Project Proposal Cover Page

To: Israel-U.S. Binational Industrial Research and Development Foundation

From: Israeli Company: KITOV SYSTEMS LTD

Office Address -	Mailing Address -
Kitov Systems	17 Ha-Mefalsim St,
Intergreen Building	PO Box 3070
17 Ha-Mefalsim St,	Petah-Tikva
Petah-Tikva 4951447	4951623
Israel	Israel
Telephone No. +972-3-3731355	
Fax No. +972-3-3731355	

From: U.S. Company: CAPVIDIA NA LLC

Office Address -	Mailing Address -
1700 Post Oak Blvd.	1700 Post Oak Blvd.
Suite 600C	Suite 600C
Houston, TX 77056 USA	Houston, TX 77056 USA
Telephone No. +1-832-280-8685	
Fax No. +1-832-572-5394	

Project Title: CAD2SCAN - – Product Design to Visual Inspection Automation

Project Duration: 18 months

Project Budget: $ 1.51M

	Israeli Company	U.S. Company
Submitted by:	Authorized Company Official	Authorized Company Official
Signature:	______________________	______________________
Printed Name:	Dr. Yossi_Rubner	Daniel Campbell
Title:	CTO	VP, Model-Based Definition
E-mail:	yossi.rubner@kitov.ai	dc@capvidia.com
Date Submitted:	Oct-14, 2020	Oct-14, 2020

B. Table of Contents

B1. List of Abbreviations

Abb.	Description
CAD	Computer-Aided Design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design
CoGQ	Cost of Good Quality (CoGQ) manufacturer prevention costs incurred from activities intended to keep production lines failures to a minimum. These can include, but are not limited to, such as: Establishing Product Specifications; Quality Planning; New Product Development and Testing; Development of a Quality Management System (QMS); Proper Employee Training; Incoming Material Inspections; Process Controls; Quality Audits; Supplier Assessments.
CoPQ	Cost of Poor Quality (CoPQ) are costs associated with defects found during production (internal failure) or after the customer received the product (external failure). Internal failures may include, but are not limited to, the following examples: Excessive Scrap; Product Re-work; Waste due to poorly designed processes; Machine breakdown due to improper maintenance; Costs associated with failure analysis. External Failures may include, but are not limited to, the following examples: Service and Repair Costs: Warranty Claims; Customer Complaints; Product or Material Returns; Incorrect Sales Orders; Incomplete BOMs; Shipping Damage due to Inadequate Packaging
MBD	Model-Based Definition (MBD) is the practice of using 3D models (such as solid models, 3D PMI and associated metadata) within 3D CAD software to define (provide specifications for) individual components and product assemblies. The types of information included are geometric dimensioning and tolerancing (GD&T), component level materials, assembly level bills of materials, engineering configurations, design intent, etc. By contrast, other methodologies have historically required accompanying use of 2D engineering drawings to provide such details.
PDM	Product data management (PDM) is the use of software to manage product data and process-related information in a single, central system. This information includes computer-aided design (CAD) data, models, parts information, manufacturing instructions, requirements, notes and documents.
PMI	Product and manufacturing information (PMI) conveys non-geometric attributes in 3D computer-aided design (CAD) and Collaborative Product Development systems necessary for manufacturing product components and assemblies. PMI may include geometric dimensions and tolerances, 3D annotation (text) and dimensions, surface finish, and material specifications. PMI is used in conjunction with the 3D model within model-based definition to allow for the elimination of 2D drawings for data set utilization.
QIF	The Quality Information Framework (QIF) is a unified XML framework standard for computer-aided quality QIF systems, available free to all implementers. QIF enables the capture, use, and re-use of metrology-related information throughout the Product Lifecycle Management (PLM) and Product Data Management (PDM) domains.
TRL	Technology readiness level (TRL) are a method for estimating the maturity of technologies during the acquisition phase of a program, developed at NASA

Abb.	Description
	during the 1970s. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology.
XML	Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. The World Wide Web Consortium's XML 1.0 Specification of 1998 and several other related specifications—all of them free open standards—define XML.

B2. List of Figures

C. Executive Summary

	Israeli Company	U.S. Company
Full company name (as appears on the Certificate of Incorporation)	KITOV SYSTEMS LTD.	Capvidia NA LLC
Company locations (headquarters and relevant division address, including full street address, state, city, zip code) – not only P.O. Box	Kitov Systems Intergreen Building 17 Ha-Mefalsim St, Petah-Tikva 4951447 Israel	1700 Post Oak Blvd. Suite 600C Houston, TX 77056 USA 22013 County Road 22 Sleepy Eye, MN 56085
Company website	www.kitov.ai	www.CAPVIDIA.COM
Year established	2014	2001
Revenues: most recent fiscal year	$1.3 million	$1.3 million
Increase / (Decrease) over previous year	30%	-13%
Number of employees	27	5
Ownership (Public / Private)	Private	Private
For private companies: comprehensive list of investors (may be sent to BIRD separately)	Hahn Automation (27%), GiTV (3%),	Capvidia NA LLC was entirely funded privately by Tomasz Luniewski and is now self-funding
Percentage ownership of the company by the other company	NONE	NONE
Relationship of the companies – - Parent/Subsidiary - Common Ownership - No common relationship - Other	No common relationship	
Number of previous BIRD projects	0	0

Israeli Company Registration Number	515108058
U.S. Company DUNS Number	051958363

Expected project title	CAD2SCAN – Product Design to Visual Inspection Automation
Estimated project budget	$1.51M
Expected project duration	18 months

Abstract:

In recent years, many areas in manufacturing have advanced with the use of sophisticated automation and advanced software. Still, over 90% of the visual quality inspection tasks are done manually. While people are highly capable of inspecting products and find anomalies, they are slow, expensive, and inconsistent.

Today, in order to grasp visual inspection requirements, an operator needs to review and extract the information from CAD drawings, read and collect the requirements from QC Book (a reference with defect examples and general quality inspection requirements) or get verbal guidance from a more experienced operator. As a result, the process of learning how to perform visual inspection is cumbersome, long, prone to errors, and hard to automate, especially for complex 3D products.

The outcome of the joint developed effort by Kitov and Capvidia will be the ability to extract semantic inspection requirements from CAD drawing and convert it to inspection language that can be used by automated platforms (e.g. Kitov-One). This brings into reality the digital thread between the CAD model and AI-automatic visual inspection solutions.

Companies Background:

About KITOV SYSYEMS LTD.

KITOV helps companies improve quality, eliminate production errors and lower manufacturing costs. Founded in 2014, KITOV created the first smart-visual-inspection solution that combines 3D imaging, AI and robotics to achieve unparallel results. Using an easy-to-use interface, a non-expert operator intuitively trains the system to inspect almost any product. This capability provides our customers significant flexibility and cost-savings vs conventional customized machine vision solutions. KITOV solutions are designed with Plug & Scan concept in mind. The system can be integrated into production lines in next to no time, making it ready-to-use INDUSTRY 4.0 solution.

In October 2018 Kitov Systems raised $10M in ‘Series A’, led by German HAHN Group (27%) Japanese GiTV VC (3%).

KITOV ONE systems have been successfully deployed in renowned manufactures around the world in key industries such as Communication, Aerospace, Automotive, Plastic, and Metal. Our systems can be found in Europe, China, Malaysia, USA, Mexico, Japan, and Israel.

About CAPVIDIA

CAPVIDIA is a leader in true MBD (model-based definition) with a focus on human and machine-readable 3D CAD models with semantic PMI (product and manufacturing information) for digital transformation downstream. 21st-century problems need 21st-century solutions. Traditional drawing-based workflows were not built for the era of the internet and Big Data. Model-based workflows are. Data interoperability empowers all downstream applications in design, manufacturing, quality, and other departments. Most importantly, data can be mapped back to the source for unlocking insights and improving processes.

Capvidia is a privately held company in the United States, and has been self-funded since its founding in 2001. Capvidia customers include a very large number of manufacturers in all industries. Some notable recent examples include Lockheed

Martin, Schneider Electric, Northrup Grumman, Raytheon, Honda, Pratt & Whitney, Baker Hughes, General Dynamics, Cisco, Medtronic, Thales, Tata, US DOD, Stryker, GE Appliances, Toyota, and many more.

Kitov brings into this engagement several years of experience in developing a revolutionized automatic inspection solution that was well adopted by key customers. From the other side, Capvidia, brings many years of experience is developing CAD interfaces to metrology equipment. The combine capabilities, experience and customer base make it a perfect match for this endeavor.

THE INNOVATION:

Visual Inspection tasks that are often done manually to verify the quality of manufactured parts. It is done painstakingly through the unreliable and non-uniform “eye test”. With the growing shift to automation and robotics, Visual Inspection is the "Achilles heel" in the Industry 4.0 transition. This results in high Cost-of-Poor-Quality (CoPQ) including cost of reworks, recalls, and damage to brand reputation. Automating Visual Inspection has an instant return on investment not only by reducing the Cost-of-Poor-quality but also by reducing the cost of labor needed for the inspection (a.k.a Cost-of-Good-Quality, (CoGQ).

The key challenge implementing automatic Visual Inspection in production lines is setting the inspection requirements. For example, today, in order to create an inspection plan on a Kitov-One system a user needs to collect the inspection requirements from QC Book (a reference with defect examples and general quality inspection requirements), CAD drawings or verbal guidance from a more experienced operator. This leads to inconsistency in setting an inspection plans and a cumbersome and expensive process.

The CAD2SCAN project addresses these challenges by enabling product design engineers to specify visual inspection requirements via CAD drawing. Then, these high-level semantic inspection requirements will be automatically translated into a low-level representation. We will use the QIF (Quality Information Framework) evolving standard for that purpose. These lower-level representations will be then converted to simple inspection commands used by automatic inspection systems such as Kitov-One, a robotic system for Visual Inspection.

For example, this revolutionized process will allow the design engineer to specify a screw for inspection on the CAD model. Then the inspection system will know to take the required images in 3D space in order to inspect the screw. Such images capture the top of the screw to see that it is not missing, or the screw head is not damaged, and additional image from the side to verify that the screw is completely tightened, etc.

A few examples what this framework includes:

- Viewpoints – where to position the camera that captures the product images
- Camera Setting – what needs to be the camera parameters for the best image
- Illumination setup – what should be the illumination intensity and position in relation to the camera and tested object
- Inspection specification:
    - inspection of existence of key components and/or the exact location
    - surfaces - scratches, dents, bumps, decolorization
    - screws (untightened, damaged head, missing)
    - labels (correct affix, text, bubbles, …)
    - connectors (bent pins, foreign objects, …), and so forth.

Behind the scenes, the system extracts from the CAD the inspection requirements into a series of 3D camera positions, illumination angles and intensity, imaging parameters, and the proper algorithms to use. Then, the Kitov system (or other automatic inspection system) can immediately perform a complete visual inspection on the product. This is done by combining classical Computer Vision and AI technologies such as Deep Learning (DL). In addition, using the CAD data, the system generates optimal robotic path that will be the fastest and most efficient, yet safe, ensuring collision avoidance.

Setting the visual inspection requirements will be managed within a model-based definition (MBD) system, starting with a digital product definition from CAD. We will support the industry leading CAD software tools (e.g., CATIA, Creo, SolidWorks, NX, etc.) that will enable us to specify the inspection requirements over the product tree and embed them as Product and Manufacturing Information (PMI) in the CAD. It is important to emphasize here that the choice of CAD software is largely unimportant; the proposed solution is a standard-based, CAD agnostic system, and does not rely on a specific proprietary CAD software vendor.

The last key component will be the software which outputs ISO QIF standard. This component connects the CAD+PMI to the Kitov-One system which performs the automated inspection, and then returns the inspection results back to the CAD software. Capvidia software technology and development efforts will be used to convert the native CAD data to the QIF standard format.

The project verify that the solution is suitable for production environments by processing real, end-user production data through the workflow. The availability of this data will help to guide the development towards robust production solution.

Collaborative Relationship:

The synergy from Kitov and Capvidia relationship will result with the following modules which together, complete the flow from CAD to inspection:

- Capvidia module: a plugin interface to common CAD software that reads semantic inspection specifications from the CAD product tree and exports it via the QIF standard. Such inspection specifications will be defined using feature attributes, comments, part libraries, etc.
- Kitov module: Systems such as Kitov-One reads the relevant information from the QIF file, parses it and transforms the semantic inspection requirements into actual system-specific commands, considering the 3D geometry and the different sub-inspection needs (often a single semantic inspection

requirement will be translated into a serious of actual inspections). The non-BIRD portion for developing the Kitov module will come from Kitov investment funds and from the on-going revenues from Kitov systems sales.

For Kitov products, the two modules will be used together. However, we plan to commercialize each of the modules separately. For example, other visual inspection equipment providers might be interested in one of the two modules for their products. Each of these two modules will have a separate pricing and will be sold by the corresponding company. As we expect that most sales will consist of selling the two modules together, we will allow the two companies to sell the other company's module for this purpose and will set a reporting mechanism and a transfer price to be paid to the other company.

Main development activities:

- Develop MBD standards that will enable engineer to specify visual inspection requirements during product design
- Expand the QIF standard to include Visual Inspection requirements
- Enable KITOV Software to receive QIF information
- Generate full inspection plan using QIF data
- Develop Visual Inspection results interface (defects by type, tolerances etc.) to convey it back to the CAD model

Commercial Potential:

Today, in manufacturing factories (in KITOV's focused market segments),16% of the of total workforce is dedicated for quality inspection. This sums up to about 3 million employees. About 50% of them are doing visual Inspection. Cost of labor only for these employees exceeds $15B per year. As one Kitov system can typically replace 2 human visual inspectors, we believe that the Total Addressable Market is several 100K systems. In the following table, we assume that the number of CAD2SCAN licenses that will be sold as the result of this project will be about 50% of deployed Kitov systems.

KITOV is planning to embed the QIF CAD Plug-in in its software. The cost of this option will be $4K per year to activate. In addition, Capvidia is planning to sell the plug-in as a standalone software plug-in that links between CAD software and customized machine vision solutions.

We already have commitments from leading US based industry manufacturers such as Cisco Systems and Jabil Inc. to assist in this project by providing actual product data and support. The following table summarizes the expected yearly revenues from the Project:

Y	Calendar year	2022	2023	2024	2025	2026	2027	2028
	Project year	1	2	3	4	5	6	7
Q	No. of units sold (Units)		0	150	400	900	1200	2000
P	Product Price ($/unit)		4	4	4	4	4	4
S	Product Sales (K$)	0	$ -	$ 600	$ 1,600	$ 3,600	$ 4,800	$ 8,000
	Accumulated Revenues (K$)			$ 600	$ 2,200	$ 5,800	$ 10,600	$ 18,600

Figure 1 - Sales Forecast

D. The Innovation

D1. limitations of the current technologies

Traditional manufacturing and industry practices are still marred in last century practices--mainly manual work and reliance on 2D drawings in world of 3D CAD models and robust data for automation and AI.

With the rise of Model-Based Enterprise (MBE), digital transformation upgrades multiple legacy practices (dimensional quality, welding, assembly instructions, etc.) to 21st century realities: Internet of Things, smart machines, automation, Big Data, and AI.

One legacy practice that can be readily improved for advanced manufacturing is visual quality inspection. Over 90% of final product visual inspection is performed manually which is limited by the human inspector's judgment, fatigue, and speed. Today, less than 10% of final product inspection is performed automatically using Machine Vision. Such Machine Vision solutions are mostly customized solutions for specific products. They are expensive as they are tailor-made for a specific product, require expert System Integrators to build and maintain, and are limited by the inspection capabilities in which they can perform. Typically, such customized solutions will be deployed only in Low-Mix-High-Volume (LMHV) lines where it is worthwhile to invest the time and money for a customized inspection solution, and will consist of many fixed cameras and lights which might have limited coverage for products with complex 3D geometry. While people are very good in their ability to inspect 3D products and find anomalies, they are slow, expensive, and inconsistent. Inspection results might be different for different people, and many defects might be missed due to fatigue, especially at the end of long shifts. The lack of a digital thread within the inspection process, along with the potential for human error and inconsistency, leads to ongoing and slow-to-adapt quality management programs. It also leads to high costs that consist of Cost-of-Good-Quality (CoGQ) which is mostly the labor costs of quality visual inspectors, and Cost-of-Poor-Quality (CoPQ) which is the cost of recalls, reworks, brand reputation, etc.

As described, at present, the field of visual inspection is heavily relied on personnel and not process. When compared to another closely adjacent discipline, dimensional inspection (metrology), visual inspection also lacks the measurement standards (like ASME Y14.5 and Y14.41) which govern the practices and methods that should be used by design engineers to specify some of the quality requirements for a product which will be inspected visually. Additionally, there are currently a lack of standards addressing the ability to carry visual inspection requirements from Computer Aided Design (CAD) software downstream to inspection systems in a machine-readable format.

D2. Product concept

The main goal of the product is the automation of visual inspection technology using data specified in the CAD digital product definition. In this project we will develop technology that will allow both automatic extraction of inspection information from the standard CAD data and also allow the product designer to embed explicit inspection requirements as part of the digital product definition in CAD and that the inspection plan will be generated automatically.

Modern CAD software allow the creation of annotated 3D models, known as a Model-Based-Definitions (MBD) where the product designer can embed in the CAD Product-and-Manufacturing-Information (PMI) which can include dimensions, tolerances, and material specifications, and specific directions how to perform the visual inspection. This project aims to create and use such PMI data in order to perform automated planning of the required visual inspection and the actual execution of the visual inspection at the manufacturing lines.

Quality Information Framework (QIF) is an ISO-standard MBD CAD developed by the Digital Metrology Standards Consortium (DMSC) to assist with the newly created automated workflows for MBE and metrology purposes. We will extend the QIF to manage data from the visual inspection domain, thus bringing it into the digital thread[1].

The actual inspection will be done on Kitov-One, a system developed by Kitov Systems that has AI-based technology that can automatically plan and perform on assembly lines a visual inspection with complete 3D coverage. Kitov systems have proven their ability to perform such inspection in actual manufacturing lines worldwide. The ability of automating the generation of inspection requirements and converting them from the CAD high-level semantic representation to the Kitov inspection system is a challenge we intend to pursue in this project.

The visual inspection will be managed within an MBD system as depicted in **Error! Reference source not found.**, starting with a digital product definition from CAD. We will use an industry leading MBD CAD software that will enable us to specify the inspection requirements over the product tree and embed them as Product and Manufacturing Information (PMI) in the CAD.

Figure 2 - Automation workflow diagram

It is important to emphasize here that the choice of CAD system is largely unimportant; this is a standard-based, CAD agnostic system being proposed, and does not rely on a specific proprietary software vendor. The last baseline component will be the QIF ISO standard that we intend to use as the means to connect the CAD+PMI generated by the CAD software to the Kitov-One system which will actually perform the automated inspection, and then return the inspection results from Kitov-One to the CAD software. Capvidia's software technology will be used to convert the native CAD data to the QIF standard format for the MBE workflow.

[1] Capvidia is a leader in developing MBE/MBD downstream workflows using QIF and has been one of the champions of the QIF format because of its robustness and capabilities for 21st century digital transformation—other 3D CAD-neutral formats predate the internet thus were not built for connectivity. Daniel Campbell, VP MBD of Capvidia, is also a member of the Board of Directors at DMSC and has guided major companies with automating manual tasks through MBD and QIF.

D3. Product uniqueness

With automated visual inspection, not only is the process automated—providing repeatability and robustness—it also provides inclusion to the digital thread through visual inspection standards and a connected flow of data moving downstream and upstream leading to data mining and AI.

By adopting MBE practice using an annotated digital 3D model as the authoritative information source for all activities in the product's lifecycle, the automation of visual inspection will be process-driven and not personnel-driven, delivering superior results compared to traditional methods (MBE methods have been tested and supported by NIST with Capvidia involved in demonstrating productivity gains).

While some automation standards (e.g. ASME Y14.5) give rise to automation of dimensional metrology, quality visual inspection (a.k.a. Cosmetic inspection) is very different and currently lack such standards. While the former is mostly based on measurements done at predefined points or between such points, visual inspection often involves integrating information from several views and applying intelligence to detect manufacturing defects. Visual inspection results can point out anomalies that were not thought of while planning the test. It might be seamless when done by human inspectors, but it requires sophisticated AI algorithms when done by automated systems.

Another compelling innovation proposed by this project is the association of inspection results to the master CAD digital product definition. Data which is gathered as a result of an MBD-based process will also be able to be mapped back to the MBD for realization of the Digital Twin concept. This opens the door to enormous opportunities related to data mining and AI. When a visual inspection is executed, the results will be digitally stored in the QIF format, thus mapping the actual product data back to the "single source of truth" -- its digital definition in CAD.

D4. Patent status

Kitov has filed patents on the process on the general concept of automated visual inspection (WO2016083897A3), the automated planning of visual inspection (WO2019156783) – assuming inspection requirements are given, and on design encoding of intercomponent inspection (provisional patent, US 63/061,207). In this project, we intend to invent and file a patent of the smart generation of the inspection requirements from CAD systems.

D5. Regulatory and technical standards

The project will rely on the ISO Quality Information Framework (QIF) standard – ISO 23952:2020. This is the preeminent MBD standard for the industrial quality domain, and is capable of carrying manufacturing product definition information, manufacturing planning information, and manufacturing actual result information. Its popularity and positive standing in the market will provide a solid foundation for the CAD2SCAN technical and commercialization efforts.

D6. Regulatory and obligations to other government agencies

Neither Kitov nor Capvidia have any obligation to other government agencies for any part of the innovation development thus far.

E. Proposed R&D Program

The following chapter provides detailed analysis of the problem and the describes the proposed approach.

E.1. Analysis of the Problem

Kitov Systems has developed Kitov-One (see Figure 3 - Kitov-One) which is an AI-based universal robotic inspection system that can convert visual inspection requirements into a test plan which can then perform a full product inspection, similar to an inspection done by a human inspector, on an entire part or product.

Figure 3 - Kitov-One

The system automatically converts the inspection requirements into series of 3D camera positions, illumination angles and intensity, imaging parameters, and the proper algorithms to perform. Inspection requirements including inspection of existence of components, surfaces (scratches, dents, bumps, decolorization, etc.), screws (untightened, damaged head, …), labels (correct affix, text, bubbles, …), connectors (bent pins, foreign objects, …), and so forth. The Kitov system can virtually perform any visual inspection done by a manual/human inspector by combining classical Computer Vision and AI technologies such as Deep Learning (DL). The Kitov system has a built in 6-axis robot which is attached to an optical head that contains a 2D color camera and several controlled LED illuminations elements. The system generates an optimal test plan in the sense that it will guarantee full coverage of the product while also determining the optimal robotic path that will be the fastest, most efficient yet safe path insuring to avoid collisions.

To teach the system how to inspect a new product, the operator currently needs to manually mark and define the inspection requirements on a manufacturing-level software tool, and the system builds an optimized inspection plan to perform the inspection. This procedure is time consuming, requires accuracy in the markings, and allows the visual inspection to be defined only at the manufacturing stage. Often, the manufacturing is done by a Contract Manufacturer (CM) which is a different entity that lacks the information needed to specify the inspection requirement.

An MBE approach would automate and streamline the process; addressing the following challenges needed for automated vision inspection:

1. Allow the product designer/OEM to define the visual inspection requirements directly on the CAD software.
2. Automated conversion of the high-level semantic inspection requirements specified by the user to PMI.
3. Automated conversion of the information in the product tree that is relevant to visual inspection to PMI (part information, geometry, material information, etc.).
4. Unified visual inspection "language" to be generated and understood by all relevant CAD software and automated visual inspection systems.
5. Seamless conversion from the visual inspection "language" to inspection plan that will performed by automated system (Kitov-One).
6. Feedback of actual inspection results to the product designer/OEM as PMI.

E.2. Proposed Approach

The developed technology will be able to be used in production environments using MBD data defined in any of the popular proprietary CAD systems used by industry (e.g., NX, Creo, CATIA, SolidWorks, Inventor, etc.). Using robust and commonplace standards like ISO QIF, end users will be able to automatically drive visual inspection on systems like Kitov One.

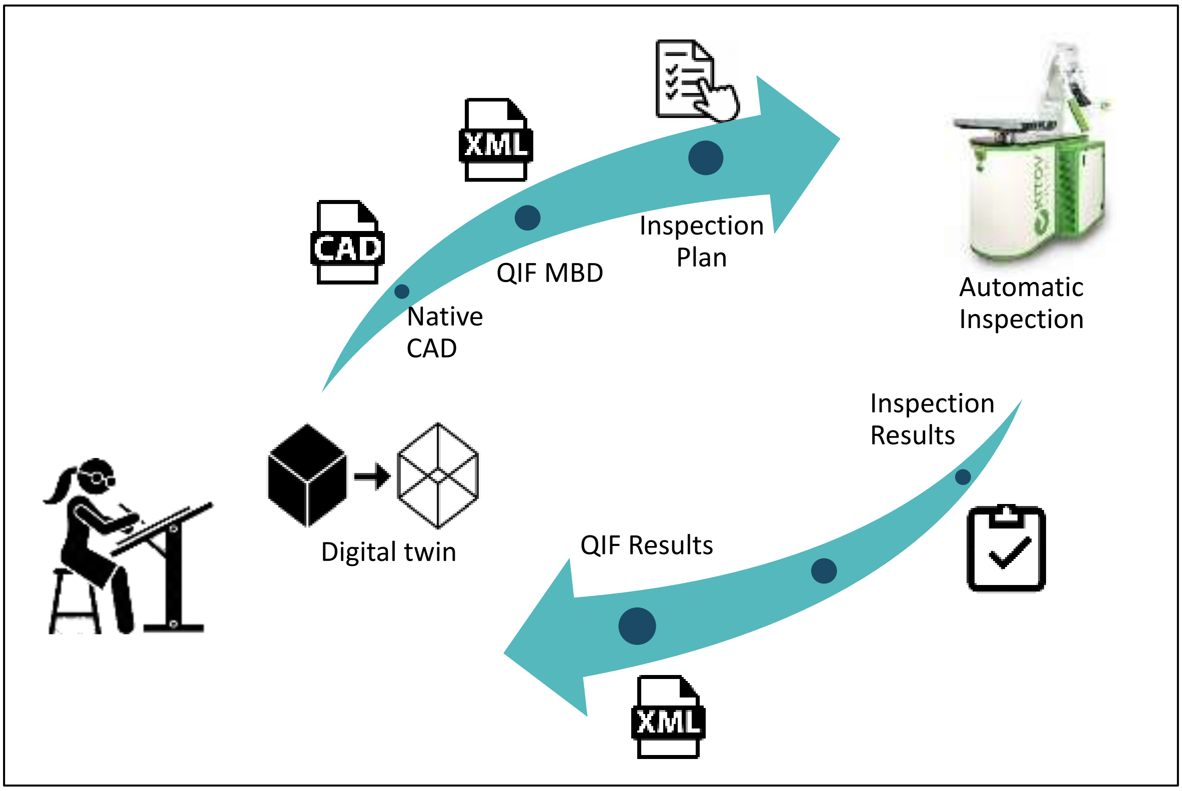


Figure 4 - Overall workflow

1. Native CAD data is converted to QIF (MBD CAD format)
2. QIF PMI is semantically-defined allowing for machine-readable import.
3. Automated visual inspection is executed by rules already established in the QIF PMI.
4. Beyond pass/fail. Data is then mapped back to the QIF for improved design & manufacturing insights, record keeping, and valuable data for digital twin association.
5. This is digital transformation: process over personnel and automation for time and cost savings.

The project will verify that the workflow is suitable for production environments by two main methods:

1. Processing real, end-user production data through the workflow. The project team will be requesting real data from end users who participate in the user interviews to be run through the workflow. The availability of this real-world data will help to guide the development of the workflow towards the robustness for a production setting.
2. A real-life demonstration using a Kitov-One system will demonstrate the technology in a production environment.

4. Identification and detailed description of each task

1	Task #:	1						
2	Task name:	User interviews						
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X	
4	Task duration (days):	60						
5	Start date (DD/MM/YY):	1/1/21		End date (DD/MM/YY):		1/3/21		
6	Company name:	[IL]		[US]		Total		
7	Task budget (K$):	49K		23K		72K		
8	Task budget (% of total):	68%		32%		100%		
9	Objective of task:	Solicitate real user feedback to understand the requirements and define the needed workflows						
10	**Task Description** (no restriction on size)							

The requirements for the CAD2SCAN workflow will be driven by industrial end users. Kitov and Capvidia will draw on their customers to define the exact pain point which needs to be addressed, and to develop a solution which will solve the problem and add value to a real manufacturing quality operation.

First, a pool of representative end-users will be identified from various industries and will be engaged to provide real-world feedback about the proposed workflow. The pool of end users will include large Original Equipment Manufacturers (OEMs) and Small and Medium-sized Enterprises (SMEs), and will be drawn from a variety of backgrounds, e.g., aerospace, heavy industry, consumer goods, electronics, medical, etc., so as to capture the diversity of different manufacturing environments. Engagement has already begun with **Cisco, Jabil, and Lam Research –** all of which are multi-billion-dollar manufacturing enterprises.

The user interview process will begin by identifying the correct subject matter experts within each user organization who is capable of discussing their quality processes in great detail. These users are, incidentally, the types of users with whom Kitov and Capvidia already have relationships.

The user will be prepared for the user interview by having seen a presentation of the concept which has been developed by Kitov and Capvidia. This will give them the background for understanding (1) the problem which is being addressed, and (2) the general methodology proposed to solve the problem.

The project team will then discuss with the end user the exact methods currently used to carry out a visual inspection process. It is not uncommon that many diverse methods for inspection will be employed, depending on the factory (for internal manufacturing), or depending on the supplier’s capabilities (for external manufacturing). A baseline of metrics for these capabilities will be captured: how long does the current inspection process take? What is the cost of the current inspection process? What types of resources does the process require? Is this process overly burdensome, such that it becomes a bottleneck in production?

Next, the project team will explore the proposed solutions with the end user. The primary question will be, is the proposed technology feasible, within a 1-3 year plan, for an organization to begin employing on the factory floor? Is their use of CAD and other digital technologies advanced enough to support such a workflow? Is their factory floor suited for the deployment of robotics? If the immediate answer to these questions is tenuous, what changes would need to be employed in order for this to fit into their 1-3 year roadmap?

Finally, the project team will request real user use cases (product definition data, parts, etc.) in order for this data to be used during the project. This will ensure that the specific technical achievements of the project will capture the very narrow requirements of each specific end user, and will ensure that the workflow will be robust for real production environments.

This task will include a trip to the US (which will be combined with a visit to Capvidia) to US customers including Jabil, Cisco, and Lam Research.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	1	

1	Task #:	2					
2	Task name:	Define use cases					
3	Company taking part in task (mark with "x")	IL:		US:		Both:	X
4	Task duration (days):	90					
5	Start date (DD/MM/YY):	1/2/21		End date (DD/MM/YY):	1/5/21		
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	55K		36K		92K	
8	Task budget (% of total):	60%		40%		100%	
9	Objective of task:	Define use-cases and MBD workflows based on the user interviews					
10	**Task Description** (no restriction on size)						

This task will define and formalize each of the use cases, workflows (epics), and user stories which will be implemented during the course of the project. The project team will employ an Agile approach to the development of the technology, involving the end users.

The use cases gathered in Task 1 come from the end users. The details of the implementation plan will be driven by the users and also by the domain knowledge of Kitov and Capvidia. The general workflows (or epics) and the specific user stories will be determined and documented in this task.

The epics will define the large development efforts which will allow for some general user functionality. For example, the user needs the ability to flag certain product surfaces as "cosmetic surfaces" of various degrees in the product definition, where the inspection must verify that there are no scratches, dents, or other visual blemishes. Then, an inspection program should be generated to inspect according to these requirements. This epic involves many different steps, both for the end user and for the project development team – but it sets an overall objective for the technology.

The user stories will define, at a lower level of detail, the specific steps to implement an epic. For example, for the epic above, there may be a user story related to how the user will flag a cosmetic surface requirement on the product definition within the SolidWorks CAD system. Another example might be a user story to automatically generate the inspection from the digital product definition containing the cosmetic inspection requirements.

The final deliverables for this task will be a concise description of the initial agile project plan. This will include:

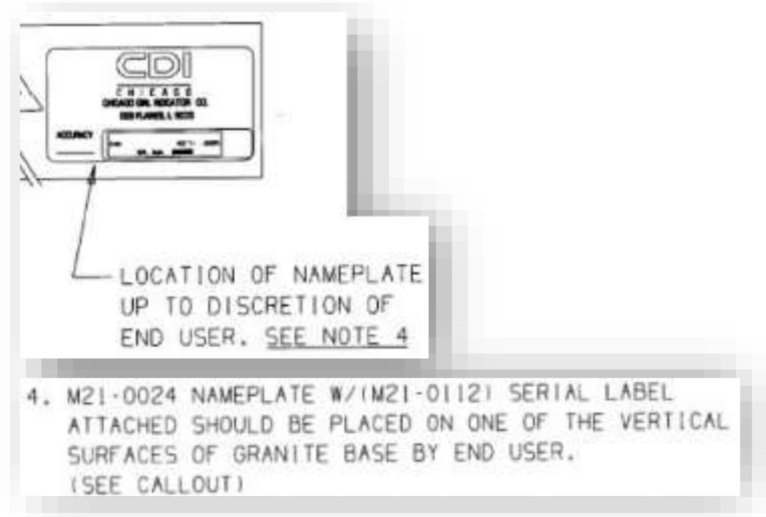
1. Use cases for the technology
2. Workflow diagrams, explaining the process and flow of data explained in each of the epics
3. Documentation of each of the user stories, detailing how a user will interact with the software and hardware interfaces

These documents will serve as the starting point for the project development effort.

11	# of the Milestone(s) to be reached:	1	
12	# of the Deliverable(s) to be provided:	2	

1	Task #:	3					
2	Task name:	"Inspection language" for CAD					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	185					
5	Start date (DD/MM/YY):	1/5/21	End date (DD/MM/YY):	1/11/21			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	99K	60K	159K			
8	Task budget (% of total):	62%	38%	100%			
9	Objective of task:	Define a simple and intuitive description of visual inspection requirements that can be embedded in existing CAD systems					
10	**Task Description** (no restriction on size)						

After having established the user stories in Task 2, we now need to specify the methods by which users will precisely define their inspection requirements in their CAD system. In the Model-Based Definition paradigm, the CAD digital product definition is treated as the source for the geometric specification of the part, and also as definitive source for the product functional and quality requirements. Specification of the product geometry in a clear and unambiguous way using CAD is a well-defined task. However, the clear, complete, and unambiguous specification of product functional and quality requirements can be a challenge. The objective is to not require a human-in-the-loop. Often, functional and quality requirements are explained using natural language, as in the example below.



While such a specification is arguably very complete, it is not machine-readable in the sense that it relies on the ability to read natural language and interpret it.

Therefore, it is essential that a “language” be created for unambiguously specifying these requirements in CAD in a machine-readable way. During this task, we will develop this language. A few examples of quality requirements which will be implemented in this “language” are:

• Verify the existence of key components in an assembly • In surface inspection, maximal length/area of a scratch and number of scratches per area • Maximum angle in which a pin can be bent in a connector The various major CAD tools provide a number of ways to attach metadata to a CAD model. The primary mechanisms are 3D annotations and model parameters (sometimes called attributes). In the spirit of Model Based Definition, these common CAD tools will be used to specify the visual inspection requirements.			
11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	3	

1	Task #:	4					
2	Task name:	Create demonstration parts					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	93					
5	Start date (DD/MM/YY):	1/5/21	End date (DD/MM/YY):	1/8/21			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	55K	30K	85K			
8	Task budget (% of total):	65%	35%	100%			
9	Objective of task:	Design and manufacture parts to be used for development and demonstration of the technology					
10	**Task Description** (no restriction on size)						

One of the important pillars for proving the robustness of this approach is to demonstrate the system of a set of parts which represents the wide variety of quality requirements found in different industries.

In this task, we will define five different demo parts on which we will demonstrate the technology. For each such part we will create a CAD model. Two of the parts we will manufacture physical parts: three sample parts each. One part will be a "golden" part, e.g. a part with no defects. On the other two, we will simulate defects for the system to detect.

The inspection requirements will be defined using the CAD software and will be stored by the developed software in the ISO QIF file as PMI. We will demonstrate the inspection capabilities by simulating actual defects on the parts and detecting them using Kitov inspection system by automatically understanding the inspection requirement in the QIF and the 3D geometry of each component in the part, converting them to a robot positions and imaging/light parameters, and performing the actual inspection.

Part I: a simple part and accurate metal box with 10 different screws on its faces and 5 labels. The goal for this demo part is to detect the following:

- missing screws / label and
- damaged screw
- bad/wrong print on the labels
- inaccurate position of the label

Part II: a complex part with non-planar geometry, preferably a real product, with several sub-assembly. The goal for this demo part is to deal with complex geometries and with tolerances of sub-part placement:

- surface defects (scratches)
- out-of-tolerance gaps between subparts

Each of these demonstration parts will need to have semantic information embedded in the form of PMI which specifies the visual requirements in the product definition. Visual inspection requires special "language" that does not currently exist in CAD / metrology. A few examples:

- Verify the existence of a component in an assembly

• In surface inspection, maximal length/area of a scratch and number of scratches per area

• Maximal angle in which a pin can be bent in a connector

We will define an easy and intuitive way such that will be easy to define and fit in the workflow of CAD programs and the product tree. The way that the data will be specified in CAD will be fully semantic and will contain all the necessary information defined in the schemas from stage 3 of the project plan

11	# of the Milestone(s) to be reached:	2	
12	# of the Deliverable(s) to be provided:	4	

1	Task #:	5					
2	Task name:	Enhance QIF data model					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	124					
5	Start date (DD/MM/YY):	1/5/21	End date (DD/MM/YY):	1/9/21			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	28K	50K	78K			
8	Task budget (% of total):	35%	65%	100%			
9	Objective of task:	Enhance the ISO QIF data structures to support visual inspection attributes					
10	**Task Description** (no restriction on size)						

ISO QIF (ISO 23952:2020) is a Model-Based Definition data format with a particular emphasis on the transmission of quality requirements to downstream manufacturing software tools. The general principle is that product requirements are specified on the CAD model, and propagated downstream to other software tools using industry standard formats.

Up until now, the emphasis for QIF MBD workflows has been on dimensional quality, and visual inspection workflows have not been as well defined. For this reason, a thorough gap analysis of the QIF standard will need to be carried out. The gap analysis will reveal any aspects of QIF which are not well suited for an MBD-based visual inspection workflow. We will examine both the downstream QIF data flow (design to inspection planning) and the upstream results feedback loop (inspection results back to design).

For example, we know in advance that there are no explicit data structures for cosmetic inspection criteria. For this particular case, the QIF data model will need to be enhanced to store all necessary information that the inspection software and hardware requires in order to generate the inspection plan.

Visual inspection processes which are well-supported by QIF will be documented. This document will explain exactly how any given visual inspection requirement is stored in the QIF format.

Visual inspection processes which are **not** well-supported by QIF will also be documented, and further dealt with in Task 6.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	5	

1	Task #:	6					
2	Task name:	QIF gap analysis					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	60					
5	Start date (DD/MM/YY):	1/2/22	End date (DD/MM/YY):	1/4/22			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	23K	25K	48K			
8	Task budget (% of total):	48%	52%	100%			
9	Objective of task:	Suggest enhancements to the QIF standard and suggest them to the QIF consortium					
10	**Task Description** (no restriction on size)						

During this task, all cases of lack of support in ISO QIF for any given visual inspection metadata will be documented into a QIF visual inspection gap analysis document.

This document will contain a list of all known gaps, as well as a definition for the data structure created in Task 5 to address this deficiency. This gap analysis document will be of tremendous value to the QIF community in that it presents known gaps in the standard, alongside tested solutions to the gaps. These improvements can then be added into the ISO standard in later versions.

The deliverables from this Task will be coordinated with the Digital Metrology Standards Consortium (DMSC, the governing body of ISO QIF) so that it can be propagated to the QIF user community. This will benefit the manufacturing community at large, it will raise awareness of the BIRD Foundation project, and it will make US and Israeli manufacturing more competitive globally.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	6	

1	Task #:	7						
2	Task name:	Capvidia CAD development						
3	Company taking part in task (mark with “x”)	IL:		US:	X	Both:		
4	Task duration (days):	123						
5	Start date (DD/MM/YY):	1/8/21		End date (DD/MM/YY):			1/12/21	
6	Company name:	[IL]			[US]		Total	
7	Task budget (K$):	0			61K		61K	
8	Task budget (% of total):	%			100%		100%	
9	Objective of task:	Develop software components required to extract visual inspection requirements from the native CAD						
10	**Task Description** (no restriction on size)							

Capvidia is a market leader in 3D software for publishing of MBD standard data. It currently has CAD technology which supports data from all the major CAD platforms used by large manufacturers, including Creo, NX, SolidWorks, and CATIA. One of the MBD standards that can be published is the QIF format.

Once the specifications for the QIF enhancements to support visual inspection have been completed in Task 3, Capvidia must implement these changes to its software packages.

The implementation of the CAD “language” for specifying visual inspection requirements will be encoded into the Capvidia CAD software. This implementation will be able to query the native CAD model for visual inspection requirements and understand the semantic nature of them.

For example, a simple Note Annotation referencing a CAD surface might say “Cosmetic A”. Under normal conditions, this Note would be interpreted as being just that – a note with an arbitrary string of characters, meant for human consumption. However if the CAD language specified in Task 3 indicates that surfaces which are called out with a note saying “Cosmetic A” should be classified as Cosmetic Surfaces with a Level A requirement, then the software will interpret it as such.

Each of the major 4 CAD formats specified above will be supported.

11	# of the Milestone(s) to be reached:	3	
12	# of the Deliverable(s) to be provided:	7	

1	Task #:	8					
2	Task name:	Capvidia data model development					
3	Company taking part in task (mark with “x”)	IL:		US:	X	Both:	
4	Task duration (days):	120					
5	Start date (DD/MM/YY):	1/8/21	End date (DD/MM/YY):	1/12/21			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	0	61K	61K			
8	Task budget (% of total):	%	100%	100%			
9	Objective of task:	Develop the CAD2SCAN data model					
10	**Task Description** (no restriction on size)						

Once the semantic nature of the visual inspection requirement has been extracted from the native CAD model, this data must be stored in the QIF data models, in order to propagate the requirements downstream in a standard, interoperable format.

During this task, Capvidia will enhance its software to support the extended data structures defined in Task 5. These data structures will contain the visual inspection requirements in a semantic, and machine-readable format.

For example, in keeping with the example in the Task Description for Task 7, a cosmetic inspection requirement would contain XML-based machine-readable information clearly specifying:

- A cosmetic visual inspection is required
- The level of cosmetic inspection required (in this case, level A)
- The surface(s) which need to be cosmetically inspected

The Capvidia software will be able to write these requirements to the QIF format, which will allow for the Kitov software to clearly understand the visual inspection requirements as specified in the authority digital product definition: the native CAD model.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	8	

1	Task #:	9					
2	Task name:	Visibility analysis					
3	Company taking part in task (mark with “x”)	IL:	X	US:		Both:	
4	Task duration (days):	244					
5	Start date (DD/MM/YY):	1/1/21		End date (DD/MM/YY):	1/9/21		
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	87K		0		87K	
8	Task budget (% of total):	100%		%		100%	
9	Objective of task:	Perform automated visibility analysis to determine which inspection test can be safely performed					
10	**Task Description** (no restriction on size)						

Each inspection requirement is generated locally for a specific component that is being inspected. However, it is possible that some inspection requirements will not be possible to be performed as the camera that is mounted on the robot cannot reach a viewpoint from which the component is visible, or as the required lighting cannot be properly illuminated. This can result from other components obscuring, partially or completely, the inspected part. For example, after placing a cover on a product, it is not possible to inspect the inside components. We need to perform a visibility tests for each inspection requirement considering the 3D model of the camera and lights used for the inspection.

The actual viewpoints needed to perform an inspection are dependent on the inspection requirements which defines the 3D poses of the camera and lights. Often, some of the resulting viewpoints might not have visibility to the inspected component so we need to consider alternative viewpoints that can perform the inspection. If we cannot find at least one valid viewpoint, we declare that inspection as not visible. For example, to verify that a screw is completely tightened, we need to take an image from an oblique angle. As there is radial symmetry, it is sufficient to find a single viewpoint from which the screw is visible.

In this task we will perform a literature survey and develop an algorithm that will optimally perform a visibility map for all the inspection requirements.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	9	

1	Task #:	10						
2	Task name:	Part naming dictionaries						
3	Company taking part in task (mark with "x")	IL:	X	US:		Both:		
4	Task duration (days):	185						
5	Start date (DD/MM/YY):	1/5/21		End date (DD/MM/YY):		1/11/21		
6	Company name:	[IL]			[US]		Total	
7	Task budget (K$):	65K			0		65K	
8	Task budget (% of total):	100%			%		100%	
9	Objective of task:	Understand and use part attributes and naming conventions for inspection						
10	**Task Description** (no restriction on size)							

In most cases, a product is made from many components such as screws, pins, resistors, cover plate, connector etc. Each such component has set of valuable parameters that can be used to set a visual inspection test for the item. For example, these parameters might be: printed information on the item, vendor, material, surface properties, color, dimensions etc.

In order to use these attributes intelligently during the inspection process we need to develop a mechanism to "read" and store this information.

One way is to use the manufacturer part attributes. This is a structured set of parameters that are defined by the manufacture for his items.   It will require to build "translator" for each such large manufacture. The "translator" will collect the required parameters and parse them into a structured CAD2SCAN database.

In other cases, OEM might use *smart part naming* conventions to unify the production files and supply chain. Such naming conventions add significant information to the data in the CAD model such as specific part information, vendor details, material information, etc. This information can improve the visual inspection as it provides additional appearance and geometrical details about the component.

There are different approaches for such naming. Some vendors defines define their own conventions while some use more standard Manufacturing Part Numbers (MPN)
For example, in Cisco smart naming conventions, a socket can be described as:
26,SIMM60,.100"C,27'AN,2ROW where: "26", is the code for socket, "SIMM60" describes the socket type and pin count, ".100"C" describes the scaping between rows (R) and contacts (C), etc.
In this task, we will develop a plugin mechanism to adapt to dictionaries from various Manufactures and OEMs and represent them in a unified representation so we can add the relevant item information to the generated inspection requirements.

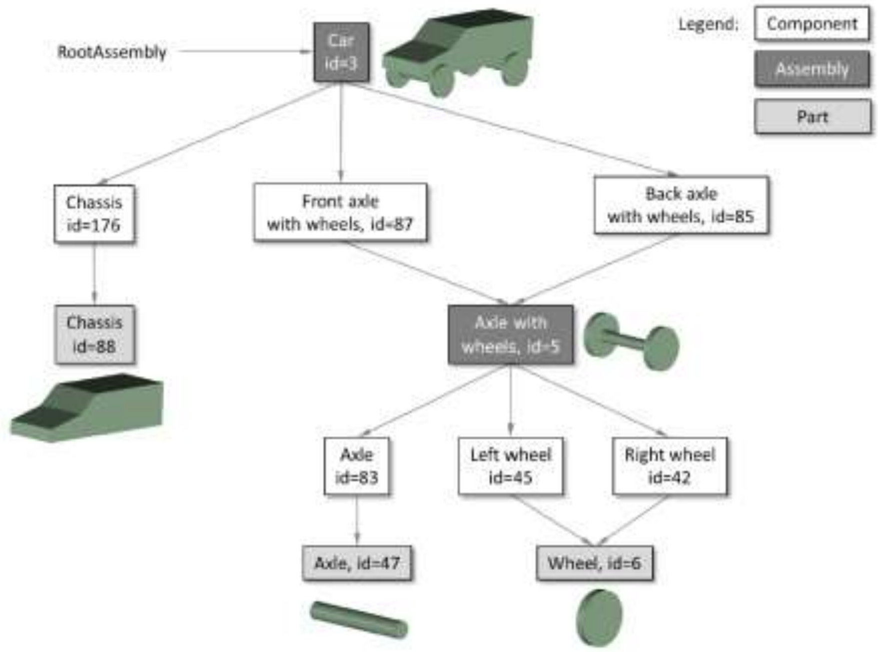
11	# of the Milestone(s) to be reached:		

12	# of the Deliverable(s) to be provided:	10	

1	Task #:	11					
2	Task name:	Generate inspection requirements					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	213					
5	Start date (DD/MM/YY):	1/8/21	End date (DD/MM/YY):	1/3/22			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	157K		157K			
8	Task budget (% of total):	100%	%	100%			
9	Objective of task:	Automatic generation of inspection requirements from QIF					
10	**Task Description** (no restriction on size)						

Analyze the product tree together with their relevant PMI to generate inspection requirements. Once we are able to specify the inspection commands in the CAD workflow, we have to generate inspection requirements that can be used by Kitov-One. To do so, we need to relate each inspection command to 3D structure and position in space on the inspected component and map the semantics of the required inspection into appropriate inspection requirements. For example, if we inspect a screw, we need to look from the direction that is normal to the screw head in order to check if the screw is not missing and the screw head is not worn. We might need also additional view from the side to realize if the screw is fully tightened. We also need to realize which components are visible to the camera and which ones are not visible and cannot be inspected.

Inspection requirements can be attached to parts, components, and assemblies. Once an inspection requirement is attached to an element, it will be available to every occurrence of that element. For example, in the following figure of a car product tree (this image from the QIF specification) we can attach inspection requirements to a wheel and it will apply to all 4 wheels of the car considering the different geometry and visibility of the surrounding.



In addition to component-specific inspection requirements, some inspection requirements are based on the relationship between multiple components. E.g. inspecting the gap between two surfaces or comparing the code from a barcode to a text on some label.

We intend to develop this software module in Python. It will get as input a QIF file that contains all information about the product tree and PMI, and extract the 3D geometry together with the PMI-based inspection commands and relate them to a semantic level "know-how" database that will generate the appropriate inspection requirements.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	11	

1	Task #:	12					
2	Task name:	Inspection generation - SolidWorks					
3	Company taking part in task (mark with “x”)	IL:	X	US:		Both:	
4	Task duration (days):	121					
5	Start date (DD/MM/YY):	1/1/21		End date (DD/MM/YY):		1/5/21	
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	80K				80K	
8	Task budget (% of total):	100%		%		100%	
9	Objective of task:	Develop plugin for SolidWorks to generate visual inspection requirements and the required geometric information needed for automated inspection					
10	**Task Description** (no restriction on size)						

In addition to generating inspection requirements from a QIF representation of a product as described in Task 11, we will develop software plugins for leading CAD software that will enable direct generation of inspection requirements from the CAD, without generating QIF as an intermediate representation. This plugin will be used for simpler products that have simple product tree, typically parts made of single material (e.g. metal molding or CNC parts) with one level of additional features (labels, screws, …)

In addition to the inspection requirements, the plugin will generate end export the part's geometry in STL format. This is needed for Kitov-One in order to perform automated inspection by proving the information needed for path planning and collision avoidance.

We chose SolidWorks as the main CAD software for this project, and will develop the plugin using C#.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	12	

1	Task #:	13					
2	Task name:	Inspection generation - CAD					
3	Company taking part in task (mark with "x")	IL:	X	US:		Both:	
4	Task duration (days):	123					
5	Start date (DD/MM/YY):	1/3/22		End date (DD/MM/YY):		1/7/22	
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	47K				47K	
8	Task budget (% of total):	100%		%		100%	
9	Objective of task:	Develop plugin for additional CAD system to generate visual inspection requirements and the required geometric information needed for automated inspection					
10	**Task Description** (no restriction on size)						

In Task 11 we generate inspection requirements from QIF representation, and in Task 12 we directly generate inspection requirements from SolidWorks. In order to ensure maximal generality and in order to increase the market for the technology, we will develop, in addition to the SolidWorks plugin, also a plugin for one additional leading CAD software. The choice of the specific CAD software will be chosen based on the results of the user interviews that will conducted in a previous task.

Similarly, to the SolidWorks plugin, we will generate inspection requirements directly from the CAD. We will aim to capture maximal commonalties between the CAD systems to ensure generality of the technology.

We will develop the plugin using C#.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	13	

1	Task #:	14					
2	Task name:	QIF feedback loop					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	154					
5	Start date (DD/MM/YY):	1/9/21		End date (DD/MM/YY):		1/2/22	
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	82K		50K		131K	
8	Task budget (% of total):	62%		38%		100%	
9	Objective of task:	Collect and embed actual inspection results into the QIF representation to close the loop with the product designer/OEM					
10	**Task Description** (no restriction on size)						

The Digital Twin concept is the idea of creating a digital replica of a physical asset or entity. It is currently a major growth area in manufacturing, as manufacturing continues to further exploit the value of big data. This concept has an important application within the domain of Model-Based Definition. The native MBD model is considered to be the “nominal” product instantiation. From this, a component, sub-assembly, or product will be created – the physical asset. As quality gathers more and more information about this physical asset, the data should be harvested as metadata to the nominal part – the instantiation of the Digital Twin. This digital data related to actual manufactured parts reveals a trove of information which serves not only to characterize and improve the manufactured good itself, but also to characterize and improve the manufacturing process.

This concept of the MBD-based digital twin will be extended to support the valuable data gathered during the course of the visual inspection. To create this feedback loop of inspection data back to the as-designed nominal model, the results from the visual inspection will be package into the ISO QIF format in the form of QIF Results.

The Kitov software will be enhanced to support the output of the visual inspection results into the ISO QIF format. This file containing the results will be able to be loaded in QIF-enabled software for viewing and analysis. Capvidia’s MBDVidia software will be enhanced to support the import of this data. When the data is imported into MBDVidia, the user will be able to see the inspection results alongside the CAD model and any other metadata that may have been gathered (e.g., dimensional inspection results).

11	# of the Milestone(s) to be reached:	4	
12	# of the Deliverable(s) to be provided:	14	

1	Task #:	15						
2	Task name:	Kitov-One adaptation						
3	Company taking part in task (mark with "x")	IL:	X	US:		Both:		
4	Task duration (days):	93						
5	Start date (DD/MM/YY):	1/11/21		End date (DD/MM/YY):		1/2/22		
6	Company name:	[IL]		[US]		Total		
7	Task budget (K$):	26K				26K		
8	Task budget (% of total):	100%		%		100%		
9	Objective of task:	Adapt Kitov-One to accommodate with the wealth of information generated for the CAD workflow and use it for automated inspection						
10	**Task Description** (no restriction on size)							

The MBE workflow and the inspection requirements we automatically generate in this project assume an inspection tool that is able to convert the inspection requirements to simple inspection elements and perform then in the manufacturing environment. Kitov-One provides an ideal platform for this purpose. It uses a robotic system to position its optical head in virtually any 3D pose, take the required images, and run the optimal inspection algorithms.

Currently, Kitov-One does not support the full set of inspection elements that will be generated from the CAD. In addition, the only way to provide Kitov's planner with inspection requirements is manually by the operator marking on the images. In this task, we will develop a new workflow for Kitov-One where the inspection requirements are automatically fed from the MBD. In addition, we will develop a preset mechanism to allow a library of presets that will correspond to the component libraries provide by the CAD software.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	15	

1	Task #:	16					
2	Task name:	Workflow integration and testing					
3	Company taking part in task (mark with "x")	IL:		US:		Both:	X
4	Task duration (days):	90					
5	Start date (DD/MM/YY):	1/2/22	End date (DD/MM/YY):	1/5/22			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	61K	33K	93K			
8	Task budget (% of total):	65%	35%	100%			
9	Objective of task:	Full integration of all the components developed in the project					
10	**Task Description** (no restriction on size)						

During this step, all software components developed during previous steps will be integrated and thoroughly tested.

Using the demonstration models developed in Task 4, the beginning-to-end workflow will be executed. This includes the export of the QIF file from the CAD systems by Capvidia, the import of the QIF-based visual inspection requirements by Kitov, the automatic generation of the inspection program, the execution of the measurement, and the output of results in the QIF format.

This integration and testing will expose the software workflow to a through QA process. During the course of this integration, there will be issues which will be revealed. These issues will be addressed by Kitov and Capvidia, and the integration & testing will be continued.

This task will continue until the workflow is fully integrated and works seamlessly.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	16	

1	Task #:	17					
2	Task name:	Demonstration					
3	Company taking part in task (mark with "x")	IL:		US:		Both:	X
4	Task duration (days):	92					
5	Start date (DD/MM/YY):	1/4/22	End date (DD/MM/YY):	1/7/22			
6	Company name:	[IL]	[US]	Total			
7	Task budget (K$):	39K	41K	80K			
8	Task budget (% of total):	49%	51%	100%			
9	Objective of task:	Demonstrate the complete project					
10	**Task Description** (no restriction on size)						

This workflow will be demonstrated on a Kitov-One robotic system. We will demonstrate that the developed system can import CAD/QIF, understand the relevant PMI and automatically inspect such physical parts.

The flow of the demo will be as follows:

1. Load one of the demonstration CAD models in a major CAD system (e.g., Creo, NX, SolidWorks, or CATIA)
2. Export the model to the QIF format using Capvidia software
3. Load the QIF model in Kitov-One and automatically generate an inspection plan
4. Inspect a "golden part" (with no defects) to learn the material properties
5. Inspect the demonstration part with known issues and present results in Kitov software
6. Export results to QIF format for re-association with native CAD digital product definition in Capvidia software

This demonstration will be carried out with the objective of making it publicly available to industrial end users. This will help to publicize the results of this BIRD project, and help with their adaptation by industry.

Additionally, end users (and in particular the end users interviewed in Task 1) will be given the opportunity to demonstrate the workflow on their own data. This this private demonstration would use proprietary data from the end user, it would be a confidential demonstration, and would be instrumental in helping to spur the adoption of the technology at that end user's factories.

11	# of the Milestone(s) to be reached:	5	
12	# of the Deliverable(s) to be provided:	17	

1	Task #:	18					
2	Task name:	Commercialization plan					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	62					
5	Start date (DD/MM/YY):	1/4/22		End date (DD/MM/YY):	1/6/22		
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	28K		13K		41K	
8	Task budget (% of total):	68%		32%		100%	
9	Objective of task:	Implement Commercialization plan					
10	**Task Description** (no restriction on size)						

During this task, a commercialization plan for the technology will be created. This commercialization plan will lay out the guidelines for Kitov and Capvidia to market, sell, and support the workflow developed by the project. The development of the plan will include the following facets:

- **Marketing**: this technology will be marketed by Kitov, by Capvidia, and also jointly by Kitov/Capvidia. In the course of their individual marketing operations with their current customers, it would benefit each company to also market this technology within the context of their existing messaging. Since each company’s market is different, their messaging is also quite different. For this reason, each company will need to identify their own way of integrating this technology into its marketing operations. In addition to this, joint marketing campaigns will be developed, starting with the public technology demonstrations.
- **Sales**: sales guidelines and processes will be established which will enable Kitov and Capvidia to work together to sell this technology to industrial end users. All aspects of the sales process will be considered during this task, including:
    - Training of application engineers in the use of standard presentation and demonstration collateral
    - Guidelines for joint efforts in pre-sales activity
    - Customer referral arrangements
    - Reseller arrangements
- **Support**: once the products are deployed at a customer location, it is essential the comprehensive and timely support is delivered in order to ensure that the customer can derive the full value of the tool. A support protocol is necessary in order to clearly establish a “line of support” where the customer can safely rely on solutions. An example of such a support protocol might be: the primary vendor of the workflow is the first line of support. A simple set of support diagnostics would be attempted in order to solve the problem. If the problem is not solved, then the support might fall back to a second line of support, where if the issue is on the Capvidia software side, it goes to Capvidia advanced technical support, and if it is on the Kitov side, then it goes to the Kitov advanced technical support team. And so on. The exact nature of this support protocol will be established in this task.

11	# of the Milestone(s) to be reached:		
12	# of the Deliverable(s) to be provided:	18	

1	Task #:	19					
2	Task name:	Final Deliverables					
3	Company taking part in task (mark with “x”)	IL:		US:		Both:	X
4	Task duration (days):	31					
5	Start date (DD/MM/YY):	1/6/22		End date (DD/MM/YY):	1/7/22		
6	Company name:	[IL]		[US]		Total	
7	Task budget (K$):	18K		11K		28K	
8	Task budget (% of total):	62%		38%		100%	
9	Objective of task:	Preparation final reports, presentation, and other deliverables for BIRD					
10	**Task Description** (no restriction on size)						
Preparation final reports, presentation, and other deliverables for BIRD. This includes collecting all software and reports prepared during the project and preparation of the final report summarizing the project and final generated products.							
11	# of the Milestone(s) to be reached:						
12	# of the Deliverable(s) to be provided:	19					

5. Setting Milestones

Some of the tasks defined in item 4, above, have **measurable milestones to reach,** as an indication of task completion. The table below lists these key milestones and deliveries.

Milestones and Deliverables Form

#	Milestone Definition / Description and How Will It be Measured	Milestone Date (MM/YY)
1	Presentation of MBD use cases	05/21
2	Demonstration parts ready	8/21
3	Automatic generation of QIF for the demonstration parts	12/21
4	QIF feedback loop demonstration	2/22
5	Full demonstration	07/22
#	Deliverable Definition & Description	Deliverable Date (MM/YY)
1	Document with a summary of user interviews	03/21
2	• Use cases for the technology • Workflow diagrams, explaining the process and flow of data explained in each of the epics • Documentation of each of the user stories, detailing how a user will interact with the software and hardware interfaces	05/21
3	Specification of the "Inspection language" + sample files in CAD format	11/21
4	Five CAD models with embedded PMI information describing the required inspection. For two of these models we will manufacture three samples	09/21
5	Document describing the QIF enhancements + sample files in QIF format	09/21
6	Formal document to be delivered to DMSC	04/22
7	Software module of Capvidia CAD plugins + Presentation	12/21
8	Software module + Presentation	12/21
9	Software module to demonstrate the visibility analysis	03/22
10	Software module + presentation of part naming dictionaries	03/22
11	Software module + examples of generating inspection requirements	09/21
12	SolidWorks plugin to directly generate inspection requirements	05/21
13	CAD plugin to directly generate inspection requirements	07/22
14	QIF files that include inspection results for the demonstration parts + visualization tool	02/22

15	Document describing the new Kitov-One inspection requirement interface	02/22
16	Integration report	05/22
17	Videos demonstrating all developed workflows	07/22
18	Commercialization plan	06/22
19	Final Deliverables	07/22
20		[end of project]

E.3 Analysis of the Project's TRL

In the following section we present the project's Technology Readiness Level (TRL), **prior** to the project's inception and **following** the project's completion. In the first **TRL table** (See below) we identify the project's current TRL and our acquaintance with the current status of the project. In addition, we provide a few examples of achievements that were accomplished prior to the project's inception that supports our TRL choice. In the second table we predict the project's TRL following its completion. We justify this prediction based on the project's goals and deliverables (as provided in section E.2), and the project's plan (as provided in section F).

TRL prior to the Project Inception	Examples substantiating the project's TRL prior to Project Inception
TRL-4	The CAD2SCAN project builds on two mature technologies which are both TRL-9: • Kitov-One by Kitov is an automated robotics inspection system which will be used to perform the actual inspection that will be generated in this project. • Capvidia's MBDVidia technology is a leading industrial CAD data translation and validation package, which will be used to generate MBD data (aka machine-readable data) for powering visual inspection automation. Based on these technologies we (Kitov+Capvidia) have built, during the last two years, the concept of CAD2SCAN. We also collaborated with Cisco as an end-user and got initial definitions and QIF samples of real products which were used to understand the elements that needs to be developed.
TRL-4 Examples - 1	In Nov 2019, Kitov created a CAD drawing for a simple part. Capvidia generated a QIF representation of that part. We manually added simple inspection requirements to the QIF and verified that the QIF format is capable to manage basic inspection requirements.
TRL-4 Examples - 2	In February 2019, we have demonstrated (mock-up) and validated the concept to Cisco on a simple part. The demonstration was done on a Kitov-One system that is installed at Flex Milpitas in CA.

Expected Project's TRL by the Project Completion	Examples substantiating the project's expected TRL by the Project's Completion (based on the Goals and Deliverables provided in section E.2)
TRL-8	Upon completion of this project, this technology is expected to be at a TRL level 8. This project will be centered on the involvement of current Kitov end-users and potential end-users, with the objective of creating a mature technology workflow which will be utilized in real production environments. Therefore, this project expects to see this technology grow from a level TRL 4 to a TRL 8.
TRL-8 Example-1	Example-1: Processing real, end-user production data through the workflow. The project team will be requesting real data from end users who participate in the user interviews to be run through the workflow. The availability of this real-world data will help to guide the development of the workflow towards the robustness for a production setting.
TRL-8 Example-2	Example-2: Demonstration of the full MBE workflow using the demonstration parts. A real-life demonstration using a Kitov-One system will demonstrate the technology.

F. Program Plan

In section we present the CAD2SCAN program plan. It consists of a chronological schedule of program activities, defined as detailed tasks in the previous section and presented below in graphical form (GANTT chart).

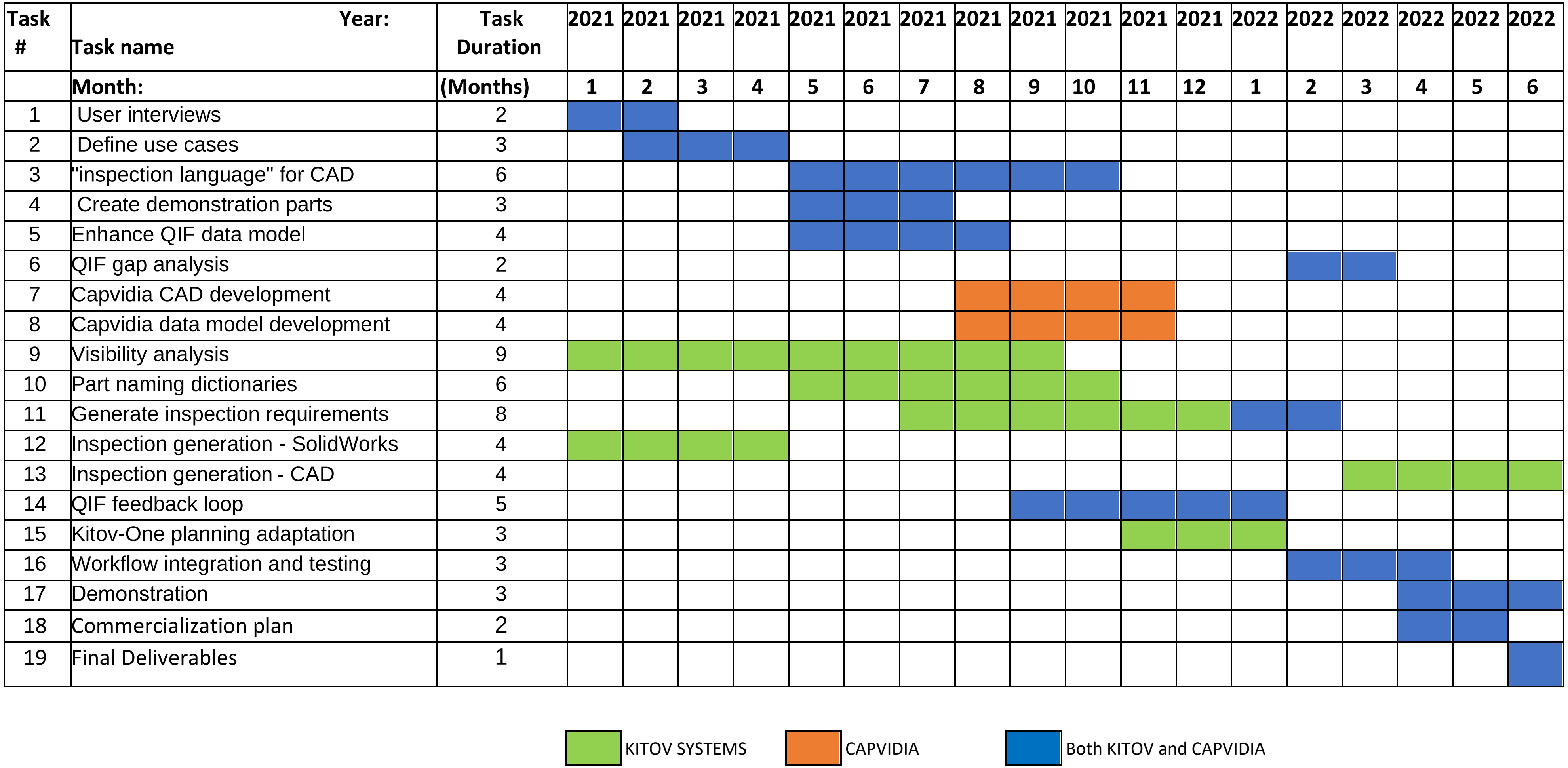


Figure 5 CAD2SCAN Project Gantt Chart

G. The Market

G.1 Market Needs

The global machine vision systems market was valued at USD 8.81 billion in 2018, and it is expected to reach a value of USD 18.50 billion by 2024, registering a CAGR of 13.32%, during the period of 2019-2024. The use of machine vision continues to grow every year. In some of the regions, the sales in machine vision are resulting in record numbers. For instance, in North America, in 2018, the sales of machine vision components and systems reached USD 2.874 billion, an increase of 9.2% over 2017, as per the Automated Imaging Association (AIA), the industry trade group and part of the Association for Advancing Automation.

Apart from this, the Asia-Pacific region is expected to record a significant growth in the 2D and 3D machine vision systems market, over the forecast period. As the region has become the manufacturing hub for the world, increased demand and quality concerns are propelling the region to look at automation technologies to keep up with customer requirements. Thus, machine vision usage is growing across various end-user industries.

Machine vision provides machines with a gift of sight, complementing or replacing manual inspection tasks, using cameras and image processing. Machine vision applications range from basic tasks, like presence detection, to real-time inspection and grading tasks in harsh environments.

Manufacturing firms across the world are realizing the benefits of machine vision systems, particularly in areas where redundant tasks, like inspection, should be performed with precision. They are playing an essential role in high-speed production lines and hazardous environments. Some of the significant benefits offered by these systems include increased Quality, productivity, reduced machine downtime, and tighter process control.

In case of a pure 2D machine vision system, the target object image acquired for processing is effectively a flat, 2D plan view. This 2D image does not provide any height information. When utilizing 2D cameras, Z (distance from camera) is generally assumed. This is not as effective as parts may move, change size, etc. and then the 2D camera may miscalculate the location.

Owing to such reasons, end-user industries are embracing 3D systems, such as KITOV solutions that enable to perform 3D quality inspection with full product coverage that provides a complete solution for current inspection tasks.

In addition, Industry 4.0 revolution fueled the development of technologies like robots, automation and artificial intelligence software that meets together in the production line to create new set of capabilities but also major implementation challenges as we will describe later.

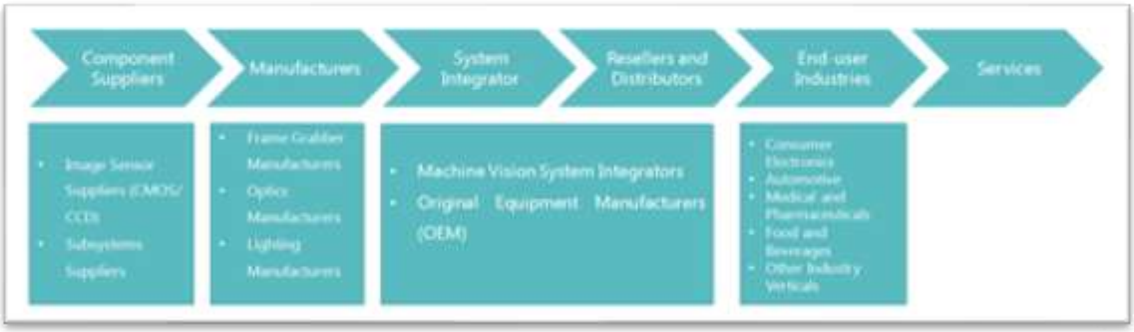


Figure 6 Machine Vision Value Chain

To better understand how the CAD2SCAN product fits into this market, one first need to understand the machine vision industry value chain. The value chain consists of component suppliers, manufacturers, systems integrators, resellers and distributors, and end-user industries (see Figure 6 above). The component suppliers include image sensor suppliers, and subsystem suppliers. Image sensors typically use the complementary metal oxide semiconductor (CMOS or charge coupled device (CCD) technology to convert light (photons) to electrical signals (electrons).

The subsystems include smart and compact subsystems (smart cameras + visions sensors). A smart camera has single embedded image sensor. They are purpose-built for specialized applications where space constraints need a compact footprint. Vision sensors utilize images captured by the camera to determine presence, orientation, and accuracy of the parts. The manufacturers of frame grabber, optics, and lighting play an essential role in the value chain.

The next step involves the integration by Original Equipment Manufacturers (OEM) such as KITOV or independent machine vison system integrators. The resellers and distributors then supply the integrated machine vison systems to different end-user industries. Some of the end-user industries include consumer electronics, automotive, food and beverages and medical and pharmaceutical, among others.

Today, to setup an inspection solution, the integrator needs to learn product's characteristics, collect the inception requirements, and explore points of interests before she can start with the integration design process. The CAD2SCAN solution aims to solve this challenge.

In addition to the Machine Vision market, Kitov systems and the CAD2SCAN solution opens a new market opportunity. Today, only about 10% of the quality visual inspection is automated. 90% are done manually by human inspectors. More than 15 Million employees work in the Automotive, Electronic manufacturing, Aerospace and Medical industries from which about 15% deal with manual visual inspection. Assuming that Kitov with CAD2SCAN can replace 50% of them results in additional market of $15B.

<u>Kitov & Capvidia and the Machine Vision MARKET</u>

KITOV brings into this engagement several years of experience in developing automatic inspection solutions that were well adopted by key customers. Kitov solutions are implemented in production lines of key industry leaders from the electronics, automotive, aerospace, and medical industries. These strategic customers gave KITOV an important access to the main inspection challenge that they are facing: **setting an inspection plan for a new product.**

From the other side, Capvidia, brings many years of experience is developing CAD interfaces to metrology equipment. It has the experience in implementing industry standards, building the interfaces into various CAD software, and access to early adopter customer base that already implemented similar standard in the metrology area.

The combine capabilities, experience and customer base make it a perfect match for this endeavor.

MARKET DRIVERS FOR CAD2SCAN

Today's increased level of automation in the manufacturing industry also demands automation of quality inspection with little human intervention. Machine vision systems, along with AI algorithms, can perform complex inspection task and identify microscopic defects as they are more sensitive than human vision. Visual inspection using machine learning (ML) reduces inspection time significantly by detecting a variety of defects as compared to conventional techniques.

Automated inspection overcomes many of the challenges of manual inspection systems. In the manufacturing industry, visual inspection errors take one of two forms. The first one is the missing of an existing defect. The second is the incorrect identification of the defect. Misses lead to the loss in quality, while incorrect identifications result in unnecessary production costs and overall waste.

Automated inspection systems surpass the standard of manual inspection. Machine vision systems surpass human vision in quality and quantity measurements owing to its accuracy, speed, and repeatability. Machine vision can also find object details too small to be detected by the human and inspect them with greater reliability

Even with the clear advantages of automated inspection, only about 10% of the visual inspection was replaced by automated solutions. There are two main reasons for that:

- Many products are very challenging for automated visual inspection. Their 3D geometry poses both technical challenges to capture the required images, and problems in defining the inspection requirements. The latter is done manually by the operator where Kitov system is installed, or by a system integrator where customized solution is deployed. It is time consuming and requires a lot of iterations to correctly define the inspection plan and is prone to inspection mistakes.
- It is expensive to deploy an automated solution. The higher costs are due to the need to customize the inspection for each inspected product. The result is that only high-volume products justify such investments.

These two problems create a great opportunity for CAD2SCAN. It allows the product designer/OEM to specify the inspection specification in a simple and intuitive way and CAD2SCAN automatically generates the inspection requirements in a way that an automated visual inspection system can process. This is a quick, accurate, and inexpensive process that overcomes the up mentioned challenges and make automated visual inspection worthwhile even for complex products and for low-volume production.

Pharmaceutical, energy and power, automotive, food industry, semiconductor, and electronics are some of the industries adopting machine vision combined with AI for quality control and machine inspection. Inspections are being performed on automobile parts, electronic components, building materials, raw materials, food, and medical supplies, among others.

MARKET CHALLENGES

CAD2SCAN depends on the availability of automated machine vision system to actually perform the inspection thus some challenges in the machine vision market will reflect to CAS2SCAN.

Recent growth in the machine vision industry has been driven by continued advances in machine vision technology, software and components. The success of machine vision applications has been tied to competent systems integration - the analysis, design, specification, and implementation of the components critical to the task. But this success is not free of many challenges.

First, machine vision depends on standard operating systems and interface protocols. The software development process requires an advanced programmer and expensive image processing libraries. PC-based machine vision systems are complex and bulky. Integrating them into existing systems can be difficult owing to the number of interfaces involved. Second, manufacturers are searching continuously for cost reduction opportunities. Without taking into account the cost of poor quality (CoPQ), justifying investment in a system that can handle a complex inspection tasks is not always trivial. Last, there is a growing need to shorten and simplify the process of setting product inspection machine vision plan. In today's production line one can find many product permutations that runs simultaneously on the same production line. As a result, setting automatic inspection solutions, using current tools, takes considerable amount and is not economical.

G.3 TOTAL Available Market

The CAD2SCAN product Market is highly correlated with machine vision solutions. We believe that as this methodology will be adopted by major manufactures, even simple inspection tasks can benefit from it. Based on discussions with key manufactures we estimate that machine vision inspection project costs between $20K-$300K per station depending on the product and the inspection complexity. To estimate the TAM (Total Available Market) we will set the average cost of machine vision project at $80K (this includes, Hardware, software, and integration costs). Based the machine vision project average cost and the global machine vision market (valued at USD 8.81 billion in 2018) we can deduct that in 2018 there were about 110K such projects. Assuming only 20% of these projects can benefit from the CAD2SCAN solution this translate into 22K units per year. As these 20% are the high end, high value projects, we estimate we can charge $4K for each implementation for software license. This bring the TAM (based on 2018 numbers) to $88M per year.

TAM Analysis Summary Table

Parameter	Value	Remarks
Machine Vision Market	$8.81B	2018 data
Average project cost	$80K	Based on $20K-$300K project cost
# of visual inspection projects	110K	Marker / average project cost
% of CAD2SCAN potential Projects	20%	High-end machine vision projects
# of potential CAD2SCAN units	22K	
CAD2SCAN Units Price	$4K	Current target price for OEM and integrators
TAM for CAD2SCAN	$88M	

Events that can alter the CAD2SCAN TAM projection are:

- The percentage of the CAD2SCAN potential projects. We estimate this can range from 10%-40%
- The expected unit price that customers will be willing to pay for software license
- Slow adoption of the CAD2SCAN solution

G.4 CAD2SCAN Market Share

Prominent companies functioning in the machine vision market include Basler AG; Cognex Corporation; Keyence Corporation; Microscan Systems, Inc.; National Instruments Corporation.; OMRON Corporation, and many more. Most of these players are offering both hardware and software solutions and continuously striving for new product developments and venture capital investments to acquire market share. Furthermore, increasing investments in R&D activities to improve machine vision technology and related developments are opening growth opportunities for the market. Prominent players are undertaking strategic initiatives such as distribution alliances, partnerships, mergers, and acquisitions to consolidate their position in the market. However, all of these players relay on the work of integrators to grasp the customer requirements, select the proper hardware and software and implement the solution in the production line.

From market share perspective, the impact of CAD2SCAN on the total machine vision market is insignificant even when taking into account the TAM (Total Available Market) which in this case it will be less than ~1%.

Harvesting vision requirements from the CAD software into machine vision solutions is a sub-market that does not exists. As the CAD2SCAN is set to make the first move in this domain, we expect that during the first 3-5 years this product will dominate this sub-market.

G.5 Additional pertinent market information

During the concept development phase for the CAD2SCAN project, KITOV and Capvidia met with potential customers and presented to them: the goals and objectives, upcoming development plans and the expected deliverables of the project. The project concept was very well received by these customers and active discussions took place. It was discussed that such initiative was long- awaited and the development and implementation of such solution will have positive impact on the manufacturing environment. In addition, cooperation during the development stage with these customers will ensure that additional stakeholders can contribute to the project design and increase the chances to result in the "right" product. Stakeholders expressed strong interest in assisting the project activities to ensure that the solution meets their need. It was also agreed that some of these customers will also enable using their manufacturing environment as beta site for the solution.

Below is a partial list of customers that we were engaged with during the last few months:

- CISCO
- LAM Research
- JABIL
- LAUNCHPAD

Here are a few sample letters from these customers:

Benny Yap
Senior Technical Leader
170 West Tasman Drive
San Jose, CA 95134

The effort proposed in the project "CAD2INSPECT" submitted to the BIRD Foundation will provide a valuable technological advancement for Cisco manufacturing efforts. Cisco spends an enormous amount of time, effort, and cost on visual inspection. This project would bring automated visual inspection in line with the MBE and digitization efforts currently ongoing at Cisco. I can commit to spend some time for end-user interviews for this project, and to provide end-user governance of the workflows developed.

LAUNCHPAD

October 12, 2020

To: The Bird Foundation

Dear BIRD committee,

Launchpad build is revolutionizing product building in the USA.
We develop the technology and products which enable customers to get instant pricing and delivery schedules, and to go from design to manufacturing of complete products in a fraction of the time it takes doing it in existing methods. Our digital thread starts with the analysis of the product 3D assembly CAD file, performs classification, assembly simulation & production planning, which is translated to control automated assembly machines.
The 3D CAD file is a key element in our solution and drives most of the down stream actions which result in a fully functional product.
Visual quality inspection is a crucial element of any manufacturing system. As we are building autonomous manufacturing platforms, the ability to get the inspection plan, directly from the CAD file, brings a huge value to us, as we can reduce or eliminate the customer technical engagement time and the programming time of the inspection tools. The ability of the CAD2SCAN to allow the product designers to add their inspection needs as PMI in the CAD perfectly fits our vision and business model.
The Kitov system is our preferred solution to be used in our Digilines and we will be relying upon an automated inspection planning to run our process autonomously.
I look forward to collaborating with Kitov and Capvidia on the CAD2SCAN product they intend to develop with the help of the BIRD foundation.

Best regards,
Ofer Ricklis
CTO, Co-Founder
Launchpad build
www.launchpad.build

G.6 Entry Barriers

Barriers to entry are factors that might prevent the CAP2SCAN to become a global machine vision standard. As a whole they comprise one of the five forces that determine the intensity of competition in an industry (the others are industry rivalry, the bargaining power of buyers, the bargaining power of suppliers and the threat of substitutes). The intensity of competition in a certain field determines the attractiveness of a market (that is, low intensity means that the market is attractive).

The following are the main barriers to entry into a setting standards in the machine vision market:

<u>Economies of scale</u>

How quickly can the CAD2SCAN product become a de facto standard for product designers to add inspection requirements using this methodology.

<u>Capital requirements</u>

The financial resources required for the R&D effort and later for commercialization of the solution to the market are sufficient to get wide acceptance.

<u>Switching costs</u>

The impact on the product design and later on the machine vision integrator to change his current development process of machine vision solutions to use the CAD2SCAN standard.

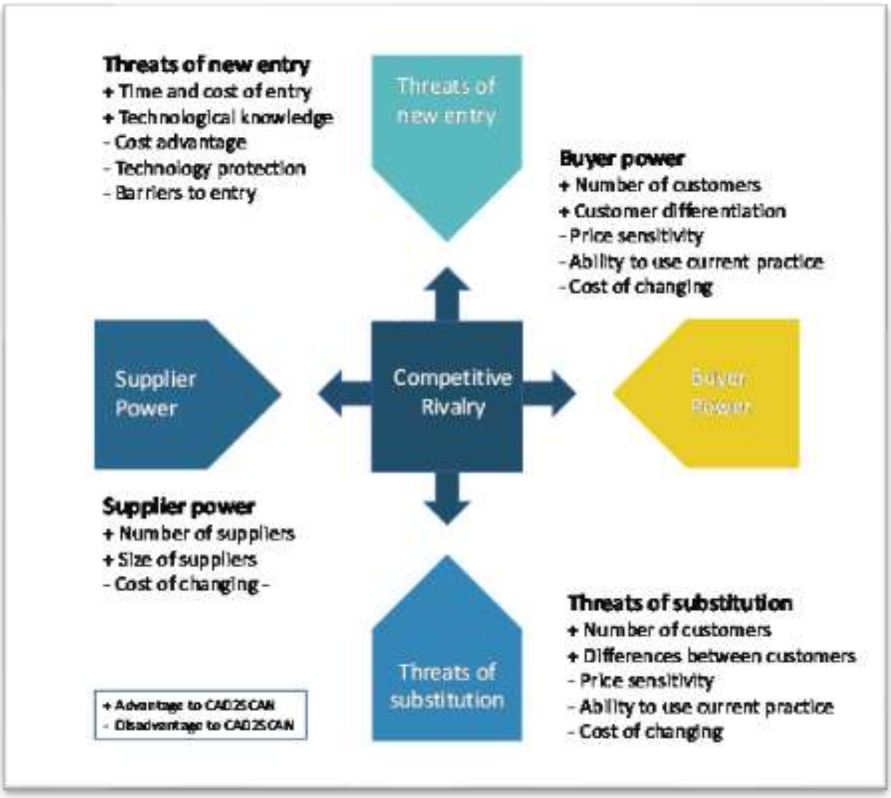


Figure 7 Competitive Analysis

G.7 Competition

In general, competitor analysis identifies and quantifies the relative strengths and weaknesses (compared with competitors or potential competitors), which could be of significance in the successful competitive strategy for the CAD2SCAN project.

Competitor analysis involves identifying and analyzing businesses which might compete directly or indirectly with this product category. The process involved in competitor analysis is to identify strengths and weaknesses of potential competitors, and the opportunities and threats for our business.

As the CAD2SCAN product, is a methodology that involves setting QIF industry standards which don't exist yet, we don't expect to face any competition in the short-term. In addition, we don't expect competition from machine vision hardware providers as they are usually more involved in the actual execution of visual inspection and less in the planning of the inspection (in fact, they can become customers of CAD2SCAN). Machine Vision Software companies might see this as an opportunity to expand their product offering. However, as this is not directly correlate to machine vision technology (classic machine vision or A.I.) we believe that the competitive risk from this area is also small.

However, we can expect that at some point, as the QIF standard for visual inspection will be widely adopted, and all the CAD design software will support it in their design software, additional software companies (even outside of the machine vision market) might use the QIF standard to develop their own software solution to assist machine vision OEM providers and solution integrators. Due to the high entry barrier, we do not expect this to happen in the next few years.

To avoid such competition, we strive to make the first into this market, lead and influence the QIF standardization creation effort and embed the solution in to KITVO current inspection solutions. In addition, keeping a reasonable product price will help the product expand quickly and gain market dominance, and will deter new entrants due to the relatively low business potential as a software solution.

SWOT ANALYSIS

Figure 8 - SWOT Analysis

The quantitative estimate of the above market size and share of the above revenue forecast should be summarized in the table below (identical to the updated Executive Summary chapter, above):

	2023	2024	2025	2026	2027	2028
Target market size for developed product (M$):	$88M	$100M	$112M	$127M	$144	$163M
Estimated Market Share [%]:		0.6%	1.4%	2.8%	3.3%	4.9%
Estimated sales quantity (units):		150	400	900	1200	2000
Estimated representative unit price ($/unit):		$4K	$4K	$4K	$4K	$4K
Estimated sales revenue (K$):		$600	$1,600	$3,600	$4,800	$8,000
Estimated cumulative sales revenue (K$):		$600	$2,200	$5,800	$10,600	$18,600

Figure 9 - TAM Analysis and sales projection

H. Commercialization – Plans and Prospects

H.1. Product Manufacturing, Marketing and Sales Activities

1. Product Production

The CAD2SCAN is software package will be offered to OEM that build machine vision solution systems for wide range of inspection applications and to machine vision integrators. Due to the nature of the product we don't foresee any major manufacturing or logistic effort that will be needed to implement it in KITOV solutions or in the market. In addition, we plan to develop it mainly using current resources and without the need to rely on any external resources. In the cashflow analysis, we estimated that the production costs will be about 1% of the revenues.

2. Marketing and Sales

The CAD2SCAN product has sales channels:

- <u>KITOV OPTION:</u> In this channel, CAD2SCAN is Integrated into KITOV ONE software as a special option. In addition to enhancing Kitov software, we will offer plugins to CAD systems that export CAD2SCAN information for Kitov. Such plugins will be used by product designers and OEMs that manufacture at CMs (Contract Manufacturers) that are using Kitov for the inspection. Users who wish to use this capability will need to purchase it separately.
- <u>STANDALONE SOFTWARE</u>: In this case, OEM or machine vision integrators, use the CAD2SCAN product to collect Inspection requirement specification from the product CAD drawing into their inspection solution, other that KITOV inspection solutions.

As stated above, KITOV will embed the solution in its software and will enable it to customer who wish to buy it. At this point. we don't envision that KITOV will sell the solution to machine vision integrators or other OEMs.

CAPVIDIA will develop a separate marketing and sales channel to reach out to Machine Vision OEM and Integrators that will use it for other automated inspection solutions.

Service and Support

The CAD2SCAN product is heavily linked into the KITOV system architecture, as a result, we project that in the period following the launch of the product, the support, and further development will be performed mainly by KITOV.

<u>Sales Channels</u>

Kitov sells its products using three main channels:

- **Direct Sales –** Kitov sell directly to strategic global manufactures that are running many production lines around the world.
- **Distributors –** distributors are usually operating in a given geographical area with good sales and support infrastructure

- **Software License** – mainly to OEM and customers who, build a Kitov design product for their internal usage.

Marketing Channels

Marketing for our solutions will start with in-person events with the following conferences:

Quality Conferences:

- Innovation Quality Conference
- World Conference on Quality
- The Quality Show

Machine Vision Conferences:

- Vision Week
- The Vision Show

Smart Technology & Manufacturing Conferences:

- Automatica
- IMTS

Model-Based Enterprise Conferences:

- NIST MBE Summit
- 3DCIC and QIF Summit

CAD Conferences:

- LiveWorx
- Realize Live
- 3DExperience World

Additionally, digital marketing campaigns (Google ads, social ads, and content marketing) are available to promote the industry and product.

3. Current Sales Channels

Kitov is planning to use the above sales channel to sell the CAD2SCAN product as a licensed option within its existing products

Capvidia sales of MBD technology are primarily carried out via a robust internal sales and support network. This is done internally primarily for two reasons: (1) the customers are mostly large enterprise users, where Capvidia prefers to work directly with the end user, rather than via a partner vendor, and (2) because the technical nature of MBD is sufficiently complex that partner vendors are not easily able to successfully market and sell the technology.

Capvidia also has a number of partners who specialize in providing services for CAD, MBD, and quality to industrial end users. In these cases, these resellers would be leveraged to market and sell this technology.

Capvidia will continue to rely on its internal sales channel as the primary channel for sales and marketing of this technology. However, as the market awareness of MBD technology matures, and the workflows developed here become more commoditized, the reliance on resellers is expected to increase.

4. Resource Analysis

Both Kitov and Capvidia have sufficient resources to match the required funds for this project and execute this project as part of its on-going operations.

In addition to a promising market potential, a solid commercialization program needs to be planned and implemented. Some of the questions to be discussed are:

H.2. Cash Flow Analysis

No.	Cash-Flow component	Derivation	N = No. of Years						
Y	Calendar year	Ist Calendar Year	2022	2023	2024	2025	2026	2027	2028
	Project year		1	2	3	4	5	6	7
Q	No. of units sold (Units)	estimate		0	150	400	900	1200	2000
P	Product Price ($/unit)	estimate		4	4	4	4	4	4
S	Product Sales (K$)	=QxP or estimate	0	$ -	$ 600	$ 1,600	$ 3,600	$ 4,800	$ 8,000
M%	Manufacturing Cost (% of sales)	5%		5%	5%	5%	5%	5%	5%
M	Manufacturing Cost (K$)	=M% x S	0	$ -	$ 30	$ 80	$ 180	$ 240	$ 400
O%	Operating Expenses (% of sales)	25%		25%	25%	25%	25%	25%	25%
O	Operating Expenses (K$)	=O% x S	0	$ -	$ 150	$ 400	$ 900	$ 1,200	$ 2,000
D	Development Expenses (K$)	estimate	1002	441					
C	Capital Expenses (K$)	estimate	46	16					
E	Depreciation (K$)	linear over 5 yrs.	9	12	12	12	12	3	0
I	Before Tax Income/Loss (K$)	=S-M-O-D-E	$ -1,011	$ -453	$ 408	$ 1,108	$ 2,508	$ 3,357	$ 5,600
T1	Cumulative Losses carried over (K$)		$ -1,011	$ -1,465	$ -1,057	$ -	$ -	$ -	$ -
T2	Taxable Income (K$)		$ -	$ -	$ -	$ 51	$ 2,508	$ 3,357	$ 5,600
T%	Income Tax Rate (%)	23%	23%	23%	23%	23%	23%	23%	23%
T	Income Tax (K$)	=T% x T2	$ -	$ -	$ -	$ 12	$ 577	$ 772	$ 1,288
OF	Operating Cash Flow (K$/Yr.)	=I+E-T	$ -1,002	$ -441	$ 420	$ 1,108	$ 1,943	$ 2,588	$ 4,312
W%	Working Capital (% of sales change)	3%	3%	3%	3%	3%	3%	3%	3%
W	Working Capital Change (K$)	=W% x (Sn-Sn-1)		$ -	$ 18	$ 30	$ 60	$ 36	$ 96
V	Residual Value of Assets		0	0	0	0	0	0	0
AF	Total Annual Cash Flow (K$)	=OF-C-W+V	$ -1,048	$ -457	$ 402	$ 1,078	$ 1,883	$ 2,552	$ 4,216
CF	Total Cumulative Cash Flow (K$)		$ -1,048	$ -1,505	$ -1,103	$ -25	$ 1,859	$ 4,411	$ 8,627
R	Annual Discount Rate (%)	15%							
DAF	Annual Discounted Cash Flow (K$)		$ -1,048	$ -397	$ 304	$ 709	$ 1,077	$ 1,269	$ 1,823
DCF	Cumulative Discounted Cash Flow (K$)		**$ -1,048**	**$ -1,445**	**$ -1,141**	**$ -432**	**$ 644**	**$ 1,913**	**$ 3,736**
IRR	Inernal Rate of Return (%)	**56%**							

I. Cooperation, Economic and Social Benefits

Cooperative Activity

For the project execution, the risk is shared equally amongst Kitov and Capvidia. Each organization is offering approximately a 1:1 ration of BIRD funding to internal company funding for the effort.

During the commercialization, marketing, sales, and support activities will be carried out jointly. The exact nature of the collaboration between Kitov and Capvidia will be detailed in Task 18 of the project effort and is briefly described in the Task Description for Task 18.

Social Impact

In manufacturing, standards help organizations develop, manufacture, and supply goods and services in a more efficient, safer, and sustainable way.

Technology innovation, economic, and political forces are creating great interest on Smart Manufacturing and the need to promote connectivity standards in the manufacturing ecosystem. Governments around the world have realized manufacturing is a major contributor to their GDP and is critical for their national competitiveness in the global economy.

Many countries have created national initiatives in response. For example, Germany launched Industry 4.0; the United States sponsors *Manufacturing USA*; China promotes its Made in China 2025; Korea calls it Manufacturing Innovation 3.0; and France named their initiative Industrie du Futur. The U.K., Sweden, Japan, India, and many other countries all have country-specific efforts as well.

What they all have in common is creating a vision and strategy for smart manufacturing supporting manufacturers' digital business transformation to drive reduced capital expenditures (CAPEX), improved time to market, reduced inventory, and improved productivity and quality. Countries and companies around the world are eager to adopt digitalization strategies and standardization because it levels the playing field for smaller companies, so they can reap the same benefits as bigger companies and remain globally competitive and relevant.

One of such US government initiatives under the *Manufacturing USA* is the *Digital Thread for Smart Manufacturing Systems*. This initiative aims to deliver methods and protocols that extend and complete the digital thread for information running through design, manufacturing and product support processes, enabling integration of smart manufacturing systems. The results of this project will accelerate the design-to-production timeline at reduced costs. We live in a new manufacturing era that has been called the Fourth Industrial Revolution, which is characterized by the digitization of manufacturing. In this era, information plays a central role. How the product's design and manufacturing information is authored, exchanged, and processed is critical to competitiveness in this era. Information 'silos' for various life cycle processes are slowly being connected to form a 'digital thread' of information that is envisioned to integrate and drive modern design, manufacturing and product support processes. Yet today, information typically flows in one direction, and gaps in the flows prevent enterprise-wide utilization of information. A complete and rich digital thread will enable manufacturing enterprises to reduce cycle time and achieve correct parts the first time. A complete and rich digital thread based on open standards will raise competitiveness of small-to-medium sized manufacturing enterprises. The CAD2SCAN project fits perfectly into this initiative as it identifies the required communications, define their information content, to formalize and promulgate descriptions of those requirements, and provides an end to end solution that exchanges and uses visual inspection requirements and results information. For more information about the *Digital Thread for Smart Manufacturing* refer to www.nist.gov.

As modern production line constantly gathers and uses digital manufacturing data. Often multiple players throughout the supply chain employ one or more proprietary software products, resulting in a critical communication break between supply chain partners. The data relevant to each partner must be intelligently organized and communicated. An important framework that deals with this issue is the QIF.

The Quality Information Framework (QIF) standard defines, organizes, and associates quality information such as measurement plans, results, part geometry and product manufacturing information (PMI), measurement templates, resources, statistical analysis, etc. The CAD2SCAN initiative, expands the QIF standard to include also visual inspection information. As visual inspection activities are in almost any production line, this project will enable manufactures to reduce costs, improve quality and reduce time to market. For more information regarding the OIF Standard organization, please refer to https://qifstandards.org/

J. Organization and Management Plan

J.1 Communication procedures

Project Management are the activities of planning, organizing, securing, monitoring and managing the necessary resources and work to deliver specific project goals and objectives in an effective and efficient way. The project management approach that we set to use was tailored to serve the needs of managing the CAD2SCAN project.

Project Procedures and Documentation

Project documentation is a key activity of project management and carries through from the start of a project to its completion. The purpose of project documentation is to ensure that both teams are on the same page and are aligned with the required tasks. For example:

project scope: ensure agreement by the managements of Capvidia and KITOV and all other project stakeholders and project team members (so that everybody shares the same expectations on what is to be delivered, what to do, when to do it, etc.).

- provide all stakeholders with a clear picture of the project requirements.
- facilitate communication with internal and external groups, using weekly ZOOM meetings and face-to-face meetings (when it will be feasible).
- provide a baseline for the monitoring and control of a project's progress.
- document important decisions made.
- Generate and provide the information required by BIRD Foundation.
- support organizational memory and act as an historical reference which can be used to increase the chances of success of future projects.

J.2 Organization Chart

The following table summarizes the key project team member involved this in project:

Role	KITOV	Capvidia
Program Manager	Adam Tabor	
Project Manager	Yossi Rubner	Daniel Campbell
Development Manager	Tamir Margalit	Victor Mikushin
Algorithms Engineer	Gil Pinsky	
Software Engineer	Miron Stiglitz	
Software Engineer	Shiran Ganor	Igor Besic
Application Engineer		Lyle Fischer
Marketing and Operations Analyst		Jimmy Nguyen

For Key personal resumes, please refer to appendix section J.5 .

J.3 New Employee Information

KITOV and Capvidia are planning to rely on existing resources and they are not planning to hire for this project new employees.

J.4 key consultants and subcontractors

KITOV and Capvidia are planning to rely on existing resources and they are not planning to use consultants and/or subcontractors.

J.5 Resume for key project members

ADAM TABOR

WORK EXPERIENCE

- **2016 – Present / KITOV Systems   Cofounder and COO**

Offer an array of skills in strategic vision implementation, business/financial acumen, talent acquisition and empowerment, leadership, performance analysis, marketing, campaign management, advertising, problem solving and operations management. Engage regularly with clients via strategic and operational reviews to evaluate client needs and to inform the direction of the team's process to serve clients. Direct all operational aspects of the company such as procurement, engineering, manufacturing, training, installation, and customer support.

- **2003 – 2015 / Self Employed – Consulting service**

Provided management, operations and supply chain consulting services to key Israeli companies: Nova Instruments – provider of metrology solutions for advanced process control used in semiconductor manufacturing / Supply Chain consultancy Revulis – a leading drip and micro irrigation manufacturer / Forecast modeling and distribution Xenom - a leading manufacturer of composite materials using high strength fiberglass and synthetic fabrics/Management consultancy.

- **2008 – 2013 / Orbotech LTD** ORBK (NASDAQ) **Manager, Global Supply Chain**

Established and managed a $40M/y world-wide supply chain unit; Directed 30 employees responsible for manufacturing, repairing, planning, Inventory Management, costing and pricing models, purchasing, quality, and logistics activities in 5 global manufacturing sites and 38 logistics centers, including a logistic hub in Hong Kong. Set the strategy and led initiatives that resulted in a 13% cost reduction and 21% inventory turns reduction while increasing service levels by 10%. Set up a repair purchasing and logistic center in China that generated significant cost savings and reduced lead-times.

- **2002 – 2008 / Hewlett-Packard Company - Indigo Division – HPQ (NASDAQ) Manager, Supply Chain Operations**

Managed the division's $600M/y outbound supply activity; directed 18 employees, was in charge of all logistics, quality, and order administration. Supported the divison's business relationships with 30 channel partners in Asia Pacific and Latin America. Led global cross-functional projects, including the implementation of HP global export compliance requirements, and participated in the HP IT Integration program with Indigo Division.

- **1999 – 2002 / Webvan Group Inc. Foster City, CA USA** WBVN (NASDAQ) ***Director, business Process***
- ***1995-1999*** **/ LSI Logic Corporation, Milpitas, CA USA** LSI (NASDAQ) ***Business Analyst WW SC Operations***
- ***1992-1994*** **/ Intel Corporation, Santa Clara, CA USA** INTC (NASDAQ) ***Consultant***

EDUCATION

- **Stanford University, Stanford, CA**

Master of Science in Engineering Management, June 1999

- **Tel-Aviv University, Tel-Aviv, Israel**

Bachelor of Science in Industrial Engineering, June 1992

Dr. Yossi (Joseph) Rubner | Founder & CTO, Kitov.ai

EDUCATION

9/94 - 5/99 Ph.D. Computer Science
Ph.D. (minor) Electrical Engineering
Stanford University, Stanford, CA, USA

9/87 - 2/91 B.Sc. Computer Engineering (summa cum laude)
Technion - Israel Institute of Technology, Haifa, Israel

9/83 - 6/84 Computer programming training (with distinction)
Israeli Defense Forces Computer Academy ("MAMRAM")

EMPLOYMENT

2014 –**Present** **Kitov.ai**, Petah Tikva, Israel. Founder & CTO

Kitov.ai provides manufacturers with fully automated visual inspection solutions that consistently find defects that are often missed by human inspectors, while providing powerful insights that help boost quality and operational efficiency.

2004 –**Present** **RTC Vision**, Rosh Ha'ayin, Israel. Founder & Chairman

RTC is a leading company developing cutting edge Computer Vision and AI technologies from generic research, through development, optimization, and QA, into successful products and applications.

7/2002 – 9/2003 **Applied Materials**, Rehovot, Israel. Manager, Image Processing, MIPG, ETEC

11/1999 – 7/2001 **Jigami Corporation**, Rosh Ha'ayin, Israel. VP R&D (-11/00) and CTO (11/00-)

7/1996 - 8/1999 **Xerox PARC (Palo Alto Research Center)**, Palo Alto, CA, USA.

2/1993 - 8/1994 **Scitex Corporation**, Herzlia, Israel.

2/1983 - 2/1993 **Israeli Defense Forces,** Captain.

TEACHING

2014, 2015 Computer Vision on Mobile Devices, IDC, Herzliya Israel
2008 Computational Photography, IDC, Herzliya Israel
2007 Video Processing, IDC, Herzliya Israel
2006 Advanced Topics in Medical Image Processing, Tel-Aviv University, Israel
1998 Pattern Recognition and Machine Intelligence (TA), Stanford University
1998 Vision and Image Processing (TA), Stanford University
1997 Mathematics for Robotics and Vision (TA), Stanford University
1996 Computer Vision (TA), Stanford University

PRIZES

2013 - Test-of-Time Award for ICCV'98 EMD paper, Helmholtz Prize for making significant impact and fundamental contributions to computer vision research.

1990 - Knesset (Israel Parliament) award for nationwide academic excellence (as the #1 student in the Computer Science department, Technion).

PUBLICATIONS

~20 papers in scientific journals and conferences

Book: Y. Rubner and C. Tomasi. Perceptual Metrics for Image Database Navigation. Kluwer Academic Publishers, Boston, December 2000.

Tamir Margalit

WORK HISTORY

05.2019 - PRESENT **KITOV.AI** **VP R&D**

- Member of Kitov management team, a startup in the field of universal 3D final inspection systems, using robotics, 3D vision and AI.
- Managing Company's R&D team as well as all R&D activities, from vision through design and implementation up to transfer to production and deployment, of both systems and software releases.
- Direct management of company's algorithms, software, QA, DevOps, system engineering and hardware teams.
- Leading end to end development, from vision to launch and deployment of new product family, with offline and inline capabilities.
- Leading all software versions development, including novel AI based hybrid detection modules, that combines traditional vision algorithms with novel DNN/CNN based detectors.

06.2017 – 05.2019	**ORBOTECH LTD – FPD DIVISION**
	Corporate VP and President of the FPD Division
06.2015 – 06.2017	**ORBOTECH LTD. – CORPORATE**
	Chief Product Officer and VP GPO
07.2011 – 06.2015	**ORBOTECH LTD. – FPD DIVISION**
	VP Product Line – FPD AOI
01.2008 – 07.2011	**ORBOTECH LTD. – PCB/FPD DIVISION**
	Product Manager (2 positions)
2004 – 2007	**ORBOTECH LTD. – PCB DIVISION**
	R**&D Manager of the AOI Product Line**
1999 – 2004	**ORBOTECH LTD. – PCB DIVISION**
	SW Manager (2 positions)
1996 – 1999	**ORBOTECH LTD. – ICP PRODUCT LINE**
	Algorithms Engineer
1994 – 1996	**DINCO & RHENIUM**
	Application Engineer

EDUCATION

2010 – 2012 **TEL AVIV UNIVERSITY** **Executive MBA - Reccanati**

1992 – 1994 **WEIZMANN INSTITUTE OF SCIENCE** **M.Sc. Physical Chemistry**

Thesis: *Light induced reactions on semiconductor surfaces, using STM and Temperature Programmed Desorption in an Ultra High Vacuum environment.* (Average: 89.5)

1989 – 1992 **TEL AVIV UNIVERSITY** **B.Sc. Chemistry**

PATENTS AND AWARDS

- Optical Inspection System: PCT/IL00/00434 US patent 7200259 B1
- Multi Modal Imaging: PCT/IL2010/000238
- Orbotech outstanding employee (CEO list) in 2001

Gil Pinsky

- MSc graduate in Computer Science with thesis in Deep Learning and Computer Vision, Weizmann Institute of Science, **GPA 91.**
- BSc graduate in Computer Engineering, Bar-Ilan University, **GPA 91.**
- Programming experience in Python, Java, MATLAB and C++/C.
- Experience working with Machine Learning related packages/frameworks such as PyTorch, Numpy, Pandas, Scikit-learn, OpenCV.
- Experience working as a Data Analyst at unit 9900 of the intelligence directorate, IDF.
- Highly motivated, creative, self-learner, analytical thinking, good interpersonal skills.

Education

2018-2020: MSc **Computer Science and Mathematics** including thesis, Weizmann Institute of Science.

2013-2017: BSc **Computer Engineering,** Bar-Ilan University.

2005-2008: Youth Excellence program in Mathematics at Bar-Ilan University, including taking courses from the BSc Mathematics program.

Professional Experience

2018-2020: **Thesis**, Weizmann Institute of Science, In-depth research for a thesis in Deep Learning and Computer Vision. Thesis subject: A new approach for image denoising from a single image using the spectral bias phenomenon of neural networks.

2017: **Final project**, Bar-Ilan University, Computer Vision algorithms for a robotic system.

2015: **Programming and design** of an Android application in Java in OJT (On-the-Job Training) with thousands of code lines. The application is currently sold on Google Play.

2010-2013: Data Analyst in unit 9900 of the intelligence directorate, IDF. Developed Geo-Spatial data analysis algorithms in Python.

Tools and Technologies:

- 3 years of experience in Python o 2 years of experience in Java & MATLAB.
- 1 year of experience in C++/C.
- Experience working with Machine Learning related packages/frameworks such as: PyTorch, CUDA, Numpy, Pandas, Scikit-learn & OpenCV.
- Experience working with Linux environments.

Languages

Hebrew: Mother tongue.
English: Fluent.

Daniel Campbell | VP Model-Based Definition, Capvidia

Mr. Daniel Campbell is the Vice President of Model-Based Definition at Capvidia. He has more than 17 years of experience in the field of digital metrology. Before Capvidia, Daniel was a Principal and the Software Director at Metrosage, where he had the primary responsibility for the design and development of the Pundit CMM measurement uncertainty simulation software. Since then, Pundit CMM has become a part of the Capvidia suite of solutions. Daniel has a solid foundation in software design and dimensional metrology. His interests in metrology have led him to lead various working groups on standards in this area for ANSI QIF. Daniel is currently the Chair of the ANSI QIF Working Group, and a member of the Board of Directors of the Dimensional Metrology Standards Consortium (DMSC). Daniel has a Bachelor of Science in Computer Science with a minor in Mathematics from the University of San Francisco.

Capabilities and Experience Highlights

- Vice President Model-Based Definition, Capvidia (2019 – present)
- Director of Business Development, Capvidia (2017 – 2019)
- Principal, Partner and Software Director, Metrosage LLC (2003 – 2017)

Standards and Community Involvement

- Member, Board of Directors, Digital Metrology Standards Consortium (DMSC)
- Member, Technology Advisory Committee, MxD Institute Chicago
- Chair, QIF Working Group

Publications

Applications of Computer Simulation in CMM Uncertainty Evaluation, Nov 2011, North American Coordinate Metrology Association Conference and Workshop, Montreal, QC, Canada, November 2-4, 2011. (Invited Paper)

Evaluating the Economic Impact of CMM Measurement Uncertainty, Mar 2010, Measurement Science Conference 2010, Pasadena, CA, March 22-26, 2010

Education

- B.S. – Computer Science, University of San Francisco (minor in mathematics)

Igor Besic | Account Manager MBD, Capvidia

Igor Besic is the Account Manager of Model-Based Definition at Capvidia. His hands-on technical expertise is a combination of end user CAD, manufacturing CNC and inspection CMM technology. This technical skillset led him to diverse professional experience in fields such as mass manufacturing for food packaging to automated inspection of structural spacecraft components, and from top down CAD of processing plants to complex surface CAD geometry of patient interfaces. Igor has a master's degree in mechanical engineering, manufacturing from University of Novi Sad, Serbia.

Experience Highlights

- Account Manager MBD, Capvidia (2020 – present)
- Manager, First Principles Labs (2019 – present)
- CMM Programmer, Quality and Methods Engineer, Northstar Aerospace, (2018 – 2020)
- Applications Engineer, Made To Measure (2016 – 2019)
- CAD designer, Resmed Ltd., Australia (2016)
- Quality Engineer, Diecast Ltd., Australia (2015)
- Engineering consultant, Ahhmigo (2012 – 2015)
- Researcher, University of Leuven, Belgium (2010)
- Researcher and Assistant Lecturer, University of Novi Sad, Serbia (2006 – 2013)
- CAD engineer, Hitard Engineering (2006)

Design Awards

- BEST DESIGN AWARD, Dispensing cap mechanism, Best design award, 1st prize, http://grabcad.com/challenges/dispensing-cap-mechanism, 2012
- BEST DESIGN AWARD, ZW3D Design Challenge – 2nd prize, http://grabcad.com/challenges/zw3d-design-challenge-holiday-edition/results, 2012

Key Publications

PATENT, Locking Cap Device and Methods, US Patent US9604765B2, Ahhmigo LLC, 2019

PATENT, Adjustable headgear tubing for a patient interface, US20190022343A1 Resmed Limited, 2019

I. Besic et al.: Accuracy improvement of laser line scanning for feature measurements on CMM. Optics and Lasers in Engineering. November 2011, ISSN: 0143-8166

Education

- M.S. – Mechanical Engineering, University of Novi Sad

Lyle Fischer | Senior Technical Manager, Capvidia

Extensive sales & marketing experience with a solid history of success through direct sales and resellers. Proven ability to develop a VAR (value added reseller) sales channel. Strong management, analytical and planning skills, and able to coordinate with the efforts of others to meet company goals. Self-motivator with productive and efficient work habits.

A solid background in sales and product experience in CAD/CAM/CAE/CFD markets.

EMPLOYMENT HISTORY

Capvidia

Senior Technical Manager 2001-Present
Started North American operations for Capvidia, a Belgium company providing CAD/CAM/CAE/CFD related products and services.

- Created a sales channel for North & South America where Capvidia' s products are now the dominant, niche product recommended and sold by over 80 resellers worldwide.
- Developed an aggressive marketing campaign from ground level focusing on company's strengths.
- Help bring new products to market by identifying customer requirements, working with upper management, and research and development team.
- Hire/Managed Sales People
- Developed strategies for attacking and penetrating automotive/aerospace industry.
- Direct sales of products and projects
- Signed VARs (Value Added Resellers) to sell Capvidia products and maintain close personal relationships with individual VAR's and customers. Assisted in sales process and helped close sales.
- Established key reference accounts - Mercedes-Benz, Daimler Chrysler, Google, John Deere, Boeing, Toyota, Honda, Volkswagen, Lockheed Martin, Nike, and others.
- Designed product presentations, demonstrations and pricing for resellers.
- Planned and managed trade shows to showcase products.
- Manage marketing activities, designed brochures, press releases, case studies, magazine articles.

XOX Corporation Co-founder 1985-2001

One of 8 people who started XOX Corporation.

- Software Engineer.
- Sales & Marketing Manager.

LEADERSHIP ROLES

Dimensional Metrology Standards Consortium – nonprofit organization | 2013 - present

- QIF MBD Working Group.
- QIF Membership and Marketing Chair.

PUBLICATIONS

Thomas D. Hedberg, Joshua Lubell, Lyle Fischer, Larry Maggiano, Allison Barnard Feeney. **Testing the Digital Thread in Support of Model-Based Manufacturing and Inspection**. Gaithersburg, MD March 8, 2016

EDUCATION

BS, Computer Science and Mathematics 1985
University of Minnesota, Morris, MN
Double Major: Computer Science & Mathematics

K. The Companies and Their Resources

About KITOV SYSTEMS LTD.

Overview

KITOV helps companies improve quality, eliminate production errors and lower manufacturing costs. Founded in 2014, KITOV created the first smart-visual-inspection solution that combines 3D imaging, AI and robotics to achieve unparallel results. Using an easy-to-use interface, a non-expert operator intuitively trains the system to inspect almost any product. This capability provides our customers significant flexibility and cost-savings vs conventional customized machine vision solutions. KITOV solutions are designed with Plug & Scan concept in mind. The system can be integrated into production lines in next to no time, making it ready-to-use INDUSTRY 4.0 solution.

In October 2018 Kitov Systems raised $10M in ‘Series A’, led by German HAHN Group and Japanese GiTV VC.

KITOV ONE systems have been successfully deployed in renowned manufactures around the world in key industries such as Communication, Aerospace, Automotive, Plastic, and Metal. Our systems can be found in Europe, China, Malaysia, USA, Mexico, Japan, and Israel.

K.1A General Company Information

Company Name: KITOV SYSTMES LTD.

Founded: 2014

Company Ownership: Privately held / Founders, German HAHN Group and Japanese GiTV VC

Principle Business: Development of smart-visual-inspection solutions that combines 3D imaging, AI and robotics

K.2A Record of performance in similar/related undertakings

From its inception, KITOV has proven its ability to develop complex software solutions in the area of A.I., machine vision, database management, UX/UI and implement them successfully in the market.   The following are a few examples:

- KITOV ONE Planner tool
- KITOV ONE Process tool
- KITOV Analytics
- KITOV Offline planner
- KITOV Offline Review Tool
- CLR Automation

K.3A Existing Project Resources

KITOV has a robust marketing, sales and support (direct and using distributors), and development team which has extensive experience developing smart visual inspection solutions. These existing resources will be leveraged to execute both the project and commercialization stages of the technology.

K.4A Previous BIRD Fund Projects

KITOV did not receive any previous funds from BIRD Foundation.

K.5A External Related Support

None.

K.6A Financial Information

	2018	2019	2020 (expected)
Revenues	$ 1.0 M	$ 1.3M	$ 2.0M
Operating Costs	$ 2.6M	$ 5.3M	$ 3.9M
Profitability	$ -2.0M	$ -4.3M	$ -2.3M

K.7A Number of employees

Number of employees in home office: 25

Number of employees in the field: 2

K.8A Project Resources

Kitov has office space in Israel (850 sqm) that can fit all the project needs and contractual agreements with manufacturing subcontractors if these will be required.

K.1B General Company Information

About Capvidia NA LLC.

CAPVIDIA is a leader in true MBD (model-based definition) with a focus on human and machine-readable 3D CAD models with semantic PMI (product and manufacturing information) for digital transformation downstream. 21st-century problems need 21st-century solutions. Traditional drawing-based workflows were not built for the era of the internet and Big Data. Model-based workflows are. Data interoperability empowers all downstream applications in design, manufacturing, quality, and other departments. Most importantly, data can be mapped back to the source for unlocking insights and improving processes.

Capvidia is a privately held company in the United States, and has been self-funded since its founding in 2001. Capvidia customers include a very large number of manufacturers in all industries. Some notable recent examples include Lockheed Martin, Schneider Electric, Northrup Grumman, Raytheon, Honda, Pratt & Whitney, Baker Hughes, General Dynamics, Cisco, Medtronic, Thales, Tata, US DOD, Stryker, GE Appliances, Toyota, and many more.

Company Name: Capvidia NA LLC.

Founded: 2001

Company Ownership: Privately held / by Tomasz Luniewski

Principle Business: Software Development in the area of MBD Workflows, CAD translation and validation

K.2B Record of performance in similar/related undertakings

Capvidia is a leader in Model-Based Definition solutions for large industrial end users. MBD is an emerging market, and Capvidia has quickly established itself over the past few years as one of a handful of dominant technology vendors who are relied upon by large enterprise. Over the course of Capvidia's technology deployments with large MBD end users across various market verticals, Capvidia has amassed a great deal of practical experience in propagating digital product requirements to downstream manufacturing and quality systems. This experience will prove essential in the project execution of this technology, and Capvidia's international leadership in the MBD market will be invaluable in the commercialization stage.

K.3B. Existing Project Resources

Capvidia has a robust marketing, sales, support, and development team which has extensive experience in this area. These existing resources will be leveraged to execute both the project and commercialization stages of the technology.

K.4B Previous BIRD Fund Projects

None

K.5B External Related Support

None

K.6B Financial Information

Capvidia NA LLC is privately held, but a summary of recent years revenues and profitability is summarized below.

	2018	2019	2020 (expected)
Revenues	$ 1.55M	$ 1.35M	$ 2.2M
Operating Costs	$ 1.2M	$ 1.1M	$ 1.4M
Profitability	$ .35 M	$ .25 M	$ .8M

K.7B Number of employees

Number of employees in home office [USA]: 5 (Capvidia has hired 2 new employees over the past 2 years)

Number of employees abroad: 25

K.8B Project Resources

Capvidia's user base is spread all over the US, Europe, Asia, and the rest of the world. For this reason, Capvidia operates entirely "virtually" with home office arrangements.

L. Project Budget

L.1 General Information

All development expenses directly associated with the project, incurred by each company throughout its entire development phase, are detailed in the budget section.

The starting date from the project is set to Jan-1st, 2022 although the company is planning to engage with some development activities immediately following the approval of the BIRD grant.

In the attached Excel files. each company presented its own activities throughout the entire duration of the project. Please refer to the *Budget* Excel files for further information.

L.2 KITOV Budget

PROPOSED PROJECT BUDGET

Company name: Kitov
Project duration: 18 months

I. Direct Labor

	Employee's Name (TBD if yet unknown)	Employee's Profession	Employee Location	Gross Annual Salary* ($)	% on Project	Cost to Project ($)
Empl. 1:	Yossi Rubner	Algorithms engineer and CTO		100,000	79%	118,356
Empl. 2:	Tamir Margalit	VP R&D		100,000	13%	19,726
Empl. 3:	Gil Pinsky	Algorithms engineer		100,000	99%	147,945
Empl. 4:	Dima Rodginsky	Software engineer		100,000	89%	133,151
Empl. 5:	Shiran Ganor	Algorithms engineer		100,000	75%	111,781
Empl. 6:	Miron Stiglitz	Software engineer		100,000	79%	118,356
Empl. 7:	Adam Tabor	Marketing and COO		100,000	30%	45,258
Empl. 8:					0%	0
Empl. 9:					0%	0
Empl.10:					0%	0
Empl. 11:					0%	0
Empl. 12:					0%	0
Empl. 13:					0%	0
Empl. 14:					0%	0
Empl. 15:					0%	0
Empl. 16:					0%	0
Empl. 17:					0%	0
Empl. 18:					0%	0
Empl. 19:					0%	0
Empl. 20:					0%	0
	Total, Direct Labor		* Including social benefits			694,573
	Overhead @ 25%					173,643
	Subtotal, Direct Labor + Overhead					868,216

II. Equipment

	Purchased Equipment Description	Purchased Cost ($/unit)	No. of Units	% On Project	% Annual Depreciation	Depreciation ($)
Item 1	SolidWorks	8,500	2	129%	33.3%	10,945
Item 2	Creo/Catia/QIF	10,000	3	129%	33.3%	19,315
Item 3	Laptop for Yossi	3,000	1	75%	33.3%	1,118
Item 4	PC (+GPU) for Miron	3,000	1	79%	33.3%	1,184
Item 5	PC (+GPU) for Gil	3,000	1	99%	33.3%	1,479
Item 6	PC (+GPU) for Dima	3,000	1	89%	33.3%	1,332
Item 7	PC (+GPU) for Shiran	3,000	1	75%	33.3%	1,118
Item 8				0%	33.3%	0
Item 9				0%	33.3%	0
Item 10				0%	33.3%	0
	Subtotal, Purchased Equipment					36,490

	Leased Equipment Description	Monthly Lease Cost ($/unit)	No. of Units	% On Project		Total Leasing Cost ($)
Item 1				0%		0
Item 2				0%		0
Item 3				0%		0
Item 4				0%		0
Item 5				0%		0
Item 6				0%		0
Item 7				0%		0
Item 8				0%		0
Item 9				0%		0
Item 10				0%		0
	Subtotal, Leased Equipment					0
	Subtotal, Purchased or Leased Equipment					36,490

III. Expendable Materials & Supplies

	Description	Cost ($)
Item 1		0
Item 2		0
Item 3		0
Item 4		0
Item 5		0
Item 6		0
Item 7		0
Item 8		0
Item 9		0
Item 10		0
	Subtotal, Expendable Materials & Supplies	0

Company name: Kitov
Project duration: 18 months

IV. Travel

Foreign Travel

	Destination	Purpose	Cost Per Person Per Trip ($)	No. of Trips	No. of People Per Trip	Duration Per Trip (days)	Cost ($)
Dest. 1	US	Visit users, visit Capvidia	5,500	4	1	14	22,000
Dest. 2				0			0
Dest. 3				0			0
Dest. 4				0			0
Dest. 5				0			0
Dest. 6				0			0
		Subtotal, Foreign Travel		4			22,000

Domestic Travel

	Destination	Purpose	Cost Per Person Per Trip ($)	No. of Trips	No. of People Per Trip	Duration Per Trip (days)	Cost ($)	
Dest. 1	US customer	User interview	1,000	2	1	2	2,000	
Dest. 2				0			0	
Dest. 3				0			0	
		Subtotal, Domestic Travel		2			2,000	
		Subtotal, Travel						24,000

V. Subcontractors

	Service to be Performed	Name of Subcontractor	Country of Service	Cost ($)	
Subcont. 1	Manufcture the demonstration parts	TBD	Israel	8,000	
Subcont. 2				0	
Subcont. 3				0	
Subcont. 4				0	
Subcont. 5				0	
Subcont. 6				0	
	Subtotal, Subcontracts				8,000

VI. Consultants

	Service to be Performed	Name of Consultant	Hourly Rate ($/Hr.)	No. of Hours	Country of Service	Cost ($)	
Consult. 1				0		0	
Consult. 2				0		0	
Consult. 3				0		0	
Consult. 4				0		0	
Consult. 5				0		0	
Consult. 6				0		0	
	Subtotal, Consultants						0

VII. Other Expenses

	Description	Cost ($)	
Item 1	Patent filing	15,000	
Item 2		0	
Item 3		0	
Item 4		0	
Item 5		0	
Item 6		0	
	Subtotal, Other Expenses		15,000

Subtotal budget, before G&A Expenses	951,707
General & Administrative Expenses (G&A) @5%	47,585
Total Project Budget for Company	999,292

Projected Expenditure, by Segment

	Segment Duration (months)	% of Total Budget	Projected Expenditure ($)
First segment			0
Second segment			0
Third segment			0
Fourth segment			0
Fifth segment			0
Sixth segment			0
Seventh segment			0
Eighth segment			0
Total	0	0%	0

L.3 Capvidia Budget

PROPOSED BUDGET

Country: US
Organization name: Capvidia
Project duration: 18 months

	Description / Details					Cost ($)	Total ($)
	I. Direct Labor						
	Employee's Name (TBD if yet unknown)	Employee's Profession	Employee Location	Gross Annual Salary* ($)	% on Project	Cost to Project ($)	
Empl. 1:	Daniel Campbell	VP Model-Based Definition	US	150,000	44%	98,125	
Empl. 2:	Lyle Fischer	Senior Technical Manager	US	130,000	46%	89,917	
Empl. 3:	Igor Besic	MBD Account Manager	US	116,500	81%	140,771	
Empl. 4:	Jimmy Nguyen	MBD Operations Analyst	US	90,000	18%	24,750	
Empl. 5:					0%	0	
Empl. 6:					0%	0	
Empl. 7:					0%	0	
Empl. 8:					0%	0	
Empl. 9:					0%	0	
Empl. 10:					0%	0	
Empl. 11:					0%	0	
Empl. 12:					0%	0	
Empl. 13:					0%	0	
Empl. 14:					0%	0	
Empl. 15:					0%	0	
Empl. 16:					0%	0	
Empl. 17:					0%	0	
Empl. 18:					0%	0	
Empl. 19:					0%	0	
Empl. 20:					0%	0	
		Total, Direct Labor	* including social benefits			353,563	
		Overhead @ 25%				88,391	
		Subtotal, Direct Labor + Overhead					441,953

	II. Equipment						
	Purchased Equipment Description	Purchased Cost ($/unit)	No. of Units	% On Project	% Annual Depreciation	Depreciation ($)	
Item 1	MBDVidia	5,800	4	46%	33.3%	5,381	
Item 2	CompareVidia	9,200	4	46%	33.3%	8,536	
Item 3	MBDVidia for Creo	3,750	4	46%	33.3%	3,479	
Item 4	FormatWorks for SolidWorks	3,750	4	46%	33.3%	3,479	
Item 5				0%	33.3%	0	
Item 6				0%	33.3%	0	
Item 7				0%	33.3%	0	
Item 8				0%	33.3%	0	
Item 9				0%	33.3%	0	
Item 10				0%	33.3%	0	
	Subtotal, Purchased Equipment					20,875	
	Leased Equipment Description	Monthly Lease Cost ($/unit)	No. of Units	% On Project		Total Leasing Cost ($)	
Item 1	MBDVidia - SMA	97	4	46%		3,229	
Item 2	CompareVidia - SMA	153	4	46%		5,121	
Item 3	MBDVidia for Creo - SMA	63	4	46%		2,088	
Item 4	FormatWorks for SolidWorks - SMA	63	4	46%		2,088	
Item 5				0%		0	
Item 6				0%		0	
Item 7				0%		0	
Item 8				0%		0	
Item 9				0%		0	
Item 10				0%		0	
	Subtotal, Leased Equipment					12,525	
	Subtotal, Purchased or Leased Equipment						33,400

	III. Expendable Materials & Supplies		
	Description	Cost ($)	
Item 1		0	
Item 2		0	
Item 3		0	
Item 4		0	
Item 5		0	
Item 6		0	
Item 7		0	
Item 8		0	
Item 9		0	
Item 10		0	
	Subtotal, Expendable Materials & Supplies		0

TOTAL ORGANIZATION BUDGET (Cont.)

Organization name: Capvidia

Description / Details	Cost ($)	Total ($)

IV. Travel

Foreign Travel

	Destination	Purpose	Cost Per Person Per Trip ($)	No. of Trips	No. of People Per Trip	Duration Per Trip (days)	Cost ($)
Dest. 1	Tel Aviv	Coordination with Kitov & e	4,450	0	3	7	0
Dest. 2				0			0
Dest. 3				0			0
Dest. 4				0			0
Dest. 5				0			0
Dest. 6				0			0
		Subtotal, Foreign Travel		0			0

Domestic Travel

	Destination	Purpose	Cost Per Person Per Trip ($)	No. of Trips	No. of People Per Trip	Duration Per Trip (days)	Cost ($)	Total ($)
Dest. 1	Customer Site	Visit major end user on site	2,050	2	3	5	12,300	
Dest. 2				0			0	
Dest. 3				0			0	
		Subtotal, Domestic Travel		2			12,300	
		Subtotal, Travel						12,300

V. Subcontractors

	Service to be Performed	Name of Subcontractor	Country of Service	Cost ($)	Total ($)
Subcont. 1				0	
Subcont. 2				0	
Subcont. 3				0	
Subcont. 4				0	
Subcont. 5				0	
Subcont. 6				0	
	Subtotal, Subcontracts				0

VI. Consultants

	Service to be Performed	Name of Consultant	Hourly Rate ($/Hr.)	No. of Hours	Country of Service	Cost ($)	Total ($)
Consult. 1				0		0	
Consult. 2				0		0	
Consult. 3				0		0	
Consult. 4				0		0	
Consult. 5				0		0	
Consult. 6				0		0	
	Subtotal, Consultants						0

VII. Other Expenses

	Description	Cost ($)	Total ($)
Item 1		0	
Item 2		0	
Item 3		0	
Item 4		0	
Item 5		0	
Item 6		0	
	Subtotal, Other Expenses		0

Subtotal budget, before G&A Expenses	487,653
General & Administrative Expenses (G&A) @5%	24,383
Total Project Budget for Organization	512,036

Projected Expenditure, by Segment

Segment #	Segment Duration (months)	% of Total Budget	Projected Expenditure ($)
1	6		0
2	6		0
3	6		0
4	6		0
5	6		0
6	6		0
Total:	36	0%	0

M. Risk Analysis

RISK ANALYSIS TABLES

Do not change format (color & font size)

TABLE 1A

			Impact		
Risk #	Name/Description	Ranking	Duration[1]	Budget[2]	Commercialization Potential[3]
1	"Inspection language" semantic gap	Medium	Medium	Low	Low
2	Lack of definitive ROI	Medium	Low	Low	Medium
3	QIF limitations for visual inspection	Low	Medium	Low	Low
4	QIF market acceptance	Low	Low	Low	Medium
5	Lack of CAD support for robust PMI	Very Low	Low	Low	Low
6	COVID19 epidemic	Medium	Medium	Low	Medium

TABLE 1B

Risk #	Name/Description	Type*
1	Today, most visual inspection activities are performed manually, and inspection specifications are given to the inspectors (either orally or as a document) in high-level semantic way, also known as QC Book. Often, the inspection specifications are given by showing images of parts with defects. We plan to define an inspection language that will have the power to describe these requirements. Being able to specify the descriptive richness of the semantics into a syntactic language is challenging.	T
2	We are planning to develop new MBE workflows in this project. We have good indications for the value they will bring to manufacturers and OEMs. We will also finetune the workflow and offering based on the user interviews we will conduct at the beginning of the project. Still we will need to adjust the cost of the automated solution with the costs of current standard practices which include both CoGQ (e.g. labor cost) and CoPQ (e.g. reworks, recalls, etc.)	E
3	QIF is an ISO standard that was designed for metrology, and not for visual inspection. This might introduce some limitations for QIF to carry all the information needed for visual inspection. For example, each metrology measurement returns a single numerical result while visual inspection can return many results (e.g. several scratches on a surface) for a single inspection, some can be non-numeric (a text typo on a label). We expect that we might need to extend the QIF and present it to the	T

	Digital Metrology Standards Consortium (DMSC), the body which governs the QIF standard, and propose an enhancement for future versions of QIF. This will provide a significant advancement to the field of manufacturing quality.	
4	We are basing large parts of the project on the QIF ISO standard. Although the QIF is winning wide acceptance it is fairly a new standard at an early development stage. In the CAD2SCAN product we are planning to use the QIF as the mechanism to translate inspection requirements and receive inspection results. We hope to utilize the QIF standard to promote other visual inspection automation vendors to adapt our workflow. This will increase the potential revenues from the project.	E
5	The main workflow in this project starts from specifying the inspection requirements using the common CAD software systems (SolidWorks, CATIA, Creo, …). We rely on their abilities to enable the user to specify the relevant attributes. We think that this a low risk as most modern CAD systems allow embedding MBD data in various ways.	E
6	The current COVID-19 epidemic has restricted budgets in many manufacturing organizations. However, this risk will be largely mitigated by the fact that manufacturing has recently made overarching efforts to increase digital manufacturing initiatives (like CAD2SCAN) in an attempt to increase productivity in environment of the pandemic restrictions.	E

***Type**: Technical (T), Project Management/Resources (M), External to the Project (E)

Ranking	**Probability of Risk Occurring**
High	Above 50%
Medium	30 – 49%
Low	10 – 29%
Very Low	1 – 10%

Impact	**Duration[1]**
High	Above 6 months
Medium	3 to 6 months
Low	Below 3 months

Impact	**Budget[2]**
High	Above 20% increase
Medium	10% to 20% increase
Low	Below 10% increase

Impact	**Commercialization Potential[3]**
High	Above 50%
Medium	30% to 50%
Low	1% to 29%

Duration of project extended by the given amount

1. Cost of project increases by the given percentage

2. Forecasted sales in the next 3 or 5 years reduced by the given percentage

N. Sundry Information – Mandatory

Israeli Company
Project Manager -

Full name and title:	Yossi Rubner
Position in company:	Founder and CTO
Email address:	yossi.rubner@kitov.ai
Direct number:	+972-3-3731355 (ext.222)
Mobile number:	+972-50-7455466

Fiscal Information Official -

Full name and title:	Ehud Helzinger
Position in company:	CFO
Email address:	ehud.helzinger@gmail.com
Direct number:	+972(0)54-4280928
Mobile number:	+972(0)54-4280928

U.S. Company
Project Manager -

Full name and title:	Daniel Campbell
Position in company:	Vice President, Model-Based Definition
Email address:	dc@capvidia.com
Direct number:	+1-415-738-7366
Mobile number:	+1-415-244-6407

Fiscal Information Official -

Full name and title:	Laurel Fischer
Position in company:	Accounting Manager
Email address:	laurel@capvidia.com
Direct number:	+1-612-260-2287
Mobile number:	+1-612-260-2287

Details of bank accounts to enable the Foundation to transfer the payments to the companies.

Israeli Company

- Name of Account	**Kitov Systems LTD.**
- Account Number	**664464**
- Name of Bank	**Bank Hapoalim B.M.**
- Branch number	**410**
- Complete bank address	**30 Sderot Emek Ayalon, Shoam, 73142, Israel.**
- IBAN number	**IL82-0124-1000-0000-0664-464**

U.S. Company

- Name of Account	**CAPVIDIA NA LLC**
- Account Number	**0752293092**
- Name of Bank	**Wells Fargo Bank**
- Complete bank address	**420 Montgomery Street, San Francisco, 94163, CA.**
- ABA Routing number	**121000248**
- SWIFT number	**WFBIUS6S**

Certificates of Incorporation – to be provided on separate pages each

משרד המשפטים
MINISTRY OF JUSTICE

רשות התאגידים

מדינת ישראל
STATE OF ISRAEL

19/02/2020

TO WHOM IT MAY CONCERN

As registrar of companies of the State of Israel, I hereby confirm that,
KITOV SYSTEMS LTD No. **515108058** is incorporated and registered under Israeli law since **14/07/2014** .
Company status: active

Respectfully,

The Israeli Corporations Authority

Registrar of Companies and Partnerships

רחוב ירמיהו 39, מגדלי הבירה בנין 1, ירושלים 9446722, ת״ד 28093 ירושלים 9128002
טלפון: 5601* http://Taagidim.justice.gov.il
שעות קבלת קהל: ימים א׳, ב׳, ד׳, ה׳ 30 :08-30 :12 ; יום ג׳ הפקדת מסמכים בלבד (בהזמנת בוטה)

רשות התאגידים
העותק שמסמך זה החתום אלקטרונית, מהווה העתק של מסמך (מקור או העתק) המצוי ביום החתימה בתיק התאגיד ברשות התאגידים

Delaware

PAGE 1

The First State

I, JEFFREY W. BULLOCK, SECRETARY OF STATE OF THE STATE OF DELAWARE DO HEREBY CERTIFY THAT THE ATTACHED IS A TRUE AND CORRECT COPY OF THE CERTIFICATE OF CONVERSION OF A DELAWARE CORPORATION UNDER THE NAME OF "TESIS-NAC INC." TO A DELAWARE LIMITED LIABILITY COMPANY, CHANGING ITS NAME FROM "TESIS-NAC INC." TO "TESIS NA LLC", FILED IN THIS OFFICE ON THE SECOND DAY OF AUGUST, A.D. 2001, AT 9 O'CLOCK A.M.

Jeffrey W. Bullock, Secretary of State

3417252 8100V

150378593

You may verify this certificate online
at corp.delaware.gov/authver.shtml

AUTHENTICATION: 2213881

DATE: 03-19-15

STATE OF DELAWARE
SECRETARY OF STATE
DIVISION OF CORPORATIONS
FILED 09:00 AM 08/02/2001
010376593 - 3417252

**CERTIFICATE OF CONVERSION
FROM A CORPORATION TO
A LIMITED LIABILITY COMPANY
PURSUANT TO SECTION 266 OF THE
DELAWARE GENERAL CORPORATION LAW**

1. The name of the corporation immediately prior to filing this Certificate is TESIS-NAC INC.

2. The Certificate of Incorporation was filed on the 24th day of July, 2001.

3. The original name of the corporation as set forth in the Certificate of Incorporation is TESIS-NAC INC.

4. The name of the limited liability company as set forth in the formation is TESIS NA LLC.

5. The conversion has been approved in accordance with the provisions of Section 266.

By: T. Luniewski

Name: TOMASZ LUNIEWSKI
Title: MANAGING DIRECTOR
TESIS Software BVBA

TESIS SOFTWARE
Technologielaan 3
3001 Leuven - Belgium
Tel. (32) 16 40 27 47
Fax (32) 16 40 32 71

Delaware

The First State

I, JEFFREY W. BULLOCK, SECRETARY OF STATE OF THE STATE OF DELAWARE DO HEREBY CERTIFY THAT THE ATTACHED IS A TRUE AND CORRECT COPY OF CERTIFICATE OF FORMATION OF "TESIS NA LLC" FILED IN THIS OFFICE ON THE SECOND DAY OF AUGUST, A.D. 2001, AT 9 O'CLOCK A.M.

3417252 8100V

150378593

You may verify this certificate online at corp.delaware.gov/authver.shtml

Jeffrey W. Bullock, Secretary of State

AUTHENTICATION: 2213881

DATE: 03-19-15

STATE OF DELAWARE
SECRETARY OF STATE
DIVISION OF CORPORATIONS
FILED 09:00 AM 08/02/2001
010376593 - 3417252

CERTIFICATE OF FORMATION

OF

TESIS NA LLC

The undersigned corporation acting as an Authorized Person of a limited liability company pursuant to the Delaware Limited Liability Company Act adopts the following Certificate of Formation.

1. Name. The name of the Limited Liability Company is: TESIS NA LLC.

2. Duration. Its period of duration shall be perpetual.

3. Registered Agent & Office. The name of its registered agent is Lexis Document Services Inc., and the address of the registered office is 30 Old Rudnick Lane, Suite 100, Dover, DE 19901, Kent County.

LexisNexis Document Solutions Inc.
Authorized Person

By: Zvjezdana Sijan
Zvjezdana Sijan, Assistant Secretary

Delaware

PAGE 1

The First State

I, JEFFREY W. BULLOCK, SECRETARY OF STATE OF THE STATE OF DELAWARE, DO HEREBY CERTIFY THE ATTACHED IS A TRUE AND CORRECT COPY OF THE CERTIFICATE OF AMENDMENT OF "TESIS NA LLC", CHANGING ITS NAME FROM "TESIS NA LLC" TO "CAPVIDIA NA LLC", FILED IN THIS OFFICE ON THE FOURTH DAY OF JANUARY, A.D. 2002, AT 9 O'CLOCK A.M.

SECRETARY OF STATE · DELAWARE · 1776 · 1793

Jeffrey W. Bullock, Secretary of State

3417252 8100

150378593

AUTHENTICATION: 2213882

DATE: 03-19-15

You may verify this certificate online at corp.delaware.gov/authver.shtml

STATE OF DELAWARE
SECRETARY OF STATE
DIVISION OF CORPORATIONS
FILED 09:00 AM 01/04/2002
020006980 - 3417252

CERTIFICATE OF AMENDMENT

OF

CERTIFICATE OF FORMATION

OF

TESIS NA LLC

TESIS NA LLC, a limited liability company organized and existing under and by virtue of the Limited Liability Company Act of the State of Delaware, DOES HEREBY CERTIFY:

1. Article 1. of the Certificate of Formation of the Limited Liability Company is hereby amended as follows:

    1. Name. The name of the Limited Liability Company is Capvidia NA LLC.

2. That the aforesaid amendment was duly adopted in accordance with the applicable provisions of Section 18-202 of Title 6 of the Delaware Code.

IN WITNESS WHEREOF, said company has caused this Certificate to be signed by an authorized person this 4th day of January, 2002.

Name: Tomasz Luniewski
Authorized Person