Real-Time Latency:
Rethinking Remote Networks

TELESAT
"You can buy your way out of bandwidth problems.

But latency is divine"
Executive summary

▲ **Latency** is the time delay over a communications link, and is primarily determined by the distance data must travel between a user and the server.

▲ **Low earth orbits (LEO) are 35 times closer to Earth** than traditional geostationary orbit (GEO) used for satellite communications. Due to the closeness and shorter data paths, LEO-based networks have latency similar to terrestrial networks\(^1\).

▲ LEO’s low latency enables fiber quality connectivity, benefiting users and service providers by:
  - Loading webpages as fast as Fiber and ~8 times faster than a traditional satellite system
  - Simplifying networks by removing need for performance accelerators
  - Improving management of secure and encrypted traffic
  - Allowing real-time applications from remote areas (e.g., VoIP, telemedicine, remote-control machines)

▲ **Telesat Lightspeed not only offers low latency but also provides**
  - High throughput and flexible capacity
  - Transformational economics
  - Highly resilient and secure global network
  - Plug and play, standard-based Ethernet service

30 – 50 milliseconds Round Trip Time (RTT)
Questions answered

▲ What is Latency?
▲ How does it vary for different technologies?

How does lower latency improve user experience?

What business outcomes can lower latency enable?

Telesat Lightspeed - what is the overall value proposition?
What is latency?

Latency is time delay over a communications link, often measured as round trip time in milliseconds.

On the Internet, user devices request data and servers respond to these requests.

Latency determines how quickly the user begins to get a response from the server.

Latency is determined primarily by the distance these requests and responses must travel, plus any processing time along the way.

For high speed Internet services, it is often latency rather than bandwidth that determines the user experience.
What is latency?

Understanding latency via an airplane analogy

<table>
<thead>
<tr>
<th>Goal</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum passengers flown in a month</td>
<td>Short route and Big plane</td>
</tr>
<tr>
<td>Maximum data packets moved in an Internet session(^1)</td>
<td>Low Latency and High bandwidth</td>
</tr>
</tbody>
</table>

Only having high bandwidth (big plane) is not enough, low latency (shortest route) is critical to maximize output.
Why latency matters on the internet

Internet protocols require low latency to run at speed

Hello Client! Are you there?
- OK, sending packets 6 to 10
- OK, sending packets 1 to 5
- Thank you Server, I received packets 1 to 5
- Yes Server, I'm here.

Data packets flow quickly when latency is low

Latency slows the process dramatically regardless of data rate
Satellite latency

The further a satellite is from earth, higher the latency (round trip time)

Relative distance of satellites from Earth

<table>
<thead>
<tr>
<th>Distance from Earth</th>
<th>Relative Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO</td>
<td>35x</td>
</tr>
<tr>
<td>MEO</td>
<td>8x</td>
</tr>
<tr>
<td>LEO</td>
<td>1x</td>
</tr>
</tbody>
</table>

1x = 1,000 km

Round Trip Time

<table>
<thead>
<tr>
<th>Satellite Type</th>
<th>Latency (Milliseconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEO</td>
<td>30-50</td>
</tr>
<tr>
<td>MEO</td>
<td>125-250</td>
</tr>
<tr>
<td>GEO</td>
<td>600-800</td>
</tr>
</tbody>
</table>
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Better user experience

LEO’s low latency enables a superior Internet experience vs GEO/MEO

- Faster web pages: 2-8x faster
- Real-time comms and control
- Faster than fiber over long distance
- Seamless experience with encrypted traffic
Web and digital media

LEO’s low latency enables fiber quality web experience

Faster web pages

Relative time to load website
Ratio vs Fiber load time

Tests conducted in Telesat simulation lab with latency setup based on a Caribbean location to Miami: LEO=28-32 ms, MEO=150 ms, GEO=700 ms (no acceleration)
Each test repeated 5 times to record average results

Telesat Lightspeed loads webpages:
- Similar to Fiber
- 2x faster vs MEO
- 6-8x faster vs GEO

<table>
<thead>
<tr>
<th></th>
<th>Fiber</th>
<th>LEO</th>
<th>MEO</th>
<th>GEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio vs Fiber load time</td>
<td>1</td>
<td>1.1</td>
<td>2</td>
<td>6-8</td>
</tr>
</tbody>
</table>
Real-time comms and control

LEO’s low latency enables real-time communication and control

**Real-time communication**

**Traditional Satellites**  
High latency causes buffering before making a connection  
Video and voice also become out of sync

**LEO Satellites**  
Video and voice are delivered in real-time in low latency LEO systems

**Real-time control**

The low latency of the LEO system removes the delay between the sending and receiving of a signal  
The LEO system enables real-time control of latency sensitive applications

**Real-time consumer applications**

- **Video Chat**
  - Skype
  - FaceTime
  - Google Hangouts

- **Interative Social Media**
  - Periscope

**Real-time enterprise applications**

- **Video Conferencing**
  - Cisco Webex
  - Skype for Business

- **Remote control**
  - UAV
  - Telemedicine
VoIP

LEO latency delivers a good VoIP user experience

Impact of latency on VoIP
MOS\(^1,2\)

![Graph showing the impact of latency on VoIP MOS](image)

Source:
1. MOS = Mean Opinion Score: higher score indicates higher user satisfaction with streaming video start time and quality
2. Packet loss 0%

- Good user experience
- Bad user experience
Long distance latency

Leveraging inter-satellite links, Telesat Lightspeed can offer lower latency across long distances vs terrestrial networks

**Round Trip Time – Telesat Lightspeed Latency vs Terrestrial Latency**

Milliseconds

- **New York City – London**
  - 1.3x Faster
  - 55 vs 70

- **London – Shenzhen**
  - 2.4x Faster
  - 92 vs 219

- **Shenzhen – New York City**
  - 1.8x Faster
  - 128 vs 225

- **Rio de Janeiro – New York City**
  - 1.3x Faster
  - 103 vs 131

- **London – Johannesburg**
  - 1.6x Faster
  - 101 vs 162

- **London – Sydney**
  - 2.4x Faster
  - 357 vs 148

LEO Latency based on Telesat Lightspeed simulations of traffic moving over only inter-satellite links, Telesat Lightspeed latency (round-trip time) is at network layer including processing latency for system and Inter-satellite links. Terrestrial data from https://wondernetwork.com/pings

92
219
128
225
103
131
101
162
357
148
Encrypted Traffic

LEO improves performance of unencrypted as well as encrypted traffic

In 2017 50% of internet traffic was encrypted – by 2019 it will be 75%\(^1\)

GEO systems use modified Internet protocols to accelerate unencrypted traffic to partially mitigate the impact of high latency

But encrypted traffic cannot be accelerated

As share of encrypted traffic on the Internet grows, benefits of GEO acceleration will decline

LEO does not need acceleration thereby ensuring high performance even with encrypted traffic
Encrypted traffic

Consumer application traffic is mostly encrypted

90+% of Google traffic is encrypted\(^1\)

\(^1\) Google Transparency Report, percentage
Encrypted traffic

Enterprise application traffic is increasingly being encrypted

Percentage of Application WAN traffic, 2015 vs. 2016

1. Aryaka - “State of the WAN” - percentage
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Business benefits of LEO’s low latency

Higher user satisfaction; improved efficiencies via real-time control

**CELLULAR BACKHAUL**
- Lower churn and simplified network with no requirement for GEO accelerators

**AVIATION**
- Terrestrial-like in-flight passenger connectivity and real-time applications for crew

**MARINE**
- Responsive passenger Internet and better real-time vessel optimization (fuel savings)

**REMOTE COMMUNITIES**
- Effective e-learning and telemedicine, urban broadband experience in remote and rural areas

**GOVERNMENT**
- Highly responsive airborne ISR and better video/VoIP chats of personnel with family

**ENERGY**
- Real-time management of production; improved crew welfare with responsive Internet
Cellular Backhaul - benefits of LEO latency

Increased end-user satisfaction and improved operational efficiency

**End User**
- No lag video chat, instant use of social media
- Improved user experience

**Network**
- Simplified network with no requirement for performance accelerators
- Fully compatible with true end-to-end encryption. No need for split encryption tunnels

User Satisfaction | Increased Revenues | Improved Efficiency & decreased costs
Aviation - benefits of LEO latency

Browse the web at 35,000 feet like both feet are on the ground

- **Passenger**
  - No lag video chat and quickly load webpages
  - Improves customer loyalty and bookings

- **Crew**
  - Real-time weather and navigation for pilots
  - Enables use of satellite for operational communications

- **Aircraft**
  - Real-time engine monitoring and preparation for maintenance issues
  - Lowers maintenance costs and increases aircraft uptime

*User Satisfaction, Increased Revenues, Improved Efficiency & decreased costs*
Remote Communities - benefits of LEO latency

Enabling broadband experience in rural and remote communities

- Compelling Internet experience to consumers and small businesses

- Real-time telemedicine and imaging
  - Improved patient experience, reduced wait times and lower medical costs

- Remote teachers, quick loading web content for in-class applications
  - Reduced digital divide from urban schools

User Satisfaction  Increased Revenues  Improved Efficiency & decreased costs
Marine - benefits of LEO latency

At-home like connectivity for passengers; improved ship-shore collaboration

- No lag video chat and quickly load webpages
- Quickly upload photos and video to social media
- Improves customer loyalty and bookings

- Real-time weather and navigation for crew
- VoIP and other latency sensitive communications

- Real-time engine monitoring and reaction to maintenance issues
- Fuel optimization
- Reduces maintenance costs and improves operational efficiency
Government - benefits of LEO latency

Highly responsive airborne ISR applications

- Accurate control and navigation
- Real time remote control for immediate response to steer, shoot, avoid collision, etc.

Unmanned Platforms

- Quickly load webpages
- VoIP applications without lag
- Improved personnel morale

Morale, Welfare & Recreation

User Satisfaction  $  Increased Revenues  Chart  Improved Efficiency & decreased costs
Energy - benefits of LEO latency

Transforming remote operations with real-time applications

- Real-time data between automated platforms and onshore control centers
- Automation of platforms increasing safety and reducing labor costs
- Improved production

- Communications with family onshore
- Remote learning
- Better crew satisfaction and retention

Operational Systems

Crew

User Satisfaction  Increased Revenues  Improved Efficiency & decreased costs
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Telesat Lightspeed: more than low latency

- **High Throughput**: Gbps links, Tbps sellable capacity
- **Low Cost**: Transformational economics
- **Global**: ‘Anywhere, Anytime’
- **Plug & Play**: Quick service deployments
- **Low Latency**: sub-50 msec RTT (space only) sub-100 msec RTT (space & ground)
- **Flexible & Focused Capacity**: 100s of Gbps in concentrated area
- **Unmatched Resilience**: Unmatched Resilience, Interference resistance, Inter satellite links
Telesat Lightspeed

Low latency + High throughput = Highest Quality of Service

GEO = Geostationary orbit; MEO = Medium Earth Orbit; HTS = High Throughput Satellite; LEO = Low Earth Orbit