



# 2021 EASA – FAA AM INDUSTRY – REGULATOR EVENT

(virtual meeting)



## WORKING GROUP 2:

### *Fatigue and Damage Tolerance (F&DT) and Non-Destructive Inspection (NDI) Considerations for Metal AM*

#### WG2 co-chairs:

M.Gorelik, Chief Scientist and Technical Advisor – Fatigue and Damage Tolerance, FAA

A.Fischersworring-Bunk, Senior Fellow Structures, MTU AeroEngines

#### **Core Team:**

Alain Santgerma (Airbus); Andre Danzig (Liebherr); Angel Martinez (ITP Aero); Armando Coro (ITP Aero); Arnaud Longuet (Safran Group); David Mills (Rolls-Royce); Doug Wells (NASA); Federica Vico (Lilium); Hilde Larsen (Norsk Titanium); Jonathan Leblanc (Safran Group); Kishore Tenneti (LMCO); Laura Kistler (Boeing); Marjolaine Cote (PWC); Markus Heinimann (Howmet Aerospace); Stefan Hermann (Liebherr); Tom Bertenshaw (GKN Aerospace); Tomas Mansson (GKN Aerospace)



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### **WG2 – Monday briefing (*20 min*)**

- Summary of 2020 outcomes
- Summary of 2021 WG2 pre-work
- Discussion the format of b/o sessions

### **Objectives of the Monday Session:**

- Overview of WG2 for the entire w/s (key outcomes of 2020 + materials developed by WG2 in 2021 – very brief summary)
- Setting the stage for two b/o sessions (Tue/Thu)

# WG#2 Description

Fatigue and damage toleration (F&DT) related qualification considerations and related certification requirements have historically presented more significant challenges for structural components produced using process-intensive manufacturing technologies, and additive manufacturing (AM) is no exception. While all the key tenets of the certification requirements apply to AM, *there is a number of material system specific considerations that need to be understood and properly accounted for*, including inherent material anomalies and their effect on fatigue life, residual stresses, non-destructive inspection (NDI) challenges, effects of post-processing, etc.

The need for developing a good understanding of these factors is further elevated by the *expected near-term introduction of high-criticality AM parts* in Civil Aviation that will be subject to F&DT regulatory requirements.

The intent of this working group is to discuss the most recent developments in these technical areas, while *building on the outcomes of the F&DT and NDI breakout sessions from the 2019 and 2020 AM Workshops*, and to further develop considerations for aviation application of AM.

The *desired outcomes* of this working group and the corresponding breakout sessions during the 2021 AM Workshop include:

- A. Formulating recommendations for standards development organizations (SDOs) / industry working groups as to which AM-specific F&DT and NDI topics should be addressed by public standards or specifications, and to develop initial technical considerations to seed such discussion
- B. To develop recommendations for enabling R&D work (identification of specific research topics)



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**WGs - development since 2020 Event (*note – breakout sessions were used since 2018 workshop*)**

- Co-chairs and Core WG Teams identified and formed in advance of the 2021 event
- WG2 theme is recognized as a carry-over from the 2020 event

**WG2 - Core Team (Aerospace Industry + Government)**

- 10+ people supported several preparation meetings\*\* in 2021
- WG2 objectives and priorities defined → *see next slide for priorities*
- Need for *tangible outputs* recognized:
  - Gap Analysis
  - Input to SDOs and Consortia work
  - Input into R&D prioritization

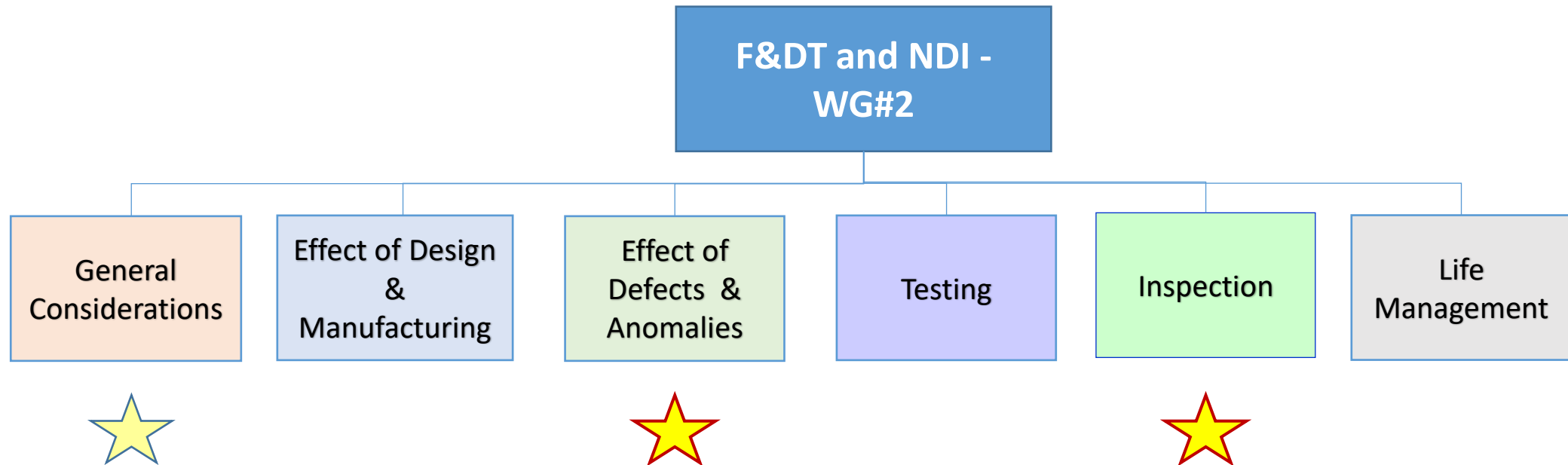
**\*\* WG2 preparation meetings held in 2021: 2<sup>nd</sup> July, 24<sup>th</sup> September, 14<sup>th</sup> October, 28<sup>th</sup> October, 5<sup>th</sup> November**

# Prioritization Result from 2020 Workshop

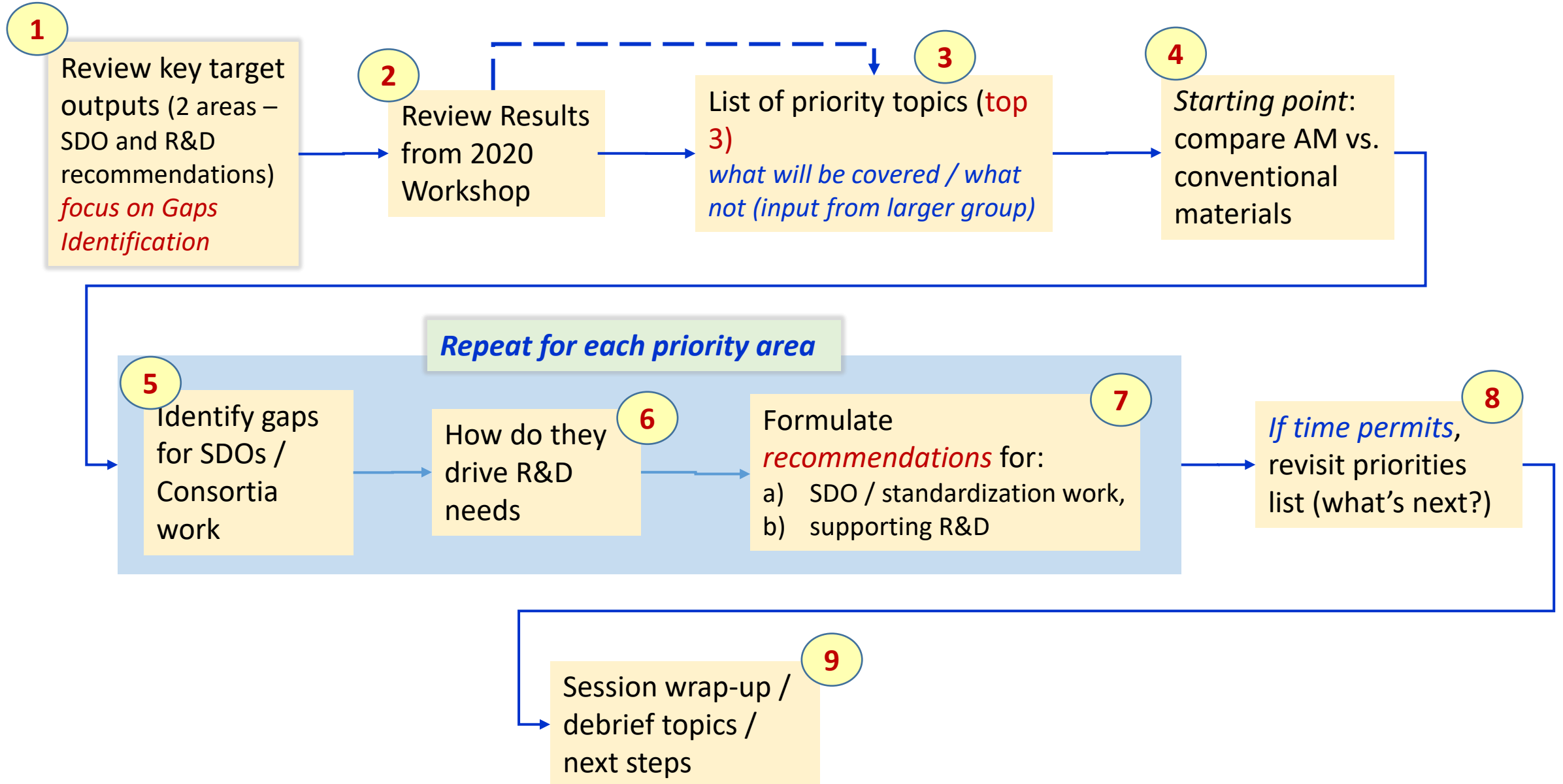
The 2020 prioritization results ("Top 3") are still deemed relevant and will be carried forward in 2021

	A	B	C	D	E	F	G	H	I	J
1			<b>1A.Fatigue</b>		<b>1B.DT</b>		<b>2A.NDI (connected to F&amp;DT)</b>		<b>2B. NDI for QA</b>	
2	<b>What are the key Q&amp;C technical challenges</b>									
3	<b>Data availability/data generation</b>									
4	1.1		a) Relevance of coupon data to part-level data	9	a) Development of defects distribution (including exceedance curves)	7	a) Development of POD data - point value vs. POD vs. a?	1	a	
5	1.1		b) Generic material allowables vs. feature-based characterization (library?)	2	b) Effect of post-processing on DT (e.g. HIP -> volume defects, surface improvements -> surface integrity, RS mitigation, heat treatment -> homogeneity and anisotropy)	1	b		b) Effect of post-processing on NDI (e.g. HIP -> volume defects, surface improvements -> surface inspectability, heat treatment -> homogeneity and anisotropy).	2
6	1.1		c) Effect of post-processing on LCF (e.g. HIP -> volume defects, surface improvements -> surface integrity, RS mitigation, heat treatment -> homogeneity and anisotropy)	3	c) Relevance of test coupons to part properties	1	c) Develop in-process inspection POD	2		
7	1.1		d) Relevance of test coupons to part properties							
8										
9	<b>Methods and tools</b>									
10	1.2	a			a) Zoning	3	a) Selection and validation of appropriate NDI methods for given application and anomaly types	5	a	
11	1.2	b) Part family considerations		1	b) Deterministic vs. Probabilistic Assessment (DT)	5	b		b	
12	1.2	c			c) Conventional S-N vs. anomaly-related framework?	2	c) Effect of post-processing on NDI (e.g. HIP ->	2	c) In-situ monitoring - longer-term objective of displacing some conventional QA/NDI	2
13	1.2	d) Conventional S-N vs. anomaly-related framework?		2	d) Assessment of geometrically complex parts	2	d) Use NDI to help understand some of the eff	1	d	
14	1.2	e) Assessment of geometrically complex parts		3	e) Effect of post-processing on DT	2	e) Develop models to predict defect effect of	3	e	
15	1.2	f) Definition and use of "knock-down" factors for fatigue		1						
16	1.2	g) Effect of post-processing on LCF (e.g. HIP -> volume defects, surface improvements -> surface integrity, RS mitigation,		3						
17										

# WG#2 Scope at a Glance



# Thought Process for WG2 Breakout Sessions





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### **Agenda: B/O Session - Day 1 (Tuesday, November 9) – 2 hrs**

- Summary of 2020 outcomes – 10 min
- Summary of 2021 WG2 pre-work – 10 min
- Discussion the format of b/o sessions – 10 min
- 3 brief (NTE 10 min) level-setting technical presentations
  - Doug Wells, NASA – 10 min
  - Andreas Fischersworrying-Bunk, MTU AeroEngines, ‘Use of a modified IQI Standard – a way forward in NDI?’ – 10 min
  - Armando Coro, ITP Aero, ‘The relevance of AM anomalies, dimensions, amounts and locations’ – 10 min
- Technical discussion – start with a list of pre-set questions, and start working through them (allowing time for the larger group’s input) – 55 min
- “Homework assignment” – ask b/o session members to review the list and provide additional questions before Thursday – 5 min





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### Agenda: **B/O Session - Day 2** (Thursday, November 11) - *4 hrs*

- Agenda review (including additional questions) – 10 min

***Note:** may not have time to address all the questions on Thu; can propose to add them to the list and continue working after the 2021 W/S (and to invite questions' authors to join)*

- Technical discussion (cont. from Tuesday) – continue working through the list of pre-set questions (allowing time for the larger group's input) – 200 min (*includes 15-20 min break, or two 10-min breaks*)
- Summary and next steps – 30 min



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### **WG2 – Friday (Nov. 12) De-brief for the Workshop Participants**

- Summary of the WG2 key outcomes (PowerPoint)
  - B/O Sessions Highlights and Summary

#### Recommendations for:

- Future Work
- Development of guidance content, e.g. input to SDOs work w.r.t. F&DT and NDI
- R&D Topics (enablers for the above)

Note: WG2 co-chairs to provide 1-2 page written summary of B/O Session #2 outcomes within 2 weeks from this Event for inclusion in the proceedings