



THE 40 YEAR TURBINE: AN ATTAINABLE GOAL FOR OUR INDUSTRY?

PERSPECTIVES FROM
WIND OPERATIONS AND MAINTENANCE PROFESSIONALS



PERSPECTIVES ON TURBINE LONGEVITY AND OTHER O&M CHALLENGES

We surveyed 170 professionals at the 2016 AWEA Wind Project O&M and Safety Conference in order to understand the issues and opportunities facing our industry. Participants included Wind Project Owners, Service Providers, OEM's, and Suppliers.

We learned that Project Owners not only have a strong interest in best maintaining their turbines, but also in extending turbine lives beyond their common life expectancy. This led us to ask, "Is a '40-Year Turbine' an attainable goal for our industry?"

Professionals identified many strategies that can help extend turbine life and reduce ongoing O&M costs. We are pleased to share with you insights from today's O&M professionals.

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THE 40 YEAR TURBINE

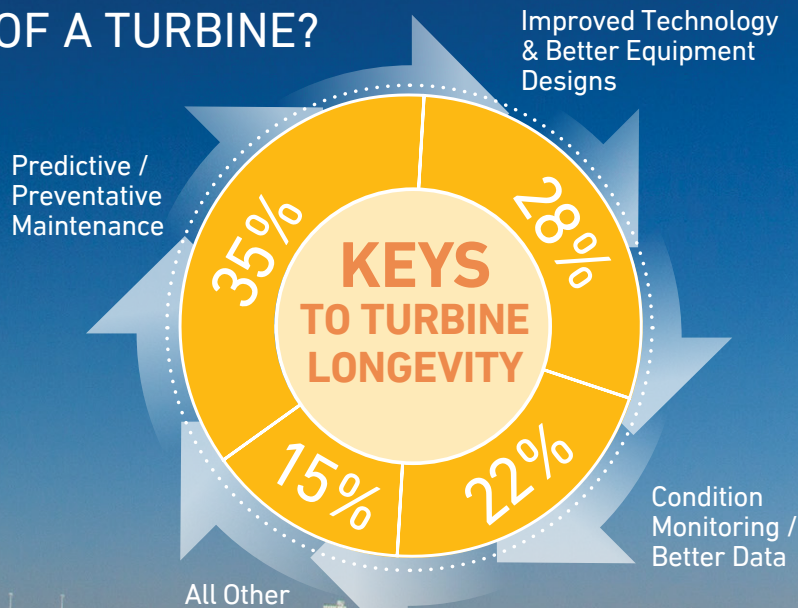
CHALLENGING WHAT'S POSSIBLE FOR **TURBINE LONGEVITY**

82% of WIND FARM OWNERS

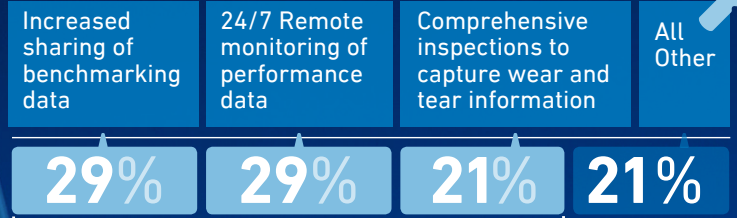
WILL **REFURBISH & MODIFY** TURBINES to **EXTEND UTILIZATION** beyond life expectancy

HOW CAN WE:

PROLONG THE LIFE OF A TURBINE?



WHAT HAS THE **BIGGEST BENEFIT** TO MAINTENANCE EFFORTS**



DATA RELATED RESPONSES

*% of Owner responses

CHALLENGE: Life expectancy is CURRENTLY LOW for several key turbine components.

- Gearbox 9 yrs
- Generator 11 yrs
- Blades 13 yrs
- Overall Turbine . . . 21 yrs

WIND ENERGY

* Coded responses to Owner open-ended answers

** Survey participant expectations based on knowledge / experience

What's Next in Energy. SM

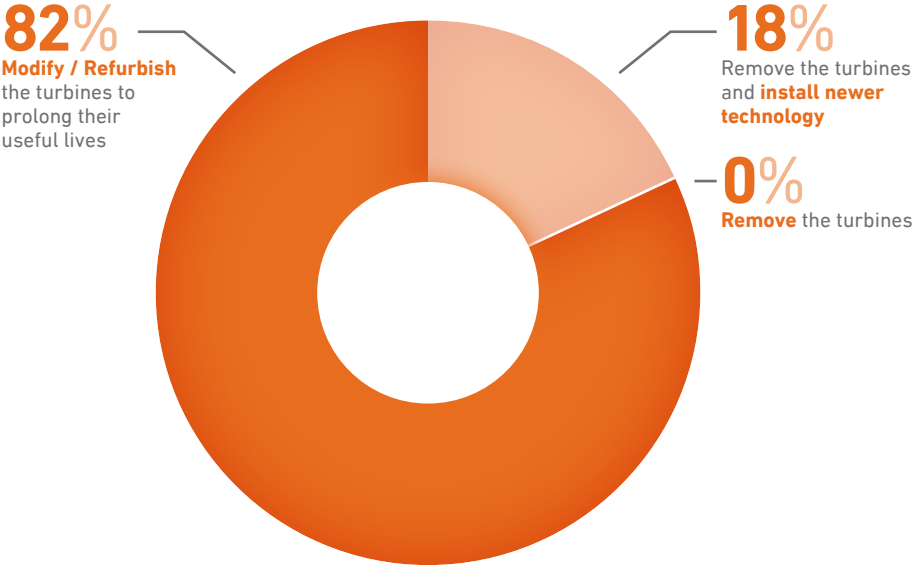


OWNER INTENTIONS: MAINTAIN ASSETS WELL INTO THE FUTURE

Wind owners have an overwhelming interest in prolonging the useful lives of their turbines beyond current operational life expectancies.

WHAT DOES YOUR COMPANY INTEND TO DO WHEN YOUR TURBINES REACH THEIR LIFE EXPECTANCY OR NEED TO BE DECOMMISSIONED?

OWNER RESPONSES



THE CHALLENGE: COMPONENT AND INFRASTRUCTURE FAILURE

THE PROLONGED, COST EFFECTIVE OPERATION OF TURBINES DEPENDS ON FINDING WAYS TO **MINIMIZE THE EXPENSE AND DOWNTIME** CAUSED BY VARIOUS COMPONENT FAILURES. O&M PROFESSIONALS HAVE RELATIVELY LOW EXPECTATIONS FOR HOW LONG CERTAIN KEY TURBINE COMPONENTS WILL LAST. .

BASED ON YOUR KNOWLEDGE OR EXPERIENCE, HOW LONG WILL THE FOLLOWING LAST BEFORE **NEEDING MAJOR REPAIRS OR REPLACEMENT?**



Gearbox



Generator



Blades



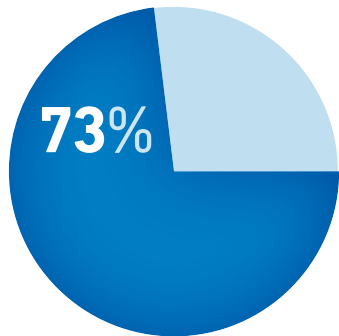
Overall Turbine

AVERAGE OF RESPONSES



THE CHALLENGE: COMPONENT AND INFRASTRUCTURE FAILURE

Nearly three-quarters of Owners are concerned about future Balance of Plant (BOP) issues



This is true even though most Owners stated that BOP issues have been modest to date. BOP infrastructure is typically designed to last 20-25 years. Like components, operation of turbines beyond their common life expectancy depends on finding effective ways to maintain BOP infrastructure.

WHEN ASKED TO NAME THE **LARGEST REASON FOR BUDGET OVERRUNS...**

NEARLY 60%

of owners said unscheduled repairs and failures

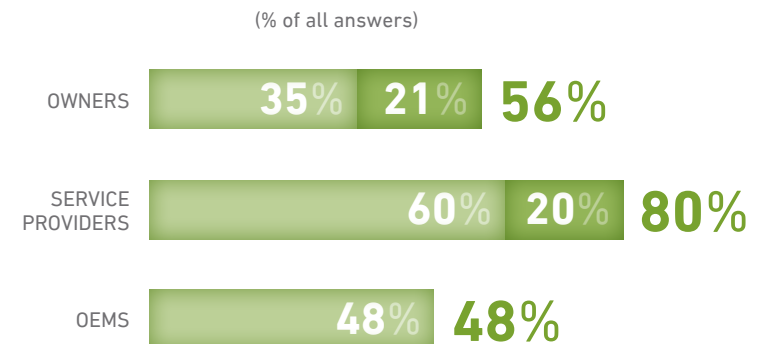


THE BEST WAYS TO PROLONG TURBINE LIFE: PREVENTATIVE AND PREDICTIVE MAINTENANCE

WHEN ASKED WHAT WOULD BEST PROLONG TURBINE LIFE, PROFESSIONALS MENTIONED PREVENTATIVE AND / OR PREDICTIVE MAINTENANCE MORE THAN ANYTHING ELSE.

HOW CAN WE AS AN INDUSTRY BEST PROLONG THE LIFE OF A TURBINE?*

- Preventative / Predictive Maintenance
- Condition Monitoring / Better Data



*Coded answers to an open-ended question.



THE BEST WAYS TO PROLONG TURBINE LIFE: PREVENTATIVE AND PREDICTIVE MAINTENANCE

CONDITION MONITORING, AND THE VALUABLE DATA IT GENERATES, ARE SEEN AS ESSENTIAL TO IMPROVING PREVENTATIVE MAINTENANCE EFFORTS.

SELECT COMMENTS ON HOW TO BEST PROLONG TURBINE LIFE:

- “ As an industry, we need better monitoring and better proactive maintenance.”
- “ We must proactively inspect and maintain concerns before they warrant complete replacements.”
- “ Continuous monitoring of large components.”
- “ We should adopt more predictive, conditioned based reliability programs.”
- “ We need more predictive maintenance based on data review.”
- “ Data, data, data! Early planning and implementation of risk based inspections.”



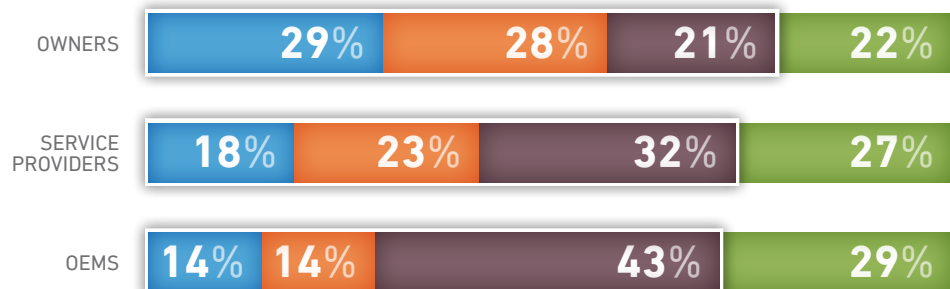
DEVELOP AND UTILIZE DATA FROM A VARIETY OF SOURCES

Data / information strategies –including condition monitoring – are seen as valuable, but also largely lacking today.

WHAT MAINTENANCE STRATEGY WOULD BRING THE GREATEST BENEFIT TO OUR INDUSTRY IF MORE BROADLY ADOPTED?

Data / Information strategies

- 24/7 Remote Monitoring of Performance Data
- Sharing of benchmarking data (turbine, drivetrain, windfarm, etc.)
- Comprehensive field inspections to capture wear and tear data
- Other answers*



*Other answer choices were “Remaining up-to date on scheduled maintenance”; “Installing blade vortex generators”, and “Upgrading drive trains and other critical components to extend the maintenance cycle.”



DEVELOP AND UTILIZE DATA FROM A VARIETY OF SOURCES

SELECT COMMENTS:

- “ The unavailability of benchmarking data and analysis is one of the greatest challenges I face.”
- “ I have to think that our future involves much more in the way of remote monitoring.”
- “ We need to conduct QA/QC inspections and follow detailed quality assurance programs.”
- “ We need to benchmark against projects displaying better performance.”
- “ We need big data strategies so we can make more highly informed decisions.”

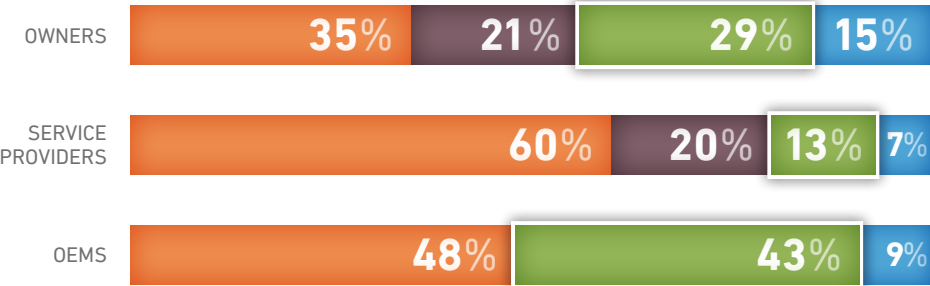
IMPROVE EQUIPMENT DESIGNS

Along with proactive maintenance and better data, professionals also believe improved designs are needed to prolong turbine life.

HOW CAN WE AS AN INDUSTRY BEST PROLONG THE LIFE OF A TURBINE?*

- Preventative / Predictive Maintenance
- Condition Monitoring / Better Data
- Better Equipment Design
- All Other

*Coded answers to an open-ended question.



IMPROVE EQUIPMENT DESIGNS

SELECT COMMENTS:

- “ Major components and systems need to be improved to help with early detection of failures.”
- “ We obviously need more substantial designs on gearboxes and generators.”

- “ We need to build maintainability factors into product designs.”
- “ Self lubricating bearings would really help.”

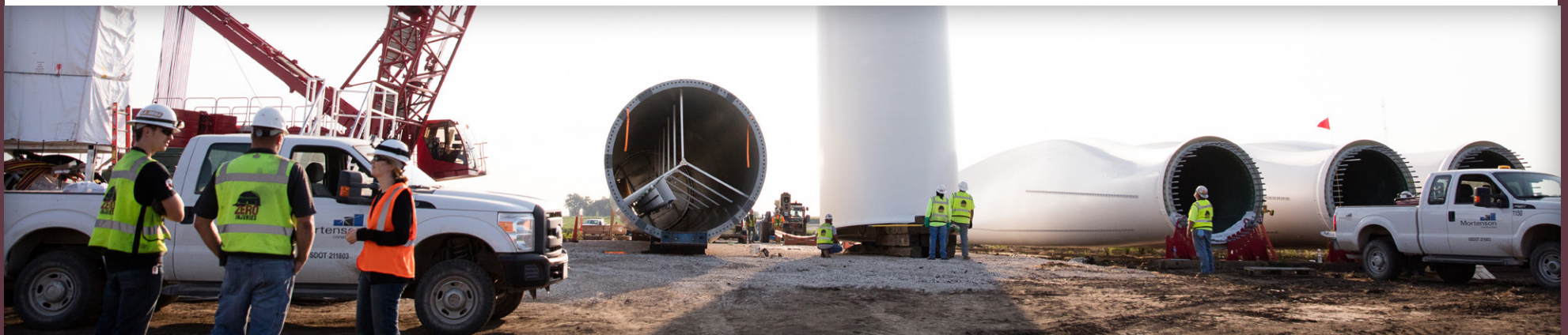
WHEN ASKED WHAT WOULD REPRESENT A **TRUE BREAKTHROUGH** IN OUR INDUSTRY...



MORE OWNERS MENTIONED **INCREASED LONGEVITY** OF COMPONENTS THAN ANYTHING ELSE

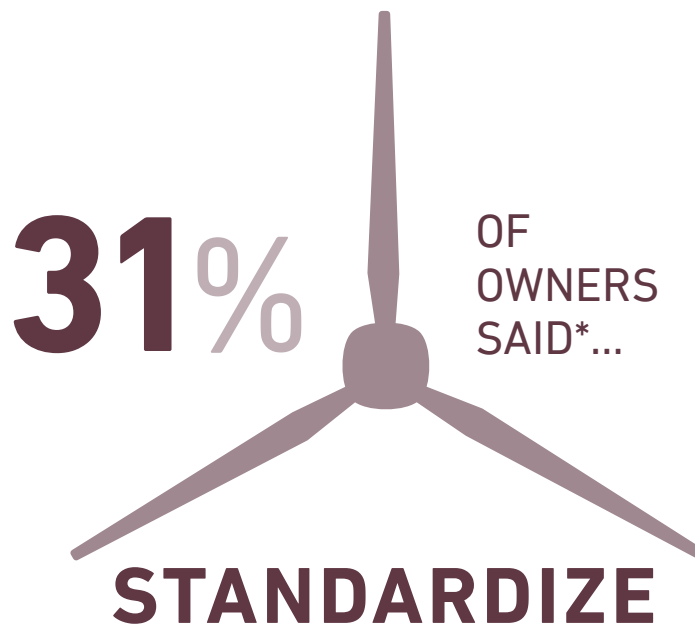


AND **OVER HALF** OF THESE OWNERS MENTIONED **GEARBOX IMPROVEMENTS**



STANDARDIZE BOTH EQUIPMENT AND APPROACHES

WHEN ASKED HOW THE INDUSTRY CAN
BETTER COLLABORATE TO REDUCE COSTS...



*Coded answers to an open-ended question. Other responses included "Share information / Practices / Data" (25%); "Better technicians" (13%), and "More long-term analysis" (6%)

1 STANDARDIZE EQUIPMENT AND PARTS

SELECT COMMENTS:

- "We would greatly benefit from a standardization of parts."
- "We need to utilize more and more standardized equipment."

2 STANDARDIZE APPROACHES

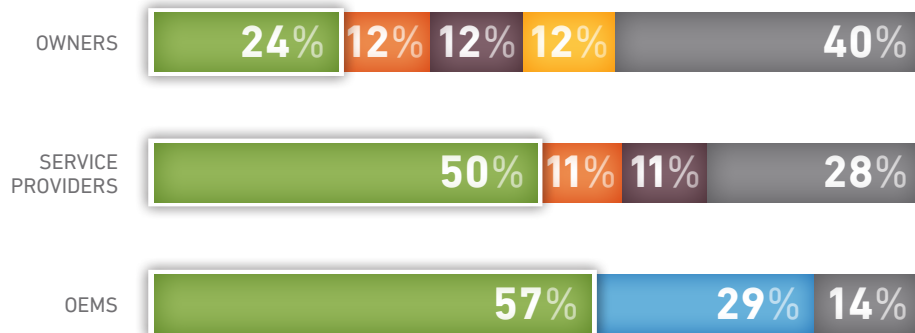
SELECT COMMENTS:

- "We need a standardized approach to benchmarking. This will allow a better negotiation point and determination of strategy."
- "We need the additional development of standards across all we do in our industry."
- "We need one standard, common database that is utilized for root cause analysis."

INVEST IN PEOPLE

WHAT IS THE SINGLE BIGGEST CHALLENGE YOU FACE IN THE OPERATION AND MAINTENANCE OF TURBINES?*

- Finding / Retaining / Developing Qualified Technicians
- Managing Costs
- Equipment Longevity
- Reliable Data and Analysis
- Technology
- Other Answers



*Coded answers to an open-ended question. Other answers included "Contractor Mgmt"; "Timeliness of Services"; "Safety"; "Managing Growth"; and "Communication"

TALENT ISSUES WERE MENTIONED MOST OFTEN AS THE **BIGGEST CHALLENGE** TO DAY-TO-DAY O&M EFFORTS. WE NEED TO FIND WAYS TO BETTER ATTRACT AND MAINTAIN TALENT AS AN INDUSTRY.

SELECT COMMENTS:

- “ Our biggest challenge is getting enough people to meet the demand for wind technicians.”
- “ It can be difficult to keep employees that are experienced from leaving to other industries.”
- “ We struggle with technician turnover.”
- “ We always have a number of young, beginning employees, which is challenging.”

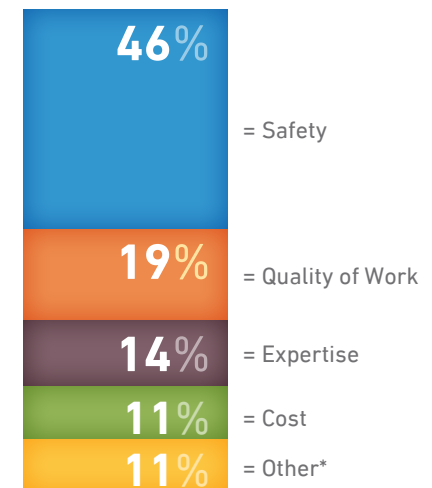


PRIORITIZE SAFETY

There are numerous risks when working on turbines, including hazardous weather; working at heights; and working around high voltages.

WHAT IS YOUR **TOP FACTOR** WHEN SELECTING A SERVICE PROVIDER?

OWNER RESPONSES



OWNERS PLACE A PREMIUM ON PARTNERS WHO **PRIORITIZE SAFETY**. THEY ALSO VALUE QUALITY AND EXPERTISE.

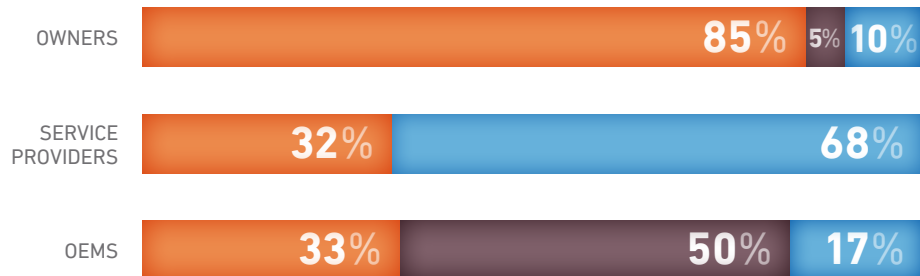
*Other answer choices were "Timeliness", "Relationships", and "Other"

KNOW WHAT'S HAPPENING AT THE GROUND LEVEL

When it comes to day-to-day O&M activities, Service Providers and OEMs believe they are much more involved than owners report they are.

HOW MUCH OF YOUR (OR AN OWNER'S) DAY-TO-DAY OPERATIONS & MAINTENANCE IS HANDLED BY...

- SELF-PERFORM
- AN OEM
- A SERVICE PROVIDER



THIS FINDING SUGGESTS AN **OPPORTUNITY** FOR PARTNERS TO MORE FULLY **COLLABORATE AND UNDERSTAND** THE RANGE OF ACTIVITIES TAKING PLACE IN THE MAINTENANCE OF TURBINES.





CLOSING THOUGHTS: THE 40 YEAR TURBINE

Professionals in this study talked about their desire to extend the lives of turbines. They believe in the power of preventative and predictive maintenance. They see condition monitoring, better data and improved best practice sharing as opportunities to enhance maintenance efforts. They also place strong value on safety, quality and expertise – which are all challenged by a lack of available talent.

Time will tell whether our industry will be able to attain an ambitious goal such as a 40 year turbine. However, this study suggests significant strides can be made if we work hard to tackle our challenges and exploit the many opportunities we face.



THANK YOU!

We sincerely thank the O&M professionals who participated in this study. Your input is tremendously valued and greatly appreciated. Our aim at Mortenson is to be in lockstep with customers and partners, resulting in a service experience that's second to none.

Mortenson is a national leader in wind energy, with more than 20 years of experience. We are dedicated to delivering the highest quality O&M services to our customers and partners through expertise and collaboration.

We strongly support the open exchange of ideas and knowledge because that kind of collaboration is the foundation of innovation. Above all else, safety is our #1 priority, and reinforced in our culture on a daily basis.

We welcome the opportunity to share more with you about our expertise, knowledge and unique capabilities to provide world-class O&M services.

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