EVALUATION OF CIMO WEATHER RADARS SURVEY

AND

WEB-BASED WEATHER RADAR DATABASE

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1. Summary

It has been already proven that, Doppler Weather Radar is an essential precipitation observing system in meteorology for very large scale areas. They have been and will continue to be a very important meteorological tool for severe weather warnings, precipitation estimation and its spatial distribution, air traffic management, disaster management, numerical weather prediction (verification and data assimilation), agriculture, hydrological, weather modification and climate applications.

Radar networks have been developed in many countries and often have been competing requirements resulting in multiple networks created by different internal agencies and not just National Meteorological and Hydrological Services(NHMS).

The fourteenth session of the Commission for Instruments and Methods of Observation (CIMO) requested the CIMO Expert Team on Remote-Sensing Upper-Air Technology and Techniques (ET RSUT&T) to establish a fully comprehensive database of the global use of weather radars.

The Survey on weather radars has been conducted by WMO to reveal current operational weather radars. Several reasons for establishing this database:

- Presenting a comprehensive web-based database for radar network planning information and resource allocation for all members
- Assisting a wide spread international exchange of radar data
- Gathering radar information to protect radio-frequency spectrum allocation
- Presenting common issues/problems and potential solutions gathered by questionnaire

This report provides analysis of the replies to the CIMO survey on weather radars and current status of the study. Weather radars operated by NHMSs are considered in these statistics. The survey is planning to be continued by an interactive web site and information of radars operated by establishments except of NHMSs are planning to be added. In section 2, overview of the questionnaire and spread sheet and in section 3 distribution method and information regarding with collected replies have been provided. In section 4 and 5, analysis of replies to the questionnaire and spread sheets respectively and key findings has been provided. Information about the current status of the world wide weather radar database web page study has been provided in section 6. Appendix A contains a copy of the Survey questionnaire and spread sheet.

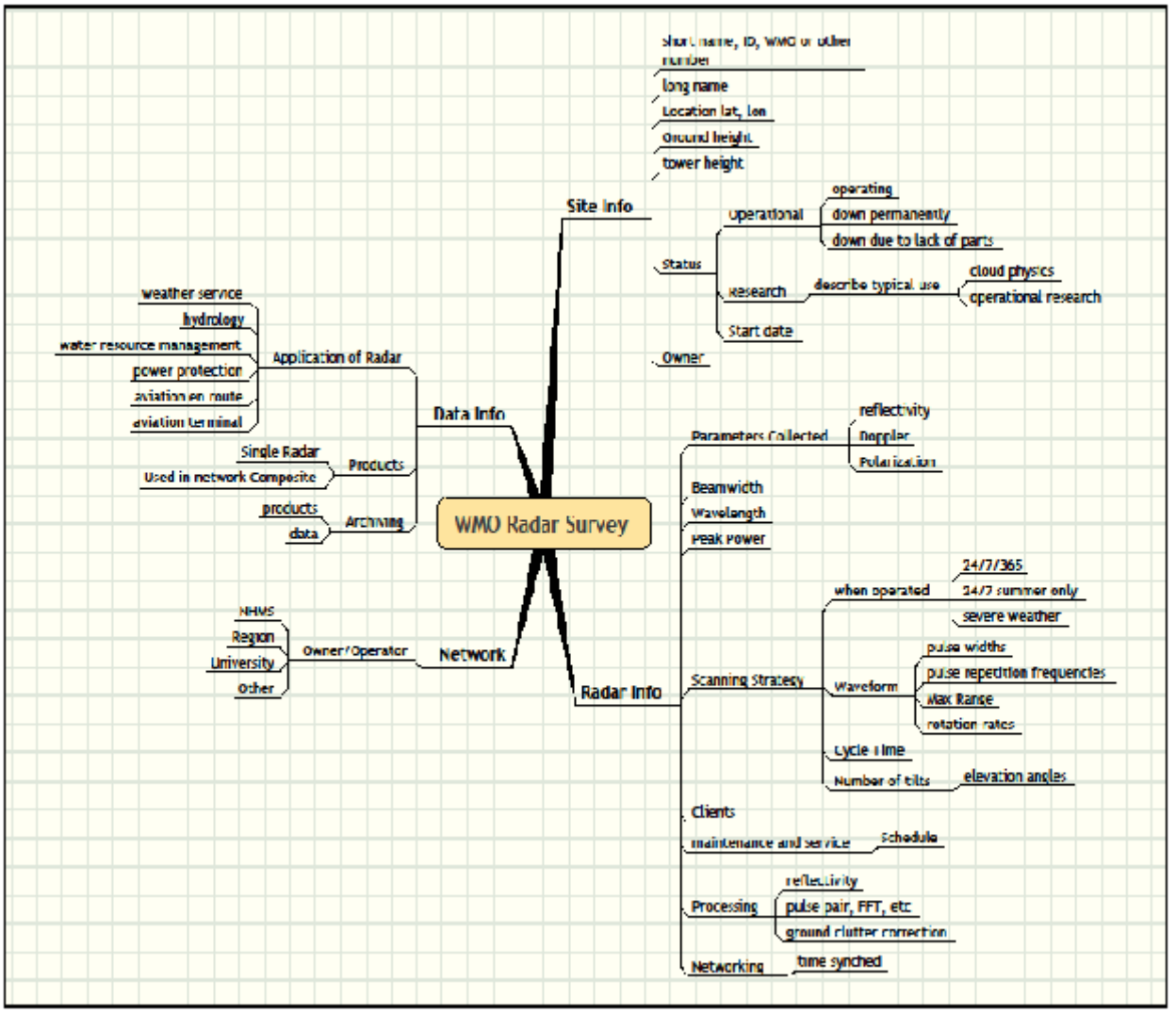
2. Overview of questionnaire and spread sheet

The survey has four main sections on the following themes:
a. Radar site(s) information
b. Radar hardware characteristics
c. Owner information
d. Data, products and applications

The radar survey is composed of a questionnaire (word form document) and a spread sheet (excel document) and available from:
http://www.wmo.int/pages/prog/www/Questionnaires.html

"**Questionnaire on Weather Radars**" is placed in **Annex I** and **"Spreadsheet"** is placed in **Annex II** of this document.

Questionnaire content diagram



3. Distribution and Replies

The questionnaire and spread sheet have been prepared by ET-RSUT&T. The survey has been sent to all WMO Members' NMHSs by WMO. The survey was conducted in English only as a MS word document and excel spread sheet.

Replies from members have encouraged us to continue establishing a comprehensive database for weather radars. Even though there are some missing data in returned questionnaires, there is a positive tendency for collaboration on weather radars for several reasons. The process of gathering replies from countries which have not responded the questionnaire and from the countries replied the questionnaire but not completed spread sheet will be continued. Methods for collecting the required data from operators of weather radars except of NHMSs (like universities, airports, TV stations) will be searched and applied.

Totally 66 countries have been replied the questionnaire by e-mail or fax. 11 countries

including Bosnia Herzegovina, Chile, Egypt, Kazakhstan, Kyrgyzstan, Mauritius, Monaco, Seychelles, Sudan, Uruguay, and Zambia informed that they are not operating weather radar. 7 countries including Algeria, Argentina, Botswana, China, Korea, Malaysia and Russia replied questionnaire due to they are operating weather radars, but their filled spread sheet haven't reached. There is no information regarding with the number and type of the radars operated by this countries for this reason. Totally 517 weather radar information have been sent by remaining 48 countries. The following table contains the list of these countries.

Country	Radar #	Country	Radar #	Country	Radar #
Austria	5	Hungary	3	Serbia	14
Azerbaijan	2	Iceland	1	Singapore	1
Bangladesh	5	Indonesia	19	Slovakia	2
Belarus	3	Iran	5	Slovenia	1
Belgium	2	Israel	1	South Africa	24
Belize	1	Italy	22	Spain	15
Brazil	2	Japan	29	Sweden	12
Bulgaria	3	Jordan	1	Thailand	26
Canada	31	Latvia	1	Trinidad& Tobago	1
Croatia	2	Myanmar	1	Tunisia	1
Cyprus	1	Netherlands	2	Turkey	6
Estonia	2	New Zealand	6	Ukraine	7
Finland	8	Norway	8	United Arab Emirates	6
France	24	Pakistan	7	United Kingdom	16
Germany	16	Panama	1	USA	159
Hong Kong	3	Poland	8	Uzbekistan	1

Many countries, except of these 66 countries, have not replied the questionnaire yet. These countries include Australia, Denmark, India, Greece, Portugal, Saudi Arabia etc. It is expected that after completing missing information, this number will be doubled. Especially, impact of the data which will be gathered from China, Australia, Russia, India, Korea and airports of USA can be expected to affect the numbers extremely.

4. Evaluation of Questionnaire Replies

Analysis was done manually. On the other hand, further analysis will be able to be realized automatically after all data stored in database web page. The survey results are presented in the form of graphs of the statistics related to each question. Key findings have been presented whenever it's possible after each question. For cakes, it is always relative to the numbers of replies (countries) unless otherwise specified.

Question 1 and 1.1: Member and Institution/Organization Name

Member and Organization information gathered by these questions

Question 1.2: Do you use weather radar systems or do you plan to apply such systems?

This question has been addressed to understand the extensity of weather radars.

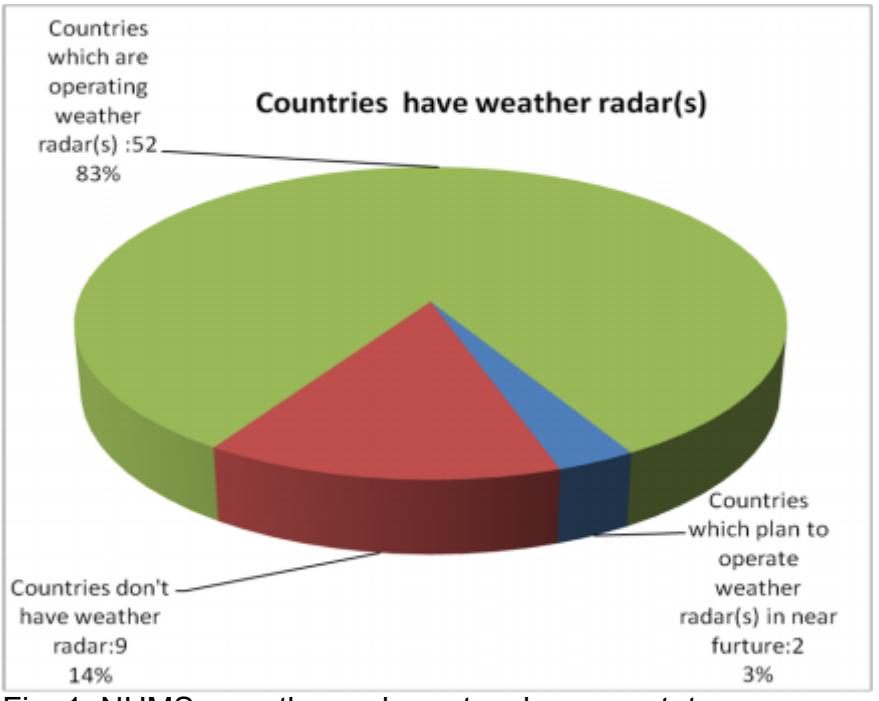


Fig. 1: NHMSs weather radar network usage status

Key findings: Most of the NHMSs have weather radar networks. It can be understood that weather radars are extensively used instruments and a part of main observing systems. We can have more information about extensity of radars operated by establishments except of NHMSs at the next stages of the study.

Question 1.3: How long has your organization been operating Radar?

This question has been included in the survey to investigate the experiences of countries in operating weather radars.

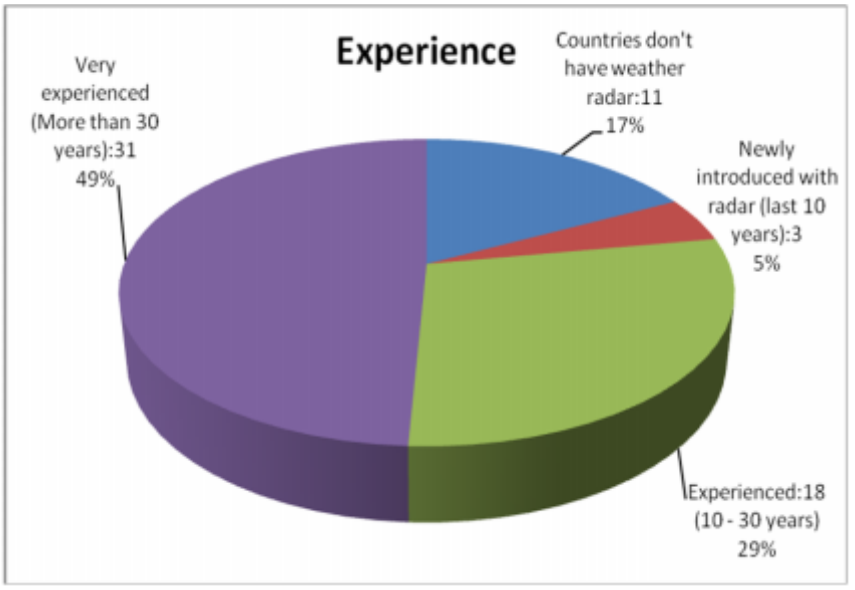


Fig. 2: Experience on weather radars

Key findings: Significant number of countries have a very good experience in operating weather radars. Considerable number of countries are not so much experienced but it can be understood that usage of weather radar systems has been spreaded quickly for a couple of decades.

Question 2: Please indicate main requirements of your organization of your radars*? (Please Specify below, e.g., severe weather warnings, hydrology, weather modification, NWP, etc)*

To investigate main requirements of radar operating organizations for weather radars, this question has been addressed.

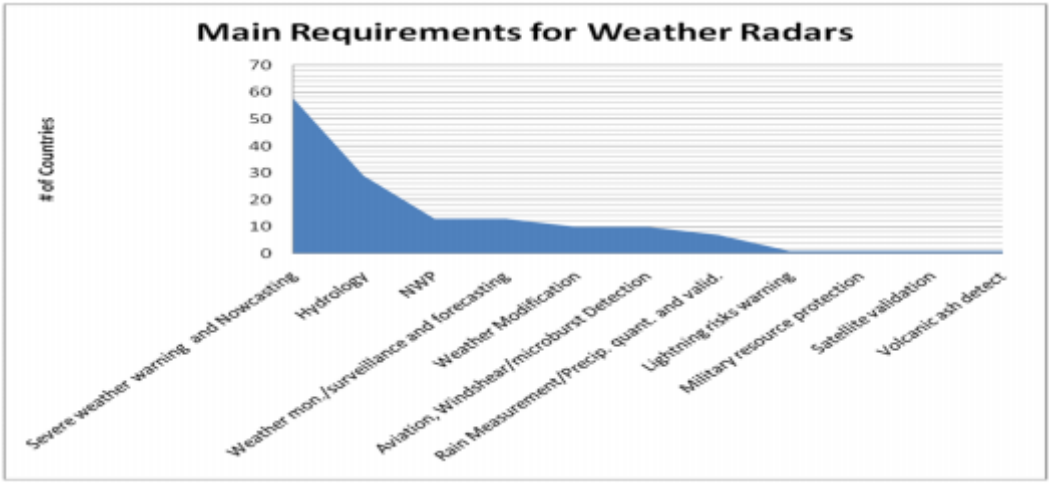


Fig. 3: Main requirements for weather radars

Key findings: Almost all participant of the survey have been indicated that "Severe Weather Warning and Nowcasting" are the main requirements for weather radars. "Hydrology" is another main requirement for significiant number of participants. For some of the participants "NWP, Weather Monitoring and Surveillance, Weather Modification, Aviation, Rain Measurement" are in the main requirements for weather radars. Applications like "Ligtning Risks Warning, Military Resource Protection, Atellite Validaton andVolcanic Ash Detection" are in the main requirements for a few participants.

Question 3: Have you hired Consultancy Service regarding radar?

This question has been included in the survey to search to what extend consultancy service needed for weather radar related issues like siting, technical specifications etc.

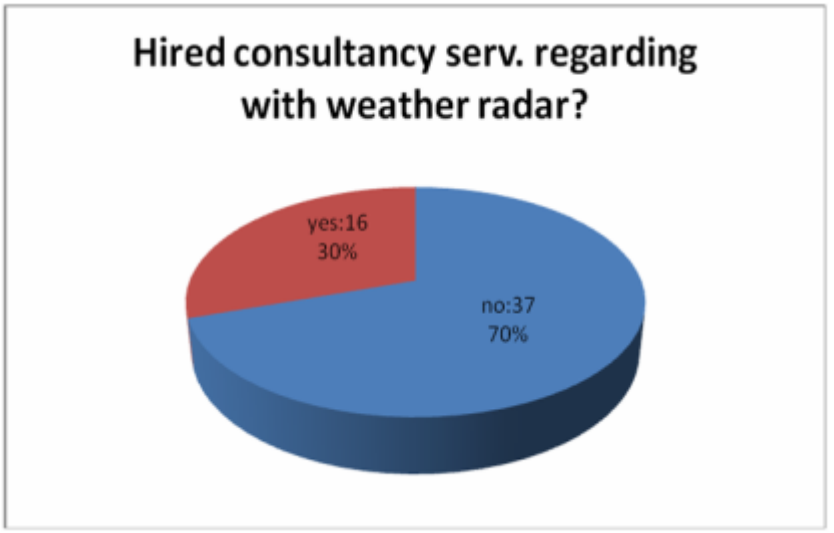


Fig. 4: Consultancy Service regarding weather radars

Significant number of participants hasn't hired a consultancy service regarding with weather radars, but almost one third of the participants hired a consultancy service. A consultancy service or support may be necessary for some of un-experienced countries for weather radars which are much more expensive and complex that other classical observing systems.

Question 4: The main criteria considered for the site selection for radars

This question has been addressed to search priorities of radar site selection criteria.

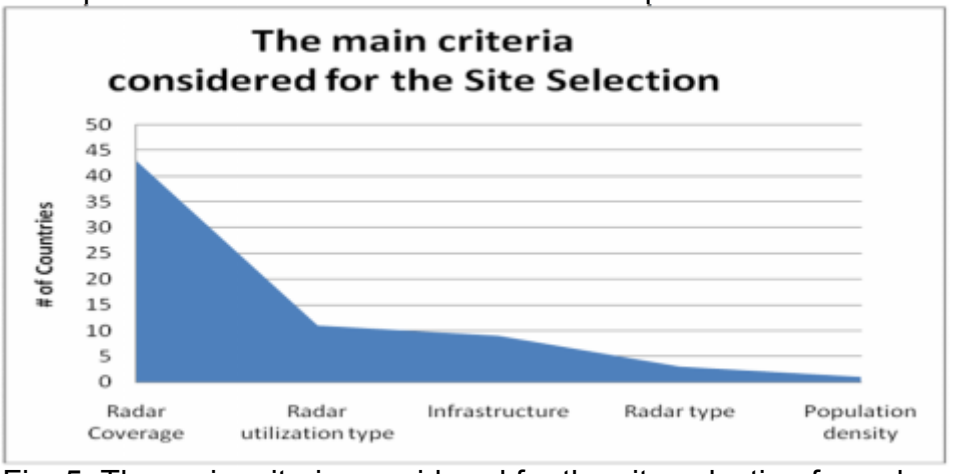


Fig. 5: The main criteria considered for the site selection for radars

Key findings: "Radar coverage" is the top priority in the site selection for most of the participants. For some participants "Radar utilization type" and "Infrastructure" are the first priority and for several participants "Radar type" and "Population density" are the first priority for site selection.

Question 5: The communication type for data transmission between remote radars and the operating centre

To investigate communication types mainly used between radar site and control center, this question has been included in the survey.

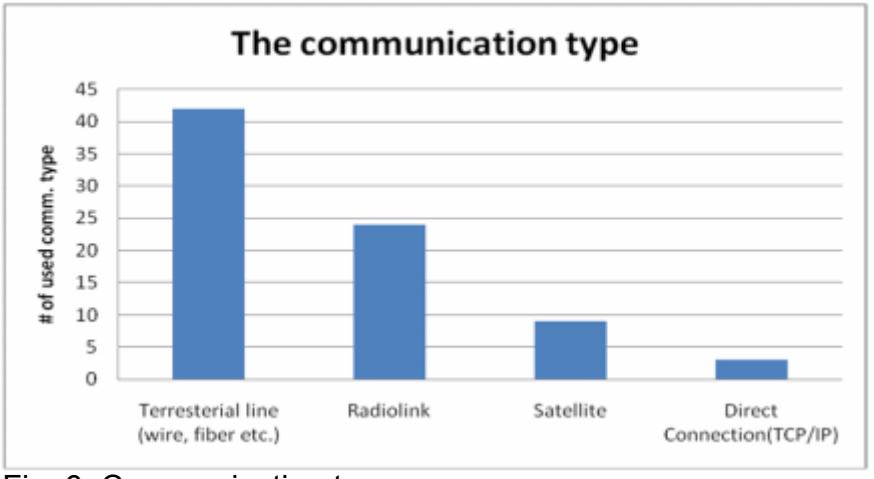


Fig. 6: Communication type

Key findings: "Terresterial lines" are most commonly used communication type between radar sites and radar centre. Significant number of participants uses radio-link for this purpose and these centres are close to the radar sites relatively. Some of the participants use satellite as main line. Cost of the satellite line might be one of the reasons for low preference. Several participants which operate radar locally use direct connection between radar site and radar centre.

Question 5.1: Communication data rates?

This question has been included in the survey to reveal communication rates used between radar sites and radar centres.

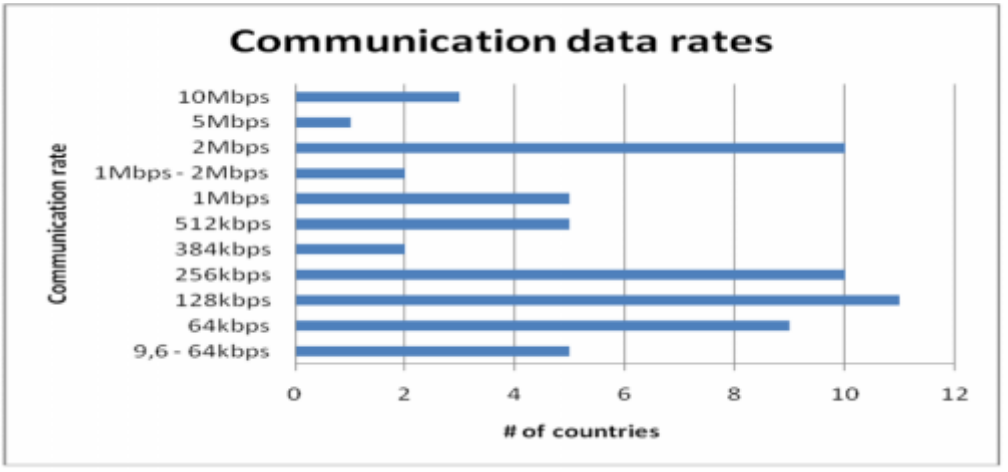


Fig. 7: Communication data rates

Key findings: There are some inconsistencies in the replies of this question. But decreasing communication prices may be one of the reasons for this. However, it can be said that communication rates between 64 and 256kbps is the most commonly used for single polarization radars. It can be expected an increase in these rates in time by the influence of the prices to get faster raw data or products and even real time images.

Question 5.2: Any back-up method available for the communication?

This question has been addressed to search availability of a back-up communication line between radar sites and radar centres.

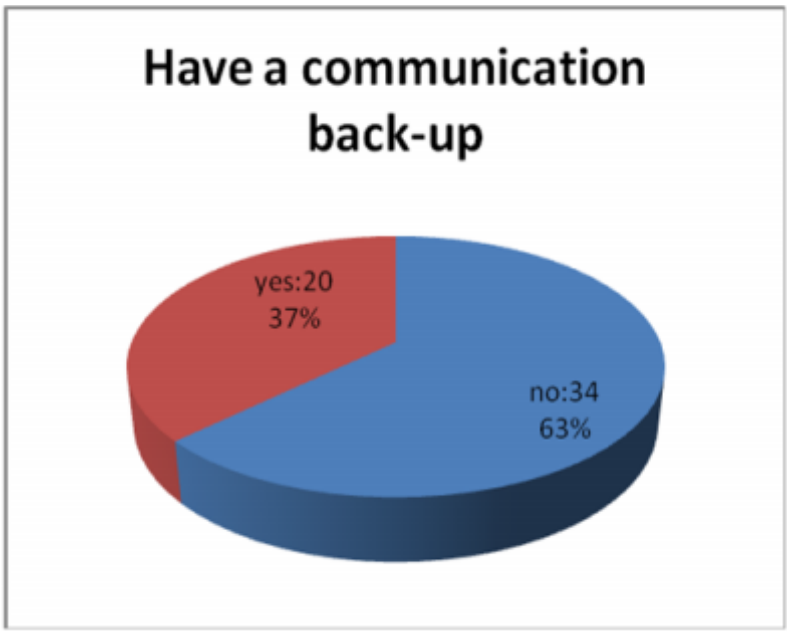


Fig. 8: Communication back-up

Key findings: Significant number of participants doesn't have a back-up line between radar sites and radar centers. On the other hand, a considerable number of participants have a back-up line. If the most prior main requirement of weather radars which was "severe weather warning and nowcasting" has been reminded, presence of a back-up line is very meaningful and beneficial.

Question 6: Which method is being used for data quality checking that is done in the signal or data processor?

Data quality checking methods realized in the signal processor has been indicated below according to the responses of the participants:

Algorithms of Software (IRIS, EDGE, Rainbow, Sanaga etc.)
SQI, CSR, CCOR, LOG, SIG thresholds
Clutter mitigation
Spurious filtering
SNR thresholding
Correction algorithms (beam blocking, clutter removal etc)
Reflectivity calibration
Digital receiver and signal processor

Solar monitoring
Data quality checking by DVIP(Digital Video Integrator Processor) Calibration
Point-target-sensoring

Question 6.1: What type of correction algorithms improving data quality do you have in your system?

This question has been addressed to the participants to investigate used "correction algorithms" for improving data quality

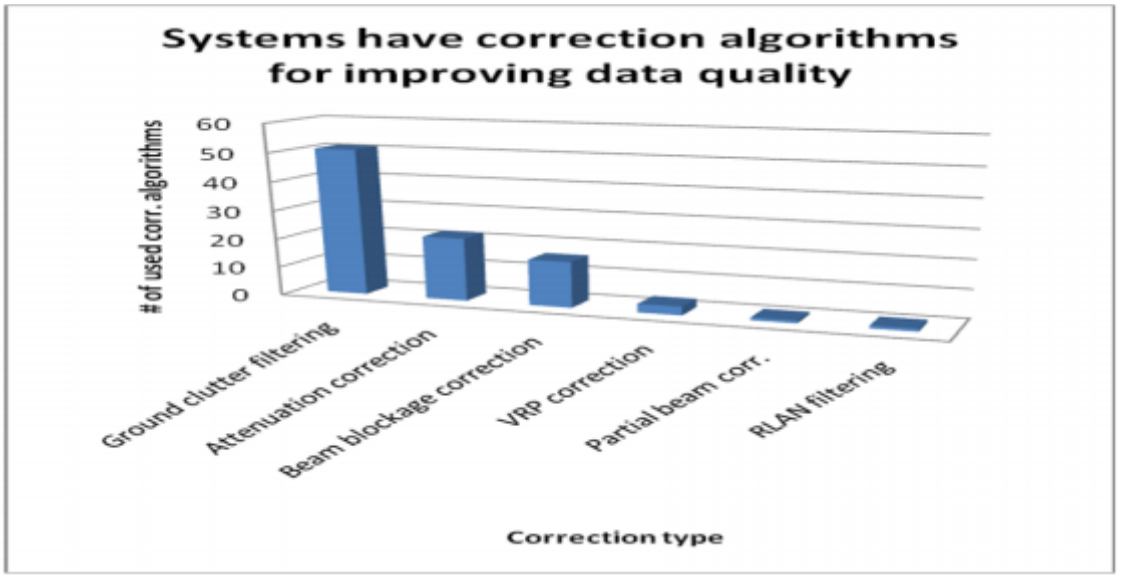


Fig. 9: Correction algorithms

Key findings: Significant number of participants has been stated that their systems have "Ground Clutter Filtering" algorithms for improving data quality. Some of the participants have "Attenuation Correction" and "Beam Blockage Correction" algorithms in their systems. Several participants indicated that "VRP Corr.", "Partial Beam Corr." and "RLAN filtering" algorithms have been included by their system.

Question 6.2: What is the average number of rain gauges for each radar?

This question has been included in the survey to reveal number of rain gauges used for Z-R calibrations for each radar.

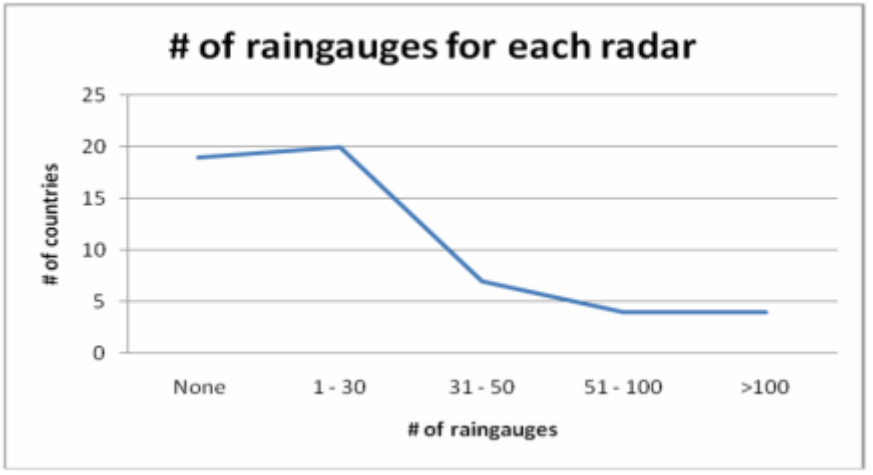


Fig. 10: Number of raingauges for each radar

Key findings: Significant number of participants doesn't have rain gauges interestingly. Again, most of the participants who are operating rain gauges have 1-30 rain gauges in the coverage of each weather radar. The rest of the participants which compose minority have a rich number of rain gauges for each radar. These participants have mainly 30-50 rain gauges, but in some cases have rain gauges reaching 400s for each radar.

Question 6.3: Do you use distrometer for data comparison? If your answer is yes, how many have been installed?

This question has been included in the survey to reveal distrometer usage for data comparison.

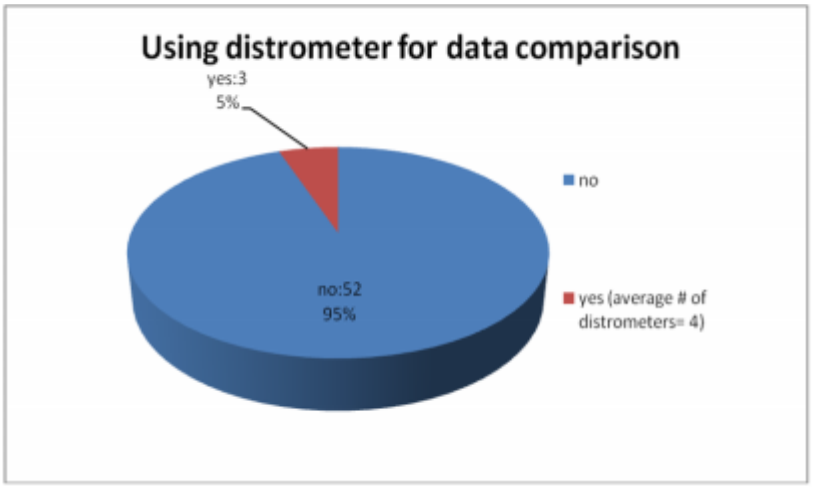


Fig. 11: Distrometer for data comparison

Key findings: Most of the participants don't use distrometers for data comparison. Since distrometers measures rain drop in terms of "reflectivity", they have been used for data comparison and/or improving data quality studies.

Question 7: What is the frequency of Preventive Maintenance for the main parts of the radars?

Since maintenance is a crucial issue for weather radar systems which have 24 hours working mechanical parts and parts which contain high voltage, to investigate intervals of preventive maintenance carried out for radars, this question has been addressed to the participants.

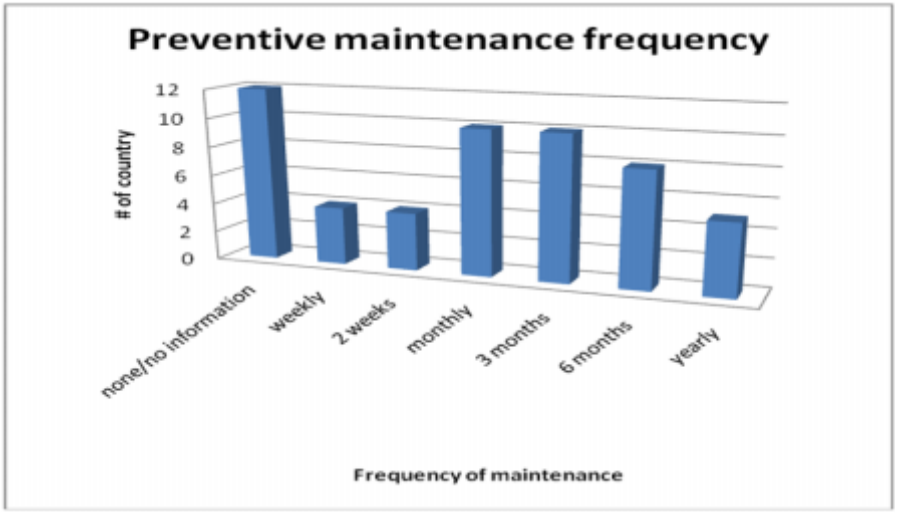


Fig. 12: Distrometer for data comparison

Key findings: "Monthly" and "3 monthly" preventive maintenance periods are the most common regular maintenance periods carried out by the participants. While some participants execute regular maintenance in fewer intervals like "6 monthly" or "yearly", on the other hand several participants carry out regular maintenance more frequently like "weekly" or "2 weekly". A considerable amount of the participants don't execute preventive maintenance to the radar systems or give no information regarding with this issue.

Question 7.1: Who carries out the maintenance of your radars after warranty period

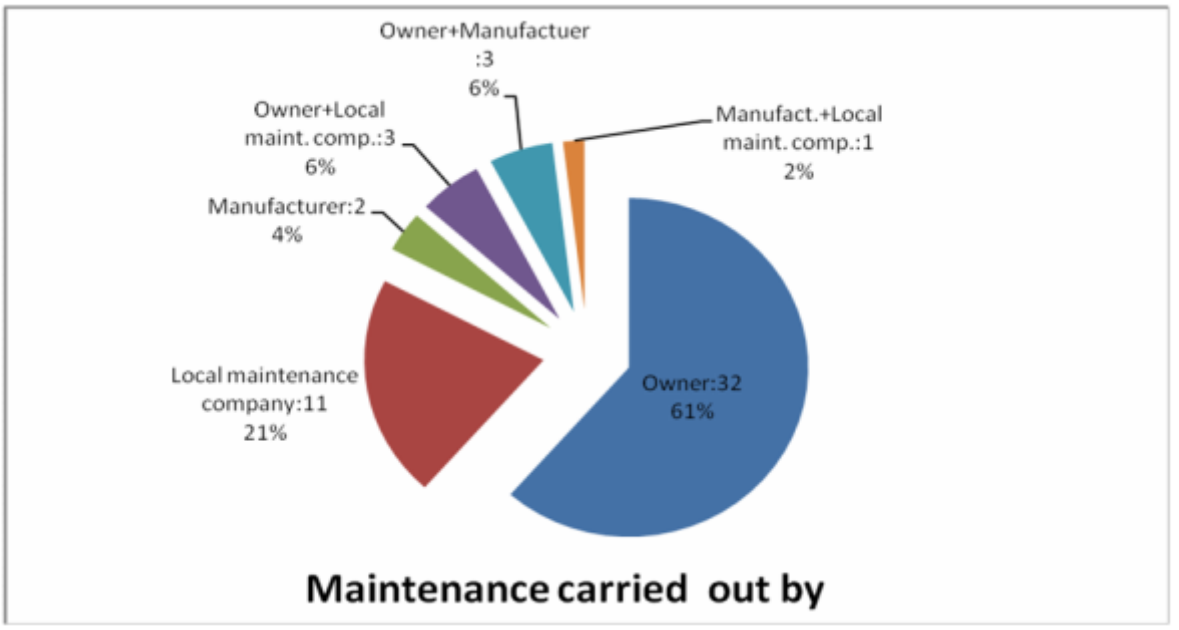


Fig. 13: Maintenance of weather radars

Key findings: Maintenance activities of weather radars are carried out by "Owner" mainly in the sense that weather radars are so specific and expensive systems, they should run continuously and they should be maintained rapidly. Similarly in some countries "Local Maintenance Companies" maintains weather radars. "Manufacturers" carry out maintenance also, but not so widespread.

Question 7.2: What are the main problems faced by your radar engineers in operating radars and solution methods?

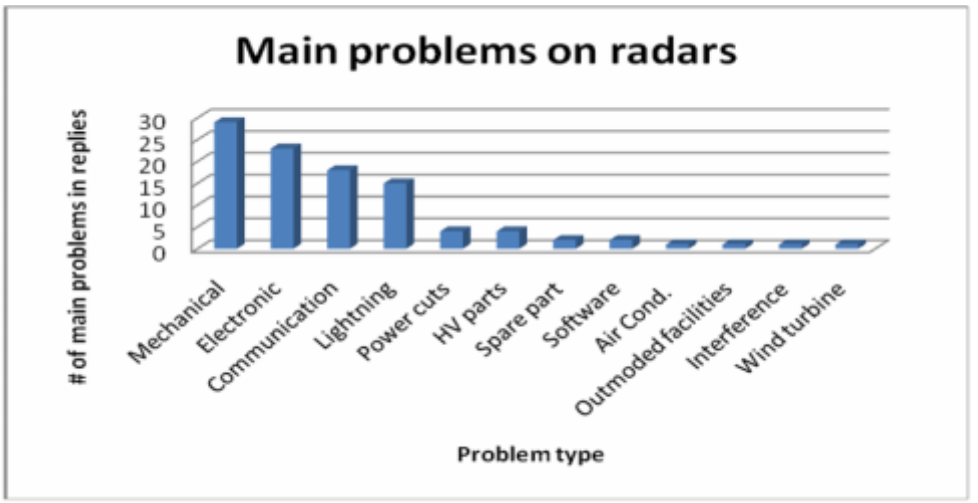


Fig. 14: Main problems on radars

Key findings: Mechanical, Electronics, Communication and Lightning problems are the main problems respectively. Precautions could be taken against this type of problems like preventive maintenance, keeping spare parts, backing-up, increasing measures. Some other problems faced in radar systems are power cuts, HV parts, shortage of spare parts, software, air conditioning, outmoded facilities, interference and wind turbines.

Question 7.3: Have you ever upgraded or are you planning to upgrade your radars? If you upgraded, Could you please give information about the upgrade process.

To gather information about the type of the common upgrades on weather radar systems, this question has been addressed.

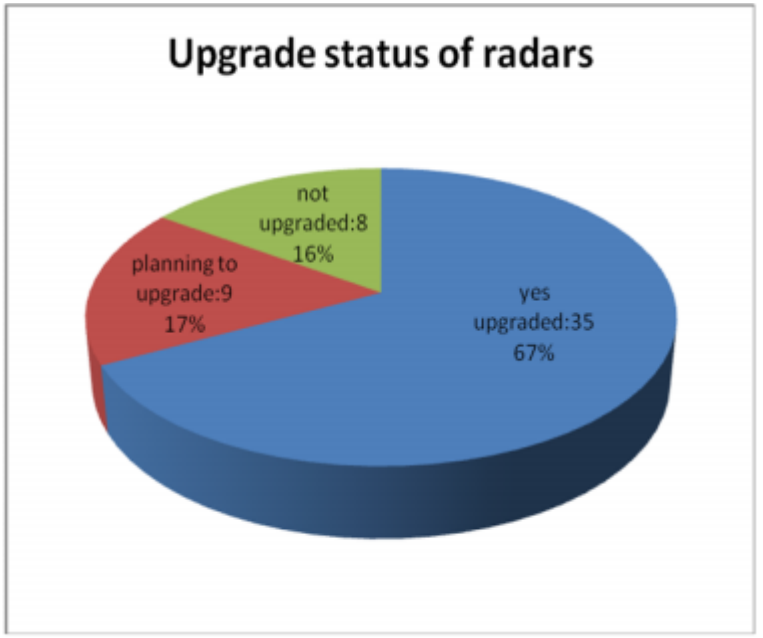


Fig. 15: Upgrade status of weather radars

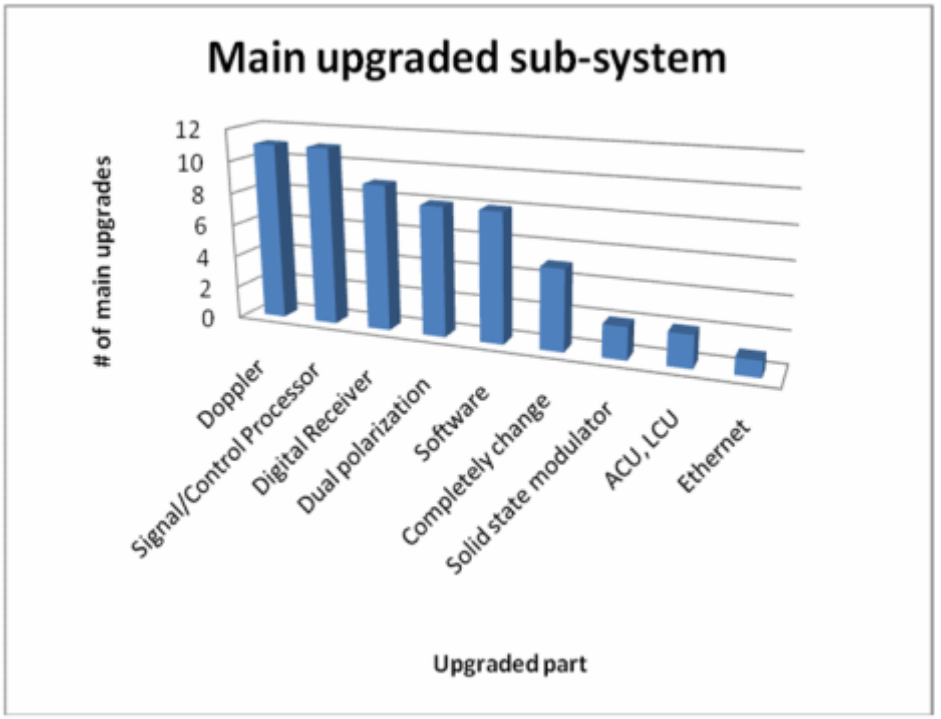


Fig. 16: Main Upgraded sub -system

Key findings: Weather radar systems are upgradable systems and some upgrades could be applied in parallel with new developments in time. "Doppler" and other "Signal/Control

Processor" upgrades have been applied to the systems according to the replies most commonly. Significant number of upgrades on "Analogue to Digital Receiver", "Dual Polarization" and "Software" has been implemented. Some of the participants "completely changed" the systems corresponding to the improvements. Several upgrades have been executed on "Solid State Modulators", "ACU/LCU Units" and "communication protocols like ethernet" with respect to the gathered information.

Question 7.4: Which countermeasures have been taken for lightning?

Owing to the fact that "Lightning" is one of the major problems faced by during radar operation, countermeasures against lightning strikes have been investigated by this question.

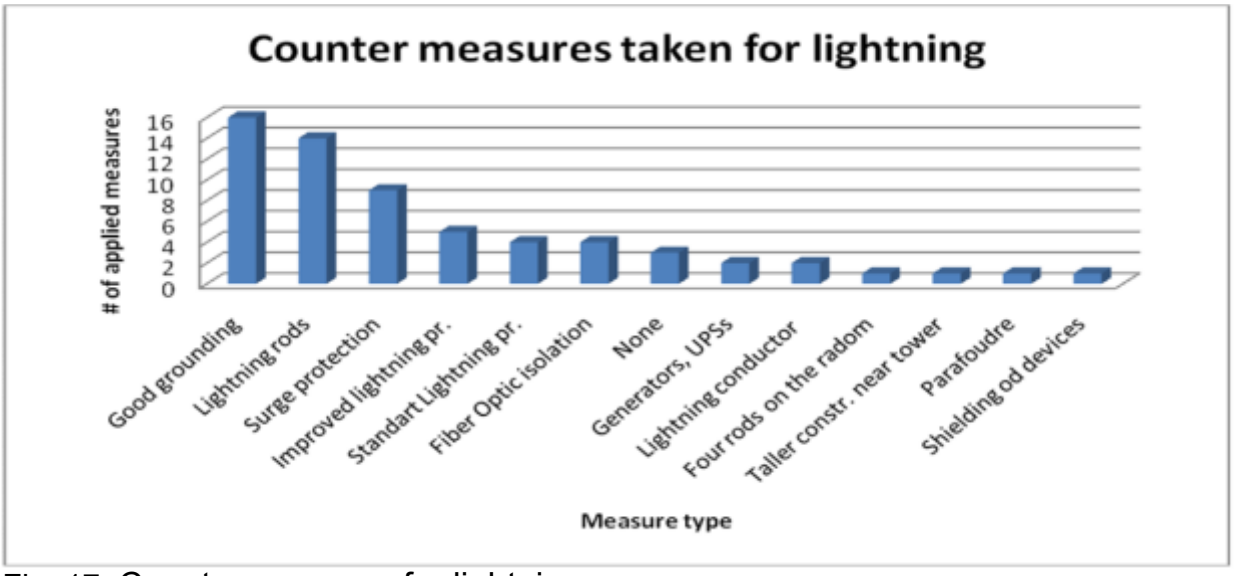


Fig. 17: Countermeasures for lightning

Key findings: "A good grounding" and "lightning rods" are the most common measures against lightning strike damages. "Surge protections" for data and power cables and "improving lightning protection like applying extra rods, decreasing grounding with more down conductors

Question 7.5: Do you carry out any calibration on your radar(s)?

Calibrations performed on the radar systems effect radar data quality. When considered this point of view, calibration activities are very crucial in radar operation.

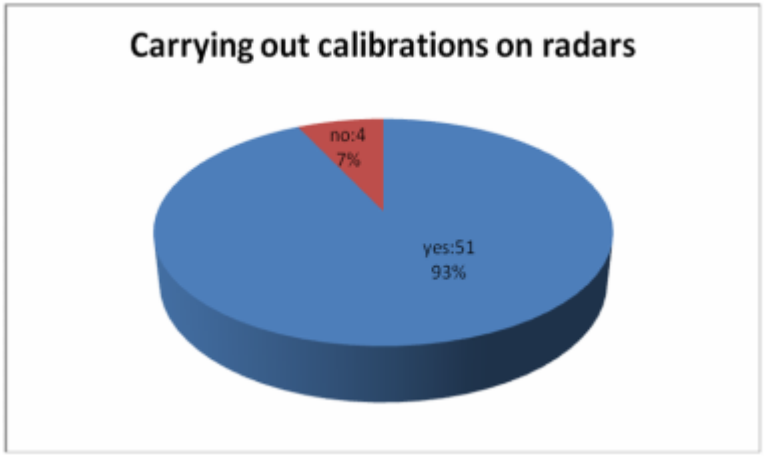


Fig. 18: Countermeasures for lightning

Key findings: Almost all participants have carried out calibration on weather radars; nevertheless several participants haven't implemented any calibration on their radar systems still.

Question 7.6: If answer to above question is yes, please specify which calibration and how frequently you carry.

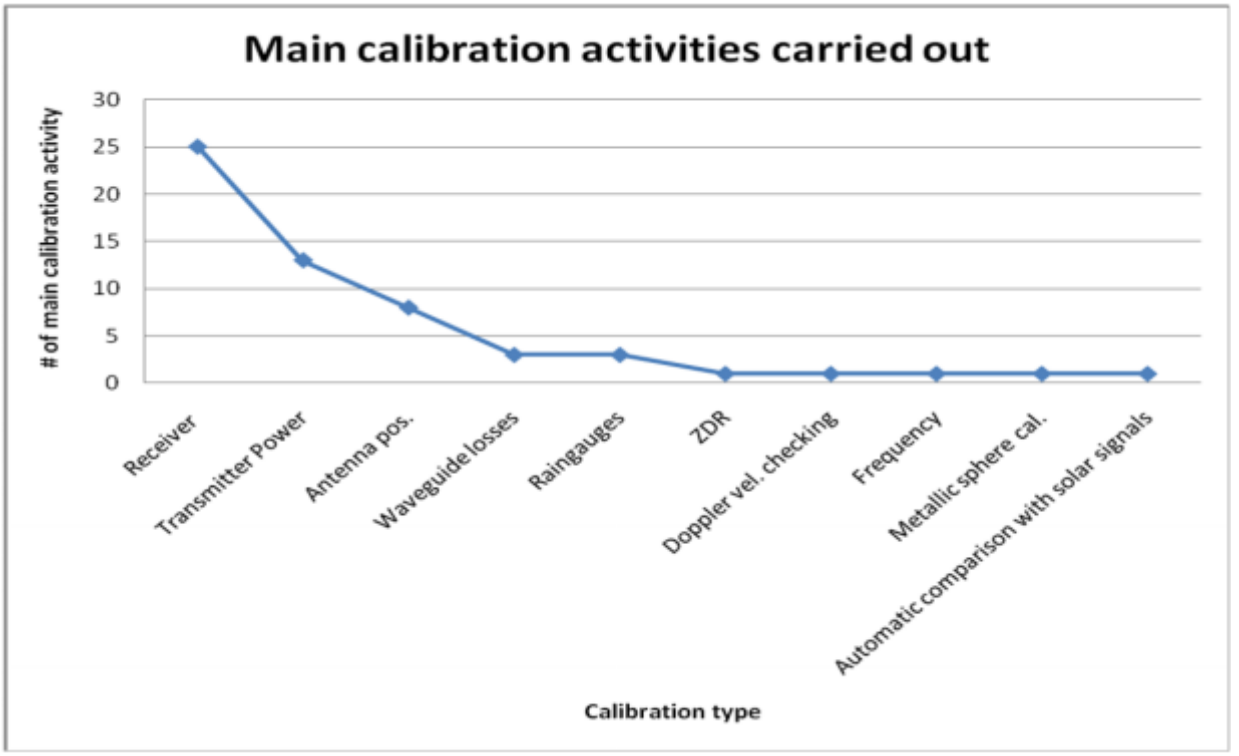


Fig. 19: Main calibration activities for weather radars

Key findings: The main calibration performed on the weather radars is "Receiver Calibration" which is performed by participants. Some of the participants carry out "TX Power" and "Antenna Position" calibrations as well. Several participants perform calibrations like "Wave guide Loss", "Rain gauge", "ZDR", "Doppler Vel. Checking", Frequency", Metallic Sphere Cal.", "Automatic Comp. with Solar Signals".

Question 8: What types of training have been carried out for operating radars? Do you collaborate with other countries or manufacturers?

Training is a must for radar operators and radar engineers. For operating a weather radar network continuous training and if possible collaboration with other NHMSs around which are operating weather radars would be very useful for having experienced staff and efficient utilization from weather radars.

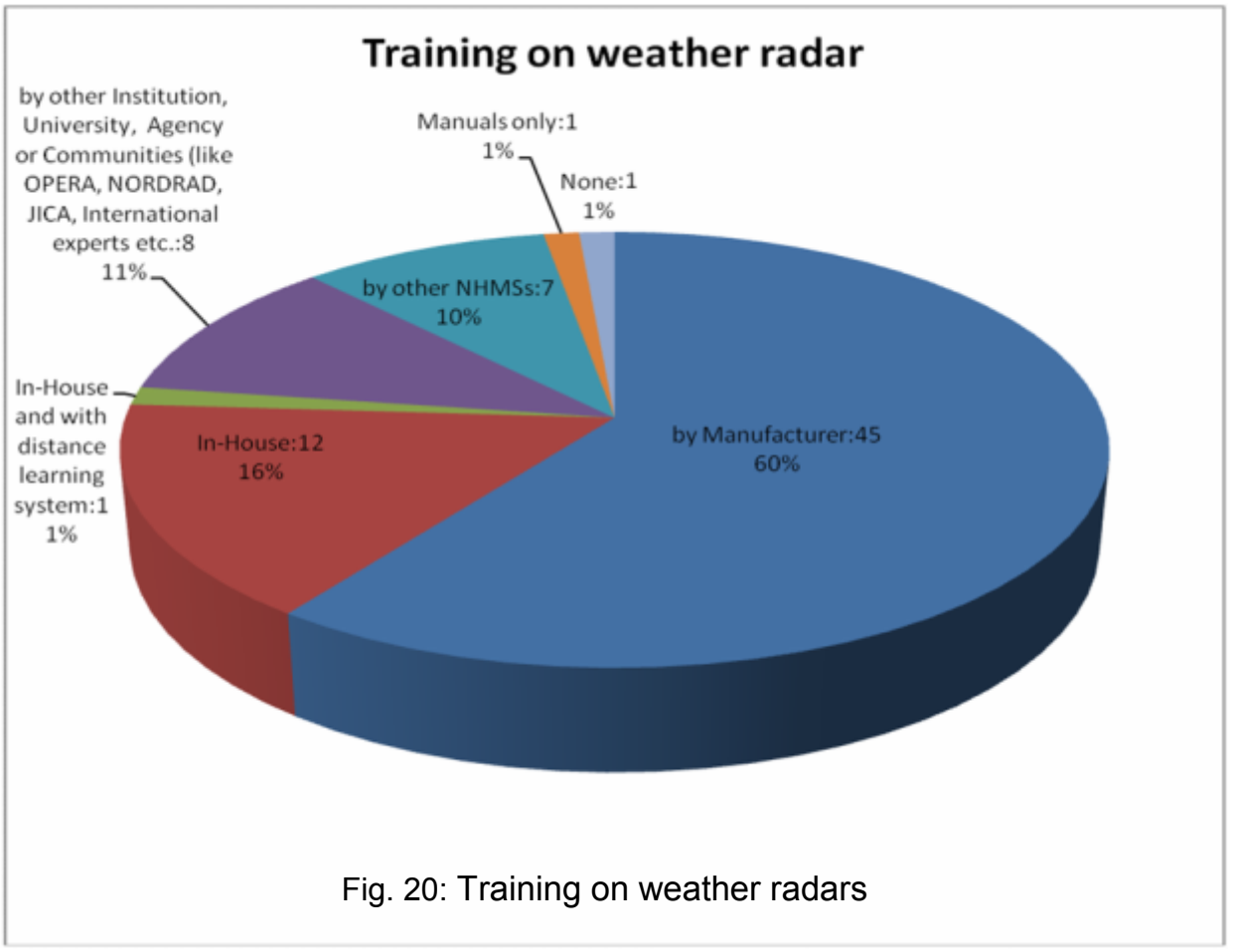


Fig. 20: Training on weather radars

Key findings: "Training by Manufacturers" is the most common training for weather radars and should be applied at least. "In-house training" is also realized by some participants which is important to train new staff. Rarely "distance learning system" has been used for in-house training also. "Training by the other NHMSs or other operators", "Training by other Institutions, Universities, Agencies, Communities (like WMO, OPERA, NORDRAD, JICA) and International Experts" has been taken by some participants. Sharing experiences and these type of trainings should be encouraged Distance learning system can be used for these kind of trainings.

Question 8.1: Do you have any recommendation about "training" of radar engineers and operators?

Key findings: Recommendation and opinions from the replies regarding with "training" about weather radars could be summarized as below:

Importance of "Continuous and frequent training", "Training of junior staff", "Training by Manufacturers", "Carrying out on the job trainings", "Trainings carried out by WMO regarding

with weather radars", "E-learning and distance learning systems", "Case studies", "Following new technologies", "OEM courses", "Workshops" have been emphasized by the participants.

Question 8.2: Mission, education level and number of the staff working on radar related works.

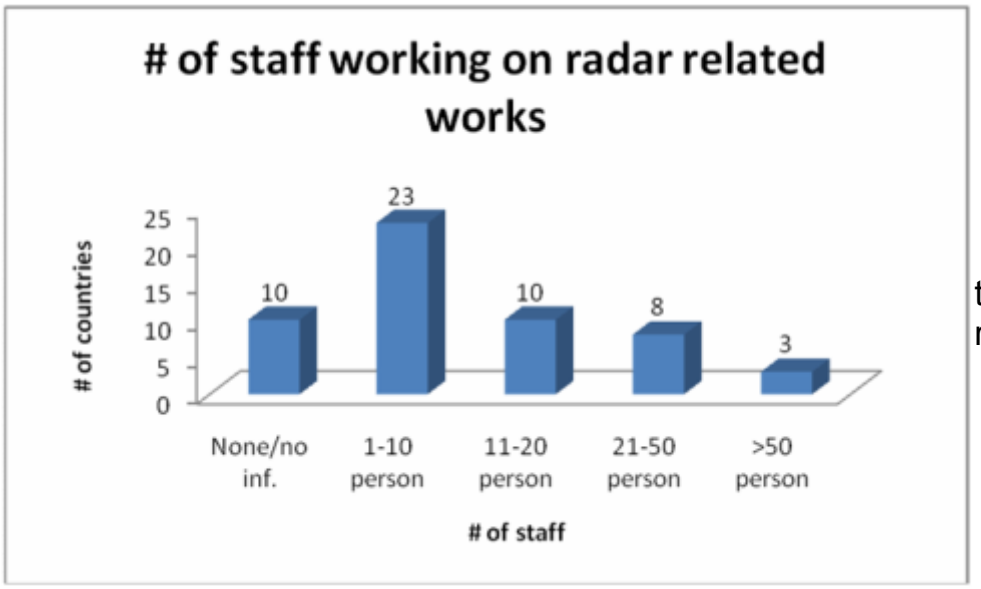


Fig. 21: Number of the staff working on radar related works

Key findings: Number of staff working related with weather radars is changing depending on size of the network and the sources of the participants. Most of the participants have been charged 1-10 people associated with operating weather radars. Several participants which have large networks have more than 50 staff for this purpose, even in some cases this number reaches up to 840 people.

Question 9: Operation procedures

This question has been addressed to the participants to investigate how frequently and in which cases weather radars have been operated.

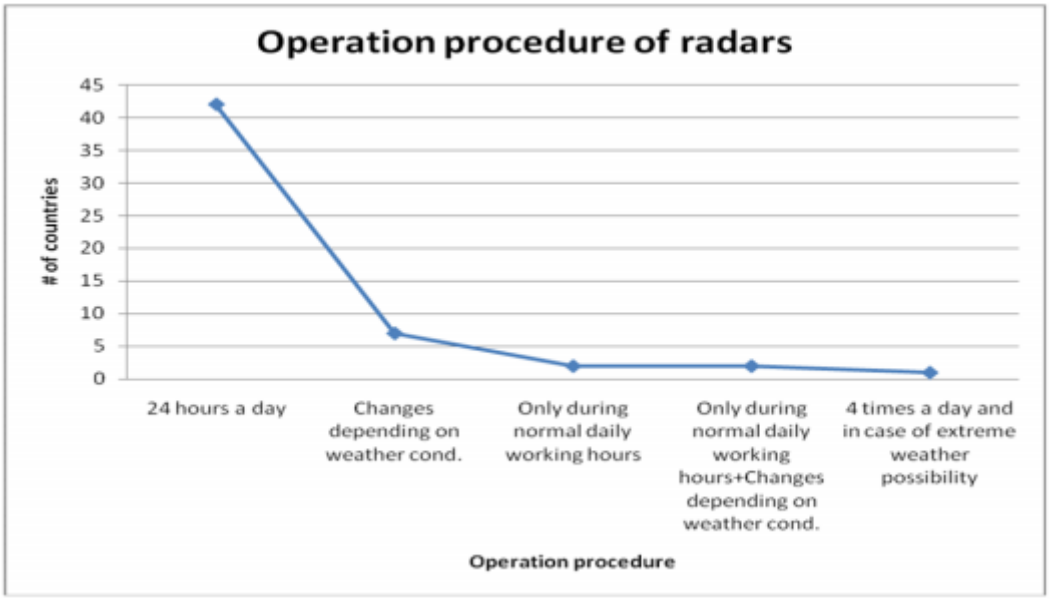


Fig. 22: Operation procedures of radars

Key findings: From the gathered information, clearly observed that most of the weather radars have been operated "24 hours a day". Some of the participants have been stated that they run weather radars "depending on weather conditions". Other several weather radar networks have been operated "only during normal daily working hours" and periodically like "4 times a day and in case of extreme weather possibility".

Question 10: Prioritize utilization of weather radars in your Organization

In general, owners have utilized from weather radars much more than their main requirements of those systems. To get the main utilization fields, this question has been included in the survey.

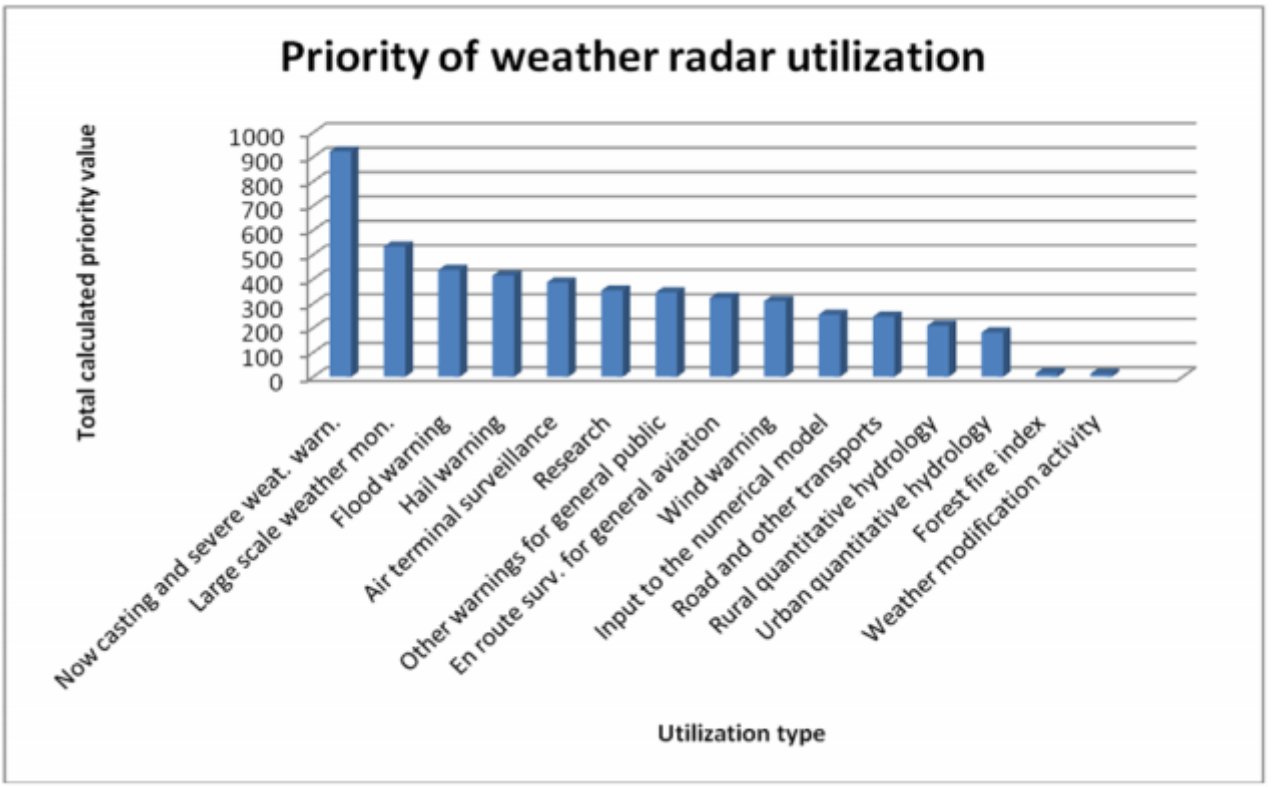


Fig. 23: Priority of weather radars utilization

Key findings: As anticipated, most common utilization is also the main requirement of the weather radars, "Nowcasting and severe weather warning". A point appointed for each priority level and total priority value calculated from responses during evaluation. Utilization of weather radars could be classified according to priority respectively:

1. Nowcasting and Severe Weather Warning,
2. Large Scale Weather Monitoring,
3. Flood Warning,
4. Hail warning,
5. Air Terminal Surveillance,
6. Research,
7. Other Warnings for General Public,
8. En route Surveillance for General Aviation,
9. Wind Warning,
10. Input to the Numerical Model,
11. Road and Other Transports,
12. Rural Quantitative Hydrology,

13. Urban Quantitative Hydrology,
14. Forest Fire Index Input,
15. Weather Modification Activity.

Question 10.1: Monitoring of the radar (time basis)

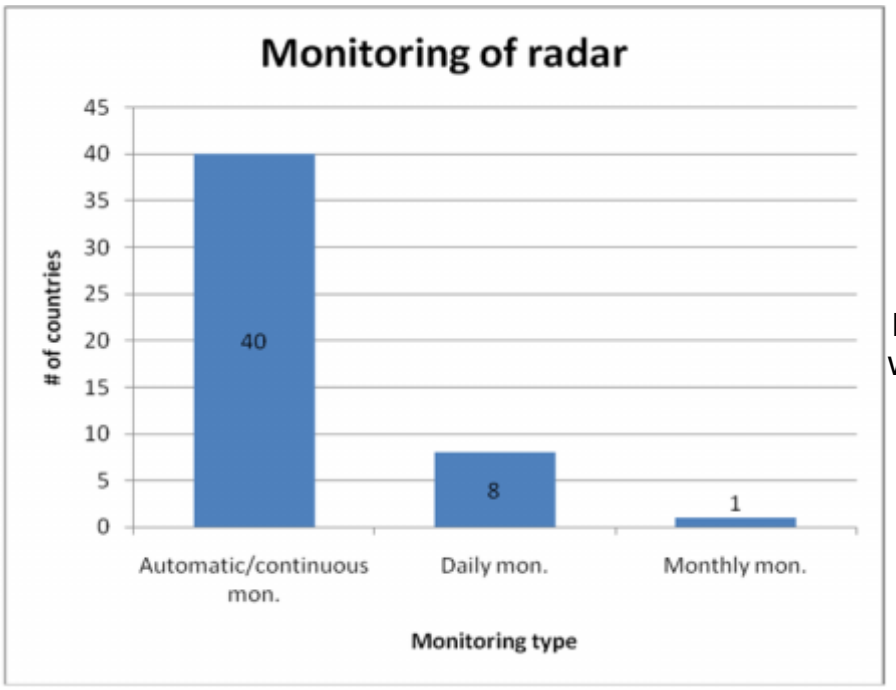


Fig. 24: Priority of weather radars utilization

Key findings: Most of the weather radars have been monitored automatically/continuous nowadays. Few radars have been monitored "daily" or with more intervals.

Question 10.2: Remote terminals used by the remote users

Weather radars have remote terminals and displays on the outside of the main radar centres for different utilizations. This question has been addressed to reveal remote terminals served.

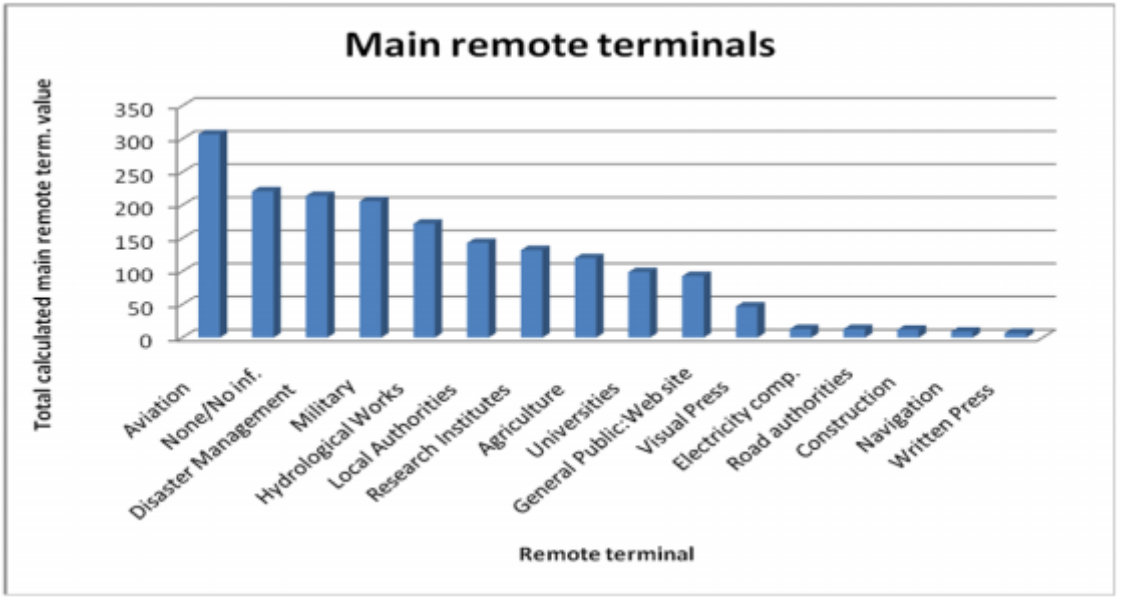


Fig. 25: Main remote terminals of weather radars

Key findings: A point appointed for each level of main remote terminal and total main remote terminal value calculated from responses during evaluation. "Aviation" is the main field that has the remote terminals of the weather radars. Considerable amount of the remote terminals has been served to "Disaster Managements" and "Militaries". Some participants have remote terminals in "Hydrological Works", "Local Authorities", "Research Institutes" and "Universities". At the least, several participants have remote terminals for "Visual Press", "Electric Companies", "Road Authorities", ""Construction Companies", "Navigation" and "Written Press".

On the other hand, considerable amount of the participants have no remote terminals and most of them serves with web pages to the General Public.

Question 10.3: Advanced use of radar data

This question has been included in the survey to reveal advanced use of weather radars.

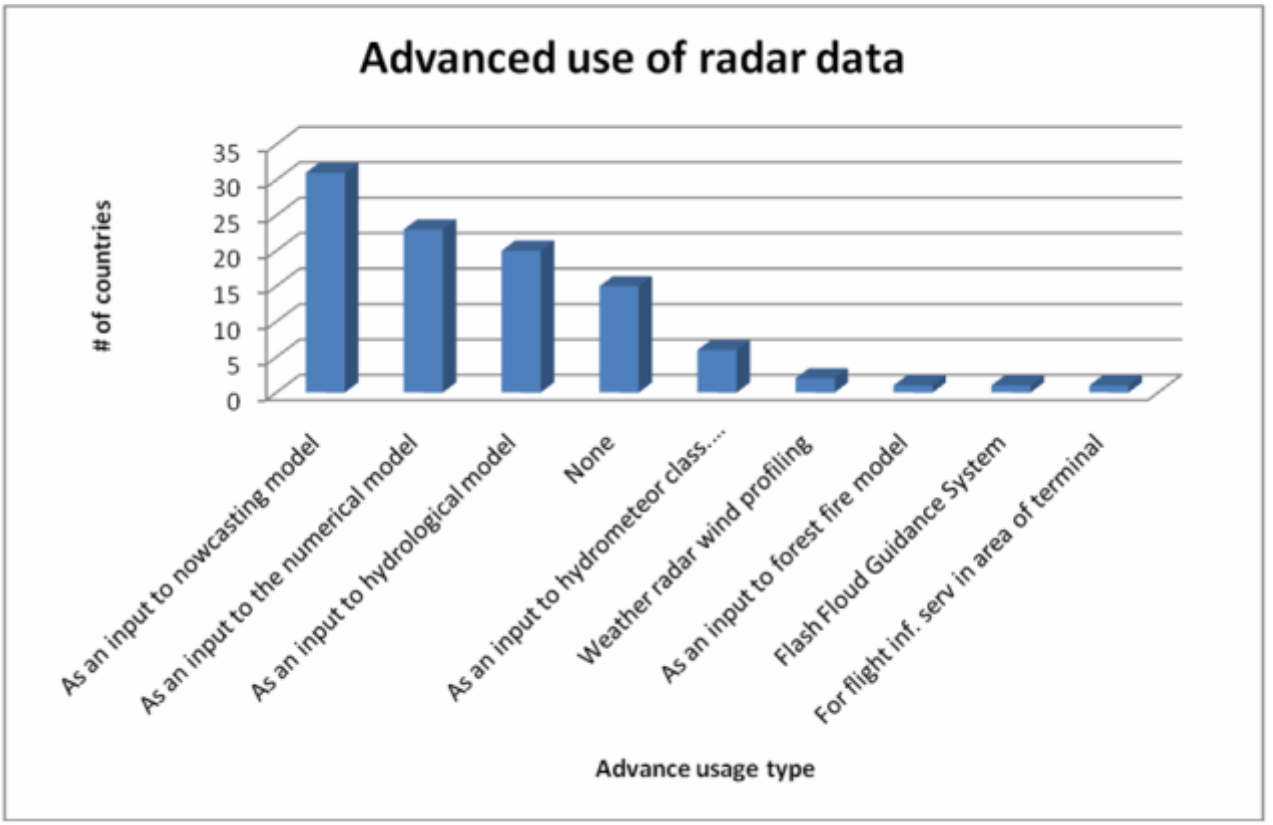


Fig. 26: Advance use of radar data

Key findings: Weather radars have been used for "as an input to nowcasting, numerical and hydrological models" as advanced use with respect to the replies mainly. Some of the participants don't have any advanced use of weather radars. Few of the participants have advanced uses like ""as an input to hydrometeor classification", "weather radar wind profiling", "as an input to forest fire model", "flash flood guidance system", "flight information service in area of terminals".

Question 10.4: Operating system running on your radar servers?

This question has been included in the survey to search operating systems used in the radar servers.

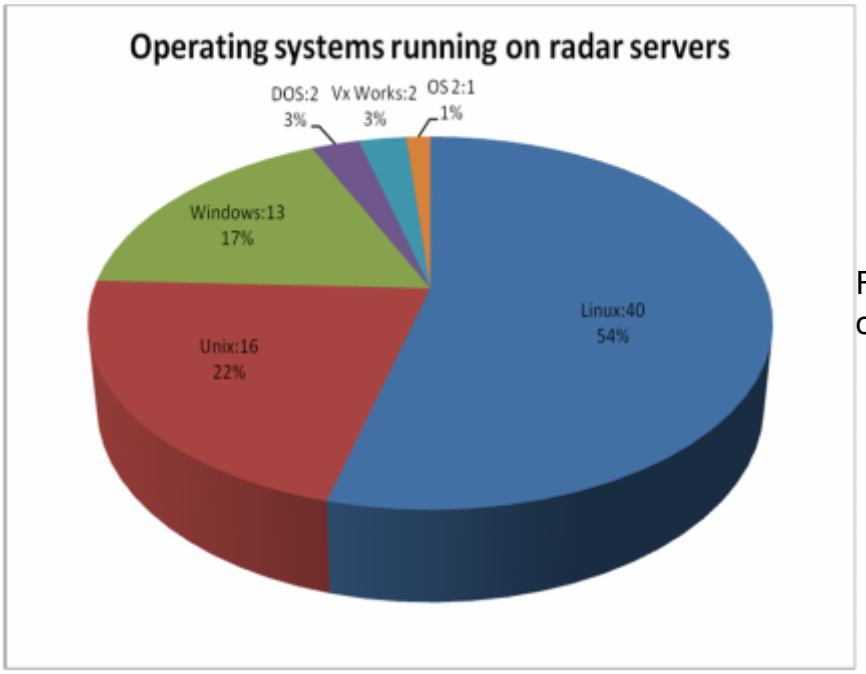


Fig. 27: Main remote terminals of weather radars

Key findings: "Linux" operating systems has been used mainly and "Unix" operating system has been used by significant number of radar servers. In addition to this, "Windows" operating system has been used by some of radar serves and several radar servers use "DOS", "Vx Works" and "OS 2" operating systems.

Question 10.5: What is the name of the radar control and data acquisition software?

To gather information about radar control and data acquisition softwares used by the participants this question has been addressed.

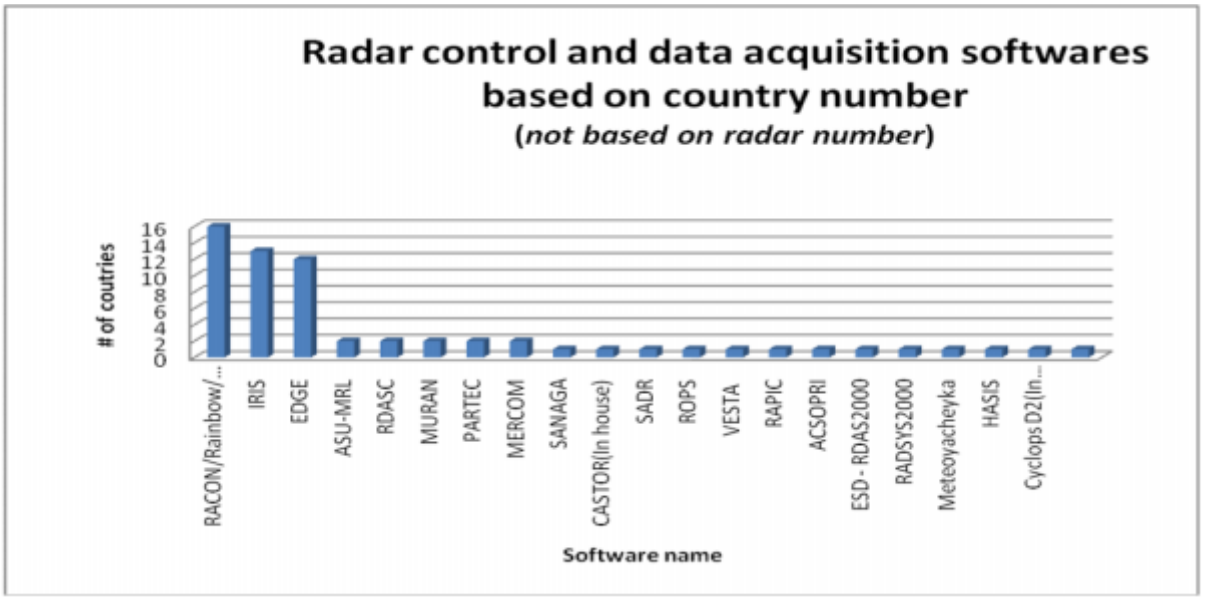


Fig. 28: Radar control and data acquisition software

Key findings: The participants have been stated the software types for radar control and data acquisition. "RACON/Rainbow/GDRX", "IRIS" and "EDGE" softwares have been used in wide range, if the number of radars don't taken in to consideration in the statistics. Please note that the evaluation is independent from the number of radars. The participants have been stated the software names without considering radar numbers.

Question 10.6: What is the name of the product generation software?
Question 10.7: How is radar products displayed?

To gather information about product generation and display softwares used by the participants those questions has been addressed.

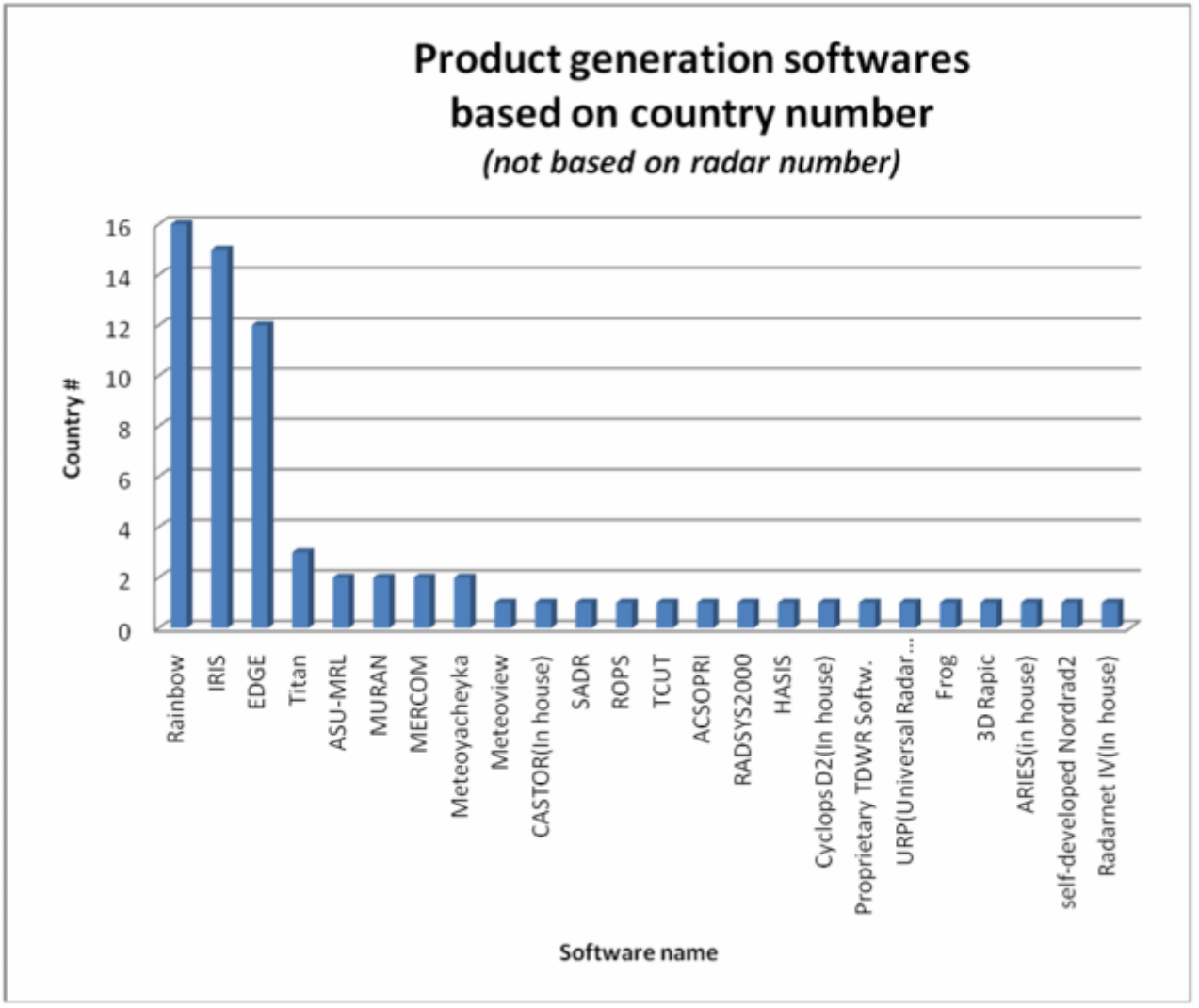


Fig. 29: Product generation software

In the graph, product generation softwares have been provided. Display for products used by participants are "Graphical (Rainbow, IRIS, EDGE, Titan etc.) display", "home grown softwares", "McIDAS workstations", "Web based user interface for Internet" and "Intranet, R&D and commercial software applications".

Key findings: The participants have been stated the software types for product generation. "Rainbow", "IRIS" and "EDGE" softwares have been used in wide range, if the number of radars don't taken in to consideration in the statistics.

Question 10.8: The user interface of your radar control/data acquisition software

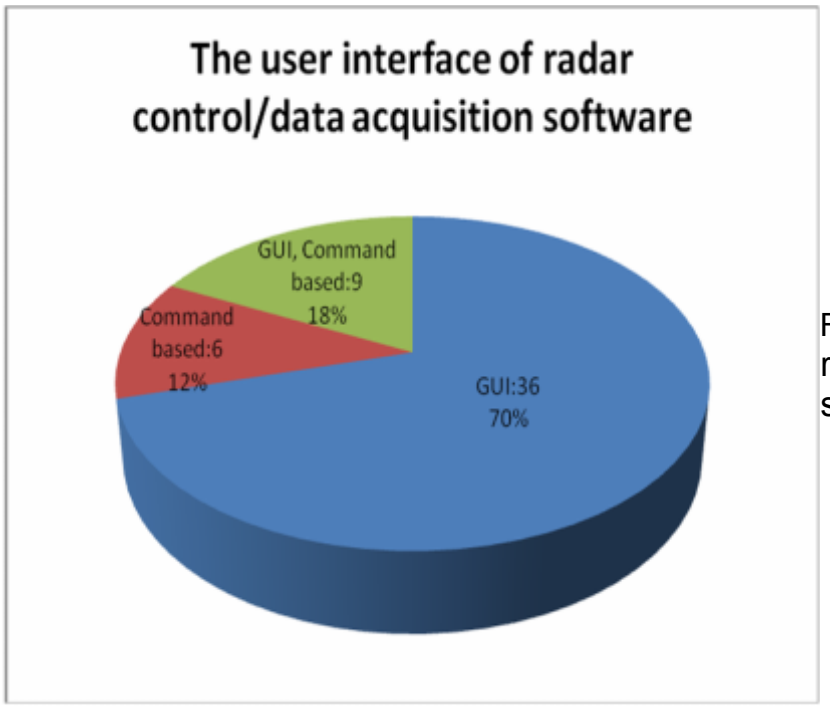


Fig. 30: User interface of radar control/data acquisition software

Key findings: Most of the weather radars have Graphical User Interfaced radar control and data acquisition softwares nowadays with respect to the replies. Few radars have only "Command based" radar control and data acquisition softwares.

Question 10.9: The method used for controlling radar network and task/product schedules.

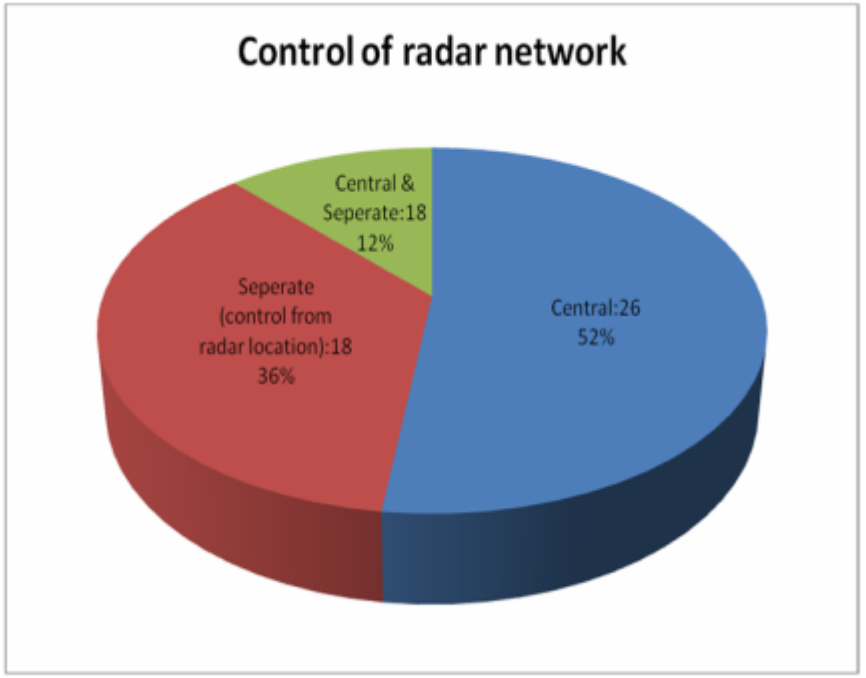


Fig. 31: Control of radar network

Key findings: Most of the weather radar networks have been controlled and operated centrally according to the gathered information. However significant number of participants stated that they have been operating their radars locally.

Question 10.10: What is the assumed radar-coverage area of your country?

This question has been included in the survey to reveal radar coverage areas of the countries.

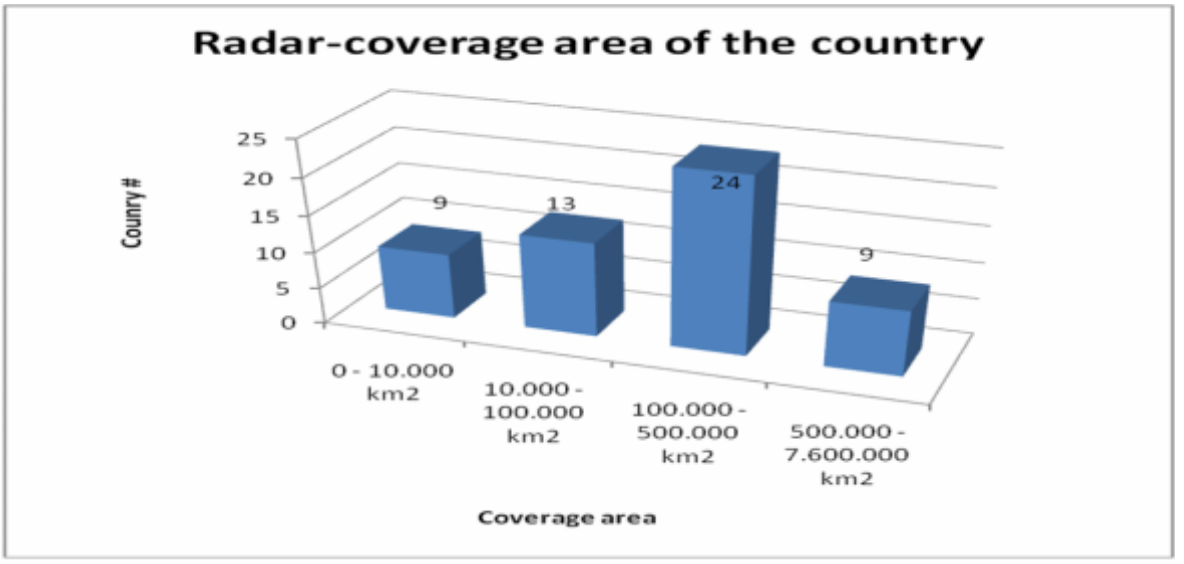


Fig. 32: Radar-coverage area of the country

Key findings: More than half of the countries have a very large radar coverage in conjunction with the areas of the countries as observed from the graph.

Question 10.11: What is the approximate percentage of radar-coverage area to your country's area?

Weather radar networks still have been enlarging in the world. Percentage of radar-coverage area to the country's area can give some idea pertaining to enlargement.

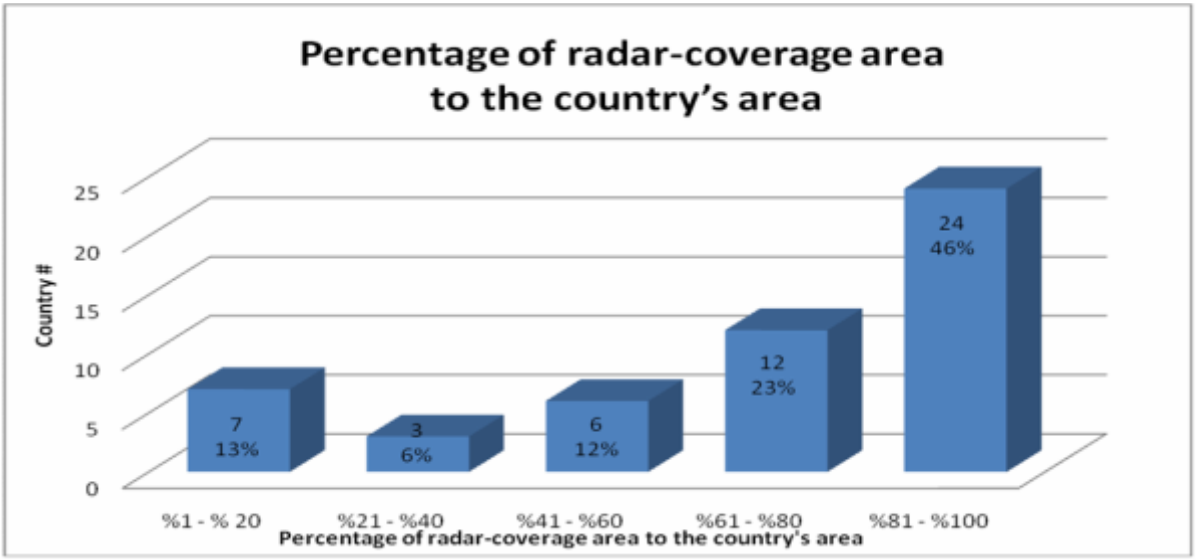


Fig. 33: Percentage of radar-coverage area to the country's area

Key findings: Less than half of the participants have been completed their radar networks approximately and almost one fourth of the participants have completed two third of their network. On the other hand, one third of the participants have less than half coverage in their countries. Considering uncompleted networks and upgrade of outmoded radars, continuity of weather radar installations can be anticipated.

Question 10.12: Number of radar systems integrated in network?

This question has been addressed to observe the number of radar integrated in the networks.

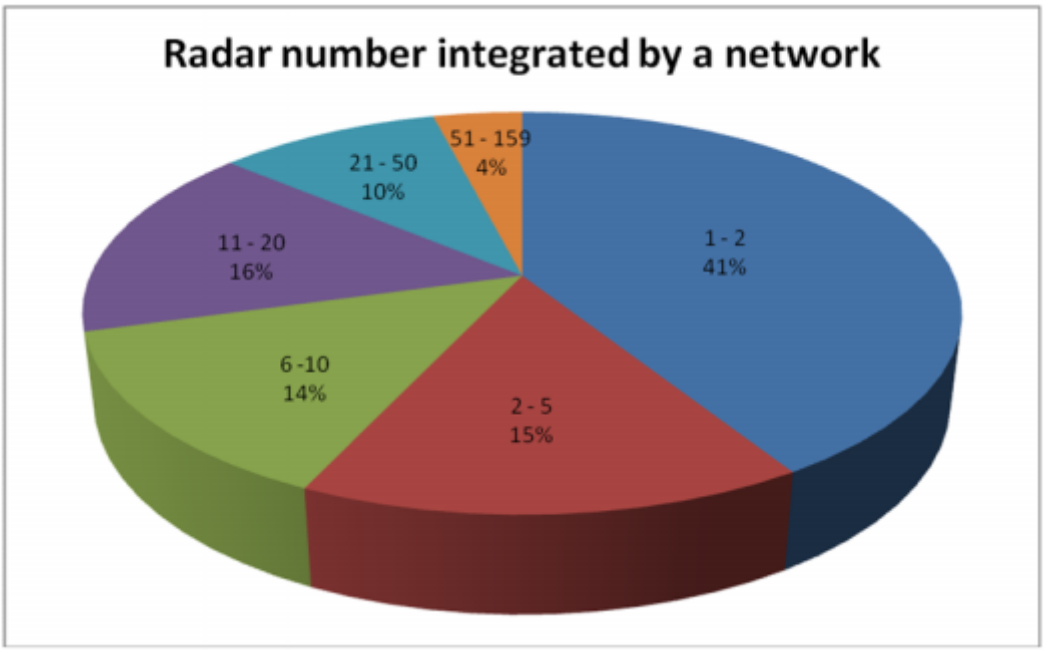


Fig. 34: Number of radar systems integrated by network

Key findings: Most of the participants operate 1 or 2 weather radars in their networks. On the other side, only several participants have a high number of weather radars in their networks, between 50 and 159. The rest and almost equivalent number of the participants have networks with "2-5", "6-10", "11-20" and "21-50" radars in line with size of the countries.

Question 10.13: How many kind of products (approximately) are generating in operating centre?

This question has been addressed to observe the number of products generated in radar operating centres.

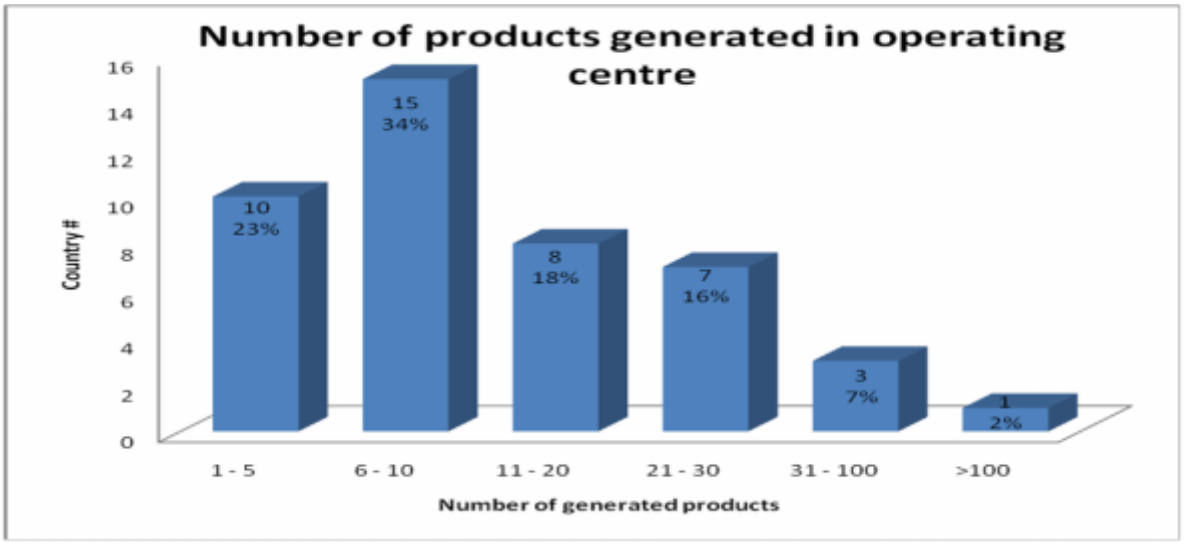


Fig. 35: Number of products generated in operating centre

Key findings: The outcome of the replies is remarkable for this question. The range of the number of the products generated starts from "1-5" to more than 100. The reasons for this huge difference would be synergetic usage of radars with other instruments and data sources, single/polarimetric radars, non-doppler/doppler radars etc. But this difference is still so high and more efficient utilization from weather radars should be endeavoured.

Question 10.14: Is there any system back-up?

For an uninterrupted operation of the weather radars some back-up options have been deployed. By this question more common back-ups has been investigated.

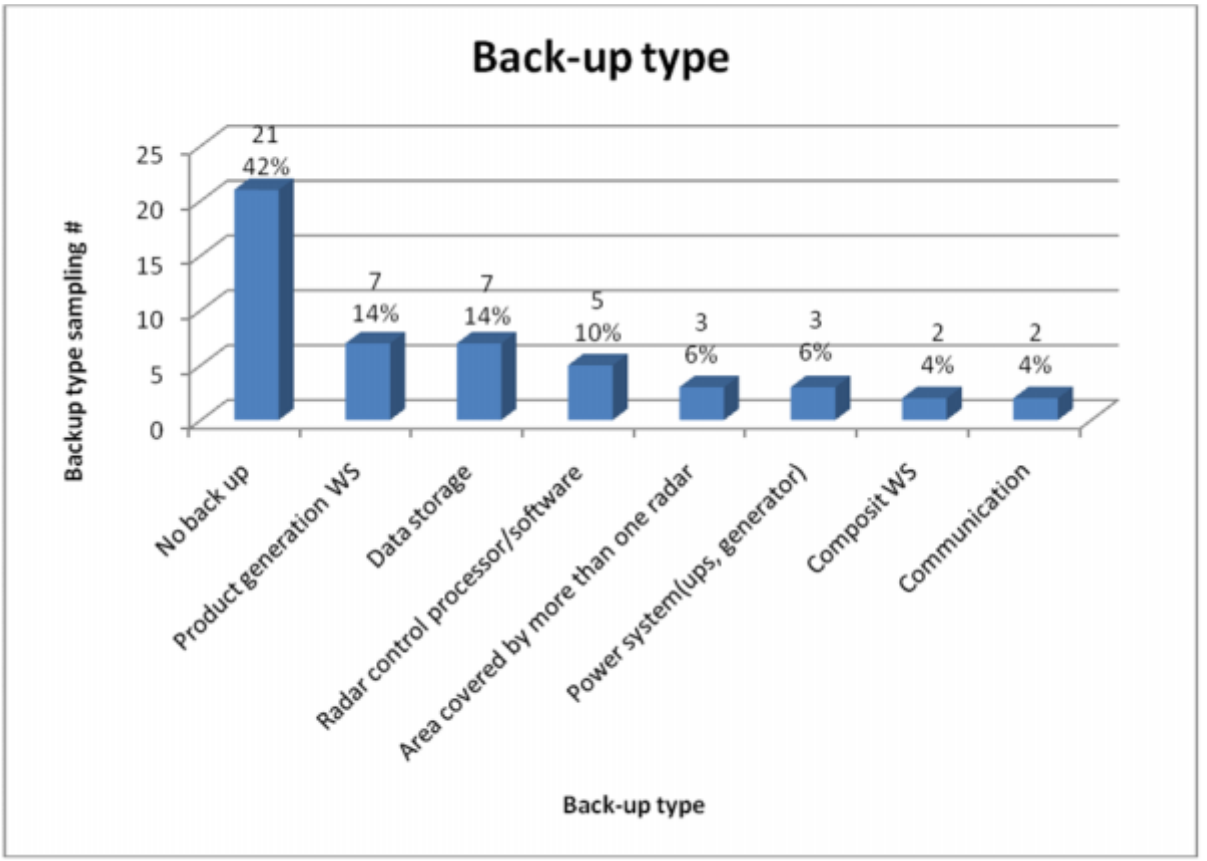


Fig. 36: Back-up types on weather radars

Key findings: Most common back-ups have been performed for "Product Generation" and "Data storage" units with respect to the replies. Those are followed by "Radar Control Processors/Softwares", "Power Systems (ups, generators etc.)", "Composite Workstations" and "Communication Equipments/Lines" respectively. Another backing-up method is "Covering same area by more than two radars". On the other hand, significant number of the participants doesn't have a back-up in radar operation which can cause an increase in interruption period.

Question 11: Please indicate if you exchange/disseminate radar data with other countries and/or organizations?

To gather information corresponding to data exchange and dissemination this question has been addressed to the participants.

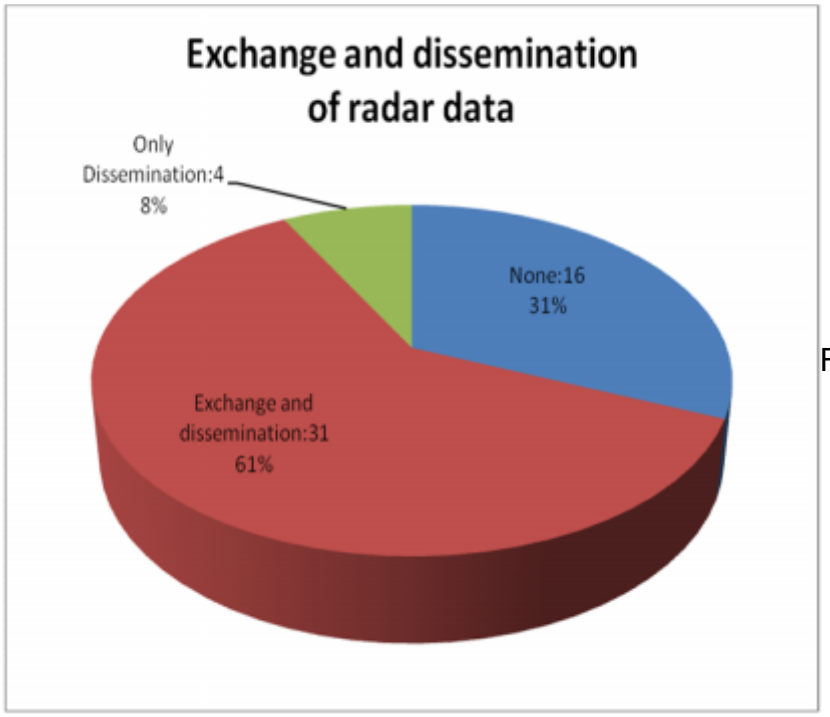


Fig. 37: Exchange/disseminate radar data

Key findings: "Data exchange and dissemination" have been performed substantially. But, considerable amount of the participants don't exchange or only disseminate radar data still. In this question, some participants have provided exchanged data type too. Pseudo CAPPI, Cwinde(VAD), PPI, SRI, ECHO TOP and raw data have been exchanged according to those information.

Question 11.1: Telecommunication method used for international data exchange and dissemination.

This question has been included in the survey to search common telecommunication methods used for international data exchange/dissemination.

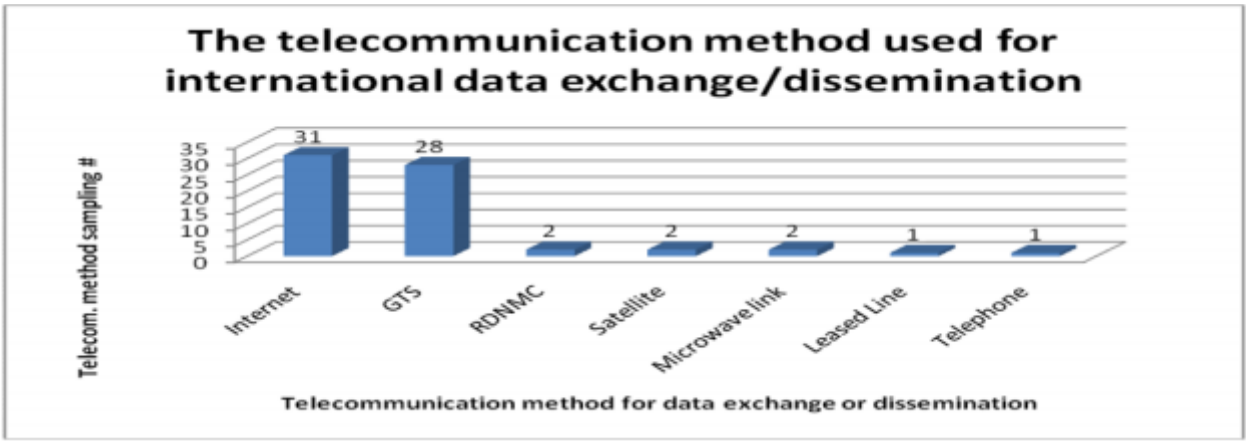


Fig. 38: Telecommunication method used for intern. data exchange and dissemination

Key findings: "Internet" and "GTS" are used for international data exchange/dissemination dominantly. However, "RDNMC", "Satellite", "Microwave link", "Leased line" and "Telephone" are used with few exceptions.

Question 11.2: What is your exchange format (s) – please list?

This question has been included in the survey to reveal exchange formats.

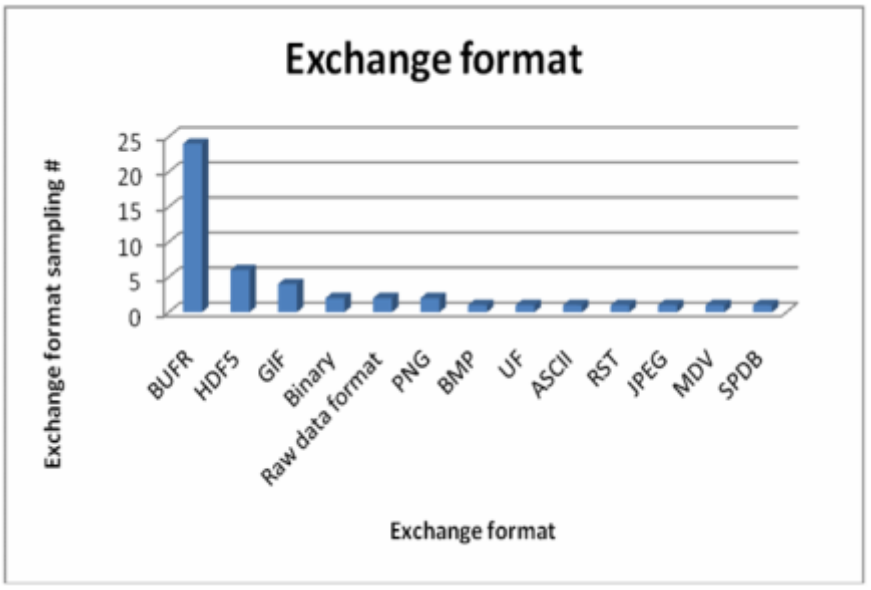


Fig. 39: Exchange Format

Key findings: "BUFR" format has been used far and away for radar data exchange. "HDF5" and "GIF" formats also have been used in some cases. On the other side, "Binary", "Raw data format", "PNG", "BMP", UF", ASCII", "RST", "JPEG", "MDV" and "SPDB" formats have been used occasionally.

Question 11.3: The data type archived

This question has been addressed to reveal distributions of archived data types.

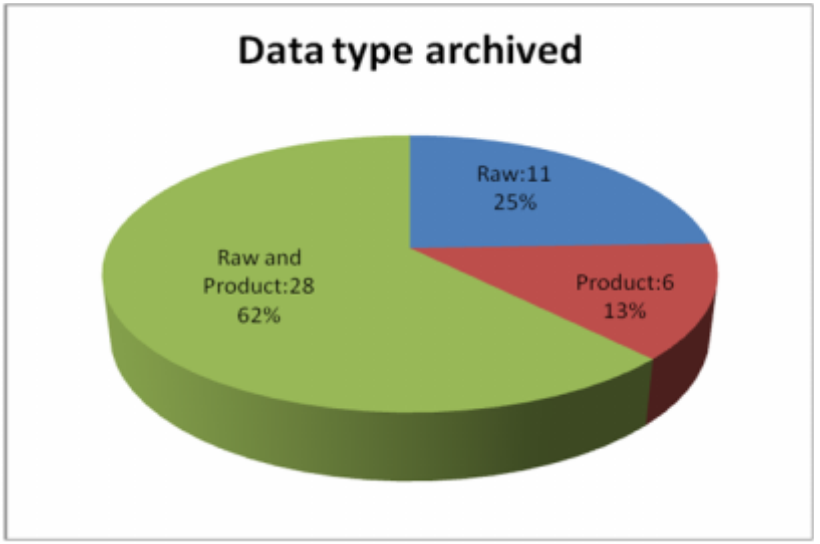


Fig. 40: Data type archived

Key findings: Most of the participants have been archiving both "raw data" and "some products". One fourth of the participants have archived only "raw data". A small portion of the participants have been archiving only some selected "products".

Question 11.4: Raw Data Archive strategy

To investigate raw data archive strategies, this question has been included in the survey.

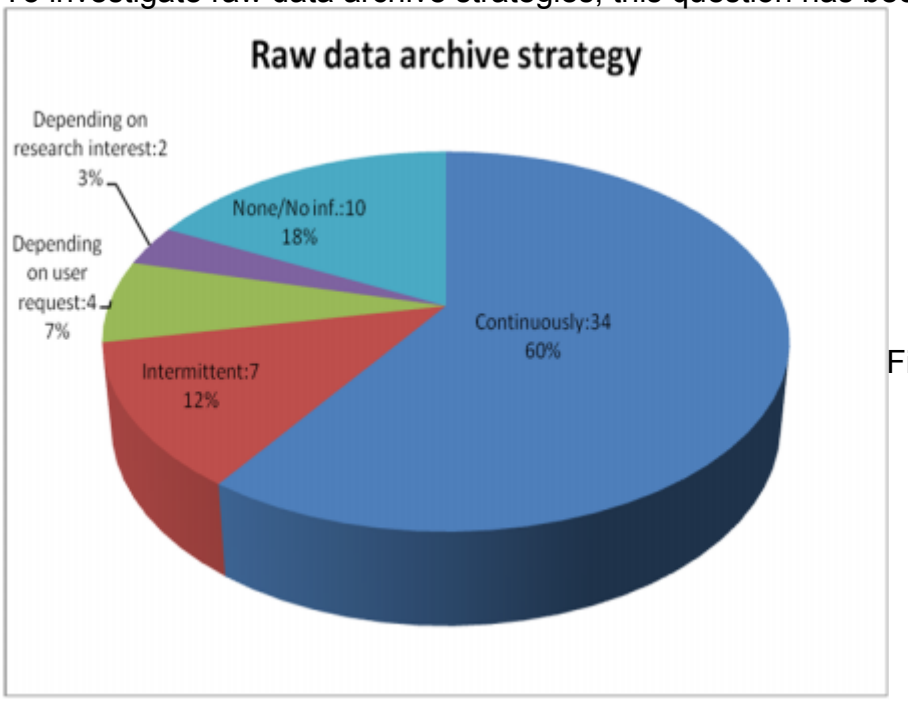


Fig. 41: Data type archived

Key findings: With respect to the replies, "continuous" archiving of raw data is the most common used strategy while considerable amount of the participants don't archive raw data. Some of the participants have been archiving raw data "intermittently". Again several participants have been archiving raw data "depending on user request" and "depending on research interest".

Question 11.5: Product Archive strategy

To investigate product archive strategies, this question has been included in the survey.

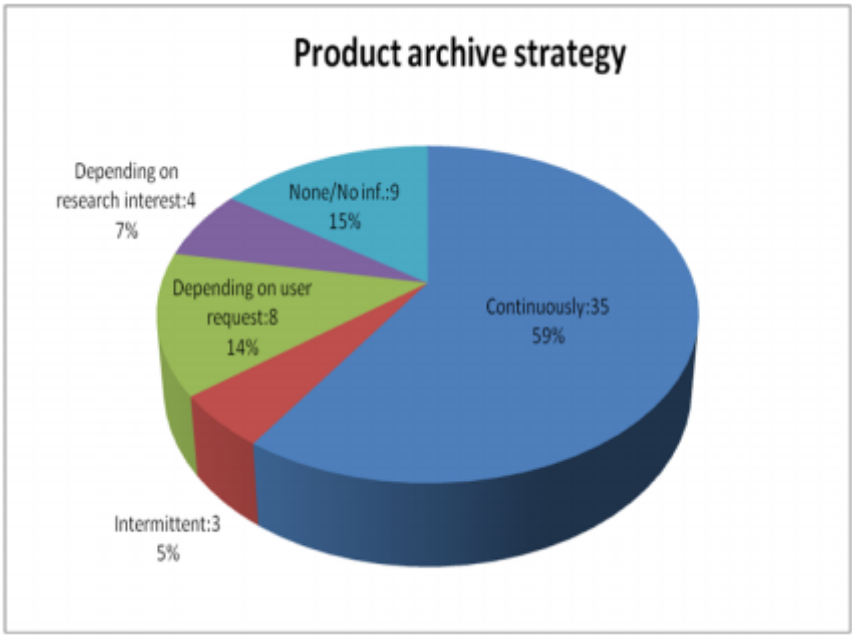


Fig. 42: Data type archived

Key findings: With respect to the replies, "continuous" archiving of products is the most common used strategy while considerable amount of the participants don't archive product.

Again some participants have been archiving products "depending on user request". Several of the participants have been archiving product "intermittently" and "depending on research interest".

Question 11.6: The archiving media type

With this question used archiving media types have been investigated.

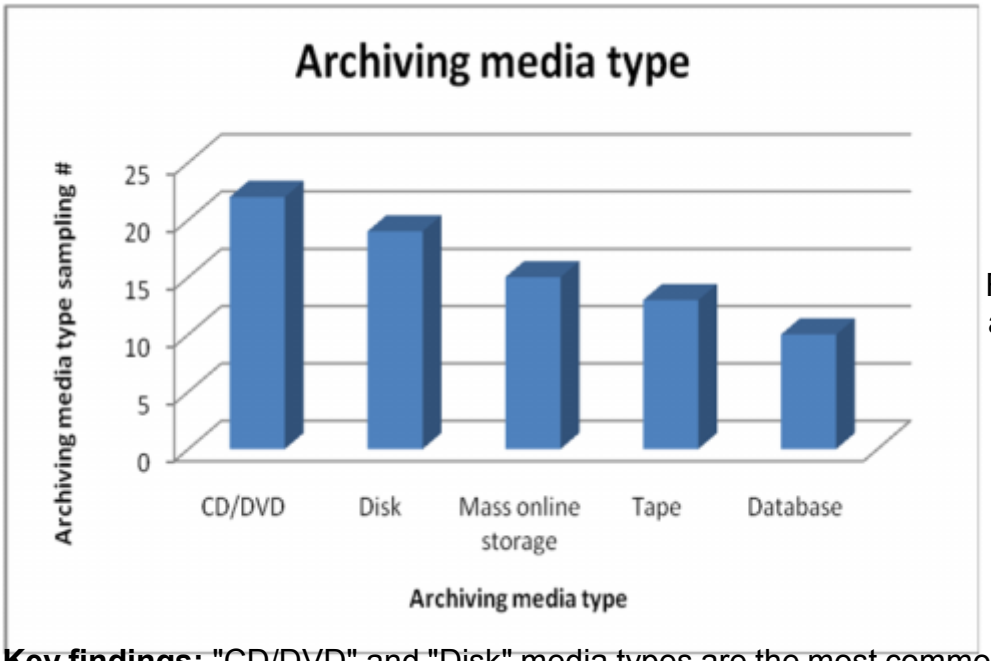


Fig. 43: Media type archiving

Key findings: "CD/DVD" and "Disk" media types are the most commonly used for archiving radar data. "Mass online storage", "Tape" and "Database" media types are also have been used for archiving respectively.

Question 11.7: If you are using a database, your archived radar data stored in

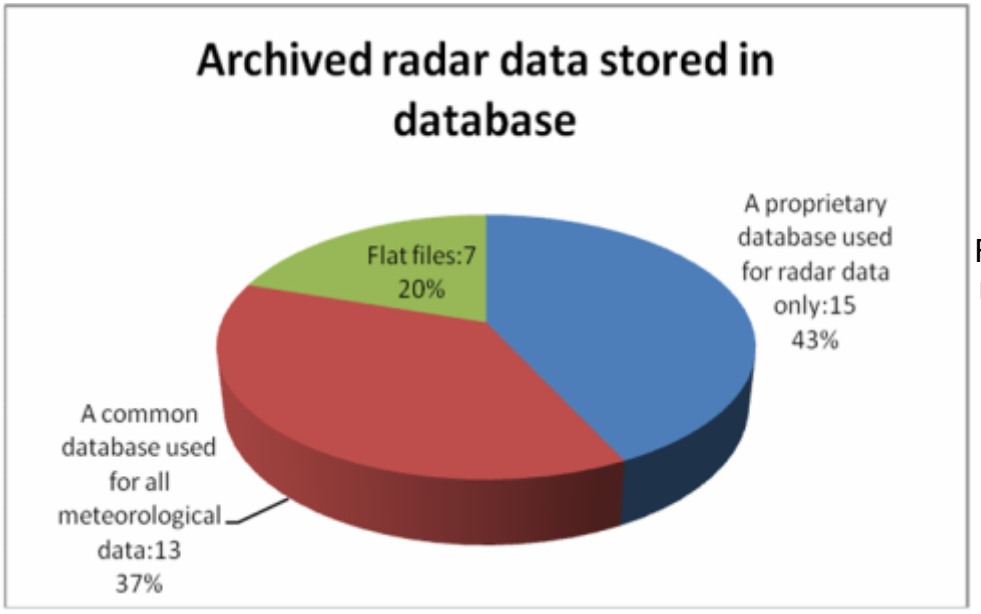


Fig. 44: Archived radar data

Key findings: Storing radar data in database as "flat files" are not so common. Generally, "a common database for all meteorological data" or "a proprietary database for radar data only" has been used by the participants.

Question 11.8: Is your archiving software

To gather more information relevant to radar data archiving softwares, this question has been addressed.

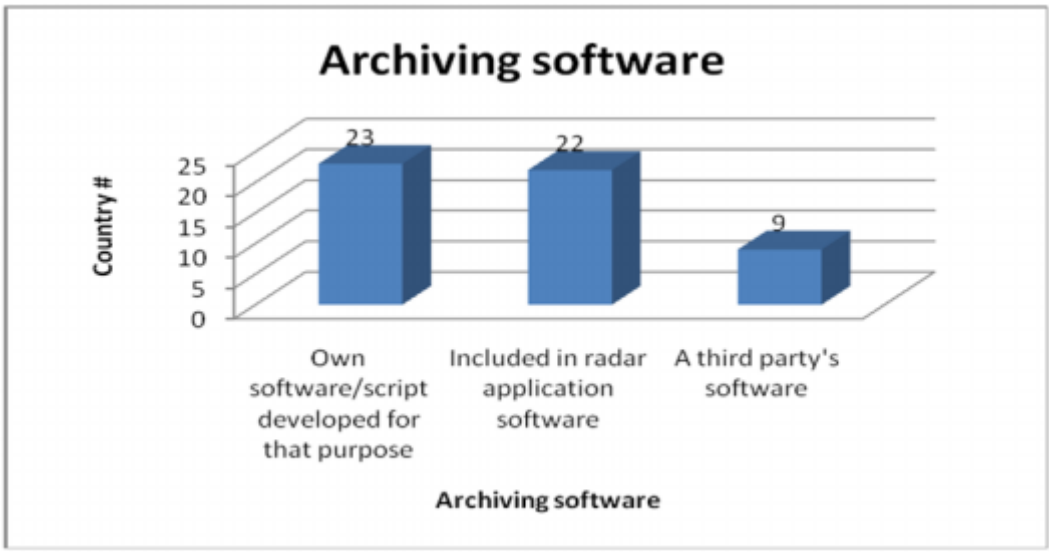


Fig. 45: Archiving software

Key findings: Most commonly "own software/script developed for radar data archiving" or "archiving software included in radar application software" have been used by the participants. Some other participants have "a third party's software" for radar data archiving.

Question 11.9: Parameters recorded and/or archived

To investigate the parameters mainly recorded, this question has been included in the survey.

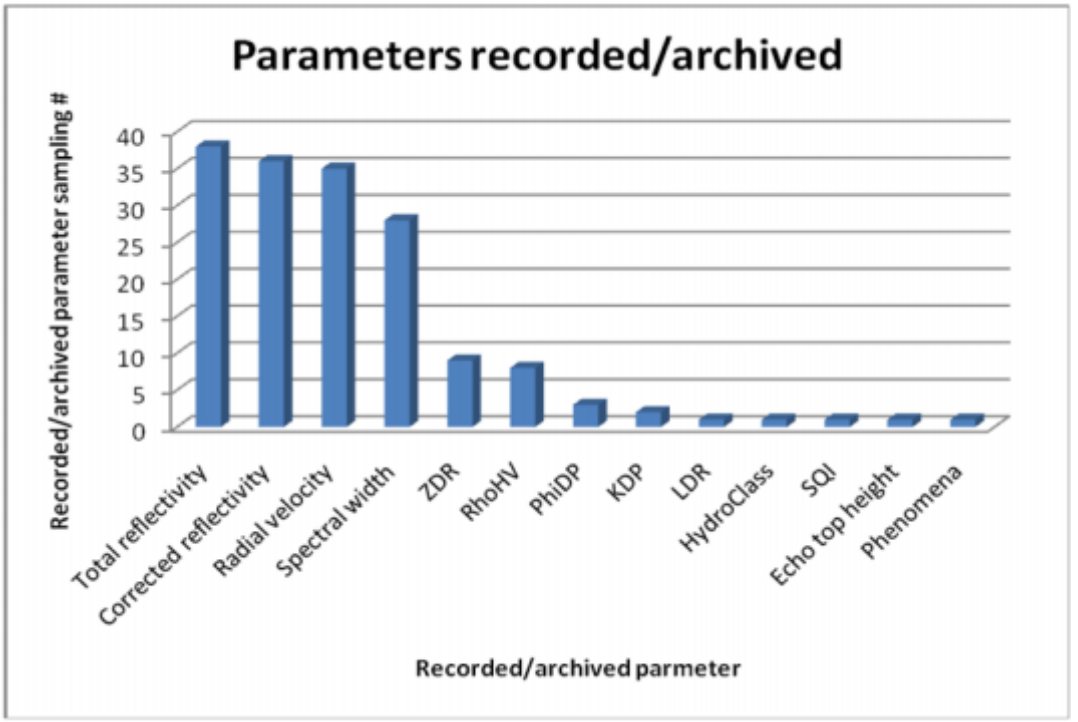


Fig. 46: Parameters recorded/archived

Key findings: There are four main parameters typically for single polarized weather radars. These are "Total reflectivity", "Corrected reflectivity", "Radial velocity" and "Spectral width" respectively with respect to the replies. "ZDR", "RhoHV", "PhiDP", "KDP" and "LDR" parameters have been recorded leastwise, since the number of polarimetric radars not so much. "Hydro-class", "SQI", Echo top height" and "Phenomena" are also some other parameters recorded by several participants.

Question 11.10: Data formats supported in radar data production

This question has been included in the survey to investigate data formats supported by softwares.

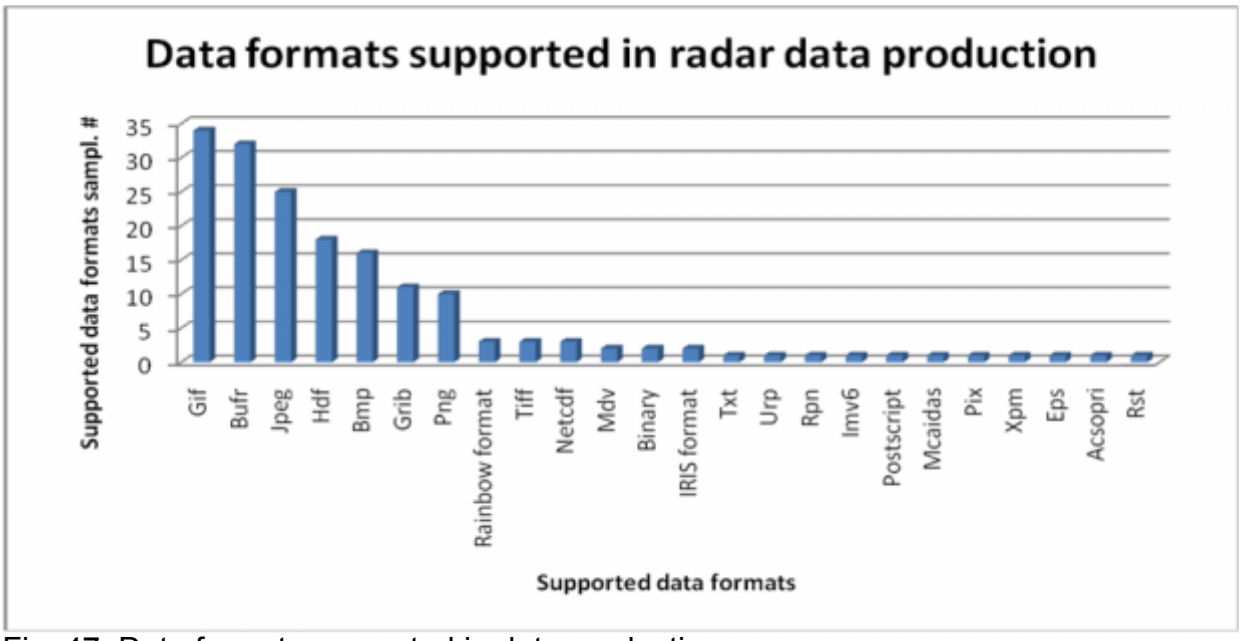


Fig. 47: Data formats supported in data production

Key findings: "GIF", "BUFR" and "JPEG" are the most wide spread formats supported by softwares. "HDF", "BMP", "GRIB" and "PNG" are some other formats considerably supported by softwares. A wide range of formats also supported the softwares listed in the graph.

Question 12: Please indicate number of data bits for archiving

This question has been addressed to gather information about number of data bits for archiving.

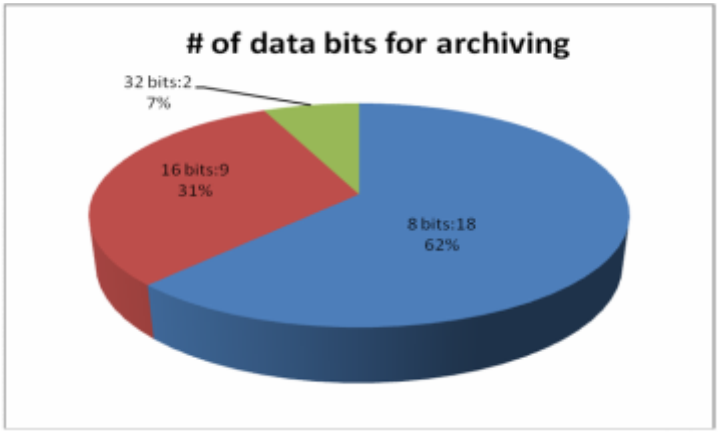


Fig. 48: Number of data bits for archiving software

Key findings: Most of the participants stores data as 8 bits and some participants have been stored data as 16 bits. 32 bits have been used by several participants for archiving. Amount of stored data can change in a wide range depending on number of data bits, number of radar, product and parameters. Some sample amount of data can be seen below:

Some samples for archived amount of data:

Country	Amount of stored data	Data bit #	Radar #	Stored data type
USA	>500 TB/year	not indicated	159	~40 products
Canada	2.5 TB/year	not indicated	31	Raw data, Product (CAPPI, PRECIP, PA, ECHOTOP),Composite
New Zealand	1.5 TB/year	not indicated	6	Raw data, PPI(reflectivity and velocity), rainfall accum., hail probability and size
Netherlands	365 GB/year	not indicated	2	Raw data and product(not indicated)
Argentina	51.6 GB/year	not indicated	2	Raw data and product(not indicated)
Slovenia	30 GB/year	not indicated	1	Raw data, -MAX, R-BASE, R-CORRECTED, H-TOP, VIL, 1H-ACC, 1D-ACC

Question 13: Can you describe your synergetic usage of radars with other instruments and data sources (satellite images, lightning detector etc.)?

This question has been addressed to reveal synergetic usages of weather radars with other instruments or data sources.

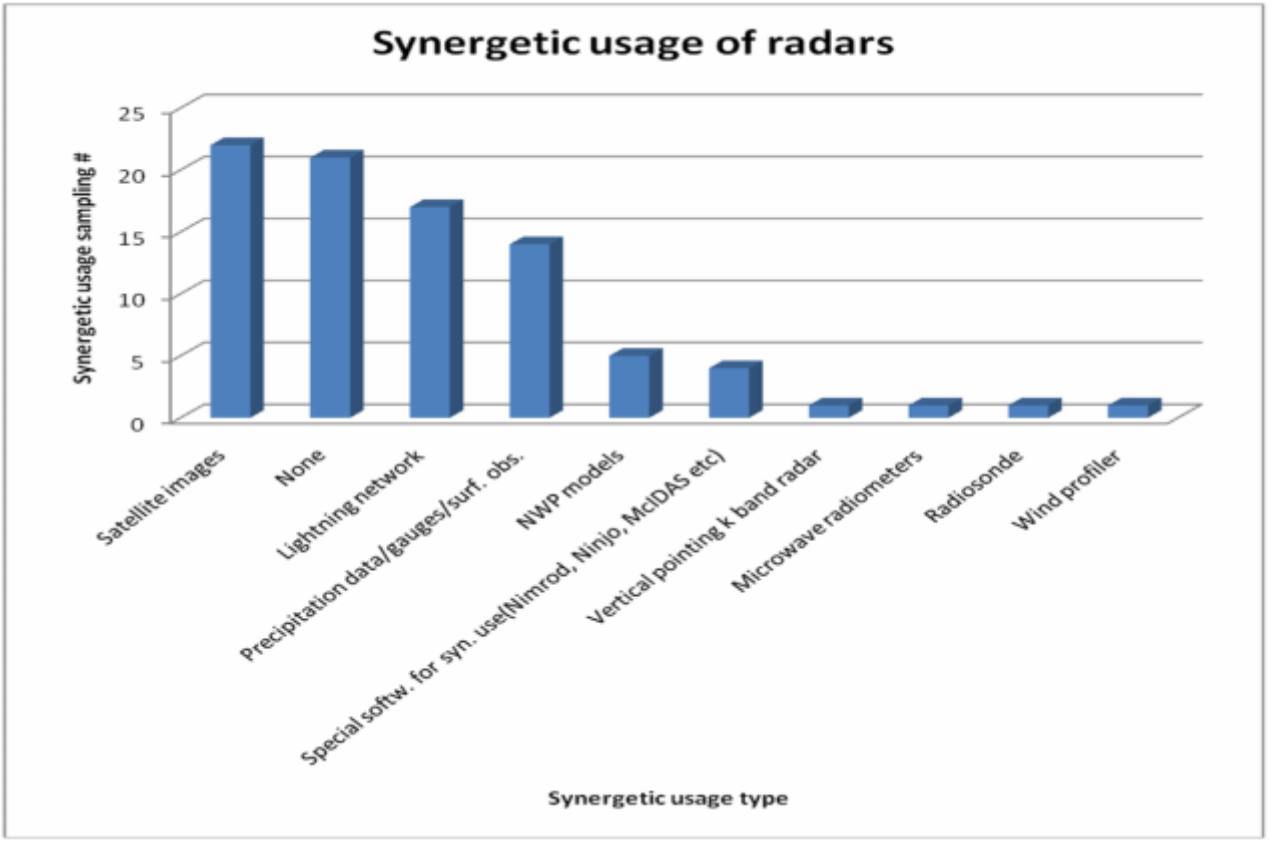


Fig. 49: Synergetic usage of radars

Key findings: Most common synergetic used instruments and data sources with radars are "satellite images", "lightning networks" and "precipitation/gauges/surface observations". "NWP models", "Special softwares like Nimrod, Ninjo, McIDAS etc.", "Vertical pointing k band radars", "Microwave radiometers", "Radiosondes", "Wind profilers" have been used with radar products. On the other hand considerable number of participants has not a synergetic usage of radars with other instruments or data sources.

Question 14: Do you have mobile weather radar? If you have, please specify in which cases do you use it?

To investigate utilization of mobile weather radars, this question has been included in the survey.

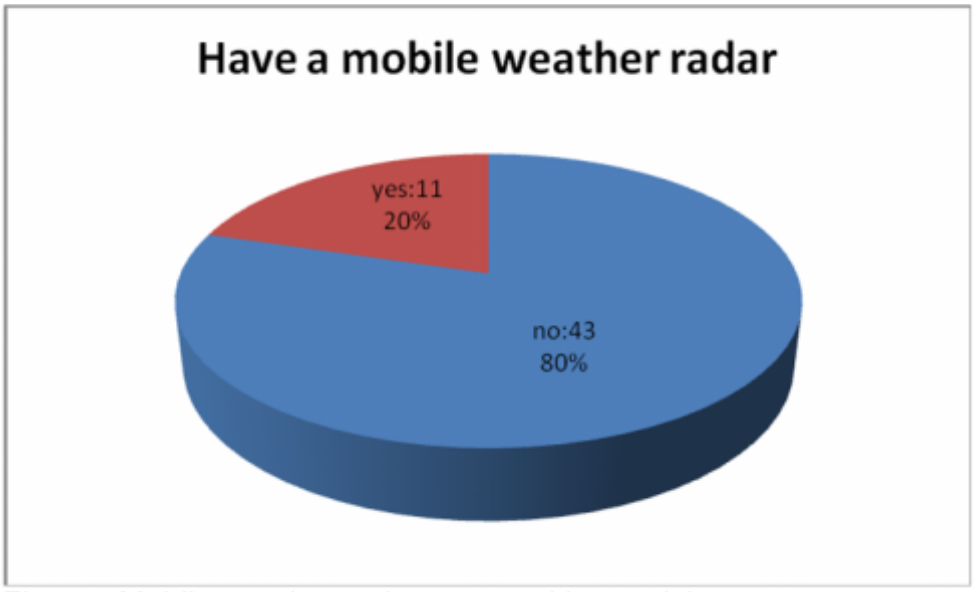


Fig. 50: Mobile weather radar operated by participants

Key findings: Mobile weather radars have not been used in a wide rande, still considerable amount of participants use mobile weather radars for :

- International airports for turbulence and shear detection
- Emergency observation
- Back-up
- Data supply of the radar locations which are rebuilded
- Military
- Research
- Cloud seeding(Artificial weather modification) and adhoc operation
- Severe Weather and disaster management
- Sporting events
- In the mountain location

Question 15: Please write your opinion, experiences and recommendation on weather radar operations.

The opinion, experience and recommendations of the participants have been provided without comment as they are, since they are important:

- ✓ *We need more training for more utilization*
- ✓ *To understand products and their usage more training is necessary*
- ✓ *Radar is essential to effectively protect life and property and critically support economic activity*
- ✓ *Regularly training, Stable budgets, knowledgeable engineering, research*
- ✓ *Radar is very important for short term forecast, propose to speed up the development of weather radar tech.*
- ✓ *Very useful equipment*
- ✓ *Interdisciplinary teamwork is essential*
- ✓ *Meteo France relies on radar manufacturers only for HW. But for small networks this may be ok, because of cost*
- ✓ *Important for forecast, hydrology, and modeling*
- ✓ *Dedicated team of experienced tech staff is very important, good communication with users for ensuring data quality*
- ✓ *Identification of different procedures to handle radar data for real time forecasting operations and advanced use in NWP*
- ✓ *Radar is very useful tool in forecasting(nowcasting) and monitoring severe weather storm and flood early warning, for weather modification*
- ✓ *We plan to operate radars centrally*
- ✓ *Surge from thunderstorm is a problem for radar HW*
- ✓ *Radar is precised than satellite, but more expensive to operate. Since 2002 it is not in operation*
- ✓ *Upgrade to dual in 4-5 years*
- ✓ *Weather radar is an increasingly useful weather monitoring tool, and has enabled the introduction of new service including. Severe Thunderstorm Warnings*
- ✓ *Weather radars are an extremely useful tool for general surveillance, nowcasting, air terminal surveillance, extreme weather warnings and have an enormous potential for data assimilation into fine mesh NWP-models (meteorological and hydrological models).*
- ✓ *For longer life of Magnetron only be operated when situation arises*
- ✓ *ACP´s weather radar is a vital component in the Flood Control Program and water management operations.*
- ✓ *Weather radars are most effective for nowcasting and are vital for weather modification use. Its value will significant increase in future*
- ✓ *We have good experiences in observing convective clouds and measuring their parameters*
- ✓ *Necessary 24h/7d operation, volume scan, min. 10minutes interval, automatic radar status monitoring tools, automatic calibration tools*

- ✓ *Essential tool for weather monitoring, nowcasting and rainfall measurements*
- ✓ *Radar data in our case is not used effectively. We have a large network with signification resolution and accuracy that will only be enhanced by the new systems. There are currently insufficient human resources to dedicate to the analysis and processing of radar data. More research needs to be done for generating products for use by the general public.*
- ✓ *Need comprehensive training and calibration*
- ✓ *Keeping experienced staff and training of new staff dealing with radars including software, network and hardware people is very important for continuous operation of a radar network. Collaboration with other countries which are operating radar is another important issue for sharing good and bad experiences. Sharing information can be achieved regional meetings, trainings, seminars, workshops and conferences. In this scope, regional training centres can be used more effectively and wide spread. Establishing a maintenance plan like training maintenance people, buying spare parts or making maintenance contract with manufacturer or other maintenance company is an important issue too.*
- ✓ *Weather radar remains an essential observational system within UK Met Office, especially with respect to the forecasting of severe weather and flooding events. In recent years, technological advances have allowed improvements in many areas, with digital signal processing enabling more data to be extracted from the radar equipment to the benefit of customers. Increased availability and reduced costs of both communications bandwidth and computing power have similarly enabled improvements to the data transferred from site, the degree of processing and the delivery to customer. Advances in remote connectivity has reduced maintenance costs as fault diagnosis, fault resolution and software upgrades can in some cases be carried out from a central location without a requirement to visit sites.*
- ✓ *This is very important for aircraft. The information incorporated into networks of radars represents big interest. Radars MRL-1 and MRL-2 which are used should be replaced with modern*
- ✓ *Amazing tools that helps the forecaster in prediction accurate forecast and it gives you the ability to issue warning ahead of the event. Moreover very good tools for doing researches too*
- ✓ *The WSR-88D network has proven itself to save lives and reduce injuries by helping more than double the tornado lead time from 5 to 13 minutes (Simons, K. M. and D. Sutter, 2005: WSR-88D radar, tornado warnings, and tornado casualties. Weather Forecasting, 20, 301-310), improving support to the National Airspace System, and aiding the economy. Many important non-meteorological uses for the radar data have evolved such as detecting smoke plumes, tracking bird migrations and habitat usage, and tracking volcanic ash plumes. The distribution of WSR-88D products and raw data in real time has been the basis for increased growth in the commercial weather sector and use by the general public to aid their daily planning and monitoring of severe weather. The use of archived radar products and raw data has been important for developing new and testing and improved meteorological algorithms on the WSR-88D, training radar operators/forecasters, and educating a new generation of meteorologists. The continuous centralized support of the system (WSR-88D Radar Operations Centre, National Logistics Support Centre, National Reconditioning Centre, and the WSR-88D triagencies) is necessary to keep the network operating at peak capability while ensuring the network's maintainability and viability for 25+ years.*
- ✓ *Good meteo radar is very useful and necessary*

5. Evaluation of Excel Sheets:

In excel spread sheet, parameters and features of each radar like "Ground Height", "Tower Height", "Band / Frequency", "Beam width", "Pulse width", "PRF", "Signal processor type", "TX type", "RX type", "Polarization", "Manufacturer", "Lowest/Highest elevation angle", "Cycle time", "MDS" and "Z-R relation" have been gathered besides radar name and location.

Question 1: Number of weather radars operated by NHMSs

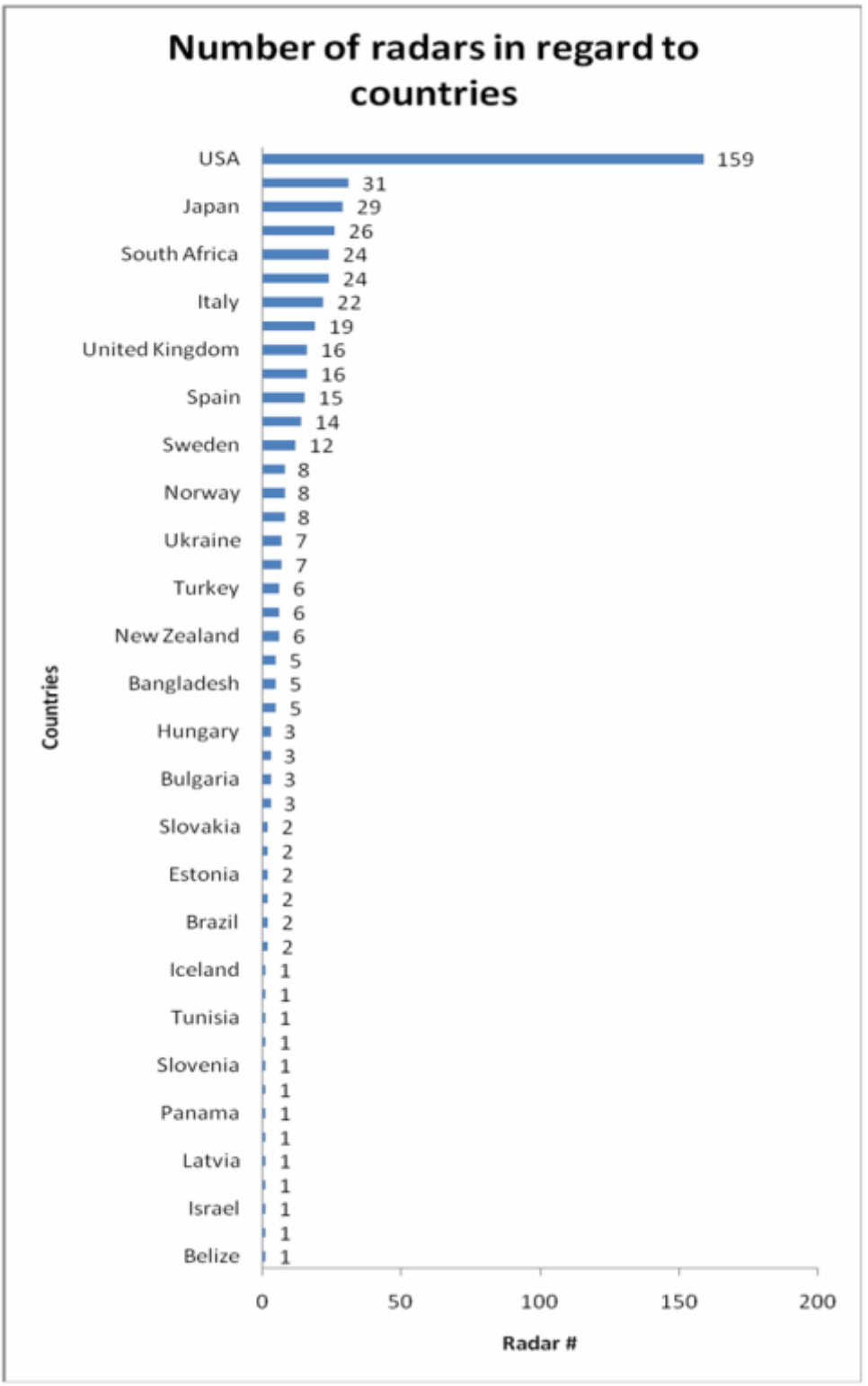


Fig. 51: Number of weather radars operated by NHMSs

In accordance with the replies, number of radar increases parallel to area of th country, level of development of the country and frequency of exposing to heavy rain in general. USA has the most number of weather radars used by NOAA, although FAA's weather radars have not been included to the survey yet. After excel sheet of the survey filled by the countries which have large networks like China, Russia etc. the graph will be updated.

Question 2: Ground height of radars

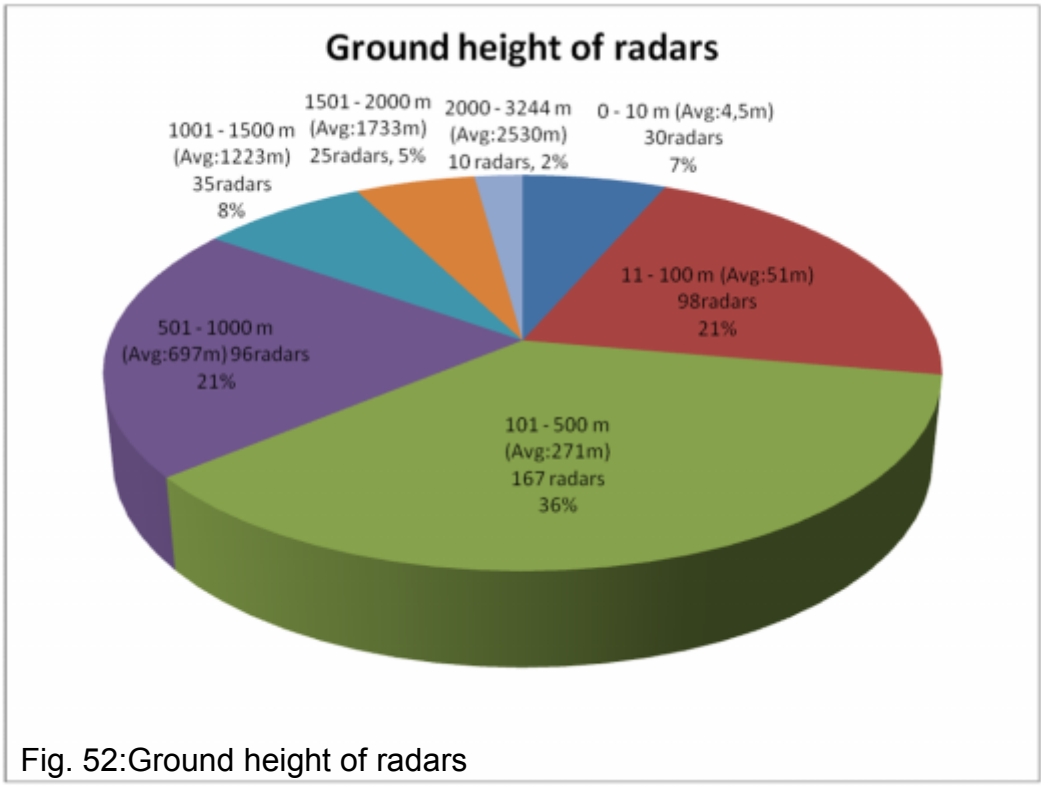


Fig. 52:Ground height of radars

Weather radars have been located "between 101m and 500m" mainly and considerable amount of the radars have been located "between 11m and 100m" and "between 501m and 1000m". The rest of the radar have been located on either almost sea level or higher levels than 1000m.

Question 3: Tower Heights

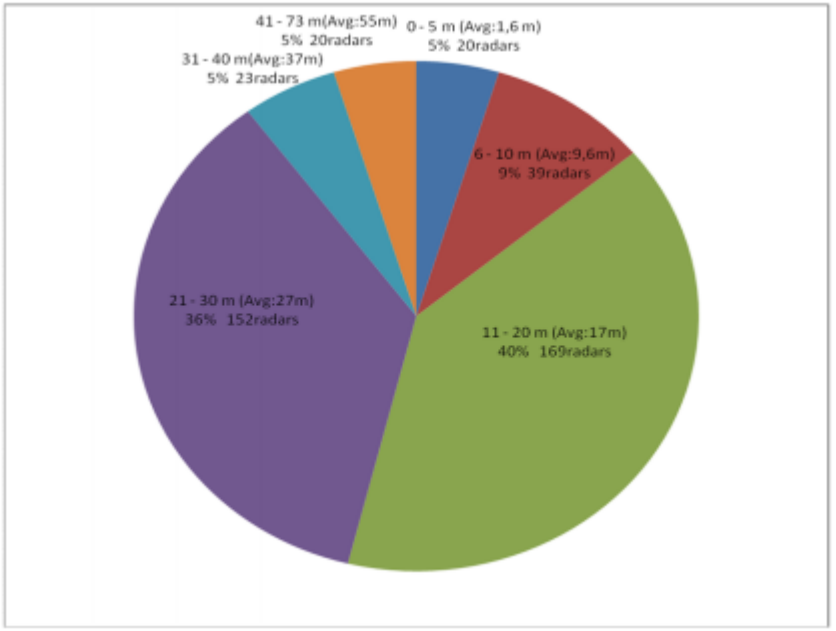


Fig. 53:Tower heights of radars

Most of the weather radar towers have a height between **"11m - 30m"** in accordance with the replies. Some of radar towers have a height between "6m - 10m". Several radar towershave a height between "0m - 5m", "31m - 40m" and "41m - 60m"

Question 4: Band of Weather Radars

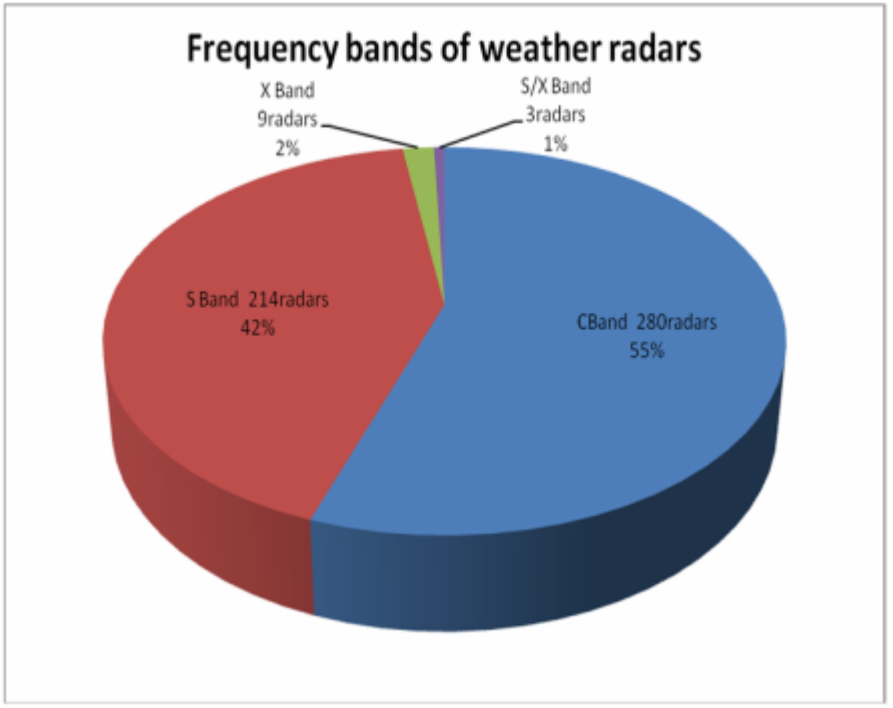


Fig. 54:Band of weather radars

Used frequency of the electromagnetic wave defines the band of the radar. "C Band" is the most commonly used band in wetaher radars. "S Band" is also another main band used for weather radars. USA has a great contribution to that with high number of S Band radars. "X Band" radars are not so common according to present replies. It can be expected that China can have contribution with its high number of X Band radars after filled excel sheet received.

Question 5: Beamwidth in weather radars

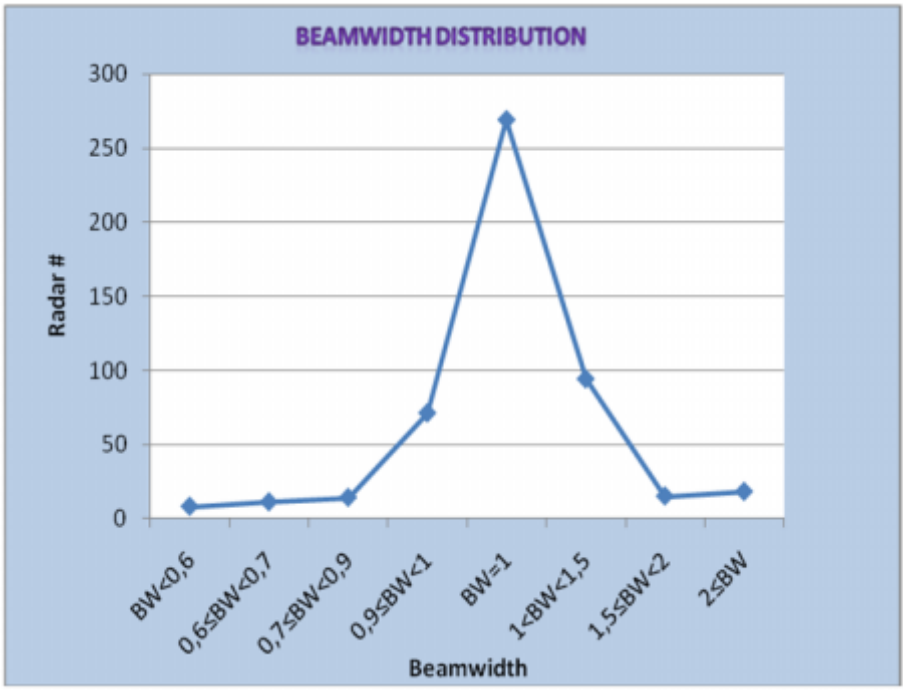


Fig. 55:Used beam widths

Beam width is a parameter which depends on antenna diameter and frequency. With respect to the replies, most common BW used in weather radars is "1degree". In addition to this, considerable amount of radars have a BW between "0.9 - 1" degrees and between "1 - 1.5" degrees. Several number of radars have a BW less than 0.9 degree which is better for weather radars and more than 1.5 degree which is worse for weather radars.

Question 6: Pulse widths used in weather radars

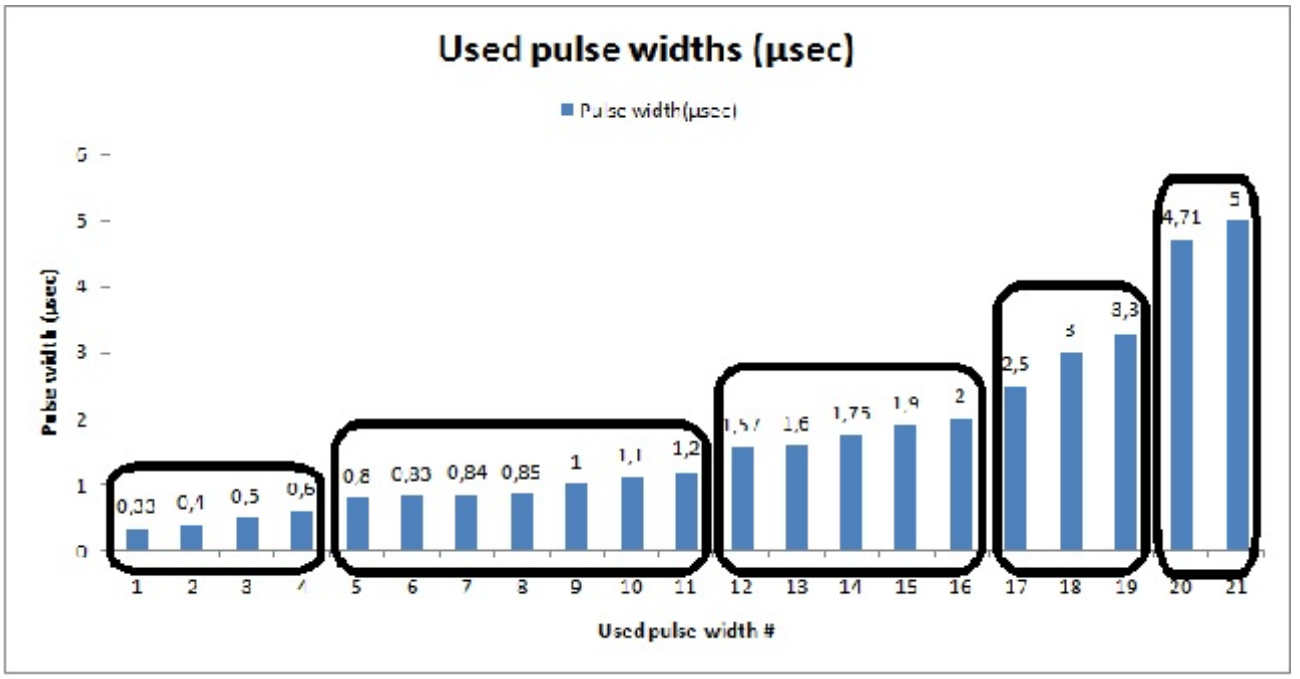


Fig. 56: Used pulsed widths

Pulse widths which can be selected in digital receivers easier than analog receivers, have been used in a wide range between 0.33 µsec and 5 µsec sccording to the replies. If the pulse widths close to each other classified, five groups can be established. "0.5 µsec", "1 µsec", "2 µsec", "3 µsec" and "5 µsec" could symbolise each group.

Question 7: PRFs used in weather radars

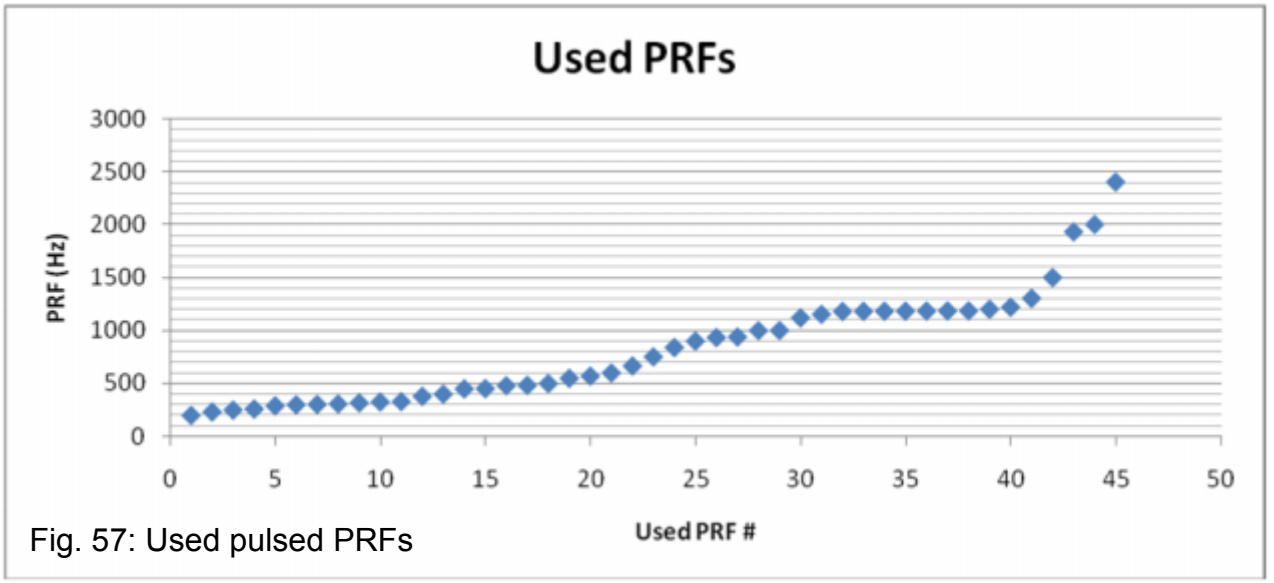


Fig. 57: Used pulsed PRFs

Pulse repetition frequency(PRF) can be changed in schedules for different tasks. With respect to the replies, PRFs have been used in a range between 200Hz and 2400Hz, according to the replies in weather radars. Most frequently used PRFs are between 200Hz and 1200Hz. A couple of participants have been used PRFs around 2000Hz.

Question 8: Signal processors used in weather radars

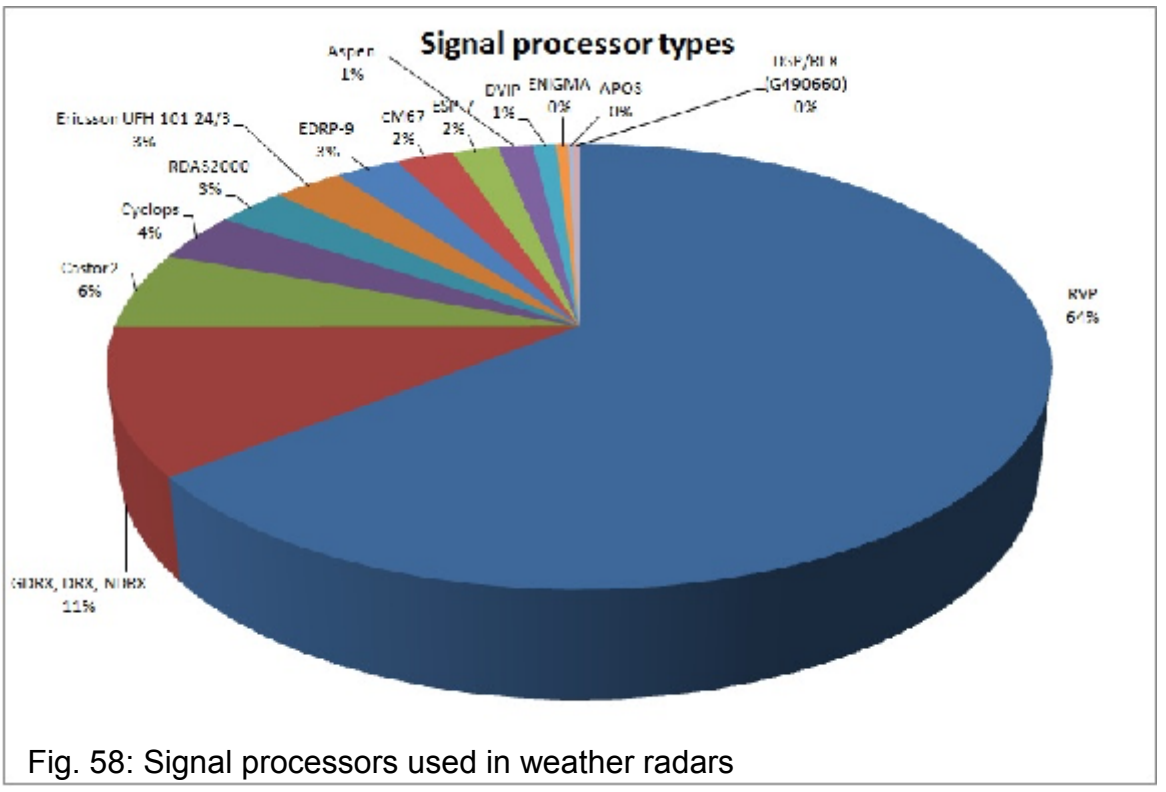


Fig. 58: Signal processors used in weather radars

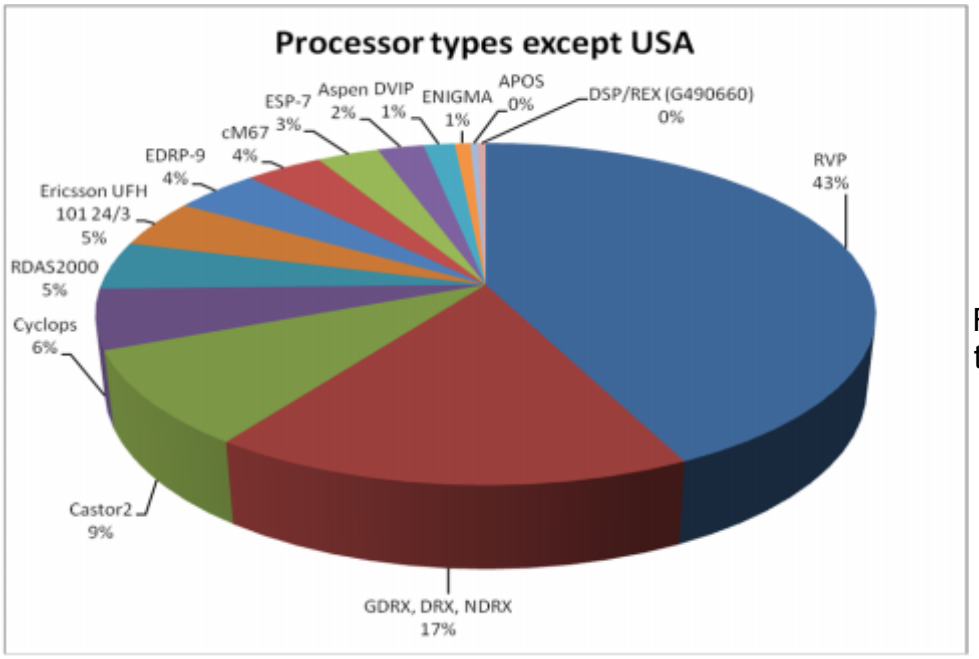


Fig. 59: Processor types except USA

In a wide range of signal processor types have been used in weather radars. "RVP" signal processor is the most commonly used processor type. "GDRX, DRX and NDRX" signal processor types have been used also by considerable amount participants. Two different graph have been prepared since USA has a great effect to the distribution. "Castor",

"Cyclops", "RDAS2000", "Ericsson", "EDRP-9", "cM67", "ESP-7", "Aspen", "DVIP", "ENIGMA", "APOS" and "DSP/REX(G490660) are other signal processor types. While some of them are new in the market, some others have not been manufactured anymore.

Question 9: Transmitter types used in weather radars

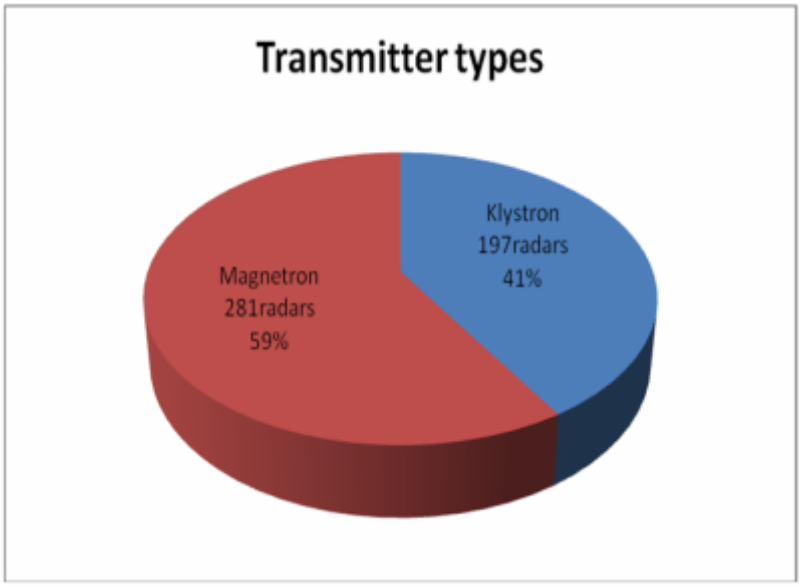


Fig. 60: Transmitter types

Vacuum tube technology have been used in weather radars in general so far. "Magnetron" type transmitters are the most common TX type as far as the current replies, in the meantime a considerable amount of "Klystron" type transmitters have been used. Relatively lower price and simpler technology of the magnetron could be a reason for being favorite. However, it can be expected that Klystron will remain on the agenda with its fully coherency which provides an advantage.

Question 10: Receiver types used in weather radars

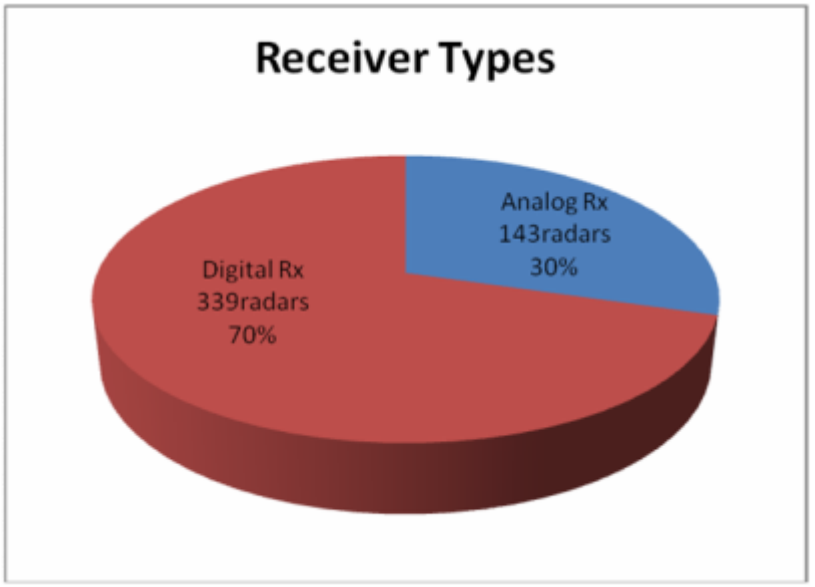


Fig. 61: Receiver types

It has been observed that, Digital Receivers which provide higher dynamic range and sensitivity, have been used in a wide range. Still some of the radars have analog receiver which is an older technology and could be expected that will give place to the digital ones with upgrades and completely changes.

Question 11: Polarization of weather radars

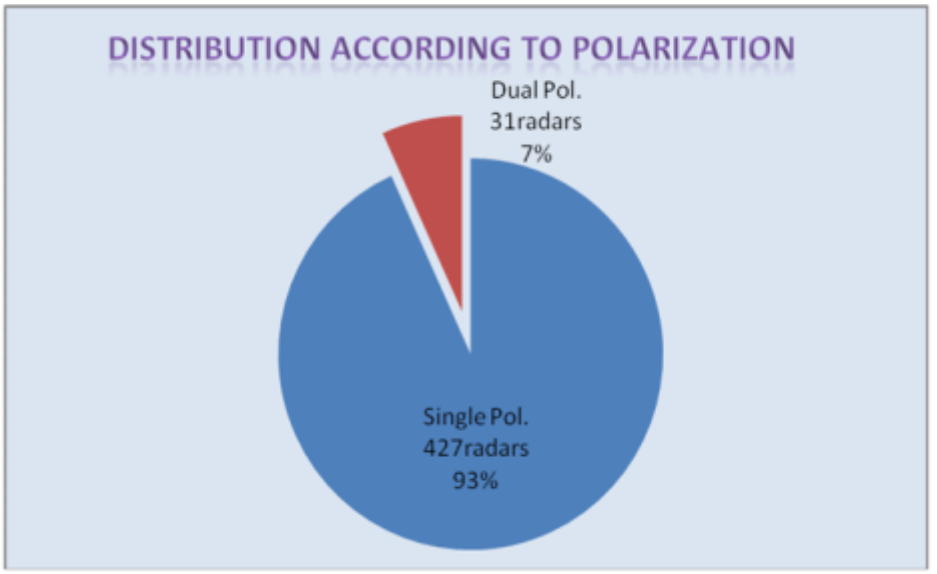


Fig. 62: Distribution according to polarization

While horizontal linear polarization has been used in single polarization weather radars, in polarimetric weather radars both horizontal and vertical linear polarizations have been used. According to the replies, almost all weather radars have single polarization and dual polarization technology are not so common still. Several particiants have been stated that they are operating polarimetric weather radars. On the other hand, advantages of polarimetric products are undeniable and usage of dual polarized weather radars has been increasing day by day.

Question 12: Radar manufacturers

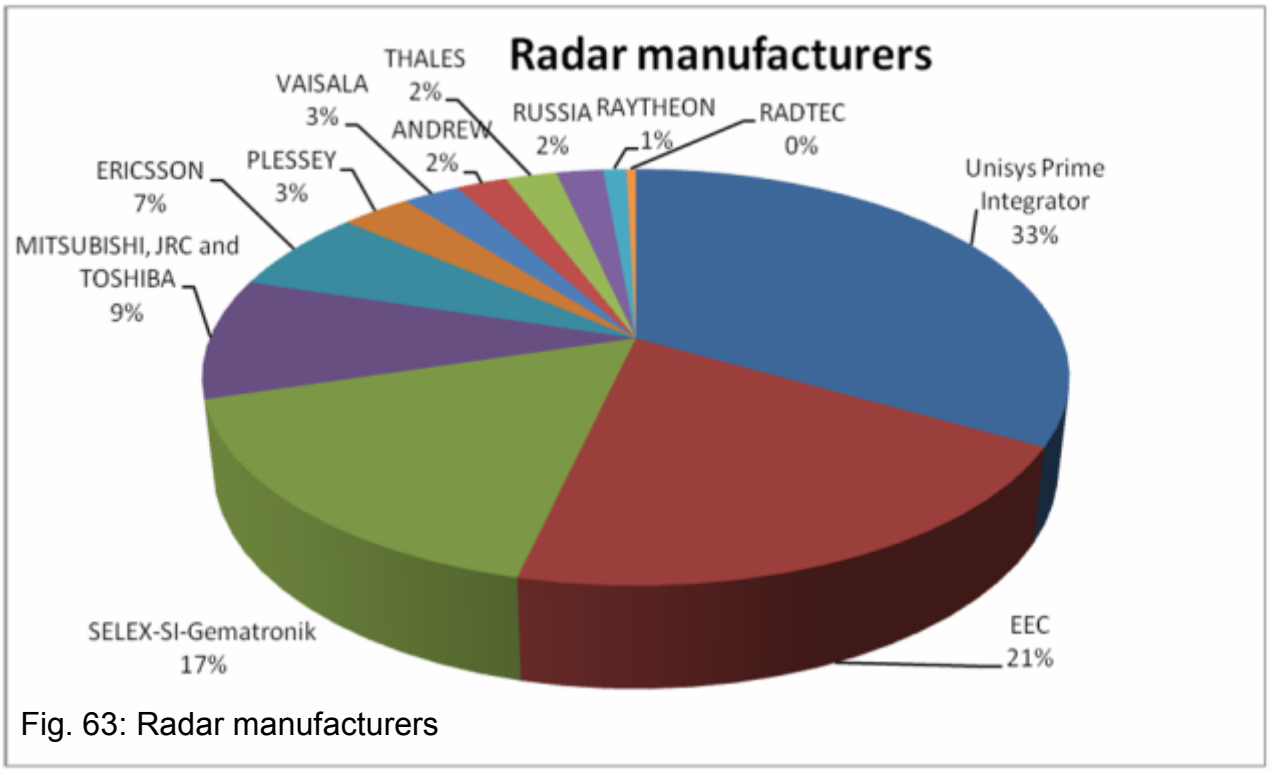


Fig. 63: Radar manufacturers

Present weather radars have been installed by a wide range of manufacturers. Radars have been installed mainly by the companies: "Unisys Prime Integrator", "EEC" and "SELEX-SI"

respectively. "Unisys Prime Integrator" is the company which has been installed radars in USA only with respect to the replies. The rest of the radars have been installed by the companies "MITSUBISHI", "JRC", "TOSHIBA", "ERICSSON", "PLESSEY", "VAISALA", "ANDREW", "THALES", "RUSSIA", RAYTHEON" and "RADTEC".

Question 13:"Lowest elevation angle" have been used in weather radars

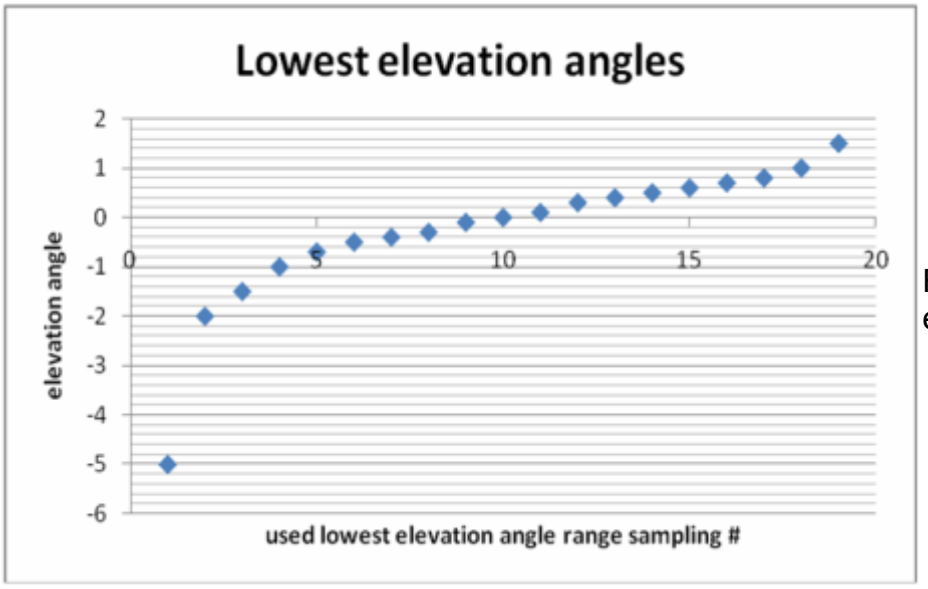


Fig. 64: Used lowest elevation angle range

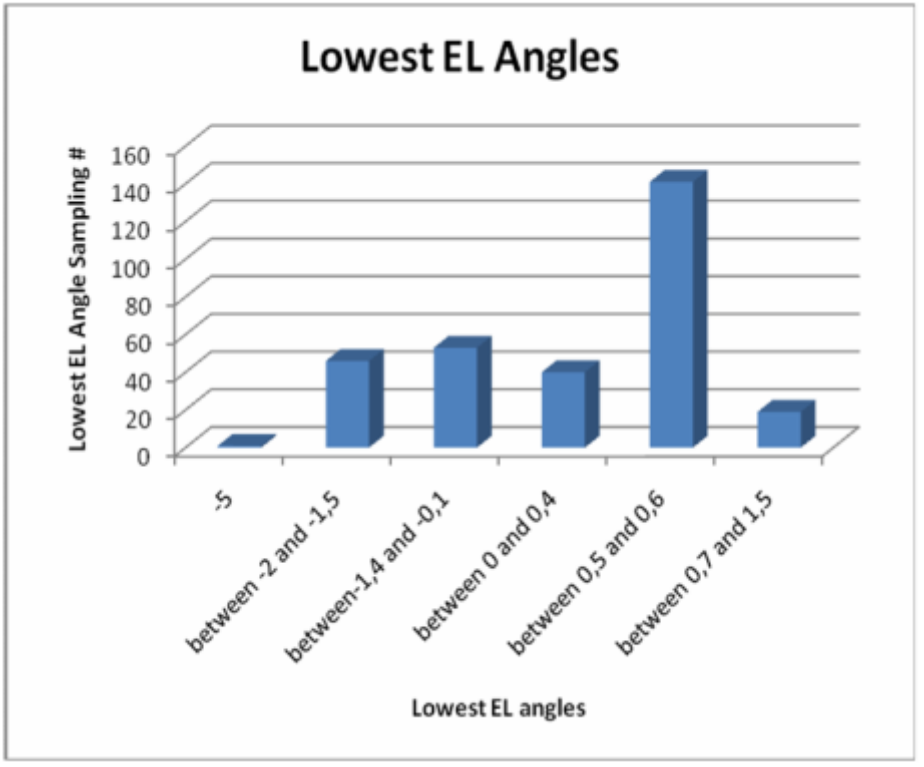


Fig. 65: Used lowest angles

Lowest elevation angles have been used by the participants cover the range between -2 degree and 1.5 degree in general. Most commonly used lowest angles are between 0.5 and 0,6 degrees. Considerable amount of the participants have been used angles between -2 and 0,4 degrees as lowest elevation angle. -5 degree is an extra-ordinary case which is apart from closest angle -2 degree.

Question 14:"Highest Elevation Angle" has been used in weather radars

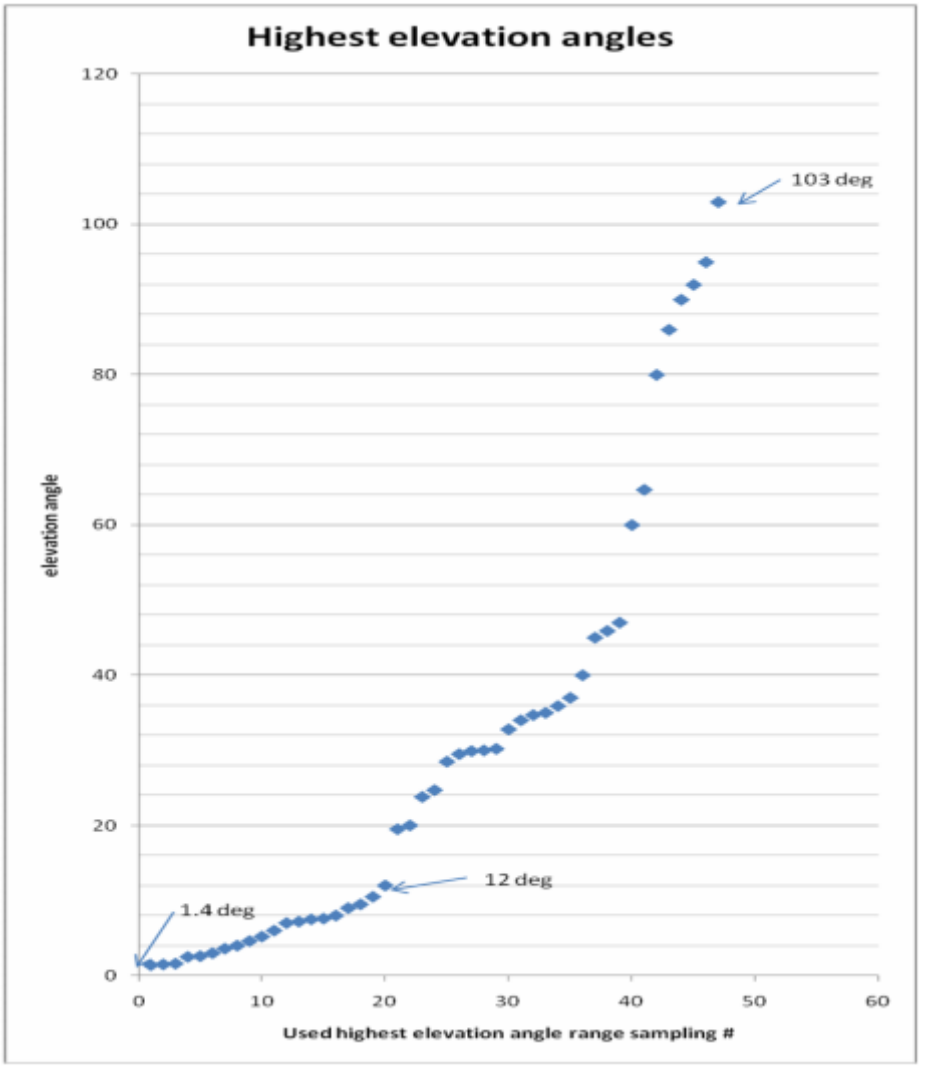


Fig. 66: Used highest elevation angle range

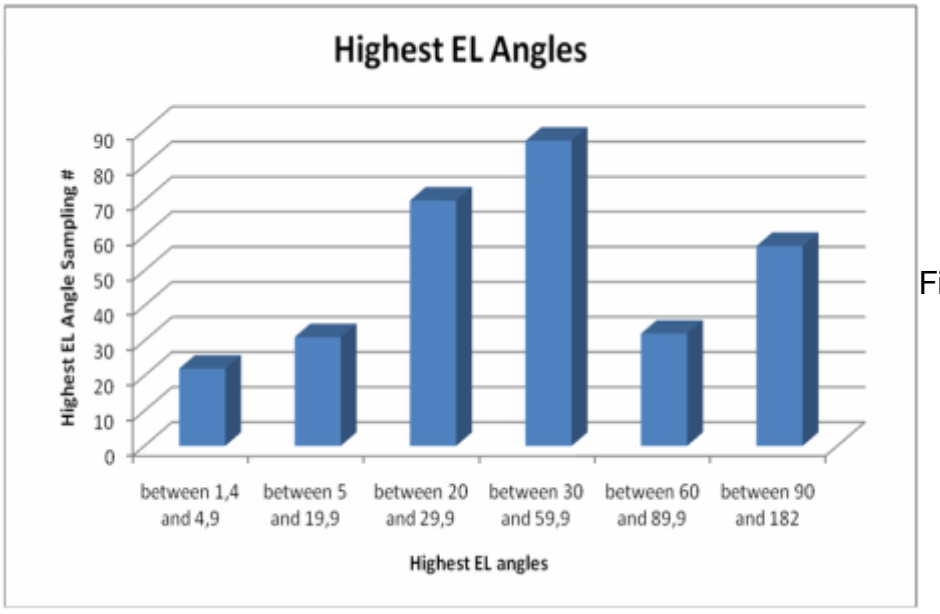


Fig. 67: Used highest angles

Highest elevation angles have been used by the participants cover the range between 1.4 degree and 103 degree. This huge difference is so remarkable. Most commonly used highest angles are between 20 and 60 degrees.

Question 15:"Cycle time" in weather radars

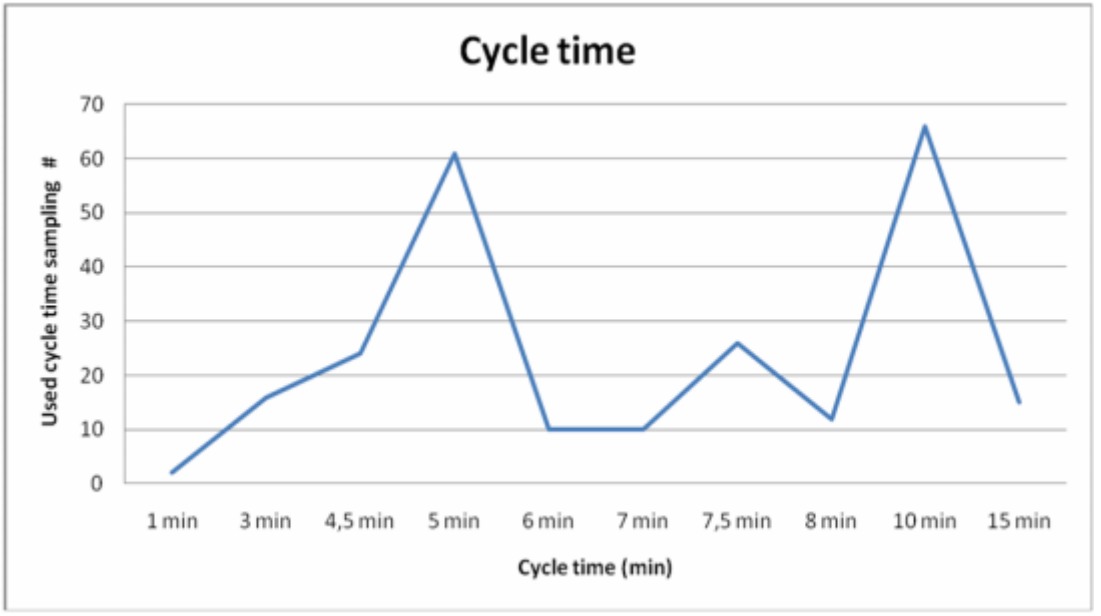


Fig. 68: Cycle time of weather radars

Volume scans adjusted by the operators define cycle time of the weather radar. If cycle time is short, more frequent products can be generated, but quality of the data reduces and vice versa if cycle time is large, interval between products will be more, but quality of the data increases. Cycle times used by the participants have been changed between 1 min. and 15 min. Most frequenty used cycle times are between 4,5 min and 10 min with respect to the replies.

Question 16: MDS in weather radars

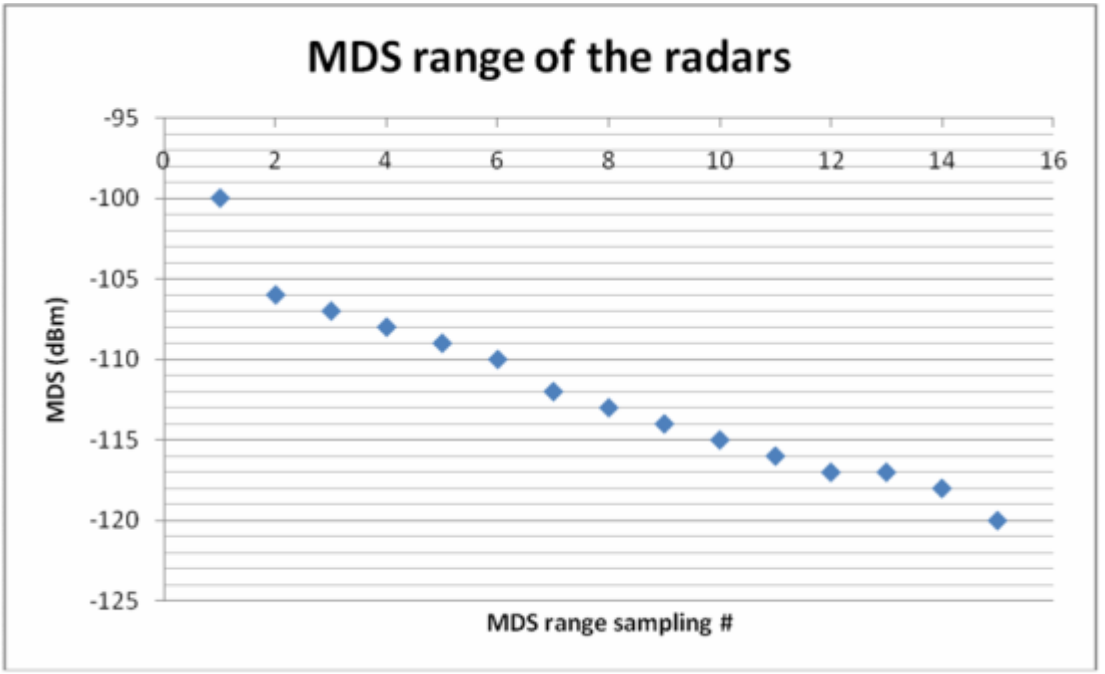


Fig. 69: MDS range of weather radars

Minimum detectable signal(MDS) is one of the important parameters of the receiver and related with the sensitivity. MDS value has been getting better with new technologies. The best MDS value is -120dBm according with the replies.

Question 17: Z-R relations used in weather radars

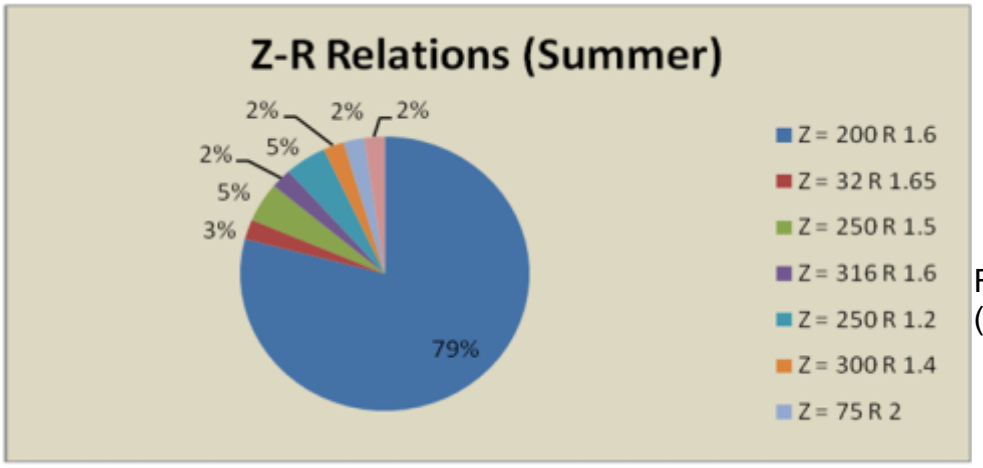


Fig. 70: Z-R Relations (Summer)

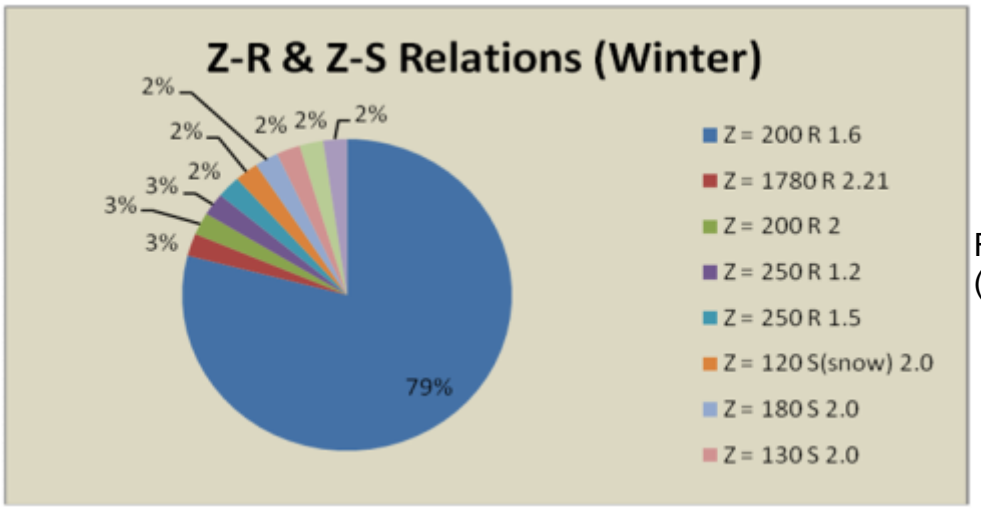


Fig. 71: Z-R Relations (Winter)

Z-R relations used by the participants for summer and winter can be seen on the graphs above. $Z=200R^{1,6}$ is the most common used relation and defined by Marshall-Palmer drop size distribution. After a statistical study a specific relation can be improved for each countries. While most of the participants have been using Marshall-Palmer's relation, some of the countries have been using different relations which are defined by specific studies.

6. Worldwide weather radar database web page

Gathered data will be presented by a webpage which will be hosted by Turkish State Meteorological Service(TSMS) and can be accessible through a link placed in the web page of WMO. A commission from Turkish State Meteorological Service has been established for development the world weather radar database web page. Weather radar networks will be able to be searched according to the parameters and all parameters of a radar can be observed via this web page. Methods for collecting the required data from these users and keeping the database up-to-date should be developed. In this context spreading/gathering the questionnaire could be continued during courses and other activities organized by WMO. However, there will be authorized persons who can update their network by approval of web page responsible people.

Url address for weather radar database web page is planned as: **http://wwr.dmi.gov.tr** and "wwr" stands for "**w**orld **w**eather **r**adars". This url will be accessible through a link placed in WMO's web page

Sample views from the web page :

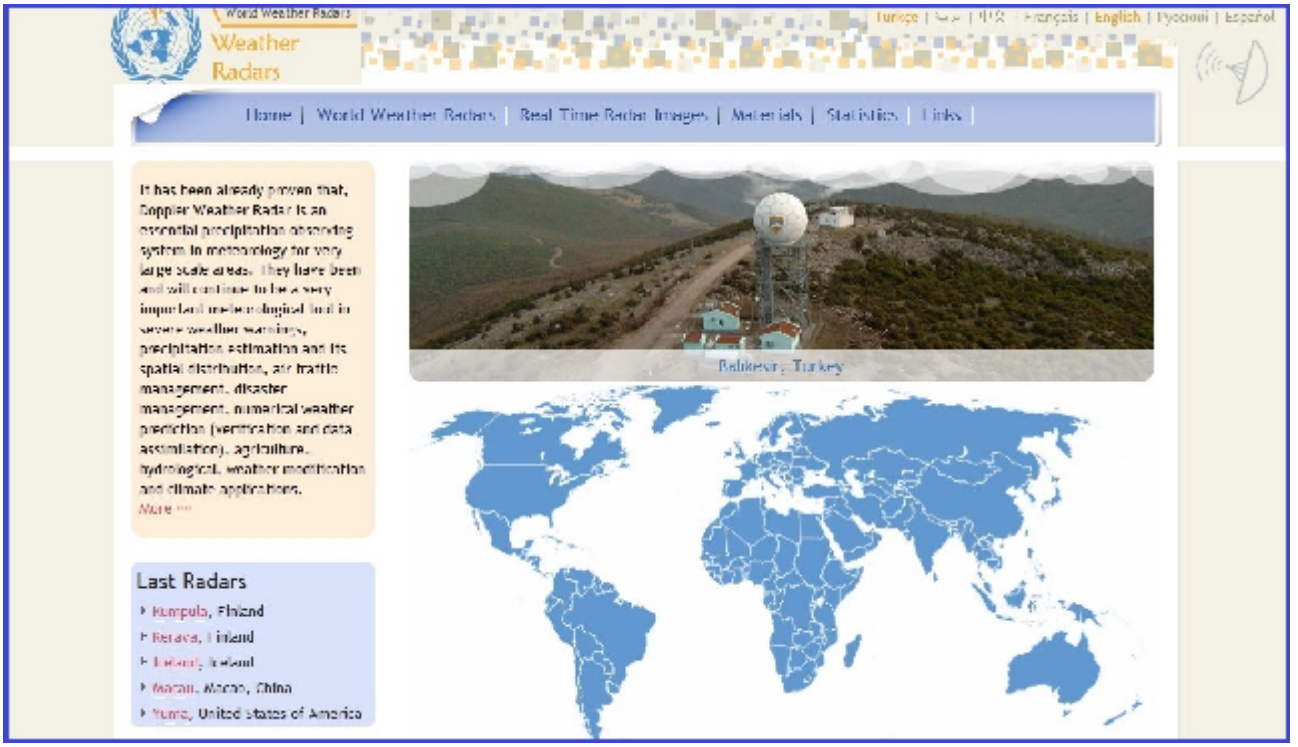


Fig. 72: Worldwide Weather Radar(WWR) Database Web Page

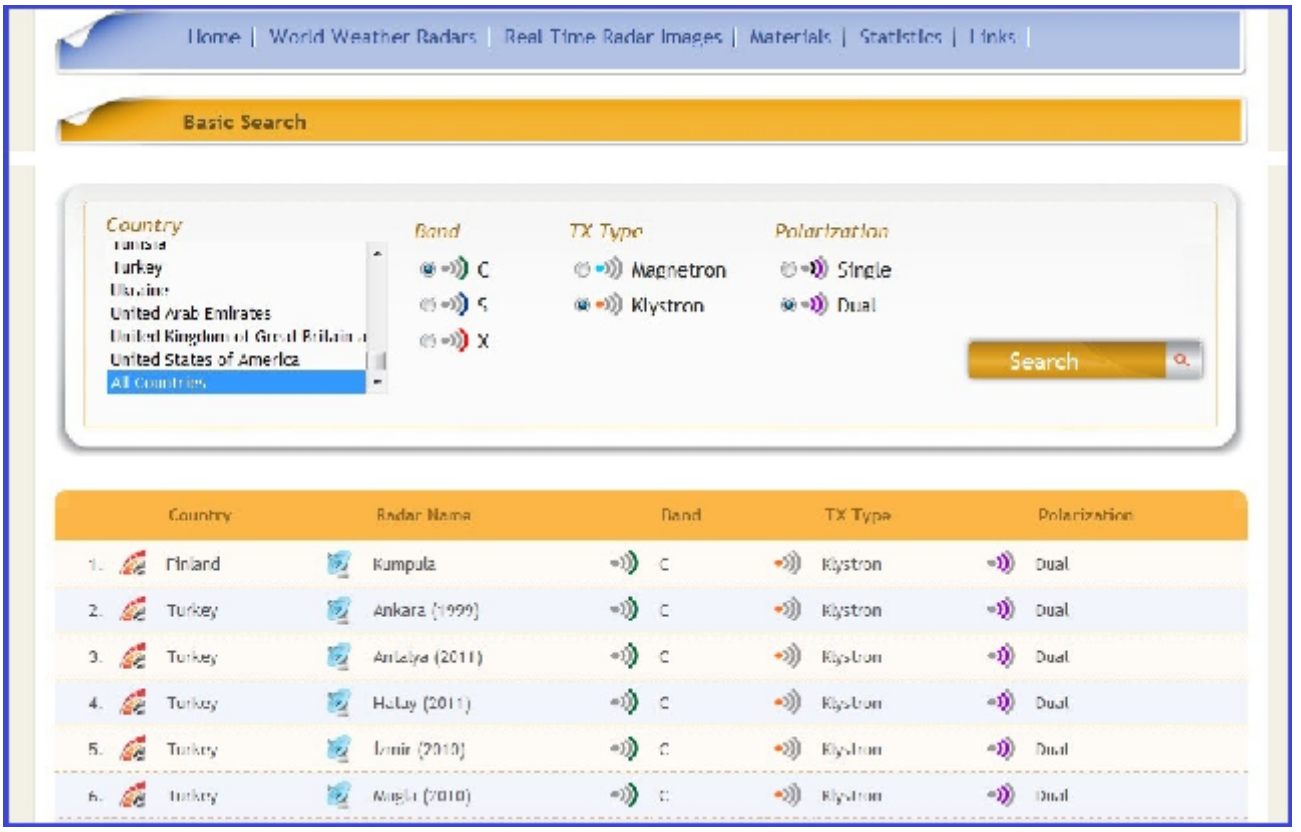


Fig. 73: Basic Search in WWR Database Web Page

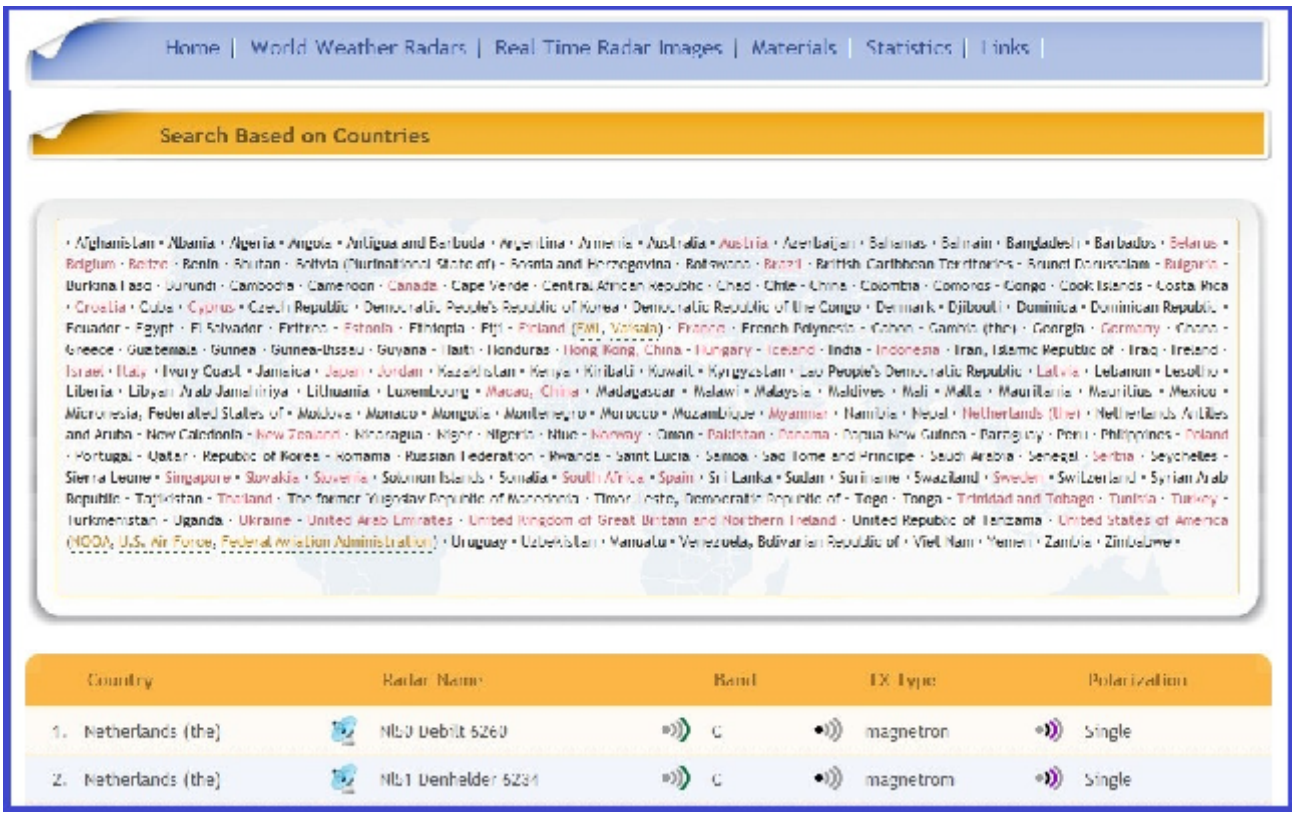


Fig. 74: Search Based on Countries in WWR Database Web Page

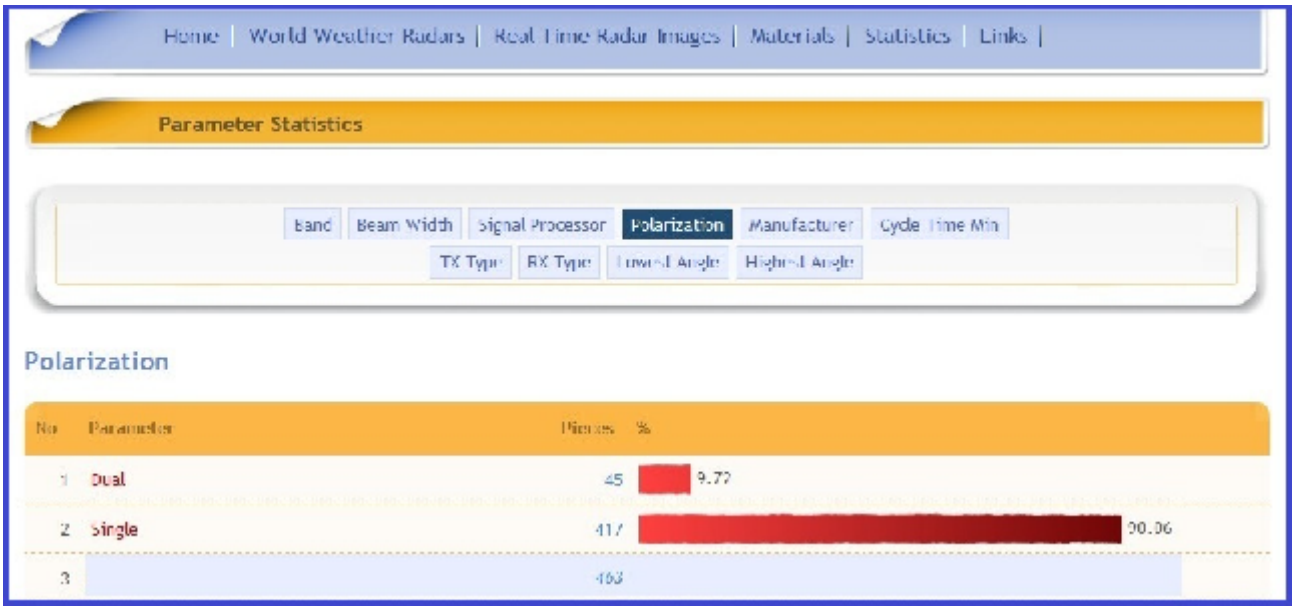


Fig. 75: Parameter Statistics in WWR Database Web Page

7. Conclusion

Replies to the questionnaire which is prepared for establishing a comprehensive web-based weather radar database are very encouraging. Even though there are some missing data in returned questionnaires, there is a positive tendency for collaboration on weather radars for several reasons. The process of gathering replies from countries which have not responded the questionnaire and the countries replied the questionnaire but not completed spread sheet will be continued. Methods for collecting the required data from operators of weather radars except of NHMSs (like universities, airports, TV stations) should be searched and applied.

This kind of global surveys will be helpfull for all WMO members. Because countries need to exchange radar data like other meteorological data with other countries for improving the capabilities for the services provided. Main areas of utilities from radars in developing countries are Nowcasting, warning and surveillance. But some advanced usages like input into Numerical Weather Prediction (NWP) models may be one of the main usages in future.

Secondly, weather radars are quite sophisticated and expensive observing systems. They are subject to continuous improvement with new technologies and planning radar network is a crucial issue. However, resources of countries for such expensive operations are limited. This kind of surveys and establishing a database can be helpful for user for planning, lead to establish some standards on some issues like data exchange and calibration, steer manufacturers to some goals and new improvements.

Another important point based on the gathered data from the replies to questionnaire is training. It can be seen that there is a huge gap between countries in this area.

Improving data quality of operational radars should be taken into consideration also. This can be achieved by wide spreading applications of correction algorithms like beam blockage correction, attenuation correction, Z-R relation studies, calibration methods and maintenance studies by trainings or encouraging collaboration between countries .

Establishing weather radar database web page presently has been performed and design of web page is being carried out in collaboration with WMO. OPERA supports database by opening its database to the study and sharing experiences.

APPENDIX A-Word form document

WORLD METEOROLOGICAL ORGANIZATION
Commission for Instruments and Methods of Observation
CIMO-OPAG on Upper-air Observation Technologies
Remote Sensing Upper-Air Technology and Techniques Expert Team

QUESTIONNAIRE

On

WEATHER RADARS

Several objectives for this survey. Primarily, it is to assess the global state of weather radars. Weather radars have traditionally been used for local or regional applications but with long term climate studies, use of radar for validation of high resolution Numerical Weather Prediction, use in assimilation into NWP models and distributed hydrological models, cross-border data exchange, their use and the quality of the radar data is now a global resource. The purpose of the survey is to begin to assess the availability, the uses and the quality of the radar data and the practices of radar maintenance and support.

The survey will also help in the global protection of radio-frequencies used by weather radar. The information requested in the spread sheet will help demonstrate the widespread use of weather radar and the technical specification. Even partial information would be useful.

This is an important time in weather radar and we appreciate the time to fill out the survey. It should not take long to fill out.

1. Member

1.1 Institute/Organization:

1.2 Do you use weather radar systems or do you plan to apply such systems?

Yes..... ☐ No..... ☐

(If your answer is Yes, you are invited to answer following questions)

1.3 How long has your organization been operating Radar:

2. Please indicate main requirements of your organization of your radars? *(Please Specify Below, e.g., severe weather warnings, hydrology, weather modification, NWP, etc)*

3. Have you hired Consultancy Service regarding radar? Yes No

☐ ☐

If you checked yes, what kind of Consultancy Service did you hire?

(Please Specify Below)

4. The main criteria considered for the site selection for radars (select only one criteria)

- Radar coverage area..... ☐
- Radar type..... ☐
- Radar utilization type (e.g. occurrence of meteorological phenomena to be monitored)……..... ☐
- Infrastructure (Power, Access road, communication, etc.)..... ☐
- Other..... ☐

(Please List)

5. The communication type for data transmission between remote radars and the operating centre

- Satellite..... ☐
- Terrestrial line (Leased line/Dial-up)..... ☐
- Radio link..... ☐
- Other..... ☐

(Please List)

5.1. Communication data rates (e.g. 128 kbps, etc.)?

5.2. Any back-up method available for the communication?

Yes..... ☐

(Please write down the type)

No…….... ☐

6. Which method is being used for data quality checking that is done in the signal or data processor? Please Specify:

6.1. What type of correction algorithms improving data quality do you have in your system?

Ground Clutter Filtering ..... ☐

Beam blockage correction..... ☐

Attenuation correction……..... ☐

Other……..... ☐

6.2. What is the average number of rain gauges for each radar?

6.3. Do you use distrometer for data comparison? If your answer is yes, how many have been installed?

7. What is the frequency of Preventive Maintenance for the main parts of the radars?

7.1 Who carries out the maintenance of your radars after warranty period?

Manufacturer..... ☐

Local Maintenance Company…… ...… ☐

Owner..... ☐

7.2 What are the main problems faced by your radar engineers in operating radars and solution methods? (Mechanical, lightning, electronically, communication, etc)

7.3. Have you ever upgraded or are you planning to upgrade your radars? If you upgraded, Could you please give information about the upgrade process.

7.4. Which countermeasures have been taken for lightning?

7.5. Do you carry out any calibration on your radar(s)?

Yes..... ☐ No..... ☐

7.6. If answer to above question is Yes, please specify which calibration and how frequently you carry.

8. What types of training have been carried out for operating radars? Do you collaborate with other countries or manufacturers?

8.1 Do you have any recommendation about "training" of radar engineers and operators?

8.2 The mission, the education level and the number of the staff working on radar related works.

Mission	Education	Number

9. Operation procedures

- Only during normal daily working hours..... ☐
- 24-hour a day..... ☐
- Changes depending on weather conditions..... ☐
- Only for extreme weather conditions..... ☐
- Other..... ☐

(Please list)

10. Prioritize utilization of weather radars in your Organization (if more than one, please mark with priority of each item as 1, 2, 3 ...)

- Large scale weather monitoring..... ☐
- Hurricane or tornado warning..... ☐
- Now casting…..... ☐
- Input to the numerical model..... ☐
- Flood warning..... ☐
- Wind warning..... ☐

- Hail warning..... ☐
- Other warnings for general public..... ☐
- Air terminal surveillance..... ☐
- En route surveillance for general aviation..... ☐
- Road and other transports..... ☐
- Rural quantitative hydrology..... ☐
- Urban quantitative hydrology..... ☐
- Research..... ☐
- Other..... ☐

(Please list)

10.1 Monitoring of the radar (time basis)

- Automatic/continuous monitoring..... ☐
- Daily monitoring..... ☐
- Weekly monitoring..... ☐
- Monthly monitoring..... ☐
- Other..... ☐

(Please list)

10.2 The number of remote terminals used (by the remote users) (if more than one, please mark with priority of each item as 1, 2, 3 ...)

- Disaster Management..... ☐
- Local Authorities..... ☐
- Hydrological Works..... ☐
- Aviation..... ☐
- Agriculture..... ☐

- Construction..... ☐
- Navigation..... ☐
- Military..... ☐
- Research Institutes..... ☐
- Universities..... ☐
- Visual Press..... ☐
- Written Press..... ☐
- Other..... ☐

(Please list)

10.3 Advanced use of radar data

- As an input to the numerical model..... ☐
- As an input to your nowcasting model..... ☐
- As an input to hydrological model..... ☐
- As an input to hydrometeor classification method..... ☐
- Other……..... ☐

(Please list)

10.4 Operating system running on your radar servers?

- UNIX..... ☐
- Linux..... ☐
- Windows..... ☐
- Other..... ☐

(Please list)

10.5 What is the name of the radar control and data acquisition software?

10.6 What is the name of the product generation software?

10.7 How is radar products displayed?

10.8 The user interface of your radar control/data acquisition software

- GUI..... ☐
- Command based..... ☐
- Other

(Please list)

10.9 The method used for controlling the radar network, task schedule and product schedule.

- Central..... ☐
- Separate (from the radar location)..... ☐
- Other..... ☐

(Please list)

10.10. What is the assumed radar-coverage area of your country? km^2

10.11. What is the approximate percentage of radar-coverage area to your country's area?

%

10.12. Number of radar systems integrated in network?

10.13. How many kind of products (approximately) are generating in operating centre?

10.14. Is there any system back-up?

- Yes ☐

(Please write down the system that has back up)

- No ☐

11. Please indicate if you exchange/disseminate radar data with other countries and/or organizations?

Exchange/Dissemination Name of the Country/Organization Type of Data

11.1. The telecommunication method used for international data exchange/dissemination.

- Internet ……..... ☐
- GTS ……..... ☐
- Teletype..... ☐
- Telephone..... ☐
- Radio telegraph..... ☐
- Radio teletype..... ☐
- Microwave..... ☐
- Satellite..... ☐
- Other..... ☐

(Please list)

11.2. What is your exchange format (s) – please list?

11.3. The data type archived

- Raw..... ☐
- Product..... ☐

(Please list the product types)

- Other..... ☐

(Please list)

11.4. Raw Data Archive strategy

- None..... ☐
- Continuously..... ☐
- Intermittent..... ☐
- Depending on user requests..... ☐
- Depending on research interest..... ☐
- Other..... ☐

(Please list)

11.5. Product Archive strategy

- None..... ☐
- Continuously..... ☐
- Intermittent..... ☐
- Depending on user requests..... ☐
- Depending on research interest..... ☐
- Other..... ☐

(Please list)

11.6. The archiving media type and capacity (for each one/total) (please write in details as dds-3 24 GB, 500 GB disk)

- Mass On-Line Storage..... ☐

- Tape..... ☐
- Disk..... ☐
- CD/DVD..... ..... ☐
- Database..... ☐
- Other..... ☐

(Please list)

11.7. If you are using a database, your archived radar data stored in

- Flat Files ……..... ☐
- A proprietary database used for radar data only..... ☐
- A common database used for all meteorological data..... ☐
- Other..... ☐

(Please list)

11.8. Is your archiving software

- Included in your radar application software..... ☐
- A third party's software..... ☐
- Your own software/script developed for that purpose..... ☐
- Other..... ☐

(Please list)

11.9. Parameters recorded and/or archived

- Total reflectivity..... ☐
- Corrected reflectivity..... ☐
- Radial velocity..... ☐
- Spectral width..... ☐

- Zdr..... ☐
- RhoHV..... ☐
- Other..... ☐

(Please list)

11.10. Data formats supported in radar data production

- Grib..... ☐
- Bufr..... ☐
- Hdf (4/5) ..... ☐
- Netcdf..... ☐
- Jpg..... ☐
- Bmp..... ☐
- Gif..... ☐
- Other..... ☐

(Please list)

12. Please indicate number of data bits for archiving.

13. Can you describe your synergetic usage of radars with other instruments and data sources (satellite images, lightning detector etc.)?

14. Do you have mobile weather radar? If you have, please specify in which cases do you use it?

15. Please write your opinion, experiences and recommendation on weather radar operations.

16. Please, write your opinion on quality of this questionnaire.

a.Please, grade this questionnaire respect to its quality.

1☐ 2☐ 3☐ 4☐ 5☐

(Quality increases from 1 to 5. For example if you think, this questionnaire is very good, choose 5 or if you think it is very bad, choose 1)

17.

Title ***First Name*** ***Family Name***

Institution :

Position :

Address :

Telephone :

Telefax :

E-mail :

URL / http :

18. Please nominate an expert person for further contact:

Title ***First Name*** ***Family Name***

Institution :

Position :

Address :

Telephone :

Telefax :

E-mail :

URL / http :

Prepared by CIMO-OPAG on Upper-air Observation Technologies
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Please, return the completed forms to the following address:

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World Meteorological Organization
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APPENDIX B- Excel Spread Sheet

Country Name

Number	Radar Name	Latitude			Longitude			Ground Height	Tower Height	Band / Frequency	Beamwidth	Pulse width	PRF
	text or number	deg	min	sec	deg	min	sec	m	m	C/S/X	deg	Range *(µSec)*	Range *(Hz)*
1													
2													

	TX Type / Power	RX Type	Polarization	Manufacturer	Lowest Angle	Highest Angle	Cycle Time	MDS	Z-R (summer)		Z-R (winter)		Z-R (others)
(DRX, Aspen, RVP etc)	(Magnetron, Klystron etc.)	*(Analog or Digital)*	*(Single or Dual)*		deg	deg	minutes	dBZ/range or degrees Kelvin or dBm	a	b	a	b	

APPENDIX C- WMO Letter to PRs on Weather Radar Survey

World Meteorological Organization
Organisation météorologique mondiale

Secrétariat
7 bis, avenue de la Paix – Case postale 2300 – CH-1211 Genève 2 – Suisse
TEL.: +41 (0) 22 730 81 11 – Fax: +41 (0) 22 730 81 81
wmo@wmo.int www.wmo.int

Our ref.: OBS/OSD/WMO/Radar-questionnaire GENEVA, 11 August 2009

Annex: 1 (available in English only)

Subject: Survey on Weather Radars

Action required: To submit the completed Questionnaire to the WMO Secretariat as soon as possible, but preferably **not later than 30 September 2009**

Dear Sir/Madam,

The fourteenth session of the Commission for Instruments and Methods of Observation (CIMO) requested the CIMO Expert Team on Remote-Sensing Upper-Air Technology and Techniques to establish a fully comprehensive database of the global use of weather radars. This would be maintained to aid the international exchange of radar data and to be used in dealing with issues like radiofrequency allocation and limitation on operational performance introduced by wind turbine operations.

In this context, the CIMO Expert Team on Remote-Sensing Upper-Air Technology and Techniques developed a questionnaire to assess the situation across WMO Members. A copy of this questionnaire is reproduced in the annex to this letter.

The questionnaire covers the following subject areas:

- General information on weather radars in use;
- Criteria used for their specifications and site selection;
- Validity checks and correction algorithms;
- Maintenance;
- Data transmission;
- Data exchange with other Members;
- Training of radar operators; and,
- Main utilization of weather radars.

To: Permanent Representatives (or Directors of Meteorological or Hydrometeorological Services) of Members of WMO (PR-8446)

In this regard, I would like to kindly invite you to complete the attached questionnaire and table and return them to the WMO Secretariat **as soon as possible, but preferably not later than 30 September 2009.** An electronic copy of the questionnaire is available at the following website: http://www.wmo.int/pages/prog/www/Questionnaires.html under: Survey on Weather Radars.

To ease the evaluation of the questionnaire, I should appreciate it if your Service would send the completed questionnaire (word document) and table (excel document) preferably as an e-mail attachment to Dr Isabelle Rüedi (iruedi@wmo.int), or via fax to the number indicated on the questionnaire.

Your collaboration in this matter is highly appreciated.

Yours faithfully,

(Hong Yan)
for the Secretary-General