EXECUTIVE SUMMARY

Innovating Remote Connectivity

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EXECUTIVE SUMMARY

Evolving technologies are broadening remote connectivity options across industry sectors

Use cases for remote connectivity are evolving from simple monitoring to real-time analysis for complex AI models. The number of data feeds is also increasing exponentially due to IoT.

These factors make finding the most cost-effective choice for remote connectivity more challenging, requiring careful evaluation of data transmission requirements, such as speed, size, and power.

This report examines evolving options for remote connectivity. New technology like 5G and edge will enable greater efficiency for complex use cases – but LPWAN will remain a low-cost alternative, while satellite is the main option for extremely long-distance and Wi-Fi 6 and 5G for short-range/high-bandwidth cases.

Attribute Assessment (relative to competing technologies):

- High (Good)
- Medium
- Low (Poor)

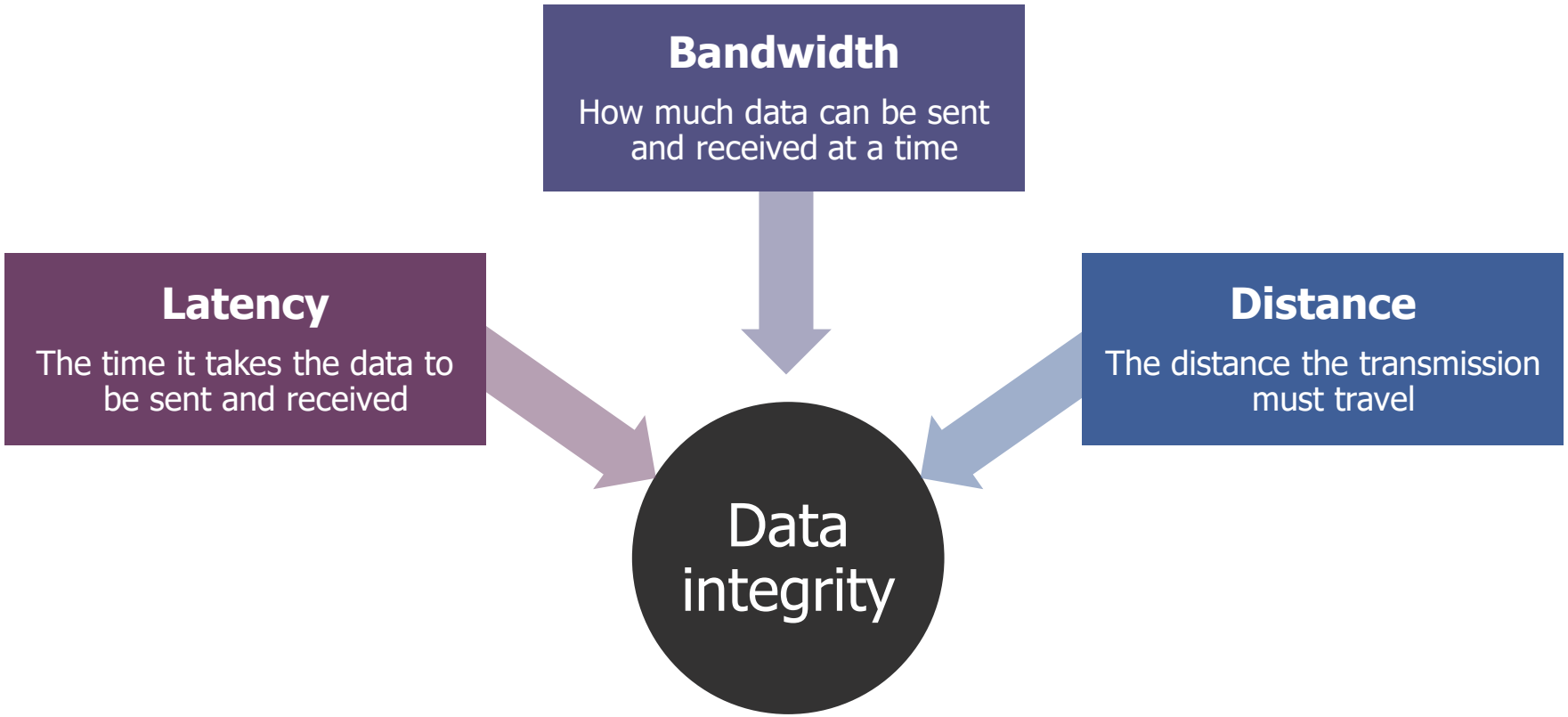
Longer-term outlook:

- Improving
- Declining

* No indicator implies no change, or neutral outlook

	Long Range Technologies				
	5G Low Band	LPWAN	4G	5G Mid Band	Satellite
Network & Data Plan Affordability			↑		↑
Hardware Affordability					
Transmission Range					
Power Efficiency					
Bandwidth			↓		
Latency		↓	↓		↑
Device Capacity					↑
Security					

For remote or local, the priority for data transmission is data integrity, dependent on latency, bandwidth, and distance



Data integrity: Data delivery without bottlenecks, inefficiencies, delays, or blackouts causing data loss.

These criteria and a few others (security, device capacity, and affordability) allow for a full technology assessment

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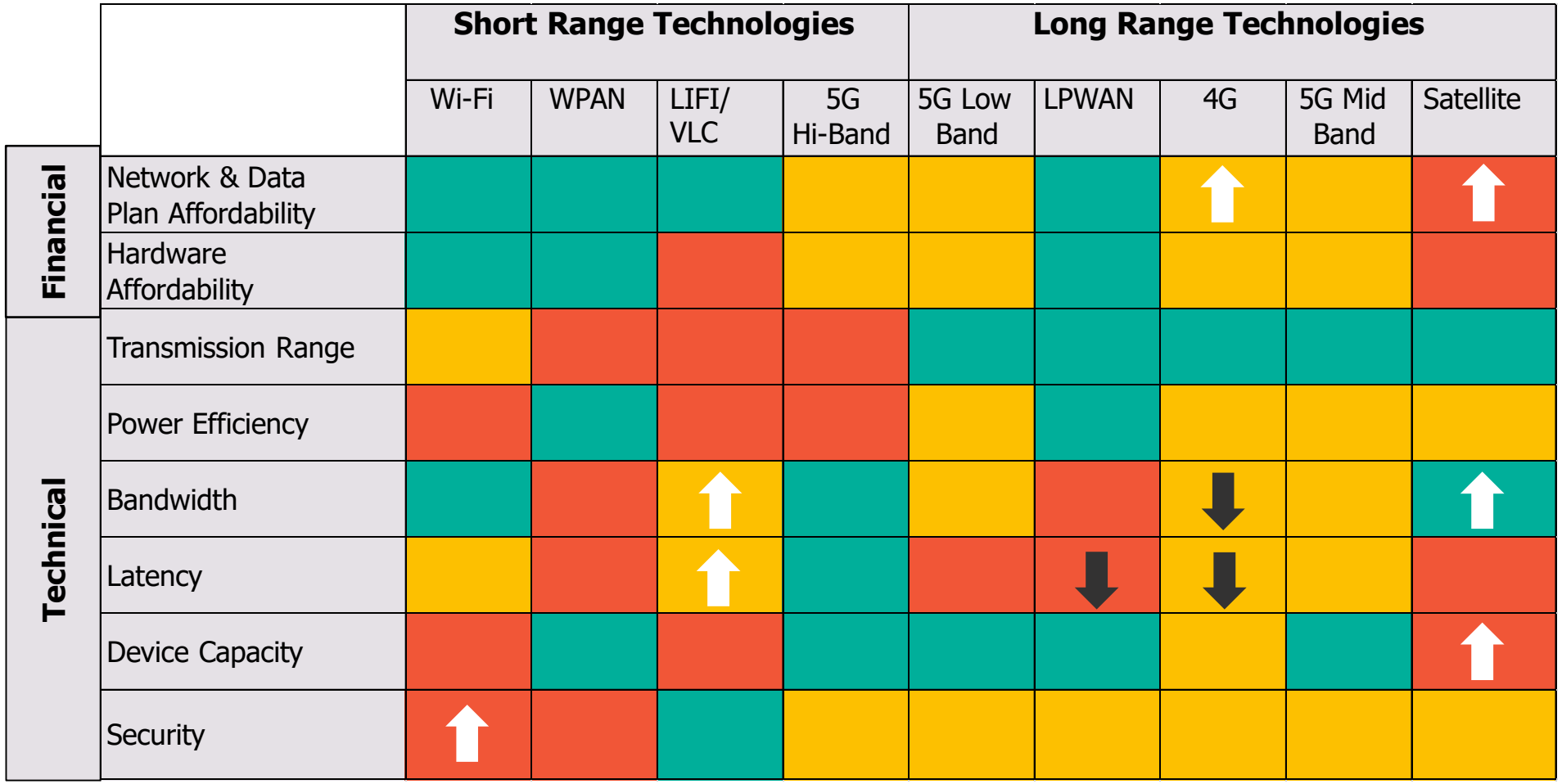

This heat map updates the assessment found in the prior report: **"Cord-Cutting" in the Enterprise: A Guide to Wireless Communications in Industry 4.0**, which covered all wireless technologies.

Focusing on remote communications technologies leaves three choices: cellular 4G/5G, LPWAN, and satellite

The trade-off between 4G cellular, LPWAN, and satellite has long been known.

For example, LPWAN's low bandwidth, which ranges from 0.1 kbps to 200 kbps, is well-suited for remote device monitoring, while satellite's high bandwidth ranging from 100 Gbps to 300 Gbps and its high cost and high latency make it suitable for long-range environmental monitoring.

Meanwhile, cellular is evolving, first with NB-IoT and low-band 5G with similar offerings to LPWAN, and midband 5G is extending the capability to slightly better than 4G in terms of speed and capacity.

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Latency		↓	↓		↑
Device Capacity					↑
Security					

Remote technology comparison: LPWAN

Advantages: LPWAN's 10 km to 30 km range makes it useful for site-based or metro/regional sensor readings, tracking, and monitoring. In addition, NB-IoT has the backing of cellular mobile network operators, while LoRa has a solid service provider network (LoRa Alliance).

Disadvantages: LPWAN's limited bandwidth (<1 to 250 kbps) makes it a poor candidate for advanced analytics or AI that require large data packets. Sigfox's proprietary service provider solution is uplink-only, as well as high-latency and low-bandwidth.

Outlook: NB-IoT and LoRa are expected to dominate LPWAN with 83% of connections by 2023, but LPWAN will ultimately remain in a low-power niche position for covering moderate distances.

Type of LPWAN	LoRa	Sigfox	NB-IoT	LTE-M
Cost per GB	$1 (crowdsource) to $15 per connection per year	$1 to $12 per connection per year	<$12 per connection per year	<$12 per connection per year
Power consumption	15 mW/byte to 77 mW/byte	33 mW/byte to 107 mW/ byte	5 mW/byte to 7 mW/byte	5 mW/byte to 7 mW/byte
Distance	2 km to 15 km on average	3 km to 30 km on average	10 km to 15 km on average	10 km to 15 km on average
Latency	>100 ms	>100 ms	>100 ms	>100 ms
Bandwidth	0.3 kbps to 50 kbps	<100 bps or 600 bps	250 kbps	250 kbps

REMOTE MANUFACTURING

Predictive Maintenance

Key Challenges: To avoid machine failures that can cause downtime and consequent loss of production, manufacturers require data collection and analysis that can monitor and predict events that may lead to failure. The solution must also provide timely recognition of any degradation and continuous self-diagnosis of components to support and plan maintenance.

Best-fit Solution: 5G

This challenge requires real-time sensing, connectivity, and analytics. Even at midband frequency, 5G provides the low latency required for near-real-time sensing, as well as high bandwidth to support analytics models. Driven by private network investments and compatibility with high-band 5G, midband 5G will become a predominant technology for remote manufacturing use cases that require near-real-time responsiveness and broad coverage.

Remote Control Robots and Industrial Machines

Key Challenges: Remote control robots require constant communication to perform discrete motions. Remote motion control for reconfiguring the plant for new processes or dynamically changing machine position also requires real-time, high-bandwidth connectivity.

Best-fit Solution: 5G

5G provides low latency and high bandwidth for bidirectional processing of large data streams. Bottom line: 5G high-band is best suited but requires high-density coverage and fiber backhaul to cover large-footprint plants or multisite operations.

REMOTE MANUFACTURING

Energy Consumption Monitoring

Key Challenges: As manufacturers seek to automate plant activities, remote monitoring and control become crucial. Applications like energy management, predictive maintenance and process control rely on reliable remote connectivity to transfer data to cloud platforms for analysis and action. When large plants are involved, cellular or LPWAN networks come into play.

Best-fit Solution: LPWAN

Cost reduction through energy management requires manufacturers to monitor and control energy consumption in real time. Large production sites with equipment spread throughout and numerous sources of energy drain – from machine operations to cooling fans – require a complex monitoring platform for data analytics. But the data transfer itself is often low-bandwidth, moderate-latency, using a low-power network like LoRa.

Case Study

SALONIT ANHOVO CEMENT

WHO & WHAT

- Salonit Anhovo was facing increasing pressure from environmental regulation. As the largest cement production factory in Slovenia, Salonit averages 85 GWh consumption and spends upward of €9 million per year on electricity. In order to drive down its energy consumption, the company rolled out a wireless energy management system (EMS).

- **DEPLOYMENT DETAILS**
  - The system provides a central dashboard to monitor and control energy consumption, in real time, from various equipment across the sprawling 3 km production site. Actility, a LoRaWAN-based LPWAN software and services provider, deployed the EMS and the LoRa network.
- **RESULTS**
  - Salonit Anhovo has become one of the top 10% most energy-efficient cement factories in Europe. The system replaced manual collection of information without the ability to act on it to reduce consumption.

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Industry sector adoption expectations

Sector	Outlook
Oil & Gas	LPWAN will remain viable for surface equipment monitoring, while satellite will continue to be required for long distances (greater that 100 km) for drilling and exploration, and 5G will come into play for well and production data analytics. In the future, autonomy for offshore assets will require hybrid 5G solutions, as satellites won't be able to support autonomous drilling.
Remote Manufacturing	LPWAN is still the optimal solution for static plant asset management, while 5G is gaining traction in predictive maintenance and mobile robotics and motion control.
Mining & Construction	LPWAN is the most cost-effective for maintenance-related equipment monitoring; however, machine automation is becoming a strong 5G use case, while satellite remains the only solution for challenging remote site inspection and management.
Supply Chain	LPWAN retains its position in tracking warehouse and logistics site-based assets, while satellite is required for cold chain monitoring, and 5G has potential for real-time tracing and tracking.
Utilities	Renewables are driving change in utility communication requirements, with wind farm monitoring relying on LPWAN technologies, with distribution analytics calling for 5G, and UAV line inspection also evolving as a 5G use case.

New Technologies

5G will emerge as a unifier: Technology is evolving to meet new use case requirements for remote connectivity. Especially important will be 5G's ability to address multiband use cases. However, 5G offers improved data integrity but limited comparative distance coverage.

Satellites become less pricey: Satellites are becoming more cost-effective and catering to IoT services.

6G will be about hot spots: 6G will emerge as an expansion of mmWave, with limited utility in remote communications.

New Use Cases

More complex requirements: The data communications landscape is shifting due to increased complexity in use cases like AI-driven analytics and virtual reality.

LPWAN remans as a niche player: LPWAN remains a low-cost alternative; however, its use will likely be to fill coverage gaps for other connectivity options rather than being the sole solution, as Wi-Fi 6 and 5G remain the hot spot contenders.

Edge will lower transmission costs: Edge improves local data processing and can serve as a gateway to hybrid solutions.

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