Computers & Industrial Engineering 75 (2014) 41–54

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

Logistics network planning for offshore air transport of oil rig crews

Nathália da Silva Sena Hermeto [a,*], Virgílio José Martins Ferreira Filho [b,1], Laura Bahiense [b,1]

[a] Petrobras Petróleo Brasileiro S.A. 20° andar, Torre Oeste, Av. República do Chile, CEP: 20031-170, 330 – Rio de Janeiro, Brazil
[b] Production Engineering Department – COPPE/UFRJ, CT, Bloco F, sala 103, Cidade Universitária, CEP: 21945-970, Rio de Janeiro, Brazil

ARTICLE INFO

Article history:
Received 21 June 2013
Received in revised form 29 May 2014
Accepted 31 May 2014
Available online 21 June 2014

Keywords:
Offshore helicopter transportation
Facilities location
Network planning
Optimization
Decision support systems
Oil industry

ABSTRACT

Oil discoveries of recent years, especially in the pre-salt Santos Basin, reflect a large increase in petroleum exploration and production in Brazil. Accordingly, drilling rig and production platform crew transport demands will increase. This transport will also become more complex as average distance between fields and Brazil's coast increases. The helicopter, the modal most used for this purpose, is the most efficient means of transport in terms of speed and safety, but also entails high costs. Optimizing the crew transport logistics network thus becomes an economically significant issue. The study presents an optimization model for crew transport logistics network planning. That model aims to provide managers with accurate information to assist their decision making in logistics infrastructure planning. Such decisions involve airfield locations, distribution of demand among airfields and fleet profile. Since composing the fleet involves considerable expenditures, and once made, this composition is not easily changed, we built several scenarios varying in demand and fleet costs to evaluate the behavior of the model we are proposing as regards processing time and quality of the solution. We have obtained good results, despite the increasing complexity of the scenarios.

1. Introduction

Oil discoveries of recent years, especially in the pre-salt of Santos Basin, reflect a large increase in petroleum exploration and production in Brazil. Accordingly, drilling rig and production platform crew transport demands will increase. This transport will also become more complex as average distance between fields and Brazil's coast increases.

The helicopter, the modal most used for this purpose, is the most efficient means of transport in terms of speed and safety, but also entails high costs. Optimizing the crew transport logistics network thus becomes an economically significant issue.

1.1. Motivation

Increasing distances, both from the coast and between marine units, hinder the formation of service routes because helicopter autonomy must be respected and available passenger capacity decreases with increasing fuel weight. Greater distances also lead to a greater need for air bases spread along the coast. In this context, logistics costs tend to cause greater impact on oil extraction costs. It is thus of great importance to design an optimized logistics network that does not impede production from fields farther offshore. The challenges relate not only to costs, however, but also to helicopter flight autonomy and passenger safety. Therefore, use of operational research models is highly important to logistics network planning and fleet forecasting for the medium and long term.

1.2. Objective

The study presents an optimization model for planning a logistics network for offshore oil rig crew transport. That model aims to provide managers with accurate information to assist their decision making in logistics infrastructure design. Such decisions involve airfield locations, demand allocation and fleet size. The model also identifies the helicopter fleet composition affording lowest location costs for different demand and fleet rent rate scenarios. These decisions involve considerable expenditures, and once made are not easily changed, underlining the value of a decision support model.

1.3. Context

Passengers have always been transported to work in offshore oil exploration and production by air (helicopter) and sea (speedboat). The air mode predominates in this activity because of the speed,

* Corresponding author. Tel.: +55 21 21445930, mobile: +55 21 996843320.
E-mail addresses: nathaliasena@petrobras.com.br (Nathália da Silva Sena Hermeto), virgilio@ufrj.br (V.J.M. Ferreira Filho), laura@pep.ufrj.br (L. Bahiense).

[1] This author is funded by CNPQ (Brazilian Nacional Council of Scientific and Technological Development).

http://dx.doi.org/10.1016/j.cie.2014.05.021
0360-8352/

flexibility and comfort offered to passengers (Brittan & Douglas, 2009). Petrobras began its activities transporting passengers to work offshore in the mid-1970s, at the start of exploration of the Campos Basin. Initially, a mix of air and sea modes was used. This continued until the mid-1990s, when an internal study found that the air mode offers better flexibility and performance (time and cost) than maritime transport (Hermeto, 2009).

Studies have shown transport by boat to be safest (Spouge, Smith, & Lewis, 1994). Not only is maritime transport slower, however, it also entails problems in transferring passengers from vessel to platform, usually done in baskets lifted by platform crane. This overflow system has operational limitations according to sea conditions and wind speed, and the operating window is smaller than for helicopters. Currently, new technologies are available for offshore crew transport, including boats that are faster (up to 50 knots) and more stable. Transfer systems have also undergone safety-enhancing technological developments. Examples include the rigid basket, which provides greater safety than conventional baskets and has been in use since 2008 in West Africa (Brittan & Douglas, 2009), as well as models of ramp that are also at the development and/or trials stage. This study, however, is limited to transport by helicopter, the only means currently used in the area studied, which comprises the Campos and Santos basins.

The logistics network currently used for helicopter transport of crews comprises the airports of Vitoria, Macaé, Cabo Frio, Jacarepaguá, Itanhaém, Navegantes and the Sao Tomé heliport, as can be seen on the map in Fig. 1. The Sao Tomé heliport is owned by Petrobras; the others are partially leased by the company.

In 2010, Macaé airport was responsible for 45% of all related passenger movement. Taken together, Macaé airport, the Sao Tome heliport and Cabo Frio International Airport, which also serves transport to the Campos Basin, account for 77% of total movement. This is because oil-related activities are highly concentrated in the Campos Basin. However, growth forecast for the coming year is concentrated in the Santos Basin's pre-salt province, which is more distant from the coast and involves greater distances between rigs than the Campos Basin.

1.4. Paper organization

This paper is organized as follows. Introduction section addressed the motivation for studying this problem and its context. Section 2 presents related work. Section 3 describes the problem, assumptions involved and presents the mathematical formulation of the problem and the approaches used to solve it. Section 4 presents the experiments conducted in an instance based on real conditions. Section 5 presents obtained results and discussions. Lastly, Section 6 concludes the paper with the final remarks and suggestions for future work.

2. Brief literature review

The issue of logistics planning has been widely studied in its various aspects. Since the initial work that dealt with radical simplification of operational problems (e.g. problems of transport and allocation) to the most current studies that seek to model the richness of real-world conditions, considering different decision levels and planning horizons.

While the older approach consisted mainly of breaking the problem into smaller problems treated deterministically, the advancement of knowledge and computational power has allowed the most recent models include many features with the idea of reflecting some real cases or focusing on some particular aspects. Among the most widespread characteristics in the recent models are: a supply chain with multiple echelons and multiple products or families of products; stochastic where the data and variables are random variables; dynamic models where the data and variables may change at every period; complex product flows, with

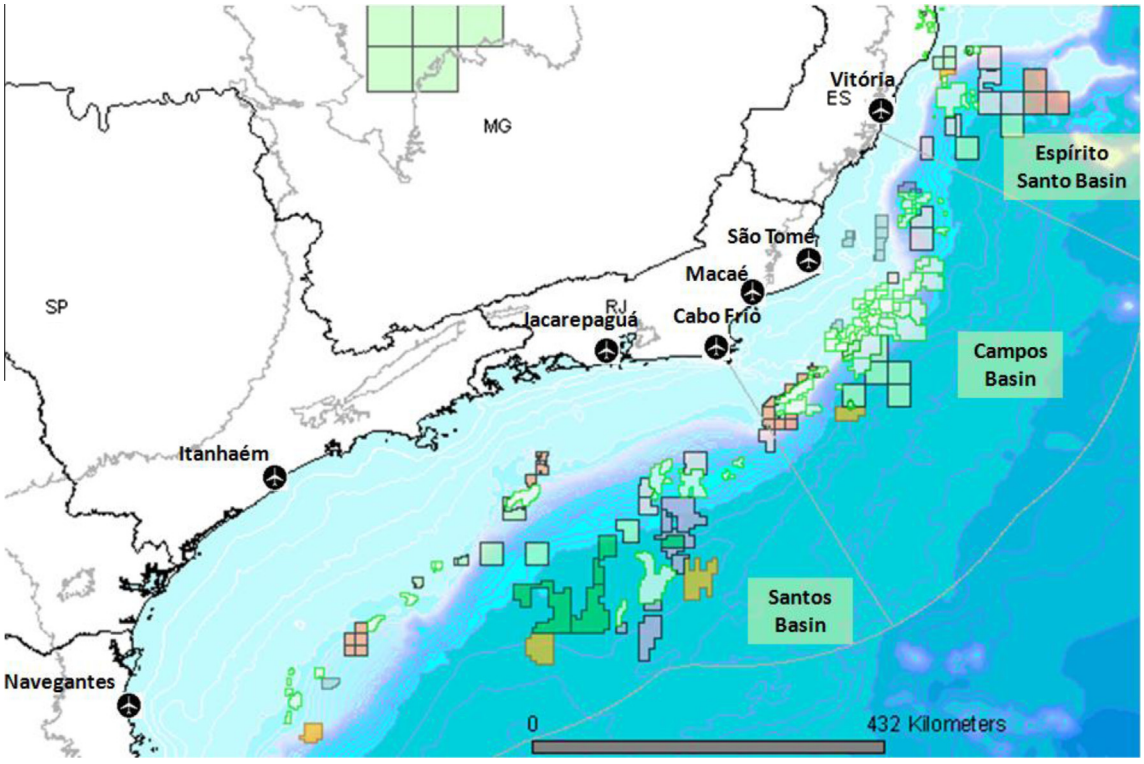

Fig. 1. Geographical distribution of airfields in the scope of the study.