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DEFENCE R&D DÉFENSE

FOAM/FORU UPGRADE FEASIBILITY REPORT FOR TIAPS SYSTEM

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Contract Number W7707-0-9954
Contractor's Report Number DN0189

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Contractor Report

DREA CR 2001-047

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Abstract

The Towed Integrated Active-Passive SONAR (TIAPS) program mandates the construction of an integrated towed array for research purposes. This towed array includes a horizontal line projector, and "active" receive module, and elements of a passive receive array. The combination of these elements in a single tow presents some difficulty with respect to transmitting high frequency electrical signals past projector elements that are driven by high voltage signals. The solution to this problem is to transmit the data from the active and passive receive arrays on optical fibres. The design of the transmitter (Fibre Optic Adapter Module, FOAM) and receiver (Fibre Optic Receive Unit, FORU) is a task in the TIAPS program. This document discusses the feasibility of upgrading the speed of the fibre connection from SONET OC-1 (51.84 Mbps) to SONET OC-3 (155.52 Mbps).

Résumé

Le programme de sonar actif-passif intégré remorqué (TIAPS) vise la construction d'un réseau remorqué intégré pour des fins de recherche. Ce réseau remorqué comporte une ligne horizontale de projection et un module de réception « actif », ainsi que des éléments d'un réseau de réception passif. La combinaison de ces éléments en un seul dispositif remorquable comporte certaines difficultés qu'entraîne l'émission de signaux électriques haute fréquence au-delà d'éléments de projecteurs qui sont excités par des signaux haute tension. La solution à ce problème consiste à émettre les données des réseaux de réception actifs et passifs au moyen de fibres optiques. La conception de l'émetteur (module adaptateur à fibres optiques FOAM) et du récepteur (module de réception à fibres optiques FORU) constitue une des tâches du programme du TIAPS. Le présent document discute de la faisabilité de l'augmentation de la vitesse de la connexion à fibres optiques de la vitesse SONET OC-1 (51,84 Mbit/s) à la vitesse SONET OC-3 (155,52 Mbit/s).

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Executive summary

The FOAM/FORU component of the TIAPS array is designed to provide a physical transport layer for data from the active and passive receive arrays. It uses five multimode optical fibres embedded in the tow cable and array to transmit the data to the surface. FOAM/FORU is being designed and constructed as a DREA internal project to deliver into the TIAPS system. The initial specifications for FOAM/FORU were to carry signals from a Pulse Code Modulation-based telemetry system such as the ADM2 passive array. The bandwidth requirements of this telemetry system are relatively modest, in the range of 26 Mbps. Design and construction of the subsystem proceeded, adopting the OC-1 (51 Mbps) standard for specifying components. As the procurement process for the DASM(D) active receive array module progressed, it became apparent that significant cost savings could be realized if ATM (Asynchronous Transfer Mode) telemetry were used instead of PCM due to increased utilization of Commercial Off The Shelf (COTS) hardware. The disadvantage of this approach was the requirement to increase the bandwidth in FOAM/FORU to the OC-3 standard (155 Mbps). This report reviews the current FOAM/FORU design and examines the feasibility of upgrading the existing, design to OC-3. The study concludes that the upgrade is possible with minimal impact by exchanging the fibre optic receiver and transmitter devices for higher-grade devices. The replacement parts are physically similar in size and use the same printed circuit board footprint. The result of this conclusion is the knowledge that the DASM(D) procurement can proceed using ATM telemetry with minimal impact on the overall design of the array.

MacLeod, H. 2001. FOAM/FORU Upgrade Feasibility Report for TIAPS System. DREA CR 2001-047. Defence Research Establishment Atlantic.

Sommaire

Les modules FOAM et FORU du réseau TIAPS sont conçus afin de constituer une couche de transport physique pour les données provenant des réseaux de réception actif et passif. Ils utilisent cinq fibres optiques multimodes insérées dans le câble de remorquage pour transmettre les données à la surface. Les modules FOAM et FORU sont conçus et construits dans le cadre d'un projet interne du CDRA visant à produire le système TIAPS. La spécification originale des modules FOAM/FORU visait la transmission de signaux d'un système de télémesure basé sur la modulation par impulsions et codage comme le réseau passif ADM2. Les exigences de ce système de télémesure sur le plan de la bande passante sont relativement faibles, soit de l'ordre de 26 Mbit/s. La conception et la fabrication du sous-système ont eu lieu. On y a adopté la norme de transmission OC-1 (51 Mbit/s) en vue du choix des composants. Pendant que le processus d'acquisition pour le module de réception actif du DASM(D) avait lieu, il s'est avéré qu'il serait nettement plus économique d'avoir recours à la télémesure utilisant le MTA (mode de transfert asynchrone) plutôt que la technique PCM dans un contexte où on utilise de plus en plus du matériel disponible sur le marché commercial courant. Cette méthode présentait toutefois l'inconvénient qu'il était nécessaire d'augmenter la largeur de bande des modules FOAM et FORU pour les porter à la norme OC-3 (155 Mbit/s). Le présent rapport examine la conception actuelle des modules FOAM et FORU ainsi que la faisabilité d'améliorer la conception actuelle pour obtenir le débit OC-3. La conclusion a laquelle on arrive est que l'amélioration peut être réalisée sans conséquences importantes en remplaçant les dispositifs émetteur et récepteur à fibres optiques par des dispositifs de meilleure qualité. Les pièces qui serviraient au remplacement sont de la même taille que les cartes imprimées précédentes et leur empreinte est identique. On en conclut que l'on peut effectuer l'acquisition de dispositifs de télémétrie MTA pour réaliser le système DASM(D) sans qu'il y ait de conséquences majeures pour l'ensemble de la conception d'ensemble.

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ABSTRACT

The Towed Integrated Active-Passive SONAR (TIAPS) program mandates the construction of an integrated towed array for research purposes. This towed array includes a horizontal line projector, an "active" receive module, and elements of a passive receive array. The combination of these elements in a single tow presents some difficulty with respect to transmitting high frequency electrical signals past projector elements that are driven by high voltage signals. The solution to this problem is to transmit the data from the active and passive receive arrays on optical fibres. The design of the transmitter (Fibre Optic Adapter Module, FOAM), and receiver (Fibre Optic Receive Unit, FORU) is a task in the TIAPS program. This document discusses the feasibility of upgrading the speed of the fibre connection from SONET OC-1 (51.84 Mbps) to SONET OC-3 (155.52 Mbps)

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ACRONYMS AND ABBREVIATIONS

ADM2	Advanced Development Model-2
DASM(D)	Directional Acoustic Sensor Module-Digital
ECL	Emitter Coupled Logic
FOAM	Fibre Optic Adapter Module
FORU	Fibre Optic Receive Unit
FORX	Fibre Optic Receiver
FOTX	Fibre Optic Transmitter
HDB3	High Density Bipolar with a maximum of three consecutive zeroes
OC	Optical Carrier
NA	Numerical Aperture
SONET	Synchronous Optical Network
TIAPS	Towed Integrated Active-Passive SONAR

1 Introduction

The Fibre Optic Adapter Module (FOAM), together with the Fibre Optic Receive Unit (FORU), form the ends of a digital data transmission system from sensor arrays in the TIAPS towed array system to receive hardware onboard the ship. The two passive hydrophone arrays generate high data rate data streams each having a bit rate in excess of 32 Mbits/sec. The data must be transmitted through approximately three kilometres of array modules, neutrally buoyant cable, and tow cable while minimizing errors. While there are six fibres available in the cables, only five are wired through other modules in the array – so that there are five 'channels' available for use. Data from each of the two passive hydrophone arrays is transmitted on two parallel lines, to provide redundancy. Thus, four of the five available fibres are necessary to transmit the four data streams. The fifth fibre is available as a further backup. Presently, this system is capable of carrying SONET OC-1 (51.84 Mbps) optical signals in each of the five fibres. The feasibility of upgrading to carry SONET OC-3 (155.52 Mbps) data is explored in this report.

1.1 Scope

This FOAM/FORU Upgrade Feasibility Report reviews the existing FOAM/FORU design and discusses the feasibility of upgrading the current hardware for compatibility with OC3 data transmission.

1.2 Reference Documents

The following documents were consulted during the course of the FOAM/FORU system evaluation.

ID	Document
1.	FOAM/FORU Statement of Requirement
2.	FOAM/FORU Way Ahead Technical Note
3.	FOAM Dual Transmitter Board Circuit Schematic
4.	FOAM Dual Receiver Board Circuit Schematic

Table 1: Reference Documentation

2 FOAM/FORU System Overview

The FOAM/FORU system is one component of the TIAPS towed array system. FOAM converts high-frequency electrical signals from the ADM2 (Advanced Development Model-2) and DASM(D) (Directional Acoustic Sensor Module-Digital) receive arrays into optical signals and transmits them through the array and tow cable to the ship. FORU receives these optical signals and recreates the electrical signals at the surface.

A block diagram of the FOAM/FORU system is shown in Figure 1. The electrical data signals from the ADM2 are translated from HDB3 format into one that can be transmitted over fibre. They are then converted to two parallel runs of fibre and transmitted to the DASM(D) module. At the DASM(D) module, the ECL electrical signals from DASM(D) are converted to two parallel runs of fibre. From this point, the four optical signals are converted back to electrical signals in order to be routed through the switch matrix which controls which of the five available fibre channels will carry each data line.

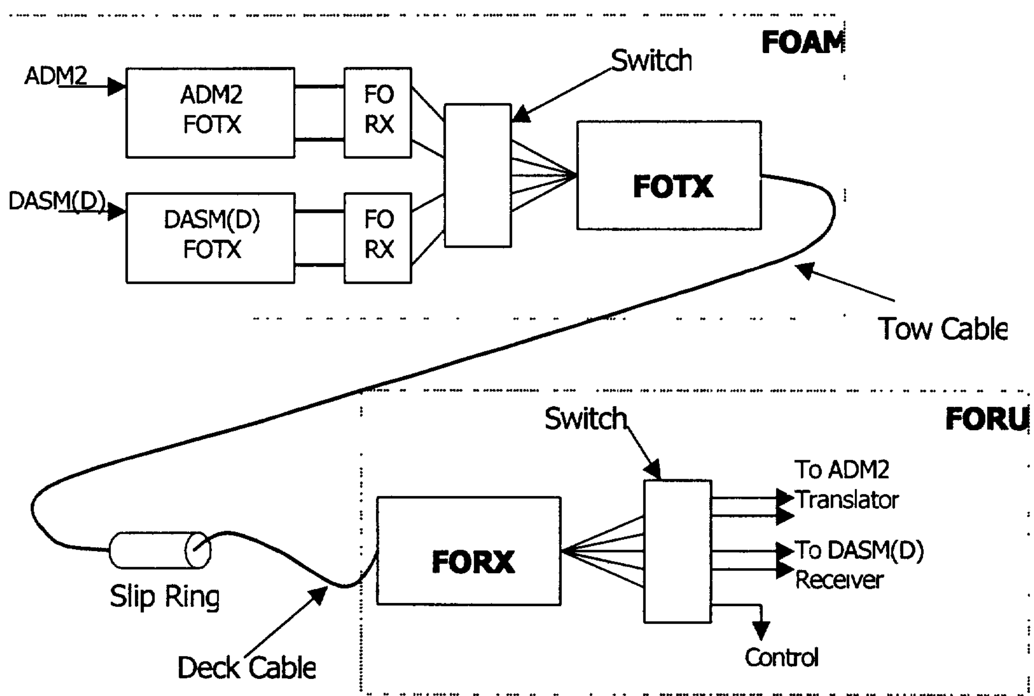

Figure 1: FOAM/FORU Block Diagram

From the switch, the electrical signals are converted back to optical signals in the FOTX. They are then transmitted over four of the five individual fibres in the fibre optic cable to the ship.

The FORU is responsible for receiving and recreating the electrical signals for each channel from the optical signals received. At this stage, the FORX returns the optical signals to electrical format and routes them through another switch matrix. Further electronics return the electrical signals to their original format and present these signals to the ADM2 and DASM(D) receivers.

3 Design Review

The content of this section has been developed from a number of sources including:

- FOAM/FORU Way Ahead Technical Note;
- FOAM Dual Transmitter Board Circuit Schematic;
- FOAM Dual Receiver Board Circuit Schematic;
- Specification sheets for components; and
- Discussions with DREA staff.

In order to determine the feasibility of upgrading the FOAM/FORU system data transmission capabilities to SONET OC-3, it is necessary to examine those system components that will be affected by faster data transmission.

The components of the FOAM/FORU system carry three types of signals:

- High-frequency data;
- Control and status; or
- Power.

Of these components, those that will be affected by the upgrade to a higher frequency are the ones carrying data signals. The components within the system that carry data are:

- Fibre optic cables;
- Dual Transmitter Board;
- Dual Receiver Board;
- Fibre Optic Rotary Joint; and
- Digital Crosspoint Switch.

Each of these components is described further in the following paragraphs.

3.1 Fibre Optic Cables

The FOAM/FORU system utilizes fibre optic cable to carry data in the neutrally buoyant cable, tow cable, deck cable, and module fibre cables. Although these cables contain six fibres, only five will be available for use. These cables have the specifications shown in Table 2 below.

	Neutrally Buoyant Cable	Tow Cable	Deck Cable	Module Fibre Cable
Size / Type	62.5/125 Multimode	62.5/125 Multimode	62.5/125 Multimode	62.5/125 Multimode
Length	600 m	1707 m	16 m	Various (max 40 m)
Index	Graded	Graded	Graded	Graded
Attenuation @1300 nm	< 9 dB/km (measured: < 1 dB/km)	1 dB/km	1 dB/km	1 dB/km
NA	0.275 **	0.275	0.275	0.275 **
Bandwidth @1300 nm	500 MHz **	500 MHz	500 MHz	500 MHz **

Table 2: Cable Specifications and Dimensions

** Note: These specifications were unavailable and were assumed equivalent to known quantities.

With a bandwidth in the fibre optic cables of 500 MHz, the data transmission capabilities of the cable are at least 500 Mbps. Thus, the capability of all the fibre cables is well above the OC-3 specifications of 155.52 Mbps, and the fibre optic cables will in no way limit the upgrade from OC-1 to OC-3 data transmission.

3.2 Dual Transmitter Board

The dual transmitter board (Ref Doc [3]) is used throughout the FOAM system to convert electrical signals to optical signals ready for transmission to fibre optic cables. On this board, data signals for two lines are converted using two SONET/SDH OC-1 Transmitters (part no. STX-01-ST-A) manufactured by Optical Communication Products, Inc. All further circuitry on the dual transmitter board is for the purpose of control and status, power, and voltage regulation. This circuitry is carrying signals at very low frequencies (about 20 Hz) and will not be affected by a change in data transmission frequency.

Data in the form of electrical signals is transmitted to the dual transmitter board through a jumper (JP1). It is then sent to the SONET Transmitter chip, which converts it to an optical signal and provides the data for transmission to the fibre optic cable. The SONET OC-1 Transmitter is capable of sending data at rates of 52 Mbps. The SONET Transmitter chip would need to be replaced in order to upgrade data transmission to the OC-3 standard of 155.52 Mbps.

3.3 Dual Optical Receiver

The dual receiver board (Ref Doc [4]) is used throughout the FORU portion of the system to convert optical signals back to electrical signals upon receipt from the fibre optic cables. On this board, data signals for two lines are converted using two SONET/SDH OC-1 Receivers (part no. SRX-01-ST-A) manufactured by Optical Communication Products, Inc. All further circuitry on the dual receiver board is for the purpose of control and status, power, and voltage regulation. This circuitry is carrying signals at very low frequencies (about 20 Hz) and will not be affected by a change in data transmission frequency.

Data in the form of optical signals is received on the dual receiver board through the fibre optic cable. It is then sent to the SONET Receiver chip, which converts it to an electrical signal and provides the data on a jumper (JP1) ready for further processing. The SONET OC-1 Receiver is capable of operating at rates of 52 Mbps. The SONET Receiver chip would need to be replaced in order to upgrade data transmission to the OC-3 standard of 155.52 Mbps.

3.4 Fibre Optic Rotary Joint

The fibre optic rotary joint (Model 190), manufactured by Focal Technologies Inc., is used at the dry-end of the FOAM/FORU system. It is a passive and bi-directional joint that allows the transfer of data and other signals on separate (two to nine) fibres across rotational interfaces. Thus, it acts as a joint to eliminate twisting of the fibre optic cables onboard the ship. Through conversation with a Focal Technologies representative, it was determined that the Fibre Optic Rotary Joint has a bandwidth of at least 500 MHz, although 1 GHz can be achieved in some situations.

Assuming the minimum bandwidth in the rotary joint of 500 MHz, its data transmission capabilities are at least 500 Mbps. Thus, the capability of the rotary joint is well above the OC-3 specifications of 155.52 Mbps, and will in no way limit the upgrade from OC-1 to OC-3 data transmission.

3.5 Digital Crosspoint Switch

A switch is used in the FOAM/FORU system to control the transmission of electrical data signals between the active and passive receive array (ADM2 and DASM(D)) receivers and the optical transmitters. The switch used is an 8 x 8 Digital Crosspoint Switch (Part

CLC018) manufactured by National Semiconductor. This switch utilizes eight independent 8:1 multiplexers to allow each output to be independently connected to any input and any input to be connected to any or all outputs. It is capable at operating at data rates exceeding 1.4 Gbps per channel.

In the FOAM/FORU system, the crosspoint switch is used to enable the signals from the ADM2 receiver (two lines) and the DASM(D) receiver (two lines) to be routed onto whichever of the five available optical fibres is desired. In addition, the switch can be used to route the output of a pseudo-random noise generator through any of the five fibres, thereby testing the operation of the fibre connection.

With a bandwidth in the digital crosspoint switch of 1.4 GHz, its data transmission capabilities are well above the OC-3 specifications of 155.52 Mbps, and will in no way limit the upgrade from OC-1 to OC-3 data transmission.

4 Upgrade Options

The process of upgrading the FOAM/FORU system to provide SONET OC-3 data transmission capabilities should be simple. Of the components considered in the earlier paragraphs, only the Dual Optical Receiver and Dual Optical Transmitter boards would be affected.

The fibre optic cables, the crosspoint switch, and the fibre optic rotary joint are each well capable of carrying data at rates above those necessary for OC-3. Each of these is able to carry data at rates of at least 500 Mbps, and as OC-3 has a frequency of 155.52 Mbps, these components will not need to be replaced.

The Dual Optical Receiver and Transmitter boards would need to be modified in order to increase frequency. Presently, the receiver and transmitter chips from Optical Communications are OC-1 capable. The same company produces replacement receiver and transmitter chips that meet the OC-3 standards. Each of the SONET Transmitters and Receivers (SRX and STX) has the following specifications in common:

- Package dimensions;
- Package style;
- Pinout;
- Electrical interface signals;
- Power supply;
- Optical output power (transmitter);
- Operating temperature (-40 to +85 °C); and
- Storage temperature (-40 to +85 °C).

The OC-3 capable transmitter (STX-03) and receiver (SRX-03) differ from the OC-1 chips (STX-01 and SRX-01) as shown in Table 3 and Table 4 below.

Parameter	STX-01	STX-03
Data Rate (Mbps)	5 to 100 (typical: 52)	50 to 300 (typical.156)
Optical Rise and Fall Time (10% to 90%) (ns)	Typical: 2 Maximum: 4	Typical: 1 Maximum: 2

Table 3: Differences between STX-01 and STX-03

Parameter	SRX-01	SRX-03
Data Rate (Mbps)	5 to 100 (typical: 52)	50 to 200 (typical:156)
Receiver Sensitivity (10^{-10} BER) (dBm)	Typical: -42.0 Minimum: -40.0	Typical: -38.0 Minimum: -35.0
Signal Detect Threshold (Increasing Light Input) (dBm)	Maximum: -40.0	Maximum: -35.0
Signal Detect Threshold (Decreasing Light Input) (dBm)	Minimum: -50.0	Minimum: -45.0

Table 4: Differences between SRX-01 and SRX-03

Apart from frequency capabilities, the OC-3 capable transmitter and receiver are virtually identical to those currently in use. The optical rise and fall time is better in the replacement transmitter. The signal-detect thresholds and the sensitivity of the replacement receiver are slightly lower than the same parameters in the current receiver. The present system was designed with a flux margin of at least 10 dB, enough to overcome the reduced sensitivity of the receiver. Thus, simply replacing the STX-01-ST-A with an STX-03-ST-A, and, similarly, replacing the SRX-01-ST-A with an SRX-03-ST-A would allow these boards to operate at the higher frequency.

5 Conclusion

It is feasible to upgrade the current FOAM/FORU component of the TIAPS system in order that it may transmit data at rates compatible with SONET OC-3 (155.52 Mbps). The option presented is simple and cost effective. By replacing the SONET/SDH Transmitters and Receivers currently in use, the system can carry data at a rate three times its current speed. As these transmitter and receiver chips have the same footprint as their predecessors, the overall board layout will not be affected by the upgrade.

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15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) TIAPS; telemetry; fibre optic; ATM

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