



10th International Workshop on Structural Health Monitoring
Stanford University, Palo Alto, CA
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“Fatigue-Free Platforms: Vision for Army Next-Generation Aircraft”

Army Sustainment Science & Technology
- Sustaining Army Aviation without Maintenance -

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Presentation Outline

- Defying "*Impossibilities*"
- Envisioning "*Discoveries*"
 - Finding & Catching "*Materials Damage Precursors*"
 - Cloning "Digital Nanomaterials Architecture (DNA)"
 - Enabling "*Reconfigurable & Self-Healing Elements*" & "*Intelligent Sensing Network*"
- Demonstrating "*Virtual Risk-informed Agile Maneuver Sustainment (VRAMS)*" Concept for Sustaining Army Next-Generation Aircraft





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Following "Uncatchable Fatigue" Damage

- From NID/E, HUMS, SHM...to "Virtual Risk-informed Agile Maneuver Sustainment"?

**Fatigue- Free
Aircraft**

UK Civil Aviation Authority Report

Legends: Health & Usage Monitoring System (HUMS) – Structural Health Monitoring (SHM)



1954 - Comet - First commercial jetliner disintegrated in flight due to cracking



1977 – Cargo flight horizontal tail failure due to fatigue



1988 - The only fatal airline incident linked to metal fatigue since the Comet



2009 – Opening in fuselage caused by metal fatigue & pre-existing fatigue cracks



2011 – Opening in fuselage caused by structural failure. Cracks also found in other five aircraft

"Southwest Airlines' recent grounding of 79 older 737s for possible skin fatigue after a piece of fuselage broke away from a jet in flight is only the latest example of cracks rupturing the U.S. airline industry today" – Washington Post, 2011



1968 – Fatal crash due to main rotor fatigue failure



? – Fatal crash due to main rotor hub fatigue failure



2009 – Fatal crash due to fatigue cracking of the main gearbox studs



2011 – Fatal crash due to fatigue cracking of main rotor blade



2009 – 2014 Series of Fatal Accidents

Civil and military helicopters also continue to experience fatigue failures!!!

How much confidence do we have in predicting and stopping the next potential aircraft catastrophic fatigue failure?

Fatigue Methods
Damage/Fatigue Tolerance
Fail Safe
Safe Life

1960

NID/E

1980

Aging Aircraft

2000

HUMS

SHM

2010

VRAMS

2048

VRAMS: Virtual Risk-informed Agile Maneuver Sustainment

- Human-manual-maintenance labor intensive and cost burdens to deal with aircraft

**STRUCTURAL
FATIGUE –**

Escalating Costs

in maintaining Army assets

- Aviation platforms have inadequate low-cost monitoring capabilities –

Escalating Costs

to operate and sustain entire Army Aviation platforms



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Defying “Impossibilities”: Army Aviation Sustainment Vision

- “Leap-ahead” capabilities to sustain Next-Generation Aircraft with “little” or without maintenance, “Zero-Maintenance (ZM)”
- Evolutionary discoveries to enable the development of Next-Generation Air Platforms with “Fatigue-Free (FF)” characteristics

***Support Sustainment Technology & Capability for Expeditionary
Force 2025 & Beyond with Reduced Logistic Footprint***



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Envisioning Discoveries: A System Level Approach: Structures Perspective

CBM/HUMS

Zero-Maint

Fatigue Free

Reliability

Virtual Risk-informed
Agile Maneuver Sustainment
(VRAMS) Capability

Self-Healing/Material State Awareness

"Digital Nanomaterial Architecture" - Additive Manufacturing

Material Damage Precursor - Failure Correlation



- Empower Army with "breakthrough" technologies & capabilities to conduct expeditionary maneuvers with *substantial reduction in operation & sustainment costs*



O&S Costs

2048

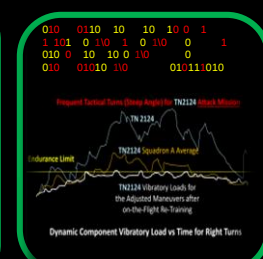
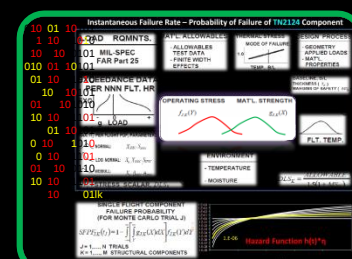
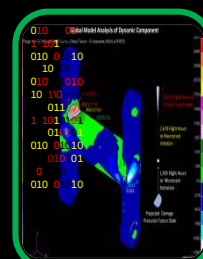
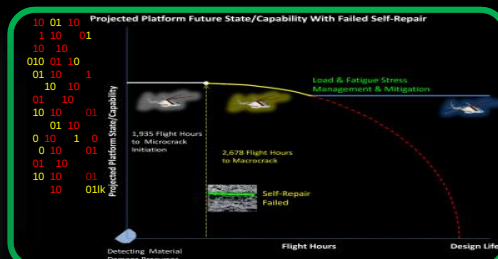
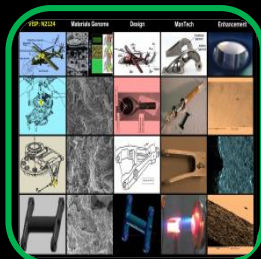
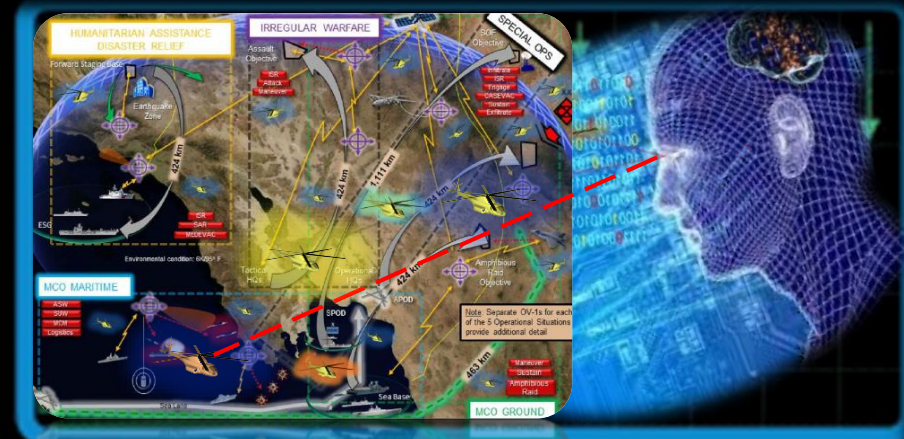
• Benefits to Soldiers:

- Immediate vehicle *health/capability state*
- Moving beyond Condition-based Maintenance (CBM) to mission-informed *material state-based awareness*
- Unburden hardware-level concern focus on *higher-level/mission-relevant operations*

VRAMS Concept

VEHICLE STATE AWARENESS & CAPABILITY

AVIATION TACTICAL OPERATION PANEL (ATOP)



System
Baseline

System
Dynamics

Capturing Damage
Precursor

Real-
Time M/S
Modeling

Risk
Assessment

Maneuver
Adaptation

Intelligent State Awareness Concept



VRAMS

On-board intelligent machine with real-time **dynamic feedback** and **Self learning**

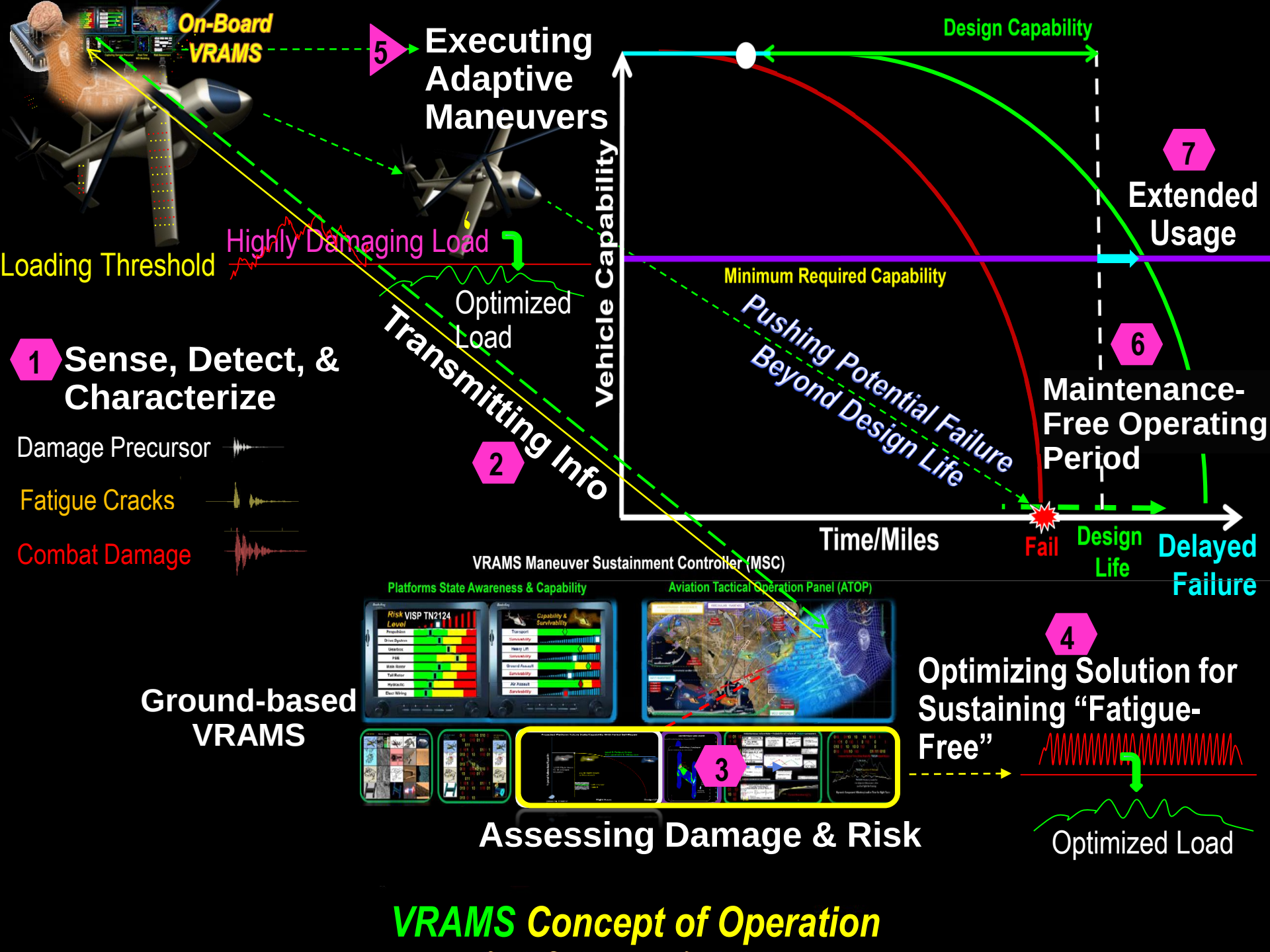
Multifunctional structures with self healing and distributed built-in sensor network

Provide critical aviation information to support **logistic & mission planning** at tactical & national levels

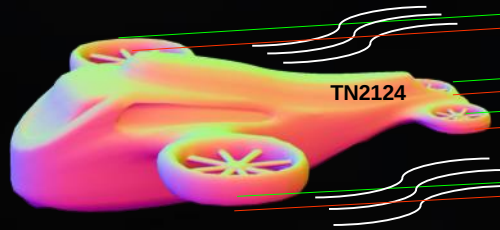


VRAMS

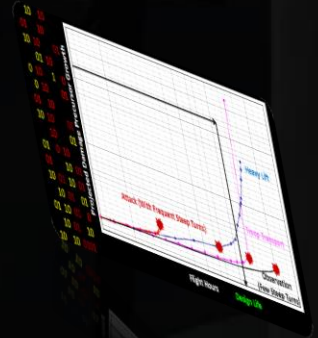
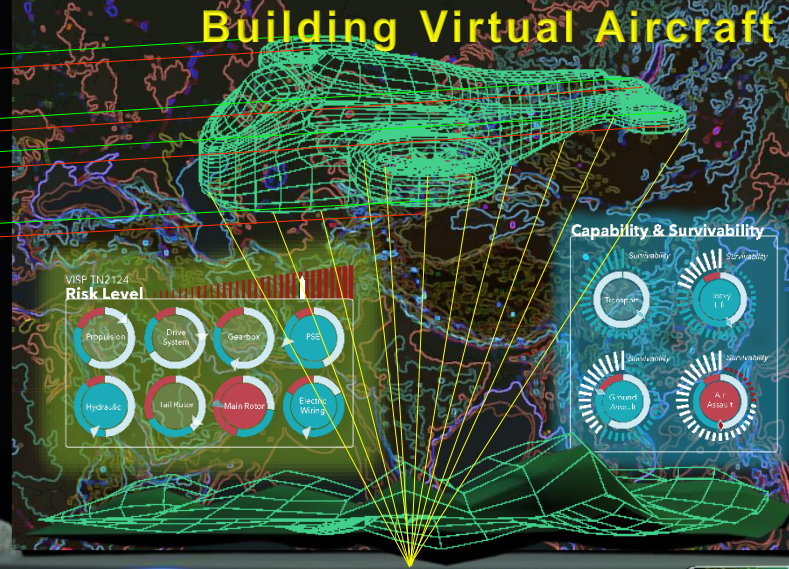
Streamline and automate aviation logistic flow to support **Global Combat Support System-Army (GCSS-A)** environment



Building Virtual Aircraft



**Synchronizing with
Real-time Platform**



QUESTIONS?

***VRAMS in Notional Futuristic Army Aviation Command
Environment***