ANALYSIS ON THE AVAILABILITY OF COMS GS

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ABSTRACT: This paper describes several reliability models to estimate COMS ground segment availability and shows assessed availability according to GS function. Due to a back-up concept among three ground center, SOC will have all H/W and S/W module to be installed in MSC and KOSC site. Therefore, all configurations and availability parameters for H/W and S/W modules in MSC and KOSC are assumed as equal with those in SOC, if related modules have same function. Prior to access availability over COMS GS function, Availability related to fundamental configuration such as series, parallel, partial operation, and module combined H/W and S/W is described. Consequently, all functions are expected to operate with more than 99% of availability.

KEY WORDS: COMS, availability, MTBF, MTTR

1. INTRODUCTION

COMS, to be launched in 2008, will be the first geostationary observation satellite in KOREA. It has three major missions such as meteorological service, ocean monitoring, and Ka-Band satellite communication. Indeed, three payload like MI (Meteorological Imager), GOCI (Geostationary Ocean Color Imager) and Ka-Band repeater are implemented to perform each related mission. COMS ground segment consists of four ground centers, namely SOC (Satellite Control Center), MSC (Meteorological Satellite Center), KOSC (Korea Ocean Satellite Center) and CTES (Communication Test Earth Station). SOC provides functions for mission operation and satellite control. It also performs backup IDACS (Image Data Acquisition and Control System) function such as MI/GOCI data processing even under the MSC and KOSC are normally working. SOC will be located within the existing KARI (Korea Aerospace Research Institute) ground station and operated by KARI. MSC is the primary data processing center for MI data. It receives MI raw data and performs pre-processing such as radiometric/geometric correction. It transmits pre-processed meteorological data to satellite as a format of LRIT/HRIT (Low/High Rate Information Transmission). LRIT/HRIT are international dissemination formats recommended by CGMS (Coordination Group for Meteorological Satellite) to increase the interoperability between member nations. MSC also performs backup SGCS (Satellite Ground Control System) in the case of emergency situation on the primary SGCS at SOC. However backup satellite operation will be performed by SOC operator by using backup SGCS at MSC. KOSC is the primary data processing center for GOCI data. Since KOSC has only a receiving capability, it has not backup function unlikely SOC and MSC. Excluding CTES, three ground center needs to exchange satellite operation/status data for MI/GOCI pre-processing, mission request for MI/GOCI payload, and several auxiliary data required for backup operation through network. The type of network has not been finalized. It is true that there are several assumptions including type of network in this paper. Other assumptions are mentioned in following chapter, if necessary. Firstly, availability parameters are defined and summarized reliability figure of each H/W module is written in this paper. Availability over the four fundamental configurations in reliability model is also described. Finally, assessed availability is expressed according to COMS ground segment's function.

2. AVAILABILITY PARAMETERS

Parameters needed to access availability are MTBF (Mean-Time Between Failure), MTTF (Mean-Time To Failure), MTTR (Mean-Time To Repair/Replace) and reaction time. MTBF is a basic measure of reliability for repairable items such as H/W modules. It is described as the number of hours that pass before a component, assembly, or system fails. MTTF is a basic measure of reliability for non-repairable items such as S/W modules. It is the mean time expected until the first failure of a piece of module. MTTF is a statistical value and is meant to be the mean over a long period of time and large number of units. In this paper, this parameter is accessed using S/W model based on technical report [1]. MTTR is time taken to repair a failed H/W or S/W module. In an operational environment, repair of H/W module means replacing. Thus H/W MTTR could be viewed to replace a failed H/W module. MTTR for S/W is defined as 0.5 hours to restore the database for a program. Reloading the program, and resuming execution. Reaction time is a mean time required for person to be ready to investigate and repair any failure of H/W and S/W modules. This value is assumed as followings,

- Reaction time during office hours (40 hours per week assumed): 0 hours
- Reaction time during rest of the day and on weekends (128 hours per week): 2 hours
- Average reaction time: 1.52 hours

3. RELIABILITY FIGURES OF H/W MODULE IN SOC

Table 1 shows MTBF/MTTR are obtained from supplier for H/W module to be implemented as SOC site. Due to a backup concept, SOC will have the same of H/W and S/W module can be installed in MSC and KOSC site. Thus, all configuration and figures for H/W and S/W modules in MSC and KOSC could be assumed as equal with those in SOC, if related modules have same functionality. In the case of antenna and dedicated line, only availability value is informed by supplier.

Table 1 List of Availability Parameters of H/W Module

Items	MTBF	MTTR	Availability
Antenna			*0.996952715*
Dedicated Line			*0.999*
L-Band Down-converter	*40,000*	*1*	
L-Band LNA	*40,000*	*3*	
MODEM/BB	*70,000*	*1*	
Router	*50,000*	*0.5*	
S-Band Down-converter	*40,000*	*1*	
S-Band LNA	*40,000*	*3*	
S-Band Up-converter	*40,000*	*1*	
SSPA	*13,600*	*1*	
Workstation	*105,660*	*24*	

4. FUNDAMENTAL CONFIGURATION IN RELIABILIY MODLE

Four configuration such as series, parallel, partial operation, and module combined H/W and S/W are used to make a reliability mode of COMS ground segment functional data flow structure. Figure 1 shows the series configuration.

Figure 1 Series Configuration

Series means that module A and module B must operate for system to operate. Thus, if the availability of module A is A_A and that of module B is A_B, then total availability is estimated as followings,

$$A_{TOT} = A_A \times A_B$$

Figure 2 shows the parallel configuration

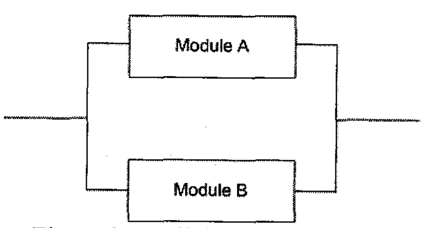

Figure 2 Parallel Configuration

Parallel means that one of two modules, module A or B is a redundant. Thus, system still operates despite of failure of one of two modules. If the availability of module A is AA and that of module B is AB, then total availability is estimated as followings,

$$A_{TOT} = 1-(1-A_A) \times (1-A_B)$$

Figure 3 shows the partial operation.

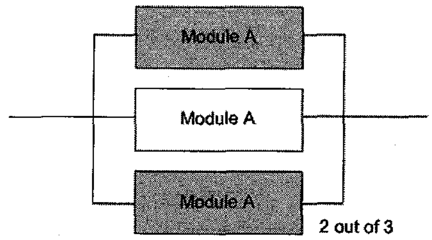

Figure 3 Partial Operation

Partial operation means system can be considered as operating when at least k of n modules is successful. For example, figure 3 shows partial operation which corresponds to 2 out of 3 modules. If three modules have a same availability, A_A, then total availability is estimated as followings,

$$A_{TOT} = \sum_{i=K}^{N} P(i,N|A_A)$$

$$P(i,N|A_A) = \binom{N}{i} A_A^i (1-A_A)^{N-i}$$

$$A_{TOT} = \sum_{i=2}^{3} P(i,N|A_A) = \binom{3}{2} A_A^2 (1-A_A)^1 + \binom{3}{3} A_A^3 (1-A_A)^0$$

Figure 4 shows the module combined H/W and S/W.

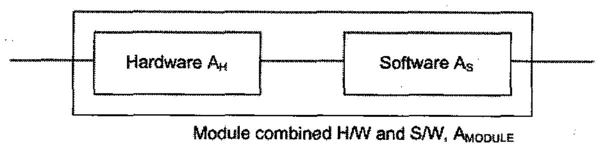

Figure 4 Module Combined H/W and S/W

In the case of module combined H/W and S/W, internal configuration can be treated as series. Thus, module availability, A_{MODULE}, is estimated as followings,

$$A_{MODULE} = A_H \times A_S$$

To estimate S/W availability, A_S, S/W model based on technical report [1] is considered. Assuming the host processor's speed as 6400 MIPS which corresponds to Xbox360 IBM "Xenon" single core, initial S/W failure rate, λ_O is calculated as 5.376. Then, failure rate (λ), MTTF and S/W availability are estimated as followings,

$$\lambda = \lambda_O \exp[-\lambda_O / (v_O \times \tau)]$$

where, v_O is total fault and τ is operating time.

$$MTTF = 1/\lambda$$

$$A_S = MTTF / (MTTF+0.5+1.52) = 0.999990884$$

5. COMS GROUND SEGMENT AVAILABILITY

Availability assessment is performed with reliability model consisted of fundamental configuration described above. For example, figure 5 shows the reliability model of MI IMPS (IMage Processing Subsystem) for radiometric/geometric correction.

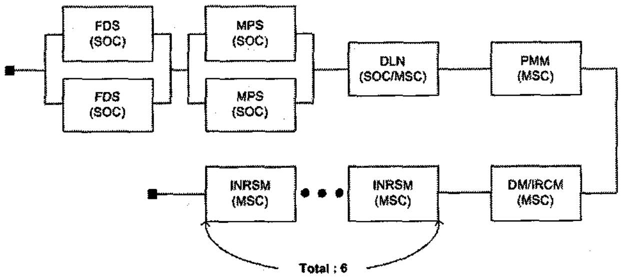

Figure 5 Reliability Model of MI IMPS

For the operation of INRSM (Image Navigation and Registration Software Module) in MSC, the SGCS ancillary data such as extracted telemetry information and ephemeredes generated by FDS (Flight Dynamic Subsystem) and event files generated by MPS (Mission Planning Subsystem) in SOC needs to be transferred via DLN between SOC and MSC. As shown in figure 5, there are two assumptions. First is the number of processor for IMPS modules like PMM (Product Management Module), DM (Decomposition Module)/IRCM (Image Radiometric Correction Module) and INRSM. Second is that the configuration of IMPS modules is only series not parallel. Above assumption will be modified when IMPS design is more specified. Availability values for reliability model in figure 5 are described in table 2.

Table 2 Availability Values for MI IMPS

Module	Configuration	MTBF (hours)	MTTR (hours)	Availability
FDS (SOC)	Module combined H/W and S/W	*105,660*	*24*	*0.9999999372*
MPS (SOC)	Module combined H/W and S/W	*105,660*	*24*	*0.9999999372*
DLN (SOC /MSC)				*0.999*
PMM (MSC)	Module combined H/W and S/W	*105,660*	*24*	*0.9997494153*
DM/IRCM (MPS)	Module combined H/W and S/W	*105,660*	*24*	*0.9997494153*
INRSM (MPS)	Module combined H/W and S/W	*105,660*	*24*	*0.9984974334*
MI IMPS				*0.9979957888*

Figure 6 shows the reliability model for MI raw data reception and radiometric/geometric correction performed in MSC. MI raw data is extracted at the output of MODME/BB after receiving SD (Sensor Data) in L-Band through antenna, LNA (Low Noise Amplifier) and DC (Down-Converter). The configuration of LNA and DC is assumed as 2 out of 3 operation. Availability values for reliability model in figure 6 are described in table 3.

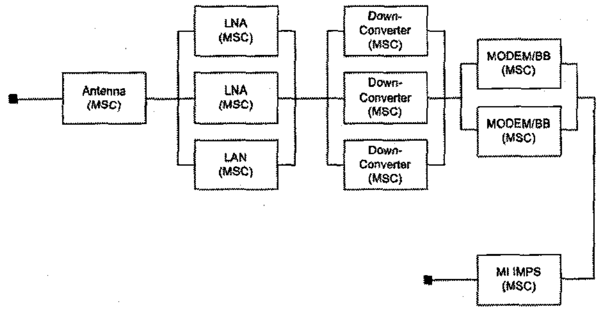

Figure 6 Reliability Model for MI Raw Data Reception and Radiometric/Geometric Correction

Table 3 Availability Values of MI Raw Data Reception and Radiometric/Geometric Correction

Module	Configuration	MTBF (hours)	MTTR (hours)	Availability
Antenna (MSC)				*0.9989527150*
LNA (MSC)	2 out of 3	*40,000*	*3*	*0.9999999617*
DC (MSC)	2 out of 3	*40,000*	*1*	*0.9999999881*
MODEM/BB (MSC)	Parallel	*70,000*	*1*	*0.9999999987*
MI IMPS (MPS)				*0.9979957888*
MI Raw Data Reception and Radiometric/Geometric Correction				*0.9969505515*

Table 4 represents the analyzed availability for all COMS GS functions. As shown, all availability is more than 99%.

Table 4 COMS GS Availability Summary

Functions of COMS GS	Availability
Mission Scheduling, Command Processing and Transmission	*0.9982646977*
Telemetry Reception, Processing and Trend Analysis	*0.9989526008*
Tracking, Ranging, Operational Orbit Determination and Prediction	*0.9987674684*
MI raw data reception and radiometric/geometric correction	*0.9969505515*
GOCI raw data reception and radiometric/geometric correction	*0.9977389773*
LRIT/HRIT generation and transmission	*0.9981683392*
SGCS C&M	*0.9999987065*
IDACS C&M	*0.9979959141*

6. CONCLUSION

This paper describes several reliability models to estimate COMS GS availability and shows assessed availability according to GS function. For the availability assessment, required parameters such as MTBF, MTTF, MTTR and reaction time are defined. Indeed, four fundamental configurations which can be piece of reliability model are explained with estimating availability. For example, reliability model and availability for MI raw data reception and radiometric/geometric correction are described. From the result of assessed availability, it is found that COMS GS functions can be operated within more than 99% of availability.

7. REFERENCE

[1] US Reliability Analysis Centre, *Reliability Techniques for Combined Hardware and Software Systems*, ref. RL. TR-92-15. This material can be purchased via www.ntis.gov