# What will 6G be? A 2023 perspective

Harish Viswanathan Head, Radio Systems Research Nokia Bell Labs



Apply appropriate data classification. Apply document ID (if applicable)

## Defining experience of the 6G Era Digital World, Immersive Experience, Metaverse



## Metaverse Industry

Digital twin Digital co-design Cooperative Robots

### Metaverse Enterprise

Immersive team collaboration Training and simulations

## Metaverse Consumer

Gaming & entertainment Social interactions Shopping



## What is required? An Industry Analyst Perspective



"The telecoms industry must map a new path for connectivity as the metaverse develops over the next decade. This path should shape thinking about what 6G becomes: a radically different network that behaves like a fabric, rather than a pipe, with an AI mediated, hyper-distributed control plane that runs across network domains that are siloed today"



## Wireless system design principles In 6G: adding three key value drivers



#### **Sustainability**

 X10 capacity increase with 50% power reduction, compared to 5G



#### **Digital inclusion**

 Aim to address three key factors: accessibility, affordability and consumability



#### Security and privacy

 Increasing security and privacy risks require higher levels of control





## The path to 6G Spectrum

Digital physical fusion



#### Spectrum 4x



6.425/7-15.35 GHz spectrum prospective bands for 6G

NOKIA

BEL

ABS

6 GHz	8 GHz	10 GHz	12 GHz	14 GHz	16 GHz	18 GHz	20 GH
6.425-7.125 7.25-7.75	7.9-9.9 10-10	.5	13.4-14	14.5-15.35	5.7-17.7		
6.425-7.125	10-10.4 1	0.4-10.5 10.7-11.7 11.7-	12.5 12.5-12.75				
6.425-7.125	10-10.41	0.4-10.5 10.7-11.7 11.7-	12.5 12.5-12.75				
6.425-7.125	10-10.410	.4-10.5 10.7-11.7 11.7-	12.8 12.5-12.75				
7.125-8.5		0-10.5 11.7-	12.75 14	14.5 14.5-14.8			
	10-10.41	0.4-10.5 10.7-11.7	_				
6.425-7.125 7.125-7.25	10-10.4 1	0.4-10.5 <u>10.7-11.7</u>	12.5-14.8				
6.425-7.125	10-10.41	0.4-10.5 10.7-11.7 11.7-13	2 12 5-12.75	14.8-15.35			
6.425-7.125 7.125-8.5	10-10.41	0.4-10.5 10.7-11.7 11.7-1	2 12.5-12.75	14.5-14.8 14.8-15.35			
6.425-7.125	10-10.41	0.4-10.5 10.7-11.7	12 5-12.75				
6.425-7.125 7.125-7.19	10-10.41	0.4-10.5 10.7-11.7 11.7-	2.75				
7.125-7.19 8.	-8.5 10	10.5 10,7-11.7 11.7	12.5 12.7-12.75	14.8-15.35			
	10-10.41	0.4-10.5 10.7-11.7	12.5-12.75	14.8-15.35			
6.425-7.125 7.125-8.5	10-10.4	0.4-10.5 10.7-11.7	12.5-12.75	14.8-15.35			

# The path to 6G xMIMO

Digital physical fusion





256 radiator size @ 3.5 GHz



SALL SALES

Spectrum 4x

1024 radiators (7 GHz) for same dimension









## The path to 6G **Energy Efficiency**



## The path to 6G Energy Efficiency

Digital physical fusion



Spectrum 4x



xMIMO 2x - 3x



Energy efficiency 50%



NOKIA BELL LABS



8 © 2023 Nokia

## The path to 6G Al Native

Digital physical fusion

#### Spectrum 4x



#### xMIMO 2x - 3x



Data architecture

#### Energy efficiency 50%



#### Transmitter / UE Receiver / Base station Wave- 5 Channel Symbol Symbol Equali-Encoding -> Mapping Beamding mation ping forming Scheduling Link adaptation CSI feedback CSI feedback encoding encoding

**ML** Framework

Al Native ~30%





Sequential training

Universal Models

## The path to 6G Architecture



#### Spectrum 4x



#### xMIMO 2x - 3x



Energy efficiency 50%



Core RAN Core 6G CA or 6G DC Status Intent 5G-6G MRSS 6G gNB **6**G gNB Dynamically Status Intent Status Intent **Re-farmed** band Controller R UE-1 UE-2 Router CNF Router

Cognitive network & automation



Al Native





Public

## The path to 6G Sensing

#### Digital physical fusion



#### Spectrum 4x



#### xMIMO 2x - 3x



#### Energy Consumption 50%







#### What determines the sensing range?

SNR is not

the limiting

factor

- Near-far problem
- Quantization
- Angular resolution
- Occlusion

Person	Cars	Drones
10m	100m	1000m

## Cognitive network & automation









## The path to 6G Security and Trust



#### Spectrum 4x



#### xMIMO 2x - 3x



#### Energy Consumption 50%





JCAS



#### Security, Privacy and Trust



## Cognitive network & automation





#### Al Native





## What is 6G?





# NO<IA BELL LABS