in more details in Markus Dolensky's article on "HST archive services implemented in Java" in this issue.

3. Other Archive Developments

3.1 GSC-II participation

In the framework of the ESA-NASA MOU renewal on HST, ESA is contributing to the completion of the Guide Star Catalogue II planned as a 2-billion object, fully homogeneous (both photometrically and astrometrically), all-sky, multicolour catalogue. The ST-ECF is involved in this major scientific endeavour by operating a pipeline that extracts the objects and by doing the quality control of about half of the 6000 photographic plates used for the generation of the catalogue. More details concerning the participation of the ST-ECF in this project are given in the article entitled "ST-ECF Participation in the GSC-II Generation Project" in this issue.

On the development side, the ESO archive is also contributing a storage method for the future export catalogue: the system will allow the storage of the entire catalogue on less than 50 GB of disk space.

3.2 Archive storage media change

The ESO/ST-ECF archive is now studying the promise of the DVD-R (Digital Versatile Disk) for astronomical data storage. The new capacity needs generated by the VLT instruments and the survey telescopes are prompting us to look into new denser yet affordable storage technologies. The prospects of the DVD are presented in "Using DVD Technology for Archiving Astronomical Data" in this issue of *The Messenger*.

4. Services Available from the ESO/ST-ECF Archive

Among the new services available from our archive, it should be noted that the post-Big Bang NTT archive data are now public. We would appreciate feedback on its usage. As a reminder, as this issue will be distributed, work on the preparation of the VLT Science Verification (SV) data will be continued. The data will be made available to astronomers from the ESO community as early as October 1. The plan is to have one set of the CD-ROM containing the SV data set sent to all the member state's astronomical institutions or university departments.

All the other services available from the ESO archive world-wide web are listed in Table 1 with their category, description and URL. For the possibility to use other, non-interactive client programmes for some of these services, please contact the authors.

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The VLT Data Volume

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The VLT will be a remarkable observing facility in many ways. Among others, the volume of data generated by its instruments will make the VLT Science Archive one of the largest data sources in astronomy. Table 1 summarises the estimated data rates (Gigabytes per night) expected from VLT instruments over the next 4 years. In estimating the data output of a given instrument, assumptions have been made on typical usage modes, e.g. infrared instruments would produce larger numbers of frames because of commonly used sky/object observing sequences. Also, for each telescope a typical mixture of usage of alternative focii has been estimated in order to obtain a total volume expected from the complete facility. MIDI and AMBER, the two first VLTI instruments (to see first light in 2001), could produce of the order of 40 GB raw

TABLE 1: Estimated data rates (GB/night) expected from VLT instruments over the next 4 years.

		1999	2000	2001	2002
UT1	ISAAC	4	4	4	4
	FORS1	0.5	0.5		
	SINFONI			0.5	0.5
	CONICA/NAOS		1.5	1.5	1.5
	CONICA (SPECKLE)		40	40	40
UT2	TESTCAM	0.5	0.5		
	UVES	2.5	2.5	2.5	2.5
	FORS2	0.5	0.5	0.5	0.5
	FLAMES			2	2
UT3	TESTCAM		0.5	0.5	
	VIMOS		20	20	20
	VISIR			1	1
UT4	TESTCAM		0.5	0.5	
	FORS1			0.5	0.5
	NIRMOS			48	48
	CRIRES				0.5
VST	WFI			3.8	15
	VLT Typical Mix (GB/Night)	**3.0**	**19.1**	**59.3**	**70.6**

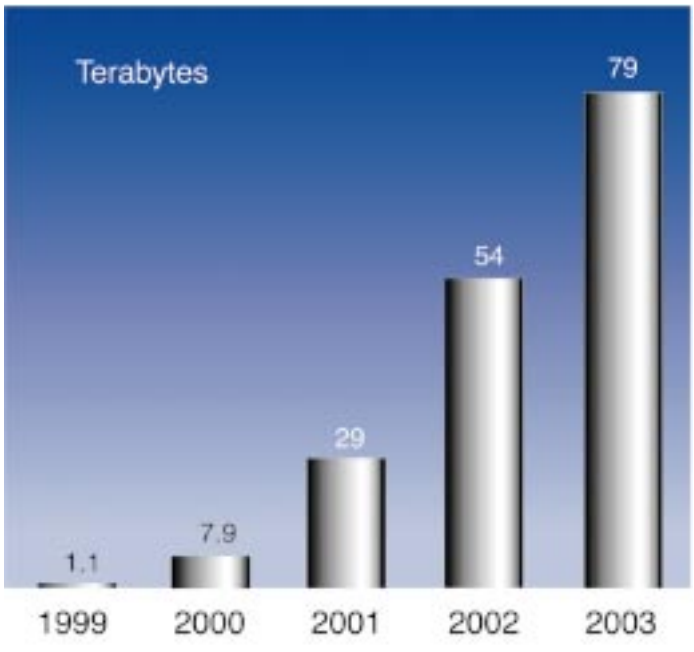

Figure 1: Cumulative data volume of the VLT Science Archive over the next 5 years.

data per night. They are not yet included in the table due to the uncertainties in their modes of operation. (The last line of the table includes VST output.)

When seen in the perspective of the cumulative data volume, these figures reveal the true dimensions of the facility. Figure 1 shows the estimated amount of data flowing into the VLT Science Archive in the years to come. For comparison, the total volume of the HST Science Archive after 8 years of operations is about half a terabyte in size (see article on "HST On-the-fly recalibration" by Micol et al. in this volume).

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Using DVD Technology for Archiving Astronomical Data

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Background

Due to the slow evolution of some astrophysical phenomena, long-term preservation of observations has always been a major concern of observatories around the world. Be it hand-drawings on paper or 19th-century glass-plate photographs, the issue at stake is how to best preserve data for the future generations.

The advent of digital imaging and recording equipment in the second half of this century has provided both more observations and denser data storage media. These media can therefore no longer be read by the human eye. Moreover, with no immediate readability to the unaided eye, digital recordings require specific equipment to decipher their content. If a lot of progress has been made in the past decades to manufacture long-lived data storage media, the same is not true for the reading/writing equipment, quickly reaching obsolescence, and the repair of which is rapidly becoming impossible. This apparent contradiction between durable media and transient reading equipment is easy to understand if one realises that the media is usually "passive" whereas the reading device is always active, with mechanical components.

Archivists must therefore reconsider storage technology every few years: a transposition of the archive content from endangered media to the newest technology has to be undertaken almost every three to five years. Another major factor pushing towards migration of data to new technology is costs: the cost of the new technology compared to the old one often brings savings per unit of volume of up to an order of magnitude and are a strong motivation for migration.

Current Situation

In the case of the ESO/HST Science Archive in Garching, since 1988, three different storage media have been used and migrated from/to: The 2GB LMSI 12″ Optical disk, the 6.4 GB Sony 12″ optical disk and the current 0.64 GB CD-R in juke boxes. The reasons for migrating from one to the other are given in Table 1 below.

We abandoned the 12″ optical disk in favour of the more common 5 1/4″ CD-R for two reasons. On the one hand, CD-R were enjoying an international standard defining the way their content should be laid out (ISO 9660). This was a guarantee of durability and multi-vendor support. On the other hand, the possibility of having all the data on-line in juke boxes was finally an affordable possibility as the cost of juke boxes for 12″ optical disks was prohibitive for our archive system (see right-most column of Table 1). This last reason sealed the fate of hardware compatibility with the HST archive at the ST ScI where the data are still on 12″OD in jukeboxes.

However, now that we have completed the migration to CD-R, we are faced with another concern: the data rate growth. The VLT and HST instruments, soon to be commissioned, will produce several TB worth of raw data per year. We could not practically keep these data using CD-ROMs in juke boxes without making major infrastructure investment in storage buildings!

The solution that addresses the density problem and keeps the advantage of the CD-R technology (direct access medium, cheap juke box capability) is the DVD.

Digital Versatile Disk (DVD)

The DVD technology has been very long to come, heralded as it was by the specialised press for a number of years already. However, various disagreements within the industry and disputes around copyright issues have considerably slowed the introduction of this technology. A few months ago, however, equipment to record one's own media (the DVD-R (see Table 2 for a brief description of the variants) became available. Our archive facility was understandably quick to procure and test the equipment and prepare the necessary software to support the device (from Pioneer Corp.). Even now, little support is available. The DVD-R can only be called such if its file system is compliant with the UDF file system. However, software drivers to support this format for both read and write are hardly available. To our knowl-

TABLE 1: The various data storage technologies used so far at the ESO/ST-ECF Archive Facility. Shaded areas represent the solutions actually implemented.. Units of cost represent an arbitrary monetary unit set to 100 per GB for the most expensive solution.

Medium Name	Reason for choice/migration to	Cost per GB	Cost per GB
		without Juke box	with Juke box
2GB/vol LMSI 12″ optical disk	Direct access, best of technology back then. In sync with ST ScI and HST archive	17	100
6.4GB/vol Sony 12″ optical disk	Direct access, factor of 2–3 cheaper to operate, previous technology difficult to maintain. In sync with ST ScI and HST archive	8	34
0.6GB/vol 5 1/4″ CD-R	Jukebox allows for online, no-operator-required access, ISO standard for file system	0.6	7.8
4.0GB/vol 5 1/4″ DVD-R	Much higher density, keeps direct access advantage of CD-ROMs	2.2	2.8