From: [redacted]
Sent: Sunday, July 9, 2023 12:08:16 AM
To: [redacted]
Cc: [redacted]
Subject: Review of ABD data for CR 507499 (R1)

All,

Following the Hot Box Detector alarm emitted for train 814V404 at Yellow Sulfur, VA (V276.3 at 17:26) for line 74 in the train, axle 299 (CR 507499- R1 bearing position) the train subsequently passed over the Ironto, VA (V266.6) Acoustic Bearing Detector location (7/6/23_19:35) where a measurement of the bearing in question was made. There were no readings from this trains passing of the Acoustic Detector that met validated criteria for opening alert message in EHMS (Railinc).

Acoustic Bearing Detector Data Background

According to the AAR RailBAM Data Summary:

Purpose

Acoustic Bearing Detectors are designed as early warning systems that detect bearing defects prior to them reaching an industry condemnable level for the purpose of preventative maintenance planning.

Background

The RailBAM acoustic detection device records audio from a train passing and produces train and axle based files with four main descriptors: Prefixes, Types, Levels and Suffixes. This data summary uses those descriptors as the vehicle for data exchange with the industry.
Goals of the data summary include:

1. Data summaries are only opened with a high confidence in a rolling surface fault.
2. Data summaries are to contain information suitable for prioritizing bearing removals.
3. Data summaries are to contain information suitable for indicating: remediation of a problem (support for auto close) or a data integrity error that led to a false opening.
4. A good pass is considered a read without a problem (prefix) and has a severity level of 4.

Prefixes: Noisy, FBS (Flanging ,Braking , Slamming), Shrk (Shriek), Clpd (Clipped) prefixes are indicative of non-bearing faults, errors, or other external inputs that may diminish the reliability of the information produced. If there is a prefix, there is likely an error with the reading.
Types: 1, 2, 3, 4
Levels are indicative of the level of noise decibels associated with a type of defect. Level 1 is the most severe with the highest decibels while level 4 is considered not to be a problem and counts towards auto closing the data summary. A level with a null value indicates no reading could be made. All null level readings will be ignored.

Suffixes: _e (extended), _m (multiple), _r(roller), _n(cone), _p(cup)

Suffixes are indicative of a particular aspect associated with a type of defect. Suffixes are based on the speed of the wheel and are a quality indicator.
Locomotives are not analyzed and no values are sent for them. A locomotive is determined by the leading and trailing indicators (locomotives use F and R while cars use A and B indicators).

Important! A clear fault is indicated by a full descriptor that has no prefix but does have a suffix. For example, RS1_p isa clear cup fault.

Opening Criteria

If a data summary creator does not have an open data summary for the asset and location, a new data summary will be opened if **either** of the following conditions are met:

a. All of the following conditions are met:
    1. BEARING_FAULT_SEVR_PREFIX must not have a value
    2. BEARING_FAULT_SEVR_CATE must be RS
    3. BEARING_FAULT_SEVR_LEVEL must be 2 or 1 (1 being the most severe)
    4. BEARING_FAULT_SEVR_DESC must have a value
b. Another data summary creator has an open data summary for that asset and location

Closing Criteria

a. Administrative -opened in error (due to detector error, AEI matching error, incorrect AEI tag placement). Message may come from web service or from EHMS website input.
b. Deleted in UMLER. Message must come from UMLER system.
c. Auto-close logic: Five sequential reads without problem (for any open data summaries on a bearing). A problem is defined as read that has severity level of 1, 2, or 3. A good reading is defined as a reading that's has a severity level of 4. If there exists 5 consecutive timestamps after the last timestamp with a problem, a close message will be published effective a close of all data summaries for that bearing.

Train 814V404 Ironto, VA Acoustic Detector Passing Review:

The readings recorded in the Vendors online detector information database (FleetOne) Indicate that the Ironto Acoustic detector measured a Running Surface (RS) Type or Level 2 (RS2) without a prefix but failed to have a suffix which is needed in order to open a message. As we look at the complete train passing measurements we see that there are multiple RS faults recorded with 113 RS2 readings throughout the train.

814.04 ABD Passing Summary (Ironto, VA 7/6/23_19:35)

Row Labels	Count of Bearing Fault
	36
.	305
FBS(4)	6
FBS(RS1)	1
FBS(RS2)	10
FBS(RS3)	4
NOISY(4)	1
NOISY(RS1)	2
NOISY(RS2)	10
NOISY(RS3)	2
RS1	7
RS2	113
RS3	379
Grand Total	**876**

CR 507499 (R1) Acoustic Passing Recent History

Vehicle Tag: **CR 507499** Vehicle Axle Number: **1** Side of Vehicle: **R**

Data Quality	Train Time	Site	Sensor Type	Vehicle Number	Train Axle Number	Vehicle Type	Axle Speed (km/h)	Lead End	Direction	Side of Track	Bearing Fault	Bearing Alert	Is Consistent	Wheel Flat	ErsDB
	7/6/2023 19:35:36	Ironto	RAILBAM	74	299	C_71	57	B	East	N	RS2		No	.	64
	6/27/2023 07:14:52	Ironto	RAILBAM	50	206	C_47	61	A	East	F	RS1		No	.	70
	6/21/2023 22:38:32	Ironto	RAILBAM	51	205	C_49	47	B	East	N	NOISY(RS1)		No	.	74
	6/17/2023 08:41:15	Ironto	RAILBAM	73	293	C_71	62	B	East	N	NOISY(RS1)		No	.	73
	6/10/2023 20:38:06	Ironto	RAILBAM	78	316	C_76	58	A	East	F	NOISY(RS2)		No	.	73
	6/2/2023 03:21:47	Ironto	RAILBAM	102	412	C_100	57	A	East	F	FBS(RS1)		No	.	73
	5/10/2023 18:41:44	Ironto	RAILBAM	32	129	C_30	36	B	East	N	NOISY(RS1)		No	.	74
	8/15/2022 15:53:04	Marion	RAILBAM	83	333	C_81	71	B	West	F	NOISY(RS1)		No	.	77
	7/17/2022 01:48:53	Marion	RAILBAM	18	73	C_16	54	B	East	N	FBS(RS1)		No	.	79
	4/2/2021 14:48:47	Ironto	RAILBAM	49	200	C_47	58	A	East	F	NOISY(RS1)		No	.	80
	3/31/2021 06:46:30	Marion	RAILBAM	13	53	C_11	56	B	West	F	NOISY(RS1)		No	.	78
	3/25/2021 03:18:50	Marion	RAILBAM	89	360	C_87	67	A	East	F	NOISY(RS1)		No	.	78
	3/11/2021 13:21:46	Ironto	RAILBAM	121	490	C_118	60	A	East	F	NOISY(RS1)		No	.	74
	2/28/2021 00:10:44	Ironto	RAILBAM	88	356	C_86	64	A	East	F	NOISY(RS1)		No	.	76
	2/19/2021 17:49:12	Ironto	RAILBAM	76	310	C_73	60	A	East	F	NOISY(RS1)		No	.	78
	2/3/2021 22:39:34	Ironto	RAILBAM	92	372	C_90	52	A	East	F	NOISY(RS1)		No	.	77
	1/27/2021 09:29:22	Ironto	RAILBAM	75	304	C_73	51	A	East	F	NOISY(RS1)		No	.	74
	1/21/2021 22:41:13	Ironto	RAILBAM	53	213	C_51	56	B	East	N	NOISY(RS1)		No	.	76
	1/10/2021 14:22:15	Ironto	RAILBAM	60	244	C_58	65	A	East	F	FBS(RS1)		No	.	78
	12/10/2020 17:47:59	Ironto	RAILBAM	32	129	C_30	64	B	East	N	NOISY(RS1)		No	.	80
	11/30/2020 15:10:39	Ironto	RAILBAM	18	76	C_16	61	A	East	F	NOISY(RS1)		No	.	79
	11/26/2020 20:41:51	Marion	RAILBAM	12	50	C_11	73	A	West	N	NOISY(RS1)		No	.	85
	11/21/2020 03:03:10	Marion	RAILBAM	37	152	C_35	69	A	East	F	NOISY(RS1)		No	.	79

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RailBAM Fault Notation

Extraneous Noise

Wheels that emit flanging, squealing and other extraneous noises have a potential to produce peaks that may appear like those of RS bearing faults - but these cannot be ignored, as they mask true bearing faults.
For example, a flanging noise could be obscuring a bearing fault of any kind.

For this reason the severity classifications for such measurements are prefixed with Clpd, Shrk, FBS or NOISY with the potential fault type and ranking shown in brackets.

- Clpd (clipped) indicates noise that causes saturation of the data acquisition equipment.
- Shrk (shrieking) indicates a strong tone in a high frequency band. This tone is removed by the RailBAM® System before further analysis, but retained in the sound file.
- FBS indicates the presence of Flanging, Braking or Slamming.
- NOISY indicates an unknown noise.

For example: FBS(RS1) indicates a potential RS1 fault associated with extraneous noise from flanging, braking or slamming.

Running Surface (RS) Faults

Running surfaces include the cup, cone and rollers of a bearing. Acoustic signatures can be caused by faults such as:

- Spalling.
- Brinelling
- Water etching.
- Electrical etching
- Corrosion

The description of the Running Surface (RS) fault is determined by the roller pass frequency – the rate at which the rollers move over the cup and cone raceways. When a description of the fault is clearly identifiable from the acoustic signal, the descriptor is appended to the severity classification.
For example, a severe cup fault would be classified as RS1_p.

The approximate roller pass frequencies and descriptors for different RS faults are given in the following table:

Fault Description	Roller Pass Frequency	Descriptor
Cone	12.5 to 14	_n
Cup	10 to 11.5	_p
Roller	3.5 to 4.8	_r
Multiple	Faults of similar severity on cup and cone.	_m
Extended	Any of the above with additional indication of an extended fault	_e

Wheel Flat (WHLFLT) Faults

Wheel flats produce noise signatures that align with one order, since the flat part of the wheel strikes the rail once per wheel rotation.
The RailBAM® System distinguishes this noise from bearing faults, and uses separate ranking thresholds to determine the severity of the acoustically detected wheel flat.

Measurement Artefact codes

RailBAM can also display two different codes in the "Fault" notation field to indicate that the measurement did not occur. These are:

- **v-** – Measurement was not analysed because the velocity was too low or too high when the corresponding bearing passed RailBAM.
- **shtr-** – Measurement was not analysed because the RailBAM shutter was not shown as fully open when the corresponding bearing passed RailBAM.

RailBAM Consistency Calculation

FleetONE provides a powerful trending capability for RailBAM acoustic data called the "RailBAM Consistency Calculation".

This calculation uses the historical set of acoustic signals measured for a bearing to determine if a consistent fault noise is present.
By determining the presence of a consistent noise, FleetONE is able to identify faults even when the bearing is not measured as a "clear" fault, or despite the presence of extraneous noise. This is done by examining how consistent the acoustic spectra is over time.

FleetONE performs this calculation as follows:

- When new bearing measurements are imported into the system, the consistency calculation is performed for every bearing that records a fault.
- The acoustic bearing spectra for the last 10 pass-by's of the same bearing are retrieved and passed to the consistency algorithm.
- The result of this calculation determines whether or not the noise produced by the bearing is repeatable, providing a high level of confidence in the measurement.
- The "Is Consistent" flag is set on each bearing measurement where this is found.

Notes

- *No evaluation is performed for bearings measured as "-" where no fault indication was found.*
- *A minimum of 3 pass-by's are required before consistency is calculated.*
- *Vehicle tags must be present in order to identify the bearing, retrieve its history and perform the consistency calculation.*
- *FleetONE calculates an internal "consistency" value between 0 and 1. When the consistency value is >0.4, the bearing will be flagged as having an acoustic signature that 'Is consistent'.*
- *Track IQ advises working with the "Is consistent" flag for identifying bearing faults. This is the default field shown throughout FleetONE.*

The consistency information is available in FleetONE in the following places:

- The "Is Consistent" flag is available on the Train Summary and Component History forms when viewing RailBAM data.
- It also is shown on the RailBAM trend graphs - highlighting periods of consistent bearing acoustic faults.
- The "Is Consistent" field is available in the search engine, allowing you to compose searches that identify consistent bearings.

RailBAM Consistency Discussion

The calculation for RailBAM consistency is discussed above.

The "Is Consistent" flag provides a strong indication that the acoustic signature is not random, and corresponds to a repeatable physical phenomena.

1. It has been shown that bearings that have repeated clear faults have very high consistency. This is as expected, as RailBAM has high confidence that these measurements indicate a bearing fault.
2. It has also been shown that for bearings that do not exhibit trends of "clear" faults (e.g. RS1, RS2, RS3 or faults with "Prefixes" indicating other noises in the sample) that the repeated presence of the "Is Consistent" flag in the history of a bearing indicates the presence of a repeatable noise.
3. Therefore, the "Is Consistent" field allows you to differentiate between low level Faults that are "one-off" vs low level faults that are repeatable.

Interpreting the underlying consistency value

Note: Track IQ recommends that you work with the "is consistent" flag, rather than the underlying consistency value.

1. As discussed above, the underlying consistency value is a value calculated between 0 and 1, where "0" represents no consistency between acoustic measurements and 1 represents perfect consistency.
2. As the acoustic signature of a bearing changes over time, so too does the consistency value. For an acoustic bearing fault, the following behaviour may be seen:
   a. If the consistency value is rising then it is likely a small fault is evolving into a nice clear line spall (e.g. the fault has a nice clean structure producing clear clicks).
   b. If the consistency value has risen and is now falling (or it started at a high level, say >0.8 and is falling) then the nice clean fault is likely starting to get more worn and is likely extending (getting bigger) with the growing probability that material is starting to contaminate the grease inside the bearing.
   c. If the consistency is fluctuating then this can be (a) a symptom of the breaking up of the running surface, (b) the fault being on the edge (or moving in and out) of the bearing loading zone or (c) the fault not generating a high noise signature due to the shallow depth of the fault.
3. While the consistency value is looking specifically for acoustic bearing fault signatures, it may be possible for other repeatable physical phenomena to also cause the consistency to rise if these phenomena generate a similar acoustic signature – for example, suspension faults, gearbox faults, motor faults.
4. When used in combination with the RailBAM fault codes, RailBAM spectra and RailBAM dB trend graphs, the consistency value and 'Is consistent' flag can provide an additional level of confidence when interpreting RailBAM data.

NOTE: Inspections of removed bearings to further validate findings for a particular fleet-bearing combination is recommended to improve interpretation of bearing behaviour within that fleet.

RailBAM Fault Categories

Individual severity classifications can be grouped into categories for use in the search engine. This allows you to examine a set of severity categories as a single group to help manage the multiple fault types. FleetONE comes with a set of pre-configured severity categories as defined in table below. Additional severity categories can be created as required within the database.® System administrators.

Severity Category	Types	Levels	Descriptors	Prefixes Allowed
Clear Level 1	RS	1	_e, _m, _r, _n, _p	No prefix
Clear Level 2	RS	2	_e, _m, _r, _n, _p	No prefix
Wheel Flats	WHLFLT	1, 2		No prefix
Potential 1&2	RS	1,2		No prefix

Notes:

- *Track IQ has high confidence in the presence of a bearing fault when it is measured as a "clear" fault - i.e. a fault with a descriptor.*
- *For faults that are not "clear" - e.g. a potential fault, a trending approach can be used via the consistency calculation, to determine the presence of a bearing fault.*
- *A severity classification may be included in more than one category. If these categories are displayed in the same fault summary, the total number of faults can include the same fault type more than once.*

Respectfully,

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