SAAB SURVEILLANCE

AM Airborne Sensor System

MARTIN BLENNIUS, OEYDEL, 20191009

Efficient solutions for safety and security, surveillance and for threat detection and protection.

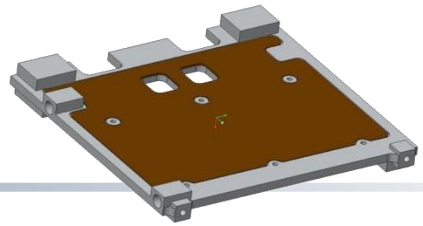
BUSINESS AREA **SURVEILLANCE**

Martin Blennius, OEYDEL

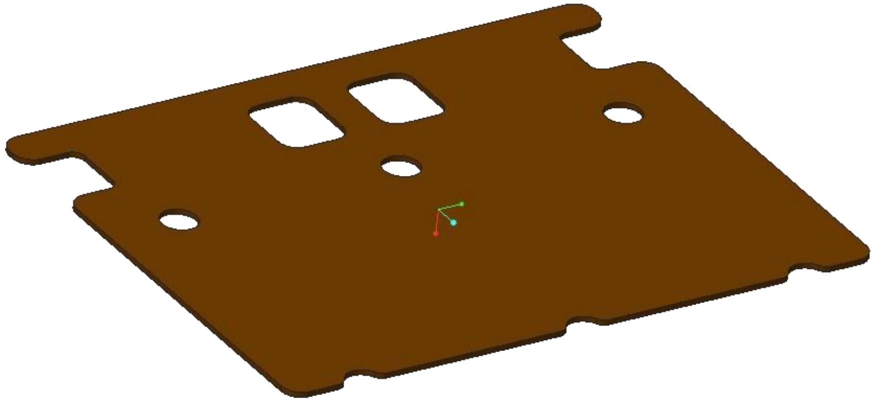
AM HEAT EXCHANGER

- The Challenge
- The Solution
- Verification
- AM Qualification

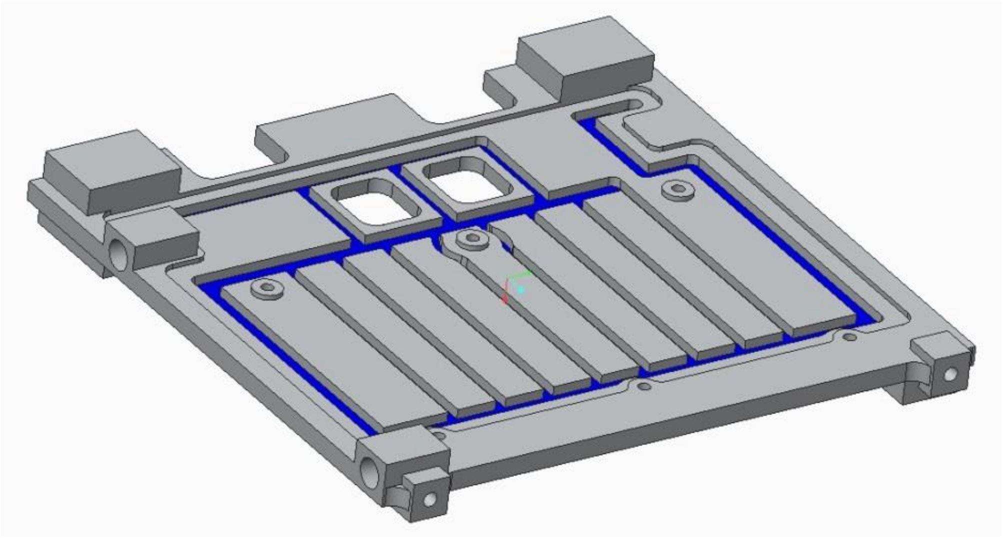
AM IN HEAT EXCHANGER
STARTED IN 2012 WITHOUT KNOWING IT



- New heat exchanger for AESA needed
- The new design had some serious drawbacks;
  - Impossible to get the adhesive to survive
  - Poor cooling performance – ΔT = 17-18 ˚C
  - High weight – M = 165 g

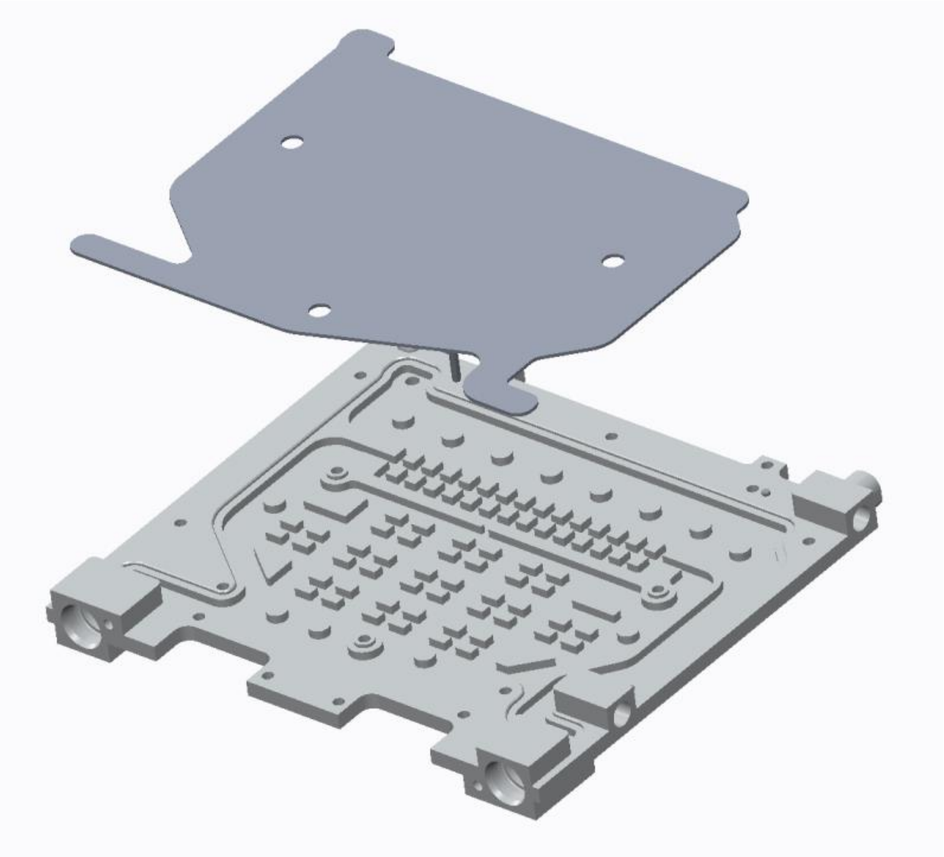


- What to do?



CONCEPTUAL PHASE – 2013-2014

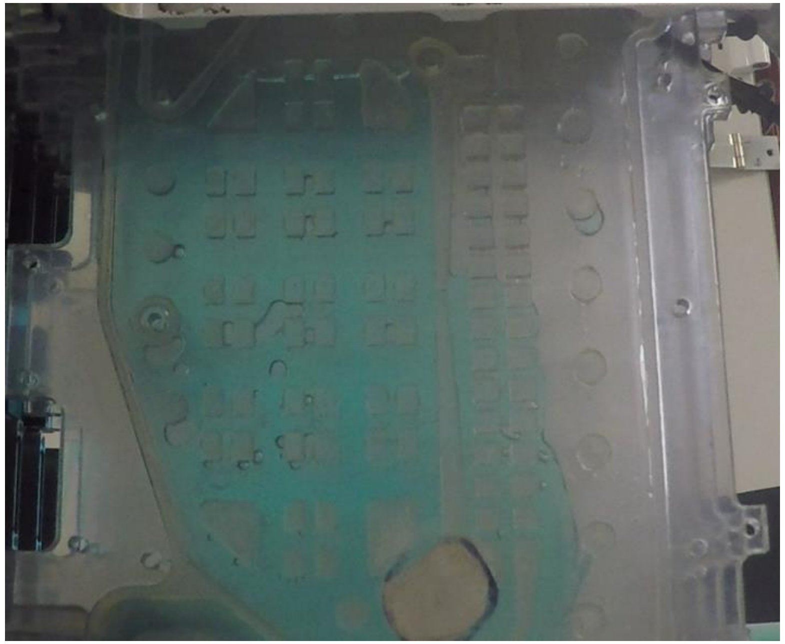
- Instead of adhesive we studied;
  - Laser welding
  - Electronic beam welding
  - Friction stir welding
  - Vacuum and dip brazing
- In parallel new design of cooling cavities was studied;
  - Traditional serial cooling channels
  - Combination of serial and parallel cooling channels
  - Only parallel cooling channels with “obstacles”, heat transfer conductors
- Only working method was dip brazed parallel cooling channels with heat transfer conductors
- After some struggle we did get rid of the salt …



ΔT = 10-11 ˚C
M = 149 g

COLD SHOWER - 2015

- We where worried about air pockets.
  - We manufactured a transparent 3D-printed plastic prototype
- And - air pockets became a horror!
- At this time we did get in contact with TTC.
  - Might it be possible to increase cooling properties and get rid of dip brazing?
  - Project decision to manufacture an AM prototype in aluminium
- What to do now with air pockets?

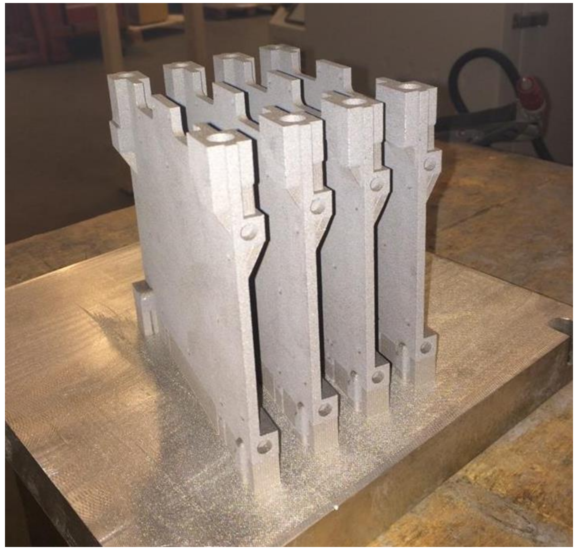


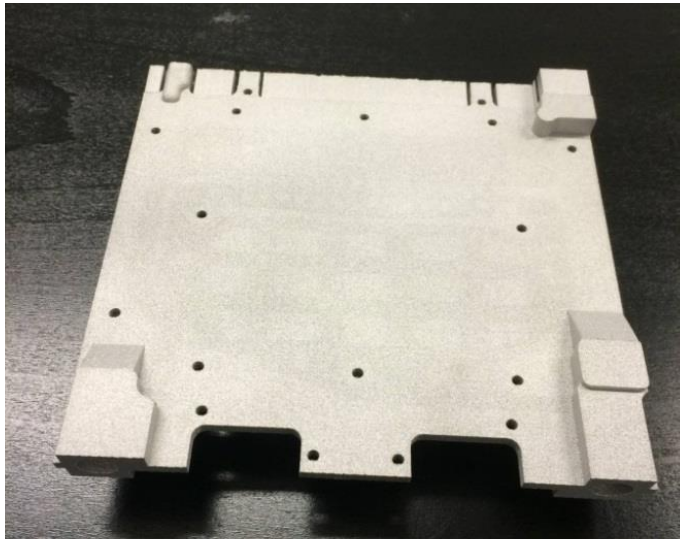
Big air pocket

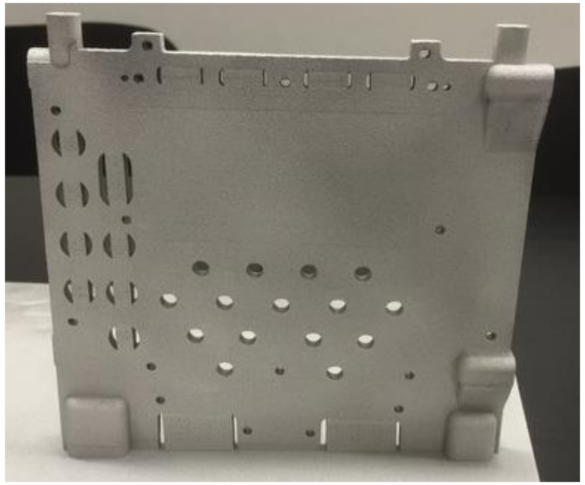
NEW MIND SET 2015

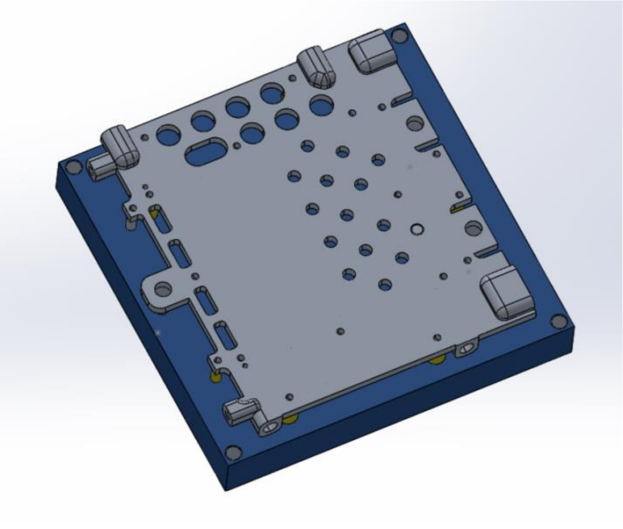
- AM open up for new features, for example small channels…
- Would one channel for evacuation of air work?
- In…
- Combination with a “special” nozzle?
- Why not?!
- Try!

A NEW WORLD OPENED

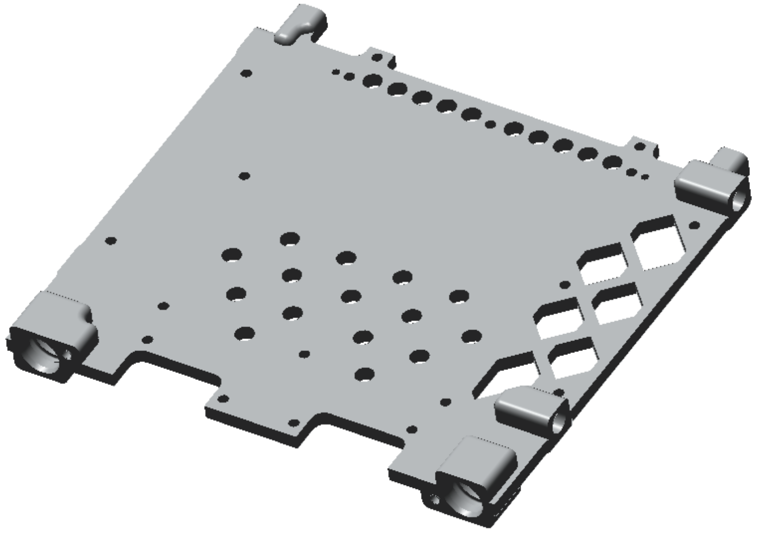








SOLUTION PHASE - 2015

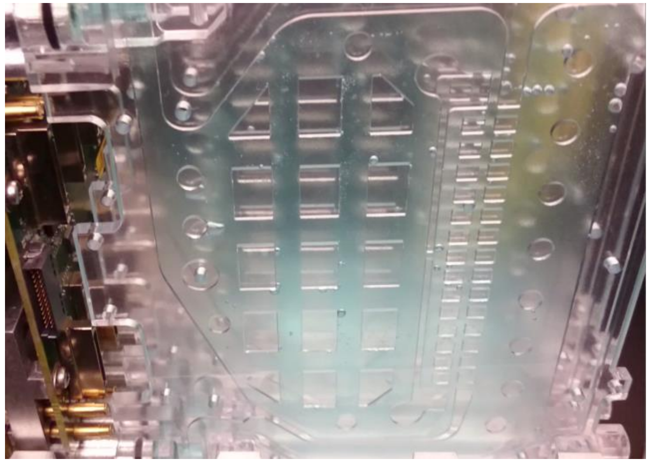


- The 3D-printing of heat exchanger prototypes went well
- Material for AM, EOS Aluminium AlSi10Mg
  - Tensile strength 460MPa (As built) 345MPa (heat treated)
  - Yield strength 240MPa (as built) 230MPa (heat treated)
  - Fatigue strength 97MPa (uncertain data)
- A new patent searched idea to get rid of air pockets was invented – a “vacuum cleaner”
- Cooling performance improved by - 10 ˚C!
- Weight reduced to 123 g (- 25%)

- Does it work?

VERIFICATION PHASE - 2016

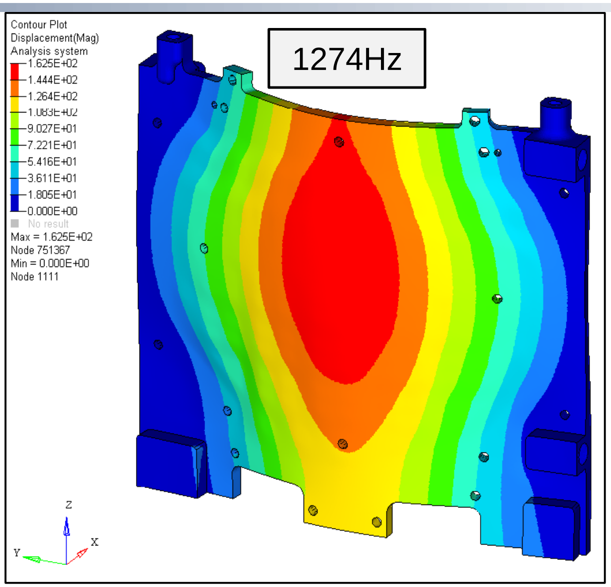
- Automatic de-airing, no air pockets
- Patent pending
- Result ok

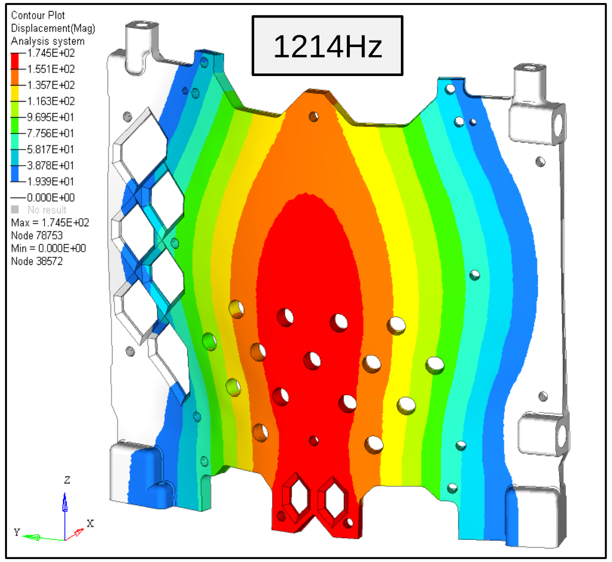


“vacuum cleaner”

STIFFNESS

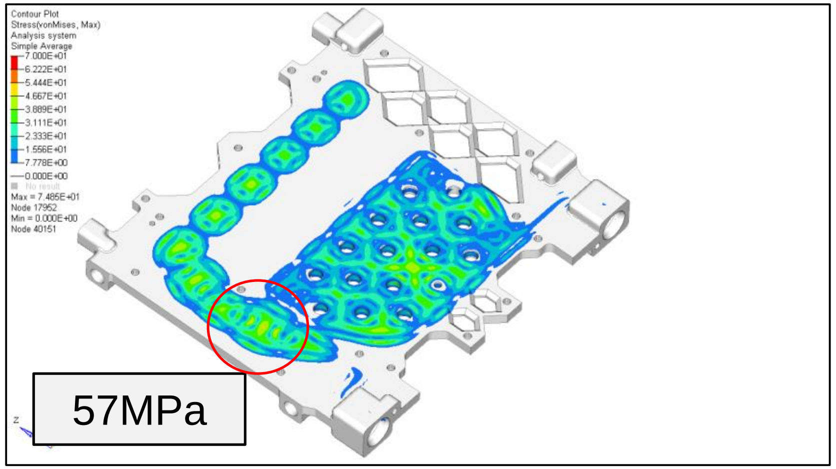
- Lower weight, reduced by 25%
- Slight lower stiffness
- Result ok

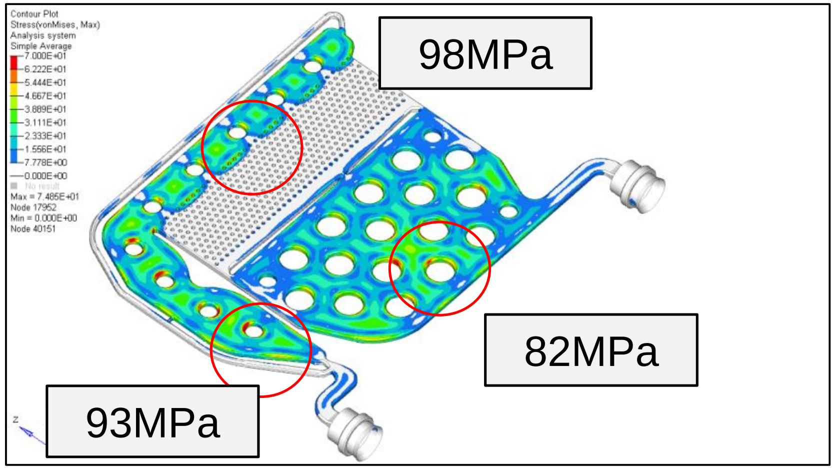




INTERNAL PRESSURE - STATIC

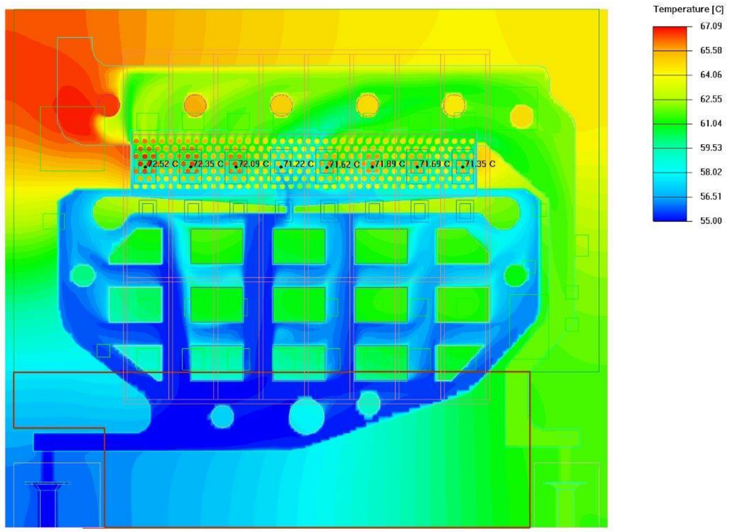
- Important with internal radius
- Easy to control stress with reinforcement
- Result ok





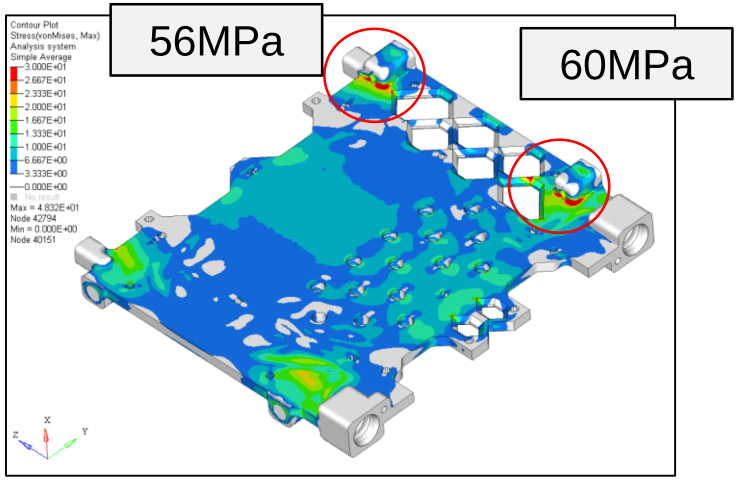
COOLING PERFORMANCE

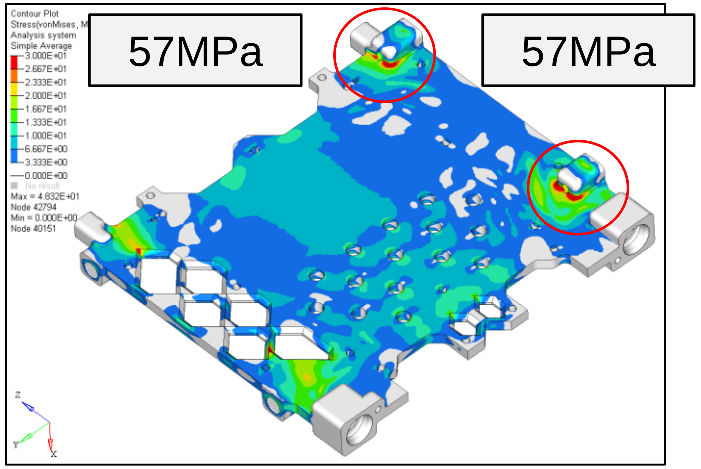
- Even, directed and efficient cooling performance
- Cooling efficiency improved with 10 ˚C
- Difference between heat sensitive amplifiers within 1 ˚C
- Cooling performance close to turbulent flow
- Result ok



FATIGUE

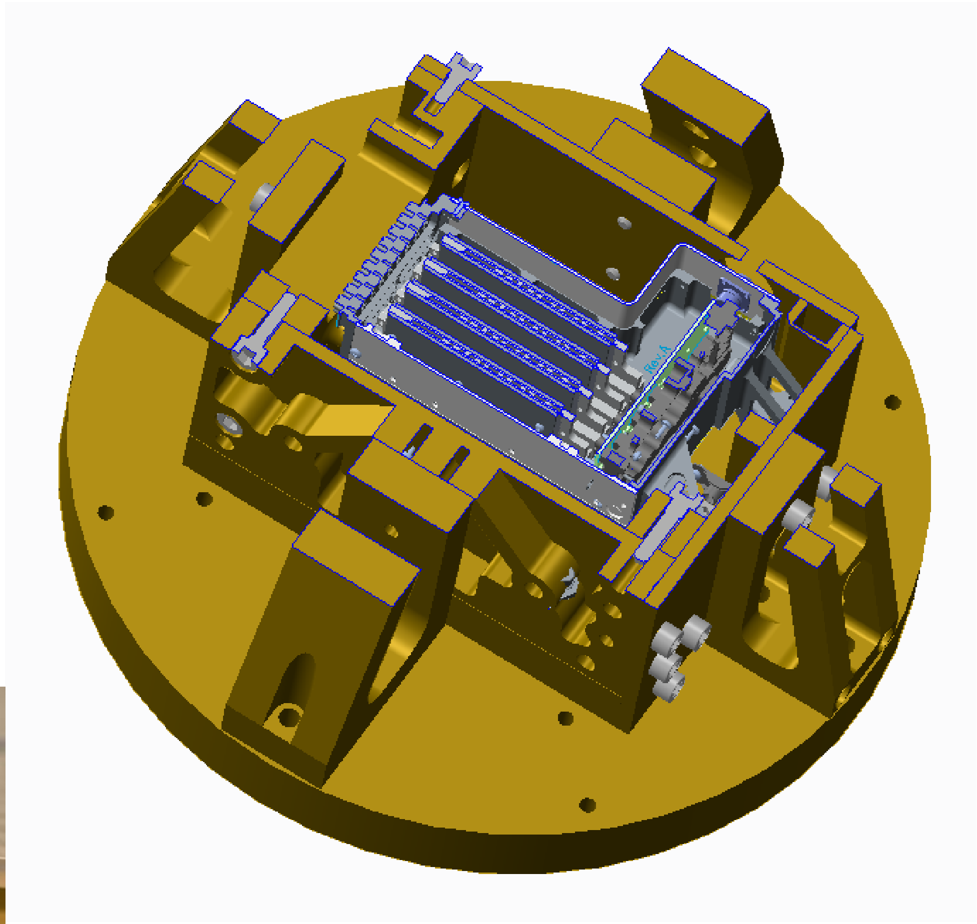
- High requirements
- High packaging requirements
- High levels, uncertain data and no standard –> warning!
- Environment test needed!





RANDOM RESPONSE VIBRATION

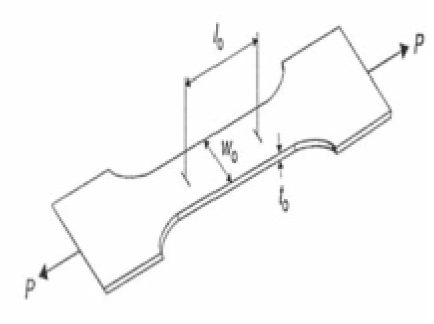
- Random response in 3 directions
- Up to GRMS 32 g^2/Hz
- No structural damages 1:th time
- Repeat
- No structural damages
- Powder at inlet/outlet discovered
- Result ok



QUALIFICATION PHASE – 2017/2018

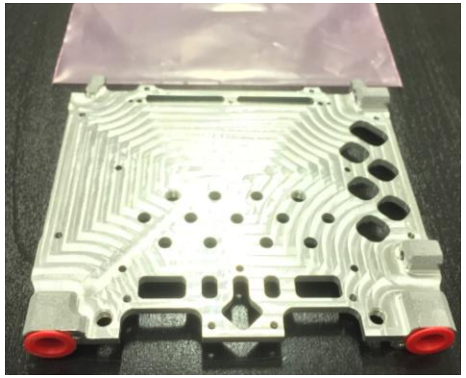
Why?

- New process – lack of standards
- Unique products och unique machines



What?

- Powder
- Material
- Product



When?

- New or changed detail/powder/parameters
- Before serial production or verification

PQ SET UP

- 1 pilot build á 4 details + 3 PQ-build á 12 details
- Checklist with 15 points:
  - Pulver: Microstructure, chemical constitution, grain size, density, porosity, degradation, traceability, re-use etc.
  - Material: LOF, microstructure, porosity, strength, effective area
  - Produkt: Dimensions, powder contamination, tightness, CT-scanning
- Sync with ISO/ASTM52910-17 & ISO/ASTM52901.2
- Sync with NASA MSFC-SPEC-3717 and 3716

Processkvalificering, PQ

Referens [1]: 101/1735-SEAM1030116/1 AM - Kvalitetssäkring och processkvalificering av kylplatta

Nr	Ansvarig	Aktivitet	Beskrivning	Plan	Status
0		Beställning	0.1 O 0.2 D 0.3 A		
1		Beredning Ämne	1.1 B 1.2 M 1.3 Pl 1.4 D 1.5 Pl	☑ 1.1 ☑ 1.2 ☑ 1.3 ☑ 1.4 ☑ 1.5	☐ 1.1 ☐ 1.2 ☐ 1.3 ☐ 1.4 ☐ 1.5
2		Pulver	2.1 D	☑ 2.1	☐ 2.1
3		Pulver	3.1 K	☑ 3.1	☐ 3.1
4		Pulver	4.1 T 4.2 D	☑ 4.1 ☑ 4.2	☐ 4.1 ☐ 4.2
5		Tillverkning Ämne	5.1 F 5.2 Ti avbro 5.3 D 5.4 A 5.5 Sä 5.6 Bl	☑ 5.1 ☑ 5.2 ☑ 5.3 ☑ 5.4 ☑ 5.5 ☐ 5.6	☐ 5.1 ☐ 5.2 ☐ 5.3 ☐ 5.4 ☐ 5.5 ☐ 5.6
6		Mätning	6.1 M 6.2 D	☐ 6.1 ☐ 6.2	☐ 6.1 ☐ 6.2
7		Provning	7.1 B 7.2 A 7.3 A r	☑ 7.1 ☑ 7.2 ☑ 7.3	☐ 7.1 ☐ 7.2 ☐ 7.3
8		Dokument-ation	8.1 F 8.2 D	☑ 8.1 ☑ 8.2	☐ 8.1 ☐ 8.2
9		Tillverkning Detalj	9.1 M 9.2 B 9.3 R 9.4 M	☑ 9.1 ☑ 9.2 ☑ 9.3 ☑ 9.4	☐ 9.1 ☐ 9.2 ☐ 9.3 ☐ 9.4
10		Provning	10.1	☐ 10.1	☐ 10.1
11		Renhet	11.1	☐ 11.1	☐ 11.1
12		Mätning	12.1 12.2	☑ 12.1 ☑ 12.2	☐ 12.1 ☐ 12.2
13		Provtryck	12.1	☑ 13.1	☐ 13.1
14		Ytbehanda	13.1 13.2	☑ 14.1 ☑ 14.2	☐ 14.1 ☐ 14.2
15		Leverans	15.1 15.2 Slutförpacka 15.3 Beräkna tillverkningstid & ledtid 15.4 Leverera	☑ 15.1 ☐ 15.2 ☑ 15.3 ☑ 15.4	☐ 15.1 ☐ 15.2 ☐ 15.3 ☐ 15.4

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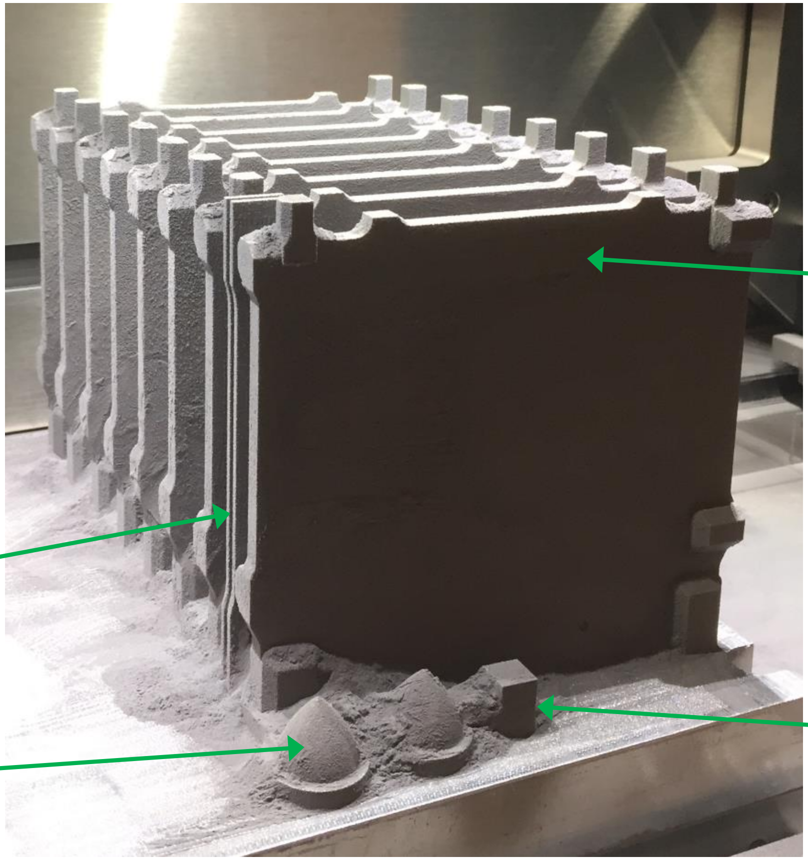
AM SET UP X3



Blanks x12

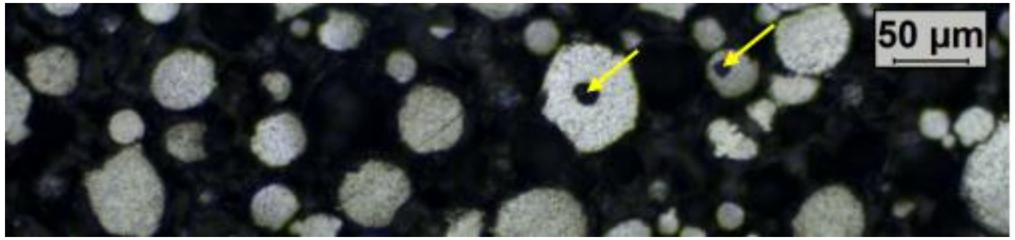
Test specimen x9

Micro cube

Powder container x2

PQ POWDER

- Powder was approved in all aspects
- We reuse powder and add the used amount at every build
- We follow NASA guidelines according to detail class and check up powder quality thoroughly every 10 builds



Tabell 5. Kemisk sammansättning [vikts-%].

Märkning	Al	Cu	Fe	Mg	Mn	Ni	O	Pb	Si	Sn	Ti	Zn
AlSi10Mg, Z261701, 20171123	rest	<0,01	0,22	0,41	<0,01	0,04	0,029	<0,01	9,92	<0,01	<0,01	<0,01
Analysgränser enligt EOS datablad:												
AlSi10Mg	*rest*	*≤0,05*	*≤0,55*	*0,2-0,45*	*≤0,45*	*≤0,05*	*-*	*≤0,05*	*9,0-11,0*	*≤0,05*	*≤0,15*	*≤0,10*
EOS mill test certificate	*rest*	*0,01*	*0,14*	*0,32*	*<0,01*	*0,02*	*-*	*<0,05*	*9,2*	*<0,05*	*0,01*	*<0,01*

Tabell 6. Storlek på pulverkorn, pulver märkt AlSi10Mg, Z261701, 20

Metod	Standard	Resultat	
Laser diffraktion	ASTM B822	**Dv (10)**	**23,7 µm**
		Dv (50)	**43,5 µm**
		Dv (90)	**73,7 µm**
Siktanalys	ASTM B214	**106 > d > 75 µm**	**0,06 %**
		75 > d > 63 µm	**11,97 %**
		63 > d > 45 µm	**31,55 %**
		d < 45 µm	**55,82 %**

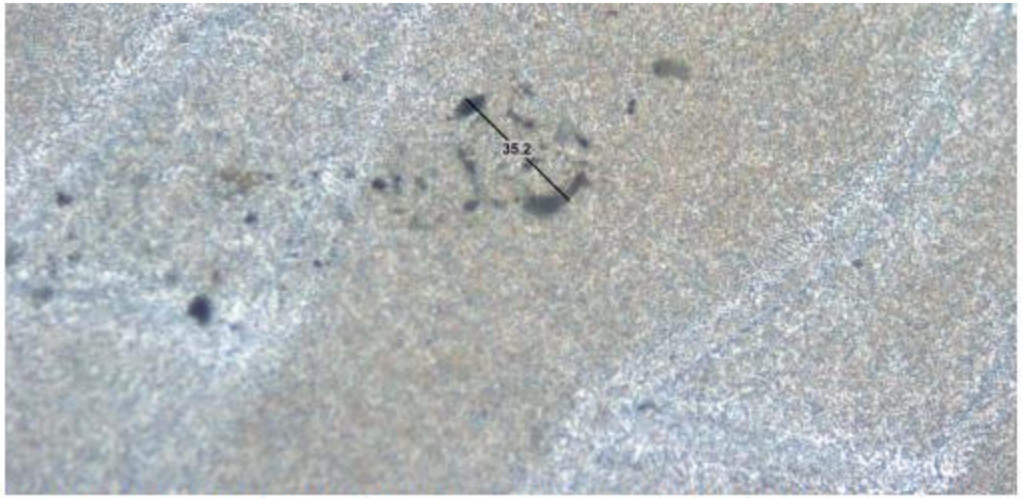
PQ MATERIAL

- Material microstructure looked as expected
- Low anisotrophy
- In first PQ run the parameters were mixed which caused poor strength results
- Be aware of rough surface – takes effective area

	Horizontal	Vertical
Ultimate tensile strength, Rm	340 MPa (49 ksi)	350 MPa (51 ksi)
Yield strength, Rp0.2	220 MPa (32 ksi)	225 MPa (33 ksi)
Elongation at break, A	12 %	9 %

RT Tensile Test - EN ISO 6892-1: 2016 B

	Dimensions [mm]	GL [mm]	$R_{p0.20}$ [N/mm²]	Rm [N/mm²]	A%	Z%	Temp [°C]	Comments
001:Axial	6.02	30.00	-	390	5.0	8.0	21.0	See Below
002:Axial	6.01	30.00	237	387	4.5	6.5	21.0	20171123/3-2
003:Longitudinal	1.97 x 12.46	50.00	225	385	5.0	-	21.0	See Below
004:Longitudinal	2.07 x 12.49	50.00	219	378	5.0	-	21.0	See Below
005:Longitudinal	2.02 x 12.49	50.00	232	376	2.5	-	21.0	See Below

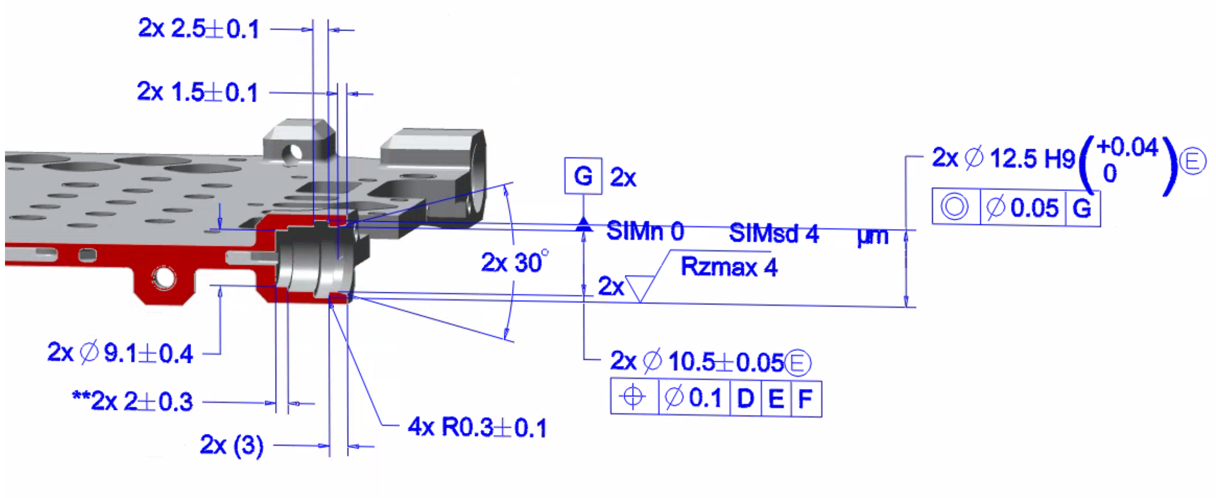


Figur 10. Dragprovstav - mitten, exempel på LOF, hög förstoring (500x), LOM.


Figur 2. Platta dragprovstavar efter genomförd provning.

PQ PRODUCT

- All blanks flatness were approved
- Geometrical measurements within tolerances
- Tightness tested up to 60 bar without failure
- We had problem with reference for machining
- CT-scanning was approved



PQ PRODUCT

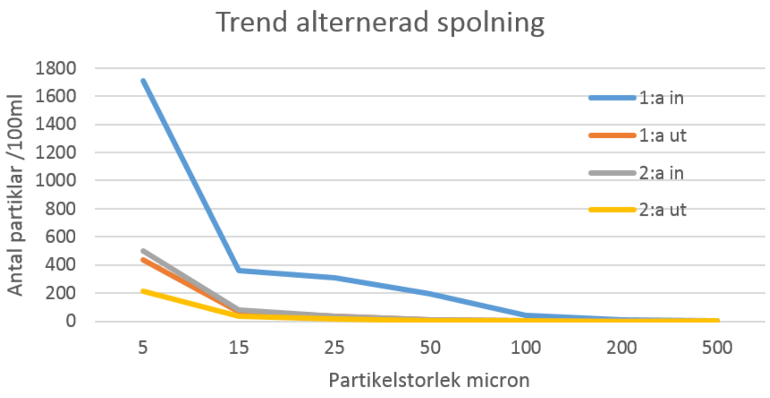
- Cleanliness was within tolerance acc to AR4059 Class 8 after new cleaning process
  - Before:

Storlek	5-15 µm	16-25 µm	26-50 µm	51-100 µm	>100 µm
Antal	2038840	662472	376528	74516	4684
Krav	3186%	5811%	18594%	20699%	7319%

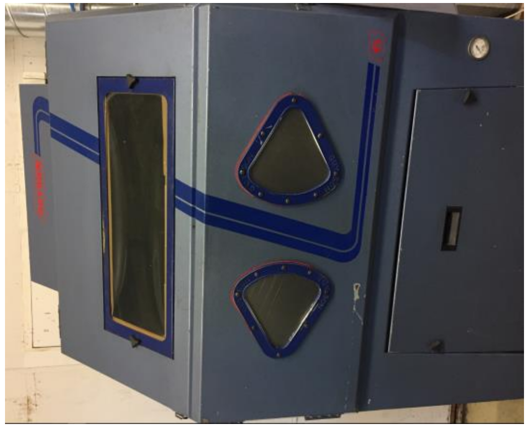
  After:

Storlek	5-15 µm	16-25 µm	26-50 µm	51-100 µm	>100 µm
Antal	1437	261	169	77	17
Krav	2%	2%	8%	21%	27%

  Trend:



- Interesting findings, other processes contaminated the product with large particles, not AM itself



Cleaning equipment. Observe the risk for powder explosions!

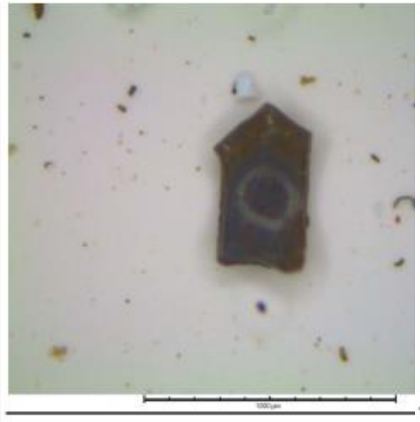


Fig 10. Part 3, solid particle. L=700µm

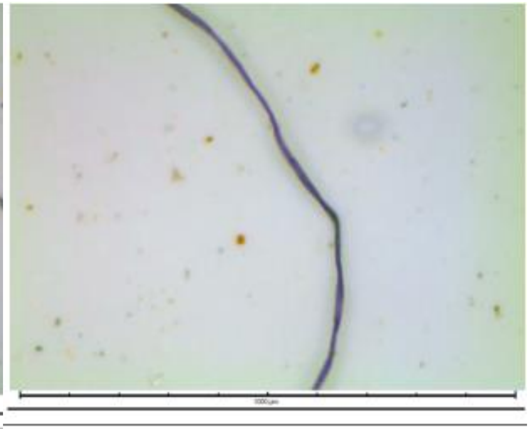


Fig 4. Part 2 Soft fiber. L = 1200µm

SUM UP

- The AM cooling plate reduce weight, resist extreme environment and improve crucial cooling performance
- Final cost slightly higher than traditional but the improvements are more than worth it
- Don´t forget the fixture
- The AM process is stable if you:
  - keep track on powder and parameters
  - use the same machine
  - always build in the same way
- Now we set up for serial production, 600 samples/year
- And proceed with other components and systems

QUESTIONS?

- Thanks for your attention!