



Progress on S53 for Rotary Gear Actuators

ESTCP Project WP-0619

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Report Documentation Page

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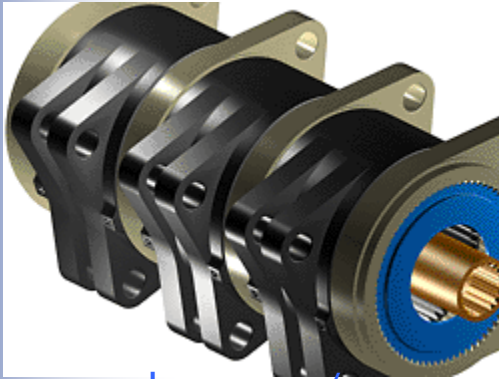
Team



- ❑ Ogden ALC, Ryan Josephson (PI)
- ❑ QuesTek Innovations LLC (steel design)
- ❑ General Atomics (testing)
- ❑ Lockheed-Martin (F-35 prime)
- ❑ Moog (WFAS RGA manufacturer)
- ❑ Curtiss-Wright (LEFAS RGA manufacturer)
- ❑ BAE Systems (galvanic testing)
- ❑ Rowan Technology Group (coordination, cost analysis)



What is an RGA?



www.zakgear.com/

Geared system to rotate one set of tabs relative to another

Used on F-18 to operate wing fold





RGAs on F-35 Lightning II

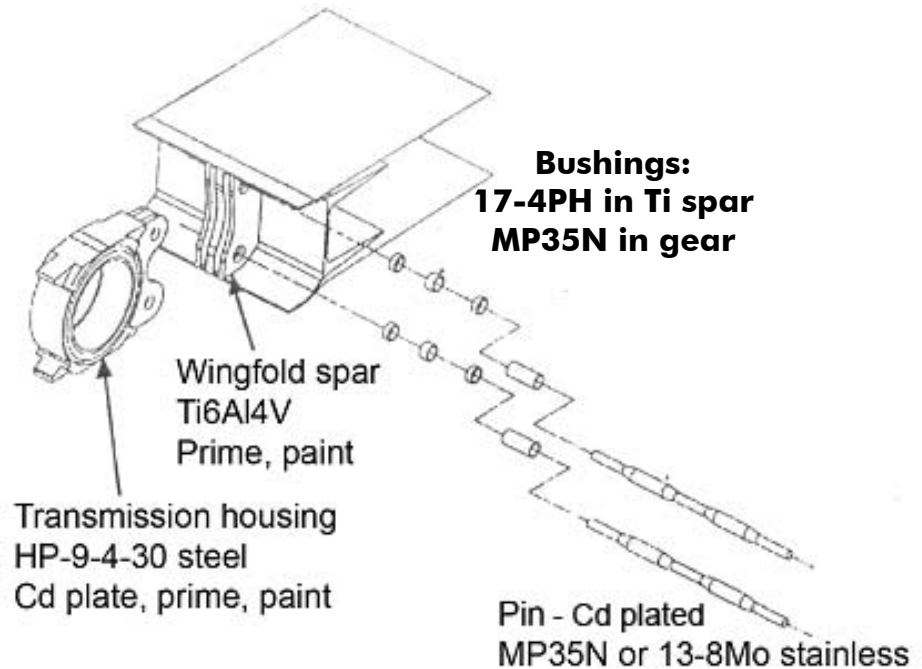


RGAs used for

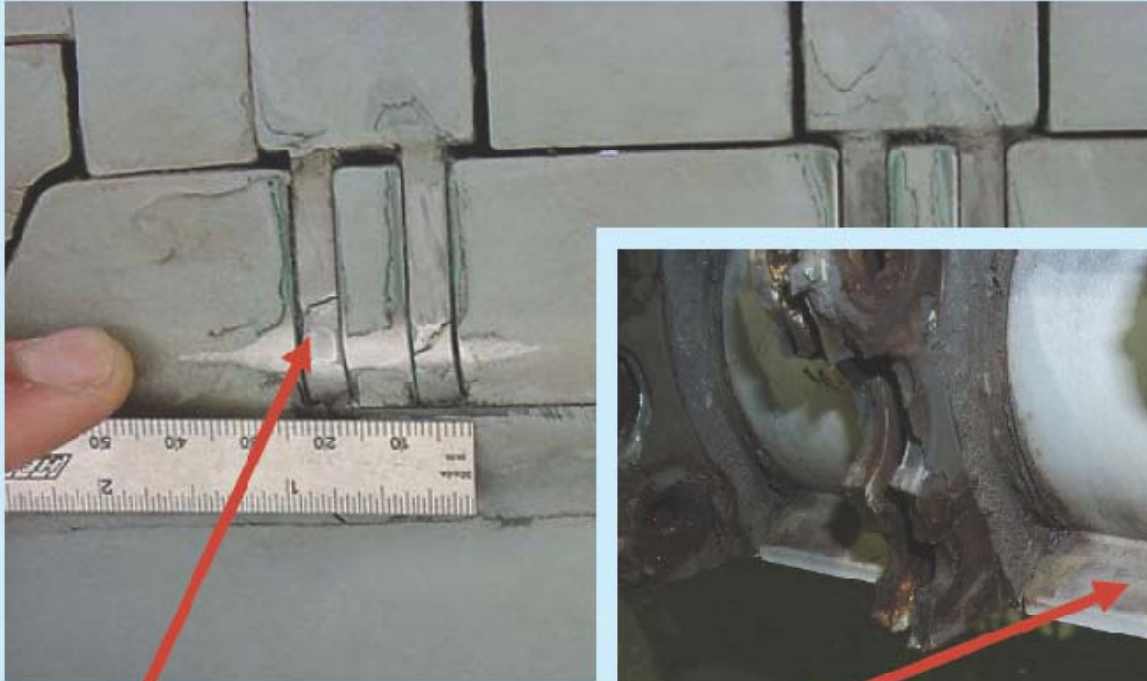
- ❑ Wing fold actuator system (WFAS)
 - Carrier variant
- ❑ Leading edge flap actuator system (LEFAS)
 - All variants



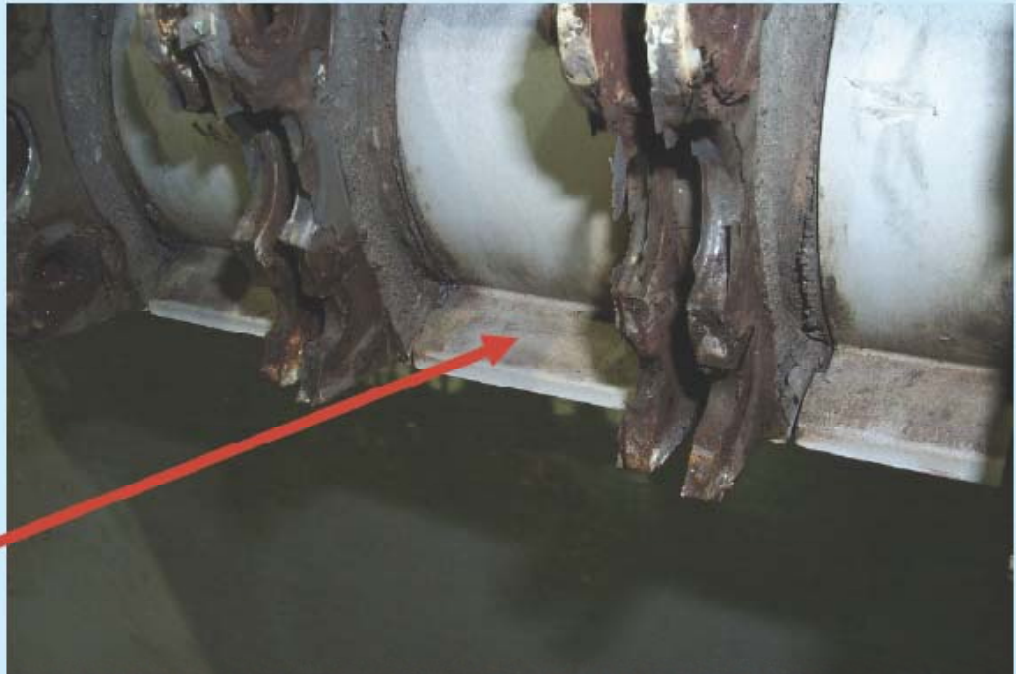
- ❑ MP35N Ni alloy rods
- ❑ HP-9-4-30 or 4340 high strength steel gears (Cd plated)
- ❑ 17-4PH stainless bushings
- ❑ Ti wing spar
- ❑ Bad galvanic couples



Galvanic corrosion of current system



Cracks



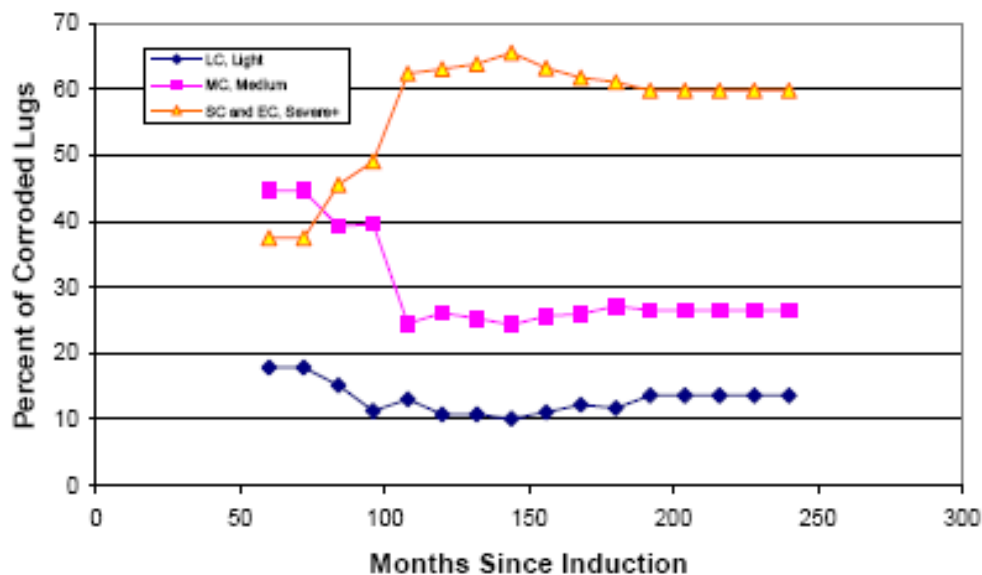
Missing Lugs



Extent of the problem

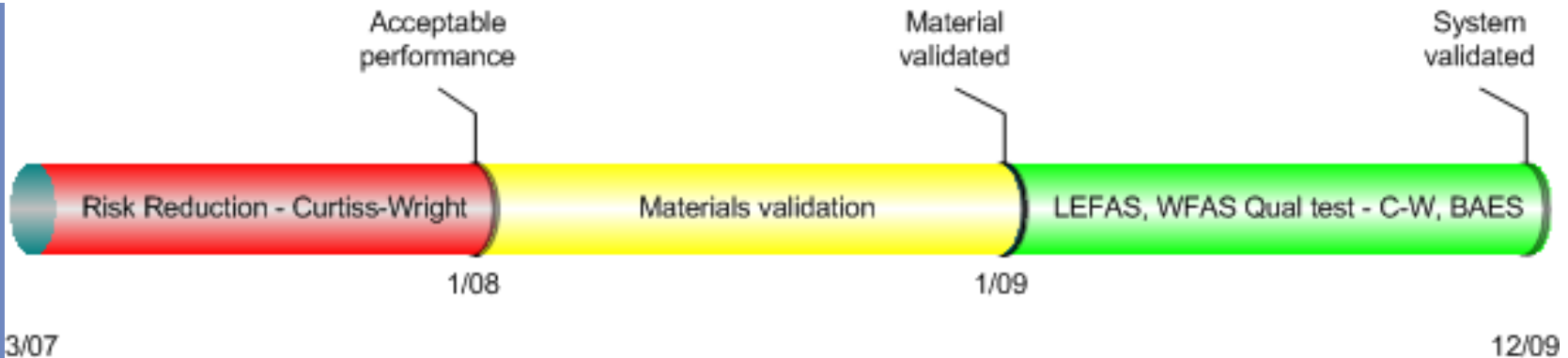


- ❑ This is a problem with all F-18 lugs
 - Matter of severity
 - Cracks come from corrosion pits
- ❑ Want to avoid this problem on F-35
- ❑ S53, being a CRES alloy, will not have progressive corrosion
 - But could still have pitting corrosion leading to fatigue
- ❑ S53 also has much better K_{1C} and K_{1SCC} so cracks will not grow as fast





Program design



- Because S53 designed for landing gear, not RGAs, program defined 1-year Risk Reduction
 - Corrosion (galvanic, crevice) at BAES in UK to match previous F-35 LEFAS testing



Parallel F-35 Program Office test program at Curtiss-Wright

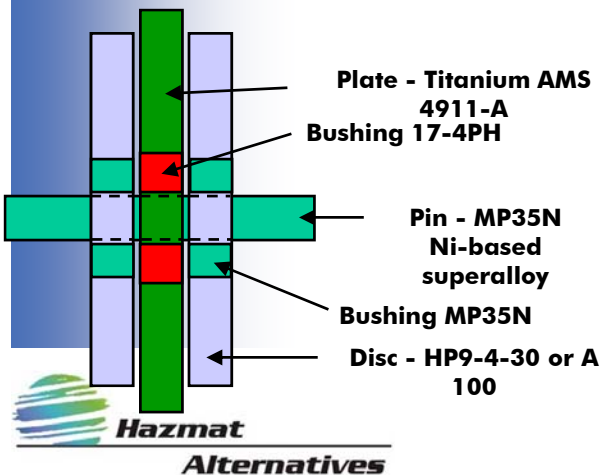


- ❑ C-W testing of growth on heat treating showed growth uniform and predictable
- ❑ Machining of test parts showed S53 is machinable in C-W shops
 - But must be sent out for heat treating as uses cryogenic steps
- ❑ C-W contracted to manufacture S53 LEFAS as demonstration and carry out mechanical testing of coupons





ASTM G85, SO₂ salt spray testing completed October 22, 2007



End of test (14 days, 336 hr)

Test #1, 2 HP9-4-30, Cd plated



Delamination of paint near bushing

No corrosion of HP9-4-30

Test #4, 5 S53, Cd plated



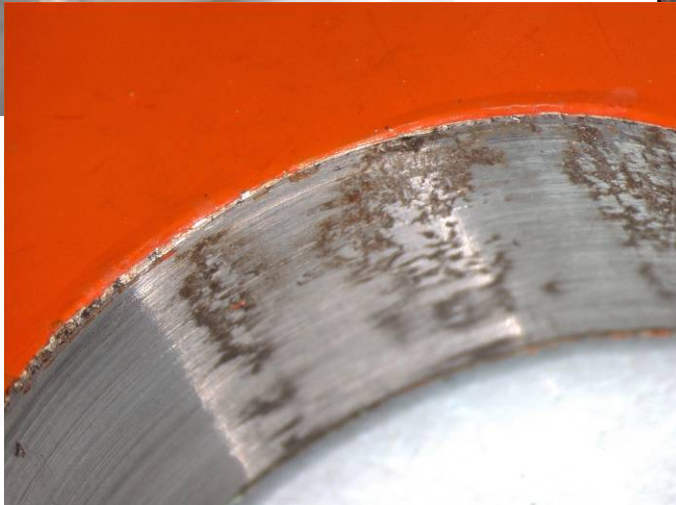
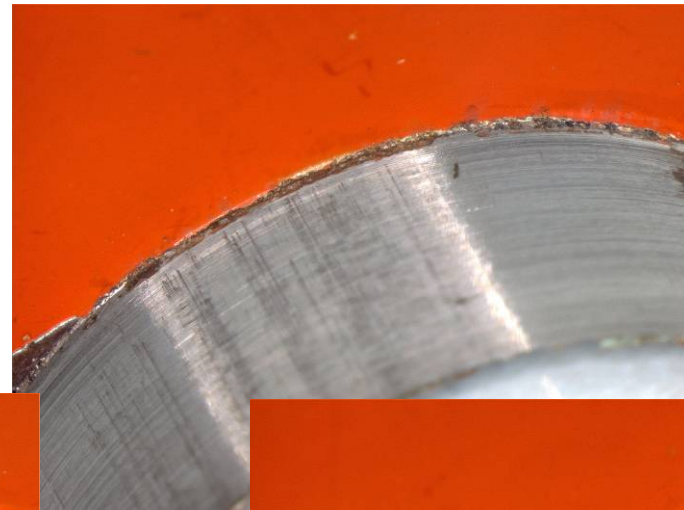
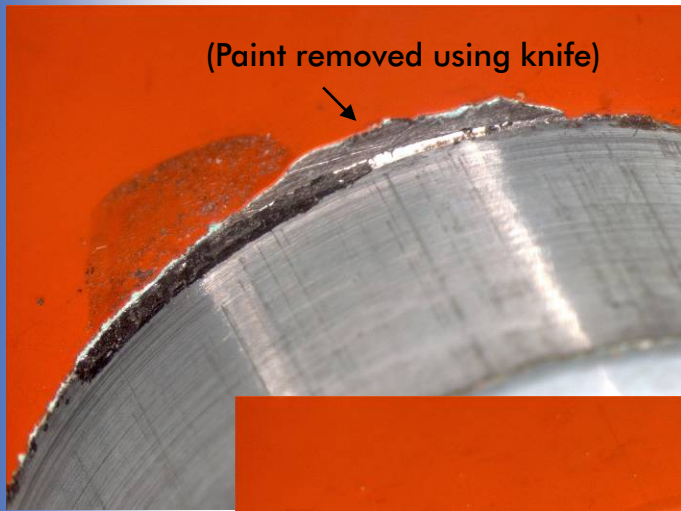
Delamination of paint near bushing

No corrosion of S53

Cd plating does a good job of corrosion protection. But adhesion of non-Cr primer is poor (needs better surface prep, vendors need to develop experience)

Final Test Results – after 14 days

S53, Boegel (no Cd plate) – bush removed - Outer surface





Qualification



- ❑ MMPDS listing and Class A allowables available shortly
- ❑ Full materials test results available shortly in Final Report of ESTCP S53 Landing Gear project
- ❑ Qualification of F-35 RGAs
 - Full LEFAS/WFAS units to be manufactured from S53
 - G85 SO₂ salt fog testing of full unit (requirement for all F-35 systems)
 - Full functional rig testing
 - If successful and cost-effective will enter program in LRIP

