TREND ANALYSIS IN COSMO-SKYMED GROUND AND ILS&OPS SEGMENTS AS CONDITION BASED MAINTENANCE AND FOR NEW USER NEEDS

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ABSTRACT

The classical Condition Based Management activities consist of periodically measures on physical characteristics of a system (e.g. temperatures, fluid levels, etc.). This type of analysis is performed on the COSMO-SkyMed Space Segment, but a Trend Analysis is also required for the Ground and ILS&Ops (Integrated Logistic Support and Operations) Segments, especially in the operational phase. So a different process has been defined to periodically check the status of overall System and to maintain it in an efficient operational status, so to answer to the user needs in the most efficient way.

INTRODUCTION

COSMO-SkyMed (1)(2) is an Earth Observation space program jointly managed by the Italian Space Agency (ASI) and It-MoD (Ministry of Defence).

In the framework of the current programmatic phase concerning the operational management (3) of the constellation, a set of qualified teams was introduced in order to perform technical, operational and engineering activities on the system. Moreover some tailored information flows were developed by ASI, It-MoD and Industrial staff in order to continuously guarantee the performances and the availability of the system and to identify potential enhancements and changes for the optimization of the overall cost/benefit ratio and the increase of the performances with respect to the original specification and user needs (6).

To support this operational management phase a Trend Analysis system has been introduced.

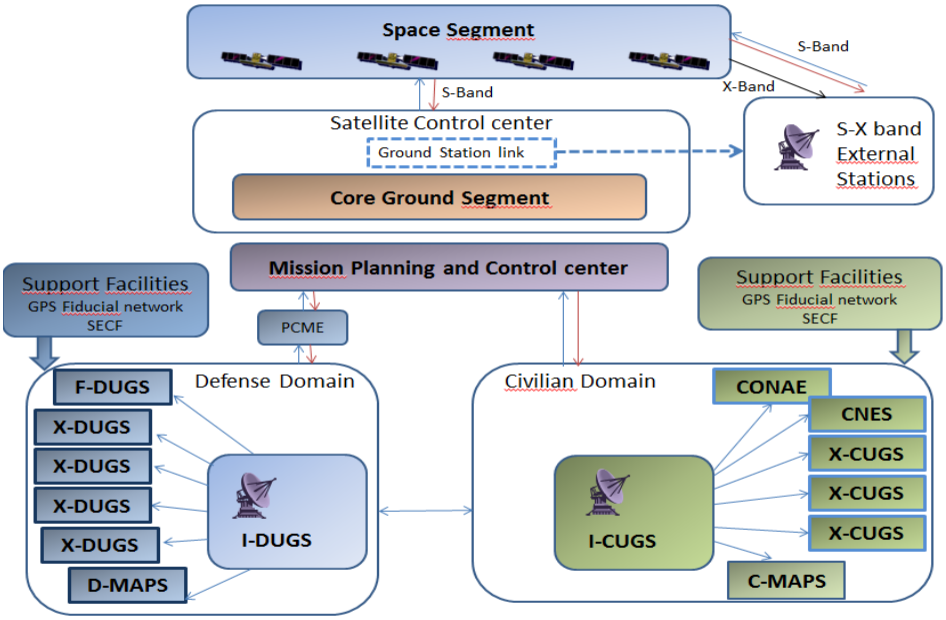


Figure 1: COSMO-SkyMed Architecture

METHODS

The application of techniques of TT (Trouble Tickets) and Trend Analysis on a system in operations has the primary objective to study the behaviour of the system to identify actions (at any level) aimed at:

- ensure that the system meets the needs of the users;
- keep the system in operating mode;
- ensure the nominal behaviour of the system.

The Trend Analysis allows evaluating:

1. the behaviour of the system in order to identify deviations from nominal behaviour and **anticipate corrective actions** before these deviations result in failure; in this case the Trend Analysis falls within the concept of Condition Based Maintenance (CBM) and the analysis is made on measurements of significant physical behaviour of the system (temperature, pressure , speed, etc.);
2. the performance of the system in a time-dependent context, in order to identify abnormal behaviour due to degradation and **anticipate corrective actions before that degradation results in not nominal behaviour**; in this case the Trend Analysis falls in a sort of concept of CBM system, applicable to the parameters at system level, and with corrective action not always defined a priori (that is to say that these actions in most cases are not described in the maintenance plan);
3. if the nominal behaviour of the system is **adequate with respect to possible evolutions of the concepts of use, of the usage scenarios, of the operational and users' needs** and of the evolutions that actually imply **new requirements**, not reported in the baseline, and deriving from:
    a. the operational experience , which leads to better define **new operational needs** and **new requirements "on field"** ;

   b. the changes in the context in which the system is operating, for example, due to **new requirements of the customer** or to the changed conditions of the support (in particular the management of obsolescence) .

In this case the Trend Analysis is carried out as evolutive or adaptive maintenance.

The Trend Analysis requires to:

- define the variables to be kept under observation,
- measure a physical quantity,
- analyse the measured values in a time dependent context and compare them with reference values,
- identify actions in a pro-active way, i.e. before a problem occurs.

It should be noted that the Trend Analysis carried out in a classic CBM, is an activity very different from the one carried out in the context of evolutive/adaptive maintenance: the CBM is an approach to preventive maintenance, which is not based on calendar interventions , but on actions defined in terms of measures of physical significant.

The CBM approach can be adopted only if it is cost/effective, if the system has specific characteristics and if it is designed for this type of maintenance:

- the specific characteristics refer to the existence of physical phenomena related to the measures, which need to have a dynamic behaviour that they can be "humanly" managed (if the change velocity of the measured quantity is not in the order of hours, the system will only fail before human intervention); typically the physical phenomena manageable via CBM are related to the wear of mechanical components, temperature variations, etc.;
- the design concerns both the presence of measuring physical quantities, both the definition of prediction models of the related phenomena.

TT and Trend Analysis in COSMO-SkyMed Ground and ILS&Ops Segments

The periodic satellite data collection and the analysis of trends is a recurring task carried out by the “Space” SET (Support Engineering Team) Team, and falls within a context of preventive maintenance support.

For what concerns the items of the Ground Segment (4) (5), it is noted that generally **they do not have adequate characteristics for a CBM classic approach**, except for the antennas (which, however, must have been designed for this approach), or for few quantities correlated to the operating state of the platform, such as the temperature of the equipment rooms.

Therefore, the analysis in this case is based:

1. on **operative feedback** from the use of the system; inside this category there are :
   a. Direct analyses on **TT**,
   b. Indirect analyses on aggregated data at the level of Failure and Data Reporting and Corrective Actions System (**FRACAS/DRACAS**), starting from the TTs,
   c. Analyses which are object of **Lesson Learned** (also starting from TT),
   d. Analyses which are object of problems dealt within **technical meeting** (starting also from TTs)
   e. direct analyses on **performance parameters**.
2. **on the assessment of the context** in which the system is operating; inside this category there are :
   a. the analysis of obsolescence (both HW and SW),

b. the analysis of **new needs**, indirectly and recurrently **expressed by the Users** over time, and which are frequently the object of one or more technical table meetings.

It is noted that in many cases the concept of trend is linked to the evaluation in the time of new requirements: for example, **new User needs not initially well-encoded**, but then expressed recursively and so more and more clear, may lead to the need of specific analyses to revise parts of the system and to make the system itself more efficient than those innovations.

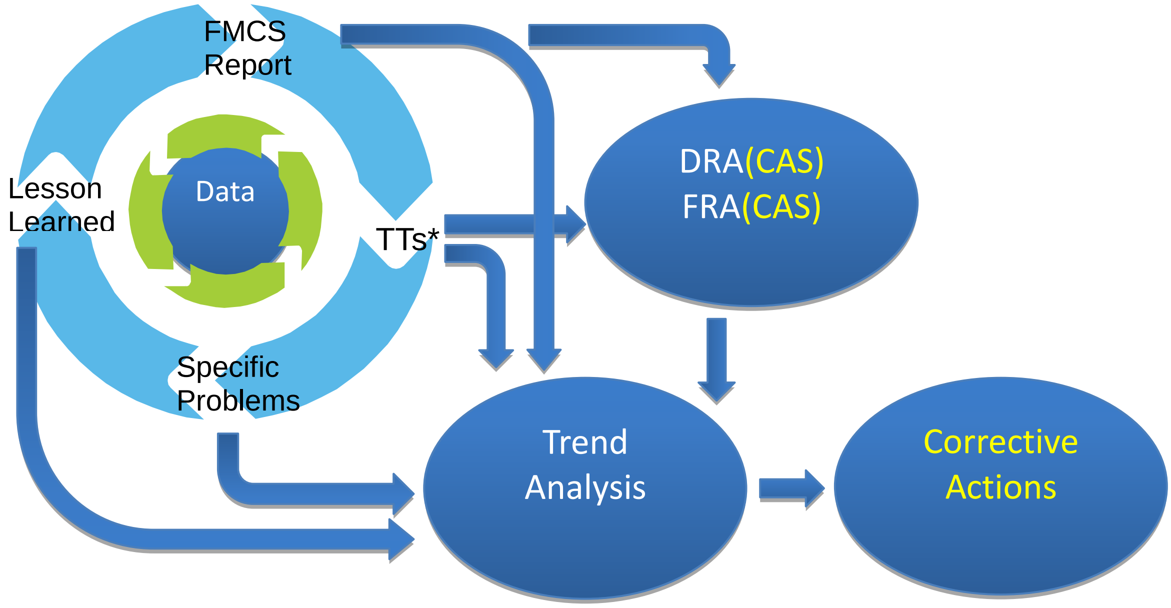
Since that the phenomena are not predicted a priori, it is generally not expected a priori to make measures of variables correlated to them. The first objective of the activity is to **identify behaviours/variables to observe/measure to analyse the phenomenon**. In this phase, the activity is performed as if a magnifying glass will be located on the system to better study the behaviour. This activity is at the core of the process because unlike the systematic monitoring of satellite parameters (which are many magnifiers well defined and placed a priori on the system), in this case it should be taken into account how to identify and "design" the needed magnifying glass.

For this activity the **TT**s define a valuable (but not only) source of data on the behaviour of the system. However the TTs are not comparable to the measurement of quantities like the CBM, but they are only a tool that helps to identify the variables to be monitored, using such **methods of aggregation** of the information such as DRACAS / FRACAS. It is important to note that the analysis DRACAS/FRACAS does not return monitored values, but provides a useful tool to identify such variables, i.e. useful to position the magnifying glass in the metaphor cited above.

Another source to activate the process of analysis consists of all those phenomena, for example periodically discussed in the review of the program, leading to define a **Lesson Learned**, or result in **Technical Tables** that lead to further investigations. For example, as part of the Technical Tables, it can be agreed to monitor a particular behaviour of the system, to study and identify possible actions.

Another source can be **log data** (if applicable and requested in advance by the SET) and possible maintainability surveys based on assessment of qualitative maintainability parameters, analysed in the LORA (Level of Repair Analysis).

Once all the behaviour or the item to be monitored have been identified, the analysis is performed to identify and monitor problems; the high-level process to be applied is sketched in next figure.



** And other information generally available from C&MMT*

Figure 2: TT and Trend Analysis process

An iterative process of data collection allows gathering series of information that include:

- FMCS (Funzione di Monitoraggio e Controllo del Sistema) Report and data, generally available from SAPM and related reports;
- Lessons Learned, generally derived from operational experience and technical board;
- Specific Problems, generally related to an overt anomaly;
- Trouble Tickets Data on occurred anomalies and other information generally available (e.g. Changes, Work Orders, Operative Instructions).

In details all the collected information are the input for the trend analysis; moreover, the information gathered from the COSMO-SkyMed Configuration and Management Tool (C&MMT) and FMCS data are used for DRA(CAS)/FRA(CAS) activities (the acronyms DRACAS/FRACAS which stand for Data and Failure Reporting Analysis and Corrective Actions System, are split in two parts, i.e. DRA-CAS and FRA-CAS). The FMCS and TTs data gathering process allows to group the information in a set of classes that represent a further input to the Trend Analysis (DRA/FRA: Data and Failure Reporting Analysis).

The results of the Trend Analysis lead to the process of define the corrective actions (CAS: Corrective Actions System). If the results of the Trend Analysis lead to the need of a corrective action, therefore its related impacts can lead to two different situations:

- If no impacts are envisaged on the Ground Segment Design but only on the parameters dimensioning the logistic support, only a process of reduced Recurring Logistic Support Analysis is required, as per logistic support elements impacted (Spare Lists, Plans, Training, Manuals, etc.).
- If impacts are envisaged on the Ground Segment, a full request of change will be required to SET/IOSS (Industrial On Site Support) Team rising a Non Conformance

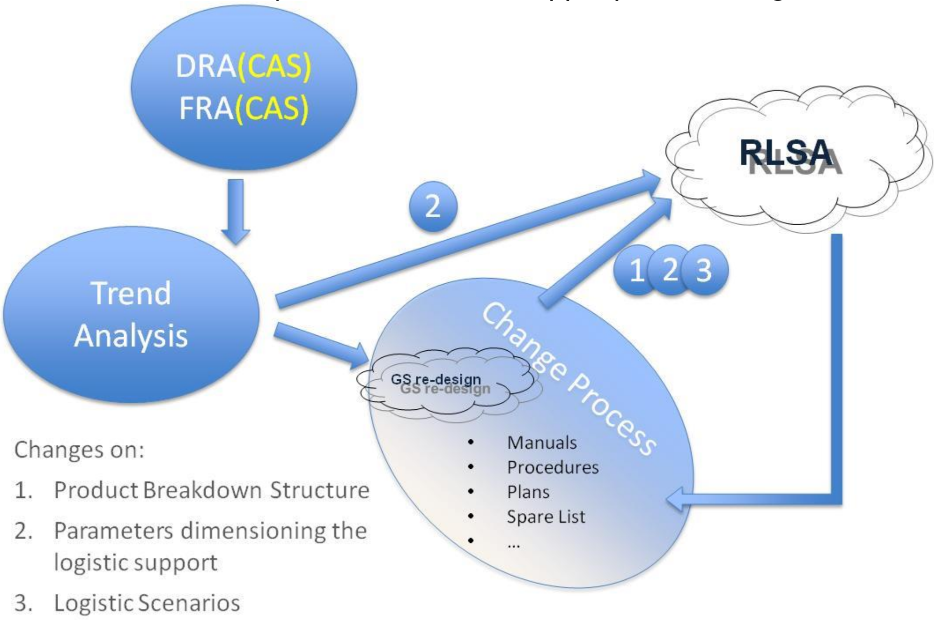


Figure 3: request of change

CONCLUSIONS

In conclusion, a TT and Trend Analysis process can be summarized as follows: a **data collection of several input** is performed; these data are all grouped and aggregated in order to be efficiently ready-to-use for example with a process based on a DRACAS/FRACAS method. The found phenomena are categorized according to the severity and recurring of events. On these bases, **corrective actions** shall be taken into account to monitor the system and in case of high severity, requests for changes or enhancements shall be performed; these can have necessary impacts on Ground and ILS&Ops Segments that induce a recurring Logistic Support Analysis.

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