March 2021

The Weather Ledger

Standardisation Report

Executive summary

This report provides insights into the role that standards play in the use of Internet-of-Things (IoT), Distributed Ledger Technology (DLT) and *smart contracts*[1] for the management of weather events in construction, as part of The Weather Ledger project. The purpose of this work is to ensure the project aligns with best practice and to inform future standards development to support scalability and future deployments of IoT and smart contracts in the construction sector.

Why standards matter

Broadly speaking, standards support the market by creating consistency, thereby instilling the confidence and trust required to de-risk investment in innovation, enabling solutions to be deployed at scale.

In the context of The Weather Ledger project, there are a number of ground-breaking areas where standards are not yet mature. We have begun by identifying how and where the provision of standards might help users deploy The Weather Ledger more easily and consistently and help provide trust in the solution.

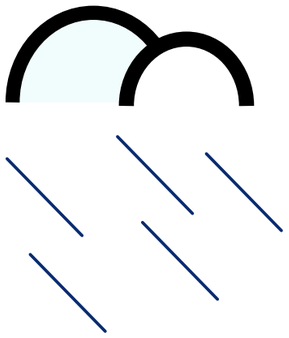
The focus includes looking at two technology strands covering both the deployment of IoT devices and the deployment of legally-compliant smart contracts in construction utilising Distributed Ledger Technology (DLT)/Blockchain[2] .

For the purposes of clarity and consistency, DLT and Blockchain are used to describe the same underlying technology here unless otherwise specified, as the terms are often used interchangeably and it is an area of active development.

As part of the work, our project partners have helped to shed light on key user challenges, relating to the deployment of the solution under development. Learnings and ideas for how the project can support development of future standards have been captured in what is an emergent technology, particularly in the construction industry.

[1] **Smart Contracts** are machine-readable digital implementations of legal contracts, typically implemented using distributed ledgers

[2] **DLT/Blockchain** refers to a type of database which is spread over multiple locations (i.e. a distributed database) and which can be used like a digital ledger to record and manage transactions.

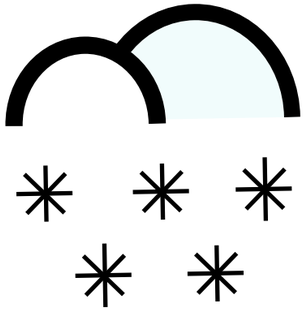


Research methodology

This report has been authored by Connected Places Catapult and has been informed by a combination of primary and secondary research, by contributing to and learning from industry and user insights led by our project partners Digital Catapult and EHAB, in collaboration with BAM Nuttall, Ferrovial Corporation UK and Clyde & Co. These insights have enabled us to identify potential user challenges that standards may be able to play a key part in solving.

We have conducted interviews with project partners and mapped the existing and emerging standards of relevance to this project. This includes in particular, reviewing standards such as the new PAS 333 (Smart Legal Contracts - Specification), that is currently under development and also by contributing to its consultation process.

On 22 July 2020 we held our first online workshop to further explore and identify key standardisation issues. Subsequently, we identified five priority areas where standards may play a key role. The partners then commented on these areas, to explore interconnected issues and to consider the impact on parts of the project, including a round of voting, allowing consensus to be gained on the highest priority areas.



Key findings

Key findings

1. Examining the landscape for DLT/ Blockchain standards has shown that there are currently 11 standards under development, with four published by ISO, but not specific to the nature of The Weather Ledger smart contract use case. We have utilised the draft PAS 333 by BSI as the most relevant standard to help better guide the development of the smart contract elements of The Weather Ledger, specifically as a progress tracker. We also worked with project partners to feed back to the BSI in support of its public consultation earlier in April 2020.

2. The standards landscape for IoT is complex and fragmented. We have identified ETSI TS 103 645 standard, Cyber Security for Consumer Internet of Things as a key standard to support baseline security for the IoT component of The Weather Ledger. A major gap was identified in the provision of standard that defines practical steps to guide the deployment and use of IoT on construction sites. This has led us to develop a set of principles and field guide with project partners, outlining 'Principles for effective deployment of IoT in construction' (links to key finding 6), providing broad guidance and relevant technical requirements, from planning, deployment through to dismantling at the end of the project's life.

3. The user insights gathered identified that there are five key areas of relevance to standardisation in the weather ledger project. Of these, three were prioritised as focus areas by project partners in our workshop held in July, considering their impact and feasibility. These are namely:

- The 1-in-10 Year Weather Event Classification
- The Design & Governance of Smart Contracts
- IoT Weather Sensor Deployment

4. Whilst the 1-in-10 Year Weather Event Classification is part of construction industry standard NEC contracts and therefore harder to influence, we are aware that there may be an opportunity to develop alternative dynamic set of standard weather clauses, that are more closely related to site specific risk profiles based on a set of parameters that could be agreed through industry consensus. This is also linked to a general need to support better management of weather risk information in construction through standardised processes for good weather information management.

5. **Smart Contract Design and Governance:** a key element of success relating to the use of smart contracts was ensuring that deployment of smart contracts have necessary checks and balances in place to build trust. Defining what these should be was agreed as important such as how to set up, manage, and secure a smart contract for weather compensation events. Alignment with the emerging PAS 333 is a key element of this and there were also a number of elements relating to governance that would be addressed through functionality of the EHAB platform.

6. **IoT Deployment:** there was a need identified for guidelines on how to set up a resilient IoT system for accurately capturing weather related data, outlining principles such as siting and placement of IoT devices, device types, calibration requirements, connectivity, power management and more.

Contents

1 An introduction to the project

The Weather Ledger project

The Weather Ledger is an Innovate UK funded project led by consortium partners EHABITATION (EHAB) Limited and supported by Clyde & Co, Connected Places Catapult, Digital Catapult, Ferrovial Corporation UK and BAM Nuttall.

It brings together advanced digital technologies, distributed ledger technology (DLT) and Internet of Things (IoT), the construction industry, and specialist legal review to create a new technology platform that will ensure fair and efficient execution of weather compensation clauses in NEC construction contracts, as well as drastically improving risk identification and transfer.

It is intended to dramatically reduce the time and cost of weather related disputes for the construction industry by creating a blockchain-based, trusted 'source of truth' for weather conditions at high levels of spatial and temporal granularity. The innovation combines this 'source of truth' with legally compatible smart contract language to create semi-automated, multi-party, legally binding clauses derived from standard NEC construction contracts, to eliminate disputes and enable resolution of weather related compensation events in near real time.

This automation will obviate significant manual claim and claim validation processes and reduce litigation. This will be even more relevant as climate change escalates, because it will generate more unpredictable weather, disrupting construction in the UK and abroad.

The project is divided into five main work packages:

WP1 – Discovery Work & Requirements
WP2 – Develop & Deploy / Trials & Feedback
WP3 – Impact Assessment
WP4 – Standardisation
WP5 – Dissemination & Commercial Strategy

The primary output is a fully functional, market tested and market ready software product standardised to match UK construction contracts. It is a platform any company can register on, input site locations, order IoT device installations, configure terms, add partners and compensation information. The platform will be ready to be scaled to meet the entire UK market during the final work package of this bid.

Connected Places Catapult's role in The Weather Ledger project

WP3 - Impact Assessment

Description: in this work package the CPC Impact Assessment Team closely follows the Discovery and Develop & Deploy phases developed by the project partners, investigating possible areas of interests for the projects and assessing the overall impact of the proposed solution.

WP4 - Standardisation

Description: in this work package the CPC City Standards Team will work in collaboration with the consortium partners and external stakeholders to identify those aspects that are of major interest from a standards point of view. The aim is to frame the solution in a Code of Practice that will enable its implementation in the UK market.

Application of Emerging Technology to The Weather Ledger. Note: this content is based on the Digital Catapult Industry Insights report.

This 12-month project will develop and demonstrate a real-world DLT & IoT-based solution for automated evidence collection, information exchange, and contract administration relating to adverse weather events at two real-world construction sites.

Internet of things devices (IoT)

Using internet of things devices (IoT) on-site, construction companies can collect accurate and highly localised weather information. This feeds into smart contracts running on a distributed ledger shared by all parties to a worksite. This immutable shared data is both transparent and auditable. Automation of contract clauses based on this trusted shared data will save time and reduce, or even eliminate, costly and wasteful disputes.

The Weather Ledger is exploring the applicability of this model, including the user experience it would provide:

- simple governance rules, no GDPR-sensitive data, no sensitive company data,
- verification replaces trust, through visible smart contract execution, immutable data and total auditability,
- simultaneous smart contract execution by all stakeholders, according to the weather data collected by IoT devices, enabling rapid alerts and swift allocation of compensation.

Smart contracts

It is hoped that this project will set a precedent for further application of distributed ledger systems in other areas of the construction industry.

Expert time can be better used for tasks that will help projects to complete more effectively and on time.

Lowering the risk of dispute will enable better collaboration within the industry and potentially eliminating disputes will result in cost savings.

Better data in general could help with more effective scheduling, to improve project delivery times. This data may be used to add value for other industries.

Product development will be undertaken with participation from all partners, maximising the value of available expertise.

Testing and iteration will be subject to detailed feedback from construction staff, on-site and office-based.

IoT devices used on a construction site are still novel, and for them to be used to collect weather data and then for the data to be used for smart contracts is entirely new and innovative.

Smart contracts and 'legal engineering' are both highly exciting emerging fields. The Weather Ledger is a world first in commercially-applicable smart contract technology, and certainly a first for construction.

Smart contracts are intended to automate the burdensome administrative work associated with disputes, which should also reduce any friction which would otherwise arise between parties. Smart contracting frees up legal experts to address more complex issues.

2 Standardisation requirements

Our approach

We take a human-centred approach to standards, to ensure that standards are not just developed for the sake of standards and are responding to help solve genuine problems. For The Weather Ledger, we worked with partners to gain a full understanding of the problems and the role that standards can play as part of the solution.

Envisioning the potential impact of standards for The Weather Ledger

For our research on standards, we started off with some high level research questions to consider different hypotheses for how standards might support the project now and into the future including:

- How might standards help users deploy The Weather Ledger more easily and consistently?
- How might standards help users trust The Weather Ledger and de-risk innovation?
- How might standards help scale the market for IoT and Smart Contracts in construction?

3 Technical review and user research synthesis

As part of our research, we considered outputs from user research interviews led by Digital Catapult with representatives from BAM and Ferrovial. We also conducted interviews with project partners including Clyde & Co, EHAB and Digital Catapult, offering expertise in the legal aspects of Smart Contracts and Blockchain technology respectively. From these insights, we then analysed and clustered the findings into key challenge areas to consider potential areas where standards could play a role in helping to solve problems.

4 Key standardisation issues

Following the technical review and user research synthesis, the following five key standardisation issues were identified:

1. The 1-in-10 Year Weather Event Classification

NEC3 stipulations on weather related compensation events require that to qualify for compensation, adverse weather must not only be severe, but that it has not occurred at that scale within a 10 year average.

We heard that the industry standard of 'a 1-in-10 year weather event' as defined by the NEC3 suite of contracts was suboptimal.

It is important to have a defined threshold for where the contracted party should be taking on risk. However, there is a need for a more contextual link to how construction site operations activity is actually affected by different types of weather conditions on the ground (wind speed, cumulative rainfall, humidity, ambient temperature, etc.), with measurable thresholds / high levels of granularity.

2. Design & Governance of Smart Contracts

Smart Contracts would have a standard format and template that can be repeated and used in different construction projects, with parties to the contract having the ability to add and remove modular terms as per their negotiations.

It would be imperative to highlight who the key actors are in managing the Smart Contract (roles of different organisations in managing the smart contract, who monitors it and who to contact if something goes wrong) and how human checks and balances will be offered, to monitor any potentially erroneous automated processes.

3. IoT Weather Sensor Management and Deployment

Current methods mean that weather data is collected from weather station equipment that may be tens of miles from the construction site meaning that a degree of objectivity and factual accuracy is lost.

Onsite measures to ensure high data quality and device calibration are important considerations to build trust and accuracy. Placement of IoT devices and power solutions also need to ensure reliability and data integrity.

There are a range of IoT device types and connection options available, guidance will be needed to determine the best fit.

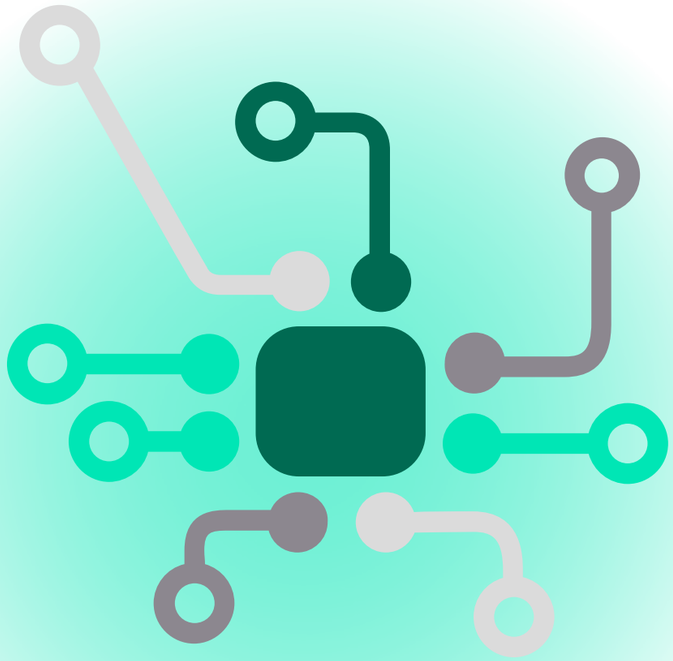
4. Interoperability & System Integration

Digitising processes with open application programme interfaces (APIs) leads to greater extensibility and interoperability with other key construction related technologies, including evolution of construction data processes, data analytics tools, and project and contract management systems (e.g. CEMAR).

5. Information Exchange

For information exchange, the data capture, information exchange and contract administration between parties are all relatively manual processes that take significant amounts of time. A standardised information exchange process would help overcome this challenge.

For example, a notification system. Any solution should be easily accessible, with an interface that is intuitive and similar to commonly used electronic devices, that allows for clear and efficient notification of 1-in-10 year weather events, informs all participants of the current status of the application and what is required next, and gives the specific data required in an accessible format.



Standardisation Workshop

Given the potential for a wide range of standardisation issues to be explored, it has been important to prioritise focus areas early on in order to achieve project targets and demonstrate a practicable contribution to the deployment of The Weather Ledger and for use in other similar projects in the future.

On 22 July 2020 we held our first workshop (conducted remotely) to further explore and identify key standardisation issues, with further exploratory sessions taking part later in July and September ensuring insights from those who could not attend. The insights have been captured from representatives across all project partner companies.

Attendees of the workshop

EHAB
Josh Graham

BAM Nuttall
Colin Evison

Ferrovial Corporation UK
Elena Perea

Clyde and Co.
Vanwyck Johnson

CP Catapult
Gavin Summerson
Sajed Amirinia
Reza Akhavan
Grit Hartung

Digital Catapult
Ian Crawford
Keerthi Thomas
Millie Spalding

The session included:

1. An overview of key standardisation issues.
2. Participants discussed these key issues, posed questions and submitted comments in the 'ideas bank' for that issue, expanding on key issue areas.
3. Each of the key ideas were then placed into an Action Priority Matrix to consider Impact vs Feasibility, focusing on practicable deliverables.
4. We then voted on these different ideas to agree the focus on what these priority issues should be for the project.
5. Finally, responsibility was allocated between project partners determining who would be contributing to, reviewing and staying informed with regards to progressing with these issues as part of the project.

Deep dive into standardisation issues

From these five key areas, we then undertook a deep dive to explore each of the five areas for standardisation as part of a workshop, using **MIRO**, a collaborative whiteboard tool.

Each group member posted questions along with ideas relating to that topic for example as illustrated in the panel below.

Questions and ideas

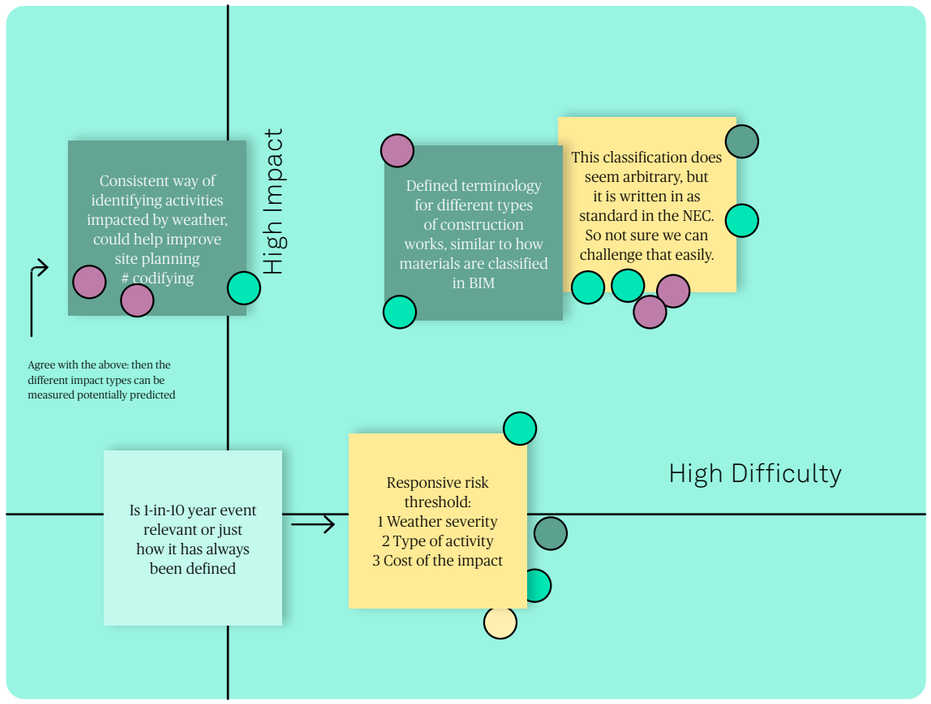
Questions	Why 1-in-10?	Ideas
Is there data on impact of weather events on site works, that could inform this?	What does this clasification mean? Why is 10 years important?	I think the priority is...
What would be the impact of having more granular definition? Agree sufficient level of granularity that has most impact	How do we calculate this and know our calculation is correct?	This is important for The Weather Ledger because...
How consitent are other events defined?	I think the priority is to get an agreement with clients in terms of the steps that are required and data consistency	In my view...
What does a more optimal definition look like?		Classify types of construction works by each type of weather
		Priority is to get agreement from all parties on a standard way of measuring weather impact on construction site actvity

For example, some of the questions and ideas for the 1 in 10 year weather classification raised the following:

- Is there data on the impact of weather events on site works, that could inform this?
- What does a more optimal definition look like?
- What would be the impact of having a more granular definition?
- The priority is to get agreement from all parties on a standard way of measuring weather impact on construction site activity
- A responsive risk threshold :1) Weather severity 2) Type of activity 3) Cost of the impact

Following this, the group then considered the impact and complexity of addressing each of these issues and each participant also took part in an exercise using dot voting for the favoured idea based on the impact and feasibility.

For example, for the 1-in-10 year weather event classification, the group was in broad agreement that its methodology is fairly arbitrary, however it is written into standard NEC contracts, so there is uncertainty to what extent it can be challenged. The group was also in broad agreement that defining a responsive risk threshold based upon weather severity, type of activity and cost of the impact was a good idea.



5 Prioritisation

The three key priority areas that were chosen and some of the upvoted comments, suggestions, and questions that accompany it (according to chosen impact and feasibility levels) are as follows:

1. The Industry Standard of a 1-in-10 Year Weather Event[3]

- defined terminology for different types of construction works, similar to how objects are classified in 3D models would aid the weather compensation event process.
- the system needs a number which is deemed as the threshold for where risk transfers from contractor to client.
- a consistent way of identifying activities impacted by weather could help improve site planning - by codifying it. The different impact types can be measured and monitored and potentially predicted.
- the existing classification does seem arbitrary, but because it is written in as standard in the NEC contracts, it is felt that it cannot be challenged easily.

2. The Design & Governance of Smart Contracts

- in terms of governance, it is probably suitable to have each party's lawyer host a node of the DLT so that they have access to the data. This should be everything they would need for ensuring compliance.

[3] For a weather compensation claim to be valid, it requires that it is shown to occur on average less frequently than once in ten years.

- no one will see the actual smart contract template as there is an easy to use interface 'on top'. This should make understanding the contract very easy.
- utilising standards would be good as current 'free text' contracts have too much variation which requires heavy review
- a simple list of what to do to set up and manage a secure smart contract would be very helpful
- contracts need to consider language and applicable law
- The Weather Ledger will have written legal terms and conditions that can be an addendum to the main contract

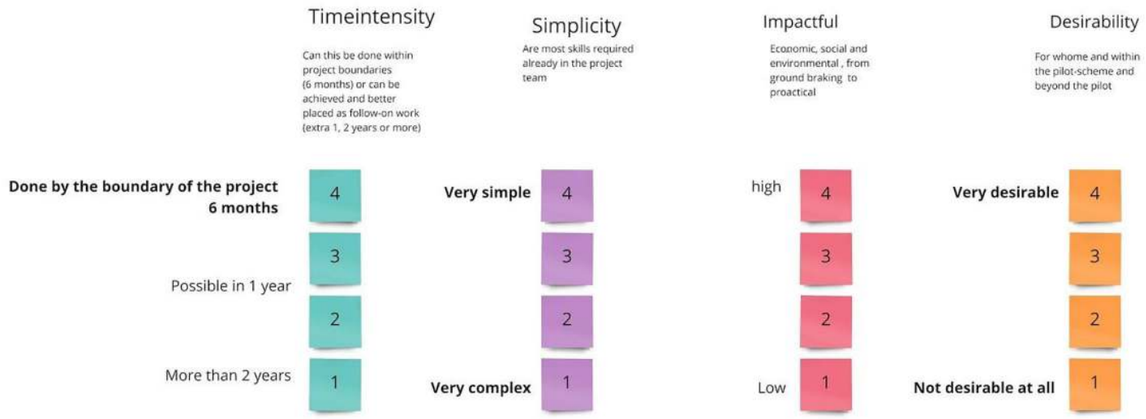
3. IoT Deployment

- the placement of devices for accurate sensing is very important
- resilience: in case of lost connection, does the sensed data get stored in the device for it to be delivered later? What system can be put in place as backup?
- a standard set of 'kits' for different levels of need: silver, gold, platinum (example). This contains instructions for setup.

What level of granularity of weather data do we need to collect? i.e. Frequency of data collection?

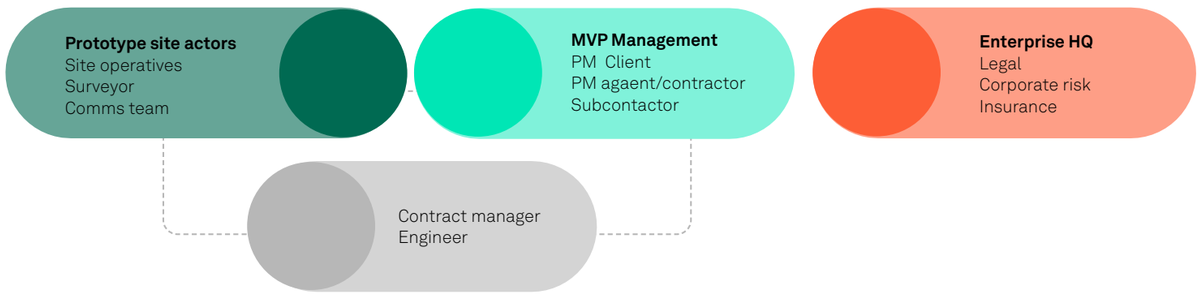
Following the workshop, insights with most votes gathered for each of the focus areas were distilled into one or two key ideas for further development as a 'Code of Practice'.

We developed a way of ranking the ideas based on set criteria, considering Simplicity, Impact, Desirability, and Time intensity (see below).



The following shows a summary of each of the three areas for further development, who the beneficiaries are, actions needed, and a feasibility score.

The beneficiaries described here are primarily the 'core' target group of actors, namely:



6

1-in-10 Year Weather Event Classification

Identifying and developing a responsive risk threshold more reflective of disruptive weather events that affect construction site operations activity. A clear description and classification of: 1. Weather severity 2. Type of construction activity 3. Cost of the disruption

Who is benefiting and how:

- Prototype site actors: automated notification of severe weather events and potential impact means less time spent / wasted on trying to operate on the site.
- Contract manager/engineer: greater certainty in approving compensation event requests
- Minimum viable product (MVP) management: less uncertainty about nature and impacts of weather compensation events, leading to less dispute time
- Enterprise HQ: greater reassurance of risk coverage parameters for insurance and legal, leading to swifter dispute resolution

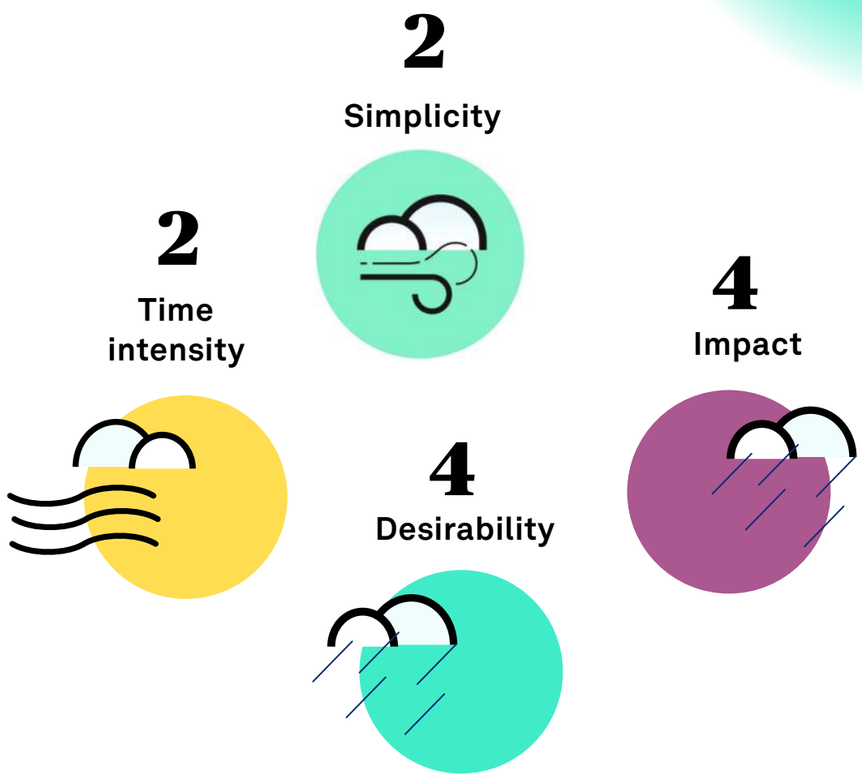
What actions are needed:

- Convening key stakeholders to explore the possibility of developing a better classification system for integration into contract templates. Consensus needs to be built on how risk is balanced - agreed by clients and contractors.
- Organise a half-day workshop (conducted in January 2021), to identify the key challenges to overcome and a potential risk model.

Who needs to be involved in developing this idea:

- Key stakeholders above, particularly clients, legal team, engineers/ construction site managers and weather event experts that understand impact

Feasibility Score



Overall Score

12/16*

*A higher score represents a more feasible and desirable area for further exploration

7

Smart Contract Design & Governance

A simple guide, showing how to set up, manage, and secure a smart contract for weather compensation events. One that is replicable and is designed with a modular approach.

Who is benefiting and how

- **Prototype site actors:** notification system linked to Smart Contract, enhancing awareness and communication.
- **Contract manager:** effective oversight of contract management.
- **MVP Management:** able to set up and manage a project more easily, with less uncertainties.
- **Enterprise HQ:** able to use guide to help early legal process/setting up smart contract and monitoring/ potential dispute issues that may arise

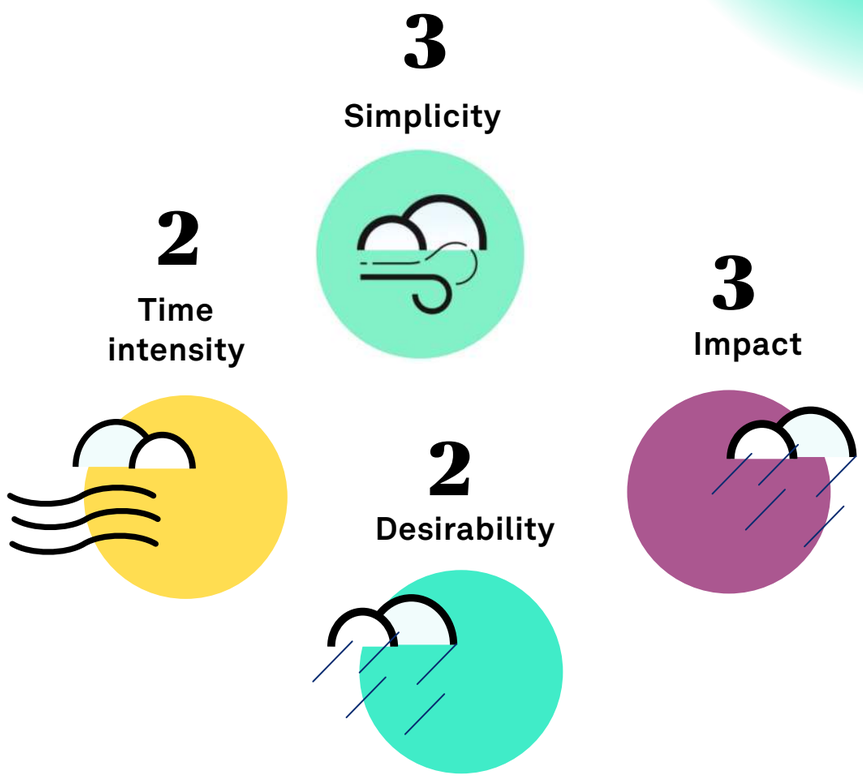
What actions are needed

- Produce simple, user-friendly guide, with step by step reference.
- Consider possible overlaps and/or complimentary relationships to evolving ISO and BSI PAS standards relating to smart contracts and blockchain.

Who needs to be involved in developing this idea:

Convene Smart Contract/Blockchain experts and weather compensation legal representatives to create guide.

Feasibility Score



Overall Score

10/16

8

Effective IoT Deployment on Construction Sites

A principles document, acting as a guide showing how to effectively deploy IoT devices on construction sites to capture hyperlocal weather data

Who is benefiting and how

- **Prototype site actors:** automated and 24/7 capture of trusted and reliable hyperlocal weather data, without much intervention other than monitoring of data platform and sensor batteries and operation,
- Contract manager: instant access to reliable weather data, cutting out the need to have recourse to third party data stores,
- MVP Management: able to have a good picture of real-time weather data and its impact on site operations, leading to better application of weather compensation claims with a low chance of rejection,
- Enterprise HQ: better able to rely on trusted data when assessing the veracity of weather compensation claims, leading to swifter dispute resolution.

What actions are needed

- Produce a principles document, covering broad guidance and technical requirements, covering the core things required for IoT deployment on construction sites. Things that need to be considered for example are where you mount weather sensors, building heights, power supply, battery and back-up systems, connectivity and communications, device positioning, quantity of sensors, monitoring tasks.

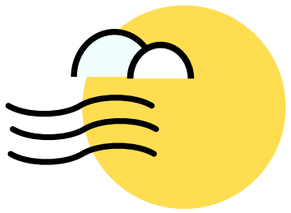
Who needs to be involved in developing this idea:

Set up a working group inviting project partners and experts to co-create documents prioritising key IoT installation issues. Research if other construction companies are doing anything similar and involve willing academic partners.

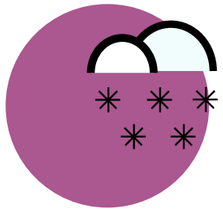
Feasibility Score

4
Simplicity

2
Time intensity



3
Impact



3
Desirability

Overall Score

10/16

9 Mapping against existing standards

In our initial research, we looked at the current standards relevant to DLT and Smart Contracts and the regulatory landscape to see if any guidance had been published which would be of benefit to The Weather Ledger.

Summary of relevant standards – Blockchain and Smart Contracts

At a high level, the UK government's **Blackitt Review (2016)** sets out findings from a review exploring how Distributed Ledger Technology can revolutionise services, both in government and the private sector. It also provided eight key recommendations including the need for technical governance.

In terms of standardisation activity, ETSI (the European Telecommunications Standards Institute) published a review of the **technology and standards landscape for distributed ledger**. NIST (the National Institute for Standards and Technology) has also published 'NISTIR 8202' providing a **Blockchain Technology Overview**.

The most comprehensive work is currently being undertaken by ISO under ISO Technical Committee ISO/TC 307 Blockchain and distributed ledger technologies, with Working Group 3 (WG3) who are focusing on Smart contracts and their applications being most relevant to the project.

There are currently 11 standards under development, with four published (updated 29.01.21 - see below). The standards highlighted in black are most relevant to The Weather Ledger including those relating to DLT/Blockchain and the design and governance of smart contracts.

ISO Standards Published

Blockchain and distributed ledger technologies – Vocabulary
ISO 22739:2020 Published: 2020-07

Blockchain and distributed ledger technologies – Privacy and personally identifiable information protection considerations
ISO/TR 23244:2020 Published 2020-05

Blockchain and distributed ledger technologies – Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems
ISO/TR 23455:2019 Published 2019-09

Blockchain and distributed ledger technologies – Security management of digital asset custodians
ISO/TR 23576:2020 Published 2020-12

ISO Standards Under Development (as of February 2021)

Blockchain and distributed ledger technologies - Use cases (Committee Stage)
ISO/DTR 3242

Blockchain and distributed ledger technologies - Identifiers of subjects and objects for the design of blockchain systems (Preparatory stage)
ISO/WD TR 6039

Blockchain and distributed ledger technologies - Data flow model for blockchain and DLT use cases
ISO/WD TR 6277 (Preparatory stage)

Blockchain and distributed ledger technologies – Vocabulary
ISO/AWI 22739 (Preparatory stage)
*to replace **ISO 22739:2020**

Blockchain and distributed ledger technologies - Overview of existing DLT systems for identity management
ISO/DTR 23249 (Committee stage)

Blockchain and distributed ledger technologies – Reference architecture
ISO/DIS 23257 (Enquiry stage)

Blockchain and distributed ledger technologies – Taxonomy and Ontology
ISO/DTS 23258 (Committee stage)

Blockchain and distributed ledger technologies – Legally binding smart contracts
ISO/AWI TS 23259 (Preparatory stage)

Blockchain and distributed ledger technologies – Guidelines for governance
ISO/DTS 23635 (Committee stage)

Blockchain and distributed ledger technologies - Overview of smart contract security good practice and issues
ISO/AWI TR 23642 (Preparatory stage)

Blockchain and distributed ledger technologies - Overview of trust anchors for DLT-based identity management (TADIM)
ISO/WD TR 23644 (Preparatory stage)

10

Summary of relevant standards – Blockchain and Smart Contracts

Smart Contract Standards

As presented in our review of DLT/ Blockchain standards, Smart Contracts form part of this landscape as an application of DLT and as such several current standards supporting Smart Contracts (e.g. ISO 23259) focus on this relationship, as opposed to standardising smart contracts themselves. However there is activity in this area, including a number of proprietary standards such as **Ethereum's ERC 20 Standard**.

BSI PAS 333: Smart Legal Contracts - Specification

Looking at 'DeJure' standards (those approved by formal bodies) it is the BSI's work on PAS 333 'Smart Legal Contracts - Specification' which is most notable in this area and also most relevant for the UK market being from the UK's national standards body.

Below: the EHAB platform defines the data model, contract logic, and the contract in natural language (based on the legal text)

As many of the relevant ISO standards are still under development and with a new national standard on its way, whilst only at draft stage, and therefore, not finally approved, we agreed that it would be prudent for the project to do a deeper dive to look at alignment where relevant, to ensure any key issues could be considered as part of the R&D process.

PAS 333 Deep Dive and alignment

PAS 333 sets out requirements to develop functional elements for use within a smart legal contract.

It provides three common template elements; natural language, model and logic. These combined elements are necessary for editing, analysing, querying and executing a smart legal contract across any product or service and in any organisation.

In collaboration with EHAB, we developed a PAS 333 progress tracker based on an assessment at different stages of the project (Discovery, Alpha, Beta, Live) so that we could track alignment.

The following areas are noteworthy in illustrating how The Weather Ledger is in alignment with aspects of PAS333 at the Beta phase and how some of these areas are being considered by EHAB when the product goes live.

It is important to note that as a pilot project, it is not feasible to expect alignment with every clause specified in PAS333. The fact that this is an on-site demonstrator deployed within a limited time frame means that disruptive weather events will not result in financial compensation, triggering automatic payment as part of the smart contract as would be the case in a fully live version.

Clause 4: Smart Legal contract Lifecycle

The development cycle of a smart legal contract shall move through the following phases:

a) **Design** – analysis of the legal text and logic for the template;

b) **Implementation** – specifying the template grammar, model and logic;

c) **Texting** – writing representative test cases;

d) **Creation** – create an instance of the contract template;

e) **Agreement** – instance of the contract template is agreed upon for execution;

f) **Signature** – electronic signature (or other) of te contract;

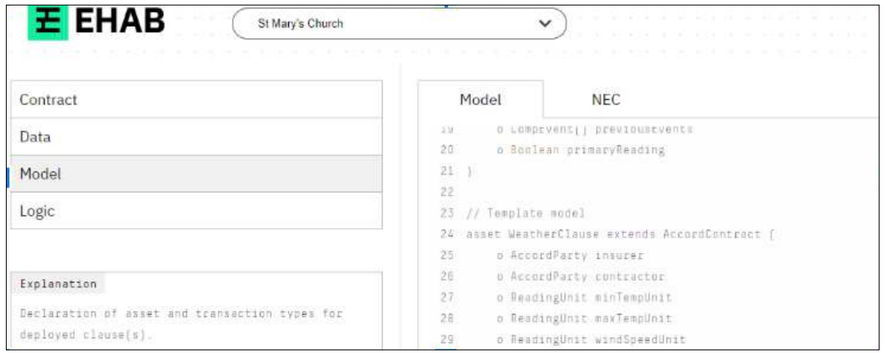
g) **Deployment** – deployment of the contract to a suitable runtime platfrom;

h) **Integration** – connecting the emart legal contract to external systems (data sources and APIs);

i) **Monitoring** – runtime monitoring of the performance of the contraact;

j) **Update** – performing any post-deployment revisions to the contract by updating or
replacing the template for the smart legal contract instance; and

k) **Completion** – termination of the runtime of the contract due to agreement between the parties and/or operation of the template logic. between the part



Smart Legal Contract Lifecycle (Clause 4)

This section of PAS 333 specifies that the development lifecycle of a smart legal contract shall move through eleven phases, from **design to completion**.
For example, as part of the **implementation phase**, The Weather Ledger has been utilising the **Accord Project's** (open source software tool for smart legal contracts) template language, which is deployed to **Hyperledger Fabric** execution engine.

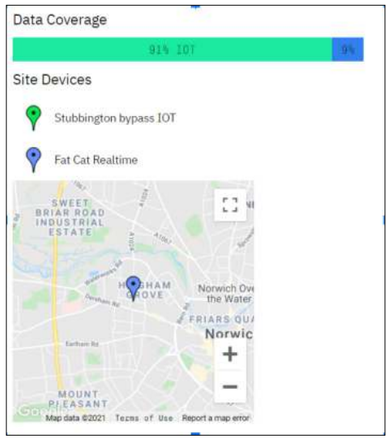
Testing is done externally, using the **Cucumber** software tool, which reads executable specifications written in plain text and validates that the software does what those specifications say.

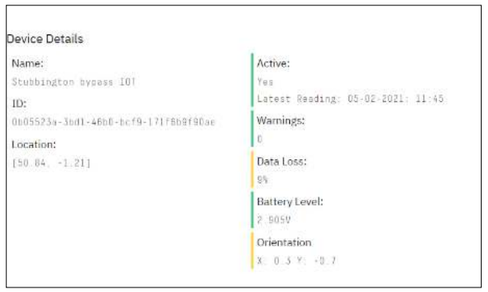
Phases such as multiparty signing of a contract are currently in research and development in the industry, so The Weather Ledger is currently using **DocuSign** to collect and manage digital signatures. It will be implementing its own integrated multisign solution in future releases.

At the live phase of the project, once the smart contracts are deployed to a Hyperledger Fabric's DLT network, all participant nodes receive live reading from the IoT weather stations on site, as well as third party weather data providers. The code that receives and manages this data is replicated across all nodes in the network and every change or new data has to be validated and confirmed by all of them. All signatories in the contract may opt to run it's own node.

As part of the **monitoring phase**, missing weather data is identified when data is received from the IoT weather stations to ensure integrity, with third party data utilised where there are any gaps in data. This is done on the platform, as seen in the image below.

As an improvement measure, it is suggested that contract clauses be included to manage issues with IoT device downtime, for example through the use of an external API or sensors deployed in other locations acting as a backup system - this functionality is already implemented in The Weather Ledger. IoT devices equipped with a warning mechanism can report on the percentage of data loss, as well as battery information and other possible issues that could be affecting the quality and integrity of their data.





Elements of a template (Clause 7)

In specifying the requirements for **transactions**, PAS333 states that they are defined to configure the interactions between a contract or clause and external environments (e.g. software systems). The Weather Ledger has done this by creating wrappers[4] around the Accord framework that provides input and output definitions.

The legal text is currently being prepared by Clyde and Co, which upon completion would enable the implementation of the **obligations**.

The structure of the data that the template requires from the outside world has already been defined, as the image below shows.

4. The legal language that describes what the code is enacting.

11

Summary of relevant standards - IoT

The current IoT standards landscape appears to be complex and fragmented.[5] Research carried out by BSI shows a daunting standards marketplace to navigate, with anything up to 400,000 standards found in preliminary IoT-relevant keyword searches sourced through database entries from over 200 standards organisations in 23 countries. Inconsistencies in indexation results in duplication and exclusion, explaining partly why so many entries appear in searches.

It is only with a matrix of refined segmentation of IoT technology layers and vertical industry segments that meaningful results can be obtained. Moreover, it is difficult to precisely define market-driven or de facto standards, who adopts them, how they are used, and to what degree of success. All this highlights the difficulty that small and big companies encounter when finding and using IoT-related standards.

There are some baseline practices and high-level standards that have been developed, covering IoT security, data protection and risk assessment processes that are worthy of note. Some of these can be viewed in a technical report by ETSI, **'IoT Standards landscape and future evolutions'** published in 2016. It provides a good analysis of the status of IoT standardisation, assesses the degree of industry and vertical market fragmentation, points towards 'actions that can increase the effectiveness of IoT standardisation, to improve interoperability, and to allow for the building of IoT ecosystems.'

[5] Navigating and Informing the IoT Standards Landscape: A Guide for SMEs and Start-Ups, Brass, I, Pothong K, Hasham M.(2019).

In the UK, The Department for Digital, Culture, Media & Sport (DCMS) published the **Code of Practice for Consumer IoT Security** in 2018, together with a comprehensive **Mapping of IoT Security Recommendations, Guidance and Standards** - with the key principles of the Code transposed into the **ETSI TS 103 645 standard, Cyber Security for Consumer Internet of Things** in February 2019. This standard covers cyber security provisions for consumer IoT, which is of relevance to The Weather Ledger. Communicating securely (clause 4.5), minimising exposed attack surfaces (4.6), making systems resilient to outages (4.9) are a few examples of the specifications that can also be applied to a construction site IoT deployment context.

There is also notable work being undertaken by ISO under ISO Technical Committee ISO/IEC JTC 1/SC 41 Internet of Things and related technologies. There are currently 29 standards published, and seven under development - managed by three different Working Groups (WG) covering IoT Architecture (WG3), IoT Interoperability (WG4), and IoT Applications (WG5). Of those published**, ISO/IEC 20924:2018 Information technology – Internet of Things (IoT) – Vocabulary, ISO/IEC TR 22417:2017 Information technology – Internet of things (IoT) use cases, and ISO/IEC 30141:2018 Internet of Things (IoT) – Reference Architecture** provides good foundations and a common knowledge-base for working within the IoT arena.

For a more in-depth analysis of critical issues in IoT product and service development, the outcome of a BSI workshop focusing on SMEs and start-ups operating in the IoT space is a good reference on understanding priority concerns, covering six key areas including: security; safety; privacy and data protection; interoperability; transparency; and promoting consumer and business awareness. More can be found in this document, **'Navigating and Informing the IoT Standards Landscape.'**

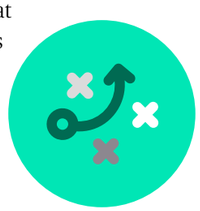
These are key issues that also appeared in the initial user research for The Weather Ledger, with trust and accuracy in 'IoT Weather Sensor Management and Deployment', 'Interoperability and System Integration', and 'Information Exchange' appearing within the top five key standardisation issues raised by project partners (see pages 13-14).

For the purposes of The Weather Ledger, the project is not developing specific IoT technologies and more looking to utilise existing solutions on the market that support the provision of hyper-localised weather data i.e. IoT weather sensors. Therefore the influence in implementing IoT standards is less relevant for the project, with the exception of utilising sensors that can support these needs and align with

From our review of current IoT standards, it's clear that most are focusing on the more technical nuances of IoT interoperability with no standards identified that provide more of a practical guide.

relevant standards where these support the project needs. The LoRA[6] Specification has been the most relevant in this case, as the preferred low-power wide-area network. Therefore, the use of devices that are compatible with LoRa was also a key factor.

However, as highlighted in our workshop, project partners did identify a clear need to ensure that any IoT set-up would provide a reliable and trustworthy source of weather data. Therefore there was a need to ensure consideration of what factors might impact upon this, particularly on construction sites that can often be remote and therefore sometimes lacking reliable power and communication infrastructure, as well as being often environments that are changeable and somewhat liable to disruption. It was therefore identified that a standard that would be most useful would be something that guided how to effectively deploy and operate an IoT setup.



From our review of current IoT standards, it's clear that most are focusing on the more technical nuances of IoT interoperability with no standards identified that provide more of a practical guide. Specifically, we looked for a standardised approach to deploying IoT devices on construction sites - one of three key priority areas identified by project partners at the post-workshop prioritisation phase.

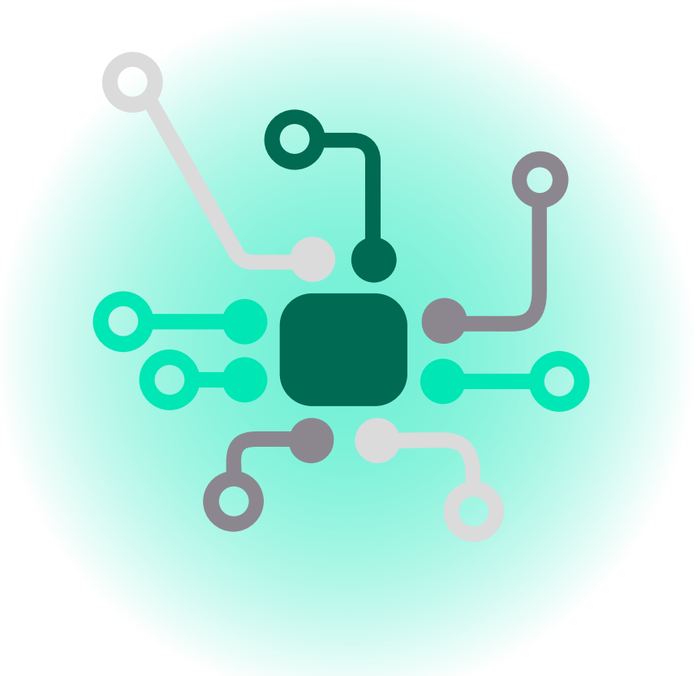
Given that the project would be learning from its own deployment and the experience from partners, this led to us collaboratively producing a user-focused field guide with project partners outlining 'Principles for effective deployment of IoT in construction', published as a separate output from this project. This document acts as broad guidance and outlines relevant technical requirements. Guiding principles are explained over five key deployment stages, from planning through to recovery. We hope that this can also benefit others that are looking to implement IoT in construction in the future and to evolve best practice in this area, saving the need to reinvent the wheel and giving greater confidence to the adoption of IoT technologies in the sector.

[6] LoRa is a wireless technology that offers long range, low power and secure data transmission for M2M (Machine to Machine) and IoT applications.

This document acts as broad guidance and outlines relevant technical requirements. Guiding principles are explained over five key deployment stages, from planning through to recovery.

12 Conclusion and next steps

Our review into the role of standards for The Weather Ledger has identified a number of areas where standards can support best practice in the deployment of IoT, DLT and Smart Contracts in construction. They can also play a role in potentially codifying and gaining consensus on new ways of implementing weather related clauses in UK Construction contracts.



The key areas of need identified in this project include:

1

Supporting Effective Deployment of IoT

The need to be able to use more localised reliable weather data was identified as a key need, with development of principles for IoT deployment gaining the highest score in the assessment of standardisation needs.

Whilst there are numerous standards relating to IoT that are available, from our review of those identified, many were overly technical and not fit for this specific need of supporting IoT deployment in construction.

There are many IoT use cases in construction, yet with the use of IoT not being widely used, a first useful step we identified is providing broad guidance on how to go about deploying IoT in construction projects, to provide some practical first steps to improve confidence in the use of IoT.

This has led to the partners creating a first set of principles for effective deployment, learning from the project. It is hoped that these can be further built on and utilised by wider industry in future IoT projects and evolve and adapt as needed.

2

Evolving standards to support Smart Contract Governance

Smart Contract design and governance was also an issue that scored highly in our review. Our deep dive into PAS 333 Smart Contract Specification provided a useful framework for the project, however we did find a high proportion of the time was spent on interpreting the meaning and intent behind a number of the requirements, with the standard not in the most 'start-up friendly' format. There were also a number of areas that were at odds with the Weather Compensation use case requirements, as fed back to the open consultation. However, we do think that such specifications have value in providing a useful framework and help provide market acceptance of smart contracts. We would therefore promote their further advancement, particularly where they are designed to evolve and adapt based on real-world applications, including considering the needs of different use cases.

3

The future of standard weather clauses in UK construction contracts

Finally, the 1-in-10 Year Weather Event Classification is a key pain point and was raised by many as being a sub-optimal definition. There is a need to evolve the standard clause towards a more risk responsive method that is more based on the actual risk level relevant to the project. We recommend this should be further investigated with key stakeholders and is the subject of a seperate white paper to be published as part of the project.

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