



NASA Hybrid Thermally Efficient Core (HyTEC) Phase 2 Q3'GFY25 to Q2'GFY26

Unlimited Rights Annual Report for CLIN 1 and 2

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List of Acronyms and Abbreviations

ACC	Active Clearance Control
ADP	Aero Design Point
CCB	Configuration Control Board
CDN	Combustor Diffuser Nozzle
CDR	Critical Design Review
CoDR	Conceptual Design Review
CFD	Computational Fluid Dynamics
CLASSIC	Combined Liner and SIN Sector Interaction Cascade
CLIN	Contract Line-Item Number
CMC	Ceramic Matrix Composite
CTDR	Conceptual Test Design Review
CTQs	Critical to Quality
DCR	Design Consensus Review
DDR	Detailed Design Review
DTDR	Detailed Test Design Review
EBC	Environmental Barrier Coating
EGT	Exhaust Gas Temperature
EIS	Entry Into Service
EPFD	Electrified Powertrain Flight Demonstration
EWC	End wall Contouring
FAR	Full Annular Rig
FOD	Foreign Object Debris
HES	Hybrid Electric System
HPC	High Pressure Compressor
HPMG	High-Pressure Motor Generator
HPT	High Pressure Turbine
HTP	High Temperature and Pressure
HYTEC	Hybrid Thermally Efficient Core
ICAO	International Civil Aviation Organization
ICDs	Interface Control Document
KPP	Key Performance Parameters
LCF	Low Cycle Fatigue
LES	Large Eddy Simulation
LPS	Low Pressure Sector
MRL	Manufacturing Readiness Level
NPI	New Product Introduction
NPSS	Numerical Propulsion System Simulation
OEM	Original Equipment Manufacturer
OIR	Overall Instrumentation Review

OPR	Overall Pressure Ratio
PCB	Product Control Board
PDR	Preliminary Design Review
PTDR	Preliminary Test Design Review
RFQ	Request for Quote
RISE	Revolutionary Innovation for Sustainable Engines
SAF	Sustainable Aviation Fuel
SLA	Stereolithography
SLIN	Sub-Contract Line-Item Number
SOA	State of the art
SPOCT	System Performance Operability Controls & Transients
TCA	Tunable Combustion Acoustics
TEH	Test Enabling Hardware
TPM	Technical Performance Measures
TRD	Test Requirement Document
TRL	Technology Readiness Level
TRT	Notre Dame Transonic Research Turbine
TSD	Thermal Systems Design
TTB	Thermal Transport Bus
TTF	Target to Fire
UND	University of Notre Dame
VDR	Validation Design Review
VEN	Variable Exhaust Nozzle

1.0 Introduction

The HyTEC Phase 2 Project focuses on the development and demonstration of high-power density, small engine core gas turbine engine technologies. The focus of HyTEC on these small engine core technologies will provide direct benefits to the next single-aisle class aircraft in terms of thermal efficiency, as well as integrate with other technologies, through increased hybridization, as they mature to provide substantial continuous fuel burn reductions during the aircraft lifecycle. These advances will strengthen the US position in the commercial aviation engine market and enable cost benefits in commercial aviation. In Government fiscal year 26 the HyTEC Project was closed and contract moved to the Subsonic Vehicle Technologies and Tools Project.

GE Aerospace is executing two major work plans as part of the HyTEC Phase 2 contract. The first is Contract Line-Item Number (CLIN) 001 and its objective is to mature High Pressure Turbine (HPT) aerodynamics technology to TRL 5 through multiple rigs so that it may be incorporated into a complete TRL 6 evaluation and unlock learnings for the engine core demonstration as applicable. CLIN 002, the second work plan, is to design, procure and test a cost shared portion of technologies on the TRL6 Compact Core test vehicle.

The compact core demonstrated through HyTEC Phase 2 along with the HPT rig TRL advancement directly matures the technologies being developed as part of the CFM RISE demonstrator program which is targeting a more than 20% fuel burn reduction at the engine level versus today's state of the art. The RISE program's objective is to advance both the novel Open Fan architecture, compact core technologies and advanced systems such as hybrid electric needed to achieve the desired fuel burn reduction to TRL6 ahead of a new product introduction in the single-aisle class aircraft in the 2030s timeframe.

2.0 Overview of Technical Plan

2.1 KPPs

The GE Aerospace Open Fan product vision is currently projected to meet or exceed the Key Performance Parameters (KPP) as summarized in Table 1.

Table 1: HyTEC KPPs with GE Aerospace product vision status, bold denoting required KPPs versus desired

KPP #	Key Performance Parameter (KPP) (NASA required KPPs in bold)	Single Aisle Success Full / Minimum
KPP-1	Fuel burn reduction attributed to the high-power density core of the OEMs vision turbofan engine	10% / 5%
KPP-2	Engine Bypass Ratio	> 15 / > 12
KPP-3	Engine Overall Pressure Ratio (OPR) (Defined at top of climb)	> 50 / > 45
KPP-4	Durability, measured in operating hours between major refurbishment.	Exceed SOA by 5% / Meet SOA Baseline
KPP-6	HPC Exit Corrected Flow	< 3 lbm/s / < 3.5 lbm/s
KPP-7	Combustor operability using Sustainable Aviation Fuel (SAF) is comparable to its performance using Jet-A/A1 fuel, as measured by lean blowout and ignition performance.	Combustor operability demonstrated with 100% SAF / > 80% SAF
KPP-8	Degree of hybridization measured by level of power extraction/insertion from the core	10% / 5%

2.1.1 Assessment Methodology

The technical performance metric progress will be monitored throughout the execution of the core demonstrator program with integrated core system assessments proposed in the content for the PDR, CDR, pre-test data assessment, and VDR. To assist in NASA's parallel, independent, progress assessments, GE Aerospace will periodically provide an Assessment Data deliverable in conjunction with life-cycle reviews, the second of which is planned in conjunction with the Preliminary Design Review. Assessment reviews and associated data deliverables will:

- Provide appropriate quantification of effects of the technology on engine performance, operability, durability, and physical characteristics.
- Identify gaps or risks for maturing and integrating technologies in a small core ground demonstration.
- Quantify the benefits of quoted and measured technical performance measurements relative to the HyTEC goals and contribution to the KPPs.
- Quantify the integrated benefits of the HyTEC funded advanced technologies that are implemented into the core demonstration as well as the synergistic combined benefit of all advanced technologies relative to the KPPs for the Product Vision when compared to a 2020 baseline.
- Provide an evaluation of the TRL level achieved using the NASA TRL definitions.
- Identify lessons learned and technology gaps needed to mature the technology for product insertion.

In addition to formal Assessment Data deliverables the GE Aerospace team has worked over the past year and will continue to support informal collaboration with the NASA Systems Analysis and Integration (SA&I) team to assist in improving overall understanding of HyTEC funded technology potential. A summary of these activities to date can be found below in Section 4.2.3

To facilitate clear traceability to KPPs, the GE Aerospace team has worked with NASA to select a 2020 industry average single aisle baseline. Progress of GE Aerospace's Open Fan Product Vision toward the KPPs, relative to this baseline, will be monitored through the progression against the TPMs of the core demonstrator.

Through the SA&I activities and planned deliverables GE Aerospace will continue to strive to provide definition of the 2020 SoA baseline and Product Visions to allow for quantification of the integrated effects and benefits of the HyTEC technology. As appropriate, TPM baselines for improvement calculations will be aligned with the average baseline.

3.0 CLIN 001 HPT Rigs

3.1 TRT Phase 3 Rig

3.1.1 Rig description and overview

The Transonic Research Turbine (TRT) rig is a low pressure / temperature single stage uncooled HPT aero test rig located at the University of Notre Dame. The rig can test isolated technologies and flow/clearance derivatives. The TRT rig allows for the test of multiple configurations while optimizing cost efficiency. It also has a low measurement uncertainty due to magnetic bearings. TRT Phase 3 will utilize clearance, speed and purge derivatives to test various designs.

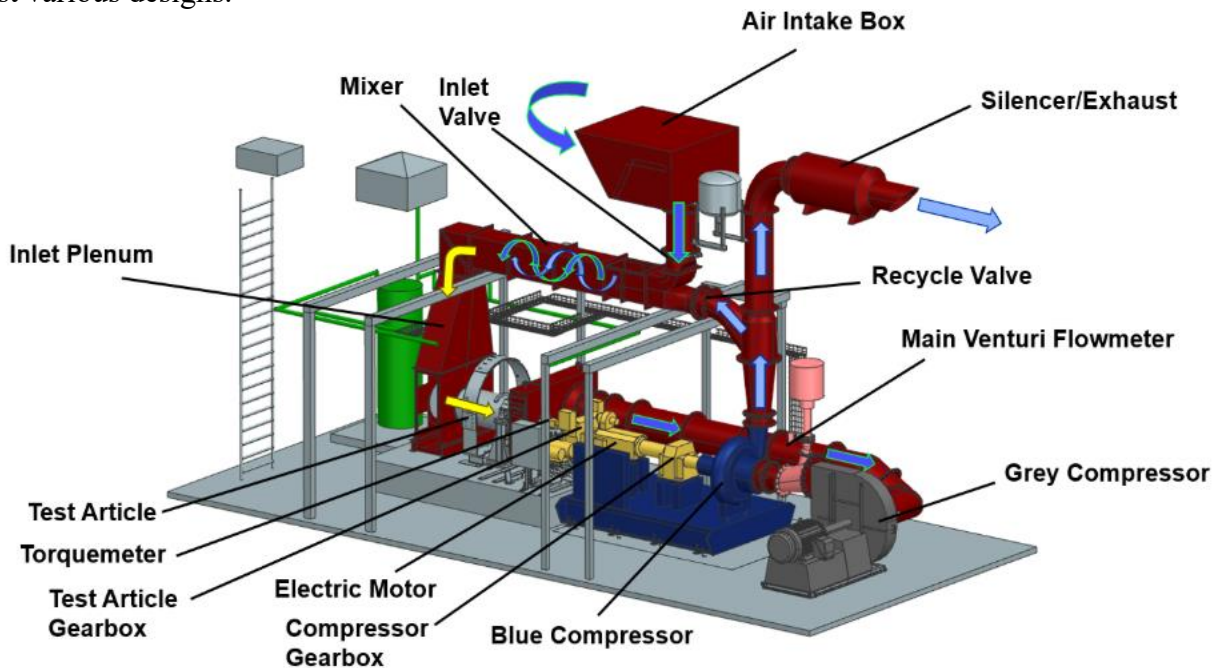


Figure 1: TRT Rig Overview

3.1.2 Annual Accomplishments

TRT Phase 3 achieved several major milestones across 2025 and into 2026. For the Nozzle and Blisk airfoil geometry, the Aero team completed Detailed Design Review (DDR) in June 2025. Approval of this review enabled the program to proceed into mechanical design and reviews. On the mechanical side, all hardware successfully passed Preliminary Design Review (PDR) in April 2025, and DDR in November 2025. These approvals authorized progression into manufacturing and the associated test design reviews. On the test facility side, the team completed the Preliminary Test Design Review (PTDR) in April 2025 and the Detailed Test Design Review (DTDR) in December 2025. In alignment with GE Aerospace test planning, TRT advanced through Tollgate 3 in November 2025 and a combined Tollgate 6 and Tollgate 9 in February 2026. The Test Design Reviews and Tollgate Reviews authorized TRT to proceed to

assembly and testing. Driven by NASA HYTEC deliverables, GE also conducted a PDR with NASA in July 2025 and completed the Critical Design Review (CDR) in February 2026.

Over the past year, TRT Phase 3 advanced significantly in hardware manufacturing, with multiple components completing fabrication and others reaching late-stage operations. The Blisks have nearly completed all manufacturing operations by February 2026. One Nozzle completed machining operations in December 2025, while the other Nozzle started final machining in February 2026. Several Test Enabling Hardware (TEH) components completed manufacturing during the year. These hardware components were re-designed in Phase 3 to further improve clearances and increase instrumentation capabilities. By February 2026, these components were installed in the test facility in preparation for the first test of the Phase 3 campaign.

3.2 CLASSIC (Cold Flow)

3.2.1 Rig description and overview

The CLASSIC rig, also known as Cold Flow rig, focuses on the combustor-turbine interface. Running in a low-temperature environment enables detailed measurements to be taken in pursuit of understanding these module interactions to assist in improving coupled combustor-turbine performance. To align with product design cycles and design objectives, the rig's objectives were reevaluated early in 2025 with approval gained to reorganize existing rig objectives into CLASSIC.

The focus of the CLASSIC rig was defined as this combustor-turbine interface, specifically addressing the risk of ingestion in the purge gap between the combustor liner and Stage 1 Nozzle (S1N). Purge flow will be varied in this gap to determine what arrangement minimizes ingestion.

Tollgate Reviews

The Tollgate 1 Review was held in Q2 2025 to refine CLASSIC's mission statement and objectives. The first phase of the rig includes a combustor upstream sized for cold flow conditions, a S1N cascade, and an axisymmetric leading-edge band geometry; the objective of this first phase shall be to commission the test vehicle and collect baseline interface data.

The Tollgate 3 Review was held in Q3 2025 to detail the CLASSIC rig's commissioning, test plan, hardware, and facility readiness details. Included in this review were decisions covering rig ownership, instrumentation requests, and the final facility location for testing. Alongside the Detailed Test Design Review, Tollgate 3 gained concurrence to begin hardware procurement for the rig's components.

Test Campaign Overview

A modular rig in nature, the test matrix for the CLASSIC rig covers three distinct rig builds with progressing purposes, as detailed in Table 2, the first of which is shown in Figure 2. The test matrix approach ensures a systematic evaluation of CLASSIC's performance, starting with commissioning tests to validate the setup and set engine-representative aero loading. Subsequent builds progress to advanced measurements such as flow field characterization, bow wave measurement, and gas ingestion analysis at the combustor-turbine interface. In this phase of testing, the rig uses a single gap geometry representative of takeoff conditions, examining variable prescribed purge flow rates in the gap.

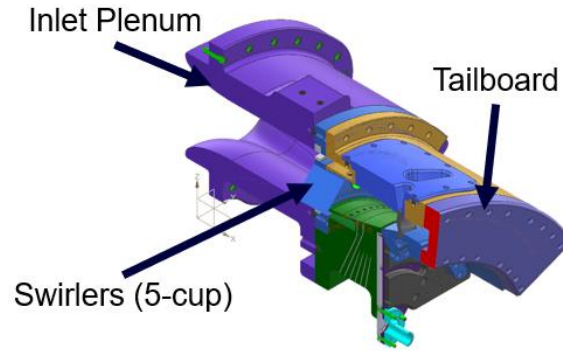


Figure 2: Phase 1 Classic Rig Aero Build Configuration. Testing will progress through each build to validate the rig, set loading, and collect progressively more detailed measurements. Modular components allow simplified swapping between builds.

Table 2: Phase 1 CLASSIC Rig Build Purposes

Test Card	(1) Aero	(2) Traverse	(3) Optical/Sniffer
Purpose	Set aero loading to match bow wave and airfoil pressure distribution	Measure combustor-S1N match plane flow profile and characterize inlet condition to S1N	Measure impact of bow wave on depth of ingestion with varied purge flow

Rig Design

The Design Consensus Review was held in Q1 2025 to gain consensus among the technical teams on the rig details necessary for inclusion to fulfill the expected test methodologies and objectives.

Design Work

The longest duration technical design effort for the CLASSIC rig involved resizing the combustor for cold flow rig conditions. Several iterations of design refinement occurred between the combustor and HPT modules. The combustor resize is expected to maintain engine flow field characteristics, with CFD analysis being conducted to compare the expected bow wave at engine and rig conditions. The aero shape for the S1N was selected for use inside of the CLASSIC rig in Q3 2025.

The test campaign will occur at a GE Aerospace Research facility in the horizontal orientation. CLASSIC's initial concept design called for the rig to be oriented vertically; minor design modifications to change orientation were required for structural support and to ensure full test facility compatibility. To support the main rig components and mate to facility air supply, additional components were developed, with the additional enabling hardware including a moveable stand and interface flange as pictured in Figure 3.

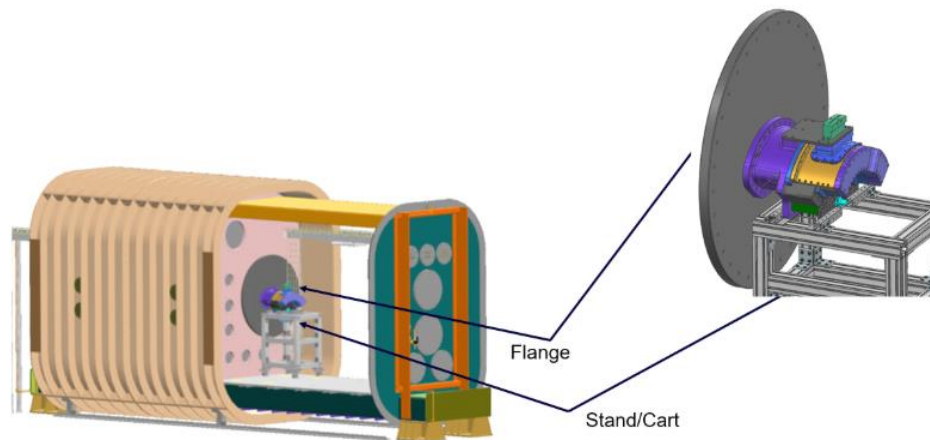


Figure 3: CLASSIC Rig as Installed in GE Aerospace Research Facility, Horizontal Orientation

Instrumentation suite

A suite of static pressure taps, traverse, and gas sniffers was developed to support detailed data collection during rig testing. A modular access panel enhances testing flexibility by allowing quick configuration changes between the builds (See Figure 2, Table 2) to meet the specific test objectives for each build.

Taps in the interface purge gap assist with ingestion measurements; probes for a single channel gas analyzer (sniffer) for CO₂ are also present in the interface purge cavity to support a more detailed understanding of gas ingestion, capable of sensing CO₂ concentrations. Within the gap, CO₂ is used as the purge flow fluid, permitting a detection distinction between standard air (i.e., what would be hot flow) and the purge CO₂ (i.e., what would be cooling flow) in the low temperature rig set up.

Upon finalization of the instrumentation suite, an internal instrumentation review was completed with the HPT Aero team to ensure the instrumentation setup aligns with testing objectives.

Hardware Procurement

Alongside TG3, a Detailed Test Design Review was held with approval of the rig's instrumentation suite and overall design. Successful completion of this review enabled the team to begin hardware procurement of machined and SLA parts.

In Q1 2026, all CLASSIC rig configurations (Table 2) were released for build to support hardware procurement. Purchase orders were placed for all hardware, with build components expected to arrive prior to their respective build's timeframe in the test schedule.

An assembly guide has been developed for use at Research to provide streamlined step-by-step instructions on initial rig assembly and modular component swaps.

3.3 HPT Aero Rig

3.3.1 Rig description and overview

The objective of the HyTEC Phase 2 HPT Aero Rig is to advance various High-Pressure Turbine (HPT) technologies to Technology Readiness Level (TRL) 5, including low solidity, advanced trailing edges, end wall contouring, advanced tips, and advanced 3D aero. Achieving TRL 5 for these technologies will be accomplished by integrating them into an HPT aero rig with product-representative interfaces in an engine relevant environment. GE Aerospace will execute the design of the HyTEC rig. GE Aerospace will also be responsible for the manufacture, assembly, installation and testing of the rig in Evendale, OH.

The figure below shows a turbine rig installed in the Evendale test cell with the test enabling hardware. Air flows from right to left with the HPT rig hardware installed just to the right of the exhaust duct.

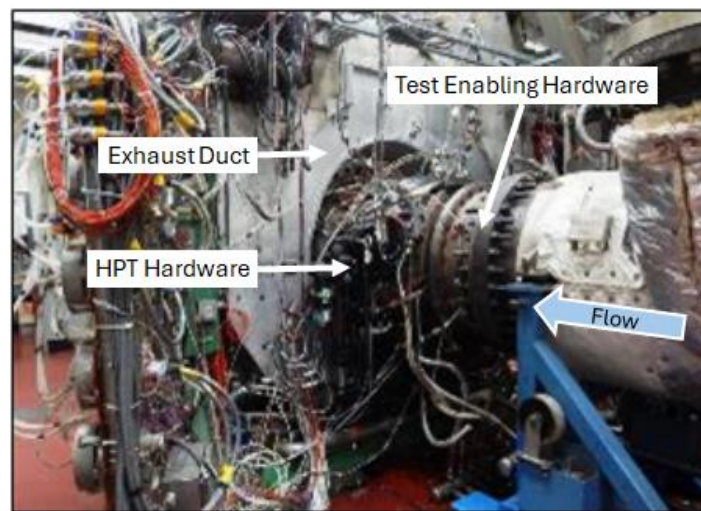


Figure 4: HPT Aero Rig Overview

3.3.2 Annual Accomplishments

In 2025, the team progressed the HPT aero rig design through several significant reviews across multiple disciplines, components, and the system. These reviews marked the completion of the conceptual design phase and kicked off the teams to work towards preliminary design.

Rig System-Level Reviews

The first accomplishment was completing the system level overview review, which covered overall rig requirements and technology objectives, program schedule, conceptual architecture and design decisions, lessons learned from previous rigs, and top risks across the system, components, and other disciplines. This review was the first comprehensive review of the rig that gathered feedback from key stakeholders on the progression of the rig. The second program level review was an instrumentation review that covered all safety and performance instrumentation required on the Rig. The proposal presented was a full team effort

including coordination with Aero, TSD, and mechanical to align the instrumentation request with the needs of all the disciplines. In the review, the team discussed the reason behind all the instrumentation ensuring agreement from the reviewers that the rig is being set up to collect all necessary data for TRL advancement and TPMs.

The aero rig CoDR focused on addressing program requirements, overall test objectives, engine-to-rig scaling, and the selection process for rig aero design points. This review included discussions on the preliminary instrumentation plan, test support equipment selection (main venturi, torquemeter, bearing cartridge, water brake), risk assessment, and planning the next steps towards the aero Preliminary Design Review (PDR). The importance of this review is to show a technical path for the HPT rig design that meets TRL5 goals, identify potential risks, and establish a clear path forward.

Discipline-Level Reviews

During this phase, the team proceeded with multiple discipline-specific Conceptual Design Reviews (CoDR) for Test Enabling Hardware (TEH) HPT rotating parts, TEH structural parts, TEH mechanical parts, dynamics design, clearance design, and thermal system design. In six separate reviews, with the experts of the individual disciplines, the teams reviewed status against program and design requirements using the analysis approaches and methodology agreed in the previous Design Consensus Reviews from 2024. These are the first reviews where the designs are thoroughly vetted to ensure architecture decisions are sound and have a path to meeting requirements through the Preliminary and Detailed design phases that follow.

Aero Design Review

One significant Aero design review was conducted. The HPT Aero Design PDR reviewed the status of the Aero design against design requirements and key program technology readiness level (TRL) and TPM objectives. This review set the geometry of the airfoils and flowpath that will be used for updates to the hardware geometry for future reviews in the preliminary design phase in middle of 2026.

The overall HPT rig incorporates several features to create a testing environment that is representative of engine operation. These include systems to shape the turbine inlet conditions, provide representative levels of inlet turbulence, and implement engine-like clearance control. The rig is sized and operated to be representative of the engine's design conditions. Key non-dimensional and operating parameters are selected so that the rig can achieve engine-relevant aerodynamic similarity within facility constraints, including for cooling and main gas-path conditions.

Within this framework, the rig operating speed and pressure ratio can be varied to assess turbine performance over a range of conditions. The achievable envelope is bounded by the capabilities of the test facility and associated hardware but remains sufficient to cover a set of operating points representative of the engine cycle's key efficiency requirements.

By thoroughly addressing these topics in both the aero design PDR and CoDR, the team ensured that the necessary elements are in place to proceed confidently into the next phase of aero design and rig implementation.

Progress Achieved – Trade Studies

The team executed on a number of trade studies selected in the prior year. The previous trade studies included topics on rig architecture and TEH equipment selections. With the trade decisions made, the team progressed the designs to build the rig around these decisions, impacting architectures such as the Active Clearance Control (ACC), secondary flow circuits, torque data acquisition, bearing architectures, and water brake system.

The HPT stator and ACC architecture initial design process involved leveraging a product like system, a decision selected in 2024. The goal of this design was to reduce eccentricity in the clearance that prior Rigs experienced with their ACC designs. This system went through initial layout to size the system and show compliance to program requirements for ability to target blade tip clearances as well as vary them for performance derivative studies. With the initial sizing in place, the team then initiated further study to refine the manufacturing methods for this single rig build.

The TEH mechanical systems team also progressed design, building on another study completed in 2024. The team down selected a specific torque sensor, water brake, and bearing system, which has now been incorporated into the rig models. The first assessment of mechanical capability and impact of the system dynamics is completed, ensuring the TEH equipment is appropriately sized and the system interactions allow for testing key specification points to generate the HPT map. In addition to design, the team is working through rebuild and refurbishment plans, with initial inspection already kicked off.

3.4 HPT CFD Collaboration Plan

3.4.1 Collaboration Plan Overview

The GE–NASA CFD collaboration focuses on improving understanding of combustor–turbine interaction and assessing whether a cold-flow rig can be used to study the impact of combustor exit patterning on the downstream turbine. In this collaboration, GE supplies representative turbine inlet geometry and operating conditions, while NASA develops and executes combustor–turbine interaction simulations. Based on the analysis results, the team may recommend modifications to an existing cold-flow rig to enable relevant clocking studies and to help validate the modeling approaches developed under this project. The collaboration has been structured to remain flexible so that modeling scope, test strategy, and rig usage can be adapted as program needs evolve, with alignment maintained through regular joint technical meetings.

3.4.2 Annual Accomplishments

Over the reporting year, GE and NASA completed key steps that position the collaboration to provide meaningful insight into combustor–turbine interaction in support of ongoing turbine development work.

Collaboration Plan Re-Scope

Following changes to the cold-flow and related rig programs, the team jointly refined the collaboration plan. The work evolved from an initial, broad modeling effort into a more focused cold-flow feasibility study. The updated objective is to determine whether a cold-flow rig can reproduce combustor–turbine interaction features in a way that is representative of hot operating conditions and to provide modeling data to support turbine development. Feasibility will be evaluated by comparing results from reacting-flow simulations to corresponding cold-flow cases. If this approach proves viable, the team may define and implement rig updates and use combined test and modeling results to inform future combustor–turbine interaction design and validation.

Under the updated plan:

- GE provides representative turbine inlet geometry, boundary conditions, and key interaction parameters
- NASA develops and runs the associated combustor–turbine interaction models
- The joint team compares reacting and cold-flow behavior and recommends rig and test strategies based on these findings

Geometry and Parameter Exchange

GE has delivered the turbine inlet geometry and associated flow-path definition, along with inlet boundary conditions and other key setup information needed for NASA to construct representative simulations. NASA is building a generic combustor representation sized to match the targeted turbine environment, and GE has provided feedback on the setup to ensure physical consistency. Both teams continue to refine models and clarify parameters through regular working sessions.

Clocking Study Definition

NASA has defined initial simulation cases that examine different relative orientations between the combustor exit pattern and the turbine inlet. These initial configurations are intended to span a useful range of behavior and provide a basis for assessing the sensitivity of turbine inlet conditions to combustor pattern alignment. Depending on the results, additional configurations may be explored in follow-on studies.

Modeling Progress

Mesh generation and initial combustor–turbine interaction calculations have been completed, and both reacting-flow and cold-flow simulations are underway. Time-averaged results from these simulations will be compared to determine whether cold-flow modeling can reproduce the key features of the hot-flow interaction with sufficient fidelity to support rig-based studies. Positive results would strengthen the case for using a cold-flow rig to study combustor–turbine interaction and to guide any rig modifications needed for future clocking investigations.

3.5 Advanced Instrumentation Collaboration Plan

3.5.1 Collaboration Plan Overview

This task is a collaboration between GE, the University of Notre Dame (UND), and NASA to develop advanced probe-based instrumentation for detailed unsteady measurements in turbine testing facilities. The primary objective is to improve the ruggedness, reliability, and accuracy of sensor technologies that have historically been constrained to low technology readiness level (TRL) environments, with a specific focus on enabling measurements in TRL 5 rig environments. The measurements of interest include time-averaged and unsteady velocity components, total pressure, total temperature, and turbulence statistics, with the ultimate goal of integrating the new instrumentation into the HPT Aero Rig.

The development effort is centered on probe-based methods rather than optical diagnostics, with emphasis on sensor type, probe size, calibration strategy, frequency response, decoupling from contaminating variables (pressure and temperature), and long-term sensor stability and life. The team will leverage its calibration jets, low-speed wind tunnels, turbine rigs, and existing testing programs to provide low-cost environments for iterative assessment of candidate instrumentation concepts prior to deployment in the HPT Aero Rig.

3.5.2 Annual Accomplishments

Over the past year, the collaboration has progressed from planning into active technology development, prototyping, and calibration of candidate probe concepts. GE, UND, and NASA aligned scope, schedule, and top-level objectives, established a development roadmap, and launched a dedicated research effort at UND.

A broad survey of probe-based instrumentation technologies was completed, followed by exploratory prototyping of several advanced concepts. Based on early testing and maturity considerations, the team elected to focus on a hotwire-based velocity measurement solution and complementary pressure/temperature sensing approaches. In parallel, candidate pressure and temperature sensing approaches have been evaluated, including traditional miniature pressure transducers and thermal probes capable of sensing combined pressure and temperature. Early prototypes have been fabricated and tested in calibration facilities, confirming feasibility and informing ongoing down-selection.

The TRL/MRL planning session conducted in October has established a structured development roadmap and risk burn-down plan that will guide future work, with the objective of delivering an integrated, multi-parameter probe suitable for installation at the inlet of the HPT performance rig.

Building on UND's initial steady-state modeling of probe geometries, GE and NASA are defining a complementary unsteady simulation effort to better understand probe-flow interactions and to refine calibration strategies for the final design.

4.0 CLIN 002 Compact core

4.1 Systems

4.1.1 Systems Background

Systems engineering encompasses a comprehensive approach to the development and integration of complex modules. It begins with the definition of requirements, ensuring that all necessary specifications and constraints are identified and addressed. This process includes the overall integration of various modules, so they work together to achieve the desired functionality. Additionally, systems engineering involves the management of trade studies, balancing different design options and their impact on the system. Systems also maintains the official demonstrator cross section.

Disciplines such as dynamics, controls, and performance along with specific thermal system design activities such as rotor thrust analysis are also considered at the system level due to their cross-module and cross-system implications.

4.1.2 Annual Accomplishments

Systems CoDR Completion: The Compact Core Systems Conceptual Design Review was successfully completed. The key findings from the System CoDR were:

- The review team agreed to progress the design to PDR.
- Weight roll-up at the time of the CoDR was higher than requirement – this would be a significant concern to the NPI program if left un-addressed. Mitigation: The Systems team took action to prioritize execution of the relevant weight reduction activities across the core to reduce it to below 5% over target.
- Durability shortfalls were identified for the Combustor Liner and HPT flow path based on the CoDR cycle which was significantly more severe than legacy benchmarks for both the Climb and Cruise phase. Mitigation: The Systems team took action to reduce the Climb and cruise severity along with an updated HPT cooling flow allocation. This updated cycle has been released for use by the design teams for PDR.
- Several actions associated with HPT airfoil producibility were identified primarily based on the new cooling technologies that are being developed. The Design team has made significant progress over the last nine months in terms of completing producibility trials and progressing on actions needed to deliver Core hardware. Delivering turbine flow path hardware to the Core test vehicle is still likely going to be the pacing item for final assembly.

Systems Conceptual Test Design review – The Compact Core Systems CTDR was successfully completed with a primary focus on the Test scope. Review team acknowledged the significant number of new technologies intended to be matured as part of the Core Test campaign and potential competing priorities. The review team recommended that the overall test sequence be prioritized to gather the required aeromechanics data on the HPC and HPT rotors based on risk

of hot-section sensor loss. This feedback is being considered as part of the overall planning of the Core Test campaign and will be reviewed again as part of PTDR (Preliminary Test Design Review).

Cross-section Updates: The Systems team hosts a series of weekly meetings intended to provide a forum to make decisions on updating the overall Core Engine cross-section. These provide a structured framework to propose changes, complete the relevant trade studies and make formal cross-section updates. Over 165+ individual trade studies were completed in 2025 to support both major and minor updates to the cross-section.

Cross-section Release for Thermal PDR: After completion of the Systems CoDR, each of the individual modules worked through their first iteration of “hot-to-cold” conversion. At the CoDR stage, each module cross-section had been maintained in the “hot” state – with the “hot” state being defined somewhat independently for each module. For instance, the Combustor flow path would have been maintained at new engine take-off conditions (to meet emissions requirements) whereas the turbine flow path would typically be maintained at Cruise (with a focus on performance requirements). The Systems team worked through each of the module interfaces to ensure radial & axial alignment. Note that the thermal models frequently span multiple modules – so it is important to have a cold cross-section as the common basis for the analysis runs. The release of the thermal (and dynamics) cross-section also enabled overall PDR design schedule to be set.

Transient LCF Mission Release: Prior to Systems CoDR, the design teams had been assessing feasibility, trade studies and benchmarking with steady state cycle points for a Level 4 (86F) ambient day for both new and deteriorated engines. As discussed before, the cycle definition for PDR was revised based on HPT durability risk assessment. Along with the revised HPT cooling flow allocation, SPOCT generated a transient LCF mission that is intended to be used for all design assessments for PDR.

PDR and DDR Execution Planning: After the completion of the Systems CoDR and subsequent release of the Transient LCF Mission and Cold x-section for Thermal and Dynamics analysis, a series of planning sessions were conducted with key stakeholders from the design execution and Manufacturing programs. These sessions were intended to better align Core Target to Fire with the updated manufacturing lead times for long lead items such as turbine airfoils and rotor forgings and firm up the required Design release milestones. As an outcome of these planning sessions, the Systems leadership team established an updated set of guiding principles for execution of the Preliminary and Detailed Design phase of the Core Test Vehicle.

Dynamics PDR: The System team worked closely with Dynamics and each of the modules to establish appropriate hand-offs for key stiffness, weight, CG information and trade-studies. This Design Review was successfully completed and enabled release of a dynamics load set to the

design teams. Additional iterations to the Rear Frame stiffness, 3B/3R spring finger and 4R bearing outer race were completed to further reduce the loads for the final load set release.

Digital Engine Fly-through Reviews: The Compact Core Systems PDE focal initiated creation of the overall Digital Engine (DE) model for the Demo Engine that includes representative 3D models of the Core engine components along with Test Enabling Hardware, Mounts and Externals. The switch to 3D rendering enables more in-depth discussions and decisions around the overall architecture, integration of the Core Test vehicle with the Test cell infrastructure, circumferential layout of the various bleed ports/service lines and Maintainability. This is a weekly review hosted by the Systems team that measures progress related to number of component models uploaded into the DE and maturation of the interface control documents (ICDs).

Module Weight Reviews: The Core weight roll-up at the time of the CoDR was above requirement. A series of individual Tech Reviews for the HPC, CDN and HPT were completed to drive closure of the action item issued at the end of the Systems CoDR. Each module review identified a list of projects that had been completed or planned to complete prior to PDR. An appropriate realization factor was applied to weight projects which were in the process of completion at the time of the Tech Review. Module target weights were refined based on the tech stack that was intended to be demonstrated on the Core vs. legacy weight benchmarks. An updated weight stack will be completed at the time of the Systems PDR based on the final summary of completed projects.

Engine Instrumentation Plan: A series of deep-dives was completed with each module to identify instrumentation needed in each of three categories – a) Operational/Safety b) TRL advancement and c) Engineering data collection. In addition to the Core turbomachinery instrumentation, the test vehicle will also include instrumentation for the Hybrid, Fuel System, Cooled Cooling Air Thermal Management & Test Enabling Hardware such as the exhaust VEN. Benchmarking to recent engine cores on the GE9X and Leap along with Cat-I rigs such as the HPC aero rig was used to balance need for instrumentation vs. available space, cost and time to incorporate. Comparative assessments of instrumentation count on Tech Mat rigs such as the Combustor Full Annular Rig or HPT Two-stage Aero Rig to the corresponding Core implementation were completed to minimize the instrumentation count on the Core. Rotating instrumentation will be led through forward and aft slip rings. A formal Engine OIR or Overall Instrumentation Review was completed to lock down the final scope and instrumentation count for each module. The design teams were authorized to issue summary TPS (instruction documents) for each module along with separate instructions for long lead hardware such as Performance Rakes, Emission Rakes and IR Camera integration. All the TPS documents are currently in the execution stage along with assignment of the instrumentation engineer responsible for final delivery.

Long Lead Hardware Releases: It became evident based on feedback from Supply Chain and Manufacturing Programs that lead times for both raw material and machining had increased

significantly compared to benchmarks set by prior Cores. The aerospace supply chain is in the middle of unprecedented demand and expansion for production hardware needs which has priority at every supplier site. The systems team worked closely with PCB (Production Control Board – a forum in which the PCB Chair along with key representatives from Sourcing, Manufacturing Programs and CCB – Configuration Control Board approves placement of purchase orders with suppliers) to develop guidelines and conduct risk-release reviews prior to release of long lead hardware. After approval of the cold cross-section, all long-lead forgings from each of the Core modules were identified and RFQ packages were created including definition of the raw material envelope and quantity (including spares). Key suppliers for powder metal rotor forgings were engaged and Purchase Orders placed after multiple rounds of negotiations around cost and priority. Feasibility of utilizing a common set of tooling between the FAR rig CMC liners and the Core CMC liner was assessed and approved. While traditionally, this phase of the program is typically launched after completion of Systems PDR, the long lead times and chosen Core Test Vehicle TTF drove the decision to release the long lead hardware definitions after systems cold cross-section release.

Technical Requirement Document: The TRD has been organized into a series of individual chapters organizing the overall requirement flow down from the Systems organization to the individual design module teams. At the highest level, Chapter 1 specifies the Engine-level requirements related to the overall Core execution guiding principles, Safety, Test Cell considerations, general requirements related to overall performance, operability, key design limits like redline speeds, durability, dynamics loads, clearances and Emissions requirements. Chapter 2 dives deeper into individual module level requirements and information statements related to the High-Pressure Compressor, Combustor, High-Pressure Turbine, Rear Frame, Mechanical Systems, SPOCT, Dynamics, Secondary Flows, Thermal Management System, Hybrid Electric, Externals, Controls and Test Enabling Hardware system Integration. In addition, there is a dedicated chapter focused on Category-I Test Rigs requirements for the Combustor Full Annular Rig, The HPT Aero Rig, HP Rotor Dynamics Rig and the Advanced Thermal Management TTB Rigs.

4.2 Systems Analysis & Integration Update

4.2.1 Description and overview

The Systems Performance Operability Controls and Transient (SPOCT) discipline serve to integrate the functional aspects of the engine design and testing. During the period leading up to the Preliminary Design Review, work centered on refining the engine cycle, developing thermodynamic models of the whole engine and the specific core test vehicle, providing data for component design and analysis and preparing for core demonstration testing.

4.2.2 Annual Accomplishments

The compact core cycle was reset at the Conceptual Design Review to account for high-pressure turbine durability. The cycle reset necessitates an update to technical performance metrics from being evaluated at take-off conditions to top-of climb conditions.

The LCF mission was defined based on the updated cycle for a deteriorated engine condition for a hot day. A transient thermodynamic model was used to generate burst and chop events aligned with product-like thrust response. The time history data from this model was provided to the module design teams for use in thermo-mechanical and durability analysis.

A transient core-only model including the high-pressure motor generator (HPMG) was released to support control system development, overspeed assessments and to refine test planning.

A conceptual test plan was assembled by mapping the required TRL advancement, KPPs and technical performance objectives to specific test conditions for the compact core. The conceptual test plan includes:

- Power calibration curves at range of inlet conditions representative from sea level to altitude
- High-pressure compressor mapping over a wide operating envelope
- Aero-mechanical surveys at high corrected compressor speeds
- Combustion testing characterizing both operability and emissions with Jet-A and SAF
- Derivative testing for bleed, hybrid power injection and extraction, and clearance effects

Preliminary pre-test performance predictions based on a preliminary version of a core-only NPSS model were produced to evaluate these planned points against design limits. The margins to limits are within historical experience for the current phase of the project and there is scope to adjust test design to accommodate limits e.g. using more inflow bleed to avoid high EGT for HPC Mapping.

The NPSS thermodynamic model of the Compact Core Test Vehicle was created by extracting and tailoring the core portion of the broader open fan product vision model. Additional models were developed for test-enabling elements such as the inlet, turbine rear frame, variable exhaust nozzle, hybrid system, cooled-cooling-air circuits as well as the facility bleed-extraction systems for compressor stages 4, 7 and compressor discharge with the latter also having inflow bleed. This core-only NPSS model has been updated with PDR phase designer feedback which includes accounting for applied instrumentation and measurement rakes. A cycle design review and methods review of this model has been completed and will form the basis of the preliminary design review and data package releases for the upcoming detailed design phase of the program.

4.2.3 KPP Status

The status of the Key Performance Parameters is outlined in Table 3. In 2026 at the conclusion of the NASA systems preliminary design review, GE Aerospace plans to deliver an updated status to the NASA team, reflecting key learnings.

Table 3: KPP Status Annual Report 2026

KPP #	Key Performance Parameter (KPP)	Full Success Single Aisle ~2035 EIS	Min Success Single Aisle ~2035 EIS	Proposal Status	Annual Report '25 Status	Systems CoDR Status	Annual Report '26 Status
KPP-1	Fuel burn reduction attributed to the high-power density engine core of the original equipment manufacturers (OEM) vision turbofan engine.	10%	5%	6%	6+%	5.9%	No change
KPP-2	Engine Bypass Ratio.	> 15	> 12	73 (Cruise) / 42 (Takeoff)	77 / 45	84 (Cruise) / 43 (Takeoff)	No change
KPP-3	Engine Overall Pressure Ratio (Defined at top of climb).	> 50	> 45	46	49	47	No change
KPP-6	HPC Exit Corrected Flow.	< 3 lbm/s	< 3.5 lbm/s	3.3 lbm/s	2.9 lbm/s	2.87 lbm/s	No change
KPP-7	Combustor operability using SAF is comparable to its performance using Jet-A/A-1fuel, as measured by lean blowout and ignition performance.	Combustor operability demonstrated with 100% SAF	Combustor operability demonstrated with >80% SAF	100% SAF Compatible	100% SAF Compatible	100% SAF Compatible	No change
KPP-8	Degree of hybridization measured by level of power extraction/insertion from the engine core.	10%	5%	> 5%	> 10%	>10%	No change

4.3 SLIN 1 HPC

4.3.1 Module Technology Overview

The Compact Core high pressure compressor (HPC) architecture applies different advanced technologies across the front, mid, and rear portions of the compressor to achieve a compact, efficient core. In the front block, the design is derived from the successful HyTEC Phase 1 three-stage design. This highly loaded front block enables inter-stage bleeds to maintain current offtake locations but deliver higher pressure, avoiding having to move bleeds downstream. This allows use of lower-temperature cooling air, which improves engine fuel-burn provided the higher stage loadings can still meet stall-margin requirements.

In the mid-stages, the HPC uses higher aero loadings and advanced vectors. In the rear stages, low-solidity airfoil technology is employed. This reduces airfoil count, which when combined with tailored vector changes, increases efficiency and improves operability at reduced solidity.

Taken together, these front-, mid-, and rear-stage technologies create an integrated, compact core compressor design that is intended to meet performance, operability, and aeromechanical stability TPM objectives. The Compact Core demonstrator will integrate this HPC with the combustor and high-pressure turbine to demonstrate overall performance and operability in an engine-representative, compact-scale environment.

4.3.2 Annual Accomplishments

Throughout this year, the Aero team advanced the Compact Core high pressure compressor (HPC) from conceptual design into preliminary and early detailed design, maintaining a strong focus on TPM targets for adiabatic efficiency and stall margin. In the first half of the year, the team optimized the Aero Design Point (ADP) and part speed aerodynamic models, with specific emphasis on improving overall efficiency and stall margin robustness. Aero and TSD worked collaboratively to ensure the HPC design continued to meet bleed source requirements. During this period, the team completed the Design Consensus Review (DCR) for the Aero Preliminary Design Review (PDR), formally defining the critical deliverables and analyses required to support the PDR. Aero 2D models were developed from the 1D pitch line designs established at the Conceptual Design Review (CoDR), and various optimization studies were conducted to ensure that performance and stall margin TPM requirements were satisfied.

On May 20, the Aero team successfully completed the internal Aero PDR, marking a milestone in the program. The PDR included a comprehensive review of the 2D model design vectors at the Aero Design Point and critical stall points, along with assessments of performance metrics, stall margin capability, and alignment with compact core requirements. Key analyses and deliverables were presented to demonstrate readiness for downstream Aero DDR and Mechanical PDR. Following the Aero PDR, the team initiated detailed airfoil designs for the airfoils, with the objective of translating the PDR design vectors into fully detailed geometries that meet performance, operability, and aeromechanical objectives. In parallel, the Aero team

worked on the hot cross section definition and release, ensuring that the geometry and loading distributions were ready to feed mechanical design and structural analysis.

Throughout the year, the team also advanced the HPC performance investigation. A performance audit identified several architectural improvements contributing to enhanced adiabatic efficiency recovery, including shroud updates, refined surface finishes, updated FOD methodology, improved tip clearances, and honeycomb seals to reduce stator seal leakages. These changes provided meaningful incremental gains in compressor efficiency and helped validate that the Compact Core HPC architecture can achieve the required performance targets while supporting broader system level fuel burn objectives.

In the second half of the year, the team continued to progress detailed airfoil designs for the airfoils and to deepen learning from NASA three stage rig testing. Multiple internal prereviews were held to confirm that the airfoil designs remained aligned with program requirements and were on track for the airfoil Detailed Design Review planned for Q2 2026. The team advanced data matching efforts on the NASA three stage rig test data to support aeromechanics for the Compact Core. The NASA HyTEC Phase 1 Three-Stage HPC VDR1 was successfully completed. These activities, combined with lessons learned, have strengthened confidence that the Compact Core HPC design can meet its performance, operability, and aeromechanical stability objectives and are providing a strong foundation for the upcoming DDR and rig test planning.

During this period, the mechanical design of all the airfoils progressed with iterations between aero, mechanical and aeromechanics design. Airfoils were designed to meet full product conditions. The aeromechanics and mechanical design of each airfoil was carefully tuned to meet design requirements. Requirements for FOD were tuned to achieve a balance between durability and performance.

The hot to cold conversion of the cross section was completed and the cold cross section was released. When initial aero geometry is released, it is in the hot condition associated with the chosen aero design point. The mechanical team then builds models based on the hot airfoil geometry for design iteration and analysis. This analysis is then used to convert the cross section to a cold state. After this conversion, the design proceeds using cold geometry for the creation of any analysis models. This timing was coordinated by Systems to produce a complete and consistent cold cross section of the core. This was then used by both dynamics and thermal analysis teams to provide design conditions for use by the design teams in upcoming PDR reviews.

Weight studies were launched to optimize and reduce the weight of the configuration to meet targets. Weight optimization trade studies were performed and incorporated into the design. A key contributor to the weight reduction was a redesign of the aft shaft. This was made possible by a systems team effort to work with dynamics to reduce rotor stiffness requirements. The shaft was updated and optimized for the reduced dynamics stiffness requirement providing a substantial weight reduction for the compressor module. Additional significant improvements were derived from detailed sizing and configuration studies. After completion of these efforts, the HPC module weight met the Systems target.

A team from systems, performance, and aero design reviewed the compressor design to determine and study potential improvements. Trade studies were performed, and aero benefits were traded against cost, weight and complexity of each change. Changes that met the trade criteria were implemented resulting in overall improvement in HPC performance.

Another critical challenge identified during the CoDR for the HPC at this compact core size is clearances. Due to the small size, build clearances required to achieve desired operating clearances are also small. To address this challenge, studies were performed to thermally match the rotor to the stator to achieve the desired transient clearance behavior. These studies were used to define appropriate materials and configuration for the aft cases. In addition, casing abradable was implemented over blade stages one through eight to enable a tighter overall running clearance accounting for product-level out of roundness assumptions.

Based on the results of these studies, the configuration was refined and is now well-positioned for PDR reviews planned for Q1'26 and Q2'26.

4.3.3 HPC Collaboration Update

Over the past year, GE Aerospace has undertaken several key activities to support the collaboration with NASA. A major milestone was the successful completion of an internal review of the aerodynamic preliminary designs, followed by a debriefing session with NASA to align the designs with the Technical Performance Measures (TPMs). These reviews helped ensure that the work remains consistent with NASA's expectations.

A structured framework was established for ongoing collaboration, including monthly meetings to review progress and address challenges. In addition, GE Aerospace has been providing externally available, published nozzle geometries to NASA to enable comparison of GE Aerospace's Large Eddy Simulation (LES) results with NASA's LES solver.

These activities have created a strong foundation for success in the next year of the contract. The insights from the reviews and debriefs have informed the design progress, while the ongoing meetings and joint simulation work provide a forum to resolve questions as they arise. By maintaining this level of engagement, the team is well positioned to achieve the project milestones and deliver high quality outcomes that meet both GE Aerospace and NASA expectations.

4.4 SLIN 2 Combustor

4.4.1 Module Technology Overview

Within the Combustor, two technologies will be matured. The first of these technologies is the use of a single wall Ceramic Matrix Composite (CMC) dome. CMCs enable small core sizes via hotter cycles and/or reduction in required cooling air. GE Aerospace's latest evolution in the use of CMC technology is the Combustor Dome. The use of a single walled CMC dome requires the development of several items including upgraded EBC, a metallic swirler attachment mechanism, a CMC-to-CMC seal, and an improved attachment mechanism between the CMC dome and the cold structure supporting the combustor.

In addition to the use of the CMC dome, the combustor will also continue to develop its ability to utilize SAF (Sustainable Aviation Fuel). This testing includes Full Annular Rig testing and Core testing and will focus on examining its effect on Light-off and Lean Blow Out.

4.4.2 Annual Accomplishments

Over the past year, multiple accomplishments have been achieved relative to design, manufacturing, and testing. From a design perspective, many changes have been incorporated into the combustor for various reasons. First, a collaborative review of the CoDR design was conducted at the facility that will be assembling the combustor. This collaboration included a review of the assembly process established by a different engine program, the proposed Compact Core assembly process, and included a trial assembly of a 3D printed Compact Core sector. The results of this collaboration yielded a need to simplify the design to improve the overall ability to assemble the combustor.

With the proposed simplifications implemented into the design, a series of simplified analysis models, anchored to the CoDR analysis, were produced to verify the capability of the new design. This included durability assessments for the CMC components as well as forced response assessments of the overall combustor.

Beyond these assessments, the design of the combustor has continued to evolve and has benefited from the results of several tests. These learnings have been incorporated into the design prior to the start of official analysis to be used for the Preliminary Design Review (PDR). This analysis process has been ongoing for several months in preparation for the PDR in April 2026.

From a manufacturing perspective, the Full Annular Rig (FAR) CMC dome is nearing completion. Informed by sector and full annular layup trials completed in 2023 and 2024, the FAR preform definition was released in December 2024. Three dome preforms have since been produced and have been inspected dimensionally, visually and internally via non-destructive evaluation. These inspection results have indicated that all three preforms are acceptable for continued processing. Notably, dimensional stability and defects met expectations established by the trial efforts. Additional trials to develop the Environmental Barrier Coating (EBC), cooling hole laser drilling processes have been completed in preparation for processing the FAR article. Multiple reviews have been completed to release the full machining definition including cooling patterns. These definition releases have been used to continue the manufacturing through final machining and coating. The first of the three dome preforms has successfully progressed through non-destructive evaluation, machining, and Environmental Barrier Coating (EBC) and is currently in the laser cooling hole process.

Relative to testing, multiple testing campaigns were completed within 2025. This includes a cold flow film test, single cup rigs like Tunable Combustion Acoustic (TCA) 3 and High Temperature and Pressure (HTP) 2, and Low-Pressure Sector (LPS) 3. A cold flow aerodynamic pressure rig, mapping passage recoveries and pressure losses within the compact combustor size began in Q4 2025 and is on track to conclude in Q1 2026. One of the single cup

rigs, TCA3, concluded the first half of the test campaign, with part 2 on track to resume in Q3 2026.

TCA3, HTP2, and LPS3 campaigns largely focused on risk burn down and TRL advancement specific to CMC dome. HTP2 tested with a thermally instrumented CMC dome and ran to high power conditions to provide data for CFD validation. In addition, HTP2 tested the impact of extreme fuel nozzle positioning due to unique thermal growth difference of an all-CMC combustor and metallic components and cleared all risk for flame holding or auto-ignition. LPS3 tests included risk burn down of the product-representative swirler attachment with a CMC dome, emulated hot side features of the CMC dome, and impact of unique fuel nozzle positioning linked to the CMC dome. All risks identified, and their impacts to most combustor aerodynamic CTQs such as emissions, efficiency, operability/relight, and combustion dynamics, have been reduced with the conclusion of the LPS3 test campaign. Emissions measurements included NO_x and nvPM and is forecast to have sufficient margin to the ICAO regulatory requirements.

Combustion dynamics remains the highest risk, in part caused by the unique hot side features of a CMC dome and the fuel nozzle positioning due to thermal growth mismatch. TCA3 part 1, similar to HTP2, tested with a thermally instrumented CMC dome. Part 1 focused primarily on swirler design screening to support the hardware release for the FAR but did include risk burn down on swirler to CMC dome attachment by quantifying impact of the metal-CMC interface leakages on flame dynamics. Part 2 will resume later in 2026, focusing on dynamic mitigation technologies such as dampers, and include detailed mapping of combustion dynamics with an offset fuel nozzle to understand risks and impacts to CTQs as the HTP2 and LPS3 campaigns have done.

4.5 SLIN 3 HPT

4.5.1 Module Technology Overview

The turbine envisioned for the compact core incorporates several new technologies to improve both aero performance and overall system performance through the reduction of cooling flow. These technologies are described below.

- **Low Solidity:** Reducing the number of airfoils while maintaining the axial chord results in lower solidity, defined as the axial width divided by the tangential pitch. This change increases the lift required from each individual airfoil, which typically leads to higher profile and secondary flow losses. However, removing airfoils also decreases cooling requirements, particularly by reducing the number of edges, which are challenging to cool and typically become life-limiting locations. Introducing cooling often comes with a degradation in aerodynamic performance, so minimizing the number of airfoils can be beneficial in reducing these cooling needs and potentially improving overall system efficiency.
- **End wall Contouring (EWC):** Contouring the platform can effectively modify the local pressure field, thereby mitigating the development of secondary flows. This strategic shaping enhances overall aerodynamic performance by addressing flow dynamics at the airfoil end wall, contributing to a more efficient turbine operation.

- **Bow Wave Mitigation:** Cooled High Pressure (HP) turbine nozzles and blades have increased airfoil thicknesses and cross-section area to accommodate internal cooling flow, creating a static pressure bow wave ahead of the leading edge. This effect is intensified in compact core turbines with higher firing temperatures, requiring more cooling flow and resulting in thicker airfoils with stronger bow waves. To ensure turbine durability, it is crucial to prevent combustion air ingestion into non-flowpath cavities with reduced temperature capability materials, as pressure variations in these gaps increase the necessary purge flow. Similar to EWC, which reduces secondary losses between airfoils, nozzle bands can be contoured upstream to manipulate the static pressure field. The strength of the bow wave decays with axial distance from the nozzle leading edge, so increasing the length of the forward nozzle bands also provides a mitigation of the bow wave effects on the necessary flow to purge non-flowpath cavities.
- **Advanced Tips:** Leakage through the tip gap between the blade and the stationary shroud causes aerodynamic loss through throat bypass (limited work extraction from leakage air) and impacts blade lift, similar to aircraft wing unloading by a tip vortex. Shaping the airfoil tip can alter the tip vortex interaction with the blade's suction side, reducing induced drag and improving turbine efficiency.
- **Advanced Aero:** This technology optimizes turbine performance by combining radial vortexing and stacking parameters on each airfoil. Radial vortexing adjusts the exit flow angle distribution along the airfoil span, affecting radial throat and work distribution. Stacking alters the placement of 2D sections relative to each other, manipulating the 3D throat plane.

4.5.2 Annual Accomplishments

In April 2025, HPT work-split optimization studies were completed considering its impact on overall turbine efficiency, flow path temperatures, coolant supply circuit back-flow margins, compressor offtake conditions and rotor thrust. The net outcome of these studies was an overall increase in turbine efficiency which was incorporated both in the Compact Core and HPT Aero rig implementations. Lessons learned from these work-split optimization studies particularly in the context of low solidity turbine architectures will be leveraged in the future for product-vision architecture decisions.

The S1 and S2 disks were resized to accommodate the increase in blade weights. Increasing the height of the disk hubs was not feasible due to challenges with the integration of the mating rotating parts, so the resizing was accomplished by slightly increasing the width of the disk bores.

In September 2025, the S1 blade basic airfoil design was finalized after selecting a tip solidity to balance aerodynamic and aeromechanic considerations. At the midspan region, airfoil stagger was adjusted, and thickness added to the pressure side to stiffen the airfoil mode. Axial width and aero loading in the upper spans were also studied to aid with final mode placement. The tech demonstrator will use dynamic strain gauge instrumentation on stage 1 blades to study the response of the predicted crossings of interest to inform the eventual product design.

In September 2025, the decision on the method of bow wave mitigation to use for the compact core was chosen. Multiple design options were evaluated for bow-wave mitigation; the team selected a configuration that satisfied performance and manufacturability targets, with alternative configurations retained for future study. CFD and cascade tests were used to confirm that the selected configuration met project flow-management and cooling objectives.

In October 2025, the HPT aerodynamic successfully passed preliminary design review, meeting its technical requirements and moving into detailed design. Risk reduction tests and rigs are planned to further validate advanced features prior to final design release. Current HPT efficiency meets target requirements, with some benefits from aero technologies still based on assumed values pending final DDR optimization.

In January 2026, the HPT module portion of the cross section was updated to reflect the cold positions of the redesigned aero design. There were also modifications to the flow path lines using relative deflection predictions and tolerance stack up. Steps were set nominally aft-facing to preserve aft-facing orientation under worst-case conditions. This avoids forward-facing steps that negatively affect aerodynamic efficiency and thermal boundary conditions. All HPT airfoils will be using a common casting design with the Turbine Aero Rig and the Core Demonstrator. The cold size of the airfoil components was determined using the colder Turbine Aero Rig demonstration conditions, to ensure the aero design intent is matched on the rig designed to measure the aerodynamic performance in detail.

4.6 SLIN 4 Hybrid Electric

4.6.1 Module Technology Overview

The Hybrid Electric System (HES) is being integrated with the Core through a drivetrain to the High-Speed Spool, enabling supplemental injection and extraction of power to improve performance of the Core.

The HES integrated with the core demonstrator is focused on enabling characterization of a hybridized core and expanding on previous turbomachinery integration and controls development. The HES used on the Core will be tested at the EPISCenter in Dayton, OH. In addition to the degree of Hybridization specified in the KPPs/TPMs, through the HyTEC Phase 2 program, a more detailed understanding of the mechanical integration challenges and solutions are being developed around future use-cases.

The integration plan includes a test enabling gearbox to ensure robustness for testing high torque loads. The capability permits demonstrating the full range of power injection and extraction levels that are currently in the RISE product vision scope, as well as transient behavior that further increases loading within the drivetrain.

4.6.2 Annual Accomplishments

The HES Module progressed through the preliminary design phase, moving towards the Preliminary Design Review planned for early 2026. The major accomplishments spanned requirement finalization, trade study down-selects, hardware capability, software and controls preparation, engine and cell integration, and completing initial assessments of the design against the hybrid use cases and TPMs.

The integration of the Hybrid Electric System continued to mature over the past year. Integration is one of the largest challenges due to the variety of interactions that need to be managed with the engine and facility across disciplines such as mechanical, thermal management, electrical, and controls.

The mechanical integration continued to mature with the drivetrain architecture and component selection between the M/G and the Core being finalized. These results were reviewed and approved in the PDR, completed in early 2026.

Another significant integration effort was with the controls team. The team developed requirements needed to establish modifications to the baseline component, engine, and facility controls developed and demonstrated on previous Hybrid Electric programs. The controls plan leverages recent learnings and is expanding capability to meet test objectives.

The team is currently preparing for the Preliminary Design Review, with a majority of the assessments complete and ready for review. The team has shown they have a path to satisfy all program requirements and will be transitioning to the Detailed Design Review phase by the end of Q1 2026.

5.0 Summary

The Advanced Core Demonstrator has made significant progress, successfully completing CoDR last year while proceeding to execute on the majority of the PDR work required to complete all module and system PDRs. In parallel, efforts and resources have ramped up to support the hardware procurement cycle, with a focus on long lead components first. The next step is to complete the Systems PDR and transition to the Critical Design Review phase for the Advanced Core Demonstrator. The HPT Aero Rig also completed CoDR last year, allowing the teams to move into the PDR phase. The HPT TRT and Cold Flow rigs completed all remaining design reviews with nearly all hardware for the TRT rig received and all hardware for the Cold Flow on order. This supports test target to fire dates as planned in 2026. In addition to the accomplishments across the test vehicles the NASA and GE Aerospace collaboration partnership continued to strengthen and make excellent progress on items at the systems level, advanced instrumentation and CFD work across both the HPC and HPT. The technical partnership has provided invaluable insights into experience and tools that will assist in the overall core demonstration and later inclusion into a new product launch.

