COSMIC

**The COSMIC Functional Size Measurement Method**
**Version 4.0.2**

# Automatic Line Switching Case Study

**Version 1.1**
**November 2018**

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# 1

# 1 AUTOMATIC LINE SWITCHING REQUIREMENTS

## 1.1 Background of the requirements

The Automatic Line Switching (ALS) system is documented in the ISO technical report: ISO/IEC TR 14143-4 (Version 2000). This ISO document provides various sets of functional requirements, described usually in a textual formal. The purpose of this ISO document is to provide researchers and practitioners with sets of requirements to be used as publicly available documents for measuring the functional size of software. The Automatic Line Switching system used in this real-time case study corresponds to set RUR B.8 of this ISO document.

## 1.2 Context

*(N.B. in the text below reproduced from ISO/IEC TR 14143-4:2000, some words have been added to help the reader to understand the text quickly. All such added words are in italics.)*

The functional requirements of the software of the ALS system below describe the control of two lines - a Work Line and a Backup Line - provided for a communication channel. If the Work Line degrades or fails the Backup Line is used instead. The decision to switch from one Line to another is made either automatically by the ALS software or by a technician at the receiving side. The switch to the Backup Line will remain in effect even after the Work Line becomes fully operational.

A standard redundancy method is used to continuously check the accuracy of the transmissions. Error correction, however, is not part of the software and is carried out externally. The error rate of a line signal will determine if the quality of a line is normal, degraded, or has failed. Since the lines are monitored continuously *by their Quality Level Change Monitors (QLCMs)* a complete loss of signal will initially be detected as a degraded quality. The expected response to a degraded or failed signal on the working line is to automatically switch to the backup line, if that line is in better condition.

## 1.3 External commands

Technicians are provided with a set of commands *for the Work Line and the Backup Line* to change the configuration of the channel *via the Channel Configuration Software on a PC*:

| | |
|---|---|
| remove line: | the line is taken out of service, |
| restore line: | the line is placed in service, |
| forced switch: | the line is selected for communication if it is not out of service, and |
| conditional switch: | the line is selected for communication, if it is not out of service and at least at the same quality as the line currently selected. |

## 1.4 Properties

a) The quality of a line has four levels:
   1. "normal" ($<10^{-9}$ error rate),
   2. "degraded" ($10^{-5}$ to $10^{-9}$ error rate),
   3. "failed" ($>10^{-5}$ error rate, or no signal), and
   4. "out of service".

b) One and only one of the two lines is selected for communication at any given time.

*The next four requirements describe what must happen to the quality of a line when a command is entered by a technician from the Channel Configuration Software on the PC.*

c) When a “remove Work Line” event *(command)* occurs:
if the Work Line is not out of service then it goes out of service,
otherwise the Work Line remains out of service.
(The behaviour on a “remove Backup Line” event is analogous).

d) When a “restore Work Line” event *(command)* occurs:
if the Work Line is out of service then it becomes normal
otherwise the level of the Work Line does not change.
(The behaviour on a “restore Backup Line” event is analogous.)

e) When a “forced switch to Work Line” event *(command)* occurs:
if the Work Line is not out of service then it becomes the selected line,
otherwise the selection of the lines remains unchanged.
(The behaviour on a “forced switch to Backup Line” event is analogous.)

f) When a “conditional switch to Work Line” event *(command)* occurs:
if the Work Line is not out of service and is not of poorer quality than the Backup Line then the Work Line becomes the selected line,
otherwise, the selection of the lines remains unchanged.
(The behaviour on a “conditional switch to Backup Line” event is analogous.)

*The next three requirements describe what must happen to the current quality level of a Line when its QLCM detects certain conditions that may result in the need to change the Line’s quality level.*

g) When a “Work Line degraded” event occurs:
if the quality of the Work Line is “normal” then it will change to “degraded”,
otherwise, the quality of the Work Line remains unchanged.
(The behaviour on a “Backup Line degraded” event is analogous.)

h) When a “Work Line failed” event occurs:
if the quality of the Work Line is “degraded” then it will change to “failed”,
otherwise, the quality of the Work Line remains unchanged.
(The behaviour on a “Backup Line failed” event is analogous.)

i) When a “Work Line cleared” *(i.e. quality is ‘normal’)* event occurs:
if the quality of the Work Line is “degraded” or “failed” then it is set to “normal”,
otherwise, the quality of the Work Line remains unchanged.
(The behaviour on a “Backup Line cleared” event is analogous.)

j) If a “remove line”, “restore line”, "line degraded”, “line failed”, or “line cleared” event occurs *(i.e. one of the events of requirements c), d), g), h) and i) occurs)*, and the currently un-selected line becomes of a higher quality than the selected line, then the selection will be switched, triggered by the ALS software.

k) Removing, restoring, deterioration, or clearing of a line does not affect the quality of the other line.

l) Switching the selected line does not affect the quality of either line.

m) It is forbidden to switch to a line that is out of service, except when both lines are out of service.

n) The selected line will only change as a result of one of the following:
   1. the selection is changed with a switch command *(provided, in the case of a conditional switch, that the quality of the other line is not out-of-service or of poorer quality than that of the currently selected line)*,
   2. the currently selected line deteriorates to a quality inferior to the other line,
   3. the currently selected line goes out of service, or
   4. the currently un-selected line clears (or is restored) to a quality better than the selected line.

*Note. There is overlap between requirements j) and n).*

*On first reading, it may appear from the requirements that each line needs two status indicators – its current 'quality' (from a)) and whether or not it is currently 'selected' to be used for communication (from b)). But with one exception, any decision by the system to switch depends only on the relative quality of the two lines – the current selection status does not matter in the system's decision to switch. The exception is a 'forced switch' which is determined wholly by the Technician, ignoring the relative quality of the two lines.*

## 1.5 Assumptions

The following assumptions are made for the measurement solution proposed in this case study:

1 The analysis of the error rate (by the standard redundancy method used to continuously check the accuracy of the transmission) is performed outside of the ALS software to be measured, by the two (hardware-software) functions, the QLCMs, which monitor the error rate as input. When a change of error rate is detected the QLCM issues one of the three following signals for each type of line: line degraded, line failed, line cleared.

2 Similarly, the physical switching between lines is assumed to be made by another (hardware/software) function, the Switch Device, triggered by a signal from the ALS software.

3 The line quality of each line (see 1.4 a) must be stored every time it is updated (changed) because the ALS software needs to know the existing status when a new status is signaled, in order to decide what to do.

4 The quality of both lines must be displayed on the Channel Configuration Panel (the display of the Channel Configuration Software on the PC), in order to enable the Technician to decide what to do.

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# 2 MEASUREMENT STRATEGY

## 2.1 Measurement purpose

The measurement purpose is to measure all of the Functional User Requirements (FUR) of the ALS software documented in the set of Reference User Requirements selected for this case study, using the COSMIC functional sizing method. FUR are derived from the functional requirements of the software which, in turn, are a subset of the Reference User Requirements (RUR).

## 2.2 Measurement scope

The measurement scope is all of the FUR. The measurement scope is therefore a subset of the ALS system requirements documented in this ISO case study, that is, only those related to software, and not those related to the hardware.

There is a single software layer for this set of requirements

## 2.3 Identification of functional users

The functional users that interact directly with this ALS software are the following devices:

a) Hardware-software devices sending information to the software:

- *Channel Configuration Panel software on the PC: issues the commands entered by the Technician*
- *Quality Level Change Monitors (for the Work/Backup Lines)*

b) Hardware-software devices receiving information from the software:

- *Switch Device, to switch to the other (currently non-selected) Line*
- *Channel Configuration Panel software on the PC, displays status of each Line.*

Note that there are two *occurrences* of the Quality Level Change Monitor, one for the Work Line and one for the Backup Line. As both are subject to the same FUR (namely: 'if a change in the quality level of the line is detected, inform the Automatic Line Switching software'), identify only one functional user *type* 'Quality Level Change Monitor', as in Figure 1.

From the requirements, as written, there are no human users interacting directly with the software being measured (the human interaction is carried out through the Channel Configuration Panel software), nor is there any other software interacting with this software being measured.

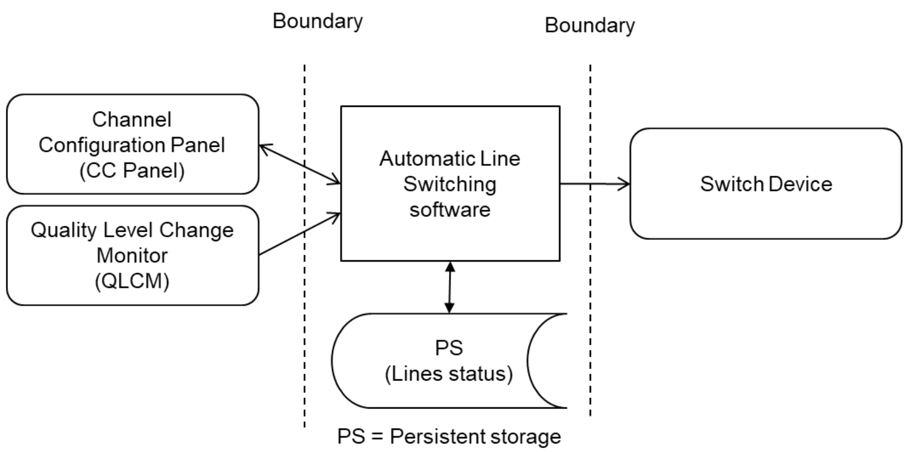


**Figure 1 – Context diagram of the Automatic Line Switching software**

## 2.4 Other measurement strategy parameters

**Level of granularity.** The software requirements of the Automatic Line Switching system are at the 'level of granularity' of a functional process because the functional users are individual hardware devices or software (not groups of these) and a single event occurs that the software must respond to (not groups of events).

**Level of Decomposition**: Not applicable

**Persistent storage.** As there is no requirement stating that the storage be accessible via another piece of software, from the COSMIC measurement perspective the data (the status of the lines) resides on persistent storage within the software boundary.

# 3 THE MAPPING AND MEASUREMENT PHASES

## 3.1 Identification of the triggering events

From the documented requirements the following triggering events are identified:

1 Remove Work Line
2 Restore Work Line
3 Forced switch to Work Line
4 Conditional switch to Work Line
5 Signal of Work Line failed
6 Signal of Work Line degraded
7 Signal of Work Line cleared

+ all similar triggering events for the Backup Line, hence 14 triggering event *occurrences*. However,

- The triggering events for the Work Line and the Backup Line of the Remove Command are analogous, as they share the same FUR of the service to be performed. This service *type* could be called ‘Remove Line’, where ‘Line’ stands for ‘Work Line’ or ‘Backup Line’). The same for the other three Commands.
- The three ‘Signal of Line Quality’ triggering events 5, 6 and 7 require different services as described by points g), h) and i) in section 1.4), i.e. lead to services with different FUR from those triggered by a technician. But again they are the same for the Work Line and for the Back-up line. Identify three triggering event types.

Total = 7 triggering event types.

## 3.2 Identification of functional processes

As the requirements for the Work line and the Backup line share the same FUR according to the properties of Chapter 2 for commands from technicians, one functional process type must be identified that accounts for handling both lines. The first four triggering events require different handling (FUR), hence identify four different functional processes.
With the line quality data from the QLCM the software produces the three ‘Line Quality Commands’, each requiring different handling, leading to three different functional processes. In total there are 7 functional processes:

1 Remove Line: the Line is taken out of service
2 Restore Line: the status of the Line is set to ‘Normal’.
3 Forced Line switch: the Line is selected for communication as long as it is in service
4 Conditional Line switch: the Line is selected for communication, as long as it is in service and at least at the same quality as the line currently selected
5 Handle QLCM Line failed signal,
6 Handle QLCM Line degraded signal, and
7 Handle QLCM Line cleared signal.

Each 'Handle...' functional process (5, 6 and 7) transforms its QLCM signal to a command to the Switch Device, which makes the physical switching between the lines.

## 3.3 Identification of objects of interest

All the data moved into and out of the ALS software and to/from persistent storage describes the same one object of interest 'Line'. The data groups moved are

| Data group name | Attributes | From/to |
|---|---|---|
| Line Command | LineID, Command (Remove, etc.) | From CC Panel to ALS |
| Line Status | LineID, Quality | From QLCM to ALS,<br>From ALS to CC Panel and to persistent storage<br>From persistent storage to ALS |
| Line Switch | LineID, Selected Y/N | From ALS to Switch Device |

## 3.4 The functional processes and their data movements

This section describes each functional process with its data movements. Sizes are indicated in the COSMIC unit: 1 COSMIC function point = 1 CFP. Data movement types are abbreviated as E = Entry, X = Exit, R = Read, W = Write.

**Functional Process: Remove line**
**Triggering Event: Remove line needed**

| Functional user | Data movement Description | Data Group moved | Data Mvt. Type | CFP |
|---|---|---|---|---|
| CC Panel | Enter Remove line command | Line Command | E | 1 |
| | Read Work/Back-up Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Remove line command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

**Functional Process: Restore line**
**Triggering Event: Restore line needed**

| Functional user | Data movement Description | Data Group moved | Data Mvt. Type | CFP |
|---|---|---|---|---|
| CC Panel | Enter Restore line command | Line Command | E | 1 |
| | Read Work/Back-up Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Restore line command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

| Functional Process: Forced Line switch<br>Triggering Event: Forced switch needed | | | | |
|---|---|---|---|---|
| **Functional user** | **Data movement Description** | **Data Group moved** | **Data Mvt. Type** | **CFP** |
| CC Panel | Enter Forced switch command | Line Command | E | 1 |
| | Read Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Forced switch command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

| Functional Process: Conditional Line switch<br>Triggering Event: Conditional switch needed | | | | |
|---|---|---|---|---|
| **Functional user** | **Data movement Description** | **Data Group moved** | **Data Mvt. Type** | **CFP** |
| CC Panel | Enter Conditional switch command | Line Command | E | 1 |
| | Read Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Conditional switch command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

| Functional Process: Handle QLCM Line failed signal<br>Triggering Event: QLCM Line failed signal | | | | |
|---|---|---|---|---|
| **Functional user** | **Data movement Description** | **Data Group moved** | **Data Mvt. Type** | **CFP** |
| QLCM | Enter QLMC Line failed signal | Line Status | E | 1 |
| | Read Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Line switch command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

| Functional Process: Handle QLCM Line degraded signal<br>Triggering Event: QLCM Line degraded signal | | | | |
|---|---|---|---|---|
| **Functional user** | **Data movement Description** | **Data Group moved** | **Data Mvt. Type** | **CFP** |
| QLCM | Enter QLMC Line degraded signal | Line Status | E | 1 |
| | Read Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Line switch command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

| Functional Process: Handle QLCM Line cleared signal<br>Triggering Event: QLCM signal | | | | |
|---|---|---|---|---|
| **Functional user** | **Data movement Description** | **Data Group moved** | **Data Mvt. Type** | **CFP** |
| QLCM | Enter QLMC Line cleared signal | Line Status | E | 1 |
| | Read Line status | Line Status | R | 1 |
| | Write Line status | Line Status | W | 1 |
| Switch device | Exit Line switch command | Line Switch | X | 1 |
| CC Panel | Display Line status | Line Status | X | 1 |
| | | | | **Total size: 5 CFP** |

The total functional size of the Automatic Line Switching software is 7 * 5 CFP = 35 CFP.

A good insight in the movement of data within a functional process gives a Message Sequence Diagram. Figure 2 shows the message 'traffic' within the 'Remove line' functional process:

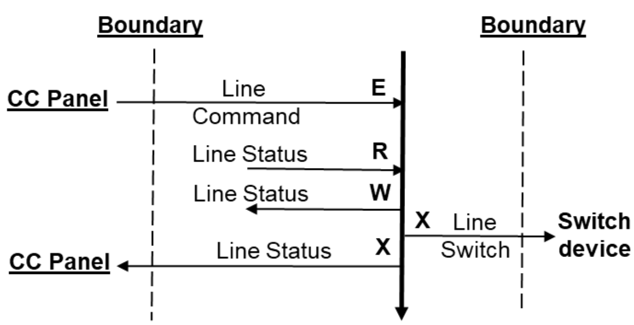


**Figure 2 – Message Sequence Diagram of Remove line**

## 3.5 Discussion of the identification of the functional processes

There are reasons for arguing that there are only two functional processes, namely one that fulfills all Technician commands and one that fulfills all changes of line status reported by a QLCM. Supporting this argument are the facts that the size, functional users and data movements of the first four processes are identical; they differ only in the *values* of their triggering Entries (the Technician commands). Similarly the size, functional users and data movements of the last three processes are identical; they also differ only in the values of the line quality detected by a QLCM. With this interpretation, the different processing paths simply result from the different input values.

However, our reason for concluding that there are seven distinct functional processes is that they result from seven different triggering events occurring in the external world. The technician makes separate decisions for the four cases dependent on his/her knowledge of what's happening in the real world. Similarly, each QLCM responds to different events depending on its detecting different physical changes in the quality of the line it is monitoring.

## 3.6 Observations on the clarity of the documented requirements

Even though the documented requirements used for this case study are coming from an ISO technical report, there is no mention in this ISO report about the quality of these requirements. IEEE Std 830-1998 recommends that requirements meet the following quality criteria:
- Correct;
- Unambiguous;
- Complete;
- Consistent;
- Ranked for importance and/or stability;
- Verifiable;
- Modifiable;
- Traceable.

In the ISO technical report, there is no claim that their sets of documented requirements meet the quality criteria specified in IEEE 830. The following uncertainties or ambiguities have therefore been noted in the Requirements:

1) It is not clear if the status and the quality of the lines are recorded. Neither is it specified where or how they should be saved.
2) There is no indication of how messages are sent or received between processes or between users and processes.
3) There is no information about the exit from the process when it is finished.
4) The Technician doesn't know the currently selected line. This will be confusing to him when he wants to return back to the beginning of the session.
5) The Requirements do not ensure the security of having acceptable quality if one line is out of service.
6) The Requirements do not cover the case where a line of 'normal' quality receives a signal that it has 'failed', without first passing through the 'degraded' quality level.

## 3.6 Observations

During the measurement process, uncertainties and ambiguities about the documented requirements have been noted and it has been necessary to make assumptions about the functionality of the system that is allocated to software. It was also observed that these requirements do not meet all of the quality criteria listed in IEEE 830.

The reader is alerted to the fact that different interpretations of the system requirements and different assumptions to correct these requirements may result in different measurements of the software functional size.

# APPENDIX - GENERAL INFORMATION

## 1 Acknowledgements


| Version 1.1 Reviewers | | |
|---|---|---|
| Alain Abran<br>École de Technologie Supérieure, Université du Québec<br>Canada | Arlan Lesterhuis*<br>MPC<br>The Netherlands | Bruce Reynolds<br>Tecolote Research<br>USA |
| Charles Symons<br>United Kingdom | Francisco Valdés Souto<br>SPINGERE<br>Mexico | |

* Editor of version 1.1 of this Case.


## 2 Version control

The following is a partial account of the evolution of this case study.

| Date | Reviewers (s) | Modifications / Additions |
|---|---|---|
| 2004-08-26 | Adel Khelifi | First Draft |
| 2004-2005 | Alain Abran, Adel Khelifi, Charles Symons | Several revisions |
| 2018 | Alain Abran, Arlan Lesterhuis, Bruce Reynolds, Charles Symons, Francisco Valdes Souto | Complete revision |

## 3 Main changes in v1.1 from v1.0 of this Guideline

Note. The nature of a change is indicated by

- ‘Method’ when a definition or rule of the COSMIC method has been changed
- ‘Editorial’ when the description of the guidance was changed to improve ease of understanding.
- ‘Correction’ when an error in the previous version v1.0 of this Guideline has been corrected.

| References in version 1.1 | Nature of change | Comment |
|---|---|---|
| General | - | The general style of the case changed to match the usual structure of the COSMIC documents. All general information (on acknowledgements, version control etc.) moved to the end of this case. |
| General | Editorial | The Automatic Line Switching (ALS) *system* is more clearly distinguished from the ALS *software*. |
| General | Correction | In v1.0, fourteen *occurrences* rather than *types* of functional processes were identified, leading to twice as many functional processes as are actually needed. This corrected and explanation added. |
| General | Editorial | The section ‘Questions & Answers’ omitted as it doesn’t add much value |
| 1.2 | Editorial | In this section the paragraph of the RUR ‘A standard redundancy method…’ added, for ease of understanding. |
| 1.3 | Editorial | For clarity in the first paragraph ‘Work Line’ and ‘Backup Line’ added |
| 2.1 | Editorial | The text of v1.0 greatly shortened; irrelevant information omitted. |
| 2.3 | Correction | In points a) and b) '-software' added, as in 1.5 it reads 'hardware-software functions' |
| 2.3 | Editorial | The outdated term ‘electro-mechanical devices’ replaced by ‘hardware-software devices’ |
| 2.3 | Editorial | Figure 1 added, the context diagram of the Automatic Line Switching software |
| 3.3 | Correction | The object of interest and the data groups moved explicitly described |
| 3.4 | Editorial | The use case diagram omitted as it didn’t add value. Two of the three Message Sequence Diagrams omitted: for illustration one suffices. |
| 3.4 | Correction | The data movements adapted to the data model of this case. Data movements added to account for the CC Panel display on the PC |

| References in version 1.1 | Nature of change | Comment |
|---|---|---|
| 3.5 | Editorial | New section added: 'Discussion of the identification of the functional processes, which explains that 7 (rather than 2) functional processes must be identified. |
| 3.6 | Editorial | Both first paragraphs removed as they repeated other information |

## 4 Change requests, comments, questions

Where the reader believes there is a defect in the text, a need for clarification, or that some text needs enhancing, please send an email to: mpc-chair@cosmic-sizing.org

You can use the forum on cosmic-sizing.org/forums to post your questions and receive answers from our world-wide community. The quality of any answers will depend on the knowledge and experience of the community member that writes the answer; the MPC cannot guarantee the correctness. Commercial organizations exist that can provide training and consultancy or tool support for the method. Please consult the www.cosmic-sizing.org web-site for further detail.