

# **Electro-optic device technologies for radio-wave and optical converged systems**

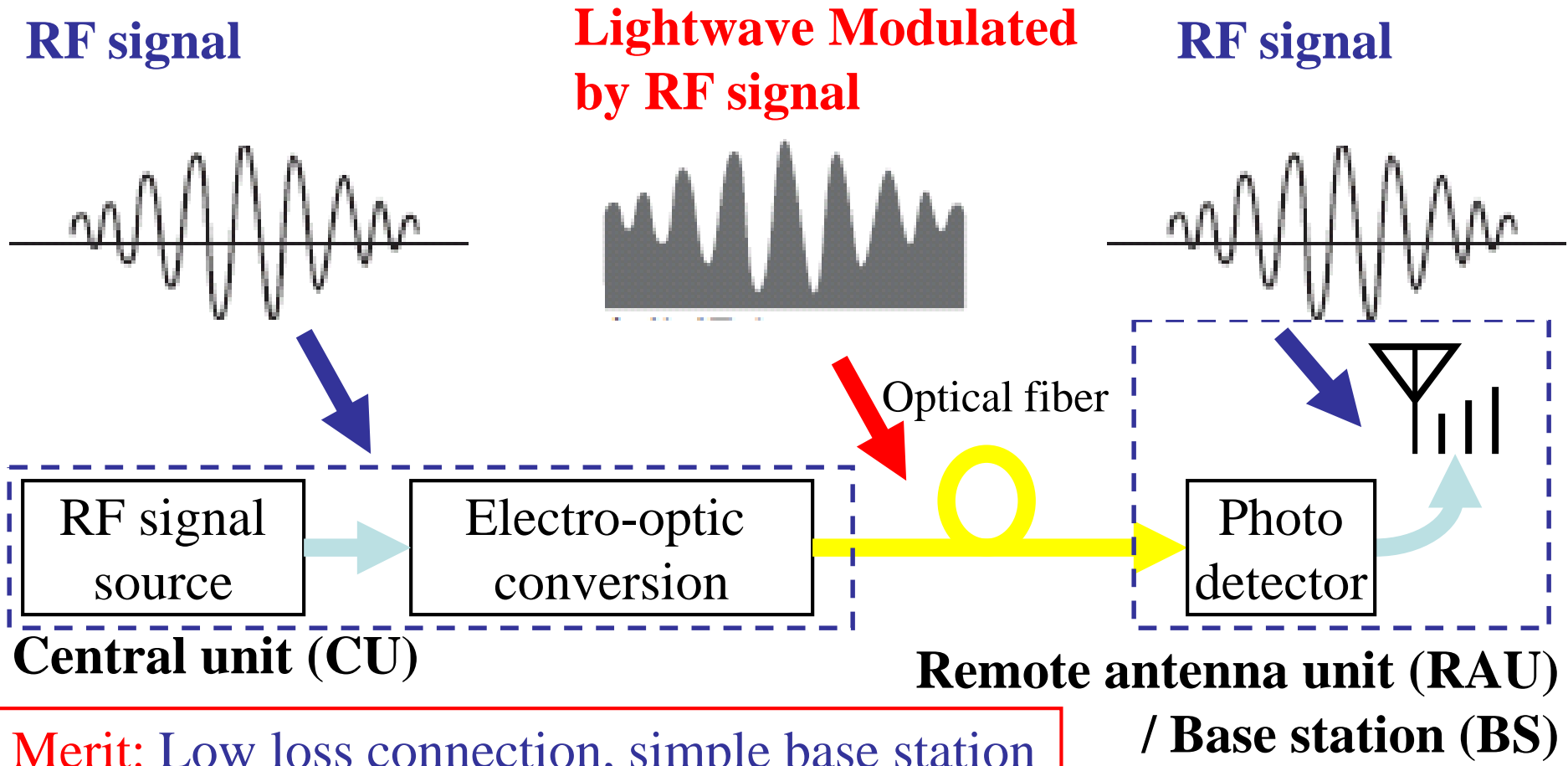
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Technology, Japan

# Basic concept of Radio-on-fiber (RoF) system

**RF signal is transmitted via optical fiber from central to antenna**

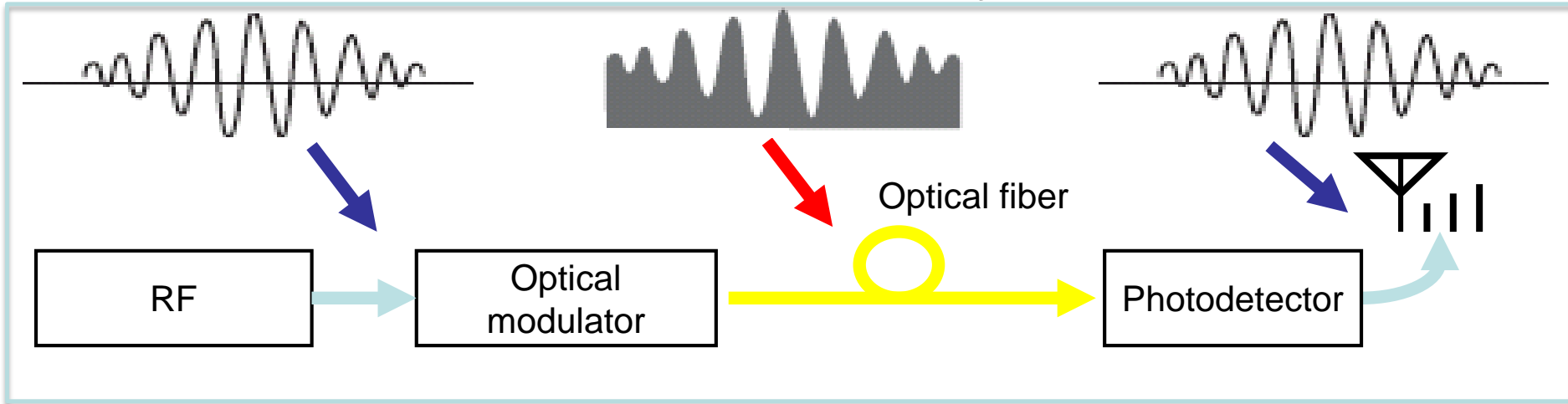


**Merit:** Low loss connection, simple base station

**/ Base station (BS)**

# Analogy of waveform transport over fiber

Waveform is transported over the fiber → Simplify the EO/OE conversions

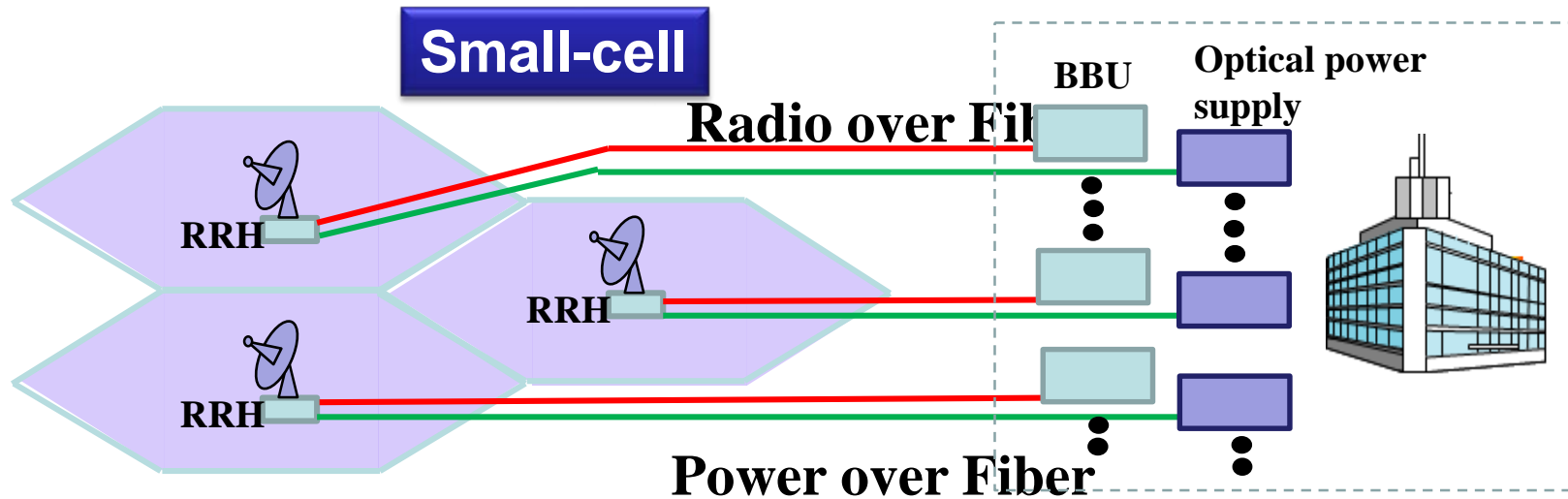


Transportation of truck cars by ferry ship → Simplify the process in the marine port



***RoF: Easy signal transport by encapsulation***

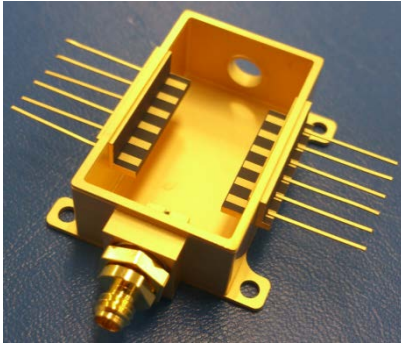
# Radio and Power over Fiber transmission in advanced wireless communication



Schematic illustration of “Radio and Power over Fiber”

# High-Speed Photodiodes

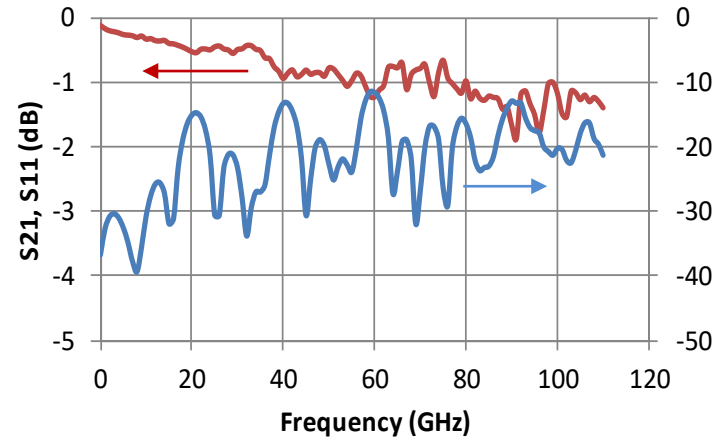
- Zero-biased ultra-high-speed photodiodes beyond 110 GHz.



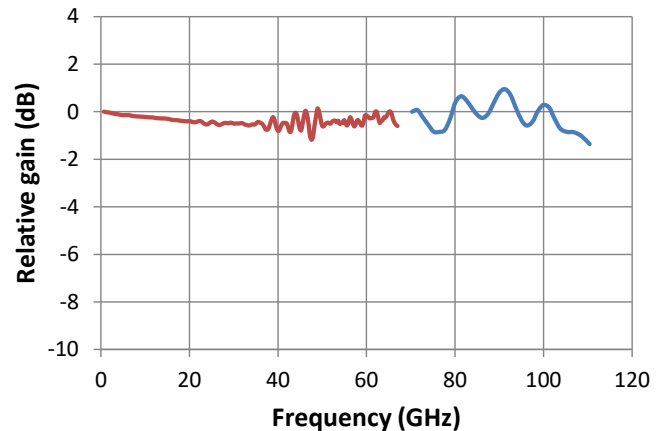
Package photo with 1mm connector



Fabricated unitraveling-carrier photodiode



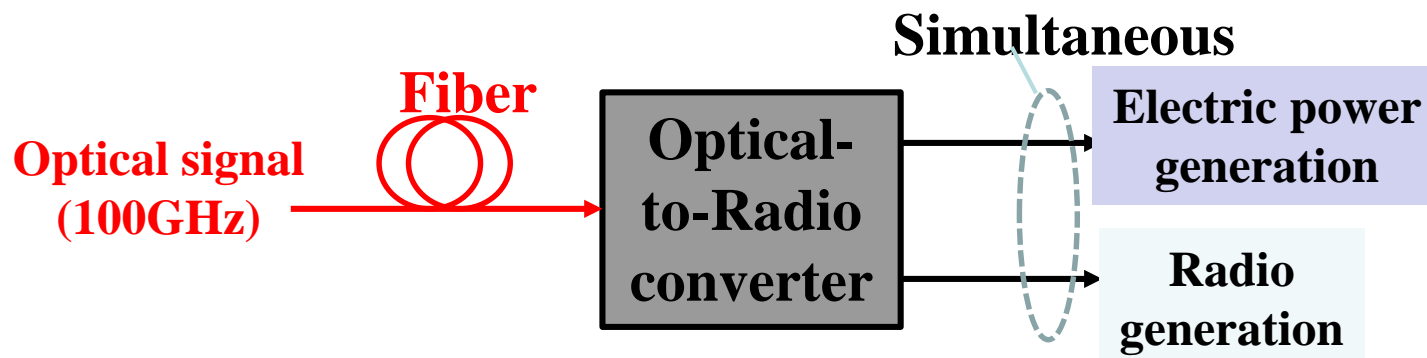
S-parameter measurement of packaged PD



Frequency response of photodiodes  
3dB Bandwidth > 110 GHz with bias=0

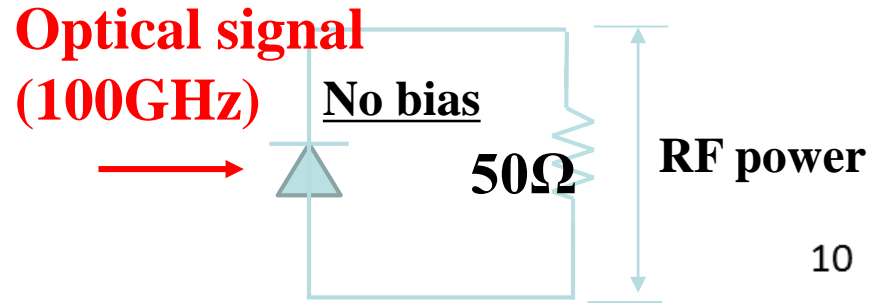
# What's "Optical-to-Radio convertor" ?

**Two functions in one photodetection device**

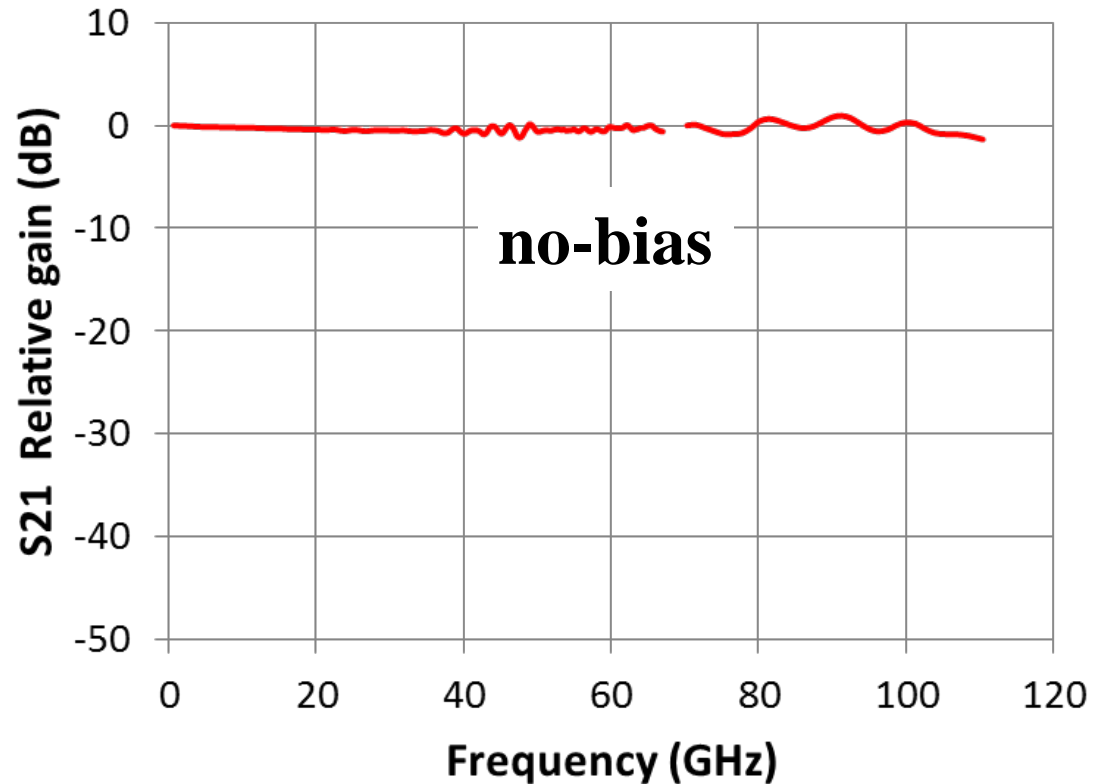


**The Optical-to-Radio convertor has a potential for electric power generation and radio generation simultaneously.**

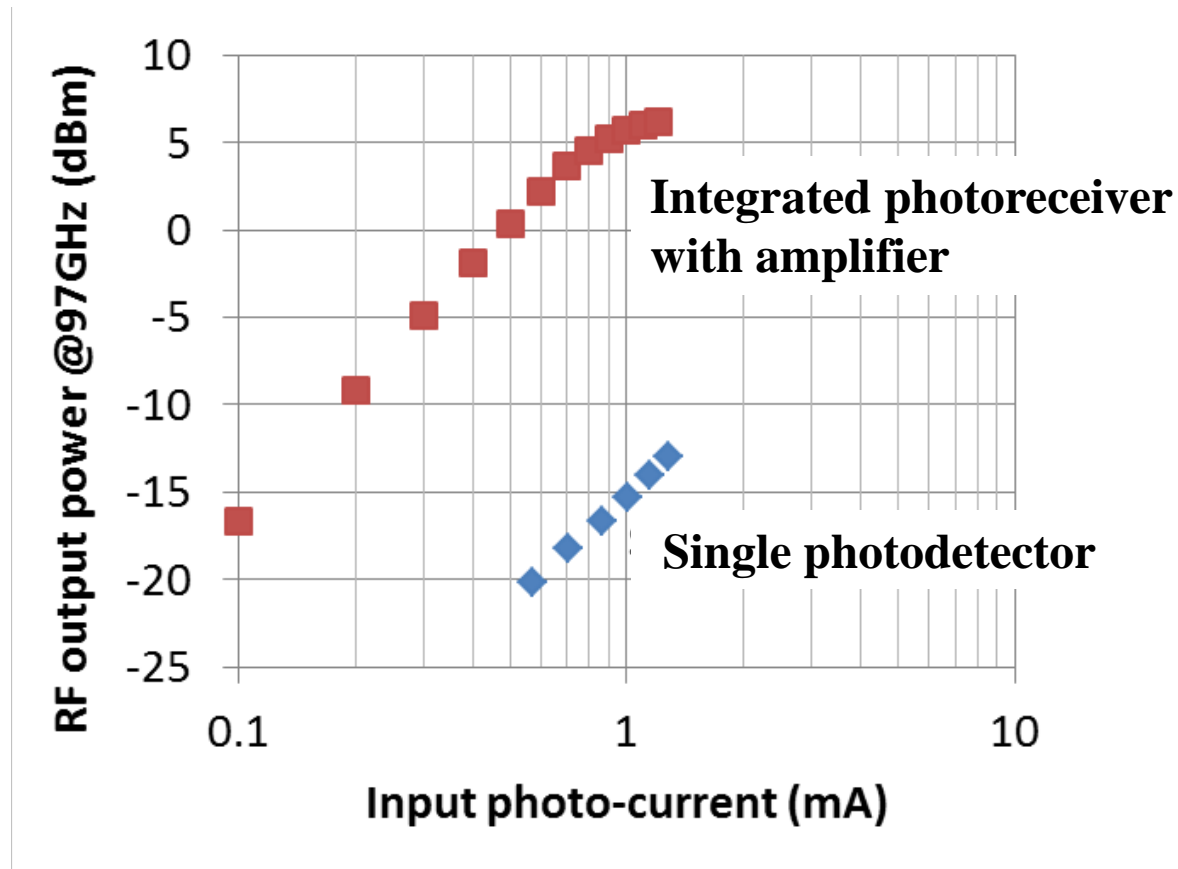
# RF signal generation characteristic



**Frequency response at 0 V**

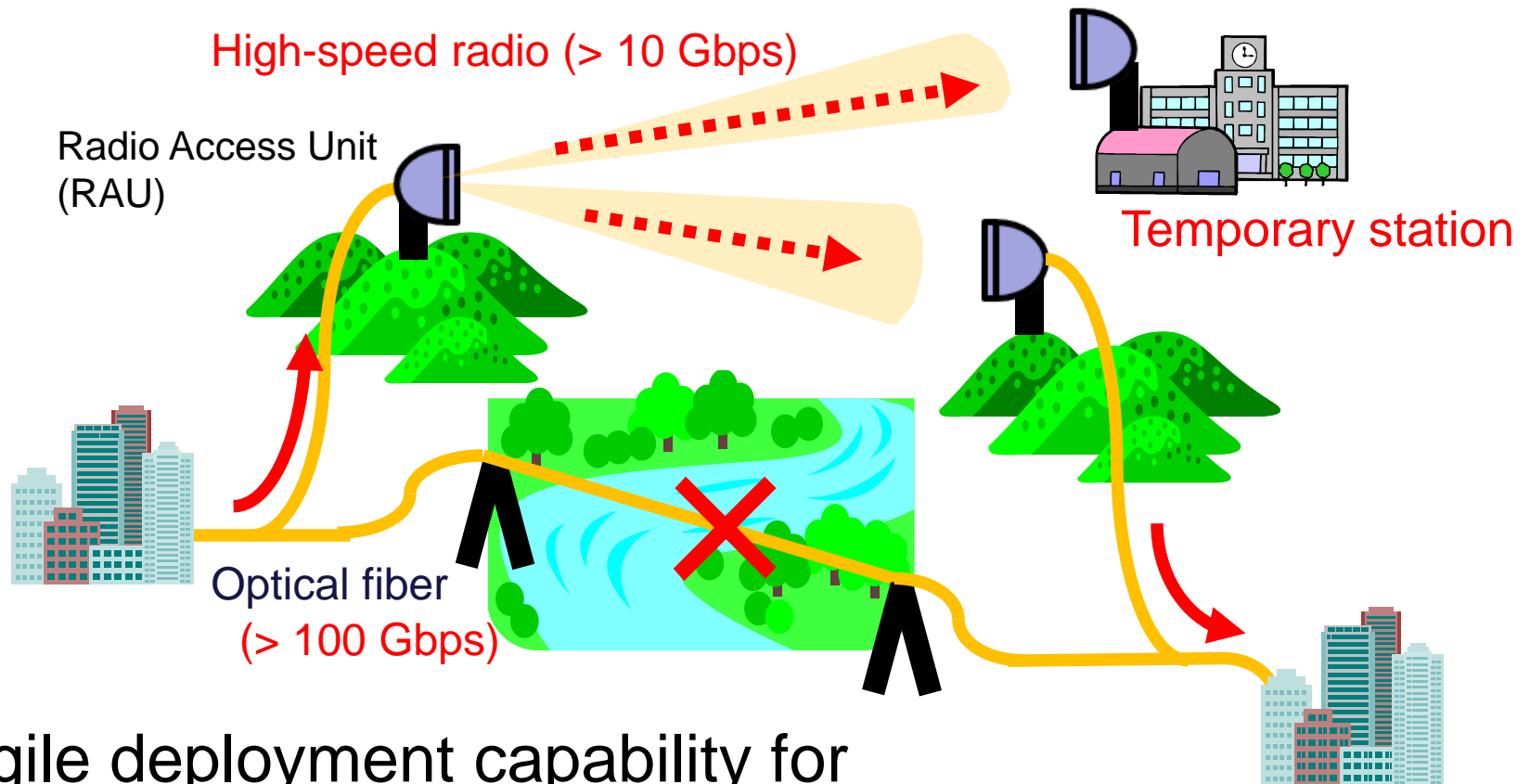


# RF output characteristics





# Concept of wired and wireless seamless transmission for resilient network

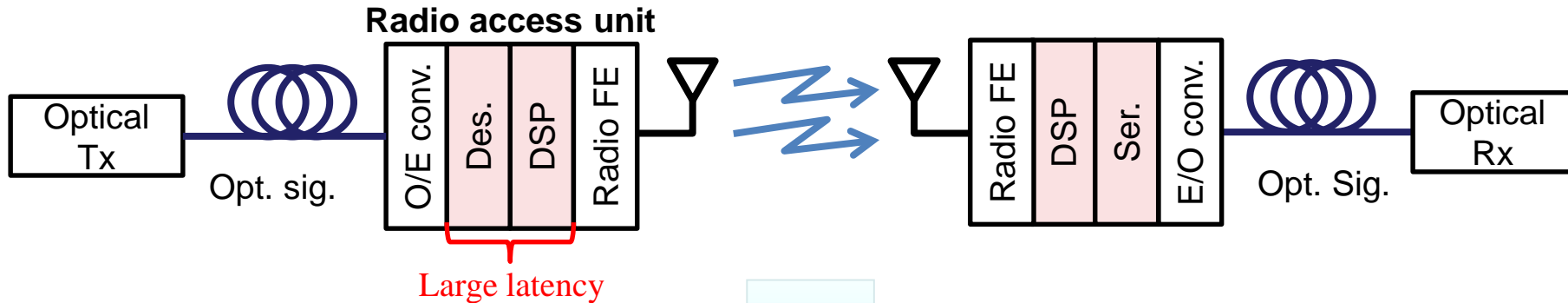


## Agile deployment capability for

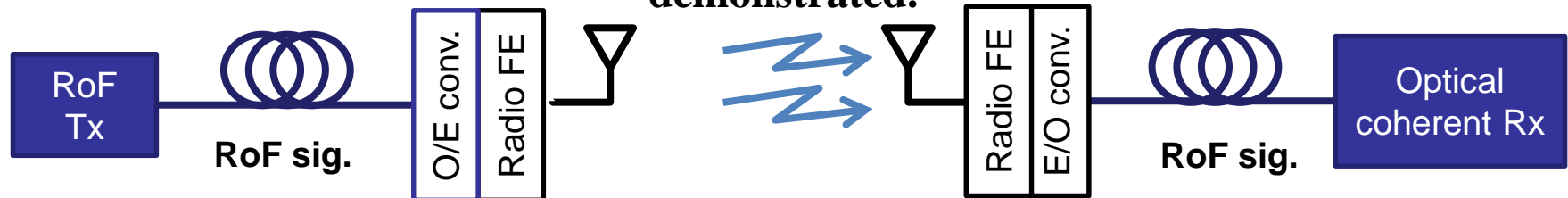
- Protection link against fiber being cut at disaster
- Temporal link to temporary station at disaster recovery
- “Last mile” solution until optical fiber deployment

# Coherent Optical & Radio Seamless Transmission on DSP-aided Radio-over-Fiber (RoF) Technology

## Conventional Optical-Radio-Optical system



## RoF-based O-R-O system

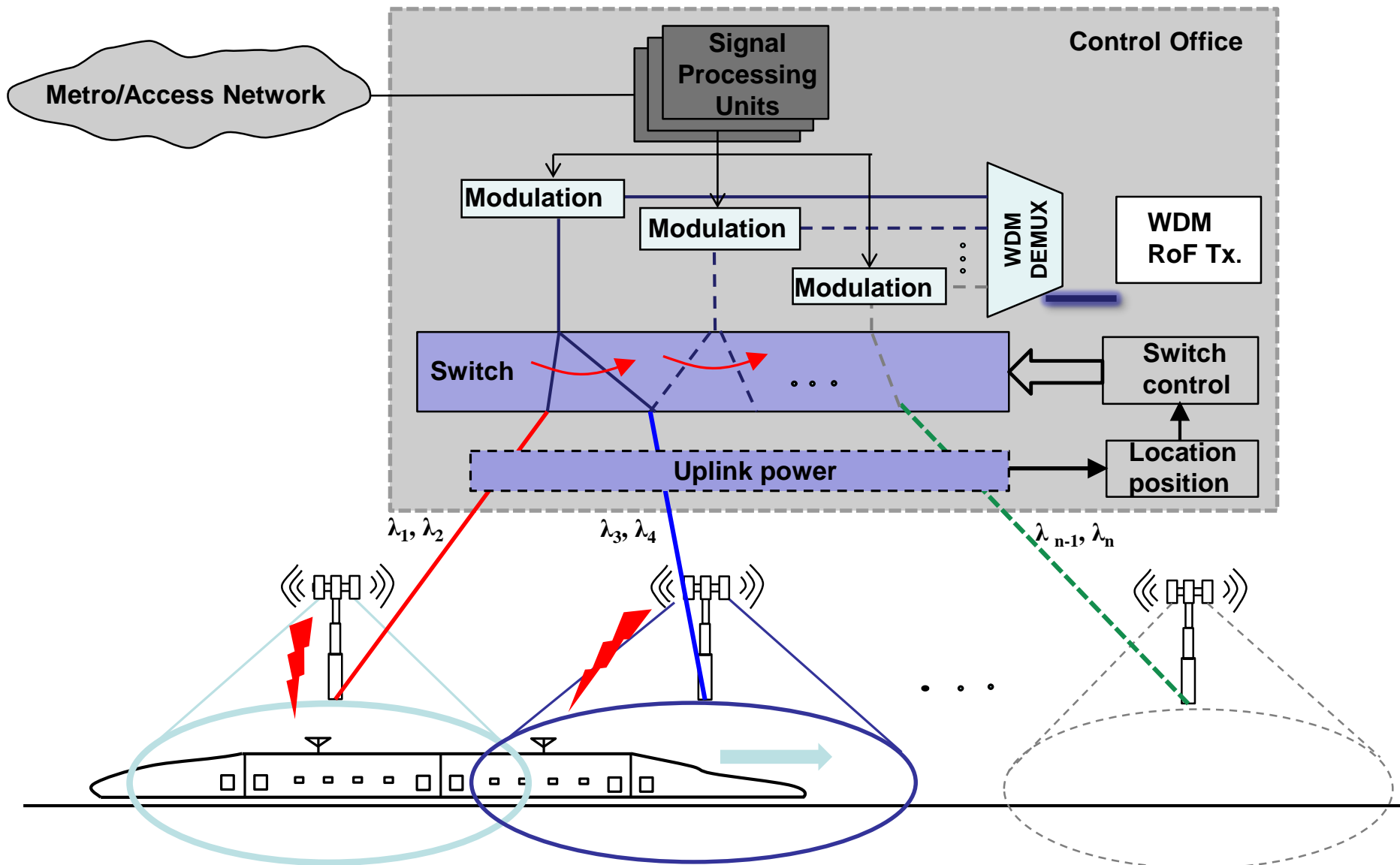


- Exclusion of DSPs at RAU reduce the latency (and power consumption?)
- Transmission impairments can be compensated by Coh. Rx.

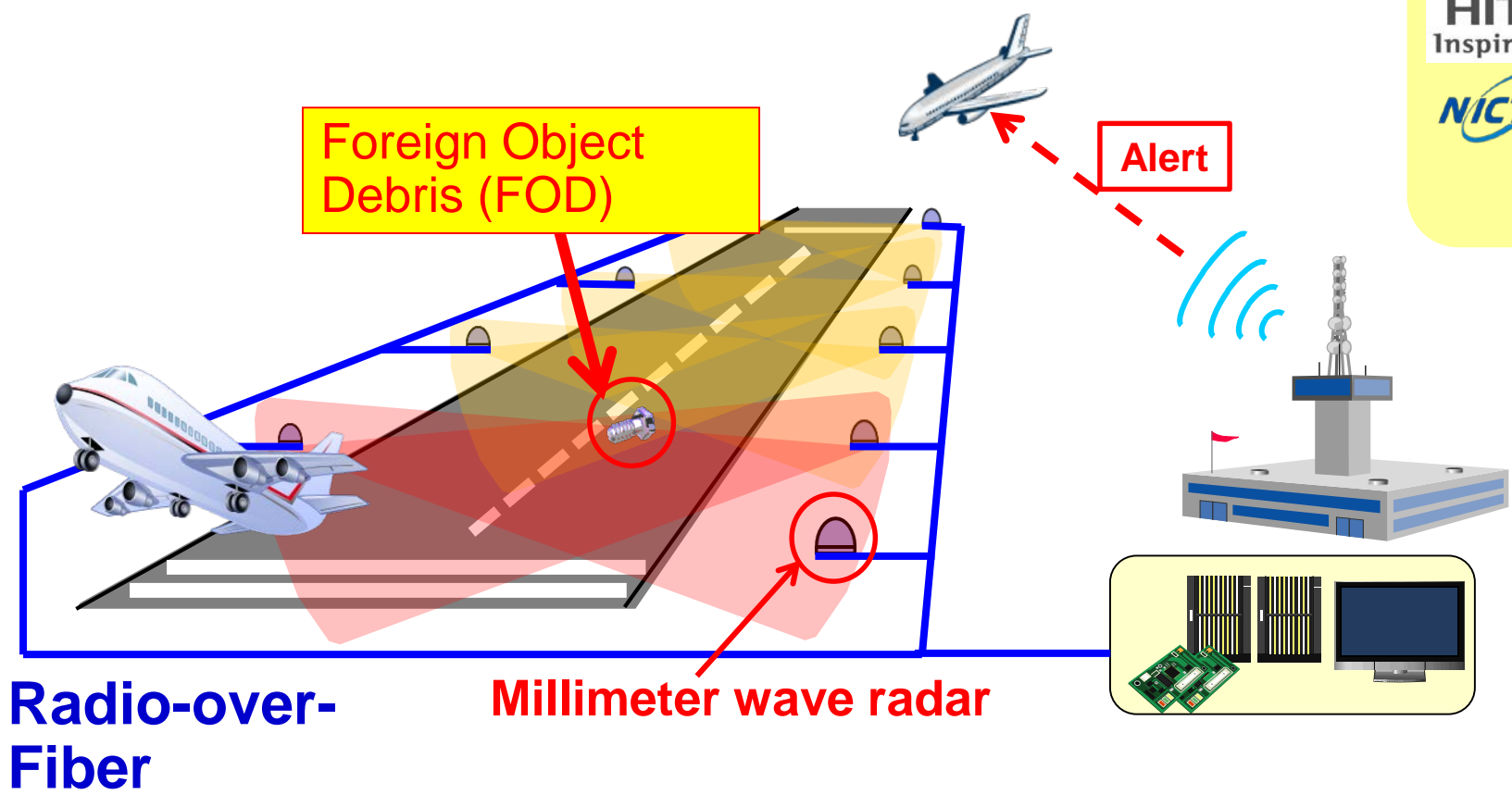
A. Kanno et al., OTu3D, OFC 2013.

A. Kanno et al., Opt. Express, 20, 29395 (2012).

# Network control and moving cell concept



# FOD Detection using Millimeter-wave RoF for Airport Runways



- Low operation cost
- Low radio-wave emission
- Scalability:
  - High-performance systems for busy airports
  - Low-cost systems for local airports
- Agile scan capability

※This research was conducted as part of the project entitled “Research and development of high-precision imaging technology using 90 GHz band linear cells,” with funding from “Research and Development to Expand Radio Frequency Resources” supported by the Ministry of Internal Affairs and Communications, Japan.

# Field trial in Narita International Airport

Linear-cell radar system is now evaluated in the B runway 34R

The image is a composite of four parts. At the top center is a site plan of Narita International Airport. A red box on the left side of the plan highlights a long, narrow area labeled 'Surveillance area (Four radar heads)'. Another red box in the center of the plan highlights a building labeled 'Central processing units'. To the left of the plan is a photograph of a tall, slender radar tower with a platform at the top. To the right of the plan is a photograph of a control room with several computer monitors on stands, a keyboard, and a chair. The site plan includes various labels in Japanese, such as '第1旅客ターミナルビル' (Terminal 1) and '第2旅客ターミナルビル' (Terminal 2).

Surveillance area  
(Four radar heads)

Central processing units

Map from [http://www.naa.jp/jp/airport/pdf/layout\\_01.pdf](http://www.naa.jp/jp/airport/pdf/layout_01.pdf)

# Standardization activity on RoF

**ITU-T SG15 Q2**

PON with RoF

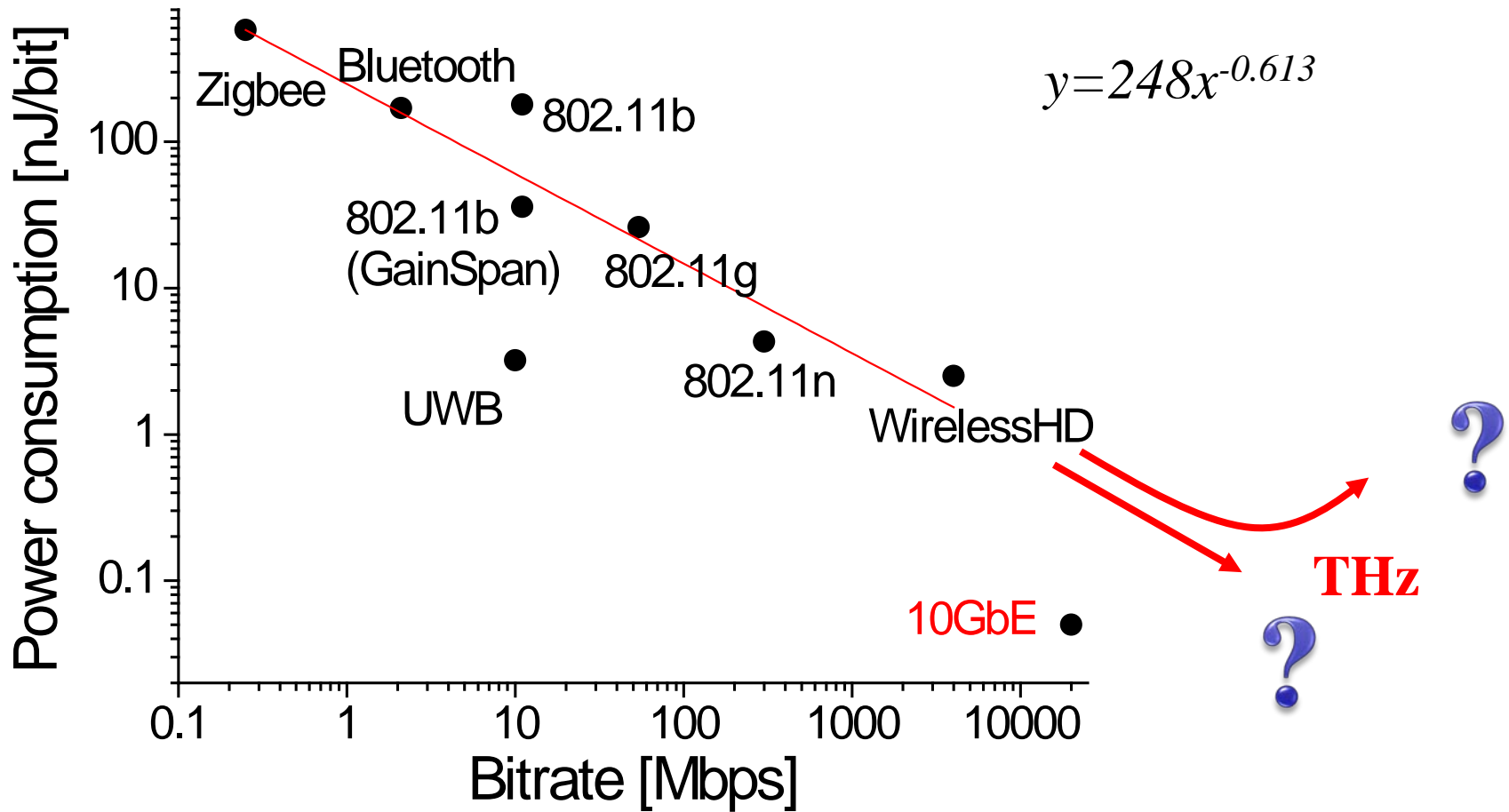
**ASTAP EG-SACS**

RoF systems for APT countries

**IEC TC103**

Precise measurement techniques for RoF components

# Bitrate and power consumption of wireless data transmitters



# Summary

- Radio-over-fiber (or waveform transfer) technology can reduce the bit rate gap between wired and wireless links.
- Possible applications:
  - High-performance measurement
  - Resilient network
  - Broadband links for high-speed train
- Standardization would be very important to establish open value chains for RoF systems