

AGREEMENT FOR
THE ANALYSIS, DESIGN, FABRICATION, SHIPPING, INSTALLATION AND DOCUMENTATION
OF VENTS FOR THE ENCLOSURE OF THE
CANADA-FRANCE-HAWAII TELESCOPE CORPORATION
OBSERVATORY FACILITY ON THE SUMMIT OF MAUNA KEA

CONTRACT NO.: ~~2011~~2012-01 05-113

THIS AGREEMENT made this ___th day of _____ in the year Two Thousand ~~Eleven~~Twelve

BETWEEN *[legal name and address of contractor]* (hereinafter referred to as “Contractor”)

AND **Canada-France-Hawaii Telescope Corporation**, a corporation duly incorporated under the laws of the State of Hawaii, USA, having an office at Kamuela, Hawaii 96743, USA (hereinafter referred to as “CFHT”)

PROJECT: Analysis, design, fabrication, shipping, installation and documentation of vents for the enclosure of the Canada-France-Hawaii Telescope Corporation’s Observatory, Mauna Kea, Hawaii.

WHEREAS: CFHT desires to modify its telescope enclosure by adding twelve (12) large airflow vents and closures.

WHEREAS: The Contractor agrees to analyze, design, fabricate and install vent units as set forth below.

WITNESS

THAT: In consideration of the premises and of the following terms, conditions, and payments, the parties agree as follows:

ARTICLE 1 – THE WORK

The Contractor shall furnish all labor, materials, tools, equipment, and supervision required to complete the work (“Work”) for the Project, according to the true intent and meaning of the Contract Documents.

The term “Work” means the analysis, design, fabrication, and installation services required by the Contract Documents, whether completed or partially completed, and includes all other labor, materials, equipment and services provided or to be provided by the Contractor to fulfill the Contractor’s obligations. The Work may constitute the whole or a part of the Project.

The Work shall be executed in a manner consistent with industry standards by qualified and efficient workers. The Contractor shall possess all professional and contractor license(s) required by law in the State of Hawaii. Contractor shall maintain all such licenses current and valid without interruption throughout the period of this contract.

The Work shall be done in a manner that will create as little obstruction and disturbance as possible to the public roads, trails, pathways, utilities, public facilities, CFHT observatory operations, and the operations of the other observatories on Mauna Kea.

ARTICLE 2 - CONTRACT SUM AND PAYMENTS

§2.1 Contract Sum

CFHT shall pay the Contractor for the performance of the Work, subject to additions and deletions as provided in the Contract documents, in current funds, the total Contract Sum, inclusive of applicable tax and duties, of:

[Amount in words] Dollars & no/100 (\$[amount in numbers].00)

§2.2 Progress Payments

Contractor shall be allowed progress payments according to the following schedule:

1. US\$ _____ (___% of the entire amount) upon the start of Work (*or execution of this Agreement*).
2. US\$ _____ (___% of the entire amount) upon the completion of _____.
3. US\$ _____ (___% of the entire amount) upon the completion of _____.
4. US\$ _____ (___% of the entire amount) upon the completion of _____.
5. US\$ _____ (___% of the entire amount) upon the completion of _____.
6. US\$ _____ (___% of the entire amount) upon the completion of _____.
7. US\$ _____ (10% of the entire amount) after completion of the entire work in accordance with Section 2.5.

The Contractor warrants and guarantees that all work and materials covered by progress or partial payments made thereon shall be free and clear of all liens, claims, security interests, or encumbrances, and shall become the sole property of CFHT. This provision shall not, however, be construed as an acceptance of the work, nor shall it be construed as relieving the Contractor from the sole responsibility for all materials and work upon which payments have been made or the restoration of any damaged work, or as waiving the right of CFHT to require the fulfillment of all the items of the Contract.

§2.3 Applications for Payment

The Contractor shall submit applications for progress payments to CFHT based on the items of work **deemed by CFHT to be** satisfactorily completed and the percentage value of the contract sum set forth in the Contract. CFHT shall make payment to the Contractor not later than 30 days after CFHT receives an Application for Payment.

§2.4 Payments to the Contractor and Subcontractors

The Contractor shall promptly pay each Subcontractor, upon receipt of payment from CFHT, out of the amount paid to the Contractor on account of such Subcontractor's portion of the Work, the amount to which said Subcontractor is entitled, reflecting percentages actually retained from payments to the Contractor on account of such Subcontractor's portion of the Work. The Contractor shall, by appropriate agreement with each Subcontractor, require each Subcontractor to make payments to sub-subcontractors in similar manner.

CFHT shall have no obligation to pay or see to the payment of money to a Subcontractor except as may otherwise be required by law.

A progress payment, or partial or entire use or occupancy of the Work by CFHT shall not constitute acceptance of Work not in accordance with the Contract Documents.

§2.5 Final Completion and Final Payment

Upon notice that the Work is ready for final inspection and acceptance and upon receipt of a final Application for Payment, CFHT will promptly make such inspection and, when CFHT finds the Work acceptable under the Contract Documents and the Contract has been fully performed, CFHT will approve the final Application for Payment.

Final payment shall not become due until the Contractor has delivered to CFHT a complete release of all liens arising out of the Contract or receipts in full covering all labor, materials and equipment for which a lien could be filed, or a bond satisfactory to CFHT to indemnify CFHT against such lien. If such lien remains unsatisfied after payments are made, the Contractor shall refund to CFHT all money that CFHT may be compelled to pay in discharging such lien, including costs and reasonable attorneys' fees.

The issuance of final payment shall constitute a waiver of claims by CFHT except those arising from:

1. liens, claims, security interests or encumbrances arising out of the Contract and unsettled;
2. failure of the Work to comply with the requirements of the Contract Documents; ~~or~~
3. terms of special warranties required by the Contract Documents; or
- ~~3.4.~~ latent defects.

Acceptance of final payment by the Contractor, a Subcontractor or material supplier shall constitute a waiver of claims by that payee except those previously made in writing and identified by that payee as unsettled at the time of final Application for Payment.

ARTICLE 3 – ENUMERATION OF THE CONTRACT DOCUMENTS

The Contract Documents, except for Modifications issued after execution of this Agreement, are enumerated as follows:

1. This Agreement for the analysis, design, fabrication, shipping, installation and documentation of vents for the enclosure of the Canada-France-Hawaii Telescope Corporation Observatory Facility.
2. The Special Conditions contained in Schedule “A.”
3. The Scope of Work, Deliverables and Specifications, contained in Schedule “B.”
4. Any agreement between CFHT and the State of Hawaii, Department of Land and Natural Resources, a copy of which will be attached as Schedule “C.” *[to be attached upon receipt]*
5. Any agreement between CFHT and the University of Hawaii, Office of Mauna Kea Management a copy of which will be attached as Schedule “D.” *[to be attached upon receipt]*

ARTICLE 4 – COMMENCEMENT AND SUBSTANTIAL COMPLETION

§4.1 Date of Commencement

The date of commencement of the Work shall be fixed in a Notice to Proceed issued by CFHT. Mobilization, ordering of materials and other preliminary actions necessary for the initial phases of the Work may be started immediately upon execution of this Agreement.

§4.2 Date of Substantial Completion

Substantial Completion is the stage in the progress of the Work when the Work, or designated portion thereof, is sufficiently complete in accordance with the terms of the Contract Documents.

The Contractor shall achieve Substantial Completion of the entire Work not later than ____ calendar days from the date of commencement, subject to adjustments of the Contract Time as provided in this Article 4.2 or in Article 4.3.

The period allowed to complete the work shall be extended by 1 (one) calendar day for each day when:

1. Scheduled work is canceled by CFHT in accordance with item 8 of Schedule "A"; or
2. On-going work is stopped by CFHT for 4 (four) hours or more, due to weather, operations or any other reason.

When CFHT determines that the Work, or designated portion thereof, is substantially complete, CFHT will issue a Certificate of Substantial Completion which shall establish the date of Substantial Completion and fix the time within which the Contractor shall finish all items on a punch list accompanying the Certificate. Warranties required by the Contract Documents shall commence on the date of Substantial Completion of the Work or designated portion thereof unless otherwise provided in the Certificate of Substantial Completion.

ARTICLE 5 –TIME

It is mutually agreed by and between the parties hereto that time shall be an essential part of this Agreement. By executing the Agreement the Contractor confirms that the Contract Time is a reasonable period for performing the Work.

If the Contractor is delayed at any time in the commencement or progress of the Work by changes ordered in the Work, by labor disputes, fire, unusual delay in deliveries, abnormal adverse weather conditions not reasonably anticipatable, unavoidable casualties or any causes beyond the Contractor's control, or by other causes which CFHT determines may justify delay, then the Contract Time shall be extended by Change Order for such reasonable time as CFHT may determine, subject to the provisions of Section 7.4.

ARTICLE 6 – LIQUIDATED DAMAGES

In case of the failure on the part of Contractor to complete the Work or portions of the Work, as specified within the time specified and agreed upon, CFHT will be damaged thereby. The amount of said damages, inclusive of expenses for inspection, superintendence and necessary traveling expenses, being difficult if not impossible of definite ascertainment and proof, it is hereby agreed that the amount of such damages shall be the sum of \$750 (seven hundred fifty dollars) for each calendar day which the Contractor has delayed in completing the work or specified portions thereof.

Contractor hereby agrees that said sum shall be paid as liquidated damages and not by way of penalty, and in case the same are not paid they shall be deducted from monies due or that may become due to the Contractor under the agreement.

GENERAL CONDITIONS

ARTICLE 7 – GENERAL PROVISIONS

§7.1 The Contract

The Contract Documents, taken together, shall constitute the entire agreement between the parties pertaining to the subject matter hereof and supersede all other agreements, documentation, understandings, negotiations and discussions, whether oral or written, prior to the date of the coming into force and effect of this agreement, ~~whether oral or written~~, of the parties and there are no warranties, representations or agreements between the parties in connection with the subject matter of the Contract Documents except as specifically set forth therein.

The Contractor, by signing this Agreement, acknowledges that it has independently assured itself that all of the contract documents enumerated in Article 3 have been provided to the Contractor and represents that it has carefully examined all such documents. The Contractor agrees that the contract documents shall be considered a part of this Agreement by reference thereto and the Contractor agrees to be bound to CFHT by the terms and provision of the contract documents so far as they apply to the Work, unless otherwise provided herein.

Each of the parties shall execute such further and other documents and instruments and other things as may be necessary to implement and carry out the intent of this Agreement.

A waiver of a breach of a provision of this Agreement shall not be binding upon any party unless it is in writing and signed by an authorized representative of the waiving party and delivered to the other party. A waiver by any party shall not constitute a continuing waiver and a waiver of one provision shall not constitute a waiver of any other provision.

~~If any provision of this Agreement is declared by a court of competent jurisdiction to be invalid, such provision shall be severed from the Agreement and the other provisions shall remain in full force and effect.~~

Subject to the provisions of Article 10, if it is determined by Arbitration or a court of competent jurisdiction that any provision of this Contract is invalid or unenforceable, such provision will be adjusted rather than voided, if possible, so that it is enforceable to the maximum extent possible, or, if it is not possible to so adjust such provision, this Contract shall be construed in all respects as if such invalid or unenforceable provision were omitted. The invalidity and unenforceability of any particular provision of this Contract shall not affect any other provision hereof, and all other provisions of the Contract shall be valid and enforceable to the fullest extent possible.

The Contractor is solely responsible for the performance of the Contract in every respect, in accordance with the normal custom of the trade. The Contractor will draw CFHT's attention to any element that could impede a good performance of the contract, especially by giving at any time any suitable information for this purpose.

This Agreement shall inure to the benefit of and be binding on the parties, their successors and permitted assignees.

§7.2 The Contract Documents

The Contract Documents consist of this Agreement and any Exhibits attached hereto, Conditions of the Contract (General, Special, and other Conditions), Drawings, Specifications, and all Modifications issued subsequent thereto. These form the Contract, and all are as fully a part of the Contract as if attached to this Agreement or repeated herein. An enumeration of the Contract Documents appears in Article 3.

In the event of discrepancies between the articles of the Agreement and any other document forming part of this Agreement, the articles of the Agreement shall govern. In the case of conflict, the order of priority for the supplementary documents is the same order as listed in Article 3. Should the Contractor discover any discrepancy or conflict between the various documents relating to this Agreement or to the Work, he shall request clarification from CFHT's technical authority. Work performed before authorization by CFHT's technical authority will be at Contractor's risk.

§7.3 Execution of the Contract

This Agreement shall be of force and effect when it shall have been executed by both parties.

Execution of the Contract by the Contractor is a representation that the Contractor has (a) visited the site, (b) become generally familiar with local conditions under which the Work is to be performed, and (c) correlated ~~personal on-site~~ observations with requirements of the Contract Documents.

§7.4 Amendments and Change Orders

This agreement may not be amended or modified except by instrument in writing duly executed by the authorities of both parties specified respectively in Article 18 of this agreement. This agreement shall not be amended, modified or supplemented by oral agreement between the parties.

CFHT may request any modifications to the Work that it deems desirable, provided the stage reached in the performance of the Work so allows. No such modification shall entail a reduction in the extent of the Contractor's warranties. Contractor shall make CFHT aware in writing of any consequences which a modification may entail. If CFHT exercises its right of modification, a written Change Order shall include the technical modifications involved and their effect on the completion dates, on the price and on the warranties.

The Contractor may propose to CFHT modifications designed to improve the conditions of performance of the agreement or the quality of the Work. If accepted by CFHT, a written Change Order or written Construction Change Directives shall include the technical modifications and their implications.

The cost or credit to CFHT from a change in the Work shall be determined by mutual agreement of the parties or, in the case of a Construction Change Directive by the Contractor's cost of labor, material, equipment, and reasonable overhead and profit. Such changes in the Work shall be authorized by written Change Order signed by CFHT and Contractor, or by written Construction Change Directives signed by CFHT.

If concealed or unknown physical conditions are encountered at the site that differ materially from those indicated in the Contract Documents or from those conditions ordinarily found to exist, the Contract Sum and Contract Time shall be equitably adjusted.

ARTICLE 8 – CFHT’S RIGHTS AND OBLIGATIONS

§8.1 CFHT’s Right to Stop Work

If the Contractor fails to correct Work that is not in accordance with the requirements of the Contract Documents, or persistently fails to carry out the Work in accordance with the Contract Documents, CFHT may issue a written order to the Contractor to stop the Work, or any portion thereof, until the cause for such order is eliminated; however the right of CFHT to stop the Work shall not give rise to a duty on the part of CFHT to exercise this right for the benefit of the Contractor or any other person or entity.

§8.2 CFHT’s Right to Carry Out the Work

If the Contractor defaults or persistently fails or neglects to carry out the Work in accordance with the Contract Documents, or fails to perform a provision of the Contract, CFHT, after 10 days' written notice to the Contractor and without prejudice to any other remedy CFHT may have, may make good such deficiencies and may deduct the reasonable cost thereof, including CFHT's expenses made necessary thereby, from the payment then or thereafter due the Contractor.

ARTICLE 9 – CONTRACTOR’S RIGHTS AND OBLIGATIONS

§9.1 Supervision and Construction Procedures

The Contractor shall supervise and direct the Work, using the Contractor's best skill and attention. The Contractor will be solely responsible for and have control over analysis, design, fabrication, and installation means, methods, techniques, sequences and procedures, and for coordinating all portions of the Work under the Contract.

The Contractor shall be responsible to CFHT for acts and omissions of the Contractor's employees, Subcontractors and their agents and employees, and other persons or entities performing portions of the Work for or on behalf of the Contractor or any of its Subcontractors.

§9.2 Labor and Materials

Unless otherwise provided in the Contract Documents, the Contractor shall provide and pay for labor, materials, equipment, tools, construction equipment and machinery, transportation, and other facilities and services necessary for proper execution and completion of the Work whether temporary or permanent and whether or not incorporated or to be incorporated in the Work.

The Contractor shall not request the loan or use of any tools or equipment from CFHT or anyone directly or indirectly employed by CFHT.

The Contractor shall enforce strict discipline and good order among the Contractor's employees, employees of Sub-contractors, sub-tier Sub-contractors, and other persons carrying out the Contract. The Contractor shall not permit employment of unfit persons or persons not skilled in tasks assigned to them.

§9.3 Warranty

The Contractor warrants to CFHT that materials and equipment furnished under the Contract will be of good quality and new, unless otherwise required or permitted by the Contract Documents, that the Work will be free from defects not inherent in the quality required or permitted, and that the Work will conform to the requirements of the Contract Documents. Work not conforming to these requirements, including substitutions not properly approved and authorized in writing, may be considered defective.

The Contractor's warranty excludes remedy for damage or defect caused by abuse, modifications not executed by the Contractor, improper or insufficient maintenance, improper operation or normal wear and tear and normal usage.

§9.4 Taxes

The Contractor shall pay sales, consumer, use and other similar taxes that are legally enacted when bids are received or negotiations concluded.

§9.5 Permits, Fees and Notices

The Contractor shall secure and pay for building permits, other permits and governmental fees, licenses and inspections necessary for proper execution and completion of the Work.

The Contractor shall comply with and give notices required by laws, ordinances, rules, regulations and lawful orders of public authorities applicable to performance of the Work.

If the Contractor performs Work knowing it to be contrary to laws, statutes, ordinances, building codes, and rules and regulations without such written notice to CFHT, the Contractor shall assume ~~appropriate~~ responsibility for such Work and shall bear the costs attributable to correction.

§9.6 Use of Site

The Contractor shall confine operations at the site to areas permitted by law, ordinances, permits and the Contract Documents and shall not unreasonably encumber the site with materials or equipment.

§9.7 Access to Work

The Contractor shall provide CFHT access to the Work in preparation and progress wherever located.

§9.8 Indemnification

All Work covered by this Contract shall be at the risk of Contractor alone.

To the fullest extent permitted by law, Contractor shall indemnify, defend and hold harmless:

- a) CFHT,
- b) the State of Hawaii, and
- c) all of their officers, directors, shareholders, partners, employees, agents, representatives, members, political subdivisions, affiliated entities, agents, representatives, successors and assigns,

from and against any and all claims, demands, losses, liabilities, damages, actions, causes of action, fines, penalties, costs, and/or expenses (including attorney's fees) for property damage, personal injury, and/or death (including those made by, or arising out of injuries or death to, employees of Contractor, Subcontractors, and all sub-tier Subcontractors, and vendors, regardless of whether Chapter 396, Hawaii Revised Statutes or any other worker's compensation laws applies to such claim) arising directly or indirectly out of: (a) the Work, (b) the operations conducted by Contractors, its Subcontractors, sub-tier Subcontractors, and/or its vendors, or (c) the obligations of Contractor under this Contract, regardless of whether the concurrent negligence of any indemnitee is alleged.

Contractor's obligations under this Article encompass, but are not limited to, CFHT's indemnity obligations to the State of Hawaii and its departments, divisions, and/or subdivisions (such indemnity obligations shall include, but are not limited to those imposed upon CFHT under a letter by and between the State of Hawaii, Department of Land and Natural Resources and CFHT).

Contractor's obligations under this Article are ineffective as to any indemnitee when such indemnitee is found to be solely negligent.

~~The Contractor and its successors and assigns shall indemnify, protect, defend and hold CFHT, the State of Hawaii and all of their officers, directors, shareholders, partners, employees, agents, representatives, successors and assigns, harmless from and against any loss, liability, claim, or demand for property damage, personal injury, and death arising out of any act or omission of the Contractor, its subcontractors, its suppliers or any of their successors, assigns, officers, employees, contractors and agents under this action or relating to or connected with this action.~~

~~In addition, to the fullest extent permitted by law, the Contractor shall defend, indemnify and hold harmless CFHT, the State of Hawaii and all of their officers, directors, shareholders, employees, partners, members, political subdivisions, affiliated entities, agents, representatives, successors and assigns from and against all claims, demands, liabilities, damages, actions, causes of actions, fines, penalties, losses, costs and expenses (including attorney's fees) arising out of or related to the performance of the Work, including, but not limited to CFHT's indemnity obligations to the State of Hawaii and its departments, divisions, and/or subdivisions (such indemnity obligations shall include, but are not limited to those imposed upon CFHT under a letter by and between the State of Hawaii, Department of Land and Natural Resources and CFHT).~~

ARTICLE 10 - CLAIMS AND DISPUTES

In the event of any dispute arising in connection with the performance of this agreement, the parties shall make every effort to settle the difference amicably. Should this prove unsatisfactory to either party, then the parties shall endeavor to resolve their disputes by mediation which, unless the parties mutually agree otherwise, shall be in accordance with the Mediation Rules, Procedures and Protocols of the Dispute Prevention & Resolution, Inc. ~~currently then~~ in effect. Request for mediation shall be filed in writing with the other party to this Agreement and with the Dispute Prevention & Resolution, Inc. in Honolulu, Hawaii. The request may be made concurrently with the filing of a demand for arbitration but, in such event, mediation shall proceed in advance of arbitration or legal or equitable proceeding, which shall be stayed pending mediation for a period of 60 days from the date of filing, unless stayed for a longer period by agreement of the parties or court order.

~~All c~~laims, disputes and other matters in question arising out of or relating to the Contract that are not resolved by mediation, shall be decided by binding arbitration pursuant to Chapter 658A, Hawaii Revised Statutes, which, unless the parties mutually agree otherwise, shall be in accordance with the Rules, Procedures and Protocols Rules of the Dispute Prevention & Resolution, Inc. currently in effect, except that nothing in this Contract shall in any way limit, or constitute a waiver of the right of any party to obtain equitable or injunctive relief from the Third Circuit Court, State of Hawaii, which shall have exclusive jurisdiction, of any such claim. The demand for arbitration shall be filed in writing with the other party to this Agreement and with the Dispute Prevention & Resolution, Inc. and shall be made within a reasonable time after the dispute has arisen. The award rendered by the sole arbitrator ~~or arbitrators~~ shall be final, and the judgment may be entered upon it in accordance with applicable law in any court having jurisdiction thereof. Except by written consent of the person or entity sought to be joined, no arbitration arising out of or relating to the Contract Documents shall include, by consolidation, joinder or in any other manner, any person or entity not a party to the Agreement under which such arbitration arises, unless it is shown at the time the demand for arbitration is filed that (1) such person or entity is substantially involved in a common question of fact or law, (2) the presence of such person or entity is required if complete relief is to be accorded in the arbitration, and (3) the interest or responsibility of such person or entity in the matter is not insubstantial. The agreement herein among the parties to the Agreement and any other written agreement to arbitrate referred to herein shall be specifically enforceable under applicable law in any court having jurisdiction thereof the Third Circuit Court, State of Hawaii, which shall have exclusive jurisdiction to enter judgment or otherwise proceed.

The meeting site for mediation and/or arbitration forums will be held at Kailua-Kona, Hawaii unless another site is mutually agreeable to the parties.

ARTICLE 11 – SUBCONTRACTORS

A Subcontractor is a person or entity who has a direct contract with the Contractor to perform a portion of the Work at the site.

Contracts between the Contractor and Subcontractors shall (1) require each Subcontractor, to the extent of the Work to be performed by the Subcontractor, to be bound to the Contractor by the terms of the Contract Documents, and to assume toward the Contractor all the obligations and responsibilities, including the responsibility for safety of the Subcontractor's Work, which the Contractor, by the Contract Documents, assumes toward CFHT, and (2) allow the

Subcontractor the benefit of all rights, remedies and redress afforded to the Contractor by these Contract Documents.

ARTICLE 12- PROTECTION OF PERSONS AND PROPERTY

§12.1 Safety Precautions and Programs

All activities conducted and all tools, equipment and machinery utilized by Contractor on the premises shall be in accordance with the provisions of the Federal and State of Hawaii Occupational Safety and Health Laws, and any other applicable Federal, State and local statutes, health standards, rules and regulations issued thereunder. The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the performance of the Contract.

The Contractor shall provide adequate, clearly marked barricades, warning signs and notices at all contract work areas for the safety of all persons and property, and protection of the work. The Contractor shall take other reasonable precautions for safety of, and shall provide reasonable protection to prevent damage, injury or loss to:

1. employees of the Contractor, ~~and~~ Subcontractors and sub-tier Subcontractors, and of CFHT on the Work and other persons who may be affected hereby;
2. the Work and materials and equipment to be incorporated therein; and
3. other property at the site or adjacent thereto.

The Contractor shall give notices and comply with applicable laws, ordinances, rules, regulations and lawful orders of public authorities bearing on safety of persons and property and their protection from damage, injury or loss. The Contractor shall promptly remedy damage and loss to property caused in whole or in part by the Contractor, a Subcontractor, a sub-subcontractor, or anyone directly or indirectly employed by any of them, or by anyone for whose acts they may be liable and for which the Contractor is responsible under this Contract, except for damage or loss solely attributable to acts or omissions of CFHT or by anyone for whose acts CFHT may be liable, ~~and not attributable to the fault or negligence of the Contractor~~. The foregoing obligations of the Contractor are in addition to the Contractor's obligations under Section 9.8.

In the event CFHT's technical authority or on-site safety representative becomes aware of an unsafe condition and notifies the Contractor or his representative thereof, the Contractor shall immediately suspend the work affected and remedy the unsafe condition. However, nothing in this Agreement shall be deemed to relieve the Contractor of his sole responsibility for the safe conduct of all his activities under this Agreement.

In addition to the measures and procedures put in place by the Contractor for the safe conduct of his-it's activities, all personnel of the Contractor, Subcontractor, and all sub-tier Subcontractors shall obey and conform to CFHT safety policies and rules while they are on CFHT premises.

§12.2 Environmental Protection

The Contractor shall be solely responsible for the safety of the Work and all persons or property impacted by the Work whether or not such safety is under the control of the Contractor. The Contractor shall obtain all permits and approvals before starting the Work and shall strictly comply with all laws, codes, statutes, requirements, guidelines and standards, including, but not limited to those established by the State of Hawaii – Department of Health, the Occupational Safety and Health Act (OSHA), HI-OSH (including Hawaii Revised Statute Chapter 396) and any and all other governmental or industry standards for operating and maintaining a safe work environment. In the event any fines or penalties are imposed upon CFHT as a result of the work performed by or on behalf of the Contractor, the Contractor shall pay such fines and/or penalties and shall be fully responsible for any resulting damages, costs or expenses.

The Contractor is aware of the sensitive nature of the Mauna Kea environment. The Contractor shall comply with all federal, state and local environmental laws and directives of the University of Hawaii Office of Mauna Kea Management (OMKM) and/or the State of Hawaii Department of Land and Natural Resources (DLNR) provided by CFHT and, in the performance of the Work, shall not release any hazardous materials. In the event of such release, the Contractor shall be solely responsible for all fines, penalties, damages, costs and expenses ("Claims") arising out

of or resulting from such release, and shall protect, defend, indemnify and hold harmless CFHT from any and all associated Claims.

ARTICLE 13 – SURETY BOND

Contractor shall furnish a surety bond, with a surety company acceptable to CFHT, in the full amount of the contract sum, guaranteeing the faithful performance of this agreement and the payment of all lawful wages and all claims of material suppliers and subcontractors engaged on the Work, for a period of not less than ~~1~~2 ~~(one)~~(two) years after completion and acceptance of the Work.

Contractor shall furnish such surety bond within 15 (fifteen) calendar days of the execution of this agreement, ~~but in any event not later than the day before commencement of the Work.~~ If any surety furnished becomes unacceptable to CFHT, or if the contract sum is increased to such an extent that the amount of any bond becomes inadequate in the opinion of CFHT, Contractor shall promptly furnish such additional security as may be required from time to time to protect the interests of CFHT and of persons supplying labor or materials for the Work.

ARTICLE 14 – INSURANCE

The Contractor shall purchase from and maintain in a company or companies lawfully authorized to do business in the jurisdiction in which the Work is located insurance for (a) protection from claims under workers' compensation acts and other employee benefit acts that are applicable, and (b) claims for damages because of bodily injury, including death, and claims for damages, other than to the Work itself, to property that may arise out of or result from the Contractor's operations under the Contract, whether such operations be by the Contractor, a Subcontractor, a sub-tier Subcontractor, or anyone directly or indirectly employed by any of them. This insurance shall be written for not less than limits of liability specified in the Contract Documents or required by law, whichever coverage is greater, and shall include contractual liability insurance applicable to the Contractor's obligations, including but not limited to coverage for claims for personal injury brought by employees of Contractor, Subcontractor, or any sub-tier Subcontractor or on account of death of any such person. Insurance obtained pursuant to this Article must provide coverages co-extensive with the Contractor's obligations under Article 9.8 Indemnification. Certificates of Insurance acceptable to CFHT and certified copies of all policies required under this Article shall be filed with CFHT 30 days prior to commencement of the Work.

Insurance required by this Agreement shall not be canceled or materially changed without giving CFHT 45 days advance written notice. Upon receipt of such notice, CFHT may direct the Contractor to stop or suspend work and may withhold payments otherwise due to Contractor until receipt of evidence of reinstatement or replacement of the required insurance.

Each certificate shall be signed by an authorized representative of the applicable insurer. The certificate for general liability shall indicate whether the form is "occurrence" or "claims made," and if it is "claim made," the retroactive date shall be prior to the effective date of this Agreement.

Subject to CFHT's approval of all underwriters, Contractor shall obtain and maintain at its expense for the duration of this agreement the following minimum insurance covering performance under this Agreement, including work performed by Subcontractors or sub-tier Subcontractors:

1. Worker's Compensation and Employers' Liability Insurance. Workers' compensation insurance shall comply with statutory and regulatory requirements of Hawaii and any other applicable jurisdiction. Employers' liability coverage shall have limits of not less than \$1,000,000.
2. Motor Vehicle Liability and No-fault Insurance. Motor vehicle liability limits shall be at least \$1,000,000 for bodily injury and \$1,000,000 for property damage and shall cover all of Subcontractors' and sub-tier Subcontractors' motor vehicles, owned, not owned, and hired. No-fault coverage shall comply with all statutory and regulatory requirements of Hawaii and any other applicable jurisdiction.
3. Commercial General Liability Insurance. The limits of commercial general liability shall be at least \$2,000,000 per occurrence, with a general aggregate of at least \$2,000,000 on a per-project basis. If not on a per-project basis, the general aggregate limit shall be at least \$4,000,000.

4. Excess (Umbrella Form) Liability Policy. The limits of excess (umbrella form) liability shall be at least \$10,000,000 per occurrence, with an aggregate of at least \$10,000,000 on a per-project basis and following form basis, with coverages not more restrictive than the underlying policies.
5. Design Professional Liability Insurance. The limits of design professional services liability insurance shall be at least \$1,000,000 per claim, with a general aggregate of at least \$1,000,000 on a per-project basis. If not on a per-project basis, the general aggregate limit shall be at least \$2,000,000.

The coverage described in (3) and (4) above shall apply to all of Contractor's operations, completed operations, contractual liability, contingent liability arising out of subcontractors and sub-tier Subcontractors, personal injury liability, and broad form property damage, and shall not exclude hazards of explosion, collapse or underground. The coverage described in (2), (3) and (4) shall be endorsed to name CFHT, the State of Hawaii and their designees as additional insureds with respect to work performed by or on behalf of Contractor and shall indicate that such coverage of the additional insureds shall be at least as broad as the additional insured endorsement form CG2010 11/85 edition or equivalent.

The coverage described in (1), (2), (3), (4) and (5) shall be endorsed to provide: (a) a waiver of subrogation in favor of CFHT, the State of Hawaii, and their designees, (b) a severability of interest provision in favor of the additional insureds, treating each additional insured as if it were their own separate policy, (c) that defense and attorney fees and costs are in addition to liability limits, (d) that the insurance required under this Contract shall be primary and noncontributing to any other similar insurance available to the additional insureds, and (e) to provide additional insured coverage to CFHT, the State of Hawaii, and their designees extending to the end of the warranty period.

~~The Contractor shall purchase from and maintain in a company or companies lawfully authorized to do business in the jurisdiction in which the Work is located insurance for protection from claims under workers' compensation acts and other employee benefit acts that are applicable, claims for damages because of bodily injury, including death, and claims for damages, other than to the Work itself, to property that may arise out of or result from the Contractor's operations under the Contract, whether such operations be by the Contractor or by a Subcontractor or anyone directly or indirectly employed by any of them. This insurance shall be written for not less than limits of liability specified in the Contract Documents or required by law, whichever coverage is greater, and shall include contractual liability insurance applicable to the Contractor's obligations. Certificates of Insurance acceptable to CFHT shall be filed with CFHT prior to commencement of the Work. Insurance required by this Agreement shall not be canceled or materially changed without giving CFHT 30 days advance written notice. Upon receipt of such notice, CFHT may direct the Contractor to stop or suspend work and may withhold payments otherwise due to Contractor until receipt of evidence of reinstatement or replacement of the required insurance.~~

~~Evidence of all required insurance, including specific provisions and endorsements, shall be provided in certificates of insurance, with copies of specific endorsements attached, furnished to CFHT prior to Contractor commencing work or preparing or delivering material, or equipment to the work site. Each certificate shall be signed by an authorized representative of the applicable insurer. The certificate for general liability shall indicate whether the form is "occurrence" or "claims made," and if it is "claim made," the retroactive date shall be prior to the effective date of this Agreement. Upon written request from CFHT, the Contractor shall provide certified copies of any required insurance policies.~~

~~Subject to CFHT's approval of all underwriters, Contractor shall obtain and maintain at its expense for the duration of this agreement the following insurance covering performance under this Agreement, including work performed by Subcontractors:~~

- ~~1. Worker's Compensation and Employers' Liability Insurance. Workers' compensation insurance shall comply with statutory and regulatory requirements of Hawaii and any other applicable jurisdiction. Employers' liability coverage shall have limits of not less than \$1,000,000.~~
- ~~2. Motor Vehicle Liability and No fault Insurance. Motor vehicle liability limits shall be at least \$1,000,000 for bodily injury and \$1,000,000 for property damage and shall cover all of Subcontractor's motor vehicles, owned, not owned, or hired. No fault coverage shall comply with all statutory and regulatory requirements of Hawaii and any other applicable jurisdiction.~~
- ~~3. Commercial General Liability Insurance. The limits of commercial general liability shall be at least \$1,000,000 per occurrence, with a general aggregate of at least \$1,000,000 on a per project basis. If not on a per project basis, the general aggregate limit shall be at least \$2,000,000.~~

~~4. Excess (Umbrella Form) Liability Policy. The limits of excess (umbrella form) liability shall be at least \$10,000,000 per occurrence, with an aggregate of at least \$10,000,000 on a per project basis and following form basis, with coverages not more restrictive than the underlying policies.~~

~~The coverage described in (3) and (4) above shall apply to all of Contractor's operations, completed operations, contractual liability, contingent liability arising out of subcontractors, personal injury liability, and broad form property damage, and shall not exclude hazards of explosion, collapse or underground. The coverage described in (2) and (3) shall be endorsed to name CFHT and its designees as additional insureds with respect to work performed by or on behalf of Contractor and shall indicate that such coverage of the additional insureds shall be at least as broad as the additional insured endorsement form CG2010-11/85 edition or equivalent. The additional insureds shall be primary and noncontributing to any other similar insurance available to the additional insureds. The coverage described in (1) and (3) shall be endorsed to include a waiver of subrogation in favor of CFHT and its designees. A copy of the additional insured endorsement and waiver of subrogation endorsement shall be attached to the certificate of insurance filed with CFHT.~~

ARTICLE 15 - CORRECTION OF WORK

The Contractor shall promptly correct Work rejected by CFHT or determined by CFHT to failing to conform to the requirements of the Contract Documents, whether discovered before or after Substantial Completion and whether or not fabricated, installed or completed. Costs of correcting such rejected Work shall be at the Contractor's expense.

In addition to the Contractor's obligations under Section 9.3, if, within two (2) years after the date of Substantial Completion of the Work or designated portion thereof or after the date for commencement of warranties established under Section 4.2, or by terms of an applicable special warranty required by the Contract Documents, any of the Work is found to be not in accordance with the requirements of the Contract Documents, the Contractor shall correct it promptly after receipt of written notice from CFHT to do so unless CFHT has previously given the Contractor a written acceptance of such condition. CFHT shall give such notice promptly after discovery of the condition. During the period for correction of Work, if CFHT fails to notify the Contractor and give the Contractor an opportunity to make the correction, CFHT waives the rights to require correction by the Contractor and to make a claim for breach of warranty.

If the Contractor fails to correct nonconforming Work within a reasonable time, CFHT may correct it in accordance with Section 8.2.

The period for correction of Work shall be extended with respect to portions of Work completed after Substantial Completion by the period of time between Substantial Completion and the actual performance of the correction of Work.

The period for correction of Work shall not be extended by corrective Work performed by the contractor pursuant to this Article 15.

ARTICLE 16 - MISCELLANEOUS PROVISIONS

§16.1 Assignment of Contract

Neither party to the Contract shall assign the Contract without written consent of the other. Where an assignment of this Contract is made, such assignment shall not relieve a party from any obligation under this Contract or impose any liability upon the other party.

§16.2 Governing Law

The Contract shall be governed by the laws of the State of Hawaii.

§16.3 Commencement of Statutory Limitation Period

As between CFHT and the Contractor, any applicable statute of limitations shall commence to run and any alleged cause of action shall be deemed to have accrued:

1. not later than the date of Substantial Completion for acts or failures to act occurring prior to the relevant date of Substantial Completion;
2. not later than the date of issuance of the Final Payment for acts or failures to act occurring subsequent to the relevant date of Substantial Completion and prior to the issuance of the Final Payment; and
3. not later than the date of the relevant act or failure to act by the Contractor for acts or failures to act occurring after the date of the Final Payment.

ARTICLE 17 - TERMINATION OF THE CONTRACT

§17.1 Termination by the Contractor

If CFHT fails to make payment for a period of 30 days through no fault of the Contractor, the Contractor may, upon seven additional days' written notice to CFHT, terminate the Contract and recover from CFHT payment for Work executed and for proven loss with respect to materials, equipment, tools, and construction equipment and machinery, including reasonable overhead, profit and damages applicable to the Contract.

§17.2 Termination by CFHT

CFHT may terminate the Contract:

1. if the Contractor:
 - a. persistently or repeatedly refuses or fails to supply enough properly skilled workers or proper materials;
 - b. fails to make payment to Subcontractors for materials or labor in accordance with the respective agreements between the Contractor and the Subcontractors;
 - c. persistently disregards laws, ordinances, or rules, regulations or orders of a public authority having jurisdiction; or
 - d. defaults in performance in accordance with the terms of this agreement; or
2. whenever CFHT shall determine that such termination is in its best interest.

When any of the above reasons exists, CFHT, may, without prejudice to any other remedy CFHT may have and after giving the Contractor 7 (seven) days' written notice, terminate the Contract and take possession of the site and of all materials, equipment, tools, and construction equipment and machinery thereon owned by the Contractor and may finish the Work by whatever reasonable method CFHT may deem expedient. Upon request of the Contractor, CFHT shall furnish to the Contractor a detailed accounting of the costs incurred by CFHT in finishing the Work.

When CFHT terminates the Contract for one of the reasons stated in this Section 17.2, the Contractor shall not be entitled to receive further payment until the Work is finished.

If the unpaid balance of the Contract Sum exceeds costs of finishing the Work, and other damages incurred by CFHT and not expressly waived, such excess shall be paid to the Contractor. If such costs and damages exceed the unpaid balance, the Contractor shall pay the difference to CFHT. The amount to be paid to the Contractor or CFHT, as the case may be, shall survive termination of the Contract.

§17.3 Termination by either Party

In the event of termination of this agreement under Sections 17.1 or 17.2, then the Contractor shall deliver to CFHT all designs, analysis, documents, parts, supplies, work in progress, work completed and other material goods acquired or produced for the performance of this agreement with monies paid by CFHT.

§17.4 Continuing Obligations

For Section 9.3, Section 9.8, Article 10, Article 11, Section 12.2, Articles 13 through 15, Section 16.2 and Section 16.3, the obligations of the parties hereto, including but not limited to the obligations of subcontractors and sub-tier Subcontractors, shall survive termination or expiration of this Contract and completion of the Work.

ARTICLE 18 – CONTRACTING AUTHORITY

§18.1 CFHT’s Contracting Authority

The authority designated by CFHT for all matters relating to this Agreement is the

Executive Director
Canada-France-Hawaii Telescope Corporation
65-1238 Mamalahoa Highway
Kamuela, HI 96743

This authority is the only person authorized to approve changes in this Agreement on behalf of CFHT.

§18.2 CFHT’s Technical Authority

The technical authority designated by CFHT for the purpose of providing directions to the Contractor with respect to the detailed technical aspects of performance under this Agreement is

Director of Engineering
Canada-France-Hawaii Telescope Corporation
65-1238 Mamalahoa Highway
Kamuela, HI 96743

CFHT may replace the individual designated as technical authority at any time by notifying Contractor in writing.

In no event shall CFHT be bound by any understanding, modifications or other matter deviating from the terms of this Agreement unless formalized by instrument executed in accordance with Article 6.4 of this Agreement.

§18.3 Contractor’s Contracting Authority

The authority designated by the Contractor for all matters relating to this Agreement is

[Name, Title and mailing address]

This authority is the only person authorized to approve changes in this Agreement on behalf of the Contractor.

ARTICLE 19 - OTHER CONDITIONS OR PROVISIONS

This Agreement entered into as of the day and year first written above.

OWNER: Dr. Christian Veillet,
Executive Director

CONTRACTOR: _____,
Title

SCHEDULE "A"

SPECIAL CONDITIONS

THE ANALYSIS, DESIGN, FABRICATION, SHIPPING, INSTALLATION AND DOCUMENTATION
OF VENTS FOR THE ENCLOSURE OF THE
CANADA-FRANCE-HAWAII TELESCOPE CORPORATION
OBSERVATORY FACILITY ON THE SUMMIT OF MAUNA KEA

[Date]

1. Project approval

At the point that the contract will be executed, CFHT will have received approval to proceed on the subject project under specific conditions established by the State of Hawaii Department of Land and Natural Resources (DLNR) and the University of Hawaii Office of Mauna Kea Management (OMKM). *[Special conditions to be listed here.]*

2. Site location and conditions

CFHT site is located on the Mauna Kea Science Reserve, a State of Hawaii conservation district. The Contractor is responsible for strictly adhering to those conditions as listed in the Contract and as required under State regulations pertaining to conservation districts and to the conditions related to work undertaken on Mauna Kea. The OMKM Rangers have the authority to visit and monitor the construction activities. All instructions and requests by the OMKM Rangers shall be complied with immediately and the Contractor shall immediately inform CFHT of all such requests and communications.

CFHT observatory is located at an altitude of approximately 13,800 ft. The weather is unpredictable and often harsh. The daytime temperature during the contract period is expected to be in the low 40s, but may drop to freezing or rise to the low 50s. High wind velocities are frequent, occasionally reaching values of more than 100 mph. Ultraviolet radiation levels are high.

Efforts requiring extensive work outside the CFHT building should not be scheduled during the months of November through March due to the high frequency of inclement weather and likely accumulation of snow and ice on the dome skin during this period.

Operations at Mauna Kea observatories will be on-going during the construction period. It is important that the Work set forth in the contract documents be performed efficiently and be of high quality to minimize disruption to the environment. The Contractor, at its sole cost and expense, is fully responsible to take measures to minimize or eliminate any interference, harm, hazard, dust, noise or nuisance. The Contractor shall not cause damage to the grounds, existing utilities or any improvements and shall not cause damage or injury to any person.

The Work must be performed during hours that an authorized representative of CFHT is on site. CFHT has designated the Operations Manager, or his designate, as CFHT authorized representative to coordinate the scheduling of the Work.

3. Altitude and medical emergencies

Be advised that because of geographical location and altitude, not all individuals are physically suited to work near the summit of Mauna Kea.

Due to the altitude and the lack of nearby medical response, a two-man rule applies. This rule requires that the Contractor have at least two individuals and a vehicle available for emergency evacuation whenever the Contractor's staff is on site. Both individuals must be able to respond in an emergency, to summon help, and to drive the vehicle.

4. Lodging and food

Lodging at the 9,200 ft. mid-level facility, Hale Pohaku, shall be provided by CFHT free of charge to the Contractor's crew on nights between consecutive days when work is performed. It is recommended that, for best acclimatization, the crew stay at the mid-level facility on such nights.

Lodging reservations include a dinner meal on the night of the reservation and a breakfast and lunch the following day. For the Contractor's crew members that do not lodge at Hale Pohaku, a lunch-time meal will be provided by CFHT free of charge at the summit lunch facility on days when work is performed.

CFHT must make advance reservations for lodging and all meals; therefore, the Contractor must provide the names and dates for such reservations by 14:00 on Fridays for the following week's reservations.

5. Travel

All costs associated with travel by the Contractor or personnel hired within the scope of the Agreement will be borne by the Contractor.

All costs associated with travel by CFHT staff or personnel hired outside the scope of the Agreement will be borne by CFHT.

6. Facilities

The Contractor shall be permitted to make use of the following facilities in CFHT observatory:

- a. existing sanitary facilities and shall keep them sanitary at all times;
- b. the staff lounge for reasonable rest periods; and
- c. telephones for reasonable use.

7. Use of cranes

Should the need arise, cranes in the CFHT building will be made available to the Contractor upon 5 days' advance notice, with the proviso that all crane operations be performed by authorized CFHT staff. All rigging and load handling will remain the responsibility of the Contractor.

8. Utilities

CFHT can supply electrical power. Low pressure air is available, but the capacity of the compressors is limited. Therefore the supply of high-volume compressed air and related hoses and power cords is the Contractor's responsibility.

Availability of water is limited to that in our storage tanks, less our needs. The capacity of the water storage tanks is 12,000 gallons. CFHT will cease making water available to the Contractor when the water tank level drops below 5,000 gallons. It is the Contractor's responsibility to monitor water usage and to notify CFHT Observatory Facility Manager at least 5 working days prior to any anticipated shortfall.

9. Access to building

The Contractor is responsible for keeping a clear access path for CFHT vehicles and delivery trucks to both the front door (South) and hatchway door (East). Occasional periods of blocked access to either one of these areas are acceptable, however these must be coordinated in advance with CFHT technical authority or his designate.

Access to CFHT building shall be provided by CFHT staff. Should the need arise, the Contractor's on-site supervisor shall be provided with a key to the building, which is to be returned at the end of each work day.

10. Work schedule and coordination with others

CFHT observatory dome houses a working telescope. The Contractor shall coordinate his work with CFHT's technical authority or the individual on site designated by CFHT's technical authority for such coordination.

The Contractor shall schedule site work for not less than 5 (five) 8-hour days or 4 (four) 10-hour days in a calendar week. CFHT may, for operational or any other reason, designate certain days on which work may not be performed. CFHT shall notify the Contractor of such designations in writing not less than 3 (three) working days in advance.

Working hours will be limited to daylight, non-astronomical observing hours as determined by CFHT's technical authority. No work shall be performed unless CFHT staff is present on site. Generally, work will be permitted between 07:00 and 16:00. All clean-up must be completed by 16:00.

Occasional work interruptions may occur when the dome has to be rotated for daytime observatory operations. Any interruptions lasting more than one-half (1/2) hour will be scheduled with the Contractor as much in advance as possible.

The Observatory Facility Manager is scheduled to work 4 days per week, usually Tuesday through Friday. During weeks with a statutory holiday, the week contains 3 working days. The working hours are 08:30 to 16:30 on the first day of a shift, 07:00 to 16:30 on the middle day(s), and 07:00 to 14:30 on the last day of a shift. CFHT will provide the Contractor with the working schedule of the Observatory Facility Manager during the project period.

CFHT must coordinate all work with the OMKM. Therefore, the Contractor shall provide CFHT Technical Authority all schedules for the Work; schedule changes must be coordinated with CFHT Technical Authority at least 2 working days in advance; one week's advance notice would be advantageous.

11. Equipment and equipment / vent unit storage

The Contractor shall furnish all equipment for accessing the exterior of the dome and for all work related to the cutting of the vent apertures in the dome skin, the installation of any reinforcement or auxiliary structures, and the physical installation of the vent units with the exception that CFHT's interior dome cranes will be provided as outline in Article 7 above.

The number of tie-off points for scaffolding or platforms on the exterior of the dome is limited. Therefore, use of a ground-based manlift is recommended. If the Contractor elects to use equipment that requires the dome structure for support, then it is the Contractor's responsibility to perform all necessary engineering assessments to ensure safe operation and positioning of equipment and personnel; and the Contractor will assume responsibility related to its use.

Unsecured storage of equipment, tools, or supplies for the job outside CFHT building is not permitted. It is suggested that the Contractor keep equipment in an enclosed and locked container on the site adjacent to the Observatory building if it is not going to be transported daily by truck. Vehicles may be parked on the site. Everything stored outside must be secured to be able to withstand high wind gusts (100 mph) and severe weather, and must be placed so as not to interfere with vehicle access to the building.

If necessary, staging areas for large equipment may be made available at lower altitudes on the summit.

To avoid clutter at the summit, the OMKM requires that vent units, which are not expected to be installed promptly, shall be staged at the Hale Pohaku mid-level facility.

12. Working telescope

CFHT dome houses a working telescope. Therefore, at the end of each day, the Contractor shall remove unused materials, equipment and scaffolds from the dome. No scaffolds, rigging or equipment that could interfere with dome rotation or telescope operations shall be permitted to remain in place at the end of the work day as the dome will rotate and the dome shutter will be opened each night.

(The Contractor is asked to comment on the above section if night-by-night telescope operation will not be possible in the vent installation plan or is likely to impose a significant financial burden on CFHT or the Contractor.)

Care must be taken to avoid any loose objects from falling into the dome since they would likely endanger persons and damage equipment.

13. Environmental restrictions and monitoring

As a condition for work on Mauna Kea, all vehicles, trailers, trucks and construction equipment are subject to inspection by the OMKM Rangers for cleanliness and for fuel, oil or coolant leakage. Inadequately cleaned construction equipment can transport unwanted non-native plant seeds and invertebrates, which can each be detrimental to the summit environment. The Contractor is required to power wash all large vehicles and equipment, especially the undercarriages, prior to bringing them to the site each time. No vehicles or equipment with fuel, oil or coolant leaks are acceptable at any time.

14. Hazardous materials

The Contractor shall provide to CFHT all Material Safety Data Sheets (MSDS) for all hazardous materials present at the site at least 2 days prior to their arrival. All hazardous materials transported to the site must be secured in a secondary containment vessel (e.g., cans stored inside 5-gallon pails). Secure storage space for hazardous materials at the observatory is available. The Contractor is responsible for maintaining the storage area clean and free of fire hazards. All materials stored at the site by the Contractor shall remain the property of the Contractor until applied or utilized in the Work.

Should a spill of hazardous materials occur, the Contractor shall immediately notify CFHT.

15. Cleaning Up

The Contractor shall keep the premises and surrounding area free from accumulation of waste materials or rubbish caused by operations under the Contract. Any oil rags, waste, etc. must be secured during performance of the Work and removed from the facilities every night leaving the premises undamaged and clean, and every precaution must be taken to avoid the danger of fire and chemical release. At completion of the Work, the Contractor shall remove from and about the Project waste materials, rubbish, the Contractor's tools, construction equipment, machinery and surplus material. The CFHT and other Mauna Kea facility waste collection receptacles will not be made available for use to the Contractor; the Contractor must provide its own waste collection receptacles.

SCHEDULE "B"

SCOPE OF WORK, DELIVERABLES AND SPECIFICATIONS

FOR THE ANALYSIS, DESIGN, FABRICATION, SHIPPING, INSTALLATION AND DOCUMENTATION
OF VENTS FOR THE ENCLOSURE OF THE
CANADA-FRANCE-HAWAII TELESCOPE CORPORATION
OBSERVATORY FACILITY ON THE SUMMIT OF MAUNA KEA

(this document is available electronically at:
http://www.cfht.hawaii.edu/en/projects/dome_venting/Contract_docs)

[Date]

BACKGROUND

The quality of images delivered by the CFHT telescope is adversely affected by variations in air temperature within the telescope dome. Air temperature differences arise through contact with large structures whose temperatures differ from ambient air as a result of their large thermal inertias and the consequent inability of these structures to follow rapid air temperature changes.

The addition of vents to the CFHT dome is intended to facilitate the passive flushing of interior air by the local wind, thereby greatly reducing air temperature variations, a process that has been successfully demonstrated at other telescope facilities and supported by recent wind and water tunnel tests by CFHT staff.

In brief, the proposed vents consist of:

- 1) Twelve (12) vent units, six on either side of the dome slit shutter track centered at angles of 71.25, 86.25, 101.25, 116.25, 131.25 and 146.25 degrees from the dome slit centerline between vertical structural webs.*
- 2) Individual vents measuring approximately 6.5 ft. (2m) wide by 18 ft. (5.5 m) high, consisting of vertically-acting weather rollup doors and internal louvers and associated drives.*

The exact widths and heights and angular locations of individual vents is not a precise requirement and can vary slightly depending on the bidder's preference and operational or design considerations. The vent width fills the horizontal separation between adjacent internal vertical structural webs. Vent height was set by estimates of the total vent area desired. If dimensional changes are considered, our preference is that the vent height be changed and that the width be maintained as large as possible. Some decrease in vent area is allowable. An increase in vent area is not anticipated.

A 3-D solid model of the dome and telescope showing the proposed vent locations but without vent unit details, generated in AutoDesk Inventor, is available on-line at:

http://www.cfht.hawaii.edu/en/projects/dome_venting/Inventor_model

The original dome design calculations (design brief) are available at:

http://www.cfht.hawaii.edu/en/projects/dome_venting/Design_docs

2-D drawings and images taken from the model are attached in Appendix A to this document.

We believed the Inventor model to be dimensionally accurate but, while it was developed from the original construction drawings and several of the geometries have been confirmed against on-site measurements, critical dimensions should be verified by the bidder. (Details of the webbing of the dome's horizontal and vertical structural members may not be accurate).

Photographs of the dome in its current, no vent condition are also available at:

http://www.cfht.hawaii.edu/en/projects/dome_venting/Dome_images

Videos and reports regarding water tunnel flow studies of a 1:160 scale model of the dome and telescope carried out at the University of Washington water tunnel facility are available at:

http://www.cfht.hawaii.edu/en/projects/dome_venting/Water_tunnel

while graphical results of CFD air flow computations are available at:

http://www.cfht.hawaii.edu/en/projects/dome_venting/CFD

SCOPE OF WORK

The work includes:

- Sufficient analysis of the CFHT dome structure sufficient to ensure the continued safe operation of the CFHT dome and the added vent units;
- Design of twelve (12) identical vent units to the level of shop drawings;
- Fabrication and installation of a vent unit prototype which, if approved, will be considered as one of the 12 delivered units.
- Fabrication and delivery to the CFHT site on Mauna Kea of all vent units, test and installation fixtures and all electro-mechanical hardware required for vent unit installation and operation;
- Installation of the vent units on the CFHT dome structure including weldments, cutting of vent holes in the existing dome skin, installation of all necessary structural reinforcements and the securing and weather sealing the vent units to the dome structure; and
- Provision of all tools, equipment and machinery needed for the handling, erection and installation of the vent units and any associated subsystems, and for their transportation from a local port to the CFHT observatory site at the summit of Mauna Kea.
- Cleanup and removal of all materials, debris etc. generated during installation.

Vent unit bid options:

There are two bid options relating to cabling and sensors on the vents:

- **OPTION A** – requires the procurement and installation of all control sensors and cabling of the vent units by the Contractor.
- **OPTION B** – requires that CFHT procure and install all control sensors and cabling on the vent units.

In either case, all cabling and control beyond the vent unit structures remain the responsibility of CFHT.

Note: Power and signal cable runs on the dome between the vent units and the vent control system and electrical power busses, and the PLC-based vent control system itself will be provided by CFHT and are NOT part of the bidder's scope of work. It is not clear at this time whether these will be in place before or after vent installation on the dome.

An individual vent unit will consist of:

- Vent frames, structural reinforcements, external rollup doors, and internal louvers
- Motors and drive boxes and their mounts sufficient to drive louvers and doors;
- Installation, handling and personnel safety systems and attachment points needed for vent unit handling, installation and ongoing maintenance.

And, if option A of the contract is selected:

- Electrical position sensors and their mounts needed to remotely sense and control each vent unit independently ;
- Cabling (mechanically sheathed) running from motors and sensors to connectors mounted at the lower edge of each vent unit.

DELIVERABLES

Deliverables include:

- A project development schedule updated monthly provided to the CFHT Technical Authority;
- A preliminary and a final design review with associated documents;
- Twelve (12) vent units, complete, operational and installed on the CFHT dome;
- A proof-of-concept prototype installed on the CFHT dome, and any engineering models and mockups as may be required;
- All engineering analysis and calculations used in the design of the vents and in planning their installation;
- All engineering-as-built design and fabrication drawings in MathWorks INVENTOR– readable form–an electronic form acceptable to CFHT;
- Complete list of commercially procured parts with vendor names;
- Two spare drive motors for each motor types used and
- Maintenance and assembly instructions / documents / procedures

And, if Option A of the contract is selected:

- Two spare sensors for all sensors types used; and
- Complete wiring and connector diagrams and connector specifications (if included in the contract)

WORK AND EQUIPMENT TO BE PROVIDED BY CFHT

- CFHT shall provide a PLC-based vent control system.
- CFHT shall design, install and trouble shoot all power and signal cables and wiring between the vent control system, the CFHT slip ring power bars and power and sensor connectors on the vent units.
- CFHT shall provide the vent control high-level software and GUI interface.
- CFHT shall provide a vent status and control logging system.
- Flow directors inboard of louvers for each vent unit (not currently expected.)

And, if Option B of the contract is selected

- CFHT shall specify, provide and install all on-vent power and signal cables and associated sensors and their mounts.
- CFHT shall remove and, after vent unit installation, shall re-install inner dome skin insulation panels at the location of vent units.

DOME VENT SPECIFICATIONS AND REQUIREMENTS

0. Codes and Regulations

Design, materials, manufacture, installation, inspection and testing of equipment covered by this specification shall meet the requirements of the latest editions and revisions of the appropriate publications of the following authorities and technical organizations at the site of installation and time of delivery.

American Gear Manufacturers Association	AGMA
American Society of Mechanical Engineers	ASME
ASTM International	ASTM
American National Standards Institute	ANSI
American Institute of Steel Construction	AISC
American Welding Society	AWS
American Bearing Manufacturers Association	ABMA
Occupational Safety and Health Administration	OSHA
National Electrical Code	NEC
National Electrical Manufacturers Association	NEMA
Nation Fire Protection Association	NFPA
Society of Reliability Engineers	SRE
Uniform Building Code	UBC
Applicable federal, state and local code, regulations and ordinances.	

1. VENT UNITS

1.1 General

Vents will be controlled by a CFHT-provided, PLC-based control system. The control system components will be mounted either on the rotating dome or off the rotating dome, perhaps at remote locations in the building. PLC control programs and higher level control and status interface software will be provided by CFHT. Details of the control system will be developed in cooperation with the successful bidder.

- 1.1.1 The dome vent units, their installation and their operation shall not adversely affect normal dome operations. Structural analysis of the dome and vent units shall be provided to CFHT to confirm that no adverse effect on the structural or operational integrity of the dome or its drives and support systems will result from vent unit installation and operation, and that the full structural integrity and operability of the current dome and its drives will be maintained during vent installation and subsequent operation.
- 1.1.2 The dome structure consists of an outer ¼ inch steel shell, vertical and horizontal internal structural members, and an inner insulation panel shell held in place with a light aluminum grid-work. The vent system design shall avoid modification to the vertical and horizontal internal structural webbing as much as possible.
- 1.1.3 No part of the vent system shall extend more than 12 inches toward the inside of the dome from the inner surface of the dome's insulating shell. Physical interference with structures in the dome will occur when the dome is turned if this requirement is not met, since telescope and dome motions are not synchronized.

- 1.1.4 The vent units and subsystems shall be designed for a minimum operational life of twenty (20) years with maintenance.
- 1.1.5 Mauna Kea is located in Seismic Zone 4 defined in the County of Hawaii Building Code. (ref. <http://www.co.hawaii.hi.us/countycode/chapter05.pdf> Section 5-1.0.69.a) Vent units and modifications to the CFHT dome shall be designed to a level that will ensure their continued normal operation in the case of a 20-year seismic event.
- 1.1.6 All components shall individually be designed or specified for a minimum operating time before major maintenance of five (5) years.
- 1.1.7 All vent components will possibly fail at some point in their operational life. Therefore, vent unit design and construction shall provide access and means to repair and / or replace all moving components, their supports and housings and all fixed sensor and mounts and all wiring runs.
- 1.1.8 Full access for maintenance of all vent unit systems shall be provided from within the interior of the dome with the weather doors fully closed.
- 1.1.9 The vent system design shall maximize access for component repair and replacement from within the dome environment since inclement weather is often associated with equipment failure, and CFHT maintains no means or equipment for routine access to the outside surface of the dome skin. Access to systems lower on the vent unit will in general be easier than for systems higher on the vent units.
- 1.1.10 Vent units shall be curved to follow the dome's vertical circular profile in order to minimize their exterior visual impact. The degree of vent unit extension beyond the outer skin of the dome shall be minimized both for aesthetics and for the practical need to minimize wind-related noise and turbulence.
- 1.1.11 Each vent unit shall consist of at least:
- 1) A frame to interface the unit to the steel CFHT dome skin;
 - 2) Vertically-acting, motor-driven, rollup weather door;
 - 3) Bracing as needed for support of the weather door against wind and ice loads;
 - 4) A set of horizontal louvers mounted internally to the weather door;
 - 5) Mounting points (tapped holes) on the inside face of the vent units, to accommodate the mounting of light-weight flow deflectors between the rollup doors and the louvers envisioned for possible future installation;
 - 6) Motors, drive boxes and their mounts needed to actuate weather doors and louvers;
 - 7) A means of access from inside the telescope dome to all functional vent unit components as needed for component replacement and maintenance by CFHT staff;
 - 8) A means for the natural drainage of accumulated water at the bottom of vent units; and
 - 9) An external horizontal structure (ice deflector) secured to the outer dome skin above each vent aperture to protect vent units from ice falling or sliding from dome surfaces above the vent unit.
- And, if contract Option A is selected:
- 10) Electronic sensors needed to remotely control and sense vent unit rollup door and louver positions and the correct or faulted vent unit operation and status;
 - 11) Mechanically sheathed electrical cabling from all motors and sensors to connectors on the lower edges of the vent units;
- 1.1.12 All vent units shall be identical and interchangeable. COTS components are preferred where available.
- 1.1.13 The outer vent system interface to the dome interior structures shall be fully weather sealed when vent rollup doors and louvers are fully closed.
- 1.1.14 The vent opening 'tunnel' from the outer dome skin to the dome interior through the space between the outer and inner dome skins shall be fully sealed from the 24 inch thick inter-skin cavity.

- 1.1.15 Each vent unit shall be provided with all motors and gearboxes, and in the case of contract Option A, all limit switches and sensing devices needed for safe and reliable remote rollup door and louver operation and status sensing.
- 1.1.16 Frames supporting the louvers and the rollup doors shall be separate units and can be mounted independently, so long as the vent cavity is fully isolated from the inter-skin volume.
- 1.1.17 Clearance of at least 18 inches shall be provided between the rollup doors and the louvers in order to accommodate possible future flow director installation.
- 1.1.18 Each vent unit shall be provided with exterior drainage from the bottom of the vent unit in order to direct water from melting snow and ice that may have accumulated between the outer rollup doors and the inner louvers.
- 1.1.19 Each vent unit rollup door and each louver system shall be individually controllable and shall return individual status signals to the CFHT-provided vent controller in order to provide maximum control flexibility.

Due to possible power limitations, the desire to configure some vents differently from other or to minimize the cost and complexity of the control environment, CFHT may elect to operate certain of the vents units in a ganged or parallel manner in which a subset of vent rollup doors or louvers receive control commands either simultaneously or in sequence.

- 1.1.20 Vent units will be exposed to heavy ice loads and to the impact of ice located higher on the outer dome skin as it slides off when melting. To protect the vent units, a robust ice shield shall be integrated into the vent unit itself or shall be attached separately to the dome skin above the vent aperture. In either case, the protective structures shall be considered to be part of the vent unit.

Vent air flow would be assisted if the ice deflectors form a continuous ring located immediately above the vent apertures. This geometry should be considered if the cost impact is not high.

- 1.1.21 Vent rollup door and louver actuation shall be motorized in both directions. It is not permissible to rely solely on the force of gravity for either the opening or the closing operation. In case of drive system failure, should the rollup doors move under their own weight or other action, this motion shall be in a direction which will close the door.
- 1.1.22 Vent rollup doors, under conditions of moderate to high winds, may shake to a degree that will result in an unacceptably high noise level within the dome. Consideration shall therefore be made in the vent unit design to limit door rattle and wind howl.

Note: Many types of rubber degrade rapidly at the summit of Mauna Kea. Rubber is therefore not recommended for noise abatement or other applications.

- 1.1.23 Mounting posts shall be provided near the center of each vent for air speed and temperature probes to be provided and installed by CFHT at some later date.

And if contract Option A is selected:

- 1.1.24 All control and sensing cables shall terminate at robust electrical connectors integrated into the lower vent unit structure.
- 1.1.25 All cabling between electrical devices up to and including termination connectors shall be provided and mounted in place.

1.2 **Rollup weather doors**

The rollup weather doors are meant to provide most of the necessary weather protection for the dome interior and to carry, possibly with the addition of internal bracing, loads associated with wind, snow and ice. The secondary use of the weather doors will be to provide gating of air flow when a vent faces directly into the wind.

1.2.1 The vent units, and the roll-up doors in particular, when fully closed, shall withstand wind speeds up to 125 mph at all dome orientations without damage or substantial leakage of wind-driven precipitation. When closed, Rollup weather door mechanisms must withstand effects of the following maximum structure design live loads applied to the rollup doors:

- 79 lbs per sq ft wind load acting radially outward from dome center
- 58 lbs per sq ft wind acting in any horizontal direction
- 30 lbs per sq ft ice load uniformly distributed acting vertically downward

(per CFHT Mechanical Engineering Design Criteria, Shutter Mechanisms, p 7 – S.N.C. – 1975)

1.2.2 *In operation, vent rollup door positions will be moved between any of 4 positions (fully open, 2/3 open, 1/3 open, fully closed) throughout the night as the individual vent-to-wind angles change several times each hour between sunset and sunrise. Very little operation is expected during daylight hours during which the vent doors will normally be closed.*

Vent rollup door systems shall be designed to operate between any of these positions, at a minimum, for an average of ten (10) partial or complete openings and ten (10) partial or complete closings per night for an average of three hundred (300) nights per year over a twenty (20) year life.

1.3 **Louvers**

The vent unit louvers have the dual function of directing air flow into the dome, and providing backup secondary weather protection for the dome interior in case of weather penetration or failure of the rollup doors.

1.3.1 Each vent unit shall be provided with a set of horizontal, fully sealable louvers interior to the roll up weather door.

1.3.2 Louvers shall be mounted on a separate, removable frame providing 18 inch clearance between the louvers and the rollup doors to accommodate possible future flow director installation. *(This provision is in effect only if the requirement for a separate frame and gap do not materially increase unit price).*

1.3.3 The louvers shall be motorized to drive between a fully closed and a fully open conditions and to multiple (minimum of 4), equally spaced intermediate positions.

1.3.4 Vent louver positions will be modulated throughout the night as the individual vent-to-wind angles change. Louvers systems shall be designed to operate between fully open and fully closed positions every five (5) minutes over a ten (10) hour night for three hundred (300) nights per year over a twenty (20) year life.

1.3.5 The time required to change from one louver configuration to any other louver configuration for individual vents shall be less than 30 seconds.

1.3.6 The time required to reconfigure all louvers, assuming that not all louvers are configured in parallel, shall be less than 3 minutes

1.3.7 Louvers shall be oriented so that, when partially open, air flow will be directed ~~up~~downward.

And, if contract Option A is selected

1.3.8 The louvers shall be provided with electronic sensors sufficient to remotely control and sense all louver positions.

2. ELECTRICAL POWER

3-phase 480 V, 200 amps electrical service is available for the operation of vent unit systems - motors, sensors, control systems, etc. - through existing slip rings mounted on the inside of the dome just below its inner catwalk. This service is used by several other devices on the dome, notably the dome slit shutter drive motors.

Existing power consumption from the dome slip rings:

<i>slit shutter opening (peak)</i>	-	<i>74 amps at 480 V</i>
<i>slit shutter opening (avg)</i>	-	<i>31 amps at 480 V</i>
<i>windscreen</i>	-	<i>17.5 amps at 480 V</i>
<i>bridge crane and cab</i>	-	<i>49 amps at 480 V</i>

Only the slit shutter will potentially be operated simultaneously with the dome vents

Power line filters (AC line reactor and / or inductive filters) may be needed on power and signal lines running to the vent units to suppress electrical noise that could either affect the vent system controls or that could affect other devices using slip ring power.

2.1 The rollup door and louver drives shall be powered on only while motion is required. Once set, power shall be removed in order to limit heat dissipation in the dome, and the louver and door systems must then be held positively in place by other means

2.2 In the case of the onset of inclement weather, the dome slit shutter closure and vent rollup door closures shall take place simultaneously or nearly simultaneously.

2.3 At the onset of inclement weather, should simultaneous rollup door closure not be possible for any reason, closure of the upwind rollup door shall take precedence over the closure of other rollup doors.

3. OPERATIONAL REQUIREMENTS AND LIMITS

3.1 The fully closed exterior vent rollup doors together with fully closed vent louvers shall provide essentially complete protection of the dome interior against the effects of inclement weather, be it rain, fog, wind, water, snow or ice entry through or around the vent aperture.

3.2 Each rollup doors shall move to a fully closed position from any open position within 1 minute.

- 3.3 If it is not possible to close all vents rollup doors simultaneously due to limitation of available power, it shall be possible to close the vents in a ganged manner, two or three at a time. In such a case all exterior vent doors shall be closed and sealed within 5 minutes of the start of the closing operation.
- 3.4 All rollup doors shall be capable of being driven to a fully closed position simultaneously from the fully open position or from any intermediate open position at any dome orientation with respect to the wind, for wind speeds up to 80 knots in weather conditions which could include rain and snow. It must not be necessary to rotate the dome vent out of the wind in order to achieve this operation.
- 3.5 All vent rollup doors shall be able to be opened partially or fully with vents oriented at any angle to the wind for all wind speeds between 0 knots and 60 knots.
- 3.6 All vent rollup doors, when driven either to a closed position, to a fully open position or to any intermediate position, shall remain in that position without the need for applied power.
- 3.7 All louvers shall be able to be positioned between fully opened and fully closed with the vents oriented at any angle to the wind for wind speeds between 0 knots and 50 knots.
- 3.8 All rollup doors and louvers shall be fully operable at all exterior air temperatures between -20 C and +20 C and for all dome skin temperatures between -30 C and +40 C, and for all dome interior temperature between -20 C and +30 C.
- 3.9 All rollup doors and louvers shall be fully operable at all relative humidities between 0 % and 100% in non-icing conditions.
- 3.10 At the start of icing conditions, when less than 1 mm of ice has accumulated on any active vent components, the associated component shall be fully functional.
- 3.11 In heavy icing conditions in which ice has built up on vent structures, there is no requirement for operation of either the rollup doors or of the louvers, but sensing of door and vent positions shall remain active and available and door and / or louver operation shall be available once the icing condition no longer exists and doors and louvers that have been closed shall remain closed unless commanded to open.
- 3.12 All individual operational components, including electronic sensors, drive boxes and motors and electronic controllers, shall function reliably at component temperatures between -30 C and +20 C. and at all relative humidities between 0% and 100 %, and when exposed to ice and or rain.

In the event of the sudden arrival of icing conditions the control system may need to 'inch' the vent rollup doors and louvers back and forth to avoid being blocked by the buildup of ice if all systems cannot be fully closed simultaneously

- 3.13 *The clearance between the top of the MegaPrime upper end (the tallest configuration of the telescope) and the inside skin of the dome has been measured at 88.75 inches.*

To ensure safe clearance between the inner most component of the dome vent units and the top of the telescope no part of a vent unit shall not extend more than 75 inches inside the inner dome skin.

4. **SAFETY**

The act of cutting the vent apertures will need to be carefully planned to minimize safety risks such as damage or injury due to falling objects and exterior, interior or inter-skin fire arising from the cutting operation, etc.

- 4.1 In order to clear electrical power boxes and other obstructions on or near the inner catwalk, the bottom edge of vent openings shall be no lower than ~~80~~ 84 inches above the inner dome catwalk floor. This provides more than ample fall protection from the catwalk floor as well. If for any reason the ~~80~~ 84 inch limit

cannot be met, then the lower edge of the vent opening shall, under no circumstance, be lower than 42 inches above the catwalk floor.

- 4.2 The vent units shall be provided with safety harness attach-points meeting OSHA standards on all four sides of the vent opening as may be needed for operations during installation and for ongoing maintenance and repair operations.
- 4.3 Open flame cutting of the dome skin or other components shall not be permitted due to anticipated fire hazards.

5. VENT INSTALLATION AND TELESCOPE OPERATION

We anticipate that vent unit structures will be delivered and stored outdoors on-site at the summit of Mauna Kea on the CFHT lease property prior to installation. Vent installation is expected to require plasma cutting of the dome skin at a single location at a time. The installation and securing of a single vent unit is not expected to exceed a rate of one installation per day and may well be slower. We also suppose that units or partial units will be mounted using either CFHT's internal cranes to transfer a unit to the mezzanine level of the upper observing floor and scaffolding to install the vent unit from inside the dome, or using an external crane and manlift if mounted from the outside.

One thought regarding vent installation considered the cutting of a vent aperture in the dome skin from the outside and installing the associated vent frame on the external face of the outer dome skin. The advantages are easy external crane access and limited incursion on telescope and 5th floor activities. A potential disadvantage is a short period between cutting the vent aperture and installation of the vent unit during which the interior of the dome would be unprotected. Even short operational delays, due perhaps to equipment malfunction, at this point could lead to unacceptable periods of exposure.

Vent units might also be installed from inside the dome. Advantages are that vents units could be mounted prior to cutting the outer skin so that once the vent apertures were cut, weather protection would already be in place. Most of the work could continue at any time of the year and under almost any weather conditions. CFHT staff would possibly have an opportunity to install cabling, sensors etc. on the units at a pace that could be tuned to other operational requirements and the completed units along with their controls could largely be tested before the external apertures were cut. Internal mounts also facilitates the early installation of a prototype.

Disadvantages include the need for an internal lifting mechanism, since the existing dome-mounted cranes cannot access vent location (the existing inter-skin truss work could possibly provide mount points for a portable or installable lifting device). Weather seals at the vent frame to dome skin interface might be more difficult. Internal scaffolding would need to be arranged in order to minimize interference with nighttime dome and telescope operations, if these can reasonably be accommodated during the installation period.

- 5.1 Cutting of the vent openings in the dome skin and the vent unit installation shall be planned for a minimum impact on nighttime telescope operation. CFHT has a strong desire for the installation to require no nights of telescope down time, if this can be accommodated with only a limited impact on cost.
- 5.2 Provision shall be made, in the case of unexpected inclement weather, for a vent aperture to be closed in a secure fashion if the vent unit cannot be mounted and sealed once the vent opening is cut.

6. COMPLIANCE WITH THE LAW AND REGULATORY AGENCIES

The installation of vent units will represent a significant change to the outward appearance of the observatory and thus will be subject to review and approval by the Office of Mauna Kea Management (OMKM) and possibly by the State Department of Land and Natural Resources (DLNR).

- 6.1 Visual representations of the proposed installed vent systems shall be provided to CFHT throughout the design process for internal and external review.
- 6.2 Modifications to the dome building shall be made in compliance with all applicable laws and regulatory agencies. The successful bidder shall be responsible for obtaining all necessary building and fire permits.

Consultation with DLNR may be needed. DLNR might require a permitting action, but probably at a relatively minor level. OMKM will want to review and approve the vent design and installation plan. We believe that the County of Hawaii, in the past, has considered the moving parts of the observatory, such as the enclosure, to be machinery and not subject to Building Code requirements.

7. COATINGS AND PAINT

- 7.1 The delivered vent units shall have a protective coating (paint or other) which will withstand the harsh weather conditions experienced on Mauna Kea. The coating shall have an expected life time of at least 5 years.

The undercoat currently in service on the dome is:

Benjamin Moore M45/M46 Epoxy Mastic Coating – 5-6 mil WFT to achieve 4 mil DFT

The finish coat (2 coats) in service on the dome is:

Benjamin Moore M74/M75 Aliphatic Acrylic Urethane Gloss – 4-5 mil WFT to achieve 2 mil DFT

For a total DFT of 8 mils.

- 7.2 The coating shall be renewable or shall be able to accept additional overcoats over time as needed for routine maintenance.
- 7.3 The contractor shall consult CFHT and shall obtain the CFHT Technical Authority's approval for the paint color and type in advance of its application.

8. DOCUMENTS

- 8.1 To guide the work required for dome vent installation, the contractor shall develop a detailed development and installation plan for approval by CFHT. The contractor shall update the schedule monthly and notify the CFHT Technical Authority promptly of any changes.
- 8.2 All design calculations and engineering analysis shall be provided to CFHT in type-written, machine readable format, preferably using Microsoft Word, with associated diagrams in .jpg or .png format.
- 8.3 All design and fabrication drawings shall be provided to CFHT in machine readable format, preferably as AutoDesk, AutoCad or AutoDesk Inventor files. Files shall reflect the as-built state of all components, drives and sensors.
- 8.4 Detailed maintenance instructions shall be provided to CFHT for the repair, replacement and or maintenance of all active or moving components.

8.5 A list of commercially procured parts, model numbers and types, and vendors shall be delivered to CFHT by the contractor before the final contract payment is issued.

Summary of documents to be delivered by vendor to CFHT:

- Project Development plan
- Vent installation plan
- Project Development schedule, updated monthly
- Engineering analysis and calculations supporting structural analysis
- Design and fabrication drawings as needed for design reviews
- As built design and fabrication drawings – a complete set
- Maintenance and replacement instructions
- List of commercially available parts, including vendor and manufacturer model

9. GLOSSARY

Vent unit – one of twelve bidder-supplied units to be installed into dome skin apertures to be created by the successful bidder. The vent unit includes frames, dome and vent reinforcement or other structural elements needed for robust operations, exterior weather doors, interior louvers, motors and drive systems, sensors and all control and sensor cabling from on-vent motors and sensors to vendor-provided connectors on the lower edge of the vent unit.

Vent weather rollup door – exterior, vertical-acting ‘garage-style’ roll up door intended to provide primary protection of the dome interior against the elements.

Vent louvers – interior horizontally ganged venetian-style closures used to throttle air flow, to partially direct air in an upward direction as it enters the telescope enclosure and to provide secondary weather protection for the dome interior.

Vent frame – exterior and interior structural elements used to attach a vent unit to the telescope enclosure and to support exterior weather rollup doors and interior louvers and drive units.

Vent control system – software, PLC hardware and firmware, and computer hardware dedicated to the operation of the vent units. The vent control system shall be provided by CFHT.

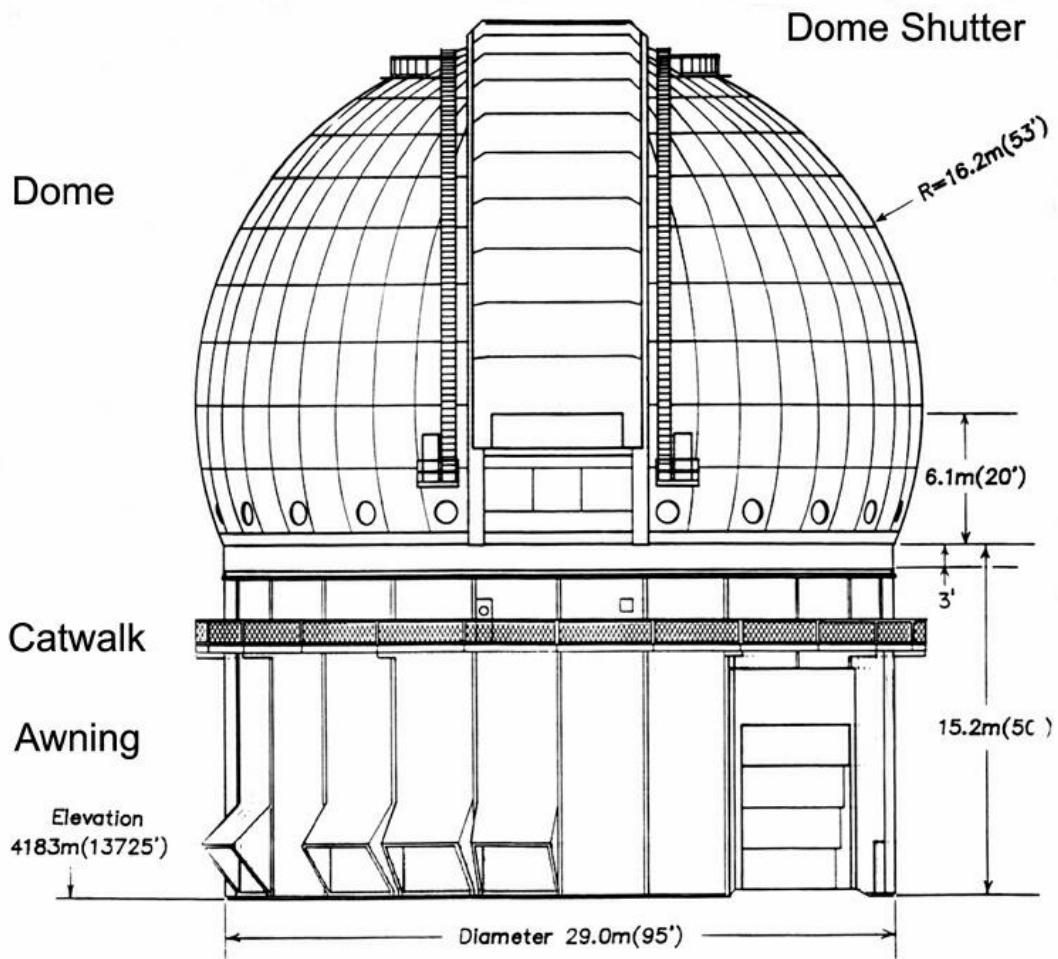
Vent control cabling and conduits – the vent cabling and conduits to be mounted on the interior of the telescope enclosure as needed to control, sense, and operate the dome vent units. The vent control cabling and conduits terminate at the vendor-supplied power and signal connectors provided on each vent unit. The vent control cabling and conduits shall be provided and installed by CFHT.

Vent unit drives and status sensors – the drive systems and sensors on each vent unit needed for operation and sensing of the vent units. These are to be provided, mounted and wired by the vendor.

Vent weather sensors – these are items such as wind speed, air temperature and direction sensors to possibly be mounted in each vent opening at a future date. These are to be provided and cabled by CFHT and will be integrated into the vent control system or the CFHT data logger by CFHT. Generic mounting posts near the center of each vent opening are part of the vent unit and shall be provided by the successful bidder.

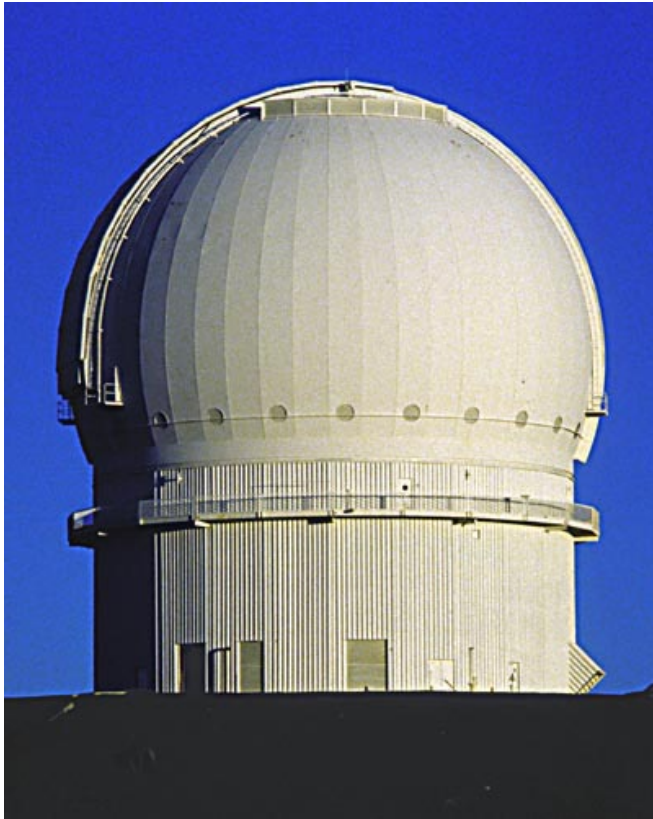
Appendix A

CFHT Dome Schematic



Exterior View
Observatory Building and Dome

A1 – Images of the Dome Exterior



CFHT seen looking East



CFHT seen looking North



Dome shutter – closed

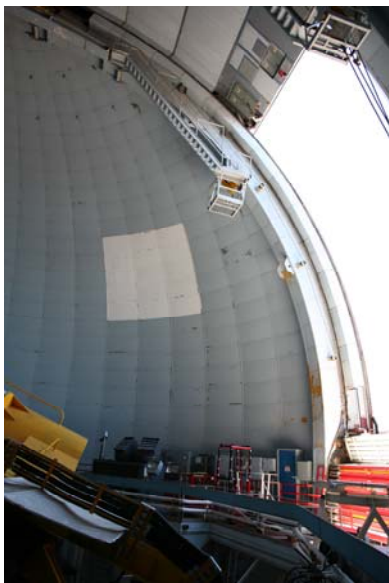


Dome shutter - open

A2 – Images of the Dome Interior



CFHT dome interior. The inner catwalk is seen with red handrails. Power slip rings are enclosed by screening below the inner catwalk.



Vent apertures should not extend below the top of the blue doors at the catwalk level in order to avoid electrical supply boxes and other obstructions.

A-3 Dome inter-skin web details

The images which follow show the dome structure in its current configuration with notional vent apertures added to the drawings. For the associated model (web page www.cfht.hawaii.edu/en/projects/dome_venting/Inventor_model) note that horizontal web framing members, triangular sections and F-chord sections are only placed in the correct locations at the vent aperture openings due to difficulties in making changes to the computer model. In other locations the placement of these members may not be correct.

I Height at at the bottom of a vent aperture

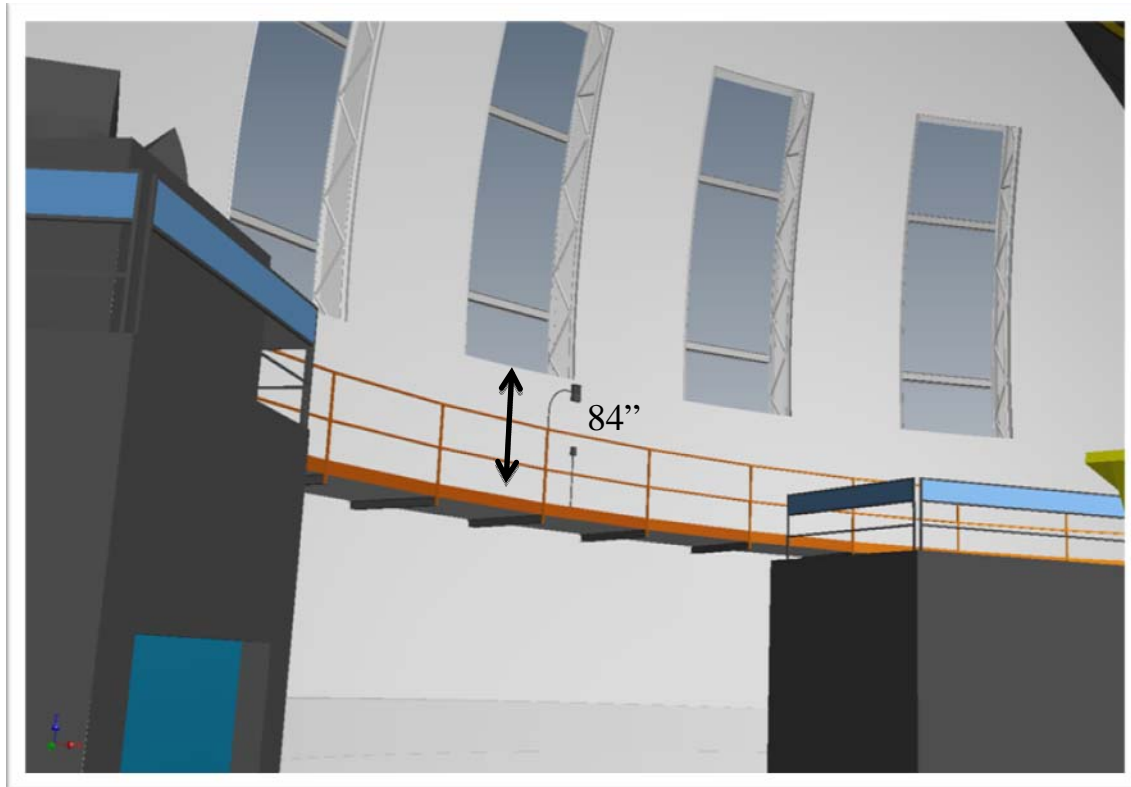


Figure 1 Location of notional vent apertures above the inner catwalk floor

The bottom of the vent aperture openings (~75" wide by ~215" high) begins 84" above the 5th floor catwalk. This is the same height as the top of the dome external access doors. Only 4 vent openings are shown in this illustration.

II Vent aperture azimuthal locations

Vent aperture openings starting at the second gore section from the arch girders. Each gore section spans 7.5 degrees in azimuth measured from dome center. The first gore section that interfaces with the arch girder has Northwest Joint #10-gauge 'F' cord sections stitch welded to the exterior skin. (see lower left corner of Brittain Steel drawing 951-1a – Shell Stiffener Detail). These horizontal shell stiffeners begin at 10 degrees below the spring line of the dome and are arrayed upward at evenly spaced 10 degree increments along the vertical circumference of the dome outer shell. The ventdor is free to maintain these sections in the final design if structurally desirable.

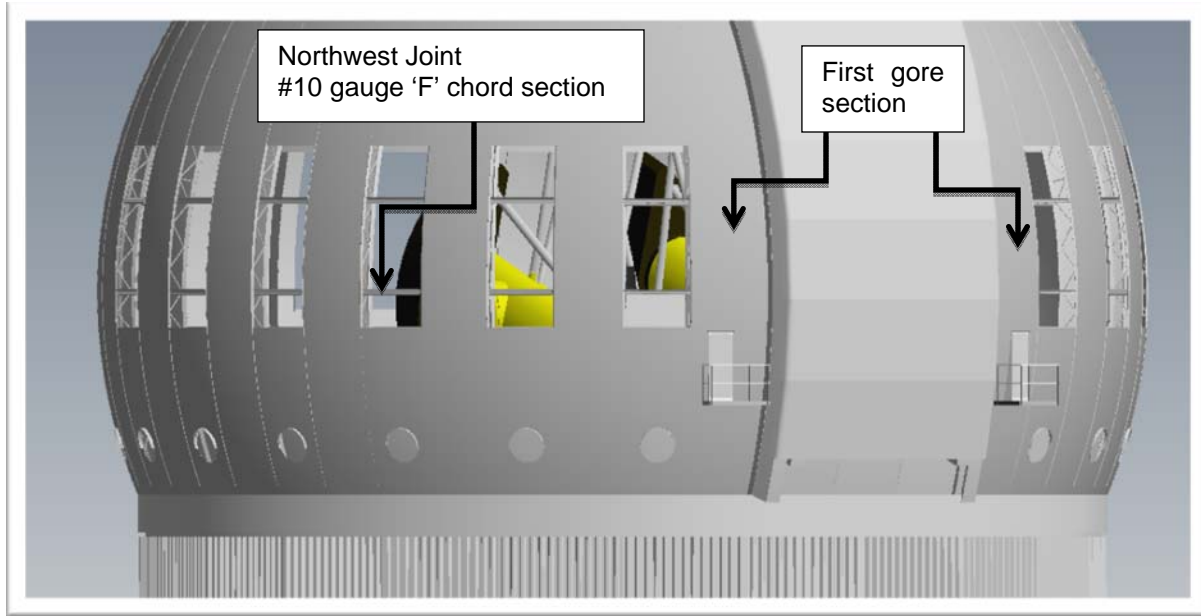


Figure 2 – Exterior view of notional vent apertures with 'F' cord sections still in place

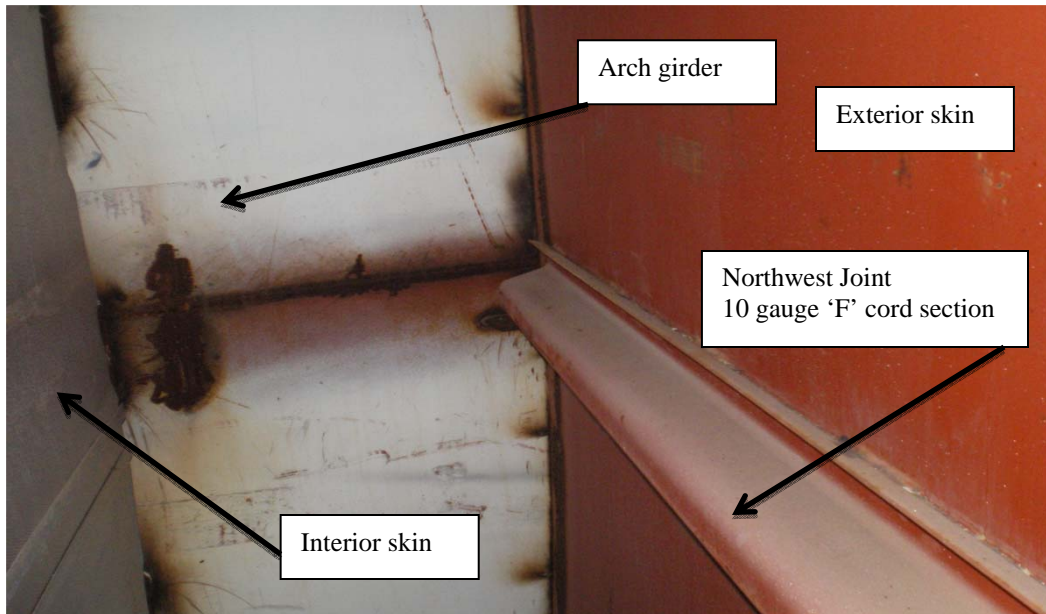


Figure 3 – Inter-skin gap showing vertical face of arch girder and a Northwest Joint 'F' chord section

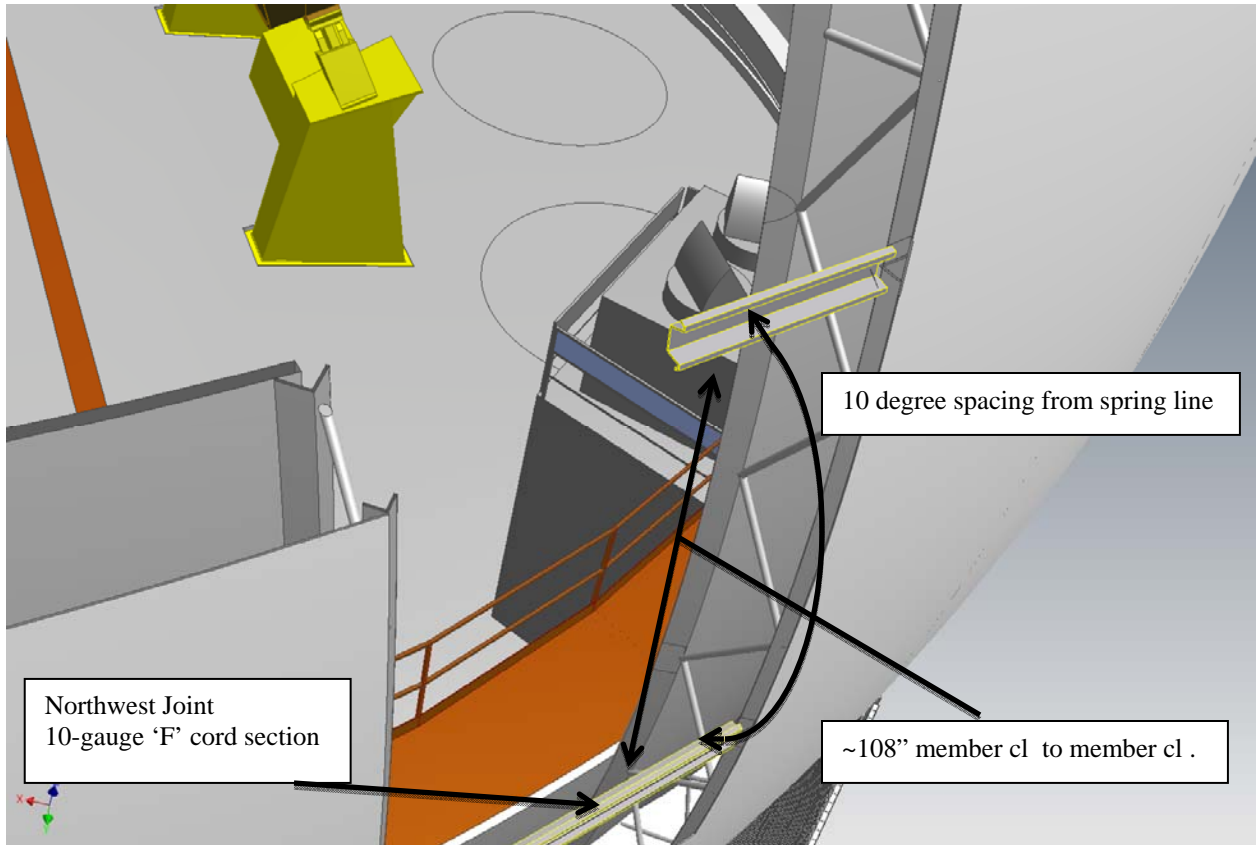


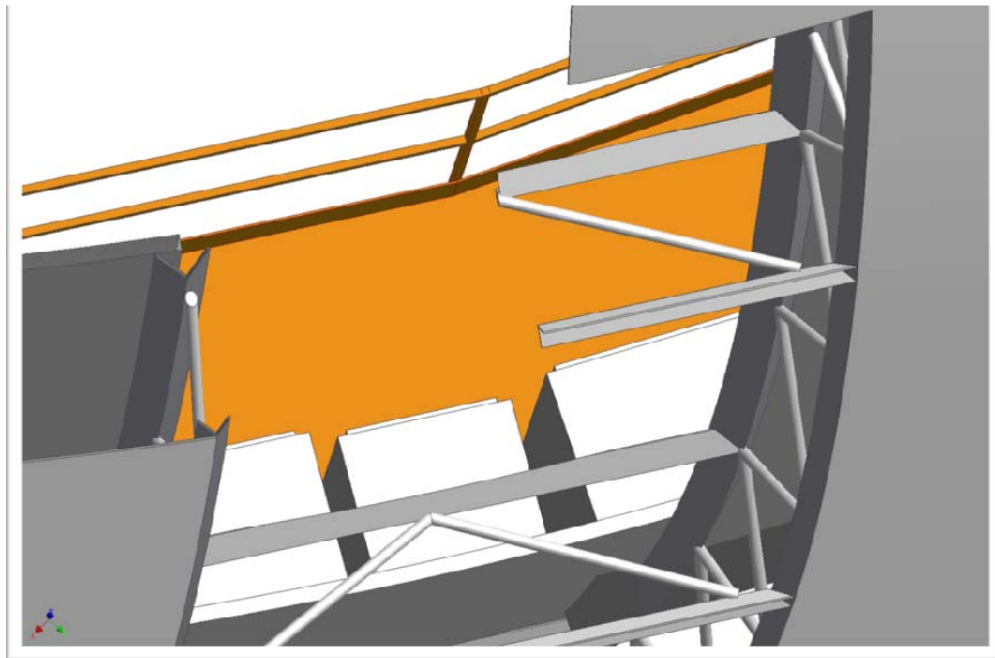
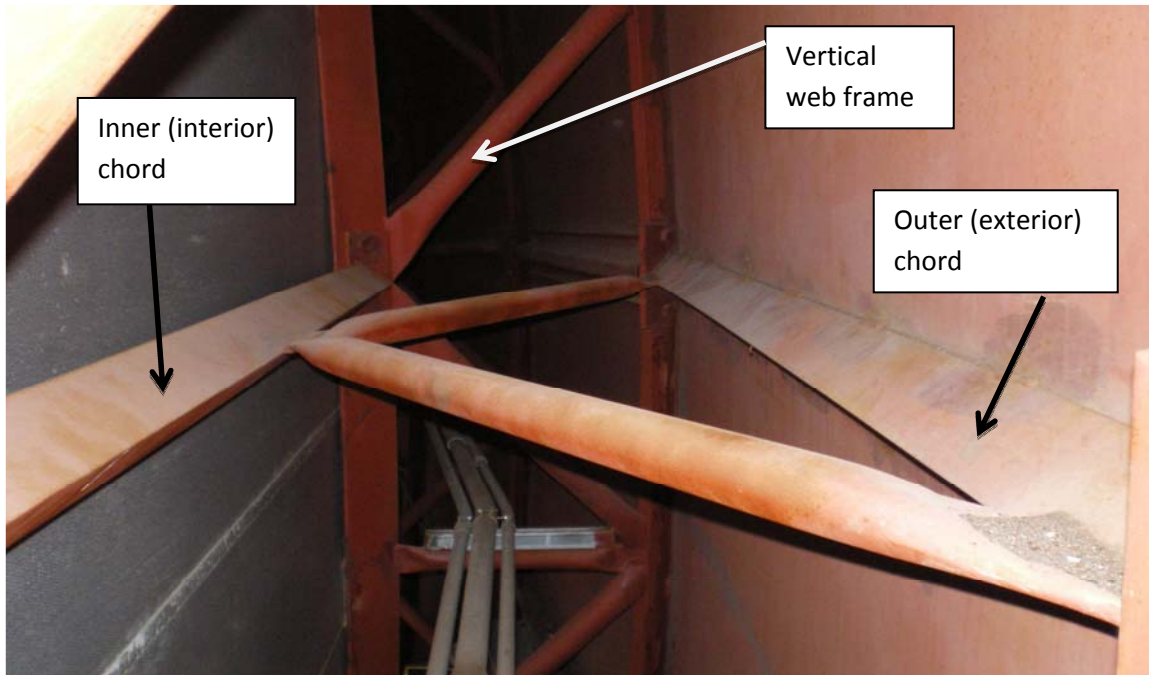
Figure 4 – Details of vent aperture location and locations of 'F' cord sections.



Figure 5 – Details of an 'open' gore section looking upward.

III Horizontal web members

The second and third and odd numbered sections thereafter counting from the arch girder, between the vertical shell rib web frame members, contain horizontal structural rib bracing web frames consisting of inner and outer 'L-section' steel chords separated by 1.5" diameter tube web section. These rib bracing frames are detailed in Britain Steel dwg's 951- 15a, 15b and 15c. The sections are joined by a bolted connection to the vertical frame members on either vertical edge of the gores and are also stitch welded to the exterior gore skin. These rib bracing web frames repeat from the third gore section every other gore.



Figures 6 and 7 Details of horizontal rib bracing web frames

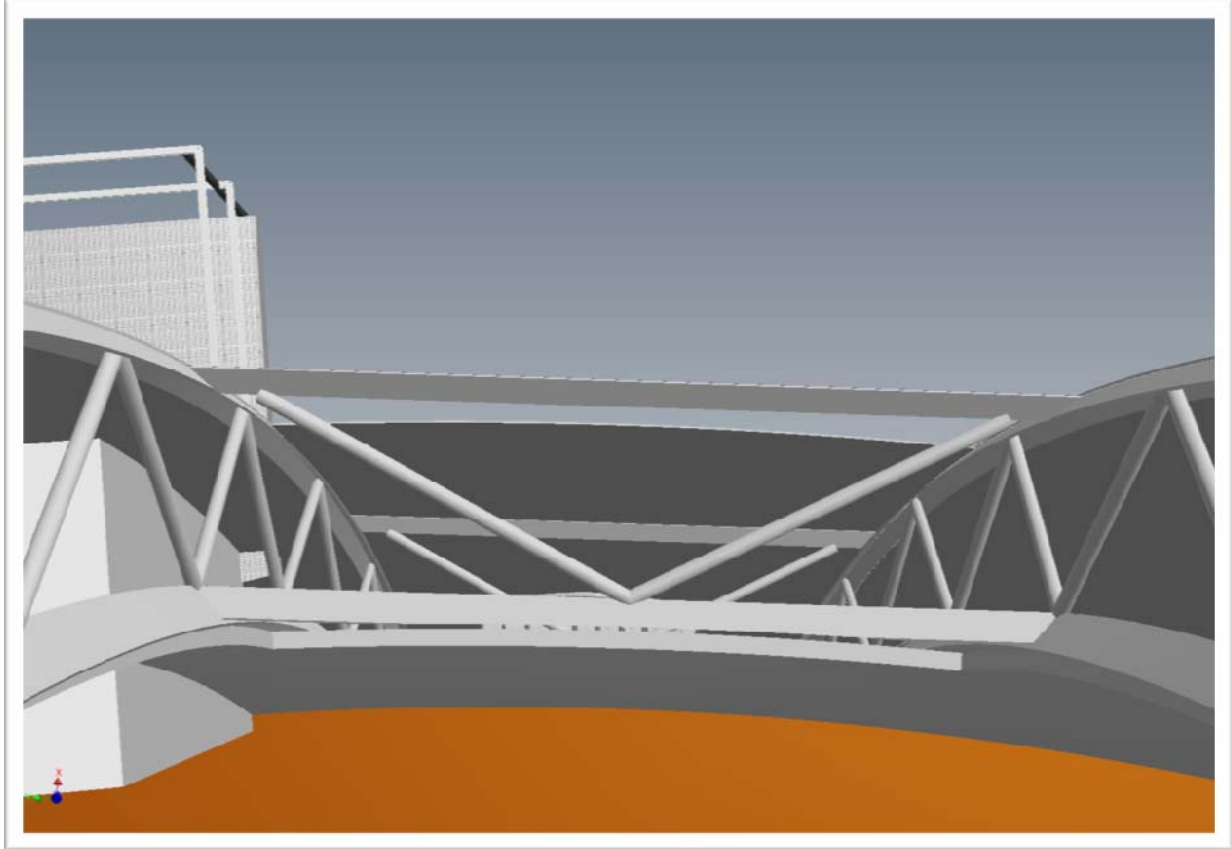
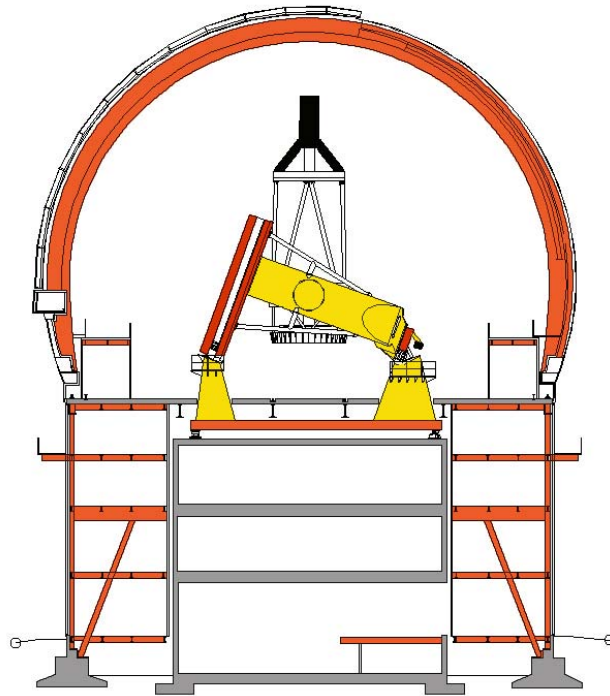


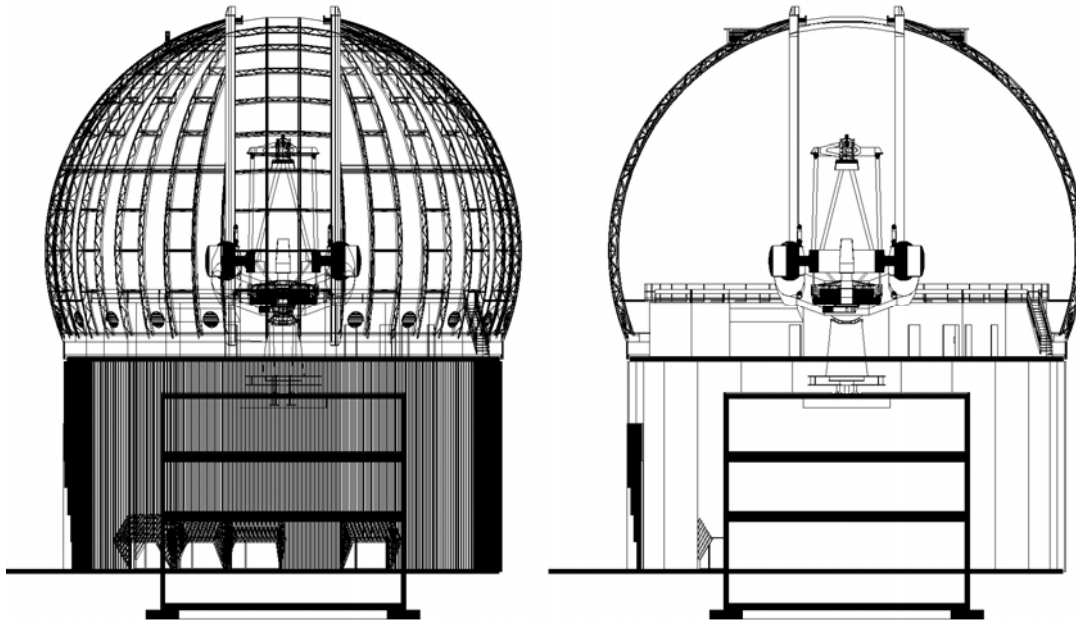
Figure 8, 9 and 10 Further details of rib bracing web frames

Dome and building cross section drawings

(a detailed solid model is available on the web)

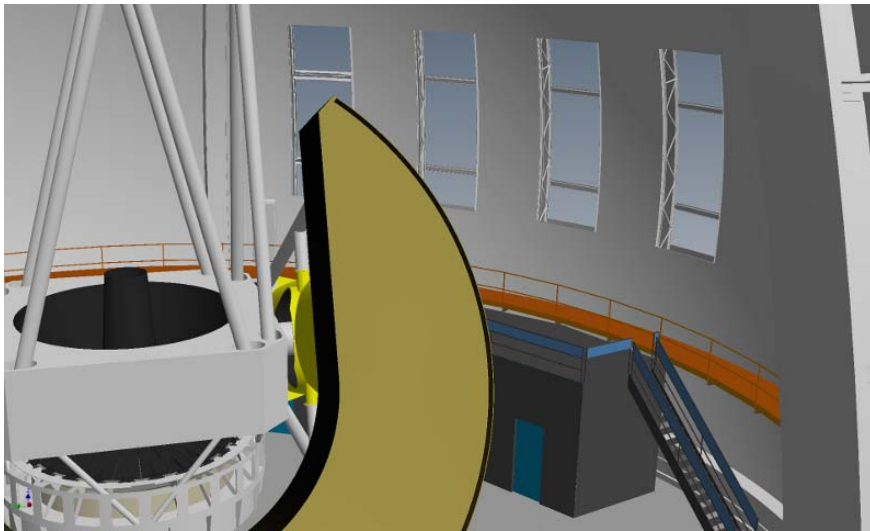
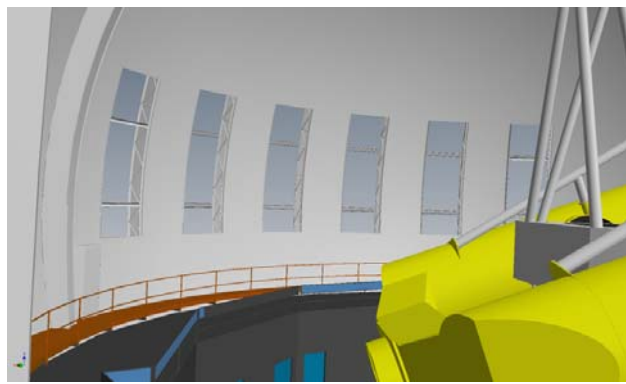
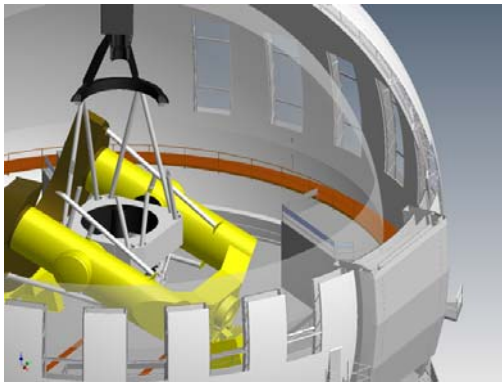
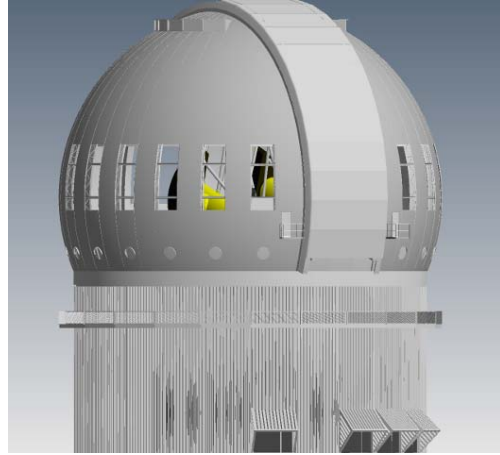
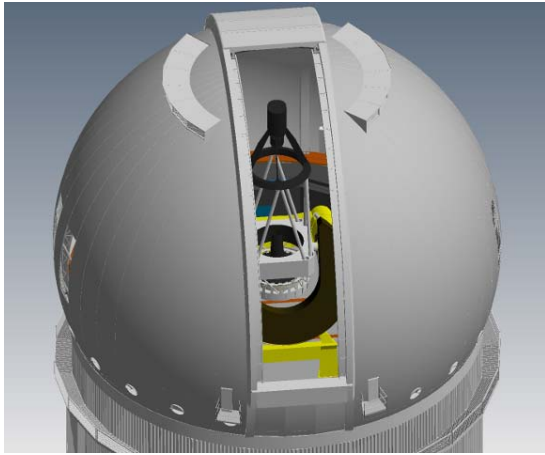


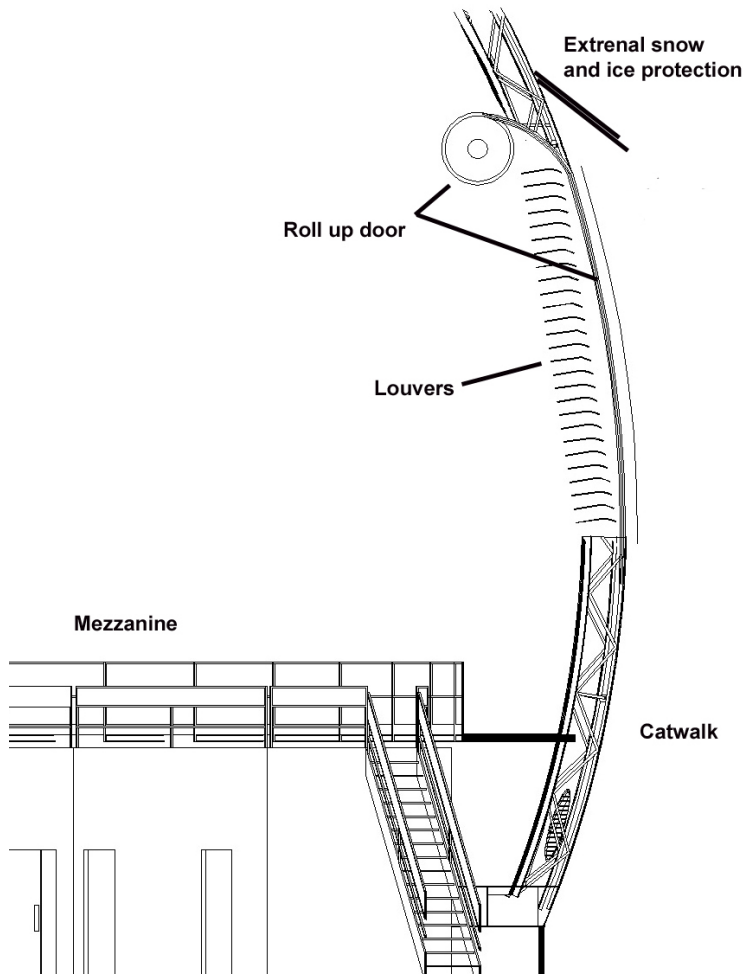
Schematic showing the dome arch girders and the location of the telescope in the building.



X-ray view looking into the open shutter, and cross section views of the dome and building taken from the Inventor solid model. The Cassegrain upper end is shown on the telescope. The Prime Focus upper end is considerably higher.

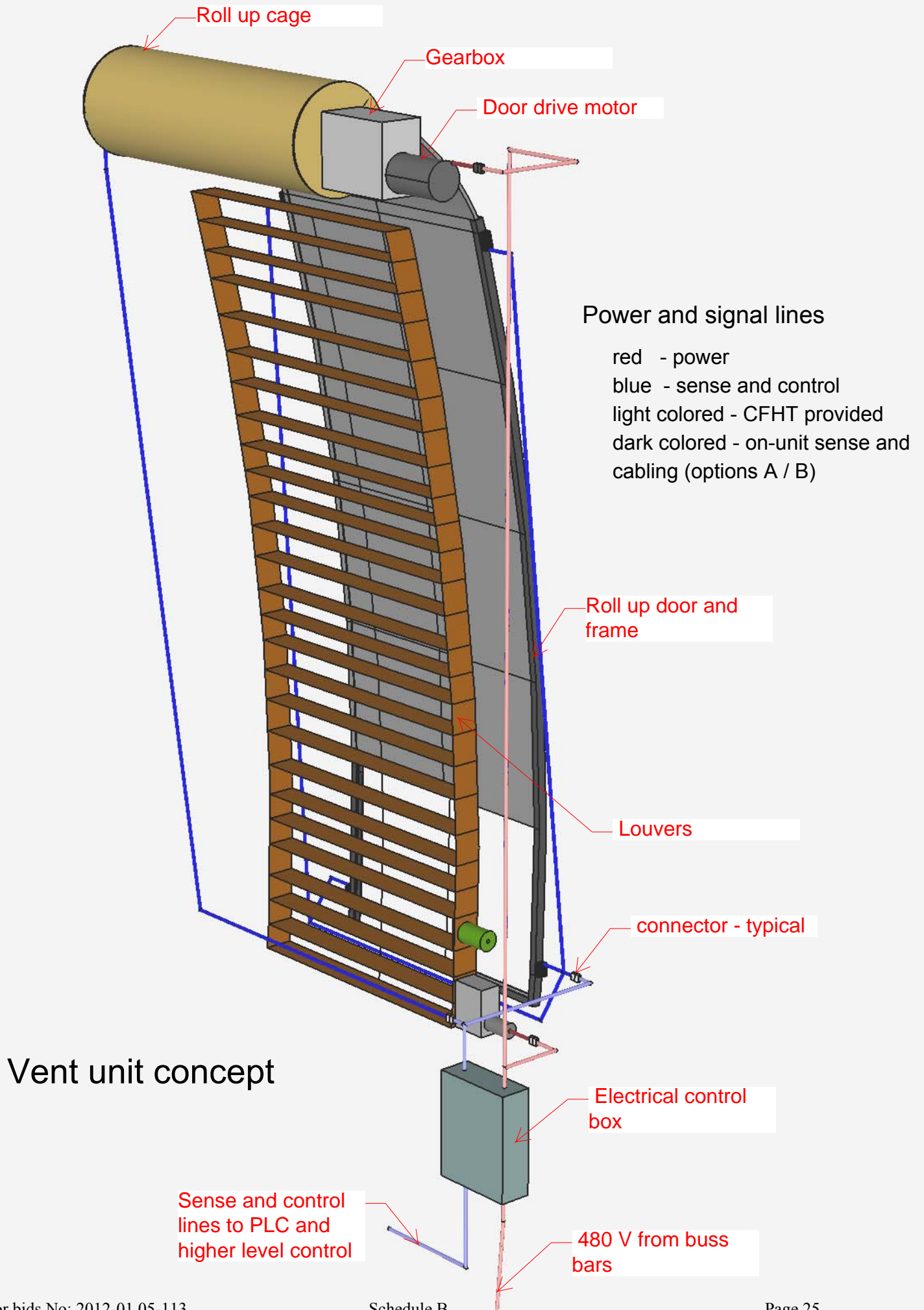
A4 – Vent location concept drawings





Vent concept drawing

A5 – Option A / B notional cabling and control diagrams



Vent unit option A / B concept clarification - lower details

notional louver encoding and on-unit cabling (option A / B)

Power runs to connectors at drive motors (CFHT provided)

Local / computer electrical control box - 1 per unit (CFHT provided)

480 V power from buss bars (CFHT provided)

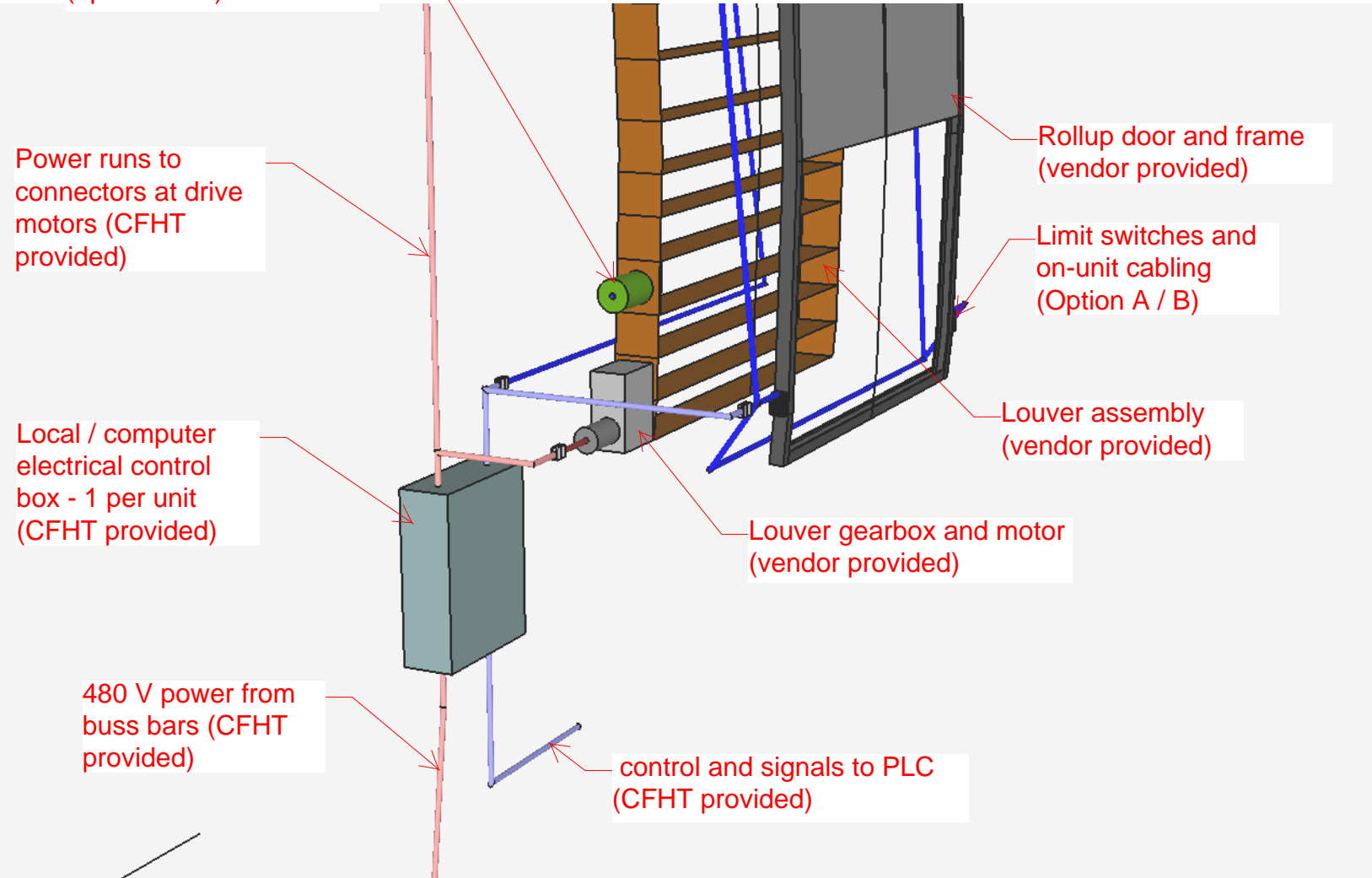
control and signals to PLC (CFHT provided)

Rollup door and frame (vendor provided)

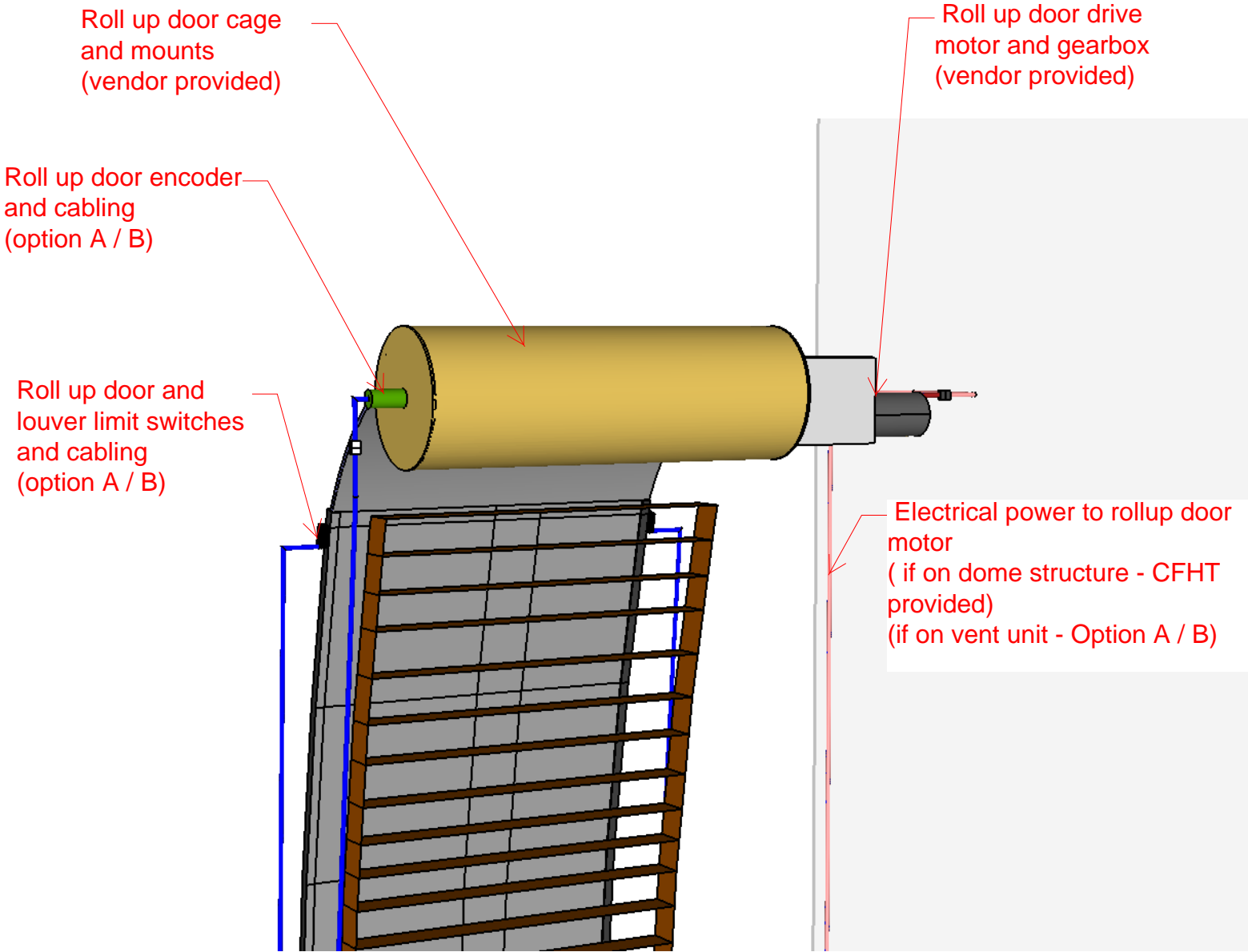
Limit switches and on-unit cabling (Option A / B)

Louver assembly (vendor provided)

Louver gearbox and motor (vendor provided)



Vent unit option A / B concept clarification - upper details



CFHT dome - notional vent units installed

