A High Mode Number Field Experiment

Prof. J. Kim Vandiver
MIT
November 26, 2003

Motivating questions

- Does lock-in occur at high mode number in uniform flows or sheared flow?
- How is the boundary between single and multi-mode behavior affected by
  - mode number,
  - shear
  - and damping
- What is the relative contribution of in-line and cross-flow response to up-crossing frequency, stress amplitude and fatigue damage rate?
- How much fairing coverage is required to prevent significant VIV?
- Can we measure hydrodynamic damping during VIV
- How does mean Cd vary with A/D and the number of participating modes.

Lake Seneca test site description

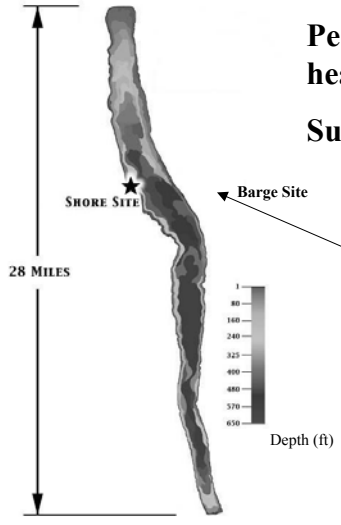
- **Navy acoustics test facility, Lake Seneca, NY**
- **Permanently moored barge with winches, cranes, support craft, instrumentation support.**
- **Day or night operation**
- **Very low waves**
- **Shore accommodations**
- **6 hours from MIT.**

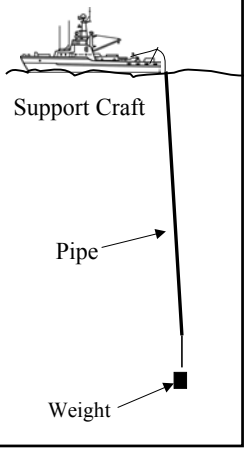
SENECA LAKE TEST FACILITY

Navy test facility at Seneca Lake NY

Permanently moored barge with heavy lift capability in 500 ft of water.

Support craft capable of towing pipe.

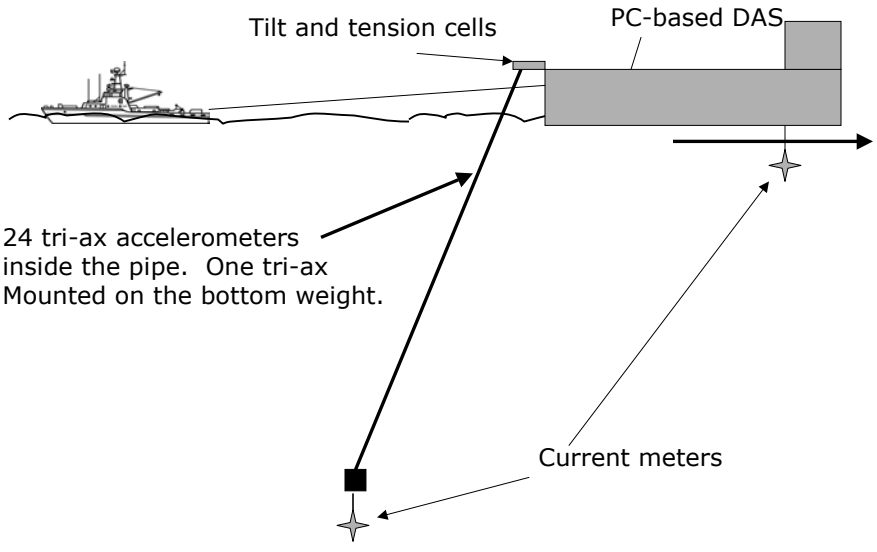




http://www.npt.nuwc.navy.mil/Seneca/index.html

Experimental Conceptual Design

- 400 foot long instrumented composite tube, 1.31 inch O.D, 1.0 inch I.D.
- 25 tri-axial accelerometers with simultaneous sampling and real time surface data collection.
- Uniform and sheared current profiles



Instrumentation intended for the Spring 2004 tests.

Pipe mechanical design

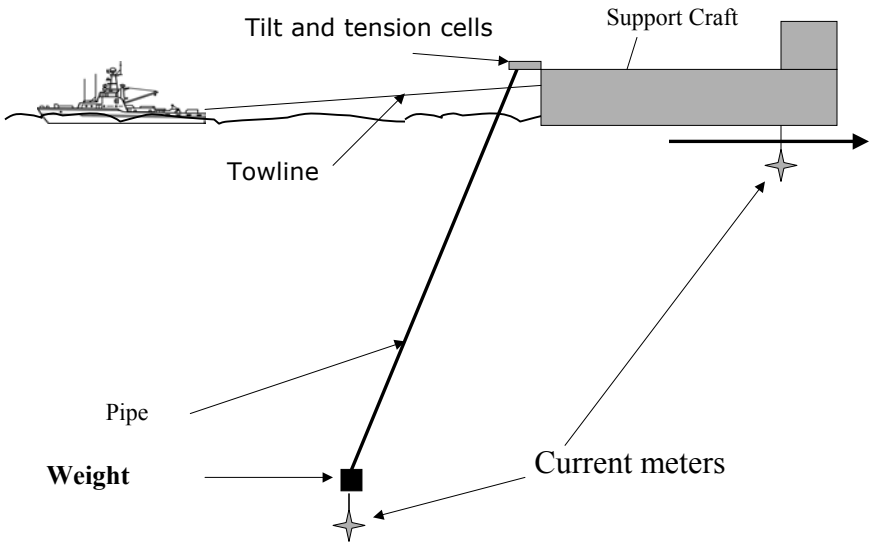
- Fiberglass reinforced composite pipe. Fiberspar Corp. Marion, MA.
- Variable length model, 100-1000ft.
- 2500 pound axial strength, 1.31 inch O.D, 1.0 inch I.D.
- Pipe deployed with a suspended 800 pound weight.
- Current meters at top and bottom.
- Mechanical assembly done by MIT and Scientific Solutions, Inc.

Instrument system design

- Networked distributed instruments.
- All instruments coordinated by a PC at the top.
- Tension cell and tilt meters at the top boundary.
- 25 Tri-ax Accelerometer/Microprocessor nodes designed and built by Electronic Devices, Inc. Temperature also reported.
- Current meter and accelerometer node at the anchor. A current meter at the top also.
- Simultaneous trigger from the top for every data sample. 100 Hz. Sample rate.
- Data stored in the PC.

Test matrix

- Pendulum swing sheared flow.
- Constant velocity towing from a boat.
- Damping tests in still and moving water.
- Full and partial coverage fairing tests.



Mechanical shakedown test, November 10-12, 2003

- Accelerometer array not yet available.
- Test with tilt meter and one bi-axial pair of accelerometers near the top end.
- Proof of concept exercise to evaluate:
  - Deployment methods
  - Bottom weight dynamics
  - Pendulum and towing techniques
  - Impact and shaker tests for damping estimation
  - Fairings
- Test complete system by late Spring 2004.

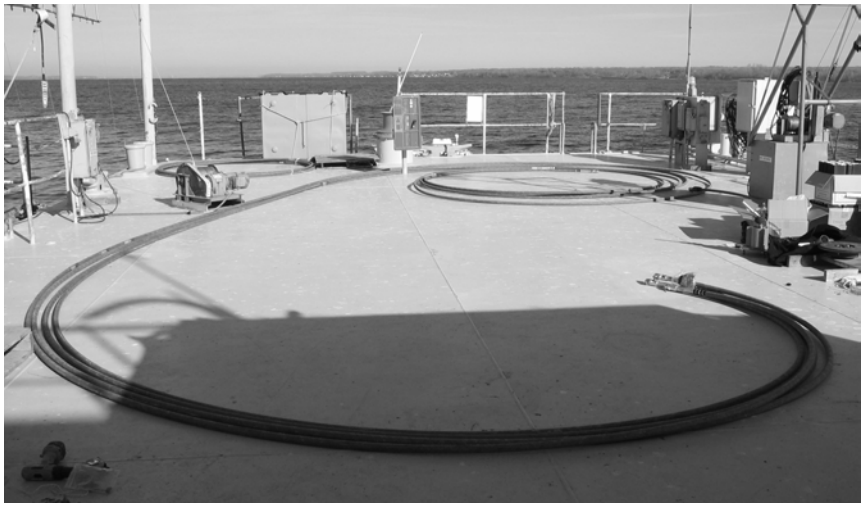
Lake Seneca Test Facility, November 10-12, 2003

PI: Prof. J. Kim Vandiver, MIT

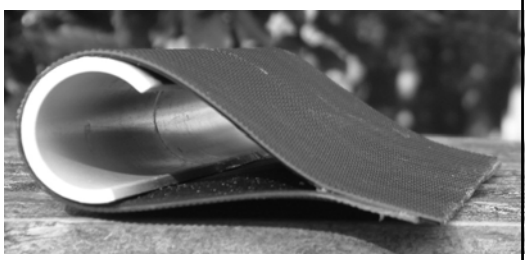
Supported by a team of 4 students, a postdoc and an engineer from SSI, as well as the crew on the Lake Seneca barge.

Hayden, Vivek and Frank Spooling pipe in Vandiver's barn.

Pipe laying on the deck: 100 ft lengths

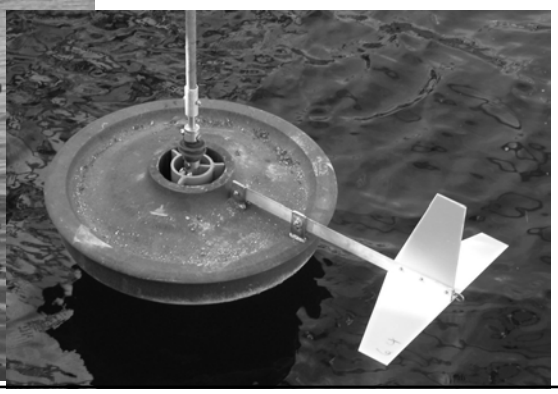


Fairing with 1.25 inch PVC pipe bearing material



Pipe assembly with 80 foot capacity crane

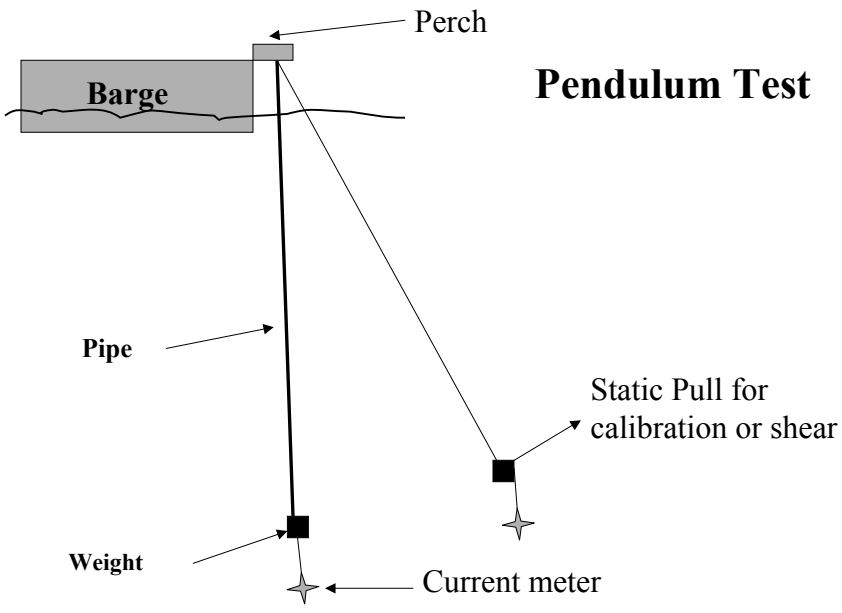
800 lb weight with current meter goes on first. Tow boat in background.



Each pipe section is joined to the previous while hanging from the temporary assembly perch.

Deepstar's Pierre Beynet inspects the completed pipe hanging in the barge test perch.

Pendulum(sheared flow) and damping proof of concept tests conducted with the pipe hanging from this perch.

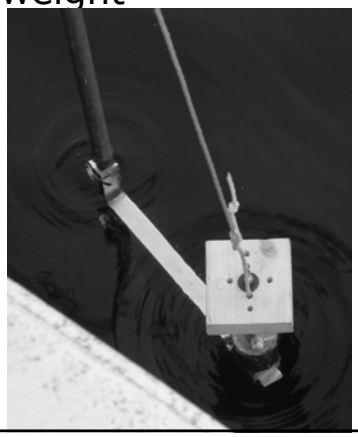


Pendulum test:

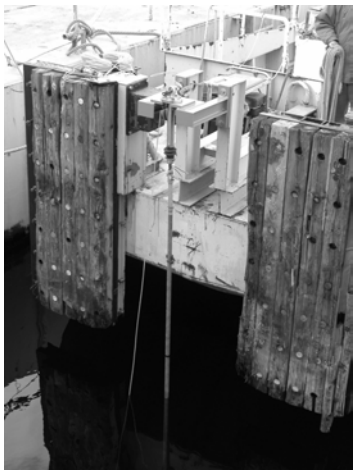
Tilt meters

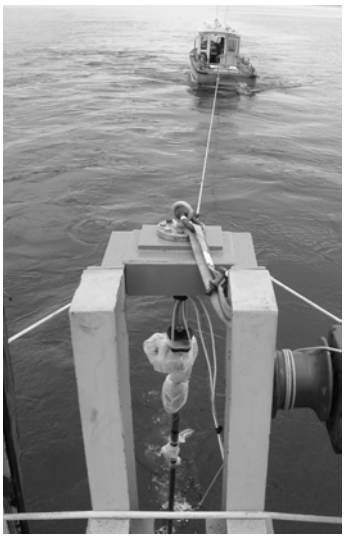
Accelerometers

Damping proof of concept tests: Rotating mass shaker(air driven) and impact test drop weight



Pipe shifted to the bow of the towboat for the uniform flow tests.





Deploying the top current meter
MIT Post-doc: Hayden Marcollo(left)
SSI Engineer: Armen Bhalavouni

Susan Swithenbank(MIT grad student) with the preliminary data acquisition system inside the van on the boat.

Tilt meter and accelerometer measurements while towing. Vigorous VIV observed.

Video from Preliminary Test Program: Lake Seneca Test

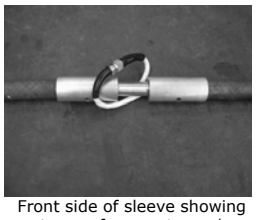
2” riser in 3 ft/s current

6402B Multi-Mode Tests (MMT), Riser – Instrumentation, for Spring 2004

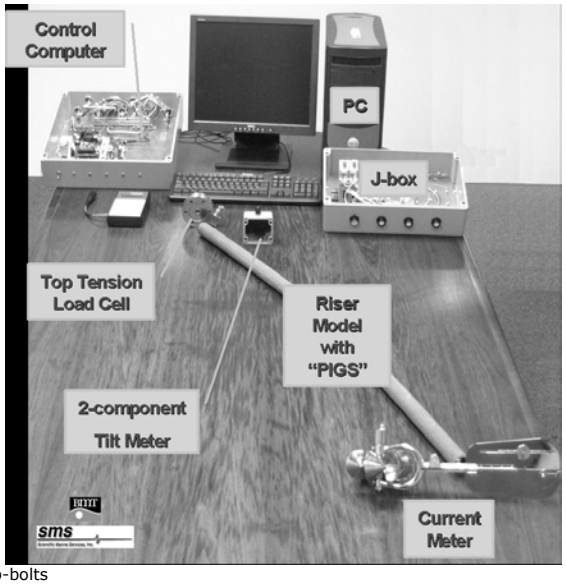
- Accelerometer network to be built by EDC Corporation.
- Network instruments and cables imbedded in pipe by MIT and SSI.
- DAS software and hardware provided by SMS.
- Current, tilt, tension and accelerometer integration by SMS

Hardware Configuration

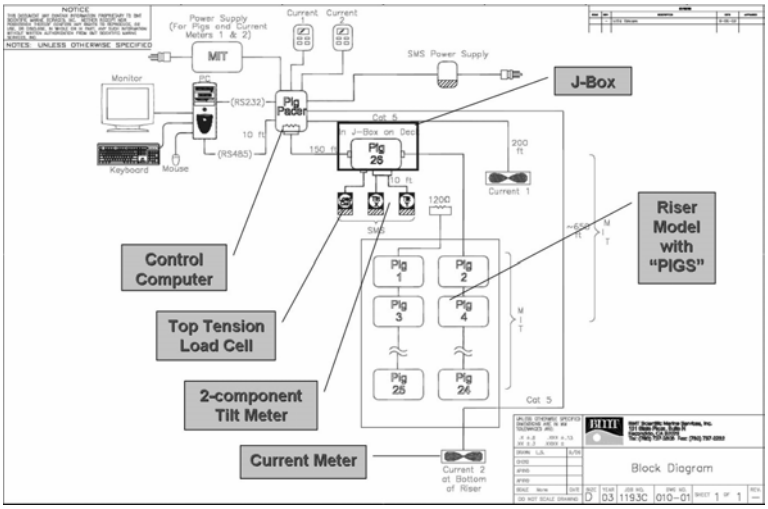
Pipe end with rod and bolt & Groove for cable



Front side of sleeve showing waterproof connector w/o makeup-bolts

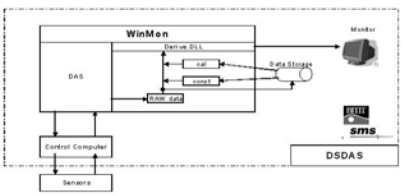


6402B Multi-Mode Tests (MMT)
Hardware Block Diagram:

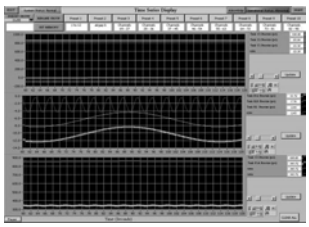


6402B Multi-Mode Tests (MMT)
Deep Star Data Acquisition System

Block Diagram



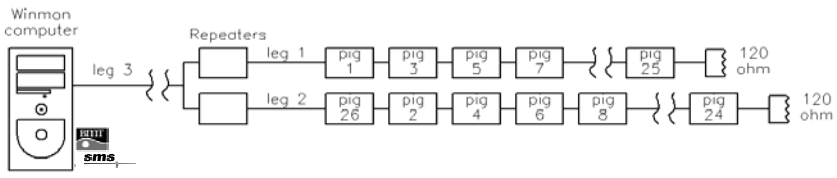
Screen Snapshot



DSDAS provides:

- Data collection from multiple input devices (**DAS module**)
- System status for each channel.
- Project specific real-time derived channels (**Derive.DLL module)**.
- Allows definition of project specific constants for use by derived channels or display clients (**CONST module**)
- **Simplified data analysis** on all measured and derived channels using constants and derived channels.
- **Storage of RAW data** and provides a simplified data analysis **results in engineering units**. *Only raw data is stored – derived channels are reconstructed during post processing.*
- Interface to supply all data to display clients.

6402B Multi-Mode Tests (MMT) Network Topology



- **To avoid bus topology problems, the network is divided into two distinct isolated networks via two B&B Electronics RS485 repeaters**
- **The first wire pair connects pigs 1,3,5,7,9…etc and the second pair connects pigs 2,4,6,8,10…etc..**
- **Each repeater drives one leg of the riser network, allowing long riser lengths (1000 ft +) and providing fault tolerance.**
- **If one leg of the network were to become shorted or otherwise faulty, the remaining leg would be un-affected and remain balanced.**
- **The two repeaters are connected together for a third network leg that is the connection to the WinMon computer.**

DS MMT Overview