WMO strategy for migration to table driven code forms

Joël Martellet, WMO, World Weather Watch, Data Processing Systems

Abstract

The traditional meteorological in-situ observations (observations in land or at sea, from ship, buoy, water profiles and upper-air soundings, etc..) are still transmitted, in 2001, in fixed alphanumeric code forms. The advantages of WMO table driven codes (BUFR and CREX) over traditional alphanumeric code forms are recalled (self-description, flexibility and expandability). The benefits of a migration to table driven codes for the meteorological observations and their data processing are expressed. It will enable transmission of any new types of data, increase the data quantity, improve the data quality and make easier the software maintenance. The strategy of WMO to migrate to table driven code forms is then presented. The existing different constraints of WMO Member Countries are considered. The proposal for a migration plan is described including respective usage of BUFR and CREX, benefits of a software house project, actions of the WMO Secretariat, actions of the WMO Member Countries, impacts on and actions of related organisations or institutes (e.g. ECMWF). Finally, future perspectives and foreseen schedule for the migration to table driven code forms are given.

Acknowledgements

This paper is based on ideas expressed by the WMO CBS Expert Team on Migration to Table Driven Code Forms. The chairman is Dr Fred Branski (USA). The members were Jean Clochard (France, Chairman Expert Team on Data Representation and Codes), Seid Amedie (Ethiopia), Heinrich Knottenberg (Germany), Keiichi Kashiwagi (Japan), Dick Blaauboer (Netherlands), Dr Vladimir Antsypovich (Russia), Milan Dragosavac (ECMWF), Dr Simon Elliott (EUMETSAT), Etienne Charpentier (JCOMMOPS).

References:

- Abridged Final Report of WMO Commission for Basic Systems, twelfth session, Geneva, 29 November-8 December 2000, pub. WMO no. 923
- World Weather Watch Twentieth Status Report on Implementation, pub. WMO no. 922
- Report of Meeting of WMO CBS Expert Team on Migration to Table Driven Code Forms, Geneva, 7-11 May 2001
- Abridged Final Report of WMO Executive Council, fifty-third session, Geneva, 5-15 June 2001, pub. WMO no. 929

List of Acronyms

ACARS	AirCraft Addressing and Reporting System
AIREP	Aircraft REPort
AWS	Automatic Weather Station
BUFR	Binary Universal Form for data Representation
CAeM	Commission for Aeronautical Meteorology
CBS	Commission for Basic Systems
CREX	Character Representation form for data EXchange
DBCP	Data Buoy Cooperation Panel
EC	Executive Council of the WMO
ECMWF	European Centre for Medium-range Weather Forecast
ET	Expert Team
ET/DR&C	Expert Team on Data Representation and Codes
EUMETNET	European Meteorological Networks
EUMETSAT	EUropean organisation for the exploitation of METeorological SATellites

FORTRAN	FORmula TRANslation
FTP	File Transfer Protocol
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GOS	Global Observing System
GRIB 1	Processed data in the form of GRId-point values expressed in Binary form - GRIB Edition 1
GRIB 2	General Regularly distributed Information in Binary form - GRIB Edition 2
GTS	Global Telecommunications System
HTML	Hyper Text Markup Language
ICAO	International Civil Aviation Organisation
IOC	Intergovernmental Oceanographic Commission
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
LINUX	Not an acronym - name of an operating system
MTN	Main Telecommunication Network
NMC	National Meteorological Centre
NMHS	National Meteorological or Hydrological Service
NMS	National Meteorological Service
NWP	Numerical Weather Prediction
RMTN	Regional Meteorological Telecommunication Network
RSMC	Regional Specialised Meteorological Centre
RTH	Regional Telecommunication Hub
SIG	Significant (weather)
SOOP	Ship Of Opportunity Programme
TAC	Traditional Alphanumeric Codes
TCP/IP	Transport Control Protocol/Internet Protocol
TDCF	Table Driven Code Forms
UNIX	Not an acronym - name of an operating system
WAFS	World Area Forecasting System
WMO	World Meteorological Organization
WWW	World Weather Watch
XBT	eXpendable Bathy Thermograph
XCTD	eXpendable Conductivity Temperature Depth sensor
XML	eXtensible Markup Language

Introduction

Meteorological observation data are the blood of all the meteorological activities of the 185 Member Countries of the World Meteorological Organisation (WMO). Efficient real time exchange of these data is crucial for operational meteorology, in particular for weather forecasting. Normalisation in the formatting of these data has been a fundamental requirement for more than 60 years. For the operation of the World Weather Watch (WWW), traditional meteorological and marine in-situ observations are still in 2001 exchanged in Traditional Alphanumeric Codes (TAC). Although their total volume is only several megabytes per day, it is still for many years, despite the constant increase in remote sensing systems, a required input for all meteorological applications. An example of the number of some observation types exchanged during one day is indicated below (from Monthly ECMWF Global Data Monitoring Report):

- FM 12 SYNOP, FM 13 SHIP, FM 18 BUOY (53837 reports)
- FM 32 PILOT (188)
- FM 35 TEMP (1166)
- FM 42 AMDAR (17252)
- AIREP (4278)

The table driven code BUFR (Binary Universal Form for the Representation of meteorological data) exists since 1985 and has been approved by the World Meteorological Organisation (WMO) for operational use in 1988. The image in characters of the binary code BUFR is CREX (Character form for the Representation and EXchange of data). WMO recommended CREX as an operational data representation code form from 3 May 2000.

The WMO table driven code forms

What will be the benefits to switch to the table driven codes instead of keeping the traditional alphanumeric codes? BUFR and CREX offer great advantages in comparison with the traditional alphanumeric codes. The main features of the table driven codes are self-description, flexibility and expandability, which are fundamental in times of fast scientific and technical evolution. In addition, BUFR offers condensation (packing). The alphanumeric code CREX provides simple readability but no packing. BUFR has been used mainly, so far, for satellite, aircraft and wind profiler observations, but also for tropical cyclone information and for archiving of all types of observational data. CREX is already used among centres for exchange of ozone data, radiological data, hydrological data, tide gauge data and soil temperature data. Ideally BUFR should always be used to exchange observations internationally. CREX should be used only if binary transmission is not possible. These two codes are the only codes that WMO needs for observation coding and are recommended for all present and future WMO applications.

Self description

In a table driven code, the presence of a datum is described in the message itself: it is the self-description feature. A section at the beginning of the message defines what data are transmitted in this message. That section will in fact contain references to predefined elements (called descriptors) stored in internationally agreed tables (listed in the official WMO Manual on Codes).

Flexibility

In CREX and BUFR the parameters are simply listed as required by the user of the codes (in fact the data producer). The datum are laid out one after the other, thus, it is very simple to read a CREX message. An item (the data value of a parameter to be transmitted in a report) will be translated in a set of characters (bytes) in CREX. It will be translated in a set of bits in BUFR. The following is an example of a surface observation from a fixed land station in SYNOP and CREX.

In code form FM 12 SYNOP:

AAXX 09091
03075 41480 62413 11073 21105 39962 40001 55019 71562 86800=

In code form FM 95 CREX:

Indicator Section	**CREX++**
Description Section	**T000101 A000 D07999++**
Data Section	**03 075 1 1989 01 09 09 00039 5845 -00308 0030 3000 075 240 0013 -073**
	-105 09962 10001 05 0019 015 07 02 075 38 20 10++
End Section	**7777**

Expandability

When there is a requirement for transmission of new parameters or new data types, new elements are simply added to the WMO BUFR and CREX Tables (to be agreed by WMO). Table driven codes can transmit almost an infinity of information. There is total flexibility. Definition of new «codes» as such is no more necessary; expansion of tables is sufficient.

The self-descriptive feature of BUFR and CREX leads to another advantage over traditional alphanumeric character codes: the relative ease of decoding a BUFR (or a CREX) message. Where a large number of specialized and complex programs are needed to decode the plethora of character codes in current use, only a single "universal BUFR (or CREX) decoder" program is capable of decoding any BUFR (or CREX) message. It is not a trivial task to

write such a BUFR decoder, but once it is done, it is done for all time. The program does not need to be modified with changes in observational requirements; only the tables need to be augmented, a relatively trivial task. For new parameters or new data types, no need to change software, just additional table entries. This is fundamental in times of fast evolution in science and technology, where there are regular requests for representation of new data types, metadata, higher resolution data in time or space and higher accuracy data.

Specific Features

BUFR offers condensation (packing), therefore voluminous data (ex. satellites, wind profilers) will require less resources for transmission and storing. BUFR also permits the transmission of associated data (flags, substituted values) with the original observation data. However, the big disadvantage is that human cannot read BUFR data directly. BUFR processing does assume the availability of well designed computer programs (decoder and encoder for the reverse) that are capable of parsing the descriptors, matching them to the bit stream of data and extracting the numbers from the bit stream, and reformatting the numbers in a way suitable for subsequent calculations. The bit oriented nature of the message also requires the availability of bit transparent communications systems which modern means offer, like TCP/IP protocol (INTERNET) or the already old X.25 protocol. Such protocols have various error detecting schemes built in so there need be little concern about the corruption of information in the transmission process.

CREX provides human readability. It is easy to understand, to code and to read (to decode) with only few hours of explanation. However, it requires for the transmission of big or many reports a substantial amount of characters. CREX tables have the same parameters as BUFR tables and are ruled by similar regulations. CREX, the image of BUFR in characters, is somehow simpler than BUFR, but does not offer the packing, nor the facility of coding associated data (quality control information, substituted values).

More data and of better quality

The reliability of binary data transmission leads to expectation for an increase in data quality and data quantity received in meteorological centres. Besides, the systematic passing of geographical coordinates (latitude, longitude, height) in every report, easily performed with the table driven codes, would alleviate the notorious WMO Volume A problems. The Volume A is updated with too much delay, the WMO secretariat receiving sometimes with considerable delay or never, the updates that the Countries should send. That solution would solve about 98% of the wrong coordinates for a station. The remaining 2% errors are due to the station itself which has being incorrectly located.

In summary:

Table driven codes, like BUFR and CREX offers:

- self description
- flexibility
- expandability
- condensation (packing), quality flags, associated values for BUFR
- simple readability for CREX

These codes are universal. They are the ideal codes for coding observations and the most adapted to the fast scientific and technological evolution of the 21st Century.

WMO decisions

Given the advantages of Table Driven Codes, the Commission for Basic Systems (CBS XII - December 2000) agreed to milestones leading to a plan for the migration from Traditional Alphanumeric Codes to Table Driven Codes. CBS XII established an Expert Team on Migration to Table Driven Codes and the WMO Executive Council (EC- LIII, June 2001) endorsed these actions.

Migration goal

Ultimately all observations should be exchanged in BUFR, which offers more features than CREX, e.g. quality flags, associated values, packing. For some countries, however, CREX can be an interim solution. The migration to table driven code forms is a big challenge for WMO Member Countries. In order to sustain a constant input flow of observation data for operational meteorological applications, the Commission for Basic Systems (CBS) listed constraints for a plan of migration to Table Driven Codes. CBS requested, it should be a smooth transition without

negative impacts on the World Weather Watch operations. The changes to Table Driven Code Forms (TDCF) will not be performed by all countries at a glance but will be progressive and voluntarily, by country and by data type. All WMO Members States should have the freedom to "switch" to BUFR (or CREX) when they want and when they are ready to do so. The migration would be a long-term process with considerable flexibility. Also, incentives for Member States to migrate to TDCF should exist. The benefits of the migration have to be clearly explained to Members. Manufacturers of observing systems as well as processing software should be made well aware of the purpose of the migration and of its benefits.

Expert Team on Migration to Table Driven Code Forms

The CBS has established an Expert Team on Migration to Table Driven Code Forms with the following terms of reference:

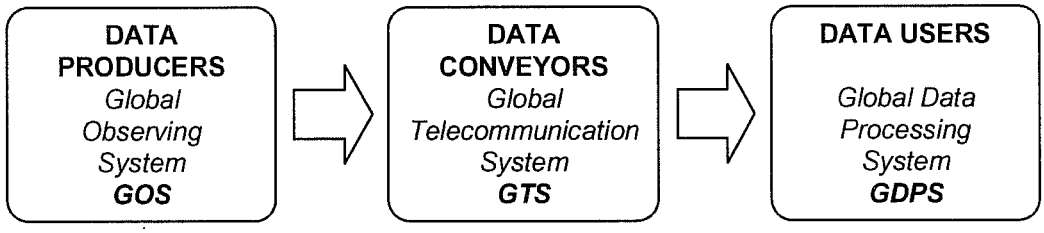
- Analysing problems due to the migration of data representation at every step of the WWW data flow and propose solutions to mitigate the impact on Members;
- Defining a software project to distribute universal BUFR, CREX and GRIB 2 encoding/decoding software to all requesting countries;
- Evaluate the relevant training needs and proposed an appropriate training programme;
- Monitor the experience gained in bi-lateral tests;
- Developing a detailed migration plan to be considered by next CBS session in 2002.

The Expert Team already met in May 2000 and started to analyse the problems of the migration to table driven code forms.

Identification of technical impacts (and possible solutions) in World Weather Watch operation due to the migration

The CBS considered that the migration to TDCF would have implications at every step of the World Weather Watch (WWW) data flow. The Expert Team tried to identify the technical impacts of the migration (and possible solutions) in all aspects of the WWW and associated operations. The Team noted that all WMO Members will not migrate at the same pace. To ensure access to data for all users, the constitution of the same observation in two types of format at some stage in the WWW data flow (concept of the double transmission or double dissemination), had to be considered. The concepts of data producers, data conveyors and data users has to be introduced to understand well the WWW data flow (see diagram below). The data producers are under the Global Observing System (GOS); the data conveyors formed the Global Telecommunication System (GTS) and the data users belong to the Global Data Processing System (GDPS). Each entities making the GOS, GTS and GDPS are all Centres located within the 185 National Meteorological or Hydrological Services (NMHSs) of the 185 WMO Member States.

THE WORLD WEATHER WATCH DATA FLOW



WMO observation data producers

One hundred eighty five National Meteorological Centres (NMCs) produce national traditional observations like SYNOP, TEMP, PILOT. A certain number of specialised collecting Centres produce:

- Satellite data (the majority already in BUFR)
- Aircraft data (AIREP, AMDAR - some already in BUFR)
- SHIP data
- BUOY data
- XBT/CTD
- Sub-surface profiling floats data

Producers will have the freedom to switch to BUFR when they need (interest of some of their users for new parameters, new data types, metadata), however, one has to ensure their other users have still access to the data. One has to analyse data flows and user requirements. Satellite data transmitted in BUFR have been used so far by a limited number of Centres running global numerical models; other users did not need these data. However, for traditional data, it may appear in many cases that the double dissemination will be necessary, that is the double transmission at some stage in BUFR and CREX (or TAC), to ensure that users who cannot receive binary data can receive in real-time the basic information. The double transmission in BUFR and TAC will not be the best since the user will not be able to receive the new parameters transmitted within the BUFR message. The manually operated WMO Members would still pass observations in TAC, but if new parameters or new data types have to be transmitted, they can use CREX. However, CREX should be seen as an interim solution; all NMCs should work at their capacity to transmit (and also receive binary data) observations coded in BUFR.

Observation sites will transmit the observation reports to a concentration site or to their NMC in a format, which could be national or non-standard, Traditional Alphanumeric Codes (TAC), CREX or BUFR (see table 1). Then different conversions may be performed and then transmission (including double transmission if there is a need for non-binary compatible users) on GTS will take place as listed in table 1. Automatic platform manufacturers should offer BUFR and CREX formats as output from their systems. All NMCs should have BUFR decoder and CREX encoder software to perform necessary conversions.

Observation site codes observation report in:	**Concentration site or National Meteorological Centre converts to:**	**Concentration site or National Meteorological Centre transmits in:**
National or other non-WMO standard format	TAC	TAC
	BUFR	BUFR
	BUFR and CREX	BUFR and CREX
	CREX	CREX
Traditional Alphanumeric Code (TAC)	No conversion	TAC
CREX	No conversion	CREX
BUFR	CREX	BUFR and CREX
	No conversion	BUFR

Table 1:

WMO observation data conveyors

The impacts of the migration on the 31 Regional Telecommunication Hubs (RTHs) which make the Global Telecommunication System (GTS) is now considered. The question is whether the most effective way to migrate would be by providing dual dissemination of data by the data producer in both traditional and table driven formats or whether translation between formats should be done at RTHs. Format translation is not a role of an RTH and many RTHs would not have the processing power to be able to do this. The additional bandwidth required by dual dissemination of code formats is relatively small and partially offset by the compressibility of BUFR encoded data. Most importantly, dual dissemination provides the greatest flexibility to WMO members from both data production and use standpoints. Dual dissemination should be the primary mechanism utilized for migration.

However, some RTHs or concentration centres may have the capability to do format translation and may decide to do translation for the needs of connected NMCs. There is in fact a significant variation of capability in different part of the GTS and among RTHs (see figure 1). RTHs in the Main Telecommunication Network have the capabilities to transmit binary data, as well as Managed Data-communication Network or satellite dissemination systems. However in other parts of the GTS there are limitations. This will result in the pace of migration varying throughout different portions of the GTS. The GTS operates still as a store and forward system. An RTH receiving data in TAC or CREX will retransmit in TAC or CREX. If data is received in BUFR, it will retransmit in BUFR. However, if it has the capability, and if it is necessary because some connected NMCs have no binary reception or processing capabilities and there was no double dissemination from the producer, it converts to CREX and transmits in CREX to the demanding NMCs. The migration will require updating of the Message Switching System Directories in RTHs. New bulletin headers have to be defined by WMO telecommunications experts.

The use of the Internet may help to solve some migration problems. For some NMCs the Internet could allow access to data originally in binary formats that are not available over their GTS link, provided meteorological observations are made available by some GDPS centres in their web or FTP server.

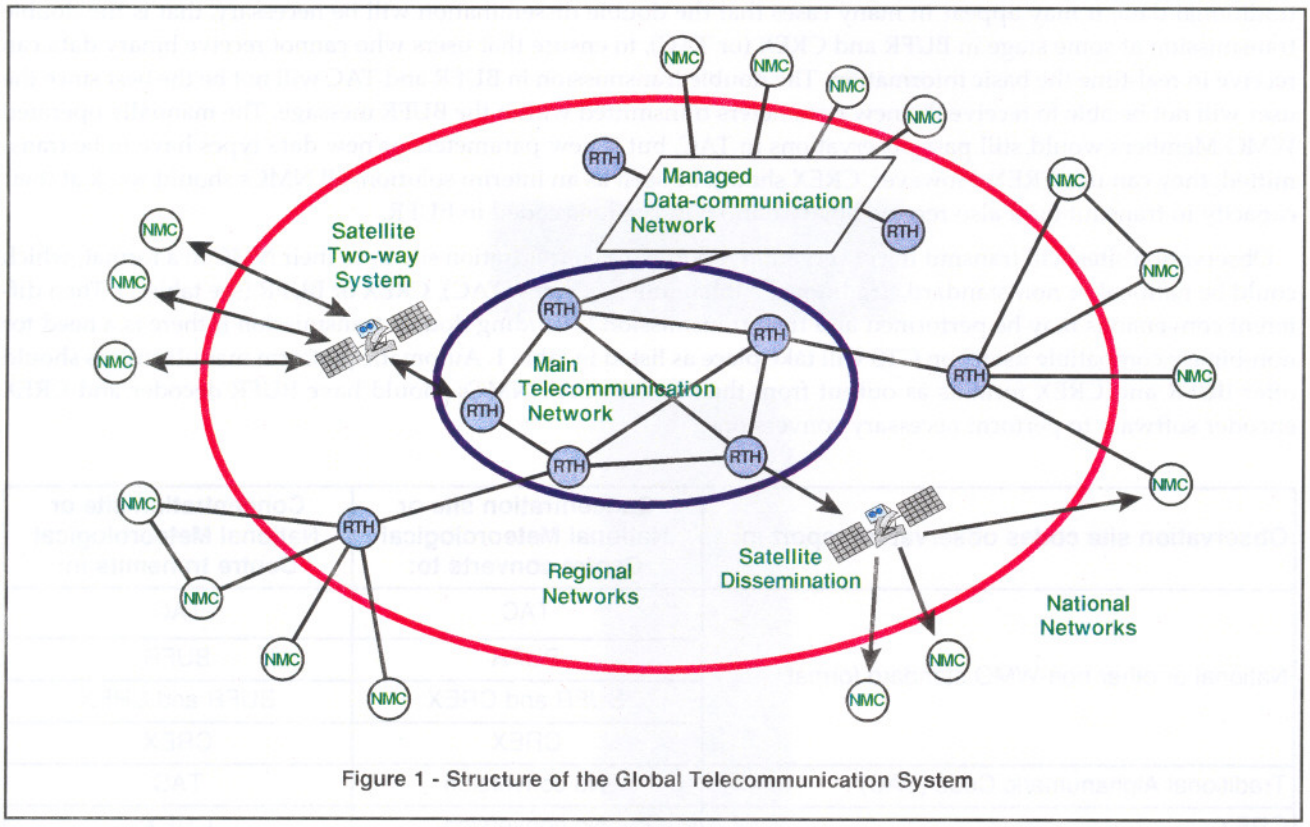


Figure 1 - Structure of the Global Telecommunication System

WMO observation data users

The users of real time meteorological data in the Global Data Processing System (GDPS) are primarily (see figure 2):

- 16 Centres running operationally global models
- 65 Centres running operationally regional or mesoscale models
- 185 (all NMCs) Centres performing regional nowcasting.

The Global Data Processing System is fed by meteorological observations. The programs receiving meteorological data are the first one to encounter the data formats, usually after having cracked the WMO Bulletins. The decoders of WMO TAC are not simple pieces of software. Two thirds of the programs, if not more, are usually dedicated to detect and correct errors in the format due to manual coding error or transmission failures. Clearly a switch to the reception of BUFR data instead of reception of WMO TAC, should improve the data quality. CREX would somehow also improve the quality, but not as much as BUFR. A universal decoder for BUFR/CREX would simplify greatly the maintenance of decoding software in pre-processing system of GDPS Centres. The big advantage of the migration to TDCF would be the facility to transmit any new data types, additional parameters like metadata, higher resolution data in time or space and higher accuracy data, which are requested by the meteorological applications, especially the data assimilation systems.

About 145 NMCs have some automated processing systems and most of them have decoders of WMO TAC. Those running global models usually have also BUFR decoders for satellite and aircraft data. Few Centres have a fully universal BUFR decoder. A great number of others might have some automated data switching systems, with a small computer processing coded observations for input to automatic plotting, or to data bases for real time access or archive. Some also have simple "turn-key" type work-stations, which receive observations in TAC. Finally there are still about 40 Centres which operates "manually".

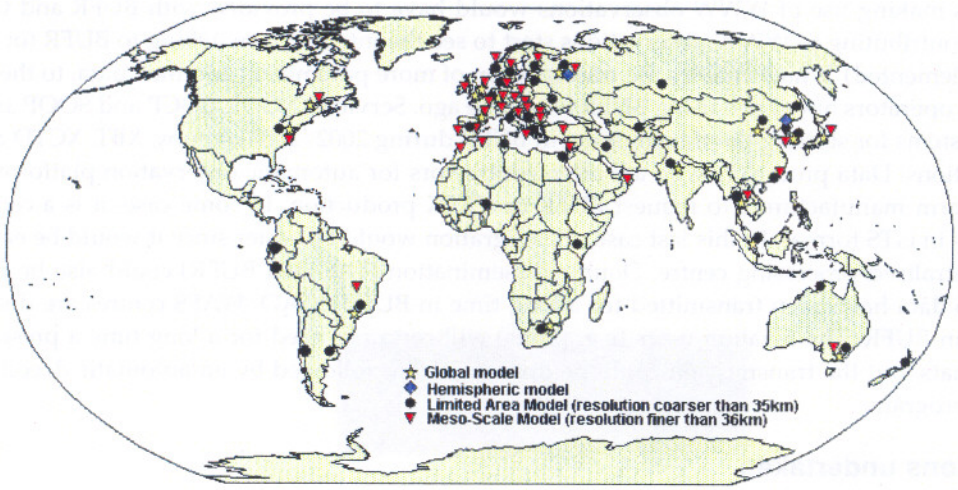


Fig 2: GDPS Centres running operational numerical models

Provision of and support for encoding and decoding software for TDCF would be necessary but not sufficient for a successful migration. It would take quite a long time for many NMHSs to introduce computer systems to process binary data and a national telecommunication network to transmit binary data to their local offices even if their NMCs and GTS Centres could deal with binary data. Furthermore, a number of advanced NMCs using automated data processing systems also used application software directly linked to TAC for data plotting, data display and database simply because most of conventional observations are coded in TAC. It should be noted that the introduction of new software (and additional hardware) for migration might have a small to significant financial impact on many NMHSs. When NMHSs will convert BUFR messages received from the GTS into character codes for their national use, there may be more sense in converting the information in CREX instead of TAC. In any case every effort should be made to avoid converting BUFR data back into TAC.

The migration to TDCF requires preparatory corrective actions at GDPS Centres to avoid missing data input. These actions can be divided in three categories:

- Some Centres will have to transform their existing decoders in their processing chain in full **universal** BUFR and CREX decoders, to avoid missing observations.
- Other Centres will have to implement a universal BUFR and CREX decoders, to be able to receive observations in BUFR or CREX. Manufacturers of "turn key" work-stations inputting GTS data would need to be approached so that they include in their software universal BUFR and CREX decoders, either in the existing systems, or for the new systems currently in development or to be developed.
- Finally, the 40 Centres, which are currently operating manually, will have to seriously consider automation with software including universal BUFR and CREX decoders. Before automation is implemented, they will be able to receive and understand CREX messages with a relatively simple training. Internet could also allow access to data originally in BUFR formats that are not available through their GTS link.

Impact of the migration to TDCF on other programmes or organisations

27. The advantages of the migration to table driven codes start to be well known not only by the World Weather Watch community, but also outside the WWW circles. One could distinguish three types of other Programmes, which are somehow connected with the WWW:

a) the Programmes depending on the operation of WWW, which provides input data to them (e.g. World Climate Programme, GCOS, Hydrology)

b) the Programmes which contribute to some data collection as input to the WWW, but which, anyway, are depending fully of the data processing of WWW (e.g. CAeM-aviation meteorology -ICAO, JCOMM-Marine Meteorology)

c) the Programmes, which contribute data to the WWW, but which do not need fully the WWW processing for operation (e.g. Satellites, Oceanography-IOC)

Programmes making use of WWW observations would have to be provided with BUFR and CREX decoders. Programmes contributing to WWW observations start to see the interest of switching to BUFR (or CREX, if BUFR cannot be implemented), which enables the transmission of more parameters and metadata, to the benefit of their users. Satellite operators have been using BUFR long time ago. Service ARGOS, DBCP and SOOP are planning and developing systems for starting the transmission in BUFR during 2002/2003 of buoy, XBT, XCTD and sub-surface floats observations. Data producers who are often contractors for automatic observation platforms have to work with the platform manufacturers to request BUFR or CREX production. In some case, it is a centralised centre, which encodes in GTS format. In this last case, the migration would be easier since it would be easy to convert to BUFR in a centralised processing centre. Double dissemination (TAC and BUFR) could also be performed for a while. ACARS data have been transmitted for a long time in BUFR. ICAO/WAFS centres are disseminating SIG weather data in BUFR. The aviation users (e.g. pilots) will certainly need for a long time a presentation in clear character formats, but the transmission could be done in BUFR, followed by an automatic decoding prior to the visualisation program.

Current actions undertaken

The WMO secretariat distributes guidance information describing in a simple manner the table driven codes and explaining their advantages. A new guide on BUFR/CREX with 3 layers has been written and will be on the WMO web in January 2002 (www.wmo.ch search right to Codes):

Layer 1: for general philosophy

Layer 2: for application interfacing users, data and telecommunication managers

Layer 3: for encoder/decoder programmers

A new WMO manual defining reporting practices which were previously associated to code forms (e.g. synoptic observations and FM 12 SYNOP) is currently being written. WMO seminars include training on TDCFs.

Actions expected from WMO Member States:

- Define migration contact points;
- Identify impacts of migration on national operation;
- Start national training programme on TDCF;
- Adjust software in observation, concentration and dissemination systems and in input data processing chain: reception, MSS, decoding, visualisation, archiving;
- Find the necessary financial resources.

What are the keys to success?

31. Training and availability of encoder/decoder software are the two main keys to success.

Training on BUFR/CREX (level 1 and level 2). WMO seminars will be organized:

- Train the trainers (WMO Regional Meteorological Training Centres, meteorological schools, colleges, universities)
- WMO Seminars on TDCFs in countries
- National training programmes within countries.

Software project:

- Software house: a centre distributing free BUFR/CREX encoder/decoder software, providing documentation, providing assistance for implementation and answering queries.

Software project requirements

BUFR and CREX define the standard format of the "physical" data layout, they are not Application Program Interfaces. Standard user interfaces have to be specified. The tasks of the software project are the following:

1. Specify the user interfaces for encoding and decoding.
2. Build software to decode/encode BUFR, CREX (and GRIB 2). At a minimum, software should compile and run on the most common dialects of UNIX (including LINUX) and WINDOWS. It should be compatible with 32-bit and 64-bit architectures.
3. The software delivered should be callable from applications, written in most common programming languages, such as FORTRAN and C.

4. Printing and display routines should be available to view the whole contents of decoded data, and should be completed by user-friendly interface(s) as appropriate (JAVA or XML on PC).
5. The user should have access to Code tables, for human reading and editing if needed, following new international addition or requirement for local table entries.
6. Documentation on the program should be clear and comprehensive, with all interfaces to external application well defined.
7. The software will be distributed to WMO Members and WMO associated Programs. It will be maintained and upgraded when required. Queries will be answered.
8. Software (or relevant data type subset) should also be made available to manufacturers of systems providing or encoding meteorological data.

After the programming development is completed, the task of the software project is estimated for one person full time.

Software house project

A software house project is a new paradigm for the WMO but it is required for a successful migration to TDCFs. A centralized unit developing and supporting application program interface software is a valuable and necessary step to ensure that modern standard data representation forms, developed and coordinated by the WMO, be used by the widest possible user community. This will be of particular use to those users with very limited computer programming resources.

Tentative migration schedule

A tentative schedule for the migration, depending on the category of TAC, has been proposed by the Expert Team on Migration and is listed below in Table 2:

	Cat. 1: common	**Cat. 2: satellite observations**	**Cat. 3: aviation***	**Cat. 4: maritime**	**Cat. 5: miscellaneous**	**Cat. 6: almost obsolete**
Traditional code forms	SYNOP SYNOP MOBIL PILOT PILOT MOBIL PILOT SHIP TEMP TEMP MOBIL TEMP SHIP TEMP DROP CLIMAT CLIMAT TEMP CLIMAT TEMP SHIP	SAREP SATEM SARAD SATOB	METAR SPECI TAF CODAR AMDAR WINTEM ARFOR ROFOR	BUOY TRACKOB BATHY TESAC WAVEOB SHIP CLIMAT SHIP	RADOB RADREP IAC IAC FLEET GRID(->GRIB) MAFOR HYDRA HYFOR RADOF	ICEAN GRAF NACLI etc. SFAZI SFLOC SFAZU ROCOB ROCOB SHIP
Start experimental exchange	**Nov. 2002** Current for wind profiler data	Current at some Centres	**2006** Current at some Centres for AMDAR	**2005** **2003** for Argos data (BUOY)	**2004**	Not applicable
Start operational exchange	**Nov. 2005**	Current at some Centres	**2008**	**2007** **2003** for Argos data (BUOY)	**2006**	Not applicable
Migration complete	**Nov. 2010**	**Nov. 2006**	**2015** **2005** for AMDAR	**2012** **2008** for Argos data (BUOY)	**2008**	Not applicable

Note: * Aviation Codes require ICAO coordination and approval.

Table 2:

Conclusion

The WMO project for migration to Table Driven Code Forms will be successful if the benefits of using TDCFs are well perceived by the WMO Member Countries, who then will be inclined to implement national programmes for their migration. Some key elements for a successful migration are already available. Guides to explain codes and migration issues are accessible on the WMO web pages. Training is already provided in WMO seminars. Encoder/decoder software is available. Templates in BUFR/CREX for all common traditional observation types have been prepared. The WMO Expert Team on Data Representation and Codes provides continuous development and maintenance of TDCFs. Central planning and coordination of the migration will be performed by the Expert Team on Migration to TDCFs. Parallel transmission of TAC along with migrated data will allow flexibility of transition. CREX can be used where infrastructure cannot support BUFR. Translation can be done between BUFR and CREX. Progress of migration will be monitored to expedite reduction of un-needed dual transmissions. Coordination with manufacturers for encoding/decoding will be done. Several producers will be able to start to transmit traditional observation data in BUFR at end of 2002 or 2003 for reports from: automatic weather stations, radiosonde stations, buoys, XBT/CTD and sub-surface profiling floats data.

The implementation of a software house project in an advanced Country or through an International Organisation will favour and help migration to table driven codes. The first beneficiaries of such a project would be the advanced Countries themselves, and all their meteorological applications, in particular their operational forecasting systems, with the prospect of receiving more data and better quality data. A support from the advanced Countries for such a financially modest project will be at the benefit of world-wide progress in operational meteorology.