

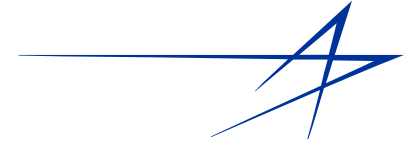
Echo Sounder Evaluation of XBT Drop Rate off the coast of Florida

Lockheed Martin Sippican



Grant Johnson
Engineering Project Manager
Ocean Products

Introduction

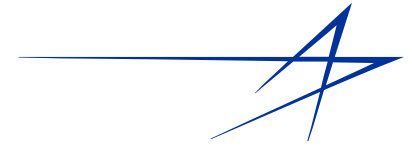


- **New fall rate evaluation approach**
 - **Echo Sounder**
 - **Distinctive probe bottom strike**
- **Preliminary results – Deep Blue probes**
 - **“New” probes fall more consistently**
 - **Some “Old” probe populations appear slower than “New” probes**
- **Echo Sounder approach**
 - **Improved method of fall rate evaluation**
 - **Encourage community-wide usage**

New Fall Rate Evaluation Approach

Echo Sounder with Probe Bottom Strike

Location and Facilities



Sea Trials

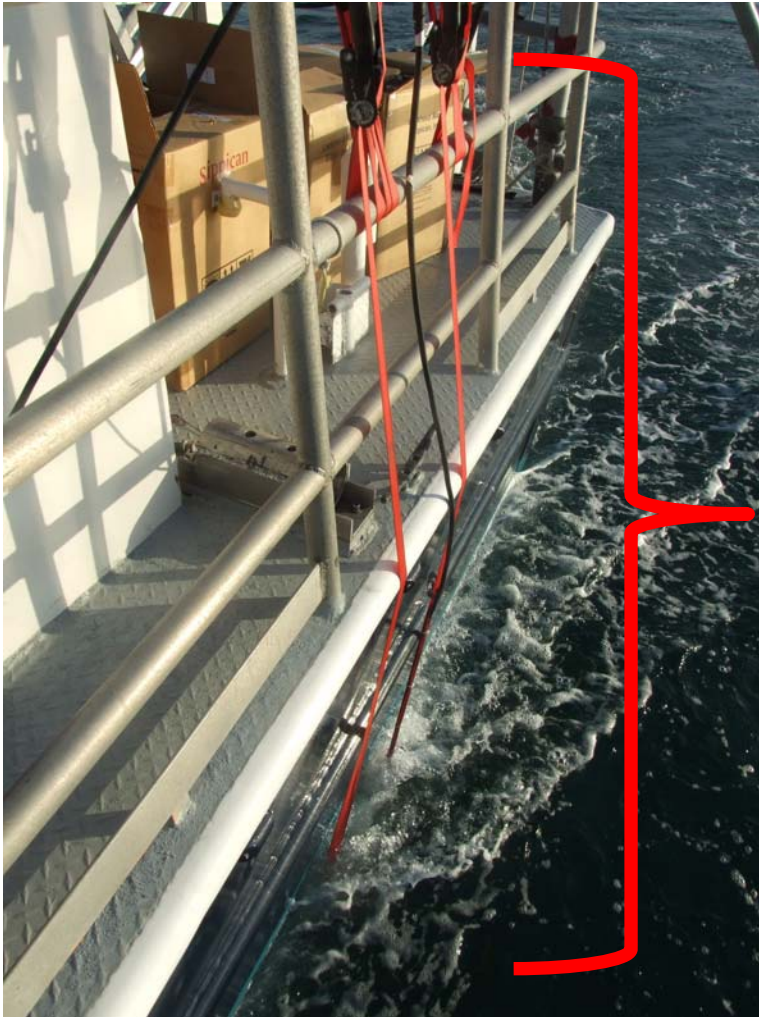
- Lockheed Martin base facility
- Lockheed Martin 50' vessel
- 35 km off the coast
- Relatively flat bottom
- 530 m average depth

50' Sea Hawk



- Large aft deck
- Custom mounting
 - Echo sounder transducer
 - Probe launchers
- Platform consistency

Transducer Mounting



- Echo sounder transducer**
- Over the side mount
 - 18” below water line

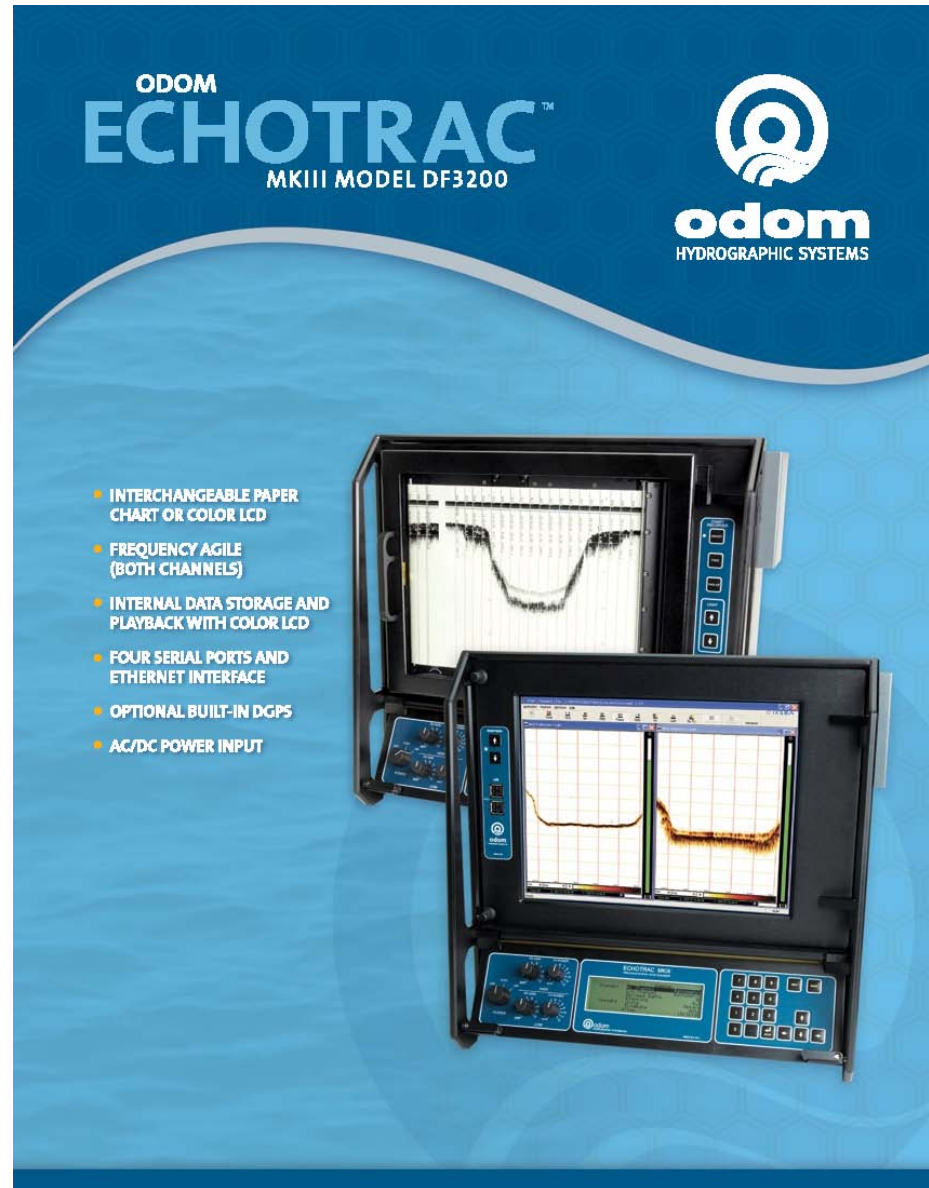
Echo Sounder

Depth Range

- 0.2 – 200m @ 200 kHz
- 0.5 – 1500m @ 33 kHz
- 1.0 – 6000m @ 12 kHz

Accuracy

- $\pm 0.1\%$ of depth
(sound velocity corrected)



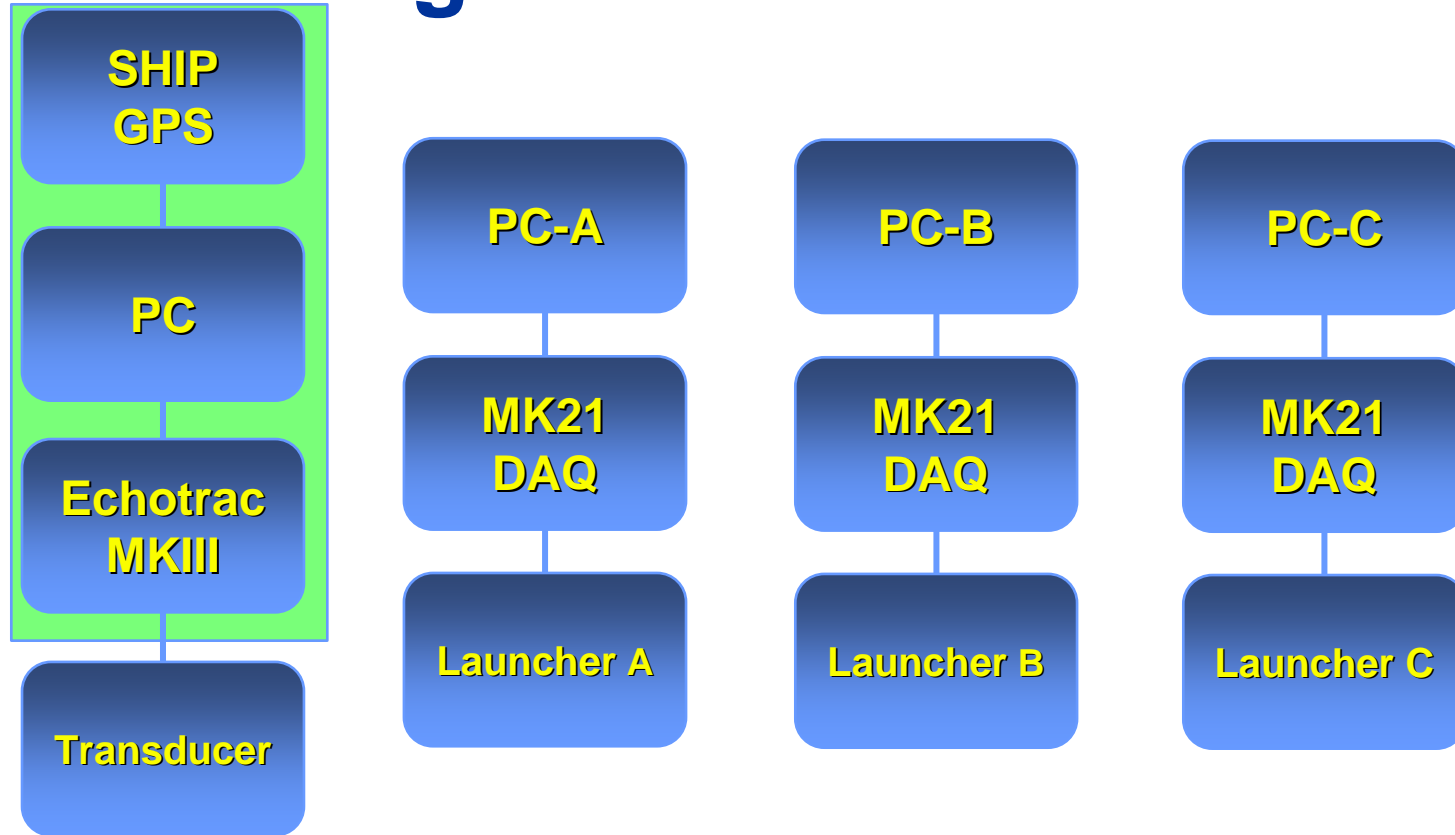
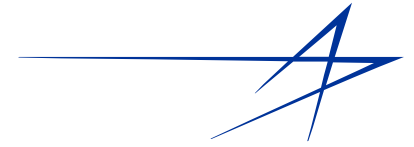
ODOM
ECHOTRAC™
MKIII MODEL DF3200

odom
HYDROGRAPHIC SYSTEMS

- INTERCHANGEABLE PAPER CHART OR COLOR LCD
- FREQUENCY AGILE (BOTH CHANNELS)
- INTERNAL DATA STORAGE AND PLAYBACK WITH COLOR LCD
- FOUR SERIAL PORTS AND ETHERNET INTERFACE
- OPTIONAL BUILT-IN DGPS
- AC/DC POWER INPUT

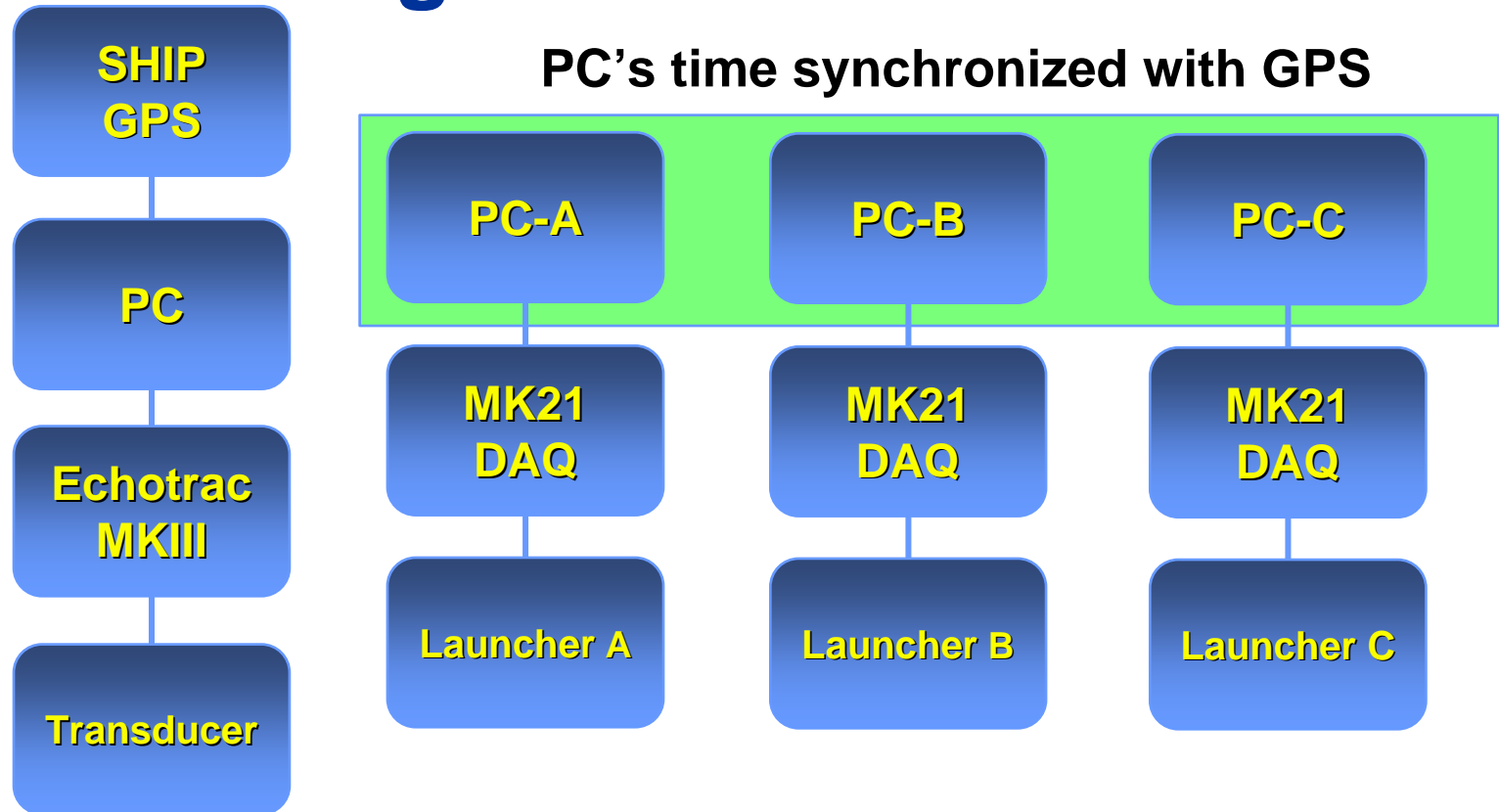
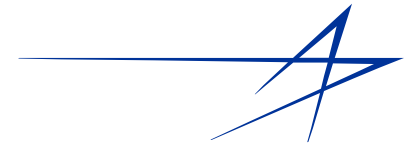
The advertisement features a blue background with a white wave graphic. It displays two views of the ODOM ECHOTRAC MKIII MODEL DF3200 Echo Sounder. The top view shows the device with a paper chart displaying a depth profile. The bottom view shows the device with a color LCD screen displaying two depth profiles. The ODOM logo and product name are prominently displayed at the top.

System Diagram



Depth data correlated with GPS time & position

System Diagram



Drop time correlated with GPS time & position

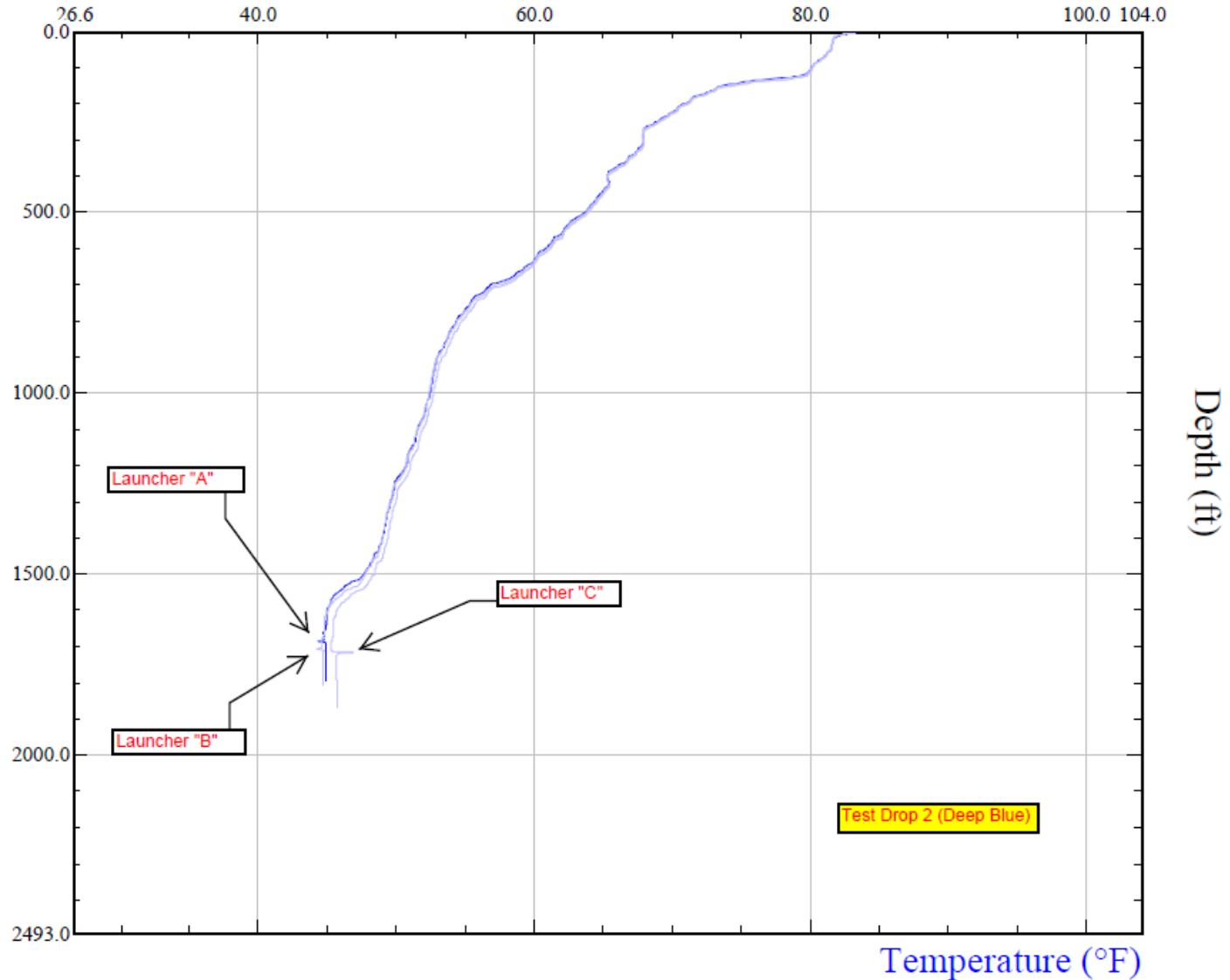
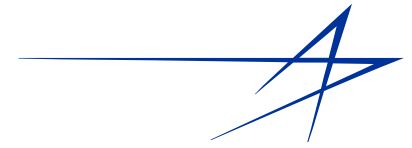
Location of 3 Launchers



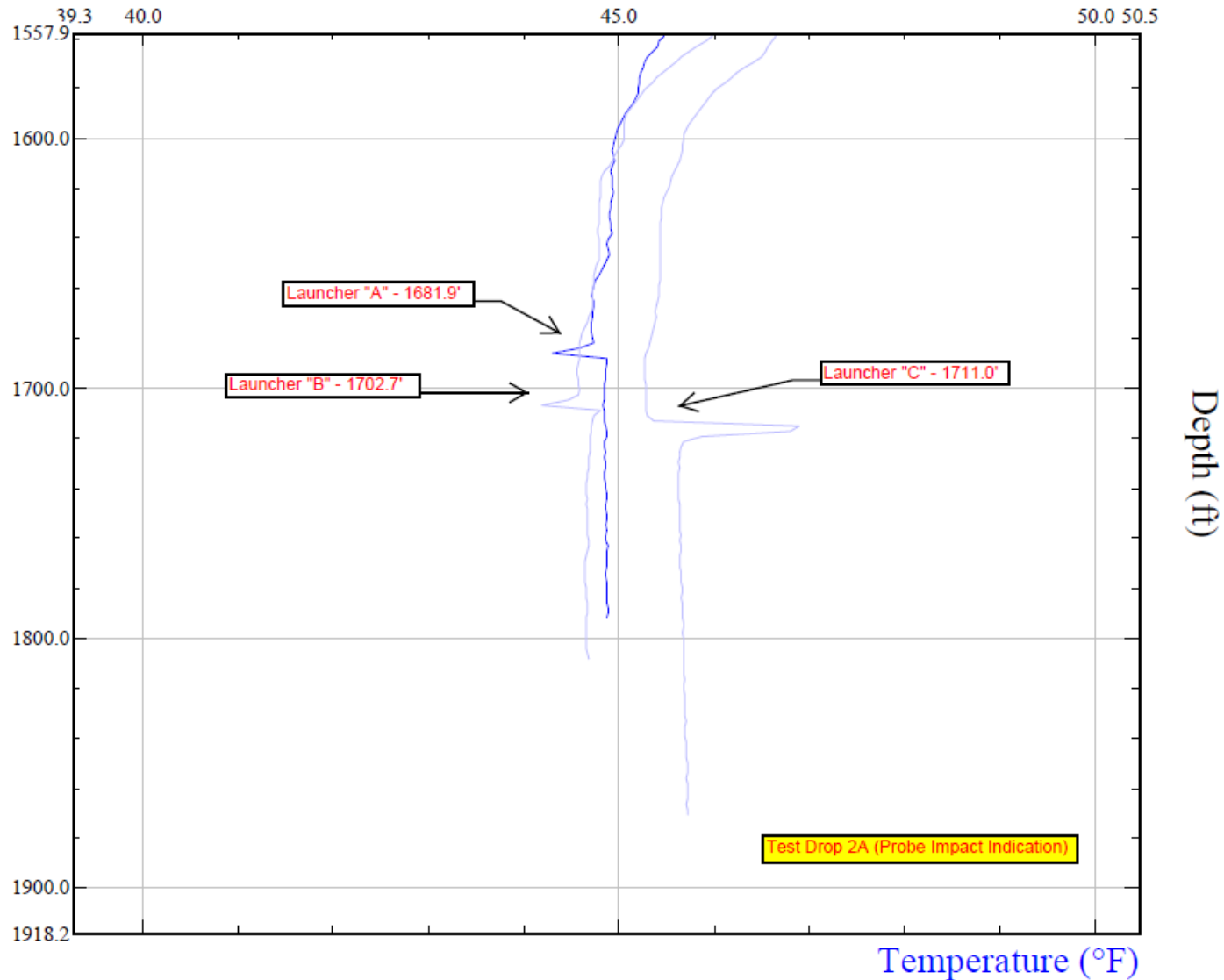
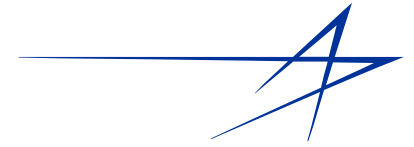
Allows simultaneous launch of 3 probes



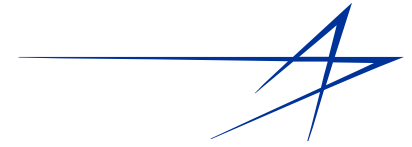
Probe Bottom Strike



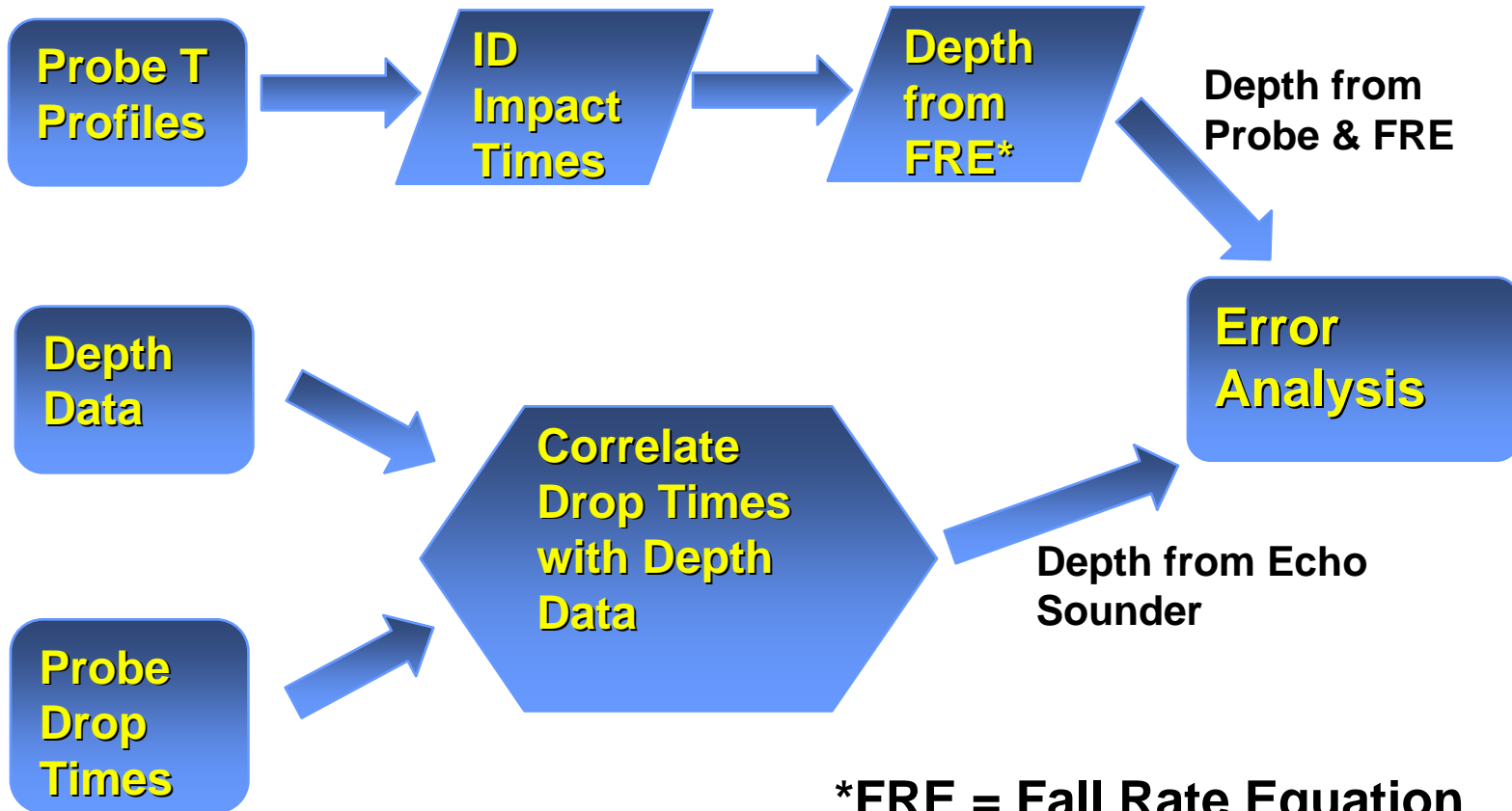
Reliable Impact Signature



Data Analysis

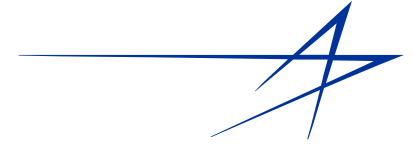


Test Data



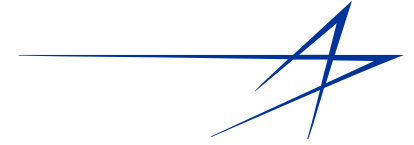
Probe Sea Trials

Definition – “New” Probes



- **Manufactured after July 2008**
- **Same probe design**
- **Decreased gap between probe nose and body**
 - **Included additional space for Vexar netting**
 - **Ensures good fit between nose and body**
- **Investigation found small Nose-to-Body gaps**
 - **Older Probe sample population**
 - **Average of 0.50 mm**
 - **New Probe sample population**
 - **Average of 0.21 mm**

Four Data Sets

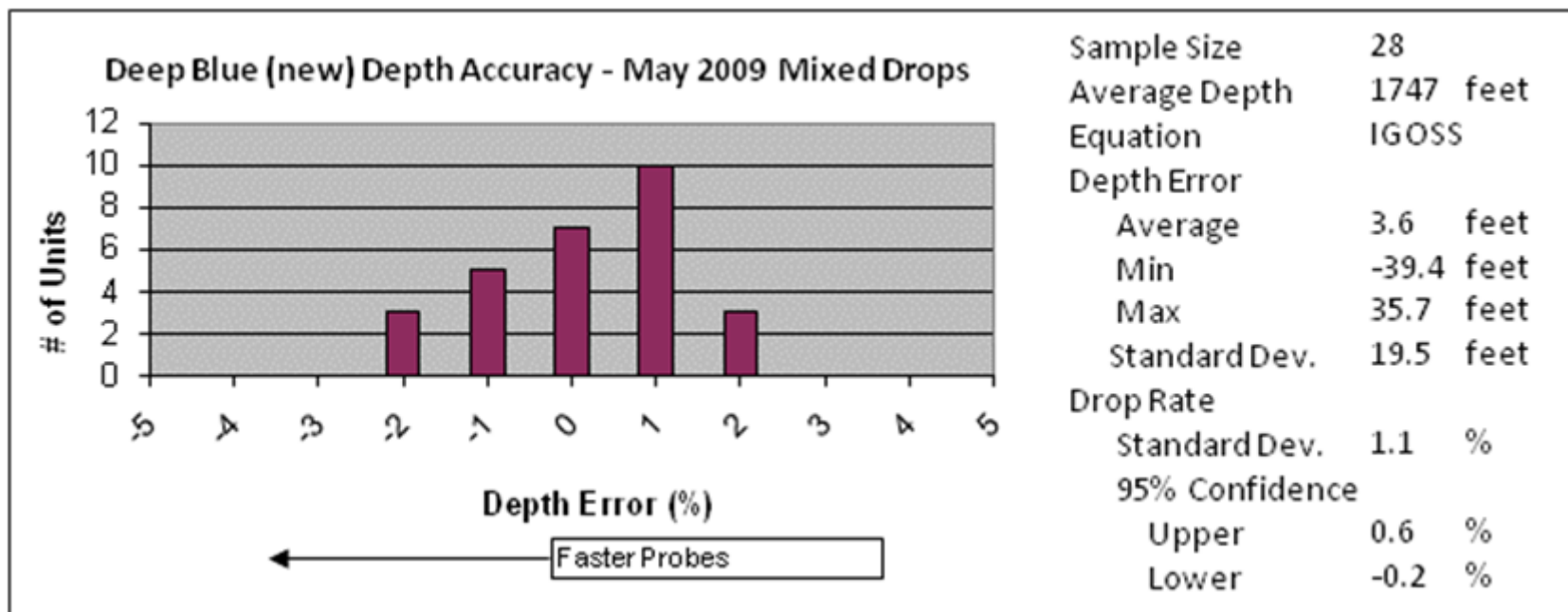


- **May 2009**
- **November 2009**
- **May 2010**
- **All data combined**

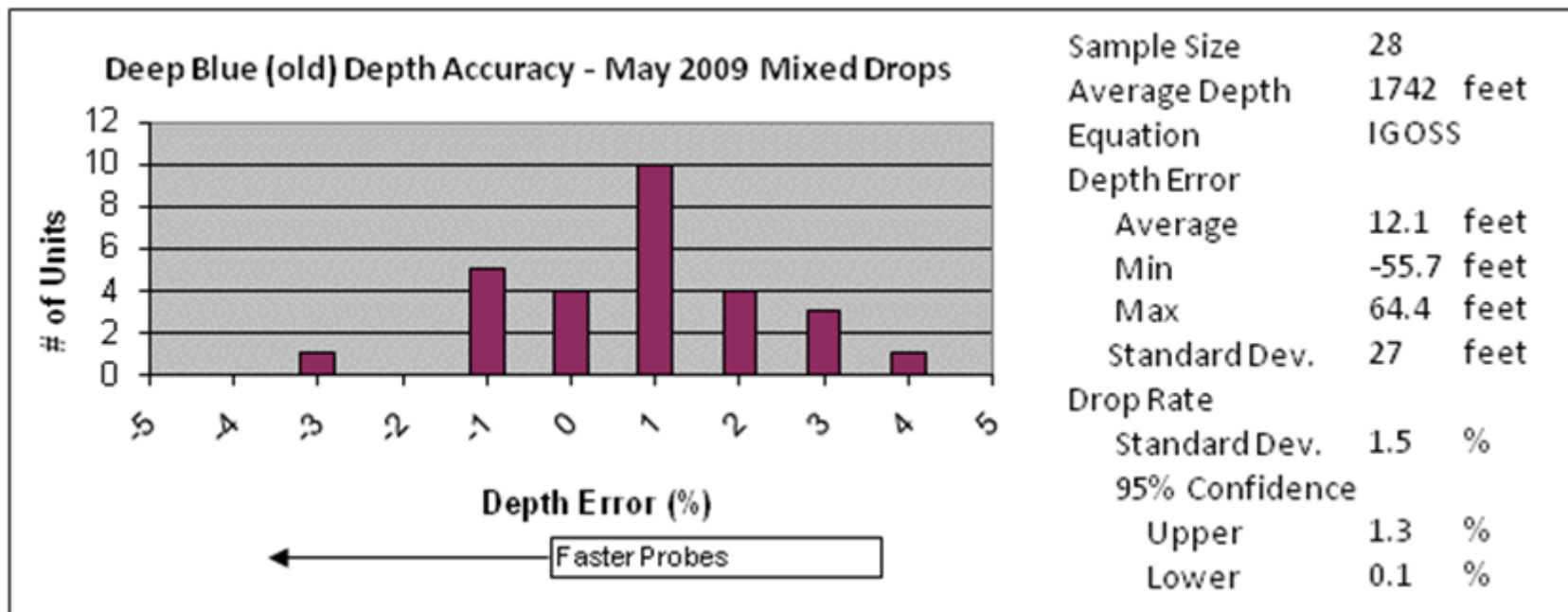
Echo Sounder Results

May 2009 Sea Trial Data

Deep Blues – New Probes



Deep Blues – Before Aug 2008



Deep Blues: May 2009 Summary



Deep Blue (Before Aug '08)

| | |
|-------------------|--------------|
| Sample Size | 28 |
| Avg. Depth | 1742 feet |
| Avg Error | 12.1 feet |
| Min Error | -55.7 feet |
| Max Error | 64.4 feet |
| Stdev | 27 feet |
| RSD | 1.5% |
| 95% Conf Interval | 0.1% 1.3% |

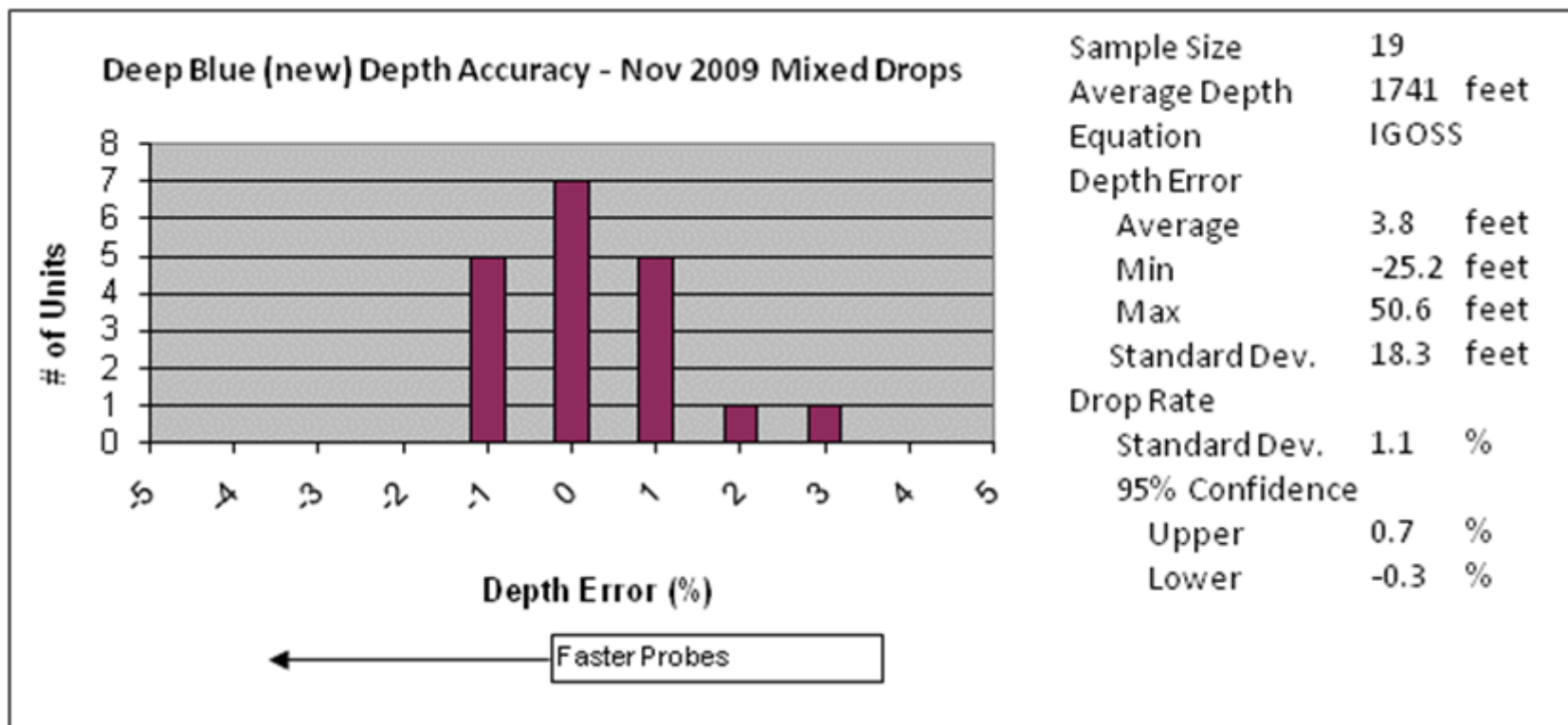
Deep Blue (New)

| | |
|-------------------|---------------|
| Sample Size | 28 |
| Avg. Depth | 1747 feet |
| Avg Error | 3.6 feet |
| Min Error | -39.4 feet |
| Max Error | 35.7 feet |
| Stdev | 19.5 feet |
| RSD | 1.1% |
| 95% Conf Interval | -0.2% 0.6% |

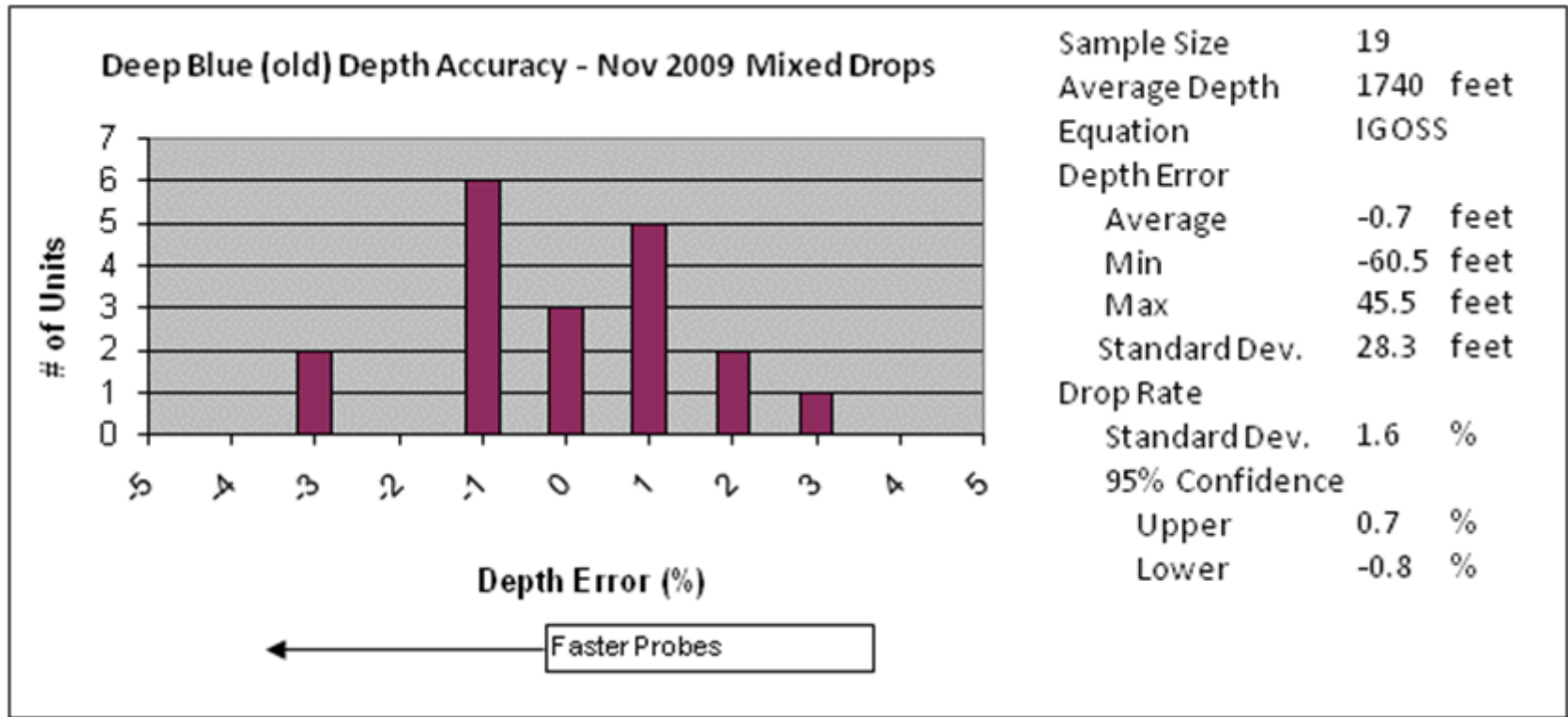
Echo Sounder Results

November 2009 Sea Trial Data

Deep Blues – New Probes



Deep Blues – Before Aug 2008



Deep Blues: Nov 2009 Summary



Deep Blue (Before Aug '08)

| | |
|-------------------|-----------------|
| Sample Size | 19 |
| Avg. Depth | 1740 feet |
| Avg Error | -0.7 feet |
| Min Error | -60.5 feet |
| Max Error | 45.5 feet |
| Stdev | 28.3 feet |
| RSD | 1.6% |
| 95% Conf Interval | -0.8% 0.7% |

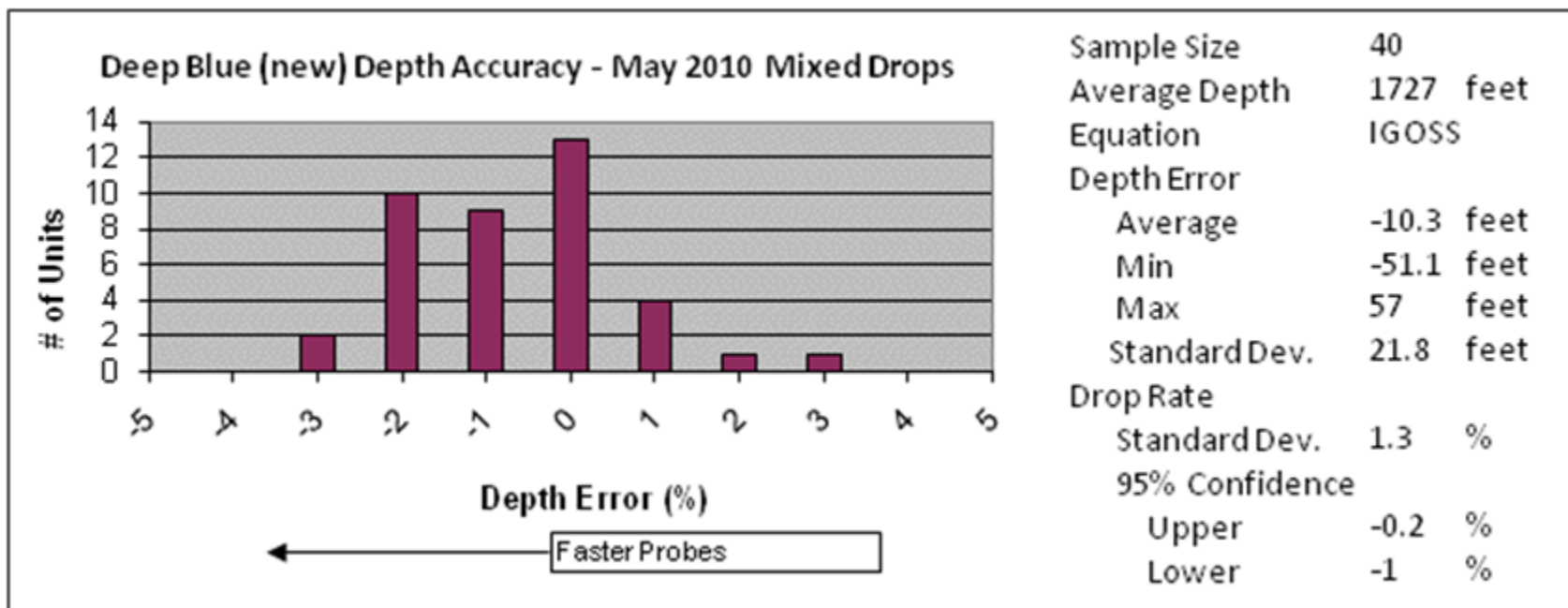
Deep Blue (New)

| | |
|-------------------|-----------------|
| Sample Size | 19 |
| Avg. Depth | 1741 feet |
| Avg Error | 3.8 feet |
| Min Error | -25.2 feet |
| Max Error | 50.6 feet |
| Stdev | 18.3 feet |
| RSD | 1.1% |
| 95% Conf Interval | -0.3% 0.7% |

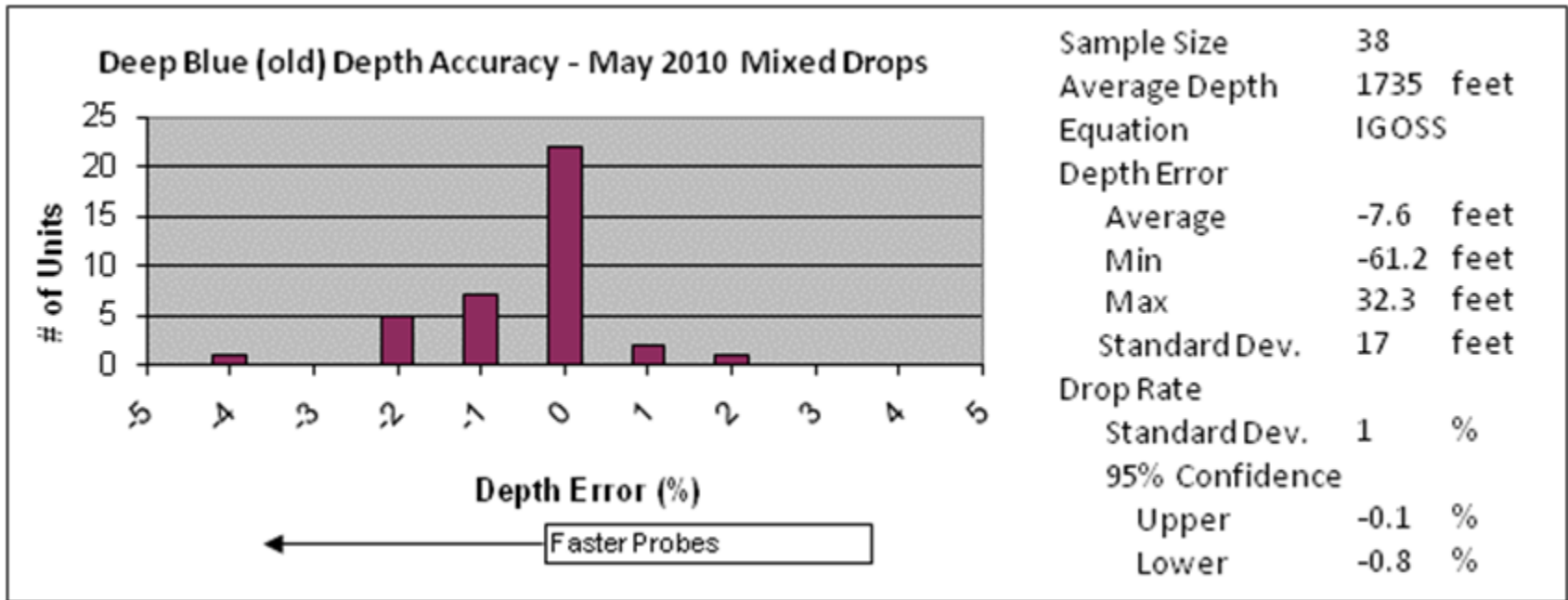
Echo Sounder Results

May 2010 Sea Trial Data

Deep Blues – New Probes



Deep Blues – Before Aug 2008



Deep Blues: May 2010 Summary



Deep Blue (Before Aug '08)

| | |
|-------------------|----------------|
| Sample Size | 38 |
| Avg. Depth | 1735 feet |
| Avg Error | -7.6 feet |
| Min Error | -61.2 feet |
| Max Error | 32.3 feet |
| Stdev | 17 feet |
| RSD | 1.0% |
| 95% Conf Interval | -0.8% -0.1% |

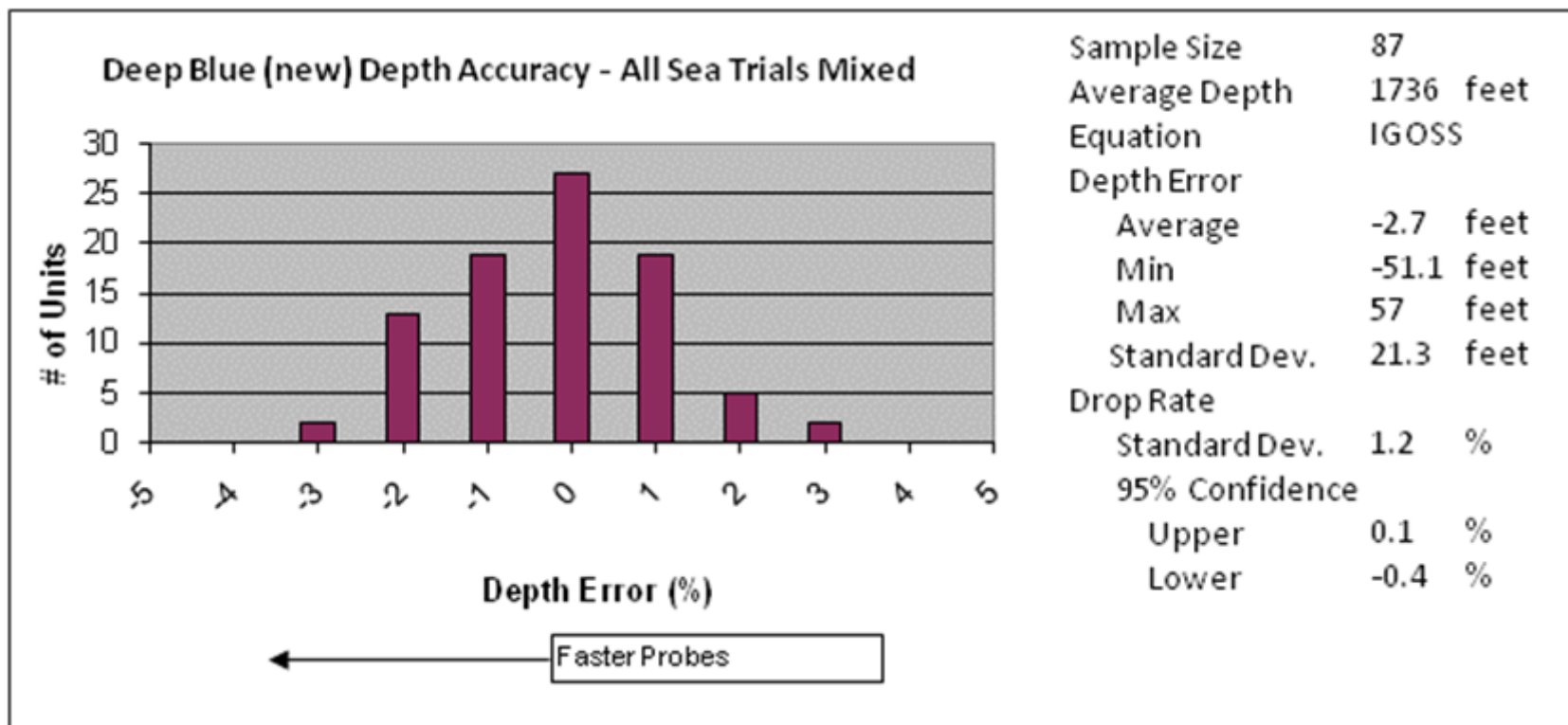
Deep Blue (New)

| | |
|-------------------|----------------|
| Sample Size | 40 |
| Avg. Depth | 1727 feet |
| Avg Error | -10.3 feet |
| Min Error | -51.1 feet |
| Max Error | 57 feet |
| Stdev | 21.8 feet |
| RSD | 1.3% |
| 95% Conf Interval | -1.0% -0.2% |

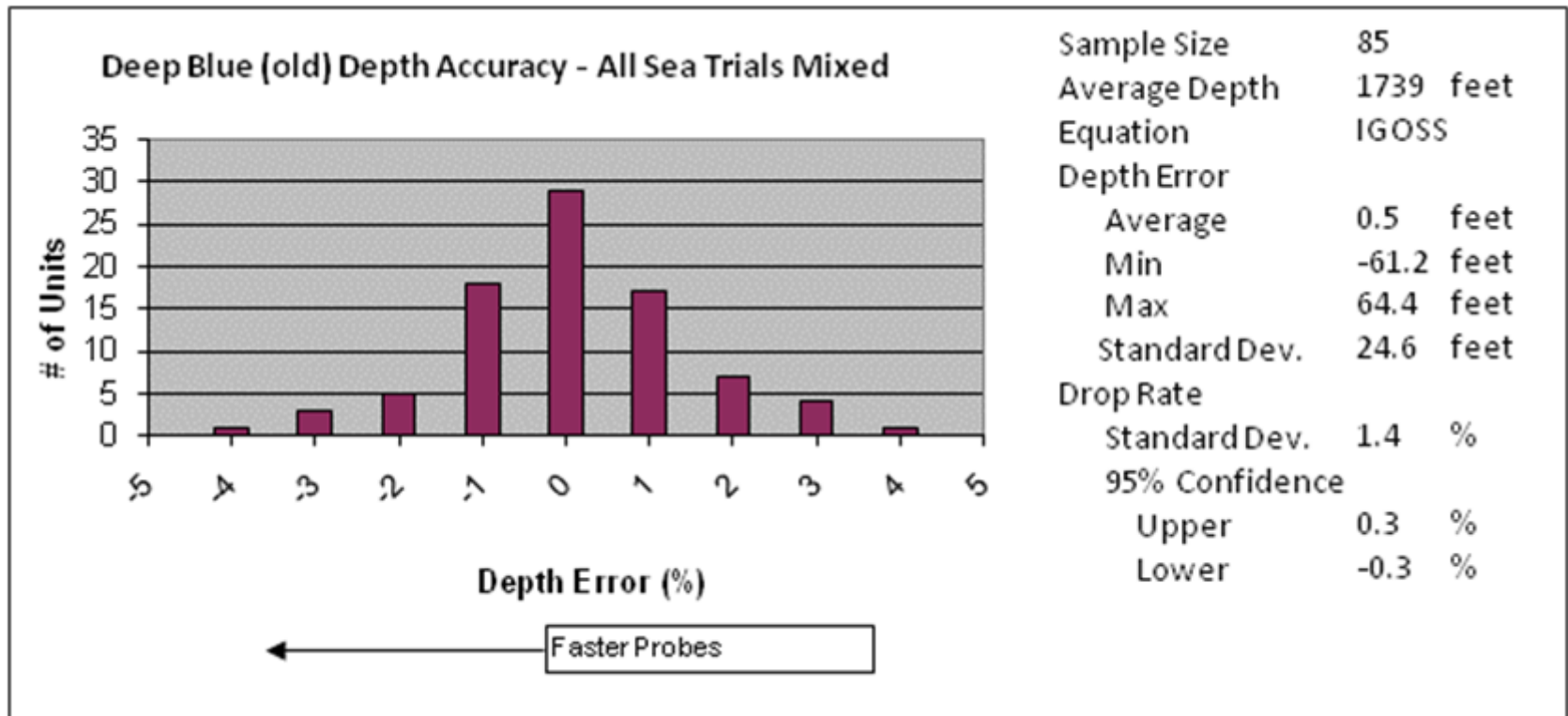
Echo Sounder Results

All Sea Trial Data

Deep Blues – New Probes



Deep Blues – Before Aug 2008



Deep Blues: All Data Summary



Deep Blue (Before Aug '08)

| | |
|-------------------|-----------------|
| Sample Size | 85 |
| Avg. Depth | 1739 feet |
| Avg Error | 0.5 feet |
| Min Error | -61.2 feet |
| Max Error | 64.4 feet |
| Stdev | 24.6 feet |
| RSD | 1.4% |
| 95% Conf Interval | -0.3% 0.3% |

Deep Blue (New)

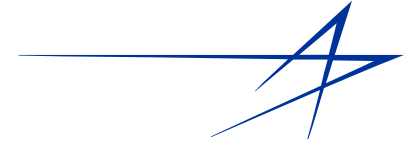
| | |
|-------------------|-----------------|
| Sample Size | 87 |
| Avg. Depth | 1736 feet |
| Avg Error | -2.7 feet |
| Min Error | -51.1 feet |
| Max Error | 57 feet |
| Stdev | 21.3 feet |
| RSD | 1.2% |
| 95% Conf Interval | -0.4% 0.1% |

New: Faster and more consistent drops

Echo Sounder Results

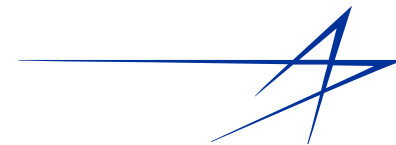
Summary

Error Sources



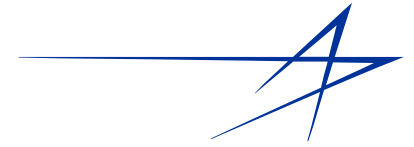
- **Impact point uncertainty**
 - **Lateral current influence**
 - **Natural trajectory variability**
 - **Error minimized by flat bottom**
- **Impact time uncertainty**
 - **Vertical current influence**
 - **Launch detection**
 - **Data sample rate**
- **Echo sounder errors**
 - **False echoes**
 - **Sound velocity**
- **Wave height**

Deep Blue Results Summary



- **Echo sounder fall rate evaluation**
 - Will continue as routine test
- **Preliminary results from three sea trials**
 - New probes on average drop faster
 - New probes generally drop more consistently
- **Results include echo sounder error**
 - Depth data quite variable
 - False echoes
 - Obtain better depth measurements
- **Continue refinement of the approach**
 - Procedural improvements
 - Depth measurement improvements

Future Plans



- **Remap the bottom**
 - **Obtain more accurate depth data**
 - **Reprocess May '09, November '09, May '10 data**
- **Repeat error analysis with new depth data**
- **Procedural improvements**
 - **Improve echo sounder technique**
 - **Identify flattest bottom**
 - **Stationary drops**
- **Continue fall rate monitoring**

