Remote Powering Distributed Resources

A case study for railways and campuses

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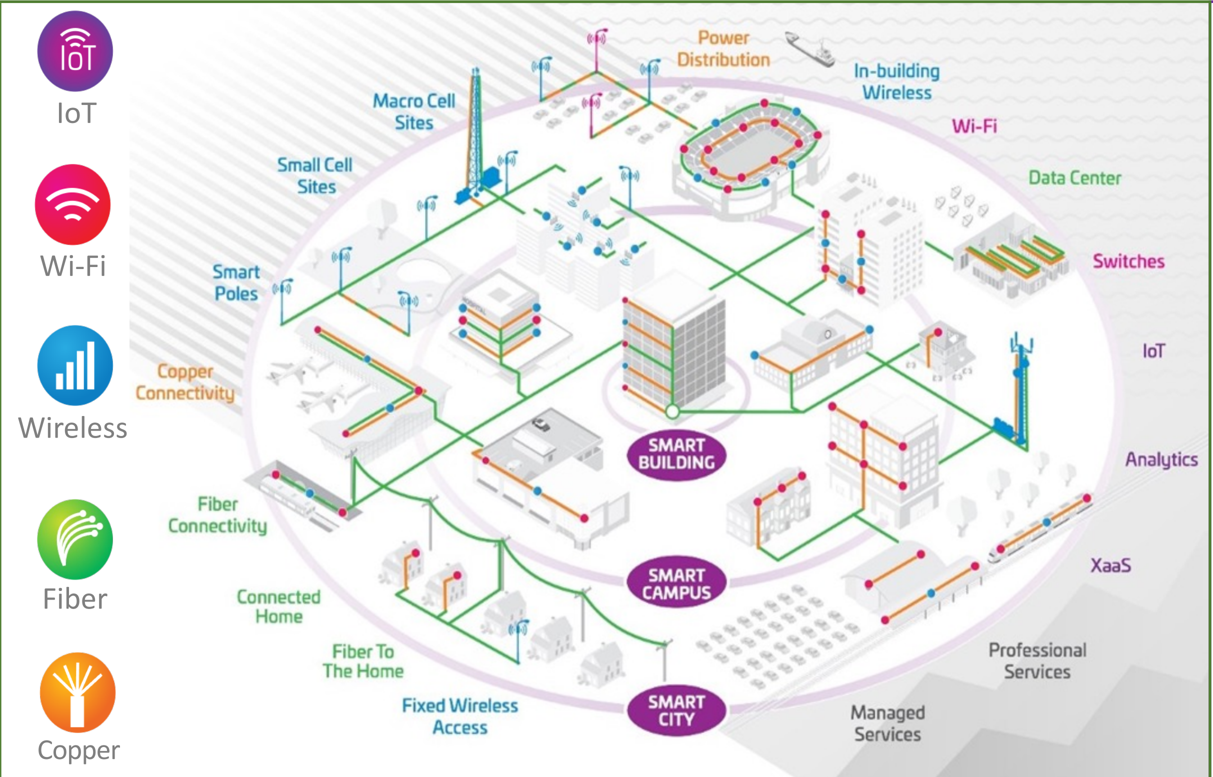

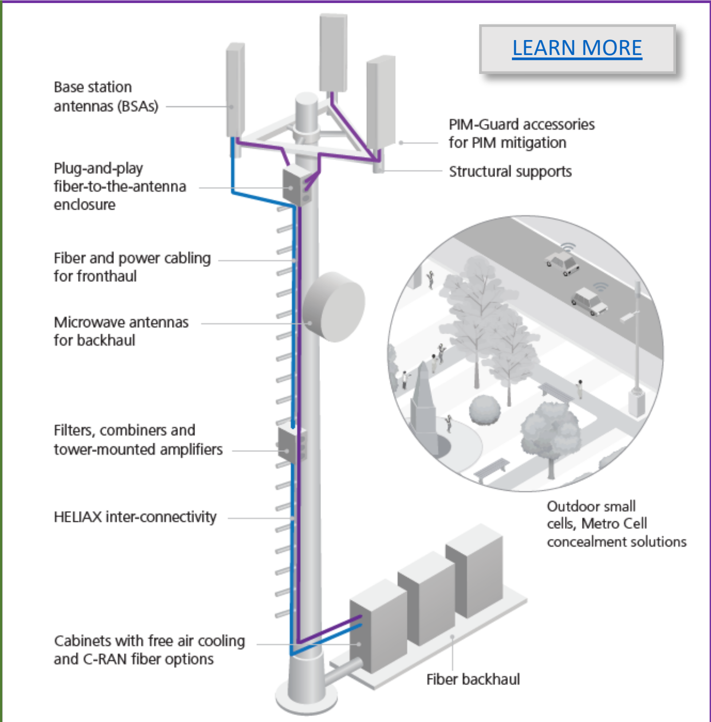

Outdoor Wireless Networks

30,000 Employees

8,5B Revenue
(2021)

A Green Agenda
Globally Responsible
Gold level CSR rating

$600MM
R&D
Investment

15,000

Global R&D and manufacturing

55 supply chain locations 10000+ Partners in 150+ countries

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At a Glance

CASE STUDY OF REMOTE POWERING DISTRIBUTED RESOURCES

Agenda:

- The Context
  - What is a Remote Powering System?
  - How does a Remote Powering System work?
- The Case Studies
  - Railway
  - Campus

What is Remote Powering?

- *It is a method of powering a device from a centralized location instead of a local AC power source*
- *Generally, 4 elements necessary to provide a distributed wireless network*

RF Components

Connectivity

AC Power

Structural Infrastructure

Costly

Long Lead Times

Lowest in Reliability

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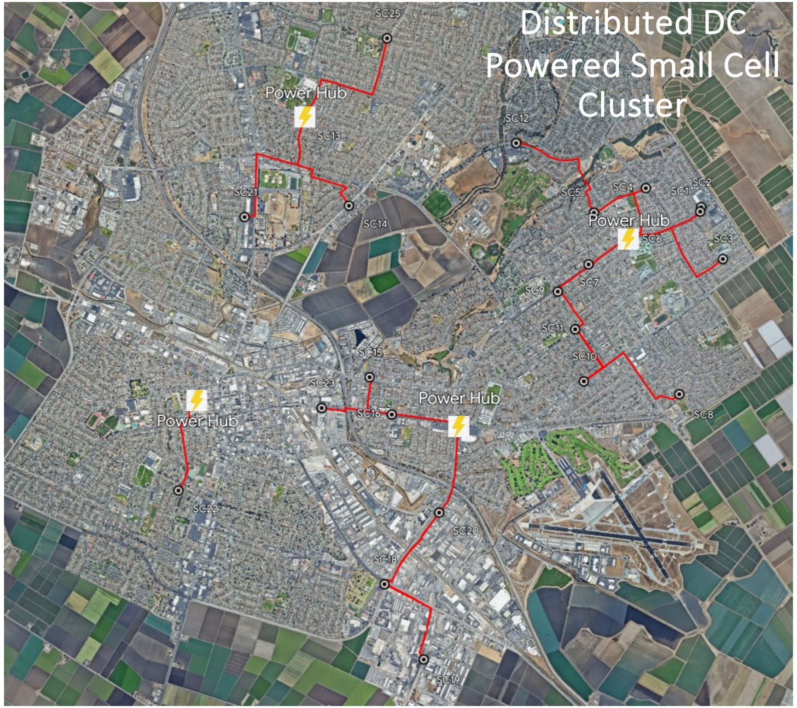
Example: Local vs Distributed

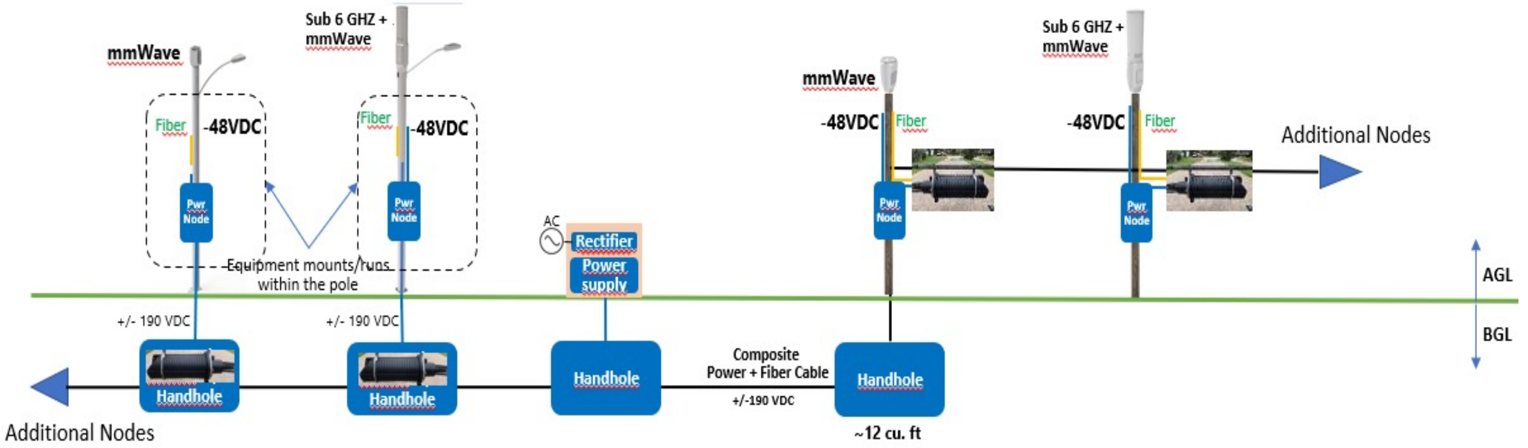


Result:

- *Reduction of AC connections from 25 to 4.*
- *By using existing communications space – power/fiber connects each distributed device*

How Distributed Power Works

- It converts the single AC connection to a DC voltage at a centrally located power hub and distributes it, along with fiber, in **a single communications cable providing the needed power and connectivity** to the distributed resources.
- The unique Power Bus architecture increases power utilization and the energy management of the distributed resources



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Distributed Power Components

- 4 Basic Elements:

POWER HUB

- Modular Power Shelf with **centralized battery** backup
- Power Bus - **Boosts Voltage** to 380 vdc for reduced line losses
- **Energy Management** function
- 4 cluster connections - 90 small cells (30 poles)
- 1 AC feed for all clusters (instead of 1/pole)
- Remote Network Connectivity

1

HYBRID or POWER ONLY TRUNK CABLES

- 144f hybrid cable – 1 dig, 2 functions
- DC bus for power distribution conductors plus up to 144 fibers
- 1 cable, 2 function - reduces construction
- Connects power and fiber to each small cell via Hybrid FOSC

2

HYBRID CLOSURE

- Primary flexibility point reduces cable runs and associated construction costs
- Connection (junction box like) for fiber and power to pole – plug and play
- Provides small cluster safety and pole isolation
- Allows OSP work without the rest of network deployment (pole, power node or radio/antenna exact locations)

3

POWER NODE

- Down convertor close to load for increased efficiency
- Small form factor pole mount for reduced footprint – ease approvals
- Connectorized interface – plug and play

4

Remote Powering Key Differentiators

Power Bus Architecture

- Distributes the power to all loads via shared power bus
  - Think of home-based power distribution with outlets, but does not require an electrician
  - Unlike point to point where each load has a dedicated transmit/receive pair
- Allows for fiber and power to be bundled in the same cable

Energy Management

- Bus architecture allows for various distributed energy resources to optimize energy usage
- Manages multiple loads and supply resources dynamically – *shave peak loads, balance supply/load resources and reinject energy to grid (AC grid support)*
- Increases critical load availability and efficiency

Increased Load

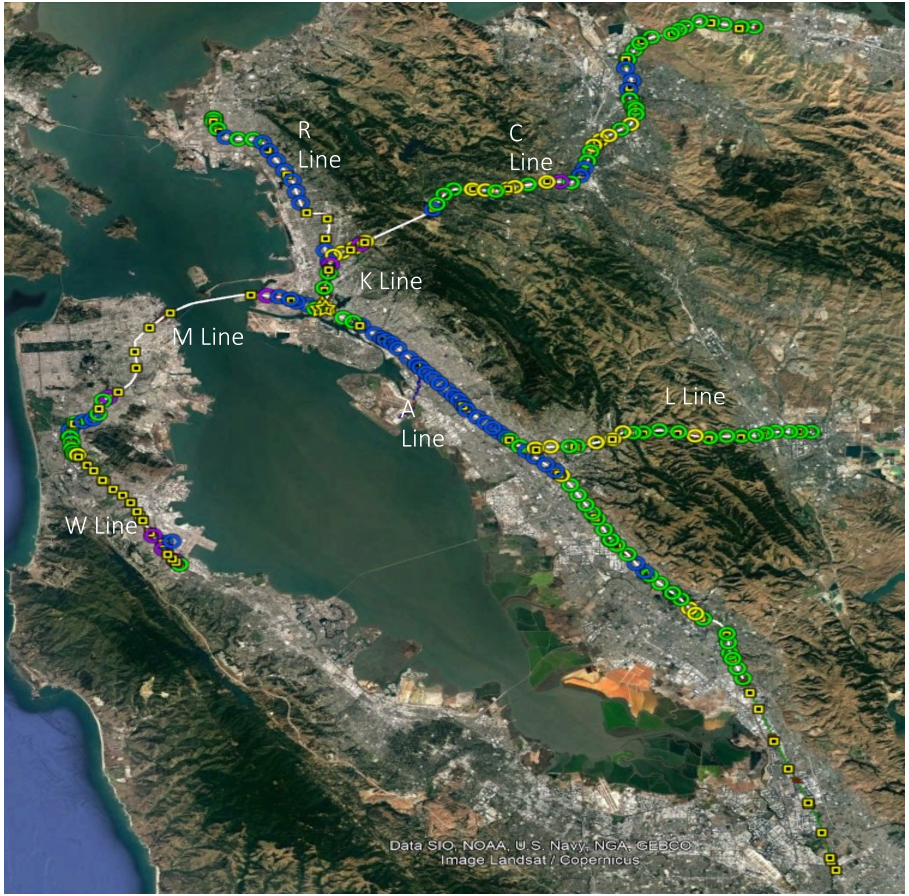
- Increases power distributed to a load by 100x compared to line powering technologies within the telecommunications space

Safety

- Compliant to new standard – ATIS 0600040: Fault Managed Power Distribution Technologies – Human Contact Fault Analysis
  - Unlimited power to load yet limits energy into a fault (think better than Class II power – IEC 60479 Zone 2 or better)
  - Allowed within telecommunications space
- Equipped with interlocked barriers to further limit energy exposure to the telecom technician

Case Study 1: Railway

Item	Challenge
1	~240 km of track - requirement to have a single continuous cable for power and fiber connectivity for ingress/egress at each station (50 sites)
	Requirement for a single cable at any location
	Power and fiber must split near track switches, can not have more than one cable in the cable raceway.
2	340 small cell locations @ 200 watts each, train to track wireless service, spaced every ~800 m
3	~110 km of track within tunnels
	Wireless service is required in each tunnel without the need to run a new cable - cable split needed
	Some tunnels have 2 and 3 levels of track (K-Line Wye)
	Wireless service is combined outside each tunnel
4	50 possible locations to get power (at each train station)
	The only AC service connection is at the train stations
	The average distance between train stations is 5 km
	Desire is to reduce the number of AC connections (function of cost)
5	Limited space within track, tunnel, stations and wayside for routing cable
	Minimize cable size and equipment everywhere
6	Rail authority required Low Smoke Halogen Free cable
7	Rail authority requirement - no metallic shield within the cable
	Concerned with current loops near 3rd rail
8	Construction activity could only occur when authorized and typically a few hours a day on a rotating schedule
	The solution must decrease time for deployment



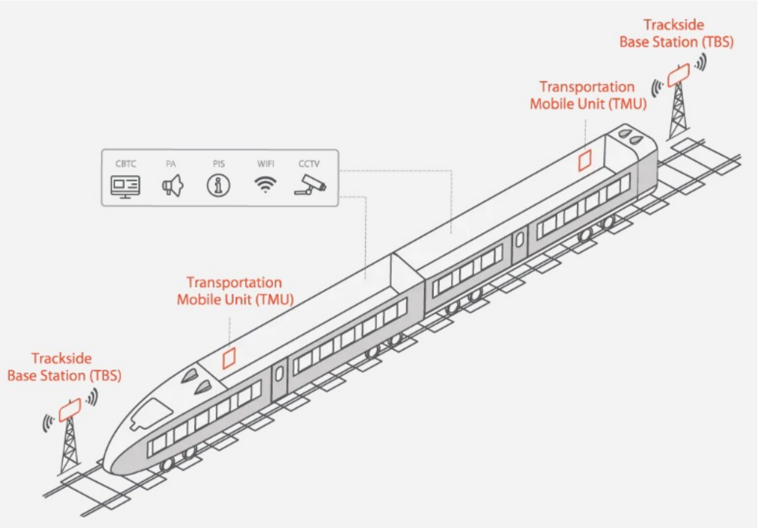
Case Study 1: Railway

Item	Challenge	Results
1	~240 km of track - requirement to have a single continuous cable for power and fiber connectivity for ingress/egress at each station (50 sites) Requirement for a single cable at any location Power and fiber must split near track switches, can not have more than one cable in the cable raceway.	The unique bus architecture allows cable splits, both power and fiber at the FOSC. This provides a single cable solution at any position along the track and within the cable raceways
2	340 small cell locations @ 200 watts each, train to track wireless service, spaced every ~800 m	The DC bus with 2x12 awg power wire provides enough capacity to power these radios for distances up to ~ 8km
3	~110 km of track within tunnels Wireless service is required in each tunnel without the need to run a new cable - cable split needed Some tunnels have 2 and 3 levels of track (K-Line Wye) Wireless service is combined outside each tunnel	The DC bus and FOSC designs allows cascading splits to support multiple levels of track within the tunnels and stations. This was not possible with competing product architectures and was one of the reasons we one this contract
4	50 possible locations to get power (at each train station) The only AC service connection is at the train stations The average distance between train stations is 5 km Desire is to reduce the number of AC connections (function of cost)	Given the reach of this system, we provide power to all 340 small cell locations on this 240 km of track by utilizing AC power from 20 of the 50 available stations, reducing the AC connection locations by 30.
5	Limited space within track, tunnel, stations and wayside for routing cable Minimize cable size and equipment everywhere	The cable design modification requests reduced the cable diameter by ~4 mm.
6	Rail authority required Low Smoke Halogen Free cable	Modified the cable design to LSZH cable. Designed and manufactured in CommScope's manufacturing facility.
7	Rail authority requirement - no metallic shield within the cable Concerned with current loops near 3rd rail	Removed the shield from the cable. Testing showed that the cable shield in not required for the Fault Managed Power to operate properly. Also passes all EMI/EMC/FCC tests. Design modifications and manufacturing performed in house.
8	Construction activity could only occur when authorized and typically a few hours a day on a rotating schedule The solution must decrease time for deployment	The bus architecture minimizes field assembly work - no wiring pair mapping for downstream nodes, single cable and FOSC has single trade to come in for power/fiber connectivity, use of well know FOSC minimizes splicing time in the field.

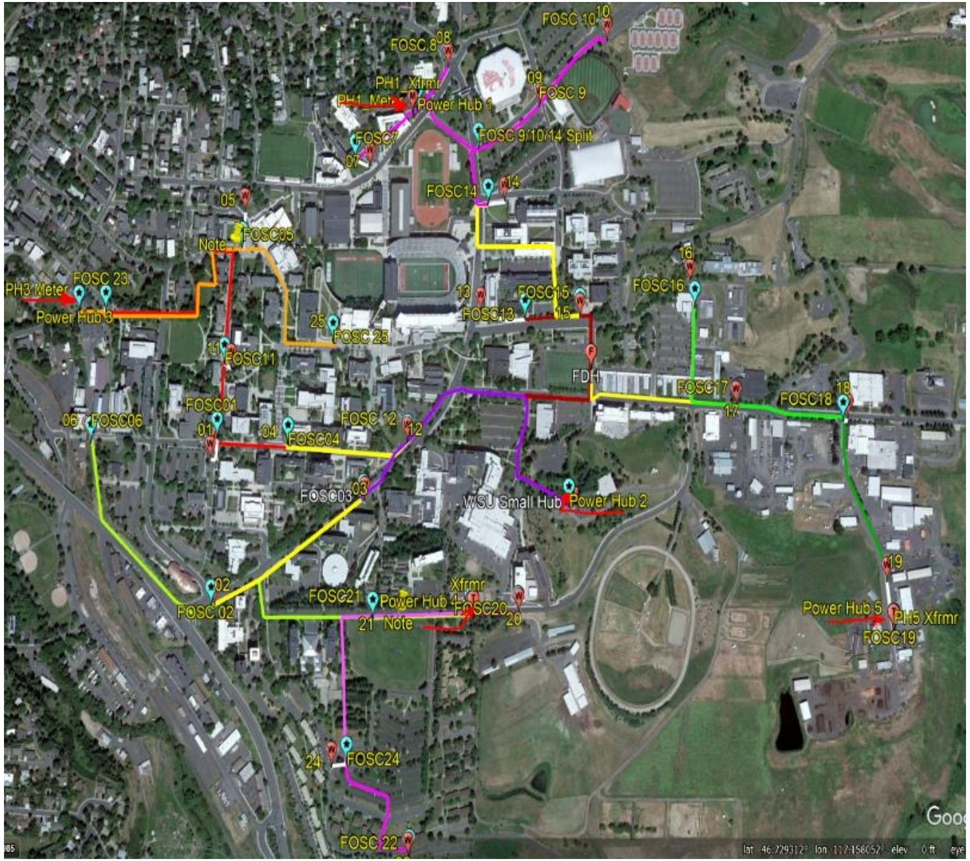
Cost Savings: 1/2 construction cost; minimized power hubs from 50 to 20

Time Savings: Not yet evaluated for this project

Other: Reliability increase (factory integrated), single company to manage, less disruptions with less equipment



Case Study 2: Campus



Item	Challenge
1	High capacity low latency wireless services are critical to college campuses
	To be competitive amongst colleges – high performance wireless services are critical
	The user population is very dense within the campus
2	15 of the 25 Wireless Sites did not have AC service
3	Cost for AC service interior to campus, in some cases, was > 100k USD
4	College authorities did not want additional equipment within the interior of the campus
5	Construction activity could only occur when students are not present (Summer and Winter break)
6	Time for construction of AC services was 2 yrs. The college wanted the system available in months (start construction in June – service available by the end of August)
7	All infrastructure was required to run within Electric Metallic Tubing (EMT) within a campus tunnel system ($$$ for tubing and $$$ for construction)
	Crucial to limit # of cable runs
8	All equipment required special paint color.

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Case Study 2: Campus

Item	Challenge	Results
1	High capacity low latency wireless services are critical to college campuses To be competitive amongst colleges – high performance wireless services are critical The user population is very dense within the campus	Provided low, mid and high frequency band services – all on one small cell pole (site). 6 radios @ 2 kW/pole 5 power hubs, 1 indoor - ~ 58 kW 30 kft (9 km) of cable - ~ 1200 ft (365 m) between poles 50 power nodes - 2/site
2	15 of the 25 Wireless Sites did not have AC service	Was able to utilize the AC service panels on the outskirts of the campus and distribute power to the interior of the campus
3	Cost for AC service interior to campus, in some cases, was > 100k USD	
4	College authorities did not want additional equipment within the interior of the campus	
5	Construction activity could only occur when students are not present (Summer and Winter break)	Solution deployment is 3 months - used existing AC service panels, - single cable to run to all small cell sites, - single company with integrated equipment, - used fiber within cable for fronthaul and backhaul of optical signals, - used FOSC as campus FDH locations, - created fiber routing and splicing tables due to single cable and utilizing power/fiber network planning tool - same cable for buried and aerial applications - no mapping of individual paired copper conductors
6	Time for construction of AC services was 2 yrs. The college wanted the system available in months (start construction in June – service available by the end of August)	
7	All infrastructure was required to run within Electric Metallic Tubing (EMT) within a campus tunnel system ($$$ for tubing and $$$ for construction) Crucial to limit # of cable runs	
8	All equipment required special paint color.	Outer surfaces of all deployed equipment matched to campus requirement
Cost: 30% of AC powered, separate power/fiber solution		
Time Savings: 1 yr. and 9 months		
Other: Reliability increase (factory integrated), single company to manage, less student disruptions (accidents, traffic, etc.)		

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Thank you
for your attention

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