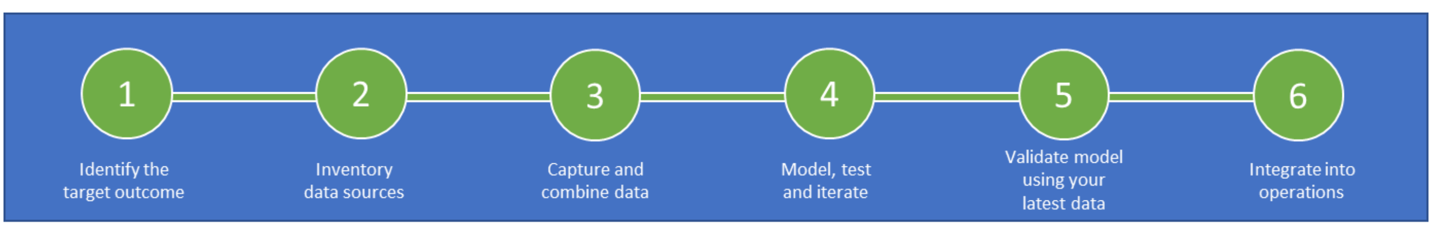
Realize the potential of IoT predictive maintenance solutions.

Imagine if you could predict equipment failures before they happen, and systematically prevent them. That's what predictive maintenance offers. It involves using data to identify warning signs of potential problems, predict when equipment needs maintenance and preemptively service that equipment before problems occur.



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1 Identify the target outcome

Start by figuring out the outcome you are looking to achieve – this determines the predictive question you need to answer, and helps you measure the success of your effort.

Decide what problem or opportunity you want to address | Outline the predictive question you want to answer | Determine the data that is likely needed to answer your question

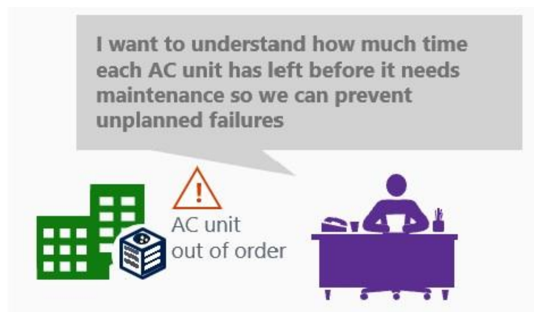
Common predictive questions include:

- Timing: How much time does the equipment have left until it fails?
- Probability: What is the probability of failure in (x) number of days or weeks?
- Cause: What is the likely cause of a given failure?
- Risk-level ranking: What equipment has the highest risk of failure?
- Maintenance recommendation: Given a certain error code and other conditions, what maintenance activity is most likely to solve the problem?

In determining a predictive question, it is important to consider the investment required to develop and operationalize a predictive model, and the projected benefits you'll see. This cost / benefit analysis will ensure you pursue a project that has business value.

With that in mind, what you predict must be something you can act on – otherwise, that prediction has no value. For example, predicting that an AC unit is going to fail in the next day is not useful if there is nothing you can do to prevent it.

The predictive question you want to answer will influence the types of data that are essential to have, and types of data that are optional. For instance, if you are looking to predict failure timing, it's not essential to have details on failure causes – although that data may still be very helpful.



2 Inventory data sources

Once you identify what you want to predict, determine whether you have the data needed to create a robust predictive model.

Determine available data sources | Identify how many historical examples you have | Evaluate whether you have the right types of data

Once you identify what you want to predict, determine whether you have the data needed to create a robust predictive model.
Start by understanding what data is available from different data sources. This can be structured or unstructured data and may come from internal systems or external parties.
Examples of relevant data include:

- Operating conditions – location, temperature, equipment operator, etc.
- Failure details – timing, weather, cause, etc.
- Repair history

Even if you think certain data will not be correlated with failure, it's useful to cast a wide net.

Next, assess whether your data will enable you to answer your original predictive question. This assessment involves determining whether you have:

- Necessary types of data
- Sufficient data

For example, you may want to predict causes of failure, but if your maintenance logs do not include failure cause details, building a predictive model could be challenging. Or, you may want to predict timing of failures, but you may not have enough historical failure data. A robust predictive model can require data on hundreds of failure instances.

Even with partial data, you can take advantage of other approaches, like anomaly detection, which involves monitoring to detect unusual trends and patterns.

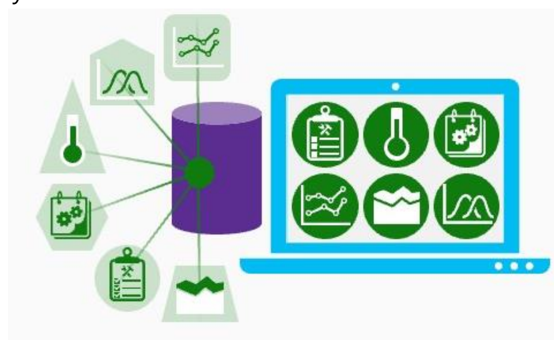
3 Capture and combine data

Now you're ready to lay the groundwork for predictive analysis.

Connect data into a consistent system and normalize it | Determine the relevant data for the problem you're trying to solve | Identify any gaps in the data

Now you're ready to lay the groundwork for predictive analysis.
This involves:

- Connecting data from different sources into a single, consistent system
  Since data may live in many different places, connecting it into a single, consistent system is a key step. In some cases, data may need to be moved, but in many cases it's a matter of connecting a data source to an analysis system. And since you are likely dealing with large volumes of data, it is important to use an analysis tool that can handle big data.



- Normalizing the data
  Normalizing data can take time but it is also critically important, especially if you are partially relying on anecdotal information from your repair teams. Normalizing data also helps to improve the accuracy and validity of your analysis.

Once your data is connected and normalized, re-assess what data may be relevant to the problem you want to solve and the type of answer you want to get.
While you can build a model based on incomplete data, this gap analysis will also inform you of future data points you want to collect.

4 Model, test and refine

With a defined problem and normalized data, the next step is to build a predictive model.

Develop statistical models | Stack-rank the models to determine the one that works best | Apply business context to evaluate the usefulness of modelling results

Your predictive analytics system should support big data and machine learning, as that will enable ongoing improvement of the model over time. As more and more data are collected, the system should be able to incorporate that new data, steadily improving the predictive power of the model.

- Start by analyzing data to identify meaningful patterns. This involves developing a set of statistical models using a subset of the data.
  As you analyze and model the data, it can be helpful to have a hypothesis you are testing. This will guide your thinking about what signals to focus on and will give you a baseline against which to evaluate the analytical results.
- Next, stank-rank the models, using the remaining data to determine which model is best at answering your predictive question.
  Remember that a model must be actionable for it to be useful, so analysis efforts should be firmly grounded in business context. For example, if your repair team needs 48 hours' notice for maintenance request fulfillment, an actionable model is one that predict failures more than 48 hours ahead of when they will occur.

Predictive modeling helps you identify conditions that indicate future equipment problems. With this information, you can adjust processes and systems to trigger preventative actions when those conditions occur. In other words, you can translate insights from the model into operational changes, which is where you see significant business value.

5 Use your latest data to validate the model

The true test of a predictive model is how well it predicts results in a live operational setting. Running a pilot is the recommended approach for validating a model's performance.

Apply your model to operational data | Revise your model based on findings

- Monitoring connected equipment
  To run an IoT-enabled predictive maintenance pilot, you need the ability to monitor equipment condition in near real time. In other words, your equipment needs to be connected and sending the latest operational data to the appropriate systems. That live data flow is what your model analyzes to detect problem signs and trigger alerts or preventative actions – like ordering a replacement part or scheduling a technician.
- Pilot planning
  Start by establishing the pilot scope, including equipment, systems and locations involved, scenarios to test, conditions under which to trigger an alert or action (e.g., automatic order of a replacement part), success measures and timing. There will be integration and configuration work needed to set trigger thresholds for alerts and actions.
- Applying your model and refining your results
  Connect your model with the relevant systems so it can begin analyzing streaming operational data and triggering alerts or activities. Using the findings from modeling, you should be able to set systems up (e.g., spare-parts system, service dispatch system) to alert or drive action when a given threshold condition is met.

Throughout the pilot, you will continuously gather new data that will help refine acceptable ranges and may also highlight new failure signals. Don't be afraid to adjust your approach based on what the latest operational data and analytics tell you – as more data is collected, advanced analytics and machine learning tools can hone your model using that data.

6 Integrate into operations

Once you've met pilot objectives and refined the model, you're ready for broader implementation.

Incorporate model into the appropriate processes and systems | Refine model based on any additional learnings | Identify operational areas for improvement. such as Inventory management, Repair schedules, Repair routes

- Operational improvements

  This will likely involve rolling out several operational changes, like a revised and/or dynamic repair schedule, or changing policies to prioritize immediate repairs when certain data exceeds a specified range. Because the operational change can be far-reaching, a phased approach is recommended so that incremental benefits can be realized.

  The operational improvements that can be made when rolling out a predictive maintenance approach are extensive – for example, you can:

  – Optimize what your repair crew is doing and when – adjust repair schedules and routes to reduce breakdowns and remove extra trips.

  – Alter your purchasing approach for spare parts so you don't need to hold excess inventory – a parts order can be triggered just in

  – Offer predictive-maintenance-as-a-service to capture annuity revenue and maintain ongoing relationships with your customers.

  These are just a few examples of how predictive maintenance enables you to increase efficiency, reduce costs and evolve your business.

- Ongoing benefits

  New benefits accrue as you incorporate new learnings and data to drive further improvements. For example, you may find new patterns in the data or acquire new sources of data that enable you to uncover more ways to create and sustain competitive advantage.

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Get started today

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[IoT Signals report]

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