Capgemini

INTELLIGENT INSPECTION

VISUAL AI AND SYNTHETIC DATA

ASSET INSPECTION

Current State:

- Drones and cameras collect videos & images
- Manual visual inspection for defects

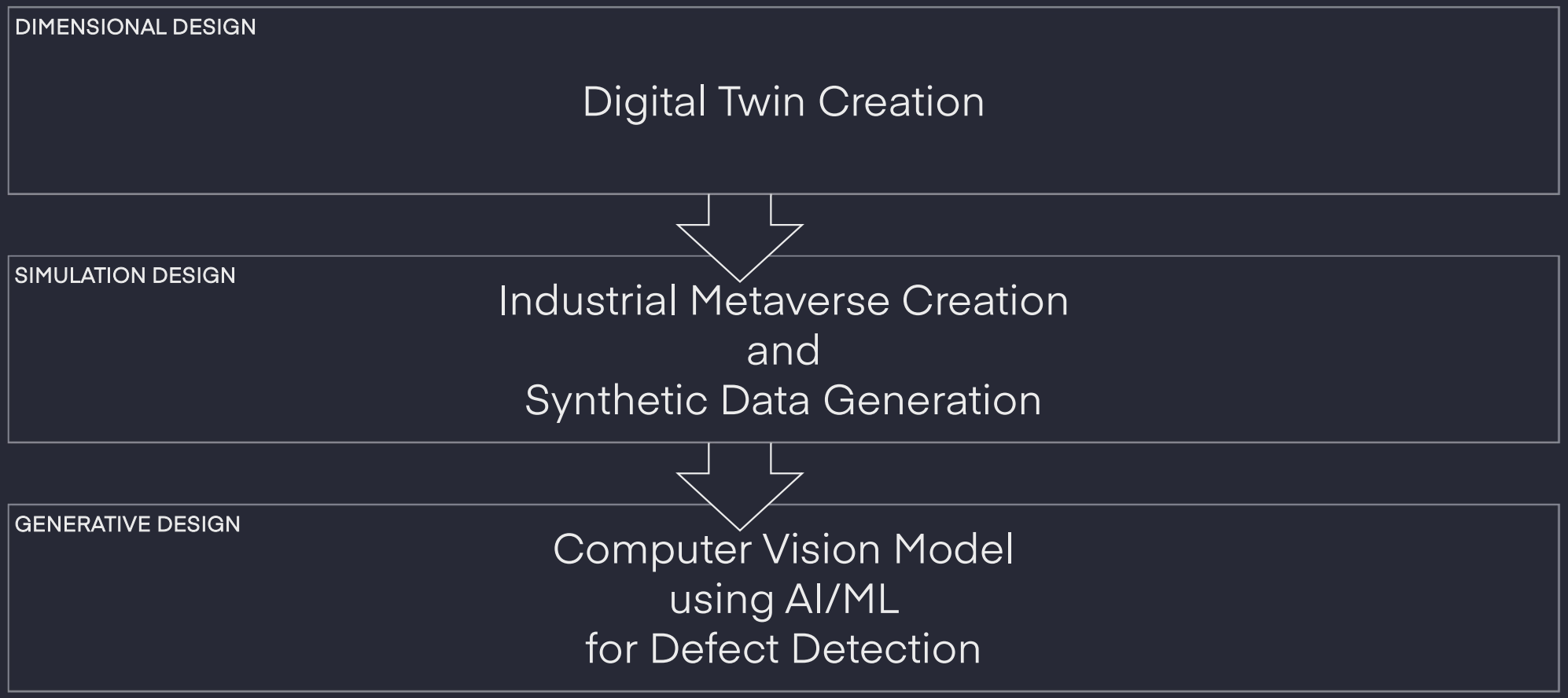
Challenges

- Time consuming and inaccurate (missed defects)
- Insufficient visuals for CV model training or no visuals for rarely occurring events

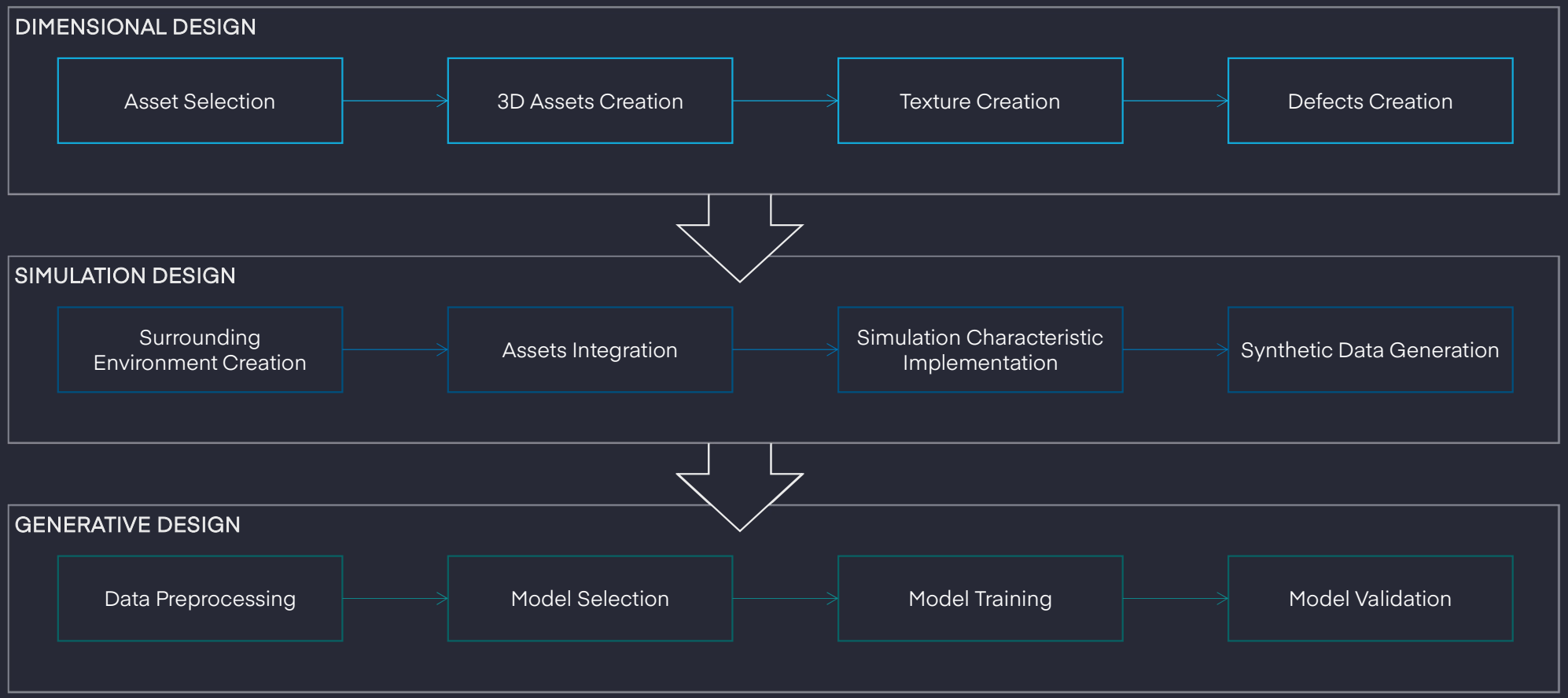
Proposed Solution

- Utilizing CG & gaming techniques to generate realistic synthetic visual data to train CV models
- Guide visual gathering techniques like drones to navigate the space that is ideal for inspection

INTELLIGENT INSPECTION
COMPUTER VISION MEETS METAVERSE



HOW DOES IT WORK



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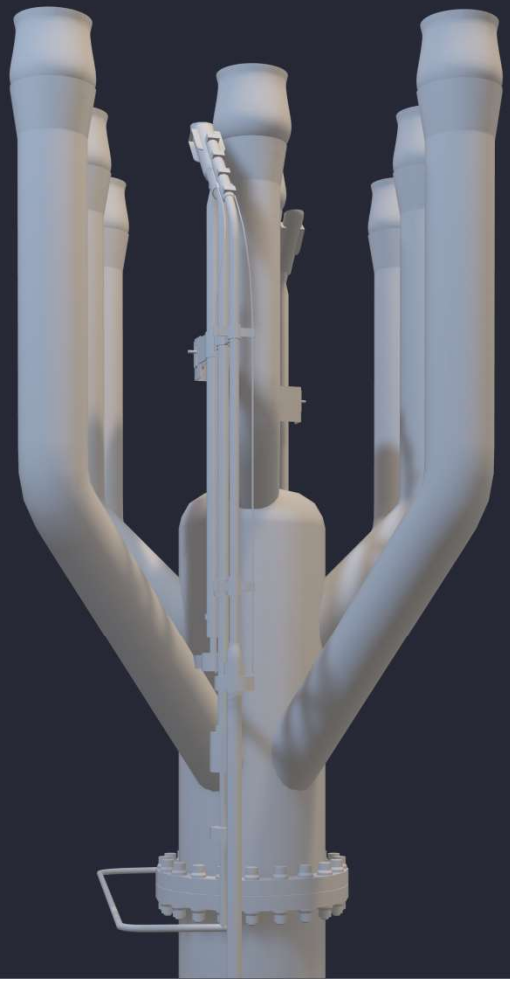
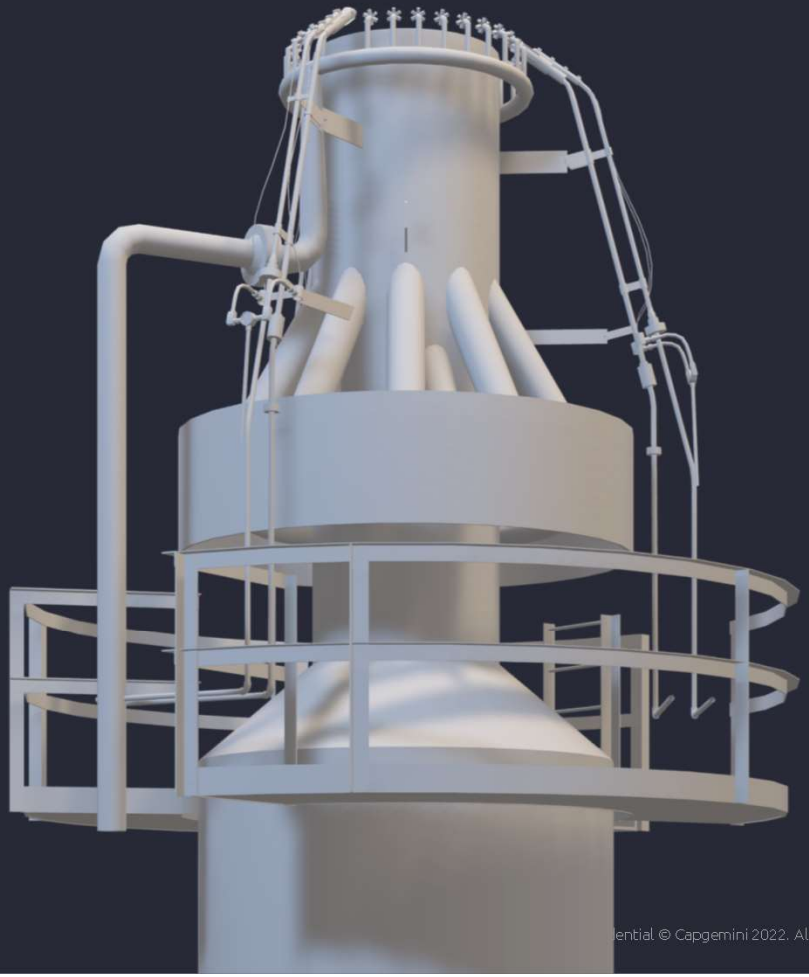
SYNTHETIC DATA GENERATION

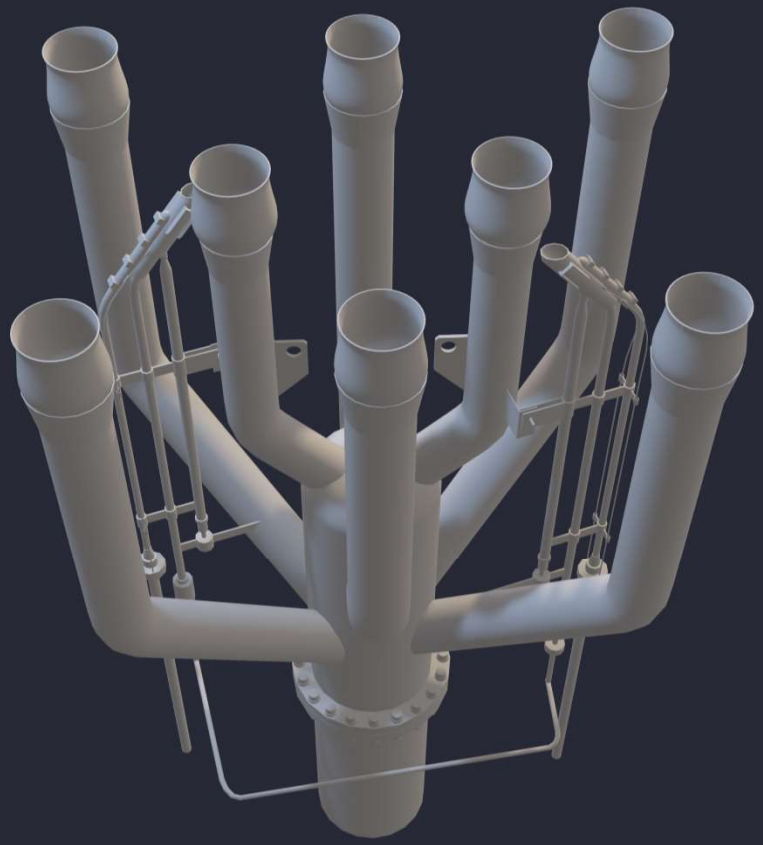
3D COMPUTER GRAPHICS AND METAVERSE

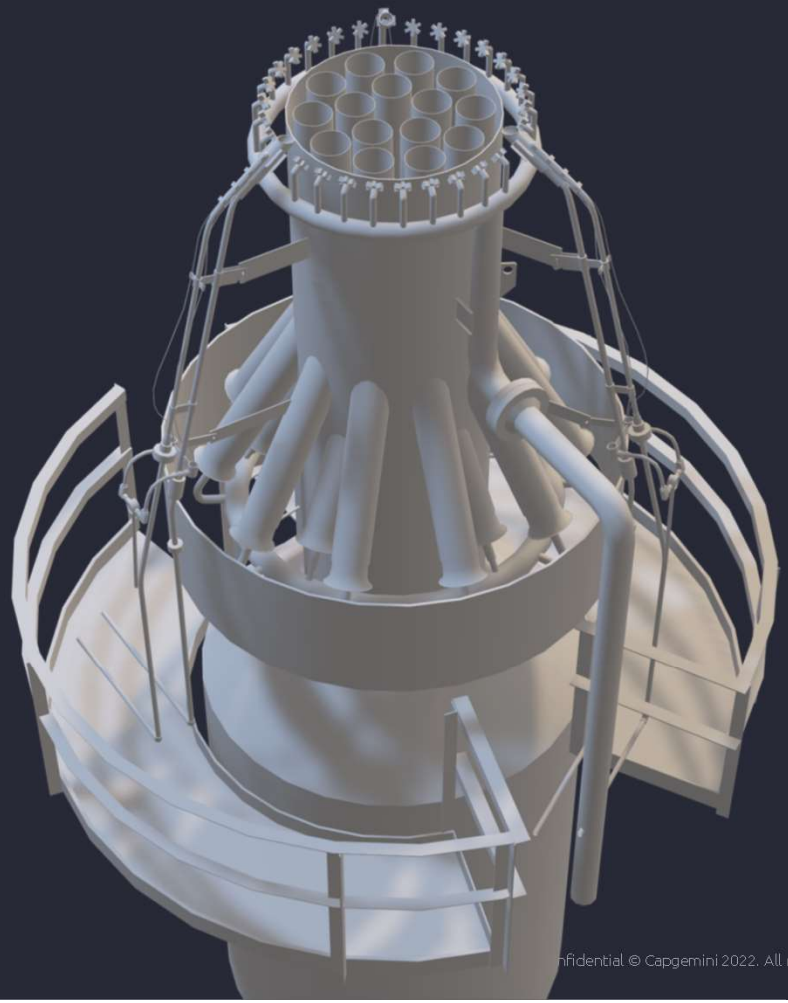
3D ASSET CREATION





3D ASSET CREATION

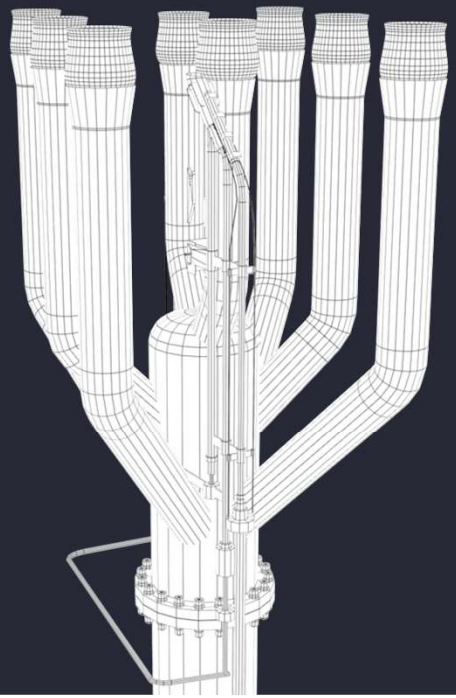


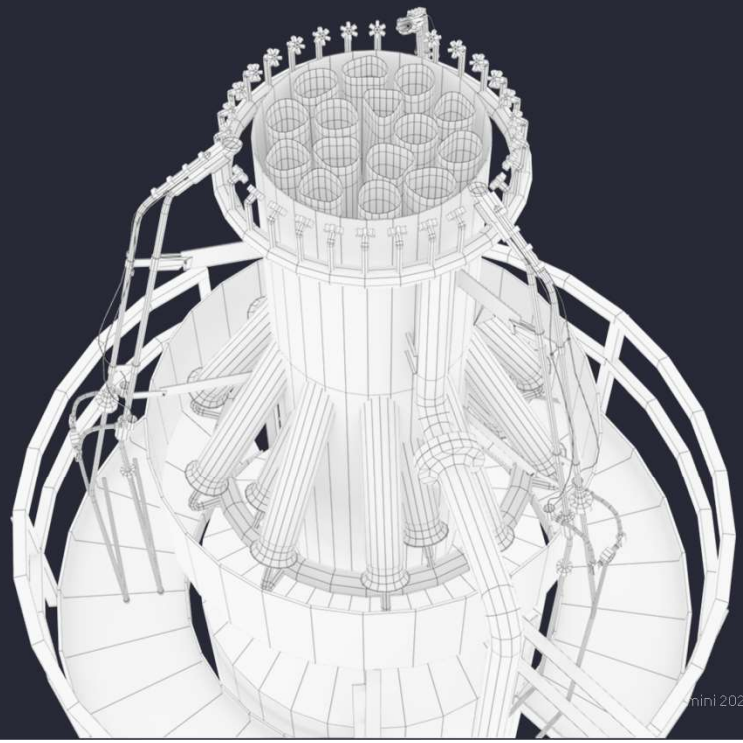


MODEL FOR THE GAME ENGINE

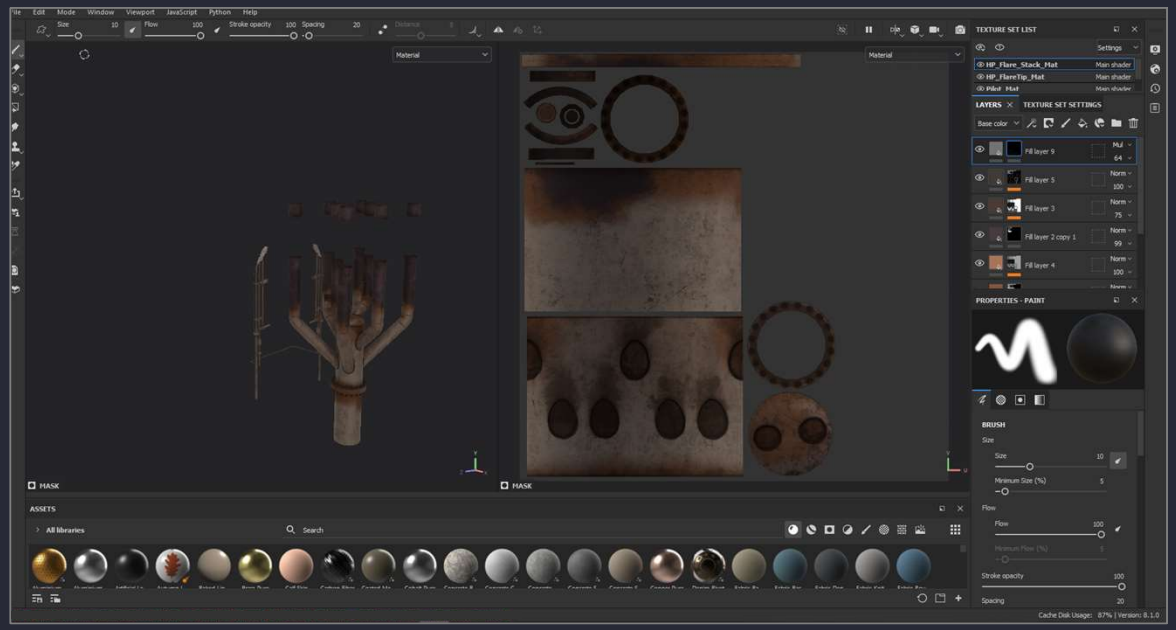
POLYGON MODELING

Game engines, such as Unity, must have 3D models made from polygons rather than Booleans or curves. The lower the polycounts, the smoother the game engine can run. So **boolean based CAD models are converted to polygon-based geometry.**





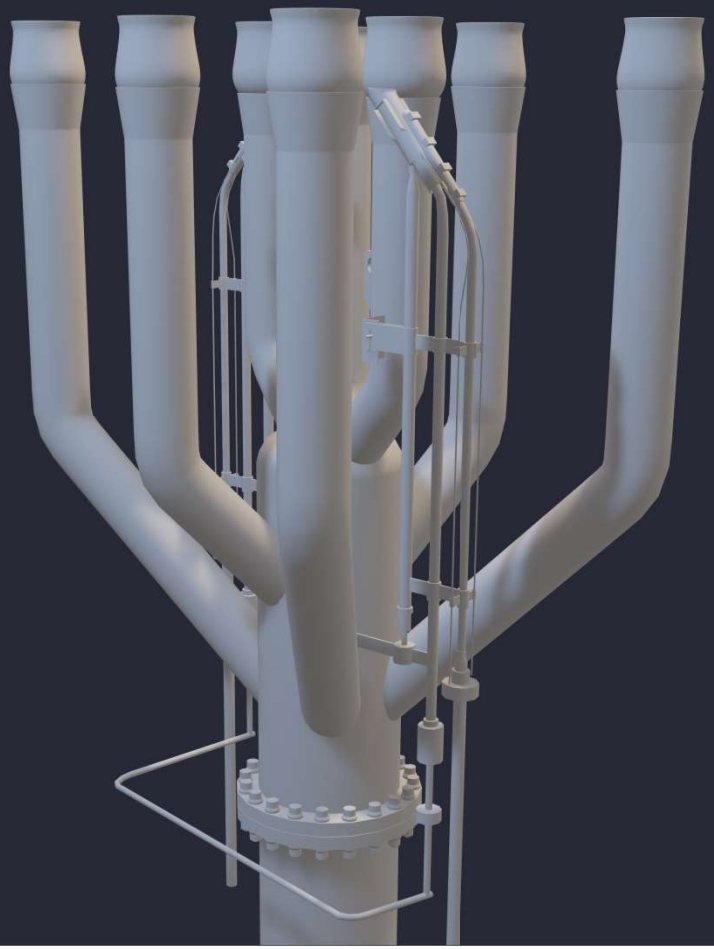
SIMULATION OF WEAR AND TEAR

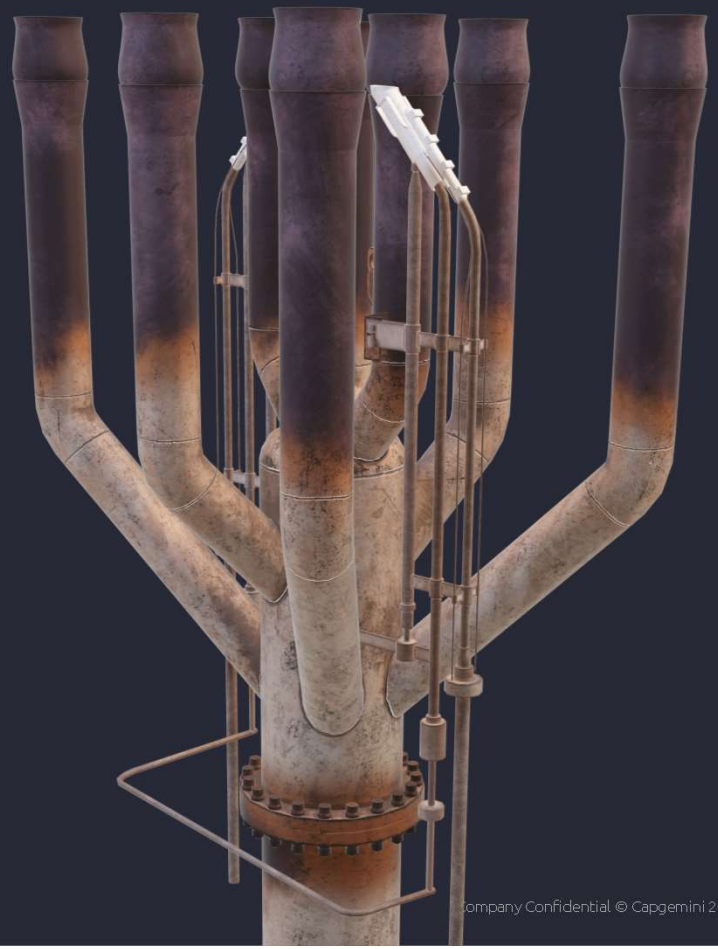


TEXTURING

Within programs like Substance Painter, the 3D models can be ‘painted’ to create realistic looking textures.

FJG0NAL DIGITAL TWINS



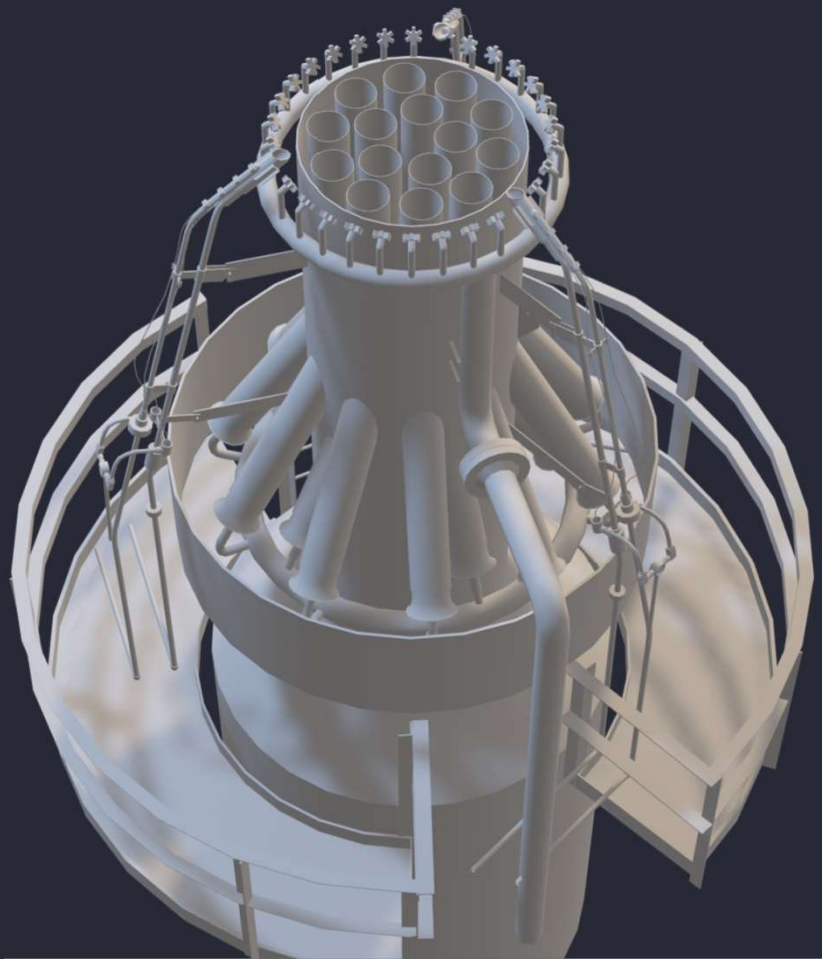


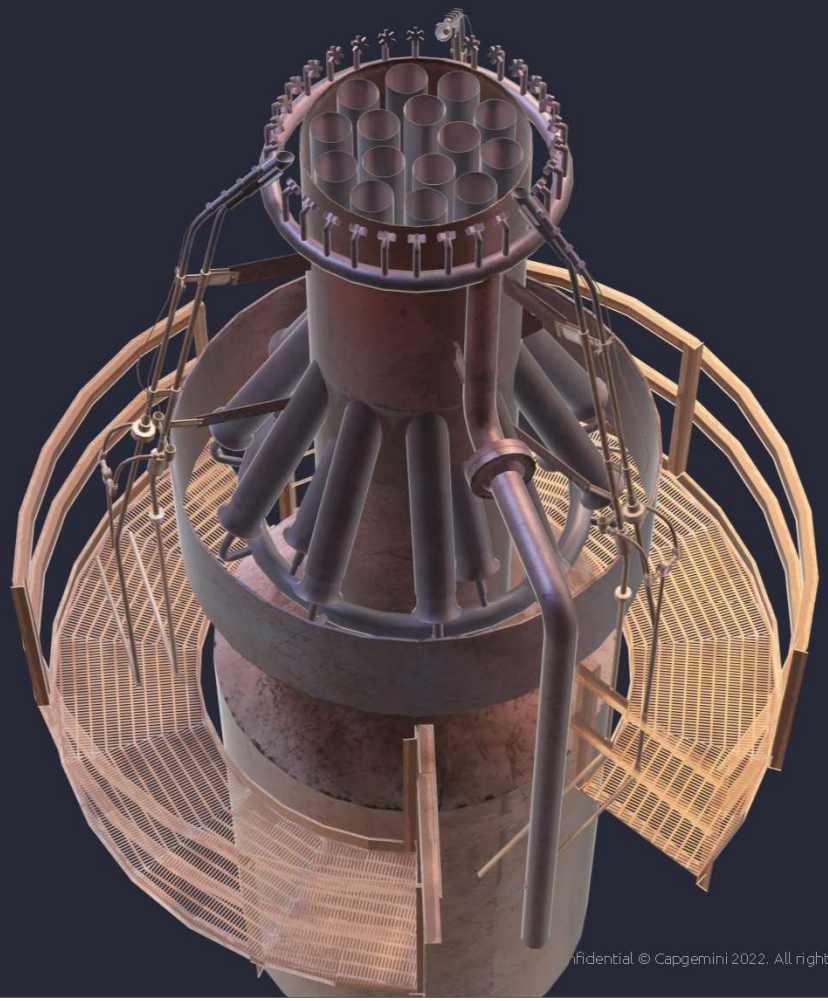
Slide 10

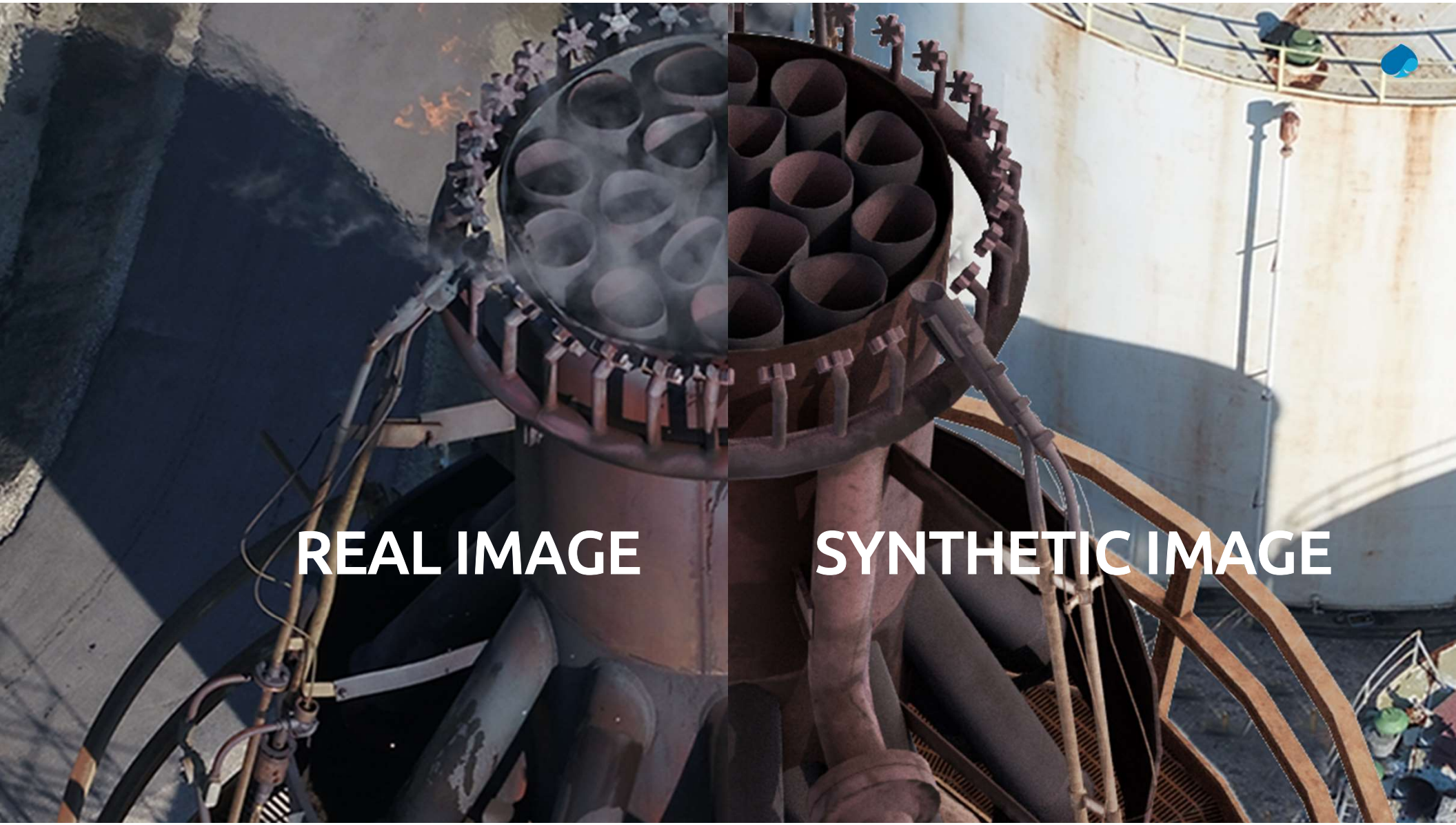
JG0 replace with textured model

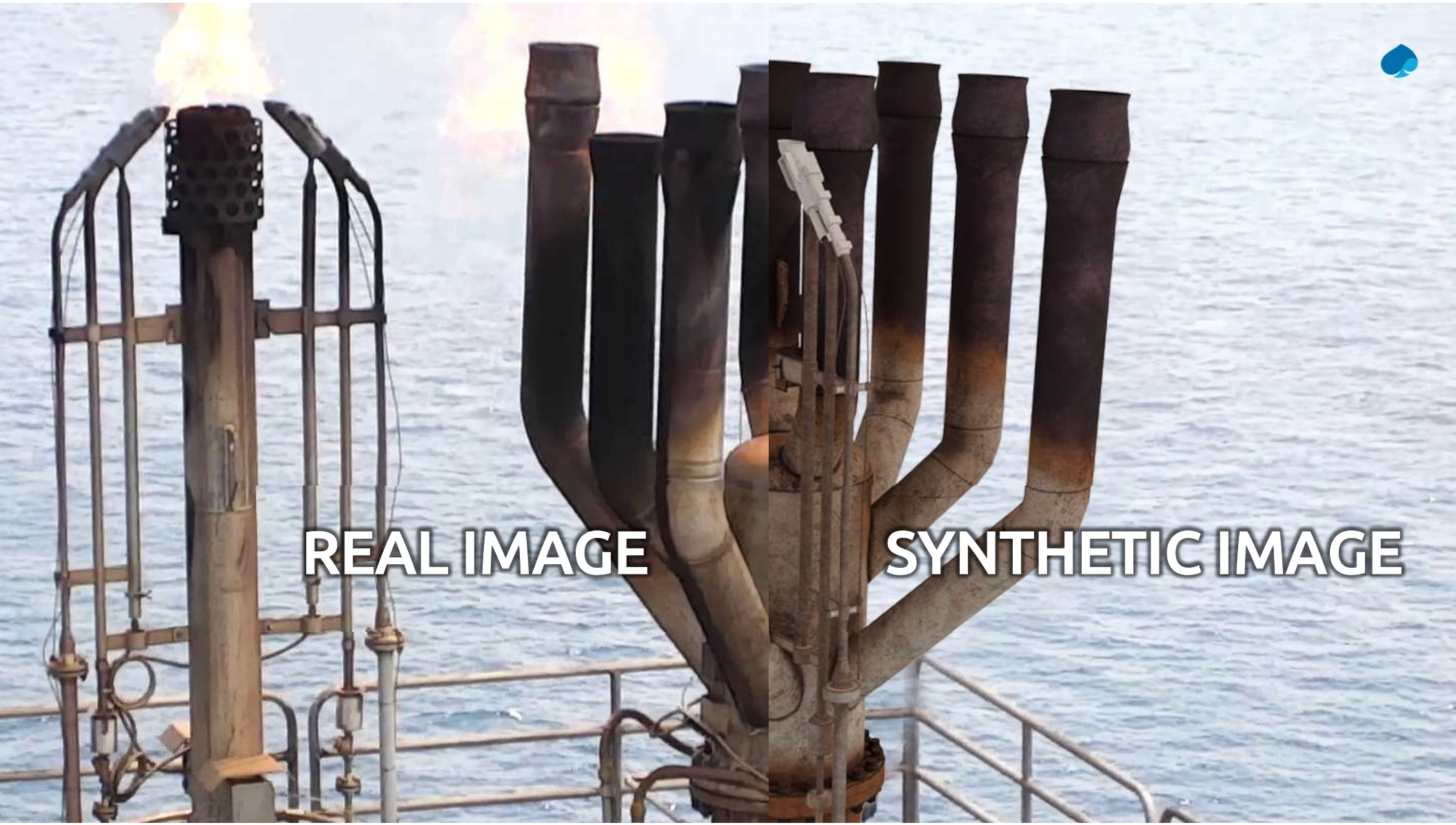
Jacob, George, 2022-08-15T02:05:49.501

FINAL DIGITAL TWINS

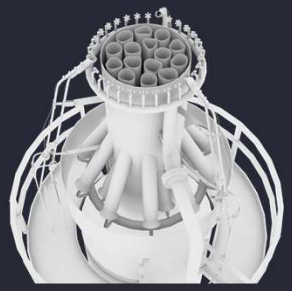




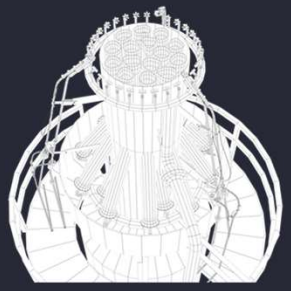

REAL IMAGE
SYNTHETIC IMAGE


REAL IMAGE
SYNTHETIC IMAGE

DIGITAL TWIN CREATION PROCESS

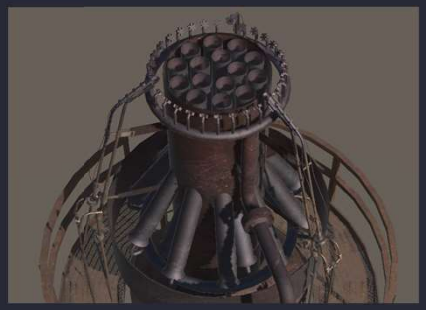


3D MODEL



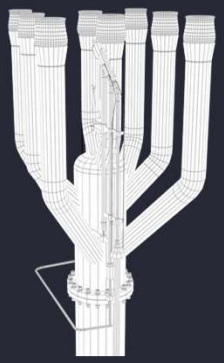
GEOMETRIZE

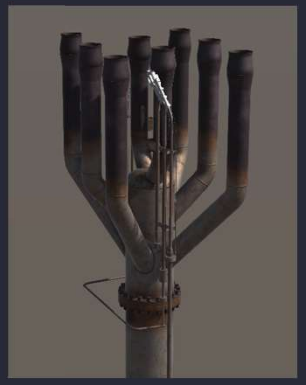
TEXTURE

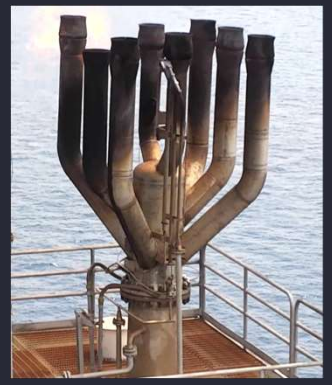


SIMULATE

REAL WORLD IMAGE



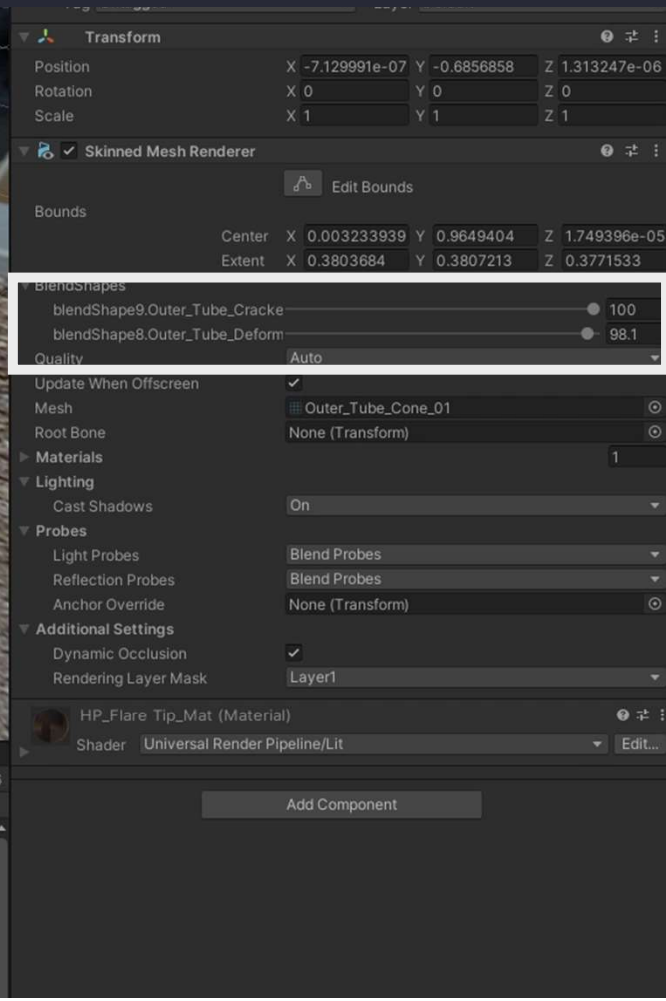


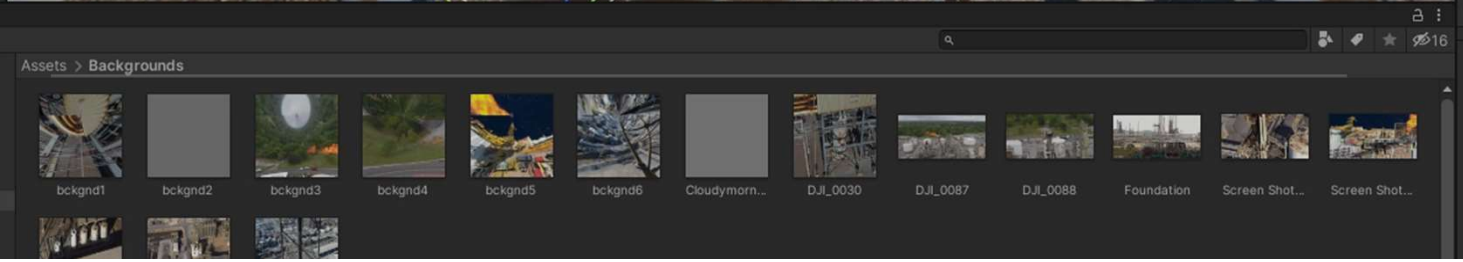


APPLYING WEAR AND TEAR

ADDING DEFORMATION AND CRACKS

Physical faults can be adjusted with nodes called BlendShapes. These nodes can be adjusted between values of 0-100 to deform the shape of the object





INDUSTRIAL METAVERSE

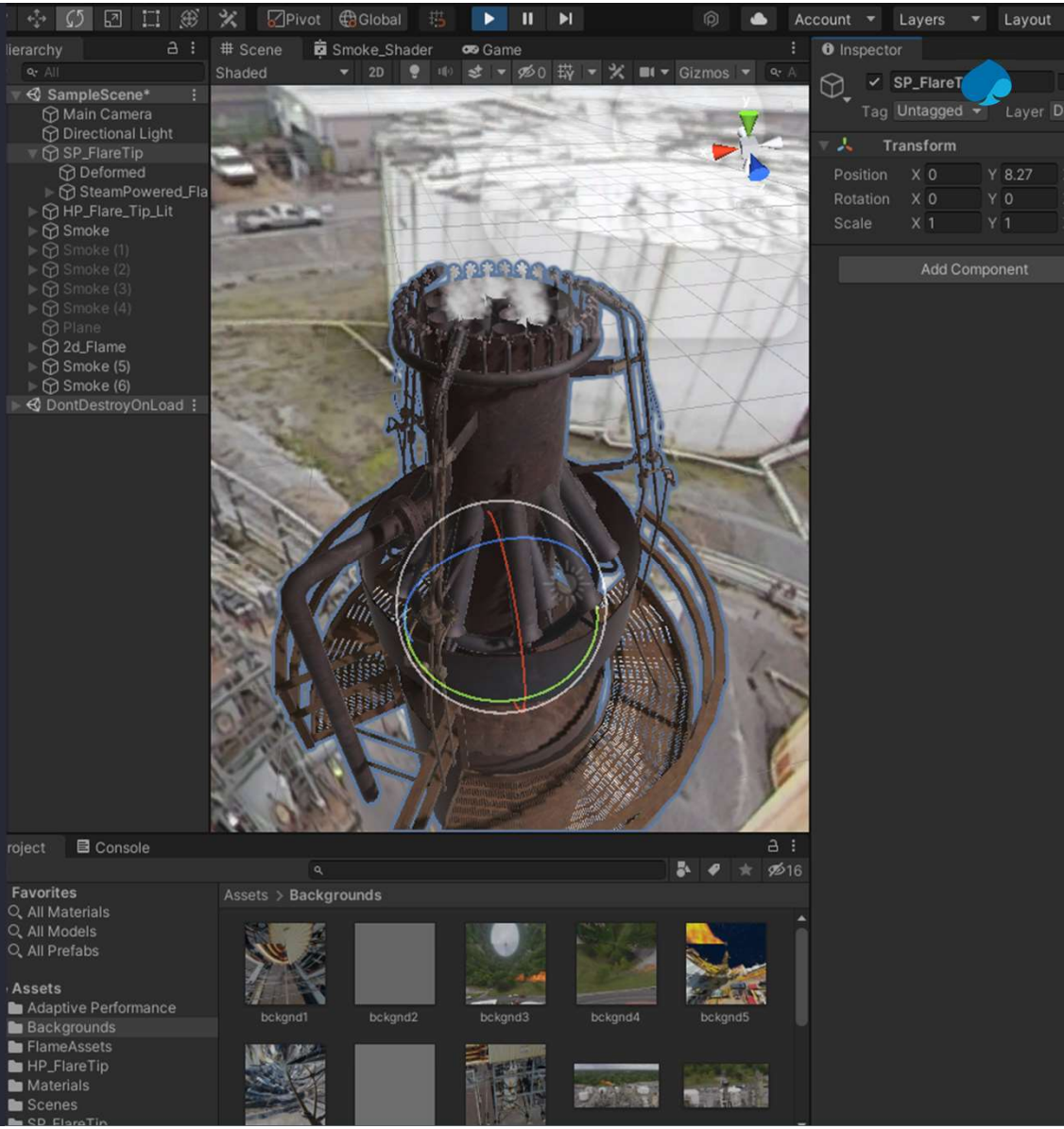
Unity Game Engine is used to create the industrial metaverse.

unity

Capgemini's partnership with Unity brings exciting new ways to collaborate in industrial metaverse and open new frontier for computer-vision based scenario detection

SIMULATION & IMAGE CAPTURE

Drone or camera path can be simulated around the asset to capture visuals needed for CV model training

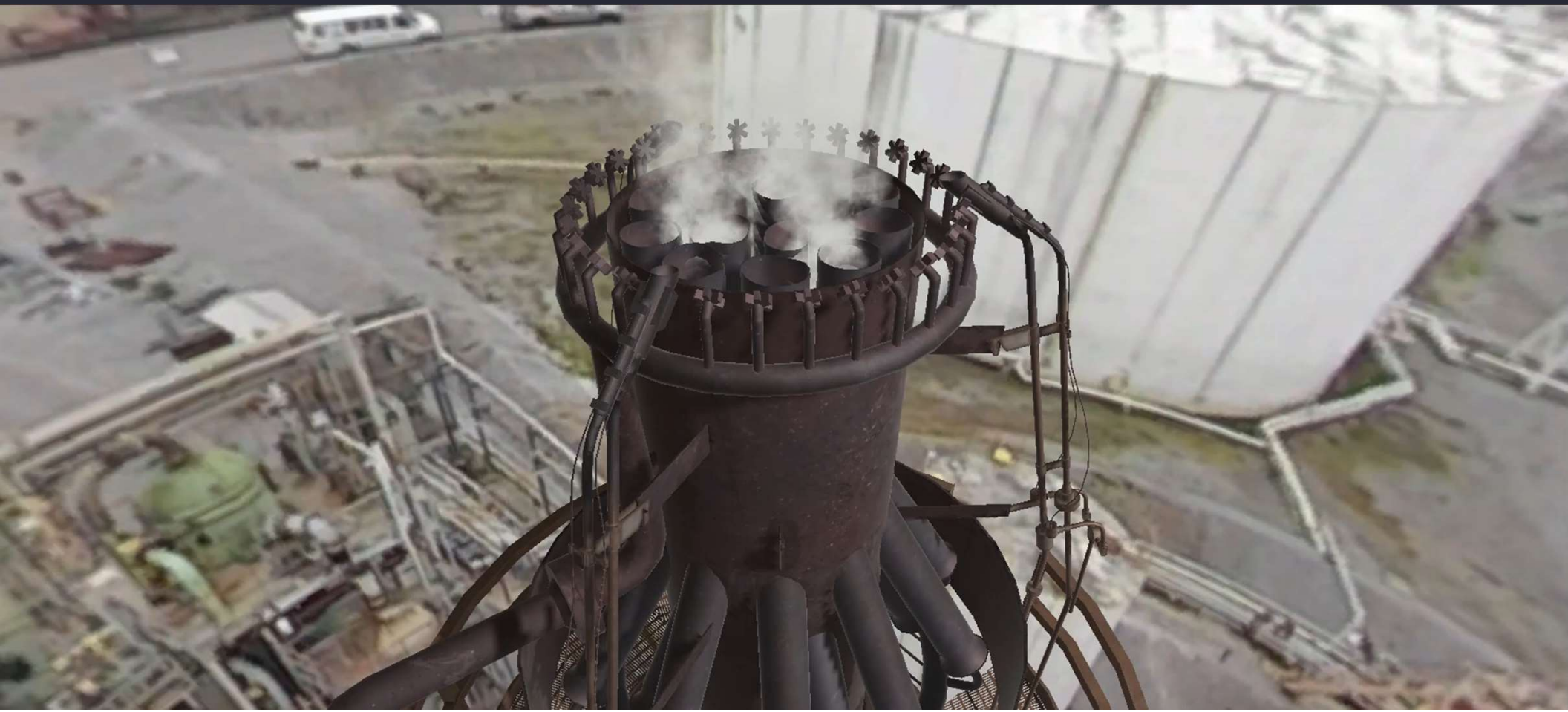


SYNTHETIC DATA GENERATION

GENERATIVE DESIGN	SIMULATION DESIGN	DATA GENERATION
Real-world scenario Simulations	Drone Flight Simulation	Image Collection
Defect Randomization	Noise Simulation	Data Labeling
Environment Randomization		

REAL-WORLD SIMULATION

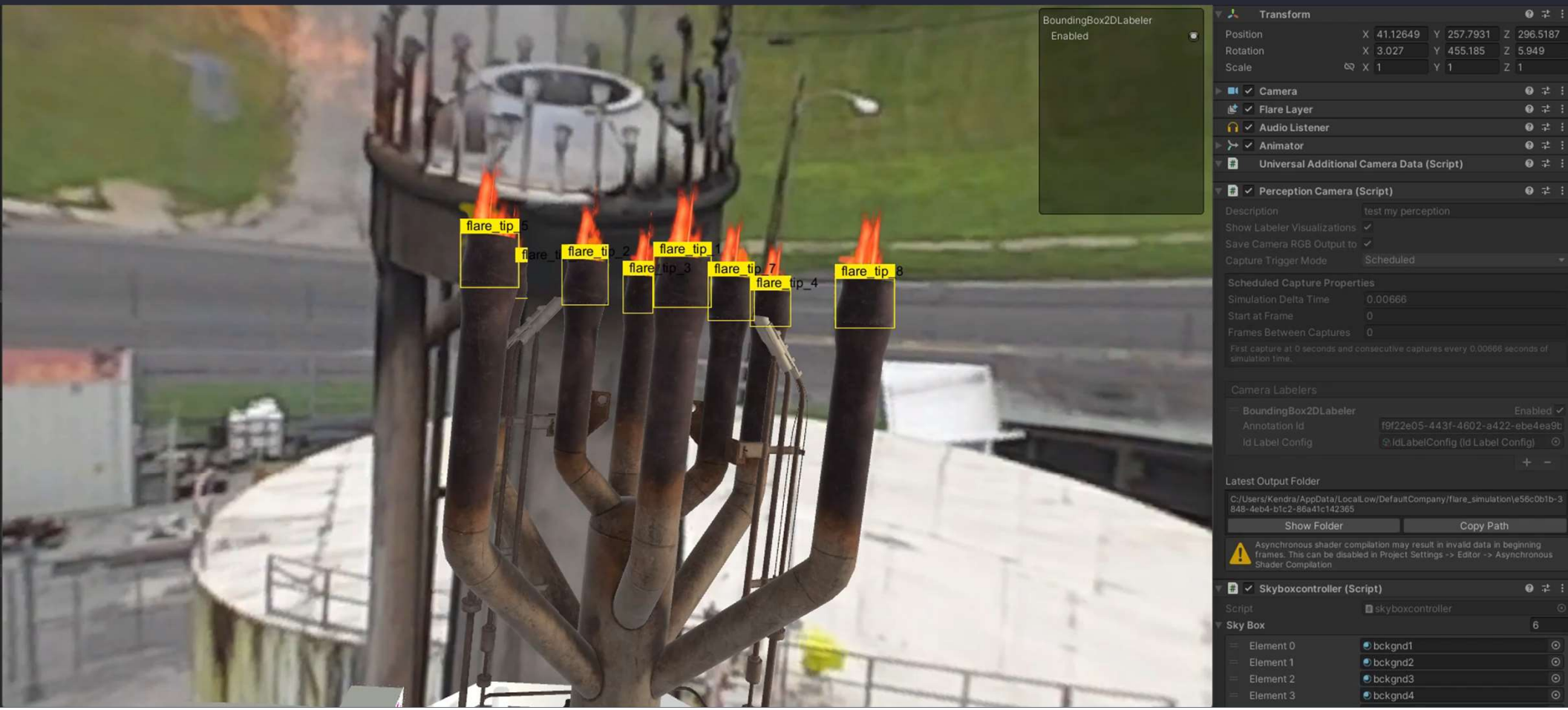
To make the digital twin closer to the real-world scenario, simulated smoke and flames were added in Unity



CAMERA SIMULATION

Camera or drone path simulation in Unity allowing gathering of visuals in many different angles needed to boost CV models confidence in identifying assets and components.

Unity's Perception Package allows to automatically label specified parts and save that location data to help train the computer vision model.



SYNTHETIC DATA GENERATION

GENERATIVE DESIGN	SIMULATION DESIGN	DATA GENERATION
Real-world scenario Simulations	Drone Flight Simulation	Image Collection
Defect Randomization	Noise Simulation	Data Labeling
Environment Randomization		

SYNTHETIC VS. REAL-WORLD DATA GATHERING

In less than a week with just 45 simulations, 15,000 synthetic images were gathered & labeled.

It is almost impossible to gather such high-volume images of a real-world scenarios and manual effort of labeling and image augmentation of the real-world objects is also extremely time consuming.

Industrial metaverse allows meticulous procedure to automatically generate data.

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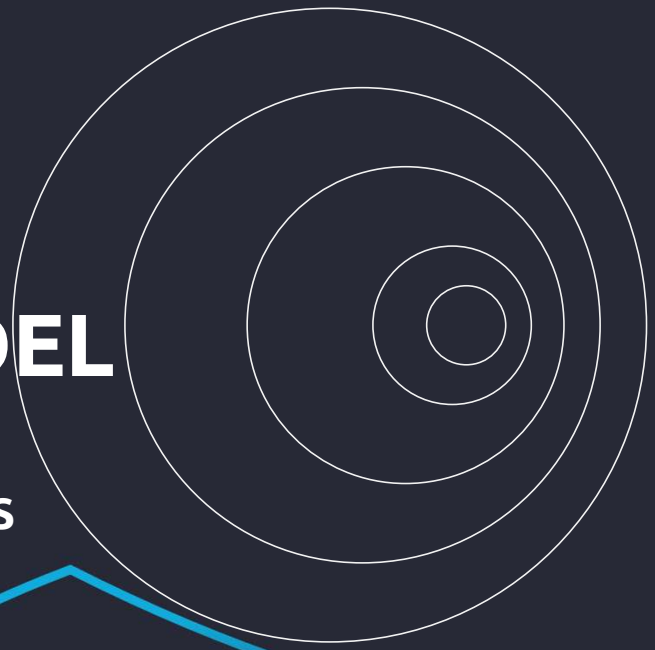
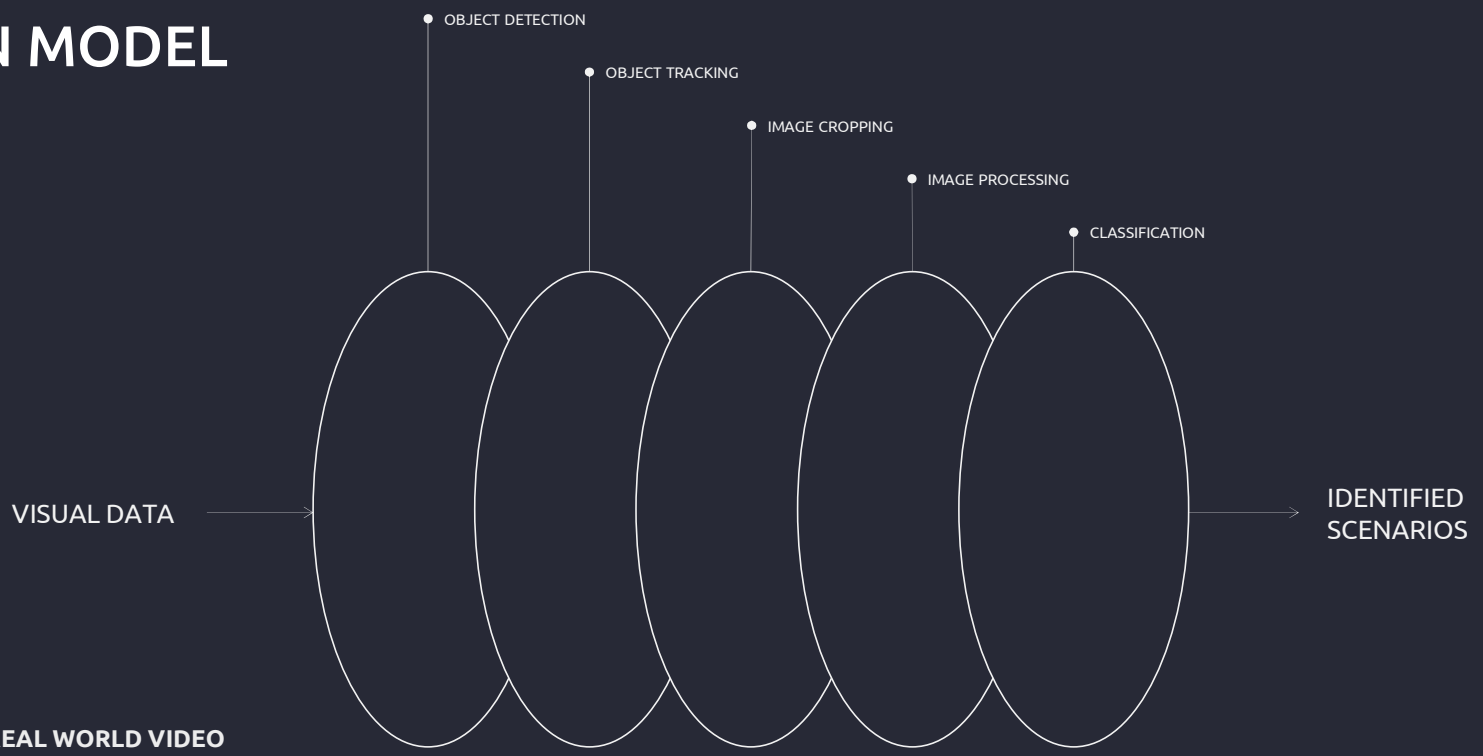
COMPUTER VISION MODEL

TRAIN ON SYNTHETIC DATA, APPLY ON REAL WORLD VISUALS



COMPUTER VISION MODEL

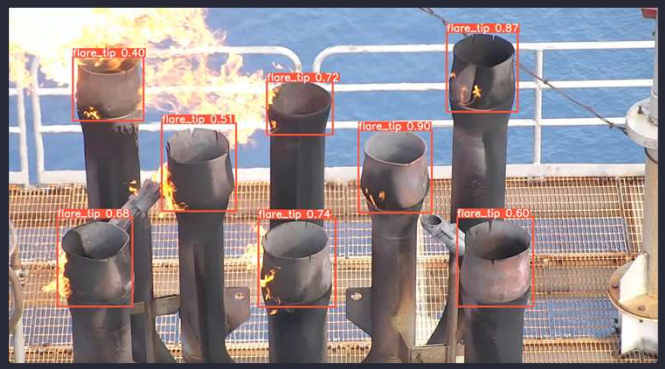


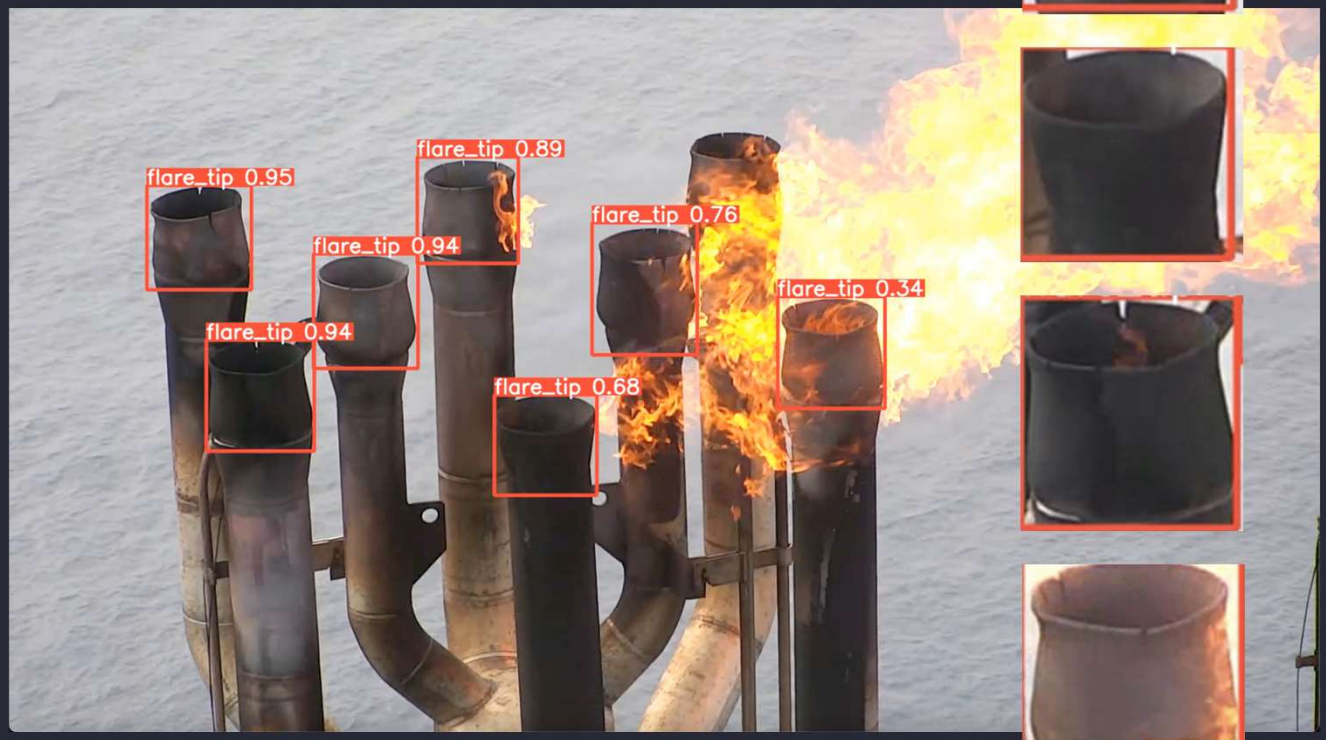
TRAIN ON SYNTHETIC DATA, APPLY ON REAL WORLD VIDEO

computer vision model will use the following techniques:

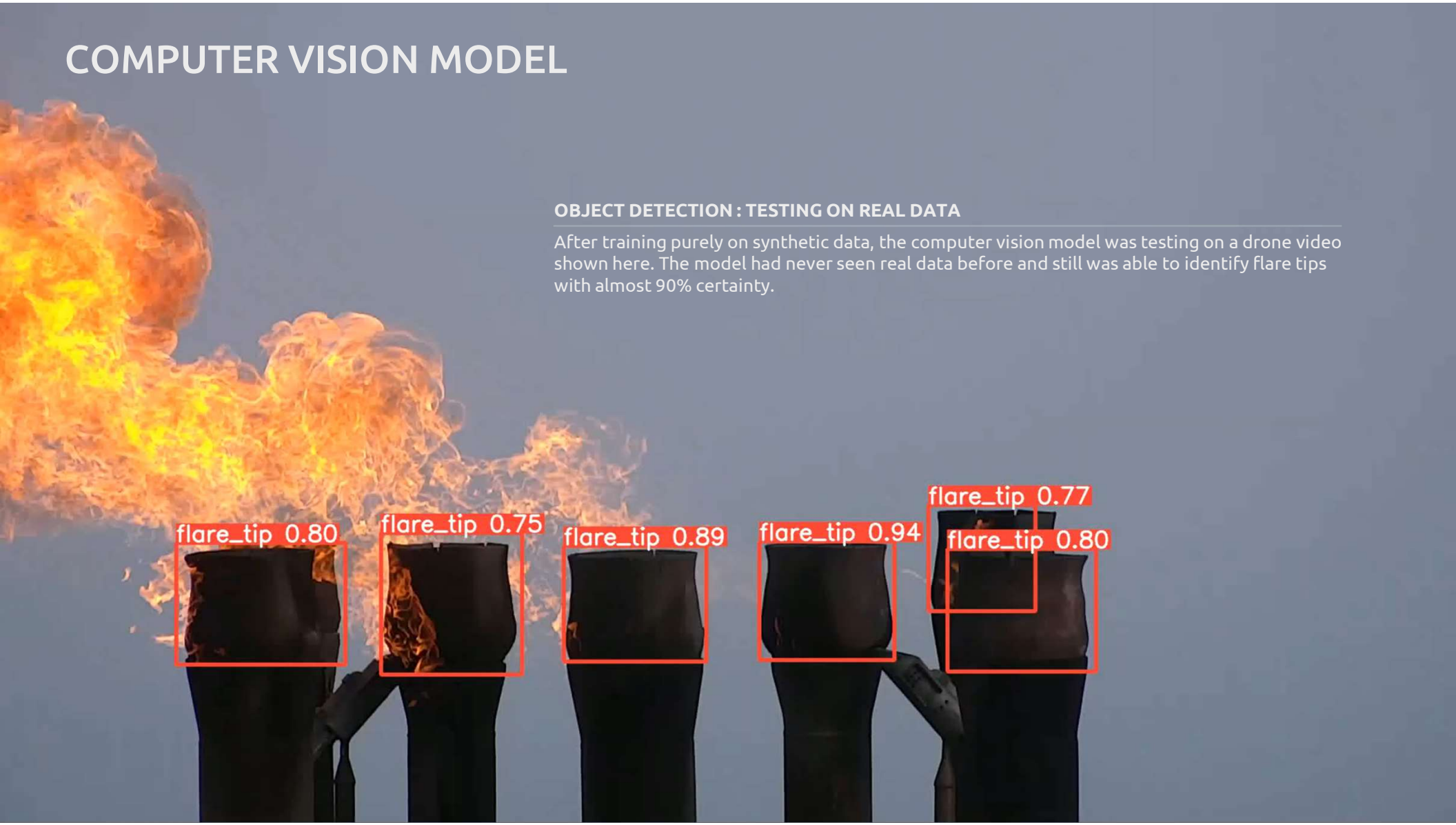
1. Detect the object to be inspected, including hierarchical objects
2. Track the objects through out the video
3. Crop the visual into smaller pieces of just the object it has detected
4. Image processing applied to enhance features
5. Classify the cropped images against trained scenarios

OBJECT DETECTION AND CROPING



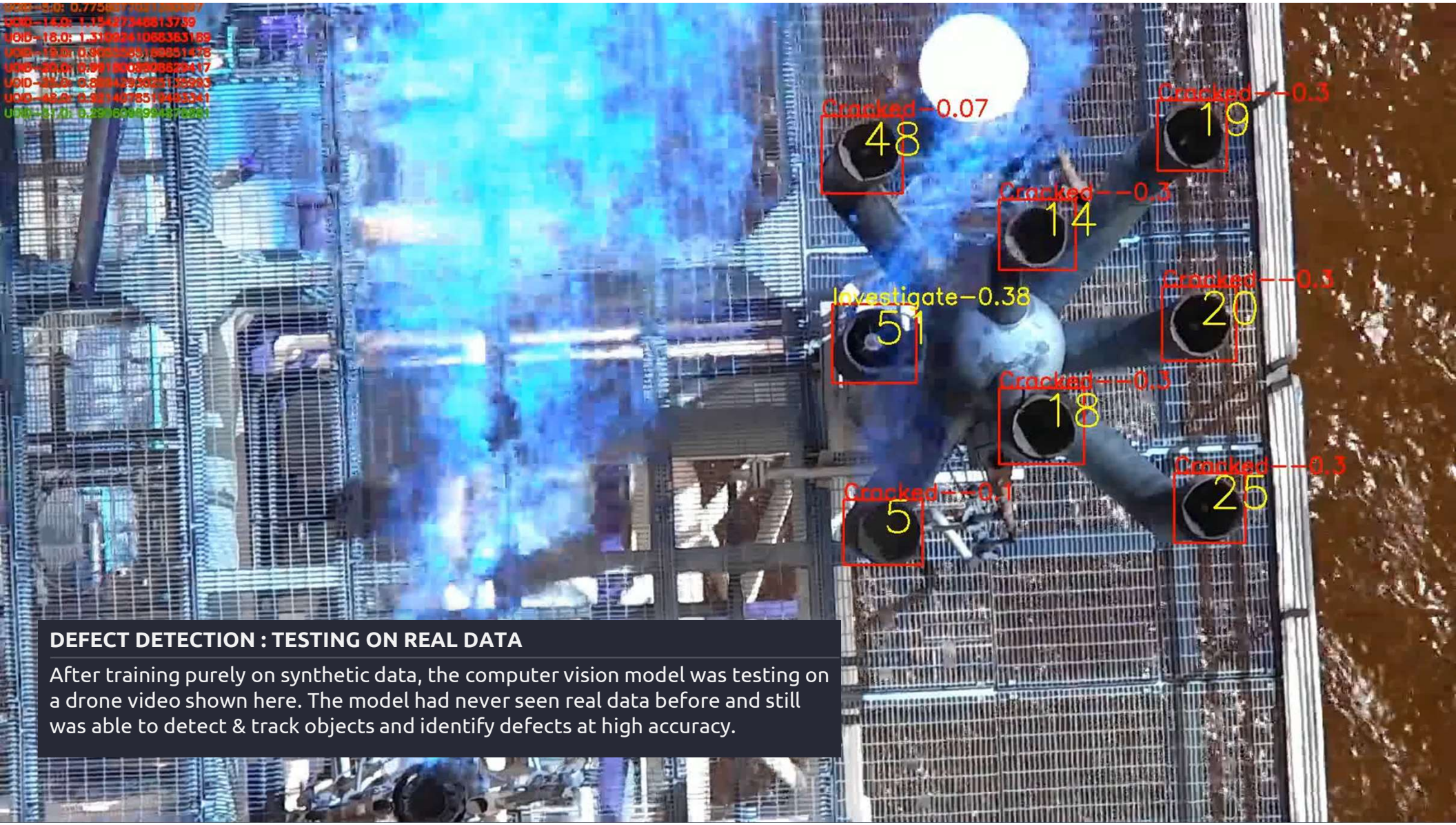


COMPUTER VISION MODEL



OBJECT DETECTION : TESTING ON REAL DATA

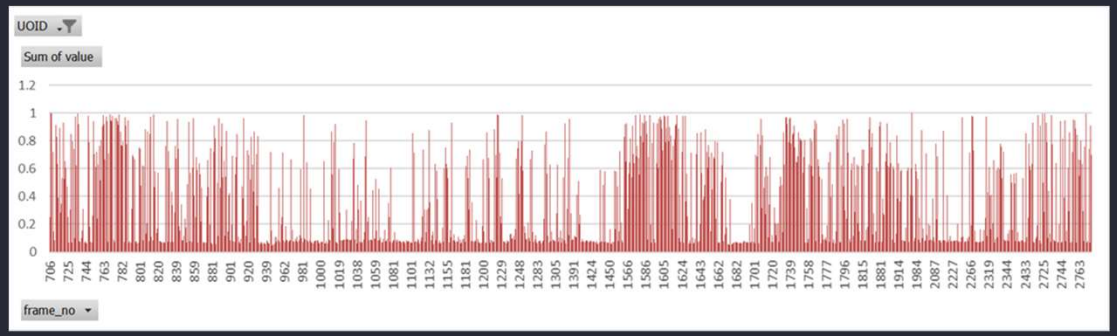
After training purely on synthetic data, the computer vision model was testing on a drone video shown here. The model had never seen real data before and still was able to identify flare tips with almost 90% certainty.



DEFECT DETECTION : TESTING ON REAL DATA

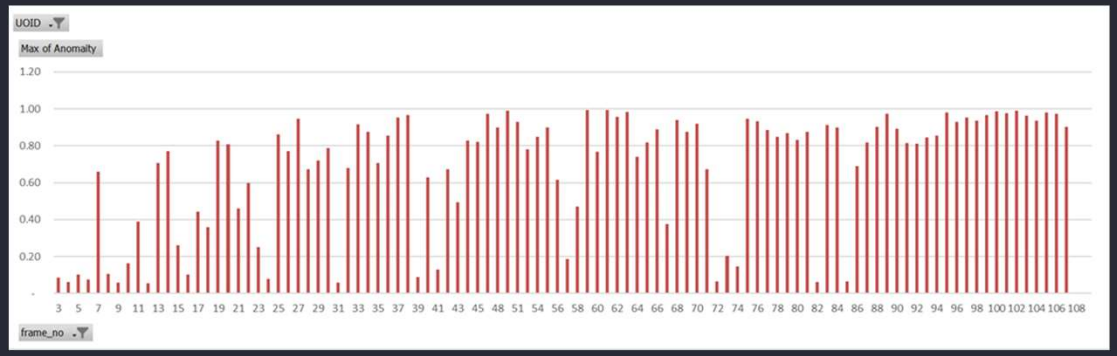
After training purely on synthetic data, the computer vision model was testing on a drone video shown here. The model had never seen real data before and still was able to detect & track objects and identify defects at high accuracy.

INSIGHTS FROM CV MODEL IS SUMMARIZED FOR CONSUMPTION



Design Class	Crack Design Parm
Big Crack	100
No Crack	0
Big Crack	100
Small Crack	10
Small Crack	9
Small Crack	10
Big Crack	100
Big Crack	100

Object ID	Sum	Average	Median
1	54.37	0.66	0.76
2	7.05	0.09	0.08
3	64.76	0.61	0.75
4	25.02	0.21	0.09
5	17.75	0.18	0.08
6	17.91	0.19	0.07
7	43.08	0.63	0.76
8	69.00	0.68	0.83



Object ID	Sum	Average	Median
5	402.72	0.37	0.19
14	682.03	0.33	0.14
18	1,095.99	0.53	0.62
19	741.41	0.63	0.71
20	1,141.39	0.56	0.63
25	1,344.58	0.66	0.72
48	387.53	0.55	0.57
51	202.23	0.41	0.13

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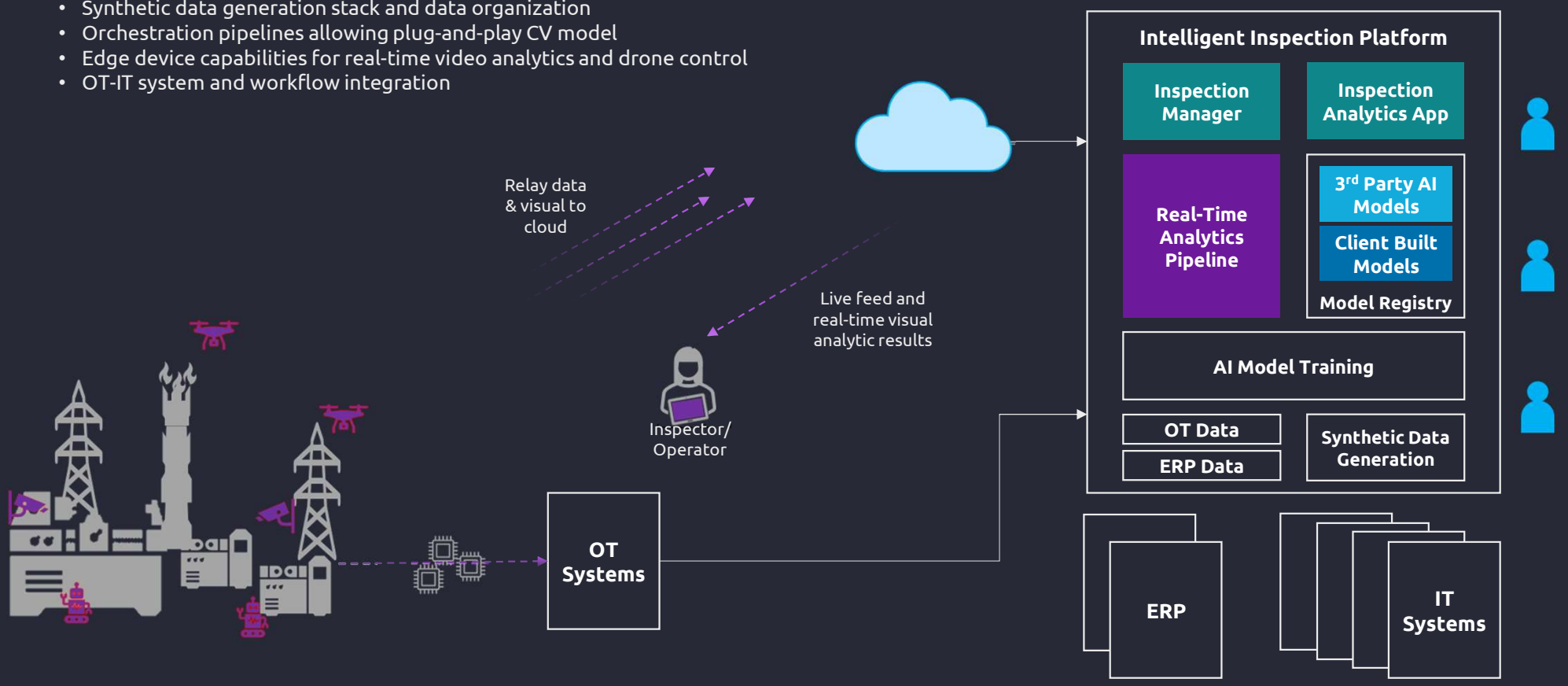
TRANSFORMING INSPECTION

INTELLIGENT INSPECTION FRAMEWORK

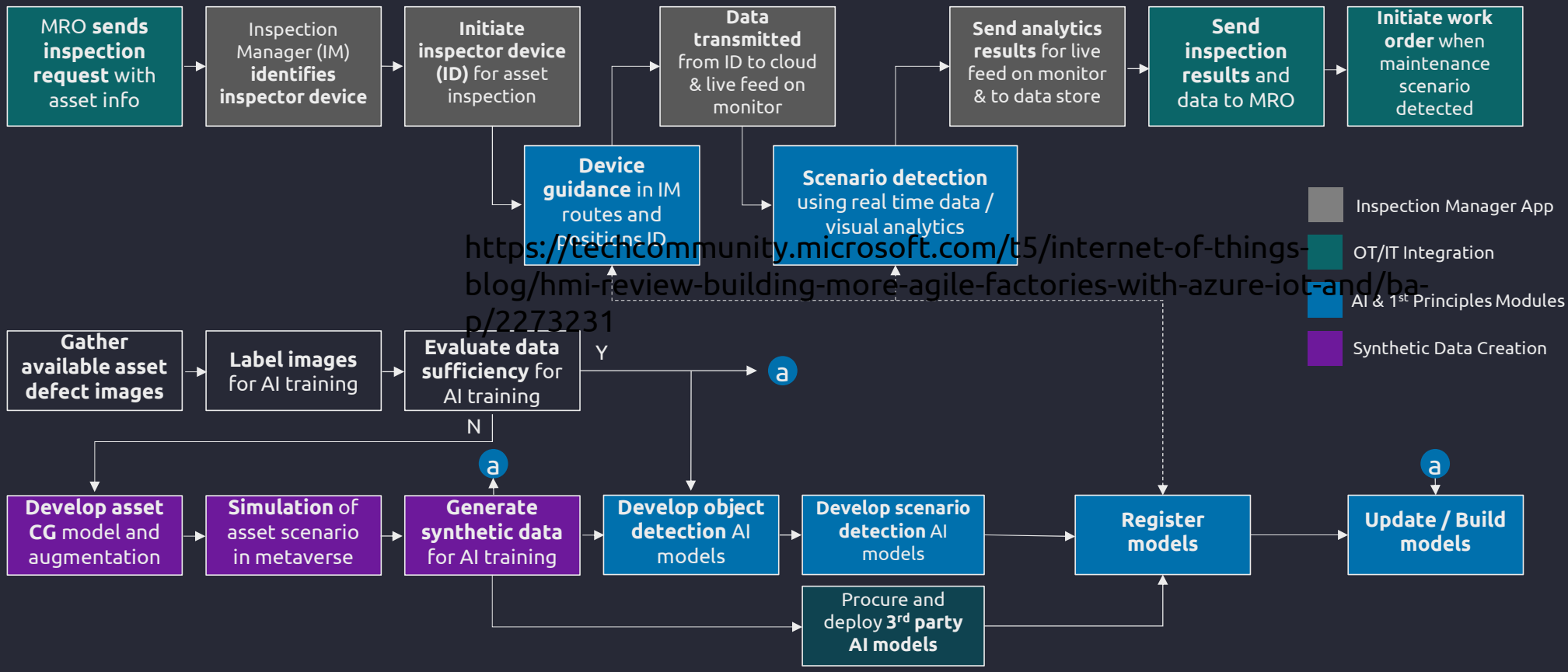
INTELLIGENT INSPECTION FRAMEWORK

REUSABLE, SCALABLE CV FRAMEWORK FOR INSPECTION

- Synthetic data generation stack and data organization
- Orchestration pipelines allowing plug-and-play CV model
- Edge device capabilities for real-time video analytics and drone control
- OT-IT system and workflow integration



INTELLIGENT INSPECTION PROCESS FLOW



PROJECT PLAN

	22-Aug	29-Aug	5-Sep	12-Sep	19-Sep	26-Sep	3-Oct	10-Oct	17-Oct	24-Oct	31-Oct	7-Nov	14-Nov	21-Nov	28-Nov	5-Dec	12-Dec	19-Dec	26-Dec
Topics	**WK1**	**WK2**	**WK3**	**WK4**	**WK5**	**WK6**	**WK7**	**WK8**	**WK9**	**WK10**	**WK11**	**WK12**	**WK13**	**WK14**	**WK15**	**WK16**	**WK17**	**WK18**	**WK19**
Phase 1																			
Back-log creations - Features, User stories																			
Infrastructure Design Planning																			
Tool Selection & Finalization																			
Environment set-up																			
Solution Architecture Design																			
Orchestration Design (pipeline)																			
Build and Unit Testing																			
Infrastructure as Code																			
Design, Build & Test																			
Integration Testing																			
Feature set Release							F1			F2									
Business Review & Acceptance																			
Realease 1												R1							
Phase 2																			
Orchestration Design (pipeline)																			
Build and Unit Testing																			
Infrastructure as Code																			
Design, Build & Test																			
Integration Testing																			
Feature set Release														F3			F4		
Business Review & Acceptance																			
Realease 2																			R2

Milestone Definitions	
F1	**Feature Set 1:** Data pipeline to fetch and organization Synthetic data (video / images – folder structure), Data Pipeline to fetch and organize Visual data from inspection device
F2	**Feature Set 2:** Object Detection ,Object Tracking and Basic level UX for displaying the results
R1	**Release 1: Framework including Feature Set 1 +2**
F3	**Feature Set 3:** Scoring pipeline for defect classification , Model re-training pipeline and IOT Data integration
F4	**Feature Set 4:** Image processing modules - contract, exposure adjustment, gray scale, B&W, Image Streaming and Improved UX for displaying the results
R2	**Release 2: Framework including Feature Set 1+2+3+4**

About Capgemini

Capgemini is a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided everyday by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of 270,000 team members in nearly 50 countries. With its strong 50 year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fuelled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms. The Group reported in 2020 global revenues of €16 billion.

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David Drake

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EUC, North America

Ali Arian

Data Science Lead
Insights and Data, North America

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