SPACING INSTRUCTIONS IN APPROACH: ASSESSING USABILITY FROM THE AIR TRAFFIC CONTROLLER PERSPECTIVE

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ACRONYMS

ADS-B Automatic dependant surveillance – broadcast.
ASAS Airborne separation assistance system.
E-TMA Extended TMA: upper and lower sectors performing pre-sequencing and sequencing of arrival flows before transfer to TMA. Usually exists around dense TMA to organise the traffic in advance, and thus facilitate the integration onto final approach. Arrival manager may be used.
FAF Final approach fix.
IAF Initial approach fix.
INI Approach control position receiving traffic from E-TMA (e.g. via IAF), organising traffic (e.g. stack management, initial vectors to delay traffic or create gaps between flows) and maintaining spacing before transfer to ITM position.
ITM Approach control position receiving traffic from INI position, handling integration onto final approach and ILS interception before transfer to tower.
TMA Terminal control area (“approach” control).

ABSTRACT

New allocation of spacing tasks between controller and flight crew is envisaged as one possible option to improve air traffic management. This allocation of spacing tasks to flight crew (denoted airborne spacing) is expected to increase controller availability and to improve safety, which in turn could enable better efficiency and/or, depending on airspace constraints, more capacity. In addition, it is expected that flight crew would gain in awareness and anticipation by taking an active part in the management of his situation. Controller-in-the-loop simulations were performed to assess feasibility and possible benefits of the airborne spacing in extended terminal areas (i.e. from cruise to initial approach). Recently, a simulation was carried out to assess usability, from a controller perspective, of airborne spacing in TMA (i.e. from initial to final approach). This paper presents first an analysis of the specificity of TMA compared to E-TMA, and explains how relevant airspace and procedures were designed. It then presents the main findings resulting from this simulation. From controller feedback, it seems that airborne spacing is usable in TMA, at least under medium-high traffic. An initial “geographical based” analysis of manoeuvring instructions suggests a positive impact on controller activity: airborne spacing seems to partly relieve the controller of issuing late vectors for integration onto final approach.

Keywords: air traffic management, approach control, airborne spacing, sequencing and merging, ADS-B, ASAS.

INTRODUCTION

New allocation of spacing tasks between controller and flight crew is envisaged as one possible option to improve air traffic management [1]. The motivation is neither to “transfer problems” nor to “give more freedom” to flight crew, but really to identify a more effective task distribution beneficial to all parties. This allocation of spacing tasks to flight crew – denoted airborne spacing2 – is expected to increase controller availability and to improve safety, which in turn could enable better efficiency and/or, depending on airspace constraints, more capacity. In addition, it is expected that flight crew would gain in awareness and anticipation by taking an active part in the management of his situation. Airborne spacing assumes new surveillance capabilities (e.g. ADS-B) along with new airborne functions (ASAS).

Airborne spacing for arrival flows of aircraft was initially studied from a theoretical perspective through mathematical simulations, to understand the intrinsic dynamics of in-trail following aircraft and identify in particular possible oscillatory effects [6][11]. Pilot perspective was also addressed through human-in-the-loop simulations [9][10][12] and flight trials [8] essentially to assess feasibility. The ATC system perspective was considered through model-based simulations, to assess impact on arrival rate of aircraft [3]. Initial investigations were also performed with controllers in approach [7].

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Since 1999, we have developed and refined a set of spacing instructions, extending the classical application of in-trail following aircraft to converging aircraft, thus allowing to handle the sequencing of arrival flows [2]. In addition to flight deck and mathematical simulations to address pilot and system perspectives [4][5], four controller-in-the-loop simulations were performed to assess feasibility and possible benefits of airborne spacing. It was observed (through the distribution of manoeuvring instructions and location of eye fixations) that the use of spacing instructions partly relieves the controller of the maintaining of sequences, and allows him to concentrate on the building of sequences. This (positive) impact on controller activity resulted in more stable and homogeneous spacing between aircraft at exit point. Although promising, these investigations were exclusively focussed on the E-TMA.

Recently, a simulation was carried out to assess usability, from a controller perspective, of airborne spacing in TMA. It was preceded by preliminary investigations and in particular a small-scale simulation. The objective of this paper is to present the different investigations and in particular a small-scale simulation. The paper is organised as follows: the first section will briefly outline the spacing instructions considered; the second one will address the TMA specificity compared to E-TMA; the third and fourth sections will explain how relevant airspace and procedures were identified and specified. The fifth one will describe the experiment setup and the last one will present the main findings.

**SPACING INSTRUCTIONS FOR SEQUENCING**

The principles of airborne spacing considered here is to provide the controller with a set of new instructions for sequencing purposes. Through these new “spacing” instructions, the flight crew is tasked to acquire and maintain a given spacing with respect to a preceding aircraft (the target). Airborne spacing is composed of three phases:

- Identification, in which the controller indicates the target aircraft to the flight crew.
- Spacing instruction, in which the controller specifies the task to perform.
- End of airborne spacing, which marks the completion of the task.

As for any standard instruction, the use of spacing instructions is at the controller’s initiative, who can decide to end its execution at any time. The flight crew however can only abort it in case of a problem onboard such as a technical failure. In terms of responsibility, as opposed to visual separation, there is no transfer of separation responsibility. Four spacing instructions for sequencing are proposed (Table 1).

<table>
<thead>
<tr>
<th>Maintain spacing</th>
<th>In-trail</th>
<th>Merging</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Remain behind”</td>
<td></td>
<td>“Merge behind”</td>
</tr>
<tr>
<td>“Heading instruction then remain behind”</td>
<td></td>
<td>“Heading instruction then merge behind”</td>
</tr>
<tr>
<td>Resume when spacing reached then maintain it</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Heading instruction then remain behind”</td>
<td></td>
<td>“Heading instruction then merge behind”</td>
</tr>
</tbody>
</table>

**Example 1.** A typical exchange between controller (left) and pilot (right).

**UNDERSTAND TMA SPECIFICITY**

Participant: Alain Zinger (Paris Orly).

Following initial discussions with an expert approach controller, it appeared that, although airborne spacing seemed appropriate for E-TMA, its use would be more problematic in TMA. In particular, the anticipation needed to set-up sequences with spacing instructions
seems hardly compatible with today practices (mainly late vectors for integration onto final approach). This raised the question: what are the main differences between E-TMA and TMA? To address this question, we restricted the analysis to the E-TMA sectors already simulated (AO and AR) and associated approach sectors (Paris Orly and Charles de Gaulle). It is acknowledged that although these sectors are thought to be representative, a study of other dense TMA in Europe has to be performed.

Two main differences have been identified: standard trajectories in E-TMA versus radar vectoring in TMA, and integration on a point in E-TMA versus integration on an axis in TMA. In addition, in TMA, the high pressure to ensure the optimum runway capacity, the lack of space and the larger turns (e.g. 180° from downwind leg to final axis), result in highly time-critical instructions. This time-criticality restricts even more the number of aircraft manageable for integration onto final approach, and generates uncertainty preventing an early planning of the final sequence order. Consequently, whereas in E-TMA the work consisted of a building phase then a maintaining phase, this is the opposite in TMA: a maintaining phase to keep spacing on each flow, followed by a last building phase for integration of flows onto final approach. This is typically the case in E-TMA with AR sector, composed of AR1 and AR2 sectors, and the TMA sectors, composed of INI and ITM positions (Figure 1).

At first sight, there could be benefits for maintaining spacing before integration onto final approach, typically on long downwind leg with flows already under airborne spacing (initiated by E-TMA). However, the relevance (usability and usefulness) of the existing spacing instructions for integration onto final approach was less obvious. The feeling was that, at least, a specific instruction (merge on an axis) had to be developed.

**Identify Relevant Airspace and Procedures**

Participants: Ludovic Boursier, Noëlle Canto, Olivier Galichet, Ronald Granju and, during debriefing, Alain Zinger (Paris Orly).

In order to get a feedback on the relevance of the concept in TMA, and identify if existing spacing instructions could be used or if new ones had to be developed (e.g. merge on an axis), an initial experiment took place in June’02. It consisted of a series of small-scale simulations with approach controllers. Four controllers from Paris Orly participated, each for half a day: a first exercise on an E-TMA sector (AO) to understand the concept and get familiar with the procedures, then a second exercise on a TMA sector. A collective debriefing took place at the end of the session.

The TMA sector consisted of a simplified Orly TMA in a West configuration³ and had to integrate flows coming from two IAF (MEL at FL070 and EPR at FL080). One flow (EPR) came through a long downwind leg, the other one (MEL) entered directly through a base leg (Figure 2). The level of traffic envisaged allowed grouping INI and ITM positions (as today in such traffic conditions), and manning this position with one controller. Compared to today’s operations (radar vectoring), the major change was the use of a unique standard trajectory for each flow from IAF to FAF (OYE).

The traffic was built to allow the controllers to test successively three different configurations: maintaining of a sequence, integration of one aircraft in a sequence, and integration of two sequences. It entered the TMA sector already under airborne spacing (initiated by the feed sector), still merging to their respective IAF. The traffic level was low (20 arrivals per hour) with sequences of up to four aircraft, equally balanced between the two IAF. All the traffic was equipped to receive spacing instructions. There was no departure.

During the experiment, the need for a dedicated merging point arose, allowing to use the “merge”

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³ To reuse part of the E-TMA preparation, itself in West configuration.

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During the collective debriefing, we tried to find out to which extent airborne spacing could be used in TMA. More precisely, we tried to address the potential use and benefits of airborne spacing, step by step, from IAF to FAF: maintaining spacing before integration onto final approach, maintaining spacing for one flow until FAF, and eventually managing integration onto final approach. Controllers mentioned that there could be a benefit to receive aircraft under airborne spacing since situations will be and will remain stable, in particular with a long downwind leg. However, they stressed that the benefit would be greater with time-based spacing due to the progressive reduction of distance (90s would be equivalent to a reduction from 8Nmi at about 250kts, to 5Nmi at about 220kts then 3Nmi at 150kts). In addition, one flow could maintain airborne spacing until FAF, but controllers mentioned that using standard trajectory may be less optimal than radar vectoring (enabling fine adjustments). The integration onto final approach under airborne spacing remains a key issue. In particular, the controllers mentioned the need to create gaps for inserting aircraft from different flows. To allow for more flexibility, they also suggested the creation of multiple merging points (and standard trajectories associated) and, in particular, some on the runway axis. Other aspects were also mentioned: would intensive vectoring (e.g. under heavy traffic) be compatible with airborne spacing? How the interaction with E-TMA could be handled? How degraded situations could be handled?

**SPECIFY DETAILED AIRSPACE AND PROCEDURES**

Since the existing spacing instructions seemed to be usable for integration onto final approach, no specific ones were developed (e.g. no merge on an axis). In addition, to avoid adding complexity, it was decided to keep the idea of a unique standard trajectory for each flow with a unique merging point. The merging point was defined as the first common point between the different converging trajectories. It was acknowledged however that the use of standard trajectories and the integration on a point would imply a modification of the working method.

In fact, this new TMA configuration becomes similar to the one used in E-TMA: standard trajectories and integration on a point. In E-TMA, the potential increase of availability with airborne spacing (findings from previous experiments) enables the grouping of pre-sequence and sequencing sectors, even under very high traffic. Considering this similarity and the need for anticipation to set-up airborne spacing, it was decided to group the INI and ITM positions, and to man this unique position with an executive and a planner controller (Figure 3). Although this grouping is used today under low traffic, it would constitute, with the level of traffic envisaged (higher than June’02), a second modification of the working method.

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**Figure 3. Proposed E-TMA and TMA configurations.**

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**ASSESS USABILITY: SETUP**

Participants: Ludovic Boursier (Paris Orly), Claudio Colacicchi (Roma), Marcia Connick (Manchester) and Liz Jordan (London Gatwick).

The objective of the November’02 session was to assess the usability of airborne spacing in approach, in particular regarding the integration of flows, the transfer from and the co-ordination with E-TMA. The airspace, procedure and traffic were based on the principles identified in June’02.

**Airspace and procedures**

The environment relied on the following principles:

- A unique standard trajectory for each flow (based on the radio failure trajectory) with a unique merging point.
- INI and ITM positions grouped.
- Sectors manned with an executive and a planning controller.

The airspace consisted of two approach sectors (INIR and INIO) for Charles De Gaulle and Orly airports (LFPG and LFPO), each with a single landing runway, in a West configuration4 (Figure 4):

- INIO: integrating flows to Orly coming from two IAF (MOLEK at FL090 and ODRAN at FL110), one base leg and one downwind leg.
- INIR: integrating flows to Charles De Gaulle coming from two IAF (OMAKO at FL100 and LORTA at FL110), both base leg.

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4 Compared to June’02, IAF and trajectories have been changed to reproduce the recent modification of the Paris TMA.
Though INIO layout is close to reality (there is today a third IAF North of ODRAN with integration on the downwind leg, but used by a very small proportion of the traffic), INIR is quite far from the existing sector (there are today two independent landing runways, each fed separately by a base leg and a downwind leg). The motivation was to simulate two distinct (single landing runway) configurations: one with a base and a downwind legs, and the other with two base legs.

Three conditions were simulated: without airborne spacing (conventional control but with standard trajectories), with distance and with time based spacing. During exercises with airborne spacing, the use of spacing instructions was at controller discretion. With airborne spacing, the proposed merging points were VAS02 for INIO and LOR12 for INIR.

The minimum standard separation was 3Nm in TMA, and the standard spacing at transfer between E-TMA and TMA were (unless explicit co-ordination): 8Nm without airborne spacing (as in today’s letter of agreement) and with distance based spacing, or 90 seconds with time based spacing.

### Table 2. Example of traffic with six sequences of four or five aircraft (for a duration of about 55 minutes).

| Number of aircraft from IAF 1 | 4 | 3 | 1 | 3 | 2 | 3 |
| Number of aircraft from IAF 2 | 0 | 1 | 3 | 2 | 3 | 3 |

**Controller position**

The environment was similar to today environment, making use of progress strips. However, no arrival manager (sequencing tool) was available. Graphical markings dedicated to spacing instructions were available, consisting of markers set around the position symbols of the aircraft under airborne spacing and of its target, and of a link between them (Figure 5). These markings served as a reminder and also allowed to visualise aircraft coming from E-TMA under airborne spacing.

**Traffic**

Similarly to June’02, the traffic was built to allow the controllers to test successively three different configurations: maintain a sequence from IAF until FAF, integrate one aircraft in a sequence, and integrate two sequences. For exercises with airborne spacing, traffic entered the TMA sectors already under airborne spacing (initiated by E-TMA and feed sectors), and merging to their respective IAF (at 8Nm for distance based spacing, or 90s for time based spacing). The traffic level was medium-high (31 arrivals per hour) with sequences of up to five aircraft, equally balanced between the two IAF (Table 2). All the traffic was equipped to receive spacing instructions. There was no departure.

**Programme**

The TMA session lasted 9 days: 4½ days of training and exploratory use, ½ day of intermediate debriefing to agree on working methods, 3 days of measured exercises and ½ day of final debriefing. Each TMA controller played as executive controller six training exercises representing low and medium traffic load, first without airborne spacing then alternatively using distance and time based spacing. Each played one measured exercise of medium-high traffic load three times: without, with distance and time based spacing. To avoid introducing a bias, the order varied. The measured period lasted 50 minutes.
Limitations

Several limitations of the experiment have to be mentioned. First of all, considering the lack of maturity of the use of spacing instructions in TMA and the short training period (compared to E-TMA training which lasted 8 days), controllers were probably not familiar enough with the concept during the measured period.

Due to the performance limitations of the graphic controller position update, only a limited number of range-rings were displayed, forcing controllers to use intensively the range&bearing tool. This induced additional workload. Despite this workaround, the overall simulator performance still remained poor, causing sometimes disturbances and errors.

In terms of implementation, two bugs impaired the use of spacing instructions: a problem of beacon detection occurring in some specific situations, limiting the use of “heading then merge”; a problem in the “at least” behaviour, preventing aircraft to re-accelerate once spacing had been reached, thus provoking controllers “puzzlement” and inducing the slowing down of the following aircraft. Although identified, these two bugs could not be fixed during the simulation without risking side effects (comprehensive tests not possible).

In terms of pilot interface, modifying the spacing value (e.g. from 8Nm to 5Nm in distance based) imposed a heavy procedure (“cancel spacing, retain target, remain at least 5Nm behind” instead of “remain now at least 5Nm behind”). In addition, there were a certain number of pilots errors due to pilot overload and bugs in their interface.

It seems that these limitations did not impair controllers understanding of the concept, however they impacted on the use of spacing instructions. Consequently, if the qualitative findings can be considered as valid, the quantitative results must be considered with caution.

ASSESS USABILITY: FINDINGS

We describe below the main findings related to airspace and procedures, method of use and controller activity. A discussion synthesises the feedback from the controllers.

Airspace and procedures

Early in the experiment (during the exploratory use), INIO controllers used to shorten the downwind trajectory, using VAS03 as merging point instead of VAS02. However, this created conflicting situations as, at some point, this shortened trajectory was not separated from the runway axis. Therefore, VAS03 had to be moved further south, at mid-distance between VAS02 and VAS04. For INIR, LOR12 was kept unchanged.

Receiving the traffic still merging on the IAF was felt too constraining. Indeed, as long as the aircraft and its target have not passed the merging point, they cannot be vectored (restriction of the instruction). It was thus decided (during the intermediate debriefing) to replace the E-TMA merging points by the first point upstream common to all corresponding trajectories. MOLEK was replaced by OKRIX, OMAKO by INKAK, and LORTA by XERAM. ODRAN was kept as merging point: because of the long downwind leg, there was no need to vector the aircraft before they had passed it. Interestingly, E-TMA controllers mentioned that this new configuration allowed checking spacing before transfer to TMA and taking corrective action if needed. It could be noted that E-TMA and TMA configurations are now similar (Figure 6).

Method of use

Controllers used spacing instructions even for integration onto final approach, i.e. for building and maintaining sequences. Although INIR was found more difficult than INIO (no downwind that would provide space and flexibility, sometimes head-on situations when vectoring aircraft), spacing instructions were used in the same manner for both sectors. Depending on situations (e.g. aircraft from the same flow or from different flows, spacing existing or to be created), they maintained, modified on-going airborne spacing, or created new ones. To describe the method used by controllers during the experiment, we detail below basic situations with two aircraft (Table 3). Situations with multiple aircraft were managed by combining the method used for these basic situations.

It was observed that with airborne spacing, controllers tended to integrate successively blocks of aircraft of one flow, then of the other, i.e. “segregating” flows. Whereas, without airborne spacing, controllers integrated aircraft per aircraft, i.e. “mixing” flows. From the measured exercises, the order at the FAF of the 32 sequences with airborne spacing (distance and time) was compared to the order of the same sequences without. Four typical configurations were identified depending on flows being mixed or segregated, with and without (Table 4). This confirmed the observations and the controllers feedback.
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### Table 3. Basic situations with two aircraft.

<table>
<thead>
<tr>
<th>Aircraft From same IAF</th>
<th>Spacing</th>
<th>Method of use</th>
<th>Spacing instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>Kept in &quot;remain&quot;(^5), trajectory shortened by giving a direct(^6)</td>
<td>Unchanged (same target, same type of instruction)</td>
<td></td>
</tr>
<tr>
<td>To be created(^7)</td>
<td>Remain cancelled and use of either conventional &quot;heading&quot; followed by &quot;merge&quot;, or &quot;heading then merge&quot;</td>
<td>Modified (same target, different type of instruction)</td>
<td></td>
</tr>
<tr>
<td>From different IAF</td>
<td>Existing</td>
<td>Use of &quot;merge&quot;</td>
<td>Created (new target)</td>
</tr>
<tr>
<td>To be created(^7)</td>
<td>Use of either conventional &quot;heading&quot; followed by &quot;merge&quot;, or &quot;heading then merge&quot;</td>
<td>Created (new target)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Comparison of sequence configurations.

<table>
<thead>
<tr>
<th>Without</th>
<th>With</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>Mixed</td>
<td>3</td>
</tr>
<tr>
<td>Segregated</td>
<td>Segregated</td>
<td>4</td>
</tr>
<tr>
<td>Mixed</td>
<td>Segregated</td>
<td>20</td>
</tr>
<tr>
<td>Segregated</td>
<td>Mixed</td>
<td>0</td>
</tr>
<tr>
<td>Undetermined (aircraft removed)</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

### Controller activity

As an initial investigation to assess the impact of airborne spacing on the controller activity, we re-used the “geographical based” analysis of instructions introduced in E-TMA [2]. It consisted in mapping the manoeuvring instructions over the considered area, and more specifically in analysing their distribution as a function of their distance to the exit point. Although we could have considered the FAF, we selected the merging points (allowing to use direct and not along track distances). It can be observed that without airborne spacing, most of the heading (and speed) instructions are issued near the merging point, whereas with airborne spacing, instructions seem to be issued all over the sector with fewer “late” instructions. This would confirm the late integration of flow without airborne spacing, and some form of anticipation when using it. It seems that time based spacing show better results than distance based, and INIO better results than INIR. However, it is not clear at this stage if this reflects the impact of sector configuration (INIO less difficult) and type of spacing (time based more appropriate), or if this results from problems encountered during the simulation (see “limitations”) and the limited sample of exercises. A global reduction of instructions can also be observed.

### Discussion

From controllers feedback and observations, the spacing instructions developed for E-TMA seem to be usable in TMA, in particular for the integration onto final approach of flows under airborne spacing. However their use implies changes in working methods: use of standard trajectories (i.e. no radar vectoring), integration on a point (i.e. not on an axis), and a unique approach control position (i.e. INI and ITM positions not separated).

Controllers mentioned that airborne spacing can give them more availability (although its setup demanded more effort in the experiment because they were not familiar with it). In addition, it was mentioned that airborne spacing provides but also requires anticipation, and allows to smooth the traffic but gives the feeling of having less pressure and hence losing capacity.

They preferred the time based spacing, in particular due to the progressive reduction of the distance, but stressed the issue of having consistent criteria for wake turbulence (e.g. time based separation). They mentioned also the need for having more information on the interface (e.g. “exactly” or “at least”), in particular when receiving aircraft from E-TMA. The “merge” instruction was preferred, whereas the “heading then merge/remain” was mentioned as requiring too much monitoring. Suggestions were made to shorten the phraseology.

Controllers reluctance to cancel airborne spacing led them to treat a group of aircraft as an entity, and integrate blocks of aircraft. The traffic load might influence the use of airborne spacing: some airborne spacing initiated by E-TMA might have to be cancelled which would increase workload. They sometimes found it easier and quicker to get back to conventional control than to re-issue spacing instructions to several aircraft. Their main concern was the recovery of abnormal situations and the need for clear emergency procedures, in particular during the management of long sequences. Sometimes, they decided to use spacing instructions

\(^5\) In distance-based, the desired spacing was possibly modified (from 8Nm “exactly” to 5Nm “at least”).
\(^6\) It could be noticed that, when giving a direct, the spacing definition is different. However, considering the small deviation angle in situations considered, the variation of actual spacing was small. A “merge” would be more appropriate but would have imposed to issue a new spacing instruction.
\(^7\) In time based, to increase spacing from 90s to 120s for wake turbulence.
\(^8\) To keep manageable control conditions when inconsistent behaviours resulting from limitations mentioned previously occurred.
although they were aware that the applicability conditions might not be respected, and that there was a risk that the spacing would not be maintained. This is an issue observed also in E-TMA.

![Manoeuvring instructions distance distribution graphs](image)

**Figure 7.** Distribution of manoeuvring instructions (speed, heading and spacing if applicable) as a function of distance to merging point (INIO on left column and INIR on right column, without spacing on first row, distance based on second row and time based on third row).
CONCLUSION

From controllers feedback, it seems that airborne spacing is usable in TMA under medium-high traffic. An initial “geographical based” analysis of manoeuvring instructions suggests a positive impact on controller activity: airborne spacing seems to partly relieve the controller of issuing late vectors for integration onto final approach. The main objective of the next experiment will be to assess its usability and usefulness in TMA under very high traffic (up to maximum capacity). The assessment will rely on methodology and metrics used for E-TMA through the three dimensions: controller activity, control effectiveness and safety. Secondary objectives should be to define and evaluate emergency procedures, and to determine “optimal” standard trajectories (trade-off between “long” ones adapted to very high traffic and “short” ones adapted to low traffic). The next experiment (planned end 2003) will thus focus on TMA, simulating the same sectors. The interaction between TMA and E-TMA, the use of arrival manager and possibly datalink (uplink of target selection by the controller, and downlink of spacing parameters selected by the flight crew), will be studied after.

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