

Maintenance & services for the LM6000 aeroderivative gas turbine



imagination at work

LM Maintenance Philosophy

Maximize Availability at a Minimum Cost

1. On-Condition Maintenance

- Easy to inspect internally allows for well-planned outages and repair only as necessary.

2. Maximize On-Site Maintenance Capability

- Provide detailed work-scope for all on-site activities

3. Minimize customer operation downtime during major maintenance actions

- Maximum 2-4 day outage with spare or lease engines



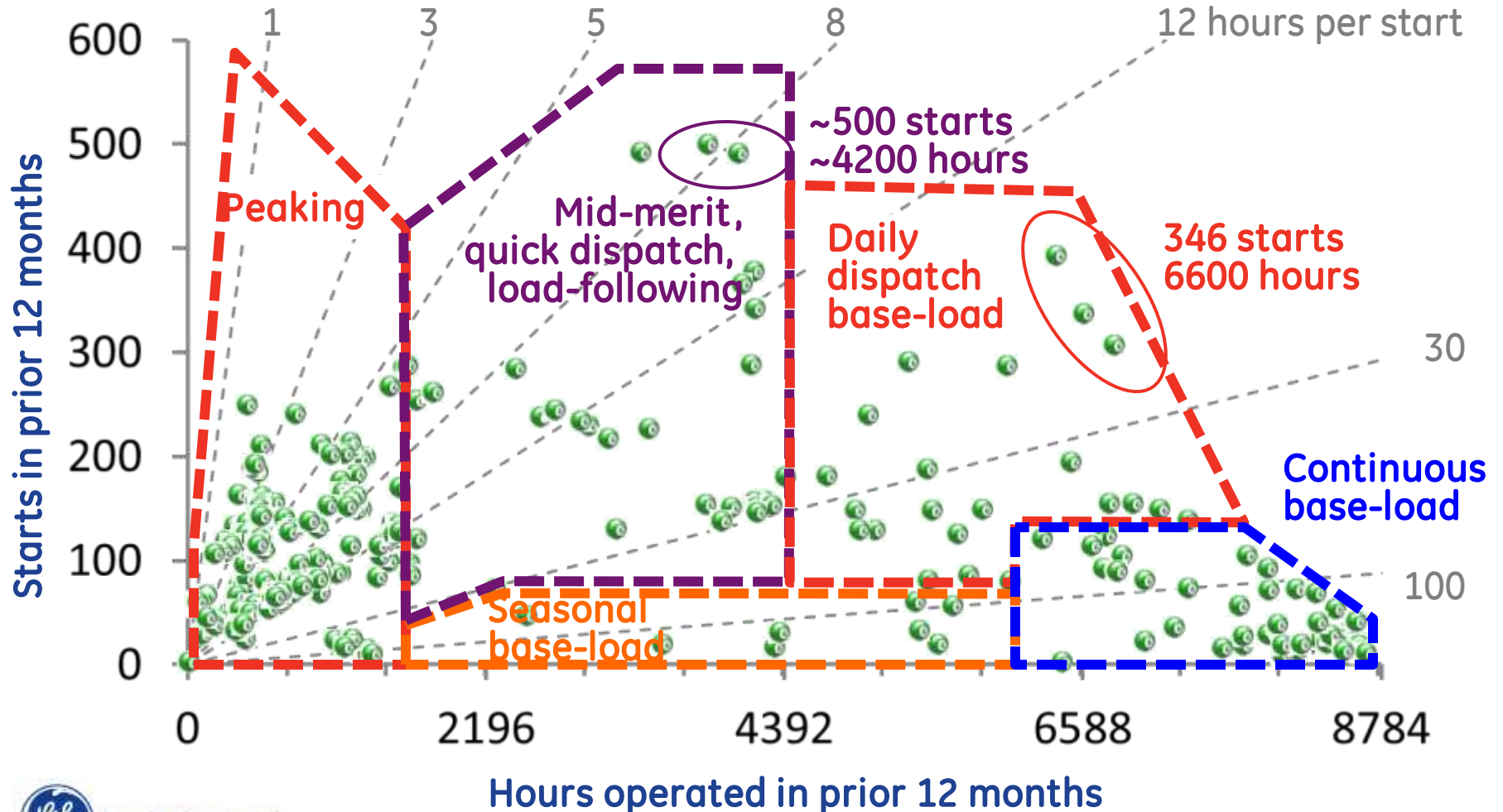
With proper planning the gas turbine should not interrupt the electric production demands. The time to do maintenance on the LM6000 gas turbine is easily scheduled during off-hours

Wide Range of Operating Schemes

LM units reporting to ORAP® for 12 month period ending July 2012

Source: ORAP®; All rights reserved: SPS®

	No. of units	Avg hours	Avg starts
LM6000	257	2767	118



Levels of Maintenance

Level I Preventative and corrective actions performed on exterior of installed gas turbine (Includes gas turbine change out)

On-Site

Level II Level I plus interior gas turbine actions performed
ON-SITE



Level III Level II plus disassembly and assembly of gas turbine down to EMU (Engine Maintenance Unit) level.

***Depot/
On-Site***

Level IV Level III plus complete disassembly and assembly of EMUs. Allows replacement of any individual piece part. Test capability required



Depot

Level V* Level IV plus repair of piece parts and control and accessory items. (*Does not exist as single entity)

On-Condition Maintenance

(For Scheduled and Corrective Maintenance)

“On-Condition”

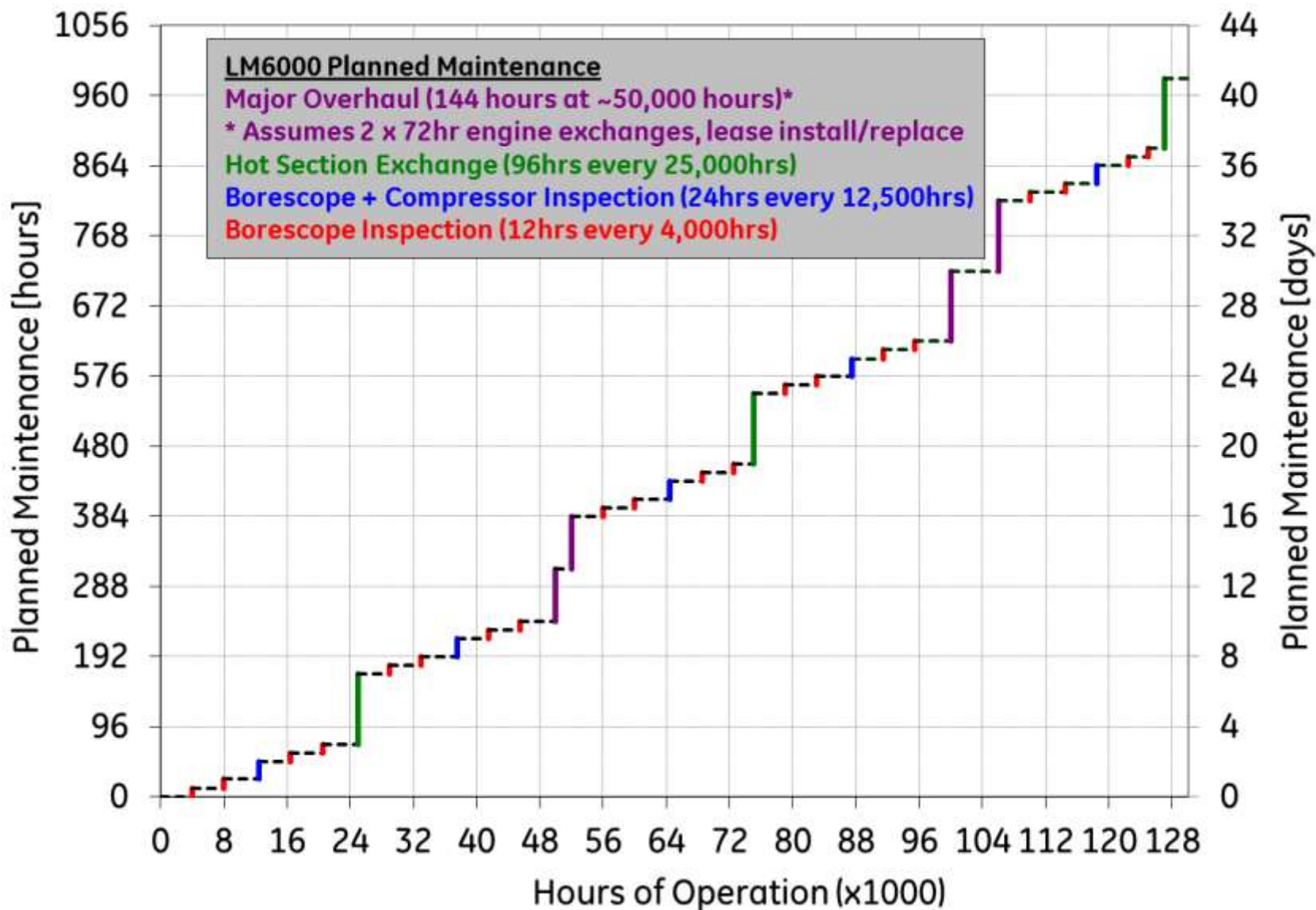
- Inspect and Repair as Necessary to Restore to Desired Operational Condition

Condition Determined by:

- Borescope Inspection Ports
- Vibration Data Monitoring
- Performance Data Monitoring
- Lube Oil Filter and Screen Inspection
- Lube Oil Analysis
- External Engine Inspections
- Re-Start Inspections & Operational Check



Planned Maintenance



Typical Scheduled Maintenance

Actual Maintenance is “On-Condition”

Hours	Scheduled Maintenance Action	Outage
4,000	Inspection (Every 4000 Hours)**	12-16 hours
25,000	On-Site Hot Section Replacement	3 days
50,000	Depot Refurbishment*	2-3 days
75,000	On-Site Hot Section Replacement	3 days
100,000	Depot Refurbishment*	2-3 days
125,000	On-Site Hot Section Replacement	3 days

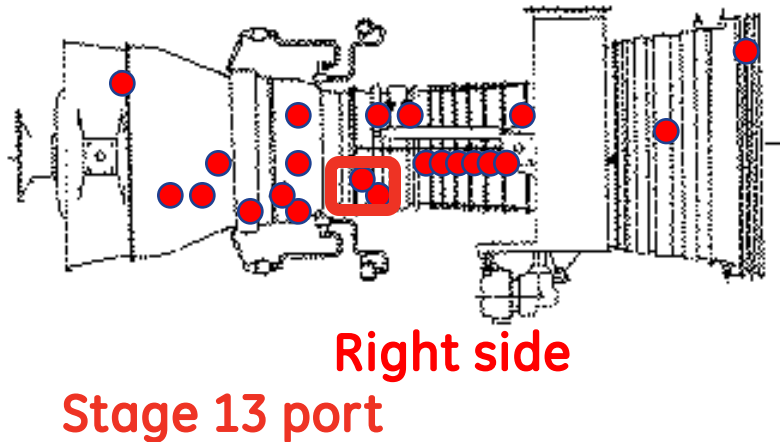
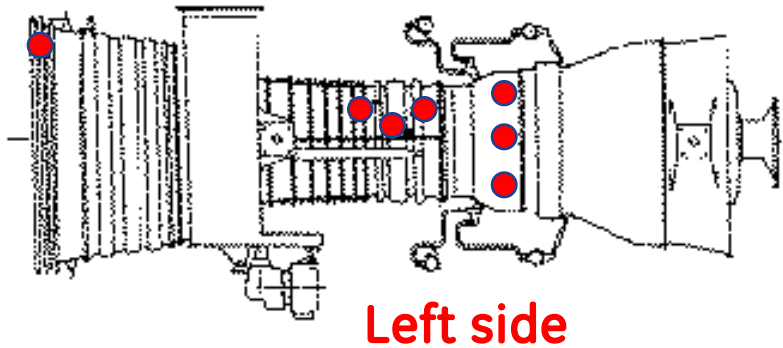
* Spare or lease engine installed during refurbishment.

** At 12,500 hours (or concurrent with every 3rd borescope) the LM6000 compressor bushing are replaced. Including borescope and bushing change this outage can take up to 24 hours

Maintenance intervals above are based on **gas fuel** operation.

Actual moment to conduct the **maintenance action** is still **determined by the condition of the hardware not the actual hour count.**

Borescope Inspections

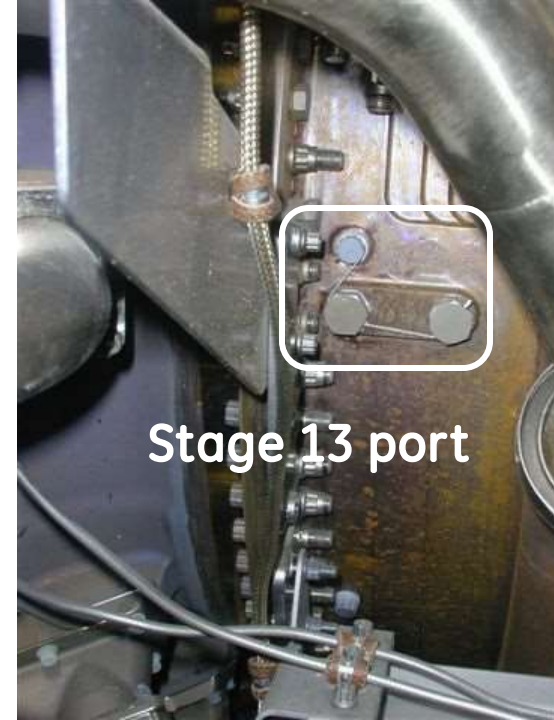


✓ Borescope ports permit inspection of the entire gas turbine:

- LPC
- HPC
- Combustor
- HPT
- LPT
- Turbine Rear Frame
- Oil system and fuel nozzles

✓ Digital transfer to the factory and engineering allows for real time analysis

✓ Borescope inspections are required every six months/4000HRs, or as directed by troubleshooting



Samples of LM6000 Borescope Inspections



LPC Blades



HPC S14 Blades



DLE Fuel nozzle



HPT S1 nozzle



HPT S1 blades

LM Maintenance - Hot Section Exchanges

- Hot-Section Exchanges
 - Repaired or New Parts Available
 - 2 to 3 Day Outage
- Customer Benefits
 - On-Site Service... No Shop Visit
 - Less Downtime... 1 Shutdown
 - Reduced Maintenance Costs
 - Firm Price... No Surprises
 - Fully Warranted Hardware
 - Immediate Availability in most cases
 - Light-Weight... easy to Handle & Transport
 - Includes required tooling, expendables and on-site labor



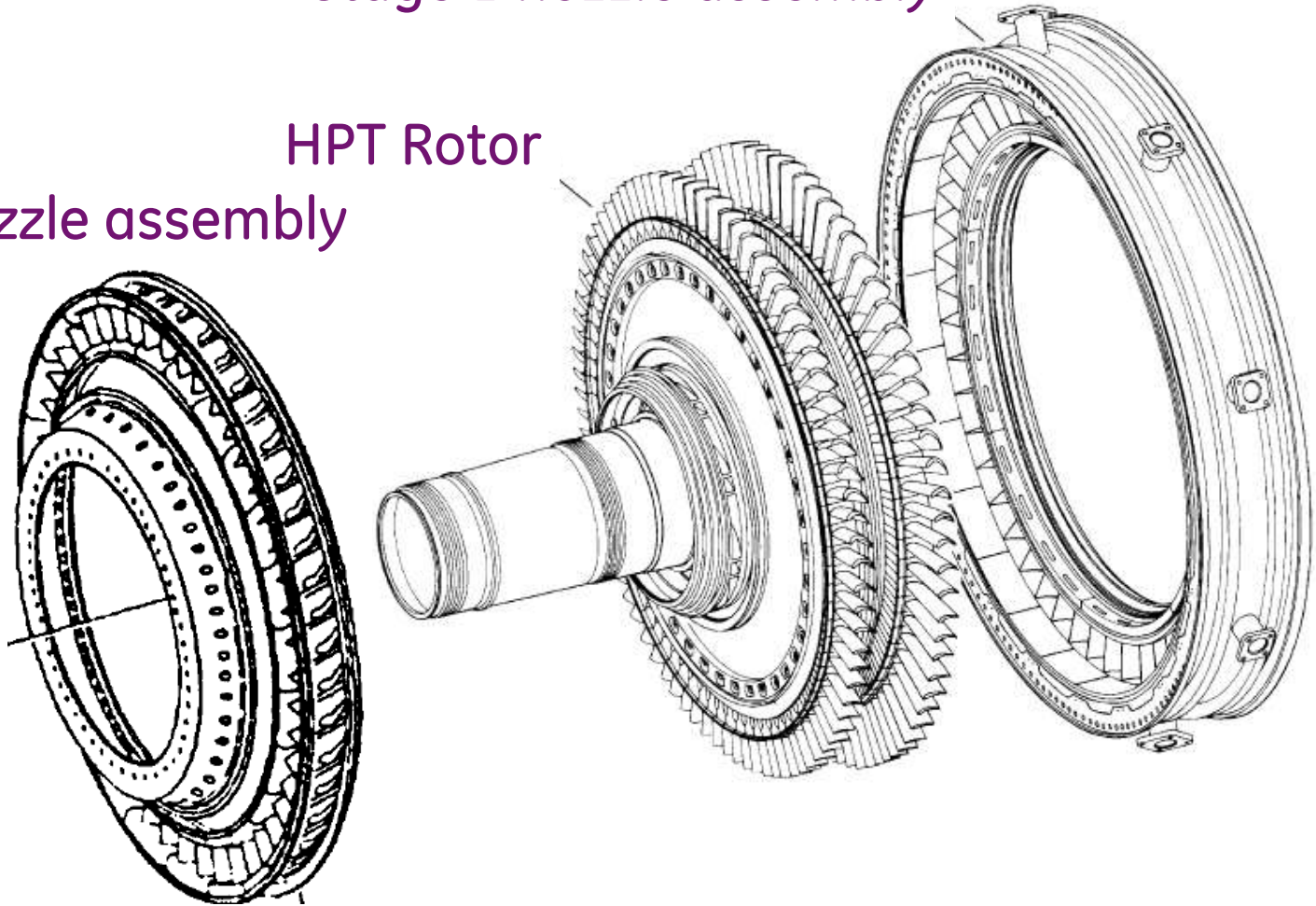
Hot Section Components

- Hot Section includes Rotable HPT Rotor, S1 and S2 Nozzles

Stage 2 nozzle assembly

HPT Rotor

Stage 1 nozzle assembly



LM Maintenance Events – Major Overhaul

- Engine is Removed from Package
- Engine is Shipped to Service Center for Major Overhaul
 - 9 – 12 Weeks
- Major Overhaul Inspect & Repair
 - High Pressure Compressor
 - Combustor Assembly
 - High Pressure Turbine
 - Nozzle Assemblies
 - Low Pressure Turbine
 - Hydraulic System, Gearbox, VIGV's



LM6000 Engine Exchange

Minimized Downtime During Depot Visits

- 2 - 3 Day Outage with Spare or Lease Engines

Package designed for ease of engine removal



LM6000 Engine Exchange



Rotable Asset Program

Rotable Engine Maintenance Unit (EMU) - Benefits

□ EMU Benefits:

- Alternative to repairing removed hardware
- On-site service (no shop visit)
- No lease engine required
- Reduced downtime (one shutdown)
- Reduced maintenance costs
- Pre-established price (no surprises)
- Fully warranted hardware

Rotable Price includes:

- Tooling
- Shipping to US location or freight forwarder

12 Month Warranty

Hardware Available 90 Days After Receipt of Purchase Order (maximum)

Removed Assemblies Become GE Property

EMU Pricing Excludes:

- Consumables & Expendables
- Field service labor

Rotable Asset Program

On-Site Hot Section Exchange Program - Benefits

GE Provides Fully Warranted, 12 Months, Components On-Site

- Fully balanced and ground HPT rotor
- Nozzle Assemblies
- Consumable Hardware
- Labor (2 reps/shift)

GE Provides Technical Assistance For

- Engine disassembly
- Removal of hot section hardware from User's engine
- Installation of GE provided hardware

Typically can be completed in a single weekend

- Single shutdown - No shop visit required
- After engine removal, change-out only requires 16-20 hours (2 reps/shift)

Contractual Service Agreements (CSA)

Comprehensive Coverage

- Corrective maintenance & unscheduled engine caused repairs
- On-Site Technical Support
- Inspections / hot section / major overhaul
- Initial spares provisioning & tooling (Optional)
- Replacement spare parts
- Lease engine use (if member)
- Transportation costs

Firm Priced Repairs & Maintenance... No Surprises

Availability Guarantee (Optional)... GE Assumes Risks

Levelled Cost Distribution through Major Overhaul

Priced by Operating Hour, Monthly or Quarterly Fee

Lease engine program & Membership

Program Features Guaranteed Availability as Outlined in Contract

- Valuable to customers with one or more full time operating engines
- Lower weekly utilization fee
- Modest annual membership fee
- Contract periods are six years in duration
- Available at reduced rates to customers with spare engine(s)

Spare Parts Services

Distribution Centers at Cincinnati International Airport and in Houston

GE expects users to have “recommended spares” on-site to improve engine availability

Maintains An Inventory Of Spare Parts For Routine And Emergency Service

Customers Specify Method Of Shipment, Expediting available

Customer Web Center – Registration On-Line

Customized Recommendations

- Each customer /site may have special requirements for availability
- GE can work with customer to develop customized listing
- Identified as consumable and insurance parts
- Improve availability by reducing downtime for part delivery
- Avoids expedite fees

Orders are screened for configuration accuracy

Monitoring & Diagnostics

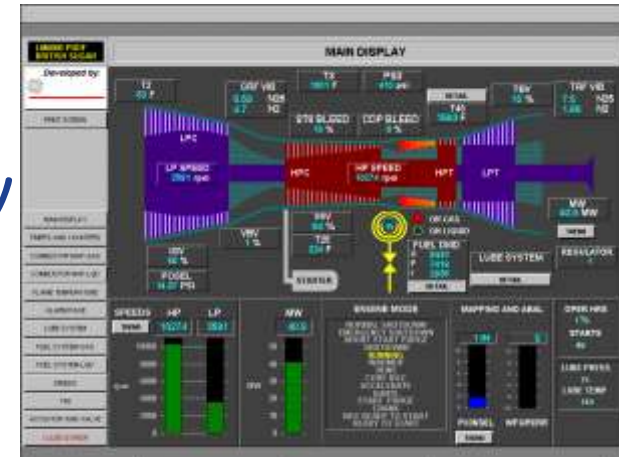
- 240 sites currently being monitored, including:
 - Power generation or mechanical drive
 - DLE and SAC combustors
 - Including very remote locations , cruise ships, pipelines and offshore platforms

Operating data acquired from control system via phone line

Valuable tool for:

- online troubleshooting with factory
- early warning of condition changes
- fault investigation
- site history & trending, etc.

Database and online viewing via the Internet



Customer Education



**Customer Technical Education Center
(CTEC)
Cincinnati, Ohio**

*Classes held at customer site require additional charges for instructor T&L

- Modern Training Facility
- Specialized Tooling and Full Scale Engines
- Familiarization Courses can be held at Customer site*

Course	Days
Familiarization (No Cost to User)	2 ½ - 3
Borescope Inspection Techniques	3 ½ - 4
On-site Maintenance (Level 1)	4 ½ - 5
Hot Section Maintenance (Level 2)	4 ½ - 5
Cold Section Maintenance (Level 2)	4 ½ - 5
Course details provided in Services Catalog	

**... Hands-On And Classroom Instruction in a
“State-Of-The-Art” Training Facility**

Keep the on-site maintenance to a minimum ...

Minimum maintenance specialization needed

- let GE provide the expertise

When major tasks are needed ...

- just get the gas turbine offsite ...
- minimal additional manpower ...
- minimizing the logistical challenge of delivering parts ...
 - It's a lot easier to ship a complete spare engine than thousands of individual parts and tools
- outage times are minimized ...
 - Gas turbines can easily be changed out in less than 48 hours (with good planning <24hours)

In summary ...

- Aircraft heritage provides for high reliability, efficiency and power
- Modular design allows for quick change out ... decreased downtime
- Prescribed service recommendations drive high availability
- Full GE Aero service capabilities provide fast response
- Customized contractual services minimize risk and maximize value