



Tackling the data analytics dilemma for predictive maintenance

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Outline

- Required skills to create a predictive maintenance solution
- The changing landscape
- Evolving predictive maintenance
- The new set of skills and infrastructure for the analytics age.

787 Entry Into Service Alert: ram fan motor



Air turn back prevented – estimated savings \$85K

Successful solutions: A product of multi-skilled teams with diverse perspectives

software programming cyber security planning operations control database admin uman factors line maintenance IT network supply chain logistics munications



Unlocking the predictive maintenance spectrum

Business Question	Day of Operations	Fault Isolation	Unscheduled Mx	Fleet Management
	How do I preposition parts and maintainers to quickly address defects when my aircraft lands?	How do I save time and money on repairs by giving maintainers better insight into a defect?	How can I add tasks to scheduled maintenance intervals to make my aircraft more efficient and prevent unscheduled maintenance?	How do I make better fleet management decisions based on how my aircraft are being used?
Type of Problem	Tactical			Strategic
Event to Action Time	Short			Long
Technology	ACMS/ACARS			QAR/CPL
Data Fidelity	Low	High		Medium

What data is useful?

Day of Di	Disc CmpInt Tx	Maint Act Tx
January	SEAT 20E BOTTOM COVER SOILED	COVER REPLACED
anuary 4,	HANDSET 4D NO MENU DISPLAY	NO TROUBLE FOUND, OP'S NORMAL. REF: AMM 44-25
015	RHT HF FAILED DURING FLIGHT, DASHES ONLY	PERFORMED RHT HF OPERATIONAL TEST-TEST PASS
	USB PORT 5D INOP	OP'S CHK GOOD. REF: AMM 44-25-23
	USB PORT SEAT 4D INOP	OP'S CHK GOOD. REF: AMM 44-25-23
	VIDEO SCREEN 5D WENT BLANK DURING FLT	OP'S NORMAL ON GRD. REF: AMM 44-25-00
anuary	STEAMER ON EXPRESSO MACHINE INOP. PIECE OF PLACSTIC STUCK INSID E S.	PLASTIC REMOVED AND NEW FROTHER NOZZLE INST
	UNABLE TO RECEIVE SECAL ON HF LEFT OR RIGHT	NIL PFL OR STS MSG RELATES. GATEWAY DATALINK I
nuary	SEATS 78 AND 88 VIDEO MONITORS INOP	REST IFE PASS SEAT, OPS CHK VIDEO MONITORS, OP
anuary	CABIN CLEANER FND A PAX SWEATER STUCKED IN THE TOILET BOWL AT LAV	SWEATER REMOVED AND OPS ON THE TOILET SYSTE
	TOILET AT 3M LAV IS BLOCKED WITH A PAIR OF SWEATPANTS	REFER TO T/L PAGE 7932707
anuary	1E VIDEO SCREEN INOP WOULD NOT ACCEPT RESET COMMAND	RESET IFE SYSTEM , OPS CK'D VIDEO AND AUDIO FOR
	CONTROL BUTTON ON HANDSET 3K MISSING.	REPLACED HANDSET AT SEAT 3K, REFERENCE A.M.M
anuary	FWD GALLEY COFFEE MAKER 110 AND 109 BEGIN BEWING THEN STOP IN THE.	BOTH COFFEE MAKERS OPS CHKD OK
anuary	EEMK OPEND NEEDS INVENTORY CHECK./ SEAL 2 ANI HISTAMINES AND ONE	INSTALLED NEW SEALED EEMK KIT P/N EEMK2000-3
anuary	OVEN #710 INOP USED EMP # 04585 EMP #23820 IS INACTIVE	GROUND OPS CHK GOOD OF VERIOUS MENU SETING
3,2015	SEAT 6K VIDEO SYSTEM INOP USED EMP # 04585 EMP #23820 IS INACTIVE	REBOOTED THE IFE SYSTEM OPS CHECK GOOD
	SEAT 41 D,E USB CHARGER INOP USED EMP # 04585 EMP #23820 IS INACTIVE	REBOOTED THE IFE SYSTEM OPS CHK GOOD
	SEL 19L HAS INCRRECT COLOR SEAL ON VEST CONTAINER SHOULD BE WHITE	REMOVED YELLOW SEAL AND REPLACED WITH WHIT
inuary	SEAT 5E IFE HANDSET DISPLAY INOP, ALL BUTTONS WORK, HALF INCH D EEP	HANDSET IN NOT IN LAX STOCK
7,2015	SCRATCH - NO SHARP EDGES.	PLACED SEAT 5E IFE HANDSET ON PLACARD
		REPLACED HANDSET, OPERATES NORMAL
	SEAT 29F VOLUME CONTROL DOES NOT WORK	RESET IFE SYSTEM, OP'S CHECKED AUDIO AT SEAT 2
nuary	16E VIDEO SCREEN INOP BLANK.	RE- BOOTED THE IRE SYSTEM POS CHECK GOOD.
	OVEN # 605- AFT GALLEY CUTS OFF/ TURNS OFF BEFOR COMLETION OF P ROG.	GROUND POS CHECKS OK FOR SERVICE.
inuary	AFT GALLEY OVEN 707 NOT HEATING	OVEN CB CYCLED. OPS CHKD OK
nuary	CABIN INETRPHONE-FROM COCKPIT HANDSET-WHEN DIALING DOOR 1L	DOOR 1L AND 1R CALL LIGHTS AND INTERPHONE OP:
2,2015	AND1R (71)INTERPHONE CHIME DOES NOT SOUND IN DOOR 1LAND 1R PILTO	REMOVED AND REPLACED SDM REF B787-81205-A1
		T/S PER FIM TASK DMC-B787-A-33-20-F5-02A-421A-A
	SEAT 7B HANDSETR DOES NOT CONTROL ENTERTAINMENT SYSTEM	7B SEAT RESET.OPS CHK O.K
nuary	SEAT 4E NO AUDIO. NO VIDEO CHANNELS.	IFE RESET CARRIED OUT. SEAT 4E OPS CHKD OK.
	SEAT 7A VIDEO MONITOR WILL NOT REBOOT.	IFE REBOOT C/OUT. SYS RESET. OPS CHKD SEAT 7A II
inuary	DOOR 2-R WILL NOT DIM	RE-CYCLED THE 2R C/B OPS CK GOOD
5,2015	FIRST AID KIT WAS OPENED BUT NOTHING USED AT 2L OVERHEAD JUMPSE AT	REPLACED THE FIRST AID KIT
	MONITOR SCREEN STUCK IN MAP MODE AT ISM STATION	REBOOTED IFE SYSTEM CHKD OK, EMPLOYEE 23820
	OVEN 106 NEEDS TO BE CLEANED BEFORE USE	CLEANED AREA CHKD OK, EMP 23820 INVALID
	WINDOW AT SEAT 4R WILL NOT DARKEN	RESET CB BY CBIC CHKD OK, EMPLOYEE 23820 INVAL
anuary	CURTAIN ON FD CREW REST FALLING DOWN BUNK ON A/C RIGHT.	SECURED CURTAIN.OPS CHK GOOD.
ebruary	G2658 111 PULLOUT COUNTER A ZONE GALLEY POSITION 111 UNIT WILL NOT	PULL OUT TABLE TRACKS CLEANED OPS NORMAL

Original Logbook	What	the computer re	turned automa	atically
Complaint Text	Component	Condition	Location	Location
RH MLG DOOROPERATED SEQ VALVE MOST LWR HYDRAULIC CONNECTION HAS A RUNNING LEAK. BY- 222319	•			





Data challenges



- Thousands of sensors measured on every 787 aircraft.
- Measurements are taken every second
- 1 year of 787 sensor measurements from one airplane is ~1TB

year?



Analytics challenge



Predictive Maintenance Alert creation

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OT DL.	SEAT 20E BOTTOM COVER SOILED	COVED DEDLACED
uary	HANDSET AD NO MENU DISDLAY	NO TROUBLE FOUND OD'S NORMAL REF- AMM 44-2
5	RHT HE FAILED DURING FLIGHT, DASHES ONLY	PERFORMED RHT HF OPERATIONAL TEST-TEST PAS
~	USB PORT 5D INOP	OP'S CHK GOOD, REF: AMM 44-25-23
	USB PORT SEAT 4D INOP	OP'S CHK GOOD, REF. AMM 44-25-23
	VIDEO SCREEN 5D WENT BLANK DURING FLT	OP'S NORMAL ON GRD. REF. AMM 44-25-00
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	UNABLE TO RECEIVE SECAL ON HE LEFT OR RIGHT	NIL PFL OR STS MSG RELATES, GATEWAY DATALINK
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uory	TOULET AT 3M LAW IS BLOCKED WITH A DAID OF SWEATDANTS	DEFED TO TA DAGE 7032707
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	CONTROL BUTTON ON HANDSET 3K MISSING	REPLACED HANDSET AT SEAT 3K, REFERENCE A.M.
uary	FWD GALLEY COFFEE MAKER 110 AND 109 BEGIN BEWING THEN STOP IN THE	BOTH COFFEE MAKERS OPS CHKD OK
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		COPERATES NORMAL
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2015	ANDIR (71)INTERPITE	AUEU SUMI REF B/8/-81205-A
	SEAT 7D HANDSETD	UB/8//A-33-20-P5-02A-421A
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	Potabytes c	f data

People **Process** 11 .

Technology

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Data science process

Phase 1 Collect, translate and store airplane data

Big Data Technology

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Phase 2 Analyze data in Spark

Phase 3 Create models to predict future faults on airplanes



Phase 4

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Predictive alerts for aircraft maintenance team & recommend actions

Data science models



Collaboration challenge: modeling power vs. interpretability

Outcome

Thousands of Potential Signatures from Terabytes of Data





Signature indicates sensor problem, saving time and \$ on troubleshooting

Real-world examples

Excessive fuel burn- Optimize fuel management

 Within a year, analysis of full flight sensor data has identified numerous pumps across the operators' fleet, 85% of the identified pumps have been replaced, resulting in >\$5M fuel savings

2.5 BLEED ACTUATOR POSITION 07:00:00 08:00:00 09:00:00 10:00:00 11:00:00 12:00:00 13:00:00 14:00:0 2.5 BLEED ACTUATOR POSITION 07:00:00 08:00:0 09:00:00 10:00:00 11:00:00 12:00:00 13:00:0 14:00:00



Intermittent Hydraulic Light Indication- Mx Cost Avoidance

 Full flight sensor data showed that pressure was above a certain threshold during indication, recommendation to change panel
avoided maintenance engine run

Analytics: delivering relevant, tangible results

- Tight coupling of analytics and aerospace domain knowledge
- System-based inter-disciplinary collaboration and approach to problem solving
- Focus on customer problems, needs and objectives



