Program Profile		
Program	Program name	Adaptive Beamforming in Terahertz 6G Networks Using Machine Learning Under Rain-Dense Atmospheric Conditions
	Category	B4: Research and Development

Summary of Program	
Program Name	Adaptive Beamforming in Terahertz 6G Networks Using Machine Learning Under Rain-Dense Atmospheric Conditions
Category	B4: Research and Development
Abstract of Program	This program introduces a machine learning-based adaptive beamforming framework for terahertz (THz) 6G networks operating in rain-dense atmospheric conditions. The system leverages real-time environmental parameters such as rain rate, humidity, and angle-of-arrival to optimize beam direction, beamwidth, and transmission power dynamically. Machine learning models, including Random Forest, XGBoost, and Deep Q-Networks, are applied to predict and refine optimal transmission strategies. Simulation results demonstrate significant gains: average SNR improved from 8.2 dB to 14.5 dB, packet loss reduced from 23.4% to 5.6%, and BER improved from 10^{-3} to 10^{-5}. This strengthens link reliability in tropical climates and contributes to the broader field of 6G research. The program integrates environmental awareness into wireless systems, enabling ultra-reliable connectivity in real-world conditions.

Details of Program		
Planning		
Objectives	Long-term Goals	Create robust 6G wireless communication systems in tropical regions, contribute to international collaborations, and prepare adaptive THz technologies for industry adoption by 2030.
	Short-term Targets	Build a real-time testbed, validate ML models with empirical rainfall data, and publish findings in IEEE journals.
	Rationale	Rain and humidity severely degrade THz signals, especially in Bangladesh and similar tropical regions. Traditional beamforming cannot adapt to such dynamics; hence, an intelligent solution is required.
Subject (Leader)	Initiator(s)	SHAJIB, Md. Sharif Uddin
	Champion(s)	SHAJIB, Md. Sharif Uddin

	Major team member(s)	Research team of EEE Department, World University of Bangladesh
Environment	Nature/Society	Tropical rainfall motivates the program while posing technical challenges.
	Industry/Market	6G requires ultra-reliable links; industry pushes for scalable, rain-resilient THz solutions.
	Citizen/Government	Citizens demand reliable connectivity; Bangladesh's *Smart Bangladesh 2041* vision supports such research, though spectrum policy gaps remain.
Resources	Human resources	Faculty, researchers, and graduate students with wireless/ML expertise.
	Financial resources	Internal funding is available; external grants are needed for scaling.
	Technological resources	MATLAB, Python, computing clusters; real-time THz testbed under development.
Mechanism	Strategy (Weight/Sequence)	(1) Develop ML algorithms → (2) Validate with simulated and empirical data → (3) Build testbed → (4) Scale to industry.
	Organization	Program aligns with WUB's EEE Department research agenda.
	Culture	University promotes applied, industry-linked innovation.
Doing		
Launch date		January 2025
Responsible organization		Department of EEE, World University of Bangladesh
Program content and process		Dual-track approach with simulation and validation. ML models (Random Forest, XGBoost, DQN) trained on ITU-based and synthetic datasets. Results: throughput, SNR, and reliability improvements. Testbed development underway.
Key highlights of the content/process		• Content: (1) ML-based beamforming, (2) Integration of real-time weather data, (3) Real-time prediction. • Process: (1) Simulation-driven design, (2) Testbed development, (3) Empirical validation.
Differences from traditional approaches		Unlike static beamforming, this system adapts dynamically to environmental data.
Progress as of today		Simulation phase completed; testbed partially validated; multiple publications in progress.
Problems in implementation		Limited THz hardware, lack of localized rain datasets, restricted funding.
Approaches to solve the problems		Synthetic dataset generation, collaboration with meteorological agencies,

	pursuit of industry/government funding.
Completion date, if completed	12/08/2026
Seeing	
Impacts on students	Gained hands-on skills in 6G/ML; produced publications; higher employability.
Impacts on professors	Positive outcomes via research impact and collaborations.
Impacts on university administration	Recognizes the program as flagship 6G research.
Responses from industry/market	Industry stakeholders, particularly telecom operators and equipment manufacturers, have shown strong interest in adaptive THz systems for 6G deployment. The demonstrated improvements in SNR, throughput, and BER directly address industry challenges in tropical climates. Experts view this program as a promising step toward developing commercially viable solutions that can be scaled to metropolitan as well as rural networks. Industry partners have expressed willingness to explore collaborative pilots once the testbed phase matures.
Responses from citizen/government	Citizens in Bangladesh and similar tropical regions benefit from improved network reliability in education, healthcare, and smart city services. Government agencies view the program as aligned with national visions like *Digital Bangladesh* and *Smart Bangladesh 2041*. While supportive, they have emphasized the need to establish clear spectrum allocation policies for THz frequencies. Overall, the government response has been positive, highlighting the initiative's role in future-proofing national communication infrastructure.
Measurable output (revenues)	Publications, patents, licensing opportunities, projected USD 20,000.
Measurable input (expenses)	Staff, labs, grants, estimated USD 10,000.
Cost-benefit analysis for effectiveness	2:1 ratio (benefits exceed costs).
Future Planning	
Where does the project go from here?	The project will evolve into a large-scale testbed integrating hybrid FSO/THz links, federated learning, and real-time rainfall sensors. By 2030, it aims to deliver deployable solutions for urban and rural connectivity in Bangladesh and beyond, positioning the university as a regional leader in 6G innovation.
Addendum	

Exhibits, pictures, diagrams, etc.	• System model diagram of THz beamforming under rain attenuation. • Simulation plots comparing static vs. ML-based beamforming (SNR, BER, packet loss). • Flowchart of the ML-assisted beamforming pipeline (feature extraction, model prediction, DQN optimization).
Reports, mimeos, monographs, books, etc.	• Research paper draft: *Adaptive Beamforming in Terahertz 6G Networks Using Machine Learning Under Rain-Dense Atmospheric Conditions* (2025). • Related IEEE publications on THz communication, rain attenuation, and ML-based beamforming. • ITU-R P.838-3 report (specific attenuation model for rain).
Others which may help explain the program (including website links)	(Include any materials that may help validate the program; links to the program's website will be especially useful.)