



# 28th Bomb Wing



*Win the Fight - Strengthen the Team - Prepare for the Future*

## CSAT 2016

### B-1 Cold Spray Initiative

Brian L. James  
28 MXG/AFETS

*- Prepare for the Future-*

***Purpose:** To discuss the field level necessity for cold spray repair on non-repairable/non-procurable B-1 components and current status of the cold spray AMRRF project.*



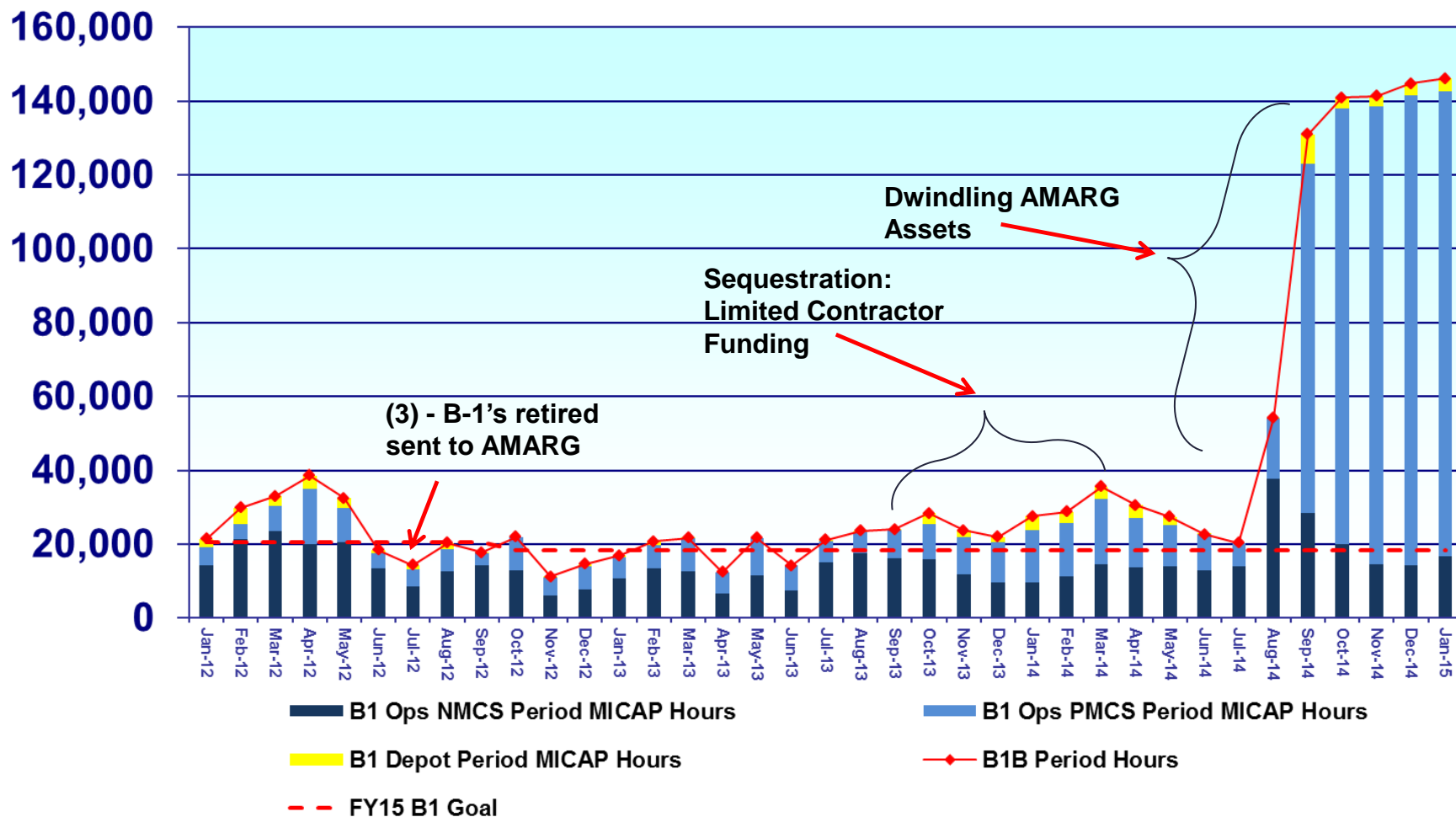
# Overview



- **B-1 Weapon System MICAP Data**
- **AA Assessment Available Aircraft**
  - **Total Non-Mission Capable – Maintenance Rate (10 Year)**
  - **Total Non-Mission Capable – Supply Rate (10 Year)**
  - **Ellsworth Health of the Fleet Snapshot – 28BW/34AMU**
  - **FY-15 Maintenance Man-hours Drivers**
- **B-1 Manning and Supply Summary (Col McFarland, 379 EMXG/CC)**
- **Rapid Innovation Fund (RIF) Update**
- **AFMC Change Evaluation Team**
- **28BW Additive Manufacture Rapid Repair Facility**
  - **AMRRF Location**
  - **Facility Layout**
  - **Authorities**
  - **Equipment**
  - **Implementation**
  - **Facility Cost**



# B-1 (WSDC - 56F) Weapon System MICAP Data



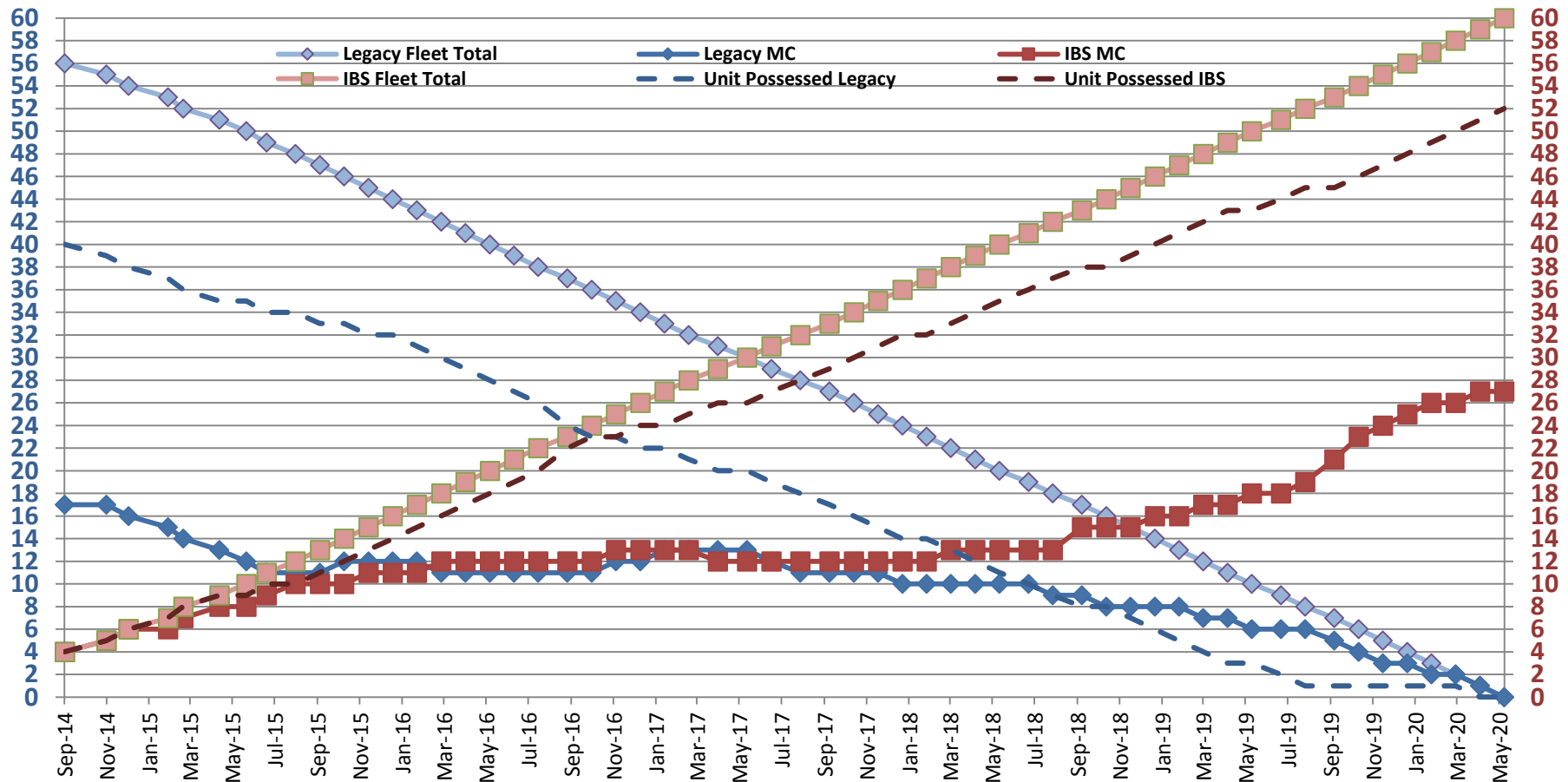


# B-1 AA Assessment Available Aircraft



## Legacy vs. IBS – Configuration Transition Timeline –

Linear projection based on programmed inputs and outputs. Projected Mission Capable (MC) numbers based on PDM & Mod schedules and AAIP attainable projections for NMCM / NMCS / NMCB / DP/ UPNR



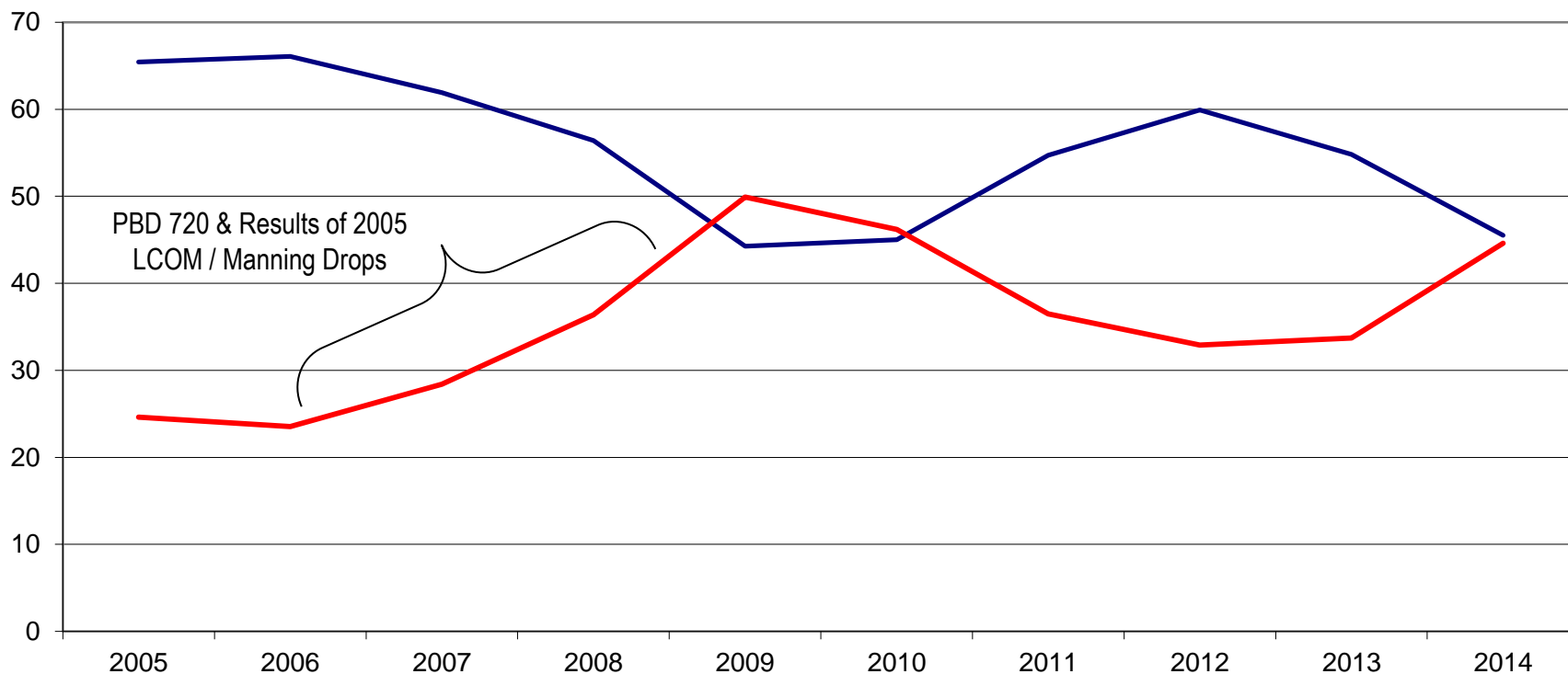


# Total Non-Mission Capable – Maintenance Rate



## 10 Years - B-1 Prime Metrics

— MC RATE — TNMCM





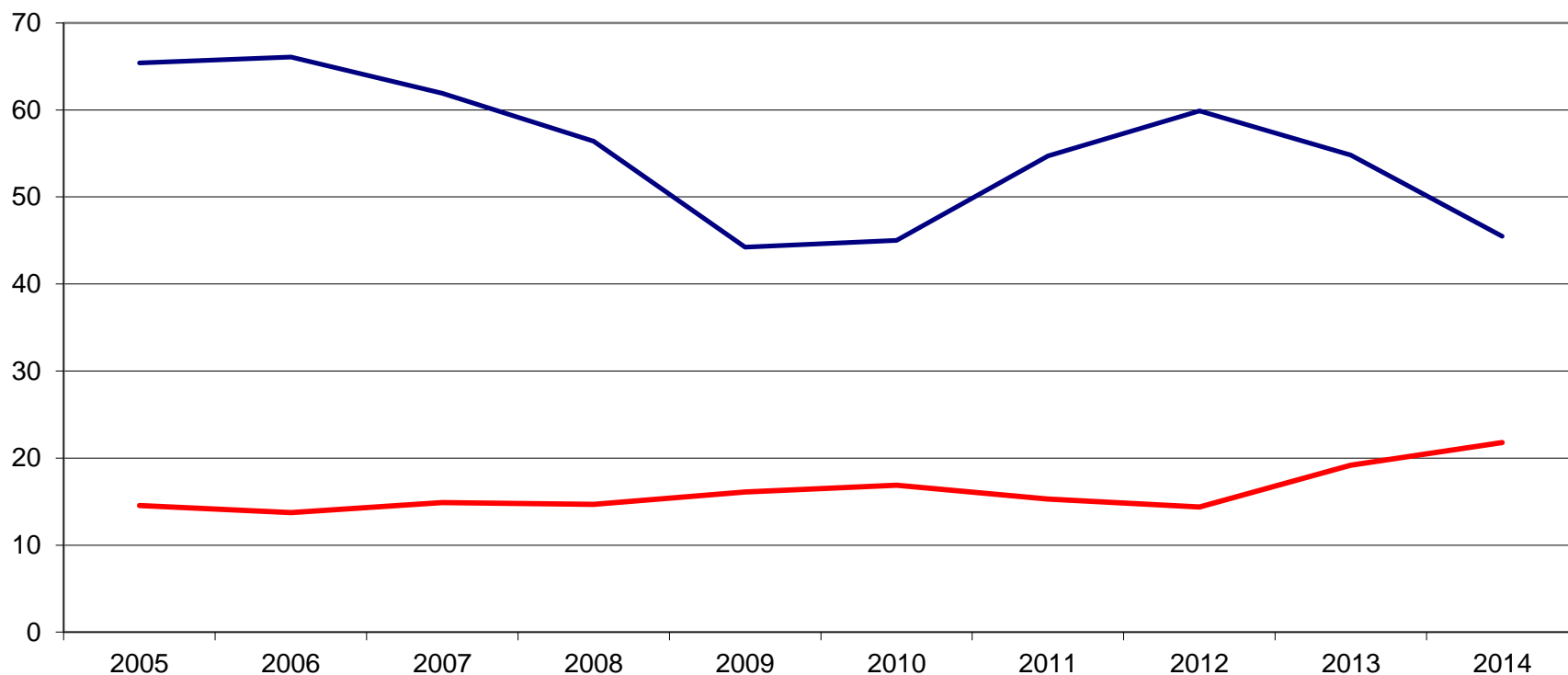
# Total Non-Mission Capable – Supply Rate



## 10 Years - B-1 Prime Metrics

— MC RATE

— TNMCS





# 28 BW/34 AMU



Home Station	Std / Goal	Oct 15	Nov 15	Dec 15	Jan 16	FY16
MC Rate	62	43.9	53.0	33.4	48.9	45.1
TNMCM Rate	36	45.4	38.6	48.1	43.5	43.8
TNMCS Rate	10	22.4	17.2	30.0	13.4	20.3
FSE Rate	65	80.0	58.5	43.2	42.9	56.9
MX/Ops Dev Rate	30	16.8	35.4	25.9	33.3	27.7
Total Abort Rate	15	10.3	14.8	14.3	23.1	15.6
Break Rate	30	16.9	10.7	14.8	17.7	15.0
12-Hour Fix Rate	58	66.7	37.5	50.0	63.6	57.1
Repeat/Recur Rate	5	1.0	0.6	0.0	0.0	0.5
Cannibalization Rate	28	34.8	38.7	50.0	24.2	36.4
Aircraft Availability		27.9	34.0	20.0	31.6	28.5
Sortie Contract / Flown		81 / 89	72 / 75	59 / 54	62 / 62	274 / 280
Hour Contract / Flown		291.5 / 319.8	254.1 / 238	223 / 194.9	219.8 / 199.5	988.4 / 952.2
Sortie UTE Rate		6.4	5.3	3.8	3.8	19.5



# B-1 Manning and Supply Summary



## ➤ Challenges

### ➤ GSC/A4 TNMCM Rate Challenge – Develop “Game Changers”

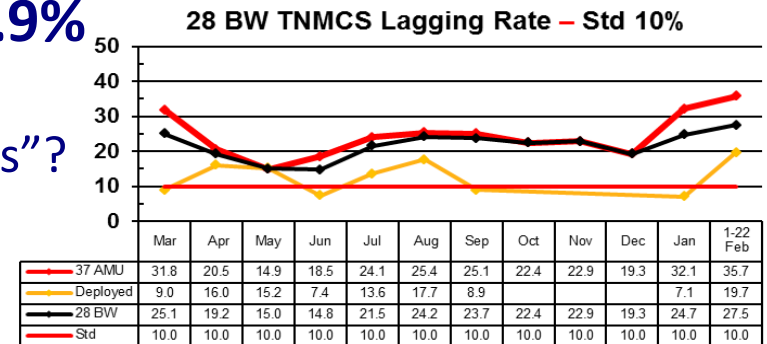
- 12-Month Avg: 39.6 TNMCM, including 51%+ Aug/Sep 2015 (TCTO 1550)
- Met TNMCM rate std 4/5 months in FY15
- What if TNMCM avg'd 79% for the last 12 months?

### ➤ TNMCS: 12-month Average is 21.9%

- 2.2X the GSC STD
- What are the TNMCS “Game Changers”?

### ➤ Bleak Manning Outlook; Parts Constraints Exacerbate Problem

- Can Not Afford to Work Each Job 3X (Cann) or Wait Weeks
- B-1 AFETS Engineering Teams: Avg 25 yrs B-1 Experience & M-1 CFT Team: Avg 16.5 yrs B-1 Experience they are both part of the answer







# FY-15 Maintenance Man-hours Drivers



## 5-Digit WUC and Description

**04199 - SPECIAL INSPECT**

**23200 - ENGINE CHANGE**

**03900 - PERIODIC, TIME, OR MAXIMUM USE, DEPOT**

**45A90 - HYDRAULIC, GENERAL TITANIUM LINES**

**46FA0 - FUEL CENTER-OF-GRAVITY MANAGEMENT (FCGMS)**

**46AAQ - MANIFOLD**

**03300 - HOURLY POSTFLT INSP / HOME STATION CHECK**

**04147 - PEN AID CONF TEST**

**73DC0 - OFFENSIVE RADAR SYSTEM (ORS)**

**46BEH - HOSE, ENG SUPPLY / MANIFOLD**

**14HD0 - FLAPS/SLATS CONTROL**

**27BA0 - GEARBOX (ADG) NO. 1**

**14HDF - PDU, FLAP/SLAT**

**73DCB - LOA, AS-3607/APQ 164**

**02100 - WASHING**

**14DA0 - SCAS CONTROL**

**03000 - LOOK PHASE OF SCHEDULED INSPECTIONS**

**52BAN - VANE, SMCS, L**

**46BA0 - FUEL TRANSFER**

**14HA0 - WINGSWEEP (W/S)**

**14AH0 - ROLL CONTROL - OUTBOARD SPOILERS**

**46FAH - DEVICE, INTERMEDIATE, SYS 1 AND 2**

**03700 - REFURBISHMENT / PROUD FLYER**

**24ABA - APU (RH)**

**41AA0 - LT/RT BLEED AIR**

**27BB0 - GEARBOX (ADG) #2**

## NMCM (H)

**5,680.38** This includes all 30, 60, 90, 150, 180 and 365 day inspections.

**3,819.08** The field records much engine maintenance on the this WUC - even when they don't "change" the engine.

**3,167.83** ISOs

**3,010.57** This is a constant recurring driver for maintenance AND supply AND CANN driver. Chaffing then Bending and shaping replacements. Need an easier simpler method.

**2,551.30** Tank troubleshooting and FCGMS ID troubleshooting

**2,246.02** Nacelle fuel tubes

**1,990.50**

**1,987.18** Chaff / Flare Dispensers - unreliable

**1,762.72**

**1,213.33** Nacelle fuel tubes

**1,064.25** Rigging - time consuming

**1,017.60** ADG replacements - running #1 APUs too much because CASS pits are inoperable

**1,013.88** Rigging, troubleshooting

**965.92** LOA & gimbal maintenance

**965.75**

**965.3**

**962.92**

**762.08**

**725.87**

**708.95**

**688.07**

**684.07**

**680.78**

**680.17**

**678.95**

**677.62**



# 2013 Rapid Innovation Fund



## ➤ Objectives :

- Cold Spray process development & testing
- Maintenance procedures
- 2 x Portable high pressure cold spray systems
- Operational test and training
- Expanded application opportunities
- Final implementation





# RIF Candidate Parts

## B-1 Forward Equipment Bay (FEB) Panel



Chafing Wear on  
Operational Panel

8 panels per aircraft  
Four panels per side  
Lt and Rt sides

AI 2024, composite bonded  
stiffened skin panel

- AI 6061 Repair Developed
- Tested 2014
- Adhesion, Tensile, Micro Exam, Impact
- AFRL Test Report
- 2 tests identified but since have been determined to be acceptable (backside impact & ductility)
- Technical analysis Complete
- Additional tests added 2016
  - Wear
  - Corrosion
  - Additional Impact Samples
  - ECD: July 2016

CS Repaired June 2012  
3.7 Years, 2233 Flight  
Hours





# RIF Candidate Parts

## B-1 Hydraulic Tubing Chafing Prevention



- CP Ti Repair Developed tested 2009-11
- Operational wear test since that time
- Ti 3Al 2.5V process requested
  - Obtained powder
  - Unable to identify qualification requirements
- Switched back to Cp Ti
- New Test plan cut down to fewer tests done on actual tubing
  - Adhesion, Micro, hardness
  - Wear Detection
  - Burst
  - Hydraulic Impulse
  - Pressurized rotating beam
  - ECD August 2016



Chafing Point  
Wear Tested

Main Landing Gear  
Line

CS Applied Jan 2011 (2 A/C)  
5 Years 4960 Combined Flt  
Hrs

Chafing Point  
Wear Tested

Nose Landing  
Gear  
Accumulator Line

CS Applied Mar 2009  
7+ Years, 2487 Flight Hours

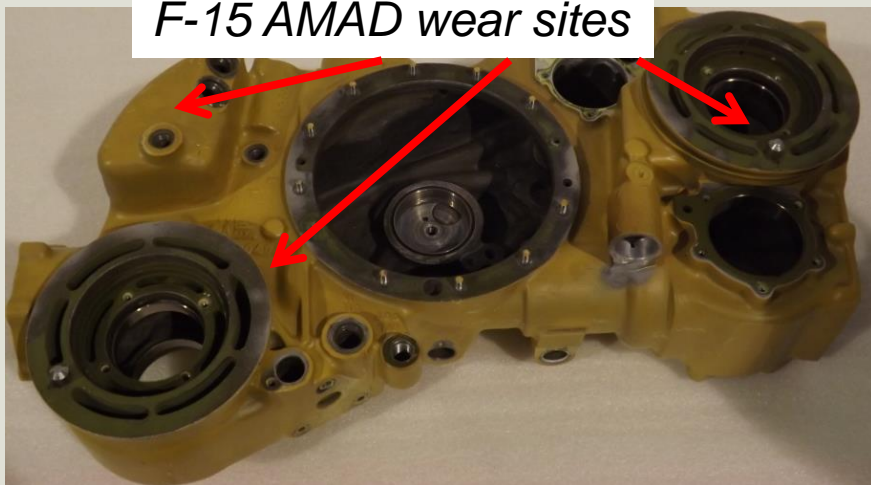


# RIF Candidate Parts

## F-15 Airframe Mounted Accessory Drive



*F-15 AMAD wear sites*



Nonstructural wear, several locations

- Technical Analysis Complete
- Al 6061 Repair Developed
- Prototypes repaired & tested 2015
  - AFRL Report Sep 2015
  - ARL Report Feb 2015
  - Adhesion, hardness, micro exam
- AFRL issue with linear indications
  - Determined acceptable Feb 2016
- Wear test added Feb 2016
  - ECD: July 2016
- Corrosion protection brought up as an issue but testing has not been required







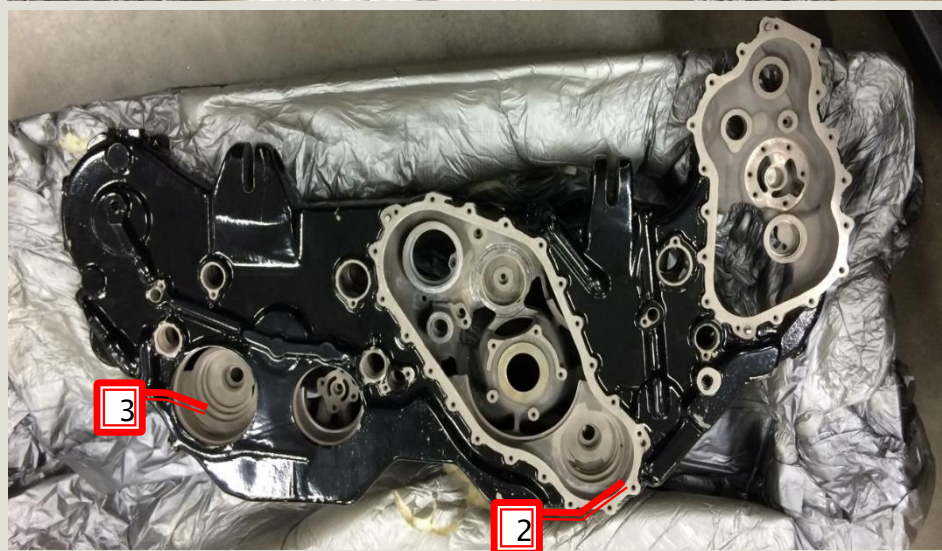
# RIF Candidate Parts

## F-16 Accessory Drive Gearbox



Nonstructural wear, several locations

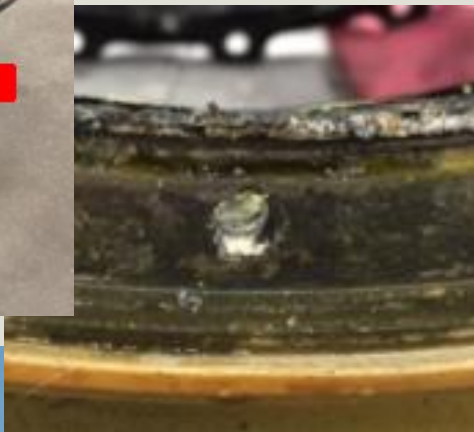
- Technical Analysis Complete
- Al 6061 Repair Developed
- Prototypes in completed
- Wear test added Feb 2016
  - ECD: June 2016
- Corrosion protection brought up as an issue but testing has not been required





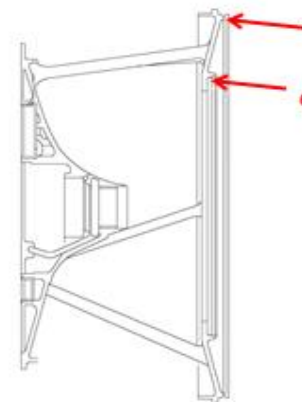
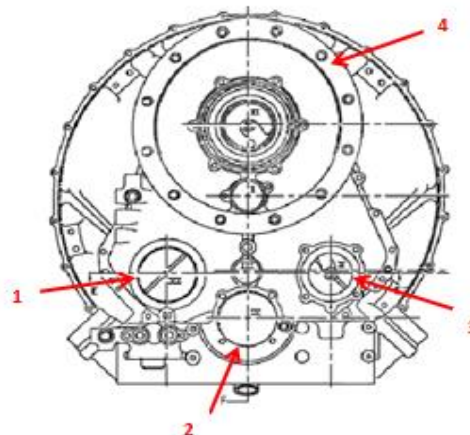
# RIF Candidate Parts

## C-5 Match Set Housing



Nonstructural corrosion, several locations

- Technical Analysis Complete
- Al 6061 Repair in development
- Test plan complete
- Testing ECD Sep 2016







# **AF Life Cycle Management Center**



**Air Force  
CET (Change Evaluation Team)  
Processes Started 14 April 2016  
Cold Spray  
*AW Process Requirements  
and  
Way Forward  
RIF Team in Correlation with LCMC***





# Change Evaluation



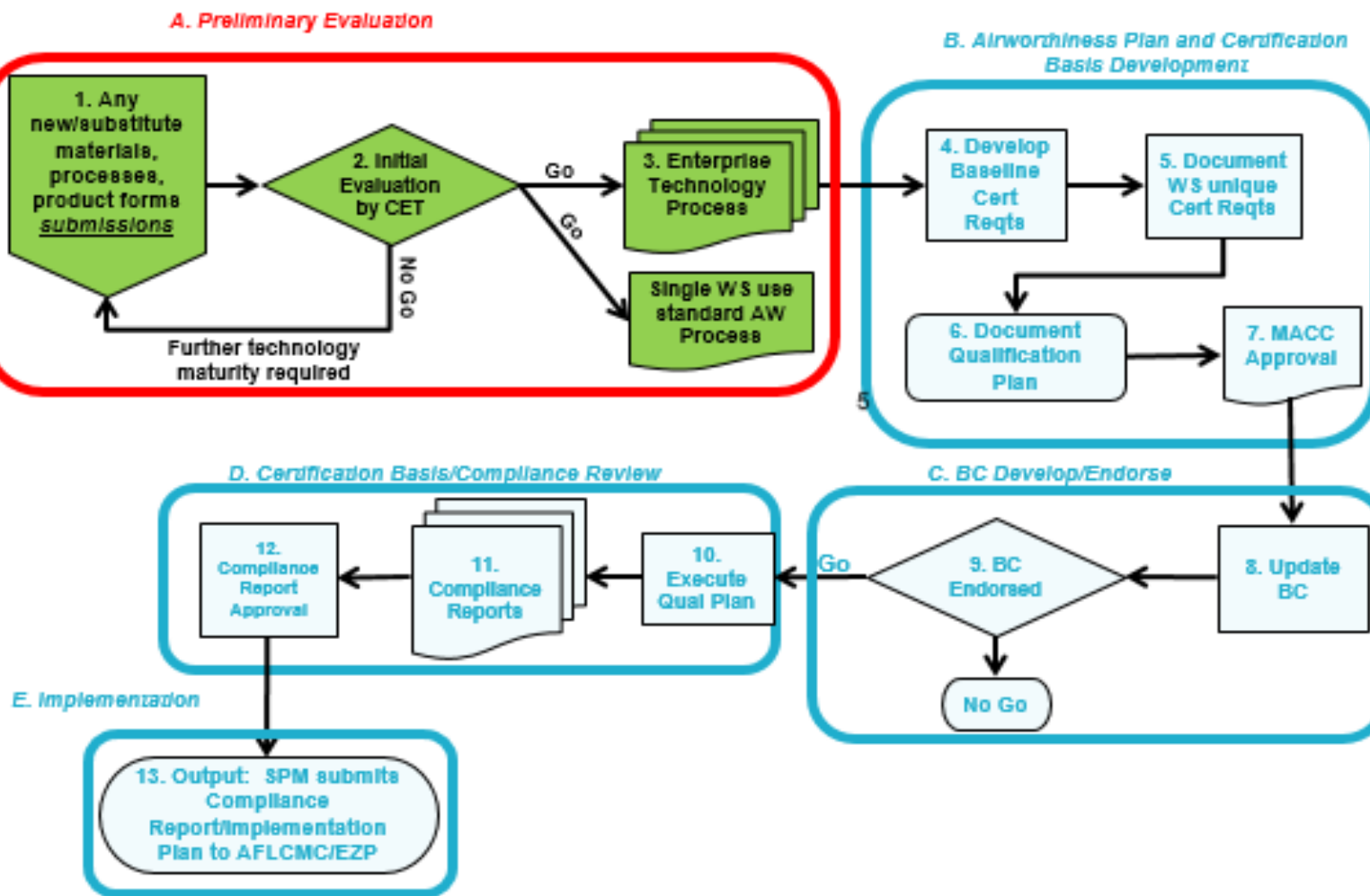
- **CET 1 Focus – Approval of non safety critical non structural repair of Aluminum (6061 Al) on Magnesium (ZE41A-T5, AZ91C-T6, EV31-T6) Parts**
- **Based on RIF parts and previous data**
- **Review by SME team**
- **Target date end of July**





# AWB-1015 Process Flow

## Preliminary Evaluation





# Preliminary Evaluation Addressing 5 Key Factors



Process begins with submission of  
**AWB-1015 Attachment 2**  
**Standard Requirements Form**

*Data demonstrating*

- 1. Stability*
- 2. Producibility*
- 3. Characterized Mechanical and Physical Properties*
- 4. Predictability of Performance*
- 5. Supportability*

Attachment 2  
AWB-1015

STANDARDIZED REQUIREMENTS FORM FOR INCOMING NEW/SUBSTITUTE MATERIALS, PROCESSES OR PRODUCT FORM PROPOSALS

Section I: Project Description

*Problem Statement* - Describe the opportunity, problem, or gap the proposal intends to address:

*Proposed Solution* - Describe the proposed solution in detail. Explain how the proposed solution addresses current weapon system opportunities, problems, or gaps. Include a top-level implementation plan:

*Airworthiness Analysis* - Include an Airworthiness Determination Form (ADF) if applicable. If an ADF is not applicable, discuss potential impacts of the new technology across the USAF enterprise:

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AWB-1015

*Solution Technology* - Describe the proposed solution's technology:

*Current Technology* - Describe current commercial technology that has been carried out on this technology and provide the Technology Readiness Level (TRL) for the technology:

*Technology from the user's perspective* - Describe the technology from the user's perspective, including any safety, health, or occupational health benefits, and warfighter readiness:

*Cost/Benefit Analysis* - Explain the projected return on investment (ROI) of the proposed technology and how long it is projected to take to achieve this ROI:

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**Key Factors are not 100% pass or you fail**  
**– Require engineering judgement and a risk based cost/benefit approach**



# 28BW Additive Manufacture Rapid Repair Facility



## AMRRF Objective

Establish a facility to develop, qualify, and field additive manufacturing technologies to manufacture or repair \*structural and non-structural components and wear surfaces of aircraft and base support equipment.

\*Structural Components are not being considered at this time.





# 28BW Additive Manufacture Rapid Repair Facility



## AMRRF Location – North Side of MXS Building 7520



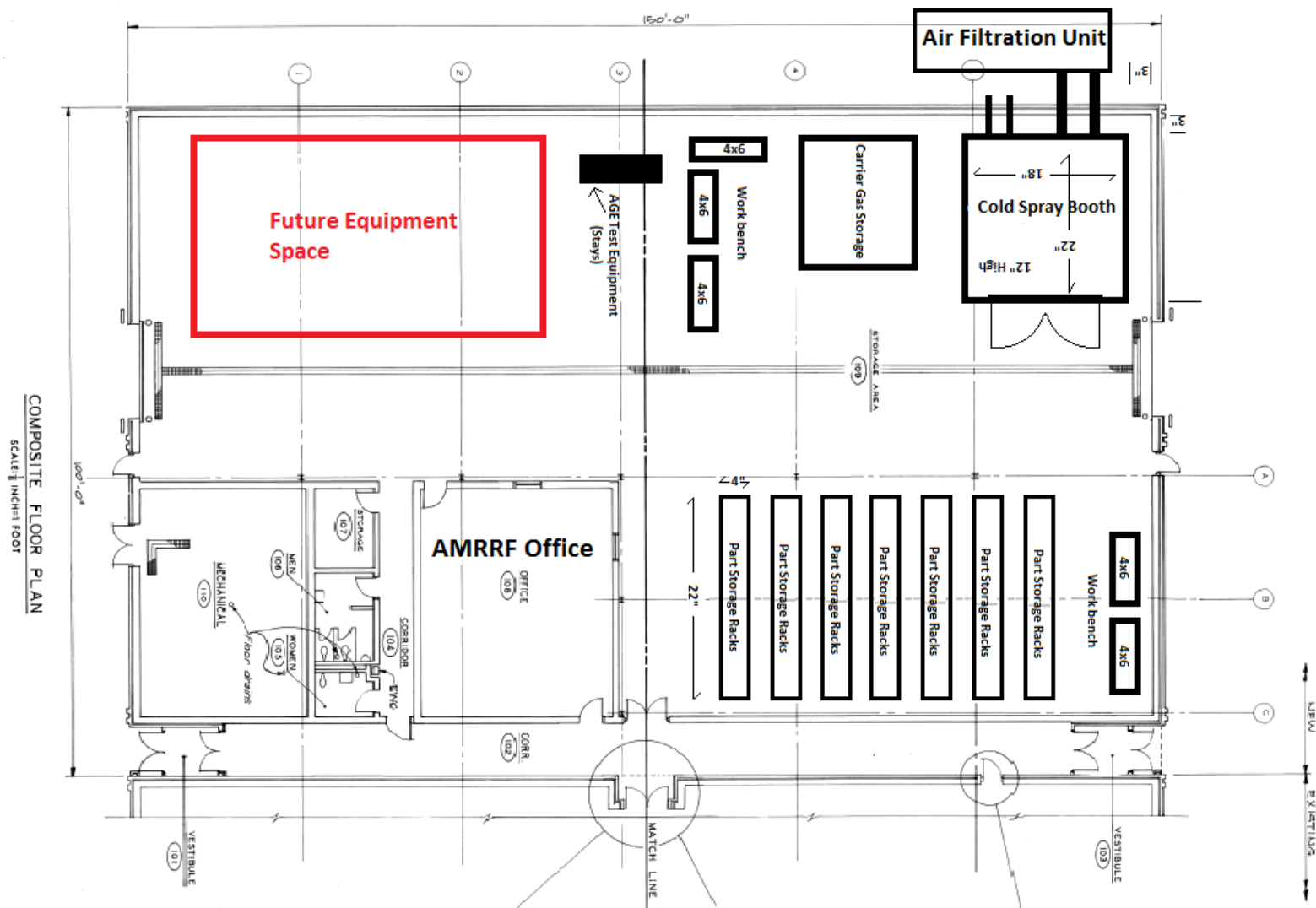




# 28BW Additive Manufacture Rapid Repair Facility

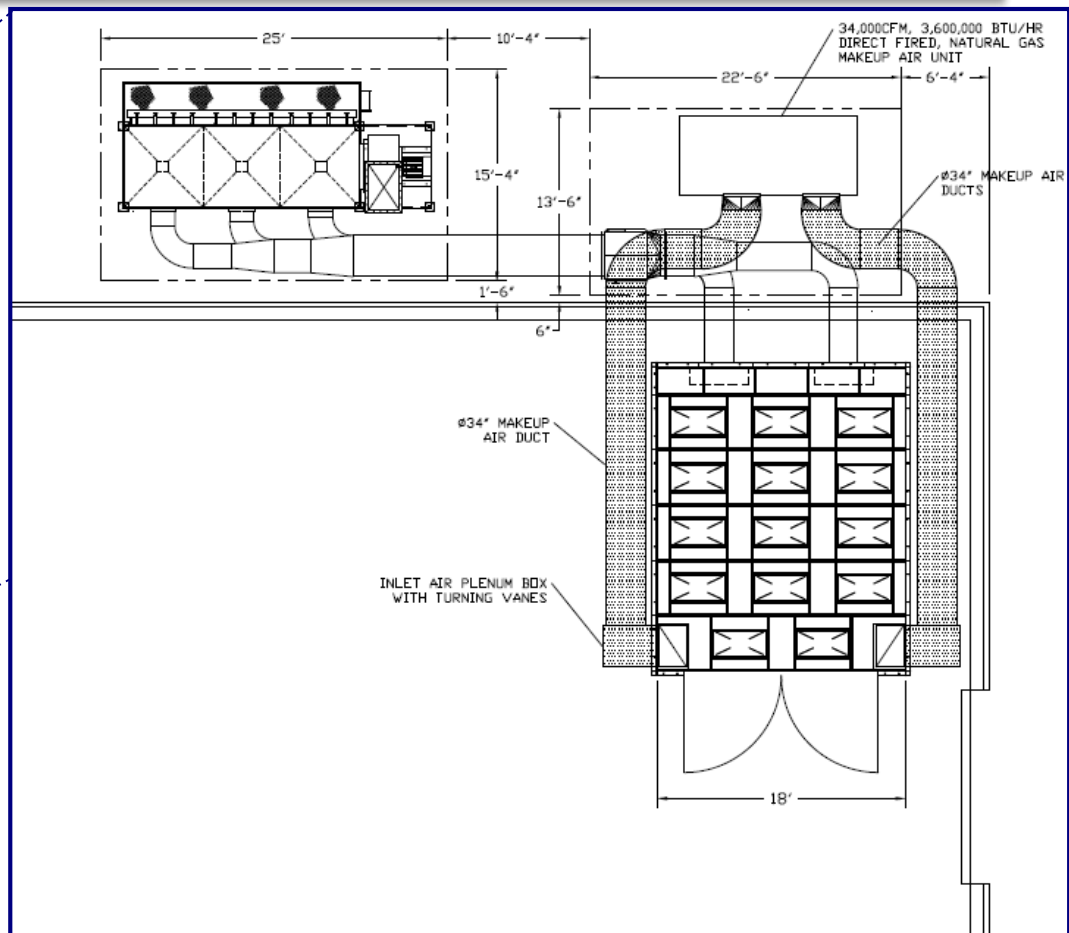
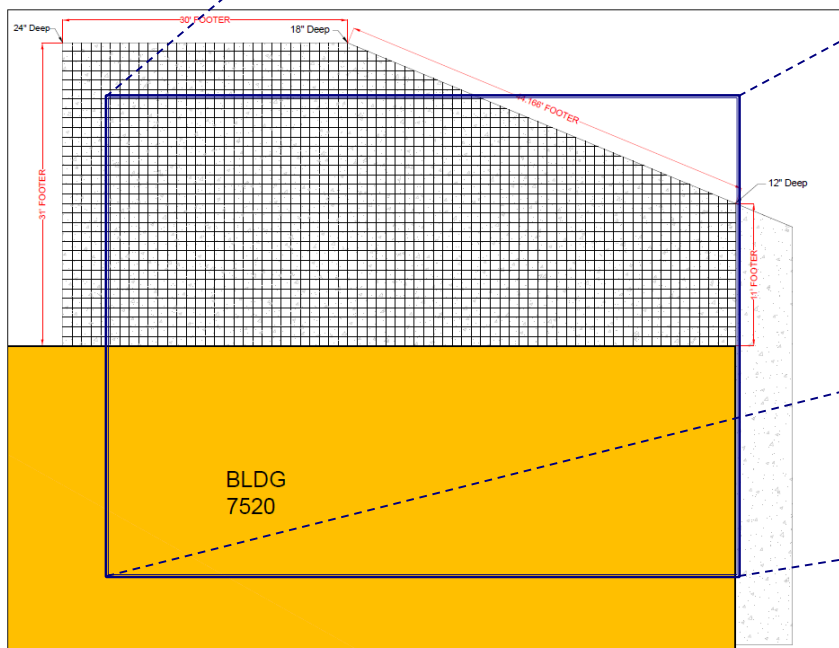
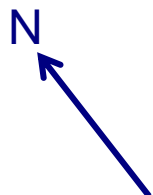


## AMRRF Layout – North Side of MXS Building 7520





# 28BW Additive Manufacture Rapid Repair Facility





# 28BW Additive Manufacture Rapid Repair Facility



**AMRRF Office**





# 28BW Additive Manufacture Rapid Repair Facility



**AMRRF Facility**



# 28BW Additive Manufacture Rapid Repair Facility



## Authorities

- AFCP P4 Initiative
- **Rapid Innovation Fund (RIF)**
  - Requires extension
  - R&D funding needed
- **Memorandum of Understanding**
  - 28 BW and SDSM&T
- **28 BW Operating Instruction**
  - 28 BW POC – Mr. Brian L. James
  - Defines operations requirements, responsibilities, etc
- **Air Force Repair Enhancement Program (AFREP)**
  - Execution Architecture
  - Avenue for O&M ROI





# 28BW Additive Manufacture Rapid Repair Facility



## Funding

- **Rapid Innovation Fund (RIF)**
  - 18 month funding (Equipment & Services)
    - Fund the first 6-to-8 months operating expenses – to 1 April 2016
    - Provides cold spray system and consumables
  - **Potential funding extension for additional 24 months (FY16)**
  - Competitive Source Selection Process (FY14)
- **Self-Sustaining by CY 2017**
- **Ellsworth/AFREP funding**
  - \$775,416 total
  - Potential additional fire suppression needed

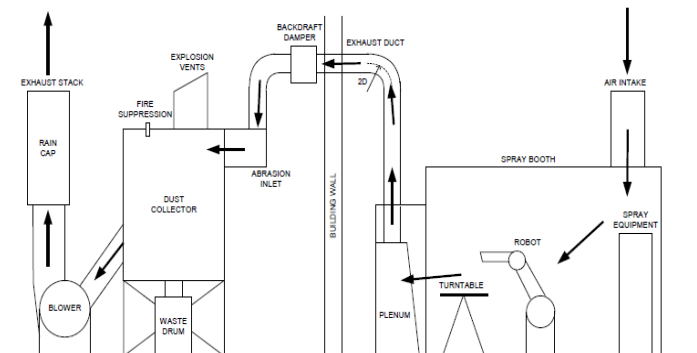


# 28BW Additive Manufacture Rapid Repair Facility



## Equipment

- **(2) Generation III Cold Spray Units delivered in FY15**
  - Ellsworth AFB Gen III July 2016
  - Dyess AFB Gen III Sept 2016
- **(1) Infrastructure and Equipment delivered in FY16**
  - Funded by Ellsworth AFREP
  - \$570,000 Equipment/Infrastructure
  - \$450,000 Carrier Gas BPA





# 28BW Additive Manufacture Rapid Repair Facility



## Implementation

- **Initial Operational Capability (August 2016)**
  - Contractor Managed Facility - Moog
  - Initial Training
- **Phase I (Ground Equipment Refurb)**
  - Use cold spray during annual refurb
    - Corrosion, wear, etc.
  - Training military technicians contractor supervised
- **Phase II (Aircraft Component Repair)**
  - Qualified components from RIF
  - Additional components





# Questions?



**Mr. Brian L. James**  
**Lead Engineer**  
**Air Force Engineering and Technical Services**





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# Backup Slides



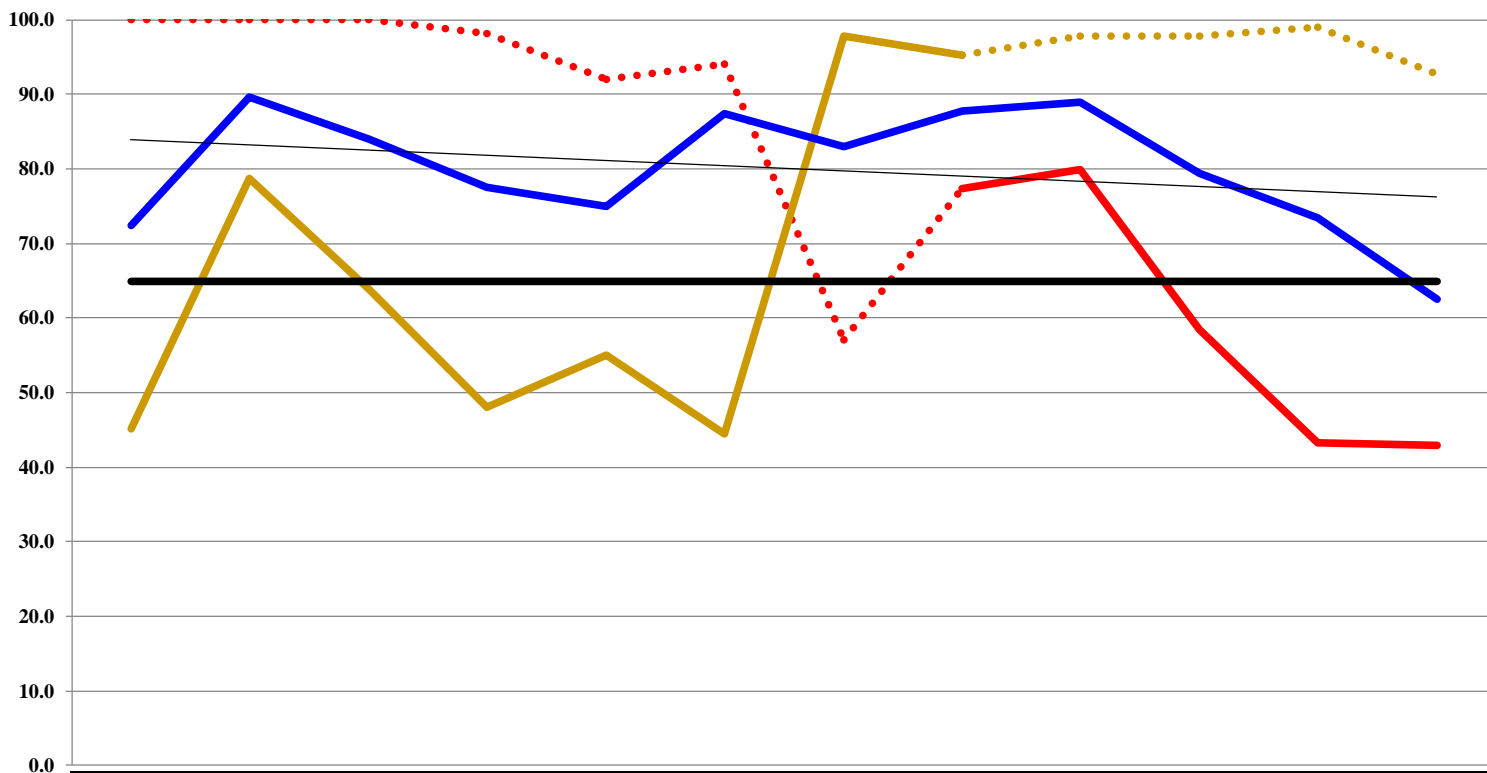
# Flying Scheduling Effectiveness Rate



STD 65%



34 AMU 37 AMU 28 BW Std Linear (28 BW)



34 AMU

37 AMU

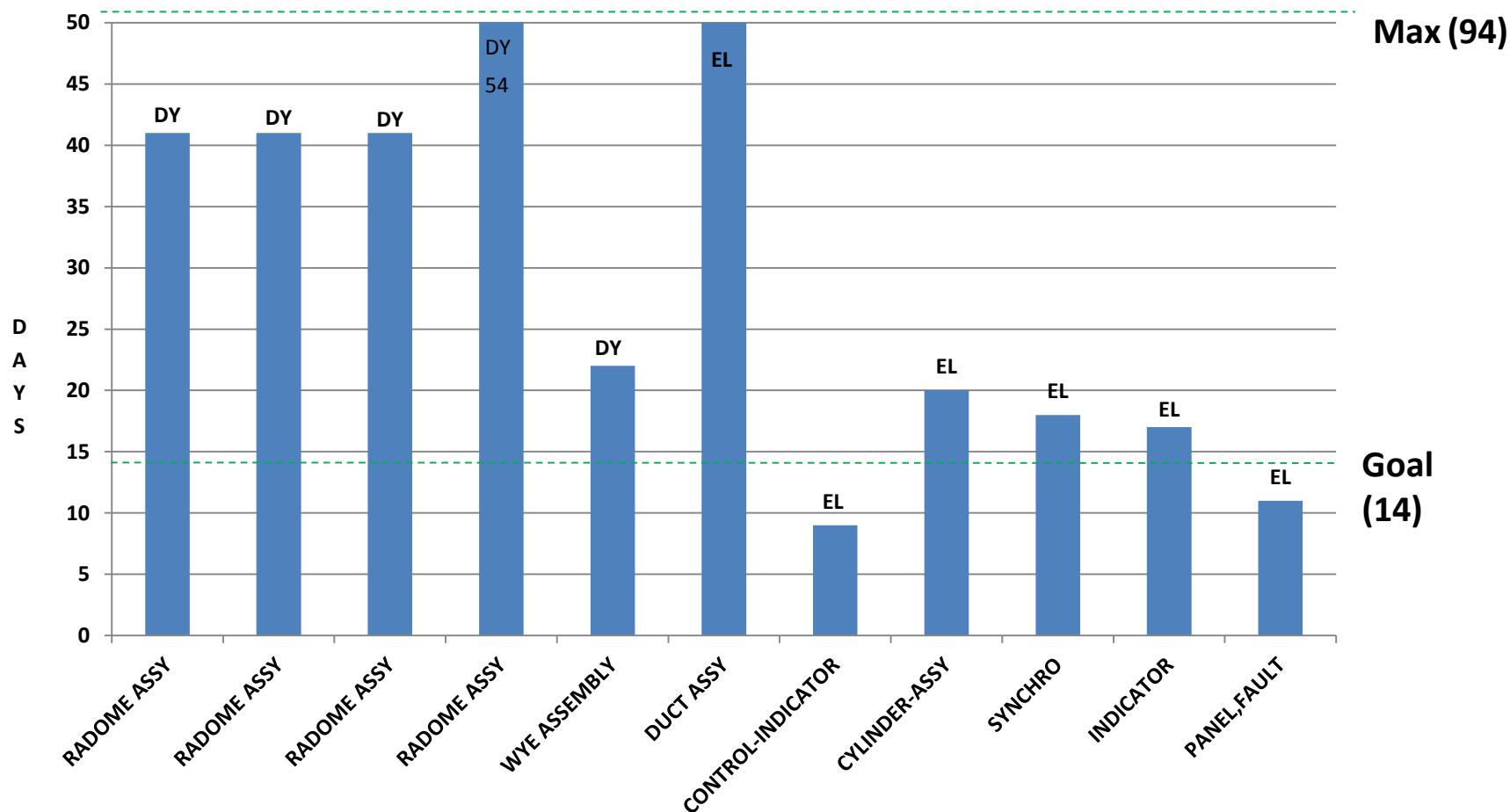
28 BW

	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	12-M
34 AMU	100.0	100.0	100.0	98.2	92.1	94.1	57.1	77.3	80.0	58.5	43.2	42.9	78.6
37 AMU	45.1	78.8	63.9	48.1	55.1	44.4	97.9	95.2	97.9	97.8	99.0	92.7	76.3
28 BW	72.4	89.6	84.0	77.6	75.0	87.5	83.0	87.7	88.9	79.4	73.4	62.6	80.1





# MICAP Cycle Time for AMARG Pulls for Dec 15 (MICAP initiation - Base receives part)

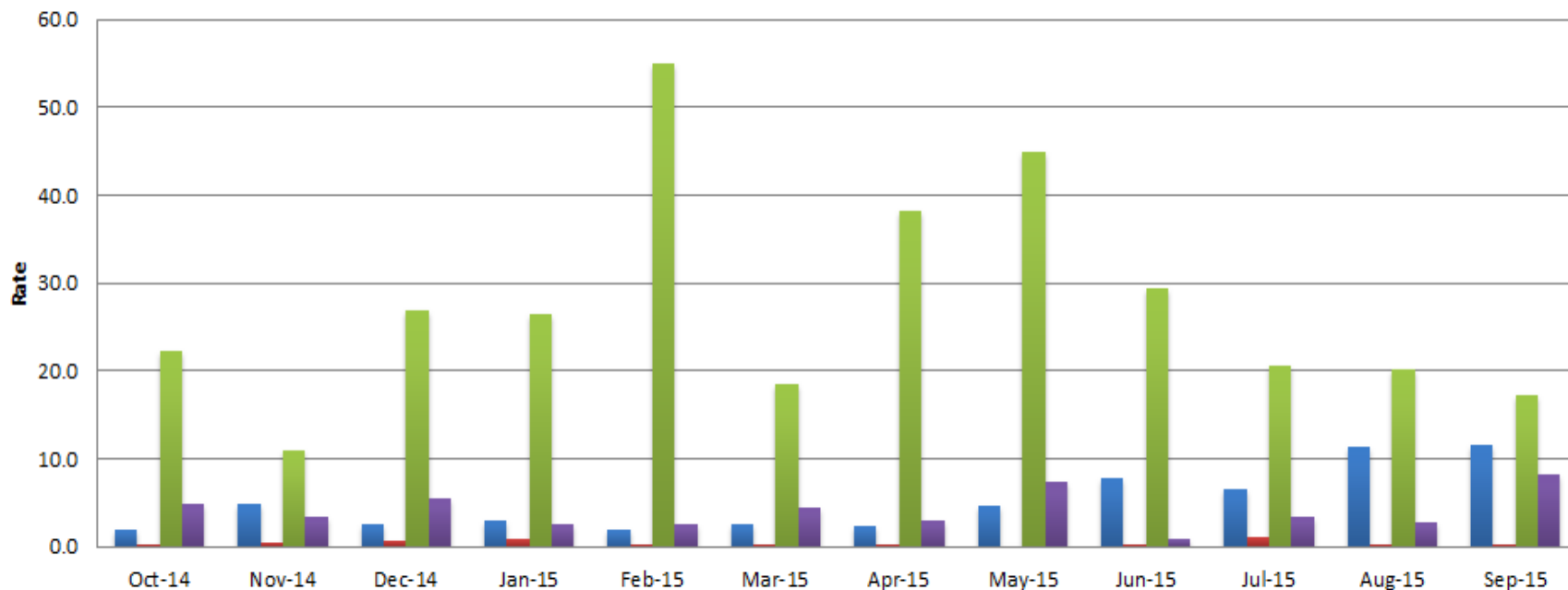




# Cannibalization Rate Comparison



CANNIBALIZATION RATE



	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15
F-22	2.0	4.9	2.5	3.0	1.9	2.5	2.3	4.7	7.9	6.5	11.3	11.5
MQ-1	0.3	0.4	0.7	0.8	0.2	0.2	0.2	0.0	0.3	1.1	0.2	0.2
B1-B	22.2	10.9	26.8	26.6	55.0	18.4	38.2	45.0	29.3	20.6	20.3	17.3
C-5	4.9	3.3	5.4	2.6	2.6	4.5	2.9	7.3	0.8	3.4	2.8	8.2



# 28BW Additive Manufacture Rapid Repair Facility



## Aircraft Component Repair

- ~7704 MICAP hours saved if we used cold spray to fix 6 B-1 FEB panels, past 2 yrs
- ~480 MICAP hours saved if we used cold spray to fix 2 hydraulic lines, past 2 yrs
- Ellsworth MXG Personnel submitted 11 ETARs to utilize cold spray to repair B-1

## Components

<u>Control Number</u>	<u>Status</u>	<u>Status Date</u>
E12-00225	Disapproved	Jun 05, 2012
E12-00248	Approved	Jun 14, 2012
E12-00410	Disapproved	Nov 15, 2012
E12-00422	Info Only	Dec 07, 2012
E14-00015	Disapproved	Jan 23, 2014
E14-00017	Disapproved	Jan 22, 2014
E14-00083	Disapproved	Apr 18, 2014
E14-00177	Disapproved	Sep 18, 2014
E15-00137	Disapproved	Oct 15, 2015
E15-00143	Disapproved	Oct 23, 2015
E15-00162	Disapproved	Dec 21, 2015

- Request Review and of all disapproved ETAR Request for approval



# Major Milestones and Timeline

## FY15



- ▼ Complete
- ▼ On-track
- ▼ Minor Disruption
- ▼ Major Disruption
- ★ Current Date

3 Sep 15: MXG completed spt equip/AMRRF office furniture purchase ▼

21 Jul 15: Cold Spray booth awarded by CONS ▼

15 Jul 15: Established initial concrete pad and power rqmts with Pauli ▼

22 Jun 15: Cold Spray booth solicited by CONS ▼

1 Jun 15: MXG compl'd SOW for CES, SE, Bio, Fire and CONS review ▼

Mar 15: MXG Building 7520 (North bay) established as AMRRF by 28 BW/CC ▼

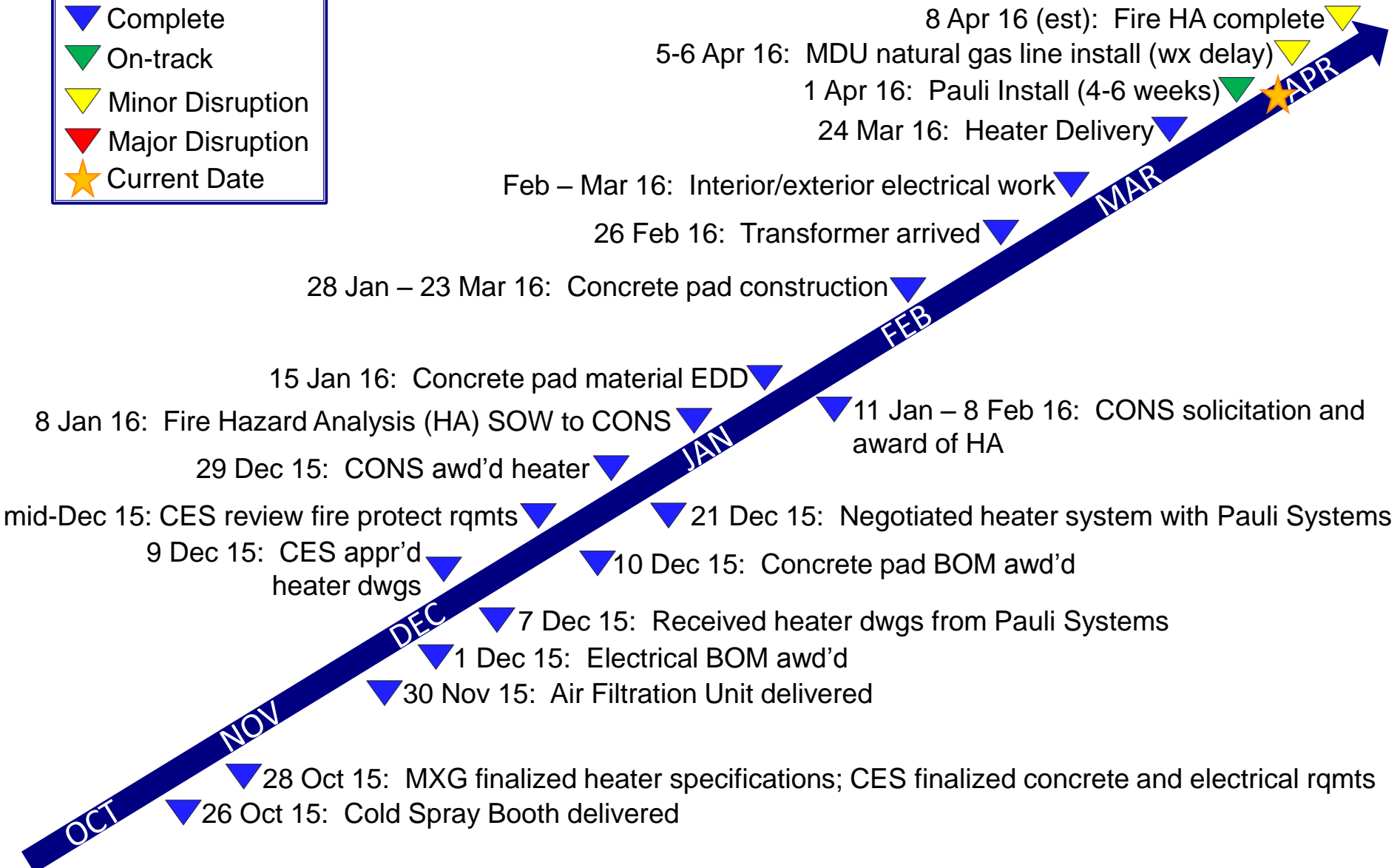


# Major Milestones and Timeline

## FY16



- ▼ Complete
- ▼ On-track
- ▼ Minor Disruption
- ▼ Major Disruption
- ★ Current Date





# Construction Update



## ➤ **Fire Hazard Analysis (HA):**

- Contract awarded 8 Feb; NTP issued 25 Feb
- Anticipated completion date: 8 Apr (42 day performance period)
- HA will determine needs for fire protection in booth as well as any potential changes to facility fire suppression system

## ➤ **In-house Construction:**

- Substantially complete; drainage and finish grading to be complete following Pauli install
- Some minor items (i.e. grounding points and compressed air line install) to be completed when Pauli is on site

## ➤ **MDU Natural Gas Line Install:**

- Scheduled for 22-23 Mar; delayed due to weather
- Rescheduled for 31 Mar-1 Apr

## ➤ **Pauli Systems Booth Install:**

- Scheduled to start 1 Apr
- Timeline of approximately 4-6 weeks to complete



# IOC Requirements and Timeline



## ➤ **Current Requirements:**

- Booth installed and operational
- Establish HAZMAT handling/storage processes
- Determine PPE needs based on bio assessment
- Define maintenance responsibilities between MXG and CES
- Execute contract mod for Moog/VRC support
  - MOU not feasible between for-profit company and USAF according to JA
  - Rapid Innovation Fund (RIF) contract being modified to incorporate EAFB

## ➤ **Timeline:**

- Contract modification and OI target
  - 15 Apr: OI draft complete
  - 15 Apr – 6 May: OI review by OCRs
- Operational Target Date: 31 May



# Way Forward



- **Continue to develop FOC requirements and timeline**
  - Potential Requirements:
    - Addition of second booth
    - Addition of media blast booths
    - Addition of 3D Printer
    - Establish lab area
    - Air Force Center of Excellence?
  - Timeline TBD
  - Funding TBD
- **AFGSC Visit Expectations**
- **Vector Check**