مدیریت فناوری‌های دیجیتال در صنعت ساخت

(بر اساس سندی از انجمن مدیریت ساخت آمریکا (CMAA))

ارائه‌دهندگان:

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نریمان درافشان

هانیه طباطبایی

زمستان ۱۴۰۳

قسمت ۱/۲

فصل اول: فناوری‌های دیجیتال در صنعت ساخت

قسمت دوم: داده

داده

۱. فایدهٔ داده

۲. مدیریت داده

۳. تولید داده

۴. پردازش داده

۵. ذخیرهٔ داده

۶. اشتراک‌گذاری و امنیت داده


data
visualization
information
context
Visualization
effective
peacebuilding
accurate
evidence
Hans
Make
viz
infographic
visual
purpose
best
questions
Data
decide
tools
please
communicate
development
communicating
value
post
Creation
main
work
important
tips
way
make
example
project
audience
useful
Checklist
Rosling
series
creating
help
provide
programs
See
visualizations
meant
values

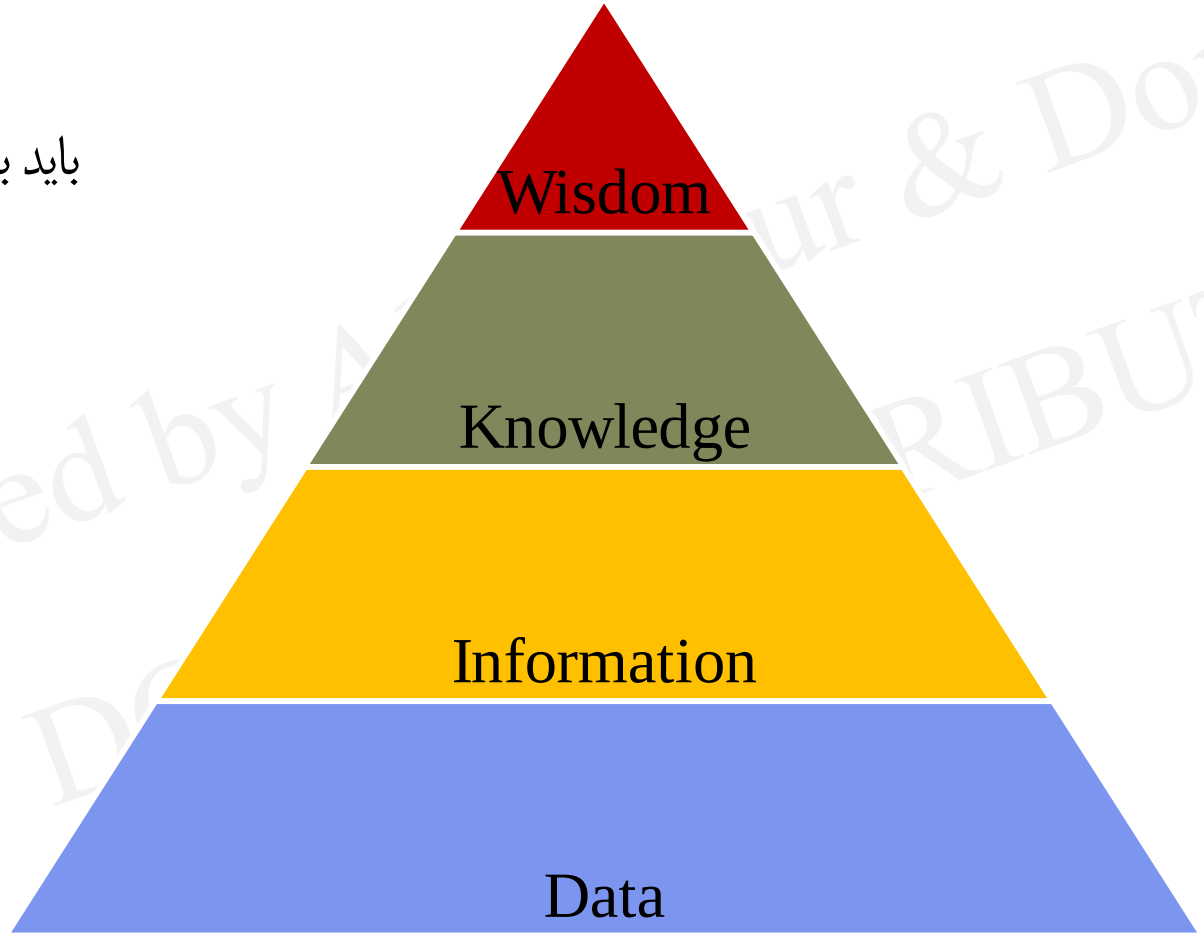
هفته‌نامهٔ اکونومیست، سال ۲۰۱۷

۱. داده

Data

هرم DIKW (۱/۶)

باید بین این ۴ مفهوم تمایز قائل شد



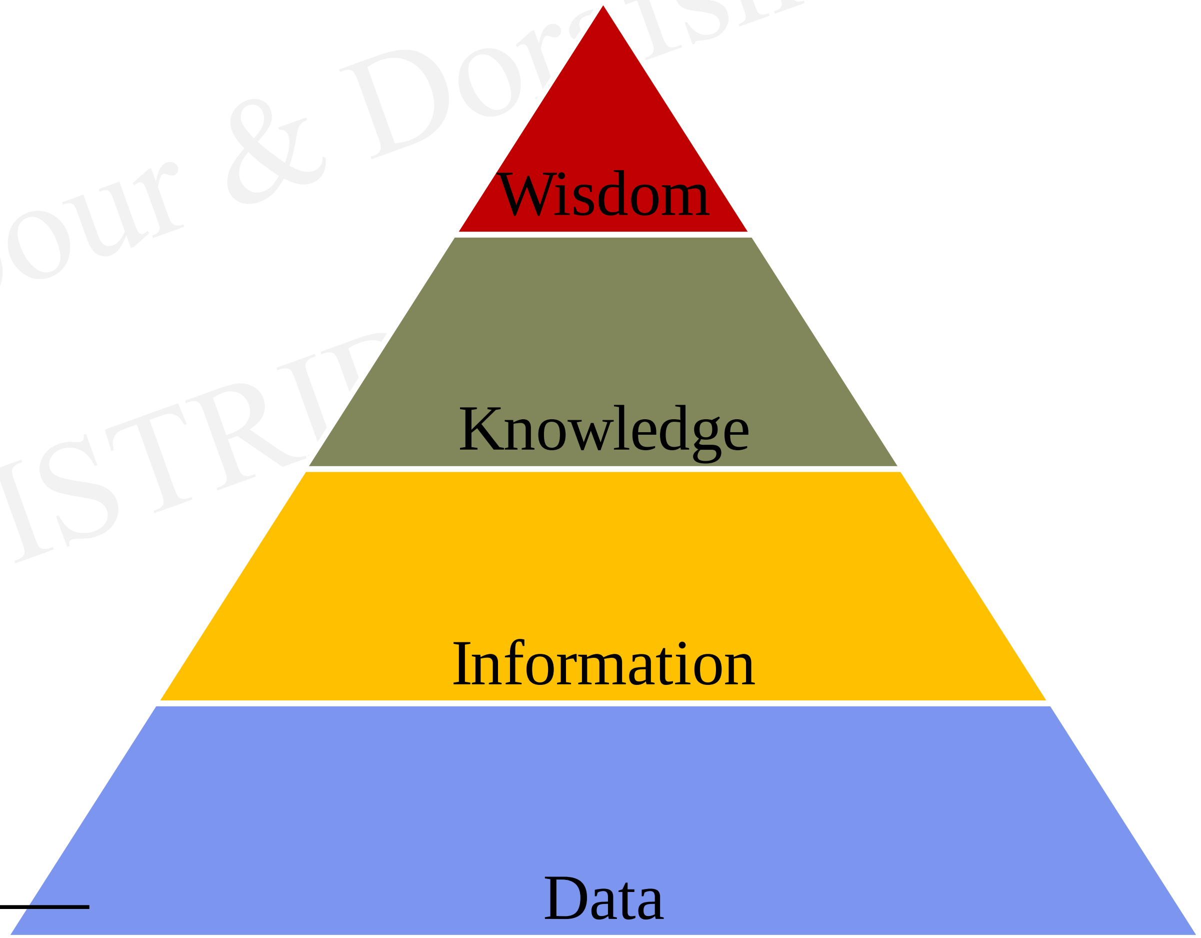
Russel L Ackoff

(۱۹۱۹ تا ۲۰۰۹)

هرم DIKW (۲/۶)

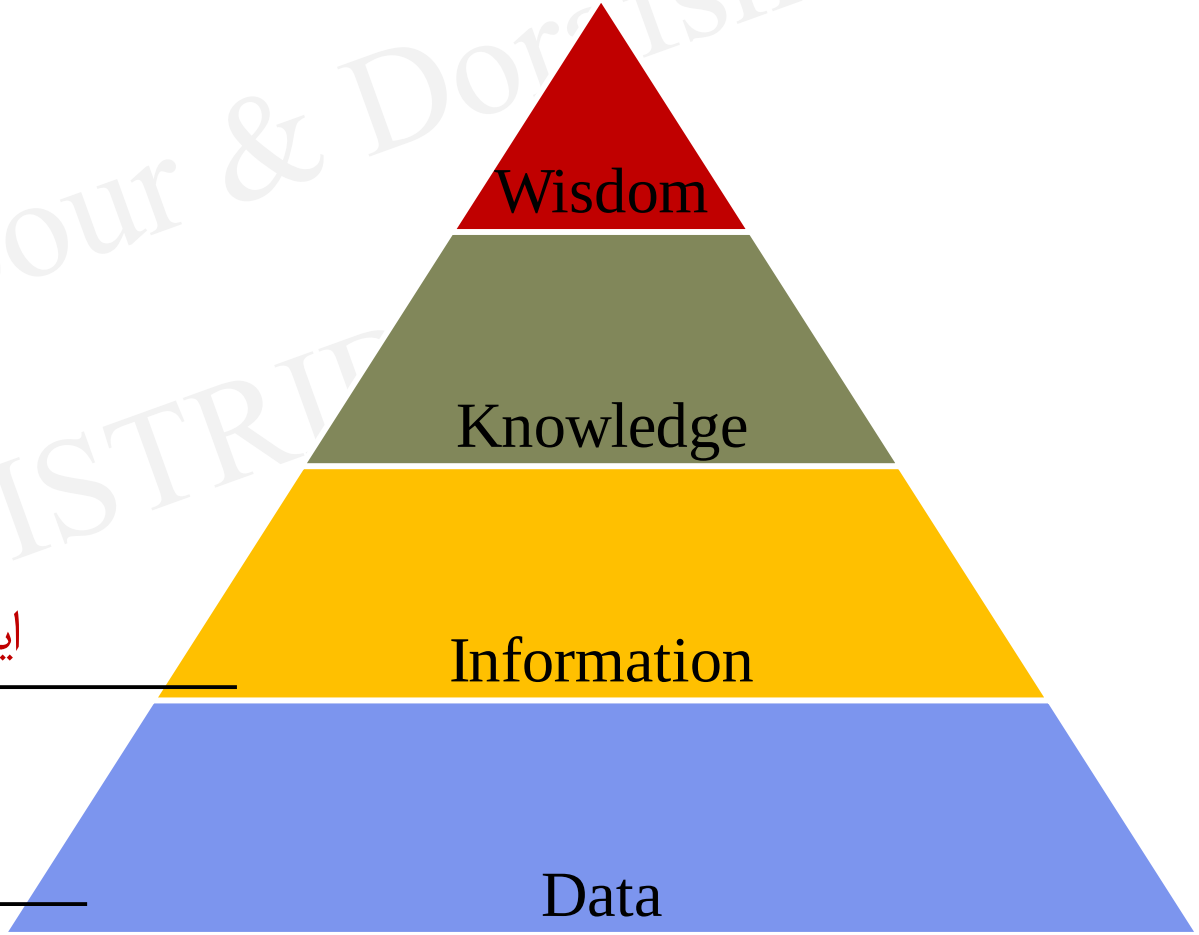
- داده‌ها خام‌ترین چیزی هستند که در دسترسمان قرار دارند
- ممکن است مفید باشد یا غیرمفید، معنادار یا بی‌معنا، درست یا نادرست
- معمولا جدول‌های خالی با داده پر می‌شوند

ورودی خام



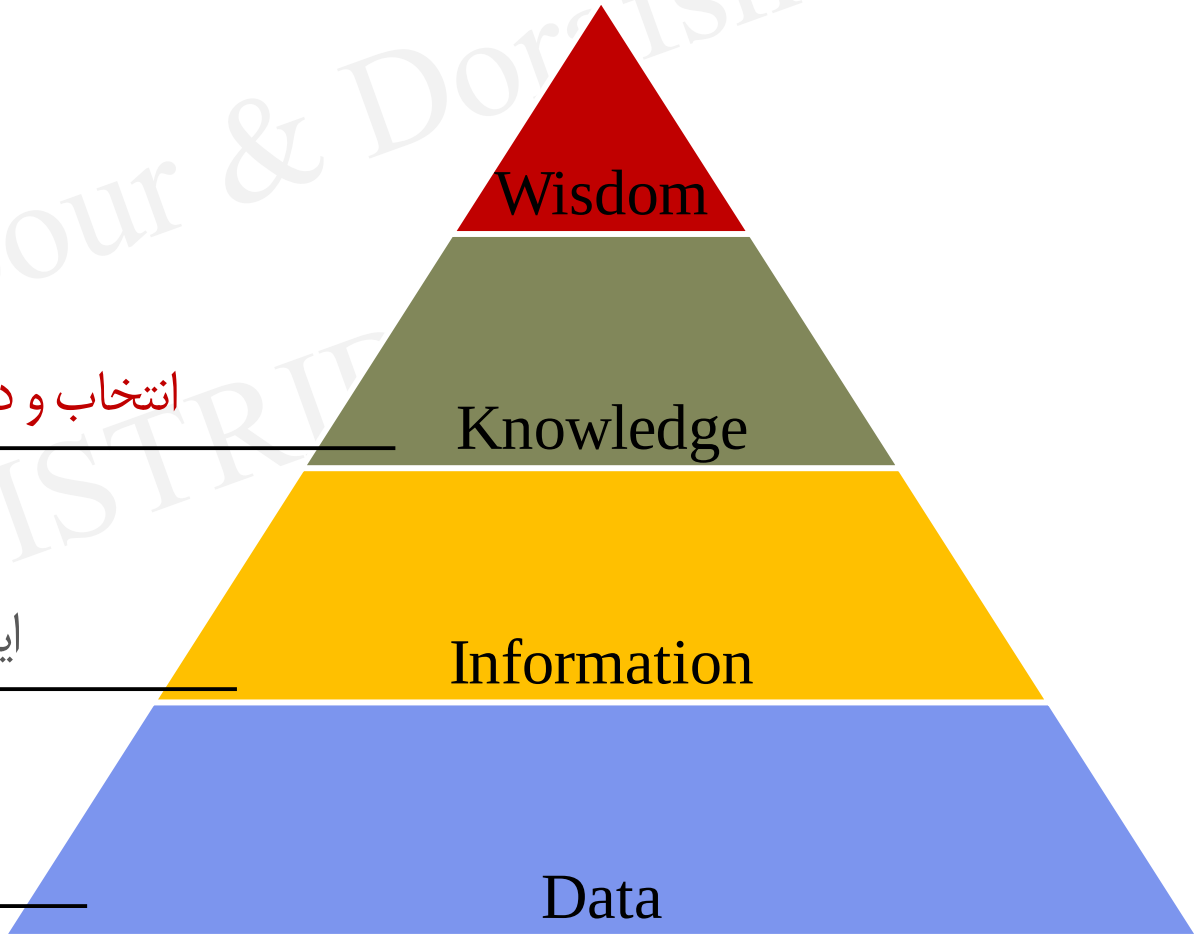
هرم DIKW (۳/۶)

- با کنار هم قرار دادن داده‌ها، می‌توان ارتباط منطقی بینشان کشف کرد: مانند شاخص‌های آماری، نحوهٔ توزیع، نرخ تغییرات
- اطلاعات، حاصل پردازش داده‌هاست



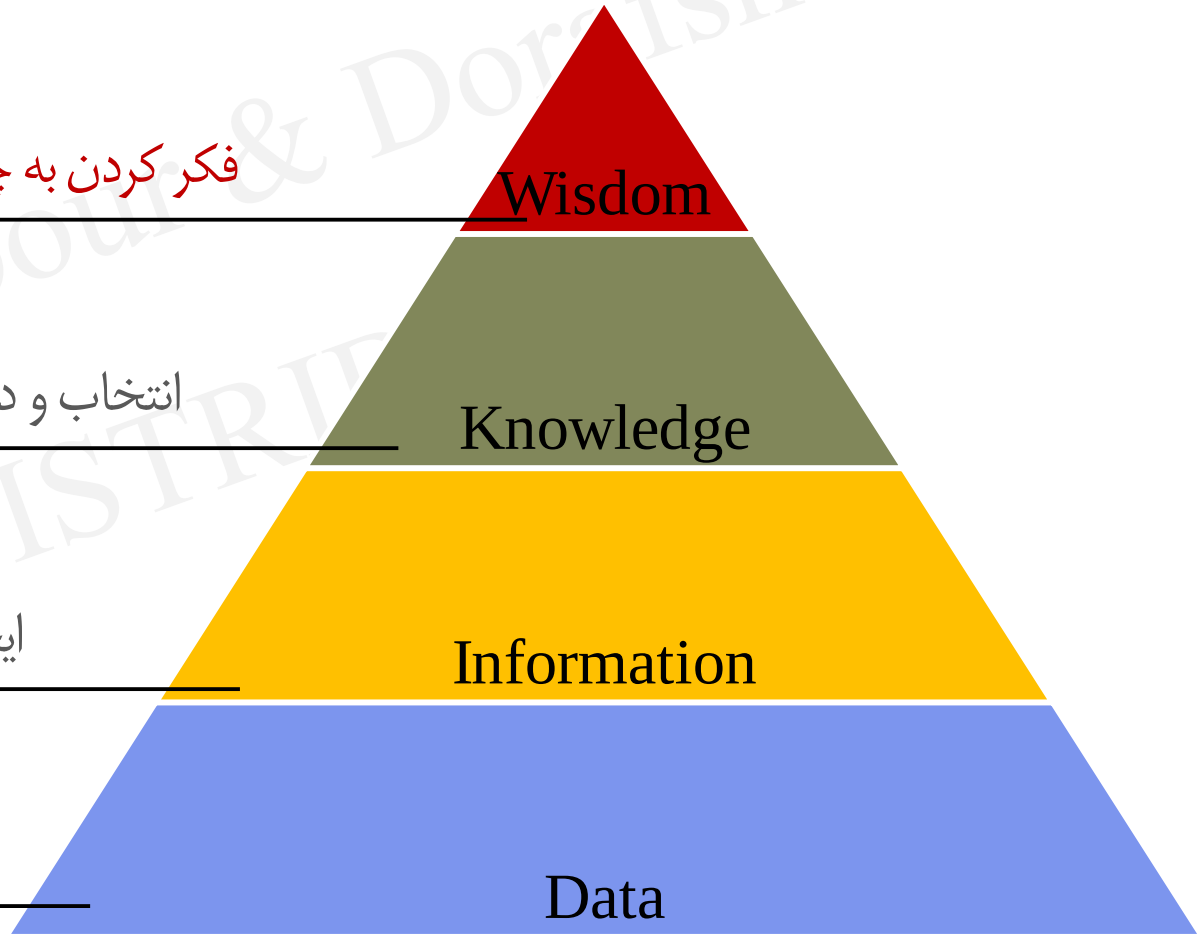
هرم DIKW (۴/۶)

- کنار گذاشتن اطلاعات غیرمفید
- دسته‌بندی و استفاده در راستای هدفی مشخص



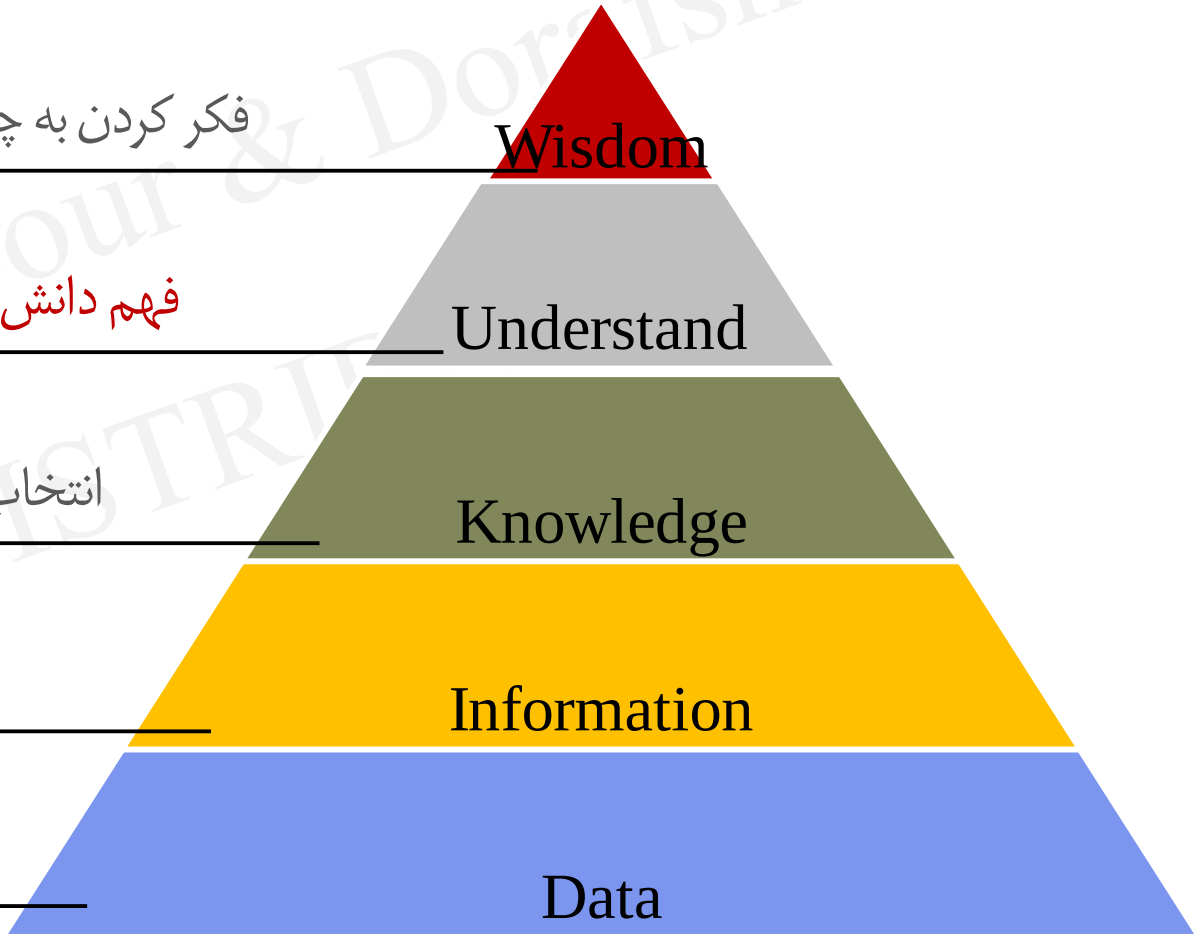
هرم DIKW (۵/۶)

- رسیدن از «چگونگی» به «چرایی»
- به چرایی‌ها فکر می‌کنیم
- علاوه بر توصیف، بحث تجویز، ارزیابی، هدف‌گذاری و ارزش‌گذاری هم دخیل هستند



هرم DIKW (۶/۶)

- فکر کردن به اهمیت و نتیجه دانش دریافت شده
- فهم تبعات و دستاوردها و کاربردهای محتمل



مثال) پروژه خط لوله انتقال آب

مصداق‌های هرکدام از ارکان هرم DIKW را بیابید.

کارشناس کنترل پروژهٔ احداث خط لولهٔ انتقال آب هستید.

گزارش‌های روزانه را دریافت می‌کنید، هر دو هفته برنامهٔ زمان‌بندی را به‌روز می‌کنید و گزارش پیشرفت ارائه می‌کنید.

در انتهای ماه ۵، ۴۰ روز تاخیر وجود داشت. در انتهای ماه ۶، این تاخیر به ۴۷ روز رسیده است.

از شما خواسته‌اند تا ببینید چرا تاخیر دارد بیشتر می‌شود.

هدف بنیادین اندازه‌گیری ...

اندازه‌گیری (داده) افراد را مطلع می‌کند

که اقدامی انجام دهند (تصمیمی بگیرند)

که در غیر این صورت انجامش نمی‌دادند (یا دیرتر انجامش می‌دادند)

Data: definition

- Data is information that the team can use to **enhance** project or program delivery. (CMAA Technology Management)

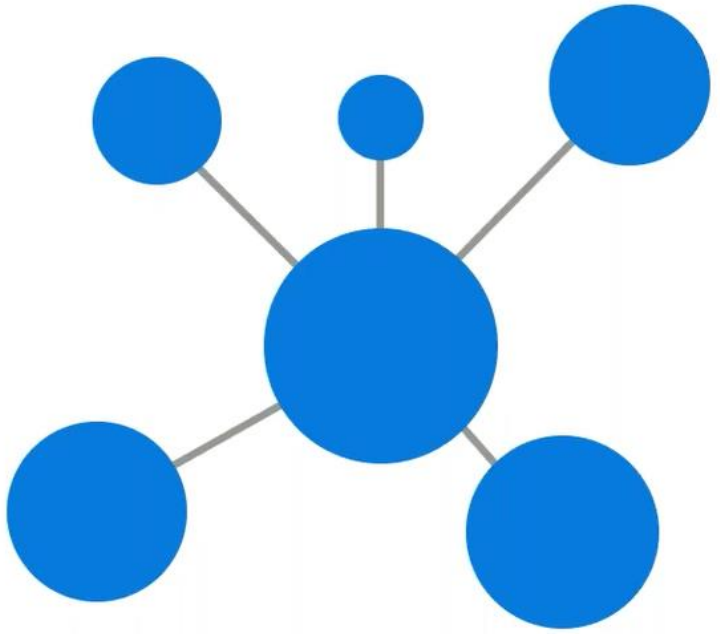
Why this definition?

- A capital construction project or program can **generate tremendous** amounts of data that the team must

sort, prioritize, and analyze to make good decisions.

What is project data?

1. Scope
2. Commutations
3. Costs
4. Application Logs

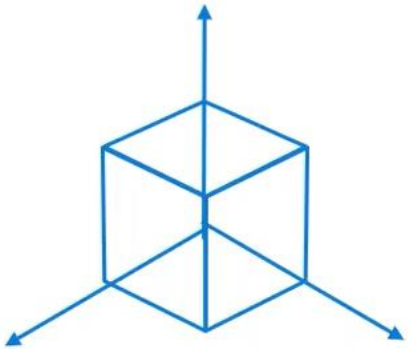


Project Data

1. **Communications**
   - RFIs
   - Submittals
   - Memos
   - Meeting minutes
   - Emails
   - Daily reports
   - Photographs

Project Data

2. **Scope**
   - Drawings
   - Specifications
   - Contractual documents



Project Data

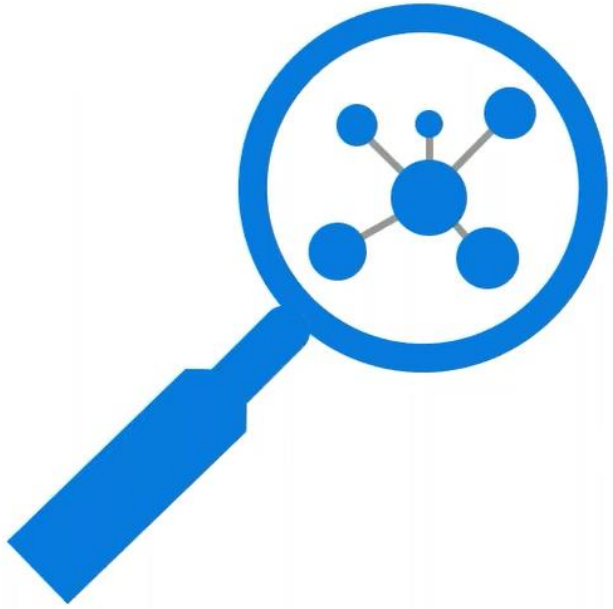
3. **Costs**
   - Contracts
   - Change orders
   - Timesheets and labor hours

Delivering value from project data?

1. Increasing profits / meeting budgets
2. Winning future work / building reputation

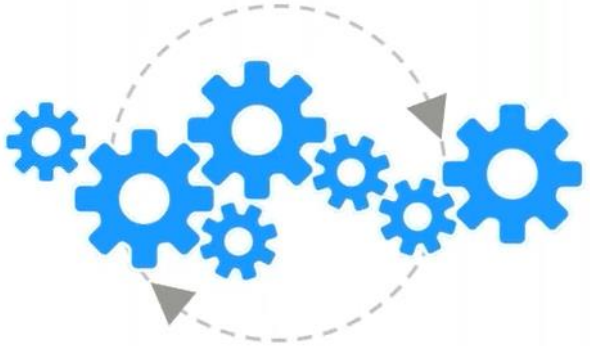
Delivering value from project data?

1. **Increasing profits / meeting budgets**
   - Risk tracking and mitigation
   - Avoiding claims
   - Reducing delays
   - Visibility into performance



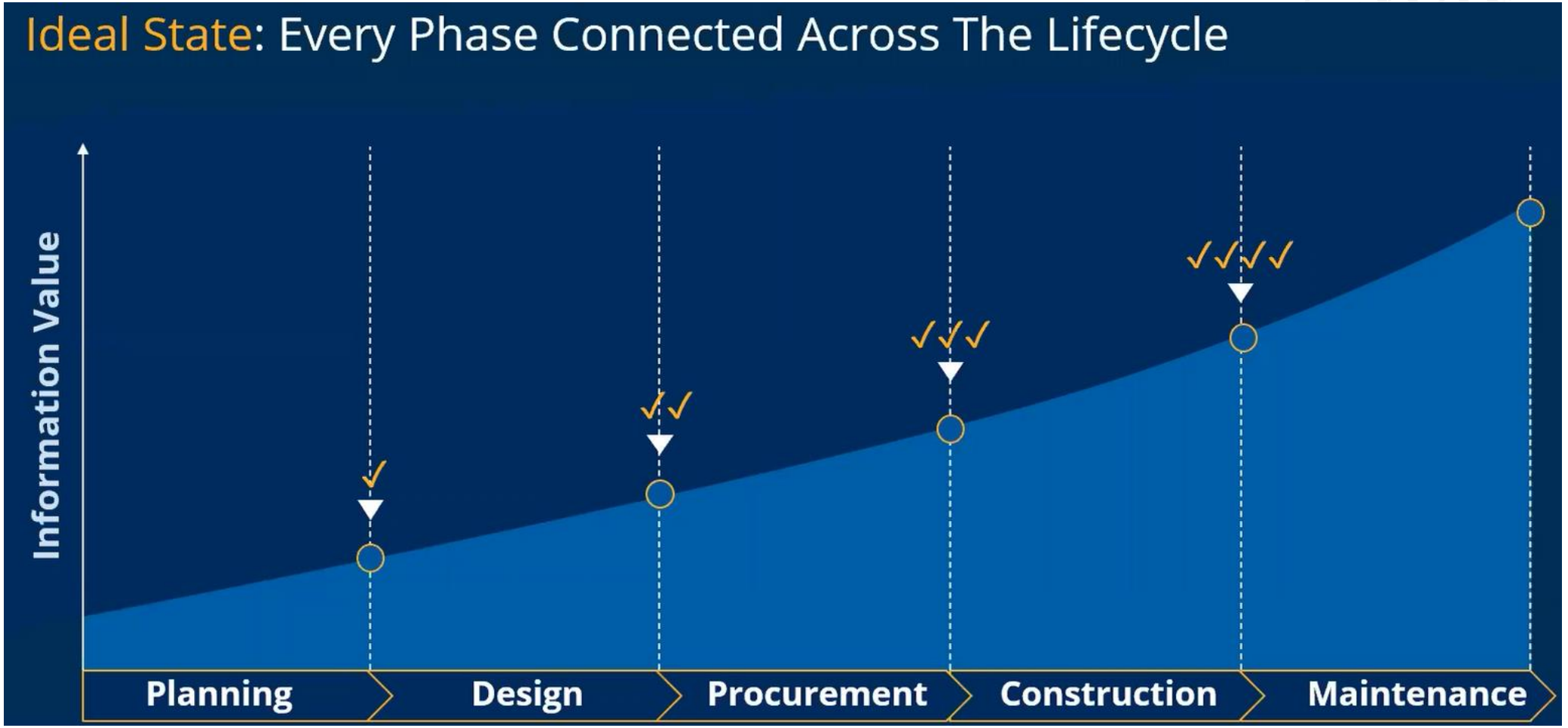
Delivering value from project data?

2. **Winning future work / building reputation**
   - New deliverables and value-added services
   - Improved communications

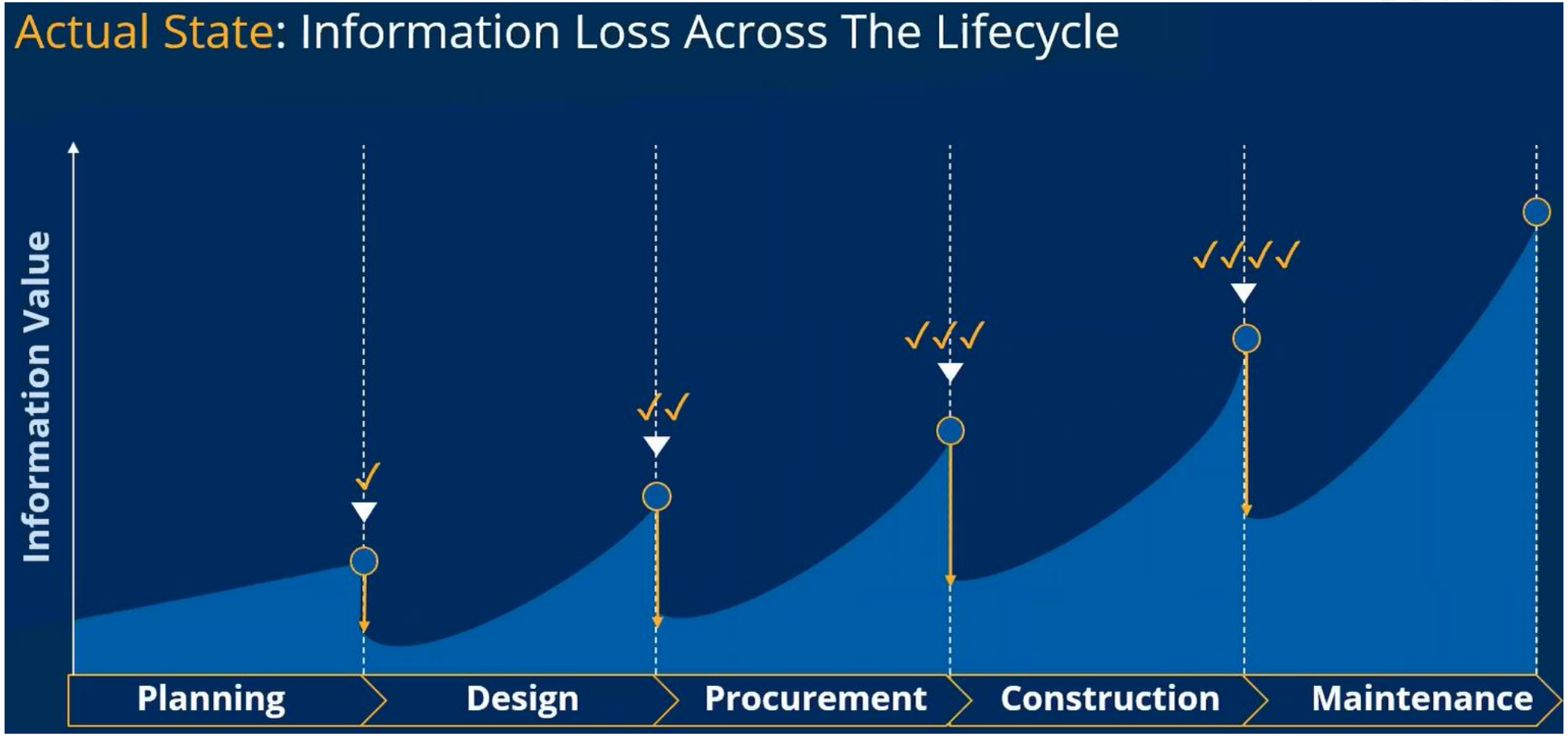


Delivering value from project data?

Delivering value from project data?



Delivering value from project data?



Data sources in construction

There are many potential design/construction data sources, including:

team members, other stakeholders, equipment, systems, tools, and software

Types of design/construction data (1/2)

- There are **many types of design/construction data**, including (but not limited to):
  - Cost data (price estimates, progress payments, etc.);
  - Schedule data (duration estimates, resource availability, start and finish dates, etc.);
  - Risk data (cost and schedule impacts, risk likelihood, risk monetary values, etc.);
  - Safety data (jobsite records, training records, a contractor's experience modification rate, etc.);

Types of design/construction data (2/2)

- There are **many types of design/construction data**, including (but not limited to):
  - Productivity data (cubic yards or linear feet placed per day, etc.);
  - Quality data (quality control/quality assurance reports, commissioning records, etc.);
  - Communications data (addenda, emails, meeting minutes, etc.);
  - Logs (application logs, automation logs, database logs, etc.).

Q.

What should be CM expertise related to data?

CM expertise related to data

The CM does not need to be an expert on data, but the CM should understand:

where project or program data comes from,

what the team needs to analyze it, and

how to use it to benefit the owner.

Data to manage delivery (1/2)

- Data is necessary to manage delivery because it helps the team **understand**
  1. What has happened,
  2. What is happening, and
  3. What may happen.
- For example, teams can use data to
  - build digital models,
  - perform estimates,
  - analyze risks, and
  - develop schedules.

The CM ensures that the team identifies subject matter experts

to evaluate data and data sources

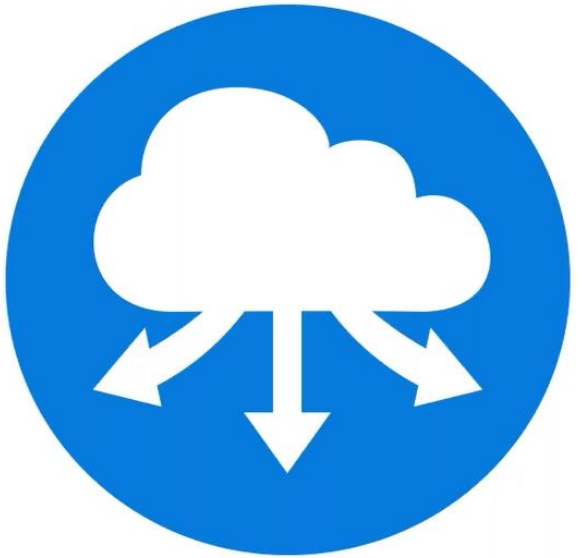
to maintain the data's integrity and useability.

۲. مدیریت داده

Data Management

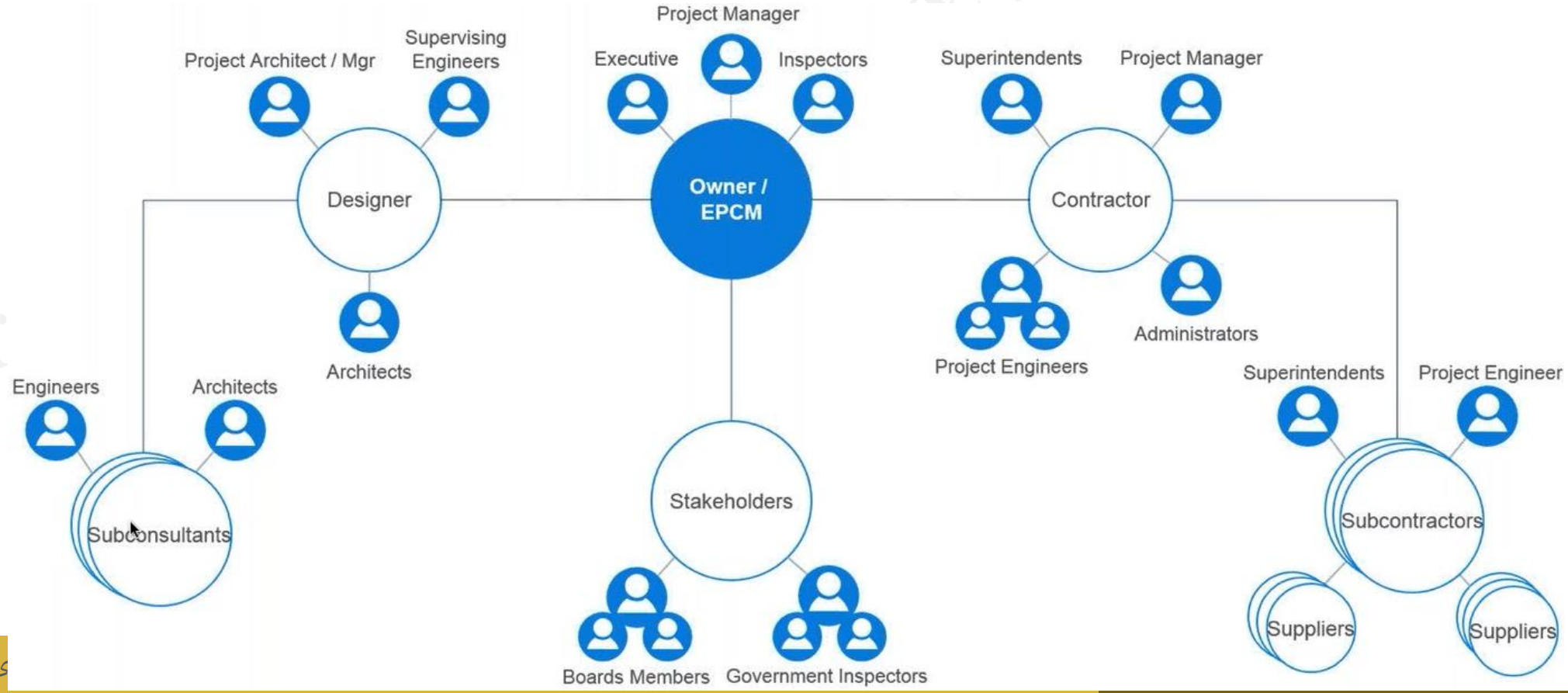
Capturing project data?

1. Minimizing impact on project participants
2. Ensure data quality



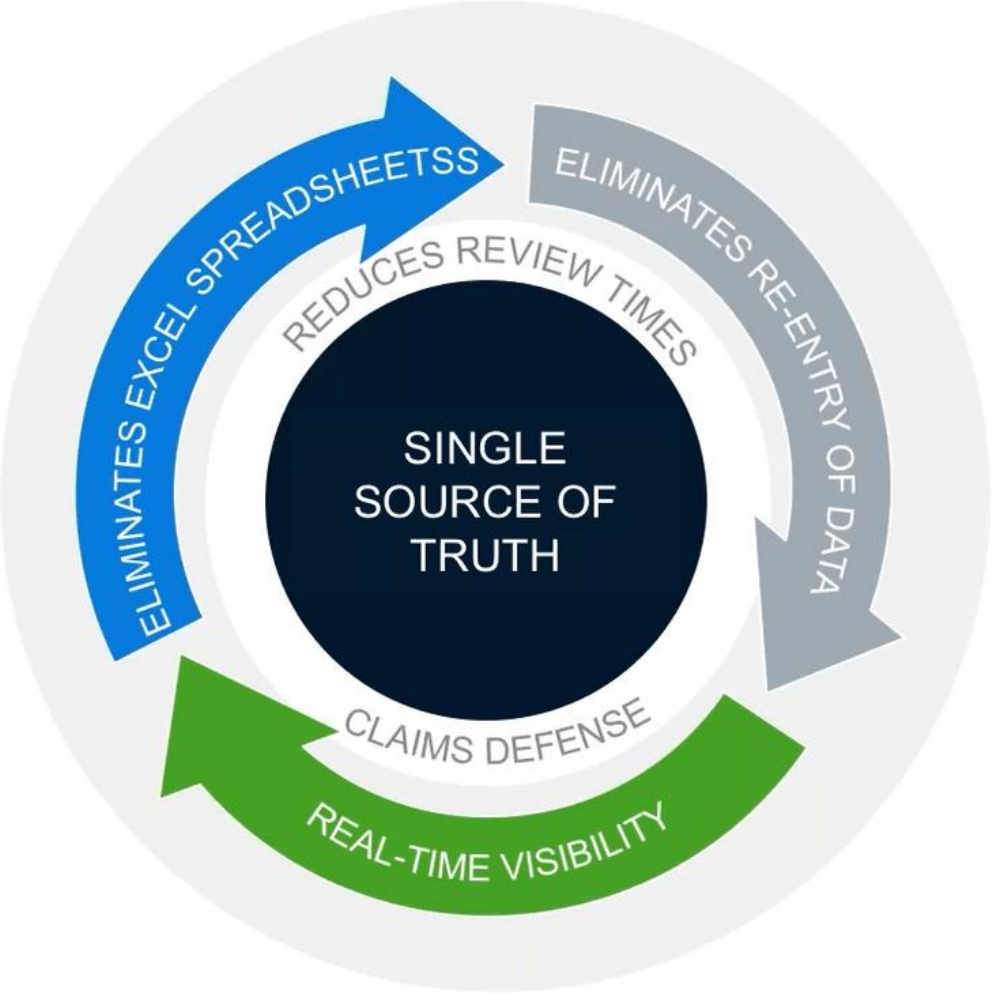
Capturing project data?

1. **Minimizing impact on project participants**
   - Capture within the workflow



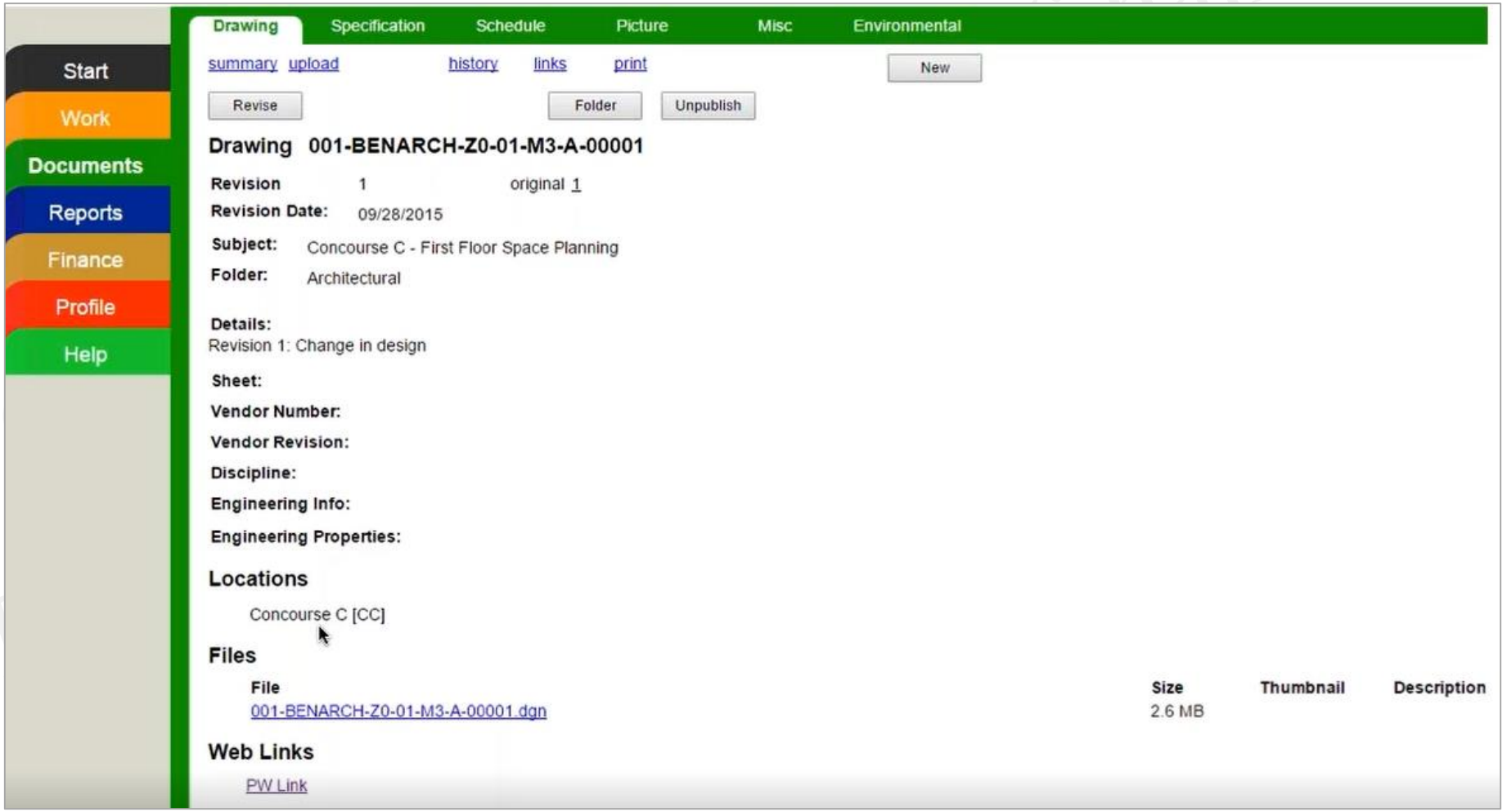
Capturing project data?

2. **Ensure data quality**
   - Change control
   - How to store for maximum use?
   - Tools for leveraging data



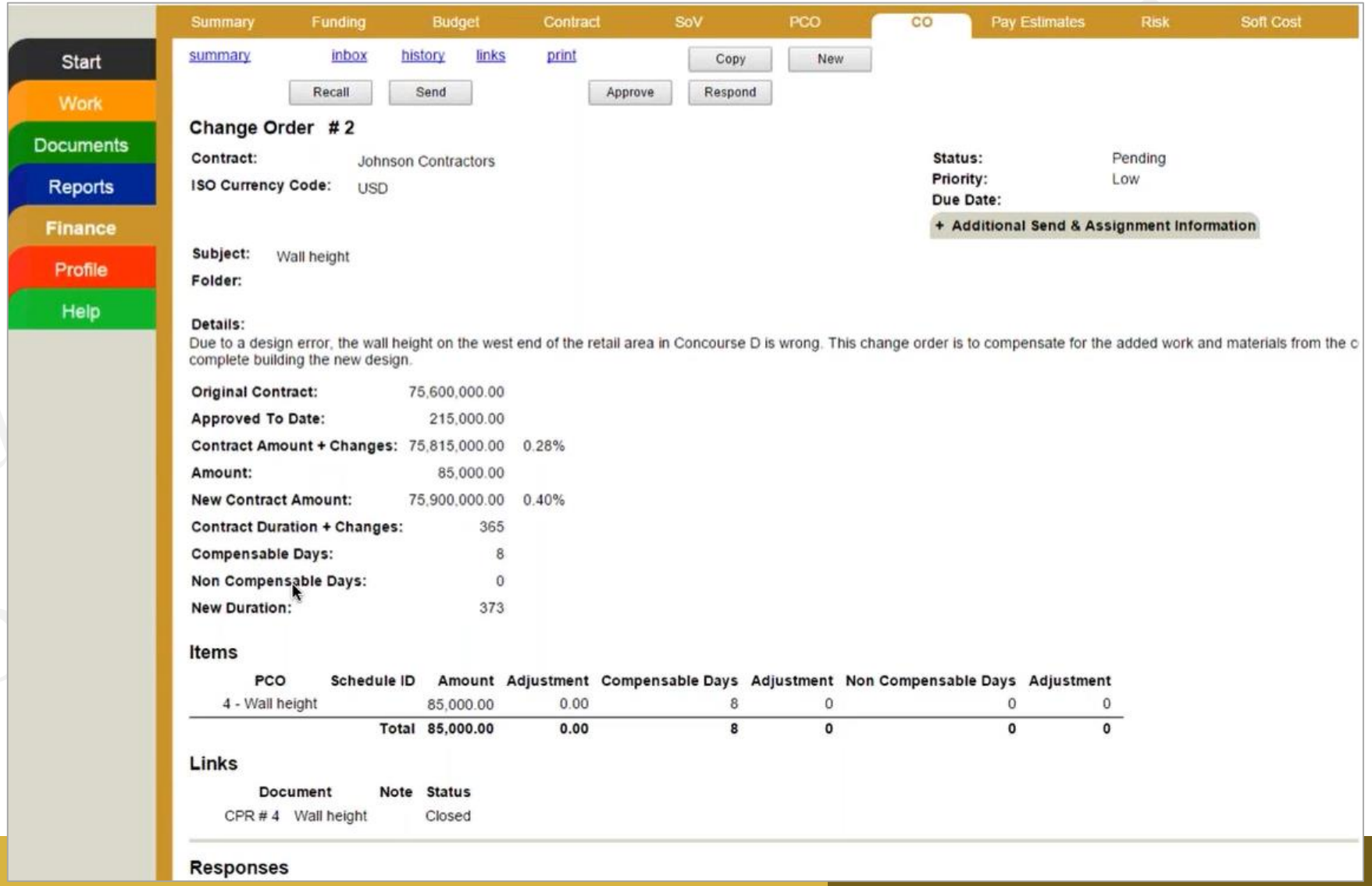
Capturing project data?

- **Change control**
  - Visioning



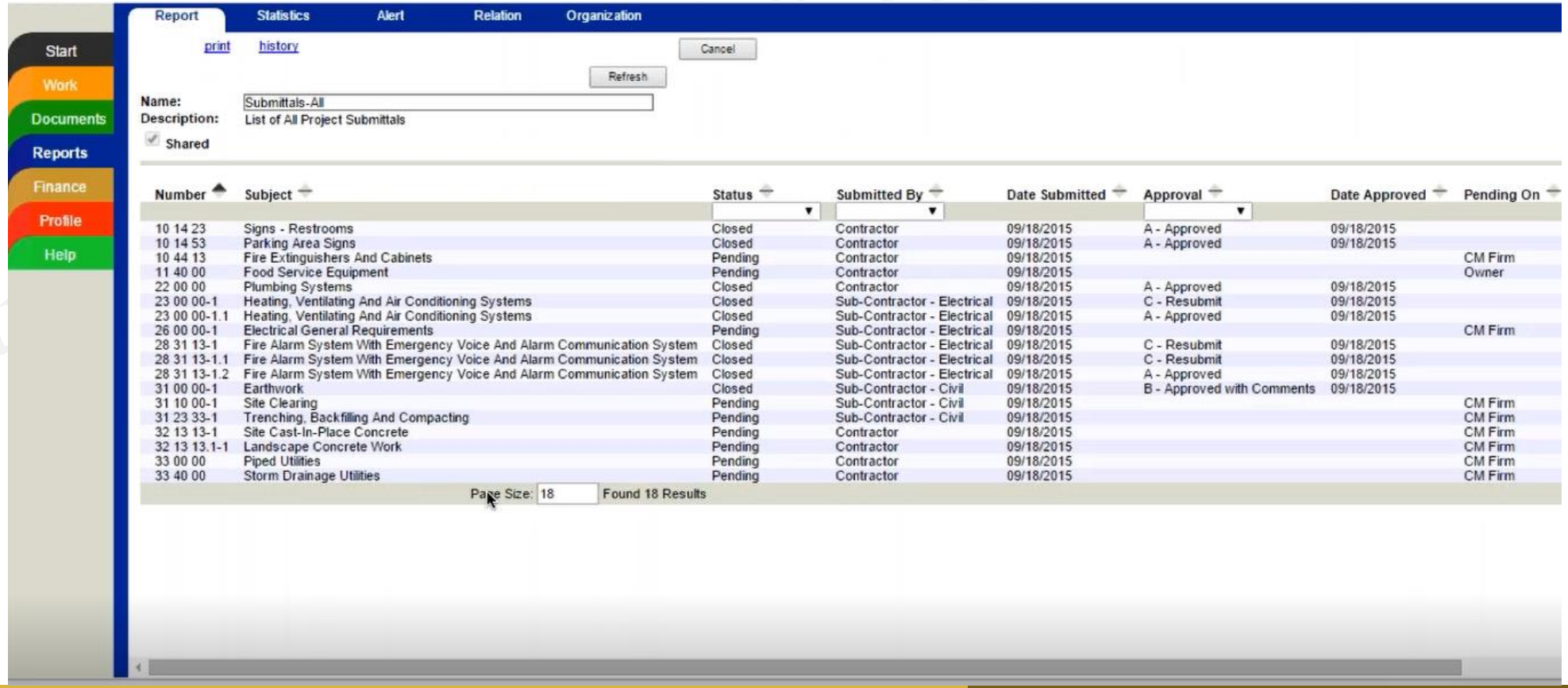
Capturing project data?

- **Change control**
  - Contract changes



Capturing project data?

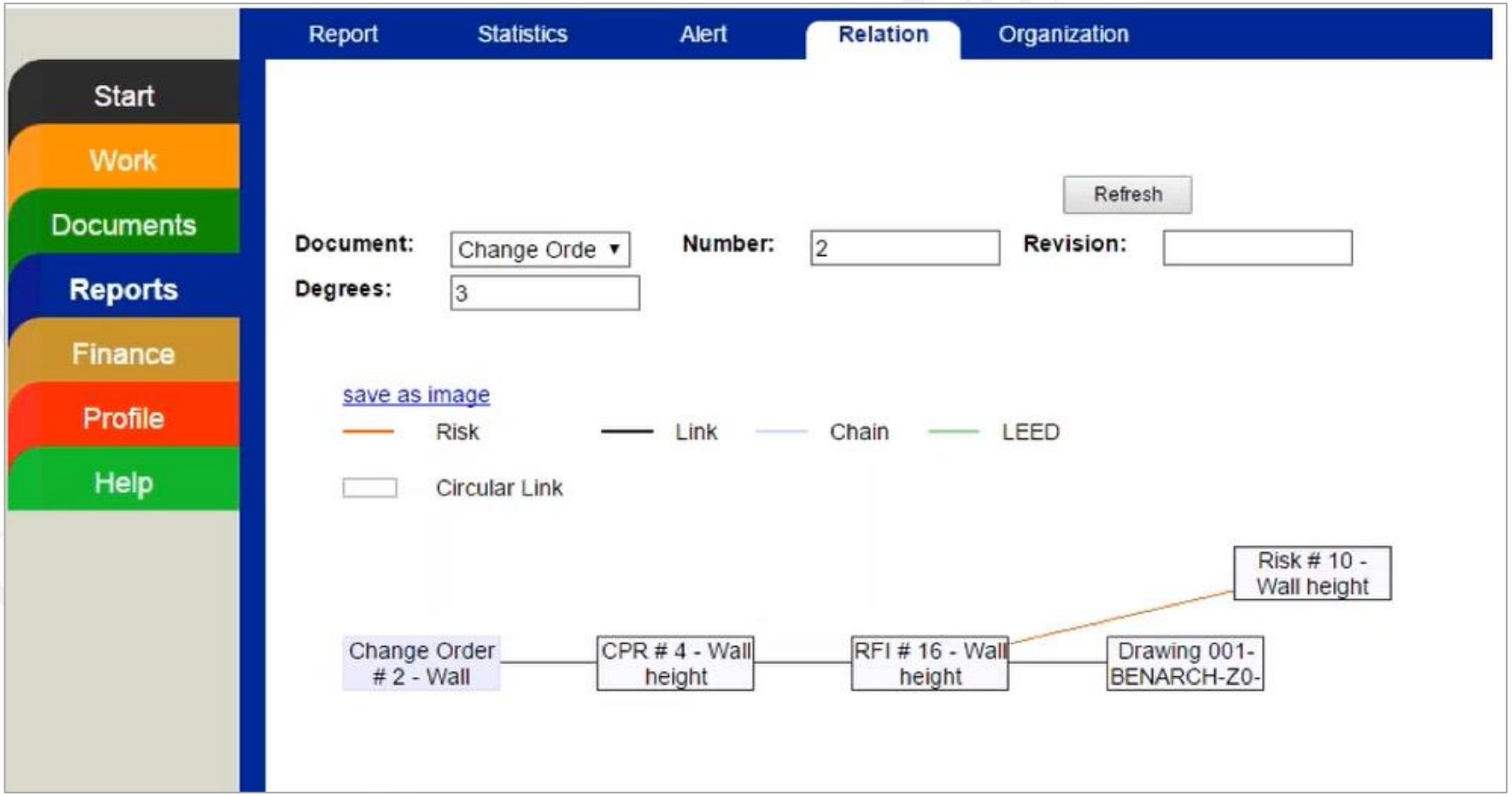
- **Leveraging data**
  - Reporting
  - Analyzing
  - Presenting



Number	Subject	Status	Submitted By	Date Submitted	Approval	Date Approved	Pending On
10 14 23	Signs - Restrooms	Closed	Contractor	09/18/2015	A - Approved	09/18/2015	
10 14 53	Parking Area Signs	Closed	Contractor	09/18/2015	A - Approved	09/18/2015	
10 44 13	Fire Extinguishers And Cabinets	Pending	Contractor	09/18/2015			CM Firm
11 40 00	Food Service Equipment	Pending	Contractor	09/18/2015			Owner
22 00 00	Plumbing Systems	Closed	Contractor	09/18/2015	A - Approved	09/18/2015	
23 00 00-1	Heating, Ventilating And Air Conditioning Systems	Closed	Sub-Contractor - Electrical	09/18/2015	C - Resubmit	09/18/2015	
23 00 00-1.1	Heating, Ventilating And Air Conditioning Systems	Closed	Sub-Contractor - Electrical	09/18/2015	A - Approved	09/18/2015	
26 00 00-1	Electrical General Requirements	Pending	Sub-Contractor - Electrical	09/18/2015			CM Firm
28 31 13-1	Fire Alarm System With Emergency Voice And Alarm Communication System	Closed	Sub-Contractor - Electrical	09/18/2015	C - Resubmit	09/18/2015	
28 31 13-1.1	Fire Alarm System With Emergency Voice And Alarm Communication System	Closed	Sub-Contractor - Electrical	09/18/2015	C - Resubmit	09/18/2015	
28 31 13-1.2	Fire Alarm System With Emergency Voice And Alarm Communication System	Closed	Sub-Contractor - Electrical	09/18/2015	A - Approved	09/18/2015	
31 00 00-1	Earthwork	Closed	Sub-Contractor - Civil	09/18/2015	B - Approved with Comments	09/18/2015	
31 10 00-1	Site Clearing	Pending	Sub-Contractor - Civil	09/18/2015			CM Firm
31 23 33-1	Trenching, Backfilling And Compacting	Pending	Sub-Contractor - Civil	09/18/2015			CM Firm
32 13 13-1	Site Cast-In-Place Concrete	Pending	Contractor	09/18/2015			CM Firm
32 13 13.1-1	Landscape Concrete Work	Pending	Contractor	09/18/2015			CM Firm
33 00 00	Piped Utilities	Pending	Contractor	09/18/2015			CM Firm
33 40 00	Storm Drainage Utilities	Pending	Contractor	09/18/2015			CM Firm

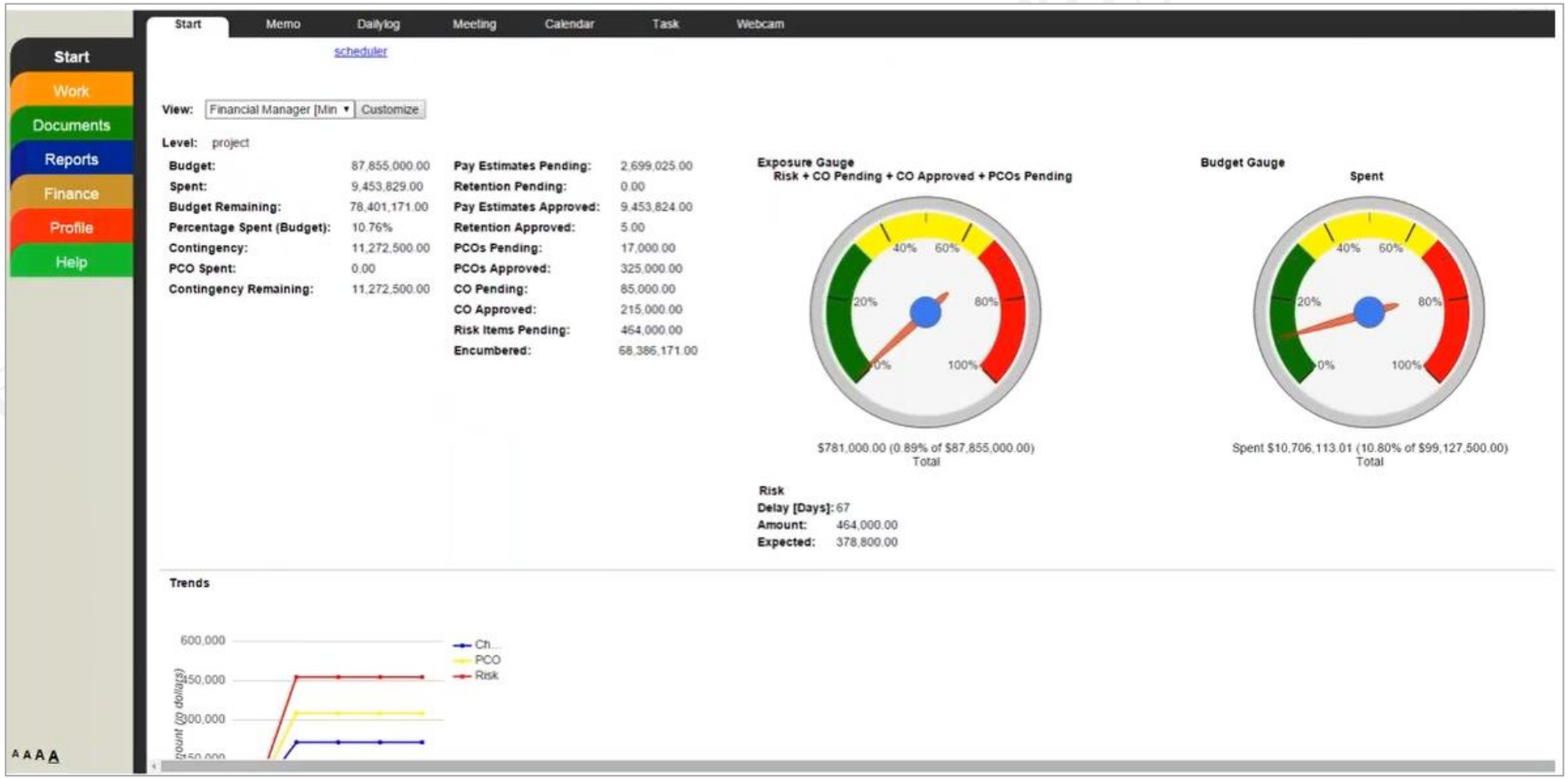
Capturing project data?

- **Leveraging data**
  - Reporting
  - Analyzing
  - Presenting



Capturing project data?

- **Leveraging data**
  - Reporting
  - Analyzing
  - Presenting



Data management

- Data management is the **practice** to
  1. Create,
  2. Process,
  3. Store,
  4. Share, and
  5. Monitor

  data.

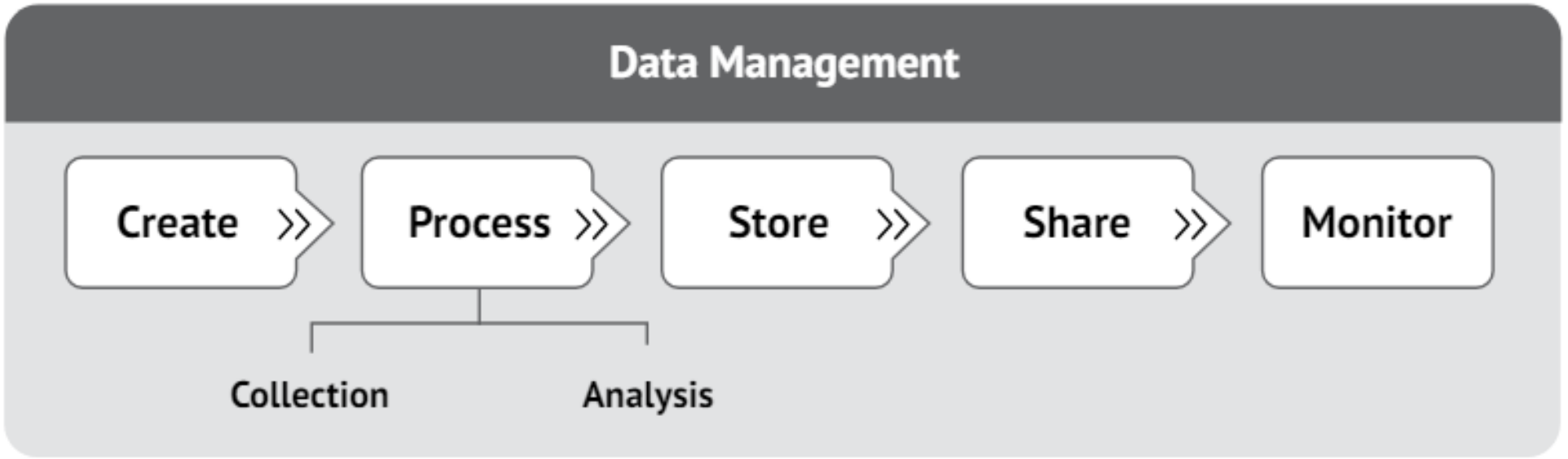
Data management

- Data management involves
  - **Collection** of data from the team and the jobsite,
  - **Processing** that data into useful information, and
  - Then **using** that information to create knowledge among the team.

Data management

- Effective data management is a critical component of technology management
  - that helps the **team**
    - Communicate,
    - Manage risk,
    - Save time,
    - Increase predictability, and
    - Improve performance.

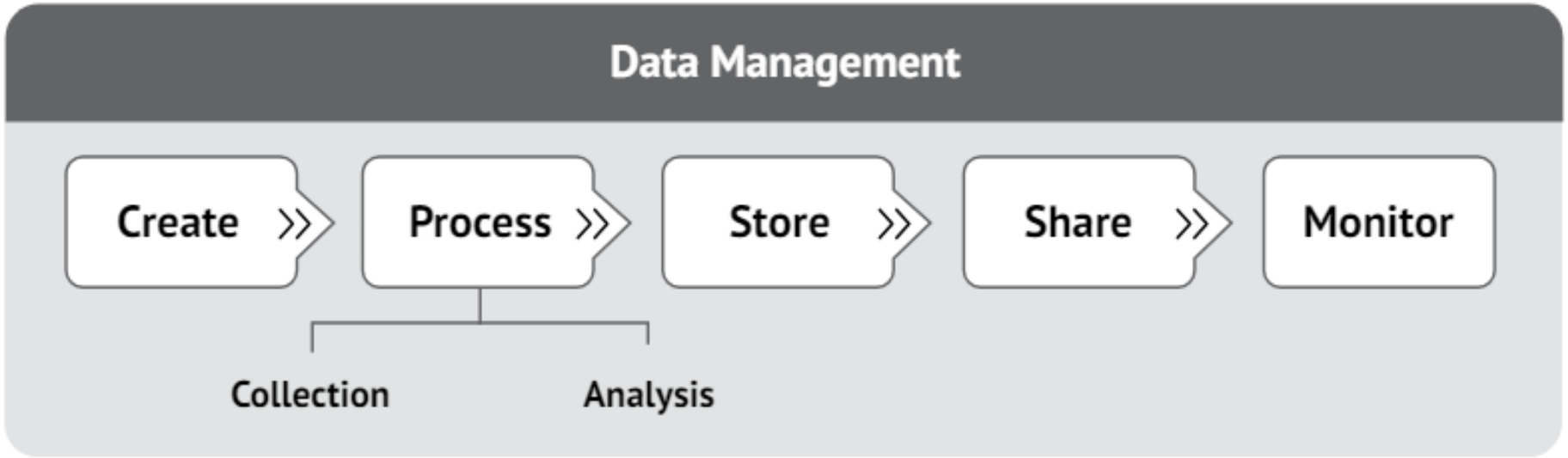
Data Management Flow



Data Management Flow

- Note that data management does not always follow the **exact sequence** shown below.

- The flow of data **may vary** depending on
  - Project's/program's technology requirements,
  - Policies and procedures, and
  - Stakeholders.



Data Management Flow

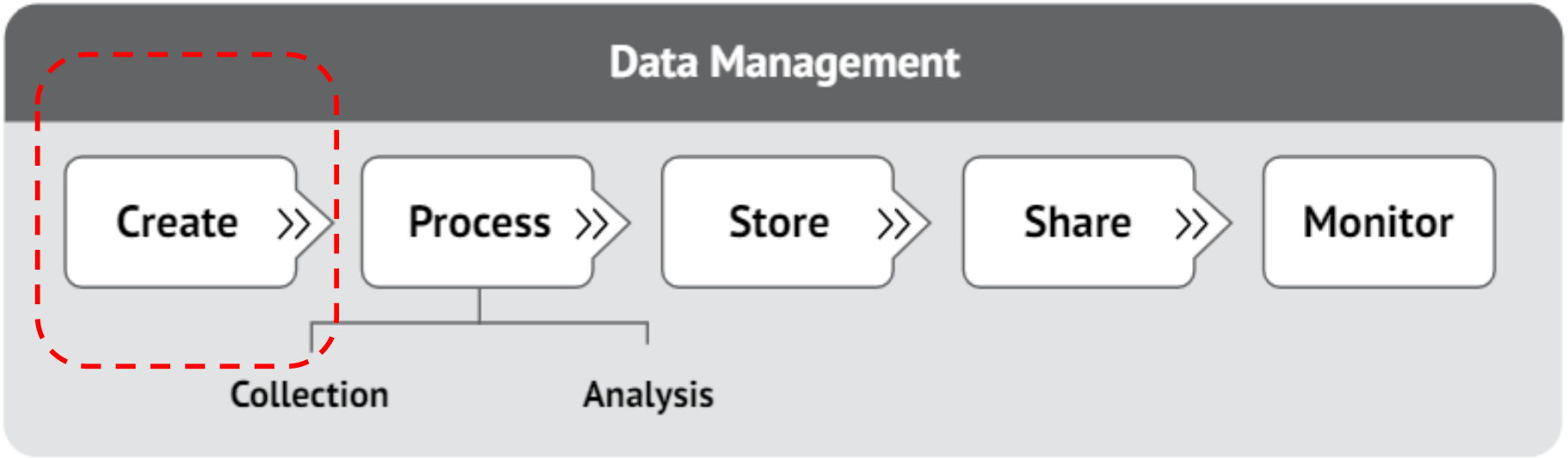
- There are also some feedback loops and overlaps among data management practices.
  - For example, processing data can sometimes create new data.

- Some technologies can also combine more than one data management activity, e.g., certain equipment can create, process, and store data simultaneously.

۳. تولید داده

Data Creation

Data Management Flow: Create



Creating data

- Many processes create data

  during design, on jobsites during construction, and throughout a structure's operational lifespan.

- Both electronic technology and human stakeholders can create data on a project or program.
- The CM should generally **understand** the **tools available** to create data and advise the owner.

What are examples of technology that create data?

What are examples of technology that create data?

Data Created by Sensors

Data Created by Equipment / Applications

Data Created by Stakeholders

Sometimes Data Creation can be empowered by other technologies and devices, like Robots, and Drones.

Cameras

- Static and 360-degree cameras can provide **photographs** and **video**

  with **real-time** status information

  from the jobsite and

  after the structure enters operation.

- Static cameras can focus on **specific locations** or **objects**.

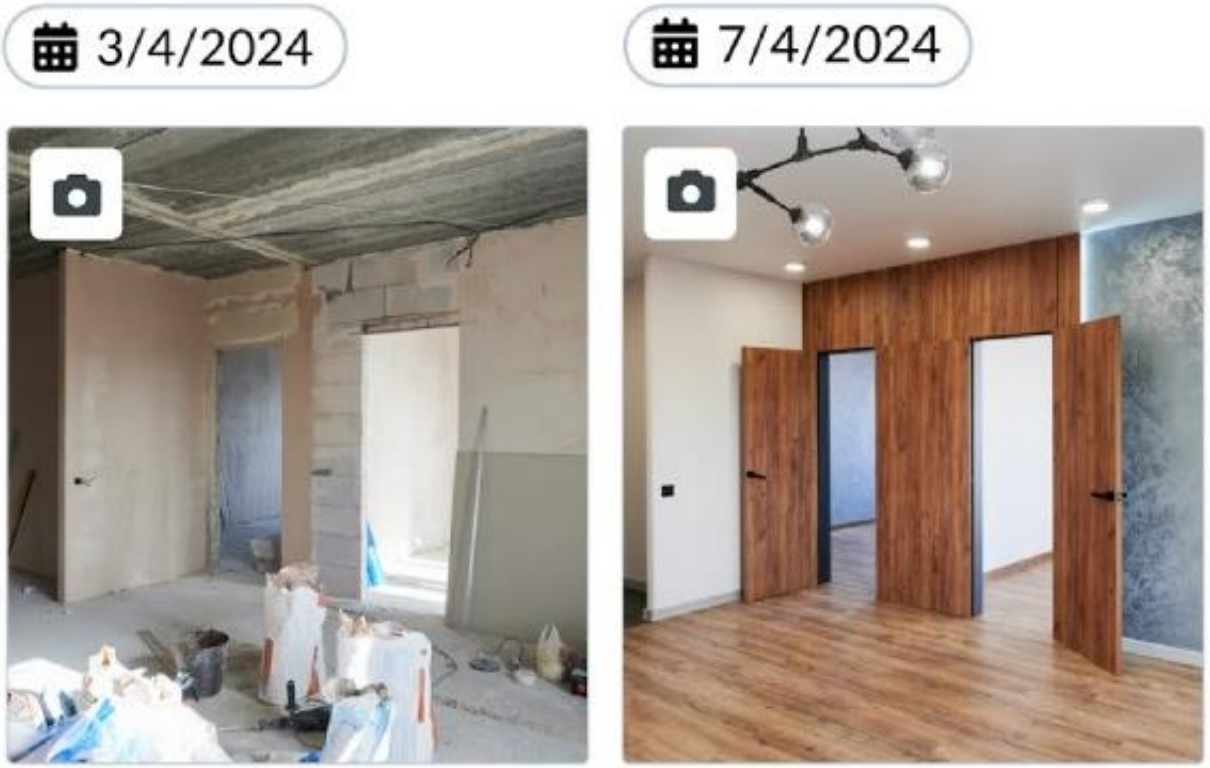
360-degree cameras

- They are small, lightweight, and portable devices
- Equipped with multiple lenses that capture a complete 360-degree view of the surroundings:

1. Take **multiple** overlapping images and
2. **Digitally stitch** them together to create a full panoramic view.

Benefits of 360-cameras

- Keeping track of how much work has been done
- Monitoring progress in real time
- Verifying the work (to some degree) if being done according to specifications.
- Virtual Reality tours can improve communications



From their 360-degree video footage,

Point Clouds and Digital Twins can be created.

We'll talk about Point Could and Digital Twin in this section

Ricoh Theta X 360 Camera

- Retail Price: $ 1199.0
- Features:
  - Image Stabilization, Real-Time Stitching, Built-In GPS
  - 2.25″ Touchscreen for Preview & Control
  - 360° 5760×2880 5.7K30 Video
  - 360° Live Streaming in 4K30
  - Up to 60MP JPEG Photos
  - Bluetooth & MIMO, 46GB Internal Memory
  - Client Mode, 3rd Party App Development

360-Camera in construction

Strength

- Affordable hardware pricing
  - In range of $ 1k to $ 2k
- Easy to Use
  - Without any complicated instructions
- Remote virtual visits like Google Maps
- Good visual support for progress tracking

Weakness

- No real-life measurements and volumes
  - Correct measurement needs supplementary data and calculations
- Limited and subjective work inspections
  - Resulted by measurement inaccuracies
- No direct support for engineering or updating BIM
  - Needs other software services for BIM integration

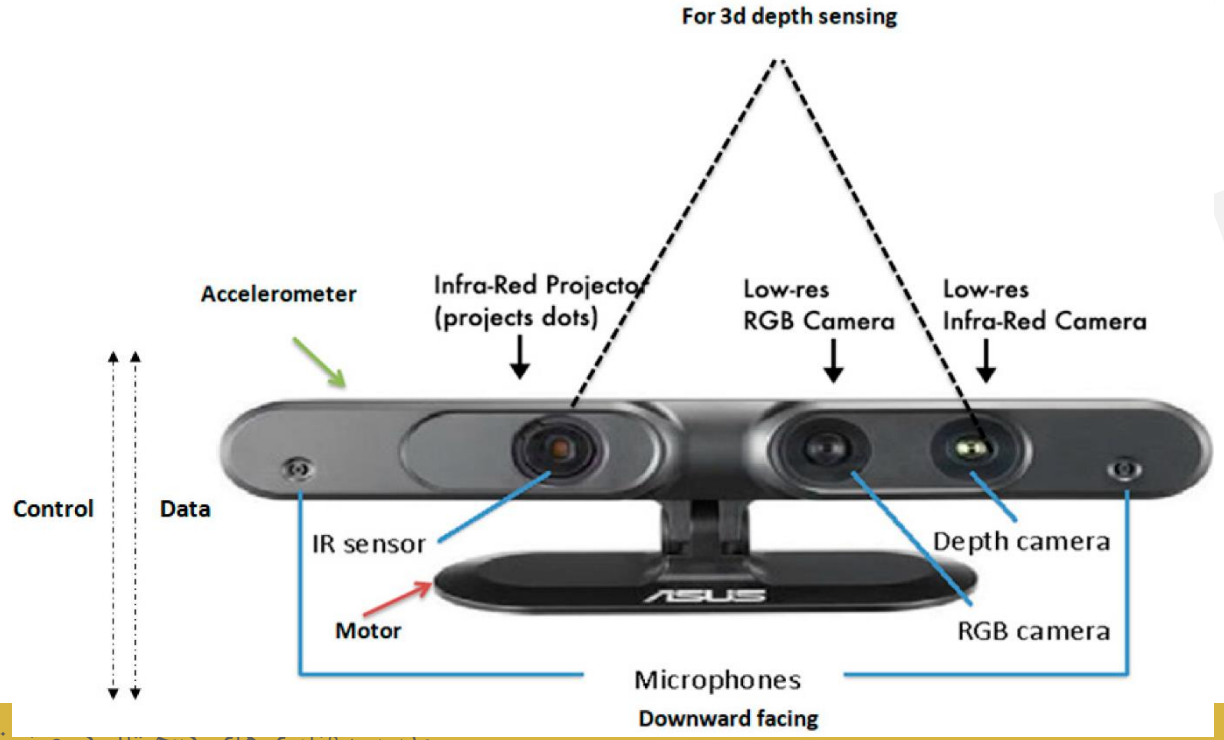
Measurement inaccuracy in 360-camera

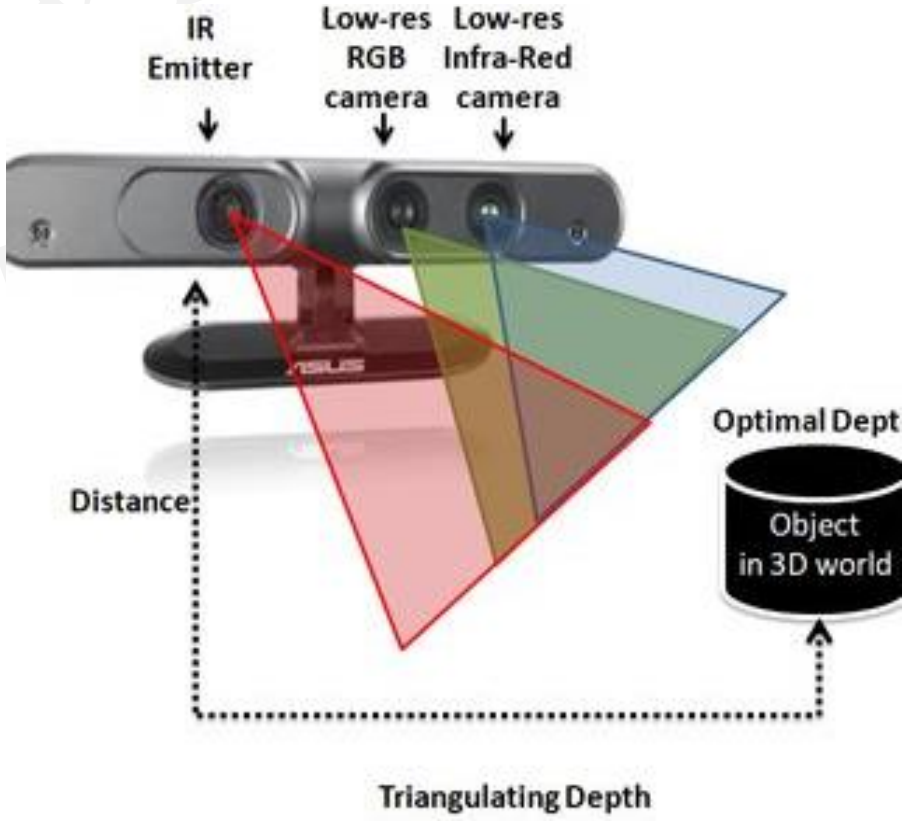
- They only capture flat images for virtual site visits, lacking real-life measurements or volumes.
- This leaves severe issues hidden until it's too late.

- In the picture: compare the distance between the two circles
- Needs other complementary data

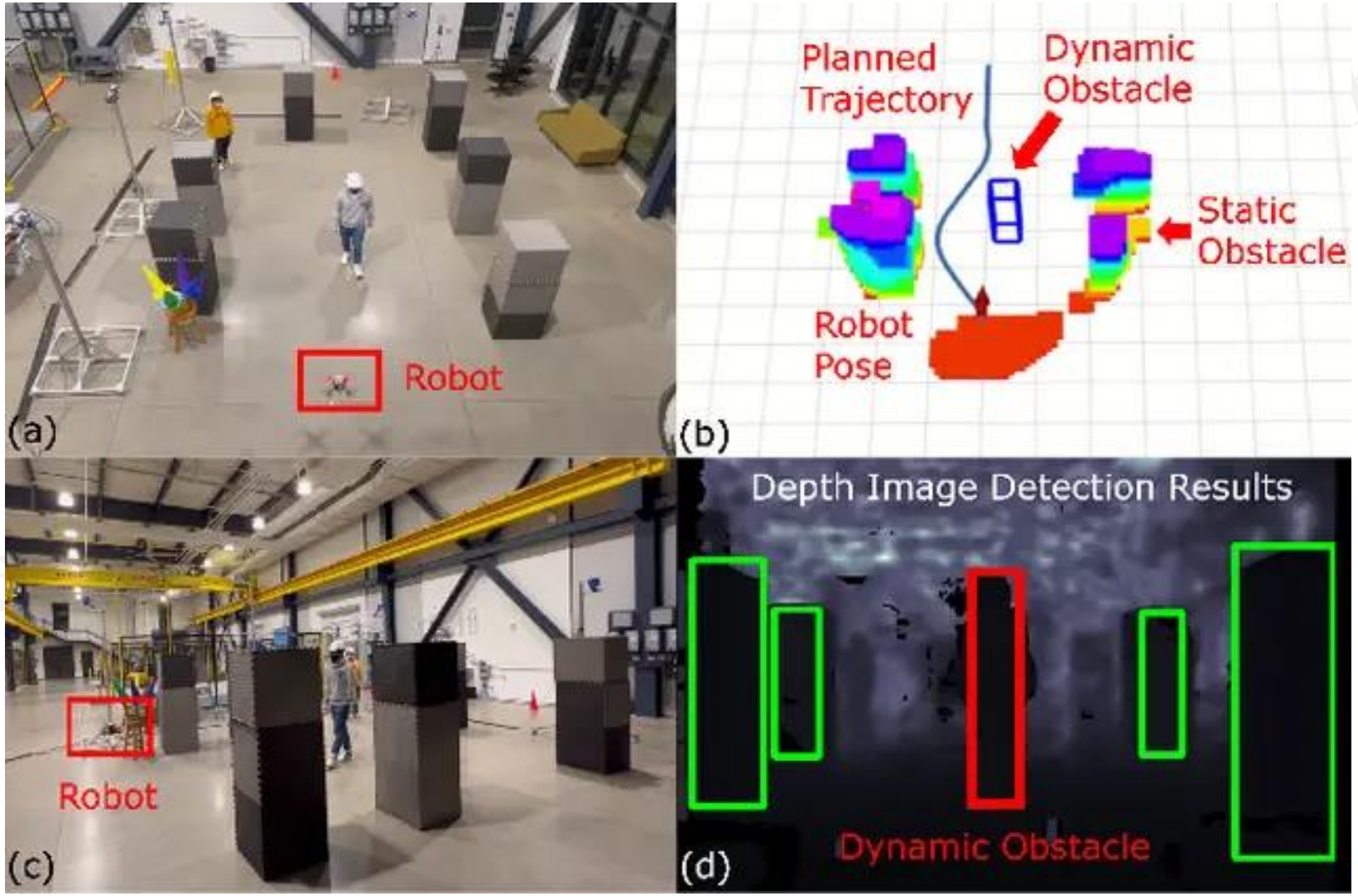
RGB-D Camera

- Used in 3D Technologies with it's depth sensing ability
- Used heavily in autonomous mobile robots, automated guided vehicles (AGV), people counting systems, and object detection.



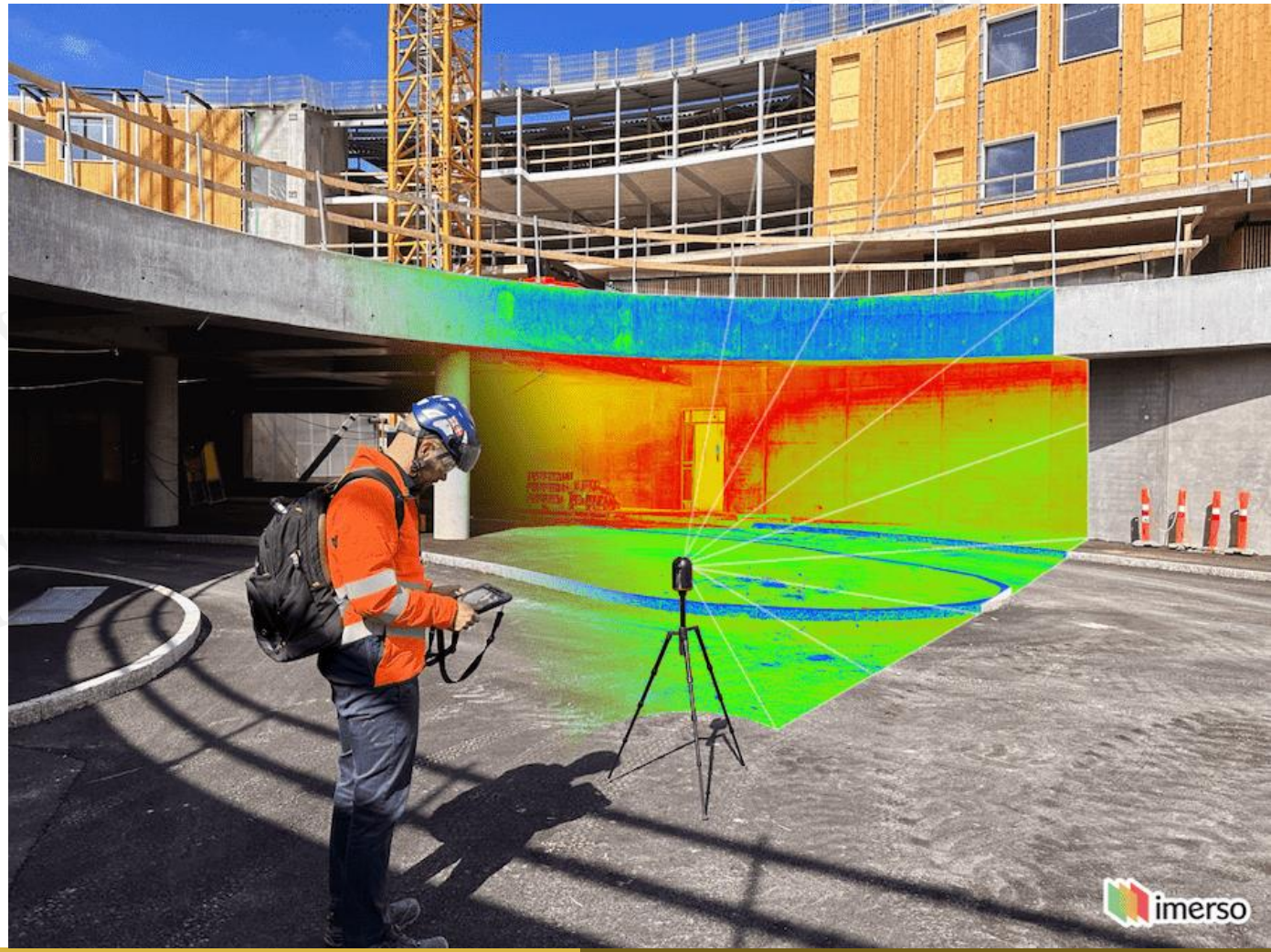


RGB-D Camera


Robot
(a)
Planned
Trajectory
Dynamic
Obstacle
Static
Obstacle
Robot
Pose
(b)
Robot
(c)
Depth Image Detection Results
Dynamic Obstacle
(d)

3D Laser Scanning

- Also called “LiDAR” and “LADAR”
- a Reality Capture technology that create a virtual representation of the jobsite
- can document construction sites in real 3D with millions of measurements in seconds, with millimeter precision.



3D laser Usage Examples – Design Phase

- captures existing properties during the planning phase
- allows loading the existing onsite conditions into popular CAD softwares
- accelerates modelling and planning work
- eliminates risk of wrong measurements and lack of context
    - Renovation and refurbishment projects can benefit tremendously from it

3D laser Usage Examples – Construction Phase

- Survey the current As-Built status at the site
- As-Built data can be used in preparation for work packages demanding precise tolerances and measurements
    - It is especially useful while using offsite construction and prefabricated elements, which are built to fixed specifications.

3D Laser Scaners in construction

Strength

- Real-life measurements and volumes
- Faster data capturing
- Faster inspections through automation
- Fewer blind spots and hidden issues
- Direct connection to BIM
- Scanners also capture 360 Images

Weakness

- High upfront investment
- Require some user learning
- Harder to analyze and share scans
- Require preparing the site in advance

  Neets setting up target markers for some devices

- Scan data is heavier than 360 photos.

Matterport Pro3

- Price $ 7000
- Depth Technology: LIDAR
- Field of View: 360° Horizontally, 295 ° Vertically
- Accuracy: +/- 20mm @10m
- Depth Resolution: 100k points per second, 1.5M points per scan
- Capture Speed: <20 seconds per scan

Cameras can also help **drones** navigate jobsite environments or areas of a facility

Drones

- Ground or aerial **drones** allow teams to

  perform remote and sometimes automated site **surveys** and **inspections**.

- An aerial drone is also called an uncrewed aerial vehicle or UAV.

- Most drones in the marketplace can **record data** about their environment.

How can they help in Construction?

ABOUT DRONE LAUNCH ACADEMY

- Founded in 2016 while I was working at FBI as a Forensic Accountant

Drones – Use cases: how can drones help? (1/4)

1. Marketing and stakeholder updates

Communicating Site Progress

- Keep stakeholders and clients up to date on a project's status
- Share collaborative maps and models with your team for better project management
- Connect the job site to the back office

DroneDeploy

Drones – Use cases: how can drones help? (2/4)

2. Dispute resolution
   - Examples:
   - Roofing materials

     (Source: Drone to $1K podcast)

Did you know that the average construction dispute costs around $19M and usually takes 17 months to settle?

Source: PropellerAero.com

- GBI: "Another way that GBI has benefitted in cost savings was through disputes with their clients over work completed. For example, there was a disagreement with an owner over the amount of pavement that GBI had completed over a twelve-mile stretch of roadway. A drone flight was conducted and GBI was able to use the calculations from the drone to confirm the amount of pavement that was used. This resulted in the gain of tens of thousands of dollars from the owner."

Source: "A Case Study on the Use of Drones on Heavy Civil Construction Projects" (Devers)

Drones – Use cases: how can drones help? (3/4)

3. Avoid re-work

Quality Control

On another job site, Brasfield & Gorrie used project design plan overlays with their CAD drawings to verify work done on a handicap-accessible ramp. Only 10-12 hours before the concrete pour, they discovered that as-designed was different than as-built, saving a potential **$10,000-plus in rework costs**.

Source: DroneDeploy.com

Drones – Use cases: how can drones help? (4/4)

4. Saving time on site work

A field engineer will often shoot a site's elevation during construction and compare progress to the final design drawing. On a healthcare project in Apopka, Florida, Brasfield & Gorrie piloted using DroneDeploy mapping to produce a Digital Elevation Model observed a **75% reduction in time required for this task.** Additionally, after this information is uploaded and processed by DroneDeploy, it allows the user to see the existing grade compared against the final grade—an objective, guaranteed assurance.

Source: DroneDeploy.com

Drones – Software tools

- Tip: popular software tools for drones in construction
  - Dronedeploy.com
  - Propeller (PropellerAero.com)
  - Pix4D.com

Drones – How to fly a drone legally in the USA (1/2)

- The old way…
  - Pilot's License
  - Section 333 Exemption

- The New way…
  - Get your Remote Pilot Certificate
  - FAA Part 107 Exam

Drones – How to fly a drone legally in the USA (2/2)

- **About the FAA exam/pilot eligibility**
  - Have to be 16 years or older
  - Read, write, and speak English
  - 60 questions, multiple choice
  - Passing score = 70%
  - Administered in testing center
  - Valid for 24 months

UAS Topics	Percentage of Items on Test
I. Regulations	15 – 25%
II. Airspace & Requirements	8 – 15%
III. Weather	11 – 16%
IV. Loading and Performance	7 – 11%
V. Operations	13 – 18%
Total Number of Questions	**60**

Note:

Practical experience and feedback tells us that this exam is MUCH more heavily weighed on Airspace topics than what is shown above.

Drones – Operating limitations

- Main limitations to be aware of:
  - Max altitude 400 ft
  - Maintain line of sight
  - Visibility of 3 miles (weather)
  - Daylight operations only
  - Cannot fly over people

SUMMARY OF SMALL UNMANNED AIRCRAFT RULE (PART 107)

Operational Limitations	• Unmanned aircraft must weigh less than 55 lbs. (25 kg). • Visual line-of-sight (VLOS) only; the unmanned aircraft must remain within VLOS of the remote pilot in command and the person manipulating the flight controls of the small UAS. Alternatively, the unmanned aircraft must remain within VLOS of the visual observer. • At all times the small unmanned aircraft must remain close enough to the remote pilot in command and the person manipulating the flight controls of the small UAS for those people to be capable of seeing the aircraft with vision unaided by any device other than corrective lenses. • Small unmanned aircraft may not operate over any persons not directly participating in the operation, not under a covered structure, and not inside a covered stationary vehicle. • Daylight-only operations, or civil twilight (30 minutes before official sunrise to 30 minutes after official sunset, local time) with appropriate anti-collision lighting. • Must yield right of way to other aircraft. • May use visual observer (VO) but not required. • First-person view camera cannot satisfy "see-and-avoid" requirement but can be used as long as requirement is satisfied in other ways. • Maximum groundspeed of 100 mph (87 knots). • Maximum altitude of 400 feet above ground level (AGL) or, if higher than 400 feet AGL, remain within 400 feet of a structure. • Minimum weather visibility of 3 miles from control station. • Operations in Class B, C, D and E airspace are allowed with the required ATC permission. • Operations in Class G airspace are allowed without ATC permission. • No person may act as a remote pilot in command or VO for more than one unmanned aircraft operation at one time. • No operations from a moving aircraft. • No operations from a moving vehicle unless the operation is over a sparsely populated area. • No careless or reckless operations. • No carriage of hazardous materials.

Source: FAA.gov

Drones – Next steps

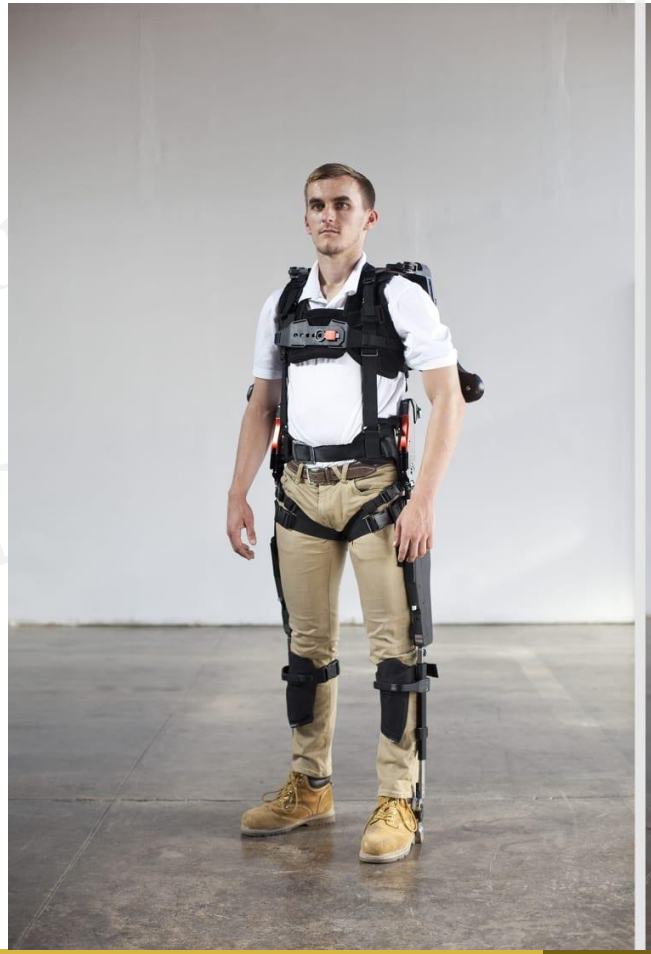
- Conversations with internal team on if utilizing drones makes sense for your projects
- Internal team vs. outsource
- Have team members pass their FAA exam

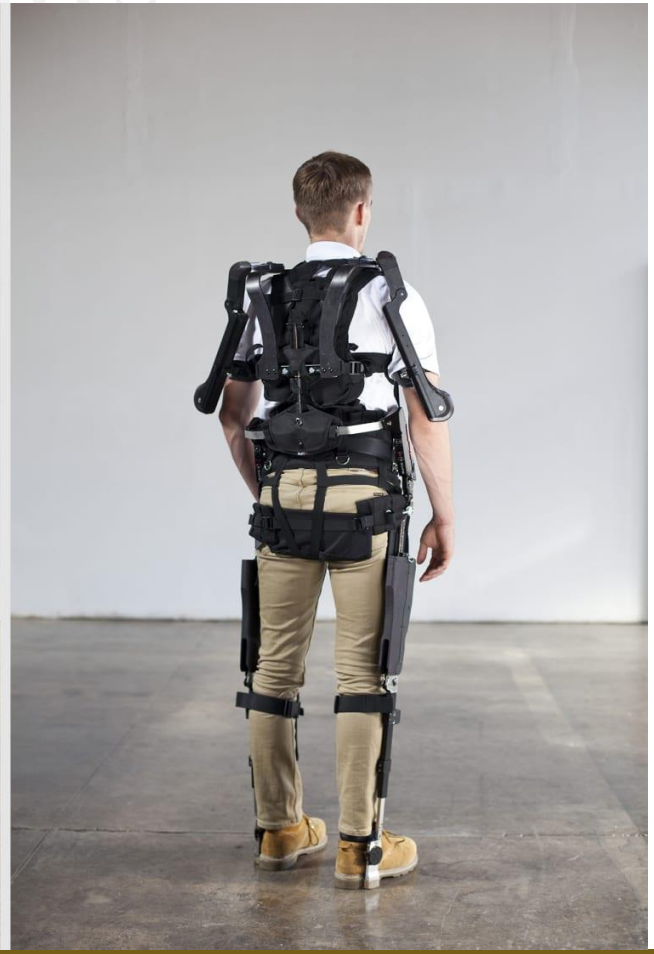
Exoskeletons

- An **exoskeleton** is a robotic suit or frame

  that a **human** can "wear" to perform

  1. Repetitive,
  2. Dangerous, or
  3. Specialized tasks.





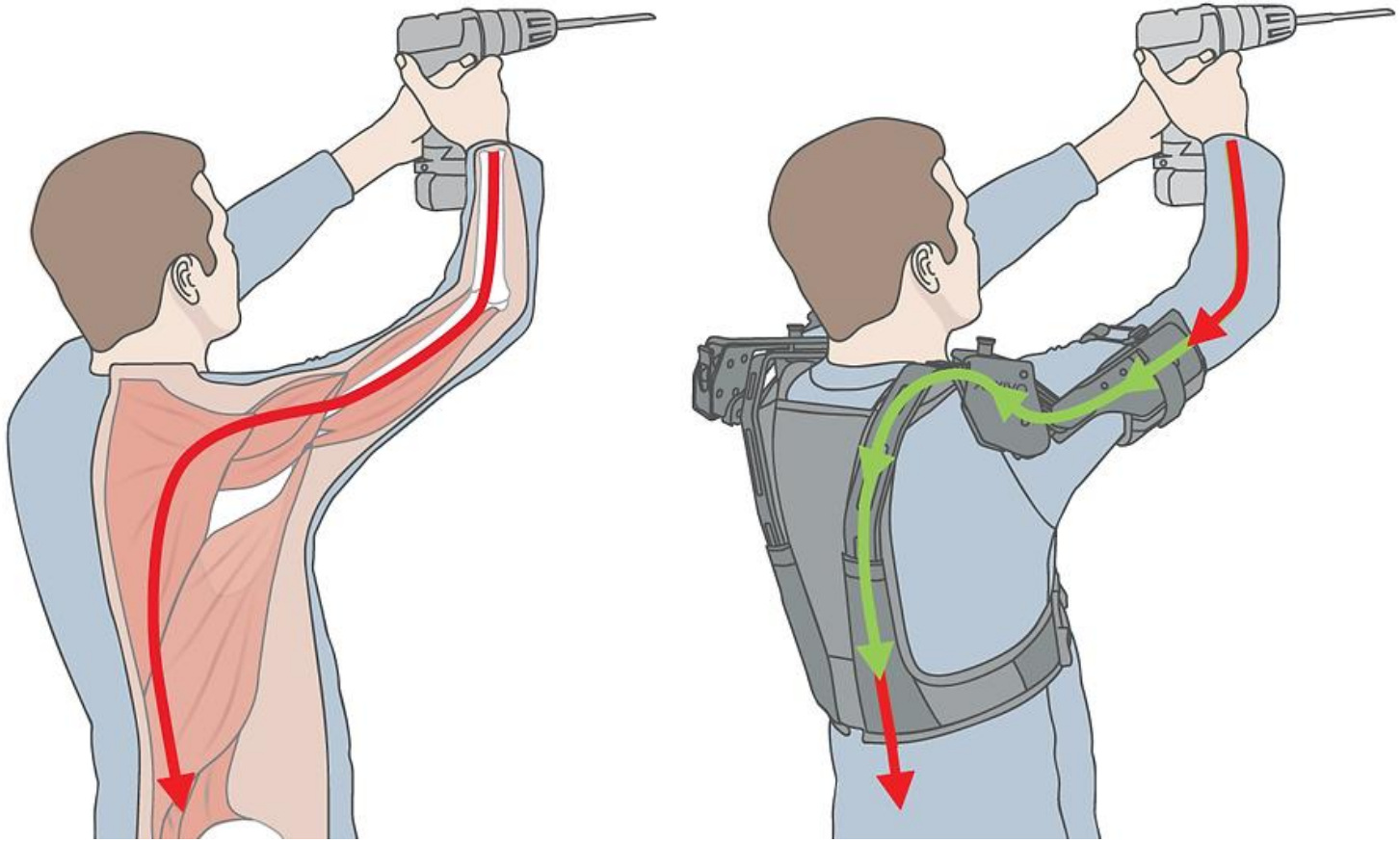
Exoskeletons

- Many **exoskeletons** can **create data** about
  - Their work,
  - Their system status (e.G., Battery level, etc.),
  - Their human operators,

    such as craft laborers on the jobsite or maintenance workers

Exoskeletons

- Can help lessen the burden on body
- Can help correct the worker posture

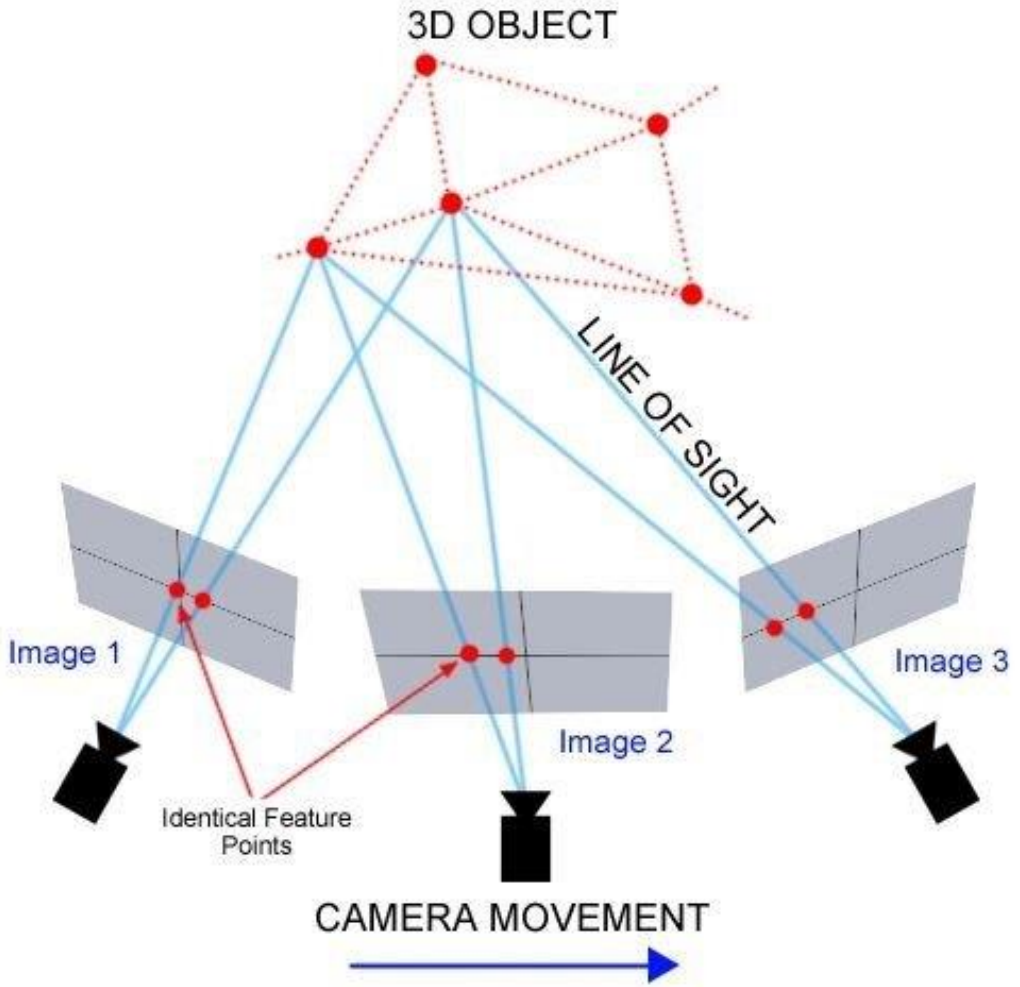


Photogrammetry

- Photogrammetry literally means the act of deriving precise measurements from photographs
- Photogrammetry is a process that
  1. **Uses overlapping photographs** of an object or area and
  2. **Converts** them into **2D or 3D** models.

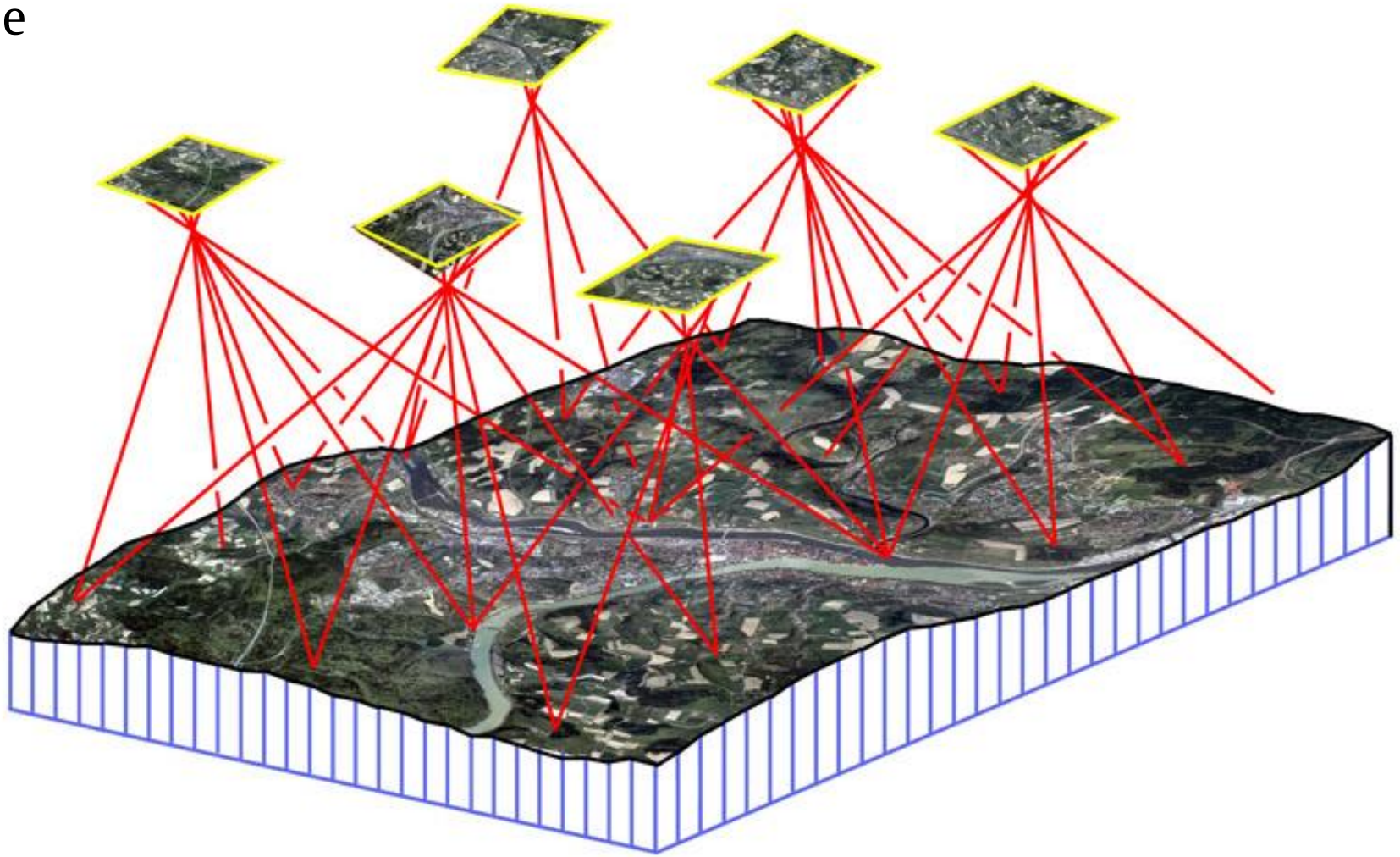
Photogrammetry

- Constructing a 3D model from several 2D pictures

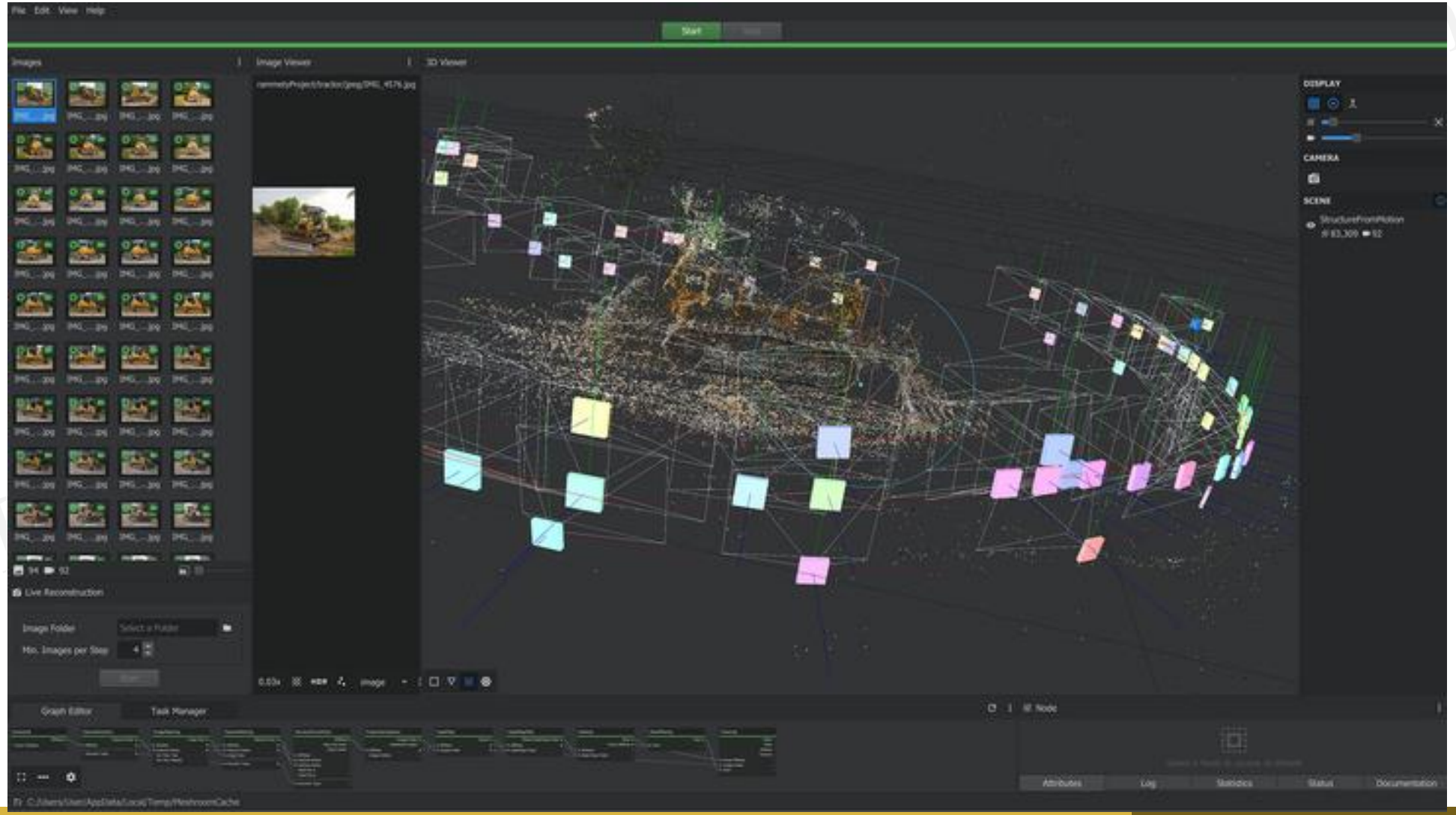


Photogrammetry

- Combining Aerial Landscape Photos into a 3D model



Software Examples: Artec 3D

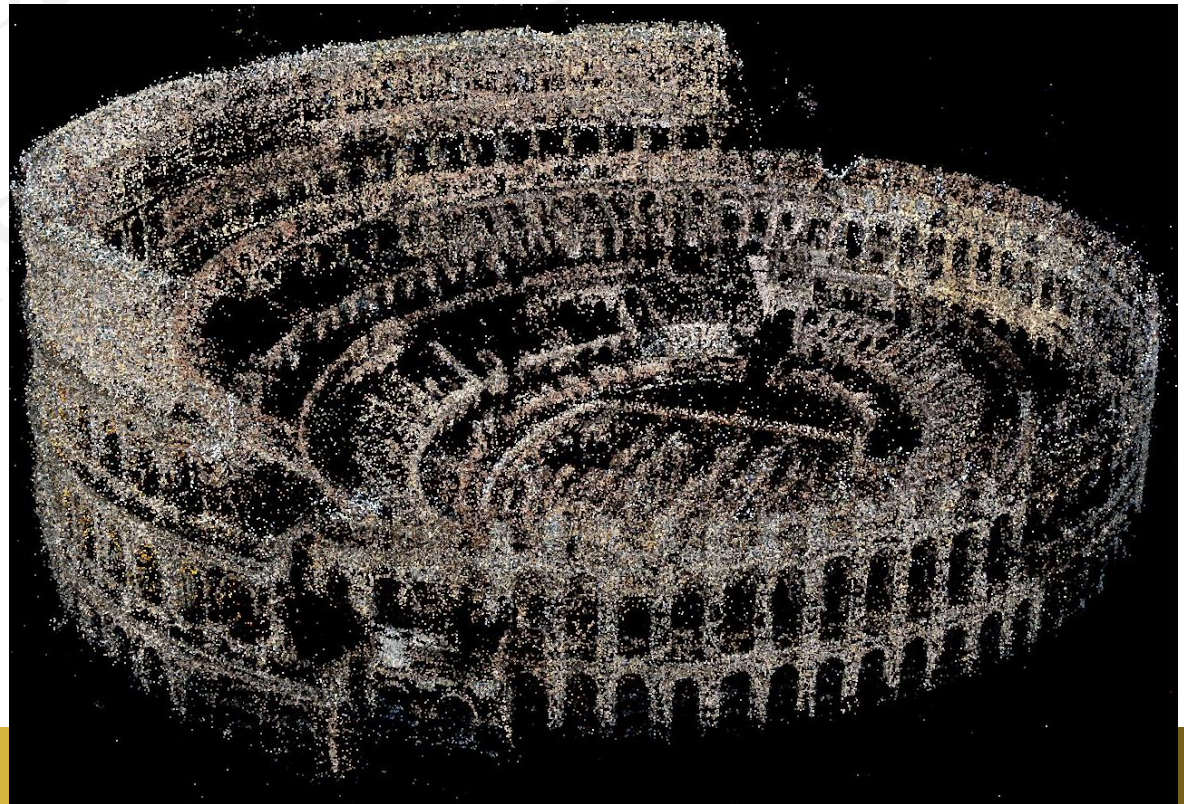


Point clouds

- In 3D modeling, a point cloud is a set of data points in a 3D coordinate system
- A point cloud uses multiple sensors located

  at different spatial points on an actual three-dimensional object

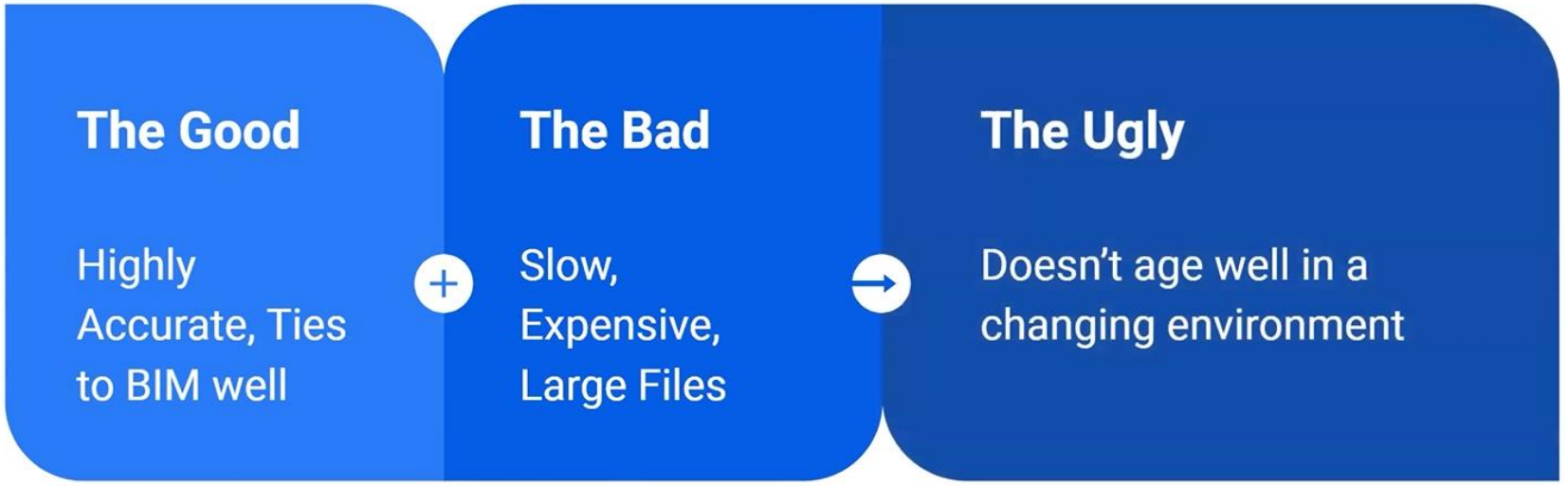
  to **create data** about that object.



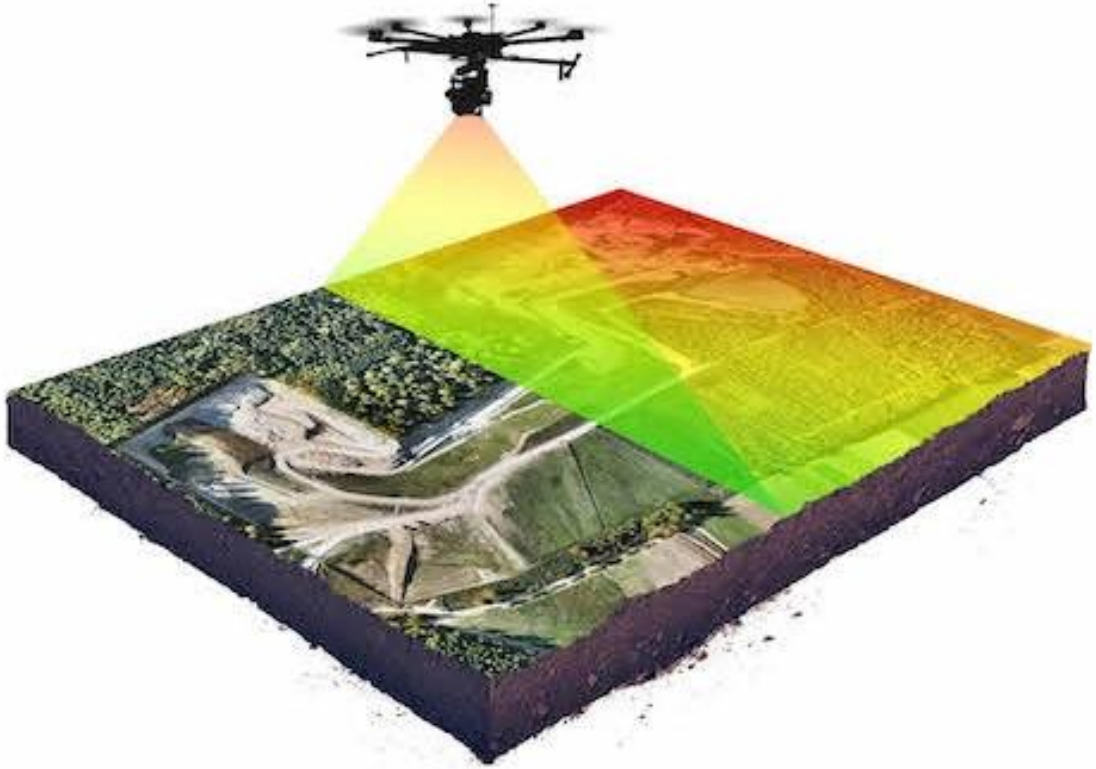
Point clouds – data creation

- Various sensors on an object in transit from a manufacturer or on a jobsite may record their location and status,

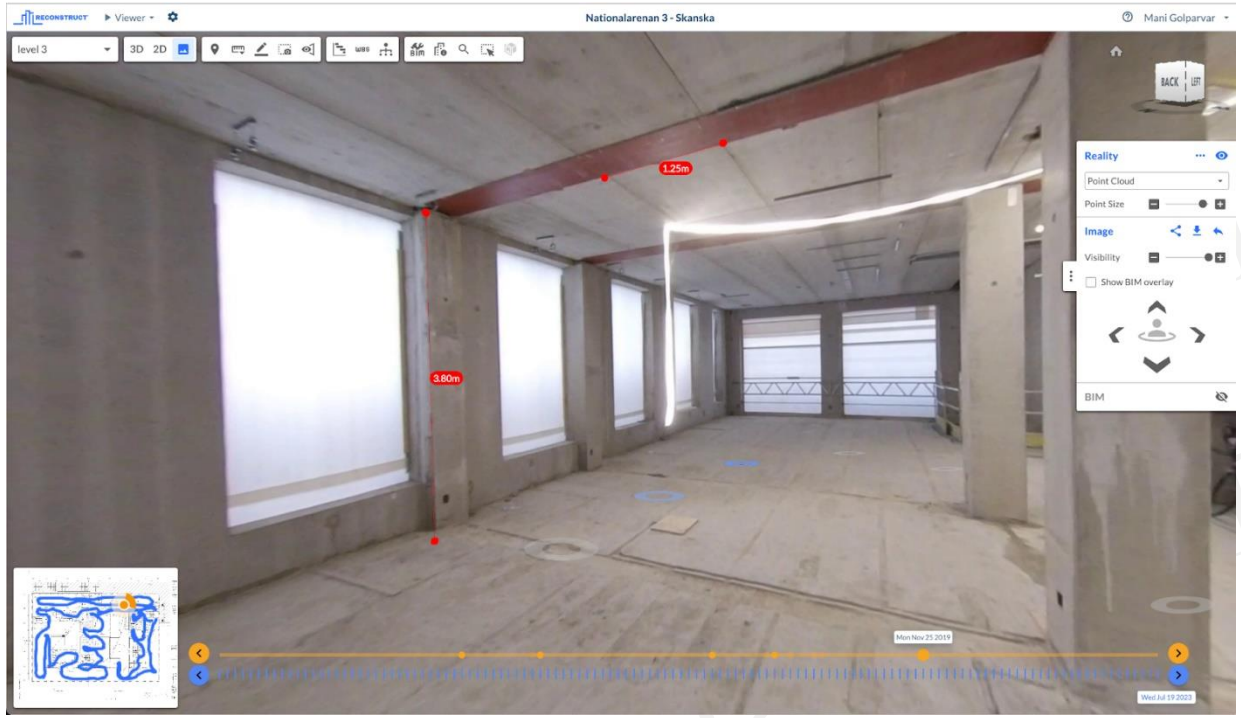
  such as an object's exact location (including the angle and its position relative to other things) as well as additional relevant information like the object's temperature, humidity, etc.



Difference between Photogrammetry and 3D Scanning



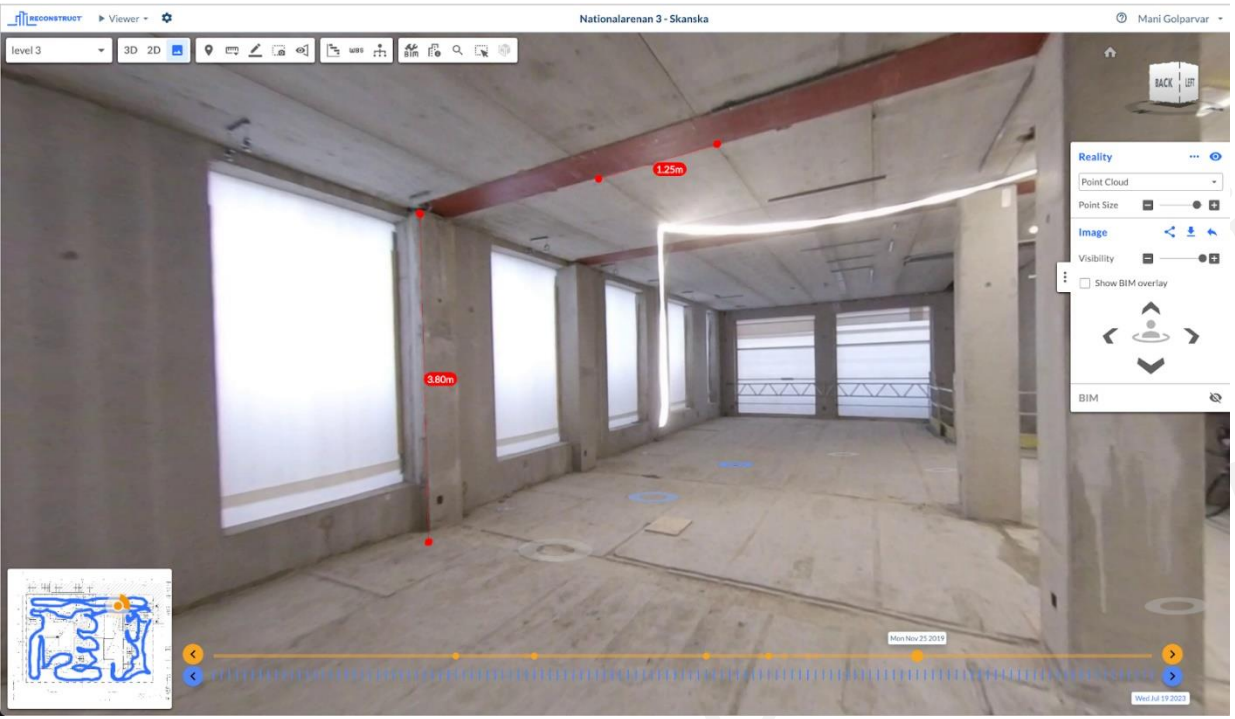
Creating Point Cloud from 360 video footage (1/3)



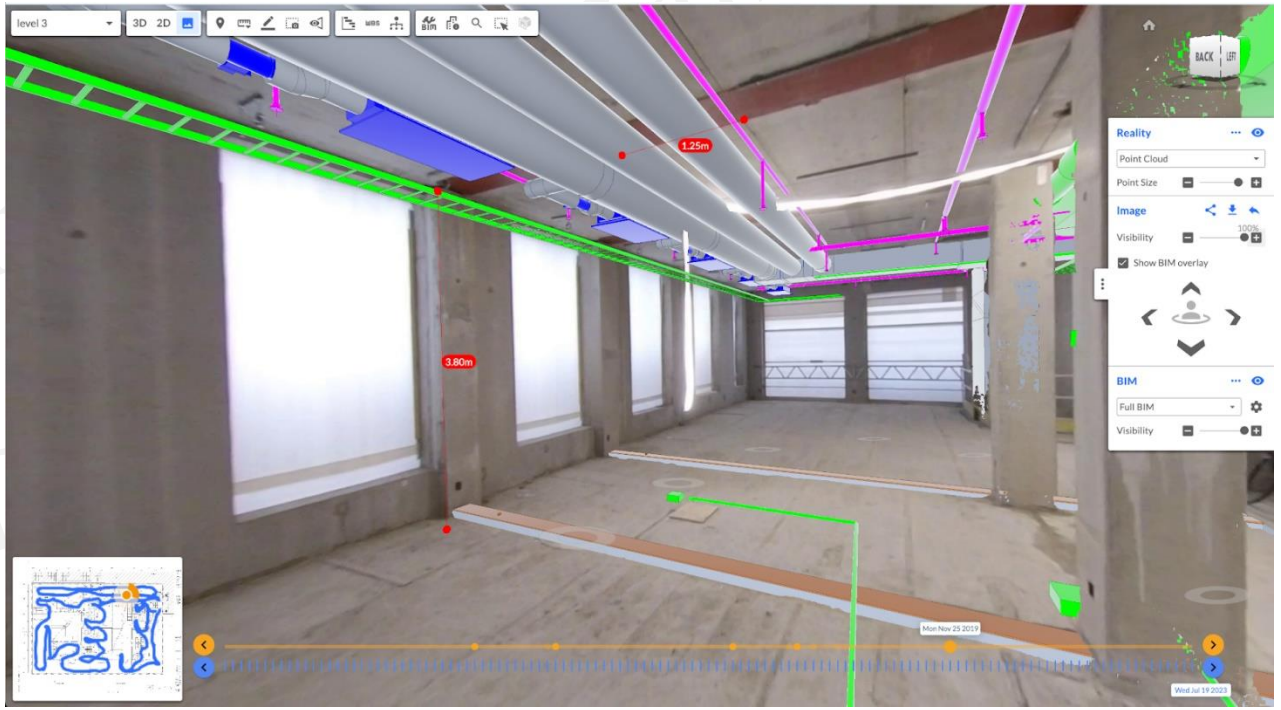
A) Measurable 360 Video Footage

B) Point Cloud view of the same 360 Footage

360 video footage, with BIM overlay (2/3)

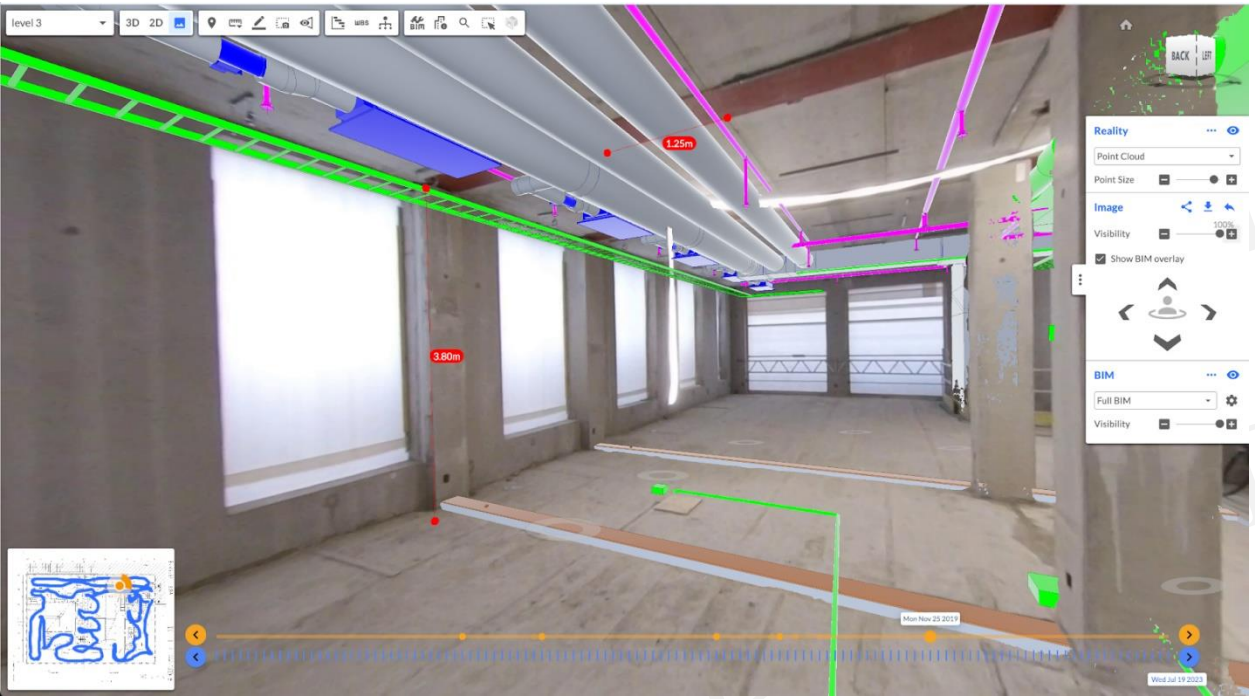


A) Measurable 360 Video Footage

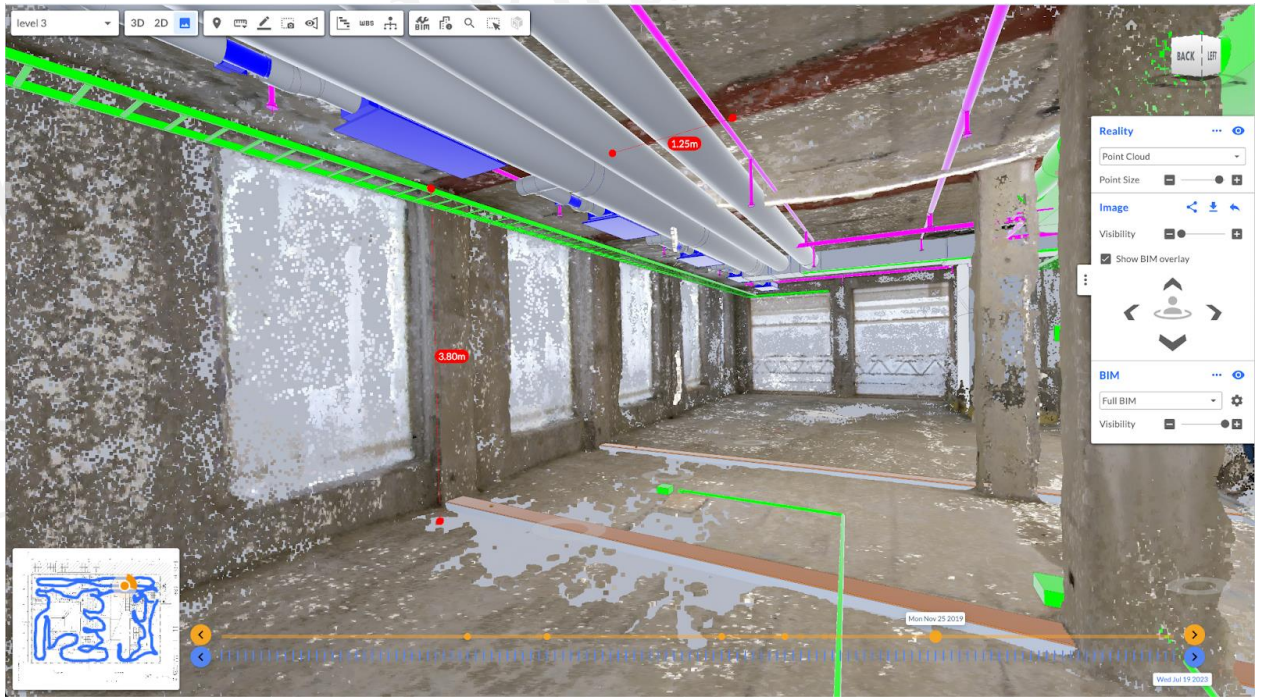


B) 360 Video Footage, Overlaid with BIM

Creating Point Cloud from 360 video footage, with BIM overlay (3/3)



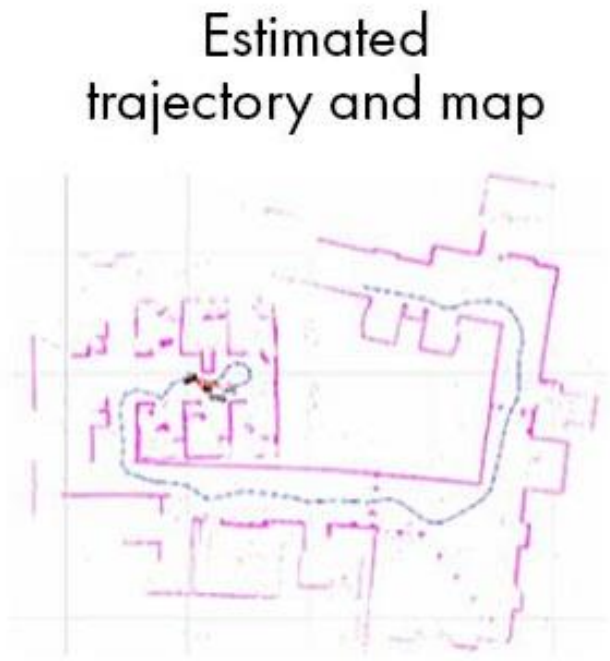
A) 360 Video Footage, Overlaid with BIM

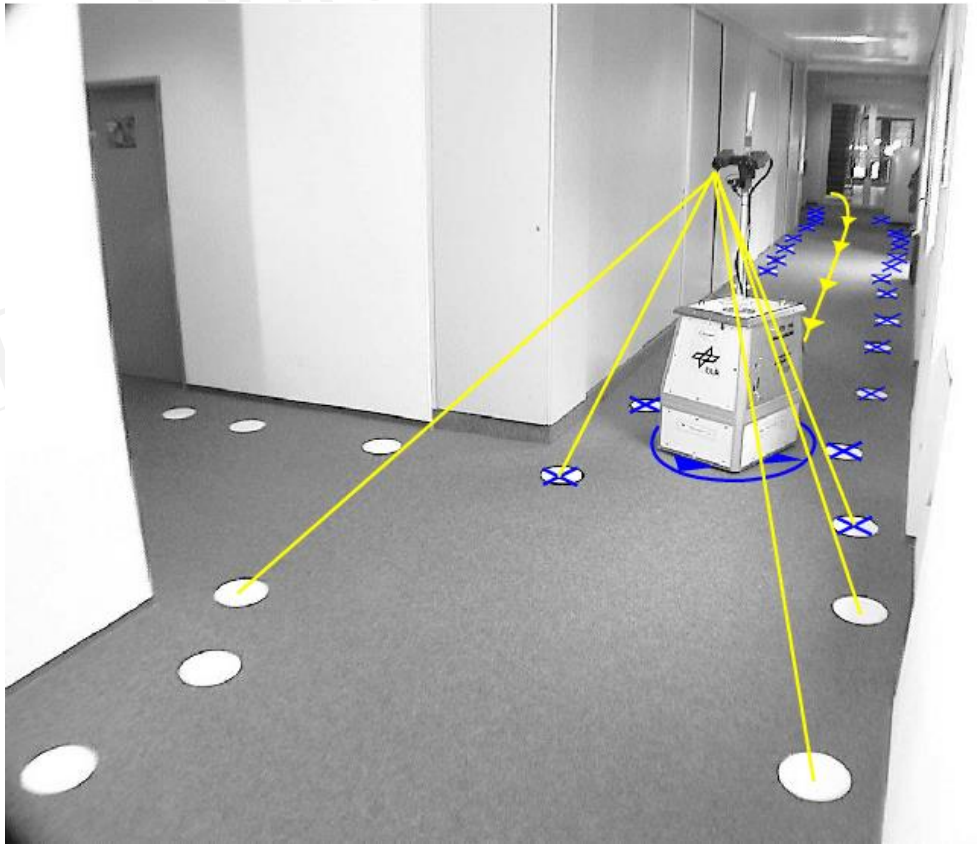


B) Point Cloud of the same Video Footage, Overlaid with BIM

Simultaneous localization and mapping (SLAM)

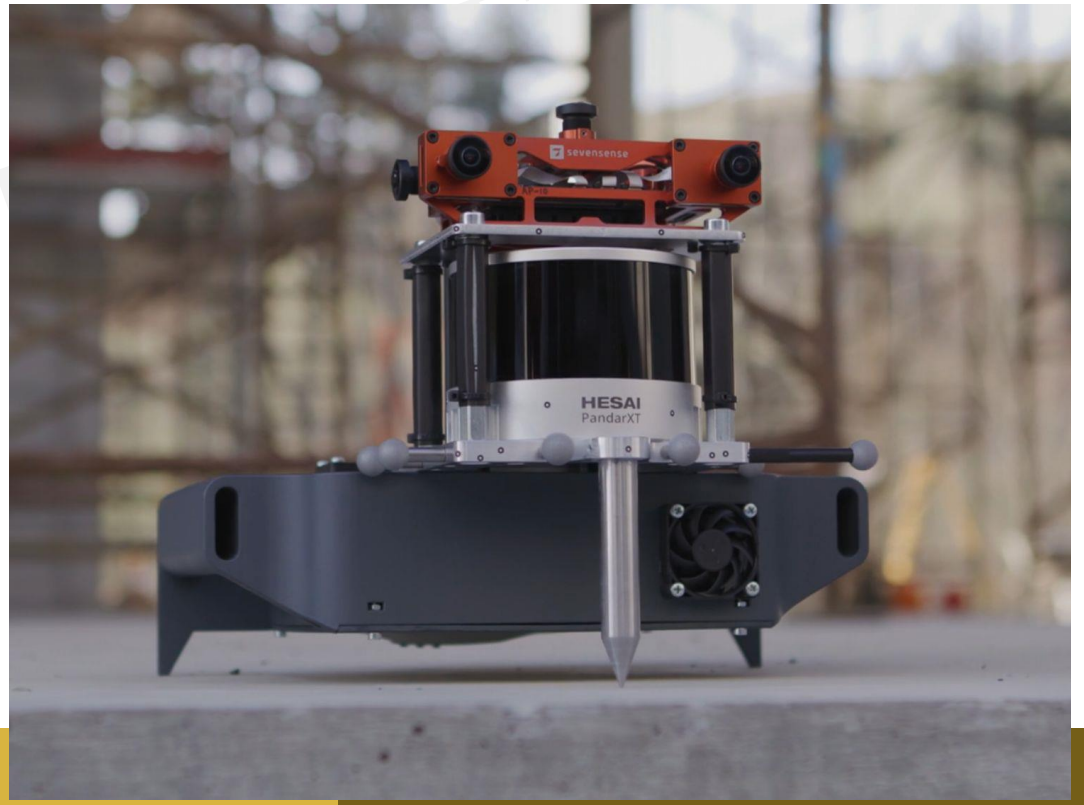
- a method used for autonomous vehicles that lets you build a map and localize your vehicle in that map at the same time





Simultaneous localization and mapping (SLAM)

- with vast improvements in computer processing speed and the availability of low-cost sensors such as cameras and laser range finders, SLAM algorithms are now used for practical applications in a growing number of fields.



Source: Handheld SLAM Suite
HILTI SLAM Challenge 2023

SLAM Usage

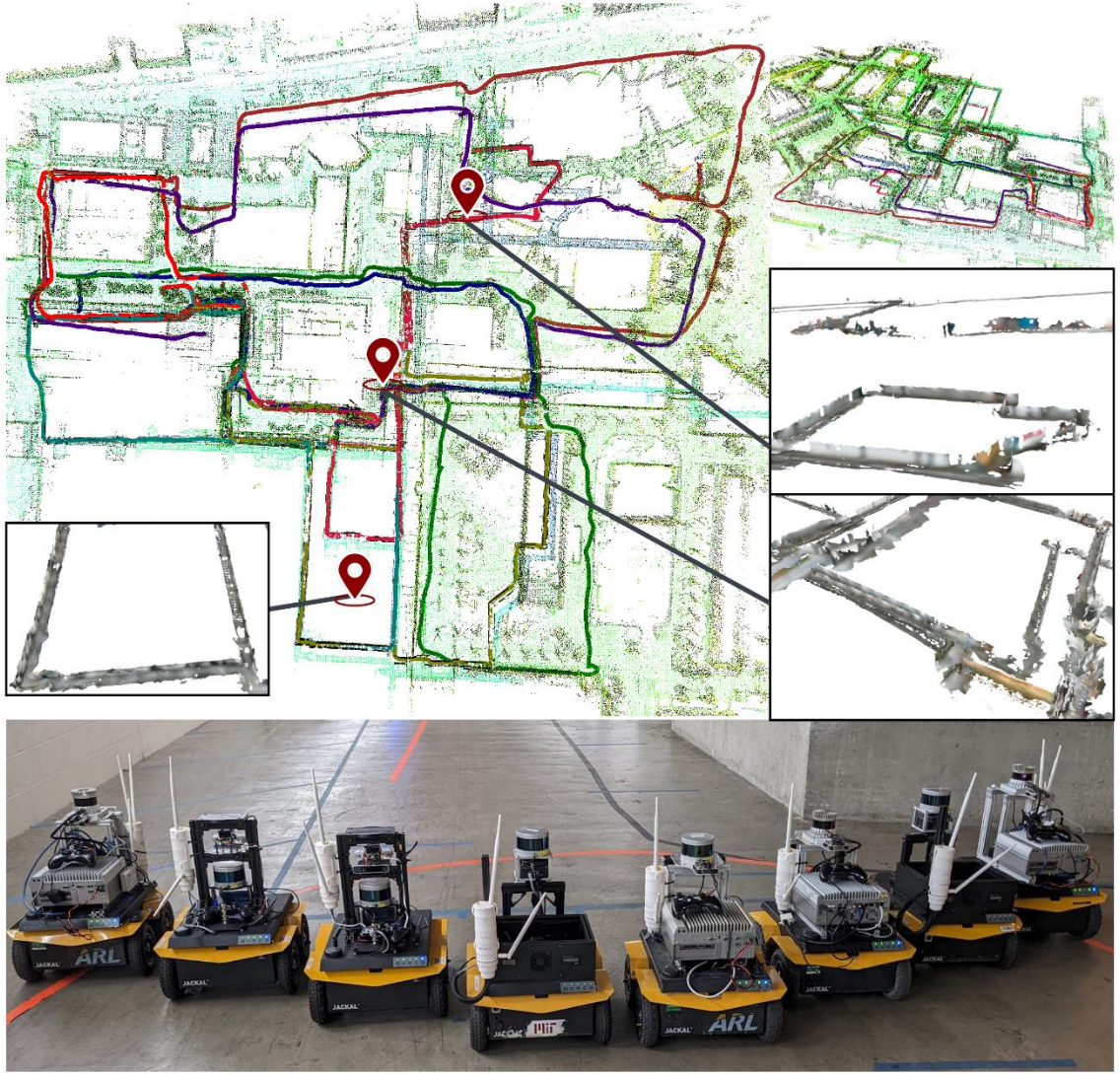
- SLAM can **make it easier** for a human to
  1. **Operate** a piece of equipment and
  2. **Help drones** perform some automated tasks.

Example:

Automate Robot inspecting inventory of a Warehouse automatedly for potential problems

SLAM Usage

- SLAM **helps** a **robot**
  1. **Identify** its location within an environment and
  2. **Create** a map of that environment.



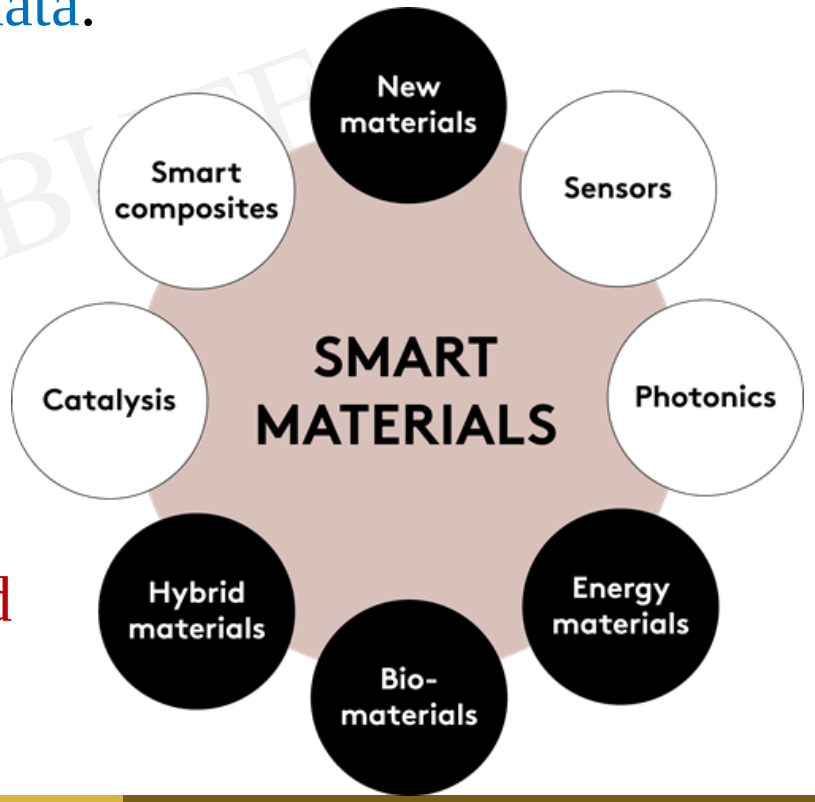
Smart equipment and materials

- Many **newer types** of construction equipment and materials have

  Built-in technology that

  can react to **changes** in their environment and **create** data.

- For Example,
  - window glass that can tint itself on sunny days;
  - highway concrete that can record automobile traffic;
  - building panels that can reduce vibrations or mute sound

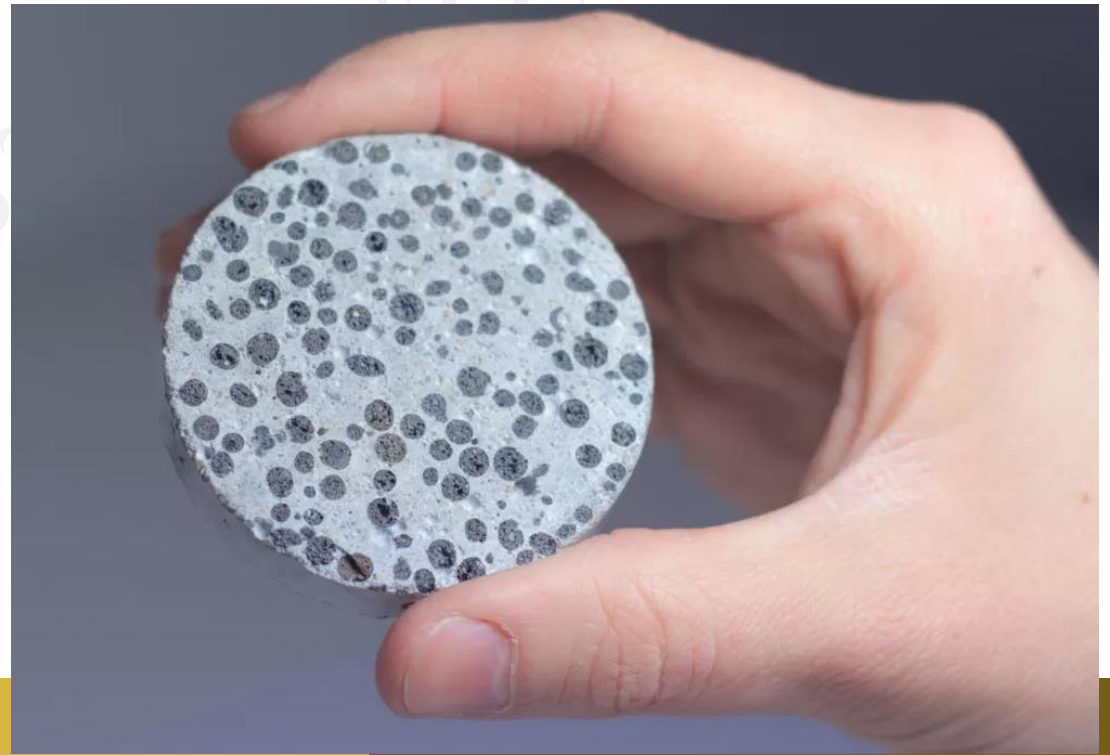


Smart Materials – Smart Glass

- also known as switchable or dynamic glass, is a type of glass that can alter its light transmission properties in response to external stimuli
- Can change color or opacity when an electrical voltage is applied
- Has applications like windows in buildings, automotive sunroofs, and display screens.
- used to enhance energy efficiency, provide privacy on demand, and improve user comfort.

Smart Materials – Bio-Concrete

- a type of concrete that incorporates certain biological or microbiological processes to enhance its properties
- One of the key features of bio-concrete is its ability to heal itself through the activity of bacteria or other microorganisms.
- The self-healing capability enhances the durability and longevity of structures, particularly in harsh environmental conditions



Smart Equipment

Location sensor

Fall risk area access(FRAA) sensor

Mobile CCTV

Hazardous gas detector

Heavy equipment access(HEA) sensor

Structure displacement Sensor

Integrated control system

Wearable sensors

- A human or object can wear a portable wireless sensor that creates **real-time data** about that person/object.
  - For example, embedded sensors in personal protective equipment can track a worker's location and safety/health information, like fatigue.

- The integration of wearable technology into standard safety equipment like hard hats, boots, and goggles is revolutionizing construction site safety

Common Wearable Sensors for Workers in Construction

1. Helmet
2. Exoskeletons
3. Smart Glasses
4. Body Wear
5. Smart Shoes
6. Clip-Ons
7. Biometric Wearables
8. Smart vests
9. Wearable Cameras
10. Smart Watch

Smart Shoes

- Can revolutionize construction worker **safety**
- Some innovative features:
  - Pressure-sensitive sensors that can detect falls
  - Advanced location tracking technology
  - Built-in charging mechanism, using power generated from walking

As wearable technology continues to advance,

it is set to become an integral part of the future landscape of construction site safety, offering more sophisticated solutions for reducing injuries and improving overall well-being

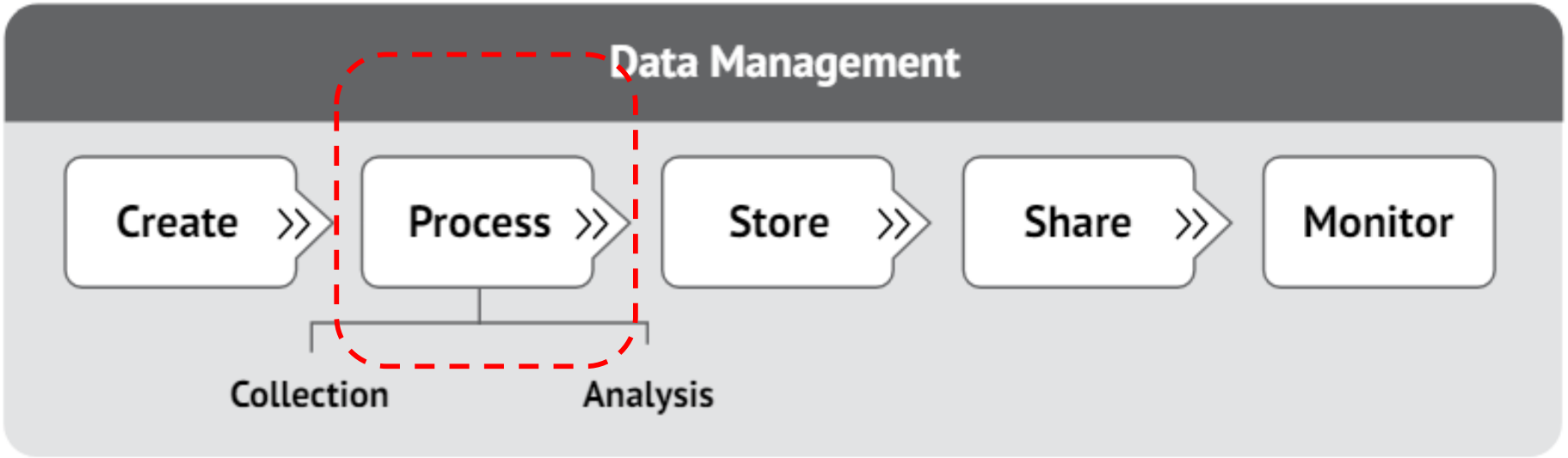
Humans

- The CM must remember that **humans also create data** to enhance delivery.
- Human methods to create data include (but are not limited to):
  1. Design reviews;
  2. Project/program controls (scheduling, earned value management analysis, risk registers, etc.);
  3. Production planning feedback from the team;
  4. Site observation reports (written daily reports, inspections, commissioning reports, quality audits, etc.); and
  5. Communications with other stakeholders.

۴. پردازش داده

Data Processing

Data Management Flow: Processing



Data processing

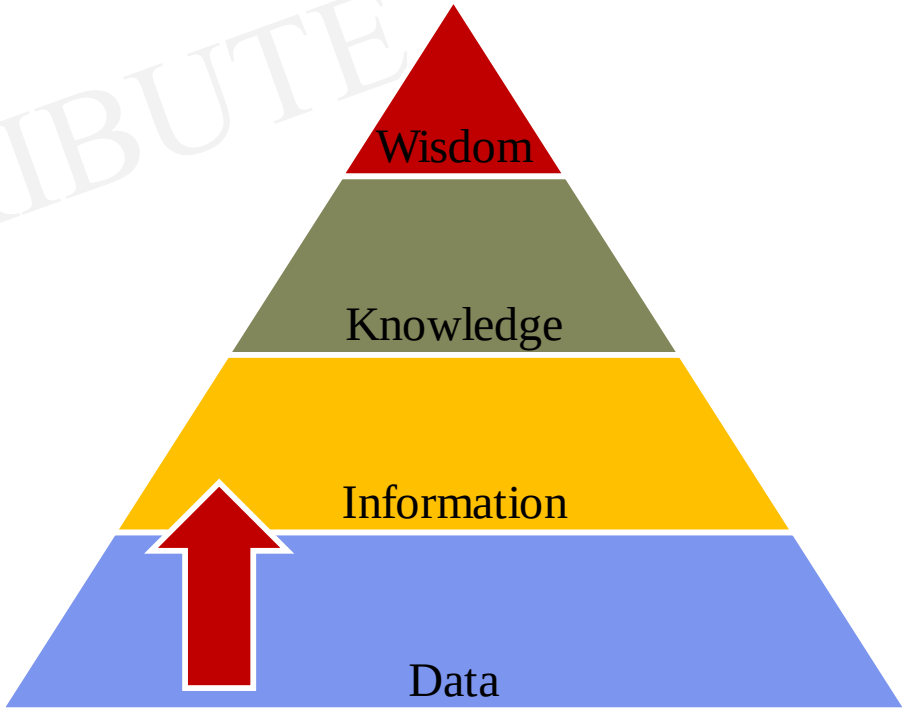
- Data processing is **collecting** and **analyzing** data

  to produce useful information

  that will help the team make decisions

  that

  1. **Enhance** performance,
  2. **Simplify** tasks,
  3. **Increase** efficiency.



Data processing

- Good data management depends on capturing and evaluating

  accurate, consistent, and properly-formatted data.

- The CM must
  - **Supervise** data processing efforts and
  - **Encourage** the owner to consider data processing tools an investment, not a cost.

Data processing

- Note that data processing involves **two steps**:
  1. collecting data;
  2. analyzing data.

- A construction project or program has **tremendous amounts of data**,

  but the **team must collect the data** to **manage** it.

- **Team members** and **digital technologies** that observe critical information must have an **opportunity to report** it.

Data processing

- The project/program must also have a **way to**

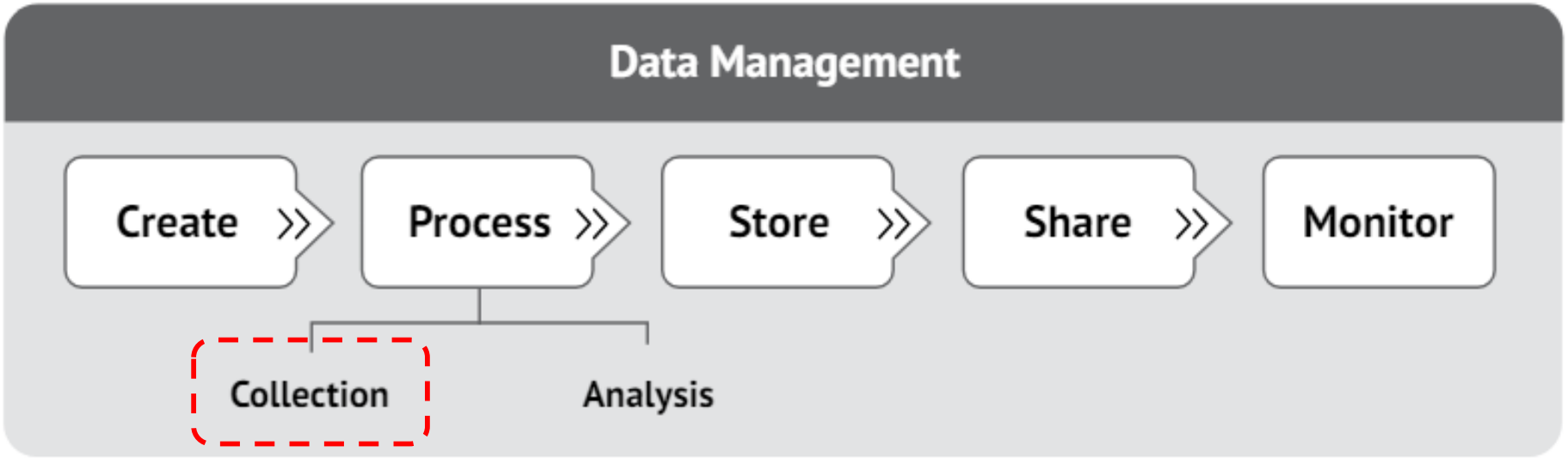
  identify, sort, and prioritize the collected data

  before the team can make an informed decision.

- This analysis may involve **team members** and **other digital technologies**

  that can interpret data and produce useful information.

Data Management Flow: Processing - Collection



Data collection

- Many technologies can create **connections** that collect data from various pieces of equipment, materials, systems, and stakeholders.
- These connections help the team **monitor progress** during
  - Design,
  - Activities on the jobsite during construction, and
  - A structure’s operation over the entire lifecycle.

What are connection types for data collection?

Manual

Semi-Automated

Fully Automated

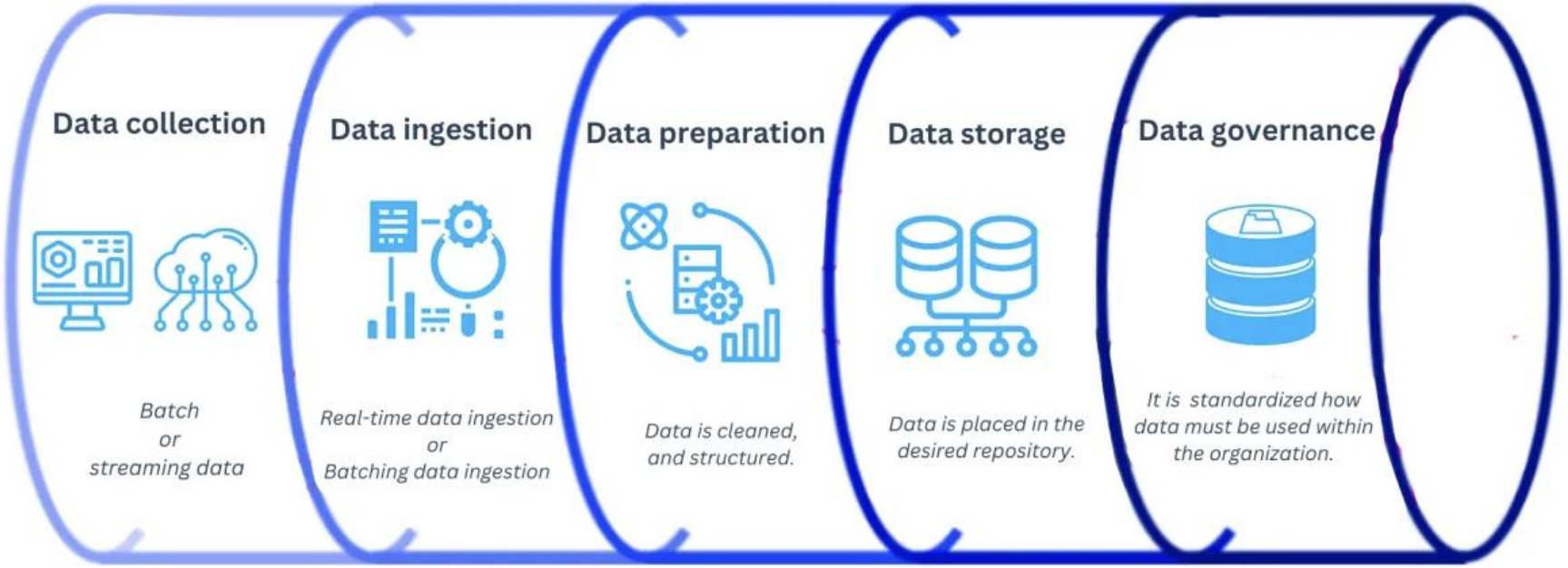
What do we need for each?

What are the examples for each one?

What are the main considerations in data collection step?

Data Pipeline

- A data pipeline is a method in which raw data is ingested from various data sources, transformed and then ported to the next stage, for analysis.
  - that next stage can be a data store, such as a data lake or data warehouse.



Data Pipeline Architecture

- There are three core steps in a Data Pipeline

1. **Data Ingestion:**

   Data is collection from various sources

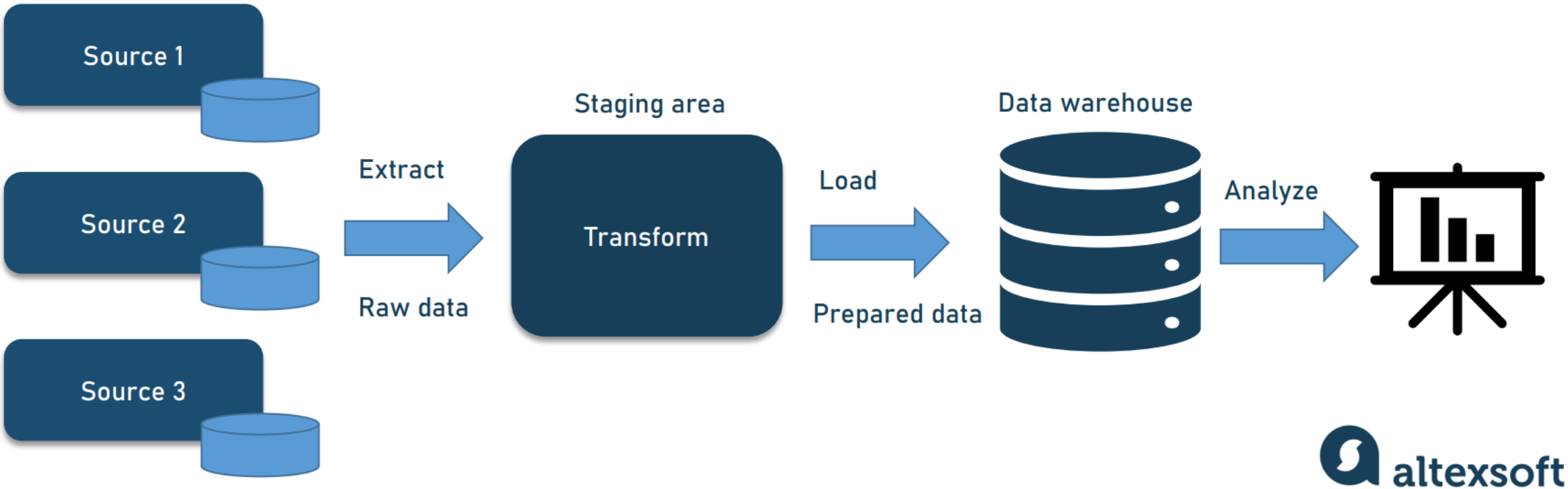
2. **Data Transformation:**

   a series of steps are executed to process data into the format required

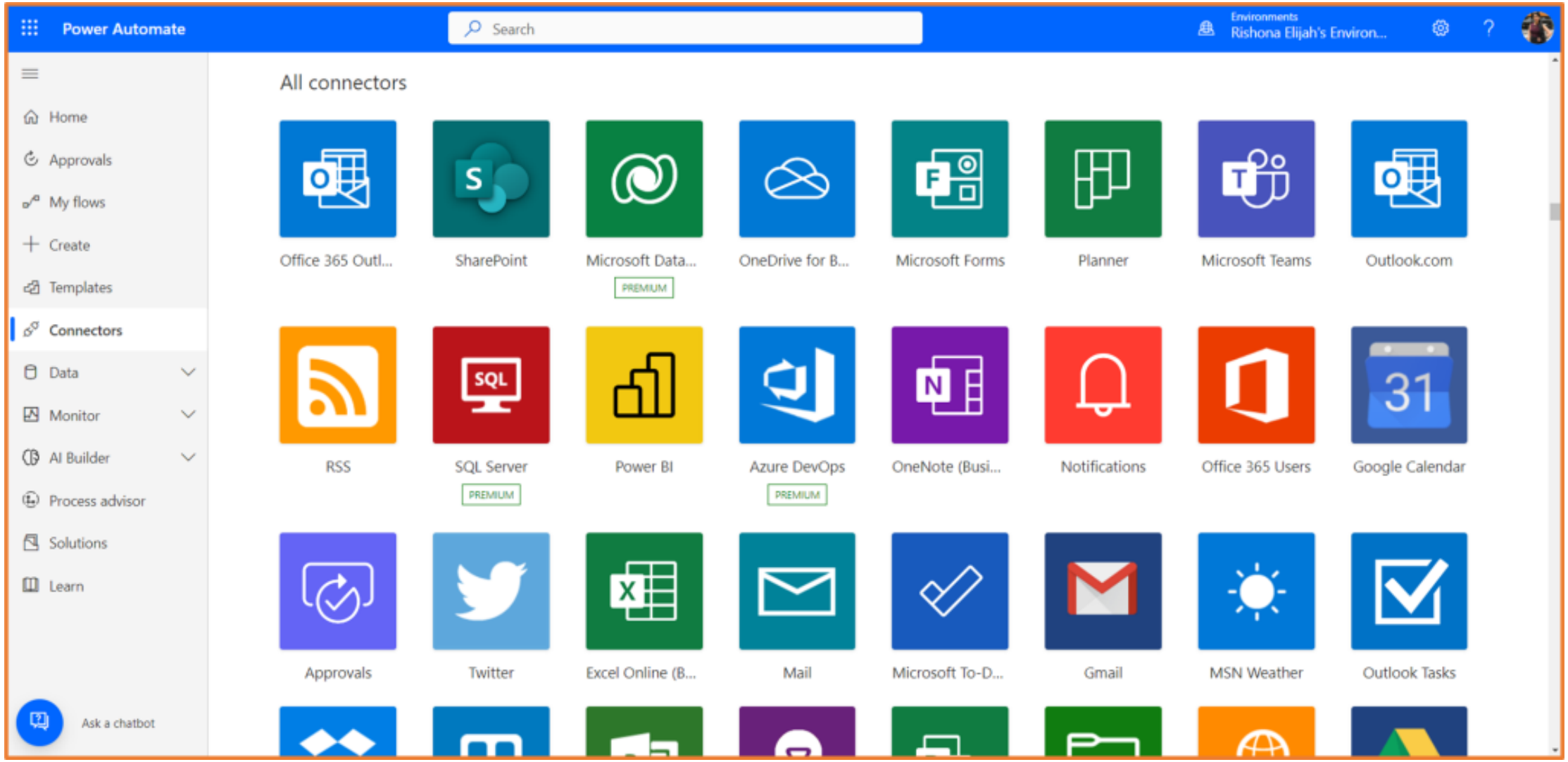
3. **Data Storage:**

   Transformed data is stored in a data repositor

ETL Pipeline



Connectors Sample



Digital Thread

- **Data connectivity** between a virtual model and a physical component is sometimes known as a **digital thread**,

  which can begin as early as design and ends after the structure's useful life.

Note that alternative definitions exist.

The term "digital thread" may also refer to the lowest level of detail in a digital design or the connection between a digital model and the owner's requirements.

CM Role in Data Collection (1/2)

- The CM must **understand** and **advise** the owner about
  - **Where** the data comes from,
  - **How** the team formats the data, and
  - Anything that **may prevent** data collection.

- A CM **ensures** that the owner has data standards to collect **consistent data**.

Standard Data

- The contract documents, PPM, or PMP/PgMP must **specify**
  - Level of detail,
  - Frequency,
  - Units of measurement,
  - Method of collecting all data.
    - Data formats
    - Collection Procedures
    - Templates
    - …

What can we achieve with

Data Consistency?

We also need to consider the necessary infrastructures…

Service Quality

High Availability

Price

Data collection – Internet of things (IoT)

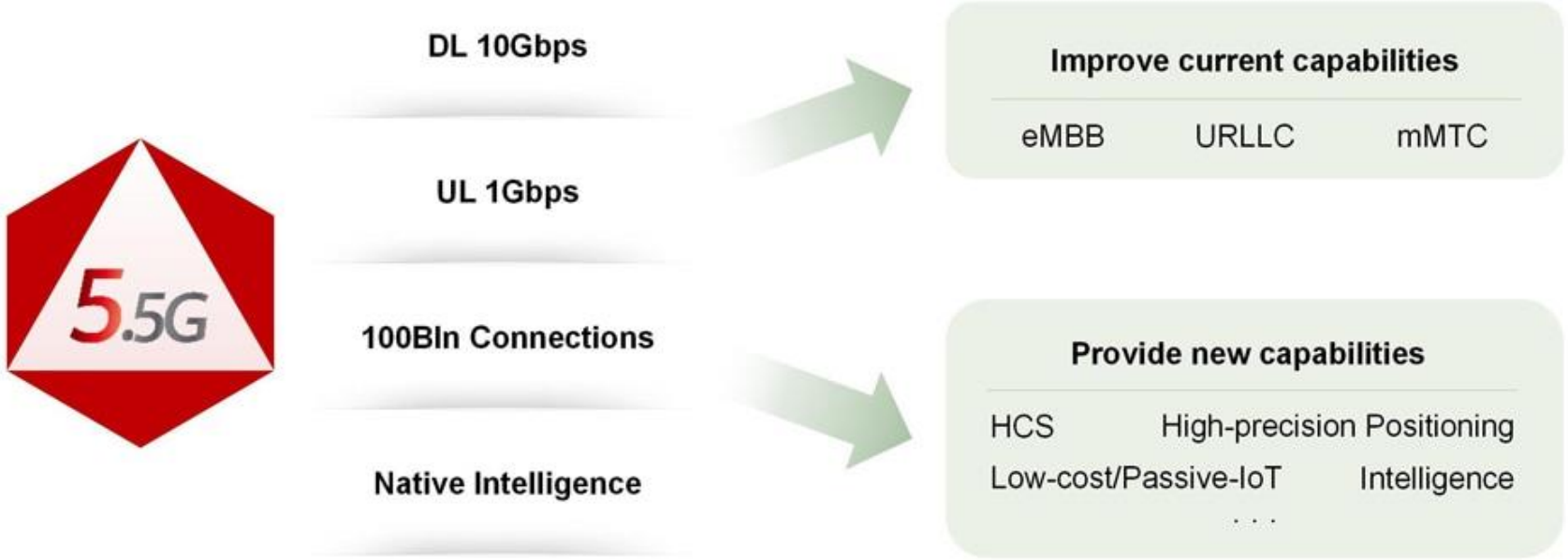
- Many **modern electronic devices** can connect to Wi-Fi, ethernet, or cellular telephone towers, which allows them to **share their data**.

- Devices on a jobsite or in a completed facility (such as specific electrical equipment or fire alarm sensors) can use IoT technology.

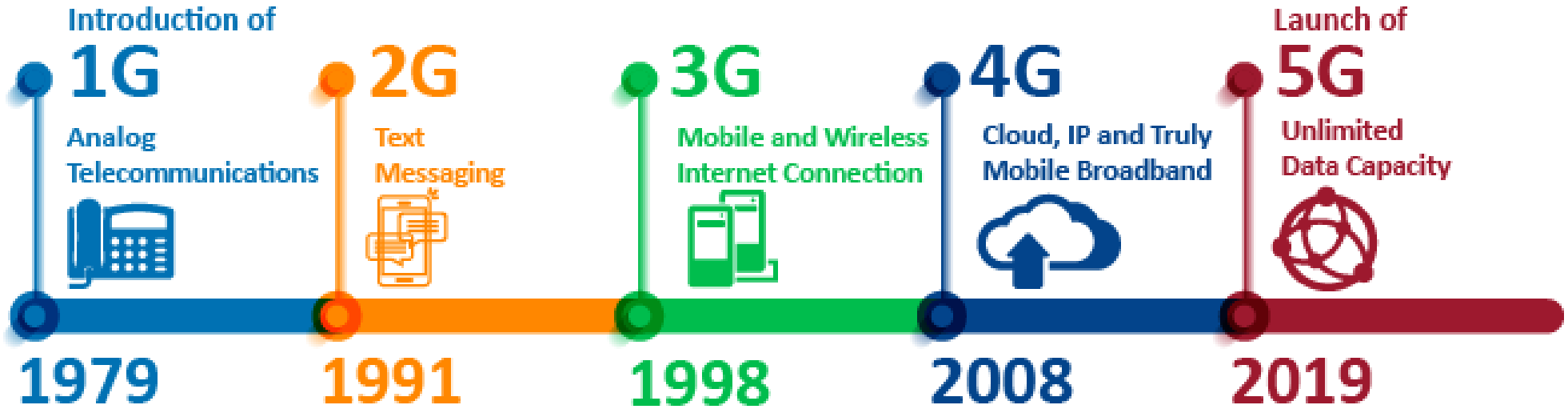
بخش ۱/۳ - بررسی فناوری اینترنت اشیا

Data collection – 5G

- 5G is the fifth generation of cellular network technology and is **at least ten times faster** than 4G LTE.
- 5G has the **speed** to share large amounts of data remotely over wireless connections, **reducing** the weight, size, and computing power needed in handheld or wearable devices.



A simplified timeline of cellular network technology



Data collection – 5G

- 5G **allows**
  - More IoT connections and
  - More intensive data processing

    on a jobsite or in a completed facility.
    - ✓ However, **remote locations often** do **not have** the latest generation of wireless communication standards or strong wireless signals.

- The CM must **understand**
  - the available wireless coverage and
  - help the team use it efficiently.

Data collection – Team

- Human information managers may need to physically collect, digitize, and format data before the team can analyze it.
- **Data** may already **exist** on paper or in business silos with **different** units of measurement, workplace cultures, etc.
- The **whole process** to properly collect, digitize, and format data is also known as "**normalizing**" or "**scrubbing**" data.
- These efforts produce **"clean" data** that the team can analyze to make decisions

What do we need to ensure this works properly?

CM Role in Data Collection (2/2) – Cont.

- If required, the CM **directs** the team's clean data collection.
- The team **cannot** collect data that is not available,

  so the CM should generally understand anything that may prevent data collection.

  - For example, staffing levels may limit the frequency of inspections, or a sensor on the jobsite may be able to record only one type of information.

- A CM must **consider** the potential ROI of **any data collection methods**.
- The CM should **advise** the owner if a piece of equipment, software, etc., to collect data has poor ROI.

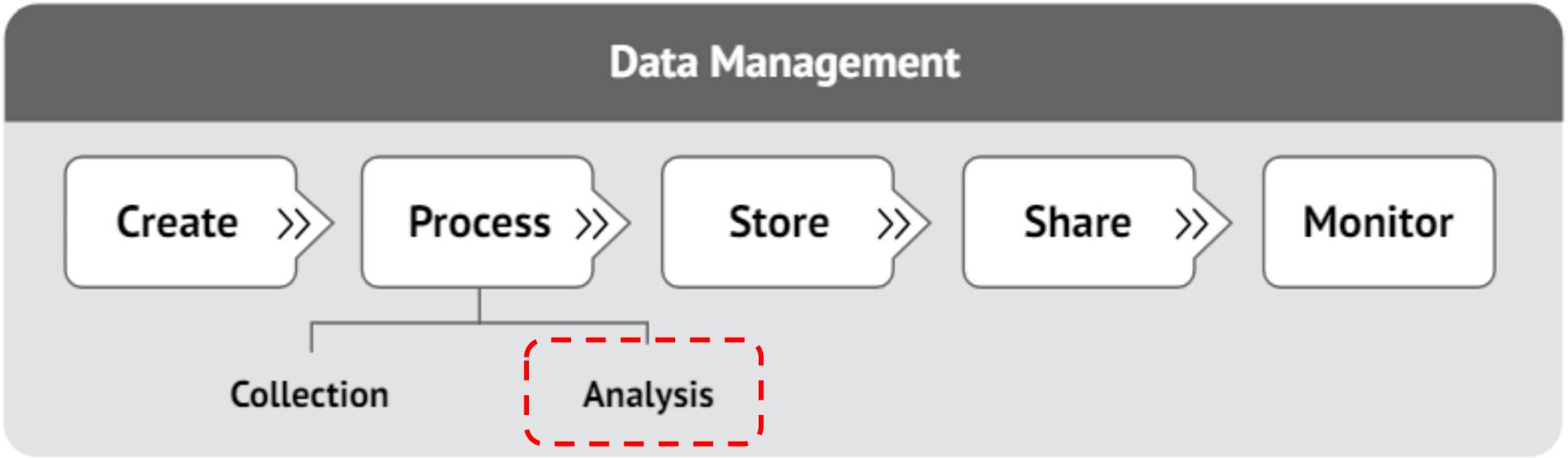
Data collection – O&M

- Ongoing data collection provides a **substantial benefit** to the owner
  - during a structure's operation and maintenance (O&M) and
  - may be an important part of the owner's quality requirements,

    so the CM **ensures** from the beginning of the project/program that the team plans data collection for the **entire lifecycle**.

- This planning process should **involve** the owner's O&M personnel.

Data Management Flow: Processing - Analysis



When good, clean data is available,

data processing allows the team to

analyze information and make better decisions

هدف بنیادین استفاده از داده

Data analysis

- Data analysis can
  - Enhance the CM’s performance,
  - Simplify tasks, and
  - Increase efficiency.
- Analysis may be
  - Descriptive (show what is happening), | توصیفی
  - Predictive (indicate what might happen), or | پیش‌بینانه
  - Prescriptive (recommend actions based on what might happen). | تجویزی

However, the data analysis is only as good as the data input.

Poorly collected data leads to poor results, i.e. “garbage in, garbage out.”

Missing or inaccurate data can weaken the team’s data analysis, which may create delays, safety issues, etc., so the CM ensures that the team uses good data collection practices.

Digital twin

- A **digital twin** is an **important** data analysis concept for construction and facility management.
- A digital twin is a **virtual model** linked to
  - Physical elements,
  - Components, and
  - Processes

    on the **actual jobsite**.

Digital twin

- Digital twins **linked** to an **asset** for the **full lifecycle**

  can use real-time and historical data

  to **help** the team make decisions and simulate future outcomes.

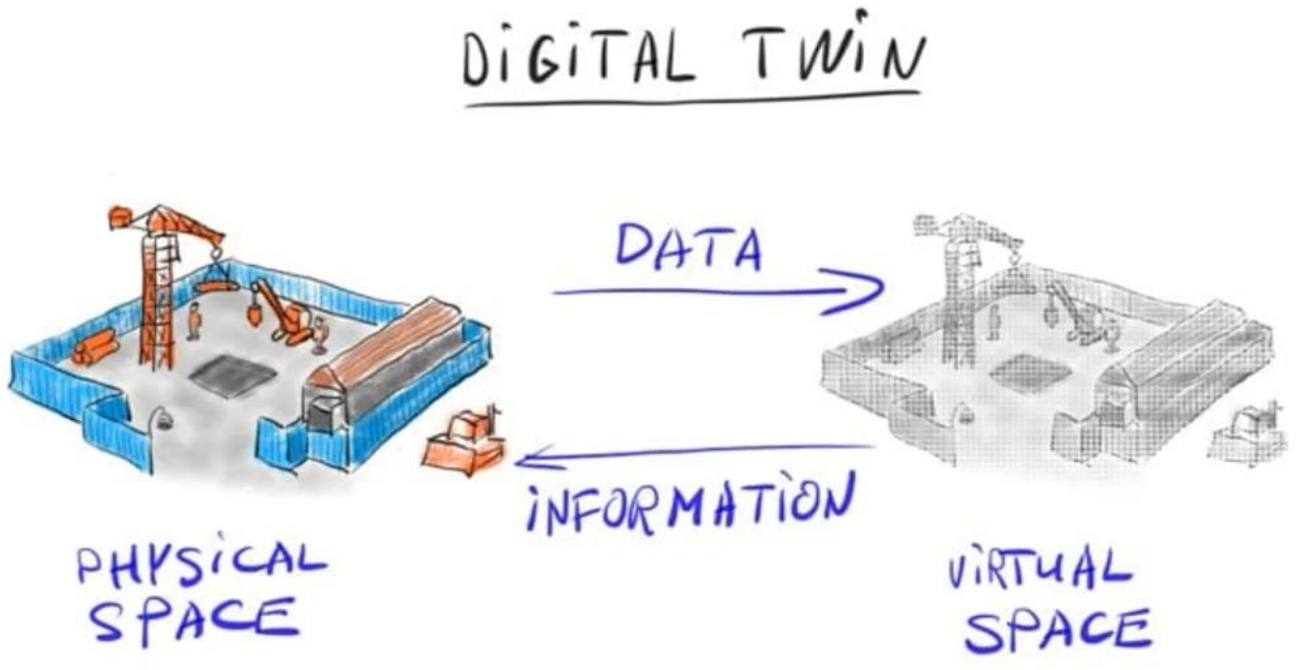
  - However, this analysis requires clean, reliable data.

- The team **manages** the digital twin in a **virtual environment**

  that should **receive** regular updates

  from **other equipment and systems** that capture and assemble this data.

What if We Could Bridge that Gap?



Increase productivity and optimize project outcomes

by:

Delivering Real-time Data Visibility & Insights

CUPIX

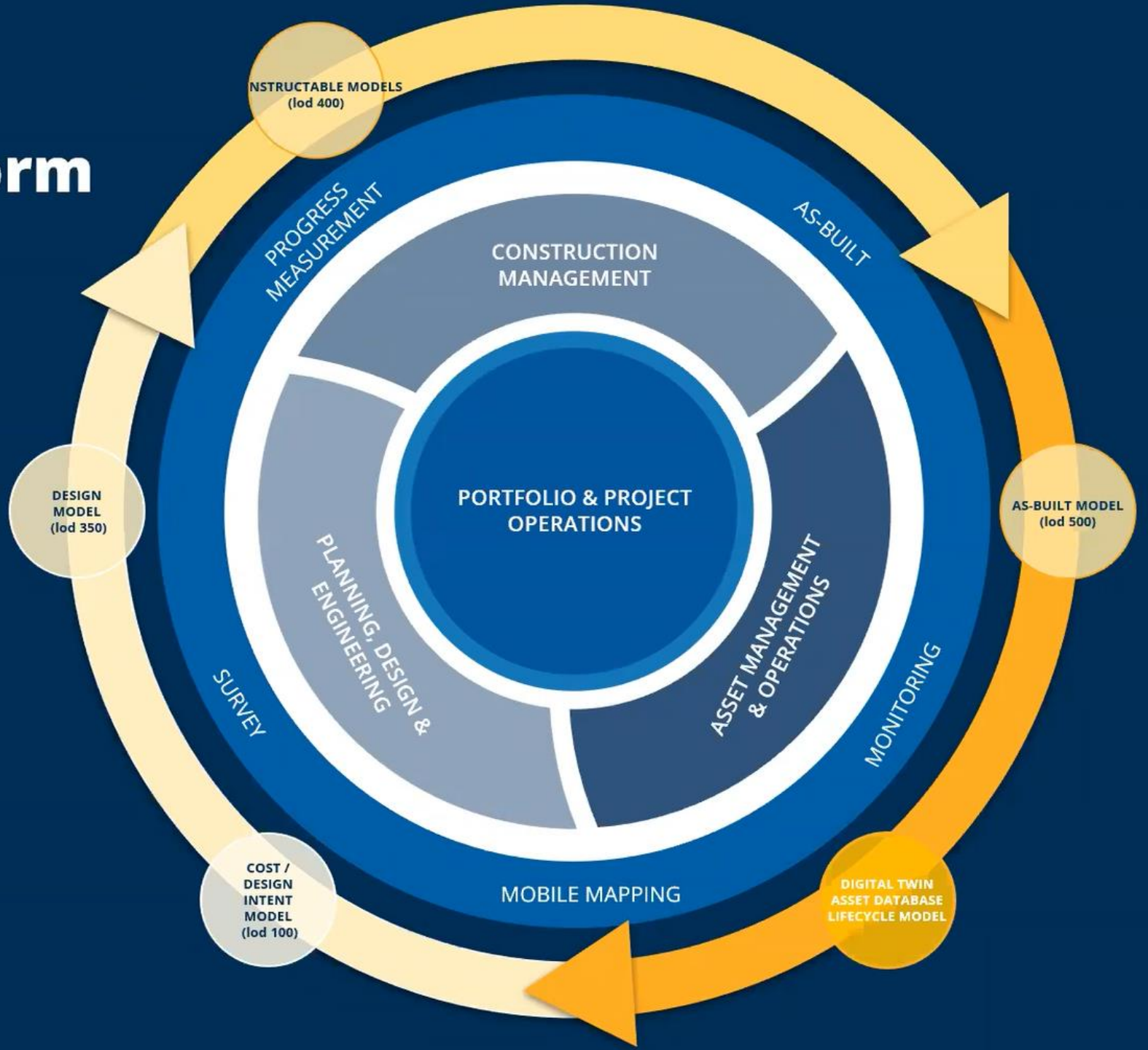
What is a “Digital Twin”?

“The bridge between the physical and digital worlds through the use of of sensors to collect data in real-time.”
-Facility Executive Magazine

- Reduce Risk
- Improve Efficiency
- Aid Decision Making
- Lower Costs
- Enhance Coordination

How Owners See Their Digital Platform

- Complete Lifecycle Solution
- Bridges the Gap Between Design, Construction, and O&M
- Centralize Data Between Stakeholders & Phases
- Captures Digital Twin



LEGEND

Field Activities
Model Evolution
Office Workflows

Data analysis – Data analysis tools

- Many tools in the marketplace also have **built-in functionality** to **analyze** (and sometimes **collect**) data.

- Some of these tools
  - **Have** their **own AI and BI capabilities**,
  - **Provide dashboards** for the team to see **real-time data**, and
  - **Combine different data** types.

Some “specific” data analysis tools and Solutions

Asset management

BIM / Virtual Design & Construction Systems

Commissioning platforms

Financial Management

Geographic information systems (GIS)

Management information systems (MIS)

Risk management

Scheduling Tools

Space planning

AI and BI

- Two other important data analysis tools in the marketplace are
  - artificial intelligence (AI) and
  - business intelligence (BI).

- AI and BI are able to **integrate** with **other systems**.
  - However, the CM must **advise** the owner on **how to maximize** the actionable knowledge from these tools.

AI and BI

- The CM must **know what data** is **essential** and **not necessary**,

  then relay that to the **appropriate database programmers** to ensure that the team accurately **interprets** scrubbed data.

- Note that **some tools** in the marketplace can also **perform both** AI and BI functions.

Artificial Intelligence

- AI tools (especially their subcategory of **machine learning** tools) apply computer algorithms to **replicate actions** that **humans perform**.

- AI software "**learns**" from the **data it receives** to attempt to **make** more accurate decisions and predictions about cost, schedule, risk, etc.

- Many AI tools provide visual, interactive "dashboards" that the team can **monitor**.

بخش ۱/۴ - بررسی تفصیلی هوش مصنوعی

However, AI is **only as good as** the data it **receives** and the **CM interpreting** the results.

It is not a silver bullet or magic wand!

AI

- Insufficient or inefficient data will **not produce reliable** AI solutions.

- **Data collection** in construction usually **lags behind** other industries,
  so **historical information** may be necessary to use **AI best**.

- Finding **historical data** may be too demanding for **smaller projects**
  but should be **easier** for **larger** projects/programs and organizations.

AI

- AI can **reduce** some risks,

  but the CM must **advise** the owner on AI's limitations and the risks that AI may **create**.

- AI may **not be able** to predict some events that would be obvious to a **human**.
  - For example, AI may be able to calculate a **zero-float schedule**

    but **not be able** to predict weather or supply chain impacts.
  - ✓ However, AI may also **identify** things that a human could not, such as

    problems with a contractor's schedule,

    which may lead to **claims.**

CM and AI

- The CM must **confirm** that **all contract documents** reflect how the **owner wishes** to use AI.

- The CM may need to **help the owner**
  - Prepare for unique or challenging claims,
  - Train staff to use AI, and
  - Ensure that all team members understand how the team will use AI.

What are the possible uses of AI in construction?

AI in Construction

CURRENT APPLICATIONS IN CONSTRUCTION

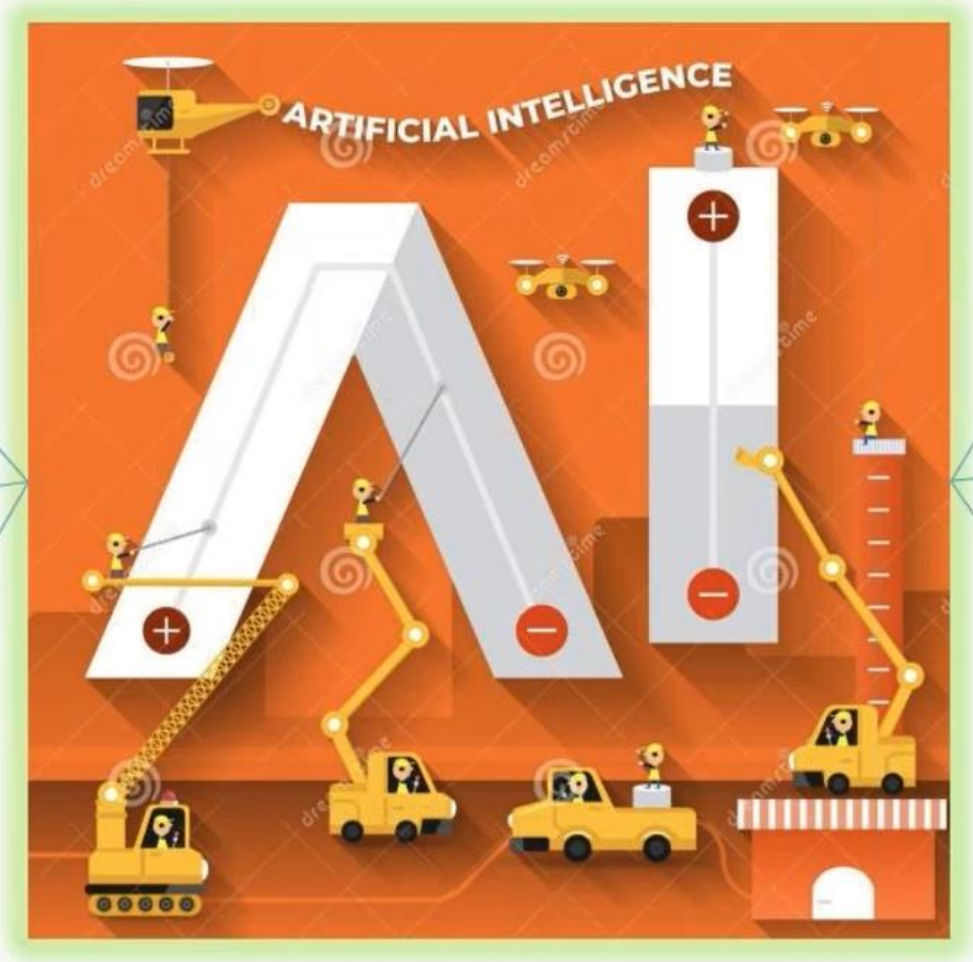
Estimating	Document Control	Scheduling
Take-offs & cataloguing data	Organizing	Proposed optimization strategies
Suggest proposed costs	Create relationships	Forecast durations
Assist in bid strategy	Convert handwriting to text	Perform cost vs time analyses

How can AI help you?

Boost Productivity

Autonomous equipment

Manage Inventory



Assess Risk

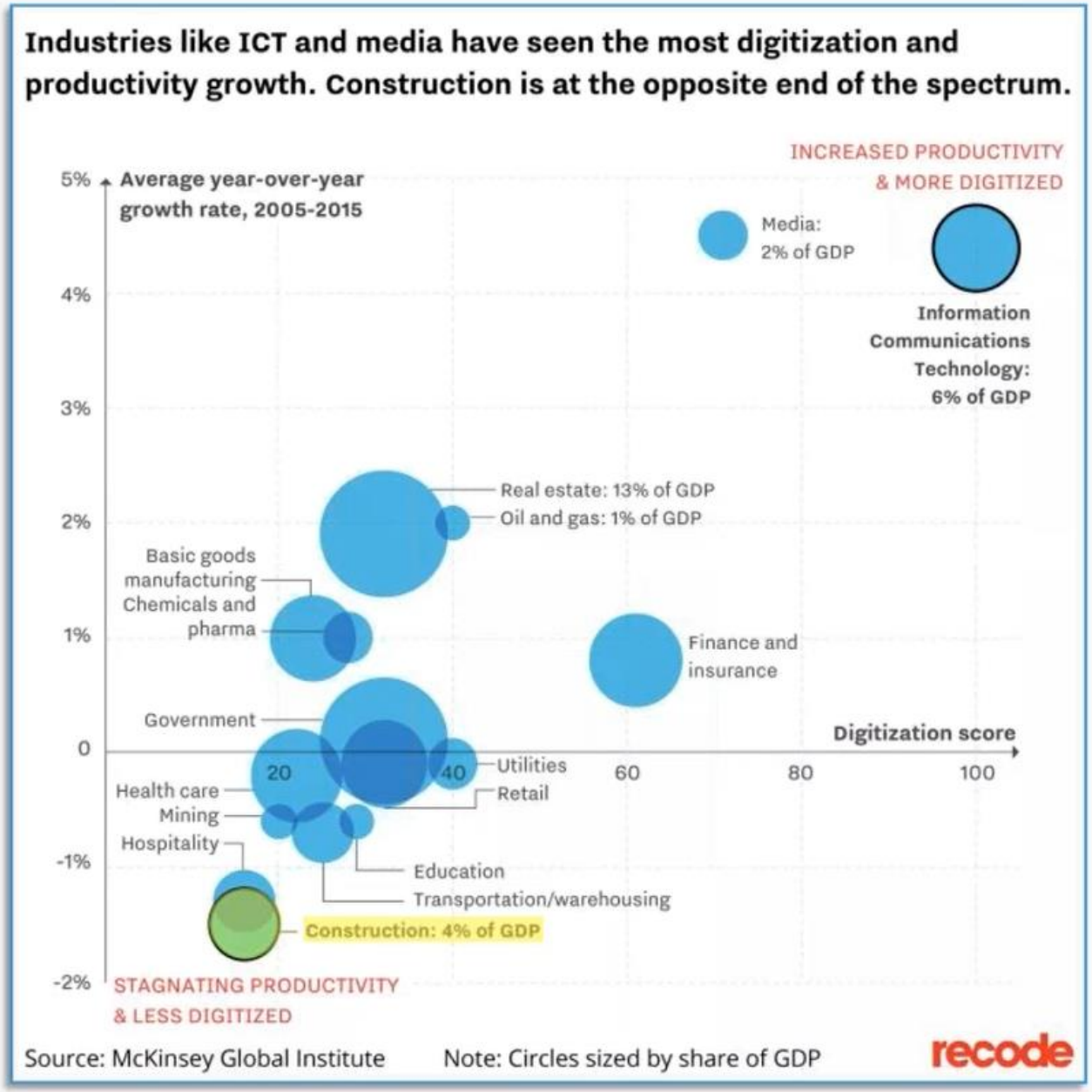
Maintain Safety

Monitor Quality

indus.ai

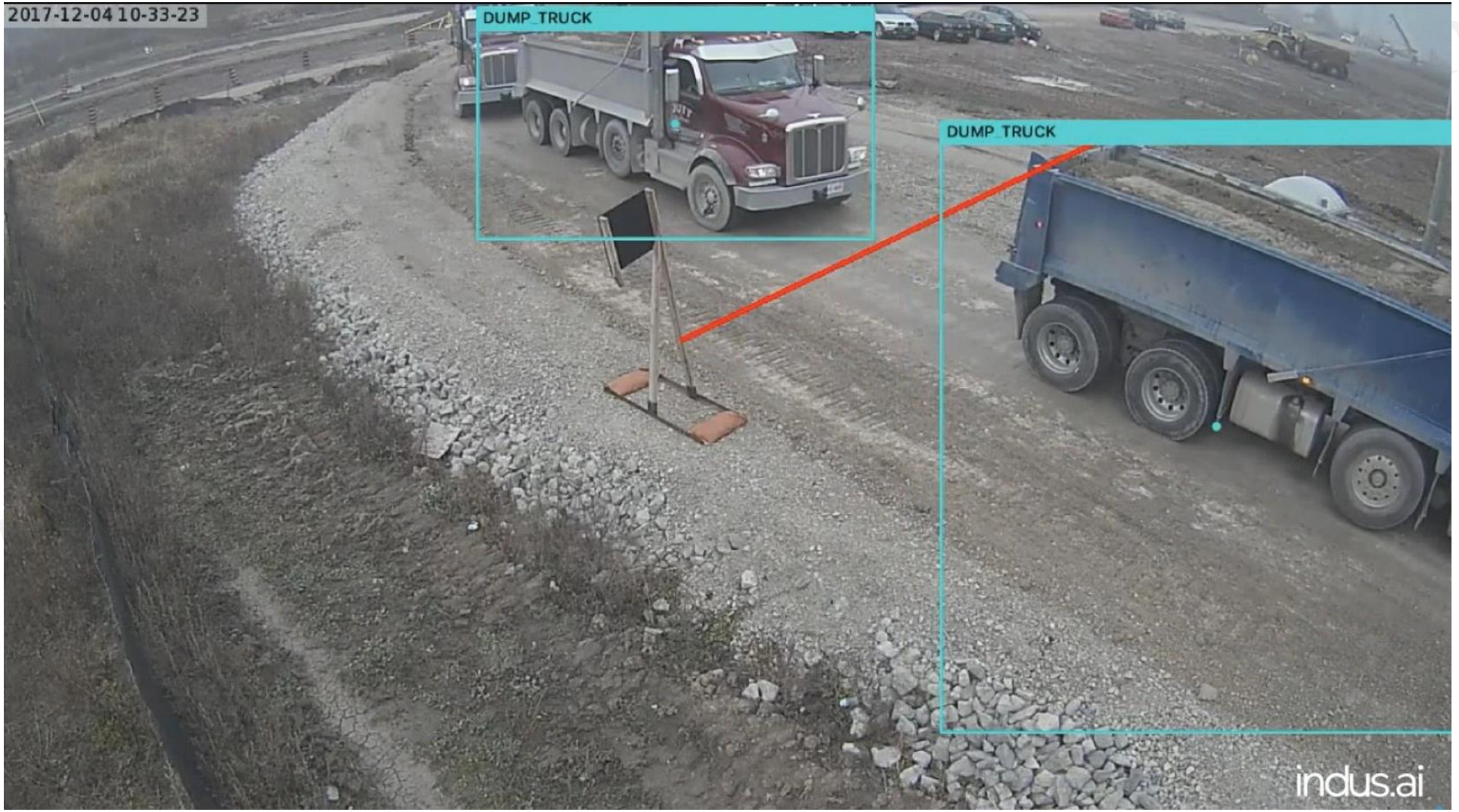
AI in Construction

Productivity & digitization have lagged



indus.ai

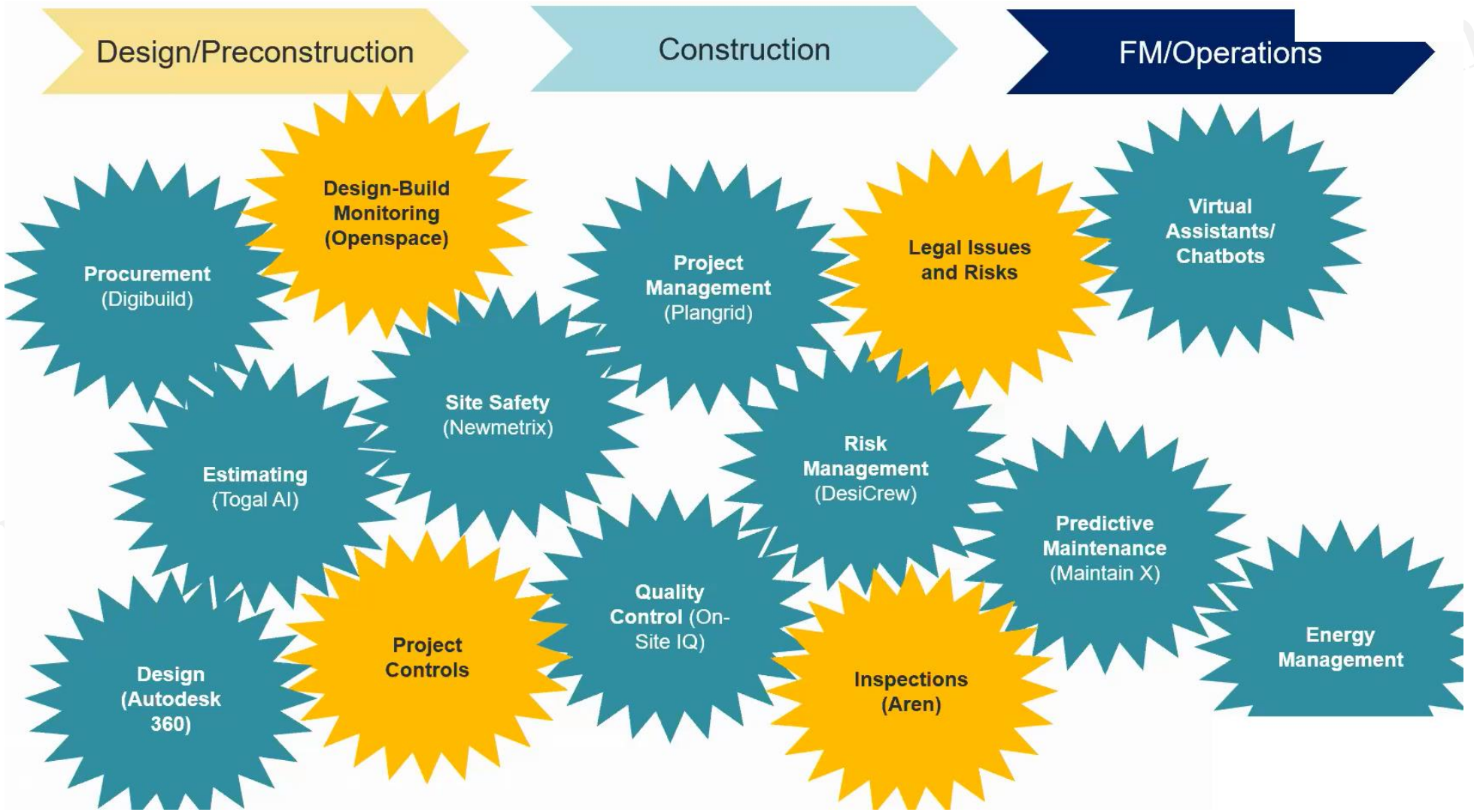
Computer Vision – Surveillance



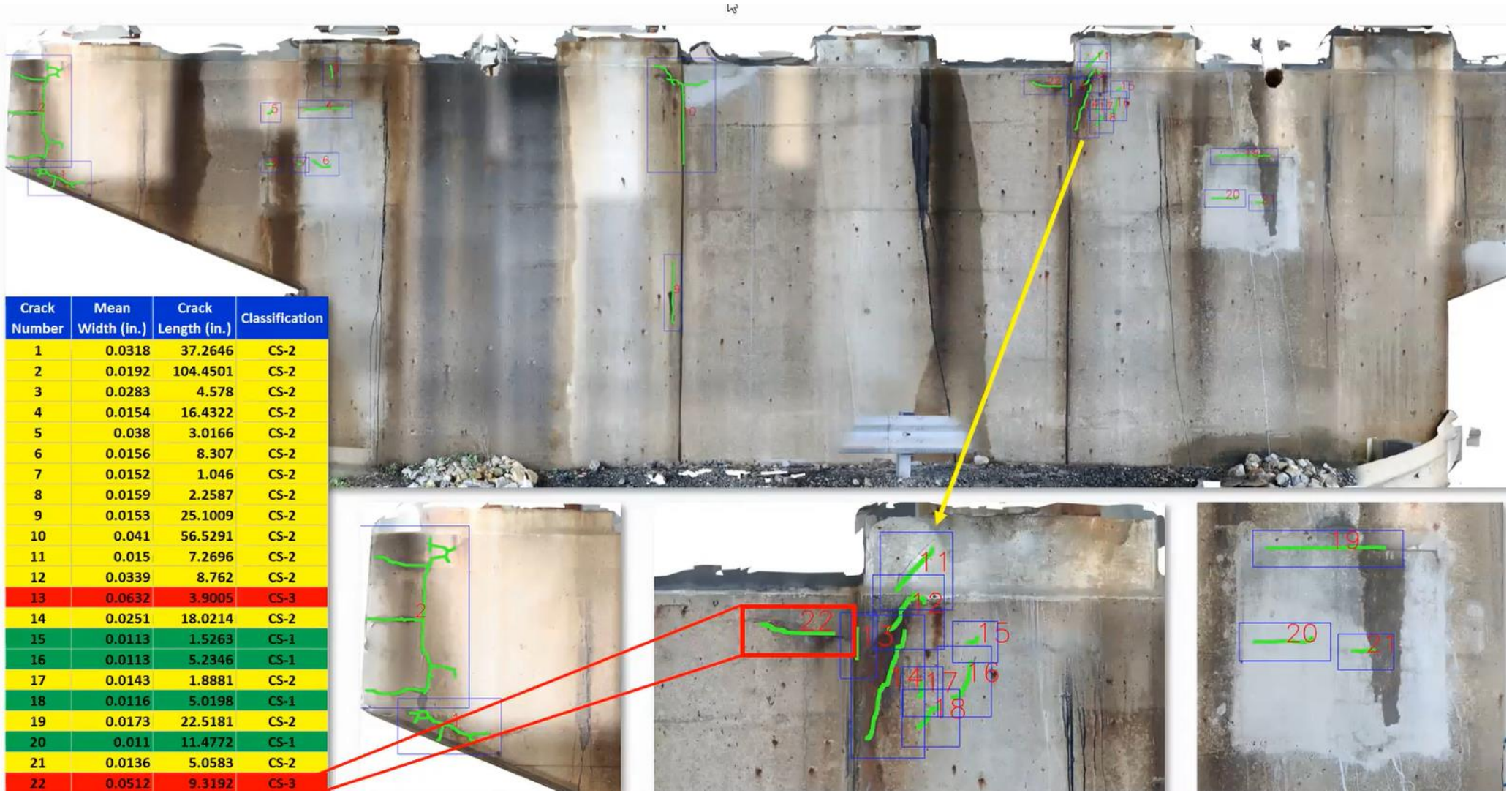
Computer Vision - Safety

Computer Vision - Safety

Some AI powered tools

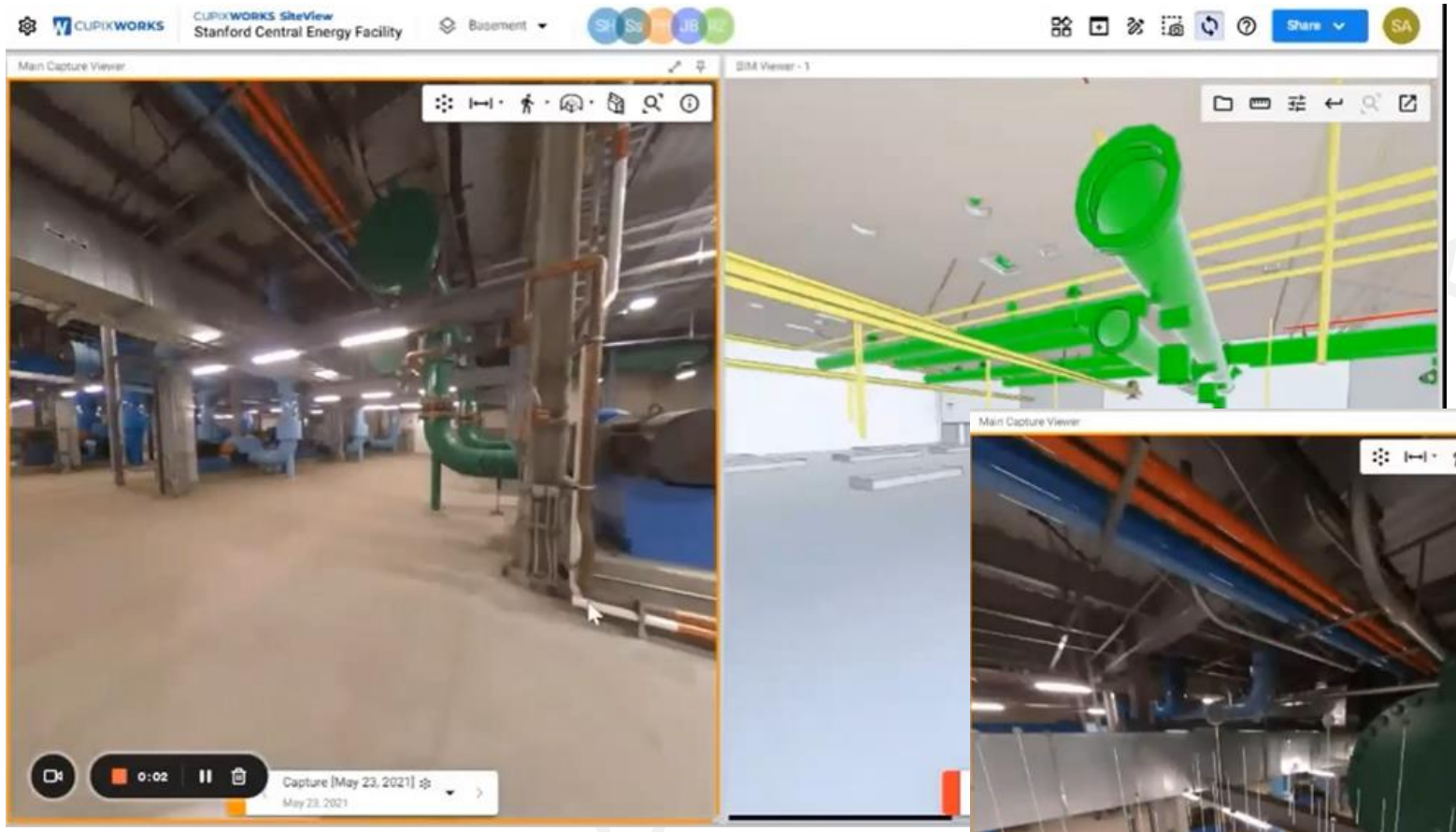


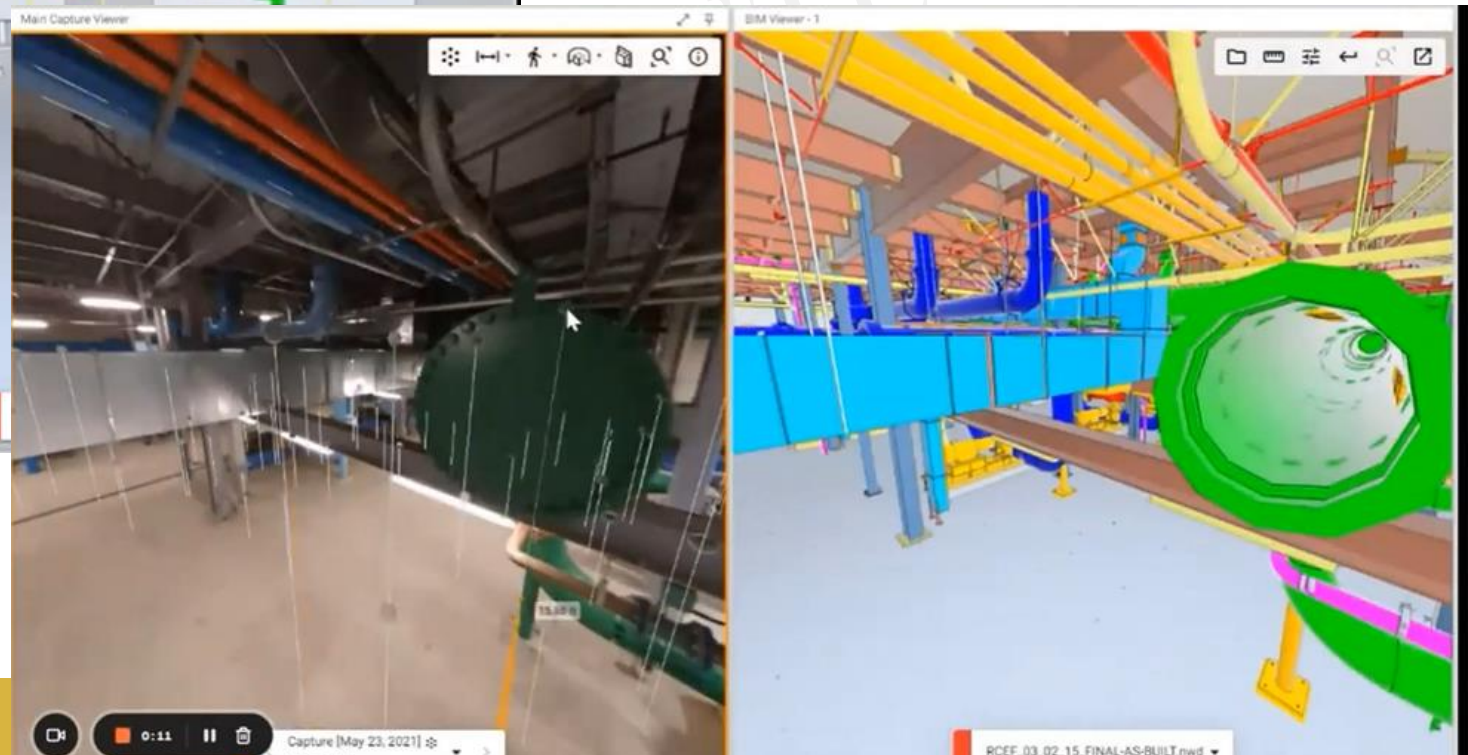
Computer Vision - Inspection



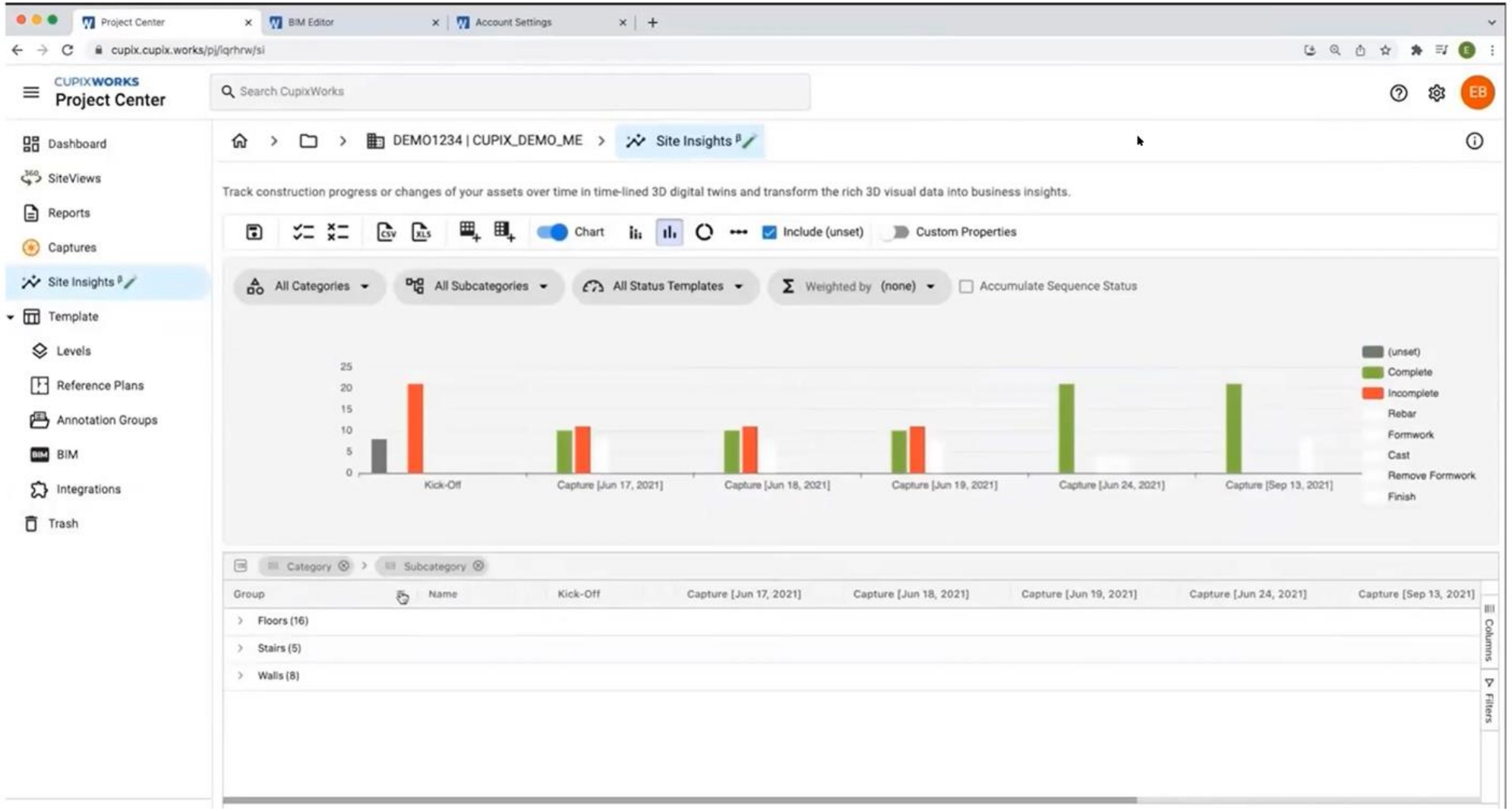
Crack Number	Mean Width (in.)	Crack Length (in.)	Classification
1	0.0318	37.2646	CS-2
2	0.0192	104.4501	CS-2
3	0.0283	4.578	CS-2
4	0.0154	16.4322	CS-2
5	0.038	3.0166	CS-2
6	0.0156	8.307	CS-2
7	0.0152	1.046	CS-2
8	0.0159	2.2587	CS-2
9	0.0153	25.1009	CS-2
10	0.041	56.5291	CS-2
11	0.015	7.2696	CS-2
12	0.0339	8.762	CS-2
13	0.0632	3.9005	CS-3
14	0.0251	18.0214	CS-2
15	0.0113	1.5263	CS-1
16	0.0113	5.2346	CS-1
17	0.0143	1.8881	CS-2
18	0.0116	5.0198	CS-1
19	0.0173	22.5181	CS-2
20	0.011	11.4772	CS-1
21	0.0136	5.0583	CS-2
22	0.0512	9.3192	CS-3

Cupix AI-Powered Capture Solution

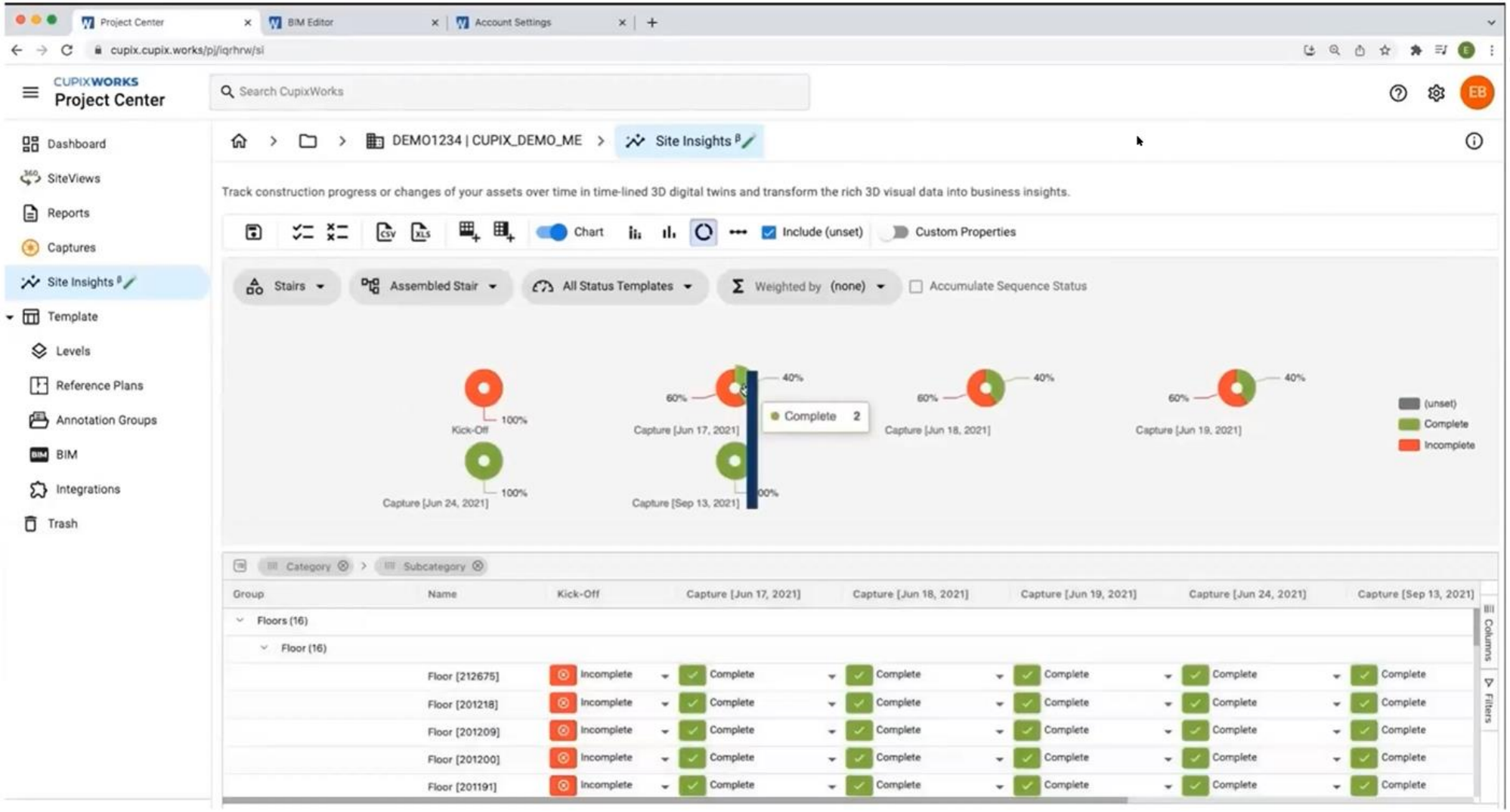




Progress Dashboard



Progress Dashboard



BI

- BI is the **systematic process** of transforming volumes of raw data into **actionable information**.

- BI tools **find patterns** using advanced algorithms and standardized methods,
  - but they can also help
    1. Collect data,
    2. Normalize/scrub data,
    3. Detect outliers, and
    4. Identify missing data.

BI

- **Modern BI** tools can
  1. **Analyze** both structured and unstructured data as well as
  2. **Present** information in dashboards that show the CM (and other stakeholders) real-time information.
- BI users can **combine** different data sets or sources to
  1. Run searches and
  2. Draw conclusions,
  - but **source data** must
    - First exist in a digital format and
    - Be accessible from the BI platform.

BI

- Like AI,
  - BI is **only as good as the data** it receives and the CM **interpreting** the results.

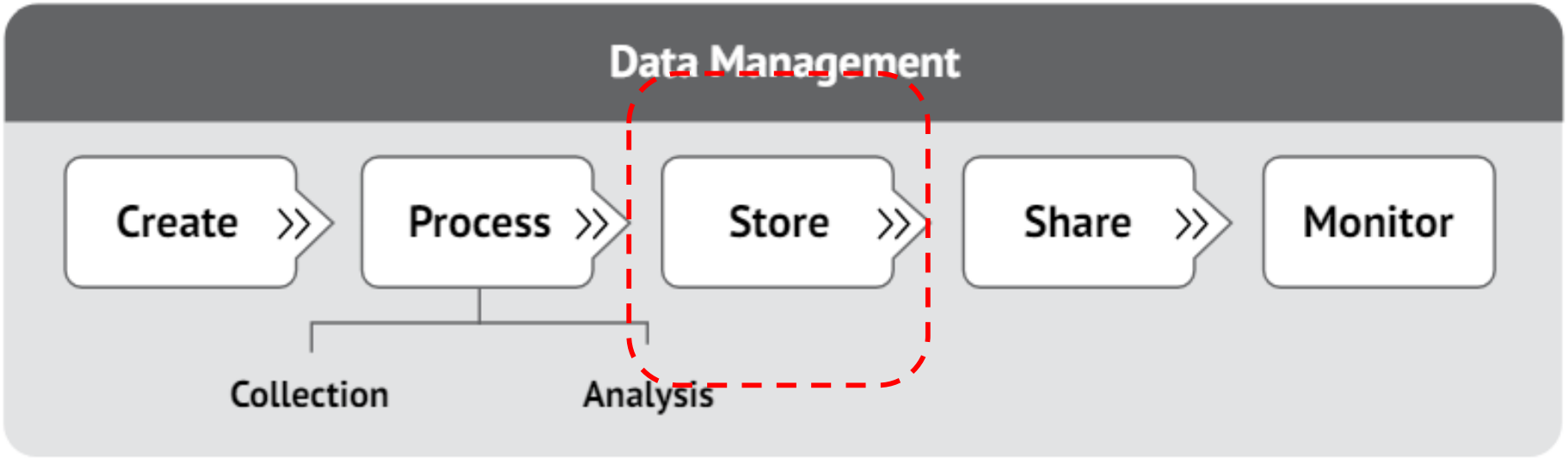
- BI tools may also
  1. **Miss** trends that would be obvious to a human (e.g., Weather) and
  2. **Identify** issues that a human could not (e.g., Scheduling problems).

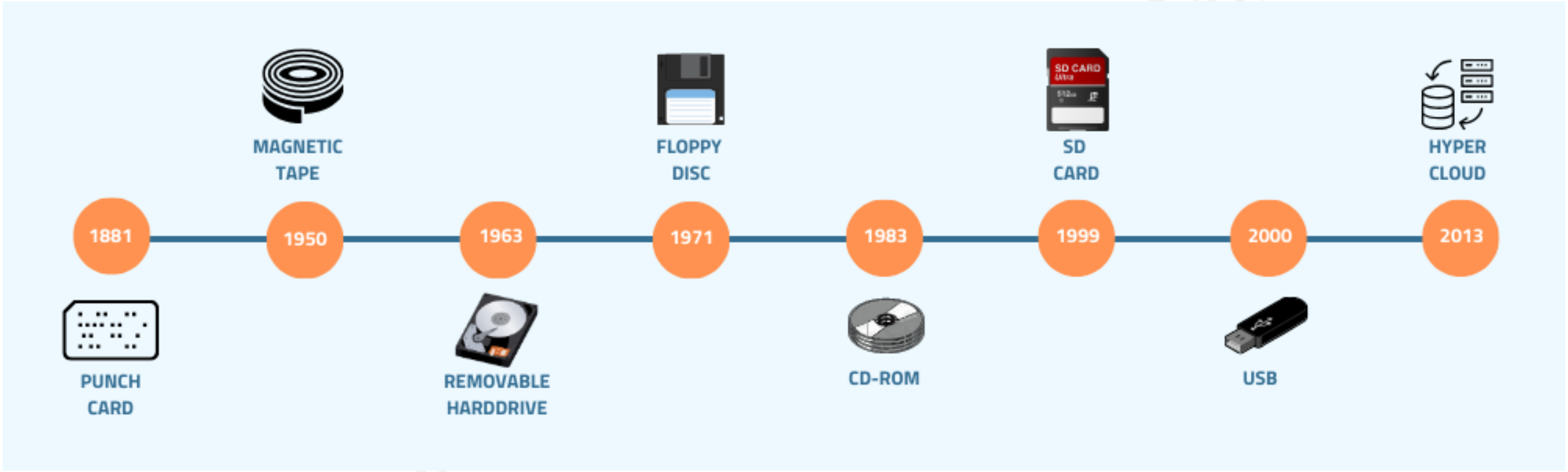
What are the most impactful obstacles in benefitting from BI solutions?

۵. ذخیرهٔ داده

Data Storage

Data Management Flow: Storage




1881
PUNCH CARD
1950
MAGNETIC TAPE
1963
REMOVABLE HARDDRIVE
1971
FLOPPY DISC
1983
CD-ROM
1999
SD CARD
2000
USB
2013
HYPER CLOUD

Data storage

- Data storage refers to **recording information** for later use.
- Data storage frequently **overlaps** with other data management activities.
  - For example, BI tools may access stored data and record their analysis simultaneously.
- Data storage is also **important** at the **end** of a project or program
  - when the team should archive data to **preserve** it for future reference.
- The owner, CM, or other stakeholders may need to reference the data for
  1. O&M,
  2. Claims, or
  3. Improve future delivery

Data storage

- It is **common** to store data and host software on **remote servers** that users can **access entirely** through the **internet** (commonly known as **“the cloud”**).
- **Cloud-based data** storage is relatively quick, cheap, and easy to deploy.
- Software and vendors who provide data **storage tools** in the cloud are known as data as a service (DaaS) software/vendors.

Data storage

- However, some owners may prefer or require local data storage
  - on the team's computers or onsite,

    collocated servers.
- This option may be **appropriate** for
  - Owners with strict security or regulatory requirements (see "cybersecurity" below) or
  - Owners that already have existing data storage infrastructure.

    - Daas options may also be too expensive for small projects.

CM and Data Storage

- The CM must realize that there are now **many options** to store data reliably,

  so the CM must **consult** with and **advise** the owner to find the **best solution.**

- **DaaS/cloud storage** is more efficient but may **not be appropriate**

  for **certain owners**.