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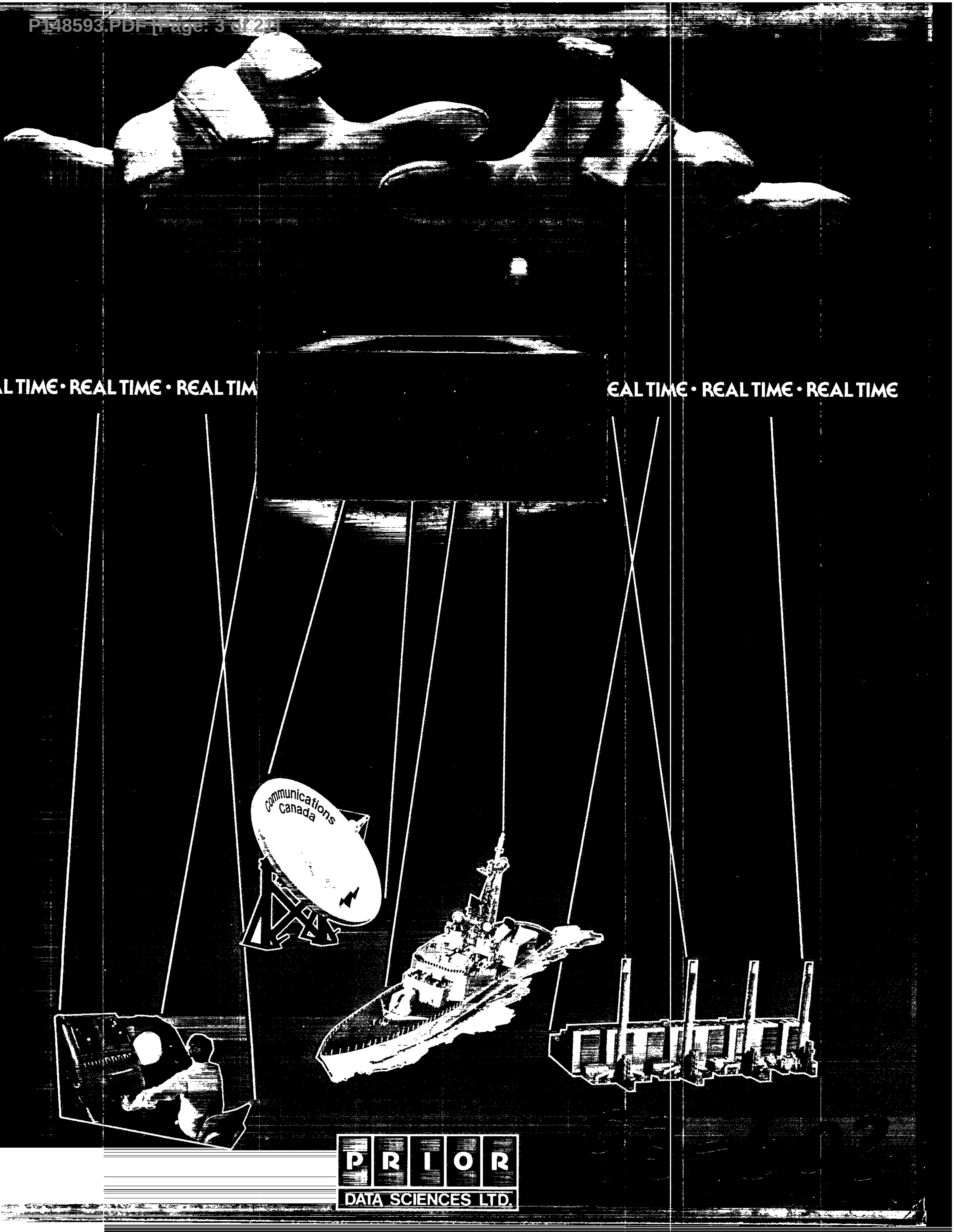
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Document No.: 92-0036-K

Issue 1: 1992 March 31

FINAL REPORT
FOR THE

MARITIME ENGAGEMENT
SIMULATION DEVELOPMENT
PHASE I

Contract Nos. W7714-0-9420/01-ST
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Prepared for:
Department of National Defence
Defence Research Establishment Ottawa

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REVISION NOTES

ISSUE	DATE	DESCRIPTION
Draft 1	1992 March 30	Submitted for internal review
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1 SCOPE

1.1 Identification

This Final Report applies to Project Mermaid, the Maritime Engagement Simulation Development - Phase I (MESD), for the Defence Research Establishment Ottawa (DREO).

1.2 System Overview

The MESD Phase I project simulates the initial phase of an anti-ship missile (asm) attack before homing head activation. The Man-Machine Interface (MMI) includes a Graphical User Interface (GUI) for user interaction with the model. The Attack Scenario Model (ASM) is conceived as the first component in a suite of several models designed to simulate entire asm engagements. Further components in the suite simulate the asm operations after seeker activation at differing levels of detail.

1.3 Document Overview

This document is the final report for the Maritime Engagement Simulation Development, Phase I.

Section 2 lists applicable documents.

Section 3 describes the Project Background.

Section 4 describes the Model Extent.

Section 5 describes the approach to the development of the software.

Section 6 lists recommendations resulting from the work.

Section 7 includes the acronyms and abbreviations used in this document.

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2 APPLICABLE DOCUMENTS

(1) Software Design Document for the Maritime Engagement Simulation Development, PRIOR Data Sciences Ltd. Document No. 91-0152-K, Issue 1, 16 December, 1991.

(2) Software Requirements Specification for the Maritime Engagement Simulation Development, PRIOR Data Sciences Ltd. Document No. 91-0010-K, Issue 1, 31 January 1991.

(3) Software User's Manual for the Maritime Engagement Simulation, PRIOR Data Sciences Ltd. Document No. 92-0034-K, Issue 1, 31 March, 1992.

(4) Technical and Managerial Proposal for the Development of Computer Simulation Models for Assessing the Effectiveness of Potential Electronic Warfare Techniques, PRIOR Data Sciences Ltd. Document K708, 27 July 1990.

(5) Software Test Report for the Maritime Engagement Simulation Development Phase I, PRIOR Data Sciences Ltd. Document No. 92-0035-K, Issue 1, 31 March, 1992.

(6) EASAMS Ltd. Future Seeker Head Specification Study. Final Report. Volume 3, System Specification. October 1990. Ref. No: 3280/FR/3.

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3 PROJECT BACKGROUND

The Attack Scenario Model is to interface with man-machine interface (MMI) software, termed the "Simulation Facility", being developed by PRIOR. Together, the integrated Simulation Facility/Attack Scenario Model is to form Phase 1 of the "Maritime Engagement Simulation" - a framework capable of allowing the end-user, the Defence Research Establishment, Ottawa (DREO), to investigate complex electronic warfare (EW) scenarios.

DREO's requirement was stimulated from a study previously undertaken by EASAMS to assess modern seeker heads and determine the modelling requirements for such systems. During this work the goal of producing a suite of three models was identified[2]. The purpose of this suite was to represent an ASM attack on a group of ships with particular reference to the detailed assessment of electronic counter-measures (ECM) and the co-ordination between hard-kill and soft-kill. The suite consisted of three components:

- Attack Scenario Model
- High Level ASM Model
- Detailed ASM Model

The first two models together represent an attack by one or several missiles on a group of target platforms deploying softkill defences. The Attack Scenario model represents all the activities occurring before seeker activation whilst the High Level ASM model is essentially a timestepping representation of the missiles after seeker activation. The Detailed ASM model is a research tool aimed at determining accurately the effects of given ECM ploys on seeker performance. It is a timestepping simulation of a single missile after seeker activation using a much faster update rate than the High Level Model.

Agreement was reached that EASAMS would develop the models themselves, drawing upon their many years experience in this area, and PRIOR would provide the MMI and support. PRIOR have direct expertise, having many years involvement in relevant modelling programmes as well as extensive software and graphics experience.

From subsequent discussions with DREO it was determined that the first work package would be for the development of the initial model in the suite, the Attack Scenario Model and its associated MMI (now termed the "Simulation Facility").

4 MODEL EXTENT

The Attack Scenario Model is a discrete event simulation of a missile attack on a group of target ships up to the point of seeker activation. That is, it models:

- a launcher capable of firing anti-ship missiles and, optionally containing a sensor
- a third party sensor platform (optional) which the launcher can use to obtain information on the target force
- a target force consisting of one or many target vessels
- one or many missiles

The third party sensor platform is modelled as having a body, a navigation system and a sensor. The body represents the physical platform moving along a pre-defined course. The navigation system is capable of supplying, on demand, the estimated position of the platform and provides an indication of the positional uncertainty. The sensor is simulated as making 360 degree sweeps with a fixed time interval between sweeps. Both the sweep and the return from this sweep are modelled as instantaneous. The sweep return consists of the positions and positional uncertainties of the targets (and the launcher). The sensor uses this information to build up a 'sensor picture'.

The launcher is modelled as a combination of a sensor platform, as above, a 'launcher picture compiler system' and a firecontrol system. The launcher picture compiler compiles 'launcher pictures', which describe the information the launcher holds on the target force. These pictures hold the positions, and positional uncertainties, of the targets the launcher has detected, through the use of either its own sensor or the third party sensor platform. The launcher picture is continually updated as the simulation progresses so that the most up-to date information is used.

The firecontrol system performs the following operations:

- The formulation of an 'attack plan'. The attack plan consists of a simplified description of the pre-seeker activation trajectories of the missiles. The missiles are modelled as executing dog-leg trajectories. The attack plan describes the ground projection of the dog-leg trajectories together with the altitude at which each leg is flown. The attack plan is compiled from a launcher picture and pre-defined instructions (user-defined).

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- Programming of the missile autopilots, so that they can fly the trajectories described in the attack plan.

- Compilation of a 'missile picture' for each individual missile. The missile picture is the (launcher's estimate of the) view the missile has of the targets at seeker activation. Like a launcher picture, it consists of the positions and positional uncertainties of the targets. The missile pictures are used to program the seekers (see below).

  Both fire-and-forget and fire-and-update missiles are represented. In the former case, the missile picture is compiled from the launcher picture available when the missile is fired together with a knowledge of the missile flight plan, the navigational inaccuracies of the missiles and an allowance for target motion between launch and seeker activation. The same procedure is applied for fire-and-update missiles, except that the seekers are assumed to be programmed at a given time <u>after</u> launch. Therefore, the launcher picture available at this time is used and allowance is only made for the target motion between the time of seeker programming and activation.

- Programming of the seekers of each individual missile. It achieves this by setting the dimensions of the missile search areas and an providing indication of which target to attack in a group. The search area size data is obtained from the associated missile picture together with pre-defined factors relating the positional uncertainty of the prime target to the search area sizes.

The representation of target vessels simply models the targets as moving along pre-defined trajectories. The missile representations similarly models the missiles as flying in accordance with their autopilot instructions (perturbed by inaccuracies in navigation) to the point of seeker activation.

5 APPROACH

5.1 Technical Approach

5.1.1 MMI

The MMI consists of a database portion and a GUI portion. In anticipation of a considerably enhanced system in the future, it was decided that the Oracle Relational Database Manager would be used for data input and to capture selected output data. This has the advantage of an additional level of abstraction from the end user, and provides significant growth potential when additional models are added, or existing ones enhanced.

The GUI portion was developed using TeleUSE, a Computer Aided Software Engineering (CASE) tool for rapid development of user interfaces using X Windows / Motif applications. Additional Ada code was produced to provide interfacing among the various parts of the application.

5.1.2 Modelling Technique

The use of an object oriented development approach and the use of the Ada language were identified as being particularly suited to required modelling. This has been implemented by designing the Attack Scenario Model as an Ada program comprising a large number of "packages". With few exceptions, these packages define "classes" in the object-oriented sense. That is, they represent real world or abstract systems, and provide facilities for creating instances, or 'objects', which can be thought of as specific examples of the classes.

More specifically, in Ada terms, almost all the packages in the model export single private data types, which represent the data part of the classes. (Because the structure of the data is not visible to the outside world, the term abstract data type, or ADT, is often used in this document.) In addition to exporting ADTs, these packages also export a number of operations (functions and procedures) that represent the methods, or functionality, associated with the class. The operations are generally of two types; selectors or constructors. Selectors allow other packages to obtain components of instances of the ADT; constructors perform operations that modify instances of the ADT.

None of the packages comprising the Attack Scenario Model proper contain any data. Rather, the dependencies amongst the major classes is such that it is only necessary to define one instance of the "attack scenario model" ADT (exported by the top-level package in the dependency hierarchy) to bring into being a complete example of the model. A specific "interface" package has been written by EASAMS which contains internally a single such instance of the "attack scenario model" ADT. It also exports a number of operations to allow the user (PRIOR's Simulation Facility) to initialize, run, observe the output of, and interact with the model.

The use of the object oriented method has led to the following benefits:

- extremely modular design (which reflects the structure of the systems being modelled)
- tight control on the visibility of data (through careful design of the "withing" relationships)
- high data security (because only the "interface" package contains data and this is well protected)
- ease of interface with the Simulation Facility (because the use of ADTs shields this facility from the internal workings of the model)

5.1.3 Tools

The Graphical User Interface of the MMI was developed using TeleUSE, a CASE tool used to ease the creation and manipulation of X-Windows / Motif applications.

Integrated use was made of the team*work* CASE tool in both the requirements, design and coding phases.

Use of these tools has lead to a modern design with clear traceability from requirements, through implementation to testing.

5.2 Development Methodology

The use of the software development lifecycle described in the following sections, together with the application of the tools noted previously, has ensured the high quality of the software.

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5.2.1 Software Requirements

The requirements were identified in a Software Requirements Specification with input from both PRIOR and EASAMS. This document was submitted to the customer following a Software Specification Review meeting at the PRIOR Kanata facility.

5.2.2 Software Design

The software was designed with input from both PRIOR (the MMI) and EASAMS (the ASM). A design document was produced and delivered to the customer following a Critical Design Review Meeting at EASAMS' facility in the U.K.

5.2.3 Module Code and Test

The individual modules were coded and passed unit testing prior to integration. Documentation specific to this activity is maintained in Company records, and is not deliverable but is available for customer review.

5.2.4 Integration and Test

The MMI code was tested at PRIOR, the model was coded, integrated, and tested by EASAMS, and then delivered to PRIOR for integration with the MMI. This activity took longer than expected. The results of this testing were submitted to the customer in the form of a Software Test Report.

5.2.5 Acceptance

EASAMS' model code was accepted at PRIOR. Following integration testing, a demonstration will scheduled to serve as the basis for acceptance by the customer. The final deliverables include a magnetic tape containing the code listings, a Software User's Manual, and this Final Report. The final deliveries follow a meeting at PRIOR with EASAMS' personnel in attendance.

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6 RECOMMENDATIONS

a. Capital Acquisitions

It is strongly recommended that the customer acquire all related software and hardware to be able to enhance and maintain the existing software. This includes a hardware platform (Sun SparcStation), Oracle Relational Database Manager, Telesoft Ada compiler, TeleUSE, and possibly Cadre team*work*. Both PRIOR and EASAMS have developed the software on in-house facilities, but the Maritime Engagement Simulation Development should be self-sustaining.

b. Extension of the Graphical Output Capability

The graphical output capability should be enhanced to include additional windows and views of the simulation as it progresses. Such views include, for example, a "horizontal-height" view displayed simultaneously with the X-Y plot as a missile dives to attack a ship. Further possibilities will arise as the software is exercised by the user.

c. Extension of the Simulation Functionality

The object oriented methodology has clearly demonstrated its use and, in particular, its ability to permit extension. Furthermore, the Attack Scenario Model has always been envisaged as the first element in a suit of models and has been designed accordingly. Therefore, the functionality of the software should be extended to the next phase, namely the construction of the "Detailed ASM" model.

d. Reuse of Existing Representations

The object oriented methodology assists the integration of existing representations. EASAMS have available an object oriented Ada representation of radar and EW propagation. This is well suited to form part of the "Detailed ASM" model and should be incorporated. Ada software is also available to represent seeker head behaviour on a pulse-by-pulse basis and this should also be incorporated into MESD.

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7 NOTES

7.1 Acronyms and Abbreviations

ADT	Abstract Data Type
ASG	Ada Structure Graph
ASM	Attack Scenario Model
asm	anti-ship missile
CASE	Computer Aided Software Engineering
DREO	Defence Research Establishment Ottawa
ECM	Electronic Countermeasures
EW	Electronic Warfare
GUI	Graphical User Interface
MESD	Maritime Engagement Simulation Development

APPENDIX A

DIRECTORY OF CODE LISTINGS

```
source/
source/GUI/
source/GUI/.Xauthority
source/GUI/.Xdefaults
source/GUI/mesd
source/GUI/mesd.do
source/GUI/.cshrc
source/GUI/Reset.pad
source/GUI/.login
source/GUI/.mwmrc
source/GUI/.profile
source/GUI/.xinitrc
source/GUI/appl.c
source/GUI/T_Initialize.pad
source/GUI/graphics.ada
source/GUI/junk.c
source/GUI/liblst.alb
source/GUI/mesd.d
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