1990 EXERCISE
OF THE
COSPAS-SARSAT 406 MHz SYSTEM

SUMMARY REPORT

C/S R.005
October 1992

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ABSTRACT

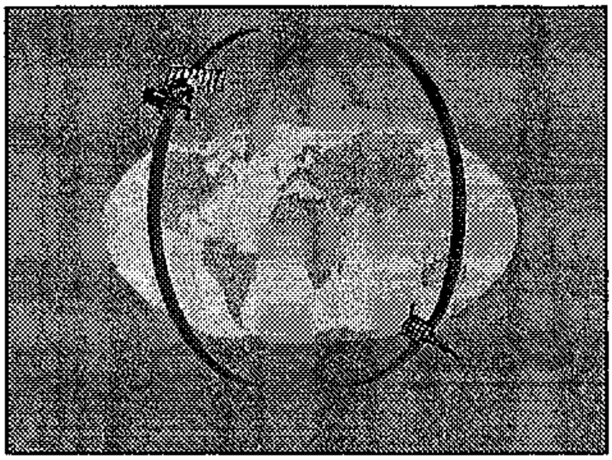
The performance characteristics of the COSPAS-SARSAT International Satellite System for Search and Rescue (SAR) in detecting and processing transmissions from 406 MHz beacons, were demonstrated in a global System Exercise conducted in October 1990.

406 MHz beacons of production quality were activated randomly in a variety of simulated distress environments. The alert and location data provided by the COSPAS-SARSAT System for these beacon transmissions were collected and processed, and the results were compared to predicted values. These results were also compared to the results of a previous System Exercise conducted in November 1986.

The 1990 Exercise results include an assessment of the following performance parameters of the 406 MHz system:

- the probability of locating 406 MHz beacons, the accuracy of the predicted locations and the ability of the System to resolve the Doppler ambiguity;
- the ability of the Ground Segment of the System to correctly distribute 406 MHz alert messages to SAR authorities; and
- the time elapsed from a 406 MHz beacon activation until the alert is received by a satellite, and the time required to process and transmit the alert to the appropriate Rescue Coordination Centre.

The purpose of this Summary Report is to briefly describe the Exercise of 1990 and to document its more significant results. Requests for additional information should be addressed to the COSPAS-SARSAT Secretariat, Inmarsat, 40 Melton Street, London NW1 2EQ, United Kingdom.



ELT	Emergency locator transmitter
EPIRB	Emergency position-indicating radio beacon
PLB	Personal locator beacon
LUT	Local user terminal
MCC	Mission control centre
RCC	Rescue coordination centre
SAR	Search and rescue

SARSAT and COSPAS Polar Orbiting Satellites

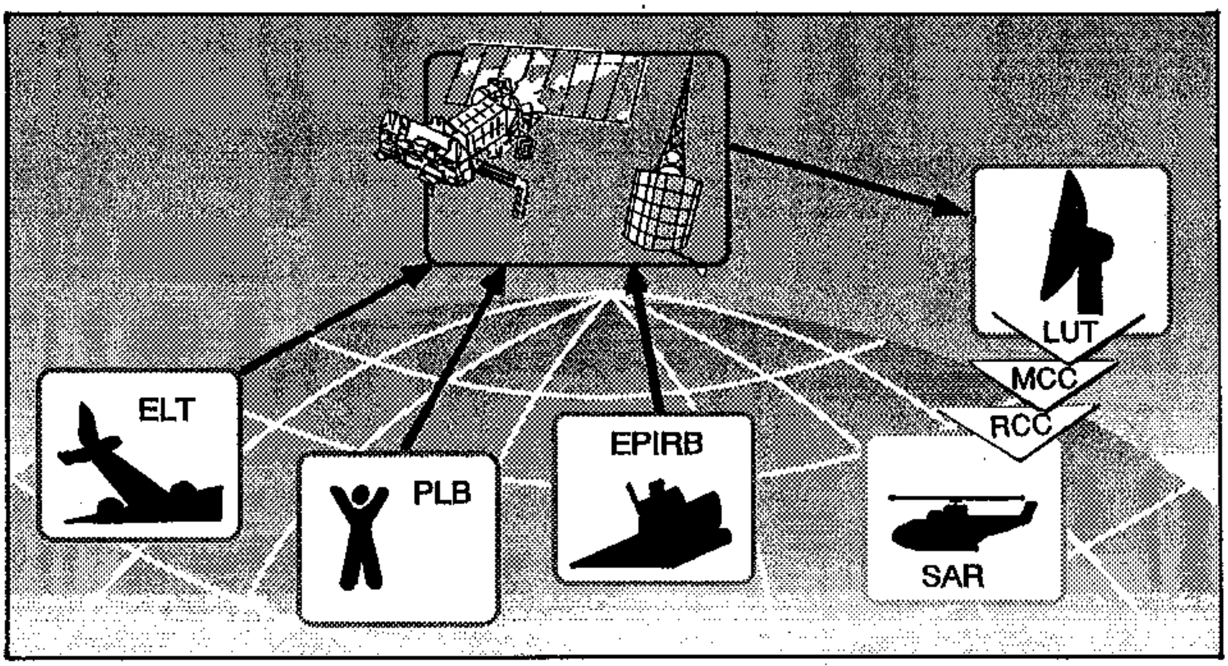


Figure 1 - Basic Concept of the COSPAS-SARSAT System

1. INTRODUCTION

1.1 Background

COSPAS-SARSAT is an international satellite system designed to assist Search and Rescue (SAR) operations, using distress beacons operating on 121.5 MHz or 406 MHz, and providing alert and location data to Rescue Coordination Centres (RCCs). Its objective is to serve all organisations in the world with responsibility for SAR operations, whether at sea or on land.

The COSPAS-SARSAT system is described in the document "Introduction to the COSPAS-SARSAT System" (C/S G.003). Its functional concept is illustrated in Figure 1.

The COSPAS-SARSAT System, in operation since September 1982, continues to evolve in order to provide more complete services to the SAR community: the number of participating countries is increasing and technological changes are implemented to enhance the capabilities of the Ground and Space Segments of the System. Selected segments of the COSPAS-SARSAT System are periodically exercised in order to demonstrate and assess its performance characteristics.

The operational capabilities of the System in receiving and processing 406 MHz distress transmissions were first quantified in the System Exercise of 1986 (document C/S R.002). However, significant changes have been made to the COSPAS-SARSAT System since 1986, including:

- Space Segment: the introduction of enhanced SARSAT satellites with global data broadcast capability (as previously available on COSPAS satellites);

- Ground Segment: the installation of additional data reception and processing facilities (i.e. Local User Terminals (LUTs) and Mission Control Centres (MCCs)); and

- Communications: the expansion of the COSPAS-SARSAT Data Distribution Plan (C/S A.001) to adapt to the expanded environment and to address the various operational situations to be dealt with by the enhanced 406 MHz system.

The operational capabilities of the System in receiving and processing 406 MHz distress transmissions were re-established in the System Exercise conducted in October 1990 (document C/S R.004).

The more significant results of the 1990 Exercise are summarised in this Report and a comparison is made, where applicable, with the results of the Exercise of 1986.

Since 1990, a number of further enhancements have been made to the COSPAS-SARSAT System. Additional satellites have been launched, new Ground Segment elements have been implemented and, based on the analysis of the 1990 Exercise, improvements have been made to the processing and distribution of alert data by the Ground Segment.

1.2 Objectives of the 1990 Exercise

The primary objectives of the Exercise of 1990 were:

a. to demonstrate the performance characteristics of the COSPAS-SARSAT System when processing 406 MHz distress transmissions from operational beacons located on land and at sea;

b. to demonstrate the performance characteristics of the System when processing data from a significant number (i.e. more than 15) of concurrently active 406 MHz beacons deployed worldwide;

c. to demonstrate the effectiveness of the COSPAS-SARSAT Data Distribution Plan (document C/S A.001); and

d. to design a standard Exercise procedure for the COSPAS-SARSAT System which could, with minor modifications, satisfy future System demonstration requirements.

1.3 Overview of the 1990 Exercise Results

The System performance characteristics measured during the 1990 System Exercise are defined in Section 3 of this Summary Report, and the results are presented in Section 4.

Table 1 provides an overview of the 1990 Exercise results and includes, for comparison, the corresponding 1986 Exercise results, when available. In addition, Table 1 includes an assessment of typical System performance regarding Location Accuracy and Ground Segment Fidelity, which results from the correction of a small number of LUT and MCC processing anomalies observed during the 1990 Exercise (see Section 4.4).

Table 1 - Overview of the 1990 Exercise Results

Performance Parameters of the 406 MHz System	Exercise of 1986	Exercise of 1990	Typical System Performance (1)
Single Pass Location Acquisition Probability (LAP)	95%	98%	98%
Location Accuracy within 5km within 10km within 20km	 72% 83% 92%	 84% 90% 94%	 87% 94% 98%
Single Pass Ambiguity Resolution	95%	95%	95%
Ground Segment Fidelity (GSF)	-	95%	98%
System Timing: a) Waiting Time • < 30 minutes • < 90 minutes • Average b) First Message Processing Time • < 30 minutes • < 90 minutes • Average	 40% 72% 53 minutes 35% 85% 56 minutes	 44% 94% 44 minutes 45% 94% 43 minutes	

Note (1): After correction of LUT/MCC processing anomalies identified during the 1990 Exercise.

The 1990 System Exercise results show significant improvements over the 1986 Exercise results, regarding Location Accuracy and System Timing characteristics. This is the consequence of enhancements made to the LUT processing algorithms and to the COSPAS-SARSAT alert data distribution procedures. It also reflects additions made to the Ground Segment and to the Space Segment, although only 3 satellites with the global mode of operation were used during the 1990 Exercise.

At its Seventh Session (CSC-7, December 1991), the COSPAS-SARSAT Council adopted the following conclusions and recommendations regarding the COSPAS-SARSAT System:

- the System effectively detects and processes data from operational 406 MHz beacons and transmits alert messages to the RCC network in a timely fashion;
- the configuration of the Ground Segment is well fitted to the current workload, but, under moderate stress (i.e. 25 beacons operating simultaneously for 12 hours), the transmission requirements exceeded the data transmission capabilities of some of the Ground Segment elements;
- the Space Segment capacity was adequate for all Exercise conditions;
- a number of data processing anomalies associated with the Ground Segment facilities were detected during the Exercise, but have since been resolved;
- Participants in the System should review the quality control procedures that exist within the Ground Segment, and develop appropriate monitoring activities, including procedures for controlling operational 406 MHz beacon performance.

1.4 Reference Documents

C/S G.003	Introduction to the COSPAS-SARSAT System
C/S A.001	COSPAS-SARSAT Data Distribution Plan
C/S R.002	COSPAS-SARSAT Exercise of 1986 (Report to the COSPAS-SARSAT Steering Committee, November 1987)
C/S R.004	COSPAS-SARSAT Exercise of 1990 (Report to the COSPAS-SARSAT Council, December 1991)

- END OF SECTION 1 -

2. DESCRIPTION OF THE 1990 EXERCISE

2.1 Participants

A number of countries were involved in the Exercise. Participants were deployed throughout the world in 34 different countries or territories, as shown in Table 2.

Table 2 - Deployment of Participants

PARTICIPANTS	LEVEL OF PARTICIPATION					
	1	2	3	4	5	6
ALASKA				x		
ANTARCTICA				x		x
ASCENSION ISLAND				x		
AUSTRALIA		x		x	x	x
BERMUDA					x	
BRAZIL				x		x
BULGARIA				x	x	x
CANADA	x	x	x	x		x
CHILE		x	x	x	x	x
DENMARK			x		x	x
FIJI				x		x
FINLAND					x	
FRANCE	x	x	x		x	x
FRENCH POLYNESIA				x		x
GABON				x		x
GREECE					x	
GREENLAND				x	x	x
HAWAII				x		
HONG KONG		x				
ICELAND					x	
INDIA		x	x	x	x	x
ITALY					x	
JAPAN			x	x	x	x
NEW ZEALAND				x	x	x
NORWAY		x	x	x	x	x
PAKISTAN					x	x
REUNION ISLAND				x		x
SOUTH AFRICA				x		x
SWEDEN					x	
SWITZERLAND					x	
UK		x	x	x	x	x
USA	x	x	x	x	x	x
USSR	x	x	x	x	x	x
VENEZUELA					x	

Key to Participation

1: Space Segment Provider
2: Ground Segment Provider
3: Beacon Provider
4: Beacon Activator
5: NOCR Message Recipient
6: Alert Message Recipient

2.2 The Space Segment

The Space Segment used in the 1990 Exercise consisted of four spacecraft: COSPAS-4, COSPAS-5, SARSAT-2 and SARSAT-4.

The SARSAT-2 spacecraft was used in local mode 406 MHz data acquisition only. The SARSAT-4, COSPAS-4 and COSPAS-5 spacecraft were capable of local mode and global mode 406 MHz data acquisition.

However, COSPAS-4 operations were restricted in the Southern hemisphere, due to unstable spacecraft attitudes. Although the 406 MHz uplink to the satellite was available in the Southern hemisphere, thus providing actual global coverage, the downlink to LUTs in that part of the world was significantly degraded.

The status of COSPAS-SARSAT satellites used during the 1990 Exercise is summarised in Table 3.

Table 3 - Status of the Space Segment in the 1990 Exercise

SPACECRAFT	AVAILABILITY OF 406 MHz		COMMENTS
	LOCAL MODE	GLOBAL MODE	
S-2	YES	NO	GLOBAL MODE DATA WAS NOT PROCESSED
S-4	YES	YES	FULLY OPERATIONAL
C-4	YES	YES	FULLY OPERATIONAL IN THE NORTHERN HEMISPHERE AND USED WITH SOME RESTRICTIONS IN THE SOUTHERN HEMISPHERE
C-5	YES	YES	FULLY OPERATIONAL

2.3 The Ground Segment

The COSPAS-SARSAT Ground Segment used during the 1990 Exercise consisted of 10 MCCs and 20 LUTs, as listed in Table 4. This is a significant increase from the 6 MCCs and 11 LUTs that were operating at the time of the Exercise of 1986.

As a consequence, a more complex data distribution network had to be tested in accordance with the procedure of the COSPAS-SARSAT Data Distribution Plan (document C/S A.001). Figure 2 illustrates the geographic distribution of the COSPAS-SARSAT Ground Segment during the 1990 Exercise.

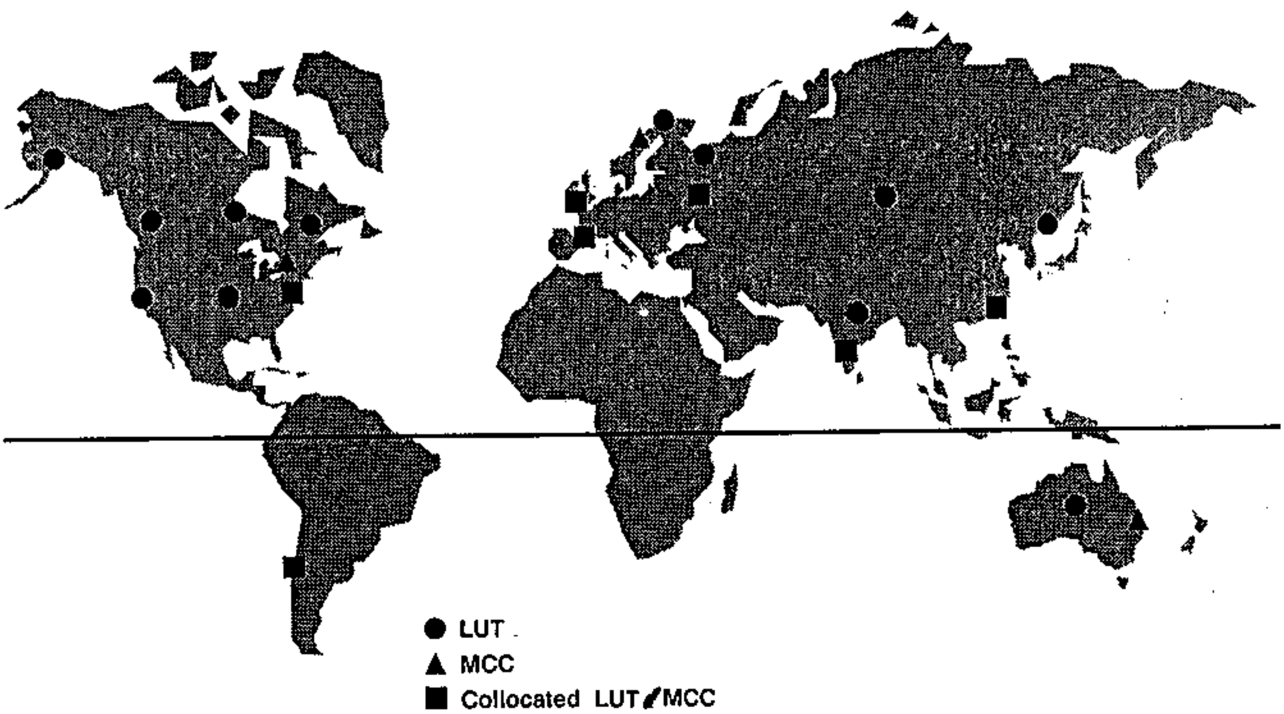


Figure 2 - Geographic Display of the Ground Segment in the 1990 Exercise

Table 4 - List of Ground Segment Facilities used during the 1990 Exercise

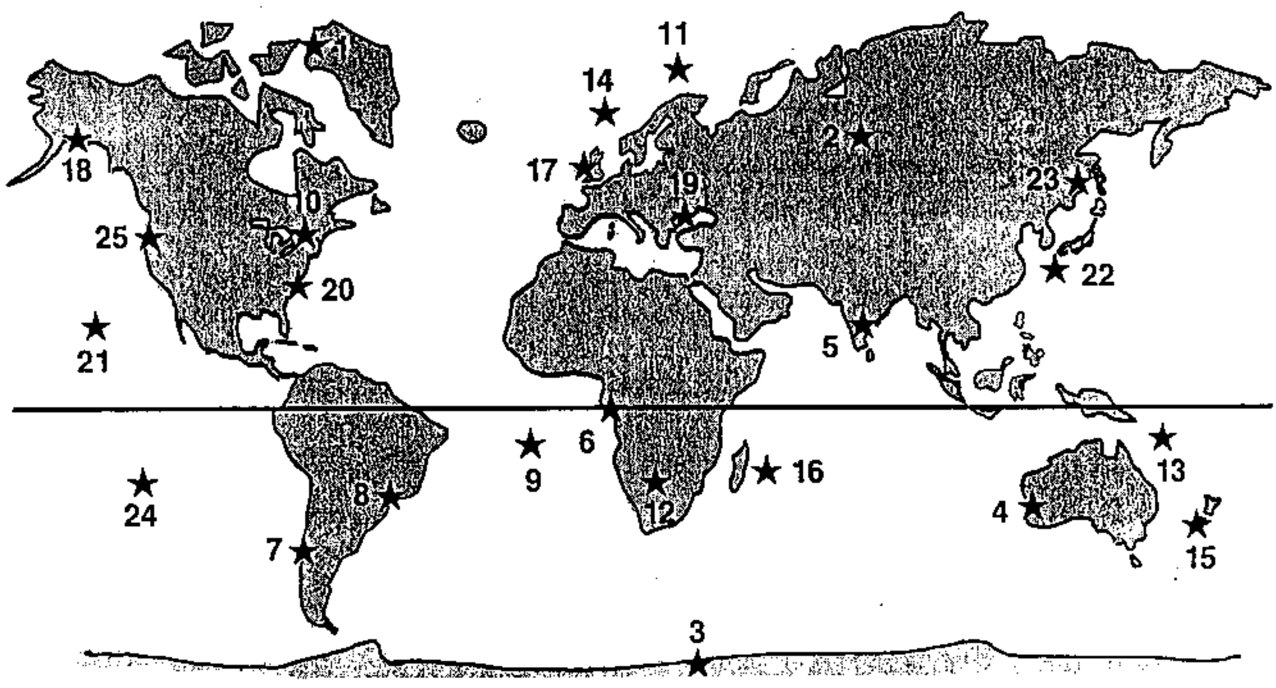
Participant	Mission Control Centres (MCCs)		Local User Terminals (LUTs)
Australia	Canberra	AUMCC	Alice Springs
Canada	Trenton	CMCC	Churchill Edmonton Goose Bay
Chile	Santiago	CHMCC	Santiago
France	Toulouse	FMCC	Toulouse
Hong Kong	Hong Kong	HKMCC	Hong Kong 1 Hong Kong 2
India	Bangalore	INMCC	Bangalore Lucknow
Norway	Bodø	NMCC	Tromsø
UK	Plymouth	UKMCC	Lasham
USA	Suitland	USMCC	Kodiak San Francisco St Louis Washington *
USSR	Moscow	CMC	Arkhangelsk Moscow Nakhodka Novosibirsk
TOTAL	10		20

Note: * The NASA LUT (SEDL) was used during the Exercise to collect additional data but it is not commissioned in the operational COSPAS-SARSAT System.

2.4 406 MHz Distress Beacons

The 406 MHz beacons used during the Exercise of 1990 were of production quality, coded with operational protocols and activated in accordance with an established script.

These beacons were located around the globe in a variety of simulated distress environments on land, on moving and drifting ships, in lifeboats, in life-rafts, and free-floating at sea.



★ Beacon Locations (Beacon numbers cross referenced to Table 5)

Figure 3 - Geographic Display of Beacon Locations in the 1990 Exercise

Table 5 - List of Beacon Locations

BEACON NUMBER	BEACON ENVIRONMENT	BEACON LOCATION	COUNTRY CODE	BEACON PROVIDER	SERVICE AREA
1	Land	Thule, Greenland	Denmark	Denmark	NMCC
2	Land	Novosibirsk, USSR	USSR	USSR	CMC
3	Land	Molodezhnaya, Antarctica	USSR	USSR	Other Areas
4	Land	Perth, Australia	Canada	UK	AUMCC
5	Land	Bangalore, India	India	India	INMCC
6	Land	Libreville, Gabon	Australia	France	FMCC
7	Land	Santiago, Chile	Chile	Chile	CHMCC
8	Land	Cachoeira Paulista, Brazil	Switzerland	USA	USMCC
9	Land	Ascension Island, UK	Pakistan	UK	UKMCC
10	Land	Trenton, Canada	Sweden	Canada	CMCC
11	Land	Spitsbergen, Norway	Iceland	Norway	NMCC
12	Land	Johannesburg, South Africa	France	France	UKMCC
13	Floating	Nadi, Fiji Islands	Norway	Japan	USMCC
14	Ship	Norwegian Sea	Bermuda	Norway	NMCC
15	Floating	New Zealand	New Zealand	France	USMCC
16	Floating	Reunion Island, France	Greece	France	FMCC
17	Ship	North Atlantic	Greenland	UK	UKMCC
18	Lifeboat	Kodiak, Alaska, USA	Italy	USA	USMCC
19	Lifeboat	Black Sea	Bulgaria	USSR	CMC
20	Lifeboat	Norfolk, Virginia, USA	Finland	USA	USMCC
21	Lifeboat	Oahu, Hawaiian Islands, USA	Brazil	USA	USMCC
22	Liferaft	Ishigaki, Ishigaki Island, Japan	Japan	Japan	USMCC
23	Liferaft	Nakhodka, USSR	USA	USSR	CMC
24	Liferaft	Tahiti, French Polynesia	Venezuela	France	FMCC
25	Liferaft	Seattle, Washington, USA	UK	USA	USMCC

2.5 Sequencing of the 1990 Exercise

The Exercise was divided into three phases:

- Phase 1 was a rehearsal, designed to confirm the readiness of beacons, facilities, software and personnel;
- Phase 2 was designed to demonstrate the performance characteristics of the System under normal conditions (i.e. no more than 6 simultaneously active beacons);
- Phase 3 was designed to demonstrate the performance characteristics of the System under moderate stress (i.e. 15 or more simultaneously active beacons).

In all phases, beacons were activated and deactivated according to an Exercise script which was established using pseudo-random numbers.

2.5.1 Phase 2 Beacon Activation

Beacons were activated and deactivated during the 70 hours of Phase 2 based on an Exercise script where each beacon was "on" for an average of 8 hours and 22 minutes, which resulted in a number of beacons being simultaneously active. However, as shown in the profile of Figure 4, no more than six (6) beacons were active concurrently.

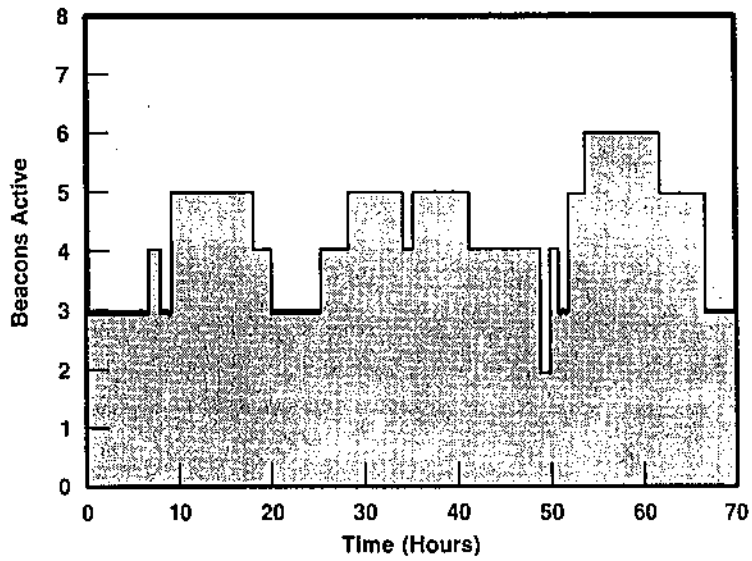


Figure 4 - Phase 2 Beacon Activation Profile

2.5.2 Phase 3 Beacon Activation

Beacons were activated and deactivated during the 24 hours of Phase 3 according to the following guideline: one additional beacon was activated each half-hour until a total of 25 beacons were simultaneously active. Then, all 25 beacons remained "on" for 12 hours, until the end of Phase 3.

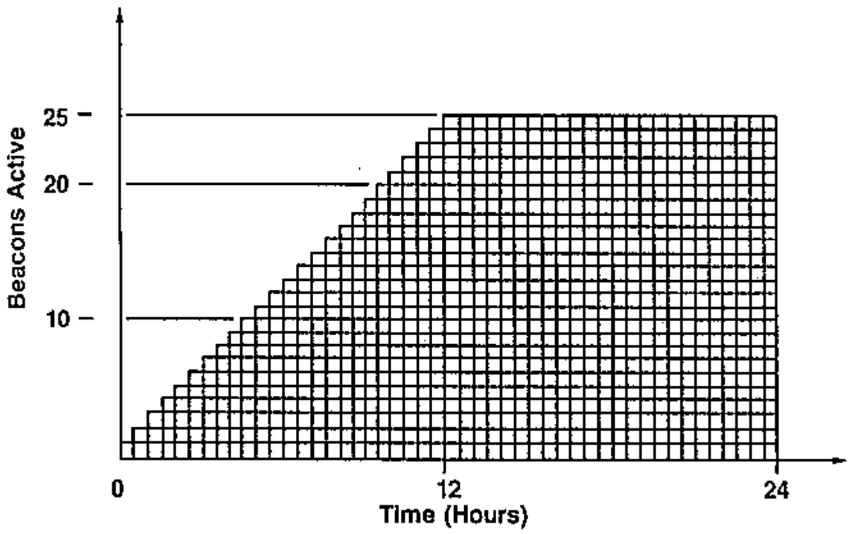


Figure 5 - Phase 3 Beacon Activation Profile

- END OF SECTION 2 -

3. DEFINITION OF PERFORMANCE CHARACTERISTICS

The following parameters were defined to characterise the System performance:

3.1 Location Acquisition Probability (LAP)

A beacon event is defined as the passage of a spacecraft over an active beacon with a maximum beacon-to-spacecraft elevation angle of 8° or more. Data from a beacon event is available to the System if it is acquired by the spacecraft and received by at least one LUT.

The Location Acquisition Probability (LAP) is defined as the number of beacon events acquired by COSPAS-SARSAT satellites, divided by the number of beacon events predicted. The LAP, expressed as a percentage, characterises the probability of acquiring a beacon location on a single pass.

To illustrate the concept, Figure 6 depicts the North-bound passage of a spacecraft within view of an active 406 MHz beacon located in Gabon (predicted beacon event). This event may be acquired by any LUT along the spacecraft subtrack, such as the LUTs at Toulouse, Lasham, Moscow, Arkhangelsk and Tromsø, indicated in Figure 6. If we assume that only the Gabon beacon was active, and that its data was acquired by at least one LUT which computed its location, then the LAP for that pass would be 100%.

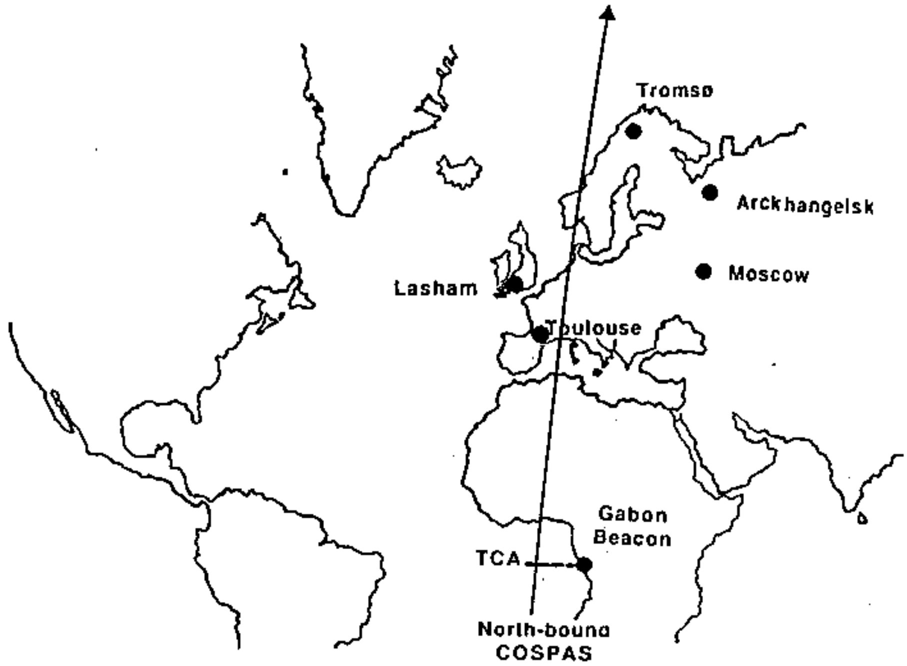


Figure 6 - System Location Acquisition Probability

3.2 Ground Segment Fidelity (GSF)

The data received by the Ground Segment results in messages which pass through a number of facilities located around the globe, prior to their transmission to SAR Services. The Ground Segment Fidelity (GSF) is a measure of the reliability of the Ground Segment in routing original messages to their correct destination.

Satellite data for each beacon event, as defined in Section 3.1, will be received by a number of LUTs and should result in a unique alert message being sent to the appropriate Rescue Coordination Centre (RCC).

The GSF is defined as the number of unique alert messages transmitted correctly to the appropriate RCC, divided by the number of unique beacon events processed by the LUTs. The GSF is expressed as a percentage.

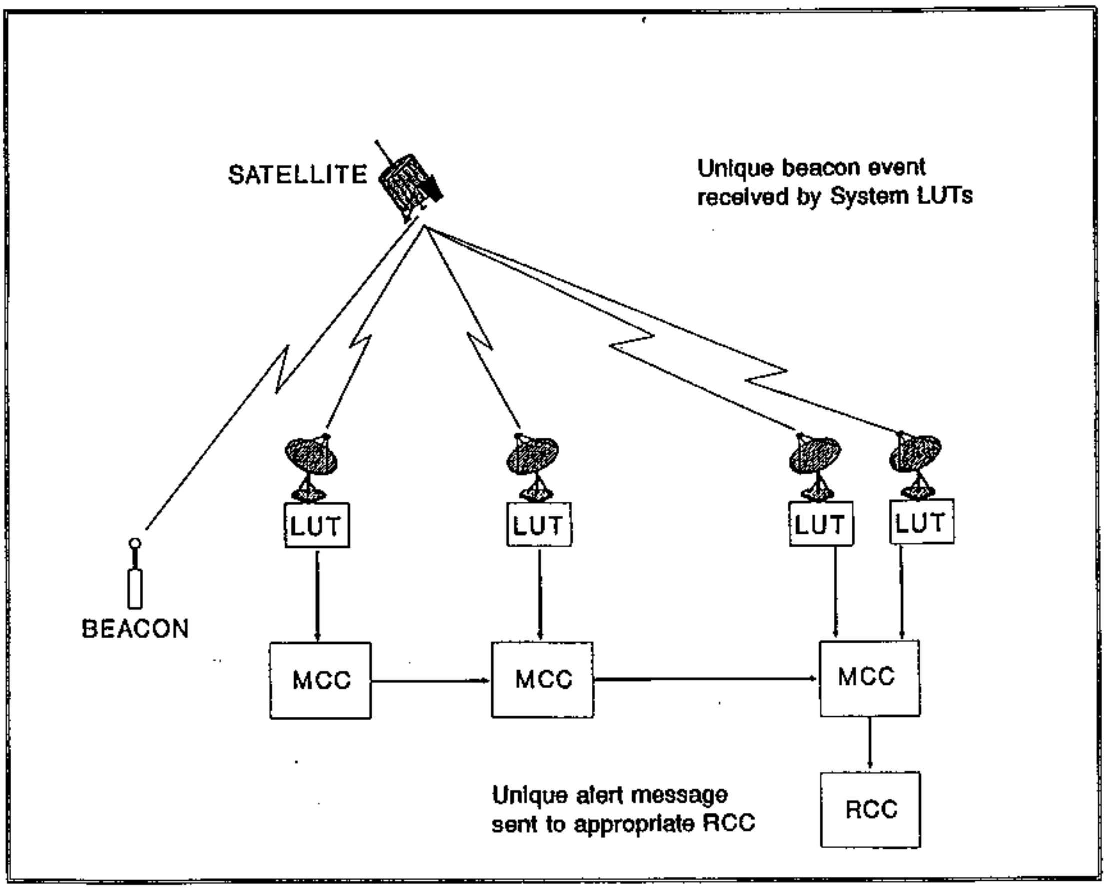


Figure 7 - Ground Segment Fidelity (GSF)

3.3 Location Accuracy

The location error is the distance in kilometres between a calculated beacon location and the actual location of the beacon. The System Location Accuracy is assessed by the statistical distribution of location errors.

3.4 System Timing

The System Timing characteristics, illustrated in Figure 8, are described by the following parameters:

3.4.1 System Waiting Time

The System Waiting Time is the time elapsed between beacon activation and the Time of Closest Approach [1] (TCA) of the first satellite pass. By definition, the System Waiting Time is measured only for the first satellite pass over an active beacon.

3.4.2 System Processing Time

The System Processing Time is the time from TCA until an MCC has received and processed the associated alert data, and has transmitted the resultant message to the appropriate RCC. The System Processing Time includes spacecraft storage time, LUT processing time, MCC processing time, and intra-system communication times. The System Processing Time is measured for the first message delivered to the appropriate RCC following each unique beacon event.

Both Waiting Time and Processing Time are assessed by their statistical distribution (see Section 4.5).

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1 Time of Closest Approach (TCA): The time at which the satellite is closest to the beacon during a satellite pass.

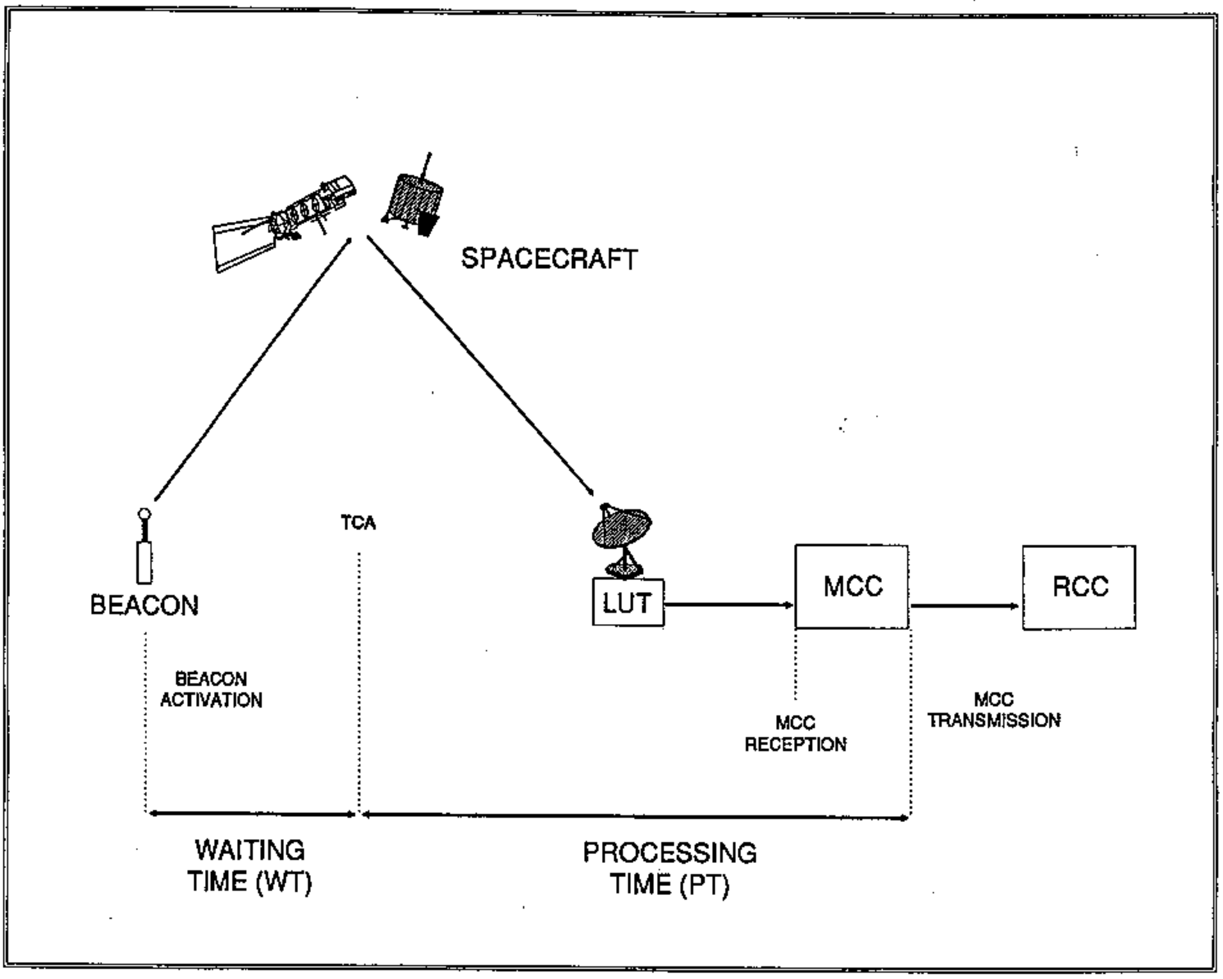


Figure 8 - System Timing

- END OF SECTION 3 -

4. STATISTICAL RESULTS OF THE 1990 EXERCISE

4.1 Data Analysis

The post-Exercise data analysis activities included an evaluation of the System ability to:

a. acquire the 406 MHz beacon transmissions and locate these beacons (i.e. System Location Acquisition Probability - LAP);

b. correctly distribute the alert messages (i.e. Ground Segment Fidelity - GSF);

c. provide accurate locations (i.e. System Location Accuracy); and

d. deliver the alert messages to RCCs in a timely fashion (i.e. System Timing characteristics, Waiting Time and Processing Time).

The 34 beacons used throughout the 1990 Exercise were activated successfully 59 times in total, during Phase 2 and Phase 3. All were detected and located in a timely fashion (see Section 4.4). These 59 activations yielded a total of more than 12,500 messages, providing a significant sample size for the follow-on statistical analysis.

The most significant results of this statistical analysis are provided hereunder.

4.2 The System Location Acquisition Probability

Combining Phase 2 and Phase 3 results, 574 out of the 585 predicted beacon events actually resulted in the acquisition of alert data and produced beacon locations, yielding a <u>Location Acquisition Probability (LAP) of 98%</u>. It should be noted, however, that the LAP is the probability of locating a beacon <u>on a single pass</u>. All beacons were located during the 1990 Exercise.

The eleven missing opportunities were associated with:

(1) the SARSAT-2 satellite's local-mode only capability,
(2) the COSPAS-4 satellite's Southern hemisphere restriction, and
(3) the activation of beacons in areas of known interference (monitored and located by the COSPAS-SARSAT System).

4.3 The System Ground Segment Fidelity

The COSPAS-SARSAT Data Distribution Plan (document C/S A.001) defines the procedures applicable by MCCs for routing alert messages through the Ground Segment communication network and distributing them to the national RCC, or the SAR Point of Contact (SPOC), responsible for the area where the beacon is located.

The GSF is a measure of the probability that a unique alert message, obtained from a satellite pass over an active beacon, will reach the appropriate SPOC or RCC, as defined in the COSPAS-SARSAT Data Distribution Plan. In Phases 2 and 3 combined, 628 of the 662 unique alert messages generated by the COSPAS-SARSAT System were correctly transmitted to SAR Services (i.e. to the appropriate SPOC/RCC). This result corresponds to a Ground Segment Fidelity (GSF) of 95%.

The follow-on analysis determined that 18 of the "missing" alert messages were incorrectly routed within the Ground Segment network because of software or procedural problems. These problems were resolved after the 1990 Exercise by implementing the required software and procedural enhancements. Had the 18 missing messages been correctly delivered (i.e. after the post-Exercise enhancements), the measured GSF of the System would have been 98%.

Although additional delays may have resulted from the missing alert messages, System redundancies and multiple satellite passes ensured that the appropriate RCC was notified of each beacon activation. Continuous monitoring of the Ground Segment is currently being reviewed to ensure that all alert messages are correctly routed.

4.4 The System Location Accuracy

4.4.1 Statistical Results

A total of 9,152 beacon locations were computed and recorded in Phases 2 and 3 of the 1990 Exercise.

The "Star Burst" display of Figure 9 is obtained by plotting each calculated location (latitude and longitude coordinates) assuming that the actual location of all beacons is at the origin (i.e. the centre of the figure). The outer circle corresponds to all calculated locations 50 kilometres or more from the true beacon location.

Figure 9 is a qualitative illustration of the System Location Accuracy.

It shows:

a. the large number of accurate positions concentrated at the centre of the figure;

b. scattered positions showing a quasi-symmetrical distribution on each side of the horizontal axis, which was interpreted as resulting from obsolete orbital parameters in several LUTs (see page 4-6);

c. locations on the 50 km circle which received detailed additional analysis.

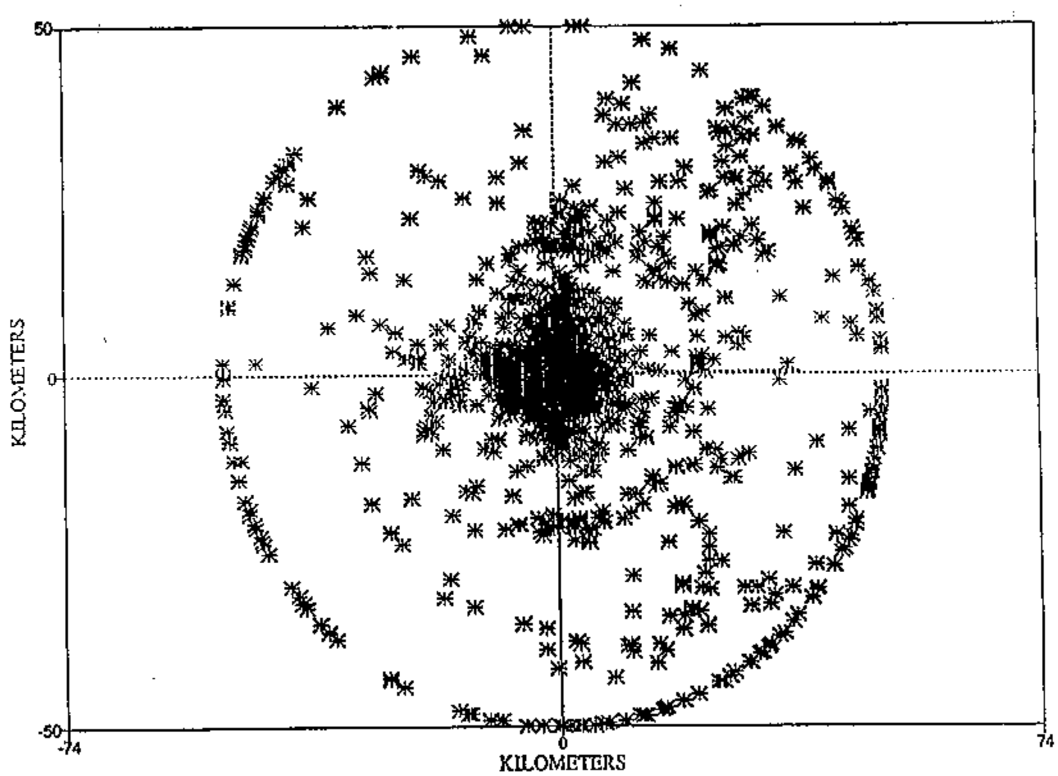
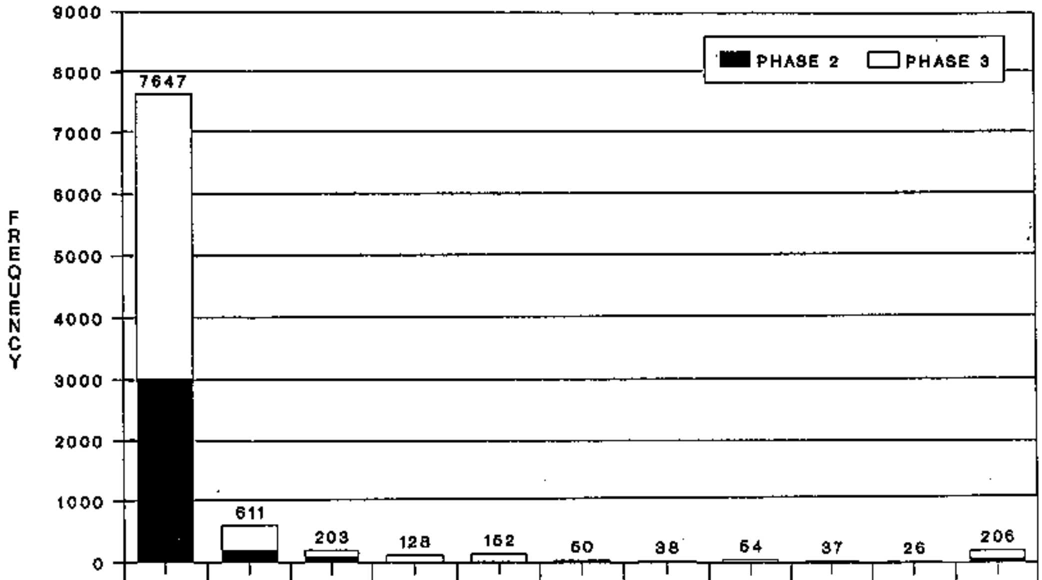


Figure 9 - Star Burst Display of Location Accuracy

Figure 10 illustrates quantitatively the System Location Accuracy. It provides the statistical distribution of location errors for the 9,152 calculated locations of Phases 2 and 3.

84% of the calculated positions were within 5 km of the actual beacon location, 90% were within 10 km and 94% were within 20 km.



	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	> 50
PHASE 3	4622	403	96	108	129	25	21	49	33	25	133
PHASE 2	3025	208	107	20	23	25	17	5	4	1	73

LOCATION ACCURACY (KM)

N = 9152
DATA FROM ELEVATION ANGLE >= 8 DEGREES
USED FOR ANALYSIS

Figure 10 - Distribution of Location Errors

4.4.2 Analysis of Location Errors Greater than 20 km.

Location errors greater than 20 km were analyzed to identify the causes or the factors affecting the location accuracy. As a result of this analysis, eleven (11) exclusive classes of error sources were identified, as listed in Table 6.

Table 6 - Classification of Location Error Sources

Classes (*)	N° of locations	% of errors ≥ 20 km	Comments
LUT Operations			
Orbit Vectors	159	28.2	Obsolete vectors in one LUT
LUT Software	112	19.9	Various software anomalies
Time Calibration (TCal)	78	13.9	TCal problems in two LUTs
Other			
Pass Geometry	43	7.7	Zenithal passes
Unknown	41	7.3	
Partial Doppler Curve	35	6.2	
3-Point Solutions	34	6.0	
Moving Beacon	18	3.2	Beacon speed: over 10 knots
4-Point Solutions	17	3.0	
LUT Hardware	17	3.0	
Beacon	9	1.6	Identified beacon problems
TOTAL	563	100	

Note: * All classes are exclusive.

Inaccuracies associated with obsolete orbit vectors (28.2%), LUT software anomalies (19.9%) and time calibration (13.9%) have subsequently been resolved, resulting in the elimination of 62% of location errors greater than 20 km. The 1990 Exercise illustrated, however, the need for continuous monitoring of LUTs' performance, to identify and eliminate defects or errors that may occur during normal System operations.

The effect on Location Accuracy of obsolete orbit parameters at the LUT is illustrated in Figure 11, which was obtained for one particular LUT and one satellite during Phase 3 of the 1990 Exercise.

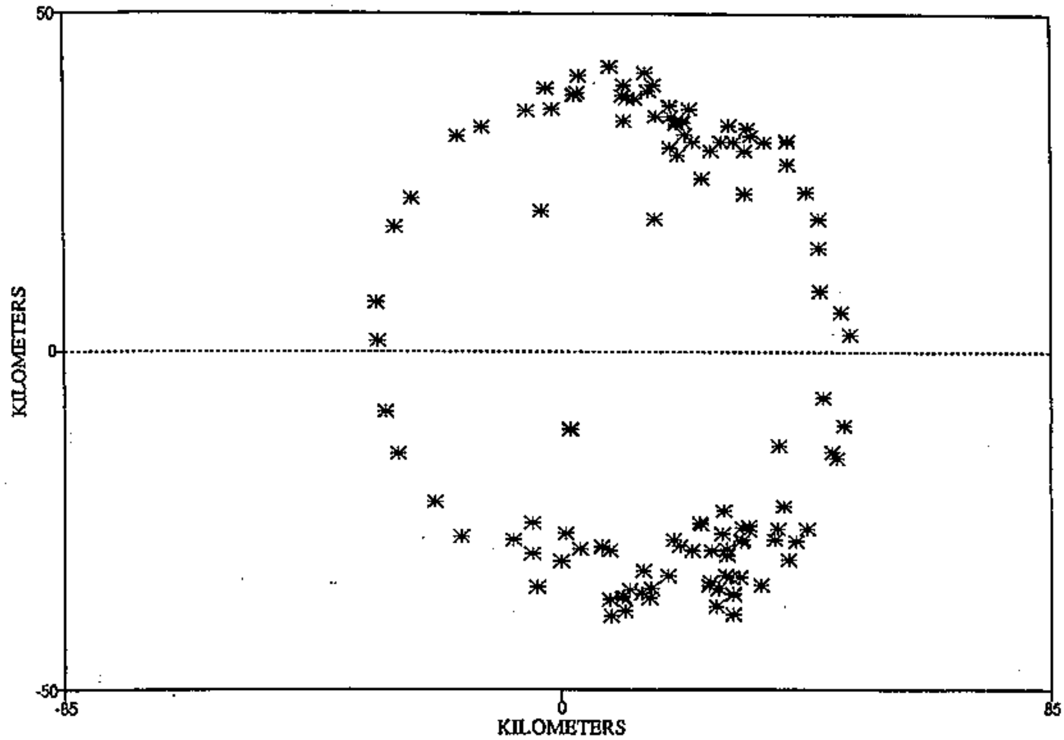
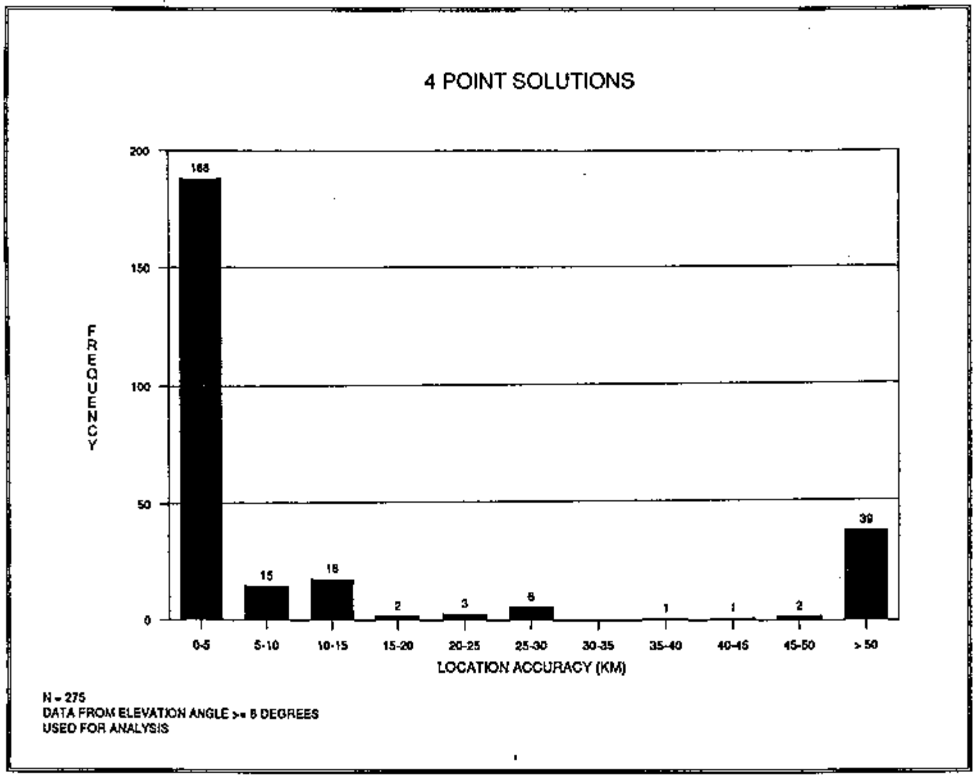


Figure 11 - Effects of Obsolete Orbit Vectors on Location Accuracy

Locations based on only 3 or 4 points on a Doppler curve, which may result from satellite passes at low elevation angles or from beacon malfunction, are often less accurate than solutions based on a larger number of data points. However, if no other information is available, these alerts with 4 or 3-point locations may be of great value to the SAR community, until more accurate locations are received from subsequent passes. Such information is currently accompanied by an indication of its quality and the addition of a clear warning in the alert message is being considered. The distribution of location accuracies for 4 and 3-point solutions is shown on Figure 12.

Investigation of other sources of error is continuing with a view to correcting, or eliminating, inaccurate locations through the development of appropriate monitoring procedures.



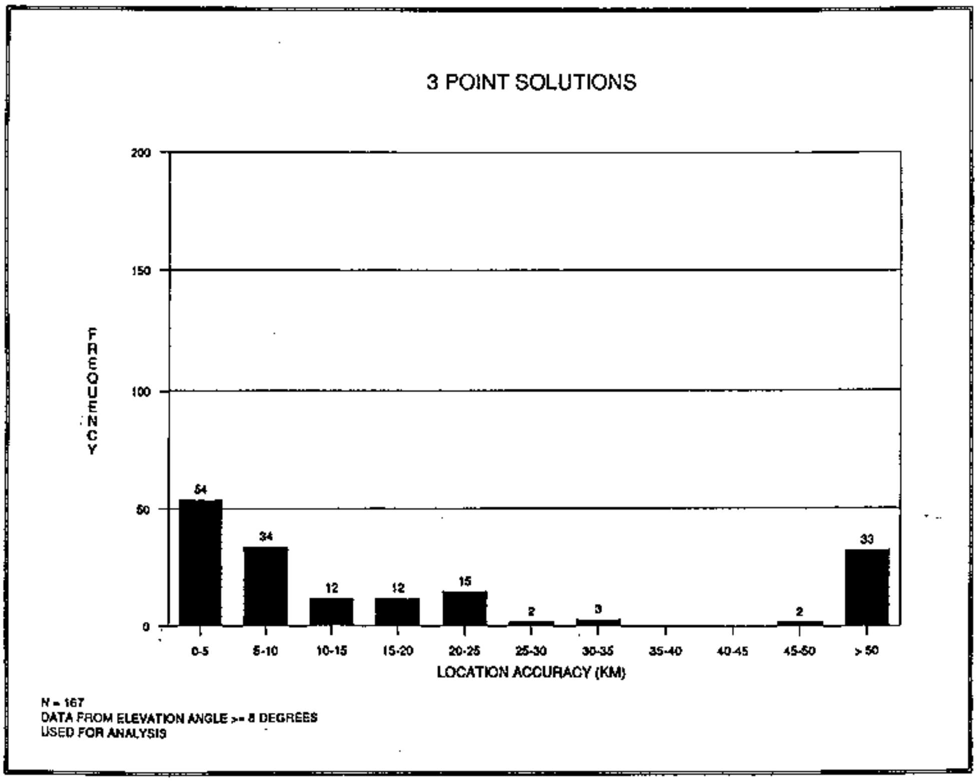


Figure 12 - Distribution of Location Errors for 4 and 3-point Solutions

4.4.3 Resolution of the Doppler Location Ambiguity

For each set of data collected during a beacon event, the beacon location algorithm of the LUT generates two locations, one on either side of the spacecraft subtrack, as shown on Figure 13. This location ambiguity is resolved by the LUT processing and the most probable location is identified as the "A-solution".

Until the Doppler location ambiguity resolution is confirmed (i.e. at the second satellite pass over the same beacon or by other sources of information), both A and B solutions are distributed to the SAR services, together with the probability attached to each solution.

During the 1990 Exercise, the correct solution (i.e. calculated location closest to actual location) was successfully selected as the A-solution for 95% of all computed locations. This result is identical to the result obtained in the 1986 Exercise.

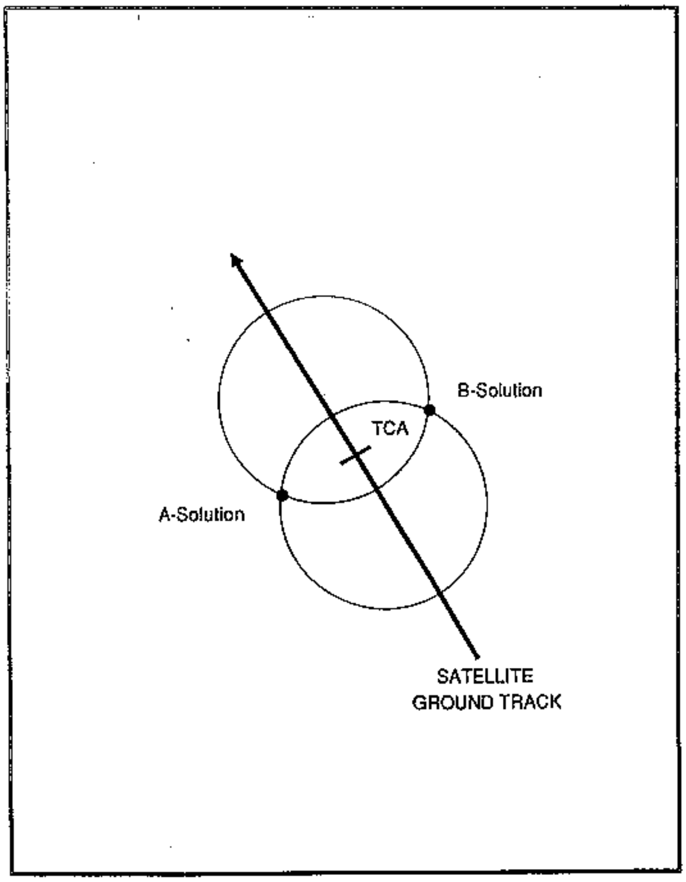


Figure 13 - Doppler Location Ambiguity

4.4.4 Summary of Location Accuracy Analysis: Typical System Performance

Following the elimination of the three error sources concerning LUT operation, as identified in Table 6, the 1990 Exercise location accuracy analysis shows that the System's typical location accuracy was : 87% within 5km of the true location and 94% within 10km. The results of the 1990 Exercise analysis are summarised in Table 7.

Table 7 - 1990 Exercise Location Accuracy and Typical System Performance

	1990 Exercise [1] Location Accuracy	Typical System [2] Performance
Within 5 km	84 %	87 %
Within 10 km	90 %	94 %
Within 20 km	94 %	98 %
Single pass Ambiguity Resolution	95 %	95 %

Notes:

1. All sources of location error included.
2. After correction of LUT processing anomalies identified in Table 6.

4.5 System Timing Statistics

The definitions of the System Timing characteristics (Waiting Time and Processing Time) are given in Section 3.4 of this Summary Report.

4.5.1 Waiting Time Results and Analysis

The distribution of System Waiting Times, from beacon activation to the first Time of Closest Approach (TCA, see Figure 8) is shown in the histogram of Figure 14.

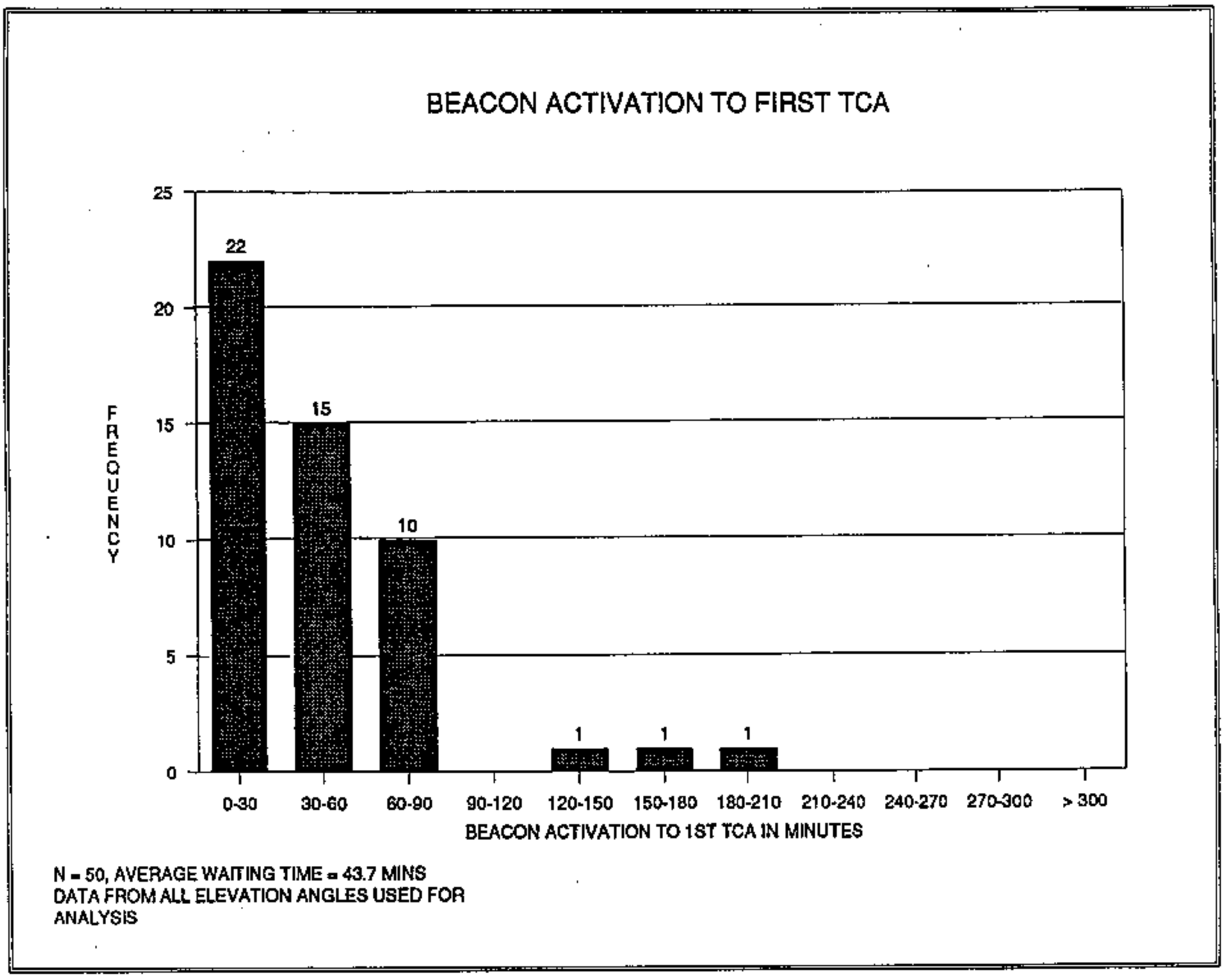


Figure 14 - System Waiting Time

Forty-seven of the 50 System Waiting Time samples occurred within 90 minutes of beacon activation and the average System Waiting Time was 44 minutes.

Three samples showed waiting times greater than 90 minutes: Oahu (163 minutes/Phase 2), Libreville (143 minutes/Phase 3) and Ascensión (186 minutes/Phase 3).

All three locations experienced earlier passages of the SARSAT-2 (S-2) spacecraft which was not operating in the global coverage mode at the time of the 1990 Exercise. No LUT was within view of S-2 during its South-bound passes over the Libreville and Ascensión beacons, and the Oahu / S-2 beacon event was not acquired by the available LUT (see the Location Acquisition Probability analysis in Section 3.1 and 4.2).

4.5.2 System Processing Time Results and Analysis

The distribution of First Message Processing Time for each beacon is given in the histogram of Figure 15. Twenty two of the 49 messages (45%) were processed in less than 30 minutes and 46 of the 49 messages (94%) in less than 90 minutes. The average First Message Processing Time was 43 minutes.

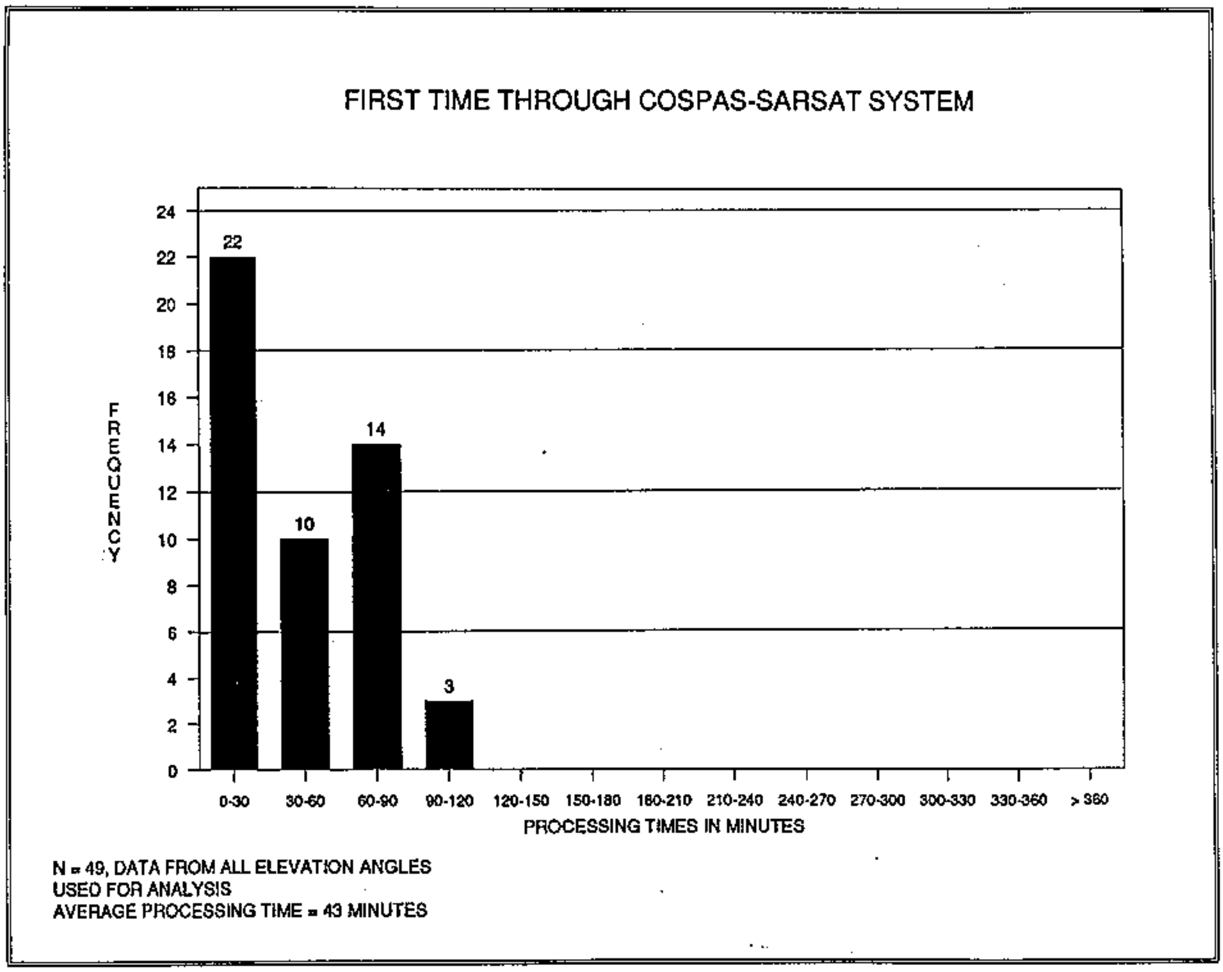


Figure 15 - System Processing Time

The three First Message Processing Times that exceeded 90 minutes were associated with beacons located at Cachoeira Paulista, Brazil (Phase 2) and Libreville, Gabon (Phase 2 and Phase 3).

The significant delays associated with the Cachoeira Paulista and Libreville beacons result from the Ground Segment configuration available at the time of the 1990 Exercise, and from MCC to RCC ground communications delays affecting the distribution of alert messages.

The satellite storage time, which represented 63% of all First Message Processing Time (i.e. over 27 minutes on average) in the 1990 Exercise, is expected to decrease as additional LUTs in strategic locations are being installed by COSPAS-SARSAT Participants.

- END OF SECTION 4 -

ANNEX A

List of Acronyms and Abbreviations Used in C/S R.005

AUMCC	Australian MCC
CMC	COSPAS Mission Centre
CMCC	Canadian MCC
CHMCC	Chilean MCC
COSPAS	space system for the search of vessels in distress
ELT	emergency locator transmitter
EPIRB	emergency position indicating radio beacon
FMCC	French MCC
GSF	ground segment fidelity
HKMCC	Hong Kong MCC
INMCC	Indian MCC
LAP	location acquisition probability
LUT	local user terminal
MCC	mission control centre
MHz	megahertz
NMCC	Norwegian MCC
NOAA	National Oceanic and Atmospheric Administration (USA)
NOCR	notification of country of beacon registration
PLB	personal locator beacon
PT	processing time

RCC	rescue coordination centre
SAR	search and rescue
SARSAT	search and rescue satellite-aided tracking
SEDL	System Evaluation and Development Laboratory
SPOC	SAR point of contact
TCA	time of closest approach
TCal	time calibration
UKMCC	United Kingdom MCC
USMCC	United States MCC
WT	waiting time

- END OF ANNEX A -
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