



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



DIMENSIONAL DESIGN

Digital Twin Creation



SIMULATION DESIGN

Industrial Metaverse Creation
and
Synthetic Data Generation

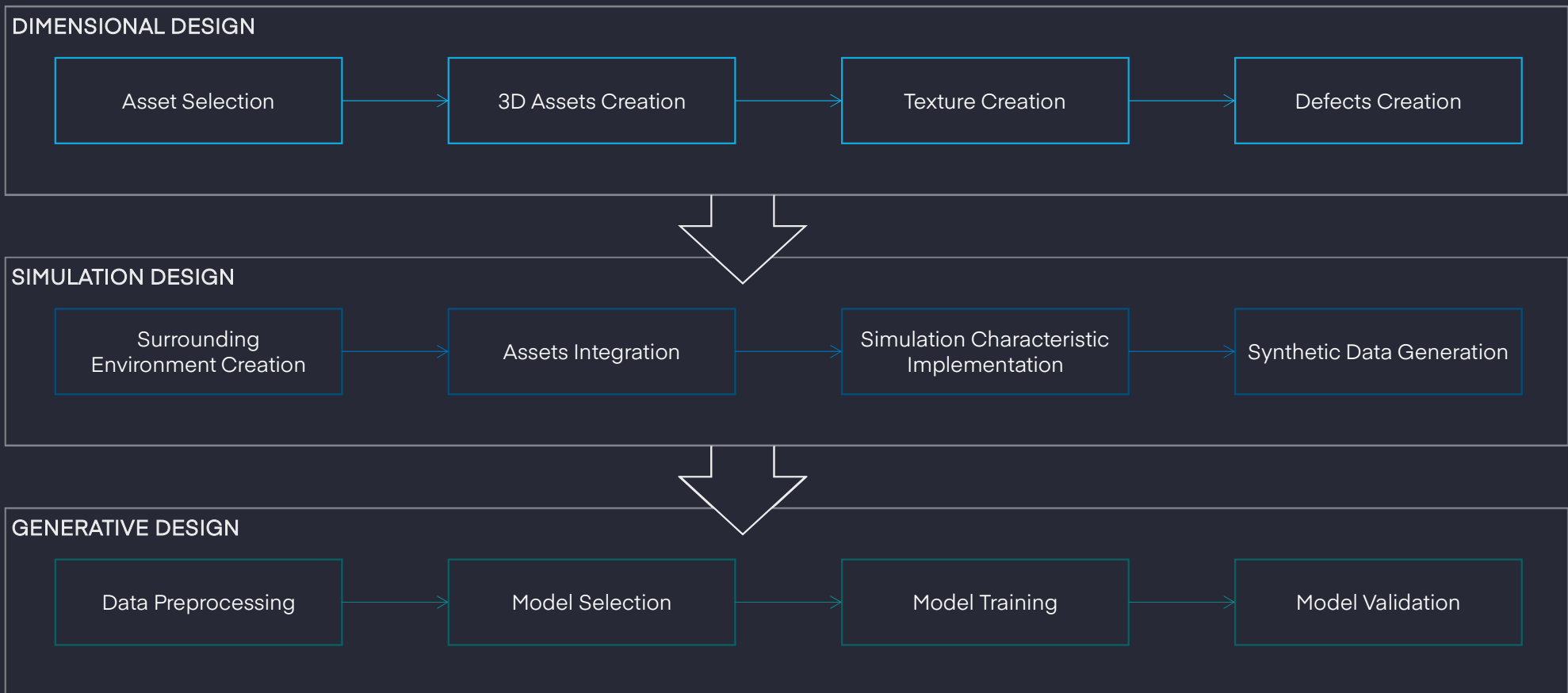


GENERATIVE DESIGN

Computer Vision Model
using AI/ML
for Defect Detection



HOW DOES IT WORK



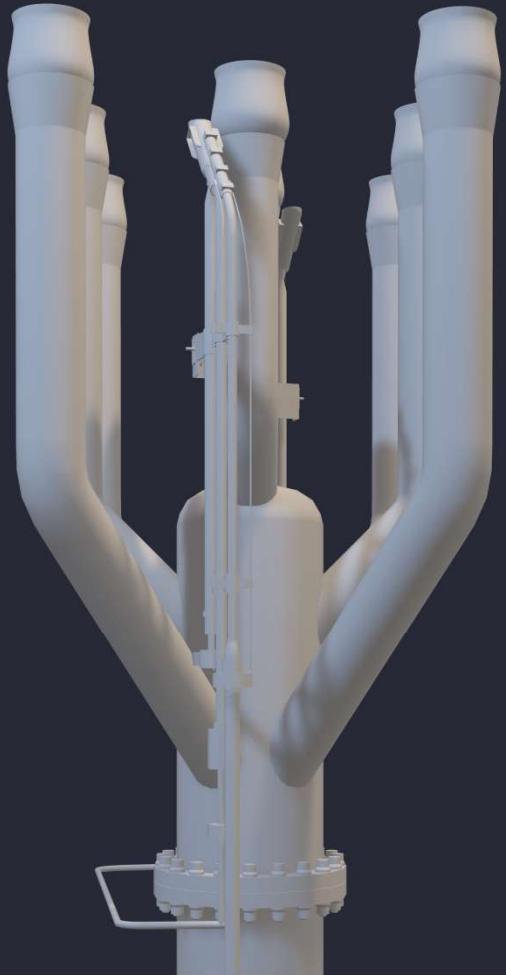


SYNTHETIC DATA GENERATION

3D COMPUTER GRAPHICS AND METAVERSE

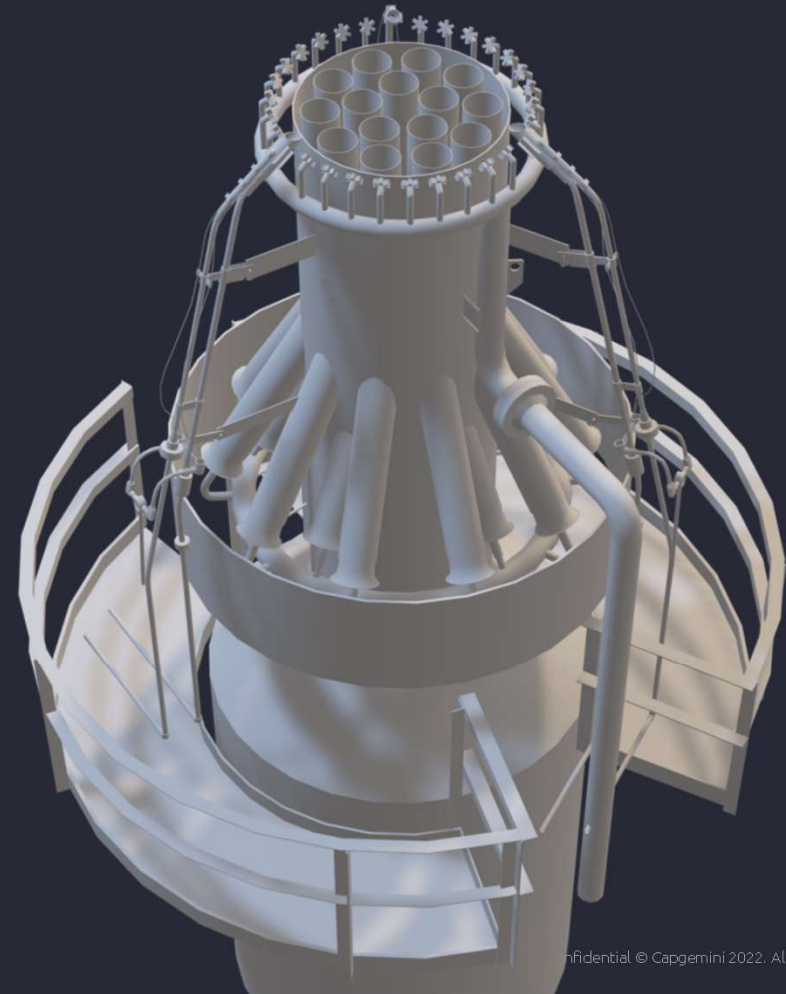
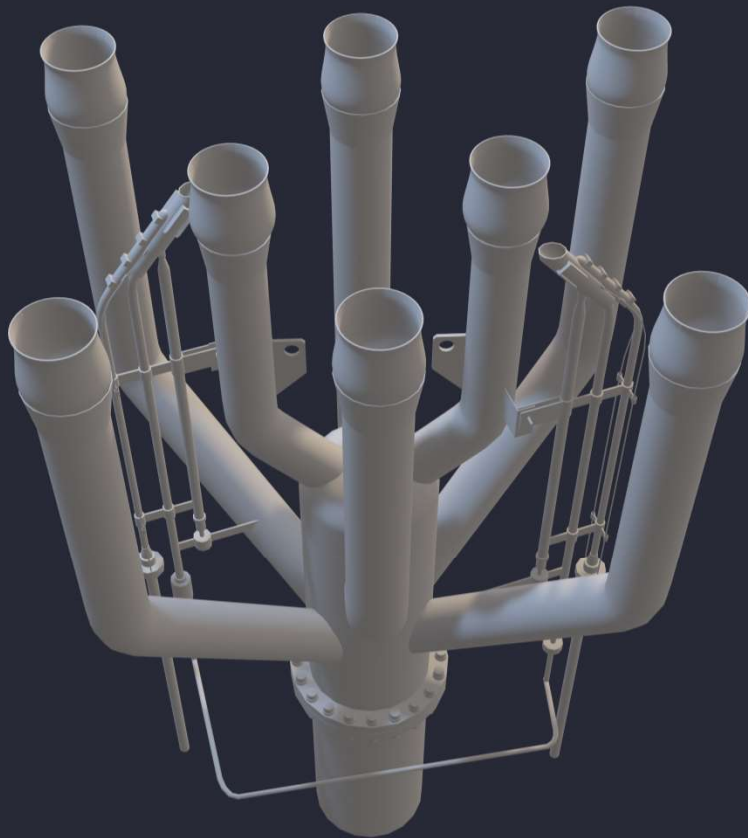


3D ASSET CREATION





3D ASSET CREATION

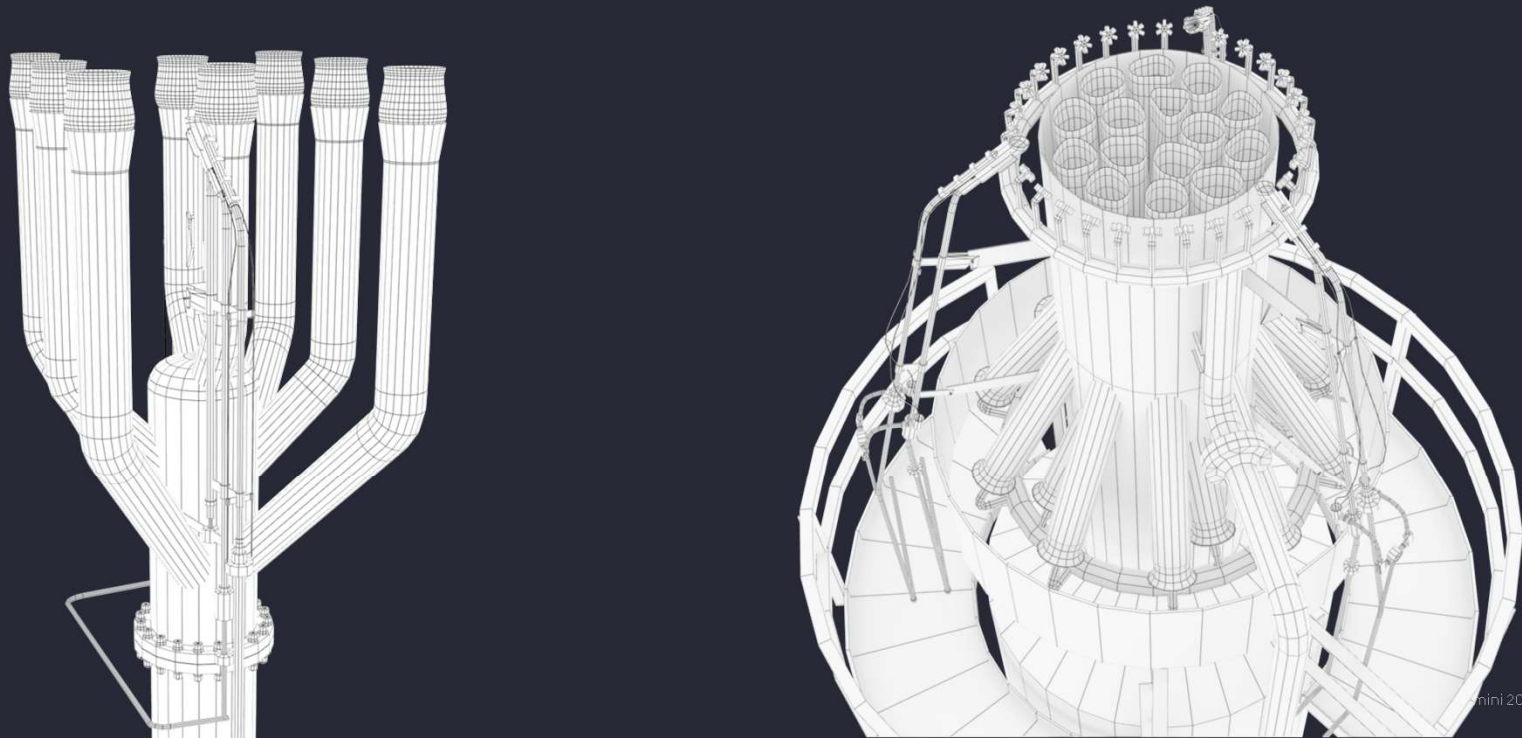




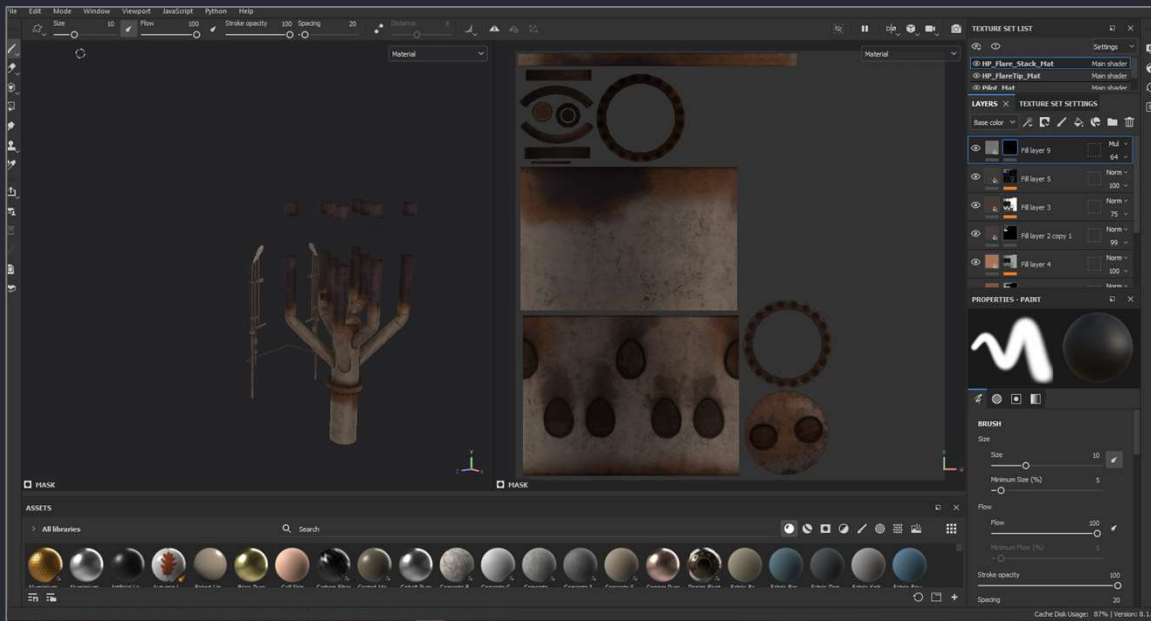
MODEL FOR THE GAME ENGINE

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



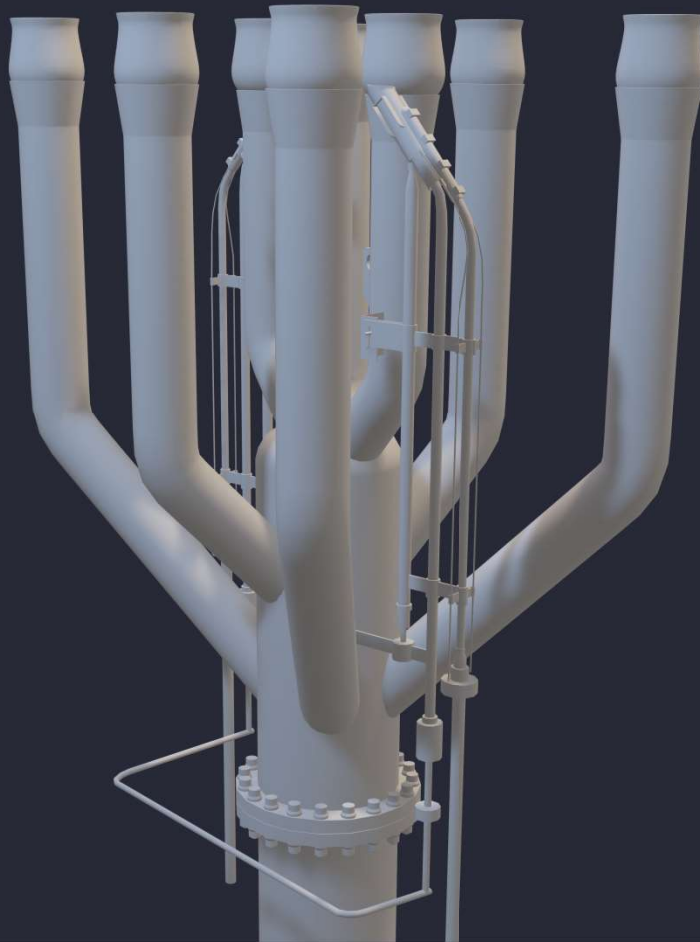
TEXTURING

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





FIGO[®] ANAL DIGITAL TWINS



Slide 10

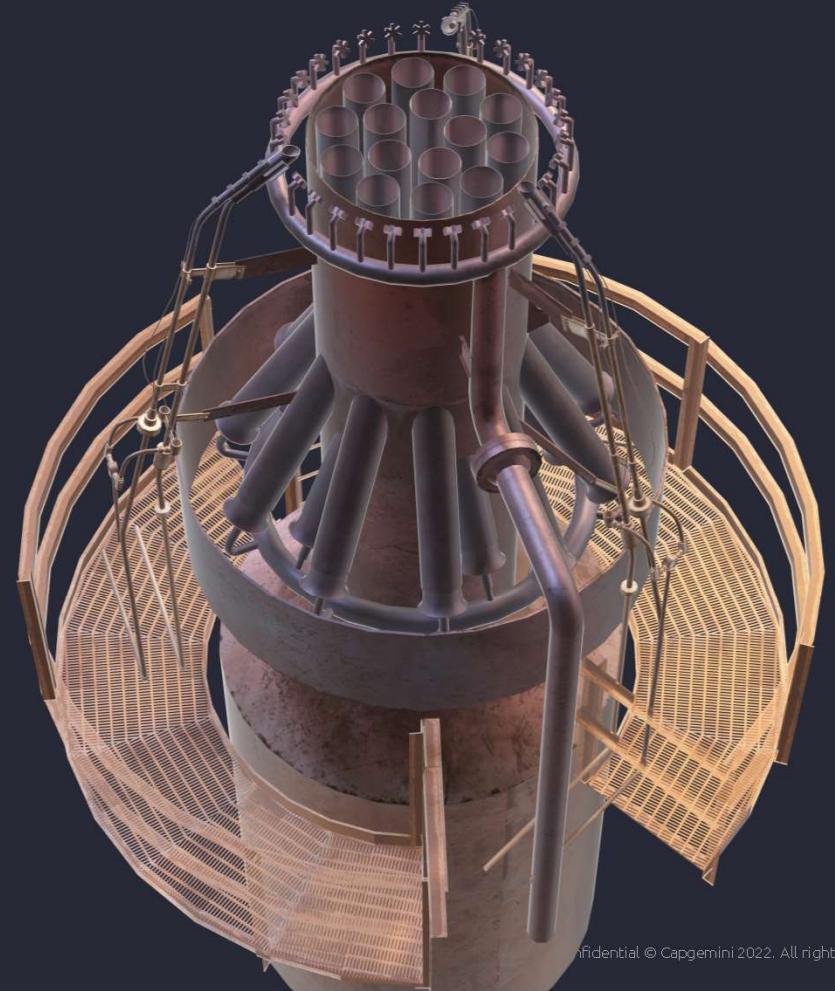
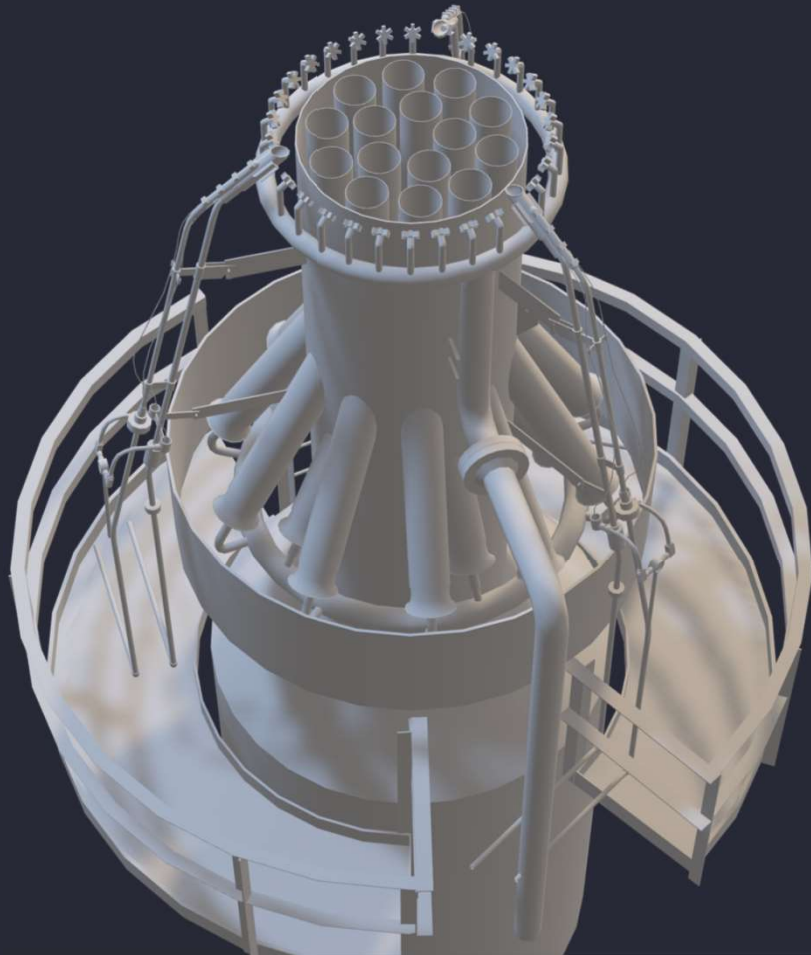
JG0

replace with textured model

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



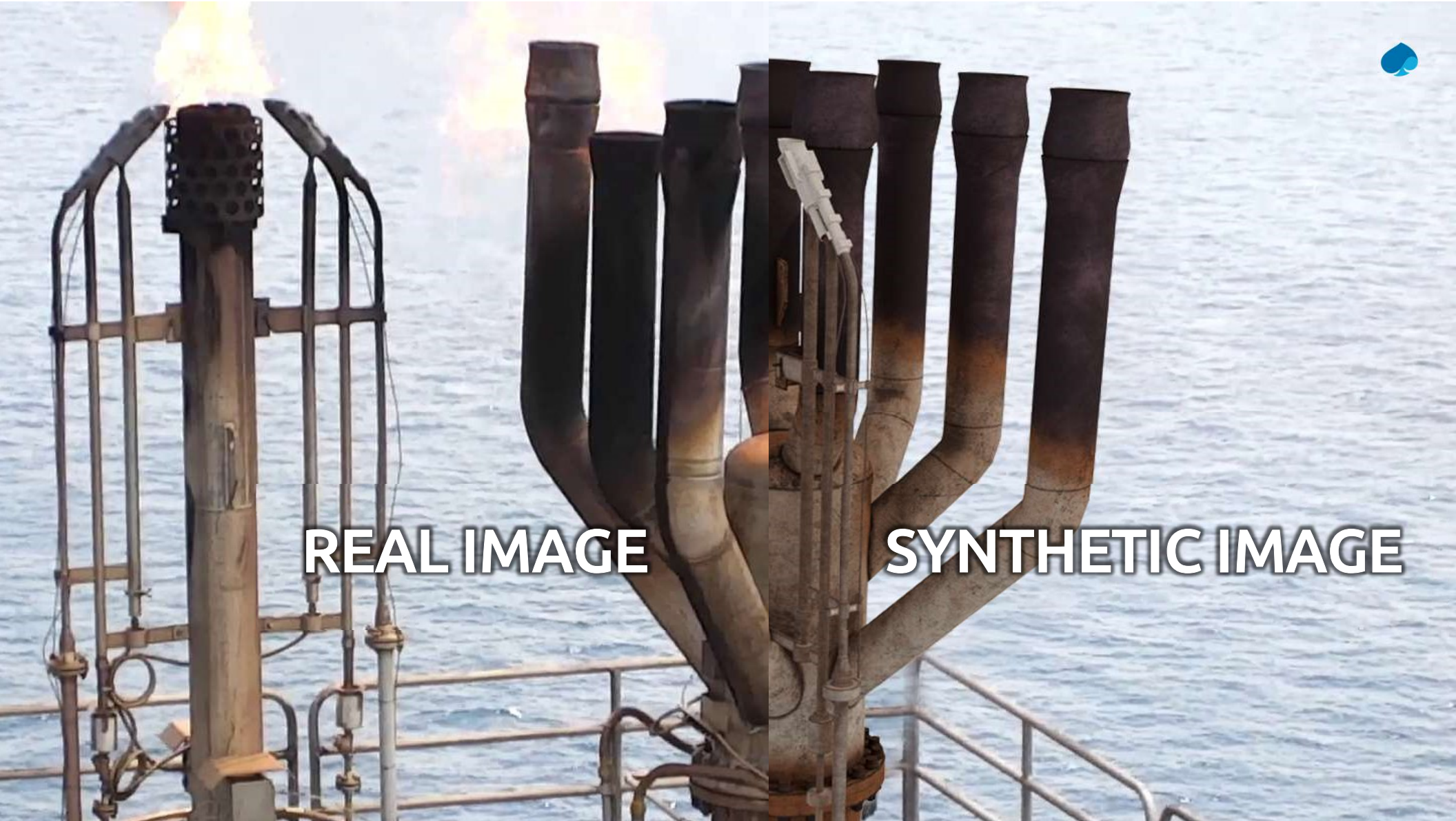
FINAL DIGITAL TWINS





REAL IMAGE

SYNTHETIC IMAGE

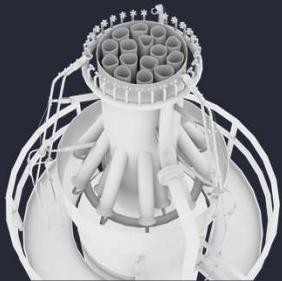


REAL IMAGE

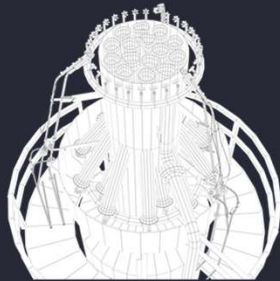
SYNTHETIC IMAGE



DIGITAL TWIN CREATION PROCESS



3D MODEL



GEOMETRIZE



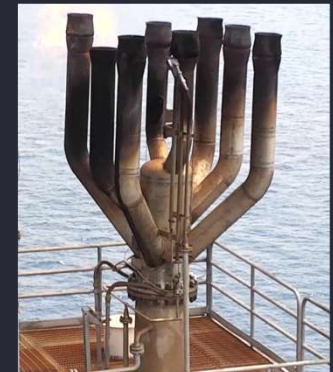
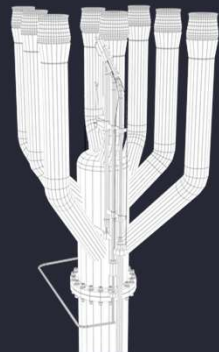
TEXTURE



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



Transform

Position	X	-7.129991e-07	Y	-0.6856858	Z	1.313247e-06
Rotation	X	0	Y	0	Z	0
Scale	X	1	Y	1	Z	1

Skinned Mesh Renderer

Bounds

Center	X	0.003233939	Y	0.9649404	Z	1.749396e-05
Extent	X	0.3803684	Y	0.3807213	Z	0.3771533

BlendShapes

blendShape9.Outer_Tube_Cracke	100
blendShape8.Outer_Tube_Deform	98.1

Quality: Auto

Update When Offscreen:

Mesh: Outer_Tube_Cone_01

Root Bone: None (Transform)

Materials: 1

Lighting

Cast Shadows: On

Probes

Light Probes: Blend Probes

Reflection Probes: Blend Probes

Anchor Override: None (Transform)

Additional Settings

Dynamic Occlusion:

Rendering Layer Mask: Layer1

HP_Flare_Tip_Mat (Material)

Shader: Universal Render Pipeline/Lit

Assets > Backgrounds

bckgnd1 bckgnd2 bckgnd3 bckgnd4 bckgnd5 bckgnd6 Cloudymorn... DJI_0030 DJI_0087 DJI_0088 Foundation Screen Shot... Screen Shot...

INDUSTRIAL METAVERSE

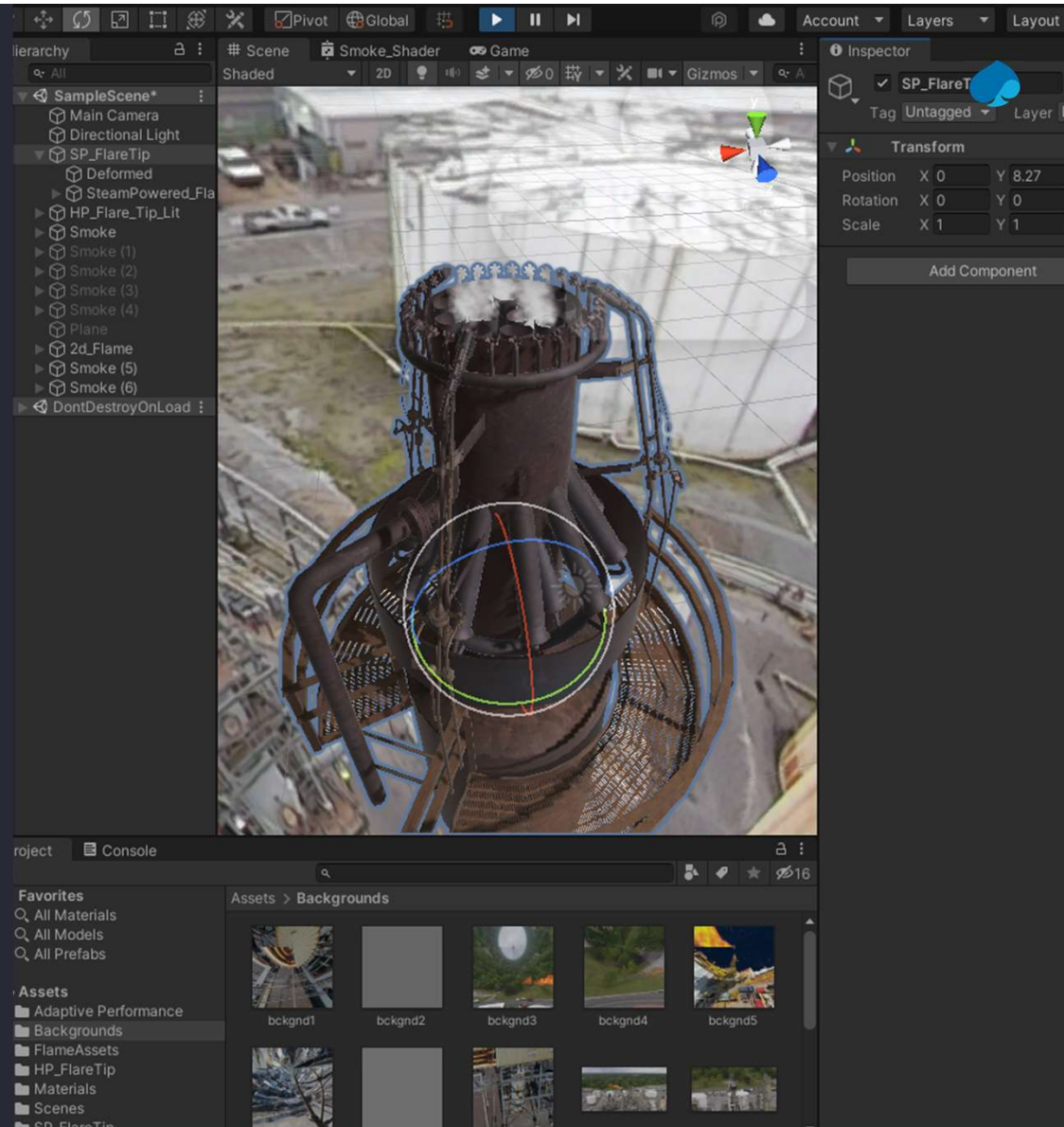
Unity Game Engine is used to create the industrial metaverse.



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



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.



Transform

Position	X	41.12649	Y	257.7931	Z	296.5187
Rotation	X	3.027	Y	455.185	Z	5.949
Scale	X	1	Y	1	Z	1

Camera

- Flare Layer
- Audio Listener
- Animator
- Universal Additional Camera Data (Script)
- Perception Camera (Script)

Perception Camera (Script)

Description: test my perception

Show Labeler Visualizations:

Save Camera RGB Output to:

Capture Trigger Mode: Scheduled

Scheduled Capture Properties

Simulation Delta Time: 0.00666

Start at Frame: 0

Frames Between Captures: 0

First capture at 0 seconds and consecutive captures every 0.00666 seconds of simulation time.

Camera Labelers

BoundingBox2DLabeler: Enabled

Annotation Id: f9f22e05-443f-4602-a422-eba4ea9b

Id Label Config: IdLabelConfig (Id Label Config)

Latest Output Folder

C:/Users/Kendra/AppData/Local/ow/DefaultCompany/flare_simulation/e56c0b1b-3848-4eb4-b1c2-86a41c142365

Show Folder Copy Path

Asynchronous shader compilation may result in invalid data in beginning frames. This can be disabled in Project Settings -> Editor -> Asynchronous Shader Compilation

Skyboxcontroller (Script)

Script: skyboxcontroller

Sky Box

Element 0	bckgnd1
Element 1	bckgnd2
Element 2	bckgnd3
Element 3	bckgnd4



SYNTHETIC DATA GENERATION

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

SYNTHETIC VS. REAL-WORLD DATA GATHERING

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

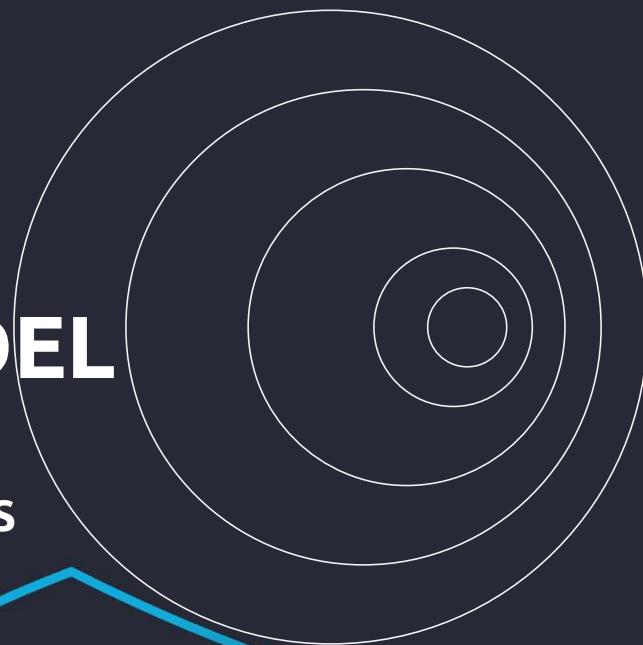
It is almost impossible to gather such high-volume images of a real-world scenarios and manual effort of labeling and image augmentation of the real-world objects is also extremely time consuming.

Industrial metaverse allows meticulous procedure to automatically generate data.



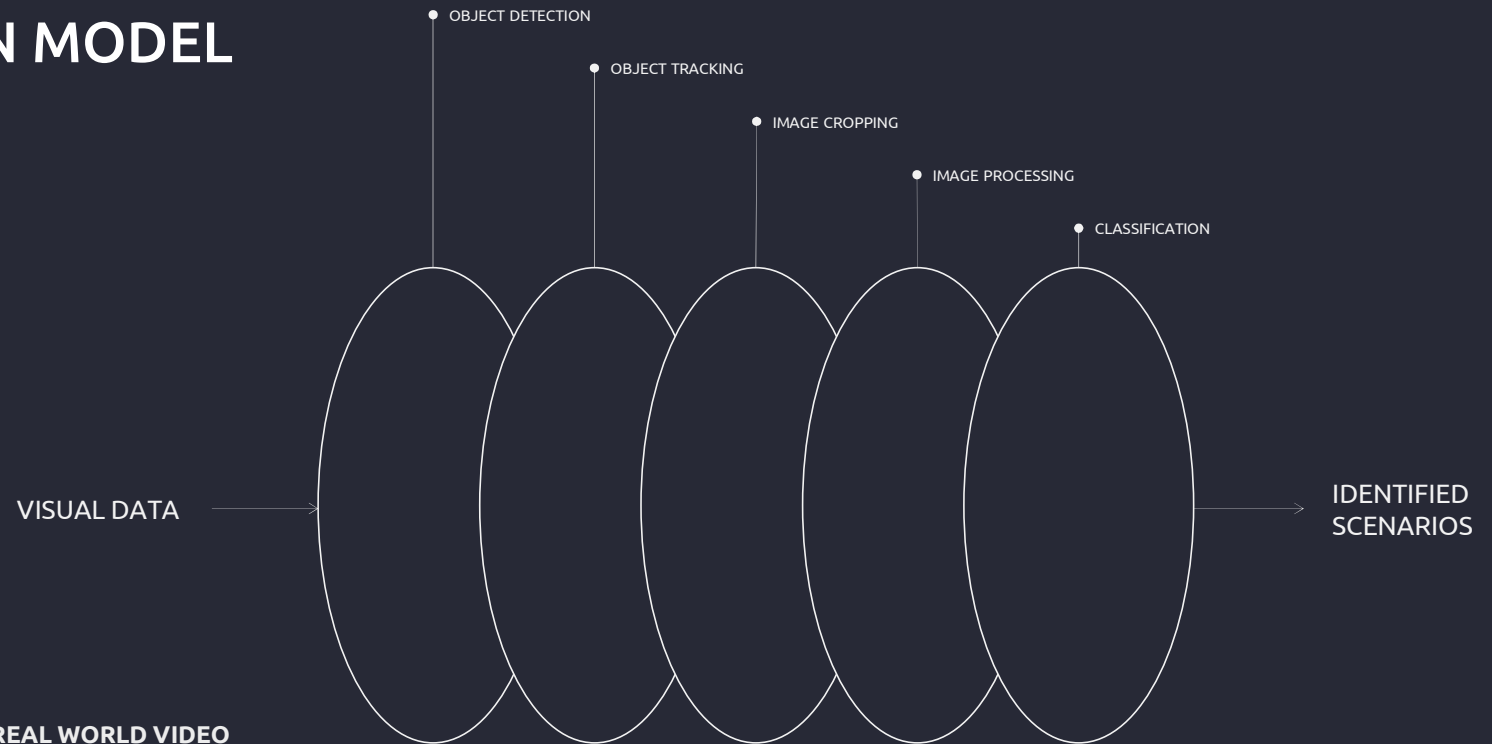
COMPUTER VISION MODEL

TRAIN ON SYNTHETIC DATA,
APPLY ON REAL WORLD VISUALS





COMPUTER VISION MODEL



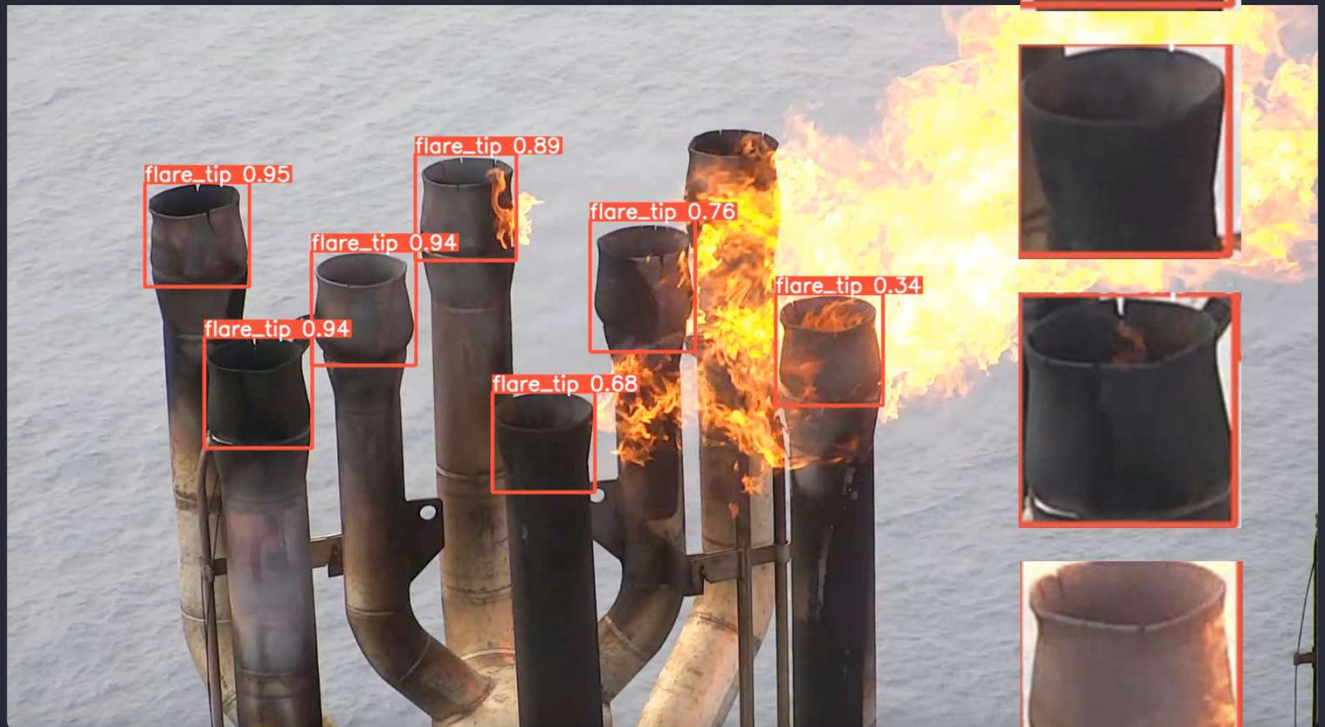
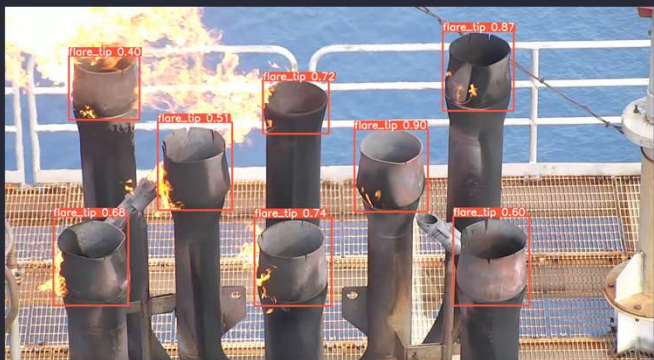
TRAIN ON SYNTHETIC DATA, APPLY ON REAL WORLD VIDEO

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 CROPPING



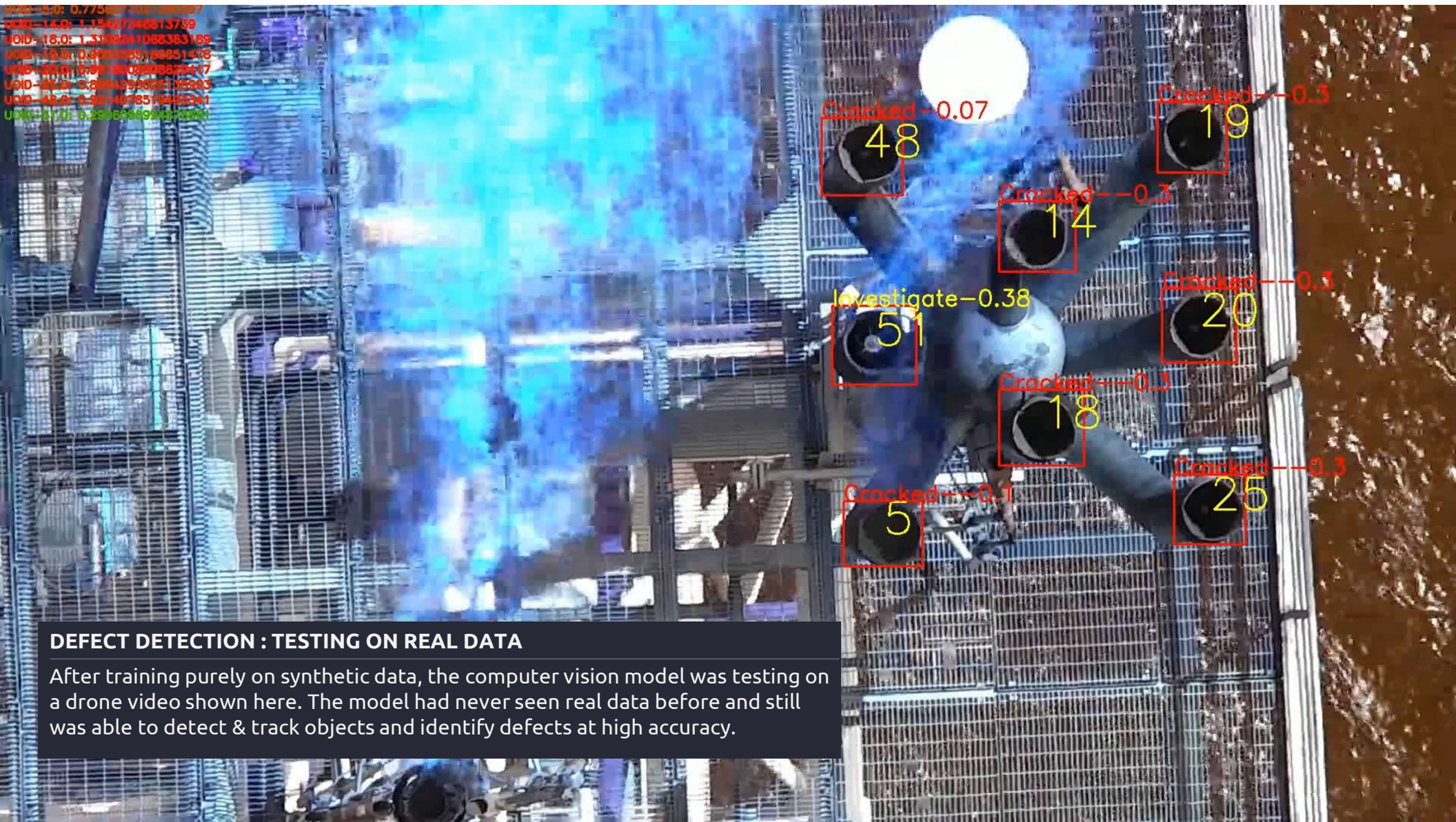
COMPUTER VISION MODEL

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.



U00-8.0: 0.775807102189287
U00-14.0: 1.15427348813739
U00-15.0: 1.3189241088383189
U00-16.0: 0.300288789851448
U00-18.0: 0.9918008908528417
U00-20.0: 0.899439983135983
U00-48.0: 0.8214078512445341
U00-51.0: 0.290698894378281

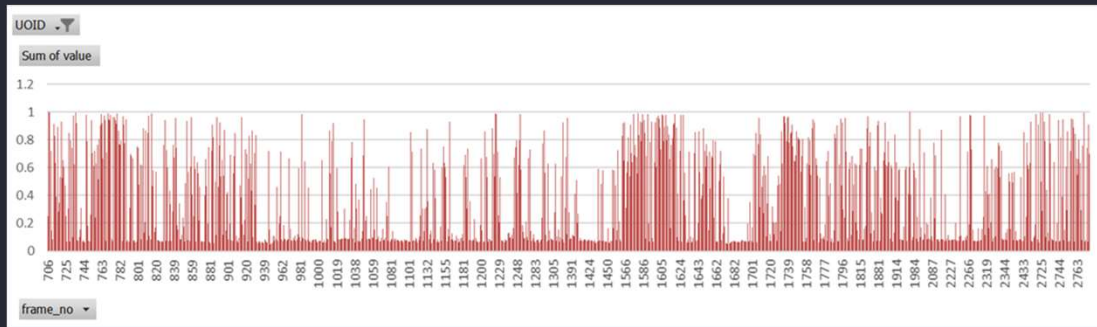


DEFECT DETECTION : TESTING ON REAL DATA

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.



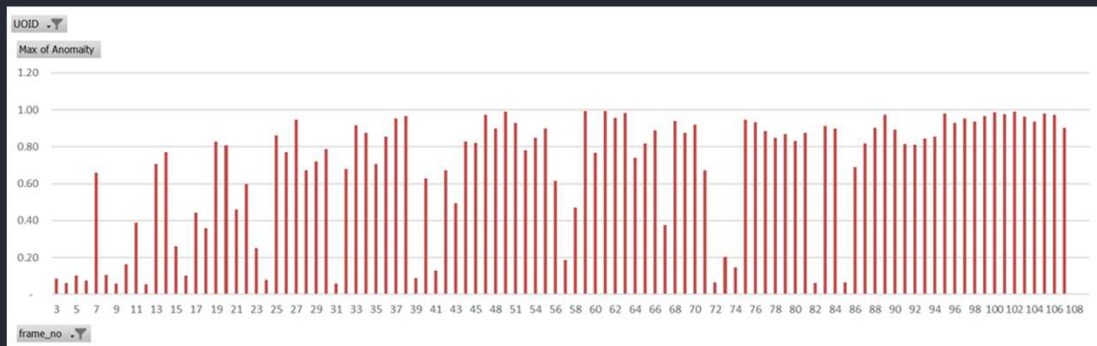
INSIGHTS FROM CV MODEL IS SUMMARIZED FOR CONSUMPTION



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
1	54.37	0.66
2	7.05	0.09
3	64.76	0.61
4	25.02	0.21
5	17.75	0.18
6	17.91	0.19
7	43.08	0.63
8	69.00	0.68

Median
0.76
0.08
0.75
0.09
0.08
0.07
0.76
0.83



Object ID	Sum	Average
5	402.72	0.37
14	682.03	0.33
18	1,095.99	0.53
19	741.41	0.63
20	1,141.39	0.56
25	1,344.58	0.66
48	387.53	0.55
51	202.23	0.41

Median
0.19
0.14
0.62
0.71
0.63
0.72
0.57
0.13



TRANSFORMING INSPECTION

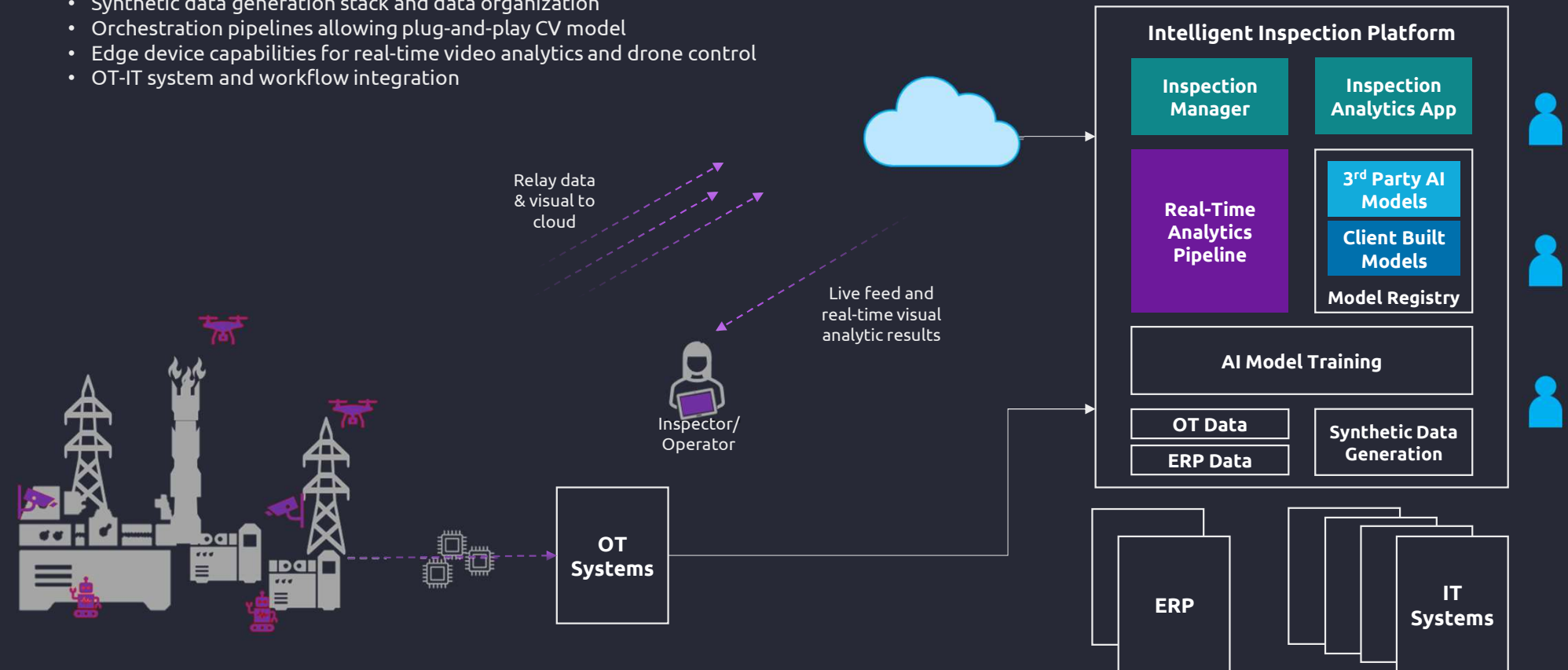
INTELLIGENT INSPECTION FRAMEWORK



INTELLIGENT INSPECTION FRAMEWORK

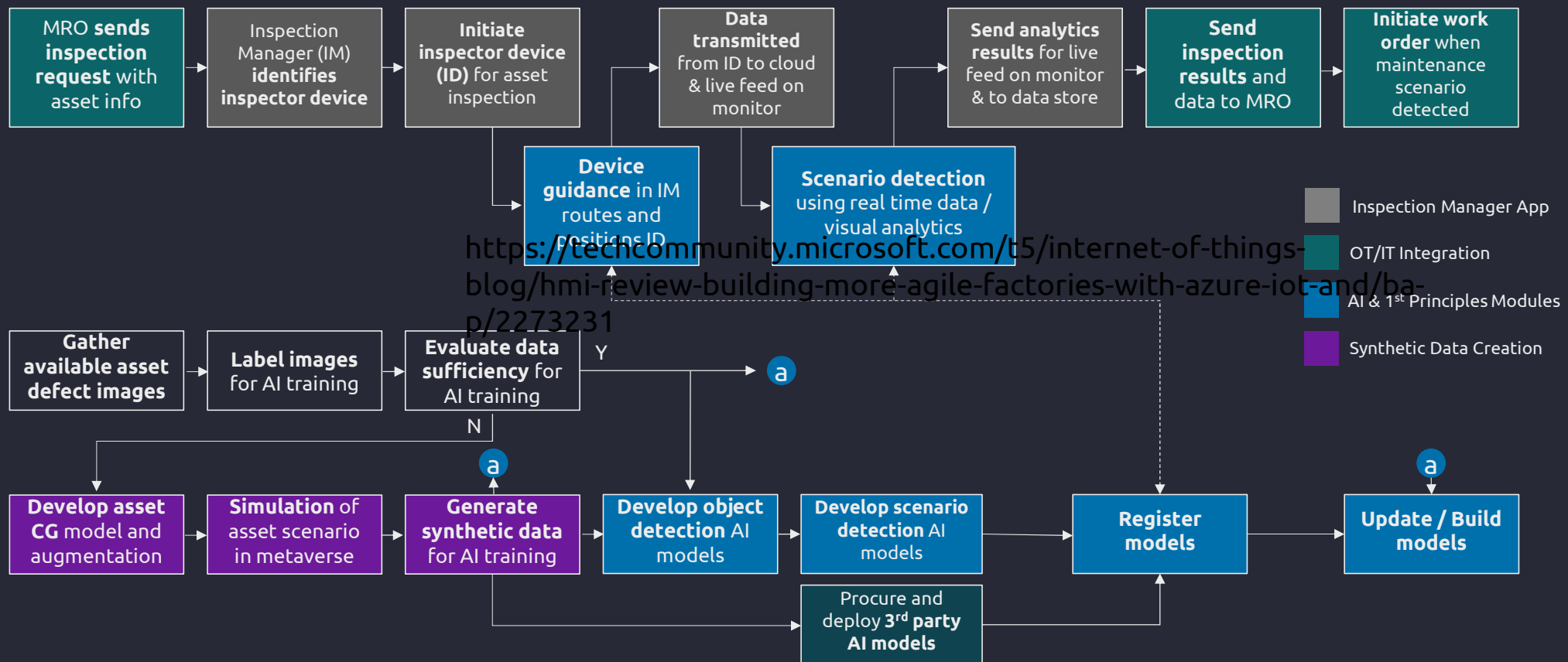
REUSABLE, SCALABLE CV FRAMEWORK FOR INSPECTION

- 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



<https://techcommunity.microsoft.com/t5/internet-of-things-blog/hmi-review-building-more-agile-factories-with-azure-iot-and/ba-p/2273231>



PROJECT PLAN

Topics	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
	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																			
Business Review & Acceptance																			
Realease 1																			
Phase 2																			
Orchestration Design (pipeline)																			
Build and Unit Testing																			
Infrastructure as Code																			
Design, Build & Test																			
Integration Testing																			
Feature set Release																			
Business Review & Acceptance																			
Realease 2																			

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

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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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