Time Line-Synopsis of Loran Exposure History

by ETCM Charles Severance (USCG, ret.) 2007

23 Jun 1979: Chief of Staff (G-CSP) (file 6260.6), concurs with a recommendation by Chief of Engineering (G-EEE-3/63) file 5001 on 17 Apr 1979 to initiate a program to monitor radiation exposure of USCG Personnel.

- Safety Program Division requests (G-CSP) to develop a program to insure Coast Guard personnel are not being overexposed to ionizing radiation.
- (G-CSP) asks Office of Health Services to include medical monitoring programs in the proposed overexposure program.
- Action is based on radiation fears stemming from electronic sources emitting EM (electromagnetic) radiation cited in finding number A-70-13-79.

May 1980: Electromagnetic Radiation Survey of US Coast Guard Omega, Loran-C, and Communication Stations by William McEnroe, M.H.S, USCG Safety Programs Division.

31 August 1982: Pacific Area Environmental Health Officer (file 65260), summarizes visit to Lorsta Middletown to assess if X-rays generated by USCG Loran station transmitters pose a significant X-ray risk at times other than when the power amplifier (PA) compartment doors are open.

- Wearing corrective lenses or safety glasses would reduce the effects of soft X-rays to a negligible level when the PA doors are open.

- X-rays produced by Loran transmitters are so low level that they attenuate quickly in air.
- Only one transmitter is assumed to operate at a time.
- The greatest risk from Loran X-rays is to the eye since they have very low penetrating power. These low level X-rays would preclude significant internal absorption."
- Fears of increased radiation from older tubes are unfounded since older tubes would normally be replaced due to changes in "wave characteristics."

6 October 1982: Pacific Area Environmental Health Officer (file 65260) summarizes second visit to Lorsta Middletown to assess if X-rays generated by Loran station transmitters pose a significant risk. Survey was conducted at a low power single rate AN/FPN-44 Loran station (Lorsta Middletown). Site was selected because of its convenient location. Survey was conducted by a PACAREA Health Officer and a Health Physicist from USPHS (FDA). The biggest concern of inspectors is electrical shock due to technicians working behind open interlocked doors and spaces.

- X-rays are found to pose no significant human health hazard.
- The very low intensity Loran X-rays do not warrant including LORSTA personnel in a Coast Guard personal film badge program.
- X-rays at closed PA doors consist of soft radiation ranging from 2.5 mR/hr to 5.5 mR/hr. Radiation fell off to undetectable levels one foot from cabinet glass door.
- X-rays one foot from PA door plane with the PA door open are 16 mR/hr. No other readings were reported, nevertheless, the

intensity is determined to be so low that it does not pose a risk to human health.

- Request PACAREA to establish a policy forbidding the circumventing of interlock systems to make emergency repairs in order to avoid any possible but unlikely radiation issues.

19 Jan 1983: Decision Paper, Chief, Safety Programs Division (G-CSP-4) (file 16564) raises concerns of non-ionizing and ionizing (X-ray) radiation at Omega, Loran-C, Commstas, aircraft, and vessel radar systems based on reports including Electromagnetic Radiation Study of USCG Omega, Loran-C and Communication Stations of May 18 1980.

- A 1979 survey conducted at various Loran Stations and Omega Stations revealed excessive exposure situations.
- Concerns are raised over potential injury to women of child bearing years and the unborn fetus.
- Many of the recommendations of previous radiation studies were not implemented.
- Federal law requires an ongoing effort to ensure that personnel are protected from excessive radiation exposures. Coast Guard does not have such a program.
- X-rays produced by High Voltage equipment in the USCG can potentially cause a variety of physiological problems ranging from severe tissue burns, to cancer and death.
- Although the health risk from some x-ray sources is minimal, not all sources have been evaluated.
- Concerns over USCG exposures are raised due to emerging scientific data indicating adverse physiological effects of

exposure to low frequency EMF, and long term low level exposure to radiation.

- Possible differences between equipment operating parameters and routines effecting higher radiation doses is cited for equipment of the same type and group.
- CCGD14 and PACREA Commanders strongly support investigating impact of radiation exposure on personnel and dependents.
- Recommended epidemiological studies are considered too expensive, and possibly unfeasible due to the small cohort.
- Dr. Guy should conduct a radiation survey of all Loran and Omega facilities within the 50 states. If significant exposure patterns are discovered, then NIOSH should assist in development of an appropriate surveillance program for CG personnel and dependents.

11 Apr 1984: COMDT (G-TES-4) (file 16564), possible EM radiation exposures to civilians due to surplus US government land sales near USCG transmitting sites.

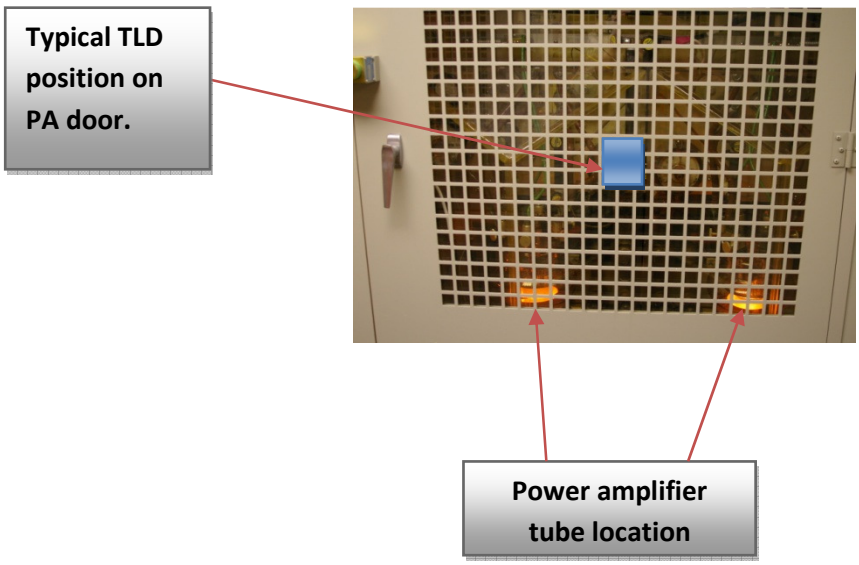
15 Oct 1986: Commandant file 6260, authorizes Paul Gailey to conduct Radiation Exposure Study at eleven USCG Loran/Omega stations.

9 June 1987: USPHS (FDA) Division of Intergovernmental Programs/CDRH in Rockville, MD, special radiological survey at Lorsta Gesashi.

- Seven radiographic film and TLDs to be positioned (one) per power amplifier cabinet when transmitter is on air.

- TLD positioned on outside of each PA tube cabinet avoiding obstruction by the metal grate which makes up the cabinet. The TLD's were centered on the outside of the glass door, and not aligned with the PA tubes or Drivers. The TLD's were above and between the tubes facing into the transmitter.

Right Half of a PA Compartment



- Testing of the second transmitter was done in the same fashion as the first, when the second transmitter was on air.
- Two sets of TLDs were kept away from the radiation as controls.
- TLDs were kept on each transmitter for seven days.
- Sketches of TLD placement, and transmitter spaces were made by the Loran crew for use by USPHS (FDA).
- All TLDs were returned to USPHS (FDA) in Rockville, MD when completed.

- Surveys were also conducted at all USCG Far East Section (FESEC) transmitter sites, and Lorsta DANA, IN.

17 June 1987: USPHS (FDA) Division of Intergovernmental Programs (HFZ-230) in Rockville, MD addresses X-ray exposure concerns of Lorsta Dana crew following radiological survey.

- Testing indicated a great deal of variance in dosimetry between TLD locations on PA cabinets.
- Variance in radiation values are not estimates of exposures by personnel, but estimates of exposure in the air near the amplifier tubes at the position of each TLD.
- Transmitter s/n 19's highest radiation readings are 2.8mR/hr and 3.4 mR/hr.
- Transmitter s/n 20's highest radiation readings are 4.1 mR/hr and 8.0 mR/HR.
- Total annual PA exposure time of 811 hours based on daily transmitter checks of 15 minutes per day (91 hours per year), and combined corrective and preventive maintenance totaling 60 hours per month (720 hours per year). Total exposure time rounded up to 900 hours per year.

Daily Transmitter Checks	91 hours/year
Combined maintenance	+ 720 hours/year
	811 hours annual exposure

Note: Total annual exposure time rounded up to 900 hours

- Total annual radiation exposure calculated: 2.5 rem/year and 3.1 rem/year for transmitter s/n 19, and 4.1 rem/year and 8 rem/year for transmitter s/n 20.

Transmitter s/n 19 annual dose based on highest X-ray reading

3.4 mR/hr	(maximum survey X-ray reading)
X 900 hours	(estimated annual exposure time)
3.1 Rem/year	

Transmitter s/n 20 annual dose based on highest X-ray reading

8.0 mR/hr	(maximum survey X-ray reading)
X 900 hours	(estimated annual exposure time)
7.2 Rem/year	

- Power fluctuations within any one of the PA tubes may be responsible for differences in PA tube doses.
- Most potential exposure estimates are below the 5 rem/year occupational exposure limit for whole body exposure.
- Distance and partial body exposures provide an additional safety margin.
- A personal dosimeter program is warranted to determine maximum exposure to personnel.

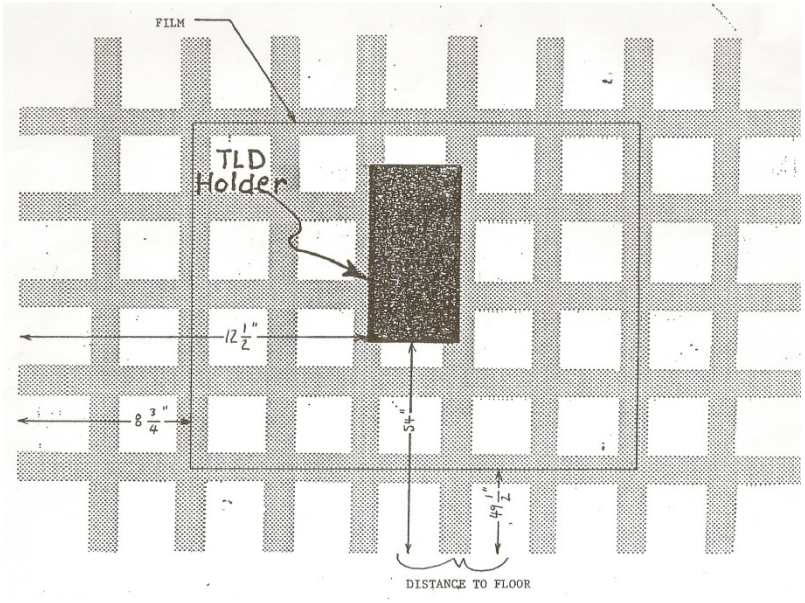
15 July 1987: Final report of Loran-C/Omega Radiation Exposure Study Modeling and Measurement of Electromagnetic Fields Near Loran-C and Omega Station by Paul Gailey.

- Most station personnel are exposed to EM field strength levels far below currently applicable occupational safety standards (AGIH, 1983 adoption).

- Potential problems include exposure to personnel climbing energized towers, high field strengths near tuning coils, and high field strengths near the tower base or feed.
- In some cases the public is permitted on station property and they may be exposed to field strengths greater than ACGIH Occupational Standards.

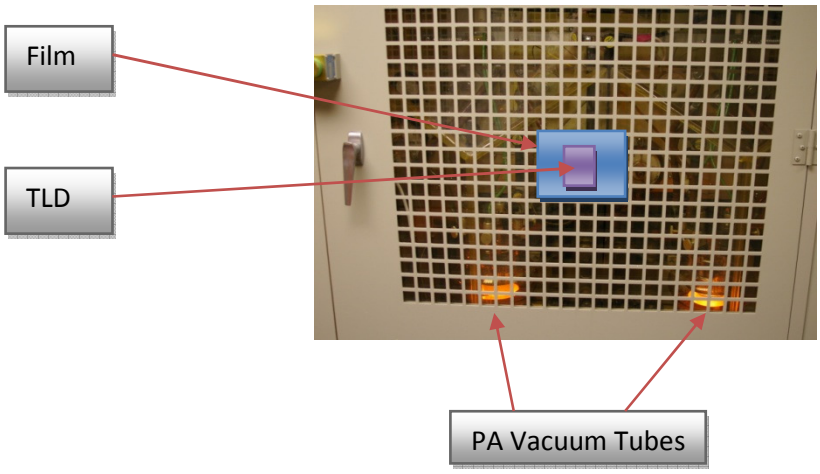
11 August 1987: Lorsta Gesashi (file10550) registers concerns about USPHS (FDA) radiation survey validity.

- Multiple Loran rates could significantly affect (increase) radiation exposure.
- Difference in the number of PA sections, and driver sections could affect (increase) radiation exposure.
- TLD's and film could not be positioned as directed because TLD's and film are much larger than the space in the PA window grate. Metal grating blocked portions of the TLD's.



- Dosimeters should have been placed in front of each PA tube, at tube level. TLDs and film were installed above and between the PA tubes and not directed at the PA tubes.

TLD and film location to scale



December 1987: Commandant (G-KOM-4) requests Loran personal dosimeter program support from Navy Medical Command. Personal dosimeters used by the USCG at medical diagnostic facilities do not function at Loran energy levels (21.5 KeV).

- Only one transmitter is assumed to be operating at any given time.
- Each transmitter is described as having seven amplifier tubes.
- Survey is intended to establish baseline X-ray exposure at each Loran station.
- USPHS (FDA(CDRH)) will not be able to provide support personal dosimeter support until fiscal year 1989

December 1987: Chief, Environmental Health and Occupational Medicine (G-KOM-4) requests funds to start a personal dosimeter

program at Lorsta Gesashi, Hokkaido, Marcus, Iwo Jima, George, and Dana. FDA is unable to provide suitable dosimeters at this time.

- Instantaneous radiological readings were taken at Lorsta Dana by placing special (unspecified) area dosimeters on the glass windows of each transmitter while it was transmitting into the antenna.
- Calculations were made based on 720 exposed hours per year and it was determined that very conservative estimates would yield 3.1 rem/year.
- Personal dosimeters used for medical diagnostic X-rays were left with the crew but found to be ineffective at Loran energy levels (21.5 KeV).
- Dosimeters were provided by CDRH to Lorsta Gesashi, Hokkaido, Marcus, Iwo Jima, and George. Their calculated annual dose estimates were 3.6, 4.3, 1.9, 4.4, and 4.2 rem/year respectively.
- CDRH radiological health physicists became alarmed with dosimeter findings. Recommended that transmitter areas be posted as radiation areas, and that a study be initiated to determine if shielding could be installed on the PA tubes. Commandant (G-KOM-4) responds, “such discussions are premature at this time.”
- Despite calls for establishing safety protocols, principles are convinced that radiation estimates are too high and exposure times are marginalized.
- As a precaution a personal dosimeter program is requested for 100 Loran personnel.

December 1988 : Commandant (G-KOM-4) announces that Navy radiation monitoring program found no significant ionizing radiation exposures at LORSTA Gesashi, Hokkaido, Iwo Jima, Marcus, and George. Radiation monitor program to be discontinued.

December 1988 : Commandant (G-KOM-4) announces that Navy radiation monitoring program found no significant ionizing radiation exposures at LORSTA Dana. Radiation monitor program to be discontinued.

28 June 1993: Subcontractor Hartfield-Dawson reports on Non-Ionizing Radiation Measurements at George Loran-C Station. Hartfield-Dawson is subcontractor for TRA Contractor who was conducting a tower inspection for MLCPAC.

- Tower inspections were to include an EM radiation survey until the OINC at Lorsta George voiced long standing concerns about X-rays. The sub contractor (Hartfield-Dawson) tested and discovered substantial X-rays levels. The contract was then amended to test for ionized radiation at all contracted Lorstas.
- Ionized radiation emissions were localized to the vacuum tubes in the transmitter.
- Measurements of X-rays were measured using the Aware Electronics RM-80 radiation monitor. The professional grade type LND-7313 pancake window alpha, beta, X-ray detector has passed all examinations, inspections, tests and calibrations of the LND Quality Assurance Procedures including DCAS MIL-Q085A, MIL-E-I and appendix B of 10CFR50. Calibration is accomplished in accordance with MIL-STD-45662. Source for

calibration and/or dose rates have calibration traceable to NIST.

- X-ray flux levels were observed to be quite uniform along the panel and window in front of the transmitter output tubes.
- Due to the dispersed nature of the X-ray source the X-ray count did not greatly decrease toward the center aisle between the two transmitters.
- Detailed measurements were taken with the standby transmitter at full power, and exposures were high enough that the total time spent by CG personnel or others in front of the transmitter should be limited in accordance with table G-18 of OSHA §1910.96(b) 29 CFR CH. XVII (7-1-92 Edition) which specifies a maximum dose of 1.25 Rems per calendar quarter.
- Hazardous X-ray levels detected at all contracted Lorstas.

11 November 1993: OINC Lorsta George (file 5103) requests Medical Monitoring Program (OMMP) for station personnel.

- Two separate tests have confirmed X-ray emissions in excess of 5 mR/hr, twice the maximum level of 2.5 mR/hr on page 3.32 part 3-13.2 of NAVSEA000-00-EIM-100.
- Radiation readings qualify transmitters as a "Radiation Area."

24 November 1993: Commander, 13th CG District (oan) (file 5103) strongly recommends personal dosimeter program for Lorsta George.

3 December 1993: USPHS (FDA) Pacific Region Radiation Survey Lorsta George in conjunction with CCGD13 was conducted with a Victoreen

440/RFC Survey Meter on 2 December 1993. Readings of 6 mR/hr were found at a level center to the tube and 1-2 cm from the PA door.

- Since the Victoreen 440 is directional the total exposure from the lineup of the tubes along the hallway may be higher than the readings reported.
- Lead impregnated acrylic shielding was tested and found to be effective in shielding X-rays.
- A personal dosimeter program established in September 1993 resulted in personal exposures of 5.7 mR/hr and 5.9 mR/hr for two of three monitored personnel.
- Concerns of radiation exposure by station personnel were explained as not likely since limits are based not on harm to the individual, but on the maximum amount of exposure that could be accepted by the cumulative gene pool.
- Concerns of radiation exposures on pregnant women were deferred to USPHS (FDA) office in Rockville, MD.

6 December 1993: Commander, 13th Coast Guard District (file 5260) reviews Radiation survey at Lorsta George on 2 December 1993.

- Personal dosimeters revealed exposures well below limits established in §29CFR1910.96 which limits exposures to 1.25 rem per calendar quarter, and 5 rem per year.
- Personnel are advised to start a log reporting times in transmitter room
- A personal dosimeter program will be started.

15 December 1993: Commander, PACAREA (Ptl) 5103 endorses Lorsta George request for monitoring X-ray exposures from nonmedical sources as soon as possible.

- Recommends personal dosimeter programs at all AN/FPN-44 stations in PACAREA, Lorsta Dana, and Actuer.
- Leaded glass in transmitter doors expected to solve the X-ray problem

4 January 1994: USPHS (National Park Service) responds to MLC Pacific (CWO Jones) for historical information on X-ray testing. Important historical files could not be found at USPHS.

10 January 1994: 102233Z Jan 94 COMCOGARD MLC PAC (TES, KSE) acknowledges hazardous X-ray levels detected at Lorsta George, despite broader tests in 1987 that indicated low readings.

- In order to reduce hazardous X-ray levels testing by MLCPAC (TES) on prototype shielding will begin, and if successful a permanent change will be ordered to all tube type transmitters.
- MLCPAC (KSE) will begin an X-ray monitoring program for PACAREA and select stations, to begin immediately and continue beyond the prototype testing period.

12 January 1994: 121709Z JAN 94 COMDT (G-TES-3, G-KSE, G-NRN-1) addresses concerns over X-ray emissions from Loran-C tube type transmitters.

- EECEN to take the lead in researching the type of glass to be used in AN/FPN-44/45 transmitters. A field change will be

issued when the proper glass is identified and exposures one reduced to acceptable levels.

- MLC should take lead in health and safety concerns such as level of exposure and affects of exposure.
- Steps taken to reduce individual exposures, and a personal monitoring program is expected to run until a field change is installed and emissions are brought to acceptable levels.

24 January 1994: Canadian Province of British Columbia, Ministry of Health recommends shielding added to each transmitter at Lorsta Williams Lake to reduce X-ray emissions to zero. Testing concluded that hazardous levels exist without the shielding. Testing was also performed on EM radiation.

NOTE: This is the Canadian report that raised concerns at several different USCG commands about high (22 mR/hr) dosimeter readings obtained by angling the survey meter down the tube throat. Actually the readings were taken between two PA tubes indicating (to some degree) the combined effects of two PA tubes on one location.

- Three different survey meters were tested and then used at Lorsta Williams Lake to confirm X-ray levels. The Keithley Model 36355 ion chamber was the most accurate.
- A table is provided to illustrate radiation readings
- A table compares the dosimetry of each survey meter.
- Radiological survey made 60 cm from the floor, where the highest reading was detected.

- Transmitter-one operating into the dummy load with full plate voltage at 0.5 amp produced 3.3 mR/hr on the PA section panel, and 10 cm from the PA section door 2.0 mR/hr
- Transmitter-two operating into the antenna at 1.0 amp with full plate voltage produced 11.4 mR/hr on the PA section panel and 5.8 mR/hr 10 cm from the PA section panel, and 3.6 mR/hr 20 cm from the PA section panel.
- Transmitter-one operating into the antenna at 1.0 amp with full plate voltage produced 22 mR/hr between two PA tubes about 5 feet above the ground.

1 February 1994: Canadian Ministry of Health, Radiation Protection Services conducted X-ray survey at Lorsta Port Hardy which operates a solid sate transmitter, AN/FPN-64(v), and no x-rays were detected.

14 February 1994: Commander, MLCPAC (file 6260.6) requests inclusion of nine Loran stations into US Naval Dosimetry Program.

16 February 1994: Canadian Health and Welfare, Radiation Protection Bureau, Ottawa, Head of Non-medical X-rays Physicist strongly recommends installation of proposed lead-acrylic impregnated shielding to attenuate radiation to background levels.

- In the interim personnel should minimize occupancy where X-rays emissions are suspected.
- Lower settings should be used when tuning the transmitters to reduce radiation.

- Considering the measured exposure levels and personal occupancy in such areas, TLD dosimeters are neither recommended nor warranted.

21 February 1994: Canadian West Coast Coordinator of Chain Operations (COCO) references Canadian letter of 16 Feb 1994 expecting shielding to be installed and personnel monitor program to be dropped if the shielding is installed.

22 February 1994: Canadian West Coast Coordinator of Chain Operations (COCO) references his own memo on 21 Feb 1994 and expects that shielding is to be installed and personnel TLDs will not be issued.

- This memo to receive wide distribution among individuals involved in X-ray issue.
- Requests time table for installation of lead impregnated glass.

23 February 1993: CCGD13 (dsh)/D13N11, Radiation Health Monitoring update.

- G-KSE decides not to get involved in TLD badge request and never forwards request to UPHS (FDA) to start program .
- MLCPAC has made arrangements with Navy to begin personal dosimeter program sometime around the end of March 1994.
- USN at Bethesda to run personal monitor program with USN Oaknoll assisting.
- First lead-acrylic shield testing to be conducted at Lorsta Middletown 2nd week in March all other stations 3rd week of March 1994.

24 February 1994: 241655Z Feb 1994 COMPACAREA receives alarming concerns from Canadians that 4PR60C vacuum tubes are emitting X-rays in the modulator section of their radars.

- Canadians report that the tubes emit higher levels of X-rays as the tubes age. Radiation increases to a level more than enough to pose a potential hazard to personnel during troubleshooting while the equipment door is open.
- It is now standard practice in Canada to use a portable X-ray monitoring device to determine which tubes are emitting high amounts of X-rays so they can be replaced.
- Technical data provided by vacuum tube manufacturer EIMAC provides a warning that X-ray emissions increase significantly with tube aging while operated at voltages over 10KV.
- 4PR60C vacuum tubes are used in VTS Puget Sound Radars, and the SPS-64 radar aboard ships.
- Request follow-up dissemination of safety alert to all units with subject equipment.

1 Mar 1994: MLCPt-142292 issues purchase order to construct four prototype X-ray shields.

25 Mar 1994: OIC Lorsta Dana, Out Brief concerning X-ray survey conducted by FDA, PHS, CCG2, and MLCA. X-rays were found to be in excess of OSHA and NAVSEA regulatory standards of 2.5 mR/hr.

- No detectable X-rays were found in plenum, storage room, or in IPA section of transmitter.

- Preventive maintenance in the rear of the 1A6 section does not result in exposure to x-rays from the other transmitter.
- X-ray readings taken with survey meter placed against the transmitter chassis. Levels decreased as survey meter was backed away from the transmitter, but exceeded limits when both transmitters were operating.
- CGPMS records and 3-years of corrective maintenance logs to be used to estimate exposure times and worst case exposure estimates as well as most likely exposure estimates.
- Highest readings were just below the PA section windows through the aluminum panel.
- Lead dental aprons hung on transmitter doors being used to protect personnel from X-rays.
- Concerns over reports that Canadians discovered 22 mR/hr while aiming the survey meter down tube's glass envelope. Attempts to duplicate Canadian finding unsuccessful at this unit.
- X-ray levels were higher on transmitter s/n 20, no mention if both transmitters were surveyed while on air.
- X-ray levels were measured in front of each PA tube at a height of 61", 40", and 34". Radiation levels were highest at 34" and then 40", the least being 61".
- X-ray reading for transmitter s/n 19:

Tube	V1	V3	V2	V4
61" height	0.1 mR/hr	0.2 mR/hr	0.5 mR/hr	1.2 mR/hr
40" height	1.4 mR/hr	1.0 mR/hr	3.0 mR/hr	2.1 mR/hr
34" height	4.4 mR/hr	3.2 mR/hr	7.9 mR/hr	6.4 mR/hr

- X-ray reading for transmitter s/n 20:

Tube	V1	V3	V2	V4
61” height	1.8 mR/hr	4.5 mR/hr	2.1 mR/hr	3.4 mR/hr
40” height	4.0 mR/hr	5.6 mR/hr	5.1 mR/hr	5.5 mR/hr
34” height	9.0 mR/hr	12.5mR/hr	11.5mR/hr	11.5mR/hr

- Walk in area behind the 1A4 section nearest the PA tubes at a height of 45” yielded 3.1 mR/hr in transmitter s/n 20 and 1.4 mR/hr in transmitter 19.

25 March 1994: D213-0015342 Concerns about Lorsta Dana radiological survey on 24 Mar 94 warns that current regulations require that no CG personnel exceed 1.25 rems exposure per calendar quarter or 5 rems annually.

- Request made to include OMSTA Lamoure in personnel dosimetry program run by MLPCPAC.
- Strongly recommend installing shielding as soon as possible, followed by further surveys to ensure maximum reduction in exposures.
- Warning that prediction of personal quarterly or annual dose is dependent on the exposure rate used and time of exposure. Some unpredictable factors such as unexpected maintenance hours and both transmitters being on line for extended periods will increase total dose received.
- Comparison of readings at Lorsta George of 6 mR/hr to Lorsta Dana of 12.5 mR/hr.
- Dental aprons installed at Lorsta Dana immediately after exposures were reported at Lorsta George.

20 April 1994: USPHS (FDA) Midwest Region Lorsta Dana radiological survey report.

- Survey meter was Victoreen 440 RF/D and reading reported to be slightly higher than actual because values are uncorrected for meter's calibration correction factor.
- Radiological readings are provided in Lorsta Dana Out Brief on 25 Mar 1994.
- "Except for the exposures measured in the passageway, all other area exposures were either non-detected or at a location in the xmtr cage area which would not significantly contribute to personal exposures."
- Hi-potting of vacuum tubes does not contribute to personal radiation exposures.
- Regarding survey readings taken within 0.5 centimeters of the glass plane, "It is unrealistic to expect personnel would spend more than a few minutes of operating at this distance from the access doors."
- Estimated personnel exposures have been based on the maximum radiation exposure measured at the location in the middle of the passageway between transmitters.
- OIC Lorsta Dana estimated that total maintenance time in X-ray effected area to be 865 MMH per year.
- Based on 865 MMH per year and an average exposure of 1.8 mR/hr (highest reading at passageway center) the maximum annual exposure for one person doing all the work would be 1.55 rems .

- Personnel at Lorsta Dana have hung lead aprons to effectively minimize exposure to X-rays.
- Recommend the use of clear plastic glass instead of lead aprons.
- Existing safety glass offers a reasonable degree of radiation attenuation.
- Distribution of maintenance man hours between technicians should insure personal exposures are below annual exposure limits.
- There should be no concern of occupational radiation exposure to the lens of the eye for station personnel.
- Assistance offered for selecting and verifying the effectiveness of X-ray shielding.

16 May 1994: OIC Lorsta Dana LorDa-001850 Out Brief concerned with MSDS, and DOD Hazardous Material Information System (HMIS) on 4PR1000A .

- HMIS reports .007 uC of thorium in tube construction
- Exposure only occurs if tube is broken
- MSDS states that cleanup protocol should be the same for any radioactive tube. CG cleanup instructions are in USCG M10550.25 chapter 2.
- Cleanup instructions call for radiac equipment to monitor space after tube is broken.
- Instructions on disposal are outdated and demanding.

17 May 1994: OIC Lorsta Dana LorDa-001872 radioactive 4PR1000A vacuum tube handling and disposal due to Thoriated Tungsten. Other Loran tubes include F-1086 and 8C25N.

25 May 1994: MLCPt-164328 distributes 88 dental lead aprons for interim X-ray protection to Lorstas George, Attu, St Paul, Kodiak, Tok, Shoal Cove, Middletown, Fallon, Searchlight, Williams Lake.

- Prototypes of clear lead shielding is progressing but requires more funds, at least $150,000.

3 June 1994: Commander, MLCPAC 6260 announces Loran station radiation dosimetry program run by the US Navy for Lorstas Attu, Fallon, George, Kodiak, Searchlight, Shoal Cove, Tok.

1 July 1994: MLCPk-1043102 fields question concerning US Navy radiation dosimetry program at Lorsta's.

- Lorsta George wants to know why the Occupational Monitoring Program delineated in the Navy Radiation Program has not started. Regular quadrennial physical exams already cover all clinical laboratory tests required for medical monitoring program. However SF-93 (Report of Medical History does not contain additional questions concerning history of radiation exposure and related family history. Finally, instituting a new OMMP program is a decision for COMDT (G-KOM) not MLC – talks are ongoing.
- Additional questions concerned handling of dosimeters.

15 July 1994: Commander, Coast Guard District Two 6260, Lorsta Dana X-ray exposure concerns and validity of 21 Feb 1994 FDA radiological survey.

- FDA calculations on exposure times were based solely on CGPMS (Preventive Maintenance) and found to be 180.5 MMH semi-annually. Documented Feedback Reports (FBR) indicated that technicians actually performed 432.5 MMH of maintenance semi-annually.
- Exposure times were estimated with only one transmitter at full plate potential. It is not uncommon for the standby transmitter to be running at full plate voltage for extended periods while being maintained. This scenario substantially increases the exposure levels.
- Annual dose predictions are based on one person performing entire workload. It is common practice for several personnel to work on the transmitter simultaneously.
- Undocumented work other than maintenance is also conducted for reasons such as training, testing, inspecting and tasking.
- Transit time to and from the coupler room is not considered.
- Exposure to visitors and women is not addressed.
- Exposures to fetuses are not addressed.
- Recommends installing shielding and follow-up with periodic monitoring.
- Limit exposure times in transmitter area.
- Maintain a personal dosimeter program even after shields are installed.

- Designate the area between the transmitters as a “Radiation Area” in accordance with §29CFR1910.96.

5 August 1994: MLCPt-181405 prototype clear plastic X-ray shields arrive at MLCPAC.

- Prototype X-ray shields to be installed at Tracen Petaluma on the week of 15 Aug 1994 to avoid disrupting an operational unit.
- Follow-up test to take place at Lorsta Middletown.

25 August 1994: Commanding Officer, CG Civil Engineering Unit Oakland 11000 Transmitter Emission of X-rays discovered during contractor testing of CEU Loran towers by contractor TRA and its sub-contractor Hartfield-Dawson.

- Most significant hazards discovered are from X-rays.
- Reports were provided informally to surveyed Lorstas shortly after actual inspections.
- Inspections found hazardous X-ray levels at all inspected Lorstas:
    - Lorsta Havre, July 26, 1993
    - Lorsta George, June 28, 29, 1993
    - Lorsta Fallon, August 13, 1993
    - Lorsta Middletown, August 26, 1993
    - Lorsta Searchlight, August 5, 1993

11 October 1994: Nuclear Associates of Carle Place, NY acknowledges successful testing of prototype impregnated acrylic shielding and confirms pricing for future orders.

21 October 1994: USPHS, FDA Pacific Region, Radiation Survey at USCG Lorsta Middletown on 6 Oct 1994 as follow-up to Lorsta George survey on 2 Dec 1993.

- X-rays are produced across voltage potentials exceeding 15 KV, and these low energy X-rays may be attenuated by wood, sheetrock, glass or thin metal.
- Loran transmitters operate at a maximum voltage of 21.5 KeV yielding X-rays with sufficient energy to penetrate thin metallic paneling.
- Fortunately, most transmitter tubes are placed well within the controlled areas at these stations and are off limits to unwary public.
- Hot spots were detected 5 mR/hr adjacent to each operational transmitter through the metallic paneling at about 3-4 feet above the floor (groin and lower chest level).
- Highest reading detected at face level near transmitter s/n 7 tubes 1A6V2 at 10 mR/hr and 1A6V4 at 8 mR/hr.
- Radiation results at each PA tube at lower chest/groin level for transmitter s/n7:

Tube	V1	V3	V2	V4
Tube Hours	1630	2000	1700	110 0
Milli Amps	.35	.36	.40	.31
X-rays	1.5 mR/hr	2.25mR/hr	5.0 mR/hr	1.8 mR/hr

- Radiation results at each PA tube at lower chest/groin level for transmitter s/n 8:

Tube	V4	V2	V3	V1
Tube Hours	1400	1400	1400	1640
Milli Amps	.29	.20	.28	.23
X-rays	2.4 mR/hr	1.5 mR/hr	1.0 mR/hr	0.9 mR/hr

- Exposure readings for TLD's were placed on the transmitters from March 25 to July 27, 1994 yielding 1.32 Rem for transmitter s/n7 and 0.68 Rem for transmitter s/n 8.
- Recommend applying principles of ALARA.
- Recommend legible radiation area warning signs be posted.
- Recommend personnel to continue wearing personal TLDs.

3 November 1994: MLCPt-204823 Lorsta George X-ray survey localized much higher radiation levels while testing affects of prototype impregnated acrylic shielding. Radiation readings were significantly higher than previous surveys which did not consider transmitter drive and geometrics of radiation through glass envelope of PA tubes. Survey was done with Victoreen 441 Ion Chamber Survey Meter.

- Radiological survey was conducted with consideration given to standby transmitter drive level. Standby transmitter drive was increased so that PA cathode currents were similar to on-air operations so that x-ray readings would be realistic.
- X-ray readings were taken at different levels including one geometrically aligned into the envelope of the tube.

- No correlation was found between new and rebuilt tubes and increases in radiation.
- Standby transmitter was found to have significantly higher radiation levels per tube.
- 1A8 rack of PA tubes had significantly higher average radiation readings
- Radiation was not detected at the Driver 1A9.
- Radiation levels in Transmitter-one, at levels 55 inches high and angled into tube envelope (55A), 54" high, and 38" high:

	Operate Mode in mR/hr			Standby Mode in mR/hr		
Tubes	55" A	54"	38"	55" A	54"	38"
1A6V1	2.1	2.5	2.2	5.0	4.7	3.2
1A6V3	8.8	6.0	4.8	12	6.0	7.0
1A6V2	7.6	5.4	5.5	16	13	7.8
1A6V4	3.8	3.8	3.9	7.2	6.4	5.8
1A7V1	4.3	4.4	2.2	7.0	6.3	3.0
1A7V3	8.4	6.3	3.0	16	14	7.0
1A7V2	4.2	3.0	3.8	11	7.6	5.4
1A7V4	6.6	6.1	4.1	14	11	6.4
1A8V1	11	7.4	6.2	22	16	8.0
1A8V3	6.3	4.2	5.6	14	9.0	8.2
1A8V2	8.4	5.8	5.4	15	10	6.5
1A8V4	12	10	7.8	20	17	10

- Radiation levels in Transmitter-Two, at levels 55 inches high and angled into tube envelope (55A), 54" high, and 38" high:

	Operate Mode in mR/hr			Standby Mode in mR/hr		
Tubes	55" A	54"	38"	55" A	54"	38"
1A6V4	4.9	4.1	2.2	7.2	5.4	3.6
1A6V2	6.4	4.5	4.4	12	7.1	7.8

1A6V3	2.5	1.4	1.8	4.4	3.2	3.2
1A6V1	2.1	1.8	1.8	3.4	2.6	2.6
1A7V4	1.2	0.7	1.4	1.6	2.2	2.8
1A7V2	2.3	2.2	2.8	5.0	3.8	4.4
1A7V3	3.2	3.0	2.1	5.9	4.5	3.6
1A7V1	6.0	5.3	5.0	12	8.6	8.0
1A8V4	shielded	shielded	shielded	7.8	5.2	6.2
1A8V2	shielded	shielded	shielded	12	9.8	5.4
1A8V3	shielded	shielded	shielded	5.9	4.5	4.0
1A8V1	shielded	shielded	shielded	16	7.2	9.5

Note: Tubes mark shielded had prototype shields which absorbed all measurable radiation.

22 November 1994: Naval Dosimetry Center Bethesda, MD registers concerns on posted TLDs in Loran personal monitor program.TLD badges are suspected of not being used properly.

- Posted dosimeters are to be placed on the boundary of controlled areas NOT on the equipment.
- Exposure results of more than one TLD routinely in excess of 500 mrem.
- TLDs posted on equipment are not an accurate reflection of personal exposure or verification that personnel did not exceed 100 mR/year.
- Subjecting TLDs to high exposures can leave a permanent residue dose on the TLDs and render them unusable for future use.
- Lorsta's are directed to reposition the TLDs to the appropriate boundary between the controlled and non-controlled areas.
- Lorsta's are directed to continue the personal dosimeter program and to badge personnel.

14 December 1994: Commander, Maintenance Logistics Command (kse) (file 6260/CN1689), overall assessment of US Navy radiological survey support for USCG Loran stations.

- There appears to be two distinct personal dosimetry programs, one started in 1988 and the current program beginning in May 1994.
- Current personal dosimeter program began due to USPHS (FDA) testing at Lorsta George. Survey detected readings as high as 6 mR/hr at the aluminum door panel across from the center of a PA tube.
- TLD's provided for personal dosimetry read 4.6 mR/hr . Note: This was a fixed TLD mounted on the transmitter that fell off at an unknown period of time, and replaced at a different location.
- Three personal monitors at Lorsta George revealed:

Badge Nr.	mrem	hours	mR/hr
One	0	1.25	0
Two	25	4.25	5.9
Three	30	5.25	5.7

- There does not appear to be any significant exposure to personnel working at the AN/FPN44/45 Lorstas, since all personal dosimeters register readings of 0 rem, with the exception of two .004 and .003 from Lorsta Attu.
- Dosimetry results from the present program are consistent with those found in 1988 study. Virtually all area monitors indicated some ionizing radiation ranging from 0.003 to1.317 rem.

- Prudent safety precautions dictate installing shielding.
- Clear Pb shields appear to be an acceptable engineering solution sufficiently reducing radiation to levels in compliance with Nuclear Regulatory Commission's ALARA standard.

2 January 1995: Procurement of 120 impregnated acrylic shields.

29 April 1996: USPHS (FDA) radiological survey follow-up to evaluate effectiveness of shielding at Lorsta Dana.

- Previous survey on March 24, 1994 using a Victoreen 440RF/D survey meter yielded readings of 12.5 mR/hr at 0.5 cm from plane of glass panel
- Current tests using the same instrument at six points in front of the glass of each PA tube indicated no detectable leakage.

30 December 1998: Commanding Officer, ISC Ketchikan 5103 addresses radiation concerns pertaining to female members assigned to Lorsta Shoal Cove.

- Although spaces are deemed safe due to shielding, adequate monitoring to confirm that the shielding is working properly is not available so it is not prudent to allow pregnant women into the transmitter room.
- Recommend that dosimeters be distributed to workers who enter and work in the transmitter spaces.
- State of Alaska will conduct a radiation survey.

21 October 1999: Commanding Officer, ISC Ketchikan radiological survey detects harmful radiation at rear of antenna coupler and calls

for shielding to be installed and area to be designated a “High Radiation Area”.

- Radiation leakage in transmitter area found to be within normal limits
- Narrow beam radiation generating approximately 1.2 Rem/hr detected at the rear of the antenna coupler.

3 November 1999: Lorsta Shoal Cove (file 5100) reports ionizing radiation survey resulting from pregnant USCG member assignment.

- USCG pregnant female non-rate watch stander had her duties altered so that she would not enter the transmitter room to prevent exposure due to possible radiation.
- Radiation study by State of Alaska revealed a hot spot behind the antenna coupler which exceeds regulatory standards.
- Prefer to avoid a dosimeter/film badge program because it is time consuming and tedious.
- Request that safety precautions be reviewed by appropriate authority.

9 April 2002: Lorsta St Paul registers concerns that unlike medical X-ray areas the Loran transmitters do not have protocols in place to warn personnel of leakage radiation around shields. Request starting a program for personal and area monitoring of radiation.

9 April 2002: COCO NORPAC recounts personal recollection of x-ray exposures.

- Wonders how many personnel we had lost in the 30 years prior to the shields being installed? He hasn’t heard of any.

- Although shields block the radiation, personnel should spend the least amount of time as possible in the area.
- Pregnant women should not be allowed to go anywhere near the PA section.
- Although shields are in place X-ray emissions are still present albeit they are blocked by lead-acrylic shields.
- All stations should have an SOP advising against women being in transmitter area, and for personnel to minimize work time in transmitter area.
- If a station is concerned about radiation exposure they should ask for a health audit.

9 April 2002: CWO advises personnel that there is no reason to be concerned about radiation. However, a concerned unit could request an audit of radiation levels.

- As long as effective shielding remains in place no unusual precautions are necessary.
- The decision to remove the pregnant female CG member from Lorsta Shoal Cove due to radiation concerns was for this specific member and not a CG wide policy.
- Current levels of protection are sufficient

9 April 2002: Lorsta St Paul reaffirms concerns about the lack of monitoring devices in the event that leakage should occur in the shielding, etc.

- Recommends a permanent personal monitor program for Loran transmitters very much like the medical diagnostic X-ray program.

15 April 2002: Commandant (G-WKH-1) asks for assistance from Commandant (G-WKS-3) concerning radiation exposures.

15 April 2002: Commandant (G-WKS-3) consensus at this office is that no radiation exposure is occurring based on all previous studies.

- Monitoring personnel for the potential risk of radiation (OMSEP) is not the answer since the effects are not likely for another 15-20 years and "to tell someone you have cancer 20 years after the fact is not of any significant benefit."
- Answer to problem is to obtain radiation monitoring devices or allow members to wear radiation devices.

15 April 2002: Lorsta St Paul agrees that personnel need not be enrolled in OMSEP, but insists that some sort of radiation monitoring program is needed.

- Burn spots on radiation shields are occurring, and there are concerns of shields breaking down without radiation monitoring devices in place.

15 April 2002: Commandant (G-WKS-3) wants to know who has the responsibility for this radiation issue.

- Is there a way to see if there is a problem?
- Cognizant SEHO should make note of this issue.

15 April 2002: Commandant (G-WKS-2) notes that MLCPAC (kse) has already been engaged in this issue. Suggests setting up a TLD, film

badge or some other program to provide an inexpensive way to tell "if the shields are breaking down or whatever."

16 April 2002: MLCPAC (kse) Safety and Environmental Health provides clarification of X-ray issue.

- "OSHA allows 1250 mR per calendar per quarter throughout a working lifetime of occupational exposure."
- "To the best of my knowledge, the shields do not deteriorate, at least not in any sense that matters in this context."
- My memory of testing…..is that the xray emission was low enough that no protection was required, under normal conditions."
- Because there is always a tendency to err on the side of safety, and because the practice … is to limit radiation to levels as low as reasonably achievable (ALARA), a decision was made to treat the potential exposure as if personnel remained in the immediate vicinity of the output side of the tubes for extended periods. Staying in the vicinity of the tubes is defined as, "actually inside the enclosure where the tubes are housed, within the area not protected by the shields."
- If it is possible for members to be exposed to radiation, or if it is determined that personnel should be wearing badges, they should be enrolled in OMSEP.
- A radiation badge program can add significant administrative overhead to a unit, and in the case of Loran does not seem to provide any benefit.
- Recent testing at Lorsta Shoal Cove revealed no leakage radiation.

- Unit policies about minimizing time in the transmitter area are appropriate but only in keeping with ARPA, rather than preventing a known or suspected hazard.

16 April 2002: COCO Southeast and South Central chains, summarizes that there is no reason to fear radiation as long as the shields are in place." Even if they are not in place, both transmitters would have to be running and a person standing between them for days."

- A pregnant USCG SN watch stander previously assigned to Lorsta Shoal Cove was concerned about her fetus so she was restricted from the operations room and transmitter room.
- A pregnant SN currently assigned to Lorsta Shoal Cove was removed from duty in the transmitter spaces based on medical and safety advice from Ketchikan. Command was initially concerned that SN was reacting to previous pregnant SN's actions because it was established that there are no exposure concerns. Member was transferred.
- There is a COMDT instruction about pregnancy and radiation in the CG but it does not discuss Lorstas.

31 March 2003: Richard Tell Associates, INC, Survey Radiofrequency Fields, Contact and Induced Currents and X-rays at Canadian Coast Guard Williams Lake Loran-C Station.

- Survey conducted for potential safety issues that might be associated with RF fields, currents, and X-rays produced by operation of Loran-C station at Williams Lake Canada found that RF electric and magnetic fields were in compliance with

limits in Canadian Safety Code-6 except for RF fields potentially exceeding limits directly beneath the transmission lines.

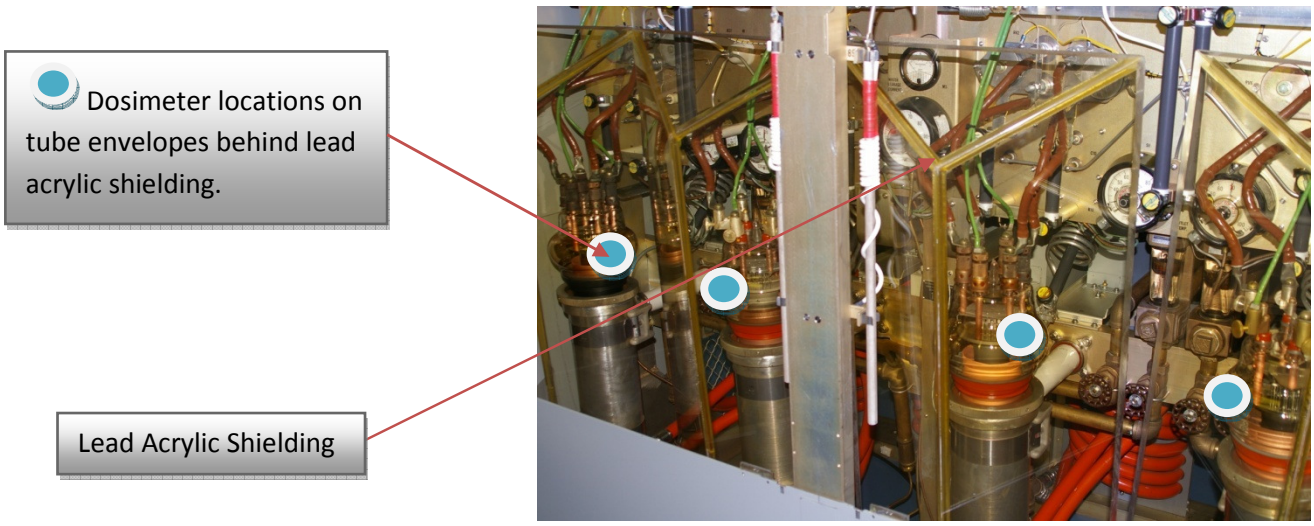
- X-ray leakage inside the transmitter cabinets where personnel may need access during operation were found to exceed limits specified in Canadian Safety Code-6 although annualized whole-body dose limit in Canadian Safety Code 32 may not likely be exceeded.
- Additional concerns:
    - RF interference with medical devices.
    - Gasoline refueling operations.
    - Lack of RF safety signs, training and RF safety awareness.
- X-rays were measured using Siemens Electrical Personal Dosimeter EPD-MK2 (SN 15542) that was calibrated on March 6, 2003 – calibration certificate available.
- EPD-MK2 operates at Loran energy levels, and can measure accumulated dose and incident dose rate with 0.1 mR/hr resolution.
- Dose rate surveys were made by holding the dosimeter at various points near the PA section for several minutes and the maximum dose rate was recorded while the orientation of dosimeter was adjusted for peak dose.
- The EPD MK2 presents dose rates relative to deep dose (H10) and skin dose (H07) values. Both were obtained for each measurement location in the survey.
- EPD MK2 passed extensive tests for susceptibility to RF fields and test results are available.

21 September 2003: Richard Tell Associates, INC., X-ray dosimetry of Lorsta Williams Lake concerned about radiation leakage in accessible areas, and offers two interpretations to X-ray specialist at Health Canada.

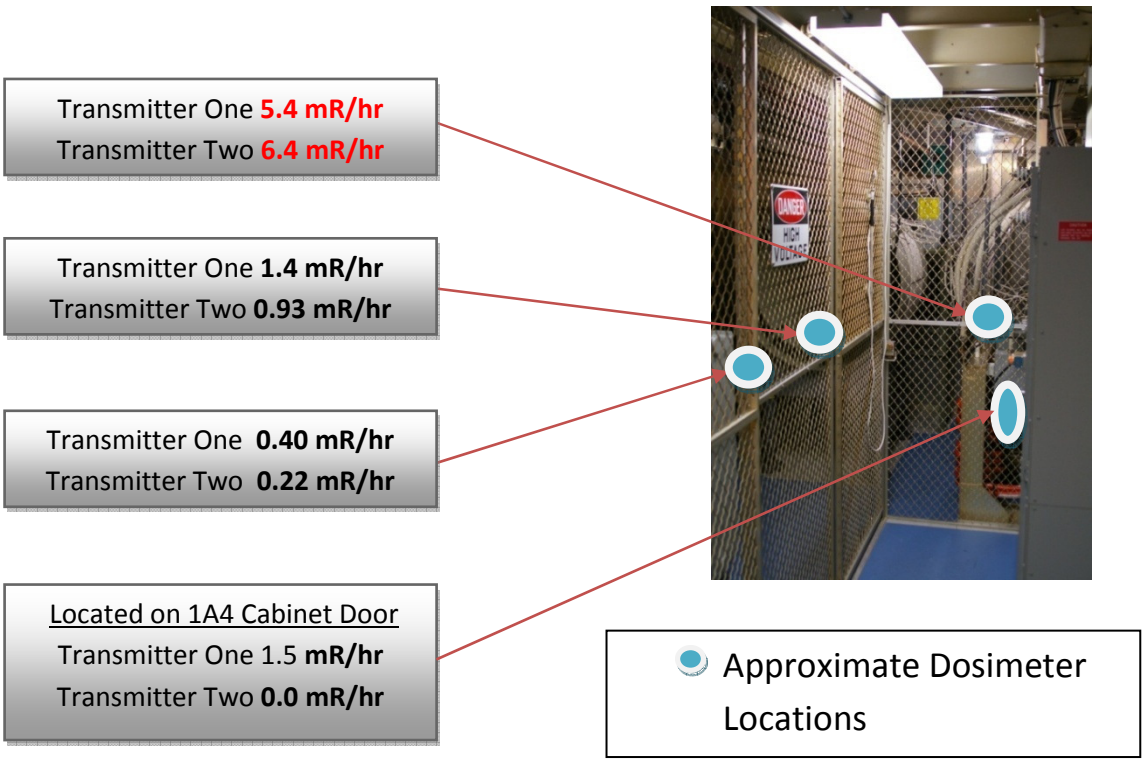
- Dosimeter readings at each PA tube envelope physically located before the tube shielding exceeded dosimeter limit of 1,000 Rad or 1,000,000 mR during the data collection period. Data collection period of 310 hours in transmitter one, and 534 hours in transmitter two.
- Dosimeter readings are made before tube lead-acrylic shield.
- Dose levels were computed at maximum dosimeter levels although their limits were exceeded.
- Data collection period of 310 hours for transmitter-one and 534 hours for transmitter-two with a total dose of 1,000 rads for all tubes except 1A6V3 in transmitter-two:

	Transmitter One	Transmitter Two
1A6V1	>3,225 mR/hr	>1,872 mR/hr
1A6V3	>3,225 mR/hr	>673 mR/hr
1A6V2	>3,225 mR/hr	>1,872 mR/hr
1A6V4	>3,225 mR/hr	>1,872 mR/hr

- Illustration of PA tube dosimetry behind shielding:



- Hazardous Leakage radiation in the access area behind the 1A4 Section cabinet was detected by dosimeters placed on the accessible part of the fence, and 1A4 cabinet door where technicians normally stand when looking for transmitter arcing.



- Dosimeter readings were made at a plane near the PA cabinet doors when the doors were open and shields installed. The highest readings on the right and left side of the cabinet were recorded. These readings indicated hazardous radiation leakage within the cabinet. No radiation is detected past the PA doors when they are closed.

Transmitter One PA Cabinet		Transmitter Two PA Cabinet	
Left Side	Right Side	Left Side	Right Side
1.8 mR/hr	3.1 mR/hr	0.9 mR/hr	4.0 mR/hr

- While there is some distinction between H10 Deep Dose Rate and H07 readings, "It is more than likely that x-ray production inside the transmitter cabinets is contained within narrow beams, making it difficult to identify exact locations of maximum radiation levels."
- Recommend a more complete assessment of possible exposures which may require a long-term strategy such as installing passive dosimeter devices at various points within the transmitter cabinets.
- Recommend longer term measurements for X-ray emissions near the transmitter output circuits.
- Several concerns about EMF radiation are registered in the report but not covered here.

24 March 2005: Department of Veterans Affairs decision for ETCS John F. Milohnick III found that service connection for acute myeloid leukemia is granted on a presumptive basis. An advisory board found

that it is likely that his leukemia is related to exposure of ionized radiation exposure during service at US Coast Guard Loran Stations.

- ETCS Milohnick was suddenly diagnosed with leukemia 24 years after completing a 3.5 year tour at Lorsta George. He died one year later from complications arising from leukemia."

"It Doesn't make any sense to tell someone twenty years later that they have cancer, "