# VieVS webinar – Scheduling and Simulations with VieSched++

In this webinar we will explore the VieSched++ software and its capabilities to generate schedules and simulations. There are manuals that show you how to schedule an R1 or VGOS session<sup>1</sup>. In contrast to these "cookbooks", here, I want to focus more on **why** you should use the algorithm/parameter you will select and not only show you which should be selected.

Before we start, let's have a look at where we find all the necessary files. If you installed VieSched++ using the Installers, you should see the following files in your install directory:

<	>	4	û Home	VieSchedpp_1.1	*		٩	=	Ξ	•••
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The "bin" folder includes all the binaries and the necessary catalog files while the "out" folder contains the generated schedules.

Inside the "bin" folder, you will find the executables "VieSchedpp" as well as "VieSchedppGUI". On Linux, you will find a shell script "VieSchedppGUI.sh" as well, this should be used to start the program.



Additionally, you can see the "AUTO\_DOWNLOAD\_CATALOGS" and "AUTO\_DOWNLOAD\_MASTER" folders. There, VieSched++ will store the most recent catalogs and master files. Do not edit any of these files here since changes will be overwritten the next time you start VieSched++.

**NOTE:** It might be, that the automated download of the catalog files fails. This has to do with special cryptography libraries that are required to download files via https. If this is the case, you need to install a compatible version of OpenSSL on your computer. However, you can also ignore the automated downloading since this is only an optional feature and simply download the latest catalog files by yourself. If you have troubles on windows, I can send you the necessary libraries.

Now, let's finally start VieSched++ and generate our first schedule.

<sup>&</sup>lt;sup>1</sup> <u>https://vievswiki.geo.tuwien.ac.at/doku.php?id=public:vieschedpp:vieschedpp</u>

# Example 1: standard 24-hour session with a global network

For this demonstration, we will generate a schedule for one of the next R1 sessions, namely *R1966*. Go to the "General" 14 tab in the VieSched++ GUI.

Since we want to generate a schedule for a session listed in the IVS master, we can simply click on "I list next" to see which sessions are starting next.

	VieS	ched++									• • •
File Basic Advanced Help Analysis											
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import from master e.g.: session code such	as "R1928" or copy line from ht	ml session master						list	next	<b>~</b>	
session code e.g.: R1823 (max 6 cha	iracter)										5
session description max 50 characters (use	e notes in "Output" for longer des	scriptions)					Ĩ				۲
time											
start: 09.09.2020 00:00				G	Sept	temb	er_	2020	D	•	
day of year: 253				М	o. Di.	Mi.	Do.	Fr.	Sa.	So.	
duration: 24.00 [b]				36 3 37 7	1 1	2	3	4	5 12	6 13	
				38 1	4 15	16	17	18	19	20	
				39 2 40 2	122 829	23 30	24	25	26	27	
				41 5	6	7	8	9	10	11	
general											
fillin-mode	✓ subnetting		idle to obs	erving	time				ſ		
	Jubrecenty			serving	anne						
✓ during scan selection	min source angle	150,00 [deg] 🗘	• yes								
a posteriori	<ul> <li>min participating stations</li> </ul>	80,00 [%]	O no								
	• min participating stations	all but 1 🌲									
experiment name				all down	loads	finish	ed su	icces	sfully	18	

Here, you should be able to find the session R1966. Double-click it to load the settings.

ghlight e.g.: "	VIEN BON	N"					
24-hour S/X	Intensive	e S/X					
Name	Code	Ops Center	Start	DOY	Duration	Stations	Correlator
IVS-R4965	R4965	USNO	24.09.2020 18:30	268	18:30	(7) Kk Ny Wn Ww Wz Yg Zc	WASH
EUVGOS-272	EV0272	VIEN	28.09.2020 10:00	272	10:0 <mark>0</mark>	(5) Is Oe Ow Ws Yj	BONN
IVS-R1966	R1966	NASA	28.09.2020 17:00	272	17:00	(12) Ag Ft Ho Ht Kk Ma Nt Ny On Sv Wz Ys	BONN
VGOS-00272	V00272	HAYS	28.09.2020 18:00	272	18:00	(9) Gs Is K2 Mg Oe Ow Wf Ws Yj	HAYS
AUS-AST068	AUA068	VIEN	29.09.2020 17:30	273	17:30	(6) Hb Ho Ht Ke Ww Yg	VIEN
IVS-R4966	R4966	USNO	01.10.2020 18:30	275	18:30	(8) Ft Ht Kk Nt Ny Wn Ww Zc	WASH
VS-R1967	R1967	NASA	05.10.2020 17:00	279	17:00	(10) Bd Ft Ht Kv Ma Ns Ny Wn Yg Zc	BONN
AOV052	AOV052	SHAO	07.10.2020 18:00	281	18:00	(6) Ho Km T6 Ur Ww Yg	SHAO
VS-R4967	R4967	USNO	08.10.2020 18:30	282	18:30	(7) Ft Ht Kk Ny Ww Wz Yg	WASH
4							•

Now, VieSched++ should have automatically inserted the correct session code, description, start time, duration, network and many other things for you.

File Basic Advanced Help Analysis	â 📝 🤜 🛸 💭 🏶 📩 🗞 🧿 📰	12													
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import from master R1966															
import from master R1966		-													
	📄 list next 🗸														
session code R1966															
session description IVS-R1966		é													
time															
start: 28.09.2020 17:00	September 2020														
day of year: 272	Mo. Di. Mi. Do. Fr. Sa. So.														
	36 31 1 2 3 4 5 6														
duration: 24,00 [h]	37 7 8 9 10 11 12 13														
	39 21 22 23 24 25 26 27														
	<b>40 28 29 30</b> 1 2 3 4														
	<b>41</b> 5 6 7 8 9 10 11														
general															
fillin-mode 🗸 subnetting	idle to observing time														
during scan selection min course and 150.00 fo	dogl *														
a postoriori															
min participating stations 80,00 [%															
Source and the source of th															
• min participating stations all but 1	<b>•</b>														

Alternatively, you could have simply entered "R1966" in the field next to "import from master" and hit enter, or you could have selected everything manually.

On this page, you can also change some of the general settings of the scheduling. For example, you can decide if you want to use **fillin-modes**, if you want to allow **subnetting** or if you want to transform **idle time to extra observation time** to reach a higher SNR.

You can also have a look at the **network** and the **source list** that is selected to see if everything is as expected. You can see which catalog files are used by browsing to the input tab. By default, VieSched++ is using the catalogs stored in the "AUTO\_DOWNLOAD\_CATALOGS" folder but you can always overwrite the default setting by saving your values using the **G** button.

In general, you would also have to make sure that you are using the right **observing mode**. You can check the selected mode in the "Mode" <sup>25</sup> tab. By default, we are using the "256-16(R1-R4)" mode. We can keep this for now.

Finally, you can click on "run" 🕨 to **start the scheduling**.

VieSched++ will first ask you if it should save the **xml file** containing all the GUI settings, click "Yes". Next, VieSched++ will ask you if it should open the folder with the results, click "Open".

After some seconds, the scheduling should be finished and you should see the following log file:

VieSchedpp log	0 X
processing file:/out/20200909140654_R1966/VieSchedpp.xml	
processing file: ./out/2020090140654_R1966/VieSchedpp.xml           Processing file: /home/mschartn/VieSchedpp_1.1/out/2020090140654_R1966/VieSchedpp.xml           [2020-09-09 14:06:55.697141] [info] VieSched++ version: 3d2ee44bd68104f3eabae8dc357b84d089ae9d4           [2020-09-09 14:06:55.697292] [info] VieSched++ GUI version: 61d04a1e09a008b2d9c874996947742f3aab35cd           [2020-09-09 14:06:55.697413] [info] virting initializing scheduler           [2020-09-09 14:06:55.701854] [warning] changing one letter code of station SVETLOE to 'A'           [2020-09-09 14:06:55.701854] [warning] changing one letter code of station SVETLOE to 'A'           [2020-09-09 14:06:55.701854] [warning] changing one letter code of station SVETLOE to 'A'           [2020-09-09 14:06:55.701854] [warning] changing onde: 256-16(R1-R4)           [2020-09-09 14:06:55.701831] [info] successfully created 336 of 336 sources           [2020-09-09 14:06:55.701831] [info] successfully created 12 of 12 stations           [2020-09-09 14:06:55.701831] [info] successfully created 66 of 66 baselines           [2020-09-09 14:06:55.7019378] [info] writing scheduling file to: r1966_iteration_0.txt           [2020-09-09 14:07:02.03891] [warning] r1966 iteration 0:long idle time! (1272 [s]) station: AGGO           [2020-09-09 14:07:02.044713] [info] writing start writing output           [2020-09-09 14:07:02.044713] [info] writing vex file to: r1966.skd           [2020-09-09 14:07:02.181962] [info] writing vex file to: r1966.skd           [2020-09-09 14:07:02.181962] [info] writing vex file to	
[2020-09-09 14:07:02.211701] [info] created scans: 348933 [2020-09-09 14:07:02.211718] [info] created observations: 5526247 [2020-09-09 14:07:02.211729] [info] created antenna pointings: 4946046 [2020-09-09 14:07:02.212845] [info] execution time: 65 516ms	
	•

In the log file, you can see that we get some warnings. The first two are not critical but the last one notes that there is a long idle time for station AGGO which we should keep in mind when we try to optimize the session further.

Additionally, you should see various files in the output folder:

<	> < VieSchedpp	_1.1 out	20200909140	654_R1966		۹ =	
$\odot$	Recent						
ŵ	Home	205EP28VS	r1966.skd	r1966.txt	r1966.vex	r1966	r1966
	Desktop	_N000	1 I J O O D KO	117 October	. is context	initializer.	iteration_0.
۵	Documents					CAC -	
÷	Downloads						
99	Music	statistics. csv	VieSchedp p.xml	VieSchedp p 2020-09-			
ø	Pictures			09_14-06- 55.000.log			
H	Videos			y			
ത	Trash						

- **r1966.skd**: this is the observation file that has to be sent to the participating stations.
- **r1966.txt**: this are the operation notes. This file is most important for the scheduler since it lists various interesting statistics and information.
- **r1966.vex**: this is another observation file that is typically used by the correlator
- **r1966\_initializer.txt**: this file lists contains some human-readable general information about the session
- **r1966\_iteration\_0.txt**: this file is a human-readable log file from VieSched++.

We will now investigate how the schedule looks like and will first try to fix the most prominent issues that we find followed by a finer optimization of the parameters to increase the quality of the result.

Let's explore some of the files:

First, you can have a look at the **r1966\_initializer.txt** file since it is the shortest. It lists if there were problems reading the input from the catalog files to create the necessary stations, sources and observing mode.

Next, we can explore the **r1966\_iteration\_0.txt** file. Here, you can see which scans are selected and get additional information. This is how a snapshot of this files looks like:

depth: 0   scan: no0055   Source: 0920-3	5 (id: 397 (id:	17398) 128)					conside	ered single scans 260, s duration: type: tar	ubnetting scans 112 17:56:51 - 17:58:02 get subnetting scan
station	delay [s]	slew     [s]	idle   [s]	preob   [s]	obs [s]	duration   start - end 	az [deg] start - end	unaz [deg]   start – end 	el [deg]   start - end
HOBART26 KOKEE	6 6	122   52	0   70	10   10	71 71	17:56:51 - 17:58:02   17:56:51 - 17:58:02	115.1484 - 115.0112 160.5749 - 160.8029	115.1484 - 115.0112 520.5749 - 520.8029	34.7987 - 34.9958   24.0887 - 24.1795
scan: no0056   Source: 2000+4	5 (id: 172 (id:	17399) 281)						duration: type: tar	18:05:14 - 18:06:42 get subnetting scan
FORTLEZA   HARTI5M   MATERA   NOTO   NYALES20   ONSALA60   SVETLOE   WETTZELL   YEBES40M	6   6   6   6   6   6   6   6   6   6	212   13   42   21   18   33   128   11   24	0   38   9   30   33   18   2   40   27	10   10   10   10   10   10   10   10	88 63 72 55 88 30 35 45	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	16.7863 - 17.0099   16.4063 - 16.3877   82.3718 - 82.4560   78.3774 - 78.4661   58.3610 - 58.3703   78.5489 - 78.6585   76.0866 - 76.0612   84.0846 - 84.1777   71.1458 - 71.2697

Additionally, this file report output from other algorithms that were selected. Here, you can see a snapshot of the "idle to observing time" algorithm:

sc	an: (id: 1	7399)					so	ource: 2000+472 (id: 281)
	station	increase   [s]	new duration   start - end	new obs     [s]		old duration start - end	old obs   [s]	
	HART15M	+67	18:05:14 - 18:07:24	130	-	18:05:14 - 18:06:17	63	
1	MATERA NOTO	+101   +39	18:05:14 - 18:08:00   18:05:14 - 18:07:05	166     111		18:05:14 - 18:06:19 18:05:14 - 18:06:26	65 72	
	NYALES20 ONSALA60	+92   +78	18:05:14 - 18:07:41   18:05:14 - 18:08:00	147     166		18:05:14 - 18:06:09 18:05:14 - 18:06:42	55   88	
	WETTZELL	+27	18:05:14 - 18:06:16	62		18:05:14 - 18:05:49	35	 

Finally, let's have a look at the most important file for optimizing scheduling, the operation notes file **r1966.txt**. In there, you can find various interesting statistics. First of all, let's explore how the stations spend their time:

	Ag	Ft	Ht	Но	Kk	Ma	Nt	Ny	On	Sv	Wz	Ys	Avg
% obs. time:	52.84	54.68	60.04	43.64	52.53	59.42	46.75	61.62	66.50	34.89	61.63	53.08	53.97
% cal. time:	1.67	2.69	4.78	3.44	4.25	4.34	4.40	5.74	4.56	4.81	7.07	6.46	4.52
% slew time:	3.20	34.67	23.03	44.03	22.48	32.37	45.70	25.06	24.47	55.62	15.41	35.05	30.09
<pre>% idle time:</pre>	40.32	6.36	9.28	6.44	18.01	1.26	0.52	4.13	1.73	1.79	11.63	1.53	8.58
% field system:	1.00	1.61	2.87	2.06	2.55	2.60	2.64	3.44	2.74	2.89	4.24	3.88	2.71
total # scans:	145	233	414	298	369	376	381	497	395	417	613	559	391
<pre># scans/hour:</pre>	6.04	9.71	17.25	12.42	15.38	15.67	15.88	20.71	16.46	17.38	25.54	23.29	16.31
total # obs:	517	1371	1758	557	1082	2313	2285	2378	2394	2335	2722	2664	1865
<pre># obs/hour:</pre>	21.54	57.12	73.25	23.21	45.08	96.38	95.21	99.08	99.75	97.29	113.42	111.00	77.69
Avg scan (sec):	314.85	202.75	125.30	126.53	123.00	136.55	106.01	107.13	145.46	72.29	86.86	82.05	135.73
<pre># Mk5 tracks:</pre>	16	16	16	16	16	16	16	16	16	16	16	16	
Total TB(M5):	1.39	1.44	1.58	1.15	1.39	1.57	1.23	1.62	1.75	0.92	1.62	1.40	1.42

You can see, that the idle time of Aggo is significantly longer than the idle time of the other stations. This is the case for several reasons: First, the sensitivity of Aggo is less than the sensitivity of the other

stations. You can check this in the "Network" Stab in VieSched++ GUI. This is especially problematic, since we are only using a 256 Mbps mode and we did use the default maximum observation duration that is 600 seconds. Additionally, Aggo is located quite remotely. Its nearest stations is Fortleza which also has a lower sensitivity than the average station.

We can note, that we maybe want to try to include Aggo better into the schedule.

Next, let's have a look how many stations are typically observing together in a scan:

Number	of	2-station	scans:	510	(	44.39	olo )
Number	of	3-station	scans:	211	(	18.36	응)
Number	of	4-station	scans:	71	(	6.18	응)
Number	of	5-station	scans:	49	(	4.26	%)
Number	of	6-station	scans:	33	(	2.87	%)
Number	of	7-station	scans:	38	(	3.31	%)
Number	of	8-station	scans:	94	(	8.18	응)
Number	of	9-station	scans:	131	(	11.40	응)
Number	of	10-station	scans:	12	(	1.04	응)
Number	of	11-station	scans:	0	(	0.00	응)
Number	of	12-station	scans:	0	(	0.00	응)
Total nu	ımbe	er of scans:	:	1149			
Total nu	ımbe	er of obs:		11188			
Total in	nteg	grated obs-t	ime:	1183773			
Average	ob	s-time:		105.8			

You can see that we here have a very high number of two station scans. Typically you want to avoid having two station scans since you only get one baseline and thus only one observation out of these. Additionally, it is not possible to calculate closure delays from two station scans.

**Note:** in the upcoming release of VieSched++ v1.2 the default minimum number of stations per scan will be three. However, in the windows v1.1 release, this is

already the case while in the Ubuntu release the minimum number of stations per scan is still two.

We can note that we would like to change the **minimum number of stations per scan to three** for this session.

Another interesting statistic in the operation notes file is the number of scans per 15 minutes. There are two tables, one showing the number of scans per station and one showing the number of scans per source. Let's first have a look at the number of scans per station:

Here, you can see that Aggo has again the lowest number of scans and observations. Additionally, you can see that there are two gaps, one for Kokee and one for Wettzell. This gaps were introduced since there are intensive sessions during this time with a higher priority than the R1 session. Since we did load the session information from the master schedule, VieSched++ automatically added the required station down time for you.

n	number of s	cans	per	15 m	inut	es:																								
ŧ	ŧscans −> c	har:	1-9	-> '	1'-'	9';	10 -	-> '	0';	11 - 3	36 -	> 'A	'-'Z	'; 3	7-62	->	'a'-'	'z';	63+	->	'#'									
l		time	sinc	e se	ssic	n st	art	(1	char	equ	lals	15	minu	tes)												#SCANS	#OBS	OBS	Time [s]	T
1	STATION	0	1 2	3	4	5	5 (	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	1		sum	average	L
1		+	++	+	+	+		+	+	+	-+	-+	-+	-+	-+	-+	-+	+	-+	-+	-+	-+	-+	-+	-+					٠I.
1	AGGO	21 2	12112	2122	1121	1122	21223	1111	1111	212	212	1121	2121	2211	2131	23421	11211	L123	1222	1112	1222	1212	2132	2211	1212	145	517	45653	314.8	T
	FORTLEZA	3323	23212	3334	1223	2213	3123	3123	3214	2223	3423	2122	2221	3322	4234	22322	24224	1233	2243	2223	22443	2223	2231	3232	33232	233	1371	47241	202.8	T
1	HART15M	4545	45443	5344	5435	3236	54553	3246	3534	15355	5652	8433	3752	5545	6485	34543	36545	5547	3563	3455	5535	4464	3354	5443	66243	414	1758	51876	125.3	T
	HOBART26	5454	32323	4223	6234	3314	13332	2242	3336	54244	1342	2322	3412	4325	4324	23433	34434	1235	2333	3343	44243	2323	3353	3223	35241	298	557	37706	126.5	L
1	KOKEE	6445	3	124	4634	3534	642	5451	3455	5256	6357	2452	3424	4556	5544	45674	45724	1245	3533	3353	4454	3436	2554	4443	45542	369	1082	45388	123.0	T
I	MATERA	5333	54235	3535	3434	3434	15536	6344	3264	14345	5554	3455	2365	4554	4345	44432	25334	1446	2654	4434	4434	4554	2442	4434	54532	376	2313	51343	136.6	L
	NOTO	5434	45245	3435	3344	3223	34443	5343	3265	53445	5354	5645	3673	3553	5246	44542	24335	5345	2655	4255	5443	4434	2342	5335	66544	381	2285	40390	106.0	T
I	NYALES20	7655	55346	3465	4454	6645	5823	7546	3566	55586	6767	6445	5456	4456	7675	55574	46447	7357	2655	6543	7757	6656	4755	6645	65625	497	2378	53243	107.1	T
	ONSALA60	6445	55336	4545	2444	5444	453	5434	3446	53347	7535	3255	3265	3554	5355	45532	26335	5447	2545	4433	5436	3644	2553	4424	54622	395	2394	57456	145.5	L
	SVETLOE	4454	43344	4555	3545	4434	16554	4555	3554	15454	4455	4355	3445	5354	5445	54452	25434	1555	3535	4535	4654	5544	5454	4345	64635	417	2335	30143	72.3	T
I	WETTZELL	8775	6	267	5765	7777	1886	7677	4788	86588	3678	7777	6887	7978	8587	68674	48677	7589	5778	6777	7767	6876	6786	7847	87665	613	2722	53246	86.9	I
I	YEBES40M	6755	75466	5767	4655	6465	6556	6577	4757	15567	7566	6767	3775	6886	7567	48664	47566	6576	5568	5556	7666	6756	5764	6854	86455	559	2664	45864	82.0	I
1.0																														

If you have a look at the number of scans per source, you can see that many sources are only scheduled for one scan and often times only with few observations. In general, it is best if every source is observed at least three times per session.

number of available sources: 336 number of scheduled sources: 157 number of scans per 15 minutes: #scans -> char: 1-9 -> '1'-'9'; 10 -> '0'; 11-36 -> 'A'-'Z'; 37-62 -> 'a'-'Z'; 63+ -> '#'

i		time	e si	nce	se	ssi	on	sta	rt	(1	chai	r e	qua	ls 1	15 1	min	ite	s)				_									_		#5	SCANS	#0	OBS	OBS	Time [s]
I SO	URCE	0	1	2	3		4	5	6		/	8	9	1	10	11	1	2	13	14	1	5	16	17	18	19	•	20	21	2	2	23	1				sum	average
1 000	3-0661	+		-+-	1		1	1	1	1	+	1	1			-+	1		1	1	+		1	+	+	-+-		+	-+-	+		+	-	12		40	910	75 9 1
1 000	8-2641				T		-	1	1	1		-	1	-	1		1		1	1			1						1				1	12		1	138	138 0 1
1 001	6+7311	1	1	1					1		1	1	1	1	1			1	1 1			1		1	1	1		1					1	18		312	1853	102 9 1
1 001	7+2001	1	-	-			1		-	1	-	1	1	-	-			± .				-		-	1	1	1	-				1	÷ .	- 10		175 I	1821	202.3
001	9+0581	-	1	1	1	1	1		1	1		-	1	1	1			1							-	-						-	i -	10		115 1	976	97.6
002	5+1971		_	-	-	-	-		-	-			-					-													1		i -	1		6	153	153.0
i 004	8-4271						1															1											i -	2		4	384	192.0
005	9+5811	1	1	1		1	1	1			1 :	1		1	1		L	1		1	1		1	L				1		1	1		i -	18		241	1469	81.6
010	4-408	1		1	1	1					1	1	1		1			1							1		1					1	i.	12		16	1374	114.5
011	9+041											1		1	1		1																1	3		8	216	72.0
011	9+115			1	1		1		1	1	1	1	1	1		1	1																1	10		75	1128	112.8
013	1-522	1	1	L				1		1			1							1										1			1	7		13	1476	210.9
013	3+476		1		1	1		1		1	1	1	1		1	1	L	1	1		1		1	L	1							1	1	15		145	1219	81.3
020	1+113					1																											1	1		6	177	177.0
020	2+319	1	L	1	1		1	1	1	1	1	1	1	1		1			2		1				1			1		1	1	1	1	20	- 1	206	1819	91.0
021	5+015					1																				1				1			1	4		31	764	191.0
022	1+067	1		1																													1	2		11	274	137.0
022	9+131							1	1	1			1			1	1	1									1						1	8	1	150	966	120.8
023	5+164																											1					1	1		3	157	157.0
030	8-611	1		1	. 1	1	1	1	1	1		1	1	1 1	1		L :	1	1	1	1	1									1	1	1	20		50 I	5537	276.9
032	2+222	1	1	L	1		1						1	1		1				1													1	8		117	1520	190.0
033	2-403		1	L										1	1	1															1	1	1	5		5	420	84.0
1	CTA26											1				1 :	L																1	3		8	138	46.0
034	6-279	1	L																													1	1	2		2	492	246.0
NR	A0150							1	1		1 1	1			1				1				1		1					1		1	1	10		14	498	49.8
040	0-319										1				1																		1	2		7	129	64.5
040	2-3621			1		1		1		1	-	1		1	1	1	1			1	ŝ					1	L	1					I.	12		29 I	1370	114.2

#### We can note, that we have to make sure that every source is at least observed three times.

Although looking at text files is a good way to explore your result, a visual inspection is often times better. You can use the **VieSched++ Analyzer** to explore the schedule as well. Go to the "Analyzer" tab and brows and for the .skd file you have just generated. Now you can click on the "run session analyzer" button. Take some time to investigate the sky-coverage and the statistics. Use the sliders on the bottom to limit the display to a shorter duration.

#### Now let's start to correct the issues we have found.

First, we will change the **minimum number of stations required in a scan** in case the default option is two for your version of VieSched++. This can be done by changing the parameters. In VieSched++, there are parameters for each station, source and baseline. The minimum number of stations per scan parameter can be found at the source-parameters  $\stackrel{\frown}{P}$ . Since we want to change this parameter in general, we can



Take a minute to explore all the parameters you have here. You can find, that there is a "minimum number of stations" parameter. Change it from two to three.

lect parameters you want to add:		📀 🛄 load 💾 sav
available	<ul> <li>ignore stations</li> </ul>	
● yes O no	available	selected
available for fillin mode		
● yes O no		~
general	Filter:	
✓ weight 1,00	required stations	
✓ min number of stations 3	available	selected
✓ min flux 0,05 [Jy]		
Max number of scans 999		~
✓ min elevation 0,00 [deg	Filter:	
✓ min sun distance 4,00 [deg	ignore baselines	
variable scan duration	available	
max scan time 0000 [c]		<u></u>
mia scantime 9999 [5]	Ag-Ft	
target SNR		

If it is already three you do not have to do anything at all.

Next, we want to extend the **maximum observation time slightly**. Note that I do not give a general recommendation to do this. The default maximum observation time should work fine in most cases. However, here we are only using a low observation rate of 256 Mbps in combination with low-sensitive stations, especially Aggo which is causing problems. Therefore, we should try if this helps us getting a better schedule. You can find the maximum observation time in the station-parameters **P**. You can, again, change the default parameters and extend the maximum observation time to 900 seconds as done before. Please also take some time to explore the parameters you have in there as well.

Additionally, we would like to increase the weight of Aggo during the scheduling. Therefore, we have to **define a new parameter** by clicking on the button **the button the b** 

		VieSched++				
le Basic Advanced Help Analysis						
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station setup axis limit buffer						
						<u></u>
manipulate setup	setup					
member 🕅 all 🔻 🕅	member	parameter	start	end	transition color	► <b></b>
	🔻 🎉 all	default	28.09.2020 17	:00 29.09.2020 17:00	) hard	
parameter default 🔹 🎦 🛉	👻 🎊 🔤 all	multi schedulir	g 28.09.2020 17	:00 29.09.2020 17:00	) hard	
start 28.09.2020.17:00	🎽 коке	E down	28.09.2020 18	:20 28.09.2020 19:40	) hard	*
Start 20.05.2020 17.00	~				<b>AA</b>	5
end 29.09.2020 17:00 🗘					× remove selecte	ed
transition hard 🔹	dense in the second section of	f				
	visual representation of	of setup				
🚔 IVS down time 🔤 🛉 add setup		plot setup for	station			
parse down time		plot setup for	Station			
have a start of the second			Setup			
novered element						
aramete						
available true						
available for fillin mode true						
max scan time [s] 600						
min scan time [s] 30						
min slew time [s] 0	17:00	23:00	05:00	11:00	17:00	
max slew time [s] 600			time			
max slew distance [deg] 175						
min slew distance [dea] 0						
lect and time (dd mm yw bhymm)				all downloss	le finiched successful	
iect end time (dd.mm.yy nn:mm)				all download	is imished successful	'Y 🗖 💌 📰

For this parameter, we would like to increase the "weight" from 1.0 to something higher, let's try 3.0. You have to give this parameter a name and click "ok" to store it.

ect parameters you w	ant to aud:			
available		-	scan time	
• yes				
available for fillin mod	a			4
	c			
yes			X 0,00 [Jy]	A
tagalong			s 0,00 [Jy]	
	no			
eneral			ignore sources	
✓ weight	3,00	\$		
min slew time	0 [s]	0	all_	
max slew time		0	0003-066	
min slew distance		0	▼ 0008-264	
max slew distance		÷.	Filter:	

Now, we need to **assign this new parameter to a station**. In our case, we have to select AGGO as the member. Now we need to make sure that the new parameter is selected as well and that the time span covers the full session duration. Both should by default be the case. Now you can click on " add setup" to apply the parameters to Aggo.

VieSched++ 🔘 🕼	ا
File Basic Advanced Help Analysis	
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Image:	>> 
17:00 23:00 05:00 11:00 17:00 time	
station setup all downloads finished successfully 💾 🕨	

Now it is time to restart the scheduling by clicking on the "run" bottom and see if these changes helped us to solve some of the most prominent issues that we spotted. Have a look at the new operation notes file and see how things have changed.

One remaining issue, is that we want to make sure that **all sources are observed three times**. Therefore, go to the conditions  $\times$  tab in VieSched++.

		VieSched++				
File Basic Advanced Help Analysis						
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source-based conditions						
member	🧏 _all_ 🔹 対	priority*	member	#scans	#observations	-7
min number of scans per source	3	\$	🧏 _all_	3	0	۲
min number of observations per source	0	•				
	🛉 add					
combine conditions	and	•				
stop if number of reduced sources below	5	\$				
max number of iterations	10	•				
$\checkmark$ gentle source reduction	for 1 iterations	\$			× remove selected	
percentage of source to reduce per iteration	50,00 [%]	•	*settings with	higher priority n	umber override previouse ones	5
✓ gentle source reduction percentage of source to reduce per iteration	for 1 iterations 50,00 [%]	•	*settings with	higher priority n	remove selected	5

You can now again click on "run" to restart the scheduling. If you have a look at the generated files, you will see that you now have more "r1966\_iteration\_X.txt" files.

<	> < VieSchedpp	o_1.1 out	202009101321	18_R1966		Q =	= •••
Ø	Recent					The second secon	
۵	Home	205EP28V5	r1966.skd	r1966.txt	r1966.vex	r1966	r1966
	Desktop	_N000				initializer.	iteration_0.
۵	Documents						CAL .
∻	Downloads				$\langle I \rangle$		
8	Music	r1966_ iteration 1.	r1966_ iteration 2.	statistics. csv	VieSchedp p.xml	VieSchedp p 2020-09-	
٥	Pictures	txt _	txt			10_13-21- 19.000 log	
				-		isteeeneg	

If you open the "**r1966\_iteration\_0.txt**" file, you can see that at the very bottom of the file the following lines are written:

ì		checking optimization con	itions new schedule w	with reduced source list necessary	1
i -		cre.	ting new schedule with	108 sources	
i -		020.	oring new benedare wrom .		
Lis	t of removed sources: (228	)			I
	1519-294 1413+135 1417+27	3 1418-192 1424+366 1424-41	1428+370 1432+200 1441-	+252 1456+044 1502+036 1504+377	
	1508-055 1519-273 1406-26	7 1520+437 1550-242 1557+03	1601+112 1602-115 1606-	398 1615+029 1622-253 1623+578	
	NGC6251 1645+224 1647-29	6 1651+391 1306+360 1056+21	1100+122 1104-445 1125-	+366 1133-032 1145+268 1156+295	
	1204+399 1219+044 1226+37	3 1243-072 0008-264 1300+58	1656-075 1308+328 1308-	+554 1318+225 1327+504 1330+476	
	1339-287 1342+662 1348+30	8 1349-439 1352-104 1354-15	1357+769 2254+074 2149-	+056 2155+312 2205+166 2208-137	
	2209+236 2214+350 2215+02	0 2216+178 2227-399 2243+04	2250+194 2252-089 2254-	024 2143-156 2300-683 2306-312	
	2307+106 2309+454 2312-31	9 2325+093 2329-384 2335-02	2353+816 2356+385 2357-	-318 2358+189 TTTZW2 1909+161	
	1659+399 1706-174 1718-64	9 1725+123 1736+324 1745+62	1746+470 1754+155 1758-	-388 1815-553 1823+689 1842+681	
	1851+488 1255-177 1920-21	1 1952+138 1954-388 1958-17	2005-489 2013+163 2017-	+743 2106+143 2123-463 2127-096	
	2141+175 2142+110 0627-19	9 0548+378 0346-279 0345+46	0556+238 0601-172 0602-	+673 0606-223 0611+131 0340+362	
	0338-214 0347-211 0630-26	1 0632-235 0641+392 0656+08	0657+172 0332+078 0714	457 0723+219 0729+259 0738+491	
	0406-127 0430+289 0434-18	8 0422-380 0422+004 0418+53	0415+398 0436-129 0414	189 0/28-/36 0//2+389 0309+/11	
	0454+944 0506-612 0400-21	9 0359+210 0524+024 0520-72	0524-240 0526+145 0527	206 0354+221 0111+021 0020+300	
	0124-211 0742-260 0022-60	2 0042:105 0115 214 0051:20	0059-346 1004 213 1004	E00 0026 202 1012:127 1016:067	
	0100-004 0055 050 0040 40	3 0943+105 0115-214 0951+26	1024 202 0025 252 0220	175 0007 007 0000 (10 0004 400	
	0109+224 0055-059 0048-42	7 1027-186 0048-097 0047+02	1034-293 0035-252 0239-	175 0257-027 0800+618 0804+499	
	0227-369 0749+540 0912+02	9 0206+136 0/4/+185 0808+01	0821+394 0201+113 0151-	4/4 0256-005 0847-120 0854-108	
	0307+380 1053+815 2319+44	4 0332-403 0104-408 2000+14	0403-132 CTA26 2318-	+U49 2126-158 22U1+1/1 U131-522	
	2144+092 1351-018 1608+24	3 1555+001 0613+570 1538+14	1806+456 1451-375 0718-	+793 1418+546 0743+277 0759+183	
	0700-197 0823+033 0920-39	7 1213-172 1013+054 1144-37	1111+149 1015+359 1101-	⊦384 1059+282 1053+704 0437-454	

This means, that VieSched++ will start a new scheduling iteration with a reduced number of sources. If you open "**r1966\_iteration\_1.txt**" you will read the following at the very top of the file:

Iter	cation nur	nber: 1										
Tota	al number	of source	es: 336									
ava:	ilable sou	urce: (108	3)									
	0003-066	0016+731	0017+200	0019+058	0025+197	0054+161	0059+581	0119+041	0119+115	0133+476	0202+319	0215+015
	0221+067	0229+131	0235+164	0308-611	0322+222	NRAO150	0402-362	0405-385	0420+022	0420-014	0446+112	0454-234
	0458-020	0506+101	0515+208	0529+483	0537-441	0544+273	0552+398	0642+449	0646-306	0648-165	0716+714	0727-115
	0736+017	0748+126	0805+410	0814+425	0827+243	0834-201	OJ287	0955+476	1030+415	1039+811	1040 + 244	1057-797
	1123+264	1124-186	1128+385	1144+402	1149-084	1212+171	3C274	1243-160	1244-255	1255-316	1324+224	1334-127
	1406-076	1417+385	1514+197	1520+319	1546+027	1606+106	1616+063	1617+229	1636+473	NRAO512	1639+230	1639-062
	DA426	1657-261	1705+018	1722+330	1726+455	1732+389	1741-038	1749+096	1751+288	1758-651	1759-396	1800+440
	1803+784	3C371	1846+322	1849+670	1908-201	1921-293	1923+210	1928+154	1929+226	1936-155	2000+472	2008-159
	3C418	2052-474	2059+034	2113+293	2214+241	2215+150	3C446	2227-088	2229+695	2255-282	2319+317	2355-106
not	available	e because	of optim:	ization:	(228)							
	0008-264	0035-252	0047+023	0048-097	0048-427	0055-059	0104-408	0109+224	0111+021	0115-214	0131-522	0134+311
	0151+474	0201+113	0206+136	0227-369	0237-027	0239+175	0256-005	0307+380	0309+411	0332+078	0332-403	CTA26
	0338-214	0340+362	0345+460	0346-279	0347-211	0354+231	0358+210	0400-319	0403-132	0406-127	0414-189	0415+398
	0418+532	0422+004	0422-380	0430+289	0434-188	0436-129	0437-454	0438-436	0442+389	0454+844	0506-612	0524+034
	0530-727	0534-340	0536+145	0537-286	0548+378	0556+238	0601-172	0602+673	0606-223	0611+131	0613+570	0627-199
	0630-261	0632-235	0641+392	0656+082	0657+172	0700-197	0714+457	0718+793	0723+219	0729+259	0738+491	0743+259
	0743+277	0747+185	0749+540	0759+183	0800+618	0804+499	0808+019	0821+394	0823+033	0847-120	0854-108	0912+029
	0920+390	0920-397	0925-203	0933+503	0943+105	0951+268	0958+346	1004-217	1004-500	1013+054	1013+127	1015+057
	1015+359	1027-186	1034-293	1053+704	1053+815	1056+212	1059+282	1100+122	1101+384	1104-445	1111+149	1125+366
	1133-032	1144-379	1145+268	1156+295	1204+399	1213-172	1219+044	1226+373	1243-072	1255-177	1300+580	1306+360
	1308+328	1308+554	1318+225	1327+504	1330+476	1339-287	1342+662	1348+308	1349-439	1351-018	1352-104	1354-152
	1357+769	1406-267	1413+135	1417+273	1418+546	1418-192	1424+366	1424-418	1428+370	1432+200	1441+252	1451-375
	1456+044	1502+036	1504+377	1508-055	1519-273	1519-294	1520+437	1538+149	1550-242	1555+001	1557+032	1601+112
	1602-115	1606-398	1608+243	1615+029	1622-253	1623+578	NGC6251	1645+224	1647-296	1651+391	1656-075	1659+399
	1706-174	1718-649	1725+123	1736+324	1745+624	1746+470	1754+155	1758+388	1806+456	1815-553	1823+689	1842+681
	1851+488	1909+161	1920-211	1952+138	1954-388	1958-179	2000+148	2005-489	2013+163	2017+743	2106+143	2123-463
	2126-158	2127-096	2141+175	2142+110	2143-156	2144+092	2149+056	2155+312	2201+171	2205+166	2208-137	2209+236
	2214+350	2215+020	2216+178	2227-399	2243+047	2250+194	2252-089	2254+024	2254+074	2300-683	2306-312	2307+106
	2309+454	2312-319	2318+049	2319+444	2325+093	2329-384	2335-027	2353+816	2356+385	2357-318	2358+189	IIIZW2

This confirms that this schedule is now generated with only 108 sources left.

If you have a look at the new operation notes file r1966.txt, you can see that we have now scheduled a lower number of different sources:

number of number of number of	av sc sc	ail hed ans	able iled per	so so 15	urce urce mir	es: es: nute	3 7 85:	36 7																								
	+	ime	sin	ce.	sess	ior	n st	art	(1	ch	ar	ean	als	15	min	ute	s)												L #SCANS	#OBS	OBS	Time [s]
SOURCE	10		L	2	3	4	5	5	6	7	8	- 40	9	10	11	1	2	13	14	15	16	17	18	19	20	21	22	23		1020	sum	average
	-   +		+	+	-+	-+-	+		+	-+-	+		+	-+	-+-	+		+	-+	+	+	-+	-+	+	+	-+	+	-+				
0003-06	61		1		1		1	1	1		1	1	1	1															9	91	701	77.9
0016+73	1				1 1	1	1	1	1			1		1		1			1	1		1				1		1	13	185	1322	101.7
0017+20	0																						1	1		1	1	1	5	21	1635	327.0
0019+05	8	1	1		1		1		1		1	1	1		1														1 9	210	3639	404.3
0054+16	1	1																						1	1		1 1	1	16	18	4378	729.7
0059+58	1	1										1 1		1	1	1	1	1	1	1		1		1		1	1	2	16	184	1695	105.9
0119+11	51		L 1							1	1	1	1	1		1													8	127	3113	389.1
0133+47	61															1		1	1			. 1			1	1			7	63	1019	145.6
0202+31	91				2	2	1				1		1	1	1	1	1		1 :	1		1						1 1	14	302	5072	362.3

Now we probably took care of the most obvious issues in the schedule.

Next, we can start to **fine-tune the scheduling**. The most important factors during scheduling are the socalled **weight factors**. So far, we simply used to default values which put an equal weight on the four most important optimization conditions:

- sky-coverage
- number of observations per scan
- scan duration
- mitigation of long idle times

We can now go to the "Weight factor" is tab and change one of the weight factors and see what happens:

Let's decrease the sky-coverage weight factor to 0.5 and restart a new schedule  $\blacktriangleright$  .

				VieS	ched++	
File Basic Advanced Help Analy	sis					
🟠 🎡   🔓 🚚 💾   🕨   I	<u>o</u>	14	0	🎘 🗲	P 🌈 🖻 🕑 🤜 🛸 💭 🎯 😓 🗞 🛛 🕑 🗐 😥	🔯 »
✓ sky-coverage	0,50	¢	14%	8	What are weight factors?	
<ul> <li>number of observations</li> </ul>	1,00	\$	28%		(and why are they so important)	5
✓ duration	1,00	•	28%		To answer this question it is necessary to understand	۲
<ul> <li>extra weight after long idle time</li> </ul>	1,00	\$	28%		now viescheu++ works:	
interval	300 [s]	\$			Generally speaking, the software is using a <b>brute force</b> approach.	
average sources	1,00	÷	0%		It is creating the schedule <b>scan after scan</b> . To select a scan, <b>all possible next scans</b> are <b>created</b>	
average stations	1,00	÷			and investigated.	
average baselines	1,00	¢	0%		This means if you have 200 sources, the software tries to create 200 next scans.	
low declination	1,00	¢	0%		If you use subnetting this number is substantially larger. The tricky thing is how to <b>decide which of all those</b> noscible next scape is the best next scap	

If restart the scheduling by clicking on  $\blacktriangleright$  you will get a different schedule. The big question is:

### How can we determine which schedule is better and which parameters should I finally use?

This can be answered by using the **multi-scheduling tool** together with **simulations**.

Let's first have a look on how we can simulate our schedules:

First, you have to browse to the "Simulation"  $\stackrel{\checkmark}{\longleftrightarrow}$  tab and check "simulate schedules". Here, you should take some time to explore which simulation parameters will be used. You can either use the same parameters for all stations (the default option) or specify individual parameters per station. Please note that by default, you will execute 1000 simulation runs per schedule.

				VieSched++				
Basic Advance	d Help Analys	is						
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insulate cebedul								
imulate schedul	es							
Simulation S	olve Priority							
								51
simulations: 10	000				fixed seed	1505894687	*show wn tab	e
Station	white noise*	clock ASD	clock dur	tropo Cn	tropo H	tropo dh	tropo dhseg tr	pp
🗸 🎉 _all	17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	\$ 200 [m]	\$ 2,00 [h] \$ 8	,0
🖗 AGGO	17,68 [ps]	\$ 1,0000e-14 [s]	\$ [50 [min]	1,80e-7 [m^-1/3]	\$ 2000 [m]	\$200 [m]	\$2,00 [h] \$8	,0
Fortle	ZA 17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	\$ 200 [m]	\$2,00 [h] \$8	,0
🌔 HART15	M [17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	\$ 200 [m]	\$ 2,00 [h] \$ 8	,0
🎤 HOBART	26 17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	\$ 200 [m]	\$ 2,00 [h] \$ 8	,0
KOKEE	17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	\$ 200 [m]	\$ 2,00 [h] \$ 8	,0
MATERA	17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	200 [m]	\$ 2,00 [h] \$ 8	,0
🖗 NOTO	17,68 [ps]	1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	200 [m]	\$ 2,00 [h] \$ 8	,0
NYALES:	20 17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	2000 [m]	200 [m]	\$ 2,00 [h] \$ 8	,0
ONSALA	60 17,68 [ps]	\$ 1,0000e-14 [s]	\$ 50 [min]	\$ 1,80e-7 [m^-1/3]	\$ 2000 [m]	200 [m]	\$ 2,00 [h] \$ 8	,0
SVETLO	E 17.68 [ps]	1.0000e-14 [s]	2 50 [min]	1.80e-7 [m^-1/3]	2000 [m]	200 [m]	2.00 [h] 28	.0
PX								-

If you have a look at the "Solve" tab, you can have a look at which parameters will be estimated during the least-squares adjustment. One thing you might want to change is to set a different station than Aggo for the reference clock. We will do this, since we know that Aggo may cause problems during the scheduling and we will probably not have a lot of observations with Aggo. In this example, I will define WETTZELL as the reference station for the clock.

Note: In the upcoming release of VieSched++ you do not have to define a reference clock manually

											8	4
Simulat	ion Solve	Priority										
	Chabians	C										
EOP	Stations	Sources		~	_							
dati	um: ITRF2014		ref	clock: 🦹 WET	TZELL 🔻		1					
	name	coord d	atum 📤	name	linear clock	quadratic clock	PWL clock	interv	val	constraint		
		$\checkmark$	V	✓ № _all_	V	V	V	60 [min]	Ŧ	1.300 [cm]	-	
1	FORTLEZA	$\checkmark$	$\checkmark$	AGGO	$\checkmark$	V	$\checkmark$	60 [min]		[ 1.300 [cm]	-	
	HART15M	$\checkmark$	V	FORTLEZA	$\checkmark$	$\checkmark$	$\checkmark$	60 [min]	÷	[1.300 [cm]	_	
	KOKEE	$\checkmark$	$\checkmark$	HART15M	$\checkmark$	$\checkmark$	$\checkmark$	60 [min]	~	1.300 [cm]	-	
	MATERA	$\checkmark$	√ ▼ 4								•	
	name	PWL ZWD	interval	constrai	nt NG	R interval	constra	aint	EGR	interval		
	v <u>№</u> _au	V	30 [min]	+ 1.500 [cm]	▼ V	180 [min] 🚽	0.050 [cm]	<b>•</b>	V	180 [min]	<b>▼</b>	
	AGGO	V		[↓ [ 1.500 [cm]	~ V	180 [min] 📮	0.050 [cm]	-	V	180 [min]	÷	
	FORTLEZA	$\checkmark$		1.500 [cm]	~ V	180 [min] 📮	0.050 [cm]	-	V	180 [min]	÷	
	HART15M	$\checkmark$		- 1.500 [cm]	~ V	180 [min] 🚽	0.050 [cm]	-	$\checkmark$	180 [min]	-	

Now you can restart the scheduling 🕨 .

This time, you should get two additional files, namely r1966\_simulator.txt and simulation\_summary.txt.

<	> 🖣 VieSchedpp	_1.1 out	202009101337	'32_R1966	► (	۹ =	
Ø	Recent						
企	Home	205ED28\/S	r1966 skd	r1966 tyt	r1966 vev	r1966	r1966
	Desktop	_N000	11900.3KG	11900.000	11900.024	initializer. txt	iteration_0.
D	Documents						9
∻	Downloads						
99	Music	r1966_ iteration 1.	r1966_ iteration_2.	r1966_ simulator.	simulation_ summary.	statistics. csv	VieSchedp p.xml
ø	Pictures	txt	txt	txt	txt		
⊨	Videos	A contract of the second secon					
1	Trash	VieSchedp					
+	Other Locations	p_2020-09- 10_13-37- 35.000.log					

Let's first have a look at the **r1966\_simulator.txt** file. In this file, you will get an overview of all the parameters you have selected for simulation and the least squares-adjustment. Additionally, it lists some more output from the adjustment including the mean formal errors and repeatabilities of all estimated parameters.

Probably more important is **simulation\_summary.txt** file. This file summarizes the most important parameters. This is a snapshot of how the file might look like for you:

mean formal errors:

ľ	v	score	#obs	XPO	YPO	duT1	NUTX	NUTY	AGGO	FORTLEZA	HART
	0	0.0000	8541	54.2487	49.4123	3.7320	24.5925	24.2923	10.9867	9.1396	5.
re	epeata	bility:									
į	v	score	#obs	XPO	YPO	dUT1	NUTX	NUTY	AGGO	FORTLEZA	HART
ŀ	0	0.0000	8541	103.6478	86.8548	6.6516	43.9676	44.6949	18.9226	15.5118	11.

As you can see, you get the information about the estimated mean formal errors for the earth orientation parameters as well as for the 3d station coordinates.

Since we die only generate one schedule, the tables only list one value. Now it is time to change this by using the **multi-scheduling tool**.

First, browse to the multi-scheduling page and enable multi-scheduling. Next, you have to select one of the parameters that you want to experiment with. The most important factors that need to be optimized are the weight factors, especially: sky-coverage, number of observations, duration and idle time. Select one of the parameters and click on " add selected".



A new window should appear where you can select the values that should be tested. You can add the values manually, by clicking on the "add" button or you can generate some values using the start, stop and step parameters. After you added the values you want to test, you can click on "Ok" to store the values.

For this demonstration, you should select the following parameters and values:

- duration: 0.66, 1.00
- number of observations: 0.66, 1.00
- sky-coverage: 0.33, 0.66
- idle time: 0.33, 0.66

	Vies	Sched++		<u> </u>
auto generate:		values:		lata aslastad
start 0,25	\$	<b>T</b> add	× de	lete selected
stop 1.00			Values	
		1 0,33		\$
step 0,25	÷.	2 0.66		<b>A</b>
-+ gener	ate			•
			X Cancel	<u>₽0</u> к

If you select parameters and assign values to those, VieSched++ will perform a grid-wise combination between all the selected values of the parameters and will generate different schedules using the combined values.

Note that VieSched++ should now generate a total of 16 schedules. This process is quite efficient since it will run in parallel on all of your available CPUs.

In reality, it might be advantageous to test more than two values per parameter (e.g.: three or four) but you need to be careful not to select too many parameters since this would generate too many schedules. **Note:** in the next version of VieSched++, some reasonable pre-defined values will be suggested to you.

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✓ multi-	scheduling meters multi core support												
max seed avail	max number of schedules:       all       I												
Para	ameters:	^ pa	rameter	member	nr. values	list of values							
- (	general		🔹 sky-coverage	🌒 globa	2	0.33	v						
	subnetting subnetting min source angle		number of observations	🌒 globa	2	1	v						
	subnetting min participating s		duration	globa	2	1	*	1					
	fillin-mode during scan selecti fillin-mode influence on scan		idle time	globa	2	0.33	*	1					
•	fillin-mode a posteriori weight factor sky-coverage number of observations duration average stations average sources average baselines idle time idle time idle time idle time interval low declination	•											
8	😤 👍 🖣	d					x remove selected	5					
use multi so	heduling					all do	wnloads finished successfully	8					

Additionally, we can use VieSched++ to help us **decide which schedule is the best for our session**. Therefore, go back to the simulations each of the "Priority" tab. Here, you should click on "output recommendation". (**Note:** in the next release of VieSched++ this option will always be selected by default.)

On this page, you can define how important specific parameters are for your session. You can select certain earth orientation parameters or station coordinates as well as the number of observations.

Although it might not be a direct goal of your session, I would always recommend to also select a **high number of observations** as a primary goal of the session by giving it a high weight since in reality, a high number of observations correlates well with the actual precision of the geodetic parameters and you can never be sure that your simulations match reality well enough.

Additionally, you can select if the quality of the schedule should be determined based on the mean formal errors or based on the repeatability.

mulate schedu										
Simulation S	Solve Prior	rity							8	
✔ output recor	nmendation						ref	erence qua	ntile: 0,75	\$
< mean forr	mal errors onl	у	bot	h equally		0		repeata	ability only	>
name	priority									
#obs	1,00	\$			33.78%					
▼ EOP	1,00	\$			33.78%					
XPO	0,20	\$			6.76%					
YPO	0,20	\$			6.76%					
dUT1	0,20	\$			6.76%					
NUTX	0,20	\$			6.76%					
NUTY	0,20	¢			6.76%					
<ul> <li>stations</li> </ul>	0,96	\$			32.43%					
AGGO	0,08	\$			2.70%					
FORTL	0,08	¢			2.70%					
HART1	. 0,08	\$			2.70%					Ŧ

Now you can restart the scheduling by clicking on " 🕨 run" again.

If you now have a look at your output folder, you should see that there are a lot more files generated as before. You should also notice, that all files have a new suffix such as "r1966\_v001.skd". The "\_v001" indicates that this schedule was generated using the first version of the multi-scheduling parameters. If you open one of the operation notes files, such as "r1966\_v001.txt" you can see which parameters were used, for example:

```
Schedule was created using multi scheduling tool
version 1
weight sky-coverage 0.33
weight number of observations 0.67
weight duration 0.67
weight idle time 0.33
```

If you have a look at the generated log file, you should see that VieSched++ suggests one version to you based on the settings you selected in the simulation, "Priority" tab.

VieSchedpp log ØE
processing file:/out/20200912145001_R1966/VieSchedpp.xml
[2020-09-12 14:50:34.150305] (0x00007f8be35a0700) [info] version 8: finished
[2020-09-12 14:50:34.925124] (0x00007f8be45a2700) [info] version 6: finished
[2020-09-12 14:50:35.439660] (0x00007f8be2d9f700) [info] version 9: finished
[2020-09-12 14:50:35.682604] (0x00007f8be259e700) [info] version 10: finished
[2020-09-12 14:50:35.773138] (0x00007f8be059a700) [info] version 14: finished
[2020-09-12 14:50:35.926548] (0x00007f8bdf598700) [info] version 16: finished
[2020-09-12 14:50:36.142231] (0x00007f8be159c700) [info] version 12: finished
[2020-09-12 14:50:36.195214] (0x00007f8be4da3700) [info] version 5: finished
[2020-09-12 14:50:36.209674] (0x00007f8be65a6700) [info] version 2: finished
[2020-09-12 14:50:36.307056] (0x00007f8be1d9d700) [info] version 11: finished
[2020-09-12 14:50:36.406164] (0x00007f8be5da5700) [info] version 3: finished
[2020-09-12 14:50:36.437827] (0x00007f8be55a4700) [info] version 4: finished
[2020-09-12 14:50:39.999301] (0x00007f8be7ac98c0) [info] vorcion 1: finished
[2020-09-12 14:50:40.016257] (0x00007f8be7ac98c0 [info] recommended schedule: version 3 (score: 1.0000 # obs: 8634)
[2020-09-12 14:50:40.016300] (0x00007f8be7ac98c0 [info] alternative schedule: version 11 (score: 0.8891 # obs: 8654)
[2020-09-12 14:50:40.016314] (0x00007f8be7ac98c0 [info] alternative schedule: version 1 (score: 0.6427 # obs: 8581)
[2020-09-12 14:50:40.016422] (0x00007f8be7ac98c0 <mark>/finite] viesched visclosing</mark>
[2020-09-12 14:50:40.016435] (0x00007f8be7ac98c0) [info] created scans: 3755400
[2020-09-12 14:50:40.016443] (0x00007f8be7ac98c0) [info] created observations: 43068364
[2020-09-12 14:50:40.016450] (0x00007f8be7ac98c0) [info] created antenna pointings: 48363300
[2020-09-12 14:50:40.021496] (0x00007f8be7ac98c0) [info] execution time: 37s 572ms

However, this recommendation follows very basic rules and you probably want to select the most promising schedule more sophisticated.

There are multiple ways how you can do this. You can either write an external tool to compare the schedules and select the best ones. If you choose this approach, notice that on every run, VieSched++ will generate a "statistics.csv" file that contains a very large number of interesting statistics and information. Since this is a simple CSV file, you can easily import and process it using Python (Pandas), Matlab, Excel or any other software you like.

Additionally, you can also use the VieSched++ statistics tool to view the content of the file.

Therefore, go to the statistics in VieSched++ and add a statistics.csv file by clicking on the "add" button.



In the middle field, you can now see all the available statistics and you see a graphical visualization of their values on the bottom. You can select parameters by checking them in the middle-top field. By default, the number of scans and number of observations are pre-selected. You can see that the number of scans are painted blue and the number of observations are painted green.

Additionally, you can add a weight to the parameters to sort the different versions. The sorting is based on the value of the parameter times their weight. You should take some time to play around with the options you have on this page to properly understand what is going on. Since the different parameter values have different orders of magnitude, it is possible to change the absolute view of the values to a relative view by changing the radiobutton on the bottom from absolute to relative.

In the following example, I did select the number of observations (blue) together with the dUT1 repeatability (green) and the average 3d station coordinate repeatability (red). Additionally, I did sort the versions based on the best average 3d coordinate values by giving their parameter a weight of -1.00 (I did use a negative value since here low numbers indicate good schedules). Furthermore, I show a relative view of the values and I did remove the minimum value to make changes even more apparent.



Again, in my example, version three is the recommended version since it is on the very left. This means that in reality, I should probably use this version.

Finally, we want to add calibration scans to our schedule to make the correlator happy. Go to the "rules" by tab and brose to the "calibration block" page.

Here, you can enable calibrator scans and define some basic rules about how often such a block should be added and how many and how long the scans should be. In general, the default options should work quite well. However, in this session I would recommend to extend the observation time to 600 seconds since we have some low-sensitive stations and a low observation mode. If you want to schedule two 600 second long scans, you should also change the start time of the "session end" block from 1200 seconds to 1800 seconds to give the stations enough time to slew between the sources.

- · ·	on scans											<u></u>	
predefined												1	
✓ session start	delay	600 [s]	<b>*</b>	scan durati	on 600 [s]	\$ s	cans per bloc	k 2	allowed	sources	: 🤻 _al	l	
session mid	offset	0 [s]	\$	scan durati	on 300 [s]	¢ s	cans per bloc	:k 2	allowed	sources	ぱ_al		
✓ session end	advance	* 1800	1	scan durati	on 600 [s]	1	cans per blog	k 2	1 allowed	sources	di 😤 al		
* make sure to	o start ea		h at the	session end	to have en	ought	time left othe	erwise fev	ver calibra	tor scans	will be s	cheduled	
				Session en									
🔿 custom 🛛 🗘													
offset from sessio	n start	duration	scar	is per block	allowed so	urces							
	A V		<del>_</del> 2		遂_all_	· · ·							
4.00 [hours]	÷		‡ 2	4 *	ぱ_all_	~							
	÷.		Ĵ 2	4 V	ぱall	~							
12.00 [hours]	÷		‡ 2	4 *	ばall	~							
16.00 [hours]	\$		‡ 2	A	ばall	~							
	\$		‡ 2	\$	₿_all_	~							
23.50 [hours]	÷		¢ 2	A 	ぱ_all_	~							

If you now click on run and open an operation notes file, you should see a list of the calibration scans:

Calibrat	or scans	<i>с</i> 1		10.00		6				<b>D10</b>			
Observat	ion listing fro	om II	ite i	21966	• SKC	tor	exp	perir	nent	R196	00		
Source	Start	DURA	ATION	IS									
name	yyddd-hhmmss	Ag	Ft	Ht	Ho	Kk	Ma	Nt	Ny	On	Sv	Wz	Ys
1741-038	20272-171000	657	633	650			629	638	652	636	600	657	638
1749+096	20272-172125	663	600	619			651	606	600	601	600	625	663
1741-038	20273-163000	652	600	640			614	625		633	602	652	631
1639-062	20273-164116	641	641	620			600	610		619	601	638	617

You will notice, that in this example, there are no calibration scans with Hobart (Ho) and Kokee (Kk). You can try to fix this by changing the weight of the stations or the weight factors but we will not go into this in this example since you should already know how to do this.

If you are happy with your schedule you could send it to the stations or upload it to the IVS server. At least, you have to distribute the .skd file, the operation notes file and the .vex file. If you browse to the "output" tab in the VieSched++ GUI, it is possible to add some general notes to the generated files as well as provide some contact information. You can make use of this option if you like.

Now, you can restart VieSched++ by clicking on the *c* button and experiment with the next session.

## Example 2: standard 1-hour intensive session with two stations

Next we will generate a schedule for an intensive session.

First, make sure that you did restart VieSched++  $\square^2$ . Now, browse to the "General"  $\square^2$  tab in the GUI and select session and select session **I20260** from the next sessions  $\square^2$ .

					Dialog				8
nighlight e.g.: '	'VIEN BONN'	1							8
24-hour S/X	Intensive S	5/X							
Name	Code	Ops Center	Start	DOY	Duration	Stations	Correlator	DB Code	<b></b>
IN320-258	Q20258	VIEN	14.09.2020 07:00	258	07:00	(4) Ny Sh Wn Wz	BONN	ХК	_
IN120-258	120258	USNO	14.09.2020 18:30	258	18:30	(2) Kk Wz	WASH	xu	
IN120-259	120259	USNO	15.09.2020 18:30	259	18:30	(3) Kk Sv Wz	WASH	XU	
IN120-260	120260	USNO	16.09.2020 18:30	260	18:30	(2) Kk Wz	WASH	XU	
IN120-261	120261	USNO	17.09.2020 18:30	261	18:30	(2) Kk Wz	WASH	XU	
IN120-262	120262	USNO	18.09.2020 18:45	262	18:45	(2) Kk Wz	WASH	xu	-
		1	1		1		-	X Can	icel @ <u>0</u> K

You will see, that this is a one-hour, two-station intensive session between Kokee and Wettzell. For this session, we need to change the observing mode to "128-16(INT)". Therefore, go to the "Mode" page and select the proper observing mode.

	VieSched++	- • ×
File Basic Advanced Help Analysis		
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I skad estalag mada		
use this sked catalog mode: 128-16(INT)		æ
simple custom mode	advanced custom mode	
sample rate 1024,00 [MHz]	start with 128-16(INT)	
sample bits 2	mode freq bbc if tracks track frame format phace cal	
efficiency factor 0,6063	· · ·	
8192 [Mbps]	Station FREQ BBC IF TRACKS PHASE_CAL_DETECT Track Frame Format	
frequency channels remove		
A 3,2564 [GHz] 1 2 X delete		
B 5,4964 [GHz] 1 1 X delete		
add band		
load 💾 save		

Next, I would recommend to reduce the **maximum allowed observation duration** from 600 seconds to let's say 180 seconds. You can do this using the station setup  $\stackrel{\text{red}}{\longrightarrow}$  by changing  $\stackrel{\text{red}}{\longrightarrow}$  the default parameter as done before.

Additionally, we can reduce the **minimum time between two scans to the same source**. This parameter can be found in the source setup  $\checkmark$ P. You can, again, change  $\checkmark$  the default parameter. Have a look for the "fixed minimum time between scans" parameter and change it from the default 1800 seconds to 1200 seconds.

In case of intensive session, the complexity of the optimization problem you have to solve is far less compared to the complexity of a global 24-hour session. In particular, we want **all stations to always observe together**. Therefore, the "number of observations" weight factor and the "extra weight after long idle time" weight factor are irrelevant. (Remember that the "number of observations" optimization criterion is based on the number of observations per scan, not per session. Additionally, there will never be long idle times since all stations are always observing together.) Let's browse to the weight factor page and disable the two unnecessary weight factors.

				Vies	Sched++	•	• •
File Basic Advanced Help Analys	sis						
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✓ sky-coverage	1,00	\$	50 <mark>%</mark>		What are weight factors?		
number of observations	1,00	÷			(and why are they so important)		5
✓ duration	1,00	\$	50 <mark>%</mark>		To answer this question it is necessary to understand		۲
extra weight after long idle time	1,00	÷			now viesched++ works:		
interval	300 [s]	4			Generally speaking, the software is using a <b>brute force</b>		

For the two remaining weight factors, we want to use the multi-scheduling tool again to test different combination of values.

Browse to the multi-scheduling page, select one of the weight factors on the left and click on " add selected". Since intensives are processed very fast, you can test a lot more different values now. You can use the "start", "stop" and "step" option to auto-generate values by clicking on " generate".

		Vie	Sch	ed++				8
auto ge	nerate:		valu	Jes:				
start	0,00	<b>*</b>		add		X del	ete sele	cted
stan	1.00				Val	lues		
stop	1,00		1	0,00				*
step	0,10	\$	2	0,10				-
		<b>-</b> generate	3	0,20				<b>*</b>
			4	0,30				-
			5	0,40				*
			6	0,50				*
			7	0,60				*
			8	0,70				*
			9	0,80				*
			10	0,90				*
			11	1,00				*
					X Car	ncel	<u></u>	к

Finally, your multi-scheduling setup should look something like this and a total of 65 schedules should be generated

VieSched++	) 🛛 😣
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list of all multi scheduling parameters all downloads finished successfully	

For intensives, it is necessary to significantly **change the simulation or in particular the parameter estimation**. Since you typically have only few stations and only few observations, it is not possible to estimate everything as it is done during a global 24-hour session. However, the default settings are especially chosen for global 24-hour session.

Go to the "Simulation"  $\checkmark$  page and browse to the "Solve" tab. From the earth orientation parameters, you should only estimate dUT1. I would also recommend to estimate the dUT1 parameter not every 24 hours but fewer, e.g.: every six hours. The exact interval is not important since we put very tight constraints on the estimates (0.0001 milliarcseconds) and thus are estimating one offset only.

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Next, we need to adjust the estimated parameters related to stations.

In typical intensives, we are not going to estimate station coordinates. Additionally, we only want to estimate a linear clock and a linear zenith wet delay (ZWD).

Therefore, browse to the "Stations" tab and deselect station coordinates, the quadratic and piecewise linear part of the clock and the north gradient (NGR) and east gradient (EGR). You should also increase the interval of the ZWD to make sure that you do only estimate one linear term for the full session. To be on the save side, I did change the interval to 300 minutes here.

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Finally, I can adjust the priorities of the session to get a recommendation about the best schedule by VieSched++. For the intensive session, we are only interested in dUT1 accuracies:

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As noted before, I would always recommend to add a high number of observations (#obs) as an additional prime goal of the session.

Finally, we can start 🕨 the scheduling and have a look at the output.

First, check that there were not errors in the log file and have a look which version VieSched++ would recommend.

Next, you can have a look at one simulation log files e.g.: **i20260\_v001\_simulator.txt**. Here you can have a look at the list of estimated parameters to check that everything is the way you want it to be:

```
List of estimated parameters
```

	#	Туре	member	reference epoch		sigma	[unit]	repeatability [unit]	
     	0   1   2   3	lin_CLK PWL_ZWD PWL_ZWD PWL_ZWD	WETTZELL   KOKEE   KOKEE	 2020.09.16 15:00:00 2020.09.16 20:00:00 2020.09 16 15:00:00	     	0.00005 1.35839 0.34604	[cm/day] [cm] [cm]	0.00008 [cm/day]   3.38939 [cm]   1.60935 [cm]   3.87403 [cm]	·    
     	4   5   6	PWL_ZWD PWL_dUT1 PWL_dUT1 PWL_dUT1	WEITZELL	2020.09.16 13:00:00 2020.09.16 20:00:00 2020.09.16 18:00:00 2020.09.17 00:00:00	   	0.30378 0.14118 0.14118	[cm] [mas] [mas]	1.60793 [cm] 0.20362 [mas] 0.20362 [mas]	

You can see, that we are now only estimating 7 parameters:

- one linear clock for Wettzell
- two piecewise estimates of the ZWD per station resulting in one linear trend of the ZWD per station
- two piecewise linear estimates for dUT1 that are very tightly constraint resulting in one offset for dUT1

You can again use the **VieSched++ Analyzer** to explore the recommended schedule. Go to the "Analyzer" tab and brows for the .skd file you have just generated. Now you can click on the "run session analyzer" button. Take some time to investigate the sky-coverage and use the sliders on the bottom to limit the display to a shorter duration.

![](_page_24_Figure_10.jpeg)

As you can see, the observations are well distributed in the north and there are no observations pointing into the south. This can be easily explained by the network and the location of the two antennas.

VieSched++ provides a special algorithm that could be used for scheduling intensive sessions. The idea is, that in theory, observations at the corners of the commonly visible sky have a lot higher influence on the accuracy of dUT1 than other observations. However, due to the remote location of these observations and the required slewing, these observations are often times avoided by the scan selection algorithm.

This is where the special **intensive algorithm** comes in play. This algorithm forces VieSched++ to observe sources that lie in the corners of the commonly visible sky. This is done every couple of minutes (by default every 15 minutes) and it will alternate between the two corners.

VieSched++	
File Basic Advanced Help Analysis	
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rules everything finished	

You can enable this option on the "Rules" Dage, by browsing to the "intensive" page.

Here, you can also find shortcuts to other parameters changes that typically have to be done for intensive scheduling, e.g.: the " intensive scheduling, e.g.: the " intensive scheduling, e.g.: the " intensive schedule are selected (as we have done manually). It is also possible to set a maximum scan duration of 90, 120, or 200 seconds (as we have done manually), or to enable some reasonable multi-scheduling.

You should click on the "P min time between two scans to source" and " multi-scheduling" button but you can ignore the rest since we manually adjusted the parameters already.

Finally, you can restart 🕨 the scheduling again.

You should take some time and go to the "Analyzer" tab again, load the new best schedule and have a look at the sequence of observations. As you can note, the new schedule should start with observing one source at the very corner of the observations.

If you have a look at the iteration log file, e.g. **i20260\_v001\_iteration\_0.txt**, you can see when and how the software tries to force a scan to a source at the corner of the commonly visible sky.

reweight sources to focus observation at corner												
readjust source selection at corner (fraction 1.556)												
readjust source selection at corner (fraction 1.372)												
readjust source selection at corner (fraction 1.646)												
readjust source selection at corner (fraction 1.411)												
increase weight of source 1324+224 to 1000.00				1								
increase weight of source 0202+319 to 909.41				1								
increase weight of source 1145+268 to 728.08												
increase weight of source 1308+328 to 722.93												
depth: 0   scan: no0000 (id: 42)   Source: 1324+224 (id: 181)			conside duration: type: target	red single scans 33   18:30:00 - 18:31:06   single source scan								
station   delay   slew   idle   preob   obs	duration	az [deg]	unaz [deg]	el [dea]								
	start - end	start - end	start - end	start - end								
KOKEE   0   0   0   0   66	18:30:00 - 18:31:06	70.0590 - 70.1475	430.0590 - 430.1475	9.8788 - 10.1190								
WETTZELL   0   0   0   0   66	18:30:00 - 18:31:06	280.9958 - 281.1918	640.9958 - 641.1918	19.9941 - 19.8171								

Now it is your time to try to improve the session even further.

For example: we did use corner switch cadence of 900 seconds. Maybe 600 seconds would be better? Maybe it is better to only allow 120 second long scans? Maybe there is anything else that should be changed. You should now be able to investigate this by yourself and generate schedules and simulations on your own.