Analysis of the First Six TSensors Summits and Findings

The genesis of TSensors initiative is provided at http://www.tsensorssummit.org/tsensorsgenesiso.html and initial rationale and objectives here: http://www.tsensorssummit.org/Resources/Why%20TSensors%20Roadmap.pdf. With time the objectives have evolved:

- Invite visionaries to talk at **TSensors Summits** about emerging ultrahigh volume sensor based applications over the next decade, capable of impacting the acceleration of Abundance, the World with no hunger, medical care to all, no pollution and energy for all.

Objective: provide advanced visibility to sensors developers, to enable early development focus which should significantly reduce the historical average 30 year new sensor development cycle.

- Develop documents called **TSensors Roadmaps**, summarizing the findings and enabling easy access for sensor developers at academic, government and industrial entities, to help them sort through emerging opportunities supporting Abundance.
- Start proactive commercialization acceleration of selected sensors providing the biggest benefit for Abundance: **TSensors Supply Chain**.

The trigger for TSensors initiative was a presentation given at the MEMS Technology Summit, Stanford University, 2010, by Muenzel Horst (now President, Bosch Akustica) outlining a potential for 7 trillion wireless sensors by 2017. Following this trigger, Dr. Bryzek organized (with partners) six dedicated TSensors Summits:

Location	Date	My Co-Chairs	Logistics by	Number of Speakers	Attendees
Stanford University	Oct 2010	Roger Howe, Kurt Petersen, Joe Mallon, Roger Grace	Mepcom/Bette Cooper	28	250
UC Berkeley	Mar 2013	Al Pisano, UC San Diego	UC Berkeley	8	140
Stanford University	Oct 2013	Roger Howe, Stanford University	Mepcom/Bette Cooper	47	250
Tokyo	Feb 2014	Susumu Kaminaga, SPP Technologies	Nikkei BP/Tsuneyuki Miyake	17	200
Munich	Sep 2014	Christoph Kutter, Fraunhoffer Institute	Fraunhoffer Institute	36	150
San Diego	Oct 2014	Al Pisano, UC San Diego	Mepcom/Bette Cooper	36	200
Tokyo	Dec 2014	Susumu Kaminaga, SPP Technologies	Nikkei BP/Tsuneyuki Miyake	41	200
Total				213	1390

As shown, Dr. Bryzek recruited 2013 TSensors presentations and had about 1400 attendees.

In addition to dedicated events, Dr. Bryzek delivered about 40 TSensors presentations across the world, all receiving enthusiastic receptions. Susumu Kaminaga delivered about 20 presentations, primarily in Japan, receiving a similar response. The combined audience was over 10,000 attendees.

TSensors initiative was split into two activities:

- **TSensors** focused on emerging ultrahigh volume sensors and
- **TSensor Systems** focused on require infrastructure for deployment of trillion sensors.

The most interesting finding from TSensors Summits was that TSensors Initiative supporting Abundance happened to be inline with the biggest economic tides in history of humans, dramatically increasing the probability of TSensors Initiative succeeding:

- Mobile markets
- Wearable markets
- Internet of Things and Everything
- Mobile Health
- Exponential Technologies
- Exponential Organizations

Dr. Bryzek selected multiple themes he considered important for Abundance, and searched for visionary speakers to present their visions in these areas. With time, he managed to focus most of invited presentations on TSensors Initiative objectives, as shown in the last line in the table below listing selected themes and number of presentations at each of the events Dr. Bryzek organized:

TSensors Theme	Stanford 2000	UC Berkeley	Stanford 2013	Tokyo Feb/14	Munich	San Diego	Tokyo Dec/14	Total
TSensors Roadmap								
Introduction to TSensors, IoT, eHealth					2			2
Healthcare Abundance: Sensors, Imagers and FDA	2	2	10	4	4	11	9	42
Feeding the New World						2	2	4
Energy Generation and Harvesting			6			1		7
Sensor Technologies, including 3D printing	1	4	20	7	15	11	6	65
Environmental Sensing: Home, City and World			2	2			2	6
Automotive Energy Consumption and Pollution	1		1		6	4	2	14
TSensors Systems (Infrastructure) Roadmap								
Emerging Network Infrastructure			1	3	2	3	7	16
Emerging 3D printed ICs								
Education: Sensors, IoT and eHealth			1			1	1	3
Sensor Analytics and Big Data			1		1		7	9
Ultralow power wirelss communication			3	1		1	1	6
Security-Privacy					6	1		7
Total	4	6	45	17	36	35	37	181
Total speakers	28	8	47	17	36	36	41	213
% Speakers focused on TSensors	14.3%	75.0%	95.7%	100.0%	100.0%	97.2%	90.2%	85.0%

In addition to visionary sensor applications and technologies, in process of running TSensors Initiative Dr. Bryzek discovered (partially due to being a member of Peter Diamandis Working Group) remarkable information about the future affecting global economy:

- The 3rd Technical Revolution fusing computing, communication and sensing is just starting, and is expected to free people from manual labor, leaving for them creative work in coming decades.

- Disruption cycle time for business has been shrinking from 65 years for companies formed 100 years ago, to about

15 years currently.
- Disruption cycle is in full swing, supported by emergence of exponential organizations reaching billion dollar sales level in 2 to 4 years.
  - While Kodak went bankrupt, Instagram was acquired for a billion dollars by Facebook in 2012. Both companies were in photography business: Kodak used linear model, Instagram exponential.

- Exponential Organizations (EXo's) are governed by a **6D** process including **D**igitization of products or services, **D**eceptive phase wherein there is under appreciation of the emerging threat, **D**isruptive phase enabling the first market Tornado, **D**ematerialization phase where products and services are converted to bits, **D**emonetization where legacy product function is available for free, and **D**emocratization enabling global distribution. Semiconductor industry is currently being threatened by printed electronics and sensors.

- Exponential Organizations are expected to destroy 40% of Fortune 500 companies in the US (similarly to Kodak story).

- Robots are expected to eliminate 50% of the US workforce by 2025.

- EXo's and robots will eliminate perhaps 70% of 144 million US jobs within 10 years.

- Sensors are a foundation for two largest economic tides in history of humans: IoT and mHealth forecasted by Cisco to reach 19 trillion dollars by 2020, from about 1 trillion last year.
  - For comparison, the entire 2014 US economy was about $16.5 trillion and global GPD around $70 trillion.

- IoT is funded at a billion dollars by multiple companies, governments and Venture Capital firms.

- eHealth got a major push from Medicine Manhattan project funded by a billionaire doctor Patrick Soon-Shiong.

- Iot is expected to generate globally about 170 million new jobs.

- A massive global retraining will be needed to prevent global unrests and support of emerging companies.

- Mobile sensor volume increased from 10 million units in 2007 (iPhone introduction) to 10 billion units in 2014. In the same timeframe, ASP decreased by almost three orders of magnitude, power consumption and size decreased by three orders of magnitude and number of transistors per sensor increased three orders of magnitude. These dramatic changes pave a foundation for IoT and eHealth sensors.

- One of the biggest challenges for TSensors is expected to be the sheer size of sensor-generated data on the order of 1 BrontoByte (1027) in 10 years.

- One of the enablers for TSensors (as well IoT and eHealth) is the cost. As sensor volumes skyrocket, their prices must go down, perhaps as low as $0.0001/sensor in ultrahigh volume applications. The only technology which can support such price level is printed semiconductors (ICs and sensors). Due to the expected volumes, such prices will still enable billion dollar sales for the suppliers.

In summary, all of us involved in organizing TSensors Summits did an outstanding job in setting up all Summits and collecting the extremely valuable information. Special thanks goes to the executive team for making this happen.

Dr. Bryzek decided to reduce the number of future Summits to one/year, to have time for developing Roadmaps. Each year will attempt to organize Summit on a different continent, moving from North America, to Asia, to Europe, to Africa, to South America and then back to North America.