

## **The 2nd ESA RAMS Conference**

# **Reliability Prediction of EEE Parts for Space Application using FIDES and MIL-HDBK-217 and HIREC's Future Approach to FIDES Reliability Analysis Services**

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# **1. Reliability Prediction of EEE Parts for Space Application using FIDES and MIL-HDBK-217**

## **2. HIREC's Approach to FIDES Reliability Analysis Services**

## **Background**

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**In Japan, MIL-HDBK-217 is used as major reliability prediction method for EEE parts onboard spacecraft – But MIL-HDBK-217 has not been updated since 1995.**

**In order to examine the advantages of FIDES, the failure rate calculation results of EEE parts for space application using FIDES and MIL-HDBK-217 were compared and considered here.**

# EEE Parts Considered

<b>Type</b>	<b>Parts Considered</b>
<b>Diodes</b>	<b>Zener diode, Schottky diode and Switching diode</b>
<b>Transistors</b>	<b>Low noise transistor, Power MOSFET and Bipolar transistor</b>
<b>Resistors</b>	<b>Film resistor, Wire wound resistor and Network resistor</b>
<b>Optoelectronics</b>	<b>Photodiode optocoupler and Phototransistor optocoupler</b>
<b>Analog ICs</b>	<b>Operational amplifier, A/D converter, D/A converter and Comparator</b>
<b>Digital ICs</b>	<b>Transceiver, SRAM and FPGA</b>
<b>Ceramic Capacitors</b>	<b>MLCC with defined and non-defined temperature coefficient</b>
<b>Tantalum Capacitors</b>	<b>Solid tantalum capacitor and Wet tantalum capacitor</b>
<b>Magnetic Components</b>	<b>Transformer and Inductor</b>
<b>Connectors</b>	<b>D-sub connector and Round connector</b>

## **Assumptions for Calculations using FIDES (1)**

- **Failure rates were calculated according to FIDES Guide 2009 Edition A.**
- **Mission profile of an equipment of a geostationary satellite, defined in New Reliability Prediction Methodology for Space Applications (NRPM), was used.**
- **Values recommended by NRPM were used for following factors.**
  - **$\Pi_{\text{application}}$ : 1.13 (launch, time to reach orbit and on-orbit phase)**
  - **$\Pi_{\text{Ruggedising}}$ : 1.0 (suppliers in the space industry)**

## **Assumptions for Calculations using FIDES (2)**

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- **Considering prime contractor of space sector, process factor was determined as follows.**
  - **$\Pi_{\text{Process}}$ : 1.484.**
- **Launch phase through the on-orbit phase was considered.**
- **FIDES ExperTool (compatible with FIDES Guide 2009 Edition A) was used as calculation tool.**

# Mission Profile Summary

			Temperature	Temperature cycling			
Phase name	ON/OFF	Calendar time	Reference temperature	$\Delta t$	Cycle duration	Number of cycles	Maximum temperature during cycling
Launch	ON	2h	15°C	0°C	2h	1	15°C
Time to reach orbit	ON	48h	15°C	10°C	24h	2	20°C
On-orbit	ON	131400h	25°C	5°C	24h	5475	27.5°C

			Humidity	Mechanical
Phase name	ON/OFF	Calendar time	Relative humidity	Random vibrations
Launch	ON	2h	70%RH	18Grms
Time to reach orbit	ON	48h	0%RH	0Grms
On-orbit	ON	131400h	0%RH	0Grms

## **Assumptions for Calculations using MIL-HDBK-217**

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- **Failure rates were calculated according to MIL-HDBK-217F, Notice 2 (1995).**
- **Stress analysis method was used for calculation.**
- **“SF (Space, Flight)” was used as the environmental factor  $\pi_E$ .**
- **Only on-orbit operations were considered, since launch time was very short.**
- **“Class S” was used as the quality factor  $\pi_Q$  of EEE parts for space applications.**



# Failure Rate Calculation Results

<b>Type</b>	<b>Number of Parts (Qty)</b>	<b>MIL-HDBK-217 (FIT)</b>	<b>FIDES (FIT)</b>
<b>Diodes</b>	<b>3</b>	<b>2.78</b>	<b>0.45</b>
<b>Transistors</b>	<b>3</b>	<b>25.70</b>	<b>0.44</b>
<b>Resistors</b>	<b>3</b>	<b>0.15</b>	<b>0.05</b>
<b>Optoelectronics</b>	<b>2</b>	<b>12.75</b>	<b>1.03</b>
<b>Analog ICs</b>	<b>4</b>	<b>35.41</b>	<b>3.88</b>
<b>Digital ICs</b>	<b>3</b>	<b>130.86</b>	<b>2.48</b>
<b>Ceramic capacitors</b>	<b>2</b>	<b>0.05</b>	<b>1.26</b>
<b>Tantalum capacitors</b>	<b>2</b>	<b>0.07</b>	<b>1.14</b>
<b>Magnetic components</b>	<b>2</b>	<b>12.81</b>	<b>0.01</b>
<b>Connectors</b>	<b>2</b>	<b>36.66</b>	<b>0.11</b>
<b>Total:</b>	<b>26</b>	<b>257.25</b>	<b>10.86</b>

## **Summary of Calculation Results (1)**

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- **The total failure rate using MIL-HDBK-217F (257.25FIT) was approximately 24 times the total failure rate using FIDES (10.86FIT).**
  - **The total failure rate using FIDES is considered to be closer to the actual value, since it is generally known that the failure rate using MIL-HDBK-217 is calculated to be approximately 10 to 100 times higher than the actual value.**

## **Summary of Calculation Results (2)**

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- **For ceramic capacitors, the failure rate using FIDES (1.26FIT) was approximately 25 times that using MIL-HDBK-217F (0.05FIT).**
  - **The failure rate using MIL-HDBK-217 is considered to be closer to the actual value, since there is field data showing a failure rate of 0.0122~0.130FIT for automotive MLCCs.**

## **Summary of Calculation Results (3)**

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- **For tantalum capacitors, the failure rate using FIDES (1.14FIT) was approximately 16 times that using MIL-HDBK-217F (0.07FIT).**
  - **The failure rate using MIL-HDBK-217 is considered to be closer to the actual value, since there is field data showing a failure rate of 0.0034FIT for industrial solid tantalum capacitors.**

## **Further Study Plan**

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- **Failure rates calculation of EEE parts onboard LEO satellites, taking into account all phases from launch to mission completion.**
  
- **Reliability Prediction of COTS EEE parts onboard spacecraft.**
  - ◆ **COTS: Commercial-Off-The-Shelf**

# **1. Reliability Prediction of EEE Parts for Space Application using FIDES and MIL-HDBK-217**

# **2. HIREC's Approach to FIDES Reliability Analysis Services**

## **HIREC's Approach to FIDES Services(1)**

- **Currently coordinating with FIDES consortium to market the Japanese translation of the FIDES Guide 2023 in Japan.**
- **HIREC will offer following services to customers in Japan:**
  - **Reliability analysis services using FIDES.**
  - **FIDES reliability analysis training services.**

## **HIREC's Approach to FIDES Services (2)**

- **In order to predict the reliability of COTS EEE parts onboard LEO spacecraft using FIDES, HIREC started joint research with a Japanese new space company.**



**Thank you!**

**Any questions / comments?**

**Please e-mail to:**

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