Community Standard Justification
Version 1.0

Title: Indoor Mapping Data Format 1.0 (IMDF)

Contributors: Michael Hoather, James Killick, Yuval Kossovsky

Organization: Apple Inc.

Address: 1 Apple Park Way, Cupertino CA 95014

Phone: 408-996-1010

Email: mhoather@apple.com
jkillick@apple.com
yuval@apple.com

Date: February 25, 2020

1.Introduction

This document provides a justification to the OGC Technical Committee (TC) for consideration of Indoor Mapping Data Format 1.0 (IMDF) as a Community standard. This justification, along with the linked candidate Community standard, will form the basis for TC review and vote to approve the start of a Work Item as the first step in the Community standard process for this standard.

The submitters agree to abide by the TC Policies and Procedures and OGC Intellectual Property Rights Policy http://www.opengeospatial.org/ogc/policies during the processing of this submission.

Once approved, the Community standard Work Item defined by this document is valid for six (6) months.

2.Overview of proposed submission

IMDF 1.0
IMDF is separable into two parts: IMDF (Specification) and IMDF Validations.

Changes to IMDF have largely involved the enhancement of category schemas. In all other respects, IMDF has remained unchanged since it was first released over a year ago. Publication of IMDF version 1.0.0 is expected to be followed by a period of stability lasting no less than a year.

When considered as a check for adherence to the specification, IMDF Validations can be expected to be enhanced both in the near-term and with any future iteration of IMDF. These enhancements may be in the form of:

- New validations
- "Decomposition" of an existing validation into several semantically-related ones that each generate a discrete "signal," as opposed to an abstract observation about a map data condition
- Configuration and "bundling" of validations by industry "vertical"

Opportunities to offer additional insights into map data conditions is expected to be welcomed by users with the "controlled" deployment of these enhancements expected to occur more frequently.

Geospatial Interoperability Requirements
IMDF feature objects represent a physical or conceptual element of an indoor map as a GeoJSON object. GeoJSON objects conform to RFC 7946, ensuring compatibility and transferability of the data.

Use Case Model
IMDF provides map data support for several use cases:

- Indoor wayfinding
- Indoor routing
- Temporal constraints
- Connectivity amongst mapped objects
- Location-based services
- Query and find by location functionality

IMDF and the Indoor Mapping Ecosystem
IMDF is relatively new among specifications targeted at indoor mapping. Though IMDF is mobile-friendly, compact, and "human-readable," this alone does not assure the success of IMDF. Successful adoption of IMDF is dependent upon the development of tools and processes to support IMDF generation and distribution.

Apple is committed to IMDF and the development of infrastructure to support IMDF. These commitments aside, IMDF is reliant upon commitments from a broader array of partners within a more extensive ecosystem of which Apple is a member. The curation of strategic partnerships with companies such as Esri, Autodesk and data integration platform developers such as Safe Software will be critical to the broader adoption of IMDF in apps and services.

Tools and services are currently available which support the view of IMDF, as well as the validation of IMDF. Additionally, tooling support includes capabilities to remediate validation errors where and when they occur.

Historical Development
The goal of creating a conceptual framework to effectively communicate a set of "human-readable" policies and procedures for modeling indoor locations was not an immediate achievement. Like many specifications, Indoor Mapping Data Format (IMDF) is ever evolving. As such, over the course of several years, this conceptual framework has undergone significant iterative development.

To a large extent, IMDF was "informed" by the creation of the Apple Venue Format (AVF) specification. As a precursor to IMDF, AVF was heavily iterated upon in an endeavor to encapsulate, within AVF, procedures that were both technically feasible and scaleable in a production environment.

Significant feedback for the IMDF specification was provided by multiple industries, notably Aviation. Airports Council International (ACI) and International Air Transport Association (IATA) have a joint data standards project for indoor data called ACRIS and PADIS respectively, and IMDF is aligned to that initiative.

An internal variant of AVF was eventually used by Apple Maps. This version would facilitate production of indoor maps, a feature on iOS 11 devices that was first announced at Apple's Worldwide Developer Conference (WWDC) in 2017.
The indoor feature for Apple Maps is now (late 2019) using IMDF as the primary production format.

The launch of indoor maps required a new enterprise-level, end-to-end business process. Multiple systems and stakeholders from several functional areas such as Data Sourcing, Cartography, Engineering, User Interface Design, Map Production, Quality Assurance, Operations, to name just a few, were involved in this effort. The challenges and opportunities that surfaced during this period of change, as well as the solutions, provided valuable insights which contributed significantly to IMDF.

3.Relationship to other OGC standards

As mentioned before, IMDF feature objects represent a physical or conceptual element of an indoor map as a GeoJSON object. GeoJSON objects conform to RFC 7946, ensuring compatibility and transferability of the data.

This proposed Community Standard has no dependencies upon any existing OGC standard.

4.Alignment with OGC Standards Baseline

CityGML, IndoorGML, and GTFS-Pathways were identified as specifications that may describe physical phenomena in a manner similar (or dissimilar) to IMDF.

CityGML

CityGML's Building module describes features that are semantically similar to some IMDF features.

CityGML Feature	IMDF Feature
Address	*Address*
FloorSurface	*Level*
Room	*Unit*
Opening	*Opening*
BuildingFurniture	*Fixture*

A declared CityGML motivation is to support 3D modeling of urban objects and "pedestrian navigation" is explicitly called out as a "target application."

While many of the above listed CityGML features require that data be captured at "Level of Detail 4" ("LOD4"), the extent to which users are capturing Buildings at LOD4 is unclear.

Though unclear how pervasive data capture at LOD4 is actually occurring in operational environments today, there is a level of similarity between how each Information Community has defined these features. As such, should it become a business requirement to support data interoperability, then we believe this to be technically feasible.

IndoorGML

The focus of IndoorGML is "*...the notion of cellular space and topological representation,*" therefore IndoorGML may externally reference an IMDF feature. In our view, IMDF and IndoorGML offer users an opportunity to leverage their synergies.

GTFS Pathways

While alignment with OGC Standards is one consideration, private attempts to bring standards to this formative area of growing business interest bears some mention.

The General Transit Feed Specification (GTFS) is a de facto standard which "...defines a common format for public transportation schedules and associated geographic information."

GTFS describes an optional set of files, namely pathways, levels, and stops, that possess a sub-set of properties and/or fixed values that are semantically similar to concepts in IMDF. While it is not uncommon for specifications to share the same concepts (A "stairs" is a "stairs," is there a better noun?), it is important to point out that IMDF and GTFS do not have "overlapping" interests. It is the purpose and meaning of these concepts within the context of their respective use case models which makes IMDF and GTFS distinct and separable.

Whereas the aforementioned GTFS files may facilitate the calculation of a routing graph, they are presumably not suitable for generating an indoor map having the characteristics of an IMDF. With the reverse being positively true about IMDF which is only intended to model an indoor environment and the physical Relationship between methods of traversal which may exist on different Levels.

In spite of these fundamental differences, potential synergies exist between IMDF and GTFS where each can potentially derive business value from the other.

Here is a brief summary of potential opportunities that exist to improve data quality and bring an enhanced product "experience" to our customers.

Extending the Routing Graph
An IMDF, like a GTFS dataset, has a conceptual boundary. Whether it is an environmental, legal, or jurisdictional boundary, each Venue, captured in IMDF, has a limited extent. The obvious challenge (and opportunity) is to offer customers a "seamless" indoor map of all connected Venues and while a solution may not be on the immediate horizon, IMDF does offer GTFS opportunities to extend its reach.

In a scenario where a transportation service is physically "contained" or integrated with a larger Venue, IMDF could be leveraged to extend the routing graph from the GTFS "stop" (stop_id) that identifies a station entrance determined by the "owner" of the GTFS dataset, to the actual Building's entrance, as modeled in IMDF.

By extending the GTFS pathway data, the "consumer" of the GTFS data feed can potentially offer a more complete "experience" that actually begins where the customer enters the physical building.

Enrichment through Derivation
Currently, GTFS pathways and levels are optional for delivery in a GTFS dataset. Theoretically, selected fields in GTFS pathways and levels could be populated by data sourced from IMDF. For example, with IMDF serving as both a reference layer and the system of record, GTFS level_name could be derived from an IMDF Level's name property. Similarly, IMDF Unit features could be used to derive data for calculation into GTFS fields such as:

- pathway_mode
- length
- min_width

Data Quality
As previously mentioned, IMDF and GTFS share some of the same concepts. These concepts, in conjunction with their possession of similar definitions, offer opportunities to enhance data quality in a mutually beneficial way.

The application of a set of bi-directional validations could signal suspicious data conditions warranting attention by data editors in one or other, or both datasets.

For example, the systematic overlay of GTFS pathway data upon IMDF Unit features, via the union of our respective Level features, can be used to generate reports about questionable intersections. For instance, an IMDF Unit category of "walkway" should only contain a GTFS pathway whose pathway_mode is similarly encoded as "walkway", and vice versa.

Typically, IMDF has a spatial extent that is greater than just walkable areas. This is due, in part, to a use case model that demands information that concerns all publicly accessible areas of a Venue. In a Transit Station, for example, IMDF includes leasable spaces ("room" Units), walkways ("walkway" Units), restrooms, and any other modeled spaces and physical objects that aid cognitive recognition in the context of a Venue of the given category.

GTFS features which do not exhibit an expected set of spatial relationships with IMDF could signal opportunities to extend the routing graph (as mentioned) and/or invoke some manual review process to ensure that data quality standards are being sufficiently met.

These are just some limited examples of how differential validations could be used to signal suspicious data conditions in either or both datasets.

5.Evidence of implementation

IMDF is used for Apple Maps indoor feature production for airports and shopping centers and since 2017 over 1000 properties around the world have been implemented. With the recent the release of a cross platform SDK for rendering IMDF, the online freely available IMDF Sandbox, and a tool for self-enabling indoor positioning the format is being adopted by many companies for use in public and private applications.

Please see section 9 for a document of known implementations of IMDF. It is reasonable to assume there are private and undisclosed uses of IMDF in the "wild" at this time.

6.Public availability

Is the proposed Community standard currently publicly available? **Yes**
URL: https://register.apple.com/resources/imdf/
The complete website explaining Apple's indoor program is here

7.Supporting member(s)

The following organizations support the submission of IMDF 1.0.0 RC1
as a candidate for Community Standard:

Autodesk
Esri
Google
New York City Department of Information Technology and Telecommunications (DOITT)
Ordnance Survey Limited
Safe Software

8.Intellectual property rights

Will the contributor retain intellectual property rights? **Yes**
If yes, the contributor will be required to work with OGC staff to properly attribute the submitter's intellectual property rights.
If no, the contributor will assign intellectual property rights to the OGC.

9.Addendum - Evidence of implementation

The following implementations use the proposed Community standard.

IMDF is used in many implementations and tools.

IMDF is found in consumer, enterprise and operations solutions.

IMDF functions as a data exchange format for geospatial data, as a display format for apps and websites, as a source of meta data about a location using apps for the blind and disabled, and as the format used to enable Apple Indoor Positioning.

A. **Implementation name:** Apple Maps
Date of most recent version: Today
Implementation description: The Indoor feature for over 80 airports and 700 malls with indoor maps and indoor positioning is informed and enabled by data from IMDF
Implementation URL:
https://www.apple.com/ios/feature-availability/#maps-indoor-maps-airports
https://www.apple.com/ios/feature-availability/#maps-indoor-maps-malls
Is implementation complete? **Yes**

B. **Implementation name**: Indoor Survey App
Date of most recent version: 3.1.3
Implementation description: Indoor Survey makes it easy for business owners to enable Apple's Indoor Positioning in their venues. Simply walk through the venue and perform surveys using the app to collect RF location data. This data can be viewed and tested in the Indoor Survey app.
Implementation URL: https://apps.apple.com/us/app/indoor-survey/id994269367
Localized to all iOS languages
Is implementation complete? **Yes**

C. **Implementation name**: Autodesk BIM 360 ops
Date of most recent version: 6/1/2019
Implementation description:Turn your Revit floorplan into a map with Indoor Mapping Data Format (IMDF). Use BIM 360 Ops with the Indoor Map and WiFi-based Apple Indoor Positioning to show technicians and vendors a path to their assigned ticket or a nearby asset.
Implementation URL: https://bim360ops.autodesk.com/indoor-map
App Store: https://apps.apple.com/us/app/bim-360-ops/id941471006
Is implementation complete? **Yes**

D. **Implementation name**: Safe Software - Integrate (IMDF) Using FME
Date of most recent version: FME 2019.1.3.1 released Oct. 21, 2019 (see https://www.safe.com/support/downloads/ for latest releases)
Implementation description: Use FME's data integration platform to convert any data to meet IMDF requirements for use in applications like Apple Maps
Implementation URL: https://www.safe.com/integrate/indoor-mapping-data-format-imdf/
Is implementation complete? **Yes**

E. **Implementation name**: Esri ArcGIS Indoors
Date of most recent version:
Implementation description:
Implementation URL: https://www.esri.com/en-us/arcgis/products/arcgis-indoors
Is implementation complete? **Yes**

F**. Implementation name**: Mappedin
Date of most recent version: Blue dot positioning within Mappedin Web, Mobile SDK and custom implementations, October 2019
Implementation description:
Once customer data is created within Mappedin CMS, we are able to generate an export and create an IMDF for Wifi Survey, for enabling indoor positioning . This allows Apple to review the venue and pass it for the next step: fingerprinting. Once fingerprinted using Apple's venue survey app, we can leverage Apple's IOS positioning to surface a blue dot location to the end user. This is done out-of-the-box for our Web App product, but can also be leveraged within the Mobile SDK. As next steps - we are working towards generating an IMDF export with a greater level of detail, allowing us to sync venue data with Apple Maps regularly.
Implementation URL: https://mappedin.com/products/wayfinding/apple-maps/
Is implementation complete? **Yes**

G**. Implementation name**: Compathnion Technology Limited - LBS SDK and CMS
Date of most recent version: Sep 2019
Implementation description: The CMS collects location-based information and venue objects from different sources of input such as GEOJSON, excel IMDF and websites. The API export to IMDF which combine all existing values into valid IMDF layers and features. We maintain the variables and changes from various client platforms and the compliance of Apple IMDF specification. Therefore, the navigation and positioning in iOS are up-to-date and in high accuracy.
Implementation URL: http://www.compathnion.com/apple.html
Is implementation complete? **Yes**

Apps using the Compathnion SDK to render and use Apple Indoor Positioning:

1. https://apps.apple.com/hk/app/新濠皇會/id1444572972

H**. Implementation name**: Point Consulting -SDK to render IMDF with Wayfinding
Date of most recent version: The set of libraries depending on the platform (iOS, Android and Web) - all have been updated between July and October 2019.
Implementation description: Point SDKs use the IMDF map data to render digital maps for both enterprise and consumer applications. They are used in applications to help passenger navigate through airports, visitors to museums and also used by Facility Management to help venue maintenance.
Implementation URL: https://www.point-consulting.com/indoormaps.html
Is implementation complete? **Yes**

Apps using the PC SDK to render IMDF and use Apple Indoor Positioning:

1. JAX Airport App
2. JAX Airport Website
2. KLM
3. Air France
4. Zurich Airport - internal app
5. Asito (Facilities Management) - internal app (being developed)
6. National Gallery of Australia
7. Singapore University of Social Sciences

I**. Implementation name**: Maphive Technology Limited - Mapxus
Date of most recent version: The production of IMDF was supported since the beta, and integrated into our indoor map production platform since Oct 2018. Since then we continue to enhance and streamline the data production pipeline. Latest revision of product that support IMDF is October.
Implementation description: Mainly to support the indoor positioning on iOS, for Blind Union for their "Smart City Walk" Project. The project officially launched on Sep 2019, which help the visually impaired individual to navigate around the city covering shopping malls, universities, hospitals, social community centres, transportation hubs.
Implementation URL: http://www.mapxus.com/imdf/
Is implementation complete? **Yes**

Apps using the Mapxus SDK to render and use Apple Indoor Positioning:

1. Hong Kong Blind Union - Smart City Walk APP, 逍遙行

J**. Implementation name:** Major League Baseball Advanced Media, L.P.
Date of most recent version: October 2019
Implementation description: Stadium Maps and Indoor Positioning for Ballparks
Implementation URL: https://apps.apple.com/us/app/mlb-ballpark/id513135722
Is implementation complete? Yes
Team apps using the MLB SDK leveraging IMDF and Apple Indoor Positioning:
Arizona Diamondbacks, Atlanta Braves, Cincinnati Reds, Cleveland Indians, Colorado Rockies, Chicago Cubs, Chicago White Sox, Detroit Tigers, Houston Astros, Kansas City Royals, Los Angeles Dodgers, Milwaukee Brewers, Minnesota Twins, New York Mets, Oakland A's, Pittsburgh Pirates, San Diego Padres, Seattle Mariners, St. Louis Cardinals, Toronto Blue Jays, Washington Nationals

K**. Implementation name: YinzCam Inc**
Date of most recent version: October 2019
Implementation description: YinzCam uses IMDF and IPS to create an interactive stadium map of the venues our clients play their games at. The map allows users to navigate around the venue, view concessions, and much more.
Implementation URL: http://www.yinzcam.com
Is implementation complete? Yes
Apps using the YinzCam SDK leveraging IMDF and Apple Indoor Positioning in alphabetical order:

Arizona Cardinals
Baltimore Ravens
Barclays Center Mobile
Carolina Panthers
Chicago Bears
Chicago Bulls (and United Center)
Cleveland Browns
Dallas Cowboys
Denver Broncos
Detroit Lions
Green Bay Packers
Houston Texans
Indian Wells Tennis Garden / BNP Paribas Tennis Open
Milwaukee Bucks
New England Patriots
New England Revolution
New York Knicks (Madison Square Garden app has turn by turn directions)
Pittsburgh Steelers
Rogers Place
San Antonio Spurs
Tamba Bay Buccaneers
Toronto FC Mobile
Toronto Maple Leafs
Toronto Raptors

L. **Implementation name**: Office of Museum Research
Date of most recent version: September 2019
Implementation description: OMR provides full-service indoor mapping, positioning, digital building management, and custom software development with a focus on value-driven customer service, and a commitment to open formats like IMDF.
Implementation URL: https://omr.org/elucid.html
Is implementation complete? **Yes**

M**. Implementation name**: Dent Reality
Date of most recent version: October 2019
Implementation description: Augmented Reality navigation and Indoor Maps, for shopping centres, airports, campuses and more. End-to-end solution, with a full-featured IMDF map builder, and mobile SDK.
Implementation URL: https://www.dentreality.com
Is implementation complete? **Yes**

N. **Implementation name**: Visioglobe Indoor Positioning
Date of most recent version: September 2019
Implementation description:
An indoor positioning system (IPS) is a system to locate objects or people inside a building using radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices.
At least three independent measurements are needed to find the indoor location.
Visioglobe technology can work with any of them, but also a combination of them.
VisioMapEditor allows IMDF import as a source format. Visioglobe works mainly with Apple WiFi based indoor positioning, also with Navibees , Pole Star and Estimote for beacon triangulation.
Implementation URL: https://visioglobe.com/ips-indoor-positioning-system/
Is implementation complete? **Yes**
Applications using the VisioGlobe SDK IMDF and Indoor Positioning:
https://apps.apple.com/fr/app/genève-aéroport-gva/id502471072

O. **Implementation name**: Navv Systems - Novatrak

Date of most recent version: October 2019

Implementation description:

Novatrack is a system that allows hospitals to control and manage their mobile teams like never before. It allows supervisors, managers, dispatchers and schedulers to see the real time location of workers and communicate with them via text messaging. It takes a process that currently resembles a 50's taxi dispatch and turns it into something that more closely resembles Air Traffic Control. Dispatchers can offer ETAs for arrivals and departures, and they can correct a worker that has become misdirected. Disputes over when a transporter arrived or when a room was cleaned are resolved with factual data.

Implementation URL: http://navv-systems.com

Is implementation complete? Yes. Spun out of Henry Ford Health in October 2019 into separate company for commercialization

P. **Implementation name:** Arora Technology Group, LLC – Venue Management Platform

Date of most recent version: VMP 1.0

Implementation description: The Arora Venue Management Platform (VMP) provides facilities operators with an easy way to convert existing floor plans into the IMDF specification which can be distributed for various use cases. This provides a single source of truth for venue information and allows facilities to be managed using exsting tools, while providing a single source for venue information to internal and third parties for support of their venue information needs.

Implementation URL: https://www.aroraengineers.com/venue-management-platform/

Is implementation complete? Yes

Q**. Implementation name:** Arora Technology Group, LLC – ATLAS Work Management

Date of most recent version: AWM 1.0

Implementation description: ATLAS Work Management provides facilities managers with a mobile platform to help them more efficiently manage asset and venue related data. AWM integrates asset and venue data visually and is able to leverage the IMDF specification to provide visually stunning floorplans with rich venue data.

Implementation URL: https://www.aroraengineers.com/expertise/arora-technology-group/

Is implementation complete? Yes

R**. Implementation name**: KNS - Venuex
Date of most recent version: October 25, 2019
Implementation description:
Venuex provides indoor site surveys and a web-based platform for indoor mapping with SDKs, APIs and a Content Management System (CMS). Venuex works with many shopping center operators, airports, hospitals and hotels.
Implementation URL: https://www.venuex.io/apple-maps/
Is implementation complete? **In Progress**

S**. Implementation name:** Ambiarc
Date of most recent version: October 25, 2019
Implementation description: Ambiarc generates interactive 3D maps from your floor plans, coupled with an SDK, to power digital experiences.
Implementation URL: www.ambiarc.com
Is implementation complete? **Yes**

Select Apps using Guidekick/Ambiarc IMDF and or Apple Indoor Positioning
The National Gallery of Art DC (App Store) IMDF, Apple IPS
Indianapolis International Airport (Web, In-Terminal Wayfinding Kiosk) IMDF
PIER 39 (Web), IMDF
The Pratt Institute (Web, Mobile App) IMDF, App in development

T**. Implementation name**: Locus Labs Inc
Date of most recent version: SDK is current
Implementation description: Provides a content management system for indoor mapping. LocusLabs works with many airports.
Implementation URL: https://locuslabs.com
Is implementation complete? **Yes**
Apps using the Locus Labs SDK leveraging IMDF and Apple Indoor Positioning:

1. American Airlines
2. United Airlines
3. Delta Airlines
4. Port of Seattle
5. Miami International Airport

All three airline apps above leverage Apple Indoor Positioning at one or more of the following airports: AMS, ATL, BNA, BOS, BWI, CLT, DAL, DEN, DFW, DTW, EWR, FLL, GVA, HOU, IAH, JAX, JFK, LAS, LAX, LGA, LGW, LHR, MDW, MIA, MSP, NRT, OAK, ORD, PHL, PIT, SAN, SEA, SJC, SNA, SYD, YEG, YUL, YVR, YYZ, ZRH

U**. Implementation name**: YAP

Date of most recent version: February 2020

Implementation description: YAP specializes in visualization for retail, healthcare, and museums. YAP provides industry-leading mobile app development services with expertise in iOS, Augmented Reality and indoor maps.

Implementation URL: https://yapstudios.com/mapping/

Is implementation complete? **Yes**