Appendix B

AGENDA

The 4th Bilateral Meeting between NHMS and KMA

(13 October 2016, Seoul, Korea)

Time	Content	Responsibility
10:00 – 10:15	**Opening of the Meeting** Opening speech by KMA (Dr. NAM Jaecheol) Speech by NHMS (Dr. Tran Hong Thai)	KMA
10:15 – 10:20	**Adoption of the Agenda**	KMA
10:20 – 11:00	**Introduction of Each Side** Presentation on the Recent developments of meteorological service of KMA (Mr. SEONG Ihncheol) Presentation on the Recent developments of hydro-meteorological service of NHMS (Dr. Dinh Thai Hung)	Both Sides
11:00 – 11:10	**Review of Cooperative Activities since the 3rd Bilateral Meeting** (Mr. SEONG Ihncheol)	KMA
11:10 – 11:45	**Future Cooperative Activities** (KMA and NHMS will introduce the activities each side propose and discuss) Cooperation on ODA projects Cooperation between regional level agencies of both Sides Enhancement of the capacity building	Both Sides
11:45 – 11:48	**Other Matters**	Both Sides
11:48 – 11:50	**Dates and Venue of the Next Bilateral Meeting**	Both Sides
11:50 – 12:00	**Closure of the Meeting**	KMA

Appendix C

List of Focal Points

The 4th Meeting between NHMS and KMA
(13 October 2016, Seoul, Korea)

5. Future Cooperative Activities

5.1 Cooperation on ODA projects between NHMS and KMA

Side	Focal Point	Division & Contact Information	
KMA	Mr. KIM Hyeongguk	Div	Meteorological Service Policy Division
		Tel	+ 82 2 21810843
		Email	khg100@korea.kr
KMA	Ms. SEO Jieun	Div	Marine Meteorology Division
		Tel	+ 82 2 21810743
		Email	marssram@korea.kr
NHMS	Mr. Dinh Thai Hung	Div	Science, Technology and International Cooperation Department
		Tel	+ 84 4 38244120
		Email	dinhthaihuwng2012@gmail.com

5.2 Cooperation on GAW activities

Side	Focal Point	Division & Contact Information	
KMA	Dr. Lee Chulkyu	Div	Climate Change Monitoring Division
		Tel	+ 82 2 21810642
		Email	chulkyu.lee@korea.kr
NHMS	Dr. Dinh Thai Hung Dr. Duong Van Khanh	Div	Science, Technology and International Cooperation Department, HYMENET
		Tel	+ 84 4 38244120
		Email	dinhthaihuwng2012@gmail.com

5.3 Cooperation between regional level agencies of both Sides

Side	Focal Point	Division & Contact Information	
KMA	Mr. Kim Eunho	Div	Gwangju Regional Meteorological Administration
		Tel	+ 82 62 7200224
		Email	simmorta@korea.kr
NHMS	Dr. Dinh Thai Hung	Div	Science, Technology and International Cooperation Department
		Tel	+ 84 4 38244120
		Email	dinhthaihuwng2012@gmail.com

5.4 Enhancement of the capacity building

Side	Focal Point	Division & Contact Information	
KMA	Ms. Yim Nayoung	Div	Human Resources Development Division
		Tel	+ 82 2 21810574
		Email	nyyim@korea.kr
NHMS	Dr. Dinh Thai Hung Dr. Hoang Duc Cuong	Div	Science, Technology and International Cooperation Department, NCHMF
		Tel	+ 84 4 38244120
		Email	dinhthaihuwng2012@gmail.com

Project:

Upgrading the Rainfall, Storm and Lightning Detection Capabilities of National Hydro-Meteorological Service, Vietnam

Package Number: FL-TB1

Execution Date: 31 .12.2014

CONTRACT

1. GENERAL PROVISIONS

1.1 Definitions

In the Contract, the following words and expressions shall have the meanings stated below. Words indicating persons or parties include corporation and other legal entities, except where the context requires otherwise.

1.1.1 The Contract

1.1.1.1 **"Contract"** means this Project Delivery Contract and its Annexes.

1.1.1.2 **"Employer's requirement"** means the documents entitled employer's requirements, as included in the Contract, and any additions and modifications to such document in accordance with the Contract.

1.1.2 Parties and Persons

1.1.2.1 **"Party"** means the Employer or the Contractor, jointly referred to as the **"Parties"**, as the context requires.

1.1.2.2 **"Employer"** means the National Hydro-Meteorological Service of Vietnam, a national institute incorporated under laws of Socialist Republic of Vietnam, with its registered office at 3 Dang Thai Than, Hoan Kiem, Hanoi, Vietnam.

1.1.2.3 **"Contractor"** means Vaisala Oyj, a company incorporated under the laws of Finland (Business ID: 0124416-2), with its registered office at Vanha Nurmijärventie 21, 01670 Vantaa, Finland.

1.1.2.4 **"Contractor's Personnel"** means the Contractor's Representative and all personnel whom the Contractor utilizes on Site, who may include the staff, labour and other personnel assisting the Contractor in the execution of the Works.

1.1.2.5 **"Subcontractor"** means any person named in the Contract as a subcontractor, or any person appointed as a subcontractor, for a part of the Works; and the legal successors in title to each of these persons.

1.1.2.6 **"FIDIC"** means the Federation Internationale des Ingenieurs-Conseils, the international federation of consulting engineers.

1.1.3 Dates, Tests, Periods and Completion

1.1.3.1 **"Commencement Date"** means the date specified in Sub-Clause 7.1 [*Commencement of Works*].

1.1.3.2 **"Time for Completion"** means the time for completing the Works or a Section (as the case may be) under Sub-Clause 7.2 [*Time for Completion*] (with any extension under Sub-Clause 7.4 [*Extension of Time for Completion*]), calculated from the Commencement Date.

1.1.3.3 **"Test on Completion"** means the site acceptance test defined in Clause 8 [*Tests on Completion (Site Acceptance Test)*] of the Contract.

1.1.3.4 **"Taking-Over Certificate"** means a certificate issued under Clause 9 [*Employer's Taking Over*].

1.1.3.5 **"Defects Notification Period"** means the period for notifying defects in the Works or a Section (as the case may be) under Sub-Clause 10.1 [*Completion of Outstanding Work and Remedying Defects*], calculated from the date on which the Works or Section is completed as certified under Sub-Clause 9.1 [*Taking Over of the Works and Sections*].

1.1.3.6 **"Performance Certificate"** means the certificate issued under Sub-Clause 10.7 [*Performance Certificate*].

1.1.3.7 **"Day"** means a calendar day and **"year"** means 365 days.

1.1.3.8 **"Execution Date"** means the date specified on the cover page of this Contract.

1.1.3.9 **"Delivery Date(s)"** means the date(s) on which the Supplies or part thereof are placed at the disposal of the Employer on the arriving means of transport ready for unloading at the named place of destination, in accordance with the delivery term DAP (Incoterms 2010).

1.1.3.10 **"FAT"** means the factory acceptance test defined in Annex 6 [*FAT Regulations*] of this Contract.

1.1.4 Money and Payments

1.1.4.1 **"Contract Price"** means the price payable to Contractor under this Contract, as detailed in Clause 12.1 [*Contract Price*] and Annex 2 [*Prices and Payment Terms*] of this Contract.

1.1.4.2 **"Foreign Currency"** means Euro in which all of the Contract Price is payable, but not the Local Currency.

1.1.4.3 **"Local Currency"** means the Vietnamese Dong.

1.1.4.4 **"Utilization Request"** means a utilization request to be made by the Ministry of Finance of Vietnam to the Bank in accordance with

the Loan Agreement for effecting the payments by the Bank to Contractor under this Contract.

1.1.4.5 **"Letter of Credit"** or **"L/C"** means irrevocable and confirmed letter of credit to be issued by Vietinbank, BIDV or Vietcombank based on the Employer's request. Letter of Credit includes reference to Loan Agreement and instructions for the Bank to debit payments approved under the Letter of Credit to the loan concerned.

1.1.4.6 **"Bank"** means Nordea Bank Finland Plc.

1.1.4.7 **"Finnish Concessional Credit Financing"** means a combination of export credits from a commercial bank and interest subsidy from public development cooperation funds. Finnish Concessional Credit Financing follows the rules and regulations of the Ministry for Foreign Affairs of Finland and Finnvera Ltd.

1.1.5 Works and Goods

1.1.5.1 **"Contractor's Equipment"** means all apparatus, machinery, vehicles and other things required for the execution and completion of the Works and the remedying of any defects. However, Contractor's Equipment excludes Temporary Works, Employer's Equipment (if any), Plant, Materials and any other things intended to form or forming part of the Permanent Works.

1.1.5.2 **"Goods"** means Contractor's Equipment, Materials, Plant and Temporary Works, or any of them as appropriate.

1.1.5.3 **"Materials"** means things of all kinds (other than Plant) intended to form or forming part of the Permanent Works, including the supply-only materials (if any) to be supplied by the Contractor under the Contract.

1.1.5.4 **"Permanent Works"** means the permanent works to be executed by the Contractor under the Contract.

1.1.5.5 **"Plant"** means the apparatus, machinery and vehicles intended to form or forming part of the Permanent Works.

1.1.5.6 **"Temporary Works"** means all temporary works of every kind (other than Contractor's Equipment) required on Site for the execution and completion of the Permanent Works and the remedying of any defects.

1.1.5.7 **"Works"** mean the Permanent Works and the Temporary Works, or either of them as appropriate.

1.1.5.8 **"Separable Portion(s)"** means separable portions of the Works. Each Lot, as defined in Annex 1 [*Special Conditions*] of this

Contract, is considered a Separable Portion within the meaning of this Contract.

1.1.5.9 **"Services"** means the services including engineering performed by Contractor as detailed in Annex 13 [*Services*] of this Contract.

1.1.5.10 **"Supplies"** means goods, materials and/or documentation included in the scope of the Project, as detailed in Annex 12 [*Supplies*] of this Contract.

1.1.6 Other Definitions

1.1.6.1 **"Contractor's Documents"** means the calculations, computer programs and other software, drawings, manuals, models and other documents of a technical nature (if any) supplied by the Contractor under the Contract.

1.1.6.2 **"Country"** means Socialist Republic of Vietnam.

1.1.6.3 **"Employer's Equipment"** means the apparatus, machinery and vehicles (if any) made available by the Employer for the use of the Contractor in the execution of the Works; but does not include Plant which has not been taken over by the Employer.

1.1.6.4 **"Force Majeure"** is defined in Clause 17 [*Force Majeure*].

1.1.6.5 **"Laws"** means all national (or state) legislation, statutes, ordinances and other laws, and regulations and by-laws of any legally constituted public authority.

1.1.6.6 **"Performance Security"** means the Performance Guarantee issued by the Bank as a security for the fulfilment of Contractor's obligations under this Contract, as defined in Clause 3.2 [*Performance Security and Warranty Guarantee*] and Annex 10 of this Contract.

1.1.6.7 **"Site"** means place(s) where the Supplies or part thereof are to be installed, including as much of the surrounding area as necessary for unloading, storage and on-Site transport of the Supplies or part thereof and installation equipment, as detailed in Annex 5 [*Sites*] of this Contract.

1.1.6.8 **"Variation"** means any change to the Works, which is instructed or approved as a variation under Clause 11 [*Variations and Adjustments*].

1.1.6.9 **"Acceptance"** means the completion of SAT of the Supplies or part thereof, or any other acceptance event as defined in Annex 7 [*SAT Regulations*] of this Contract.

1.1.6.10 **"Advance Payment Guarantee"** means the guarantee issued by the Bank as a security for possible repayment of the advance payment, as defined in Clause 12.2 [*Advance Payment*] and Annex 9 [*Advance Payment Guarantee*] of this Contract.

1.1.6.11 **"Consignee"** means the Employer or another party designated by the Employer responsible for customs and importation of the Supplies and Services.

1.1.6.12 **"Foreign Contractor Tax"** or **"FCT"** means the foreign contractor tax in Vietnam, which applies to Contractor as a foreign contractor carrying out the Project in Vietnam, and which consists of value added tax and corporate income tax.

1.1.6.13 **"In Writing"** means communication by document signed by both Parties, or by letter, fax, e-mail and by such other verifiable means as agreed by Parties.

1.1.6.14 **"License(s)"** means the license(s) as detailed in Clause 2.2 [*Permits, Licenses or Approvals*] and Annex 14 [*Licenses*] of this Contract.

1.1.6.15 **"Loan Agreement"** means the credit loan agreement signed between the Ministry of Finance of the Socialist Republic of Vietnam and the Bank to finance the Project.

1.1.6.16 **"Lot(s)"** means the Separable Portion(s) as specified in Annex 1 [*Special Conditions*] of this Contract.

1.1.6.17 **"Warranty Guarantee"** means the guarantee issued by the Bank as a security for the fulfilment of Contractor's warranty obligations, as defined in Clause 3.2 [*Performance Security and Warranty Guarantee*] and Annex 11 [*Warranty Guarantee*] of this Contract.

1.1.6.18 **"Warranty Period"** means the period of eighteen (18) months commencing on the earliest event of (i) Acceptance of the Supplies or part thereof, or (ii) six (6) moths from the Delivery Date(s) of the Supplies or part thereof.

1.2 Interpretation

In the Contract, except where the context requires otherwise:

(a) words indicating one gender include all genders;

(b) word indicating the singular also include the plural and words indicating the plural also include the singular;

(c) provisions including the word "agree", "agreed" or "agreement" require the agreement to be recorded in writing, and

(d) "written" or "in writing" means communication by document signed by both Parties, or by letter, fax, e-mail and by such other verifiable means as agreed by Parties.

The marginal words and other headings shall not be taken into consideration in the interpretation of these Conditions.

Entire Agreement. This Contract represents the entire understanding and agreement between the Parties with respect to the subject matter hereof and supersedes all prior negotiations, understandings and agreements relating to the subject matter hereof.

Non-Waiver. Failure to enforce any right under this Contract will not be deemed a waiver of future enforcement of that or any other right.

Costs. Each Party shall bear its own costs and expenses incurred in relation to the preparation and execution of transactions contemplated by this Contract.

Surviving Articles. Any provision of this Contract which by its nature may be deemed to survive the expiry or termination of this Contract shall so survive.

1.3 Communications

Wherever the Contract provides for the giving or issuing of approvals, certificates, consents, determinations, notices and requests, these communications shall be:

(a) in writing and delivered by hand (against receipt), sent by mail or courier, or transmitted using any of the agreed systems of electronic transmission, and

(b) delivered, sent or transmitted to the address for the recipient's communications as stated below;

Employer:

National Hydro-Meteorological Service of Vietnam
3 Dang Thai Than,
Hoan Kiem,
Hanoi,
Vietnam

Tel.: +84 4 38244918
Fax.: +84 4 38244916.

Contractor:

Vaisala Oyj
Vanha Nurmijärventie 21,
01670 Vantaa,
Finland

Tel.: +358 9 89491
Fax.: +358 9 8949 2227
Email: firstname.lastname@vaisala.com.

However:

(i) if the recipient gives notice of another address, communications shall thereafter be delivered accordingly; and

(ii) if the recipient has not stated otherwise when requesting an approval or consent, it may be sent to the address from which the request was issued.

Approvals, certificates, consents and determinations shall not be unreasonably withheld or delayed. When a certificate is issued to a Party, the certifier shall send a copy to the other party.

1.4 Law and Language

This Contract shall be governed by the laws of Finland, without regard to its conflict of laws rules. It is expressly agreed that the application of United Nations Convention on Contracts for the International Sale of Goods (CISG) shall be excluded.

Contractor shall ensure compliance to the relevant technical standards, laws and regulations of the Socialist Republic of Vietnam in relation to the Project.

For avoidance of doubt, the Parties acknowledge that Contractor is not familiar with the content of the Vietnamese laws, regulations and decisions and in case of any discrepancies between this Contract and the said laws, regulations and decisions, this Contract shall prevail.

The English language version of this Contract shall be the only version having binding effect. For the avoidance of doubt, any translation of this Contract shall be for convenience only.

The language for communications shall be the English language.

1.5 Priority of Documents

This Contract consists of this main Contract document and the following Annexes. The following Annexes shall form an integral part of this Contract in the following order of precedence:

Annex 1	Special Conditions
Annex 2	Prices and Payment Terms
Annex 3	Proposed items and quantities
Annex 4	Project Plan
Annex 5	Sites
Annex 6	FAT Regulations
Annex 7	SAT Regulations

Annex 8	Letter of Credit Opening Procedure
Annex 9	Advance Payment Guarantee
Annex 10	Performance Guarantee
Annex 11	Warranty Guarantee
Annex 12	Supplies
Annex 13	Services
Annex 14	Licenses
Annex 14.1	IRIS RDA Software License Agreement
Annex 14.2	General License Conditions of Vaisala Group
Annex 14.3	SmartMet Software License Conditions
Annex 15	Contact Persons
Annex 16	Employer's Requirement.

In case of any discrepancy between the main body of this Contract document and any of its Annexes, the main body of this Contract shall prevail.

1.6 Assignment

Neither Party shall assign the whole or any part of the Contract or any benefit or interest in or under the Contract.

1.7 Care and Supply of Documents

Each of the Contractor's Documents shall be in the custody and care of the Contractor, unless and until taken over by the Employer.

The Contractor shall keep, on the Site, a copy of the Contract, publications named in the Specification, the Contractor's Documents (if any), the Drawings and Variations and other communications given under the Contract. The Employer's Personnel shall have the right of access to all these documents at all reasonable times.

If a Party becomes aware of an error or defect of a technical nature in a document, which was prepared for use in executing the Works, the Party shall promptly give notice to the other Party of such error or defect.

1.8 Employer's Use of Contractor's Documents

As between the Parties, the Contractor shall retain the copyright and other intellectual property rights in the Contractor's Documents and other design documents made by (or on behalf of) the Contractor.

The Contractor shall be deemed (by signing the Contract) to give to the Employer a non-terminable transferable non-exclusive royalty-free license to copy, use and communicate the Contractor's Project specific Documents, including making and using modifications of them. This license shall:

(a) apply throughout the actual or intended working life (whichever is longer) of the relevant parts of the Works,

(b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's Documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works, and

(c) in the case of Contractor's Documents which are in the form of computer programs and other software, those are governed by the Software License Conditions as described in Annex 14 [*Licenses*].

The Contractor's Documents and other design documents made by (or on behalf of) the Contractor shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Employer for purposes other than those permitted under this Sub-Clause.

1.9 Contractor's Use of Employer's Documents

As between the Parties, the Employer shall retain the copyright and other intellectual property rights in the specifications, the drawings and other documents made by (or on behalf of) the Employer. The Contractor may, at his cost, copy, use, and obtain communication of these documents for the purposes of the Contract. They shall not without the Employer's consent, be copied, used or communicated to a third party by the Contractor except as necessary for the purposes of the Contract.

1.10 Confidential Details

The Contractor shall disclose all such confidential and other information as the Employer may reasonably require in order to verify the Contractor's compliance with the Contract.

Neither Party shall disclose, transfer, transmit or otherwise make available to a third party this Contract or any confidential information submitted in connection with the Project without the written authorization of the other Party, unless and to the extent required for the purpose of fulfilling the obligations under this Contract. The obligations of this Sub-Clause shall survive the expiry, completion and/or termination of this Contract for a period of three (3) years.

Confidentiality requirement does not limit Contractor's or its sub-contractor's rights to publish basic Contract information, such as the Country and the Employer, the Contract Price, general content of the Supplies and Services, and progress of the Project. These publications can be in form of stock exchange releases, marketing articles, reference lists, publications at the internet site, etc.

Furthermore both Parties have the right to provide necessary information to governmental authorities in Finland and in Vietnam as requested by those authorities to review, accept and verify the Contract.

1.11 Compliance with Laws

The Contractor shall, in performing this Contract, comply with the law applicable to this Contract, as specified in the Clause 1.4 [*Law and Language*].

The Employer shall have obtained (or shall obtain) the planning, zoning or similar permission for the Project, and any other permissions described in or incidental to this Contract as having been (or being) obtained by the Employer, and the Employer shall indemnify and hold the Contractor harmless against and from the consequences of any failure to do so.

The Employer shall be responsible for all taxes, custom duties and charges levied in connection with the import of the Supplies and Services to Vietnam, and for any other local custom duties, taxes and charges arising out of or in connection with this Contract.

Notwithstanding the foregoing, the Contractor shall be responsible for the corporate income tax part of the Foreign Contractor Tax.

The Employer shall bear the value added tax part of the Foreign Contractor Tax, and shall withhold the corporate income tax part of the Foreign Contractor Tax from its payment to the Contractor. Therefore the Employer shall withhold, declare and pay the respective amounts on behalf of Contractor in accordance with the applicable regulations.

2. THE EMPLOYER

2.1 Right of Access to the Site

The Employer shall give the Contractor right of access to, and possession of, all parts of the Site within the time (or times) stated in the Contract. The right and possession may not be exclusive to the Contractor. If, under the Contract, the Employer is required to give (to the Contractor) possession of any foundation, structure, plant or means of access, the Employer shall do so in the time and manner stated in the Contract. However, the Employer may withhold any such right or possession until the Performance Security has been received.

If no such time is stated in the Contract, the Employer shall give the Contractor right of access to, and possession of, the Site within such times as may be required to enable the Contractor to proceed in accordance with the programme submitted under project plan in Annex 4 [*Project Plan*].

If the Contractor suffers delay and/or incurs cost as a result of a failure by the Employer to give any such right or possession within such time, the Contractor shall give notice to the Employer and shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

After receiving this notice the Contractor shall revise the project plan and inform the Employer. The new project plan shall be accepted by both Parties. The acceptance needs to be received within 10 days of the Contractor providing the new project plan, otherwise it shall be regarded as accepted.

However, if and to the extent that the Employer's failure was caused by any error or delay by the Contractor, including an error in, or delay in the submission of, any of the Contractor's Documents, the Contractor shall not be entitled to such extension of time.

2.2 Permits, Licences or Approvals

The Employer shall (where he is in a position to do so) provide reasonable assistance to the Contractor at the request of the Contractor:

(a) by obtaining copies of the Laws of the Country which are relevant to the Contract but are not readily available, and

(b) for the Contractor's applications for any permits, licences or approvals required by the Laws of the Country:

  (i) which the Contractor is required to obtain under Sub-Clause 1.11 [*Compliance with Laws*],

  (ii) for the delivery of Goods, including clearance through customs, and

  (iii) for the export of Contractor's Equipment when it is removed from the Site.

Software provided to the Employer under this Contract shall be governed by the following license conditions, as applicable:

(i) IRIS RDA Software License Agreement, as specified in Annex 14.1 [*IRIS RDA Software License Agreement*] of this Contract; and/or

(ii) General License Conditions of Vaisala Group, as specified in Annex 14.2 [*General License Conditions of Vaisala Group*] of this Contract.

In addition, certain SmartMet software products provided to the Employer by the Contractor's subcontractor shall be governed by the end user license agreement as specified in Annex 14.3 [*SmartMet Software License Conditions*].

Notwithstanding anything to the contrary in the above defined license conditions, all Licenses shall be perpetual, fully paid-up and royalty free.

In case of computer failure, the Employer has the right to transfer the software license to another computer.

2.3 Employer's Personnel

The Employer shall be responsible for ensuring that the Employer's Personnel and the Employer's other contractors on the Site:

(a) cooperate with the Contractor's efforts under Sub-Clause 3.5 [*Cooperation*], and

(b) take actions similar to those which the Contractor is required to take under sub-paragraphs (a), (b) and (c) of Sub-Clause 3.7 [*Safety Procedures*] and under Sub-Clause 3.18 [*Protection of the Environment*].

2.4 Employer's Financial Arrangements

The Employer shall submit, within 28 days after receiving any request from the Contractor, reasonable evidence that financial arrangements have been made and are being maintained which will enable the Employer to pay the Contract Price (as estimated at that time) in accordance with Clause 12 [*Contract Price and Payment*]. If the Employer intends to make any change to his financial arrangements, the Employer needs to inform the Contractor and gain Contractor's acceptance on the change.

3. THE CONTRACTOR

3.1 Contractor's General Obligations

The Contractor shall design execute and complete the Project in accordance with the Contract, and shall remedy any defects in the Supplies in accordance with the Contract. When completed, the Works shall meet the approved system design as defined in the Contract.

The Contractor shall provide the Supplies and Contractor's Documents specified in the Contract, and all Contractor's Personnel, Goods, consumables and other things and services, whether of a temporary or permanent nature, required in and for this design, execution, completion and remedying of defects.

The Contractor shall include any work which is necessary to complete Contractor's scope of the works as defined in this Contract in a safe and proper manner, excluding the works and responsibilities of the Employer.

The Contractor shall, whenever required by the Employer, submit details of the arrangements and methods which the Contractor proposes to adopt for the execution of the Works. No significant alteration to these arrangements and methods shall be made without this having previously been notified to the Employer.

3.2 Performance Security and Warranty Guarantee

The Contractor shall obtain the Performance Guarantee in the form specified in Annex 10 [*Performance Guarantee*] of this Contract. Performance Guarantee shall be in the amount corresponding to 5% of the Contract Price. Performance

Guarantee shall be issued before the advance payment is made, and released gradually against the issuance of the Warranty Guarantee of each separate Lot, however not later than upon the expiry of a period of 720 days from the effective date of this Contract. In case the project plan shall be extended, the duration of the Performance Guarantee can be extended by mutual agreement of the Parties.

The Contractor shall obtain the Warranty Guarantee in the form specified in Annex 11 [*Warranty Guarantee*] of this Contract. Warranty Guarantee shall be in the amount corresponding to 5% of the Contract Price. Warranty Guarantee shall be issued gradually upon the release of the Performance Guarantee of each separate Lot, and released gradually in connection with the expiry of the Warranty Period of each separate Lot, however not later than on 31 December 2018. In case the project plan shall be extended, the duration of the Warranty Guarantee can be extended by mutual agreement of the Parties.

All guarantees shall be subject to the Uniform Rules for Demand Guarantees (URDG) 2010 revision (ICC Publication No. 758.) or any subsequent revision of the same.

The Contractor shall deliver the Performance Security to the Employer within 28 days after the Commencement Date.

The Contractor shall ensure that the Performance Security is valid and enforceable until the Contractor has executed and completed the Works and remedied any defects.

The Employer shall not make a claim under the Performance Security, except for amounts to which the Employer is entitled under the Contract in the event of:

(a) failure by the Contractor to extend the validity of the Performance Security as described in the preceding paragraphs, in which event the Employer may claim the full amount of the Performance Security,

(b) failure by the Contractor to pay the Employer an amount due, as either agreed by the Contractor or determined under Clause 18 [*Claims, Disputes and Arbitration*], within 84 days after this agreement or determination,

(c) failure by the Contractor to remedy a default within 84 days after receiving the Employer's notice requiring the default to be remedied, or

(d) circumstances which entitle the Employer to termination under Sub-Clause 13.2 [*Termination by Employer*], irrespective of whether notice of termination has been given.

The Employer shall indemnify and hold the Contractor harmless against and from all damages, losses and expenses (including legal fees and expenses)

resulting from a claim under the Performance Security to the extent to which the Employer was not entitled to make the claim.

The Employer shall return the Performance Security to the Contractor within 21 days after receiving a copy of the Performance Certificate.

3.3 Subcontractors

The Contractor shall not subcontract the whole of the Works.

The Contractor shall be responsible for the acts or defaults of any Subcontractor, his agents or employees, as if they were the acts or defaults of the Contractor. Unless otherwise stated in the Contract:

(a) the Contractor shall not be required to obtain consent to suppliers of Materials, or to a subcontract for which the Subcontractor is named in the Contract;

(b) the prior consent of the Employer shall bee obtained to other proposed Subcontractors;

(c) the Contractor shall give the Employer not less than 28 days notice of the intended date of the commencement of each Subcontractor's work, and of the commencement of such work on the Site.

3.4 Nominated Subcontractors

The Contractor is entitled to use following subcontractors;

- Finnish Meteorological Institute, a research and service agency under the Ministry of Transport and Communications of Finland incorporated under laws of Finland, with its registered office at Erik Palménin aukio 1, 00560 Helsinki, Finland (Business Identity Code 0244664-7), and

- Vietnam Environmental and Hydrometeorological Equipment J.S. Company - HYMETCO, a company incorporated under laws of Vietnam, with its registered office at 62/23 Nguyen Chi Thanh Road, Dong Da District, Hanoi, Vietnam.

- APTES VIETNAM; JSC, a company incorporated under laws of Vietnam, with its registered office at Unit 1008/29T2 Hoang Dao Thuy street, Cau Giay district, Hanoi, Vietnam

In case there is a change in the subcontractors the Contractor shall notify the Employer of the change.

Any significant subcontractor not mentioned in the Contract must be approved by the Employer. Such approval shall not be unreasonably withheld.

3.5 Co-operation

The Contractor shall, as specified in the Contract, allow appropriate opportunities for carrying out work to:

(a) the Employer's Personnel,

(b) any other contractors employed by the Employer, and

(c) the personnel of any legally constituted public authorities, who may be employed in the execution on or near the Site of any work not included in the Contract.

Any such instruction shall constitute a Variation if and to the extent that it causes the Contractor to incur unforeseeable cost.

3.6 Setting Out

The Contractor shall set out the Works in relation to original points, lines and levels of reference specified in the Contract. The Contractor shall be responsible for the correct positioning of all parts of the Works, and shall rectify any error in the positions, levels, dimensions or alignment of the Works as specified in the approved system design and scope of works.

The Employer shall be responsible for any errors in these specified or notified items of reference, but the Contractor shall use reasonable efforts to verify their accuracy before they are used.

If the Contractor suffers delay and/or incurs cost from executing work which was necessitated by an error in these items of reference, and an experienced contractor could not reasonably have discovered such error and avoided this delay and/or cost, the Contractor shall give notice to the Employer and shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

3.7 Safety Procedures

The Contractor shall:

(a) comply with all applicable safety regulations,

(b) take care for the safety of all persons entitled to be on the Site,

(c) use reasonable efforts to keep the Site and Works clear of unnecessary obstruction so as to avoid danger to these persons,

(d) provide fencing, lighting, guarding and watching of the Works as found appropriate by the Contractor until completion and taking over under Clause 9 [*Employer's Taking Over*], and

(e) provide any Temporary Works (including guards and fences) which may be necessary, because of the execution of the Works, for the use and protection of the public and of owners and occupiers of adjacent land.

3.8 Quality Assurance

The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the Contract. The system shall be in accordance with the details stated in the Contract. The Employer shall be entitled to audit any aspect of the system at their own cost.

Details of all appropriate procedures and compliance documents shall be submitted to the Employer for information before each design and execution stage is commenced. When any document of a technical nature is issued to the Employer, evidence of the prior approval by the Contractor himself shall be apparent on the document itself.

Compliance with the quality assurance system shall not relieve the Contractor of any of his duties, obligations or responsibilities under the Contract.

3.9 Site Data

The Employer shall have made available to the Contractor for his information, prior to the Commencement Date, all relevant data in the Employer's possession on sub-surface and hydrological conditions at the Site, including environmental aspects. The Employer shall similarly make available to the Contractor all such data, which come into the Employer's possession after the Commencement Date. The Contractor shall be responsible for interpreting all such data.

To the extent which was practicable (taking account of cost and time), the Contractor shall be deemed to have obtained all necessary information as to risks, contingencies and other circumstances which may influence or affect the Works. To the same extent, the Contractor shall be deemed to have inspected and examined the Sites prior to commencing the Works., including (without limitation):

(a) the form and nature of the Site, including sub-surface conditions,

(b) the hydrological and climatic conditions,

(c) the extent and nature of the work and Goods necessary for the execution and completion of the Works and the remedying of any defects,

(d) the Laws, procedures and labour practices of the Country, and

(e) the Contractor's requirements for access, accommodation, facilities, personnel, power, transport, water and other services.

3.10 Sufficiency of the Accepted Contract Amount

The Contractor shall be deemed to:

(a) have satisfied himself as to the correctness and sufficiency of the Accepted Contract Amount, and

(b) have based the Accepted Contract Amount on the data, interpretations, necessary information, inspections, examinations and satisfaction as to all relevant matters referred to in Sub-Clause 3.9 [*Site Data*].

Unless otherwise stated in the Contract, the Accepted Contract Amount covers all the Contractor's obligations under the Contract (including those under Provisional Sums, if any) and all things necessary for the proper execution and completion of the Works and the remedying of any defects.

3.11 Unforeseeable Physical Conditions

In this Sub-Clause, "physical conditions" means natural physical conditions and man-made and other physical obstructions and pollutants, which the Contractor encounters at the Site when executing the Works, including sub-surface and hydrological conditions but excluding climatic conditions.

If the Contractor encounters adverse physical conditions, which he considers to have been unforeseeable, the Contractor shall give notice to the Employer as soon as practicable.

This notice shall describe the physical conditions so that they can be inspected by the Employer, and shall set out the reasons why the Contractor considers them to be unforeseeable. The Contractor shall continue executing the Works, using such proper and reasonable measures as are appropriate for the physical conditions, and shall comply with any instructions, which the Employer may give. If an instruction constitutes a Variation, Clause 11 [*Variations and Adjustments*] shall apply.

If and to the extent that the Contractor encounters physical conditions, which are unforeseeable, gives such a notice, and suffers delay and/or incurs cost due to these conditions, the Contractor shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

After receiving such notice and inspecting and/or investigating these physical conditions, the Employer shall provide an alternative Site for installation.

3.12 Rights of Way and Facilities

The Contractor shall bear all costs and charges for special and/or temporary rights-of-way, which he may require, including those for access to the Site. The Contractor shall also obtain, at his risk and cost, any additional facilities outside the Site, which he may require for the purposes of the Works.

For the avoidance of doubt the road access to the Site(s) shall be provided by the Employer.

3.13 Avoidance of Interference

The Contractor shall not interfere unnecessarily or improperly with:

(a) the convenience of the public, or

(b) the access to and use and occupation of all roads and footpaths, irrespective of whether they are public or in the possession of the Employer or of others.

The Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from any such unnecessary or improper interference.

3.14 Access Route

The Employer is responsible for provision of the access route.

The Contractor shall use reasonable efforts to prevent any road or bridge from being damaged by the Contractor's traffic or by the Contractor's Personnel. These efforts shall include the proper use of appropriate vehicles and routes.

Except as otherwise stated in the Contract:

(a) the Contractor shall provide all necessary signs or directions along access routes, and shall obtain any permission which may be required from the relevant authorities for his use of routes, signs and directions.

3.15 Transport of Goods

Unless otherwise stated in the Contract:

(a) the Contractor shall give the Employer not less than 21 days notice of the date on which any major item of the Supplies will be delivered to the Site;

(b) the Contractor shall be responsible for packing, loading, transporting, unloading, storing and protecting all Goods and other things required for the Works; and

(c) the Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from the transport of Goods, and shall negotiate and pay all claims arising from their transport.

Delivery term shall be DAP (delivery places: each Site), Vietnam (INCOTERMS 2010).

Partial deliveries are allowed, and the Contractor shall retain the right to choose the Supplies to be included in each individual delivery.

If Project includes Services to be performed on Site(s), such Services shall be delivered on Site(s) detailed in Annex 13 [*Services*].

Transfer of risk shall take place upon delivery as per the delivery term defined in this Sub-Clause. Supplies shall remain the property of the Contractor until paid for in full, including payment for Services.

The Employer shall be responsible for the import and appropriate storage at the customs clearance of the Supplies, and for the taxes, customs duties, import related charges, and costs thereof incurring in Vietnam.

3.16 Export Law Assurances; Import and Other Permits

The subject technology of Project, including all data, information, Supplies and Services provided hereunder, may be controlled for export purposes under the Export Administration Act of 1979 (50 USC 2401-2410), the Export Administration Regulations promulgated thereunder (15 CFR 768-799), the International Traffic in Arms Regulations (22 CFR 120-128 and 130) and the Foreign Corrupt Practices Act and their successor and supplemental laws and regulations, together with other applicable laws and regulations (collectively the "Export Regulations"). The Employer acknowledges that: (1) the Export Regulations impose restrictions on the import, export, and transfer of certain categories of data, articles and services to third countries and non-U.S. residents (including foreign persons working legally in the United States); (2) licenses from the US Department of State and/or the US Department of Commerce and other authorities may be required before such data, articles and/or related services can be exported; and (3) such licenses may impose further restrictions on use and further disclosure of such data and articles. The Employer agrees to comply with all Export Regulations as they relate to the import, export and re-export of the subject technology hereof. The Employer shall have full responsibility for obtaining any export licenses or authorizations required to fulfil its obligations under Project.

The Employer shall obtain any governmental and other permits, consents and authorizations required to import, install and use Supplies.

3.17 Contractor's Equipment

The Contractor shall be responsible for all Contractors' Equipment. When brought on to the Site, Contractor's Equipment shall be deemed to be exclusively intended for the execution of the Works.

3.18 Protection of the Environment

The Contractor shall take all reasonable steps to protect the environment (both on and off the Site) and to limit damage and nuisance to people and property resulting from pollution, noise and other results of his operations.

The Contractor shall ensure that emissions, surface discharges and effluent from the Contractor's activities shall not exceed the values indicated in the Contract, and shall not exceed the values prescribed by applicable Laws.

3.19 Electricity, Water and Gas

The Employer is responsible for the provision of the power, water and telecommunicatons to the Site(s).

The Contractor shall be entitled to use for the purposes of the Works such supplies of electricity, water, gas and other services as may be available on the Site.

The quantities consumed and the amounts due (at these prices) for such services for the duration until the Site Acceptance shall be paid by the Contractor to the relevant local supplier as per existing rates applicable in Vietnam.

3.20 Progress Reports

Unless otherwise stated in the Contract, bi-monthly progress reports shall be prepared by the Contractor and submitted to the Employer in six copies. The first report shall cover the period up to the end of the first calendar month following the Commencement Date. Reports shall be submitted bi-monthly thereafter, each within 7 days after the last day of the period to which it relates.

Reporting shall continue until the Contractor has completed all work, which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

Each report shall include relevant updates to:

(a) charts and detailed descriptions of progress, including each stage of design (if any), Contractor's Documents, procurement, manufacture, delivery to Site, construction erection and testing; and including these stages for work by each nominated Subcontractor (as defined in Sub-Clause 3.4 [*Nominated Subcontractors*]),

(b) photographs showing the status of manufacture and of progress on the Site,

(c) for the manufacture of each main item of Supplies, the name of the manufacturer, manufacture location, percentage progress, and the actual or expected dates of:

  (a) commencement of manufacture,

  (ii) Contractor's inspections,

  (iii) tests, and

  (iv) shipment and arrival at the Site;

(d) the details described in Sub-Clause 5.10 [*Records of Contractor's Personnel and Equipment*];

(e) copies of quality assurance documents, test results and certificates of Materials;

(f) list of notices given by the Employer and notices given under Sub-Clause 18.1 [*Contractor's Claims*];

(g) safety statistics, including details of any hazardous incidents and activities relating to environmental aspects and public relations, and

(h) comparisons of actual and planned progress, with details of any events or circumstances which may jeopardize the completion in accordance with the Contract, and the measures being (or to be) adopted to overcome delays.

3.21 Security of the Site

Unless otherwise stated in the Contract:

(a) the Contractor and Employer shall mutually be responsible for keeping unauthorized persons off the Site, and

(b) authorized persons shall be limited to the Contractor's Personnel and the Employer's Personnel, and to any other personnel notified to the Contractor, by the Employer, as authorized personnel of the Employer's other contractors on the Site.

3.22 Contractor's Operation on Site

The Contractor shall confine his operations to the Site, and to any additional areas, which may be obtained by the Contractor and agreed by the Employer as working areas. The Contractor shall take all necessary precautions to keep Contractor's Equipment and Contractor's Personnel within the Site and these additional areas, and to keep them off adjacent land.

During the execution of the Works, the Contractor shall keep the Site free from all unnecessary obstruction, and shall store or dispose of any Contractor's Equipment or surplus materials. The Contractor shall clear away and remove from the Site any wreckage, rubbish and Temporary Works, which are no longer required.

Upon the issue of a Taking-Over Certificate, the Contractor shall clear away and remove, from that part of the Site and Works to which the Taking-Over Certificate refers, all Contractor's Equipment, surplus material, wreckage, rubbish and Temporary Works. The Contractor shall leave that part of the Site and the Works in a clean and safe condition. However, the Contractor may retain on Site, during the Defects Notification Period, such Goods as are required for the Contractor to fulfil obligations under the Contract.

3.23 Fossils

All fossils, coins, articles of value or antiquity, and structures and other remains or items of geological or archaeological interest found on the Site shall be placed under the care and authority of the Employer. The Contractor shall take reasonable precautions to prevent Contractor's Personnel or other persons, from removing or damaging any of these findings.

The Contractor shall, upon discovery of any such finding, promptly give notice to the Employer, who shall issue instructions for dealing with it. If the Contractor suffers delay and/or incurs cost from complying with the instructions, the Contractor shall give a further notice to the Employer and shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

4. DESIGN

4.1 General Design Obligations

The Contractor shall carry out, and be responsible for, the design of the Works. Design shall be prepared by qualified designers who are engineers or other professionals.

The Contractor warrants that he, his designers and design Subcontractor have the experience and capability necessary for the design. The Contractor undertakes that the designers shall be available to attend discussions with the Employer at all reasonable times, until the expiry date of the relevant Defects Notification Period.

Upon receiving notice under Sub-Clause 7.1 [*Commencement of Work*], the Contractor shall scrutinize the Employer's Requirement as specified in the Annex 16 (including design criteria and calculations, if any), calculated from the Commencement Date, the Contractor shall give notice to the Employer of any error, fault or other defect found in the Employer's Requirements or these items of reference.

The Contractor submits to the Employer detailed design for the Employer's review and comment. Employer's comments to the design, if any, must be received within ninety (90) days after submission. After Employer's design approval, the design is frozen and implementation may commence. In case the approval is not received within ninety (90) days then the Parties will agree new approval deadline In Writing.

4.2 Contractor's Documents

The Contractor's Documents shall comprise the documents specified in the Contract. The Contractor's Documents shall be written in the language for communications defined in Sub-Clause 1.4 [*Law and Language*]. Relevant documents shall be translated to Vietnamese language (for convenience).

The Contractor shall prepare all Contractor's Documents, and shall prepare any other documents necessary to instruct the Contractor's Personnel. The

Employer's Personnel shall have the right to inspect the preparation of all these documents at its own costs, wherever they are being prepared.

4.3 Technical Standard and Regulations

The design of the Supplies, the Contractor's Documents and the execution of the Project will be in accordance with:

(a) the Laws applicable to the Contract, and

(b) the documents forming the Contract, as altered or modified by Variations.

4.4 Technical Standard and Regulations

The design of the Supplies, the Contractor's Documents and the execution of the Project shall comply with the technical standards, building, construction and environmental Laws, and Laws applicable to the product being produced from the Works, and the Employer's Requirement as specified in Annex 16 [*Employer's Requirement*], and as defined in Sub-Clause 1.4 [*Law and Language*].

All these Laws shall, in respect of the Works and each Section, be those prevailing on the Commencement Date, unless stated otherwise.

4.5 Training

The Contractor shall carry out the training of Employer's Personnel in the operation and maintenance of the Works in accordance with Annex 13 [*Services*].

4.6 As-Built Documents

The Contractor shall prepare, and keep up-to-date during the Contract period, a set of "as-built" records of the execution of the Project specific Works in accordance with Sub-Clause 1.4 [*Law and Language*]. These records shall be kept on the Site and shall be used exclusively for the purposes of this Sub-Clause. Two copies shall be supplied to the Employer prior to the commencement of the Site Acceptance Tests.

The Works shall not be considered to be completed for the purposes of taking-over under Sub-Clause 9.1 [*Taking Over of the Works and Sections*] until the Employer has received these documents.

4.7 Operation and Maintenance Manuals

Prior to the commencement of the Tests on Completion, the Contractor shall supply to the Employer the operation and maintenance manuals in sufficient detail for the Employer to operate, maintain, dismantle, adjust and repair the Supplies.

The Works shall not be considered to be completed for the purposes of taking-over under Sub-Clause 9.1 [*Taking Over of the Works and Sections*] until the Employer has received final operation and maintenance manuals.

4.8 Design Error

If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in the Contractor's Documents prior to the date of the design freeze, the Contractor shall use reasonable efforts to correct them. Insofar as the foregoing relate to software supplied under the Contract, the applicable software license conditions as attached to the Contract shall apply.

5. STAFF AND LABOUR

5.1 Engagement of Staff and Labour

The Contractor shall make arrangements for the engagement of personnel.

5.2 Rates of Wages and Conditions of Labour

The Contractor shall pay rates of wages, and observe conditions of labour, which are not lower than those established for the trade or industry where the work is carried out

5.3 Persons in the Service of Employer

The Contractor shall not recruit, or attempt to recruit, staff and labour from amongst the Employer's Personnel.

5.4 Labour Laws

The Contractor shall comply with all the relevant labour Laws applicable to the Contractor's Personnel under the Law applicable to the Contract, including Laws relating to their employment, health and safety, and shall allow them all their legal rights.

The Contractor shall require his employees to obey all laws applicable to the Contract, including those concerning safety at work.

5.5 Working Hours

No work shall be carried out on the Site on locally recognized days of rest, or outside the normal working hours, unless:

(a) otherwise stated in the Contract,

(b) the Contractor gives consent, or

(c) the work is unavoidable, or necessary for the protection of life or property or for the safety of the Works, in which case the Contractor shall immediately advise the Employer.

5.6 Facilities for Staff and Labour

The Contractor shall provide and maintain all necessary accommodation and welfare facilities for the Contractor's Personnel.

The Contractor shall not permit any of the Contractor's Personnel to maintain any temporary or permanent living quarters within the structures forming part of the Supplies.

5.7 Health and Safety

The Contractor shall at all times take all reasonable precautions to maintain the health and safety of the Contractor's Personnel. In collaboration with local health authorities, the Contractor shall ensure that sufficient first aid facilities are available at the Site during the Works for the Contractor's Personnel and hygiene requirements for the prevention of epidemics are followed.

The Contractor shall send, to the Employer, details of any accident as soon as practicable after its occurrence.

5.8 Contractor's Superintendence

The Contractor's Superintendent means Contractor's Project Manager. Throughout the design and execution of the Works, and as long thereafter as is necessary to fulfil the Contractor's obligations, the Contractor shall provide all necessary superintendence to plan, arrange, direct, manage, inspect and test the work.

Superintendence shall be given by a sufficient number of persons having adequate knowledge of the language for communications (defined in Sub-Clause 1.4 [*Law and Language*]) and of the operations to be carried out (including the methods and techniques required, the hazards likely to be encountered and methods of preventing accidents), for the satisfactory and safe execution of the Works.

5.9 Contractor's Personnel

The Contractor's Personnel shall be appropriately qualified, skilled and experienced in their respective trades or occupations, as required for the Contractor to execute the Project in accordance with the Contract. The Employer may require the Contractor to remove (or cause to be moved) any person employed on the Site or Works, including the Contractor's Representative if applicable, who:

(a) persists in any significant misconduct or lack of care,

(b) carries out duties incompetently or negligently,

(c) fails to conform with any provisions of the Contract, or

(d) persists in any conduct which is prejudicial to safety, health, or the protection of the environment.

If appropriate, the Contractor shall then appoint (or cause to be appointed) a suitable replacement person.

5.10 Records of Contractor's Personnel and Equipment

The Contractor shall submit, to the Employer, details showing the Contractor's Personnel and of each major Contractor's Equipment on the Site. Details shall be submitted sufficiently to keep the Employer informed at the bi-monthly reporting (Sub-Clause 3.20 [*Progress Reports*]) until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

5.11 Disorderly Conduct

The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or amongst the Contractor's Personnel, and to preserve peace and protection of persons and property on the Site.

6. PLANT, MATERIALS AND WORKMANSHIP

6.1 Manner of Execution

The Contractor shall carry out the execution of the Project:

(a) in accordance specified in the Contract,

(b) in a proper workmanlike and careful manner, in accordance with recognized good practice, and

(c) with properly equipped facilities and non-hazardous Materials, except as otherwise specified in the Contract.

6.2 Inspection

The Employer's Personnel shall at all reasonable times:

(a) have full access to all parts of the Site and to all places from which natural Materials are being obtained for the construction of the Project, and

(b) during production, manufacture and construction (at the Site and elsewhere), be entitled to examine and inspect the materials and workmanship, and to check the progress of manufacture of the Supplies, all at Employer's cost.

The Contractor shall give the Employer's Personnel full opportunity to carry out these activities, including providing access, facilities, permissions and safety equipment. No such activity shall relieve the Contractor from any obligation or responsibility.

The Contractor shall give notice to the Employer when the civil works on Site have been prepared . The Employer shall then carry out the examination or inspection within 5 days. In case no examination or inspection will be done during that time the Contractor has the right to proceed with the Works. If the

Contractor fails to give the notice, he shall, if and when required by the Employer, uncover the work and thereafter reinstate and make good, all at the Contractor's cost.

6.3 Testing

This Sub-Clause shall apply to all tests specified in the Contract.

Testing of the Supplies and Services excluding the local civil works on Site shall be performed in accordance with the processes, procedures and methods detailed in Annex 6 [*FAT Regulations*] and Annex 7 [*SAT Regulations*] of the Contract and the conditions below shall not apply to those.

Testing the Local Civil Works;

The Contractor shall provide testing results for the material used in civil works to the Employer, and the results should be approved by the Employer within 5 days. In case no approval has been received within 5 days, the results shall be deemed to be approved.

If the Contractor suffers delay and/or incurs cost from complying with these instructions or as a result of a delay for which the Employer is responsible, the Contractor shall give notice to the Employer and shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

6.4 Rejection

If, as a result of an examination, inspection, measurement or testing, any Supplies is found to be defective or otherwise not in accordance with the Contract, the Employer may reject the Supplies by giving notice to the Contractor, with reasons. The Contractor shall then promptly make good the defect and ensure that the rejected item complies with the Contract.

Minor deficiencies which do not affect the quality, specification stated at the design freeze, and operation of Supplies shall not prevent FAT or SAT from being completed and accepted. In case minor deficiencies shall be found, the repair of those deficiencies shall be agreed between the Parties.

If the Employer requires this part of Supplies to be retested, the tests shall be repeated under the same terms and conditions. If the rejection and retesting cause the Employer to incur additional costs, the Contractor shall pay these costs to the Employer.

6.5 Remedial Work

Notwithstanding any previous test or certification, the Employer may instruct the Contractor to:

(a) remove from the Site and replace any Equipment or Materials which is not in accordance with the Contract,

(b) remove and re-execute any other work which is not in accordance with the Contract, and

(c) execute any work which is urgently required for the safety of the Works, whether because of an accident, unforeseeable event or otherwise.

The Contractor shall comply with the instruction within a reasonable time, or immediately if urgency is specified under sub-paragraph (c).

6.6 Ownership of the Supplies

The ownership of the Supplies will transfer to the Employer when they have been paid in full.

The transfer of ownership does not release the Contractor from the warranty obligations as stated in this Contract.

6.7 Royalties

The software provided under the Contract shall be perpetual and royalty free and governed by the software license conditions as stated in Annex 14 [*Licenses*].

Unless otherwise stated in the Employer's Requirement, the Contractor shall pay all royalties, rents and other payments for:

(a) natural Materials obtained from outside the Site, and

(b) the disposal of material from demolitions and excavations and of other surplus material (whether natural or man-made), except to the extent that disposal areas within the Site are specified in the Contract.

7. COMMENCEMENT, DELAYS AND SUSPENSION

7.1 Commencement of Work

This Contract shall enter into force on the Execution Date, subject to the conditions precedent defined below, and shall remain in force until both Parties have fulfilled their obligations hereunder.

Conditions precedent:

(i) Loan Agreement has become effective; and

(ii) All the necessary decisions, approvals and permissions required by and related to the Finnish Concessional Credit Financing have been fulfilled; and

(iii) Relevant Vietnamese authorities have approved this Contract and Vaisala has received a written confirmation thereof; and

(iv) The Employer has approved the engineering design submitted by the Contractor.

If the above conditions precedent have not been fulfilled within nine (9) months from the Execution Date, this Contract shall be considered null and void.

The commencement of the engineering design shall start latest 28 days after the Execution Date.

Provided that the conditions precedent have been fulfilled, the Project must commence within six (6) months from the date conditions precedent have been fulfilled (Commencement Date).

7.2 Time for Completion

Preliminary project plan for the Project is presented in Annex 4 [*Project Plan*] of the Contract. The project plan is preliminary and dependent on the actual commencement of the Project in accordance with the dates stated therein.

The Contractor shall have the right to revise the project plan. Any revision shall be notified to the Employer and to be approved by the Employer without undue delay.

7.3 Programme

The Contractor shall submit a detailed project plan to the Employer within 28 days after receiving the notice under Sub-Clause 7.1 [*Commencement of Works*]. The Contractor shall also submit a revised project plan whenever the previous project plan is inconsistent with actual progress or with the Contractor's obligations. Each project plan shall include:

(a) the order in which the Contractor intends to carry out the Works, including the anticipated timing of each stage of design (if any), Contractor's Documents, manufacture, inspection, delivery to Site, construction, erection, testing, commissioning and trial operation,

(b) the sequence and timing of inspections and tests specified in the Contract, and

(c) a supporting report which includes:

  (i) a general description of the methods which the Contractor intends to adopt, and of the major stages, in the execution of the Works, and

  (ii) details showing the Contractor's reasonable estimate of the number of Contractor's Personnel and of major Contractor's Equipment, required in the Site for each major stage.

Unless the Employer, within 2 days after receiving a project plan, gives notice to the Contractor stating the extent to which it does not comply with the Contract, the Contractor shall proceed in accordance with the programme, subject to his other obligations under the Contract. The Employer's Personnel shall be entitled to rely upon the project plan when planning their activities.

The Contractor shall promptly give notice to the Employer of specific probable future events or circumstances, which may adversely affect the work or delay the execution of the Works. The Employer may require the Contractor to submit an estimate of the anticipated effect of the future event or circumstances, and/or a proposal under Sub-Clause 11.3 [*Variation Procedure*].

If, at any time, the Employer gives notice to the Contractor that a programme fails (to the extent stated) to comply with the Contract or to be consistent with actual progress and the Contractor's stated intentions, the Contractor shall submit a revised project plan to the Employer in accordance with this Sub-Clause.

7.4 Extension of Time for Completion

The Contractor shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to an extension of the Time for Completion if and to the extent that completion for the purposes of Sub-Clause 9.1 [*Taking Over of the Works and Sections*] is or will be delayed by any of the following causes:

(a) a Variation (unless an adjustment to the Time for Completion has been agreed under Sub-Clause 11.3 [*Variation Procedure*]),

(b) a cause of delay giving an entitlement to extension of time under a Sub-Clause of the Contract,

(c) exceptionally adverse climatic conditions,

(d) unforeseeable shortages in the availability of personnel or Goods caused by epidemic or governmental actions, or

(e) any delay, impediment or prevention caused by or attributable to the Employer, the Employer's Personnel, or the Employer's other contractors on the Site.

If the Contractor considers himself to be entitled to an extension of the Time for Completion, the Contractor shall give notice to the Employer in accordance with Sub-Clause 18.1 [*Contractor's Claims*] and the extension shall be agreed in mutual negotiations between the Parties.

7.5 Delays Caused by Authorities

If the following conditions apply, namely:

(a) the Contractor has diligently followed the procedures laid down by the relevant legally constituted public authorities in the Country,

(b) these authorities delay or disrupt the Contractor's work, and

(c) the delay or disruption was unforeseeable,

then this delay or disruption will be considered as a cause of delay under subparagraph (b) of Sub-Clause 7.4 [*Extension of Time for Completion*].

7.6 Rate of Progress

If, at any time:

(a) actual progress is too slow to complete within the Time for Completion, and/or

(b) progress has fallen (or will fall) behind the current programme under Sub-Clause 7.3 [*Programme*],

other than as a result of a cause listed in Sub-Clause 7.4 [*Extension of Time for Completion*], then the Employer may instruct the Contractor to submit, under Sub-Clause 7.3 [*Programme*], a revised project plan and supporting report describing the revised methods which the Contractor proposes to adopt in order to expedite progress and complete within the Time for Completion.

Unless the Employer notifies otherwise, the Contractor shall adopt these revised methods, which may require increases in the working hours and/or in the numbers of Contractor's Personnel and/or Goods, at the risk and cost of the Contractor.

7.7 Suspension of Work

Any suspension of works would need to based on mutual agreement between both Parties.

7.8 Consequences of Suspension

If the Contractor suffers delay and/or incurs cost from complying with the Employer's instructions under Sub-Clause 7.7 [*Suspension of Work*] and/or from resuming the work, the Contractor shall give notice to the Employer and shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

The Contractor shall not be entitled to an extension of time for making good the consequences of the Contractor's faulty design, workmanship or materials, or of the Contractor's failure to protect, store or secure in accordance with Sub-Clause 7.7 [*Suspension of Work*].

7.9 Payment for the Supplies in Event of Suspension

The Contractor shall be entitled to payment of the value (as at the date of suspension) of the Supplies which have not been delivered to Site, if:

(a) the work on Site or delivery of Supplies have been suspended for more than 28 days due to the Employer's suspension, and

(b) the Contractor has marked the Site and/or Supplies as the Employer's property in accordance with the Employer's instructions.

7.10 Prolonged Suspension

If the suspension under Sub-Clause 7.7 [*Suspension of Work*] has continued for more than 84 days, the Contractor may request the Employer's permission to proceed. If the Employer does not give permission within 28 days after being requested to do so, the Contractor may, by giving notice to the Employer, treat the suspension as an omission under Clause 11 [*Variation and Adjustments*] of the affected part of the Works. If the suspension affects the whole of the Works, the Contractor may give notice of termination under Sub-Clause 14.2 [*Termination by Contractor*].

7.11 Resumption of Work

After the permission or instruction to proceed is given, the Contractor and the Employer shall jointly examine the Works and the Supplies affected by the suspension. The Contractor shall make good any deterioration or defect in or loss of the Works or Supplies which has occurred during the suspension.

8. TESTS ON COMPLETION (Site Acceptance Test)

8.1 Contractor's Obligations

The Contractor shall carry out the Tests on Completion in accordance with this Clause and Sub-Clause 6.3 [*Testing*], after providing the documents in accordance with Sub-Clause 4.6 [*As-Built Documents*] and Sub-Clause 4.7 [*Operation and Maintenance Manuals*].

The Contractor shall give to the Employer not less than 14 days' notice of the date after which the Contractor will be ready to carry out each of the Tests on Completion (Site Acceptance Test). Unless otherwise agreed, Tests on Completion shall be carried out within 14 days after this date.

Tests on Completion shall be performed in accordance with the processes, procedures and methods detailed in Annex 7 [*SAT Regulations*] of the Contract.

8.2 Delayed Tests

If the Tests on Completion are being unduly delayed by the Employer, Sub-Clause 6.3 [*Testing*] and/or Sub-Clause 9.2 [*Interference with Tests on Completion*] shall be applicable.

If the Tests on Completion are being unduly delayed by the Contractor, the Employer may by notice require the Contractor to carry out the Tests within 21 days after receiving the notice. The Contractor shall carry out the Tests on such days within that period as the Contractor may fix and of which he shall give notice to the Employer.

If the Contractor fails to carry out the Tests on Completion within the period of 42 days, the Employer's Personnel may proceed with the Tests at the risk and cost of the Contractor. The Tests on Completion shall then be deemed to have

been carried out in the presence of the Contractor and the results of the Tests shall be accepted as accurate.

8.3 Retesting

If the Works, or a Section, fail to pass the Tests on Completion, Sub-Clause 6.4 [*Rejection*] shall apply, and the Employer or the Contractor may require the failed Tests, and Tests on Completion on any related work, to be repeated under the same terms and conditions.

8.4 Failure to Pass Tests on Completion

If the Works, or a Section, fail to pass the Tests on Completion repeated under Sub-Clause 8.3 [*Retesting*], the Employer shall be entitled to:

(a) order further repetition of Tests on Completion under Sub-Clause 8.3 [*Retesting*].

In case after repeated tests on completion the failure deprives the Employer of substantially the whole benefit of the Works or Section, the Employer may reject the Works or Section (as the case may be), in which case paragraph (c) of Sub-Clause 10.3 [*Failure to Remedy Defects*] shall apply.

Minor deficiencies which do not affect the quality, specification stated at the design freeze, and operation of Supplies shall not prevent SAT from being completed and accepted. In case minor deficiencies shall be found, the repair of those deficiencies shall be agreed between the Parties.

9. EMPLOYER'S TAKING OVER

9.1 Taking Over of the Works and Sections

Any reference to Taking Over in the Contract shall be considered a reference to Acceptance as defined in the Definitions of the Contract.

Except as stated in Sub-Clause 8.4 [*Failure to Pass Tests on Completion*], the Works shall be taken over by the Employer when (i) SAT of the Supplies or part thereof has been completed, and (ii) a Taking-Over Certificate (SAT certificate) for the Works has been issued, as specified in Annex 7 [*SAT Regulations*], or (iii) the system has been taken into use by the Employer.

The Contractor may notify the Employer of readiness of the Supplies for SAT not earlier than 14 days before the Works will, in the Contractor's opinion, be complete and ready for SAT. If the Works are divided into Separable Portions called Lots, the Contractor may similarly apply for a SAT i.e. Taking-Over Certificate for each Lot.

Taking over the Supplies and Services shall be performed in accordance with the processes, procedures and methods detailed in Annex 7 [*SAT Regulations*] of this Contract.

Supplies and Services shall be deemed finally accepted, and Contractor's obligations under Project completely fulfilled, upon signing of SAT protocol, or

upon taking Supplies wholly or in part into operational use, whichever occurs first.

Commencement of Warranty Period apply separately to each Lot.

The Employer shall, within 28 days after receiving the Contractor's application:

(a) issue the Site Acceptance Certificate (Taking-Over Certificate) to the Contractor, stating the date on which the Works or Lot were completed in accordance with the Contract, except for any minor outstanding work and defects which will not substantially affect the use of the Works or Lot for their intended purpose (either until or whilst this work is completed and these defects are remedied); or

(b) reject the application, giving reasons and specifying the work required to be done by the Contractor to enable the Taking-Over Certificate to be issued. The Contractor shall then complete this work before issuing a further notice under this Sub-Clause.

If the Employer fails either to issue the Site Acceptance Certificate (Taking-Over Certificate) or to reject the Contractor's application within the period of 28 days and if the Works or Section (as the case may be) are substantially in accordance with the Contract, the Site Acceptance Certificate (Taking-Over Certificate) shall be deemed to have been issued on the last day of that period.

9.2 Interference with Tests on Completion

If the Contractor is prevented, for more than 14 days, from carrying out the Tests on Completion by a cause for which the Employer is responsible, the Employer shall be deemed to have taken over the Works or Separable Portion i.e. Lot (as the case may be) on the date when the Tests on Completion would otherwise have been completed.

The Employer shall then issue a Taking-Over Certificate accordingly, and the Contractor shall carry out the Tests on Completion as soon as practicable.

If the Contractor suffers delay as a result of this delay in carrying out the Tests on Completion, the Contractor shall give notice to the Employer and shall be entitled subject to Sub-Clause 18.1 [*Contractor's Claims*] to:

(a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*].

9.3 Surfaces Requiring Reinstatement

Except as otherwise stated in a Taking-Over Certificate, a certificate for a Section or part of the Works shall not be deemed to certify completion of any ground or other surfaces requiring reinstatement for the Contractor's scope of works.

10. DEFECTS LIABILITY

10.1 Completion of Outstanding Work and Remedying Defects

Subject to the warranty conditions detailed in this Clause and the applicable software license conditions attached to the Contract, in order that the Works and Contractor's Documents and each Section shall be in the condition required by the Contract (fair wear and tear excepted), the Contractor shall:

(a) complete any work which is outstanding on the date stated in a SAT certificate, within reasonable time as mutually agreed, and

(b) remedy defects, as may be notified by (or on behalf of) the Employer on or before the expiry date of the Defects Notification Period for the Supplies or part thereof (as the case may be), all in accordance with the warranty conditions detailed in this Clause.

If a defect appears or damage occurs, the Contractor shall be notified accordingly, by (or on behalf of) the Employer.

The Contractor hereby warrants Supplies to be free from defects in workmanship and material during a period of eighteen (18) months. If any of Supplies proves to be defective in workmanship or material within the period herein provided, the Contractor undertakes, to the exclusion of any other remedy, to repair or at its own option replace defective Supplies or part thereof, and otherwise on the same conditions as for the original Supplies or part thereof, without extension to the original warranty time. Defective Supplies replaced in accordance with this Clause shall be placed at the disposal of the Contractor.

The Contractor warrants that Services are performed in a workmanlike manner. If any of Services proves to be inadequate or faulty and should this cause malfunction or non-functioning of Supplies, the Contractor shall at its option either re-perform Services or repair or replace Supplies in question.

This warranty is subject to the following conditions:

a) A substantiated claim In Writing as to any alleged defects shall have been received by the Contractor within thirty (30) days after the defect or fault became known or occurred; and

b) The allegedly defective Supplies or part thereof shall, should the Contractor so require, be sent to the works of the Contractor or to such other place as the Contractor may indicate In Writing, freight and insurance prepaid and properly packed and labelled, unless the Contractor agrees to inspect and repair or replace Supplies on site.

This warranty does not however apply when the defect has been caused through:

a) wear and tear;

b) accident, theft or vandalism;

c) forces of nature;

d) misuse or other unsuitable or unauthorized use of Supplies or negligence or error in storing, maintaining or handling of Supplies;

e) erroneous installation or assembly or failure to service Supplies or otherwise follow Contractor's service instructions, including any repairs or installation or assembly or service made by unauthorized personnel not approved by the Contractor, or replacements with parts not manufactured or supplied by the Contractor;

f) modifications or changes to Supplies as well as any adding to them without Contractor's prior authorization;

g) other factors depending on Employer or a third party.

Notwithstanding the aforesaid, The Contractor's liability under this Clause shall not apply to any defects arising out of materials, designs or instructions provided by Employer.

This warranty is expressly in lieu of and excludes all other conditions, warranties and liabilities, express or implied, whether under law, statute or otherwise, including without limitation ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE, and all other obligations and liabilities of the Contractor or its representatives with respect to any defect or deficiency applicable to or resulting directly or indirectly from Supplies, which obligations and liabilities are hereby expressly excluded and waived. The Contractor's liability shall under no circumstances exceed the price of any of Supplies for which a warranty claim is made, nor shall the Contractor in any circumstances be liable for lost profits or other consequential loss, whether direct or indirect, or for special damages.

The Warranty Period shall commence on the earliest event of:

a) Acceptance of Supplies or part thereof, as per the acceptance regulations defined in the Contract; or

b) Six (6) months from the delivery of Supplies or part thereof, as per the delivery term defined in the Contract.

10.2 Cost of remedying Defects

All work referred to in sub-paragraph (b) of Sub-Clause 10.1 [*Completion of Outstanding Work and Remedying Defects*] shall be executed at the risk and cost of the Contractor, as defined in Sub-Clause 10.1 [*Completion of Outstanding Work and Remedying Defects*].

10.3 Failure to Remedy Defects

If the Contractor fails to remedy any defect or damage within a reasonable time, such time not being less than 42 days after the Contractor's receipt of the detailed notice of the defect, a date may be fixed by (or on behalf of) the Employer, on or by which the defect or damage is to be remedied. The Contractor shall be given reasonable notice of this date.

If the Contractor fails to commence reasonable actions to remedy the defect or damage by this notified date and this remedial work was to be executed at the cost of the Contractor under the warranty conditions specified above, the Employer may (at his option):

(a) carry out the work himself or by others, in a reasonable manner and at the Contractor's cost to be withdrawn from the Contractor's Performance or Warranty Guarantee, but the Contractor shall have no responsibility for this work;

(c) if the defect deprives the Employer the whole benefit of the Works, terminate the Contract as a whole, or in respect of such major part which cannot be put to the intended use. Without prejudice to any other rights, under the Contract or otherwise, the Employer shall then be entitled to recover sums paid for the Works related to the defective portion or such part (as the case may be).

10.4 Removal of Defective Work

If the defect or damage cannot be remedied expeditiously on the Site and the Employer gives consent, the Contractor may remove from the Site for the purposes of repair such Supplies or part thereof as are defective or damaged.

10.5 Right of Access

Until the Performance Certificate has been issued, the Contractor shall have the right of access to all parts of the Works and to records of the operation and performance of the Works, except as may be inconsistent with the Employer's reasonable security restrictions.

10.6 Contractor to Search

The Contractor shall, if required by the Employer, search for the cause of any defect and take appropriate actions in accordance with the above warranty conditions.

10.7 Performance Certificate

Performance Certificate means the SAT certificate.

Site Acceptance Tests (SATs) shall be conducted according to Contractor's standard processes, procedures and methods, as notified by Contractor.

Installation of Supplies shall be followed by SAT without delay. Presence of Customer representative(s) is required at SAT, but in their absence, Contractor may perform SAT alone. SAT protocol shall be signed by the representatives of Parties, or in the absence of Customer representative(s), by Contractor's representative alone.

Minor deficiencies which do not affect the operation of Supplies shall not prevent FAT or SAT from being completed and accepted.

Supplies and Services shall be deemed finally accepted, and Contractor's obligations under Project completely fulfilled, upon signing of SAT protocol, or upon taking Supplies wholly or in part into operational use, whichever occurs first.

As the Project includes Separable Portions (Lots), Contractor may notify Customer In Writing that acceptance of such Separable Portions will take place individually for each such portion. The interpretation and application of FAT,

SAT, Acceptance, completion of Project and commencement of Warranty Period apply separately to each Separable Portion, and references to Supplies and Services under Project mean those parts of Supplies and Services included in the relevant Separable Portion.

10.8 Unfulfilled Obligations

After the Performance Certificate has been issued, each Party shall remain liable for the fulfillment of any obligation, which remains unperformed at that time. For the purposes of determining the nature and extent of unperformed obligations, the Contract shall be deemed to remain in force.

10.9 Clearance of Site

Upon receiving the Performance Certificate, the Contractor shall remove any remaining Contractor's Equipment, surplus material, wreckage, rubbish and Temporary Works from the Site.

If all these items have not been removed within 28 days after the Employer receives a copy of the Performance Certificate, the Employer may sell or otherwise dispose of any remaining items. The Employer shall be entitled to be paid the costs incurred in connection with, or attributable to, such sale or disposal and restoring the Site.

Any balance of the moneys from the sale shall be paid to the Contractor. If these moneys are less than the Employer's costs, the Contractor shall pay the outstanding balance to the Employer.

11. VARIATIONS AND ADJUSTMENTS

11.1 Right to Vary

This Clause shall apply without limiting the Contractor's right to certain additional charges as per Annex 14.

Variations may be proposed by either Party at any time prior to issuing the SAT certificate for the Works,. A Variation shall not comprise the omission of any work which is to be carried out by others.

The Parties shall negotiate the contents and effects of each Variation proposal, unless the Contractor promptly gives notice to the Employer stating (with supporting particulars) that (i) the Contractor cannot readily obtain the Goods required for the Variation, (ii) it will reduce the safety or suitability of the Works, or (iii) it will have an adverse impact on the achievement of the Schedule of Guarantees. Upon receiving this notice, both Parties shall cancel, confirm or vary the instruction.

11.2 Value Engineering

The Contractor may, at any time, submit to the Employer a written proposal which (in the Contractor's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the

Works, (iii) improve the efficiency or value to the Employer of the completed Works, or (iv) otherwise be of benefit to the Employer.

The proposal shall be prepared at the cost of the Contractor and shall include the items listed in Sub-Clause 11.3 [*Variation Procedure*].

11.3 Variation Procedure

Each proposal for Variation shall be followed by:

(a) Contractor's description of the proposed design and/or work to be performed and a programme for its execution,

(b) the Contractor's proposal for any necessary modifications to the programme according to Sub-Clause 7.3 [*Programme*] and to the Time for Completion, and

(c) the Contractor's proposal for adjustment to the Contract Price.

The Employer shall, as soon as practicable after receiving such proposal (under Sub-Clause 11.2 [*Value Engineering*] or otherwise), respond with approval, disapproval or comments, after which the Parties shall aim to agree on the final contents and effects of the Variation.

Each instruction to execute a Variation, with any requirements for the recording of costs shall be issued by the Employer to the Contractor, who shall acknowledge receipt.

12. CONTRACT PRICE AND PAYMENT

12.1 Contract Price

The Contract Price shall be the lump sum of Euro 20,228,000.00, (Grand total contract amount Euro twenty million two hundred twenty-eight thousand only). The prices are: (i) net of FCT value added tax; and (ii) gross of FCT corporate income tax.

The Employer shall be responsible for all taxes, customs duties and charges levied in connection with the import of the Supplies and Services to Vietnam, and for any other local customs duties, taxes and charges arising out of or in connection with this Contract. Notwithstanding the foregoing, the Contractor shall be responsible for the corporate income tax part of the Foreign Contractor Tax. The Employer shall bear the value added tax part of the Foreign Contractor Tax, and shall withhold the corporate income tax part of the Foreign Contractor Tax from its payment to the Contractor. Therefore the Employer shall withhold, declare and pay the respective amounts on behalf of the Contractor in accordance with the applicable regulations.

Any quantities before the design freeze which may be set out in this Contract are estimated quantities and are not to be taken as the actual and correct quantities of the Works which the Contractor is required to execute.

Contract Price shall be divided to following Lots:

- Lot 1; Engineering Design Euro 200,000.00 (Euro two hundred thousand only)
- Lot 2; 1st Weather Radar Euro 2,290,326.00 (Euro two million two hundred ninety thousand three hundred twenty six only)
- Lot 3; 2nd Weather Radar Euro 2,290,326.00 (Euro two million two hundred ninety thousand three hundred twenty six only)
- Lot 4; 3rd Weather Radar Euro 2,290,326.00 (Euro two million two hundred ninety thousand three hundred twenty six only)
- Lot 5; 4th Weather Radar Euro 2,290,326.00 (Euro two million two hundred ninety thousand three hundred twenty six only)
- Lot 6; 5th Weather Radar Euro 2,290,326.00 (Euro two million two hundred ninety thousand three hundred twenty six only)
- Lot 7; 1st Weather Radar Upgrade Euro 417,833.00 (Euro four hundred seventeen thousand eight hundred thirty three only)
- Lot 8; 2nd Weather Radar Upgrade Euro 417,833.00 (Euro four hundred seventeen thousand eight hundred thirty three only)
- Lot 9; 3rd Weather Radar Upgrade Euro 417,833.00 (Euro four hundred seventeen thousand eight hundred thirty three only)
- Lot 10; Weather Radar Central Site and Composite Euro 1,266,300.00 (Euro one million two hundred sixty six thousand three hundred only)
- Lot 11; Lightning Detection System Euro 2,927,294.00 (Euro two million nine hundred twenty seven thousand two hundred ninety four only)
- Lot 12; SmartMet system Euro 2,677,797.00 (Euro two million six hundred seventy seven thousand seven hundred ninety seven only)
- Lot 13; Spare Parts Euro 451,480.00 (Euro four hundred fifty-one thousand four hundred eighty only)

The present Contract will be financed for 100% under the Finnish Concessional Credit Financing under the Loan Agreement to be made between Nordea Bank Finland Plc and the Ministry of Finance of Vietnam. Payments to be effected under the Contract will be made by Nordea Bank Finland Plc from the said loan directly to the Contractor based on Utilization Requests issued by Ministry of Finance of Vietnam after instruction from the Employer, or based on the Letter of Credit, all as detailed in this Contract.

12.2 Advance Payment

30% advance payment of the total Contract Price shall be paid within forty-five (45) days after the Commencement Date, in any event before the commencement of works related to the Project.

The advance payment shall be made against following documents:

- invoice;
- Advance Payment Guarantee for the full value of the advance payment; and
- Performance Guarantee in the amount corresponding to 5% of the Contract Price.

The advance payment shall be based on Utilization Request ("UR"). The UR is issued by the Ministry of Finance of Vietnam based on payment instruction from the Employer. The Employer undertakes to ensure that the UR is issued without delay after the conditions for the payment have been fulfilled.

12.3 Scheduled Payments

Scheduled payments after the advance payment will be for each individual Lot. The terms and procedures of payment according to which the Employer will reimburse the Contractor are following.

Lot Payment Schedule:

For Lot 1;

1) 70% final payment for the Lot 1 within forty-five (45) days after the design freeze against invoice only. Final payment shall be based on Utilization Requests ("UR"). The UR is issued by the Ministry of Finance of Vietnam based on payment instruction from the Employer. The Employer undertakes to ensure that the UR is issued without delay after the conditions for the payment have been fulfilled.

For Lot 2-13;

1) 50% scheduled payment for each individual Lot by irrevocable and confirmed Letter of Credit against shipping documents inclusive of packing list, certificate of origin, invoice, and certificate of quantity.

2) 20% final payment for each individual Lot within forty-five (45) days after SAT of the Supplies of the respective Lot against SAT certificate, invoice and the Warranty Guarantee. Final payment shall be based on Utilization Requests ("UR"). The UR is issued by the Ministry of Finance of Vietnam based on payment instruction from the Employer. The Employer undertakes to ensure that the UR is issued without delay after the conditions for the payment have been fulfilled.

The Contractor has right to cease any further shipments or works in case the payments have not been made according to this Contract.

12.4 Delayed Payment

The Contractor has the right to cease any further shipments or works in case the payments have not been made according to this contract within forty-five (45) days.

12.5 Currencies of Payment

The Contract Price shall be paid in Euro.

13. TERMINATION BY EMPLOYER

13.1 Notice to Correct

If the Contractor fails to carry out any obligation under the Contract, the Employer may by notice require the Contractor to make good the failure and to remedy it within a reasonable time.

13.2 Termination by Employer

The Employer shall be entitled to terminate the Contract by giving of at least forty-five (45) days' written notice of its intention to do so, if the Contractor:

(a) fails to issue the Performance Guarantee and does not rectify the failure with the said period of at least forty-five (45) days,

(b) abandons the whole of the Works for period of sixty (60) days without reasonable excuse, or otherwise plainly demonstrates the intention not to continue performance of his obligations under the Contract,

(c) without reasonable excuse fails:

  (i) to commence reasonable actions to rectify the Contractor's material breach of the Contract within sixty (60) days after the Contractor's receipt of a detailed written notice specifying such breach,

(d) subcontracts the whole of the Works or assigns the whole of the Contract without the required agreement,

(e) becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with his creditors, or carries on business under a receiver, trustee or manager for the benefit of his creditors, or

(f) is found to be in violation of any applicable bribery Laws related to the Contract.

In any of these events or circumstances, the Employer may, upon giving the said forty-five (45) days' notice to the Contractor, terminate the Contract and expel the Contractor from the Site. However, in the case of sub-paragraph (e) or (f), the Employer may by notice terminate the Contract immediately.

The Employer's election to terminate the Contract shall not prejudice any other rights of the Employer, under the Contract or otherwise.

The Contractor shall then leave the Site and deliver design documents made by or for him, to the Employer. However, the Contractor shall use his best efforts to comply immediately with any reasonable instructions included in the notice (i) for the assignment of any subcontract, and (ii) for the protection of life or property or for the safety of the Works.

After termination, the Employer may complete the Works and/or arrange for any other entities to do so. The Employer and these entities may then use any Goods, Contractor's Documents and other design documents made by or on behalf of the Contractor and as are delivered to the Employer prior to the date of the termination.

The Employer shall then give notice that the Contractor's Equipment and Temporary Works will be released to the Contractor at or near the Site. The Contractor shall promptly arrange their removal, at the risk and cost of the Contractor. However, if by the time the Contractor has failed to make a payment due to the Employer, these items may be sold by the Employer in order to recover this payment. Any balance of the proceeds shall then be paid to the Contractor.

13.3 Valuation at Date of Termination

As soon as practicable after a notice of termination under Sub-Clause 13.2 [*Termination by Employer*] has taken effect, the Contractor shall submit to the Employer a calculation on the value of the Works, Goods and Contractor's Documents, and any other sums due to the Contractor for work executed in accordance with the Contract. Based on the Contractor's calculation the Parties shall negotiate the final value due to the Contractor.

Failing an agreement on this matter, this matter shall be referred to dispute resolution in accordance with the Contract.

13.4 Payment after Termination

The final value determined in accordance with Sub-Clause 13.3 [*Valuation at Date of Termination*] above shall be paid to the Contractor within forty-five (45) days after such determination.

14. SUSPENSION AND TERMINATION BY CONTRACTOR

14.1 Contractor's Entitlement to Suspend Work

If the Employer fails to pay any sum due to the Contractor in accordance with the Contract, the Contractor may, after giving not less than 45 days notice to the Employer, suspend work (or reduce the rate of work) unless and until the Contractor has received any such payment.

The Contractor's action shall not prejudice his entitlements to financing charges under Sub-Clause 12.4 [*Delayed Payment*] and to termination under Sub-Clause 14.2 [*Termination by Contractor*].

If the Contractor subsequently receives such payment before giving a notice of termination, the Contractor shall resume normal working as soon as is reasonably practicable.

If the Contractor suffers delay as a result of suspending work (or reducing the rate of work) in accordance with this Sub-Clause, the Contractor shall give notice to the Employer and shall be entitled to:

(a) an extension of time for any such delay, it completion is or will be delayed, under Sub-Clause 7.4 [*Extension of Time for Completion*.

14.2 Termination by Contractor

The Contractor shall be entitled to terminate the Contract if:

(a) the Contractor does not receive the reasonable evidence within 42 days after giving notice under Sub-Clause 14.1 [*Contractor's Entitlement to Suspend Work*] in respect of a failure to comply with Sub-Clause 2.4 [*Employer's Financial Arrangements*], or the Employer's payment obligations in accordance with the Contract,

(b) the Employer substantially fails to perform his obligations under the Contract, and does not rectify the situation within forty-five (45) days,

(c) the Employer fails to comply with Sub-Clause 1.6 [*Assignment*],

(d) a prolonged suspension affects the whole of the Works as described in Sub-Clause 7.10 [*Prolonged Suspension*], or

(e) the Employer becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with his creditors, or carries on business under a receiver, trustee or manager for the benefit of his creditors.

In any of these events or circumstances, the Contractor may, upon giving 45 days' notice to the Employer, terminate the Contract. However, in the case of sub-paragraph (d) or (e), the Contractor may by notice terminate the Contract immediately.

The Contractor's election to terminate the Contract shall not prejudice any other rights of the Contractor, under the Contract or otherwise.

14.3 Cessation of Work and Removal of Contractor's Equipment

After a notice of termination under Sub-Clause 14.2 [*Termination by Contractor*] has taken effect, the Contractor shall promptly:

(a) cease all further work, except for such work as may have been instructed by the Employer for the protection of life or property or for the safety of the Works.

(b) hand over Supplies and other work, for which the Contractor has received payment, and

(c) remove all Contractor's Equipment from the Site, except as necessary for safety, and leave the Site.

14.4 Payment on Termination

After a notice of termination under Sub-Clause 14.2 [*Termination by Contractor*] has taken effect, the Employer shall promptly:

(a) return the Performance Guarantee and the Warranty Guarantee to the Contractor, and

(b) pay the Contractor in accordance with the below.

Contractor shall submit to the Employer a calculation on the value of the Supplies to agree or determine the value of the Works, Goods and Contractor's Documents, delivered to the Employer prior to the date of termination and any other sums due to the Contractor for Work executed in accordance with the Contract.

Based on the Contractor's calculation the Parties shall negotiate the final value due to the Contractor.

Failing an agreement on this matter, this matter shall be referred to dispute resolution in accordance with the Contract.

The final value determined in accordance with this Clause shall be paid to the Contractor within forty-five (45) days after such determination.

15. RISK AND RESPONSIBILITY

15.1 Indemnities

The Contractor shall indemnify and hold harmless the Employer, the Employer's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of:

(a) bodily injury, sickness, disease or death of any person whatsoever arising out of or in the course of or by reason of the Contractor's design (if any), the execution and completion of the Works and the remedying of any defects, unless attributable to any negligence, willful act or

breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, contractors other than the Contractor, or any third party for which the Contractor is not responsible, and

(b) damage to or loss of any property, real or personal (other than the Works), to the extent that such damage or loss:

(i) arises out of or in the course of or by reason of the Contractor's design (if any), the execution and completion of the Works and the remedying of any defects, and

(ii) is attributable to any negligence, willful act or breach of the Contract by the Contractor, the Contractor's Personnel, their respective agents, or anyone directly or indirectly employed by any of them.

The Employer shall indemnify and hold harmless the Contractor, the Contractor's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of (1) bodily injury, sickness, disease or death, which is attributable to any negligence, willful act of breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, contractors other than the Contractor, or any third party for which the Contractor is not responsible, and (2) the matters for which liability may be excluded from insurance coverage, as described in Clause 16 [*Insurance*].

15.2 Contractor's Care of the Works

The Contractor shall take full responsibility for the care of the Works and Goods from the Commencement Date until the SAT certificate is issued (or is deemed to be issued under Sub-Clause 9.1 [*Taking Over of the Works and Sections*]) for the Works, when responsibility for the care of the Works shall pass to the Employer. If a Taking-Over Certificate is issued (or is so deemed to be issued) for any Section or part of the Works, responsibility for the care of the Section on part shall then pass to the Employer.

After responsibility has accordingly passed to the Employer, the Contractor shall take responsibility for the care of any work, which is outstanding on the date stated in a SAT certificate, until this outstanding work has been completed.

If any loss or damage happens to the Works, Goods or Contractor's Documents during the period when the Contractor is responsible for the care, from any cause not listed in Sub-Clause 15.3 [*Employer's Risks*], the Contractor shall rectify the loss or damage at the Contractor's risk and cost, so that the Works, Goods and Contractor's Documents conform with the Contract.

The Contractor shall be liable for any loss or damage caused by any actions performed by the Contractor after a SAT certificate has been issued.

15.3 Employer's Risks

The risks referred to in Sub-Clause 15.4 [*Consequences of Employer's Risks*] below are:

(a) war, hostilities (whether war be declared or not), invasion, act of foreign enemies,

(b) rebellion, terrorism, revolution, insurrection, military or usurped power, or civil war, within the Country,

(c) riot, commotion or disorder within the Country by persons, other than the Contractor's Personnel and other employees of the Contractor and Subcontractors,

(d) munitions of war, explosives materials, ionizing radiation or contamination by radio-activity, within the Country, expect as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio-activity,

(e) pressure waves caused by aircraft or other aerial devices traveling at sonic or supersonic speeds,

(f) use or occupation by the Employer of any part of the Permanent Works,

(g) design of any part of the Works by the Employer's Personnel or by others for whom the Employer is responsible, and

(h) any operation of the forces of nature which is unforeseeable or against which an experienced contractor could not reasonably have been expected to have taken adequate preventative precautions.

15.4 Consequences of Employer's Risks

If and to the extent that any of the risks listed in Sub-Clause 15.3 [*Employer's Risks*] above results in loss or damage to the Works, Goods or Contractor's Documents, the Contractor shall promptly give notice to the Employer and shall rectify this loss or damage to the extent required by the Employer.

If the Contractor suffers delay and/or incurs cost from rectifying this loss or damage, the Contractor shall give a further notice to the Employer and shall be entitled to:

(a) an extension of time for any such delay, if completion is or will be delayed under Sub-Clause 7.4 [*Extension of Time for Completion*].

15.5 Intellectual and Industrial Property Rights

In this Sub-Clause, "infringement" means an infringement (or alleged infringement of any patent, registered design, copyright, trademark, trade name, trade secret or other intellectual or industrial property right relating to the Works, and "claim" means a claim (or proceedings pursuing a claim) alleging an infringement.

Whenever a Party does not give notice to the other Party of any claim within 28 days of receiving the claim, this first Party shall be deemed to have waived his right to indemnity under this Sub-Clause.

The Employer shall indemnify and hold the Contractor harmless against and from any claim alleging an infringement, which is or was:

(a) an unavoidable result of the Contractor's compliance with the Employer's Requirements, or

(b) a result of any Works being used by the Employer:

(i) for a purpose other than that indicated by the Contract, or

(ii) in conjunction with anything not supplied by the Contractor, unless such use was disclosed to the Contractor prior to the Commencement Date or is stated in the Contract.

The Contractor shall indemnify and hold the Employer harmless against and from any other claim which arises out of or in relation to (i) the Contractor's design, manufacture, construction or execution of the Works, (ii) the use of Contractor's Equipment, or (iii) the proper use of the Works as indicated in the Contract.

If a Party is entitled to be indemnified under this Sub-Clause, the indemnifying Party may (at its cost) conduct negotiations for the settlement of the claim, and any litigation or arbitration, which may arise from it. The other Party shall, at the request and cost of the indemnifying Party, assist in contesting the claim. This other Party (and its Personnel) shall not make any admission, which might be prejudicial to the indemnifying Party, unless the indemnifying Party failed to take over the conduct of any negotiations, litigation or arbitration upon being requested to do so by such other Party.

The indemnity under this Sub-Clause is limited, and shall not extend to infringements resulting from:

(i) use or adaptation by the Contractor of the Employer's parts, designs or specific instructions;

(ii) franchise, use or sale of Supplies by the Employer in combination with other equipment or devices, for which Supplies were not designed;

(iii) alterations of Supplies by the Employer;

(iv) patent, trademark, copyright or registered design to which the Employer or any entity related directly or indirectly to the Employer has any direct or indirect interest; or

(v) the Employer's failure to take into use, if applicable, updated components delivered by the Contractor for avoiding the infringement.

15.6 Limitation of Liability

Neither Party shall be liable to the other Party for loss of use of any Works, loss of profit, loss of any contract or for any indirect or consequential loss or damage which may be suffered by the other Party in connection with the Contract, other than under Sub-Clause 14.4 [*Payment on Termination*] and Sub-Clause 15.1 [*Indemnities*]. The foregoing exclusions shall not apply to the Contractor's entitlement to profit where specifically and explicitly granted under the Contract.

The total liability of the Contractor to the Employer, under or in connection with the Contract other than under Sub-Clause 3.19 [*Electricity, Water and Gas*], Sub-Clause 15.1 [*Indemnities*] and Sub-Clause 15.5 [*Intellectual and Industrial Property Rights*], shall not exceed the Contract Price or part thereof actually paid to the Contractor.

This Sub-Clause shall not limit liability in any case of fraud, deliberate default or gross negligence by the defaulting Party.

16. INSURANCE

16.1 General Requirements for Insurances

In this Clause, "Insuring Party" means, for each type of insurance, the Party responsible for effecting and maintaining the insurance specified in the relevant Sub-Clause.

Wherever the Contractor is the insuring Party, each insurance shall be effected with reputable insurers.

Wherever the Employer is the insuring Party, each insurance shall be effected with insurers and in terms consistent with industry standards.

Each policy insuring against loss or damage shall provide for payments to be made in the currencies specified in each such policy.

The relevant insuring party shall, upon request and within reasonable times submit to the other Party:

(a) evidence that the insurances described in this Clause have been effected, and

(b) general descriptions of the coverage of the policies for the insurance described in Sub-Clause 16.2 [*Insurance for Works*] and Sub-Clause 16.3 [*Insurance against Injury to Persons and Damage to Property*].

Each Party shall comply with the conditions stipulated in each of the insurance policies. The insuring Party shall keep the insurers informed of any relevant

changes to the execution of the Works and ensure that insurance is maintained in accordance with this Clause.

Each Party shall notify the other Party of any material alteration to the terms of any insurance.

If the insuring Party fails to effect and keep in force of any of the insurances it is required to effect and maintain under the Contract, or fails to provide satisfactory evidence in accordance with this Sub-Clause, the other Party may (at its option and without prejudice to any other right or remedy) effect insurance for the relevant coverage and pay the premiums due. The insuring Party shall pay the amount of these premiums to the other Party, and the Contract Price shall be adjusted accordingly.

Nothing in this Clause limits the obligations, liabilities or responsibilities of the Contractor or the Employer, under the other terms of the Contract or otherwise. Any amounts not insured or not recovered from the insurers shall be borne by the Contractor and/or the Employer in accordance with the obligations, liabilities or responsibilities of the Contract. However, if the insuring Party fails to effect and keep in force an insurance which is available and which it is required to effect and maintain under the Contract, and the other Party neither approves the omission nor effects insurance for the coverage relevant to this default, any moneys which should have been recoverable under this insurance shall be paid by the insuring Party, but subject to the limitations set forth in Sub-Clause 15.6 [*Limitation of Liability*].

16.2 Insurance for Works

The insuring Party shall insure the Works for not less than Euro 5,000,000.00 (Five Million Euro only) . This insurance shall be effective from the date by which the evidence is to be submitted under sub-paragraph (a) of Sub-Clause 16.1 [*General Requirements for Insurances*], until the date of issue of the Taking-Over Certificate for the Works.

The insuring Party shall maintain this insurance to provide coverage until the date of issue of the SAT certificate, for loss or damage for which the Contractor is liable under the Contract and the Law applicable to the Contract and which arises from a cause occurring prior to the issue of the SAT certificate.

Unless otherwise stated in the Contract, insurance under this Sub-Clause:

(a) shall be effected and maintained by the Contractor as insuring Party,

(b) shall cover all loss and damage,

(c) may however exclude loss of, damage to, and reinstatement of:

(i) a part of the Works which is in a defective condition due to a defect in its design, materials or workmanship (but coverage shall include any other parts which are lost or damaged as a direct

result of this defective condition and not as described in sub-paragraph (ii) below),

(ii) a part of the Works which is lost or damaged in order to reinstate any other part of the Works if this other part is in a defective condition due to a defect in its design, materials or workmanship,

(iv) a part of the Works which has been taken over by the Employer, except to the extent that the Contractor is liable for the loss or damage, and

(v) Goods while they are not in the Country, and

(vi) Any other exclusion of loss, damage or re-instatement as per the terms and conditions of any such insurance policy.

16.3 Insurance against Injury to Persons and Damage to Property

The insuring Party shall insure against that Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except things insured under Sub-Clause 16.2 [*Insurance for Works*] or to any person (except persons insured under Sub-Clause 16.4 [*Insurance of Contractor's Personnel*], for which the Party is liable under the Contract, and which may arise out of the Contractor's performance of the Contract and occurring before the issue of the SAT certificate.

Unless otherwise stated in the Contract, the insurances specified in this Sub-Clause:

(a) shall be effected and maintained by the Contractor as insuring Party,

(b) shall be extended to cover liability for all loss and damage to the Employer's property (except things insured under Sub-Clause 16.2 [*Insurance for Works*]) arising out of the Contractor's performance of the Contract, and

(c) may however exclude liability to the extent that arises from:

(i) the Employer's right to have the Permanent Works executed on, over, under, in or through any land, and to occupy this land for the Permanent Works,

(ii) damage which is an unavoidable result of the Contractor's obligations to execute the Works and remedy any defects,

(iii) a cause listed in Sub-Clause 15.3 [*Employer's Risks*], and

(iv) Any other excluded event or occurance as per the terms and conditions of any such insurance policy.

16.4 Insurance of Contractor's Personnel

The Contractor shall effect and maintain insurance against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel.

The insurance shall be maintained in full force and effect during the whole time that these personnel are assisting in the execution of the Works. For a Subcontractor's employees, the insurance may be effected by the Subcontractor, but the Contractor shall be responsible for compliance with this Clause.

17. FORCE MAJEURE

17.1 Definition of Force Majeure

In this Clause, "Force Majeure" means an exceptional event or circumstance:

(a) which is beyond a Party's control,

(b) which such Party could not reasonably have foreseen before entering into the Contract,

(c) which, having arisen, such Party could not reasonably have avoided or overcome, and

(d) which is not substantially attributable to the Party invoking Force Majeure.

Force Majeure may include but is not limited to exceptional events or circumstances of the kind listed below, so long as conditions (a) to (d) above are satisfied:

(i) war, hostilities (whether war be declared or not), invasion, act of foreign enemies,

(ii) rebellion, terrorism, revolution, insurrection, military or usurped power, or civil war,

(iii) riot, commotion, disorder, strike or lockout by persons other than the Contractor's Personnel and other employees of the Contractor and Sub-contractors,

(iv) munitions of war, explosive materials, ionizing radiation or contamination by radio-activity, except as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio-activity,

(v) natural catastrophes such as earthquake, hurricane, typhoon or volcanic activity,

(vi) widespread diseases,

(vii) shortage of power, telecommunication, fuel, or means of transportation or similar events, and

(viii) import, export or currency restriction or embargo and with respect to the Contractor's performance, regulations or acts (or failures to act) of any governmental or other authority.

17.2 Notice of Force Majeure

If a Party is or will be prevented from performing any of its obligations under the Contract by Force Majeure, then it shall give notice to the other Party of the event or circumstances constituting the Force Majeure and shall specify the obligations, the performance of which is or will be prevented. The notice shall be given within 14 days after the Party became aware of the relevant event or circumstance constituting Force Majeure.

The Party shall, having given notice, be excused from the performance of such obligations for so long as such Force Majeure prevents it from performing them.

Notwithstanding any other provision of this Clause, Force Majeure shall not apply to obligations of either Party to make payments to the other Party under the Contract.

17.3 Duty to Minimize Delay

Each Party shall at all times use all reasonable endeavours to minimize any delay in the performance of the Contract as a result of Force Majeure.

A Party shall give notice to the other Party when it ceases to be affected by the Force Majeure.

17.4 Consequence of Force Majeure

If the Contractor is prevented from performing any of his obligations under the Contract by Force Majeure of which notice has been given under Sub-Clause 17.2 [*Notice of Force Majeure*], and suffers delay by reason of such Force Majeure, the Contractor shall be entitled to:

(a) an extension of time for any such delay, if completion is or will be delayed.

17.5 Force Majeure Affecting Subcontractor

If any Subcontractor is entitled under any contract or agreement relating to the Works to relief from force majeure on terms additional to or broader than those specified in this Clause, such additional or broader force majeure events or circumstances shall not excuse the Contractor's non-performance or entitle him to relief under this Clause.

17.6 Optional Termination, Payment and Release

If the execution of substantially all the Works in progress is prevented for a continuous period of 84 days by reason of Force Majeure of which notice has been given under Sub-Clause 17.2 [*Notice of Force Majeure*], or for multiple periods which total more than 140 days due to the same notified Force Majeure, then either Party may give to the other Party a notice of termination of the Contract. In this event, the termination shall take effect 7 days after the notice is given, and the Contractor shall proceed in accordance with Sub-Clause 14.3 [*Cessation of Work and Removal of Contractor's Equipment*], and the Employer shall pay the Contractor in accordance with Sub-Clause 14.4 [*Payment on Termination*].

17.7 Release from Performance under the Law

Notwithstanding any other provision of this Clause, if any event or circumstance outside the control of the Parties (including, but not limited to, Force Majeure) arises which makes it impossible or unlawful for either or both Parties to fulfil its or their contractual obligations or which, under the law governing the Contract, entitles the parties to be released from further performance of the Contract, then upon notice by either Party to other Party of such event or circumstance:

(a) the Parties shall be discharged from further performance, without prejudice to the rights of either Party in respect of any previous breach of the Contract, and

(b) the sum payable by the Employer to the Contractor shall be the same as would have been payable under Sub-Clause 17.6 [*Optional Termination, Payment and Release*] if the Contract had been terminated under Sub-Clause 17.6 [*Optional Termination, Payment and Release*].

18. CLAIM, DISPUTES AND ARBITRATION

18.1 Contractor's Claims

If the Contractor considers himself to be entitled to any extension of the Time for Completion and/or any additional payment, under the Contract or otherwise

in connection with the Contract, the Contractor shall give notice to the Employer, describing the event or circumstance giving rise to the claim. The notice shall be given as soon as practicable.

The Contractor may also submit any other notices, which are required by the Contract, and supporting particulars for the claim, all as relevant to such event or circumstance.

The Contractor shall keep such contemporary records as may be necessary to substantiate any claim

Within 42 days after the Contractor became aware of the event or circumstance giving rise to the claim, or within such other period as may be proposed by the Contractor and approved by the Employer, the Contractor shall send to the Employer a claim which includes supporting particulars of the basis of the claim and of the extension of time and/or additional payment claimed. If the event or circumstance giving rise to the claim has a continuing effect:

(a) this claim shall be considered as interim;

(b) the Contractor shall send further interim at monthly intervals, giving the accumulated delay and/or amount claimed, and such further particulars as the Employer may reasonably require; and

(c) the Contractor shall send a final claim within reasonable time after the end of the effects resulting from the event or circumstance, or within such other period as may be proposed by the Contractor and approved by the Employer.

Based on the Contractor's claim, the Parties shall negotiate and agree on the effects of such claim to time schedule and/or Contract Price and Parties' obligations and responsibilities. Failing an agreement on these matters, they shall be referred to dispute resolution in accordance with this Clause 18 [*Claim, Disputes and Arbitration*].

18.2 Amicable Settlement

The Parties shall first attempt to settle any dispute relating to or arising from the Contract through good faith negotiations between the Parties' responsible project personnel.

If the Parties' responsible Project personnel fail to reach an agreement on the dispute, they shall refer the matter to the Parties' top management level personnel.

18.3 Arbitration

Unless settled amicably, any dispute shall be finally settled by binding arbitration in accordance with the Rules of Arbitration of the International Chamber of Commerce. The arbitral tribunal shall consist of three (3) arbitrators. Each Party shall appoint one (1) arbitrator, and the chairman shall be appointed in accordance with the Arbitration Rules of the International Chamber of Commerce. Any court having jurisdiction over the matter may enter judgment on the arbitration award. The arbitration shall be held in Singapore, and be conducted in the English language.

Arbitration may be commenced prior to or after completion of the Works. The rights and obligations of the Parties shall not be altered by reason of any arbitration being conducted during the progress of the Works.

19. Signatures

This Contract has been drawn in eight (8) identical original copies duly signed by the Parties' authorized representatives.

In _____, on _____
For and on behalf of
VAISALA OYJ

.....
Name PANU PARPANEN
Title DIRECTOR, METEOROLOGY

.....
Name
Title

In Hanoi, on Dec. 31. 2014
For and on behalf of
NATIONAL HYDRO-METEOROLOGICAL SERVICE, VIETNAM

.....
Name
Title Trần Hùng Thái

.....
Name
Title

ANNEXES

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9. BÁO CÁO KHOA HỌC TỔNG QUAN

000825

BỘ TÀI NGUYÊN VÀ MÔI TRƯỜNG
VIỆN KHOA HỌC
KHÍ TƯỢNG THỦY VĂN VÀ BIẾN ĐỔI KHÍ HẬU

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

BÁO CÁO KHOA HỌC TỔNG QUAN

A. THÔNG TIN CÁ NHÂN

1. Họ và tên ứng viên: Trần Hồng Thái
2. Ngày tháng năm sinh: 04/8/1974; Nam ☑; Nữ ☐ ; Dân tộc: Kinh
3. Quê quán: xã/phường, huyện/quận, tỉnh/thành phố: Kim Lộc, Can Lộc, Hà Tĩnh.
4. Quá trình được đào tạo (ĐH, ThS, TS, TSKH):
   - Được cấp bằng ĐH ngày 30 tháng 9 năm 1997 Ngành: Kỹ thuật và công nghệ, chuyên ngành: Tự động hóa điều khiển quá trình nhiệt năng.
   Nơi cấp bằng ĐH (trường, nước): Trường Đại học Năng lượng Matxcơva, Cộng hòa Liên bang Nga.
   - Được cấp bằng ThS ngày 01 tháng 7 năm 1998, Ngành: Kỹ thuật và công nghệ, chuyên ngành: Tự động hóa điều khiển quá trình nhiệt năng.
   Nơi cấp bằng ThS (trường, nước): Trường Đại học Năng lượng Matxcơva, Cộng hòa Liên bang Nga.
   - Được cấp bằng TS ngày 08 tháng 7 năm 2005, ngành: Khoa học Trái Đất và Toán học, chuyên ngành: Tính toán khoa học trong lĩnh vực Thủy văn - Môi trường.
   Nơi cấp bằng TS (trường, nước): Đại học tổng hợp Heidelberg, Cộng hòa Liên bang Đức.
5. Chức vụ hiện nay: Tổng cục trưởng; Chức vụ cao nhất đã qua: Tổng cục trưởng
6. Cơ quan công tác hiện nay: Tổng cục Khí tượng Thủy văn
7. Thỉnh giảng tại cơ sở giáo dục đại học (nếu có):
   1. Trường Đại học Khoa học Tự nhiên - Đại học Quốc gia Hà Nội.
   Ngành: Khoa học Trái Đất; Chuyên ngành: Thủy văn học.
   2. Viện Khoa học Khí tượng Thủy văn và Môi trường (đào tạo Tiến sĩ);
   Ngành: Khoa học Trái Đất; Chuyên ngành: Quản lý Tài nguyên và Môi trường; Thủy văn học; Biến đổi khí hậu và phát triển bền vững.
   3. Khoa Các khoa học liên ngành Đại học Quốc gia Hà Nội (trước đây là Khoa Đào tạo sau Đại học, Đại học Quốc gia Hà Nội).
   Ngành: Khoa học Trái Đất; Chuyên ngành: Biến đổi khí hậu.
8. Đã nghỉ hưu từ tháng.....năm.....(chưa nghỉ hưu).....
9. Hiện nay là (đánh dấu vào ô phù hợp):

Giảng viên ☐; Giảng viên thỉnh giảng ☑; Nghiên cứu viên ☐; Cán bộ quản lý ☑; Các công tác khác ☐; Hưu trí ☐

B. NỘI DUNG BÁO CÁO

Năm 1998, khi trở thành nghiên cứu sinh tại Trung tâm tính toán khoa học liên ngành (*Interdisciplinary Center for Scientific Computing - IWR*), Đại học Tổng hợp Heidelberg Ứng viên được tiếp cận với phương pháp nghiên cứu khoa học liên ngành (Khoa học Trái Đất và Khoa học tính toán), năm 2005 đã bảo vệ thành công Luận án tiến sĩ ngành Khoa học Trái Đất và Toán học (chuyên ngành: Phương pháp tính trong khoa học thủy văn và môi trường) với đề tài "***Phương pháp số giải bài toán mô phỏng, xác định tham số và điều khiển tối ưu cho hệ thống sông Hồng - sông Thái Bình***". Về nước từ tháng 8 năm 2005 đến tháng 1/2014, Ứng viên làm việc tại Viện Khoa học Khí tượng Thủy văn và Môi trường, Bộ Tài nguyên và Môi trường, ngạch nghiên cứu viên (Nghiên cứu viên chính) và giảng viên kiêm nhiệm. Từ 1/2014 đến nay Ứng viên làm việc tại Trung tâm Khí tượng Thủy văn quốc gia nay là Tổng cục Khí

tượng Thủy văn, Bộ Tài nguyên và Môi trường. Năm 2011, Ứng viên vinh dự được công nhận là Phó Giáo sư ngành Khoa học Trái Đất, liên ngành Khoa học Trái Đất - Mỏ. Trên mọi lĩnh vực công tác Ứng viên đều cố gắng hết sức phục vụ sự nghiệp phát triển ngành khí tượng thủy văn nói chung và công tác đào tạo, nghiên cứu nói riêng. Dưới đây là một số kết quả của các hoạt động đó.

I. NGHIÊN CỨU KHOA HỌC

Là cán bộ nghiên cứu khoa học kiêm công tác giảng dạy, Ứng viên đã định hướng rõ công tác nghiên cứu khoa học của mình với 3 mục tiêu chính: (1) Gắn mục tiêu nghiên cứu với phục vụ hiệu quả sự phát triển kinh tế - xã hội, công tác quản lý về tài nguyên nước và môi trường; (2) Gắn liền công tác nghiên cứu khoa học với công tác giảng dạy và đào tạo; (3) Phát triển, mở rộng hướng nghiên cứu ứng dụng thành quả khoa học vào thực tiễn. Các công trình khoa học tập trung vào 01 hướng chính:

(1) Phát triển phương pháp số, mô hình toán giải bài toán mô phỏng, xác định thông số tự động; điều khiển, dự báo trong lĩnh vực thủy văn, tài nguyên nước và môi trường ứng dụng cho nghiên cứu liên ngành về biến đổi khí hậu và tác động của nó đến môi trường - kinh tế - xã hội.

Trong suốt quá trình nghiên cứu khoa học và giảng dạy của mình, đặc biệt từ năm 2012 (sau khi Ứng viên được Nhà nước công nhận học hàm Phó Giáo sư), Ứng viên đã ý thức được rằng, bên cạnh nhiệm vụ trực tiếp nghiên cứu khoa học và giảng dạy, việc định hướng nghiên cứu, thành lập, duy trì và phát triển các nhóm nghiên cứu (Nhóm) bền vững đối với nền khoa học nói chung và khoa học Trái Đất nói riêng là một việc có ý nghĩa quan trọng. Vì vậy, trong hai hướng nghiên cứu chính của mình, Ứng viên luôn trăn trở, phân tích nhằm đặt ra các bài toán, các vấn đề nghiên cứu cụ thể, có tính mới, sáng tạo và khoa học. Kết quả đạt được tại mỗi bài toán, vấn đề nghiên cứu là cơ sở cho các công bố khoa học, các giáo trình, sách chuyên khảo và luôn luôn gắn chặt với công tác đào tạo. Hai hướng nghiên cứu chính của Ứng viên được trình bày cụ thể như sau:

1. Phát triển phương pháp số, mô hình toán giải bài toán mô phỏng, xác định thông số tự động; điều khiển, dự báo trong lĩnh vực thủy văn, tài nguyên nước và môi trường

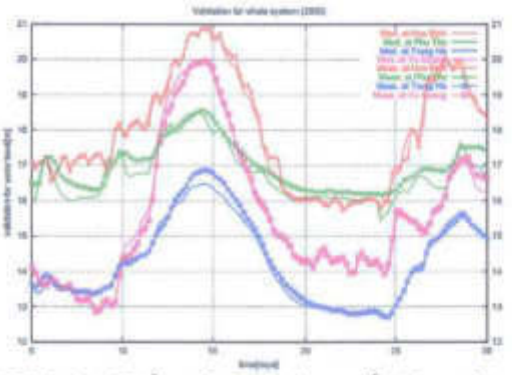
1.1 Phát triển phương pháp, kỹ thuật tính toán (Numerical methods); ứng dụng và phát triển các phần mềm mã nguồn mở kết hợp với sử dụng các mô hình động lực thương mại, các mô hình thống kê để giải quyết các vấn đề thực tiễn

May mắn được học tập, làm việc và trưởng thành tại Trung tâm tính toán khoa học liên ngành (IWR) Heidelberg, Ứng viên nhận thức được tính toán khoa học là một công cụ quan trọng, có thể kết hợp giữa các môn khoa học tự nhiên, tin học và toán học. Với sự hướng dẫn tận tình của GS. TSKH. TS danh dự Hans Georg Bock và GS. TSKH. TS danh dự Willie Jaeger, hai nhà khoa học hàng đầu của CHLB Đức trong lĩnh vực tính toán khoa học, Ứng viên đã lựa chọn hướng nghiên cứu đầu tiên cho mình là Tính toán khoa học trong lĩnh vực khoa học Trái Đất, cụ thể là lĩnh vực thủy văn - môi trường. Nghiên cứu đầu tiên Ứng viên thực hiện thành công theo hướng này, bảo vệ thành công Luận án tiến sĩ "*Phương pháp số giải bài toán mô phỏng, xác định tham số và điều khiển tối ưu cho hệ thống Sông Hồng - Sông Thái Bình*". Phương pháp số đã được sử dụng để giải hệ phương trình phi tuyến bậc nhất dạng Hyperbolic Saint - Venant (mô phỏng dòng chảy 1 chiều trong sông) với điểm mới là đã sử dụng lược đồ hiệu chỉnh sai số tại mỗi bước tính theo thời gian, nhờ đó, độ lớn của lưới tính tại mỗi bước tính được lựa chọn hợp lý, thỏa mãn điều kiện ổn định CFL (*Courant - Friedrichs- Lewy Condition*). Mô hình chạy ổn định, hiệu quả hơn so với các phương pháp với bước tính cố định.

Lần đầu tiên, Ứng viên đã xây dựng thành công phương pháp xác định các thông số thủy lực của mô hình một cách tự động thông qua thiết lập và giải bài toán bình phương tối thiểu. Trong đó, các thông số là nghiệm của bài toán tối ưu, sao cho giá trị mực nước (hoặc lưu lượng) tính toán trong mô hình "phù hợp nhất" với các giá trị đo đạc tương ứng tại các trạm quan trắc (Hình 1). Đây là bài toán tối ưu có ràng buộc với số chiều rất lớn do việc rời rạc hóa hệ phương trình *Saint - Venant* theo không gian và thời gian, được giải bằng phương pháp *Gauss-Newton* mở rộng (phát triển tại Trung tâm tính toán khoa học liên ngành (*Das Interdisziplinaere*

Zentrum fuer Wissenschaftliches Rechnen - IWR). Kết quả của nghiên cứu này đã được công bố trong Tạp chí Khí tượng Thủy văn số 586, 14-22, 2009.

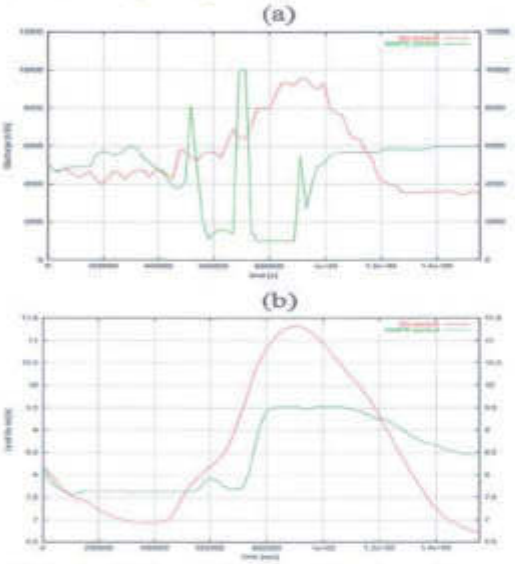
Ngoài việc xác định thông số và mô phỏng dòng chảy, phương pháp nêu trên còn cho phép giải bài toán điều khiển tối ưu. Ứng viên đã áp dụng để tìm một lược đồ điều hành hồ chứa thủy điện Hòa Bình với mục tiêu cắt giảm lũ hiệu quả mà vẫn đảm bảo việc sản xuất điện (Hình 2). Kết quả nghiên cứu được công bố tại Báo cáo Hội nghị Khoa học toàn quốc về Công nghệ dự báo Khí tượng Thủy văn Lần thứ VI, Tập 2, trang 45-60, 2001-2005.



Hình 1. Kiểm định thông số cho toàn bộ hệ thống sông Hồng

Tiếp tục hướng nghiên cứu này, năm 2009, Ứng viên đã hoàn thành Đề tài cấp Bộ "*Xây dựng mô hình dự báo nguy cơ mức độ ô nhiễm và xác định nguồn gây ô nhiễm cho hạ lưu sông Sài Gòn - Đồng Nai*". Trong quá trình thực hiện đề tài này, Ứng viên đã xây dựng Nhóm nghiên cứu tại Trung tâm Tư vấn KTTV và BĐKH với định hướng chuyên môn sâu về mô hình toán mô phỏng các quá trình thủy động lực và lan truyền chất trong tự nhiên:

- Khai thác, ứng dụng các phần mềm thương mại, phần mềm mã nguồn mở để giải quyết các vấn đề thực tiễn: mô hình hóa quá trình vận chuyển bùn cát lơ lửng; mô hình mô phỏng hiện trạng và dự báo xu thế biến đổi chất lượng nước cho hệ thống sông bị ô nhiễm; tính toán cân bằng nước cho các lưu vực sông. Kết quả nghiên cứu được công bố trong Tuyển tập công trình Hội nghị khoa học Cơ học Thủy Khí toàn quốc, năm 2007.
- Xây dựng mô hình dự báo xu thế diễn biến môi trường nước và không khí phù hợp với các chiến lược, kế hoạch phát triển kinh tế - xã hội.
- Xây dựng phương pháp đánh giá nhanh xác định tải lượng ô nhiễm trên các dòng sông hẹp một chiều.



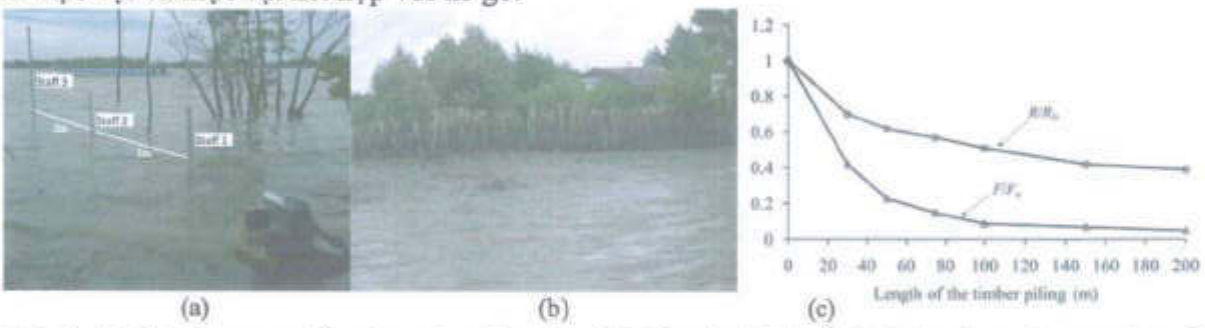
Hình 2. Hiệu quả cắt giảm lưu lượng nước đến hồ Hòa Bình (a) và lưu lượng nước tại Hà Nội (b) trận lũ năm 2000

- Mở rộng hướng nghiên cứu xác định nguồn ô nhiễm bằng phương pháp giải bài toán ngược (*Inverse problem*): đã xây dựng thành công bộ mô hình xác định nhanh nguồn ô nhiễm PSQIS (*Pollutant Sources Quick Indentification Software*) cho khu vực cửa sông - cửa biển, biển 2 chiều. Bộ phần mềm PSQIS được Tổ công tác thuộc Bộ Tài nguyên và Môi trường áp dụng hiệu quả trong việc thực hiện nhiệm vụ xác định nguyên nhân ô nhiễm dầu trên suốt dải bờ biển Việt Nam vào cuối năm 2006, đầu năm 2007 để báo cáo trước Chính phủ và trước Quốc hội.

Từ năm 2009 trở lại đây, trên cơ sở kết quả dự án: "*Điều tra, đánh giá và cảnh báo biến động của các yếu tố khí tượng thủy văn có nguy cơ gây tổn thương tài nguyên - môi trường vùng biển và dải ven biển Việt Nam, đề xuất các giải pháp phòng tránh và ứng phó*" của Bộ Tài nguyên và Môi trường, Ứng viên và một số cộng sự thuộc Viện Khoa học Khí tượng Thủy văn và Môi trường đã tập trung, nghiên cứu, ứng dụng và phát triển các mô hình số trị mã nguồn mở bằng ngôn ngữ FORTRAN, kết hợp giữa mô hình khí tượng, mô hình thủy động lực để giải các bài toán tương tác biển - khí quyển. Hiện nay, Nhóm đang ứng dụng và phát triển mô hình DELFT3D trong môi trường LINUX để có thể chạy liên hoàn với mô hình khí tượng (*Weather Research and Forecast - WRF*) trong tính toán dự báo trường mực nước, dòng chảy, nước dâng do bão. Quá trình nghiên cứu giúp Ứng viên hiểu thấu đáo hơn việc nghiên cứu về phương pháp số cho quá trình thủy động lực trong sông cần tích hợp với mô hình khí tượng và hải. Nhiều câu

hỏi đặt ra trong quá trình nghiên cứu nhằm tạo ra bức tranh ngày một tường minh hơn về mặt khoa học và đồng thời nghiên cứu sâu hơn các quá trình đó.

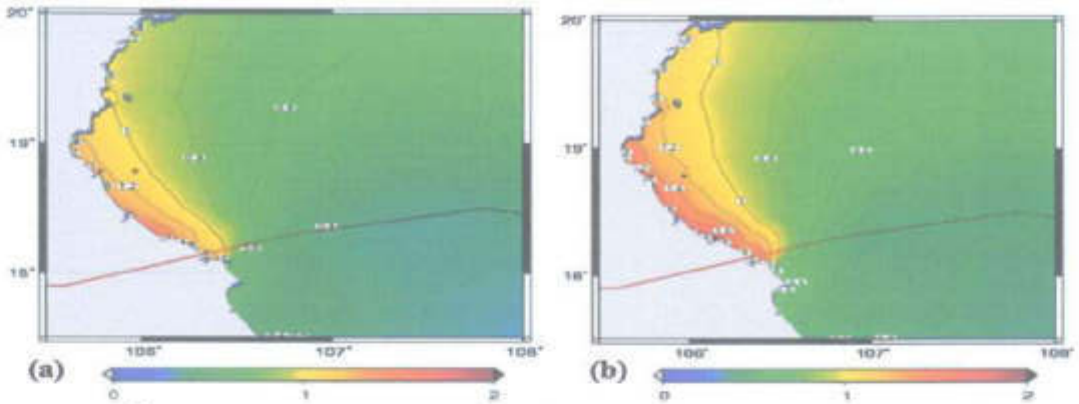
Từ năm 2014 đến tháng 3/2018, sau khi nhận nhiệm vụ Phó Tổng Giám đốc phụ trách công tác nghiên cứu khoa học tại Trung tâm Khí tượng Thủy văn quốc gia, Ứng viên đã định hướng và trực tiếp tham gia chỉ đạo một số đề tài nghiên cứu các cấp khác nhau phục vụ công tác phòng tránh thiên tai. Ứng viên đã tiếp tục đẩy mạnh khoa học tính toán vào phục vụ công tác dự báo, đã trực tiếp chỉ đạo xây dựng Nhóm thuộc Trung tâm Dự báo khí tượng thủy văn Trung ương nay là Trung tâm Dự báo KTTV quốc gia. Một bài toán thú vị về áp dụng phương pháp phần tử hữu hạn giải quyết bài toán sóng động lực, mưa - dòng chảy một chiều đã được Ứng viên cùng các đồng nghiệp Viện KTTV và BĐKH, Trường Đại học Khoa học Tự nhiên Hà Nội nghiên cứu thành công vào năm 2016, được công bố tại Tạp chí quốc tế (*A finite element one-dimensional kinematic wave rainfall-runoff model, Pacific Science Review A: Natural Science and Engineering, 2016, 233-240*). Hiện tượng xói lở bờ trên các sông Cà Mau đã được nghiên cứu trong đề tài nghiên cứu cơ bản "*Nghiên cứu tác động của sóng tàu đến xói lở bờ và đề xuất giải pháp tự nhiên giảm thiểu tác động*" do Quỹ phát triển khoa học quốc gia tài trợ. Đề tài đã đưa ra một số chỉ tiêu về mức độ suy giảm độ cao và áp lực sóng tại đường bờ theo các thông số của thực vật, kè gỗ ven sông Cà Mau, kết quả đã được công bố trên Tạp chí quốc tế trong hệ thống SCI (*Effect of river vegetation with timber piling on ship wave attenuation: Investigation by field survey and numerical modeling, Ocean Engineering, 2017, 129, 37-45*) (Hình 3). Trong nghiên cứu này, mô hình số dựa trên hệ phương trình Boussinesq hai chiều có xét đến suy giảm sóng do thực vật đã được phát triển để tính toán quá trình lan truyền sóng qua bãi thực vật và thực vật kết hợp với kè gỗ.



(a) (b) (c)

Hình 3. Hình ảnh quan trắc sóng tàu trên sông Cà Mau (a); kè gỗ và thảm thực vật ven sông Cà Mau (b); Mức độ suy giảm độ cao sóng (R/R_0) và áp lực sóng tàu (F/F_0) tại bờ theo chiều dài kè gỗ (c). Trường hợp kè kết hợp với thực vật, và chỉ số "0" là cho trường hợp không có kè và thực vật.

Ngoài ra, trong một đề tài nghiên cứu cấp Bộ năm 2014 - 2016 "*Nghiên cứu lựa chọn mô hình dự báo nước dâng do bão và dự báo nghiệp vụ tại Việt Nam*", Nhóm đã nghiên cứu và áp dụng mô hình tích hợp nước dâng, sóng và thủy triều (mô hình SuWAT) vào dự báo nghiệp vụ nước dâng do bão. Công nghệ dự báo nước dâng do bão hiện đang được triển khai vào dự báo nghiệp vụ ở Trung tâm Dự báo khí tượng thủy văn Trung ương, sản phẩm của đề tài đã được công bố trên Tạp chí và hội thảo quốc tế có uy tín *Elvervier* (*Impact of the interaction of surge, wave and tide on a storm surge on the north coast of Vietnam, Procedia IUTAM, 2017*). Kết quả nghiên cứu chỉ ra rằng để dự báo nước dâng bão được chính xác cần thiết phải sử dụng mô hình số trị tích hợp thủy triều, sóng biển và nước dâng bão, nhất là tại khu vực ven bờ có địa hình nông và biên độ thủy triều lớn như ven biển Bắc Bộ và khu vực ven biển miền Trung của Việt Nam. Kết quả nghiên cứu được công bố trên Tạp chí Khí tượng Thủy văn số 687-3/2018. Nghiên cứu cũng chỉ ra rằng nước dâng do ứng xuất bức xạ sóng chỉ được tính toán đầy đủ trên lưới tính có độ phân giải cao (Hình 4).



Hình 4. Phân bố độ cao nước dâng trong bão Washi trong trường hợp: (a) mô hình không tích hợp sóng; (b) mô hình tích hợp sóng.

Từ cuối năm 2015 đến nay, hiện tượng mực nước biển dâng cao dị thường tại ven biển miền Trung và Nam Bộ đã được Nhóm triển khai nghiên cứu trong đề tài nghiên cứu khoa học và công nghệ cấp Nhà nước do Ứng viên trực tiếp chỉ đạo "*Nghiên cứu nguyên nhân và xây dựng quy trình công nghệ cảnh báo, dự báo hiện tượng mực nước biển dâng dị thường tại miền Trung và Nam Bộ Việt Nam*". Kết quả nghiên cứu ban đầu đã được công bố trên Tạp chí Khí tượng Thủy văn, số 676-4/2017. Theo hướng nghiên cứu này: 02 nghiên cứu sinh đã bảo vệ thành công luận án tiến sĩ (TS. Đỗ Đình Chiến, 2016; TS. Doãn Tiến Hà, 2016).

Các vấn đề tập trung nghiên cứu theo hướng này:

- Xây dựng công cụ tính toán khoa học, tối ưu hóa, quy hoạch động để giải các bài toán trong lĩnh vực Khoa học Trái Đất;
- Khai thác những phần mềm đa năng (thương mại và mã nguồn mở) theo hướng tích hợp các nhóm mô hình: Khí tượng - khí hậu, hải văn - thủy văn, ngập lụt, GIS, v.v. để giải quyết các vấn đề thực tế có tính chất tổng hợp.

1.2 Kết hợp sử dụng các mô hình động lực với các công cụ khoa học khác (xác suất thống kê, điều tra khảo sát, sinh thái học, v.v.) nghiên cứu các vấn đề có tính tổng hợp, như dòng chảy môi trường, quy hoạch tài nguyên nước, biển, v.v.

Đánh giá dòng chảy môi trường (DCMT) và quy hoạch tài nguyên, môi trường nước: là những vấn đề tương đối mới, rất cần thiết để thực hiện quản lý tổng hợp phát triển bền vững tài nguyên nước. Để nghiên cứu dòng chảy môi trường cần sử dụng tổng hợp nhiều phương pháp nghiên cứu: các mô hình toán thủy văn, thủy lực mô phỏng chế độ dòng chảy, kết hợp với các mô hình tính toán, phân tích sinh thái môi trường để mô phỏng các điều kiện sinh sống của các loài thủy sinh, các hệ sinh thái nước. Năm 2006, Ứng viên chủ nhiệm đề tài nghiên cứu cơ bản "*Nghiên cứu cơ sở khoa học trong việc đánh giá dòng chảy môi trường*". Kết quả nghiên cứu đã được công bố trên Tạp chí Khí tượng Thủy văn: Số 568, 2008 và Số 603, 2011. Báo cáo Hội nghị khoa học toàn quốc về công nghệ dự báo khí tượng thủy văn Lần thứ VI, Tập 2, 2001 - 2005. Cũng xuất phát từ đây, Nhóm tiếp tục tham gia nhiều nghiên cứu trong hướng này:

- Năm 2008 - 2010, Ứng viên tham gia Đề tài cấp Bộ Tài nguyên và Môi trường "*Đánh giá dòng chảy môi trường cho sông Hồng - Thái Bình*"; Đề tài cấp nhà nước "*Nghiên cứu xác định dòng chảy môi trường của hệ thống sông Hồng - sông Thái Bình và đề xuất các giải pháp duy trì dòng chảy môi trường phù hợp với các yêu cầu phát triển bền vững tài nguyên nước*", Mã số KC.08.22/06-10. Một số kết quả đã được công bố trên Tạp chí Khí tượng Thủy văn, số 589, 2010;
- Năm 2009 - 2011, Ứng viên được giao chủ trì nhiệm vụ nghiên cứu "*Xác định ngưỡng chịu tải cho sông Nhuệ - sông Đáy*" đã có kết quả được công bố trên Tạp chí Khí tượng Thủy văn: Số 591, 2010; Số 595, 2010; Số 604, 2011 và Số 605, 2011.

Từ năm 2006, khi chủ trì lập quy hoạch tài nguyên nước cho lưu vực sông Cầu, vùng kinh tế trọng điểm Bắc bộ và khu vực kinh tế trọng điểm phía Nam, Nhóm đã xây dựng các mô hình tính toán: dòng chảy từ mưa trong lưu vực; mô phỏng và dự báo diễn biến dòng chảy, chất lượng nước trong các con sông/đoạn sông; cân bằng nước hệ thống theo các kịch bản phát triển

và những giải pháp cụ thể nhằm: (1) Phân bổ, chia sẻ tài nguyên nước một cách hợp lý, đảm bảo sự phát triển hài hòa của các ngành trong các khu vực lập quy hoạch; (2) Bảo vệ các hệ sinh thái, thủy sinh đang bị đe dọa, hoặc có nguy cơ bị đe dọa; (3) Phòng, chống, giảm thiểu các tác hại do nước gây ra, như: lũ, ngập lụt, vỡ đê, vỡ đập, v.v. Các kết quả nghiên cứu đã được công bố tại Tạp chí Khí tượng Thủy văn: Số 578, 2009 và Số 604, 2011.

Năm 2009, Ứng viên chủ trì thực hiện nhiệm vụ *"Lập quy hoạch bảo vệ môi trường lưu vực sông Nhuệ - sông Đáy đến năm 2015 và định hướng đến năm 2020"*. Một số kết quả nghiên cứu đã được trình bày tại các hội thảo quốc tế tại Hà Nội, Melbourne và được công bố tại Tạp chí Khí tượng Thủy văn số 591, 2010; Số 595, 2010; và số 605, 2011. Trong thời gian này, nhận thấy vấn đề về đánh giá chế độ thủy văn tại vùng đồng bằng sông Hồng - Thái Bình rất quan trọng, bản thân cùng các nhà khoa học thuộc Viện Hàn lâm Khoa học Việt Nam và các nhà khoa học ngoài nước đã tiến hành nghiên cứu về chế độ thủy văn cho vùng này. Kết quả nghiên cứu đã được công bố trong bài báo quốc tế ISI (*Hydrological regime and water budget of the Red River Delta (Northern Vietnam), Journal of Asian Earth Sciences, 37, 219-228, 2010).*

Các kết quả nghiên cứu tiếp theo liên quan đến vấn đề này từ năm 2013 được công bố trên các Tạp chí quốc tế, kỷ yếu hội thảo quốc tế, như: *Water balance and nutrient delivery in a densely populated delta for a future sustainable environment, Proceedings of HP1, IAHS-IAPSO-IASPEI Assembly, 2013* và *Hydrological regime of a tidal system in the Red River Delta, northern Vietnam, Proceedings of FRIEND-Water 2014*; *Modeling the effect of thermal diffusion process from nuclear power plants in Vietnam, Journal of Energy and Power Engineering, 8, 403-418, 2017*; *Genesis and quality of groundwater in the Southeastern region of Southern Vietnam, Journal of Environmental and Engineering A, 6, 277-292, 2017; Application of 1D-2D coupled modeling in water quality assessment: A case study in Ca Mau Peninsula, Vietnam, Physics and Chemistry of the Earth, 2018; Application of a two-dimensional model for flooding and floodplain simulation: Case study in Tra Khuc-Song Ve river in Viet Nam, Lowland Technology International, 2018; Application of 2D modeling in simulation the erosion of dykes on Thach Han river basin in Vietnam, Lowland Technology International, 2018; Assessing Cumulative Impacts of the Proposed Lower Mekong Basin Hydropower Cascade on the Mekong River Floodplains and Delta - Overview of Integrated Modeling Methods and Results, Journal of Hydrology, 2018.*

Từ năm 2012, hướng nghiên cứu này được phát triển một cách tổng hợp và rõ nét hơn với việc chủ trì thực hiện thành công đề tài nghiên cứu cấp nhà nước "***Nghiên cứu ảnh hưởng của biến đổi khí hậu đến sự biến đổi tài nguyên nước Đồng bằng sông Cửu Long***". Đề tài đã đạt được những mục tiêu rất cụ thể: (i) Đưa ra được ảnh hưởng của biến đổi khí hậu đến sự biến đổi tài nguyên nước mặt ở Đồng bằng sông Cửu Long; (ii) Xác định được khả năng bảo đảm nguồn nước mặt đối với sự phát triển bền vững ở ĐBSCL, phòng tránh lũ lụt cho các giai đoạn đến năm 2050; (iii) Đề xuất các giải pháp thích ứng với BĐKH, phục vụ khai thác và sử dụng hợp lý tài nguyên nước vùng ĐBSCL. Một số kết quả nghiên cứu của đề tài đã được công bố tại Tạp chí Khoa học Đại học Quốc gia Hà Nội: Tập 29, 2013; Tạp chí Khí tượng Thủy văn: Số 633, 2013; Số 643, 2014 và xuất bản được 01 cuốn sách chuyên khảo "*Ảnh hưởng của Biến đổi khí hậu đến tài nguyên nước và ngập lụt vùng Đồng bằng sông Cửu Long*", NXB Khoa học Tự nhiên và công nghệ, 2014.

Trong những năm đầu công tác tại Viện Khí tượng Thủy văn (nay là Viện khoa học KTTV và BĐKH), bản thân nhận thấy nếu chỉ phát huy thế mạnh truyền thống của viện vốn về nghiên cứu về khoa học tự nhiên thì chủ đề nghiên cứu không phong phú, toàn diện và đóng góp cho cuộc sống sẽ có nhiều hạn chế. Từ 2006, Ứng viên đã cùng các đồng nghiệp bắt đầu nghiên cứu một cách nghiêm túc vấn đề mang tính kết hợp chặt chẽ giữa khoa học tự nhiên và khoa học xã hội nhân văn bằng nhiệm vụ "**Đánh giá mối quan hệ tương tác giữa thiên tai - môi trường - đói nghèo và sinh kế**". Nghiên cứu này đòi hỏi sự phối hợp, tích hợp nhiều phương pháp nghiên cứu: mô hình động lực (mô phỏng các yếu tố môi trường); điều tra, khảo sát thực địa, khảo sát cộng đồng, khảo sát chuyên gia; phân tích, tổng hợp; mô hình thống kê, v.v. Sản phẩm của Nhóm mà Ứng viên tâm đắc nhất trong hướng nghiên cứu này là Bộ chỉ thị đầu tiên ở Việt

Nam đã được UNDP công bố, lồng ghép 3 yếu tố Đói nghèo - Môi trường - Sinh kế, với 117 chỉ thị, trong đó gồm 23 chỉ thị về đói nghèo, 64 chỉ thị về môi trường và 30 chỉ thị về sinh kế. Định hướng nghiên cứu này đã góp phần tạo nền tảng cho việc hình thành những mã ngành đào tạo tiến sỹ về quản lý tài nguyên môi trường, BĐKH ngày nay ở Viện mà Ứng viên may mắn được tham gia trong suốt quá trình xây dựng và triển khai chương trình đào tạo.

Năm 2007, khi thực hiện nghiên cứu xác định các nguyên nhân gây ô nhiễm môi trường trong và sau thiên tai (bão, lũ, lụt), đã đưa ra bức tranh tổng thể về những tác động đến môi trường do thiên tai cụ thể tại 5 tỉnh: Ninh Bình, Thanh Hóa, Nghệ An, Hà Tĩnh và Quảng Bình. Một số kết quả được công bố tại Tạp chí Khí tượng Thủy văn số 589, 2010 và nhiều tạp chí, kỷ yếu hội thảo khác.

Ứng viên tiếp tục duy trì, trực tiếp tham gia và tổ chức các hoạt động nghiên cứu đào tạo theo hướng nghiên cứu này tại Trung tâm Tư vấn Khí tượng Thủy văn và môi trường. Từ năm 2012 đến nay, tiếp theo các kết quả nghiên cứu trong giai đoạn trước, trong khuôn khổ của Chương trình khoa học công nghệ cấp Quốc gia về Tài nguyên Môi trường và Biến đổi khí hậu, Nhóm đã tổ chức nghiên cứu sâu hơn về mối tương tác của thiên tai, biến đổi khí hậu và môi trường - kinh tế - xã hội; xác định các tiêu chí đánh giá tính thích ứng, tính bền vững của môi trường - kinh tế - xã hội trong bối cảnh biến đổi khí hậu. Một số kết quả nghiên cứu được công bố tại Tạp chí Khí tượng Thủy văn: Số 615, 2012; Tạp chí Khoa học Đại học Quốc gia Hà Nội, Tập 29, trang 187-194, 2013. Những kinh nghiệm nghiên cứu được đúc kết lại thành một số giáo trình, sách chuyên khảo như sau: 03 sách chuyên khảo "*Biến đổi khí hậu và các hệ sinh thái ven biển Việt Nam*", NXB lao động, 2009; sách chuyên khảo "*Tài nguyên nước các hệ thống sông chính Việt Nam*", NXB Khoa học và Kỹ thuật, 2012; sách chuyên khảo "*Quy hoạch bảo vệ môi trường*", NXB Khoa học Tự nhiên và công nghệ, 2012; 01 sách giáo trình "*Cân bằng nước và quản lý tổng hợp tài nguyên nước*", NXB Khoa học Tự nhiên và Công nghệ, 2012. Có trên 10 học viên cao học đã hoàn thành luận văn theo hướng nghiên cứu này.

Từ năm 2015 đến nay, là người trực tiếp chỉ đạo xây dựng và thực hiện các dự án hợp tác quốc tế trong lĩnh vực KTTV (điển hình như dự án Nâng cấp khả năng đo mưa, dự báo bão và giông sét của Trung tâm KTTV Quốc gia (ODA Phần Lan)), tập trung vào việc tăng cường mạng lưới quan trắc tự động, phối hợp cùng quan trắc phi truyền thống, như mạng lưới Radar, mạng lưới định vị giông sét, hệ thống giám sát bằng ảnh vệ tinh, v.v. để tạo ra những bộ dữ liệu đầu vào hiệu quả, đồng bộ phục vụ các mô hình dự báo KTTV, môi trường. Một trong những sản phẩm khoa học quan trọng của các dự án này là xây dựng được các mô hình tích hợp các sản phẩm dự báo để tạo ra sản phẩm thông tin KTTV, môi trường phục vụ nhu cầu phát triển các ngành kinh tế - xã hội. Công tác đào tạo cán bộ trình độ cao (thạc sĩ, tiến sĩ) để từng bước làm chủ các công nghệ hiện đại cũng được xác định là những nội dung, sản phẩm quan trọng của các dự án. Có 01 nghiên cứu sinh (Phạm Xuân Dương) đang nghiên cứu theo hướng này, dự kiến sẽ hoàn thành luận án vào năm 2019.

Các vấn đề tiếp tục nghiên cứu theo hướng này:

- Nghiên cứu về các phương pháp chi phí - lợi ích trong giải quyết các vấn đề trong lĩnh vực tài nguyên - môi trường;
- Nghiên cứu phương pháp luận đánh giá tính tổn thương môi trường - kinh tế - xã hội.

1.3 ***Ứng dụng nghiên cứu liên ngành về biến đổi khí hậu và tác động của nó đến môi trường - kinh tế - xã hội***

Từ tháng 9 năm 2007, Ứng viên được tham gia Tổ soạn thảo Chương trình mục tiêu quốc gia ứng phó với biến đổi khí hậu. Chương trình được Thủ tướng Chính phủ phê duyệt ngày 3 tháng 12 năm 2008 - đây là căn cứ quan trọng cho các hoạt động nghiên cứu, triển khai ứng phó với biến đổi khí hậu. Trong thời gian từ 2008 - 2009, Nhóm tại Trung tâm Tư vấn Khí tượng Thủy văn và Môi trường đã phối hợp với Quỹ Rockelfeller triển khai nhiệm vụ nghiên cứu, đánh giá khả năng chống chọi của các thành phố châu Á dưới tác động của biến đổi khí hậu, trong đó Việt Nam có 03 thành phố: Cần Thơ, Quy Nhơn và Đà Nẵng được tiến hành nghiên cứu thí điểm. Với DANIDA, đã thực hiện dự án nghiên cứu đánh giá tác động của biến đổi khí hậu đến tài nguyên nước Việt Nam. Các kết quả nghiên cứu đã được trình bày tại các hội thảo

tham vấn quốc tế và trong nước; gửi đến các bộ, ngành và địa phương. Các kết quả đã được công bố tại Tạp chí khoa học, Các khoa học Trái Đất (*VNU Journal of Science, Earth Science*): Số 2, 2011; Tạp chí Khí tượng Thủy văn: Số 589, 2010; Số 589, 2010; Số 605, 2011; Số 605, 2011. Tạp chí Khoa học, Các khoa học Trái Đất (*VNU Journal of Earth Sciences*): Tập 26, số 4, 2010; Tập 27, số 1, 2011; Tập 27, số 1 và số 2, 2011; Tập 27, số 2, 2011.

Từ năm 2012 đến nay Ứng viên đã xây dựng và phát triển Nhóm nghiên cứu sâu hơn về BĐKH để phục vụ trực tiếp các ngành, địa phương gồm rất nhiều các nhà khoa học đến từ Viện khoa học Khí tượng thủy văn và biến đổi khí hậu, trường Đại học Khoa học Tự nhiên - Đại học Quốc gia Hà Nội, trường đại học DaYeh Đài Loan cùng các viện nghiên cứu khác trong và ngoài nước. Mục tiêu nghiên cứu xây dựng phương pháp khoa học liên ngành, tích hợp công cụ mô hình toán và các phương pháp nghiên cứu hiện đại như: GIS, viễn thám, phương pháp chuyên gia, các phương pháp điều tra xã hội - nhân văn để nghiên cứu về BĐKH bao gồm:

- Nghiên cứu về xu hướng thiên tai trong bối cảnh BĐKH. Các kết quả nghiên cứu này được công bố tại Tuyển tập báo cáo Hội thảo khoa học quốc gia về Khí tượng, Thủy văn, Môi trường và Biến đổi khí hậu lần thứ XV, Tập 1, 2012; Tạp chí Khí tượng Thủy văn: Số 621, 2012; số 645, 2014; số 671, 2016; số 664, 2016; Tạp chí *Vietnam Journal of Earth Sciences*, 39, 4, 2017; Tạp chí Đại học Quốc gia Hà Nội, Tập 29, 2013; Tạp chí Khí tượng Thủy văn, số 699-3/2019.
- Nghiên cứu về BĐKH và tác động của BĐKH đến một số loại hình thiên tai nguy hiểm. Ứng viên đã chủ trì nhiều nghiên cứu lập kế hoạch hành động và ứng phó với BĐKH của nhiều tỉnh thành trong cả nước. Các kết quả nghiên cứu này được công bố tại Tạp chí Khí tượng Thủy văn: Số 633, 2013; Số 643, 2014; Số 660, 2015; Số 665, 2016; Tạp chí Phát triển Khoa học và Công nghệ: Tập 20, T4, 2017; Tạp chí Khoa học Đại học Quốc gia Hà Nội, Tập 29, 2013; Tuyển tập báo cáo Hội thảo khoa học quốc gia về Khí tượng, Thủy văn, Môi trường và Biến đổi khí hậu lần thứ XV, XVI, Tập 1, Tập 2, 2012.
- Nghiên cứu các phương pháp về đánh giá tính dễ bị tổn thương, rủi ro, xây dựng kế hoạch ứng phó với BĐKH và đề xuất một số chính sách liên quan đến BĐKH ở nhiều khu vực khác nhau tập trung vào các vùng miền đặc thù. Các kết quả nghiên cứu này được công bố tại Tạp chí Khí tượng Thủy văn: Số Số 642, 2014; Số 660, 2015; Tạp chí Biển Việt Nam, tháng 8+9, 2015; Tạp chí Khí tượng Thủy văn, số 698-2/2019; Tuyển tập báo cáo Hội thảo khoa học Quốc gia về Khí tượng, Thủy văn, Môi trường và Biến đổi khí hậu lần thứ XVI, Tập 1, 2013; Tuyển tập báo cáo Hội thảo khoa học Quốc gia về Khí tượng, Thủy văn, Môi trường và Biến đổi khí hậu lần thứ XVI, Tập 1, 2013.

Có 03 nghiên cứu sinh đã bảo vệ thành công luận án tiến sĩ theo hướng này (TS. Hoàng Anh Huy, 2013; TS. Trần Duy Hiền, 2017; TS. Phạm Thanh Long, 2018) và 01 nghiên cứu sinh (Hoàng Văn Đại) dự kiến sẽ hoàn thành Luận án vào 2019. Trong thời gian tới, Ứng viên sẽ tập trung vào tiếp tục phát triển Nhóm về đánh giá tính tổn thương, tác động của biến đổi khí hậu, tập trung vào các tác động đến kinh tế - xã hội, các bài toán chi phi lợi ích; đẩy mạnh đào tạo, tuyên truyền về biến đổi khí hậu dưới nhiều hình thức khác nhau.

Tóm lại, kể từ sau khi bảo vệ thành công luận án tiến sĩ vào năm 2005, Ứng viên đã kiên trì phát triển hướng nghiên cứu về tính toán khoa học trong lĩnh vực thủy văn - hải văn - môi trường. Mô hình toán học là công cụ hiệu quả để nghiên cứu, giải quyết các vấn đề thực tiễn.

Sau đây là 5 công trình khoa học tiêu biểu nhất của Ứng viên:

1. Hydrological regime and water budget of the Red River Delta (Northern Vietnam), Luu Thi Nguyet Minh, Garnier Josette, Billen Gilles, Orange Didier, Némery Julien, Le Thi Phuong Quynh, Tran Hong Thai, Le Lan Anh (2010), Journal of Asian Earth Sciences (ISSN: 13678120), 37, 219-228, ISI, IF = 2,335, H-Index = 92.

2. Assessing Cumulative Impacts of the Proposed Lower Mekong Basin Hydropower Cascade on the Mekong River Floodplains and Delta - Overview of Integrated Modeling Methods and Results. Le Duc Trung, Nguyen Anh Duc, Linh Thu Nguyen, Tran Hong Thai, Anwar Khan, Kurt Rautenstrauch, Cheryl Schmidtc (2018), Journal of Hydrology (ISSN: 0022-1694), SCI, ISI, IF = 3,727, H-index 178 (Available online 13 January 2018).

3. Impact of the interaction of surge, wave and tide on a storm surge on the north coast of Vietnam. Tran Hong Thai, Nguyen Ba Thuy, Vu Hai Dang, Sooyoul Kim, Lars Robert Hole (2017), Procedia IUTAM (ISSN: 2210-9838), 25, 82-91. SCOPUS, H-index 15.

4. Effect of river vegetation with timber piling on ship wave attenuatin: Investigation by field survey and numerical modeling, Nguyen Ba Thuy, N.A.K. Nandasena, Vu Hai Dang, Sooyoul Kim, Nguyen Xuan Hien, Lars Robert Hole, Tran Hong Thai (2017), Ocean Engineering (ISSN: 00298018), 129, 37-45, SCI, Scopus, IF = 1,894, H-Index 68.

5. Ảnh hưởng của biến đổi khí hậu đến tài nguyên nước và ngập lụt vùng đồng bằng sông Cửu Long, Trần Hồng Thái (Chủ biên), Hoàng Minh Tuyển, Lương Hữu Dũng, Châu Trần Vĩnh (2014), Nhà xuất bản Khoa học Tự nhiên và Công nghệ, ISBN: 978-604-913-236-0.

II. ĐÀO TẠO

1. Đào tạo cán bộ

Ứng viên rất tâm đắc với công tác đào tạo lực lượng cán bộ nghiên cứu trẻ. Chính vì vậy, Ứng viên đã luôn cố gắng tạo môi trường làm việc thuận lợi để những cán bộ nghiên cứu trẻ được tiếp thu những kiến thức mới, được học hỏi và trưởng thành thông qua công việc nghiên cứu. Bản thân luôn luôn tìm tòi, mở ra những hướng nghiên cứu mới (như trình bày trên), đã hình thành và duy trì các Nhóm nghiên cứu độc lập, không ngừng phát triển và đào tạo lực lượng nghiên cứu cả về lượng và chất. Bản thân đã chủ động tìm kiếm sự hỗ trợ, hợp tác quốc tế cho công tác nghiên cứu khoa học và đào tạo cán bộ Hàng năm, nhiều lượt cán bộ nghiên cứu trẻ được Ứng viên tạo điều kiện cử đi học tập, phối hợp nghiên cứu ngắn hạn tại nhiều cơ sở đào tạo trên thế giới.

2. Xây dựng khung chương trình và chương trình đào tạo

Năm 2009, Ứng viên đã phối hợp cùng Nhóm chuyên gia thuộc Đại học Quốc gia Hà Nội, dưới sự tài trợ của Dự án tăng cường năng lực ứng phó với Biến đổi khí hậu của UNDP xây dựng Chương trình đào tạo thạc sĩ về biến đổi khí hậu.

Ngoài ra, Ứng viên đã trực tiếp chủ trì và tham gia xây dựng 03 chương trình đào tạo: (1) Chương trình đào tạo tiến sĩ Quản lý tài nguyên và bảo vệ môi trường tại Viện khoa học Khí tượng Thủy văn và Biến đổi khí hậu (năm 2011); (2) Chương trình đào tạo cử nhân Biến đổi khí hậu và Phát triển bền vững tại Trường Đại học Tài nguyên và Môi trường Hà Nội (năm 2011); (3) Chương trình đào tạo Thạc sĩ ngành Năng lượng bền vững và Biến đổi khí hậu tại Trường Đại học Tài nguyên và Môi trường Tp. Hồ Chí Minh.

3. Kết quả giảng dạy

3.1. Tính toán khoa học trong lĩnh vực thủy văn - môi trường:

Từ tháng 5 năm 2001 đến tháng 6 năm 2005, Ứng viên đã tham gia công tác giảng dạy tại Đại học Tổng hợp Heidelberg với những công việc cụ thể: Xây dựng bài giảng; hướng dẫn sinh viên thực tập nghiên cứu tại nhóm nghiên cứu mô hình và tối ưu thuộc IWR; tổ chức các seminar khoa học, các khóa đào tạo về phương pháp tính, mô hình, phần mềm. Hiện nay, Ứng viên vẫn duy trì nghiên cứu, giảng dạy về tính toán khoa học, ứng dụng mô hình tính toán cho các khóa đào tạo sau đại học, các chuyên đề nâng cao.

3.2. Thủy văn - Tài nguyên nước - môi trường:

Ứng viên tham gia giảng dạy các môn học theo 04 hướng nghiên cứu chính: *(1) Mô hình toán thủy văn; (2) Quy hoạch và quản lý tài nguyên nước; (3) Biến đổi khí hậu; (4) Khoa học môi trường.*

4. Biên soạn giáo trình, bài giảng

Ứng viên đã tham gia biên soạn tổng cộng 10 cuốn sách giáo trình và chuyên khảo (đều được các cơ sở đào tạo trên đại học, đại học sử dụng làm giáo trình, sách chuyên khảo): Sách chuyên khảo: "*Biến đổi khí hậu và các hệ sinh thái ven biển*", xuất bản tại Nhà xuất bản Lao động, Hà Nội, 2009; "*Tài nguyên nước các hệ thống sông chính Việt Nam*", nhà xuất bản Khoa học và Kỹ thuật, 2012; "*Quy hoạch bảo vệ môi trường*", Nhà xuất bản Khoa học tự nhiên và công nghệ, 2012; "*Ảnh hưởng của Biến đổi khí hậu đến tài nguyên nước và ngập lụt vùng Đồng bằng sông Cửu Long*", Nhà xuất bản bản Khoa học tự nhiên và công nghệ, 2014; "*Đánh giá ngưỡng chịu tải môi trường nước sông Nhuệ và sông Đáy*", Nhà xuất bản bản Khoa học tự

nhiên và công nghệ, 2017; 02 sách chuyên khảo quốc tế: "*Application Couple Model in Saltwater Intrusion Forecasting in Estuary*" và "*Adaptation to Climate Change on the Saltwater Intrusion in Estuaries*", Nhà xuất bản LAP LAMBERT Academic Publishing, 2017.

Sách giáo trình: 03 cuốn sách giáo trình "*Cân bằng nước và quản lý tổng hợp tài nguyên nước*", Nhà xuất bản Khoa học Tự nhiên và công nghệ, 2012; "*Giáo trình Biến đổi khí hậu*", Nhà xuất bản Khoa học tự nhiên và công nghệ, 2017 và "*Giáo trình Thích ứng và Giảm nhẹ với biến đổi khí hậu*", Nhà xuất bản Đại học Quốc gia Hà Nội, 2017.

5. Hướng dẫn luận án, luận văn và khóa luận

Từ năm 2005 đến nay: đã hướng dẫn thành công 06 NCS (03 chính, 03 phụ); hướng dẫn thành công khoảng 20 học viên cao học và nhiều sinh viên đã bảo vệ khóa luận tốt nghiệp. Đề tài luận án, luận văn thạc sĩ khoa học của các học viên cao học, khóa luận tốt nghiệp của sinh viên do Ứng viên hướng dẫn tập trung vào 2 hướng nghiên cứu chính nêu trên.

III. KẾT LUẬN

1) Là một cán bộ kiêm nhiệm công tác giảng dạy và nghiên cứu khoa học, Ứng viên đã thực hiện đầy đủ các quy định trong công tác giảng dạy đại học, sau đại học và nghiên cứu khoa học.

2) Đến nay, Ứng viên đã công bố 108 bài báo Khoa học, Hội thảo trong nước và quốc tế, trong đó có 11 bài báo Khoa học quốc tế, tác giả chính của (02 bài SCI, 01 bài ISI, 02 bài SCOPUS); 35 bài báo khoa học trong nước tác giả chính; đã và đang thực hiện gần 22 nhiệm vụ nghiên cứu khoa học, trong đó chủ trì 01 đề tài cấp nhà nước (đã nghiệm thu); 4 đề tài nhánh thuộc các đề tài cấp nhà nước (đã nghiệm thu); chủ trì 01 đề tài cấp bộ (đã nghiệm thu); chủ trì 01 đề tài cơ bản (đã nghiệm thu); chủ trì 05 nhiệm vụ nghiên cứu cấp bộ; chủ trì 03 nhiệm vụ nghiên cứu cấp tổng cục; đã tham gia chủ biên, biên soạn 10 cuốn sách trong đó có 02 cuốn sách xuất bản quốc tế; hướng dẫn thành công 06 NCS, trong đó: Hướng dẫn chính 03 NCS (đã nhận bằng TS); Hướng dẫn phụ 03 NCS (đã nhận bằng TS).

3) Ứng viên luôn tự đào tạo để nâng cao trình độ chuyên môn nghiệp vụ, ngoại ngữ, có thái độ nghiêm túc, tâm huyết trong nghiên cứu khoa học và giảng dạy, được học viên quý mến, đồng nghiệp tín nhiệm và có sự cộng tác rất tốt với đồng nghiệp trong NCKH.

Những điều đã trình bày trên cho phép Ứng viên tự đánh giá bản thân có đủ điều kiện để đăng ký xét công nhận đạt tiêu chuẩn chức danh Giáo sư.

Hà Nội, ngày 28 tháng 06 năm 2019

NGƯỜI VIẾT BÁO CÁO

PGS. TS. Trần Hồng Thái

- 000835

MINISTRY OF NATURE RESOURCES ENVIRONMENT
VIETNAM INSTITUTE OF METEOROLOGY HYDROLOGY AND CLIMATE CHANGE

SOCIALIST REPUBLIC OF VIET NAM
Independence - Freedom - Happiness

AN OVERVIEW REPORT ON SCIENTIFIC RESULTS

A. PERSONAL INFORMATION

1. Full name: Tran Hong Thai
2. Date of birth: August 4, 1974 Gender: Male Ethnic: Kinh
3. Hometown: Kim Loc district, Can Loc commune, Ha Tinh Province.
4. Training process
   - Bachelor degree of Engineering and Technology, Specialization: Thermal Power Energy on September 30, 1997 at Moscow Power Engineering Institute, Russia.
   - Master degree of Engineering and Technology, Specialization: Thermal Power Energy on July 8, 2005 at Moscow Power Engineering Institute, Russia.
   - PhD degree of Earth Science and Mathematics, Specialization: Scientific calculation of Hydrology - Environment on July 8, 2005 at Heidelberg University, German.
5. Current position: Administrator
6. Current agency: Viet Nam Meteorological and Hydrological Administration
7. Visiting Lecturer
   1. Ha Noi University Science - Viet Nam University of Science
      Faculty: Earth Science - Major: Hydrology
   2. Institute of Meteorology hydrology and Environment
      Faculty: Earth Science - Major: Management of Natural Resources and Environment
   3. VNU School of Interdisciplinary studies (formerly known as VNU School of Graduate Studies)
      Faculty: Earth Science - Major: Climate change
8. Retirement: not yet
9. Current

Lecturer ☐; Visiting Lecturer ☑; Researcher ☐; Managers ☑; Other duties ☐; Retirement ☐

B. REPORTS CONTENT

In 1998, I became a doctoral student at the Interdisciplinary Center for Scientific Computing (IWR), Heidelberg University. I had access to interdisciplinary scientific research methods (Science Earth and Computational Science). In 2005, I successfully defended my doctorate in Earth Science and Mathematics (major: Method of calculation in hydrology and environment) titled "***Numerical methods for simulation, parameter estimation and optimal control for Red River - Thai Binh River system***". From August 2005 to January 2014, I worked at the Institute of Meteorology, Hydrology and Environment (currently it is known as the Vietnam Institute of Meteorology, Hydrology and Climate Change) under the Ministry of Natural Resources and Environment, Vietnam as a researcher (Principal researcher) and a visiting lecturer. From January 2014 until now, I have become the Administrator of Viet Nam Hydro-Meteorological Administration). In 2011, I was recognized as Associate Professor in Earth Sciences, in the interdisciplinary field of Earth Sciences and Mining. In all fields, I have tried my best to make contributions on hydro-meteorology in general and on training and research in particular. The results of above-mentioned activities are shown as follows:

I. SCIENCE RESEARCH RESULTS

As a researcher and a visiting lecturer, I have oriented my scientific research activities under three main objectives: (1) Linking research objectives to effectively serve socio-economic development, water resources and environmental management; (2) Applying scientific research to teaching and training; and (3) Developing and applying scientific achievements in practice. All research projects focus on a main directions:

(1) Developing numerical methods and mathematical models to solve simulation problems, determine automatic parameters - control and forecast in the field of hydrology, water resources and environment application to interdisciplinary research on climate change and its impact on environment - economy - society.

During my years of research and teaching, especially since 2012 (after I was recognized by the State as Associate Professor), I have become fully aware of the need to create research topics as well as orientation, establishment and maintenance of research teams in Earth Sciences and other fields of sciences. Devising research topics will become a more important supplement to my direct duties in scientific research and teaching. My main research direction stimulates me to seek out new ways to analyze and solve research problems through new, innovative scientific research approaches. The results of all my research endeavors are presented in scientific publications, textbooks and monograph books for teaching programs and training courses. The results are summarized as follows:

1.1. Developing numerical methods, mathematical models to solve simulation problems, determine automatic parameters; control and forecast in the field of hydrology, water resources and the environment

I was fortunate to study and work at the Interdisciplinary Center for Scientific Computing (IWR), Heidelberg, where I realized that Scientific Computing is a vital tool which can be utilized for natural sciences, informatics and mathematics. With the dedicated guidance of Prof. Dr. h.c. mult. Hans Georg Bock and Prof. Dr. h.c. mult. Willie Jäger, the two leading scientists in Germany in the field of Scientific Computing, I chose my first research direction in Scientific computing in Earth Sciences, in particular the field of environmental hydrology.

I successfully implemented this first research direction by completing my PhD dissertation "*Numerical methods for simulation, parameter estimation and optimal control for Red River - Thai Binh River system*". The numerical methods were used to solve the non-linear hyperbolic Saint Venant Equations (simulating the one-dimensional river flow) with an innovative point of using the calibration curve at each step over time, thus, the grid size at each step was appropriately selected, satisfying the stable condition of the CLF (*Courant - Friedrichs - Lewy Condition*). This model ran more steadily and efficiently than other methods with fixed calculation steps.

To the best of my knowledge, this was the first time a method was introduced to determine the topographic and hydraulic parameters automatically through setting and solving the least squares problem. In this way, the parameters are the solution of the optimal problem, so that water level (discharge) was calculated to be "fit" with corresponding measured values at the hydrological stations. This is an optimal math problem that is bound to large dimensions due to the discretization of the *Saint Venant* equations in space and time. The problem was solved by an extension of the *Gauss-Newton* method (developed at the Interdisciplinary Center for Scientific Computing - IWR). Its results were published in the Scientific and Technical Hydro-meteorological Journal No. 586, pp. 14-22, 2009.

In addition to identifying parameters and simulating flow, the above-mentioned method also enabled us to solve the optimal control problem. I designed a scheme of the reservoir operation of Hoa Binh Hydropower plant with the objective of effectively reducing flooding as well as ensuring the production of electricity (***Figure 1***). The result was published in the 6th National Conference on Hydrological Forecasting Technologies, Vol. 2, pp. 45-60, 2001 - 2005.

Continuing this research direction, in 2009, I completed the ministerial-level project "*Development of a model to forecast the risk of pollution levels and identify the pollution sources for the downstream of Sai Gon - Dong Nai River*". According to the implementation of this project, I formed a research team at the Hydro-meteorology and Climate Change Consulting and Service Center specializing in computational models simulating hydrodynamic process and substance spread in nature:

- Exploitation and application of commercial and open-source software to solve practical problems: suspended sediment transport, water quality current status and trend for polluted river systems; the estimation of water balance in a river basin. The results of this study were published in the Proceedings of the National Conference on Hydraulic Mechanics, in 2007.
- Development of a forecasting model to monitor water and air changes in line with plans and strategies of the socio-economic development;
- Development of a rapid assessment method to determine the pollutant loads in one-way narrow rivers.
- Expanding the research direction to determine the sources of pollution by *Inverse problem*: successfully built a set of models to quickly determine pollution sources (*Pollutant Sources Quick Identification Software-PSQIS)* for two-dimensional estuaries. This software PSQIS has been utilized by a working group at the Ministry of Natural Resources and Environment to identify the causes of oil pollution in the coastal areas at the end of the year 2006 and the beginning of the year 2007 to report to the Government and National Assembly.

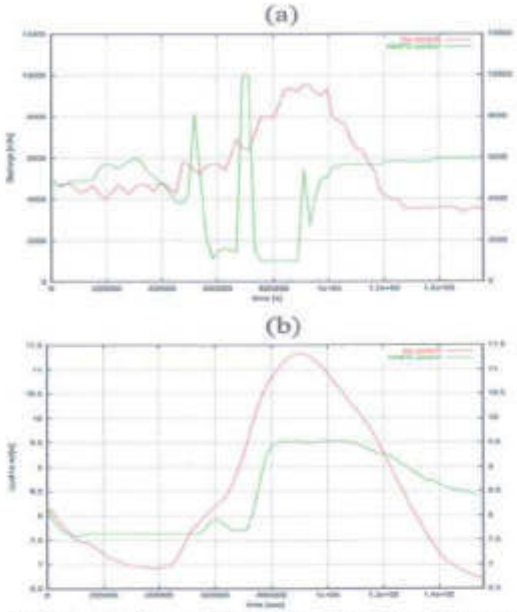


Figure 1. The effectiveness of reducing the amount of water discharge to Hoa Binh reservoir (a) and at Hanoi station (b) used the data of the flood event in 2000

From 2009 onwards, on the basis of the results of the project: "Investigation, evaluation and warning of changes in meteorological and hydrological factors at risk of damaging natural resources - environment in the seas and coastal areas, proposing solutions to prevent and respond" of the Ministry of Natural Resources and Environment, my colleagues at the Institute of Meteorology, Hydrology and Climate change and I conducted a study and developed an open-source numerical model in the FORTRAN language, combining with meteorological and hydrodynamic models to solve the problem of atmosphere-ocean interaction. Currently, the research team is applying and developing DELFT 3D model in the LINUX environment to link with *Weather Research and Forecast - WRF* in predicting water level, discharge and storm surges. During the research, I gained an understanding of the need to integrate numerical methods for hydrodynamic processes in rivers and meteorological and marine models. Many questions have been raised during the research to create a more complete picture about related problems.

From 2014 to March, 2013 after having been appointed as the Deputy General Director and having been in charge of scientific research at the National Hydro-meteorological Service, I have directly chaired a number of projects at different levels in the field of natural disaster prevention and control. I have promoted scientific computing to serve forecasting and have directly established a research team under the National Center for Hydro-meteorological Forecasting. Together with colleagues at the Institute of Meteorology, Hydrology and Climate change and Hanoi University of Science, Vietnam National University, I successfully applied the finite element method to solve the problem of one-dimensional dynamic wave for watershed rainfall-runoff routing; and in 2016, the research was published in an International journal (Title:

A finite element one-dimensional kinematic wave rainfall-runoff model, Pacific Science Review A: Natural Science and Engineering). Coastal erosion in Ca Mau River was studied in a research project "*Research on the impact of ship's wave on coastal erosion and proposed natural measures to mitigate its impact*" funded by the National Science Development Fund. The research project provided indicators of degraded level of the height and wave pressure at the shoreline using river vegetation parameters and timber piling in Ca Mau River. The results were published in an international journal, which is under the SCI and Scopus systems (Title: *Effect of river vegetation with timber piling on ship wave attenuation: Investigation by field survey and numerical modeling, Ocean Engineering, 2017, 129, 37-45*) (***Figure 2***). In this research, the numerical model based on two-dimensional Boussinesq equations to consider the effect of drag force due the presence of vegetation to estimate the wave propagation when the waves pass through vegetation and timber piling.

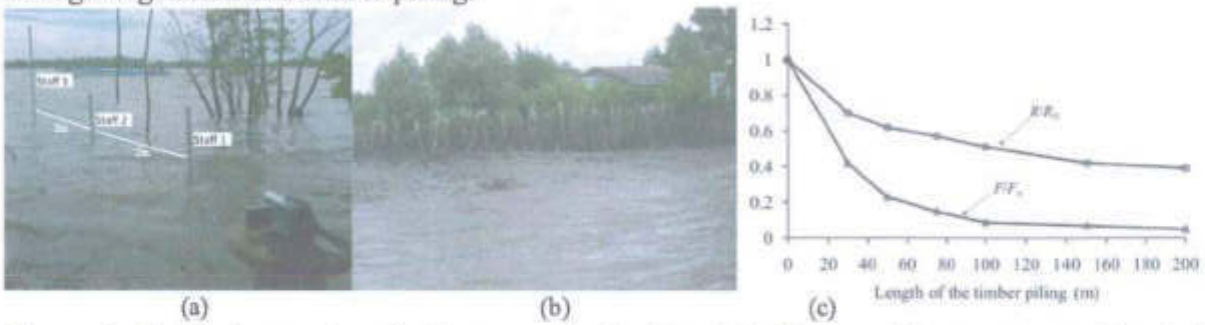


Figure 2. Field observation of ship waves in Ca Mau (a); Timber piling constructed and river vegetation (b); The degraded level of wave height *(R/R_0) and ship wave pressure (F/F_0) at the shore depending on the length of timber piling (c)*

In addition, in a ministerial-level project from 2014 to 2016 with the title: "*Model selection for storm surges forecasting and operational forecasting in Vietnam*", the research team applied the tide-surge-wave coupling model (SuWAT model) for operational forecasting of storm surges. The technology for storm surges forecasting is used in operational forecasting at the National Center for Hydro-meteorological Forecasting and the research was published in an *Elsevier* journal and one international conference (*Tran Hong Thai, Nguyen Ba Thuy, Vu Hai Dang, Sooyoul Kim and Lars RobertHole (2017). Impact of the interaction of surge, wave and tide on a storm surge on the north coast of Vietnam, Procedia IUTAM (ISSN: 22109838), Elsevier, (Scopus), H-Index 12*). The results indicate that to forecast storm surges accurately, numerical models are necessary to integrate with tides, waves and storm surges, especially at the coastline where the terrain is narrow and the amplitude of tides is large, such as the north coastline of Vietnam. The results were published on Vietnam Journal of Hydro-Meteorology No.687-March, 2018. The research also showed that storm surges caused by wave radiation stress were fully calculated in the calculation grid with high resolution (***Figure 3***).

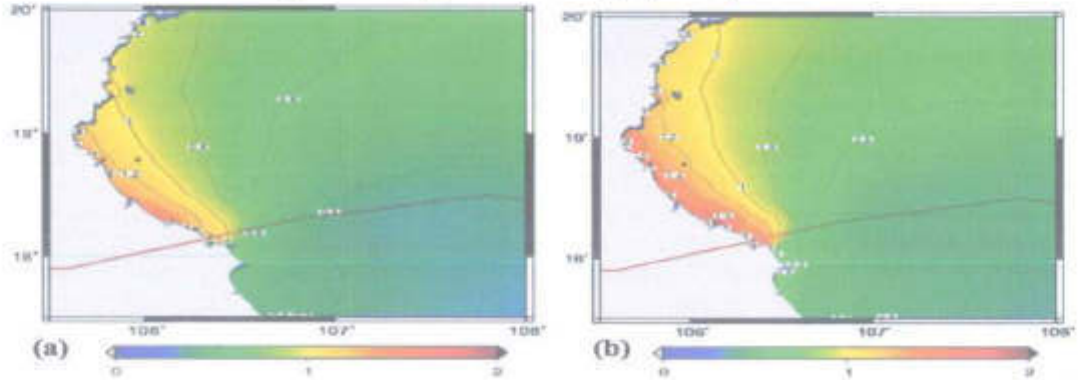


Figure 3. Distribution of the storm surge height during Typhoon Washi occurred in the case uncoupled (a) and coupled with wave (b)

From 2015 until now, the abnormal sea level rise in the central and southern coastal areas was studied in a national-level project with the title: "*Research on the causes of abnormal sea*

level rise and development of technological forecasting procedures in the Central and Southern areas of Vietnam" and I was the team leader of this project. The initial results were published in The Scientific and Technical Hydro-meteorological Journal, No. 676 - 4/2017. Two PhD students successfully completed their PhD dissertations based on this research (Dr. Do Dinh Chien, 2016 and Dr. Doan Tien Ha, 2016).

The problems will be continued to focus on this research direction:

- Developing scientific computing tools, optimization and dynamic planning tools for solving problems in the field of Earth sciences;
- Utilizing multi-functional software (commercial and open-source) to integrate the models such as Meteorology - Climate, Marine - Hydrology, Flooding, GIS, etc. to solve practical problems related to different research fields.

1.2 Combining the use of dynamic models with other scientific tools (statistical probability, field investigation and survey, ecology, etc.) to solve the complicated problems such as environmental flow, marine and water resources planning, etc.

The assessment of environmental flow and water resources and environmental planning are relatively new problems and necessary for integrated water resources management and sustainable development of water resources. In order to study environmental flow, it is necessary to use a combination of research methods such as hydrological and hydraulic models to simulate the flow regime combined with other models related to the environmental - ecological analysis system to simulate the living conditions of aquatic species and aquatic ecosystems. In 2006, I chaired a research project titled "*Studying the research basis on environmental flow assessment*" (***Figure 4***). The results of this project were published in the Scientific and Technical Hydro-meteorological Journal No. 568, 2008 and No. 603, 2011 and in the 6th National Conference on Technologies of hydro-meteorological forecasting, Vol. 2, 2001 - 2005. Based on this project, the research team has continued to conduct a number of research projects based on this research direction:

- From 2008 - 2010: I took part in a project of the Ministry of Natural Resources and Environment with the title: *"Environmental flow assessment for Red-Thai Binh River"*; and a national-level project with the title *"Identification of the environmental flow in Red-Thai Binh River System and proposed measures to maintain environmental flow in line with the requirements of the sustainable development of water resources", Coded KC.08.22/06-10.* Some of the results from the research were published in the Scientific and Technical Hydro-meteorological Journal, No. 589, 2010;
- From 2009 - 2011: I was the team leader of the project with the title: *"Identification of the threshold loads for Nhue River - Day River"* and its results were published in the Scientific and Technical Hydro-meteorological Journal No. 591, 2010; No. 595, 2010; No. 604, 2011 and No. 605, 2011.

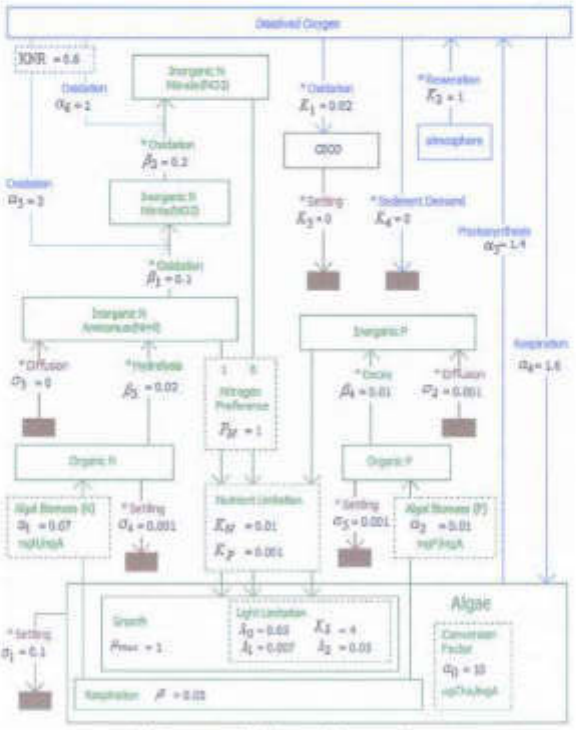


Figure 4. Nutrition chart

In 2006, I formed a research team to develop master plans for water resources for the Cau River basin and for the key economic area of northern regions. The team developed the models to estimate rainfall-runoff process, flow changes, water quality in the river, water balance corresponding with the scenarios of socio-economic development and specific solutions: (1) To allocate and share water resources effectively and ensure the harmonious development among

sectors in the river basin; (2) To protect the endangered or threatened species in the ecosystem; (3) To prevent and mitigate impacts related to water such as flood, flooding, dyke and reservoir failures, etc. The results of this project were published in the Scientific and Technical Hydro-meteorological Journal No. 578, 2009; No. 604, 2011.

In 2009, I led the team to implement the project with the title: *"Environmental protection Planning in Nhue - Day River basin up to 2015 and vision to 2020"*. Some of the results were published at international conferences in Hanoi, Melbourne and published in the Scientific and Technical Hydro-meteorological Journal No. 591, 2010; No. 595, 2010; and No. 605, 2011. During this period of time, the urgent demand on hydrological assessments in the Red River Delta - Thai Binh basin was taken into consideration by experts from the Vietnam Academy of Science and Technology and international experts. The results of this research were published in Journal of Asian Earth Science (*Hydrological regime and water budget of the Red River Delta (Northern Vietnam), Journal of Asian Earth Sciences, 37, 219-228, 2010)* in SCIE and Scopus systems with H-Index 92.

The remaining results related to this project were later published in international journals and seminars in 2013, such as: *Water balance and nutrient delivery in a densely populated delta for a future sustainable environment, Proceedings of HP1, IAHS-IAPSO-IASPEI Assembly, 2013* and *Hydrological regime of a tidal system in the Red River Delta, northern Vietnam, Proceedings of FRIEND-Water 2014; Modeling the effect of thermal diffusion process from nuclear power plants in Vietnam, Journal of Energy and Power Engineering, 8, 403-418, 2017; Genesis and quality of groundwater in the Southeastern region of Southern Vietnam, Journal of Environmental and Engineering A, 6, 277-292, 2017. Application of 1D-2D coupled modeling in water quality assessment: A case study in Ca Mau Peninsula, Vietnam, Physics and Chemistry of the Earth, 2018; Application of a two-dimensional model for flooding and floodplain simulation: Case study in Tra Khuc-Song Ve river in Viet Nam, Lowland Technology International, 2018; Application of 2D modeling in simulation the erosion of dykes on Thach Han river basin in Vietnam, Lowland Technology International, 2018; Assessing Cumulative Impacts of the Proposed Lower Mekong Basin Hydropower Cascade on the Mekong River Floodplains and Delta - Overview of Integrated Modeling Methods and Results, Journal of Hydrology, 2018.*

From 2012, this research direction has been developed in a more comprehensive manner by a national-level research project with the title: ***"Impacts of climate change on water resources in the Mekong Delta"***. The project achieved specific objectives: (i) Identifying the impacts of climate change on water resources in the Mekong Delta; (ii) Determining surface water supply to ensure the sustainable development in the Mekong Delta and flood prevention and control towards 2050; (iii) Proposed measures for climate change adaptation, effective exploitation of water resources in the Mekong Delta. Some of the results from this research were published in the Journal of Science, VNU, Hanoi: No. 29, 2013; Scientific and Technical Hydro-meteorological Journal No. 633, 2013; No. 643, 2014 and in a monograph book "*Impacts of climate change on water resources and flooding in the Mekong Delta*", Science and Technology Publishing House, 2014.

In my early years at the Institute of Meteorology, Hydrology and Environment, I realized that if researchers only focused on the traditional research strengths of the Institute in natural sciences, the research topics would be limited and the ability of applying outcomes of each research topic for socio-economic development in Vietnam will be insufficient. Therefore, since 2006, my colleagues and I have started to study research topics combining natural sciences with social sciences and one of the research projects was implemented with the title "***Assessment of natural disaster - environment - poverty and livelihood***". This research required the integration of a number of research methods such as statistical models, dynamic models (simulation of environmental factors), field investigation and survey for community and experts; analysis and synthesis, etc. The most noticeable result in this research project was the first set of indicators in Vietnam being published by UNDP related to three elements of Poverty - Environment -

Livelihood, with 117 indicators in which 23 for poverty, 63 for environment and 30 for livelihood. This research direction laid a foundation to develop PhD training programs in management of water resources, environment and climate change in the Institute of Meteorology, Hydrology and Environment and I was fortunate to be involved in the overall process of preparing and implementing the training programs.

In 2007, one research project was conducted to identify the causes of environmental pollution during and after natural disasters (typhoons, flood, flooding) and gave a comprehensive picture of the environmental impacts caused by natural disasters in five provinces, namely Ninh Binh, Thanh Hoa, Nghe An, Ha Tinh and Quang Binh. The results were published in the Scientific and Technical Hydro-meteorological Journal no. 589, 2010 and many other journals and seminars.

I have continued to participate in projects and research activities related to this research direction at the Consulting Center of Hydro-Meteorology and Environment. Since 2012, within the framework of the National Science and Technology Program on Natural Resources, Environment and Climate Change, my research team implemented comprehensive studies on the interactions among natural disasters, climate change and environment - society - economy; identified the indicators for assessing adaptation and sustainability of environment - society - economy in the context of climate change. The results were published in the Scientific and Technical Hydro-meteorological Journal no. 615, 2012 and the Journal of Science, Vietnam National University, No. 29, pp 187-194, 2013. Additionally, the valuable experiences were synthesized into textbooks and monographs books such as "*Climate change and coastal ecosystems in Vietnam*", Labor Publishing House, Hanoi, 2009; "*Water resources in major river systems in Vietnam*", the Science and Technics Publishing House, 2012; "*Environmental protection planning*", the Publishing House for Natural Science and Technology, 2012; "*Water balance and integrated water resources management*", the Publishing House for Natural Science and Technology, 2012. More than 10 postgraduate students completed their theses in this research direction.

Since 2015, I have been directly in charge of the development and implementation of the international cooperation projects in the field of Hydro-meteorology. Typically, one of the projects is upgrading rain observation network, forecasting capacity for typhoons and thunderstorms of the National Hydro-Meteorological Service (Finnish ODA), focusing on strengthening automated observation network in collaboration with non-traditional observation methods, such as radar, image surveillance system, etc. in order to create efficient synchronization for the database as an input of hydro-meteorological and environmental forecasting models. One of the important scientific outcomes is the integrated forecast products to serve the socio-economic development goals. Another important outcome of these projects is training high-level staff (master and PhD) to use modern technologies. A PhD student (Pham Xuan Duong) is studying the research direction and he is due to complete his PhD in 2019.

The problems will be focused on this research direction:

- Research on cost-benefit methods in solving problems in the field of natural resources and environment;
- Research on methodology for vulnerability assessment for environment - society - economy.

1.3 Application to interdisciplinary research on climate change and its impacts on the environment - society - economy

In September 2007, I took part in the pilot team of the National Target Program to Respond to Climate Change. The program was approved by the Prime Minister on December 3rd, 2008. It is an important basis for the implementation of research activities to respond to climate change.

From 2008 - 2009, the research team at the Consulting Center for Hydro-Meteorology and Environment worked with the Rockefeller Foundation to conduct a study and assessment of climate change-resilient Asian cities, in which 3 cities in Vietnam were piloted namely Can Tho,

Quy Nhon and Da Nang. The team also cooperated with DANIDA to conduct an assessment of the impacts of climate change on water resources in Vietnam. The research results were presented at domestic and international consulting conferences and delivered to all authority levels in Vietnam. The results of this research were published in the VNU Journal of Science, Earth Science No. 2, pp. 119-126, 2011; The Scientific and Technical Hydro-meteorological Journal, No. 589, 2010; No. 589, 2010; No. 605, 2011; No. 605, 2011; The VNU Journal of Science, Earth Science Volume 26, No. 4, 2010; Volume 27, No. 1, 2011; Vol. 27, Vol. 1 and Vol. 2, 2011; Vol. 27, No. 2, 2011.

Since 2012, I have established and developed a research team specialized in climate change to serve sectors and provinces directly including experts from the Institute of Meteorology, Hydrology and Climate change, University of Science - National University of Hanoi, DaYeh University of Taiwan and other domestic and international research institutes. The objectives of the research are to develop an interdisciplinary scientific method to integrate computational modeling tools and modern research methods such as remote sensing GIS, expert consulting, human and social surveys to study on climate change. The detailed outcomes of the research are described as follows:

- Research on changes of natural disasters in the context of climate change. The results of this research were published in Proceedings of the 15th National Symposium on Meteorology, Hydrology, Environment and Climate change, Vol. 1, 2012; the Scientific and Technical Hydro-meteorological Journal No. 621, 2012; No. 645, 2014; No. 671, 2016; No. 664, 2016; *Vietnam Journal of Earth Sciences*, 39, 4, 2017; Journal of Science of VNU, Hanoi, Vol. 29, 2013, Vietnam Journal of Hydro-Meteorology Vol.699 - March, 2018
- Research on climate change and its impacts on severe natural disaster events. I have led several studies to develop an action plan to respond to climate change in different provinces. Their results were published in the Scientific and Technical Hydro-meteorological Journal No. 633, 2013; No. 643, 2014; No. 660, 2015; No. 665, 2016; The Journal of Science and Technology Vol. 20, April 2017; Journal of Science, VNU, Hanoi, Vol. 29, 2013; Proceedings of the 16th National Symposium on Meteorology, Hydrology, Environment and Climate change, No. 2, 2012; Proceedings of the 15th and 16th National Symposium on Meteorology, Hydrology, Environment and Climate change, No. 1, 2012; Proceedings of the 15th National Symposium on Meteorology, Hydrology, Environment and Climate change, Vol. 1 and 2, 2012.

Research on methods to assess the vulnerability, risk and to develop an action plan to respond to climate change, proposed climate change policies for many regions and especially for key areas. The results of this research were published in the Scientific and Technical Hydro-meteorological Journal No. 642, 2014; No. 660, 2015; Vietnam Journal of Sea, August and September 2015; Vietnam Journal of Hydro-Meteorology Vol.698-Feb, 2019; Proceedings of the 16th National Symposium on Meteorology, Hydrology, Environment and Climate change, Vol. 1, 2013. Following this research direction, three PhD candidates successfully completed their PhD dissertations (Dr. Hoang Anh Duy, 2013; Dr. Tran Duy Hien, 2017; Pham Thanh Long, 2018) and one PhD student (Hoang Van Dai, expected to complete in 2019). In the future, I expect to focus more on training and developing research teams to study assessments on vulnerability and impacts of climate change, especially socio-economic impacts, cost-benefit analysis; promoting training and dissemination on climate change in various forms.

To summarize, after successfully completing my PhD dissertation in 2005, I have persistently developed research directions in training and scientific computing in the fields of hydro-meteorology and environment. Computational models are effective tools to research and solve practical problems.

05 most remarkable scientific works

1. Hydrological regime and water budget of the Red River Delta (Northern Vietnam), Luu Thi Nguyet Minh, Garnier Josette, Billen Gilles, Orange Didier, Némery Julien, Le Thi Phuong Quynh, Tran Hong Thai, Le Lan Anh (2010), Journal of Asian Earth Sciences (ISSN: 13678120), 37, 219-228, ISI, IF = 2,335, H-Index = 92.

2. Assessing Cumulative Impacts of the Proposed Lower Mekong Basin Hydropower Cascade on the Mekong River Floodplains and Delta - Overview of Integrated Modeling Methods and Results. Le Duc Trung, Nguyen Anh Duc, Linh Thu Nguyen, Tran Hong Thai, Anwar Khan, Kurt Rautenstrauch, Cheryl Schmidtc (2018), Journal of Hydrology (ISSN: 0022-1694), SCI, ISI, IF = 3,727, H-index 178 (Available online 13 January 2018).

3. Impact of the interaction of surge, wave and tide on a storm surge on the north coast of Vietnam. Tran Hong Thai, Nguyen Ba Thuy, Vu Hai Dang, Sooyoul Kim, Lars Robert Hole (2017), Procedia IUTAM (ISSN: 2210-9838), 25, 82-91. SCOPUS, H-index 15.

4. Effect of river vegetation with timber piling on ship wave attenuatin: Investigation by field survey and numerical modeling, Nguyen Ba Thuy, N.A.K. Nandasena, Vu Hai Dang, Sooyoul Kim, Nguyen Xuan Hien, Lars Robert Hole, Tran Hong Thai (2017), Ocean Engineering (ISSN: 00298018), 129, 37-45, SCI, Scopus, IF = 1,894, H-Index 68.

5. Impact of climate change on water resources and flooding in the Mekong Delta, Tran Hong Thai (Chef Editor), Hoang Minh Tuyen, Luong Huu Dung, Chau Tran Vinh (2014), Natural Science and Technology Publisher, ISBN: 978-604-913-236-0.

II. TRAINING RESULTS

1. Staff training programs

I am very enthusiastic about training young researchers. As a result, many research teams have formed to establish working environments where young researchers can obtain new knowledge, experiences and develop necessary skills. Since 2005, I have been continuously exploring new research directions (as mentioned above) and forming independent research teams with a view to both quality and quantity of research capacity building.

Personally, I have actively searched for support, international cooperation for scientific research and staff training programs. Through discussions and workshops, new cooperation programs have been established and developed effectively. Every year, a number of young researchers have been given opportunities with my support to attend short-term training courses and collaborate with the training centers in research projects.

2. Development of training framework and training programs

In 2009, I collaborated with the research team of Vietnam National University, Hanoi, funded by UNDP's project about capacity building to respond to climate change. The project supported development of training programs for Master degree in Climate Change. In addition, I directly chaired and participated in the development of 3 training programs: (1) Doctoral program on Natural Resource Management and Environmental Protection at the Institute of Meteorology, Hydrology and Climate Change (in 2011); (2) Bachelor program on Climate Change and Sustainable development at Hanoi University of Natural Resources and Environment (in 2011); and (3) Master program on Sustainable Energy and Climate Change at University of Natural Resources and Environment, Ho Chi Minh City.

3. Teaching results

3.1. Scientific computing in hydrology and environment:

From May 2001 to June 2005, I taught at the Heidelberg University. The activities were including preparing lectures; supervising intern students at the IWR's modeling and optimization team; organizing scientific seminars and training courses on computing methods, models, and software. At present, I have continued to participate in research and teaching programs on scientific computing and application of computational models for postgraduate training courses and advanced topics.

3.2. Hydrology - Water resources - Environment:

I have taught different subjects in four main research areas: *(1) Hydrological models; (2) Water resources planning and management; (3) Climate change; and (4) Environmental science.*

4. Compilation of textbooks and lectures

I have contributed to compile 10 textbooks and monograph books (all of them are used by postgraduate courses):

Monographs: "*Climate change and coastal ecosystems*", Labor Publishing House, Hanoi, 2009; "*Water resources in major river systems in Vietnam*", the Science and Technics Publishing House, 2012; "*Environmental protection planning*", Science and Technology Publishing House, 2012; "*Impacts of climate change on the water resources and flooding in Mekong Delta*", Science and Technology Publishing House, 2014; "*Assessment of threshold load of Nhue and Day Rivers*", Science and Technology Publishing House, 2017; 02 international monographs: "*Application Couple Model in Saltwater Intrusion Forecasting in Estuary*" and "*Adaptation to Climate Change on the Saltwater Intrusion in Estuaries*", Lambert Academic Publishing, 2017.

Textbooks: 3 textbooks "*Water balance and integrated water resources management*", the Publishing House for Natural Science and Technology, 2012; "*Climate change*", Publishing House for Natural Science and Technology, 2017 and "*Climate change adaptation and mitigation*", Vietnam National University Press, 2017.

5. Supervision for Bachelor, Master and PhD thesis

Since 2005, I have successfully supervised 06 PhD students (being principal supervisor for 03 PhD students and being co-supervisor for 03 PhD students); and about 20 Master Students. The topics of the theses have focused on the two above-mentioned research directions.

III. SELF-ASSESSMENT

1) As a researcher and a visiting lecturer, I have fulfilled the requirements in teaching at graduate and postgraduate levels and scientific research.

2) I have published 108 research articles in domestic and international journals and conferences, in which 11 of them are international journals with key author (02 SCI, 01 ISI and 02 Scopus articles); 35 published local articles with principal author. I have implemented approximately 22 scientific research projects, which I chaired 1 national-level project (accepted); 4 sub-national level projects (accepted); 1 ministerial-level project (accepted) and 5 ministerial-level research tasks; 1 grassroots-level project and 3 grassroots-level research tasks. I have been a chief author of 10 textbooks and monograph books, in which 2 of them are internationally published. I have supervised successfully 06 PhD students, in which I am a principal supervisor of 3 PhD students (received their PhD degrees) and a co-supervisor of 03 PhD students (received their PhD degrees).

3) I undertake self-directed learning to improve my professional skills and foreign language ability, and I have always paid serious attention and enthusiasm to my professional responsibilities in scientific research and teaching. With all my efforts, I am appreciated by my students and colleagues, as well as having achieved successful collaboration with them in scientific research.

With the above mentioned introduction, I am self-evaluated that I am fully qualified for registration and being considered for accreditation of the Professor title.

Hanoi, June 28, 2019

Assoc. Prof. Dr. Tran Hong Thai