VII

DIGITISATION OF SCHMIDT DATA

https://doi.org/10.1017/S0252921100021886 Published online by Cambridge University Press

The Future Utilisation of Schmidt Telescopes
ASP Conference Series, Vol. 84, 1995
J. M. Chapman, R. D. Cannon, S. J. Harrison and B. Hidayat (eds)

Digitisation, Archiving, and Distribution of Photographic Data from Schmidt Surveys

Barry M. Lasker

Space Telescope Science Institute, Baltimore, Maryland, U.S.A.

Abstract. The limititations to the use of data from the major Schmidt surveys, i.e. grain noise as well as practical considerations of image processing and astrometry, are discussed, together with the question of mounting films on microdensitometer platens. Next, the major scanning systems dedicated to Schmidt surveys, their accomplishments, and their future programs are considered. Finally, the archiving and distribution of the scan data is discussed, and some suggestions regarding future directions are made.

1. Introduction

The current status and plans for the major photographic sky surveys have been reviewed by Morgan et al. (1992 and this volume; see also comments on two less well-known northern surveys in Lasker 1994). Modern utilization of these surveys, i.e. computer-based procedures for catalog construction, finding charts, telescope operations etc., depend on their digitisation with high speed scanning machines. Summaries of individual scanning systems may be found in the recent workshops (Geneva, edited by Jaschek 1989; Edinburgh, by MacGillivary and Thompson 1991; and Potsdam, by West et al. 1994) and in recent issues of the IAU "Wide Field Imaging" *Newsletter* (MacGillivray 1991 ff). Additionally, overviews of the digitisation topic may be found in Monet (1994) and Lasker (1994).

The limiting astrometric and photometric capabilities of photographic plates have been developed by Lee and van Altena (1983) in the formalism of a covariance analysis based on plate granularity as the *only* noise source, i.e. with centroiding and astrometric errors excluded. In view of the current changes in photography, particularly the growing importance of Kodak Tech Pan emulsion on a 4415 base (cf. Parker in this volume), the Lee and van Altena Table I updated with that emulsion is reproduced as our Table I. The Kodak Granularity G is defined as the rms grain noise as measured in 1810 μm^2 samples with a diffuse densitometer. The parameter c_0 (given both in microns and in arcseconds at the Schmidt scale of 67"/mm) is indicative of the astrometric precision that can *in principle* be achieved for well-exposed images.[1] While Lee and van Altena do approach such precisions for large scale astrograph plates, actual performance with Schmidt plates falls short of this limit by about a decade, perhaps because

[1] Lee and van Altena also show the comparable photometric precision to be of order of 0.01 mag.

of deficiencies in the available centroiders (see discussion contributions by Stobie, Reid and Lasker elsewhere in this volume). One may therefore conclude that the limits of astrometry from Schmidt plates have yet to be approached and that continued work on centroiders as well as on removing systematic errors from the astrometric solutions (Taff, Lattanzi and Bucciarelli 1990; Bucciarelli, Lattanzi and Taff 1993; Röser in this volume) is appropriate.

Table 1. The Lee and van Altena Table I, Revisited.

Emulsion	G	c_0	
103aO	0.030	0.58 μm	0.″039
IIaO	0.019	0.37	0.025
IIIaJ	0.016	0.31	0.021
Tech Pan	0.010	0.19	0.013

Another concern associated with the increased use of film is its proper mounting in the scanning machines. The two less-than-satisfactory approaches taken so far involve the use of a cover glass or an index-matching liquid. Cover glasses compromise the performance of the machines; and this is particularly serious for laser-illuminated systems, in which multiple reflections are more troublesome. Index-matching fluids (a water-glycerin mixture or nonane (C_9H_{20})) have been used with some success but are operationally tedious and cause damage if they come in contact with the emulsion side of the film. Additionally, nonane is considered a hazardous material[2]; and, while possibly acceptable for small experiments, is inappropriate for ongoing routine use. In the quest for better solutions, a system based on tensioning the film is under consideration at ROE (H. MacGillivray, private communication) and a platen vacuum system at ST ScI.

2. The Measuring Machines and their Programs

This section contains a short summary of the major measuring machines dedicated to Schmidt surveys, together with their recent accomplishments and long term plans. Photographs of these instruments are given as Figures 1–6. (Many other fine measuring machines are not described here, as their programmatic emphasis is less specifically on Schmidt surveys.)

The APM at Cambridge is based on laser illumination with an acousto-optic deflector to achieve a large number of channels. The APM has been used to scan the POSS-I surveys, and catalogs based on them are available for collaborative use in Cambridge. Future plans include the UK J/EJ and OR/R surveys, as well as the AAO SES R (Second Epoch Survey, made with the UK Schmidt) and the POSS–II as they become available.

[2]A few selected items from the material safety data sheet are "Irritating to eyes, respiratory system and skin", "mechanical exhaust required", "safety shower and eye-bath [required]","... chemical, physical, and toxicological properties have not been thoroughly, investigated", courtesy of Aldrich Chemical Co., Milwaukee, WI.

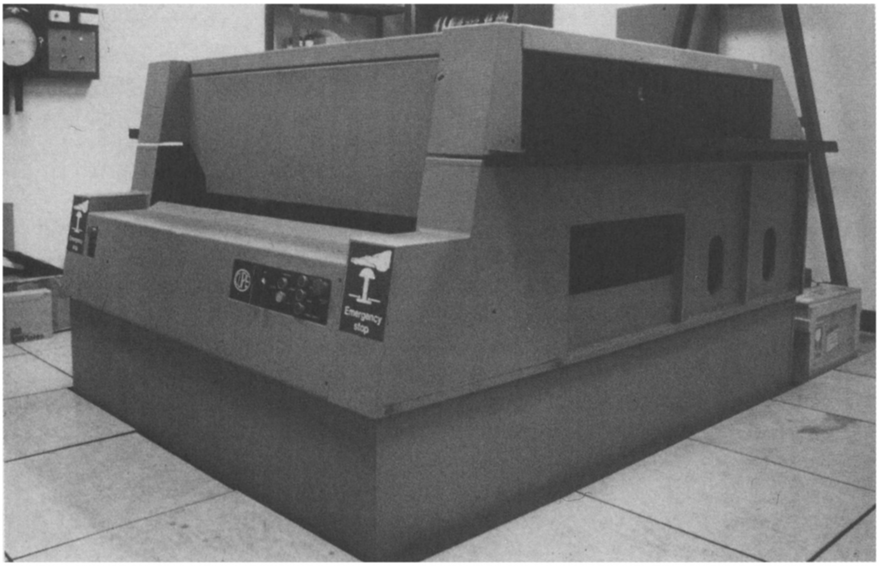

Figure 1. The APM Machine at the Institute of Astronomy, Cambridge.

The COSMOS machine at Edinburgh is based on a CRT-illuminated flying spot. COSMOS has been used to construct scans and catalogs of the UK J surveys, and these are available at ROE, NRL, and AAO. COSMOS was retired in 1993 and has been superseded by SuperCOSMOS, which is a multi-channel system based on a linear array, with telecentric optics to control the scattered light. Programs for SuperCOSMOS include, at the highest priority, rescanning the UK J/EJ survey, scanning the SES R survey, and with lower priority, the POSS–I and –II and the ESO B and R.

The two PDS machines at ST ScI are classical two-microscope microdensitometers. These have been used to scan the Palomar Quick V and POSS–I (E) surveys and the UK J/EJ surveys. Future programs include scanning the POSS–II and the AAO SES original plates and distributing the raster data. The combined data will be used to construct a new all-sky catalog containing colors and proper motions. GAMMA (Guide star Automated Measuring MAchine) is a major upgrade built on the PDS mechanical substrate. It is laser illuminated with an acousto-optic deflector to achieve a *small* number of channels, while retaining the mechanical fast-scan capability.

The APS machine at Minnesota is based on a laser spot deflected with a rapidly rotating octagon-prism and is capable of scanning two plates simultaneously. This system has been used to scan and catalog the POSS–I in both colors. A subset of the catalog (initial release of nine plates at the NGP, with expansion planned for the near future), is available from the ADS (Astrophysics Data System). Future programs include proper motion work with the 1970 "Luyten" survey and catalogs based on the POSS–II.

https://doi.org/10.1017/S0252921100021886 Published online by Cambridge University Press

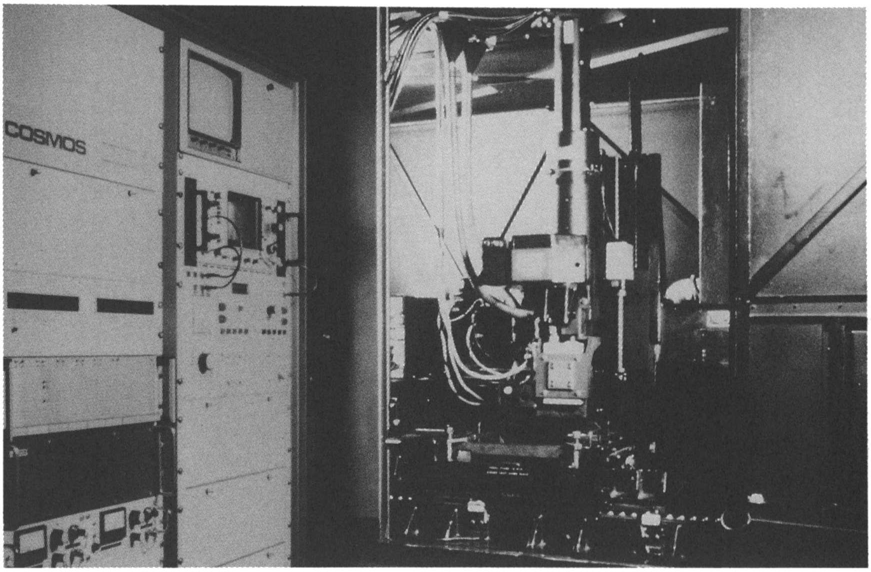

Figure 2. The COSMOS Machine at Royal Observatory Edinburgh.

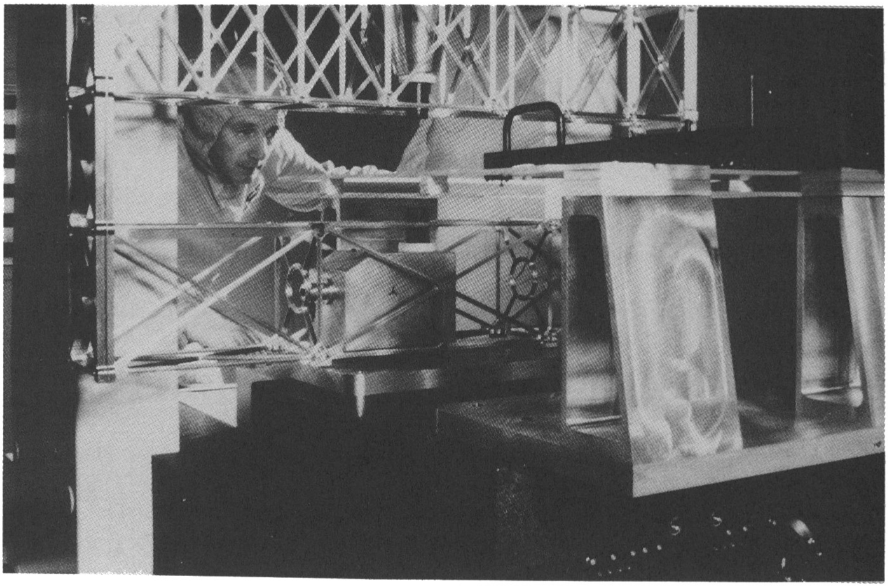

Figure 3. The SuperCOSMOS Machine at Royal Observatory Edinburgh.

https://doi.org/10.1017/S0252921100021886 Published online by Cambridge University Press

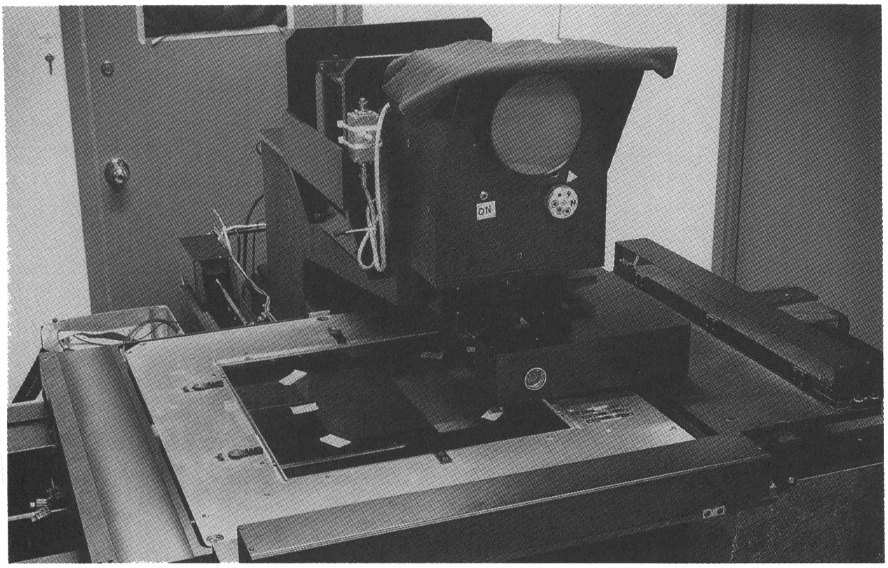

Figure 4. One of the PDS/GAMMA Machines at Space Telescope Science Institute.

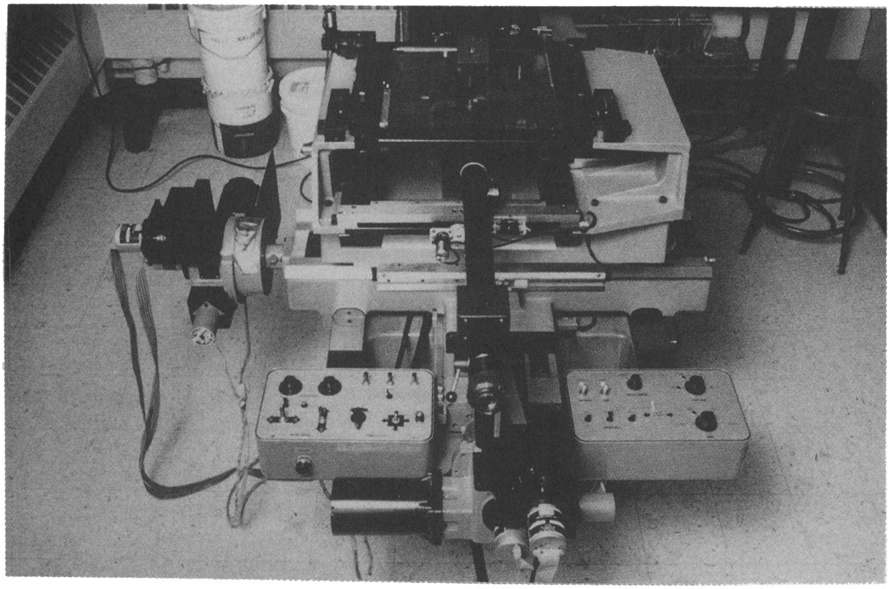

Figure 5. The APS Machine at the University of Minnesota.

https://doi.org/10.1017/S0252921100021886 Published online by Cambridge University Press

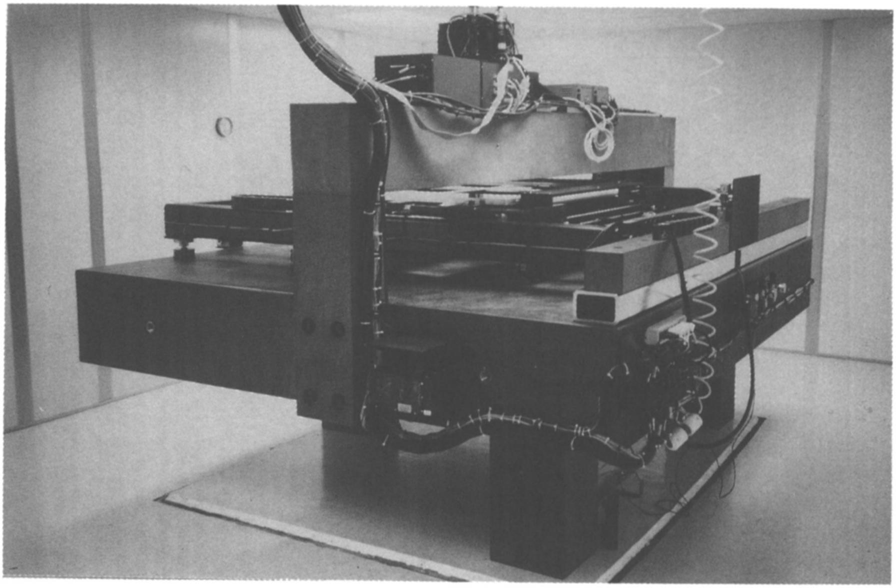

Figure 6. The PPM Machine at the U.S. Naval Observatory, Flagstaff.

The PPM machine at US Naval Observatory, Flagstaff, is based on CCD cameras and features extensive software to compensate the astrometric field-effects in individual CCD frames. The PPM is capable of scanning four plates simultaneously. This machine will be used to scan the POSS–I and the POSS–II originals, as well as a special set of short exposures made on the same grid to improve the astrometric reference frame. The goal is a new northern hemisphere catalog of high astrometric quality.

With the exception of the original PDS configuration, all of these systems are capable of supporting a 1000 plate per year program. Some are in principle capable of going even faster, but one may expect that such speeds will exceed the capabilities of a reasonably sized staff to manange and operate the machines and process the data.

A uniform set of test data for these systems is not available, and it must also be noted that three of them (SuperCOSMOS, GAMMA, and PPM) are still in their commissioning phases. While detailed performance comparisons are therefore premature, some speculations may be possible. The photometric performance clearly depends on dynamic range and control of scattered light. The classical microdensitometer arrangement (PDS) is best in this regard, but only at a great cost in speed. Perhaps only slightly inferior to that are the laser configurations which restricts the egress aperture because only a small number of channels are used (GAMMA) and the white light system with telecentric optics (SuperCOSMOS). The limits to astrometric performance depend on environmental control and precision of the metrology system. One would expect the newer machines to have better metrology, but this is presently hard to evaluate quantatively. A final environmental point for laser-based metrology

https://doi.org/10.1017/S0252921100021886 Published online by Cambridge University Press

configurations is that atmospheric pressure variations may be a significant effect (0.35 μm over 350 mm for a 2.5 mm pressure variation); machines which do not compensate this should not be used during front passages.

3. Archiving and Distribution

The size of a minimal set of all-sky scans (1788 plates on the five degree grid, in one color, 15 μm pixels) is 2 Tbytes; and of course one needs to scan multiple passbands, e.g. the three of the POSS–II. Such volumes of data are stored at the scanning institutions on optical disk or magnetic tape, cf. Pirenne (1994). However, their distribution in this form is impractical, and some kind of data compression based on the sacrifice of a controlled part of the sky data is used in all current programs. One popular approach, *thresholding*, identifies the astronomical objects (as density excesses above the sky), extracts them from the raster, and distributes the extracted "cutouts" together with with an object catalog. A prominent example of this approach is the ROE/NRL catalog (Yentis et al. 1992), which has now been distributed to several centers.

The other approach, *compression with loss*, works by not fully encoding the details of the noise in the sky background and in the image structures. The major example of this is the project, based on the H-transform, to put the ST ScI scans of the UK SERC J/EJ survey onto a set of 61 CD ROMs (White et al. 1992, also announcement in *PASP*, **106**, 108 [1994]), with 40 discs covering the 1950 POSS–I (E) to follow in a year. The initial distribution of this set will be to about 200 sites.

4. Future Directions

The use of computer networks, e.g. Internet, and the publication of large databases on CD ROMs are both presently accepted as viable methods of distributing large sets of scan and catalog data. One may expect both methods to receive continuing usage, with the small-scale or casual user tending to prefer the low cost and minimal equipment requirements associated with the Internet, while the convenience and reliability of local CD ROMs will be a major advantage to the large-scale or the schedule-driven user.

Not all of the present measuring systems will be supported and maintained very far into the next century. (Even if there is institutional willingness to keep machines open, the costs of maintenance as electronic and computer elements become "no longer available" will lead to non-trivial requirements.) Therefore, it is important that we now begin programs to identify and scan important historical plate collections (cf. Tsvetkov in this volume) and that this work be done with a high level of coordination among the various institutions. It is also worth considering the reconfiguration of at least one scanning machine into a state suitable for very high speed scanning with only modest photometric and astrometric precision, perhaps with rather large pixels.

A final suggestion, first heard by this reviewer at Potsdam, should receive serious consideration: to rephotograph the entire sky on Tech Pan 4415 film. This would be a 1788 field program split between a northern and a southern site; and the superior properties of this material are well presented by Parker et al. elsewhere in this volume. If such a project were to be undertaken, shifting the entire grid by 2.5 degrees should be considered; this would move the plate-based systematics (with respect to the present surveys) and would force them to a different spatial frequency.

Acknowledgments

The summary of the measuring machines and their programs could not have been written without the active cooperation of Roberta Humphreys (APS), Mike Irwin (APM), Harvey MacGillivray (COSMOS/SuperCOSMOS), and David Monet (PPM). We also thank Quentin Parker and his colleagues at the AAO for furnishing the quantatitive data on Tech Pan granularity. Most of this paper was written while the author enjoyed the hospitality of the AAO. The ST ScI is operated by AURA, Inc., under contract to NASA.

References

Bucciarelli B., Lattanzi M. G. & Taff L. G., 1993, ApJS, 84, 91

Jaschek C., ed.,1989, "Digitized Optical Sky Surveys," in Bull. Inform. du CDS, No. 37

Lasker B. M., 1994, in *Galactic Structure from Large Databases*, A.G. Davis Philip, ed., in press

Lee J.-F. & van Altena W., 1983, AJ, 88, 1683

MacGillivray H. T., ed., 1991 ff, Newsletter, IAU Working Group on Wide Field Imaging (ROE, Edinburgh)

MacGillivray H. T. & Thompson E. B., eds, 1992, *Digitized Optical Sky Surveys*, (Kluwer, Dordrecht)

Monet D. G., 1994, in *Astronomy from Wide-Field Imaging*, Proc. IAU Symp. 161, in press

Morgan D. H., Tritton S. B., Savage A., Hartley M. & Cannon R. D., 1992, in *Digitized Optical Sky Surveys*, H. T. MacGillivray & E. B. Thompson, eds (Kluwer, Dordrecht), p. 11

Pirenne B., 1994, in *Astronomy from Wide-Field Imaging*, Proc. IAU Symp. 161, in press

Taff L. G., Lattanzi M. G. & Bucciarelli B., 1990, ApJ, 358, 359

West R., et al., eds, 1994, *Astronomy from Wield-Field Imaging*, Proc. IAU Symp. 161, in press

White R. L, Postman M. & Lattanzi M. G., 1992, in *Digitized Optical Sky Surveys*, H. T. MacGillivray & E. B. Thompson, eds, (Kluwer, Dordrecht), p. 167

Yentis D. J., Cruddace R. G., Gursky H., Stuart B. V., Wallin J. F., MacGillivray H. T. & Collins C. A., 1992, in *Digitized Optical Sky Surveys*, H. T. MacGillivray & E. B. Thompson, eds, (Kluwer, Dordrecht), p. 67

Discussion

Tsvetkov: We know that there are plate archives produced with different wide field instruments (astrographs, small cameras etc.), with different plate limits in comparison with the deep sky surveys like POSS and UKST/ESO. What type of microdensitometer device do you suggest would be most suited for digitisation purposes of these plate collections.

Lasker: Clearly, we need to adjust the measuring machine to the plate properties. For example, there is little sense in using a very precise (e.g. laser interferometer machine) for plates of little astrometric interest. As for the sample interval, I suggest that a very fine scan and Fourier study be made for each kind of plate to be processed; from the power spectrum one can then pick an appropriate sample interval. For patrol plates, I'd think that simple machines based on linear arrays or CCD's, mounted on a simple commercial XY table, would suffice. One such machine was demonstrated by Kroll at Potsdam and others are described in the Potsdam volume.

Cannon: On your last suggestion, that we might shift the plate centres by half a frame for the second epoch survey, don't you think that might spoil the internal accuracy of the proper motions at the most precise level? What would the expert astrometrists say?

Lasker: The trend in Schmidt astrometry is for reductions that incorporate local corrections on a scale of approximately one degree or less (cf. papers at this meeting and at Potsdam). Such approaches are not particularly sensitive to the exact position of the plate centres. Also, as POSS-I and POSS-II are already on different centres, we may expect that considerable effort will go into this problem.

Reid: So much has changed in the Schmidt telescopes themselves, that changing the plate centres in any future survey will be a minor perturbation. Whether you want to consider another survey for astrometric purposes within the next fifteen years is something I will discuss later.