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15TH SYMPOSIUM ON INDUSTRIAL APPLICATIONS OF GAS TURBINES



RECENT ADVANCEMENTS IN FACTORY PACKAGING TECHNOLOGY

by

GE Power Systems

**Presented at the 15th Symposium on Industrial Application of Gas Turbines
Banff, Alberta, Canada - October 13 - 17, 2003**

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

Biographies Session 1.4

Jim Prochaska

Jim Prochaska is presently Manager of Evaluations, Analysis & Pricing for GE's Aero Energy Products business, located in Houston, TX.. His organization assists potential customers in their project development activities using a variety of technical and economic analysis models.

GE Aero Energy builds and services GE gas turbine generator units in the 5 to 50 MW range. Prime movers utilized are the GE5, GE10, LM2000, LM2500, LM2500+ and LM6000 engines manufactured in Evendale, Ohio and Florence, Italy. The complete packages are completed and tested in Houston.

Jim joined GE Aero Energy (Stewart & Stevenson at the time) in 1985, working in Account and Sales Manager positions. Previously, he was with GE's Power Systems group since 1973, working in sales and application engineering for power generation products.

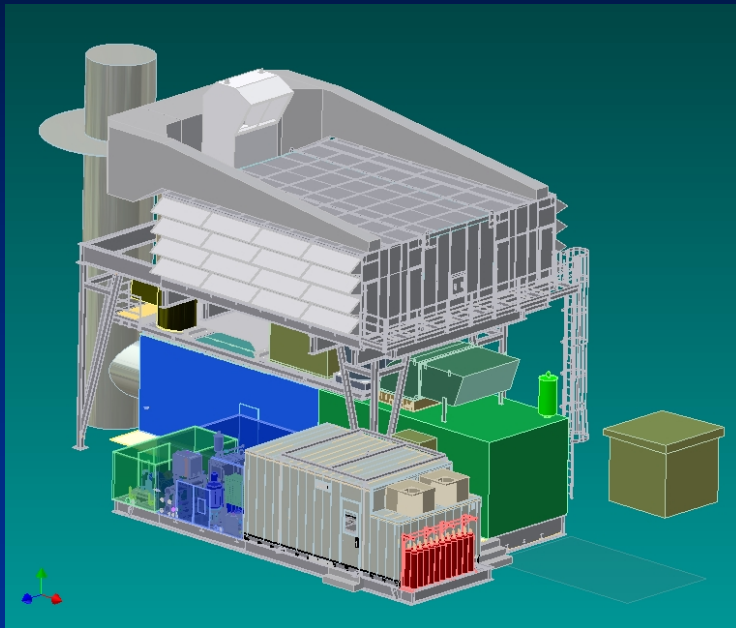
Jim received a Bachelor's Degree in Mechanical Engineering from University of Houston in 1973, and an MS, Electric Power from Union College in 1975. He holds a US Patent and is a registered professional engineer in the State of Texas.

Jim and his wife, Vivian, live in Houston with their three daughters.



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Recent Advancements in Factory Packaging Technology



IAGT 15th Symposium

October 14-17, 2003

Package Improvement Goals ...

- **Maintain Current Capabilities**
- **Reduce Customer Installation Requirements**
- **Lower Total Installed Cost**
- **Shorter Installation Time**
- **Improved Maintainability**
- **Higher Reliability / Availability**

Measurable Improvements

How did we determine what to improve?

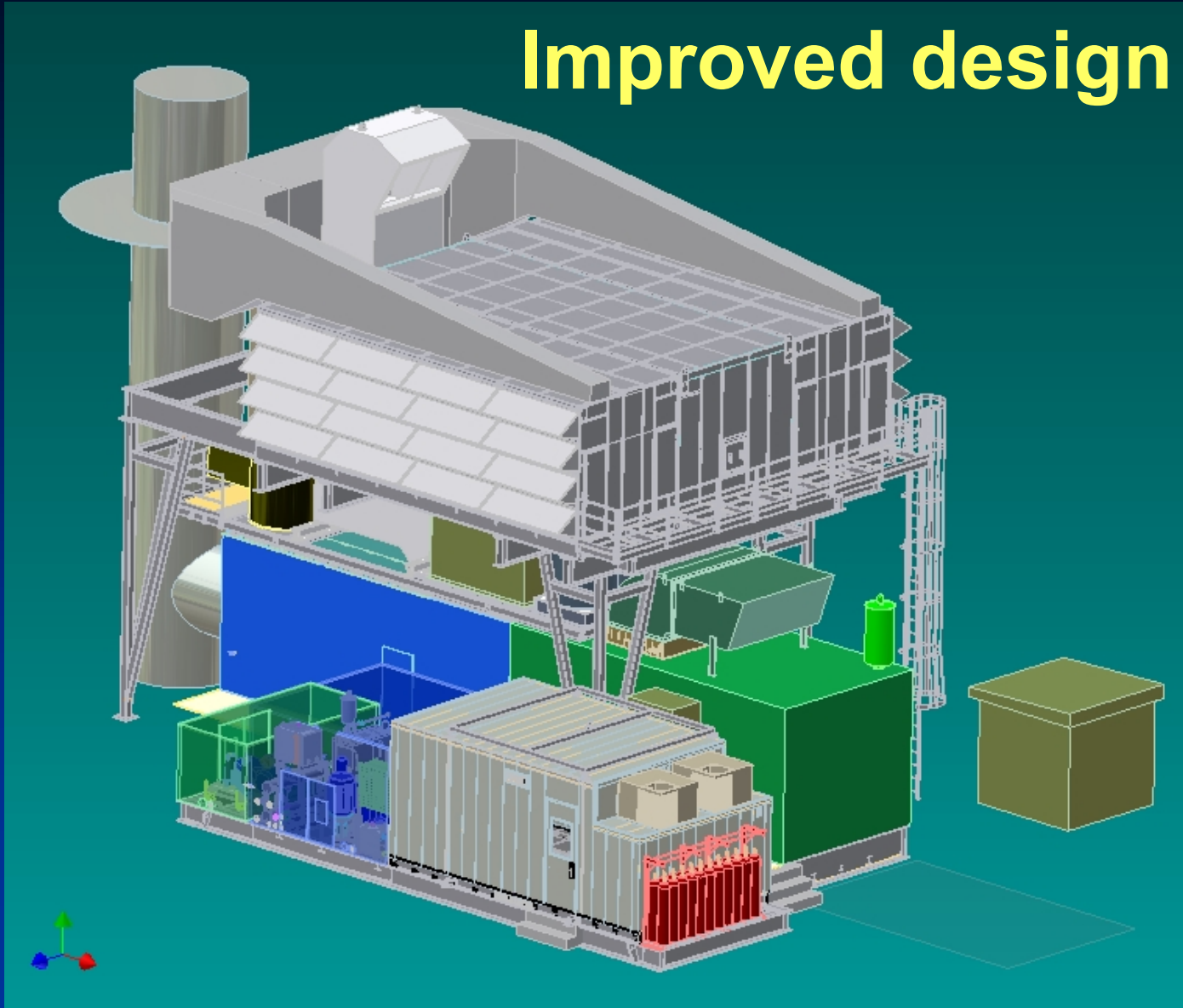
- Customer Input (User Conference, Site Visits and Surveys)**
- Identifying Problems Systems (ORAP, Warranty, Customer feedback)**
- Use of Proven Methods and Technology from other product lines such as the TM2500 and Marine 2500**
- Use of Best Practices from Current Designs**
- Latest Technology**

Customer Input is Driving Change

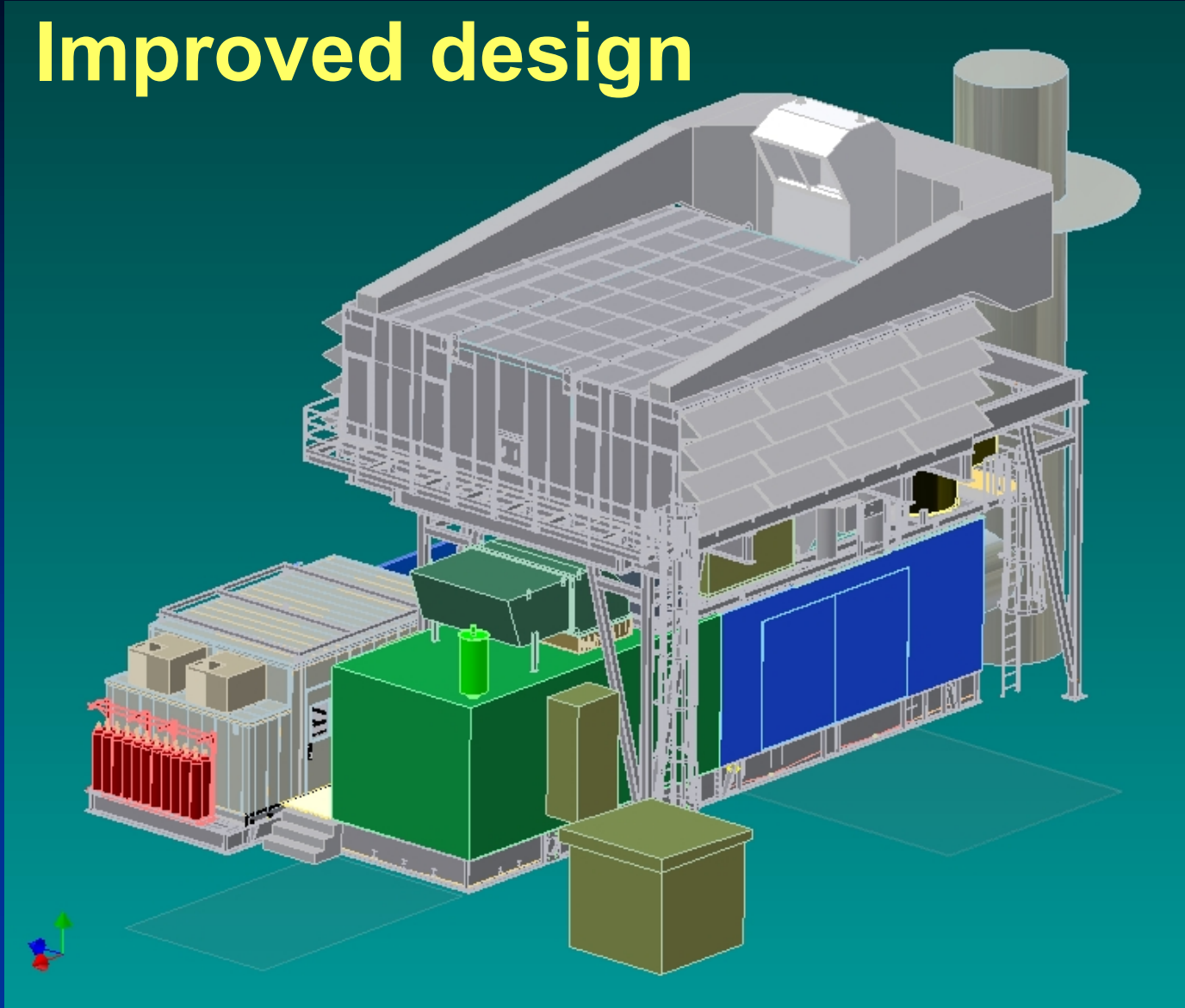
Previous design

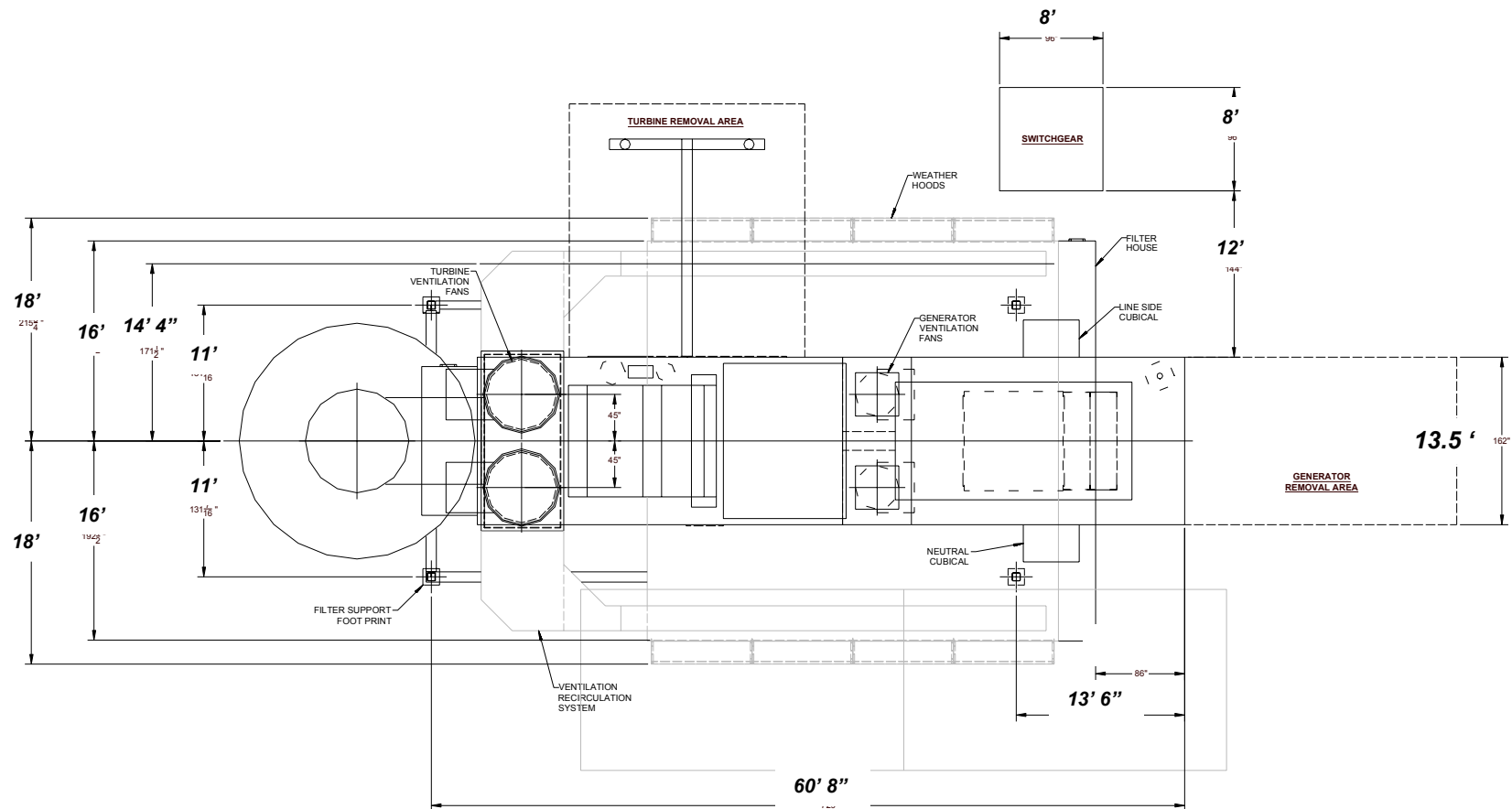


Improved design

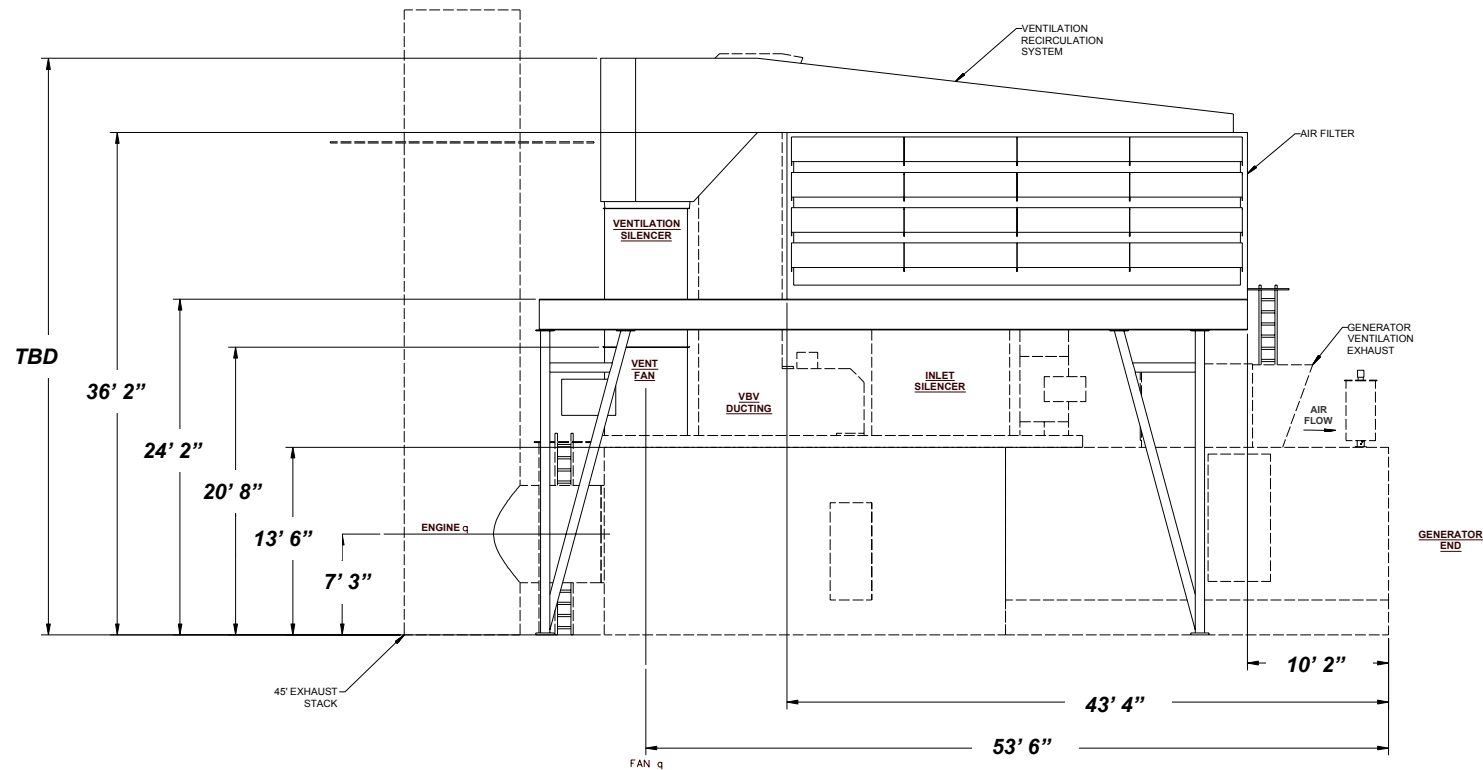


Improved design





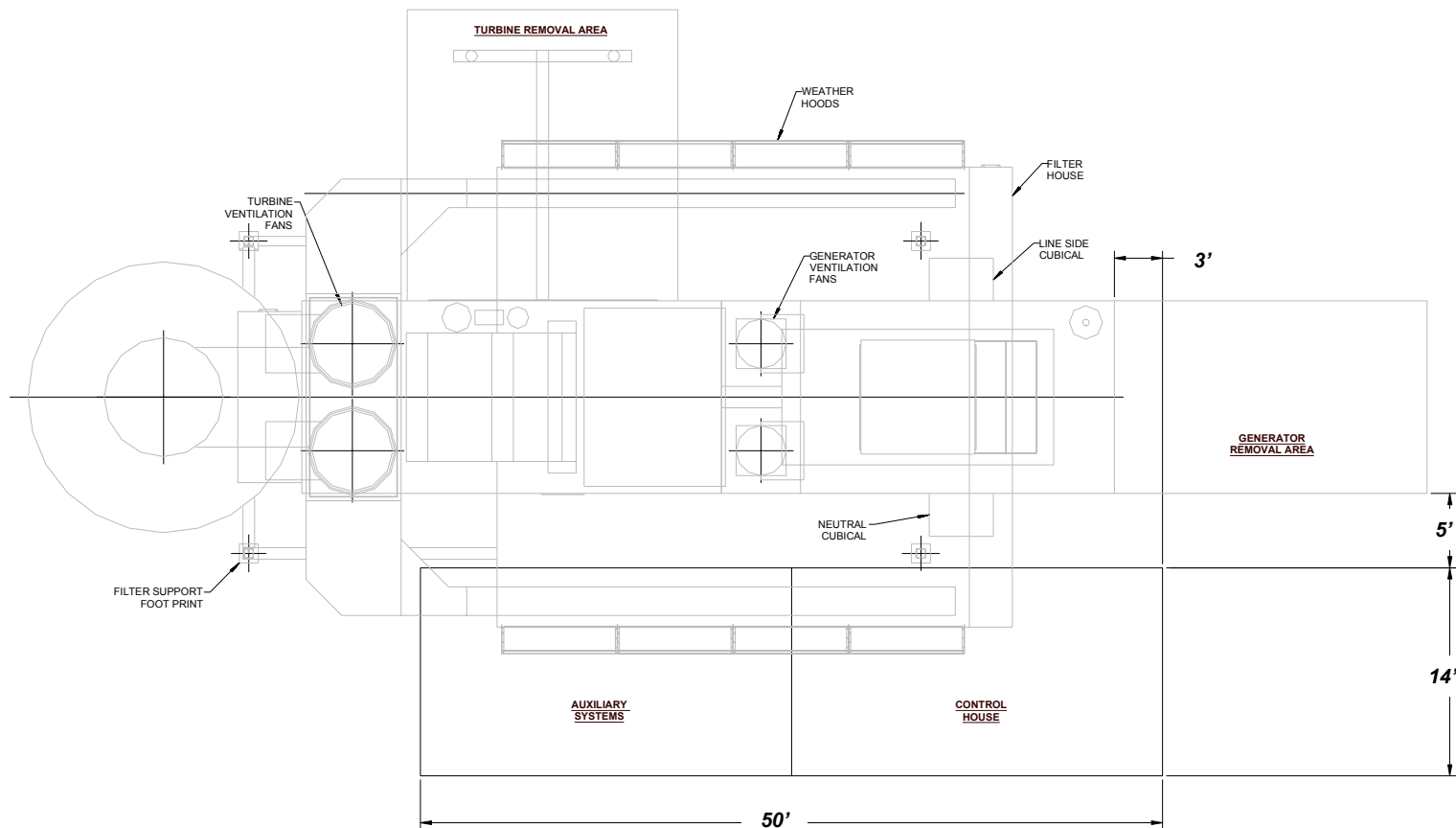
Left Hand Unit General Arrangement



LM 6000 Next Generation

GE Aero Energy Products

Left Hand Unit General Arrangement



Reduced Customer Installation Requirements

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- **Reduced Interfaces**

- Standard Pre-wired Control House
- Standard Pre-wired MCC
- Auxiliary Skid Pre-wired

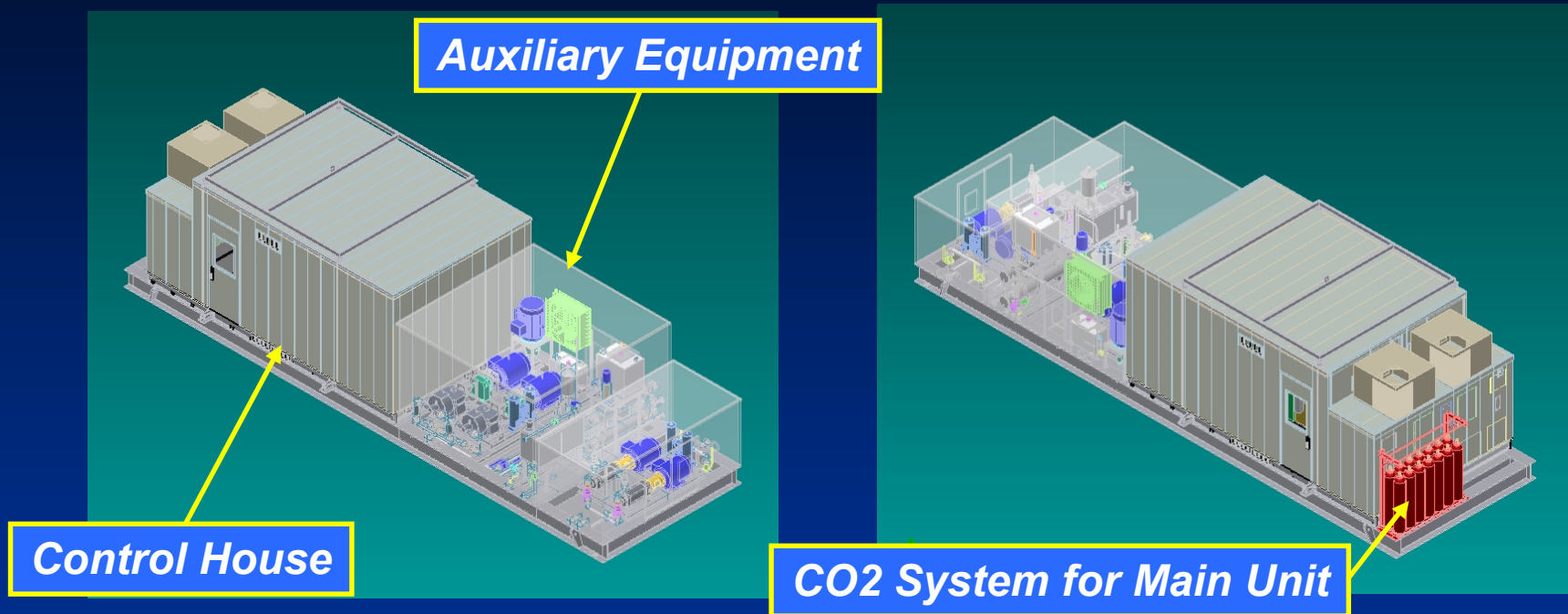
- **Standardized BOP Scope**

- Standard Switchgear, Breaker and MCC
- Standard 125 Vdc Batteries
- Standard Gas Filter
- Standard Cable Tray between Control House and Turbine Skid

- **Standard Options**

- Optional HP Water Injection Filter and HP Liquid Fuel Filter
- Optional Ventilation Recirc Anti-Icing and Evaporative Cooling Systems
- Optional Ladders, Platforms and Walkways
- Optional off-skid Gas Purge Valves

How we will simplify customer interfaces ...

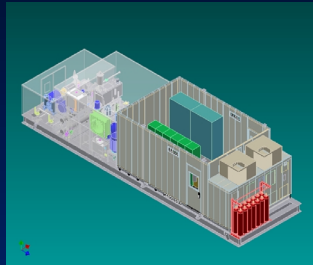


With the Control House located on the Auxiliary Skid and all terminations for Auxiliary equipment completed in the factory the cable runs have been significantly reduced. They have been further reduced by using Fiber Optic cable on all communication paths between skids with the exceptions of the Fire, Vibration and Emergency Shutdown switches.

Control House

GE Aero Energy Products

How we will simplify customer interfaces



**Fire & Gas
Battery Charger**

24VDC Battery Chargers

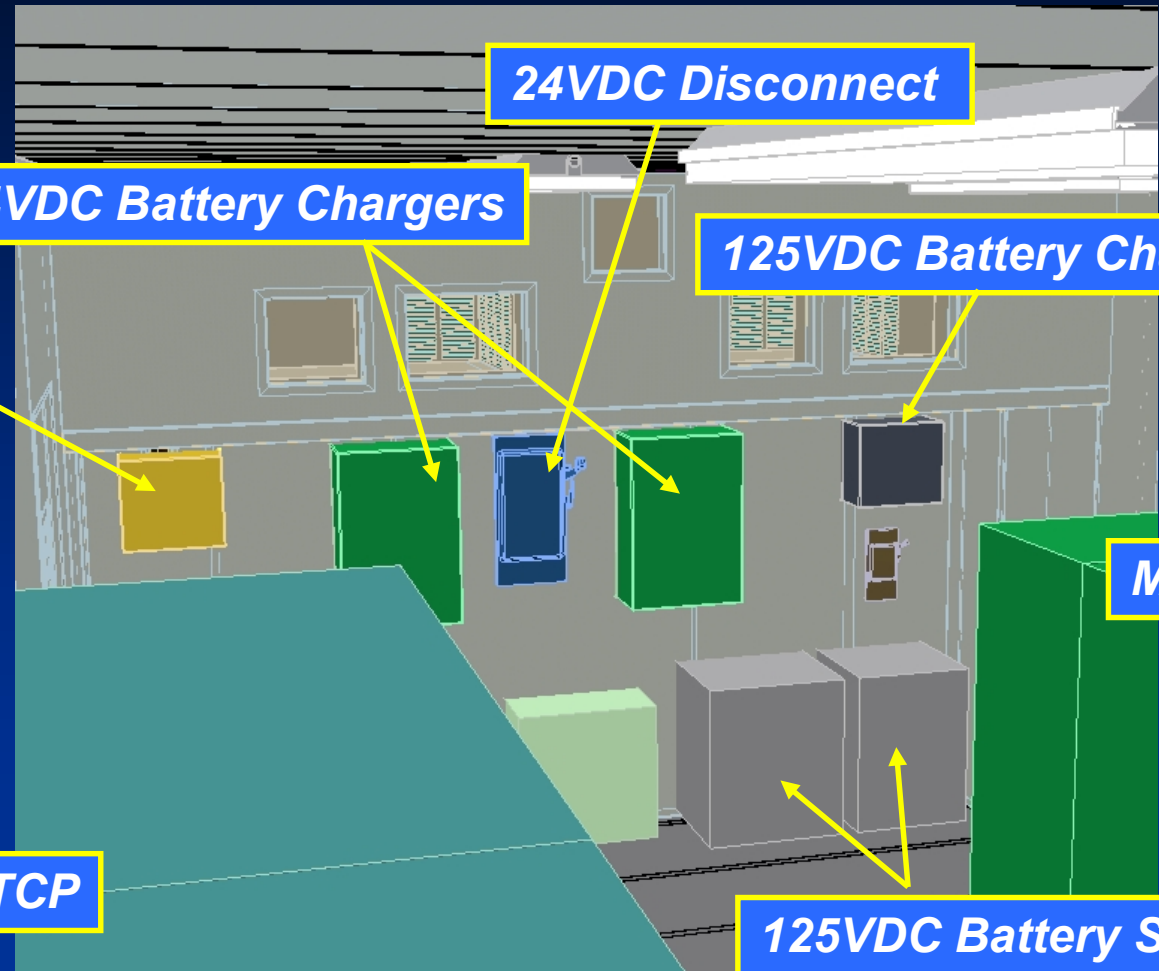
24VDC Disconnect

125VDC Battery Chargers

MCC

TCP

125VDC Battery System



Former design - LM 6000 Auxiliary Skids



Liquid Fuel Skid



Auxiliary Skid with
~ GLO system
~ TLO System
~ Water Wash System
~ Hydraulic Start



Water Injection Skid



C02 Skid



Control House



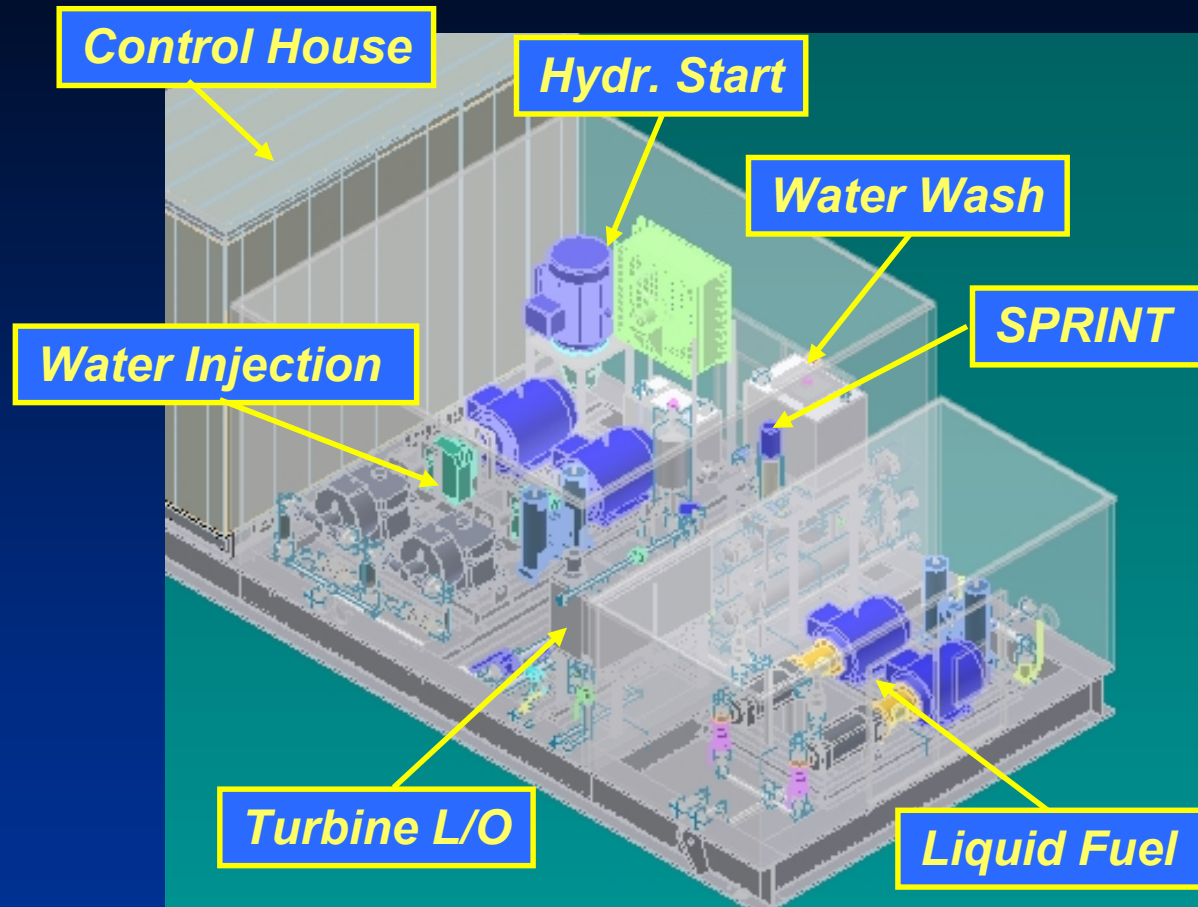
SMEC Skid



SPRINT Skid

LM 6000 New Auxiliary Skid

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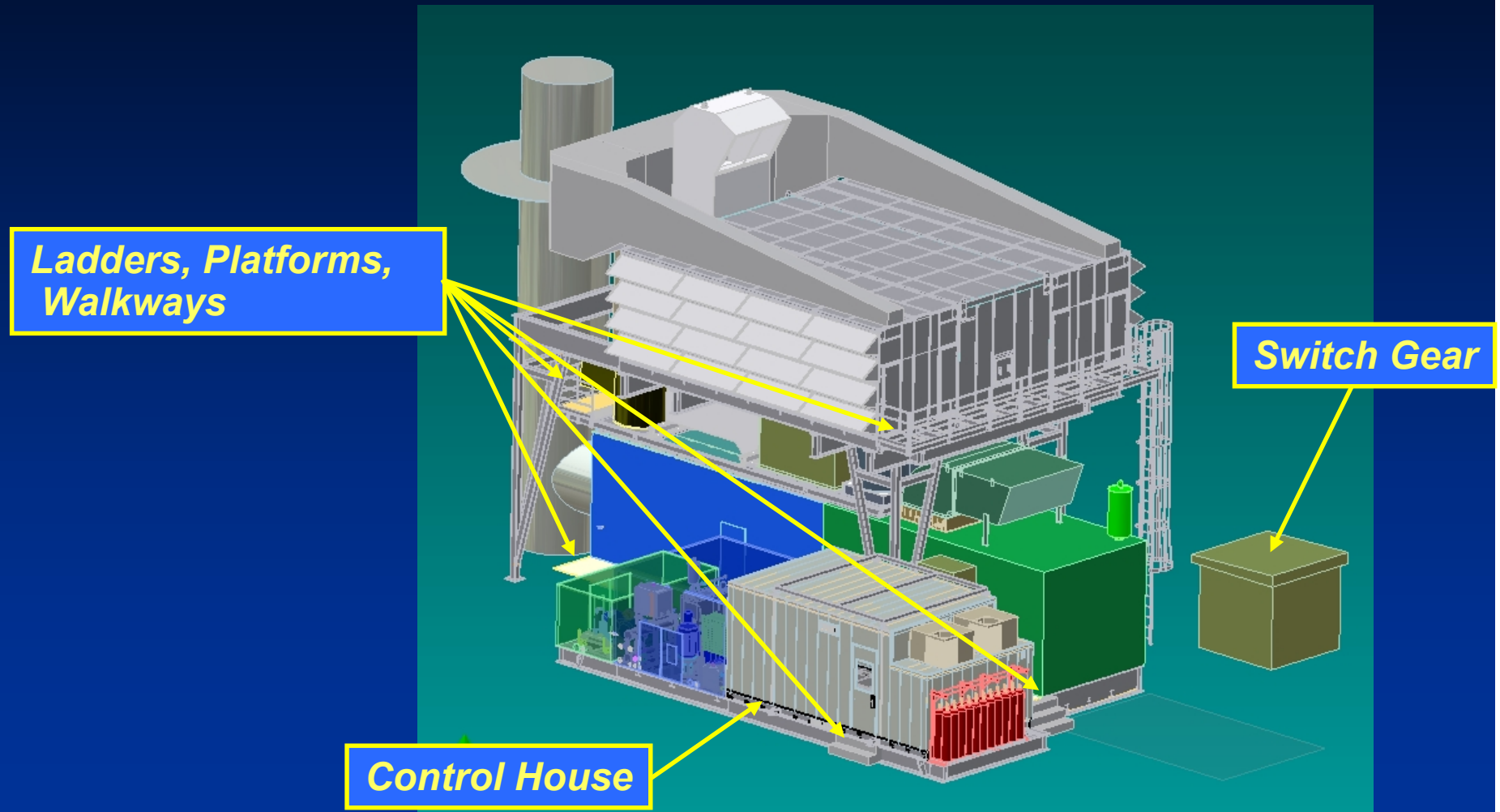


Advantages:

- ***Reduce Customer Interfaces***
- ***Reduction in Field Wiring***
- ***Shorter Installation Time***
- ***Less Package Interconnects***
- ***Reduction in Cable Trays***

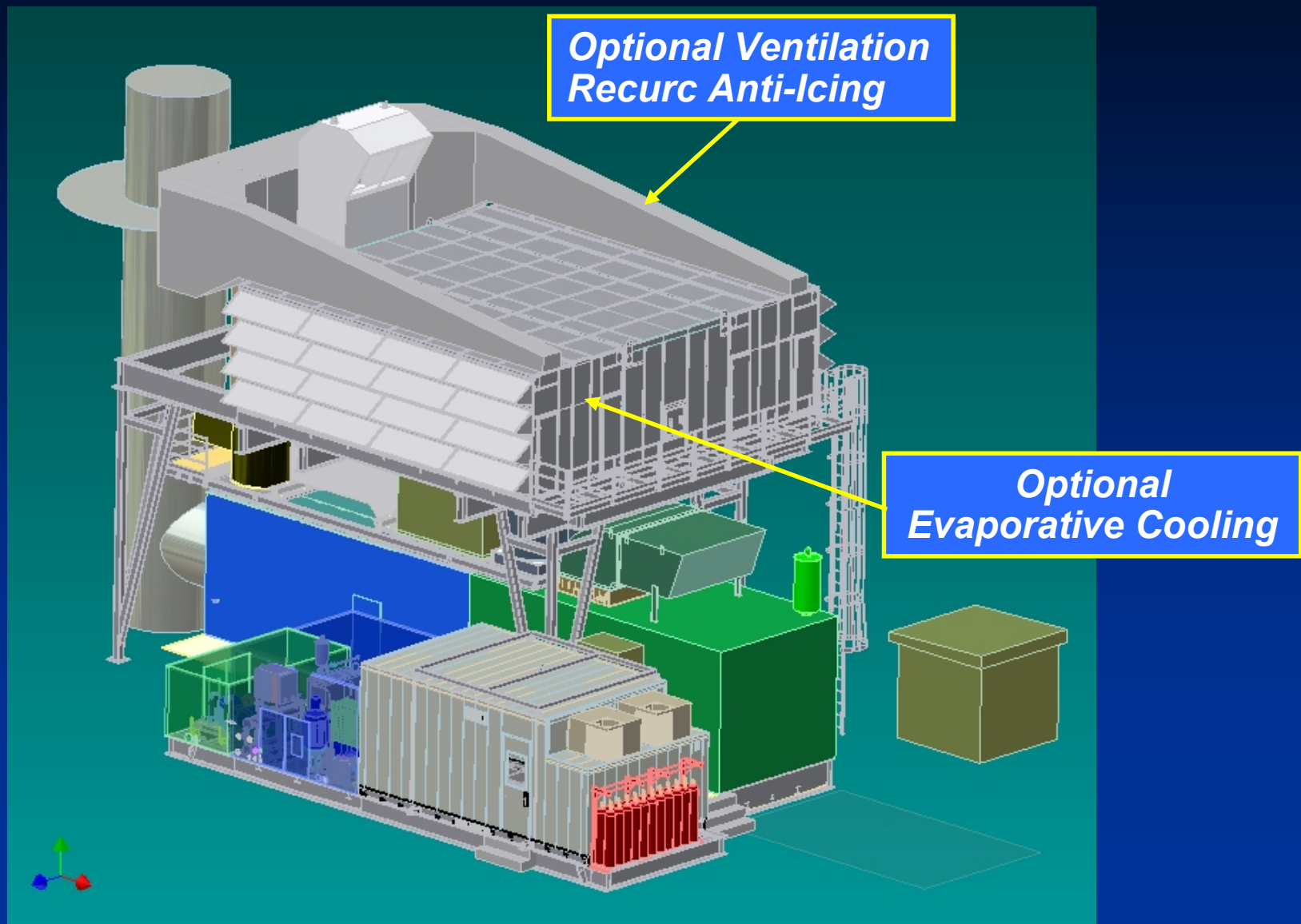
Note: The Generator Lube Oil System is located in the Generator Enclosure

Simplified customer interfaces



Optional Equipment

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EVAP Cooling System

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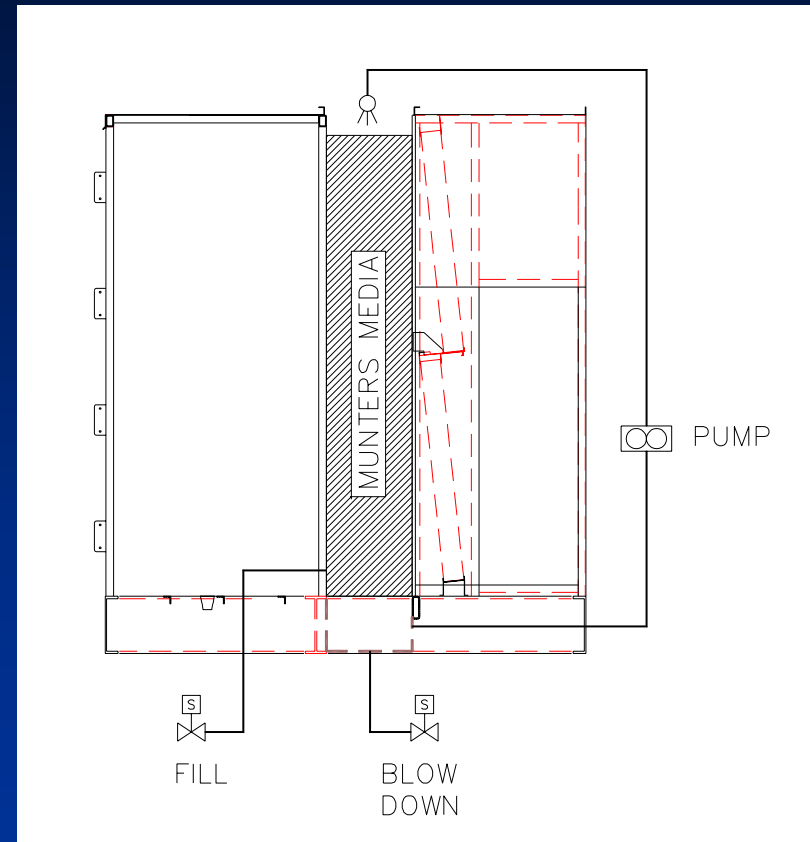
The Evaporative Cooling System is placed in the coil sections. (Two Coil Sections per Filter)

The Media is located in the coil module in place of the coils.

The water sump is located directly under the media and is used to collect and store the water. The sump is complete with automatic blow down and fill valves.

The motor driven pump is located in the walkway and provides the water to the spray bar above the media.

Demister panels are located downstream of the media to prevent the filter elements from getting saturated with water.



LM 6000 Anti-Icing System

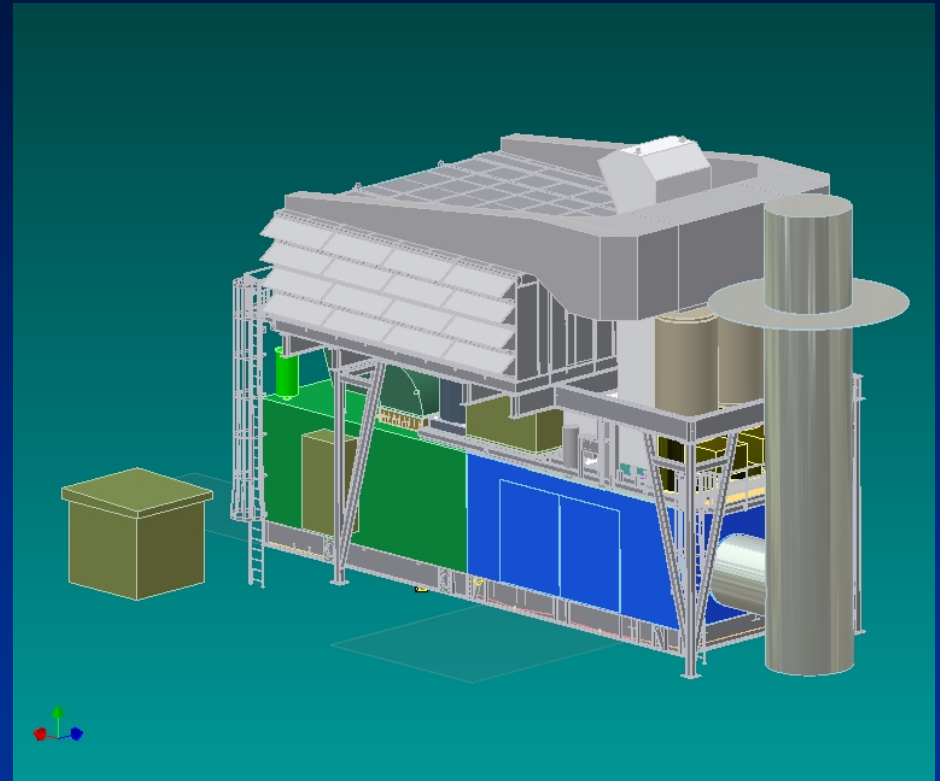
GE Aero Energy Products

The Ventilation Recirculation System is used for Anti-Icing of Combustion Air System.

The System takes waste heat from the Turbine Compartment and distributes it upstream of the filter elements.

Dampers are used to regulate the air flow to the filter house and what is not used is discharged to atmosphere.

Gas detectors in the Turbine compartment will initiate the dampers to vent to atmosphere if there is detection of gas in the air stream



Lower Installed Cost ...

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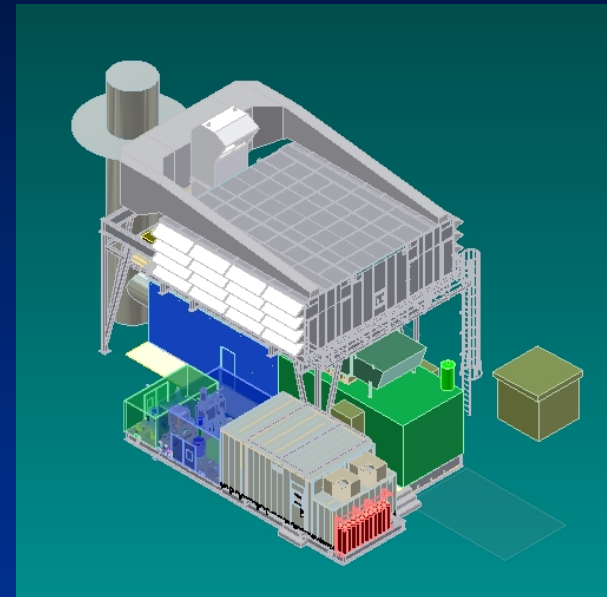
- **70% Reduction in Electrical and Mechanical interconnects**
- **25% Reduction in Concrete**
- **40% Reduction in Installation and Commissioning Schedule with associated Labor and Overhead Savings**

Shorter Installation Time ...

Shorter Installation Time

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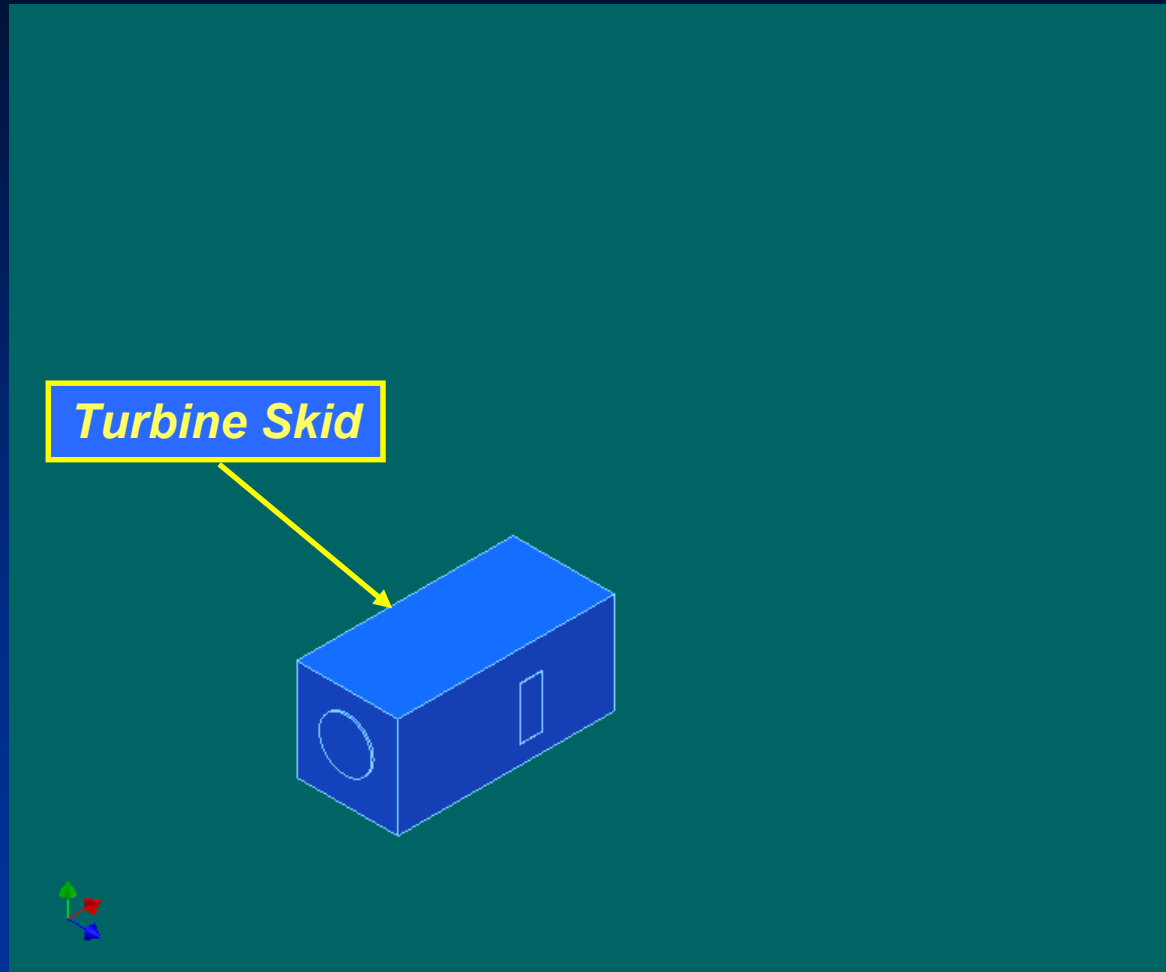
- **Elimination of Copper Wiring by use of Fiber-Optic**
 - Reduction of Field Wiring
 - Reduction in Electrical Noise



With the Control House located on the Auxiliary Skid and all terminations for Auxiliary equipment completed in the factory the cable runs have been significantly reduced. They have been further reduced by using Fiber Optic cable on all communication paths between skids with the exceptions of the Fire, Vibration and Emergency Shutdown switches.

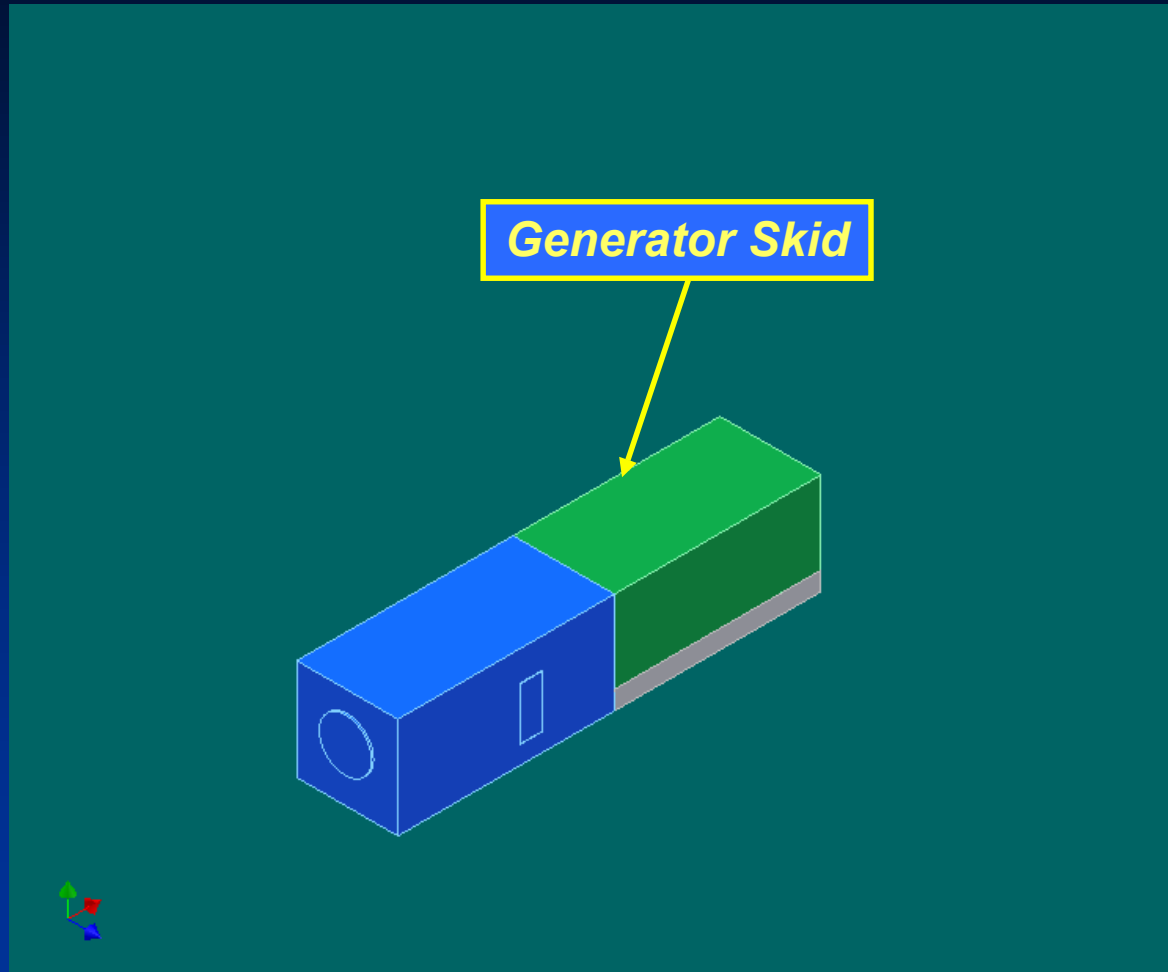
Shorter Installation Time ...

GE Aero Energy Products



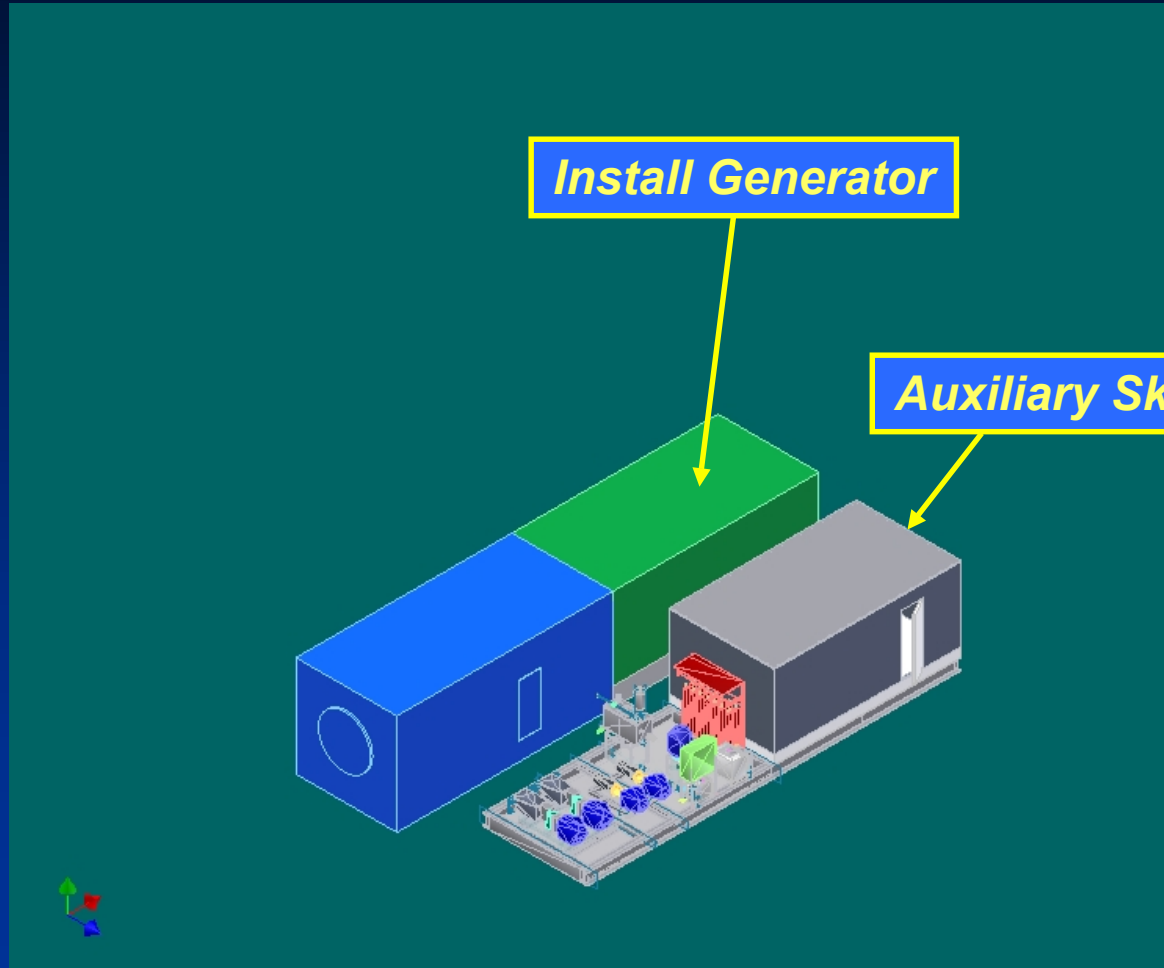
•Step 1

- Receiving and Staging Equipment (5days)
- Prepare Skid Foundation (1day)
- Setting Turbine Enclosure (1day)



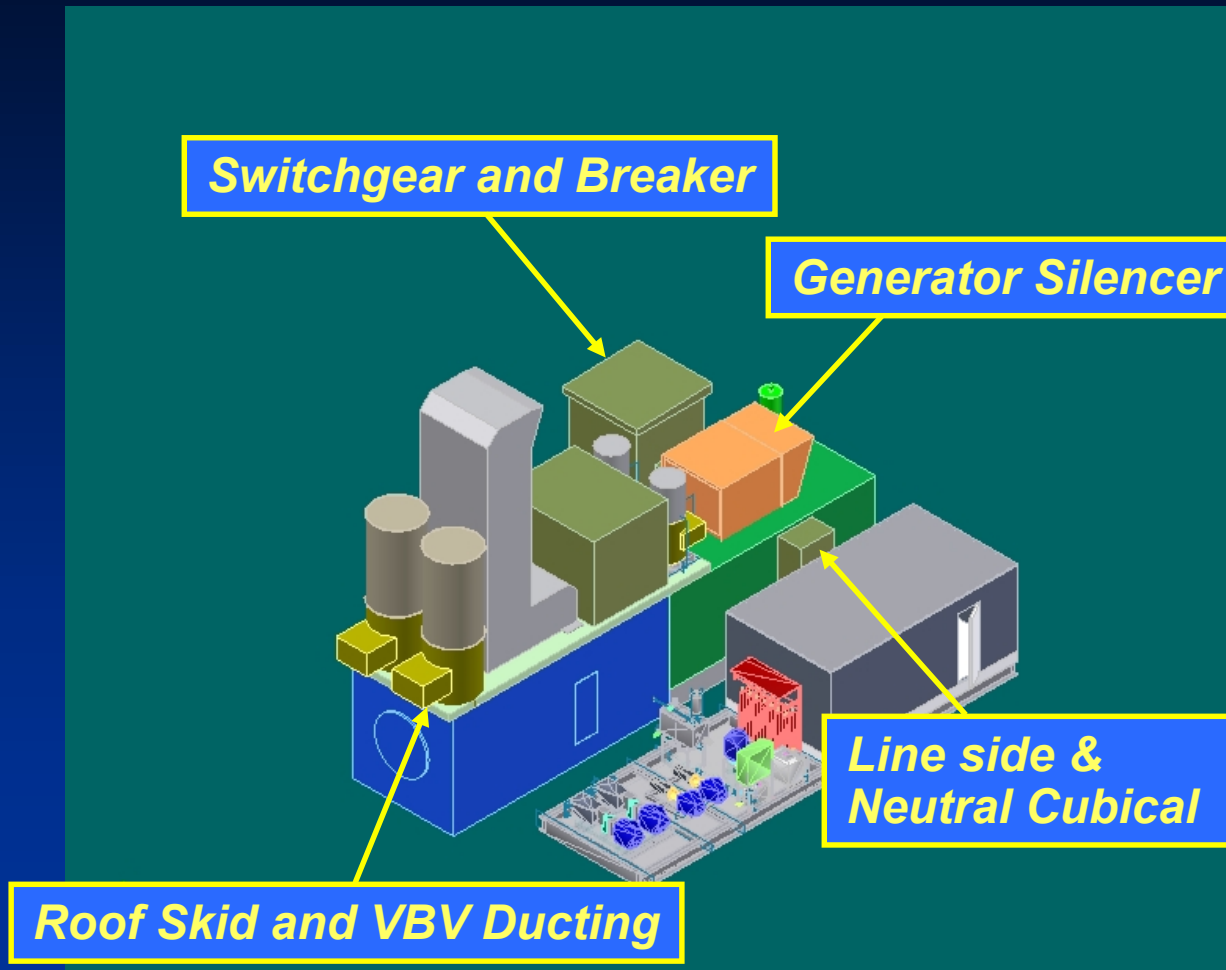
•Step 2

**-Setting Generator
Enclosure (1day)**



•Step 3

- Install Generator
- Setting Aux Skid (1day)
- Assemble Roof Skid (2days)
- Assemble Air Filter (5days)



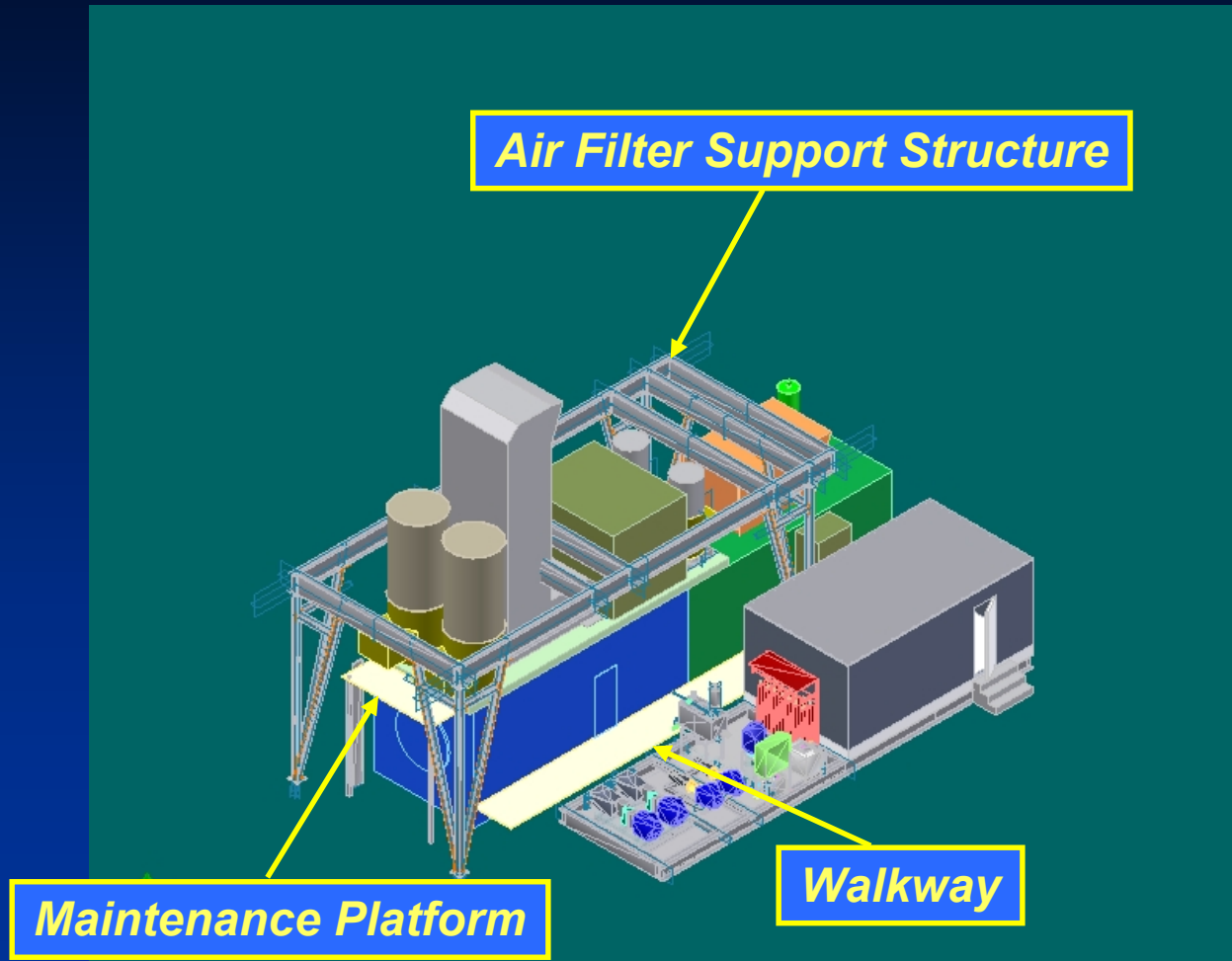
•Step 4

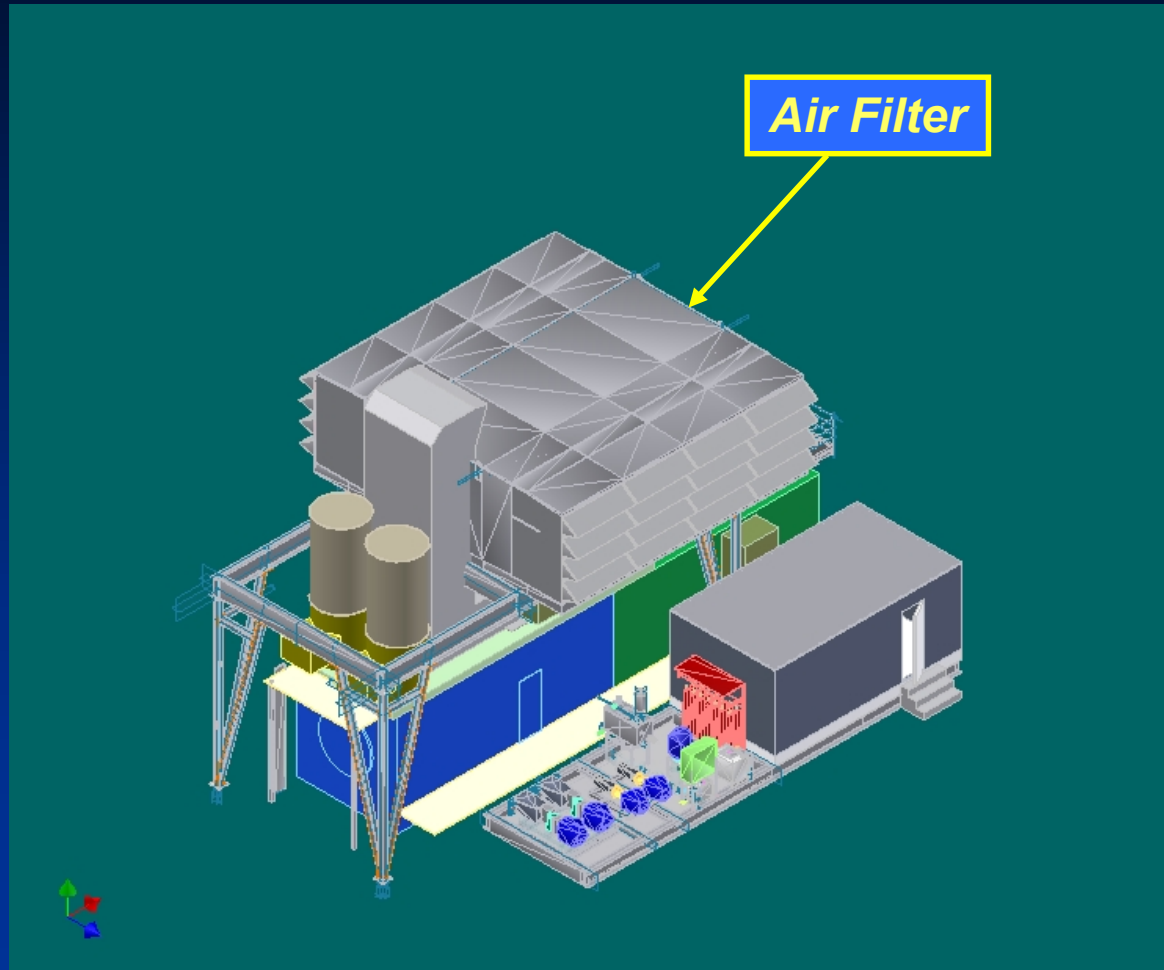
- Install Generator Roof Mounted Equipment (1days)
- Install Line side & Neutral Cubical (3days)
- Set Roof Skid (1day)
- Set Switchgear (2days)

•Step 5

-Assemble Air Filter Support Structure(2days)

-Assemble walkways and Platforms(2days)





•Step 6

**-Install Air Filter
(1Day)**

-Step 7

**-Complete Turbine
Alignment (1day)**

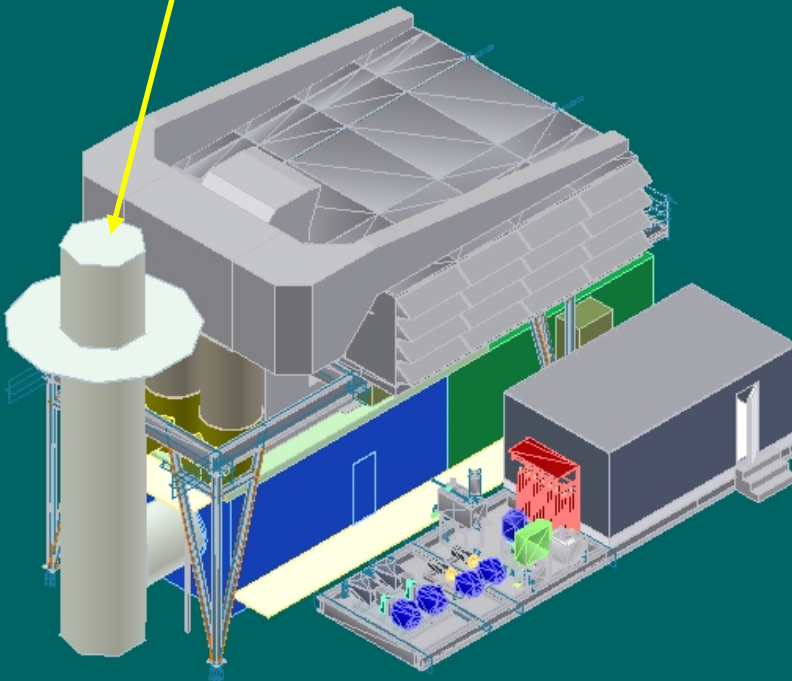
**-Complete All
Interconnects
(2days)**

**-Complete Package
Dress-out (4days)**

-Step 8

**-Package Grouting
(2days)**

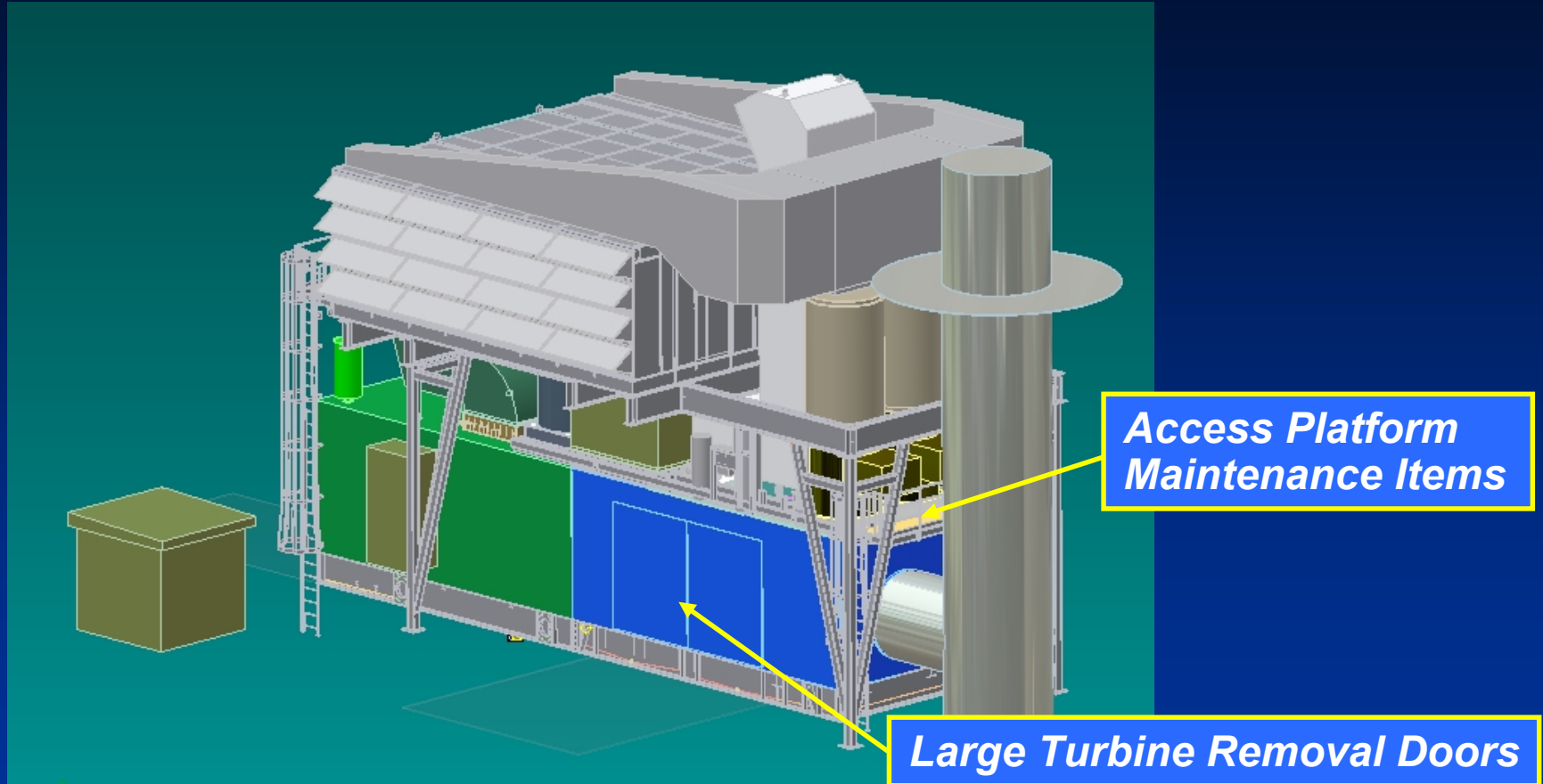
(Optional) Exhaust System



Improved Maintainability ...

Improved Maintainability ...

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Improved Maintainability ...

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- **Better Access to Maintenance Items**
 - **Vertically Mounted FCV**
 - **More room inside enclosure around piping systems**
 - **Lift eyes and rails for Removal/Repair of heavy components**
 - **Maintenance items located outside of Turbine and Generator enclosures (i.e. filters, valves)**
- **Shorter Engine Change Out Time**
 - **Larger Turbine Removal Doors**
 - **Longer Rail for Turbine Removal**
- **Addition of Hinges on the Inlet Volute**
- **Additional Ladders and Platforms for Maintenance**

Improved Maintainability ...

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- **Increase Visibility Inside Package**
 - **Better Lighting inside Package**
 - **Strategically Located Windows**
- **Separate Drains with sight glasses (TLO)**
- **Elimination of Low Points in Tubing Runs to Sensors**
- **All Controls integrated into one Control Platform**

Improved Reliability ...

Improved Reliability ...

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- **Package Mounted Controls**
- **Replacing Switches with Transmitters**
- **Online Calibration Capability of Redundant Transmitters via Software Switch**
- **ISP (Input Selection Protocol)**
- **Faster I/O Speed Provides Greater Resolution for Trending and Troubleshooting (from 60ms to 10ms)**
- **Faster CPU Speed (300 MHz to 500 MHz)**
- **Better Remote Monitoring (Dial into HMI)**
- **Redundant Power Supplies**

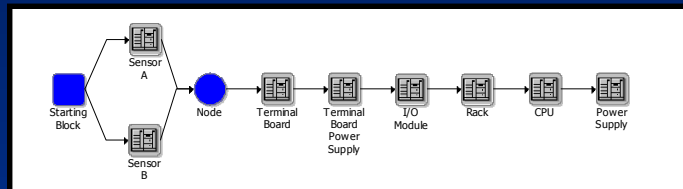
Dual Redundant Control System (MKVI e)

- **Redundant Instruments, Processors and I/O Paths**
 - **Redundant Transmitters for Critical Systems (Eliminating Single Point Failures)**
- **100% Distributive I/O for Fuel Control & Sequencer**
- **Reduced Vibration Trips by Cross Voting Rotor Station Mounted Accelerometers**

- **Fire System**

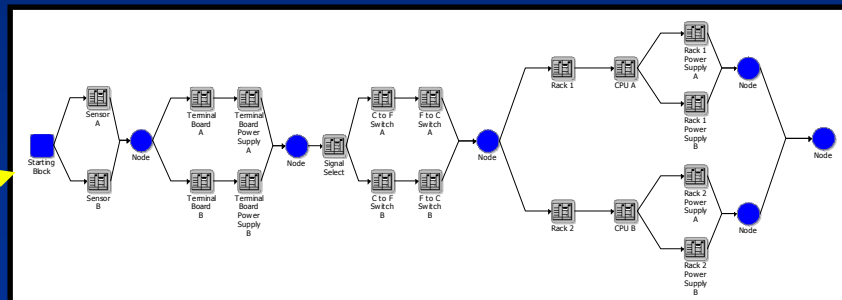
- **Self Diagnostics of System**
- **Use of LON (Local Operation Network) Eliminating 95% System Interconnects**
- **Expandability (Loop System)**
- **Addition of CO2 Bottles**
- **Improved Enclosure Sealing**

- **Next Generation Dual Redundant Control System (MKVI e)**
 - Redundant Instruments, Processors and I/O Paths
 - Redundant Transmitters for Critical Systems (Reduction in Single Point Failures)



Old (MKVI) model

New (MKVI e) model

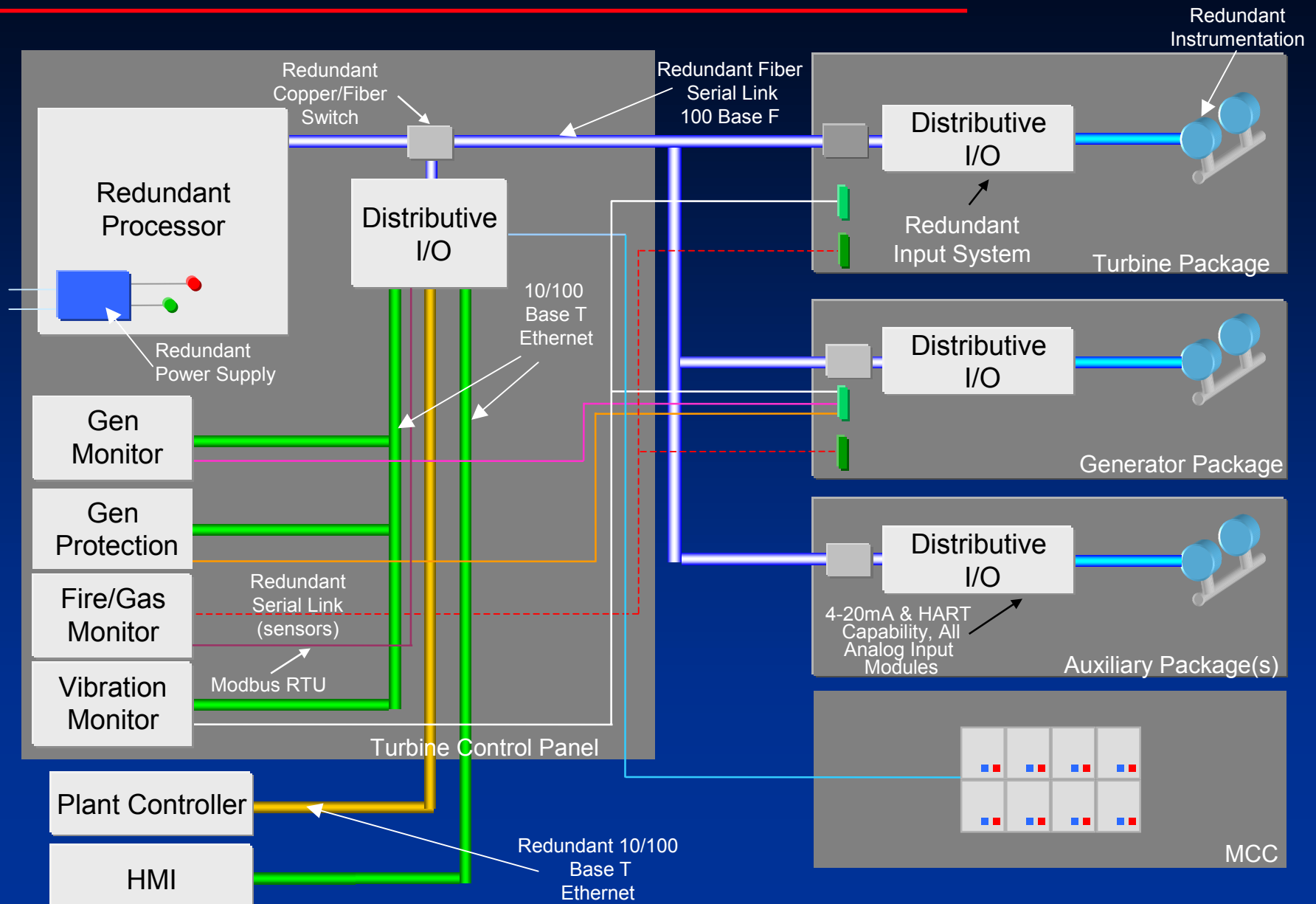


Notes:

- 1) There is no failure mode associated with the Nodes
- 2) The Signal Select is not a component in the system (Logic only) All other items are system components.

Control Systems

GE Aero Energy Products



Package Improvements – Summary ...

- ✓ **Maintain Current Capabilities**
- ✓ **Reduce Customer Installation Requirements**
- ✓ **Lower Total Installed Cost**
- ✓ **Shorter Installation Time**
- ✓ **Improved Maintainability**
- ✓ **Higher Reliability / Availability**