Project Name:	Electronics Industry General Guidelines	**Start Date:**	2009-01-01
Project Number:	1	**Completion Date:**	2009-12-31

The following guidelines are intended to provide examples of "experimental development" projects which would qualify for Canadian SR&ED (Scientific Research & Experimental Development) tax credits.

Content Summary:

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Project Name: Electronics Industry General Guidelines

Scientific or Technological Objectives:

No objectives have been identified.
[THESE GUIDELINES ARE BASED ON EXCERPTS OF: "GUIDANCE ON ELIGIBILITY OF SOFTWARE PROJECTS FOR THE SR&ED TAX CREDITS" AS PUBLISHED BY THE CRA IN CO-OPERATION WITH CATA & THE SOFTWARE INDUSTRY.]

Advancement - Note that the advancement in technology can rarely be described by listing design functions and features at an "end-user" level. Advances are typically made through innovation in designs, techniques or constructs within the field of electrical or electronic engineering. The advancement need not be large.

Evidence of Technological Advancement could include credible third party literature or comparisons of the capabilities sought against those previously available from the taxpayer himself. As in a court of law, there are no rigid definitions of what constitutes credible evidence.

Technology or Knowledge Base Level:

No benchmarks have been identified.
Hint: As a means to identify the advancement(s), the taxpayer might identify the technological reason why his technique was not used before. How does it compare with earlier solutions or with the current solution of a competitor? What earlier technical constraint has been overcome?

Field of Science/Technology:

Electrical and electronic engineering (2.02.01)

Project Details:

Intended Results:	Develop new processes, Develop new materials, devices, or products, Improve existing processes, Improve existing materials, devices, or products
Work locations:	No work locations have been specified.
Key Employees:	Albert Einstein (Electronics - B.Sc. (1980) / Unknown), Mike Philips (Unknown / Unknown), Nicola Tesla (Unknown / Unknown)
Evidence types:	None.

Scientific or Technological Advancement:

Uncertainty #1: Technological Uncertainty: Key evidence examples
The objective here is to outline options for developing sets of questions which may act as catalyst to provide an effective and efficient method of identifying key evidence of eligibility.

1. Identify the limitations/constraints imposed by the technology components being utilized. What technical challenges did these constraints create?

2. Identify the degree of control the claimant has to modify the technology components. What technical challenges did these constraints create? Examples:

- Are you using any of the components in a unique, previously undocumented or unconventional fashion?

- Is the vendor able to confirm the suitability of these components for use in said fashion?

- Is the vendor capable of providing a deterministic description of the components predicted response when used in this unique fashion?

[NOTE: THE CRA FINDS THIS TYPE OF THIRD PARTY EVIDENCE VERY VALUABLE AS SUPPORTING EVIDENCE THAT THE WORK INVOLVED A "DEPARTURE FROM STANDARD PRACTICE" AS SUCH WE RECOMMEND THAT THIS EVIDENCE BE SAVED WHENEVER POSSIBLE.]

3. Identify the constraints or uncertainties or paradoxes presented when certain components/objects/technology platforms

are operated in conjunction with other electronic entities. Do you have control over these interactions; can you or the vendors of these components predict the effects of these interactions?

4. Identify any constraints resulting from considerations of:
-feedback
-communication distortion
-magnetic fields, crossing fields, interference
-impedance, resistance
-power conversion, pulses
-footprint - fitting in all components / chips, etc
-interaction and compatibility of components - old versus new components
-power outputs - battery life, power management
-heat dissipation rate
-ambient conditions (humidity, dust)
-conductivity
-frequencies
-Amps, Volts, Power, Resistance, capacitors, etc.

What technical challenges did these constraints create?

5. Identify any key characteristics of a technology platform you are using to which the manufacturer of the technology component cannot provide a fully deterministic characterization of the platform when utilized in the fashion required by your project.

6. Is the integrated performance of the electronic components incorporated within the project fully deterministic? I.E. can the behavior of the components be fully projected both on a stand alone basis as well as when operating within an integrated environment? Can you predict the desired outcome? If not, why?

7. What technology risks/constraints/problems appeared after the project began?

8. What was or will be hard or technically difficult to do & why?

9. What restrictions are presented by the attributes of objects/components?

The most significant underlying key variables are:

feedback (unresolved), impedance, resistance (unresolved), footprint (unresolved), heat dissipation (unresolved), frequencies (unresolved)

Activity #1-1: Eligible Activities (Fiscal Year 2009)

Methods of experimentation:

No experimentation methods have been recorded for this Activity.

Related issues to illustrate via research steps:
- What technical alternatives did you look at, what did you discard & why?
- What are the technical design trades-offs associated with these alternatives?
- What are/were the possible technical outcomes other than the results you are seeking?

Experimental Work:
An experiment within the context of the SR&ED Program involves setting up test conditions and making observations or measurements aimed at filling gaps in our technical knowledge. The result of the experiment, whether it is successful or unsuccessful, provides an increase in knowledge of electronic systems relative to the Technological Advancement sought and/or the Technological Uncertainties.

The new knowledge is applicable beyond the system under test. Thus inherently, Technological Uncertainties are associated with advancements in technology knowledge. One making a claim should always be able to identify the technological advancement in his knowledge that is associated with solving a technological uncertainty, i.e. what was learned through experimentation.

Resolving problems through a "trial-and-error" approach is eligible support work, but it is not the basis for a Technological Advancement, as the knowledge gained does not produce a true improvement in our understanding of the technologies.

QUANTIFICATION:
[REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS

OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Results:

No results have been recorded for this Activity.

[NOTE: IF THERE WERE ANY TEST RESULTS FROM THIS ACTIVITY THAN THESE SHOULD BE STATED HERE]

Conclusion:

Related issues to illustrate via conclusions:

If you had to do it again what would you do differently?

[NOTE: THE IDEAL CONCLUSIONS WOULD BRIEFLY DETAIL HOW THE RESULTS COMPARED WITH INITIAL EXPECTATIONS AND OUTLINE ANY FURTHER CONCLUSIONS WHICH COULD AFFECT FUTURE DEVELOPMENTS OF THISNATURE.]

Project Name:	Battery Pack Design	**Start Date:**	2009-01-01
Project Number:	901	**Completion Date:**	2009-10-01

Project Details: Battery Pack Design

Scientific or Technological Objectives:

Measurement	Current Performance	Objective	Has results?
Avg. Range (km)	30	600	Yes
Minimize production cost ($ per unit)	15	10	Yes
Minimize size (inches cube)	12	9	Yes
Minimize charging rate (hours per cycle)	2	1.2	Yes

[SOURCE: "BATTERY CHOICE AND MANAGEMENT FOR NEW GENERATION ELECTRIC VEHICLES" BY ANTONIO AFFANNI, ALBERTO BELLINI, GIOVANNI FRANCESCHINI, PAOLO GUGLIELMI, CARLA TASSONI, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOLUME 52, NUMBER 5, OCTOBER 2005]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The objective of this project is to design a battery pack for a prototype high-performance electric scooter.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citing:

- Internet searches: 25 sites / articles -- No solution was found
- Patent searches: 5 patents -- Non meet the objectives performance
- Competitive products or processes: 10 products -- None provide the range or performance we desire.
- Similar prior in-house technologies: 3 products / processes -- own designs performance is insufficient

Different types of Electric Vehicles (EV) have been recently designed with the aim of solving pollution problems caused by the emission of gasoline-powered engines. Environmental problems promote the adoption of New Generation Electric Vehicles (NGEV) for urban transportation. One of the weakest points of electric vehicles is the battery system. Vehicle autonomy and therefore accurate detection of battery state of charge (SoC) together with battery expected life, i.e. battery state of healthy (SoH), are among the major drawbacks that prevent the introduction of electric vehicles in the consumer market. Electric scooters may provide the most feasible opportunity among EV. They may be a replacement product for primary use vehicles, especially in Europe and Asia provided that drive performances, safety and cost issues are similar to gasoline-powered scooters.

Company X is working on a battery pack design for their prototype high performance electric scooter. Emphasis is on vehicle range and performance.

Field of Science/Technology:

Electrical and electronic engineering (2.02.01)

Project Details:

Intended Results:	Develop new materials, devices, or products
Work locations:	Analysis, Research Facility
Key Employees:	Mike Philips (Unknown / Unknown), Nicola Tesla (Unknown / Unknown), Albert Einstein (Electronics - B.Sc. (1980) / Unknown)
Evidence types:	None.

Scientific or Technological Advancement:

Uncertainty #1: Design of Battery Pack

What battery technology will meet the required performance, (range, rate of acceleration, maximum speed) and safety criteria?

[NOTE: THE GOALS SHOULD BE QUANTIFIED WHENEVER POSSIBLE.]

The most significant underlying key variables are:

range, rate of acceleration, maximum speed

Activity #1-1: Literature review on battery technologies (Fiscal Year 2009)

Methods of experimentation:

- Analysis / simulation: 4 alternatives

  A literature review was conducted. Four battery technologies were considered:
  - lead-acid,
  - NiMH,
  - Lithium ion (Li-Ion), and
  - Lithium ion polymer (Li-Poly).

  They were compared in terms of energy density, energy-to-weight ratio, charge times, rate of loss of charge when not in use, lifespan, safety issues and cost.

Results:

No results have been recorded for this Activity.

[NOTE: IF THERE WERE ANY TEST RESULTS FROM THIS ACTIVITY THAN THESE SHOULD BE STATED HERE]

Conclusion:

Of the four technologies considered, Li-Ion and Li-Poly offer the best energy density and energy-to-weight ratios. Li-Ion batteries offer fast charge times and slow rate of loss of charge when not in use. Li-Poly batteries offer the potential of fast charge times and slow rate of loss of charge, but this is an emerging technology and the batteries currently available do not perform up to their potential in this area.

Both Li-Ion and Li-Poly can have a shorter lifespan and can be more dangerous than lead-acid and NiMH batteries if care is not taken. They also cost much more than lead-acid or NiMH batteries.

Since Li-Ion batteries can meet the required performance demands, while also offering fast charge times and slow self-discharge rates, Company X decided to proceed with this technology. Care will need to be taken in the design of the battery management system to ensure that safety and battery lifespan concerns are met.

Most significant variables concluded on: range

Activity #1-2: Configuration of Battery Pack (Fiscal Year 2009)

Methods of experimentation:

- Process trials: 20 runs / samples - 5 trials each for the 4 different configurations considered.

  [AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

  Several possible configurations of the Li-Ion cells were considered. To reach the desired operating voltage, several cells were connected in series. To increase the battery capacity, resulting in the desired range for the vehicle, several sets of cells in series were connected in parallel.

  [NOTE: THIS DESCRIPTION SHOULD BE MORE SPECIFIC - WHICH CONFIGURATIONS WERE CONSIDERED? HOW DID THEY DIFFER? WHY WAS THE ONE SELECTED BETTER THAN THE OTHERS?]

Results:

- Avg. Range: 100 km (12% of objective)
- Minimize production cost: 11 $ per unit (80% of objective)
- Minimize size: 8.5 inches cube (116% of objective)

Conclusion:

The adopted battery system is composed of Li-Ion cells with a combination of serial and parallel connections.

[NOTE: THESE "CONCLUSIONS" ARE CURRENTLY BASED TOO HEAVILY ON A "GOALS - RESULTS" ORIENTATION. IT IS THE "PROCESS" OF GETTING TO THE ANSWER (AND CLARIFICATION THAT TECHNICAL ANALYSIS WAS BEING CONTINUALLY PERFORMED THROUGHOUT THE PROCESS) RATHER THAN THE FINAL ANSWER WHICH IS IMPORTANT TO ILLUSTRATE TO THE CRA SCIENCE AUDITOR. WE SHOULD TRY TO PROVIDE TECHNICAL CONCLUSION(S) OR HYPOTHESES ABOUT WHY EACH OF THE RESULTS IS FELT TO BE THE OPTIMAL METHOD AND TO ILLUSTRATE THAT KNOWLEDGE HAS BEEN ASSIMILATED INTO COMPANY X'S KNOWLEDGE BASE.]

Most significant variables concluded on: maximum speed, range, rate of acceleration

Uncertainty #2: Design of Battery Management System

Due to manufacturing asymmetries in Li-Ion cells, charge and discharge cycles lead to cell unbalancing between the cells that reduces battery capacity and can lead to safety problems. Therefore cell equalization and monitoring is essential. Because of the high voltage level and high performance demands, no solution is currently available on the market.

Can a battery management system be designed that will handle the high voltage levels required, prolong battery lifespan and meet safety requirements?

[NOTE: THE GOALS SHOULD BE QUANTIFIED WHERE POSSIBLE. I.E. VOLTAGE LEVELS REQUIRED, DESIRED LIFESPAN ETC.]

The most significant underlying key variables are:

voltage level, battery lifespan, safety requirements, charge and discharge cycles (unresolved)

Activity #2-1: Design of Battery Management System (Fiscal Year 2009)

Methods of experimentation:

- Physical prototypes: 2 samples (with 10 revisions) - The first prototype had severe issues when it came to equalizing cell discharge, creating safety concerns.

  [AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

  Through development and experimentation with several approaches a dedicated battery system was designed that can monitor battery state of charge and equalize cell discharging, ensuring safety and prolonging battery life.

  [NOTE: AGAIN, THIS DESCRIPTION SHOULD BE MORE SPECIFIC - WHICH APPROACHES WERE CONSIDERED? WHAT ISSUES WERE ENCOUNTERED? HOW DID THE SELECTED APPROACH DIFFER FROM THE OTHERS CONSIDERED?]

Results:

- Avg. Range: 550 km (91% of objective)
- Minimize charging rate: 1.1 hours per cycle (112% of objective)

Conclusion:

The Battery Management System together with the Battery Pack resulted in a Battery System that is able to provide the desired operating voltage and capacity required to meet the scooter performance criteria (range, rate of acceleration, speed), as well as prolong battery life and meet safety requirements.

Future Work: Road tests will be performed to see how well the battery system performs when installed in the prototype scooter.

Most significant variables concluded on: battery lifespan, safety requirements, voltage level

Project Name:	Battery Pack Design	**Start Date:**	2009-01-01
Project Number:	901	**Completion Date:**	2009-10-01

901 - Battery Pack Design

Benchmarks:
Internet searches: 25 sites / articles
Patent searches: 5 patents
Competitive products or processes: 10 products
Similar prior in-house technologies: 3 products /

Objectives:
Avg. Range: 600 km
Minimize production cost: 10 $ per unit
Minimize size: 9 inches cube
Minimize charging rate: 1.2 hours per cycle

Uncertainty: 1 - Design of Battery Pack

Key Variables: maximum speed, range, rate of acceleration

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Literature review on battery technologies	Analysis / simulation: 4 alternatives	(none)	range	255.00	1,000.00	2,400.00	2009
2 - Configuration of Battery Pack	Process trials: 20 runs / samples	Minimize production cost: 11 $ per unit (80 %) Minimize size: 8.5 inches cube (116 %) Avg. Range: 100 km (12 %)	range rate of acceleration maximum speed	200.00	970.00	2,540.00	2009

Uncertainty: 2 - Design of Battery Management System

Key Variables: battery lifespan, charge and discharge cycles, safety requirements, voltage level

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Design of Battery Management System	Physical prototypes: 2 samples ... prototype revisions: 10 revisions	Avg. Range: 550 km (91 %) Minimize charging rate: 1.1 hours per cycle (112 %)	voltage level battery lifespan safety requirements	300.00	2,100.00	1,372.00	2009

Project Name:	New Under fill Material	**Start Date:**	2008-07-01
Project Number:	902	**Completion Date:**	2009-06-30

Project Details: New Under fill Material

Scientific or Technological Objectives:

Measurement	Current Performance	Objective	Have results?
Viscosity@25C (Kcps)	35	28	Yes
maximum cost ($ per kilogram)	0	23	Yes
improve flip chip package reliability (%)	90	95	Yes

[SOURCE: "DEVELOPMENT OF NOVEL FILLER TECHNOLOGY FOR NO-FLOW AND WAFER LEVEL UNDERFILL MATERIALS" BY SLAWOMIR RUBINSZTAJN, DONALD BUCKLEY, JOHN CAMPBELL, DAVID ESLER, ERIC FIVELAND, ANANTH PRABHAKUMAR, DONNA SHERMAN, AND SANDEEP TONAPI GENERAL ELECTRIC COMPANY GLOBAL RESEARCH CENTER 1 RESEARCH CIRCLE, NISKAYUNA, NY 12309, JOURNAL OF ELECTRONIC PACKAGING -- JUNE 2005 -- VOLUME 127, ISSUE 2, PP. 77-85]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The objective of this project is to develop a new under fill material to improve flip chip package reliability.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citing:

- Internet searches: 23 sites / articles -- Insufficient data
- Patent searches: 5 patents -- No solution found
- Competitive products or processes: 2 products -- companies did not reveal the secret
- Potential components: 1 products – Nano silica filled composite is promising material, but properties can vary widely.

Flip chip technology is one of the fastest growing segments of electronic packaging due to its advantages in size, performance, flexibility, reliability and cost over other packaging methods. Unfortunately, flip chip package design has a significant drawback related to the mismatch of coefficient of thermal expansion between the silicon chip and the organic substrate, which leads to premature failures of the package. Package reliability can be improved by the application of suitable "under fill" adhesive joining the surface of the chip to the surface.

Nano silica filled composite is a promising material for the no-flow under fill in flip-chip application. However, as the filler size decreases into the nano length scale, the rheological, mechanical, and thermal mechanical properties of the composite change significantly.

Company X is trying to design a nano composite formulation with desirable material properties for no-flow under fill applications.

Field of Science/Technology:

Electrical and electronic engineering (2.02.01)

Project Details:

Intended Results:	Develop new processes, Develop new materials, devices, or products
Work locations:	Lab
Key Employees:	Mike Philips (Unknown / Unknown), Albert Einstein (Electronics - B.Sc. (1980) / Unknown), Nicola Tesla (Unknown / Unknown)
Evidence types:	None.

Scientific or Technological Advancement:

Uncertainty #1: Effect of filler size and surface treatment

How does the filler size and surface treatment affect the properties of the resulting composite material? Can a nano silica filled composite material be designed that will meet the required rheological, mechanical and thermal properties?

[NOTE: THE DESIRED MATERIAL PROPERTIES SHOULD BE STATED QUANTITATIVELY.]

Project Name:	New Under fill Material	**Start Date:**	2008-07-01
Project Number:	902	**Completion Date:**	2009-06-30

The most significant underlying key variables are:

filler size, surface treatment, process variables

Activity #1-1: Effect of filler loadings and surface treatments (Fiscal Year 2009)

Methods of experimentation:

- Process trials: 20 runs / samples - 8 filler loadings each prepared 2 ways, plus control samples.

  Mono-dispersed nano silica grains of 100nm were used as the filler. An epoxy/anhydride mixture was used as the base resin formulation. Eight different filler loadings were studied - from 5wt% to 40wt%. Each of the filler loading was prepared with two ways - with or without silane coupling agents as the surface treatment. Control samples with micron-size silica fillers were prepared for comparison. Each resulting composite material was examined for transparency, curing behavior, and coefficient of thermal expansion, rheology, density, moisture absorption and dispersion of the nanosilica in the cured composite material.

Results:

- Viscosity@25C: 28 Kcps (100% of objective)
- maximum cost: 25 $ per kilogram (108% of objective)
- improve flip chip package reliability: 95 % (100% of objective)

Conclusion:

It was found that the nano-size filler had a desirable effect on certain properties. For example, the filler treatment significantly reduced the viscosity of the nano composite, improving the processing capability of the under fill.

The Tgs (glass transition temperature - the temperature at which a polymer drastically changes its properties) of the nano composites with untreated silica were found to decrease with the increasing filler loading. This could be a disadvantage, depending on the end application of the chip.

Unfortunately it was also found that the presence of the nano silica could hinder the curing reaction, especially at the late stage of cure. This is unacceptable if this material is to be used in production.

Further work will focus on improving the curing reaction of the nano silica composite material.

Most significant variables concluded on: filler size, process variables, and surface treatment

902 - New Underfill Material

Benchmarks:	Internet searches: 23 sites / articles Patent searches: 5 patents Competitive products or processes: 2 products Potential components: 1 products	**Objectives:**	Viscosity@25C: 28 Kcps maximum cost: 23 $ per kilogram improve flip chip package reliability: 95 %

Uncertainty: 1 - Effect of filler size and surface treatment

Key Variables: filler size, process variables, surface treatment

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Effect of filler loadings and surface treatments	Process trials: 20 runs / samples	maximum cost: 25 $ per kilogram (108 %) improve flip chip package reliability: 95 % (100 %) Viscosity@25C: 28 Kcps (100 %)	filler size process variables surface treatment	400.00	235.00	1,850.00	2009

Project Details: Attenuation of Acoustic and Electromagnetic Noise

Scientific or Technological Objectives:

Measurement	Current Performance	Objective	Have results?
Acoustic Noise (dB)	115	80	Yes
maximum production cost ($ per unit)	0	5500	Yes
Maintain flattening the peaks of noise spectra (%)	100	100	Yes

[SOURCE: "EXPERIMENTAL INVESTIGATION OF A NAVAL PROPULSION DRIVE MODEL WITH THE PWM-BASED ATTENUATION OF THE ACOUSTIC AND ELECTROMAGNETIC NOISE" BY KONSTANTIN BORISOV, THOMAS CALVERT, JOHN A. KLEPPE, ELAINE MARTIN AND ANDRZEJ M. TRZYNADLOWSKI, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOLUME 53, NUMBER 2, APRIL 2006]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The objective of this project is to reduce acoustic and electromagnetic noise and vibration in an electric propulsion system used for naval vessels.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citing:

- Internet searches: 12 sites / articles -- articles on acoustic and electromagnetic noise, and vibration
- Patent searches: 5 patents -- acoustic and electromagnetic noise, and vibration reduction patents did not yield relative info
- Similar prior in-house technologies: 1 products / processes -- Must now meet more stringent performance requirements, as outlined below.

Company X supplies electric propulsion systems for naval vessels, particularly electric submarines, in which noise mitigation is crucial for survivability. They have been asked to provide a propulsion system that meets more stringent acoustic noise, electromagnetic noise, and vibration levels than previously required. The company currently uses the classic deterministic pulse width modulation (PWM) in the drive's inverter. They are aware of research that shows that using a randomized pulse width modulation (RPWM) flattens the peaks of noise spectra. They are uncertain whether RPWM will reduce noise sufficiently to meet their customer's criteria. They are also uncertain whether the current drive control unit will be able to handle the additional computational load associated with RPWM.

Field of Science/Technology:

Electrical and electronic engineering (2.02.01)

Project Details:

Intended Results:	Improve existing materials, devices, or products
Work locations:	Lab
Key Employees:	Nicola Tesla (Unknown / Unknown), Albert Einstein (Electronics - B.Sc. (1980) / Unknown), Mike Philips (Unknown / Unknown)
Evidence types:	None.

Scientific or Technological Advancement:

Uncertainty #1: Feasibility of Randomized Pulse Width Modulation

Will employing RPWM in the drive's inverter sufficiently reduce acoustic and electromagnetic noise, and vibration? Can the current drive control unit handle the additional computational load associated with RPWM?

[NOTE: THE DESIRED NOISE LEVELS SHOULD BE STATED QUANTITATIVELY. SPECIFIC STATEMENTS AS TO THE LIMITS OF THE CONTROL UNIT ARE PREFERRED. ALSO, IS THERE A REASON WHY OTHER CONTROL UNITS ARE NOT CONSIDERED?]

Project Name:	Attenuation of Acoustic and Electromagnetic Noise	**Start Date:**	2009-05-01
Project Number:	1001	**Completion Date:**	2010-04-30

The most significant underlying key variables are:

vibration, acoustic pollution, electromagnetic noise, Pulse Width Modulation methods

Activity #1-1: Implement RPWM and analyze noise spectra (Fiscal Year 2010)

Methods of experimentation:

- Process trials: 3 runs / samples - Three methods compared: PWM, RPWM I, RPWM II, as outlined below.

Experiments were performed on the drive in a laboratory setting. Two PWM methods were initially compared:
(1) the classic deterministic PWM, characterized by a constant switching period equal to the sampling period of the digital modulator,
(2) the known RPWM technique, referred to as RPWM I, in which the switching and sampling periods are varied simultaneously in a random manner.

Analysis of the noise spectra produced by RPWM I show that this method reduces acoustic noise, electromagnetic noise, and vibration sufficiently to meet the required targets.

Although randomizing both the switching and the sampling periods was possible in a laboratory setting where the drive was controlled by a PC, there was concern that this would not be feasible with the control unit that was to be used on the final model. Therefore, a simplified RPWM method, referred to as RPWM II, with a constant sampling period and the switching periods randomly varied around an average value equal to the sampling period, was tried. Analysis of the noise spectra produced by this simplified RPWM method showed that it was only marginally less effective in flattening the peaks of noise spectra compared with the original RPWM method, producing noise levels that met the requirements. Because the sample period was constant the computational load was greatly decreased, and this method was able to be implemented using available control units.

[NOTE: AGAIN, THIS DESCRIPTION SHOULD BE MORE SPECIFIC IN TERMS OF QUANTITATIVE RESULTS.]

Results:

- Acoustic Noise: 75 dB (114% of objective)
- maximum production cost: 5000 $ per unit (90% of objective)
- Maintain flattening the peaks of noise spectra: 100 % (100% of objective)

Conclusion:

Of the two Randomized Pulse Width Modulation methods examined, both produced acceptably low noise levels.

The simplified RPWM method is technically more convenient than the original RPWM method, while only marginally less effective in flattening the peaks of noise spectra. Since it achieved the desired noise levels and could be implemented using the available control unit, it was implemented in the final propulsion system.

Most significant variables concluded on: acoustic pollution, electromagnetic noise, Pulse Width Modulation methods, vibration

1001 - Attenuation of Acoustic and Electromagnetic Noise

Benchmarks:	Internet searches: 12 sites / articles Patent searches: 5 patents Similar prior in-house technologies: 1 products /	**Objectives:**	Acoustic Noise: 80 dB maximum production cost: 5500 $ per unit Maintain flattening the peaks of noise spectra: 100 %
Uncertainty:	1 - Feasibility of Randomized Pulse Width Modulation	**Key Variables:**	acoustic polution, electromagnetic noise, Pulse Width Modulation methods, vibration

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Implement RPWM and analyze noise spectra	Process trials: 3 runs / samples	maximum production cost: 5000 $ per unit (90 %) Maintain flattening the peaks of noise spectra: 100 % (100 %) Acoustic Noise: 75 dB (114 %)	acoustic polution electromagnetic noise Pulse Width Modulation methods vibration	250.00	1,200.00	970.00	2010