

Protection of the C-17 Airplane during Semi Prepared Runway Operations

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ABSTRACT

The C-17 airplane operates in some of the most challenging environments in the world including semi prepared runway operations (SPRO). Typical semi-prepared runways are composed of a compacted soil aggregate of sand, silt, gravel, and rocks.

When the airplane lands or takes off from a semi-prepared runway, debris, including sand, gravel, rocks and, mud is kicked up from the nose landing gear (NLG) and the main landing gear (MLG) tires. As the airplane accelerates to takeoff or decelerates from landing touchdown, this airborne debris impacts the underbelly and any component mounted on the underbelly. The result is the erosion of the protective surface coating and damage to systems that protrude below the fuselage into the debris path.

The financial burden caused by SPRO damage is significant due to maintenance costs, spares costs and Non-Mission Capable (NMC) time. A study was commissioned by Air Mobility Command in 2007 to develop integrated solutions to protect the airplane from damage during SPRO operations.

This paper summarizes the results of the study, including damage to the airplane when exposed to different types of SPRO environment, solution concepts, the method of selecting the solutions and the solutions being implemented for protection of the C-17 airplane.

INTRODUCTION

The objective of this study was to provide the US Air Force 516th Aeronautical Systems Group and Air Mobility Command (AMC) with design concepts and trade-off analysis of hardware concept alternatives for additional protection of the airplane from damage during Semi-Prepared Runway Operations (SPRO). These landing and takeoff operations take place in remote, austere locations where the runways are typically composed of packed aggregate which breaks down during repeated operations. The landings and takeoffs cause debris to become airborne and impact the aircraft under fuselage and subsystems as shown in Figure 1. The study provides an integrated solution for SPRO damage reduction and includes a roadmap and a measure of effectiveness for each solution along with a schedule and cost estimate.

The financial burden to the USAF C-17 fleet, caused by SPRO damage, is estimated to be over \$40M per year due to cost of maintenance, Non Mission capable (NMC) time, cost of spares, etc.



Figure 1- SPRO

BACKGROUND

Typical semi prepared runways are composed of a compacted aggregate of sand, gravel, silt and rocks. Moisture content and aggregate composition impact the compaction of the soil and the type and amount of airborne debris generated during aircraft SPRO. The relative proportions of soil, clay, sand and rock content determine the degree of damage observed during SPRO. Large rocks up to 2 inches wide and other debris have been observed on some fields as shown in Figure 2. However, the largest amount of erosion damage is caused by fine sand and silt suspended in the air. The photos in Figure 2 show aggregate mixes, unintended debris and conditions common to SPRO fields.

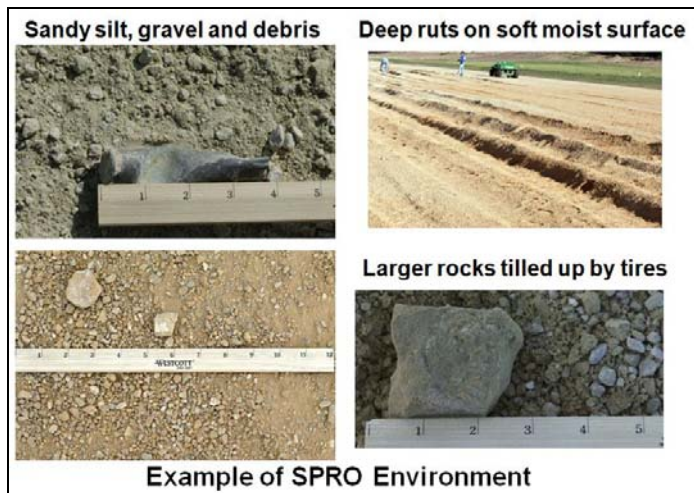


Figure 2- SPRO Environment

The runway aggregate is lofted from a runway surface by the nose and main landing gear tires as an airplane accelerates for takeoff or decelerates after landing. Takeoff and touchdown speeds in excess of 120 knots result in a significant amount of energy being imparted to the runway surface aggregate. When the inboard and outboard edges of the nose landing gear (NLG) and the main landing gear (MLG) tires encounter loose material, the energy transfer lofts the material into the path of the on coming aircraft structure, as illustrated in Figures 3 and 4. This airborne debris impacts the underbelly and any object protruding below the underbelly, such as an antenna, drain mast or light. The result is erosion of surface coatings and damage to systems.

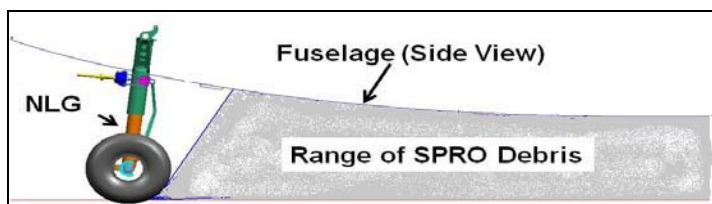


Figure 3 - NLG Lofted Debris Coverage

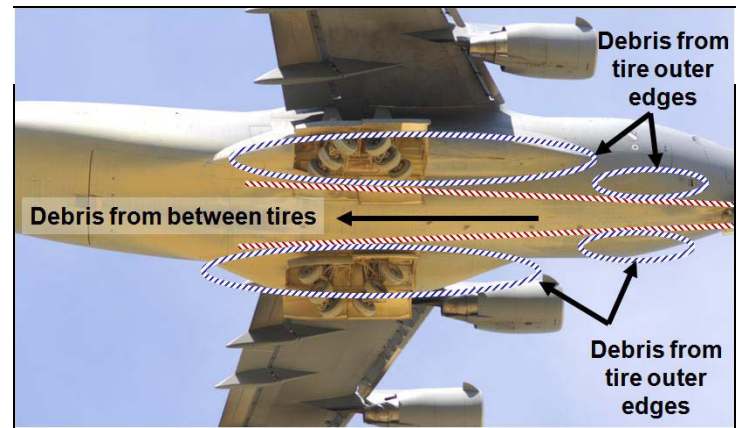


Figure- 4 Primary Debris Impact Areas on Aircraft

When high moisture content is present on the runway surface, fine wet silt and mud adhere to the underside of the aircraft, as shown in Figure 5. This mud covers the fuselage, landing gear pod interior and exterior and the main landing gear wheel structure. This can add a few hundred pounds to the aircraft's weight, which impacts mission fuel burn. No structural damage was observed as a result of mud impact. Overall, less damage to the aircraft was observed during the wet ground operations than on a dry surface. Functionality of critical systems and increased post mission maintenance are impacted however, due to plugged drains and vents.

The vulnerable position of the main landing gear doors is also visible in Figure 5. The position of these doors leaves the door leading edges and inside surface susceptible to impact damage during SPRO.

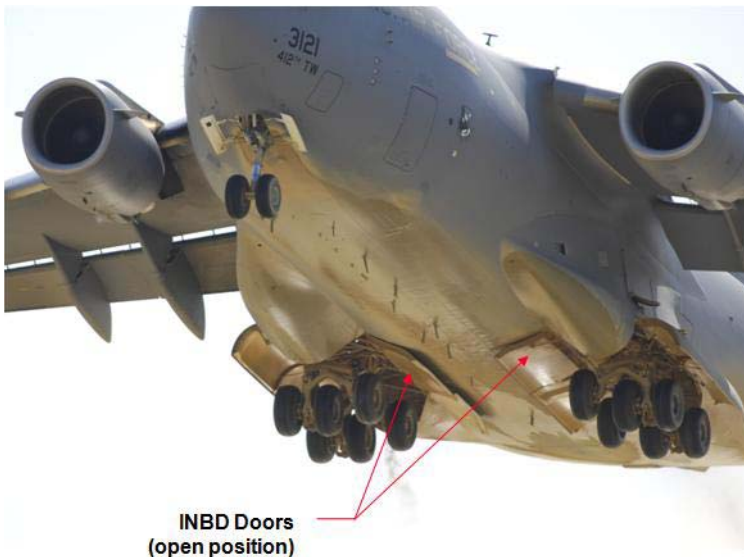


Figure 5 - Mud adhering to aircraft underbelly

DAMAGED AREAS

Examination of the test aircraft during the SPRO testing and historical data show damage to the under fuselage area of the aircraft and to the following systems and structures:

- Fuselage and wheel well pod skin paint
- Antennas – Figure 6
- Anti-collision light (ACL) - Figure 7
- Vents and drains – Figure 8
- Inboard MLG doors – Figure 9
- MLG axels and posts – Figure 10
- MLG pod structure – not shown
- Ram air inlet vent scoops in MLG pod – not shown
- Electrical cables – Figure 11

Eroded antenna shell leading edges



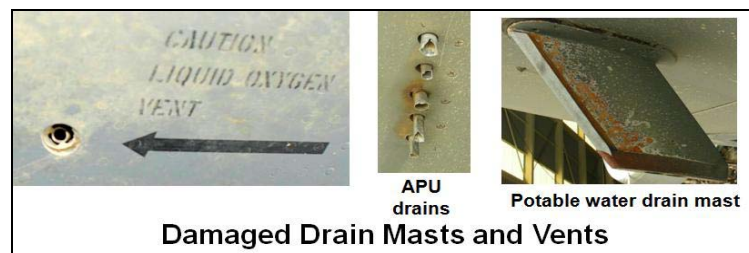
Figure 6 - Damaged Antenna



High Profile ACL

Low Profile ACL

Figure 7- Damaged lower anti-collision lights



Damaged Drain Masts and Vents

Figure 8- Damaged Drains and Vents