

MEMO Date: 28 October 2018
To: Rob Gilliland
From: L. William Chapin, II, FAIA
Subject: Tensile membrane facts.



Rob, Anne Ruby forwarded your response to Alex Riley about the tensile membrane building pricing and performance and, knowing that it was inaccurate, asked me to respond with facts about it. I am not surprised by the extent of the inaccuracy of information you have been given in light of my own recent experience with Daytona Beach city staff; so, here are the real facts supported by documentation.

First, I am attaching the most recent update of specs and pricing from Big Top. Inc, which is who I worked with on the two pavilions, plus a graphic which shows what they use for their proposal. The projected total all-in price of \$2.2M includes proposals I got from two vendors of transportable modules for kitchen, lavatories, offices, infirmary, etc. (To see what they look like, stop by the Protogroup field offices beachside.) The modules would be secured to meet hurricane code, and their floor level would be the same as the slab height for the tensile membrane modules, thereby meeting ADA specs at no extra cost.

The tensile modules carry a hurricane rating at 160mph, which is 50mph higher than any hurricane that has ever reached this far inland in Florida. The membrane is far from flimsy. It is a heavy fiberglass mesh which is impregnated with high-tech Teflon mastic that renders it extraordinarily impervious to projectile penetration. I am securing a sample to show its physical properties.

I am enclosing graphics from the San Diego Convention Center, the Denver Airport and the Vancouver Cruise Terminal, all of which show the versatility of tensile membrane structures. The interior image shows how truly equivalent it is to any hard-structure enclosed space. After 25 years, if the fabric needs to be replaced, the frame continues to be used and just the membrane is changed out. On a hard-structure building, the roof rarely lasts more than 25 years and then needs to be replaced, and that replacement cost is roughly equivalent to that of the tensile membrane replacement, so the two systems enjoy equivalent permanence. True, it is slightly more expensive to heat and cool a tensile membrane building than a conventional building, but that cost is mostly offset by its translucency, which eliminates need to provide lighting during daytime.

As for comparative costs, I am attaching the budgetary numbers developed by the First Step LLC when they thought they were the providers based on your city resolution 16-205, which shows the cost gap between tensile and conventional as generated then. The tensile numbers has gone up less than 20%: the city design cost has more than doubled without a kitchen or equipment and furnishings.

Tensile membrane has been proven to be a true budget-saver as shown in the Denver Airport example. I recently asked Curt Fentress to relate that experience for me, and I am attaching his assistant's history of the project for your review. His office number is here if you wish to call & verify: (303) 722-5000

The biggest problem with the Hall-Ogle basic floor plan is that they have attempted to save money by combining the dining/lounge areas of the separate pavilions into one common room. The problem arises as a result of attempting to manage a blended population that ranges in behavioral profile from ex-felons, alcoholics, the mentally disturbed, all the way to the ordinary men and women who comprise a sizable proportion of the homeless. As Dr, Robert Marbut has pointed out when asked, the staffing cost and liability risks skyrocket when the mixed populations aren't securely segregated in separate pavilions, such as the case in the Pinellas County, FL and Orlando shelters, for example. Dr. Marbut can be reached at (210) 260-9696 or email MarbutR@aol.com

Finally, as the military has demonstrated countless times, tensile membrane structures can be erected rapidly because of the all-at-once production process, instead of the step-by-step process of conventional construction.

I hope this is helpful, Rob. Feel free to call with any questions, corresponding references, etc.



Alex Riley

I contacted the commissioners. I only got one answer from Rob Gilliland:

Alex:

Do you realize that the tensile fabric option is 10% cheaper, the maintenance is 25% higher, and the lifespan is half that of traditional construction? So, you are actually advocating for the more expensive option.

Thanks,
Rob

COMPARISON OF TIME, COST, OF ERECTING CONVENTIONAL BUILDING VS TENSILE FABRIC BUILDING (15 yr + level fabric)

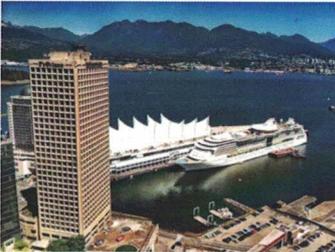
TASK	CONVENTIONAL	TENSILE
COMPLETE CONTRACT DOCUMENTS.	2 1/2 MO.	1 MO.
ADVERTISE FOR CONTRACTOR PROPOSALS	1 MO.	1 MO.
SELECT AND NEGOTIATE CONTRACT	1/2 MO.	1/2 MO.
ADD 4'-0" FILL IN 18" LIFTS FOR PAD		
TIME FORECASTED FOR SETTLEMENT	3 1/2 MO.	----
BUILD STEMWALL & PLACE PRECAST DECK	----	1 MO.
OPTIMUM CONSTRUCTION TIME*	8 MOS	----
OUTFITTING WITH TENS FAB STRUCTURE & PLACING SERVICE MODULES**	----	2 MO
MOVE-IN & BEGIN SERVICES	1/2 MO	1/2 MO
CONTINGENCY/WEATHER (10%)	1 1/2 MO	1.2 MO
TOTAL TIME	17.5 MO	6.5 MO
ESTIMATED COST	\$2,800,000	\$1,500,000

BENEFITS OF OF 1 YEAR TIME SAVING - CONVENTIONAL CONSTRUCTION VS.TENSILE FABRIC

- HALIFAX HEALTH E.R. SAVINGS
- SAVINGS ON SPREAD OF RELATIVE CONSTRUCTION COSTS
- LAW ENFORCEMENT COSTS (MAY NOT CHANGE, BUT MAKES MORE EFFICIENT)
- ENHANCEMENT OF BEACHSIDE AMBIENCE, SAFETY.
- ENHANCEMENT OF OTHER COMMERCIAL LOCALE AMBIENCE, SAFETY.
- POSITIVE IMPACT ON HOTEL/MOTEL OPERATORS BUSINESS.
- SAVINGS OF MOVING SEGMENT OF RECOVERED HOMELESS FROM GOVERNMENT SUPPORT TO SELF-DEPENDENCY.

EXACT \$\$\$ TALLY OF SAVINGS WOULD BE IMPOSSIBLE, BUT IT CAN CLEARLY BE SEEN THAT THE SAVINGS OVER THE 11 MONTHS WOULD BE WELL IN EXCESS OF \$3,000,000.

- * BEST-CASE ESTIMATE OF TIME BY **COLEMAN-GOODEMOTE CONSTRUCTION COMPANY** AND **M. L. UNDERWOOD CONSTRUCTION**. (DUE TO CURRENT SUPERHOT BUILDING ENVIRONMENT, THIS TIME PROBABLY WOULD BE LONGER.) - 16 AUGUST 2017
- * RECONFIRMED 11 JULY 2017 QUOTE - 16 AUGUST 2017



VANCOUVER, B.C. CANADA CRUISE TERMINAL 1993

EXISTING TENSILE FABRIC STRUCTURES



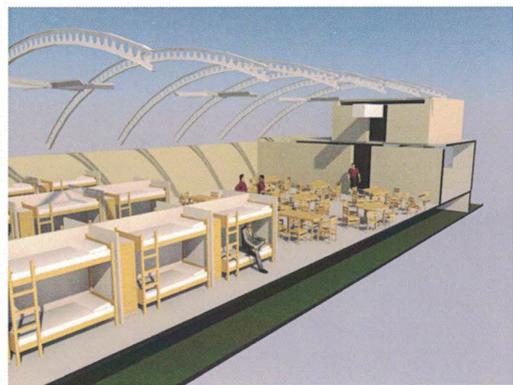
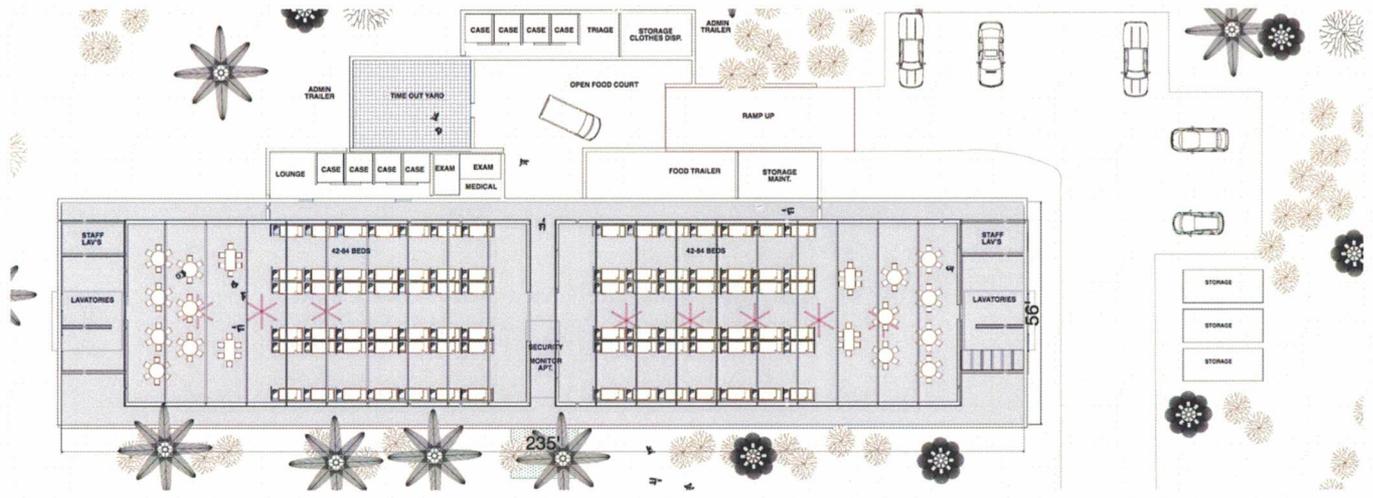
SAN DIEGO, CALIFORNIA CONVENTION CENTER - 1986



DENVER, COLORADO, AIRPORT - 2005

While major tensile fabric structures have been produced since the 1950's, the science of hi-tech membranes and computer-generated support system designs have continued to be refined in recent years to the point where these structures' applicability for additional building types has increased exponentially, because of the benefits of cost, speed of erection, aesthetics, and longevity.





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November 1, 2018

Bill Chapin
 L. William Chapin
 315 North Atlantic Ave
 Daytona Beach, FL 32118

Dear Mr. Bill Chapin,

Please review the following quotation.

Proposal for: William Chapin "Bill"

ITEM	QTY	DESCRIPTION	PRICE
Vinyl Structure	2	<ul style="list-style-type: none"> 50' Wide X 100' Long X 20' Center Height X 12' Side wall \$54,600.00 per building 18 OZ. Cover, Translucent White, Flame Retardant PVC Laminated fabric with polyester scrim. 10 - 12 year fabric life span 22oz fabric please add \$6,000.00 12 - 15 year fabric life span - per building 28oz fabric please add \$20,000.00 20+ year fabric life span - per building Frame Members: 30" truss using heavy wall tubular steel on 10' centers. Anchoring to be provided for a customer supplied concrete mounted foundation Unless otherwise stated, foundations other than concrete are assumed at 90% compaction or greater. It is the customer's responsibility to specify any foundation requirements prior to placing order. Fabric will end at ground level. All weld joints are coated for corrosion protection. All connections are made using a male to female/slip fit junction. 	\$ 109,200.00
End Wall	4	<ul style="list-style-type: none"> Access end wall - \$7,000.00 per end wall 1ea 10'wide x 10'high disappearing door per building and 2ea personnel door per end wall, per building. Disappearing door to include all the necessary winch, trolleys, pulleys, cables, and a manual winch. Disappearing doors are not a pre engineered door system and should be considered a flap. Engineered door systems are available but require additional funds. 	\$ 28,000.00
Light Kit	1	<ul style="list-style-type: none"> Light Kit - \$7,300 per light kit 10each 277v LED Lights per kit, Reloc" (plug and play light system), switches and panel box. Reloc wiring may not be suitable for every application. Customer is responsible for approving wiring prior to placing order. Other wiring, power supply, connection options etc. are available upon request but may require additional funds. It is the customer's responsibility to verify with Big Top your power requirements prior to placing order. Extra lights are available at additional cost The main power supply connection to the provided panel box(s) is the responsibility of the customer. 	\$ 14,600.00



HVAC Kit	2	<ul style="list-style-type: none"> 6 each 480 volt 3 phase 10ton HVAC units – 3 per building Units will include panel box(s). \$36,600.00 per kit Panel box(s) are to be installed in the corner of the building, power cable, remote box and cable, panel box, and 20' of supply and return Mil Spec Flex Ducts. Units cannot be exchanged for a different power supply once ordered! Please specify your power requirements prior to placing an order if they are different from what is listed above! Additional charges may apply for optional power supplies.  <p>The main power and connection to the panel box is the responsibility of the customer! The customer is responsible for insuring that each HVAC unit is wired properly prior to commissioning each unit. If the customer neglects to insure the HVAC motors have been wired properly you run the risk of damaging the motors. The customer will bear all financial cost to replace or repair the HVAC unit in the event this occurs. Units will be installed up to 15' around the perimeter of the shelter. Customer is responsible for ensuring that area is level. Units have to be installed on a level grade.</p>	\$ 73,200.00
Installation Estimated: 4 work days per building	1	<ul style="list-style-type: none"> Installation: Big Top Shelters will install the above shelter systems at your Daytona Beach, FL 32118 facility. Big Top Shelters will be responsible for all equipment, and non- union labor. Customer will be responsible for any and all safety course(s), training, 24/7 access to the site, removing all underground and overhead utilities, permits, dumpster for trash removal, foundation work, portalet or toilet facilities in near proximity to the site, special badges for clearance etc. prior to mobilization. Big Top Shelters is an installer of our product. We are not a construction company. If your site requires special licenses, has permit requirements, then a general contractor may be required. (See installation clause at the bottom of page.) 	\$ 38,000.00
Engineering	1	<ul style="list-style-type: none"> Engineering: Stamped engineering by a professional engineer If Engineering is required, please provide the correct wind, snow, seismic load and exposure category for the location where the shelter will be LOCATED. Extra funds will be required if any consultation is to be had with any building official or your engineer If your site requires special licenses, permits, or other accessory items to meet the local code requirements or project specific requirements then a general contractor may be required. If the shelter is purchased or installed prior to any permit approval the customer bears the cost of any upgrades to meet local code. All engineering to support the structure is considered "by others", unless specifically noted on our drawings. That includes, but is not limited to, Shipping containers, concrete, soil, asphalt, custom support steel, etc. 	\$ 1,800.00
Trim Kit	2	<ul style="list-style-type: none"> Trim Kit Seals fabric to building base rail or specified foundation Please specify prior to placing order 	\$ 900.00
Shipping and Handling	1	<ul style="list-style-type: none"> FOB Perry FL: Daytona Beach, FL 32118 Shipping is primarily via 102" x 48' long flatbed trailers. To maximize stacking, there is little to no dunnage below the frames. Due to weight and handling issues, dunnage can possibly result in damage to the frame. If you require dunnage there COULD be additional costs due to lessened space on the flatbed or special stacking requirements. 	\$ 2,400.00
GRAND TOTAL		US DOLLARS.	\$ 268,100.00

Big Top Manufacturing
Toll Free 1-800-277-8677 - International 011-850-584-7786
www.bigtopshelters.com
l.houck@bigtopshelters.com



Payment Terms: 50% Deposit With Order - Remaining Balance is Due Prior to Shipping. Big Top accepts cash, credit cards (3% processing fee applies on all orders greater than \$3,000.00 when using a credit card), check, wire transfer, and ACH transactions. Please make all checks payable to Big Top Manufacturing Inc.

Lead Time: 3-4 weeks from the date of an approved purchase order. Lead times can be subject to change at any time. Please allow an extra 2 weeks to any order containing engineering. Lead times are estimated based on our current schedule at the time of the dated proposal. The actual lead times will be based on the current schedule at the time of signed and approved purchase order date, and or with an approved deposit.

Taxes and Fees: Big Top Manufacturing is a Florida based company. Big Top Manufacturing does not collect out of state or international sales tax. The customer is responsible for any and all local taxes, state taxes, federal taxes, fees, tariffs and duties that can be associated with this purchase.

If any other sales or purchasing forms or documents are used in connection with the sale(s), supply, and/or purchase of the above listed products the terms which are inconsistent with our sales proposal that are different from, or in addition to the provisions of this agreement shall be null and void and shall have no force or effect whatsoever.

Please ensure that your balance is paid at least 5 days prior to shipping. Your building will not be shipped and or released until full payment has been received. Orders using net or special negotiated payment terms are subject to other rules. Please contact the main office with any questions or concerns.

Sincerely,
Lance Houck
Technical Sales Representative
l.houck@bigtopshelters.com

Approved This _____ Day of _____, 2018
P. O. #: _____

Approved By: _____

Title: _____

Technical assistance/installation clause:

Fees for services are \$ 830.00 for the United States and its territories, Canada, and the Caribbean. International Services are \$1100.00 USD per day per person. Included is hotel, rental car, meals, taxis, and airport parking. Expenses for airfare, visas, transfers, special job site training, ferries, and others will be billed at actual costs. On domestic and international installations, the daily fee extends from portal to portal from Perry, Florida. The Daily fee continues during the week Monday through Sunday regardless of whether work can be performed on Saturday or Sunday. Travel arrangements and accommodations are to be arranged or agreed to by Big Top Mfg. or the technician. (Domestic & International flights are to be coach class and the hotel accommodations are to be with a standard chain hotel). All remaining balances will be settled on prior to the departure of the technician from the job site. There may be some international regions where a service technician is not available. Call for details.

Big Top will not be responsible for any damage to the grounds, shrubbery, underground utilities, asphalt, concrete, etc. due to the normal construction process necessary to install the above shelters unless specifically provided for in the purchase contract.

In the event the above proposal includes metal/aluminum entry equipment doors, unless the shelter is built on level concrete, we cannot take responsibility for its operation. If uneven - such as is routinely encountered on asphalt or soil, the framework will likely require modification on site resulting in additional costs.

Big Top will provide soil or concrete wedge anchors as a standard form of anchoring. Big Top makes no representation as to the structural integrity or suitability of the concrete or soil. Any other anchoring surface or method is at the sole risk of the end user. No representation is made as to water drainage due to slope or foundation issues.

Shelter is to be installed in accordance with the provided assembly instructions, under the guidance of our technician or via Big Top. If the end user chooses to owner install the shelter, finished photos are required including photos of the shelter with the anchors properly installed. In the event the shelter is ever relocated, new photos will be required including anchorage photos.

In the event the end user chooses to employ our technician, we make no representation as to the quality, suitability, or performance of the laborers or equipment provided. The estimate given is based upon typical installations worldwide but is not a guaranteed level of performance.

If Big Top is to fully install the shelter, unencumbered access is necessary. We assume a 7 day workweek. If the weekends cannot be worked, we will need to know this in ADVANCE to modify the proposal.

End user is responsible for permitting and any local taxes or tariffs, if any. If a turn-key installation by Big Top, it is the end user's responsibility to determine Big Top's ability to install the shelter based upon local licensing or permitting issues. All costs associated with this to be borne by the end user.

Shelter is defined as an equipment item. Proper maintenance is necessary to extend the life of the shelter frame, fabric, doors, and access panels. Proper maintenance includes but is not limited to checking fabric for proper taught ness and adjusting as necessary, adjusting cables, pulleys, trolleys, turnbuckles, lubricating moving parts, inspecting nuts, bolts, etc.

Lighting, winches, heating, A/C, dehumidification units, doors, etc. are covered under the product manufacturer's warranty.

Big Top Shelters is the installer of our product. We are not a construction company. If your site requires special licenses, permitting, or other accessory items to meet your local code requirements then a general contractor may be required. If the shelter is purchased or installed prior to permit approval the customer bears the cost of any upgrades to meet local code. All electrical packages sold are to the NEC only.

Big Top Manufacturing
Toll Free 1-800-277-8677 - International 011-850-584-7786
www.bigtopshelters.com
l.houck@bigtopshelters.com

A brief description of the history of Denver International Airport's Passenger Terminal Complex

October 24, 2018

- The original project was experiencing severe budgeting and scheduling overruns
- The City of Denver wanted to cut costs significantly while creating a memorable and significant piece of civic architecture
- The Fentress design team proposed using a catenary cable support system employing a tensile Teflon-coated fiberglass fabric.
- Because of Denver's climate, engineers performed wind and snow tests on the fabric, modifying the design to withstand extreme weather conditions.
- The 1200-foot-by-240-foot tensile roof structure added significant daylighting and became the largest structure in the world to enclose a building space.
- This solution drastically reduced material and construction costs and time
- It is cleaned periodically using soap and water and an expected life span of over 50-years
- It was built in 1993 and is still serving the 5th busiest airport in the world

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Special Report

ARCHITECTS & ENGINEERS

Special Report

Builders see way clear to use of new high-tech fabric

By L. WILLIAM CHAPIN II

Perhaps the most exciting building material to appear on the scene of contemporary architecture in recent years is not some sophisticated plastic or ultrahigh-compression concrete material, but a type of cloth.

However to just use the term "cloth" for this new generation of fabrics is rather like describing the Chicago Bulls as several fellows who get together to play a little basketball.

The cloth is a woven electrical-grade fiberglass impregnated with a Teflon PTFE coating, resulting in an ultra-strong membrane that looks more like a sheet of plastic than a fabric. The Teflon coating creates a heavy film that gives the material its ability to withstand severe climactic changes and UV bombardment year after year.

In most contemporary applications this material is stretched over rigid, lightweight spaceframes or high-tension cables. The resulting structure is relatively static, spans vast distances and is as permanent as most hard-material buildings. With its virtues of lightness and ease of erection, it can span vast distances in circumstances where a heavy structure would not be practical.

The design flexibility and special attributes make it suitable for wonderful new and surprising applications. It is starting to appear in all sorts of building types from retail facilities to transportation terminals to sports stadiums, and is becoming more popular all the time as architects discover

its extraordinary virtues.

Take, for example, the new Denver airport. Certainly the Colorado plain on which the airport sits gets exposed to as severe an array of climactic conditions as any place, and yet the whole main concourse is covered with nothing but acres of membrane.

The reason why it works so well in cold Colorado is in the ability of membrane structures to act as net converters of energy. At first blush it would seem like the building would be underinsulated,

but when one evaluates the total energy consumption — including heating, cooling, lighting and mechanical equipment costs — the tension-membrane material turns out to be a very efficient way to cover heated space in cold climates relative to most other traditional systems.

The secret to this energy efficiency is in the membrane's translucency. When the membrane is first manufactured, it is a light beige, but when exposed for several days to daylight, the beige turns to pure white. The Teflon outer surface is continually cleansed by normal rainfall, and the result is that the area covered by a membrane structure literally glows with natural illumination.

At night, powerful but efficient lights shine up against the underside of the material, resulting in an overall even illumination. In the winter, solar heat gain contributes substantially to the cost of heating the enclosed space under the membrane. And during daylight hours the cost of providing artificial light is virtually zero.

The advent of the computer has aided tremendously in the architectural design of tension-membrane structures. Dramatic and complex

curved shapes can be created through the use of computers, then translated directly into high-tension wires, large tubular spaceframes and multishaped panels of membrane.

These membranes are not so new that they haven't been tested in actual usage. The first major tension-membrane project was erected in 1956, and was used to cover a college sports structure in Ohio. That same structure is still in place and remains in good repair.

During the 1960s and '70s, countless tennis domes were created where tension-membrane structures were held in place by internal air pressure. It was during this time when the first hint of the flexibility of

these systems emerged. For example, when the huge Fort Drum construction contracts were let during the early '70s, one innovative contractor was able to work through the winter months by enclosing his construction site with a gigantic bubble that was held in place by air pressure.

One of the most sophisticated facilities for creating tension-membrane structures happens to be in Amherst at Birdair Inc. corporate headquarters. Birdair has been creating tension-membrane structures in its upstate facility since the late 1950s.

Today, the company prefabricates its gigantic projects in a 70,000-square-foot warehouse that is surgically clean and highly efficient. Tailor's shears have been replaced by mammoth computer-driven cutting machines. And rather than stitching together the various panels of these structures, they are chemically welded at their edges with heat and pressure. The resulting product ends up being virtually seamless.

As you might guess, all this technology does not come cheap. These structures can range from \$20 to \$40 per square foot, but measured against most any other covering system of equivalent virtuosity, that is a steal. When you add the ability of these membrane structures to provide high illumination along with shade and cover from the elements, the price tag is extremely justifiable. □

L. William Chapin II, a fellow in the American Institute of Architects, is a principal in the Rochester firm of Chapin and Tomasetti Architects P.C.

To just use the term "cloth" for this new generation of fabrics is rather like describing the Chicago Bulls as several fellows who get together to play a little basketball.

Generator Sets and Power Systems