APPENDIX I: GUARDRAILS

Section 1: Terminology and Guidance

Ref.	Term	Description/Guidance
1.1.	**Should/Should not.**	Where this Appendix says that a value "should not" be set below or above some value, this means that the guardrail is a recommendation or guideline, and the specific value could be open to discussion or alteration by a suitably expert group recognized by the Cardano community in light of experience with the Cardano Blockchain governance system or the operation of the Cardano Blockchain.
1.2.	**Must/Must not.**	Where this Appendix says that a value "must not" be set below or above some value, this means that the guardrail is a requirement that will be enforced by Cardano Blockchain ledger rules, types or other built-in mechanisms where possible, and that if not followed could cause a protocol failure, security breach or other undesirable outcome.
1.3.	**Benchmarking.**	Benchmarking refers to careful system level performance evaluation that is designed to show a-priori that, for example, 95% of blocks will be diffused across a global network of Cardano Blockchain nodes within the required 5s time interval in all cases. This may require construction of specific test workflows and execution on a large test network of Cardano nodes, simulating a global Cardano Blockchain network.
1.4.	**Performance analysis.**	Performance analysis refers to projecting theoretical performance, empirical benchmarking or simulation results to predict actual system behavior. For example, performance results obtained from tests in a controlled test environment (such as a collection of data centers with known networking properties) may be extrapolated to inform likely performance behavior in a real Cardano Blockchain network environment.
1.5.	**Simulation.**	Simulation refers to synthetic execution that is designed to inform performance/functionality decisions in a repeatable way. For example, the IOSim Cardano Blockchain module allows the operation of the Haskell networking stack to be simulated in a controlled and repeatable way, allowing issues to be detected before code deployment.
1.6.	**Performance Monitoring.**	Performance monitoring involves measuring the actual behavior of the Cardano Blockchain network, for example, by using timing probes to evaluate round-trip times, or test blocks to assess overall network

Ref.	Term	Description/Guidance
		health. It complements benchmarking and performance analysis by providing information about actual system behavior that cannot be obtained using simulated workloads or theoretical analysis.
1.7.	**Reverting Changes.**	Where performance monitoring shows that actual network behavior following a change is inconsistent with the performance requirements for the Cardano Blockchain, then the change must be reverted to its previous state if that is possible. For example, if the block size is increased from 100KB to 120KB and 95% of blocks are no longer diffused within 5s, then a change must be made to revert the block size to 100KB. If this is not possible, then one or more alternative changes must be made that will ensure that the performance requirements are met.
1.8.	**Severity Levels.**	Issues that affect the Cardano Blockchain network are classified by severity level, where: ● Severity 1 is a critical incident or issue with very high impact to the security, performance or functionality of the Cardano Blockchain network. ● Severity 2 is a major incident or issue with significant impact to the security, performance or functionality of the Cardano Blockchain network. ● Severity 3 is a minor incident or issue with low impact to the security, performance or functionality of the Cardano Blockchain network.
1.9.	**Future Performance Requirements.**	Planned development such as new mechanisms for out- of-memory storage may impact block diffusion or other times. When changing parameters, it is necessary to consider these future performance requirements as well as the current operation of the Cardano Blockchain. Until development is complete, the requirements will be conservative; they may then be relaxed to account for actual timing behavior.

Section 2: Automated Checking via Guardrails Script

A script hash is associated with the constitution hash when a **New Constitution or Guardrails Script** governance action is enacted. It acts as an additional safeguard to the ledger rules and types, filtering non-compliant governance actions.

The guardrails script only affects two types of governance actions:

- **Parameter Update** actions, and
- **Treasury Withdrawal** actions.

The script is executed when either of these types of governance action is submitted on-chain. This avoids scenarios where, for example, an erroneous script could prevent the chain from ever enacting a Hard Fork action, resulting in a deadlock.

There are three different situations that apply to script usage:

Symbol and Explanation

- (y) The script can be used to enforce the guardrail.
- (x) The script cannot be used to enforce the guardrail.
- (~ - reason) The script cannot be used to enforce the guardrail for the reason given, but future ledger changes could enable this.

Guardrails may overlap, in which case the most restrictive set of guardrails will apply. Where a parameter is not explicitly listed in this document, then the script **must not** permit any changes to the parameter. Conversely, where a parameter is explicitly listed in this document but no checkable guardrails are specified, the script **must not** impose any constraints on changes to the parameter.

Section 3: Protocol Parameter Update Actions

Below are guardrails and guidelines for changing updatable protocol parameter settings via the protocol parameter update governance action such that the Cardano Blockchain is never in an unrecoverable state as a result of such changes.

3.1 Parameter Names

There are at least five different sources of parameter names, and these are not always consistent:

1. The name used in the Genesis file
2. The name used in protocol parameter update governance actions
3. The name used internally in ledger rules
4. The name used in the formal ledger specification
5. The name used in research papers

Where these parameter names differ, this Appendix uses the second convention.

Guardrails	
PARAM-01 (y)	Any protocol parameter that is not explicitly named in this document **must not** be changed by a Parameter update governance action.
PARAM-02 (y)	Where a protocol parameter is explicitly listed in this document but no checkable guardrails are specified, the guardrails script **must not** impose any constraints on changes to the parameter. Checkable guardrails are shown by a (y) .

3.2 Security Critical Protocol Parameters

3.2.1 Operationally Critical Protocol Parameters

Description	**Parameter name**
maximum block body size	(*maxBlockBodySize*)
maximum transaction size	(*maxTxSize*)
maximum block header size	(*maxBlockHeaderSize*)
maximum size of a serialized asset value	(*maxValueSize*)
maximum script execution/memory units in a single block	(*maxBlockExecutionUnits[steps/memory]*)
minimum fee coefficient	(*txFeePerByte*)
minimum fee constant	(*txFeeFixed*)
minimum fee per byte for reference scripts	(*minFeeRefScriptCoinsPerByte*)
minimum Lovelace deposit per byte of serialized UTxO	(*utxoCostPerByte*)
governance action deposit	(*govDeposit*)

Guardrails to Operationally Critical Protocol Parameters	
PARAM-03 (y)	Critical protocol parameters require an SPO vote in addition to a DRep vote: SPOs **must** say "yes" with a collective support of more than 50% of all active block production stake. This is enforced by the guardrails on the stake pool voting threshold.
PARAM-04 (x)	At least 3 months **should** normally pass between the publication of an off- chain proposal to change a critical protocol parameter and the

submission of the corresponding on-chain governance action. This guardrail may be relaxed in the event of a Severity 1 or Severity 2 network issue following careful technical discussion and evaluation.

3.2.2 Governance System Critical Protocol Parameters

Description	Parameter name
delegation key Lovelace deposit	(*stakeAddressDeposit*)
pool registration Lovelace deposit	(*stakePoolDeposit*)
minimum fixed rewards cut for pools	(*minPoolCost*)
DRep deposit amount	(*dRepDeposit*)
minimal Constitutional Committee size	(*committeeMinSize*)
maximum term length (in epochs) for the Constitutional Committee members	(*committeeMaxTermLimit*)

Guardrails to the Governance System Critical Protocol Parameters

PARAM-05 (y)	DReps **must** vote "yes" with a collective support of more than 50% of all active voting stake. This is enforced by DRep voting threshold guardrails.
PARAM-06 (x)	At least 3 months **should** pass between an off-chain proposal to change a governance system critical protocol parameter and the submission of the corresponding governance action. In the event of a Severity 1 or Severity 2 network issue this may be relaxed subject to careful technical evaluation.

3.3 Economic Parameters

3.3.1 Specific Economic Parameters

Transaction fee per byte (txFeePerByte) and fixed transaction fee (txFeeFixed)	Defines the cost for basic transactions in Lovelace: *fee(tx) = txFeeFixed + txFeePerByte x nBytes(tx)*

Guardrails to Specific Economic Parameters	
TFPB-01 (y)	*txFeePerByte* **must not** be lower than 30 (0.000030 ada) This protects against low-cost denial of service attacks
TFPB-02 (y)	*txFeePerByte* **must not** exceed 1,000 (0.001 ada) This ensures that transactions can be paid for
TFPB-03 (y)	*txFeePerByte* **must not** be negative
TFF-01 (y)	*txFeeFixed* **must not** be lower than 100,000 (0.1 ada) This protects against low-cost denial of service attacks
TFF-02 (y)	*txFeeFixed* **must not** exceed 10,000,000 (10 ada) This ensures that transactions can be paid for
TFF-03 (y)	*txFeeFixed* **must not** be negative
TFGEN-01 (x - "should")	To maintain a consistent level of protection against denial-of-service attacks, *txFeeFixed* and *txFeeFixed* **should** be adjusted whenever Plutus Execution prices are adjusted (executionUnitPrices[steps/memory])
TFGEN-02 (x - unquantifiable)	Any changes to *txFeeFixed* or *txFeeFixed* **mu$f$st** consider the implications of reducing the cost of a denial-of-service attack or increasing the maximum transaction fee so that it becomes impossible to construct a transaction.

3.3.2 UTxO cost per byte (utxoCostPerByte)

UTxO cost per byte (utxoCostPerByte)	Defines the cost for storage in UTxOs. • Sets a minimum threshold on ada that is held within a single UTxO. • Provides protection against low-cost denial of service attack on UTxO storage.

DoS protection decreases in line with the free node memory (proportional to UTxO growth).

- Helps reduce long term storage costs.
- Provides an incentive to return UTxOs when no longer needed.

Should significantly exceed minimum tx cost.

Guardrails to UTxO cost per byte

UCPB-01 (y)	*utxoCostPerByte* **must not** be lower than 3,000 (0.003 ada)
UCPB-02 (y)	*utxoCostPerByte* **must not** exceed 6,500 (0.0065 ada)
UCPB-03 (y)	*utxoCostPerByte* **must not** be zero
UCPB-04 (y)	*utxoCostPerByte* **must not** be negative
UCPB-05 (x - "should")	Changes **should** account for: i) The acceptable cost of attack ii) The acceptable time for an attack (at least one epoch is assumed) iii) The acceptable memory configuration for full node users (assumed to be 16GB for wallets or 24GB for stake pools) iv) The sizes of UTxOs, and v) The current total node memory usage

3.3.3 Stake Address Deposit

Stake address deposit (stakeAddressDeposit)

- Ensures that stake addresses are retired when no longer needed.
- Helps reduce long term storage costs.
- Helps limit CPU and memory costs in the ledger.

The rationale for the deposit is to incentivize that scarce memory resources are returned when they are no longer required. Reducing the number of active stake addresses also reduces processing and memory costs at the epoch boundary when calculating stake snapshots.

Guardrails to Stake Address Deposit	
SAD-01 (y)	*stakeAddressDeposit* **must not** be lower than 1,000,000 (1 ada)
SAD-02 (y)	*stakeAddressDeposit* **must not** exceed 5,000,000 (5 ada)
SAD-03 (y)	*stakeAddressDeposit* **must not** be negative

3.3.4 Minimum Pool Cost	
Minimum Pool Cost (minPoolCost)	The minimum pool cost is part of the rewards mechanism. The minimum pool cost is transferred to the pool rewards address before any delegator rewards are paid.

Guardrails to Minimum Pool Cost	
MPC-01 (y)	*minPoolCost* **must not** be negative
MPC-02 (y)	*minPoolCost* **must not** exceed 500,000,000 Lovelace (500 ada)
MPC-03 (x - "should")	*minPoolCost* **should** be set in line with the economic cost for operating a pool

3.3.5 Treasury Cut	
Treasury Cut (treasuryCut)	The treasury cut is part of the rewards mechanism. ● The treasury cut portion of the monetary expansion is transferred to the treasury before any pool rewards are paid. ● Can be set in the range 0.0-1.0 (0%-100%).

Guardrails to Treasury Cut	
TC-01 (y)	*treasuryCut* **must not** be lower than 0.1 (10%)
TC-02 (y)	*treasuryCut* **must not** exceed 0.3 (30%)
TC-03 (y)	*treasuryCut* **must not** be negative
TC-04 (y)	*treasuryCut* **must not** exceed 1.0 (100%)
TC-05 (~ - no access to change history)	*treasuryCut* **must not** be changed more than once in any 36 epoch period (approximately 6 months when considering 5-day epochs)

3.3.6 Monetary Expansion Rate

Monetary Expansion Rate (monetaryExpansion)	The monetary expansion rate is part of the rewards mechanism. ● The monetary expansion rate controls the amount of reserves that is used for rewards each epoch. ● The monetary expansion rate governs the long-term sustainability of Cardano. ● The reserves are gradually depleted until no rewards are supplied.

Guardrails to Monetary Expansion Rate	
ME-01 (y)	*monetaryExpansion* **must not** exceed 0.005
ME-02 (y)	*monetaryExpansion* **must not** be lower than 0.001
ME-03 (y)	*monetaryExpansion* **must not** be negative
ME-04 (x - "should")	*monetaryExpansion* **should not** be varied by more than +/- 10% in any 73-epoch period (approximately 12 months when considering 5-day epochs)
ME-05 (x - "should")	*monetaryExpansion* **should not** be changed more than once in any 36-epoch period (approximately 6 months)

3.3.7 Plutus Script Execution Prices

Plutus Script Execution Prices (executionUnitPrices[priceSteps/priceMemory])	• Define the fees for executing Plutus scripts. • Gives an economic return for Plutus script execution. • Provides security against low-cost DoS attacks.

Guardrails to Plutus Script Execution Prices

EIUP-PS-01 (y)	*executionUnitPrices[priceSteps]* **must not** exceed 2,000 / 10,000,000
EIUP-PS-02 (y)	*executionUnitPrices[priceSteps]* **must not** be lower than 500 / 10,000,000
EIUP-PM-01 (y)	*executionUnitPrices[priceMemory]* **must not** exceed 2,000 / 10,000
EIUP-PM-02 (y)	*executionUnitPrices[priceMemory]* **must not** be lower than 400 / 10,000
EIUP-GEN-01 (x - "similar to")	The execution prices **must** be set so that: i) the cost of executing a transaction with maximum CPU steps is similar to the cost of a maximum sized non-script transaction and ii) the cost of executing a transaction with maximum memory units is similar to the cost of a maximum sized non-script transaction
EIUP-GEN-02 (x - "should")	The execution prices **should** be adjusted whenever transaction fees are adjusted (*txFeeFixed/txFeePerByte*). The goal is to ensure that the processing delay is similar for "full" transactions, regardless of their type. This helps ensure that the requirements on block diffusion/propagation times are met.

3.3.8 Transaction fee per byte for a reference script

Transaction fee per byte for a reference script (minFeeRefScriptCoinsPerByte)	Defines the cost for using Plutus reference scripts in Lovelace

Guardrails to Transaction fee per byte for a reference script

MFRS-01 (y)	*minFeeRefScriptCoinsPerByte* **must not** exceed 1,000 (0.001 ada) This ensures that transactions can be paid for.
MFRS-02 (y)	*minFeeRefScriptCoinsPerByte* **must not** be negative
MFRS-03 (x - "should")	To maintain a consistent level of protection against denial-of-service attacks, *minFeeRefScriptCoinsPerByte* **should** be adjusted whenever Plutus Execution prices are adjusted (*executionUnitPrices[steps/memory]*) and whenever *txFeeFixed* is adjusted.
MFRS-04 (x - unquantifiable)	Any changes to *minFeeRefScriptCoinsPerByte* **must** consider the implications of reducing the cost of a denial-of-service attack or increasing the maximum transaction fee.

3.4 Network Parameters

Guardrails to Network Parameters

NETWORK-01 (x - "should")	No individual network parameter **should** change more than once per two epochs.
NETWORK-02 (x - "should")	Only one network parameter **should** be changed per epoch unless they are directly correlated, e.g., per-transaction and per-block memory unit limits.

3.4.1 Block Size

Block Size (maxBlockBodySize)	The maximum size of a block, in Bytes.

Guardrails to Block Size	
MBBS-01 (y)	*maxBlockBodySize* **must not** exceed 122,880 Bytes (120KiB)
MBBS-02 (y)	*maxBlockBodySize* **must not** be lower than 24,576 Bytes (24KiB)
MBBS-03 (x - "exceptional circumstances")	*maxBlockBodySize* **must not** be decreased, other than in exceptional circumstances where there are potential problems with security, performance or functionality
MBBS-04 (~ - no access to existing parameter values)	*maxBlockBodySize* **must** be large enough to include at least one transaction (that is, *maxBlockBodySize* **must** be at least *maxTxSize*)
MBBS-05 (x - "should")	*maxBlockBodySize* **should** be changed by at most 10,240 Bytes (10KiB) per epoch (5 days), and preferably by 8,192 Bytes (8KiB) or less per epoch
MBBS-06 (x - "should")	The block size **should not** induce an additional Transmission Control Protocol (TCP) round trip. Any increase beyond this must be backed by performance analysis, simulation and benchmarking
MBBS-07 (x - "unquantifiable")	The impact of any change to *maxBlockBodySize* **must** be confirmed by detailed benchmarking/simulation and not exceed the requirements of the block diffusion/propagation time budgets, as described below. Any increase to *maxBlockBodySize* must also consider future requirements for Plutus script execution (*maxBlockExecutionUnits[steps]*) against the total block diffusion target of 3s with 95% block propagation within 5s. The limit on maximum block size may be increased in the future if this is supported by benchmarking and monitoring results

3.4.2Transaction Size	
Transaction Size (maxTxSize)	The maximum size of a transaction, in Bytes.

Guardrails to Transaction Size	
MTS-01 (y)	*maxTxSize* **must not** exceed 32,768 Bytes (32KiB)
MTS-02 (y)	*maxTxSize* **must not** be negative
MTS-03 (~ - no access to existing	*maxTxSize* **must not** be decreased

parameter values)	
MTS-04 (~ - no access to existing parameter values)	*maxTxSize* **must not** exceed *maxBlockBodySize*
MTS-05 (x - "should")	*maxTxSize* **should not** be increased by more than 2,560 Bytes (2.5KiB) in any epoch, and preferably **should** be increased by 2,048 Bytes (2KiB) or less per epoch
MTS-06 (x - "should")	*maxTxSize* **should not** exceed 1/4 of the block size

3.4.3 Memory Unit Limits

Memory Unit Limits (maxBlockExecutionUnits[memory], maxTxExecutionUnits[memory])	The limit on the maximum number of memory units that can be used by Plutus scripts, either per-transaction or per-block.

Guardrails to Memory Unit Limits

MTEU-M-01 (y)	*maxTxExecutionUnits[memory]* **must not** exceed 40,000,000 units
MTEU-M-02 (y)	*maxTxExecutionUnits[memory]* **must not** be negative
MTEU-M-03 (~ - no access to existing parameter values)	*maxTxExecutionUnits[memory]* **must not** be decreased
MTEU-M-04 (x - "should") *maxTxExecutionUnits[memory]*	**should not** be increased by more than 2,500,000 units in any epoch
MBEU-M-01 (y) *maxBlockExecutionUnits[memory]*	**must not** exceed 120,000,000 units
MBEU-M-02 (y)	*maxBlockExecutionUnits[memory]* **must not** be negative

MBEU-M-03 (x - "should") *maxBlockExecutionUnits[memory]*	**should not** be changed (increased or decreased) by more than 10,000,000 units in any epoch
MBEU-M-04 (x - unquantifiable)	The impact of any change to *maxBlockExecutionUnits[memory]* **must** be confirmed by detailed benchmarking/simulation and not exceed the requirements of the diffusion/propagation time budgets, as also impacted by *maxBlockExecutionUnits[steps]*. Any increase **must** also consider previously agreed future requirements for the total block size (*maxBlockBodySize*) measured against the total block diffusion target of 3s with 95% block propagation within 5s. Future Plutus performance improvements may allow the per-block limit to be increased, but must be balanced against the overall diffusion limits as specified in the previous sentence, and future requirements
MEU-M-01 (~ - no access to existing parameter values) *	maxBlockExecutionUnits[memory]* **must not** be less than *maxTxExecutionUnits[memory]*

3.4.4 Changes to CPU Unit Limits

CPU Unit Limits (maxBlockExecutionUnits[steps], maxTxExecutionUnits[steps])	The limit on the maximum number of CPU steps that can be used by Plutus scripts, either per-transaction or per-block.

Guardrails to CPU Unit Limits

MTEU-S-01 (y)	*maxTxExecutionUnits[steps]* **must not** exceed 15,000,000,000 (15Bn) units
MTEU-S-02 (y)	*maxTxExecutionUnits[steps]* **must not** be negative
MTEU-S-03 (~ - no access to existing parameter values)	*maxTxExecutionUnits[steps]* **must not** be decreased
MTEU-S-04 (x - "should") *maxTxExecutionUnits[steps]*	**should not** be increased by more than 500,000,000 (500M) units in any epoch (5 days)

MBEU-S-01 (y) *maxBlockExecutionUnits[steps]*	**must not** exceed 40,000,000,000 (40Bn) units
MBEU-S-02 (y) *maxBlockExecutionUnits[steps]*	**must not** be negative
MBEU-S-03 (x - "should") *maxBlockExecutionUnits[steps]*	**should not** be changed (increased or decreased) by more than 2,000,000,000 (2Bn) units in any epoch (5 days)
MBEU-S-04 (x - unquantifiable)	The impact of the change to *maxBlockExecutionUnits[steps]* **must** be confirmed by detailed benchmarking/simulation and not exceed the requirements of the block diffusion/propagation time budgets, as also impacted by *maxBlockExecutionUnits[memory]*. Any increase **must** also consider previously identified future requirements for the total block size (*maxBlockBodySize*) measured against the total block diffusion target of 3s with 95% block propagation within 5s. Future Plutus performance improvements may allow the per-block limit to be increased, but **must** be balanced against the overall diffusion limits as specified in the previous sentence, and future requirements
MEU-S-01 (~ - no access to existing parameter values)	*maxBlockExecutionUnits[steps]* **must not** be less than *maxTxExecutionUnits[steps]*

3.4.5 Block Header Size

Block Header Size (maxBlockHeaderSize)	The size of the block header. Note that increasing the block header size may affect the overall block size (*maxBlockBodySize*).

Guardrails to Block Header Size

MBHS-01 (y)	*maxBlockHeaderSize* **must not** exceed 5,000 Bytes
MBHS-02 (y)	*maxBlockHeaderSize* **must not** be negative

MBHS-03 (x - "largest valid header" is subject to change)	*maxBlockHeaderSize* **must** be large enough for the largest valid header
MBHS-04 (x - "should")	*maxBlockHeaderSize* **should** only normally be increased if the protocol changes
MBHS-05 (x - "should")	*maxBlockHeaderSize* **should** be within TCP's initial congestion window (3 or 10 MTUs)

3.5 Technical/Security Parameters

3.5.1 Target Number of Stake Pools

Target Number of Stake Pools (stakePoolTargetNum)	Sets the target number of stake pools. The expected number of pools when the network is in the equilibrium state. ● Primarily a security parameter, ensuring decentralization by pool division or replication. ● Has an economic effect as well as a security affect. Economic advice is also required when changing this parameter. ● Large changes in this parameter will trigger mass redelegation events.

Guardrails to Target Number of Stake Pools

SPTN-01 (y)	*stakePoolTargetNum* **must not** be lower than 250
SPTN-02 (y)	*stakePoolTargetNum* **must not** exceed 2,000
SPTN-03 (y)	*stakePoolTargetNum* **must not** be negative
SPTN-04 (y)	*stakePoolTargetNum* **must not** be zero

3.5.2 Pledge Influence Factor

Pledge Influence Factor (poolPledgeInfluence)	● Enables the pledge protection mechanism Provides protection against

	Sybil attack. • Higher values reward pools that have more pledge and penalize pools that have less pledge. • Has an economic effect as well as technical effect. Economic advice is also required. • Can be set in the range 0.0-infinity

Guardrails to Pledge Influence Factor	
PPI-01 (y)	*poolPledgeInfluence* **must not** be lower than 0.1
PPI-02 (y)	*poolPledgeInfluence* **must not** exceed 1.0
PPI-03 (y)	*poolPledgeInfluence* **must not** be negative
PPI-04 (x - "should")	*poolPledgeInfluence* **should not** vary by more than +/- 10% in any 18-epoch period (approximately 3 months)

3.5.3 Pool Retirement Window	
Pool Retirement Window (poolRetireMaxEpoch)	Defines the maximum number of epochs notice that a pool can give when planning to retire.

Guardrails to Pool Retirement Window	
PRME-01 (y)	*poolRetireMaxEpoch* **must not** be negative
PRME-02 (x - "should")	*poolRetireMaxEpoch* **should not** be lower than 1

3.5.4 Collateral Percentage

Collateral Percentage (collateralPercentage)	Defines how much collateral must be provided when executing a Plutus script as a percentage of the normal execution cost. ● Collateral is additional to fee payments. ● If a script fails to execute, then the collateral is lost. ● The collateral is never lost if a script executes successfully. Provides security against low-cost attacks by making it more expensive rather than less expensive to execute failed scripts.

Guardrails to Collateral Percentage

CP-01 (y)	*collateralPercentage* **must not** be lower than 100
CP-02 (y)	*collateralPercentage* **must not** exceed 200
CP-03 (y)	*collateralPercentage* **must not** be negative
CP-04 (y)	*collateralPercentage* **must not** be zero

3.5.5 Maximum Number of Collateral Inputs

Maximum number of collateral inputs (maxCollateralInputs)	Defines the maximum number of inputs that can be used for collateral when executing a Plutus script.

Guardrails to Maximum Number of Collateral Inputs

MCI-01 (y) *maxCollateralInputs*	**must not** be lower than 1

3.5.6 Maximum Value Size

Maximum Value Size (maxValueSize)	The limit on the serialized size of the Value in each output.

Guardrails to Maximum Value Size	
MVS-01 (y)	*maxValueSize* **must not** exceed 12,288 Bytes (12KiB)
MVS-02 (y)	*maxValueSize* **must not** be negative
MVS-03 (~ - no access to existing parameter values)	*maxValueSize* **must** be less than *maxTxSize*
MVS-04 (~ - no access to existing parameter values)	*maxValueSize* **must not** be reduced
MVS-05 (x - "sensible output" is subject to interpretation)	*maxValueSize* **must** be large enough to allow sensible outputs (e.g. any existing on-chain output or anticipated outputs that could be produced by new ledger rules)

3.5.7 Plutus Cost Models	
Plutus Cost Models (costModels)	Define the base costs for each Plutus primitive in terms of CPU and memory unit. There are about 150 distinct micro-parameters in total. Cost models are defined for each Plutus language version. A new language version may introduce additional micro-parameters or remove existing micro-parameters.

Guardrails to Plutus Cost Models	
PCM-01 (x - unquantifiable)	*Cost model* values **must** be set by benchmarking on a reference architecture
PCM-02 (x - primitives and language versions aren't introduced in transactions)	The *cost model* **must** be updated if new primitives are introduced or a new Plutus language version is added
PCM-03 (~ - no access to *Plutus cost model*	*Cost model* values **should not** be negative

parameters)

PCM-04 (~ - no access to *Plutus cost model* parameters)	A *cost model* **must** be supplied for each Plutus language version that the protocol supports

3.6 Governance Parameters

3.6.1 Deposit for Governance Actions

Deposit for Governance Actions (govDeposit)	The deposit that is charged when submitting a governance action. Helps to limit the number of actions that are submitted.

Guardrails to Deposit for Governance Actions

GD-01 (y)	*govDeposit* **must not** be negative
GD-02 (y)	*govDeposit* **must not** be lower than 1,000,000 (1 ada)
GD-03 (y)	*govDeposit* **must not** exceed 10,000,000,000,000 (10 Million ada)
GD-04 (x - "should")	*govDeposit* **should** be adjusted in line with fiat changes

3.6.2 Deposit for DReps

Deposit for DReps (dRepDeposit)	The deposit that is charged when registering a DRep. Helps to limit the number of active DReps.

Guardrails to Deposit for DReps

DRD-01 (y)	*dRepDeposit* **must not** be negative
DRD-02 (y)	*dRepDeposit* **must not** be lower than 1,000,000 (1 ada)
DRD-03 (y)	*dRepDeposit* **must not** exceed 100,000,000,000 (100,000 ada)
DRD-04 (x - "should")	*dRepDeposit* **should** be adjusted in line with fiat changes

3.6.3 DRep Activity Period

DRep Activity Period (dRepActivity)	The period (as a whole number of epochs) after which a DRep is considered to be inactive for vote calculation purposes, if they do not vote on any proposal.

Guardrails to DRep Activity Period

DRA-01 (y)	*dRepActivity* **must not** be lower than 13 epochs (2 months)
DRA-02 (y)	*dRepActivity* **must not** exceed 37 epochs (6 months)
DRA-03 (y)	*dRepActivity* **must not** be negative
DRA-04 (~ - no access to existing parameter values)	*dRepActivity* **must** be greater than *govActionLifetime*
DRA-05 (x - "should")	*dRepActivity* **should** be calculated in human terms (2 months etc) DRep and SPO Governance Action Thresholds dRepVotingThresholds[...], poolVotingThresholds[...])

3.6.4 Thresholds on Active Voting Stake Required to Ratify Specific Governance Actions

Thresholds on the active voting stake that is required to ratify a specific type of governance action by DReps and/or SPOs. This ensures legitimacy of the action.

***dRepVotingThresholds*:**

- *dvtCommitteeNoConfidence*
- *dvtCommitteeNormal*
- *dvtHardForkInitiation*
- *dvtMotionNoConfidence*
- *dvtPPEconomicGroup*
- *dvtPPGovGroup*
- *dvtPPNetworkGroup*

- *dvtPPTechnicalGroup*
- *dvtTreasuryWithdrawal*
- *dvtUpdateToConstitution*

***poolVotingThresholds*:**

- *pvtCommitteeNoConfidence*
- *pvtCommitteeNormal*
- *pvtHardForkInitiation*
- *pvtMotionNoConfidence*
- *pvtPPSecurityGroup*

Guardrails to Voting Thresholds

VT-GEN-01 (y)	All thresholds **must** be greater than 50% and less than or equal to 100%
VT-GEN-02 (y)	Economic, network and technical parameter thresholds **must** be in the range 51% - 75%
VT-GEN-03 (y)	Governance parameter thresholds **must** be in the range 75% - 90%
VT-HF-01 (y)	*Hard fork** action thresholds **must** be in the range 51%-80%
VT-CON-01 (y)	**New Constitution or guardrails script action** thresholds **must** be in the range 65%-90%
VT-CC-01 (y)	**Update Constitutional Committee action** thresholds **must** be in the range 51%-90%
VT-NC-01 (y)	**No confidence** action thresholds **must** be in the range 51%-75%

3.6.5 Governance Action Lifetime

Governance Action Lifetime (govActionLifetime)	The period after which a governance action will expire if it is not enacted • As a whole number of epochs

Guardrails to Governance Action Lifetime	
GAL-01 (y)	*govActionLifetime* **must not** be lower than 1 epoch (5 days)
GAL-02 (y)	*govActionLifetime* **must not** exceed 15 epochs (75 days)
GAL-03 (x - "should")	*govActionLifetime* **should not** be lower than 2 epochs (10 days)
GAL-04 (x - "should") *govActionLifetime*	**should** be calibrated in terms of calendar days (eg 30 days, two weeks), to allow sufficient time for voting etc. to take place
GAL-05 (~ - no access to existing parameter values)	*govActionLifetime* **must** be less than *dRepActivity*

3.6.6 Maximum Constitutional Committee Term

Maximum Constitutional Committee Term (committeeMaxTermLimit)	The limit on the maximum term that a committee member may serve.

Guardrails to Maximum Constitutional Committee Term	
CMTL-01 (y)	*committeeMaxTermLimit* **must not** be zero
CMTL-02 (y)	*committeeMaxTermLimit* **must not** be negative
CMTL-03 (y)	*committeeMaxTermLimit* **must not** be lower than 18 epochs (90 days, or approximately 3 months)
CMTL-04 (y)	*committeeMaxTermLimit* **must not** exceed 293 epochs (approximately 4 years)
CMTL-05 (x - "should")	*committeeMaxTermLimit* **should not** exceed 220 epochs (approximately 3 years)

3.6.7 Minimum size of the Constitutional Committee

The minimum size of the Constitutional Committee (committeeMinSize)	The least number of members that can be included in a Constitutional Committee

following a governance action to change the Constitutional Committee.

Guardrails to the minimum size of the Constitutional Committee	
CMS-01 (y)	*committeeMinSize* **must not** be negative CMS-02 (y) *committeeMinSize* **must not** be lower than 3
CMS-02 (y)	*committeeMinSize* **must not** be lower than 3
CMS-03 (y)	*committeeMinSize* **must not** exceed 10

3.7 Monitoring and Reversion of Parameter Changes

All network parameter changes **must be** monitored carefully for no less than 2 epochs (10 days)

- Changes **must** be reverted as soon as possible if block propagation delays exceed 4.5s for more than 5% of blocks over any 6 hour rolling window All other parameter changes should be monitored.
- The reversion plan **should** be implemented if the overall effect on performance, security or functionality is unacceptable.

A specific reversion/recovery plan **must be** produced for each parameter change. This plan must include:

- Which parameters need to change and in which ways in order to return to the previous state (or a similar state).
- How to recover the network in the event of disastrous failure.

This plan **should** be followed if problems are observed following the parameter change. Note that not all changes can be reverted. Additional care must be taken when making changes to these parameters.

3.8 Non-Updatable Protocol Parameters

Some fundamental protocol parameters cannot be changed by the Protocol Parameter Update governance action. These parameters can only be changed in a new Genesis file as part of a hard fork. It is not necessary to provide specific guardrails on updating these parameters.

Section 4: Treasury Withdrawal Actions

Treasury Withdrawal Actions

Treasury withdrawal actions specify the destination and amount of a number of withdrawals from

the Cardano treasury.

Guardrails to the Treasury Withdrawal Action	
TREASURY-01 (x)	DReps **must** define a net change limit for the Cardano Treasury's balance per period of time.
TREASURY-02 (x)	The budget for the Cardano Treasury **must not** exceed the net change limit for the Cardano Treasury's balance per period of time.
TREASURY-03 (x)	The budget for the Cardano Treasury **must** be denominated in ada.
TREASURY-04 (x)	Treasury withdrawals **must not** be ratified without a Cardano Budget in in effect pursuant to a previous on-chain governance action agreed by the DReps with a threshold of greater than 50% of the active voting stake.

Section 5: Hard Fork Initiation Actions

Hard Fork Initiation Actions

The **hard fork initiation** action requires both a new major and a new minor protocol version to be specified as positive integers.

As the result of a hard fork, new updatable protocol parameters may be introduced. Guardrails may be defined for these parameters, which will take effect following the hard fork. Existing updatable protocol parameters may also be deprecated by the hard fork, in which case the guardrails become obsolete for all future changes.

Guardrails to Hard Fork Initiation Actions	
HARDFORK-01 (~ - no access to existing parameter values)	The major protocol version **must** be the same as or one greater than the major version that will be enacted immediately prior to this change. If the major protocol version is one greater, then the minor protocol version **must** be zero.
HARDFORK-02 (~ - no access to existing parameter values)	The minor protocol version **must** be no less than the minor version that will be enacted immediately prior to this change.
HARDFORK-03 (~ - no access to existing parameter values)	At least one of the protocol versions (major or minor or both) **must** change.

HARDFORK-04 (x)	At least 85% of stake pools by active stake **should** have upgraded to a Cardano node version that is capable of processing the rules associated with the new protocol version.
HARDFORK-05 (x)	Any new updatable protocol parameters that are introduced with a hard fork **must** be included in this Appendix and suitable guardrails defined for those parameters.
HARDFORK-06 (x)	Settings for any new protocol parameters that are introduced with a hard fork **must** be included in the appropriate Genesis file.
HARDFORK-07 (x)	Any deprecated protocol parameters **must** be indicated in this Appendix.
HARDFORK-08 (~ - no access to *Plutus cost model* parameters)	New Plutus versions **must** be supported by a version-specific *Plutus cost model* that covers each primitive that is available in the new Plutus version.

Section 6: Update Constitutional Committee Or Threshold Actions

Update Constitutional Committee Or Threshold Actions

Update Constitutional Committee or Threshold governance actions may change the size, composition or required voting thresholds for the Constitutional Committee.

Guardrails to Updates to Constitutional Committee Or Threshold Actions

UPDATE-CC-01 (x)	**Update Constitutional Committee and/or threshold** **and/or term** governance actions **must not** be ratified until ada holders have ratified through an on-chain governance action the Final Constitution.

Section 7: New Constitution Or Guardrails Script Actions

New Constitution Or Guardrails Script Actions

New constitution or guardrails script actions change the hash of the on-chain constitution and the associated guardrails script.

Guardrails to New Constitution Or Guardrails Script Actions	
NEW-CONSTITUTION-01 (x)	A **New Constitution** **or Guardrails Script** governance action **must** be submitted to define any required guardrails for new parameters that are introduced via a Hard Fork governance action

Section 8: No Confidence Actions

No Confidence Actions

No confidence actions signal a state of no confidence in the governance system. No guardrails are imposed on **No Confidence** actions.

Guardrails to New Constitution Or Guardrails Script Actions

None

Section 9: Info Actions

Info Actions

Info actions are not enacted on-chain. No guardrails are imposed on **Info** actions.

Guardrails to Info Actions

None

Section 10: List Of Protocol Parameter Groups

The protocol parameters are grouped by type, allowing different thresholds to be set for each group.

10.1 Network Group

- *maximum block body size* (*maxBlockBodySize*)
- *maximum transaction size* (*maxTxSize*)
- *maximum block header size* (*maxBlockHeaderSize*)

- *maximum size of a serialized asset value* (*maxValueSize*)
- *maximum script execution units in a single transaction* (*maxTxExecutionUnits[steps]*)
- *maximum script execution units in a single block* (*maxBlockExecutionUnits[steps]*)
- *maximum number of collateral inputs* (*maxCollateralInputs*)

10.2 Economic Group

- *minimum fee coefficient* (*txFeePerByte*)
- *minimum fee constant* (*txFeeFixed*)
- *minimum fee per byte for reference scripts* (*minFeeRefScriptCoinsPerByte*)
- *delegation key Lovelace deposit* (*stakeAddressDeposit*)
- *pool registration Lovelace deposit* (*stakePoolDeposit*)
- *monetary expansion* (*monetaryExpansion*)
- *treasury expansion* (*treasuryCut*)
- *minimum fixed rewards cut for pools* (*minPoolCost*)
- *minimum Lovelace deposit per byte of serialized UTxO* (*coinsPerUTxOByte*)
- *prices of Plutus execution units* (*executionUnitPrices[priceSteps/priceMemory]*)

10.3 Technical Group

- *pool pledge influence* (*poolPledgeInfluence*)
- *pool retirement maximum epoch* (*poolRetireMaxEpoch*)
- *desired number of pools* (*stakePoolTargetNum*)
- *Plutus execution cost models* (*costModels*)
- *proportion of collateral needed for scripts* (*collateralPercentage*)

10.4 Governance Group

- *governance voting thresholds* (*dRepVotingThresholds[...], poolVotingThresholds[...]*)
- *governance action maximum lifetime in epochs* (*govActionLifetime*)
- *governance action deposit* (*govActionDeposit*)
- *DRep deposit amount* (*dRepDeposit*)
- *DRep activity period in epochs* (*dRepActivity*)
- *minimal constitutional committee size* (*committeeMinSize*)
- *maximum term length (in epochs) for the constitutional committee members* (*committeeMaxTermLimit*)