Journal of Air Transport Management 71 (2018) 64–72

Contents lists available at ScienceDirect

Journal of Air Transport Management

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

Application of underground short-haul freight pipelines to large airports

Sirwan Shahooei[a,*], Ferika Farooghi[b], Seyed Ehsan Zahedzahedani[b], Mohsen Shahandashti[c], Siamak Ardekani[c]

[a] Graduate lecturer and Researcher, Department of Civil Engineering, University of Texas at Arlington, USA
[b] Graduate Teaching and Research Assistant, Department of Civil Engineering, University of Texas at Arlington, USA
[c] Professor, Department of Civil Engineering, University of Texas at Arlington, USA

ARTICLE INFO

Keywords:
Air cargo
Airport management
Freight pipeline
Underground freight transportation
Intermodal freight transportation
Airport security

ABSTRACT

The Dallas Fort Worth International Airport handles about 600,000 metric tons of cargo annually. These shipments are currently transported by trucks from the airport cargo terminals. An underground freight transportation (UFT) system has the potential to substantially reduce the truck traffic within the DFW Airport area and thus improve safety, efficiency, and air quality. The main reason for designing a UFT system in the DFW Airport is security vulnerability, when trucks drive under or near active runways and taxiways and may have hazardous or explosive cargo. Besides, the proposed UFT system is expected to reduce the number of trucks on airport grounds and the airport access roadways, thus enhancing both the roadway access capacity and safety as well as reducing adverse environmental impacts such as emissions and noise. The objective of this paper is to examine the feasibility of underground short-haul freight pipelines to a large airport such as Dallas-Fort Worth (DFW) International Airport. The proposed short-haul UFT system transports standard air freight crates between an airport cargo terminal and a distribution center off the secured airport grounds. The DFW Airport UFT system design includes planning level configurations of the tracks, vehicle, propulsion system, end-point terminals, and loading/unloading mechanisms at those terminals. Operational attributes such as speeds, headways, loading/unloading times, and line capacities are also determined.

1. Introduction

The objective of this paper is to design a short-haul underground freight transportation (UFT) system to be applied to a large airport and investigate the operational attributes of such system. In order to better understand parameters used in design and operation of the UFT pipeline, Dallas-Fort Worth (DFW) International Airport is considered for application of the UFT system. Using realistic parameters from DFW Airport helps in better understanding of system components, feasible design alternatives, and operational attributes. The proposed UFT line transports standard air freight crates between the cargo terminal and a distribution center off the secured airport grounds via an underground pipeline system. The secured airport grounds, also called airport operations area (AOA), refer to the area of the airport bounded by a fence to/from which access is restricted (DFW Airport 2011). The main reason for selecting a distribution center off the AOA is security vulnerability when trucks drive under or near active runways and taxiways and may have hazardous or explosive cargo. Also, regarding safety issues, an off-airport distribution center helps to reduce the percentage of trucks in the mix of the traffic to/from airport terminals. Reducing the truck traffic in airport area also enhances the environmental quality of the airport specifically noise and air pollution.

Most studies about freight pipeline are concentrated on the economic feasibility of such systems or construction of the tunnels. In this paper, the potential origin-destination points within and around the airport are identified for the proposed UFT pipeline. The planning-level configuration of the system including the capsule size, the tunnel dimensions, the tracks, the end terminals, and the cargo storage and intermodal cargo handling are designed. Moreover, operational attributes for the system are addressed as well including running gear systems, power requirements, operational speeds and headways, loading/unloading times, and associated line capacities.

The proposed UFT system is believed to substantially reduce the number of trucks on airport area and the airport access roadways, thus enhancing both the roadway access capacity and safety as well as reducing adverse environmental impacts such as emissions and noise. If the UFT lines are connected to intermodal rail terminals, the reduction in truck traffic in urban highways will extend beyond the airport access

* Corresponding author. Tel.: +1 682 240 2054; fax: 817 272 2630.
E-mail addresses: sirwan.shahooei@uta.edu (S. Shahooei), ferika.farooghi@mavs.uta.edu (F. Farooghi), seyedehsan.zahedzahedani@mavs.uta.edu (S.E. Zahedzahedani), mohsen@uta.edu (M. Shahandashti), ardekani@uta.edu (S. Ardekani).

https://doi.org/10.1016/j.jairtraman.2018.06.008
Received 1 March 2018; Received in revised form 21 May 2018; Accepted 10 June 2018

roads to the overall urban roadway network which in turn would have wider congestion mitigation and emissions and noise reduction benefits for the overall region.

2. Literature review

Literature review on previous various freight pipelines studies (either proposed as a concept or constructed as a pilot project or systems already in operation) were examined. These studies included studies conducted for the Federal Highway Administration by Volpe, the National Transportation Systems Center, and others (Vance et al., 1994), (Zandi et al., 1976). A focus of the literature review was innovative approaches that may have been undertaken in these projects such as innovative construction methods, propulsion systems, loading/unloading mechanisms.

Some of those projects include the Sydney Freight Circle for container transport from Port of Sydney to seven distribution warehouses (Fiars, 2009), the container port expansion project in Shanghai (Guo et al., 2008), and currently operating systems in the mining industry (Liu and Lenau, 2005), (Kosugi and Sanai, 1999). A comprehensive study for constructing a pneumatic capsule pipeline in New York city prepared by Liu (Liu, 2004). This study suggests a network of tunnels below ground in New York City with scattered stations that use elevators for bringing up pallet-size loads to the surface. In addition, the Freight Shuttle System proposed by Roop et al. (2001) were examined.

Switzerland is planning to construct a comprehensive freight pipeline system to connect major cargo hubs and distribution centers to major cities. This system named: “Cargo Sous Terrain”, is fully automated and is designed for pallet and crate size loads. The first phase of this system is expected to launch by 2030 (Cargo Sous Terrain AG, 2016).

In the Netherlands, the importance of flower export made the authorities, along with major flower producers and the Schiphol airport, design an underground pipeline system that can deliver fresh flowers to the airport as fast as possible. This system is designed to be fully automated and uses 200 to 400 Automatic Guided Vehicles (AGVs) for transporting freight in routes of 16–25 miles (van der Heijden et al., 2002). There are newer UFT systems in Europe which are designed or tested after 2010: “Mole” solution in the UK, uses Linear Induction Motors (LIM) and is in the laboratory test phase. The Pipe&Net system in Italy also uses a LIM as the propulsion system and is designed to connect two major hubs. The Underground Container Mover (UCM) is a UFT system designed in Belgium and is designed to solve the freight transfer problem in Belgium ports (ISUFT, 2015).

The most well-known system of pipeline transportation is the Hyperloop One. This system was originally designed to transport people in vacuum tubes in order to get the maximum speed. With the increase in the importance of cargo transportation, the Hyperloop one system is taking steps to design a hybrid system that can carry both people and cargo. This system has launched pilot test successfully, and more studies are undergoing for a full-scale system in Texas, Colorado, Florida, Chicago, Dubai, and UK (Hyperloop One, 2016).

A few studies are completed in Texas for constructing a UFT pipeline. This includes a study at University of Texas at Arlington that integrates the UFT system and existing highways and uses the existing right of way to design an UFT to transport shipping containers between Port of Houston to Dallas. (Najafi et al., 2016). Another study was done in Texas Transportation Institute to examine the feasibility of construction of a freight pipeline system along the I35 highway between Laredo border and San Antonio (Roop et al., 2001). These studies have formed the basis for schematic designs of various elements of the proposed UFT line.

3. Problem statement

DFW airport is one of the busiest airports in the nation (Airports Council International, 2016). The proposed UFT line has the potential to substantially reduce the truck traffic within the DFW Airport grounds and thus improve safety, efficiency, and air quality. In 2014 there was almost an equal amount of imports and exports; about 298,600 metric tons of imports and about 300,000 metric tons of exports (Bureau of Census, 2015). These cargos are currently transported by trucks from the cargo terminals. Assuming each truck is fully-loaded to its maximum legal weight (about 22 metric tons of cargo), there would be about 27,000 fully-loaded trucks per year coming into or leaving the air terminals. The proposed UFT line would alleviate the need for these trucks to enter the secured airport area and instead enter the perimeter UFT terminus point. Such systems would have the potential to reduce the number of trucks on urban roadways, thus enhancing both the roadway capacity and safety as well as reducing adverse environmental impacts such as emissions and noise.

4. Identifying terminal points

One end of the UFT system should be close to the DFW cargo terminal so loads can be embarked directly from the airplane to the UFT system. The other terminus point for the DFW airport UFT system must be close to the major highways in the area, so trucks can easily reach the terminal to pick up or unload their freight. The terminal also should have consistent land use with the surrounding area, so its 24- hour operation is not disruptive. Based on an examination of the DFW Master Plan, industrial land use has the highest compatibility with distribution center and terminal activities. Three potential candidate sites with compatible land use are considered for the satellite terminal location. These include the Northwest Logistics Center, the International Commerce Park (northeast of the airport), and the Proposed Intermodal Freight Terminal southeast of the airport. Fig. 1 highlights the location of all three suggested terminal points in relation to the cargo terminal and surrounding roadways.

The access highways to Northwest Logistic Center and the International Commerce Park are already operating at levels of service C and D. The access roadways for the proposed intermodal Freight Terminal are all at level of service A. Given the above, the proposed intermodal Freight terminal appears to be the most suitable candidate for the off-airport satellite terminal for the UFT line.

5. Design CharactERIstics

5.1. Freight dimensions

In the design of the tunnel and vehicle, International Air Transport Association (IATA) A-2 Crate is considered as the design freight size, namely the IATA Type A-2 (Code: DAA) crate. As illustrated in Fig. 2, this crate is 125 inches long, 88 inches wide, and 79 inches high (317 cm × 223 cm × 200 cm). It has a maximum gross weight of 13,300 lbs or 6 metric tons.

5.2. Tunnel construction

A straight tunnel can be used to connect the two proposed terminus points. As illustrated schematically in Fig. 3, the distance between the two points is 8100 ft. For the aforementioned freight size, a cylindrical tunnel is envisioned. Cylindrical tunnels are more suitable where tunnel boring machines (TBMs) are to be used, such as in this application where runways and taxiways cannot be disrupted by using cut-and-cover construction methods.

The depth of the tunnel, considering the soil conditions and underground utility lines is considered to be 40 ft. Tunneling using tunnel boring machines (TBM) is recommended for this project. This method has the least impact on the normal operation of the Airport. Based on the diameter of the tunnel and geotechnical considerations, the segmental lining is suggested for the tunnel structure and lining.