

VALIDATION OF AN OPERATOR SUPPORT SYSTEM

Dr ir Cees de Wijs

CMG Den Haag BV - Division Advanced Technology
P.O. Box 187 - 2501 CD the Hague - The Netherlands
Tel: +31 70 3029302 - Fax: +31 70 3029300 - E-mail: Cees.de.Wijs@cmg.nl

ir Jan P.M.M. Vis

Ministry of Transport, Public Works and Water Management
Transport Research Center
P.O. Box 1031 - 3000 BA Rotterdam - The Netherlands
Tel: +31 10 2825877 - Fax: +31 10 2825644 - E-mail: j.p.m.m.vis@avv.rws.minvenw.nl

INTRODUCTION

Currently the Dutch Ministry of Transport (Transport Research Center) is engaged in the design and implementation of a generic Operator Support System in the Netherlands. This Operator Support System (OSS) is a distributed system to support traffic operators and traffic managers at operating centers. The aim is to provide common operating facilities for the various dynamic traffic management systems and other related systems for motorway (traffic) management. Examples of such Motorway Management Systems (MMS) are monitoring, signalling, ramp metering, incident management systems and future automatic toll systems. Also meteo-systems and communication infrastructure management systems are foreseen to be controlled via the OSS.

The use of common software and the consistency in the graphical (map-oriented) user interface between different motorway management systems results in a consistent transparent view on all applications for the operator. Main benefits related to this feature are a more efficient execution of the operator task, less training effort, and a reduction of the number of control consoles at an operating center. The non-hierarchical architecture of the operator support system enables handover of operational tasks between operating centers during night shifts or quiet periods. Furthermore, several tasks can be executed via so-called scripts in an unattended mode. This feature will result in more efficient traffic control requiring less manpower during relative expensive working hours.

Evidently such a system can be exploited successfully only when severe reliability, performance, connectivity and scalability requirements are met. This paper presents the

way of working that has been followed to verify the underlying design and to validate the functional and technical feasibility of the system architecture.

The focus is put on application of well-known standards and techniques for mission critical system analysis and design (MIL-STD 490/498/499, IEC 1508 and MIL-STD 1629A/FMECA).

First the main features of the OSS architecture are presented. Subsequently the underlying technologies are briefly described. The third paragraph describes the applied validation framework. Finally the fourth paragraph presents the main findings of the OSS validation.

THE OSS ARCHITECTURE

The OSS architecture has been based upon two main concepts traffic management domains and traffic management centers (so-called operator control centers). The concept has a decentralised non-hierarchical structure, where each region holds its own responsibilities for traffic management tasks. A traffic management domain contains a number of traffic infrastructure objects (such as Road Side stations, Matrix signs, Detectors and Cross sections of lanes) and a number of traffic management tasks. Each operator control center encompasses an administrator and a number of operators.

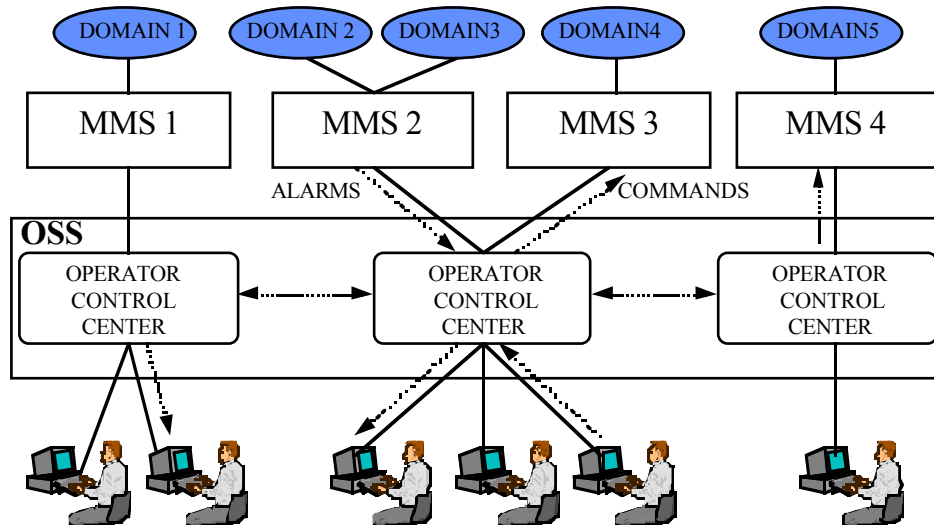


Figure I: Architecture of the Operator Support System

Each operator control center (OCS) is responsible for the configuration and operation of a number of traffic management domains. All operator control centres are to be integrated in a network such that [1]:

- an operator control centre can request and receive alarms and traffic data from all other operator centres. The event-driven (exception based) control of the OSS ensures that the task load of an operator remains within reasonable limits. Alarms are correlated and grouped before presentation to the operator takes place;
- an operator control centre can authorise another operator centre to take over all of its control tasks and responsibilities. The authorisation contains an exclusivity restriction (not more than one operator is executing a specific task simultaneously) and a continuity restriction (an activated task is controlled by at least one operator).
- new Motorway Management Systems can be easily added to the existing operating centres so that scalability and extensibility is ensured.

The OSS system has been designed in such a way that:

- real-time data from various Motorway Management Systems can be displayed dynamically on a single integrated graphical user interface with road maps;
- the various Motorway Management Systems can be controlled by simple point and click manipulations of the operators;
- the user interface allows the users to zoom stepwise from a geographical survey map into a schematic detailed display of a specific road segment or crossroad along with all equipment. In addition, also other objects such as rain showers and areas of fog can be displayed.

MAIN TECHNOLOGIES OF THE OSS

The main technologies of OSS encompass:

- a User Terminal Agent at each operator work station, which provides a graphical user interface based on OSF/X open windowing. The interface contains functionality for manipulation of map symbols and creation of scripts.
- Relational database technology to store maps, scripts, authorisation and event logs. There is at least one database server at each operating center with replication facilities

to exchange updated maps or infrastructure configurations between all operating centers. Geographical maps are implemented based on the GDF standard.

- Routing technology, to control the communication (event reports and request/response operations) between the OSS and motorway management systems and to control the communication between the distributed operating centers. The routing functionality ensures the secure routing of requests (invocations of operations) to their destination, routing responses (results of operations and error reports), and the distribution of event reports to the registered subscribers for those reports.

The communication protocol consists of two layers [2]:

- the request/response protocol layer (asynchronous event reporting, based on a restricted set of services from the OSI Remote Operations Service and Protocol ISO 9072). This layer enables the service user to include type and time information in the request and event messages that will be used by the higher protocol layer.
- the objectmanagement protocol layer (based on a restricted set of services from OSI CMIS and CMIP (OSI ISO9595/OSI ISO9596). This protocol layer enables the operator to create, delete and manipulate objects at a peer service users. The services include such operations as get, set, create, and delete. This implies that object attribute values can be obtained as well as changed. Typical reports at this layer are configuration state changes, security reports and alarm reports.

It is currently anticipated that the RR protocol will be implemented on top of a transport protocol such as TCP/IP.

THE VALIDATION APPROACH

The validation approach has been built upon the following viewpoints on feasibility:

Feasibility from a functional point of view (usability). Here the key question is will the system sufficiently support the operator during task execution? The main evaluation criteria here were:

- the coverage of the OSS functions compared with existing operational command and control reference systems;
- the reliability of the OSS in terms of availability conditions (continuous mode) and failure probabilities (demand mode) for specific OSS functions [3];

- the performance in terms of the accuracy of the alarm and status reports communicated asynchronously to the OSS, the representation time needed to build up a comprehensible presentation on screen and the processing time of operator commands or scripts to invoke operations in the underlying motorway management systems.

Feasibility from technical point of view. Here the key question is can the system be built in such a way that:

- connectivity with motorways management systems and scalability is ensured?;
- the implementation meets the underlying specifications, based on modular decomposition of software components and allocation of functions to these components?;
- future maintenance of OSS components (road maps, configuration database, software and the technical infrastructure) can be executed against reasonable effort?

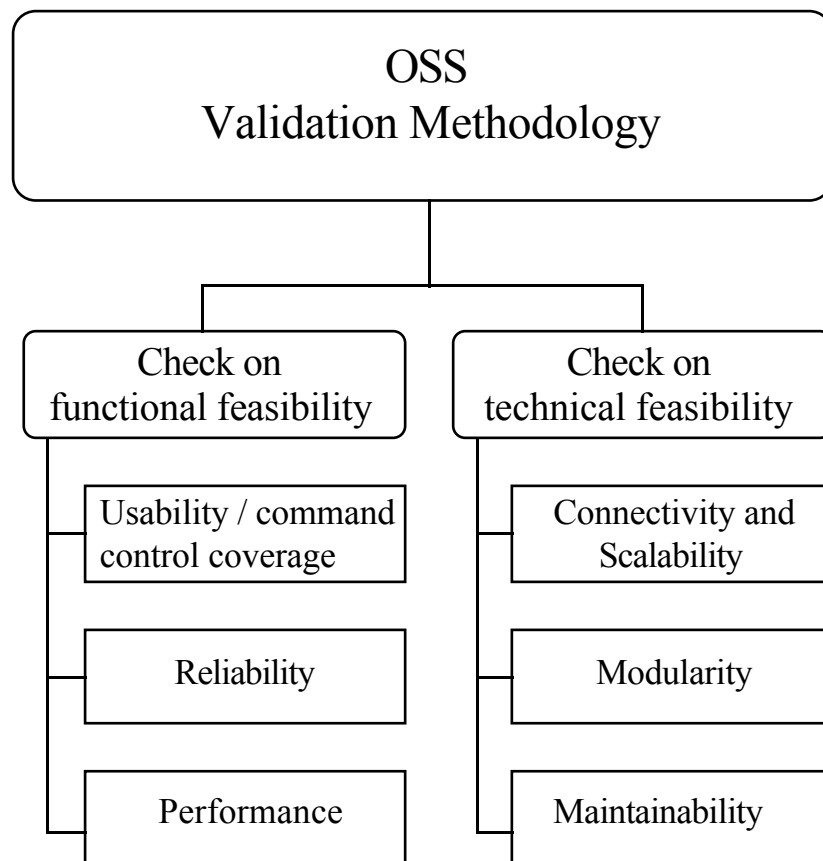


Figure II : Schematic outline of the validation approach

THE MAIN FINDINGS

Functional Feasibility of the OSS System

No severe omissions were found in the functionality of OSS concept in comparison with the other reference systems, although trend logs and simulation are not included yet. Given the open architecture these functions are expected to be built in afterwards relatively easy.

Although 7x24 hours availability (continuous mode) has been specified, no specific requirements were found for the tolerated duration of disturbances or repair times. A unscheduled shut down of the OSS will not directly lead to danger for life or severe economic damage. During day shifts motorway management system may be controlled autonomously (in the traditional way) from a local operating center. However, during night shifts when tasks are rerouted from one operating center to another (via remote handover) a shut down of the currently running operating center will result in a complete uncontrolled situation in the management domain of the unattended operating center. It was concluded that the reliability of the OSS can not be analysed in isolation, instead the complete chain of systems from the road toward the operating center has to be taken into account.

A more profound risk analysis based on existing international standards such as MIL-STD 1629A (Failure Modes and Effects Criticality Analysis) and IEC 1508 (Safety related Systems) has been recommended to obtain facts about the risks of operations disturbances in traffic management centers and the effectiveness of counter measures and risk aversion strategies [3].

The accuracy of alarm and status event reports has been defined in the order of magnitude of 1 second. Also the presentation and processing times have been defined in the order of magnitude of 1 to 5 seconds. This seems reasonable compared with other reference systems and considered relative to the delays in the underlying traffic management systems. It was found that the monitoring system needs at least 1 minute to calculate average traffic speed and traffic density, and the signalling systems needs 4 seconds to poll the underlying detection stations and 10 seconds to detect possible congestion.

Technical Feasibility of the OSS System

The OSS has been divided into several modular subsystems (computers software configuration items) based on the MIL-STD 2167 that provide a profound basis for structured development and controlled testing.

With respect to maintainability of the future OSS system it was found that the consistency between the central OSS configuration database and the configuration databases of the underlying motorway management systems is critical. To tackle this problem not only technical issues have to be resolved but in particular existing autonomous control organisations have to be harmonised and rearranged. Another point of concern is the software distribution and version control between operator centers. Because not all centers can be upgraded simultaneously with new software, the OSS must allow several centers to operate under different software versions. This implies that at any time upward compatibility must be ensured.

Relevance of the findings for European initiatives on Traffic Management Centers

At present no comparable systems are developed in Europe. The results of this validation approach may be used during analysis of the DATEX (Date Exchange) interoperability specifications that should lead to further standardisation for communication between international traffic management centers [4]. In particular the application of the GDF standard on a large scale outside the domain of route-guidance may lead to new insights about object definitions.

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