

# ITU WORKSHOP

## Activities of ITU-R Study Group 3 on radiowave propagation

### Working Party 3M – 4 Measurements, Software and Testing

EuCAP 2024, Glasgow

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ESA/ESTEC TEC-EFW, The Netherlands

EuCAP 2024, ITU-R SG3 Workshop



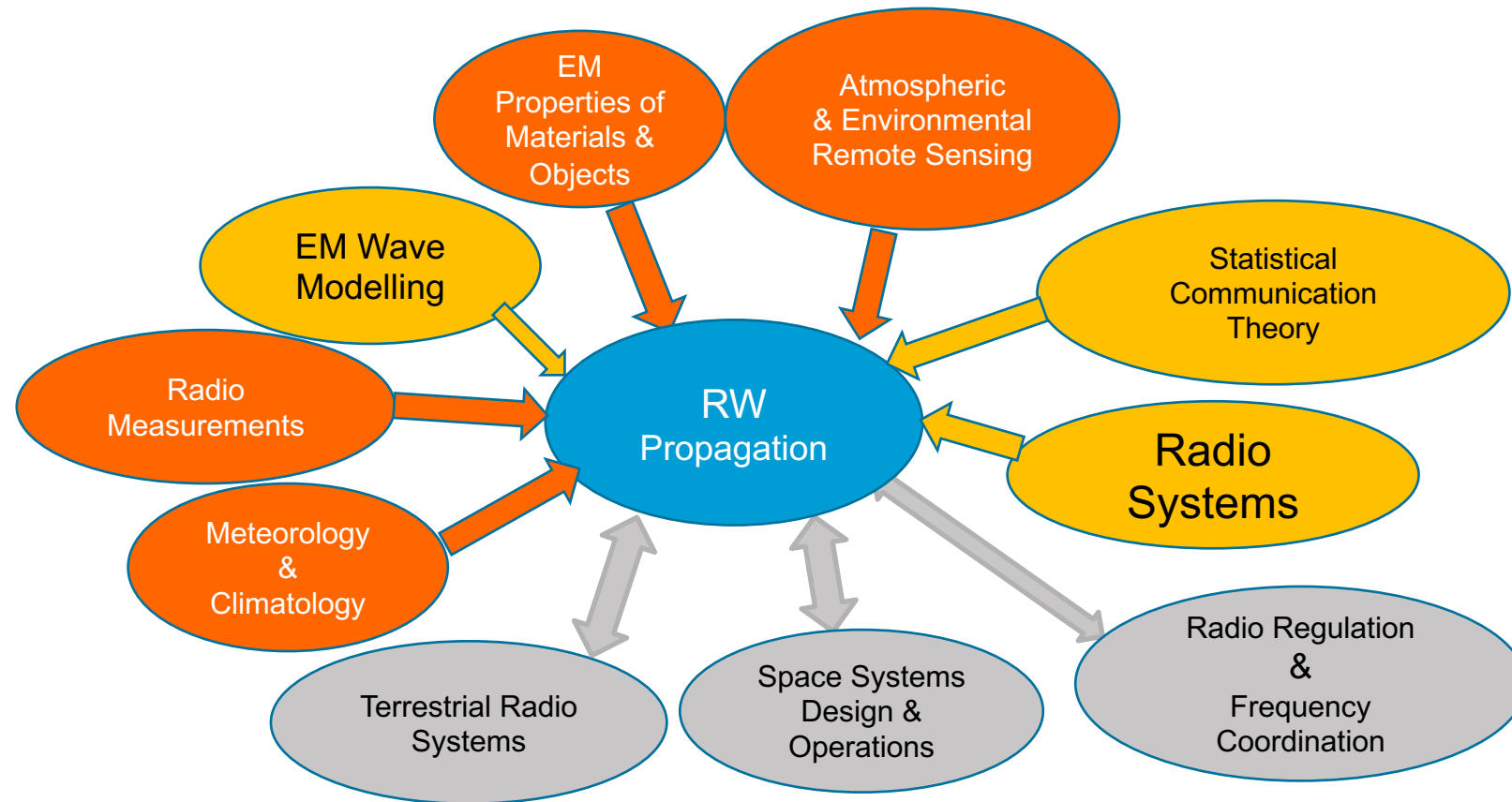
# Contents

- Introduction
- Experimental Data (DBSG3)
- Software & Digital Maps (DIGSG3)
- Conclusions
- Acknowledgements

# Introduction

# Introduction

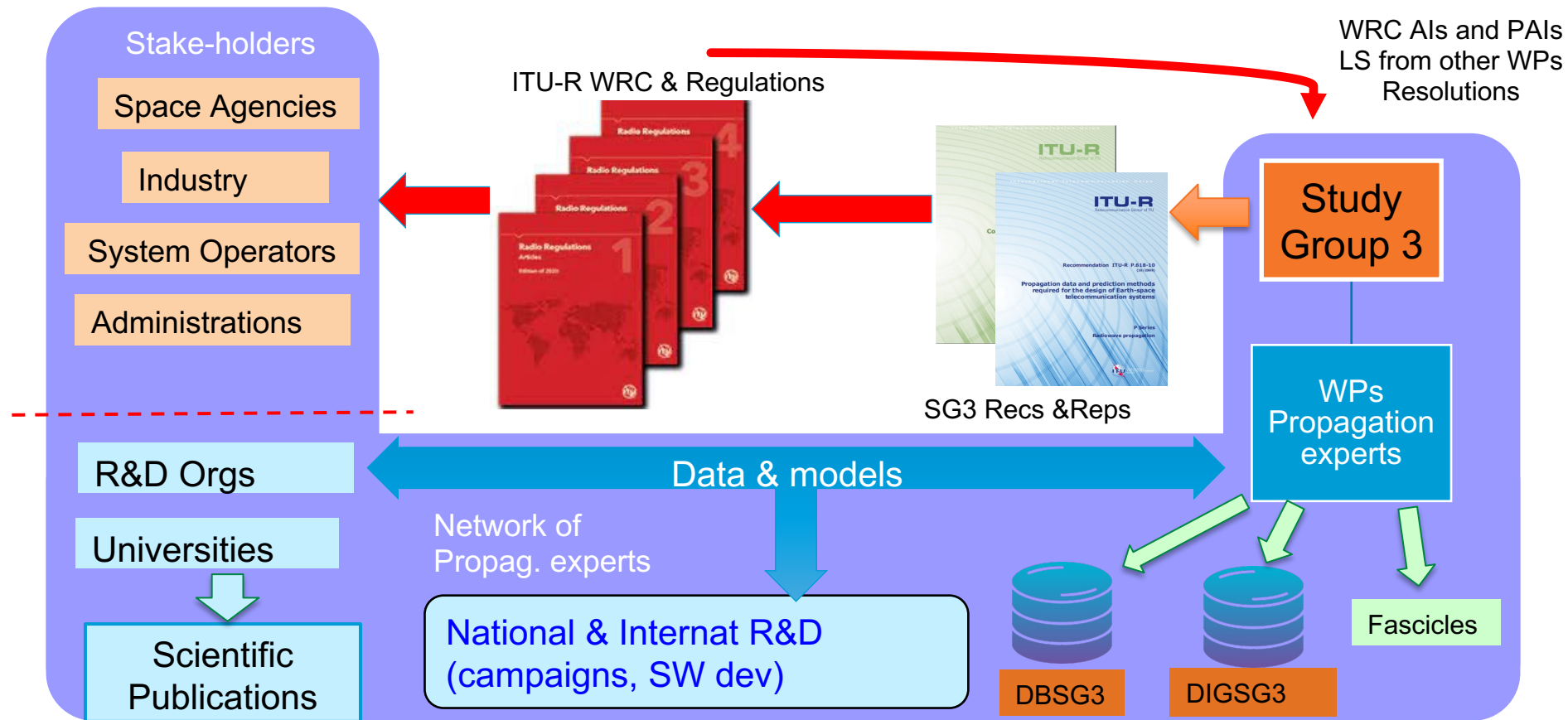
What is entailed by Radiowave propagation ? (cross-road of several disciplines)



3M4 Topics

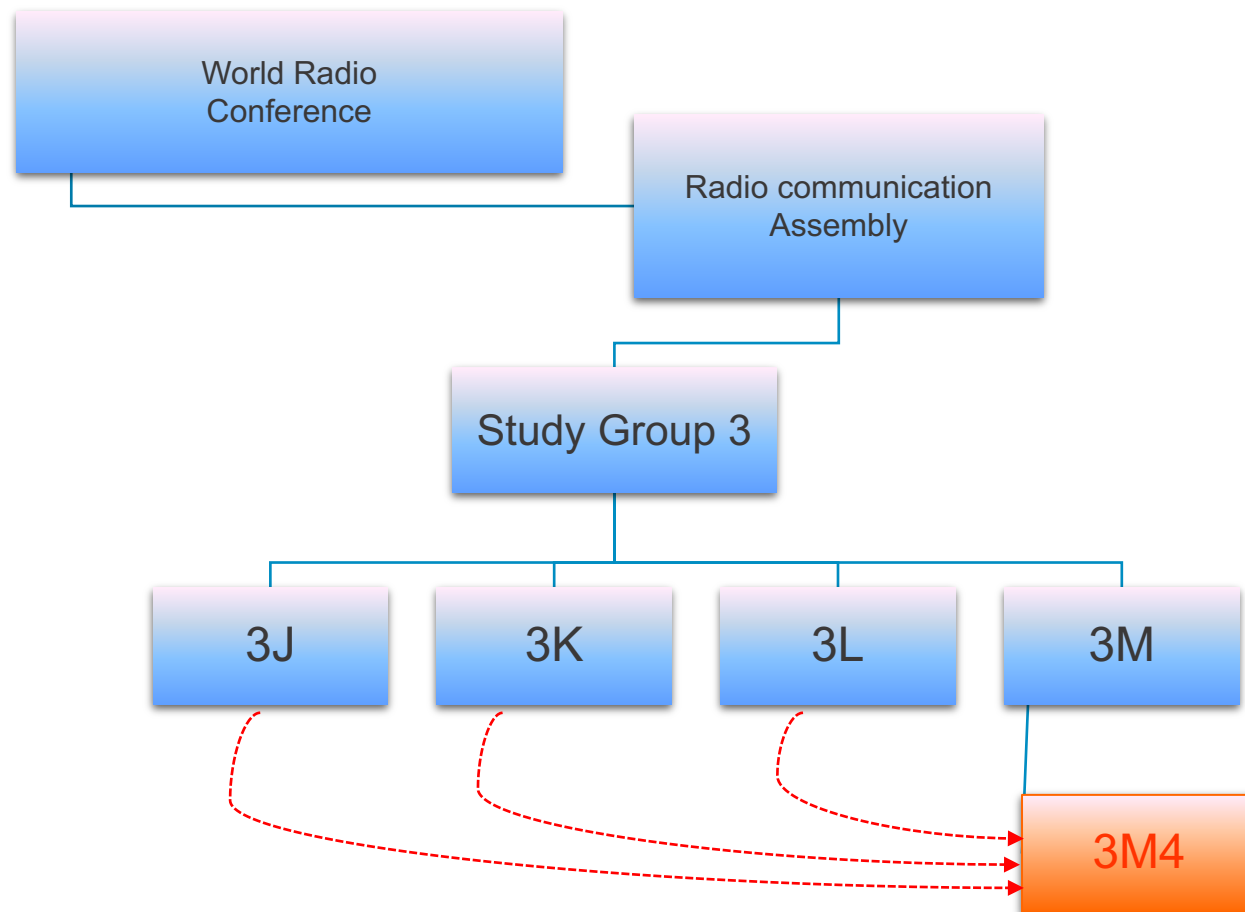
# Introduction

How do we get contributions ? (work-flow with stake-holders)



# Introduction

## 3M4: Where we are and what we do ? (Working methods)



### ITU-R Assigned Texts

- Question 236: Use of Machine Learning
- Resolution 25: Computer Programs for SG3
- Recommendation P.311: Experimental data
- Recommendation P.2147: SW & Digital Maps

### 3M4 Main Topics (in collaboration with all WPs)

- Experimental data and methods
- SW and digital products, development and maintenance methods

### Produced Texts

- Information for experimental data submissions
- Public Fascicles on experimental methods
- \* SG3 experimental database (DBSG3)
- Information for SW submission
- SG3 WEB page for SW and validation data
- \* SG3 SW repository (DIGSG3)

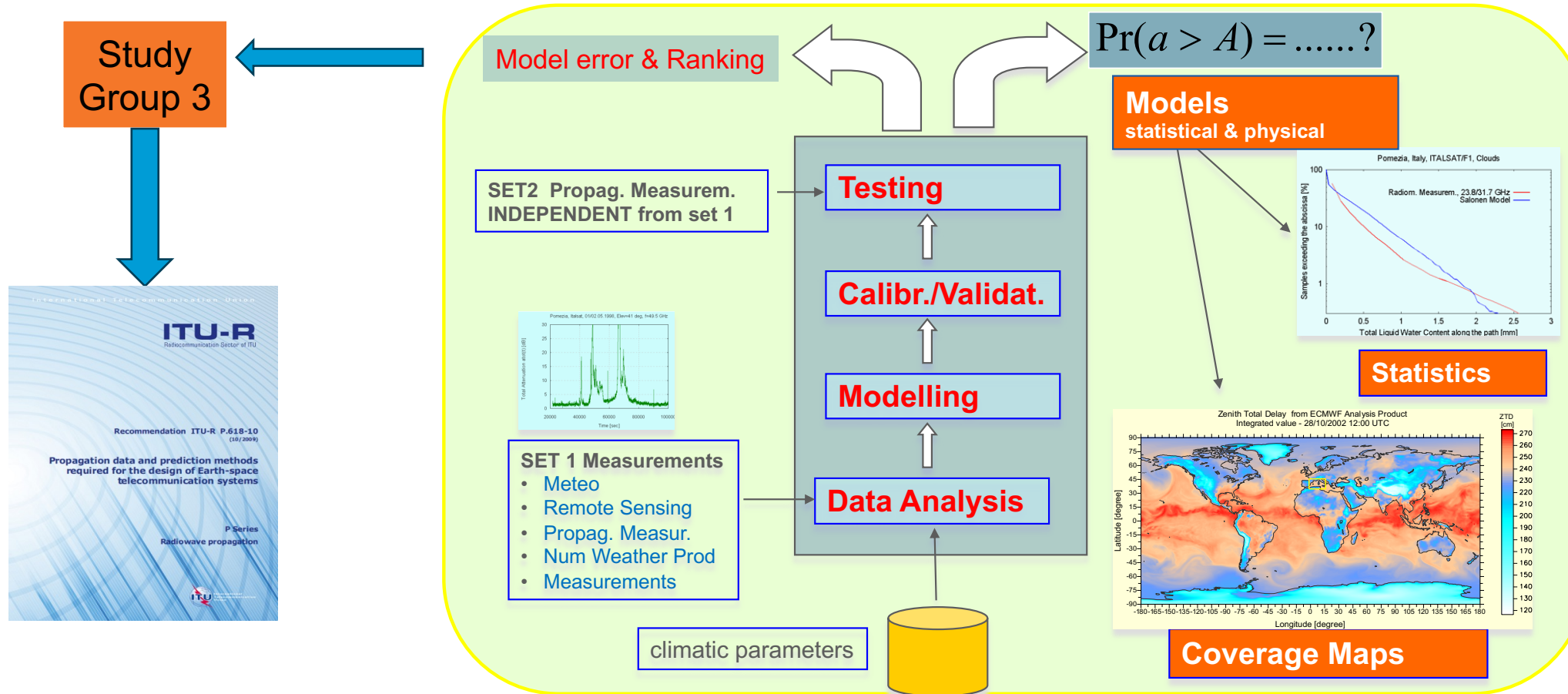
\*SG3 Restricted access

# SG3 Experimental Data

## DBSG3

# Experimental data (DBSG3 and Fascicles)

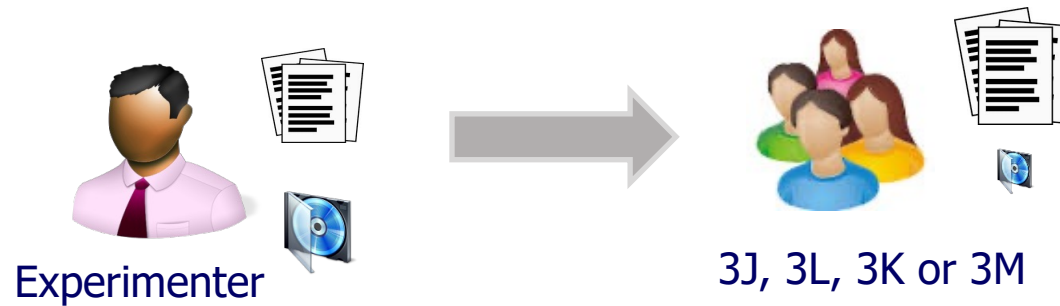
Why do we need experimental data ? (Test for recommendation)





# Experimental data (DBSG3 and Fascicles)

How submitted data are studied ? (WG discussion & reference expert)



## STEP 1:

### Before the meeting

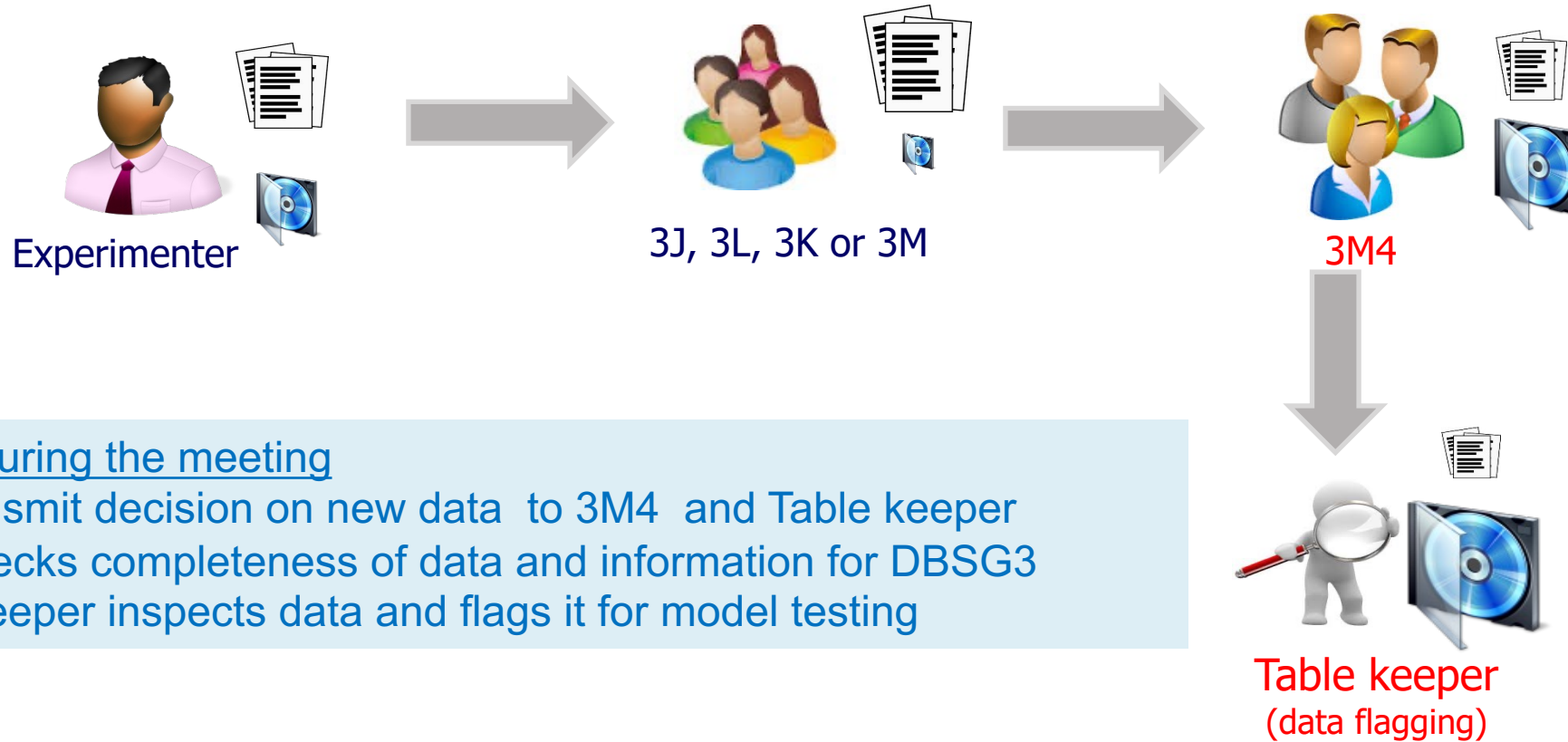
Experimenter Submits new data and information document to a WP

### During the meeting

WP evaluates the contribution, focusing on the information on the experiment and its results

# Experimental data (DBSG3 and Fascicles)

How submitted data are studied ? (WG discussion & reference expert)

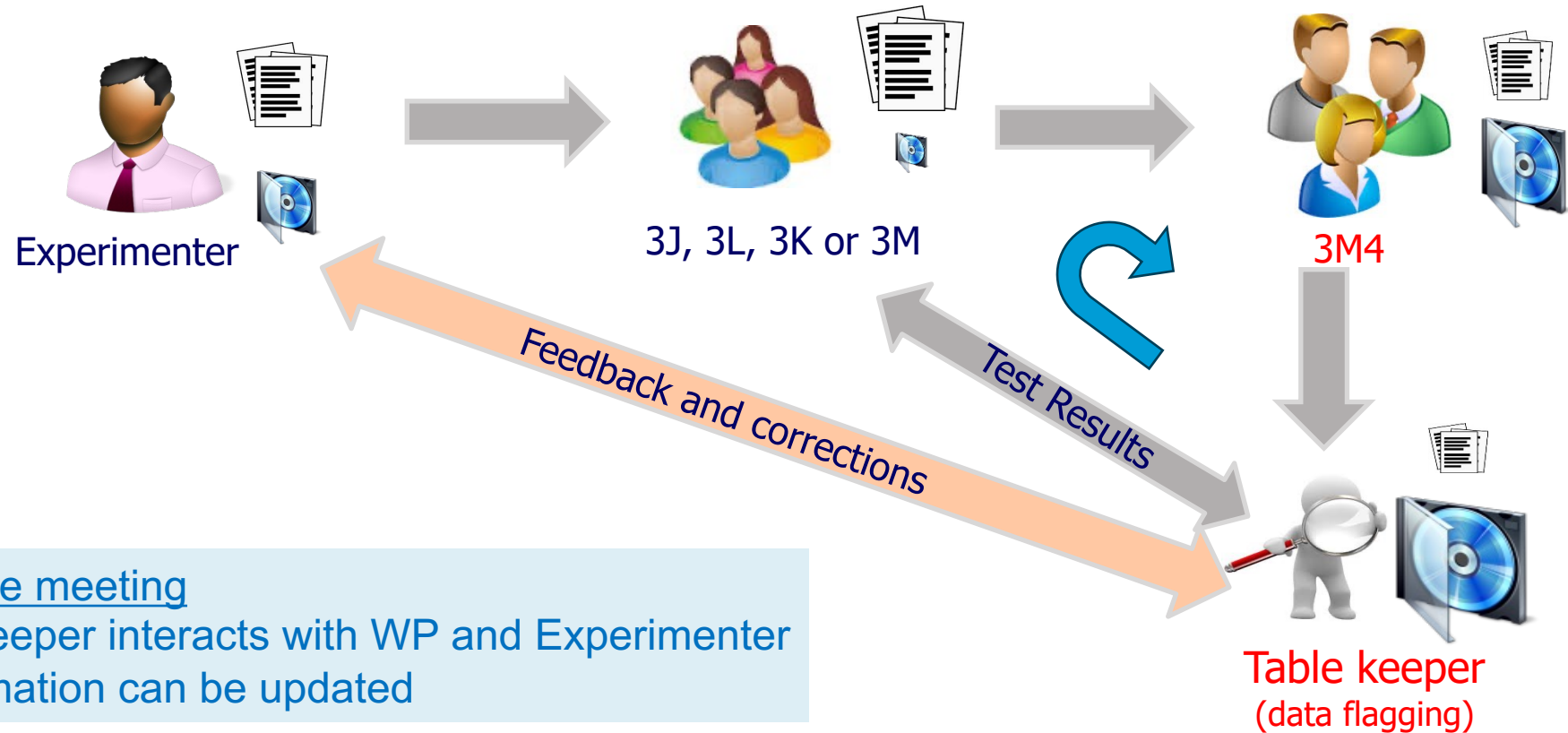


## STEP 2: During the meeting

- WP transmit decision on new data to 3M4 and Table keeper
- 3M4 checks completeness of data and information for DBSG3
- Table keeper inspects data and flags it for model testing

# Experimental data (DBSG3 and Fascicles)

How submitted data are studied ? (WG discussion & reference expert)

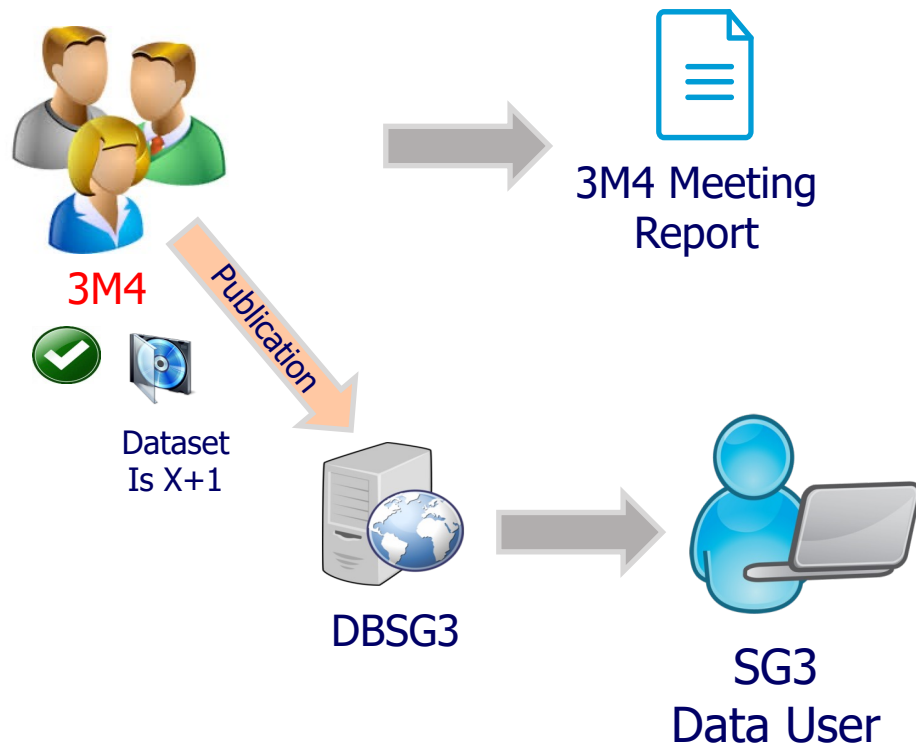


## STEP 3: During the meeting

- 3M4 & Table Keeper interacts with WP and Experimenter
- Data and information can be updated

# Experimental data (DBSG3 and Fascicles)

How submitted data are studied ? (WG discussion & reference expert)



STEP 4: At the end of the meeting:

3M4

- Issues a report on all data studied during the meeting (Annex to 3M Chairman Report as input for next meeting)
- Stores all approved data on DBSG3, using version control

SG3 member can access data on DBSG3

# Experimental data (DBSG3 and Fascicles)

How submitted data are studied ? (WG discussion & reference expert)



## STEP 5: During Intersession period

Experimenter:

- can submit corrected/reprocessed data

Table keeper:

- can consider corrected data and update DBSG3
- reports to CG-3M2

CG-3M2:

- Produces a CG-3M2 report for next 3M meeting

Publication

Dataset  
Is X+Y

DBSG3

SG3  
Data User

# Experimental data (DBSG3 and Fascicles)

What data are we looking for ?

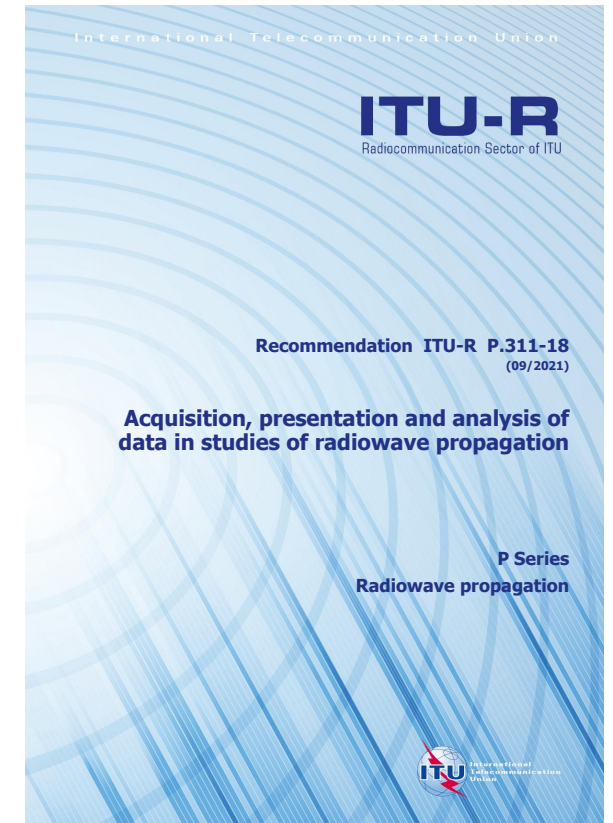
What are the requirements for data submission ?

See ITU-R Rec. P.311

## 4 List of the data banks of Radiocommunication Study Group 3 concerning tropospheric propagation

### 4.4 Part IV: Radiometeorological data

Table IV-1:	Annual and monthly statistics of rain intensity
Table IV-2:	Rain integration time conversion factor
Table IV-3:	Annual and monthly statistics of sky noise temperature
Table IV-4:	Statistics of mean surface refractivity
Table IV-5:	Statistics of rain event duration
Table IV-6:	Statistics of evaporation ducts
Table IV-7:	Statistics of cloud cover
Table IV-8:	Spatial statistics dependence of rain intensity
Table IV-9:	Annual and monthly statistics of total columnar water vapour content
Table IV-10:	Annual and monthly statistics of total columnar cloud liquid water content
Table IV-11:	Statistics of rain cell characteristics parameters
Table IV-12:	Statistics rain drop size distribution
Table IV-13:	Annual and monthly statistics of tropospheric excess path length



# Experimental data (DBSG3 and Fascicles)

How data shall be presented to SG3 ?

See formatted tables for data submission

<https://www.itu.int/en/ITU-R/study-groups/rsg3/Pages/dtbank-form-tables.aspx>

1

**Part IV: Radiometeorological data**

TABLE IV-1 – Statistics of yearly and monthly rain intensity\*

Station number -----  
 RG site name -----  
 RG country<sup>(1)</sup> -----  
 RG latitude (-90..+90) (degrees) -----  
 RG longitude (0..360) (degrees) E -----  
 RG altitude amsl  $h_g$  (m) -----

**Measurement:** Experiment No. -----  
 Rain gauge type -----  
 RG resolution (mm/h) -----  
 RG integration time (s) -----  
 RG accumulation per tip (mm/tip) -----  
 RG aperture (cm<sup>2</sup>) -----

Start date (yyyy.mm.dd) -----  
 End date (yyyy.mm.dd) -----

**Table a** <sup>(6) (7)</sup>:

$R$ : Yearly/monthly rain rate exceeded for 0.001%, 0.002%, 0.003%, 0.005%, 0.01%, 0.02%, 0.03%, 0.05%, 0.1%, 0.2%, 0.3%, 0.5%, 1%, 2%, 3%, 5% and 10% of the measurement period -  $R$  (mm/h) <sup>(8)</sup>  
 $R_{wm}$ : Rain rate exceeded for percentage of worst month -  $R_{wm}$  (mm/h) <sup>(9)</sup>  
 $R_t$ : Yearly/monthly total accumulation of rain during the measurement period  $R_t$  (mm) for single years. For the full period, MEAN monthly and yearly amounts are required.

- 2 -

Period of year	Year	Worst month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$d_t$ <sup>(10)</sup> (days)														
$d_g$ <sup>(10)</sup> (days)														
$p_0$ <sup>(5)</sup> (%)														
$R$ 0.001 <sup>(10)</sup> (mm/h)														
$R$ 0.002 <sup>(10)</sup> (mm/h)														
$R$ 0.003 <sup>(10)</sup> (mm/h)														
$R$ 0.005 <sup>(10)</sup> (mm/h)														
$R$ 0.01 <sup>(10)</sup> (mm/h)														
$R$ 0.02 <sup>(10)</sup> (mm/h)														
$R$ 0.03 <sup>(10)</sup> (mm/h)														
$R$ 0.05 <sup>(10)</sup> (mm/h)														
$R$ 0.1 <sup>(10)</sup> (mm/h)														
$R$ 0.2 <sup>(10)</sup> (mm/h)														
$R$ 0.3 <sup>(10)</sup> (mm/h)														
$R$ 0.5 <sup>(10)</sup> (mm/h)														
$R$ 1 <sup>(10)</sup> (mm/h)														
$R$ 2 <sup>(10)</sup> (mm/h)														
$R$ 3 <sup>(10)</sup> (mm/h)														
$R$ 5 <sup>(10)</sup> (mm/h)														
$R$ 10 <sup>(10)</sup> (mm/h)														
$R_t$ (mm)														
Snow included <sup>(11)</sup>														
RG up-time <sup>(12)</sup> (%)														



# Experimental data (DBSG3 and Fascicles)

- Information on last measurements ? (Annex X 3M Chair Rep, New measurements)

Table	Title	Table Keeper	Refer. Input doc	STATUS	Link to the DBSG3 repository
I-1	L-O-S rain attenuation statistics	R. Vieitas, F. Neves	<a href="#">3M/403</a> <a href="#">3M/408</a>	<ul style="list-style-type: none"> <li>approved by 3M-1</li> <li>approved by TK</li> </ul>	<a href="#">Table I-1 DBSG3 Repository</a>
II-1	Slant path annual and monthly statistics of total attenuation, rain attenuation and rain rate	C. Riva L. Castanet	<a href="#">3M/399</a> , <a href="#">3M/429</a> <a href="#">3M/434</a>	<ul style="list-style-type: none"> <li>approved by 3M-2</li> <li>approved by TK</li> </ul>	<a href="#">Table II-1 DBSG3 Repository</a>
IV-1	Statistics of rain intensity	L. Castanet X. Boulanger	<a href="#">3M/407</a>	<ul style="list-style-type: none"> <li>approved by 3J-2</li> <li>approved by TK</li> </ul>	DBSG3 Repository/Part IV <a href="#">Radiometeorological data</a> : IV-01
XI-1	Indoor site-general basic transmission loss	F. Lewicki	<a href="#">3M/300</a> , <a href="#">3M/311</a> <a href="#">3M/405</a> <a href="#">3M/414</a> <a href="#">3M/417*</a>	<ul style="list-style-type: none"> <li>Approved by 3K3</li> <li>Approved by TKr</li> <li>Allocated to CG-3K-6</li> </ul>	<a href="#">DBSG3 Repository/ Part XI Short-range path data/X1-1</a>

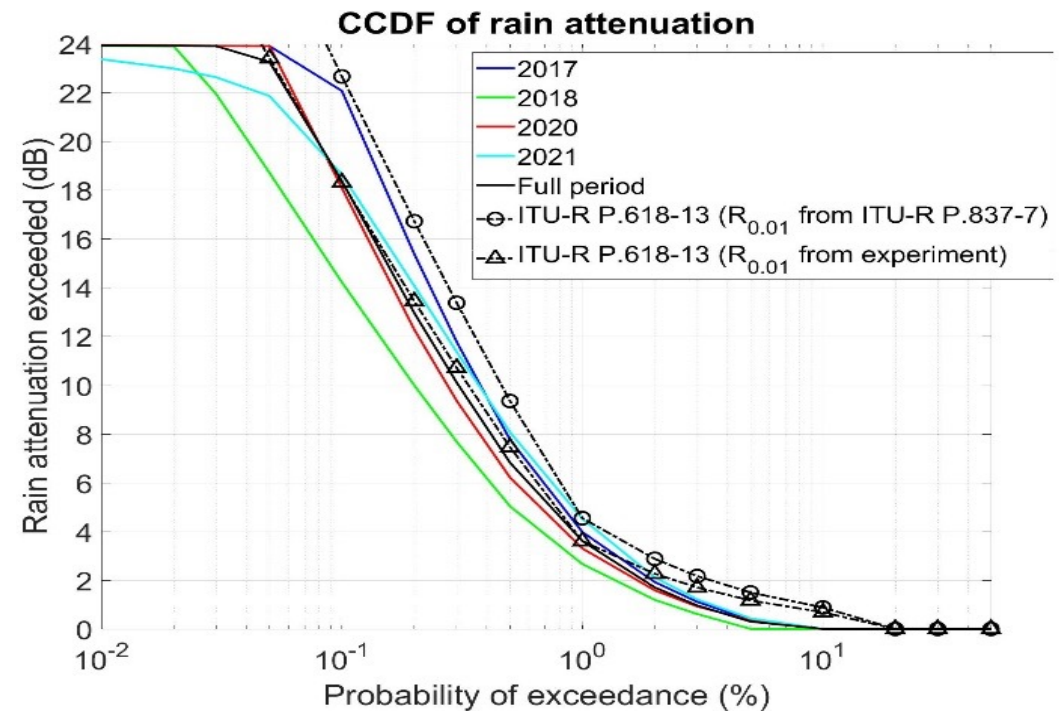
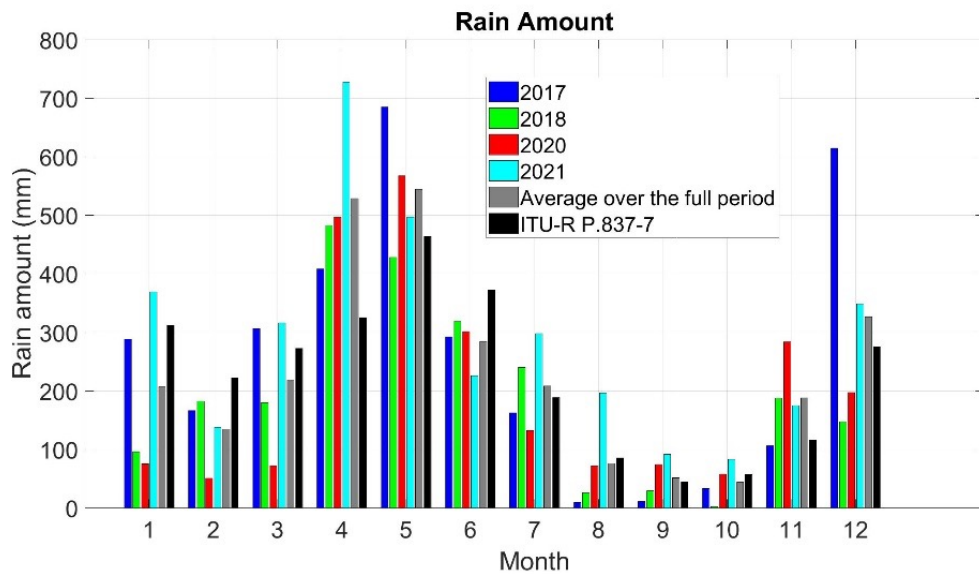
3M4 meeting reports includes new tables for data submission and list of table keepers



# Experimental data (DBSG3 and Fascicles)

Some examples from 2023 submissions

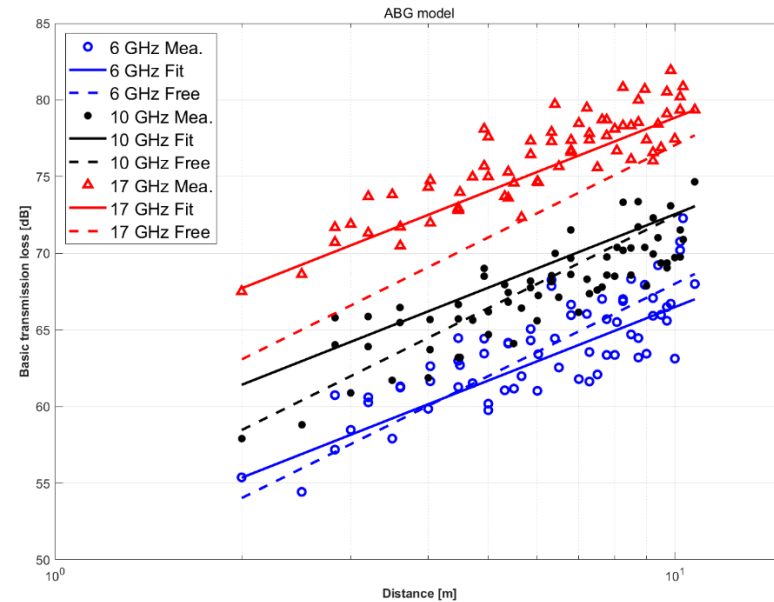
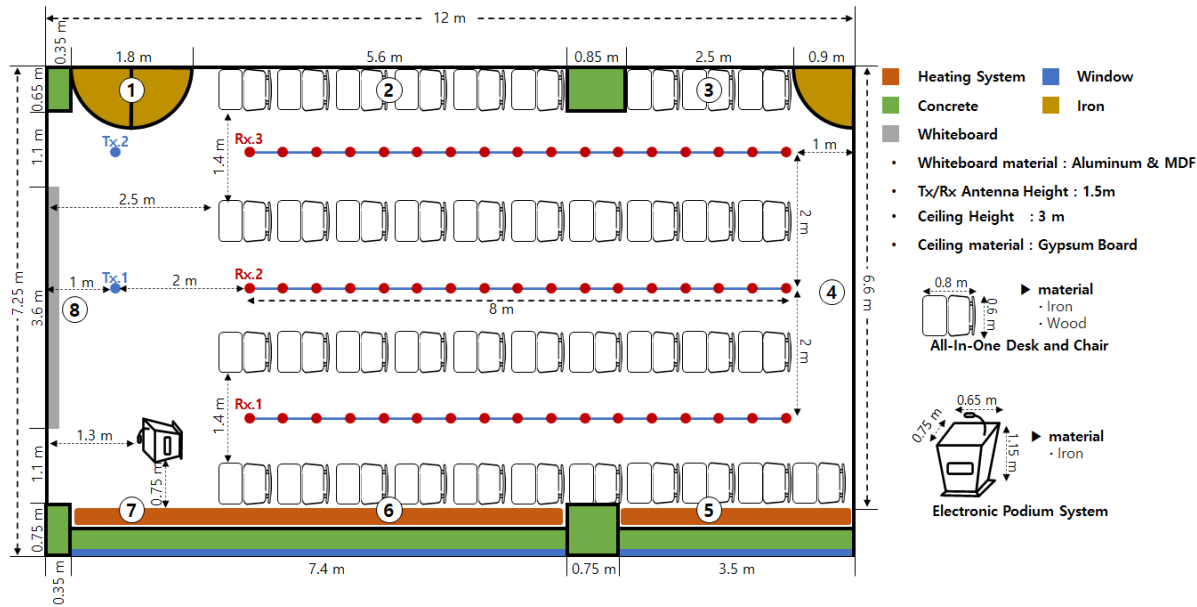
Table II-1: Ka band rain attenuation statistics in Kourou, French Guiana (tropical location)



# Experimental data (DBSG3 and Fascicles)

Some examples from 2023 submissions

Table XI-1: Indoor site-general basic transmission loss (lecture room, Korea)



# Experimental data (DBSG3 and Fascicles)

- How to perform measurements and how data are tested ? (See Fascicles)

FASCICLE	TITLE
<a href="#">3M/FAS/1</a>	Testing variables used for the selection of prediction methods
<a href="#">3M/FAS/4</a>	Procedure to compute Narrow-band statistics of broadcasting-satellite fades in Mobile-Satellite services
<a href="#">3M/FAS/6</a>	Application, validation and data processing of <u>atmospheric path length standard deviation</u> statistics for ground-based antenna array performance predictions
<a href="#">3M/FAS/8</a>	The processing of tipping bucket rain gauge data for Study Group 3 experimental database
<a href="#">3M/FAS/9</a>	The derivation of rain cell characteristics from weather radar data for Table IV-11
<a href="#">3M/FAS/10</a>	Information describing source of air-ground channel measurement data to be used for contributions to Study Group 3 data banks, formatted Tables Part VII, Mobile-Satellite services
<a href="#">3M/FAS/11</a>	Guidelines for parameter extraction and testing of land mobile satellite narrowband channel models

See all Fascicles: <https://www.itu.int/en/ITU-R/study-groups/rsg3/Pages/fascicles.aspx>

# SG3 Digital Products

(SW and Digital Maps)

## DIGSG3

# SG3 Software and Digital Maps (DIGSG3)

Why Digital Products (SW and Digital maps) ?

- \* SG3 Recommendations may require the use Digital Products
  - + SG3 studies are usually performed with Digital Products
- User benefits of ready-to-use SG3 Digital Products  
*(no need to perform SW implementation and validation of a rec)*

## ITU & SG3 Terminology

- \* Integral/Normative digital products, published in ITU-R P Recs web pages
- + Supplemental/Informative Digital Products, published in SG3 SW WEB page:  
<https://www.itu.int/en/ITU-R/study-groups/rsg3/Pages/iono-tropo-spheric.aspx>

# SG3 Software and Digital Maps (DIGSG3)

## Some SG3 guidelines

- There are no patents on DIGSG3 neither are expected in the future
- SW license for its use and redistribution
  - At submission: Agreement to ITU License for evaluation by SG3
  - For publication: Copyright declaration and License statement
- Submitter must own copyright, otherwise copyright owner must approve use  
*e.g. a figure from an IEEE publication*
- Executable code increases the liability of SG3,  
source code must be provided to SG3 for the evaluation
- SW must be documented  
Installation and User instructions, Testing results and Validation cases
- SW should be maintained  
bug correction, porting to new environment/OS/language, etc. ....

# SG3 Software and Digital Maps (DIGSG3)

How SG3 evaluates and approves Digital Products ?

See ITU-R Rec. P.1247

*recommends*

- 1 that ITU-R members submit digital products on propagation to Study Group 3 following the principles and guidelines contained in Annexes 1 and 2;
- 2 that the principles and guidelines contained in Annexes 1 and 2, apply to new or updated digital products submitted after the entry into force of this Recommendation.

NOTE – Digital products that are not required to apply a particular ITU-R P-series Recommendation are supplemental digital products which support ITU-R P-series Recommendations in Study Group 3 should be available on the ITU-R Study Group 3 website for digital products.

### 3 Information to be provided for evaluation of computer programs

- The submitter shall provide a signed statement of agreement to terms set in Annex B, ‘License agreement of Software for evaluation of the ITU Recommendation and use of the Software to evaluate or test output’ of the ITU Software Copyright Guidelines.
- The submitter should describe in detail the characteristics and the background information in the input document to the appropriate Study Group 3 Working Party meeting. In particular for the evaluation of the proposed computer program the submitter should provide the following information:
  - The procedure for installation and instructions to use the application.
  - The description of the performed testing and identification of proposed validation cases; including test environments, test data and expected and obtained test results.
  - A statement of compliance of the proposed computer program with ITU-R Study Group 3 validation examples, if applicable. Otherwise, the submitter shall provide validation examples.



# SG3 Software and Digital Maps (DIGSG3)

How Digital Products shall be presented to SG3 ?

See templates for submission of digital products [https://www.itu.int/en/ITU-R/study-groups/rsg3/Documents/SG3\\_templates\\_for\\_digital\\_products.zip](https://www.itu.int/en/ITU-R/study-groups/rsg3/Documents/SG3_templates_for_digital_products.zip)

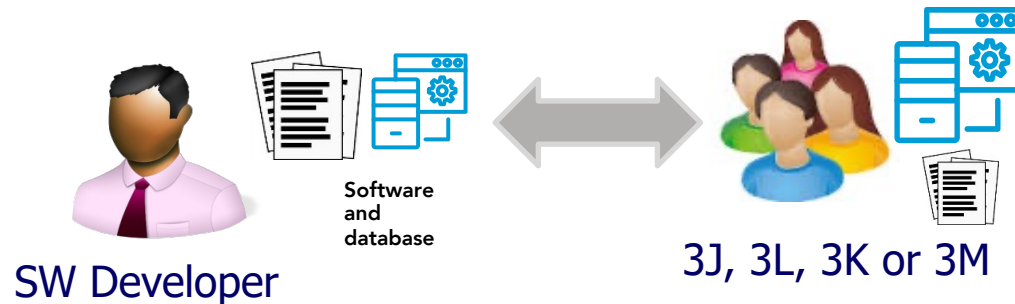
ITU-R Study Group 3 Computer Program Description	
Complete the information requested in each field of the form. One may advance by tabbing from field to field.	
<b>1. DIGITAL PRODUCT</b>	
1.1 Name of digital product:	
1.2 Short name:	
1.3 Programming language(s):	
1.4 Tested on Operating Systems:	
1.5 Related study field(s): <sup>1</sup>	
1.6 Short description (e.g. main functionalities implemented, etc.) <sup>2</sup>	
1.7 ITU-R Radiowave Propagation Recommendation(s) implemented in the product:	
(A list of ITU-R P. Recommendations can be found at <a href="https://www.itu.int/rec/R-REC-P/en">https://www.itu.int/rec/R-REC-P/en</a> .)	
1.8 Insert here edition of Recommendation(s) if different from the one in force at the moment of submission of the form	
1.9 Check, if digital product supplements <input type="checkbox"/> or is integral part <input type="checkbox"/> to above Recommendation	

2. INFORMATION FOR COMPUTER PROGRAM EVALUATION	
2.1 Contact person (Name and email address), or ITU-R Study Group 3 Working Party:	
2.2 Conditions and limits for the use of the computer program (if any):	
2.3 Installation guide document:	
2.4 User guide document:	
2.5 Test report document <sup>3</sup> :	
2.6 Dependency on other computer programs:	
2.7 Dependency on digital data sets (Digital Maps and Reference Numerical Data):	
2.8 List of Input parameters (including digital representation and units) or reference to User's Manual:	
2.9 List of Output parameters (including digital representation and units) or reference to User's Manual:	



# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?



## STEP 1:

### Before the meeting

Developer Submits new SW and information document to a WP

### During WP meeting

WP evaluates the computer program, its validation and the implemented model

WP interacts with the SW developer

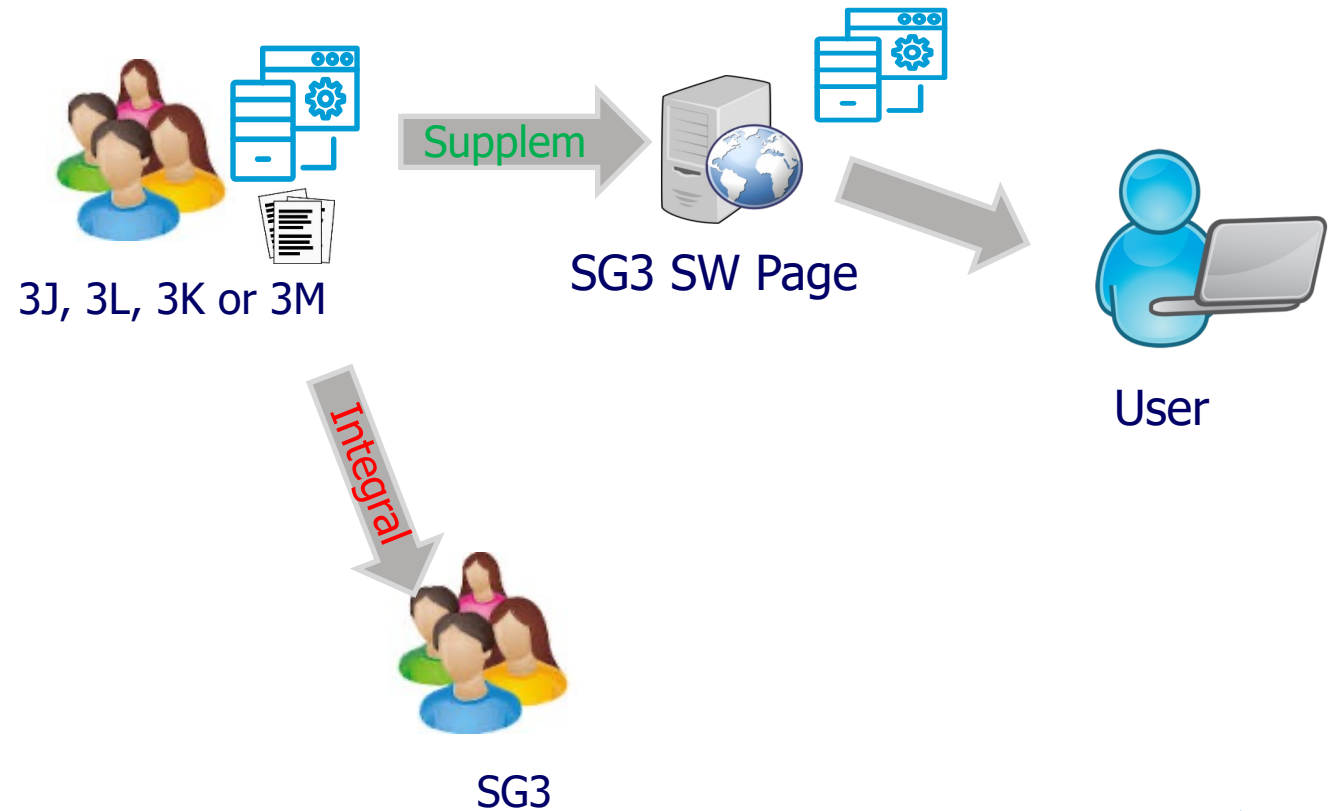
In case SW and its documentation can be updated

# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?

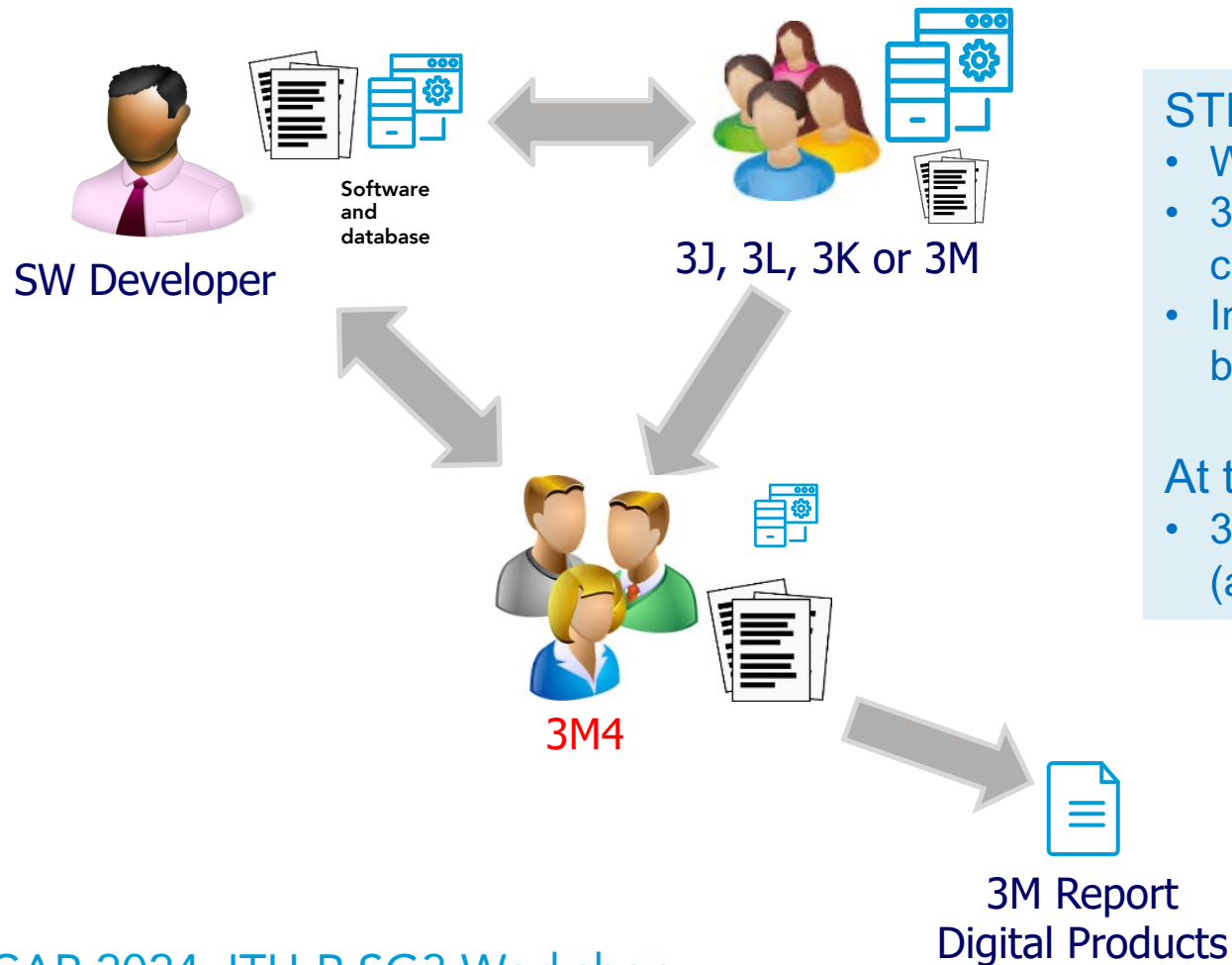
STEP 2: At WP meeting  
WP decides type of SW:

- **Supplemental SW**  
published on SG3 SW WEB page
- **Integral SW**  
submitted to SG3



# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?



## STEP 3: During 3M meeting

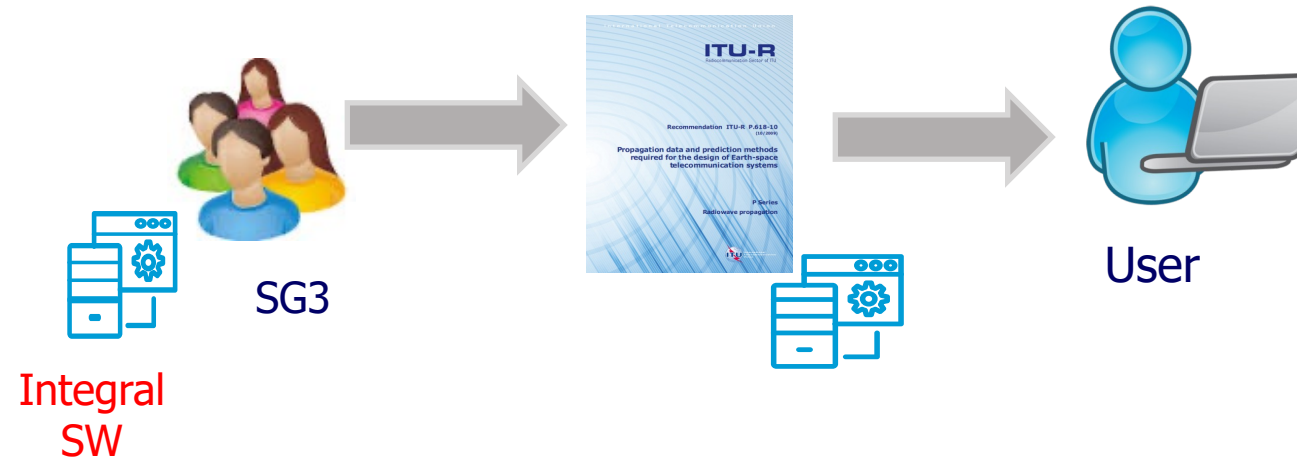
- WP informs 3M4 of the decision on SW
- 3M4 focuses on required information on the SW and check completeness of information
- In case SW and its documentation can be updated by 3M4 in cooperation with SW Developer

## At the end of 3M4 meeting

- 3M4 reports SW in 3M Report on Digital Products (annex to 3M Chairman report, input to next meeting)

# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?

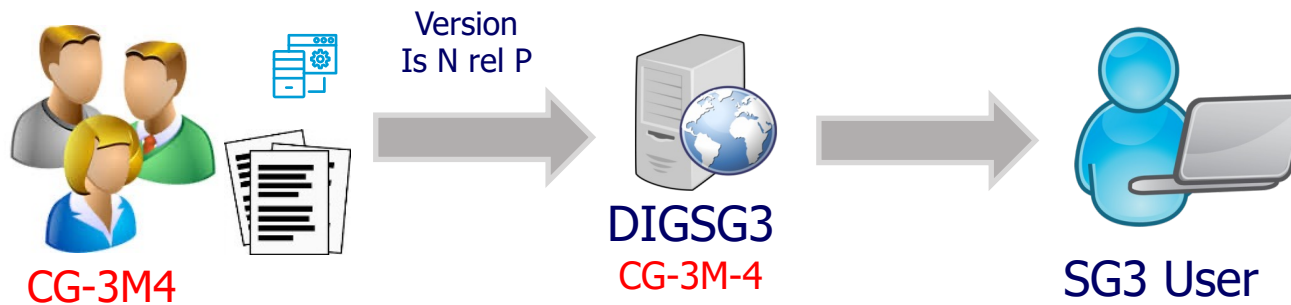


STEP 4: at SG3 meeting

- SG3 adopts **Integral SW**
- **Integral SW** is included in P Rec

# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?



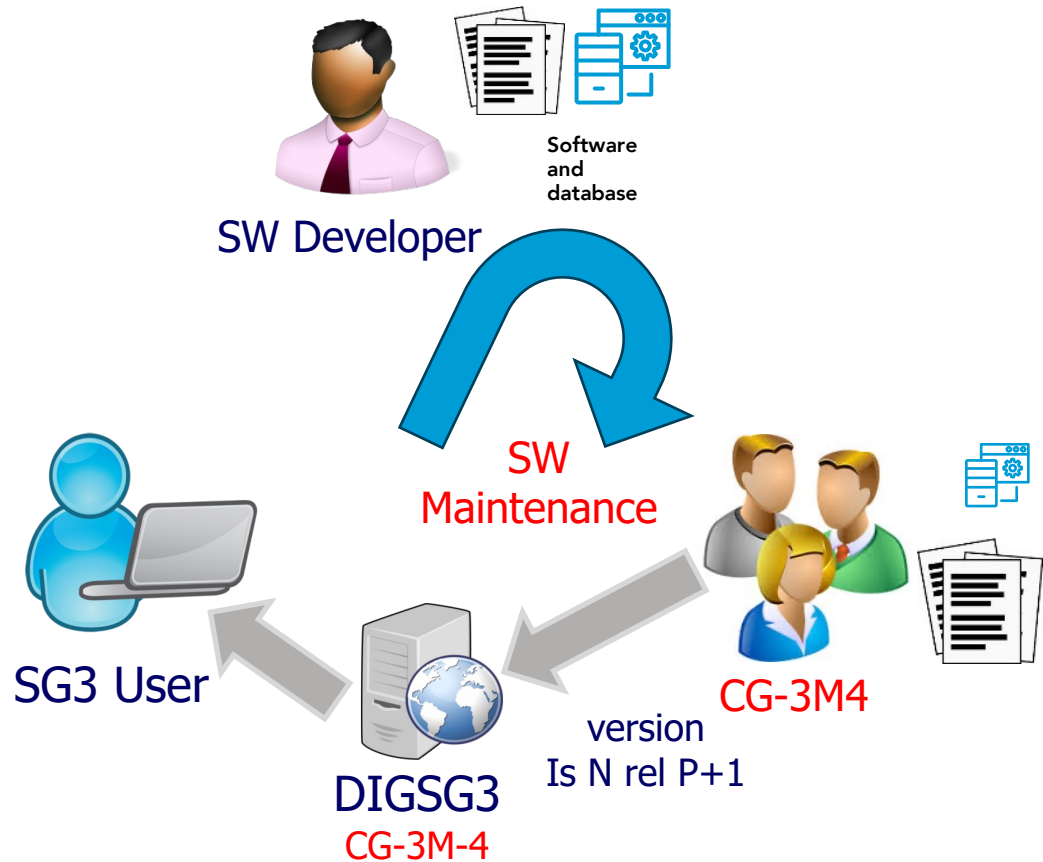
STEP 5: After the meeting

CG-3M4:

- stores SW on DIGSG3 using version control
- SG3 user can study SW

# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?



STEP 6: During intersession period  
CG-3M4, developer and SG3 user:

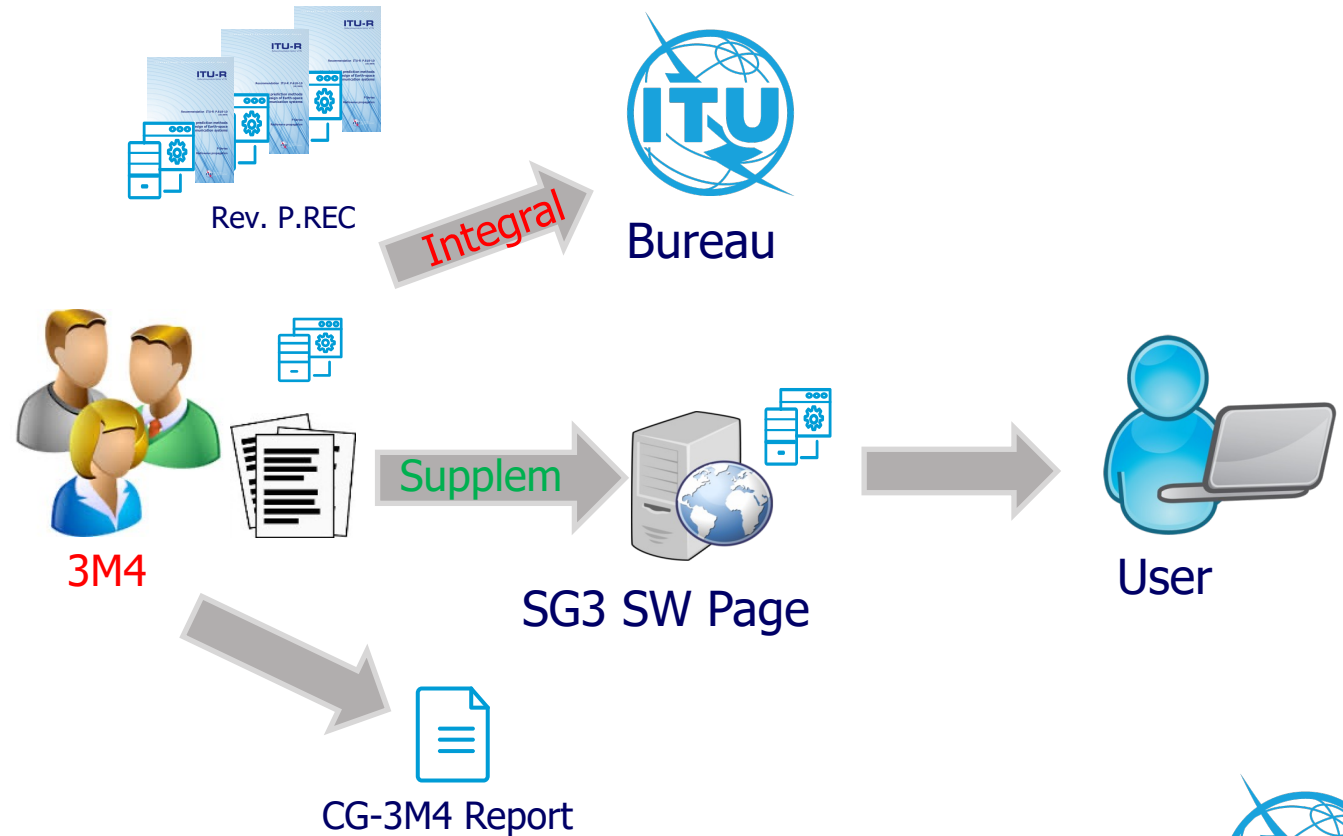
- Performs SW Maintenance
- Performs SW update
- Release new version of SW on DIGSG3

# SG3 Software and Digital Maps (DIGSG3)

How digital products are studied and maintained ?

## STEP 7: During intersession period CG-3M-4:

- Updates versions on SG3 SW page
- Check list of revised P.REC
- Advises ITU BR
- Issues GG-3M4 Report



# SG3 Software and Digital Maps (DIGSG3)

- Information on SW ? (Annex X 3M Chair Rep, New Digital Products)

Name of the SW Package/Digital Product	Rec. ITU-R	Source - Contact Information	Ver.	Ref Input Document	Status (Res. ITU-R 25-3)
C++ executable implementation of Recommendation ITU-R P.528-5	P.528-5	United States of America - William Kozma ( <a href="mailto:wkozma@ntia.gov">wkozma@ntia.gov</a> )	5.0.1.0	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published
MATLAB/Octave implementation of Recommendation ITU-R P.528-5	P.528-5	Switzerland (Confederation of) - Ivica Stevanovic ( <a href="mailto:Ivica.Stevanovic@bakom.admin.ch">Ivica.Stevanovic@bakom.admin.ch</a> )	5.0.1	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published
Update of MATLAB/Octave implementation of Recommendation ITU-R P.452	P.452-17	Switzerland (Confederation of) - Ivica Stevanovic ( <a href="mailto:Ivica.Stevanovic@bakom.admin.ch">Ivica.Stevanovic@bakom.admin.ch</a> )	16.3	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published
Update of MATLAB/Octave implementation of Recommendation ITU-R P.1546	P.1546-6	Switzerland (Confederation of) - Ivica Stevanovic ( <a href="mailto:Ivica.Stevanovic@bakom.admin.ch">Ivica.Stevanovic@bakom.admin.ch</a> )	6.2	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published
Update of MATLAB/Octave implementation of Recommendation ITU-R P.1812	P.1812-6	Switzerland (Confederation of) - Ivica Stevanovic ( <a href="mailto:Ivica.Stevanovic@bakom.admin.ch">Ivica.Stevanovic@bakom.admin.ch</a> )	6.0	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published
Update of MATLAB/Octave implementation of Recommendation ITU-R P.2001	P.2001-4	Switzerland (Confederation of) - Ivica Stevanovic ( <a href="mailto:Ivica.Stevanovic@bakom.admin.ch">Ivica.Stevanovic@bakom.admin.ch</a> )	3.1	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published
LFMF-SmoothEarth Executable	P.368-10	United States of America - Erik Hill ( <a href="mailto:ehill@ntia.gov">ehill@ntia.gov</a> ) Billy Kozma ( <a href="mailto:wkozma@ntia.gov">wkozma@ntia.gov</a> )	1.1.0.0	<a href="#">3M/389</a>	Approved by WP; Checked by CG 3M-4; Published



# Conclusions

# Conclusions

- Consolidated SG3work methods for experimental data
  - Submit new data
  - Review and update current types of measurements
  - Propose new types of measurements
  - Expand knowledge base of experimental techniques
- Definition of SG3work methods for SW and digital maps, consolidation on-going
  - Submit new Digital Products and maintain existing ones
  - Expand knowledge base of to improve efficiency, quality and interoperability of SW
- Future areas
  - Machine Learning: shall we use it and how ?
  - Migrate DIGSG3 to a distributed version control and collaborative system
  - Define methods to enlarge network of developers beyond SG3
  - Others ? See 3M4 Workplan or submit proposals for next meeting

# Acknowledgements

- All 3M4 participants for sharing their experimental results and SW developments
- All those chairing 3M4 drafting groups and correspondence groups for their important work to evaluate all the contributions and prepare 3M4 texts
- All table keepers for their essential role of reference scientific experts on measurements
- To the ITU-R BR and SG3 Counsellor for their constant guidance and relentless and professional support

**Many Thanks !**

