Multibeam Hydrographic Mapping Technology Used on the Colorado River Channel In Grand Canyon

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USGS science for a changing world
GCMRC, SURVEY DEPARTMENT

Introduction:

In 1999 GCMRC survey department began development of a multibeam hydrographic mapping system to facilitate all monitoring efforts requiring sub-aqueous measurements. Hydrographic data collection methods were designed to acquire monitoring products such as:

* Topographic maps
*Triangulated Irregular Network models (TIN)
* Aquatic habitat models
* Sediment aggregation and degradation
* Hydrologic stage discharge modeling
* Cross-section analysis

Purpose:

Hydrographic technology is used in the Grand Canyon primarily to measure changes in the river channel. The primary changes that occur are due to the movement of sediment.

These changes are monitored by hydro-acoustic measurements that are accurately positioned over the course of the river channel.

Objectives:

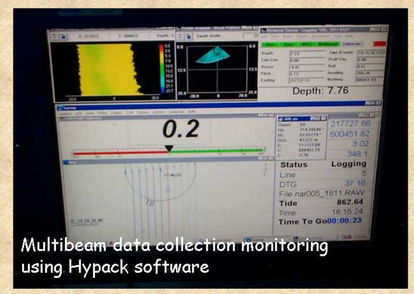
One of the GCMRC Survey Department objectives is to produce a channel map of the entire river in the Grand Canyon within a 5-year period. Multibeam technology is the only method currently available with sufficient productivity to accomplish the channel mapping objectives. This technology offers a swath coverage that results in a high resolution mapping product. Multibeam systems require extremely accurate positioning and motion compensation to successfully map the river bottom. A robotic total station tracking system is used to accomplish the positioning.

Collecting Multibeam Data

Equipment and system setup

Multibeam Data Collection in Glen Canyon

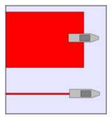
...and the Little Colorado River confluence



Multibeam data collection monitoring using Hypack software

Multibeam Theory and Dynamics

1. Survey Coverage

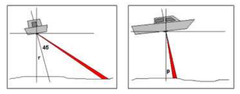


- Multibeam surveys a 2-dimensional area
- Single beam surveys a 1-D line directly under the boat.

2. Multibeam Systems

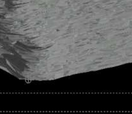
- Increasing coverage with water depth.
- Rough water operation.
- Mounting options – vertical or rotated.

3. Beam Geometry



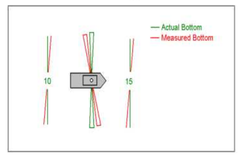
- Boat rotations due to roll and pitch must be compensated.
- Roll and pitch are measured by a Heave Compensator (MRU, VRU).

4. Beam Geometry (cont.)

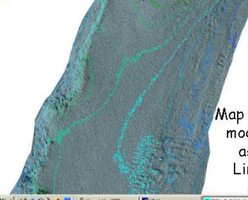


- Boat heading must be considered
- Heading measured by Gyro, Compass or GPS antenna array.

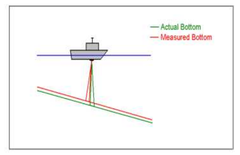
5. Yaw Misalignment



6. Roll Misalignment



7. Pitch Misalignment

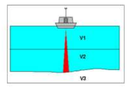


8. Position Latency

- Latency is the delay time between position fix and MB transmission. When latency isn't correct, the boat isn't where you think it is.

9. Acoustics - Simple

Vertical Beam



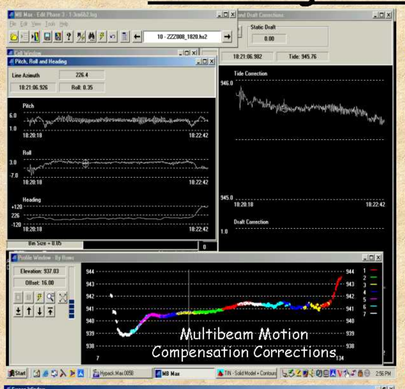
- No change in direction at velocity change.
- Average sound velocity is sufficient.

10. Acoustics – Not so simple

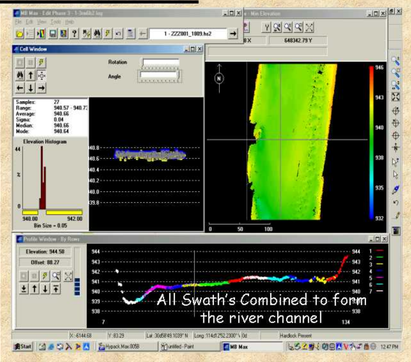
Slanted beam

- Refraction (ray bending) at SV change.
- Requires sound velocity profile.
- Look for "Smiley Faces" (refraction errors).

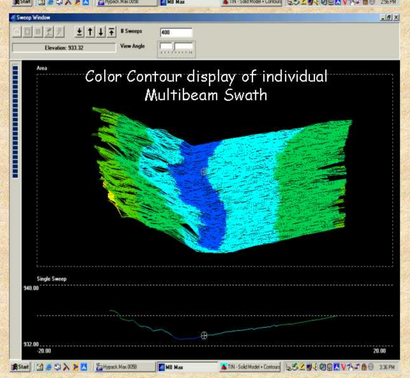
Processing Multibeam Data



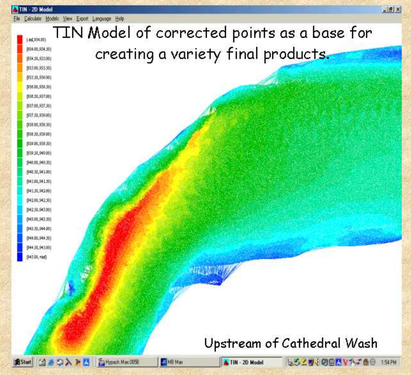
Multibeam Motion Compensation Corrections



All Swath's Combined to form the river channel



Color Contour display of individual Multibeam Swath



TIN Model of corrected points as a base for creating a variety final products.

Upstream of Cathedral Wash

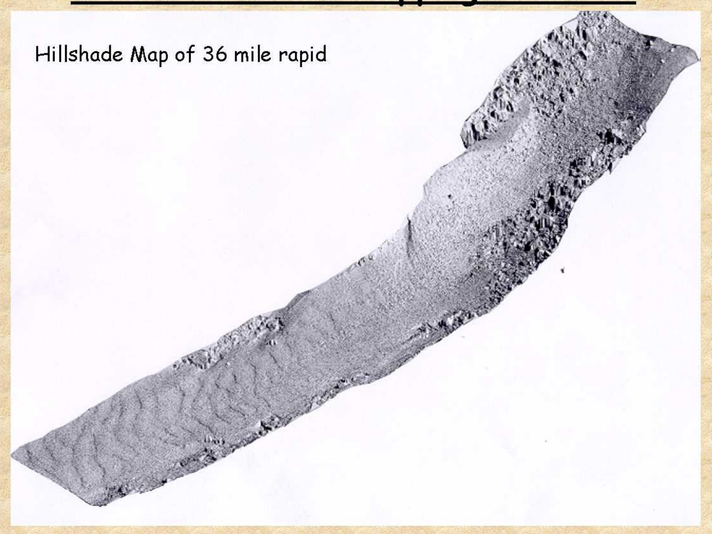
Hillshade display of individual Multibeam Swath

~10 m

Map created from TIN model and displayed as Color Contour Lines overlayed on Shaded Relief

Multibeam Final Mapping Products

Hillshade Map of 36 mile rapid



Color Shaded Relief Map of Paria Rapid

Summary of Accurate Positioning for Multibeam Data.

1. GPS Control Network transfers accurate positioning from rim points to selected points along the river.

2. Conventional Measurements transfer accurate positioning to strategically located control points.

3. Positioning instruments are set up on accurately positioned control points and robotically track the boats position.