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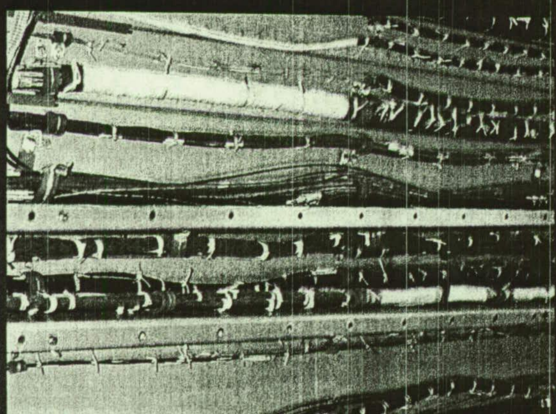
Commercial Use of KSC's Cable Inspection Technologies and Potential Opportunities in the Near Future

Pedro Medelius, Ph.D., ASRC Aerospace Inc.



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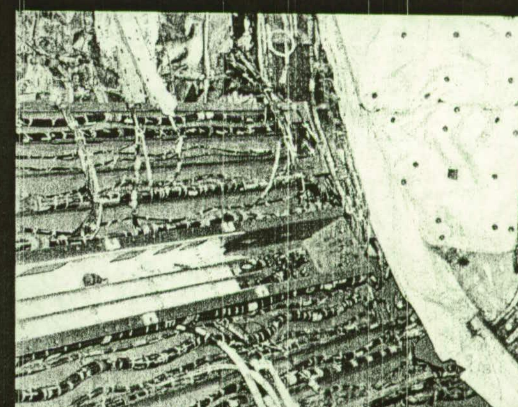

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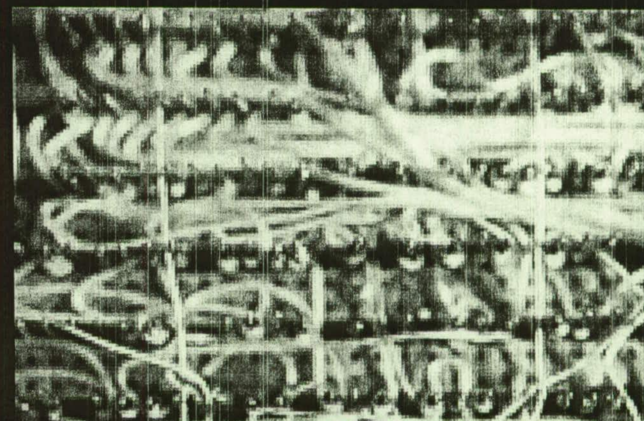
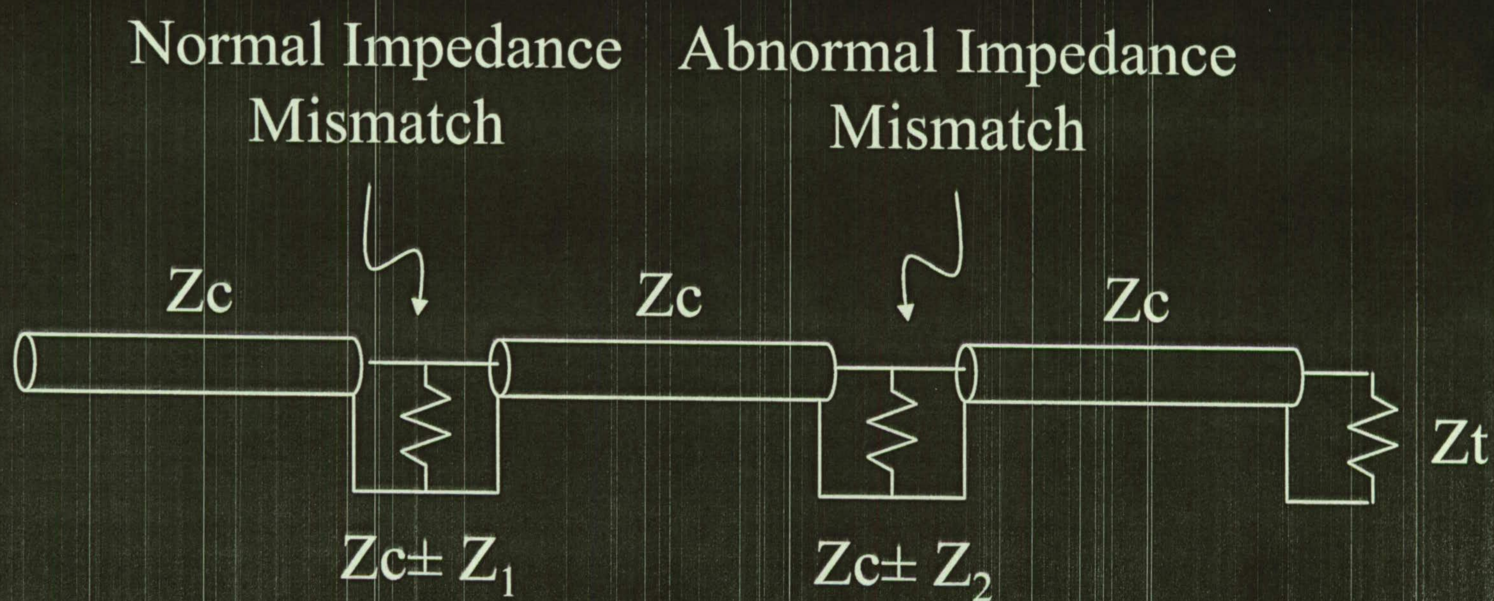


Problem Statement

- Aging of signal and power cables
- Reliable power and signal transmission $\Rightarrow$ continuous safe operation of vehicles
- Proactive vs. reactive responses to cable failures
- Detecting broken wires, insulation failures, etc.

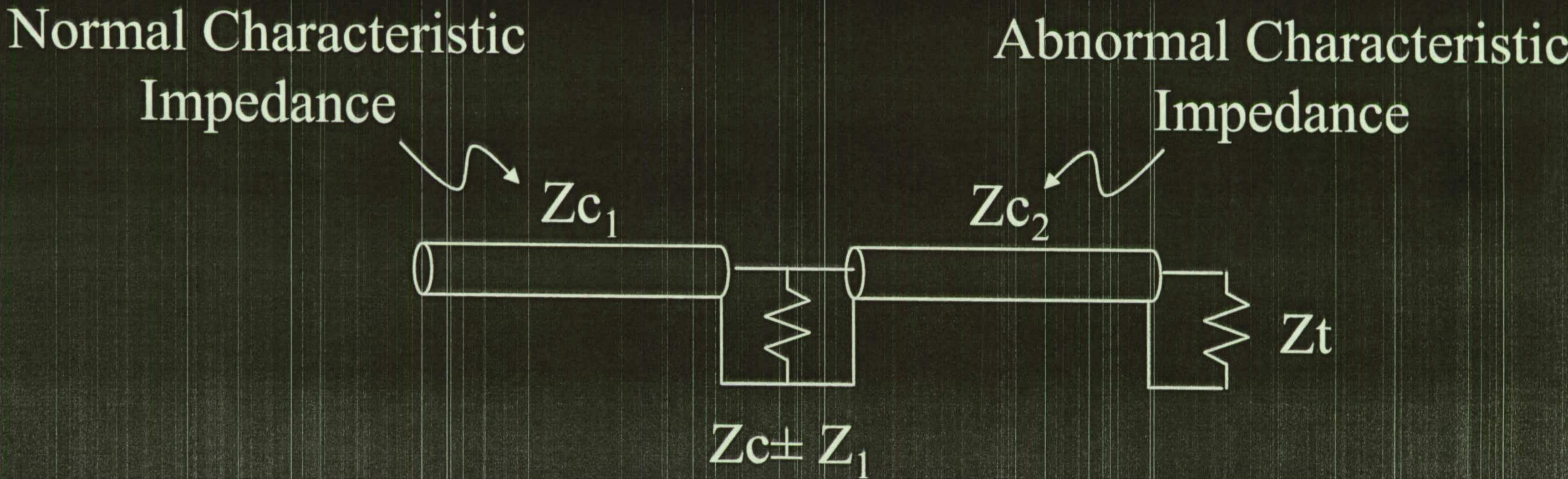
Problem Statement

- Characterization of hard to detect cable failures to differentiate between normal and abnormal impedance mismatches



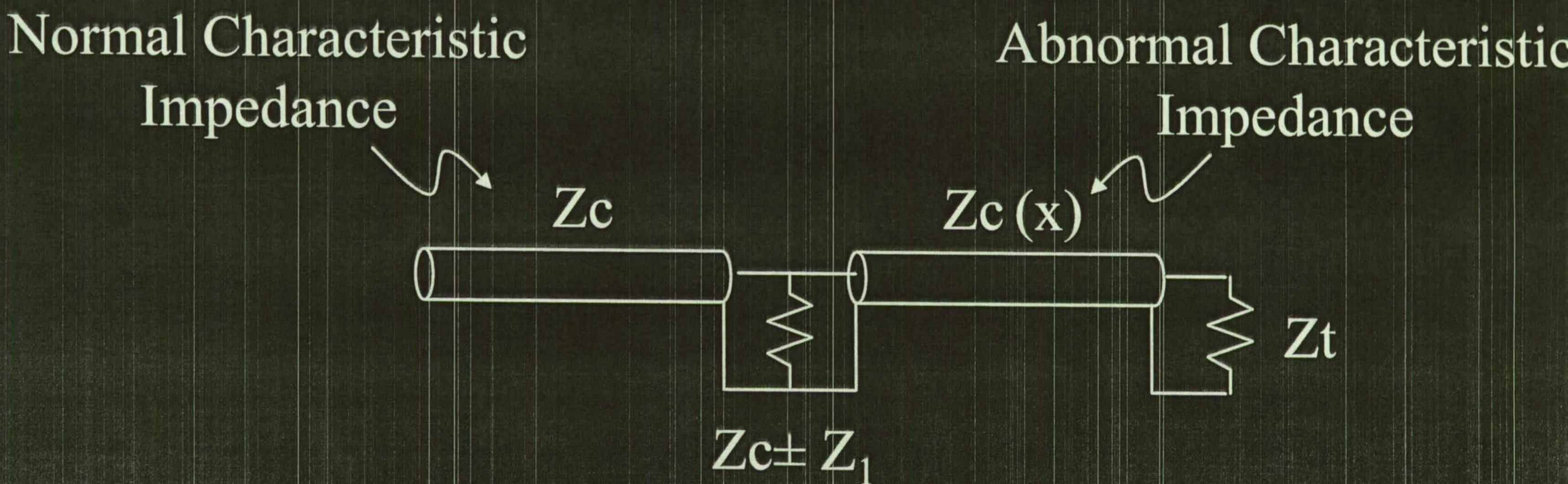
Problem Statement

- Characterization of hard to detect cable failures to differentiate between normal and abnormal characteristic impedance mismatches



Problem Statement

- Characterization of hard to detect cable failures to detect variable characteristic impedances



Objective

- Develop test equipment which will non-intrusively test the continuity of a measurement's signal path from the transducer up to the Multiplexer/Demultiplexer.
- Develop test equipment which will allow the location of a cable open or short to be determined so that it may be repaired.

Technology Transfer

- The National Aeronautics and Space Administration offered the SWR technology to over fifty industry leaders in a competitive based award effort. Each industry participant submitted a developmental and market application plan. Eclypse International Corporation was awarded a license for the SWR technology under Patent # 5,977,773, Exclusive Patent License Agreement # DE-287.

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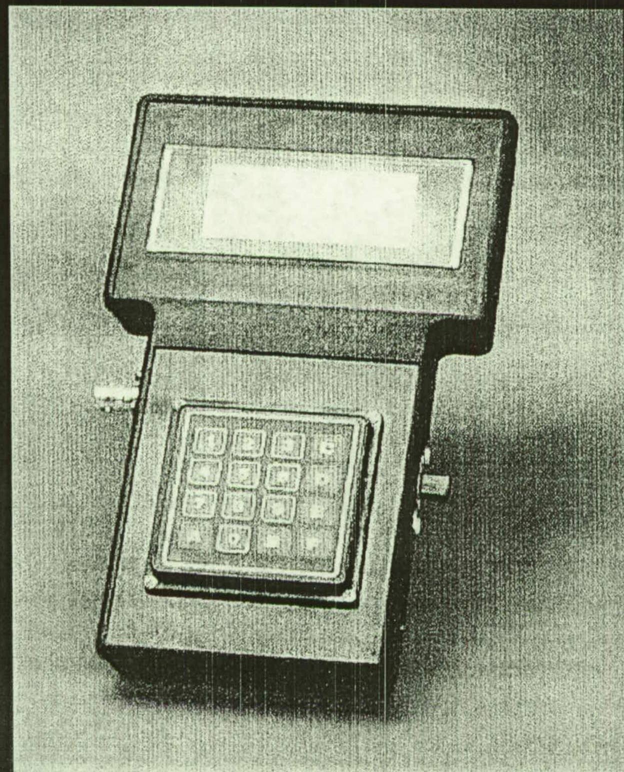
Prototype Cable Tester



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Commercial Cable Tester

Commercial Cable Tester

- Eclypse developed multiple configurations of the Model ESP SWR fault location meters that provide a reliable, hand-held instrument to verify the location of a “hard fault” down paths of electrical power and signal distribution sub-systems that reside inside complex vehicle systems.
- The initial production, handheld, battery powered test sets made preliminary market entry in the last quarter of 2001 for beta testing, and have a specified range of 1,000 feet and fault location accuracy of 0.75 percent.

Commercial Cable Tester

- Other features include an alphanumeric display, keypad, rechargeable battery (8-hour operating time), power management (auto shut off), illuminated display and keypad, serial data port, drip/splash proof and shock resistant case, operating range in -20 to +60 degrees C.
- It also includes a simple menu-driven architecture and 99 programmable settings for various conductor types.

Commercial Cable Tester

- A parallel effort related to this technology is the Model ESP Scientific that is currently being used for Impedance Spectroscopy techniques that the Federal Aviation Administration (FAA) funds (Reference Figure 2).
- Longer range plans include the integration of the reflectometry technology with the Eclypse analyzer and switching matrix products to augment existing automatic test of large distribution systems rapidly, accurately, repeatable, and at low cost.

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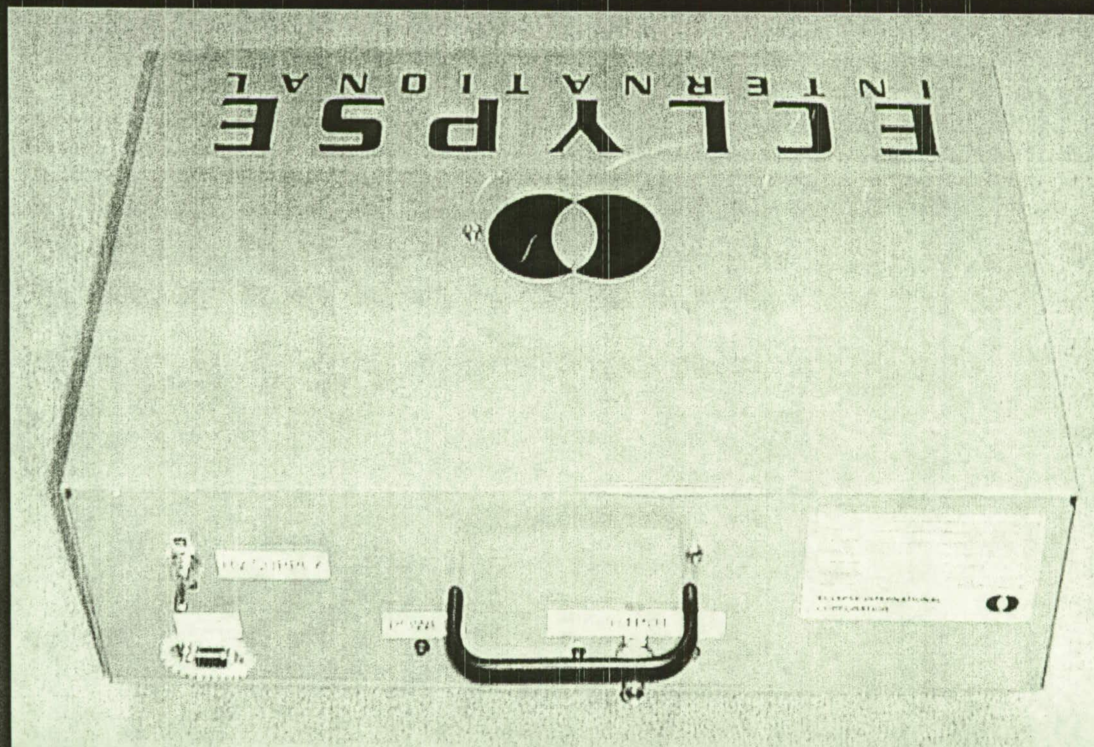
Commercial Cable Tester



Commercial Cable Tester

- The Model ESP has been a very successful in today's market. Customers to date include NASA, FAA certified repair facilities, commercial aircraft manufacturers and operators, U.S. and NATO military agencies, and include industry areas not related to aircraft operations.
- The Department of Energy, rail operators, elevator maintenance firms and many others also have this technology to aid in locating faults quickly and accurately with tremendous savings.

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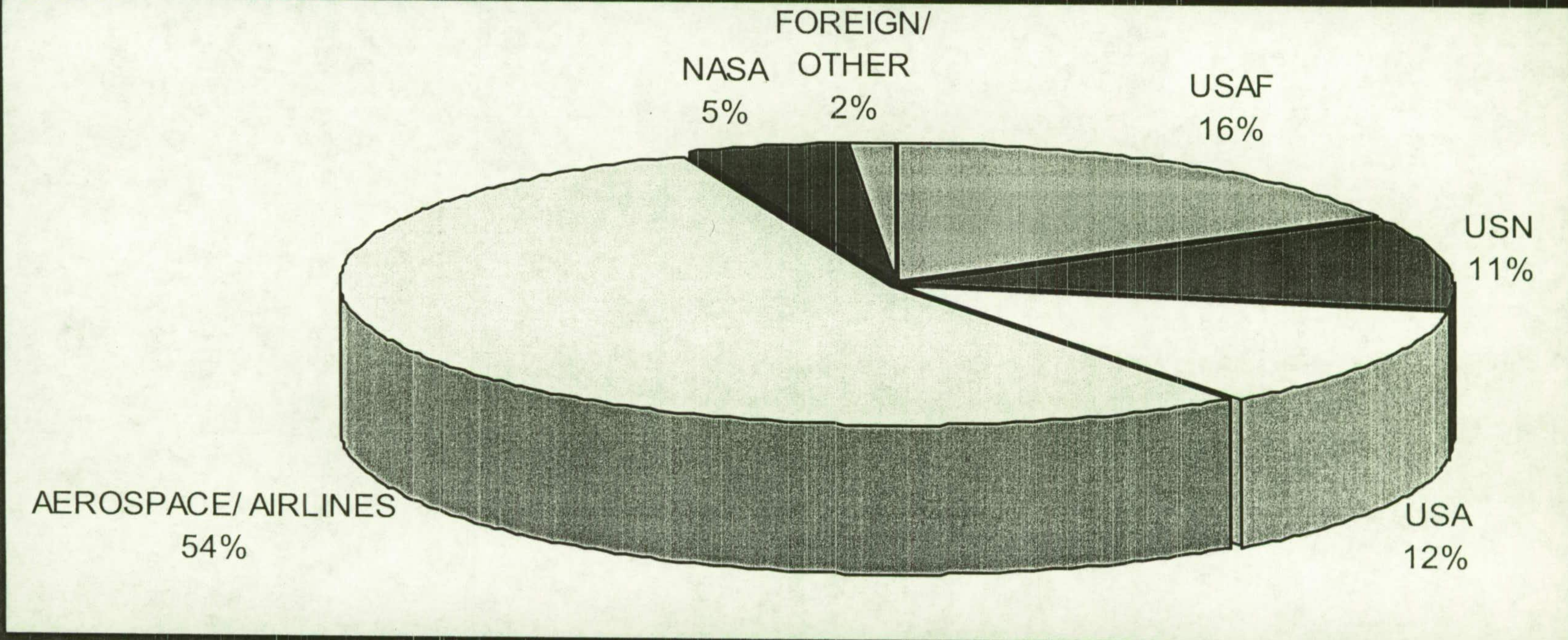
Commercial Cable Tester



Technology Commercialization activities have resulted in both technology transfer (spinoff) AND technology infusion (spin-in.)

Future Development

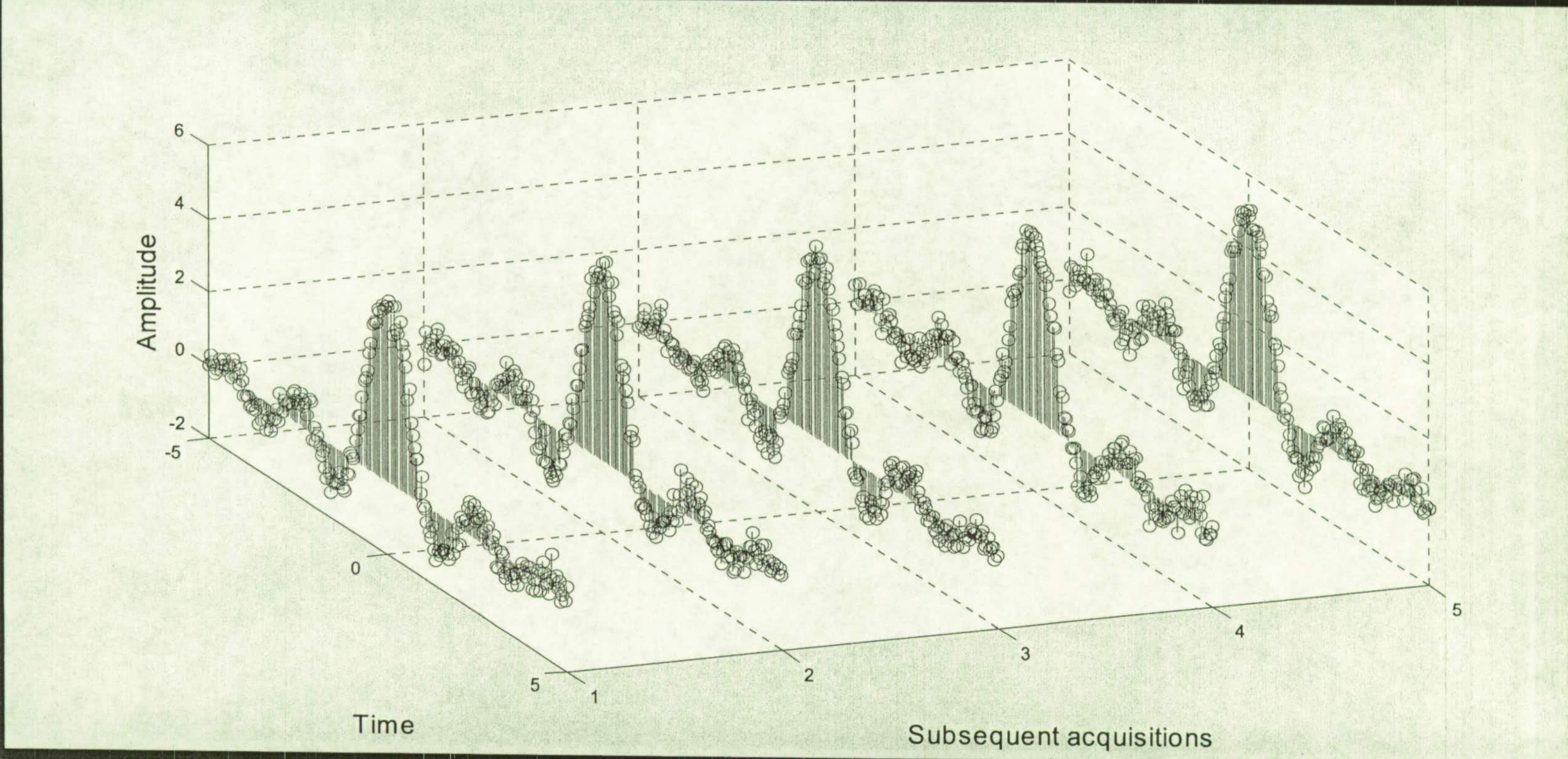
- Develop a highly repeatable pulse generator
- Develop an ultra low jitter timing circuitry to exploit the capabilities of advanced digital signal processing
- Advanced signal processing to improve resolution of data acquisition

Spatial Resolution

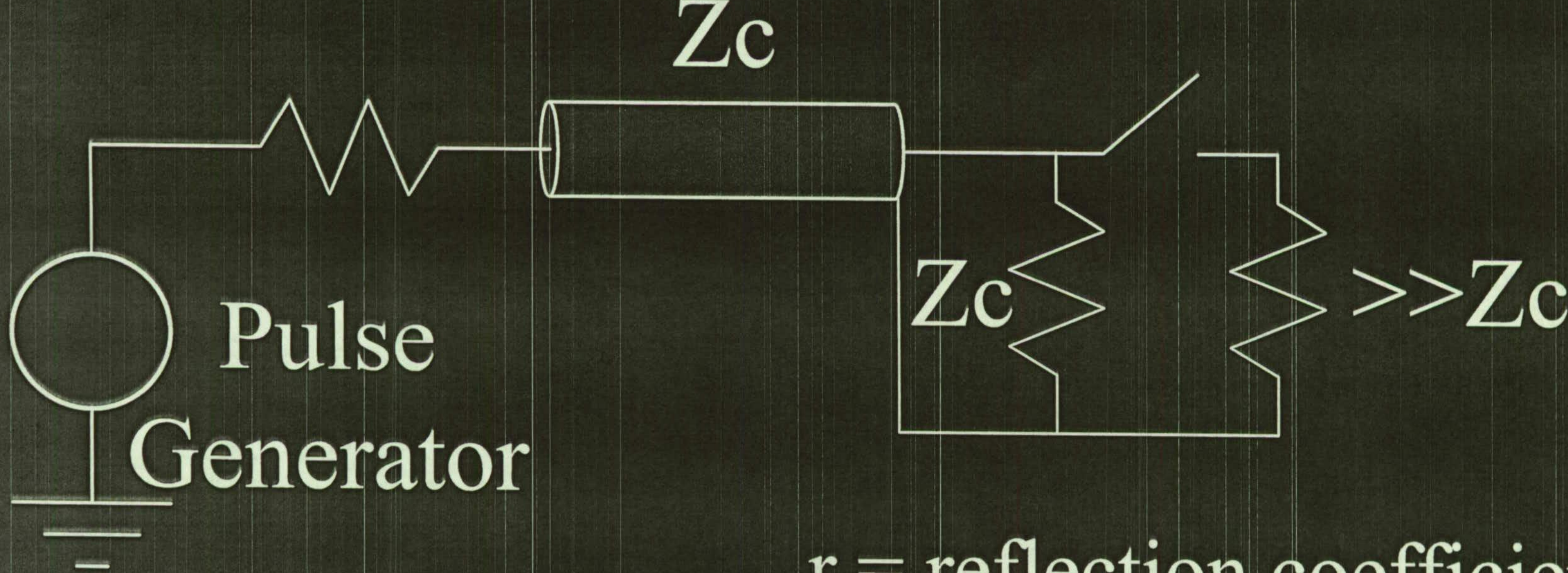
- Measurements have to be conducted with a large enough bandwidth in order to provided sufficient information to identify the type of fault.

Bandwidth	Timing resolution	Spatial resolution
		Vp=0.7
100 MHz	5 ns	1.05 m
200 MHz	2.5 ns	52.5 cm
500 MHz	1 ns	21 cm
1 GHz	0.5 ns	10.5 cm
2 GHz	0.25 ns	5.25 cm
5 GHz	0.1 ns	2.1 cm
10 GHz	0.05 ns	1.05 cm

Subsequent Acquisitions



Sensing Small Impedance Changes



r = reflection coefficient

Zn = normalized load impedance

Z_0 = Characteristic impedance of line

$r = (Zn-1)/(Zn+1)$

$Zn = Z/Z_0$

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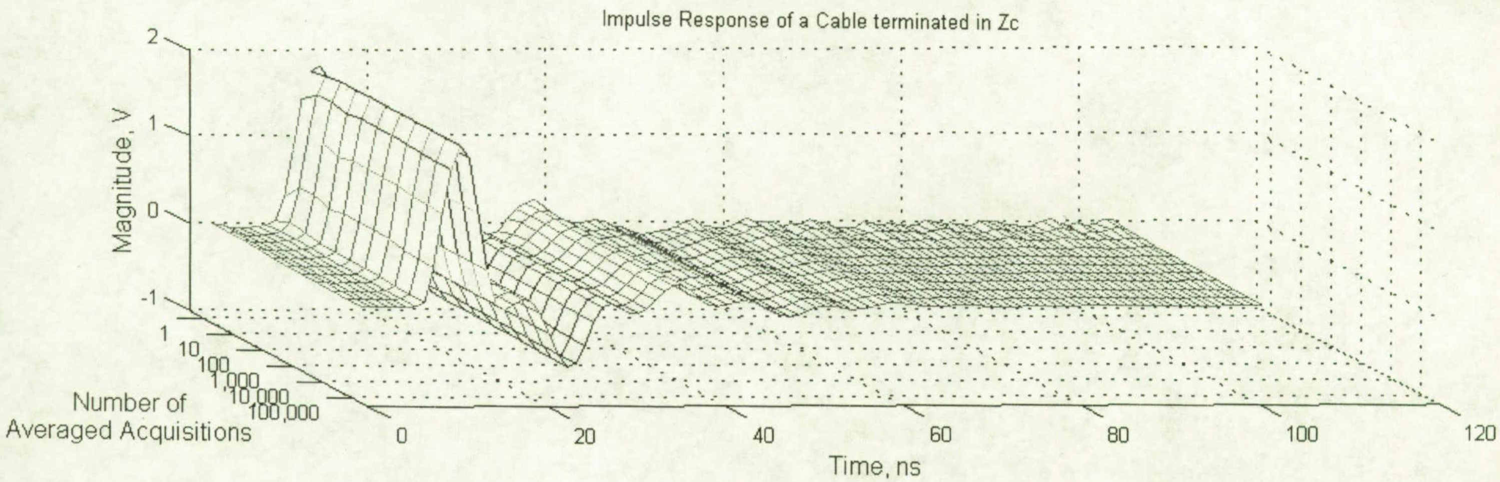
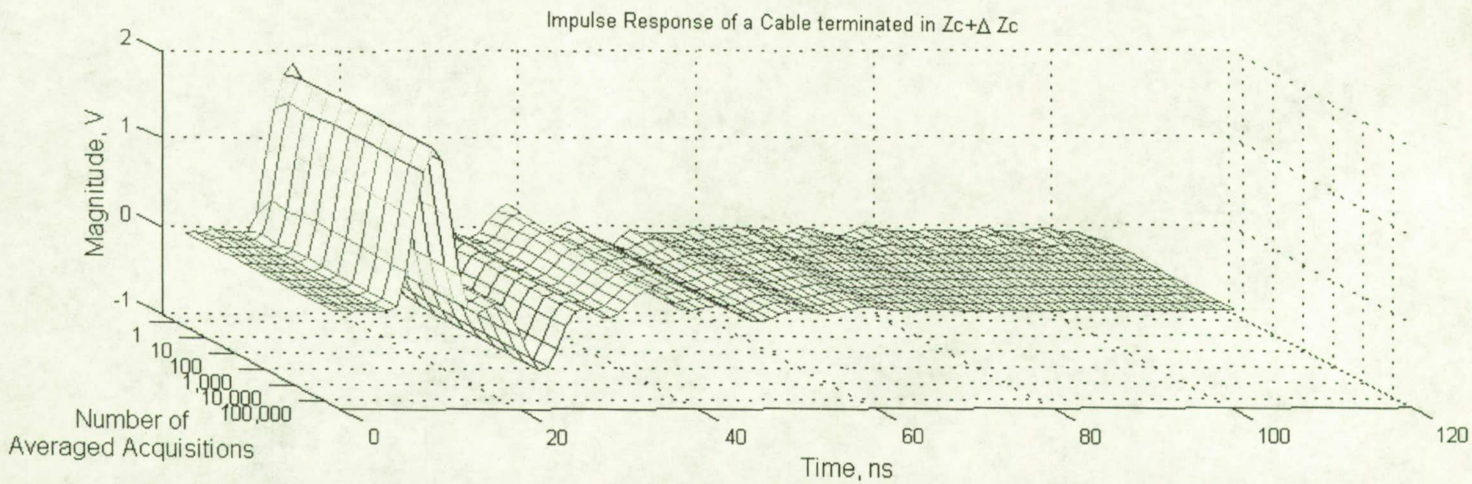
Sensing Small Impedance Changes





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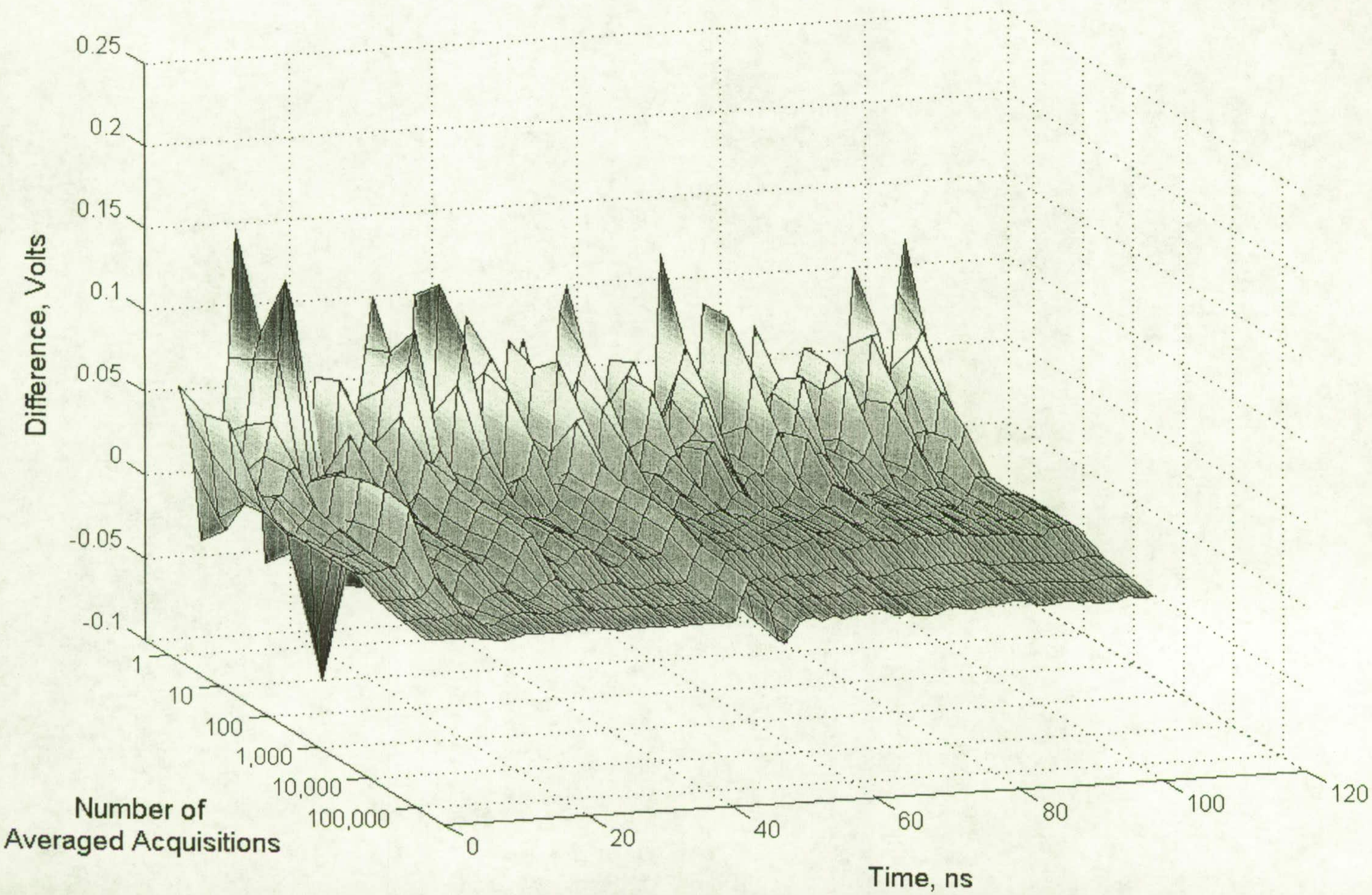
Sensing Small Impedance Changes



Future Work

- Improve the current design to allow detections of minimum impedance mismatches (highly sensitive), space changing characteristic impedances, and different characteristic impedances (non transmission line type cables)
- Develop algorithms to extract more information from reflection waveforms with less acquisitions (faster testing)

Future Work

- Testing and Characterization of small discontinuities to detect and localize true cable problems
- Usage of latest state-of-the-art components to increase sampling frequency and resolution