A WHITE PAPER FROM TAQTILE

# Digitally Transforming Manufacturing Jobs

## EXECUTIVE SUMMARY

Manufacturing is currently being transformed by the fourth industrial revolution, Industry 4.0. Technologies, such as augmented reality (AR), artificial intelligence (AI), cloud computing, analytics, internet of things (IoT), and 5G are enabling a connected ecosystem that is increasing automation, improving communication and monitoring, and enabling new levels of analysis and production. However, the growing complexity of operating and maintaining equipment and factories is increasing dramatically while the availability of experienced technicians who understand this equipment decreases and the skills gap of the workforce widens. Furthermore, for manufacturers of complex equipment and systems, supporting these systems can also be complicated and costly because of this complexity and the lack of experts.

Taqtile's Manifest is an enterprise software-as-a-service (SaaS) platform that extends excellence and expertise to enable flawless workflows of procedures, ensuring precision and accuracy. Manifest will harness, distribute, and apply what your experts know and give deskless workers instant virtual access to, and step-by-step guidance from, your most experienced technicians and trainers anywhere, anytime. Jobs get done more efficiently and more consistently and training new workers is faster and more effective.

## CHALLENGES DURING THE INDUSTRY 4.0 REVOLUTION

In order to realize all that industry 4.0 promises, manufacturers face significant challenges brought on by so much change and disruption.

1. **Complex work environment.** Factories, systems, equipment, and procedures are becoming increasingly automated, connected and therefore more complex. There is so much new technology: Bluetooth-enabled tools, IoT sensors, 5G connectivity, mobile devices, XR headsets and wearables, robots, and automation. Operating and maintaining equipment with these technologies can be complicated. The workforce needs to be adaptive and develop new skills that are very different than the operational skills required in the past. Similarly, this complexity and new technology creates challenges with provisioning, supporting and maintaining the downstream use of many manufacturers' products, while distributors, service partners and customers require more training and assistance.
2. **Market demand for agility.** To remain competitive, many manufacturers are required to deliver more products or custom configurations and unique SKUs for specific channel partners or customers. More variety, smaller quantity orders, and shorter lead times are also often required. So, manufacturing needs to be agile. Operations need to be flexible and quickly adapt and change for different line layouts and configurations.
3. **Growing skills gap.** Global manufacturing workforces are aging and expertise and institutional knowledge is disappearing with every retiring technician and engineer. Younger workers are less experienced with less exposure to trades and industrial operations. Yet, as digital natives, many have expectations and desires to work with digital tools and the latest technology in their workplace. Turnover and attrition rates have never been higher as the new generation trade lifetime employment for flexibility and advancement. But traditional training methods can still take years to bring an apprentice fully up to speed.
4. **Disrupting forces.** Disruption from COVID continues to wreak havoc in many locations. Physical distancing, vaccination and testing requirements are still limiting expert availability and travel and often dictating skeleton crews. Economic counter actions have further exacerbated workforce shortages and availability of new employees. This disruption will likely linger for years and new disruptive forces, such as climate change, will, no doubt, introduce new challenges that require more continuity solutions in the future.
5. **Silos of operations and expertise.** Despite the advances in technology, connectivity, and integration, silos of expertise and operations continue to persist – especially within the deskless workforce. Digital transformation has been slow and limited for a lot of these workers because of the lack of suitable devices, data connectivity, and solutions. So, job performance can vary widely due to variations of people, places, procedures, and equipment.

## TRANSFORMATION OF THE DESKLESS WORKFORCE

As Industry 4.0 drives large scale changes in manufacturing systems and operations, deskless workers cannot be left behind. Regardless of the significant levels of automation currently being introduced into manufacturing environments, providing these workers with digital tools and solutions will be necessary to operate at the production levels required to be competitive in the future. Some of what is needed include:

1. **Digitized documentation and tools.** Physical manuals, paper-based procedures, clipboards, and the like need to be replaced with modern tools and solutions. Creating, updating, locating, and using paper documents is outdated and fraught with issues. Often written instructions are misinterpreted. So, procedures that leverage video and other media, 3D models, AR augmentation improve overall comprehension and limit misunderstanding.
2. **Standardized and digitized procedures.** Easy to comprehend and follow, standardized procedures are key to precision, accuracy, consistency and safety across different personnel, locations, equipment, and directives. For the myriad of procedures that cannot be automated, standardized, and consistent execution is critical.
3. **Efficient knowledge transfer.** Coordination, collaboration, and machine interaction will be more complex yet needed more than ever. Efficient and effective training, on-boarding, skills refreshing, and guidance and assistance will be required to transfer skills and expertise quickly and efficiently to less skilled workers.
4. **Device and platform flexibility.** Operational and maintenance procedures need to be digitized and accessible from devices that are suitable for the array of different environments and conditions. Suitable devices have long been a limiting factor for digital transforming components of manufacturing operations. With the emergence of mobile and wearable devices viable for manufacturing uses, solutions and tools need to provide broad device support to provide the right tool for each job and environment.
5. **Remote solutions.** By necessity, efficiency, or convenience, many teams are geographically diverse. Hybrid work models have emerged and will remain. Tools and solutions for deskless workers must support remote collaboration and assistance scenarios.
6. **On-demand and offline content.** Deskless workers need access to knowledge when and where they need it. High-speed wireless connectivity, such as 5G, enables instant access to content and assistance. But for many austere and remote conditions, work instructions and guidance need to be accessible while disconnected and offline.
7. **Integration.** As more devices and machines become connected, more data than ever is becoming available. But that data needs to be accessible in solutions that help people use it. Often deskless workers will need real-time access to this data to make better decisions. And operational data related to job history and performance; fault reporting and resolution; or inspections and auditing needs to be integrated with business systems for archiving and compliance or to automatically trigger downstream workflows.

## MANIFEST ENABLES OPERATIONAL EXCELLENCE

Taqtile's Manifest leverages AR and cloud computing to remove operational silos. It provides a platform to capture expertise, document procedures and provide guidance and direction to enable flawless operational workflows everywhere and every time. By aggregating these critical components of the operational systems, procedures and tasks are completed more efficiently and consistently:

- **Procedures.** Experts document and digitize procedures and augment step-by-step guidance with audio, videos, PDF documents, digital twins, and spatially anchored AR elements. Workers follow these instructions to accurately execute tasks, and management evaluates results and performance leading to continuous improvement.
- **People.** Regardless of skill level and experience, institutional knowledge, expert assistance, and collaboration is enabled and available – whenever it is needed – so teams are connected, and work is done consistently
- **Places.** Traditional physical barriers disappear. Work gets done consistently wherever the job is and on whatever devices are already being used–regardless of individual, team, or equipment locations.
- **Machines.** Workers interact with equipment and IoT sensor data in real-time and then data is integrated with operational data and enterprise-wide systems for archiving and analysis.

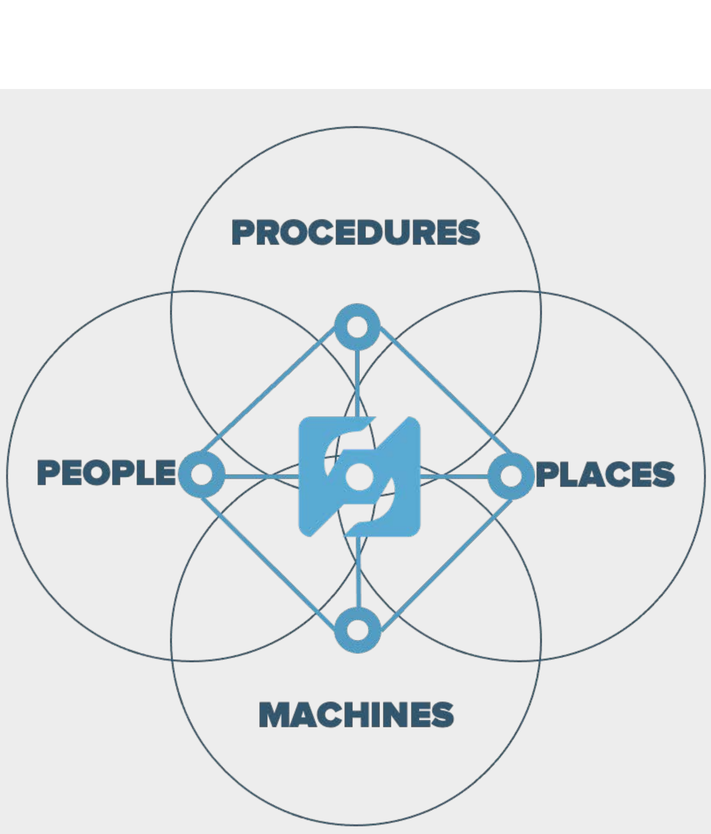


*Figure: Manifest unites four data domains to digitally augment operations*

At the core of Manifest is the job – a specific procedure that has been created for a specific task to be performed on a specific piece of equipment by a specific worker. Workers complete jobs by following the procedure. Their results and performance are recorded and archived for compliance and continuous improvements. By harnessing, distributing, and applying knowledge, the deskless workforce gets jobs done better and more consistently.

**Harness knowledge.** Manifest helps capture and document complex procedures digitally and augment step-by-step work instructions with audio, video, spatial markers, 3D models, PDF documents and illustrations. Instructions can then be virtually displayed over actual equipment to provide easy to comprehend guidance.  Creating these instructions requires no coding or special skills and many different devices can be used. Complex, non-linear instructions can be created that provide dynamic guidance based on real-time data, environmental conditions, or human judgement.

- Easy and fast start with minimal configuration
- On-the-job and in situ content creation on many different types of devices
- Support for static and animated 3D models and digital twins


*Image 1: iPads are used to create spatial markers that associate instructions with a specific location on a machine.*


*Image 2: Spatial markers associated with instructions show operators which buttons to use to perform a procedure.*

**Distribute knowledge.** Manifest is both device and platform agnostic allowing it to be used in different cloud environments or in a completely disconnected environment. It will operate in the most remote and austere conditions and locations. With an Open API, Manifest will seamlessly integrate and share data with other systems and machines to incorporate real-time information to users for better decision making. Manifest archives performance data and results for analysis and continued improvement and optimization.

- Offline, disconnected authoring and operating in the most secure and remote locations
- Broad device support including HoloLens, Magic Leap, RealWear, Android devices, iPads, and PCs with Chrome browsers
- Enterprise grade, secure platform with encryption, back-up, and role-based administration

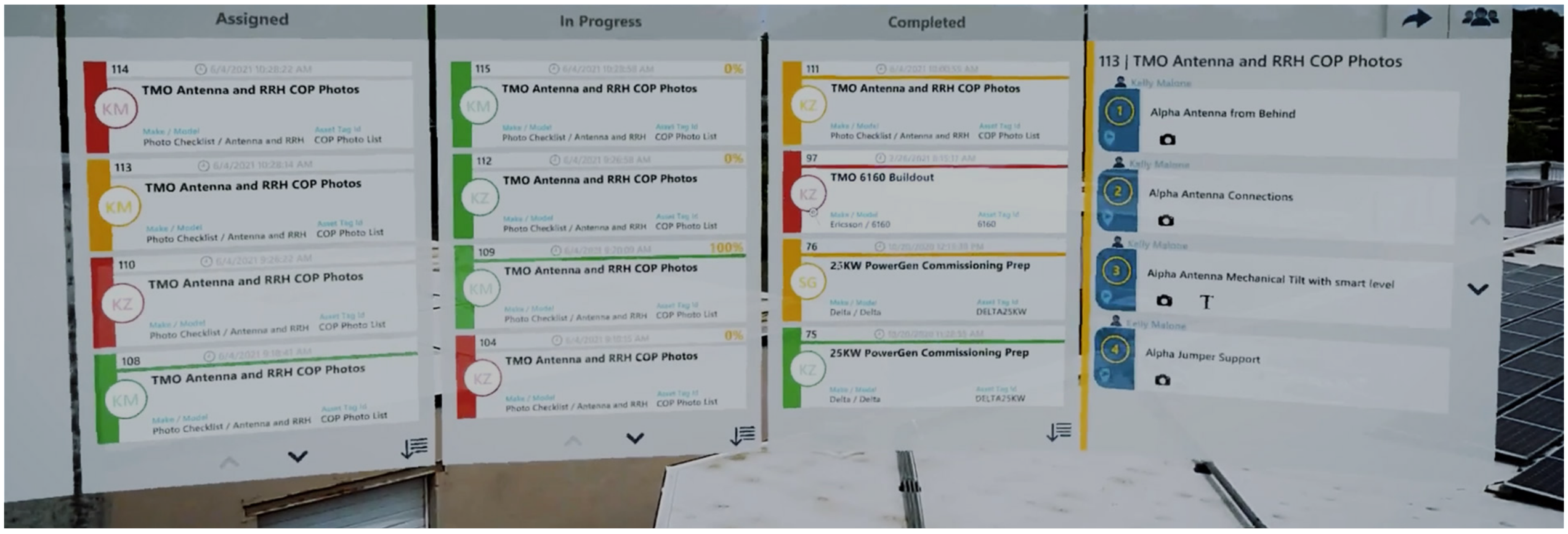


*Image 3: The Job Board shows all job procedures that have been assigned, in progress, or completed. Managers can drill down for performance data and current progress.*

**Apply knowledge.** By following standardized instructions, people complete tasks more accurately and consistently. Integrated remote communication and collaboration capabilities enable people to reach out to experts, share video and context for assistance and specialized guidance. Execution of procedures and tasks can be shared across individuals and teams with Manifest orchestrating the collaboration. Input can be captured during operations to collect images, videos, and other data to record conditions or collect evidence of accurate completion of a task. All of this can be done, hands-free, with a heads-up display and voice commands.

- Scheduling and assigning of jobs across teams and individuals, regardless of location
- Integrated remote assistance and collaboration capabilities
- Complete fault reporting system for easily flagging, reviewing, resolving, and archiving operational and procedural faults for improving auditing and inspections
- Access to real-time IoT data that can be viewed by operators and incorporated with the job performance history

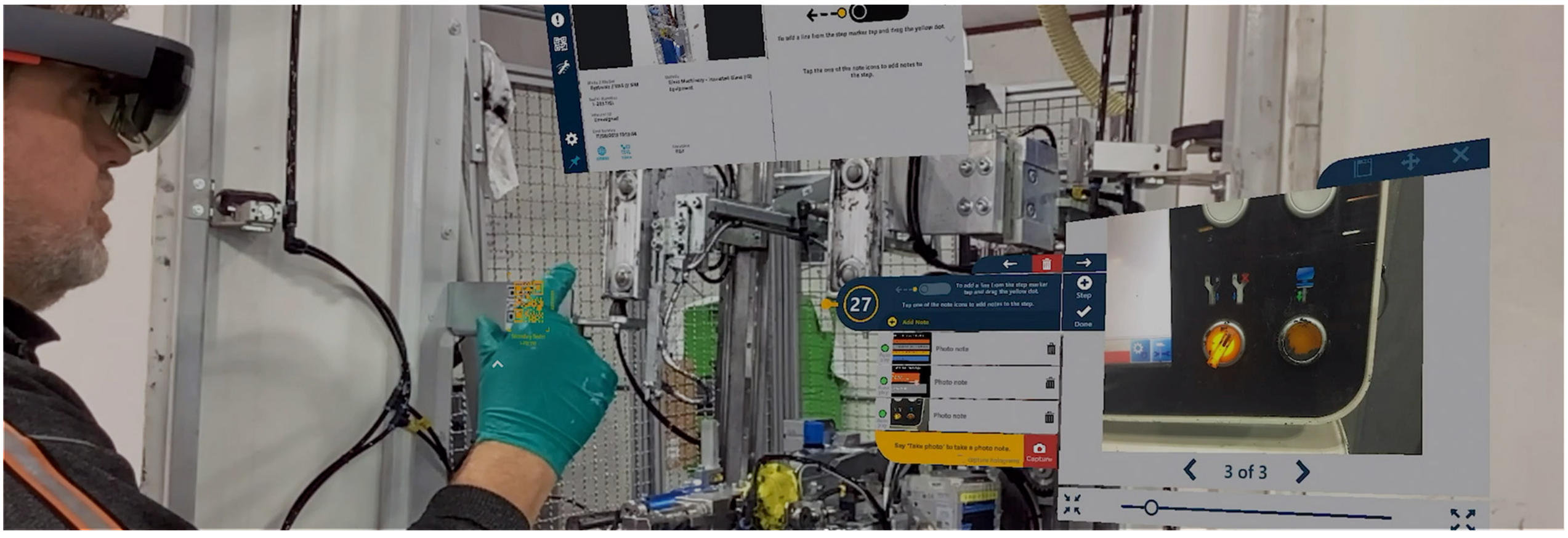


*Image 4: Workers follow step-by-step guidance augmented with videos, PDF documents, and 3D models.*

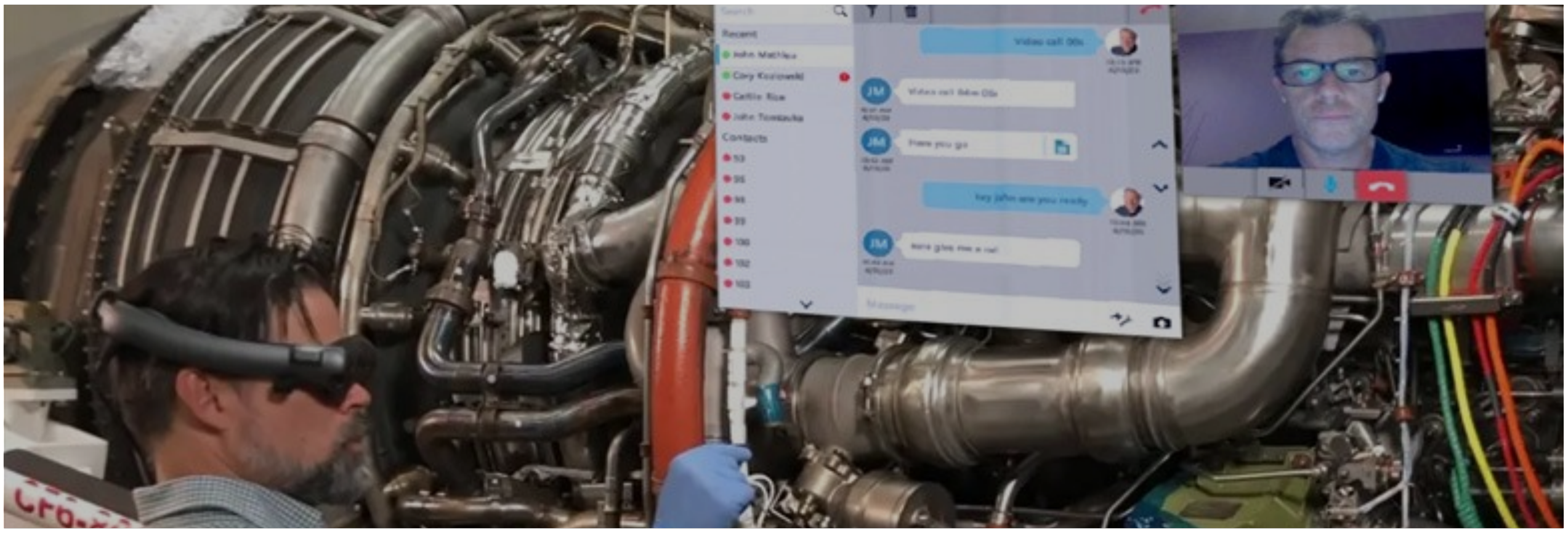


*Image 5: If a worker should encounter a problem, they can reach out to colleagues via video chats for remote assistance.*

## MANIFEST ENABLES OPERATIONAL EXCELLENCE

Manifest provides an unparalleled platform for enhancing operational proficiency and is differentiated from other solutions in many important ways:

| FEATURE | BENEFIT |
|---|---|
| End to end job management system | Manifest does not just provide a platform for guidance and work instructions. It provides a complete job performance system for scheduling, coordinating, executing, and analyzing procedures and results. |
| Enhanced with augmented reality | Step-by-step instructions can be overlayed over real-world equipment. Spatial markers and holograms provide means to navigate and interact with the instructions. And static or animated 3D models, with embedded real-time IoT data, provide a greater level of context and understanding. |
| Fully integrated team collaboration & remote assistance | Teams can execute jobs, whether colocated or remote, with task orchestration and visibility. Remote experts are always accessible via video chats where “see what I see” video can be shared, and guidance can be provided using AR spatial markers. |
| Integrated fault reporting system | Complete fault reporting system for easily flagging, reviewing, resolving, and archiving operational and procedural faults for improving auditing and inspections. |
| Easy and in situ authoring | Simple and fast authoring tools for creating and capturing step-by-step procedures over real-world environments and equipment without the need for specialized skills. |
| Flexible deployment | A fully containerized solution that allows for any cloud or on-premise deployments and enables operating completely offline. |
| Broad device support | Device flexibility with support for AR head-mounted displays such as HoloLens and Magic Leap, Android devices, iPads, and even monocular devices, and wearable tablets such as RealWear. |
| Multi-layer security | Enterprise-grade access control, encryption, and back up have enabled Manifest to be deployed in the most secure environments. |
| Machine integration | Real-time IoT sensor data that can be visualized within Manifest UI to better inform operators and enable better and safer decision making. |

## MANIFEST, 5G, AND MANUFACTURING

5G, the next generation of wireless telecommunications connectivity, is a key enabler of Industry 4.0 and the transformation of the deskless workforce. For manufacturers, 5G offers the connectivity that they have long needed within their facilities. It is cheaper than wired connections and more reliable than Wi-Fi in plant floor environments. It has increased capacity and its ability to segment and dedicate bandwidth to specific equipment will enable the proliferation of connected IoT sensors. And its increased bandwidth and lower latency will make it possible for bandwidth-intensive activities like video chatting to become viable.

Manifest is uniquely positioned to leverage 5G to empower deskless workers. With built-in capabilities to integrate IoT sensor data. Manifest provides technicians with real-time data in their headsets or mobile device to make better decisions and to act more quickly. Manifest's integrated remote assistance and collaboration capabilities will leverage 5G connectivity to enable a greater level of collaboration. Team members can reach out to remote experts via a video chat or stream "see-what-I-can-see" video to provide context while troubleshooting with a colleague. 3D models and digital twins can also be shared and viewed over these connections.

Manifest's fully containerized architecture also uniquely enables it to leverage multi-access-edge computing (MEC) that will be delivered with the next generation, 5G networks. MEC will bring technology resources closer to the devices and the people that use them. Ultra low latency, faster access to data, better security, and cloud processing of IoT data are some of the benefits.  Implications for Manifest users are significant. Remote rendering of 3D models or processing of video could occur in an edge server much closer to users, resulting in faster video and viewing of digital twins. More IoT sensor data can be collected and processed, giving technicians better real-time data, often from a broader geographical area, for more accurate and safer decision making.

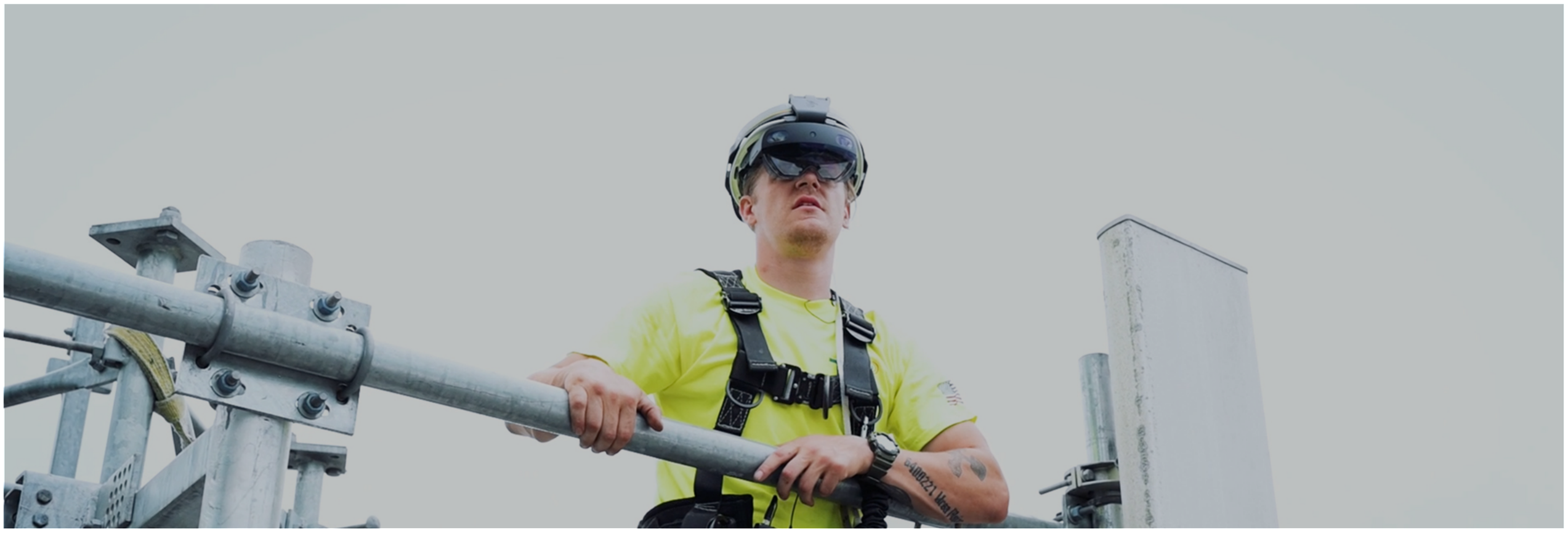

*Image 7: With 5G connectivity, workers can access Manifest instructions and guidance in the more remote locations.*

## MANIFEST AND DIGITAL TWINS

Although not a requirement to use Manifest, 3D Models and digital twins can be used to augment Manifest instructions and guidance to provide a powerful operations and training tool. Digital twins are static or animated 3D models of real-world equipment which can be integrated and animated with IoT sensor data, such as RPMs, pressure, and temperature. Using digital twins with Manifest empowers workers to view and virtually interact with physically large pieces of equipment. Digital twins provide access to clear, uncomplicated views of the equipment and its individual components, making it easier to follow repair and maintenance procedures on-site, perform training in a classroom, and review equipment remotely.

Digital twins are simple to incorporate into Manifest, requiring little to no 3D CAD expertise. Views from different perspectives and animations can be made available to operators via Manifest drop-down menus or automatically displayed in the context of a specific step or task. Virtual views inside the equipment itself are possible, enabling operators to see the state of the equipment and understand how individual pieces of machinery are constructed. Animations can show a sequence of parts to be removed or how a machine is reassembled.

Manifest provides a full set of tools and capability for managing and manipulating 3D content, incorporating it in step-by-step instructions, and providing operators will the ability to view and interact with these models from a headset or other device.

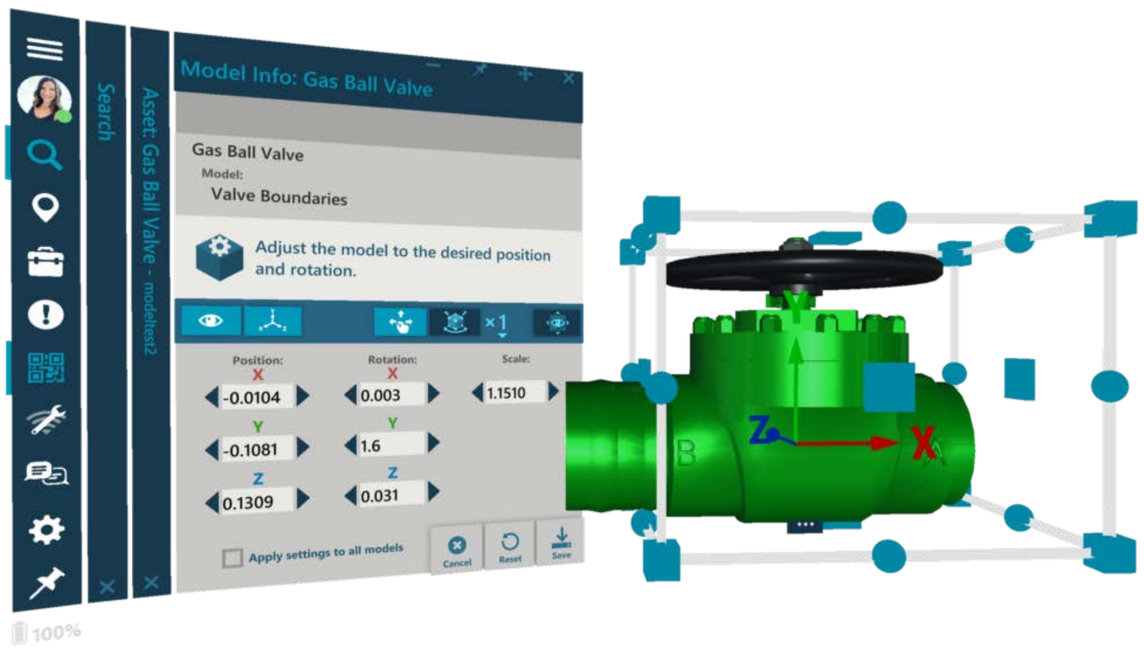


*Image 6: Manifest has an extensive set of tools for manipulating digital twins.*

## ENABLING INDUSTRY 4.0 AND ENHANCING MANUFACTURING OPERATIONS

Manifest helps individuals, teams and organizations get their jobs done more consistently, more accurately, and safer.

1. **Increase operational efficiencies.** Help deskless workers, regardless of skills and experience, complete their tasks consistently and more efficiently by providing on-the-job equipment familiarization and operation
2. **Reduce errors and scrap.** Perform operational tasks more accurately and more consistently to increase quality and avoid mistakes that lead to scrapped product and more manufacturing runs
3. **Minimize downtime.** Complete preventive or break-fix maintenance tasks more accurately to avoid costly errors that increase downtime and keep equipment and facilities in better shape
4. **Accelerate troubleshooting and times to resolution.** Provide guidance for non-linear workflows to help technicians diagnose, troubleshoot, and resolve unplanned issues faster
5. **Perform more accurate inspections and audits.** Structured guidance ensure that inspections are done consistently across individuals, teams, and locations and any issues discovered are captured, reported, and resolved
6. **Decrease on-boarding and training times.** Provide hands-on, immersive training and instruction in the classroom, remotely or at the equipment to facilitate comprehension and increase knowledge retention
7. **Increase safety.** Step-by-step instructions ensure that critical steps are not missed or skipped. AR headsets frees up hands to make for a safer way to work on equipment in many environments
8. **Decrease support costs and travel.** Virtually connect your experts to less experienced workers or your customers to provide augmented guidance and support - regardless of location
9. **Create a force multiplier.** By providing workers and teams instant access to knowledge and expertise, everyone becomes an expert and more is accomplished with less people
10. **Drive continuous improvements.** Collect and integrate job performance data by equipment, location, teams and individuals to create a continuous feedback loop for process and procedural improvements

### 3 Weeks to 3 Days

PBC Linear, a machine manufacturer, speeds up technician training by using Manifest. New workers can get up to speed in three days, not their usual three weeks. Training can be done remotely or at equipment where comprehension is faster.

### 0% Task Error Rate vs. 92% Error Rate

US Air Force Research Labs saw the rate of error occurrence by first year air maintenance mechanics on C-5 engine component replacement workflows drop from 92%, when using traditional technical manual-based methods, to 0% after implementing Manifest. Maintenance tasks are done more consistently more accurately.

### From 2 Hours to 40 Minutes

Technicians at PGT Industries, a Florida-based window manufacturer, now complete a 2-hour machine maintenance procedure in 40 minutes using step-by-step guided instructions created in Manifest. Downtime due to preventive and unplanned maintenance has dropped significantly.

## ABOUT TAQTILE

Digital transformation of organizations' operations continues to accelerate but silos of excellence and expertise persist. Leveraging technologies such as AR, cloud computing, and LTE/5G networks, Manifest removes these silos with a single, integrated platform. Manifest enables flawless operational workflows everywhere and every time by aggregating the critical components of your operational systems – people, procedures, places, and machines - so that jobs get done more efficiently and consistently.

Now more than ever, experts matter. We believe the increasing complexity of industrial machinery, systems, and factories, combined with retiring experts, means that experts matter more today than they ever have. We have made it our mission as a company to make everyone an expert by giving them knowledge when and where they need it.

Companies around the world recognize Manifest as a leading solution for improving operational proficiency and a platform that gives deskless workers instant virtual access to, and step-by-step guidance from, your most experienced technicians and trainers anywhere, anytime.

# MANIFEST IN MANUFACTURING

## 2018

Flow Waterjets is the inventor and world leader in waterjet cutting. They use Manifest to help people familiarize themselves with their machines' operations.

DuPont uses Manifest in their Silicon Valley lab testing facilities where they have digitized and documented the operational procedures required to run their lab equipment so that their customers can learn their systems quickly.

PBC Linear, a manufacturer of complex linear motion machines and systems, uses Manifest to capture and transfer knowledge. They are digitizing hundreds of procedures for thousands of SKUs to decrease training times and costs and increase operational efficiencies.

Jabil, an innovative global manufacturer, builds a diverse set of products ranging from leading edge consumer electronics to personal home care devices. They use Manifest to help guide less experienced workers on their manufacturing lines.

AWE uses Manifest to manufacture ordinance more efficiently.

Safe Boats designs and manufacturers the most reliable boats used by law enforcement and first responders. They use the latest manufacturing tools and technologies, including Manifest.

PGT Industries is a Florida-based manufacturer of windows and doors.  Like many US manufacturers, their workforce is aging and retiring, and they have used Manifest to help new technician become productive faster. As an example, they use Manifest to document and guide technicians performing regular maintenance procedures such as replacing a dynamic mixer on an insulated glass sealing machine.

A leader in AR headsets, Magic Leap is not only an enabler of AR-enabled work instructions, but they are also a user.

Fairbanks been making power systems for over 100 years. They have used Manifest to improve their maintenance workflows and enable remote assistance for their technicians.

Aurora Process is an innovative manufacturer of complex packing equipment. They use Manifest to build these machines to enable other manufacturers to do their best work.

## 2021