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On-board Adaptive Attenuation Compensation Technique for Future Satellite Communication

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***Abstract* – Rain attenuation is powerful to interrupt the service availability of satellite communication especially in higher frequency above 20 GHz. Several countermeasure techniques has been propose to maintain satellite link service. In this paper, we evaluate the performance of boost beam method as one of satellite power control method by using rain radar data produced by Japan Meteorological Agency. We use boost power constant at 20 mm/h approximately equivalent to 10 dB of power margin at 22 GHz link. We divide boost beam size to 50,100,150 and 200 km and 1 to 4 of boost beam number. We analyze the cumulative distribution of rainfall rate intensity in case of no boost and each boost case. We confirm this method can be reduce rain attenuation effect in many peak areas.**

***Index Terms* — Boost beam, Satellite power control, Rain attenuation.**

I. Introduction

Adaptive satellite power control as boost beam method [1] is propose to be an alternative way to reduce the effect of attenuation due to rain. The boost beam concept is derived from the rainfall rate data as much as reliable in order to handle in the worst case of rain attenuation effect. This work uses rain radar data which are available all over Japan. Also this method relates to satellite power margin and on-board beam selection. The multi-beam or modified beam pattern has been propose to be suitable for 21-GHz band satellite broadcasting system [2]. For the next satellite generation, the backup power need to be install in satellite and the power must enough for compensate the rain attenuation effect to maintain the service availability on ground user. The number of boost beam and coverage area will be designed from the cumulative rainfall intensity in those areas. Moreover, these strategy will be used in each case depend on how much rainfall rate occurrence.

II. Data Analysis

We used rain radar data all over Japan produced by Japan Meteorological Agency. The rain radar data are available every 5 minute interval time and about 1 km mesh point. Rainfall intensity is derived by using radar map of precipitation and surface rain gauge observation data over 1,300 station throughout Japan. This paper used 4 years data from July 2009. The boost beam effect is derived from the cumulative distribution all over Japan. The parameters used for simulation are given as follows.

- Rain radar data from July 2009 – June 2013 (4 years)
- Boost beam size: 50,100,150 and 200 km
- Boost beam numbers: 1,2,3 and 4
- Boost amount (fixed value): 20 mm/h
  (Rain attenuation equivalent to about 10 dB at 22 GHz)
- Boost point searching: Maximum rain intensity over Japan
  (Boost beam overlap is not allowed)

III. Boost Beam Concept Simulation

A. *Boost beam efficiency*

As ITU Recommendation P.618-11[3] concerned rainfall rate value at cumulative time percentage (P) of 0.01%, it is mean 99.99% of service availability. Fig. 1 shows rain intensity derived from rain radar data for 4 years in every 5 minute of interval time over Japan areas. We can observed the large rain intensity more than 60 mm/h which is most occurred at south and along the east coast of Japan.

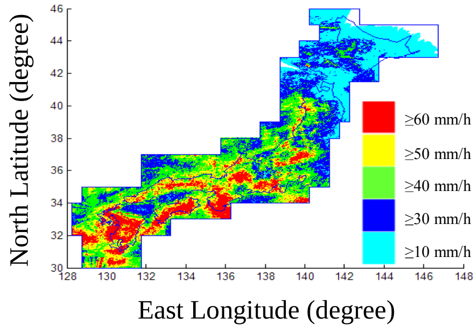

Fig. 1. Rain intensity at P 0.01% with no boost

In each boost case, Figs. 2 and 3 show rain intensity with 20 mm/h of boost amount and compare between boost case -14- and -42- where -nm- indicates that n boost beams and beam size is m (1,2,3 and 4 corresponds to 50,100,150 and 200 km). Because of these 2 cases there are same the coverage boost areas about 40,000 km^2 but we can observed difference of rain intensity between these cases. More specifically, the boost case -42- is more efficient than -14- case. Because of in fact, the strong rain intensity is not group in the same area but it is spread out depend on geographic conditions. In case of 1 beam with 200 km diameter, many rain intensity is reduced in widely within the coverage boost areas but it does not mean many peak rain intensity was reduced. On the other hand, in case of 4 beams with 100km diameter, 4 points of maximum rain intensity areas is boosted. This is cause why the boost case of -42- is more effective than -14- case.

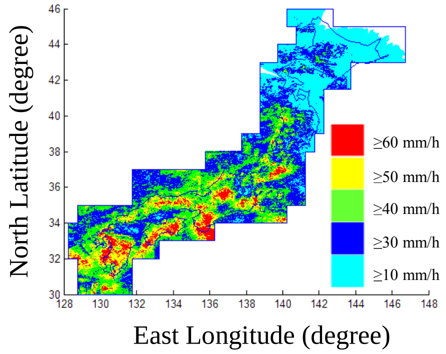

Fig. 2. Rain intensity at P 0.01% with boost (-14-) and 20 mm/h boost

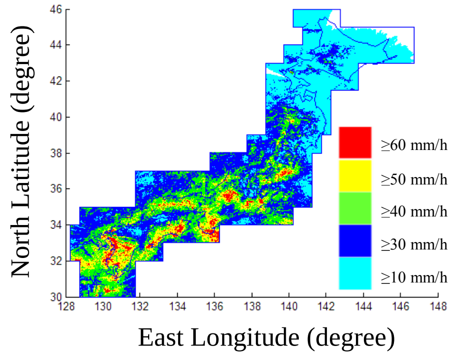

Fig. 3. Rain intensity at P 0.01% with boost (-42-) and 20 mm/h boost

B. Place rate observation

To confirm the performance of boost beam concept, all places boost effect over Japan is shown in Fig. 4. We derived program to obtain all places to compare as same as previous case -14-, -42- and no boost case. The place rate means area percentage where certain effective rain intensity values are exceeded over Japan. This place rate can be statistically derived from Japan mainland area with about 1 km mesh. In our data analysis, we have about 729,700 place values.

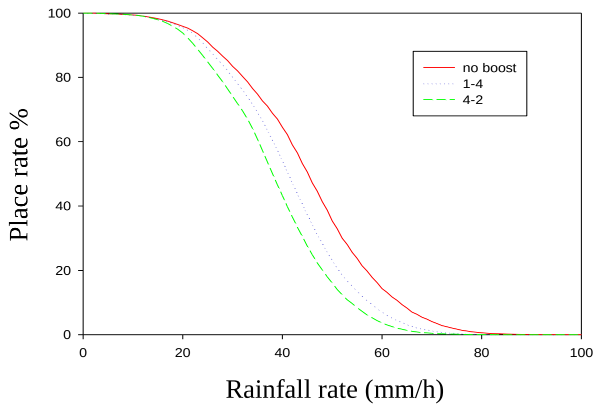

Fig. 4. Place rate percentage with 20 mm/h of boost amount at P 0.01%

Fig.5 shows boost gain at place rate of 50% for each combination of beam number and beam size. For example, as previous explanation of -14- and -42- case, we can observed boost gain of -42- case is better than -14- case about 3 mm/h or correspond to 1.5 dB at 50% of place rate in the same effective areas. For another example, the maximum of boost gain at -44- case and the minimum at -11- case which is very large difference about 8 mm/h or approximately to 4 dB. Of course, by increased the number of boost beams, the boost gain will be increased directly.

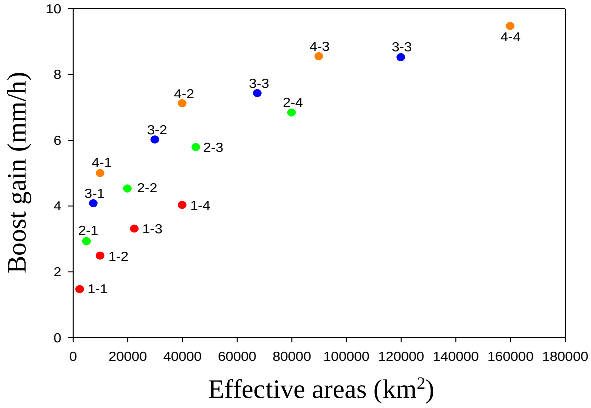

Fig. 5. Place rate of 50% with 20 mm/h of boost amount

IV. Conclusion

We analyze rain radar data all over Japan for 4 years with 5 minute of time interval in order to evaluate and propose this boost beam method for future satellite communication system in higher frequency band. The boost beam fixed value of 20mm/h corresponds to about 10 dB at 22 GHz for the satellite power backup. The results of rain intensity is clearly improved when boost beam is apply. We also estimated boost effective areas at 50% of total and the boost gain is increasingly better when more number of beam is used. Finally, the optimization of boost beam concept depend on beam number, beam size, boost value and cumulative distribution of rainfall rate statistics.

Acknowledgment

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References

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[3] Recommendation ITU R P.618-11, “Propagation data and prediction methods required for the design of Earth-space telecommunication systems,” 2013.