**CORE SERVICE DESIGN:**

**ExpressRoute**

atabricks

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# Overview

This document covers the baseline design for the ExpressRoute core service. The intention of this document is to define the overall resource design in isolation from a specific application. It is aimed to highlight the general process and requirements for building a ExpressRoute in a repeatable fashion with consistent configurations. Design decisions and justifications have been included in the Architecture section, and this document can be used as a reference for new builds that require a ExpressRoute.

This design caters to a Level 2 design which covers both Microsoft’s WAF (Well Architected Framework)[[1]](#footnote-2) and the Department of Health Control list.

Any deviations required to the standards defined in this document will require separate exemption and approval from the Cloud Governance Forum if they are required for any reason for a specific build.

## Purpose and Audience

This document will outline the standard design and configuration of this Azure service in Ambulance Victoria’s Azure tenancy as a baseline for any application infrastructure deployments.

This design is intended to:

* Meet Microsoft WAF standards.
* Meet the controls stipulated by the Department of Health.
* Define the baseline required for the deployment of the resource.

The audience for this document is those involved in the planning, designing, and implementing of the Application/Data infrastructure. This includes:

* + Ambulance Victoria IT staff

It is assumed that the reader knows and is familiar with Azure Cloud concepts and related topics.

## Scope and Key Deliverables

The scope of this core service design is to define the baseline deployment requirements and standards for the ExpressRoute core service.

The key deliverables for this are:

* This design to outline the service definition Level 2 baseline standards.
* A technical configuration document that defines the deployment of this resource for each of the Service Tiers, or for any other logical standard such as size
* IaC templates for repeatable deployment of this core service

## Glossary and Definitions

|  |  |
| --- | --- |
| **Term** | **Definition** |
| **AV** | Ambulance Victoria |
| **WAF** | Well Architected Framework |
| **CAF** | Cloud Adoption Framework |
| **Level 1** | Refers to a resource that has been designed to a CAF standard |
| **Level 2** | Refers to a resource that has been designed to a WAF standard with Department of Health controls overlayed |
| **AZ 2** | Refers to Ambulance Victoria’s legacy Azure Landing Zone still in use in some regards |
| **AZ 3** | Refers to Ambulance Victoria’s current Azure Landing Zone, also referred to as the Enterprise landing zone. This is the target state for migrations. |
| **SLA** | Service Level Agreement as defined by Microsoft |
| **DH** | Department of Health |
| **IaC** | Infrastructure as Code |
| **NSG** | Network Security Groups |

Table 1: Glossary and definitions

# Executive Summary

This design covers the baseline standards for the ExpressRoute Core Service. This service has been assessed against the five pillars of WAF as well as the Department of Health Security Controls.

This section contains a summary of the major design decisions that have been made for defining the baseline of this resource as an outcome of the WAF and Security analysis detailed throughout this document.

Of the five WAF Pillars, it was found that all pillars were relevant. For the ExpressRoute, since it is a critical network structure, it is a Platinum service.

For this service the main baseline configurations include:

* The circuits will be configured in an active-active configuration.
* ExpressRoute circuits will be used, ExpressRoute Direct will not be used.
* The Standard SKU for ExpressRoute circuits will be used.
* The Standard Gateway SKU will be used.
* The two peering locations will be Melbourne and Sydney.
* Service health alerts will be configured for “Degraded” and “Unavailable” statuses.

# Resource Cost

The pricing construct is the same for both the Australia East and Australia Southeast regions. The ExpressRoute Circuit costs are as follows[[2]](#footnote-3):

**Metered Data Plan**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Circuit bandwidth | Standard Price per month | Premium price per month | Inbound data transfer included | Outbound data transfer included |
| 50 Mbps | **$83.429** | **$235.116** | Unlimited | None |
| 100 Mbps | **$151.688** | **$417.141** | Unlimited | None |
| 200 Mbps | **$219.947** | **$675.010** | Unlimited | None |
| 500 Mbps | **$439.894** | **$1,653.395** | Unlimited | None |
| 1 Gbps | **$661.358** | **$2,860.827** | Unlimited | None |
| 2 Gbps | **$1,322.716** | **$4,735.685** | Unlimited | None |
| 5 Gbps | **$3,306.789** | **$7,857.414** | Unlimited | None |
| 10 Gbps | **$5,157.376** | **$9,708.002** | Unlimited | None |

Table 2: Pricing construct for ExpressRoute circuits on a metered plan

**Unlimited Data Plan**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Circuit bandwidth | Standard Price per month | Premium price per month | Inbound data transfer included | Outbound data transfer included |
| 50 Mbps | N/A | **$925.294** | **$1,076.982** | Unlimited |
| 100 Mbps | N/A | **$1,865.757** | **$2,131.210** | Unlimited |
| 200 Mbps | N/A | **$3,488.814** | **$3,943.876** | Unlimited |
| 500 Mbps | N/A | **$7,887.752** | **$9,101.252** | Unlimited |
| 1 Gbps | **$2,427.001** | **$13,196.815** | **$15,396.284** | Unlimited |
| 2 Gbps | **$3,792.189** | **$26,393.630** | **$29,806.599** | Unlimited |
| 5 Gbps | **$5,915.814** | **$62,191.885** | **$66,742.511** | Unlimited |
| 10 Gbps | **$9,101.252** | **$124,383.770** | **$128,934.396** | Unlimited |

Table 3: Pricing construct for ExpressRoute circuits on the unlimited plan

# WAF and Security Control Alignment

The following are the five pillars of the Microsoft Well Architected Framework:

* [Reliability](https://learn.microsoft.com/en-us/azure/well-architected/#reliability)
* [Cost optimization](https://learn.microsoft.com/en-us/azure/well-architected/#cost-optimization)
* [Operational excellence](https://learn.microsoft.com/en-us/azure/well-architected/#operational-excellence)
* [Performance efficiency](https://learn.microsoft.com/en-us/azure/well-architected/#performance-efficiency)
* [Security](https://learn.microsoft.com/en-us/azure/well-architected/#security)

For this design, the security section will also cover the Department of Health Controls in addition with any Microsoft Security Best Practices. Each of these sections will detail relevant controls or baseline requirements for this core service that will be put in place.

## Reliability

### Overview

The term reliability refers to the availability of the system and its ability to recover from failure[[3]](#footnote-4). Resiliency strategies must be built into each element of the architecture. The pillars of reliability include:

* Design for business requirements
* Design for failure
* Observe application health.
* Drive Automation

### ExpressRoute Reliability Checklist

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | Checklist Item | Applicable to AV | Built Into Design | Enforcement Option | Applicability |
| **R1** | Plan for ExpressRoute circuit or ExpressRoute Direct | Yes | Yes | IaC | At deployment |
| **R2** | Physical layer diversity | Yes | No | Operational | At deployment – service provider and On-Prem configuration |
| **R3** | Plan for geo-redundant circuits | Yes | Yes | IaC | At deployment |
| **R4** | Plan for Active-Active connectivity | Yes | Yes | IaC | At deployment |
| **R5** | Planning for Virtual Network Gateways | Yes | Yes | IaC | At deployment |
| **R6** | Monitor circuits and gateway health | Yes | Yes | IaC | At deployment |
| **R7** | Enable service health | Yes | Yes | IaC | At deployment |

Table 4: WAF Reliability checklist summary

## Cost Optimisation

### Overview

The cost optimisation pillar is structured to support creating cost-effective workloads in the cloud[[4]](#footnote-5). It looks at removal of unnecessary spend and improving operational efficiency. The principles of cost optimisation revolve around:

* Choosing the correct resources
* Setting up budgets and maintaining cost constraints
* Dynamically allocate and deallocate resources
* Optimising workloads whilst aiming for scalable costs
* Continuously monitoring and cost managing

### ExpressRoute Cost Optimisation Checklist

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | Checklist Item | Applicable to AV | Built Into Template | Enforcement Option | Applicability |
| **CO1** | Familiarize yourself with ExpressRoute pricing | Yes | No | Governance | Operational – at deployment |
| **CO2** | Determine SKU and bandwidth required | Yes | No | Governance | Operational – at deployment |
| **CO3** | Determine the ExpressRoute virtual network gateway size | Yes | No | Governance | Operational – at deployment |
| **CO4** | Monitor cost and create budget alerts | Yes | No | Governance | Operational – at deployment and continuous |
| **CO5** | Deprovision and delete ExpressRoute circuits no longer in use. | Yes | No | Governance | Operational – at decommission |

Table 5: WAF Cost Optimisation checklist summary

## Operational Excellence

### Overview

Operational Excellence aims to ensure that once the architecture is built, the ongoing operations are flawless. This includes repeatable and reliable deployments, automating to eliminate human error. To do this the following must be considered:

* Optimise the build and release process (including CI/CD and IaC)
* Understand Operational Health
* Test recovery and failure
* Focus on continuous improvement
* Use loosely coupled architecture

### ExpressRoute Operational Excellence Checklist

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | Checklist Item | Applicable to AV | Built Into Template | Enforcement Option | Applicability |
| **OE1** | Configure connection monitoring | Yes | No | Operational | Operational – both Cloud and On-Prem builds required |
| **OE2** | Configure Service Health | Yes | Yes | IaC | At deployment |
| **OE3** | Review metrics with Network Insights | Yes | No | Governance | Operational |
| **OE4** | Review ExpressRoute resource metrics | Yes | No | Governance | Operational |

Table 6: WAF Operational Excellence checklist summary

## Performance Efficiency

### Overview

Performance Efficiency refers to the ability of your systems and applications to meet user demands without breaking or creating a negative user experience[[5]](#footnote-6). This covers capacity and scalability:

* Design for horizontal scaling.
* Run stress and performance tests.
* Continuously monitor performances, particularly in Production systems.

### ExpressRoute Performance Efficiency Checklist

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | Checklist Item | Applicable to AV | Built Into Template | Enforcement Option | Applicability |
| **PE1** | Test ExpressRoute gateway performance to meet work-load requirements. | Yes | No | Governance | Operational |
| **PE2** | Increase the size of the ExpressRoute gateway. | No | No | N/A | N/A |
| **PE3** | Upgrade ExpressRoute circuit bandwidth. | No | No | N/A | N/A |
| **PE4** | Enable ExpressRoute FastPath for higher throughput. | No | No | N/A | N/A |
| **PE5** | Monitor ExpressRoute circuit and gateway metrics | Yes | No | IaC | At deployment |

Table 7: WAF Performance Efficiency checklist summary

## Security

### Overview

Security refers to the ability of the environment to resist and manage threats.

This section covers both Microsoft Best Practices as well as relevant security controls provided by the Department of Health. With respect to the Microsoft WAF, Security is underpinned by the following[[6]](#footnote-7):

* Plan resources and how to harden them
* Automate and use least privilege
* Classify and encrypt data
* Monitor system security, plan incident response
* Identify and protect endpoints
* Protect against code-level vulnerabilities
* Model and test against potential threats

In addition to the Microsoft controls, the Department of Health has mandated security posture to Ambulance Victoria. Note there may be duplication between the Microsoft Security Best Practices and the Department of Health controls.

The following Microsoft Security Benchmark Controls are applicable:

* LT-4: Enable logging for security investigation.

# Architecture Summary

## Resource Overview

Azure ExpressRoute offers a private connection, via a connectivity provider, to extend On-Premises networks into Azure[[7]](#footnote-8). Traffic over an ExpressRoute will not traverse the public Internet so it is considered a secure connectivity model.

An ExpressRoute circuit as a resource in Azure is a logical connection between On-Premises infrastructure and Microsoft cloud services via the connectivity provider. Each circuit can be in the same region or across multiple regions. The circuits are not mapped to a physical entity.

### ExpressRoute Circuit SKUs

The ExpressRoute Circuit itself has three SKU offerings: Local, Standard, and Premium.

The Local SKU is the most limited as it offers connectivity to one or two Azure regions in or near the same metro. A major limitation is that you can only advertise routes from the corresponding local region of the ExpressRoute circuit, and you won't be able to receive routes for other regions different than the defined Local region8. The Local SKU also has a minimum requirement of 1 GBPs.

The Standard SKU provides connectivity across a geo-political area, so you can send and receive data from any Azure region in that area without needing to pay additional fees over and above the existing plan charges[[8]](#footnote-9).

The Premium SKU offers global connectivity and is the most expensive of the three.

### ExpressRoute Gateway SKUs

The Gateway SKU in Australia East and Southeast is available in the following SKUs:

* Standard
* High Performance
* Ultra Performance

The following details the differences:

|  |  |  |  |
| --- | --- | --- | --- |
| Gateway SKU | VPN Gateway and ExpressRoute coexistence | FastPath | Max Number of Circuit Connections |
| **Standard** | Yes | No | 4 |
| **High Performance** | Yes | No | 8 |
| **Ultra Performance** | Yes | Yes | 16 |

Table 9: Summary of Gateway SKUs

### Peering Types

There are three peering types available[[9]](#footnote-10):

* Microsoft Peering
* Azure Private Peering
* Azure Public Peering (to be deprecated)

Existing ExpressRoutes may have all three available, but new ExpressRoutes will only have Microsoft Peering and Azure Private Peering as Public Peering will be deprecated.

Connectivity to Microsoft online services such as M365 and Azure PaaS occur through the Microsoft peering routing domain.

Azure Private Peering supports Azure compute services (IaaS) and cloud services (PaaS) deployed within a virtual network to be connected via the private peering domain. It is considered an extension of your core network.

## RBAC

For ExpressRoute circuits, the following specific roles that can be applied:

|  |  |
| --- | --- |
| Role Name | Description |
| Network Contributor | Lets you manage networks, but not access to them. |

Table 10: RBAC roles relevant for this core service

## Design Decisions and Justifications

This section covers the design decisions and justifications that reflect the findings of the WAF and Security alignment. This will form the baseline requirements for the ExpressRoute core service and will be captured in the accompanying Configuration Template with a set of pre-approved deployment settings for this resource. Any changes, modifications or removals to the pre-approved deployments must have specific approval from the Cloud Governance Forum prior to deployment.

Note that this document does not contain design decision beyond the Microsoft Well Architected Framework and Security baseline requirements. Any design decisions beyond this scope, such as for BGP routing and general routing across, inbound and outbound from the environment.

### ExpressRoute Circuit Selection

**Design Reference:** Table 4 – [R1](#_ExpressRoute_Reliability_Checklist)

**Design Decision**: Use ExpressRoute circuits instead of ExpressRoute Direct.

**Design Justification**: the bandwidth required currently is 100 Mbps or 1 GBps. ExpressRoute Direct provides dual 100 Gbps or 10 Gbps connectivity. ExpressRoute Direct is better suited for global companies that require this connectivity across multiple regions. As such the regular ExpressRoute circuit is better suited both from a technical configuration and financially with the current utilisation.

### ExpressRoute SKU Selection

**Design Reference:** Table 5 – [CO2](#_ExpressRoute_Cost_Optimisation)

**Design Decision:** The Standard SKU will be used.

**Design Justification:** Given that connectivity across Australia East and Southeast only is required, the Premium SKU is not required. The Local SKU also has limitations with how routing can only be advertised within the region where the peering is defined.

### Gateway SKU Selection

**Design Reference:** Table 5 - [CO3](#_ExpressRoute_Cost_Optimisation)

**Design Decision:** Use the Standard SKU

**Design Justification:** The Standard SKU is the appropriate size required for Ambulance Victoria’s bandwidth and connection requirements. It allows for 4 circuit connections and can co-exist with a VPN Gateway, with a bandwidth of 1 GBPs. From a cost perspective it is also the cheapest SKU that meets the sizing requirements.

### VPN Failover

**Design Reference:** N/A

Design Decision: VPN failover will not be implemented.

Design Justification: Given the active-active configuration across the two Azure regions, it is not necessary to have an additional failover mechanism. Additionally, the cost of running the VPN in case of failover is unfavourable given the highly available setup of the ExpressRoutes.

### ExpressRoute Peering Selections

**Design Reference:** N/A

**Design Decision:** Private peering and Microsoft peering will be used.

**Design Justification:** Microsoft peering will be used to connect to Microsoft online services out of Azure Southeast and Azure East securely. Private peering will also be used to effectively extend the private network across On-Prem and Azure.

### Physical Layer Diversity

**Design Reference:** Table 4 – [R2](#_ExpressRoute_Reliability_Checklist)

**Design Decision:** Physical Layer Diversity will be implemented across two physically separate locations.

**Design Justification:** The connections will be across physically separate locations - MCN Equinix Melbourne and MCN Equinix Sydney, with cross peering at each region.

### Geo Redundancy

**Design Reference:** Table 4 – [R3](#_ExpressRoute_Reliability_Checklist)

**Design Decision:** ExpressRoute circuits will be setup in more than one peering location (Melbourne and Sydney).

**Design Justification:** To plan for Disaster Recovery and to ensure that services continue to operate in the event of an entire region outage, ExpressRoute circuits can have peering in multiple locations to allow diverse paths for traffic to follow. Each ExpressRoute circuit will have two peering locations: Melbourne and Sydney.

### Active-Active

**Design Reference:** Table 4 – [R4](#_ExpressRoute_Reliability_Checklist)

**Design Decision:** Configure ExpressRoute in Active-Active mode.

**Design Justification:** configuring Azure ExpressRoute in active-active mode reduces the Mean Time To Recovery (MTTR). Given that ExpressRoute will be a Platinum service by default it is imperative that it has high availability. With an active-active configuration an availability of 99.95% is guaranteed.

### Create Available Gateways

**Design Reference:** Table 4 – [R5](#_ExpressRoute_Reliability_Checklist)

**Design Decision:** Two Gateways will be deployed for high availability. Zone awareness is not available in Australia Southeast so cannot be implemented in the Primary region.

**Design Justification:** Having a gateway in each region with the active-active configuration previously discussed meets availability requirements sufficiently. The Australia East Gateway can be made to be zonally redundant if required, noting that this is not the Primary region and so it is not specifically recommended to do this.

### Connection Monitoring

**Design Reference:** Table 6 - [OE1](#_ExpressRoute_Operational_Excellence)

**Design Decision:** Connection Monitoring will be configured. Note that it is not currently configured and will need to be actioned.

**Design Justification:** Connection Monitoring assists identifying any network and connectivity issues along the private peering. Note that this involves multiple agents installed at both the Cloud and On-Premises sides on Virtual Machines

### ExpressRoute Monitoring

**Design Reference:** Table 7 – [PE5](#_ExpressRoute_Performance_Efficiency), Microsoft Security Benchmark LT-4

**Design Decision:** Diagnostics will be sent to the central log analytics workspace for each region for both the ExpressRoute circuits and the gateways.

**Design Justification:** Sending the logs centrally allows administrators the ability to query and diagnose potential issues that have impacted the environment more easily and identify root causes.

### Service Health

**Design Reference:** Table 4 – [R7](#_ExpressRoute_Reliability_Checklist)

**Design Decision:** Service health alerts will be configured for ExpressRoute circuits and the associated Gateways.

**Design** **Justification:** Service health notifications will alert administrators of outages as they happen to improve the response times to a potential disaster. To minimise alert fatigue, only alerts for resource status of “Degraded” and “Unavailable” will be sent to alert administrators that these major resources are down or impaired.

# Azure Policies

There are no Azure Policies required for this service.

# Configuration Templates

## Primary Region ExpressRoute Circuit

|  |  |
| --- | --- |
| Configuration Item | Configuration Value |
| **Name** | erc-prd-ause-hub-01 |
| **Subscription** | AV ALZ Connectivity |
| **Resource Group** | rg-prd-ause-connectivity-01 |
| **Provider** | Equinix |
| **Peering Location** | Melbourne |
| **Bandwidth** | 1 Gbps |
| **SKU** | Standard |
| **Billing Model** | Metered |
| **Allow classic operations** | No |
| ***Connections Settings*** |  |
| **Ause Connection Name** | con-gw-erc-vnet-prd-ause-hub-01-to-avsoutheast |
| **Ause Connection Type** | ExpressRoute |
| **Ause Connection Gateway peer** | ergw-prd-ause-hub-01 |
| **Auea Connection Name** | con-gw-erc-vnet-prd-auea-hub-01-to-avsoutheast |
| **Auea Connection Type** | ExpressRoute |
| **Auea Connection Gateway peer** | ergw-prd-auea-hub-01 |
| ***Peerings*** |  |
| **Azure Private primary subnet** | 192.168.18.200/30 |
| **Azure Private secondary subnet** | 192.168.18.204/30 |
| **Microsoft primary subnet** | 103.207.92.184/30 |
| **Microsoft secondary subnet** | 103.207.92.188/30 |

## Primary Region ExpressRoute Gateway

|  |  |
| --- | --- |
| Configuration Item | Configuration Value |
| **Name** | ergw-prd-ause-hub-01 |
| **Subscription** | AV ALZ Connectivity |
| **Resource Group** | rg-prd-ause-connectivity-01 |
| **Gateway Type** | ExpressRoute |
| **SKU** | Standard |
| **Virtual Network/Subnet** | vnet-prd-auea-hub-01/GatewaySubnet |
| **Public IP Name** | pip-ergw-prd-ause-hub-01 |
| **Public IP Tier** | Regional |
| **Public IP SKU** | Standard |

## Secondary Region ExpressRoute Circuit

|  |  |
| --- | --- |
| Configuration Item | Configuration Value |
| **Name** | erc-prd-auea-hub-01 |
| **Subscription** | AV ALZ Connectivity |
| **Resource Group** | rg-prd-auea-connectivity-01 |
| **Provider** | Equinix |
| **Peering Location** | Sydney |
| **Bandwidth** | 1 Gbps |
| **SKU** | Standard |
| **Billing Model** | Metered |
| **Allow classic operations** | No |
| ***Connections Settings*** |  |
| **Ause Connection Name** | con-gw-erc-vnet-prd-auea-hub-01-to-aveast |
| **Ause Connection Type** | ExpressRoute |
| **Ause Connection Gateway peer** | ergw-prd-auea-hub-01 |
| **Auea Connection Name** | con-gw-erc-vnet-prd-ause-hub-01-to-aveast |
| **Auea Connection Type** | ExpressRoute |
| **Auea Connection Gateway peer** | ergw-prd-ause-hub-01 |
| ***Peerings*** |  |
| **Azure Private primary subnet** | 192.168.18.208/30 |
| **Azure Private secondary subnet** | 192.168.18.212/30 |
| **Microsoft primary subnet** | 103.207.92.192/30 |
| **Microsoft secondary subnet** | 103.207.92.196/30 |

## SecondaryRegion ExpressRoute Gateway

|  |  |
| --- | --- |
| Configuration Item | Configuration Value |
| **Name** | ergw-prd-auea-hub-01 |
| **Subscription** | AV ALZ Connectivity |
| **Resource Group** | rg-prd-auea-connectivity-01 |
| **Gateway Type** | ExpressRoute |
| **SKU** | Standard |
| **Public IP Name** | pip-ergw-prd-auea-hub-01 |
| **Public IP Tier** | Regional |
| **Public IP SKU** | Standard |

# Acceptance

Signature of this page by appropriately delegated representatives of ​Ambulance Victoria​ signifies acceptance of this design document.

Logicalis will commence build and implementation work once it receives a signed copy of this design document.

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|  |  |
| --- | --- |
| Project | Core Services |
| Document Version | 1.0 |

**Signed on behalf of Ambulance Victoria**

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| Signature |  |
| Date signed |  |

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| Date signed |  |

1. https://learn.microsoft.com/en-us/azure/well-architected/ [↑](#footnote-ref-2)
2. https://azure.microsoft.com/en-us/pricing/details/expressroute/ [↑](#footnote-ref-3)
3. https://learn.microsoft.com/en-us/azure/well-architected/resiliency/overview [↑](#footnote-ref-4)
4. https://learn.microsoft.com/en-us/azure/well-architected/cost/overview [↑](#footnote-ref-5)
5. https://learn.microsoft.com/en-us/azure/well-architected/scalability/overview [↑](#footnote-ref-6)
6. https://learn.microsoft.com/en-us/azure/well-architected/security/security-principles [↑](#footnote-ref-7)
7. https://learn.microsoft.com/en-us/azure/expressroute/expressroute-introduction [↑](#footnote-ref-8)
8. https://azure.microsoft.com/en-us/pricing/details/expressroute/ [↑](#footnote-ref-9)
9. https://learn.microsoft.com/en-us/azure/expressroute/expressroute-circuit-peerings [↑](#footnote-ref-10)