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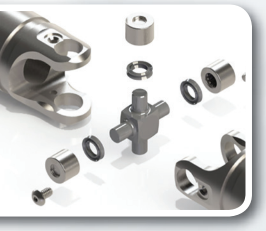

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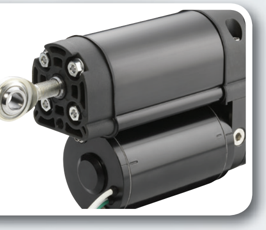

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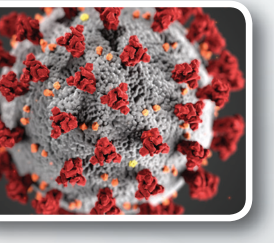

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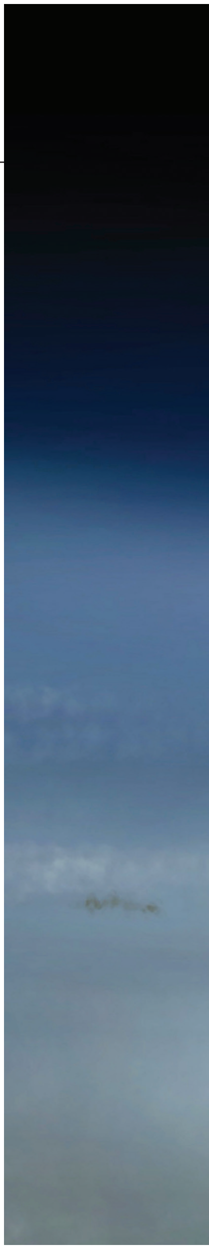


Custom bearing solution for *jet engine* application

Speed ratings, loads, and cost are foundational FAQs for any new bearings system — but what about the other, more in-depth factors like vibration, preload, or lubrication in lower temperatures? Here, we cover a few of the less frequently asked questions you might consider when designing your next bearing arrangement.

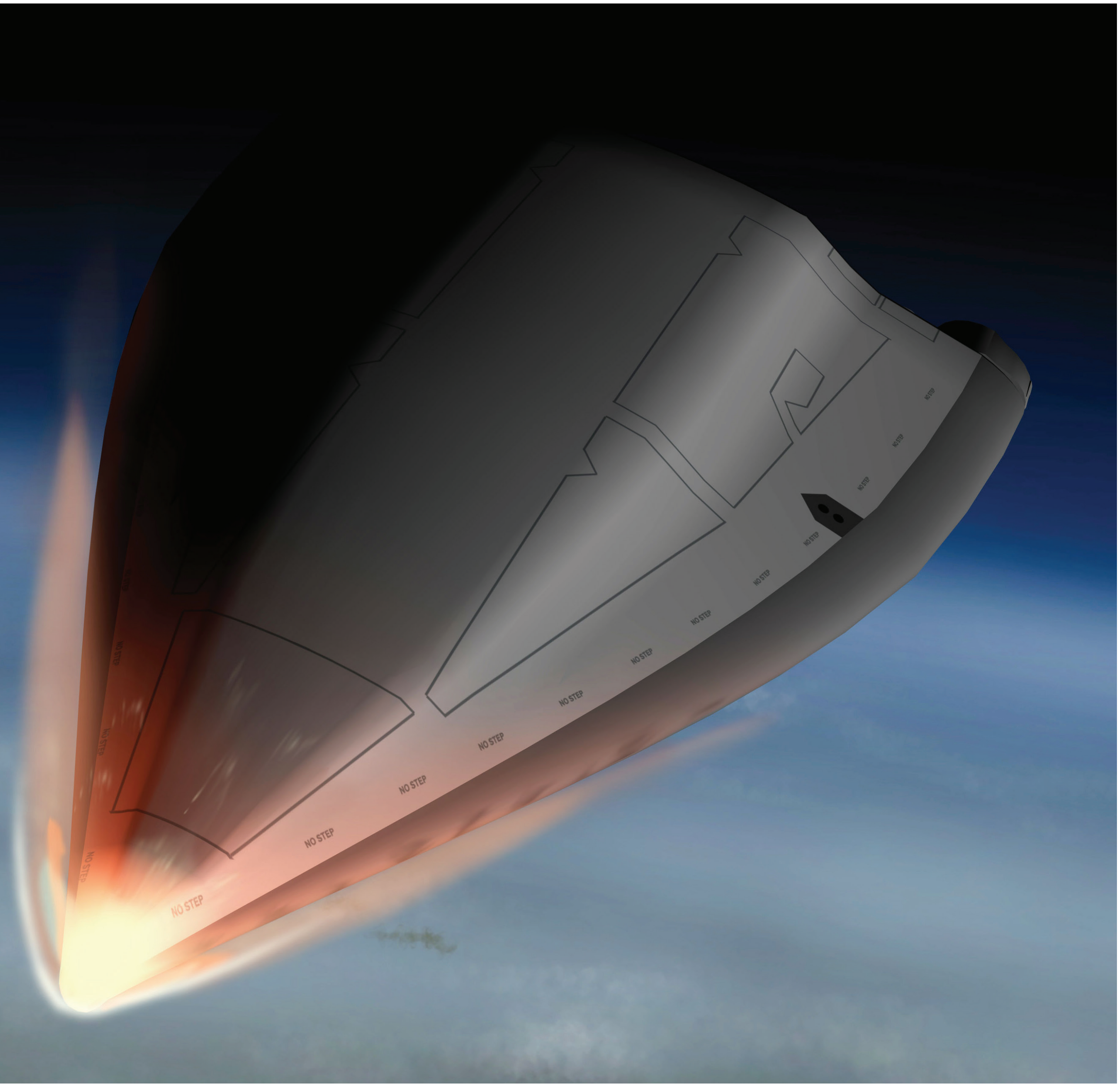
Edited by **Mike Santora** | Associate Editor

For unmanned vehicles that achieve hypersonic speeds, the performance of the combustion engine is paramount. Ball bearings play a crucial role in the fuel delivery system. After calculating the basic rating life — the total number of revolutions before the first evidence of material fatigue occurs — engineers select bearings that will meet the design or desired life. The life of a bearing under actual operating conditions before it fails or must be replaced is the bearing service life. And if that service life precedes the desired time of operation for the vehicle, prohibiting it from reaching its destination, the dreaded MF occurs — mission failure.

For a manufacturer of the propulsion system (jet engines) of these unmanned, hypersonic vehicles, optimization is critical. Every facet of operations — materials, working conditions, and controllable variables — must be optimized. These details are imperative at hypersonic speeds where air molecules separate, and high-temperature effects stress the vehicle and its sub-systems.

"Anything mission-critical has to be 100% reliable," explained Steven Sanchez, Engineering Manager at AST Bearings' headquarters in New Jersey. "The ability to accomplish the mission safely must be achievable and repeatable."

In its initial design of the engine, the manufacturer encountered a performance weakness: the bearing configurations selected yielded at most 30 seconds of vehicle life before experiencing a catastrophic failure (in some cases, bearing failure was almost immediate). Bearing failure at these high speeds



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results in fractured components and flying debris damaging other components, such as the turbine, and in turn, lead to complete engine failure.

The manufacturer sought a more durable bearing configuration beyond the standard product offering, one that would allow their vehicle to operate for longer. The manufacturer reached out to AST to find a solution.

AST engineers sought to improve the bearing life significantly, targeting a factor of 10, a projection that, if achieved, would substantially expand the capability of the end user's vehicle.

First, engineers considered dimensional constraints, mounting options, and bearing size. A common approach would have been to deploy larger bearings, which would increase the calculated bearing life (the bigger the bearing, the greater the load capacity). But they quickly dismissed the idea, as the cost for the manufacturer to re–tool the manufacturing process of the contiguous components would have been prohibitive. As a result, engineers needed to design a solution that fit in the existing bearing space.

Next, using custom rolling element bearing analysis software, engineers modeled and ran multiple simulations to determine the elastic behavior of the vehicle's existing ball bearings, which would provide insights into the cause of failure. After the analysis, they discovered that extreme axial forces from the turbine were causing potential ball truncation and edge stresses. Engineers then applied those findings to proposed modifications and assessed their impact.

Having determined the failure mode and zeroed in on the root cause, the engineering team developed a series of

The entire process was collaborative, *with AST engineers engaging with the manufacturer to confirm whether the suggested changes were practical. The whole process took roughly three months.*

design modifications. These changes were introduced incrementally, and through the use of modeling and simulation, the efficacy was validated. Relocation of one of the bearing sets, along with changing the contact angle of the balls, solved the axial loading issue.

"Changing the distance between the bearings on one common shaft can greatly reduce the final loading per bearing; it was finding that 'sweet spot' that became the challenge," Sanchez said.

A later simulation, focusing on operating and environmental conditions, led to changing from stainless steel to ceramic balls. This last tweak extended life even further. Later testing with actual hardware proved to be a success.

"It's a highly analytical process, you select one parameter, and you change it incrementally to gauge behavior," said Sanchez. "Obviously, you're trying to make moves that don't make things worse. And as you make tweaks, you look for improvements that allow you to move onto the next sequence."

The entire process was collaborative, with AST engineers engaging with the manufacturer to confirm whether the suggested changes were practical. The whole process took roughly three months.

Collectively, those changes improved bearing life by a factor of 10 — the initial goal. The improvement eliminated premature failure in the bearings, delivering the performance boost that the manufacturer sought. DW

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