Samen van Kennis naar Innovatie

Wanneer weten we voldoende om nieuwe oppervlaktebehandelingen betrouwbaar toe te passen op defensie materieel?

Arjan Cornet

TU Delft



2026



Zelensky condemns US extension of Russian sanctions waiver

The US argues that the waiver is meant to ease the energy supply crunch sparked by the US-Israel war with Iran.



Russia launches deadliest aerial attack in months, killing 18 in Ukraine

A Ukrainian drone attack killed two people in Russia, Moscow says, after an Orthodox Easter truce.



Guernsey trio send third aid vehicle to Ukraine

The vehicle will be driven to Mykolaiv, where it will be converted into an ambulance.

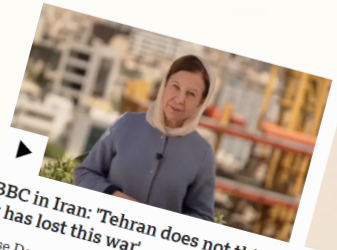


Ukraine's military to get biggest-ever shipment of UK drones

With attention on the Middle East, Defence Secretary John Healey said 'Putin wants us to be distracted.'



'Fear is everywhere': BBC reports from Mexican city turned into war zone by drug cartel feud



BBC in Iran: 'Tehran does not think it has lost this war'

Lyse Doucet says Iranians want a solution to the long-running animosity with the US, but leaders is not willing to make a deal on Washington's terms.



Lebanon seeks peace, but Hezbollah needs to be convinced first

The Lebanese government go into peace talks with limited influence over the group.



Some Iran-linked ships have crossed US blockade, data suggests

At least four vessels tracked from Iranian ports appear to have crossed a US blockade line in the Gulf of Oman, analysis of ship-tracking data suggests.



Lyse Doucet: Under fragile ceasefire, Iranians wonder if US deal can be done

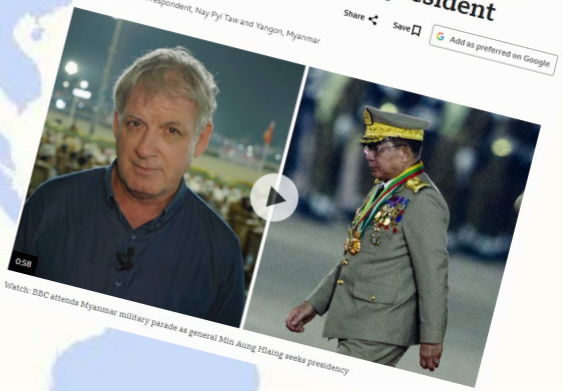
The BBC's chief international correspondent reports from Iran as diplomatic efforts to avoid a return to war intensify.

Myanmar's coup leader who set off a brutal civil war becomes president

3 April 2026

Jonathan Head

South East Asia correspondent, Nay Pyi Taw and Yangon, Myanmar



Watch: BBC attends Myanmar military parade as general Min Aung Hlaing seeks presidency

Source: ACLED

UNPREDICTABLE CONDITIONS IN MILITARY AVIATION

CARRIERS – MARITIME ENVIRONMENT



- Salt spray corrosion
- High humidity & precipitation
- Strong, gusty winds
- Rapid temperature changes

Variable sea states, deck motion, limited recovery space

DESERT AIRBASES – ARID ENVIRONMENT



- Sand & dust ingestion
- High heat extremes
- Low humidity & dryness
- Dust storms & poor visibility

Blowing sand, extreme heat, visibility degradation

MOUNTAIN & FOREST ENVIRONMENTS



- Elevation & density altitude
- Rapid weather changes
- Dense terrain & limited LZs
- Precipitation, fog & icing

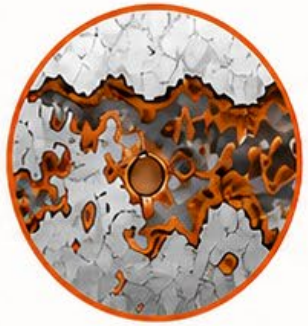
Terrain masking, turbulence, limited infrastructure

ATTACK OPERATIONS – EXTREME COLD



- Extreme cold (sub-zero)
- Icing & snow accumulation
- Strong winds & turbulence
- Battery & fuel performance

Cold soak, reduced performance, system stress



CORROSION (MOST COSTLY)

- Electrochemical degradation
- Environmental exposure (salt, humidity, chemicals)
- Coating breakdown

High lifecycle cost



STRUCTURAL FATIGUE (MOST CRITICAL)

- Crack initiation
- Crack growth
- Final fracture

Cyclic loading

High risk of catastrophic failure

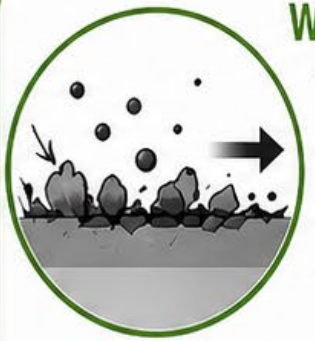


OVERLOAD

- Load exceeds design limit
- Impact or shock loading
- Plastic deformation or fracture

Sudden, acute failure





WEAR / ABRASION / EROSION

- Frictional contact
- Particle impact
- Fluid flow / cavitation

Progressive material loss

DEGRADATION → DAMAGE → FAILURE

REDUCED OPERATIONAL AVAILABILITY

OPERATIONAL IMPACT OF CORROSION

IMPACT ON COSTS AND AVAILABILITY — BASED ON U.S. DoD DATA

1 LIFECYCLE COST EXPANSION

Based on U.S. DoD studies, corrosion impact extends beyond direct repair costs.

BASED ON U.S. DoD DATA:

- GAO corrosion reports
- DoD corrosion studies
- AMPP (NACE) DoD data

APPLIED PRINCIPLE:

Total lifecycle impact =

5 – 10x

direct corrosion cost

U.S. DoD ESTIMATE (EXPANDED IMPACT)

$20 – $40 BILLION

ANNUALLY

(Direct corrosion cost ~ $2 – $4 billion annually)

REPRESENTS:

- Maintenance burden
- Downtime / availability loss
- Premature replacement
- Operational inefficiencies

2 IMPACT DECOMPOSITION: COSTS AND AVAILABILITY

COST IMPACT BREAKDOWN

(Share of Total Lifecycle Cost)

COST CATEGORY	BASIS (U.S. DoD)	SHARE
Prev. maintenance & inspection	CPCP programs, maintenance man-hours	30 - 40%
Repair & restoration	Depot-level maintenance data	25 - 35%
Early replacement	LCC degradation effects	15 - 25%
Downtime & capability loss	GAO readiness impact	10 - 15%

AVAILABILITY IMPACT BREAKDOWN

(Contribution to Non-Availability*)

AVAILABILITY DRIVER	IMPACT MECHANISM	SHARE*
Inspection & detection	Assets taken out of service for inspection	15 - 25%
Maintenance & repair	Repair actions require aircraft/equipment down-time	35 - 45%
Part / component lead time	Waiting for parts, suppliers, or logistics	20 - 30%
Rework & quality issues	Rework, recurring corrosion returns	5 - 15%

* Share of total non-availability hours due to corrosion

3 TRANSLATION TO NL-MOD (SCALING METHOD)

STEP 1 BUDGET SCALING

DoD budget ~ $800B

NL-MOD budget ~ €15 – 20B

Scale factor ≈ 1:40

STEP 2 ASSET COMPARABILITY

Similar platforms:

- F-35
- Naval vessels
- Rotary-wing aircraft

Comparable corrosion mechanisms and operational environments

STEP 3 APPLICATION

DoD corrosion cost scaled proportionally to NL-MOD

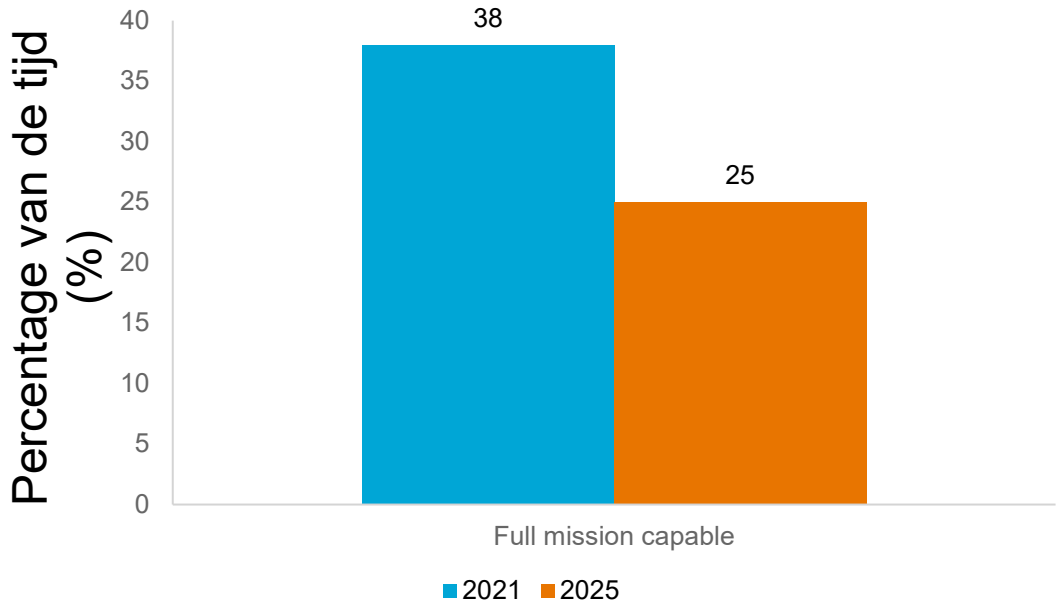
NL-MOD CORROSION COST ESTIMATE (ANNUAL IMPACT)

€0.50 – €1.00 BILLION

(Direct corrosion cost ~ €50 – €100 million annually)

SOURCES (U.S. DoD): GAO-11-490R (Mar 2011) | GAO-12-823R (Jul 2012) | AMPP (formerly NACE) DoD Corrosion Cost Update (2016) | DoD Operating & Support (O&S) Cost Structure Guidance | Aerospace Corrosion Prevention & Control Programs (CPCP)

Beschikbaarheid is een aantoonbare opgave



Corrosie is één van de knelpunten

Ook onderdelen, reparatiecapaciteit en software spelen een rol.

GAO (2026), Amerikaanse F-35 instandhouding, GAO-26-108113

Geen Nederlandse cijfers en geen meting van het afzonderlijke corrosie-effect.

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Low availability → Loss in air dominance

Oppervlaktebescherming ondersteund inzetbaarheid



Beschermen → corrosie voorkomen

Beperken onderhoud en stilstand

Beschikbaarheid ondersteund operationeel vermogen

Slagkracht, Luchtdominantie & Afschrikking

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Oekraïne: Innoveren → snel leren én volhouden

Enige overlevingsmodus tegen grootschalige agressie…

Operationele terugkoppeling

- Concrete behoefte
- Snel beproeven en aanpassen
- Ervaring terug naar ontwikkelaars

Steun en industriële capaciteit

- Kennis en middelen verbinden
- Oplossingen kunnen produceren
- Levering volhouden
- Opschalen (productie + faciliteiten)
  - Lokaal → internationaal

Innovatie en internationale steun versterken het weerstandsvermogen.

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Innovatie met een doel



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Van kennis naar toepassing

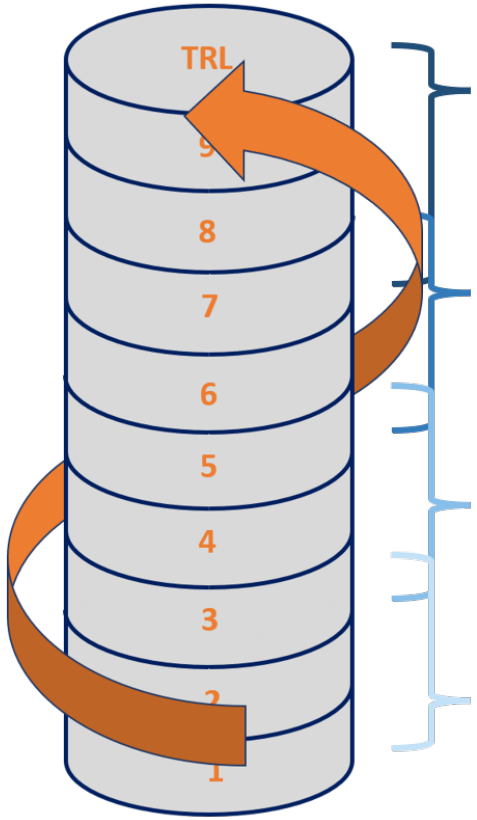
Samenwerking door de hele innovatieketen

Samenwerkende partijen

Valley of dead

- Industrie
- Eindgebruiker
- Engineering
- Kennisinstituten
- Universiteiten

Technology Readiness Level (TRL)



Van onderzoek naar applicatie

4. Toepassing
3. Certificatie
2. Validatie
1. Kennisopbouw

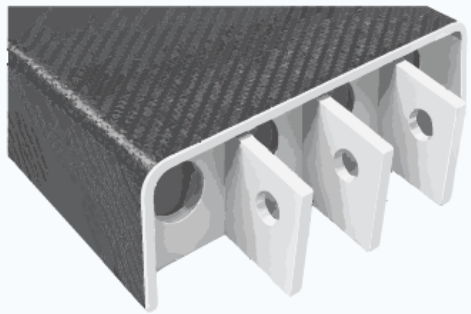
Schematische weergave: rollen en fasen overlappen.

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Innovatie vanuit een probleem

Research topics mapped to key corrosion challenges in military aerospace

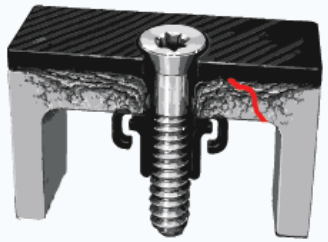
1 Multi-Material & Galvanic Corrosion



- Active corrosion protection: CFRP combined with Al
- Galvanic coupling between dissimilar materials

Related challenges
- Chromate replacement
- Hard-to-detect corrosion

2 Corrosion–Fatigue



- Environmental assisted cracking (7xxx series)
- Corrosion acts as crack initiation site
- Corrosion + cyclic loading accelerate failure

3 Prediction & Qualification



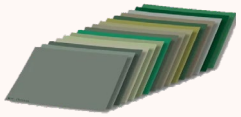
- Lifetime prediction: accelerated testing & qualification
- Environmental factors: electrolyte film, temperature, humidity, salt spray

Related challenges
- Lifetime prediction,
- Chromate replacement

4 Protection & Monitoring Technologies

Advanced protection technologies (example)

Improved coating



Corrosion preventive compound



Monitoring / sensing technologies (example)

Electrochemical corrosion sensor



- Electrochemical sensors to monitor corrosion activity
- Sensors for early detection and hidden corrosion

Related challenges
- Lifetime prediction
- Chromate replacement
- Improving corrosion protection







Hoe kan u bijdragen aan innovatie voor Defensie?

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