

Mike Cocca

***1 Jornados Latinamericanas sobre
Compresion de Gas Natural
Upgrade en Turbinas Gas***



Uprate Considerations

- Performance Improvements (Output/Heat Rate)
- Maintenance/Inspection Interval Extensions
- Availability/Reliability Improvements
- Emissions Impact/Regulatory Agencies
- Life Extension
- Thorough Review of Gas Turbine Components and Accessories Systems for Compatibility
- Thorough Review of Load Equipment and Accessories for Compatibility

New Unit Technology/Components

MS5/1 Advance Tech Uprate Hardware

Sourcebook

Code

5001 A-K

5001L/LA/M

5001N/P/R

FR1L	- Floating Seal Transition Pieces	X	X	X
FR1G	- TBC Coated Combustion Liners with Splash Plate Crossfire Tube Collars	X	X	X
FT3O	- 2 Vane Stage 1 Nozzle	X	X	X
FT3R	- GTD111 Stage 1 Bucket	X	X	X
FT3T	- 4 Vane Cast Segment Stage 2 Nozzle	X	X	X
FT3E	- Shrouded Tip Stage 2 Bucket and New Stage 2 Turbine Wheel	X	X	-
	- Turbine Shell	X	-	-
	- Distance Piece	X	-	-
	- Stage 1 Turbine Wheel	X	-	-
	- Outer Combustion Casings	X	-	-
	- Exhaust Frame	X	-	-
FS1U	- Stainless Steel Exhaust Diffuser (Hi-Temp Only)	X	X	-
FS2V	- High Pressure Packing Brush Seal	X	X	X
FS2T	- Honey Comb Stage 2 Shrouds (may require S2B)	X	X	X
FS2Y	- Improved Sealing Stage 1 Shroud	X	X	X
FS2Z	- Stage 2 Nozzle Brush Seal	X	X	X
FS5A	- Abraidable Coating on S1S	X	X	X

Advance Seals

MS5001 Models A - P Advanced Technology Uprate Package Hardware

Brush Seals

- *Minimize Air Leakage*
- *Tolerant of Misalignments*
- *More Durable than Labyrinth Seals*

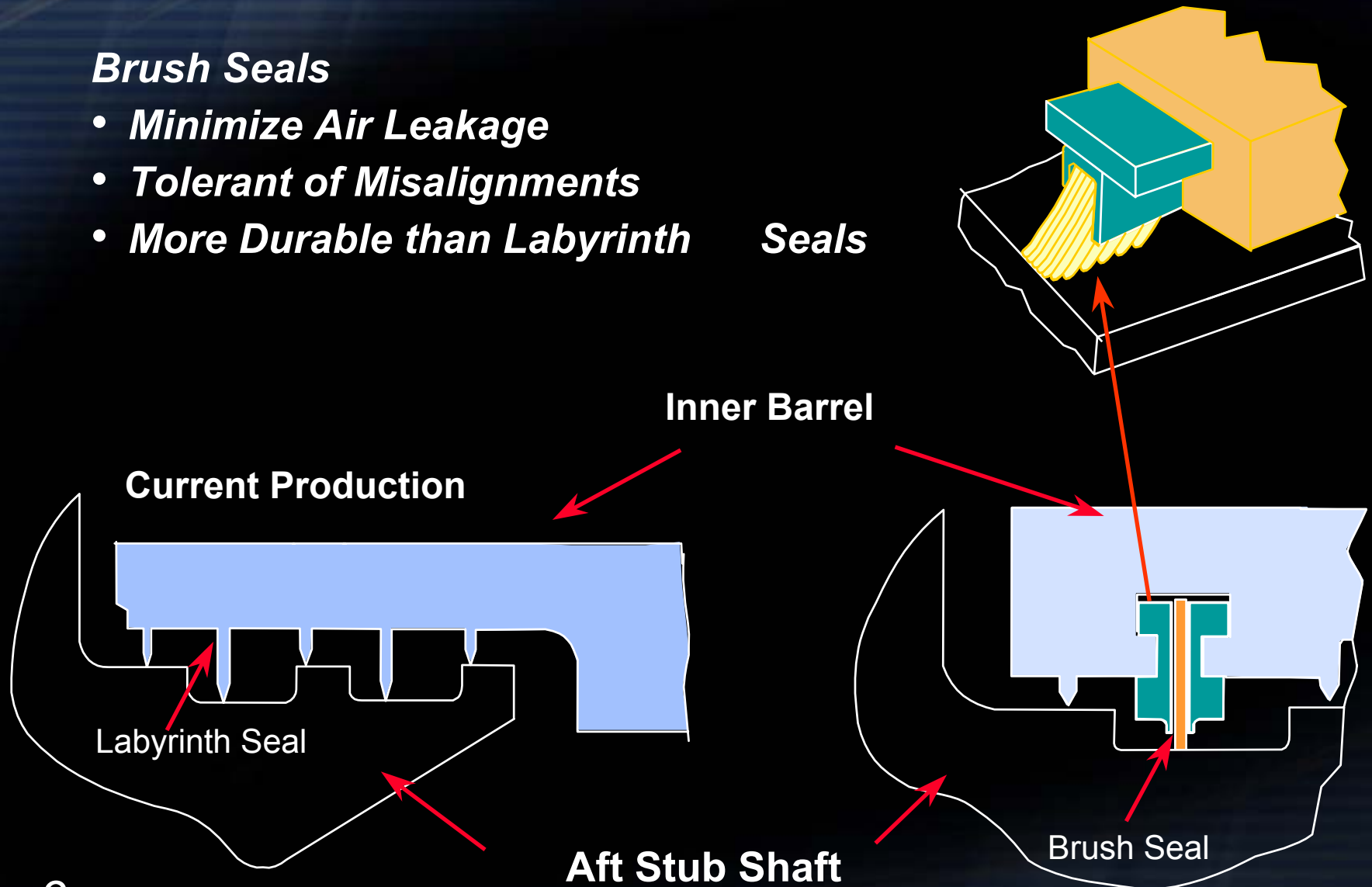


Fig 6

- Minimize Air Leakage to Bearing Cavity
- Reduce Oil Mist

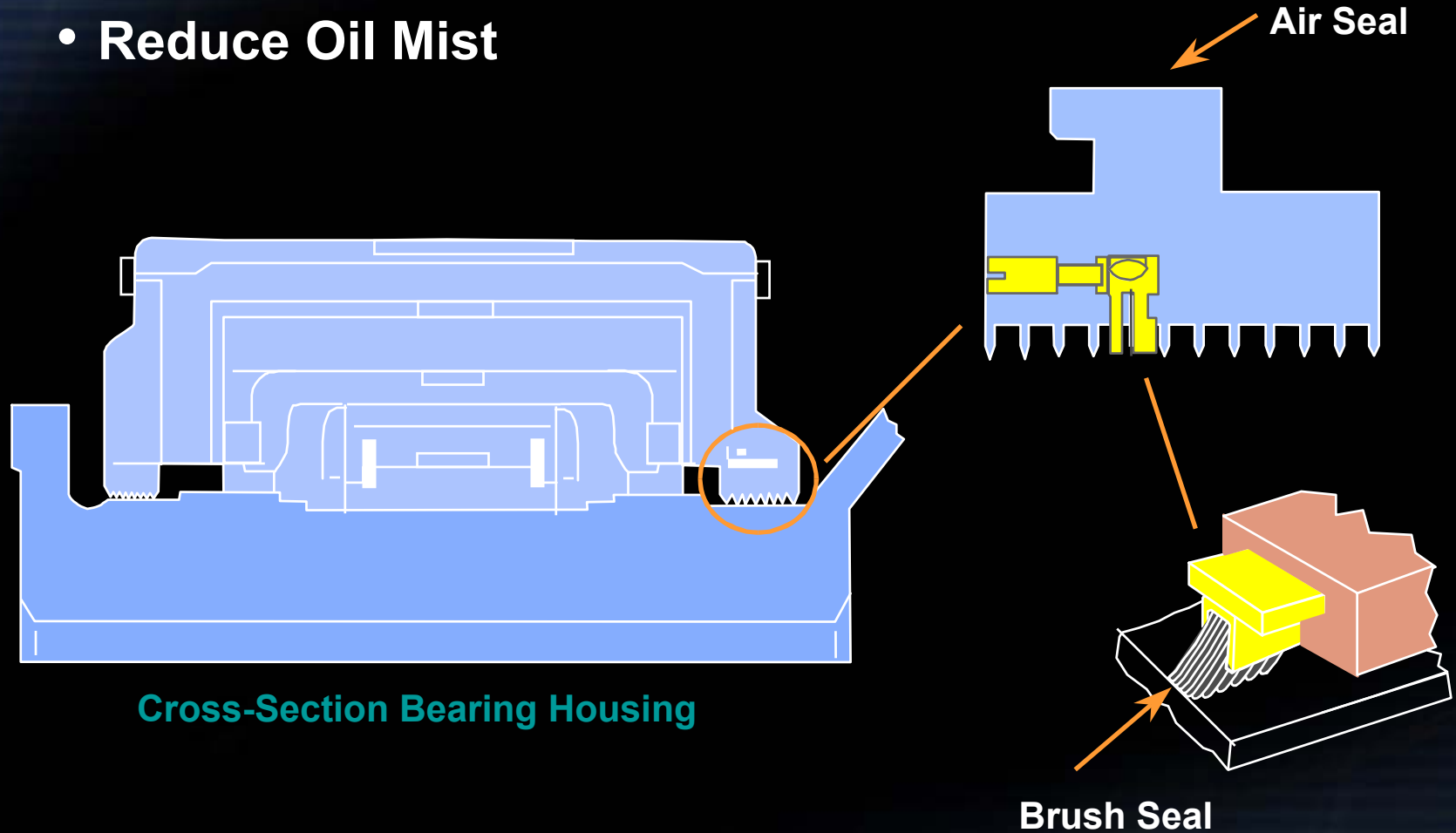
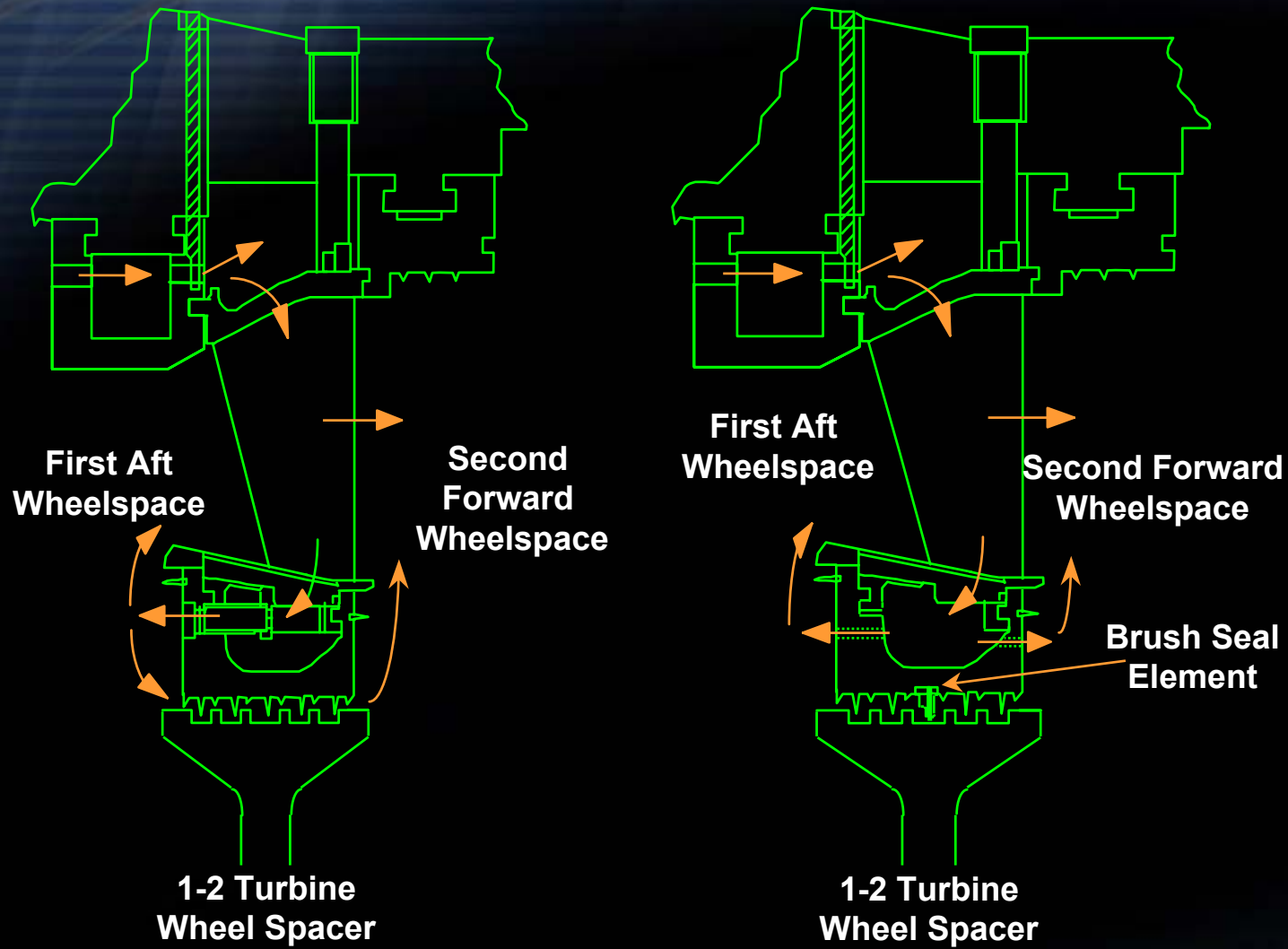


Fig 7



Current Stage 2 Nozzle Design **Proposed Stage 2 Nozzle Design**

GER 3751-

Honeycomb Shroud Blocks

- *Honeycomb Shrouds*
 - *Reduces Leakage*
 - *Greater Rub Tolerance*
- *Requires Buckets with Cutter Teeth*

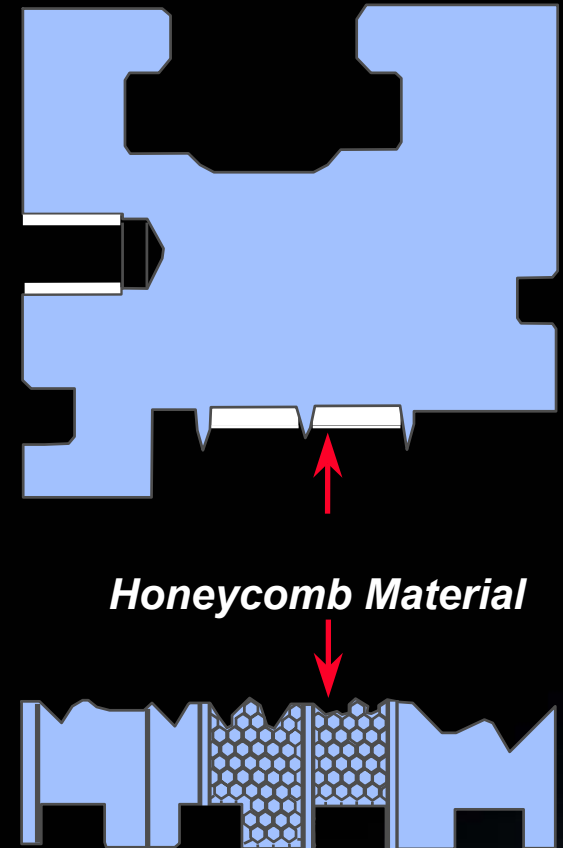
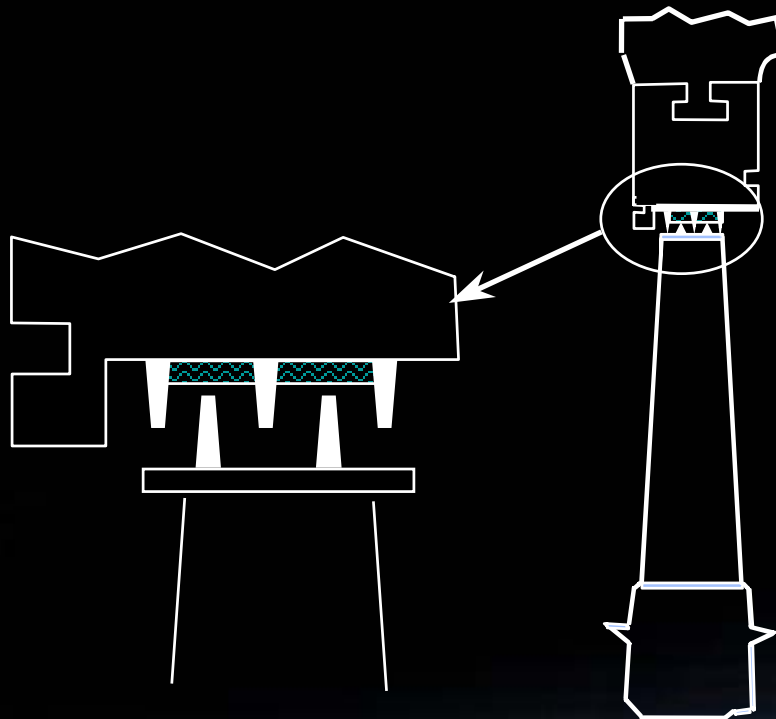


Fig 9

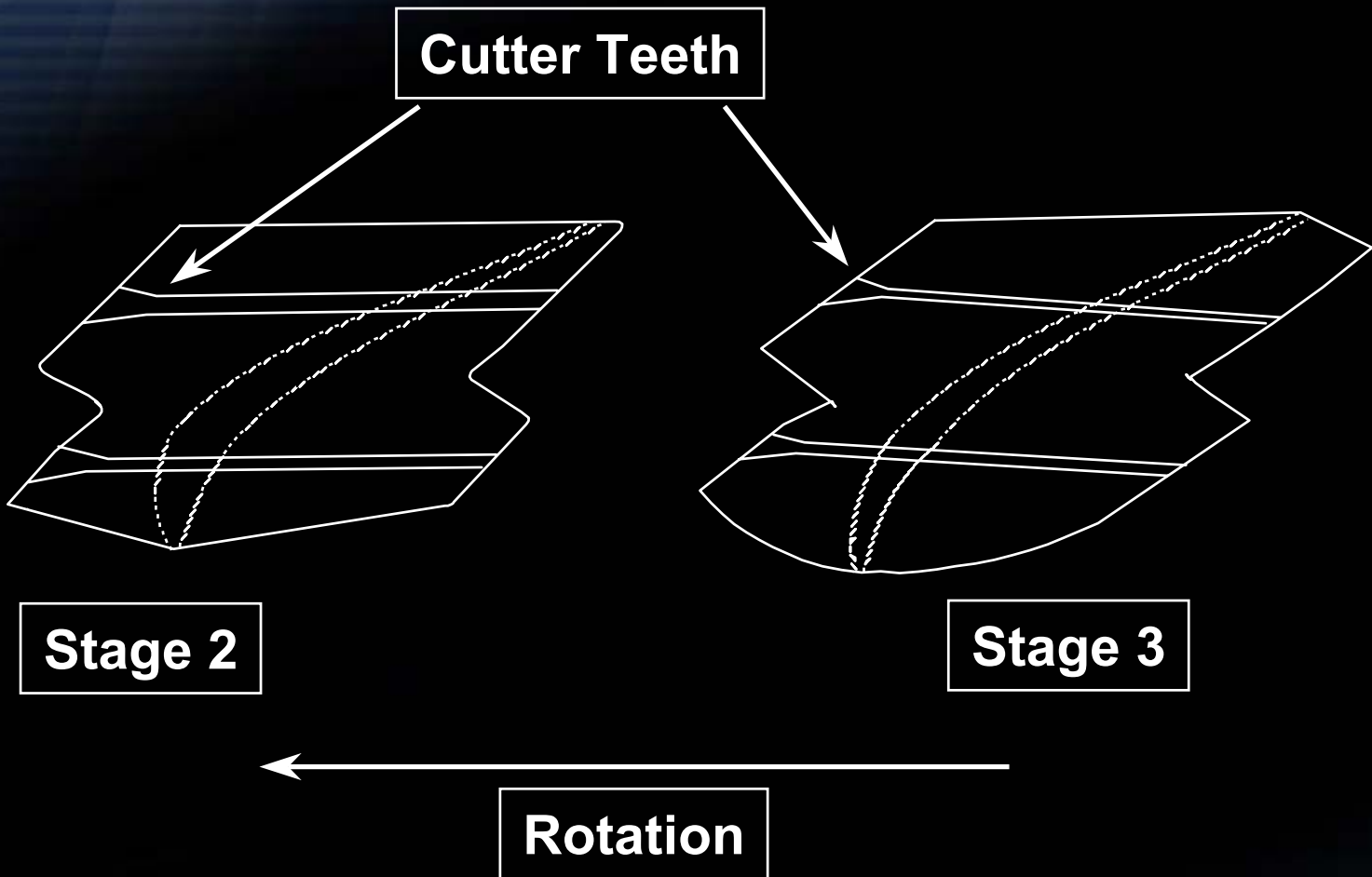


Fig 10

First Stage Shroud Cloth Seals

- New Material and Improved Sealing
- Improved Performance (Pending Audit)

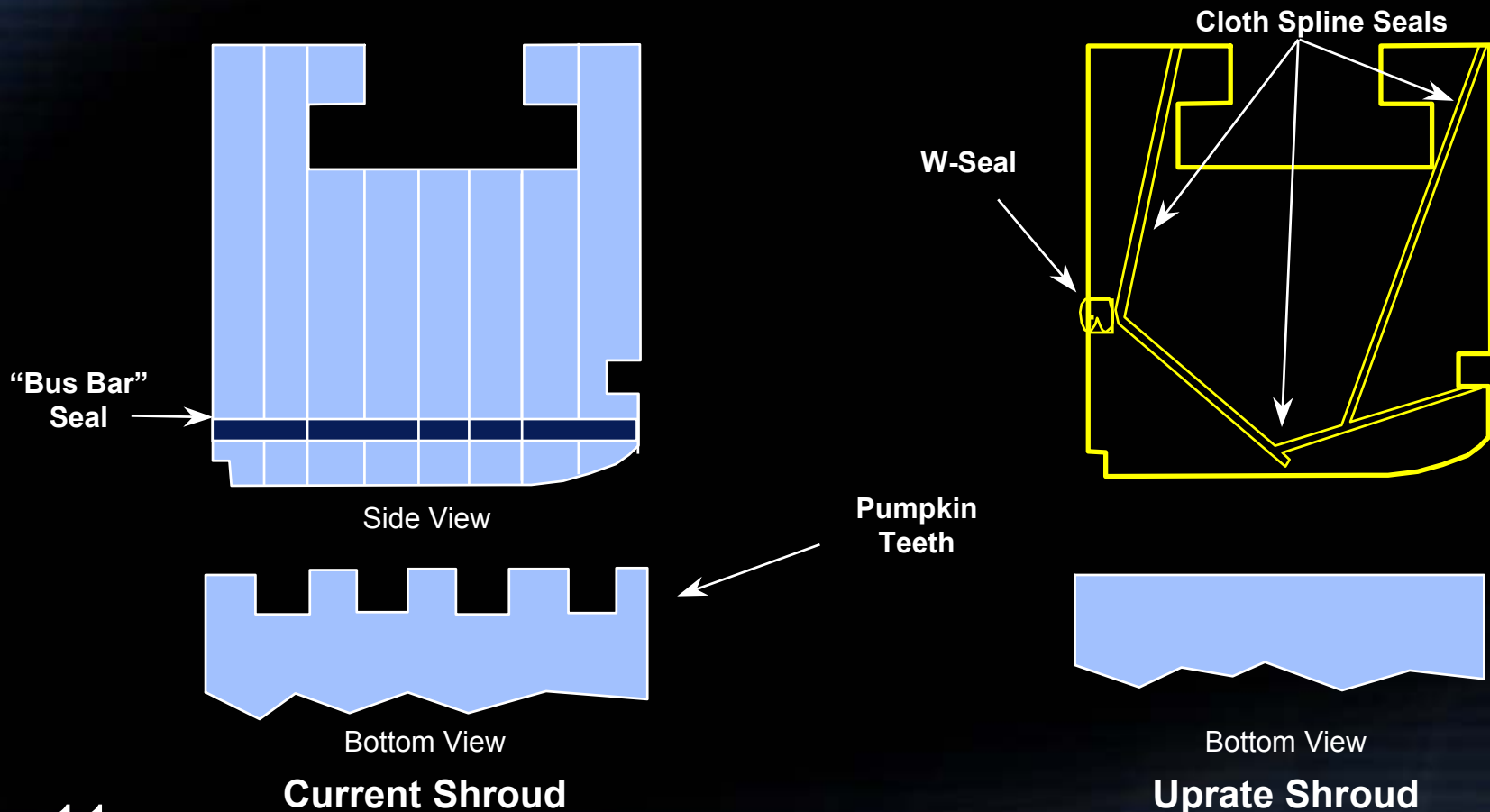
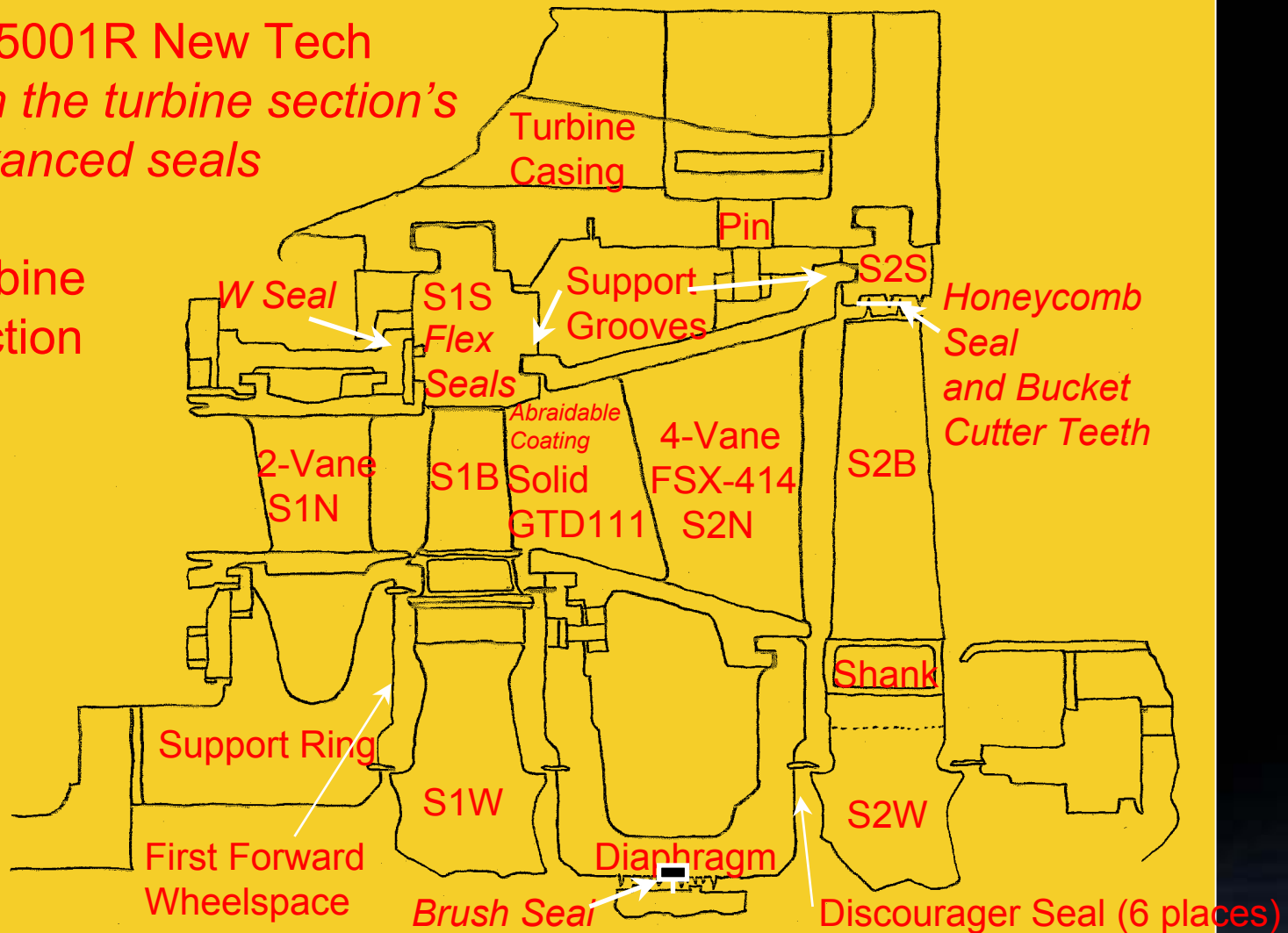


Fig 11

MS5/I Advance Tech Uprate Hardware

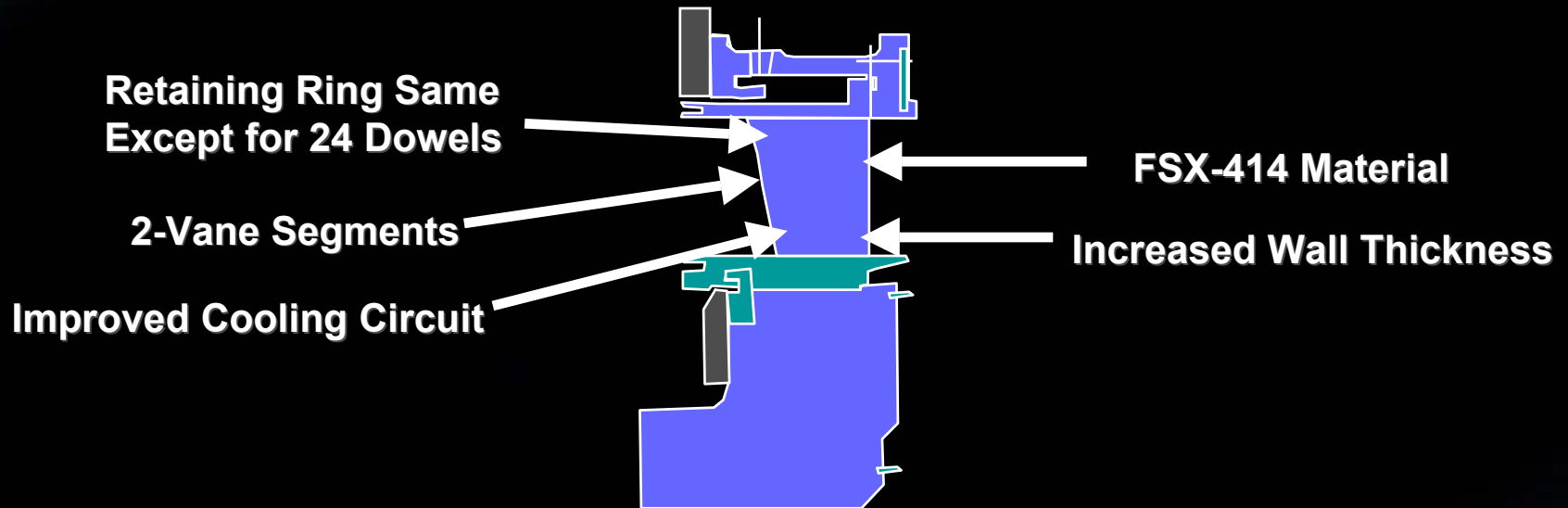
MS5001P New Tech and
MS5001R New Tech
with the turbine section's
advanced seals

Turbine
Section



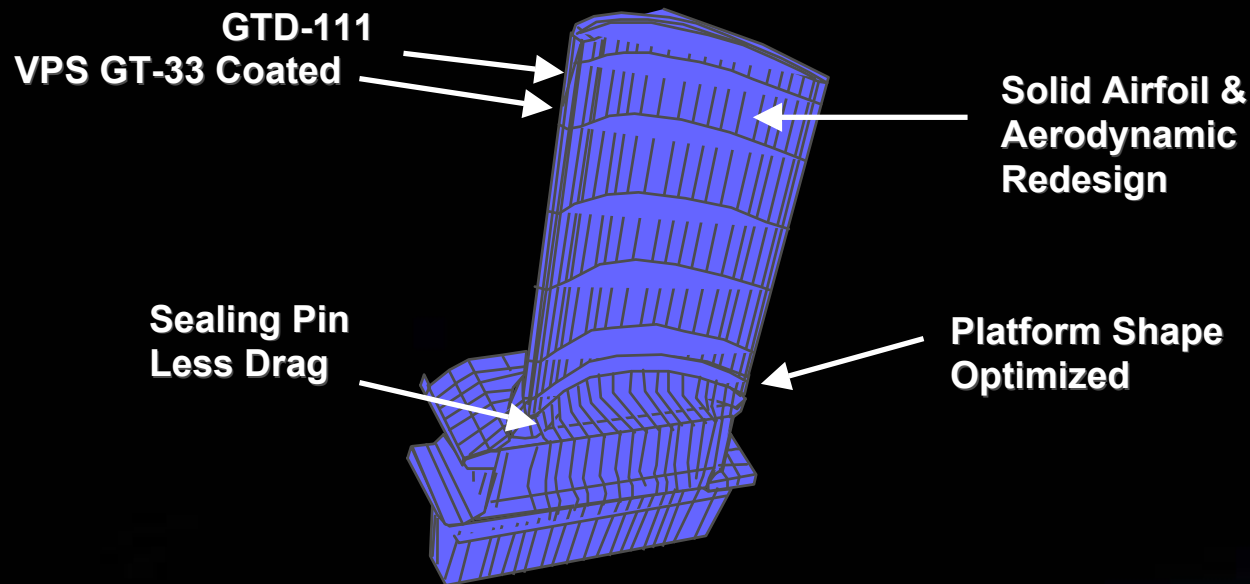
MS5001 New-Tech First Stage Nozzle

- *Increased wall thickness for greater resistance to ballooning*
- *Repositioned trailing edge cooling holes to reduce cracking*
- *Two-vane per segment design to reduce sidewall cracking*

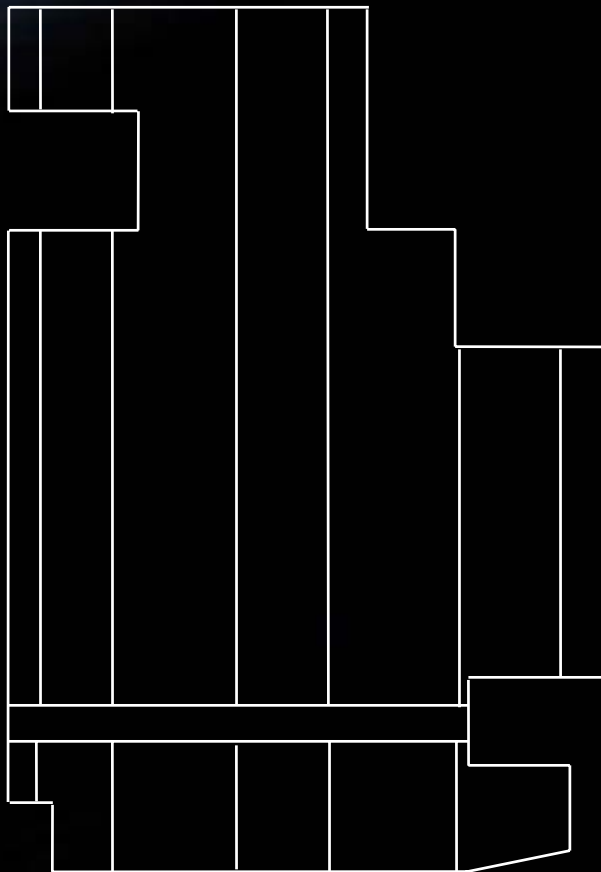


MS5001 New-Tech First Stage Buckets

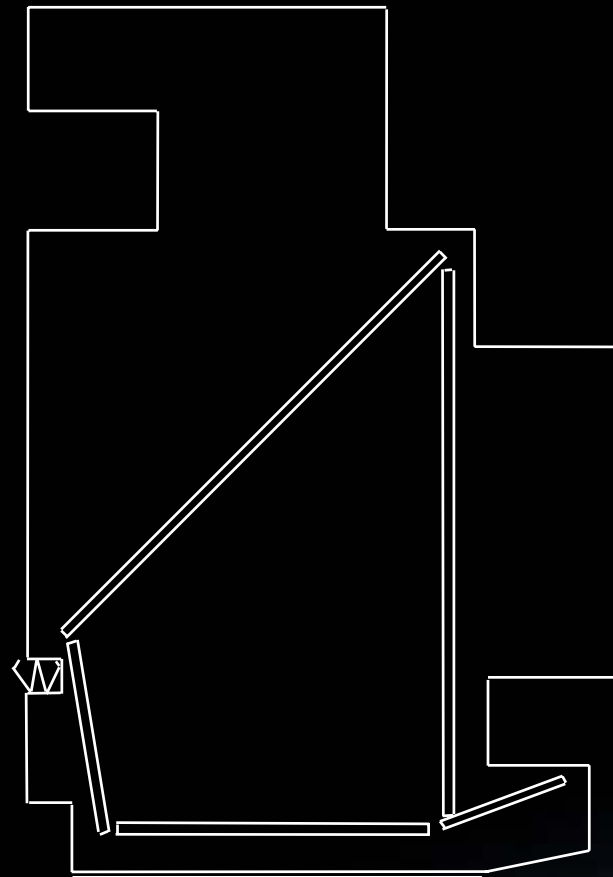
- *Solid buckets to improve FOD resistance*
- *GTD-111 material for improved rupture and fatigue strength*
- *GT-33 coated for improved corrosion protection*



MS5001 S1 Shroud Block Sealing Designs



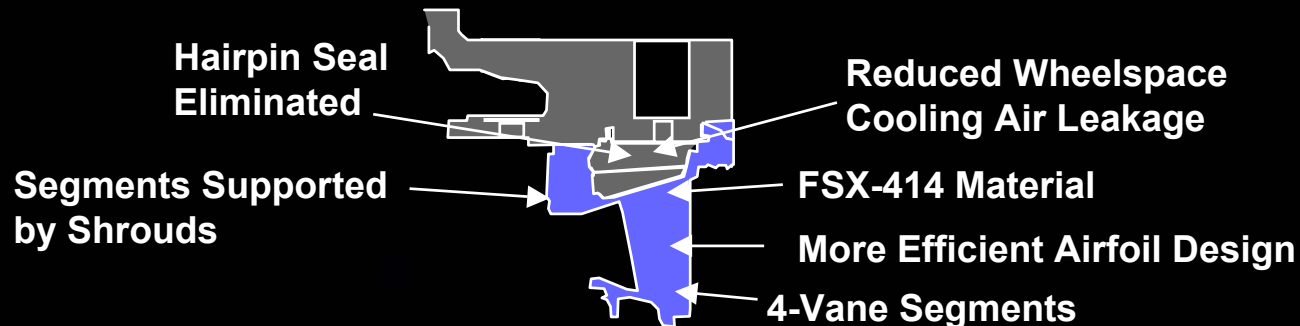
Traditional "Pumpkin Teeth" Design



Advanced Seals:
FS2Y Flexible Spline Seals and "W" Seal,
FS6A Abraidable Coating

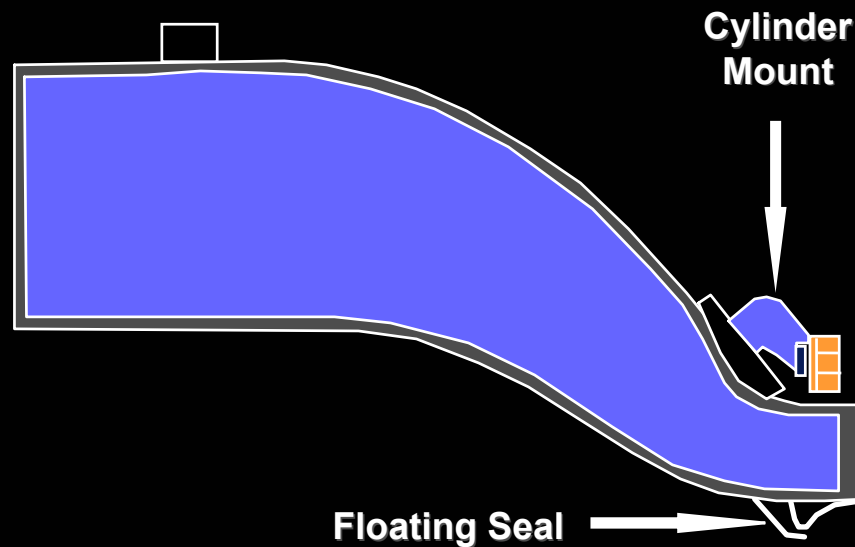
MS5001 New-Tech Second Stage Nozzle

- *Four-vane per segment design to reduce cracking*
- *Supported by First & Second Stage Shrouds to minimize out-of-roundness*
- *Interstage packing alignment procedure is simplified*
- *More efficient design for increased power and reduced heat rate*
- *FSX-414 material to increase resistance to creep deflection*



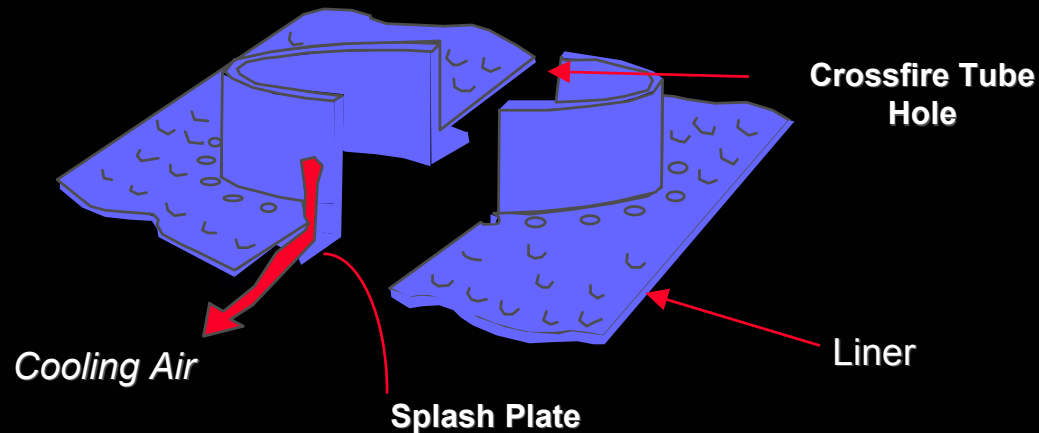
MS5001 Advance-Tech Transition Piece

- *Floating seal design to reduce wear and crack resistance*
- *Cylinder mount-to-body design to increase torsional stiffness*
- *Hastalloy-X*
- *Available with Extendor™ Features*



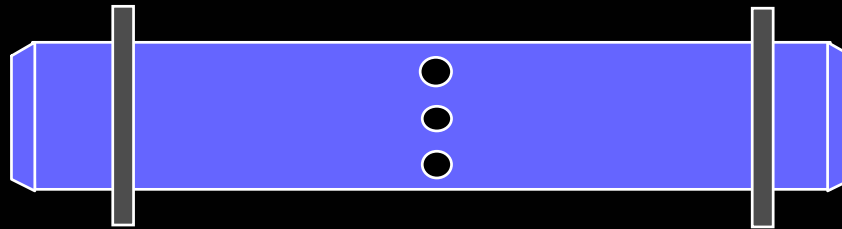
MS5001 Advanced-Tech Combustion Liner

- *Impingement Cooling of Crossfire Tube collar to minimize cracking*
- *Added Thermal Barrier Coating (TBC) to increase part life*
- *Improved collar material (HS-188) to increase wear resistance*
- *Improved liner material (Hastelloy-X) to increase part life*
- *Available in a Low NOx Lean-Head-End Design*
- *Available with Extendor™ Features*

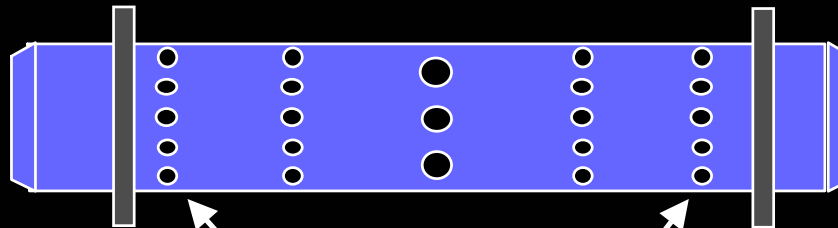


New-Tech Cross-fire Tubes.

Can include Hardcoating.



Standard Dual Fuel Crossfire Tube



Swirl Cooling Holes

MS5/1 Advance Tech Uprate Hardware

MS 5001P Uprate Summary

	<u>Output</u>	<u>Heat Rate</u>
Advanced Tech Update (FT3M)	+6.0%	-1.0%
GTD 450 IGV's (Pre 1978/post 1978) (FT3B/FT3C)	+3.9%/1.9%	-0.2/0.5%
86° IGV's	+0.2%	+0.1%
High Pressure Pkg Brush Seals (FS2V)	+0.6%	-0.4%
Stage 2 Shroud Honeycomb Seals (FS2T)	+0.4%	-0.4%
5355 RPM Turbine Speed (FT3X)	+3.0% (at High Ambients)	
Stage 1 Shroud Cloth Seals (FS2Y)	+0.5%	-0.5%
Inner Stage Brush Seal (FS2Z)	+1.0%	-0.5%
S1S Abraidable Coating Seals (FS5A)	+0.4%	-0.3%
Total	+16.0/14.0%	-3.2/-3.5%

MS5/2 Advance Tech Uprate Hardware

Sourcebook
Code

MS5002A MS5002B

FT2J	2 Vane Stage 1 Nozzle	X	X
FT2K	GTD111 Directionally Solidified Stage 1 Bucket	X	X
FR1G	TBC Coated Combustion Liners With Splash Plate Cooled Crossfire Tube Collars	X	X
FR1G	Swirl Cooled Crossfire Tubes With Hardfacing	X	X
-	LP Thrust Bearing Pad	X	X
FS1Y	Up-Drain #2 Bearing Liner	X	X
-	Turbine Shell Insulation Packs	X	X
-	HP & LP Turbine Rotor Bolt Tightening (Low Ambient Temp. Applications Only)	X	X
-	Stage 2 Bucket	X	-
FS1U	Stainless Steel Exhaust Diffuser (Hi-Temp Only)	X	-
FS2V	High Pressure Packing Brush Seal	X	X
FS2T	Honey Comb Stage 2 Shrouds (may require S2B)	X	X
FS2Y	Improved Sealing Stage 1 Shroud	X	X
FS5A	Abraidable Coating on S1S	X	X
FS2X	#2 Bearing Brush Seals	X	X

Advance Seals

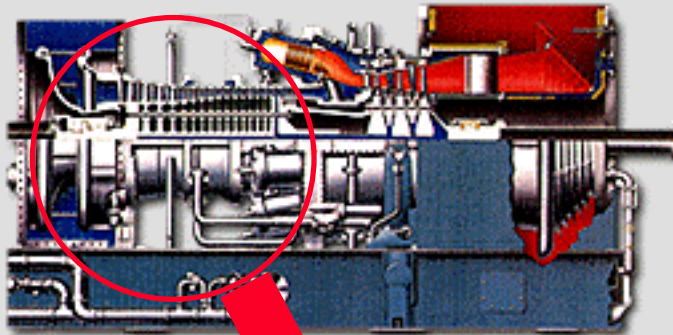
MS5002A and B Advanced Technology Uprate Package Hardware Changes

MS5/2 Advance Tech Uprate Hardware

Frame 5-2B to C Advanced Tech. Uprate	<u>Output</u>	<u>Heat Rate</u>
• GTD-450 High Flow IGV's	+1.6%	-0.3%
• MS5/2B to C Advance Tech. Uprate	+7.0%	-0.1%
• 5/2C with D-Type Stage 1 Nozzle	+2.0%	-1.5%
• High Pressure Packing Brush Seals	+0.5%	-0.4%
• #2 Bearing Brush Seals	+0.2%	-0.1%
• Improved Sealing Stage 1 Shroud	+0.5%	-0.3%
• Stage 2 Honey Comb Shroud Blocks	<u>+0.4%</u>	<u>-0.4%</u>
Total:	+12.6%	-3.1%

MS5/2 Advance Tech Uprate Hardware

MS6001B

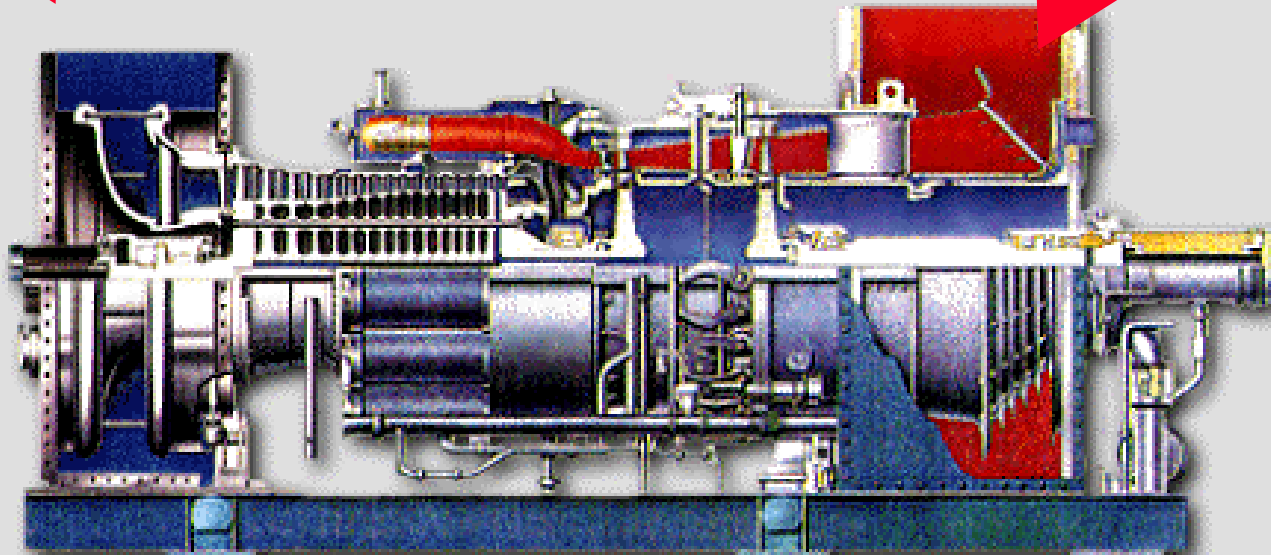
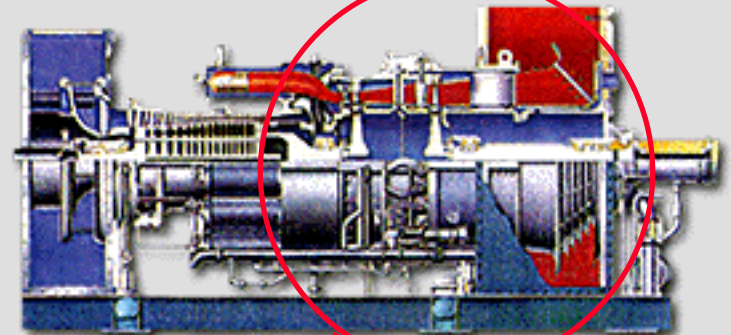


**Combine
Two Proven
Technologies**

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MS5002D

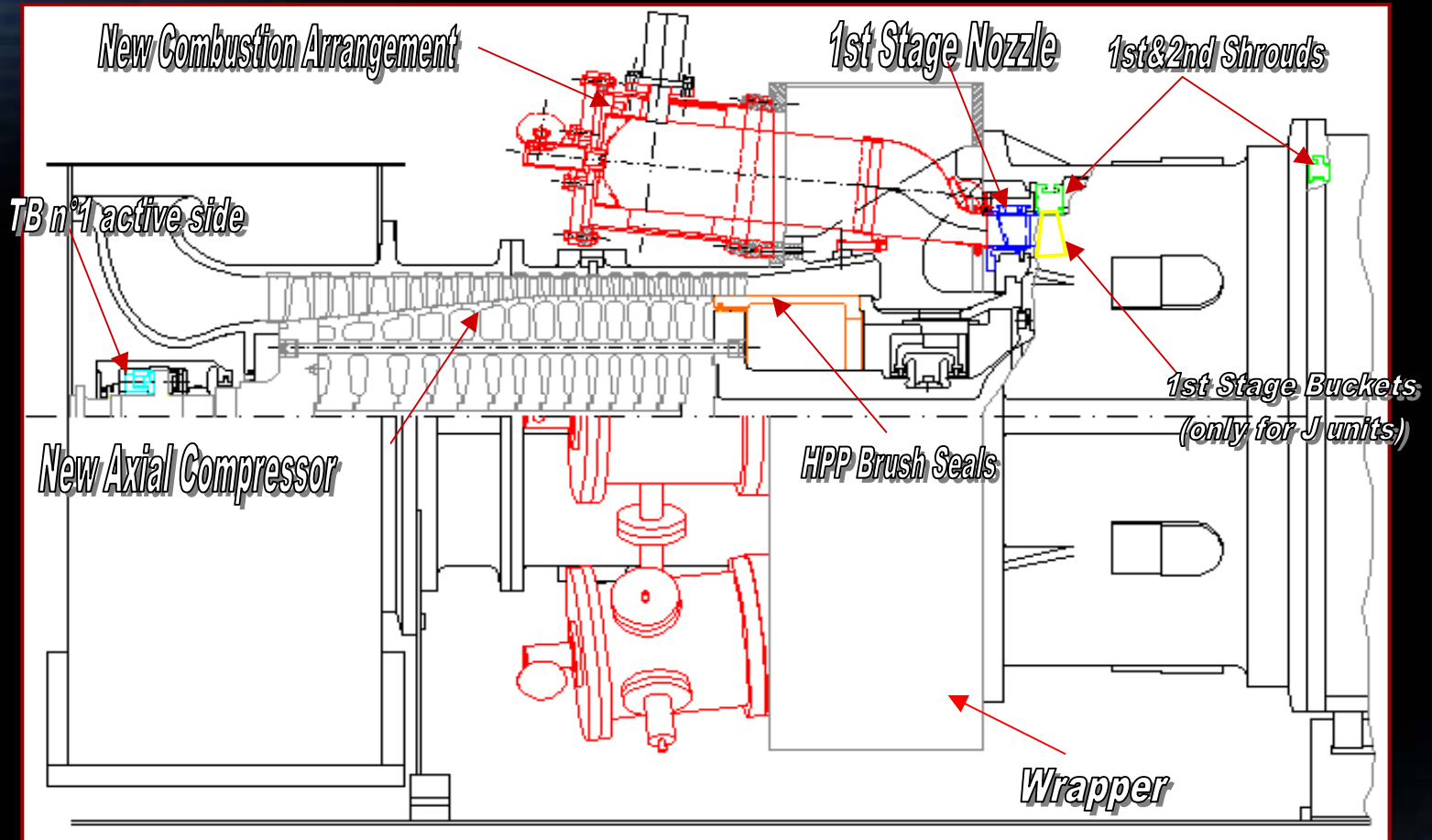
MS5002B



MS5/2 Advance Tech Uprate Hardware

Frame 5-2B to D Advanced Tech. Uprate	<u>Output</u>	<u>Heat Rate</u>
• GTD-450 High Flow IGV's	+1.6%	-0.3%
• MS5/2B to D Advance Tech. Uprate	+20.0%	-0.1%
• High Pressure Packing Brush Seals	+0.5%	-0.4%
• #2 Bearing Brush Seals	+0.2%	-0.1%
• Improved Sealing Stage 1 Shroud	+0.5%	-0.3%
• Stage 2 Honey Comb Shroud Blocks	<u>+0.4%</u>	<u>-0.4%</u>
Total:	+23.8%	-1.6%

Sectional drawing of the New MS3002K



MS3002K Module for Zero Hour



Complete 32K unit.

MS3002K BENEFITS

Typical₁ Simple Cycle Uprate Performance increases.

	<u>Output</u>	<u>Heat Rate</u>
MS3162K Adv Tech Uprate (FT1W) includes;	+8.0%	-7.15%
Complete Stator Blade Arr including High Flow IGV's (FT1F)	+2.0%	-0.50%
New Axial Compressor Rotor		
HPP Brush Seal (FS2V)		
MS3152J Adv Tech Uprate (FT1D)	+3.70%	-0.30%
MS32K (or J) Advance tech combustion Combustion System.		
Stage 1 Turbine Nozzle and support ring		
DS GTD-111 Stage One Buckets		
Active Thrust Bearings for the High and Low Pressure Rotors.		
Anti-Surge system including piping arrangement and valves.		
	32K Uprate include J/NT	
Stage 1 Shroud Cloth Seal (FS2Y)	+0.50%	-0.50%
Stage 2 Shroud Honeycomb Seal (FS2T)	+0.40%	-0.40%
	+10.9%	-8.55%

1) Performance impact for typical machine, actual site performance may vary.

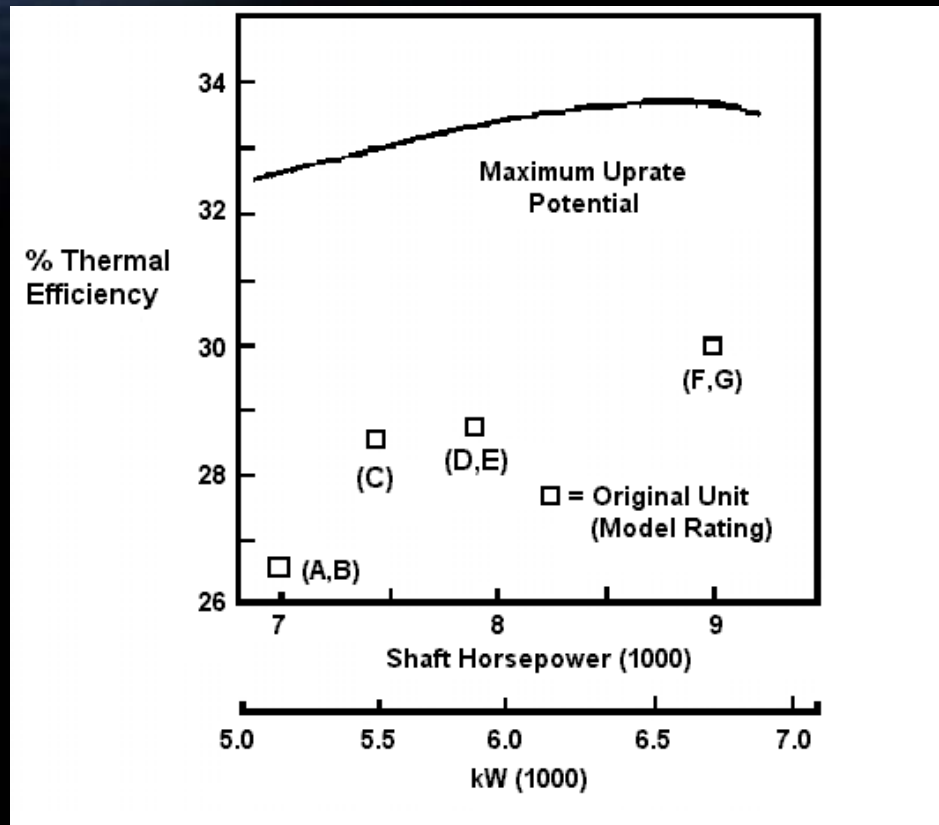
32K uprate significantly improves machine.

MS3/2A-G Advance Tech Uprate Hardware

	<u>3002A/B</u>	<u>3002C THRU G</u>
• 2 Vane Stage 1 Nozzle	X	X
• GTD 111 Stage 1 Bucket	X	X
• High-Pressure Turbine Rotor Assembly	X	X
• Stage 2 Nozzle	X	X
• GTD 111 Stage 2 Bucket	X	X
• Low-Pressure Turbine Rotor Assembly	X	X
• Floating Seal Transition Piece	X	X
• Turbine Shell	X	X
• Combustion Liners	X	X
• Splash Plate Crossfire Tube Collars	X	X
• Exhaust Diffuser	X	X
• Round-The-Corner Combustion	X	-

Figure 26 MS3002 A Through G Uprate Parts

MS3/2A-G Advance Tech Uprate Hardware



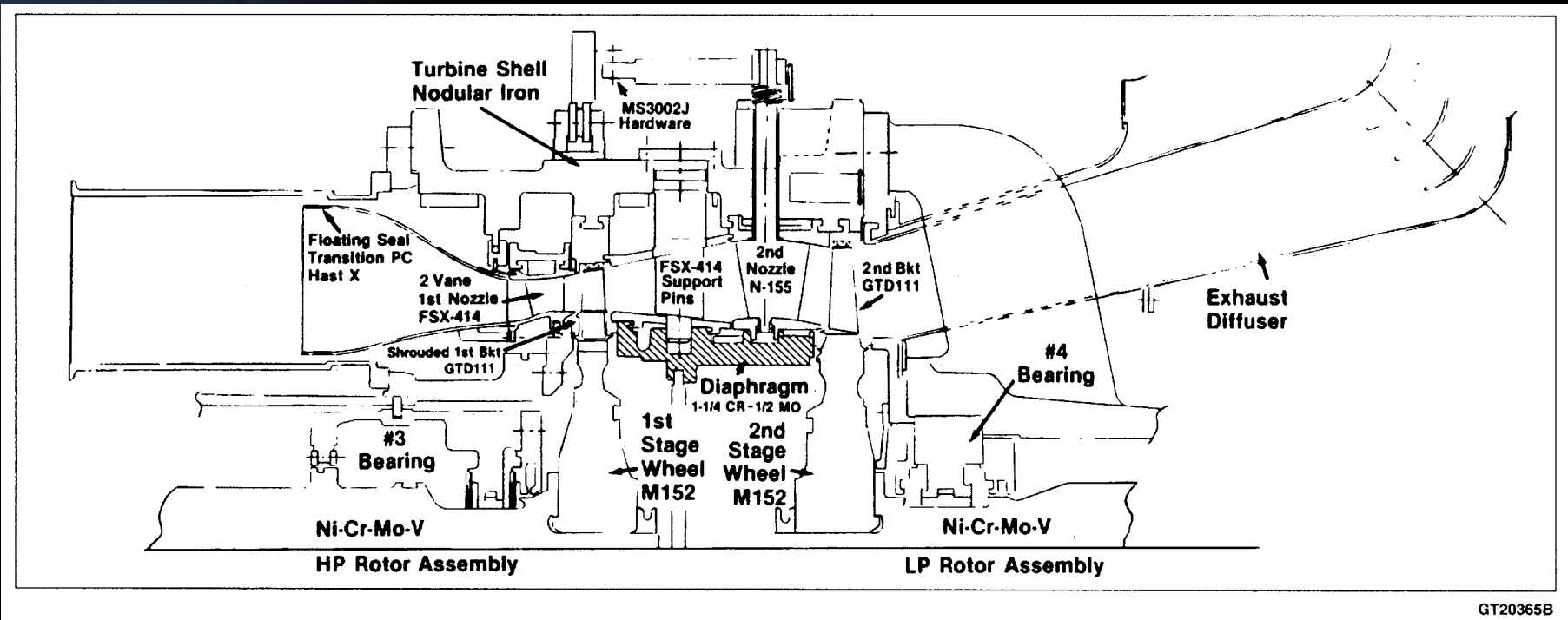
Regenerative Cycle
HP Speed = 6520 rpm
LP Speed = 600 rpm
75 ° IGV
NEMA Conditions
No Inlet or Exhaust Duct
Pressure Drops

Regenerator
86% Effectiveness
1.5% Air Side $\Delta P/P$
1.5% Gas Side $\Delta P/P$

Figure 27. MS3002 A through G uprate parts

GER 3751-27

MS3/2A-G Advance Tech Uprate Hardware



GT20365B

Figure 29 Modernization and Uprate Program

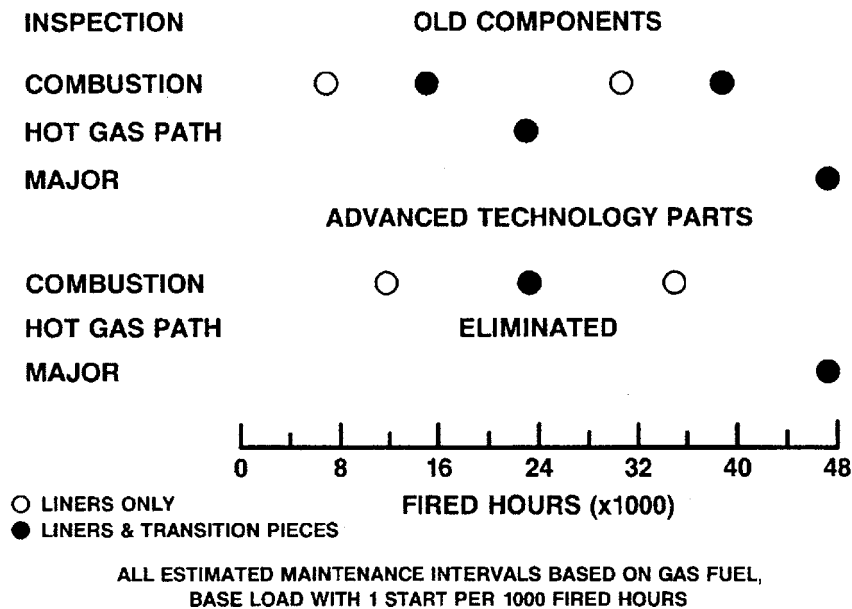
Upgrading Benefits and Strategy

Nuovo Pignone Global Service

Mike Cocca



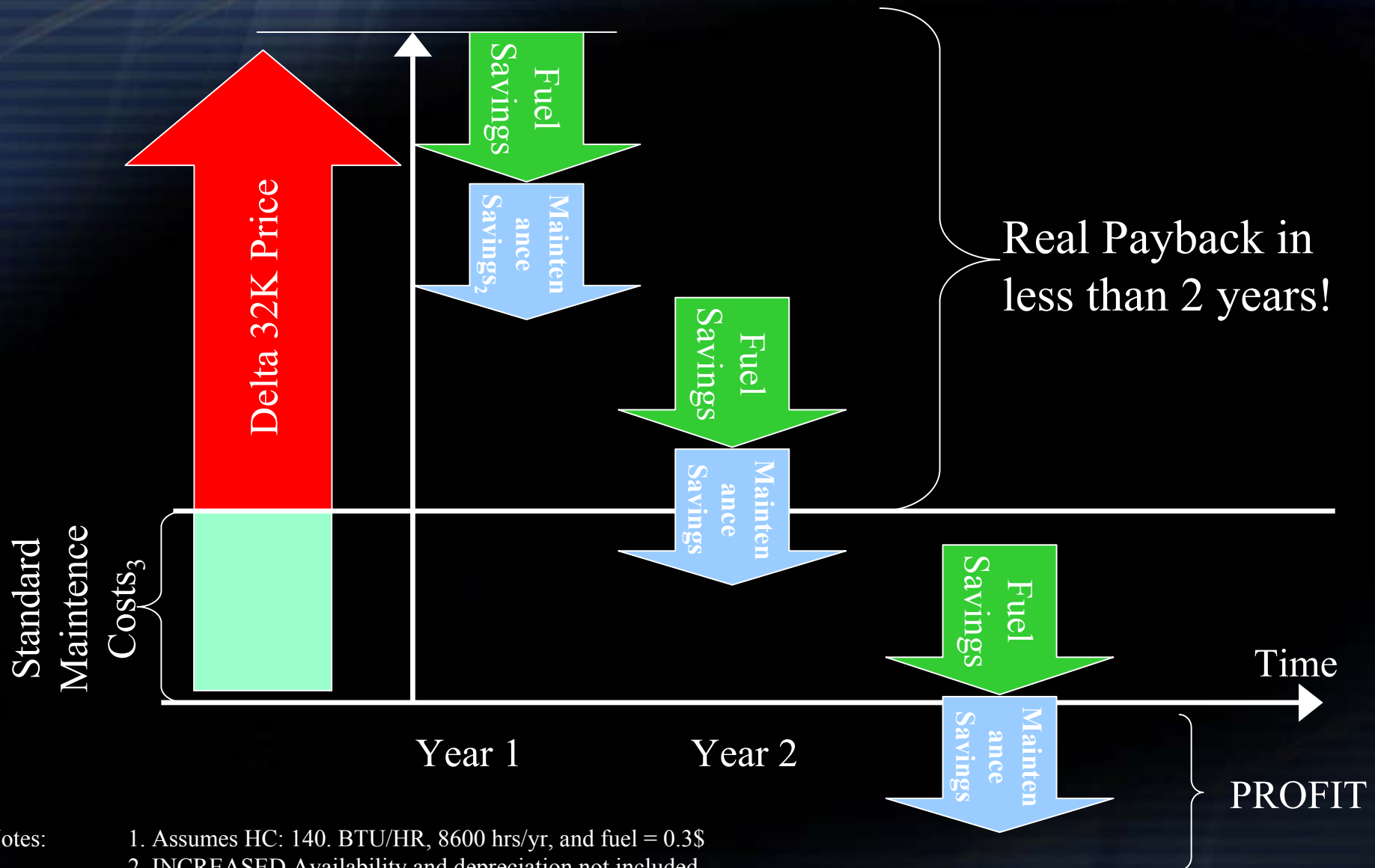
MS3/2A-G Advance Tech Uprate Hardware



GT18452A

Figure 28 MS3001/MS5001/MS5002 Advanced Technology Packages Maintenance Intervals

UPRATE BENEFITS



Notes:

1. Assumes HC: 140. BTU/HR, 8600 hrs/yr, and fuel = 0.3\$
2. INCREASED Availability and depreciation not included.
3. Assumes standard HGPcosts. MI costs higher and payback is thus quicker.

Pipeline Station Uprate vs. Add-On Unit

