MARCON 2023
Utilizing Motion Amplification® for Vibration Analysis & Beyond

Dan Nower: VP-Corporate Accounts
Andrew Dougherty: Director-Market Development
Agenda

• Introductions
• A little about RDI Technologies
• Brief Overview of Motion Amplification®
• Modal Amplified™: Modal Analysis with Motion Amplification
• Iris Explorer™: Motion Amplification with Spot®
• Tach Synchronization
• Question and Answers
We are RDI Technologies

RDI Technologies® is the global market leader in Motion Amplification® solutions. Since 2015, we have supported government and corporate customers with camera-based vibration analysis solutions, helping them optimize reliability and asset performance, while reducing risk and cost.

**INNOVATION:** Inventor of Motion Amplification® technology; pioneer of the camera as the industrial sensor

**EXPERIENCE:** 200+ years vibration solutions and industry experience

**SOLUTIONS:** Non-contact, camera-based Monitoring, Measurement, Robotic and High-speed camera solutions

**INVESTMENTS:** Acquired Fasted Imaging, Inc., 2022
Brief Introduction to Motion Amplification®
What is Motion Amplification®?
Technology Overview: Motion Amplification®

• Turn every active pixel into a displacement sensor to measure vibration & motion

• Standard Video to Show & Measure that very small movement (<1 µm) not visible to the human eye

• Patented methods and processing algorithms to convert changes in light into meaningful vibration/motion data

• Sub-Pixel Movement Measurement
Benefits of Motion Amplification®

- **Improved Safety**: Totally non-contact
- **Very versatile technology**
- **Complementary (Not Replacement) Tool**: Optimize RCA
- **Diverse applications**: Rotating Machinery, Structures, Manufacturing Processes, Piping, many more
- **Setup & acquire Data in Minutes**, easy to deploy
- **Very Quick Return on Investment**
- **Less Training Required**: takes only a few days to become proficient
- **Enhanced Communication**: This technology creates actionable information: “Video empowers facility resources to act!”
Typical Acquisition Process, Traditional

Vibration Measurement Locations -
NON-Simultaneous Data
Report: Detailed Explanation or Exception List with Spectra and Waveforms
Typical Acquisition Process, Visual

Vibration Measurement Locations -

SIMULTANEOUS Data

Report: Video with optional Spectra & Waveform
Bearing housing loose in clamp
Motion Amplification®
Introductory Case Histories
Quick Problem Solving, Whole Asset
Quick Problem Solving, Zoomed to Motion
Frequency Based Filtering Mining Conveyor: Overall
Conveyor: Gearbox Output = 2 Hz
Conveyor: Hydraulic Motor/Pump = 25 Hz
Conveyor Background: Not Obvious
Motion Amplified®
Modal Analysis with
Motion Amplification®
What is Modal Analysis?

- Modal analysis is the process of finding the inherent natural vibration properties of a structure.
- A natural vibration state is defined by its mode shape, its natural frequency and the associated damping.
- Data Acquisition includes a measured response from a known input (instrumented hammer or shaker).
- Derived out of physical measurement results (normally at rest) by fitting a mathematical model to these results.
- This is referred to as experimental modal analysis.
Modal Analysis Acquisition

Instrumented Hammer

Shaker
Modal Analysis Model

Model of Project
Modal Amplified<sup>TM</sup>

Bringing the power of Motion Amplification<sup>®️</sup> to Modal Testing.

Modal Amplified changes the game with Motion Amplification Technology. Modal Amplified allows you to get Modal results in a matter of minutes all the way from capture to visualizing the modes shapes, complete with dozens, even hundreds of sensors measured across the structure.

Modal testing is a time-intensive, complex process requiring re-work and a high level of expertise.
Modal Amplified™

Main Features/Value

• Leverages simultaneous measurement of the force input with the response measured directly from the camera
• See your structure respond real world vs model
• Test on small/large components
• Capture and analyze findings in one platform
• Automatically creates master lists of mode shapes
• Eliminates need to recapture data
• Non-contact; Test structure never altered or destroyed- Fast, easy set-up
• View data in platform, or export easily

Automatically calculates mode shape measurements and filters video to the vibration frequencies that are of interest, instantly capturing mode shapes, natural frequency, associated dampening and movement the human eye and sensors cannot always detect, all within the software.
Modal Amplified™

The power of Motion Amplification in Modal Testing

Get Modal results in a matter of minutes all the way from capture to visualizing the modes shapes

- Leverage simultaneous measurement of the force input with the response measured directly from the camera.
- Immediately visualize the resulting modes shapes all the way from capture to visualizing the modes shapes, complete with dozens, even hundreds of sensors measured across the structure.
- Place dozens, even hundreds of sensors across the structure through virtual regions of interests.

GET TO YOUR DATA FASTER
### Why Use **Motion Amplification®** for Modal Testing?

<table>
<thead>
<tr>
<th>MODELING</th>
<th>VS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated model, not real recorded images. Cartoons can be low resolution “Stick Figures”.</td>
<td>Motion of a real figure/test object. Everyone understands a video.</td>
</tr>
<tr>
<td>Animated determined by number of measurement points collected. May suffer from &quot;Geometric Aliasing&quot;. may be interpolated for more density.</td>
<td>With 2.3M sensors (full HD), “Geometric Aliasing” will not be a problem. “Mass Loading” not an issue.</td>
</tr>
<tr>
<td>Complex test subjects require complex modeling skillset. Difficult to capture aftermarket component characteristics.</td>
<td>No modeling needed.</td>
</tr>
<tr>
<td>Various levels of setup are required including sensor mapping, placement, fixation, wiring; DAQ setup and programming; Collect data.</td>
<td>Camera and lens selection based on field of view (non-contact measurement).</td>
</tr>
<tr>
<td>May need to export data into visualization software (specifically vibration data collectors).</td>
<td>Review findings on same computer, software suite.</td>
</tr>
</tbody>
</table>
Modal Amplified™ : Simple Data Acquisition

Get Modal results in a matter of minutes all the way from capture to visualizing the modes shapes.
Modal Amplified™ | Technical Details

- Any IEPE Impact Hammer
- Integrates a Reference Accelerometer
- 24 bit ADC
- Export waveform, spectrum, coherence, FRF, and phase to UFF file.
- Unlimited Virtual Displacement Sensors
- Stability Diagram with Mode Shape Detection
- Measures Waveform, Spectrum, Coherence, FRF, Phase, and Force Input.
- Coherence Map
- Shaker Input and Control
  - Sine Sweep
  - Chirp
  - Broadband Noise
  - User Defined Wave File
- Measurements in 3D
- Compatible with our High-Speed Iris MX Camera
- Impact, Operational, and Shaker Modes
Iris Explorer™
Motion Amplification®
with Spot®
Our newest Motion Amplification solution – Iris Explorer™
Routes with Spot
Iris Explorer™ payload for Spot® Overview

Boston Dynamics and RDI Technologies integrated technology combines the **mobility and automation of Spot** with the **exceptional visibility and precision of Motion Amplification®**.

This allows industrial customers to take next-generation vibration analysis right to the asset in even the most remote or hazardous environments.

- The Iris Explorer robotic route-based vibration analysis solution means customers can perform **high volume, highly repeatable** autonomous route-based vibration analysis with reduced risk and increased efficiency.
Predictive Maintenance/Reliability challenges driving development of Iris Explorer

**FLEXIBILITY**
I need more flexibility capturing data on a route, I want to be able to see 4 of the 6 or 7 triggers not all of the data. I don’t want to capture the entire route data, **just specific data** like waveform and ONLY when it meets certain parameters.

**REPEATABILITY, ACCESSIBILITY**
I need a closer eye on assets with a **repeatable, remote view with control from main locations** to remote locations, across states. And I want to be able to **perform more routes** with the ability to change routes as needed.

**EFFICIENCY**
Calendar-based maintenance is inefficient as engineers spend much of their time checking equipment in good working condition, taking up an engineer’s time that could use to perform more complex and high-impact activities.

**SAFETY, VISIBILITY, COST**
I am only able to perform advanced analysis on my top assets. **I should be covering more assets, but I don’t have the resources.** Safety is paramount and I need to reduce costs.
Iris Explorer™

Meeting the challenges: Motion Amplification and Spot combine for a powerful, autonomous vibration analysis solution.

- **Spot®** – Teleoperation, route-based vehicle to capture data and explore without boundaries – that means you can automate routine inspections and capture data safely, accurately, and frequently.

- **Motion Amplification®** payload – Every pixel becomes a displacement sensor measuring vibration and motion, allowing you to see what the human eye cannot. You get full asset field-of-view, every data point measured and quantified helping you see vibrational relationships and undiscovered faults.
**Iris Explorer™**

**Impact:** Cover more assets in a fraction of the time. Safer, more efficient; make data acquisition cheaper, more diverse, and more consistent.

**Maximum visibility of assets and sites**
Reach equipment and spaces that are insufficiently covered by fixed sensors or inaccessible by people. Inspect multiple angles, locations and vibration previously inaccessible.

**High volume routes, flexible autonomy**
Teach new inspection routes in minutes and let Spot repeat it autonomously. Pivot quickly to change or add routes as many times as you want. With Spot you can run more diverse and higher route volumes than a human.

**Highly repeatable, automated vibration analysis**
Automated feature finding allows you to repeatedly and effortlessly capture the exact same image every time, every route, in any environment as many times as you want.

**Know what to work on and when**
Manage data volume by focusing on the most relevant data. Choose specific data sets to capture like waveform or spectral. Then set conditional, automated triggers for notification **only** when the data meets your parameters, so you don’t waste time collecting all data, just what you need.

**Automated, real-time reporting**
Monitor for chronic trends or emergent issues with longitudinal view of assets. Historical, **all** displayed ROIs – spectrum, waveform, and orbit – combined into a single CSV file.

**Impact:** Cover more assets in a fraction of the time. Safer, more efficient; make data acquisition cheaper, more diverse, and more consistent.
Highly repeatable, automated

- Motion Amplification Automated Feature Finding allows you to repeatedly and effortlessly capture the exact same image, every time, every route, every position, in any environment as many times as you want.

- 30 times or 3000. No human programming bias. Applies the same observation protocols on the thousandth inspection as it was programmed to do on the first.

- By reducing the time it takes to check safety-critical equipment, users can reinvest those resources toward maintaining production-critical equipment and performing other important tasks.

**Challenge:** Calendar-based maintenance is an inefficient method of checking the status of equipment, as engineers spend much of their time checking equipment in good working condition. Data collection is labor intensive, taking up time that experienced specialists could use to perform more complex and high-impact activities.
Trending, reporting, real-time data

- **Waterfall plots** – repeatable, change in frequency over time, location. Monitor for chronic trends or emergent issues with longitudinal view of assets. **Historical, all displayed ROIs** – spectrum, waveform, and orbit – combined into a single CSV file.

- From design to inspection set Iris Explorer + Spot spot up on route and collect every hour on an asset

**Challenge:** Approaching the data problem with fixed sensors is just not scalable given the complexity of the installation process. And manual methods are just not effective or efficient.

**TREND, DETECT, SOLVE AUTONOMOUSLY:** Unique ability to lock spectrum span provides data certainty across multiple recordings – see how frequencies change over time for repeatable data sets. Scan assets instantly to see motion in real time. View data immediately without the need to calculate.
Control remotely, autonomously

**Challenge:** I need a closer eye on things with a repeatable, remote view with control from main locations to remote locations, across states. I want to be able to perform more routes with the flexibility to change routes as needed.

- **Control remotely** across plant, site, or regions through internet connection.
- Live camera feed, full camera control
- Perform inspections remotely like piping, pumps, fans, cooling towers, agitators
- View live data from between different sites

- **Teach new inspection routes in minutes** and let Spot repeat it autonomously. Pivot quickly to change or add routes as many times as you want. With Spot you can run more diverse and higher route volumes than a human.

- **Send Spot into a hot area** - Explore unstructured and dangerous environments with unprecedented mobility and visibility, going where wheeled robots and drones cannot.
Know what to work on and when

**Challenge:** I need more flexibility capturing data on a route, I want to be able to see 4 of the 6 or 7 triggers not all of the data. I don’t want to capture the entire route data, just specific data like waveform and ONLY when it meets certain parameters.

- **Don’t miss a data point:** Motion Amplification captures full field of view and allows you to allows you to manage data volume by focusing on the **most relevant data**.

- **Don’t perform the entire route again:** Choose specific data sets to capture like waveform or spectral. Then set conditional, automated triggers for notification **only** when the data meets your parameters, so you don’t waste time collecting **all** data, just what you need.

- **Flexible:** Capture vibration on-the-fly and view data immediately. From overall spectrum, to refined data or a single data point.

Active condition monitoring is time-consuming, meticulous work; if rushed or done improperly, data has little value and entire routes must be redone.
Maximum visibility of assets/sites

Challenge: How can I get a real, true picture of what’s happening with assets on complicated industrial sites? Stationary cameras and sensors cannot cover every angle of our assets and sites.

- See connections of vibrations and **how one data point affects another in one plot** – different frequencies and their relationships.

- See **past the prompt** – behaving like looseness isn’t always indicative of loose, ie, pipes bending vs a pump bearing.

- Reach equipment and spaces that are insufficiently covered by fixed sensors, wheeled robots or drones. Inspect multiple angles, locations and vibration **previously inaccessible**.

- Capture more data than sensors - **2.5 million data points**, unpacking more information from every pixel.

Is it really loose?
Spot Payload Hardware
Isolated Network
PROOF OF CONCEPT
Help your team demonstrate proof of concept and demonstrate ROI through POC for both Motion Amplification and Spot.

MOTION AMPLIFICATION AND SPOT TRAINING
New to Spot and Motion Amplification? We’ll walk you through everything from unboxing to running your first autonomous mission. Continuous training and software updates.

MOTION AMPLIFICATION MENTORING & DATA ACQUISITION & ANALYSIS
Motion Amplification program assessment to review the current asset state, best practices, and new areas of implementation to improve outcomes. We visit your site, acquires recordings of the assets using our proprietary products, and analyzes those recordings.

TROUBLESHOOT
Support and integration teams, Motion Amplification payload and Spot Care maintenance.
Summary - Iris Explorer™ payload for Spot®

**AUTONOMOUS, ROUTE-BASED VIBRATION MONITORING**
Capture data and explore without boundaries – that means you can automate routine inspections and capture data safely, accurately, and frequently.

**MOTION AMPLIFICATION TECHNOLOGY**
Every pixel becomes a displacement sensor measuring vibration and motion, allowing you to see what the human eye cannot.

**DOESN’T REPLACE HUMANS, MAKES THEM MORE EFFICIENT, KNOWLEDGABLE**
By reducing the time it takes to check safety-critical equipment, users can reinvest those resources toward maintaining production-critical equipment and performing other important tasks.

**SAFETY, VISIBILITY, COST**
Increased safety, higher visibility across assets while reducing cost.
External Tachometer with Motion Amplification®
Shaft Freeze: Reveal Rotating Component Problems

Shaft Movement
Fan blades (measured with external tach)

Filtered @ .42Hz
Couplings: Torsional (external tach)
Cooling Towers (external tach)

ACC Fan - Tac Sync Set-Up
90.3 RPM

Motion Amplification Camera IRIS M

Tac

Additional LED lights

Acquisition Unit
Motion Amplification®
The Applications are Endless...
Contact information:

**Dan Nower** (Vice President-Corporate Accounts)
- Email: [Dan.Nower@rditechnologies.com](mailto:Dan.Nower@rditechnologies.com)
- Phone: 865-250-9378
- LinkedIn: [https://www.linkedin.com/in/dan-nowor-13a35b2b/](https://www.linkedin.com/in/dan-nowor-13a35b2b/)

**Andrew Dougherty** (Director of Market Development)
- Email: [Andrew.Dougherty@rditechnologies.com](mailto:Andrew.Dougherty@rditechnologies.com)
- Phone: 865-599-4409
- LinkedIn: [https://www.linkedin.com/in/andrew-dougherty-a0babb6/](https://www.linkedin.com/in/andrew-dougherty-a0babb6/)