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CASE STUDY
Alfa Romeo Racing ORLEN & Additive Industries

Additive Studios

Design & Manufacture of AM F1 Chassis Inserts

Executive Summary

This case study showcases how F1 team Alfa Romeo Racing ORLEN are leveraging the freedoms of additive manufacturing to create safety critical titanium Ti6Al4V chassis inserts for their F1 race car. The entire process from design through to assembly and testing is presented, highlighting the value AM has brought to this F1 component, an industry where short lead times and parts of the highest quality are critical.

Sauber Group Overview

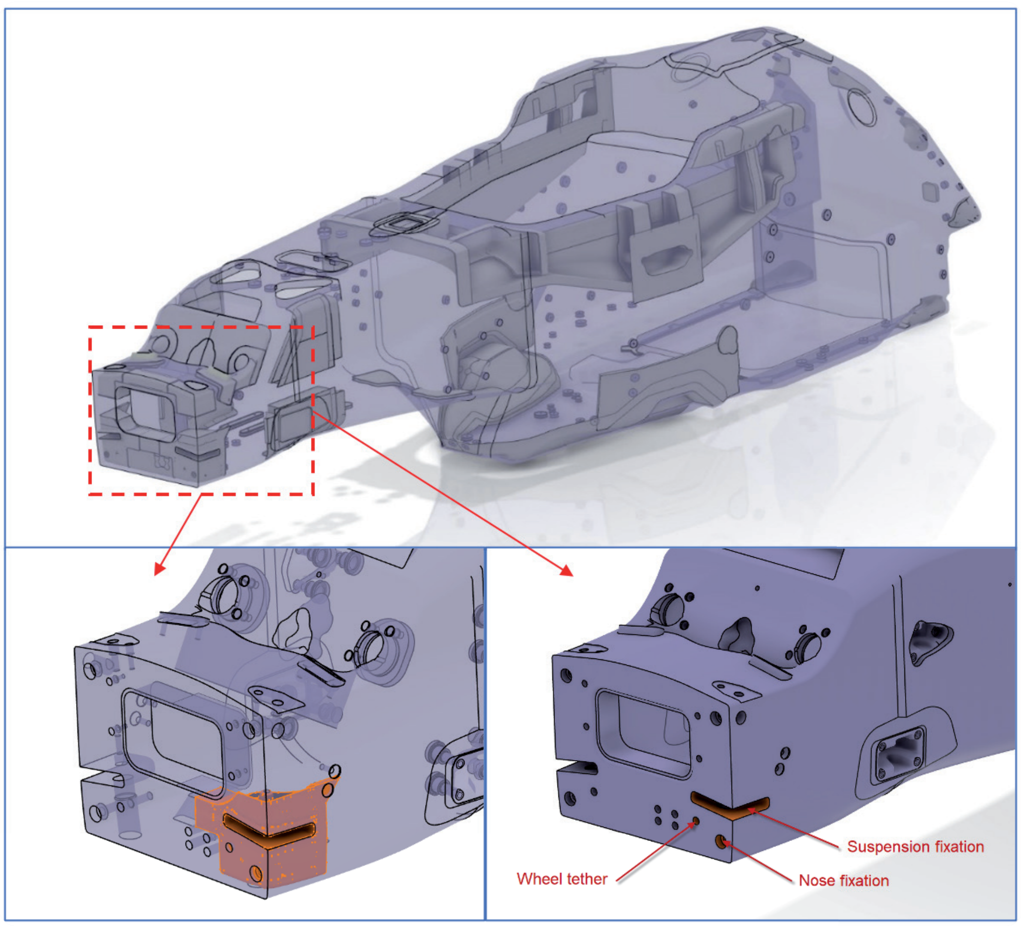
Since its founding in 1970, the passion for racing has been at the heart of Sauber. Following its own Formula One debut in 1993, Sauber Motorsport AG has established one of the few traditional and privately held teams in the sport. After 25 years of competition in Formula One, the company launched a long-term partnership with Alfa Romeo in 2018 and enters the 2021 championship under the new team name Alfa Romeo Racing ORLEN. The Sauber Group are experienced AM users, with 4 MetalFAB1 metal AM printers and have used this expertise to implement many AM components on their F1 race car, including the front suspension chassis inserts.

Component Overview

The chassis of an F1 car is the main structural component which houses the driver and from which all components, assemblies and systems are attached to. It is typically made from a lightweight but very stiff honeycomb composite sandwich panel structure. Where components of the car interface with the chassis (e.g. suspension, engine, coolers), chassis inserts are used to add local reinforcement to the composite sandwich panel. Depending on the function and level of stress acting, different materials can be used for the inserts from carbon and aluminium to very high strength titanium.

This case study showcases the design and manufacture of the two front suspension inserts on the Sauber C41 F1 racecar and are located in the front lower corner of the chassis. Their function is to accommodate the front suspension assembly fixation (lower wishbone and forward leg), but also to retain the wheel tether, to ensure the wheel does not become separated from the car in the event of suspension failure.

This Class A safety critical part(s), is additively manufactured from titanium (Ti6Al4V Gd 23) on the Additive Industries MetalFAB1 system, to cope with the high fatigue and alternating loads experienced. The inserts are designed to last the entire racing season, as they are permanently bonded within the laminate of the chassis. This equates to 200,000 cycles of design life with alternating suspension loads of 65kN tensile, and 30kN compressive. These chassis inserts are approximately 110x100x130mm in size, and weigh 580g each.



Location of front suspension inserts within the chassis

CAD views of front suspension chassis insert

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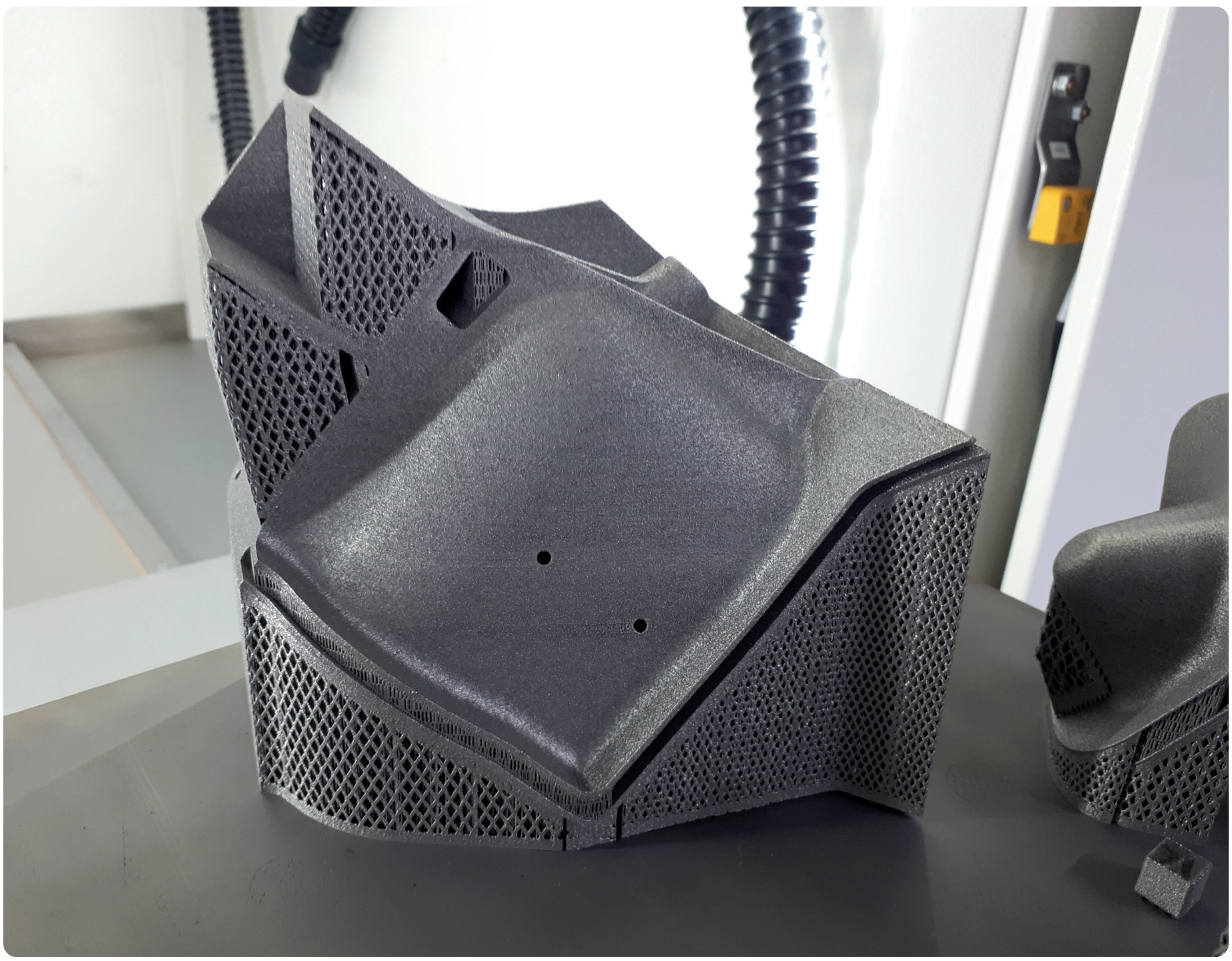
Part Benefit added by AM & MetalFAB1

Previously, the chassis inserts were machined in multiple parts and assembled together, before being bonded into the chassis. Additively manufacturing the inserts, has enabled integration of these multiple parts into one component, drastically simplifying the assembly process. The design freedoms of AM, have also enabled an optimised ultra-lightweight design to be created, enabling undercut features, unconstrained by tooling access. Additionally, AM has removed the need for expensive and complex tooling during the manufacturing process.

As Sauber are now fully utilising an Additive Manufacturing solution, a direct cost comparison to a machined version is challenging. However, on a previous race car (C36) iteration, the AM solution saved approximately 1800 Euro per insert, through component integration streamlining the manufacturing process.

The large 420x420mm build plate size of the MetalFAB1 (MF1), allows Sauber to build multiple sets of inserts in one build. The ability to print autonomously with multiple full field lasers on the MF1, allows production to be running unmanned over the weekend – a key requirement to realising the short lead time and agile production requirements for F1. Sauber also benefit from the multiple core configuration available with MF1, allowing one build to start as soon as the other print is finished and beginning automated powder removal.

From a quality perspective, the inert atmosphere on the MetalFAB1 also ensures powder is stored in a safe and inert environment.

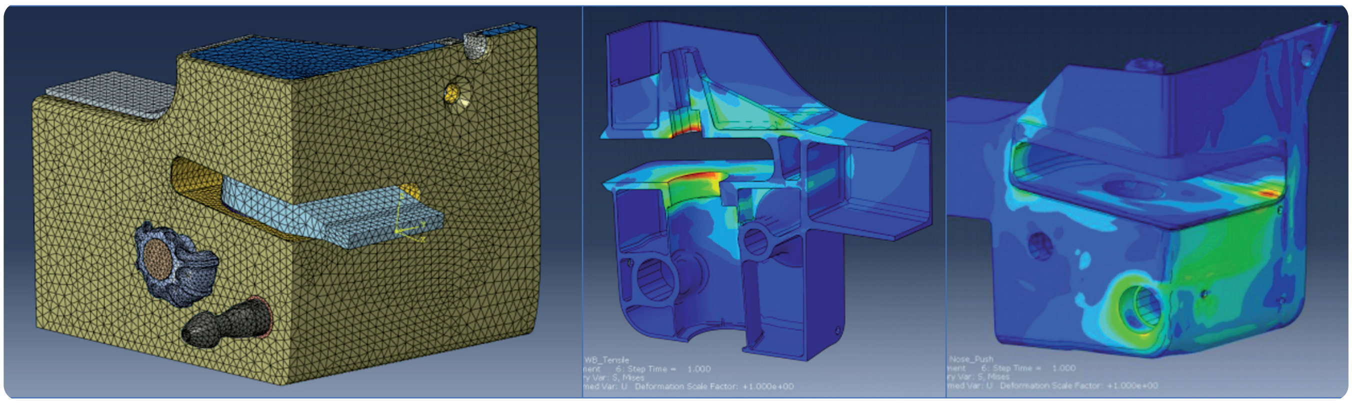


CHASSIS INSERT PIRINTED ON MF1 build Plate

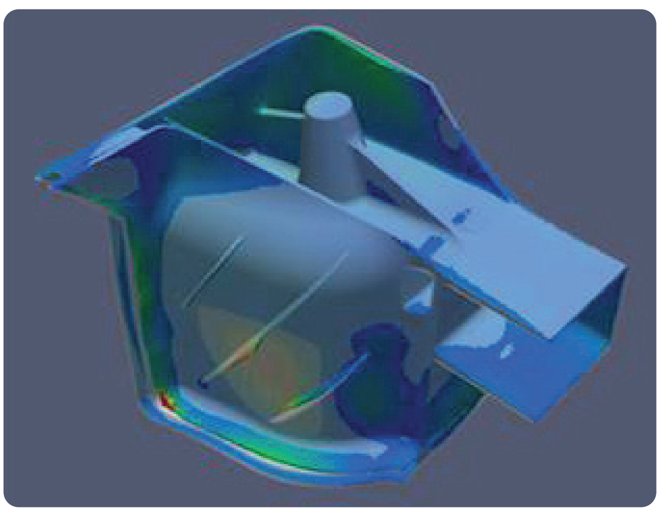
Part Design Process

The chassis inserts have been designed to fulfil the full range of demanding load cases being transmitted from the wishbone suspension, nose push-off loading and wheel tether loads. Non-Linear Finite Element Analysis is used to accurately model the "real world" racing conditions on the part. This includes modelling the bonding between the insert and the chassis sandwich panel structure, ensuring the part and surrounding area are strong enough to withstand the demanding loading for the 200,000 design life requirement.

Many design iterations are completed, with the goal to minimise the weight of the part, whilst ensuring it meets the fatigue loading requirements for the design life.



FEA Mesh & Stress Plots from one design iteration



Output from Build Simulation showing addition of stiffening ribs

Design for AM considerations

In conjunction with optimising the part design for functional use, design for AM considerations are embedded into the design methodology. The part is designed and orientated on the build plate to minimise the support structure needed.

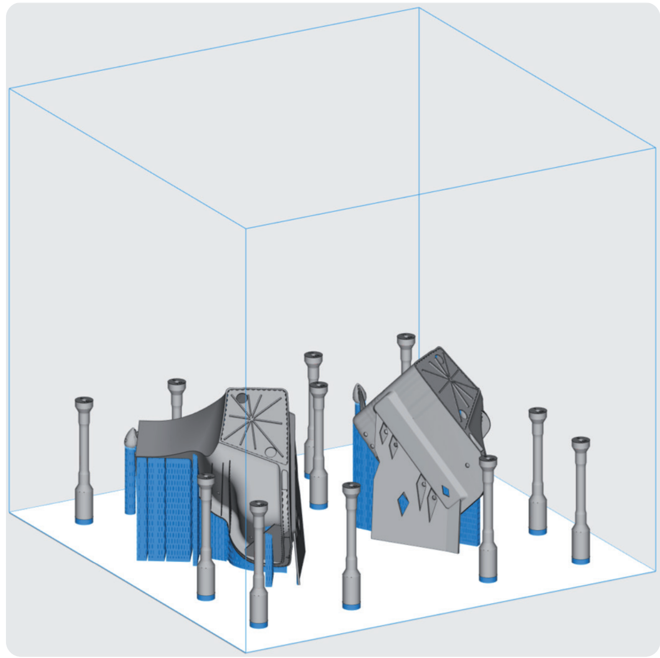
Build simulation software is used to simulate how the part will behave during the printing and heat treatment process. The thin wall geometry of the part makes it susceptible to unwanted distortion, and so stiffening ribs are added to ensure the part geometry is held in close tolerance to the original 3D CAD model, achieving the required surface profile tolerance.

Part Manufacturing Process

With the design phase complete, the part geometry is prepared for manufacture. Temporary support structure is added to the Chassis Inserts, along with tensile test coupons to monitor the quality of the build. The full field laser capability of the MF1, allows each chassis insert to be built with a separate laser, without compromising the quality of the parts. The parts are built using Additive Industries 50um Ti6Al4V parameter set, developed for our customers.

Following printing, the parts undergo a Hot Isostatic Press (HIP) heat treatment which acts to relieve the residual stresses from the printing process, reduce micro-porosity, and also optimise the microstructure of the components for optimal mechanical performance.

Any temporary support structure is then removed, before the components complete a 2 hour tumbling process to further improve the surface finish.

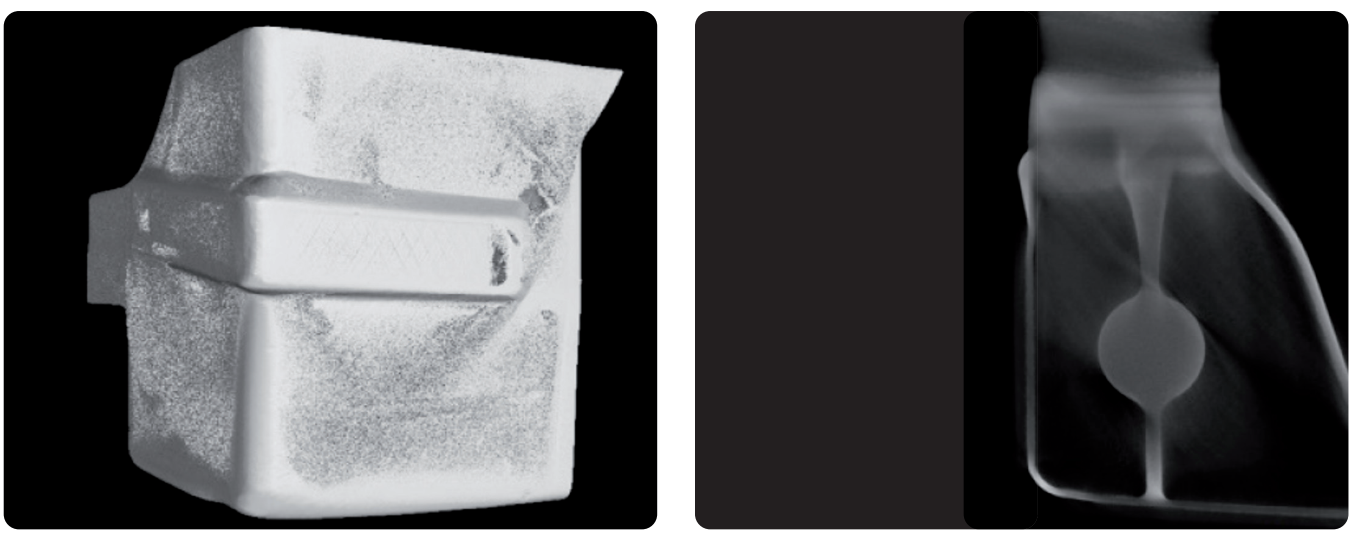


Chassis Insert Build Setup

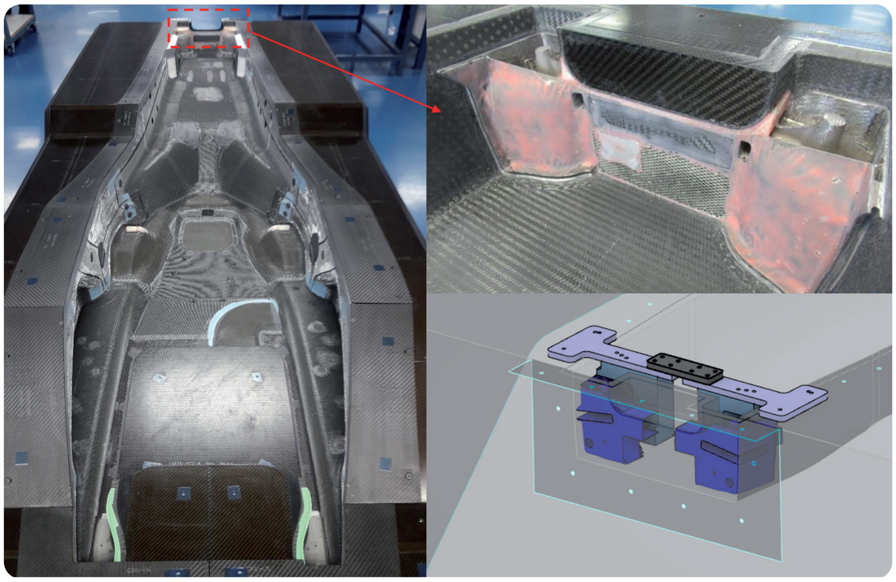
Part Inspection

Each set of chassis inserts follow a strict inspection and quality assessment process before being released for assembly. A 3D scan of the inserts is performed to verify the part is within defined tolerances. Following this, material test coupons built with the components are tested to verify the mechanical properties. By adding these samples to every build, a database of data is created to not only assess the quality of one specific build, but provide an overview of the MF1 printing quality throughout the machines life.

The chassis inserts are then CT scanned to verify the parts do not have any significant internal defects that would compromise the performance. This is particularly important for safety critical class A components, such as the chassis inserts.



CT scan of printed Chassis Inserts



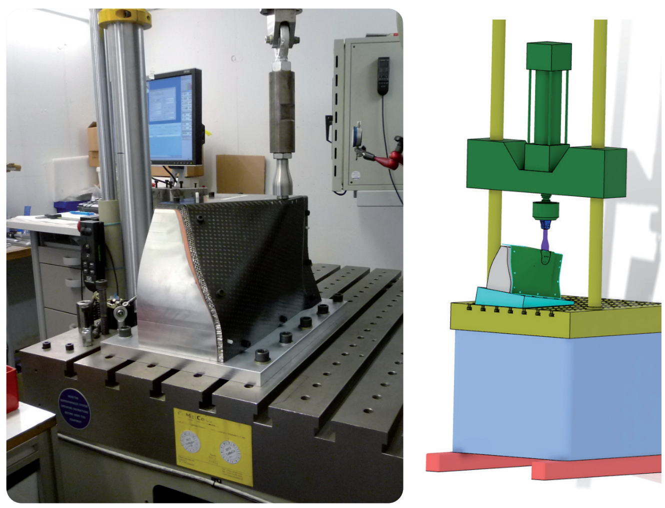
Chassis lower half with inserts bonded in place before laminating of inner skin

Component Assembly Process

With manufacturing complete, the inserts are assembled into the main car chassis. The inserts are bonded onto the cured outer carbon skin of the lower half of the chassis. The inner skin is then later laminated and cured over the top.

Component Testing

With significant part inspection and coupon testing already complete, the chassis inserts are then tested within the context of the chassis assembly to ensure they perform as required. This is done using a physical test rig, where a small section of the chassis assembly is subjected to static and dynamic loads mimicking the loads experienced during racing. By performing the tests in this way, the section of the chassis assembly is a direct representation of the race car, following exactly the same production process. Once the testing campaign is completed satisfactorily, the technology is then released to be used on race car for the season.



Section of Chassis with insert being tested to validate performance

Summary

This case study has demonstrated how F1 team Alfa Romeo Racing ORLEN are leveraging the freedoms of Additive manufacturing to create safety critical Ti6Al4V chassis inserts for their F1 race car. The design freedoms of AM have been leveraged to create an ultra-lightweight, integrated single component optimised for the significant loads imparted. The autonomous and full field laser capability of the MF1, enables the demanding F1 production requirements to be met whilst maintaining high part quality.

> At Additive Industries, our objective is the success of our customers in achieving the lowest cost per part at market leading part quality. We pride ourselves on our flexibility to work with our MetalFAB users in achieving their industrial goals.

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