Technetics Group Overview
Corporate Structure and Capabilities
Technetics Daytona Beach Focus

Engineered Solutions for Demanding Environments
Unified Branding & Market Strategy

Partner of choice for engineered solutions in demanding applications and environments

- Semiconductor
- Aerospace
- Energy
- Medical / Pharmaceutical
One-stop Shop for Sealing Applications

- Lower load, high performance static sealing
- Dynamic large displacement hermetic sealing
- High pressure, high temp static sealing
- Abradable sealing
- Elastomeric, fire resistant sealing
- Chemical resistant sealing
- Quick disconnect sealing systems

Partner of choice for engineered sealing solutions in demanding applications and environments
Global Footprint
Revenue by Market

- Semiconductor, 31%
- Aerospace, 19%
- Oil and Gas, 10%
- Pharma, 5%
- Land Based Turbines, 4%
- Medical, 2%
- Other, 15%
- Nuclear, 14%
Daytona Beach, FL

- Formerly known as Tara Technologies
- Edge-welded bellows based components
- Manufacturing Belfab® brand products since 1954
- 52,000 sqft, 130 employees
- Aerospace, semiconductor, energy and medical markets
- SEA Operational Excellence award winner
- AS9100, ISO 9001 and NADCAP (welding, heat treat)
- Manufacturing facilities in Daytona Beach, FL and Singapore
Breadth of Capabilities

Precision Components

Assemblies

System Integration

Surface Tech
Aerospace Applications

- Aneroids - Sensors
- Reservoirs - Avionics Cooling
- Rotary Seals - Turbo Shafts
- Actuators / Sensors - Flight Controls
- Fuel Drains
- Electro-Hydraulic Actuators (EHAs) - Flight Controls
- High Pressure Maintenance Free Accumulators (HPMFAs) - Main Hydraulics & Brake Systems
## Major Platform Presence

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Breadth of Capabilities

- Precision Components
- Assemblies
- System Integration
- Surface Tech
Aerospace Products - TG Daytona Beach

- **Edge-welded bellow Precision Components**
  - Contact Seals/Drains (Kiss Seals)
  - Altitude Sensors
  - Contacting Dynamic Face Seals
  - Hydrodynamic Face Seals

- **Complex High-Performance Assemblies**
  - High-pressure maintenance free accumulators
  - Close-loop coolant system reservoirs

- **Surface treatment**
  - Thermal barrier spray coatings
  - Anti-wear spray coatings
  - Electron beam texturing
Bellows Construction

“Diaphragm”

“Convolution”

“Bellows Core”

- 80% Compression from Free Length
- Hermetic Seal
- Life of the Aircraft (1M+ cycle-life)
Altitude Sensors (Aneroids)

• High Precision Mechanical Altitude Sensor
  – Hermetic construction, bellows hermetically sealed with a fill gas
  – Stoke per unit altitude is controlled by very precise bellows spring rate

• Applications
  – Fuel control systems
  – Ejection seats (auto-arm)
  – Environmental Control Systems
  – Throttling valves
Carbon Face Seals

- Carbon face maintains contact with rotor via edge-welded bellows
  - Forgiving for axial and radial excursions
  - Accommodate high-temperature applications

- Designed and manufactured by TG Daytona since 1954

- High-temp 900F (482C) to cryogenic applications

- Also spring-energized and o-ring energized seal capability

- Spring and O-ring energized for less demanding requirement

- Applications
  - A330/B767 APU Main shaft / Gearbox
  - F-15/F-16 AMAD APU Main shaft
  - CH-47 Chinook Main Propulsion
Dynamic Sealing Positions In An Aircraft Engine

Air to Oil Sealing Main Bearing Sumps

Oil sealing gearbox and accessories
Contacting Carbon Face Seals

- Contacting Carbon Face Seals
  - Used where Air-Oil separation is needed at a rotating interface

- Typical Applications
  - Main-shaft bearing positions
  - Gearbox interfaces
  - High-duty turbo-pump locations

- Bellows-based Face Seals
  - Edge-welded bellows energizes seal providing positive contact between carbon face and rotor
  - Utilized where temperature prohibits use of elastomeric o-ring to provide positive contact
Hydrodynamic “Lift-off” Face Seals

- Next technology beyond contacting face seals
  - Pumping groves machined into mating rotor
  - Slow speed, carbon contacts rotor to prevent leakage
  - Increased speed, carbon separates from rotor, 0.001”- 0.003” air film
  - Non-contact = improved wear rates, longer life seal

- TG Daytona developing industry leading analytical tools

- In-house test rig under development - operational Q1 2013
  - Ability to test at temperature and simulated altitude (60,000 ft)

- Capability to provide bellows, o-ring, and spring energized solutions
**FEA and Analysis Capabilities**

- **Bellows Seal Design and analysis**
  - Modal Analysis
  - Lumped parameter vibration models
  - Tracking analysis
  - Fatigue Analysis
    - Cumulative fatigue damage
  - Profile shape optimization using FEA for superior fatigue, spring rate, and MED performance
  - Simulate Forming Manufacturing Processes and handling
  - Multi-linear Material Properties

- **Face seals**
  - Monolithic carbons
  - Composite seal rings

- **Same FEA thermal/mechanical analysis as bellows seals**

- **Optimize secondary seal design to minimize hysteresis**
  - Improved tracking

- **Design secondary seal for long life**
Seals Test Rig (Q2 2013)

- Preliminary performance objectives
  - Air temperatures up to 700F (370C)
  - Oil temperatures up to 350F (175C)
  - Pressures up to 100 psid
  - Altitude simulation up to 60,000 ft
  - Shaft speeds up to 70,000 rpm for hydrodynamic seals
  - Seal diameters from 1” up to 4” diameters

- Desired instrumentation
  - Torque (for contacting seals)
  - Low and high pressures near interface
  - Dynamic air leakage rate
  - Oil leakage
  - Carbon face temperatures at multiple locations
  - Air side and oil side temperatures in the seal cavity
  - Position sensors on seal face
Accumulators / Reservoirs

- High-Pressure, Maintenance-Free
  - 5,000 psi and higher
  - Fluid side pressure balanced by factory gas pre-charge
  - Fully welded, hermetically sealed assemblies = no maintenance
  - Does not require periodic gas charging in the field
  - Life of the aircraft/spacecraft

- Reservoirs
  - Low duty, volume compensation
  - Closed loop cooling systems
  - Fully welded assembly means zero potential leakage (critical for some media)
Applications

• Electro-Hydrostatic Actuators
  – Primary flight control actuators
  – Accumulator accommodates rapid flight control movement
  – Maintains system pressure
  – Landing Gear actuation

• Braking Systems
  – Main hydraulics
  – Emergency braking system (energy storage)

• Closed-loop Cooling Systems
  – Avionics/Sensor package cooling
  – Galley cooling
HPMFA (High-Pressure Maintenance-Free Accumulator)

- Weld Plug
- Guide (PTFE)
- Separator (vented)
- PEEK Seal
- End Flange
- Fluid Port
- Housing
- Gas Charge
- Piston
- Bellows
- Tee Fitting

- 100% welded construction
- Hermetically sealed
- Thermal compensation
- Life of aircraft
Competitive Technologies

**Piston**
- Gas Leakage to Fluid System
  - Elastomer Permeability
  - Wear of Piston / Housing
- Gas Leakage to Atmosphere
- Charging Valve

**Bladder / Diaphragm**
- Gas Leakage to Fluid System
  - Bladder / Diaphragm Permeability
- Gas Leakage to Atmosphere
  - Charging Valve
HPMFA (High-Pressure Maintenance-Free Accumulator)

- All potential leak path interfaces are hermetically sealed by welds
Accumulator Applications

Program and Application

Iron Gyro, Accumulator
Sverdru, ISS, Accumulator
Mecon Troll Project, Volume Compensator
Mirage 2000, IMEWS Counter-Measure System, TUCT Accumulator
Coolant Reservoir, Double Laser System
Lockheed Martin PAC-3, Radar Seeker Cooling, Volume Compensator
Defender Gun Accumulator, U.S. Army
Active Suspension System Accumulator
JPATS, Emergency Landing Gear & Flaps, Accumulator

Customer

Honeywell
NASA AMES
ABB Offshore Technology
TRITON ET DIVISION
Cymer
BOEING
Lockheed Martin
Ford Motor Co.
Dowty Aerospace

Hamilton Sundstrand
Northrop Grumman-Norden
Northrop Grumman-Norden
Valcor Engineering
RINI Technologies
LIFE SYSTEMS
LIFE SYSTEMS
Eaton-Vickers
NASA GRC

Hamilton Sundstrand
Fairchild
Honeywell
ABSC
Parker
LIFE SYSTEMS
Lockheed Martin
Western Design (Howden)
Valcor Engineering
Rolls Royce Allison

Hamilton Sundstrand
NASA Johnson
Westinghouse EMD
Honeywell
NASA MSFC
Crane Lear Romec
Schlumberger
Honeywell
Raytheon
NASA MSFC

Hamilton Sundstrand
TRW
NASA Johnson
Honeywell

Programs and Applications

Ares TVC Flight HPMFA
NG PRI Accumulator
X-33, Cooling, Accumulator
F7X, Emergency Brake Accumulator
F7X, Hydraulic System
ISS, Urine Waste Water, Accumulator
Juno Nutation Damper
Gen. Dynamics, M1A1/A2 Tanks, Thermal Mgmt. Sys., Accumulator
F/A-18 E&F, Emergency Landing Gear System APU Accumulator
Lockheed-Martin Alenia C-27J, Prop. Pitch Control, Accumulator

Titan IV, Turbopump Hydraulics, Accumulator
X-38, Cooling Freon System, Tandem Accumulators
Petrobras, High Flow Boosting, Accumulator
Lockheed Martin, F-35 JSF, PAO Reservoir
ISS, TECS (MSRR-1) & FCF, Water Accumulator
Lockheed Martin, F-22, Coolant Reservoir
DWCS Pressure Balanced Accumulator
ISS, Internal Thermal Control System, Accumulator
ALTAIR Radar Cooling, Water Accumulator
ISS, Waste Water, Reservoir

ISS, Air Conditioning System, Accumulator
IHI Japan, ISS, JEM, ECS, Accumulator
X-38, Cooling Water System, Accumulator
Airbus A350 SCS CDM Accumulator
Textbook Definition of Thermal Spray

A group of “thick film” surface modification processes in which finely divided metallic or non-metallic surfacing materials are deposited in a molten or semi-molten condition on a prepared substrate to form a spray deposit.

Particle temp, velocity, and size affect the coating properties.
Our Thermal Spray Processes

The melted or softened particulates impact the prepared surface where they flatten and bond to the substrate building-up, pass by pass to create a well-bonded coating. Post-spray heat treatment can create a metallurgical bond and precipitate secondary phases.
Coatings in a Turbine

Compressor Section
- Low temperature abradables; felt metal or aluminum-based APS coatings
- Higher temperature abradables; nickel-based APS coatings
- Tungsten carbide wear coatings

Combustion Section
- Thermal barrier coatings with MCrAlY bond coatings

Turbine Section
- MCrAlY rub / abradable coatings, MCrAlY oxidation coatings, thermal barrier coatings

- Rotating blades
- Stationary vanes
- Combustion liners
- Transition ducts
- Seals
Engineered Coatings

- Coating Selection and Optimization
  - Current performance and requirements of alloy/coating
  - Kepner-Tregoe analysis of failures/problems / decisions
  - Identify alternative coatings
  - Feedstock (alloy, size, etc) selection
  - Design of Experiments DOE of gun parameters
    - Optimize residual stress, efficiency, hardness, bond strength, porosity, wear/erosion resistance, etc.
    - Define process window

Coating Performance

Feedstock Material Properties

Process Optimization and Control
Turbine Coating Families

- **Bond/Oxidation/Corrosion Coatings**
  - EM-1413 HVOF Ni-5Al
  - EM-1413F APS Ni-5Al
  - EM-5001 HVOF CoNiCrAlY
  - EM-5010 HVOF NiCoCrAlYHf

- **Thermal Barrier Coatings**
  - EM-3401F APS 8%Yttria-Stabilized Zirconia
  - EM-3402F APS 8%YSZ, high purity
  - EM-3410F APS Advanced TBC, NASA

- **Diffusion-Aluminide Coatings**
  - EM-1051F APS aluminum + diffusion heat treatment
  - EM-1051S Slurry aluminum + diffusion heat treatment
  - *Either can be applied directly to superalloy surfaces or to MCrAlY coatings*

- **Fretting Wear Coatings**
  - EM-1210F APS Copper-Nickel-Indium
  - EM-1114 HVOF Tribaloy 800
  - EM-1114F APS Tribaloy 800
  - EM-2002 HVOF WC-Co
  - EM-2510 HVOF Cr3C2-NiCr

- **Abreadable/Clearance Control Coatings**
  - EM-4001F APS A1Si-20Boron Nitride
  - EM-4010F APS A1Si-40Polyester
  - EM-4045F APS NiCrAl-21Bentonite
Deland, FL

- Aerospace, Defense & Land Based Turbine quality trained workforce
- 50,000 square feet
- Feltmetal® Abradables, Acoustics and Metal Brush Seals
- Have manufactured Gas Path Seals for over 40 years.
- Formerly known as Technetics - acquired in January 2010
- AS9100
Products

- Three Product Families
  - Acoustic Feltmetal®
  - Abradable Feltmetal®
  - Metal Brush Seals

- Other Products
  - Non-Acoustic Feltmetal®
  - Wick Materials
  - Burner Plates
  - Porous Applications
  - Propeller Brakes
Acoustic Feltmetal®

• Lined Ducts for Various Applications
  – Fan Ducts
  – Inlet Cowlings, Inlet Ducting
  – Auxiliary Power Units (APU)
  – Environmental Control System (ECS)

• High Temperature Resistance:
  – Stainless Steels - service up to 930F/500C
  – Hastelloy-X - service up to 1100F/600C
  – FeCrAlY - service up to 2000F/1100C

• Low Weight

• Low Pressure Drop

• Effectiveness with changing noise and gas flows.

• Erosion and Corrosion Resistant
Abradable Seals

• Superior Performance
  – Lower load during excursion
  – Improved blade tip wear rate
  – Lower blade tip temperature

• Materials
  – Hastelloy-X, up to 1,350F
  – FeCrAlY, up to 1,800F

• Blade Tip Speeds up to 1,400 ft/s

• Radial and Axial sealing
Abradable Seal Applications

- BLADE OUTER AIR SEALS
- INNER AIR SEALS
- Labyrinth Seals
- Fan
- LPC
- HPC
- LPT
- HPT
Brush Seals

- Improved Leakage Performance
  - 5X - 17X over labyrinth seals
  - Significant efficiency gains
  - Metal Brush Seals

- Brush seal technology
  - Absorb radial deflection during transient operation
  - Follows the rotor back to steady-state position
  - Maintains minimum leakage

- Brush pack material
  - Cobalt or nickel alloy
  - 50 - 150 micron dia.
  - Optimal combination of wear and oxidation resistance
Columbia, SC

- Aerospace and Nuclear quality trained workforce
- Formerly known as Helicoflex
- EnPro Industries 2008 Business of the Year
- High Performance Metal Seals
Seal configurations

- **Helicoflex**
  - Ultra-high vacuum or very low pressure applications
  - Ideal for sealing on smooth surfaces
  - $1 \times 10^{-9}$ He cc/sec

- **O-flex**
  - High-pressure/temperature
  - Minimal spring back, moderate-high seating load
  - $1 \times 10^{-9}$ He cc/sec

- **C-flex**
  - High-pressure applications
  - Lower seating load than O-flex, used when less clamping force is available
  - $1 \times 10^{-4} \rightarrow 1 \times 10^{-9}$ He cc/sec
Seal Configurations

• **E-Flex**
  - Very low load
  - High spring back, reusable
  - < 25cc/sec Nitrogen @ 50 psig per circumferential inch

• **Machined Seals (K-seal, Boss seal)**
  - Gas & Liquid Fuel Delivery
  - AS5202 ports, Nozzles, AN Fittings, etc.
  - Cryogenic to 1,800F
  - Up to 15k psi
  - $1 \times 10^{-5}$ He cc/sec
Plating Options

- Available to improve sealing performance with less than desirable surface finish (> 16 RMS)

- PTFE T < 450°F
- Silver < 8,00°F
- Gold < 1,200°F
- Nickel < 1,600°F

- Typical thicknesses 0.001” - 0.003”
# Resilient Metal Seals

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### Seating Load
- High
- Moderate

### Leak Rate Approximation
- Helium
- Ultra-Helium
- Helium Bubble
- Low Bubble
- Helium

### Leak Legend
- Recommended - Excellent
- Recommended - Good
- Optional - Special Design
- Not Recommended

### Approximate Leak Rates per Meter of Circumference
- Ultra-Helium: $\leq 1 \times 10^{-11}$ std. cc/sec He
- Helium: $\leq 1 \times 10^{-9}$ std. cc/sec He
- Bubble: $\leq 1 \times 10^{-4}$ std. cc/sec He
- Low Bubble: $\leq 25$ cc/sec @ 50 psig Nitrogen per inch of diameter
## Typical Applications

### Aerospace

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<tr>
<td>Laser &amp; RF Guidance Systems</td>
<td>DELTA®</td>
<td>HELICOFLEX®</td>
<td></td>
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</tbody>
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Leicester, England

- Formerly known as Wide Range Elastomers, Ltd.
- Formed 2002 (privately owned SME)
- 52,000 sqft, 130 employees
- Business founded on niche market
  - Polymer seals for UK military aerospace aftermarket
- Grown customer base to 100+
- Acquired in October 2009
- AS/EN9100
Airframe Seals

- **Standard sections**
  - Molded, cut, profiled

- **Materials**
  - Silicone w/ reinforcement
  - Fluorosilicone w/ reinforcement

- **Reinforcement materials**
  - Dacron Nylon (misc. grades)
  - Glass fabric
  - Metal inserts (Aluminum, St. Steel)
  - Composite inserts (pre-preg, GRP)
Fire Seals

• Standard sections and 3D molded shapes
  – Molded, cut, profiled

• Silicone material with
  – Glass cloth
  – Nomex
  – Ceramic

• Operating temp -60C to 230C

• Fireproof
  – Resist flame penetration, 1100C for 15 minutes