A deployable truss having multiple rigid transverse sections, forming triangles, rectangles or other shapes, where adjacent transverse sections are connected by multiple three-piece longerons hinged together and to the transverse sections. In a folded configuration, the each longeron has a central link that maintains spacing between adjacent transverse sections, providing stowage space for load modules such as stacks of deployable panels. The longeron structure also ensures that deployment of the truss proceeds in a linear fashion and that the deployed truss is relatively rigid. Multiple stay wires coupling adjacent transverse sections further enhances structural rigidity.
DOUBLE KNEE JOINTED LONGERON TRUSS FOR SPACE STRUCTURES

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to deployable space structures and, more particularly, to truss structures that are essentially rigid when deployed, but which are foldable for compact stowage in a launch vehicle. As used in architecture, the term “truss” is usually applied to an assemblage of structural members that supports a load at two principal points, acting like a beam but reducing the size and weight that would be required if a single beam member were used. More generally, the term “truss” may also be applied to cantilevered structures supported at one end, as in the boom of a crane, or a boom attached to a space vehicle and carrying a load of some kind, such as an antenna or an array of panels.

[0002] A deployable truss typically consists of multiple rigid members connected by hinges in such a way as to be deployable into a relatively rigid truss structure, and to be foldable for compact stowage in a launch vehicle. Deployable trusses for use in space have two major requirements, in addition to being foldable to a compact configuration for launching. First, the truss must deploy in a predictable and preferably linear fashion when commanded to do so and, second, the truss in its deployed configuration should be relatively stable and rigid in order to perform its desired function. For many applications of deployable trusses, there is a third requirement. Ideally, the truss in its launch configuration should provide adequate room for stowing modules that will be carried by the deployed truss. For example, if the truss is to carry an array of flat panels, space should ideally be provided for stacks of these panels, disposed in such a manner that facilitates their deployment when the truss is deployed. The present invention satisfies or exceeds all of these requirements.

SUMMARY OF THE INVENTION

[0003] The present invention resides in a deployable truss that provides for linear and predictable deployment and, in the folded configuration, provides room for stowing other deployable components between adjacent sections of the truss. Briefly, and in general terms, the deployable truss of the invention comprises a plurality of similar transverse sections, each comprising multiple members joined to form a rigid, generally coplanar structure, the transverse sections being arrayed in a parallel spaced relationship along a longitudinal axis generally perpendicular to the transverse sections. Located between adjacent transverse sections is a plurality of foldable longerons connected by hinges to the transverse sections. The longerons are deployable from a folded configuration that minimizes spacing between adjacent transverse sections of the truss and a deployed configuration that maximizes the spacing and forms a rigid truss structure with the transverse sections.

[0004] Each of the foldable longerons has three connected sections, including two longeron arms and an intermediate longeron link. Each of the longeron arms has first and second ends and is connected by its first end to a hinge point on one of the adjacent transverse sections. The longeron link is connected to the second ends of the longeron arms by additional hinges. On full deployment, each longeron has its three sections aligned and locked in position. In the folded configuration, each longeron arm is pivoted into the plane of the transverse section to which it is connected, and the longeron links maintain a minimum spacing between adjacent transverse sections.

[0005] In one disclosed embodiment of the invention, each transverse section of the truss is rectangular and four foldable longerons are connected between corresponding corners of adjacent rectangular transverse sections of the truss. In another disclosed embodiment of the invention, each transverse section of the truss is triangular and three foldable longerons are connected between corresponding corners of adjacent triangular transverse sections of the truss.

[0006] The truss may further comprise means for urging the transverse sections apart from each other along the longitudinal axis, unfolding the longerons to their fully extended position, in which the truss is said to be deployed. Preferably, the truss also comprises a plurality of stay wires disposed between and connected to adjacent transverse sections. The stay wires enhance the structural rigidity of the deployed truss.

[0007] It will be appreciated from the foregoing that the present invention provides a significant advance in the field of deployable trusses. In particular, the truss of the invention deploys in a linear and predictable manner and is constructed to leave a minimum spacing between adjacent transverse sections in the folded configuration. Other aspects and advantages of the invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1A is a perspective view depicting a rectangular truss in accordance with the invention, shown in a folded configuration and having just two transverse sections by way of illustration.

[0009] FIGS. 1B and 1C are views similar to FIG. 1A, but showing the rectangular truss in two different intermediate stages of deployment.

[0010] FIG. 1D is a view similar to FIG. 1A, but showing the rectangular truss fully deployed.

[0011] FIG. 2 is an enlarged perspective view similar to FIG. 1A, but showing a rectangular truss with three transverse sections, in the folded configuration.

[0012] FIG. 3A is a perspective view of a triangular truss having four transverse sections, shown in a folded configuration.

[0013] FIG. 3B is a view similar to FIG. 3A, but showing the triangular truss in a partially deployed configuration.

[0014] FIG. 3C is a view similar to FIG. 3A, but showing the triangular truss in a fully deployed configuration.

DETAILED DESCRIPTION OF THE INVENTION

[0015] As shown in the drawings for purposes of illustration, the present invention is concerned with deployable trusses suitable for use in space applications. Deployable trusses of the prior art have not always been deployable in a stable and linear fashion and have not provided adequate
space in the folded configuration for stowage of load modules that will be carried on the deployed truss.

[0016] In accordance with the present invention, a deployable truss includes a plurality of transverse sections, each of which has multiple members connected in a rigid polygonal shape, and a plurality of double hinged longeron sections connecting corresponding points on adjacent transverse sections.

[0017] As shown in FIGS. 1A-1D, for example, the truss structure of the invention includes multiple rectangular (or square) transverse sections, two of which are indicated at 10a and 10b. Each of the rectangular sections 10a and 10b is rendered rigid by the nature of the connections of its four members, as well as by the interconnecting longeron structure now to be described. Connecting each corresponding pair of corners of the rectangular sections 10a and 10b is a three-piece longeron 12, having two longeron arms 12a and 12b connected at one end by hinges to the rectangular sections 10a and 10b, respectively, and an intermediate longeron link 12c, connected by additional hinges to the other ends of the longeron arms. Thus, each longeron 12 has three sections 12a, 12b and 12c connected together by hinges.

[0018] In the folded configuration of FIG. 1a, the four longeron arms 12a are folded into a position in which they are essentially in the same plane as the rectangular transverse section 10a. Similarly, the longeron arms 12b are folded into a position in which they are essentially in the same plane as the other rectangular transverse section 10b. The four longeron links 12c are aligned in a parallel configuration, perpendicular to the planes of the rectangular transverse sections 10a and 10b.

[0019] As the rectangular truss is deployed, the rectangular transverse sections 10a and 10b move further apart and the longeron arms 12a and 12b rotate away from the planes of the rectangular sections and toward an orientation aligned with the longeron links 12c. When deployment is complete, each longeron 12 has its sections 12a, 12b and 12c in collinear alignment, as shown in FIG. 1D. During the transition to the deployed configuration, the constraints imposed by the pin hinges connecting the longeron components, and connecting the longerons to the transverse sections, maintains the two transverse sections 10a and 10b parallel and ensures that the two sections move apart along a perpendicular axis. These relationships apply to each pair of adjacent transverse sections, so that deployment of a truss with multiple transverse sections is constrained to proceed in a completely linear fashion. Deployment energy is supplied by any conventional means, such as spring-loading one or more of the hinges, driving at least one pair of the transverse sections apart using a motor or other means. To enhance rigidity of the deployed structure, adjacent transverse sections may be interconnected by multiple stay wires. These are not shown in FIGS. 1A-1D but will be discussed with reference to FIGS. 3A-3C.

[0020] FIG. 2 depicts a truss in the folded configuration, with three rectangular transverse sections 10a, 10b and 10c. The three-part longeron are again referred to by numerals 12a, 12b and 12c. As can be seen in the figure, each longeron arm 12a and 12b is attached to one of the transverse sections 10a, 10b and 10c by a pin hinge, which permits the longeron arm to pivot about the pin in a plane of rotation that is perpendicular to the plane of the transverse section. Each longeron link 12c is hinged to the longeron arms 12a, 12b making up the longeron, but means for pin hinges having pins or axes parallel to the pins in the hinges at the other end of the longeron arms 12a, 12b. In other words, the three members of each longeron are constrained to move, during deployment, in the same plane. When any two adjacent transverse sections are moved apart, these constraints keep the sections 10 parallel and also keep the longeron links parallel with each other and with the longitudinal axis, as discussed with reference to FIGS. 1A-1D. In general, the structure may be scaled to any larger number of sections, and deployment will still proceed in a linear fashion, either sequentially from section to section, or simultaneously for all the sections.

[0021] FIG. 3A shows truss with four triangular transverse sections 20a, 20b, 20c and 20d, and multiple longeron 22 interconnecting adjacent transverse sections. As in the rectangular truss, so with the triangular truss each longeron 22 has three sections, including two longeron arms 22a and 22b coupled by hinges to the respective triangular transverse sections, such as 20a and 20b, and a longeron link 22c coupled by hinges to the two longeron arms 22a and 22b. In the folded configuration shown in FIG. 3A, the longeron links 22c effectively space adjacent transverse sections apart and provide stowage space for modules to be carried on the deployed truss. As shown in the drawings, these modules may be stacks of radiation panels 30, for example. FIG. 3B shows the triangular truss of FIG. 3A when partially deployed, and FIG. 3C shows the triangular truss fully deployed.

[0022] Interconnecting each adjacent pair of transverse sections, such as sections 20a and 20b, are six stay wires 32. Each pair of stay wires 32 is connected between a point on one transverse section to two non-corresponding points on the adjacent transverse section. The stay wires enhance the rigidity, especially torsional rigidity, of the deployed truss.

[0023] The deployable truss of the present invention is well suited for use in a variety of space missions, including civilian missions such as interplanetary orbiters, and military missions such as space based radar. The simplicity of deployment of the truss makes it useful for unmanned as well as manned missions.

[0024] It will be appreciated that the deployable truss structure of the invention represents a significant advance in the field of deployable trusses. In particular, the truss of the invention is deployable stably and linearly, provides a desirably rigid structure once deployed, and provides stowage space for deployable components, such as panels, thereby facilitating their deployment with the truss. It will also be appreciated that, although specific embodiments of the invention have been described in detail for purposes of illustration, various modifications may be made without departing from the spirit and scope of the invention. Accordingly, the invention should not be limited except as by the appended claims.

1. A deployable truss, comprising:
   a plurality of similar transverse sections, each comprising multiple members joined to form a rigid, generally coplanar structure, the transverse sections being
arrayed in a parallel spaced relationship along a longitudinal axis generally perpendicular to the transverse sections; and

located between adjacent transverse sections, a plurality of foldable longerons connected by hinges to the transverse sections, and deployable from a folded configuration that minimizes spacing between adjacent transverse sections and a deployed configuration that maximizes the spacing and forms a rigid truss structure with the transverse sections;

wherein each of the foldable longerons comprises first and second longeron arms, each having first and second ends and connected by their first ends to corresponding hinge points at corners of adjacent rectangular transverse sections, and a longeron link connected to the second ends of the first and second longeron arms by additional hinge points.

2. A deployable truss as defined in claim 1, wherein:

each transverse section of the truss is rectangular; and

four foldable longerons are connected between corresponding corners of adjacent rectangular transverse sections of the truss.

3. A deployable truss as defined in claim 1, wherein:

each transverse section of the truss is triangular; and

three foldable longerons are connected between corresponding corners of adjacent triangular transverse sections of the truss.

4. A deployable truss as defined in claim 1, and further comprising:

means for urging the transverse sections apart from each other along the longitudinal axis, wherein the longerons unfold to a fully extended position in which the truss is said to be deployed.

5. A deployable truss as defined in claim 4, wherein the truss is foldable to a compact configuration in which the longeron arms are pivoted into positions generally coplanar with the transverse sections to which they are attached, and the longeron links remain perpendicular to the transverse sections and determine a minimum spacing between the transverse sections, to allow room for stowing other deployable components.

6. A deployable truss as defined in claim 1, and further comprising:

disposed between and connected to adjacent transverse sections, a plurality of stay wires that enhance the structural rigidity of the deployed truss.

7. A deployable truss, comprising:

a plurality of transverse sections, each of which has four structural members connected to form a rectangle, the rectangular transverse sections being arrayed in a parallel spaced relationship along a longitudinal axis generally perpendicular to the rectangular transverse sections; and

located between successive pairs of adjacent rectangular transverse sections, four foldable longerons connected by pin hinges to the respective corners of the rectangular transverse sections, and deployable from a folded configuration that minimizes spacing between adjacent transverse sections and a deployed configuration that maximizes the spacing and forms a rigid truss structure with the transverse sections;

wherein each of the foldable longerons comprises first and second longeron arms, each having first and second ends and connected by their first ends to corresponding hinge points at corners of adjacent rectangular transverse sections, and a longeron link connected to the second ends of the first and second longeron arms by additional hinge points;

and wherein the deployable truss further comprises a plurality of stay wires connected between non-opposed corners of adjacent rectangular transverse sections, to provide enhanced rigidity;

and wherein the longeron links determine a minimum spacing between adjacent rectangular transverse sections in the folded configuration, allowing other components to be stowed between the rectangular transverse sections.

8. A deployable truss as defined in claim 7, and further comprising:

means for urging the rectangular transverse sections apart from each other and into the deployed configuration of the truss in which the longerons are fully extended; and

means for locking the longerons in their fully extended positions.

9. A deployable truss, comprising:

a plurality of transverse sections, each of which has three structural members connected to form a triangle, the triangular transverse sections being arrayed in a parallel spaced relationship along a longitudinal axis generally perpendicular to the triangular transverse sections; and

located between successive pairs of adjacent triangular transverse sections, three foldable longerons connected by pin hinges to the respective corners of the triangular transverse sections, and deployable from a folded configuration that minimizes spacing between adjacent transverse sections and a deployed configuration that maximizes the spacing and forms a rigid truss structure with the transverse sections;

wherein each of the foldable longerons comprises first and second longeron arms, each having first and second ends and connected by their first ends to corresponding hinge points at corners of adjacent triangular transverse sections, and a longeron link connected to the second ends of the first and second longeron arms by additional hinge points;

and wherein the deployable truss further comprises a plurality of stay wires connected between non-opposed corners of adjacent rectangular transverse sections, to provide enhanced rigidity;

and wherein the longeron links determine a minimum spacing between adjacent triangular transverse sections in the folded configuration, allowing other components to be stowed between the triangular transverse sections.

10. A deployable truss as defined in claim 9, and further comprising:

means for urging the triangular transverse sections apart from each other and into the deployed configuration of the truss in which the longerons are fully extended; and

means for locking the longerons in their fully extended positions.