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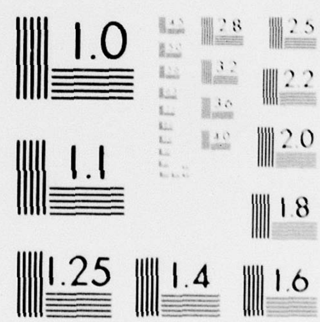
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Technical Report 440

TADIXS OCEAN NETWORK PLAN

A proposal for the FCC-to-TFCC satellite linkage via TADIXS for each FCC area of operations

LCDR JL Dodd
CT Ogata
WJ Pomper

Final plan
1 Apr - 1 Jun 79

1 June 1979

Prepared for
Naval Electronic Systems Command
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Approved for public release; distribution unlimited

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OBJECTIVE

Conduct a study and develop an ocean network plan to show (1) the TADIXS ocean coverage assigned to each FCC and (2) the communications concepts required to assure FCC-to-TFCC linkage throughout the ocean area responsibility of each FCC.

RESULTS

1. A network plan has been developed that allows FCC-TFCC communication for all locations within the area of responsibility of each FCC.

2. System backup for the loss of a uhf satellite is discussed; uhf and narrowband shf backups are considered and effects analyzed.

RECOMMENDATIONS

1. Take due care in routing data and control lines to avoid the problem of differential time delay over long paths.

2. Use landlines in place of double-hop satellite accesses in the Pacific to decrease the impact of the loss of a uhf satellite.

3. Investigate the possible communication path for FCC-FCC contact that could be provided by this network plan.

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BACKGROUND

The Fleet Satellite Communication System (FLTSATCOM) provides communication links via satellite between designated mobile platforms and shore sites. The coverage area for these communication links will be worldwide between the latitudes of 70°N and 70°S. Four satellites in geosynchronous orbit will be located at longitudes 23°W, 75°E, 172°E and 100°W. The system includes satellites, rf terminals, subscriber subsystems, personnel, training, documentation, and logistic support.

The FLTSATCOM subsystem of interest in this report is the Tactical Data Information Exchange Subsystem (TADIXS), a direct communications network between Navy fleet command centers (FCC) ashore and task force command centers (TFCC) afloat. The TADIXS rf channel will carry digitized half-duplex communications at 2.4 kilobits per second over the uhf or uhf–demand assigned multiple access (DAMA) FLTSATCOM system and will be compatible with the Defense Satellite Communications System (DSCS) shf satellites. TADIXS will also use low-speed hf for relay and backup. A TFCC which has lost its satellite communication capability will use this hf compatibility for backup transmission and reception of alert precedence traffic between itself and the nearest TADIXS link controller. The shore station locations and uhf FLTSATCOM satellite coverages are shown in figure 1.

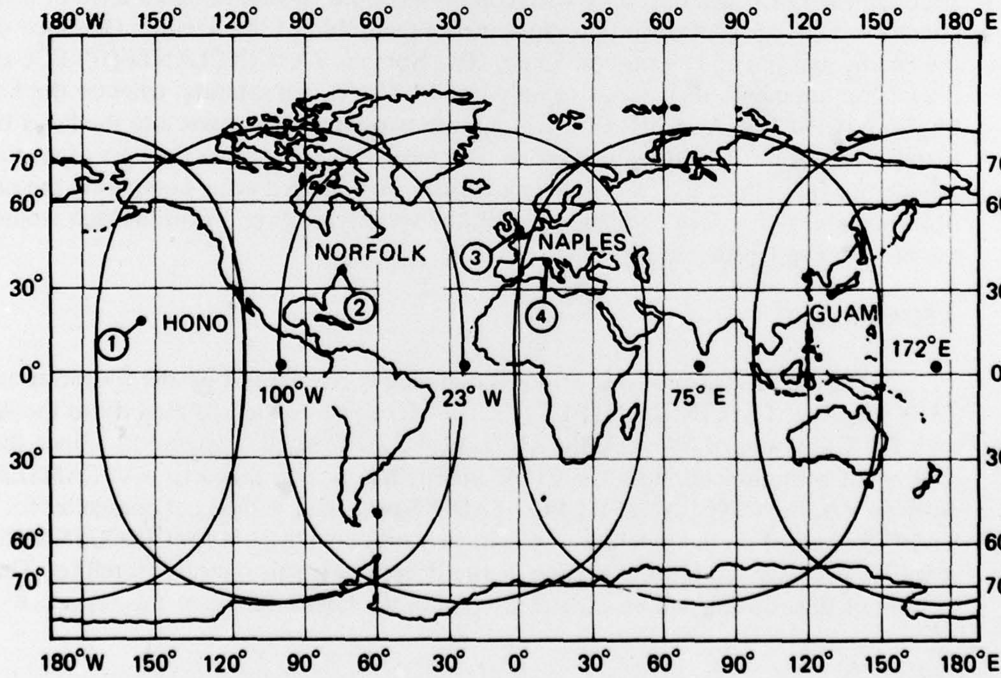

Figure 1. FLTSATCOM satellite coverage (10° look angle) and TADIXS installations (shore): (1) Pearl Harbor HI, (2) Norfolk VA, (3) London, England, (4) Naples, Italy–transmitter only.

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WORK OBJECTIVES

The objectives of this work were to conduct a study of requirements and to develop a network plan to show (1) the TADIXS ocean coverage assigned to each FCC and (2) the communications concept required to assure FCC-to-TFCC linkage throughout the ocean area responsibility of each FCC.

WORK PROCEDURES

Each FCC site was visited to determine the probable traffic loading and required connectivity for the ocean area of responsibility. This involved visits to the sites depicted in figure 1 as TADIXS shore sites. Both operational and technical local area personnel were interviewed to obtain the required information and were briefed with basic information on TADIXS. Installation planners were pleased with the proposed system because of both its small physical size and the low power requirements of the ON-143(V)X/USQ (the TADIXS link controller). Through these visits, we learned of the local differences that will require each TADIXS FCC installation to be unique even though all the systems share the same concept and communications design.

WORLD VIEW

The three FCC sites will be communicating with mobile forces deployed worldwide, although each FCC will deal only with communications to subordinated units in its area of operation. The areas of operation range in size from that of the Atlantic Ocean to that of the Pacific and Indian Oceans combined. The Norfolk VA (CINCLANTFLT) FCC can support its requirements with access to only one FLTSATCOM satellite, whereas the London, England, (CINCUSNAVEUR) FCC will require two satellite accesses and the Pearl Harbor HI (CINCPACFLT) FCC will require access to three satellites to cover the area of responsibility assigned to that commander. These conclusions were arrived at by comparing the ocean area of responsibility for each commander with the various satellite footprints that would be required to overlap that area.

ATLANTIC

The Atlantic area of operations is completely overlapped by the footprint of the 23°W satellite. The CINCLANTFLT (CLF) FCC can be connected directly to the Atlantic area TFCCs by way of NAVCAMSLANT and the 23°W satellite (figure 2). Since the responsibility for communication on the 23°W satellite has been assigned to NAVCAMSLANT, Norfolk VA, the CINCLANTFLT FCC TADIXS processor will be net controller for the TADIXS channel on this satellite. To achieve world coverage (ie for CINCUSNAVEUR), it will be necessary to route a portion of the European traffic over this satellite. The discussion of this routing will be expanded upon in the later sections of this report.

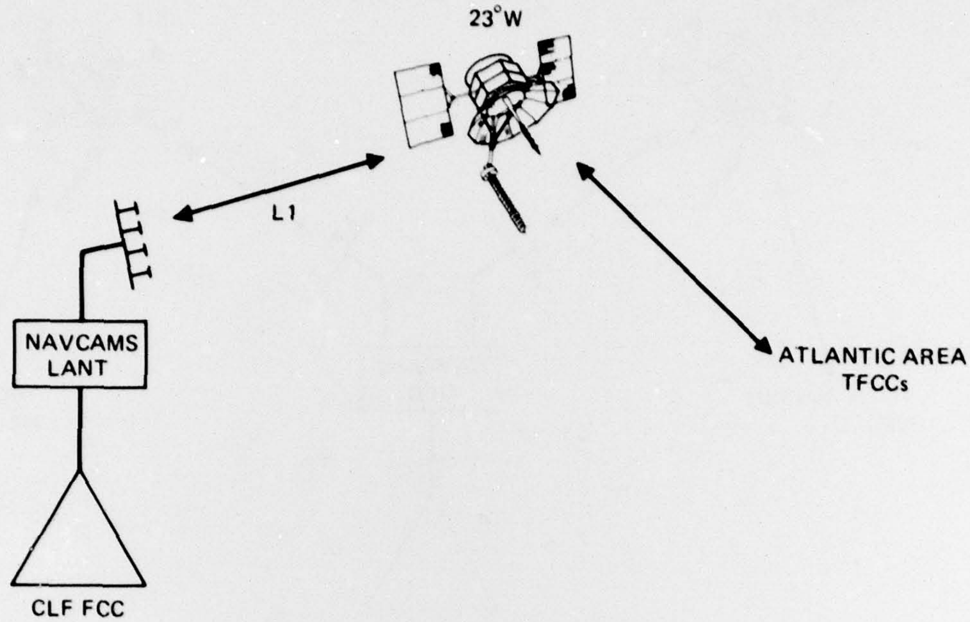

Figure 2. Atlantic area FCC-TFCC connectivity.

EUROPEAN

The FCC for CINCUSNAVEUR (CNE) is located in London, England, but the transmitting site is located in Naples, Italy. Figure 1 shows that both the 23°W and the 75°E satellites are visible from Naples; the footprints of both are required to cover the territory over which forces subordinate to CINCUSNAVEUR may operate. Most operations will occur under the view of the 75°E (Indian Ocean) satellite, but some will require access to the 23°W (Atlantic) satellite. These circuits are designated as E1 and E2 in this report (figure 3). The CINCLANTFLT TADIXS controller is the net controller on the 23°W satellite, so all members of circuit E1 participate as subscribers only.

Since responsibility for communication on the 75°E (Indian Ocean) satellite has been assigned to NAVCAMSMED, Naples, Italy, the CINCUSNAVEUR FCC TADIXS processor will be net controller for the TADIXS channel on this satellite. To achieve world coverage (ie for CINCPACFLT), it will be necessary to route part of the Pacific traffic over this satellite. Details are given in later sections of this report.

PACIFIC

The CINCPACFLT (CPF) FCC is located in Makalapa HI, but the ocean area of responsibility of CINCPACFLT stretches from the Western United States almost to the eastern coast of Africa, a huge area. Figure 1 shows that the footprints of three FLTSATCOM satellites will be required to span it: the 100°W (CONUS), the 172°E (WEST PAC),

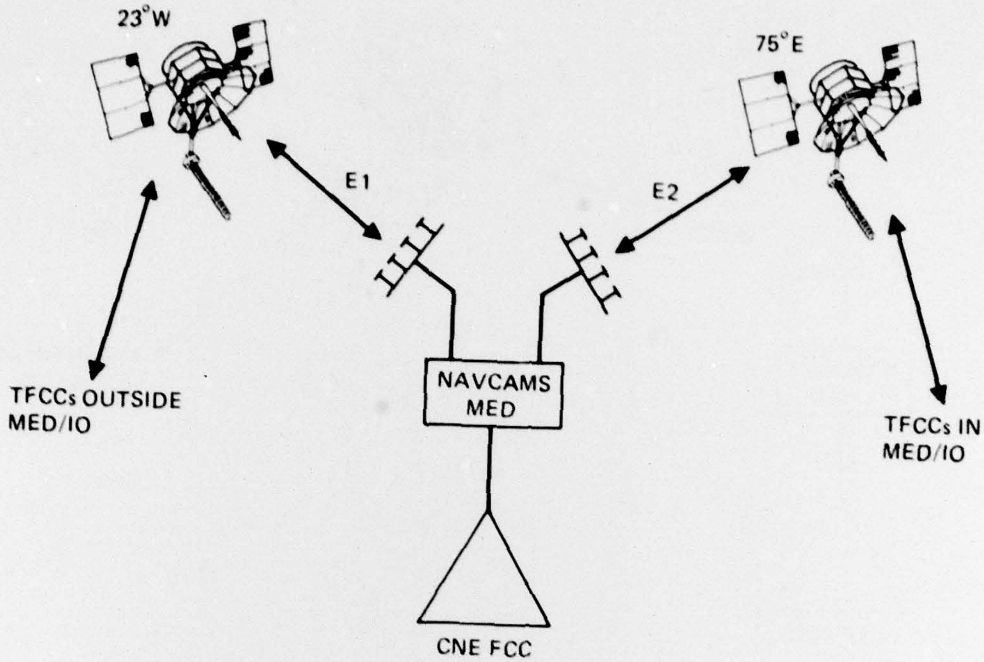

Figure 3. European area FCC-TFCC connectivity.

and the 75°E (IO) satellites (figure 4). Signal routing must be provided via two communications area master stations: NAVCAMSEASTPAC, Wahiawa HI and NAVCAMSWESTPAC, Finegayan, Guam. Responsibility for communication on the 100°W satellite has been assigned to NAVCAMSEASTPAC, while that on the 172°E satellite has been assigned to NAVCAMSWESTPAC. Since the communication responsibility for the 75°E satellite was assigned to NAVCAMSMED, as noted earlier, the TADIXS channel on this satellite will be shared with the CINCUSNAVEUR FCC, who will act as the net controller, and all members of circuit P3 will participate as subscribers only.

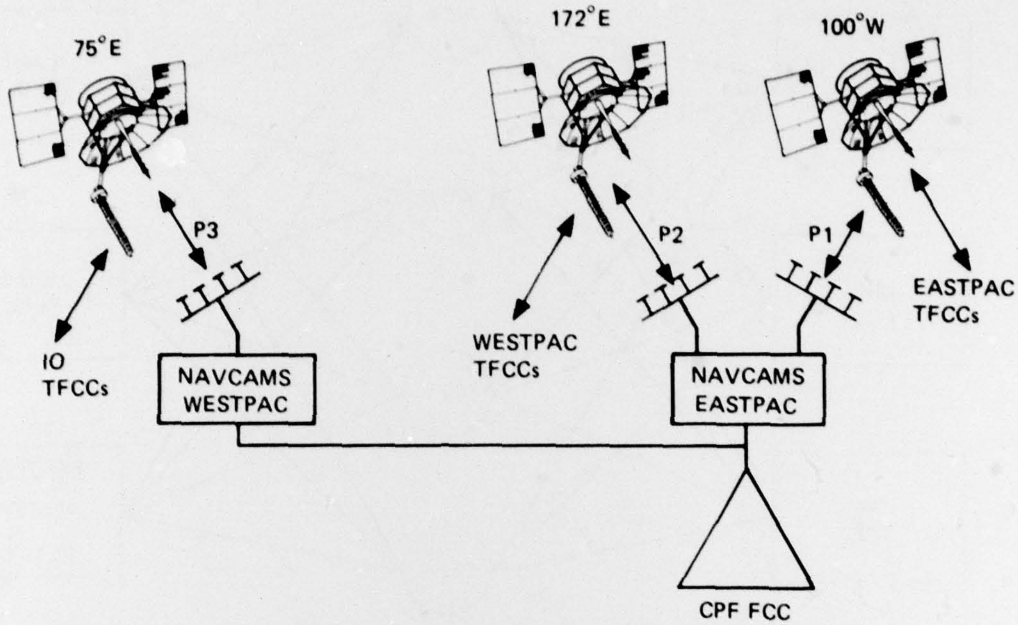

Figure 4. Pacific area FCC-TFCC connectivity.

DUAL USAGE

MAPPING THE EARTH

TADIXS is required to connect FCCs with TFCCs worldwide – within the north-south latitude footprint limits of the FLTSATCOM spacecraft – using four satellites among three FCCs and up to ten TFCCs in each satellite footprint. Figure 5 shows this schematically.

Figure 5 shows all the possible links that could be established, with all three FCCs using each satellite. Two factors moderate the required number of links, however. First, each FCC has to communicate only with TFCCs in its area of responsibility, not worldwide. Second, the world is partitioned into zones of unequal ocean surface areas of assigned responsibilities.

Figure 6 shows the minimum connectivity required for each FCC to communicate with TFCCs in its area of responsibility. A glance back at figure 1 discloses that both CINCUSNAVEUR and CINCPACFLT have areas of responsibility larger than one FLTSATCOM satellite footprint.

The minimum connectivity that allows each FCC to cover its area of responsibility is shown in figure 7, schematically, and in figure 8, geographically. Note that two satellites – 100°W and 172°E – are used by only one FCC (CINCPACFLT), and two satellites are shared by two FCCs – the 75°E satellite by CINCUSNAVEUR and CINCPACFLT, the 23°W satellite by CINCLANTFLT and CINCUSNAVEUR.

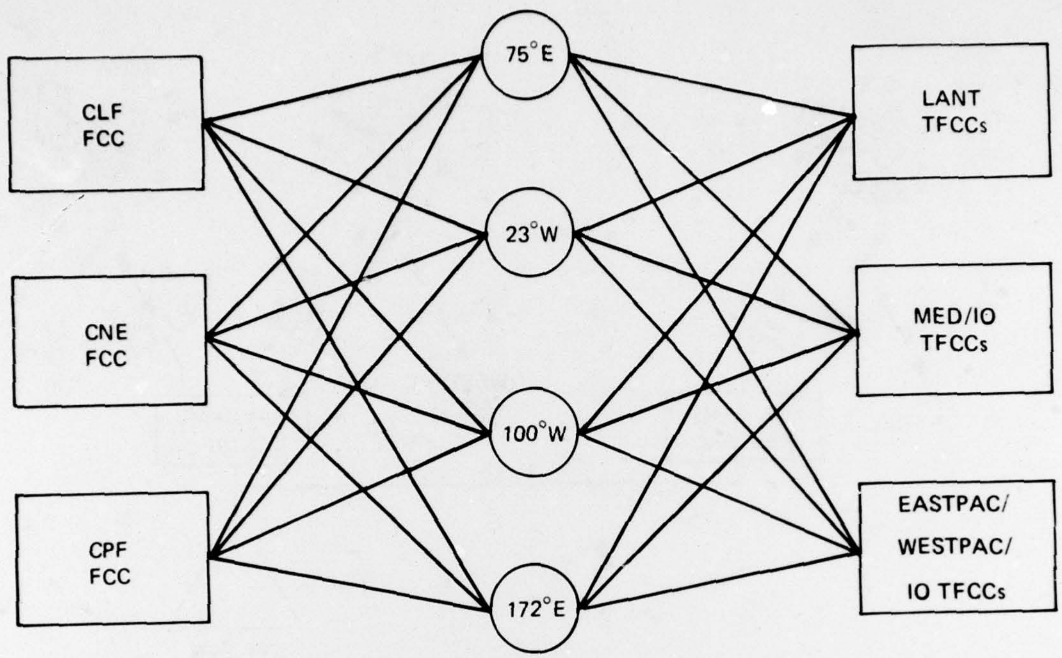

Figure 5. Possible FCC-TFCC connections.

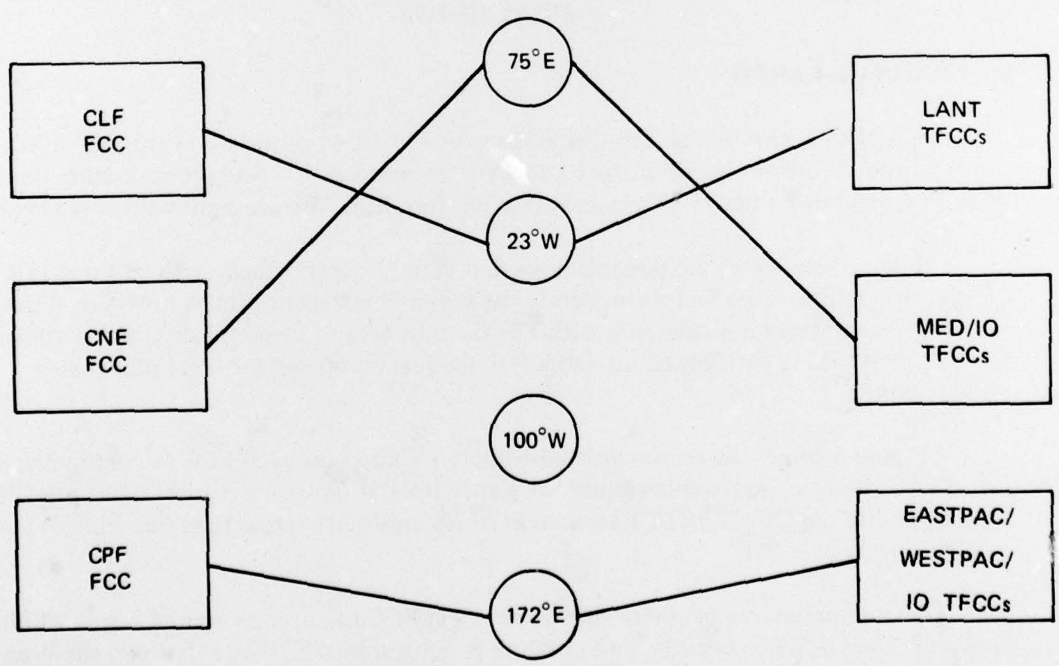

Figure 6. Minimum connectivity for one footprint coverage.

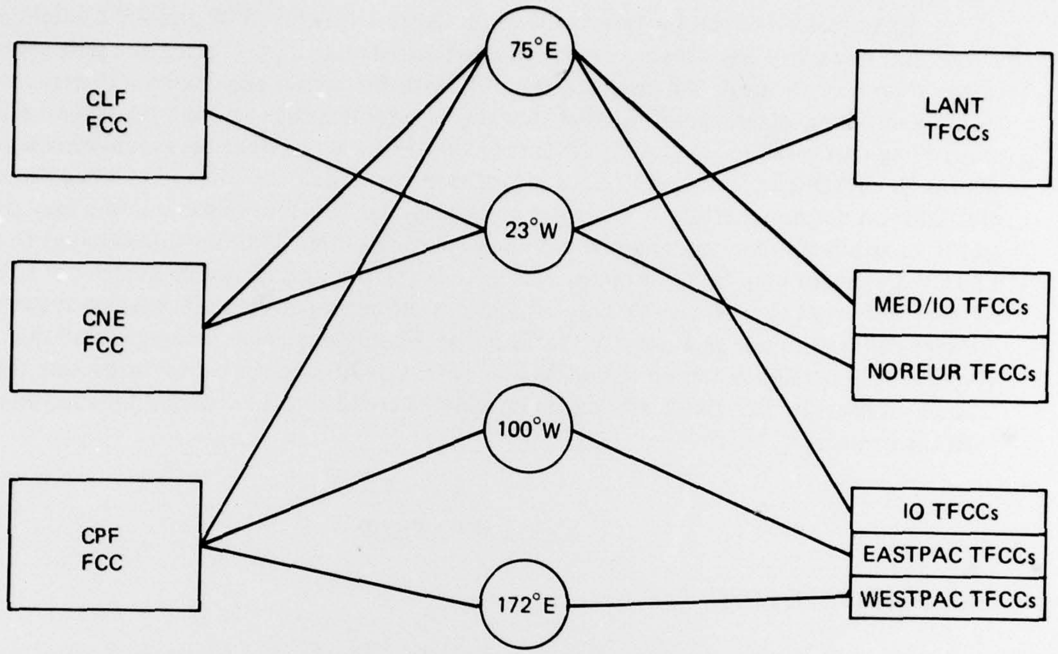

Figure 7. Minimum required connectivity to map areas of responsibility.

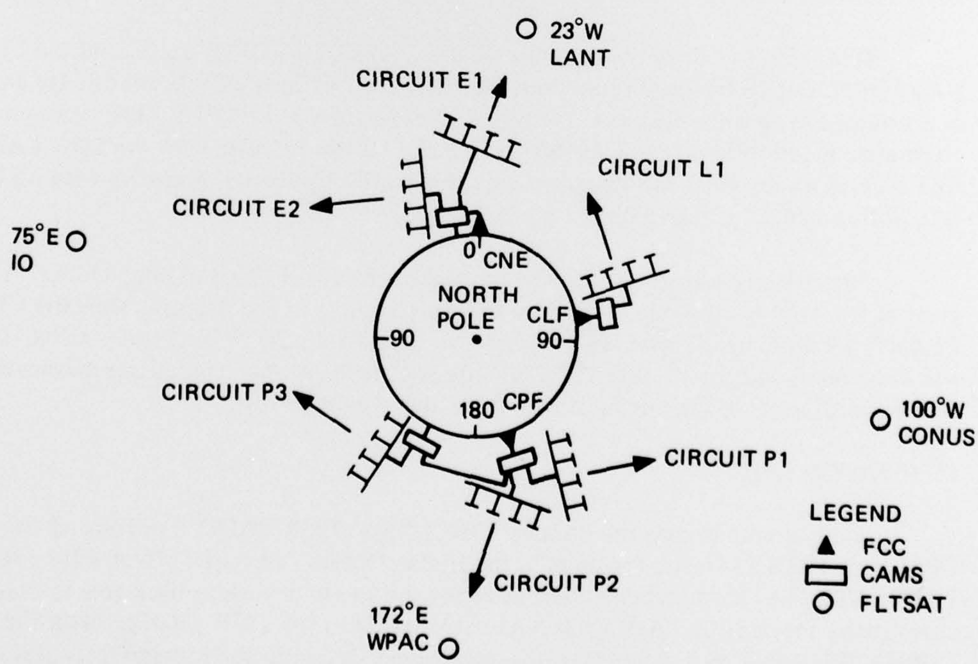

Figure 8. World summary view of TADIXS nets(TFCCs not shown).

SATELLITE SHARING

Examination of the footprints shown in figure 1 for the 23°W and 75°E satellites shows that one party has a higher expectation of actual channel use, given the past histories of the areas of operation. By assigning the FCC with the higher expected usage as net controller and taking advantage of the fact that the communications area master station (CAMS) controlling that satellite is located adjacent to that FCC, we see that the actual effects of sharing the TADIXS channel are not as severe as might initially be assumed. Since the current limit on net membership is 11 (1 net controller and 10 subscribers; any one may pass traffic to another), sharing a channel will mean that only nine TFCCs (subordinated to two FLTCINCs) at sea may be full-time subscribers. Increasing the allowable number of subscribers will result in a drop in system throughput (or equivalently an increase in system message delivery time), an approach that is not recommended. It is recommended that the TADIXS channel allocation on the 23°W and 75°E satellites be shared by restricting the number of users to 11. Extraordinary requirements could then be handled by coordination with the respective CAMS.

SYSTEM BACKUP

UHF SATELLITE LOSS

The system presented up to now may be thought of as "uhf primary." The loss of one FLTSATCOM spacecraft (without replacement) will drop the system into the "uhf secondary" mode, with various effects on the TADIXS nets.

23°W Satellite Lost

This satellite carries the primary CINCLANTFLT TADIXS traffic and the CINCUSNAVEUR TADIXS traffic for units outside the footprint of the 75°E satellite (ie units afloat in northern European areas, etc). No initial effect occurs in PACFLT. The recommended alternative is to reorient NAVCAMSLANT to the 100°W satellite with the CINCLANTFLT FCC as a subscriber. (Subscribers can pass traffic to other subscribers with no loss of system throughput or responsiveness.) See figure 9.

Net membership would then be limited to the two FCCs and nine TFCCs. The footprint of the 100°W satellite covers only the western part of the Atlantic, thus the CINCLANTFLT FCC would have only partial coverage, to the 30°W longitude. CINCUSNAVEUR would be restricted to only the 75°E satellite and its footprint. Direct communication via satellite with units in the northern European area would be lost.

75°E Satellite Lost

This satellite carries the primary CINCUSNAVEUR TADIXS traffic and the CINCPACFLT TADIXS traffic for units in the Indian Ocean. No initial effect will be felt in LANTFLT. The recommended alternative for this mode is to drop back to a limited coverage by reorienting TADIXS at NAVCAMSMED to the 23°W satellite, with the CINCUSNAVEUR FCC as a subscriber. Broad coverage is lost in the Indian Ocean not only for CINCUSNAVEUR but also for CINCPACFLT (figure 10).

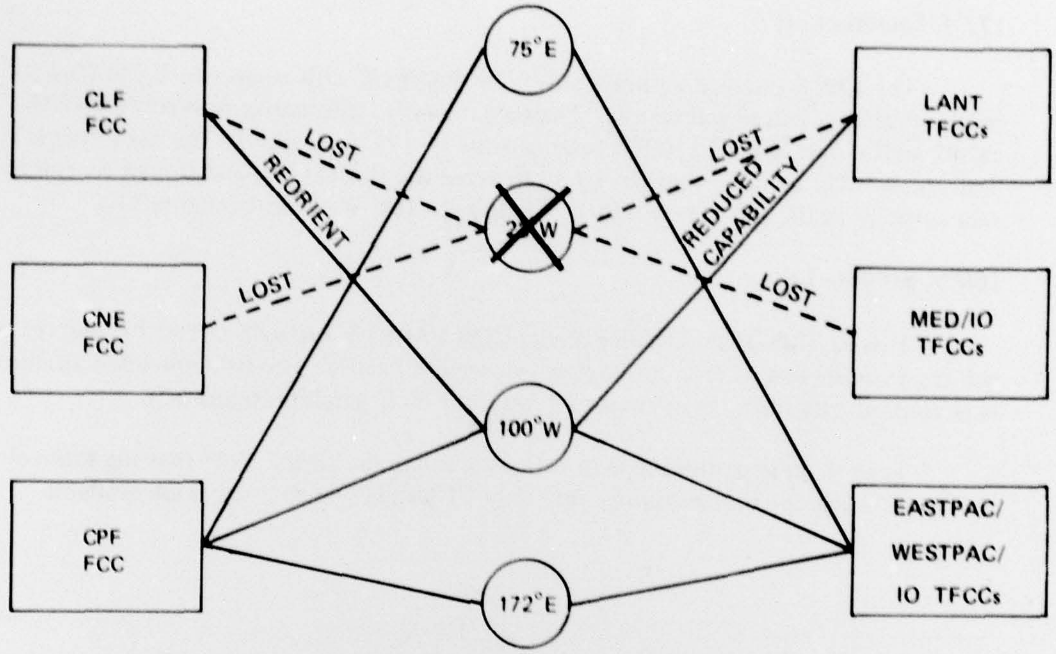

Figure 9. TADIXS connectivity with 23°W satellite lost.

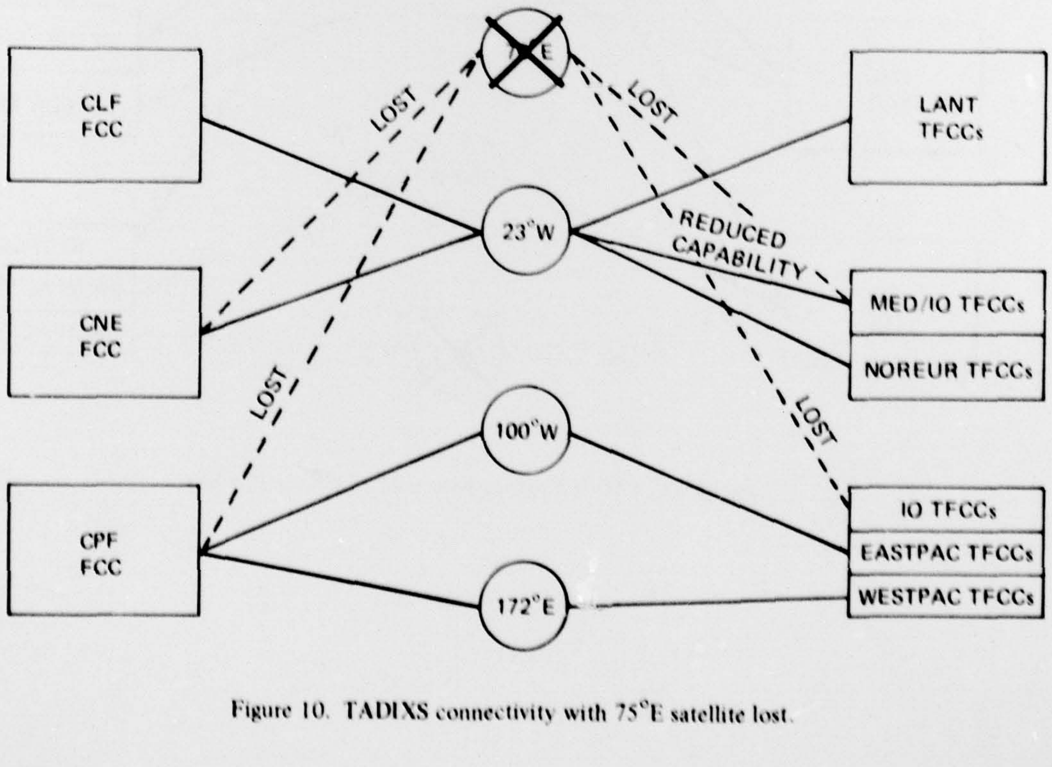

Figure 10. TADIXS connectivity with 75°E satellite lost.

172°E Satellite Lost

The 172°E satellite supports only CINCPACFLT with respect to TADIXS, and central Pacific coverage will be lost. The recommended alternative is to route TADIXS net P2 traffic over nets P1 (100°W satellite) and P3 (75°E satellite). The net effect is to limit the number of subscribers to 10, to increase the traffic load, and to lose central Pacific area coverage in the gap between the 75°E and the 100°W satellites (figure 11).

100°W Satellite Lost

This FLTSATCOM satellite carries CINCPACFLT TADIXS circuit P1, and its loss will result in the loss of area coverage in the eastern Pacific. The recommended alternative is to route the P1 traffic over circuit P2 via the 172°E satellite (figure 12).

Table 1 presents the above information in tabular form. Note that the rationale for choosing the backup mode assumes that only FLTSATCOM spacecraft are available.

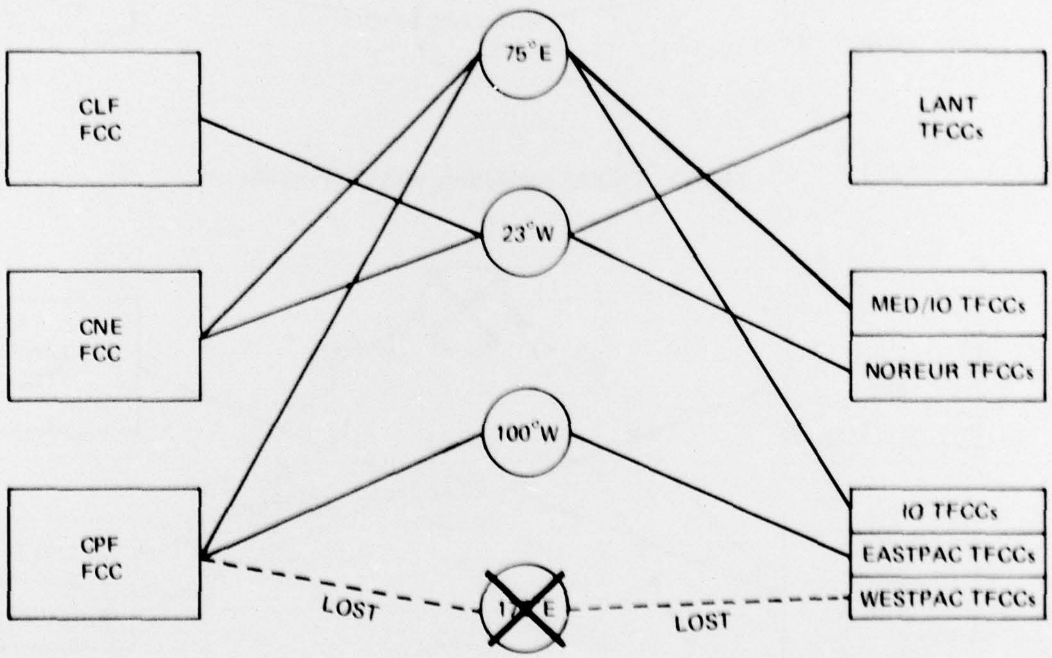

Figure 11. TADIXS connectivity with 172°E satellite lost.

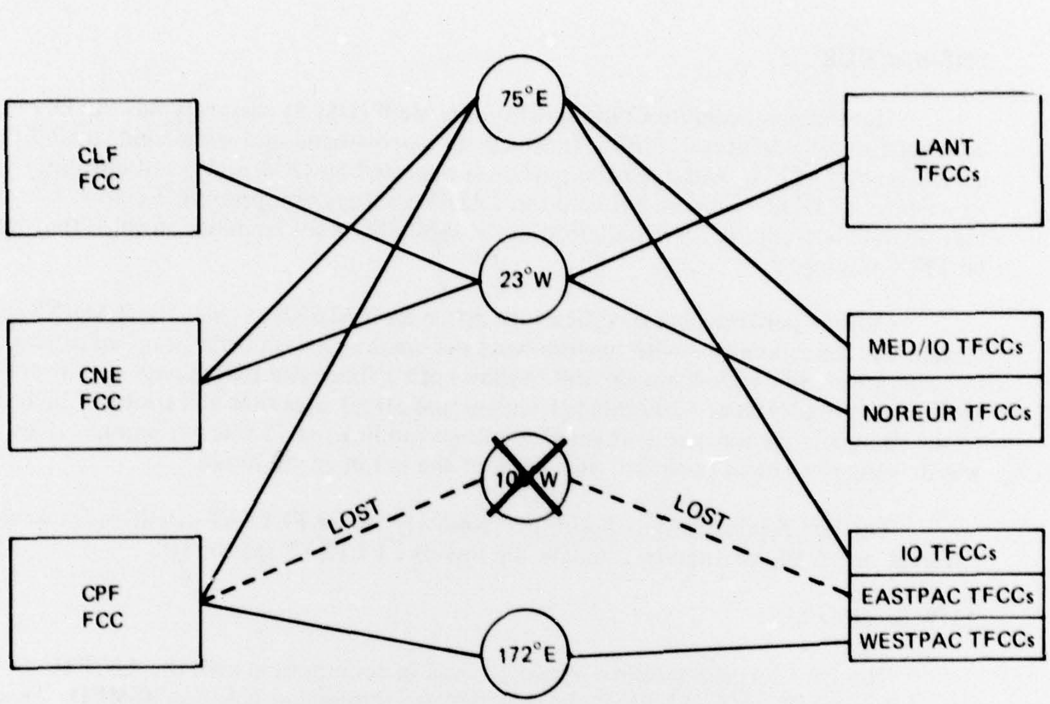

Figure 12. TADIXS connectivity with 100°W satellite lost.

Table 1. Summary of recommended alternatives and lost capabilities for the loss of one FLTSATCOM spacecraft.

Satellite Lost	Recommended Alternative (uhf backup)	Effects
23°W	NAVCAMSLANT Reorient to 100°W	1) Area coverage lost in east LANT for both CLF and CNE 2) CPF loses slots on 100°W satellite (east PAC net) due to influx of CLF subscribers.
75°E	NAVCAMSMED Reorient to 23°W	1) Area coverage lost in IO for both CNE and CPF 2) CLF loses slots on 23°W satellite (LANT net) due to influx of CNE subscribers
172°E	Route TADIXS P2 over P1 and P3	1) Area coverage lost in central Pacific 2) CPF loses slots on 100°W satellite (east PAC net) due to influx of WPAC subscribers and both CPF and CNE lose slots on 75°E (IO net)
100°W	Route TADIXS P1 over P2	1) Area coverage lost in eastern Pacific 2) CPF loses slots on 172°E satellite (WPAC net) due to influx of EPAC subscribers

SHF BACKUP

The Defense Satellite Communication System (DSCS) currently has the Phase II constellation of satellites in orbit, offering both narrow-band and wide-band capabilities at shf (see figure 13). Although this system is operated by DCA and is not currently tasked to support TADIXS, plans to back up the TADIXS subsystem, presented below, take advantage of the plans calling for installation of the AN/WSC-6 shf terminal on ships that will also be TFCC-equipped.

Current performance specifications differ for TADIXS at shf. The TADIXS subsystem will be compatible with narrow-band shf operation with little or no modification, but operation with wide-band shf will require both a shore site that always acts as net controller and broadcasts at 1200 bits per second and afloat sites that will transmit their data to the shore site via independent simplex full-period links at 75 bits per second. This concept was developed to yield optimum operation of the net in an AJ mode.

The DSCS satellites are distributed similarly to the FLTSAT satellites for worldwide coverage and could be used to mitigate the loss of a FLTSAT spacecraft.

23°W Satellite Lost

The LANT DSCS satellite would be used in conjunction with the AN/FSC-78 shf terminal at NAVCAMSLANT and the AN/MSC-61 terminal at NAVCAMSMED. This will support circuits L1 and E1, with the CINCLANTFLT FCC/NAVCAMSLANT acting as control.

75°E Satellite Lost

The IND DSCS satellite would be used in conjunction with the AN/MSC-61 shf terminal at NAVCAMSMED and the AN/MSC-61 at Clark AFB, Phillipines (circuit extension via landline from NAVCAMSWESTPAC). This will support circuits E2 and P3 with CINCUSNAVEUR FCC/NAVCAMSMED acting as control.

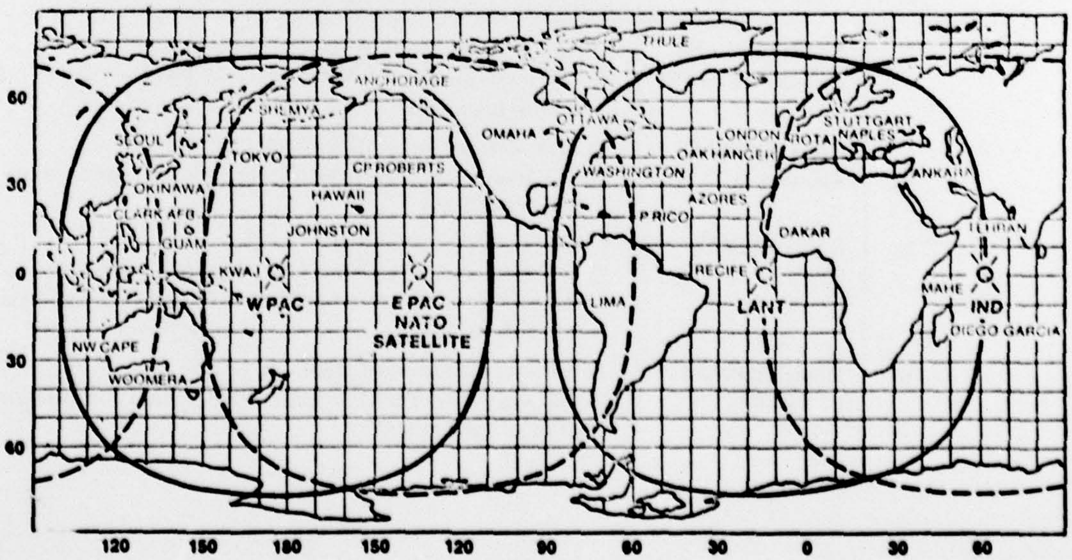

Figure 13. DSCS Phase II satellite coverage.

172°E Satellite Lost

The WPAC DSCS satellite would be used in conjunction with the AN/FSC-78 shf terminal at NAVCAMSEASTPAC to support circuit P2. Control will be CINCPACFLT FCC/NAVCAMSEASTPAC.

100°W Satellite Lost

The EPAC NATO DSCS satellite would be used in conjunction with the AN/FSC-78 at NAVCAMSEASTPAC to support circuit P1. Control will be CINCPACFLT FCC/NAVCAMSEASTPAC.

The above backup network plans ignore the current use of the DSCS and assume that it would be available to act as a stopgap in case a uhf FLTSAT is lost.

The use of the wide-band capabilities of the shf satellite would be handled for coverage purposes in a manner very similar to the uhf and narrow-band shf plans provided. The only difference would be the use of CLARK AFB as the ground terminal for the CINCPACFLT IO TADIXS coverage.

HF BACKUP

Maintaining a TADIXS net via an hf path is probably not possible with the present state of the art nor with the expected advances in modems, etc. The basic problem with maintaining a net on an hf path is the ground-wave versus sky-wave dichotomy in hf: the efficient frequencies for inter-TFCC operation would not be those for FCC–TFCC communication, and vice-versa. Thus for TADIXS, hf is restricted to use by a nearby TFCC in supplying the connectivity for the TFCC which has lost its uhf SATCOM capability.

CONCLUSIONS

To supply the FCC–to–TFCC TADIXS connectivity with only four uhf satellites requires that the FCCs access one or more FLTSAT satellites. Indeed, six TADIXS nets will be required on a worldwide basis to support the TADIXS concept. Two of these nets will be activated only for specific out-of-area operations.

These results are summarized in table 2.

Table 2. Network plan summary.

Circuit	FCC	Satellite	Full-time Requirement
L1	CLF	23°W	Yes
E1	CNE	23°W	No
E2	CNE	75°E	Yes
P1	CPF	100°W	Yes
P2	CPF	172°E	Yes
P3	CPF	75°E	No

RECOMMENDATIONS

The surface path lengths for FCC-to-TFCC connectivity can become quite long. Therefore, care must be taken to route the control lines with the data to prevent differential time-delay problems.

It is recommended that for the path to get circuit P3 onto the 75°E satellite, a land-line be used from Hawaii to Guam. This prevents loss of the 172°E satellite from removing access to the 75°E satellite, as would occur if that link were via the 172°E satellite.

An interesting sidelight exists if TADIXS is implemented as suggested in this report: the network could easily include an FCC-to-FCC link via the shared channels, ie CINCLANTFLT-to-CINCUSNAVEUR and CINCUSNAVEUR-to-CINPACFLT. It is recommended that this aspect be given further study and incorporated in TADIXS if found desirable.