

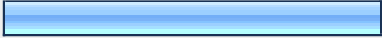






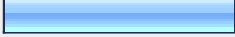








Future of Sensors






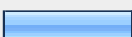
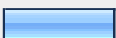
1. Have you had any experience or familiarity with sensors within the past 5 years?			
		Response Percent	Response Count
Yes		96.1%	439
No		3.9%	18
<i>answered question</i>			457
<i>skipped question</i>			0

2. Who has been your primary employer within the past 5 years?			
		Response Percent	Response Count
University		41.5%	177
Industry, business		46.6%	199
Government, municipal, and public services		6.6%	28
Military		1.6%	7
Other (please specify)		3.7%	16
<i>answered question</i>			427
<i>skipped question</i>			30

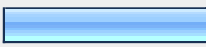

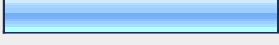
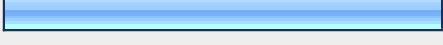
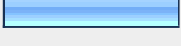


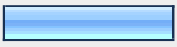

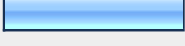
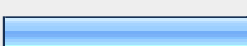
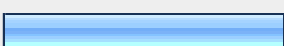
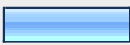

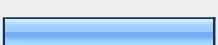
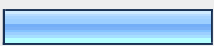
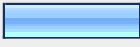

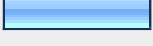
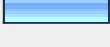

3. What has been your primary type of work in the past 5 years?


		Response Percent	Response Count
University research, teaching, instruction		39.9%	167
Industrial research		11.5%	48
Design, development		25.3%	106
Manufacturing		3.3%	14
Installation, technical support, maintenance		5.3%	22
Marketing		6.4%	27
Administration, monitoring, contracts		1.4%	6
Consulting		4.3%	18
Other (please specify)		2.6%	11
		<i>answered question</i>	419
		<i>skipped question</i>	38


















4. What has been your predominant involvement with sensors over the past 5 years?

		Response Percent	Response Count
developing custom sensors (< 10 sensors/year)		17.8%	71
developing custom systems containing sensor(s) (< 10 systems/year)		34.6%	138
manufacturing or selling sensors (> 10 sensors/year)		8.0%	32
manufacturing or selling mass-produced equipment containing sensors (> 10 products/year)		4.8%	19
installing and maintaining sensors		8.8%	35
monitoring or managing sensor acquisition		14.0%	56
Other (please specify)		12.0%	48
		<i>answered question</i>	399
		<i>skipped question</i>	58

5. In what fields of application have you encountered or used sensors? Check ALL that apply.

		Response Percent	Response Count
Aerospace (including military aerospace vehicles)		22.1%	85
Agricultural machinery, vehicles		15.8%	61
Automotive		30.1%	116
Basic scientific research		48.3%	186
Buildings, structures, HVAC		19.0%	73
Business and financial systems		1.6%	6
Civil infrastructure, municipal services		13.8%	53
Consumer products		18.4%	71
Ecology, biology		10.9%	42
Food, pharmaceutical - factory, process control, distribution		19.5%	75
Manufacturing, OEM, assembly		26.8%	103
Medicine, healthcare		30.6%	118
Military (NOT including military aerospace vehicles, see aerospace)		13.5%	52
Mining		8.8%	34
Petroleum, natural gas, chemical - drilling, pumping, refining, distribution		23.1%	89
Power generation and distribution		22.6%	87
Security - homeland, local (e.g. police and fire)		14.8%	57
Test facility, metrology, compliance		22.6%	87
Transportation - trucking, railroad		15.8%	61
Transportation - ships, boats, barges, ferries		11.4%	44
Warehousing, logistics, distribution		9.1%	35

Other (please specify)		8.3%	32
		answered question	385
		skipped question	72

6. Pick the ONE field of application that you have the MOST familiarity, expertise.			
		Response Percent	Response Count
Aerospace (including military aerospace vehicles)		6.3%	24
Agricultural machinery, vehicles		1.6%	6
Automotive		6.9%	26
Basic scientific research		20.4%	77
Buildings, structures, HVAC		1.6%	6
Business and financial systems		0.0%	0
Civil infrastructure, municipal services		2.4%	9
Consumer products		2.6%	10
Ecology, biology		1.6%	6
Food, pharmaceutical - factory, process control, distribution		3.4%	13
Industrial machinery, vehicles		7.1%	27
Manufacturing, OEM, assembly		5.3%	20
Medicine, healthcare		7.1%	27
Military (NOT including military aerospace vehicles, see aerospace)		2.4%	9
Mining		1.1%	4
Petroleum, natural gas, chemical - drilling, pumping, refining, distribution		7.4%	28
Power generation and distribution		4.8%	18
Security - homeland, local (e.g. police and fire)		2.4%	9

Test facility, metrology, compliance		5.0%	19
Transportation - trucking, railroad		2.1%	8
Transportation - ships, boats, barges, ferries		0.5%	2
Warehousing, logistics, distribution		1.6%	6
Other (please specify)		6.3%	24
answered question			378
skipped question			79

7. Rate each of these characteristics for sensors in the field of application that you chose in question 6.					
	very important	important	low importance	not important	Response Count
Dependability	58.4% (206)	34.8% (123)	5.7% (20)	1.1% (4)	353
Cost	32.6% (117)	49.0% (176)	15.6% (56)	2.8% (10)	359
Power consumption	33.1% (118)	34.0% (121)	27.0% (96)	5.9% (21)	356
Size, volume, mass	26.1% (93)	53.5% (191)	18.8% (67)	1.7% (6)	357
Environmental extremes	34.8% (123)	39.9% (141)	21.2% (75)	4.0% (14)	353
Ease of diagnostics	28.7% (102)	50.7% (180)	17.5% (62)	3.1% (11)	355
Security of data	21.9% (78)	33.1% (118)	33.1% (118)	11.8% (42)	356
Installed longevity	42.2% (149)	44.8% (158)	11.3% (40)	1.7% (6)	353
Comments					10
answered question					364
skipped question					93

8. Predict how these sensor parameters will change within the next 5 years.							
	0%	+10%	+20%	+50%	+100%	>+100%	Response Count
Speed	7.1% (25)	25.3% (89)	23.0% (81)	27.8% (98)	8.5% (30)	8.2% (29)	352
Accuracy/resolution	3.3% (12)	19.4% (70)	31.7% (114)	28.1% (101)	11.7% (42)	5.8% (21)	360
Conservation of power (reduced consumption)	3.9% (14)	11.0% (39)	24.5% (87)	34.6% (123)	14.4% (51)	11.5% (41)	355
% decrease in size	3.1% (11)	15.5% (55)	25.4% (90)	33.8% (120)	12.7% (45)	9.6% (34)	355
Comments							10
answered question							362
skipped question							95

9. Predict how sensor networks will change within the next 5 years. (The numbers and types of sensors are per system, as is the total bandwidth.)							
	0%	+20%	+50%	+100%	+200%	>+200%	Response Count
Numbers of sensors	1.8% (6)	21.4% (70)	26.0% (85)	26.6% (87)	11.6% (38)	12.5% (41)	327
Types of sensors	4.8% (16)	32.4% (107)	27.9% (92)	23.6% (78)	6.7% (22)	4.5% (15)	330
Network bandwidth	4.0% (13)	19.7% (64)	29.5% (96)	29.8% (97)	9.5% (31)	7.4% (24)	325
Secure transmission	5.3% (17)	25.1% (81)	32.2% (104)	25.1% (81)	7.7% (25)	4.6% (15)	323
Comments							11
answered question							332
skipped question							125

10. What will be the rate of increase in numbers of sensor networks?							
	0%	+20%	+50%	+100%	+200%	>+200%	Response Count
Wired	8.6% (28)	51.4% (168)	25.4% (83)	9.8% (32)	2.8% (9)	2.1% (7)	327
Wireless	1.5% (5)	10.9% (36)	26.0% (86)	27.2% (90)	19.3% (64)	15.1% (50)	331
Optical	8.7% (28)	34.2% (110)	29.2% (94)	18.6% (60)	5.9% (19)	3.4% (11)	322
Other (please specify)							9
answered question							333
skipped question							124

11. This completes the predictive portion of the survey. Do you wish to tell us about your application?			
		Response Percent	Response Count
Yes, I'll answer more questions		47.8%	164
No, end the survey		52.2%	179
answered question			343
skipped question			114

12. Please select ONE sensor type with which you have recent or the most experience.

		Response Percent	Response Count
electric field		1.1%	2
voltage, current		6.1%	11
magnetic field		3.3%	6
electromagnetic		2.2%	4
proximity, occupancy, motion		2.2%	4
position, displacement		5.5%	10
velocity, acceleration		9.4%	17
force, strain, mass		3.9%	7
temperature		13.8%	25
pressure		13.8%	25
humidity, moisture		3.9%	7
fluid level		0.6%	1
mass, fluid, gas flow		2.2%	4
acoustic, ultrasonic		5.0%	9
radar, microwave - transmitted, reflected		2.2%	4
optical - transmitted, reflected, fiber optic		9.4%	17
optical - imaging		3.3%	6
radiation		0.0%	0
chemical		5.5%	10
biological		2.2%	4
Other (please specify)		4.4%	8
		answered question	181
		skipped question	276

13. What are the sampling speeds for this particular type of sensor? Even if the sensor operates asynchronously, give your best estimate in samples per second (sps) -----

	<1	1	10	100	1K	10K	100K	1M	10M	100M	1G
Minimum	22.8% (36)	17.7% (28)	15.2% (24)	11.4% (18)	13.3% (21)	8.2% (13)	7.0% (11)	0.6% (1)	2.5% (4)	0.6% (1)	0.6% (1)
Average	8.3% (13)	12.2% (19)	14.7% (23)	16.7% (26)	16.0% (25)	14.1% (22)	7.1% (11)	6.4% (10)	1.3% (2)	1.9% (3)	0.6% (1)
Maximum	5.8% (9)	5.1% (8)	11.5% (18)	10.9% (17)	17.3% (27)	13.5% (21)	14.1% (22)	7.1% (11)	5.8% (9)	2.6% (4)	3.2% (5)
Sensor speed not defined in samples per second											
<i>an</i>											

14. What is the range of accuracy for this particular type of sensor? ENOB = effective number of bits Approximate relation of ENOB
 10 bits / 62 dB 18 bits / 110 dB 4 bits / 26 dB 12 bits / 74 dB 20 bits / 122 dB 6 bits / 38 dB 14
 8 bits / 50 dB 16 bits / 98 dB 24 bits / 146 dB -----

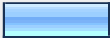
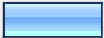
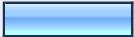
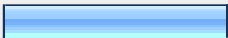
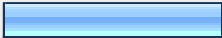



	pulse/contact closure	2	4	6	8	10	12	14	16	18
Minimum accuracy	8.1% (11)	6.6% (9)	5.9% (8)	8.1% (11)	26.5% (36)	18.4% (25)	16.9% (23)	2.2% (3)	4.4% (6)	0.7% (1)
Average accuracy	3.0% (4)	2.2% (3)	7.4% (10)	3.7% (5)	8.9% (12)	18.5% (25)	28.9% (39)	8.1% (11)	11.9% (16)	3.0% (4)
Maximum accuracy	3.0% (4)	3.0% (4)	1.5% (2)	3.0% (4)	5.3% (7)	6.1% (8)	21.2% (28)	6.1% (8)	21.2% (28)	8.3% (11)
Sensor accuracy not defined in bits										

15. What is the bandwidth of this particular sensor? Even if the data transmission is not continuous, give your best estimates of the bandwidths. ----- Bandwidth (Bytes/sec) -----

	pulse/switch closure	<1	1-100	100-1K	1K-10K	10K-100K	100K-1M	1M-10M	10M-100M	100M-1G
Minimum	4.7% (6)	7.8% (10)	30.2% (39)	19.4% (25)	20.9% (27)	10.1% (13)	1.6% (2)	3.1% (4)	1.6% (2)	0.8% (1)
Average	2.3% (3)	2.3% (3)	19.7% (26)	18.2% (24)	25.0% (33)	15.9% (21)	8.3% (11)	3.0% (4)	2.3% (3)	1.5% (2)
Maximum	2.4% (3)	1.6% (2)	11.1% (14)	13.5% (17)	19.8% (25)	19.0% (24)	15.1% (19)	7.9% (10)	3.2% (4)	1.6% (2)
Sensor bandwidth not defined in bytes/sec (please										
<i>answered question</i>										
<i>skipped question</i>										


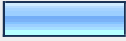
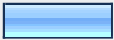


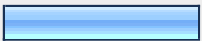



16. What is the power consumption of this particular sensor? Even if the level of power consumption is not fixed, give your best estimates of the average levels of power consumption. (uW = microwatt, mW = milliwatt, W = watt)

	<1 uW	1-10uW	10-100uW	100uW-1mW	1-10mW	10-100mW	100mW-1W	1-10W	>10W	Response Count
Minimum	8.3% (11)	11.4% (15)	19.7% (26)	18.9% (25)	19.7% (26)	10.6% (14)	8.3% (11)	2.3% (3)	0.8% (1)	
Average	1.5% (2)	6.6% (9)	12.4% (17)	17.5% (24)	24.1% (33)	17.5% (24)	13.9% (19)	5.8% (8)	0.7% (1)	
Maximum	0.8% (1)	3.9% (5)	8.6% (11)	7.8% (10)	24.2% (31)	20.3% (26)	21.9% (28)	8.6% (11)	3.9% (5)	
Other (please specify)										
<i>answered question</i>										
<i>skipped question</i>										

17. For this particular sensor, what is the general size (volume) of the sensor (includes the transducer)?		Response Percent	Response Count
<0.03 ml (3 mm x 3 mm x 3 mm)		11.3%	17
<0.1 ml (5 mm x 5 mm x 5 mm)		10.6%	16
<1 ml (1 cm x 1 cm x 1 cm)		13.9%	21
<10 ml (2.2 cm x 2.2 cm x 2.2 cm, or about 1 cubic inch)		24.5%	37
<100 ml (5 cm x 5 cm x 4 cm or about 8 cubic inches)		23.8%	36
<1 liter (10 cm x 10 cm x 10 cm or about 32 cubic inches)		6.0%	9
> 1 liter		4.0%	6
Other (comment on varying sizes if applicable)		6.0%	9
answered question			151
skipped question			306

18. For this particular sensor, what is the range of distances from the transducer to the data collection module or computer?									
	<20 cm	20-50 cm	0.5-1 m	1-2 m	2-5 m	5-10 m	10-50 m	>50 m	Response Count
Minimum	33.6% (45)	14.2% (19)	17.9% (24)	8.2% (11)	7.5% (10)	7.5% (10)	6.0% (8)	5.2% (7)	134
Average	12.9% (18)	12.1% (17)	11.4% (16)	16.4% (23)	7.9% (11)	14.3% (20)	14.3% (20)	10.7% (15)	140
Maximum	10.0% (13)	6.9% (9)	5.4% (7)	7.7% (10)	13.8% (18)	9.2% (12)	13.8% (18)	33.1% (43)	130
Other (please specify)									5
answered question									146
skipped question									311





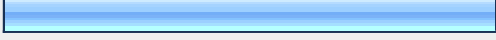

19. For your chosen sensor and field of application, what format is the data transmission from the sensor to the data collection module or computer?

		Response Percent	Response Count
Digital - wired		33.8%	52
Digital - wireless		13.0%	20
Digital - combination of wired and wireless		11.7%	18
Digital - optical		2.6%	4
Current loop		5.8%	9
Raw analog signal - wired		21.4%	33
Raw analog signal - wireless		5.2%	8
Raw analog signal - combination of wired and wireless		1.9%	3
Raw analog signal - optical		1.9%	3
Other (please specify)		2.6%	4
		answered question	154
		skipped question	303

20. How many different TYPES of sensors are typically incorporated into a system?

	1	2	3	4	5	6 - 10	>10	Response Count	
Minimum/system	56.8% (79)	15.1% (21)	13.7% (19)	5.0% (7)	3.6% (5)	3.6% (5)	2.2% (3)	139	
Average/system	14.9% (22)	27.7% (41)	20.9% (31)	12.2% (18)	10.8% (16)	8.1% (12)	5.4% (8)	148	
Maximum/system	8.6% (12)	8.6% (12)	13.6% (19)	15.0% (21)	14.3% (20)	20.7% (29)	19.3% (27)	140	
Other (please specify)								1	
								answered question	149
								skipped question	308

21. How many TOTAL sensors are typically incorporated into a system?									
	1	2	3-5	6-10	11-20	21-50	50-100	>100	Response Count
Minimum/system	41.2% (56)	19.9% (27)	17.6% (24)	7.4% (10)	5.9% (8)	4.4% (6)	2.2% (3)	1.5% (2)	136
Average/system	9.9% (14)	12.0% (17)	25.4% (36)	21.1% (30)	10.6% (15)	7.7% (11)	9.9% (14)	3.5% (5)	142
Maximum/system	5.2% (7)	5.2% (7)	14.8% (20)	14.8% (20)	14.1% (19)	13.3% (18)	11.9% (16)	20.7% (28)	135
Other (please specify)									3
answered question									145
skipped question									312

22. Are any security measures used in the data transmission from the sensor to the data collection module or computer?			
		Response Percent	Response Count
Highly sophisticated encryption with hardened enclosure and restricted physical access		6.0%	9
Hardened enclosure and restricted physical access		9.9%	15
Restricted physical access only		20.5%	31
Encryption only		7.3%	11
None		54.3%	82
Other (please specify)		2.0%	3
answered question			151
skipped question			306

23. What is the environment that this particular sensor must endure in this particular field of application? Office: - Temperature ranges from 0 to 50 C - Mild vibration and shock (drop to concrete floor from 1 m) - Humidity ranges from 10% to 80% - Pressure from sea level to 5000 m - EMI is nominal, power drops and brown outs, surges, spikes, ESD Medical: - Temperature ranges from 0 to 50 C - Mild vibration and shock (drop to concrete floor from 1 m) - Humidity ranges from 0% to 100% condensing, sometimes immersion - Corrosion in implanted devices - Pressure from sea level to 5000 m - EMI can be moderate, power drop outs, surges, spikes, ESD, RFI, reversed battery leads Industrial: - Temperature ranges from -40 to 85 C - Potentially severe vibration and shock - Humidity ranges from 0% to 100% condensing, sometimes immersion - Corrosion in caustic liquids and gases - Potentially volatile gases or liquids - Pressure from multiple atmospheres to near vacuum - EMI can be severe, power drop outs, surges, spikes, ESD, RFI Military: - Temperature ranges from -40 to 125 C - Potentially severe vibration and shock - Humidity ranges from 0% to 100% condensing, sometimes immersion - Corrosion in caustic liquids and gases - Pressure from multiple atmospheres to near vacuum - EMI can be severe, power drop outs, surges, spikes, ESD, RFI, Extreme (any or all of the following): - Temperature ranges much greater than from -40 to 125 C - Severe vibration and shock - Humidity ranges from 0% to immersion - Corrosion in caustic liquids and gases - Volatile gases or liquids - Pressure from many atmospheres to vacuum - EMI is severe, power drop outs, surges, spikes, ESD, RFI - Ionizing radiation, high energy particles and rays

	Office	Medical	Industrial	Military	Extreme	Response Count
Least severe	57.0% (81)	7.7% (11)	27.5% (39)	4.9% (7)	2.8% (4)	142
Typical, predominate	9.6% (14)	16.4% (24)	57.5% (84)	10.3% (15)	6.2% (9)	146
Most severe	5.7% (8)	9.2% (13)	29.1% (41)	25.5% (36)	30.5% (43)	141
					Other (please specify)	4
					<i>answered question</i>	149
					<i>skipped question</i>	308