Work package number [9]	WP6	**Lead beneficiary** [10]	2 - CNRS
Work package title	Geodetic capabilities		
Start month	1	**End month**	42

Objectives

This work package will enable geodetic use of the JIVE data processor. When validated, this mode will allow the use of the JIV-ERIC infrastructure for high accuracy (global) astrometric and geodetic applications. In addition it will provide means to verify the data quality on a more fundamental level and improve the accuracy with which EVN station positions are known.

Astronomers typically use the EVN for self-calibration or phase-referencing imaging, or for phase-referencing relative astrometry in which the positions of a target are determined relative to a nearby reference source. The data produced by the EVN software correlator at JIVE (SFXC) contains visibility phases calculated on the basis of an a-priori correlator model that accounts for the earth/sky geometry, relativistic effects and propagation effects at the time of the observations. This correlator model, although it can be linked to the output data, is not yet included in the files that the astronomer receives.

If the data files contained this correlator model, scientists could use this for:
• Absolute astrometry to determine source positions directly in the ICRF, which would provide the means to find new reference sources in targeted areas of the sky, which in turn could improve the astrometry derived from the current phase-referencing practice.
• Geodesy, which can determine the position of the participating telescopes by observing sources of known positions spread over the whole sky. This would be especially useful to the EVN for new telescopes or those that do not have the specific receivers necessary to participate in IVS observations.
• Accounting for changes in the correlator model that may arise between epochs of multi-epoch programmes, or from the use of different correlators. This will give the users more flexibility and will allow the JIVE staff to do detailed quality checks.

A preliminary assessment of the astrometric quality of the SFXC was done at JIVE in 2015, with a re-correlation of four stations from an IVS 24-hour geodetic observation. A member of the geodetic VLBI community compared the standard output files from this re-correlation, plus the correlator model used for the original IVS geodetic correlation. The preliminary conclusion was that a fairly straightforward engineering effort would be sufficient to make SFXC ready for precise absolute astrometry. In fact, the exercise illustrated that in some cases a sensitivity improvement could result from the use of the SFXC correlation algorithm.

This demonstration of the astrometric quality and favourable sensitivity of the SFXC was a first step towards being able to deploy geodetic capabilities. Using standard data-analysis methods these will be directly accessible to both astronomy and geodesy.

Description of work and role of partners

WP6 - Geodetic capabilities [Months: 1-42]
CNRS, JIV-ERIC
Task1. Data interface. The first task is to attach the correlator model to the data product following international standards. This is a straightforward task for the experts at JIVE who understand the time series description of the correlator model. However, careful comparison of the model delay computed at arbitrary times using the correlator algorithm with the resulting data correction files will be needed to validate this transformation.

Task 2. Experiment definition. Because they cannot rely on tracking a nearby calibrator, the scheduling strategies for geodetic and absolute astrometry observations differ from those used in more typical EVN observations. In particular, the need to obtain atmospheric calibration over the whole sky often requires forming sub-arrays within the overall set of participating telescopes ("sub-netting"). Because of these different strategies, these observations often use a different scheduling program, that makes schedule files in a format which is different from the usual EVN schedules. The ability to handle sub-netting (different sets of telescopes/sources at the same time) and to read in the different schedule format needs to be developed for the local SFXC environment.

One or more test observations would be conducted and analysed to validate the newly implemented SFXC features and correlator-model information in the AIPS tables.

Task 3. Application: Station Positions. We propose to carry out (at least) one full-scale geodetic-style observation to determine the positions of EVN telescopes that do not participate in standard IVS observations. A similar observation at 6cm wavelength was done in 2000 by Bordeaux experts to determine the positions of the telescopes at Jodrell Bank (UK), Westerbork (NL), and Torun (PL). These positions, along with a plate-motion model, have formed the basis of the location used for these telescopes in subsequent EVN observations. A separate 1.3cm geodetic-style observation in 2006 determined the position of the Jodrell Bank Mark2 telescope, consistent with the earlier determination when accounting for the modelled tectonic plate motion. A new 1.3cm observation would thus enable a new determination of the position (and the motion) of the Mark2 telescope, as well as of the Torun telescope which has obtained a 1.3cm receiver since the previous observations, with a long enough time-baseline to measure the site velocity empirically rather than through a plate-motion model. A new 6cm observation would extend these advantages to Westerbork, which cannot observe at 1.3cm. The advantage of shorter-wavelength observations is that they reduce ionospheric effects and thereby yield better precision.

Such observations will also provide improved accuracy for several new telescopes, notably Irbene (LV) and the Sardina Radio Telescope (IT). As such the proposed programme is connected to the work on integrating new antennas (WP5) and future observing with antennas in Africa (WP9). It is worth noting that many of the telescopes we are serving have a keen interest to participate in large scale geodetic programmes, for which this work will be a starting point.

WP leaders: CNRS (Patrick Charlot, Bordeaux) and JIVE (Bob Campbell)

Participation per Partner

Partner number and short name	WP6 effort
1 - JIV-ERIC	12.00
2 - CNRS	24.00
Total	36.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D6.1	New correlator data products	1 - JIV-ERIC	Other	Public	12
D6.2	Software to deal with geodetic observing schedules	1 - JIV-ERIC	Other	Public	18
D6.3	Analysis of EVN station positions	2 - CNRS	Report	Public	40

Description of deliverables

D6.1 : New correlator data products [12]

New correlator data products, verified for use with geodatic software

D6.2 : Software to deal with geodetic observing schedules [18]

Software to deal with geodetic observing schedules, verified by tests observations

D6.3 : Analysis of EVN station positions [40]

Document with analysis of EVN station position determination

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	New correlator data products	1 - JIV-ERIC	12	New correlator data products, available to user community
MS18	Software to deal with geodetic observing schedules	1 - JIV-ERIC	18	Software to deal with geodetic observing schedules, available to user community
MS19	Analysis of EVN station positions	2 - CNRS	40	Analysis of EVN station positions, presentation to EVN TOG