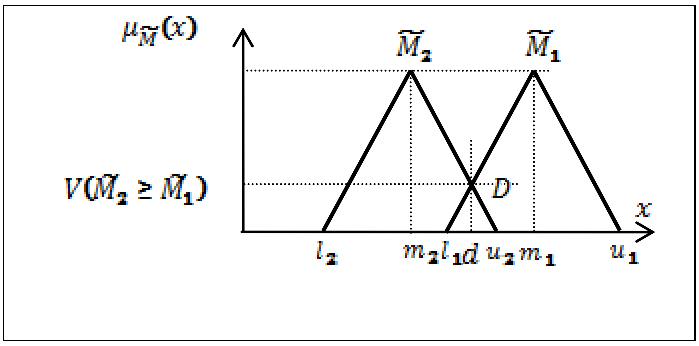


Figure 3. Intersection Point d between two TFNs, $\widetilde{M}_1$ and $\widetilde{M}_2$

Step 4: The degree possibility of a convex fuzzy number to be greater than k convex fuzzy numbers $M_i (i = 1,2, \dots k)$ can be defined by

$$V(\widetilde{M} \geq \widetilde{M}_1, \widetilde{M}_2, \dots, \widetilde{M}_k) = V[(\widetilde{M} \geq \widetilde{M}_1) \text{ and } [V(\widetilde{M} \geq \widetilde{M}_2) \text{and } (\widetilde{M} \geq \widetilde{M}_k)] = \min V(\widetilde{M} \geq \widetilde{M}_i) \; i = 1, 2, \dots . k. \tag{11}$$

Assuming that

$$d^{'}(A_i) = \min V(S_i \geq S_k), k = 1,2, \ldots, n; k \neq i \quad (12)$$

Then, the weight vector is obtained as follows:

$$w^{'} = \left(d^{'}(A_1), d^{'}(A_2), \ldots\ldots, d^{'}(A_n)\right)^T \quad (13)$$

Where $A_i (i = 1,2, \ldots, n)$ are n elements.

Step 5: After normalization, the normalized vectors are defined as:

$$w = \left(d(A_1), d(A_2), \ldots\ldots, d(A_n)\right)^T \quad (14)$$

Where w is a non-fuzzy number.

The normalized weight vector is calculated as $Nw_i = \frac{w_i}{\sum w_i}$.

3.2. Fuzzy Goal Programming

Route selection problem with varied preferences is a typical decision-making problem involving multi criteria and objectives. Therefore, it often has conflicting sourcing goal subjects like cost, time and service quality. To maximize the utility function and fulfil the decision maker's aspiration levels FGP [13,14] was implemented in solving this decision-making problem. Furthermore, the decision makers can define linguistic priorities with setting membership functions on goal values by considering the fuzzy logic.

A FGP can be formulated as follows [13]:

Max Subject to $X \in F$, (F is a feasible set), $X \geq \mathbf{0}$. (15)

Where is the extra continuous variable, $Z_k(X)$ is the linear function of the k th goal, X is $1 \times N$ vector of decision variables and $\mu_k(Z_k(X))$ is the fuzzy membership function of k th objective.

The preference-based membership functions are expressed as follows:

$$\text{for } Z_k(X) \gtrsim g_k, k = 1,2,\dots,k_1 \quad (16)$$

$$\text{for } Z_k(X) \lesssim g_k, k = k_1 + 1,\dots,K \quad (17)$$

Where l_k and u_k are, respectively, the lower and upper tolerance limits for the k th fuzzy goal. $[(g]_k - l_k)$ as well as $(u_1k - g_1k)$ are the tolerances which are subjectively chosen. $\gtrsim$ and $\lesssim$ represent the fuzzified versions of $\geq$ and $\leq$. g_k is the aspiration level of the k th goal. $Z_k(X) \gtrsim g_k$ indicates the k th fuzzy goal approximately being essentially greater than or equal to the aspiration level g_k, whereas $Z_k(X) \lesssim g_k$ is to be understood as essentially less than or equal.

4. IMPLEMENTATION OF FAHP-FGP IN A REAL-WORLD CASE

Over the past decade freight transport volume between Turkey and the EU has grown rapidly and has generally been coupled with growth in gross domestic product. A white goods producer company based in Turkey that produces refrigerators and washing machines wants to transport the products from its factory in Bursa to a customer in Austria. The company works with different MTPs for each possible multimodal route. Transport units can be either semi-trailer or complete unit. The shipper wants to select an optimal multimodal route as the normal operation route by road route is disrupted at this moment because of cross-border road construction problem. The company established an expert group to decide on selection criteria and alternative routes with conducting a variety of rapid appraisals and surveys including brainstorming, semi-structured interviews. According to expert suggestions, the final hierarchy of selection criteria and routes are listed in Figure 4. The criteria which are considered during the selection of the optimal multimodal route include freight cost, transport time, risk of multimodal route and service level of MTP.

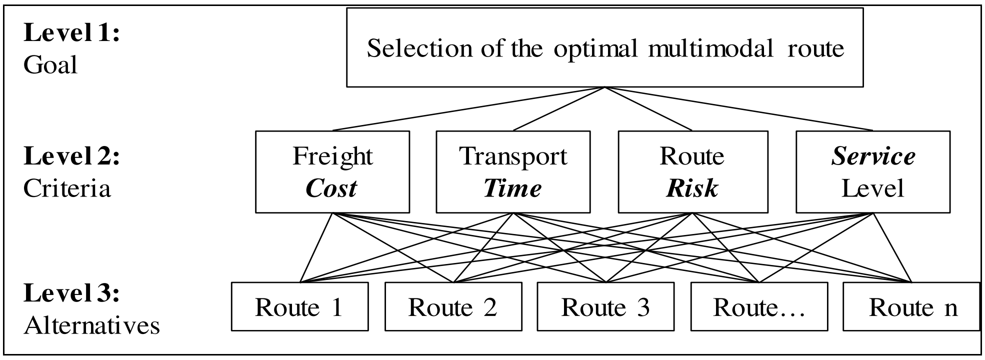


Figure 4. Hierarchy of Route Selection Problem

The expert group prioritized these criteria with three customers' freight conditions; respectively with slow (Case1), normal (Case2) and fast (Case3) transport by using FAHP method. By applying formulas from Equations (1) to (14).

S1=(0.2031,0.3008,0,4716), S2=(0.1525,0.2161,0.2720),

S3=(0.1623,0.2167,0.2957), S4=(0.1875,0.2665,0.3786),

V(S1≥S2)=1,V(S2≥S1)=0.45,V(S3≥S1)=0.52,V(S4≥S1)=0.84,

V(S1≥S3)=1,V(S2≥S3)=0.99,(S3≥S2)=1,V(S4≥S2)=1,

V(S1≥S4)=1,V(S2≥S4)=0.63,V(S3≥S4)=0.69,V(S4≥S3)=1,

d'(Cost)=1,*d'*(*Time*)=0.45,*d'*(*Risk*)=0.52,*d'*(*Service*)=0.84,

w'=(1,0.45,0.52,0.84)T, *w*=(0.36,0.16,0.19,0.30),*CR*=0.095.

In this calculation, a set of linguistic values is used

I=(*very low=VL,low=L,medium low=ML,medium=M,medium high=MH,high=H, very high=VH*

in order to denote the importance weight of each criterion. TFNs corresponding to these linguistic values are:

VL=(0.0,0.0,0.1), *L*=(0.0,0.1,0.3), *ML*=(0.1,0.3,0.5),

M=(0.3,0.5,0.7),*MH*=(0.5,0.7,0.9),*H*=(0.7,0.9,1.0).

Table 1. shows the fuzzy expert evaluation of selection criteria for slow transport.

Table 1. The Fuzzy Evaluation of Criteria for Case1

#	Cost	Time	Risk	Service	Weight
Cost	(1,1,1)	(1,1.11,1.43)	(1.43,2,3.34)	(0.7,0.9,1)	0.36
Time	(0.7,0.9,1)	(1,1,1)	(0.9,1,1)	(0.5,0.7,0.9)	0.16
Risk	(0.3,0.5,0.7)	(1,1,1.11)	(1,1,1)	(1,1.11,1.43)	0.19
Service	(1,1.11,1.43)	(1.11, 1.43,2)	(0.7,0.9,1)	(1,1,1)	0.30

The consistency ratio of expert judgments is checked. The ratio of consistency (CR) should not be greater than 0.10 . Else, expert should re-enter the judgments. First of all, the consistency index should be calculated with Equation (18), where $\lambda_{\max}$ is main value of comparison matrix, and n is number of columns.

$$CI = \frac{[(\lambda]_{max} - n)}{(n-1)} \tag{18}$$

Consistency ratio is calculated by using Equation (19), where RI is the random index.

$$CR = \frac{CI}{RI} \tag{19}$$

After the consistency check the weight of criteria according to three cases are determined as seen in Table 2. For the Case 1, cost is ranked as prior criterion, as the freight can be transported slowly therefore the route can be mainly cost efficient whereas for the Case 2, the prior criterion is risk and for the Case 3, cost and time are ranked as prior criteria.

The expert group determined ten potential multimodal routes according to the existing rail route, road route and sea route within O-D shown in Figure 5. There are number of sea ports ($v_1 n$) and railway terminals ($t_1 n$) in this transport network.

Table 2. The Weight of Criteria According to Cases

Goals	Case1	Case2	Case3
Cost	0.36	0.25	0.31
Time	0.16	0.15	0.31
Risk	0.19	0.39	0.18
Service	0.30	0.21	0.21
CR	0.095	0.088	0.077

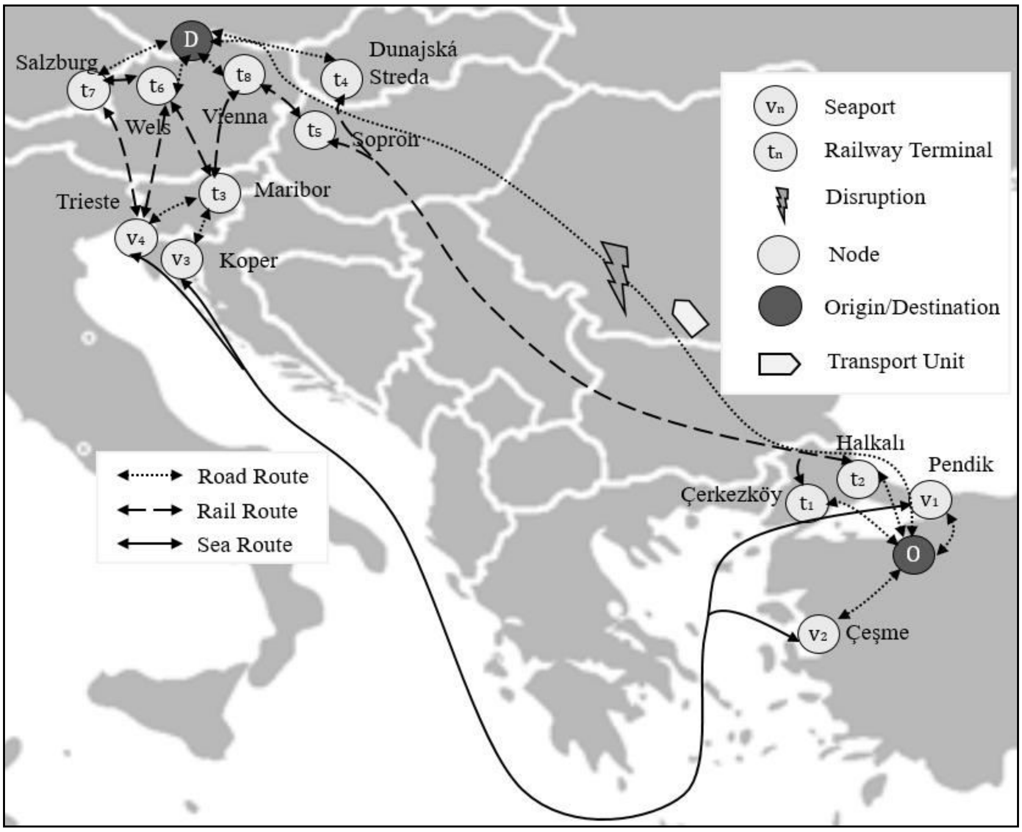


Figure 5. Multimodal Transport Routes between O-D in case of a Disruption

The main legs of transport network are operated via using sea and/or rail transport modes where all transport units are carried by using two types of transport: RoRo vessel and RoLa train. RoLa (rolling road) train services are specially designed wagons to carry wheeled cargo by rail route to/from the ports/terminals, whereas RoRo (roll-on/roll-off) vessels are specially types of ships designed to carry wheeled cargo by sea route to/from the ports. The initial (pre-haulage) and final legs (end-haulage) are operated by road route. The values of cost and time frame of each route are offered directly by MTPs that provide the transport services for those paths. The transport unit cost of semi-trailer is Euro and the time shows the total traveling time per day. Risk and service values are generated according the expert consensus. The higher score of risk means the higher average risk for route. The higher score of service means that MTP can provide a better average service for selected route. Table 3. denotes the route table according to each route and selection criteria.

Table 3. The Route Table for Multimodal Transport between O-D

#	Multimodal Route	Trans. Modes	Cost	Time	Risk	Service
1	$O - t_2 - t_4 - D$	rail	2800	6.5	10	6
2	$O - v_1 - v_4 - t_7 - D$	sea-rail	3800	7	6	8
3	$O - t_1 - t_5 - t_8 - D$	rail-rail	3500	8.5	8	8
4	$O - t_2 - t_8 - D$	rail	3200	10.5	6	6
5	$O - v_1 - v_4 - t_7 - t_6 - D$	sea-rail-rail	2900	7	10	8
6	$O - v_1 - v_3 - t_3 - t_6 - D$	sea-road-rail	3100	9	6	4
7	$O - v_1 - v_4 - t_3 - t_6 - D$	sea-road-rail	3050	6	8	6
8	$O - v_2 - v_4 - t_7 - D$	sea-rail	3000	8	4	6
9	$O - t_2 - t_6 - D$	rail	2900	9	6	8
10	$O - v_1 - v_4 - t_6 - D$	sea-rail	2950	8.5	6	4

There are four goals for the route selection, including cost, time, risk and service. Table 4. summarizes the lower and upper bound of the goals for the route selection. To determine the optimal multimodal route, the goals are formulated with FGP according to Equations (15) to (17) as detailed in the appendix. This problem is presented and solved by using LINGO 13.0 software package to obtain the solutions seen in Table 5.

Table 4. The Goals for Route Selection

Constraints		Goals	Lower bound	Upper bound	Difference
G_1	*Minimize*	Cost	0	3000	3000
G_2	*Minimize*	Time	0	10	10
G_3	*Minimize*	Risk	0	8	8
G_4	*Maximize*	Service	6	10	4

Table 5. Result from Case1, Case2 and Case 3

	Route	Cost	Time	Risk	Service	Deviation
#	Target goal	3000	10	8	10	
Case1	**Weight**	**0.36**	**0.16**	**0.19**	**0.30**	
10	$O-v_1-v_4-t_6-D$	2950	8.5	6	4	8.83
6	$O-v_1-v_3-t_3-t_6-D$	3100	9	6	4	9.83
8	$O-v_2-v_4-t_7-D$	3000	8	4	6	11.50
4	$O-t_2-t_8-D$	3200	10.5	6	6	14.53
Case2	**Weight**	**0.36**	**0.16**	**0.19**	**0.30**	
8	$O-v_2-v_4-t_7-D$	3000	8	4	6	8.87
10	$O-v_1-v_4-t_6-D$	2950	8.5	6	4	13.25
6	$O-v_1-v_3-t_3-t_6-D$	3100	9	6	4	13.75
4	$O-t_2-t_8-D$	3200	10.5	6	6	16.53
Case3	**Weight**	**0.31**	**0.31**	**0.18**	**0.21**	
10	$O-v_1-v_4-t_6-D$	2950	8.5	6	4	10.58
6	$O-v_1-v_3-t_3-t_6-D$	3100	9	6	4	10.58
4	$O-t_2-t_8-D$	3200	10.5	6	6	11.06
8	$O-v_2-v_4-t_7-D$	3000	8	4	6	12.37

The result gives a list of possible routes. According to result of Case 1, slow transport, the prior route is the route 10 which uses sea and rail routes. Transport cost is 2950 Euro, time period is 8.5 days, risk scale is 6 and service level is 4. The result of Case 2 shows that the prior route is the route

8, which is composed of sea and rail routes. Transport cost is 3000, time period is 8 days, risk scale is 4 and service level is 6. The result of Case 3 denotes the route 10 as prior route which is the combination of sea and rail routes. Transport cost is 2950 Euro, time period is 8.5 days, risk scale is 6 and service level is 4.

5. EVALUATIONS AND CONCLUSION

The aim of this study is to develop and adapt a route selection methodology by integrating FAHP and FGP techniques that can evaluate criteria in decision-making and optimization on a multimodal transport route for transport users in case of any disruption. The main contribution of this research is to use pre-selected qualitative and quantitative criteria in order to solve a real-world case problem by applying FAHP-FGP techniques. The proposed method is accurate, flexible and efficient system, and support the transport network planner or operator to decide on an optimal route rapidly if any disruption occurs throughout transport network. According to needs of transport users or freight conditions, decision maker can evaluate other alternative routes and decide on an optimal one. This proposed approach can be applied in different transport scenarios with using other transport modes.

ACKNOWLEDGEMENTS

This study was supported by Turkish-German University Scientific Research Projects Commission under the grant no: 2016BM0009.

APPENDIX

Max=0.36*C1+0.16*C2+0.19*C3+0.30*C4; (ForCase1)

C1≤(3000−(6.7*X1−26.7*X2−16.7*X3−6.7*X4+3.3*X5−3.3*X6−1.7*X7+ 3.3*X9+1.7*X10))/3000; (ForG1:MinimizeCost)

C2≤(10−(65*X1+70*X2+85*X3+105*X4+70*X5+90*X6+60*X7+80*X8 +90*X9+85*X10))/10; (ForG2MinimizeTime)

C3≤(8−(−25*X1+25*X2+25*X4−25*X5+25*X6+50*X8+25*X9+25*X10))/8; (ForG3:MinimizeRisk)

C4≤((40*X1+20*X2+20*X3+40*X4+20*X5+60*X6+40*X7+40*X8+20* X9+60*X10)−10)/4; (ForG4:MaximizeService)

X1+X2+···+X10=1,Xj=0 or 1: j=1,2,…,10.

REFERENCES

[1] SteadieSeifi, M., Dellaert, N., Nuijten, W., Van Woensel, T., and Raoufi, R. (2014). "Multimodal Freight Transportation Planning: A Literature Review". ***European Journal of Operational Research***, vol. 233, no.1, pp.1-15.

[2] Cao, C., Gao, Z., and Li, K. (2012). "Capacity Allocation Problem with Random Demands for the Rail Container Carrier". ***European Journal of Operational Research***, vol.217, pp.214–221.

[3] Kayikci, Y., and Catay, B. (2017). ***Revenue-based slot allocation and pricing framework for multimodal transport networks***. Paper presented at the 22nd International Symposium on Logistics (ISL2017), Ljubljana, Slovenia.

[4] Murray-Tuite, P.M., and Mahmassani, H.S. (2004). "Methodology for the Determination of Vulnerable Links in a Transportation Network". ***Transportation Research Record***, vol.1882, pp.88-96.

[5] Faturechi, R., and Miller-Hooks, E. (2014). "Travel Time Resilience of Roadway Networks under Disaster". ***Transportation Research Part B***, vol.70, pp.47-64.

[6] UBAK. (2014). "Türkiye Kombine Taşımacılık Strateji Belgesi", UDH, Ankara. Retrieved from http://www.ubak.gov.tr/ BLSM_WIYS/TMKDG/tr/ doc/20150106_122025_64574_1_ 64896. pdf (Access Date: 12.11.2018).

[7] Harris, I., Wang, Y., and Wang, H. (2015). "ICT in Multimodal Transport and Technological Trends: Unleashing Potential for the Future", ***International Journal of Production Economics***, vol.159, pp.88-103.

[8] Woxenius, J. (2007). "Generic Framework For Transport Network Designs: Applications And Treatment In Intermodal Freight Transport Literature", ***Transport Reviews***, vol.27, pp.733-749.

[9] Macharis, C., and Bontekoning, Y.M. (2004). "Opportunities for OR in Intermodal Freight Transport Research: A Review". ***European Journal of Operational Research***, vol.153, no.2, pp. 400-416.

[10] Crainic, T.G., and Rousseau, J.M. (1986). "Multicommodity, Multimode Freight Transportation: A General Modeling and Algorithmic Framework for the Service Network Design Problem". ***Transportation Research B: Methodology***, vol.208, pp.225–242.

[11] Saaty, T. (1980). ***The Analytic Hierarchy Process***. New York:McGraw-Hill.

[12] Chang, D.Y. (1996). "Applications of the Extent Analysis Method on FAHP". ***European Journal of Operational Research***, vol.95, no.3, pp.649-655.

[13] Narasimhan, R. (1980). "Goal Programming in a Fuzzy Environment". ***Decision Sciences***, vol.11, no.2, pp.325-336.

[14] Zimmermann, H.J. (1978). "Fuzzy Programming and Linear Programming with Several Objective Functions". ***Fuzzy Sets and Systems***, vol.1, no.1, pp.45–55.

JOURNAL OF NAVAL SCIENCES AND ENGINEERING (JNSE) PUBLISHING RULES

Submission of Papers: Manuscripts submitted to the journal should not be published elsewhere or sent for publication. Authors are requested to submit an electronic copy of their original works to given "system address" (preferred) or one hard-copy to mail address and a soft-copy to "e-mail address" below. It is necessary for the authors to submit their manuscripts together with the "Copyright Release Form". "Copyright Release Form" can be downloaded from the web page ("Copyright" page) of JNSE.

System Address:
http://dergipark.gov.tr/jnse

Address:
Dr. Mehmet Bilge Kağan ÖNAÇAN
Milli Savunma Üniversitesi
Barbaros Deniz Bilimleri ve Mühendisliği Enstitüsü
Deniz Harp Okulu Yerleşkesi
34942 Tuzla/ İSTANBUL/TÜRKİYE

E-mail: jnse@dho.edu.tr

Types of Contributions: The journal publishes original papers, review articles; technical notes; short communications; book reviews; letters to the editor; extended reports of conferences and meetings.

Manuscript Evaluation Process: The Peer Review Step:

- The content and the layout format of manuscript are examined and the originality of study is checked by iThenticate software programme.
- The language and correlation of the abstract with Turkish part are checked.
- Manuscript which has a similarity index above 40% is rejected. Manuscript, which has a similarity index between 20% and 40% (not more than 4% from a single source), which is not appropriate for the writing rules of JNSE or which needs correction in English and Turkish abstract, is informed to the author and it is requested to revise the manuscript by the author within "two weeks". Otherwise, the manuscript is considered as a withdrawal.

Our journal uses **double-blind** review, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process. So, the uploaded manuscript does not contain the name, address and affiliation of author(s). The manuscript evaluation steps are as follows;

- Editor is assigned by the Editor in Chief
- The relevant reviewers are assigned by the Editor
- As a result of the reviewer's evaluation, the manuscript may be rejected, accepted or a correction for the manuscript may be requested.
- If the negative feedback is given by major number of the reviewers the process is terminated and the article is rejected.
- If major/minor revisions are required for the manuscript, the author has to do this revision according to the reviewers' comments in "three weeks".
- If the revision is accepted by the reviewers, the article is accepted.

The workflow diagram for the evaluation process can be accessed from the web page of the journal.

The articles submitted to JNSE to be published are free of article submission, processing and publication charges. The accepted articles are published **free-of-charge** as online from the journal website and printed.

DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ (DBMD) YAYIN KURALLARI

Yazıların Gönderilmesi: Dergiye gönderilen makaleler başka bir yerde yayımlanmamış ya da yayımlanmak üzere gönderilmemiş olmalıdır. Yayımlanması istenilen yazılar aşağıda verilen adresten sisteme yüklenmeli (tercih edilen) veya aşağıdaki adrese bir kopya kâğıda basılı olarak, aynı zamanda e-mail adresine de dijital olarak gönderilmelidir. Dergimize makale gönderen yazarların makaleleriyle birlikte "Yayın Hakkı Devir Formu"nu da göndermeleri gerekmektedir. "Yayın Hakkı Devir Formu"na DBMD web sayfasındaki "Telif Hakkı" sayfasından erişilebilmektedir.

Sistem Adresi:
http://dergipark.gov.tr/jnse

Adres:
Dr. Mehmet Bilge Kağan ÖNAÇAN
Barbaros Deniz Bilimleri ve Mühendisliği Enstitüsü
Deniz Harp Okulu Yerleşkesi
34942 Tuzla/ İSTANBUL/TÜRKİYE

E-mail: jnse@dho.edu.tr

Yazı Türleri: Dergide; orijinal yazılar, derlemeler, teknik notlar, kitap incelemeleri, editöre mektuplar ile konferans ve toplantıların genişletilmiş raporları yayımlanır.

Yazıların Değerlendirilme Süreci: Makalenin Ön Kontrol Süreci:

- Makalenin içeriği ve yazım formatı incelenir ve iThenticate programı ile benzerlik taraması yapılır.
- Makalenin İngilizce özetinin, Türkçe öz ile uygunluğu ve yazım dili kontrol edilir.
- Benzerlik oranı %40'ın üzerinde olan makale reddedilir. Benzerlik oranı %20 ile %40 arasında olan (tek bir kaynakla benzerlik %5'ten fazla olmamalıdır), yazım formatına uymayan ya da İngilizce ve Türkçe özetinde düzeltme gereken makale yazara bildirilir ve "iki hafta" içerisinde makalenin düzeltilmesi istenir. Aksi takdirde makale çekilmiş kabul edilir.

Dergimiz, makale değerlendirme sürecinde **çift-kör** hakemlik sistemini kullanmaktadır. Buna göre değerlendirme sürecinde hakem ve yazarlar birbirlerinin bilgilerini görememektedir. Bu yüzden, yüklenen ön yükleme formatında yazar(lar)ın isim, adres ve bağlı olduğu kuruluş(lar) yer almamaktadır. Makale değerlendirme sürecindeki adımlar aşağıdaki gibidir;

- Baş editör tarafından makaleye editör atanır.
- Editör makale için hakemleri atar.
- Hakem değerlendirmesi sonucunda makale reddedilebilir, kabul edilebilir veya makalenin düzeltilmesi istenebilir.
- Hakem görüşlerinin çoğunluğu doğrultusunda makale ret edilmişse süreç sonlandırılır ve makale reddedilir.
- Makale için düzeltme istenirse hakem görüşleri doğrultusunda yazarın düzeltmeleri en geç "üç hafta" içerisinde yapması istenir.
- Makale kabul alırsa düzenleme aşamasına geçilir.

Değerlendirme sürecine ilişkin iş akış sürecine, dergi web sayfasından erişilebilir.

DBMD'ye yayımlanmak üzere gönderilen makaleler; makale gönderim, işlem ve yayın ücretinden muaftır. Kabul edilen makaleler, **ücretsiz** olarak basılı şekilde ve dergi web sayfasından çevrimiçi (on-line) olarak yayınlanmaktadır.

JOURNAL OF NAVAL SCIENCES AND ENGINEERING (JNSE)
WRITING RULES

General: Manuscripts must be prepared in MS Word, single-spaced with justify. Font: Times New Roman, 12 points. Margins: left 4,5 cm- right 3,5 cm, top 5 cm- bottom 7 cm, header 3,25 cm- footer 6 cm, gutter 0. Paper type: A4. Page numbers should be on the middle of bottom of page with -1-, -2-, -3- etc format. Using footnotes is not allowed.

Body of Text: Follow this order when typing manuscripts: Title, Authors, Abstract, Keywords, Title (Turkish), Abstract (Turkish), Keywords (Turkish), Main Text, Appendix (if any), References.

Title: Title should reflect objectives of the paper clearly, be easily understandable and not exceed 15 words.

Abstracts: Each paper should have an abstract with 100-200 words and have a structured form, i.e. standard structure of an article (background, purpose, material and methods used, results, conclusion).

Paper Length: The manuscript should be minimum 2000 words or 5 pages, maximum 7000 words or 25 pages including references.

Keywords: Author must provide some keywords (between 3 and 5) that will be used to classify the paper.

Unit: International System of Unit (Système Internationale d'Unités; SI) (https://www.britannica.com/science/International-System-of-Units) should be used for all scientific and laboratory data.

References: Referring to references should be in the text by using reference numbers in parenthesis (i.e. [2]).

List of References: Publications cited in the text should only be presented in a list of references following the text of the manuscript. References should be listed according to their orders in which they are cited in the manuscript, i.e., [1] cited first, [2] cited next, and so on. An example of a reference list is below.

Examples:

[1] Berndt, T. (2002). "Friendship Quality and Social Development", ***Current Directions in Psychological Science***, vol.82, no.3, pp.114-140. **(Single authored article)**

[2] Rother, M. and Shook, J. (1999). "Learning to See: Value Stream Mapping to Create Value and Eliminate Muda", ***The Lean Enterprise Institute***, vol.22, no.4, pp.3-4**. (Multi-authored article)**

[3] Okamoto, G. (1999). ***Smart Antenna Systems and Wireless LANs,*** Boston: Kluwer Academic Publishers. **(Single Author Books)**

[4] Author, A. (Year). "Title of document", Retrieved from http://wwwwwwwwwwwwwwwwwwwww wwwwwwwwwwwwwww (Access Date: 00.00.0000). **(Internet Sources)**

[5] Lastname, F.N. (Year). Title of dissertation (Doctoral dissertation). University Name, Institute Name, City. (Retrieved from Name of database). **(Published Dissertation)**

[6] Bergmann, P. G. (1993). Relativity, ***In The New Encyclopedia Britannica,*** (Vol. 26, pp. 501-508). Chicago, IL: Encyclopedia Britannica**.(Encyclopedia)**

[7] Author, A. A. (Year, Month Day). "Title of article", ***Title of Newspaper***. Retrieved from http://www.someaddress.com/full/url/wwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwww wwwwwwwwwww wwwwwwwwwwwwwww **(Newspaper article)**

[8] Önaçan, M.B.K., Uluağ, M., Önel, T. and Medeni, T.D. (2018). "Selection of Plagiarism Detection Software and Its Integration Into Moodle for Universities: An Example of Open Source Software Use in Developing Countries". Ricardo Queirós (ed.), Emerging Trends, Techniques, and Tools for Massive Open Online Course (MOOC) Management, ***IGI Global***, 250-265, pp. 255. **(Book chapter)**

Abbreviations and Acronyms: Standard abbreviations and acronyms should be used for each related discipline. Acronyms should be identified at the first occurrence in the text. Abbreviations and acronyms may also be attached to main text as an appendix.

Equations and Formulas: Equations and formulas should be numbered consecutively. These numbers must be shown within parentheses being aligned to right. In the text, equations and formulas should be referred with their numbers given in parentheses. Comprehensive formulas, not appropriate to be written in the texts, should be prepared in figures.

Figures and Tables: Figures and tables should be numbered consecutively. In the text referring to figures and tables should be made by typing "Figure 1" or "Table 1" etc. A suitable title should be assigned to each of them.

DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ (DBMD)
YAZIM KURALLARI

Genel Bilgiler: Yazılar; Microsoft Word'de tek satır aralığı ve iki yana yaslanarak hazırlanmalıdır. Yazı tipi: Times New Roman, 12 punto. Kenar boşlukları: sol 4,5 cm- sağ 3,5 cm- üst 5 cm- alt 7 cm- üst bilgi 3,25 cm- alt bilgi 6 cm, oluk 0. Kağıt ölçüsü: A4. Sayfa numaraları sayfanın alt ortasında -1-, -2-, -3- şeklinde yer almalıdır. Dipnot kullanılmamalıdır.

Yazı Yapısı: Yazı şu sırada hazırlanmalıdır: Başlık, Yazarlar, Özet, Anahtar Kelimeler, Başlık (Türkçe), Özet (Türkçe), Anahtar Kelimeler (Türkçe), Ana Metin, Ek (varsa), Referanslar.

Başlık: Başlık; açık, net, anlaşılır olmalı ve 15 kelimeyi geçmemelidir.

Öz (Abstract): Yazı, 100-200 kelimelik, arka plan, amaç, yöntem, bulgular ve sonuçtan oluşan yapılandırılmış bir özeti içermelidir.

Sayfa Sayısı: Dergiye gönderilecek yazıların boyutu, kaynakça dahil asgari 2000 kelime veya 5 sayfa, azami 7000 kelime veya 25 sayfa arasında olmalıdır.

Anahtar Kelimeler: Yazıyı sınıflandırmaya yarayacak, anahtar görevi yapan 3-5 kelime yer almalıdır.

Birimler: Yazının uluslararası alanlarda da kolay izlenebilir ve anlaşılabilir olması için Uluslararası Birim Sistemine (https://www.britannica.com/science/International-System-of-Units) uygun olarak hazırlanması gerekir.

Referans: Referanslar dipnotlar ile değil metin içinde açılacak parantezlerde yer alan referans numarası ile ([2] gibi) yapılmalıdır.

Referans Listesi: Makalenin ana metninden sonra sadece yazıda gönderme yapılan eserler yer almalıdır. Gönderme yapılan eserler, ana metin içerisinde atıf yapıldıkları sıraya göre listelenmelidir, yani ilk atıf yapılan eser [1], ikinci atıf yapılan eser [2] olmalı ve bu şekilde devam etmelidir. Bir referans listesi örneği aşağıdadır.

Örnekler:

[1] Berndt, T. (2002). "Friendship Quality and Social Development", ***Current Directions in Psychological Science***, vol.82, no.3, pp.114-140. **(Tek yazarlı makale)**

[2] Rother, M. and Shook, J. (1999). "Learning to See: Value Stream Mapping to Create Value and Eliminate Muda", ***The Lean Enterprise Institute***, vol.22, no.4, pp.3-4**. (Çok yazarlı makale);**

[3] Okamoto, G. (1999). ***Smart Antenna Systems and Wireless LANs,*** Boston: Kluwer Academic Publishers. **(Tek yazarlı kitap)**

[4] Author, A. (Year). "Title of document", Retrieved from http://wwwwwwwwwwwwwwwww wwwwwwww wwwwwwwwwww (Access Date: 00.00.0000). **(İnternet kaynakları)**

[5] Lastname, F.N. (Year). Title of dissertation (Doctoral dissertation). University Name, Institute Name, City. (Retrieved from Name of database). **(Yayınlanmış tez)**

[6] Bergmann, P. G. (1993). Relativity, ***In The New Encyclopedia Britannica,*** (Vol. 26, pp. 501-508). Chicago, IL: Encyclopedia Britannica**.(Ansiklopedi)**

[7] Author, A. A. (Year, Month Day). "Title of article", ***Title of Newspaper***. Retrieved from http://www.someaddress.com/full/url/wwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwww wwwww wwwwwwwwwwwwwwwwwwwwwwwwwwwwww **(Gazete makalesi)**

[8] Önaçan, M.B.K., Uluağ, M., Önel, T. and Medeni, T.D. (2018). "Selection of Plagiarism Detection Software and Its Integration Into Moodle for Universities: An Example of Open Source Software Use in Developing Countries". Ricardo Queirós (ed.), Emerging Trends, Techniques, and Tools for Massive Open Online Course (MOOC) Management, ***IGI Global***, 250-265, pp. 255. **(Kitap bölümü)**

Notasyon ve Kısaltmalar: İlgili bilim alanının standart notasyon ve kısaltmaları kullanılmalı, yeni notasyonlar ise metin içinde ilk geçtiği yerde tanımlanmalıdır. Gerekli durumlarda, notasyon ve kısaltmalar ek olarak konulabilir.

Denklem ve Formüller: Denklem ve formüller ardışık olarak numaralandırılmalı ve bu numaralar sağa dayalı parantez içinde yazılmalıdır. Metin içinde denklem ve formüllere parantez içinde yazılan numaraları ile atıfta bulunulmalıdır. Metin arasında verilmesi uygun olmayan kapsamlı formüller şekil olarak hazırlanmalıdır.

Şekiller ve Tablolar: Şekiller ve tablolar, ardışık olarak numaralandırılmalıdır. Bunlara metin içinde "Şekil 1" veya "Tablo 1" şeklinde atıfta bulunulmalıdır. Her bir şekil ve tablo için uygun bir başlık kullanılmalıdır.

NATIONAL DEFENSE UNIVERSITY
BARBAROS NAVAL SCIENCES AND ENGINEERING INSTITUTE
JOURNAL OF NAVAL SCIENCES AND ENGINEERING

VOLUME: 14 NUMBER: 2 NOVEMBER 2018 ISSN: 1304-2025

CONTENTS / İÇİNDEKİLER

MİLLİ SAVUNMA ÜNİVERSİTESİ
BARBAROS DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ ENSTİTÜSÜ
DENİZ BİLİMLERİ VE MÜHENDİSLİĞİ DERGİSİ

CİLT: 14 SAYI: 2 KASIM 2018 ISSN: 1304-2025