

High performance IMU and Accelerometer



Small IMU



IMU



CAN interface



Accelerometer

CONTENTS

- 1. EPSON Sensing Technologies**
2. Auto-controlling / IMU
3. Structure Health Monitoring

1. EPSON sensing technologies

■ An intellectual property leader

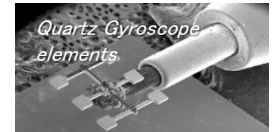
Epson is among the industry leaders in patent quantity and quality in product categories such as inkjet printers and projectors. Its world-class IP capabilities support the creation of original core technologies.

Ranking by number of patent applications laid open to the public in different product categories

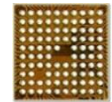
Japan	Inkjet printers	1 st	USA	Inkjet printers	1 st
	Projectors	1 st		Projectors	1 st
	Quartz devices	1 st		Quartz devices	2 nd
	Gyrosensors	1 st		Gyrosensors	1 st

Note: Ranked by number of patent applications filed over the past 20 years (1996 - 2015).
(Source: Epson research)

■ Quartz material realize high accuracy sensing technology.

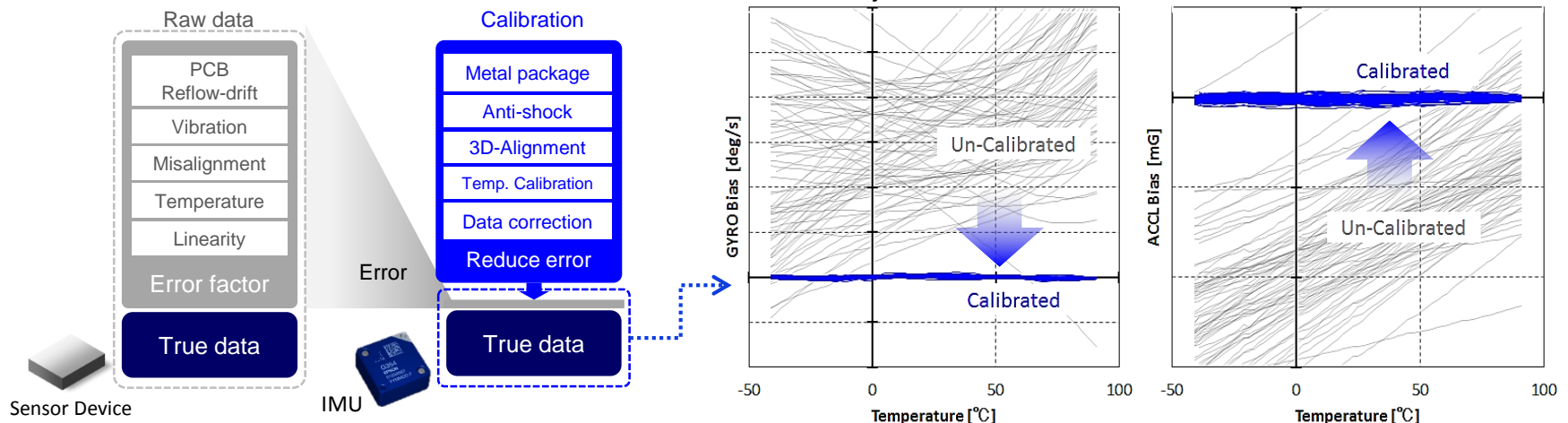


■ Dedicated SoC reduce size & power



Dedicated SoC






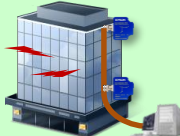



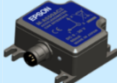

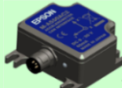
■ Error correction technologies



1. Easy to operate & Secure infrastructures

■ EPSON sensing technologies resolve infrastructure issue

- ① Convenient: Easy to operate / Auto-control
- ② Safety : Detect damaged asset for Earthquake & Disaster
- ③ Secure: Diagnosis for bridge fatigue monitoring




		①Easy to operate & Auto-control						②Safety	③Secure
Purpose		High efficiency / Autonomous / Unmanned control						SHM: Structure Health Monitoring	
Applications		<div>✓ GNSS/Locator (Precision Agriculture・ICT Construction・ADAS)</div> <div>✓ Stabilization (Gimble・Antenna) 、Attitude control</div> <div>✓ MHM(Machine Health Monitoring)</div> <div></div>						Detect damage	Diagnosis
									
Measure		Trajectory, Localization, Attitude, Vibration						Inclination / Earthquake	Displacement
Products Lineup		IMU (Inertial Measurement Unit)						Quartz accelerometer	
		High-end G370	w/EKF G365	Hi-Perform G364	Wide-range G354	Small V340	CAN-I/F G550	Built-In A351AS , A351AU	CAN, RS422-I/F A550AC2, A550AR2
Gyro	Range	±450dps		±200dph	±450dps	±450dps	±150dps	---	
	Bias Stability	0.8dph	1.8dph	2.2dph	3.0dph	3.5dph	3.5dph	---	
Acc.	Range	±4G or ±10G		±3G	±5G	±5.8G	±5G	±5G	
	Repeatability	±2mG	±3mG	---		---	---	Resolution : 0.002μrad , 0.06μG	
Interface		SPI/UART				SPI/UART	CAN	SPI (AS), UART (AU)	CAN(AC2), RS422(AR2)
Package form									
Size(mm),Weight		 24x24x10, 10g				 10x12x4, 1g		 24x24x19, 12g	 52x52x26, 81g

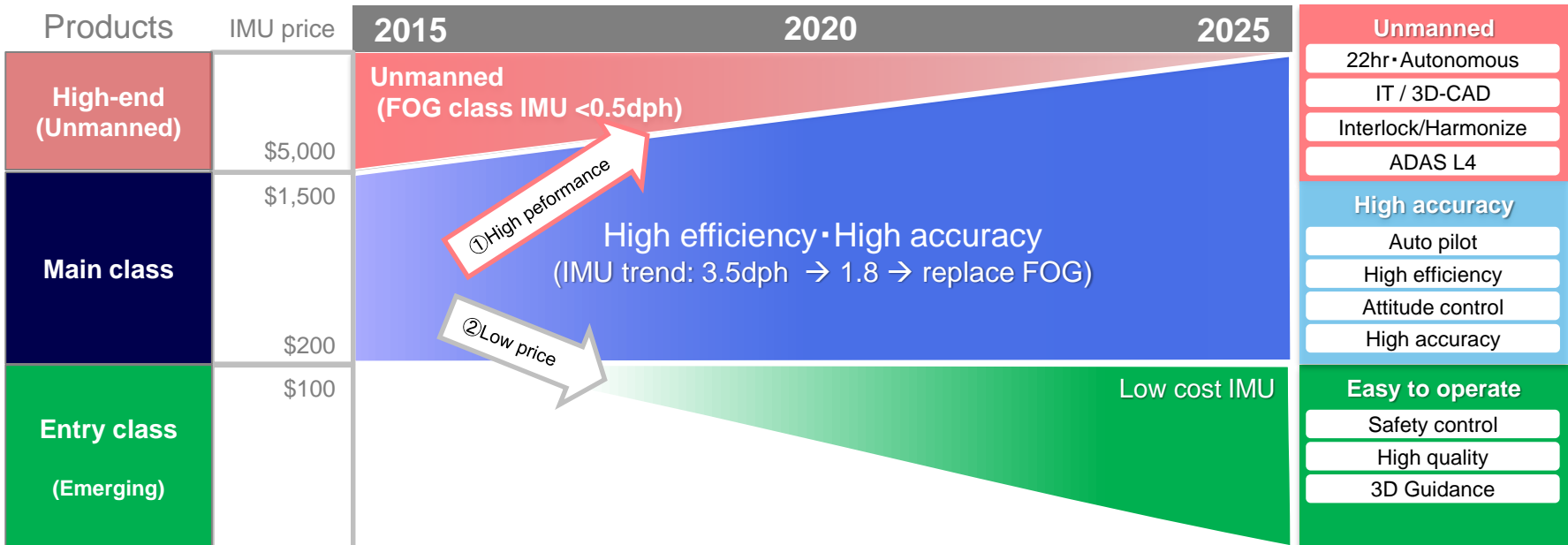
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1. EPSON Sensing Technologies
- 2. Auto-controlling / IMU**
3. Structure Health Monitoring

2. Macro-Trend : Unmanned / Auto-control

Class	Purpose	IMU performance
■ High end:	Unmanned	FOG class (0.5dph)
■ Main:	Auto-control	1~6dph
■ Low end:	Easy to operate	Low cost

Category	Low end	Main	Highend
Accuracy	Sub-meter(<1m)	Deci-meter(<10cm)	Centi-meter (<1cm)
Purpose	Easy to operate	Auto control	Autonomous / Unmanned
Function	Safety Control High Quality 3D Guidance 	Autopilot Gas saving High accuracy 	24Hr Unmanned IT 



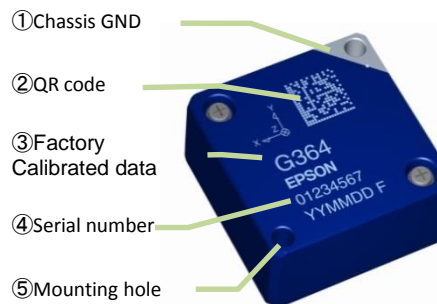
2. Advantages

High Reliability G3X Platform

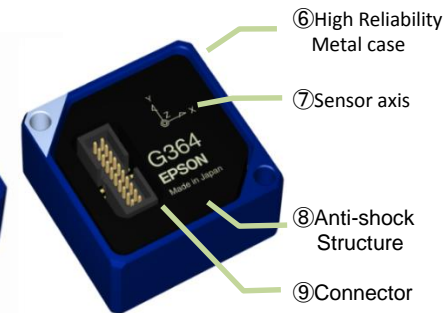
G3X Platform (M-G364/M-G354) is 1inch square small form factor, designed to bring out stable performance even under unstable environment.

New products planned for the future will also use the same G3X platform. The compatibility of hardware and software interfaces will bring the improvement of the performance simply by replacing the IMU, reducing the development cost, engineering resource, and evaluation time of the customer.

G3X platform (Case side)



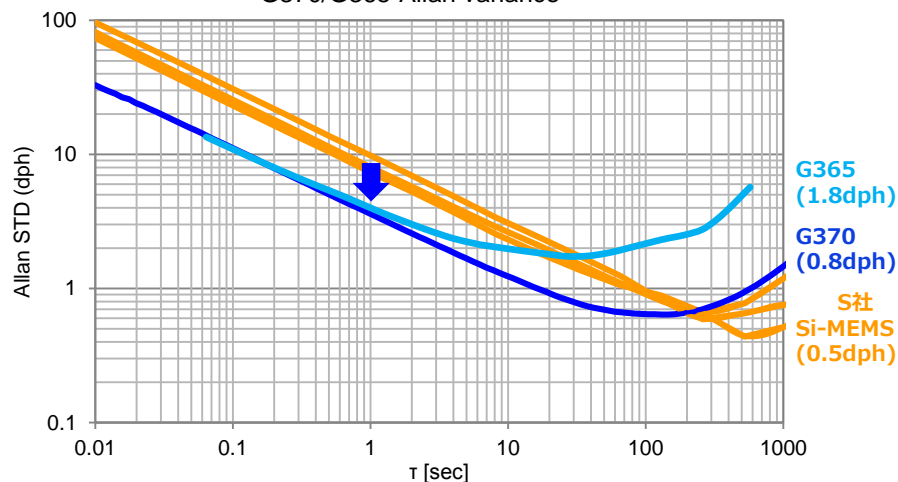
G3X platform (Connector side)



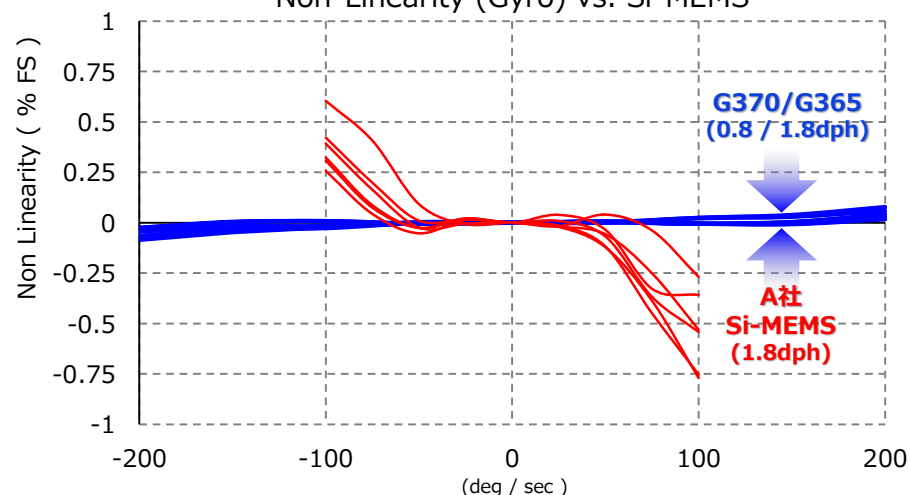
Lower noise & Superior dynamic motion characteristics

- ✓ High Accuracy & Stability
 - ✓ Low noise & Non-Linearity
 - ✓ High productivity & High yield
- ... Quartz-MEMS is higher stability and lower noise than Si-MEMS
- ... Dynamic motion characteristics

G370/G365 Allan variance



Non-Linearity (Gyro) vs. Si-MEMS



2. NovAtel SPAN Brochure

Enclosures PwrPak7-E1



COMPACT OEM7™ ENCLOSURE
DELIVERS NOVATEL'S LEADING
SPAN® GNSS+INS TECHNOLOGY



Epson G320 MEMS IMU to deliver world class NovAtel

Ultra high-end FOG



SPAN-CPT™

- Features NovAtel's OEM628 GNSS receiver, fiber optic gyros and Micro ElectroMechanical Systems (MEMS) accelerometers in one
- This product is not ISTAR controlled, reducing cross border difficulties

Dimensions: 152 x 142 x 89 mm
Weight: 2.28 kg
Operating Temperature: -40°C to +65°C
GPS L1, L2, L2C + GLONASS L1, L2 + BeiDou¹ + SBAS + L-Band

Honeywell
FOG-IMU



High-end IMU



SPAN-IGM-S1

- Features the OEM615 receiver and STIM300 IMU
- The STIM300 is a tactical grade IMU with MEMS gyros and accel
- This product is not ISTAR controlled, reducing cross border difficulties
- Stacks with a FlexPak6 receiver to create a compact ALIGN® head

Dimensions: 152 x 142 x 51 mm
Weight: 540 g
Operating Temperature: -40°C to +65°C
GPS L1, L2, L2C + GLONASS L1, L2 + SBAS

Sensoror
STIM300
0.5dph



Old Main products



SPAN-IGM-A1

- Features the OEM615 receiver and ADIS-16488 IMU
- The ADIS-16488 is a cost effective IMU with MEMS gyros and accel
- This product is not ISTAR controlled, reducing cross border difficulties
- Stacks with a FlexPak6 receiver to create a compact ALIGN® head

Dimensions: 152 x 142 x 51 mm
Weight: 515 g
Operating Temperature: -40°C to +65°C
GPS L1, L2, L2C + GLONASS L1, L2 + SBAS

ADI
ADIS16488
6dph



New Main products



PwrPak7-E1²

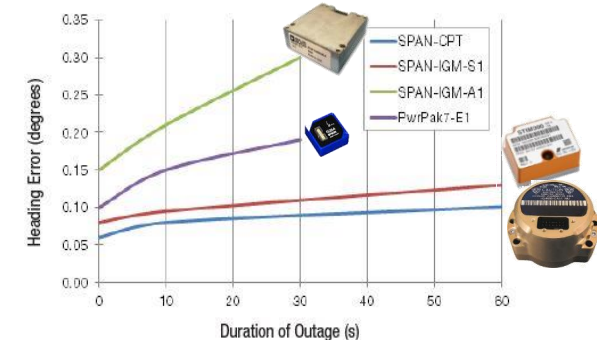
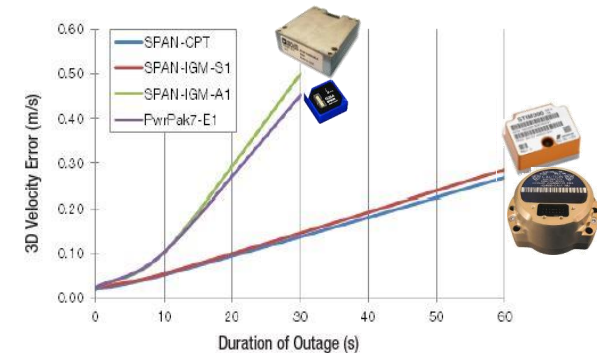
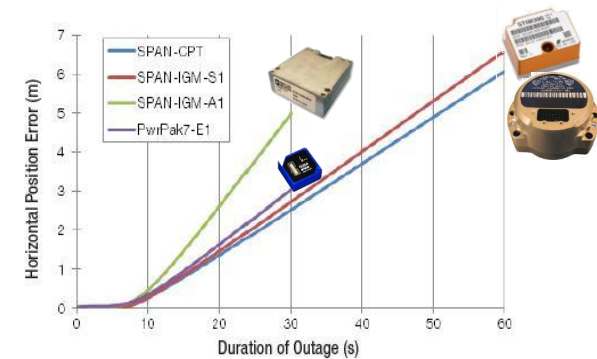
- Next Generation OEM7™ receiver provides an all-constellation, multi-constellation GNSS receiver
- Integrated Epson G320 MEMS IMU offers cost effective INS performance
- Multiple communication interfaces for easy integration and installation
- Built-in Wi-Fi and 16 GB of internal data logging storage

Dimensions: 147 x 145 x 53 mm
Weight: 510 g
Operating Temperature: -40°C to +75°C
GPS L1 C/A, L1C, L2C, L2P, L5 + GLONASS L1 C/A, L2C, L2P, L3, L5 + BeiDou B1, B2, B3 + Galileo E1, E5 AltBOC, E5a, E5b, E6 + IRNSS L5 + SBAS L1, L5 + QZSS L1 C/A, L1C, L2C, L5, L6 + L-Band

EPSON
M-G320
3.5dph

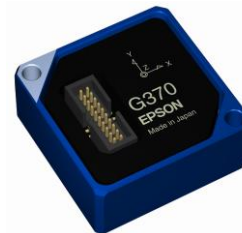


Position error without GPS



New Features





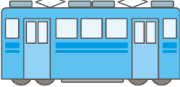

- Newly developed high-performance sensors
- High performance with wide dynamic range
- Backward compatible with M-G364/354
- Low power 16mA
- Real-time orientation angle output with EKF (G365)



Product number		M-G370	M-G365
Rate range	Triple gyroscopes	$\pm 450^{\circ} / \text{sec}$	
	Tri-axis accelerometer	$\pm 4G / \pm 10G$	
Accuracy and stability	Gyro bias instability	$0.8^{\circ} / \text{hr}$	$1.8^{\circ} / \text{hr}$
	Angle random walk	$0.06^{\circ} / \sqrt{\text{hr}}$	$0.08^{\circ} / \sqrt{\text{hr}}$
Scale factor non-linearity	Triple gyroscopes	0.05 %FS ($< 300^{\circ} / \text{sec}$)	
	Tri-axis accelerometer	0.1 %FS ($< 5 G$)	
Orientation angle output		-	Tilt angle (X & Y axes) Euler angles (Roll & Pitch)
Output resolution		16-bit / 32-bit	
Digital serial interfaces		SPI & UART	
Internal compensation at factory (w/ -40° C to 85° C)		Bias, scale factor, misalignment (axis to axis)	
Output data rate		Up to 2,000 Sps	
Calibration & operating temperature range		-40° C to $+85^{\circ} \text{ C}$	
Current consumption		16 mA @ 3.3 V	
Other features		External trigger input, etc.	
Size		24 x 24 x 10 mm	
Weight		10 g	

2. Dynamic tilt angle function (M-G365)

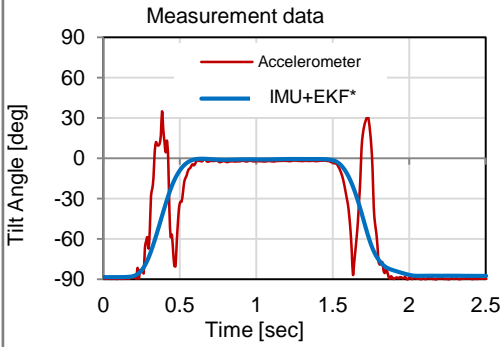
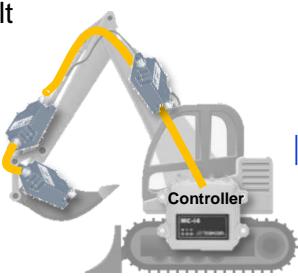
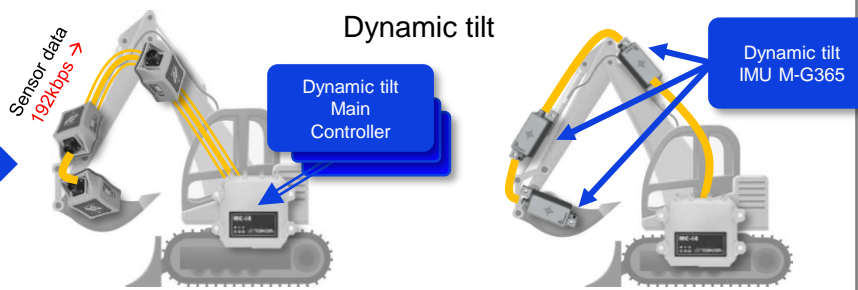
■ Applications

Agriculture	Construction	ADAS	Camera/ Antenna	Train	Drone
					
Straight & Horizontal line	High speed arm	Autonomous	Stabilization	Monitoring	Attitude

■ Advantages

- High speed motion control: Reduce work time & Precision control
- Distributed processing: Reduce processing power & data rate

➤ Technology revolution

Feature	Current technology	New technology	
	Tilt sensor/ Inclinometer	IMU + EKF*(Controller side)	IMU with EKF
Static measurement	Static measurement	3D High speed motion	Distributed processing
Sensor data (J1939 250kbps_{max})	6.4kbps (Multi-node)	192kbps (single node/cable)	6.4kbps (Multi-node)
Low cost system	Low cost system	Higher performance CPU	Low cost CPU
	Static Tilt 	Dynamic tilt 	

*EKF: Extended Karman Filter

2. Main Applications

Robotic Vehicle / ADAS Level 3/4~



Precision Agriculture / ICT Construction machine

Usage: GNSS / Localization



Usage: Attitude control

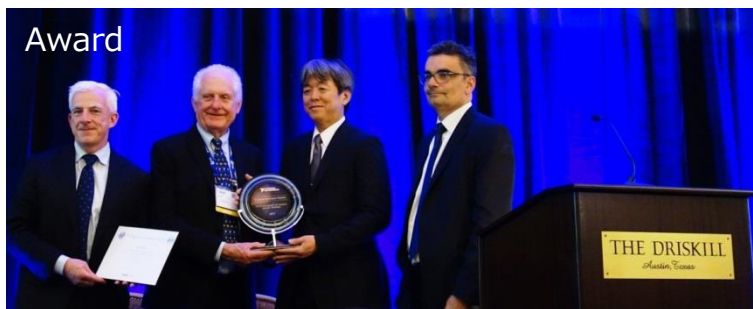


Stabilization

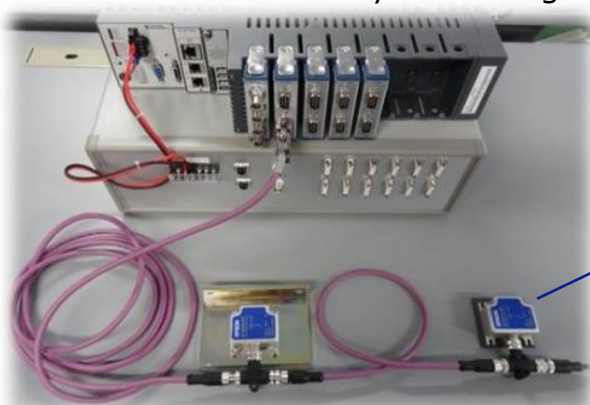


■ Time synchronization measurement system

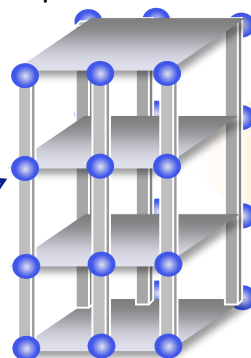
- Sensors: IMU M-G550PC 152pcs (Total 912ch nodes)
- System: Time synchronization measurement system using standard CAN
- Condition: 18F building model (Height 25m)
 - National Instruments Engineering Impact Award
 - 2016: Grand prize at general category (JAPAN)
 - 2017: Intel Internet of Things Award (US)



Standard CAN Controller system using NI



Time Synchronization
152pcs IMU

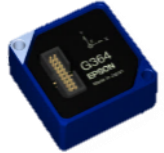


E-Defence test equipment

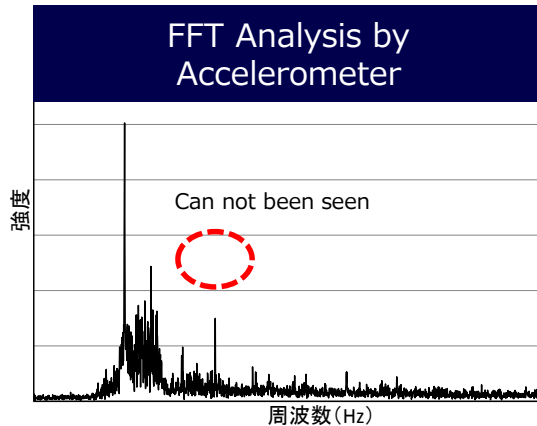
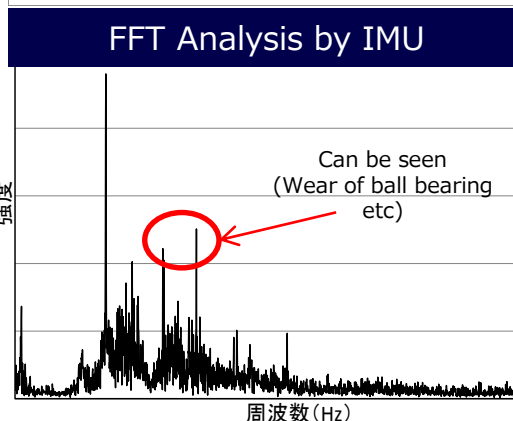
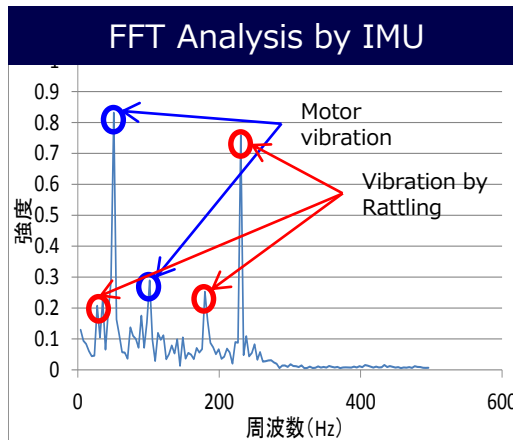
2. Predictive Maintenance

: Analysis of motor equipment (IMU 6-axis analysis)

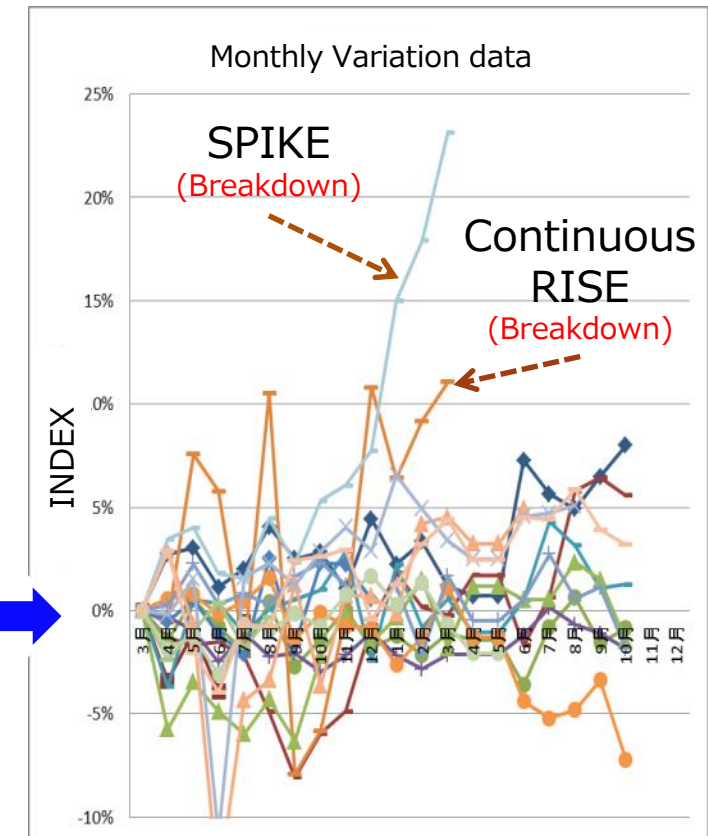
- Issues: Repair costs by production line down due to Dry Pump
- Solution: Failure prediction by 3D analysis using IMU
- Advantage: Planned Replacement in advance, Avoid the issues



Rotational vibration are difficult to measure by acceleration



Dry Pump Monitoring Data

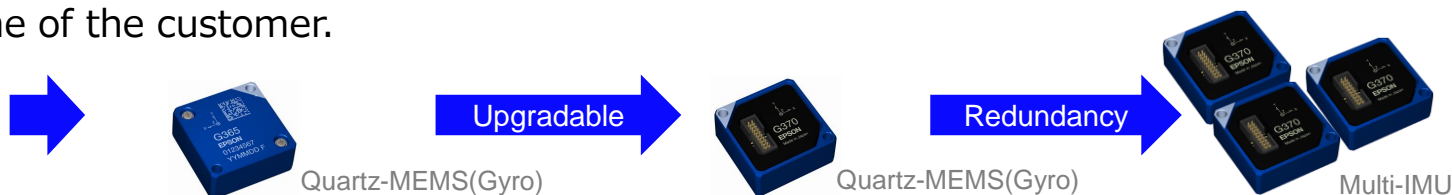


2. G3X platform is upgradeable products

G3X platform (G370/365/364/354);

G3X Platform is 1inch square small form factor, designed to bring out stable performance even under unstable environment. New products planned for the future will also use the same G3X platform. The compatibility of hardware and software interfaces will bring the improvement of the performance simply by replacing the IMU, reducing the development cost, engineering resource, and evaluation time of the customer.

- 1 Vender
- 1 platform(G3x)
- 3 Performances



EPSON G3X IMU	M-G365	M-G370	Quad M-G370
Gyro. BIS (dph)	1.8	0.8	0.5~0.4 (X3~4pcs)
Gyro. Range(dps)	±450		
Acc. Range (G)	±4 / ±10		
Size	24x24x10mm		

Other vendors	ADI - ADIS16465		ADI - ADIS16495		Sensoror - STIM300	KVH - GEO FOG 3D
Gyro. BIS (dph)	2.3	2	1.6	0.8	0.5	0.1 (0.7 w/temp)
Gyro. Range(dps)	±450	±125	±450	±125	±400	±490
Acc. Range (G)	±8		±8/(40)		±10	±10
Connector	16pin Header		24pin Header		D-SUB 15pin	RS422
Size	22x24x9mm		44x47x14mm		39x45x22mm	94x94x95mm

- 3 Venders
- 4 IMU
- 6 Performances



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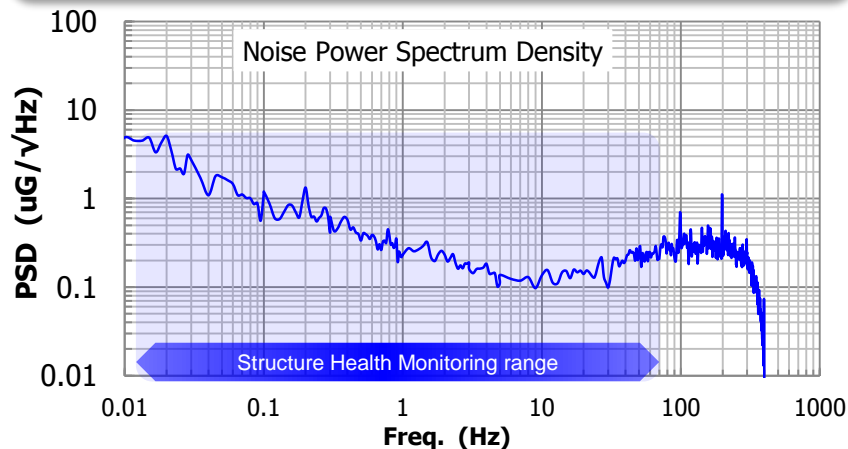
EPSON
EXCEED YOUR VISION

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3. Advantage: Quartz accelerometer (M-A351/A550)

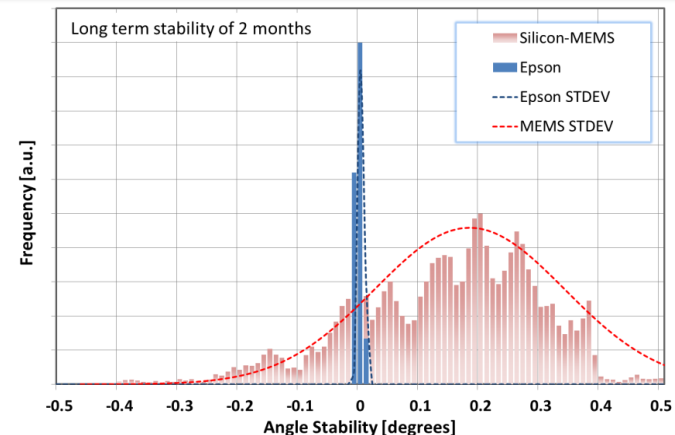
Low Noise and High Resolution

M-A351 outputs digital 32bit data on each X/Y/Z axis with a resolution of 0.06 μ G/LSB. This accelerometer can detect slow vibration, small displacement, and high resolution angle and is suitable for structure health monitoring, seismic observation and earthquake detection.

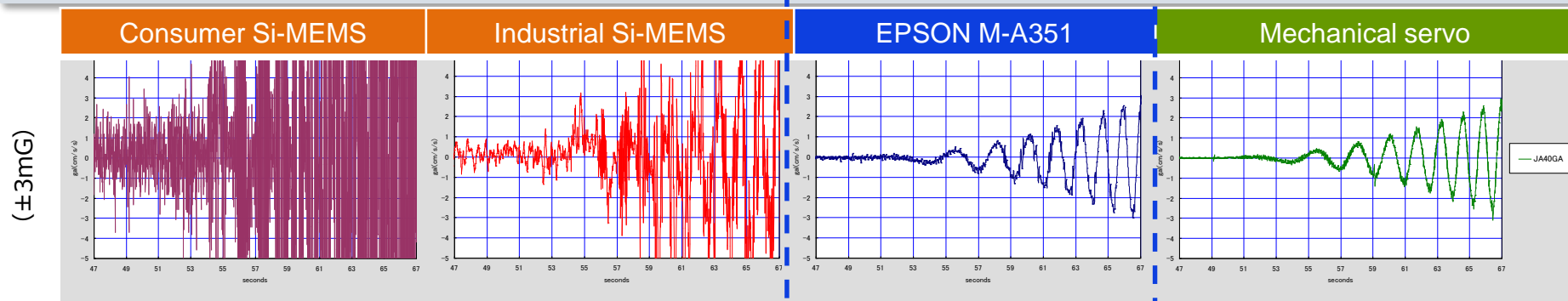


High Stability

M-A351 is equipped with a crystal element using micro-fabrication technology of high precision quartz material to enable customer to measure acceleration, tilt angle with high stability. This is an ideal sensor for analysis and diagnosis of large-sized structures that need to capture small changes because of its inherent ability to capture highly stable measurements over a long period of time.

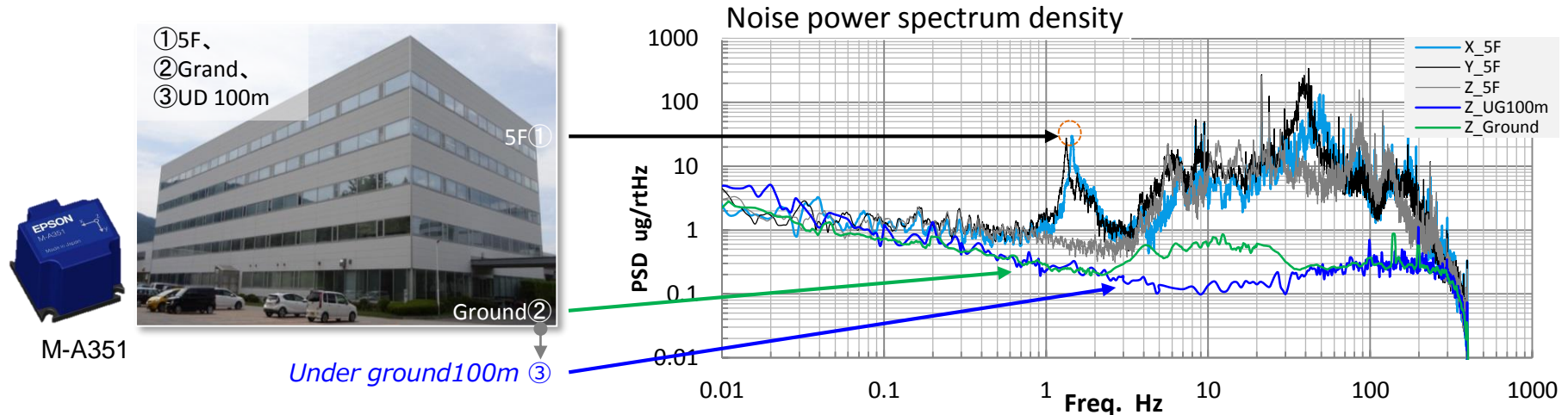


Comparison data



3. Application 1

■ Building monitoring for earthquake and Diagnosis fatigue issue

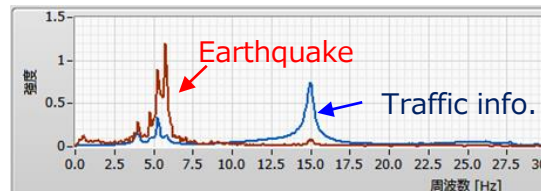


■ Bridge monitoring for traffic information



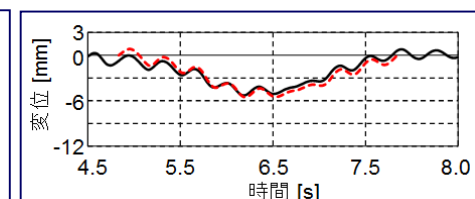
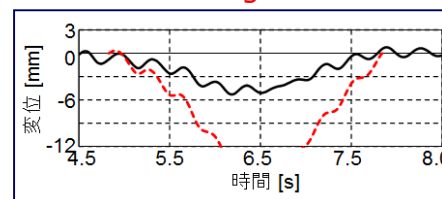
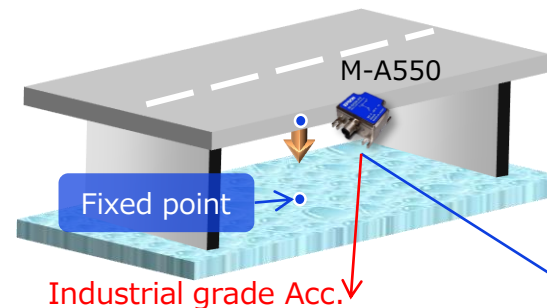
M-A550

FFT analyze



Bridge	Amp.	Traffic	Location
K	3.3	Estimates Traffics	Center
I	3.1		Center
PC	3.4		Center
	3.7		Side

■ Displacement measurement of bridge monitoring for diagnosis



3. Application 2: Geotechnical engineering

■ Purpose

- Monitoring & Diagnosis
 - ✓ Quality control for precision machine prevent from noise issue
 - ✓ Detect root cause of noise source
 - ✓ Measure Earthquake damage
- Analyzing
 - ✓ Investigation of abnormal vibration for Surrounding building, heavy machinery
 - ✓ Vibration reduction, Digitization, Quality relationship analyze

■ Advantage: M-A351/A550

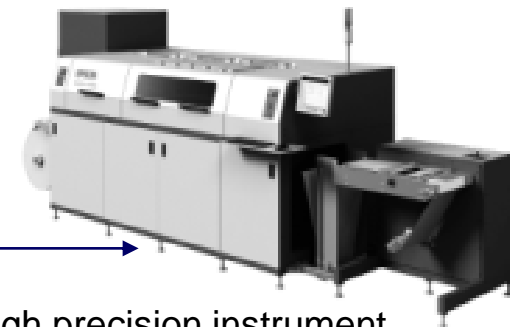
- Portability
 - Low power & All digital
 - High resolution & Low noise
- ... Small size, Light weight
 - ... USB power on PC / Digital I/F



M-A351



M-A550



High precision instrument

