Appendix A

Reference Code:	

(Fill up by RMC)

International Collaborative Research Funding (ICRF) Application Form

A	**TITLE OF PROPOSED RESEARCH:** Network Design Optimization for Improving Petroleum Distribution Efficiency During and Post-COVID 19 outbreak in Indonesia
B	**DETAILS OF RESEARCHER**
B(i)	**Name of Project Leader:** Anak Agung Ngurah Perwira Redi, Ph.D., CSCA **IC / Passport Number:** B2913598
B(ii)	**Position (Please tick *(√)*):** ☐ **Professor** ☐ **Assoc. Prof. / Dr.** ☑ **Sen. Lect./ Lecturer**
B(iii)	**Faculty /School/Centre/Unit (Please provide full address):** Universitas Pertamina / Faculty of Industrial Technology / Department of Logistics Engineering
B(iv)	**Office Telephone No.:** **Handphone No.:** 081384971470
B(v)	**E-mail Address:** wira.redi@universitaspertamina.ac.id wira.redi@gmail.com
B(vi)	**Date of first appointment with this University:** 31 August 2018

<table>
<tr><td>B(vii)</td><td>Type of Service (Please tick (√)):
☐ Permanent ☑ Contract (State contract expiry date): 31 August 2020</td></tr>
<tr><td>C</td><td>RESEARCH INFORMATION</td></tr>
<tr><td>C(i)</td><td>Research Area (Please tick (√):
☐ Self sustainable living: Green and Clean Technology
☐ Smart Mobility: Propulsion & Transport Infrastructure Technology
☐ Personalized Care: Health Analytics Technology
☐ Hydrocarbon Recovery: Enhanced Oil Recovery Technology
☐ Gas Contaminant Management: Purification Technology of Contaminated Gas
☐ Autonomous Facilities: Autonomous System & Technology

Other: Petroleum Supply Chain Management.

Please Specify:
____
______________________________</td></tr>
<tr><td>C(ii)</td><td>Location of Research:
Tempat penyelidikan dijalankan:

Laboratorium Sistem Distribusi Logistik , Faculty of Industrial Technology, Department of Logistics Engineering, Universitas Pertamina, DKI Jakarta, Indonesia</td></tr>
<tr><td>C(iii)</td><td>Duration of this research (Maximum 12 month):

Duration: 12 Month

From : 31 August 2020

To : 31 August 2021</td></tr>
</table>

C(iv)	**Other Researchers:** *(Please include your curriculum vitae, if necessary)*

Bil	Name	Institution Details	Specialization	Role in the Project
1	Nur Layli Rachmawati, S.T., M.T.	Universitas Pertamina	Operation Research, Discrete Simulation, Dual Channel Supply Chain, Industrial Optimization	Co-Project Leader
2	Adji Candra Kurniawan S.T., M.T.	Universitas Pertamina	Agent Based Simulation, Supply Chain Management.	Project Member
3	Dimas Bayu Endrayana Dharmowijoyo, PhD	Universiti Teknologi Petronas	Transportation and urban planning.	Project Collaborator
4	Eko Gito Prabowo	PT Pertamina EP	Procurement,	Project Collaborator
5	Parida Jewpanya, PhD	Rajamanggala University of Technology	Operation Research, Metaheuristics, Mathematical Modeling	Project Collaborator

C(v)	**Research projects that have been completed or ongoing by researchers for the last three years. Please provide title of research, duration, year commence and year ending.**

Title of Research	Duration	Start Date	End Date
Studi Key Success Factors Analysis to the Implementation of "Pasti Prima" at Pertamina Gas Station	12 Month	Jan 2017	Jan 2018
Algoritma Branch and Price untuk permasalahan Penjadwalan Quay Crane dengan Mempertimbangkan Kestabilan Kapal	12 Month	Aug 2017	Aug 2018
Ground Vehicle and Drone Combination for Disaster Relief Mapping Operation	36 Month	Aug 2020	Aug 2022
Smart Locker for Humanitarian Logistics	12 Month	Aug 2018	Aug 2019

C(vi)	**Please furnish information on academic publications that has been published by the researchers for the last three (3) years. (Example: Journals, Books, Chapters in books, etc)**

Title of publication	Name of journals/books	Year published
An intermodal hub location problem for container distribution in Indonesia.	Computers & Operations Research (Scopus Q1)	**2019**
The path cover problem: formulation and a hybrid metaheuristic.	*Expert Systems with Applications* (Scopus Q1)	**2019**
Team orienteering problem with time windows and time-dependent scores	*Computers & Industrial Engineering* (Scopus Q1)	**2019**
Simulated annealing heuristic for the general share-a-ride problem.	*Engineering Optimization* (Scopus Q2)	**2019**
Selective discrete particle swarm optimization for team orienteering problem with time windows and partial scores.	*Computers & Industrial Engineering* (Scopus Q1)	**2020**
Novel hybrid metaheuristic algorithm for optimization of construction site layout planning.	*Algorithms*(Scopus Q3)	**2020**

C(vii)

Executive Summary of Research Proposal (maximum 300 words)
(Please include the background of research, literature reviews, objectives, research methodology and expected outcomes from the research project)

This project aims to develop a model to optimize the design of the petroleum network in Indonesia with additional research limitations focused on the downstream sector of the petroleum industry under pandemic and post-pandemic situations. This project set out to create a better understanding of the infrastructure requirements in Indonesia, and particularly the port-rail-road-pipeline interface.

Port-Road-Rail-Pipeline connectivity is crucial for petroleum logistics efficiency in Indonesia. The lack of rail-road-port-pipeline connectivity and the low usage of multimodal transportation is one of the potential factors that can be improved to address the problems. In this study, multi-levels of planning approaches are proposed. The planning levels can be categorized into strategic planning and tactical planning models. The strategic planning model considers factor such as location of terminals, additional connectivity requirements, and the future plan of the long term planning infrastructure. The proposed model take accounts the mode split availability, flow, capacities, and infrastructure utilization for a given transportation networks.

At the end of the project, this project is expected to be completing a conference paper and a journal paper. The conference paper are aimed at well-known International conference that related with the topic of this research. The journal paper is targeting an international journal that already been indexed by Scopus.

C(viii)	**Detailed proposal of the research project:**

(a) Research background, including Hypothesis /Research Questions and Literature Reviews.

Petroleum, as a source of energy for various industrial activities has a very significant impact. So that good management is needed. Common problems faced in the petroleum industry are spread throughout the supply chain of activities from upstream to downstream. However, there is an interesting problem for further research, namely the network design for petroleum distribution. As known, the network design consisting of transportation and routes is part of the logistics function. The network design problem (NDP) is a strategical decision-making problem in planning, designing, and managing network with the aim to make efficient use of limited resources for optimizing network performance (Xu, Chen, & Yang, 2016).

In Indonesia, which is an archipelagic country, to be able to obtain an optimal petroleum network design will certainly have challenges that must be overcome. The problem that must be solved to get an optimal petroleum network design is to determine the optimal mode of transportation and route from the initial destination to the end. More specifically, in the archipelagic country, the journey from the starting point to the endpoint has many choices of routes, and the longer distance it is possible to require a combination of modes of transportation such as a combination of land-sea or land-air transportation.

Since WHO announced The Covid-19 pandemic on March 11st, 2020, everything must be adjusted, including business operations. The pandemic gave implications for business such as the uncertainty of demand was rise because the behavior of customers has changed, problem on delivery because of mobility restriction and others. Those problems are faced for most of the industries, include oil and gas company. Since the flight was closed, factories were shut down, and people mobility was restricted, the demand for oil and gas was disrupted. These conditions make the problem more complex (Norouzi, Zarazua de Rubens, Choubanpishehzafar, & Enevoldsen, 2020).

Based on the problems that have been explained, this study tries to develop a model to optimize the design of the petroleum network in Indonesia with additional research limitations focused on the downstream sector of the petroleum industry. In this research, we develop scenarios for several conditions during and post-pandemic, we compare and analyze the results.

Applying the concept and intermodal hub model for network design problems in petroleum in Indonesia has the opportunity to reduce operational costs through optimization and efficiency of transportation management.

(b) Objective (s) of the Research

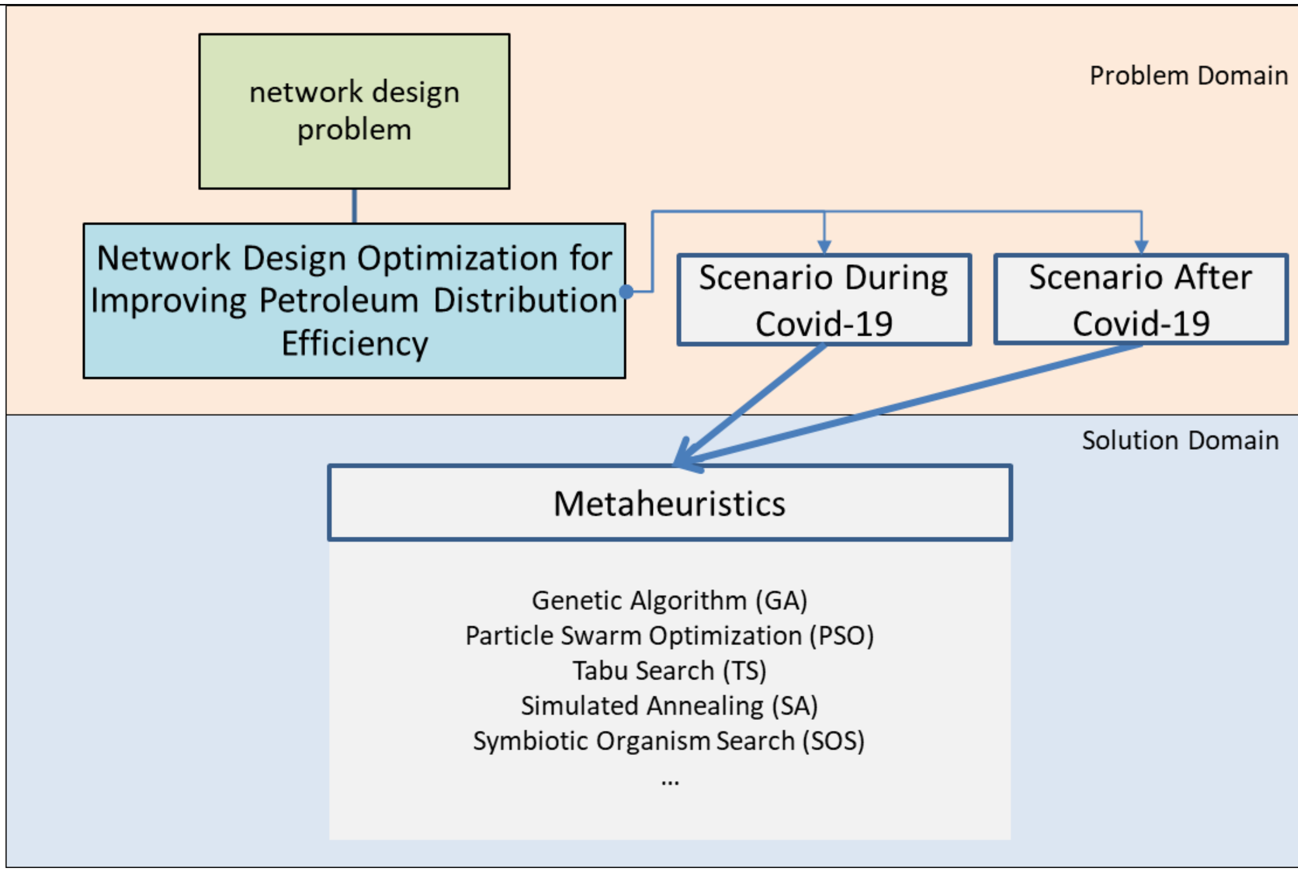
This study embarks on the following objectives:

1) *To assess the current condition of the petroleum network design in Indonesia*
2) *To develop an optimization model for petroleum distribution by considering multi-mode transportation under pandemic and post-pandemic schemes*
3) *To make recommendations based on an optimal model for improving the efficiency of the petroleum network design in Indonesia*

(c) Methodology

Description of Methodology

The methodology being used in this project is described in four parts—the first parts regarding the optimization modelling approach. In the modelling section, we described the formulation of Network Design Optimization for Petroleum Distribution (NDOPD). Then, the development of the solution approach are described in the following section. Figure 3 illustrates the relationship between the problem domain and solution domain considered in this project. At the end of this methodology section, flow chart, and milestones schedules are presented.



Network Design Optimization for Petroleum Distribution (NDOPD).

Consider is a directed transportation network where N is a set of nodes, and E is a set of links. The set of links E contains of link (i,j) that denote a connection between nodes i and node j. A set of commodity transportation request M are given. Each pair of request, m, is consist of information for which dm unit of commodity must be sent from origin node O(m) to destination node D(m). The cost for any routing plan is the total cost corresponding to the number of flow on the links. For each link, the cost is assumed to be non-convex piecewise linear function of the total flow on the link. Each piecewise linear segment consist of cost components such as: a fixed cost , a variable cost , and lower and upper bounds of commodity flow along each link. The naming convention for this problem has been varying in the literature. We decide to call the model as multimodal multi commodity flow problem based on naming convention (Chang, 2008). Basically this model, is simplified version of the model proposed by Chang (2008). In NDOPD, we drop the consideration of time windows constraint. Instead of multi objective cost function, NDOPD use single objective cost function.

Problem (P)
$$Z_p = \min \sum_{ij} \sum_{r} \sum_{m} C_{ij}^{r} X_{ij}^{mr} + \sum_{ij} \sum_{r} F_{ij}^{r} Y_{ij}^{r} \qquad (1)$$

Subject to
$$\sum_j W_{ij}^m - \sum_j W_{ji}^m = \begin{cases} d_m & if \quad i = O(m) \\ -d_m & if \quad i = D(m) \\ 0 & otherwise \end{cases} \qquad \forall m \in M \text{ and } i \in N \qquad (2)$$

$$W_{ij}^m \le \sum_r X_{ij}^{mr} \qquad \forall (ij) \in E \text{ and } \forall m \in M \qquad (3)$$

$$X_{ij}^{mr} \le d_m Y_{ij}^r \qquad \forall (ij) \in E, \forall m \in M \text{ and } \forall r \in R \qquad (4)$$

$$\sum_m X_{ij}^{mr} \geq M_{ij}^{r-1} Y_{ij}^r \qquad \forall (ij) \in E \text{ and } \forall r \in R \qquad (5)$$

$$\sum_m X_{ij}^{mr} \leq M_{ij}^{r} Y_{ij}^r \qquad \forall (ij) \in E \text{ and } \forall r \in R \qquad (6)$$

$$\sum_r Y_{ij}^r \leq 1 \qquad \forall (ij) \in E \qquad (7)$$

$$Y_{ij}^r \in (0,1) \qquad \forall (ij) \in E \text{ and } \forall r \in R \qquad (8)$$

$$X_{ij}^{mr} \geq 0 \qquad \forall (ij) \in E, \forall m \in M \text{ and } \forall r \in R \qquad (9)$$

$$W_{ij}^{m} \geq 0 \qquad \forall (ij) \in E \text{ and } \forall m \in M \qquad (10)$$

The objective function (1) is to minimize the total transportation cost associated with variable cost and fixed cost. Constraint (2) is the network flow conservation equation. Constraint (3) ensure that the flow of commodity m on link (i,j) does not exceed the total flow of the same commodity in all possible ranges of link (i,j). Constraint (4) ensure a range r is chosen on link (i,j) if it is used to transporting m with a flow requirement of dm unit. Constraint (5) and (6) ensure the total flow on link (i,j) is fall in the feasible range between lower and upper limit of the selected range r . Constraint (7) set that at most one range is selected for each link (i,j). Integrality of decision variable Y_{ij}^r is described in constraint (8). Constraints (9) and (10) are the non-negativity condition for the variable X_{ij}^{mr} and W_{ij}^{m} .

Symbiotic Organism Search Heuristics

The Symbiotic Organism Search (SOS) algorithm is a population-based evolutionary algorithm. It has been reported that being successfully implemented on several complex optimization problem. The algorithm itself influenced by the nature phenomena. In nature, the relationship and interaction in-between living entities in the environment known as a symbiotic relationship. Common symbiotic relationships found in nature are mutualism, commensalism, and parasitism.

Figure 1 shows a real-world biological interaction diagram categorized by the effect to the organism that is involved in the interaction. These categories consist of mutualism, commensalism, parasitism, amensalism, competition, and neutralism. In mutualism, organisms benefit from each other’s interaction, such as the interaction between starling birds and buffalo. Starling birds eat ticks (food) from a buffalo’s skin, which in turn reduces the itching on a buffalo’s skin. Commensalism takes place when one organism gets benefits, while the other organism is neither significantly harmed nor helped - for example, the interaction between clown fish and anemone where clown fish use anemone as hiding spot, while anemone doesnt affected. Parasitism takes place when an organism obtains benefits from a particular interaction, while the other organism is harmed - for example, the anopheles mosquito and the human body. Anopheles mosquitos induce a parasite into the human body that poses fatal threats, causing the human whose body was infected to die eventually. Amensalism is an interaction whereby an organism inflicts harm upon another organism without receiving any costs or benefits. An example of amensalism is where sheep or cattle trample grass. While the presence of the grass causes negligible detrimental effects to the animal's hoof, the grass suffers from being crushed. Competition is an interaction between organisms that harms each other. Different from the previous interactions, neutralism is a conceptual type of interaction that describes the relationship between two species that interacts, but does not affect each other. Examples of true neutralism are virtually impossible to prove, and so this concept is sometimes considered as being non-existent. This context of natural phenomena can thus be adopted in order to create a simple yet useful metaheuristic algorithm.

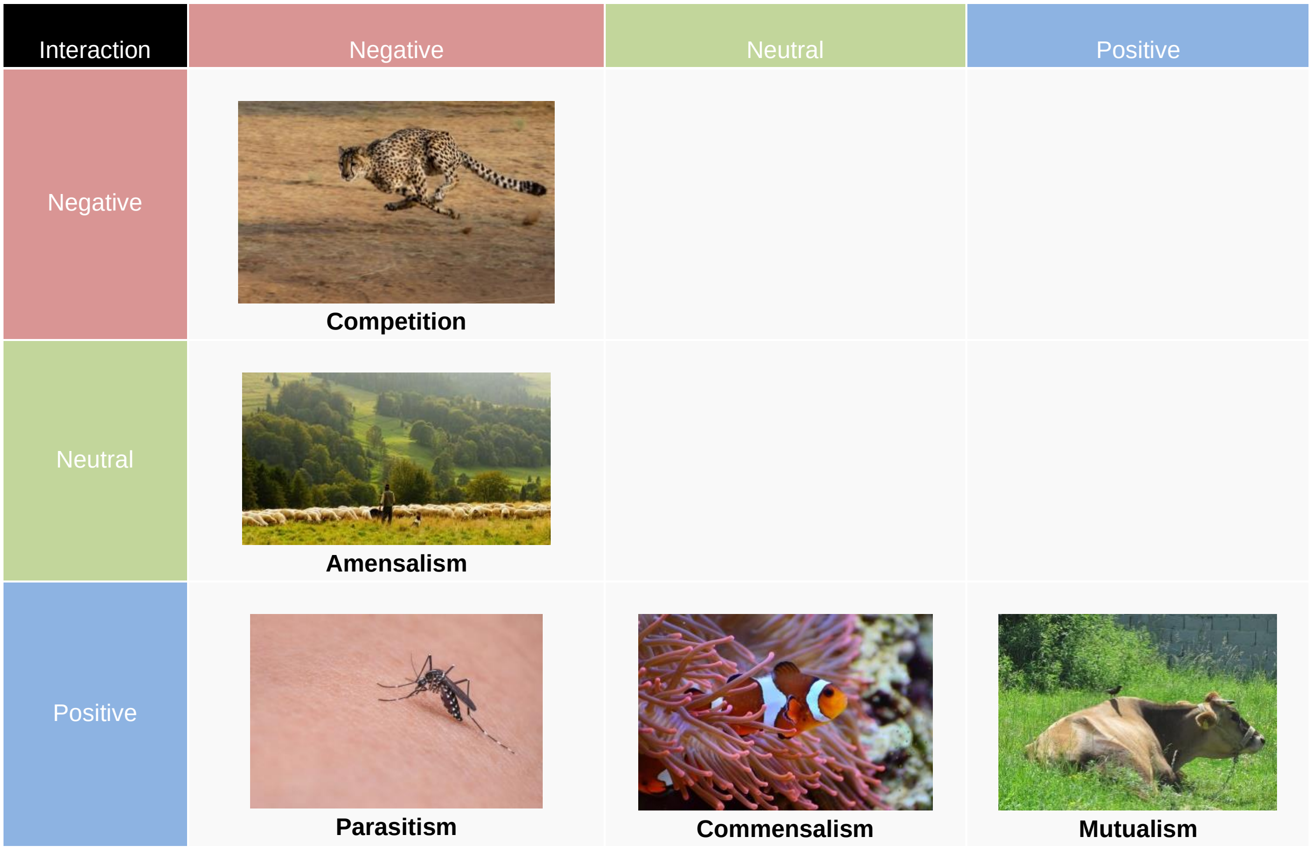


Figure 1 Real-world biological interaction diagram

In this study the implementation of SOS are modified to solve NDOPD. The implementation of Bi-SOS are shown in Figure 2. The algorithm starts from a population of randomly generated solutions known as an initial ecosystem. A new solution, denoted as an organism, is then generated based on three new neighborhood operators denoted as phases: mutualism phase, commensalism phase, and parasitism phase. The characteristic of each phase determines the movement of the organism and the decision to replace an organism. After finishing all the phases, another iteration of the Bi-SOS algorithm begins, and the whole process is repeated until termination criteria are met.

Pseudocode SOS for NDOPD (*eco_size, max_iter, max_nonimprove, pf*)
Step 1: Set $v = 0$; n=0; T=T_0;
Step 2: Generate initial population of X_i for $i = 1\ldots$ *eco_size*;
Step 3: Evaluate $f(X_i)$ for $i = 1,\ldots,$ *eco_size*;
Then F_{best} = *minimum*($f(X_i)$) for $i = 1\ldots$ *eco_size*;
$X_{best} = X_i$ for the corresponding *minimum*($f(X_i)$);
Step 4: For each X_i in $i = 1\ldots$ *eco_size*;
Step 4.1: Mutualism phase
Step 4.1.1: Select one organism randomly, X_j, where $X_j \neq X_i$;
BF_1 = 1 or 2; BF_2 = 1 or 2;
Mutual_Vector = $(X_i + X_j) / 2$;
Step 4.1.2: Generate $X_{inew} = X_i + U(0,1) * (X_{best} - Mutual\_Vector * BF_1)$;
Generate $X_{jnew} = X_j + U(0,1) * (X_{best} - Mutual\_Vector * BF_2)$;
Step 4.1.3: if $f(X_{inew}) < f(X_i)$ then $X_i = X_{inew}$;
if $f(X_{jnew}) < f(X_j)$ then $X_j = X_{jnew}$;
Step 4.2: Commensalism phase
Step 4.2.1: Select one organism randomly, X_j, where $X_j \neq X_i$;
Step 4.2.2: Generate $X_{inew} = X_i + U(-1,1) * (X_{best} - X_j)$;
Step 4.2.3: if $f(X_{inew}) < f(X_i)$ then $X_i = X_{inew}$;
Step 4.3: Parasitism Phase
Step 4.3.1: Select one organism randomly, X_j, where $X_j \neq X_i$;
Step 4.3.2: Generate $X_{parasite}$ from organism X_i;
Step 4.3.3: if $f(X_{parasite}) < f(X_j)$ then $X_j = X_{parasite}$;
Step 4.7: Update ParetoFront (*ParetoFront, X*)
Step 4.8: if $Obj(X_i) < F_{best}$ then $X_{best} = X_i$; $F_{best} = Obj(X_i)$; $n = 0$;
Step 5: $v = v + 1$; $n = n + 1$; $T = T * Alpha$;
Step 6: if $v > max\_iter$ or $n > max\_nonimprove$ then { terminate Bi-SOS; }
Else {Go to Step 3}

Figure 2 Pseudocode of Bi-SOS

The SOS framework has shown a successful implementation when applied to the engineering optimization problem. SOS was first used in a wide variety of unconstrained mathematical problems and structural engineering design problems.

Milestones and Dates

Milestone	Timeline	Output
Successful project acceptance	31 /11/2020	UP-UTP confirmed awarding the project
Project team initiation complete	31/12/2020	Appointment of research assistant
Specification of data required for the	31/01/2021	Data requirements signed off by Industrial partners (if possible). Otherwise, secondary publicly available data is used
Network Design Optimization for Petroleum Distribution model requirements specified	31/02/2021	Optimization model requirements signed off by all research collaborators
Model test data instances and expected outcomes specified	31/04/2021	Test data signed off by all research collaborators
NDOPD optimization model – first version	31/05/2021	Test data instances run through the model to produce expected results
Data collection complete	31/02/2021	Data available to modelleng and optimization team
SOS algorithm development for solving NDOPD	31/05/2021	The algorithm successfully solved the problem
Researcher visitation UP-UTP	31/06/2021	Research collaborator conducting visitation
Presentation of Partial result of NDOPD in conferences	31/09/2021	Attending and presenting the research in conferences
Embedded the solution framework into the Decision support software	31/11/2021	Decision support software available for all collaborators
Project Report	31/12/2021	Document project report available.

(d) Expected Results/Benefit

1. Novel theories/New findings/Knowledge

	At the end of this research, it is expected to develop an optimization model and algorithm to solve network design optimization for petroleum distribution in indonesia where the character of network Indonesia is special. The result of applying this algorithm is to minimize the distribution cost. **2. *Research Publications*** At the end of the project, this project is expected to be completing an international journal paper and a conference paper. The journal paper is targeting scopus indexed while the conference paper are aimed at a well-known international conference that related with this research. **3. *Specific or Potential Applications*** The potential application of this research is optimization based logistics simulation software. Optimization based software has been developed to allow this type of sophisticated analysis for decision making. **4. *Number of PhD and Masters (by research) Students*** *(Not applicable at Universitas Pertamina).*
D	**ACCESS TO EQUIPMENT AND MATERIAL**

	Equipment	Location
	Example / *Contoh***:** ***HRTEM*** **XRD**	**UiTM** **UKM**

E	**BUDGET BREAKDOWN**		
	Please indicate your estimated budget for this research and details of expenditure according to the guidelines attached.		
	Budget details	**Amount requested by applicant (USD)**	**Description of the budget**
E(i)	**Vote 11000 - Wages and Allowances for Temporary and Contract Personnel**	**800**	**For hiring project assistants (students)**
E(ii)	**Vote 21000 - Travel and Transportation**	**1,000**	Travel to UTP and to conference

E(iii)	**Vote 24000 - Rental**	**500**	For car rent to gather data and interview
E(iv)	**Vote 27000 - Research Materials & Supplies**		
E(v)	**Vote 28000 - Minor Modifications and Repairs**		
E(vi)	**Vote 29000 - Special Services**	**1200**	**For the conference registration fee**
E(vii)	**Vote 35000 - Special Equipment and Accessories**	**2,500**	**PC for high performance numerical simulation**
TOTAL AMOUNT		**6000 USD**	
F	**DECLARATION BY APPLICANT** **(Please tick *(√)*)**		

I hereby confess that:

☐ √ **1. All information stated here are accurate, the secretariat has right to reject or to cancel the offer without prior notice if there is any inaccurate information given.**

☐ √ ***2.*** **Application of this fundamental research is presented for the Universiti Teknologi PETRONAS-International Collaborative Research Funding.**

☐ √ ***3.*** **Application of this research is also presented for the other reasearch grant/s (grant's name and total amount)**

Date : 30 June 2020

Applicant's Signature : ....

G	**RECOMMENDATION** ***(Vice Chancellor/Deputy Vice Chancellor (Research and Innovation)/Director of Research Management Center)***
	Please tick (√) **Recommended:** ☐ ***A.*** **Highly Recommended** ☐ **B. Recommended** ☐ **C. Not Recommended (*Please specify reason*)** **Comments:** -- -- -- -- -- -- -- -- **Name:** **Signature:** **Date:**

Note: APPLICATIONS SUBMITTED WILL BE TREATED IN FULL CONFIDENCE. THE DECISION OF THE UTP-ICRF APPROVAL COMMITTEE IS FINAL.