UTC Aerospace Systems

Airbus A350 XWB
Ram Air Turbine (RAT)

Operation, Maintenance & Troubleshooting Training Course

A350 XWB Ram Air Turbine
For Training Use Only (Level III)

DOC ID# EPSA350RAT
Original Issue: 2015JAN30
Revision: 2015JAN30

THIS PAGE INTENTIONALLY LEFT BLANK

Disclaimer

This Training Manual is not an official UTC Aerospace Systems publication and is not intended for any use other than student training. Material contained herein is written and assembled for the purpose of providing the student with organized notes on the subject matter to be discussed during classroom presentation and to enhance the information contained in applicable manuals. It has been written based on the current state of design and information available at the time. This document does not amend or supersede information contained in any UTC Aerospace Systems manual or document. Always refer to the authorized publications before performing any maintenance activities in connection with the subject systems or components.

Table of Contents

Airbus A350 XWB Ram Air Turbine

Acronyms

Acronyms & Abbreviations

A	Amp, Ampere
A, B, C	Phase Designation
A/C	Aircraft
ABD	Airbus Directive or procedure
AC	Alternating Current
ACMS	Aircraft Conditions Monitoring System
AOA	Angle of Attack
ARINC	Aeronautical Radio Incorporated
ATP	Acceptance Test Procedure
BIT	Built in Test
BITE	Built in Test Equipment
CDS	Central Display System
CMC	Centralized Maintenance Computer
DC	Direct Current
EGLC	Emergency Generator Line Contactor
GCS	Generator Control Switch
GCU	Generator Control Unit
GEN	Generator
GLC	Generator Line Contactor
GTT	Ground Test Tool
IDG	Integrated Drive Generator
IFSD	In-flight Shutdown
ILRU	Line Replaceable Unit
MIDFS	Mechanical Interfaces Detailed Functional Specification
N/A	Not Applicable
NBPT	No Break Power Transfer
OF	Over frequency
OV	Over voltage
P/N	Part Number
PF	Power Factor
POR	Point Of Regulation
RAT	Ram Air Turbine
RPM	Revolution Per Minute
SRD	System Requirements Document
SW	Switch
TEFO	Total Engine Flame Out
TRU	Transformer Rectifier Unit
UF	Under-frequency
UV	Under-voltage
VAC	Volt Alternating Current
VDC	Volt Direct Current
VR	Voltage Regulation
VS	Versus

Airbus A350 XWB Ram Air Turbine

Module 1 - RAT Overview

Why a Ram Air Turbine?

"The airplane must be designed so that it is controllable if all engines fail."

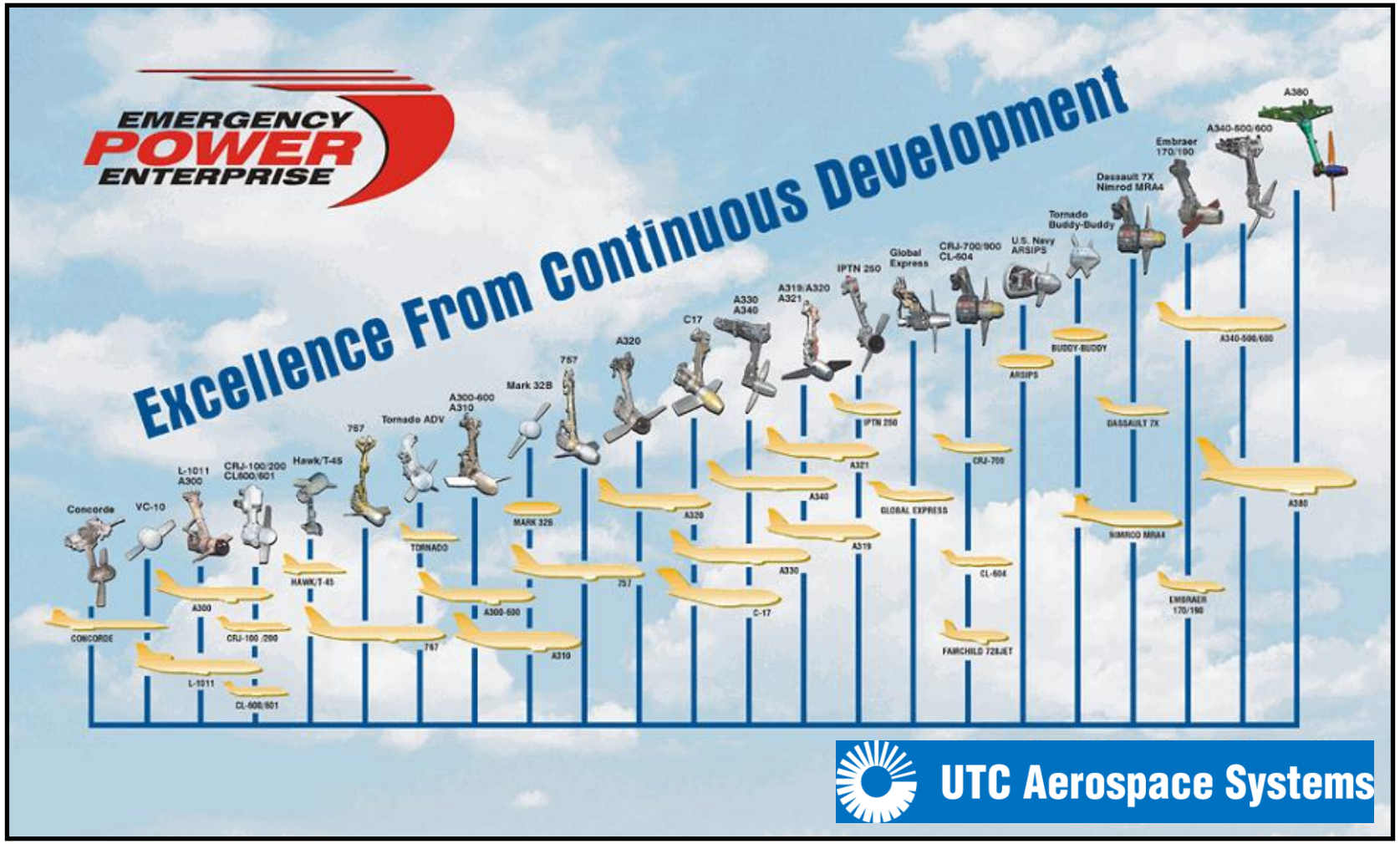
14 CFR 25 – Airworthiness Standards: Transport Category Airplanes, Section 25.671 (d)

- **Potential Solutions**
  - **Engine wind milling**
    - Typically does not provide enough power
    - Poor wind milling performance on high bypass engines
  - **Batteries**
    - Large and heavy
  - **APU**
    - Difficulty starting at high altitudes
    - Susceptible to fuel related problems (starvation/contamination)
  - **RAT**
    - Provides unlimited power over full flight envelope
    - Not susceptible to fuel related problems
    - Smallest size and lightest weight

Lives Saved by RATs

Lives Saved	Date	Cause of Deployment
17	December 1974	Fuel Mismanagement (Commercial)
172	May 1983	Engine Failure (Commercial)
69	July 1983	Ran out of fuel (Commercial)
205	August 1983	Engine Failure (Commercial)
263	November 1993	Ran out of fuel (Commercial)
2	March 1914	Fuel Contamination (Business Jet)
4	October 1994	Engine Failure (Business Jet)
2	August 1998	Engine Failure (Military Aircraft)
150	July 2000	Ran out of fuel (Commercial)
250	March 2001	Engine Failure (Commercial)
304	August 2001	Ran out of fuel (Commercial)
33	January 2005	Electrical Failure (Commercial)
140	May 2007	Engine Failure (Commercial)

Legacy RATs



Leading Particulars from CMM

Direction of Rotation	Clockwise
Unit Rating	40/50 kVA
Rated Power	50kVA at 0.75 pf
Overload Power	60kVA at 1.0 pf
Terminal Voltage (L-N)	235 V +3V/-2V
Generator Frequency	389 Hz to 539 Hz
Generator Speed	7800 to 10780 rpm
Governed Turbine Speed (no load)	3940 to 4340 rpm
Governed Turbine Speed (rated load)	3840 to 4240 rpm
Length, Stowed	98.054 inches (2490.5715 mm)
Length, Deployed	61.565 inches (1563.7510 mm)
Width	13.356 inches (339.2424 mm)
Height, Stowed	18.481 inchers (469.4174 mm)
Height, Deployed	73.596 inches (1869.3384 mm)
Weight (Maximum)	371 pounds (168.28 kg)
Hub Diameter	9.000 inches 228.6000 mm)
Blade Diameter	50 inches (1270 mm)

Airbus A350 XWB Ram Air Turbine

THIS PAGE INTENTIONALLY LEFT BLANK

Airbus A350 XWB Ram Air Turbine

Module 2 - RAT System Overview

RAT System

Hardware

- RAT system output is 3-phase 235/408 V AC power used for aircraft emergencies or in-flight training
- RAT is stowed and non-operative during normal flight
- RAT operation is commanded by manual deployment or automatic deployment in an emergency
  - **On-aircraft equipment**
    - RAT System consists of
      - **RAT Module** – turbine, gearbox, generator, actuator, & strut contained within a frame
      - **GCU**
      - **Stow Panel**
  - **Non-flight equipment**
    - **Ground Test Tool** (GTT) to back-drive the RAT during ground check-out (purchased directly from GTT supplier under a separate contract)
    - **Ground Maintenance Safety Pin** to prevent inadvertent deployment of RAT on ground. Supplied by Airbus

Emergency Power Supplied

- **Powers aircraft AC essential bus bar if main electrical generating system fails**
  - Primary flight control electro hydraulic actuators on all 3 control axis and electric slat motors
  - Electric fuel pumps
  - Landing gear
  - Miscellaneous loads
  - 28 VDC essential network Supplied through battery charger rectifier unit
- **2 configurations of electrical emergency**
  - Total loss of main electrical system
  - Total engine flame-out (TEFO), which leads to total loss of hydraulic and electric power

RAT System Description

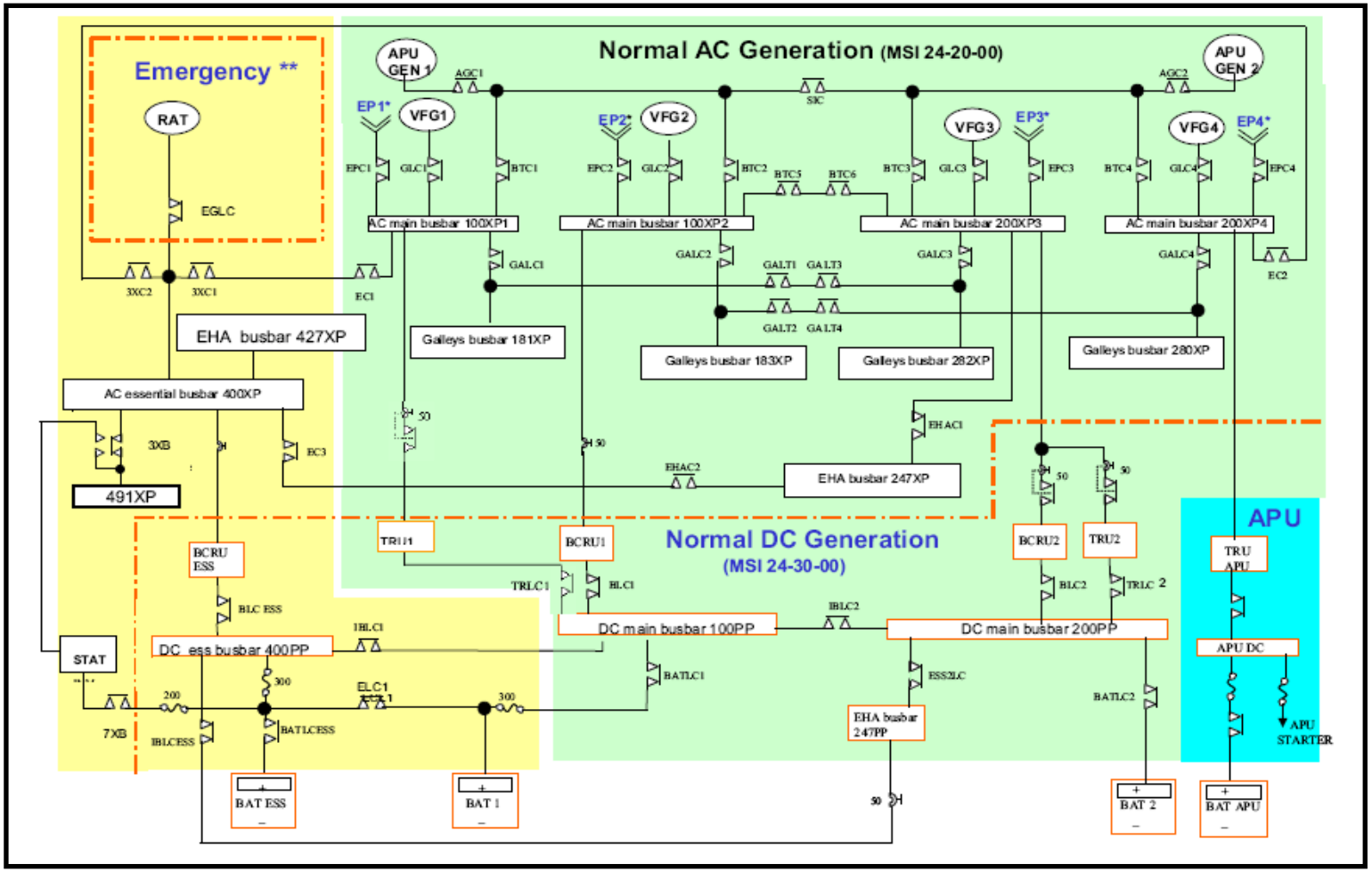
- Alternating Current (AC) emergency electrical generating system
- Mechanically-governed turbine attached to a gearbox assembly
- Gearbox assembly attached to strut assembly and then the generator assembly
- Turbine assembly is variable-pitch, two-blade
  - Blades turns clockwise when seen from the front
  - Supplies mechanical power through the gearbox assembly to a drive shaft in strut assembly
  - Integrated actuator/uplock
- Drive shaft turns and supplies mechanical power to turn the generator assembly
- System controlled by a Generator Control Unit (GCU)
- Powers aircraft AC essential bus bar if main electrical generating system fails
- The generator contains two heaters. The aircraft supplies 115 Volts Alternating Current (Vac) to the heaters. Only one heater operates at a time
  - Heater usage alternates every flight. Controlled by aircraft

- **RAT can be deployed at aircraft speeds of 120 KEAS to MMO 0.89**
  - Governing range 3580-4950 RPM (389-539 Hz)
  - Turbine speed 3580 RPM minimum at low airspeed and low altitude conditions
  - Input speed to generator is 7783 to 10772 rpm when turbine is operating and controlled by GCU (2.1739 gearbox ratio)

- **Generator supplies**
  - 40 kilo-Volt-Amperes (kVA) with a power factor (PF) of 0.75 to 1.0 at 140 to 175 knots equivalent airspeed (keas) with a 45 percent maximum pressure loss
  - 50 kVA with a PF of 0.75 to 1.0 PF for airspeeds greater than 175 keas and 10% pressure loss
  - 80 kVA with a PF of 0.75 to 1.0 PF (for 300 milliseconds) when loads are changing

- **Electrical power supplied at 235 Volts (V) at point of regulation (POR)**

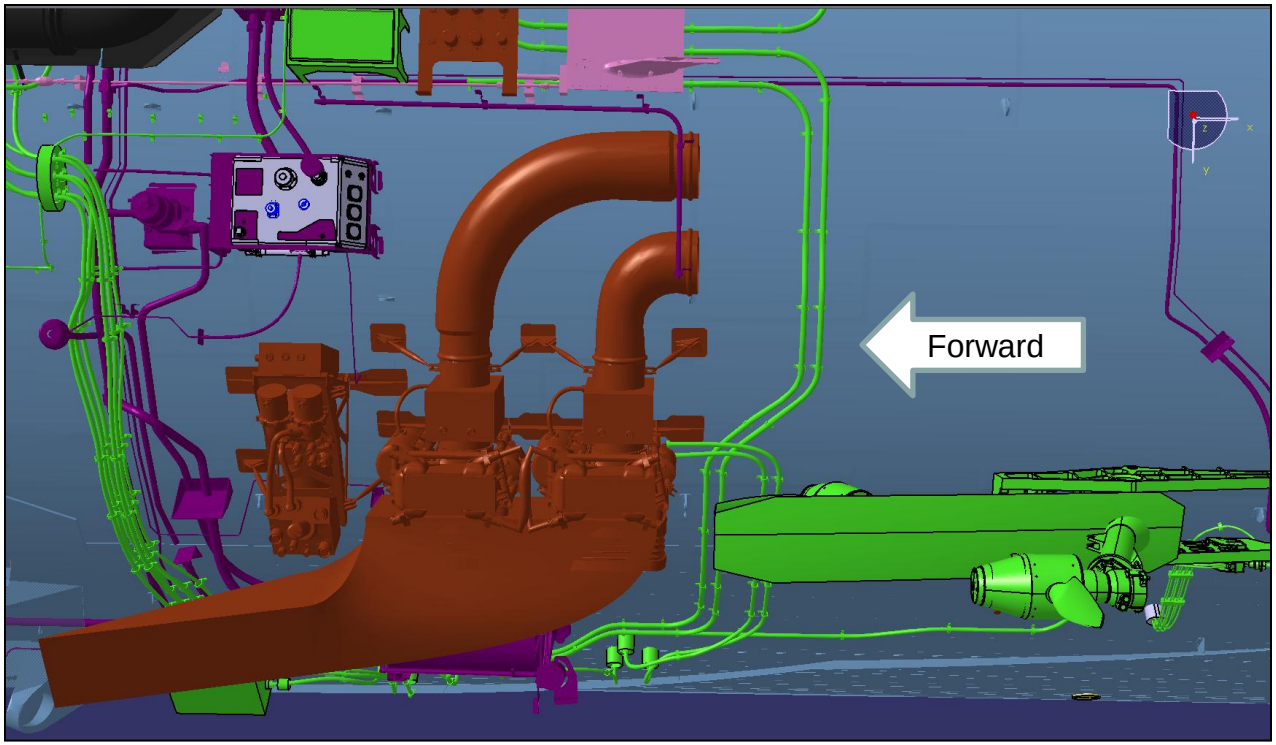
RAT System Electrical Architecture



Airbus A350 XWB Ram Air Turbine

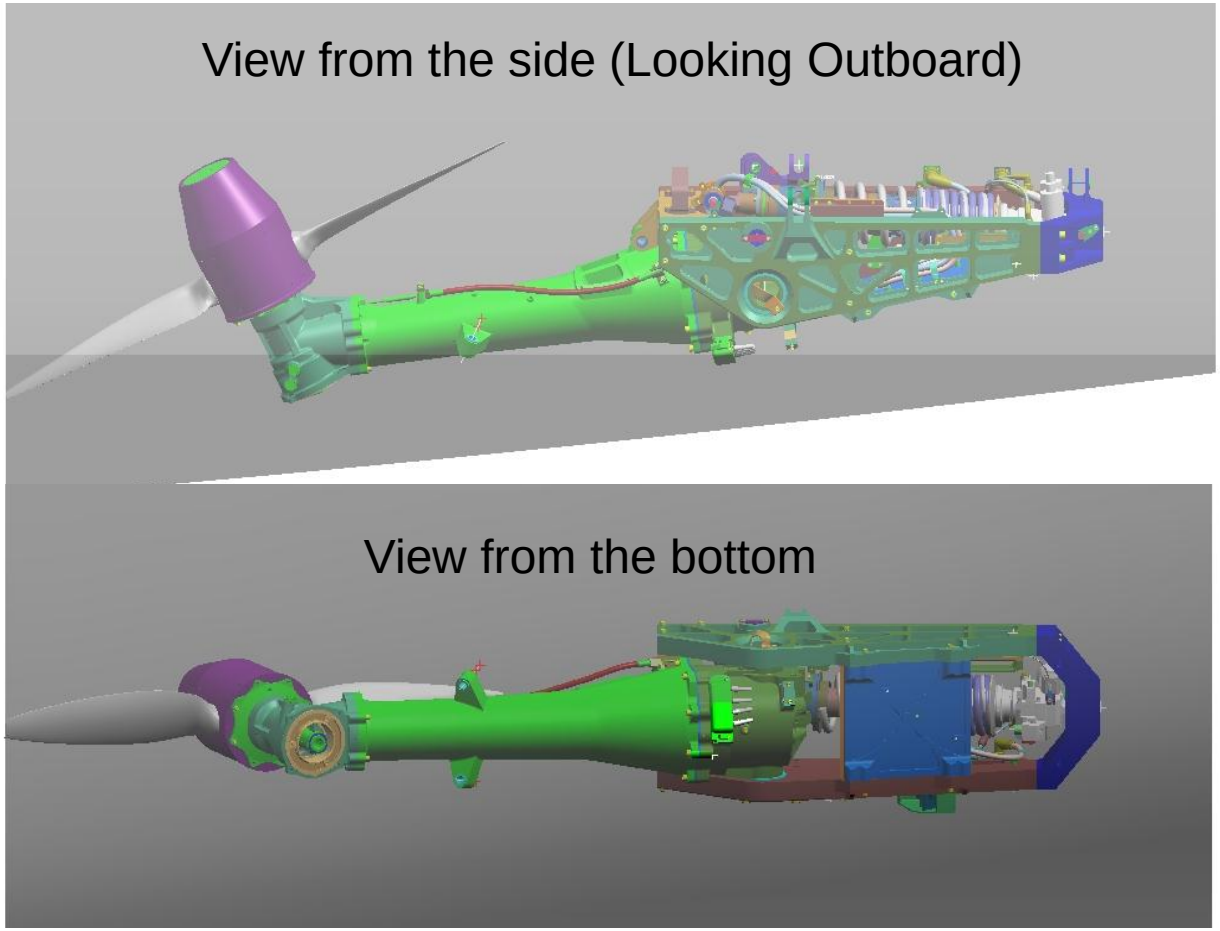
Module 3 - Aircraft Mechanical Interface (Mounting)

RAT System Equipment
Location on Aircraft



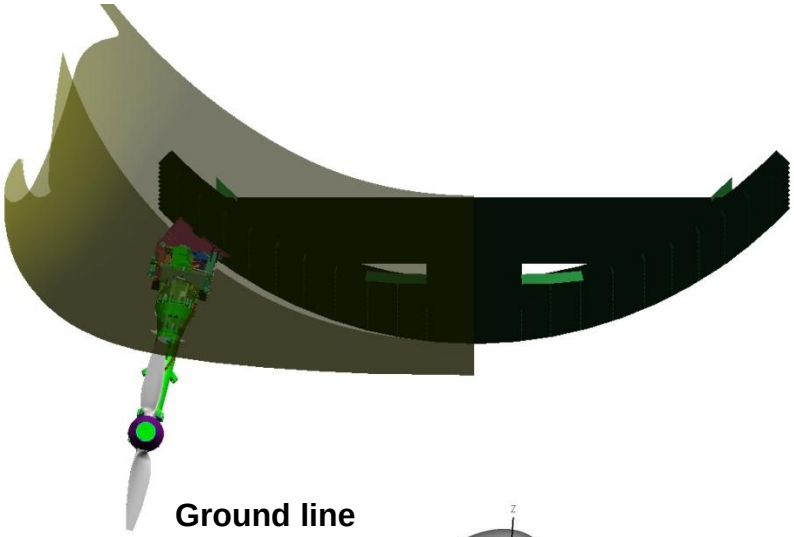
Looking Up Into Aircraft

RAT System Equipment Envelope – Stowed

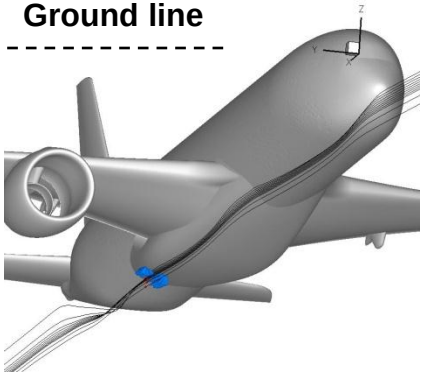


RAT System Equipment Envelope – Deployed

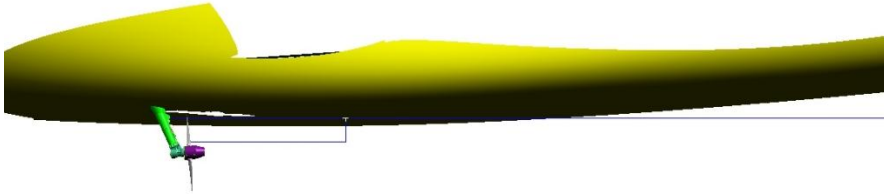
- **Generator air inlet located outside RAT bay (deployed)**

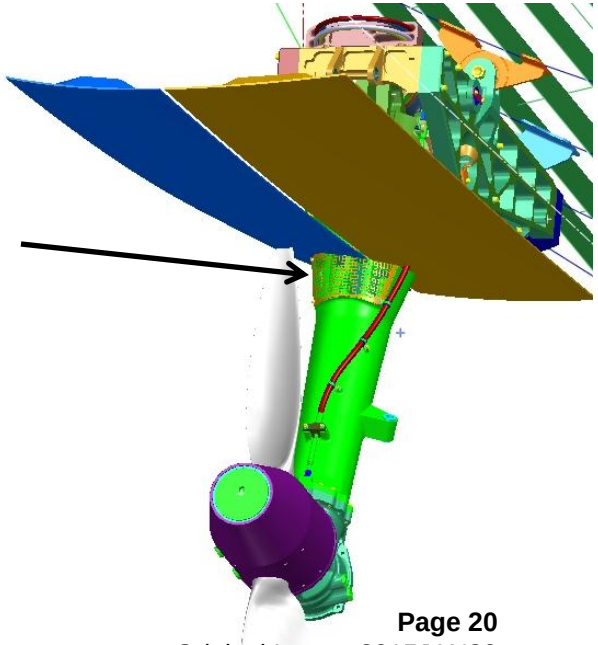


Ground line



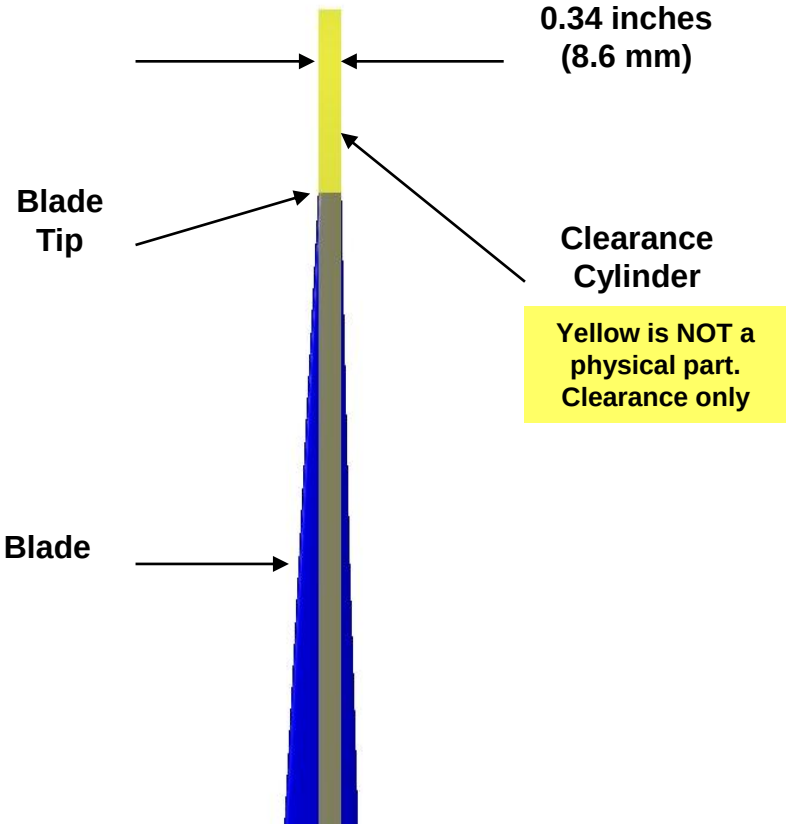
Shown with 3 degree AOA



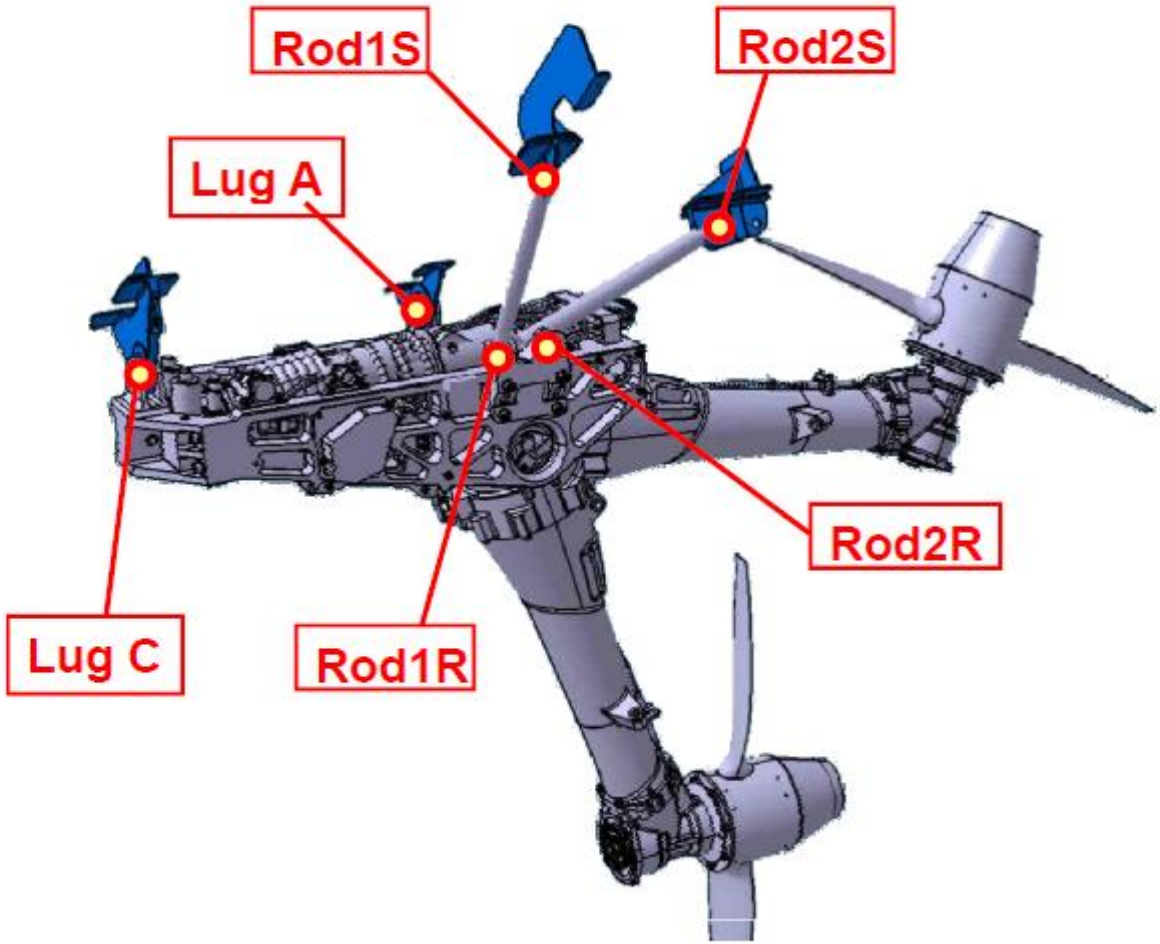


RAT System Equipment
Envelope – Door to Blade Clearance

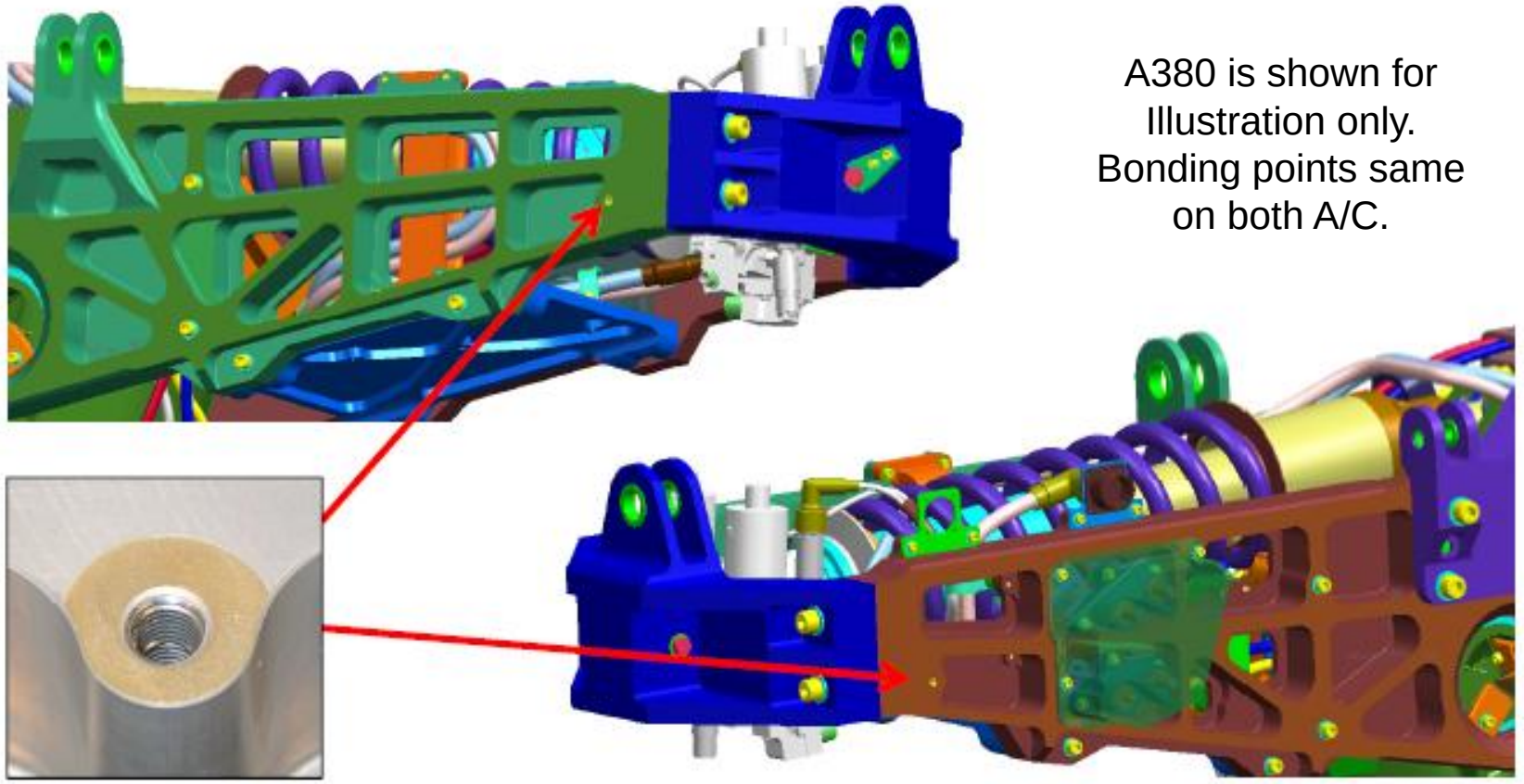
- Blade disc clearance cylinder used during deployment
  - Blade tip radius + 2.0 inches (51 mm); matches tip thickness
- Blade clearance cylinder not used for stow abort
  - Slow RAT strut rotation (~5 seconds from restow start until blade tips are near doors)
- 53 degree stow abort angle
  - Related to turbine release angle during deployment
- Airbus verified adequate clearance from doors for deploy and restow cases



Aircraft Interface

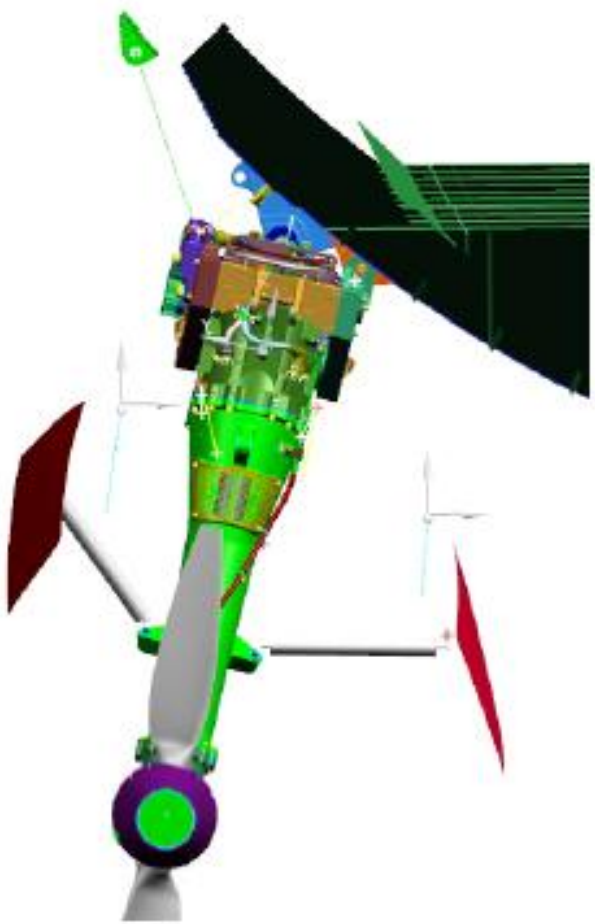


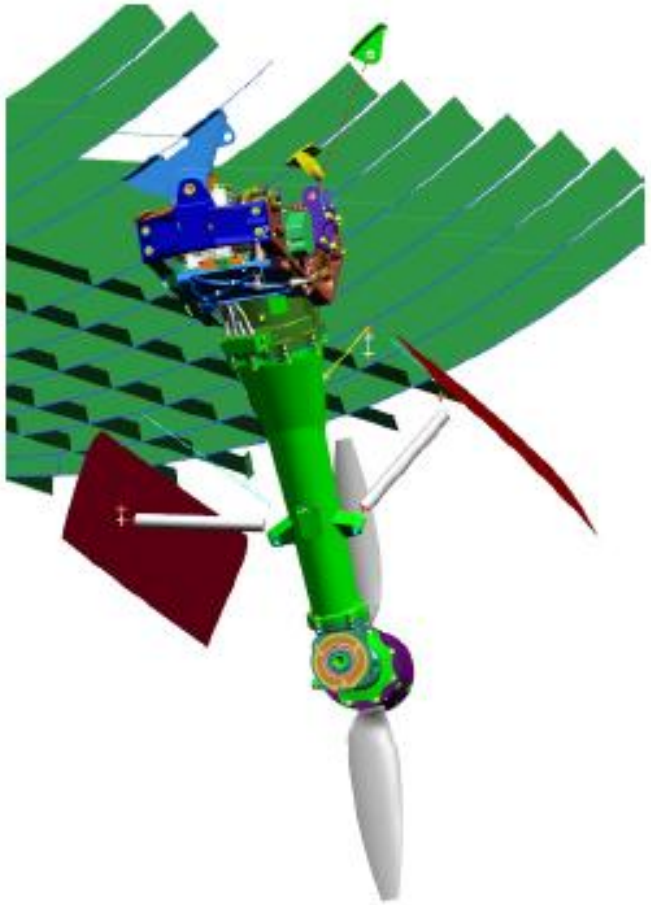
Aircraft Interface
Bonding Points



A380 is shown for Illustration only. Bonding points same on both A/C.

Aircraft Interface
Door Rigging Points



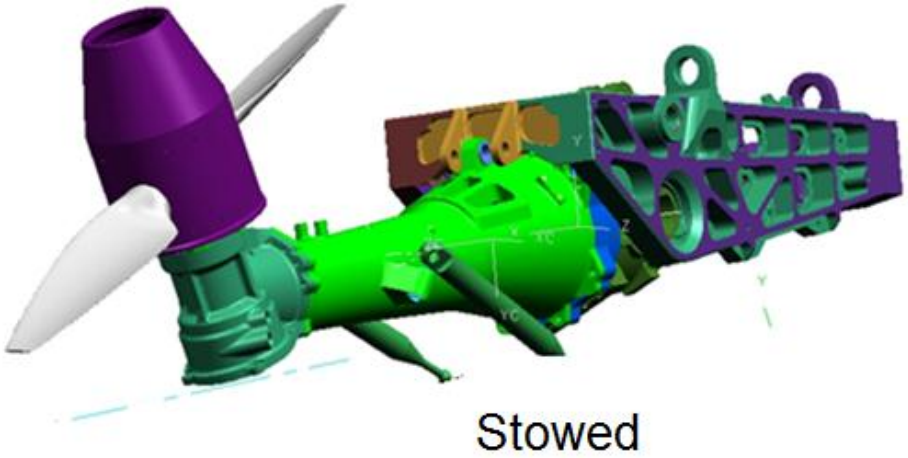


Airbus A350 XWB Ram Air Turbine

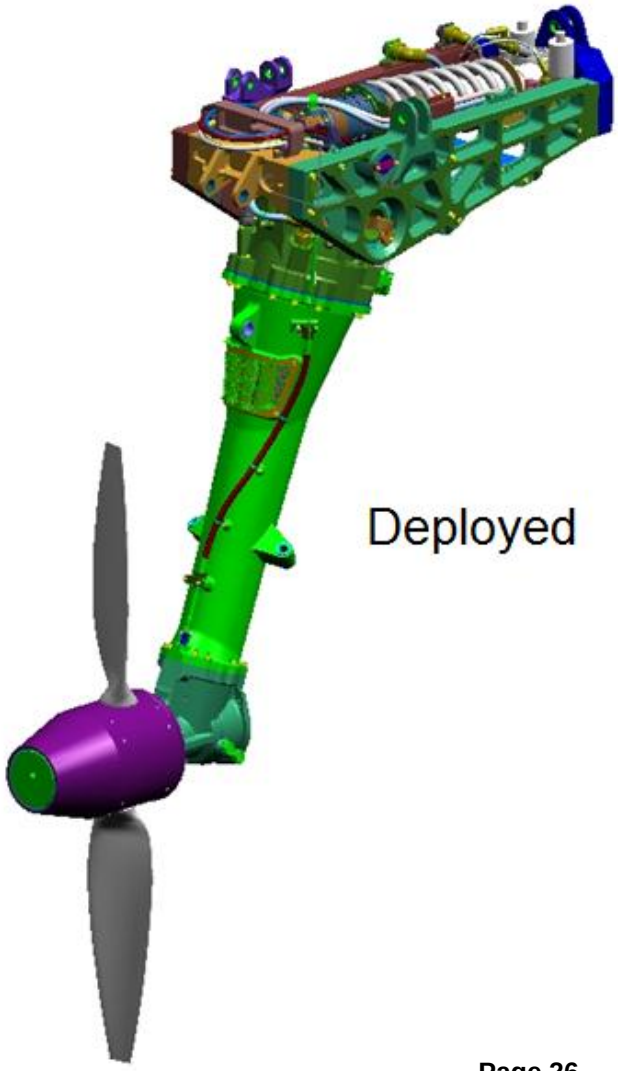
Module 4 - System Operation

Operation – RAT Speeds & Frequencies

- **Turbine governing speed range: 3580-4955 RPM**
  - **Power provided down to 2285 RPM (370 Hz)**
  - Turbine speed = generator speed / 2.1739 gearbox ratio (50/23)
  - Generator output voltage frequency = generator RPM / 15



Stowed



Deployed

Operation – Deployment & Start-up *(1 of 3)*

- **RAT activation in emergency condition**
  - When an Emergency condition is declared, (TEFO or Total Loss of Electric generation), EEPDC (Emergency Electrical Power Distribution Centre) receives the input information. Once the input is analyzed, the EEPDC sends an output signal to the Actuator Deploy Solenoid. The Battery Essential supplies 28 V DC power to 703PP Hot Busbar in order to supply the Uplock Deploy Solenoid.
  - In case of an automatic deployment fault or manual test, there is a secondary release solenoid, via the Overhead Panel in the cockpit (RAT MAN ON). This is the manual deploy process.
  - When the Actuator Deploy Solenoid is energized, the internal actuator releases the actuator initiating RAT deployment. The spring loaded deployment actuator forces RAT to extend into the airstream. The fairing doors are opened by two struts symmetrically attached to RAT strut. The RAT will rotate from 0º (stowed and locked) to 63º (fully deployed).
  - When the Strut-RAT Leg has rotated nearly 56º, the turbine, which at this point had been locked, is released and commences to freely spin into the airstream. Full Strut-RAT Leg deployment is achieved at 63º, forming Turbine and Strut – Leg a 108.75º angle.
  - There is a Downlock device inside the Actuator that prevents RAT Module from forced stowing.

Continued…

Operation – Deployment & Start-up *(2 of 3)*

- **RAT activation in emergency condition** *(continued)*
  - As turbine reaches operating speed, counterweight forces overcome combined blade and governor spring forces, pushing yoke plate and spring seat assembly forward.
  - Linear movement of yoke plate causes blades to turn from their stowed fine pitch position to a coarser angle, reducing speed and available torque.
    - Equilibrium occurs when blade angle corresponds to torque necessary to react serviceable load.
    - Decrease from steady state speed causes blades to move back towards fine pitch where less power is extracted from airstream.
  - Kinetic energy of airstream is converted to mechanical energy to drive shaft inside strut and connected to spiral gear set in gearbox.
  - Gearbox increases turbine speed by 2.4286 ratio to drive generator.
  - The PMG supplies AC power to the GCU in order to supply housekeeping consumption, feed the internal power supply and provide DC current to the exciter field. Therefore, AC electrical current is rectified inside the GCU. The GCU supplies the stator of the exciter field with DC current and is used to excite windings of the main Generator. The GCU regulates the magnitude of this current once the POR voltage is being sensed.

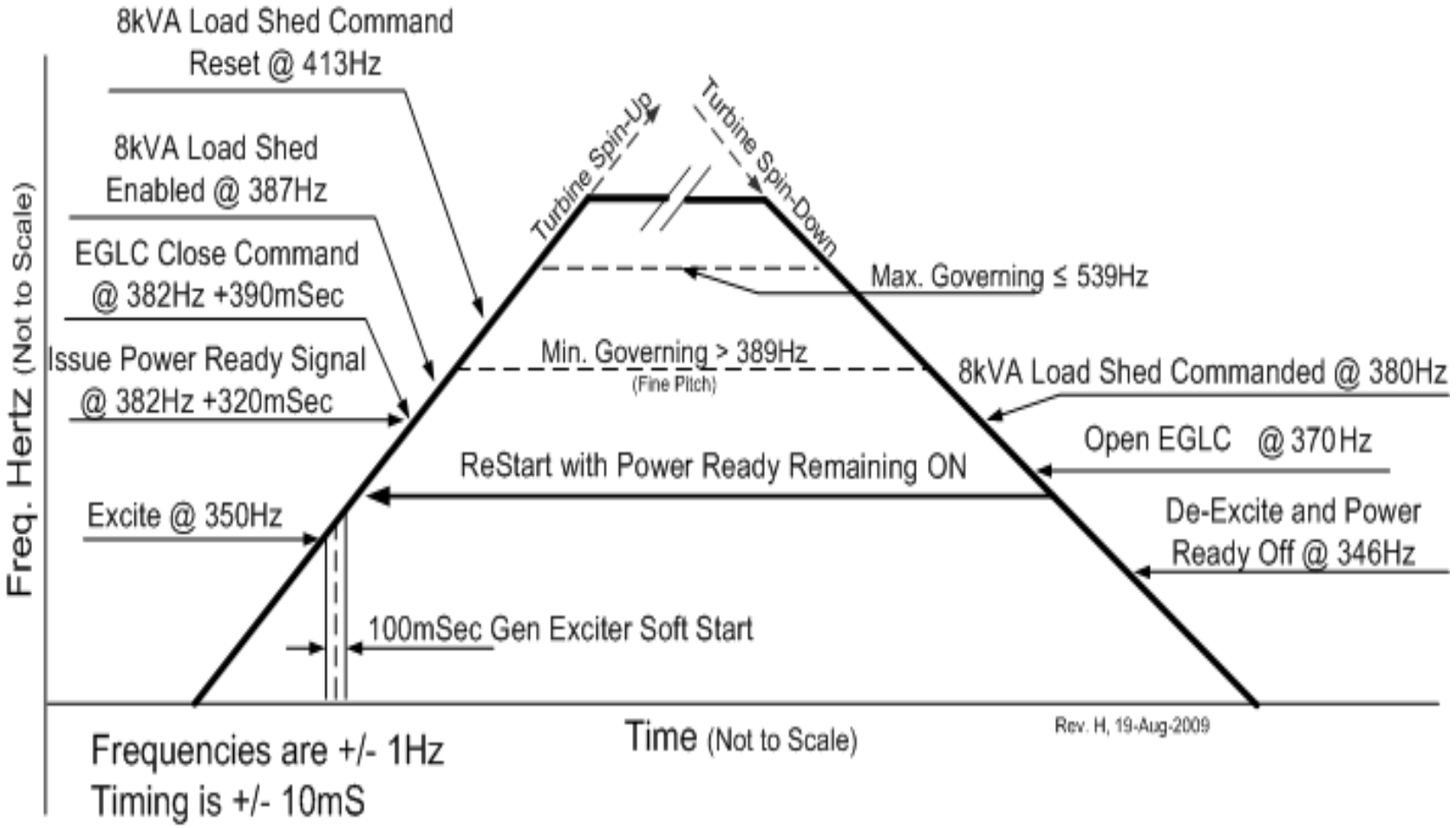
Continued…

Operation – Deployment & Start-up *(3 of 3)*

- **RAT activation in emergency condition** *(continued)*
  - At this point, the EEPDC commands a RAT Protections Inhibit discrete signal **(Protections inhibit)** to the GCU in order to inhibit these protections and to ensure RAT generator availability.
  - Once the Generator has reached 382 Hz frequency plus a delay of 320 ms, the GCU sends a discrete signal to EEPDC **(Power ready signal)** to open the contactors of the main Busbars 3XC1 and 3XC2.
    - **NOTE:** Opening of 3XC1& 3XC2 contactors is mandatory to avoid RAT overload. This is mainly due to EC1 & EC2 contactors, which are initially driven by PEPDC (Primary Electrical Power Distribution Center). Due to the loss of normal network (PEPDC), control of EC1 or EC2 contactors is lost. So they could remain in closed position.
  - When 382 Hz (plus a delay of 370 ms) is achieved the EGLC is commanded to close. It is the GCU, which controls this action by means of a power signal 28 VDC/OC.
  - At this point the GCU commands a discrete signal (**RAT status**) indicating the availability of the RAT. The RAT will be available if the RAT is generating AND the EGLC is closed AND the RAT is OK.

All of the above has occurred in less than ONE SECOND

Operation – RAT Speeds & Frequencies



Operation - Shutdown

- GCU detects slowing generator speed as aircraft operating conditions result in slower turbine speed.
- GCU removes GLC closure command, then de-excites generator.
- RAT is off line as aircraft speed drops below RAT operating range.

Airbus A350 XWB Ram Air Turbine

THIS PAGE INTENTIONALLY LEFT BLANK

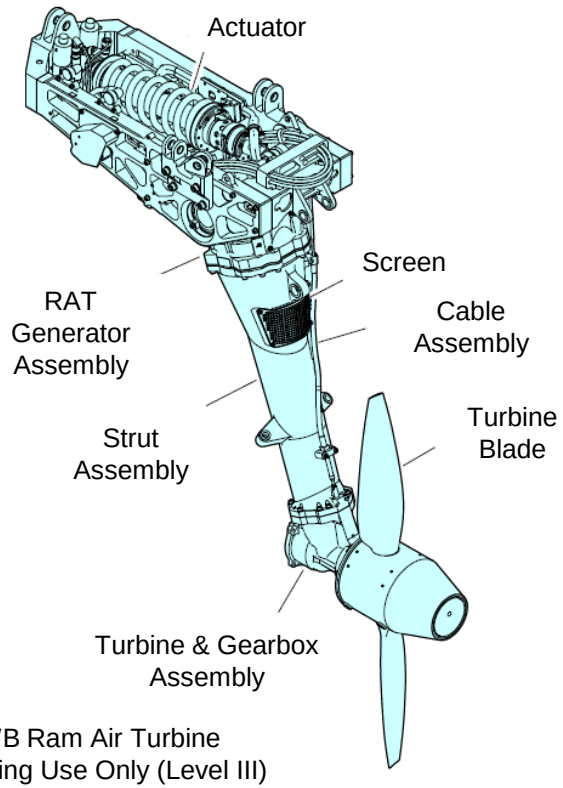
Airbus A350 XWB Ram Air Turbine

Module 5 - Component Description

RAT System Description

RAT Module

- GCU
- Stow Panel
- Ground Test (Backdrive)



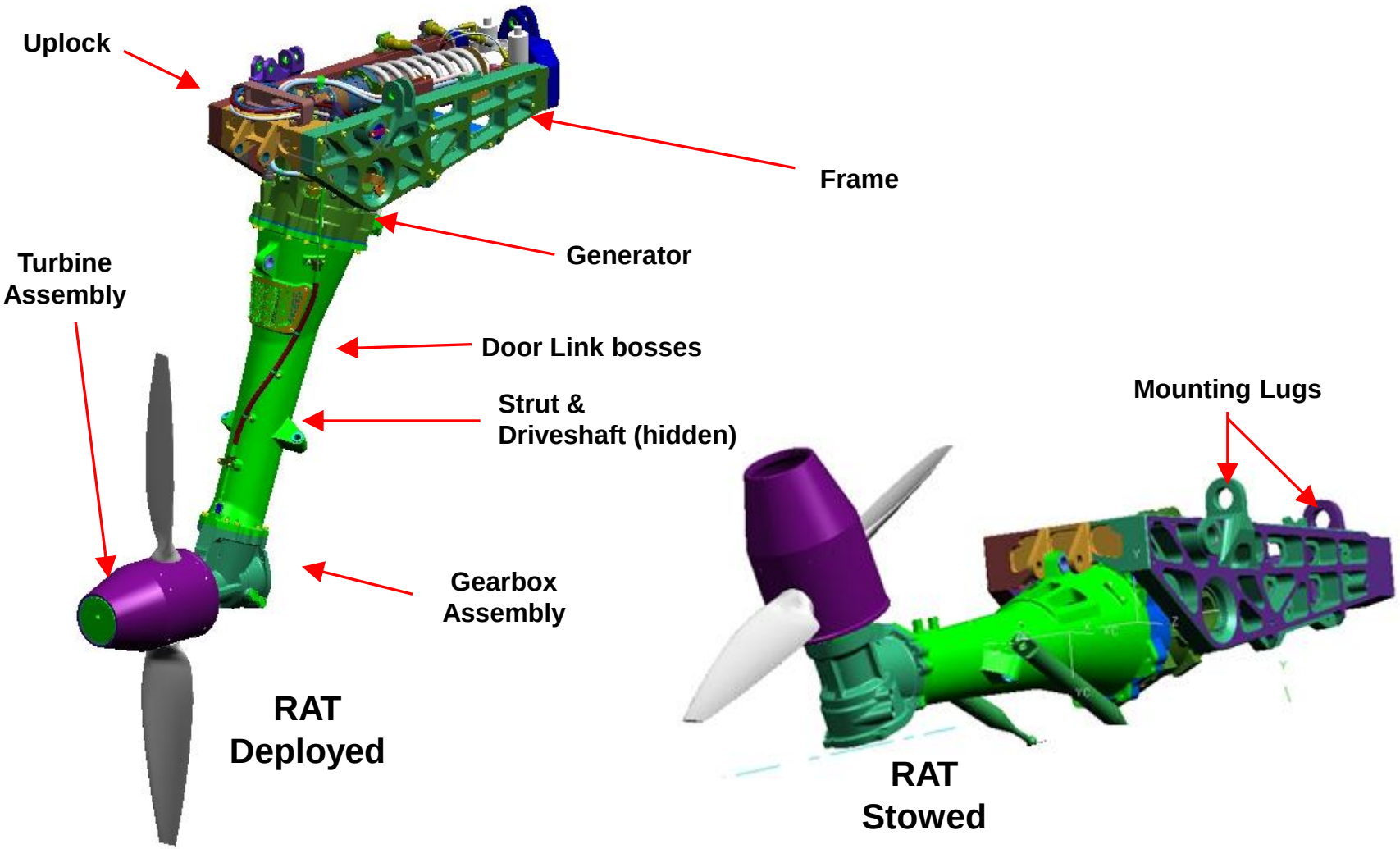
- 50 inch (1270 mm) Diameter Turbine
  - Provides power levels appropriate for A350
    - 75 shaft HP @ 140 keas aircraft speed, 35% dynamic pressure loss
  - Incorporates advanced technology features
    - High performance advanced design flutter free blades
    - Mechanical governor
    - No turbine anti-icing device
    - Air Cooled Generator (70Kva, 3-phase 235/400 Vac power)
    - Two Generator Heaters
    - Frame Mount for Quick Assembly into Aircraft
    - External Uplock to handle Windmilling condition
    - A/C hydraulics for Retraction RAT on the ground
    - Rotation feeders and electrical harness
    - Stationary electrical interfaces provided

Component Description – RAT Module

RAT Module consists of:

- **Turbine Assembly**
  - Mechanical counter weight governor to control speed
  - Blades tested for flutter
  - Anti-icing device to prevent damaging ice accumulation and/or shedding
- **Gearbox Assembly**
  - Splash lubrication and cooling
  - Single stage, 2.1739:1 ratio spiral bevel gears that transmit power from turbine to generator
- **Strut**
  - Structural support between turbine/gearbox and generator
  - Key member in natural frequency stiffness chain
  - Interface with aircraft door links
- **Drive Shaft**
  - Spline driven with seals at each end
  - Supported by mating shafts at each end
- **Electrical Generator**
  - 50 kVA rated 6-pole 235/408 VAC
  - PMG stage provides power to the GCU
  - Exciter stage with rotation rectifier
- **Frame**
  - Structural member that supports the RAT module components and sub-assemblies
  - Interface with the A/C flap track beam structure
- **Deployment Actuator**
  - Controls deployment with internal damping
  - Controls retraction with electrical signal from the stow panel and hydraulic power from the aircraft
  - Secures the RAT in the Stowed position with internal uplock
  - Provides deployment release function in response to aircraft electrical command
  - Releases the RAT with a 28VDC nominal signal to either of 2 independent solenoid coils (automatic deploy or manual deploy)
  - Stowed Position Indicator (Micro Switch) provides lock status to the Stow Panel and A/C

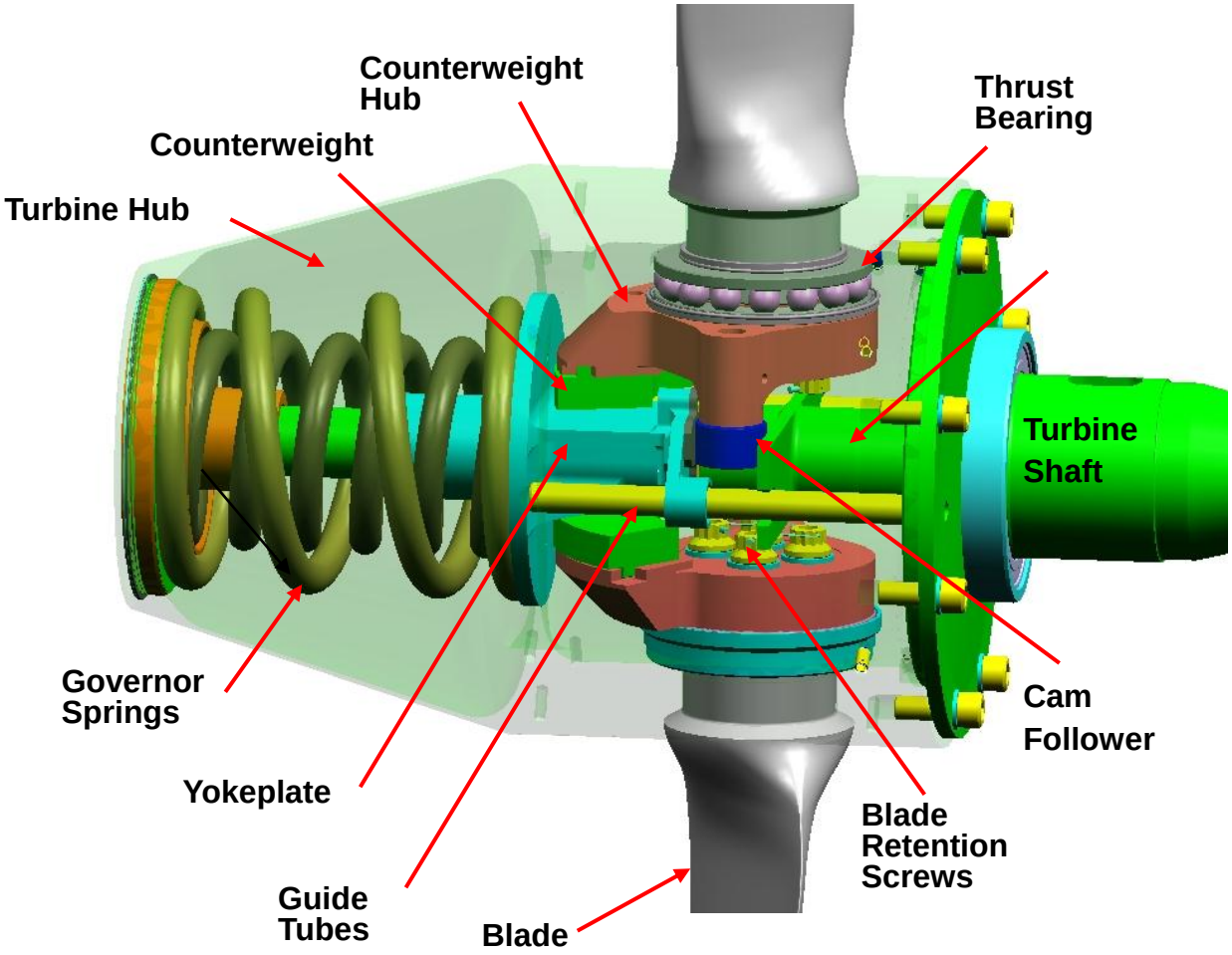
Component Description – RAT Module



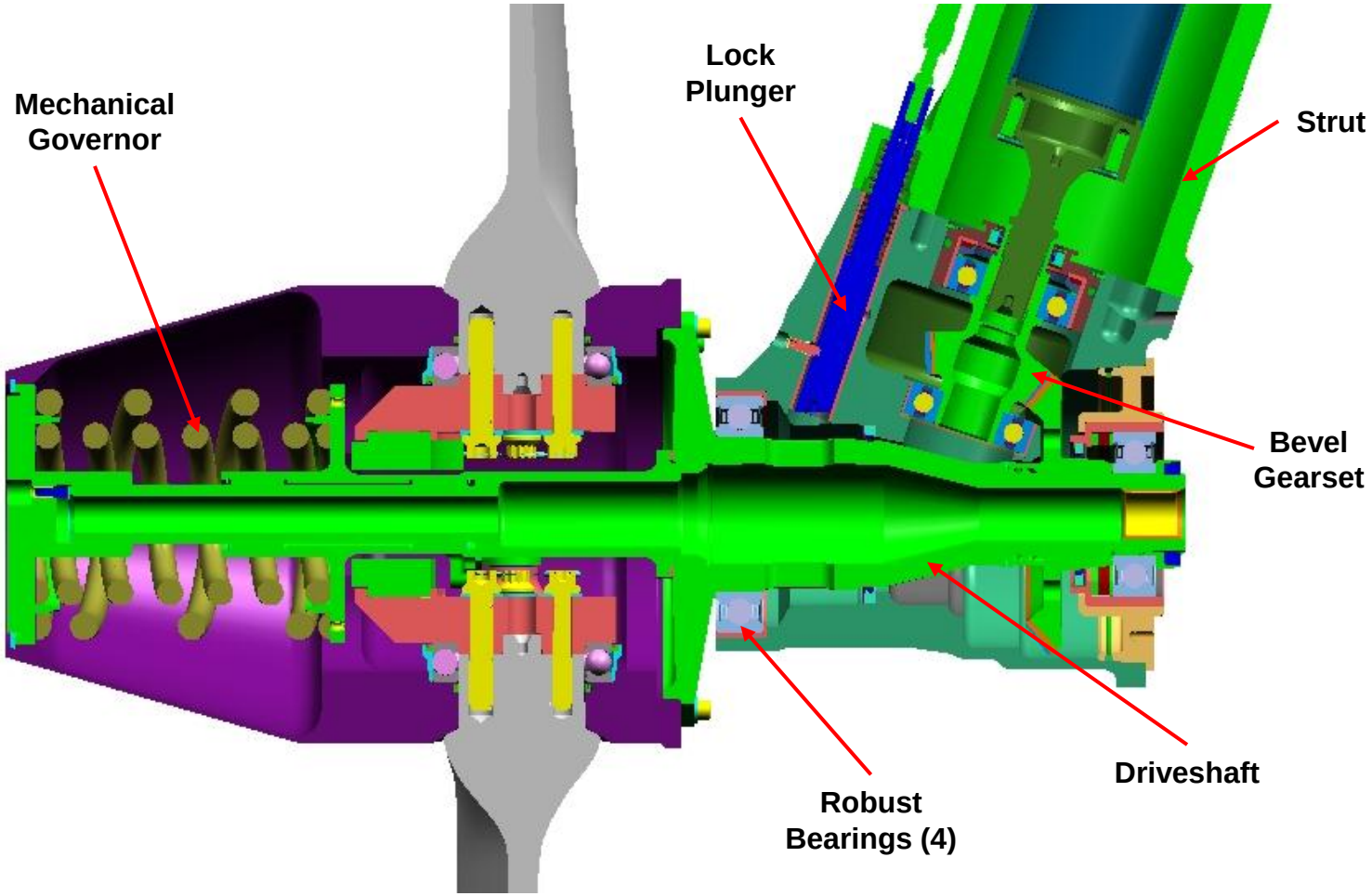
Turbine Assembly

RAT Module

- **Turbine Assembly**
  - Turbine Is a proven design
  - s all of the latest Hamilton Sundstrand RAT designs - starts with blades at fine pitch for simplicity
  - During operation, blade pitch angles are adjusted to maintain torque equilibrium
  - Turbine shaft is supported by 2 bearings in gearbox
  - Anti-Icing Device (Eddy Current Generator) at nose is not required but space will be provided



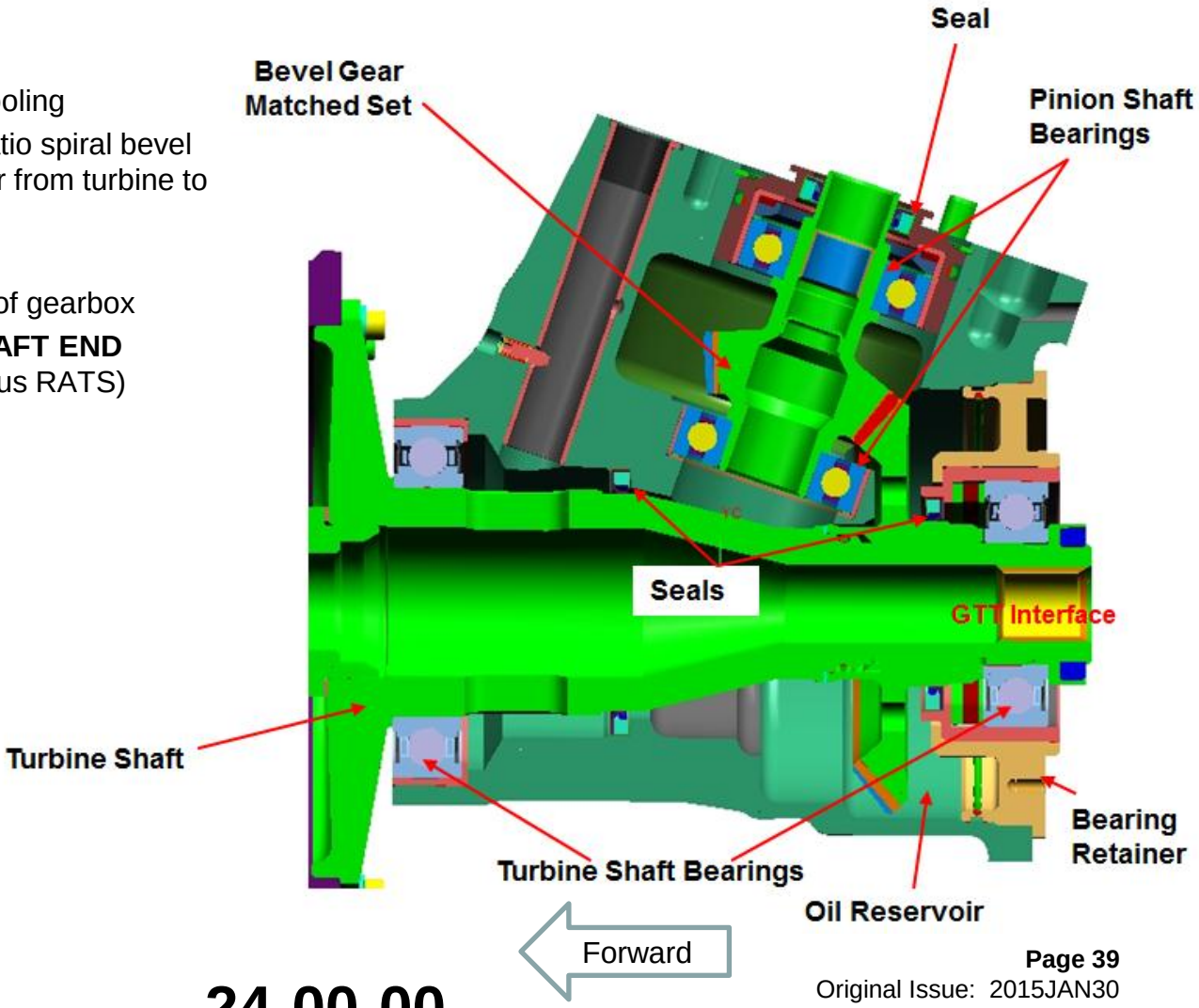
RAT Module Turbine/Gearbox Interface



Component Description – Gearbox Assembly

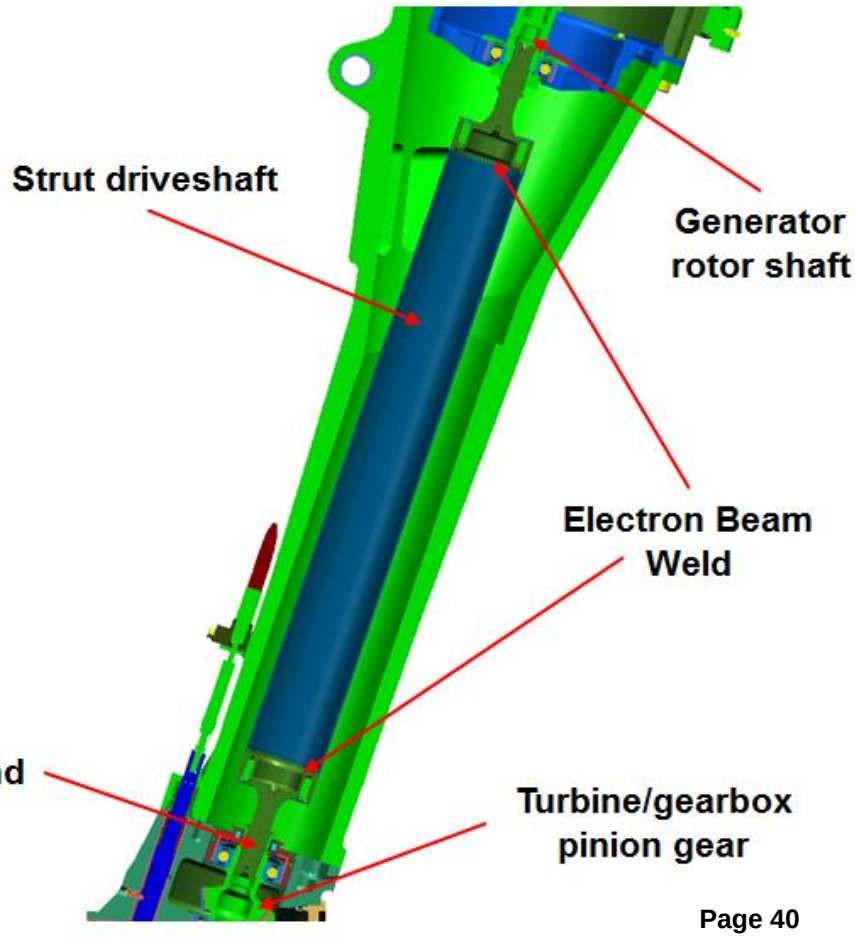
RAT Module

- **Gearbox Assembly**
  - Splash lubrication and cooling
  - Single stage, 2.1739:1 ratio spiral bevel gears that transmit power from turbine to generator
  - Speed Ratio 50:23
  - GTT interface at aft end of gearbox
  - **NO COVER PLATE AT AFT END** (Different than other Airbus RATS)



Component Description – Strut & Driveshaft Section View

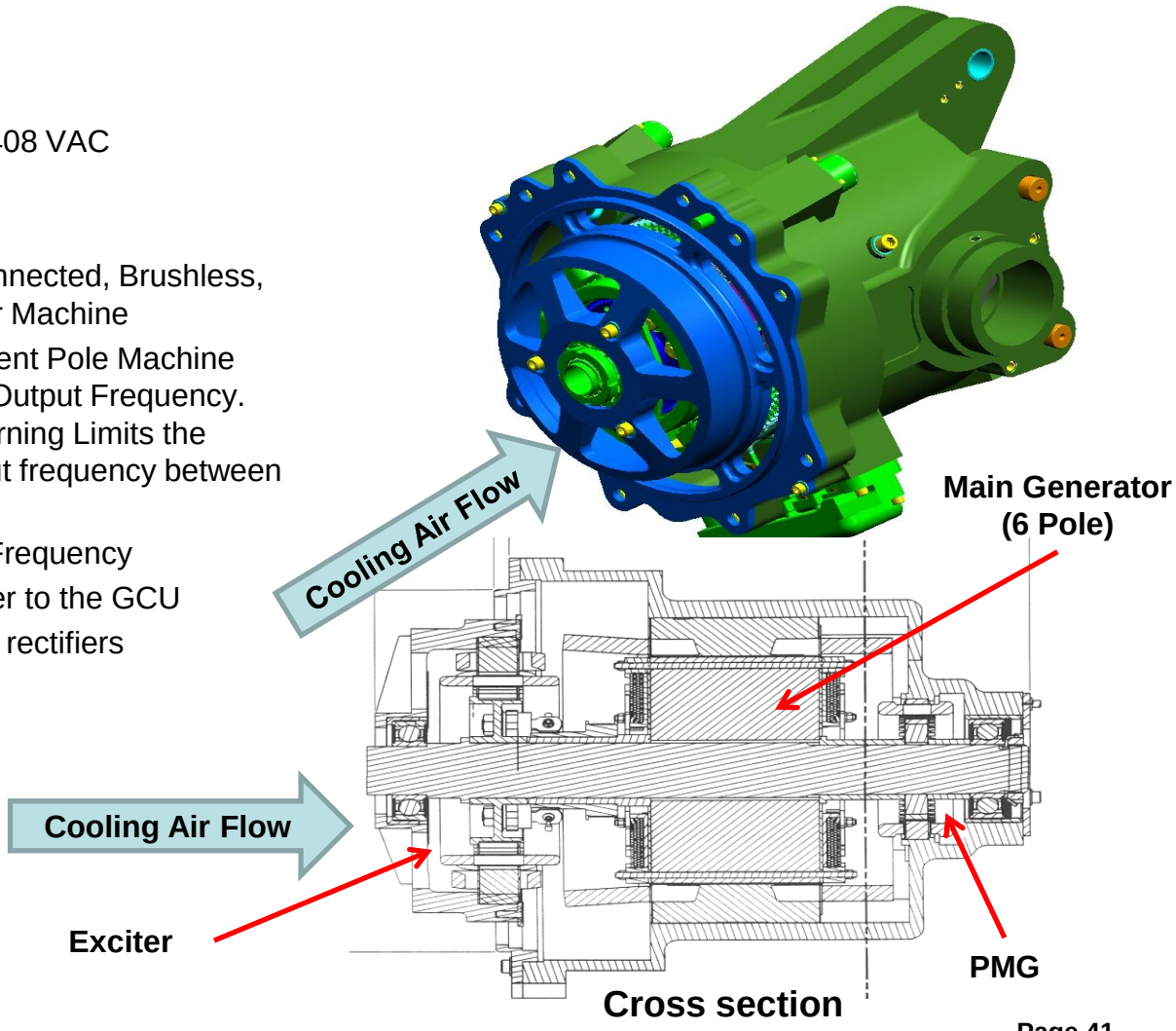
- **Strut and Driveshaft**
  - Connects turbine gearbox pinion to generator rotor shaft
  - Splined ends welded to tube section
  - Design similar to other RATs
- **Strut**
  - Structural support between turbine/gearbox and generator
  - Cylindrical Construction for stiffness requirements
  - Includes a Lug and Roller for Uplock Engagement
  - Includes 2 Lugs for the 2 Strut Link Attachments
  - Includes Vents for Generator Cooling Air Intake
  - Interface with aircraft door links
- **Drive Shaft**
  - Spans the Gap Between Gearbox Upper Gear and Generator Shaft
  - Shaft has Splined End Caps



Component Description – Electrical Generator

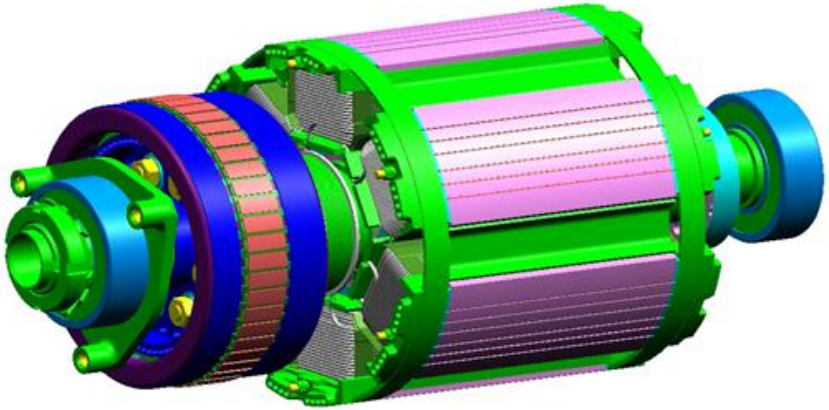
RAT Module

- **Electrical Generator**
  - 50 kVA rated 6-pole 235/408 VAC
  - Grease Packed Bearings
  - Air Cooled
  - 3 Phase, 4 Wire, Wye Connected, Brushless, 6 Pole – Rotating Rectifier Machine
  - Variable, High Speed Salient Pole Machine which produces Variable Output Frequency. RAT Module Speed Governing Limits the functional generator output frequency between 389 and 539 Hz.
  - Rated Load sized at Min Frequency
  - PMG stage provides power to the GCU
  - Exciter stage with rotating rectifiers

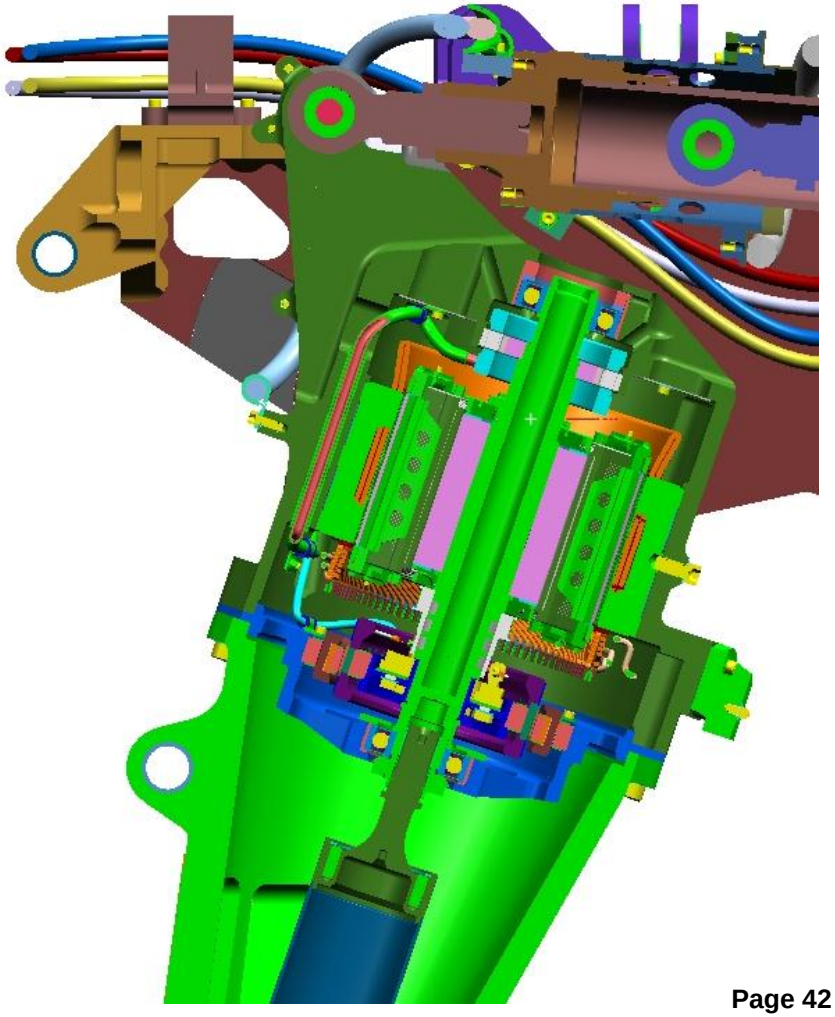


RAT Module Generator/Frame Interface

- **Generator**
  - Driven by strut driveshaft
  - Permanent magnet generator
  - Exciter stator/rotor
  - Main output stage
  - Load path between actuator and strut leg
  - Pivots in frame bushings

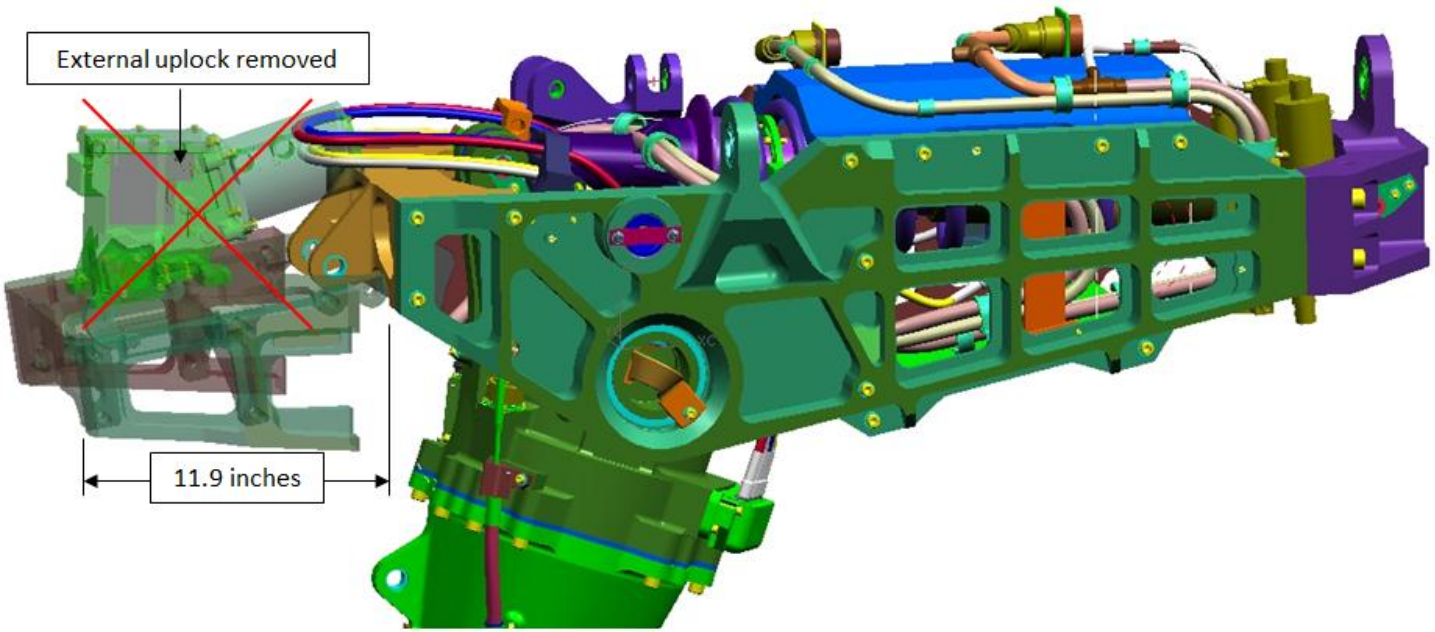


Generator Rotor



Component Description – Frame

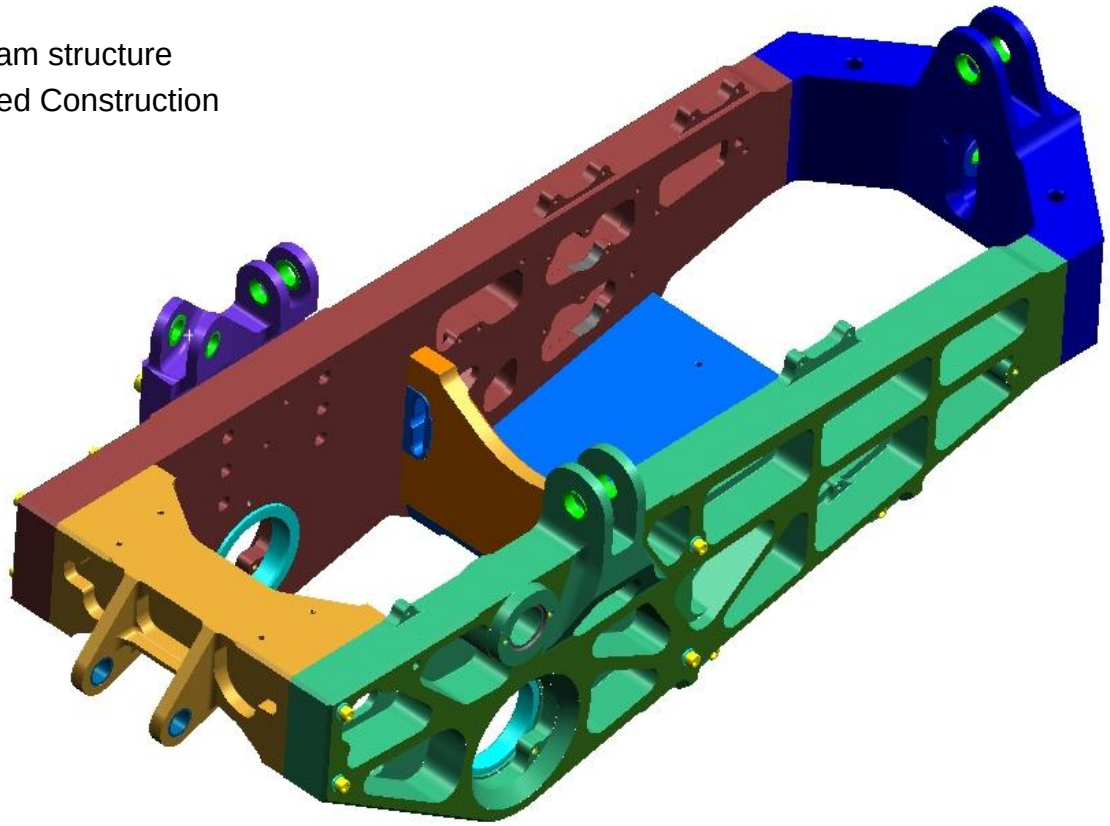
- **External Uplock Removed, Frame Shortened**
  - Uplock function now part of actuator
  - Significant weight savings



Component Description – Frame

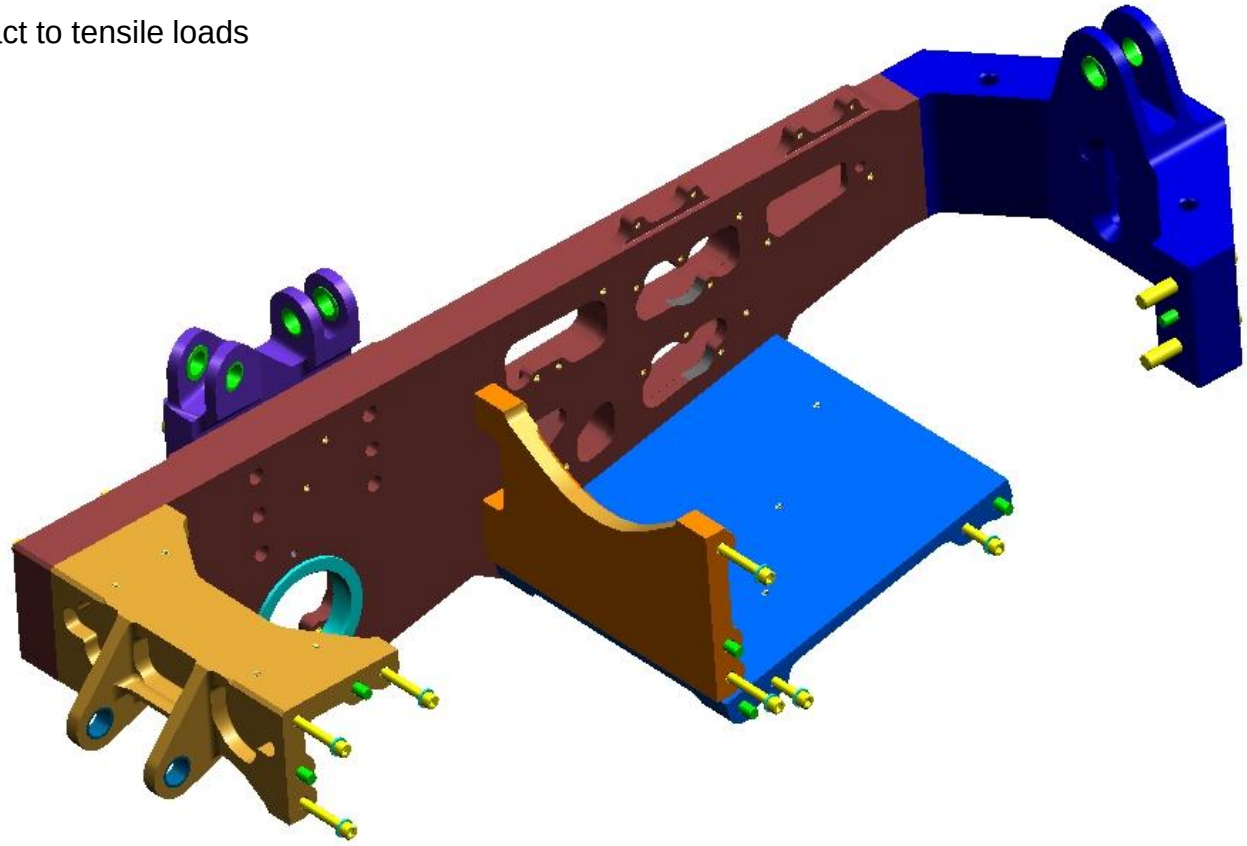
RAT Module

- **Frame (Sized primarily for stiffness)**
  - Structural member that supports the RAT module components and sub-assemblies
  - Interface with the A/C flap track beam structure
  - 7 Separate Pieces – Pinned & Bolted Construction
    - Aft Support
    - Plates
    - Left Panel
    - Spanner Plate
    - Right Panel
    - Front Support
    - Support Rod Bracket
  - Safety Pin interface
  - Pivot Axis Bushings
  - Pinned and bolted construction
  - Similar to A330/A340/A380



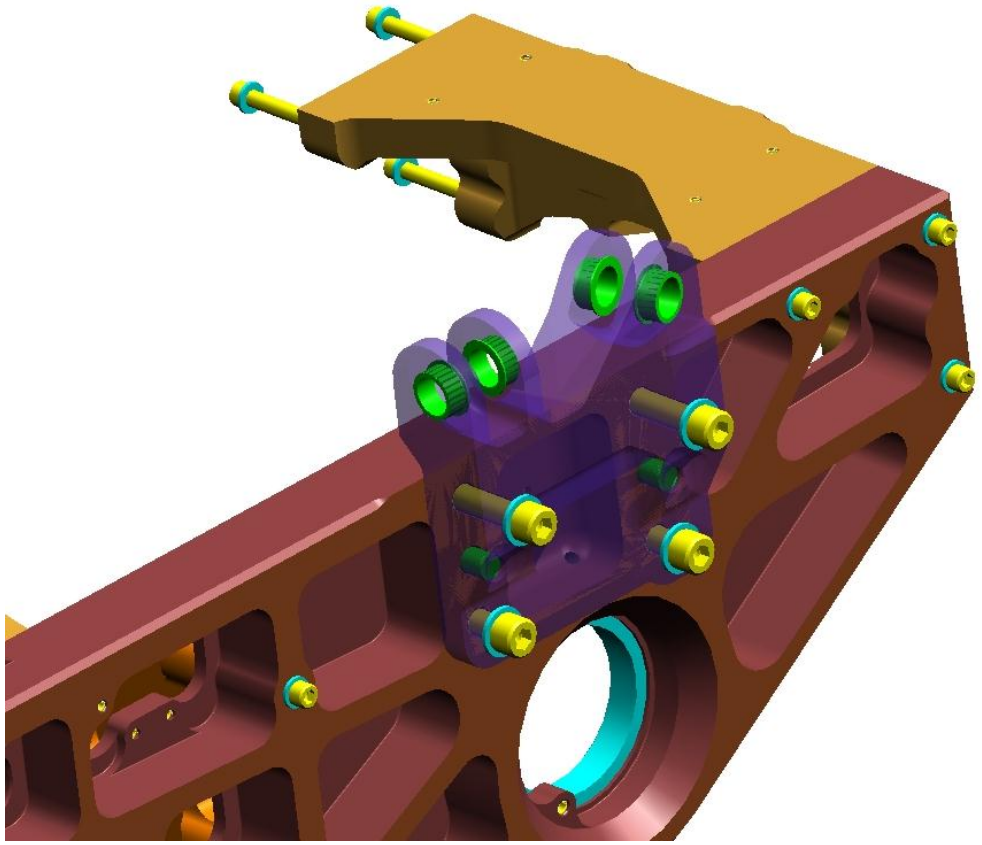
Component Description – Frame

- **Pinned and bolted construction**
  - Pins react to shear loads
  - Preloaded fasteners react to tensile loads



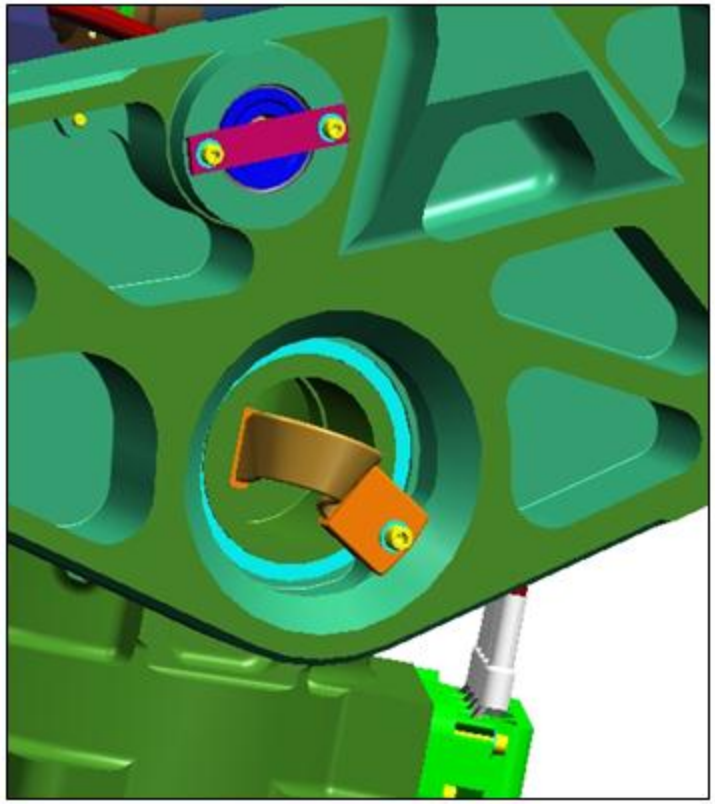
Component Description – Frame

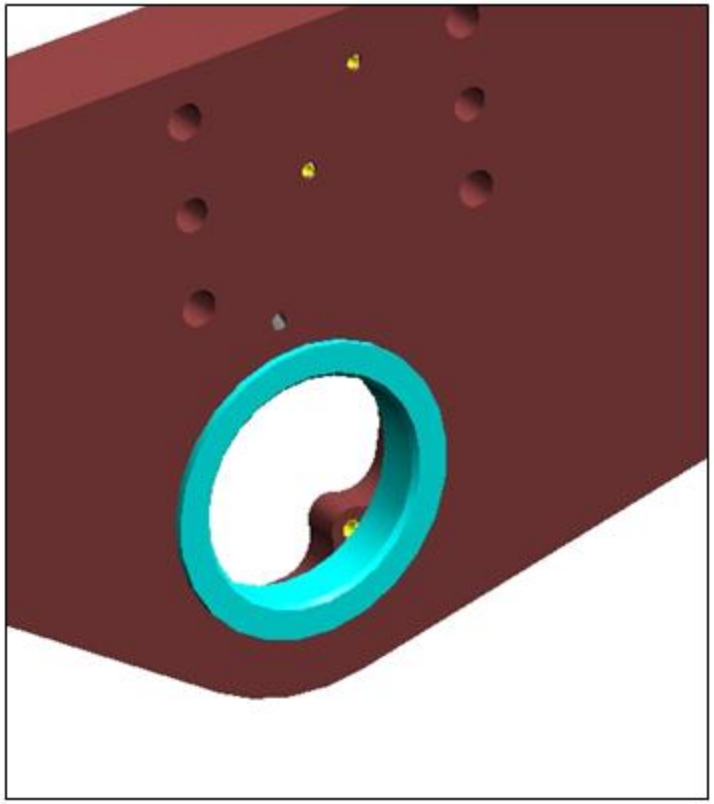
- **Support Rod Bracket pinned and bolted construction**



Component Description – Frame

- **Pivot Axis Bushings**
  - Woven Dacron/Teflon construction
  - Same part as used in A380 RAT

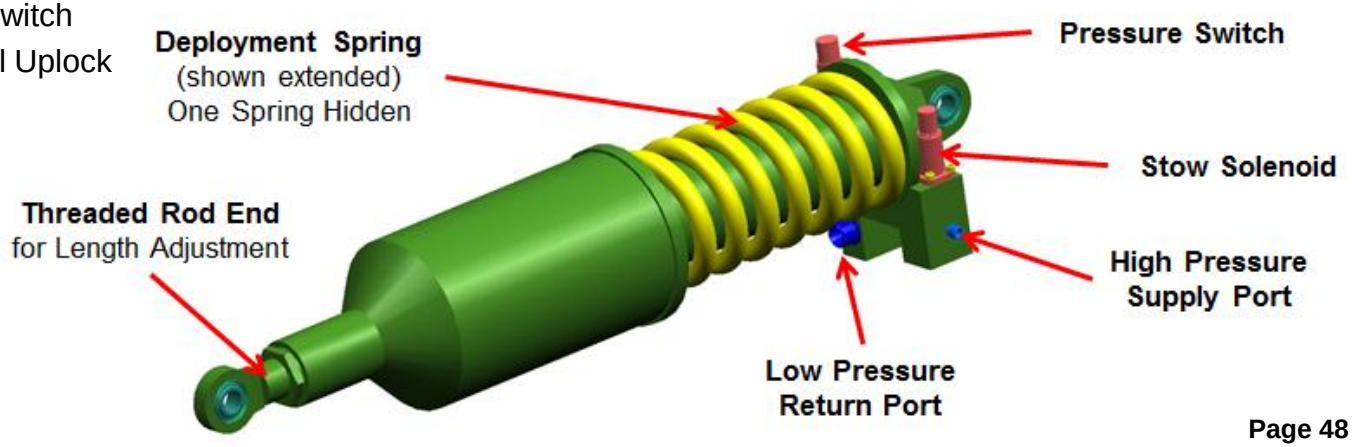




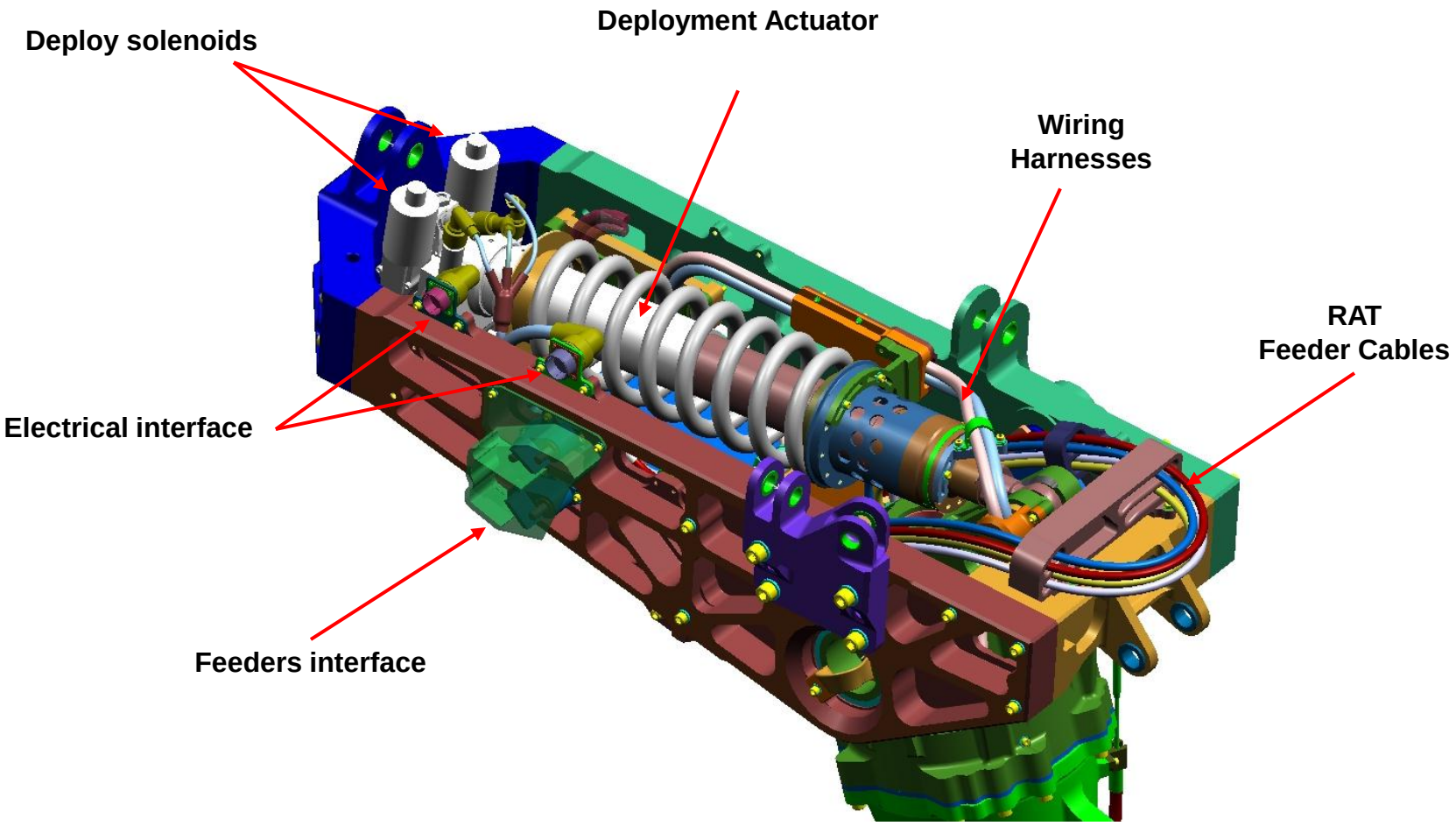
Component Description – Actuator

RAT Module

- **Actuator (purchased item made to an HS design specification by Arkwin Ind. AND UTAS Poland)**
  - Controls deployment with internal damping
  - Controls retraction with electrical signal from the stow panel and hydraulic power from the aircraft
  - Features;
    - Dual Deployment Springs – both work to push RAT out at start of deployment
    - Downlock – prevents upward rotation of RAT after reaching deployed position
    - Stow Solenoid – diverts aircraft hydraulic pressure to the control valve
    - Control Valve – shuttles under pressure from stow solenoid to route high pressure to the piston chamber to retract the actuator
    - Pressure Switch – indicates if high pressure is present in piston chamber
      - Normal condition during retract/restow
      - Abnormal condition during RAT standby mode that could prevent deployment
    - Stow Switch
    - Internal Uplock



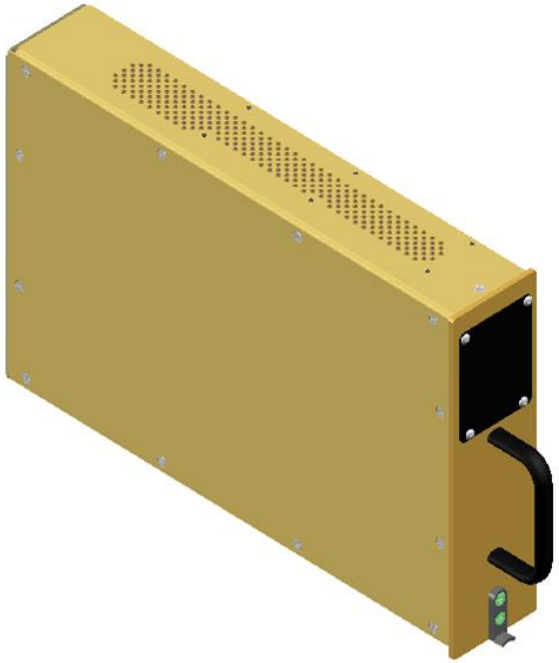
RAT Module Frame/Actuator Interface



Component Description – Generator Control Unit

RAT Module

- **GCU**
- Stow Panel
- Ground Test Picture (Backdrive)



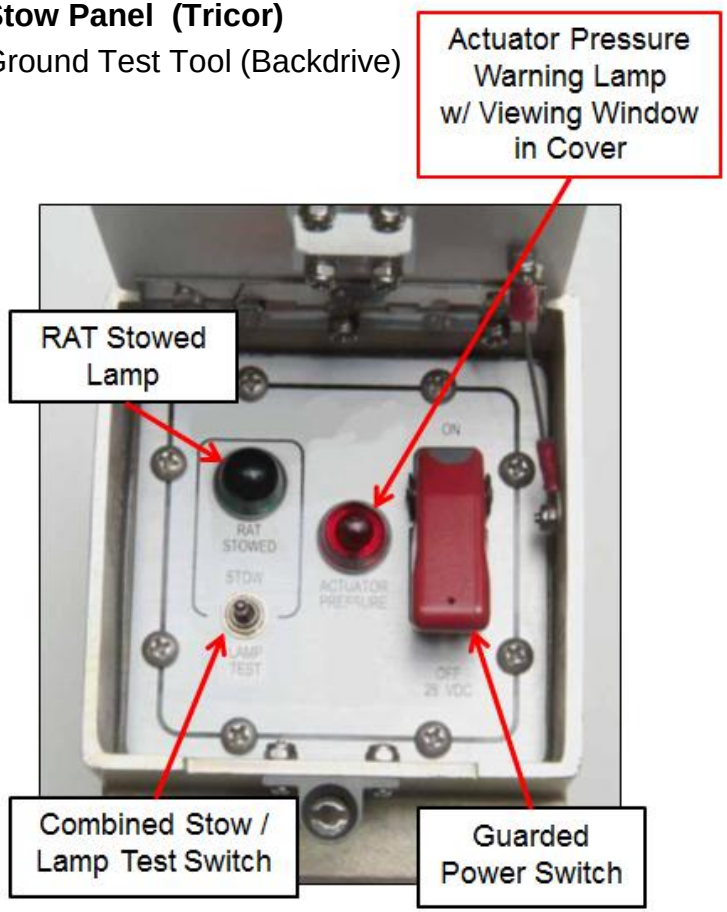
- Electronic Controller based on the A380/A400M RAT GCUs and is responsible for the following functions;
  - Regulation of POR Voltage Within Specified Range & Envelope
  - Functional Control of RAT System and Status Reporting
  - System Monitoring, Protection and Fault Management of RAT System
    - Over Voltage (OV)
    - Under Voltage (UV)
    - Over Current (OC)
    - Differential Protection (DP)

    NOTE: Protections are locked out during emergency deployment of RAT "Protective Inhibit Mode" so are only active for flight or ground test
    - Built-In Test
    - One Way Communication through ARINC 429 Data Bus
- Design to Requirements of ARINC Spec 600-13
  - 2 MCU Form Factor LRU
  - 7.1 lb/3.2 kg
  - Natural Convection Cooling
  - Mother / Daughter Cards Configuration
  - Meets A350 EMI and Vibration Levels
  - Estimated Maximum GCU Heat Dissipation

Component Description – Stow Panel

RAT Module

- GCU
- **Stow Panel (Tricor)**
- Ground Test Tool (Backdrive)



- Stow Panel
  - On/Off Power Switch & Single Stow/Lamp Test Switch
  - Independent of RAT module Stow Abort mechanism
  - Operating Voltage 15 – 32.5 Vdc
  - Electrical Connector (on back)
    - EN2997SE71415MN
  - Actuator Pressure Switch Current – 1.0 A max
  - Actuator Stow Solenoid Power
    - 32 W max
    - 15 – 32.5 Vcd, -55°C to +70°C
  - LED Current
    - 1.0 A max during LED Display Test
  - Enhanced Internal Grounding
    - For higher fault currents

Back Side of Stow Panel showing connector

Component Description – Ground Test Tool

RAT Module

- GCU
- Stow Panel
- **Ground Test Tool (GTT)**
  - For Backdrive

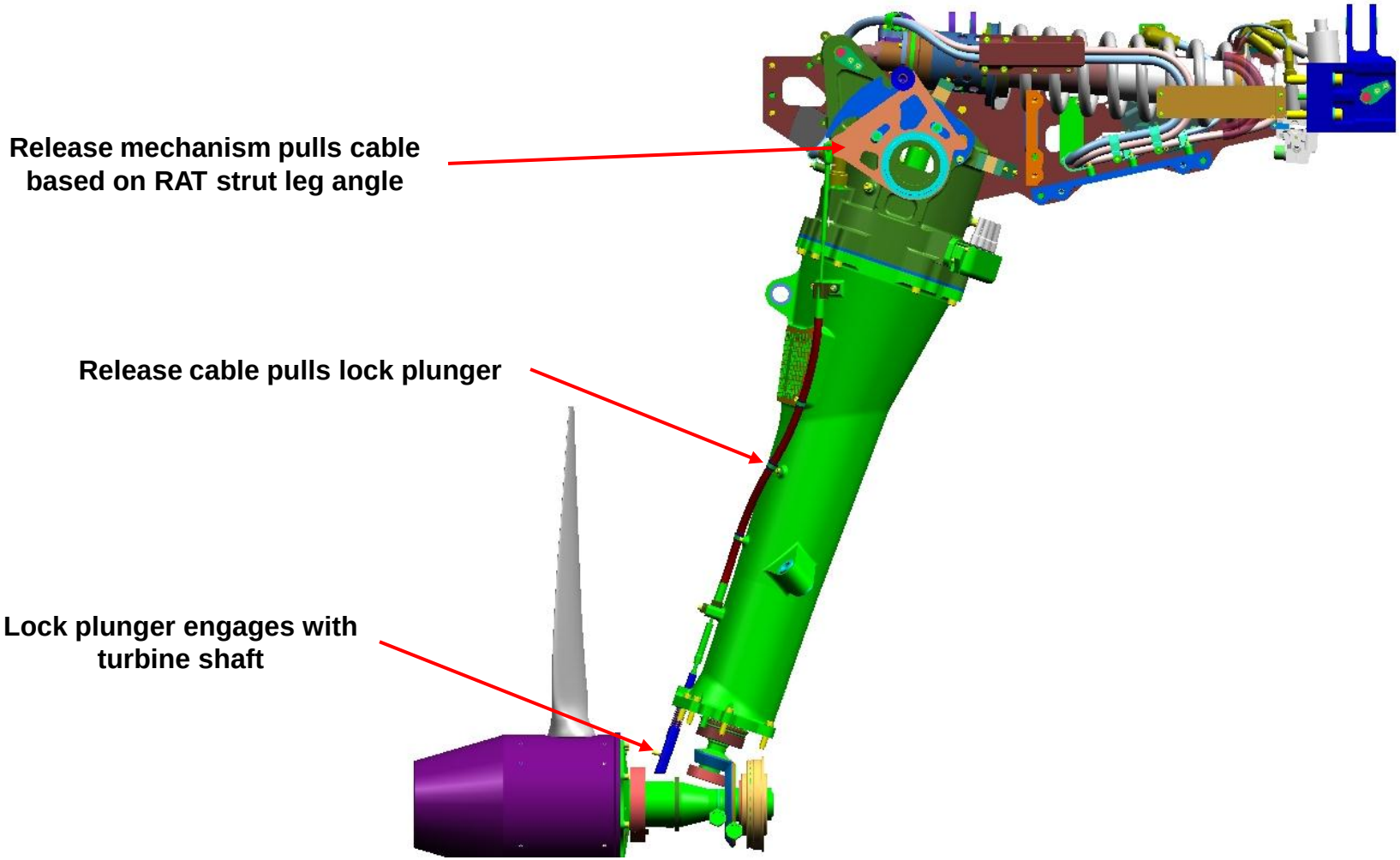
    Details of GTT later in presentation

- Ground Test Tool (GTT)
  - Hydraulic Ground Test Motor Bolts to the back of the Turbine
  - Driven by 5000 PSI Hydraulic Cart
  - Need to support hoses
  - Supplied by **Tronair**

Airbus A350 XWB Ram Air Turbine

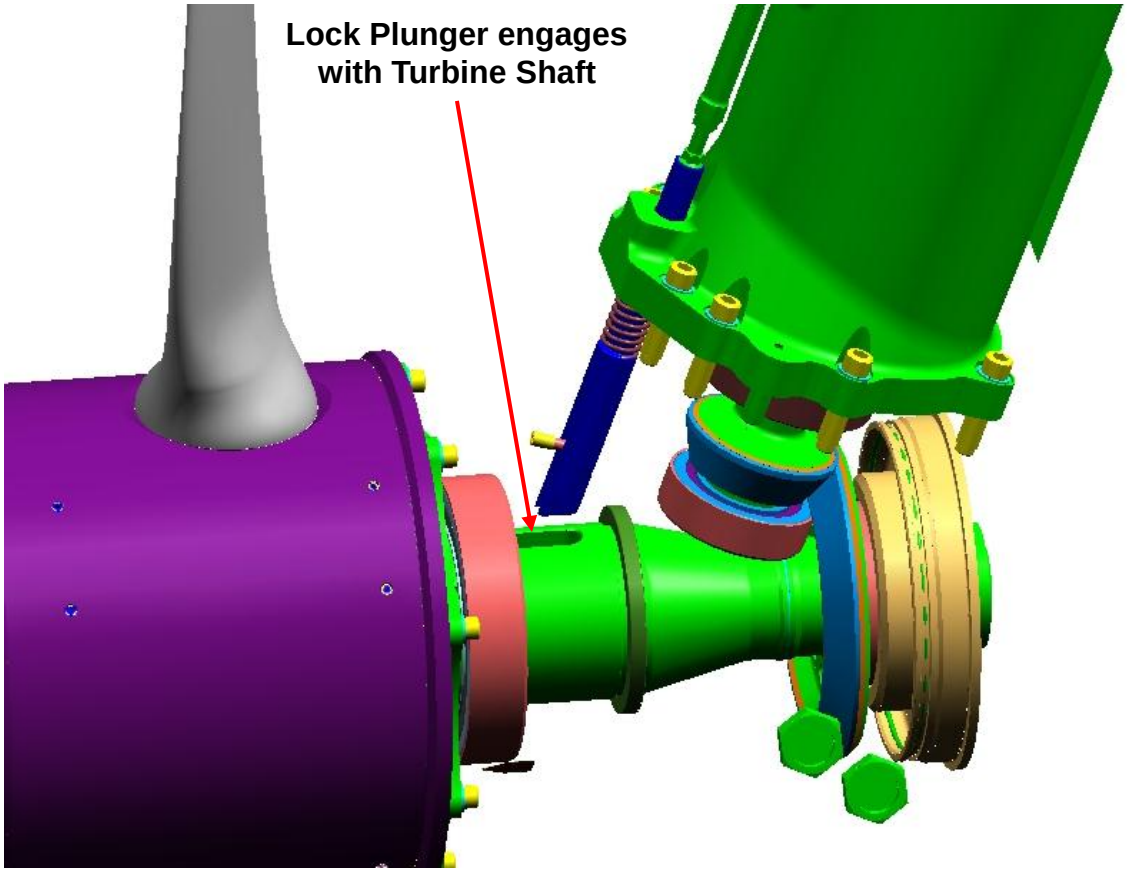
Module 6 - Component Operation

Component Operation – Turbine Lock Mechanism



Component Operation – Turbine Lock Mechanism

- **Proven lock plunger design**
  - Non-galling Nitronic 60 stainless steel



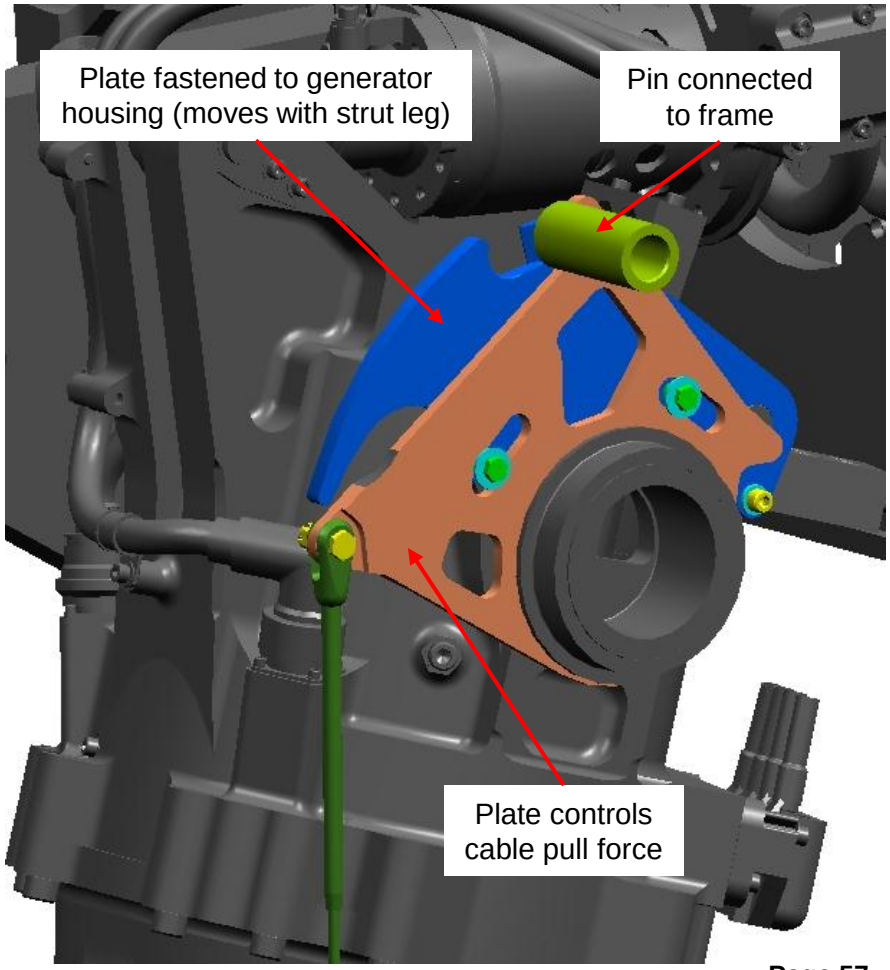
Component Operation – Turbine Lock Mechanism

- Release cable design similar to most other RATs
  - Stranded steel tensile member
  - Wrapped steel/poly casing
  - Pre-stretched at supplier
- Attached to strut with loop clamps
- Routing minimizes deflection
- Spring preload (tension) for use with stow abort mechanism

Component Operation – Turbine Lock Mechanism

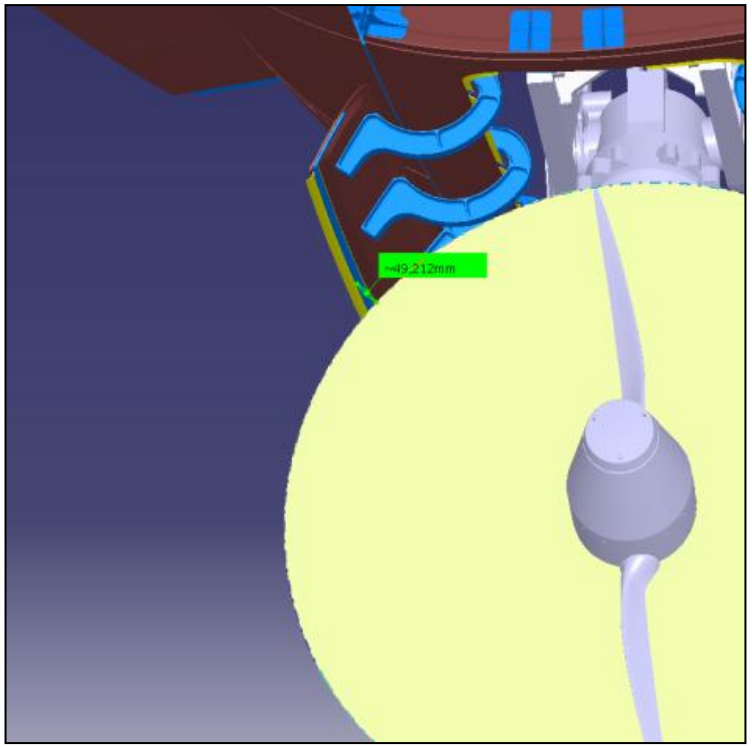
- Release mechanism uses kinematics of fixed and moving RAT members to pull release cable
  - Repeatable release point
  - No assembly adjustment (except for plunger & cable)

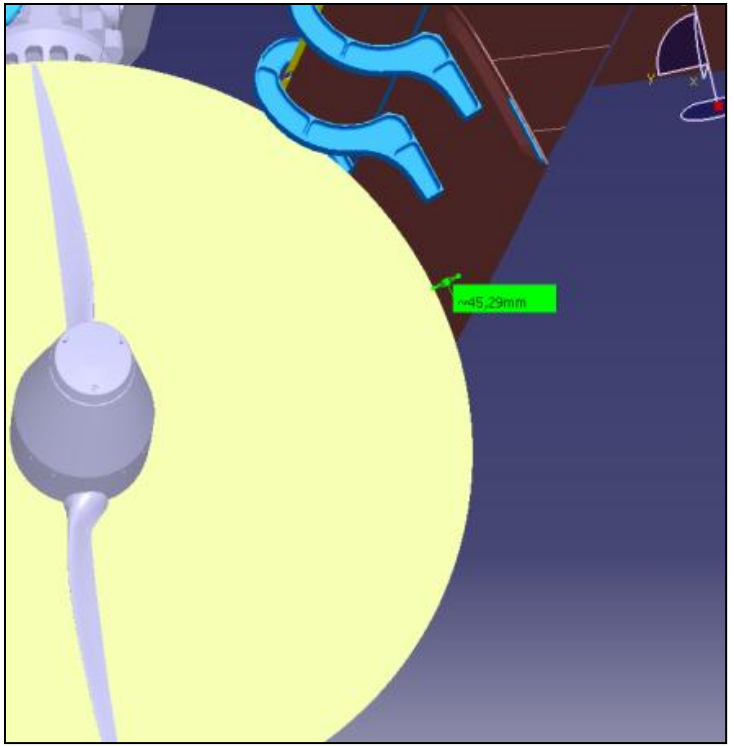
- Also functions as stow abort mechanism if blades are misaligned
  - Senses plunger position
  - Physically stops strut motion toward stowed



Component Operation – Turbine Lock Mechanism

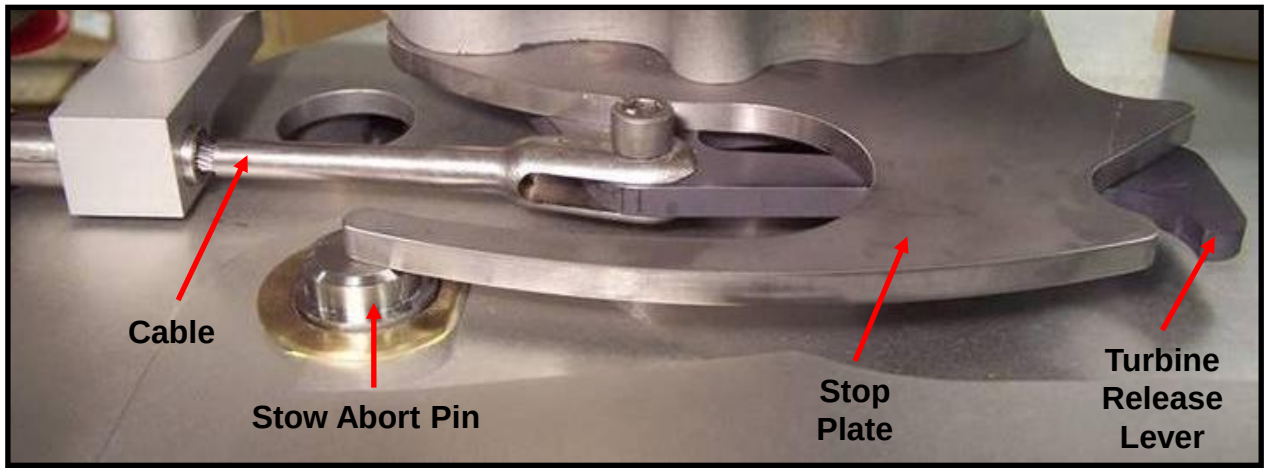
- **Stow abort conditions**
  - RAT mechanism stops misaligned restow before 53 degrees
  - Airbus analyses show blade-door clearance of 45 mm minimum



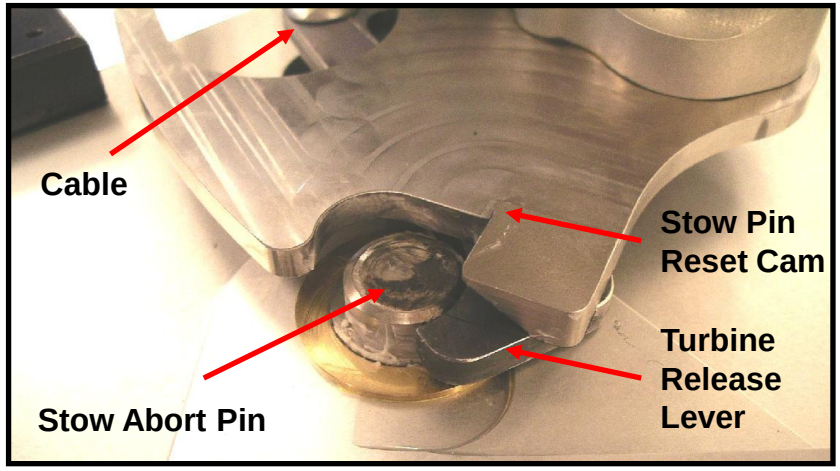


Component Operation – Turbine Lock Mechanism

- **Normal Stowed Position**

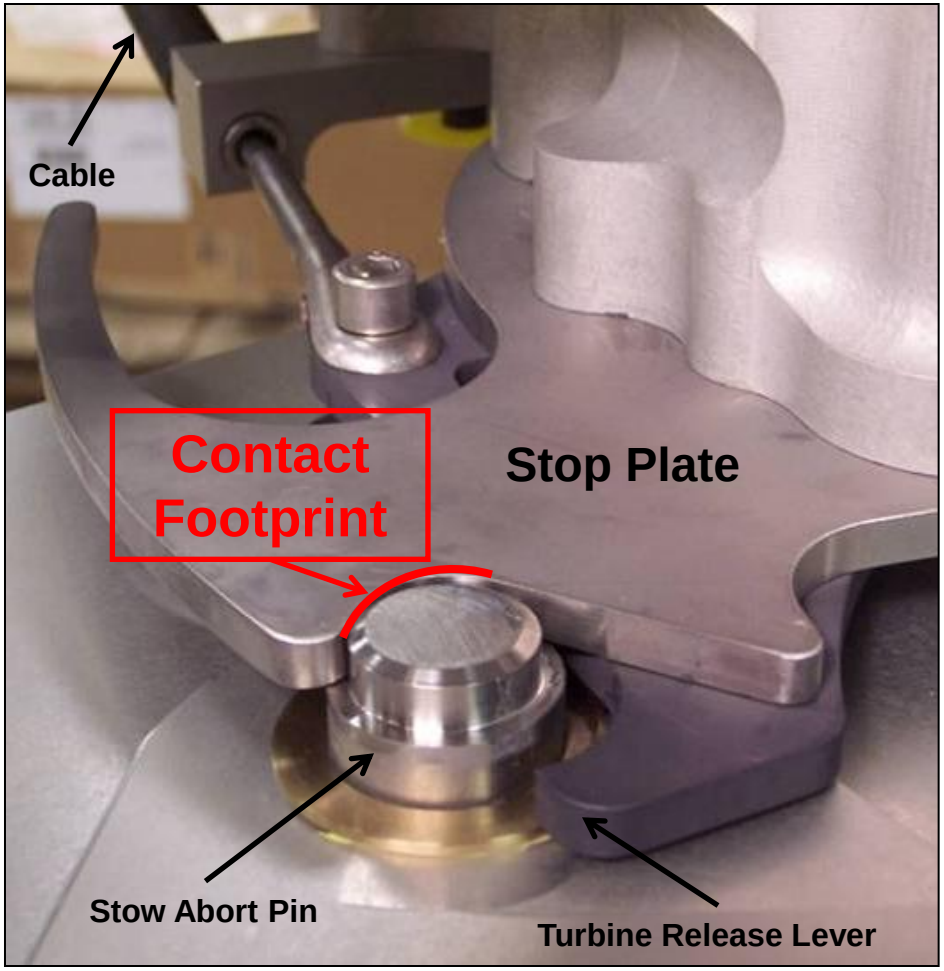


- **Normal Deployed Position**



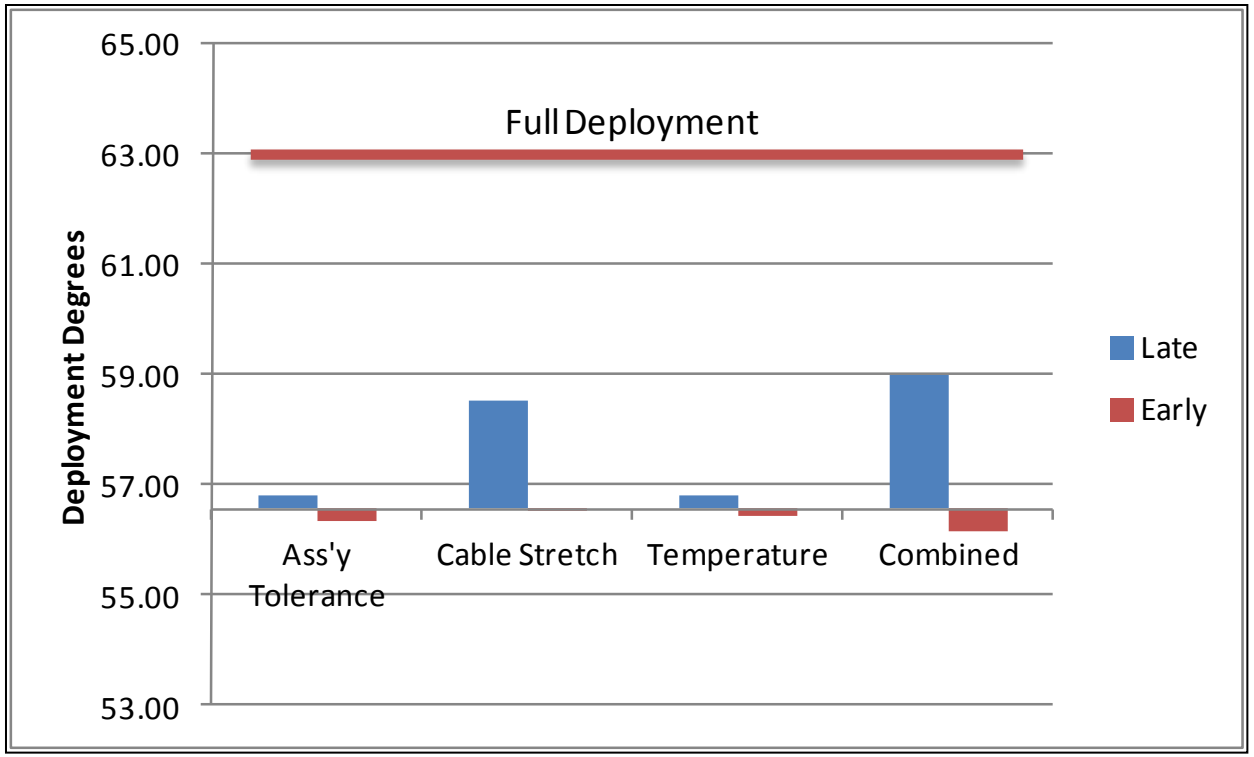
Component Operation – Turbine Lock Mechanism

- **Stow Abort in Effect**



Component Operation – Turbine Lock Mechanism

- **Turbine release range of 56-59 deg from stowed**
  - Nominal release angle = 56.58 deg
  - Earliest release = 56.18 deg
  - Latest release = 59.00 deg
- **Fully deployed = 63.0 deg**

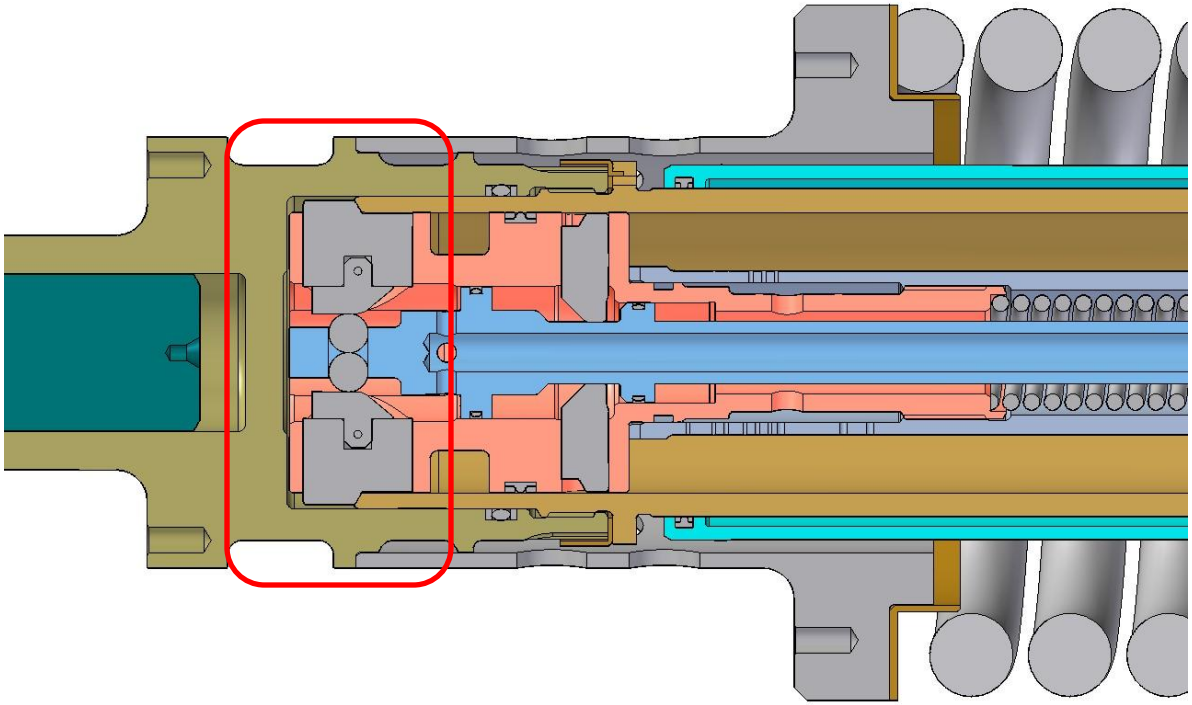


Component Operation – Actuator

- **Actuator**
  - Extends turbine into airstream under all aero & g loads
    - Via extension spring preload
    - No hydraulic pressure required
  - Controls extension rate using internal hydraulic damping
    - Higher damping near extended position
    - Limits dynamic loading
  - Either deploy solenoid will release actuator
  - Restow on ground using aircraft hydraulic system pressure and stow panel command signal
- **Pressure switch**
  - Senses abnormal pressure when stowed
  - Indicates normal pressure during restow
- Stowed switch indicates RAT in stowed/locked position
- Direct interface with aircraft hydraulic lines and deploy solenoid wire bundles
- Restow solenoid and switches interface with aircraft through RAT wiring harness

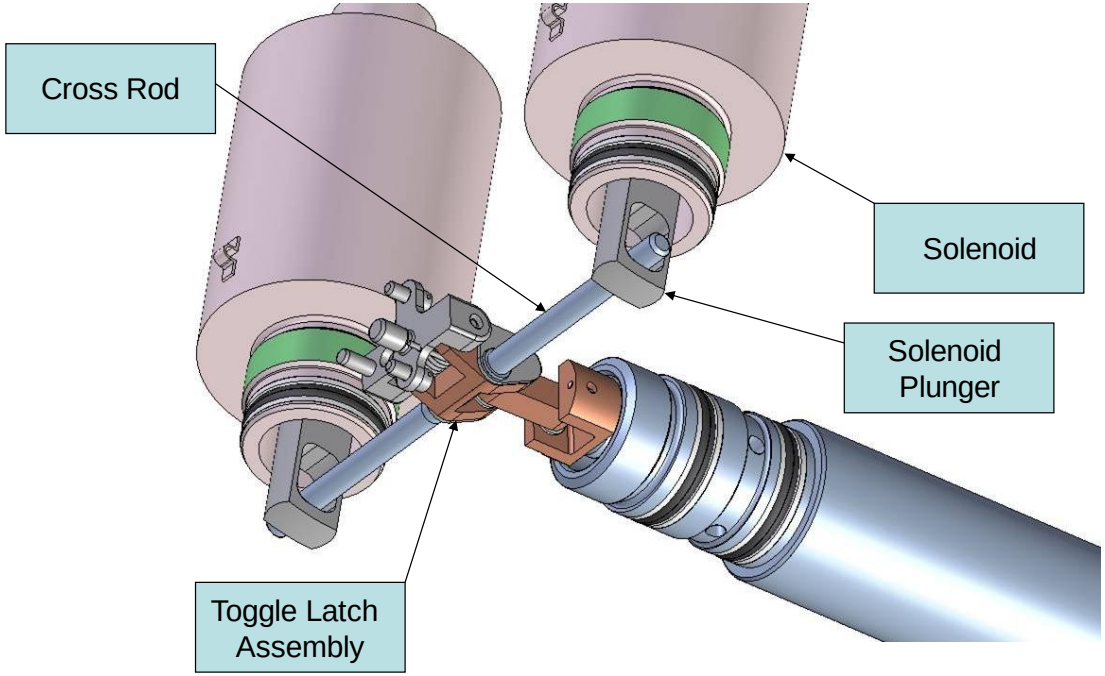
Component Operation – Actuator

- **Integral Uplock (Retracted Position)**
  - Automatically engages when RAT reaches stowed position
  - Released by deploy solenoid action on latch mechanism
  - Pawl and roller design for strength and low friction



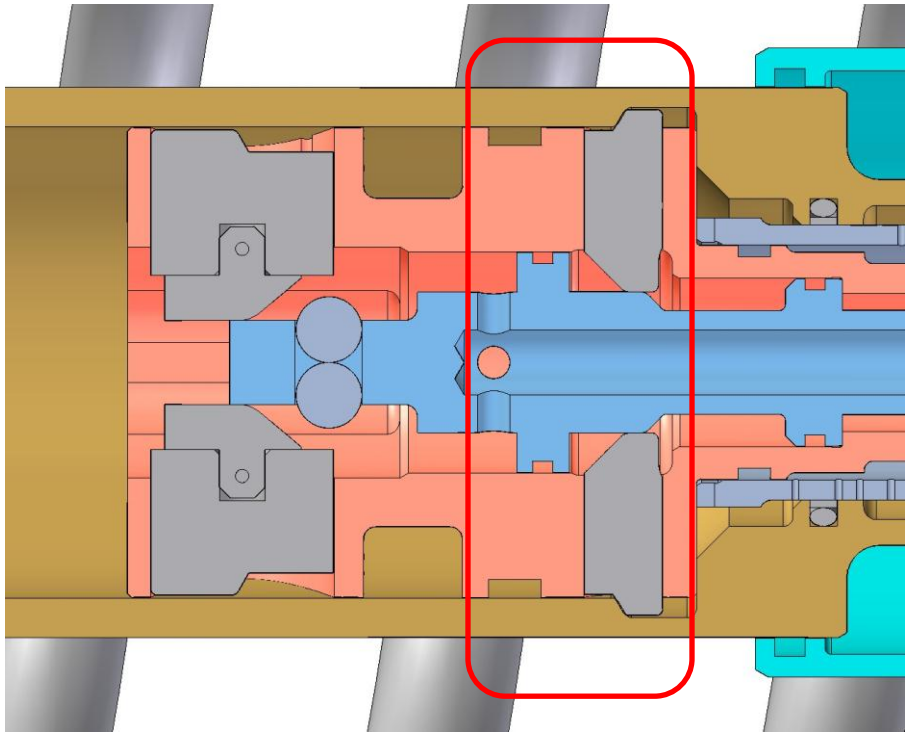
Component Operation – Actuator

- **Internal uplock**
  - Overcenter latch mechanism released by either deploy solenoid
  - Capable of unlocking under worst case (max tensile) external loads and spring loads
  - Maintains locked position without relying on friction



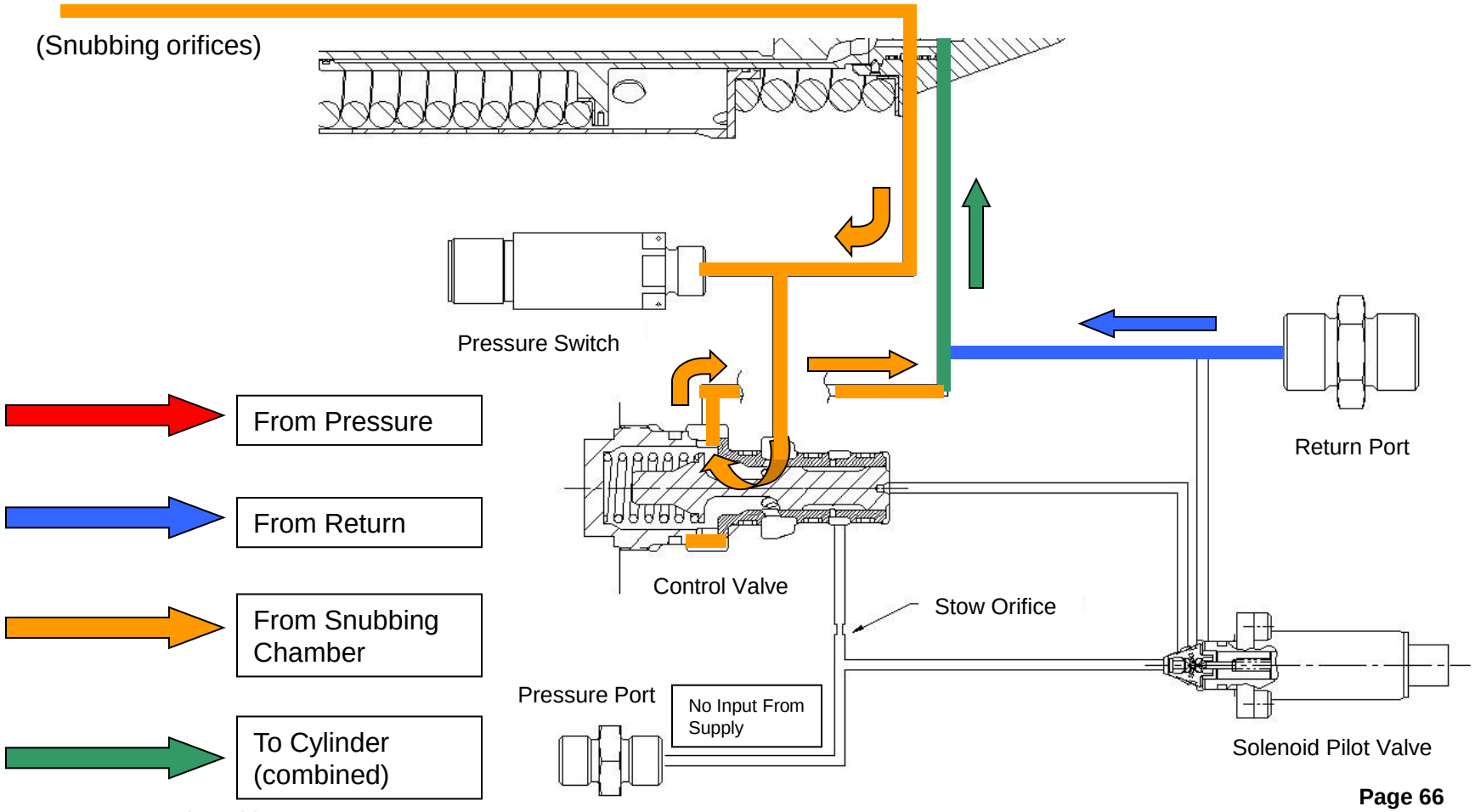
Component Operation – Actuator

- **Integral Downlock (Extended Position)**
  - Automatically engages at end of extension stroke
  - Released by application of hydraulic pressure during restow
  - Robust pawl design



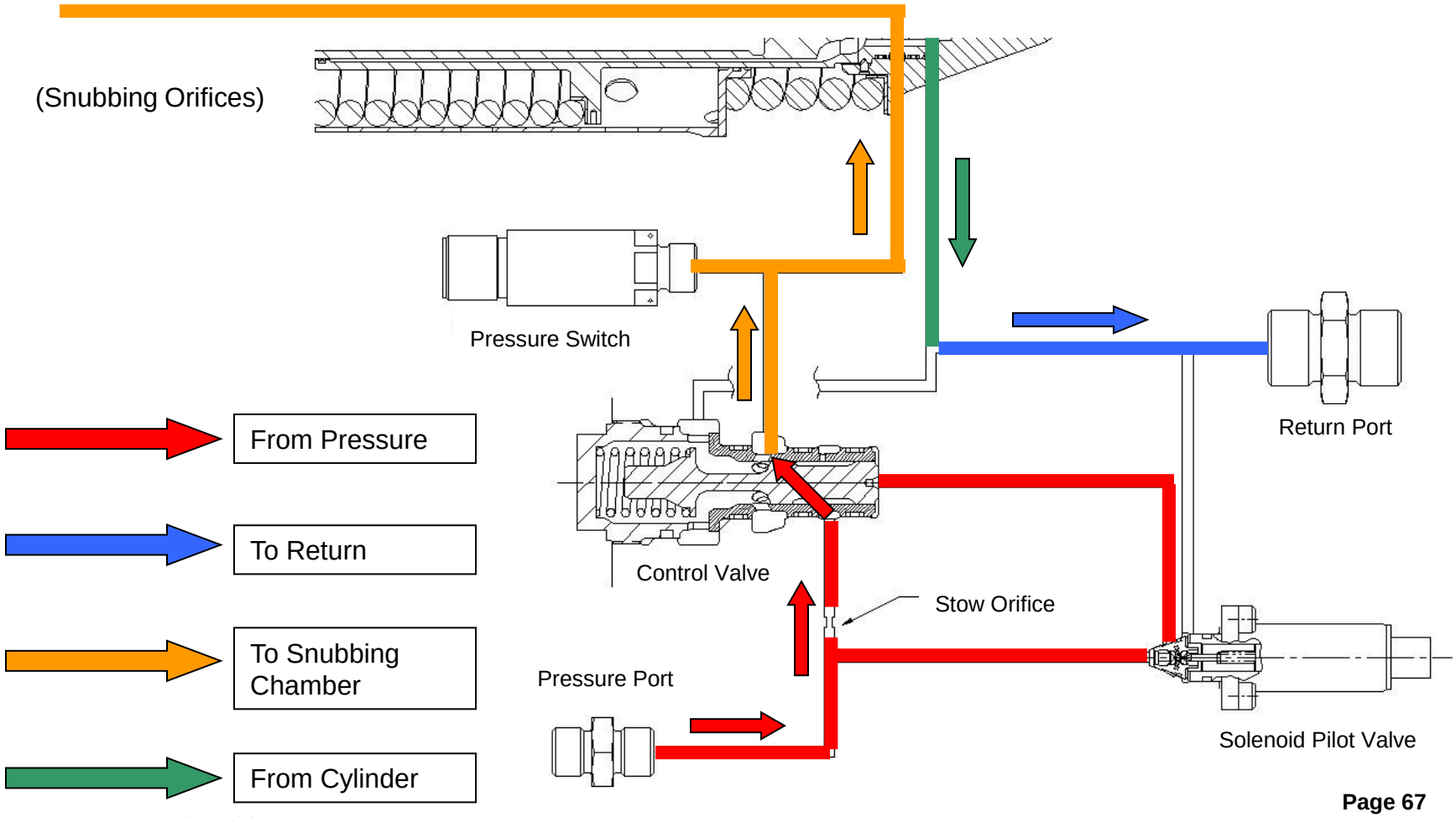
Actuator Hydraulic Operation – Deployment

- **Hydraulic flow during DEPLOYMENT**



Actuator Hydraulic Operation – Restow

- **Hydraulic flow during RESTOW**



Actuator Hydraulic Operation

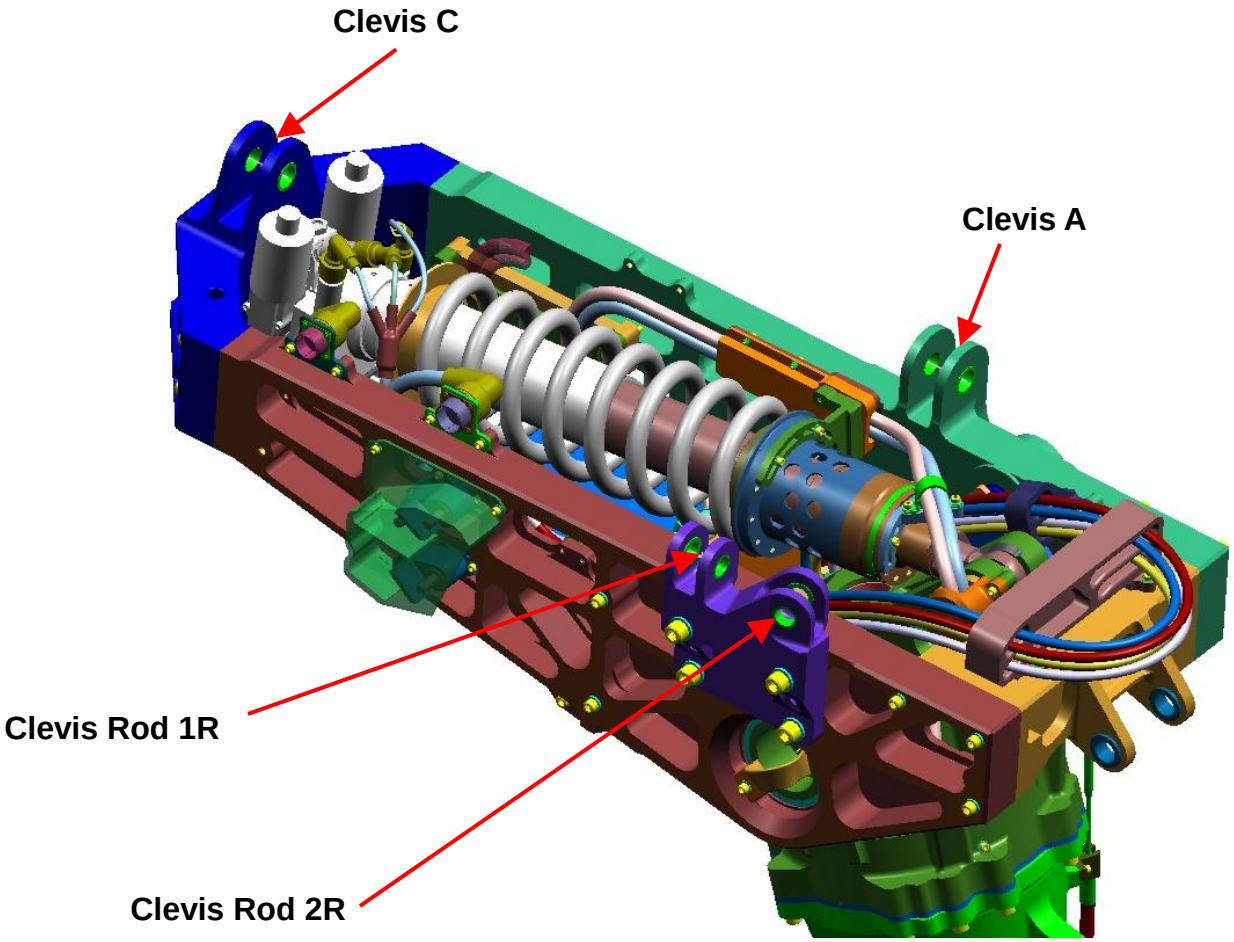
THIS PAGE INTENTIONALLY LEFT BLANK

Airbus A350 XWB Ram Air Turbine

Module 7 - Aircraft Interfaces

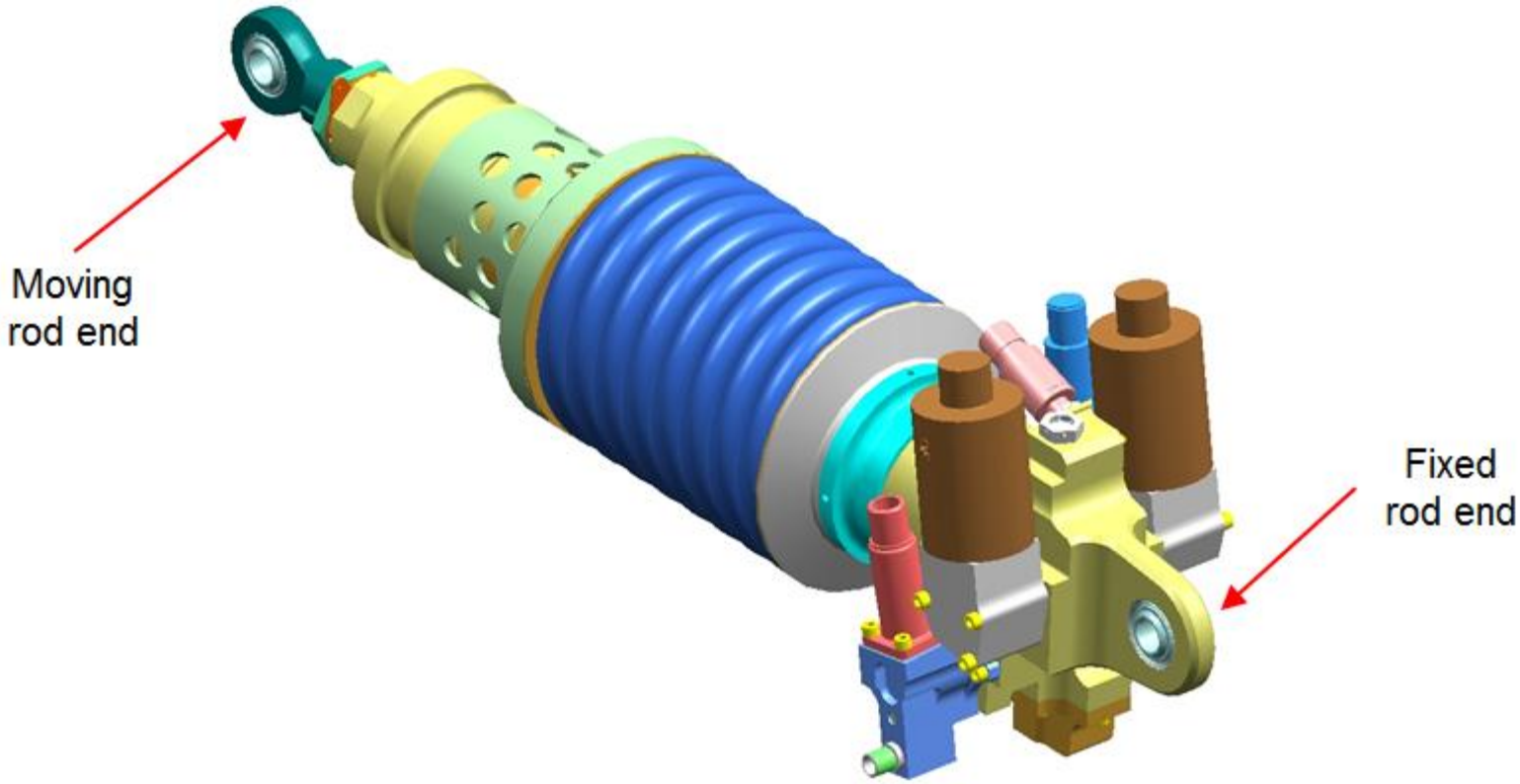
Mechanical Interface – Aircraft Mounting

- **Mounting Lugs / Clevises**



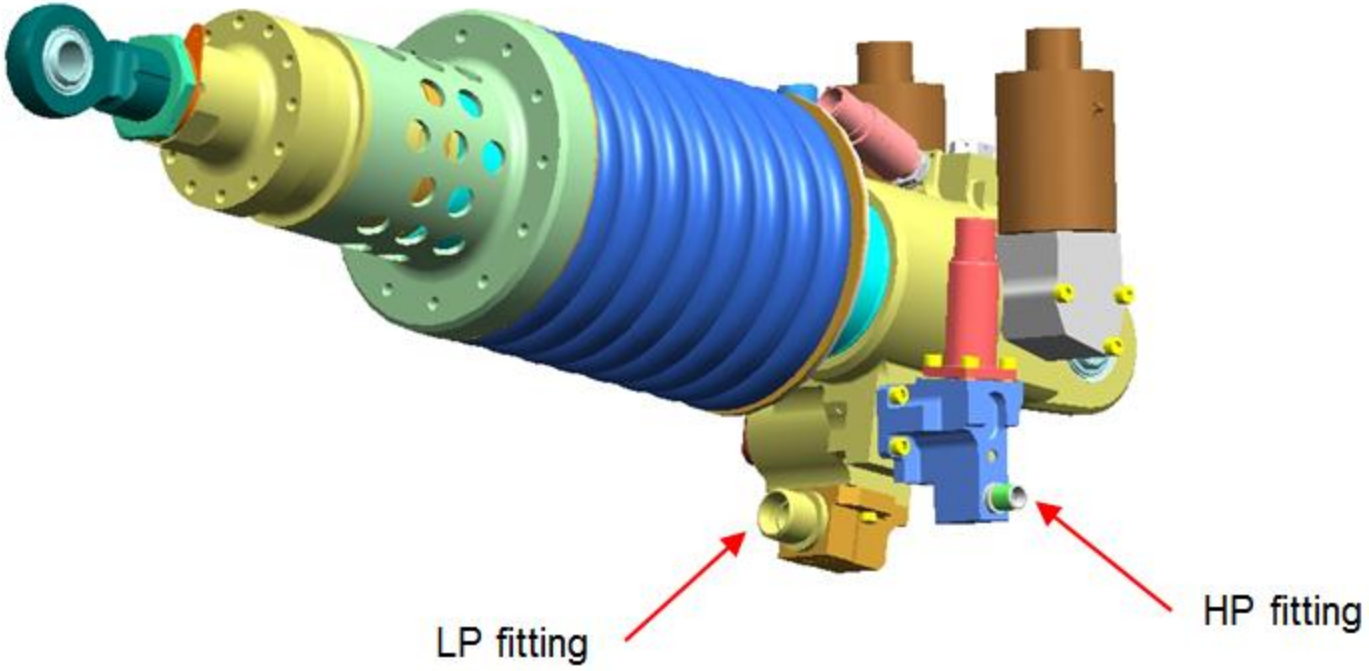
Mechanical Interface – Aircraft Mounting

- **Mounting lugs**



Hydraulic Interface – Aircraft Mounting

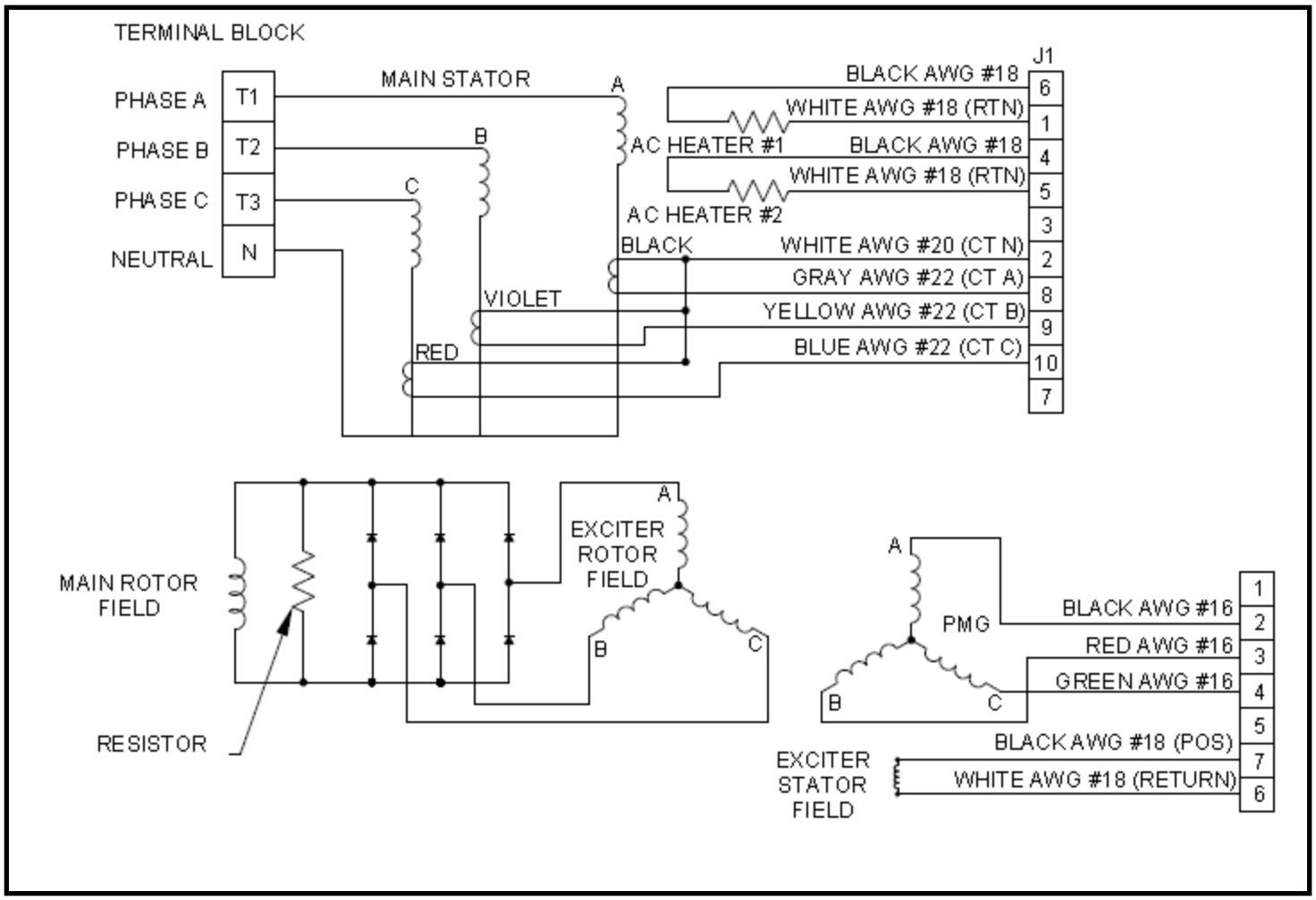
- **Pressure fittings**



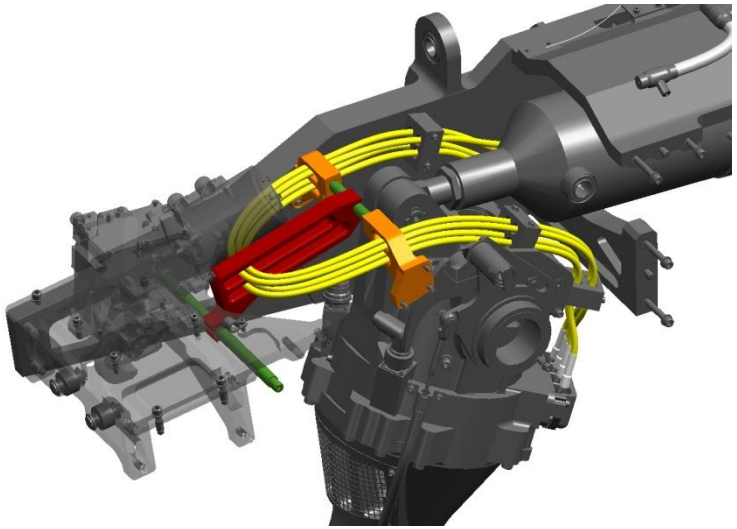
Airbus A350 XWB Ram Air Turbine

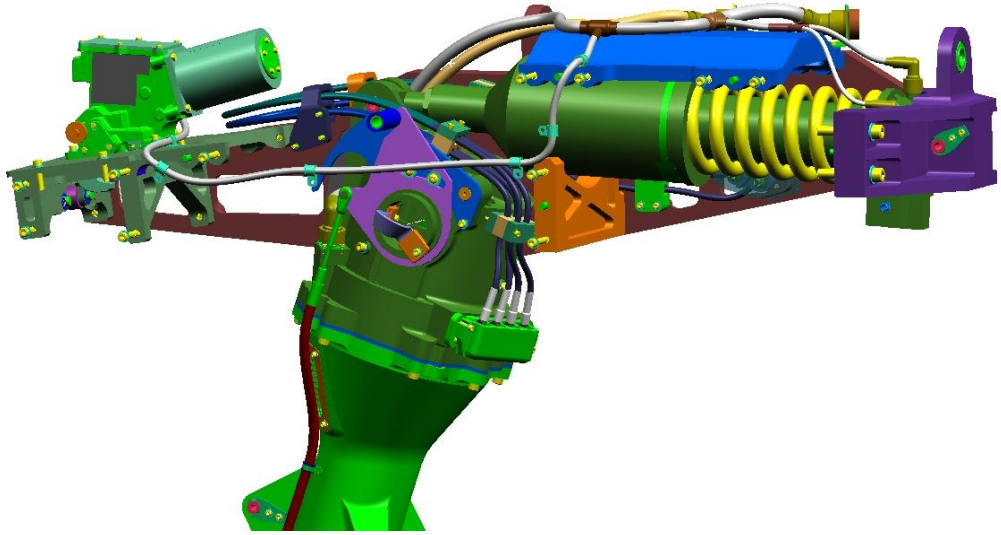
Module 8 - Electrical Interfaces

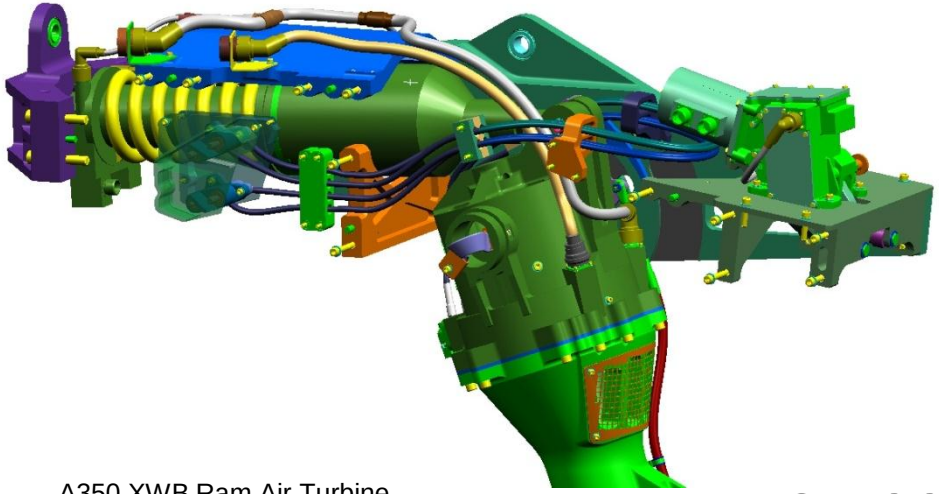
A350 XWB RAT Pin to Pin Connections

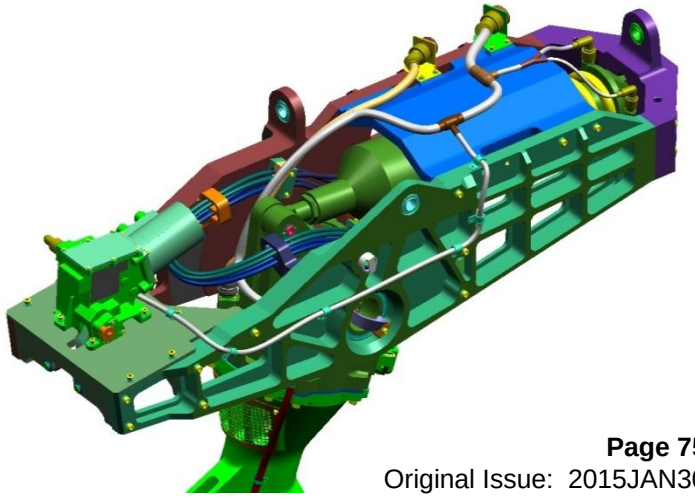


Electrical Interfaces – Harness Runs



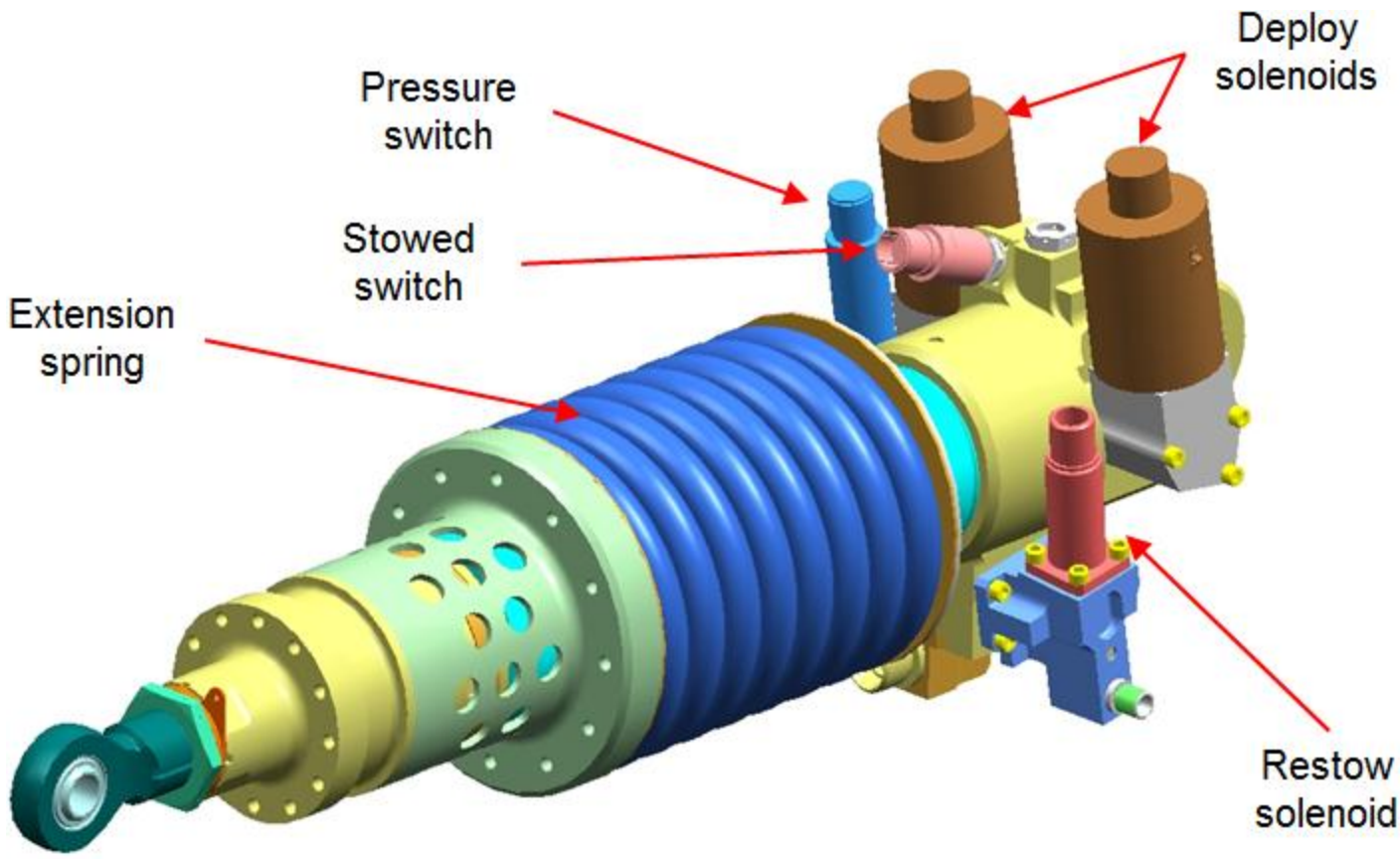






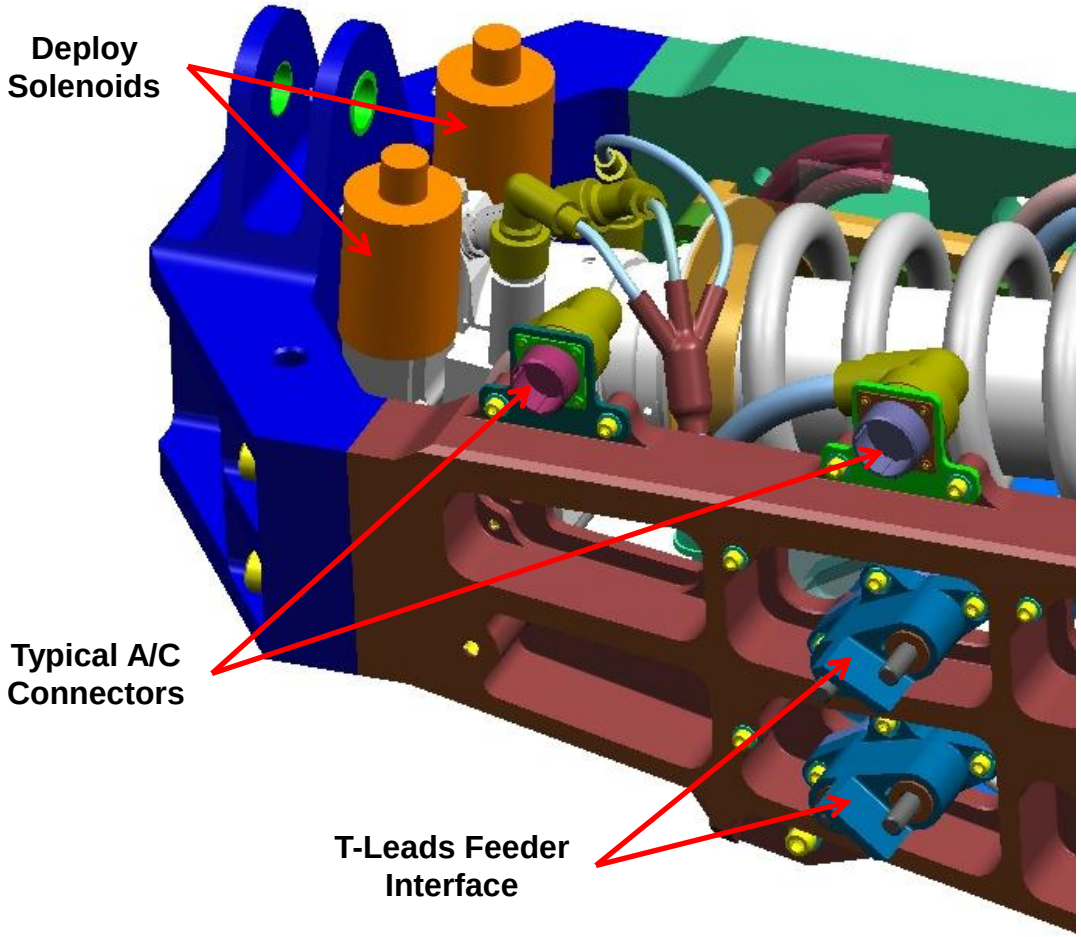
Electrical Interface – Aircraft Mounting

- **Connectors**



Electrical Interfaces

- **Wiring Interfaces**
  - Deploy Solenoids x 2
  - Connectors x 2
  - T-Leads x 4

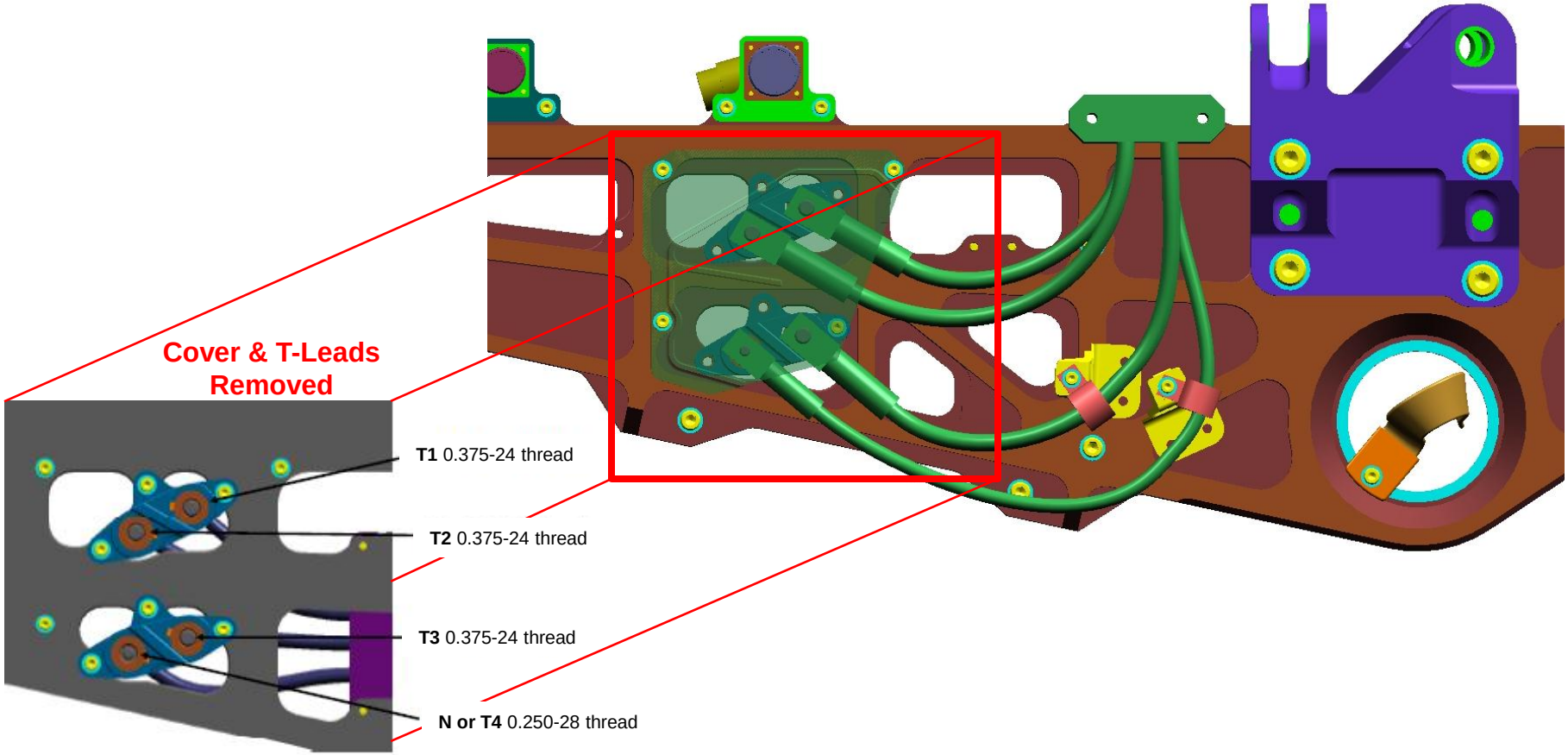


Electrical Interfaces- Feeder Wire Cover

- **Removable Feeder Terminal Cover**
  - Cover shipped with RAT (secured in position with 3 screws + 3 washers)
  - Installed by Airbus after Feeder Wires are connected with Epoxy Primer
  - Torqued to 20-22 in-lb.

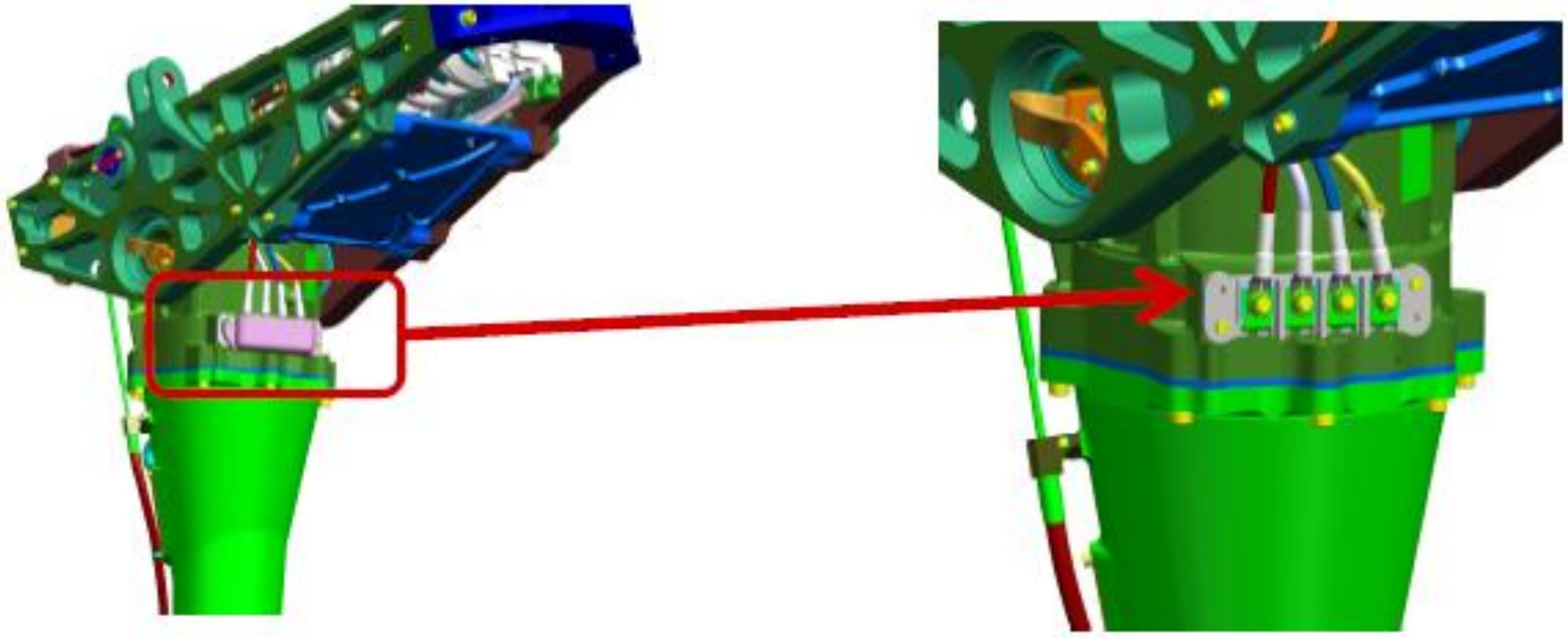
Electrical Interfaces- Feeder Wire Interface

- **Support brackets**
  - 24 mm distance between mounting holes
  - Brackets are A/C hardware



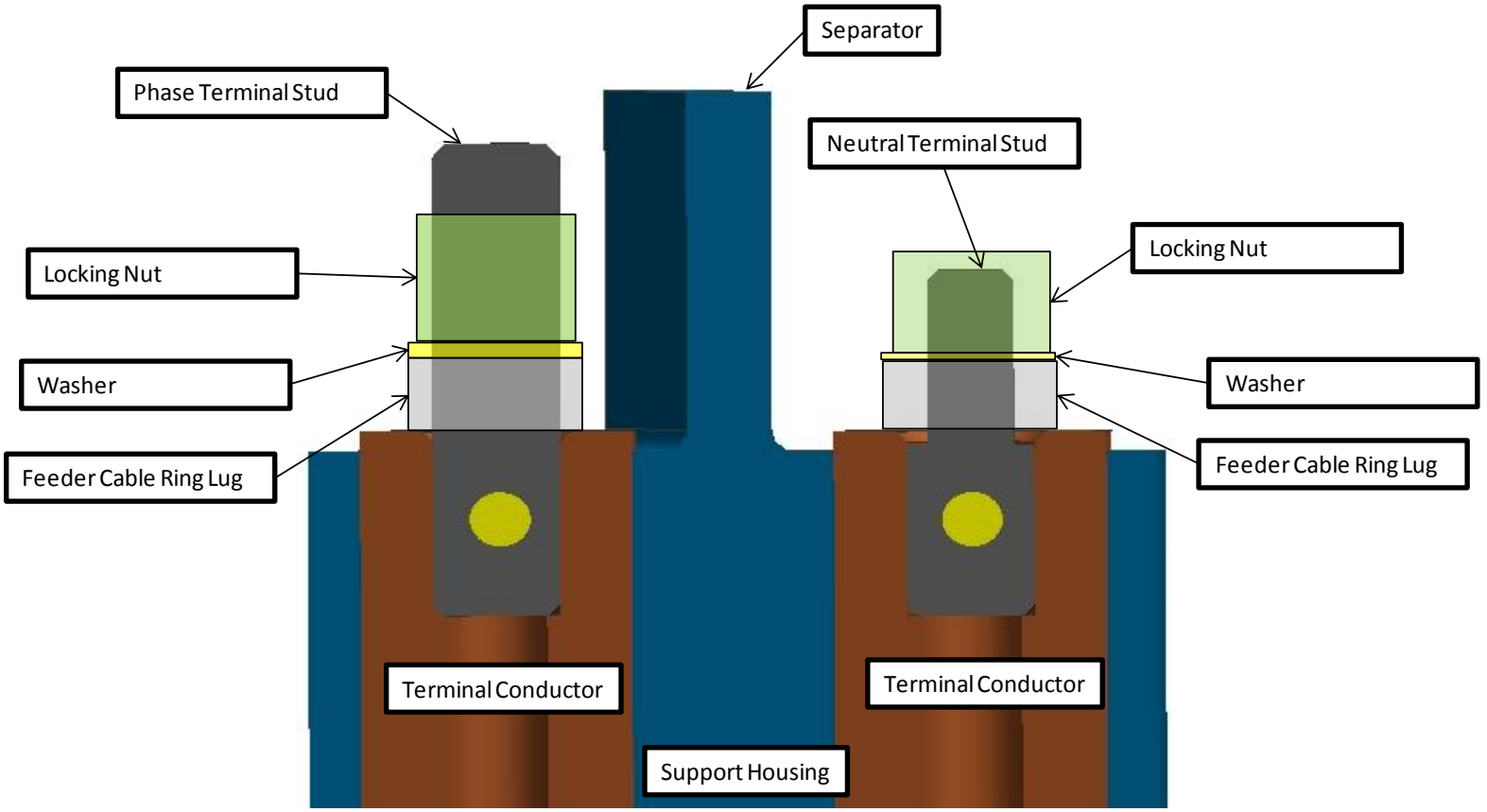
Electrical Interfaces- Feeder Wire to Strut (NOT A/C Interfaces)

- **Generator T-Leads A, B, C, N**



Electrical Interfaces- Feeder Wires to Terminal Block

- **Generator T-Leads A, B, C, N**
  - Neutral Stud does not protrude through locking nut
  - Same HS terminals as A380 RAT



Electrical Interfaces- Feeder Wires to Terminal Block

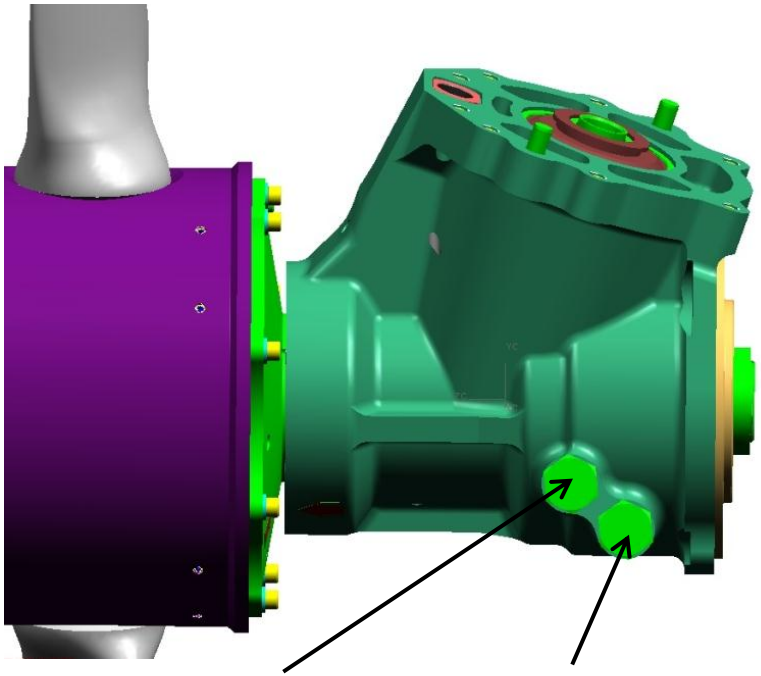
THIS PAGE INTENTIONALLY LEFT BLANK

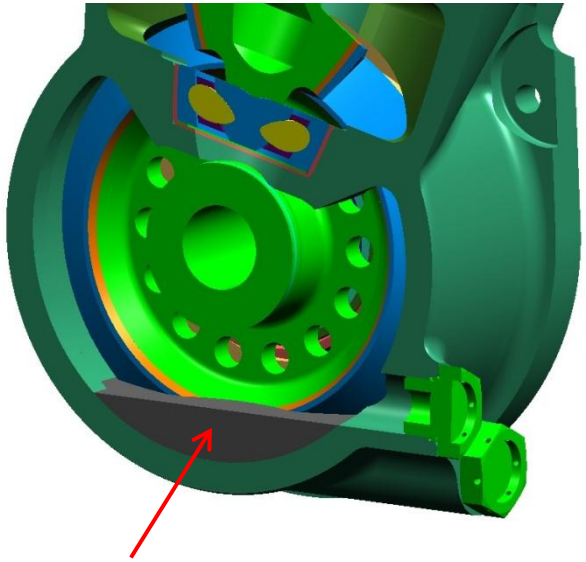
Airbus A350 XWB Ram Air Turbine

Module 9 - Maintenance & Servicing

Gearbox Oil Servicing

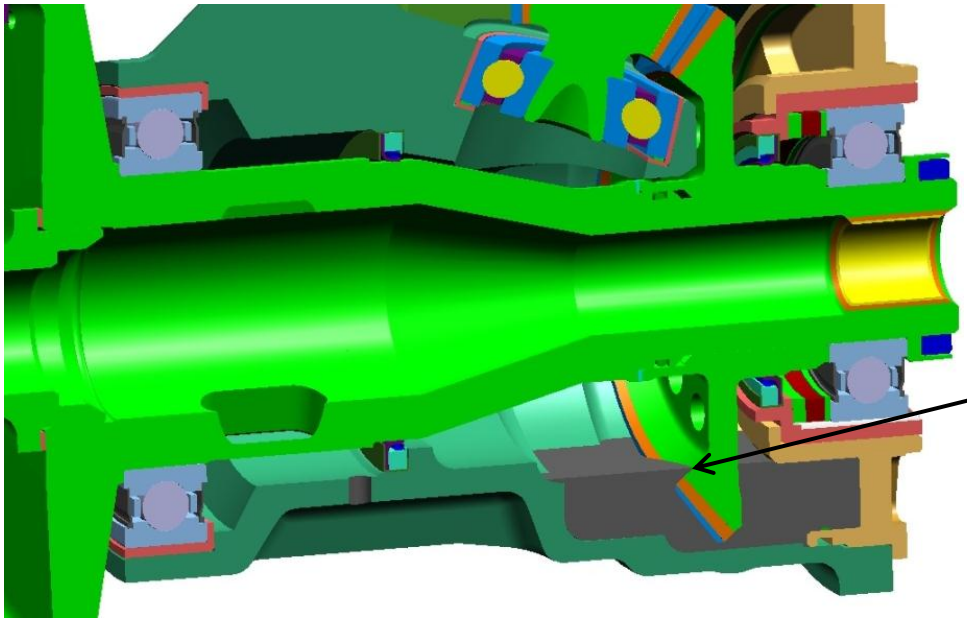
- **Gearbox Oil Level**
  - Fill to Spill at deployed orientation when installed on the aircraft

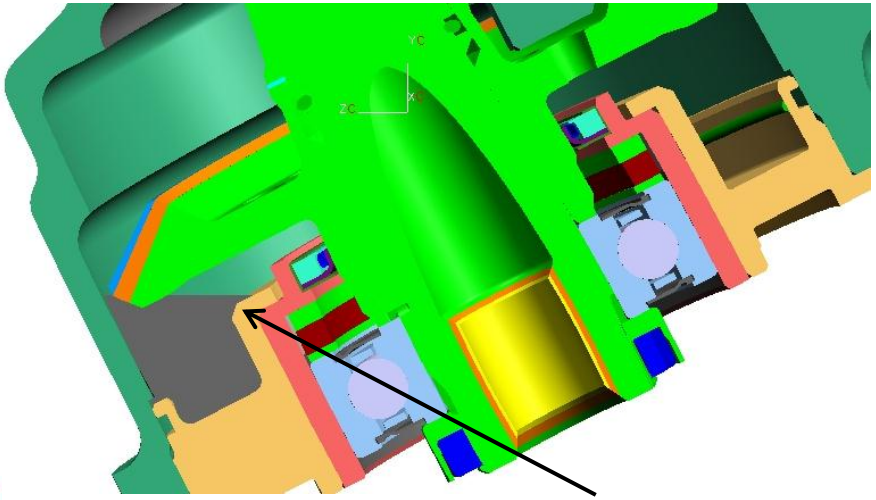




Gearbox Oil Management

- **Oil is drained off gear and seal when RAT is stowed**
  - Reduces the losses from the gear churning in cold oil during startup
  - Reduces the potential for leakage
- **Seal cases are steel, to prevent potential leakage problems**





Stowed Position Oil Level

Deployed Position Oil Level

Maintenance and Servicing

THIS PAGE INTENTIONALLY LEFT BLANK

Airbus A350 XWB Ram Air Turbine

Module 10 - Testing & Troubleshooting

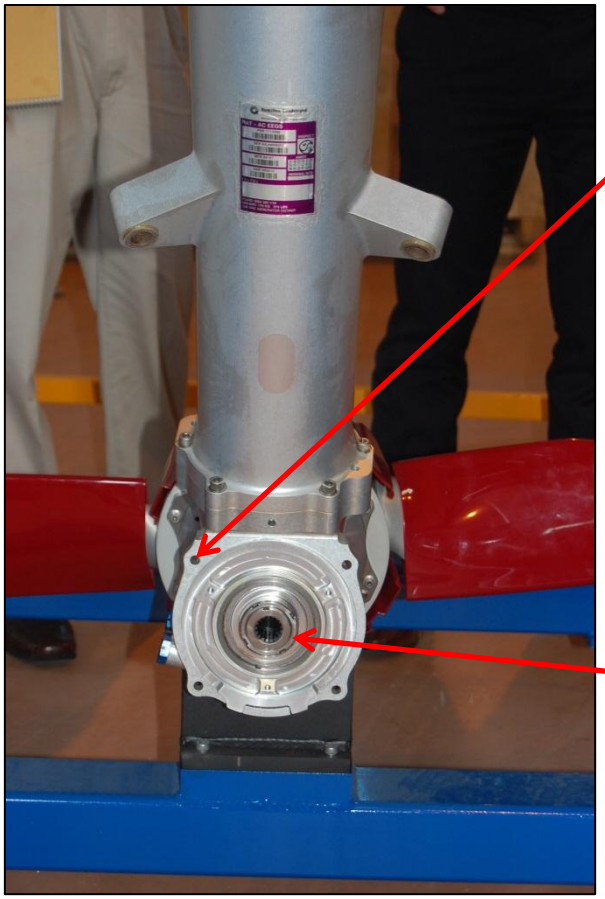
Component Description – Ground Test Tool

- Hydraulic Ground Test Motor Bolts to the back of the Turbine
- Driven by 5000 PSI Hydraulic Cart
- Need to support hoses
- Supplied by **Tronair**

RAT Test Motor with Hoses

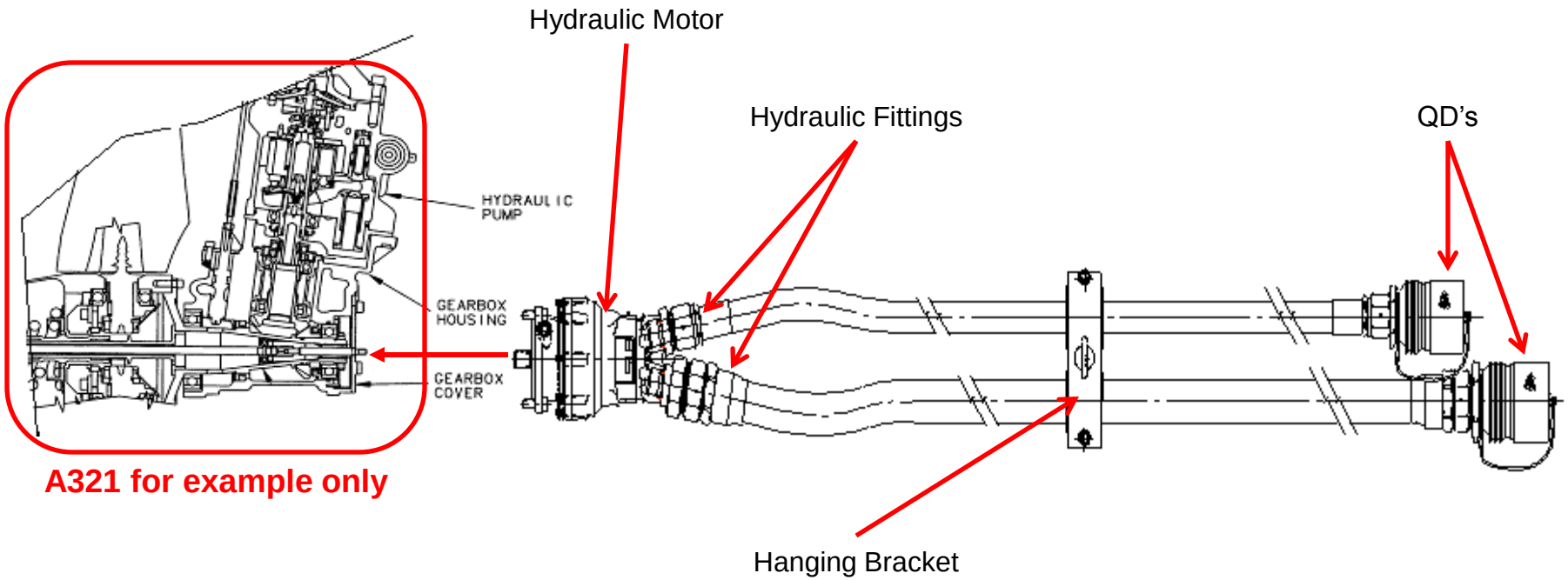
Ground Test Tool Interface

- **Female Spline remains open to atmosphere. No AFT cover is used OR available for this RAT**



Ground Test Tool Interface

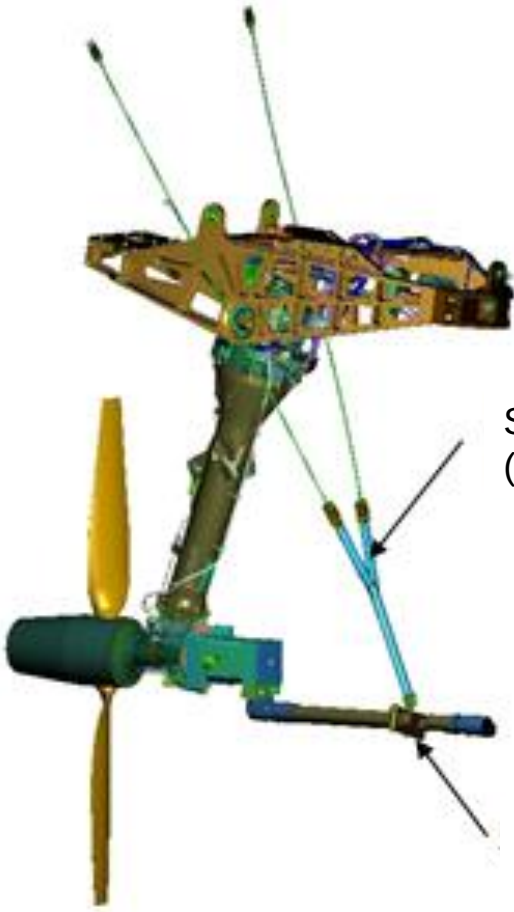
- Ground Test Tool attaches to rear of RAT lower gearbox assembly (attached after RAT rear gearbox plate is removed.
- Hanging bracket provides strain relief.



A321 for example only

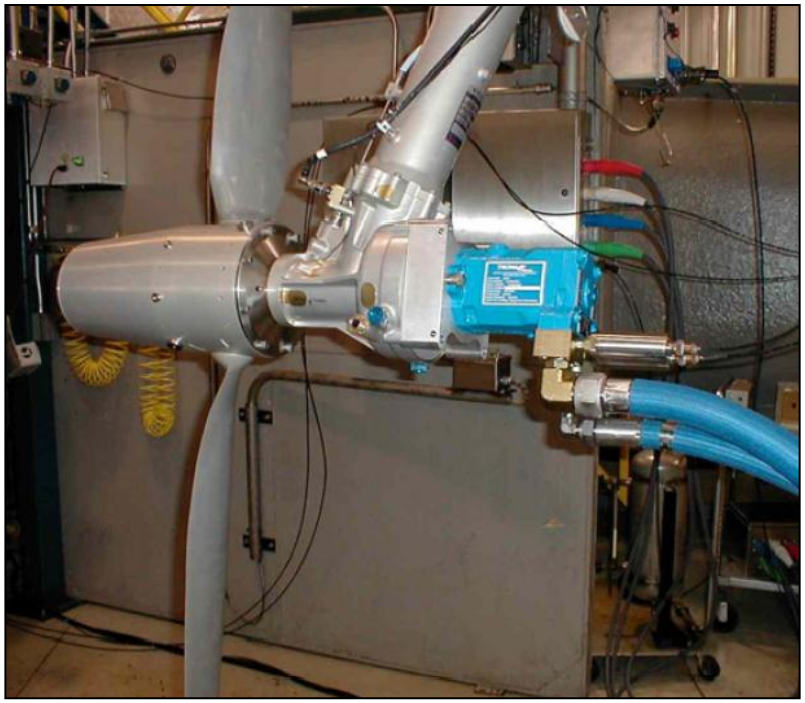
Ground Test Tool Interface

- Proposed Hanging Bracket Support



Ground Test Setup

- **RAT Deployed and connected to GTT**



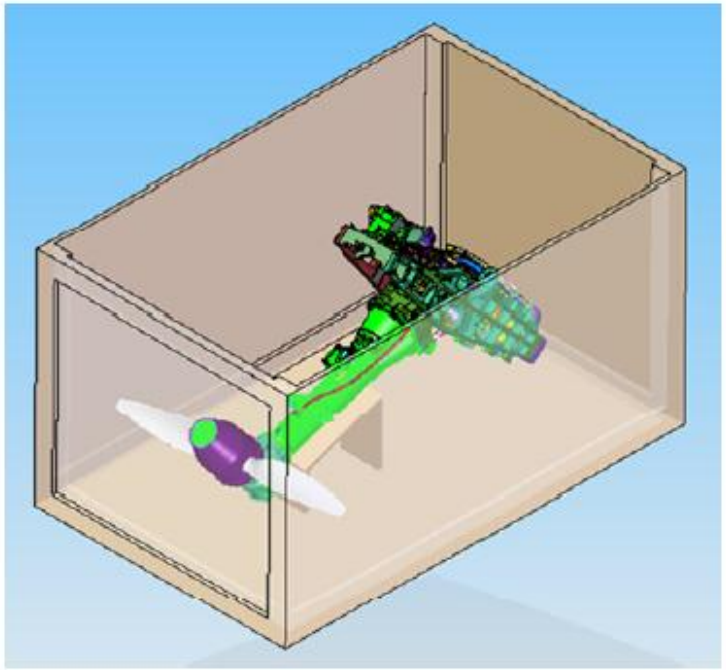
- **RAT in Safety Cage and ready for Ground Test**

Airbus A350 XWB Ram Air Turbine

Module 11 - Shipping & Handling

RAT Shipping and Handling

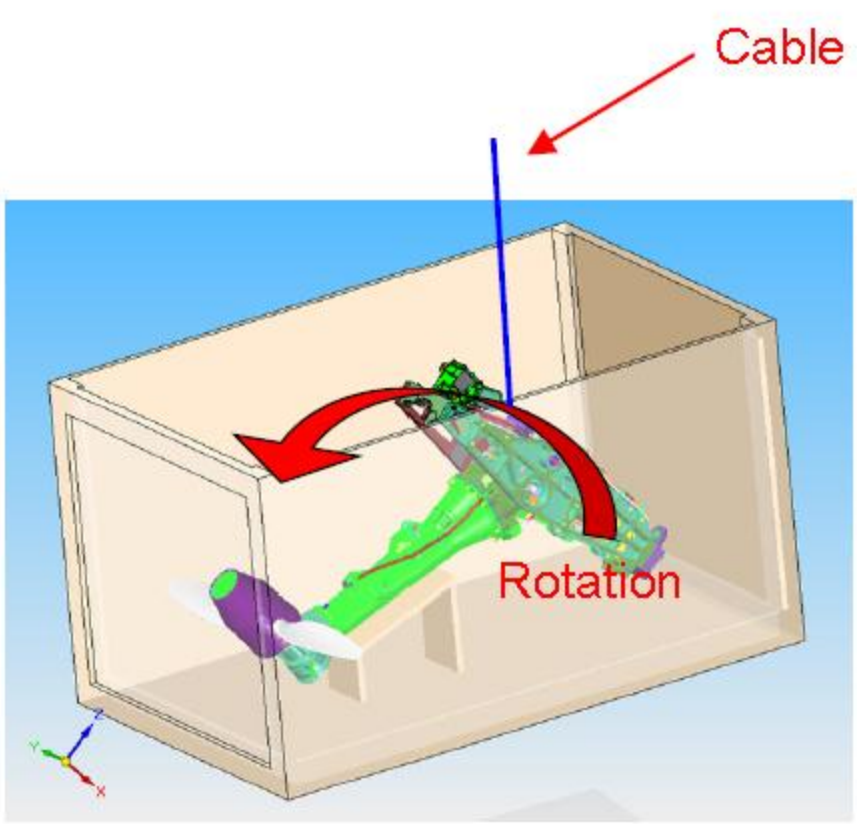
- **RAT is in reclined position during shipment**
- **Supported at rear frame and lower gearbox by foam padding**
- **Additional padding between RAT side frames and sides of shipping container**

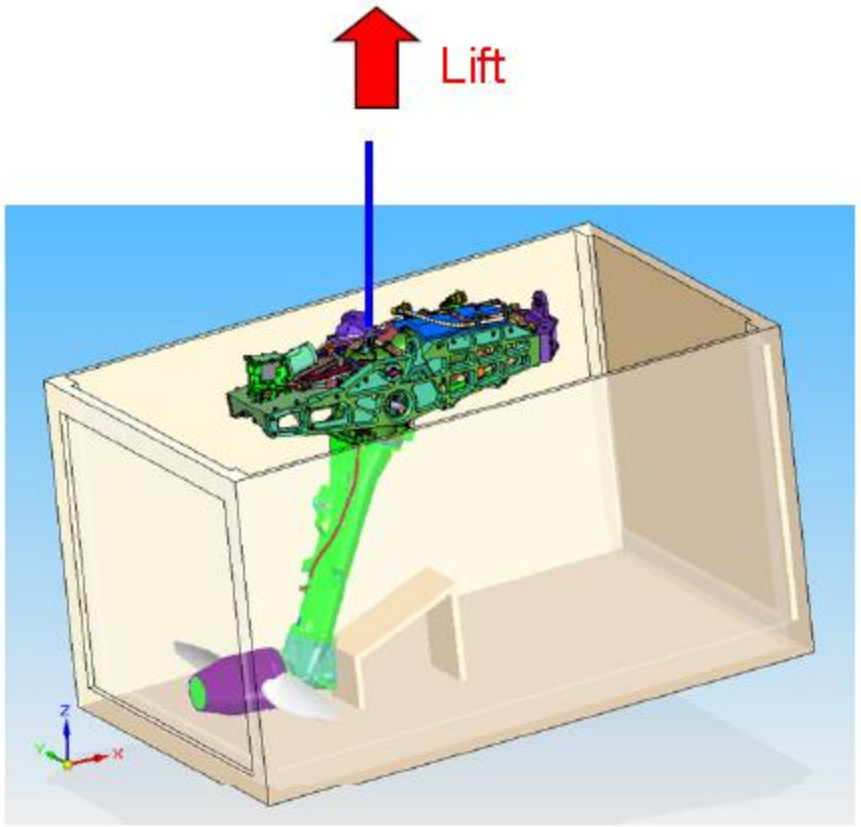


- **Advantages**
  - **Durable**
    - Multi-layer cardboard exterior
    - Thick foam interior walls
  - **Lighter weight, smaller volume compared to flat wooden crate**
    - Minimizes shipping costs
  - **Easier to disassemble and unload**
    - Multiple lightweight sections
    - No special tools (other than lifting bracket)
    - Load/Remove RAT from under aircraft using a single lifting point
  - **Complete product enclosure**
    - Renders the RAT insusceptible to loss or tampering
  - **Interior cushioning**
    - Substantial pre-cut foam padding for RAT support and protection
  - **No loose parts**
    - Banded closure (no screws or nails)
  - **Integral wooden skid**
  - **Disposable**
    - Re-usable (within limits) if desired

RAT Shipping and Handling

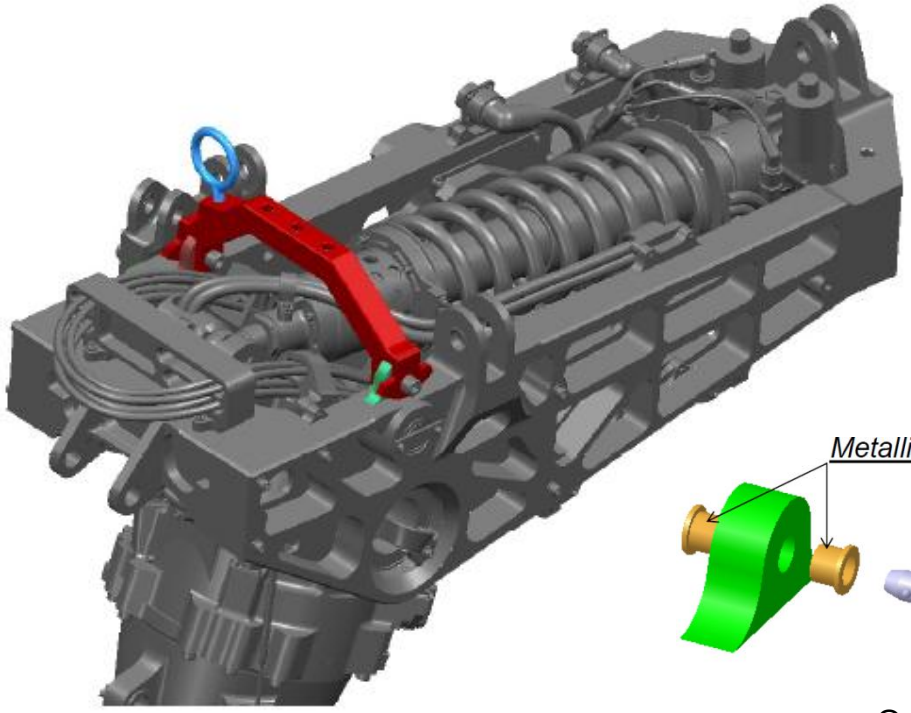
- **Lifting Process from Shipping Container**

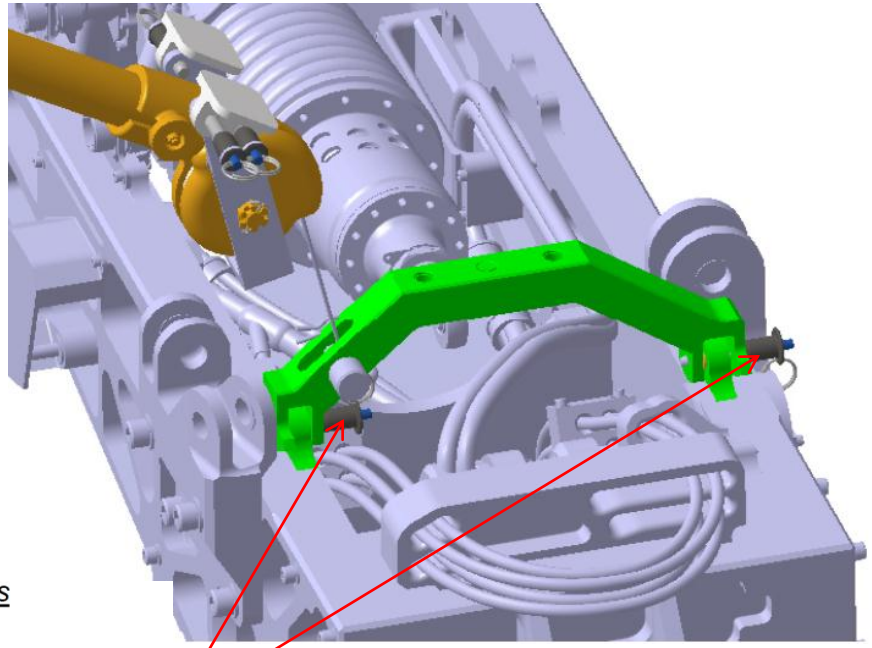


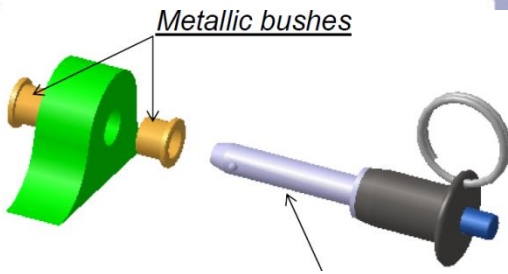


RAT Shipping and Handling

- **Airbus GSE Lifting Methodology**
  - Lifting Bracket/Fixture attaches to RAT frame
  - Allows hoisting cable to connect via an eye bolt or Disdbury Hoist via GSE pins
  - Removed from RAT after installation on aircraft

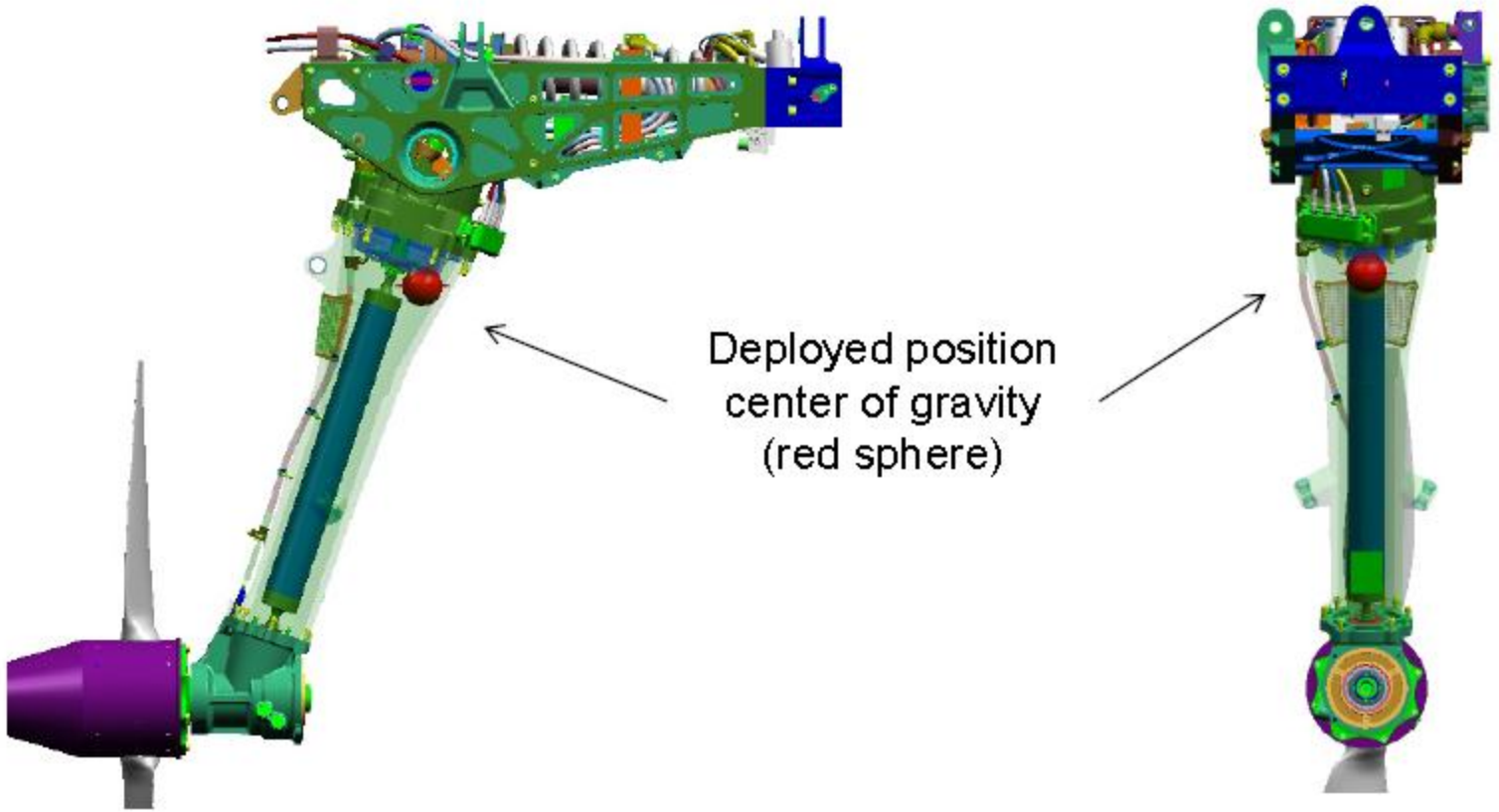






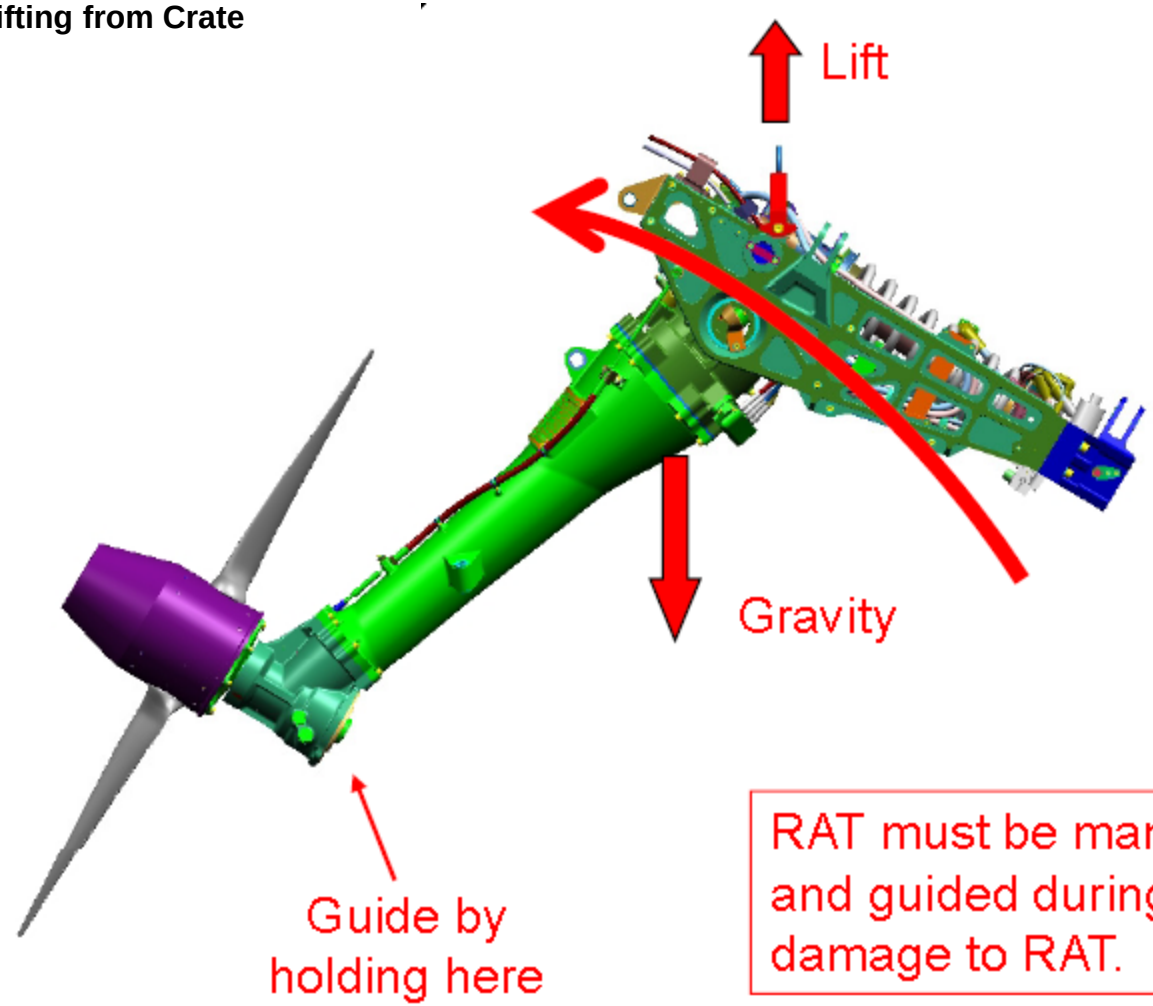
RAT Shipping and Handling

- **RAT Center of Gravity (CG)**
  - CG is directly below lifting point



RAT Shipping and Handling

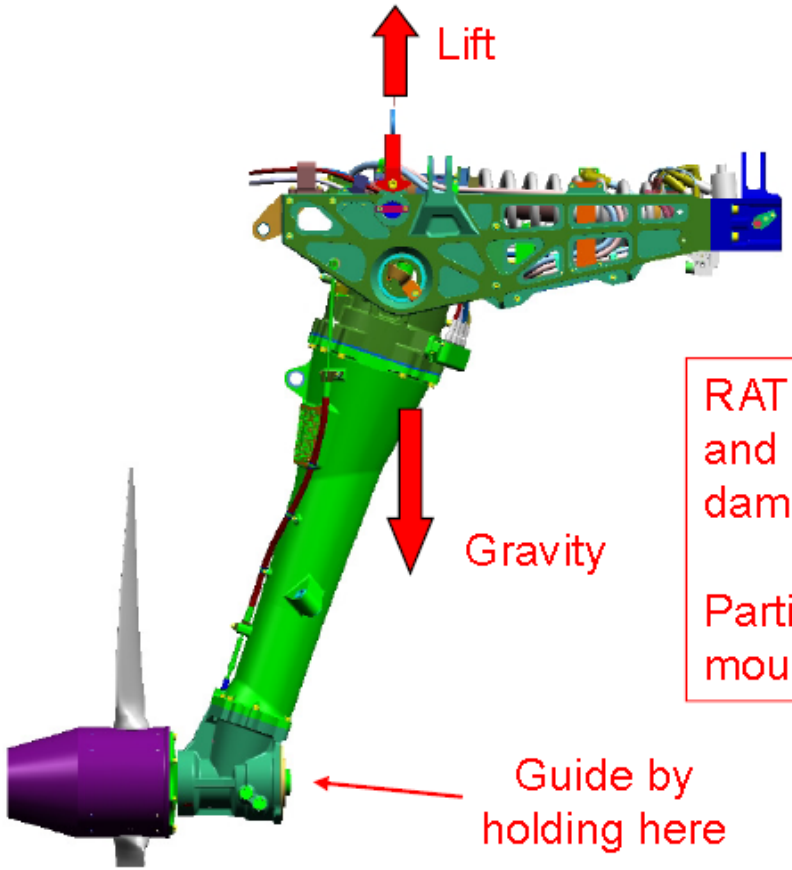
- **Lifting from Crate**



RAT must be manually stabilized and guided during lifting to avoid damage to RAT.

RAT Shipping and Handling

- **Lifting into Aircraft**

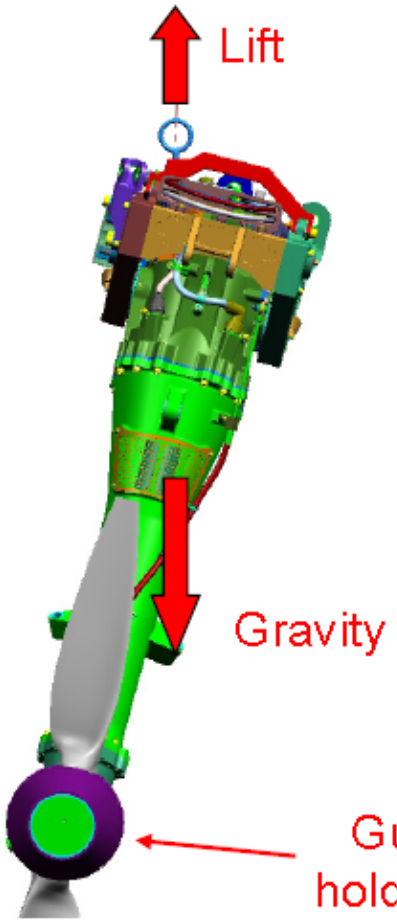


RAT must be manually stabilized and guided during lifting to avoid damage to RAT or aircraft.

Particularly important when aligning mounting lug features.

RAT Shipping and Handling

- **Lifting into Aircraft**

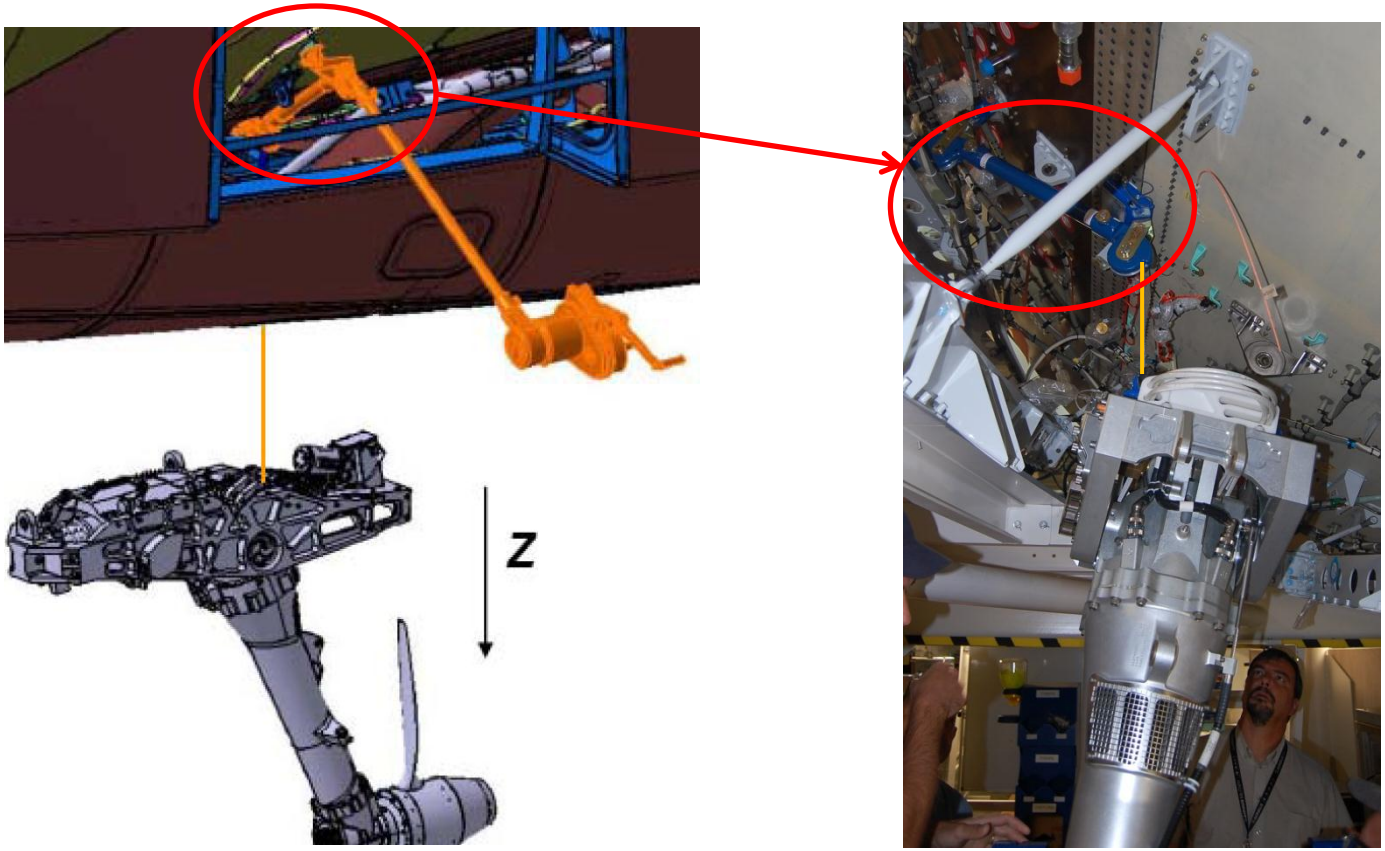


RAT must be manually stabilized and guided during lifting to avoid damage to RAT or aircraft.

Particularly important when aligning mounting lug features.

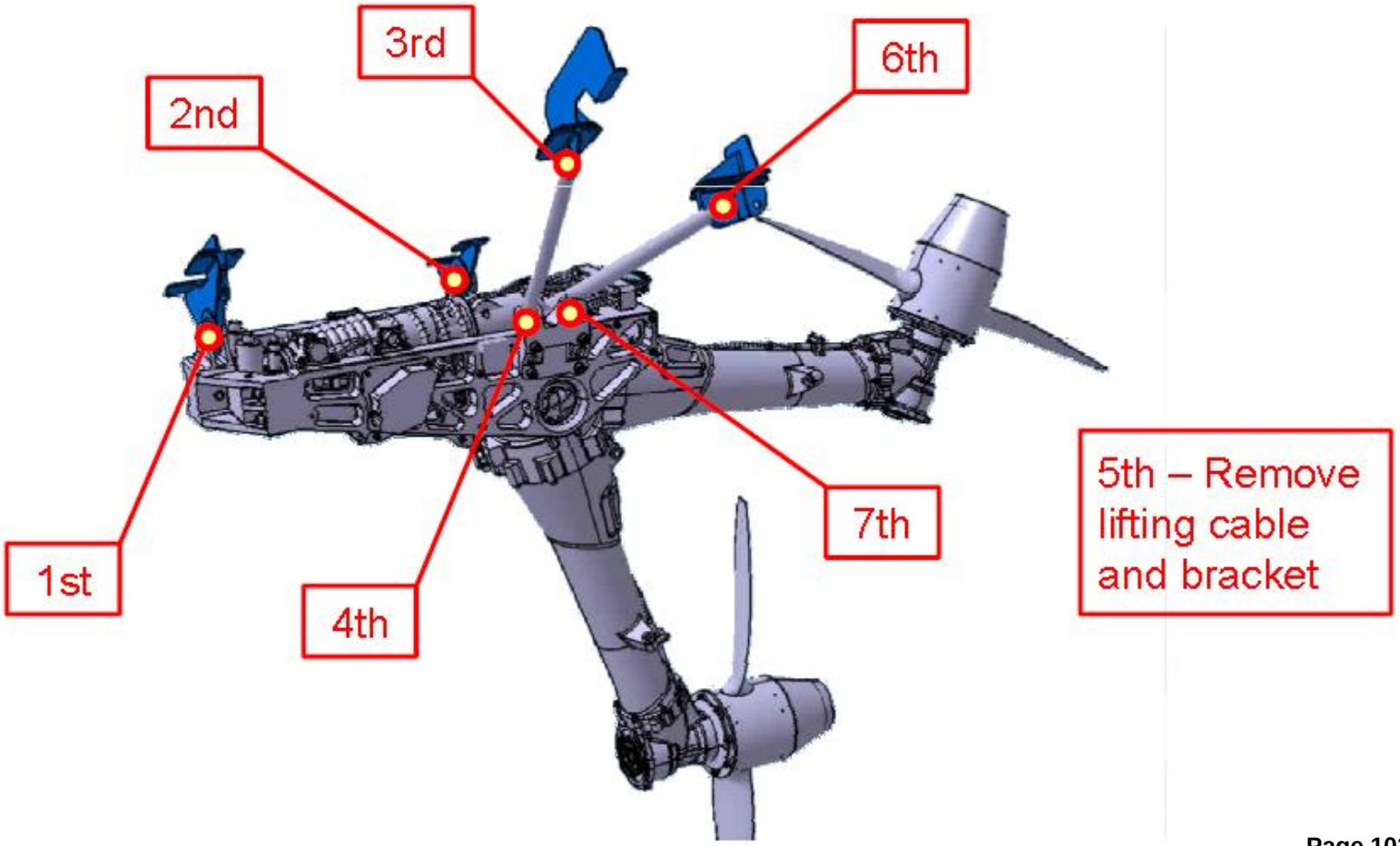
RAT Shipping & Handling
Mounting Winch

- **Fishing Pole Mounting Winch**



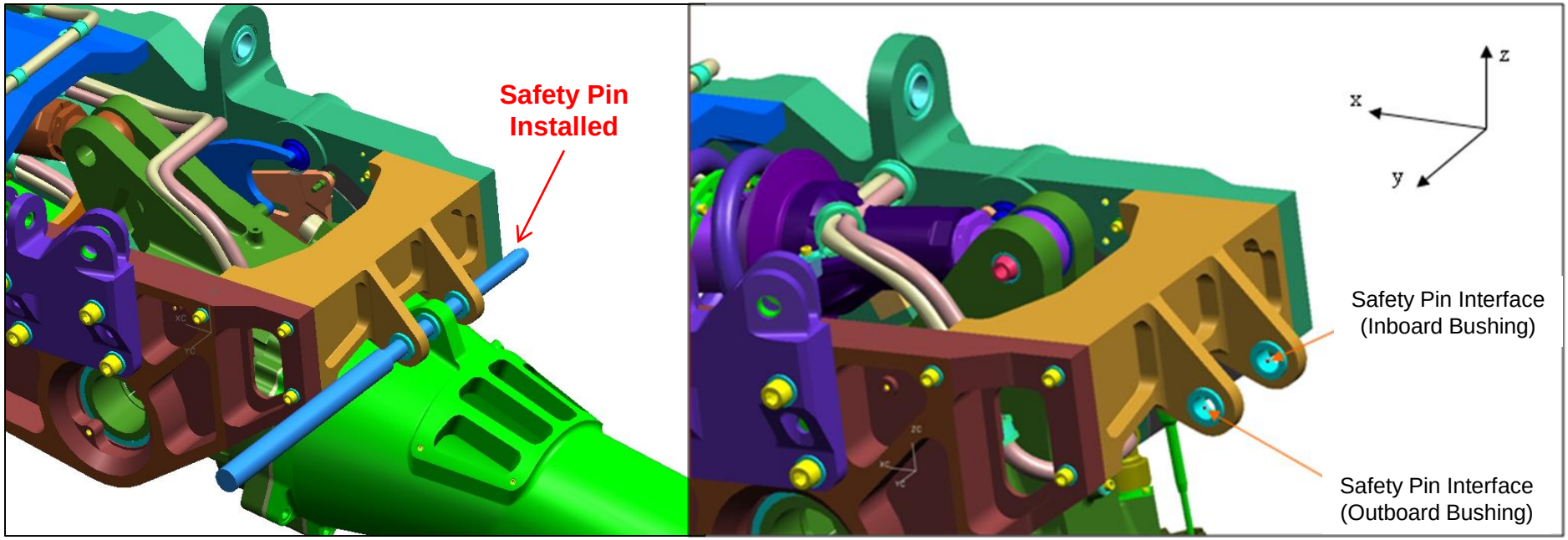
RAT Shipping and Handling

- **Connection to Fuselage – Recommended Order**
  - **1 and 2 can be in reverse order, balance of connections must follow sequence shown**



Maintenance Safety Pin

- **Safety Pin to be used any time doors are open or when there is maintenance being performed under or near the RAT so that RAT cannot be deployed inadvertently from the flight deck.**
  - Pin Diameter 22.2 +/- .025 mm (0.874 +/-0.001 inch)



For more information on **UTC Aerospace Systems** training programs

http://myHS.HamiltonSundstrand.com