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Technical Report

# EXISTING SYSTEM MODIFICATIONS REPORT

A Report as Part of  
USAKA Long Range Planning Study

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19 ABSTRACT (Continue on reverse if necessary and identify by block number) This report describes modifications to existing sensors at Kwajalein in order to ensure they are capable of meeting mission requirements and user needs in the 1990's. Modifications and capability improvements for KREMS radar (ALTAIR, TRADEX, ALCCOR, and MMW) as well as the FPQ-19, MPS-36's, telemetry and RADOTS are described. This is part of a series of reports aimed at developing a long range plan for the sensors at Kwajalein. <i>Keywords: Guided missile ranges, KREMS (Army Strategic Defense Command Research Development Site), Air Traffic Control Systems, Ballistic Test Instrumentation, FPQ-19 (Army Strategic Defense Command), ALCCOR (Army Strategic Defense Command), Radar tracking, (E.D.)</i>					
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## 1.0 INTRODUCTION

This report is part of the USAKA long range plan development activity in which user needs and existing capability at USAKA have been ascertained and shortfalls identified. These have been reported in two previous reports as part of this project. Following this shortfall determination, existing system modifications, new systems, and research activities to meet these shortfalls were identified and analyzed. This report contains the description and reporting of existing system modifications. New systems and research activities to meet shortfalls are described in a separate document entitled "New Systems and Research Activities Report - USAKA Long Range Planning Study."

This volume documents the proposed future modifications to existing systems at USAKA. There has been no attempt to describe or justify the modifications in progress; however, it is essential to understand those efforts in order to have a baseline for departure.

System modifications may be required due to reliability requirements, operational efficiency improvements, or user shortfalls. If a subsystem is so old it requires replacement, it is frequently logical to enhance the system capability during modification. If an enhanced capability is not integral to the modification, the system modification will not be discussed. This is particularly true of subsystems that require periodic replacement due to normal wear and tear. Funding for these subsystems should be included in "repair parts" of the operational and maintenance (O&M) budget.

Each proposed system modification will be described technically followed by the subjective discussion of the contribution and justification of each modification. Estimated cost and duration for each mod is included along with the user's needs. Modification costs are in FY-89 dollars. The estimated costs to complete the mods includes all hardware, software, and any additional engineering labor,

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i.e., performed by a subcontractor in the development of the sensor modification. Any existing engineering labor and all O&M costs are not included.

The final section contains the recommended priority of each effort. As annual funding visibility becomes available, priorities may change. However, the information contained should assist USAKA in justifying and protecting a budget that has continuity; as most system mods are multi-year.

## 2.0 BASELINE

It is assumed that the following system modifications currently in progress will be successfully completed:

## KREMS Radars

- a. MMW Sensitivity Improvements
- b. MMW Improvements in Track Range
- c. ALCOR Computer Upgrade
- d. TRADEX Computer / Timing Upgrade
- e. New L and S Band Waveforms
- f. New TRADEX Antenna Servos
- g. TRADEX 32 Multitarget Tracker
- h. TRADEX Spacetrack Capability

## Other Instrumentation

- a. Meck Communication Upgrades for ERIS
- b. GPS Support for ERIS
- c. MaST Ellipticity of the MPS-36 on Illeginni
- d. KRSS Upgrades
- e. TM S-Band Antenna Feed Modification (Limited)
- f. Meck Optics, Timing and TM Upgrade for ERIS
- g. C<sup>5</sup>CS ICC and ROCC Replacement
- h. Weather Satellite Automated Data Handling System  
utilizing McIDAS

In order to establish the USAKA Technical Capability Baseline relative to the USAKA Instrumentation Manual it is necessary to define the status of the Hydroacoustic Impact Timing System (HITS) and the Splash Detection Radars. HITS was operational in the Kwajalein lagoon for many years and then put on inactive status by removing the hydrophones and velocimeters. Recently, upon reactivation of the system, it was concluded that the inwater components had deteriorated

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to such a point that HITS is no longer available and a complete new system is required. Similarly, the SDR's have exceeded their life expectancy with no source of major repair parts. Therefore, no system modifications to the SDR's are recommended until an analysis of the scoring requirements/capabilities can be completed. Any USAKA scoring or impact timing systems will be considered a new start and the subject of a separate study.

### 3.0 KREMS MODIFICATIONS

The following are the modifications to KREMS radars which need to be considered for implementation in the near term (1-5 years).

#### 3.1 KCC - Automated Target Identification

##### Description

This modification encompasses hardware and software changes at the sensors and the KREMS Control Center (KCC). It will take radar signature and metric data, compare the radars with each other and with pre-mission data, and display the results to the operators. Software algorithms to perform pattern recognition and metric target association will be required. Enhanced computational power and display capability and provisions for higher communication data rates may also be required. For re-entry missions, the individual sensors are expected to perform initial target identification which will then be verified by KCC. For Space Surveillance activities, ALTAIR will maintain a data base of satellite signature data and perform comparisons of current track data with the data base to identify objects and to flag changes in orientation, stability, and motion. Improved multi-object tracking and display at ALTAIR and TRADEX is a prerequisite for this effort.

##### Enhanced Capability

The goal for this major modification is to provide more reliable data acquisition on complex missions and to allow users to fly more objects on each mission, an important objective when the supply of boosters is limited. KREMS is very successful at meeting its objectives when deployments are nominal. When deployments are non-nominal or unexpected deployment debris is observed, the operators

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need extra time to identify the objects in the complex and are likely to fall behind. Particularly on missions with sequential re-entries where it is necessary to acquire the next object to reenter very rapidly, the result can be a complete loss of data on important one-of-a-kind objects. By using the computers to do much of the work which an operator currently does to identify objects, the work can be accomplished more rapidly and reliably for complex multi-object missions.

### Cost and Duration

The work is envisioned as a continuing task for the Lexington computer upgrade personnel, a mix of Lincoln, GE, and GTE personnel. The schedule will be driven by the availability of personnel and the completion of the improved multi-target tracker at ALTAIR. It is currently envisioned as a 3-4 year program. Personnel costs at Lexington and site will be covered by the normal support contracts. Hardware enhancements will cost a maximum of \$1,000K and require 18 months to procure and install.

### User Needs

Tests are becoming increasingly more complex. The users are requesting data on more objects than can be reliably handled. The KCC automated ID system will allow quicker and more positive identification necessary for reliable data gathering on complex multi-object missions. An additional benefit will be decreased reliance on the skill of the operators. Numbers and qualifications of the operators may be relaxed, and a reduced requirement for training (OJT) should result.

### 3.2 ALTAIR - DTSP Replacement

#### Description

The digital track signal processor (DTSP) is an ALTAIR subsystem which does range and angle error extraction and provides real-time cross-section data on the radar tracked target. It will be replaced by using the digital outputs of the Universal Signal Processor (USP) and moving the functions into the new array processor and the central computer. The ability to perform coherent integration on the tracked target in all modes will be part of this modification. This is the third step in the multi-year effort to modernize and integrate the ALTAIR signal system. The USP which can compress all waveforms with time-bandwidth products less than or equal to the present waveforms is the first step. The second step is to replace the obsolete Programmable Signal Processor (PSP) which is used for pulse compression, integration, detection and range and angle marking in Space Surveillance modes. With that work done, the DTSP replacement is accomplished by writing new software to use the hardware from steps one and two.

#### Enhanced Capability

The present system has three different signal processing paths each with their own detectors and A/D converters. Calibrations and transitions from one mode to another are complicated by this structure. With the completion of this effort the Space Surveillance and radar signal systems will be integrated. Some improvements are:

1. Coherent integration will be available for long-range/small-target acquisition for re-entry missions or near-earth satellite tracking. Present problems with detecting New

Foreign Launches (NFL) which can not be tracked and transitions from near-earth to deep space would be eliminated.

2. With the same signal path for all modes, calibration will be the same for all modes. Angle calibration for all modes can be provided by skin tracking GPS satellites.
3. Long pulses, now available in Space Surveillance modes only would be available for re-entry missions.
4. Improved reliability by replacing the obsolete NOVA computer currently used in the DTSP subsystems.

## Cost and Duration

This work is primarily a software task. Array processor software will be provided by CONUS personnel under the normal support contract. Additional equipment and software support packages are estimated to cost \$50K. VAX software and integration will be performed by the normal complement of site personnel. The task should take less than a year and be completed by the end of FY91.

## User Needs

BSD and the Navy require longer pulses. Acquiring targets at longer ranges allows more time for complex sorting and improves the ability to handle complex missions. Improved calibration and data accuracy is needed by all users.

### 3.3 ALTAIR - Auto Acquisition of Multi-Objects

#### Description

The multi-object tracking function of the ALTAIR Recording System (ARS) will be moved to the array processor and automated. The array processor will process approximately eleven samples per target on up to 32 targets, performing integration as necessary, and range and angle error measurement. The VAX will form and maintain track files and determine which samples from the USP to send to the array processor. The remaining capacity of the array processor is used to perform a range search function in a step and dwell fashion, performing integration and detection on approximately 11 km segments. Under VAX control separate recording buffers will be loaded with samples around designated tracked targets and recorded.

#### Enhanced Capability

This modification completes the integration of the signal paths and eliminates any calibration differences between radar and recording system. Capability enhancements important to complex multi-object missions are achieved as follows:

1. Acquisition of multi-targets is automated so all detectable targets will be acquired quickly when the ALTAIR antenna is moved to a different part of the complex.
2. Longer range/smaller targets can be acquired due to track integration.
3. Minimum spacing between targets will be reduced from the present 600 m to essentially the resolution of the waveform.

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4. Three coordinate tracks of the auxiliary targets will be performed instead of the current range-only tracks.
5. The sampling rate on the recorded data will be doubled allowing much better retracking and improved S/N through reduction of straddling loss.

### Cost and Duration

The major task is the development of software which will be performed by normal site and CONUS support personnel. New recording data buffers and displays will be required. Augmentation or modification of the data recorders may be required. The cost of these hardware changes will not exceed \$1,000K. Implementation is expected to begin in FY91 and take 24 months.

### User Needs

This effort is essential for the site multi-object handling upgrade and thus for any user's complex missions, particularly to support BCD closely spaced object requirements. It will support multi-object satellite tracking as well, be useful on any NFL, and needed for ASAT work. The calibration improvements will give all users more accurate data. Automated acquisition will provide more reliable operation with less skilled operators.

### **3.4 ALTAIR - VAX Replacement**

#### Description

The current VAX - 11/785 computers will be replaced with new VAX computers. Interface modifications and some restructuring of software will also be required. It is estimated that by FY92 the ALTAIR

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computation requirements will exceed the current capacity, necessitating replacement.

### Enhanced Capability

The ALTAIR signal system upgrade and other ongoing modifications will require more computer power than the present computers can provide. Newer machines in the VAX line can easily provide 10 or more times the throughput of the present computers.

### Cost and Duration

New computer hardware will cost approximately \$1,500K. Software and interface modifications will be accomplished by normal site support personnel. It is estimated that hardware procurement can be accomplished in 12 months.

### User Needs

This modification is needed to support the signal system upgrade which is required to satisfy projected user requirements. The present VAX computers are approximately 10 years old and the new computers will provide more reliable operation.

## **3.5 ALTAIR - Improved Frequency Selective Subreflector (FSS)**

### Description

A new space frame FSS will be designed, fabricated, and installed at ALTAIR. Its size and shape will be modified slightly to provide improved performance. Currently there is no spare FSS and its loss would mean extensive ALTAIR downtime.

### Enhanced Capability

Paper studies have shown that a UHF sensitivity improvement of approximately .6 dB should be achieved. In deep space operations, observations are made at 30 dB S/N. Even small S/N improvements increase the observation rate significantly. A .6 dB improvement will allow a 15% increase in tracking rate, a significant increase in the number of objects which can be tracked per unit time.

### Cost and Duration

The cost to fabricate an FSS is less than \$100K. The additional electronic and mechanical design effort needed for the improved version is minor and included in existing resources. The task can be accomplished in 10 months.

### User Needs

The U.S. Space Command has a requirement to track an ever-increasing deep space catalog. A 15% improvement is significant and will assist all users of ALTAIR data. Due to the combined action of solar radiation, moisture and microwave power, the fiberglass structure of the FSS does have limited life, and a spare is necessary for reliable operation.

## 3.6 ALCOR - Real-Time Coherent Integration

### Description

A STAR array processor will be added to the system to provide real-time coherent integration. Interface hardware must be designed and built to provide data paths from the timing and data unit (TADU) to the STAR and from the STAR to the Gould central computer. An

additional MASSCOMP display and interfaces to the STAR are also necessary. Software for the STAR, Gould, and MASSCOMP are also required.

#### Enhanced Capability

Longer-range acquisition and tracking of targets is achieved in all modes. ALCOR's sensitivity is low enough that it can only track small targets very close to re-entry. With this modification acquisition range could be more than doubled, allowing better re-entry tracks and data. It would also allow ALCOR to track and image many satellites which it cannot now see.

#### Cost and Duration

The cost of equipment is approximately \$500K. Software development is an ongoing task for the computer upgrade personnel. It is estimated 12 months will be required to procure and install the STAR array processor.

#### User Needs

USASDC and BSD have target programs which require longer range tracking. Also, Space Command's SOI requires a capability to track and image more satellites. Acquiring at longer ranges gives the operators more time to identify objects and improves reliability of operations.

### 3.7 TRADEX - Improved Real-Time Integration

#### Description

This modification will replace the small array processor at TRADEX with a more capable and easier to program STAR array processor and

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provide the software to perform coherent integration of both L and S-band data at both polarizations.

### Enhanced Capability

As a part of the computer upgrade, TRADEX will have a dual frequency range track capability. For exoatmospheric tracks the goal is to obtain real-time ionospheric corrections. The new array processor will allow coherent integration at both frequencies and extend the ionospheric correction capability to very long ranges. The accuracy of TRADEX metrics will be improved for deep-space satellite tracks, space-based experiments like the DELTA missions, and during the early tracks on re-entry missions. For the KREMS automated target identification effort it is expected that measurements of spin and precession periods will be very important. On re-entry vehicles the orthogonal polarization (O.P.) data and particularly the S-band O.P. data is likely to give the best measurement of spin period, so coherent processing of O.P. data is important for this effort.

### Cost and Duration

A STAR array processor and the initial complement of software can be purchased at a cost of \$400K. The modification can be completed in 12 months.

### User Needs

This modification is a prerequisite for Automated Target Identification and thus serves all users who want to fly more objects per mission with improved long-range metric accuracy. The new array processor is easier to program than the old and should result in some decrease in future software costs.

### 3.8 TRADEX - S-Band Refurbishment

#### Description

The TRADEX S-band microwave system is no longer able to support the full average power of the system, and the transmitter tube vendor, Varian, has stated they can no longer rebuild the tube. When the next tube failure occurs a new tube must be developed since Varian will not repair the failed tube. With both the tube and microwave system to be replaced the frequency of the system could be modified as well. The current frequency was selected only to avoid interference with the MSR radar. Increasing the frequency would provide several advantages. At any frequency over 4 GHz a bandwidth of 500 MHz would be achievable, giving the radar an imaging capability like ALCOR's but with much greater sensitivity. Increasing the frequency also increases the antenna gain and microwave and dish losses, while decreasing the antenna beamwidth. For frequencies up to normal C-band a net sensitivity gain would be achieved.

The narrower beamwidth would increase angle accuracy if a tracking capability were added. With the added bandwidth and angle tracking, long-range imaging and metrics would be possible and justify increases in sensitivity. Very high average power and long pulses are options to be considered. Table 1 summarizes the parameters, capabilities, and costs for 6 options starting with a simple tube replacement for \$2M to a new TRADEX frequency for \$25M

#### 3.8.1 Option 1 - Simple Replacement

Description - A new tube will be developed to the specifications of the original tube and the microwave system is rehabilitated to operate at the full peak and average power.

**TABLE 1  
TRADEX S-BAND REFURBISHMENT**

<b>OPTION AND NAME</b>	<b>FREQ GHZ</b>	<b>BANDWIDTH MHZ</b>	<b>PULSE WIDTH μSEC</b>	<b>SINGLE PULSE S/N</b>	<b>MAX PRF Hz</b>	<b>1 SEC INTEGRATED S/N</b>	<b>COST \$M</b>
3.8.1. SIMPLE REPLACEMENT	2.9	280	94	38	300	63	2.0
3.8.2. INCREASED POWER	2.9	280	94	38	1300	69	7.5
3.8.3. HIGHER FREQUENCY	4-6	500	94	40	300	65	11
3.8.4. NEW SIGNAL PROCESSING	4-6	500	500	47.5	56	65	18
3.8.5. ANGLE TRACKING	4-6	500	500	47.5	56	65	23
3.8.6. MAX SENSITIVITY	4-6	500	500	49	250	73	25
CURRENT ALCOR		500	10	22	200	45	

\*SIGNAL TO NOISE ON OdBSM AT 1000KM RANGE

Enhanced Capability - The system would operate as it was originally specified. The average power and integrated sensitivity would be approximately 6 dB better than can now be achieved.

Cost and Duration - The tube development would cost approximately \$850K and production tubes approximately \$250K each. The total for four tubes would be \$1.6M and would take approximately 2 years. The microwave rehabilitation should be completed for approximately \$400K resulting in a total cost of \$2M.

User Needs - This modification is simply a replacement of obsolete and worn out equipment.

### 3.8.2 Option 2 - Increased Power

Description - A new tube will be developed to operate at higher duty cycle to provide 500 kW of average power. It could also be specified to provide a bandwidth of up to 350 MHz. The cooling of all the microwave components would have to be improved to handle the increased power, and many would have to be redesigned for increased bandwidth. Prime power, cooling, high voltage power supplies, and the modulator would be replaced or modified to provide the 6+ dB increase in average power.

Enhanced Capability - Integrated signal to noise would be improved by 6 dB. The range resolution of the system would be improved if the wider bandwidth option were selected.

Cost and Duration - The total cost for this modification would be approximately \$7.5M and it would require approximately 36 months to complete.

User Needs - This modification provides 6 dB more sensitivity than the simple tube replacement, but not enough bandwidth or capability to meet any recognized shortfalls of the current system.

### 3.8.3 Option 3 - Higher Frequency

Description - This option is viewed as an interim step towards a system of greatly enhanced capability. It provides the system design for the full system, the present capability at a new higher frequency, small changes to give 500 MHz frequency jumped bursts (FJB), and a tube and microwave system designed for the final .5 MW of average power.

Enhanced Capability - For many users the signature data at a higher frequency would be of interest in itself. If the frequency were lower than C-band, the .5m resolution of the FJB would answer phenomenology questions about effects which are observed at C-band and apparently not at the current S-band. Sensitivity would be increased by approximately 2 dB due to increased antenna gain.

Cost and Duration - This effort could be completed in approximately 36 months at a cost of \$11M.

User Needs - Data with .5m range resolution at a new frequency will be provided. The obsolete tubes and worn out microwave system will be replaced.

### 3.8.4 Option 4 - New Signal Processing

Description - A new signal processing system will be developed and installed. The primary goal would be 500 MHz chirp and burst waveform for imaging and high resolution re-entry measurements. More flexible PRN waveforms, power programming, and frequency diversity are other

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capabilities which might be added. Where four signal paths would be needed for future angle tracking those provisions would be added also.

Enhanced Capability - The resultant system will have imaging capability like ALCOR, but with 20 dB greater sensitivity. Satellites could be imaged at much greater ranges and support for space-based experiments like the DELTA missions or intercepts like ERIS would be greatly enhanced. The signal processing flexibility enhancements would support users who wish to understand what various excursions can yield.

Cost and Duration - This portion of the total task will require 3.5 years and cost approximately \$7M. Total elapsed time for changing to higher frequency and installation of the new signal processor (Options 3 and 4) would be approximately 4.5 years and a total cost of \$18M.

User Needs - The longer-range imaging capability would be very valuable on SDC missions like DELTA and ERIS to determine target orientation and to perform damage assessment based on imaging small features and motion changes. The signal processing flexibility would serve intelligence users trying to understand the capability of USSR sensors. Also, this system supports Space Command's requirements for an imaging system with greater sensitivity than ALCOR.

### 3.8.5 Option 5 - Angle Tracking

Description - The previously described system is enhanced with the addition of angle tracking capability. A new feed, angle channels, recording capability and tracking software are added.

Enhanced Capability - With the high sensitivity and 2.5m beamwidth of the option 4 system, the quality of the TRADEX mount, and the capability of the L-band system, the addition of an angle tracking

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capability will make the system an excellent long-range metric sensor. It has the same sensitivity as the ALTAIR system, but as a dual frequency tracker with L-band it should have much greater range and range rate accuracy due to better ionospheric corrections, and approximately a factor of 10 better angle accuracy. For exoatmospheric intercepts and experiments it would provide improved miss distance measurements and excellent damage assessment measurements based on small trajectory changes.

Cost and Duration - This portion of the total job would cost approximately \$5M and take 2 years. The total cost for a system of this capability would be approximately \$25M and take approximately 5 years to complete.

User Needs - The metric capabilities of the radar would be extremely valuable for SDI experiments and would meet the Space Commands requirements for longer-range imaging and more accurate metrics. With a dual frequency angle tracking capability, TRADEX would be less dependent on the L-band system for successful data collection.

### 3.8.6 Option 6 - Maximum Sensitivity

Description - The prime power and cooling systems, high voltage power supplies, and modulator are upgraded to allow the tube to operate at its full .5 MW average power capability. The antenna will be resurfaced with a finer mesh for an additional gain of 1.5 dB.

Enhanced Capability - The 8 dB sensitivity enhancement would allow the radar to image many deep-space satellites and to operate at the higher prf's necessary to image more rapidly rotating objects. With this last upgrade its imaging sensitivity would be 28 dB greater than that of the current ALCOR system.

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Cost and Duration - These additional changes would cost approximately \$2M and increase the total cost of the upgrade to \$25M and about 5.5 years duration.

User Needs - This system coupled with Haystack and a new system in Turkey or Diego Garcia would give Space Command complete imaging coverage of the equatorial geosynchronous satellite belt.

### 3.9 MMW - 2 GHz Bandwidth at 35 GHz

#### Description

Current activities at MMW are providing a beam waveguide system to reduce losses and enhance power handling capability. The new tube development provides increased output power and a broader bandwidth capability. This particular enhancement would follow the BWG and tube development and incorporate a waveform generator and a pulse compression system capable of handling a 2 GHz bandwidth waveform. This would be consistent with the design of the beam waveguide and the new tube.

#### Enhanced Capability

The increased resolution provided by 2 GHz bandwidth would be useful in four areas:

1. More detailed near-earth satellite images
2. Improved signature diagnostics on US target development tests
3. Improved metric accuracy
4. An improved test bed for examining high resolution BMD discriminations techniques

### Cost and Duration

Equipment for this task is estimated to cost \$800K and take 18 months to implement and become operational.

### User Needs

The improved quality of satellite images would benefit SPACECOM analysts. The improved metrics and signature diagnostics would benefit BSD in the development of new higher performance systems. This capability would later be useful to SAC as these advanced systems transitioned to operational test. The enhanced BMD discrimination test capability would be of interest to SDIO-SATKA activities.

### 3.10 ~~MMW~~ - 20 dB Sensitivity Enhancement at 95 GHz

#### Description

The sensitivity of the 95 GHz radar is upgraded by installing a beam waveguide system in place of the present microwave waveguide and adding a cryogenic receiver and dual transmitter tubes. The total improvement will be approximately 20 dB.

#### Enhanced Capability

The current system has very limited sensitivity and can only take data on re-entry vehicles in mid re-entry. With 20 dB greater sensitivity it could collect quality data throughout re-entry. The data which has been obtained indicates that there are significant phenomenology changes at the higher frequency which might be useful for discrimination. To investigate the phenomenology differences and to collect a data base for other potential applications which would operate at frequencies above 35 GHz, the modification is necessary.

Cost and Duration

The equipment for this task is estimated to cost \$1.2M and take 24 months to implement and become operational.

User Needs

The 20 dB sensitivity enhancement is required if useful re-entry data is to be collected.

**3.11 MMW - All Range Narrowband Window**

Description

Hardware to perform all range pulse compression and display of the narrowband principle polarization channel will be provided.

Enhanced Capability

The current system processes a very limited range extent. Since it operates at ambiguous prf's, weather clutter can appear at any range and cause loss of track before the operators can react. With all range pulse compression and display the operators can see the impending weather problem and change prf or coast to alleviate the problem.

Cost and Duration

The cost for pulse compression equipment and displays will be approximately \$150K. Purchase and integration with the system should be accomplished within 12 months.

User Needs

Loss of track due to weather clutter interference would be greatly reduced by this modification.

### 3.12 MMW Simultaneous 35 GHz and 95 GHz Transmission

Description

This modification is a follow-on to the 2 GHz bandwidth and 95 GHz sensitivity enhancement modifications. The system hardware and software will be modified to allow simultaneous transmission of 35 GHz and 95 GHz pulses instead of the alternate pulse capability which now exists. The current ramp generator and the new 2 GHz ramp generators will both be used, one for each frequency.

Enhanced Capability

The system is only capable of transmitting 2000 pps. When the pulses are split between the two frequencies and further between wide and narrowband, the resulting prf's are frequently too low for good imaging or for phased derived range measurements. The modification will allow the prf at each frequency to be 2000 pps, effectively doubling the prf when data at both frequencies are needed.

Cost and Duration

Provided the other modifications have been accomplished, the modification should be primarily an effort for normal site personnel. Hardware purchases of less than \$100K would be required. Approximately one year would be required for implementation and checkout.

User Needs

Responsive to user requirements for simultaneous collection of 35 GHz and 95 GHz.

**3.13 MMW C-Band Beacon Tracker**

Description

A C-band beacon tracking system will be added to the MMW radar to permit the MMW to acquire and track beacon equipped targets at longer ranges than possible in a skin track mode.

Enhanced Capability

The system would be the most capable beacon tracker at USAKA. The large dish gives excellent sensitivity allowing high S/N measurements at long ranges and successful operation with low power beacon transponders. It also gives a narrow beam-width allowing more precise angle measurements. The quality of the MMW mount is superior to the similar sized ALCOR dish so superior angle accuracy will be achieved. Specific enhancements are:

1. The system will give very accurate beacon metrics which would be particularly valuable for exo intercepts and space experiments.
2. The beamwidth will be much larger than the 35 GHz beam allowing MMW to acquire targets on its own and operate independently from ALCOR, an important advantage on missions with multi-object objectives.
3. On many missions, but particularly intercepts when both target vehicle and interceptor must be tracked, a second (in

addition to ALCOR) accurate and sensitive beacon tracker would be very valuable.

Cost and Duration

A very conservative estimate of the cost, including spares is \$7M with approximately 30 months required for implementation.

User Needs

BSD, Navy, SAC require the accurate metrics this system could provide. Even with the use of GPS, SDI intercepts will require backup radar tracks of as great accuracy as possible. Target acquisition reliability at MMW will be enhanced.

#### 4.0 PAN AM INSTRUMENTATION MODIFICATIONS

The following are the modifications to range assets and equipment which are operated by Pan Am that need to be considered for implementation in the next 1 to 3 years.

##### 4.1 FPQ-19 Logarithmic IF Amplifier Adjunct

###### Description

The Phased Derived Range (PDR) technique uses In-phase and Quadrature-phase (I&Q) skin track data and smoothed range track data to calculate a more precise range measurement. To implement the PDR technique it was necessary to record the I&Q, range, received peak signal strength, and transmit pulse data. The current limitation of the AN/FPQ-19 PDR subsystem is that the received peak signal strength is extracted from an auxiliary port of the non-track channel. The non-track channel utilizes a linear IF amplifier which limits the dynamic range to approximately 25 dB. Therefore, this part of the PDR data is limited to an endoatmospheric target range.

An adjunct to the non-track channel can be implemented to increase the dynamic range of the PDR system. A log amp will provide a dynamic range of 80 dB. It utilizes a known logarithmic transfer function to compress a wide input range to a much narrower output range.

A log amp will be installed in the IF receiver to provide this dynamic range. A power divider will be required to split the signal and an IF amplifier required to preserve the current signal strength. A variable attenuator will be required to prevent saturation of the log amp. The log amp output will be connected directly to the PDR via an A/D converter. The PDR system software modifications will include adding the tasks to read the A/D converter, performing the necessary functions to convert the log amp output to a power representation, and recording this information. The existing connection to the PDR shall

be maintained to continue the collection of frequency shift data which will be lost through the log amp.

#### Enhanced Capability

The logarithmic IF amplifier adjunct will increase the dynamic range of the PDR system, thereby increasing the range at which PDR data may be acquired. This will, in turn, provide the user with exoatmospheric, transition, and endoatmospheric data for the Best Estimate of Trajectory (BET) development. The PDR capability realizes a range accuracy improvement from 6 meters (without PDR) to better than a centimeter. The significant enhancement is the RV track time sensitivity allowing the PDR thresholds to go from 25dB to 80dB dynamic range improvement.

#### Cost and Duration

The estimated cost for this modification is \$50K and will take about 10 months to procure and install.

#### User Needs

One of the most consistent USAKA shortfalls noted was multiple object metric tracking capability. All users desire more metric track if only for redundancy and improved accuracy by a different aspect angle to enhance the BET. The improved sensitivity of the FPQ-19 from 25 to 80 dB will allow exo track greatly enhancing the pierce point metric determination.

## 4.2 FPQ-19 Parametric Amplifier Replacement

### Description

The AN/ FPQ-19 radar's RF subsystem is a three-channel receiver with a pair of parametric amplifiers in cascade to provide a gain of 24-29 dB over the frequency range. The gain of a paramp is obtained by mixing the received signal with a local oscillator signal which is provided by a Gunn Diode Oscillator (GDO). Each paramp's gain peaks at a specific GDO frequency. This frequency is dependent upon the size of the GDO cavity and varies from day to day, dependent upon temperature and humidity. Therefore, the GDO frequency (or GDO cavity) must be adjusted to maintain maximum gain. However, the design of the GDO limits the adjustment range and frequently does not provide the specified maximum gain. If one channel's paramp is unable to obtain maximum gain, the other two channels must be back down in gain to maintain a flat frequency response throughout the RF subsystem.

Another deficiency with the parametric amplifier subsystem is that the first stage paramp is designed to be cooled by a thermoelectric cooler and the second stage to be thermally stabilized by a heater plate. However, when moisture accumulates inside the RF enclosure, ice forms on the first stage amplifier. The mechanical effects of the ice build-up deform the delicate GDO cavity, causing drifting of the GDO frequency. A third disadvantage of paramps is their complexity and high cost of repair. The circuitry of the paramps and associated GDOs is such that on-island repair is not possible. The requirement is to correct the operational and maintainability problems of the paramps while maintaining the required gain and flatness across the frequency band.

### Enhanced Capability

Amplifier technology has evolved in the last ten years so that it is most practical and cost effective to replace the paramps with newer technology. The paramps will be replaced with Gallium Arsenide Field Effect Transistors (GaAsFETs) which will provide the necessary gain and flatness without periodic adjustments and reduce system noise by 1.5 - 2.0 dB. The design of GaAsFETs is simple and more reliable than the paramps, making the GaAsFETs essentially maintenance free.

This project will eliminate the six paramps and their associated GDOs, thermoelectric cooling systems, thermostable heater plates, and power supplies which are mounted in an RF enclosure box located in the feed and the remote control panel located in the strip chart recorder cabinet will be removed. The new equipment will be limited to three GaAsFETs with internal RF limiters and the required power supplies. Improved performance by reducing system noise will be realized with the 2dB sensitivity improvement.

### Cost and Duration

The estimated total cost to procure and install the paramps is \$80K. It will take 12 months to complete the project.

### User Needs

The 2dB potential gain in the system sensitivity will improve radar performance accuracy for the user. However, the significant advantage is the cost effectiveness of the mod in reduced system complexity and lower maintenance costs. This is difficult to quantify, but it is estimated that the material cost of this mod will be saved in repair parts in less than four years. The material cost of the paramps is currently \$100K.

### 4.3 FPQ-19 Computer Upgrade

#### Description

The primary task is to provide a replacement for the Tracking Data Processing System (TDPS). This system is composed of the Modcomp IV/35 computer and the Interface-to-Antenna Control Console (IACC). A radar simulator and a system select switch will be fabricated for this project. The Modcomp IV/35 computer has been discontinued and is no longer supported by the manufacturer. Therefore, maintenance support and replacement parts for this equipment are very expensive and time consuming to obtain. The IACC is an older piece of equipment which is poorly documented and constructed using wire-wrap technology. The age of this equipment, coupled with the poor documentation, causes the maintenance time on this unit to be high.

The requirements for this upgrade are: a) Replace the Modcomp IV/35 and the IACC, b) design and fabricate a radar simulator, c) design and fabricate a system select switch, d) implement the Phased Derived Range-Data Recording Subsystem (PDR-DRSS) through the Phase III requirements and e) implement the Ada programming language in a real-time environment.

#### Enhanced Capability

The following items will be considered during design of the system to ensure that they can be implemented without the procurement of additional hardware:

- a. The ability to process the radar data at the Pulse Repetition Frequency (PRF) rate (i.e., 160, 320, or 640 Hz).
- b. A real-time Ada programming language compiler, assembler, and debugger.

- c. Expansion capacity to allow for installation of the Radar Weather Augmentation System (RWAS).
- d. Capabilities which the present system cannot perform - record the non-track logarithmic received signal, azimuth and elevation decoder outputs, and transmitted pulse amplitude.
- e. The ability to smooth the data at the radars at the PRF rate to enhance the safety solutions.

The AN/FPQ-19 computer upgrade will consist of a modular computer system configured in a front-end/host format. This approach will consolidate the command and control requirements of the AN/FPQ-19 radar systems into a real-time system. The I/O front-end shall be an IEEE-P1014 VME bus architecture. This front-end shall be interfaced to the real-time host computer via a direct memory access (DMA) interface which supports parallel data transfers between the host computer and VME front-end. In compliance with the DOD directive to implement Ada as the programming language for applications software, an Ada software development system will be provided with this system. Additionally, a FORTRAN software development system will be provided to aid in the conversion of existing software code to the Ada programming language. A host system assembler will also be procured.

#### Cost and Duration

The total cost of this upgrade is \$1.1M with \$800K the cost of equipment. From the start of competitive procurement through systems engineering tests will be 36 months.

#### User Needs

The computer upgrade will not improve the basic radar performance for the user. However, since there is no known source of repair parts

for the Modcomp IV, a catastrophic failure to the computer will shut down the radar until a replacement computer can be obtained, at least 18 months. The benefits to the user are listed in "Enhanced Capability."

#### 4.4 FPQ-19 Optics Enhancement

##### Description

The AN/FPQ-19 Radar uses what is known as the Radar Video Metric System (RVMS). The system has long since required upgrade and appears to suffer in some critical areas. To perform repair or replacement of the optical sensor, the optical front end must be disassembled exposing the optics to the salt air and humidity. The camera has a dark spot close to the center of the field of view which could conflict with tracking when used to in the optical track mode. The spot appears to be a burned or damaged spot on the image tube. The camera is an Intensified Silicon Intensifier Target (ISIT). The ISIT cannot be calibrated to obtain intensity data. The new optical sensor must provide gain and intensifier gate duration information to properly characterize the sensor and calibrate the optical system.

##### Enhanced Capability

The addition of a new optical front end will eliminate problems of exposing optical surfaces when upgrading the camera sensor and provide a narrower focal length, larger aperture lens for increased coverage in the earlier stages of Reentry Vehicle (RV) trajectory.

Superior video tracking capability will be provided in association with the proposed AN/FPQ-19 computer upgrade. The new tracker will include tracker refresh at 60 Hz, a minimum trackable target size of 1 pixel (512 x 240) field size, a minimum trackable target signal to noise ratio of at least 2:1, provide multi-gray level target tracking for automatic thresholding of a target whose gray-scale value differs

in any way from the background, and offset aim-point tracking to provide operator selectable azimuth and elevation null point difference from the center of the tracking gate. The tracker will be built according to the VME bus standard which is in agreement with the Real-Time Subsystem (RTS) standard already in effect on range. Since the system will basically be built in a single VME chassis, the vendor will be required to provide extra slots for future enhancements. Enhancements will include a video signal preprocessing function, an automatic target acquisition function, and a multiple target tracking function. The new tracker system will be designed on an open architecture to provide long term range benefits such as updating the CPU, adding new or additional Input/Output (I/O) capability, and possible lower system maintenance cost.

Future programs will benefit from this modification in that geometrically distorted and larger than real life images, which occur when tube type sensors are subjected to intense light sources, will be eliminated. Tracking data will improve with the capability of the new tracker by providing a harder track at all elevations. Most importantly, a tracker based on open architecture design will make it cost effective for potential users to invest in the range. Users can obtain enhanced tracking capability by only purchasing an appropriate module to add the capability of interest and pay for the revision of the Supervisory Processor which is coded in a high level language. In summary, this optics upgrade will provide Super RADOT type quality videometric angle data to complement the excellent PDR range data.

#### Cost and Duration

The total equipment cost for all optics modifications to the FPQ-19 Radar is \$690K and will take 8 months to complete.

User Needs

When taking the PDR range precision of 1 cm and the enhanced optics angle accuracy of 0.023 milliradians, a pierce point (120 KM) absolute accuracy of 10 meters is realized. This represents an improvement of 6% as the current beacon track accuracy is 60 meters. All range users will profit from this enhanced metric capability. The limitation will be, as in all ground based optics, the degree of cloud cover.

The HEDI program will directly benefit from this modification as the enhanced optics will give a hard track at low elevation angles where radar multipath degrades tracking. This is of interest since the FPQ-19 has line of sight to high performance interceptors launched off Meck Island.

#### 4.5 FPQ-19 Range Machine Upgrade

Description

The AN/FPQ-19 Radar system is a high-accuracy, long-range mono-pulse radar consisting in part of a Range machine subsystem which determines the range of the tracked object by locating the centroid of the received signal. This method is susceptible to corruption by targets which present an oscillating Radar Cross Section (RCS). This Range machine should be upgraded to one whose operating principle is based upon the location of the received signal peak. In addition, the Automatic Gain Control (AGC) is currently set using the previous signal. This also causes saturation from an oscillating RCS. The AGC should be set according to the particular signal or the average of signals received.

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## Enhanced Capability

Currently a range fluctuation as great as 300 meters is possible due to the necessity of filtering the AGC signal of widely scintillating targets. If a pulse to pulse change of greater than 16dB is detected, the pulse is rejected by a software fix. A design solution will give a nominal range fluctuation of 6 meters.

## Cost and Duration

The total estimated cost is \$440K with 12 months estimated to procure and modify the radar.

## User Needs

The range machine limitation reduces the application of FPQ-19 data to any user requiring accurate range data from a scintillating target. The software fix is a crude solution to a precise radar. The inherent range accuracy reliability can profit all range radar users as the upgrade will restore the radar to the original specification.

### 4.6 MPS-36 Computer Upgrade

#### Description

The computer system upgrade to be performed on each of the two AN/MPS-36 radar systems includes replacement of the Data Output and Recording Subsystem (DORS) with a host computer system and Versa Module European (VME) technology. The DORS is composed of the DORS interface unit and an embedded Perkin-Elmer 8/32 computer system. DORS acquires data from various radar subsystems; it formats, records, and refines the data, then transmits the data to the USAKA instrumentation system. Further, DORS drives the radar displays, performs target simulation, testing, and calibration functions.

Each DORS interface unit is constructed of discrete components and wire-wrap technology. The discrete components are not of adequate speed, and are increasingly difficult to obtain. The wire-wrap boards have a decreasing mean time between failure. Therefore, the DORS interface hardware needs to be replaced. The Perkin-Elmer 8/32 computers were procured and installed in 1976. These processors have been placed on a "non-current" status by the manufacturer, and cannot be economically maintained. Finally, the computational speed of these processors is not adequate to provide for future enhancements such as the increased sampling rates which are to be incorporated, the Antenna/Feed Replacement, and the Radar Error Determination System (REDS) Upgrade.

#### Enhanced Capability

The replacement computer system must perform the same functions as the current systems: calibration, data acquisition, vehicle tracking, and data output to remote sites. The new system must also provide a real-time operating environment developed with modern technology to improve the overall performance of the radar system. It must provide a path for future radar system enhancements such as optical sensors and their associated components and the VME boards which will replace the current REDS system. Thus, with this computer system replacement, each AN/MPS-36 will be able to provide a more useful data product to the Range and to the Honolulu Data Reduction Facility.

Another enhancement in the new MPS-36 computer is the ability to smooth the data at the PRF rate at the radar. This is desirable for the safety solution as opposed to smoothing filtered data at the RDS rate of 10 samples per second.

The computer replacement will consist of a modular computer system configured in a front-end/host format. This approach will consolidate the command and control requirements of the AN/MPS-36 radar systems into real-time systems using industry-standard VME technology as the host computers' I/O front-end system. The VME front-end shall be

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interfaced to a real-time host computer via a Direct Memory Access (DMA) interface which supports parallel transfers between the front-end and the host. This configuration will replace the DORS interface unit and the embedded Perkin-Elmer 8/32 computer system. Both a FORTRAN compiler and a fully supported Ada software environment will be provided with this system. The software engineers will use the Radar Simulator (to be procured as part of the AN/FPQ-19 computer Upgrade) to test applications software. The use of this simulator will enable software verification prior to actual system installation.

### Cost and Duration

The total cost for both MPS-36's computer upgrades is \$1.64M. It is estimated that it will take 42 months to complete the project; from competitive procurement through checkout. Each radar will only be down for a period of 4 months and these periods will be staggered. A ten months time savings can be realized if the software is written in Huntsville with the computers delivered and checked out in Huntsville prior to installation.

### User Needs

The MPS-36 computer upgrade will do little to improve the metric track capability except for the ability to utilize optical data from the mount. However, the computers are far beyond their service life with repair parts difficult to obtain. A catastrophic failure of the computer would render the radar inoperable until this new computer could be designed, produced, and installed.

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### 4.7 MPS-36 Optics Upgrade

#### Description

The current AN/MPS-36 video system is known as a Radar Error Determination System (REDS). The original REDS was based on 945-line operation which eventually became obsolete. When this occurred, the system was modified for 525-line operation. As technology advanced, it appeared that solid state sensors would be useful replacements for the original cameras which were no longer supported by the manufacturer. Replacement was explored with the procurement of interim low-cost Charge Coupled Device (CCD) sensor-based TV cameras.

Since these interim cameras have been in operation, certain benefits and shortcomings have been identified. New sensors will be intensified to increase sensitivity and electronically gated to prevent over-exposure of the sensor chip and prevent blooming which is a normal characteristic of video sensors presently on range. These sensors are available from a variety of sources. Currently two such sensors are being tested on range aboard the Super RADOTS in support of both the Film-to-Video Conversion Project and the Radar Optics Enhancement Projects.

The Tracking Error Detection System (TEDS) which provides video tracking capability on each video field is no longer economically repairable due to out-of-production Integrated Circuits (IC), deteriorated wire-wraps and corroded IC sockets.

#### Enhanced Capability

Superior video tracking capability will be provided in association with the proposed AN/MPS-36 computer upgrade. The new tracker will include tracker refresh at 60 Hz, a minimum trackable target size of 1 pixel (512 x 240 field size), a minimum trackable target signal to noise ratio of at least 2:1, provide multi-gray level target tracking for automatic thresholding of a target whose gray-scale value differs

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In any way from the background, and offset aim-point tracking to provide operator selectable azimuth and elevation null point difference from the center of the tracking gate. The tracker will be built according to the VME bus standard which is in agreement with the Real-Time Subsystem (RTS) standard already in effect on range. Since the system will basically be built in a single VME chassis, the vendor will be required to provide extra slots for future enhancements. Future enhancements may include a video signal preprocessing function, an automatic target acquisition function, and a multiple target tracking function. Also, the new tracker system will be designed on an open architecture to provide long term range benefits such as updating the CPU, adding new or additional Input/Output (I/O) capability, and possible lower system maintenance cost.

Future programs will benefit from this modification as it will prevent geometrically distorted and larger than real life images which occur when tube type sensors are subjected to intense light sources. Tracking data will improve with the increased capability of the new tracker by providing a harder track at all elevations. Most importantly, a tracker based on an open architecture design will make it more lucrative for potential users to invest in the range since to obtain enhanced tracking capability a user must only purchase an appropriate module to add the capability of interest and pay for the revision of the Supervisory Processor code which will be written in a high level language.

### Cost and Duration

The total cost for installing all optics modifications to both the MPS-36's is \$700K with 18 months necessary for modification.

### User Needs

With an MPS-36 located in the mid-atoll, either on Legan or Illeginni, a hard video track at low elevation angles is possible for

high performance interceptors launched off Meck Island. Additionally, the metric solution of an optical radar will give another object track (beacon) to ease the multi-track requirement. The accuracy of the combined solution should approach that of the FPQ-19.

#### 4.8 MPS-36 Feed and Receiver Replacement

##### Description

The antenna feed is a five-horn, two hybrid, monopulse feed located at the focus of the parabolic reflector and capable of horizontal, vertical, right-hand circular, and left-hand circular polarizations. The center horn transmits and receives the reference signal while the four outer horns generate the elevation and azimuth error received signals. Comparators are used in the error channels to produce the angle-error signals which are fed to the time-share error signal sampler. This device switches at the pulse-repetition frequency to produce the azimuth error, elevation error, minus azimuth error, and minus elevation error signals. These are combined with the reference signal to yield the reference-plus-error and reference-minus-error signals. These two signals are passed through the rotary joints and fed to low-noise, wide-band parametric amplifiers, which may be bypassed if required. The amplified outputs are divided to feed two pairs of RF mixers on each channel where the RF is converted to IF. One pair of IF is sent to the echo receiver and the other to the beacon receiver.

The primary problem with the present feed configuration is the crosstalk phenomenon. Crosstalk is the cross-coupling between the different modes, azimuth and elevation error detection. The excitation of an elevation difference mode in horns #1 and #2 induces fields in horns #3 and #4 which are 180 degrees out of phase with respect to one another, creating an azimuth error signal. The opposite is true for the excitation of an azimuth difference mode. This inter-element coupling is considered the primary contributor to

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the crosstalk problems experienced with the AN/MPS-36 radars. The effect of crosstalk is to cause the radar to "spiral" around the target and, if the signal-to-noise ratio is high enough as it will be for close in targets, i.e. Meck launches, complete loss of track may occur.

A characteristic limitation of two-channel receivers are their inability to utilize all the data available. The implementation of the time-shared error signal sampler necessarily eradicates 50% of the angle-error signals. The manner of manipulation of the data required for a two-channel receiver does not permit isolation of the azimuth and elevation signals. This alone may be a contributor to crosstalk as well as limiting the data utility possibilities.

Finally, due to the corrosive environment at USAKA, it was necessary to relocate the two-stage parametric amplifiers (and other equipment located in the RF head) from the lowboy to a small permanent building. This required longer waveguide runs which introduce losses. In addition, the parametric amplifiers are old technology and complex. Frequent maintenance is required to maintain them at minimal performance levels.

The antenna/reflector is a front-end parabolic circular antenna with a diameter of twelve feet, providing a minimum gain of 43-dB over the entire frequency range. The reflector consists of an aluminum shell with a honeycomb structure sandwiched between. The USAKA environment requires constant corrosion control efforts and still results in the cracking and blistering of the aluminum shell. These abrasions allow water seepage into the honeycomb sandwich. The water remains in the cells of the honeycomb structure causing the weight of the reflector to increase as well as misbalance. The end result is the overall deterioration of the reflector and the loss of loop gain. The AN/MPS-36 radars were installed at USAKA in 1975. Since 1980, three reflectors have been replaced. Considering the amount of corrosion control time expended on these systems, this replacement rate is unacceptable.

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### Enhanced Capability

In 1984, Flam & Russell Inc. performed a feed modification on the AN/MPS-36 (SN/2) at Vandenberg Air Force Base which reduced the crosstalk experienced to less than 10% from previous levels of 50-100%. This was accomplished by replacing the original five-horn, two-hybrid feed system with a four-horn, four-hybrid system. The excitation of an elevation difference mode in the four-horn, four-hybrid feed induces fields which also yield an elevation difference mode. The same is true for the excitation of an azimuth difference mode. This makes the four-horn, four-hybrid feed system immune to crosstalk. A similar modification shall be performed to eliminate the crosstalk problems.

In addition, the front-end parabolic feed/reflector was replaced with a shaped Cassegrain feed/reflector system. The dual reflector system allows the sub-reflector to partially cancel the cross-polarization generated by the main reflector. This, in turn, also reduces crosstalk. Other advantages provided by a Cassegrain reflector are higher aperture efficiency, thus increasing gain; lower noise temperature; allows sum/difference mode performance tradeoff to be optimized, phase matching tolerances are easier to maintain, and feed support system mechanical design is simplified.

### Cost and Duration

The total cost to modify the feed and receivers of both MPS-36 radars is \$2.0M and will take 36 months. The modifications will be staggered so that one 36 will always be operational.

### User Needs

The basic improvement by this mod is the elimination of potential loss of target track due to the spiraling effect at high signal to

noise ratio. The increased gain will improve the metric track accuracy for all range users.

#### 4.9 Telephone System Expansion

##### Description

The administrative telephone exchanges procured by USAKA provided three Dimension 2000 PABXs. One PABX is located in Building 1010, Kwajalein, one in Building 8185 at Roi-Namur, and one in Building 5050 at Meck. As initially installed, the Kwajalein PABX was equipped to connect 2164 subscribers, the Roi-Namur PABX to connect 637 subscribers, and the Meck PABX to connect 302 subscribers. All three PABXs are equipped for additional subscriber line expansion by the addition of line card modules and appropriate software and/or software modifications.

The Kwajalein PABX currently serves 2155 subscriber lines and is thus operating at full capacity. A total of 136 new family housing units are now ready for occupancy. An additional 200 Bachelor Quarters are in the planning stage for Kwajalein. The ERIS Project, and other SDI programs to be conducted at USAKA will increase the number of administrative telephone subscribers on Kwajalein by an estimated 745.

The Roi-Namur PABX currently serves 632 subscriber lines and is thus operating at full capacity. New bachelor quarters for 100 personnel and SDI programs requiring increased Roi-Namur manning are scheduled for CY90 and beyond. It is estimated that total new subscribers required at Roi-Namur by CY90 is 180.

The Meck PABX capacity is sufficient to serve all Meck subscribers projected through the next five years without expansion.

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### Enhanced Capability

Sufficient line port cards and carriers to add up to a maximum of 2000 new subscriber lines to the Kwajalein PABX and up to 400 new subscriber lines at the Roi-Namur PABX are required. This will ensure that the telephone exchange subscriber fill rates fall within the desired range of 70% to 85%. The exact number of lines to be added will be determined by a site survey. Cabinets will be required as necessary to accommodate the expansion equipment, however, no building modification or construction will be required at either site.

### Cost and Duration

It is estimated that \$250K and 4 months will be required, after a vendor has been selected and a subcontract approved.

### User Needs

The telephone expansion could be defined as a base support project. However, since reliable communications to all instrumentation sites is a critical mission support function, it properly is considered part of the sensor support network. With near total saturation of the current system, any voice/data telephone growth will have to come at the expense of base support.

#### 4.10 TM Programmable Data Switch

##### Description

The Carlos TM site has been operating for the past 20-plus years with patch cord type signal switching and distribution. The more complex data formats and equipment configurations associated with present and future missions require a more sophisticated and reliable method of quickly changing the system configuration as mission

requirements dictate. A programmable, computer-controlled switching matrix capable of patching RF and analog/digital signals is required.

#### Enhanced Capability

If the existing patch panels are not replaced, the future complex data formats cannot be supported. All state-of-the-art telemetry equipment such as data receivers, combiners, recorders, bit synchronizers, PCM decoders, etc., are capable of being controlled by a host computer. The data distribution system should also have this capability.

#### Cost and Duration

It is estimated that \$500K will be required to automate the patch panels and this can be accomplished in 14 months.

#### User Needs

Most all user data rates and modes are significantly increasing in proportion to test complexity. It is necessary for USAKA to keep pace with TM format complexity by reconfiguring data in milliseconds (automatically) rather than hours (manual patch panel). With a programmable data switch, downlink format changes can be accommodated without data loss. For example, ERIS has planned 15 different TM downlink modes; all of which could be handled with a programmable data switch.

### **4.11 TM System Signal Data Rate Upgrade**

#### Description

It is necessary to process the higher data rate signals received due to the greater bandwidth. Currently the receivers, combiners,

distribution system and recorders limit the data rate to about 2 megabits/sec (Mbps). The "weakest link" currently is the copper wire distribution system followed closely by the recorders which have a maximum bandwidth of about 3 Mbps. To realize a data rate approaching 25 Mbps new receiver and combiner components are required in addition to new fiber optic interfaces and additional recorders. The existing receivers and combiners are difficult to maintain as repair parts are scarce for the wide variety of manufacturers. The data rate upgrade program would provide commonality of subsystems realizing a cost savings in spare parts and operator training.

#### Enhanced Capability

The TM system signal data rate upgrade would provide USAKA with a 25 Mbps TM capability. This would be achieved by upgrading selected receivers and combiner components and adding higher data rate fiber optics and HDDR recorders with wide band up front digitizers.

#### Cost and Duration

The total cost to upgrade all TM ground stations is \$1.75M and requires 12 months from go-ahead to checkout.

#### User Needs

TM data rate requirements continue to increase. All out year users are looking at data rates around 15-20 Mbps, thus far exceeding USAKA capability.

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### User Needs

Currently there is no USAKA TM capability in the 2.3 to 2.4 GHz bandwidth. The advanced SDI programs all have increased number of downlinks requiring increased bandwidth. Additionally, Air Force instrumented RV's required increased TM sensitivity and signal stability to support diagnostic effort on doppler fuzing.

### **4.13 Film to Video Conversion**

#### Description

The replacement of the 70mm and 16mm film cameras with solid-state video sensors will provide significant cost savings per mission due to the present costs of procuring and processing photographic film. To utilize the video format, a video data insertion and retrieval strip will be put onto each frame of the video. This strip will be used by HDRF to retrieve the pointing, timing, and videometric calibration data relative to the frame of video being viewed. Additional video hardware will be procured to accommodate expanded video systems at each site.

The computer system being used by the RADOTs is a Perkin-Elmer 3210. An effort is underway to add a VME bus chassis to the PE 3210. The schedule for software development on the RADOTs requires that installation of VME chassis with I/O and VDIR boards at all RADOT sites be completed before software development begins. The RADOT computer system will require a more extensive development effort in both hardware and software than the Super RADOTs because the RADOTs were not designed for collecting metric video data. The two 70mm cameras and one 16mm film camera on each site will be replaced with a pair of Xybion ISG-205 cameras and one Xybion SVC-11 camera.

The software required to support the RADOT conversion will be similar in design to that of the Super RADOT. To insure real-time

operation, the system control will be based on servicing interrupts. The generation of a 60 Hz interrupt will be required to support the bar code insertion on the video data from the camera which replaces the 70mm film camera. The present PE 3210 software which executes on the PE 3210 was originally ported from the Super RADOT and modified for the RADOT configuration. Interrupt Service Routines (ISR) will be written under PDOS which is being used by the VME chassis. These routines will be used to handle writing data to magnetic tape, reading RTI data, and operating the VDIR and character generator boards.

#### Enhanced Capability

The enhanced capability is the potential to close the photo processing laboratory motion picture facility. Engineering sequential and documentary motion picture coverage could be accommodated by off island resources. This annual saving of \$400K would be realized as soon as all the video data collection capability was demonstrated.

#### Cost and Duration

The total cost, hardware and software development, is \$1.46M and will require 13 months to complete.

#### User Needs

An advantage to the user will be reduced cost by the elimination of film costs and processing. Additionally, there will be a slight acceleration of post mission data analysis with the automated videometric data analysis capability. The invested costs could be realized in about 4 years in the O&M saving by having all MOPIC processing done off-island.

#### 4.14 C<sup>5</sup>CS User Capability

##### Description

The Consolidated Command, Control, and Communication Center (C<sup>5</sup>) Project began as a means to improve system reliability and enhance the OPSEC posture of the USAKA, while contemporaneously providing a vehicle for replacement of the CDC 7600 Instrumentation Acquisition System (IAS) main computer. The implementation of C<sup>5</sup> will consolidate all the primary mission control functions into a single control area to be located within the newly-renovated Range Command Building. Mission functions to be consolidated include: The Range Operations Control Center (ROCC), the Master Timing Center (MTC), the Instrumentation Control Center (ICC), the Technical Control Facility (TCF), and the Status Display Consoles (SDCs). Software support for the conversion of the existing application computer programs and the generation of replacement programs compatible with the new system will be required.

The USAKA Instrumentation System (IAS) is composed of a central computational and distribution system and sensor systems situated strategically throughout the Kwajalein Atoll. The new central system, known as C<sup>5</sup>CS, will input tracking information produced both internally and externally to USAKA, refine that data, and provide real-time guidance to a subset of the USAKA sensors. Additionally, C<sup>5</sup>CS will serve as a central facility for post-mission data reduction and analysis of tracking and impact data recorded by the various IAS sensor systems. The information above defines the main functions of this system during a mission, however there is sufficient computer power to perform many additional tasks.

The C<sup>5</sup>CS has various configurations of Digital Equipment Corporation computers, MicroVAX IIs, and a host system, a VAX 8820 dual processor system that serves as the front-end to the Cray XMP/14se supercomputer. The Cray is a powerful tool whose computational speed can be used for multiple applications in support

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of the Kwajalein Atoll. For example, Cray CPU time can be sold to other on-island contractors who have the need to develop and analyze very high CPU-intensive simulators and benchmarks which require hours of CPU time on a non-supercomputer. The going rate for one hour of Cray CPU time is \$1,000.00.

### Enhanced Capability

This upgrade will provide a matrix switch which will allow remote users to log into the DEC 8820 and write software using the Ada, C, FORTRAN, and Pascal programming languages and submit batch jobs to execute on the Cray. During a defined period when remote users are logged onto the system and executing their jobs on the Cray at a fixed-dollar rate, the C<sup>5</sup>CS classified data associated with mission support will be taken off-line to prevent exposure to non-secured personnel. The VAX 8820 and Cray supercomputer system accounting utilities will effectively generate itemized monthly reports identifying the user CPU and paper usage. This will ensure adequate billing and generate excellent records to track these activities. This will also allow for incorporation of the Re-entry Environmental Measurements Program (REMP) subsystem of the Meteorological Environmental Test Support (METS) contractor and take on various tasks associated with the Kwajalein Range Safety System (RSS).

### Cost and Duration

The cost to complete the C<sup>5</sup>CS User Capability is \$250K and will take 3 months.

### User Needs

This modification is simply a cost effective move to more efficiently utilize the computation capability on USAKA. It does not support a specific user shortfall but, once available, will enhance

all users. For Meck Island users, it will be essential to have a higher capacity data link than the DMS.

#### 4.15 C<sup>5</sup>CS System Completion

##### Description

Communication hardware and software which will allow for testing the C<sup>5</sup>CS and ICC systems in parallel will have to be procured and installed. The hardware extent of the project will include communication hardware which will allow for piping simulated and mission data to the C<sup>5</sup>CS system for verification and certification of this system. Also, communication hardware and software required to relocate the flight safety officer's function to the C<sup>5</sup>CS facility will be procured. The operation systems associated with C<sup>5</sup> will be maintained to the current revision level. This effort will call for subcontractor support in modifying drivers provided by the subcontractors. The latest vectorized version of ADA compiler to execute on the Cray will be procured.

##### Enhanced Capability

The major factor promoting the C<sup>5</sup> program is the need to replace old and technologically obsolete equipment. This equipment is rapidly becoming unsupportable. Consolidation of resources will be achieved as the major USAKA systems (IAS, ROCC, Meteorological REMP System, SAFETY, MTC, TCF, ASNS, and DMS) are currently located in different buildings. Consolidation will enhance the efficiency of communication between computers and system operators, thereby having efficient manpower utilization. Providing one main facility room will also permit efficiency in cooling, electrical maintenance, and physical plant design and maintenance. The new C<sup>5</sup> hardware and its physical arrangement will provide an increase in performance to meet the current and future requirements for USAKA. Additionally, the

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consolidation of the primary computer systems, the communication system, and the mission display consoles into one building will also enhance the security of computer information and facility access. Reliability and maintenance will be improved by consolidation and modernization. The age of the current systems is having a tremendous impact on the cost of maintenance and reliability. The maintenance cost of the CDC 7600 alone is a major item in the operation budget of the Range.

The C<sup>5</sup>CS project will allow input tracking information from both internal and external sources to be refined and transformed so that real-time guidance can be furnished a variety of USAKA sensors.

Also, the completed C<sup>5</sup>CS will serve as a central facility for post mission data reduction and analysis of tracking and impact data recorded by the various IAS sensor systems.

### Cost and Duration

The C<sup>5</sup>CS project will require \$750K to procure necessary hardware and software to complete this effort. The estimated time frame for the completion of this project is 14 months.

### User Needs

There is no user shortfall that will be filled by this modification. However, the O&M cost savings in calculation of the support system and elimination of the CDC maintenance will pay for the mod in a few years. The big investment in the C<sup>5</sup> project has been made; this modification will realize all the benefits.

#### 4.16 Inter Island Undersea Fiber Optics System

##### Description

The Digital Microwave System (DMS) currently providing the sole intra-range transmission medium is physically limited to a maximum total bandwidth of 45 megabits/second (672 voice-frequency channels). Since this total bandwidth must serve all administrative and operational voice and data traffic between range sites and some bandwidth allocation is static, the maximum effective available channel bandwidth is 1.544 megabits/second. The number of such 1.5 mbps channels available is 28, of which a maximum of three are available for dynamic reallocation. Utilization of such a 1.5 mbps channel for specialized applications (e.g., high-rate data, compressed video) requires procurement and installation of specialized, high-cost multiplexer/demultiplexer equipment. Expansion of the DMS existing equipment is not possible. Expansion by replacement of all radios and associated ancillary equipment can only add a second 45 mbps channel and would retain the above described channelization and allocation limitations. Available digital microwave technology limits channelization and allocation to standard North American Digital Hierarchy rates of 1.544, 6.312, and 44.736 mbps rates and multiplexing schemes.

##### Enhanced Capability

Replacement of the DMS with an undersea fiber optic transmission system would initially provide a total bandwidth capability of at least 500 megabits/per second/per fiber. This order-of-magnitude increase in available bandwidth would accommodate all existing and foreseeable voice and low-rate (under 1.544 mbps) data requirements and would permit continued utilization of DMS multiplexer equipment for those applications. Capabilities heretofore unavailable at USAKA would be available either by dedicating individual fibers to very-high

data rates or by utilizing the inherent, per-fiber bandwidth increase through multiplexing. Full-motion video, very-high bandwidth telemetry, and radar video transmission between range sites would be available for the first time. Provision of these capabilities through microwave transmission, either digital or analog, is not technologically possible. The hardware-bound digital multiplex hierarchy inherent in the DMS will be replaced with a transmission medium capable of accommodating any reasonable bandwidth and multiplexing scheme by simply replacing terminal equipment.

#### Cost and Duration

The total cost to competitively procure and install the system and Pan Am to checkout the new capability is \$8.1M and will take 48 months. The 8.1M is broken into 6.7M for fiber optics hardware, 0.4M for installation, and 1.0M for support to include cost of the barge, delta engineering, location survey, shore anchors, etc.

#### User Needs

Transmission bandwidth inevitably grows just as mission complexity grows. It is near impossible to quantify the user requirements. However, a dual launch GSTS or a AOA/GBR-X/HEDI experiment will far exceed the DMS capability. The additional advantage of security O&M savings on the DMS towers and RFI elimination cannot be quantified.

#### **4.17 FCA Van Upgrade**

##### Description

To continue to control and monitor the electromagnetic environment in and around USAKA, additional and replacement equipment will be required. The USAKA frequency control and analysis mission includes detection and determination of the angle of incoming RF signals.

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Currently, the FCA mobile facility can provide direction finding of RF signals from 10 MHz to 1.0 GHz with a resolution of approximately 60 degrees using the log periodic antenna. To be able to pinpoint an incoming RF signal to less than 0.5 degrees of accuracy, an automatic direction finding (ADF) system is required.

### Enhanced Capability

The FCA mobile facility has no capability for recording intermittent intelligence bearing signals and high-speed transients for post-mission analysis. The waveform recorder will sample analog signals (up to 20 million readings-per-second), convert the samples to digital form and store the representations in memory. These data can be re-created on a CRT display and expanded for analysis. Without a waveform recorder, the FCA van will not be able to capture intermittent RF and high-speed transients for analysis.

### Cost and Duration

The cost to upgrade the FCA van with essential replacement in addition to adding the ADF and waveform recorder capability is \$345K. This upgrade will take 12 months.

### User Needs

The FCA upgrade will not eliminate any users shortfalls. The improved intelligence capability by detecting and pinpointing external RF signals will improve security at USAKA.

**4.18 FPQ-19, Radar Weather Augmentation System(RWAS)**Description

For most of the missile testing at USAKA, the flight times from the launch point to the impact area are in the order of thirty minutes. From the time of launch commit to impact, the weather conditions in the impact area at USAKA can change drastically. Offensive missile systems have become so sophisticated that minor variations in weather conditions along the flight path such as water, ice particles, and wind velocity affect the system accuracy. Therefore, a technique is required at USAKA which will measure the variations along the flight path and provide data which will allow accurate prediction of weather conditions during the critical test period. The RWAS shall provide the entry path measurement capability and weather prediction data to meet the requirement. The RWAS shall be installed as part of the AN/FPQ-19 Radar.

The RWAS shall be used for mission meteorological research and data base development by collecting data from special Radar scans, data collection during missions, mapping the three-dimensional distribution of clouds, establishing a three-dimensional echo frequency climatology, and measuring cloud distribution along the mission reentry paths. Hardware and software which provide similar data have been developed and are operating at several NASA and NOAA facilities and at the University of North Dakota. Although the USAKA requirement is somewhat different, the basic design is similar and the design risk is very low. There are three known sources for this equipment, and this will allow a competitive procurement.

The RWAS shall accept signals from the AN/FPQ-19 Radar and provide real-time system control, signal and data processing, archiving, and display of intensity differential reflectivity, velocity, and spectral width information derived from the Radar signals. The RWAS shall be

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completely self-contained in its own free-standing cabinet or racks, except for the displays, printer and the remote control and display for the Radar operator.

### Enhanced Capability

The RWAS shall have four basic modes of operation: (1) the Correlation mode, (2) the Position Plan Indication (PPI) mode, (3) the Range Height (RHI) mode, and (4) the Co-Track mode. In the Offset Correlation mode, three different pieces of equipment are involved: the weather aircraft, the Radar, and a second radar tracking the weather aircraft. The Radar shall be slaved to the second tracking radar and shall be offset to track in front of the aircraft. The RWAS shall receive position data (X, Y, Z, or A, E, R) via USAKA's Radar Distribution System (RDS) and shall continuously adjust the range gates so that the center gate is at the aircraft and weather data is collected in front of the aircraft by an offset. The offset shall be a pre-mission set parameter.

In the PPI mode, the Radar shall make a series of conical scans no more than 15 degrees in elevation with azimuth limits and scan rates specified by the weather station. The scan specifications shall be transmitted to the RWAS computer via a low-speed communication data set, and shall be displayed at the Radar console for verification by the Radar operator. The Radar operator shall have the option to accept or reject the proposed scan. In either case, the result shall be transmitted to the weather station. If the scan requirement is accepted by the Radar operator, the data shall be automatically transferred to the Radar computer and begin the scanning assignment.

In the RHI mode, the Radar shall make a series of vertical scans at a specified azimuth with elevation limits and scan rates specified by the weather station. The scan specifications shall be transmitted to the RWAS computer via a low-speed communication data set, and shall be displayed at the Radar's console for verification by the Radar operator. The RWAS operator shall have the option to accept or reject

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the proposed scan. In either case, the result shall be transmitted to the weather station. If the scan requirement is accepted by the Radar operator, the data shall be automatically transferred to the Radar computer and begin the scanning assignment.

In the Co-Track mode, the Radar shall be operating in the normal tracking mode. The Radar IF from the non-track channel and other pertinent Radar data shall be transmitted to the RWAS. The RWAS signal processor shall be independent of the Radar in order to process meteorological data while the Radar is tracking a target. This mode shall provide the best possible estimate of actual real-time weather conditions along the mission target path. In this mode the weather station shall not specify any of the scan parameters. The range gates shall be positioned so that the center gate is the target being tracked. All other RWAS parameters shall be automatically set to the maximum, based upon mission requirements.

### Cost and Duration

The total cost to procure and install the RWAS is estimated at \$400K and 18 months. It must be noted that the normal FPQ-19 O&M crew can collect data, on a non-interference basis, during normal duty hours. However, if extensive data is required, additional operating personnel will be required along with higher radar maintenance costs.

### User Needs

All range users that target RV's into USAKA want to know precisely the environment flown through. This modification will assist by providing a weather scan. Additionally, this mod can optimize the test support point (TSP) for optics and met aircraft by finding the cloud free line of sight to the target trajectory. Most all aircraft have ceiling limitations well below the tops of the connectively generated cirrus clouds. In the long term, GBR-X can provide an excellent weather map with its higher power and appropriate frequency.

In the anticipation of GBR-X, it appears cost effective to demonstrate and integrate the radar weather scan capability with the FPQ-19.

#### 4.19 DMS Bulk and Voice Encryption

##### Description

Bulk encryption of selected DS-1 (24 channels, 1.544 Mbps) trunks on the DMS protects mission-support voice and data circuits from unauthorized interception. To improve the USAKA OPSEC posture, it is proposed to bulk encrypt all DMS channels using GFE DS-3 encryption devices. This equipment can be retrofitted to the replacement fiber optic transmission systems to provide the same level of protection.

The USAKA secure voice capability has been significantly improved over the last five years by the augmentation of AUTOSEVOCOM service with the BSVMN, a private secure voice network linking Government and contractor facilities, limited STU-II installations, and the DOD STS Secure Voice Network. There is a current program which supplied approximately 50 GFE STU III instruments to selected USAKA subscribers.

##### Enhanced Capability

To significantly improve the OPSEC posture of USAKA, it is proposed to increase the number of STU-III secure voice instruments in a phased program over the next five years. The goal of the program is to provide convenient secure voice capability to the maximum number of official telephone users at USAKA. This will provide protection to intra-USAKA voice traffic and increase the protection of USAKA-CONUS voice traffic as the population of STU-III terminals in service throughout the DOD and contractor community increases.

Cost and Duration

To provide 30 STU-III terminals and bulk encryption of the DMS is estimated at \$810K and includes all COMSEC requirements. It will require 3 months to install the systems.

User Needs

There are no user shortfalls that will be eliminated by this modification. However, all users will profit by the added security of the voice communications within the atoll.

## 5.0 AEROMET METEOROLOGICAL MODIFICATIONS

The following are those proposed modifications to meteorological sensors operated and maintained by Aeromet. However, due to the unique meteorological situation at USAKA, it is deemed necessary to present an overview or introduction to the three proposed system modifications. Each modification will support the three basic met requirements at USAKA. These three basic met user requirements are: Commit to Launch, Select the Airborne Optical Test Support Point (TSP), and Characterization of the R/V Environment.

Perhaps the greatest single impact of cost to a user is the decision to launch based upon meteorological considerations. Generally, the user wants a met decision 10 hours in advance. In parts of the globe where weather patterns are fully understood and adequate sensors exist to provide confidence in the forecast, this 10 hour request is not unreasonable. However, at USAKA there are few surrounding sensors to define weather patterns. Another factor that makes met forecasting in the tropics so difficult is the absence of frontal activity. At USAKA or any tropical area, the scientific characterization of the weather patterns are in their infancy. This is due to lack of sensor data. It is only recently that "invisible" high altitude cirrus clouds have been acknowledged to be so prevalent. These clouds top out at about 47K ft and contain high density particles that not only obstruct optical measurements, but invalidate many reentry tests. The forecasting of where these clouds will be 8-10 hours in the future is virtually impossible without additional sensors. The high cirrus clouds, the remnant of large tropical cells, drift for many hours, even days, at about 30 knots, so that their prediction to assist the user in launch commitment is possible given the proper sensor data. User cost savings can be realized by eliminating late countdown scrubs due to met.

The second requirement at USAKA is the TSP of an optical airborne platform, like AOA or OAMP, to optimize data collection. Some

platforms are hundreds of miles from the event without the capability of going above the high cirrus. A clear line of sight (CLOS) can be obtained if there is sufficient data to predict the new TSP or adjust the countdown. With the addition of McIDAS satellite inputs and the following modifications, airborne platforms can be positioned for cloud-free line of sight.

The third general met user requirement is to characterize the flight path, for either reentry vehicles or outgoing interceptors. Once again, it is necessary to predict the environment in the corridor since most experiments have meteorological constraints. Post mission analysis is required to assist in weapon system evaluation. The unique USAKA environment is complicated by the lack of met stations in close proximity. The closest met sounding inputs are Majuro, Pohnpei, Truk and Tarawa, however, they are only once a day, at noon. Midway, Wake, and Guam provide twice-a-day inputs which assist in forecasting general trends, but are of limited use in predicting or characterizing the local environment. The addition of the following met sensors would greatly assist in the characterization of the USAKA environment in support of users' requirements.

### 5.1 Weather Sensor

#### Description

The weather sensor modification is inputting a ground-based cloud characterization radar into the existing met station cloud scan capability. An X-band radar with sufficient power and sensitivity will satisfy the requirements for cloud height measurements and cloud characterization. Such a radar will be able to detect low and mid-level convective and stratiform clouds and the high, thin cirriform clouds prevalent in the tropics. It will be a pulsed radar having the capability to scan 360 degrees in azimuth and 90 degrees in elevation

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for the purpose of sweeping the full sky. Being a volume scan radar, it can achieve this sweep in minutes whereas it takes ALCOR as long to provide a single slice of azimuth.

### Radar Characteristics

Transmitter Power	1400 kw
Antenna Diameter	32 ft
Operating Frequency	9.5 GHz
Noise Figure	6.5 dB
Pulse Length	4.0 $\mu$ S
Signal-to-Noise Ratio	3.0 dB
dB (z) Level	-40. dB (z)
Integrator Gates	512.

### Enhanced Capability

There are three major areas which will benefit by the inclusion of a ground based cloud characterization sensor at USAKA:

1. Radar attenuation estimates have been critical to previous missions, and will be so in the future. With the addition of a radar dedicated solely to meteorological tasks, these estimates can be made most accurately.
2. Many missile operations at USAKA require the characterization of clouds in reentry corridors. This requires an accurate measurement of cloud heights, bases, particle mass, and extent of aerial coverage.
3. Accurate weather forecasting and analysis to support commitment to launch. Real-time information in this area is absolutely critical to the success of a forecast.

The radar will add needed, real-time information about the current state of the clouds around the range to the meteorological data currently used by the USAKA weather station in support of mission objectives.

## Cost and Duration

The development costs and time for the weather sensor input will be \$800K and take 18 months.

## User Needs

All range users which launch or have reentry targets near Roi-Namur will benefit from the inclusion of the weather sensor at USAKA.

## 5.2 NOWCAST

### Description

Future test requirements for optical data, long term forecasting (10 hours to 24 hours) and high accuracy forecasting (no particles above 40  $\mu\text{m}$  in the reentry path) necessitates improved meteorological modeling and forecasting over and above that which currently exists at Kwajalein. This project would involve the implementation at USAKA of a three-dimensional cloud modeling capability for forecasting weather at Kwajalein and the surrounding area. The model has been partially developed as part of a Small Business Innovative Research (SBIR) from BSD and designed to meet their need for more stringent weather criteria for the evaluation of vehicle performance, optical data requirements and radar imaging of targets.

The model consists of a twenty layer modeling capability up to 50 Kft for an area 400 nautical miles around Kwajalein. It contains both a one hundred Km cellular modeling large area forecasting capability for longer term forecasting and a fine mesh (25 Km) capability for

shorter term higher resolution forecasting. In addition, the cloud models are capable of modeling individual clouds and forecasting cloud behavior at resolutions as low as 150 meters.

The models utilize the fundamental meteorological equations of motion to simulate atmospheric processes and project the results of the forces at work in the atmosphere proceeding a few hours into the future. The model currently runs on an Alliant FX-4 minisupercomputer but can readily be ported to other machines. Input data to the model includes; 1) pressures from a global weather forecasting model, 2) infrared irradiances from GMS satellite and TOVS soundings from the NOAA polar orbiting satellites, 3) rawinsonde observations from within the geographical area covered by the model, 4) region surface ambient pressure, temperatures, humidity and winds and sea-surface temperatures, and 5) climatological values of sea-surface temperature. Other input such as aircraft measurements and radar weather data will be able to be inputted after NOWCAST is made operational at Kwajalein. NOWCAST will need to be installed at USAKA, interfaced to data sources and made operational so that real-time modeling results are available.

#### Enhanced Capability

NOWCAST would provide realistic weather forecasting at USAKA for the next twenty four hour period. The information would be presented in graphical form and continuously updated so that as uncertainties and changes in weather patterns developed, the prediction confidence could be assessed. More timely launch feasibility predictions and efficient test countdowns would result. Location for optical aircraft and probability of obtaining CLOS to test trajectories would be able to be determined. The assessment of weather for the evaluation of vehicle performance and the data requirements for testing could be made more stringent.

Cost and Duration

The implementation of the modeling capability at Kwajalein would cost \$400K and take 12 months. This assumes that the computing facilities needed for running the model are available at Kwajalein (the CRAY). (If a computer must also be provided, an additional \$500K to \$800K would be necessary to purchase the computing capability required to run the model.)

User Needs

The two most significant changes in testing requirements at Kwajalein that will be occurring over the next ten years is the need for optical data signatures and the need to handle more complex tests with increased resolution and accuracy required. Both of these needs will necessitate improved meteorological forecasting capability. This model is one of the elements in addition to more and better meteorological measurements which will be necessary for obtaining the accurate weather forecasting which will be necessary in the future. The routine implementation of airborne optical measurements in the longer wave infrared regions will not be possible without improved meteorological forecasting and prediction capability.

**5.3 LIDAR and Radiometer for HARP Aircraft**Description

A LASER radar (LIDAR) transmits a laser pulse in the visible or near infrared portion of the electromagnetic spectrum. It measures energy that is backscattered by cloud particles, atmospheric aerosols, and gaseous molecules. The backscattered energy is measured as a function of range from the LIDAR, which allows the bases and tops of scatterers such as clouds to be determined. If multiple wavelengths of light are used (e.g., 0.53 and 1.03  $\mu\text{m}$ ) the molecular scattering

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can be distinguished from aerosol and hydrometer scattering so that cirrus clouds can be identified unambiguously. Quantitative estimates of ice crystal concentration and ice water mass can be derived from relationships between optical depth and ice scatterers. The implementation of LIDAR capability on the HARP would require that a dual-wavelength LIDAR be built and connected to the existing HARP data system. While a few airborne LIDARs are in existence, they are not common items, and the existing LIDAR systems either use antiquated data processing equipment, are too large and heavy to use in the HARP, or are very expensive to maintain.

A radiometer is capable of making continuous measurements of atmospheric radiance in several wavebands, aerosol overburden, water vapor overburden, and ozone overburden. A radiometer would provide direct indications of conditions where atmospheric irradiance is high enough to impact the gathering of IR target signatures. A radiometer would allow the "seeing" conditions to be mapped and could provide input to atmospheric transmittance models. A radiometer that might be used on the HARP is the Cold Optics Radiometer (COR) that was developed at the University of Denver and was used at Kwajalein during the KITE program under direction of the AOA office. The COR contains a mosaic of nine separate detectors each with a field of view of approximately 1.4 by 3.0 degrees. In the past the COR has used filters centered on 7.2 and 11.4  $\mu\text{m}$ , and can utilize five filters simultaneously.

#### Enhanced Capabilities

Implementation of a LIDAR and an infrared radiometer on the HARP aircraft would provide USAKA the ability to quantitatively assess the environmental character of the atmosphere above the HARP. This would allow the determination of conditions that may induce undesired effects on reentry vehicles or degrade the ability of range sensors to make measurements in infrared and other wavebands.

An upward-looking airborne LIDAR would be able to detect ice crystals and other aerosols and quantify their depth and

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concentration. A radiometer would be able to measure atmospheric irradiance in five wavebands and would allow determination of high irradiance caused by atmospheric aerosols and gasses.

Combined data from both a LIDAR and radiometer would allow the determination environmental characteristics that could not be determined by either system alone. For example, 3-D maps of cirrus clouds, "seeing" conditions, and other parameters could be over a 150 mile range normal to the HARP flight path.

### Costs and Duration

Development and implementation of a dual-wavelength LIDAR would cost approximately \$350K and require 12 labor months to complete. Adaptation and installation of the Cold Optics Radiometer on the HARP would cost an additional \$100K for a total of \$450K.

### User Needs

Users such as AOA, HEDI, and any others that gather visible or IR signature data could utilize the augmented HARP capability to select TSPs, make launch commitments, and to characterize the environment in which measurements are made. Users such as BSD may require the determination of hydrometer-free reentry environments for a commitment to launch and for reentry environment characterization.

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## 6.0 RECOMMENDED PRIORITY

The establishment of a prioritization of the system modifications of Sections 3, 4, and 5 is difficult because of changing test requirements and system status. For example, modifications that are designed to improve system reliability can become critical as system behavior starts to deteriorate. Therefore it is expected that these priorities need to be periodically reviewed as system experience indicates a change in operational status of various components.

### 6.1 Rationale

Because this study was driven by an assessment of User Needs and the role of USAKA is to provide data and information to users, the following prioritization system was used to establish priority.

- |  |   |
|--|---|
| 1. Unique means of satisfying User Needs | 4 |
| 2. System Reliability Improvement        | 3 |
| 3. Operational Cost Savings              | 2 |
| 4. Cost and Time of Implementation       | 1 |

These weighting factors were applied to the thirty-five modifications listed and the following priorities developed. Twenty five of the modifications are primarily user needs driven, five are primarily reliability improvement driven, and six are primarily designed to improve efficiency. These considerations are indicated in the priority list of the following table.

<u>Priority</u>	<u>Modification</u>	<u>Cost</u>	<u>Months to Implement</u>	<u>Primary Driver</u>
1	(4.1) FPQ-19 Logarithmic IF Amplifier	\$ 50K	10	User Needs
2	(3.7) TRADEX Improved Real-Time Integration	\$400K	12	User Needs

3	(3.3) ALTAIR Auto Acquisition of Multi-Objects	\$1000K	24	User Needs
4	(3.2) ALTAIR DTSP Replacement	\$ 50K	12	User Needs
5	(4.4) FPQ-19 Optics Enhancement	\$690K	8	User Needs
6	(3.1) KCC-Automated Target Identification	\$1000K	48	User Needs
7	(5.3) LIDAR for HARP	\$450K	12	User Needs
8	(5.2) NOWCAST	\$400K	12	User Needs
9	(4.12) TM Antenna Feed System Upgrade	\$410K	12	User Needs
10	(4.11) TM Receiver and Combiner Replacement	\$1750K	12	User Needs
11	(4.19) DMS Bulk and Voice Encryption	\$810K	3	User Security
12	(5.1) Weather Sensor	\$800K	18	User Needs
13	(3.5) ALTAIR (FSS)	\$100K	10	Reliability
14	(4.2) FPQ-19 Parametric Amplifier Replacement	\$ 80K	8	Efficiency Improvement
15	(3.11) MMW All-Range Narrowband Window	\$150K	12	User Needs
16	(4.10) Programmable Data Switch	\$500K	14	User Needs
17	(4.14) C <sup>5</sup> CS User Capability	\$250K	3	Efficiency Improvement
18	(3.9) MMW-2 GHz Bandwidth at 35 GHz	\$800K	18	User Needs
19	(3.12) MMW Simultaneous 35 & 95 GHz Transmission	\$100K	12	User Needs
20	(3.6) ALCOR Real-Time Coherent Integration	\$500K	12	Reliability
21	(4.18) FPQ-19 RWAS	\$400K	18	User Needs

22	(3.4) ALTAIR Vax Replacement	\$1500K	12	Reliability
23	(4.3) FPQ-19 Computer Upgrade	\$1100K	36	Reliability
24	(4.6) MPS-36 Computer Upgrade	\$1640K	42	Reliability
25	(4.5) FPQ-19 Range Machine Upgrade	\$440K	12	User Needs
26	(4.7) MPS-36 Optics Upgrade	\$700K	18	User Needs
27	(4.13) Film to Video Conversion	\$1460K	13	Efficiency Improvement
28	(4.15) C <sup>5</sup> CS System Completion	\$750K	14	Efficiency Improvement
29	(4.16) Inter Island Undersea Fiber Optics System	\$8100K	48	User Needs
30	(3.8) TRADEX S-Band Refurbishment	\$2M-25M	24-60	User Needs & Reliability
31	(4.8) MPS-36 Feed & Receiver Replacement	\$2000	36	User Needs
32	(3.10) MMW 20 dB Sensitivity Enhancement at 95 GHz	\$1200	14	User Needs
33	(3.13) MMW C-Band Beacon Tracker	\$7000	30	User Needs
34	(4.17) FCA Van Upgrade	\$345K	12	Reliability & Security
35	(4.9) Telephone System Expansion	\$250	4	Reliability & Efficiency

## 6.2 Priority Discussion

The most immediate and universal need from the User Needs study was the need for optical data measurement capability. The available platforms for obtaining this data are all airborne and all are vulnerable to cloud obscuration. Therefore more accurate meteorological predictions will be necessary in order to utilize the optical instruments and platforms. For this reason accurate

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meteorological prediction capability becomes a very important asset for satisfying this user need. However, multi-object tracking capability was also an indicated need from the user needs study and there are several modifications that would provide this capability. The meteorological modifications do not provide optical data directly, and thus were given slightly lower priority than actual sensor modifications that satisfied user needs.

Another important need from the User Needs survey is the need for multiple object tracking capability. Therefore, the modifications to provide this capability are also of very high priority. Modifications 4.1, 3.7, 3.3, and 3.1 are given very high ratings, ordered by cost.

Additional telemetry capability was stated by the users as needed for future tests and resulted in modifications to provide that capability also receiving a high priority.

Following these high priority items based on user needs, some reliability, and efficiency improvement items received fairly high priority because of their importance for maintaining the test range capability and their relatively low cost. Cost becomes an important consideration for the more expensive modifications because ten (10) \$800K projects can be done for the price of one \$8M project.

It should again be emphasized that this was a user needs based sensor study. Therefore considerations needed for range operations such as communications and security improvements naturally receive a lower priority than actual sensor improvements. Also, some modifications which have major reliability implications will move up in priority as the existing system deteriorates. Therefore these priorities are dynamic rather than static.

Another important factor is that these priorities are meant to be generally lumped and the specific order in a neighborhood has frequently only cost significance. For example, looking at priorities on a higher level, there are only ten priority levels. These are:

- |   |                              |
|---|------------------------------|
| A | 4.1, 3.7, 3.3, 3.2, 4.4, 3.1 |
| B | 5.3, 5.2                     |
| C | 4.12, 4.11, 4.19             |

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D	5.1, 3.5, 4.2, 3.11, 4.10
E	4.14, 3.9, 3.12, 3.6, 4.18
F	3.4, 4.3, 4.6
G	4.5, 4.7, 4.13
H	4.15, 4.16, 3.8, 4.8
I	3.10, 3.13
J	4.17, 4.9

These levels represent comparable modifications (for example F is all computer upgrades) whose major impact is similar and where order or modification selected for initial implementation is largely cost-based.

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