2013

M2M Telematics & Predictive Analytics

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Contents

EXECUTIVE SUMMARY

Number of machine-to-machine (M2M) device connections world-wide is expected to grow from 130 million in 2012 to 2.14 billion by 2021, while the total world-wide M2M management market is expected to grow from USD459 million in 2012 to USD1.1 billion in 2016 at 23% CAGR (Figure 1).

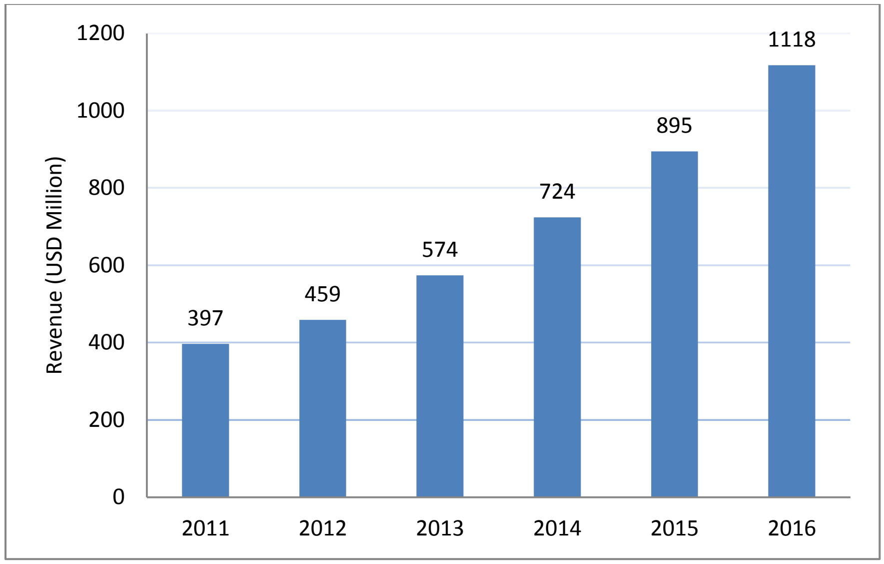


FIGURE 1 M2M MANAGEMENT MARKET FORECAST (SOURCE: ANALYSYS MASON, 2012)

CSPs are actively exploring opportunities for providing M2M solutions to industry sectors such as automotive and transport, energy and utilities, security and surveillance, public safety, financial services, retail, healthcare, and warehousing and distribution.

- Automotive:
  - Vehicle & Asset Tracking: Real-time GPS/GSM evaluation and tracking
  - Fleet management: Real-time predictive maintenance, inventory control, optimal work-schedules
  - Eco-routing: Real-time traffic monitoring systems for vehicle efficiency and passenger safety with cooperative M2M interactions
- Healthcare:
  - Telemedicine: Health monitoring and remote medicine administration
  - Assisted Living: Supportive sensor aids and safety guides
- Retail:
  - Match sales: Real-time auctioning for buyer's basket
  - Supply chain monitoring: Real-time environment conditions of goods, location tracking
  - Connected cabinets: Real-time stock level display, revenue reports, targeted advertising
- Finance:
  - Usage-based Insurance Services
- Energy & Utilities:

- Smart Grid: Real-time network optimization with demand based generation, load-based distribution and smart metering capabilities
- Monitoring & Control: Remote monitoring operational metrics, such as pipeline pressure, temperature etc.

As the global energy usage continues to surge, the confluence of M2M telematics and real-time analytics is the key for delivering green solutions.

Take an example of electric vehicle (EV) that you drive home and connect to the electric grid, letting it figure out your next commute requirement from the calendar appointments on your hand-held or mobile, and your grid's active load usage and non-peak hours from the energy provider, all summed up to auto-tune its own recharging schedule to reduce the load on grid while taking into account any emergency commutes that might be required based on your personal commute history and your associations – computed all without the need for slightest manual intervention, that's M2M Telematics hand-in-hand with real-time analytics at work.

Intelligent devices, such as the EV presented above, are the promise of M2M. On a broader note, the machine-to-machine (M2M) communication operations include both, intelligent control of remote machine parts (telematics) and remote measurement of various sensor readings (telemetry). A typical definition of M2M in mobile space is, machines using network resources to communicate with remote application infrastructure for monitoring and control, either of the machine itself or its surrounding environment.

The possibility of having billions of devices being uniquely addressable with IPV6 (Internet Protocol version 6), the advent of seamless wireless communications with improved standardization and broadband signal capabilities, and the onslaught of real-time analytics on commodity hardware with large data sets being processed in parallel – all are contributing to the success of M2M telematics systems with real-time predictive analytic capabilities. A typical architecture of such a system reads as shown in Figure 2.

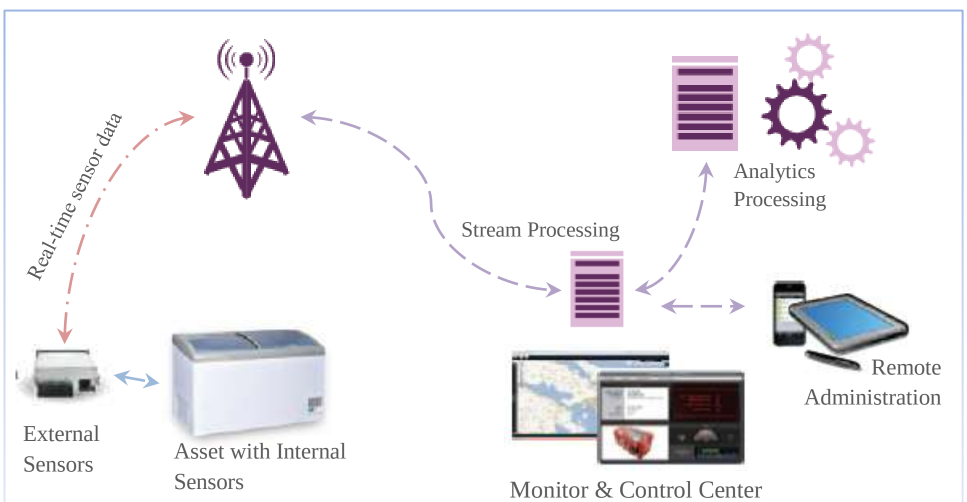


FIGURE 2 M2M TELEMATICS WITH PREDICTIVE ANALYTICS SYSTEM

M2M Drivers

Key drivers for M2M initiatives are as below:

- Telematics and telemetry are increasingly being perceived as sources of greater operational efficiency and cost reduction.
    - Automated monitoring of heating, ventilation and cooling are few driving factors for *smart buildings*
    - Street lights that operate based on traffic flow, alternate automatic routing based on peak-hours etc. are driving factors for *smart cities*
    - Predictive maintenance through improved system monitoring, remote monitoring of farms and mining operations etc. are cost saving factors
- Regulatory requirements for safety and energy efficiency are pushing the utility sector and automotive industries to use innovative ways of M2M methods
    - Emergency calling, accident alerts, cooperative driving etc. are compelling factors for automotive industry
    - *Smart meters* and energy demand response are driving factors for Utilities industry
- Standardization and adaptation of IPV6 across industry has opened the possibility for billions of uniquely addressable IP devices
- Wide rollout of 3G and LTE networks are providing devices with *always on* connectivity and increased bandwidth enabling M2M segment applications such as remote surveillance, asset tracker, health meters etc.
- Smart application development is creating new opportunities for application developers to build applications for every possible segment, right from smart homes to smart amenities
- Innovations in the retail and consumer electronics segment are pushing the boundaries of connectivity, with applications such as wireless payments to connected satellite navigation systems

The electronics and communications industry is rapidly moving towards intelligent, addressable, embeddable devices enabling seamless communications between every device. Following sections describe the embedded and mobile based telematics trends and the potential revenue opportunities, followed by a sector-focus case study.

Embedded Telematics Trends

	Key Information	Remarks
2.5G GPRS	- Dominant embedded technology in Europe	- New systems should be using 3G
3G CDMA	- CDMA2000 is dominant in USA - Europe is moving to WCDMA	- Also used in Japan, Korea and China - eCall may use either GPRS or WCDMA
3.5G HSPA	- New systems are evolving rapidly on HSPA	- Available in Europe for Luxury cars
4G LTE	- Industry wide deployments are expected to be available by 2015	- May be year earlier for Luxury brands

In summary, embedded telematics are likely to continue using 3G and 3.5G technologies until 2015 in the developed countries, and even longer in other areas. LTE is expected to become mainstream 4G technology for mobile phone industry and auto-industry. WiMax missed its opportunity to become mainstream technology, but will become a niche player in most regions.

Mobile Device Telematics Trends

Mobile device telematics leverage operator's mobile phone to establish communication between instrument and the monitoring station. Predominantly used in vehicles and automobiles, driven by the need for hands-free interface (HFI). The trends are:

	Key Information	Remarks
Mobile Phone HFI	- Available for long time by OEMs	- Initially wired, then Bluetooth
Telematics Service	- Evolving as a popular telematics approach - Primarily for infotainment services	- Popularized by Ford SYNC success - Lower reliability than embedded link
Telematics Service & Smartphone Apps	- Leverage wealth of auto-related smart Apps - Smart phone to H-U apps integration emerging	- Likely to become necessity by 2015 timeframe - Need for technology solutions to lower driver distraction

Some of the prominent market implementations for automobile telematics in North America segment are:

OEM	Service	Features	Launch	Technology
GM	OnStar/MyLink/IntelliLink/CUE	eCall/bCall, SVR, Vehicle Slow Down, Google, Mobile App	1996	Embedded/ Mobile Device
BMW	ConnectDrive / BMW Assist	eCall/bCall, Concierge, Lock/Unlock, Diagnostics, Google Services, Tracking, Full Browsing, Mobile Apps, Traffic	2001	Embedded/ Mobile Device
Ford	Sync/ MyFord Touch / MyFord Mobile	eCall/bCall, Navigation, Weather, Traffic, Mobile Apps, Live Operator	2007	Embedded/ Mobile Device
Toyota	Safety Connect / Entune	SOS/ACN, Roadside Assistance, Stolen Vehicle Location, Entune	2009	Embedded/ Mobile Device
Audi	Audi Connect	Navigation, Weather, Gas prices, Travel Info, News, Wi-Fi Hotspot	2011	Embedded
Mercedes	mBrace	eCall/bCall, SVR, Crisis Assist, Google Send to Car, Traffic, Weather, Concierge, Lock/Unlock, Car Finder, Diagnostics, Mobile App	2011	Embedded
Nissan	Nissan CarWings	Charge Levels, Charging Stations, Comparison of Drivers, Google Send to Car	2011	Embedded
Hyundai	Blue Link	Navi, eCall/bCall, Weather,	2011	Embedded

		Traffic, POI Voice Rec, Geo Fence, SVR, Diagnostics, Mobile App	

Despite the present and emerging mobile connectivity trend, embedded wireless modules are expected to grow significantly, mainly due to the stringent quality requirements and reliability standards that hand-held devices fail to meet adequately.

Tight automotive requirements are also expected to be in place to sustain the growth of safety and security critical equipment that will be mandated by government regulations, such as eCall in Europe. The European eCall regulations will in fact force all new vehicles by 2015 to adapt a connectivity link for emergency call.

The reality is that regulations such as eCall will give raise to further significant demand for telematics, enabling several additional services to be layered on top of basic emergency call. Some of the potential applications on those lines are:

- Remote Diagnostics
- Remote Vehicle Control
- Vehicle Software Upgrade
- Electronic Toll Collection
- Eco-Driving
- Off-Board Navigation
- Smart Traffic Control
- Usage-based Insurance Services
- Condition-based Maintenance etc.

It is the combination of Telematics with Predictive Analytics on Real-time Big Data that makes many of these innovations, such as smart traffic control, usage-based insurance, condition-based maintenance etc… possible, and smart players are already reaping enormous benefits by employing these in their strategic offerings.

The following sections present an in-depth review on a sector-focus case-study, namely Condition-based maintenance, describing how predictive analytics and telematics are working together to reduce maintenance costs.

Predictive Maintenance

Maintenance, considered as a non-value add function, is ever more requested to contribute higher and higher for costs reduction, keeping the machines in excellent working condition, while satisfying the stringent safety and operational requirements. Manufacturers and operators employ array of maintenance strategies to address that, all of which can be broadly categorized as below:

- Corrective Maintenance
- Preventive Maintenance
- Predictive Maintenance

Corrective maintenance is the classic *Run-to-Failure* reactive maintenance that has no special maintenance plan in place. The machine is *assumed* to be fit unless proven otherwise.

> "… In many cases, scheduled overhaul increases the overall failure rate by introducing a high infant mortality rate into an otherwise stable system…"
>
> - RCM Guide, NASA

- Cons:
    - High risk of collateral damage and secondary failure
    - High production downtime
    - Overtime labor and high cost of spare parts
- Pros:
    - Machines are not *over-maintained*
    - No overhead of *condition monitoring* or planning costs

Preventive maintenance (PM) is the popular *periodic maintenance* strategy that is actively employed by all manufacturers and operators in the industry today. An optimal breakdown window is pre-calculated (at the time of component design or installation, based on a wide range of models describing the degradation process of equipment, cost structure and admissible maintenance etc.), and a preventive maintenance schedule is laid out. Maintenance is carried-out on those periodic intervals, *assuming* that the machine is *going to break* otherwise.

- Cons:
    - Calendar-based maintenance: Machines are repaired when there are no faults
    - There will still be *unscheduled* breakdowns
- Pros:
    - Fewer catastrophic failures and lesser collateral damage
    - Greater control over spare-parts and inventory
    - Maintenance is performed in controlled manner, with a rough estimate of costs well-known ahead of time

Predictive Maintenance (PdM) is an emerging alternative to the above two that employs predictive analytics over real-time data collected (streamed) from parts of the machine to a centralized processor that detects variations in the functional parameters and detects anomalies that can potentially lead to breakdowns. The real-time nature of the analytics helps identify the functional breakdowns long before they happen but soon after their potential cause arises.

> "… Preventive maintenance is how fleets attempt to avoid breakdowns today. But new thinking is moving towards predictive repairs, transforming time-or mileage-based model with one that is based on evidence of need…"

- Pros:
    - Unexpected breakdown is reduced or even completely eliminated
    - Parts are ordered when needed and maintenance performed when convenient
    - Equipment life is maximized
- Cons:
    - High investment costs
    - Additional skills might be required

Predictive maintenance, also known as Condition Based Maintenance (CBM) differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule.

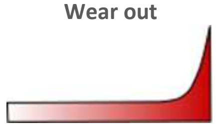
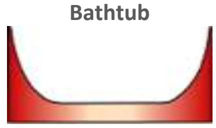
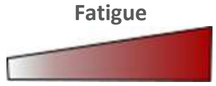
For example, a typical preventive maintenance strategy demands automobile operators to change the engine oil after every 3,000 to 5,000 Miles traveled. No concern is given to the actual condition of vehicle or performance capability of the oil.

If on the other hand, the operator has some way of knowing or somehow measuring the actual condition of the vehicle and the oil lubrication properties, he/she gains the potential to extend the vehicle usage and postpone oil change until the vehicle has traveled 10,000 Miles, or perhaps pre-pone the oil change in case of any abnormality.

Predictive analytics with M2M telematics provides such deep insights into the machine operations and full functionality status – giving rise to optimal maintenance schedules with improved machine availability.

Underlying preventive maintenance is the popular belief that machine failures are directly related to machine operating age, which studies indicate not to be true always. Failures are not always linear in nature. Studies indicate that 89% of the problems are random with no direct relation to the age. Table 1 showcases some of these well-known failure patterns and their conditional probability (Y-axis) with respect to Time (X-axis).

TABLE 1 FAILURE CONDITIONAL PROBABILITY CURVES (SOURCE: JOHN MOUBRAY, NOWLAN & HEAP)

Age-Related = 11%	Random = 89%
Wear out  Type A = 2%	Infant Mortality  Type B = 68%
Bathtub  Type E = 4%	Initial Break-in Period  Type C = 7%
Fatigue  Type F = 5%	Relatively Constant  Type D = 14%

"Predictive analytics help reduce over-maintenance, decrease operational costs and maximize equipment availability"

Complex items frequently demonstrate some infant mortality, after which their failure probability either increases gradually or remains constant, and a marked wear-out age is not common. Considering this fact, the chance of a preventive maintenance avoiding a potential failure is low, as there is every possibility that the system can fail right after a scheduled maintenance. Thus, preventive maintenance imposes additional costs of repair. Predictive Maintenance reduces such additional costs by scheduling maintenance if and only when a potential breakdown symptom is identified.

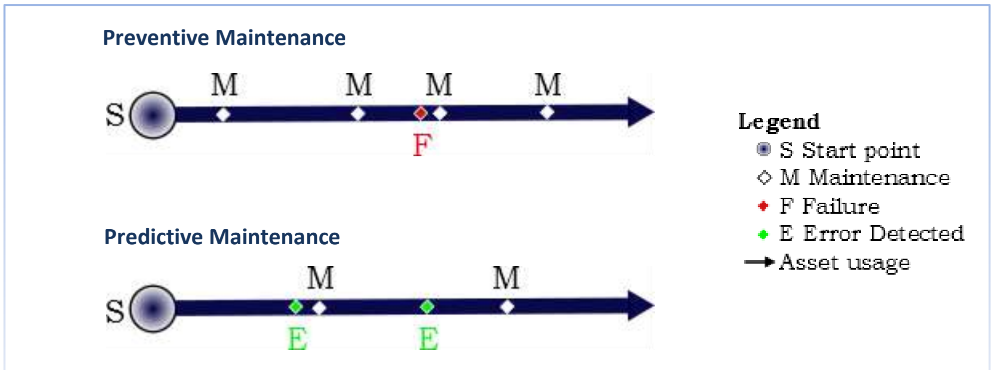


FIGURE 3 PREDICTIVE MAINTENANCE SCHEDULES ARE SMARTER AND CONVENIENT

However, the costs of monitoring equipment and monitoring operations should not exceed the original asset replacement costs; lest the whole point of Predictive Maintenance becomes moot. Studies have estimated that a properly functioning CBM program can provide savings of 8% to 12% over the traditional maintenance schemes. Independent surveys indicate the following industrial average savings resultant from initiation of a functional predictive maintenance program:

- Reduction in maintenance costs: 25% to 30%
- Elimination of breakdowns: 70% to 75%
- Reduction in equipment or process downtime: 35% to 45%
- Increase in production: 20% to 25%

Apart from the above, improved worker and environment safety, increased component availability, better product quality etc. are making more and more manufacturers and operators embrace CBM based management solutions.

SOLUTION ENABLERS

Predictive Maintenance or Condition-Based-Maintenance Management (CBMM) solution is enabled by three major technology enhancements over a traditional maintenance schedule:

1. Remote Sensor Monitoring & Data Capturing
2. Real-time Stream Processing of Sensor Data
3. Predictive Analytics

“…Predictive technology does not avoid failures – rather what it avoids is the high-costs associated with the failures, by providing early warnings of the failures so that operators can decide when and where to address them before they actually happen”

CBMM solutions essentially operate by having sensors attached to remote assets (mobile or stationary) that send continuous streams of data about the assets' operational conditions to a monitoring station that then analyzes them in real-time using predictive analytic models and detects any problems in the behavior or state of the asset. Once a problem is detected, appropriate pre-configured action is taken to notify the operator or manufacture for corrective action. The monitoring station in question can be on the same network as that of the sensors or it could be in a remote location far away from them, connected through wide area networks or satellite networks.

Nature of the sensors being monitored, frequency of the data getting collected and precision of the analytic models being used – all affect the quality of the prediction results. Thus, it is imperative that manufacturers and operators define all these parameters with utmost care while deploying a condition-based-maintenance management system. This, however, entails a thorough understanding of the system under operation and expects a clear-cut answer as to what is being monitored and what is expected out of such monitoring. Some of the questions that can help manufacturers and operators along those lines are:

For monitoring:

- Which parts of the system or asset are expected to be monitored?
- What type of data is expected to be collected and which type of sensors give such data? For example, visual data, thermal data etc.
- What is the expected frequency for the data collection?
- How should any failures in the sensors be handled?

For real-time stream collection and processing at the monitoring station:

- What is the acceptable data processing latency?
- How to deal with imperfections in the received data? For example, a faulty sensor sending incorrect data
- What should be done with the collected data after processing?

For Analytics sub-system:

- Which analysis technique accurately models the asset/system behavior?
- What is the definition of *acceptable* behavior and *anomaly*?
- What should be the response in case of any anomaly detection?
- What should be the reasonable timeframe between anomaly detection and corrective action?
- How to deal with situations where there are multiple anomalies detected at the same time?

Generic and security related questions:

- Who should be allowed to access the collected data and analysis results?

- What is the change management process required in case one wants to tune the tracking and analysis parameters?

The following section briefly summarizes some of the industry standard methods used in CBMM systems and can help in answering the above questions.

THE METHODOLOGY

The primary component in a condition-based-monitoring management solution is a sensor array and the measurements it provide. Some of the widely used measurement techniques in the industry are:

- Temperature Measurement: Thermal indicators, such as temperature-sensitive paint, thermography etc., help detect potential failures arising out of temperature changes in the equipment. Excessive mechanical friction, degraded heat transfer, poor electrical connections are some of the problems that can be detected with this type of measurement.

Method	Description	Applications
Point Temperature	A thermocouple or RTD	Can be used on all accessible surfaces
Area Pyrometer	IR radiation measured from a surface, often with laser sight	Good for walk around temperature checks on machines and panels
Temperature Paint	Chemical indicators calibrated to change colors at specified temperature	Works great for inspection rounds
Thermography	Handheld still or video camera sensitive to emitted IR	Best for remote monitoring. Requires good training

- Dynamic Monitoring: Spectrum analysis, shock pulse analysis are some of the dynamic monitoring methods that measure and analyze energy emitted from mechanical equipment in the form of waves, vibration, pulses and acoustic effects. Wear and tear, imbalance, misalignment and internal surface damage are some of the problems that can be detected with this type of measurement.

Method	Description	Applications
ISO Filtered velocity	2Hz-1kHz filtered velocity	A general condition indicator
SPM	Carpet and Peak related to demodulation of sensor resonance around 30kHz	Single value bearing indicator method
Acoustic Emission	Distress & dB, demodulates a 100kHz carrier sensitive to stress waves	Better indicator than ISO velocity, without the ISO comfort zone
Vibration Meters	Combine velocity, bearing and acceleration techniques	ISO Velocity, envelope and high frequency acceleration give best performance
4-20mA sensors	Filter data converted to DCS/PLC compatible signal	Useful to home-in on specific problems by special order

- Fluid Analysis: Ferrography, particle counter testing are some of the fluid analysis methods performed on different types of oils, such as lubrication, hydraulic, insulation oil etc., to identify any potential problems of wear and tear in the machines. Machine degradation, oil contamination, improper oil consistency, oil deterioration are some of the problems that can be detected with this method. The main areas of analysis in this are:
    - Fluid physical properties: Viscosity, appearance
    - Fluid chemical properties: TBN, TAN, additives, contamination, % water
    - Fluid contamination: ISO cleanliness, Ferrography, Spectroscopy, dissolved gases
    - Machine health: Wear metals associated with plant components
- Corrosion Monitoring: Methods such as Coupon testing, Corrometer testing help identify the extent of corrosion, corrosion rate and state (active/passive corrosion) for the materials used in the asset.
- Non-destructive Testing: Involves using non-destructive methods, such as X-Rays, ultrasonic etc., to detect any potential anomalies arising internal to the asset structure. Most of these tests can be performed while the asset is online and being used
- Electrical testing and Monitoring: High potential testing, power signal analysis are some of the prominent electrical condition monitoring mechanisms that try to identify any changes in the system properties, such as resistance, conductivity, dielectric strength and potential. Electrical insulation deterioration, broken motor rotor bars and shorted motor stator lamination etc. are some of the problems that can be detected with this type of mechanism
- Observation and Surveillance: Visual, audio and touch inspection criteria are some of the surveillance condition monitoring techniques based on the human sensory capabilities. They act as supplement to other condition-monitoring techniques and help detect problems such as loose/worn parts, leaking equipment, poor electrical and pipe connections, stream leaks, pressure relief valve leaks and surface roughness changes etc.

Once the appropriate measurement mechanisms are in place, the next step is the event definition phase: to define what constitutes an *acceptable* system behavior and what is to be considered as *anomaly*. It is useless to put costly monitoring equipment in place, without knowing what to expect out of it. Expert opinion and judgment (such as manufacturer's recommendations), published information (such as case studies), historical data etc. are some of the good sources that can help in this task. The definition of *anomaly* should be unambiguous and easy to detect. If the cost of anomaly detection far exceeds the costs of consequences of that anomaly, then it is not a valid scenario for implementing CBM.

The next step that follows the event definition phase is, determining event inspection frequency. Frequency of any of form of condition-based-maintenance is based on the fact that most failures do not occur instantaneously, and that it is often possible to detect them during their final stages of deterioration. If evidence can be found that something is in the final stages of failure, it is possible to take action for preventing it from failing completely and/or avoid the consequences.

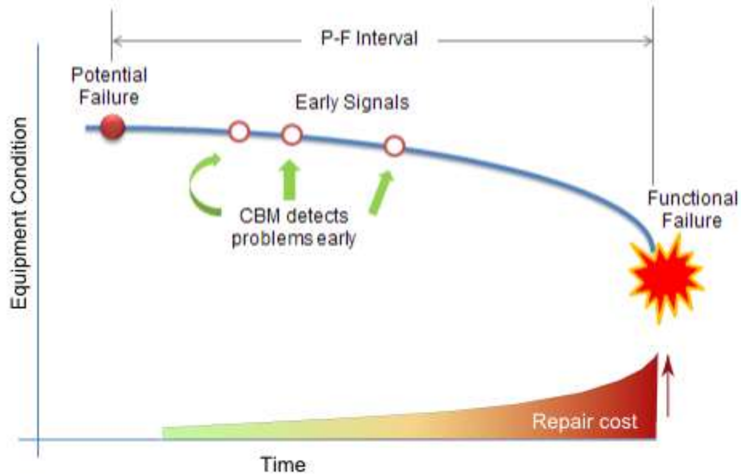


FIGURE 4 MEASUREMENT FREQUENCIES CAN BE DETERMINED WITH P-F INTERVAL

The failure behavior typically exhibited by majority of the systems in operation is as showcased in Figure 4. During operation, over a period of time, the systems enter a phase of potential failure (P), and start displaying few early signs of wear & tear and other stressful behaviors that if neglected finally lead to full functional failure (F). For most of the systems the time interval between the potential failure point (P) and full function failure (F) is large enough to allow detection and prevention of the failure.

This time gap between P and F is what is popularly known as the *P-F Interval* in the literature, and any cost-effective maintenance strategy should try to maximize on it. The P-F Interval could be in hours or days, or even weeks or months, based on the complexity of the system and the unit of measurement - for it is not uncommon to see the P-F Interval being measured in non-time units, such as stop-start cycles or units of output etc. Based on the failure mode and the unit of measurement, the P-F Interval can end up varying from fractions of a second to several decades (on temporal scale).

Be whatever the unit of measurement and the P-F interval, a successful CBMM system should be capable of detecting the early signals after P and respond to them long before F. The response action typically consists of multiple steps (as laid out below) and should all be accompanied within the P-F interval.

1. Analyzing the root-cause based on detected early signals
2. Planning corrective action based on the analyzed root-cause
3. Organizing the resources to implement the laid out plan
4. Actual implementation of the corrective action plan

The amount of time needed for these response actions usually vary, from a matter of hours (e.g. until the end of operating cycle or end of shift), minutes (e.g. to clear people from a failing building), to weeks or even months (e.g. until a major shutdown).

Thus, it is a common practice to use the inspection interval to be half the P-F interval. This will ensure that there is at-least half the P-F interval remaining after the potential-failure detection for corrective action plan. However, it should be noted that most of the times earlier the corrective action plans are implemented, lower the cost – in which cases, some other smaller fraction of P-F interval can be used as the inspection interval, so that potential problems can be detected as early as possible and rectified.

However, an important point to be remembered is P-F interval is not an easy metric to be computed. It varies from asset type to asset type, environment to environment and even from one asset to another with in the same asset type (based on its previous fault history and working conditions). Understanding the failure patterns, and identifying the class of pattern to which the asset belongs, its past fault history, manufacturer's recommendations, operating conditions, expert judgment etc. are some of the sources that can help in arriving at an accurate P-F interval for any given asset/system.

At each inspection interval, the CBMM system collects data from sensors and uses one of the following methods to determine the condition of the asset being monitored:

- Trend Analysis: Reviews the data to find if the asset being monitored is on an obvious and immediate *downward* slide toward failure. Typically a minimum of three monitoring points are recommended for arriving at a trend accurately as a reliable measure to find if the condition is deprecating linearly.
- Pattern recognition: Decodes the causal relations between certain type of events and machine failures. For example, after being used for a certain product run, one of the components used in the asset fails due to stresses that are unique to that run
- Critical range and limits: Tests to verify if the data is within a critical range limit (set by professional intuition)
- Statistical process analysis: Existing failure record data (retrieved from warranty claims, data archives and case-study histories) is driven through analytical procedures to find an accurate model for the failure curves and the new data is compared against those models to identify any potential failures.

Based on the failure mode and asset class the right method for the prediction can vary. For example, assets that fall into type E class (bathtub pattern) usually benefit from Weibull distribution, while split system approach is used for complex systems with multiple sub-systems.

Stream processing the arriving data can help build the trend analysis and critical range limits, but to accurately process pattern recognition and statistical model building methods, past history data is as important as the new arriving data. Thus, typically CBM management systems should keep record of old data for some reasonable amount of time before they are archived or destroyed. This time period varies from domain to domain and may even be regulated by local country laws. For example, financial fraud records may need to be kept active for longer time, in the range of 7 to 15 years per se, while flight records generated from airplane internal sensors are typically discarded after the journey completion (primarily due to it being voluminous, though this trend could soon change as the big data warehousing gets more prominent).

Another reason the old data streams become important is to identify any potential *outliers* in the streamed-in data from the sensors. While monitoring for the faults in the assets, it is possible that the sensor that is taking the readings, being a machine itself, could fail and start sending faulty records. Intelligent CBM management systems capable of detecting such outliers will try to isolate these faulty sensors and notify the appropriate personal for corrective action, or substitute it with proper estimated data based on previous records. In either case, human inspection is as much necessary as a completely automated monitoring system – for automation only complements the human surveillance efforts, not replace them. Thus, many automated monitoring systems provide a way for manual override for configurable parts of their functionality.

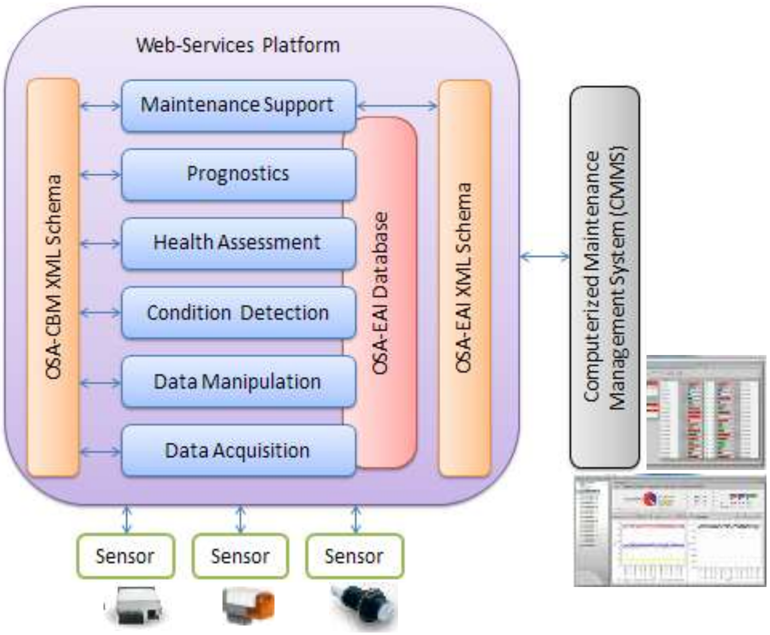


FIGURE 5 CBM MANAGEMENT SYSTEM ARCHITECTURE

Typically a CBM management solution will have an administrative console that lets the operators define and update various parameters, such as the critical limits, response notifications, default corrective actions etc. Advanced management systems also allow the administrators to access the monitoring solution functionality remotely through web UI and mobile UI, capable of sending periodic digests weekly or monthly for pre-configured stake-holders reporting the status of the asset being monitored on a regular basis. With architectures like the one shown in Figure 5 and common interface standards such as IEEE 1451, IEEE 1232, MIMOSA and OSA-CBM, advanced management systems integrations become possible among disparate software and hardware components from different vendors, all working hard together just for one single purpose – to provide the operators maximum usage out of their assets.

BEST PRACTICES GUIDELINES

Here are few guidelines that can help in formulating the best practices for maintenance strategies:

- Try organizing and reviewing repair tasks in cost descending order.
- Since planned component replacement is less costly than unscheduled repair visits, review maintenance costs by apparatus class and repair task for improvement.
- In case of fleet management, read work order comments for specifics regarding repairs and note the mileage. Take into consideration the environment where the vehicle works as the terrain or weather may affect maintenance.
- Review current component brands' performance. A different brand or a higher quality of the same brand may last longer.
- Investigate each repair task in detail before taking action. Ensure that every action taken will further reduce maintenance costs and downtime.

- After instituting changes, track repairs to validate anticipated results and document the cost savings. Share the cost savings with all involved personnel to improve relationships and foster a team approach for a good management practice.
- Look for similarities on specific components that may indicate design flaws or the need for additional technician training. Frequent breakdowns on specific units can indicate abuse or poor operator practices. Look for opportunities to lower maintenance costs and at the same time improve repair practices and operator care.
- One of the highest maintenance costs for fleets is tires; therefore, take time researching this expense. The right quality tire for the job function will make a difference. Make sure tire ratings are correct for the weight of the vehicle fully loaded. Consider the tread design, ply rating, composition, and heat rating.
- Review service calls, breakdowns, and towing expenses for possible predictive maintenance by unit and cause by month. Note that it incurs additional costs to dispatch a vendor or an employee to perform on-site repairs or towing units to a repair facility. As instances are reviewed and appropriate action is taken, the number of such instances should decrease, thereby reducing maintenance costs.

Concluding Remarks

Emergence of uniquely addressable embeddable devices has raised the bar on M2M capabilities. Though the technology itself is not new, its application has been quite limited until now. M2M technologies generate volumes of data that are orders of magnitude larger than what operators have dealt with previously. Real-time big data computation capabilities have opened the flood gates for creating new predictive analytics capabilities into an otherwise simple data log systems, enabling real-time control and monitoring to take preventive action in case of any anomalies. Condition-based-maintenance, usage-based-insurance, smart metering and demand-based load generation etc. are some of the predictive analytics use cases for M2M. The possibilities are rich and early players are reaping the benefits through cost-savings and innovative service offerings.

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About Author

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