

Introduction of Enhancement of Legal Compliance for Mitsubishi Electric Corporation / Lithium- ion Battery

3rd IAASS October 21st, 2008



“Building a safer space together”

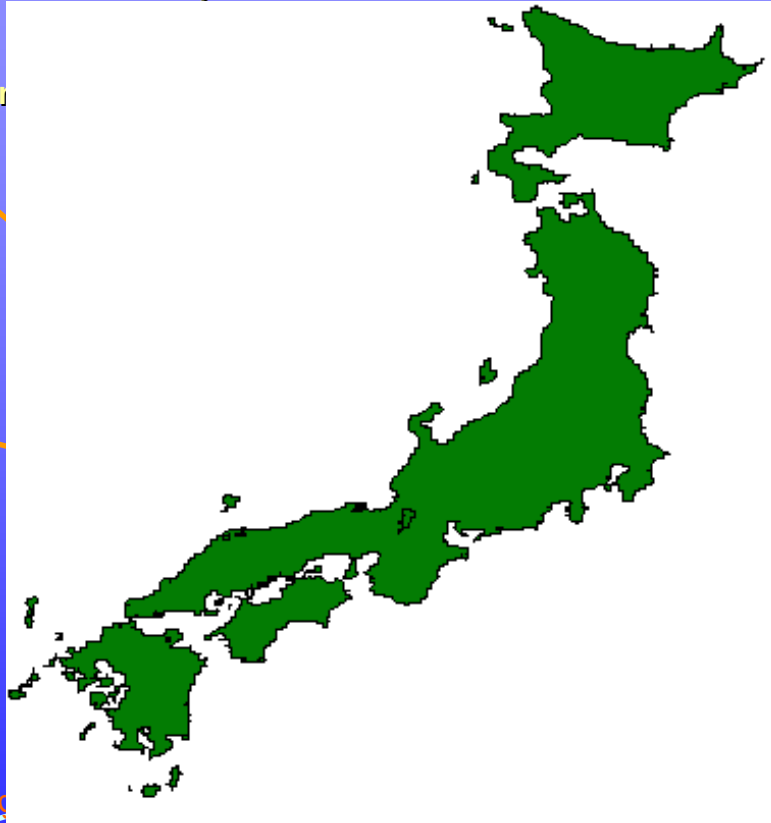
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- 1. Introduction / Mitsubishi Satellite Business Overview**
- 2. System Safety Management in Mitsubishi Electric/Kamakura Works**
- 3. Actual Example of Mitsubishi Electric's System Safety Management**
- 4. Enhancement of Legal Compliance of Lithium-ion Battery**
- 5. Conclusions**

1. Introduction

Mitsubishi Satellite Business Overview

**Mitsubishi
Electric's
Facility**



**Communication Systems Center
(Ground Segment)**



**Advanced Technology
R&D Center**



**JAXA
Tanegashima Space Center**



**Information Technology
R&D Center**



**Kamakura Works
(Space Segment)**

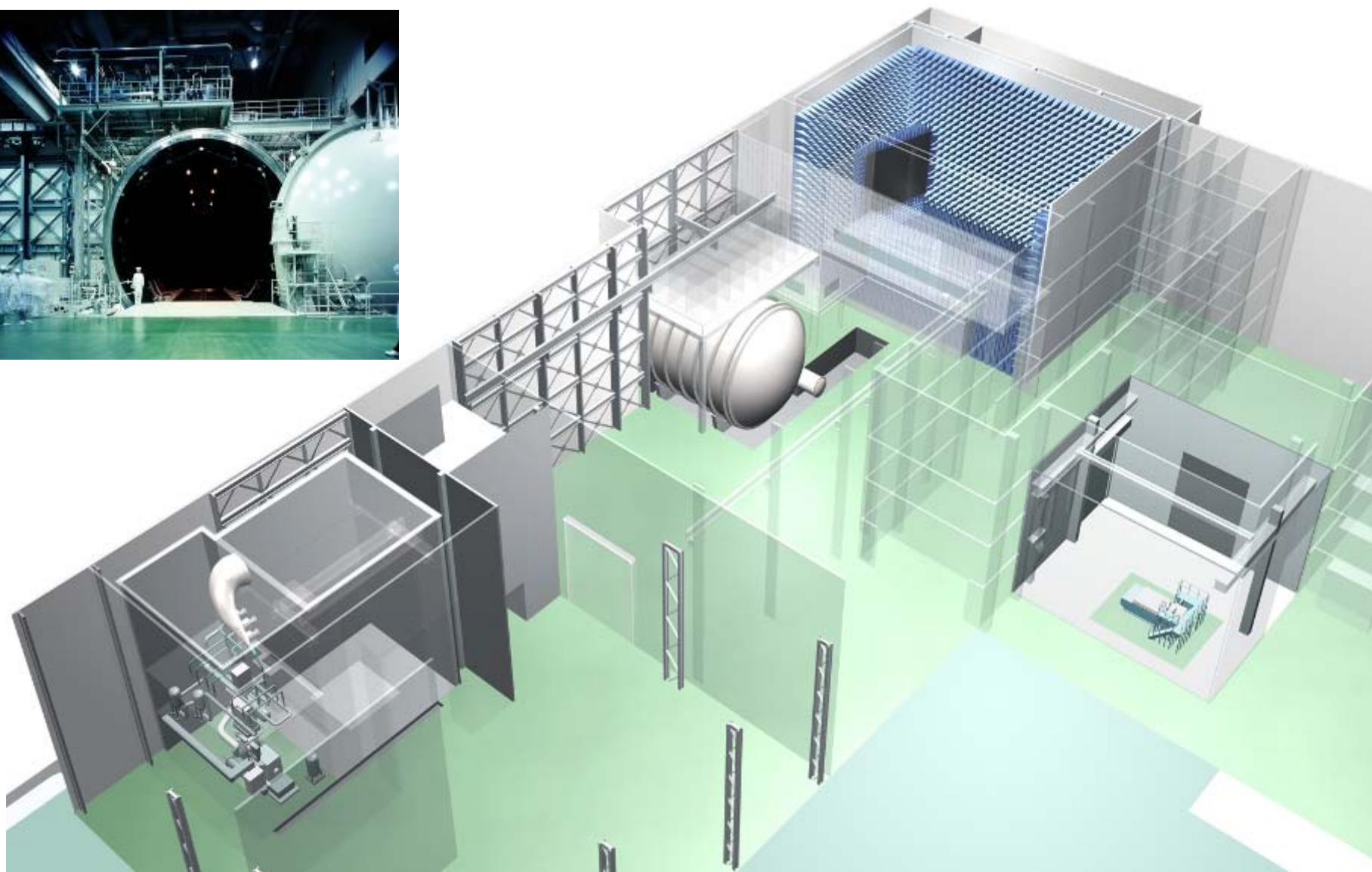


**Sagami Plant
under Kamakura Works
(Composite Material)**



Head Office

Internal View of the Satellite Integration and Test Facility



Overview of Satellite Onboard Equipment

SSPA



S band



Ku band
(Development)



X band



C band (High Power)



L band



C band (low Power)

RF Equipment



C-LNA



C-Dual Power BTX



Ku-RX



Ka/IF-RX



IF/Ku-TX

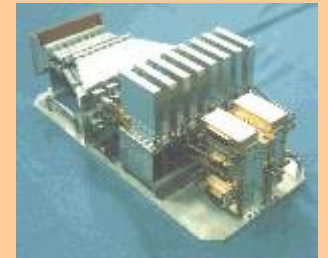


IF/Ka-TX

Antenna



Dual Gridded Type



Ka-band APAA

Bus Equipment



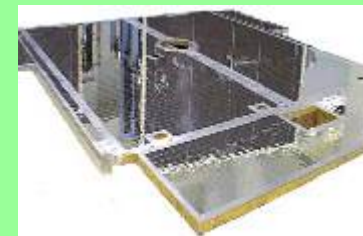
Solar Array Panel



Solar Array
Substrate



Li-Ion Battery Assembly



Heat Pipe Embedded
honeycomb Panel



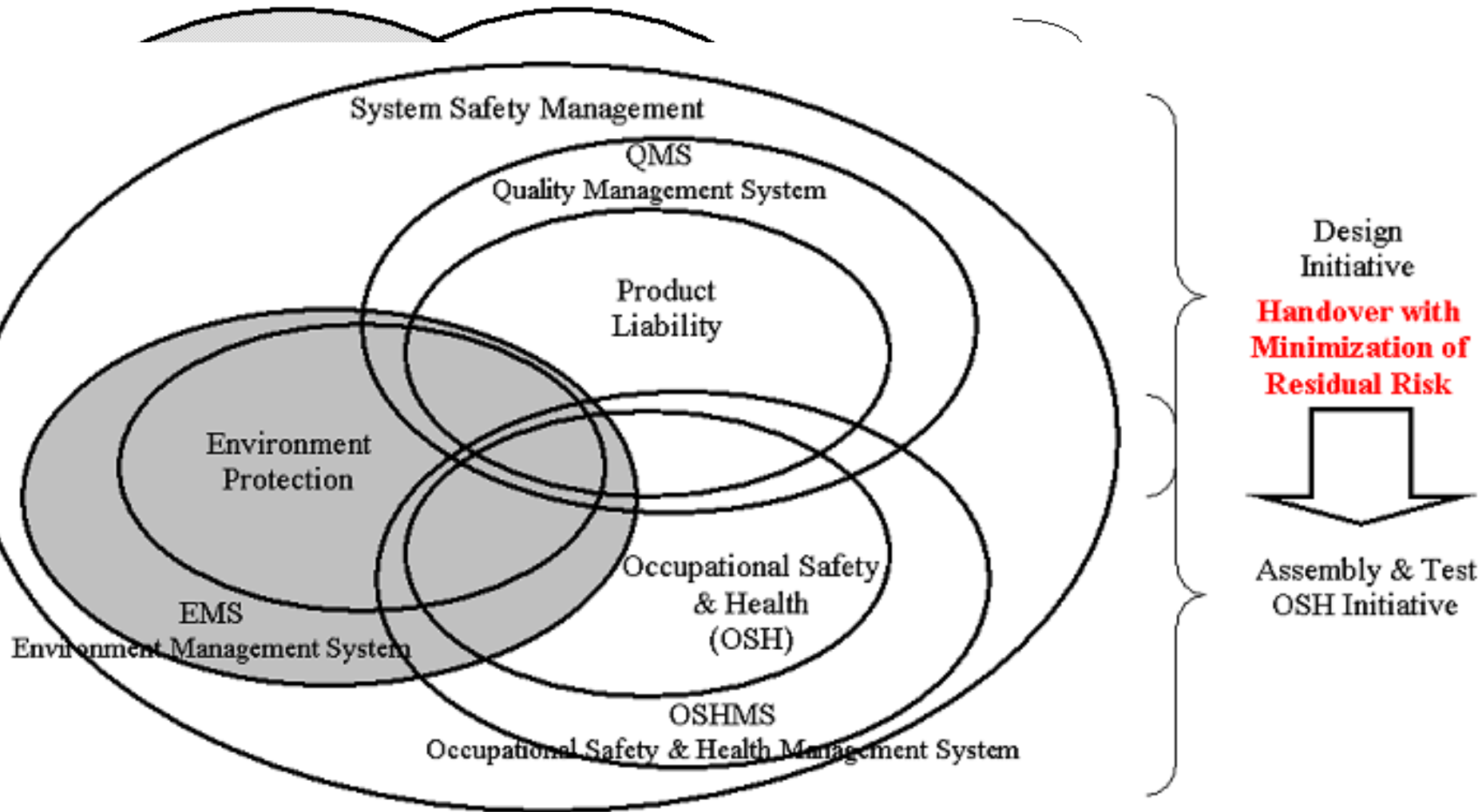
20mN Ion Engine
System



2. System Safety Management Activities in Mitsubishi Electric/Kamakura Works

**Mitsubishi Electric Corporation / Kamakura Works
established **System Safety Management Group**
in Quality Assurance Department in 2003.**

**System Safety Management Group has been making efforts
to reinforce management activities of space products &
projects from the view point of **System Safety**.**



3. Actual Example of Mitsubishi Electric's System Safety Management



Figure 4. LIBM 100A 24S SB

Capacity	: 8640 (Whr)		
Voltage	: 79 - 96 (V)		
Cell Capacity	: 100 (Ah)		
Width	: 315 mm	Length	: 705mm
		Height	: 273mm
Mass	: 78 kg	Specific Energy	: 110 Whr/kg



Figure 5. LIBM 050A 11S S

Capacity	: 2035 (Whr)		
Voltage	: 37 - 44 (V)		
Cell Capacity	: 50 (Ah)		
Width	: 328 mm	Length	: 405mm
		Height	: 174.5mm
Mass	: 26.4 kg	Specific Energy	: 77 Whr/kg



Figure 6. LIBM 100A 10S S

Capacity	: 3600 (Whr)		
Voltage	: 33 - 40 (V)		
Cell Capacity	: 100 (Ah)		
Width	: 328 mm	Length	: 352mm
		Height	: 275mm
Mass	: 39.5 kg	Specific Energy	: 100.3 Whr/kg



Figure 7. LIBM 100A 13S B

Capacity	: 4680 (Whr)		
Voltage	: 39 - 52 (V)		
Cell Capacity	: 100 (Ah)		
Width	: 328 mm	Length	: 720mm
		Height	: 230mm
Mass	: 45.2 kg	Specific Energy	: 103.4 Whr/kg



Figure 8. LIBM 175A 12S SB

Capacity	: 7560 (Whr)		
Voltage	: 36 - 50 (V)		
Cell Capacity	: 175 (Ah)		
Width	: 336 mm	Length	: 449mm
		Height	: 289mm
Mass	: 70.6 kg	Specific Energy	: 107 Whr/kg



Figure 9. LIBM 175A 18S SB

Capacity	: 12800 (Whr)		
Voltage	: 72.6 (V)		
Cell Capacity	: 175 (Ah)		
Width	: 435 mm	Length	: 535mm
		Height	: 333mm
Mass	: 106 kg	Specific Energy	: 120 Whr/kg

<Advantages of Lithium-ion Battery>

- **Reduction of battery size and weight because of larger specific energy and higher cell voltage**
- **Higher low bus voltage limit because of fewer voltage change in discharge condition**
- **Easier maintenance during launch campaign due to fewer cell self-discharge characteristics**
- **Deletion of reconditioning due to no memory effect**
- **Deletion of voltage-thermal control due to fewer temperature dependency of charge-discharge characteristics**

<Potential Hazards of Lithium-ion Battery>

Larger Energy and Higher Voltage



IAASS* October 2006 Newsletter

*) International Association for the Advancement of Space Safety

<Lithium-ion Battery Cell Safety Features>

- **Separator Shutdown Function**
- **Cell Fuse Function**
- **Pressure Relief Function**

Safety Evaluation for Lithium-ion Battery

Table 4. Results of qualitative risk assessment (a sample)

Identified Hazard	Residual Risk
Explosion	I E
Short, Electric Shock	I E
Contamination, Electrolyte Leakage	II E
Handling, Heavy Items	II E
Minute toxic components of blowout gas	I E

Note : Fire hazard is included in explosion hazard.

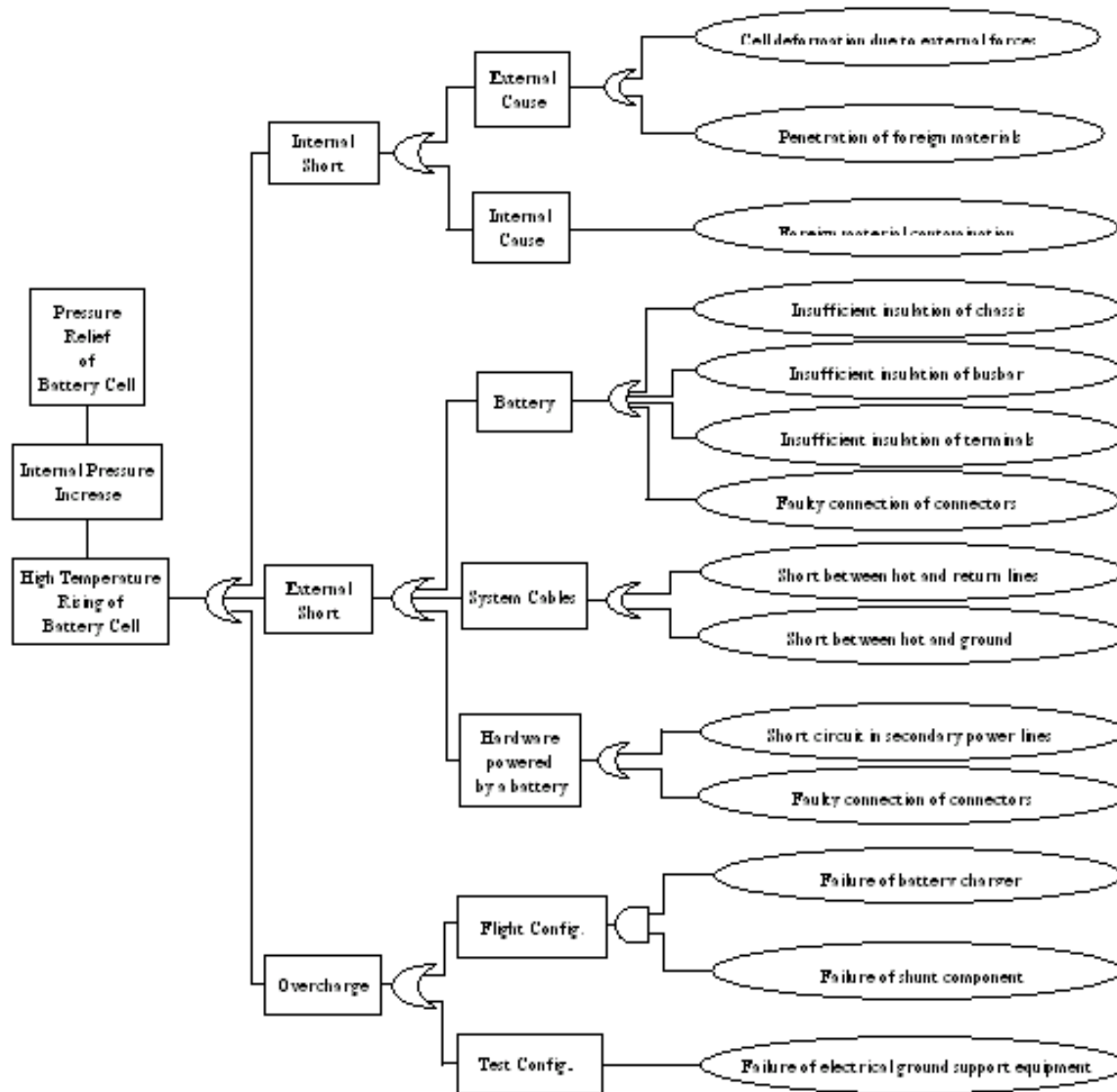


Table 5. Test results of safety verification

Test Item	Test Conditions	Abnormal Occurrence						Note: Counter Measures
		Battery Cell Capacity	Rupture Disk Open	Electrolyte Leakage	Smoke	Fire	Cell Weld Cracking	
Overcharge	From full charge to 200% overcharge at 50 amperes C.C.	175 Ah cell	No	No	No	No	No	2FT with protective functions
	From full charge to 200% overcharge at 50 amperes C.C.	100 Ah cell	No	No	No	No	No	Ditto
Forced Discharge	From discharge condition at 100 amperes C.C.	50 Ah cell	No	No	No	No	No	Ditto
External Short Circuit	Full charge condition	50 Ah cell	No	No	No	No	No	2FT with protective function and multilayer insulation
	External resistance 1.00 mΩ							
	Full charge condition	50 Ah cell	No	No	No	No	No	Ditto
	External resistance 0.75 mΩ							
Full charge condition	50 Ah cell	No	No	No	No	No	Ditto	
External resistance 0.50 mΩ								
Penetration of Foreign Materials	SOC 30%	100 Ah cell	No	No	No	No	No	2FT with protective function, SOC control, specialized tool and protective equipment
		175 Ah cell	No	No	No	No	No	Ditto
	SOC 10%	100 Ah cell	No	No	No	No	No	Ditto
		50 Ah cell	No	No	No	No	No	Ditto
Crush	Full charge condition (X axis)	175 Ah cell	No	No	No	No	No	Ditto
	Full charge condition (Y axis)	175 Ah cell	No	Yes	No	No	No	Ditto
	Full charge condition (Z axis)	175 Ah cell	No	Yes	No	No	No	Ditto
	Full charge condition (X axis)	100 Ah cell	No	No	No	No	No	Ditto
	Full charge condition (Y axis)	100 Ah cell	No	Yes	No	No	No	Ditto
	Full charge condition (Z axis)	100 Ah cell	No	Yes	No	No	No	Ditto
Rupture Disk Stress Cycle	More than 40,000 cycles	50 Ah cell	No	No	No	No	No	4 samples, more than 300,000 cycles

SOC : State of Charge

C.C. : Constant Current

2FT : Dual Fault Tolerant

Table 6. Test results of abuse test

Test Item	Test Conditions	Battery Cell Capacity	Abnormal Occurrence					Note : Counter Measures
			Rupture Disk Open	Electrolyte Leakage	Smoke	Fire	Cell Weld Cracking	
Overcharge	From full charge to no limit overcharge at 50 amperes C.C.	175 Ah cell	Yes	Yes	Yes	Yes	Yes	2FT with protective functions
	From full charge to no limit overcharge at 50 amperes C.C.	100 Ah cell	Yes	Yes	Yes	Yes	Yes	Ditto
Penetration of Foreign Materials	Full charge condition	100 Ah cell	Yes	Yes	Yes	No	No	2FT with protective function, SOC control, specialized tool and protective equipment
		50 Ah cell	Yes	Yes	Yes	No	No	Ditto
	SOC 50%	100 Ah cell	Yes	Yes	Yes	No	No	Ditto

SOC : State of Charge

C.C. : Constant Current

2FT : Dual Fault Tolerant

Counter Measures based on the Risk Assessment & Safety Verification Tests

- **Protective functions of battery cell**
 - Cell fusible link
 - Separator shutdown
 - Cell protection circuit
- **Advanced charger and charging conditions**
- **SOC controlling**
- **Specialized tool preparation**
- **Protective equipment preparation**
- **Hazard awareness promotion**
- **Education and training**

4. Enhancement of Legal Compliance of Lithium-ion Battery

“Electrical Appliance and Material Safety Law” revised in 2008

Lithium-ion battery added into the regulated item table

COTS (Commercial-Off-The-Shelf) Lithium-ion battery and battery cell newly produced or imported after November 20th, 2008 are required to attach PSE mark.

Electrical Appliance and Material Safety Law has no application to our products directly.

Our product safety review board requests all engineers and project staffs of Kamakura Works to reconfirm their risk assessments.

Because COTS lithium-ion batteries are used for test equipments, portable instruments and so on.

the law database of electronic government

<http://law.e-gov.go.jp/cgi-bin/idxsearch.cgi>

“Kiken-butu” : “hazardous material” or “dangerous goods”
191 laws and regulations

“Lithium” : 26 laws and regulations

Table 1. Summary of Law Survey related to Satellite Use Large Capacity Lithium-Ion Battery

Category	Law Title	Application & Measures
Production /Handling /Storage	Industrial Safety and Health Law	<p>The materials of positive electrode and the binder fall into the category which requires to notify the names of dangerous materials. But, after receiving battery cells from the vendor, there is no possibility to expose directly these dangerous materials.</p> <p>Thus this law has no application to our processes.</p> <p>This information is provided to assembly workers and test technicians in safety training.</p> <p>From the view point of better safety management, Material Safety Data Sheet (MSDS) of Lithium-ion battery cell is disclosed to our customers.</p>
	Fire Defense Law	<p>The electrolyte falls into the category which requires special control as dangerous material.</p> <p>But, the amount of usage is far below regulated volume. Thus this law has no application to our processes.</p> <p>From the view point of better safety management, potential hazard is disclosed to related sections and used for safety training to make fire fighting easier and safer.</p>

Table 1. Summary of Law Survey related to Satellite Use Large Capacity Lithium-Ion Battery (Cont.)

Category	Law Title	Application & Measures
Disposal	Law for the Promotion of Effective Utilization of Resources	<p>Some smaller sizes of battery cells fall into the category which require the description of “Li-ion” for recycling. But, our Lithium-ion batteries are produced for satellite use. Contamination from marking paint outgassing must be minimized and all products are traceable to intended end-usages. Therefore, “Li-ion” or equivalent marking is given as assembly level of product and documentation.</p> <p>From the view point of better safety management, information of disposal consideration is clarified in instruction manual.</p>
	Waste Management Law	<p>This law requests end user to dispose used batteries properly. Thus recommendation based on the law requirements is clarified in instruction manual.</p> <p>From the view point of better safety management, battery usage plan is confirmed by Mitsubishi Electric and customer in the beginning of project.</p>

Table 1. Summary of Law Survey related to Satellite Use Large Capacity Lithium-Ion Battery (Cont.)

Category	Law Title	Application & Measures
<p>Transportation</p> <p>Land Transportation</p>	<p>Not Applicable</p>	<p>Although it is common that land transportation is restricted by the regulations like 49CFR in the US and ADR/RID in Europe, there is no equivalent laws related to land transportation of lithium-ion battery in Japan at this moment. There is the letter of “the Safety Regulations pursuant to the Road Vehicles Act” if the total volume of electrolyte exceeds the prescribed volume in Fire Defense Law. The specified volume is very large. Thus this law has no application to our business activities.</p> <p>From the view point of better safety management, when our space use large capacity lithium-ion battery is transported by truck in Japan, our battery has complied with UN T1 to T8 test and been obtained UN class 9 / UN3090 designation. The battery is packed in a special container which is equivalent to UN certified one. A charter service is used.</p> <p>For international transportation, it must undergo in accordance with local regulations. Necessary information is prepared when customer requests in advance.</p>

Table 1. Summary of Law Survey related to Satellite Use Large Capacity Lithium-Ion Battery (Cont.)

Category	Law Title	Application & Measures
Transportation		
Marine Transportation	Regulations for the Carriage and Storage of Dangerous Goods in Ships	<p>Our lithium-ion battery falls into the category of dangerous goods.</p> <p>Detailed requirements are specified in Notification for Establishing Standards for the Carriage of Dangerous Goods in Ships.</p>
	Notification for Establishing Standards for the Carriage of Dangerous Goods in Ships	<p>Our lithium-ion battery falls into the category of dangerous goods number 3090.</p> <p>The requirements of this regulation are almost equivalent to ones of IATA Dangerous Goods Regulations.</p> <p>Our battery has complied with UN T1 to T8 test and been obtained UN class 9 / UN3090 designation. The battery is packed in a special container which is certified the compliance with the UN specifications by HK (Nippon Hakuyouhin Kentei Kyokai).</p> <p>For international transportation, the IMO (International Maritime Organization) designation is obtained.</p> <p style="padding-left: 40px;">Class -, Packaging Group II, IMO-Labels 9</p> <p style="padding-left: 40px;">Proper Shipping name Lithium batteries, UN3090</p> <p>The designation will be also changed in accordance with the change of UN number explained in "Air Transportation".</p>

Table 1. Summary of Law Survey related to Satellite Use Large Capacity Lithium-Ion Battery (Cont.)

Category	Law Title	Application & Measures
Transportation		
Air Transportation	The Regulations Relating to Enforcement of Civil Aeronautics Law	<p>Our lithium-ion battery falls into the category of class 9 : miscellaneous dangerous substances & articles.</p> <p>Our battery has complied with UN T1 to T8 test and been obtained UN class 9 / UN3090 designation. The battery is packed in a special container which is certified the compliance with the UN specifications by HK (Nippon Hakuyouhin Kentei Kyokai).</p> <p>After the above preparation, we negotiate with an air carrier to receive authorization from the minister of land, infrastructure and transportation.</p> <p>For international transportation, the IATA-DGR (International Air Transportation Association–Dangerous Goods Regulations) designation is obtained.</p> <p style="padding-left: 40px;">Class -, Packaging Group II, ICAO-Labels 9 Proper Shipping name Lithium batteries, UN3090</p> <p>As the latest movement, the designation of UN3090 “lithium battery” will be divided into two categories, UN3090 “Lithium-metal Battery” and UN3480 “Lithium-ion Battery” on Jan. 1st, 2009.</p> <p>Japanese government and related organizations announce that they will also move to and use the same designations on the same day. Our lithium-ion battery will be obtained UN3480.</p>

Table 1. Summary of Law Survey related to Satellite Use Large Capacity Lithium-Ion Battery (Cont.)

Category	Law Title	Application & Measures
Export Control	Export Trade Control Ordinance	Some revised requirements have no application to the lithium-ion battery. As voluntary activity, explanatory material regarding "No License Required" is prepared.

5. Conclusions

- **Mitsubishi Satellite Business Overview**
- **System Safety Management Activities in Mitsubishi Electric Corporation / Kamakura Works**
- **Enhancement of Legal Compliance of Lithium-ion Battery**

Based on our experience, we will

- **Enhance inherent safety design of our products**
- **Keep efforts to establish our system safety practices firmly**
- **Focus on more effective standardization of system safety management and harmonization with other management systems like QMS, OSHMS, EMS and ISMS.**

Mitsubishi Electric DS-2000 Standard Satellite Bus Platform



Thank you !!

Questions ???