

# Safety Considerations of the 525 Relentless Drive System

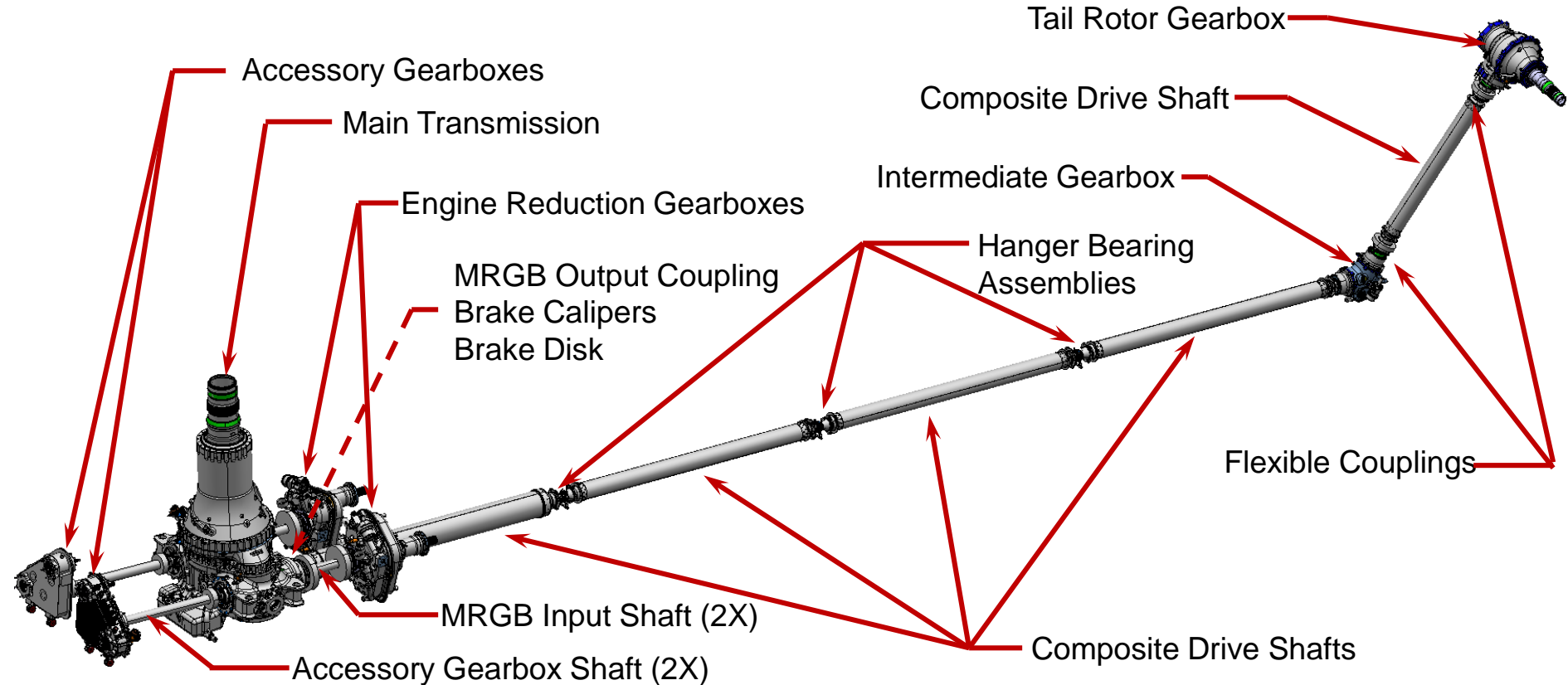


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# Bell 525 Drive System



# Bell 525 Drive System Key Attributes

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## 525 Drive System Configuration:

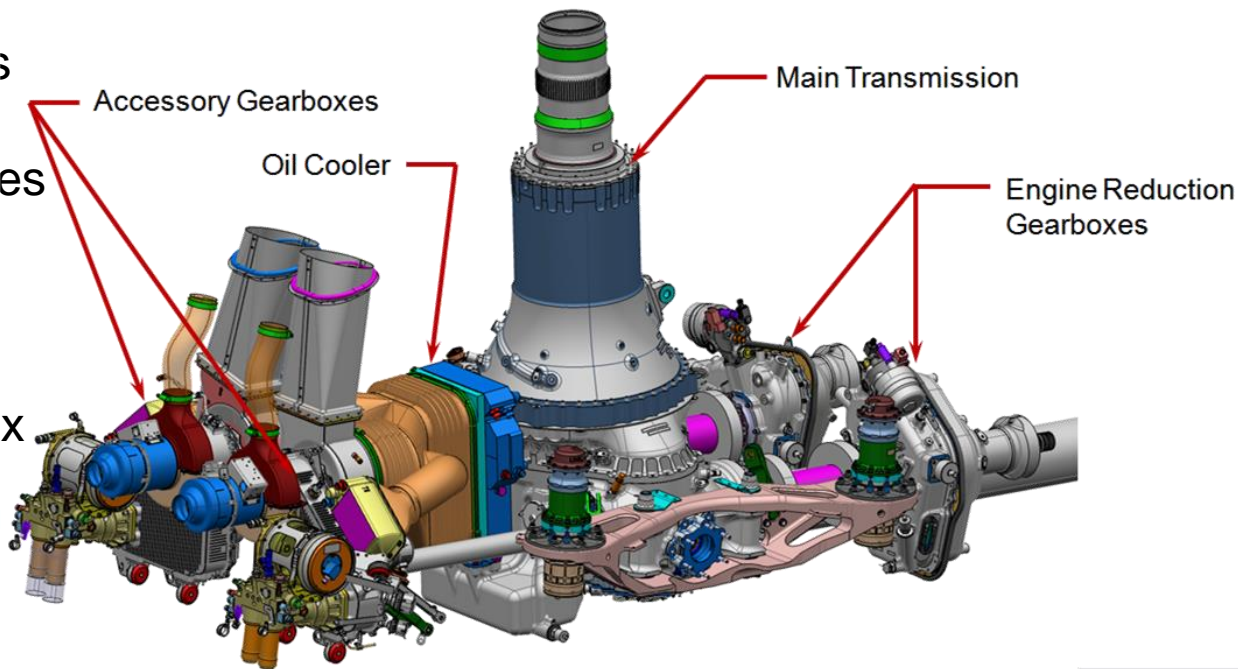
- Minimizes the number of single load path components
- Provides maximum system separation and redundancy
- Minimizes maintenance required and maintenance related incidents
- Minimizes the potential of loss of lube events
- Maximizes MRGB loss of lube capability

## 525 Drive System Configuration Maximizes Aircraft Safety

# Bell 525 Drive System – Key Elements

## Incorporating system separation:

- Separate Engine Reduction Gearboxes to isolate failures from remainder of drive system (freewheeling clutches in the Main Rotor Gearbox)
- Separate, Dual Accessory Gearboxes isolate failures from the Main Rotor Gearbox
- Gearbox driven accessories are distributed among the separate systems





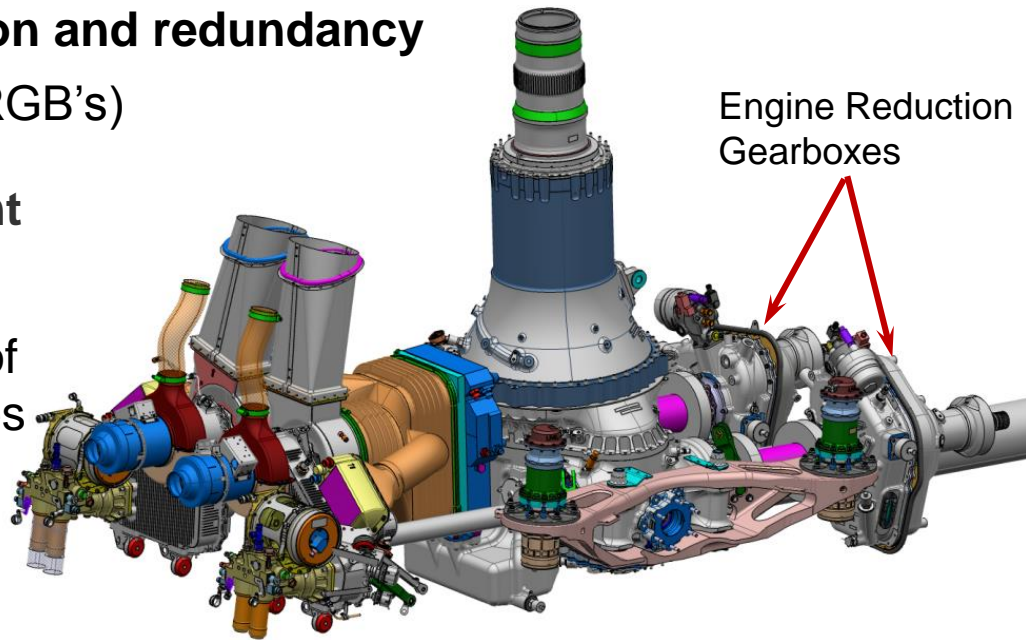
# Bell 525 Drive System Configuration

**Provides maximum system separation and redundancy**

- Dual Engine Reduction Gearboxes (RGB's)

**Each RGB is completely independent**

- No RGB driven accessories
- Completely isolated from remainder of drive system via freewheeling clutches in MRGB



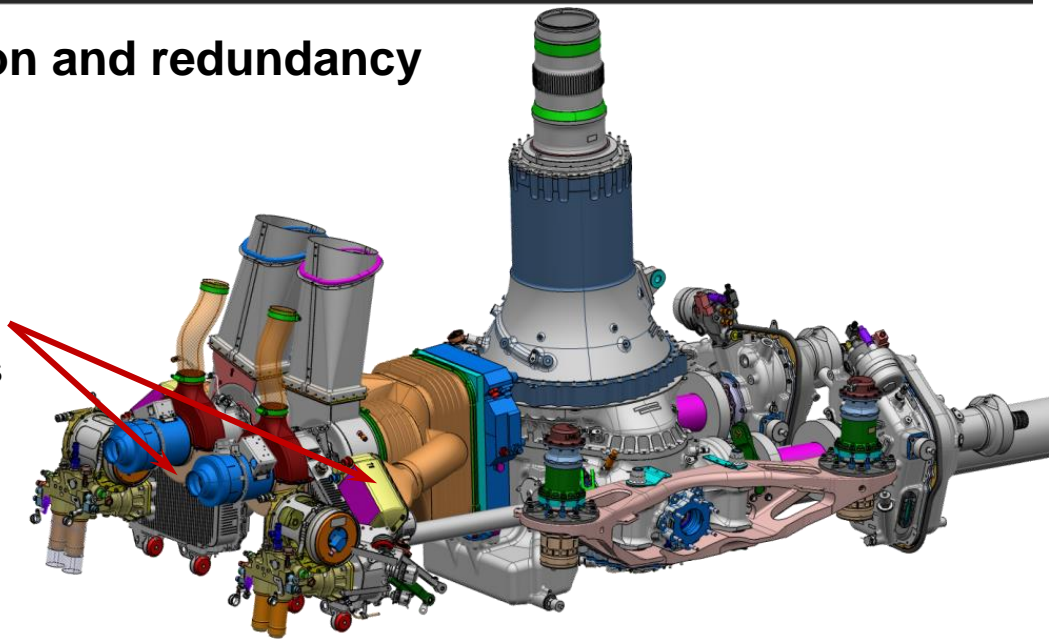
**Loss of a single RGB does not prevent continued safe flight**  
**– Safe flight continues via OEI operation**

# Bell 525 Drive System Configuration

**Provides maximum system separation and redundancy**

- Dual Accessory Gearboxes (AGB's)

Accessory  
Gearboxes



**Loss of a single AGB does not prevent continued safe flight**

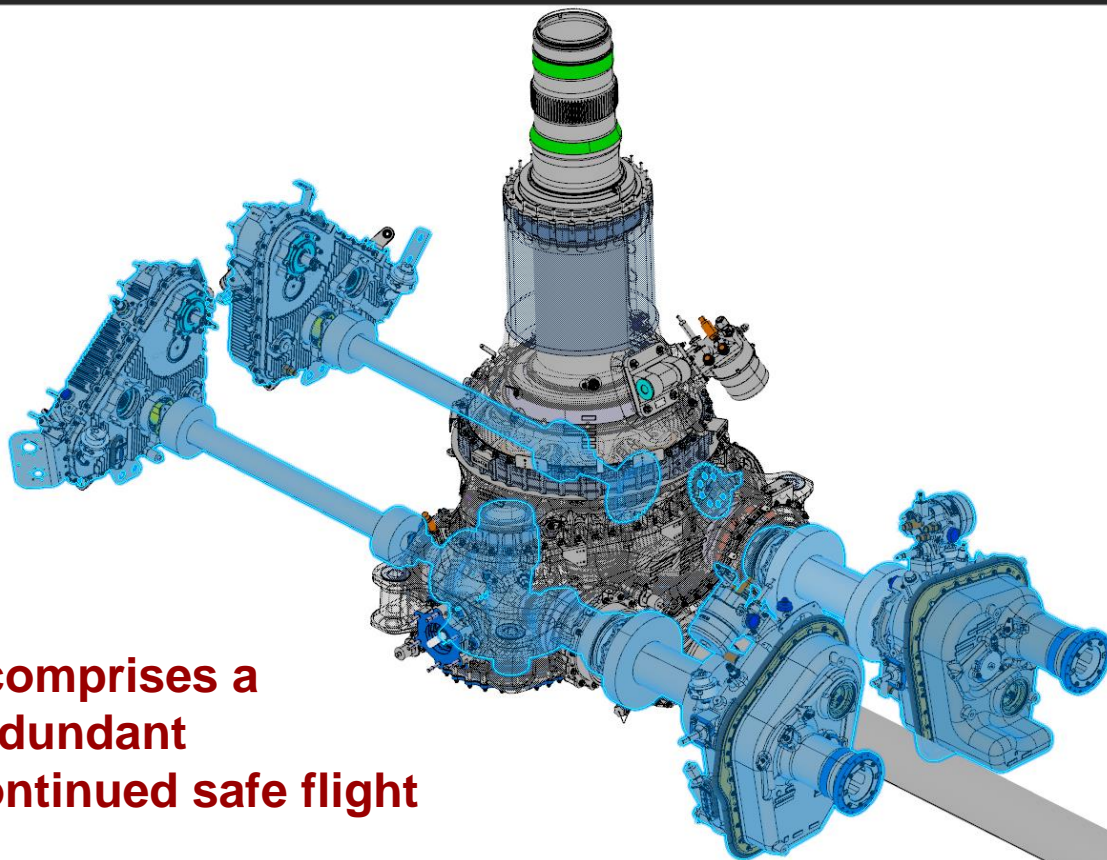
- All accessories duplicated on other AGB
- 3<sup>rd</sup> generator and hydraulic power pack also mounted on MRGB

# Bell 525 Drive System Configuration

Minimize the number of single load path components

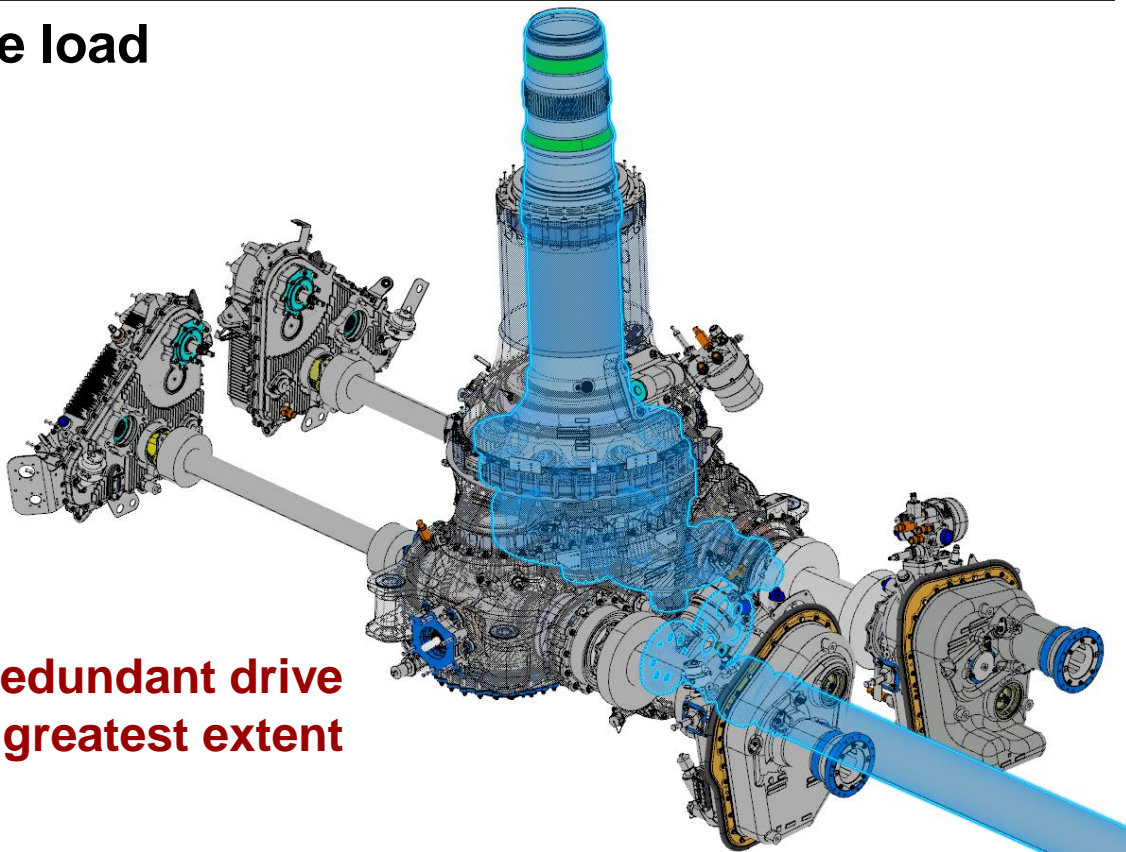
**Dual Load (torque) Paths:**

**Each highlighted component comprises a redundant drive path or is a redundant component not required for continued safe flight**



# Bell 525 Drive System Configuration

**Minimize the number of single load path components**



**Single Load (torque) Paths**

**Components that do not have a redundant drive path has been minimized to the greatest extent possible**

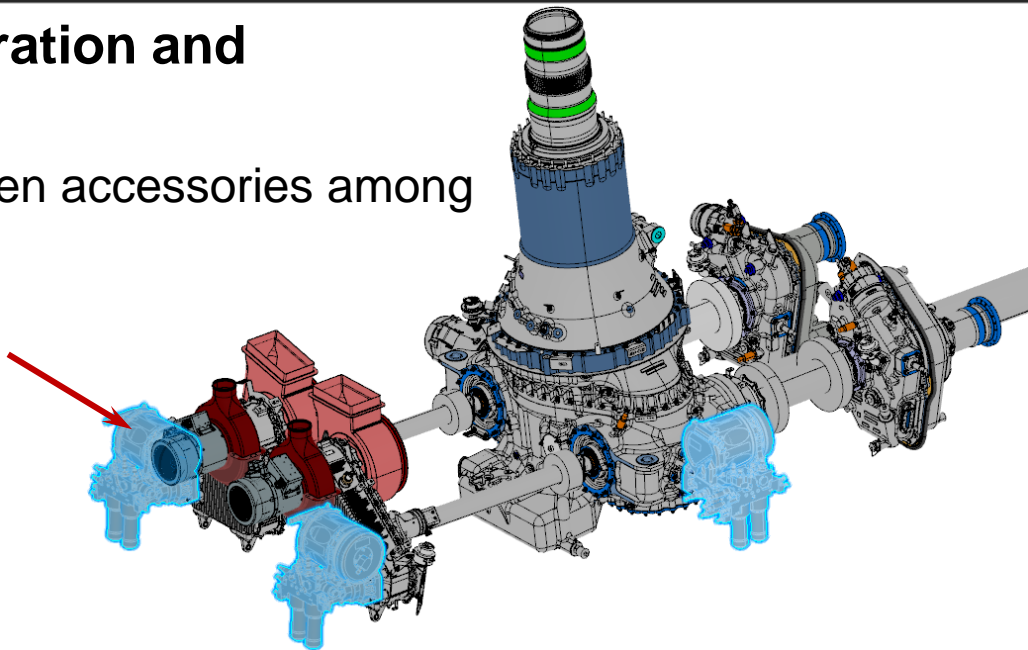


# Bell 525 Drive System Configuration

## Provide maximum system separation and redundancy

- The distribution of the gearbox driven accessories among the separate systems

Hydraulic Power Pack  
(3 places)



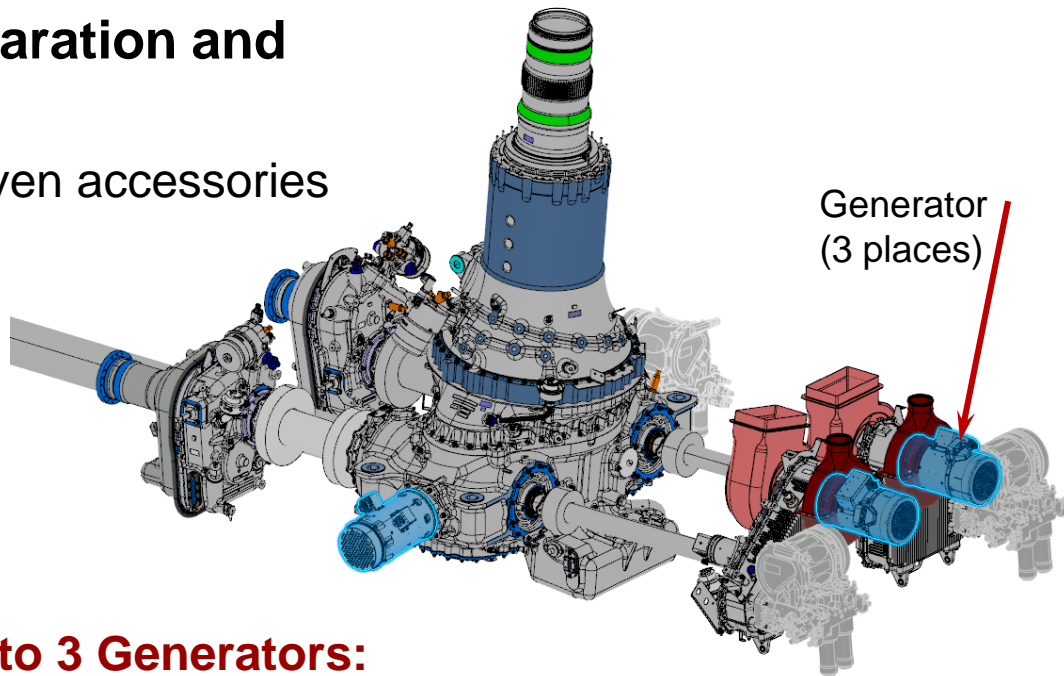
## 525 Drive System provides power to 3 Hydraulic Systems:

- Each driven by a different gearbox
- All 3 continue to be driven in OEI & AEI operation

# Bell 525 Drive System Configuration

## Provide maximum system separation and redundancy

- The distribution of the gearbox driven accessories among the separate systems



## 525 Drive System provides power to 3 Generators:

- Each driven by a different gearbox
- All 3 continue to be driven in OEI & AEI operation

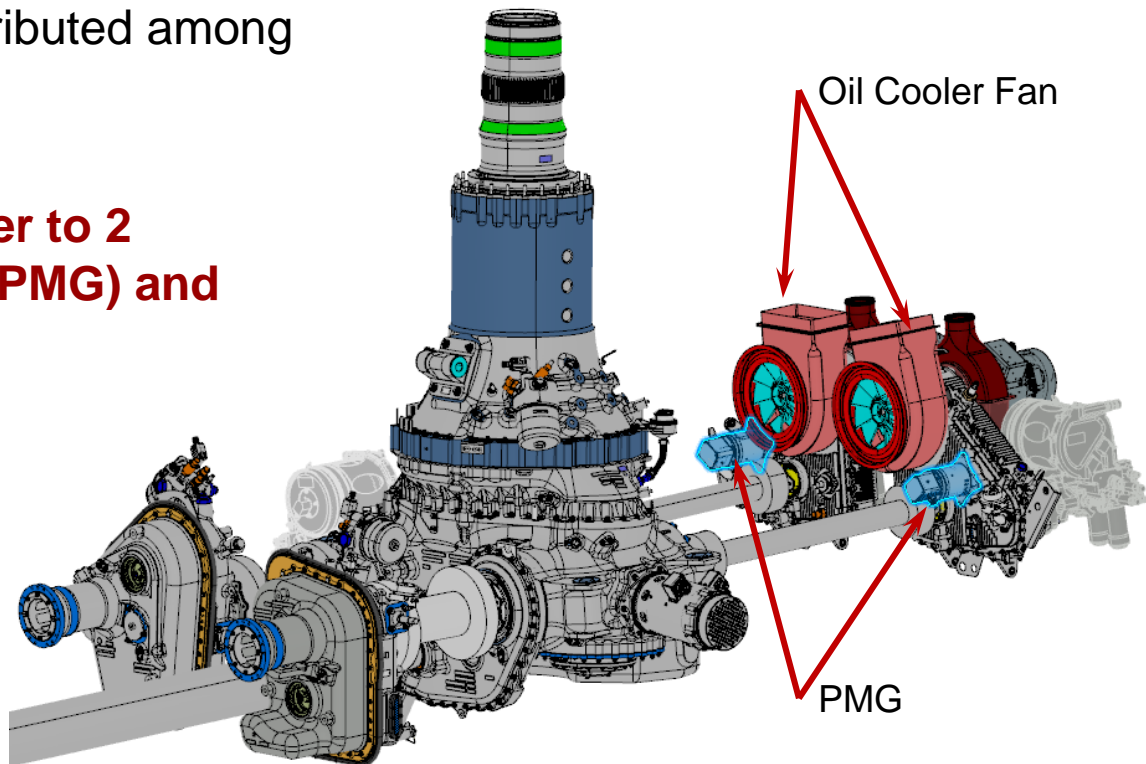
# Bell 525 Drive System Configuration

**Provide maximum system separation and redundancy**

- Gearbox driven accessories distributed among separate systems

**525 Drive System provides power to 2 Permanent Magnet Generators (PMG) and two Oil Cooler Blowers:**

- Each driven by a different gearbox
- Both continue to be driven in OEI & AEI operation



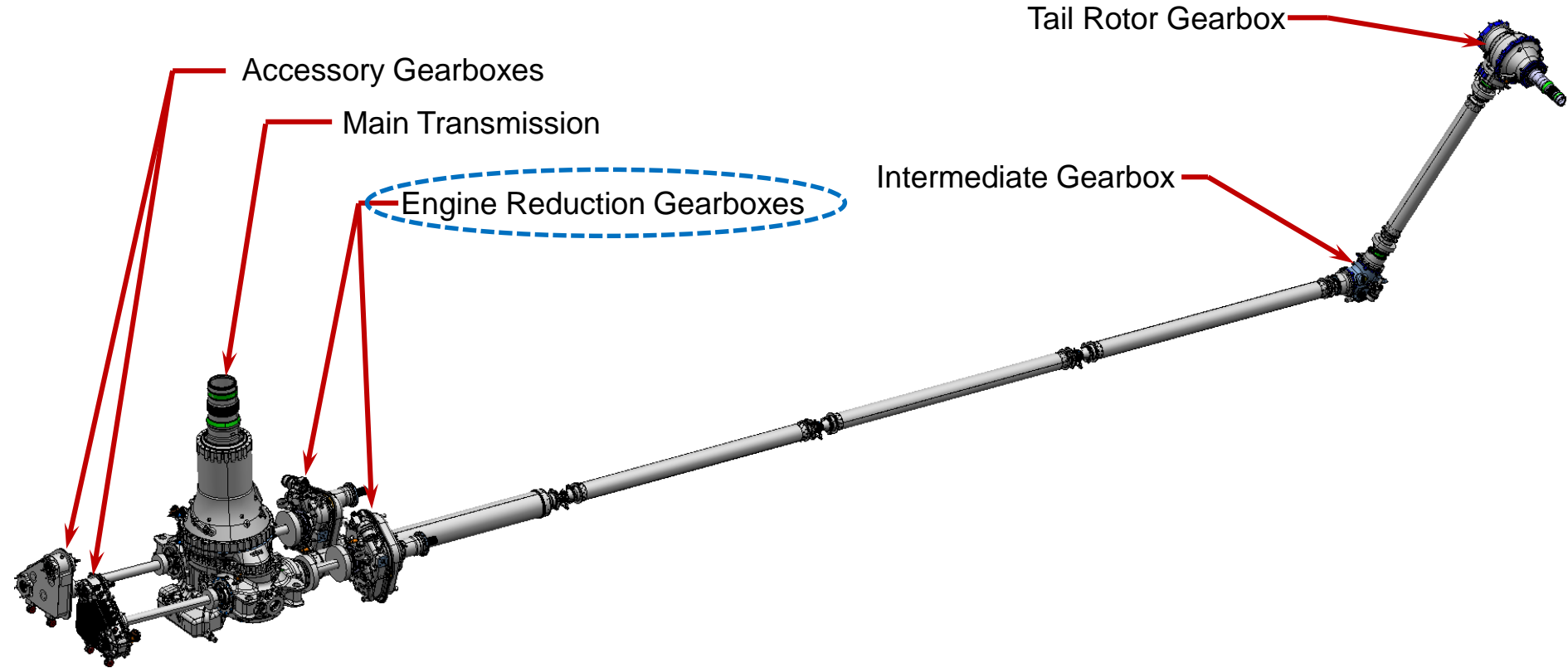
# Bell 525 Drive System Configuration

**All 525 pressurized gearboxes share the following safety and maintenance related features:**

- Oil filter and oil fill cap mounted high for ease of maintenance
  - Oil fill cap located such that leaving off will not result in oil loss from gearbox
- Oil filter head and all gearbox pressurized oil transfer accomplished with dual o-ring transfer tubes
  - These are not dependent on compression from fasteners for sealing
- Oil filter bowl threads directly into filter head eliminating fasteners from the parts removed for maintenance
  - Eliminating fastener failure issues from repeated removals
- Pressure transducer, pressure switch, and two temperature sensors for redundancy
  - Pressure switch at end of oil circuit to monitor health of entire lube system
- Maximum number of sensors & components located on filter head to minimize openings in main case and ease of maintenance access and inspections
- Oil filter impending and full bypass indicators can greatly reduce maintenance actions and prevent unnecessary opening of the lubrication system
  - The impending bypass indicators have both visual indication and electronic signal indication.
  - If triggered, an impending bypass message will appear to the crew upon landing
- Oil level sensors augment the oil level sight gauge displaying the oil level in each gearbox to the cockpit prior to engine rotation

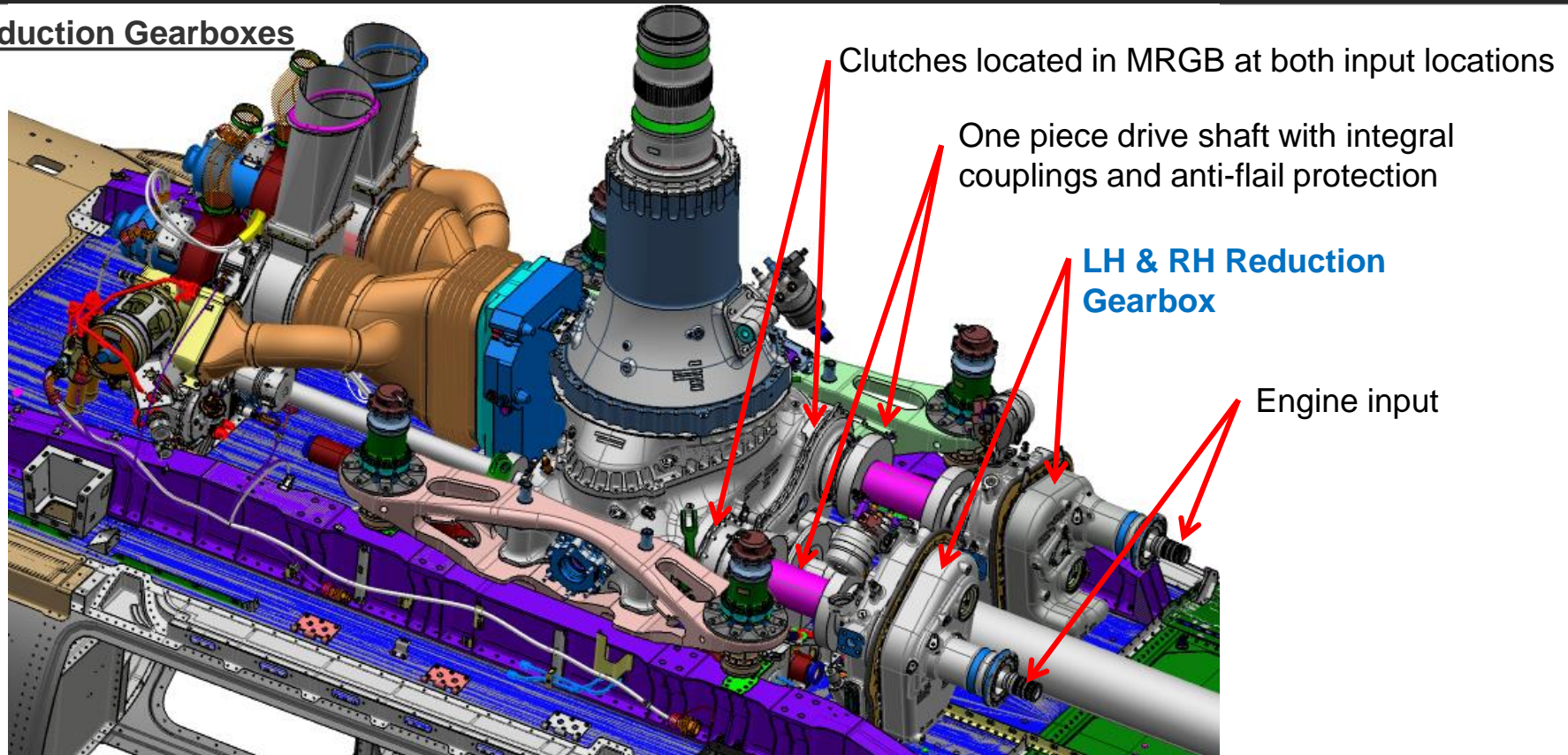


# Bell 525 Drive System



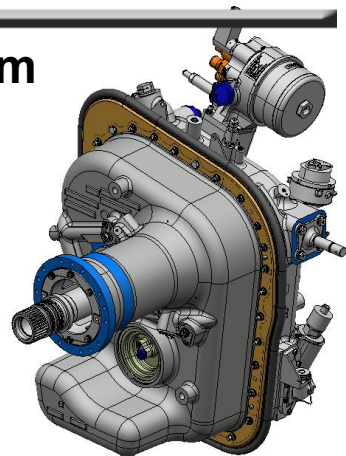
# Bell 525 Drive System

## Reduction Gearboxes



# Bell 525 Drive System

The independent Reduction Gearboxes (RGB's) transmit torque from the engines to the Main Rotor Gearbox while reducing speed from 21,000 to 6000 RPM. This removes high speed gears and bearings from the Main Rotor Gearbox



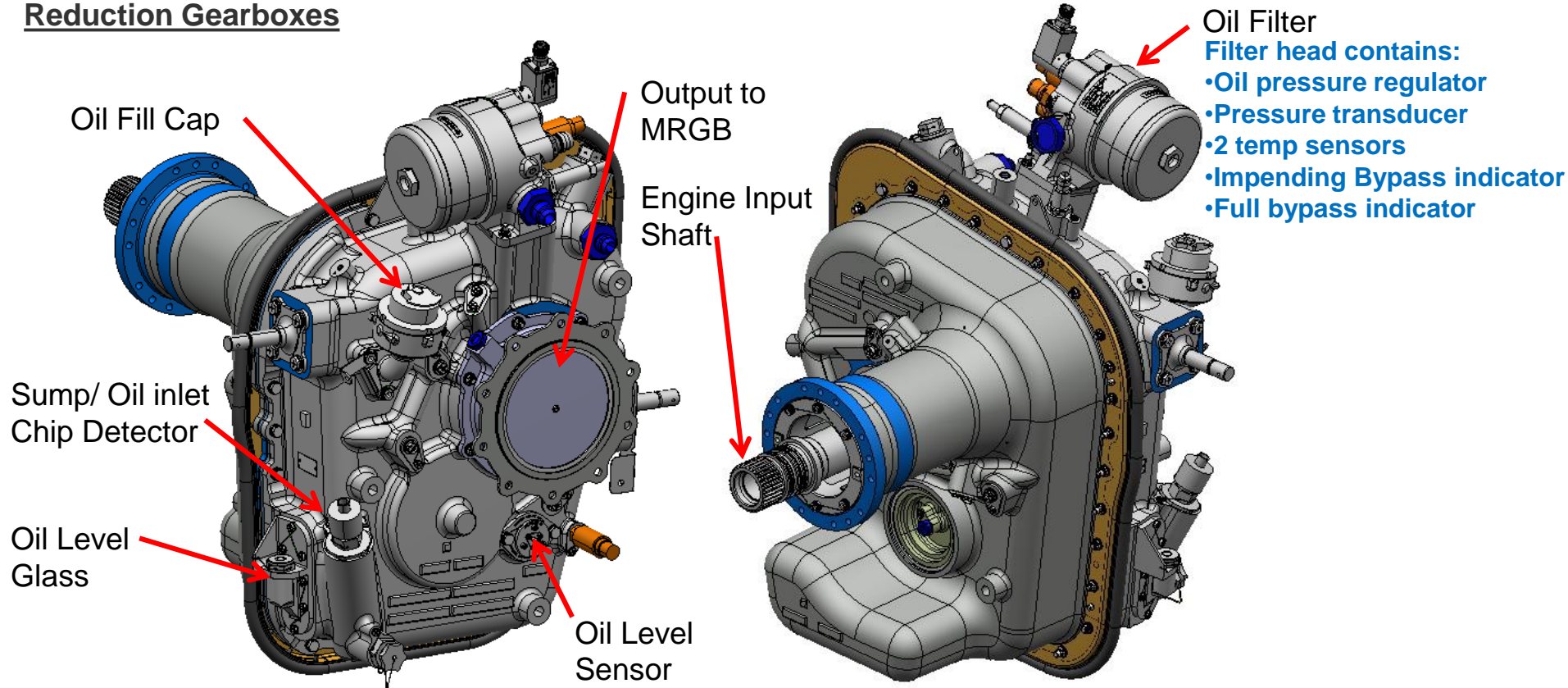
## Notable safety and maintenance related features:

(In addition to those shared with other gearboxes)

- Utilizes a simple two mesh reduction for safely reducing engine output speed to a low MRGB input speed
  - Contains only 3 gears, supporting bearings, and an internal oil pump
- No accessories driven by reduction gearboxes
- Fuzz burning chip detector at oil pump inlet
- Each Reduction Gearbox contains its own independent lube system
- Engine input with an internal one piece splined shaft piloted at each end

# Bell 525 Drive System

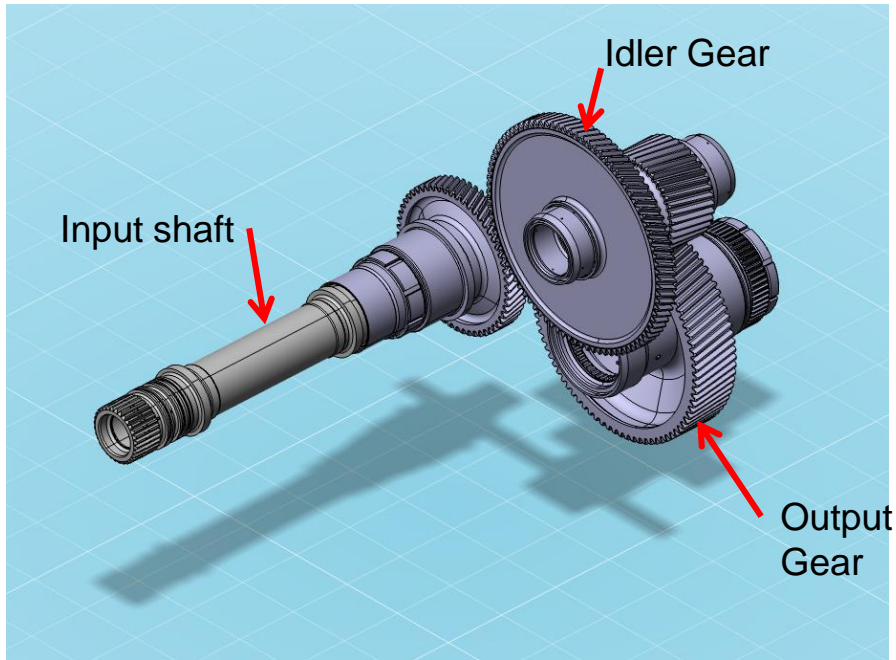
## Reduction Gearboxes



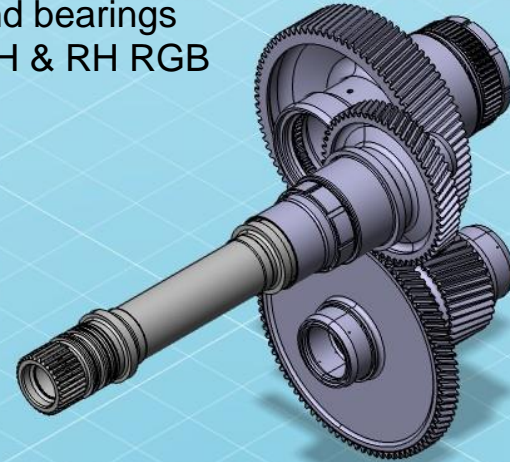


# Bell 525 Drive System

Both LH & RH RGB's utilize a simple two mesh three gear reduction for engine output speed to MRGB input speed



Exact same gears, shafts, and bearings used in LH & RH RGB



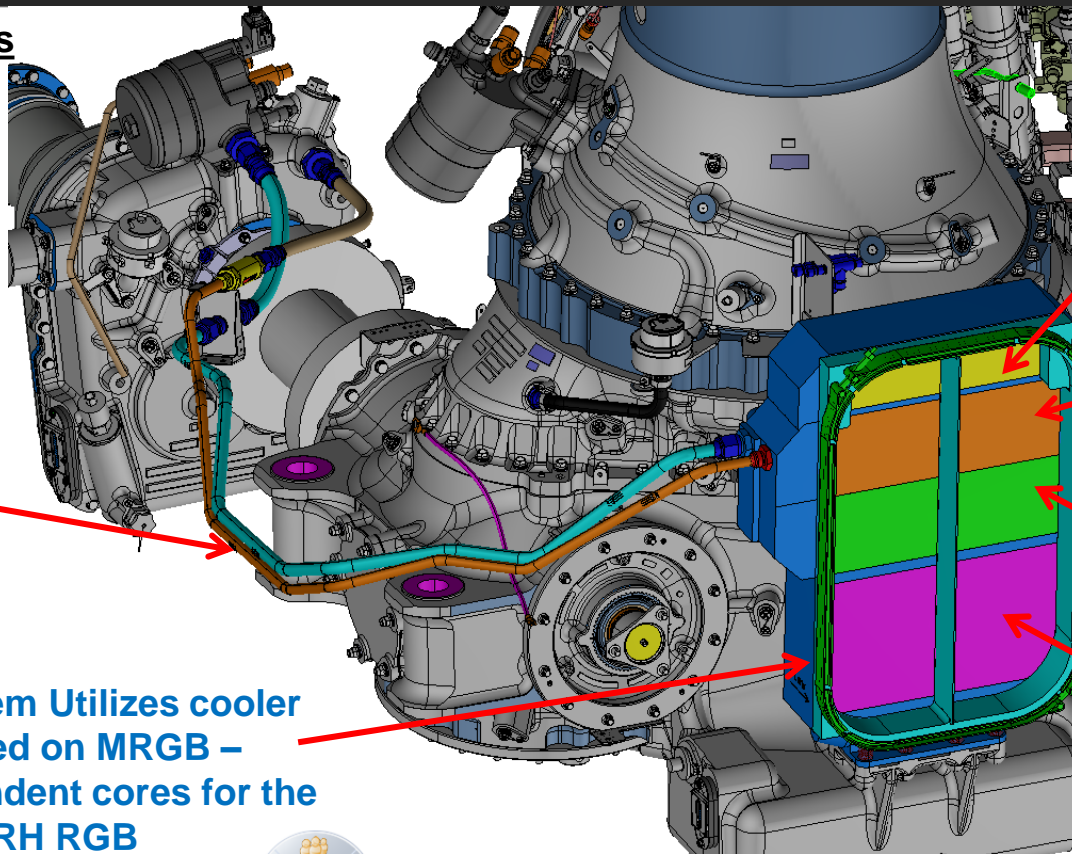
# Bell 525 Drive System Lubrication

## Reduction Gearboxes

View Looking Aft

Oil lines for LH & RH are routed on opposite sides of the AC for system separation

Lubrication System Utilizes cooler assembly mounted on MRGB –  
Separate independent cores for the MRGB and LH & RH RGB



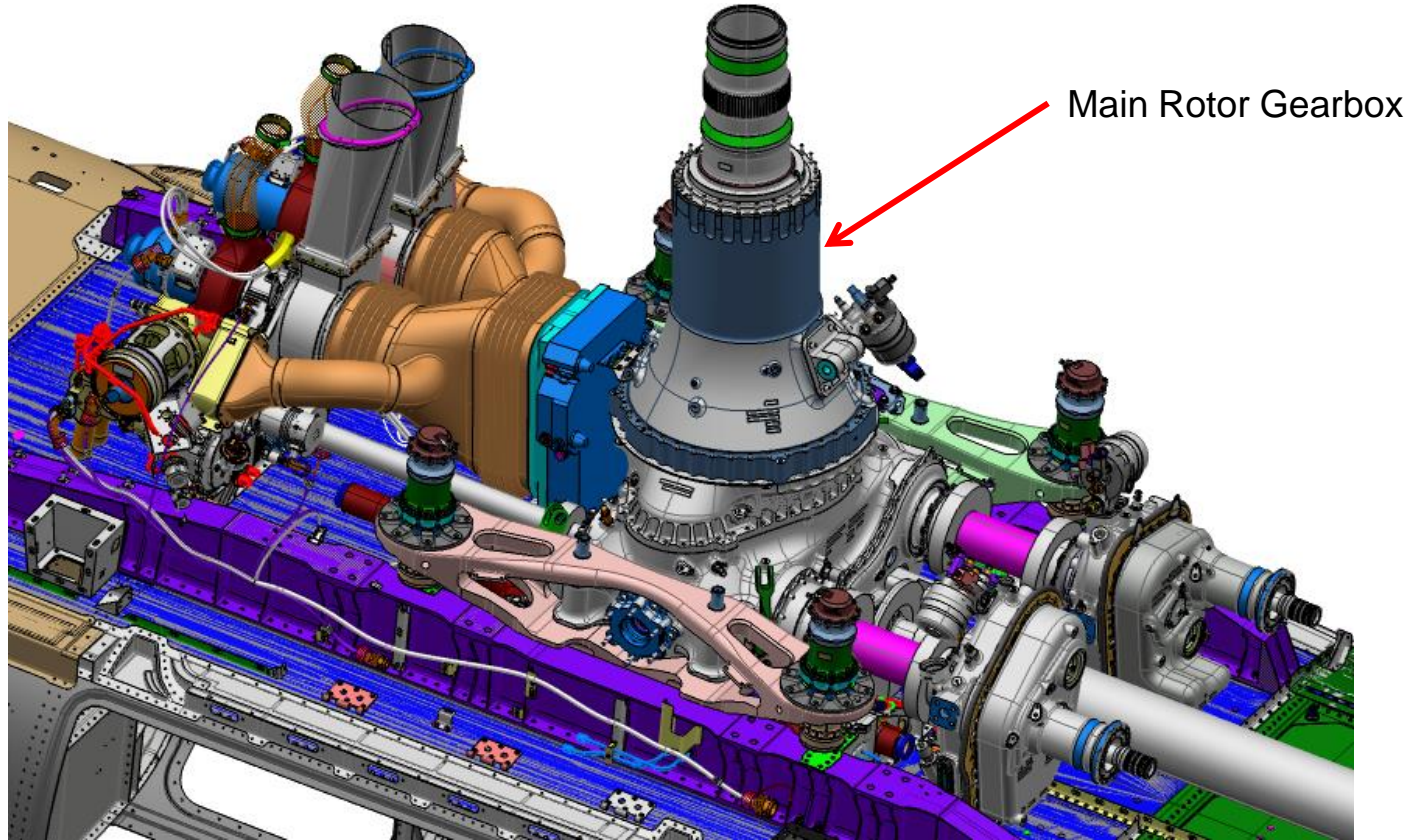
Hydraulic  
core

RH RGB  
core

LH RGB  
core

MRGB core

# Bell 525 Drive System





# Bell 525 Drive System

**The Main Rotor Gearbox (MRGB) transmits torque from the Reduction Gearboxes to the Main Rotor Mast, the Accessory Gearboxes, the Hydraulic Pump and Generator that is mounted to the MRGB, and to the Tail Rotor Drive Shaft.**

## **Notable safety and maintenance related features:**

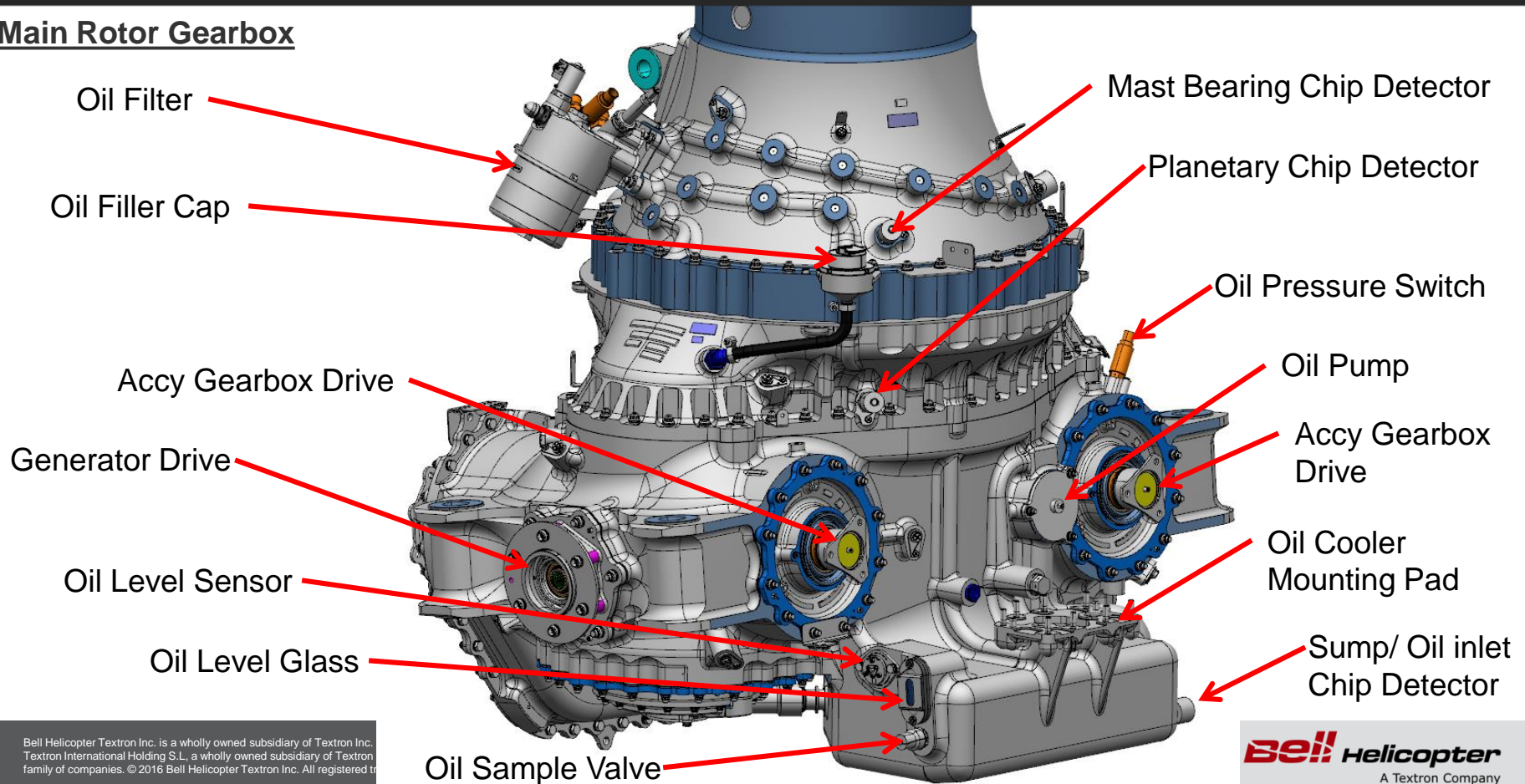
(In addition to those shared with other gearboxes)

- Highest speed components held to less than 6000 rpm by keeping high speed gearing separate in the Reduction Gearboxes
- Clutches at LH & RH inputs from Reduction Gearboxes allow single engine start and decoupling of either engine/Reduction Gearbox for single engine operation
- Single overhung low speed planetary reducing part count and eliminating the heat generation that a high speed planetary would produce
- Oil cooler mounted directly to gearbox with o-ringed transfer tubes
  - Elimination of all external fluid lines for the main rotor gearbox
- Compartmentalized chip detection with multiple detectors with fuzz burn capability
- Oil sampling valve for periodic verification of oil quality
- Rain guard mounted over mast seal acting as a labyrinth seal and preventing water intrusion into gearbox
- Rotor Brake system independent of all other systems with proximity probes and cockpit annunciation of position



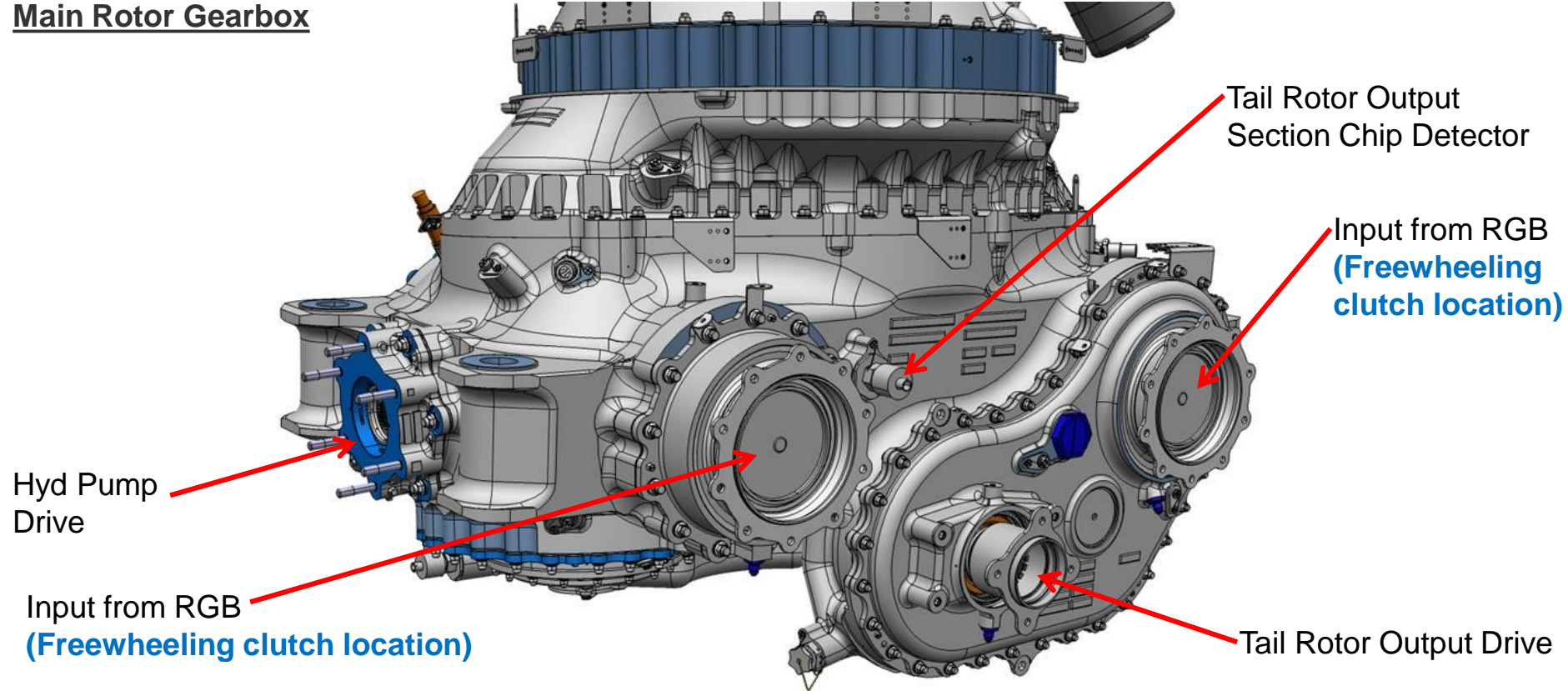
# Bell 525 Drive System

## Main Rotor Gearbox



# Bell 525 Drive System

## Main Rotor Gearbox



# Bell 525 Drive System

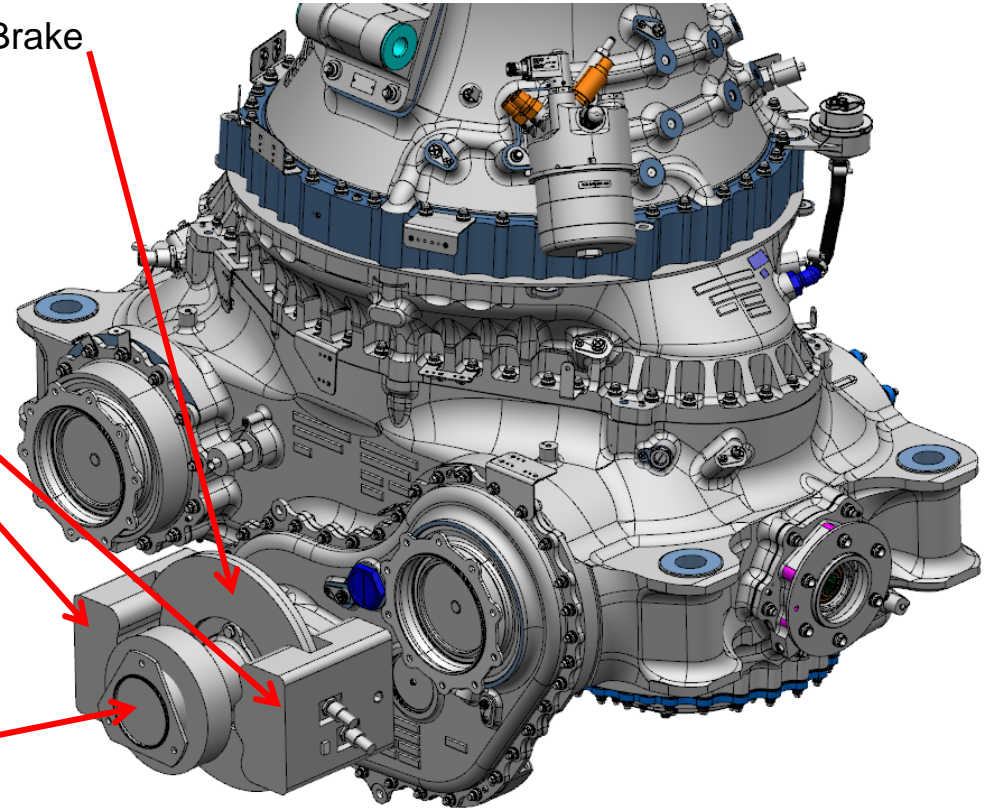
## Main Rotor Gearbox

### ▲ Rotor Brake Calipers

- ▲ •Proximity sensors mounted in the calipers positively determine retraction of each brake pad and provide cockpit annunciation of rotor brake actuation
- Hydraulic master cylinder assembly is independent of other systems
- Remotely located handle in the cockpit with mechanical linkages connecting directly to the rotor brake master cylinder

Rotor Brake Disk

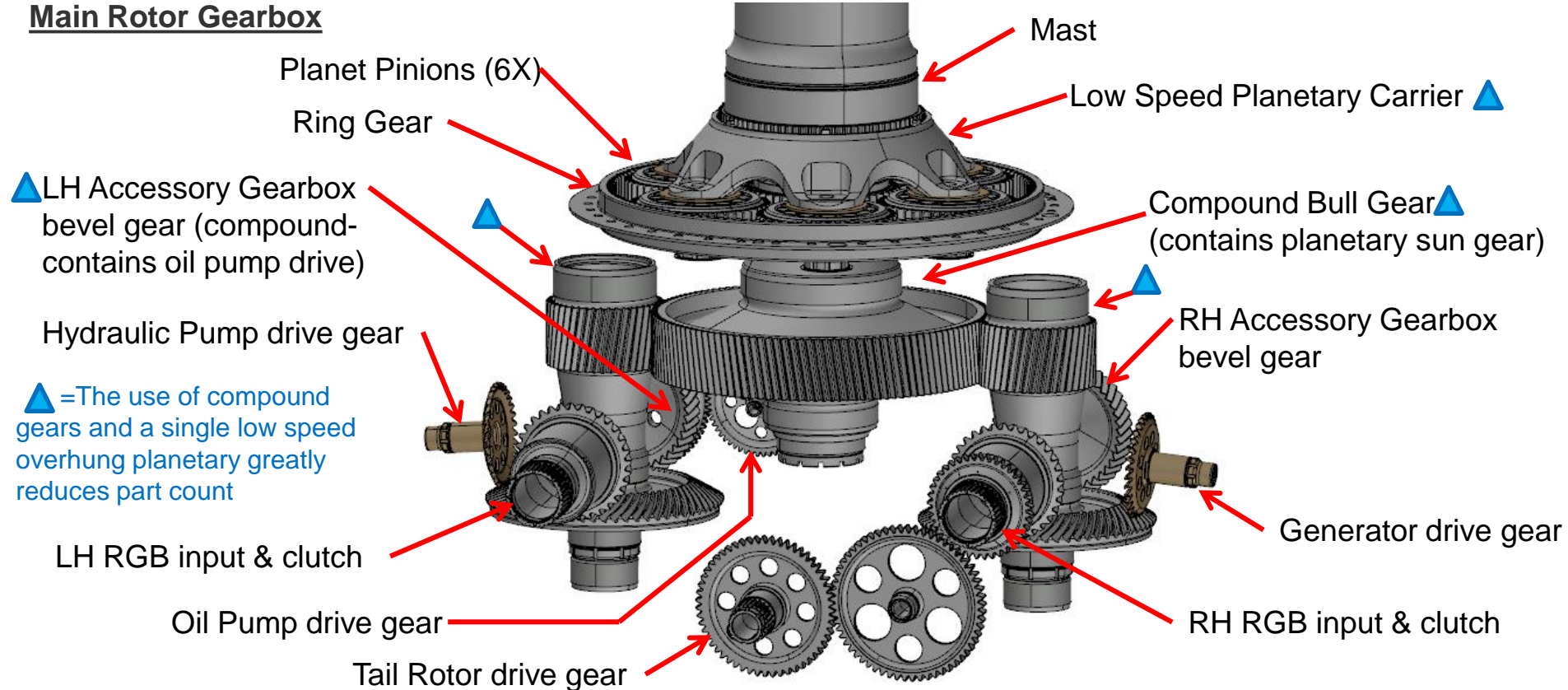
Tail Rotor Output Coupling





# Bell 525 Drive System

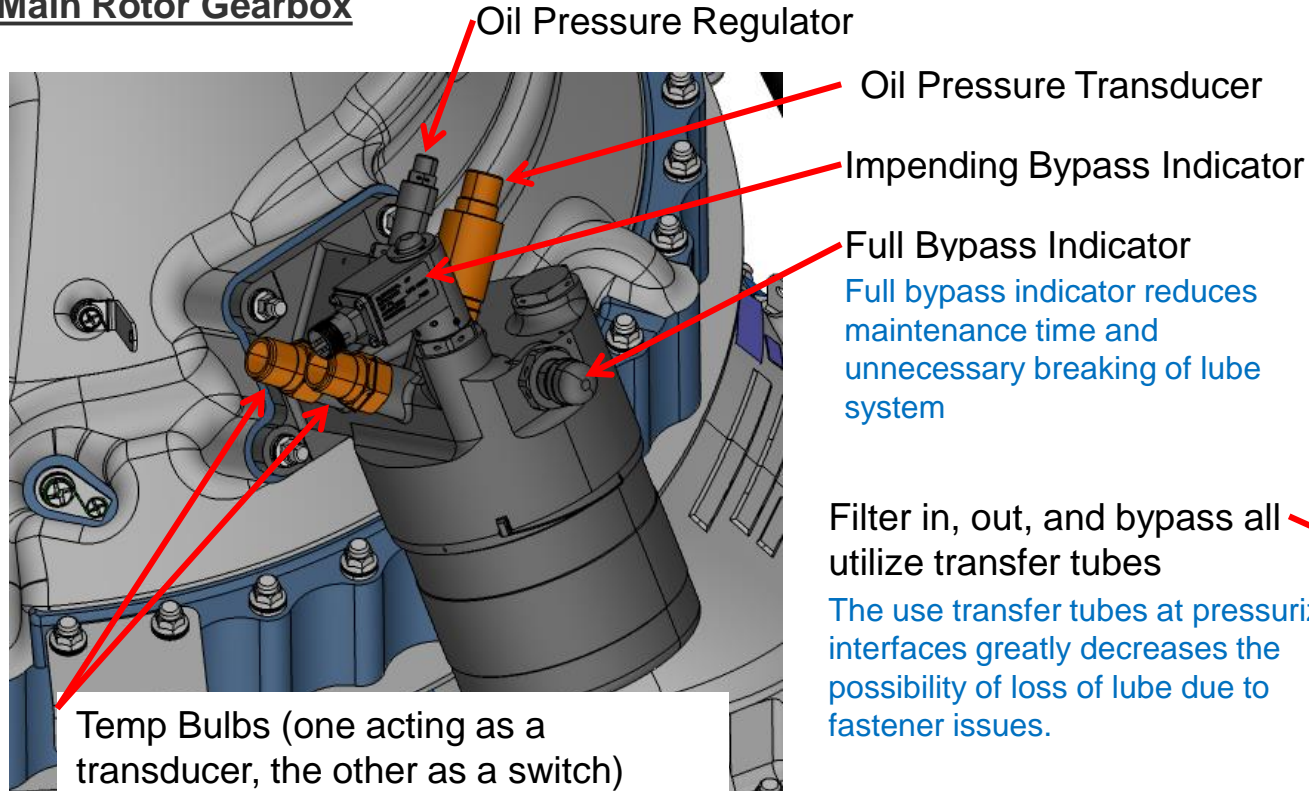
## Main Rotor Gearbox





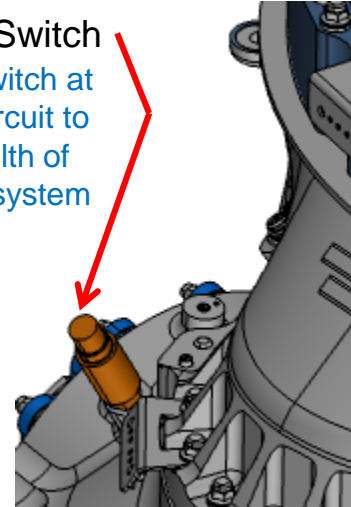
# Bell 525 Drive System

## Main Rotor Gearbox



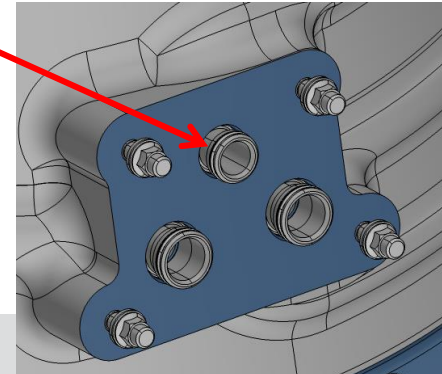
Pressure Switch

Pressure switch at end of oil circuit to monitor health of entire lube system

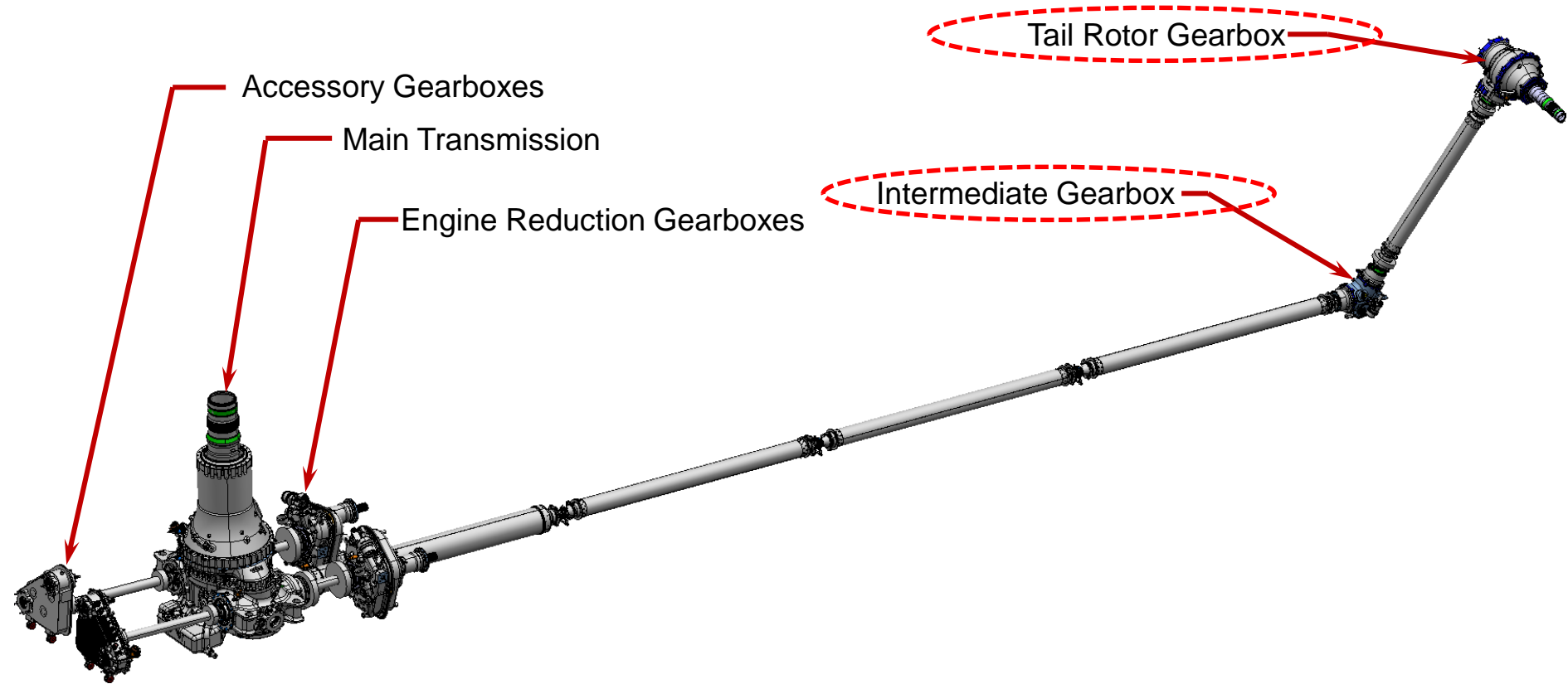


Filter in, out, and bypass all utilize transfer tubes

The use transfer tubes at pressurized interfaces greatly decreases the possibility of loss of lube due to fastener issues.



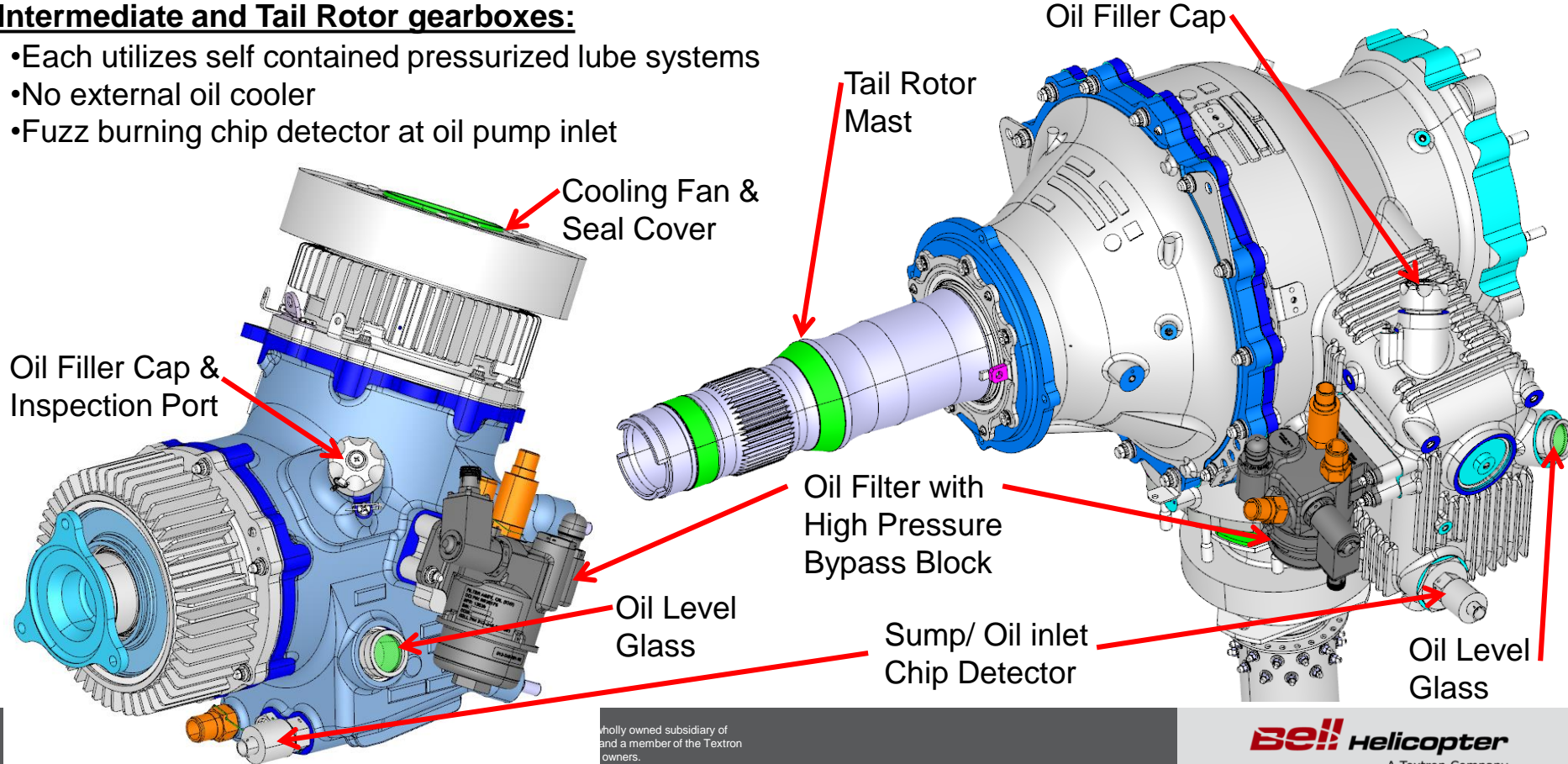
# Bell 525 Drive System



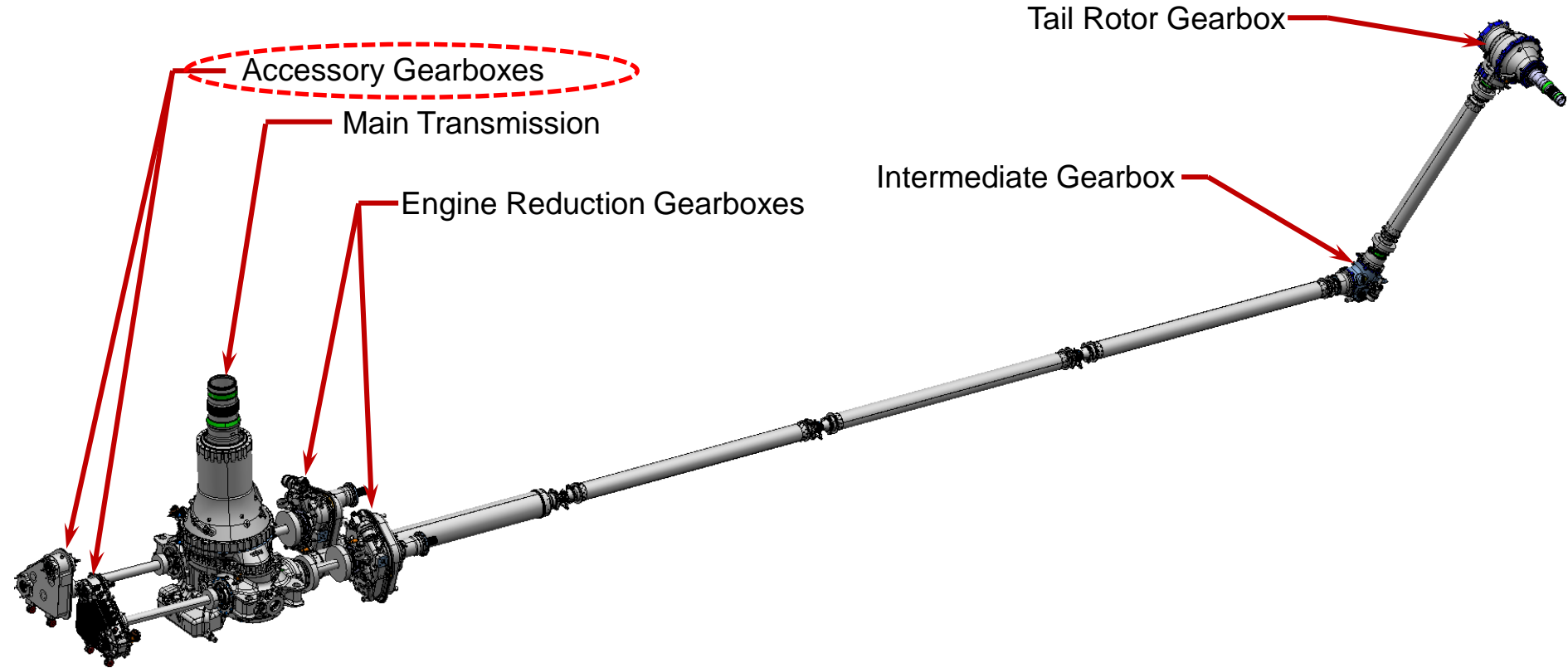
# Bell 525 Drive System

## Intermediate and Tail Rotor gearboxes:

- Each utilizes self contained pressurized lube systems
- No external oil cooler
- Fuzz burning chip detector at oil pump inlet



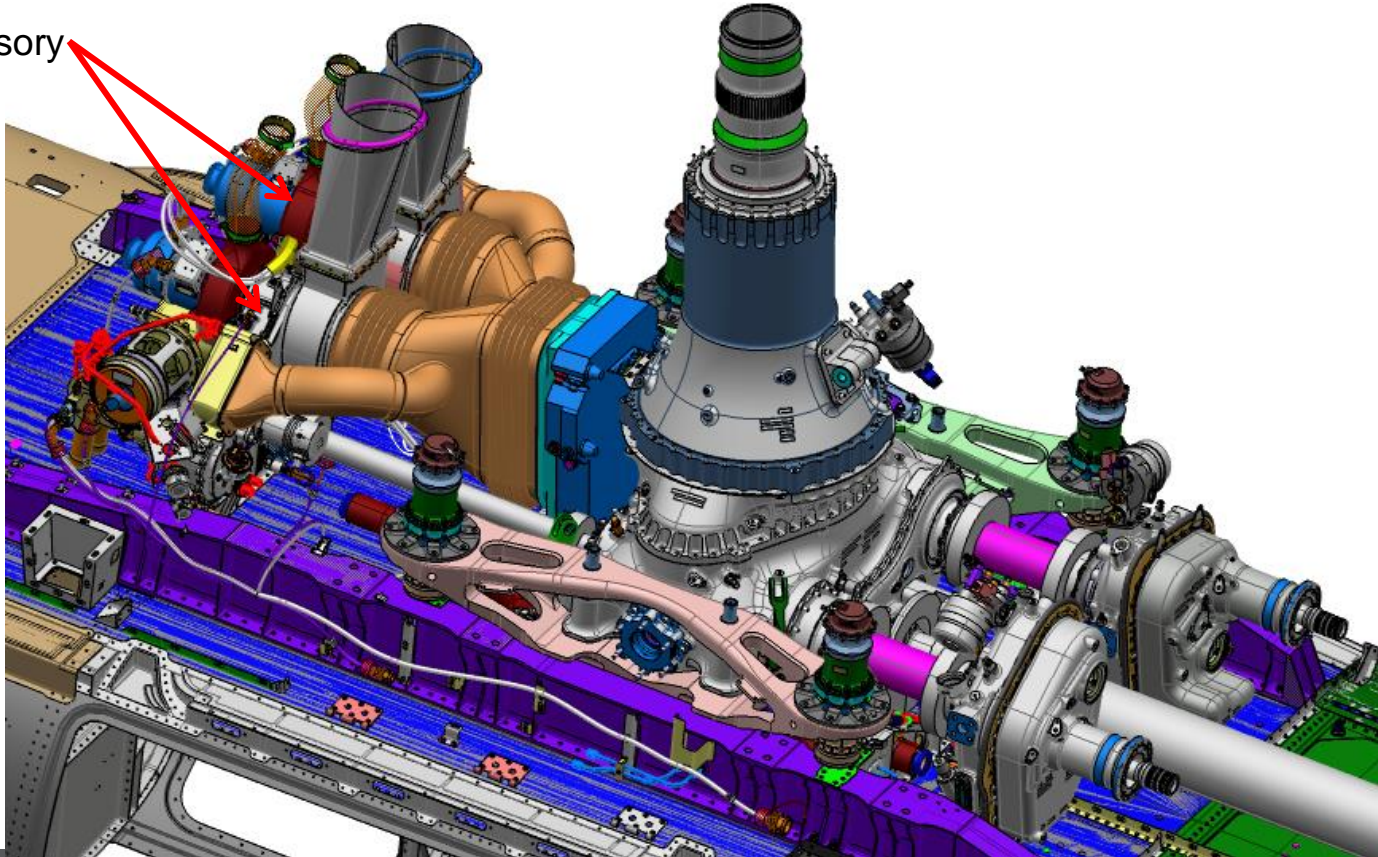
# Bell 525 Drive System





# Bell 525 Drive System

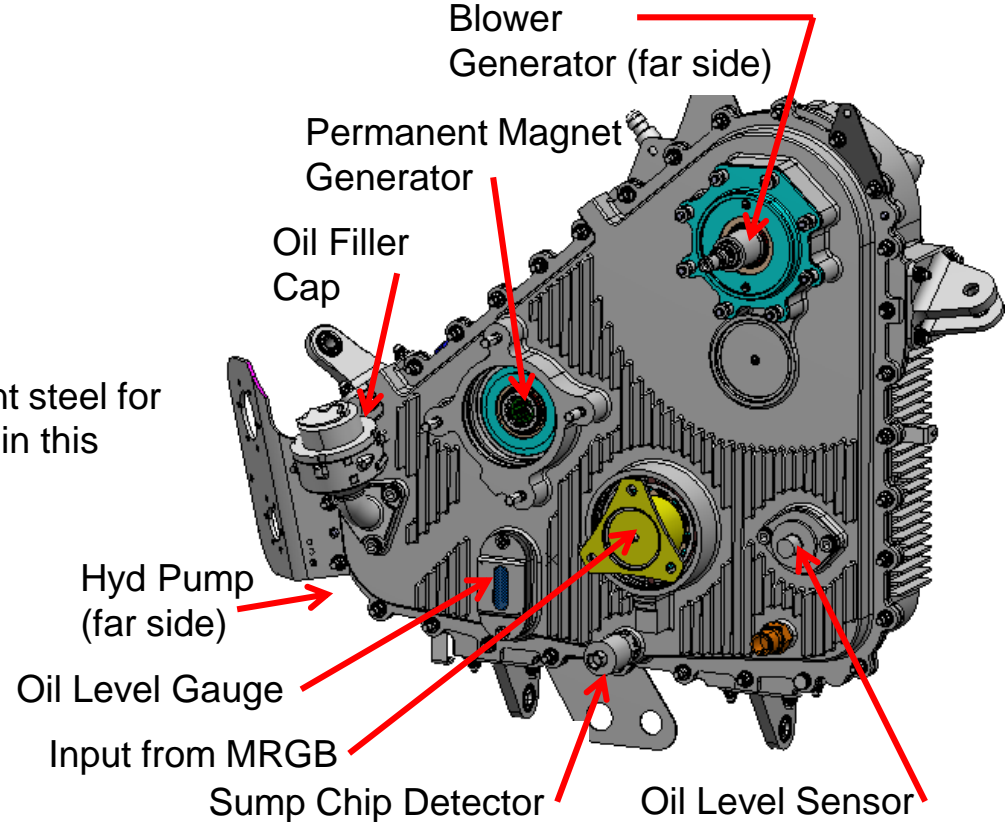
LH & RH Accessory  
Gearbox



# Bell 525 Drive System

## Accessory Gearbox (LH shown)

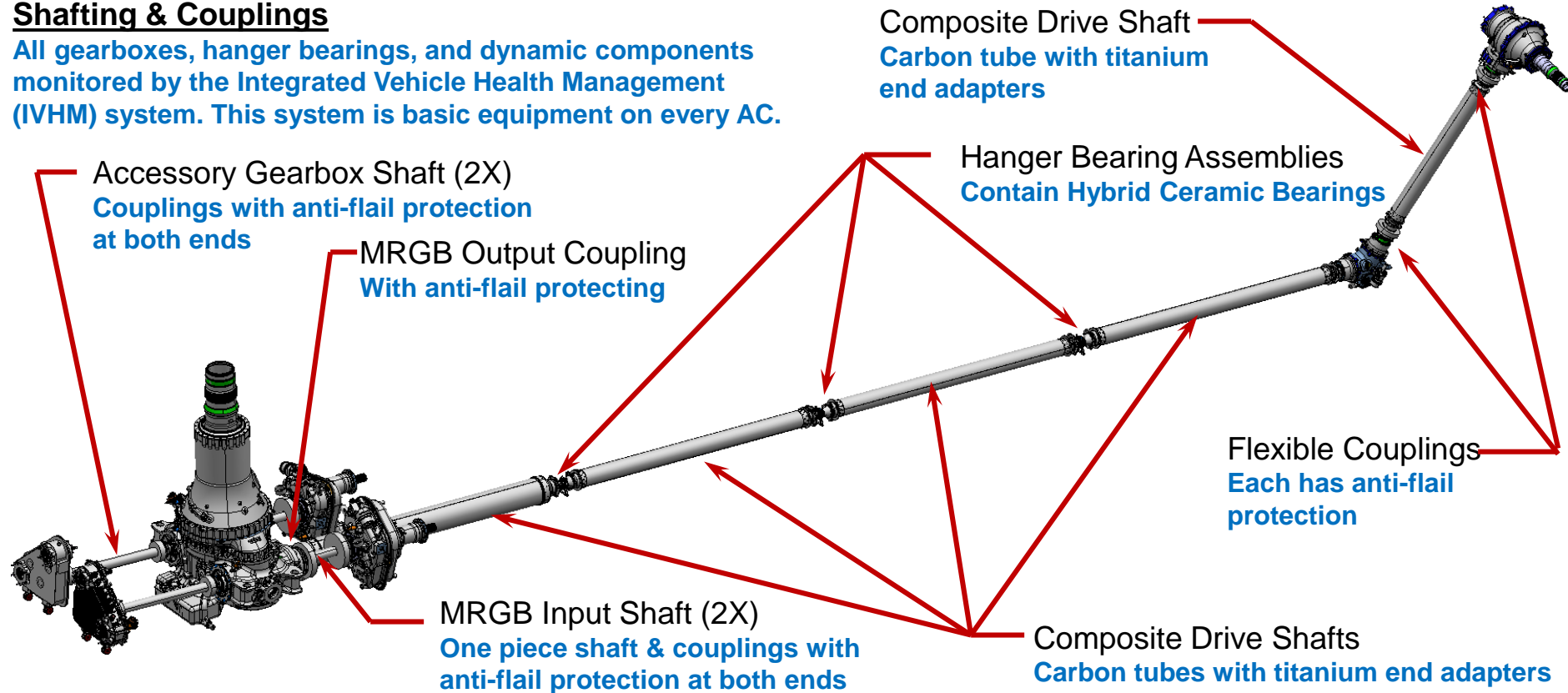
- Simple spur gear train driving all accessories
- All moving parts are splash lubricated
  - No external oil cooler
  - No pressurized oil leak path
- Fuzz burning chip detector
- Blower impeller mounted directly to protruding gear
  - No need for external grease packed bearings
  - Protruding portion of gear is corrosion resistant steel for decreased wear and protection from corrosion in this environment



# Bell 525 Drive System

## Shafting & Couplings

All gearboxes, hanger bearings, and dynamic components monitored by the Integrated Vehicle Health Management (IVHM) system. This system is basic equipment on every AC.



# The Relentless Drive System incorporates an innovative arrangement and construction of components that collectively minimize the possibility of a loss of lubrication event and ensure that the maximum flight time is achieved if such an event does occur.

Transfer tubes for all pressurized oil interfaces to eliminate the loss of lubricant in the event of loss of attachment fastener torque

No external oil lines on MRGB

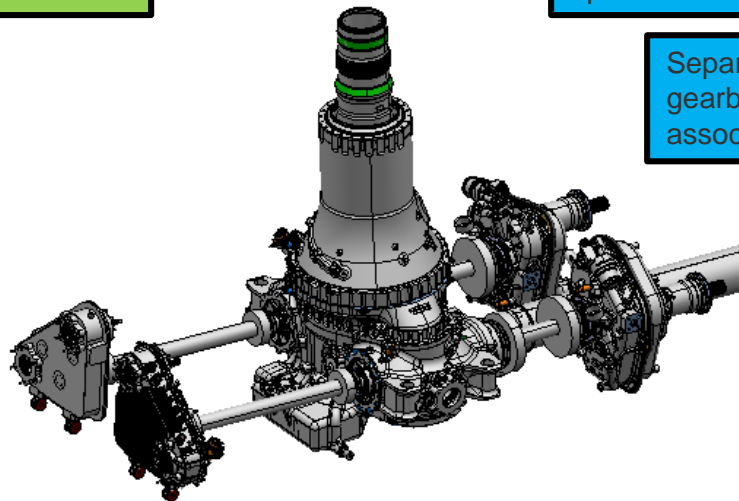
Isotropic Super finished gear teeth resulting in an improved surface finish and maximizing the ability of these gears to operate in a reduced lubrication environment

Oil cooler mounted directly to the main rotor gearbox

Separate non pressurized accessory gearboxes eliminating the oil leak paths that could lead to a loss of lubrication event

All oil filter bowls are screw on in lieu held on with small fasteners eliminating fastener failure issue from repeated removals

Elimination of a high speed planetary and the heat generation associated with it during a loss of lubrication event.



Separate, isolated, and redundant engine reduction gearboxes that take the high speed gearing and associated heat generation out of the MRGB

Ring gear and case joint design to efficiently transmit heat away from the planetary gears in the event of a loss of lubrication

The use of high hot hardness material utilized for primary torque carrying components and supporting bearings maximizing their continued operation in the event of a loss of lubrication

Gear tooth geometry specifically designed to minimize sliding reducing heat generation at the teeth and the tendency to score during a loss of lubrication event.

The use of coarse pitch power gears with clearance or backlash allowing for the expansion during high heat loss of lubrication events

 = Minimize the probability of a loss of lubrication (LOL) event  
 = Maximize the flight time after LOL if such an event does occur