A Traffic-Conflicts Technique for Examining Urban Intersection Problems, by Chr Hydén, Lund Institue of Technology. (Sweden)

1. INTRODUCTION

This paper primarily describes a three-year project which was completed 1976.

The aim of this project was to develop a traffic-conflicts technique which should be useful when studying all kinds of safety problems in urban intersections. One of the criterias when starting this project was that the technique should be simple to use both in research work and in practical planning. The traditional use of accident-analysis in traffic safety planning creates great problems in some areas. This conflicts- technique is primarily meant to be an alternative to accident analysis within the following main areas of interest:

1/ What are the main safety problems in urban traffic to-day?
2/ What kind of events/hazardous behaviours lead to accidents?
3/ What are the real accident causes and what part plays the different factors involved, such as the different road users involved, the physical layout, the traffic situation, the vehicle and the external conditions (light, wheather,etc.)?
4/ What is the optimal combination of different countermeasures totally or in a part of the network at a given time?
5/ What are the estimated safety benefits from different solutions according to item 4/ and what are the actual effects of the countermeasures implemented?

A natural approach to to solve the problems associated with the use of accident analysis is to define a kind of event that fullfills the following criterias:

1/ The event shall be much more frequent than accidents.
2/ The degree of seriousness of an event must be clearly defined so that the accident probability is obvious.
3/ The full history of the events must be easily and reliably recorded.

2. DEFINITION OF A SERIOUS CONFLICT

Based on the criterias mentioned in section 1 we define a conflict as a situation which had led to an accident if none of the road-users involved had taken any evasive action. We believe that the degree of seriousness of conflicts may be determined by focusing on the moment when the first of the conflict- involved road-users

starts taking evasive action. The degree of seriousness may be defined as the remaining time to an accident (in the following TO) if both road-users involved had continued with unchanged speeds and directions. By watching video-taped conflicts, we however found out that there were clear indications that some of the road-users consiously lowered there TO-value by braking (swerving or accelerating) as late as possible according to their opinion of a safe behaviour. It became quite clear that a threshold level exists at approximately 1.5 seconds.

This means that a conflict with a TO-value below 1.5 seconds is characterized by the fact that (almost) no road-user volontarily puts herself in such a situation. This therefore forms the natural basis for a definition of a serious conflict:

A serious conflict occurs when the time to accident (TO) is below 1.5 seconds.
A conflict definition of this kind has the following advantages:

1/ The accident probability is quite obvious. The different actions and possibilities to avoid an accident are quite limited because most of the psychological part of the process may be disregarded (e.g. the perception and reaction times of the road-users involved). The situation also requires an immediate action which also limits the number of possible further actions.

2/ The definition may be applied on all kind of urban intersection conflicts (i e conflicts between all kind of road-users in all different kinds of situations).

3. THE RECORDING OF SERIOUS CONFLICTS

One of the basic items in the development of this conflicts-technique was to develop a recording technique which was easy to use. The best way of accomplishing this is to use human observers for ground-level observation. However this makes great demands on the operationalisation of the conflict-criterion in order to achieve a certain reliability.

In this project the observers are trained to determine the TO-values of conflicts in an indirect way. The training of observers is based on studies of video-taped , TO-classified conflicts. The observers learn to relate the suddeness and violence in a certain situation to the actual TO-value obtained by calculations from the video-taped situations.

In this way the observers are trained to discern the "threshold level" defined by the TO-value 1.5 seconds and to separate serious conflicts from non-serious ones.

Tests of the observer reliability have been carried out in the following way:

A number of trained observers performed, at the same time, conflict recording in the same intersection. The observers worked quite independantly of each other. Simultaneously the intersection was covered by a continous video-recording. Figure 1 shows an example of one of the tests that is carried out.

Another way of studying the consitency in conflict-counts is to compare counts carried out at different occasions in the same intersections and where the expected number of serious conflicts is estimated to be as equal as possible at the different occasions. This was done in a number of intersections in the city of Malmö. The intersections were studied in two different years (1974 and 1975). The studies were carried out at the same time of the year (may), the same weekdays (mon-fri) and at the same time of the day (11.30-13.00). Other factors influencing the expected number of serious conflicts, such as traffic volume, wheather and light conditions, were to be considered approximately constant between the two studies, except for a small increase in traffic volumes. In the 1974- studies the number of serious conflicts per minute was 0.035 (40/1155/ while the corresponding figure for 1975 was 0.037 (44/1176). The small difference, approximately 8 %, is quite acceptable and may also be partly explained by the increase in vehicle traffic.

4. RELATION BETWEEN SERIOUS CONFLICTS AND ACCIDENTS

The fundamental problems encountered during the formulation of an analytical model for the relation between serious conflicts and accidents caused us, at an early stage, to concentrate on an empirical model. To accomplish this, studies were carried out in a total of 115 intersections. At each intersection conflict-recording was carried out for seven hours on average. For each intersection accident-data (injury accidents only) were collected for seven to eight years, starting 1968 (the year after the change to right hand traffic in Sweden).

The study was divided into the following three steps:

1A/ 50 intersections in Malmö were studied in 1974 to differentiate which variables were important for the relation.

1B/ The same intersections were studied again in 1975. The purpose was to study the stability in the conflict frequency and to increase the data-base.

2/ 15 new intersections in Malmö were studied in 1976 to clarify the relations' variation within the same urban area.

3/ 50 intersections in Stockholm were studied in 1976 to study whether the relations vary with the characteristics and size of the urban area.

In a first preliminary analysis a computer program for stepwise linear regression (BMD02R) was used on data collected in the 50 intersections in Malmö.

According to the results of the regressions, the relation between the number of observed conflicts per time period and the number of accidents per time period should depend mainly on 3 variables for the kind of road-user and 4 variables for the vehicle speeds. The following descriptive chart was compiled:

	Car - Car	Car-Bicycle	Car-Pedestrian
Traffic class 1			
Traffic class 2			
Traffic class 3			
Traffic class 4			

where

Traffic class 1 = All situations in low speed intersections and and situations with only turning vehicles involved in high speed intersections

2 = Situations with only turning vehicles involved in signalized intersections

3 = Situations with at least one straight forward going vehicle involved in high speed intersections

4 = Situations with at least one straight forward going vehicle involved in signalized intersections

Low speed intersection = Non-signalized intersection with a median speed for passing vehicles below 30 km/h in all directions of flows

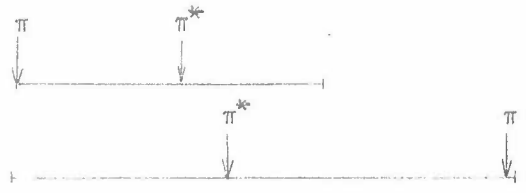
High speed intersection= Non-signalized intersection with a median speed exceeding 30 km/h in one or more of the direction of flows

For each of the twelve elements a conversion factor = number of accidents/ number of serious conflicts per time unit was calculated.The change in traffic volumes, from the time covered by the accident analysis (an average for all years) to the time of conflict-recording, was also considered in the calculations. The results indicated a small number of accidents or conflicts in some of the elements. This creates a great uncertainty in the estimated ratios. A merging of some of the elements therefore was considered. It is seen by studying the traffic class division, which mainly describes the speed differences of the involved road-users that class 1 and 2 may be considered equal as can class 3 and 4. It should be possible then, to combine into 2 classes. A division by kind of road-user is mainly done to describe differences in the probability of a personal injury occuring in a serous conflict. From this point of view, it should be possible to merge classes where unprotected road-users are involved.

The merges can be described by the following figure with the twelve elements as a base:

	Car - Car	Car - Bicycle	Car-Pedestrian
Traffic class 1	Cell 1	Cell 3	
Traffic class 2			
Traffic class 3	Cell 2	Cell 4	
Traffic class 4			

The reasonability of the proposed merge from 12 elements to 4 cells has been tested statistically for all three selections of intersections. The results indicate that in all three cases a merge is reasonable. Conversion factors for the three different selections were calculated. Figure 1 and 2 give the results of these calculations.The results from the two Malmö-studies show a very good correspondence regarding the estimated ratio between accidents and serious conflicts(π^*).However this doesn't mean, with total certainty, that the real π- values are identical. If we, having the maximum bad luck, have recieved the estimations of π which are far from the real π- values for respective data and in different directions, the π- estimations for the groups of data can eventually give the same value even though the real π- values are different. This is shown in the following figure:



It is impossible to establish the existence of this situation.

It could be stated though, that there is a 5% risk of the one groups of data's real value to fall outside the estimated π- value's confidence intervals limit on one side. The risk that the other group of data's real π- value will fall outside ofits confidence interval is equally large. The probability that this would be the case simultaneously for both estimations is very unlikely.

The only way to establish whether two groups of data can be unified, through the reasoning of this kind, is to decrease their confidence intervals i e collect more conflict - and accident data, until it can be considered certain thet the two groups of data's real π- values lie close enough to each other. It is a question of judgment whether this is the case for the Malmö-15 and Malmö-50. We do believe this to be the case.

If we consider the π-estimations of the Stockholm data, we find that this corresponds very well with that of Malmö's for the car-car cells. However in the cells that concern inprotected road-users the Stockholm π-estimations are lower. The most probable explanation of the differences between Stockholm and Malmö is the special difficulties for bicyclists in Stockholm due to the heavy vehicle traffic and the relatively small number of bicyclists. It is possible that a more thorough analysis than this project allowed could explain these differences. So far we can not establish that the differences are so large that a unification is not considered appropriate.

5. PRACTICAL APPLICATIONS

One of the main application areas is evaluation studies. Under assignment of the Road Safety Office the Department has carried out before- and after studies on four locations where local speed limits of 30 km/h were enforced. The goal was to expose whether the school-children's safety improved, and if so, what this improvement was dependant upon. The speed limit was posted on two types of signs:

1/ Ordinary sign that stated that the speed limit was valid only Mondays-Fridays 07.30 - 16.00

2/ Adjustable sign automatically controlled indicating 30 km/h during the time the children were on their way to and from school.

In each test, one before- and two after studies were completed. Each study covered five weekdays except for one test where the study time was doubled because the conflict-frequency was too low. This decision to double the length of the time was already determined during the before-study.

In each study conflict recording, traffic counting and speed recording was done. The speed was measured with the use of a "datalogg" developed at the Department. Two tubes stretched across the road recorded in the datalogg the passage time of each vehicle. The collected data was registered on tape, which then were computerized. Besides the vehicle speed, the number of vehicles and pedestrians in different flows was also recorded with use of the datalogg.

The vehicles passages were divided with regard to whether children were on or close to the street or whether no children were visible and also which speed limit was enforced. The results of the conflict studies are given in the following table, which concerns the number of conflicts with pedestrians (children) involved:

Location	Before	After I[1/]	After II[2/]
Kommendörsgatan, Stockholm 3/	22	13	8
Abrahamsbergsvägen,Stockholm 3/	8	4	6
Nygatan, Vetlanda 4/	10	4	2
Erik Dahlbergsg, Södertälje 4/	22	14	7
Total	52	35	23

1/ Carried out appr. one month after the introduction of the speed limit

2/ Carried out one half-to one year after the introduction of the speed limit

3/ Ordinary signs

4/ Adjustable signs

The number of conflicts have decreased significantly in all four tests. Besides, in three of the four tests, the number of conflicts continued to decrease by the second after-study. This is true for both tests with adjustable signs.

It can also be mentioned that the conflicts before and after the introduction of the speed limit are of the same type except that the speed of the vehicles involved was constantly lower in the after studies. The relations between accidents and conflicts illustrated earlier in this paper clearly show that the relations are dependant on the speed meaning, the lower the speed, less the probability that an accident should occur. The positive effects in terms of a decrease in the number of conflicts, thus is strengthened by the fact that the conflicts have also become less seroius.

Through the counts of traffic volumes and control of wheather conditions in the different studies, it could be established that the decrease in the number of conflicts must be explained by the decrease in the vehicle speeds. The speed recordings can be summarized as follows:

On locations with ordinary signs the average speed decreased by 3.2 km/h while the adjustable signs gave a reduction of 8.9 km/h. The presence of children caused a constant decrease of yet one km/h.

A conclusion drawn from the speed recordings is that the drivers demonstrated a fairly good understanding of the need for the speed limit through the adjustment of their speed with consideration to the risk of conflicts.

6. OFFICIAL OPINION ON THE USE OF THE TRAFFIC-CONFLICTS TECHNIQUE

In Sweden there has been a growing interest in using the traffic-conflicts technique during the last years. One example of this is the project described in section 5. The results obtained formed the basis for new official guidelines concerning the use of special speed limits at schools.

At present the Public Roads Administration reflects on funding a project which aims at modifying the existing technique for rural intersection studies. Two pilot studies are already completed.

The governmental Transport Research Delegation, who has sponsored the development of the existing conflicts-technique, now sponsors research projects in the area of pedestrian and bicycle safety in urban traffic, where the traffic-conflicts technique is applied.

TABLE 1

CONFLICT SITUATION NO	TIME OF DAY	KIND OF ROAD USER INVOLVED 1/	SERIOUS CONFLICT ACCORDING TO EVALUATION OF VIDEOTAPES 2/	SERIOUS CONFLICT ACCORDING TO THE OBSERVERS' RECORDING 2/					SCORES	
				A	E	H	J	M	POSSIBLE	ERRATIC
1	16.08	C - B	1	1	1	2	1	-	5	1
2	16.11	C - P	3	3	3	3	3	-	5	1
3	16.17	C - C	-	-	1	-	-	-		1
4	16.20	C - P	3	3	3	3	3	3	5	
5	16.30	C - P	4	4	4	4	4	4	5	
6	16.54	C - C	-	-	3	-	-	-		1
7	16.55	C - B	1	-	-	1	1	1	5	2
8	17.01	C - M	1	1	1	1	1	1	5	
9	17.03	C - C	4	4	4	4	2	4	5	
10	17.35	C - C	2	2	2	1	2	2	5	
Total:				7	9	8	8	6	40	6
Number of errors per observer:				1	3	0	0	2		

1/ KIND OF ROAD USER INVOLVED: C = Car driver
B = Bicyclist
P = Pedestrian
M = Moped driver

ERRATIC SCORES (MEAN VALUE): $\frac{6}{40} = 15\ \%$

2/ The figures concern the degree of seriousness in four classes of the serious conflicts

Location: No 13 in Malmö, Amiralsgatan-Spånehusvägen. Wednesday, 1974.06.05, 16.00-18.00

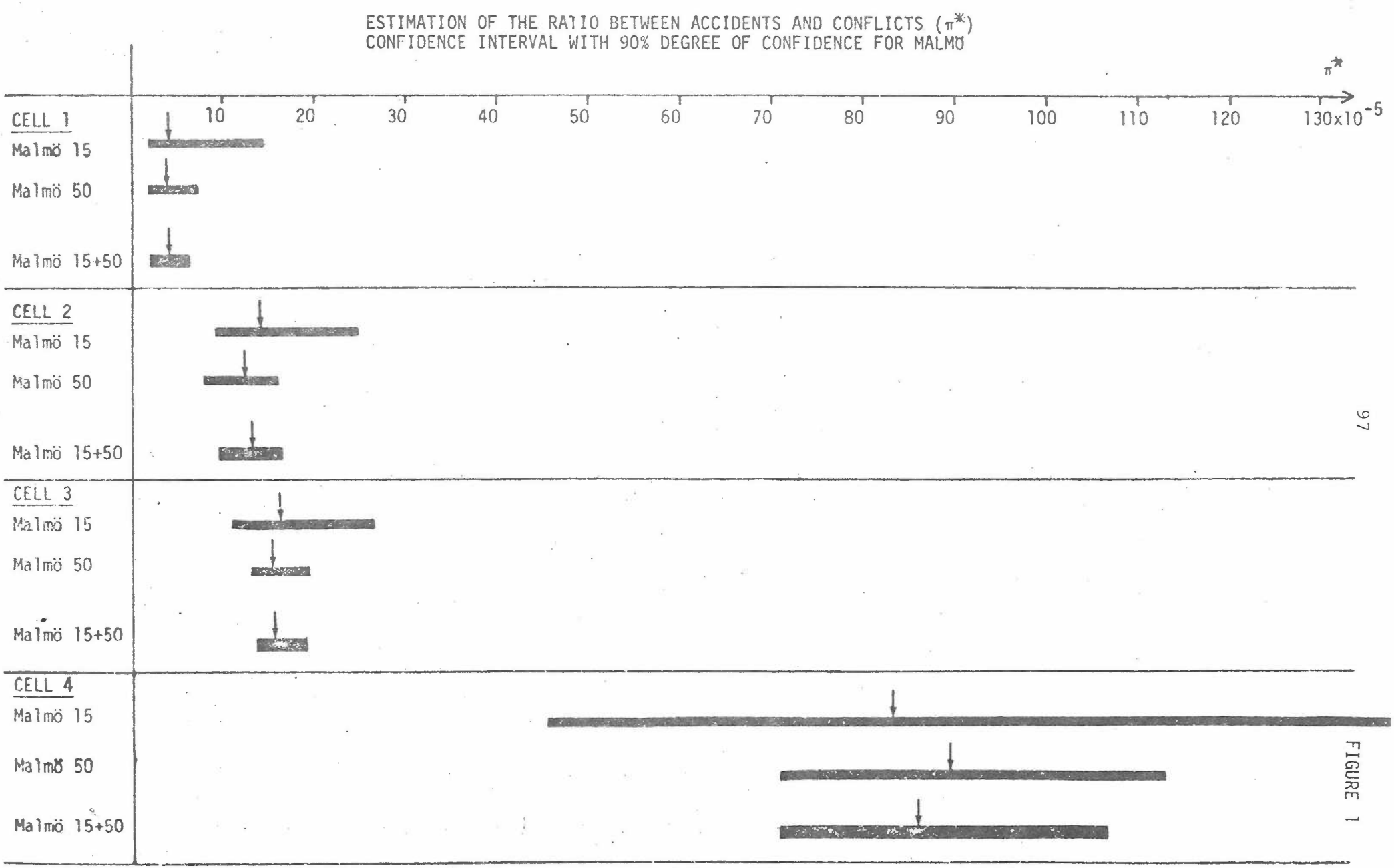

ESTIMATION OF THE RATIO BETWEEN ACCIDENTS AND CONFLICTS (π^*)
CONFIDENCE INTERVAL WITH 90% DEGREE OF CONFIDENCE FOR MALMÖ
π^*
10
20
30
40
50
60
70
80
90
100
110
120
130x10^{-5}
CELL 1
Malmö 15
Malmö 50
Malmö 15+50
CELL 2
Malmö 15
Malmö 50
Malmö 15+50
CELL 3
Malmö 15
Malmö 50
Malmö 15+50
CELL 4
Malmö 15
Malmö 50
Malmö 15+50

FIGURE 1

ESTIMATION OF RATIO BETWEEN ACCIDENTS AND CONFLICTS (π^*)
CONFIDENCE INTERVAL WITH 90% DEGREE OF CONFIDENCE FOR STOCKHOLM AND MALMÖ

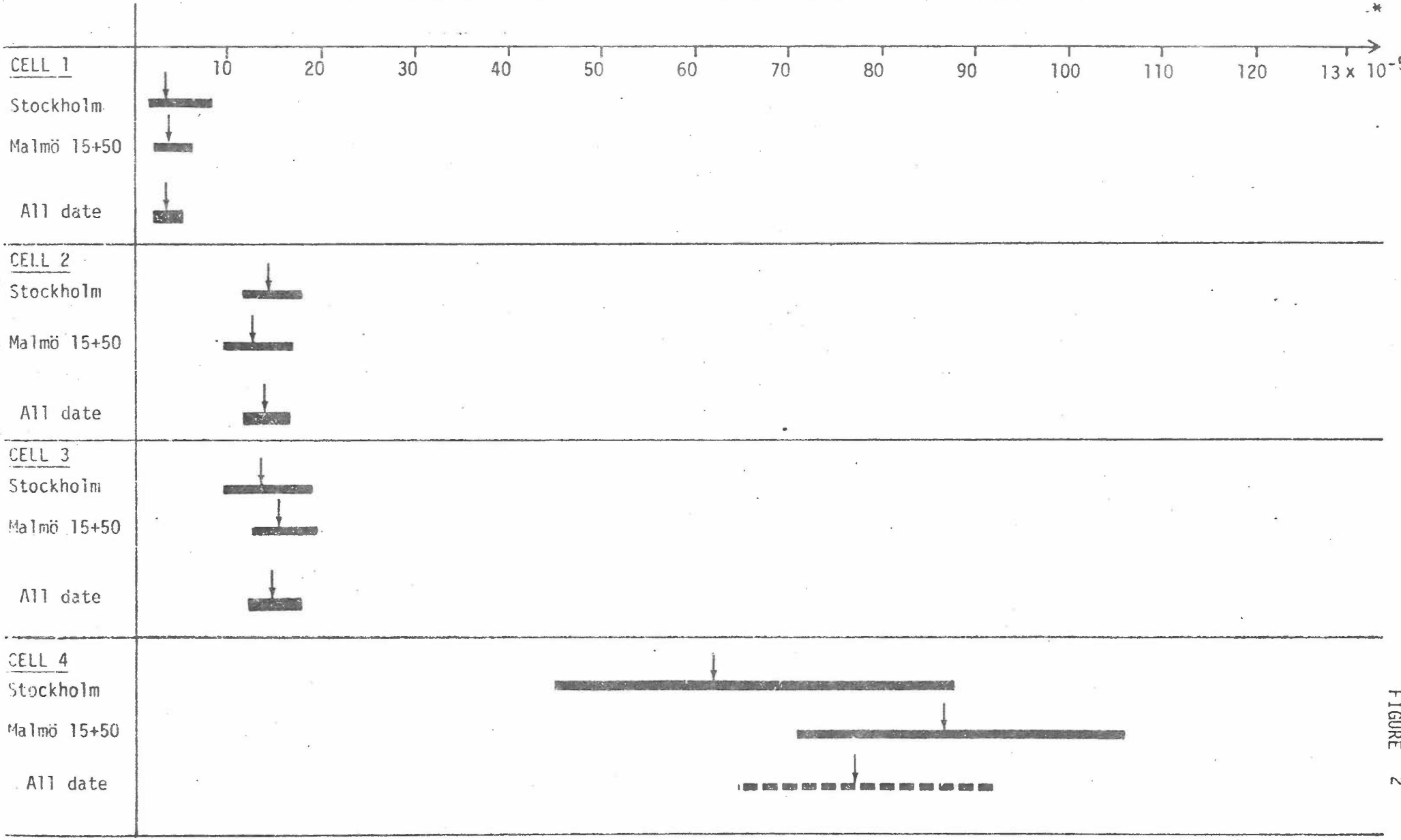


FIGURE 2