Information Handling in Astronomy - Historical Vistas
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HALF A CENTURY OF INTENSE MATURATION

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Abstract. The 20^{th} century, and especially its second half, has seen a dramatic change in the way data were collected, recorded and handled, as well as how the ultimate product was distributed either to scientists, to students or to the public at large. Beyond a compact historical review, this paper offers also a few considerations touching issues such as the available manpower and the place of astronomy in our society.

1. From Freezing in the Domes ...

That mountain gear had been bought in the early seventies at a well-known sports shop downtown in Paris' *Quartier Latin*. It was a *must* for a young astronomer who was going to visit observatories round the world. Much of astronomical observing was still then carried out from within the domes, with an inside temperature equal to the outside one in order to avoid air turbulence through the opening (that would blur images). In deep winter, this meant freezing for twelve hour periods.

So in order to survive, it was necessary to look like a Michelin *Bibendum* dressed in that mountain gear complete with lined shoes, thick trousers and hooded jacket stuffed with bird down. Only the fur gloves would be temporarily taken off for the necessary operations with the hands and then put on again.

That equipment was so cosy and warm that it must have happened at least once to every astronomer and night assistant of the time to fall sound asleep in the loneliness and darkness of the dome, occasionally with the help of a gentle music. Under the sky lurking through the dome opening, the telescope drive was then left to itself, gently steering the instrument out of that opening[1]. Also, without precise guiding, the objects pointed at would then be drifting out of the spectrograph slits or the photometer diaphragms, or leaving potatoid and trailed images on Schmidt plates ...

Yes, this happened even to the best ones (but do not expect them to brag about it) and generally during the weakest part of the night or while digesting the midnight meal. Nights were long in winter, observing runs were sometimes very long too (occasionally lasting one full month, something unimaginable today), and sleeping hours during the day were not many: it was necessary to review daily all the work done during the previous long night and to prepare the next long one.

If still in the seventies that beloved mountain gear was a bulky, albeit not so heavy part of the luggage when travelling to observatories round the world (Fig. 1), it was not going to be so for very long.

Thanks to the development of detectors, computers, electronics and communications, astronomers would be progressively and almost totally removed from the domes, spending their observing sessions in air-conditioned rooms, not only with light and comfortable seating, but also with facilities at hand for real-time or quick-look analysis of the collected data. Rapidly, all these became digitized and recorded on magnetic media. At the same time, things would also be influenced from up there, high above ground, by space-borne instruments.

2. ... to Novel Observing and Data Handling

The *International Ultraviolet Explorer (IUE)*[2] (see Fig. 2), launched on 26 January 1978, has been the first space-borne instrument welcoming visiting astronomers in real time, just like most ground-based observatories, with the difference that the telescope was not in an adjacent dome, but in a geosynchronous orbit over the Atlantic Ocean. It was shut down on 30 September 1996 after 18 successful years of operations (while its expected lifetime was three years), having become by then the longest astronomy space mission with more than 100,000 observations of celestial objects of all kinds, ten dedicated international symposia and more than 3,500 scientific papers at the time it was turned off. A fantastic achievement for a 45cm telescope.

In many respects, IUE has been the precursor of modern astronomical observing. Integral to the satellite exploitation were the strict procedures, such as those for spacecraft handover between the two ground stations op-

[1]Very few were then the domes equipped with servo-mechanisms coupling telescope and dome slit movements.

[2]For details on the *International Ultraviolet Explorer (IUE)*, see for instance the eight post-commissioning papers published in *Nature* **275** (5 October 1978) and the commemoration volume edited by Kondo *et al.* (1987).

Figure 1. Astronomers J. Manfroid (left) and A. Heck moving down from Mount Chiran station of Haute Provence Observatory on 21 December 1979: dressed in mountain gear of the time (also used for observing), radio in backpack, luggage on sledge topped by snowshoes needed over deep snowdrifts. Photometric data were still collected in analog mode there. Located at an altitude of about 1900m on the first ridge of the Alps from the West, built in 1974 by French CNRS and decommissioned from professional observing in 1986, that station is now in the hands of a local educational association.

erating it (GSFC in the US and Vilspa in Europe), as well as the chains of commands and responsibilities needed in space operations for the instrument safety and for the efficiency of observing: visiting astronomer, resident astronomer, telescope operator, spacecraft controllers monitoring also communications and computer center, plus overall permanent IUE control at NASA.

People realized that those procedures used for a spacecraft in geosynchronous orbit at some 36,000km from the Earth could be applied for remotely piloting a telescope at "only" a few thousand kilometers distance somewhere on Earth – saving travel money, substantial travel time, time difference disturbance and fatigue to the observers.

They also realized that the assistance provided to visiting astronomers through the team of resident ones, as well as the flexibility and dynamics introduced in the scheduling, for targets of opportunity and service observing for instance, could be extrapolated to ground-based instruments for optimizing their return (see *e.g.* Robson 2001). Additionally, with the panchromatization of astronomy and the multiplication of joint observing campaigns (see *e.g.* Peterson *et al.* 2001), procedures were progressively generalized and standardized for all instruments, ground-based or space-borne.

But more importantly in the context of this book, the space agencies operating IUE (NASA, ESA & SERC) agreed on real data policies which inspired modern astronomical archives avoiding, as has happened too often in the past, data disappearing for ever on the shelves or in the drawers of the original observers – when they were logged at all.

An IUE policy was to declare the data publicly available one year after the corresponding observations had been conducted. This meant too that an *ad hoc* service had to be set up by the agencies, providing access to the data archived. This, in turn, involved sometimes reprocessing large amounts of data, or transfering data to new media as the technology evolved. Living archives were born. Lessons from IUE can also be found in projects for "virtual observatories" (see *e.g.* Benvenuti 2002).

3. A Dramatic and Quick Evolution

It has been an exciting time to be an active part of this evolution, both as a "ground-based" and a "space" observer, but also as a heavy user of big amounts of data for personal research, as a developer of databases, and as an insider in archive/data centers and in their followers.

That evolution from individual records to catalogs, data centers, information hubs and nowadays "virtual observatory" projects has already been dealt with in a chapter of the previous volume (Heck 2000c) where other specific points have been tackled too such as:
– astronomy as essentially as a "virtual" science,
– the structure of the information flow in astronomy (Fig. 3),
– "virtual observatory (VO)" projects,
– success stories (such as CDS'),
– methodological lessons learned,
– the real slot of electronic publishing,
– quality versus automation,
– the need of prospective,
– education and communication,
and so on.
There is no need to repeat here those discussions. Please refer to the paper mentioned as well as to Heck (2002).

A couple of additional comments are however in order considering the historical perspective of the present volume.

4. A Big and Complex "Business" Today

The self-explicit graph on Fig. 3 gives a schematic idea of today's astronomy information flow, from data collection to processed information tuned

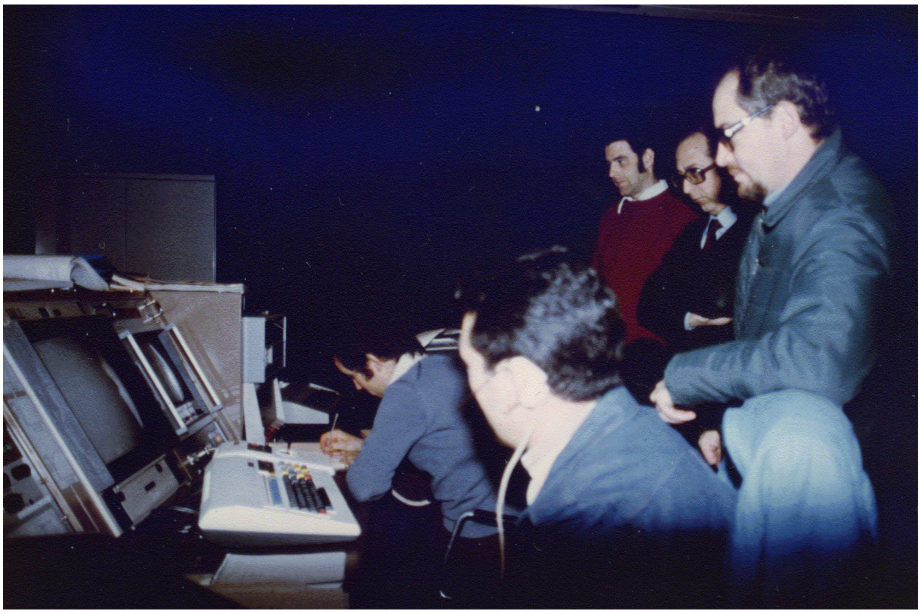

Figure 2. Observing with the *International Ultraviolet Explorer (IUE)* at Vilspa on 5 April 1978. From left to right: Telescope Operator F.J. Castro, (then) Resident Astronomer A. Heck, (then) Deputy Observatory Controller M.V. Penston and Visiting Astronomers M. Perinotto and S. Aiello. This was the first European observing run with visiting astronomers after commissioning the spacecraft and its scientific instrument. IUE has been the precursor of modern astronomical observing in many respects (see text), including through the policies applied to the data collected.

to various audiences, including internal iterations and input from related disciplines. Such a variety of perspectives is to be found in the present volume and in the previous one (Heck 2000a).

Astronomy has also become a big business as any visitor to the exhibition areas of AAS Meetings[3] (for instance) can appreciate nowadays: big projects for telescopes, arrays, spacecraft, auxiliary instrumentation, not to forget surveys, VOs, and so on.

As pleasantly recalled by Blaauw (2001), 17th-century Johannes Vermeer's *"Astronomer"* did not know all the deadlines we have to meet today, nor the selection committees, nor the referees, nor the financial austerity imposed on university scientific research, and so on. Such a reasonably quiet life was still largerly taking place among our colleagues in the first half of the 20th century.

Many of us have experienced a dramatic evolution over the last decades of the 20th century. Perhaps only the youngest astronomers would not re-

[3]AAS = American Astronomical Society (`http://www.aas.org/`).

member how (not so long ago) we were still using mechanical typewriters, speaking to colleagues over noisy phone lines (sometimes hard to connect and frequently breaking down) and how we were dependent, to work and publish, on what nowadays we call the "snail mail". At that time, we happily ignored the e-mail stress, we had no e-boxes flooded daily with hundreds of spams and we were saved from masses of junk mail.

People of my end-of-WWII generation still started working on their thesis with mechanical computing machines and slide rulers. Then came the first computers (see also Albrecht 2003) using tons of punched cards – something today students look at with puzzling anxiety before starring right in your eyes as if they were meeting jurassic remnants in real life.

I still remember the day the first HP pocket calculator was introduced to us at Liège Institute of Astrophysics and when the first IBM 360 became operational at the University Computer Center (monopolizing half the basement of the Institute of Mathematics). The stellar evolution programs of my Liège colleagues, as well as my own maximum-likelihood algorithms, would suddenly take less than entire nights to converge – something done today in a few seconds on my already old portable computer.

At the same time, and because of such increasing computer capabilities, methodologies were developed to deal with bigger amounts of data as well as with textual material. Bibliometry had taken off (see also Abt 2003, Albrecht 2000, Corbin 2003, Eichhorn *et al.* 2003, Lequeux 2000 and Grothkopf 2000).

Education was not left aside. In Liège, at the end of the sixties, L. Houziaux had designed a pioneering machine (Houziaux 1974) to teach astronomy, certainly rudimentary by nowadays standards, but it was a fully working device, complete with sound, slides, multiple choices, steps backwards, etc.

By the beginning of the nineties, the spread of networks and the availability of the World-Wide Web (WWW) had given additional dimensions, not only to work and to communicate, but also to educate and to interact with the society at large (see also Bishop 2003, Madsen & West 2000, Maran *et al.* 2000, Norton *et al.* 2000, Percy 2000, Petersen 2003 and Petersen & Petersen 2000), including active amateur astronomers (*cf.* Sect. 2.5 of Heck 2000d) who benefitted fully of the evolution (see also Dunlop 2003 and Mattei & Waagen 2000).

But before the advent of sophisticated information handling methodologies, there was an enormous development and diversification of instrumentation with a surge of momentum in the sixties-seventies which could be illustrated by the series of three conferences co-organized by the European Southern Observatory (ESO) on large telescope design (West 1971),

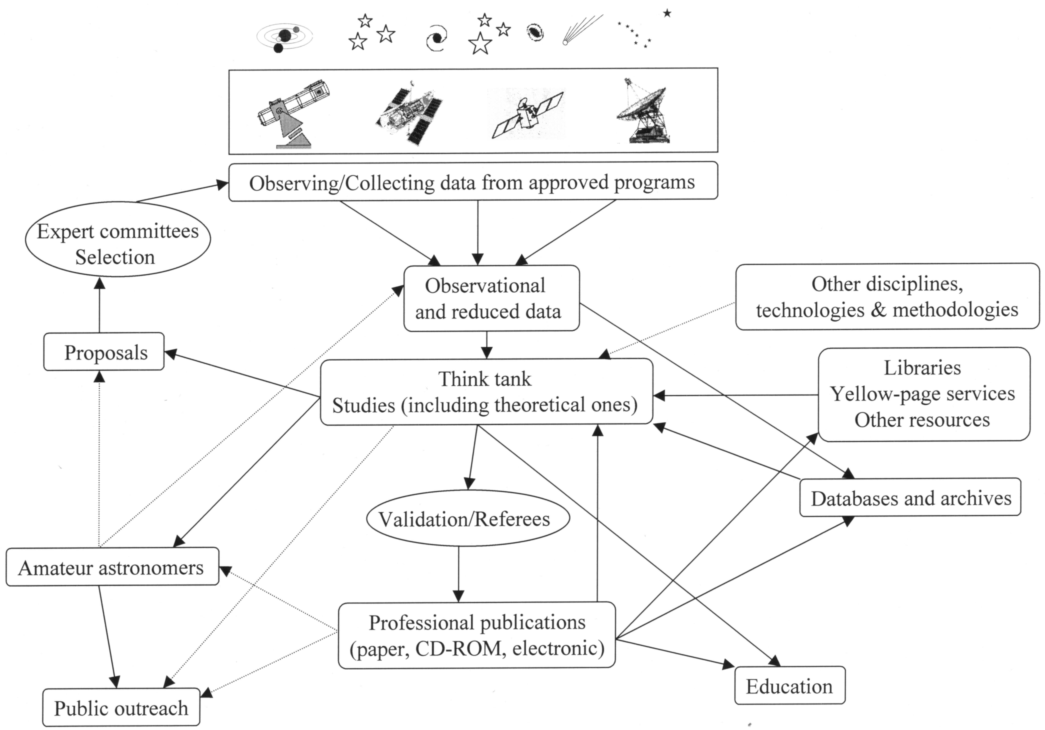

Figure 3. An illustration of the information flow in astronomy (Heck 2000b).

on auxiliary instrumentation for large telescopes (Laustsen & Reiz 1972) and on research programs for large instruments (Reiz 1974).

The media had a parallel evolution. From paper sheets and photographic plates, via punched cards, paper tapes, microfiches[4] and microfilms, to magnetic drums, magnetic tapes of all kinds and disks of all sorts, one simple conclusion is immediate: the medium life is short nowadays!

The 20^{th} century has also been a period when the measurement of time – our sometimes paradoxical reference when diving into the cosmos – evolved dramatically (see *e.g.* Biémont 2003).

Professional associations and, first of all, our world-wide league, the International Astronomical Union (IAU), had also to adapt themselves to the new media and context (see *e.g.* Andersen 2000 and Batten & McNally 2003).

5. "Objectivization" and "Massification" of Information

With its natural intelligence package behind it, the human eye is an exceptional instrument perceiving an extremely large range of contrasts, tones and nuances as any visual planetary observer can testify. People who attended total solar eclipses are also generally disappointed not to find later on, in pictures and movies, the same magnificence they saw when witnessing that fascinating natural phenomenon.

But, as we all know, the human eye has its limitations. First of all – and this is perhaps the most important restriction for us astronomers – it is operating only in the visual range, per definition. Second, its sensitivity is rather limited. We have therefore to assist it by collecting and intensifying devices that, at the same time, are also able to work outside the visual range (radio, infrared, ultraviolet, X-rays, γ rays, ...) and that can be sent outside the turbulent filter of the Earth's atmosphere.

Third, the cerebral firmware behind the human senses has also its complex limitations. It is able to recognize instantly a voice, including its emotional contents – something machines are still largely unable to do efficiently today. But it cannot deal, as fast as computers, with complex calculations or huge amounts of data. Its possible lack of objectivity is another serious issue.

Therefore data have been progressively recorded through mechanical, analytical, photographical and, of course, always more diversified electronic means. This increasingly removed observational and instrumental biases while improving speed, sensitivity, spectral range, dimensionality and resolution.

[4]Still remember the microfiches hailed at the beginning of the seventies as The Medium of the Future because of its compactness? How many of us are still using them today?

Computer and software packages, tools and standards have been adapted to astronomical needs (see *e.g.* Albrecht 2003, Banse 2003, Cheung & Leisawitz 2000, Greisen 2003a&b, Grosbøl & Biereichel 2003, Hanisch 2000, Jacoby & Tody 2000 and Wallace & Warren-Smith 2000), including history-making FITS (Greisen 2003a & Wells 2000). Notes Greisen (2003a): "Our community needs to adopt a more aggressive and inclusive process for standards development".

Earlier concepts, such as the "data flow" one, were given a stricter and more rigorous formulation (Quinn 1996) for an optimum transition of the raw data from the collecting devices to the final product in the hands of the users.

Interoperability of astronomy-related resources has become, more than ever, a critical issue (Genova 2002) with the global integration of those resources in VO projects and others.

Sophisticated algorithms have been progressively developed too in order to deal with bigger and bigger amounts of multidimensional data (including non-quantitative ones) under less and less restrictive conditions. Dedicated conferences have been organized. See *e.g.* Heck (2000c) and Murtagh (2000), as well as the references quoted therein.

We are still a way from W. Gibson's (1986) characters, "jacking in" directly with knowledge bases – if it will ever happen without elaborated assistance compensating the brain complexities mentioned earlier. From the succint and compact historical evolution described above, it should be clear, however, that the profile needed today for a young astronomer is very far from what it was only three decades ago (a trifle, in terms of astronomical timescales), when juggling with slide rulers and expertise with logarithmic tables were among the requirements.

6. In fine

A few final comments might be in order.

6.1. COSMIC TERATOLOGY?

News bulletins rarely speak of trains and planes that arrive on time. Physicians are quite logically interested in illnesses, deviations, abnormalities of all kinds since they have to remove them – as much as possible – from people's lives.

There is no need to run detailed statistics of astronomical research programs and publications to realize that quite a significant part of our activities are devoted to cosmic teratology, *i.e.* to the study of peculiarities, deviations, and so on. Are we however dedicating enough time to the study of "normal" objects? We do not have to cure celestial objects, so there is no real emergency justifying that we neglect thorough investigations of "normalities", needed to build reference sequences, in turn necessary to better understand peculiarities.

Briefly coming back for an example to the IUE satellite, when we were putting together an atlas of ultraviolet spectra of normal stars (Heck *et al.* 1984), most selection committee members recognized the importance of the program (and most used the atlas subsequently), but the pressure was so strong for observing non-normal objects that it has been really difficult to obtain the observing shifts needed for completing the samples of normal spectral sequences. They were systematically given the lowest priorities in terms of time assignment.

Quite naturally, the more we observe objects, the more peculiarities, variabilities, etc., are found – which makes in turn more important the need to define normalities and references. Big projects are not new (see *e.g.* Jones 2003). It would be appropriate upcoming ones dedicate an *ad hoc* fraction of their activities to general cosmic characteristics and properties, and do not concentrate excessively on deviations and peculiarities.

6.2. WHERE MANPOWER MATTERS ALSO

It is said that only 1% of all samples and data from the Moon missions have been analyzed, that about 10% of them have been "looked at", and that the rest has been stowed away, probably for ever.

Have we the same situation in astronomy? Some time ago, I tried to run a survey on the usage of databases and archives in astronomy, but never received exploitable answers. The most plausible reason is that probably database managers do not really have the data to say how much of their holdings have been used (analyzed in details or other) and what percentage led to publications, resp. to advancement of knowledge.

One of the conclusions by Abt (2003) is that: "If we want to increase our output of papers, we should employ more astronomers rather than to build more telescopes".

Although this might not seem related at first sight, I have continually to remind people that the prices of Kluwer's books, including this one, are of the same order as those of any books of the same quality, be they reference works, conributed or edited books, monographs or others[5].

For some mysterious reasons, astronomers always seem to expect to receive things for free or cheap[6]. But exactly because the astronomy com-

[5]In order to lower their prices (and the inherent risks), other publishers are in practice requesting book editors or conference organizers to purchase themselves a minimum number of copies.

[6]This comment could be put in parallel with the discussion by Albrecht (2003) about astronomers abhoring commercial software packages also for some unclear reasons.

munity is small, the circulation of professional astronomical publications is small and prices of commercial products cannot be brought down as much as one would hope for.

Increasing manpower in astronomy goes much beyond training more good students. It is directly related to the importance the society is giving to our science today. After the end of the Cold War and long after the landing of man on the Moon, the society at large has now openly other priorities (such as health, environment, security, unemployment, ...) than space investigations or cosmological perceptions.

It is up to all of us, through education, public relations and appropriate representation, to act in such a way our science occupy the rank we believe it should have in mankind's priorities. This is a daily task.

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