



# **GTEN 2019 Symposium**

**October 21-23, 2019 | Banff, Alberta**

## **19-GTEN-101**

# **EVOLUTIONARY IMPROVEMENTS OF SIEMENS SGT-A35 GAS TURBINE (INDUSTRIAL RB211)**

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**Presented at the Gas Turbines Energy Network (GTEN) 2019 Symposium  
Banff, Alberta, Canada - October 2019**

**The GTEN Committee shall not be responsible for statements or opinions advanced in technical papers or in symposium or meeting discussions.**



## GTEN 2019 Symposium

# Agenda



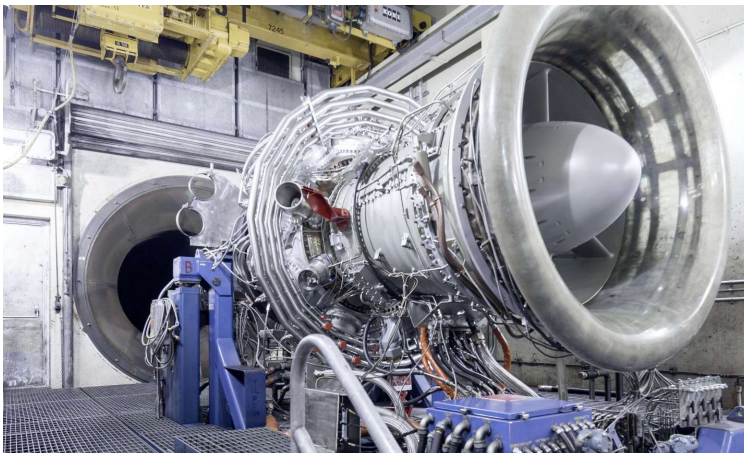
- **SGT-A35 Product & Applications**
- Evolutionary enhancements
- Using disruptive technologies  
...wisely



# GTEN 2019 Symposium

**SGT-A35 (Industrial RB211)**

**Trusted power, everywhere**



- ✓ Over 43 million service hours across wide application range
- ✓ Continuously improved to achieve class-leading reliability
- ✓ Aero lineage provides high efficiency and operational agility
- ✓ Low emission dry / wet options
- ✓ Fast engine exchange to maximize uptime and availability
- ✓ No “hot lockout” by inherent design

**Proven in mission-critical service to support Customer operations worldwide**

## Mechanical Drive

### Pipeline compression



## Power Generation

### Floating offshore



### Fixed offshore







### Industrial Power





## GTEN 2019 Symposium

# Siemens Aeroderivative Gas Turbines

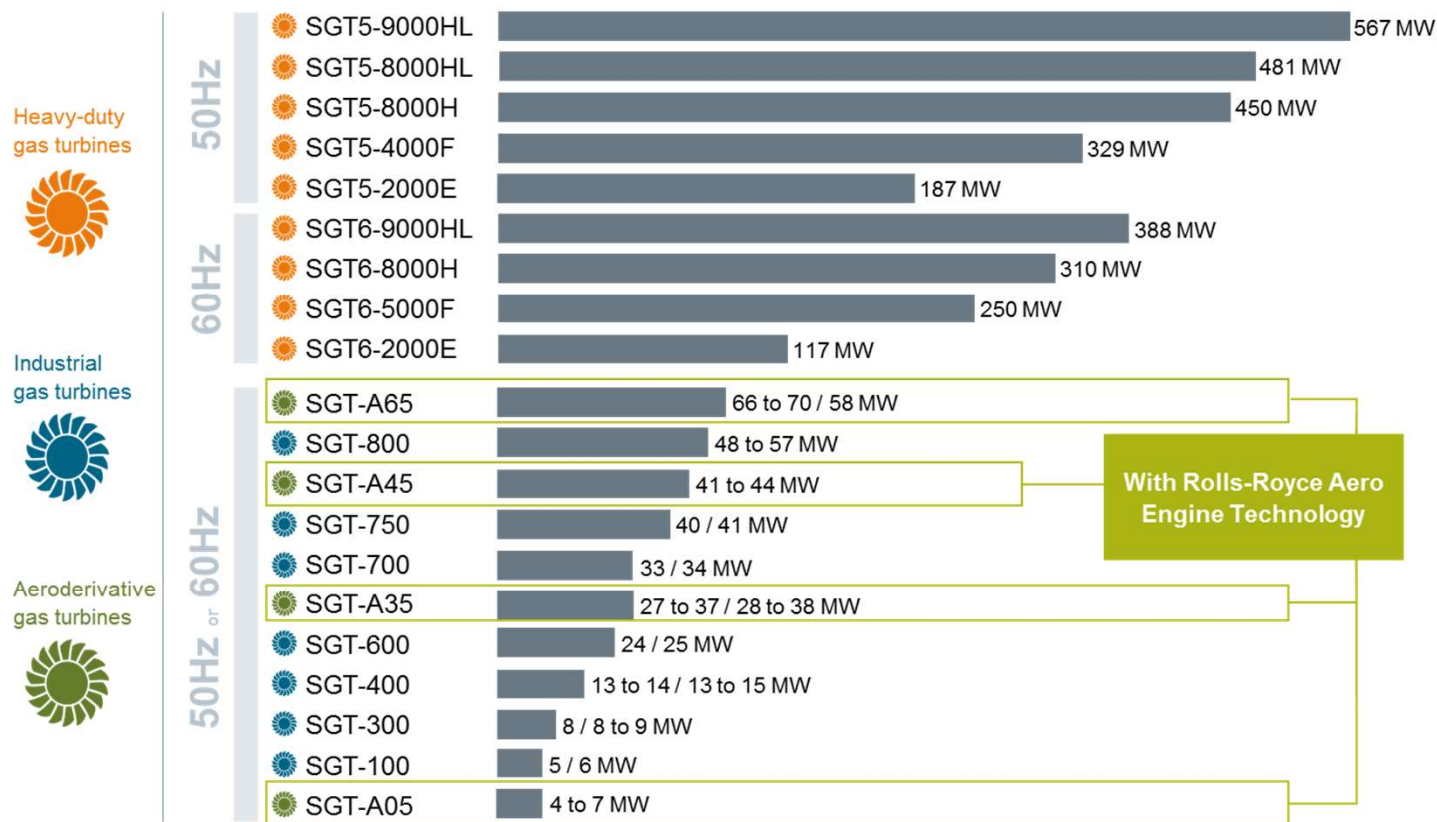
	Rolls-Royce name	Siemens name
	Industrial 501-K	SGT-A05
	Industrial Avon 200	SGT-A20
	Industrial RB211	SGT-A35
	Industrial Trent 60	SGT-A65





# GTEN 2019 Symposium

## Siemens Gas Turbine Portfolio



Power Generation / Mechanical Drive ISO ratings



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# SGT-A35 Portfolio

### Gas generator

**G**  
(Intro 1993)



**GT(A)**  
(Intro 1999)



**GT(B)**  
(Intro 2017)



### Power turbine

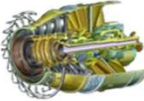
**RT62 4,800 rpm**  
(Intro 1985)



**RT61 4,850 rpm**  
(Intro 2001)



**ST30 3,000 – 3,600 rpm**  
(Intro 2008<sup>1</sup>)



### Gas turbine

**SGT-A35 (G62)** 29.1 MW<sub>s</sub>  
**SGT-A35 (GT62)** 30.9 MW<sub>s</sub>



**SGT-A35 (GT61)** 33.8 MW<sub>s</sub>



**SGT-A35 (GT30 34 MW)** 33.7 MW<sub>s</sub>  
**SGT-A35 (GT30 38 MW)** 38.1 MW<sub>s</sub>



### Focus applications

**Pipeline compression**  
(Mechanical drive)

**Offshore**  
mechanical drive/  
power generation

**Offshore**  
mechanical drive/  
power generation

<sup>1</sup> ST30 Power Turbine Entry Into Service with Rolls-Royce MT30 Marine gas turbine

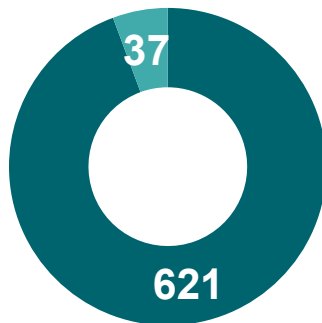
**Modular variants for an ideal application fit**



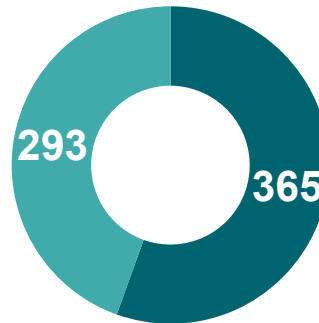
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# SGT-A35 (Industrial RB211) Fleet statistics

over **650 units**

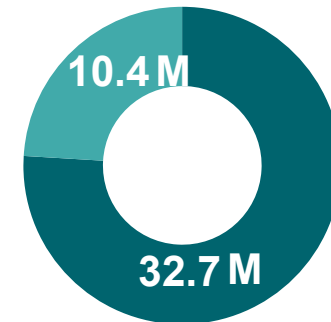


■ Oil & Gas



■ Onshore ■ Offshore

over **43M hrs**



■ Mechanical Drive

Lead unit hours

>206,000

Fleet in Canada

> 90 units and > 9M hrs

Last update: September 2019



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# SGT-A35 recent orders

**Offshore  
Production  
(Generation +  
Compression)**

**23x SGT-A35 units of which:**

- ❑ 17x SGT-A35 (GT30)
- ❑ 4x SGT-A35 (GT61)
- ❑ 2x SGT-A35 (G62)



**Pipeline  
Compression**

**8x SGT-A35 (GT61) DLE units  
with Siemens RFBB 36 pipeline  
compressor**



**Strong position in fast-growing Oil & Gas markets**





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# A consistent product strategy

- Focus on core applications
- Incremental enhancements to a proven and reliable product
- Technology “download” from Siemens, Rolls-Royce, Dresser-Rand

### Pipeline Compression



- ☐ OPEX improvements: heat rate, service cycle
- ☐ Power Turbine incremental improvements (RT62, RT61)
- ☐ DLE emissions – NO<sub>x</sub> and CO capability

Roadmap supported by Siemens leadership in Additive Manufacturing



### Offshore O&G



- ☐ Intro GT30 variant – compact package, 34 MW and 38 MW
- ☐ Incremental Reliability, Availability & Maintainability
- ☐ Improvements of Dual Fuel DLE capability

Sustained R&D investment in a product line of strategic importance to Siemens



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# Agenda



- SGT-A35 Product & Applications
- **Evolutionary enhancements**
- Using disruptive technologies  
...wisely



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# RT62X Power Turbine enhancement

### Benefits – configured to suit

- ☐ Power Turbine Time Between Overhauls up to 132k hrs
- ☐ Heat rate improvement up to 2.5%
- ☐ Power increase up to 6%
- ☐ Flexible offerings to optimize power or life enhancement
- ☐ Available for aftermarket and new unit

### Scope – applying proven technology

- ☐ 1<sup>st</sup> and 2<sup>nd</sup> stage nozzle guide vanes
- ☐ 1<sup>st</sup> and 2<sup>nd</sup> stage blades
- ☐ Honeycomb tip seals
- ☐ Casing insulation
- ☐ GT operating limits
- ☐ No change to: Gas Generator, PT casing, disc interface

Applicability			
SGT-A35	G56 / C56	DLE	non-DLE
	G62 / C62		
	GT62		
	GT61		
	GT30		



Incremental benefits, tailored to Operator requirements

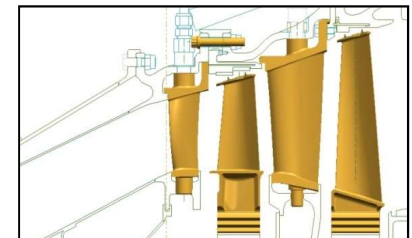


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## Key parameters – RT62X Upgrade

RT62 Current				RT62X Upgrade		
SGT-A35 Variant	Gas Generator	MTBO	Power Turbine Entry Temp. (PTET)	Power gain (ISO)	Heat Rate gain (ISO)	MTBO
C62 *	– C *	Case-by-case	750 °C	2%	2.7%	Case-by-case
G62	– G	100k hrs	780 °C	2%	2.5%	132k hrs
			785 °C	3%	2.7%	100k hrs
GT62	– GT	100k hrs	780 °C	2%	2.4%	132k hrs
		50k hrs	790 °C	3%	2.5%	100k hrs
			800 °C	6%	2.6%	50k hrs

(\*) Aftermarket only



Applies 3D vortex design and materials proven in RT61



Flexible offerings to optimize for life or power enhancement





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# RT61 Time Between Overhauls 100k hrs

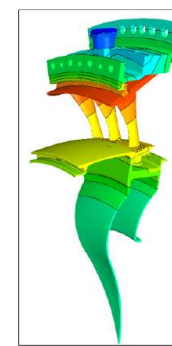
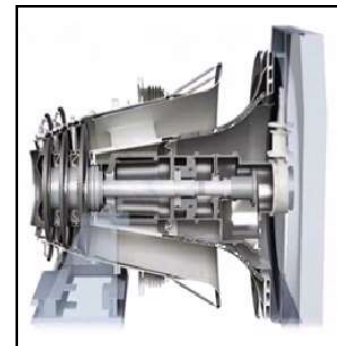
### Benefits

- ☐ Double Time Between Overhauls (TBO) 50k hrs to 100k hrs
- ☐ Increased availability
- ☐ OPEX savings
- ☐ No interim inspection up to 100,000 hours
- ☐ Now standard for new units
- ☐ Drop-in upgrade for existing units

### Scope

- ☐ Application of Siemens proprietary coating, a proven technology, to life limited components of the power turbine:
  - ☐ 1st stage vanes
  - ☐ Blade tip seals
- ☐ Improved corrosion and oxidation protection
- ☐ No change in geometry and performance

Applicability			
SGT-A35	G56 / C56	DLE	non-DLE
	G62 / C62		
	GT62		
	GT61		
	GT30		





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## RT61 “Cold Match” 1<sup>st</sup> stage Optimized performance in cold climates

Applicability			
SGT-A35	G56 / C56	DLE	non-DLE
	G62 / C62		
	GT62		
	GT61		
	GT30		

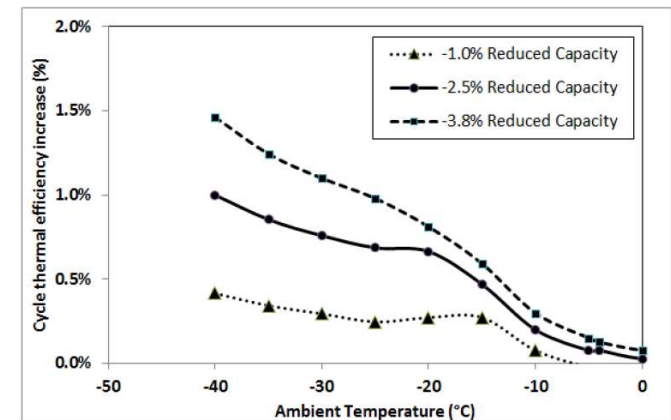
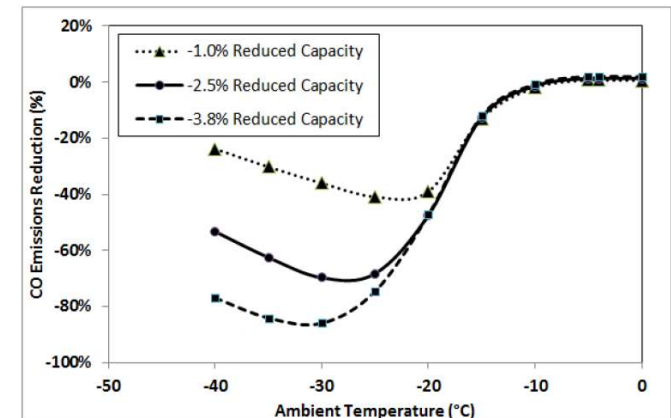
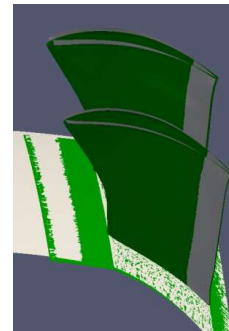
### Benefits

- ❑ Enhanced performance in cold ambient and part power conditions (ref. pipeline stations in Western Canada):
  - ❑ Improved heat rate (up to ~ 1%)
  - ❑ Reduced CO emissions – up to ~ 40%
- ❑ Power Turbine overall design unchanged

### Scope

- ❑ “Skewed” close stage 1 vane (reduced effective area)
- ❑ No change to RT61X 100k mean-time to overhaul
- ❑ New vane fast-tracked via 3D printed wax pattern casting

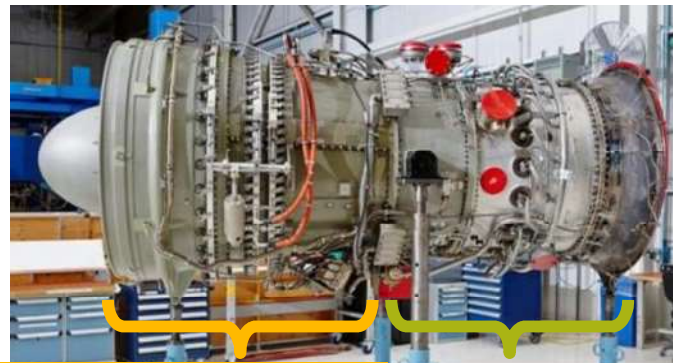
7x units ordered for pipeline compression stations in Western Canada





# SGT-A35 Core Engine up-rate

- **SGT-A35 (GT30)** available in **two variants: 34 MW and 38 MW**
- **10% more power** – highest in its class
- Based on proven **compressor upgrade**
- **Same firing temperature**
- Same **package interfaces**



Upgraded compressor

Existing hot end



Same Power Turbine

Nominal ISO rating	34 MW	38 MW
<b>Mechanical Drive (3,429 rpm)</b>		
Shaft power output	33.7 MW	38.1 MW
Shaft thermal efficiency	39.1 %	40.3 %
<b>60 Hz electrical generation</b>		
Power output A/C	33.2 MW	37.4 MW
Simple-Cycle Efficiency	38.5 %	39.7 %

**Significant performance gain through evolutionary upgrade**



## GTEN 2019 Symposium

# Agenda



- SGT-A35 Product & Applications
- Evolutionary enhancements
- **Using disruptive technologies  
...wisely**





## GTEN 2019 Symposium

# The disruption: Additive Manufacturing (AM)



Siemens is a world leader in applied AM

**120,000** operating hours on Siemens turbines

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**40** 3D printing machines operational worldwide

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**100** specialized engineers

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**200** components identified for AM until 2025

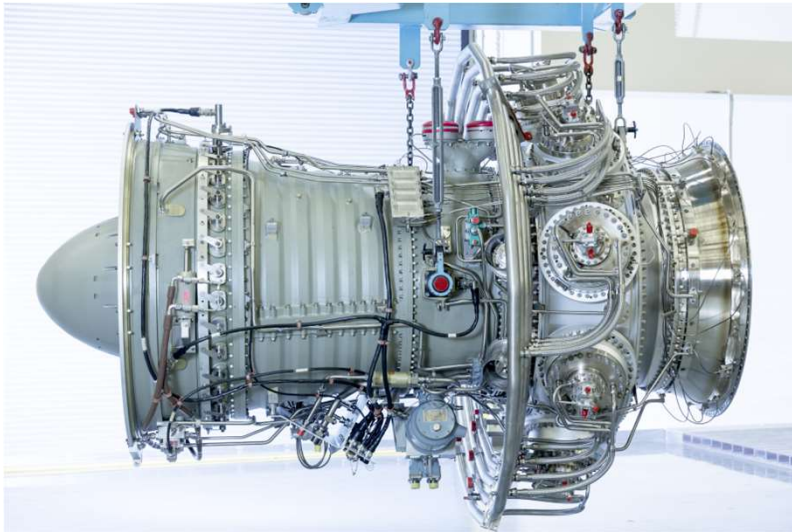
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**15** components already commercially implemented



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# Application case: SGT-A35 DLE



- ☐ Air & fuel pre-mixed for low NO<sub>x</sub> and CO
- ☐ Two pre-mixed stages for flexible operation
- ☐ Dual Fuel option



**200+**

Engine fleet  
SGT-A35 DLE

**7 Million**

Combined  
fleet hours

**3+ Million\***

DLE fleet in  
Canada

**150,000 hrs\***

Fleet leader

\* Last update: September 2019

**AM provides ideal optimization opportunity for 3D flow passages**



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# Case Study: Dual Fuel DLE injector

## Utilizing Additive Manufacturing to enhance capability

### Background

- ❑ Existing DF DLE injector based on proven Gas-Only design, with slight differences in some features
- ❑ Non-optimal noise signature when running at very low-power
- ❑ Root Cause: positioning of gas fuel injection holes (constrained by manufacturing process)

### Solution

- ✓ **Additive Manufacturing** of Central Fuel Injector – benchmarked to **proven gas-only design**
- ✓ Fuel passages optimized in ways **not viable with conventional manufacturing**
- ✓ Robust validation – **4x iterations in ~ 7 months**
- ✓ Released to production with **much shorter development cycle time**
- ✓ **Low-power noise anomaly now eliminated**



**AM extends design space with game-changing speed of iterations**

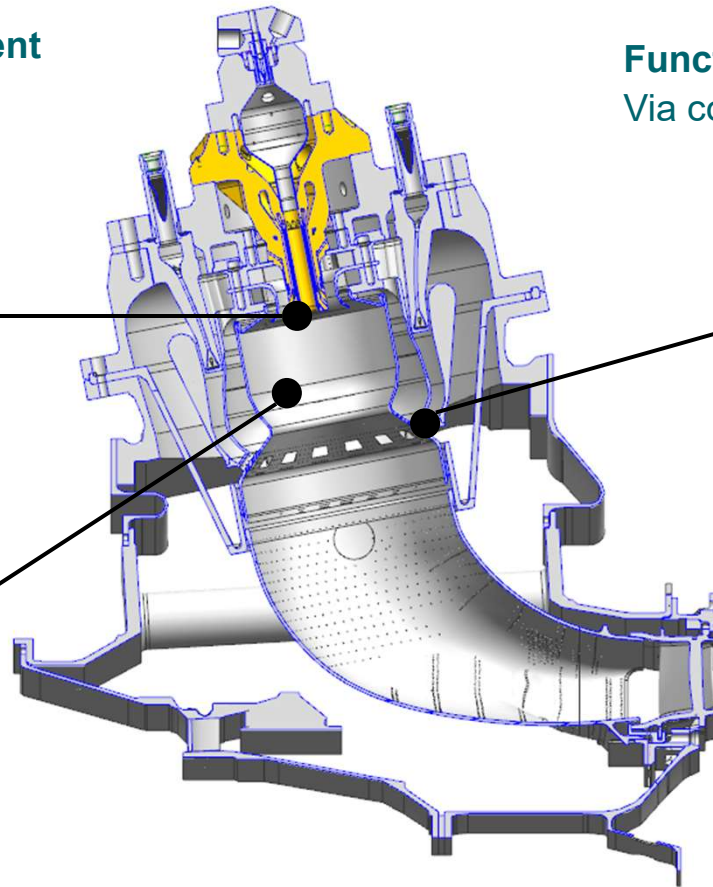


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# SGT-A35 DLE enhancement

Incremental improvements to a proven architecture

**AM Component development**  
Rigorous qualification



**Functional validation & optimization**  
Via combustion rig & engine testing



- ❑ AM enables agile & robust iterative development
- ❑ Combined with experience on known systems, Customer input & rigorous validation
- ❑ Only use AM where it makes sense to enhance the overall product functionality





# **Conclusions**

- ☐ **The SGT-A35 remains strategic to Siemens**
- ☐ **Strong position in core applications: Offshore Oil & Gas and Pipeline Compression**
- ☐ **Sustained R&D investment with a consistent product strategy**
- ☐ **Several life cycle enhancements recently released**
- ☐ **Applying latest advancements like AM selectively to enhance specific features**

**Incremental improvements – stay true to a trusted legacy**