Fundamental Study of Potential Demand and Capacity Expansion Measures of Alternative Transportation by Air in the case of Tokaido Shinkansen Disruption

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1.Background and Objectives

▶ Disruption of High-speed Rail (Shinkansen) by Big Natural Disasters

・Shinkansen lines stopped its operation for a long time in the past disaster. (Ex. Great East Japan Earthquake)

・Nankai Big Earthquake is expected to occur in the near future, and Tokaido Shinkansen (Highest demand line) might be also damaged.

▶ Alternative transport by air

・Air Transport have taken a role of the alternative transportation of Shinkansen at the past disasters.

・But the transport capacity of the air is usually much less than that of Shinkansen.

⇒Capacity limit of the congested airports（Haneda・Itami etc）and aircr

- How much demand can be generated in alternative transport by air?
- How can the capacity of the air be expanded?

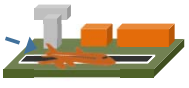
Alternate transport of Shinkansen

▲ Temporary Flights are used by Shinkansen users

▼Airplane with increased flight

As the demand increases, the congested airport can't manage
⇒It needs cooperation with other airports

▲Neighboring Airport



▲Congested Airport

▶Objectives

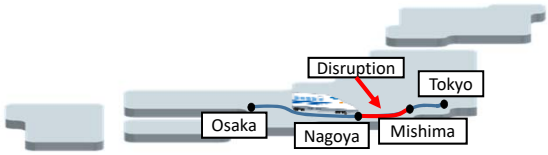
- To calculate **the demand of passenger for alternative air routes** when Nankai Earthquake occurs and Tokaido-Shinkansen is stopped.
- To propose the **capacity expansion measures of alternative transport by air.**

2. Estimation of passenger demand for alternative air routes

① Assumption of the disruption section of Shinkansen

- Disruption area

➢ Tokaido Shinkansen Mishima station to Nagoya station



② Estimation of mode choice model (Air, Train and Car)

$$P(a,b) = \frac{\exp(V_a + \lambda\Lambda)\exp(V_b + V_{ab})}{\sum_{a'}\exp(V_{a'} + \lambda\Lambda)\sum_{b'}\exp(V_{b'} + V_{ab'})}$$

$$\Lambda = \ln\sum_{b'}\exp(V_{b'} + V_{ab'})$$

P(a,b) : choice probability of mode (a,b)
Λ : logsum variable of air and train
V_a : Utility value of public transportation and car selection
V_b : Utility value of air and train selection
V_{ab} : Utility value related to two stages

☐ Source of data

- Inter-regional Travel Survey in Japan(2010)
- NITAS (MLIT)

	β	t-value
Total travel times(min)	-1.38E-02	-15.7
Total cost(yen)	-1.02E-04	-13.9
Car constant term	0.380	3.35
ρ^2	0.248	
λ	0.619	
Time value(yen/hour)	8,087	

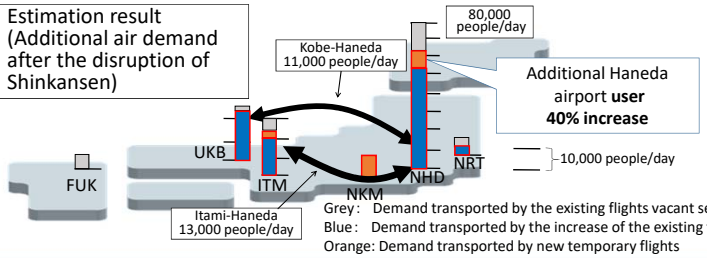
③ Estimation of passenger demand of each air route

1) Estimation of air passengers demand between all OD pairs by the mode choice model after the change of transport LOS by Shinkansen disruption.
2) For all OD pairs, distribute the air demand to vacant seats of existing regular flights if there is the convenient regular flight.
3) If the demands of 2) are over the capacity of the existing flights, the frequency of the regular flights are increased.
4) If there are no convenient existing flights, we assume the new temporary air routes are operated between the nearest airports.

☐ Source of data

- Inter-regional Travel Survey in Japan(2010)
- Statistics of air transport in Japan
- NITAS (MLIT)
- flightradar24

● Estimation result (Additional air demand after the disruption of Shinkansen)



Grey : Demand transported by the existing flights vacant seats
Blue : Demand transported by the increase of the existing flights
Orange: Demand transported by new temporary flights

3. Capacity expansion measures of alternative transport by air

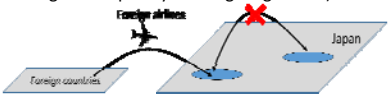
① Air Fleet Capacity

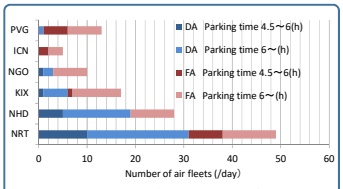
・Shift of the regular flights to high-demand air route from less-demand air route that have enough vacant seats.

・To utilize the international flight fleets which stay in Japanese airports for enough time to operate one round-trip domestic flight.

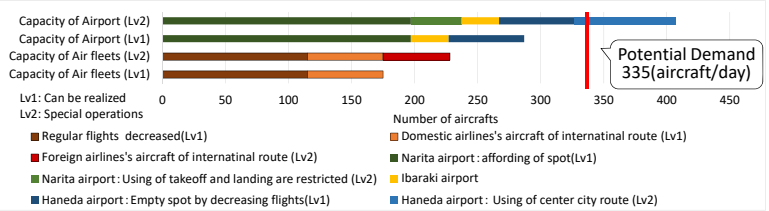
⇒For the foreign airlines, **Cabotage regulation must be deregulated for the disaster emergency period.**

(Foreign airlines can not usually transport domestic passengers in Japan by cabotage regulation)



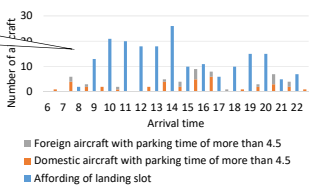


・ At the main international airports, there are long-staying aircrafts to some extents.
・ At Narita airport, relatively large number of international aircraft is available even if it is limited to domestic airlines.



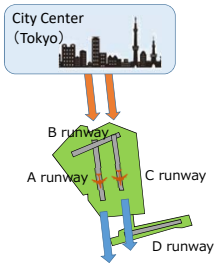
- **if special operations are possible, airport capacity for additional flights can be created.**
- Air fleet capacity is more severe than airport capacity, but capacity expansion measures like utilization of international flight fleets can be useful option.

Narita airport have vacant slots and available international aircrafts

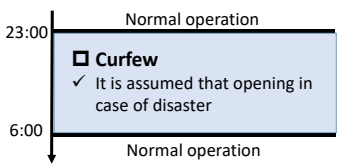


② Airport capacity

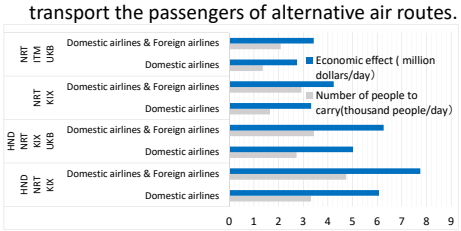
・ Capacity expansion by the use of new air route over the downtown Tokyo(NHD)



・ Use of runway in times when takeoff and landing are restricted(NRT)



- we estimates the users benefit of the air fleet capacity expansion measures in case that the international flight fleets at main airports are used for the domestic air routes to transport the passengers of alternative air routes.



$$LS_{ij} = \frac{\lambda}{\theta} ln \sum \exp(V_{ijm})$$

LS_{ij} : Logsum value of zone ij
V_{ijm} : Utility of transport zone ij or route m
Θ, λ : parameters in mode-choice model

As a result, we can secure bigger transport capacity than in the case of the Great East Japan Earthquake.

4. Conclusion

- We estimated the potential demand for alternative transport by air and the capacity expansion measures in case of Tokaido Shinkansen disruption.
- In the current operation, the capacity of airports and air fleets are much less than the potential demand, but i**t is possible to cover demand by conducting special management.**