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Broadband Deployment and Government Policies in Islands: Case Studies in Japan

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1. Introduction

Limited Internet access in less favored regions was not apparent when narrowband access including "dial-up" access and "Integrated Services Digital Networks (ISDN)" using existing telephone networks was common, because "universal telephone services" are practically obligatory for telecom incumbents. E-mailing and basic Internet browsing using primitive Internet access were widespread in developed societies. In addition, mobile Internet use via cellular phones has been rapidly growing in these societies. However, geographical gaps in Internet access increased after broadband services became widely available in developed countries in the 2000s. Unlike basic telephone voice services, the provision of universal broadband services has not yet become obligatory in most countries. (Picot and Wernick, 2007)

Although broadband availability has increased, differences in access, the so-called "geographical digital divide," remain. (Greenstein and Prince, 2007) The conditions for broadband deployment in less favored regions, such as mountainous areas or small remote islands, are particularly severe because of their small populations.

One severe challenge facing universal broadband access is a problem known as the "last mile" problem which refers to making the connection between a subscriber and the nearest Internet access point.(Downes and Greenstein, 2007) This challenge is very true in the broadband deployment in mountainous areas. A communication channel connecting scattered dwellings along a narrow valley and the access point of Internet is quite costly and Internet services are unprofitable for a private service provider. (Arai and Naganuma, 2010)

However, there are different difficulties in the broadband deployment in islands. The highest barrier to broadband deployment in an island is the means to connect the network of the island with the backbone Internet networks in the mainland. Submarine optical cable is the best way for the connection in respects of capacity and stability. Submarine optical cable network is, however, quite costly both to construct and to keep operation. The allocation of the large cost is a serious challenge for the broadband deployment in islands. In an island with relatively large population, where sufficient

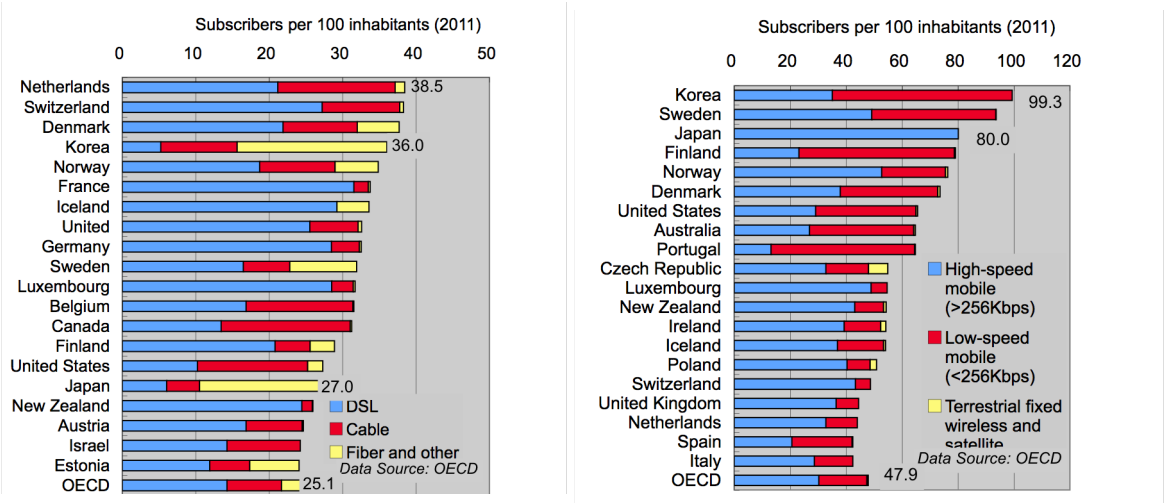
number of subscribers can be expected, a private telecom carrier may construct a submarine optical network and provide broadband services in the island. However, when telecomm-carriers assess the profitability of the submarine network to be insufficient for commercial services, people in the island are compelled to abandon broadband services unless they find some alternative means for the network construction.

Despite the difficulty of oversea connection, broadband have been deployed in almost all of inhabited islands of Japan in the latter half of 2000s. Manifold solutions for the challenge have been developed both in the respect of telecom technology and in the respect of the institution for the network construction and operation. The local governments played a key role in the deployment process, and the Japanese Government provided positive supports to the local governments. In this study, we will examine the geographical difficulties in broadband deployment in islands and the government policies to overcome the difficulties based on several case studies in Japan.

2. Diffusion of broadband services and limited broadband access areas in Japan

Before discussing the case studies, let us take a brief overview of diffusion of broadband in Japan. The statistics of broadband show that the penetration rates of fixed, or wired broadband are, in general, on the highest level in North European countries. The rate of Japan is slightly higher than the average of OECD member countries. Fiber-to-the-home (FTTH) penetrates considerably in Japan and Korea.(Figure 1a)

OECD starts publish the statistics of wireless broadband in 2011. This statistics reveals that Japan is the third in wireless broadband diffusion among OECD member countries. The share of high-speed mobile connection of Japan is significantly higher the other countries.(Figure 1b)



a. Fixed (wired) broadband b. Wireless services

Figure 1 Broadband subscribers in selected countries of OECD (2011)

In Japan, broadband services via cable television networks were launched in 1998. DSL diffused around 2000 to 2005, then tends to be declining. FTTH has rapidly grown since 2005. (Figure 2)

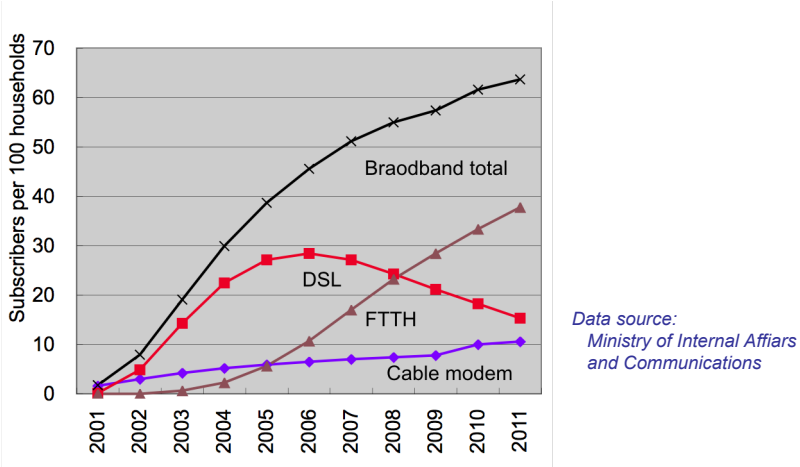


Figure 2 Penetration of broadband services in Japan

The Japanese Government has been promoting the diffusion of broadband since 2000. The government has taken positive policies for broadband penetration into Japanese society. For example, in the "u-Japan (ubiquitous Japan)" policy package, the government set the goal to have nationwide universal broadband access no later then 2010. (Arai and Naganuma, 2010)

According the result of a questionnaire survey carried by the authors in 2009 and 2010, for more than 70% of the municipalities throughout the country, less than 1% of residents had no broadband access. Overall, most municipalities in Japan had broadband access to some extent. However, for more than a quarter of the municipalities, more than 10% of their residents did not have any broadband services. Limited broadband access areas truly remained at the time of the survey. (Arai, Naganuma and Satake, 2011; Arai, Naganuma and Satake, 2012)

The questionnaire survey also revealed that limited broadband access was typically found in mountainous areas and islands.(Figure 3) Although scattered settlements along winding roads need long communication lines in mountainous areas, in islands, the connection between the

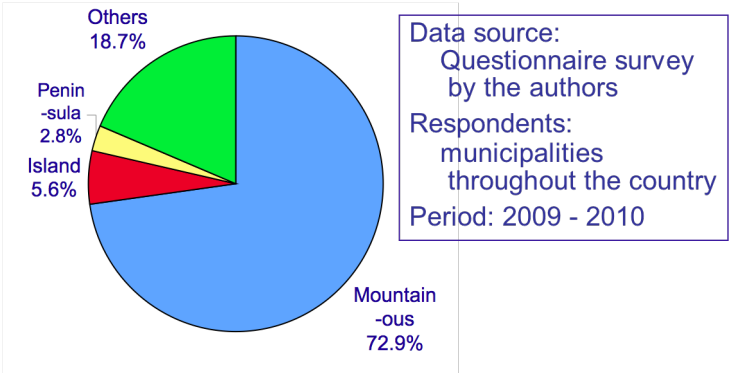


Figure 3 Geographical features of the areas without broadband

islands and the mainland is a severe difficulty for broadband deployment as discussed later.

However, many broadband deployment projects in islands by the local governments have been carried out around 2000. In these projects, various solutions to overcome the difficulties due to the characteristics of islands. We studied five selected cases of the projects in islands and examined geographical difficulties and solutions in broadband deployment by the local governments.

3. Five Cases

Here we will focus five cases of broadband deployments in islands in selected areas of Japan. In the technological respect of communication construction, these cases can be classified into three types. (Figure 4) In the first type, submarine optical cable connection between the island network and the backbone networks in the mainland was newly constructed. *Ogasawara* and *Daitoh* are classified to this type. In the second type, high-speed wireless access such as Wi-Max was chosen as the means of oversea connection. *Tokashiki* belongs to the second type.

Although both the first type and the second type accompany the construction of new communication channel, no new channel was constructed in the third type. Existing oversea channels were employed in there cases. An existing aerial oversea fiber-line is utilized in *Ohsaki-Kamishima*. Submarine fiber lines, which is constructed and operated by a commercial telecom-carrier, is leased in the case of *Toshima*.

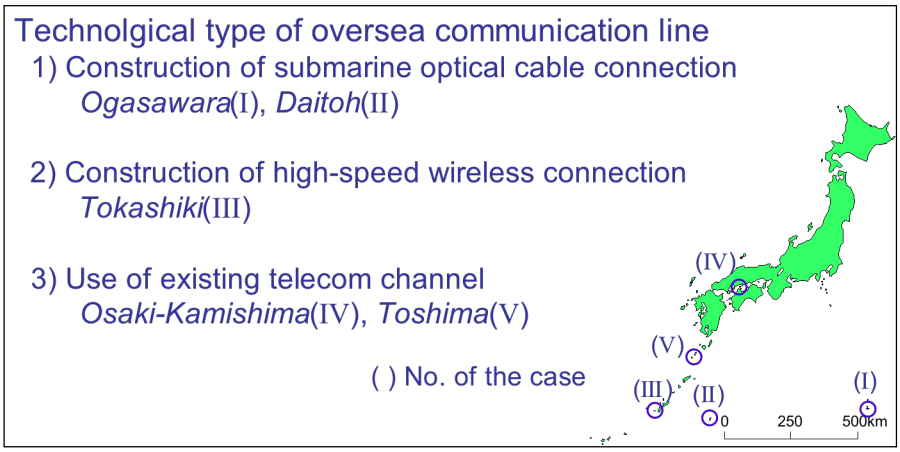


Figure 4 Location of five case study areas

The outlines of each deployment projects are the following.

Case I: *Ogasawara*

Ogasawara is a group of islands belongs to *Tokyo* Metropolitan (*Tokyo*-To), which is located in the Pacific Ocean, 1000km away from the Japanese mainland. *Chichijima* Island and *Hahajima* Island are inhabited islands and constitute *Ogasawara* Village.

Total population of the village is about 2,500. A submarine fiber line was constructed by the deployment project in the period from 2009 to 2011. The submarine line is about 1,000km long and connects *Ogasawara*'s digital network with *Hachjojima* Island, where the nearest access point to the Japanese mainland is located. The submarine cable is shared with Internet services and the transmission of terrestrial digital television broadcasting. Before the submarine line was deployed, satellite connections were used for analog television broadcasting and narrowband Internet services. Access condition of Internet services in the islands was drastically improved by the submarine line. (Figure 5)

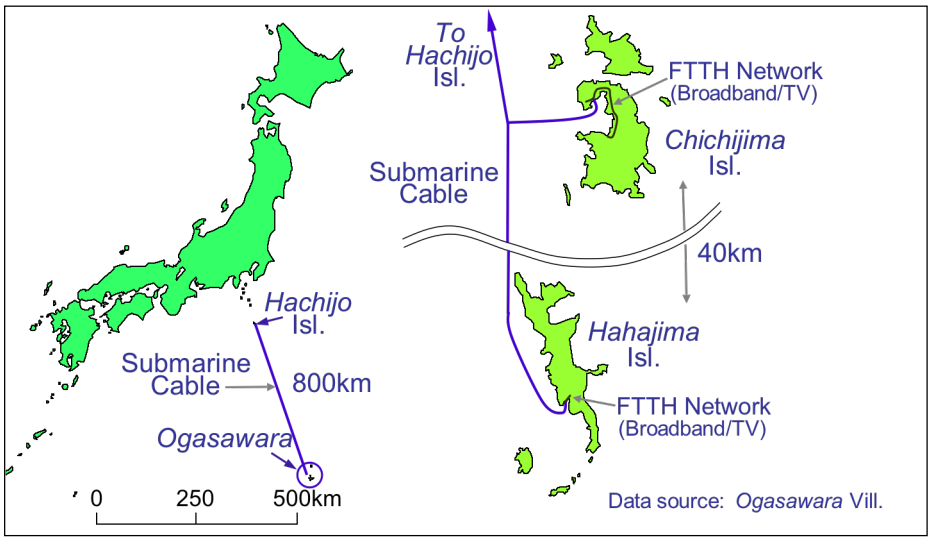


Figure 5 Case I: *Ogasawara* : The construction of submarine optical cable line

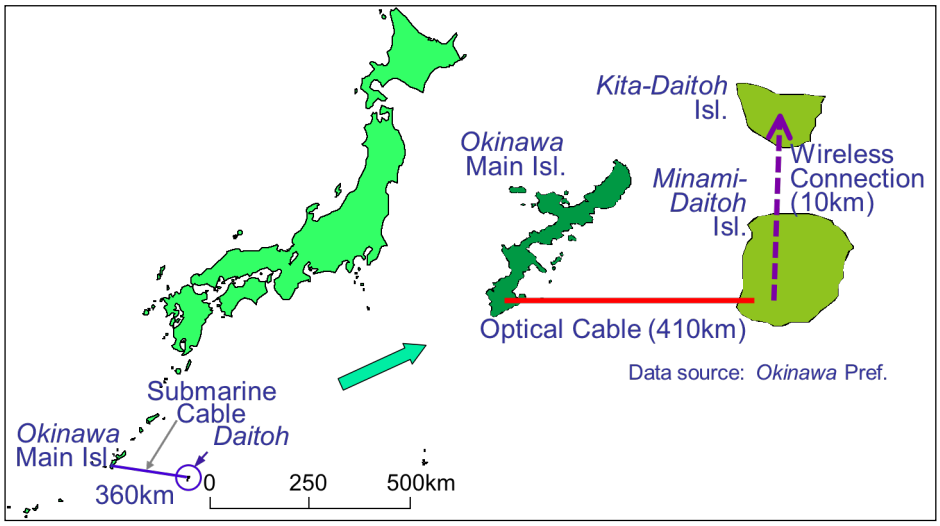


Figure 6 Case II: *Daitoh* : The construction of submarine optical cable line

Case II: *Daitoh*

Daitoh consists of two inhabited islands: *Mninami-Daithojima* and *Kita-Daithojima*, which belongs to *Okinawa* Prefecture. The population of these islands are about 1200 and 500 respectably. *Daitoh* is 360km away from the *Okinawa* main-island (*Okinawajima*). A satellite connection for analog television broadcasting had been used, before the new oversea connection was constructed. The satellite connection was the same one used for *Ogasawara*. A submarine fiber line of 410km long was constructed from 2009 to 2011. The submarine line connects *Minam-Daitohjima* with the *Okinawa* Main-Island. Wireless access is employed for the connection between *Minami-Daitohjima* and *Kita-Daitohjima.* The submarine connection is shared with Internet services and digital broadcasting similar to *Ogasawara*.(Figure 6)

Case III: *Tokashiki*

Tokashiki is a island of about 700 residents belonging to *Okinawa* Prefecture. Although *Tokashiki* is located about 30km away from the *Okinawa* main-island, *Zamami* Island, which is of 5.5km away from *Tokashiki*, is connected with the *Okinawa* Main-Island by the submarine fiber line of a telecom carrier. In the case of *Tokashiki*, Fixed Wi-Max wireless access is employed for the connection between *Tokasihi*'s network and the access point in *Zamami* Island. Fixed Wi-Max connection is also used for the user network in the island. Before the deployment of the Wi-Max connection, the residents of *Tokashiki* could use only narrowband Internet services via a submarine co-axial line. The Wi-Max network provides services similar to the ADSL quality.(Figure 7)

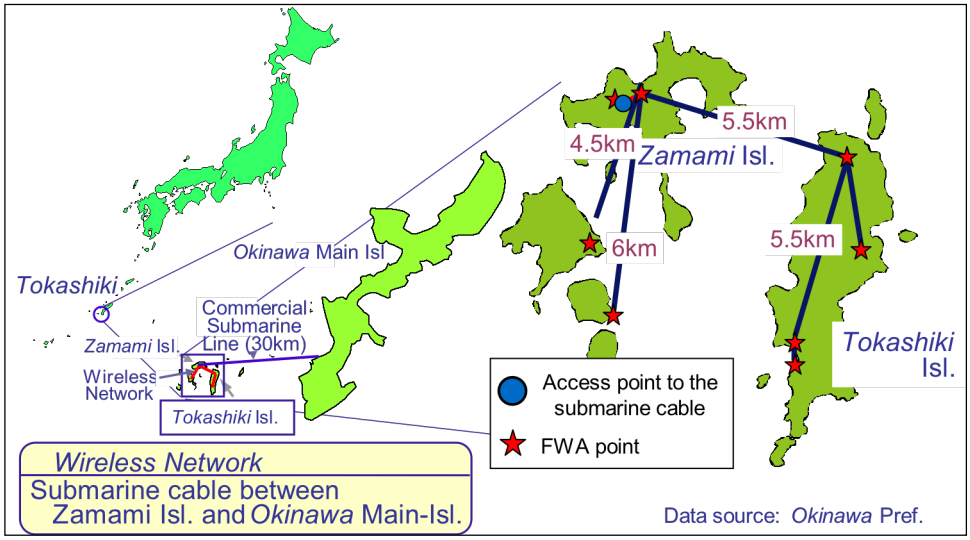


Figure 7 Case III: *Tokashiki*: The construction of wireless network

Case IV: *Ohsaki-Kamishima*

Ohsaki-Kamishima is a island of 9,000 population located in *Setonaikai* Sea. The island belongs to *Hiroshima* Prefecture and is of 3km away from the coast of the Japan Mainland. Oversea connection between *Ohsaki-Kashima* and the mainland is exceptional. A aerial fiber line over the strait has been constructed by a electric power company for power supply control. When the broadband network in the island was deployed, this fiber line was utilized for the oversea connection to the mainland. The island FTTH network is connected to Internet backbone via the network of a telecom subsidiary of the electric power company, which is also the operator of the island network. Free space optical laser access and fixed wireless access are employed for the connection between *Ohsaki-Kamishima* and two small islands.(Figure 8)

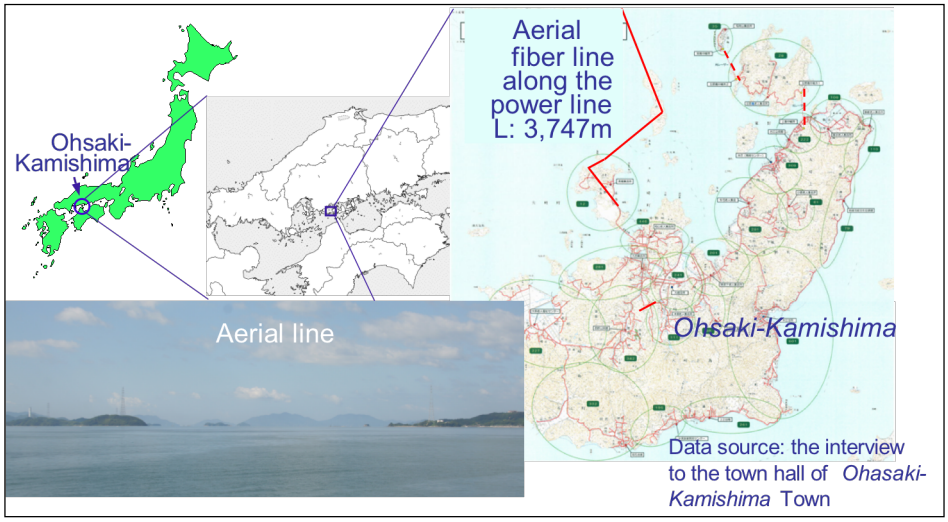


Figure 8 Case IV: *Ohsaki-Kamishima*: The use of existing telecom channel

Case V: *Toshima*

Toshima is a group of islands belonging to *Kagoshima* Prefecture. *Toshima* consists of seven inhabited islands and is located at from 200 to 300km apart from the *Kagoshima* Mainland. Total population of seven islands is about 600. Large distance between the islands and the mainland and small population reduce greatly the profitability of a new submarine fiber line. However, a telecom incumbent, NTT West -Japan, has constructed its submarine fiber lines from the *Kagoshima* Mainland via *Yakushima* Island to three islands of *Toshima*, which are a part of the trunk telecommunication route between the Japan mainland and *Okinawa* Islands. *Toshima* Village, the local government of *Toshima*, chose NTT's leased telecom-line service, which is called “Mega Data Nets” to construct the digital network of the village. *Toshima* Village constructed also the wireless access lines between the three islands connected to NTT’s lines and the other islands. All public facilities and almost all of

houses are connected to the village's network. However, limited capacity of the NTT's leased lines, which is up to 10Mbps, reduces the quality of the networks services, especially video services.(Figure 9)

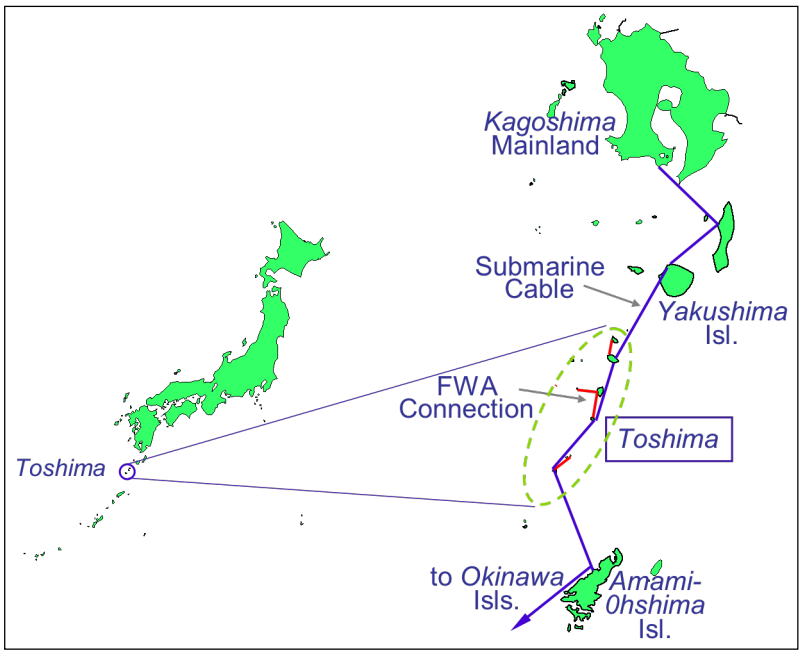


Figure 9 Case V: *Toshima*: The use of existing telecom channel

4. Technologies of oversea connection

A comparison between submarine cable and wireless connection shows clearly the difference of suitable distance of oversea communication for each technological solution. Table 1 shows the features of the construction of wireless connections. Wireless connections of small islands which were found in our case studies are added to Table 1. Table 2 summarizes the features of the cases which consist the construction of submarine optical cable lines by the governments. The distance of wireless connection is up to 25km. Total population of the targeted islands of wireless connections is less than one thousand. Even in the case of the island of very small population, such as the islands belongings to *Ohsaki-Kamishima*, wireless connection can be employed, when the connection distance is small.

On the other hand, for the case of larger distance of oversea connection than thirty kilometer, the construction of submarine fiber line is chosen. The distance of wireless access is limited near to the sight distance, which depends on the earth radius. When the distance of oversea connection exceeds the limitation of wireless connection, only fiber access can be employed. However submarine fiber cable is quite costly and reduces the profitability of a oversea telecom business. In the cases of *Ogasawara* and *Daitoh*, the possibility of commercial communication services is completely hopeless due to large distances to the mainland and to small population of the islands. Most of expenses for

Table 1 Features of the construction of wireless connection

		Tokashiki	*Daitoh*[2)]	*Ohsaki-Kamishima*[2)]	*Toshima*[2)]
Period of the deployment(fis. y.)		2006	2009-11	2001-03	2008-10
Total population of the targeted islands		730	514	66	304
No. of subscribers		157(39.0%)			
Distance of oversea FWA		5.5km	10km	0.8 -1.3km	15-25km
Total expense (mill. Yen)		180[1)]	unkown	unkown	unkown
Share of the cost	National Gov.	8/10	2/3	80%	83%
	Prefecture Gov.	1/3	1/3	none	none
	Local Gov.	0.2%	none	10%	17%

Note 1): Total expenses includes the deployment of Wi-Max user access
2): Oversea connections between small islands and the main-island

Table 2 Features of the construction of submarine optical cable line

		Ogasawara[1)2)]	*Daitoh*[1)2)3)]
Period of the deployment(fiscal year)		2009-10	2009-11
Total population of the islands		2,417	1,771
No. of subscribers:		824(58.8%)	228 (27.7%)
Length of cable		1,000km	420 km
Total expense		9,600mill. Yen	4,300 mill. Yen
Share of the cost :	National Gov.	2/3	2/3
	Prefecture Gov.	1/3	1/3
	Local Gov.	none	none

Note:1) The submarine cable is shared betweem Internet services and terrestrial digital TV broadcasting.
2) The satelite connection for terrestrial analog TV broadcasting was replaced by the submarine connection.
3) The telecom carrier (NTT) shared a part of the expenses

Table 3 Features of the use of existing telecom channel owned by the telecom carrier

		Osaki-Kamishima	*Toshima*
Period of the deployment(fis. y.)		2001-03	2008-10
Total population		8,636	579
No. of subscribers:		1,064(24.6%)	242 (66.3%)
Telecom carrier		Energia Com.	NTTWest-Japan
Contract		IRU contract	leased line
Communication line		aerial line	submarine cable
Total length of Oversea lines		4km	100km
Annual expense		included in IRU contract	5mill. Yen
Share of the expense	National Gov.	-	2/3
	Local Gov.	-	1/3

Note: *Toshima*'s Network is shared between the goverment-use and resident-use

the construction of submarine lines are borne by the national and regional governments in both cases. The small local government of the island can hardly share the cost of a submarine line. Therefore, some national policy scheme to support the submarine line construction is undoubtedly needed.

When the distance of the oversea line exceeds the limitation of wireless access and no national support can be gained, only way to deploy broadband is lease of an existing commercial submarine telecom line. Noting to say, some commercial submarine telecom lines are needed for this way. The case of *Toshima* can be fortunately applicable this condition. *Ohsaki-Kamishima* is an exceptional case of the use of an existing oversea telecom channel. In this case, they can use an aerial fiber line between the island and the mainland constructed by the electric power company of the region. (Table 3)

5. Institution for the construction and operation

Almost all of local governments carrying broadband deployment projects have no ability to operate the broadband network. In islands, they cannot also operate the oversea telecom lines by themselves. To overcome this difficulty, three solutions can be employed. (Table 4)

	a) Entrustment	b) IRU contract	c) Leased
Construction	government	government	telecom -carier
Business license	government	telecom -carrier	telecom -carier
Operation	telecom -carrier	telecom -carrier	telecom -carrier
Income/Expense	government	telecom -carrier	government
Operation fee	government → carrier	-	-
Lease charge	-	-	government → carrier
Expenses of renewal	government	government	telecom -carrier

Table 4 Features of the institutions of the construction and operation of oversea line

A solution is the entrustment with the operation of the oversea line to a private telecom carrier. In this way, a local government constructs the network and entrusts a telecom carrier with the operation. The government collects subscriber charge and pays the operation fee to the telecom carrier. When the income from the subscribers falls short of the operation fee, the government must fill the deficit with the general budget. *Tokashiki*'s wireless oversea connection and user access are operated by the entrustment

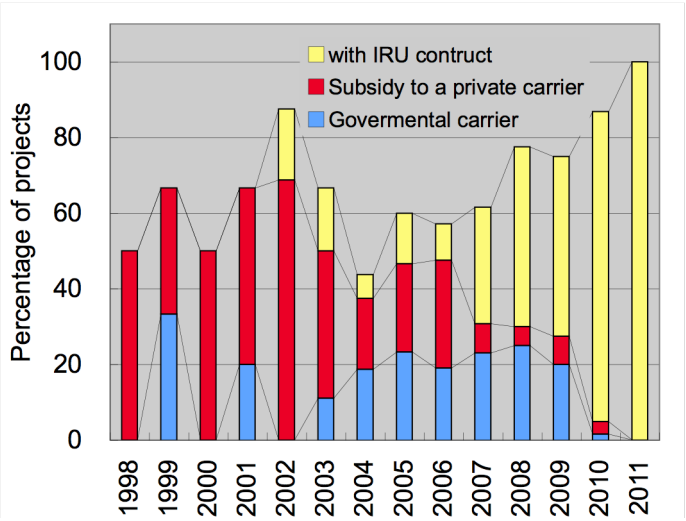
to NTT West-Japan, which is a leading telecom company of Japan. (Table 5)

Table 5 Entrustment with the operation to a private telecom carrier

	Tokashiki
Entrusted carrier	NTT W-J
Entrusted operations	wireless oversea line user access
Note: NTT W-J: NTT West-Japan	

The Indefeasible Right of User (IRU) contract is an alternative solution. A local government constructs a telecom network and leases it to a private telecom carrier. Using the IRU contract, broadband services of private telecom carriers can be provided even in the area where a broadband business is unprofitable. In the business model of IRU contract, the telecom carrier collects subscriber fee and operates the network. The government only constructs the network and has no responsibility for the network operation. The IRU model has the advantage that the government has no responsibility for the network operation.

Because of this advantage for local governments, the broadband deployment projects with the IRU contract has diffused in Japan in the latter half of 2000's.(Figure 10) In our cases, *Ogasawara*'s submarine line is operated by NTT East-Japan based on the IRU contract. In *Ohsaki-Kamishima*'s broadband deployment, *Energia* Communication Inc., a subsidiary of the electric power company, operates the island FTTH network based on the IRU contract. The oversea aerial fiber line mentioned above is provided in a part of the operation contract. (Table 6)



Data source:
The Questionnaire Surveyby the authors

Figure 10 Percentage of broadband deployment projects with IRU contracts (1998-2011)

However, no telecom carrier agrees to make the IRU contract, when the operation business is estimated as unprofitable for the telecom carrier. Actually, no carrier agreed the IRU contract for broadband services in the case of *Toshima*. The local government was compelled to launch its own telecom business using leased lines.(Table 7)

	Ogasawara	*Ohsaki-Kamishima*
Local government	*Tokyo* Metropolitan	*Ohsaki-Kamishima* Town
Telecom-carrier	NTT East Japan	*Energia Communications* Inc. (A subsidiary of The *Chugoku Electric Power* Co., Inc.)
Term of IRU contract	10 years	20 years
Facilities covered by the contract	submarine line between the islands andthe mainland	FTTH network[1] in the island

Note:1) The oversea communication line connecting the island network with the mainland Internet-backbone is provided by the telecom-carrier.

Table 6 IRU contract between the local government and a private telecom carrier

Lessor	NTT West-Japan
Submarine route	A part of the trunk telecom ruote between the Japan mainland and *Okinawa* islnads
Leased lines	The *Kyusyu* mianland - *Nakanosima* - *Akuishijima* - *Takarajima*
Annual lease charge	5mil. Yen
Speed	1Mbps - 10Mbps

Table 7 Leased submarine lines in *Toshima*

6. The national scheme of broadband deployment and oversea communication line

When local governments aim to deploy broadband in their territories, almost all of governments face the shortage of development budgets. For the local governments of islands, the challenge of budgets are quite severe because the deployment cost is very large despite small size of the government finance. Therefore, the finance support by the national government is needed. The Japanese Government has taken the national strategy including the "u-Japan" policy package aiming to diffuse broadband completely throughout the whole country. A series of subsidy programs, for example, the "Regional Telecommunication Infrastructure Deployment Grants" subsidizing the deployment of broadband networks for resident-use, constitute the general scheme of the Japanese Government for broadband deployment.

However there is a severe difficulty for broadband deployment in islands in the general scheme. These programs aim mainly to support the deployment of the internal network in each municipal territory and cannot apply to most of the deployments of oversea communication lines. Actually, all constructions of new oversea

communication lines connecting to outside the municipalities were subsidized by the programs of the special regional development schemes as the cases of *Ogasawara*, *Daitoh* and *Tokashiki*.

A small island, where commercial oversea communication services are unprofitable, cannot gain the means for broadband deployment under the general scheme of the national government. There are two solutions for the island.

The first is the construction of wireless connection line. The cost of wireless connection is far lower than submarine cable connection. Actually, many wireless connections are employed between very small islands and the main island. On the other hand, wireless connection has the limitation of the communication distance as mentioned above. In addition, the capacity of wireless connection is limited comparing to optical fiber. In the case of *Ohsaki-Kamishima*, wireless connection between the main island and the mainland could not be employed, because the volume of service demand was estimated to exceed the limit of wireless connection.

The second solution is the utilizing of existing communication lines of telecom carriers. Of coarse, this solutions cannot be chosen unless suitable communication lines have been constructed. Fortunately, *Ohsaki-Kamishima* can use the aerial fiber line of a electric power company. *Toshima* is located just on the trunk route of fiber connection between the Japan mainland and *Okinawa*. The local government takes NTT West-Japan's submarine telecom lines on lease and entrust the network operation to the same company. However, due to the large cost of leased lines, the capacity of the oversea lines must be limited less than 10Mbps. The limitation of leased line capacity reduces the quality of broadband services.

7. Conclusion

In this study, we examined the geographical difficulties in broadband deployment in islands and the government policies to overcome the difficulties based on several case studies in Japan. The results of the study are summarized as follows.

A significant number of small inhabited islands had severe challenges to deploy broadband, due to the difficulties of oversea communications. Many local governments with no broadband access in the islands aimed to deploy broadband under the support policies of the Japanese Government.

However, a small island, where commercial oversea communication services are unprofitable, cannot gain the means for broadband deployment unless some special programs are established out of the general scheme.

The use of low-cost wireless connection and the utilizing of existing lines of telecom carriers are the ways to overcome the difficulties of small islands. However, there are some limitations of the distance, the capacity and the existence of suitable telecom lines in these solutions.

Acknowledgement
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