

NGATS, oil, and the future.

Term essay

Air traffic policy seminar

MIT

Matti J Kinnunen

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1 Introduction

Cheap and readily available air traffic is essential part of current way of life in USA and other developed world. In USA only, the number of air passengers is currently about 1.7 million per day and is expected to double or even triple in next 20 years [BTS, table 1-34, NGATS, p 8]. These passengers travel in total 503,339 million miles, which is about 11% of the highway passenger miles [BTS, table 1-37].

Air traffic is also essential for the functioning of the industry, which increasingly uses air cargo in its supply chains: one third of U.S. exports use air cargo [NGATS, p 7]. Inside USA, the amount of air cargo was 13,849,146 tons in 2004 [BTS, table 1-34]. Air traffic is also a major employer employing about 600,000 workers in 2004 [May].

Current air traffic system faces several threats. In this essay we will discuss how the price and availability of oil will impact the air traffic system. Most of existing airlines are not profitable, when the price of oil is more than \$40 a barrel [GS, p 1]. However, the price of oil may well rise further, and even reach \$100 a barrel [GW]. Such a price would be disastrous for current airlines, and would most likely slow the growth of air traffic.

At the same time, the Joint Planning and Development office (later, JPDO) has initiated the development of the next generation air transportation system (later, NGATS). The NGATS-plan [NGATS] does not explicitly discuss the price of oil at length. The purpose of this essay is to fill in this gap.

2 NGATS summary

The purpose of NGATS is to “meet the air transportation safety, security, mobility, efficiency, and capacity needs beyond those currently included in the FAA’s Operational Evolution Plan”. The plan covers years from 2005 to 2025.

For the purposes of this essay, one of key strategies centers on “introducing new policies, operational procedures, and technologies to minimize emissions on the environment. ... This effort includes exploration of alternative fuels, engine and aircraft designs.”.

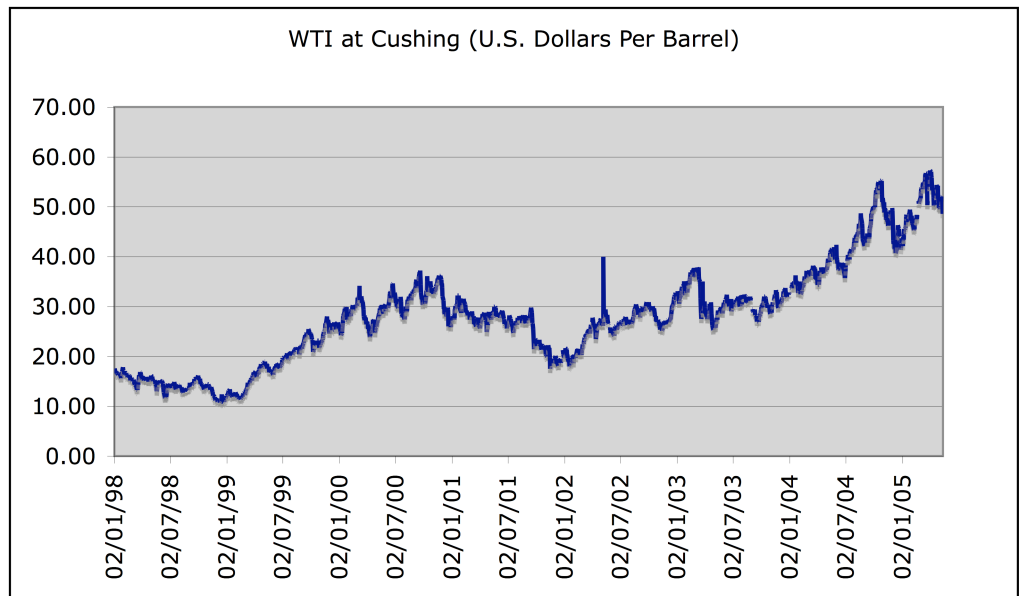
NGATS plan has several system goals. One of them calls for reducing noise, emissions, and fuel consumption [NGATS, p 9], thus also reducing air traffic contribution to global warming. Ways to achieve this include intelligent flight planning with improved management capabilities. The plan assumes that these will enable more efficient flight-envelopes resulting in lower fuel consumption.

The NGATS plan has eight transformation strategies. From the point of price of oil and fuel, the most important is the strategy number 6 called “develop environmental protection that allows sustained aviation growth”. It calls for “reducing uncertainty in emerging issues of climate change”, and for beginning long-term research on alternative fuels. Since the total amount of emission from air traffic is proportional to the amount of fuel burned [IATA], we do not discuss the greenhouse effect in this essay. For alternative fuels, see chapter 6.

3 Price of oil

At the time of writing this essay, the price of crude oil was about \$48. The graph¹ below show the price of oil per barrel since beginning of 1998.

We can see that the price of oil has been rising for the last 3.5 years. There are many explanations for the rise: political unrest in Nigeria,



Venezuela, the war in Iraq with the inability of bringing the Iraqi oil production up, and sporadic fighting in Saudi-Arabia. If these were the only reasons, we might expect the price to come down in the near future, when these political problems have been solved. There is, however, reasons for graver concern: according to many experts, the world may be approaching the peak of oil.

¹ Source: Energy Information Association: www.eia.doe.gov.

The concept of peak of oil was coined by Marion Hubbert in 1959. Hubbert predicted, that the oil production in USA would peak in 1970 and decline rapidly after this. His reasoning goes as follows: since there is a finite amount of oil in the ground, the more we discover oil, the smaller the probability of finding more will become. Therefore, its rate of growth of discovery will slow down, and eventually the growth will stop altogether. When this happens, half of the oil has been already pumped. At this point the production will peak, and decline thereafter.

Since the demand of oil is going to continue to grow (due to economic growth, especially in China, India, and other rapidly industrializing countries), and supply decrease, the price is going to increase rapidly. The price may well reach \$100 per barrel rapidly and continue rising. [Robert, pp 45-52, Goodstein, pp 26-30, GW].

The exact date of peak is not known. Some sources [GW] claim that the peak will occur in 2006, others in 2010 [Roberts, p 52], still others are more optimistic and estimate the peak to occur in 2020 [Greene, 2003]. In any case, the peak is likely to occur during the planning period of NGATS, which means that the air traffic system must adapt to oil prices of more than \$50 per barrel.

4 Airline economics and oil

Fuel is a major part of the overall expenses of airlines. According to [Committee], the cost of fuel makes 15% of total operating costs of a major airline, 25% of a regional one. This translates into revenues as follows: a \$2 increase in price of oil requires 1% increase in revenue in order to maintain same profitability level [GS, p 5]. In pure dollar terms, according to [May] one dollar increase in price of oil causes \$425 million increase in operating expenses of the airline industry.

Let's then assume oil price of \$100 per barrel, an increase of at least 100% from current prices. Airlines' operating costs would increase by (at least) \$21 billion dollars. In other words, the revenues would need to increase by at least 25% for them to be as (non)profitable as currently.

Clearly, such an increase of costs would necessitate significant increases in the prices of services (tickets and cargo). Increasing prices is likely to decrease demand; in the longer run, the economy should find new ways

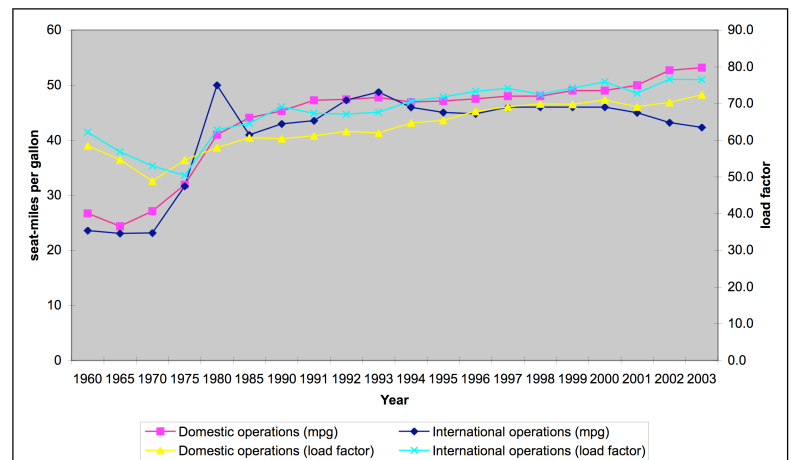
of operating with less air traffic. All this may render the current air traffic forecasts useless, or at least overly optimistic.

5 Aircraft fuel efficiency

The total amount of fuel consumed by domestic commercial aviation was about 13,000 million gallons in 2004. This is about 10% of the fuel consumed by passenger road traffic [BTS, table 4-5]. International aviation consumed in addition 4.800 million gallons of fuel.

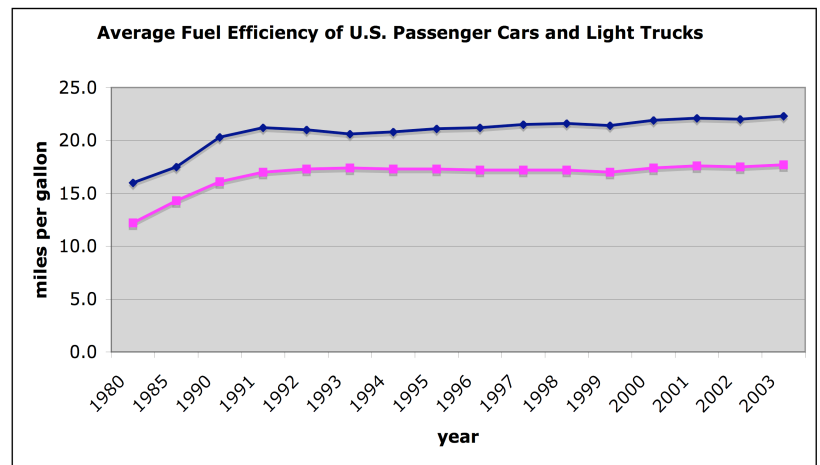
In 2003, the average seat-miles per gallon was 53 and 42 for domestic and international air traffic, respectively. The next graph shows how the energy efficiency of air traffic has increased since 1960.

The chart shows that the average seat-miles per gallon in domestic airt traffic has increased almost steadily, and followed closely the increase of the load factor. In international traffic, the both averages are lower, and the average seat-miles per gallon has actually decreased in since 2000, for reasons which are outside the topic of this essay.



Today air traffic is already remarkably energy efficient when compared to road traffic. The next chart presents the development of efficiency of passenger cars and light truck (SUVs) in USA.

These charts show that a car needs to have 2 passengers in order to be as fuel efficient as a airliner. Furthermore, the gaps seem to getting bigger as airliners get more efficient.



Given the likelihood of high oil prices, there is a large incentive in developing more efficient airliners². In the long run, this would increase the seat-mile per gallon – it takes new technologies up to 20 years to become common in air traffic system, since the average life of a airliner is more than 25 years [Greene, 1990, p 109, NGATS, p 13]. It is instructive to take a look at some research, both new and old, to see how large improvements are currently considered feasible.

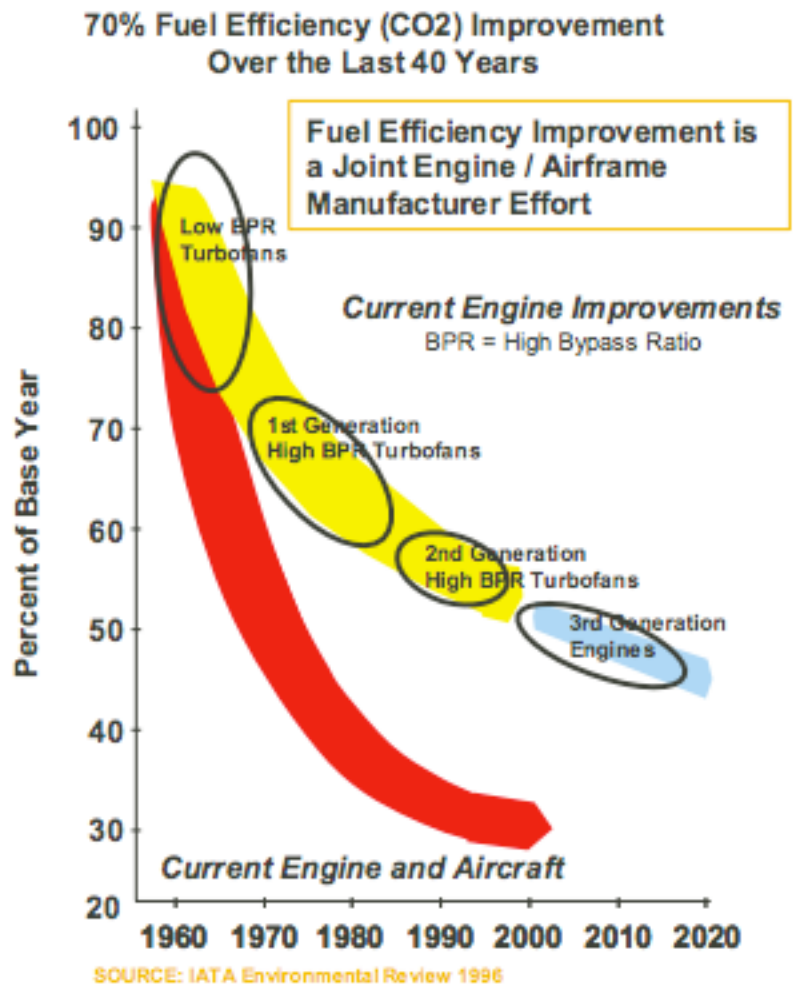
In 1990, David Green [Green, 1990] estimated that technological advances in would reducing drag by 15-20%, weight by 15-25% , and improve jet engines' specific fuel consumption by 20-30% by the year 2010. All this together would increase the seat-mile per gallon to the range of 110-150. Today, 15 years later, this estimate has turned out to be slightly optimistic. The most modern and largest airliner, the Airbus A380, is claimed to achieve 95 seat-miles per gallon [Airbus].

IATA estimates that the fuel efficiency of its members total fleet would increase 10% between 2000 and 2010 [IATA]. This is slightly less than the increase of 17% achieved between 1990 and 2000. The assumption behind this forecast is gradual introduction of “best available technologies” in airlines fleets. In addition, IATA claims, that 9% in system-wide fuel efficiency would be achievable by 2010 by adopting improved air traffic management. These improvements are the same as those mention in the NGATS-plan.

IATA further estimates, that airlines can achieve up to 6% increase in fuel-efficiency by, e.g., maximizing the load factors, using minimal number of engines when taxiing, using more simulation in training, using external electricity instead on-board engines when airliner is standing at the gate, and by improving overall maintenance of airliners.

² The bad economic situation of airlines darkens the picture: can they afford any new planes.

All these action together can increase the average seat-miles per gallon up to 110 in the total fleet (whole fleet as good as A380 and realizing the extra improvements) by 2025. This would mean an improvement of approximately of 100% when compared to the fleet of 2004. If the total air traffic will increase as forecasted in the NGATS-plan, the total usage of fuel in air traffic would increase by 50%. This estimate is very optimistic, since the total renewal of the fleet is not likely happen. If this forecast would materialize, the total improvement in the next 20 years would be larger than the total improvement in the last 40 years, which is show in the graph above.



6 Hydrogen as an alternative fuel

The increasing price of oil will eventually increase interest in alternative fuels for air traffic. The most promising of them is liquid hydrogen (LH). It has several advantages: it is lighter and has higher caloric value than kerosene, which reduces the weight of fuel 2.8 times, it does not produce greenhouse gases, and there is basically unlimited amount of LH available given enough energy to produce it. The main disadvantages are larger volume of LH when compared to kerosene, and the fact that LH has to be stored in very cold temperatures, both of which require new airliner designs.

Airbus has started a research program³ aiming at designing and implementing an hydrogen powered airliner [Faass]. The project intends to perform full system analysis of hydrogen airliner. Preliminary results show, that all categories of airliners may be hydrogen powered, operation weight increase of 20-25% due to lighter fuel and that energy consumption of airliner increases due to higher flight weight. The analysis also shows that using hydrogen as fuel is likely to make airliners safer.

Thus, it seems possible to replace kerosene with hydrogen as the fuel of airliners. Replacing the kerosene based land infrastructure will also be necessary and may turn out to be harder, and will certainly require long time. For example, the current production of LH in Europe is 17 tons, whereas converting intra-Europe air traffic to hydrogen would require 30,000 tons. The most likely solution is to produce hydrogen at airports using electrolysis.

For these reasons it is unlikely that significant amount of hydrogen aviation would become reality before 2025. High energy prices or dramatic climatic changes may, however, speed up the transition, as they may speed up it in other sectors of society.

7 Conclusions

The coming rise of the price of oil will change the economic landscape dramatically. Expensive oil is going to hurt the transportation sector of the economy especially hard in the USA, since almost all transportation uses oil. In order to alleviate the pain of transitions, the government should do the following.

First, it should encourage novel business models in aviation. One way of doing this is to let existing, non-profitable airlines go bankrupt. This would free-up capital, both financial and human, needed for adapting to higher prices of oil.

Second, it should implement the parts of the NGATS-plan, which reduce the fuel consumption of all airliners, even if it would leave other parts unimplemented.

³ NASA has also similar research going on, but we do not summarize it here.

Third, it should invest heavily in making hydrogen powered airliners reality. There are at least two reasons for this. First, the number of airports is much smaller than the number of gasoline station, thus introducing hydrogen facilities in airports/for aviation is smaller task than introducing them for road traffic. Second, the long production life of airliners together with the long time it takes to design new ones means that society must start the transition early. The only stakeholder capable of mandating early start is the government.

Fourth, the governments in USA and in other developed world must start replacing short-haul flights with high-speed train services. Trains are not dependent on fossil fuel, and will thus provide for smoother transition to hydrogen based transportation economy.

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