Design Considerations for a Lightweight Modular Causeway Section (LMCS)

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Outline

- Objective
- Desired Causeway Capabilities/Objectives
- Key Performance Parameters
  - Transportability
  - Deployability and Recoverability
  - Trafficability
  - Durability
  - Survivability
  - Maintainability
- Concept Evaluation Matrices
- Questions

Objective

To convey significant factors that impact design considerations and concepts for a TSV-transportable rapidly deployable lightweight causeway

Desired Causeway Capabilities/Objectives

- Lightweight and compact
- ISO Compatible
- Rapidly transportable by and deployable from TSV/(HSC?)
- Minimal shipboard storage requirements
- Provide up to 150-ft of bridging ship-to-shore
- Support 70-ton XM1A tank
- Operate within sheltered ports and harbors (open coast?, rivers?, ?,?)
- Interface with existing and emerging causeway systems (i.e. INLS, MCS, NL)
- Interface with JLOTS lighterage and watercraft
- Meet requirements for maintainability, reliability, MTBF, service life, etc.,

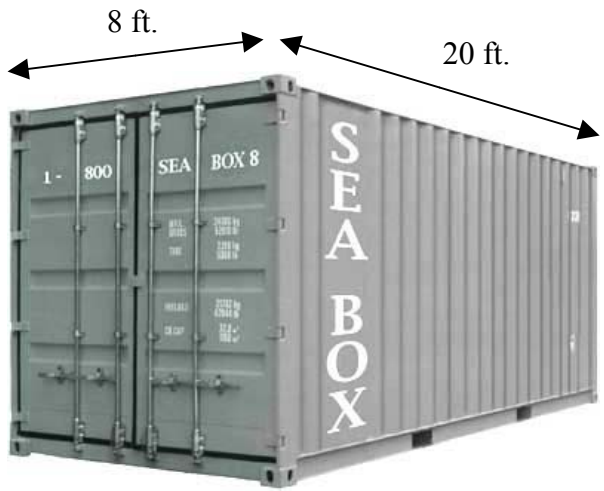
Concepts Considered

- **Rapid Dredge Fill/ Quay Construction**
  - **Using Hydrobeam Barrier**
- **Modular Causeway Section (MCS)**
  - **All Steel or Composite**
- **Grounded Causeway Concept (GCC)**
  - **Bottom Founded with Hydrobeams**
- ✓ **Lightweight Modular Causeway Section (LMCS)**
  - **Floating using Airbeams**

Key Performance Parameters

Transportability

- Weight of system
- ISO compatibility
  - 20 ft. x 8 ft. footprint
  - Material Handling Equipment (MHE) compatibility
- TSV storage location
  - Last on, first off of first TSV



Key Performance Parameters

Deployability and Recoverability

1. Causeway
    - Deployment/Recovery method and time/speed
        - Weight and size (20-ft segment width limit?)
        - Mooring
        - Assembling/disassembling
            - → Shipboard vs. sea-state connections/disconnections
            - → Manual vs. automated labor
    - Opening Size in TSV/HSC for deployment
2. Vehicle Cargo and Materials Offload
    - Ramp and causeway interface
        - Surface deck deflection
        - Ramp system configurations?

Key Performance Parameters

Trafficability

- Weight and speed of vehicle(s) over causeway
  - roll stability
  - deck/joint flexure
  - sea-state/environmental effects
- Number of vehicles on causeway
  - → Entire causeway system
  - → Per stiffened section
  - → Clearance between vehicles
- Maximum lane width relative to causeway section width
  - M1A1 / M1A2 Abrams is 12 ft. wide

Key Performance Parameters

Durability

- "Wear and tear" on fabrics
  - LMCS Floatation devices along ocean floor
    - → Pneumatic tube fabric
    - → Webbing matrix material
  - Deck surface from trafficking
- Degradation of mechanical elements (cables, hinges, etc.)
  - Fatigue: loading and bending life cycles
    - → Material and design
- Other materials/components useful lifespan

Key Performance Parameters

Maintainability

- In-water vs. shipboard maintenance
- Time to repair or replace component (routine vs. emergency)
- Number of loading cycles prior to rehabilitation for system/component
- Whether or not problem is deemed "critical" - continue with operation or abort until problem is fixed

    - Ex: LMCS air leak(s)

        → Number

        → Location relative to load and/or stiffened section

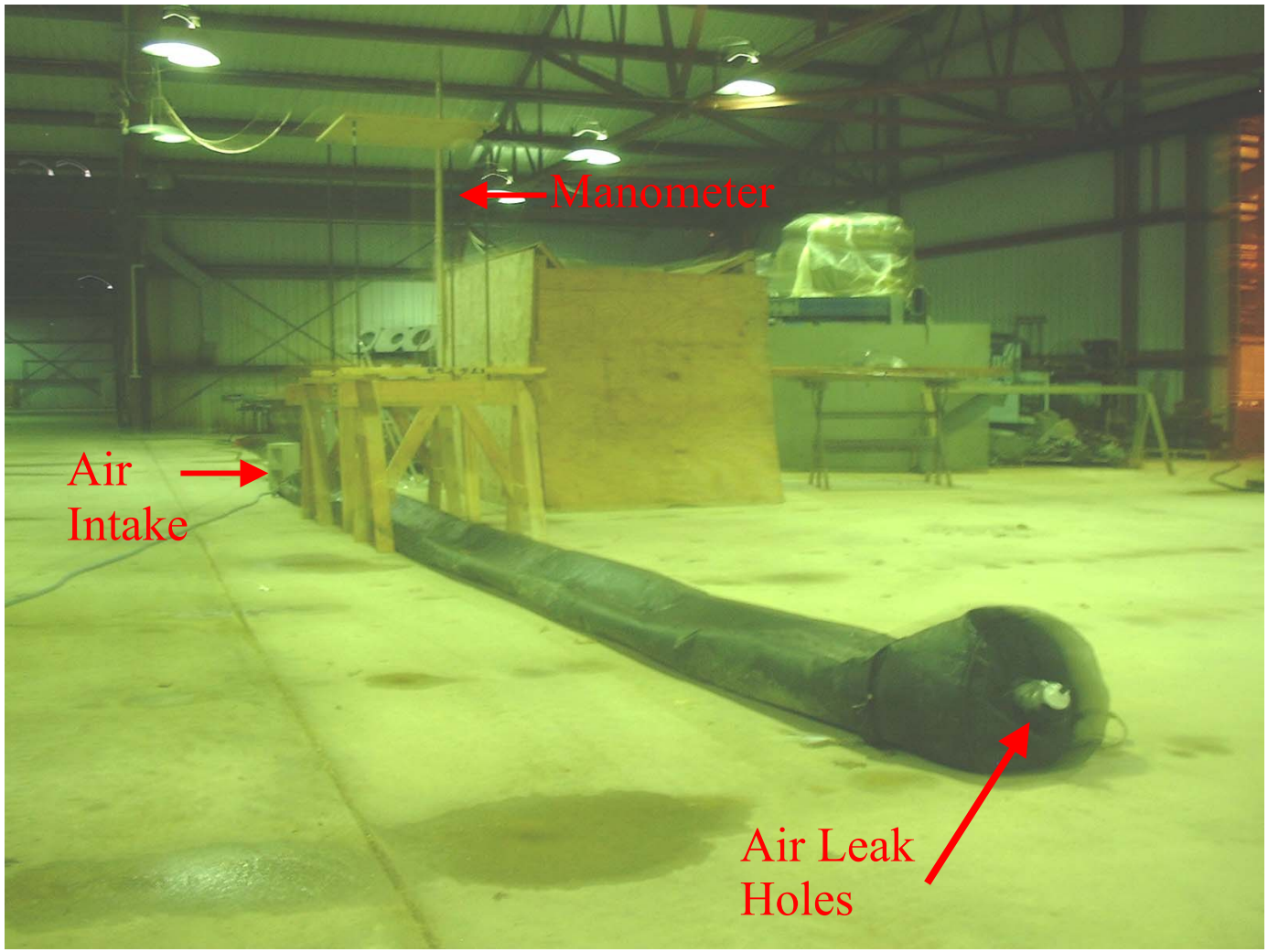
Key Performance Parameters

Survivability

- Potential system failures (catastrophic or non-catastrophic)
  - Air leaks in LMCS floatation devices
    - ⟶ Number
    - ⟶ Location relative to displaced load and/or stiffened section
    - ⟶ *Being examined by CHL and QED*
  - Breakage in joint connections
    - ⟶ Number
    - ⟶ Location relative to displaced load and/or stiffened section
- Other
  - Severe weather and wave conditions
  - Collision damage

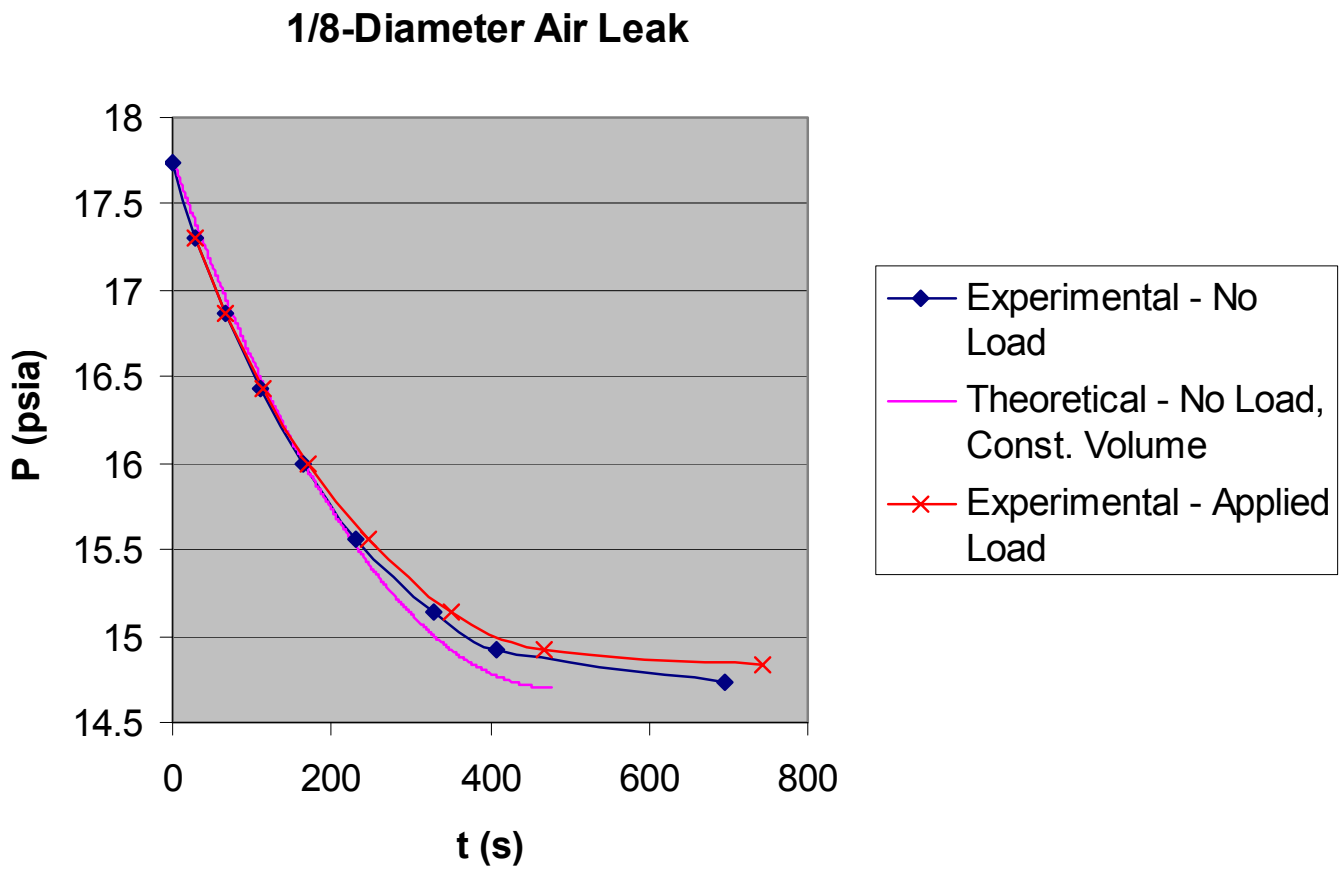
Survivability

Floatation Device Air Leak Analysis



Survivability
Floatation Device Air Leak Analysis

Graphical Results



Survivability
Floatation Device Air Leak Analysis

Preliminary Conclusions

- Internal pressure change in floatation device *can be adequately predicted for non-catastrophic failure conditions*
- Additional efforts to examine effects of multiple tubes/applied loads are ongoing
- Time of failure due to small arms punctures should be adequate to employ possible failure alternatives for damage control

Evaluation of Options Considered

Options / Parameters	MCS: All Steel/Composite Construction	GCC: Bottom-Founded With Hydrobeam Supports	LMCS: Floating With Airbeam Supports
Trafficability	3 Easily accomodates wheeled and tracked vehicles	2 Will accommodate wheeled and tracked vehicles	2 Will accommodate wheeled and tracked vehicles
Deployability and Recoverability	1 Days to deploy	2 >12 hours	3 <12 hours
Maintainability	3 Fairly easy to maintain	1 Not easily accessible for repair/replacement	2 Replacement of components could be designed for above water operation
Durability	3 20 year lifespan	2 Hydrobeams replacement every 5 years	2 Airbeams replacement every 5 years
Survivability	3 Will survive small arms fire	2 Can be designed to survive small arms fire	2 Can be designed to survive small arms fire
Transportability	0 **Not presently TSV-Transportable**	2 Could be designed to be TSV transportable	*3* Easily TSV-transportable
Totals	**13**	**11**	✓ *14*

Note: Rapid Dredge Fill Option omitted

LMCS Options Presently Being Evaluated

Parameters \ Options	*Floatation with sectional stiffness derived from straps/tube pressure*	*Floatation with sectional stiffness designed into superstructure – independent of air pressure*
Trafficability	2	2
Deployability and Recoverability	2	2
Maintainability	2	2
Durability	2	2
Survivability	**1** Air Leaks - Deck stiffness compromised - Sinking – *catastrophic* - *Closed Cell Foam alternative?*	**2** Air Leaks - Deck stiffness *not* compromised - Sinking – *catastrophic* - *Closed Cell Foam alternative?*
Transportability	2	2

Both options viable at this point

Questions

Floatation Device Air Leak Analysis
Additional Information

Numerical Model

- Coupling of two gas equations

(1)

$$P = \frac{mRT}{MV}$$

Ideal gas equation

(2)

$$Q = C_D A (2gdP)^{1/2} [k/(k-1)]^{1/2} [(P_A/P)^{2/k} - (P_A/P)^{(k+1)/k}]^{1/2}$$

Subsonic mass flow rate equation for a pressurized gas system

- Conditions
  - Subsonic (low pressure) flow
  - Constant vessel volume for theoretical model

Floatation Device Air Leak Analysis
Additional Information

Graphical Results

- 1/8-in., 7/32-in., and 1/2-in. air leaks

Deviation in theoretical and experimental plots occurs between **16** to **15.50 psia**