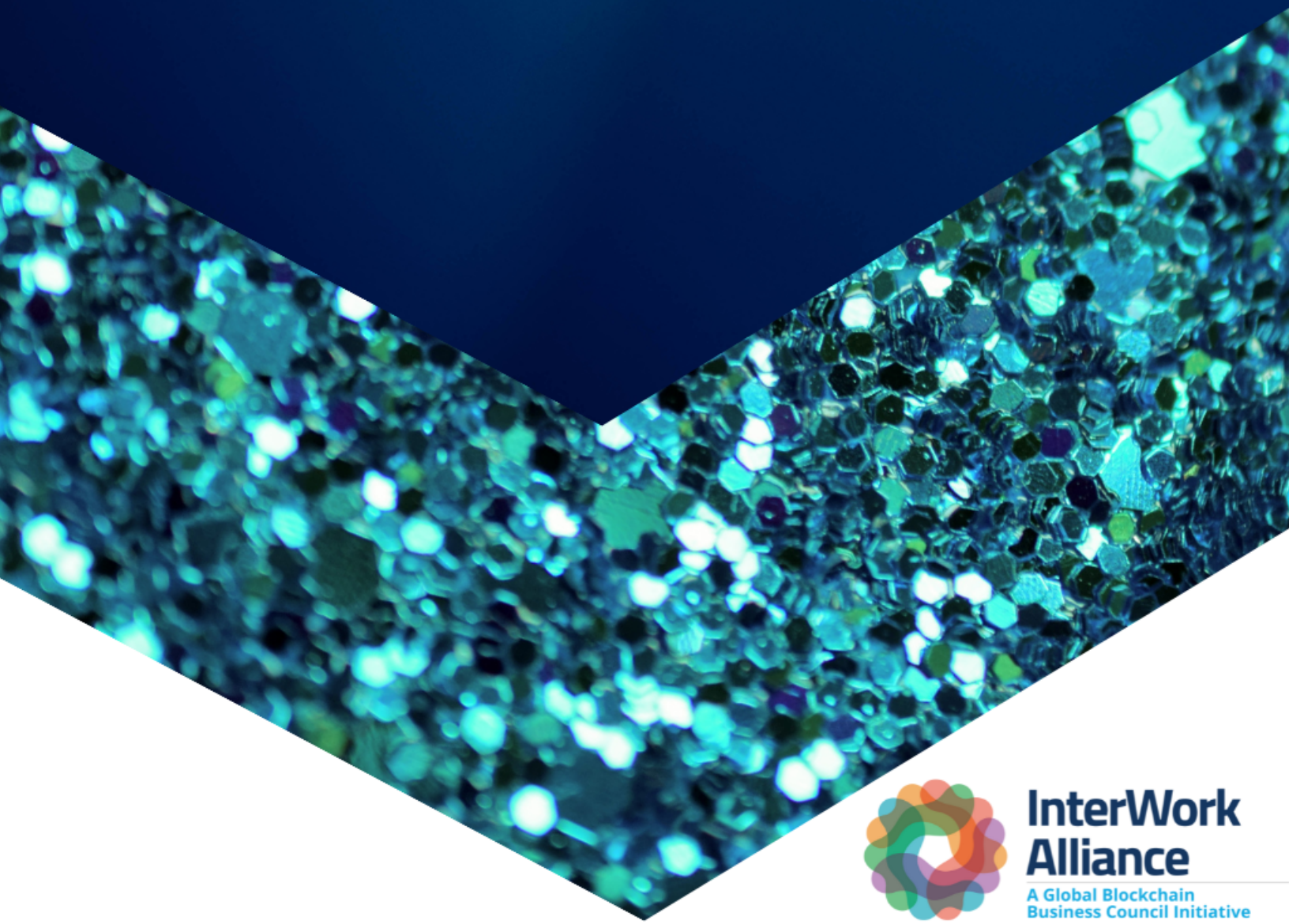
Digital Measurement, Reporting & Verification (dMRV) Framework

Version 2



InterWork Alliance

A Global Blockchain Business Council Initiative


GBBC
Global Blockchain
Business Council

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Foreword

The first version of the Digital Measurement, Reporting & Verification (dMRV) Framework was published in late 2021. Since that time, the membership of the InterWork Alliance (IWA) and Global Blockchain Business Council (GBBC) have shared the framework broadly throughout the sustainability ecosystem and put it through its paces to find missing elements, refine definitions, and strive to establish common ground to help unify the way ecological and environmental products like voluntary carbon credits are manufactured or originated.

This document will replace its predecessor in its entirety due to the hard work and collaboration of its contributors. But we are not done. There are still improvements to be made and refinements to be discovered as we all set forth to implement these specifications and commit to returning the lessons learned back for the next version of this specification in the future.

We invite you to join us on this journey to help scale these markets by shoring up its foundations by creating consistent, comparable, interoperable, and hopefully higher-quality digital ecological assets to help all of us achieve our personal, organizational, and global goals.

DISCLAIMER: This document is intended as an introduction and basis for further dialogue and cooperation with all relevant stakeholders. Neither the individual taskforce members nor their organizations have agreed to or adopted this document in its entirety. The following is an incomplete, pioneering work in progress intended to cultivate further cooperative effort on the keystone elements and best practices with the intention to align around a common governance set of standards, specifications, and classification systems. We encourage participation and collaboration with other organizations and actors within the industry as well as regulators and welcome their feedback and commentary for the next version. The taskforce members do not presently endorse any specific regulatory treatment, and do not formally endorse or ratify any particular independent efforts to develop market governance frameworks.

We encourage those that can join us in the GBBC/IWA, or are already members not currently active in our group, to reach out and engage with us.

Executive Summary

To scale environmental markets we need to digitize the origination, or manufacturing, process and products. This new digital approach will enable the creation of standardized, comparable, and differentiated products from a wide variety of sources and lower their creation costs to make them more accessible and trustworthy.

The Digital MRV Framework defines the terminology, roles, process workflows, generic evidence packaging, and attestations that digital MRV solutions should follow to originate these next generation digital assets. The framework defines a generic roles-based process along with an extensible data model to facilitate a consistent taxonomy across infrastructure and asset classes and allow for customization of the diverse array of activities that can produce these new assets.

The framework can better enable investments in, and generation of, high-quality, well-documented ecological assets at scale. This framework defines the variables that enable the application of a wide variety of standards, protocols, and technologies that can be used in combination to create high-quality projects and claims, ready for validation and verification.

A harmonized, standardized framework agreed upon by market participants will enable investors, buyers, and other participants in global environmental markets to ensure the credibility and integrity of outcomes while maintaining the rigor and the requisite documented evidence to indisputably track impacts. Additionally, the MRV framework, when implemented, can ensure that double-counting and double-crediting do not occur – safeguarding market integrity. Tokenization alone will not and does not prevent double-counting, only tokens with corresponding, cryptographically-linked MRV audit trails have the opportunity to prove, on a public ledger, a lack of double-counting.

While this paper is focused on the business aspects of the framework, the InterWork Alliance has also produced a technical specification that delves deeper into the details for those implementing solutions based on the framework. This specification can be found at:

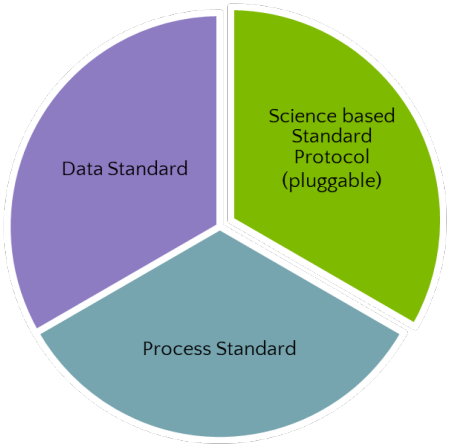
https://interworkalliance.github.io/TokenTaxonomyFramework/dmrv/spec/index.html

Framework

The Digital MRV Framework provides the high-level, implementation-neutral, specification for creating a solution that creates standardized claims into an open ecosystem for validation, verification, and crediting. This framework builds off the "Voluntary Ecological Markets Overview Version 2" standard[1] that was previously published by the InterWork Alliance to enhance global agreement on terms, definitions, and basic understanding of the process for creating ecological or environmental assets like carbon credits.

This framework brings Process, Data, and interchangeable science-based Quality Standards together that can operate under a governance framework to facilitate adjustments and create an inclusive and fair playing field for all participants.

Figure 1: Governance



The modular Quality Standard is specific to the type of activity being implemented and the source of beneficial claims. These Quality Standards are typically modular in themselves and combine a "methodology" or "protocol" that is specific for the activity being measured or monitored, a generic program or process, and options for implementation that enable optimal methods for measuring and qualifying project claims (e.g., additionality, permanence, etc.). Quality Standards define steps to establish a valid project and detail the required evidence and calculations used to quantify the benefit of the project's activity (e.g., mtCO2e removed).

The Quality Standard that a project follows will set the guidelines for what data collection requirements exist for a digital MRV solution. For instance, the Quality Standard will specify the evidence that should be collected, from which sources the evidence should be gathered, and what cadence the evidence will be reported. The Process and Common Data Standard remain the same across Accountable Impact Organizations.

Traditionally, Quality Standards have been governed by accredited registries (e.g., by ICROA) as options that project developers can choose from. However, recent advancements and innovation have led to the development of new "methodologies" and "protocols" by consortia, start-ups, and academia that are accelerating time to market and issuing credits using non-traditional techniques. This is likely a symptom of the traditional market infrastructure being unable to scale to meet the advancements and governance of new techniques. As Quality Standards and market participants become digitized and optimized, it is likely that the future form factor of environmental markets will resemble a convergence of traditional and innovative solutions.

1 https://gbbcouncil.org/wp-content/uploads/2022/09/Voluntary-Ecological-Markets-Version-2-InterWork-Alliance.pdf

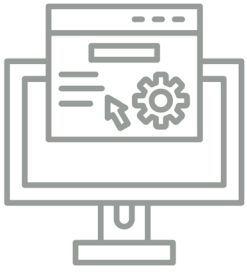
Framework Components

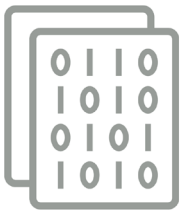
The framework defines components that represent roles, process artifacts, and subsystems that work together to package evidence in a claim that can be independently verified in standard processes. Each of these components provides a placeholder or variable that can be replaced with a specific actor, artifact or subsystem, allowing the framework to be generic and support a wide and diverse set of implementations.

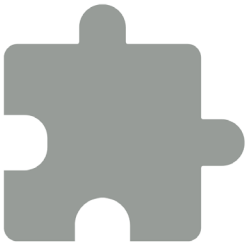
For example, solutions using the framework for soil carbon sequestration through agricultural practices would have different standards and sources of evidence than a direct air capture program, but each solution would create a standard claim that plugs into a standard process.

	**MRV Network** A shared set of infrastructure where the Data and Process standards are implemented that provides storage, compute, ledgering, and other capabilities for all participants. A Data standard includes the generic data elements that all activities should generate as well as specific "Quality Standard" data properties required by the standard. A Process standard includes the generic "lifecycle" of originating claims and workflow elements to enable automation.
	**Accountable Impact Organization (AIO)** The identity and metadata about a program or project that will be hosting or sponsoring one or more Activity Impact Modules (AIMs). The AIO is a way to group multiple modular projects logically to support different business models. Each AIO has one or more "owners" that references the accountable identity, i.e., individual or organization. For example, an AIO can represent a single farm that will want to have a project that makes carbon removal claims and another that will make water claims. Each claim type is associated with a different Quality Standard and will result in different credit types being issued, but are managed by a single organization. Or an AIO can represent an organization that will host multiple AIMs in different geographic locations, like solar deployments in different countries or states. Examples: • A farm that will have one or more AIMs for each Quality Standard it will implement for its location. • A solar company that will have an AIM for each solar deployment they will make renewable energy claims from.

	**Activity Impact Module (AIM)** An AIM is a "child" of an AIO and is a unique combination of a location, land area or facility, and a Quality Standard that will be followed for the location. The AIM is a party to the Verification Process Agreement where the Quality Standard is identified as well as the verifier(s) and issuing registry. Each AIM can have one or more "developers" and "sponsors" that references the individual(s) or organization(s) in these roles. A "developer represents the part performing the activity and a "sponsor" could be a separate financier of the activity. AIMs are the source for the claims process and is where the evidence is provided for creating one or more claims about beneficial impact, such as a claim of carbon removal. For example, an AIO may want to create claims for carbon removal and water for the same location, thus having an AIM for each. An AIM must be validated before it can begin submitting claims for verification.
	**Project Design Document (PDD)** An Activity Impact Module needs to be validated or approved by an appropriate authority, i.e., the validation body or issuing registry, before the claims verification process can begin. This is when a project's baseline is established and the activities of the project will be tracked and reported. This traditionally has been done in a PDD, a word processing document that follows a template provided by the issuing registry.
	**Accounting & Ecological Claims Registry** An organization that maintains and governs a portfolio of protocols or methodologies which certifies Validation and Verification Bodies (VVBs) to validate projects and verify their claims based on the protocol or methodology and then issue credits from these validated and verified claims.

	**Certification Standards Body** An organization that creates and certifies science-based standards, e.g., protocols and methodologies, for measuring environmental impacts and benefits. This may be an industry consortium, academic partnerships, or a single organization.
	**Quality Standard** Requirements for measuring outcomes, based on approved methodologies or protocols, that result in high-quality credits being issued. A Quality Standard can encompass a Standard Protocol or Methodology, a crediting program, measurement tools, and certification requirements for a VVB.
	**Standard Protocol (Methodology)** A science-based standard, often called a methodology, that is incorporated in a Quality Standard for making a claim that a specific activity leads to an quantifiable environmental impact, for example, that a project activity caused the removal of a specified quantity of carbon over a certain period. A protocol is specific to the type of activity and can vary based on its location, time, duration, etc. It defines the kind, amount, and frequency of evidence collected from required source(s) and formulae for using the evidence to determine the values of the claim. For example, determining the amount of carbon removal as well as other attributes like durability, additionality, co-benefits, etc.
	**Validation & Verification Body (VVB)** An organization that is certified to validate and verify claims, based on a standard, to ensure that the protocols and methodologies were followed and that the evidence collected supports the claims. The VVB first validates the AIO's plan against the Quality Standard being followed; once completed, the claims verification process can begin. In conjunction with the Verification Automations, VVB's work can be scaled or enhanced.
	**Verification Automations** Solutions, platforms, services, etc., designed to accelerate the verification of claims. Depending on the Quality Standard, it may be able, with appropriate audit requirements, to perform full verification of claims issuance of impact credits. For other Quality Standards, these platforms or services may automate and prepare findings data that are evaluated by a VVB in order to speed up and support a continuous verification process.

	**Project Validation** Before an Activity Impact Module can begin creating claims for verification, the project must be validated, against the Quality Standard being followed, by a certified VVB. This process can vary, but usually includes several steps and requires the production of documents like a Project Design Document (PDD) and may also include legal documents to be submitted like proof of ownership, title, lease, etc.
	**Verification Process Agreement** An agreement between the Activity Impact Module, Standard (registry) and the VVB for the claims process. Here the terms and conditions of the verification process are agreed to and documented. All artifacts in the claim process are linked to this agreement. The AIM may choose to switch standards or VVB and create a new agreement for verification.
	**Impact Claim** Made by an Activity Impact Module in accordance with its validated Project Design Document (PDD). The PDD follows the requirements of a quality standard, an applicable methodology, and protocols required to generate the necessary evidence for validation of the claim. A completed claim output is similar to a Monitoring Report, except that it is primarily intended to be machine readable, whereas a Monitoring Report is designed to be human readable. Some solutions may generate both machine and human readable output.
	**Claim Source** A registered source of claim data that can be raw source data from a device/sensor or a device/user/application and 3rd party reference data like satellite images or remote sensing. These sources are registered with the Impact Claim as valid sources of evidence.
	**Claim Checkpoint** A submission of prescribed evidence data made towards an impact claim based on a cadence or schedule required by the standard methodology or protocol being followed. An impact claim is made of a collection of checkpoints.

	**MRV Extension** An MRV Extension is an extensible JSON object that contains the MRV data that is specific to the Quality Standard/Methodology. MRV Extensions can be defined by the methodology developers or the verifier, or Verification Automations, to include attributes or data that are helpful to have on the ledger. A Quality Standard can define multiple MRV Extensions that can be attached to the dMRV process and data types to collect context-specific data points from appropriate sources. The components defined are common or generic to allow for maximum re-use, but the framework will need to support Quality Standard (methodology/protocol) extensions to allow for the monitoring, reporting, and verification of data that is specific to the Quality Standard being followed. As such, Quality Standards can define MRV Extensions that are specific for their methodology and add them to Activity Impact Modules, Claims, Checkpoints, etc. These extensions can be a collection of simple name/value pairs or schema-based, versioned, and optionally provide documentation so that the extensions get reused by many projects following the same Quality Standard.
	**Span Data Package (SDP)** Contains evidence data from one or more registered sources that is used to create a claim checkpoint over a specific time span. Sources may be 1st party, automated, application/device data, or reference data. The SDP is immutably stored, and its cryptographic fingerprint is recorded in the claim checkpoint.
	**Span Data Package (SDP) Manifest** A JSON file in the root of the SDP that contains metadata about the contents of the SDP. This includes identifiers like the Accountable Impact Organization, the Activity Impact Module, and the Claim the SDP is for as well as extensible MRV and Quality Standard metadata that is defined by the participants and stored on the MRV network. It can include digital signatures of claim sources.

Digital MRV Solution

An implementation of this framework that follows a protocol using a combination of technical devices, services, data sources, and applications to automate as much of the claim creation process as possible.

A digital MRV solution is comprised of 2 parts:

- A Digital Measurement and Reporting Solution that an Accountable Impact Organization uses to create Impact Claims by checking evidence in via checkpoints.
- A Verification solution that the VVB uses to verify Impact Claims created by the Accountable Impact Organization via the Digital Measurement and Reporting Solution.

These 2 solutions integrate and communicate with each other using MRV transactions and extensions, messages, and events.

Long Term Monitoring Solution

A solution that monitors AIMs that have had credits issued that looks for events that would impact those issued credits, e.g., a reversal event.

For example, a Monitoring Solution may use geospatial data and analysis to detect a forest fire, early harvest or disease that causes a significant decrease or reversal of an issued carbon credit's durability and quantity.

Processed Claim

Once an impact claim is open for verification, the verifier (VVB) will begin processing the Impact Claim it is verifying and will open a Processed Claim once verification begins. To support continuous verification, an AIM developer(s) can continue submitting checkpoints throughout the claim period and the VVB can add Checkpoint Results as they are verified. Once the processed claim is completed, the platform and/or VVB finalizes the Impact Claim and provides the necessary data in the request for issuance for the issuing registry to consider. The data review process is captured in the Processed Claim and recorded in the Checkpoint Result.

	**Checkpoint Result** To support continuous verification, a VVB may create a Checkpoint Result for each Checkpoint that is verified. This checkpoint result may contain communications between the VVB and the Accountable Impact Organization about the data contained in the checkpoint, such as a request for clarification. The Checkpoint Result should contain a verified link to a package of verification data, similar to the Span Data Package.
	**Impact Token: Carbon Removal Unit (Example Unit)** An issued digital asset, from a processed claim, that represents one metric tonne of CO2e (for example) of carbon removal or reduction. These credits are issued by an issuing authority and, once issued, the Processed Claim is finalized. This credit is cryptographically linked to its processed impact claim sources for full transparency.

Framework Component Relationships

Framework components have relationships with other components. For example, an Activity Impact Module (AIM) is dependent on the Standard Protocol chosen in which to base its claims on. The VVB selected must be certified to verify claims for the Standard the AIM is using.

Of note, Carbon Credits and other Impact Benefit products are used to offset, or remove in this case, carbon to net effective emissions downward. The action of using a credit is commonly referred to as retirement. In this framework, the credit is derived from an impact claim and its progression through the validation and verification process. As a claim progresses through its lifecycle and moves on to the next stage, it is finalized, which means it is made permanently read-only and linked to its successor.

The framework relationship map:

AIO -> AIM
The AIM is a child entity of its parent Accountable Impact Organization (AIO).

AIM -> Quality Standard
The AIM is bound, or contracted, to follow a standard in which to form and create its impact claims.

VVB -> Quality Standard
The VVB must be certified to validate claims for the Quality Standard bound to the AIM.

Quality Standard -> MRV Extensions
A Quality Standard can define MRV Extensions.

AIM -> Quality Standard -> Impact Claim
The Impact Claim is a child of its parent AIM and is based on the Standard Protocol in the Quality Standard.

AIM -> VVB -> Quality Standard -> Verification Process Agreement
A Verification Process Agreement has signatories representing the AIM, VVB and Quality Standard participating in the claims process.

AIM -> Claim Source(s)
Claim sources are registered with the AIM they are providing evidence for. These sources can be devices, applications or reference data.

AIM -> MRV Extension(s)
AIMs can have one or more attached MRV Extensions.

AIM -> Validations
An AIM will have at least one validation before verification can begin which contains the validation artifacts created between the Accountable Impact Organization and the VVB.

Claim Source -> MRV Extension(s)
A Claim Source can have one or more attached MRV Extensions.

Claim Source -> Impact Claim
Sources of evidence collected are registered with the Impact Claim.

Claim Checkpoint -> Impact Claim
Claim Checkpoints are children of an Impact Claim which maintains a collection of checkpoints and sources.

Claim Sources -> Span Data Package
Only registered claim sources are allowed to have their data included in the Span Data Package.

Span Data Package -> Manifest
Each SDP contains a manifest.json file in the root of the package that contains metadata about its contents.

Span Data Package -> MRV Extension(s)
A Span Data Package can have one or more attached MRV Extensions.

Span Data Package (SDP) -> Claim Checkpoint
The SDP is the input to create a Claim Checkpoint.

Impact Claim -> VVB
Once notified, verification of the Impact Claim by the VVB or Verification Automations can begin.

Impact Claim -> MRV Extension(s)
A Claim can have one or more attached MRV Extensions.

VVB -> Processed Claim
Once verification of an Impact Claim begins, the Processed Claim is created by the VVB and Checkpoint Results are created as Checkpoints are processed. The Processed Claim, along with its checkpoint results, allow for continuous verification progress to be demonstrated and monitored.

Processed Claim -> Impact Claim
When the Impact Claim is open for verification, the Processed Claim is created and the two claim states become cryptographically linked.

Processed Claim -> MRV Extension(s)
A Processed Claim can have one or more attached MRV Extensions.

Processed Claim -> Standard (Registry)
The Standard (Registry) is notified when the Processed Claim is finalized.

Standard (Registry) -> Carbon Removal Unit (example unit)
The Standard (Registry) conducts a final quality check on the Processed Claim and then issues a Carbon Removal Unit and finalizes the Processed Claim.

Carbon Removal Unit (example unit) -> Processed Claim
The Carbon Removal Unit is cryptographically linked to the finalized Processed Claim.

Artifact Details

Accountable Impact Organization

The Accountable Impact Organization establishes an organizational identity for one or more 'child', or 'sub', Activity Impact Module(s) and only contains basic organizational information primarily used for identification. Establishing a hierarchical project structure allows for organizational and benefit projects to be arranged logically, enabling many different business scenarios.

Activity Impact Module (AIM)

An Activity Impact Module, is a 'child' of an Accountable Impact Organization, and serves as the system of record for the actual type of project work that generates an impact being measured. It contains information about who the developers or workers are, the project's geographical boundary, its link to a Quality Standard, etc. It can have one or more "developers" and "sponsors", where a developer is the party performing activities and a sponsor can be financing them. AIM developers, or their automations, are responsible for submitting claim checkpoints. Activity Impact Modules are validated and are the source of impact claims to be verified.

AIM Sources

Activity Impact Modules produce claims that contain evidence. In order for the contained evidence's provenance to be established, a 'claim source' must be registered with the AIM. Some examples of claim sources would be:

- A device or sensor that takes measurements
- An application that runs on a mobile device that uses the devices' sensors, GPS, etc., and the authenticated user to collect and submit evidence
- A 'reference' source could be a Factor Library like the US EPA, IPCC, etc. libraries and version
- A 'service' like a geospatial or satellite provider to provide biomass estimates or other remote sensing capabilities.

Because the capabilities of these sources of evidence can vary, the method for establishing an identity for them to register will as well. There are several techniques for identifying a source and various ways to ensure evidence integrity to prove that evidence came from a registered source.

Newer methods for establishing identity and integrity of data will be more thorough and trusted, but we also need to support older, less capable sources of evidence that can be phased out over time in favor of fully identified and validated sources.

For example, newer devices can establish an identity based on Decentralized Identities and Verifiable Credentials[1] and are able to attest to their own evidence, see Attestation. Other devices may be able to support PKI infrastructure[2] and digitally sign their evidence. And in many cases, only a device make, model and serial number are available. In this specification we provide a general framework to support as wide a range of sources and compatibility as possible, while recommending that sources migrate over time to higher trust capabilities.

1 https://www.w3.org/TR/vc-data-model/#introduction
2 https://www.enisa.europa.eu/topics/incident-response/glossary/public-key-infrastructure-pki#

Verification Process Agreement

The Verification Process Agreement documents the parties, rules, policies, and procedures between the AIM (or Accountable Impact Organization), Standard, VVB, and/or other required parties for the creation, verification, and issuance of credits for claims made under the agreement. Every artifact created in this process is linked back to the Verification Process Agreement. There is the potential for the Verification Process Agreement to be implemented as a set of smart contracts or other processes.

The details such as the Standard, Version, and Protocol are all agreed to by the signatories of the agreement. An AIM may choose to switch standards or VVBs, which would require a new Verification Process Agreement to be executed and the old agreement archived.

Property	Type	Req	Specification
id : String	String	M	Unique identifier for the VerificationProcessAgreement, See § 3.91 Data Type: Id for details.
name : String	String	M	The name of the Verification Process Agreement, usually the name of the project - name of the issuing registry.
description : String	String	M	A description of the Verification Process Agreement and where special instructions are provided.
signatories : Signatory	Array	M	A collection of signatories, the AIM owner, Issuing Registry, VVB and verification platform are examples of signatories. See § 3.36 Data Type: Signatory for details.
qualityStandard : QualityStandard	Object	M	The quality standard being used for the verification. See § 3.46 Data Type QualityStandard for details.
mrvRequirements : MRVRequirements	Object	M	The MRV requirements being used for the verification. See § 3.47 Data Type MRVRequirements for details.
agreementDate : Date	Date	M	The date the agreement was signed. See § 3.51 Data Type: Date for details.
estimatedAnnualCredits :	String	O	The quantity of credits that are expected to be generated annually.
aimId : Id	String	M	The unique identifier for the corresponding AIM. See § 3.91 Data Type: Id for details.
AuditSchedule : AuditSchedule	String	M	The string representation of the audit schedule, see § 3.78 Data Type: AuditSchedule for details.
Audits : Audits	Object	M	The audits that are required for the verification agreement. See § 3.35 Data Type: Audits for details.

Figure 2: Properties of a Verification Process Agreement

MRV Extensions

To allow for the Digital MRV process to be customizable for each Quality Standard (methodology, protocol, tools, etc.), extensions can be defined and attached to Activity Impact Modules, Claims, etc.

Digital MRV Extensions should be defined by the participants, in the context of a Quality Standard, in the origination/manufacturing process (e.g., Methodology Developer, Issuing Registry, VVB). A Digital MRV Extension should have a type, name, version, description, and optional documentation, then can contain any structure of data expressed in name/value pairs and does not need to be understood by the network, just by the participants in the process for that protocol or methodology.

MRV Extensions are process or data type context-specific and are scoped by their type, meaning they can be defined to be attached to a specific data type, e.g., Activity Impact Module, Claim Source, Impact Claim, Checkpoint, Span Data Package, Processed Claim, etc. In doing so they can record context-specific data elements that are required for that data type for the Quality Standard being followed. For example, an AIM MRV Extension can apply additional geospatial configuration data to a project, or a Claim Source can record additional identifying metadata to increase its record of provenance.

MRV Extensions should be agreed upon between the project application supplying the evidence and the Verification Automations and/or VVB in order to streamline and optimize the process. It is expected that the development of standardized MRV Extensions will be adopted and incorporated into solutions digitizing Quality Standards.

See the companion specification for details:
https://interworkalliance.github.io/TokenTaxonomyFramework/dmrv/spec/index.html

Span Data Package

A span data package is a file package (.zip, etc.) that contains data from registered sources that is to be stored as evidence for a claim. It is up to the digital MRV solution as to the actual data format(s) so long as it is agreed to and understood by the parties involved in the verification process.

Each SDP has a “manifest.json” file in the root of the package that contains metadata about the files included and the sources the evidence originates from. The manifest.json is extensible to allow for specific extensions for digital MRV solutions and Quality Standards.

Claim sources are registered with the Impact Claim and provided an ID, this ID is used to validate and verify that the data contained within the SDP is from the registered source. Some sources may be capable of digitally signing their evidence, in which case the source’s public key would be registered with its ID.

Example claim sources that can be registered:

- IoT Sensors
- Reference Data (Satellite, Remote Sensing, etc.)
- In-person application/device/human

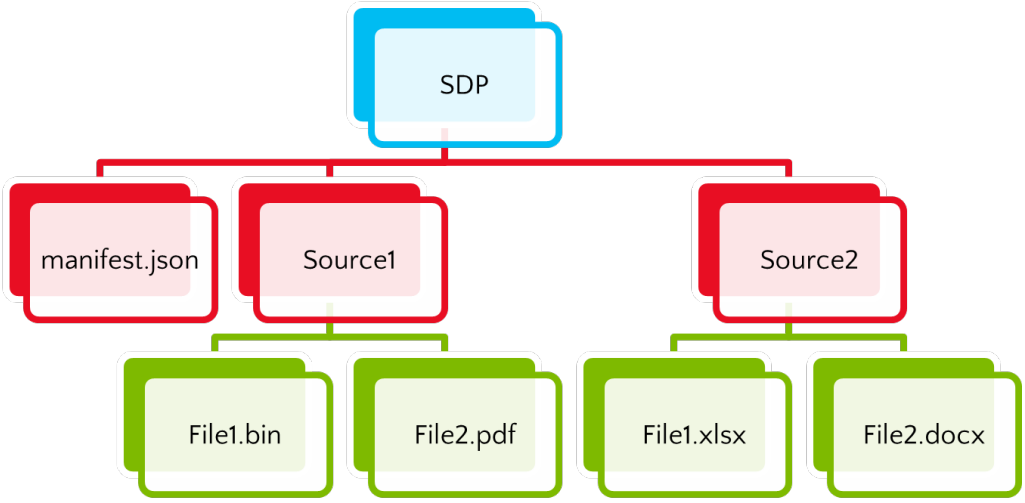


Figure 3: Span Data Package

The manifest.json file within the SDP file can contain methodology- or protocol-specific attributes or properties that can be defined and values stored. This allows for each protocol or methodology to have a customized digital MRV implementation, yet also co-exist with other digitized protocols or methodologies.

It is expected, but not required, that an implementation would read the manifest.json file and record it in the checkpoint so that it is stored in the ledger and the SDP file can be persisted in an appropriate data store. This allows for the network implementation to support placing dMRV-specific data on the ledger, without having to "understand" every Quality Standard it supports.

Claim Checkpoint

Once the digital MRV solution creates an SDP, it will need to submit it to the Impact Claim as a Claim Checkpoint. The SDP will be securely stored and a cryptographic fingerprint for the SDP acts as a receipt embedded in the checkpoint.

Impact Claim

The Impact Claim is the standard foundation for digital MRV solutions to create and submit a claim on the MRV network. It has metadata about the claim and collections of children entities such as sources, checkpoints, and co-benefits.

The Impact Claim, once it is open for verification, notifies the VVB/Verification Automations to begin verification. Although it is likely that only a single VVB/Verification Automation would be verifying a claim, because claims are composed of checkpoints, it is possible for multiple VVBs/Verification Automations to split verification across checkpoints. An AIM would support multiple VVBs/Verification Automations and would have these parties identified as signatories to the Verification Process Agreement. Validation and verification can be conducted by separate entities.

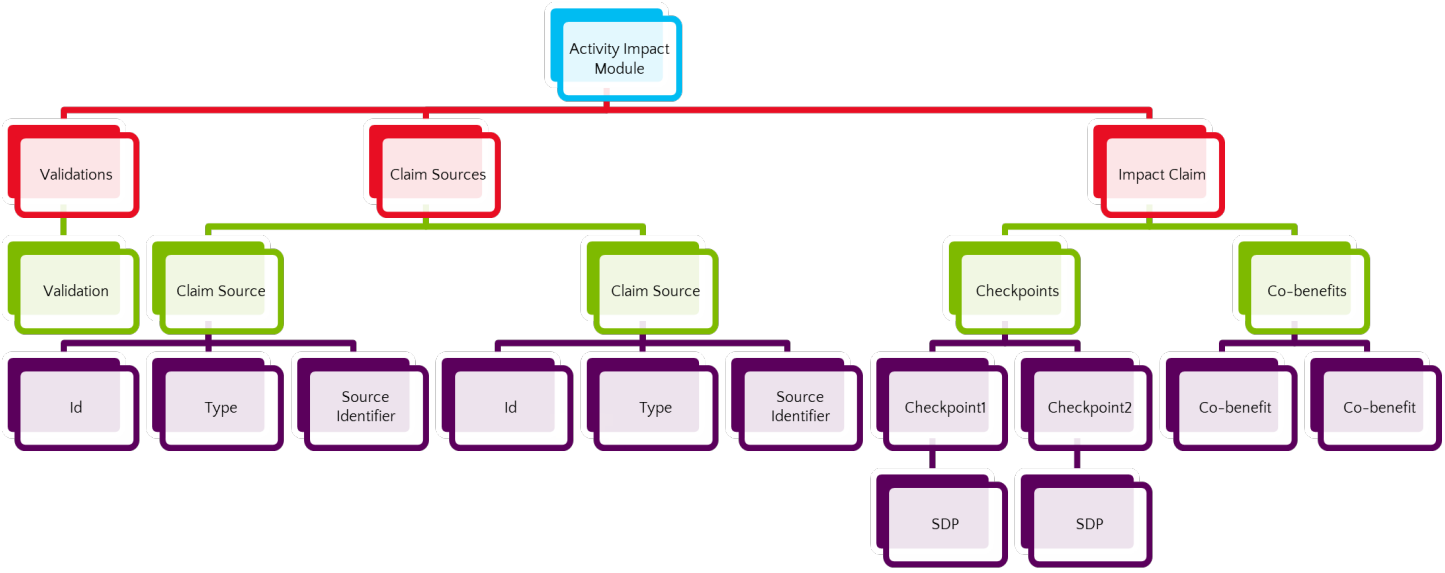


Figure 4: Impact Claim

Processed Claim

The processed claim is created by the Verification Automations or VVB to record its findings during the validation and verification process. Once the processed claim is completed, the platform and/or VVB finalizes the Impact Claim and provides the necessary data in the request for issuance for the issuing registry to consider.

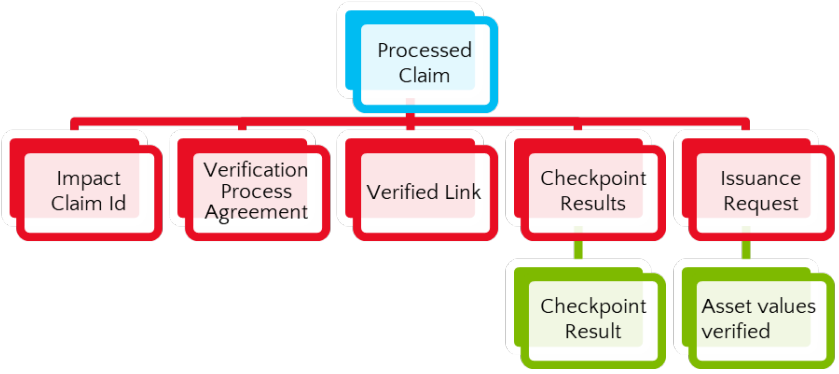


Figure 5: Processed Claim

Impact Benefit Token Example: Carbon Removal Unit

The IWA VEM Overview generically describes a tokenized value representing an impact benefit token. It provides an example of a carbon reduction/removal unit:

- Carbon Removal or Reduction Unit token (CRU) – is for removals or reductions and is non-fungible with other tokens of any type.

There is another token designed for distribution or markets called a Carbon Reference Token (CRT) that references CRUs; it is not covered in this framework.

The credit that is issued by the standard (registry) upon final verification of a Processed Claim finalizes that Processed Claim. This creates a chain of lineage from the issued credit to its Processed Claim and to the source Impact Claim.

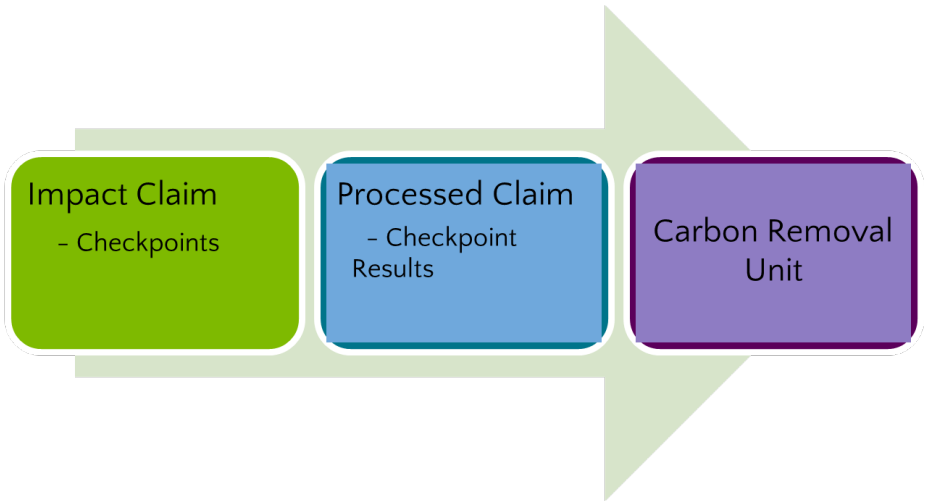


Figure 6: Carbon Removal Unit Generation

Framework Process Flow

Components in the framework work together following a process that generates artifacts documenting and attesting each step along the way. Participants in this process are actors fulfilling a role in the process, contributing data, verification, and attestation that is cryptographically and immutably recorded by the MRV network.

The MRV network is the system of record for the participants in the process where entities like the Accountable Impact Organization, Activity Impact Module, and Impact Claims are recorded.

Project Validation: Step 1

Activity Impact Modules are required to be validated by a VVB according to the Quality Standard the AIM is following. The validation of an AIM may include multiple steps that usually have associated documentation that is generated or supplied. For example, an AIM will usually be required to produce a Project Design Document (PDD), which provides details about the project, what activities are to be conducted, and how evidence about these activities and their results will be collected. Additionally, an AIM may need to produce documents that prove land ownership or a lease to ensure that the AIM is properly licensed by authorities to conduct the activities.

Because the validation process can vary based on the Quality Standard (e.g., one that is for a nature-based project type vs.one that is for an engineering-based project type), the process is flexible to allow for Quality Standard-specific validation processes to fit within the generic framework.

Each AIM will have a collection of Validations that establishes the time the validation was performed, when it expires, as well as links to all of the steps that occurred or are in progress with verified links to any documents those steps produce.

Claims Process: Step 2 - Impact Claims

1. An Accountable Impact Organization, the identity of a source project that can make different types of claims, establishes an Activity Impact Module for each type of claim the host project will create, e.g., Carbon Removal, Carbon Reduction, water, etc.

2. An Activity Impact Module selects a Quality Standard from a Standard Registry that matches the activity they will conduct to make a claim, e.g., Direct Air Capture, Soil – Crop Rotation & Covering, Forestry, etc.

    a. There is a lot of development and refinement needed for Quality Standards for Carbon Removals and Reductions to digitize the protocols.
    b. There may be scenarios where a Quality Standard is not under management of a Standard Registry, but another organization on the network would support the standard and issue credits for it.

3. The Quality Standard will lay out a "protocol" that prescribes the sources and cadence of evidence that needs to be collected (measured/monitored).

    a. Development of AIM applications that will collect and submit the prescribed evidence, and a corresponding Verification Service or Platform to help automate the verification, is expected as quality standards digitize.

4. Activity Impact Modules begin creating Impact Claims based on this protocol.

5. An Impact Claim is made up of a collection of Checkpoints.

6. A Checkpoint is a submission of evidence as prescribed by the protocol.

    a. Protocol developers are encouraged to define a regular or event-based cadence for the creation of checkpoints so that claim progress can be tracked downstream.

7. The MRV Network stores the evidence and records its cryptographic fingerprint in the ledger (checkpoints).

8. This process defines the Digital Measurement and Reporting Solution area for MRV.

9. There can potentially be a many-to-many ratio between Quality Standard and Digital Measurement and Reporting Solution, meaning that a dMRV Solution may be able to support multiple types of Quality Standards AND a Quality Standard may be supported by multiple dMRV Solutions.

Claims Process: Step 3 - Processed Claims

1. An Impact Claim needs to be verified by a Validation & Verification Body (VVB) and may be assisted by a Verification Automation or Service that automates verification of evidence as much as possible. A VVB is certified by the Standard Registry that governs the selected Quality Standard for the Impact Claim.

2. Once an Impact Claim is open for verification, it will notify the Verification Automations/VVB that it is ready to begin processing.

    a. The Impact Claim is verified by the Verification Automations/VVB as defined in the Verification Process Agreement and should not be processed by any other party.
    b. The AIM can continue to submit Checkpoints to the claim for continuous verification.

3. The Verification Automations/VVB will verify each of the Impact Claim's checkpoints to determine the total benefit – e.g., how many metric tonnes of CO2e were removed or replaced. The MRV network provides the chain of custody and cryptographic evidence to authenticity.

4. The verification process will generate a report of its findings in a Processed Claim.

    a. Once the Processed Claim is created, the Impact Claim is linked to the Processed Claim and verification can begin.

b. Once the reporting period and final checkpoint has been processed, the Verification Automations and/or VVB finalizes the Impact Claim and provides the necessary data in the request for issuance for the issuing registry to consider, containing the property values that were verified, e.g., total tonnes, co-benefits, etc.
c. The Processed Claim is finalized.

5. The Standard Registry that governs the Quality Standard used is notified of the Processed Claim.

6. The Verification solutions can be built and operated by Standard Registries or operated by independent organizations. There will be consolidation of these solutions aligned to the types of Quality Standards being used: e.g., Verification Automations focused on Forest Carbon, Soil Carbon, etc.

7. These solutions align to the Digital Measurement and Reporting Solutions via the Quality Standard being followed (data formats, data sources, factors, etc.).

MRV Claims Process: Step 4 – Issuing Credits

1. The Standard Registry will reserve the Processed Claim to prevent any other registry from issuing credits.

2. The Standard Registry may perform an additional KYC/Compliance check for the Accountable Impact Organization to ensure that compliance has been maintained.

3. Credits are issued based on the Processed Claim's findings/proposed credit: e.g., a Carbon Removal Unit equal to 20mtCO2e.

    a. These credits become the property of the Accountable Impact Organization.

4. Credits may be enlisted in a Long-Term Monitoring solution (e.g., for nature-based carbon removals like soil and forestry). This monitoring system can determine deviations in durability or permanence that can result in the revocation and replacement of credits issued.

Following these processes, roles, and solutions - each creating, attesting, and contributing to the artifacts along the way - will create an Impact Credit that contains a transparent link to its lifecycle data.

Quality Standard to Digital MRV Mapping

A Digital MRV solution needs to follow a Quality Standard and the methodology or protocol it contains for its implementation. It would be optimal for methodology and protocol developers to be aware of this framework and be able to prescribe evidence collection methods and checkpoint cadence for the building of Impact Claims.

For example, protocol developers can prescribe:

- A data source: a device, an application or reference data that can provide evidence to support the claim. As these devices produce data, further considerations will need to be made on error/exception handling and data utilization in the case of errors.
    - Specify the data source identity parameters required for the source to be registered to submit valid evidence. Can include device identifiers, application certificate, user identifiers, geolocation and time stamps, reference data URL with data hash, etc.
    - Specify the data format for the evidence a registered source should submit, including if the data should be digitally signed. This can include the data type (i.e., file extensions), meta-data, etc.
    - Specify the cadence which evidence should be included in a Span Data Package for submission as a checkpoint.
    - Specify the cadence at which a device must be inspected and recalibrated for it to remain a registered and valid source of data.
    - Specify the data format in which the evidence of device inspection and recalibration should be submitted.
- The establishment of a cadence for claim checkpoints for building the Impact Claim over time. These can be event-based checkpoints (e.g., agricultural events between crop rotations) or time-based (e.g., every day/week/month).

Attestations

Attestations provide opportunities for context in MRV data. Conceptually, attestations can be the data within the project or the commentary around the project. For project data, “Direct Data Attestations” can come from individuals, project developers, verifiers, and/or directly from devices asserting an event that is represented digitally on the public ledger.

Attestations, metadata, or “Tags” describing digital entities, such as actors, calculations, or their quantifiable outcomes, allow for more context to exist about Accountable Impact Organizations within the market, which inherently have a relationship with credit pricing and can describe overall project effectiveness.

For these “Tags” about the project to have further meaning they need to have an understanding of the real-world activity and the digital data model. This brings to light both “High-Definition” workflow data in digital MRV and its relationship within data models to “Low-Definition” attributes, which form higher order concepts that act as metrics for the market and ecological outcomes. Attributes are formed by providing a relationship of specific schemas, data, and calculations to higher order concepts such as Additionality, Durability, and Leakage, but can span to much broader concepts including co-benefits and SDG-oriented statistics.

The level of granularity, accuracy, and the breadth of information covered, in addition to the consistency of the information, form the basis for reputation of both the project and actors involved in the Accountable Impact Organization. Some examples of attestations surrounding a project can be represented in Tags as described below:

- tags can be created by any actor with a valid ID (recommended to be a DID).
- created tags should be credentialed, i.e., it should be clear who and when created or added to a particular tag.
- tags can have cumulative scores, e.g., two people independently creating/assigning the same tag to the same artifact results in both tagging actions recorded (credentialed etc.), and the 'tag score' is then counted as 2.
- It is possible for users to untag the item; however, this action does not remove the record of tagging in the first place, it just records the action of untagging (also credentialed) and reduces the score by 1.
- tags should be able to be associated with any identifiable entity/thing/artifact that uses and/or produces, such as:
    - actors, including SRs (i.e. DIDs)
    - schemas
    - policies and policy modules
    - VCs/VPs
    - tokens
    - smart contracts (ie. addresses)
- tags can be created after the (immutable) artifacts are produced, therefore tags are external to artifacts.
- it should be possible to create and/or follow tag ontologies containing the definition or description of tags.
- tag registry[-ies] should be discoverable and usable by automated indexing systems.

An example of tags in the Hedera ecosystem can be found in the Appendix. While the IWA and the participants do not prescribe or endorse Hedera specifically, it is important to include a reference implementation to demonstrate what tagging might look like.

Reputation

For reputation to take effect, based on digital MRV data and attestations, it is suggested to use a credential model that is fully traceable and contextually aware. Although reputation is often thought of in the context of projects, companies, or individuals, reputation should be considered to be extensible to devices, methodologies, or even specific sections of a methodology. This allows for a more complex understanding of a project and substantive details. Although this is often price-focused, reputation can also facilitate discourse on effectiveness of a project or any element or actor involved in a project. There should not need to be a single data model; however, using public ledgers and associated tooling, there should be an opportunity for reputation systems to form based on open standards and access to non-confidential information.

Confidentiality in Attributes & Asset Generation

The data associated with a project that may be relevant to reputation will likely be limited as we transition to a more digitally native format. However, there are also privacy and confidentiality considerations that may not have been fully considered in the analog format.

To enable confidentiality in MRV data, there are multiple approaches to privacy; however, there are specific requirements to enable this in the requirements of an MRV workflow. The below example is not an endorsement of a specific approach, but shows an example reference based on W3C standards.

Reference Example

In a reference example for generating Digital Ecological Assets, the Hedera Guardian uses the W3C standards of Decentralized Identifiers (DIDs), Verifiable Credentials (VCs), and Verifiable Presentations (VPs) in order to capture digitally signed documents that are stored on the decentralized InterPlanetary File System (IPFS).

Guardian uses VCs & VPs for a variety of data types - particularly:

- Monitoring, Reporting & Verification (MRV) data capturing the actual carbon reduction, removals, or renewable energy generation.
- The policies that digitize the methodology. In this context of carbon debits & credits, a methodology is a framework document that defines the rules governing the MRV process and the criteria for minting tokens corresponding to that MRV process.

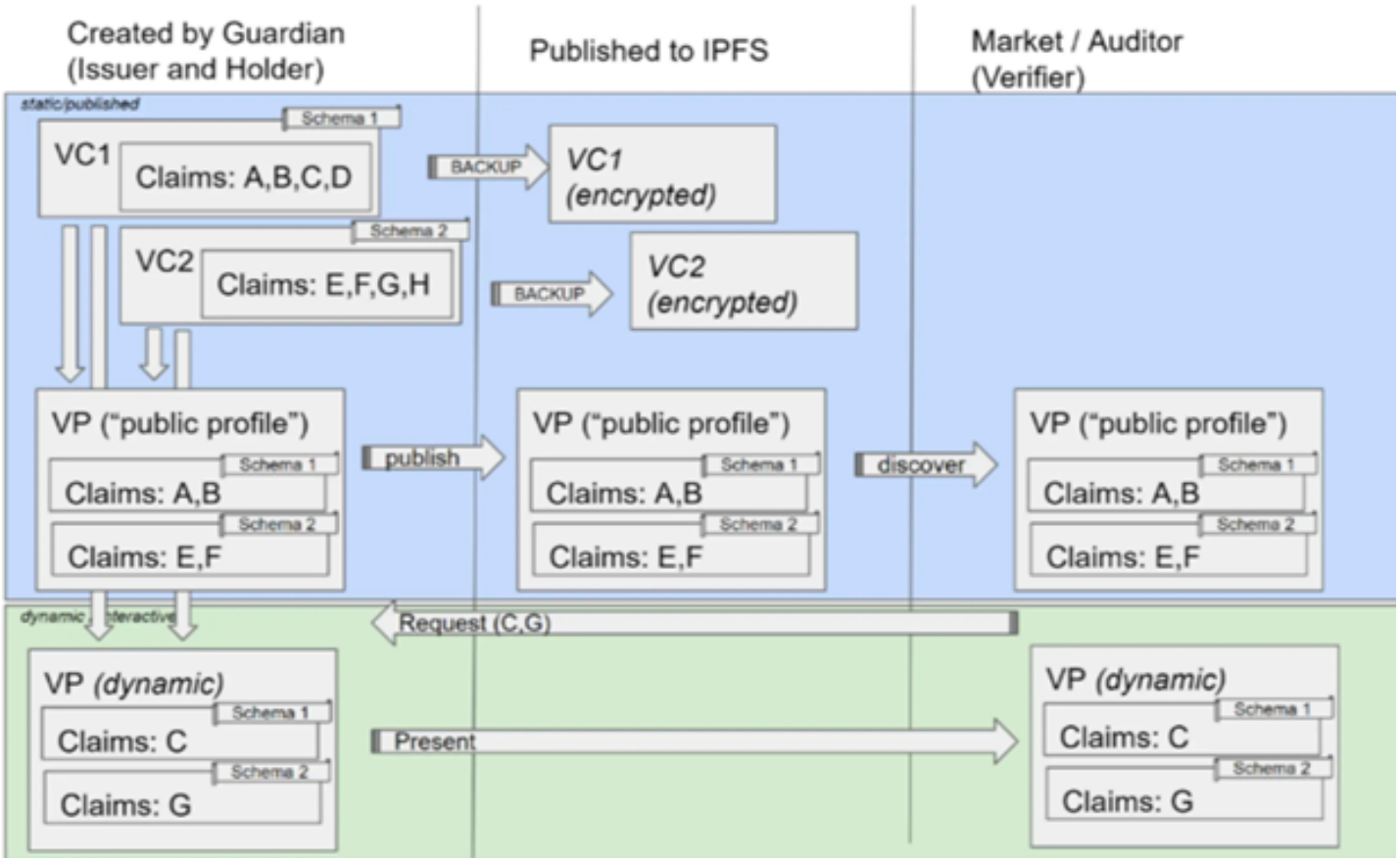
The current Guardian model publishes MRV data as a VC and creates a corresponding VP, apriori from that VC, and stores the VP on IPFS. The VP (and the VC within) can be retrieved from IPFS at any time and are, by default, unencrypted.

While this default transparency enables easy validation of provenance chains, it may not be acceptable to all enterprises considering using Guardian to track emissions of their manufacturing processes. While a business may recognize the need to be fully transparent about the amount of CO2 emissions associated with their business processes, they may wish to keep some details of those processes less than fully public to protect associated intellectual property and confidentiality.

Separately, confidentiality may be required to protect an individual's information. For instance, a homeowner that installed solar panels may not want their street address public, but recognize that the approximate location is important for assessing the credibility of energy production.

This sort of confidentiality can be challenging to reconcile with the desired transparency and composability and the fundamental choice of using a public Distributed Ledger Technology (DLT), like Hedera, to track the provenance of Environmental, Social, and Governance (ESG) assets.

Below is an example of attestations with selective disclosure. This model enables delivery of digital MRV generated attributes that include information which may not be publicly disclosed due to confidentiality concern.



Co-benefits & Modular Benefits

Today's voluntary carbon credits have "co-benefits" attached that map to one or more of the UN Sustainable Development Goals (SDGs). While these attached co-benefits can provide additional information about the project the credit is sourced from, they are not subject to the same validation and verification requirements of the actual credit that they are attached to.

This is not to say that these co-benefits are without merit, just a recognition that these co-benefits are attributes that cannot stand or be traded on their own yet. This specification continues to recognize these UN SDG-based co-benefits and enables projects, verifiers, and issuing registries to include them in their processes and attach them to credits issued. We refer to this type of co-benefit to be dependent, meaning the co-benefit is dependent on a credit in order to be traded and cannot be separated from the credit it is dependent on.

There are some co-benefits, and others in development, that are intended to be able to stand on their own and be either bundled with a credit or traded separately. These Independent Co-Benefits should follow the same process as an Activity Impact Module, meaning they are sourced from the same Accountable Impact Organization, but are defined in their own AIM that is mapped to a Quality Standard for the Co-benefit type, and need validation and verification of claims.

Dependent co-benefits are defined within the AIM for the credit they are dependent upon, and Independent co-benefits are defined in their own AIM.

Moving Forward

Continued collaboration is required to both improve and continuously refine this framework so that it can help establish a common understanding of the Process and Data standards needed to support interchangeable Quality Standards. This modular approach to standardization along with a foundation based on common terms and shared data descriptions should aid in the development of new Quality Standards for a wide range of products in the future.

Thank you to those who have already submitted feedback on the framework. We recognize that there are likely still areas that need to be further addressed and explored. As this guidance is implemented in real use cases, we welcome and appreciate your continued feedback on this paper as we work to continue to refine the Digital MRV Framework and provide robust guidance to implementers and those interested in understanding how a digital MRV solution functions.

If you have feedback you would like to provide to the IWA working group, please send that to IWA@gbbcouncil.org so the group can consider it for future versions of the document.

Appendix

Tagging Example

An example of tags can be seen here regarding Energy efficiency measures in thermal applications of non-renewable biomass. The below example demonstrates a Hedera-based implementation of a technology standards-based tagging architecture which can cover all public artifacts produced by Guardian instances. This is not advocating for a specific platform for implementation, but serves as an example of how tagging could be represented.

Methodologies (which are represented digitally as policies) can be tagged with additional contextual information on parameters such as "Estimating biomass fuel savings (B_y)".

A working paper published by the Stockholm Environment Institute (SEI) detailed several issues with cookstove methodologies such as CDM's AMS II.G, specifically related to the following parameters:

- Estimating biomass fuel savings (B_y)
- Fraction of nonrenewable biomass (f_{NRB})
- Default emission factors ($EF_{projected\_fossilfuel}$)

Regarding Estimating biomass fuel savings (B_y), this parameter is calculated based on the efficiency of old devices to be replaced and the efficiency of project devices. Under the CDM methodology *AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass*, there are three methods that a project proponent can choose from to estimate device efficiency, the Kitchen Performance Test (KPT), Water Boiling Test (WBT), or Controlled Cooking Test (CCT). However, there have been some considerable criticisms and concerns related to the WBT outlined by the SEI working paper. In general, the WBT — which is performed in a lab — results do not translate well to actual performance in the field. The KPT, by contrast, involves testing the devices by local cooks in actual households based on actual cooking tasks to provide a more accurate efficiency test.

In this use case, a project proponent conducting a cookstove project, using AMS-II.G., and opting to use the KPT method can tag the parameter '*Efficiency of the project device i and batch j ($n_{new,i,j}$)*' to provide additional information about how the parameter was estimated and how this impacts the parameter's value. Within this tag, the project proponent can have a description of the KPT and monitoring approach implemented, and the benefits relative to the WBT option. They can also specify what the parameter's value (project device efficiency) would have been under the WBT method.

This tag can be discoverable and linked to the project and parameter to provide useful information for interested stakeholders such as other project proponents seeking more accurate alternatives to the WBT, or marketplaces and purchasers looking to identify projects that have more robust monitoring and quantification approaches.

Tag Name	Cookstove Efficiency Test and Monitoring Method
Project ID	XYZ321
Methodology	AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass
Associated Parameter	Efficiency of the project device i and batch j ($n_{new,i,j}$)
Method Implemented	Kitchen Performance Test (KPT) and Monitoring
Description	Under the CDM methodology AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass, there are three methods that a project proponent can choose from to estimate device efficiency, the Kitchen Performance Test (KPT), Water Boiling Test (WBT), or Controlled Cooking Test (CCT). However, there have been some considerable criticisms and concerns related to the accuracy of the WBT. In general, laboratory tests results do not translate well to actual performance in the field. The KPT, by contrast, involves testing the devices by local cooks in actual households for actual cooking tasks to provide a more accurate efficiency test. This project implements the KPT method, which is a community test (performed in actual households); measuring fuel use in households based on normal cooking tasks over several days. This approach subtracts the quantity of woody biomass used by project participants (based on a random sample) from the amount of biomass used by a representative sample of non participant households. Both are measured over a three-day period. Total biomass available in the household is weighed at the start and end of each day or meal to measure the weight of fuel used.
Parameter Value Under the Water Boiling Test (WBT) Method	44%

Tagging Implementation example:

Tag actions can be implemented on an immutable ledger, such as Hedera, for tamper-proof, auditable and credentialed event records such as in the following example:


```
{
  “id”: “964c9e42-5483-4385-ba2f-71328f17f952”,
  “status”: “ISSUE”,
  “type”: “Tag”,
  “action”: “publish-tag”,
  “lang”: “en-US”,
  “uuid”: “ecd3e6b5-e5d9-4111-aadf-e9ea9d5b5763”,
  “name”: “Cookstove Efficiency Test and Monitoring Method”,
  “description”: “”,
  “owner”:
“did:hedera:mainnet:4XjqvXeMYPes1dmPVEfMmewNgER8zedFir3ufZN2gnMP_0.0.3732665”,
  “target”: “1694106714.582861517”,
  “operation”: “Create”,
  “date”: “2023-09-07T17:14:01.904Z”,
  “entity”: “Policy”,
  “cid”: “bafkreiaiihlee66mncrzah2her35rjd3srr3rdjuiyzw6uzvyfhsfaejwe”,
  “uri”: “ipfs://bafkreiaiihlee66mncrzah2her35rjd3srr3rdjuiyzw6uzvyfhsfaejwe”
}
```


Tags can contain or refer to extended information, secured by the cryptographic signature protecting against tampering as the following example demonstrates:


```
{
  “id”: “urn:uuid:e7916131-aa98-45fa-ab89-f1fcfceaf033”,
  “type”: [
    “VerifiableCredential”
  ],
  “issuer”:
“did:hedera:mainnet:4XjqvXeMYPes1dmPVEfMmewNgER8zedFir3ufZN2gnMP_0.0.3732665”,
  “issuanceDate”: “2023-09-07T17:14:01.930Z”,
  “@context”: [
    “https://www.w3.org/2018/credentials/v1”,
    “ipfs://bafkreicx6ecmje427oxss4w4ifw43mu7qezsct6ee3g6vra6fr32yrbda4”
  ],
  “credentialSubject”: [
    {
      “methodology”: “AMS-II.G.: Energy efficiency measures in thermal
applications of non-renewable biomass”,
      “associatedParameter”: “Efficiency of the project device i and batch j
(Nnew,i,j)”,
      “methodImplemented”: “Kitchen Performance Test (KPT) and Monitoring”,
      “description”: “Under the CDM methodology AMS-II.G.: Energy efficiency
measures in thermal applications of non-renewable biomass, there are three
```

```
methods that a project proponent can choose from to estimate device efficiency,
the Kitchen Performance Test (KPT), Water Boiling Test (WBT), or Controlled
Cooking Test (CCT). However, there have been some considerable criticisms
and concerns related to the accuracy of the WBT. In general, laboratory tests
results do not translate well to actual performance in the field. The KPT, by
contrast, involves testing the devices by local cooks in actual households
for actual cooking tasks to provide a more accurate efficiency test. This
project implements the KPT method, which is a community test (performed in
actual households); measuring fuel use in households based on normal cooking
tasks over several days. This approach subtracts the quantity of woody biomass
used by project participants (based on a random sample) from the amount of
biomass used by a representative sample of nonparticipant households. Both are
measured over a three-day period. Total biomass available in the household is
weighed at the start and end of each day or meal to measure the weight of fuel
used.",
      "parameter": 44,
      "@context": [
        "ipfs://bafkreicx6ecmje427oxss4w4ifw43mu7qezsct6ee3g6vra6fr32yrbda4"
      ],
      "id":
"did:hedera:mainnet:4XjqvXeMYPes1dmPVEfMmewNgER8zedFir3ufZN2gnMP_0.0.3732665",
      "type": "a9f8123a-4ec7-4cb9-a4ba-62170bcb9b08&1.0.0"
    }
  ],
  "proof": {
    "type": "Ed25519Signature2018",
    "created": "2023-09-07T17:14:01Z",
    "verificationMethod": "did:hedera:mainnet:4XjqvXeMYPes1dmPVEfMmewNgER8zedFi
r3ufZN2gnMP_0.0.3732665#did-root-key",
    "proofPurpose": "assertionMethod",
    "jws": "eyJhbGciOiJFZERTQSIsImI2NCI6ZmFsc2UsImNyaXQiOlsiYjY0Il19..
QHHRxHLzT1KmpByZiyweWOPghvZ2B0E_
JNjb7rJNXrM2S0sIq3F2E2p99G7roJYBz3ZbLrgFA3Jo2CaNBx1RBA"
  }
}
```


These code samples are equivalent to the tag example given earlier.

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