DIGITAL TWIN FINLAND
Project proposal for HX industrial participation

PRE-STUDY

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VERSION MANAGEMENT

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ACRONYMS AND ABBREVIATIONS

AFDA	Association of Finnish Defence and Aerospace Industries (PIA in Finnish)
BF	Business Finland
BIM	Building Information Modeling.
bSI	buildingSMART International, a global authority driving the digital transformation of the built asset environment.
C2	Command and control system
CoE-LaSR	The Centre of Excellence in Laser Scanning Research under FGI/NLS
ESA	European Space Agency
ETL	Extract, transform, load
FDF	The Finnish Defence Forces
FGI	The Finnish Geospatial Research Institute (FGI), part of the National Land Survey Finland
FLIC	The Finnish Location Information Cluster, a cluster of Finnish companies in GEO-ICT business.
FTIA	The Finnish Transport Infrastructure Agency
GIS	Geographic Information System.
HXIP	HX industrial participation
HX-OEM	The HX fighter bidders (OEM, Original Equipment Manufacturer) Boeing, BAES, Dassault, Lockheed Martin and Saab
IFC	The Industry Foundation Classes (IFC) data model is intended to describe architectural, building and construction industry data. It is a platform neutral, open file format specification that is not controlled by a single vendor or group of vendors
LOD	level of detail (0-4), determining the detail level of a 3d spatial dataset
LVC	Live Virtual Construct solutions
NLS	The National Land Survey
OEM	Original Equipment Manufacturer
OGC	Open Geospatial Consortium, an international consortium creating standards for geospatial community.
PTAL	Geospatial Platform of the National Land Survey (Paikkatietoalusta in Finnish)
SDI	Spatial Data Infrastructure: a data infrastructure implementing a framework of geographic data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way
Traficom	The Finnish Transport and Communications Agency
VTT	VTT Technical Research Centre of Finland Ltd
VR	Virtual reality
WCS	Web Coverage Service, defines Web-based retrieval of digital geospatial information representing space/time-varying phenomena.
WFS	Web Feature Service interface
WMS	Web Map Service

1 INTRODUCTION

1.1 HX industrial participation (HXIP)

Finland will replace its Hornet fighters by 2030. The bidding process for the procurement is now ongoing. The procurement includes an obligation for industrial participation: the winning bidder and its partners will cooperate with Finnish companies, with the value of the participation being 30 percent of the purchase price.

Successful participation in HXIP can result into growth of competence, networks and technological capability of the Finnish defense, safety and ICT industries.

The industrial participation in the HX fighter program is open to Finnish companies and research organizations. The participation projects must involve technologies that are critical to national safety or related to strategic industrial know-how

The HX fighter bidders (OEM, Original Equipment Manufacturer) include Boeing, BAES, Dassault, Lockheed Martin and Saab. Finnish participants can propose their projects to all these companies, their partners or only to the parties of the Finnish participant's choosing.

Finland is committed to open, equal and non-discriminatory bidding process. The industrial participation solutions offered to Finland will be evaluated carefully and equally in the course of the procurement process

Business Finland (BF) has appointed a HXIP team, led by Markku Lehikoinen, for activating and coordinating the Finnish companies and research organizations in formulating relevant project proposals for the HXIP.

This document describes one concrete project proposal for the HXIP.

Further information about HXIP can be found in the document *Industrial participation in defence procurements* by the Finnish Ministry of Defence (see Bibliography [i]), and in Business Finland website https://www.businessfinland.fi/en/for-finnish-customers/services/programs/hx-fighter-program/.

1.2 HX system needs

1.2.1 Minimum requirement

The acquired fighter system in any case will need 3D map material from Finland and the surrounding areas. For training, simulation and operation planning purposes, this kind of modern, standardized 3D representation of the terrain and infrastructure is a necessity. There must also be a process for updating the material, enriching it from specific areas of interest, and for expanding the geographical coverage of it.

1.2.2 Common requirements of different defence branches

On the other hand, the "Preliminary Assessment for Replacing the Capabilities of the Hornet Fleet"[ii] (2015) emphasizes *"the use of common standardized information systems and communication services for the defense branches"* and, more generally, the use of a common knowledge base for snapshots.

Furthermore, the "Preliminary Assessment for Replacing the Capabilities of the Hornet Fleet" (see Bibliography [iii]) says e.g. the following: *"…the availability of information has been significantly improved by moving to common standardized information systems and data communication services of the defense branches . This allows for efficient and mutually supportive use of the systems of different branches of defense, creating the conditions for increasing the pace of operations ."*

[iv]This is in favor of creating the 3D map of Finland and neighboring areas universal and compatible with other branches of defense and other safety & security authorities.
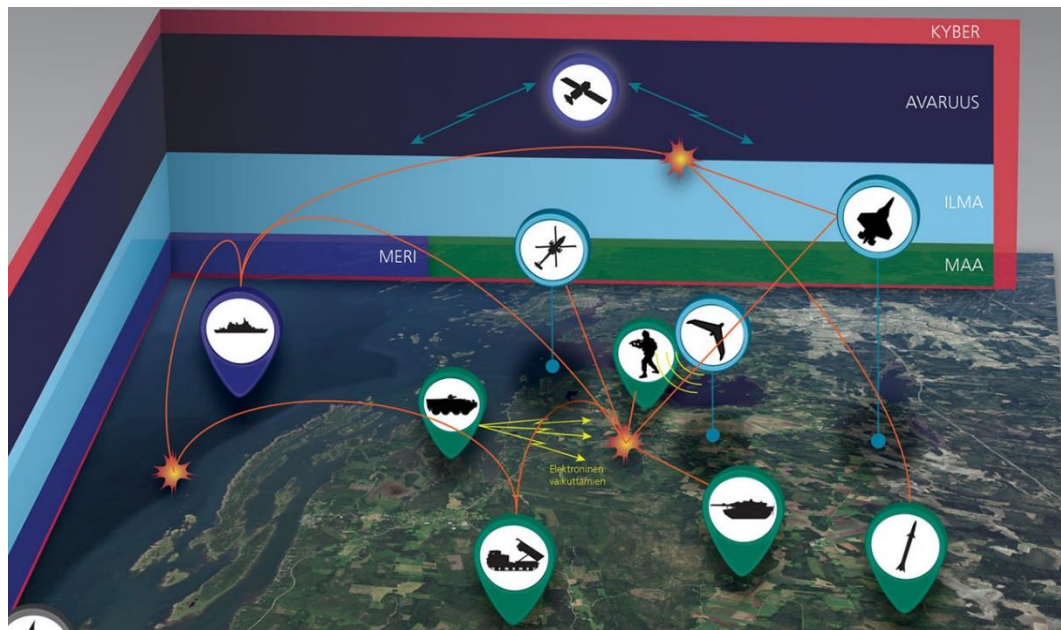
Figure 1-1: A vision of a joint operational picture for all defence branches. Source: FDF, Ruotuväki magazine 4/2018 (See Bibliography)

1.3 Need for joint situational awareness by Finnish security authorities

In the meetings with multiple key officers of FDF and the Finnish Ministry of Internal Affairs, it has become clear that there is a need to create and maintain a Digital Twin of the physical world to be used as a foundation for joint multi domain (land, sea, air, police, fire & rescue, etc.) situational awareness.

The need for creating a **common spatial data platform for security authorities** is strongly written in the "Report on spatial data policy[v]" published by the Ministry of Agriculture and Forestry in 2018. The report has been approved in the Finnish Parliament in November 2018. The vision of the report is: Finland

has the most innovative and secure spatial data ecosystem in the world. The aim of the report is to oblige all actors in the public sector to see to the interoperability of spatial data and access to it in a way that they can be used by the public authorities and companies as efficiently as possible. At the same time a high standard of information security and personal data protection must be ensured. The report describes a natural shift from maps towards a joint 3d representation of the world.

1.4 Methodology and purpose of this pre-study

This pre-study has been prepared in 2019 as a joint effort of a large number of companies, authorities and research institutes, which together form a Finnish business-driven ecosystem that has co-operated already for decades in creating the national and municipal spatial data infrastructures (SDI), geospatial solutions for multiple business vertical including planning & construction, forestry, defence and fire & rescue.

Information for this pre-study has been collected in a series of meetings and workshops with selected key stakeholders and potential members of the suggested ecosystem. The following meetings, discussions and workshops have been held:

- The Finnish Defence Forces:
    - meetings with multiple branches and key stakeholders including the CDO of the Defence Command and the Head of the Topographic Service.

- Ministry of Interior:
    - Director General of Rescue: 30/09/2019

- National Land Survey of Finland:
    - Director General, 03/12/2019
    - Head of the Finnish Geospatial Research Institute (FGI), 10/12/2019
    - Project Director of the Geospatial Platform Project, 26/11/2019

- The City of Helsinki:
    - Chief of ICT development at the Division of Urban Environment until 9/2019

- The companies:

    - Finnish Location Information Cluster (FLIC) workshop with 8 companies: 26/11/2019. The aim of the workshop was to discuss the Digital Twin Finland initiative for HXIP, focusing in the role of FLIC member companies. These companies participated: Sitowise (https://www.sitowise.com/en), Spatineo (https://www.spatineo.com/), Terratec Finland (https://www.terratec.fi/), Karttakeskus / Tapio (https://tapio.fi/briefly-in-english/), CGI Finland (https://www.cgi.fi/fi), Gispo (https://www.gispo.fi/en/home/), Geotrim (https://geotrim.fi) and Mitta (https://www.mitta.fi/en/home/). All 8 companies expressed high motivation and intent to participate in the proposal.
    - Insta DefSec Oy: 25/09/2019

- Other individual companies: Fleetonomy 27/11/2019, Varjo 9/12/2019, Iceye: 12/12/2019, Inplace Systems (multiple dates).

- Research institutes:
  - VTT, 13/12/2019
  - FGI, 10/12/2019

In addition to bilateral meetings, information has been gathered from websites and other written materials.

The **purpose** of this pre-study is to outline a vision for the concrete project proposal that is going to be written in co-operation with the cluster and stakeholders in early 2020. The project proposal will combine the Finnish know-how with the expertise of the HX-OEM and result into clear measurable benefits for a) the FDF, b) the Finnish authorities and largely for the whole society, c) the HX-OEM and d) the business ecosystem.

2 SOLUTION PROPOSED

2.1 The concept of Digital Twin

2.1.1 Background

The concept of Digital Twin has been originally created for mechanical engineering and production, but with the rapid development of IoT and ICT in general it has quickly become a viable vision also in other industries, including urban development and construction.

In his master's thesis[vi] "Digital twin – from mechanical engineering to designing smart cities", Leo Ouni has analyzed how digital twin can be implemented from mechanical engineering and production into GIS environment, urban planning and smart city solutions.

There are many definitions for Digital Twin, including "A dynamic virtual representation of a physical object or system across its lifecycle, using real-time data to enable understanding, learning and reasoning" by Bolton, McColl-Kennedy, Cheung, Gallen, Orsingher, Witell & Zaki, (2018).[vii]

The concept of Digital Twin has been recognized as a potential vision also in defence sector, especially in command & control systems, training (including LVC solutions) and in decision support.

2.1.2 Static and dynamic information

When discussing Digital Twin, it is important to understand that there are two categories of information in Digital twin: static and dynamic. Both of these have to be managed in order to achieve the real digital twin of anything.

In this project proposal the goal is to create an automated process that results into a digital twin of the static world: terrain, infrastructure (above ground and underground) and buildings. Weather, road conditions, traffic and locations of vehicles or individuals are dynamic information that must be captured via IoT systems. A combination of static and dynamic results into a digital twin.

2.2 The globally leading Finnish expertise

The Finnish companies and research institutes unquestionably have the world's leading capability to model, manage and share built environment and terrain in a standard and consistent way. The concept of "Digital Twin of the physical environment" has been created by Finnish GIS and BIM centers of excellence and there is a global demand for this expertise in the construction industry and many other business verticals.

Figure 2-1: A digital twin of Pasila district in Helsinki, Finland, as a fusion of GIS and BIM information including future timeline until 2023. Credit: City of Helsinki and Sitowise.

2.2.1 Digital twin concept developed in urban development

One of the key competencies of the proposed business and research ecosystem is to combine detailed three-dimensional building information models (BIM) with national and municipal spatial data sets (GIS). This capability has been developed in urban planning and construction industry.

An **automated process** to produce this combination in any given geographic location globally is a **core goal of this proposal**.

This concept of Digital Twin has been developed and jointly delivered by the Finnish public/private ecosystem to many business verticals, including urban planning and construction and asset & facility management.
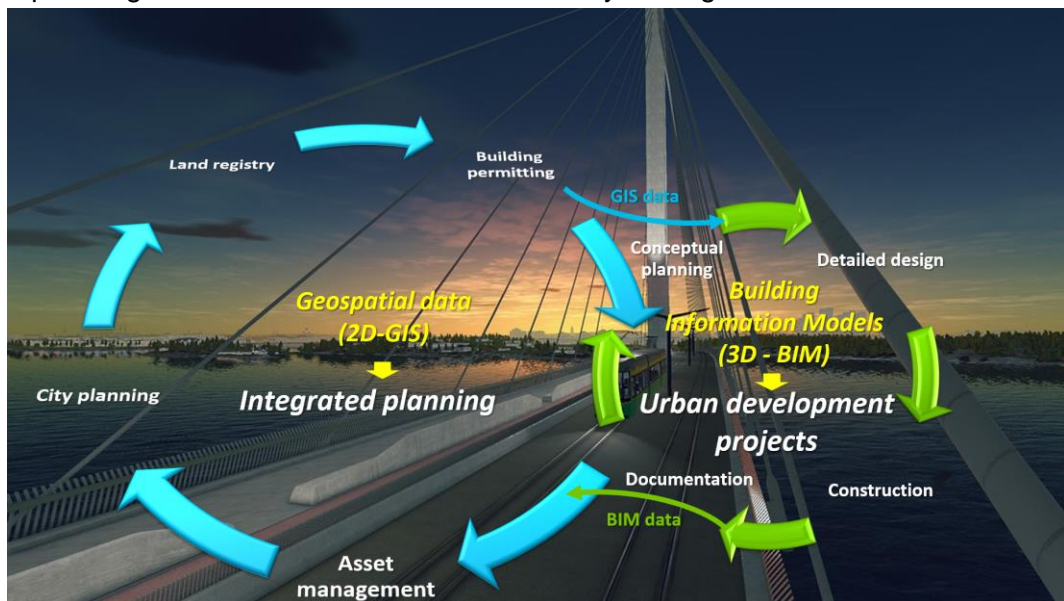

Figure 2-2: Approach for utilizing the concept of combining GIS & BIM information developed in urban planning

The core of the proposed approach is in utilizing data that already exists and enriching it from where data does not exist. On national and city level there are plenty of geospatial **GIS** datasets that are generated and used in public processes and GIS systems on national and municipal level. Some of the companies specialized in providing these solutions, and working with geospatial data are Spatineo, Karttakeskus, CGI, Gispo, InPlace and Sitowise, among others.

In processes of urban development (conceptual planning, detailed design and construction) the concept of Building Information Modeling (**BIM**) is globally used. Majority of all new buildings and infrastructure are planned and constructed by using BIM data. In other words, there is a lot of detailed, well-structured and growingly standardized 3d data about built environment available, but it is not used for other purposes than planning and construction. Some companies specialized in this include Sitowise, Infrakit, Novatron and Destia.

2.2.2 Earth observation capabilities

In Finland there is a very active network of companies and research institutes that focus in earth observation, space technology, LiDAR and other reality capture technologies. In addition, there is a lot of research and development in applying AI/ML for automated object recognition and modeling. Companies working on this field include ICEYE, Terratec, Mitta and Geotrim.

The Finnish research institutes, e.g. the Finnish Geospatial Research Institute (FGI) are recognized as global thought leaders in modeling or physical environment with LiDAR technology.

VTT is the leading innovation center e.g. for Remote Sensing and Artificial Intelligence based solutions for Earth Observation. With over 2000 researchers, and over 75 years of experience of top-level research and science-based results VTT s part of Finland's innovation system and operates under the mandate of the Ministry of Employment and the Economy.

2.3 Global standardization of real-world modeling

This process of creating Digital Twins of physical environment is based on international standards for spatial and building data management. There are two important organizations creating these standards: Open Geospatial Consortium (OGC, https://www.opengeospatial.org/) and buildingSMART International (bSI, https://www.buildingsmart.org/). OGC's standardization focuses in geospatial data (GIS), and bSI in BIM (building information model) data. During the last 2-3 years OGC and bSI have started to specify standards with a holistic approach, aiming at a joint standard for storing and exchanging GIS and BIM information globally. The latest standardization development include extension for the IFC (Industry Foundation Classes) data model.

Figure 2-3: The global organizations leading the way for built environment information standardization

2.4 Target

2.4.1 Business vision

Short-term (ca. 2021-2023): The ecosystem will supply the Digital Twin Finland data and its maintenance process, essential for the use of the new HX system purchased in Finland, as part of HXIP or industrial cooperation, enriched with the added value of OEM. The end result will be a joint reference data for situational awareness systems of all security authorities, crucial for national security.

The longer-term target (2022-2030) is to export the Digital Twin concept to the global market by integrating it with the portfolio of the HX-OEM. The aim is also to enrich the concept with OEM expertise and products. The target is at least € 1 billion in business for Finnish companies.

2.4.2 Process flow

As shown in Figure 3-3, the process flow can be divided into the following phases:

- Source data provision
- Source data aggregation and management
- Complementary data collection
- Sharing data via interfaces
- Using the data
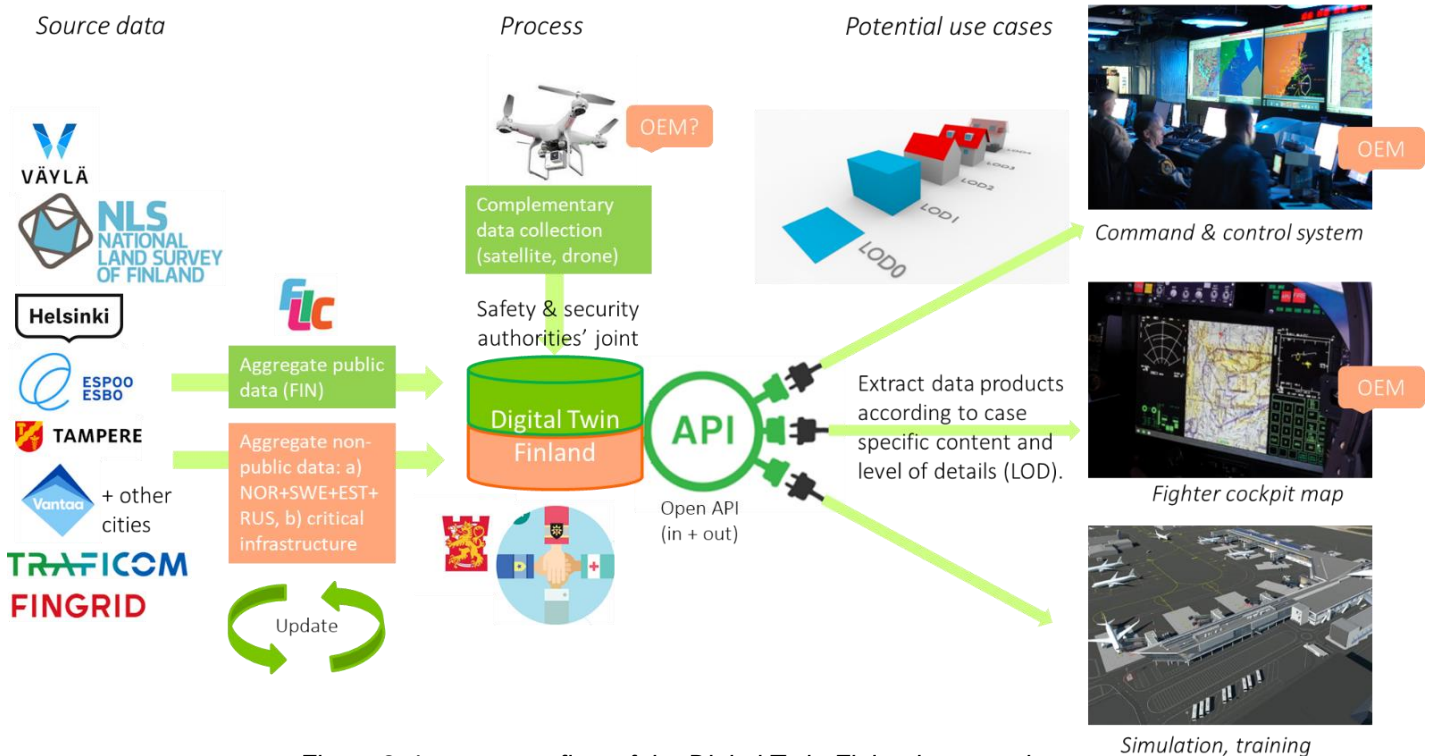
Figure 2-4: a process flow of the Digital Twin Finland proposal

Each phase and the consortium in contribution to it is described in the next Chapter 4 "Consortium, stakeholders and their roles".

3 CONSORTIUM MEMBERS AND ROLES

3.1 Coordinator / prime

The consortium needs a lead company that will work as a prime and/or coordinator in all actions related to the project. This company needs to be a partner of the Finnish defense forces. This company should be interested in investing in developing new technology and solutions for modeling of nature and built environment.

3.2 The triple helix model

The triple helix model of innovation refers to a set of interactions between academia, industry and governments, to foster economic and social development[viii].

In Digital Twin Finland project, this model is a very natural framework, within which the necessary research, business development and role of governmental authorities have a mutual goal: to result into a new concept for the benefit of whole Finnish society and for the HX project and its stakeholders.

Figure 3-1: The triple helix model

3.3 Source data providers

As building blocks for the Digital Twin, the plan is to use all existing public and non-public spatial data that is relevant for security authorities and the HX system. In Finland much of the spatial data is open and can be accessed on

national and regional level from open interfaces (WCS, WMS, WFS) and geo-portals (file downloads).

3.3.1 National level data

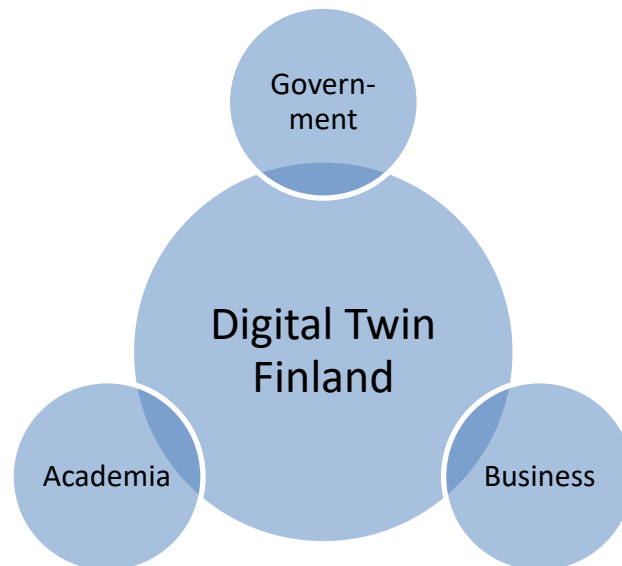On **national level** some of the most relevant data providers for this proposal are:

3.3.1.1   The National Land Survey

The National Land Survey (NLS, https://www.maanmittauslaitos.fi/en) manages topographic data from the entire Finland. NLS datasets contain, for example, place names, roads, buildings, waterways, fields, topographic features and elevations as well as administrative boundaries.

NLS provides all their data for the benefit of whole society via different channels, re-sellers and platforms.

NLS has expressed interested in participating in the project as provider of the national spatial data, and the digital framework including the open interfaces to access the national spatial data, and the new Geospatial Platform ("Paikkatietoalusta" or PTAL in Finnish). PTAL could act as a national framework in terms of data aggregation from municipalities and other national and regional spatial data providers to a national platform. NLS sees this initiative as the first step towards a joint spatial data platform of Finnish safety & security authorities, which was highlighted in the "Report on spatial data policy" by the Ministry of Agriculture and Forestry, as referred to in chapter 2.3.

In addition to spatial data content, NLS can provide national frameworks, guidelines and standards for data and metadata model and implementation, as well as for data quality control.

3.3.1.2   The Finnish Transport Infrastructure Agency (FTIA)

FTIA (https://vayla.fi/web/en) provides the most comprehensive data about traffic networks and their attributes and status, including road, railway and waterway network and infrastructure.

3.3.1.3   The Finnish Transport and Communications Agency (Traficom)

Traficom, https://www.traficom.fi/en/, is an authority in licence, registration and approval matters. It promotes traffic safety and the smooth functioning of the transport system and ensures that everyone in Finland has access to high-quality and secure communications connections and services. Traficom hosts and further develops a national database of critical infrastructure such as electricity, water and communication networks.

3.3.2 Public and non-public data

Part of required spatial data from Finland and the neighboring countries is public and available as open data. However, data outside of Finland, and especially data about critical infrastructure is non-public. These non-public data

should be accesses with separate data sharing agreements with the data own-
ers.

Management of non-public data within FDF, and the framework for granting ac-
cess to it must be considered and solved during the implementation of this pro-
ject.

3.3.3 City level data

Cities host major spatial data assets of the terrain and infrastructure within
their territories. For example, cities of Helsinki, Espoo, Vantaa and Tampere
publish their 3d city model via open interfaces.

For example, City of Helsinki offers over 600 layers of open spatial data via ge-
oportal https://kartta.hel.fi/, including LiDAR data for the city and the City Model
as two versions: structured CityGML model and as a triangle mesh model.
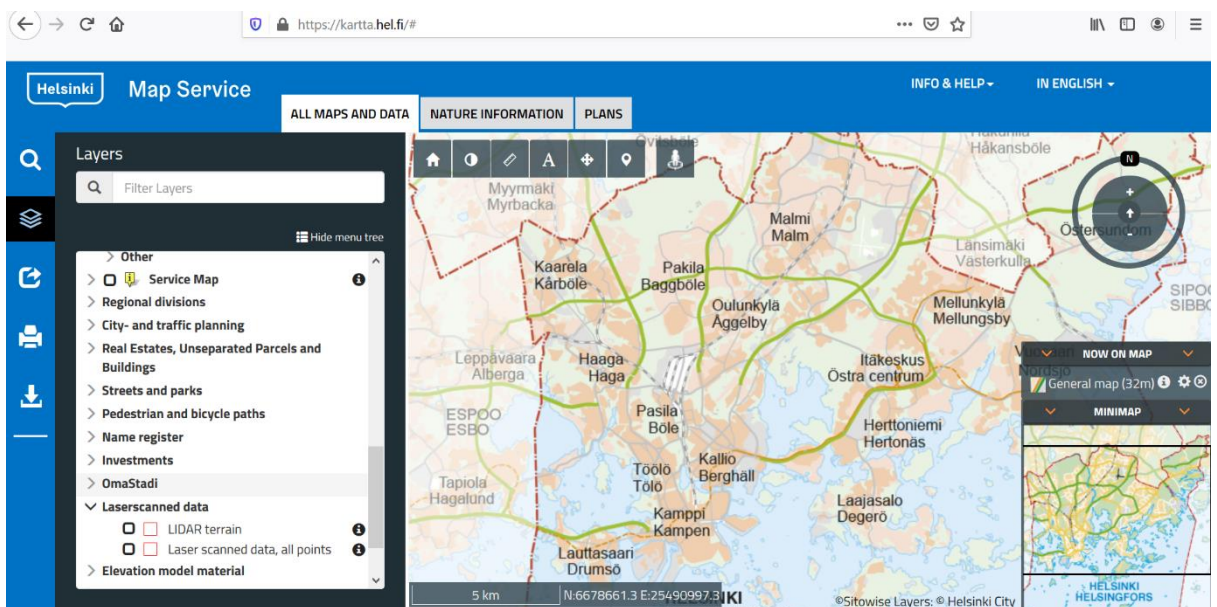
*Figure 3-2: Map service of City of Helsinki, providing 600 open data layers as source data for the Digi-
tal Twin*

3.4   Solution providers for data aggregation and man-
agement

As described in Chapter 3.2, the source spatial data is aggregated into a cen-
trally organized spatial database "Digital Twin Finland" with an ETL (extract,
transform, load) process.

The "Digital Twin Finland" database will have a data model that is compatible
with the national and international standards specified by the Open Geospatial
Consortium and buildingSMART International.

This process makes use of all relevant national and municipal frameworks (e.g.
Land Survey's Geospatial Platform, and open data services of the cities).

It is important to emphasize that there is a need to automate this process, to be able to run it with any given frequency.

This part of the process is going to be developed by the companies of the Finnish Location Information Cluster (Flic), and some other companies with specialized capabilities: Sitowise (https://www.sitowise.com/en), Spatineo (https://www.spatineo.com/), Karttakeskus / Tapio (https://tapio.fi/briefly-in-english/), CGI Finland (https://www.cgi.fi/fi), Gispo (https://www.gispo.fi/en/home/), Trimble (https://www.trimble.com/, https://localgov.trimble.com/trimble-locus.html) as well as other member companies of Flic Other potential companies include Fleetonomy (https://fleetonomy.io), with focus in automated creation of digital twins.

The Finnish Location Information Cluster (FLIC)

Finnish Location Information Cluster (https://www.flic.fi/in-english/) is founded in 2013 as a co-operative body for companies in GEO-ICT business. The aim of the cluster is to encourage businesses in the field, to ensure the development of competence, support the internationalization and clarify the roles of the public and private offering of services. FLIC is a member of the Technology Industries of Finland (Teknologiateollisuus, https://teknologiateollisuus.fi/en/technology-finland).

3.5 Solution providers for complementary data capture

With rapid development of earth observation technology including new sensors, LiDAR, SAR, micro-satellites, and drones, it is possible and straightforward to map any area of interest anywhere in the world quickly, reliably, precisely, cost-efficiently and frequently. As the business plan is to ramp up the concept in Finland, and then deliver it together with the HX-OEM to other markets globally, this capability is crucial. The Finnish research institutes and companies are forerunners in this domain.

Some key competencies of the Finnish ecosystem include:

- globally leading research in LiDAR applications
- expertise in SAR technologies; hi-resolution and frequent reality capture
- fast, flexible and frequent satellite EO capability
- accurate and detailed satellite SAR data
- ability to automatically detect objects from LiDAR, photogrammetry & SAR

Some of the companies focusing in this domain are:

- ICEYE (https://www.iceye.com/)
- Terratec Finland (https://www.terratec.fi/)
- Geotrim (https://geotrim.fi)
- Mitta (https://www.mitta.fi/en/home/)
- Space Systems Finland (https://www.ssf.fi/)

A strong support for this part of the process is provided by the Finnish research institutes including FGI, VTT, Aalto University and University of Helsinki.

3.6 Data managers and distributors

Managing access to different data (public, non-public, classified) will have to be solved. Between different stakeholders of FDF and of other security authorities it must be agreed on which organization will host the data and provide access to it. This pre-study does not provide a solution for that challenge, but it must be discussed and agreed on when starting to plan and implement Digital Twin Finland.

Another issued to be discussed and agreed on is where and by which organization the Digital Twin Finland database will be hosted.

3.7 Users of the data

Figure 3-3: Concept of LOD (level of detail)

For each use case, a certain content with a certain level of detail (LOD) is needed. The aim is to have a portal with a web coverage service (WCS) showing what kind of data (which LOD level) is available spatially. For example, if there will be a map display in the HX cockpit, LOD0 or LOD1 data will serve the purpose. But it there is a rescue operation in a specific building, LOD4 is needed.

If the required LOD level is not available, there should be a standard operating procedure (SOP) for acquiring one with a given delivery time and cost.

3.7.1 Command and control (C2) system providers

The Finnish defence, aerospace and security industry is represented by AFDA, the Association of Finnish Defence and Aerospace Industries (https://pia.teknologiateollisuus.fi/fi/node/60). AFDA covers almost all the defence related industries in Finland with ca. 120 member companies. AFDA has close relations with the Finnish Ministry of Defence and Defence Forces. AFDA is the focal point to defence industries in Finland.

Under AFDA there are many companies providing command & control systems, including Insta (https://www.insta.fi/en/industries/defence), InPlace Systems (https://www.inplace.fi/), Patria and many others.

The *Digital Twin Finland* project provides consistent base data for new kind of live, virtual and constructive (LVC) simulations, which are provided by Finnish C2 providers such as Insta.

In addition, there are C2 systems used also in fire, rescue and police operations. These systems can benefit from the same data.

There is strong synergy between *Digital Twin Finland* cluster/project and a new business cluster for *Situational Awareness* solutions coordinated and ramped up during 2019 by Business Finland. These two clusters complement each other.

3.7.2 HX system, including fighter cockpit

Obviously for operation planning, operation, navigation, training and simulation purposes, a comprehensive 3d map material is needed. This is one, but not the only one, use case for the Digital Twin Finland solution.

3.7.3 Simulator and training system providers

3.7.3.1   Existing simulator systems

Different branches of FDF have existing simulator environments that would benefit from a systematic content provision system. Some examples of current simulator platforms in FDF are:

- Virtual Battlespace (https://www.bisimulations.com/products/vbs3)
- Saab Ground Combat Indoor Trainer (https://saab.com/land/training-and-simulation/virtual-training/ground-combat-idt/)

In addition, navy, air force and army all have multiple other branch specific simulation systems.

With help of Digital Twin Finland project, all these systems could consume the same, joint source data, which would add to **increased cross-domain situational awareness** and **cost-efficiency**.

3.7.3.2   New, revolutionary VR technology providers

Since Finnish companies produce some of the globally most popular games, there is substantial game and virtualization competence in Finland.

For example, Varjo (https://varjo.com/) is a Finnish company that develops human-eye resolution VR and XR products. Varjo creates new kind of immersive computing, where virtual, augmented and physical realities become one.

Another example is Imagesoft (https://imagesoft.fi/), providing high quality maritime simulation systems.

From the perspective of VR system providers, the Digital Twin Finland initiative offers a solution for automated production of high-resolution virtual models of the physical world, thus providing content VR equipment not only in defence industry but for all other businesses such as urban planning and construction.

3.7.4 Other use cases

In addition to needs in C2 systems, HX system and in simulation & training activities, all defence branches (**land, sea, air**) have other processes and needs where a joint Digital Twin Finland would be a valuable asset

In **fire & rescue** preparations, planning and operations, there is a natural need for accurate (LOD4) 3d models of buildings. Digital Twin Finland will offer a standard framework for accessing relevant data for these processes, all the way to LOD4.

3.8 Research institutes

As mentioned in chapter 3.2.2., there are world class research institutes that focus in earth observation, space technology, LiDAR and other reality capture technologies. In addition, there is a lot of research in applying AI/ML for automated object recognition and modeling.

Additionally, in the past few years the NewSpace sector has emerged fast and Finland has become one of the leading countries with range of start-ups and growth companies developing innovative space businesses.

Among others, the following institutes do business-driven world-class research:

3.8.1 VTT

3.8.1.1 Capabilities

With over 2000 researchers, VTT (https://www.vttresearch.com/) is the leading innovation center e.g. for Remote Sensing and Artificial Intelligence based solutions for Earth Observation.

VTT has been in space business more than 30 years. VTT is a strategic partner for European Space Agency (ESA) to develop e.g. beyond 5G terrestrial and satellite integration.

In November, 2019, VTT announced partnership with Viasat, the leading GEO satellite broadband operator. VTT will develop with Viasat 5G Non-terrestrial and terrestrial integration. Focus is in Norther European markets and Applications like Autonomous Systems and Solutions for the Arctic region.

Two satellites are orbiting currently with VTT's Hyperspectral payloads. The Reaktor Hello World has the first infrared hyperspectral ever to be flown on a nanosatellite. VTT delivers the World's smallest commercial advanced hyperspectral imager enabling, e.g. Earth Observation of mineral compositions, waste & ocean monitoring, agriculture and geology.

VTT also develops Hypersepctral solution to the HERA-mission, i.e. part of the international 'Asteroid Impact Deflection Assessment' experiment.

3.8.1.2   *Potential role in the project*

- To collaborate with Finland based industrial and advanced technology providers in developing novel AI, analytics, and e.g. next generation Positioning, Navigation and Timing solutions meeting the most demanding needs.
- VTT is leading the 5G & Beyond Non-terrestrial/Terrestrial Pre-Commercial development in Europe, which could be a core technology for Ultra Low Latency and Standards based Secure Wide Area Networking.
- VTT has advanced sensors, which we could tailor or further develop to meet the sensing needs and specified use cases, e.g. Radars, Hyperspectral Imaging.
- Testing and measurements development using VTT's unique R&D infrastructures and world leading knowhow.
- Connectivity technologies complementing existing solutions could be made commercially available, e.g. Silicon Photonics based 100+Tbit/sec cloud processing new ICT solutions.
- VTT has been the leading contributor to e.g. LuxTurrim5G, an unique Smart Cities Platform concept, incl. UAVs and Surveillance. The new phase (Neutralhost) studies new business models and could be relevant to further develop.

VTT is a close partner of FDF.

3.8.2 The Finnish Geospatial Research Institute (FGI)

The Finnish Geospatial Research Institute (FGI, https://www.maanmittauslaitos.fi/en/research) conducts innovative research and expert work within the field of spatial data. The esteemed international research institute offers reliable information for the benefit of society.

Regarding Digital Twin Finland project, some of the most relevant research domains of FGI are:

- Centre of Excellence in Laser Scanning Research (CoE-LaSR, https://laserscanning.fi/): indisputably one of the world's leading competence centers that create new knowledge, science, openings and breakthroughs in the emerging field of laser scanning. CoE-LaSR is home of more than 30 Dr.Sc and PhD's and is funded from Academy of Finland Centres of Excellence programme.
- DroneFinland (https://dronefinland.fi/in-english/): a research and innovation center for drone remote sensing.
- Pointcloud (https://pointcloud.fi/in-english/): focuses on the use of 3D measuring technique known as laser scanning, and thereby creates preconditions for the growth of the Finnish 3D industry.

FGI is a close partner of FDF.

3.8.3 Aalto University, Department of Built Environment, Geoinformatics

The Department of Built Environment is an active research partner of FDF, having conducted extensive research e.g. about situational awareness and use of geoinformatics in it.

The research areas of the Geoinformatic group include:

- Geodesy
- Geoinformation technology
- Digital photogrammetry
- Laser scanning and Remote sensing.

More information and reference studies can be found in:
https://www.aalto.fi/en/department-of-built-environment/geoinformatics.

3.8.4 Other research institutes

Relevant research for the context of this pre-study is conducted by many other institutes including the University of Helsinki (e.g. spatiotemporal data analytics), and University of Oulu (BIM research).

3.9 The Finnish Defence Forces

3.9.1 Processes

HX project will have impact to multiple branches of FDF. The following is to clarify the roles of some branches and processes of FDF:

- **Training and simulation**: In the Defence Command there is an existing cross-domain strategy and roadmap for training and simulation systems and processes. In order to maximize the benefits of *Digital Twin Finland* project, the concrete objectives of it should be aligned with existing roadmap of FDF.

- **Command and control** in different branches (air force, navy, army, cyber, space): The Defence Command coordinates the C2 development in FDF, and provides a joint service architecture for it. Within the architecture, topographic data is one of the core datasets that is utilized in many processes.

- **The Air Force** has a key role in operating the HX system. Roles and responsibilities in data management and dissemination must be discussed and agreed on during the implementation of *Digital Twin* Finland project.

3.9.2 Links to other governmental authorities

To maximize the impact of *Digital Twin* Finland, link to other governmental authorities is crucial. Especially two links are important: 1) **Fire & rescue & police & border security & customs**: the goal should be a joint solution for all security authorities and 2) the roadmap of **National Land Survey** as the official producer and aggregator of nationwide spatial data should be closely linked with *Digital Twin Finland* roadmap, to avoid duplicate investments. As stated in chapter 2.3, the "Report on spatial data policy[1]" published by the Ministry of Agriculture and Forestry and approved by the Finnish Parliament in 2018, calls for governmental co-operation.

3.9.3 Data security

As the plan is to include both public and non-public data in *Digital Twin Finland*, it is crucial to have a plan for data governance and security. Security can be an issue for specific source data, or for an algorithm-processed data even when it is built from open data.

Additionally, the non-public data must be transferred via restricted network, which adds to complexity and must be taken into account in planning and implementation of *Digital Twin* Finland.

3.10 OEM

It is expected that the selected original equipment manufacturer (OEM) has valuable intellectual knowhow they can provide for the project.

The proposed project should be seen as a joint effort to which each party has a contribution. For the context of this project proposal, all five OEM candidates have strong capabilities and resources. For example, software and technologies for "**rapid mapping**" and **earth observation** can be seen as added value from the OEM to the project.

In addition, all five OEM candidates have a strong **global market position**, not only in defence business. This can provide new market opportunities for the Finnish ecosystem globally. **Virtual reality** and **simulation** technologies combined with the Finnish VR/AR/XR competence could be mutually beneficial.

A more comprehensive benefit analysis should be made during the first quarter of 2020 when this pre-study is developed to a more concrete commercial proposal.

4 BENEFITS

It must be emphasized that this is a pre-study, and the benefit analysis at this point is not complete. During the bidding process in 2020 this pre-study and its added value to the consortium and stakeholders must be given a deeper analysis. The benefits identified at the pre-study phase can be summarized as follows.

4.1　For the Finnish Defense Forces

Already the preliminary study on the replacement of Hornet fleet performance (2015) says e.g. the following: "…the availability of information has been significantly improved by moving to common standardized information systems and data communication services of the defense branches. This allows for efficient and mutually supportive use of the systems of different branches of defense, creating the conditions for increasing the pace of operations".

In other words, the FDF sees this project initiative of high value, and it has been confirmed by multiple key stakeholders of FDF in the discussions related to this pre-study.

4.2 For the Finnish society

As mentioned in the Introduction chapter, the need for creating a **common spatial data platform for security authorities** is strongly written in the "Report on spatial data policy[ix]" published by the Ministry of Agriculture and Forestry and approved by the Finnish Parliament in 2018. Goals of the Digital Twin Finland project proposed in this pre-study are exactly the same as what the report calls for.

In other words: if project *Digital Twin Finland* will be included in HXIP, it will directly benefit the Finnish security authorities (military, police, fire & rescue, border control etc.) by providing a digital asset that is significant for national security and would have to be invested in regardless of HXIP contribution.

4.3 For Finnish companies

4.3.1 Generic benefits of HXIP

As stated in Business Finland HXIP website[x], the industrial participation in the HX fighter program will provide Finnish companies and research organizations with new, international business opportunities. In addition, the participation will strengthen the competence and abilities of the selected project partners and Finland in terms of technologies that are critical to national safety.

Among other things, the benefits to the participants may include:

- Long-term, global partnerships and customers
- New markets, licenses and certificates
- Additional competence and training provided by world-class professionals
- Differentiating from the competitors
- Access to latest research
- Software and technologies as technology transfers
- Profiling as industry forerunners to entice more skilled people

4.3.2 Concrete opportunities identified by the companies

- Many governmental authorities need exactly this project, which means business opportunities **largely in the Finnish society**. Concretely, this could become "The Spatial Data Infrastructure for Safety & Security Authorities", as stated in the "Report on spatial data policy[1]" published by the Ministry of Agriculture and Forestry and approved by the Finnish Parliament in 2018
- The **cluster is already tested** in other business verticals, it is not only ramped up for HXIP nor only for defence sector. This means there is a credible consortium already in place, which can expand internationally to many business verticals. This growth plan could potentially be speeded up with a Business Finland funding instrument.
- As all HX-OEM candidates have business also in other verticals than defence (e.g. smart city, urban planning, intelligent and autonomous traffic), the door is open to co-operation between the OEM's and the Finnish ecosystem in **any business vertical and in any geographic market area**.
- This *Digital Twin* Finland project can potentially ignite development of completely **new products and services** that cannot be yet foreseen.

- By applying the latest satellite/drone/photogrammetry/LiDAR technology & AI/ML, the consortium could create a fully automated global workflow for "digital twinning", which would **revolutionize** the production and create a strong competitive edge for the consortium globally.
- This project should not only be seen as a data processing challenge, but instead as an opportunity to deploy **automation, AI/ML**, real digital twin understanding from other verticals, and many other **value-added services**.
- The concept should be immediately **global**.

4.4 For Finnish research institutes

With help of OEM, the Finnish research institutes have access to additional applicable state-of-the-art research, as well as wider global networks and partnerships.

In addition, almost all of the opportunities identified by the companies (see 5.1.2) are very applicable to the research institutes.

4.5 For the OEM and its partners

The OEM can take advantage of Finnish excellence described in this pre-study, thereby strengthening the overall HX supply and its export opportunities to other countries globally.

As all OEM candidates have business also in other verticals than defence (e.g. smart city, urban planning, intelligent and autonomous traffic), the door is open to apply the joint competence of the consortium into any business vertical and in any geographic market area.

The closer the co-operation with the OEM and the Finnish business ecosystem is, the more OEM can benefit from it. One way for the OEM to join closely the Finnish business ecosystem could be establishing a branch in Finland.

After this pre-study the benefits for stakeholders must be analyzed on a more concrete level in early 2020.

5 INITIAL BUSINESS PLAN

5.1 Business targets

Chapter 5.1.2 lists concrete business opportunities for the companies. Including all targeted business verticals, the consortium *Digital Twin Finland* should aim at a revenue level of 1 Billion USD globally, together with the HX-OEM.

5.2 Action points 2020

During 2020 HXIP proposals will be developed into concrete and detailed enough project proposals. The following steps can be seen for the *Digital Twin Finland* proposal:

1) Introduce this pre-study to all HX-OEM's. (Q1)

2) A joint workshop to specify concrete goals and launch plan for the business ecosystem, focus in all business verticals and market areas. (Q1)

3) Process the pre-study into a detailed commercial proposal, including a project plan with budgets and timetables. (Q1)

4) Initiate an ongoing dialogue about this pre-study with the HX-OEM's, FDF, BF and the consortium. (Q1-Q2)

5) Create a high-level business plan covering all business verticals and targeted market areas. (Q1-Q2)

6) Commercial negotiations and contract agreements. (Q3-Q4)

This initial plan will be incrementally refined in 2020 as the HXIP process moves on.

SITOWISE IN SHORT

Sitowise is a specialist consulting company with 1,700 personnel that provides its customers the full range of built environment services from planning to expert and digital services under the same roof. We are one of the largest planning and consulting agencies in the construction industry in Finland, the leading expert in diversified urban projects, and a pioneer in data-driven management and data modelling. Our comprehensive services generate new and repair old - thus creating a sustainable and intelligent living environment.

Our actions are based on a deep understanding of our customers' requirements, wishes and expectations. We offer comprehensive services from a single address throughout the entire construction life cycle:

- Planning and consultancy services for entities that develop infrastructure and the living environment
- Extensive advisory services for new-build and renovation sites in the house-building sector
- Comprehensive project management services for planning, initiating, implementing and maintaining building projects
- Cost-efficient asset management and mobility processes with digital services including GIS and BIM competencies.

We have offices close to our customers at 27 locations in Finland, Sweden, Estonia and Latvia. We have the strongest project expertise in the sector and a wide-ranging, high-quality service offering, enabling us to create the solutions that will build a sustainable future.

Facts about Sitowise:

- The fourth largest design and consultancy company in the field of the built environment in Finland
- More than 40 years' experience and 90,000 successful projects
- 1,700 infrastructure and house-building experts in Finland, Sweden and Baltic countries
- Operations in 21 locations in Finland: Espoo, Helsinki, Joensuu, Jyväskylä, Kotka, Kouvola, Kuopio, Lahti, Lappeenranta, Mikkeli, Oulu, Pori, Pornainen, Raisio, Rovaniemi, Salo, Savonlinna, Seinäjoki, Tampere, Turku, Vaasa
- Subsidiaries in Sweden, Estonia, and Latvia
- Owned by personnel working for the company and by Intera Partners, a private equity investor

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