अधपत्रा COUNTERFOIL

इसे फाड़कर प्रेषक अपने पास रख ले।
To be detached and kept by the Sender.

पोस्टल आर्डर
₹ 10
POSTAL ORDER

किसे अदा करना
To whom payable A/o Election Comm. of India

किस डाकघर में
At what Office Nirvachan Sadan,

क्या इसे क्रास किया है
Whether crossed No

भेजने की तारीख
Date sent 27/2/19

44F 057992

No. RTI/ECI/2019/1

Date: 27/02/2019

From,
Venkatesh Nayak
#55A, 3rd Floor
Siddharth Chambers-1
Kalu Sarai, New Delhi – 110 016

To,
The Central Public Information Officer
Election Commission of India
Nirvachan Sadan
Ashoka Road, New Delhi- 110 001

Dear sir,

Sub: Submission of request for information under *The Right to Information Act, 2005*

I. Apropos of the advice of the Central Information Commission (CIC) tendered to your Commission in its decision dated 11/09/2018 (copy enclosed), in the matter of *Sunil Kishore Ahya vs CPIO, Election Commission of India & Ors.,* [Second Appeal No. CIC/ECOMM/A/2017/171660], I would like to obtain the following information under the RTI Act:

a) A clear photocopy of all official records and documents and annexures, if any, that contain details of action taken to comply with the said advice of the CIC; and

b) A clear photocopy of all file notings and annexures, if any, relating to the information described at **para #I(a)** above.

II. Apropos of your Commission's August 2018 publication entitled: **Status Paper on Electronic Voting Machine (EVM)**, Edition-3, I would like to obtain the following information under the RTI Act:

i) A clear photocopy of all reports of the Technical Evaluation Committees received since 1990 till date regarding EVMs and VVPATs, along with annexures, if any;

ii) A clear photocopy of the report of the forensic examination of EVMs conducted by the Central Forensic Science Laboratory (CFSL) pursuant to the direction of the Bombay High Court in EP No. 15 of 2014 along with annexures, if any; and

iii) The complete list of manufacturers of micro-controllers used in the EVMs along with their postal addresses.

III. As your Commission is not listed as a public authority on the RTI Online Facility (https://rtionline.gov.in/) set up by the Government of India, I would like to obtain the following information under the RTI Act:

a) The reasons for not joining the aforementioned facility to enable citizens to submit RTI applications to this Commission electronically; and

b) The details of action taken by your Commission, till date, to join the aforementioned facility to enable citizens to submit RTI applications to this Commission electronically.

I am a citizen of India. I have enclosed an IPO (bearing #44F 057992) for Rs. 10/- towards payment of the prescribed application fee. I would like to receive the information described above at my postal address mentioned above. Kindly inform me of the additional fees payable for obtaining the said information.

Thanking you,

Yours sincerely,

S.S. Venkatesh Nayak 27/2/19

Venkatesh Nayak

By Speed Post/ E-mail

Election Commission of India

Nirvachan Sadan, Ashoka Road, New Delhi - 110001

No. 4/RTI/ET/2019-EDPS /219 Dated 27.03.2019

To

Mr. Venkatesh Nayak,
55A, 3rd Floor,
Siddharth Chambers-1,
Kalu Sarai, New Delhi - 110016

Sub: Application under the Right to Information Act, 2005 - reg

Sir,

Please refer to your RTI application dated 27.02.2019 received in the Commission on 28.02.2019.

The information sought by you are as under:

Point No.	Reply
1	As per record, file is under submission.
2	i) You may obtain the requisite documents (64 pages) by depositing copying charges of Rs. 128/-@ Rs.2/- per page. The above said amount may be deposited by way of cash against proper receipt/IPO/Bankers cheque/Demand draft payable in favour of "Under Secretary" or "Accounts officer", Election Commission of India. The IPO must also be made payable at "Post Office, Nirvachan Sadan" New Delhi. ii) The examination of EVM by Central Forensic Science Laboratory (CFSL) was ordered by Bombay High Court in an Election Petition and the record was submitted to the Hon'ble Court in sealed cover. iii) Exclusively concerned with manufacturers. Particulars of the manufacturers are as under :- M/s Bharat Electronics Limited, Nagavara, Outer Ring Road, Bangalore -560045, Karnataka M/s Electronics Corporation of India Limited, EMSD, ECIL EVM Manufacturing Unit, MCU, IDA Cherapalli Phase-II, Post-HCL, Hyderabad – 500062 (Telangana).
3	The RTI online facility is available on the Commission's website www.eci.gov.in under head file RTI Online the hyper link is http://rti.nic.in

2. The details of First Appellate Authority are as under ;-

Shri Nikhil Kumar,
Director (EVM) & FAA,
Election Commission of India, Nirvachan Sadan, New Delhi – 110001.
E-Mail :evmtech@eci.gov.in

Yours faithfully,

Soumyajit Ghosh

(Soumyajit Ghosh)
Under Secretary & CPIO

No. RTI/ECI/2019/1

Date: 03/04/2019

WITHOUT PREJUDICE

To,
Shri Saumyajit Ghosh
CPIO & Under Secretary
Election Commission of India
Nirvachan Sadan
Ashoka Road
New Delhi – 110 001

Dear sir,

Sub: Payment of additional fee for obtaining information under *The Right to Information Act, 2005*

Ref: Your communication of No. 4/RTI/ET/2019-EDPS/219 dated 27/03/2019

Apropos of your fee intimation letter of number and date captioned above, sent in response to my RTI application of number captioned above and dated 27/02//2019, I have enclosed IPOs (bearing numbers 2 13 628850; 2D 338829; 44F 060140; 44F 060143 and 51H 065100) for Rs. 128/- (Rupees one hundred and twenty eight only) as advised.

Kindly note that this fee is being remitted **WITHOUT PREJUDICE** to my right to submit an appeal and/or complaint against your reply to the remaining queries of the instant RTI application, as per the provisions of the RTI Act.

Kindly send the information described at para #2(i) of the instant RTI application to my postal address mentioned above.

Thanking you,
Yours sincerely,

S. S. Venkatesh Nayak

'03/04/19

Venkatesh Nayak
#55A, 3rd Floor
Siddharth Chambers-1
Kalu Sarai
New Delhi – 110 016

अधपत्रा COUNTERFOIL

इसे फाड़कर प्रेषक अपने पास रख ले।
To be detached and kept by the Sender.

पोस्टल आर्डर

₹100

POSTAL ORDER

किसे अदा करना
To whom payable A/O
ECI

किस डाकघर में
At what Office GPO, Nsdh

क्या इसे क्रास किया है
Whether crossed NO

भेजने की तारीख
Date sent 03/04/19

51H 065100

अधपत्रा COUNTERFOIL

इसे फाड़कर प्रेषक अपने पास रख ले।
To be detached and kept by the Sender.

पोस्टल आर्डर

₹10

POSTAL ORDER

किसे अदा करना
To whom payable A/O
ECI

किस डाकघर में
At what Office GPO, Nsdh

क्या इसे क्रास किया है
Whether crossed NO

भेजने की तारीख
Date sent 03/04/19

44F 060143

अधपत्रा COUNTERFOIL

इसे फाड़कर प्रेषक अपने पास रख ले।
To be detached and kept by the Sender.

पोस्टल आर्डर

₹10

POSTAL ORDER

किसे अदा करना
To whom payable A/O
ECI

किस डाकघर में
At what Office GPO, Nsdh

क्या इसे क्रास किया है
Whether crossed NO

भेजने की तारीख
Date sent 03/04/19

44F 060140

अधपत्रा COUNTERFOIL

इसे फाड़कर प्रेषक अपने पास रख ले।
To be detached and kept by the Sender.

पोस्टल आर्डर

रुपए 7.00 Rs.

POSTAL ORDER

किसे अदा करना
To whom payable A/O
ECI

किस डाकघर में
At what Office GPO, Nsdh

क्या इसे क्रास किया है
Whether crossed NO

भेजने की तारीख
Date sent 03/04/19

2D 338829

अधपत्रा COUNTERFOIL

इसे फाड़कर प्रेषक अपने पास रख ले।
To be detached and kept by the Sender.

पोस्टल आर्डर

रुपया 1.00 Re.

POSTAL ORDER

किसे अदा करना
To whom payable A/O
ECI

किस डाकघर में
At what Office GPO, Nsdh

क्या इसे क्रास किया है
Whether crossed NO

भेजने की तारीख
Date sent 03/04/19

13 628850

ELECTION COMMISSION OF INDIA

Nirvachan Sadan Ashoka Road, New Delhi – 110 001

No. 4/RTI/ET/2019-EDPS | 532 Dated 05.04.2019

To

Mr. Venkatesh Nayak,
#55A, 3rd Floor,
Siddharth Chambers -1,
Kalu Sarai, New Delhi - 110016

Subject: - Application under the Right to Information Act, 2005-Reg.

Sir,

I am directed to refer to your RTI application dated 27.02.2019 and Commission's letter no. 4/RTI/ET/2019-EDPS dated 27.03.2019 and to forward herewith the documents (64 pages) (Copy enclosed) against the necessary copying charges.

Yours faithfully,

Soumyajit Ghosh

(SOUMYAJIT GHOSH)
UNDER SECRETARY & CPIO

REPORT OF THE
EXPERT COMMITTEE FOR TECHNICAL
EVALUATION OF THE ELECTRONIC
VOTING MACHINE

APRIL 1990

REPORT OF THE EXPERT COMMITTEE
FOR THE TECHNICAL EVALUATION
OF THE ELECTRONIC VOTING MACHINE (EVM)

The Committee constituted for the technical evaluation of the Electronic Voting Machine (EVM), vide Govt. Order No. DOE/CCI/EVM/89 dated April 10, 1990 (Annexure I), met formally on 23rd April, 1990, and again on 25th April, 1990. The Committee had the benefit of Technical presentations by M/s. BEL and M/s. ECIL, the two Manufacturers of the EVM. The Committee also met Shri Peri Sastry, Chief Election Commissioner, Smt. V.S. Ramadevi, Secretary, Legislative Dept., Ministry of Law & Justice, Shri Ganesan, Adviser, Electoral Reforms Commission, Shri S. Ravi, Joint Secretary, DOE and Shri G.S. Varadan, Addl. Director, DOE. One unit of EVM was taken to IIT Delhi Laboratory for detailed evaluation. The Committee also examined various documents presented to it by the Manufacturers. These documents are enclosed as Annexures. Based on the above deliberations, the Committee is pleased to submit the enclosed Report. The committee wishes to place on record its indebtedness to the Department of Electronics for all the assistance that it extended to the Committee for the early completion of its task.

Dr.C.Rao Kasarbada

Prof P.V.Indiresan

Prof S.Sampath

REPORT OF THE EXPERT COMMITTEE FOR THE TECHNICAL EVALUATION OF THE ELECTRONIC VOTING MACHINE

1.0 Background of Electronic Voting Machine

Over the last ten years the Election Commission of India, from time to time has put forward the idea of introducing the Electronic Voting Machine in the election process in India. Towards this end, the Election Commission induced two major industrial enterprises namely M/s. Electronics Corporation of India Ltd., Hyderabad and M/s. Bharat Electronics Ltd., Bangalore to design and develop suitable versions of the Electronic Voting Machine for introduction in our elections. With the approval of the Govt. of India, in 1982, the machines were introduced in 11 Constituencies and put to use and on the whole the systems worked satisfactorily. The design of the Electronic Voting Machine has since gone through several iterations and an advanced version has become available from both M/s. Electronics Corporation of India Ltd., and M/s. Bharat Electronics Ltd. The Election Commission was most anxious to introduce the machine in the electoral process in the general elections in 1989. Due to apprehensions articulated by leaders of political parties, the decision to introduce the Electronic Voting Machine was deferred by the Election Commission.

The Electoral Reforms Committee is of the view that the Electronic Voting Machine should be evaluated in an objective manner from the technical point of view with special reference to the possibility that the Electronic Voting Machine can be tampered with. Accordingly, at the request by the Electoral Reforms Committee, the Department of

Electronics constituted an Expert Committee to carry out the envisaged technical evaluation. This Report is the outcome of this evaluation.

2.0 MANUFACTURERS PRESENTATION

M/s. Bharat Electronics Ltd., and M/s. Electronics Corporation of India Ltd., made a presentation on the operational, technical and manufacturing aspects of the Electronic Voting Machine to the Experts Committee.

The agencies also conducted a mock poll before the Committee. The possible physical methods of tampering were also demonstrated highlighting the security of the design.

The details of the presentation are enclosed in Annexures III and IV.

3.0 EVALUATION OF ELECTRONIC VOTING MACHINE

3.1 There are three major points to be considered in evaluating the Electronic Voting Machine that has been developed and manufactured in the country.

a. Does it meet all the needs of Election Commission?
b. Is the design stable and tamper-proof?
c. Is the manufacturing quality of a high enough standard to provide adequate reliability?

3.2 As regards the first question, the Election Commission is the only agency which can provide the answer. As for the third question, it is evident, from an inspection of the machines, that they are indeed of exceptionally high quality. As regards the second question, the following points need to be considered:

a. Can the system be altered at site?
b. Can the system be replaced by a different mechanism?
c. Can the system be tampered with while in operation?

The Committee addressed itself to these three questions.

3.3 The System consists essentially of three components

a. the Control Module
b. the Balloting Unit; and
c. The inter-connecting cable between the two Units.

The Committee has looked into the possibility of tampering in respect of each one of these three components.

3.4 With regard to the nature of the design and the difficulty involved in tampering, it is noted that the program imbedded in the device is completely fixed and unalterable, and therefore, there is no means or access by which the system can be modified from outside.

3.5 In view of the above, the only way by which the System can be tampered with is to replace it entirely by a new one. Though this is theoretically feasible, by a simple physical inspection of the equipment, this can be ruled out.

3.6 It is feasible to modify the Balloting Unit alone. However, it cannot be done in such a way that it can escape physical inspection.

3.7 This leaves the question of tampering, with the inter connecting cable. This tampering could happen in two ways. One may attach a device on top of the cable. This requires skilled operation and will naturally be visible to all the

voters. At the same time, the Committee has seen the Polling booth arrangements that have been finalised by the Election Commission. The Committee notes with satisfaction that the entire cable is in the public view all the time, any such a tampering becomes self-evident. Further, in case any such device has been attached to the cable, it will leave tell-tale punch marks which can be recognised easily. Therefore, this probability also is ruled out by the Committee.

Another method by which the system may be interfered with is to insert a device between the cable and the connector situated inside the Polling Unit. This can be obviated by a simple administrative precaution at the time the Polling Unit is sealed. The Presiding Officer may be asked to exhibit the cable to all the Polling agents and get their certificate to make sure that no device has been inserted between the cable and the socket. Once the cable is inserted and the Machine is sealed, this kind of tampering is impossible.

3.8 In this manner, the Committee has looked into all possibilities of tampering with the Machine and has come to the conclusion that there is no way of altering the results of the polls provided due security precautions are enforced. In case for any reason the Unit has been tampered, it immediately gives an indication that the system has malfunctioned and this remains as a permanet record on the Machine which can be checked and cross-checked at any time later.

3.9 In view of all these factors, the Committee unanimously certified that the System is tamper-proof in the intended environment. For these reasons, the Committee recommends that the system may be accepted and put to use.

3.10 Any system of this nature requires proper preventive maintenance. Hundreds of thousands of the units are to be used in any major election and in between they will be stored for long periods of time. During this period due to attack by vermin, rats, fungus or due to mechanical damage, the system might malfunction. Therefore, as a preventive measure, the Committee recommends that before every election the manufacturers may be asked to check (this can be done very fast through a very simple exerciser) and ensure that all the units are functioning as designed. Incidentally, this method will check, what is called 'the signature of Machine' and thereby the Manufacturers will be able to certify that the Machine is identical to what they had supplied and it has not been replaced by any other.

3.11 In brief, the Committee recommends that the System may be accepted subject to the following precautions:

1. It is ensured in every polling booth that the cable is visible all the time.
2. After the polling, the cable and Balloting unit is physically inspected for any mechanical damage.
3. At the time of the insertion of the cable, it is formally recorded by the Presiding Officer and the polling agents that no device has been inserted between the cable and the connector.
4. All the instruments are checked as a matter of preventive maintenance and as a matter of abundant caution, to ensure that they are working satisfactorily and according to the original embedded programme.

4.0 Issues raised by various Organisations and related Technical problems

The issues that arise from the use of Electronic Voting Machines are as under:

i) The Machine may not function properly
ii) The Machine may be damaged upsetting the Polling process.
iii) The Machine could be tampered with, and design may not be secure ('Trojan Horse').
iv) The Machine denies the candidates the right to recount.
v) The Voting machines are biased against the poor.

These issues are examined in detail in the following paragraphs.

4.1 *Machines may not function properly*

This is a question of reliability. The reliability of the equipment depends on the design, selection of components, procurement and inspection of components, Manufacturing process, storage and re-inspection mechanisms.

The resultant failures may be catastrophic or non-catastrophic in nature. The design has been perfected over a long period. The Manufacturers have confirmed the usage of approved components with due derating for reliable operation. A Committee consisting of representatives of Standards And Quality Assurance Establishment (SQAE) of Department of Defence, the Directorate of Standards, Testing and Quality Control (STQC) of the Department of Electronics, and Representatives of Election Commission, reviewed total quality assurance aspects of the Machine through the Manufacturers. The former two were also involved in the acceptance testing.

The equipments have also gone through climatic tests prescribed in the Quality Assurance (QA) manuals. The Committee noted that the failure rates during the trial period are insignificant.

In addition, the catastrophic failure may occur because of failure of the Microcontroller Chip, in which case repolling may be necessary. The cases of non-catastrophic failure can be catered to by the redeployment of a spare Machine. Similarly the Ballot Unit can also be replaced with a time loss of utmost 15-20 minutes in case of a catastrophic failure.

4.2 *Machines may be tampered with*

This seems to be major issue of concern. The contents of 'Annals of Democracy' an article, that appeared in New Yorker on November 7, 1988, as well as a press clipping on the same lines 'Dangers of Fraud in Computer voting' have been noted by the Committee.

The major advantage of the Electronic Voting Machine developed in India is the fixed programme nature of the system. The programme is permanently fused and hence cannot be tampered with even if it can be accessed. Even then, as a matter of abundant precaution, the instuments' signature may be tested by the suppliers before a poll to check that they have not been replaced. Since the presently discussed Electronic Voting Machine is a different type of equipment, the possible methods of tampering are different and have already been highlighted in the Section 3.0.

4.3 *The Machine may be damaged upsetting the poll process*

The damage is understood to be physical damage and the technical consequences of such physical damage are as under:

1. Ballot Unit damage

Physically strong and agile people or mentally deranged people may damage the Ballot Unit which is stationed a little away from the Polling Officer.

i) in case of catastrophic damage (break in the Ballot Unit into pieces using hammers etc.), the Ballot Unit could be replaced without affecting the poll upto that point.

ii) in case of attempted damage by making one of the switches stuck, apparently disabling the other switches, a link-error alerts the Poll Officer who can set right the mechanism; in the event he can not set right the mechanism replacement as alternative is available.

2. Cable Unit Damage

No wrong information gets recorded. The cable can be replaced.

3. Control Unit damage

If the Control Unit is damaged, the poll could be continued with a second Control Unit. since the poll information upto the point is safely stored in the memory. However it should be noted that Control Unit

damage is equivalent to snatching [illegible] the Ballot box, and suitable administrative procedures may be followed, including repoll as per Election Commission norms.

4.4 *The Machine denies the right to Recount*

On the contrary, the whole process is stored in the memory, and can be dumped through a Printer to get the detailed picture of voting. With the added administrative procedures of the Election Commission to maintain a register of the voters in the sequence of their voting, not only the process of recount is possible but also verification of the recount against any possible tampering is also possible.

4.5 *Bias against the poor*

While the comment on the bias against the poor as reflected in certain articles has been noted, the experience of the Election Commission in trials so far does not confirm the same. This is mainly because the equipment is simple and in fact even simpler than stamping the conventional Ballot paper to which the voter is already accustomed.

5.0 <u>Advantages of Electronic Voting Machine</u>

The Committee noted the following advantages of the Electronic Voting Machine, as they emerged in various discussions:

- possible reduction of time between the time of withdrawal of nominations and the commencement of Polling, resulting in considerable, saving in matters relating to maintenance of law and order, candidates' expenditure on campaigning etc.
- considerable saving in printing of stationery and transportation of large volume of Election material.

- discouraging booth capture by limiting the number of votes that can be cast in an hour to no more than 300 in a booth, thus allowing time for the Law and Order Machinery to take appropriate remedial action.
- the procedure for mock poll incorporated into the system generates confidence in the voting community on the operation of the system.
- the system eliminates invalid voting, which in several cases is understood to be comparable to the difference between the winning candidate and losing candidate.
- the counting time is drastically reduced , and eliminates mischief at counting, as well as eliminates the possible building up of tension/disorderly scenes during the counting process due to the short time in which the counting will get completed with the introduction of the Electronic Voting Machine.
- the entire process of voting is recorded in sequence and is available for analysis by the Election Commission at a later date against any contingency.
- Possibility of the introduction of Mobile Polling Booths to facilitate fuller participation of people in the election process.

6.0 Recommendations

1. Sample electrical check of the Control Unit and the Ballot Unit prior to the Polling. The diagnostic check to be prescribed by the Manufacturers so as to ensure that the embedded programme has not been tampered with.

2. Inspection of the Ballot Unit/Control Unit as well as the cable at the time of the insertion of the Ballot paper by the Returning Officer with suitable aids to ensure that duplicate equipments are not used.

3. Ensuring, in every Polling Booth, that the interconnecting Cable is visible at all times.

4. Ensuring, in every Polling Booth, that no device is inserted between the Cable-Connector and the Control Unit.

5. Carrying out on a sample basis, recounting of votes in certain booths at an appropriate administrative level, to act as a deterrent against potential mischief-makers so as to generate a climate of confidence about the infallible nature of electoral process.

7.0 Conclusions

The Committee after a review of the material presented to it has come to the following conclusions:

i) The basic Electronic Voting Machine developed by M/s. Bharat Electronics Limited (BEL) and M/s. Electronics Corporation of India Limited (ECIL) under the over-all aegis of the Election Commission and the Department of Electronics is a secure system.

The security emanates from two very important basic factors:

a) The fixed programme nature of the software which is fused into the processor which is effectively unalterable.

b) The faithful recording of all events in the processor and the possibility of recalling the same with the added administrative procedures prescribed by the Election Commission which make available the sequence of voters voting- rendering it possible to verify the recorded vote in case of any doubt with regard to possible tampering.

ii) With the provision of non-volatile memory, any physical interruption leads to the retention of all information upto that point.

iii) With the system as designed by the above agencies with built-in security, the Election Commission and the Government only need to ensure the security of the equipment, to safeguard the sanctity of the electoral

process. The Committee further recommends that certain procedural safegaurds as stated in Section 6.0 should be implemented.

iv) The Committee wishes to place on record the high level of accomplishments of the Engineers and Scientists of M/s. Bharat Electronics Limited and M/s. Electronics Corporation of India Limited in developing an Electronic Voting Machine using the latest technology.

v) The Committee unanimously recommends the use of the Electronic Voting Machines with out further loss of time.

S.RAVI
JOINT SECRETARY
TELE: 81 1320

MOST IMMEDIATE
BY HAND TODAY

GOVERNMENT OF INDIA
DEPARTMENT OF ELECTRONICS
LOK NAYAK BHAVAN, (3rd Floor)
KHAN MARKET,
NEW DELHI-110003
TLX. Nos. 31-65193 & 31-66526
Gram: DEPTELECTRON

D.O. No. DOE/CCI/EVM/89

DATED April 11.1990

Dear Prof. Sampath,

The Electoral Reforms Committee in its meeting held on 31.3.90 suggested to Secretary, Department of Electronics that the Electronic Voting Machine developed by M/s ECIL and M/s BEL should be objectively evaluated by a Group of Experts: in particular from the point of view of rigging, that is to say, whether the machine could, at any point of time, be tampered with. It has, therefore, been decided to form a Committee of three experts comprising of a distinguished council member of the Institution of Electronics & Telecommunication Engineers, a distinguished Prof. of IIT and the Director of Electronics Research & Development Centre, Trivandrum.

It has further been decided to request you as a Council Member of the IETE to be the Chairman of the Expert Group. Prof. P.V.Indiresan of IIT Delhi and Dr. Rao C.Kasarabada Director, ER&DC, Trivandrum, are the other members.

The Committee may submit its report to the Department of Electronics preferably by 24.4.90 or latest by 30th of this month so as to enable the Government of take a decision in the matter before a Bill is introduced in the Parliament in May 1990. Secretarial assistance to the Committee will be provided by the New Delhi Centre of the Appropriate Automation Promotion Programme of Department of Electronics.

With regards.

Yours sincerely,

S. Ravi

(S. Ravi)

Prof. S. Sampath,
Chairman, R.A.C.
Defence Research & Development Organisation,
Ministry of Defence, Sena Bhavan,
New Delhi.

Copy to:

1. Smt. V.S. Rama Devi, Secretary, Legislative Department, Ministry of Law & Justice, New Delhi.

Copy also to:

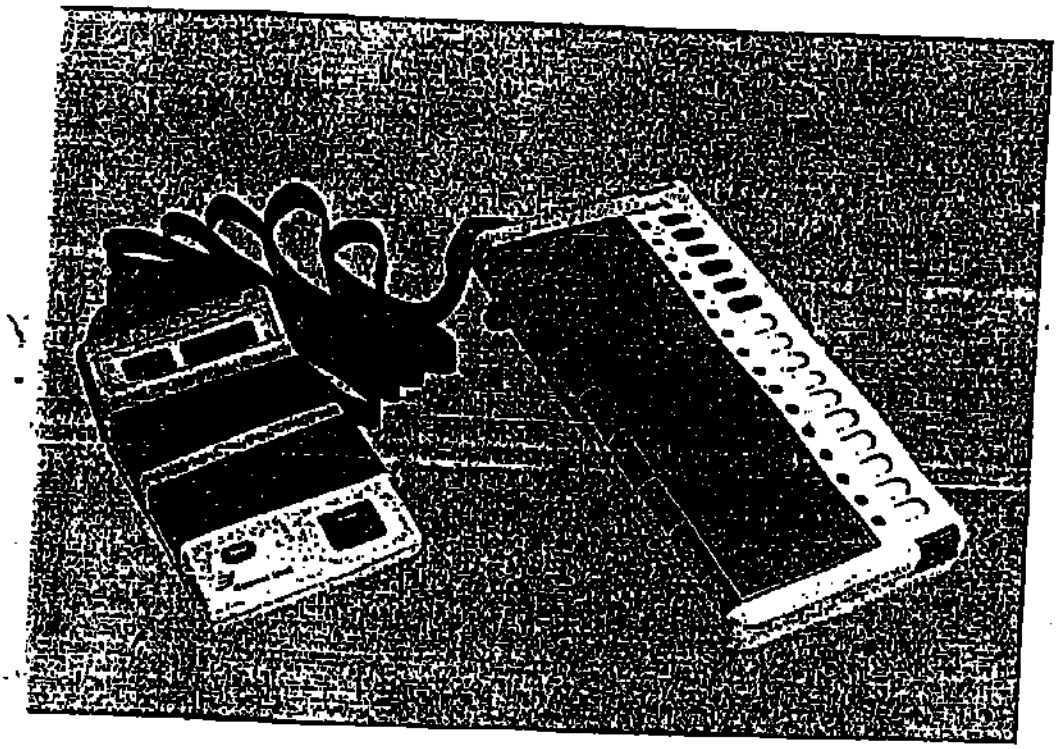
2. Shri B.S. Prabhakar, Managing Director, ECIL, Hyderabad

3. Capt. S. Prabhala, Chairman & Mg. Director, BEL, Bangalore

- They are requested to provide all assistance to the Committee in their work.

(S. Ravi)

E V M MANUAL



ELECTION COMMISSION OF INDIA

1990

Report of the Expert Committee
for
The Technical Evaluation
of
The Upgraded Electronic Voting Machine

September 2006

REPORT OF THE EXPERT COMMITTEE FOR EVALUATION OF THE UPGRADED ELECTRONIC VOTING MACHINE (EVM)

Acknowledgement

The EVMs, introduced in 1990 have provided excellent service in assisting the voting process in India. These machines are now nearing the end of their life, and need to be replaced. The two PSU companies BEL and ECIL which have been manufacturing these EVMs have developed new designs incorporating some additional features as desired by the Commission. This committee was constituted by the Commission vide their reference: 51/8/16/2004 PLN-IV/Vol III/804-806 dated 29/12/2005 to evaluate these upgraded EVM's.

The Committee met in New Delhi in January 2006 at IIT Delhi, where representatives of BEL and ECIL demonstrated their machines and presented the salient features of their respective designs, including the steps taken to incorporate the additional features as mandated by the Commission. This Committee suggested some additional technical evaluation such as on EMI/EMC standards to be performed on the machines. Subsequently in January 2006, the Committee traveled to Bangalore (BEL) and to Hyderabad (ECIL) and conducted in depth evaluation of the machines and held technical discussions with the entire development teams of BEL and ECIL. Additional essential enhancements to the design of the EVMs and their utility and feasibility were also discussed in this visit.

The Committee also studied the inputs that the Commission and the manufacturers have received from the public over the years on the EVMs. The results of this study have been incorporated into the report of the Committee.

It will be in place to acknowledge that the very thorough evaluation conducted by the expert evaluation committee in 1990 on the then EVMs was also re-visited through their report and, the recommendations made by the 1990 committee being extremely important for the fair conduct of elections using EVMs and, additionally having proven their worth during elections in past 15 years, have been incorporated in this report as well.

This Committee acknowledges with pleasure the cordial, stimulating and very effective interactions with the technical teams of both BEL and ECIL.

Finally, this Committee gratefully acknowledges all the support of the Chief Election Commissioner and all staff of the Commission, in conducting this study.

Prof. A K Agarwala
Member

Prof. D T Shahani
Member

Prof. P V Indiresan 6.9.06
Chairman

New Delhi
5th September, 2006

REPORT OF THE EXPERT COMMITTEE (2006) FOR THE TECHNICAL EVALUATION OF THE UPGRADED ELECTRONIC VOTING MACHINE

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REPORT OF THE EXPERT COMMITTEE (2006) FOR THE TECHNICAL EVALUATION OF THE UPGRADED ELECTRONIC VOTING MACHINE

1.0 Background of Electronic Voting Machine (EVM)

(a) Introduction

During the seventies the Election Commission of India, put forward the idea of introducing Electronic Voting Machine (EVM) in the election process in India. Towards this end, the Election Commission induced two major industrial enterprises namely M/s. Electronics Corporation of India Ltd., Hyderabad and M/s. Bharat Electronics Ltd., Bangalore to design and develop suitable versions of the Electronic Voting Machine for introduction in elections. With the approval of the Govt. of India, in 1982, the machines were introduced in 11 constituencies and put to use. On the whole, the systems worked satisfactorily.

The Electoral Reforms Committee in their review at that time suggested that the EVM be evaluated in an objective manner from the technical point of view with special reference to the possibility that the EVM can be tampered with. Accordingly, at the request by the Electoral Reforms Committee, the then Department of Electronics constituted an expert committee to carry out the technical evaluation. The expert committee in 1990 after a thorough review of the design, manufacturing, testing processes, recommended accepting the EVM's while taking certain precautions so that the EVM is easy to use, is rugged, well maintained and cannot be tampered with.

The EVMs have since then been in use for over 15 years and have proved their reliability and conduct of tamper-proof elections, year after year.

(b) Present Status:

The EVMs having served over 15 years are due for replacement. Further, based on experience gained from extensive field use, the Election Commission asked BEL and ECIL to introduce additional features, to further the cause of reliability and tamper-proof working in the new EVMs to be manufactured.

(c) Expert Committee on Upgraded EVM's - 2006 :

The Election Commission set up a technical expert committee in Dec. 2005 under chairmanship of Prof. P.V. Indiresen, with Prof. D.T. Shahani & Prof. A.K. Agarwala of IIT Delhi as members to examine the upgraded EVM's and give their recommendations by Feb 2006. (Ref: 51/8/16/2004 PLN-IV/Vol III/39 dated 4-1-2006). In view of additional testing that the committee asked from ECIL and BEL the term of the committee was further extended. After explaining the findings of the study as well as the main recommendations to the Election Commission on 4-7-2006 the final report is being submitted by the committee.

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2.0 Manufacturers' Presentation

Early in January 2006 on request of the committee, M/s. Bharat Electronics Ltd., and M/s. Electronics Corporation of India Ltd., made presentations on the operational, technical and manufacturing aspects of the EVM to the committee explaining the earlier features and design and also demonstrating the additional features and new design changes incorporated.

The agencies also conducted mock polls before the committee. Specifically the possible physical methods of tampering and the countermeasures incorporated in the design were also demonstrated, highlighting the enhanced security and tamper-proofness of the design.

Committee members subsequently visited ECIL Hyderabad and BEL Bangalore and inspected the manufacturing and testing process of the EVM. Discussions were held in great detail with their engineers on hardware and software aspects of the design with specific reference to integrity of the voting data recorded in the EVM and possibilities of tampering this data .

After the above meeting , the committee, considering the advances in technology since 1990, made the following initial recommendations:

(i) BEL & ECIL to conduct EMI/EMC tests and modify hardware (if needed) so that the EVM design strictly complies with existing standards.

(ii) Introduce Dynamic Coding of Key no's to enhance security of data transmitted from Ballot Unit (BU) to Control Unit (CU).

(iii) Introduce Time Diversity in data recording to eliminate effects of random noise.

(iv) Every key press on EVM, even if invalid, be electronically "date–time stamped" and kept as permanent record (in the EVM memory).

Accordingly BEL and ECIL asked for additional time for (I) EMI/EMC compliance and reported compliance to EMI/EMC standards by mid February. Implementation of points (ii), (iii) and (iv) would only enhance data security capability on lines of current practices but the operating features will remain the same. It was agreed by the manufacturers that these could be implemented and that it primarily involved some alterations in the software, while hardware design would remain the same. Once the software was modified by the manufacturers to meet the above recommendations, only a detailed check of functional working of the modified EVM would be needed, which EC as the user could do on its own or get done before inducting the upgraded EVMs.

3.0 Evaluation of the Upgraded Electronic Voting Machine

3.1 There are *three* major points to be considered in overall evaluation of the Electronic Voting Machine that has been developed and manufactured in the country.

a. Does it meet the functional specifications of the Election Commission?
b. Is the manufacturing quality of a high enough standard to provide adequate reliability?
c. Is the design stable and tamper-proof?

3.2 The first question (a) is for the Election Commission as the buyer-user to examine. As for the second question (b) a detailed inspection of the machines as well as the manufacturing process at ECIL and BEL showed that they are indeed of exceptionally high quality. The third question (c) needed a detailed consideration of all aspects of design. In particular, the following points needed to be addressed to:

a. Can the hardware units CU, BU, Cable system be altered at the site of voting?
b. Can the system be replaced by a different mechanism (hardware or software)?
c. Can the data be tampered with during balloting in operation?
d. Can data be manipulated before, or after the voting period?
e. Can battery low occurring during balloting cause incorrect data record?
f. Is correct date-time being registered on each vote in the EVM?
g. Is the EVM susceptible to data corruption by Electro Magnetic Interference?

The Committee addressed these questions as explained in sections below.

3.3 The EVM System consists essentially of *three* hardware sub-systems and *one* oftware, namely:

a. Control Unit (CU)
b. Ballot Unit (BU)
c. Interconnection Cable between CU & BU

The CU is the main unit which stores all data and controls the functioning of EVM. The voter presses his voter choice key on the Ballot Unit (BU) and the function of the BU is basically to transmit faithfully to CU the key pressed by voter (i.e. Key number of candidate voted) for being recorded in the CU memory. The data is transferred from BU to CU through the Interconnecting Cable. ***The faithful recording of the voting data, unbiased and tamper-proof functioning of CU is critical to the conduct of a fair election.*** The program embedded in the microchip in the CU dictates the functioning of CU. Thus for functioning of the system there is a fourth hidden entity namely,

d. The ***program*** (software) embedded in the microchip in the CU.

The committee looked into the possibility of tampering in respect of each one of the above mentioned four subsystems.

3.4 If the integrity of original program in the microchip is maintained, and the key pressed by the voter on BU is faithfully recorded by the CU, then the election through EVM will be fair. Firstly the tamper-proof-ness of the program is considered. With regard to the technology used and complexity involved in tampering with the program in the microchip the following observation are relevant.

(a) The program is burnt into the microchip on a "one time programmable" basis (OTP), and once burnt in it cannot be read, copied out, altered and re-fed into the chip at all. It is can be fed once only in the chip, and that too only at manufacturing level, is secret and not amenable to any changes once installed in the machine.

(b) The microchip is allotted a unique ID (at manufacturing stage) embedded into its memory. The ID is a complex code or "digital signature" which can tell whether the microchip belongs to the manufacturer or not. The code is not known to any individual engineer in the production. However, it can be verified on a manufacturer test table that the microchip is genuine belonging to the manufacturer. Thus any attempt to replace the CU from some other source is detectable as the EVM would simply become inoperative.

(c) This unique ID mates to the E^2 PROM (within the CU where all the voting data will be stored during an election) and, the micro-controller, at the instant of first power-up of CU at the time of manufacturing. Subsequently, the CU will not function if the ID stored in the micro-controller memory does not match that in the E^2 PROM. Thus any item to modify the data stored in the E^2 PROM by replacing the E^2 PROM will automatically make the EVM inoperative.

(d) It is noted that for biasing the program to favour a particular candidate, the "key number" allotted to the candidate is essential to be known, and this information for various elections to be conducted in the future cannot possibly be known at the EVM's manufacturing stage. Hence no bias can be introduced in the program at the time of manufacture of the chip. Furthermore instead of a Static Key Code, the Dynamic Coding of key numbers of BU advised by the committee, enhances secrecy of key no's being transferred from BU to CU so any intervention at the connecting cable end for biasing results during voting period will not be feasible.

The committee examined the possibility of a "Trojan horse" sub-program being willfully activated after knowing key number allocation to favour a particular key (i.e. candidate), by activating the "Trojan Horse" through some mechanism at time of poll. Such entry is viable only thro' "specific Key presses sequence" on CU or by wireless signal or CU ports. The former activity is not viable as *all* "key presses" are to be time-date-logged in the memory (as per advise of committee), and a "repeat pattern" in all CU's at various booths can be easily visible on post-election analysis. The activation of "Trojan Horse" by wireless is also not viable as CU does not have any high frequency receiver and data decoder for wireless, and hence cannot accept any coded signal by wireless. The CU ports accept only specially encrypted and dynamically coded data from BU. Data from any other device cannot be accepted by CU. Hence data cannot be biased via manufacture stage program or by wireless command or by some other unit introduced in place of BU during voting.

(e) Thus for introducing a (tampered Trojan horse) program, considering the nature of production technology of the CU, BU electronic cards, the only possible process is to "physically *replace*" the CU card by another one

containing a tainted micro-chip, *in the time interval between knowing the candidate key-no's and polling.* While continuing to explore this possibility one has to say at the outset that implementing this needs complicity of an enormous number of people at Manufacturer, Election Commission and State machinery, and is impractical realistically speaking.

However, in order to defeat even such a remote possibility the committee suggests introduction of an additional seal (by EC and party representatives) on the CU/BU electronic ***card prior to fixation of candidate key-nos. The Election Commission may consider the feasibility of incorporating this seal in their poll protocol if they regard such an event realistic considering the level of security provided to EVMs in this period.***

(f) The new feature of indicating the battery charge status precludes probability of low battery occurring during balloting. Even if battery were to turn low during polling, the E^2PROM storage being non-volatile memory is saved and already stored data is not corrupted. Additional feature that is built in is the shut-off of the memory much before battery reaches "brown voltage" condition.

(g) Sleep mode features enhances battery life since even if EVM is accidentally left ON, then when not being used actively, the the EVM will go in sleep mode and this will save battery power automatically.

3.5 This leaves the question of tampering, with the Inter-Connecting cable between CU and BU. This tampering could happen in three ways:

(i) One may attach a device on top of the cable. This requires skilled operation and will naturally be visible to all the voters. At the same time, the Committee has seen the Polling booth arrangements that have been finalized by the Election Commission. The Committee notes with satisfaction that the entire cable is in the public view all the time, any such tampering becomes self-evident. Further, in case any such device has been attached to the cable, it will leave telltale punch marks which can be recognized easily. Therefore this probability also is ruled out by the Committee.

(ii) Second method by which the system may be interfered with is to insert a device between the cable and the connector situated inside the Polling Unit. This can be obviated by a simple administrative precaution at the time the Ballot Unit is sealed. The Presiding Officer may be asked to exhibit the cable to all the Polling agents and get their certificate to make sure that no device has been inserted between the cable and the socket. Once the cable is inserted and the machine is sealed, this kind of tampering is impossible.

Special encryption and dynamic coding of key no's recommended by the Committee will further preclude CU from accepting data from any source other than a valid BU.

Any illegal attempt to communicate with CU is automatically detected and a LINK error is flashed on display drawing immediate attention of the poll officers.

(iii) The third is via wireless signal injection. This possibility has been excluded by making it mandatory that EVMs be EMI/EMC compliant to standards. Also the CU does not have wireless receiver or data decoder and hence it cannot recieve data via wireless coded/signal. The manufacturers have also reported that presence of excessive EMI causes jamming (in which case LINK error is reported by CU) but in no case it corrupts earlier stored data or record incorrect data.

3.6 In this manner, the committee to the best of its ability has looked into all possibilities of tampering with the EVM and has come to the conclusion that there is no way of altering the results of the polls before, during and after the poll duration provided, due security precautions already in force and additional modifications suggested by the committee are enforced and the sealing at various stages is adhered to. In case for any reason the Unit has been tampered, it immediately gives an indication that the system has malfunctioned and this remains as a permanent record on the Machine and this record can be checked at any time later.

Most importantly it is noted that the EVM's are subject to mock-poll validation at various stages in front of all party representatives. This is the best proof of validation of fairness of the program as well as data being stored inside. The seals are second level protection, as give highest level of access inside the machine only to the officers conducting the poll , and the party representatives procedures in full view of public and all concerned.

3.7 In view of all these factors, the Committee unanimously certifies that the EVM system is tamper-proof in the intended environment when due precautions are taken. For these reasons, the Committee recommends that the upgraded EVM with suggested modifications, testing and operating precautions may be accepted and put to use.

3.8 Any system of this nature requires proper preventive maintenance. Hundreds of thousands of the units are to be used in any major election and in between they will be stored for long periods of time. During this period due to attack by vermin, rats, fungus or due to mechanical danger, the system might malfunction. Therefore, as a preventive measure, the Committee recommends that before every election the manufacturers may be asked to check (this can be done very fast through a very simple exerciser) and ensure that all the units are functioning as designed. Incidentally, this method will be checked, by what is called 'the self test signature of Machine' and thereby the Manufacturers will be able to certify that the Machine is identical to what they has supplied and it has not been modified or replaced by any other.

3.9 The Committee's main recommendation is that the upgraded EVM may be accepted subject to the following:

(a) EVM's be EMI/EMC compliant. (NEW)

(b) Dynamic Coding of Key no's to enhance security of data transmitted from Ballot Unit (BU) to Control Unit (CU) be introduced. (NEW)

(c) Time diversity in data recording be introduced to eliminate effects of random noise. (NEW)

(d) Every key press on EVM, even if invalid, is date-time stamped and kept as permanent record. (NEW)

(e) Additional seal of electronic cards in CU, BU *may be* introduced by EC to be operated *just before* the candidate-list is declared as per 3.4e. (NEW)

(f) All the instruments are checked as a matter of preventive maintenance before election and as a matter of abundant caution, to ensure that they are working satisfactorily and according to the original embedded program.

(g) The battery condition should be in MEDIUM or HIGH at start of election as displayed on the EVM.

(h) It is ensured in every polling booth that the cable is visible all the time.

(i) At the time of the insertion of the cable it is formally recorded by the Presiding Officer and the polling agents, that no device has been inserted between the cable and the connector

(j) After the polling, the cable and Balloting unit is physically inspected for any mechanical damage, or seal intact.

4.0 Concerns raised by various Organizations (1990-2005)

The concerns that arise from correspondence placed before the committee by the Commission and the manufacturers from various interested parties as regards the use/ malfunction or tampering of EVMs are listed as under:

(i) The Machine may not function properly
(ii) The Machine may be damaged upsetting the Polling process
(iii) The Machine could be tampered with, and design may not be secure ('Trojan Horse')
(iv) The Machine denies the candidates the right to recount
(v) The Voting machines are biased against the poor
(vi) Possibility of false data transfer altering or erasing voting date in CU memory before or after voting
(vii) Apprehension in the form of a) changes within the machine after three hours of commencement of b) the changes in the machine data transferring (after 60% of the votes polled) of the 5 lowest candidates to the favored candidates
(viii) Apprehension of Electro Magnetic Interference affecting the EVM's stored data after election but before counting and storing the machines in Electro magnetically shielded Faraday cages. Remote signals can be send from a distance to generate resonant frequency of the circuits and make the machine function in some other way.
(ix) Physical shock EVM can withstand on bumpy road in rural areas and possibility of electro-mechanical components to reset EVM or ECU due to jerk
(x) EVM could contain the following flaws: Faulty logic, incorrect algorithm, erroneous data flow, error in circuit design, mistakes in software code, mistake in data base

While most of these issues have been addressed to in section 3, they are again responded to question-wise below for sake of clarity.

4.1 *Machines may not function properly*

This is a question of reliability. The reliability of an equipment depends on the design, selection of components, procurement and inspection of components, manufacturing process, storage and re-inspection mechanisms.

The resultant failures may be catastrophic or non-catastrophic in nature. The design has been perfected over a long period. The manufacturers have confirmed the usage of approved components with due de-rating for reliable operation. Then have also got it certified from agencies authorized by GOI for Standards, Testing and Quality Control & EMI/EMC and representatives of Election Commission reviewed total quality assurance aspects of the Machine through the Manufacturers.

The equipments have also gone through climatic tests prescribed in the Quality Assurance (QA) manuals. The Committee noted that the failure rates during the trial period are insignificant.

In addition, the catastrophic failure may occur because of failure of the Micro-controller Chip, in which case re-polling may be necessary. The cases of non-catastrophic failure can be catered to by the redeployment of a spare machine. Similarly the Ballot Unit can also be replaced with a time loss of utmost 15-20 minutes in case of a catastrophic failure.

4.2 *The Machine may be damaged upsetting the poll process*

The damage is understood to be physical damaged and the technical consequences of such physical damage are as under:

(a) <u>Ballot Unit damage</u>

Physically strong and agile people or mentally deranged people may damage the Ballot Unit which is stationed a little away from the Polling Officer.

(i) in case of catastrophic damage (break in the Ballot Unit into pieces using hammers etc.), the Ballot Unit could be replaced without affecting the polling data till that point of time.

(ii) In case of attempted damage by making one of the switches stuck, apparently disabling the other switches, a "LINK" error is displayed which alerts the Poll Officer, who can then set right the mechanism; and in the event he can not set right the mechanism then replacement as an alternative is available.

(b) Cable Unit Damage

No wrong information gets recorded and LINK Error is displayed. The cable can be replaced.

(c) Control Unit damage

If the Control Unit is damaged, the poll could be continued with a second Control Unit, since the poll data till that time is safely stored in the memory and which can retrieved with the help of manufacturer in full vision of party representatives. However it should be noted that Control Unit damage is equivalent to snatching the Ballot box, and suitable administrative procedures may be followed, including re-poll as per Election Commission norms.

(d) EMI Jamming:

EVMs can be jammed like all electronic equipment. In that event it will display LINK error, but no wrong data gets entered. Earlier recorded data remains intact and machine reverts to proper functioning after jamming influence is removed. This has been verified by manufacturers via independent EMI/EMC certifying agencies approved by GOI. Thus fair election functions cannot be tampered with by EMI jamming. Reports suggest that magnitude of radiation needed to jam is high and not very practical to generate near the polling booth.

4.3 *Machines may be tampered with*

This seems to be major issue of concern. The committee has therefore attached high priority to it and suggested ways to make the process tamper-proof.

Since the presently discussed Electronic Voting Machine is a different type of equipment than the traditional ballot box, the possible methods of tampering are different and have already been highlighted in the Section 3.2 through 3.9. However summarily one can say that the major advantage of the EVM developed in India is the fixed program nature of the system. The program is permanently fused and hence cannot be read or tampered with even if it can be accessed from other source. Even then, as a matter of abundant precaution, the instrument's signature may be tested by the suppliers before a poll to check that it has not been replaced. An additional seal on CU, BU cards prior to candidate key allocation may be introduced to ensure that the card is not replaced (section 3.4 and, in particular section 3.4f).

4.4 *The Machine denies the right to Recount*

On the contrary, the whole process is stored in the memory, and can be dumped through a Printer to get the detailed picture of voting. With the added administrative procedures of the Election Commission to maintain a register of the voters in the sequence of their voting, not only the process of recount is possible but also verification of the recount against any possible tampering is also possible. Each role and key press is time/date stamped.

4.5 *Bias against the poor*

While the comment on the bias against the poor as reflected in certain articles has been noted, the experience of the Election Commission in trials so far does not confirm the same. This is mainly because the equipment is simple and in fact even simpler than stamping the conventional Ballot paper to which the voter is already accustomed.

4.6 *Possibility of false data transfer altering or erasing voting date in CU memory before or after voting.*

The following is noted by the committee:

(a) Security due to Encryption

(i) The Electronic voting machine is an embedded system with fused firmware which cannot be read copied or altered. Dual E^2PROM memory with I^2C Protocol with digital signature during factory is incorporated so EVM can not be substituted.

(ii) Expert committee has recommended that the encrypted code is dynamically changed by software at each vote cast, so that it cannot be decoded during time interval between two votes. Therefore, only genuine BU's can feed voting data to CU.

(iii) Data is stored in E^2 PROM in CU which cannot be physically accessed as Election Officer seals the CU in presence of party representative.

(iv) E^2 PROM is digital signature matched with embedded processor, and hence CU will not work at all if some other E^2 PROM was inserted, assuming that despite sealing attempt was made to replace it.

(v) Data can be fed to CU E^2 PROM only through BU. Special encrypting is used in passing data from BU to CU. If some duplicate BU is connected the codes can't match and CU will not accept date. LINK error is displayed.

(b) Data Integrity Enhancement due to real time DATE-TIME stamp.

(i) Any vote entered in CU through genuine BU has a real time clock DATE-TIME stamp. The clock is embedded in CU and cannot be changed by anybody since CU is 'Sealed' in presence party representation.

(ii) During the ballot, the voting data along with the date & time stamping with internal clock (which cannot be altered after start of election) is written in the memory location. Hence all entries compulsorily have real time date stamp. Each key press on CU also is DATE-TIME stamp recorded.

(Iii) Any data fed "before" election can be recognized by date-time stamp.

(iv) Any data fed for "mock election" conducted by Election officer in presence of party representative is also date-time stamped.

(v) Thus any data fed outside the "voting period" can be easily identified by date-time stamp.

(vi) The voting data is written serially as the voting progresses. (Close Button pressed by Election Officer in presence of party representatives at end of balloting also is DATE-TIME stamped.)

(vii) Further as each key press in EVM units whether valid or invalid is date-time stamped and recorded no activation of a possible "Trojan Horse" by any specific key press sequence on EVM during poll can possibly go unnoticed.

(viii) After voting is completed, the software does not permit to write any further data to any location in the memory. After the CLOSE operation, the machine permits only the display of the result. Hence no data can be fed after polling has ended.

(ix) The machine has a facility to transfer the data out to display, printer or computer only after the result is seen at least once. Even after the issue of the data transfer command, the machine identifies the rightful gadget before the transfer of data to printer, computer. The machine has no provision to receive any data from outside devices, other than a valid BU.

4.7 *Apprehension in the form of a) changes within the machine after three hours of commencement of b) the changes in the machine data transferring (after 60% of the votes polled) of the 5 lowest candidates to the favored candidates.*

The EVM is an embedded and factory masked firmware and all the machines have same software & it is not polling station specific. It is based on single transfer vote to the voted candidates, and the sequence holds from the start of poll to the end of poll & is not dependent on time. **Any system can be tested randomly by mock poll to prove this performance.** *Further as each key press in EVM units whether valid or invalid is dat-/time stamped and recorded no activation of a possible "Trojan Horse" during poll can possibly go unnoticed*

4.8 *Apprehension of Electro Magnetic interference effecting the EVM's stored data after election but before counting and storing the machines in Electro magnetically shielded Faraday cages. Remote signals can be send from a distance to generate resonant frequency of the circuits and make the machine function in some other way.*

(a) The equipment has passed EMI/EMC tests as per standards

(b) CU and BU perform without malfunction even when impressed with electromagnetic interference at levels as required by international standard, for electronic equipment as per reports submitted by manufacturers..

(c) CU and BU have been subjected to interference levels much higher than EMI/EMC standards and verified that voting data is not altered and no wrong data gets recorded during interference.

(d) CU & BU can atmost be "jammed" by fields higher than, EMI /EMC standards. However, it is impractical of generate such high fields at the ballot location. Further it is much easier to "break" the CU and BU as rather than jam it.

(e) Under no circumstance wrong data is entered in CU through BU even under severe EMI, or already stored data altered.

(f) CU, BU resumes normal functions when strong EMI us removed. LINK Error is displayed during EMI jamming.

4.9 *Physical shock EVM can withstand on bumpy road in rural areas and possibility of electro-mechanical components to reset EVM or ECU due to jerk.*

BEL and ECIL have reported, to cover this aspect, which is a JSS 55555, which takes care of bump test up to an acceleration of 40 g. It may also be noted that any mechanical operation, such as "re-set switch operation", cannot be realized in "power off mode" to alter the poll counts inadvertently.

4.10 *EVM could contain the following flaws: Faulty logic, incorrect algorithm, erroneous data flow, error in circuit design, mistakes in software code, mistake in data base.*

(a) The EVM is an embedded system and all functional checks are performed and fully tested before fusing of the software. The fused firmware cannot be read and cannot be reprogrammed at all.

(b) All write operations in memory are followed by read operation verified on spot. The committee has recommended time diversity while writing to the memory devices. All EVMs are tested for all functions prior to election. *Number of mock polls can be conducted before start of balloting to ensure on the spot to party representatives that EVM is fairly recording.* Any failure including that due to any random noise would be detected and incorrect data entry would be automatically rejected. Only correct data would be recorded. In case any hardware component results in an inoperative condition, it is detected and displayed as ERROR message and taken care of only by either removing the offending condition or replacing the EVM if need be.

5.0 Advantages of the Electronic Voting Machine

Having considered in detail various apprehensions it will also be appropriate to highlight the various advantages of EVMs as well.

- Possible reduction of time between the time of withdrawal of nominations and the commencement of Polling, resulting in considerable, saving in matters

relating to maintenance of law and order, candidates' expenditure on campaigning etc.

- Considerable saving in printing of stationery and transportation of large volume of Election material.
- Discouraging booth capture limiting the number of votes that can be cast in an hour to no more than 300 in a booth, thus allowing time for the Law and Order Machinery to take appropriate remedial action.
- The provision of a procedure for conducting mock-poll to verify correct functioning of the EVM before a poll and that too in full public view, generates confidence in the voting community on the fair operation of the system.
- The system eliminates invalid voting, which in several cases is understood to be comparable to the difference between the winning candidate and losing candidate.
- The counting time is drastically reduced, and eliminates mischief at counting, as well as eliminates the possible building up of tension/disorderly scenes during the counting process due to the short time in which the counting will get completed with the introduction of the EVM.
- The entire process of voting is recorded with real time date-time stamp in sequence and is available for analysis by the Election Commission at a later date against any contingency. Possibility of the introduction of Mobile Polling Booths to facilitate fuller participation of people in the election process. New features introduced in the present proposed EVM's in tune of recent advances, have greatly enhanced capability of conduction of fair elections with EVMs.
- Each vote is date-time stamped, so that any attempt at rigging say too slow voting or rapid voting in limited time, or voting before or after election period is duly recorded in memory.
- Data on past 20 election including mode elections giving a unique "history of use" signature which is unique to each individual CU, and in parallel the whole manual record is also available independently with EC, both of which can be checked and co-related post election, if needed.

6. Recommendations

Recommendations of the committee are given in three parts, namely (i) Design changes, (ii) Polling-time precautions and (iii) Futuristic actions.

The EVMs shown to the committee have undergone hardware design change to comply with EMI/EMC regulations at the suggestion of the committee. Additional changes to improve data integrity have been discussed with the Election Commission and EVM manufacturers as being desirable and feasible to implement which will however need due software changes to be done in the micro-chip. The EVM would naturally have to be fully tested after incorporation of these changes and this testing should be got done by the Election Commission prior to the induction of EVMs.

Secondly, certain key precautions on EVM use need to be taken during polling process and these have been highlighted in (ii) "Polling process precautions" part.

Last but not the least, it is strongly felt by the committee that while the upgraded machine with suggested changes is strongly immune to data corruption, it does not ensure "voter-identity" which is very important, and is presently accomplished using human judgement. However new technologies are emerging to be available in free market which can hopefully address to this issue. It is suggested in (iii) "Future actions" that several methods of bio-metric identification be introduced on trial basis in the elections and feasibility of integrating them with EVM be explored, so that the next generation of EVMs can be even more comprehensive in ensuring fair elections.

(i) Design Changes

(a) EVM's be EMI/EMC compliant. (NEW)

(b) Dynamic Coding of Key no's to enhance security of data transmitted from Ballot Unit (BU) to Control Unit (CU) be introduced. (NEW)

(c) Time diversity in data recording be introduced to eliminate effects of noise(NEW).

(d) Every key press on EVM even if invalid, is date – time stamped and kept as permanent record (NEW)

(e) Additional seal of electronic cards in CU, BU *may be* introduced by EC to be operated just before the candidate-list is declared. (NEW). EC may examine its pre-poll security arrangements of EVMs and may introduce this seal only if they arrangements cannot be full-proof. (NEW)

(ii) Pre-poll, During-poll and Post-poll precautions

Pre-Poll

(a). Preventive Maintenance: Sample electrical check of the Control Unit and the Ballot Unit prior to the polling. The diagnostic check to be prescribed by the Manufacturers so as to ensure that the embedded program has not been tampered with.

(b) Candidate key number allocation stage: Prior to this *additional sealing* of electronic card of CU, BU in front of party representatives. (This is a very stringent step and EC may decide whether it would like to introduce this practice with reference to (e) above)

During Poll Time

(a) Inspection of the Ballot Unit/Control Unit as well as the cable at the time of the insertion of the Ballot paper by the Returning Officer with suitable aids to ensure that duplicate equipment are not used.

(b). Ensuring, in every Polling Booth, that the inter-connecting cable is visible at all times.

(c). Ensuring, in every Polling Booth, that no device is inserted between the Cable-Connector and the Control Unit.

(d) Conducting Pre-Poll "Mock Poll" immediate before start of balloting.

Post Poll

Carrying out on a sample basis, recounting of votes in certain booths post poll at an appropriate administrative level, to act as a deterrent against potential mischief-makers so as to generate a climate of confidence about the infallible nature of electoral process.

(iii) Futuristic actions

Bio-metric ID

Notwithstanding all care taken in design of EVMs and procedures as mentioned in the report, the process of election could be vitiated if due care on voter identity is not exercised. The present procedure for voter identity verification is man dependent and its limitations are only too well known to merit explanation here. The use of bio-metric ID has grown significantly in many applications worldwide and the advantages in its use in an Election process can hardly be over emphasized. The committee has discussed the possibility of interfacing Biometric ID system with present EVMs. It is felt that several issues namely choice of bio-metric parameters suitable for large scale application, costs and administrative logistics, voter ID data bank, etc. need more detailed study and field trials before finalization and introduction. Nevertheless unless some preliminary exercises are carried out the vetting of these issues would be impractical. *Hence it is strongly recommended that EC motivates BEL and ECIL to initiate prototype design and development towards implementation EVM-cum-Biometric ID system and trials are conducted to validate the system.* For starters, simply recording voter biometric identity during election could itself be a strong deterrent to mischief-makers besides generating useful trial information required for final design.

7.0 Conclusions

The committee after a review of the material presented to it has felt it necessary to highlight certain very key conclusions and recommendations as below:

(i) The basic Electronic Voting Machine developed by M/s. Bharat Electronics Limited (BEL) and M/s. Electronics Corporation of India Limited (ECIL) is a secure system.

The security emanates from two very important basic factors:

(a) The fixed program nature of the software which is fused into the processor and which is effectively unalterable.

(b) The faithful recording of all events in the processor (electronically) and the possibility of recalling the same with the added (manual)

administrative procedures on BU, CU at various stages in public view prescribed by the Election Commission which make available the sequence of voters voting rendering it possible to verify the recorded vote in case of any doubt with regard to possible tampering.

(ii) With the provision of non-volatile memory, any physical interruption leads to the retention of all voting information till that point.

(iii) With the system as designed by the above agencies having built-in security, the Election Commission and the Government only need to ensure the security of the equipment, to safeguard the sanctity of the electoral process. The procedural safeguards as stated in Section 6.0 should be implemented.

(iv) The Committee wishes to place on record the high level of accomplishments of the Engineers and Scientists of M/s. Bharat Electronics Limited and M/s. Electronics Corporation of India Limited in developing an Electronic Voting Machine using the latest technology.

(v) The Committee unanimously recommends the use of the upgraded EVMs in elections after due modifications stated in this report.

(vi) Committee also recommends strongly that bio-metric method of voter identification is pursued by EC and tested for feasibility in large population & integrating this sub-system with EVM in future.

Report of the Technical Committee for Evaluating Usability of EVMs of 1989-90 Prodcution Batch

September 2007

Acknowledgement

The Election Commission of India vide its note of No.51/8/16/2007 PLN-IV (Disposal)/1460 of 10-4-07 intimated that they have been advised by manufacturers of EVMs (namely BEL and ECIL), that the life of EVMs is about 15 years and that it is risky to use machines older than 15 years old in future elections. Thus both have recommended disposal of the entire 1989-90 batch of 1.5 lacs EVMs made by them.

The Commission expressed its concern that a huge amount of money (Rs 150 crore) from public exchequer was spent on procurement of 1.5 lac numbers of EVMs. Hence it would be unjustified to throw away each and every EVM of 89-90 batch simply on one single criteria namely, that a period of 15 years as "estimated" by BEL and ECIL had elapsed.

The Election Commission vide its above reference constituted a Technical Committee comprising of Prof. P V Indiresan, Prof. D T Shahani & Prof. A K Agarwala to give its opinion on whether EVMs of 89-90 batch have become unusable.

In a discussion with the CEC in April 2007, the specific agenda for the Committee's work was framed. In arriving at an acceptable method to determine usability of 89-90 batch EVMs for elections in immediate future, the Committee remained in regular touch with ECIL and BEL during April to June, and there were three meetings, one in April (Hydrabad), and two in June (at IIT Delhi and Banglore respectively).

This Committee acknowledges with gratitude, the co-operation extended by the technical teams of both BEL and ECIL in providing all available data on failures and the servicing records on the EVMs and their active participation in working out a method of weeding out less reliable EVMs

Finally, this Committee gratefully acknowledges all the support of the Chief Election Commissioner and all staff of the Commission, in conducting this study.

Prof. A K Agarwala
Member

Prof. D T Shahani
Member

Prof. P V Indiresan
Chairman

SUMMARY

Electronic Voting Machines (EVMs) were developed and manufactured by ECIL and BEL and supplied to the EC starting from 1989-90. The regular use of these machines began only in 2001. The oldest lot of 1,50,000 machines have thus been in use (although intermittently) for almost 17 years. The CEC had constituted a technical committee in April 2007 with the following objectives:

(1) To consider whether all EVMs of 89-90 batch be disposed outright
(2) If not, then to work out a method of testing and sorting by which certain number of the older and less reliable EVMs could be disposed of thereby having lesser failure rates in immediate future elections.
(3) To recommend a procedure for gradual disposal of an old batch.

The committee examined the various analytical methods for estimating the life of an equipment (Section 3); and concluded that these methods including the MTBF estimation cannot now be applied to the EVM 89-90 production batch mainly because the technical data on the components used is not now available and also the field data on servicing is sparse (Section 4). Further as per the requirement of CEC, a method has been jointly worked out with ECIL and BEL to weed out less reliable EVMs.

The methodology to be used to weed out the less reliable EVMs was then considered by the committee (section 5). It was noted that:

(a) The EVMs were used only for four years namely 2002 to 2005 in the elections, wherein BEL and ECIL pre-tested the EVMs before each election.
(b) Due to only intermittent use, the components and the equipment have had much less than the expected share of use-related-stress that would reasonably have occurred were the EVMs in continual use since their manufacture. Therefore machine deterioration may be strongly impacted by poor storage conditions.
(c) Any method to be adopted for repair of faulty EVMs from 89-90 batch should give due consideration to issues (among others) of component availability and PCB integrity

Finally, a step by step procedure (Section 6) to weed out and dispose off potentially unreliable EVMs was suggested by the committee in joint consultation with BEL and ECIL. The main points are:

(a) All EVMs of 89-90 batch be removed from storage and consolidated in batches having similar storage conditions. The batches may vary in size from 500 to 1000 consistent with the criterion of similar storage condition.
(b) Each EVM be inspected for its operational readiness as per established Pre-election preventive maintenance procedures.
(c) Each of the manufacturers, BEL and ECIL will find out the overall current failure percentage FP(net) for the EVMs manufactured by them in 1989-90.

(d) The failure percentage FP(batch) will be computed for each batch
(e) Any batch having FP(batch) > 2xFP(net) be outright rejected, as these are the batches wherein environmental poor storage conditions have caused more damage than average. In batches wherein FP(batch) < 2xFP(net), the EVMs that are functional be used in future elections, but the ones that were found faulty be rejected.

The committee also suggested (Section 7) that for the newly manufactured EVMs the following steps be followed:

(a) The manufacturer related MTBF data on components and, field data on servicing and time of actual usage be strictly maintained, so that scientifically acceptable MTBFs are worked out, and write off as per prevailing practices in future times be followed.
(b) Adequate stock of spares be preserved.
(c) Packaging and storing of EVMs be made more secure from environmental influences.

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1. Background

The Election Commission of India vide its note of No.51/8/16/2007 PLN-IV (Disposal)/1460 of 10-4-07 intimated that they have been advised by manufacturers of EVMs (namely BEL and ECIL), that the life of EVMs is about 15 years and that it is risky to use machines older than 15 years old in future elections. Thus both have recommended disposal of the entire 1989-90 batch of 1.5 lacs EVMs made by them.

The Commission expressed its concern that a huge amount of money (Rs 150 crore) from public exchequer was spent on procurement of 1.5 lac numbers of EVMs. Hence it would be unjustified to throw away each and every EVM of 89-90 batch simply on one single criteria namely, that a period of 15 years as "estimated" by BEL and ECIL had elapsed.

The Election Commission vide its above reference constituted a Technical Committee comprising of Prof. P V Indiresan, Prof. D T Shahani & Prof. A K Agarwala to give its opinion on whether EVMs of 89-90 batch have become unusable.

The Committee felt that it needed to discuss with CEC and his senior colleagues the *detailed nature of queries* the Commission had in its mind so that these could be adequately addressed to in its study. In the meet with EC members, the Committee clarified that the period estimated as MTBF (Mean Time Between Failure) does not mean that all equipment corresponding to an old batch will suddenly collapse if used beyond MTBF period. Usage beyond MTBF period implied that the percentage failure that may be encountered is likely to be more than the average percentage failure in the pre MTBF period. In past, failures did occur in EVMs during election and the faults were attended to by keeping extra units ready at hand. *There has also been not a single report from ECIL and BEL that Election Data was "lost or modified" on account of failure of any EVM.*

The CEC clarified that while reliability calculations indicate that a particular percentage of EVMs might fail, what the Commission was interested in knowing was whether the Committee could help in *identifying a process of testing or sorting the 1989-90 EVMs wherein the "weaker" of the lot could be identified and removed from use*. This would on one and give increased reliability in using the batch in immediate future, on the other hand it will set in place a mechanism to replace the 89-90 batch over a period of time. Further, considering that the process of procurement and disposal of EVMs is continuous, the Commission requested the Committee to suggest guidelines for replacement of new EVMs that may be procured in future.

2. Objectives before the Technical Committee

(1) To consider whether all EVMs of 89-90 batch be disposed outright
(2) If not, then to work out a method of testing and sorting by which certain number of the older and less reliable EVMs could be disposed of thereby having lesser failure rates in immediate future elections.
(3) To recommend a procedure for gradual disposal of an old batch.

3. Brief Survey of Methods of Prediction / Estimation of Reliable Lifetime

Failure is the inability of an equipment to perform its intended function. *Reliability is the ability of an equipment to perform its intended functions in the intended environment for the specified period of time.* Reliability of an equipment is a matter of concern to everybody, be it a critical mission or the day to day mundane work of a commoner. Understandably there is great interest in predicting or estimating useful (*read* reliable) life time of a product. Many methods have been developed over years to arrive at this magic figure.

One should mention here that there are two different ways of arriving at useful life of an equipment. *One* is a method that uses information like life-cycle of individual components under stress and the architecture of the overall assembly to predict service lifetime of reliable operation. The *other* is to use field data of the product (as done by servicing and maintenance unit of a company) and estimate the time period of use after which failures become more frequent. This method uses actual reliability performance observed on field and should be used wherever possible.

It is important to recognize that *predicting* useful service life of product strongly relies on the ability of manufacturer to produce each part with great repeatability so as not only to deliver the same function / value but also, age or degrade identically. This indeed is a tall order, but in mathematical modeling such assumptions are routinely made. Of course more the perfection in production process more the correlation of actual performance with the prediction.

In practice only for critical missions is the production process of components and quality adherence made stringent enough to lend itself to reasonably accurate mathematical modeling and so, make lifetime prediction a credible business. In most situations a *similarly carried* out production process (both at component and assembly level) by *different manufacturers* leads to *widely varying reliability* of final products. As a common consumer, one is only too familiar associating reliability with a particular brand name and that too for very genuine reasons indeed.

Therefore understandably the various methods used for prediction / estimation of reliable life time of equipment have fallen to disrepute as often we only see actual

life realizations widely different from predicted ones. But the fault is not of the model of prediction rather of the choice of inapplicable assumptions in the model.

Another issue is the misinterpretation of variety of terms that have come to be used with different methods of prediction. A typical case is the common (and undoubtedly incorrect) understanding of the term MTBF (Mean Time Between Failure). The misconception is that MTBF corresponds to realistic service life of the equipment. The reasons are that the model used to compute MTBF assumes many factors not only to do with quality control (which perhaps a good company may actually adhere to) but also to the *post sale use* of the product by the consumer which is indeed very hard to predict. *A model will work only to the extent its assumptions are valid.* Further, whether the MTBF figure is *estimated* from field data or *predicted* from purely theoretical considerations is also an important factor which determines its credibility.

It would suffice to close discussion on the above point with the observation that for a company which has long existence, and has sufficient field data on similar products it should use more of estimation than prediction of reliable life time of its products as field based estimation truly reflects the extent of achieved quality control and also actual pattern of use by customer. The anomaly of the same product having different reliability on account of being manufactured by different companies is also resolved easily with logic stated above.

Some of the earlier and more later developed life prediction / estimation techniques are listed below for completeness of report. One of the earliest prediction methods is MIL HDBK 217 (now less utilised) which used parts count based prediction and parts stress analysis prediction methods. Telecondia prediction model SR 332 (2001) uses many of MIL 217 methods but also reflects field experiences. HRD (Handbook of Reliability Data) covers more devices than MIL 217 but has lesser incorporation of field experience. Reliability Block Diagram method examines the location of a component in the system and tries to relate its influence on overall reliability. Markov model represents the system by various states it can assume (state graph) and includes failures as possible states the system can assume. FMECA (Failure Mode Effects and Criticality Analysis) dwells upon failure mode analysis of the product, and can be used to predict reliability except that modeling data needed by it be difficult to get. Fault Tree analyses path of failure event down to component level, but fault data needed by model is difficult to get. HALT (Highly Accelerated Life Testing) establishes time taken to take a product to its breaking point by subjecting it to high but carefully controlled stresses.

It should be borne in mind that many of the above methods have the goal of improving product design during design cycle by using *predicted* life time rather than of actually providing realistic lifetimes.

Reliability estimation techniques that use field data to estimate life time either direct data on the specific product (if available) or rely on field data of other

similar products made in past. Since this calculation is based on actual events, it is reflective of actually achieved quality assurance by the company and realistic use pattern by the consumer. *Estimation* of service life by this method is more realistic than *predicted* values.

For obtaining a meaningful estimate of reliable lifetime of the 89-90 batch EVMs the committee felt that as the EVMs were manufactured under high quality assurance standards at BEL and ECIL, the data needed for the mathematical predictive model is definitely worth considering. Further as the EVMs have been in field in active use for many years, the estimate based on actual servicing experience over the years i.e. the second method should also be definitely attempted.

4. Estimating Usability of 89-90 batch EVMs from Standard MTBF Models

The Committee examined the possibility of *predicting* and *estimating* MTBF of the EVMs by the two methods, as explained above.

Predicted Mean Time Between Failures (MTBF) as discussed is an important parameter for estimating useful life of equipment. For equipment that follow a well defined quality control regime in procurement of specified quality components, closely controlled and audited manufacturing and inspection processes, the estimation of MTBF of manufactured equipment from the MTBF of individual components is a scientifically accepted practice. As BEL and ECIL have reported high Quality Assurance standards in EVM manufacture Committee first examined possibility of applying the *prediction* method.

The Committee requested BEL and ECIL (vide Appendix I) to submit data on various aspects of EVMs e.g. MTBF of various components as available from manufacturers, manufacturing and quality assurance steps, utilization hours of the equipment in past 17 years, servicing records etc. As far as manufacturing process is concerned, the details were provided by ECIL and summarized in Appendix II, from where it evident that a high quality of production and quality assurance has been followed by BEL and ECIL.

However in respect of numerous *other* information (asked vide Appendix I) the committee was informed (vide ECIL: GM (IT&TG) 29-5-07) that (a) in respect of MTBF data, they have not preserved all the needed component data as of 89-90 batch nor the same is currently available from manufacturers as numerous components then used are not under manufacture currently, and so only part data is available. Further in later discussions the company reps intimated that (b) data on detailed hours logged in by EVMs is not available but only number of elections in which they were used is available.

Instead however BEL and ECIL submitted a jointly prepared report, "Study of Reliability Degradation of EVMs of 1989 Batch" (dated 24-5-07) in which MTBF prediction for EVMs of 89-90 batch was computed by them based on some

assumptions regarding (a) missing data on reliability (or MTBF) of components and (b) actual field usage of equipment.

The Committee was of the view that in the first place most of the electronic solid state components had an inherent MTBF very large compared to the elapsed period (of 17 years). Also that the EVMs were actively used in elections for short periods of time in a year. This was apparent from the almost nil number of failures in these components from the service / repair reports available on the past EVM batches.

In consequence the MTBF in EVMs would therefore be dominantly decided by the weakest links namely the buzzers, micro-switches, connectors, cables that had moving parts, were not hermetically sealed and were amenable to mechanical wear and tear and environmental degradation.

The Committee is of the view that with both (a) complete information on manufacturer supplied component MTBF data, needed on these very devices being not available, and also (b) the actual service hours of use of EVMs not available, the prediction of 15 years MTBF of EVMs with assumed figures as done by BEL and ECIL was not really an appropriate exercise.

So if the MTBF of 15 years as worked out by BEL and ECIL were to turn out correct it would be more on account of chance than correct use of laid out procedures.

Considering the limitations posed by lack of data on the *prediction* method, the Committee then considered the possibility of using the ***estimation*** method by using field data of operational experience on EVMs, in terms of number of failures, types of failures, failure rates etc. The idea was to work out *failure rate* versus *usage time* and see if the "bucket curve" of failure rate could be worked out and then examine if 17 years corresponds to the point of occurrence of increasing failure rate in existing batch of 89-90 EVMs. In this context the Committee posed another set of queries to BEL and ECIL, as per Appendix III (which basically is a subset of Appendix I).

A summary reply from BEL is enclosed as Appendix IV. The servicing / failure record shows that:

(a) As per Item 1, that 2.5% of EVMs over a period of 15 years (2005) were considered *unserviceable* since their inception in 1990 .

(b) As per Item 2, no meaningful failure rate versus service period could be obtained as EVMs were used only for four years (2002 to 2005) during 15 year period 1990-2005. The limited record on failures (per year or per election in the year) encountered in elections between 2002 and 2005, is not sufficient to construct a reasonable failure rate "bucket" curve. Thus neither the average failure rate during mid of 17 years period could be evaluated nor the threshold of

occurrence of higher failure rate could be identified. *Thus validating that 15 (as predicted by BEL and ECIL) or 17 years (as of now) period from date of manufacture of EVMs corresponds to the MTBF could not reasonably be verified from the data provided.*

Hence the method of estimation from field records of servicing cannot be reasonably be applied to the 89-90 EVM batch to arrive at their MTBF.

(c) All that one can observe from the servicing data provided by BEL, ECIL is that during 11 years of storage and 4 years of use, about 10.5% failures in all occurred.

(d) *An examination of typical faults shows that major failures were due to micro-switches, buttons, toggle switches and buzzers which is only to be expected and will continue to be so in newer EVMs as well. It must be emphasized that these are items that are routinely replaced on failure in any equipment, and equipment are not thrown away because of failure of such parts, subject of course to the condition that only limited de-soldering / soldering is involved, keeping in view the integrity of the printed circuit board.*

(e) From Item 3, no failure on account of capacitor has been reported (or not recorded). Yet contrary to this actual observed field experience (or lack of maintaining data on servicing) on capacitors, a risk priority number of 6 (on scale of 10) has been used on capacitors in another theoretical computation (FMECA) provided by ECIL and BEL. *The use of certain figures in models where assumptions don't match with observed ground reality is not in the correct spirit of method of MTBF estimation.*

The Committee concluded that due to lack of sufficient field data on the 1989-90 batch of EVMs, the standard methods of predicting or estimating MTBF could not be reasonably used.

In this context an <u>additional</u> method needed to be worked out to determine usability of the batch.

5. Method Recommended for Determining Usability of 1989-90 batch EVMs

In arriving at an acceptable method to determine usability of 89-90 batch EVMs for elections in immediate future, the Committee remained in regular touch with ECIL and BEL during April and June, and there were three meetings, one in April (Hydrabad), and two in June (at IIT Delhi and Banglore respectively).

The Committee made its reservations known to ECIL and BEL on their MTBF estimates and suggested that the both ECIL and BEL work out some method of weeding out the less reliable EVMs.

It was agreed in the joint meet of 29 June, chaired by Prof. P V Indiresan, that the Committee members and scientists from BEL and ECIL will jointly work out a mechanism to check (a) the reliability of the existing 89-90 batch EVMs, and (b) a test procedure to weed out the less reliable ones, giving due considerations to the following factors observations drawn from field records:

(a) The EVMs though made in 1989-90, were not used for many years till 2002 due to resistance from some legislatures, and so were merely stored for the first 12 years. It was recognized that if a newly designed product (as happened with the 89-90 batch of EVMs) is put in cold-storage in this manner (not used for 12 years), the interest of the design teams would diminish, the teams would disperse, and much of the initial data that would otherwise been collected and preserved would be lost. This fact accounts for the non-availability of all data needed for *prediction* of MTBF rather than any omission on part of manufacturers who have an excellent track record and in fact have shown tremendous fortitude and innovation in maintaining the EVMs over all these years despite heavy odds.

(b) The EVMs were used only for four years namely 2002 to 2005 in the elections, wherein BEL and ECIL pre-tested the EVMs before each election, and many of the faults that are reported by them were detected and repaired in this period. This accounts for the non-availability of crucial failure rate data during the first 12 years, rendering limited field data inadequate both in the quantum and format to *estimate* MTBF from field performance.

(c) Further the long period of *dis-use* of EVMs points at the fact that the components and the equipment have *much less* than the expected share of use-related-*stress* that would reasonably have occurred were the EVMs in continual use in elections since their manufacture. *It is therefore reasonable to assume that any faults that would occur in such a situation are not likely to be on account of stress but more on account of poor storage conditions which might accelerate corrosion of metallic parts and degradation of plastic parts etc. This factor will call for careful examination on case to case basis depending upon the storage condition of the EVMs.*

(d) In considering attempting any repair actions on faulty EVMs (of 89-90 batch) one has to bear in mind the following factors, limitations and possibilities:

(i) Numerous components then used are not available today (Appendix IV)

(ii) In considering de-soldering / soldering actions in part replacement the retention of *PCB integrity will be in question. So no soldering action on PCBs be undertaken.*

(iii) The original ATEs (Automatic Test Equipment) for these EVMs is not available. In addition for any fault so detected, restrictions (i) and (ii) above are likely to inhibit corrective actions.

(iv) However cables between CU BU are amenable to replacement and that should be liberally done.

(v) Switches not directly soldered to PCBs may be replaced where needed.

(vi) Similarly any mechanical chassis parts could be replaced where available

(vii) *Inspection procedures applicable to detecting degradation of parts from poor storage conditions should be intensified.*

(viii) *As storage conditions for thousands of EVMs stored will not be identical so the degradation occurring on account of poor storage will not be same. Hence the removal of EVMs from present storage spaces be done with extreme regard to separating them in batches that might have faced similar abuse in poor storage e.g. units on the floor, near walls may experience high humidity due to likely presence of water seepage. These should be segregated separately as a batch. In this way batches be segregated to the extent possible based on careful visual inspection or any other suitable indicators and marked for future reference and actions.*

6. Recommended Methodology for Weeding out 1989-90 EVMs for Disposal

Based on above the following procedure for weeding out is recommended:

(a) All EVMs of 89-90 batch be removed from storage and consolidated in batches as per 5(d)(viii). The batches may vary in size from 500 to 1000 consistent with 5(d)(viii).

(b) Each EVM be inspected for its operational readiness as per Pre-election preventive maintenance procedures being followed in past subject to 5(d) (i) through (vi)

(c) However prior to the test, all keys and switches be randomly operated for few tens of times.

(d) Each of manufacturers, BEL and ECIL will find out the overall current failure percentage FP(net) for the EVMs of their respective manufacture without including problems as 5(d) (iv), (v) and (vi) in the failure count.

(e) The failure percentage FP(batch) will be computed for each batch as defined in 6(a).

(f) All EVMs in Batches having FP(batch) > 2xFP(net) be outright rejected, as these are the batches wherein environmental poor storage conditions have caused more damage than average. In batches wherein FP(batch) < 2xFP(net), the EVMs that are functional be used in future elections, but the ones that were found faulty be rejected.

(g) The procedure could be repeated annually or as opportunity comes and further rejections continued till the 1989-90 batches are completely disposed off.

7. Recommended Methodology for Newly Made EVMs

(a) For newly manufactured EVMs, the manufacturer related MTBF data on components and, field data on servicing and actual usage be strictly maintained, so that scientifically acceptable MTBF are worked out, and write off as per prevailing practices in future times be followed.

(b) *Suitable percentage of spares as anticipated from MTBF data on 7(a) above is preserved so that obsolescence of parts does not unduly shorten attainable service life time of the newly manufactured EVMs.*

(c) Packaging and storing of EVMs be made more secure to minimize storage related degradation.

Appendix I

MTBF Related Information Asked for 1989-90 Batch of EVMs

A. Circuits & Parts

1. Detailed Circuit Diagrams of CU, BU
2. Detailed Parts List & Manufacturers
3. Manufacturer Specified Cycles of Use and shelf life for all Electromechanical Components (switches, connectors, cables etc.)
4. Operational Ratings, Maximum Ratings, Shelf Life & MTBF as given by Manufacturer on all solid state active components
5. Operational Ratings, Maximum Ratings, Shelf Life & MTBF as given by Manufacturer on all passive components
6. Shelf Life of "all other" miscellaneous parts / materials used
7. List of parts that have become obsolete as of 2007
8. Number of Solid State parts Replaced while servicing in previous 17 years "Component wise"
9. Number of Passive Components replaced while servicing in previous 17 years "component wise"
10. Manufacturer guaranteed logic levels (voltage), rise, fall and propagation times of digital components used.
11. List of components that may have been replaced in subsequent batches (1990 to 2000) either on account of obsolescence or reliability. Data as above on replaced devices.
12. Last batch of EVMs manufactured confirming to the design of 1989.
13. EVMs of 1989 design and make manufactured and supplied between 1990 and 2000 (numbers - year wise).
14. Number of EVMs declared unserviceable (year wise).
15. List of faults in EVMs in decreasing order of frequency of occurrence

B. Manufacturing Process, Quality Tests, and Pre-&-Post Delivery Inspection

1. Specify manufacturing process used for the 1989 design and make
2. Pre-qualification tests on PCB, its insulation & mechanical strength
3. List and specify Post-fabrication tests on PCB like current capacity of conductor lines, cracks, PTH, and electrical integrity.
4. List and Specify pre-qualification tests on component batches procured (active, passive and electromechanical components)
5. List and Specify Pre-delivery electronic tests like voltage levels, waveform (timings), on wired PCBs, along with recommended corrective action for expected faults.
6. List and Specify Pre-Delivery for processor and memory chips and corrective action.

7. Detailed PCB Layout with line spacing and thickness.
8. List and Specify pre-delivery tests on PCB wired electromechanical components (inclusive of cables and connectors) and corrective measures.
9. List and Specify Post Delivery Tests on items B 5,6, 8 as needed in servicing and maintenance and recommended corrective measures.
10. List and Specify Preventive maintenance checks and tests inclusive and additional to B 9 and recommended corrective measures.
11. Give Trouble shooting charts on CU and BU of 1989 batch EVMs, original and any revisions during 1990-2000 period, as well as recommended corrective actions for faults encountered.
12. Submit plan and its revisions for maintaining inventory for attending to faults in 1990-2000 period for the very large number of EVMs supplied in this period.
13. Specify "Time of Repair at Factory" for most common faults observed on EVMs (inclusive of diagnostics)
14. Specify recommended procedure as advised to client for long term storage.

Appendix II

Quality Assurance Procedures / Parameters for 89-90 Batch EVMs

The only two manufacturers for 1989-90 batch EVMs namely BEL and EVMs (both PSUs)as per their report follow high standards in manufacture of EVMs commensurate with MIL standards. A few of the key quality assurance procedures as per their reports are listed below (taken from ECIL document):

1. Inward Inspection of Components for CU and BU

Sl.No.	Component	Sampling / Inspection Plan
1.	Resistors	One component per reel
2	Capacitors	do
3	Crystals	AQL 1.5%
4	EPROMS, ICs	Sampling / Functionality
5	Buzzer	AQL 1.5%
6	Connectors	AQL 1.5 %
7	Cables	100% in Test Jigs
8	Switches	AQL 1.5%
9	LEDS / Displays	AQL 1.5%
10	PCBs	100% Visual
11	Cases / Covers etc.	100% Visual

2. In Process Inspection

This is done for CU and BU at various process stages namely: Component insertion, wave soldering, in circuit testing on ATE, PWA testing, pre-assembly and final Inspection.

3. Process Audit

Daily (internal 3rd party) audits of various processes like PCB Baking, Thermal Shock, Anti-static measures, Mechanical Assembly, ATE etc.

4. Final Inspection

The final inspection for CU and BU is performed separately. When BUs are tested, the CU is used as test jig and vice versa. Final Inspection involves visual and physical inspection, self tests and functional test.

5. Environmental Tests

These are performed to check ability of equipment to work in intended environment. They include vibration, high temperature, damp heat, low temperature, bump test etc at one in ten thousand sampling.

Remarks: The 89-90 batch EVMs as per BEL / ECIL reports were manufactured with high quality components, using high standards of inward inspection, tightly controlled manufacturing processes and subjected to quality assurance processes commensurate with MIL standards.

Appendix III

Modified Information Requested on 89-90 batch EVM

1. Written OFF Units: Of the 75,000 units each supplied by BEL and ECIL, the number of EVMs written off till date.
2. Record of Servicing: Action taken on each pair: For period 2000 onwards given. For period 1989 to 2000 to be given. Request to give data in processed form.
3. Post Delivery Trouble shooting Chart: To be given, inclusive of remedial measures.
4. Cycles of Use/Shelf life: To be given for all electromechanical and mechanical components (micro-switches, toggle switches, slide switches, buzzers, connectors, cables, fasteners, ant other preferable from standard source.
5. Capacitors: any issue of replacement to be brought to notice.
6. Obsolescence: List of Parts.
7. ATE: Possibility of using present ATEs with "bed of nails" and program reconfiguration/remaking.
8. Pre-Delivery Tests on systems: ECIL has given, BEL to give.
9. Pre Delivery Quantity checks: On components, waveforms, memories and electromechanical components (for 1989 design).
10. Preventive maintenance procedure.
11. Turn Around Period for repair.

Appendix IV

Points clarified by BEL as per Queries of Appendix III

1. **Written off EVM 1989 Units till date:** 75,000
   As per records 1804 EVMs-1989 have been declared unserviceable.

2. **Record of Servicing-actions taken for servicing:**

UP 2002	475
HP 2004	29
UP 2004	5654
UP 2004	604
UP 2005	1216
Total	**7978**

Major Problems:

1)	Doors Damaged	154
2)	Buzzer	142
3)	Toggle Switch	118
4)	Buttons	203
5)	LEDs	52
6)	Displays	87
7)	Microswitch	238
8)	Link Error	
9)	Connectors Damaged	32

3. **Post Delivery Trouble shooting charts are included:**

   Major remedial measures
   1. Change of parts as listed in (2)

4. **Cycles of use of Electromechanical/Mechanical Components:**

1.	Microswitch	25000
2.	Toggle switch	10000
3.	Slide switch	2000
4.	Connectors	500
5.	Buzzers	30 hrs
6.	Mechanical components- No life specified.	

5. **Capacitors-Any issue of Replacement:**
   No records of capacitor replacement

6. **Obsolescence –List of Parts:**
   11 parts obsolete which includes critical parts like micro-controller and EEPROMs.

7. **Automatic Testing.–Possibility of using ATEs to check 89-90 batch:**
   Present Agilent ATE can be used for EVM 1989 with modified bed of nails and modified program at an additional investment of Rs 10 Lacs.

8. **Pre-delivery Tests on systems:**
   Tests are carried out as per the "Production Test Procedure" and "Acceptance Test Procedure" of the company.

9. **Pre-delivery Quality checks:**
   1. Qualification Test Plan for Electromechanical components before approval of components.
   2. Qualification approval of EVM before production.
   3. ESS Plan for manufacture of EVM (100 % production)
   4. EVM Quality Plan-Sampling Daily.

10. **Preventive Maintenance Procedure:**
    All EVMs checked before Elections.

11. **Turn around time for repair of 89-90 batch EVMs:**
    100/day if a servicing line is set up

REPORT OF THE TECHNICAL EXPERT COMMITTEE (2013) FOR THE TECHNICAL EVALUATION OF THE UPGRADED 2006 ELECTRONIC VOTING MACHINE

1.0 Introduction

Electronic Voting Machines are successfully being used in our Country for over a decade. Election Commission is confident about the accuracy and tamper proof nature of EVMs used by ECI. Election Commission has decided to procure some more EVMs for use in the forthcoming Parliament Elections. After the last batch of EVMs produced after 2006, there have been suggestions for additional features from stakeholders. There have been also been several advances in technology since the last model of EVMs was developed. In view of the above the Commission has asked the Manufacturers to present their proposal on upgrading the 2006 EVM and present it to the Technical Experts Committee who will study the proposal and make suitable recommendation to the Commission. This report summarizes the main recommendations of TEC.

A brief referral and summary of recommendations of earlier TECs have been provided to bring out continuity of approach and completeness to the report.

2.0 Background of Electronic Voting Machine (EVM)

(a) Introduction of EVMs in Indian Election system

The use of Electronic Voting Machines (EVM) in the Indian Election System owes its origin to the Election Commission of India (ECI) putting forward this idea in early seventies. Two major public sector industrial enterprises namely M/s. Electronics Corporation of India Ltd., Hyderabad and M/s. Bharat Electronics Ltd., Bangalore, having proven credentials in electronics design of high quality, were asked by ECI to design and develop suitable version of the EVM for use in elections. In 1982, the EVMs were introduced in 11 constituencies and put to use. The experience with these first EVMs was satisfactory.

(b) Expert Committee of 1990

Before inducting use of EVMs on a larger scale, the Electoral Reforms Committee (ERC) set up in 1990 felt that the EVM be thoroughly reviewed for it being tamper-proof and being completely compliant to requirements of Election functions. Towards this the then Department of Electronics at request of ERC, constituted an expert committee to carry out the technical evaluation of EVM for examining its functionality and any susceptibility to tampering.

This expert committee in 1990 after a thorough review of the design, manufacturing, testing processes and operations, recommended accepting the EVM's while taking certain precautions so that the EVM is easy to use, is rugged, well maintained and cannot be tampered with. Some key observations, recommendations and precautions in the report are:

- Committee noted that the program embedded in the device is completely fixed and unalterable, and therefore, there is no means or access by which the system can be modified from outside with intention of tampering.
- Carry out Preventive Maintenance check of the Control Unit and the Ballot Unit by manufacturers, prior to the polling, and ensuring that duplicate equipment are not used.
- Inspection of the Ballot Unit, Control Unit as well as the cable at the time of the insertion of the Ballot paper by the Returning Officer with suitable aids to ensure that duplicate equipment are not used.

- Ensuring, in every Polling Booth, that the inter-connecting cable between CU and BU is visible at all times.
- Ensuring, in every Polling Booth, that no device is inserted between the Cable-Connector and the Control Unit.
- Conducting Pre-Poll "Mock Poll" immediate before start of balloting to verify that EVM is performing correctly for all the Election functions.

These EVMs, with special technological features, precautions recommended by the Expert Committee and meticulous administrative measures followed by the Commission were then used in 1998, continued to be used for over 10 years proving their reliability and conduct of tamper-proof elections, year after year.

(c) Expert Committee of 2006

Based on experience and feedback gained from extensive field use, the Election Commission asked BEL and ECIL to introduce additional features, to further the cause of reliability and tamper-proof working in the new EVMs to be manufactured. The Election Commission also set up a technical expert committee in December 2005 to examine the proposal of Manufacturers for upgraded EVM's before its manufacture and use in elections. The expert committee held numerous discussions with manufacturers (BEL and ECIL), looked into the operation of EVMs, visited the premises of manufactures to inspect the quality manufacturing facilities, and also asked them to conduct additional tests on the proposed EVMs. The expert committee also studied the feedback, suggestions and concerns as received by ECI over the decade long use of EVMs.

The expert committee, recommended the continuation of the basic technology of one time programmability used in Indian EVMs, precautions suggested by the 1990 expert committee and the administrative procedures followed by the Commission, all of which had proven their mettle in making EVM rugged and resistant to tampering. Further keeping in view feedback received by Commission on EVMs, new features recommended by Commission and the advances in technology, the expert committee suggested features additional to the EVM as follows:

- EVM's be EMI/EMC compliant.
- Dynamic Coding of Key no's to enhance security of data transmitted from Ballot Unit (BU) to Control Unit (CU) be introduced.
- Time diversity in data recording be introduced to eliminate effects of random noise
- Every key press on EVM, even if invalid, is date–time stamped and kept as permanent record. Every vote be stored with time and date stamped electronically.
- All the EVMs be checked by manufacturers as a matter of preventive maintenance before election and as a matter of abundant caution, to ensure that they are working satisfactorily and according to the original embedded program.

(c) Public debate on EVMs 2010

In 2010 a certain amount of public debate on EVMs took place.

To understand the concerns better, the Commission announced that anybody could come to the Commission premises, give their views, and any one claiming that ECMs could be tampered with, to come to Commission and demonstrate publicly any claim of tampering the EVM by doing so in front of everybody in the Commission and to the expert committee. They could also suggest additional features.

This exercise was continued for over six months, but no such demonstration of actual tampering of EVMs could be made by anybody in the Commissions premises. The Commission took feedback of all concerned and suggestions from those who visited the Commission during this exercise.

Two events resulting from these interactions are significant to mention:

One of the EVM activists group along with some scientists from abroad had published a paper on the Indian EVM. Despite claims made in the paper, no one came forward to actually demonstrate to Commission the claim made in the paper of being able to tamper with the EVM used by Commission. *Significantly the paper could not show how the EVM units (having OTP chip) could be reprogrammed to introduce a Trojan in an existing chip in the existing EVMs. Some tampering attempts that required either the chip or EVM circuit card to be "replaced" or extra hardware be "added" were discussed in the paper.* Towards viability of "replacement and addition" to tamper, while acknowledging the many levels at which security was provided for in the EVM, the paper chose to dismiss them lightly, providing very loose arguments perhaps, to suit convenience of bolstering the claim.

It is pertinent to point here that prior to the above exercise there had been a few claims that EVMs could be tampered with, which were heard in the Courts, but as none of them could be proved in the Courts as well, and such claims were dismissed in the Courts as well.

Election Commission naturally has been confident all along about the accuracy and tamper proof nature of EVMs used by ECI.

An extremely significant outcome of the interaction initiated by Commission was that most stakeholders wanted the EVMs to continue be used in elections and in fact offered numerous suggestions for additional features.

The suggestions and features suggested by the stakeholders for the EVMs were taken note of by the Commission.

(d) Expert Committee of 2011

With due regard to the suggestions received on the EVMs from stakeholders, and with a view to addressing their concerns, and also to deal with added scope of work involved in reviewing the EVMs, the Commission expanded the expert committee of 2006 by inducting experts from IIT Kanpur and IIT Bombay.

The Expert Committee spent considerable time with civic groups who had been actively communicating their views to ECI, and also with stakeholders, by attending the meetings organized by ECI. The Committee also discussed with manufacturers the details of implementation of suggestions of earlier Expert Committees. One of the key suggestions that was received was introducing an additional feature of VVPAT (Voter Verifiable Paper Audit Trial) which involved adding another accessory unit termed VVPAT to the existing CU and BU. Such a unit was envisaged for printing the cast vote on a small ballot slip which would be visible to the voter at time of voting, and be securely stored in a compartment for a possible hand-count.

The main objectives in front of the Expert Committee were twofold.

(A) EVM reliability and its Tamper-Proof nature: This objective is the same as since 1990, namely to consider the following points and suggest improvements commensurate with advances in technology:

i. Does the EVM meet the functional specifications of the Election Commission?
ii. Is the EVM manufacturing quality of a high enough standard to provide adequate reliability?
iii. Is the EVM design stable and tamper-proof?

(B) To look into the feasibility of VVPAT: Towards this extensive interaction between TEC and manufacturers have taken place 2011 to 2013. Manufacturers have made prototypes that were put to two technical trials by ECI, one in 2011, and second after changes in 2012. Currently improved prototypes are due for trial run in a by-election. The detailed recommendations on VVPAT will be made once the performance of VVPATs in these trials is evaluated.

3. Recommendations of Expert Committee for EVM to be manufactured in 2013.

The Expert Committee noted that the main operations of EVM that involved CU and BU did not involve any significant changes. The key operational features of EVM 2013 were therefore essentially the same as earlier EVMs. "EVM" referred below includes Control Unit, Ballot Unit and all accessory units already in use and others that are in trial or development stages considering recommendations for the up-gradation.

However over the years newer techniques for strengthening tamperproof and authentication features had emerged and these were increasingly finding use and acceptance in electronics systems. Further the Election Commission had projected that making EVMs made by BEL and ECIL "interoperable" will greatly improve EVM stock management in states and even lead to cost reduction.

Hence the Expert Committee after detailed deliberations with ECI and manufacturers since 2011 recommended the following:

i. Tamper-Detect-Modules for the EVMs : All EVMs and their accessory units to be provided with a tamper detect module so that on any tamper attempt on the units will make it completely in-operable.
ii. EVM Data Security: EVMs to use PKI based authentication and session key establishment mechanisms in all EVM-unit communication for enhancing security of data in EVMs and also so that no unauthorized module can participate in data transfer, or attempt to modify election data, within and between EVM units.
iii. EVM Units Authentication: For authentication of EVM units, Digital Certificates of units issued by manufacturers to be incorporated that ensure that only units manufactured by BEL and ECIL can work with each other, and the EVM units mutually authenticate each other as a matter of routine, and only on successful authentication operate as an EVM. The certificates of units authenticate the public key of the units and the entire chain of certificate trust must be established before using the public key of units for authentication purposes.
iv. Inter-operability of EVMs made by BEL and ECIL: EVM units made by BEL and ECIL should use a common Standard Software and Communication Interface and ensure complete inter-operability of their EVM units without exception. Due care in PKI and Certificate incorporation should be taken including the re-certification stage.
v. Transparency of EVM Code: Facility to be provided in EVM units so that Code in the EVM units can be read out by an approved external unit and the code so read may be compared with corresponding reference code to show that code is same as that in reference units. The scope of comparison is only to ensure that there is no Trojan or other malware for EVMs in use. Election Commission may consider the format (binary or hex or any other) in which the reference code is made available and

modalities of preserving the reference code including code revisions. This provision being introduced for the first time; may be done in a phased manner with due-caution. Thus the Commission may initially consider undertaking this exercise in a limited scale as per mechanisms they deem fit and availability of logistics say at FLC stage, and/or third party. Thereafter having gained the experience on modalities and logistics needed, and the time that will be required to set up these logistics on larger scale, later extend access to this facility.

vi. Authentication of EVM Code: EVMs be provided with code verifying units (FLCUs) that can examine the code in any EVM unit for any malware via challenge-response techniques. Election Commission can consider introducing modalities incorporating such code verifying units say at First Level Check (FLC) and/or third party, and later at any stage of election as Commission may deem fit, considering experience gained at FLC and logistics involved in such verification.

vii. Secure Manufacturing of EVMs: While BEL and ECIL are using secure facilities in their manufacture, the EVMs would now incorporated new features like PKI. Manufacturers therefore should incorporate the latest Secure Manufacturing Technology in making of EVMs considering requirements of PKI.

viii. Self-diagnostics facility in EVM Units: Electrical and other parameters required for routine checking should be measured and stored digitally and used for self-diagnostics and be made available for external display as and when needed. Specifically, the EVM units having their own display and /or printing interface shall include giving a display and/or print-out of self-diagnostics reports of their own and accessory units.

ix. Environmental Tests: While these are being routinely carried out by BEL and ECIL, it is recommended that the tests be up-scaled in their intensity of stress and in sample sizing to individual EVM units so as to increase their robustness in transportation.

x. EMI/EMC Testing of EVMs: While these have been introduced on EVMs since 2006, it is recommended that the emission tests be up-scaled by near-probes as that may lead to detection of any wireless devices.

xi. EVM Interconnecting Cable Testing: These cables including their connectors must be subjected to the standard impedance measurement and cable parameter testing as for communication cables / connectors, including insulation breakdown tests.

xii. Accessory EVM Units under design and evaluation stages: All EVM units that are under design / trial stages, shall follow all the technical, QA, documentation features as for upgraded EVMs and be completely compatible with the new EVMs. The Commission may consider issuing specific recommendations for such units prior to manufacturing.

xiii. Third Party Checks: While BEL and ECIL have been using robust Quality Assurance practices, the Election Commission may consider introducing gradually third party check of EVM units at all and any stage from manufacture to final use, to ensure robustness and correct functioning of EVMs. The scope of tests and their modalities can be reviewed and revised time to time. This will put to rest any concern of "insider-attack" on EVMs.

xiv. EVM Prototypes Checking: EVMs scheduled for manufacture in 2013 may be mass-manufactured after the manufacturers show working prototypes and demonstrate all features as recommended by Technical Expert Committee and after final approval of Election Commission.

xv. EVM Documentation (prior and after Purchase Order): Prior to placing order on EVMs Election Commission may kindly consider asking the manufacturers to submit one document on Operations and Features of the Upgraded EVM (and units) and another listing details of all Quality Assurance tests that can be carried out at various stages by them and by third party. These documents will be revised as and on change is incorporated.

xvi. <u>EVM Units Designs</u>: Commission is requested to advise manufacturers to maintain a proper record of technical designs of all EVM units with due care, and updates them as per revisions time to time for both software and hardware.

Prof Rajat Moona **Prof Dinesh Sharma** **Prof A K Agarwala** **Prof D T Shahani**

Date: 10-07-2013