

Upgrading of Bofors L/70 SAK 40 N67 EI.



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1 INTRODUCTION

1.1 GENERAL

The purpose of the modification of the Bofors 40/L70 and introducing a new electric drive system, is to ensure that the Gun can function as a modern, efficient and cost-effective Air-defence system for another 20 years after modification. The major advantages with the modified system can be described as follows:

- ◆ **Extended technical life span** by replacing the expensive and maintenance intensive components and sub-systems in the existing gun with new, more simple and commercial available components achieve extended technical life span.
- ◆ **Reduced life cycle cost** is achieved by low cost modification and low operation and maintenance cost after the modification has been carried out.
- ◆ **Short delivery time for spare parts** is achieved by introducing standard industrial off the shelf components combined with “easy to produce” special components. For the new concept, all components are available within 4 – 8 weeks from our workshop or sub-suppliers.
- ◆ **Standard industrial components are introduced when possible**, is achieved with focus on this subject during the design period of the new system, an about 70% of all components used are standard off the shelf components.
- ◆ **Reduced weight** is mainly achieved by removing all hydraulic components, and also removing of the transmission unit in the centre beam and replace this with a new electric drive motor for elevation on the upper mounting. (approx. 900kg reduced)

1.2 MAJOR ADVANTAGES WITH THE MODIFIED GUN :

The main goal with modification of the Bofors 40 mm gun was to maintain or improve the original version. To verify this we have measured four important parameters:

1. Precision

The precision of the gun has been improved both in training and elevation by installation of new gearboxes with less number of transmission units from motor to moving part. Improved precision is also achieved by installation of a new syncro box connected directly on moving shaft for elevation and training.

2. Operation

The gun is, after modification, equipped with equipment for remote control via C³I system or it can be locally controlled from inside the gun. For remote control the system can be operated in a closed servo loop from a C³I system. The new system also gives the C³I system dynamic position feed back. For local control inside the gun a new laying unit has been developed with new improved joystick with dead mans control and firing switch integrated in the joystick.

3. Maintenance

After modification we have seen that man-hours involved in the original system are drastically reduced:

- ◆ **Hydraulic;** all hydraulic components are removed, no maintenance.
- ◆ **Mechanical;** many components are removed and/or replaced by more simple components. By introducing new components in stainless steel, also corrosion problems are reduced.
- ◆ **Electric;** by using standard off the shelf components which are tested and produced in a much larger scale, the faults are reduced, besides the fact that spare parts are inexpensive and delivery time short.

4. Operational/tactical – availability

Due to the fact that the gun after modification is:

Easier to operate

Fewer malfunctions occur

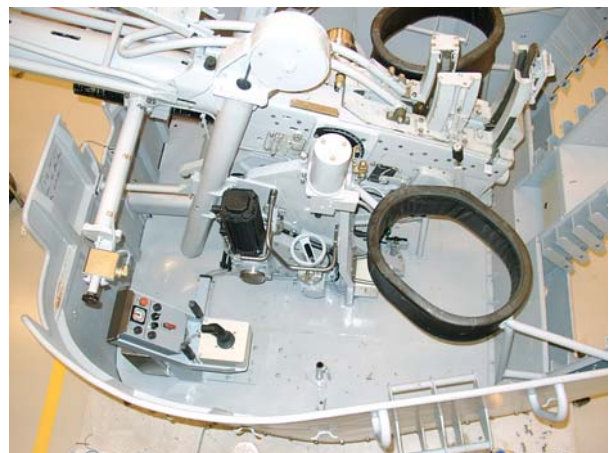
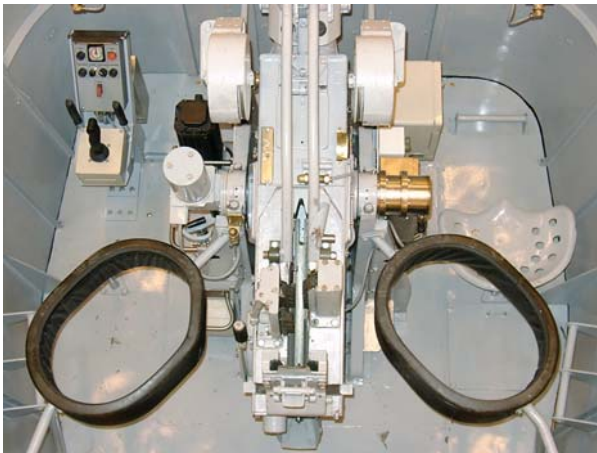
Increased availability on spare parts

Less components to maintain

More simple maintenance work

The gun is more operation/tactical – available.

Top view of modified gun:



2 DESCRIPTION

The Bofors 40mm Automatic Gun L/70 in Deck Mounting, type SAK 40 N67 is a close-range anti-aircraft weapon, mounted in a single-barrel mounting. The barrel, the breech mechanism and the loading device, the elevation system, are designed to give a continuous high rate of fire.

The Guns upper carriage consists of right and left side frame with upper plate and platform. In front of the platform is a protection shield and an ammunition rack is mounted on the backside. The plate and platform is supported on a pedestal.

The Gun is equipped with arrangements for machine adjustments for training and elevation, and can be connected to remote control from a fire control instrument. The motor for training is mounted on a socket under the slewing ring, and the motor for elevation is mounted on left side frame.

The Guns electrical equipment consists of components for machine adjustments, equipment for launching and starting arrangements for the electrical motors. Some parts of the electrical equipment are connected to a network central apart from the Gun.

Normally the Gun is connected to the fire control instruments and the network central, which then is connected to the power station on the ship.

3 DATA

3.1 MAIN DATA:

◆ Main power supply			3x440V 60 Hz
AUX. POWER SUPPLY 1	integrated in syst.		115V/400Hz, 150VA
AUX. POWER SUPPLY 2	integrated in syst.		24V DC, 50VA
◆ Syncro type		Muirhead	11CX4b, 11CT4b
			11CDX4b, 11TR4b
◆ Syncro, trading conditions	Training	Coarse	1:1
	Training	Fine	9:1
	Elevation	Coarse	1:1
	Elevation	Fine	9:1
◆ Elevation	Electrical AC servo motor with amplifier		
GEAR RATIO	Motor to elevation gear arc		400:1
◆ Training	Electrical AC servo motor with amplifier		
GEAR RATIO	Motor to elevation gear arc		207:1

Weights:

Elevation mass		kg	560
Upper + lower carriage incl. adjustment mechanism		kg	1.260
Protection cover		kg	90
Network central		kg	90
	Total weight	kg	2.000

3.2 GUN MOVEMENT CHARACTERISTICS

The gun movement characteristic data will be:

◆ Elevation requirements			-10° to +90°
TRAINING REQUIREMENTS			unlimited rotation
ELEVATION SPEED			45°/s
TRAINING SPEED			85°/s
ELEVATION ACCELERATION			approx. 135°/s ²
TRAINING ACCELERATION			approx. 127°/s ²

3.3 STATIC LINING UP, ACCURACY

The static lining up of the gun will be measured on the barrel, and represents the deviation from computer signal and barrel, with the following values:

ACCURACY ELEVATION			$\pm 0,03^\circ$ max
ACCURACY TRAINING			$\pm 0,03^\circ$ max

4 DESCRIPTION OF MODIFICATIONS

4.1 ELECTRICAL SYSTEM

CONTROL UNIT

The Bofors 40mm Automatic Gun L70 in deck mounting is fitted with power-operated gear for local and remote control. It is also fitted with cranks for hand operation of the gun in elevation and training.

The gun will be locally controlled from a control unit located on the left-hand side of the platform. For tracking, the gun captain will use a sight attached to a breech casing.

The joystick will be moved in all directions by the gun captain. A rearward or forward movement results in an elevating speed upwards or downwards proportional to the angle turn, while a simultaneous movement to the left or right imparts a corresponding training speed to the gun in the direction of that movement.

The existing control unit will be removed, and the gun will be fitted with a new control unit with a joystick and all functions available for the gun operator. The new control unit will be placed in a fixed position.



Figure 1 Control unit

GUN FIRING

The existing mechanical limitation for the gun firing will be removed. After modification the weapon will have two separate and independent electrical/mechanical systems, which will follow a pre-defined limitation curve.

The gun will have an electrical firing only as normal operation mode. Operation of the firing is performed either from a firing switch on the joystick or from the firing computer.

GUN FIRING NORMAL DRIVE LIMITATION

Normal drive and firing limitation will be pre-programmed in a drive limitation card for both training and elevation. The limitation card can be reprogrammed with other settings.

GUN FIRING, BACKUP SAFETY

As a second safety, a backup system based on an electric/mechanical device for drive and firing limitation will be installed for :

- ◆ Upper limit
- ◆ Lower limit
- ◆ Sideways limitation (sector limitation)

GUN FIRING, MECHANICAL CHAIN MECHANISM

All mechanical parts on the firing chain up to the elevating mass will be removed.

GUN FIRING, ELECTRICAL/MECHANICAL MECHANISM

An electrical/mechanical fire application will be fitted. A firing magnet will be positioned adjacent to the firing rod.

GUN FIRING, FIRING MAGNET

The firing magnet will have an inrush of 0,13s and an outrush of 0,08s. Given data are normal load.

GUN FIRING, SERVICE FIRING

The service firing should be possible to operate mechanically by hand (only in service mode). The handle is mechanically locked in operational mode.



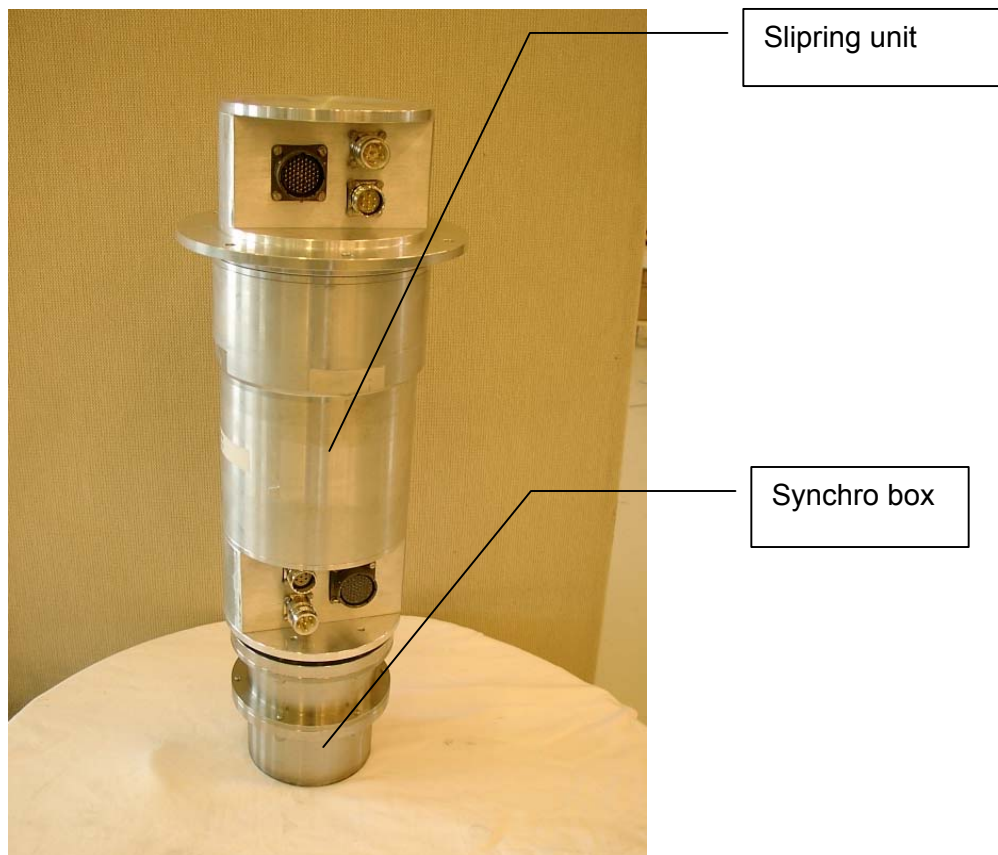
Firing magnet arrangement

PIVOT, MECHANICAL PARTS

All mechanical parts in the pivot will be removed.

PIVOT, SLIP RING

The existing slip ring contains 30 rings. The slipring unit will be modified to contain 54 connectors in order to incorporate the increased demand for power and control signals. Syncro box for training will be mounted in the end of the slipring unit.



Slipring unit with 54 rings and syncro box training.

ELECTRICAL CONTROL SYSTEM

All electrical boxes and units will be removed from the existing gun and replaced by new units. As an electrical connection between the upper and lower mounting, a slip ring unit will be installed.

The gun will be remotely controlled by a computer or locally controlled by a joystick. In remote control, the drive signal is given from the computer via the syncro control chain to the AC servo drive system. An internal servo control loop will correct the position automatically after the incoming signal.

UPPER MOUNTING, MODIFICATIONS

As a minimum, the following equipment will be modified/changed on the upper mounting:

- ◆ Firing magnet
- ◆ Laying gear with a control panel with the following functions:
- ◆ A firing safety switch, light dimmer, local/remote push buttons, start/stop push buttons, training indicator, motor break switch on/off and a joystick.
- ◆ Connector for communication.
- ◆ Motor for elevation.
- ◆ Syncro box for elevation
- ◆ Emergency stop switch for safety crew.
- ◆ Lights for aiming device, elevation indicator and loading unit in dedicated positions.
- ◆ Limit switches for locking device.

LOWER MOUNTING, EXISTING EQUIPMENT

All existing hydraulic, electric, mechanical parts and brackets on lower mounting will be removed.

LOWER MOUNTING, MODIFICATIONS

As a minimum, the following equipment will be modified/changed on the lower mounting:

- ◆ Junction boxes
- ◆ Motor/gear for training
- ◆ Stop firing bell
- ◆ Syncro box for training

MAIN ELECTRICAL CONTROL PANEL

All electrical components necessary to drive and operate the gun will be placed in one electrical control panel located on the lower platform. This panel will be connected to the gun in one end, and to the remote control unit in the other end.

FUNCTIONS OF THE MAIN ELECTRICAL CONTROL SYSTEM

The main electrical control panel will be installed below deck on a dedicated position, and will as a minimum contain the following main components:

- a) Main switch
- b) Power distribution
- c) Power supply
- d) AC servo drives for training and elevation motor
- e) Logic control unit for all logic functions of the gun
- f) Signal interface cards between syncro chains and servo drives
- g) CDX syncros for the aim test and adjustments
- h) CX syncros for the gun's 0-position
- i) Normal drive and firing limitation card
- j) Test and measuring point
- k) "Gun follow" interface card for firing limitation with angle deviation between the gun and the firing computer system.

POWER SUPPLY

As a power supply we are offering UPS to be integrated on the gun. For charging the UPS, a diesel generating set of 15kVA can be installed. The diesel generator will start automatically when the battery voltage on the UPS requires.

Diesel generating set has the following data:

- Power : 15 kVA
- Voltage : 3x380V, 50Hz
- RPM : 3.000 rpm

PRINCIPLE OF THE CONTROL SYSTEM

1. Local control

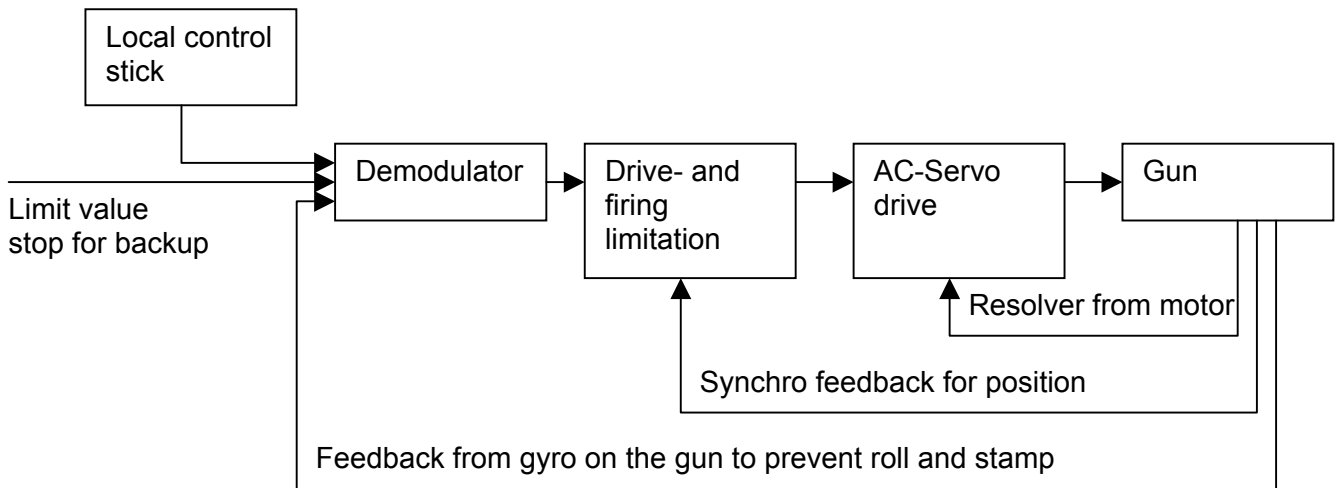


Fig. 1

2. Remote control

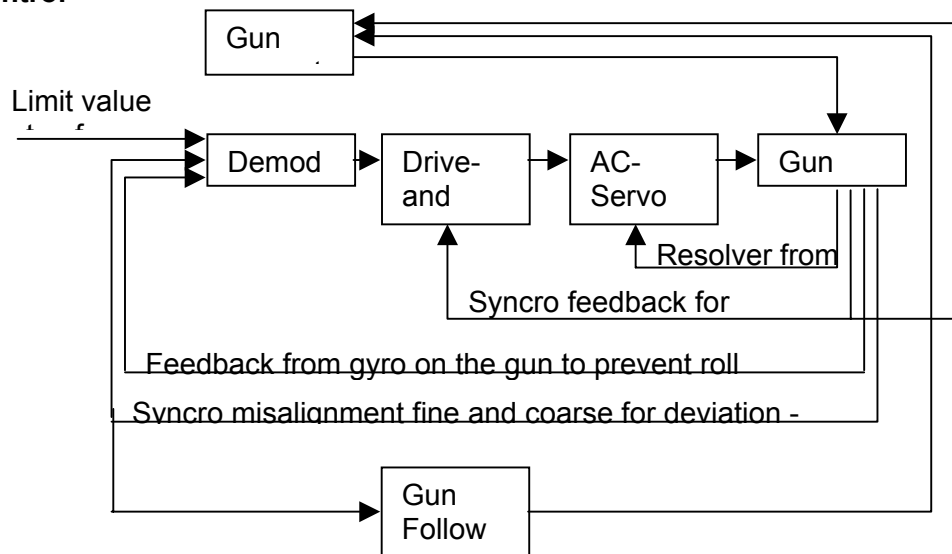


Fig. 2

4.2 MECHANICAL SYSTEM

UPPER MOUNTING

The upper mounting will consist of a rotating platform on a lower mounting. On the upper mounting there will be two balancing devices for the elevating mass.

The platform will have two seats for the gun layers. In addition it will be equipped with handles for service operation (training and elevation). A laying unit for local control and gun firing and all the control functions in an electrical box-unit will be available for the gun operator.

The platform will be fitted with a 3 mm steel shield and two waist-high supports will prevent the loaders from being disturbed by rapid training movements during power operation. On the rear part of the platform there will be two ammunition racks.

ELEVATION GEAR

The elevation gear will be replaced with an electrical motor and gear which comply with the existing eccentrically adjustment available today.

SERVICE HANDLES

The gun will be fitted with service handles (maintenance) to move the gun both in training and elevation.

GUN SAFETY

The gun will not be allowed to operate electrically when either of the service handles is in operation positions.

LOWER MOUNTING

The lower mounting of the gun will consist of a gear and an electrical motor for training, junction box and a synchro unit connected to the slip ring unit.

LOWER MOUNTING, EXISTING EQUIPMENT

All existing hydraulic, electric, mechanical parts and brackets on the lower mounting will be removed.

LOWER MOUNTING, ADJUSTMENT OF GEAR TO GEAR ARC.

The foundation for the new gear will be designed for an easy adjustment of the gearbox in order to obtain an optimal adjustment (clearing) between the gearbox and the training gear arc.