

# 7F Products and Solutions

Upgrades and services to enhance performance, reliability, and efficiency



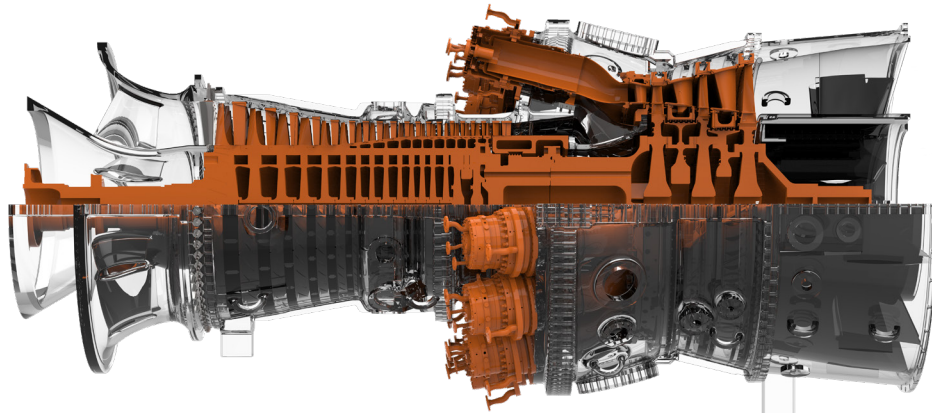
PSM's 7F solutions optimize turbine performance, extend component life, reduce emissions, and improve reliability with advanced engineering and technology.

# PSM Products and Services

Combining technical expertise, rapid market response, flexible solutions, advanced tools, and extensive OEM cross-platform experience, PSM is the industry-leading supplier of 7F alternative products and services.

Specializing in retrofitting 7F units to meet current and future market demands, PSM offers over 25 years of experience in upgrading gas turbines and their components, providing tailored solutions to fit your plant's specific needs.

PSM continues to deliver innovative, high-quality design solutions for emerging 7F fleet issues, ensuring reliable performance for gas turbine power plants.



***Lower Emissions – Improved Efficiency and Performance – Extended Lifetime – Lower Maintenance Costs  
– Fuel Flexibility – Increased Reliability – Advanced Technology***

## **PSM's FlameSheet™ combustor provides significant performance**

- + Achieves single-digit NOx and CO emissions across the load range
- + Enhanced fuel flexibility with a 30% Modified Wobbe Index
- + Superior turndown capabilities as low as 26% (even lower with Exhaust Bleed)

## **Gas Turbine Optimization Packages (GTOP™) deliver significant output and heat rate benefits\***

- + Delivers up to 15% output increase (simple cycle)
- + Mode-switching logic to tailor the operating profile to your needs
  - » Coupled with FlameSheet™ further widening the operating profile
- + Interchangeable with OEM 7F hardware\*\*

## **7F Rotor Seed Program**

- + Provides replacement rotors and rotor components to eliminate downtime during outages
- + Offers both flared and unflared designs
- + Includes upgraded turbine and compressor components



***Complete Compressor, Combustor, and Turbine flow path offering  
Proven Sole Source for Aftermarket 7F GT Performance Upgrades  
Independent Technical & Manufacturing Capability to Address Product Issues***

*\*Quoted benefits are for ISO day operation. Simple Cycle benefits assume from prior published 7F.03 capabilities*

*\*\*See PSM representative for interchangeability on all GTOP programs*

# GTOP™: Gas Turbine Optimization Package

PSM's 7F upgrade packages provide flexibility, enabling users to optimize performance and maintenance schedules to their individual requirements.

	Maintenance Mode (32K):	Performance Mode (24K):	Peak Mode:	Hardware and Logic Upgrades
<b>GTOP Lite</b> 	Up to +2.8% MW			Minimal hardware scope New R0, S0, & S1 aerodynamic design IGV schedule change
<b>GTOP3.0</b> 	Up to +3.3% MW, -1.5% HR	Up to +6% MW, -1.8% HR	Up to +8.8% MW, -2.3% HR	AutoTune with mode-switching logic Low ΔP combustor, low cooling flow S1 & S2 nozzles
<b>GTOP3.1</b> 	Up to +6% MW, -2.0% HR	Up to 8.8% MW, -2.3% HR	Up to 11.7% MW, 2.7% HR	Combines both GTOP Lite & GTOP3.0 Add compatible GTOP4 S3 bucket & shroud for an increase to 207MW (+10MW) on a cold day
<b>GTOP4.0</b> 	Up to +9% MW, -4% HR	Up to +12% MW, -5% HR	Up to +14.6% MW, -5.3% HR	New aerodynamic HGP section – SX S1B, modular S1N with printed vane Compatible with AGP hardware New technology! AutoTune with mode-switching logic
<b>GTOP4.1</b> 	Up to +12% MW, -5% HR	Up to +15% MW, -5% HR	Up to +17.4% MW, -5% HR	Includes GTOP Lite & GTOP4.0
<b>FlameTOP™</b> 	Turndown as low as 26% Up to 80% hydrogen			Combine FlameSheet™ with any GTOP Program!

\*Quoted benefits are for ISO day operation. Simple Cycle benefits assume from prior published 7F.03 capabilities

\*\*See PSM representative for interchangeability on all GTOP programs



# Gas Turbine Optimization Package: GTOP4

GTOP4 and GTOP4.1 deliver exceptional results in power output and efficiency by utilizing the latest technology for superior performance. GTOP4 components are set-wise compatible with AGP/7F.04 hardware.\*\*

## 1st stage nozzle

- + Utilizes proven 501F R1 vane and additive technology!
- + Optimized aerodynamic design
- + 3D-printed airfoil with most capable alloy powder
- + Improved cooling flow system
- + Revolutionary cooling designs (only 3D printing)
- + Enhanced durability (reduced thermal gradients)
- + Competitive overall life cycle cost

## 1st stage buckets

- + New airfoil aerodynamic design for efficiency gains
- + Optimized Core design
- + Improved cooling efficiency, resulting in lower metal temperatures
- + 2nd Generation single crystal alloy for enhanced capability
- + Cast in tip

## 1st stage shroud block

- + IN738 shroud alloy
- + Multilayer abrasion resistant coating technology
  - » Hot rub rig testing conducted at engine conditions
- + Optimized cooling design

## 2nd stage nozzle

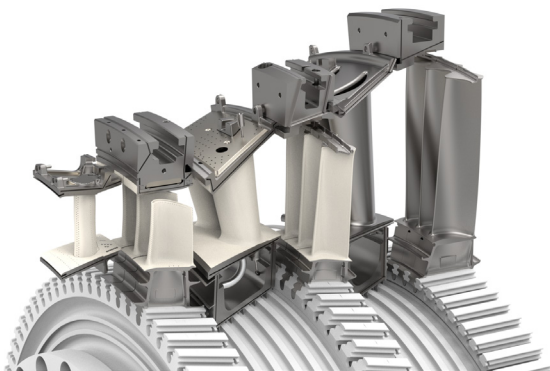
- + Repairable nickel-based alloy
- + New aerodynamic design
- + Full thermal barrier coating (TBC) coating
- + Improved sealing

## 2nd stage bucket

- + PSM116 Material
- + Optimized 3D aerodynamic shape with full TBC coating
- + 11 STEM cooling holes
- + Cored tip with perimeter shroud cooling
- + Optimized shroud profile

## 3rd stage bucket

- + Redesigned airfoil and shroud geometry to improve flutter margin:
- + Applicable for both GTOP4 and GTOP3 applications
  - » Allows GT output limit increase in GTOP3 applications from 197MW →207MW
- + Redesigned shroud configuration to address creep issues with OEM AGP/7F.04 design
- + PSM GTOP4 R3B design setwise compatible with .03, GTOP3 and AGP/7F.04 turbines\*\*



GTOP4.0	Maintenance Mode (32k)	Performance Mode (24k)	Peak Mode
SC Power*	Up to +9%	Up to +12%	Up to +14.6%
SC HR*	Up to -4%	Up to -5%	Up to -5.3%

GTOP4.1	Maintenance Mode (32k)	Performance Mode (24k)	Peak Mode
SC Power*	Up to +13%	Up to +15%	Up to +17.4%
SC HR*	Up to -4%	Up to -5%	Up to -5.6%

\* Quoted benefits are for ISO day operation. Simple Cycle benefits assume from prior published OEM 7F.03 capabilities

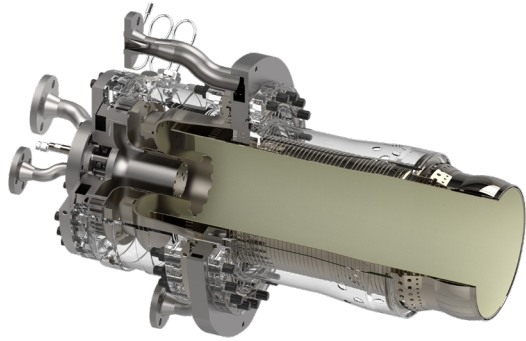
\*\* PSM buckets require PSM style shroud blocks on installation



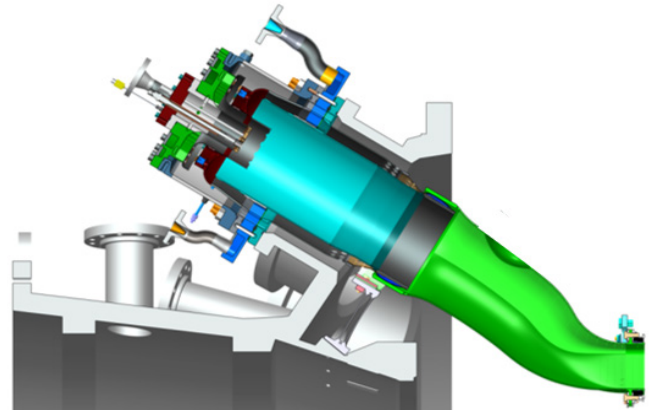
# FlameSheet™

## Superior Turndown, Fuel Flexibility, and Emissions Capability

**Future-Proof your engine today!** FlameSheet™ is the ultimate combustor solution to meet new operational needs. As the power generation market faces challenges from renewable energy penetration, low natural gas prices from fracking, and dynamic financial market changes, users must reevaluate their fleets to stay relevant. FlameSheet™ provides unparalleled flexibility, preparing your engine for both current operational demands and the future hydrogen economy.



CROSS SECTION VIEW. FLAMESHEET™ IS NOW AVAILABLE ON MOST ENGINE MODELS



### FlameSheet™ Benefits

- + Up to a 30% increase in GT operating load range with single digit NOx and CO
- + Optional low-load HRSG protection setting
- + Superior Fuel Flexibility:
  - » 30% Modified Wobbe Index
  - » Ideally suited for alternate fuel operation, including hydrogen, ethane, and propane
    - + Up to 40-80% Hydrogen blend\*
    - + Up to 40% Ethanes (C2)
    - + Up to 10% Butanes (C4-C6)
    - + Up to 20% Propane (C3)
  - » PSM is progressing towards 100% Hydrogen capability!
- + NOx as low as 5ppm
- + Peaking power at constant NOx emissions
- + Dual fuel capable
- + Inspection intervals up to 32K hours / 1,250 starts
- + Compatible with existing GT controllers and fuel skids
- + Turndown as low as 26% (even lower with Exhaust Bleed!)

### FlameSheet™ = TWO Combustors in ONE

FlameSheet™ employs a simple, two-stage radially-inflow “combustor-within-a-combustor” concept, allowing staged operation at various load conditions. At high loads, both combustors are used, with the outer combustor flame structure forming an annular “sheet of flame” around the inner combustor. At low loads, the outer combustor is predominantly used. Leveraging trapped vortex stabilization aerodynamics, the outer combustor operates with excellent stability and remains sufficiently hot at very low loads to consume CO (which typically limits low-load operation). The outer combustor operates with excellent stability and remains sufficiently hot at very low loads to consume CO (CO typically limits low load operation).



# Flexibility Solutions

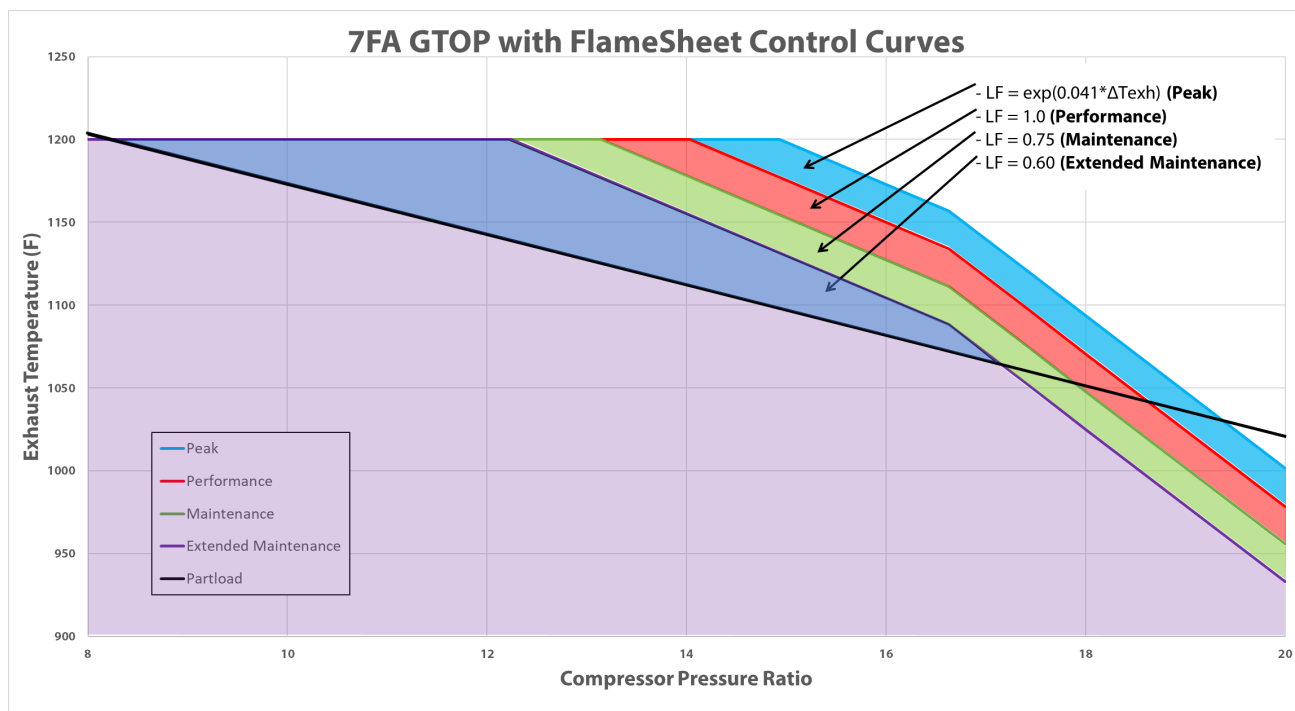
PSM offers a wide variety of products and solutions to extend the operating window of your 7F unit, ensuring it meets today's and tomorrow's operating needs.

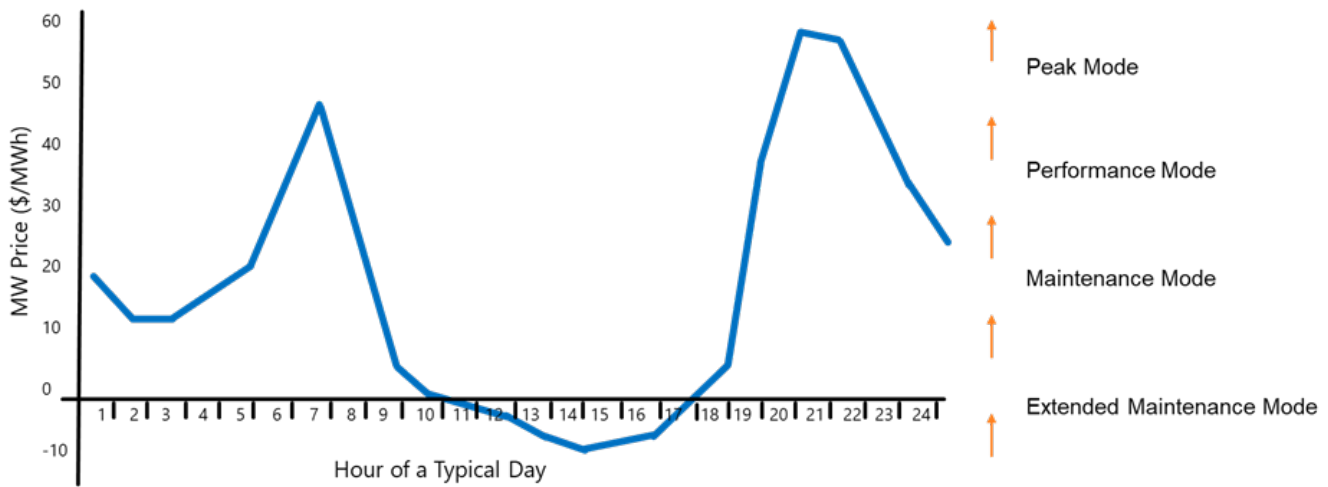
## FlexSuite Modules with AutoTune

- + FlexStart, FlexRamp, Power+, Peak+, and enhanced Turndown modules
  - » Improved ramp rates achievable during fully heat-soaked normal operation
  - » Increased ramping capabilities for hot, warm, and cold starts
  - » Dynamic optimization of unit minimum load during turndown
- + AutoTune
  - » Allows for quicker load ramping by learning over time and revisiting safe operating points
  - » Advanced algorithm for transient dynamics tuning when the engine is unstable
  - » Minimize low load point by maintaining output just above pre-mix transfer

## FlameSheet™ and GTOP Packages – FlexSuite Logic

- + Coupling GTOP with FlameSheet™ allows for more options of control curve options, providing customers with extended maintenance mode
- + FlexCounters with FlexSuite allow for variable operating parameters when beneficial
- + With GTOP and FlameSheet™ (FlameTOP) combined, additional operating modes are available to leverage peak performance when market conditions are favorable and save on hardware debit when they are not
  - » Life Factors for Extended Maintenance Mode curve equate to 40,000 hrs (total operating hours are capped at 32,000 hours per interval) and can be intermixed with performance and peak mode to extend overall operation while taking advantage of market conditions
- + This is maintained by multiple control curves as shown in the accompanying graph





### Exhaust Bleed

- + Offers up to an additional 10% turndown!
- + Can be coupled with FlameSheet™ to maximize turndown
- + Bypasses compressor shell flow to the exhaust
  - » Maintains combustor firing temperature for CO control
  - » Allows IGV close/pinch and higher exhaust temperature to achieve minimum turndown capability
- + Minimizes the need for HRSG attemperator through the exhaust bleed cooling effect
- + Allows for additional turndown while managing exhaust temperature for safe operation
- + Multi-frame capable (7F,501F, 7B/E, etc.)

### Wet Compression

Wet compression packages can be added as standalone solutions or incorporated with our GTOP upgrade packages for additional power output when market conditions are favorable.



# Digital Products

## Maximizing Plant Performance

PSM's Digital Technology Portfolio maximizes your plant's performance before, during, or after large equipment upgrades. Often, combining multiple engineered systems creates overlapping redundancy, which, when fully understood, provides significant optimization potential. Over the last decade, PSM has combined our domain expertise in GT technology, combustion system design, engine upgrades, engine operation from our M&D Center, and controls logic experience with balance of plant operations and advanced controls methods to create innovative optimization tools. Using proprietary and patented controls blocks, we offer multiple optimization features tailored to your individual needs.



## FlexSuite and AutoTune

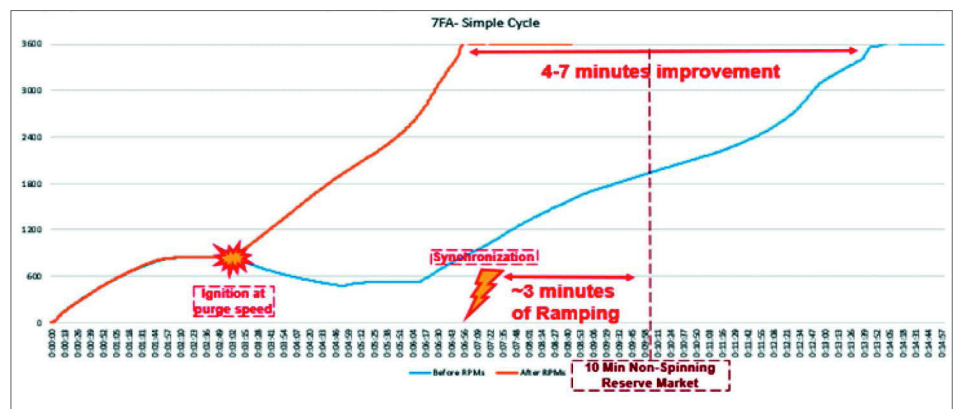
A portfolio of applications for your existing controller, FlexSuite from PSM, provides digital optimization for your power plant operations. Whether you seek operational reliability improvements or increased operational flexibility, there are multiple optimization features offered to suit your individual needs.

## FlexSuite Building Blocks

- + Combustion Optimization
- + Start-up / Shut-down Optimization
- + Enlarged Load Range
- + Efficiency and Lifetime
- + Fuel Flexibility
- + Grid Support
- + Service Flexibility

## Start-Up Optimization

FlexStart & FlexRamp: Increase Reliability and Availability through control logic improvements and adaptations that allow your GT's to better meet your performance needs. No matter if you are in a 10 minute start-up market or auxiliary services, being able to start faster and subsequently ramp fast both before and after heat soak can provide significant monetary value.



Example 7F rotor RPM with FlexStart controls logic optimization, gets SCGT to grid synchronization 7 minutes faster than originally commissioned allowing plant to operate in 10 minute spinning reserve market

## AutoTune

Intelligent GT combustion optimization for emissions and combustion dynamics while maximizing operational range and fuel variation. Utilize in conjunction with FlexSuite, FlameSheet™, and GTOPTM™ to maximize the optimization potential.

### System Features

- + AutoTune is an expert advisory system that provides extra level of intelligent protection to your existing controller
- + External to control system
- + HMI screen seamlessly integrated
- + Patented learning algorithms eliminate the need for seasonal tunes and provide significant system enhancement.



### Tuning Optimization

- + **Dynamics:** Improved hardware life and Lean Blow Out mitigation
- + **Emissions:** Consistent emissions even with atmospheric/climate/seasonal changes at varying load points
- + **Learning:** Intelligent learning of known operational points reduces the need for tuning and minimizes errors

**Transient tuning:** Adapts to cycling of units and responds to dynamic changes.

**Trip Avoidance:** Provides ultra-fast reaction if the combustor is flaming out to prevent a trip.

### AutoTune Learns

Patented learning algorithms capture information from successful and unsuccessful tuning events. Over time, AutoTune learns and significantly reduces the need for tuning under similar operating conditions.

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## FlexSuite – Flexibility Building Blocks

PSM's FlexSuite offers additional controller modules compatible with most control systems and designed to optimize your plant's performance.

### Extended Turndown

- + Dynamic optimization of unit minimum load
- + AutoTune monitors emissions and combustion dynamics to safely meet load target or hold at lowest safe point of operation
- + Integrated with both manual load control or AGC drive load targets
- + Learns over time by saving ambient condition profiles, allowing for quicker load ramp when revisiting safe operating points

### Operational Flexibility

With PSM's patented algorithms, it is possible to maximize the GT output according to climate conditions and actual system performance. For example, if you want to maximize seasonal peak power potential, Peak+ continuously seeks to maximize the load range while maintaining emissions and dynamics. Three optional modes are available:

- + **Power+:** Current firing temperature range with no impact on hardware life
- + **Peak+:** Option for increased peak firing mode to achieve greater improvements, with some hardware lifetime debit
- + **Turndown:** - minimizing low load point by maintaining output just above pre-mix transfer

While running on AGC or remote dispatch: Peak+/Power+, Turndown & Transient Tuning all active during Automated Generation Control and do not require stable load conditions before optimizing.

# Rotor Management Solutions

Capitalizing on a portfolio of rotor and blading design upgrades, along with full 3D steady-state and transient analysis models, PSM offers a comprehensive exchange rotor service. With a PSM LTE rotor, you can minimize downtime and optimize your capital investment.

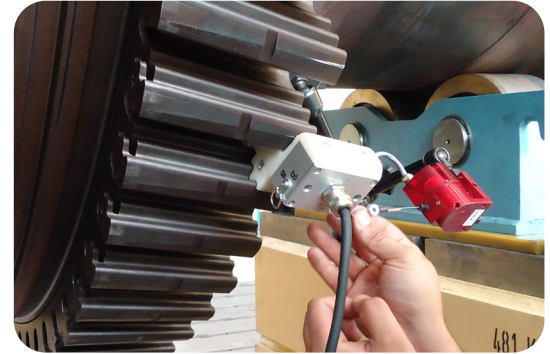
## Capabilities

- + Unstack and deblade
- + Reblade and tip grind new blades
- + R0 retention plug modification
- + Compressor clocking optimization
- + Patch ring repairs
- + Complete rotor structural analysis to support repairs
- + Proprietary design flared and unflared compressor blading with reliability improvements
- + Seed rotor to support rotor exchange program

## Rotor Lifetime Extension (LTE)

PSM's Rotor LTE program extends the useful lifetime of your rotor. Leveraging advancements in computing power, material properties, fracture mechanics methodologies, and inspection techniques, it is now possible to assess the potential to run rotors beyond their original published limits. Rotor LTE is enabled by:

- + Advanced non-destructive inspection techniques to detect surface and volume flaws
- + Complete rotor material characterization.
- + Full 3D Finite Element Analysis (FEA) models for thermal and structural analysis
- + Inspection results and operational history fed back to the FEA model

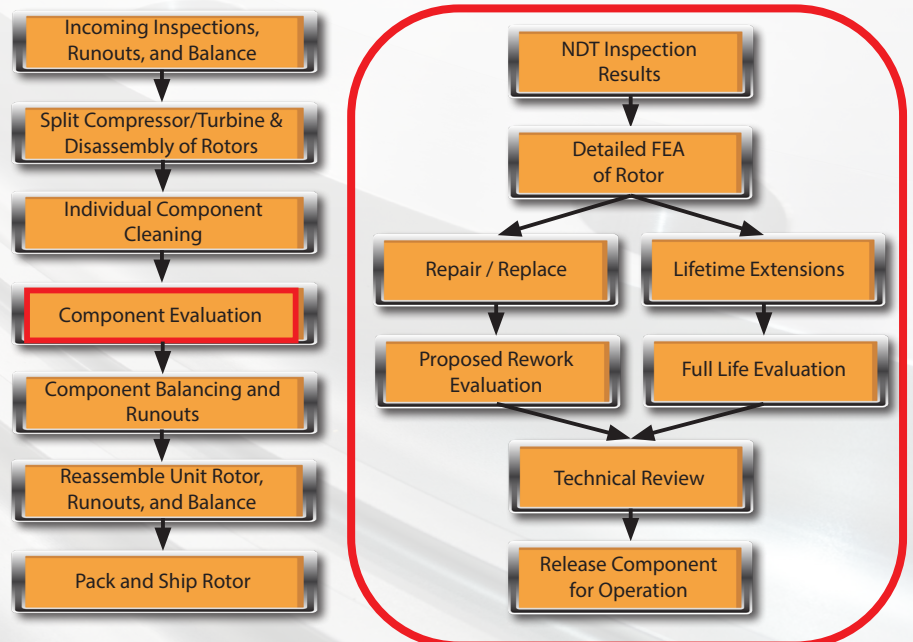


ROTOR BEING TESTED



PSM SEED ROTOR INSTALLED WITH NEW ROW 9-17 COMPRESSOR WHEELS

## Component Evaluation





## Compressor Solutions Available

- + Developed in response to the emerging fleet Compressor Wheel 0 (CW0) dovetail slot cracking issue, PSM's CW0 incorporates a new dovetail profile to reduce stresses in the known crack locations.
- + PSM replacement Compressor Wheels 9-17 (CW9-17) feature the latest 7F.03 / 7F.04 upgraded geometries:
  - » Round bottom dovetail geometry (CW12-17) to eliminate cracking associated with the original flat bottom dovetail geometry
  - » Robust Back End (RBE) CW14-17 disk geometry
  - » CW9-17 wheels feature the latest conical flowpath, enabling 7F.01 compressor rotor upgrades from the original cylindrical flowpath
  - » In-situ blend, polish, and peen of first turbine disk cooling slot, with additional life-enhancing solutions available upon full destack



## New Turbine Components

PSM is First in the aftermarket with new Stage 1 Turbine Wheel!

- + Features include an upgraded nickel alloy with recontoured slot to address known field issues with the OEM-style slots.
- + For existing OEM turbine wheels, PSM offers CoolMod, mitigating the risk of cracking and potentially extending life without replacement.

## PSM's Upgraded 1-2 Spacer

- + Features include upgraded nickel alloy and an improved drop-in compatible design to address limiting factors, particularly affecting starts-based units.

Contact your PSM representative for additional rotor solutions!



TURBINE ROTOR IN STACK

# 7F Compressor Reliability Solutions

## Common Fleet Stator Issues:

- + **Shim migration and liberation:** This can result in significant downstream compressor hardware impact damage.
- + **S0-S4 carrier ring corrosion and lock-up:** Can cause high cycle fatigue (HCF) failures and negatively impact maintainability, as corroded carriers can be difficult to remove, sometimes requiring a rotor lift and destructive removal.
- + **Excessive case hook fit wear:** This can result in stator rock or stepping, leading to forced outages, with wear issues most pronounced in the aft compressor stages.
- + **Tip rubs:** Can initiate tip cracks and cause pieces of stator tips to liberate, resulting in compressor hardware impact damage.

## Enhanced Stator Reliability Design Features:

- + 100% shimless design to eliminate shim liberation risk
- + Squealer tips standard to minimize potential for tip cracks and stator material liberation due to rubs against the rotor during operation
- + Full radial machining geometry for optimum part damping
- + Shotpeening for enhanced material capability
- + Passivation for corrosion resistance
- + Interchangeable with OEM design by sets
- + Complete offering for flared and unflared compressor flowpaths available

## Common Fleet Rotor Blade Issues:

- + **R0 HCF failures:** Can cause significant downstream damage.
- + **Attachment fretting and crack initiation**
- + **Tip rubs:** Cause material degradation, leading to tip crack initiation and material liberation, which can result in downstream compressor hardware impact damage.

## Enhanced Rotor Blade Reliability Design Feature:

- + Squealer tips standard to minimize potential for tip cracks and blade material liberation due to rubs against the case during operation
- + Shotpeening for enhanced material capability
- + Passivation for corrosion resistance
- + Attachment undercuts to avoid fretting and potential cracks
- + All required spacers available
- + Interchangeable with OEM design by sets
- + In-situ blade tip grinding capability to ensure tip clearance requirements are achieved
- + Complete offering for flared and unflared compressor flowpaths available



## First to Market with a Proven R0 Design Solution

Since its introduction, the 7F.03 R0 compressor blade has been a major maintenance issue for end users. PSM completely redesigned this component, delivering a design solution that met requirements in only 10 months. This solution has been operational since 2008.

- + Erosion and corrosion-tolerant design
- + Material upgraded to a higher strength alloy
- + Compound variable conical fillet introduced to reduce stresses

- + Airfoil restacked to reduce steady stresses along the leading edge
- + Retuned airfoil to reduce vibratory stress response
- + PSM's patented R0 Blade retention design replaces the OEM "Biscuit Mod" retention feature and does not rely on staking to retain R0
- + No IGV modifications required for installation
- + No requirements for replicas or extraordinary inspections

## Providing Proven Compressor Solutions for Over a Decade

PSM offers a complete compressor flowpath product line for flared and unflared 7F units, with reliability upgrades to solve common compressor durability issues. The product line was developed using PSM's proven compressor design approach.

1. **Customer Need Identification:** Addressing issues from stator wear to R0 HCF failures, which limit operators' ability to reliably and profitably operate their machines.
2. **Problem Identification:** Understanding the root cause through detailed analytical models, engine testing, stator strain gauging, rotor blade vibration monitoring, and metallurgical evaluations.

3. **Design Solution Implementation:** Implementing design enhancements once the root cause is understood, rigorously evaluated through PSM's internal gate review process.
4. **Validation:** Using engine instrumentation to validate performance and tracking fleet leader components to ensure reliability meets expectations.

PSM's compressor design approach consistently provides timely, high-quality design solutions.





# 7F Compressor Stator Reliability Solutions

In addition to the standard design features, PSM incorporates additional enhancements for S0-S4 and S13-EGV designs to address specific reliability issues in these rows.

## S0 – S4 Carrier Ring Row Solution

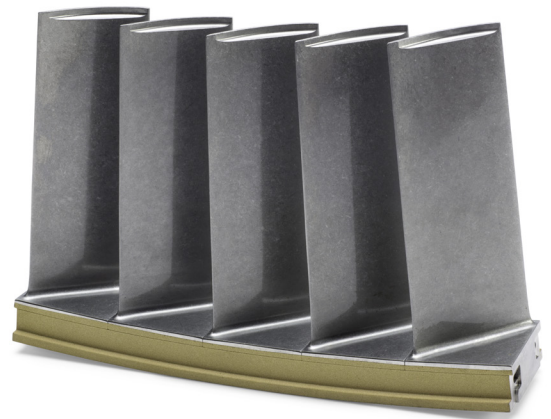
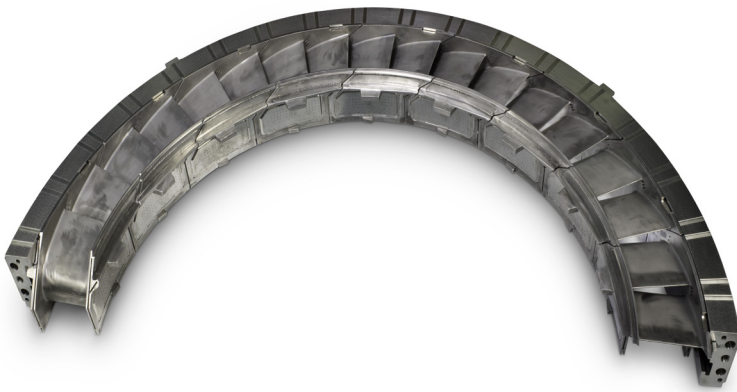
- + Carriers are forged from an upgraded, corrosion-resistant alloy to prevent carrier/case “lock-up” and address corrosion, reducing the risk of stator HCF failures.
- + Increased number of carrier ring segments for improved installation and removal process.
- + Asymmetric vane spacing on S0 & S1 to reduce vibratory driver strength on R0 & R1 blades.
- + Redesigned S3 to prevent HCF failures.
- + Added a groove to attach tooling for easier disassembly.
- + Flared and unflared variants available.

## S13 – S16 Hook Ring Solution

- + S13 - S16 stators are joined together at the OD using a patented Hook Ring design, creating packs of 4 or 5 vanes and eliminating wear issues experienced with the OEM single airfoil design.
- + Patented Hook Rings include an aluminum bronze coating for anti-galling prevention.
- + No case modification required for installation.

## S17 and EGV Welded Pack Solution

- + Design incorporates stators into tip-shrouded packs of 5 joined together at both the OD and ID using a PSM patented design.
- + Eliminates vibratory failures and wear issues experienced with the OEM single airfoil design stators.
- + Prevents damage to EGV, R17 blade, Compressor Wheel 17, and the inner barrel associated with OEM shrouded S17 bolt failures.
- + Design options available for standard and “FB-Style” inner barrel configurations.
- + Designs do not use a V-seal.



# DLN 2.6 Combustion Hardware

## “Brazeless” Combustion Cover

- + All machined and welded design with no brazed inserts, eliminating recurrent braze joint failures in brazed designs.
- + Available for gas-only and dual-fuel applications.
- + Compatible with PSM and OEM fuel nozzles.

## Fuel Nozzles

- + PSM nozzles are internally purged.
- + PSM nozzles on OEM covers mitigate the typical NOx increase when OEM cover brazed joints fail.



## Liner Cap Assembly

- + Caps caps with improved cooling to reduce thermal gradients.
- + Effusion plate made from higher strength Haynes® 282® material.
- + Improved manufacturing technique for cooling holes reduces propensity for cracks.
- + Addresses cracking and durability issues experienced with OEM caps.



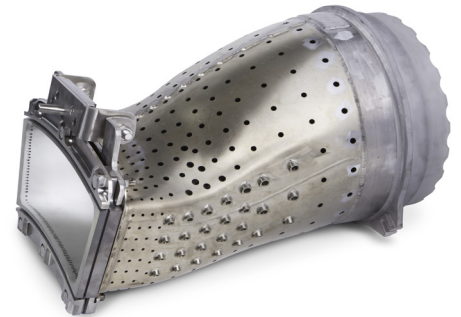
## Combustion Liner

- + Manufactured from proven NIMONIC® 263 material.
- + Enhanced cooling design at the liner aft end for improved durability.
- + Proprietary PSM 450 Thermal Barrier Coating (TBC) applied for enhanced reliability.



## Transition Piece

- + Thermally free mount to 1st stage nozzle to address impingement duct cracking.
- + Tighter fit between impingement sleeve and duct body improves cooling effectiveness.
- + Manufactured from proven NIMONIC® 263 material.
- + Aft attachment moved to exit frame to eliminate cracking in that region of the component.
- + Patented cooling features reduce metal temperature by up to 100°F.
- + Hard coat on all mating surfaces reduces wear.



# 7F.03 and GTO3 Compatible Buckets and Shrouds

## Turbine Buckets

### 1st Stage Bucket

- + Directionally Solidified (DS) casting for improved capability.
- + Latest design features a cast-in, TBC-coated tip plate for enhanced reliability and reduced repair scope.
- + Advanced cooling technology to address tip and platform durability issues.
- + Full platform trailing edge (TE) undercut to eliminate TE cracking.
- + Includes attachment relief cuts to address turbine wheel cooling air slot and lockwire tab cracking.
- + Externally coated with durable Strain Tolerant Micro Cracked Thermal Barrier Coating (STMC-TBC®) and internally aluminide coated.



### 2nd Stage Bucket

- + Conventionally cast from patented PSM 116 material for improved durability and repairability.
- + Improved cooling scheme with fully turbulated cooling holes.
- + Tip shrouds feature several design upgrades to eliminate shroud lifting and localized creep cracking.
- + Buckets are externally TBC-coated and internally aluminide coated.
- + Includes attachment relief cuts to address turbine wheel cooling air slot and lockwire tab cracking.



### 3rd Stage Bucket

- + Conventionally cast from patented PSM 116 material for improved durability and repairability.
- + Features scalloped shrouds to counteract shroud lifting. Z-Notch features a larger hard face surface area to reduce wear and fretting.
- + Externally MCrAlY coated.



## Turbine Shrouds

### Standard Features

- + Segment-to-segment seals are PSM's patented flexible seals, providing superior intersegment gap sealing and improved efficiency. PSM flexible seals have proven reusability post repair.

### 1st Stage Shroud Block

- + Shroud tiles are externally coated with durable Strain Tolerant Micro Cracked Thermal Barrier Coating (STMC-TBC®).
- + Improved cooling design provides positive cooling outflow margins, eliminating hot gas ingestion issues.

### 2nd Stage Shroud Block

- + Manufactured from Haynes® HR 120® alloy.

### 3rd Stage Shroud Block

- + Manufactured from 310 SS alloy.





## 7F.03 and GTOP3 Compatible Nozzles

### Turbine Nozzles

#### Standard Features

- + Nozzles are conventionally cast from PSM 109, a nickel-based material with superior mechanical integrity and creep properties relative to cobalt-based alloys, providing reduced life cycle cost. PSM 109 has proven weldability at repair.
- + Segment-to-segment seals are PSM's patented flexible seals, providing superior intersegment gap sealing and improved efficiency. PSM flexible seals have proven reusability post repair.

#### 1st Stage Nozzle and Outer Retaining Ring

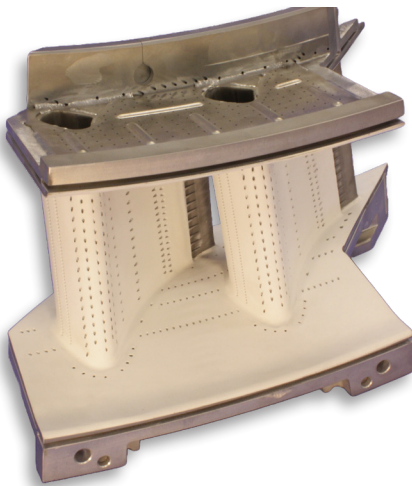
- + Fully externally coated with MCrAlY metallic bond and TBC for oxidation resistance and reduced metal temperatures.
- + Cooling air is redistributed to the platform and sidewalls for improved durability.
- + ID rail redesigned to reduce stiffness that contributes to high airfoil stresses and cracking.
- + Parallel chordal hinge to seal between nozzle ID and supporting ring.
- + PSM 109 alloy provides a proven reduction in Thermo-Mechanical Fatigue (TMF) cracking compared to cobalt-based alloys.

#### 2nd Stage Nozzle

- + Fullyexternally coated with MCrAlY metallic bond coat and TBC for oxidation resistance and reduced metal temperatures.
- + Upgraded trailing edge cooling design.
- + Furnished with attached diaphragms made from 310 SS, an upgraded alloy, to address field oxidation issues.

#### 3rd Stage Nozzle

- + Furnished with attached diaphragms.



# Long Term Agreements

## Summary of Offerings

As a leading parts provider, PSM offers comprehensive and flexible Long Term Agreements for 7F, 501F, 6B, and 7E models, aimed at reducing lifecycle costs for the end user. Our engineered part designs increase component life and extend program intervals, eliminating inspections and providing significant cost

savings over the contract's life. Additionally, our improvements to OEM designs and reconditioning processes reduce the fallout of hot gas parts. PSM has also assembled a highly skilled and experienced field service team capable of industry-leading outage performance.

## Flexible Agreements — to fit the customer needs

Types of PSM Service Agreement Offerings			
Included Product Offerings	Long Term Agreement (LTA)	Long Term Maintenance Agreement (LTMA)	Frame Agreement
Parts Supply	✓	✓	✓
Reconditioning	✓	✓	✓
Field Services	✓	✓	Optional
Monitoring & Diagnostics (Remote Monitoring)	✓	Optional	Optional
Contract Manager	✓	Optional	Optional

PSM has developed a flexible concept for Long Term Agreements tailored to meet dynamic market conditions and customer needs. Our agreements aim to offer competitive pricing and leverage the full portfolio of PSM offerings. They can include not only gas turbines but also generators, steam turbines, and auxiliary systems. The focus is on optimizing maintenance budgets, guaranteeing part life, minimal parts fallout, coverage during unscheduled inspections, inventory control, and proactive contract management for total coverage.

In summary, our diverse agreement offerings are designed to optimize your maintenance budget. They provide competitive guarantees on parts life, minimal parts fallout, comprehensive coverage during unscheduled inspections, effective inventory control, and proactive contract management, all to ensure complete coverage.

## Scope of Supply — based on the customer requirements

Customers define the scope of Long Term Agreements, which can range from full service to specific pricing agreements. Services offered by PSM include:

- + Parts Supply
- + Reconditioning
- + Field Services, including craft labor
- + Monitoring & Diagnostics (e.g., Remote Monitoring)
- + Contract Management
- + Inventory Management
- + Parts Tracking
- + Engineering Assessments
- + System Technical Support
- + Emergency Response



# Service Capabilities including Monitoring & Diagnostics

## PSM services a diverse portfolio of GT components, control and combustion system platforms

- + Reliable coverage from basic support through complex root cause analysis.
- + Service Engineering extends beyond traditional support to incorporate best practices from all platforms & systems.
- + Strong processes & infrastructure position PSM to further grow capabilities.

### Engineering Assessment

- + A dedicated team supports our Field Service, Project Management, Sales & Tendering, R&D, Fleet Management, Global Execution Centers, and Customers.
- + Over 400 events per typical outage season evaluated and answered.

Team access to all parts of the PSM organization ensures quick event disposition.

### Tuning and Commissioning

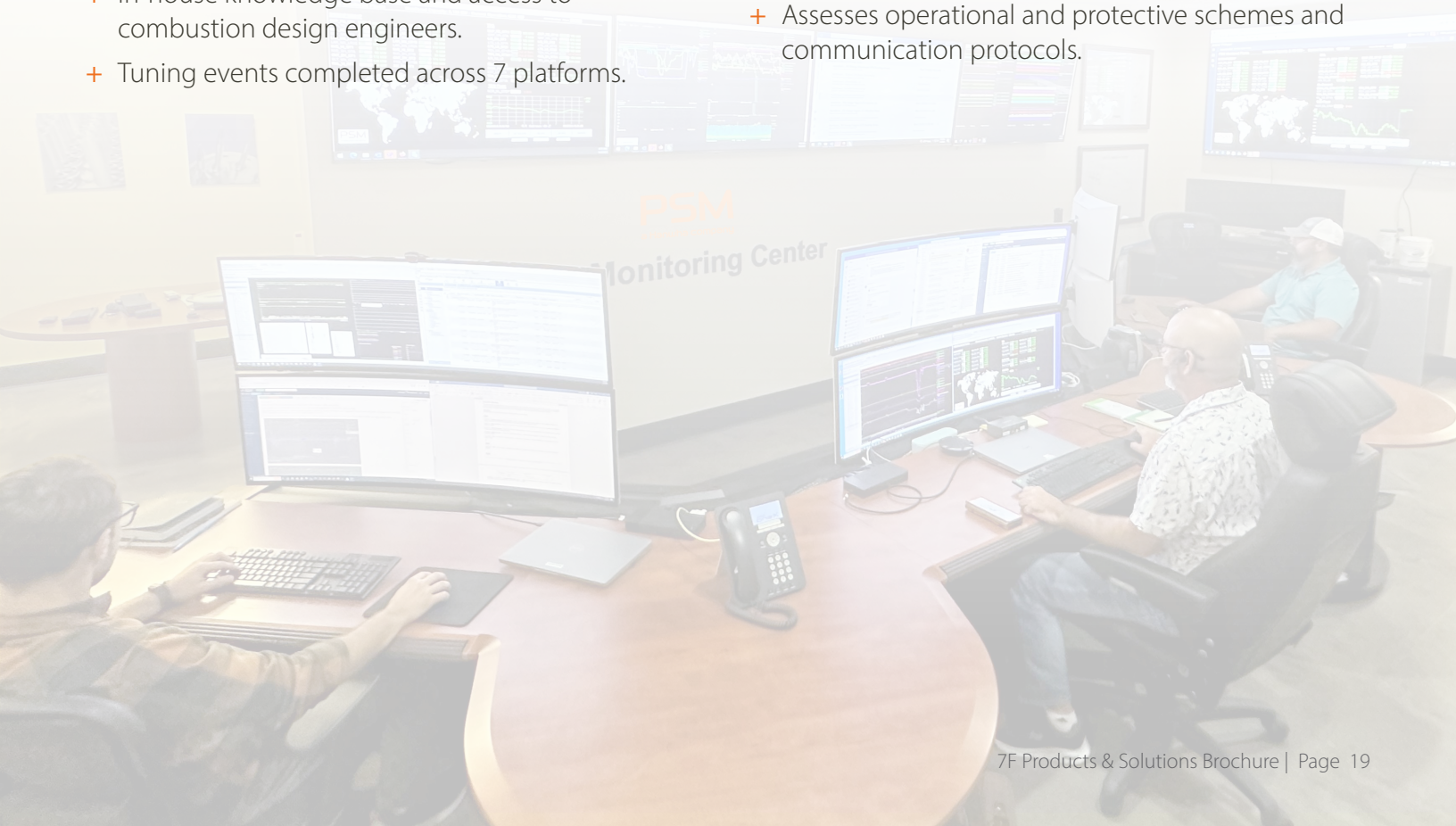
- + Over 200 tunes per year across a wide variety of combustion technology and control systems
- + Strong expertise in both OEM & PSM Combustion systems.
- + In-house knowledge base and access to combustion design engineers.
- + Tuning events completed across 7 platforms.

### Monitoring and Diagnostics

- + Over 50 units and 10 GW monitored.
- + Global cloud-based infrastructure with redundancy.
- + 24/7 Monitoring.
- + Monthly Operational Assessment Reports (OAR's) included monitoring of customer-selected parameters.

### Controls Design and Development

- + Controls-related services across seven different platforms.
- + Support customers and PSM technology initiatives.
- + Designed to support controls replacement, expansion projects, or technology development.
- + Assesses operational and protective schemes and communication protocols.



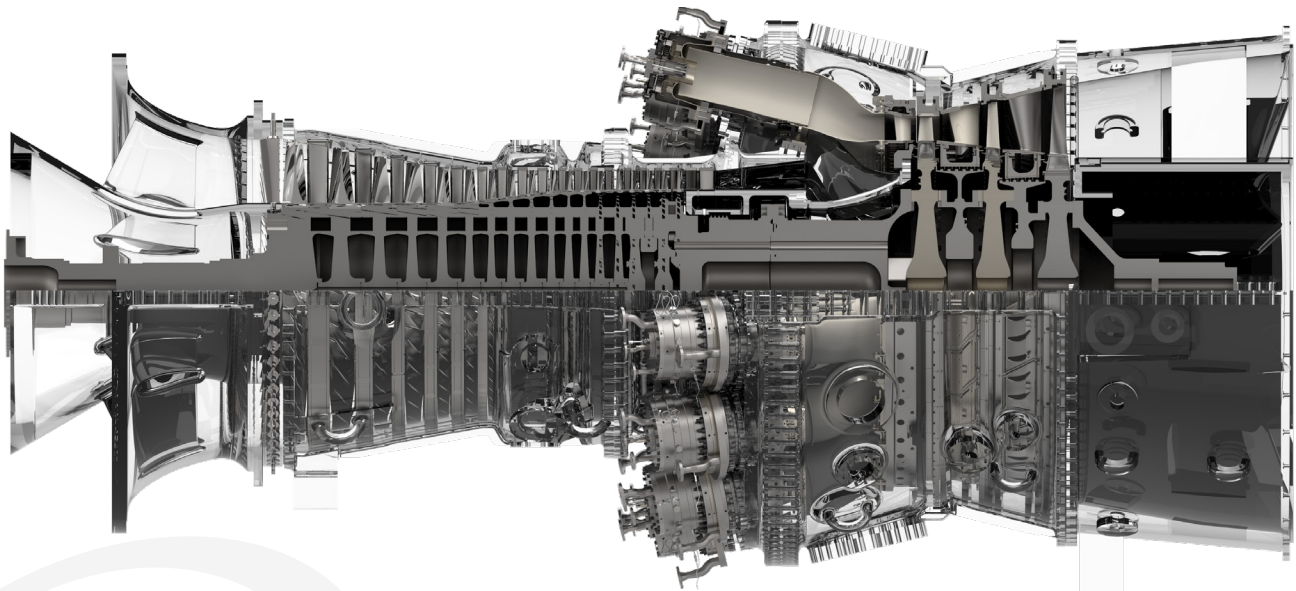


# PSM - A Hanwha Company

The growing interest in the hydrogen economy is driven by the need to address climate change and transition to sustainable energy sources. However, challenges remain, including high production and storage costs, and extensive infrastructure requirements for distribution and transportation.

As a Hanwha subsidiary, PSM is uniquely positioned to leverage the expertise and resources of the Hanwha family to accelerate hydrogen development and adoption as a clean energy source. Hanwha's global presence and diverse business interests in areas like solar energy and defense provide PSM access to a wide array of technologies, markets, and partnerships.

Collaboration with Hanwha Q CELLS, a leader in large-scale solar projects, enables PSM to integrate hydrogen production with solar energy systems, fostering more sustainable and efficient energy solutions.



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