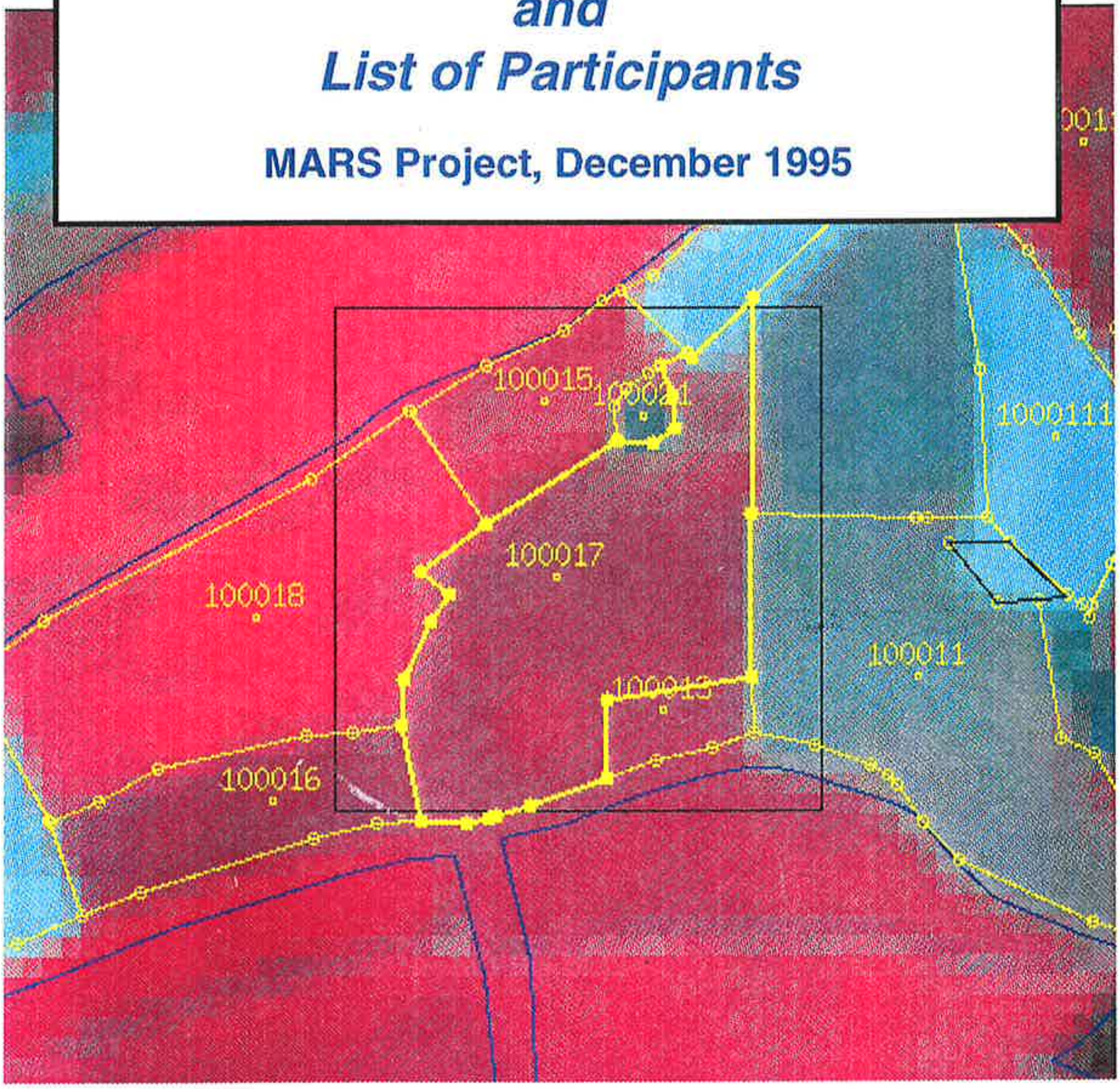
Conference on

"1995 Controls with Remote-Sensing"

November, 21 and 22, 1995
Grand Hotel DINO, BAVENO, LAGO MAGGIORE.

Programme, Summary of Presentations and List of Participants

MARS Project, December 1995



EUROPEAN COMMISSION

DG VI AGRICULTURE,
G4 - EAGGF.

DG XII - RESEARCH,
J.R.C. of ISPRA, ITALY.
I.R.S.A. - MARS Project.

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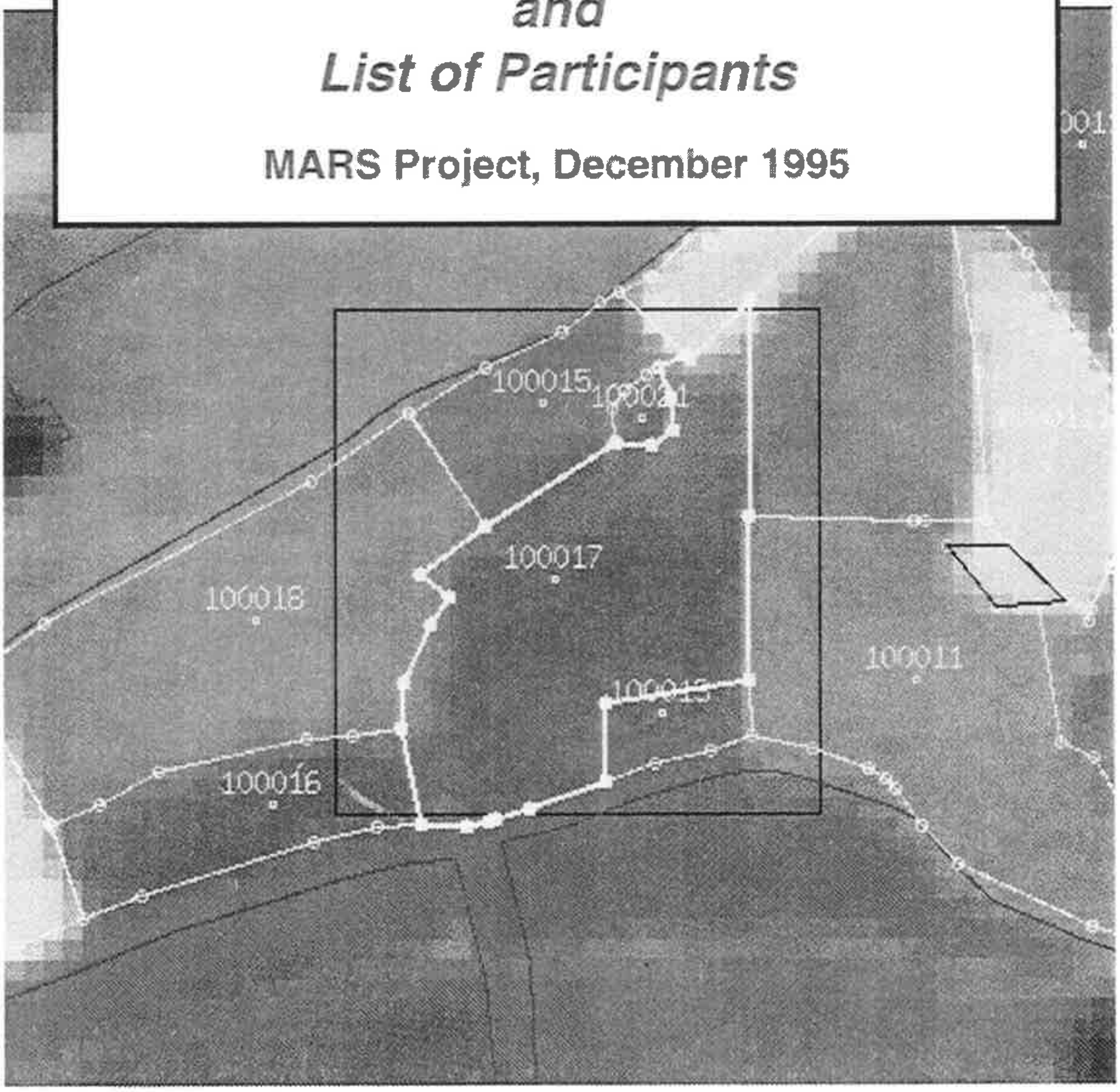

EUROPEAN COMMISSION

DG VI AGRICULTURE,
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I.R.S.A. - MARS Project.

Institute of Remote Sensing Applications, J.R.C., ISPRA - DG VI G4.
Conference on "Area Aid Controls by Remote-Sensing"
21 - 22 November 1995, Grand hotel Dino, BAVENO, Lago Maggiore, ITALY.

EUROPEAN COMMISSION - DG XII - RESEARCH
JOINT RESEARCH CENTRE, ISPRA
Institute for Remote Sensing Applications
MARS Project

Programme - TUESDAY 21 November: "TECHNICAL ISSUES"

9h 00 - 10h 00. Introduction. J. MEYER ROUX *(Deputy Director of I.R.S.A.)*, P. DE WINNE*(Head of Unit, DG VI - G4).*

- 10 h. 30 - 10 h. 40: "Summary of the Control by Remote Sensing work programme, 1995", ***M. V. de STEENE*** *(DG VI - G4).*

10h. 00- 10h. 30. Coffee break - Poster session - Software demonstrations.

10h 30- 12h 30, Session 1: Orthorectification of satellite image and airborne data.

Session President: **C. CANNAFOGLIA** *(Dir. Centrale del Catasto Italiano, Min. delle Finanze)*
- 10 h. 30 - 10 h. 40: "Why orthorectification?", ***S. KAY*** *(MARS Project, IRSA).*
- 10 h. 40 - 11 h. 10: "High altitude and space image orthocorrection for mapping applications", ***I. DOWMAN*** *(Uni. College, London).*
- 11 h. 10 - 11 h. 30: "Possibilities in the production of orthoimagery", ***T. WESTIN*** *(SATELLITBILD, S.).*
- 11h. 30 - 11 h. 40: "Modelling errors in image rectification", ***S. KAY*** *(MARS Project, IRSA).*
- 11h. 40 - 12 h. 00: "Use of ortho and non-ortho rectified aerial photography in control operations", ***M. MIRANDA*** *(GEOMETRAL, P.).*
- 12 h. 00 - 12 h. 30: Questions, debate.

12h. 30- 14h. 00. Buffet lunch - Poster session - Software demonstrations.

14h 00 - 15h 30, Session 2: The use of imaging RADAR.

Session President: **G. PACI** *(ESA ESRIN, I.).*
- 14 h. 00 - 14 h. 15: "EAGGF SAR requirements and techniques used; 1993-95", ***K. TEMPANY*** *(Expert, DG VI - G4).*
- 14 h. 15 - 14 h. 30: "RADAR applied to vegetation monitoring; strengths and constraints", ***M. SHARMAN.*** *(DG XII - D4).*
- 14 h. 30 - 15 h. 00: "The use of ERS-1 SAR data for 1995 control of area-based subsidies in the UK", ***A. SOWTER*** *(NRSC, UK).*
- 15 h. 00 - 15 h. 15: "Spaceborne SAR data in the MARS STAT project: uses and prospects", ***H. De GROOF*** *(MARS Project, IRSA).*
- 15 h. 15 - 15 h. 30: Questions, debate.

15h. 30 - 16h. 00. Coffee break - Poster session - Software demonstrations.

16h 00 - 18h 00, Session 3: Classification and automated Control.

Session President: **J. TAYLOR** *(Silsoe College, UK)*
- 16 h. 00 - 16 h. 15: "Principles and overview", ***J. TAYLOR*** *(Silsoe College, UK)*
- 16 h. 15 - 16 h. 30: "Result of use of automated classification and control in 1995", ***J.M. TERRES*** *(MARS Project, IRSA).*
- 16 h. 30 - 16 h. 50: "Automated control and decision rules used in the Netherlands, 1995", ***F. V. der LAAN*** *(GEORAS, NL).*
- 16 h. 50 - 17 h. 10: "Use of image classification for the controls in Spain", ***M.A. GALIANO SEGOVIA*** *(TRAGSATEC, E.).*
- 17 h. 10 - 17 h. 30: "Classification and automated control in France, 1995", ***P.N. PASCAUD*** *(SOTEMA, F.).*
- 17 h. 30 - 18 h. 00: Questions, debate.

18h. 00 - 19h. 00. Poster session - Software demonstrations.

N.B: *At 19h 30, reception hosted by the Director of the Institute of Remote Sensing Applications.*

Programme - WEDNESDAY 22 November: "STRATEGIC and OPERATIONAL ISSUES"

8h 30 - 10h 30, Session 4: Satellite image and/or aerial photography.

Session President: **K. HOLM** *(Kampsax- Geoplan, DK.)*
- 08 h. 30 - 09 h. 00: "Results and summary, 1995", ***J. DELINCE*** *(DG VI- G4)*
- 09 h. 00 - 09 h. 30: "Principles and constraints of aerial photography", ***A. CASTAGNOLI*** *(Compagnia Generale Riprese Aeree, I.).*
- 09 h. 30 - 09 h. 45: "The use of aerial photos combined with satellite data in Finland", ***A. VERTANEN*** *(Nat. Land Survey, FL).*
- 09h. 45 - 10 h. 00: "The use of aerial photos combined with rapid field visits in Belgium", ***P. COUNET*** *(Da VINCI - IRCO, B).*
- 10 h. 00 - 10 h. 30: Questions, debate.

10h. 30- 11h. 00 Coffee break - Poster session - Software demonstrations.

11h 00 - 12h 30: Session 5: Current technical and operational Constraints.

Session President: **Y. BERGER** *(Ministère de l'Agriculture, F.)*
- 11 h. 00 - 11 h. 20: "Results and summary, 1995", ***O. LEO*** *(Expert, MARS Project).*
- 11 h. 20 - 11 h. 35: "Organisation and meeting project deadlines", ***A. RELIN*** *(GAF, D.)*
- 11 h. 35 - 11 h. 50: "Constraints imposed by data quality", ***N. SEKOURIS*** *(ERATOSTHENES, G.).*
- 11 h. 50 - 12 h. 00: "Remote sensing control efficiency", ***M. SZKOLNY*** *(NRSC, UK).*
- 12 h. 00 - 12 h. 30: Questions, debate.

12h. 30- 14h. 00. Buffet lunch - Poster session - Software demonstrations.

14h 00 - 16h 00: Session 6: Results 1995, future prospects and conclusion.

Session President: **J. MEYER ROUX** *(Deputy Director of I.R.S.A.).*
- 14 h. 00 - 14 h. 20: "Results and prospects" ***M. Van de STEENE*** *(DG VI G4).*
- 14 h. 20 - 14 h. 40: "Constraints and potential developments" ***D. LEPOUTRE*** *(GEOSYS, F.)*
- 14 h. 40 - 15 h. 00: "The future of remote sensing control within the Integrated System" ***L. Mc GEOWN*** *(MALLON, IRL).*
- 15 h. 00 - 16 h. 00: Final discussion.

16h. 00- 18h. 00. Coffee break - Poster session - Software demonstrations.

Institut des Applications de la Télédétection, CCR D'ISPRA - DG VI G4.
Conférence "Contrôles par télédétection des aides à la superficie"
21 et 22 novembre 1995, Grand Hôtel Dino, BAVENO, Lago Maggiore, ITALIE.

COMMISSION EUROPEENNE - DG XII - RECHERCHE
CENTRE COMMUN DE RECHERCHE D'ISPRA
Institut des Applications de la Télédétection
Projet MARS

Programme du MARDI 21 novembre: "POINTS TECHNIQUES"

9h 00 - 10h 00: Introductions. J. MEYER ROUX *(Directeur Adjoint de l'I.A.TD.)*, P. DE WINNE *(Chef d'Unité DG VI - G4).*

- 9 h. 40 - 10 h. 00: "Résumés des travaux de contrôle par Télédétection en 1995", ***M. V. de STEENE*** *(DG VI - G4).*

10h. 00- 10h. 30 Pause café - Poster session - Démonstration de logiciels

10h 30- 12h 30, Session 1: Orthorectification des données satellite et aériennes.

Président de la Session: **C. CANNAFOGLIA** *(Dir. Centrale del Catasto Italiano, Min. delle Finanze)*

- 10 h. 30 - 10 h. 40: "Pourquoi des orthorectifications?", ***S. KAY*** *(Projet MARS, I.A.TD.)*
- 10 h. 40 - 11 h. 10: "L'orthocorrection dans les applications cartographiques et topographiques", ***I. DOWMAN*** *(Uni. College, London).*
- 11 h. 10 - 11 h. 30: "Les options possibles de production d'ortho-images", ***T. WESTIN*** *(SATELLITBILD, S.).*
- 11h. 30 - 11 h. 40: "La modélisation des erreurs dans la rectification d'image", ***S. KAY*** *(Projet MARS, I.A.TD.).*
- 11h. 40 - 12 h. 00: "Les alternatives possibles à l'orthorectification", ***M. MIRANDA*** *(GEOMETRAL, P.).*
- 12 h. 00 - 12 h. 30: Débat, questions et réponses.

12h. 30- 14h. 00. Buffet - Poster session - Démonstration de logiciels.

14h 00 - 15h 30, Session 2: L'utilisation des données S.A.R.

Président de la Session: **G. PACI** *(ESA ESRIN, I.).*

- 14 h. 00 - 14 h. 15: "Les besoins du FEOGA et l'utilisation des données SAR, 1993-1995", ***K. TEMPANY*** *(Expert, DG VI - G4).*
- 14 h. 15 - 14 h. 30: "Le suivi de la végétation avec les données Radar: atouts et contraintes", ***M. SHARMAN.*** *(DG XII - D4).*
- 14 h. 30 - 15 h. 00: "L'utilisation des données SAR ERS1 pour les contrôles au Royaume-Uni en 1995", ***A. SOWTER*** *(NRSC, U.K.).*
- 15 h. 00 - 15 h. 15: "Les données spatiales SAR dans MARS-STAT: utilisations et perspectives", ***H. De GROOF*** *(Projet MARS, I.A.TD.).*
- 15 h. 15 - 15 h. 30: Débat, questions et réponses.

15h. 30- 16h. 00 Pause café - Poster session - Démonstration de logiciels.

16h 00 - 18h 00, Session 3: Classification et contrôle automatique.

Président de la Session: **J. TAYLOR** *(Silsoe College, UK.)*

- 16 h. 00 - 16 h. 15: "Principes et généralités", ***J. TAYLOR*** *(Silsoe College, UK.)*
- 16 h. 15 - 16 h. 30: "Bilan de l'utilisation des classifications et contrôles automatiques en 1995", ***J.M. TERRES*** *(Projet MARS, I.A.TD.)*
- 16 h. 30 - 16 h. 50: "Le contrôle automatique et les modèles de décision utilisés aux Pays-Bas, 1995", ***F. V. der LAAN*** *(GEORAS, HEIDEMIJ, NL).*
- 16 h. 50 - 17 h. 10: "L'utilisation de la classification pour les contrôles en Espagne", ***M.A. GALIANO SEGOVIA*** *(TRAGSATEC, E.).*
- 17 h. 10 - 17 h. 30: "Classification et contrôle automatique en France en 1995 ", ***P.N. PASCAUD*** *(SOTEMA, F.).*
- 17 h. 30 - 18 h. 00: Débat, questions et réponses.

18h. 00- 19h. 00. Poster session - Démonstration de logiciels.

N.B: *A 19h 30, apéritif d'honneur offert par la Direction de l'Institut des Applications de la Télédétection.*

Programme du MERCREDI 22 novembre: "STRATEGIES, MISES en OEUVRE et PERSPECTIVES"

8h 30 - 10h 30, Session 4: Données satellite et / ou photographies aériennes.

Président de la Session: **K. HOLM** *(Kampsax- Geoplan, DK.)*
- 08 h. 30 - 09 h. 00: "Bilan et synthèse 95", ***J. DELINCE*** *(DG VI- G4).*
- 09 h. 00 - 09 h. 30: "Principes et contraintes d'une prise de vue aérienne", ***A. CASTAGNOLI*** *(Compagnia Generale Riprese Aeree, I.).*
- 09 h. 30 - 09 h. 45: "L'utilisation de photos combinées avec des données satellite en Finlande", ***A. VERTANEN*** *(Nat. Land Survey, FIN).*
- 09h. 45 - 10 h. 00: "L'utilisation des photos combinées avec des visites rapides en Belgique", ***P. COUNET*** *(Da VINCI - IRCO, B).*
- 10 h. 00 - 10 h. 30: Débat, questions et réponses.

10h. 30- 11h. 00 Pause café - Poster session - Démonstration de logiciels.

11h 00 - 12h 30: Session 5: Les principales limitations actuelles.

Président de la Session: **Y. BERGER** *(Ministère de l'Agriculture, F.)*
- 11 h. 00 - 11 h. 20: "Bilan et synthèse 95", ***O. LEO*** *(Expert, Projet MARS, I.A.TD.).*
- 11 h. 20 - 11 h. 35: "Organisation et respect des délais", ***A. RELIN*** *(GAF, D.)*
- 11 h. 35 - 11 h. 50: "Les contraintes de qualité des données", ***N. SEKOURIS*** *(ERATOSTHENES, EL.).*
- 11 h. 50 - 12 h. 00: "L'efficacité du contrôle par télédétection", ***M. SZKOLNY*** *(NRSC, U.K).*
- 12 h. 00 - 12 h. 30: Débat, questions et réponses.

12h. 30- 14h. 00. Buffet - Poster session - Démonstration de logiciels.

14h 00 - 16h 00: Session 6: Bilan 95, orientations futures, et conclusions

Président de la Session: **J. MEYER ROUX** *(Directeur Adjoint de l'I.A.TD.).*
- 14 h. 00 - 14 h. 20: "Bilan et perspectives" ***M. Van de STEENE*** *(DG VI G4).*
- 14 h. 20 - 14 h. 40: "Contraintes et ouvertures potentielles" ***D. LEPOUTRE*** *(GEOSYS, F.)*
- 14 h. 40- 15 h. 00: "Le futur des contrôles par télédétection dans le cadre du système intégré" ***L. McGEOWN*** *(MALLON, IRL.).*
- 15 h. 00- 16 h. 00: Discussion finale.

16h. 00- 18h. 00. Pause café - Poster session - Démonstration de logiciels.

INTRODUCTIONS

PDW95/mrd (0100)

CCR D'ISPRA - VI.G.4

Contrôles par télédétection 1995

Conférence de BAVENO

21 et 22 novembre 1995

introduction

P. DE WINNE

Chef de l'unité VI.G.4

Monsieur le Président, Mesdames et Messieurs, nous voici au début de la conférence "Contrôle par Télédétection 1995" organisé par le CCR en relation avec le FEOGA. Elle a pour objectif d'approfondir les aspects techniques du contrôle par télédétection et de tirer des conclusions de la campagne 95.

Je crois que c'est à juste titre qu'il a été décidé de scinder en deux parties la réunion finale des opérations de contrôle par télédétection qui avait lieu traditionnellement chaque année à Bruxelles. Ceci permet de mieux approfondir chacune des questions qui nous concernent actuellement, les aspects liés à la technique même et qui sont traités lors de cette conférence, et les aspects organisationnels et administratifs, à étudier ensemble avec les administrations des Etats membres..

Comme nous avons fait à Belgirate il y a deux ans, je crois qu'il est utile, au début de cette conférence de dessiner le cadre dans lequel nous nous trouvons. Pourquoi le contrôle par télédétection est-il important pour le FEOGA, quel est l'historique de cette méthode de contrôle et quelles sont les orientations que nous voyons pour le futur ?

Depuis 1962, la Politique Agricole Commune (PAC) est un des fondements de l'Union Européenne (UE). En 1992, le Conseil l'a "réformée". Il a introduit une série de subventions directes aux agriculteurs calculées directement ou indirectement à l'hectare, alors qu'auparavant elles étaient attribuées à la quantité et versées à des intermédiaires (stockeurs, exportateurs, transformateurs). Cette Réforme concerne les principales cultures arables et certaines superficies fourragères et implique aussi le gel obligatoire d'une partie de la superficie cultivable. Les subventions versées dans le cadre de la Réforme représentent environ 18 milliards d'Ecus, soit environ la moitié des dépenses agricoles, ou le quart du budget total de l'Union Européenne.

Pour assurer la gestion de la Réforme de la PAC, un "système intégré de gestion et de contrôle" des subventions communautaires a été introduit. Il prévoit qu'avant 1996, tous les Etats membres devront avoir mis en place notamment un système déclaratif unifié, une base de données informatisées, un système d'identification des parcelles agricoles et des animaux, ainsi qu'un dispositif unifié pour les contrôles. Parmi ceux-ci et en option, des contrôles par télédétection sont expressément autorisés.

La mise en place progressive du SIGC est de la responsabilité de chaque Etat membre. La Commission n'intervient que pour fournir une assistance technique et un cofinancement des dépenses par le FEOGA. Elle veille aussi à une qualité suffisante des travaux dans tous les Etats membres, qui garantisse l'égalité de traitement de tous les producteurs de l'Union.

Le SIGC prévoit donc, en option, le contrôle par télédétection des déclarations concernant les terres arables et les cultures fourragères. Le choix est laissé aux Etats membres. L'alternative est un contrôle "traditionnel" par visites sur place. Quelle que soit la méthode choisie, un minimum de 5% des déclarations doit être contrôlé. La réglementation est aussi applicable dans les nouveaux Etats membres ayant adhéré à l'Union en 1995 (Autriche, Finlande, Suède). Cette année, tous les Etats membres de l'Union européenne (à l'exception de l'Autriche et du Luxembourg) ont décidé de participer à ce type de contrôles.

Vous savez que les contrôles par télédétection ont été conçus comme une étape intermédiaire entre la réception d'une demande d'aide et la décision de l'administration sur son éligibilité. Ces contrôles par télédétection ont pour objectifs principaux de

- réduire les coûts des inspections sur place en réduisant leur nombre;

- concentrer à priori les inspections sur le terrain sur les demandes apparues non conformes ou incertaines, et

- fournir des renseignements complémentaires aux inspecteurs chargés de trancher sur le terrain

Le nombre total des déclarations à vérifier varie chaque année aux alentours de 2,9 millions donc au minimum 145.000 exploitations agricoles sont à contrôler sur le terrain annuellement. Ceci représente un travail immense. Le nombre de demandes d'aides contrôlés à l'aide de la télédétection est passé de 34.000 en '93 à 70.000 en '94 et 100.000 en '95. Les sites couverts sont passés de 44 en '93 à 56 en '94 et 107 en '95.

Depuis 1994, le règlement n° 165/94 officialise la collaboration au sein de l'Union en matière de télédétection, mais toujours sur une base volontaire. Les programmes de contrôle organisés en commun sont cofinancés sur fonds partagés, nationaux et communautaires. A partir de 1995, la part de l'Union est de 50 %, avec une clé de répartition des fonds entre Etats membres, et pour une durée de 5 ans. De plus, hors cofinancement, un crédit séparé est destiné à l'expérimentation ponctuelle ou à de l'assistance technique aux Etats membres, ainsi qu'à l'achat des images, qui reste pour des raisons évidentes, centralisé par le FEOGA. Par contre, les frais administratifs, y compris les contrôles de terrain, ne sont jamais pris en charge par la Commission.

Le montant dépensé dans le cadre de ce régime de l'exercice de la télédétection était de 8,8 mio écus en 1993. Le régime de cofinancement a commencé en 1994 par une contradiction in terminis c.à.d. un cofinancement à 100 % pour la Commission. Cette année-ci, 1995, pour la première fois, le vrai cofinancement à 50 % était appliqué. Plusieurs craignaient un recul marqué dans le taux d'application de la méthode. Le contraire est vrai. En effet, le nombre de dossiers contrôlés par télédétection a augmenté de 40 % en 1995. Cette constatation est très importante ! Toutefois, des conclusions hâtives sont dangereuses! On peut seulement en conclure que si le prix de la télétédection était la moitié du prix actuel, sa place comme méthode de contrôle serait acquise. On devra approfondir ce point afin de pouvoir décider, en 1998 sur l'éventualité ou la nécessité d'un prolongement du régime de cofinancement.

Le coût moyen du contrôle par télédétection satellitaire dans l'Union Européenne était de 307 écus par déclaration en 1992. En 1993, ce chiffre est descendu à 255 écus et en 1994 à 201 écus. En 1995 le coût moyen par dossier baissé de nouveau. Cette réduction des coûts de la télédétection est le résultat entre autres de progrès méthodologiques et aussi d'économies d'échelle. Le coût moyen des contrôles de terrain équivalents a été évalué par les Etats membres entre 160 et 600 écus par exploitation, ce qui permet de considérer que dans la plupart des cas, la télédétection est compétitive. Les dépenses totales par télédétection sont restées inférieures à 12 millions d'écus en 1995, soit moins de 0,7 pour mille des subventions contrôlés.

Quand nous nous sommes vus ici il y a deux ans, je vous ai parlé de la possibilité d'utiliser la télédétection non pas seulement dans le cadre stricte de contrôle, mais aussi comme instrument utilisé pour la création de systèmes d'identification de parcelles agricoles tel que le parcellaire dans le système intégré ou les casiers viticole ou oléicole.

En effet, le point de départ du SIGC est l'identification des parcelles cultivées, puisque les subventions sont calculées sur cette base. La demande de subvention annuelle doit décrire la localisation, la superficie et l'utilisation de chacune des parcelles agricoles à subsidier. Selon les traditions nationales, chaque Etat membre a opté pour des systèmes de localisation qui lui sont propres, mais qui peuvent être subdivisés en deux groupes : références cadastrales ou cartographiques. Les références cadastrales sont basées en général sur des registres fiscaux décrivant les propriétés foncières. Les références cartographiques font appel à des cartes topographiques à grande échelle ou à des ortho-photoplans. Dans certains Etats membres ou certaines régions, le cadastre est inexistant ou peu utilisable. De même, de bonnes cartes à grande échelle ne sont pas disponibles partout. Il faut donc parfois créer des documents nouveaux permettant aux agriculteurs de faire leur déclaration. Des travaux ont été entrepris pour délimiter les parcelles directement sur des images de satellite ou des photographies aériennes récentes. L'exemple le plus connu de l'utilisation des images de satellite à cette fin est l'expérience dans le département de l'Oise en France. Cette expérience réussie n'a toutefois pas été étendue ailleurs. La raison est que dans le reste de la France les régions sont plus morcelées et donc moins biens adaptées à des documents tirés d'images satellitaires. Signalons dans ce même cadre aussi des essais de segmentation automatique de parcelles et de calcul de leur superficie qui n'ont pas été concluants.

D'autre part l'approche se basant sur des photos aériennes semble être la solution en Grèce et au Portugal. Sur base d'études pilotes une méthodologie a été mise au point afin de pouvoir déterminer sur des ortho-photos des groupes de parcelles ou ilots de cultures ayant des limites fixes tels que de chemins, fossés, murs ou rangées d'arbres. Actuellement, dans ces deux Etats membres, des travaux de création de documents déclaratifs basés sur des ortho-photos sont entrepris, mais cette méthode est aussi utilisée en Belgique, au Danemark, en Irlande et au Pays-Bas.

Sur base de cette série de constatations je crois qu'on peut dire que la méthode de contrôle par télédétection a dépassé clairement le stade d'expérimentation et est maintenant bien répandu dans toute l'Europe. Ceci ne veut toutefois pas dire qu'on entre dans une période calme où la méthode, une fois mise au point, poursuit sa vie automatique. Quatre points essentiels attirent notre attention.

On ne peut tout d'abord pas nier le point faible de la télédétection : son calendrier. Celui-ci est extrêmement serré. L'administration souhaite retarder les déclarations le plus tard possible de façon à éviter que de trop nombreux agriculteurs ne rectifient ensuite leur plan de culture. Le contractants eux-mêmes désirent une dernière image obtenue tard dans la saison culturale pour bien reconnaître les cultures d'été. Il y a lieu toutefois de réaliser que les résultats doivent être livrés avant la récolte, faute de quoi les contrôles sur place deviennent difficiles ou même impossibles.Cette année de nouveau nous avons dû constater des dates de remise de dossiers jusque fin septembre, voir même la première moitié d'octobre dans 3 Etats membres. Ceci est clairement non satisfaisant.

Un deuxième point à voir est celui de l'appréciation de la fiabilité de la méthodologie. Des procédures plus robustes de validations des résultats doivent être élaborées. La possibilité de mettre en place un contrôle de qualité est actuellement étudiée notamment sur base d'une étude de faisabilité. Il y a lieu maintenant de définir plus clairement la stratégie relative à ce contrôle de qualité en collaboration avec les Etats Membres signataires des contrats. L'approche pourrait se baser sur une description détaillée des différentes actions à entreprendre par chacune des parties concernées, ainsi que les normes minimales à fixer pour chacune de ces actions. Le système de contrôle même devra se baser sur des engagements pris au niveau du contrôle interne par les contractants mêmes, couplé à des contrôles ponctuels par sondage aussi bien par l'Etat membre que par les services de la Commission.

Troisièmement, il y a aussi lieu d'approfondir la discussion entre l'approche pour le contrôle se basant sur des images satelitaires et celle se basant sur des photos aériennes. Une étude sérieuse et complète des relations coûts/efficacité des deux méthodes de travail est plus qu'urgente. Dans cette étude, aussi bien les coûts des images, de l'interprétation et des contrôles terrain, différents pour chacune des méthodes, doivent être pris en compte. En outre, devra-t-on essayer de calculer l'efficacité de chacune de ces méthodes ainsi que la flexibilité d'utilisation notamment en ce qui concerne le respect des dates. A mon avis, nous devrions pouvoir finaliser une telle étude dans le premier trimestre de 1996.

Quatrièmement et finalement il est aussi de notre devoir de remettre en question continuellement le bien-fondé des méthodes de travail que nous utilisons. A cette fin, la compilation de statistiques détaillés des constatations faites lors de la télédétection et des résultats terrains est indispensable. La question simple à laquelle nous devons oser répondre est: "combien d'écus demandés irrégulièrement ont été économisés grâce à l'utilisation de la télédétection ?", et ceci en comparaison avec des méthodes de contrôle classiques. Je sais bien, il est impossible d'inclure dans ce calcul l'énorme effet dissuasif du contrôle par télédétection. Ceci ne veut toutefois pas dire qu'il faut écarter de voir les réalités du terrain.

Vous constaterez que tout au long de cette exposé, quand j'ai parlé de l'évolution de la télédétection, j'ai surtout mis l'accent sur le fait que cette méthode a prouvé sa raison d'être. En conséquence, en ce qui concerne l'engagement des services du FEOGA dans l'exécution annuelle des travaux de contrôle par télédétection, je considère qu'il y a lieu de responsabiliser encore plus les Etats membres en plein application du principe de subsidiarité. Nos interventions lors des redactions des contrats, de la poursuite des travaux et lors de la formulation des conclusions finales devraient progressivement se limiter en stricte minimum. Ainsi nous pouvons reprendre notre rôle primaire de motivation et d'orientation, le rôle de promoteur de nouvelles techniques modernes de contrôle mais aussi notre rôle de contrôleur européen de l'utilisation de l'argent du FEOGA et des systèmes de contrôles mis en place par les Etats membres. Un vrai contrôleur ne peut pas être impliqué dans l'exécution même des tâches qu'il doit contrôler. C'est dans ce cadre notamment aussi que nos activités pour le contrôle de qualité doivent être vus. C'est aussi dans ce cadre que je n'exclu pas que des contrôles ponctuels dans certaines régions soient organisés par le FEOGA même..

Je crois pouvoir dire en conclusion que la Commission dispose de méthodes de gestion et de contrôle par télédétection qui sont à la pointe du progrès. Je suis convaincu que des séminaires comme celui qu'on vient de commencer aujourd'hui contribuent à cette technologie et donc en améliorent son efficacité.

Je vous remercie.

COMMISSION EUROPÉENNE
DIRECTION GÉNÉRALE VI
AGRICULTURE
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Bruxelles, the 17.11.95
MV/mv (EXP09510)

Baveno Conference, 21 - 22 November 1995

Overview of the 1995 RS controls

1. Main 1995 results

1.1 13 participating MS (10 in 1994): come-back of Portugal, + Finland and Sweden. 19 contractors. As a consequence, the Commission technical support has necessarily been light.

1.2 The Recommendations have largely been used.

1.3 3 "official" techniques : satellites, aerial photography, and satellite + photo. Radar complement for 1 site.

1.4 Image acquisitions

	SPOT P	SPOT XS	Landsat TM	SAR ERS	TOTAL
Contrôle des références (images d'archives)		32	130		162
Validation des limites de parcelles	51				51
Images supplémentaires pour couples stéréo	2				2
Automne 1994		57	10		67
Printemps et été 1995		198	15	6	219
Total	53	287	155	6	501

The Commission has provided ortho-images for 3 sites of Portugal.

1.5 Quality Control : first trial by JRC in 1995, parallel to a feasibility study delivered to JRC. Still under progress. We still miss data from some contractors.

1.6 Software : at least 6 software have been "exported" to other contractors (2 BE, IT, NL, UK, and CACHOO).

1.7 Delays, especially in receiving the dossiers, delivering the field documents, and inspecting the refused cases are still a major problem in some MS, even for aerial photography.

1.8 Eurocourse : one has been organised in Ispra (EN-FR), the second in Germany (representatives of 3 MS).

1.9 Statistics : see tables 1 to 16 (circulated separately).

2. Perspectives

2.1 Short term : 1996 TS published 20.11 (14 participating MS, including Austria). Main points :
  - more flexible rules for fields outside the control area;
  - the choice between satellites and aerial photography (or both) is fully open;
  - a broad choice of software is available;
  - quality control : internal, external, + possibly percentage of accepted dossiers;
  - rules for archive keeping.

2.2 Relative stability of the main Regulations (Reform and co-funding).

2.3 Possible limited extension of the IACS : dried fodder, rice, cotton, flax, supporting measures of the Reform (Reg. 2078 and 2080/92). Conversely, with 14 MS, the territorial extension limit is reached.

2.4 The implementation of IACS is close to operationality : parcellaire, databases, declarative documents, etc. Possible merging with vineyard and olive tree registers under study.

2.5 Some steps may be anticipated by the Administrations before signing the contract: ordering the cadastral maps, looking for archive aerial photography or organising a 1996 flight, etc.

2.6 The synergy between IACS and RS may still be improved: data bases, ortho-photo maps, digital parcellaire, etc.

2.7 Possible new earth observation data:
  - Radarsat
  - IRS 1C next year ?
  - other VHR satellites ?
  - SPOT 4 and 5.

2.8 Other issues linked to data acquisition:
  - shorter production delays for SPOT achieved;
  - acquisition conflicts when requesting data over Europe : the flexibility in selecting the sites is limited and a more strict definition of the windows will be necessary;
  - we can expect a stronger concurrence between SPOT P and aerial photography (due to pixel size and acquisition conflicts);
  - use archive data to alleviate acquisition conflicts (SPOT P) and timetable problems (aerial photography) by?
  - more security through a radar "backup" ?
  - stabilise the criteria to choose the geometric correction process.

2.9 GPS for ground data collection or tie points.

2.10 Automatic classification if possible, in order to save time and decrease the cost.

2.11 A better selectivity of the photo-interpretation should still be ensured (e.g. rejected dossiers found to be acceptable on-the-spot), the tolerances should be refined (especially for aerial photography).

2.12 Continued evolution of the relative responsibilities of the MS and Commission (full MS responsibility in 1999 ?)

2.13 The Administration could ensure better internal ability to technically follow the contracts. More transparency from the contractor in the contract performance (e.g. trough formalised exchanges).

2.14 Pluri-annual contracts ?

2.15 Quality control (to be organised at the profit of the final client, i.e. the MS).

2.16 Cost-benefit analysis and competitiveness with "traditional" control: per dossier prices are down from 307 to 150 ECU since 1992. Several studies are under progress.

2.17 The final goal still remains to keep errors and frauds detrimental to IACS under control, not to promote scientific research, pilot studies, or job creation.

2.18 What after 1998 ?

SESSION 1

Orthorectification of satellite image and airborne data

EUROPEAN COMMISSION
DIRECTORATE GENERAL XII - JRC
SCIENCE, RESEARCH AND DEVELOPMENT - JOINT RESEARCH CENTRE
Institute for Remote Sensing Applications
Agriculture Information Systems Unit

Simon KAY

MARS-PAC project, JRC

Presentation at the *Conference on "Area Aid Controls by Remote-Sensing"*
21 - 22 November 1995, Grand hotel Dino, BAVENO, Lago Maggiore, ITALY

Why orthorectification?

Orthorectification provides a tool for the production of geometrically corrected imagery, within the context of the programme of control by remote sensing.

In this presentation, a basic introduction to orthorectification of satellite and aerial imagery will be made, followed by the justification for the use of this technique in the project.

Although orthorectification corrects for all kinds of geometric error in imagery, a major emphasis is placed on displacement due to relief. This displacement can be of the order of 5 to 10 pixels on the different imagery used, if the relief is not correctly modelled in the processing of the image.

Three main reasons justify the use of precisely corrected imagery:

- Regulatory: the use, location and area of the parcel are declared by the farmer - all three can be checked by remote sensing;
- Technical: good matching between imagery is a fundamental requirement of the photointerpretation process required, and this is best assured by a mapping approach for geometric correction;
- Development of the parcel identification systems (PIS) in the Member States concerned means that the imagery must match the PISs in terms of precision.

The goals for correction, taken from the technical specification for the control programme, clearly show that the errors expected varies with image type. It is the responsibility of the contractor to decide how to achieve these goals, as a function of the resources available and the error anticipated.

An approach for modelling errors

Two approaches for determining the quality of corrected imagery are presented. The first, based upon ASPRS standards for cartographic quality control, applies a check on control points of known quality. The second, developed with experience of projects managed by the Commission and the JRC, attempts to model the physical processing of aerial or satellite imagery rectification.

These two models help us to examine how to optimise the use of the resources at our disposal. For example, in the use of aerial photography, different hypotheses can be tested, adjusting parameters such as GCP quality, focal length, flying height, film resolution, etc., in order to determine whether savings can be made in the execution of the image acquisition and processing chains.

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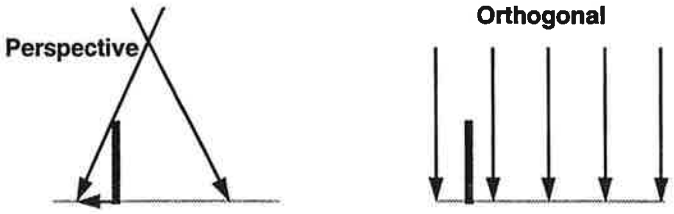
Institute for Remote Sensing Applications
Agriculture Information Systems Unit

Why Orthorectification?

- Part 1
  - What is orthorectification?
  - What sort of errors?
  - Why orthorectification?
    - regulatory
    - technical
    - practical
  - Technical goals for correction
- Part 2
  - Modelling errors
    - Checking with GCPs
    - Checking by physical modelling

What is orthorectification?

- The correction of imagery from a sensor-specific projection to a map projection, using a physical model of sensor position, orientation
- This process is generally termed <u>orthocorrection</u>



What is orthorectification?

- Systematic use of sensor orientation data (position, orientation of instrument)
- Intersects "look-vector" for each pixel with physical terrain surface, using digital elevation model (DEM)
- Compared to a standard warp, it <u>systematically</u> removes relief displacement

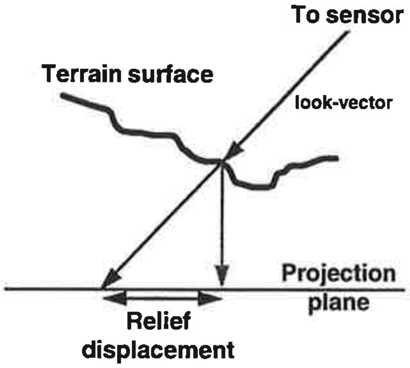
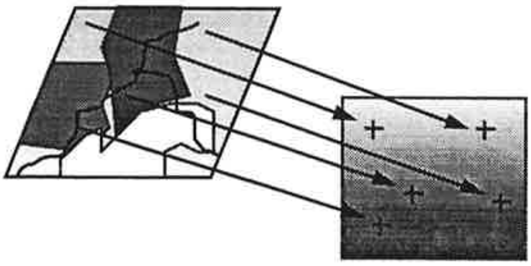


Image warping

- Warping identifies an affine or polynomial transformation between the image space and the map projection space
- Non-systematic
- Quick, easy, requires few inputs



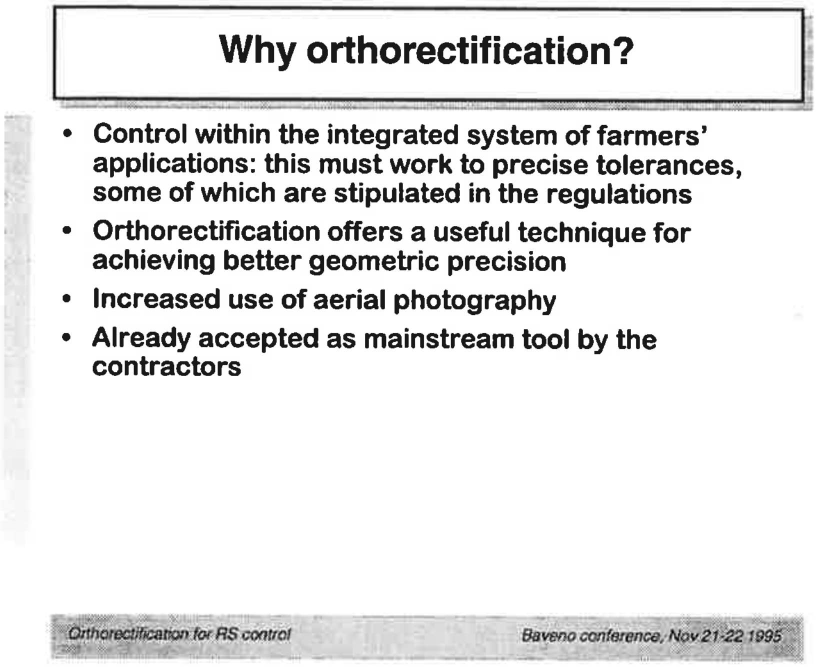
Aerial photography

- Effects are very noticeable due to:
  - low sensor altitude (focal length vs sensor height)
  - high off-nadir viewing (typically up to 45°)

Relief displacement with SPOT-Pan

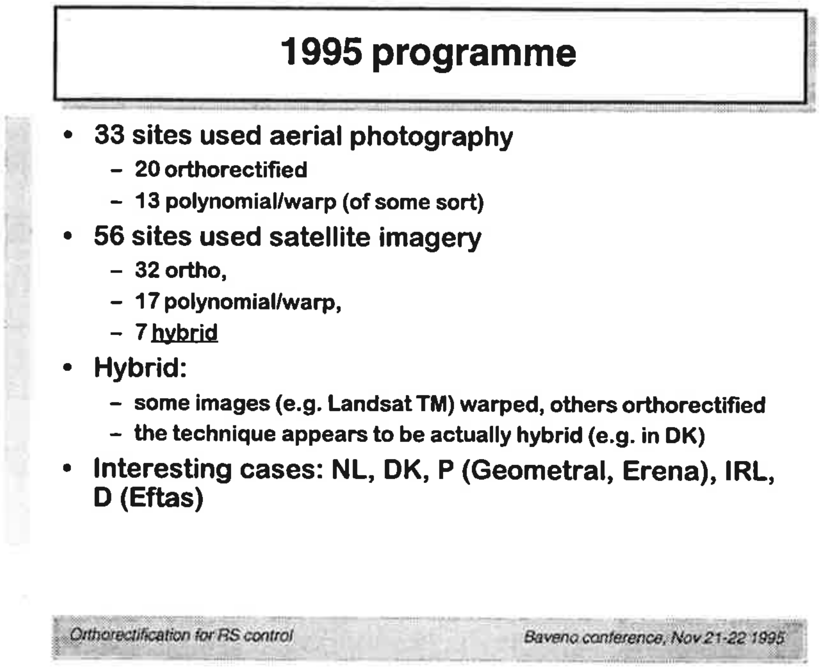
- Varies with view (incidence) angle and with terrain height
- Table gives approximate displacement in pixels for the incidence angle of the image

Relief	3°	8°	11°	14°	17°	20°	23°	26°	29°	32°
50m	0.3	0.7	1.0	1.2	1.5	1.8	2.1	2.4	2.8	3.1
100m	0.5	1.4	1.9	2.5	3.1	3.6	4.2	4.9	5.5	6.2
150m	0.8	2.1	2.9	3.7	4.6	5.5	6.4	7.3	8.3	9.4
200m	1.0	2.8	3.9	5.0	6.1	7.3	8.5	9.8	11.1	12.5
250m	1.3	3.5	4.9	6.2	7.6	9.1	10.6	12.2	13.9	15.6
300m	1.6	4.2	5.8	7.5	9.2	10.9	12.7	14.6	16.6	18.7
350m	1.8	4.9	6.8	8.7	10.7	12.7	14.9	17.1	19.4	21.9
400m	2.1	5.6	7.8	10.0	12.2	14.6	17.0	19.5	22.2	25.0
450m	2.4	6.3	8.7	11.2	13.8	16.4	19.1	21.9	24.9	28.1



Why orthorectification?

- Control within the integrated system of farmers' applications: this must work to precise tolerances, some of which are stipulated in the regulations
- Orthorectification offers a useful technique for achieving better geometric precision
- Increased use of aerial photography
- Already accepted as mainstream tool by the contractors



1995 programme

- 33 sites used aerial photography
  - 20 orthorectified
  - 13 polynomial/warp (of some sort)
- 56 sites used satellite imagery
  - 32 ortho,
  - 17 polynomial/warp,
  - 7 hybrid
- Hybrid:
  - some images (e.g. Landsat TM) warped, others orthorectified
  - the technique appears to be actually hybrid (e.g. in DK)
- Interesting cases: NL, DK, P (Geometral, Erena), IRL, D (Eftas)

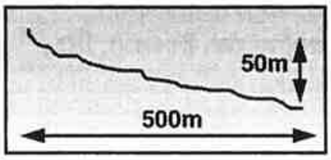
Precision in location and area - 1

- Regulation 3887/92 (Art 4) requires that a farmer identifies, for each agricultural parcel:
  - area
  - location
  - use
- Location and area - so position and scale are goals for monitoring and control.
- Must be compatible with "checking" under the integrated system.
- All three can be checked by remote sensing
  - Use in the session this afternoon on automated classification

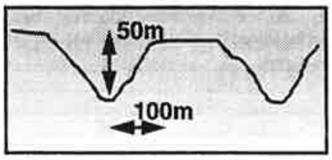
Precision in location and area - 2

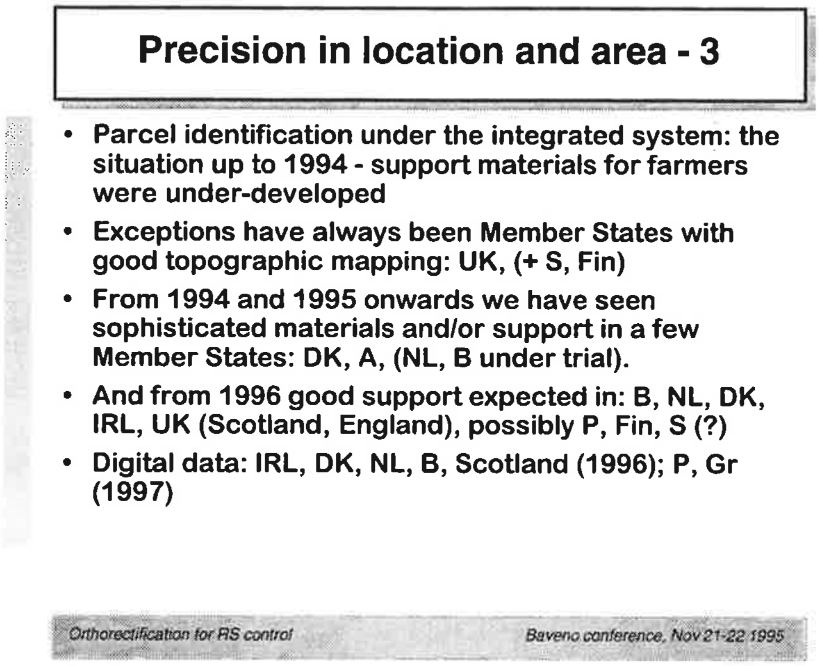
- Technical - easier to get better relative precision if good absolute precision
- Linked to use of the Digital Elevation Model (DEM)
- Depends upon frequency and magnitude of relief

Low frequency (e.g. NL)



High frequency (e.g. P)

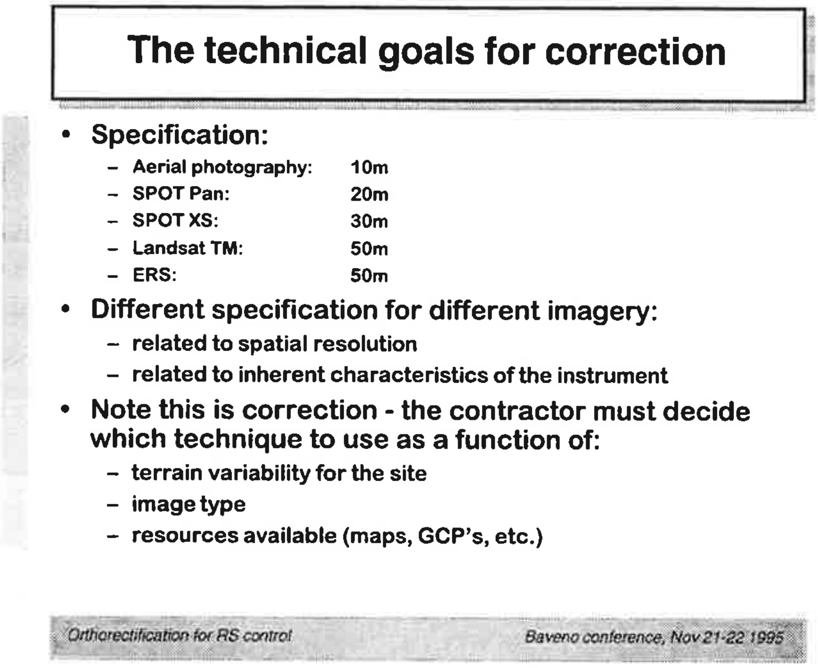




Precision in location and area - 3

- Parcel identification under the integrated system: the situation up to 1994 - support materials for farmers were under-developed
- Exceptions have always been Member States with good topographic mapping: UK, (+ S, Fin)
- From 1994 and 1995 onwards we have seen sophisticated materials and/or support in a few Member States: DK, A, (NL, B under trial).
- And from 1996 good support expected in: B, NL, DK, IRL, UK (Scotland, England), possibly P, Fin, S (?)
- Digital data: IRL, DK, NL, B, Scotland (1996); P, Gr (1997)

Orthorectification for RS control *Baveno conference, Nov 21-22 1995*



The technical goals for correction

- Specification:
  - Aerial photography: 10m
  - SPOT Pan: 20m
  - SPOT XS: 30m
  - Landsat TM: 50m
  - ERS: 50m
- Different specification for different imagery:
  - related to spatial resolution
  - related to inherent characteristics of the instrument
- Note this is correction - the contractor must decide which technique to use as a function of:
  - terrain variability for the site
  - image type
  - resources available (maps, GCP's, etc.)

Orthorectification for RS control *Baveno conference, Nov 21-22 1995*

What resources are required? And when must we orthorectify?

- How long is a piece of string?
- Image type varies from medium spatial resolution, vertical looking (Landsat TM) to high resolution high view angle (e.g. 1:20,000 aerial photography.
- Let's look to the other speakers in this session to answer these questions...

Modelling error in orthoimagery

- Two approaches for modelling errors
- Quality control against check points
  - Method (ASPRS)
  - Requirements
- Modelling correction quality
  - Demonstration of the model
  - Effects of adjusting various parameters: spatial resolution, height data, GCP quality.
  - Balancing input against resources: a look at optimising resources.

An approach for undertaking Quality Control

- ASPRS approach to error checking:
  - "well-defined" points;
  - can also be applied to height checking/DEMs;
- Check point quality?
  - all data have errors
  - therefore => the check set must be sufficiently better in quality usually set at:

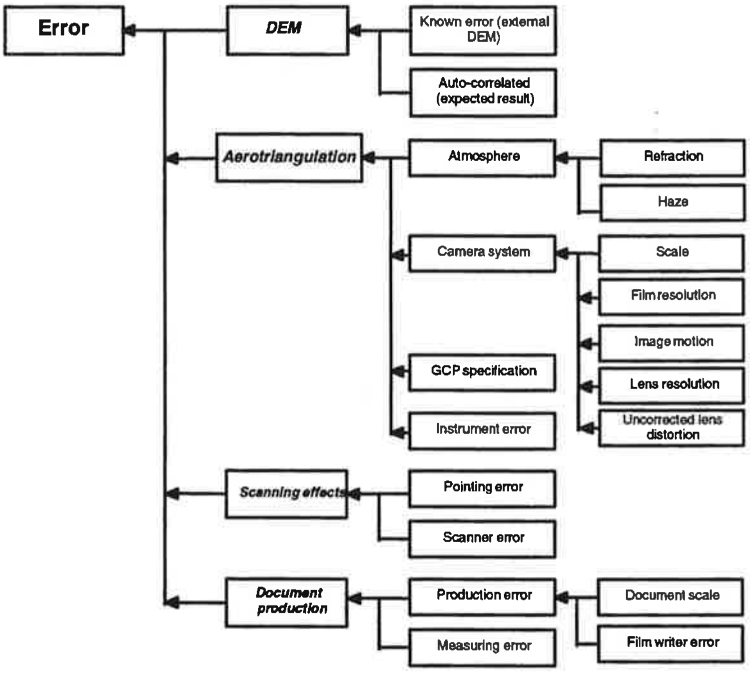
RMSE check set = 1/3 RMSE of quality goal

- What is it that must be checked (absolute/relative)?
- How many points?
- What results should be expected?

Orthophoto error propagation model

- Based upon standard error propagation theory
  - Camera system
  - Atmospheric effects
  - Film resolution
  - Image motion
  - Ground control
  - Observation instruments
  - Digital Terrain Model
  - Scanning
  - Orthophoto modelling software
  - Document production

$$\sigma=\sqrt{r_1^2+r_2^2\cdots r_n^2}$$



- **Error**
  - ***DEM***
    - Known error (external DEM)
    - Auto-correlated (expected result)
  - ***Aerotriangulation***
    - Atmosphere
      - Refraction
      - Haze
    - Camera system
      - Scale
      - Film resolution
      - Image motion
      - Lens resolution
      - Uncorrected lens distortion
    - GCP specification
    - Instrument error
  - ***Scanning effects***
    - Pointing error
    - Scanner error
  - ***Document production***
    - Production error
      - Document scale
      - Film writer error
    - Measuring error

"Minimum requirements" for achieving these goals

- DTM - stereo autocorrelated or map input?
- GCP's - best distributions. Making use of existing resources;
  - maps,
  - trig points,
  - nationally archived photogrammetric points.
- Image/instrument configurations
  - focal length;
  - flying heights;
  - "usable area" (or for SPOT, usable view angle);
  - overlap/stereo cover (also for SPOT);

Conference on "Area Aid Controls by Remote Sensing, Baveno, 21st - 22nd November 1995

Geometric correction of satellite and airborne images

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Abstract

The techniques of producing orthoimages, (that is images corrected for the distortions caused by the sensor, the platform and the relief of the ground), from aerial photographs is well established and has been used for may years. In recent years it has become a digital technique using images scanned from aerial photographs. This makes the whole process more flexible and increases the similarities with orthocorrection of satellite images. Whilst the process is similar with satellite data the heritage of the processes is different and ortho image production from satellite data is related to the much simpler operation of 'warping' an image to ground control points selected from a map. This does not need a digital elevation model (DEM) and is not such a rigorous process, hence is more subject to errors. The accurate correction of satellite data requires accurate ground control points and good DEMs. A good mathematical model of the sensor geometry is also required.

All of the generally available data may be used and sensor models are available. The pixel size or resoluion may be a limiting factor in determining accuracy (Landsat and SAR) but generally geometric accuracy can be better that the pixel size.

The presentation will set out the background to the process of orthoimage production and will discuss methods and systems which are available with some examples of results. There is a distinction to be made between the software derived from image processing systems designed for remote sensing (for example ERDAS) and those designed for photogrammetry. There are also important issues relating to the ease of use of the systems and the statistics which indicate the accuracy of the process.

The availability of DEMs is another important issue and some information is given on the sources of DEMs and the methods of deriving them from satellite data.

The reduction of effort in obtaining ground control points can influence the economy and accuracy of systems. It is possible to employ automatic processes to register images with images and such systems are coming into production. It is more difficult to automate the process of registering images to maps although this technique is currently of great interest for research. A way of reducing the amount of effort in image to map registration is to only carry out that process once and to subsequently register images to a previously registered image.

In conclusion it can be said that accurate methods are available for all types of data but that the issue is to obtain the necessary input (DEMs and ground control points) and to carry out ortho image production in an efficient and cost effective manner.

GEOMETRIC CORRECTION OF SATELLITE AND AIRBORNE IMAGES
(Production of orthoimages)

Ian Dowman
University College London

- Introduction
- Distortions in images
- Methods of correction
    - techniques
    - systems
- Accuracy
- Sources of digital elevation models
- Automation
- Conclusions

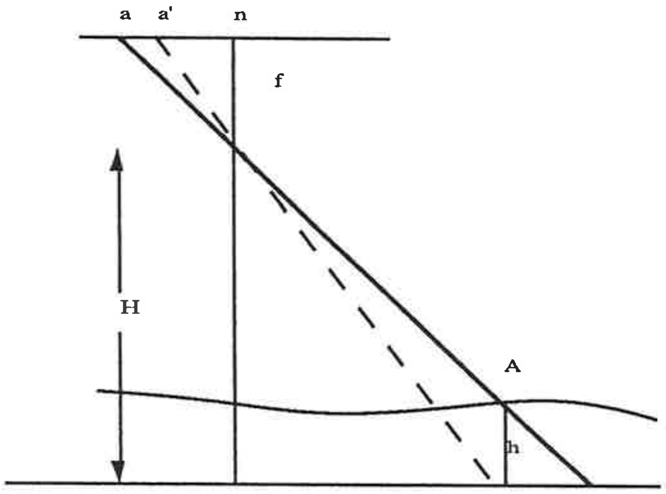
INTRODUCTION AND BACKGROUND

- Traditional method of correcting satellite images has been image warping problems created by relief in some cases
- Orthoimages have been produced from aerial photography for many years
- Orthoimage production from aerial photographs depend on good orientation based on accurate ground control points and a DEM produced from the same stereo pair.
- A major issue when using satellite imagery is the availability of ground control and a Digital Elevation Model (DEM) at a reasonable cost

PRINCIPLE DISTORTIONS

- Relief - varies with type of sensor and terrain
- Earth curvature (importance of map projections), earth rotation
- Platform movement - rotation (roll, pitch and yaw) and velocity
- Sensor distortions - scanning, panoramic

CHARACTERISTICS OF DISTORTION DUE TO RELIEF

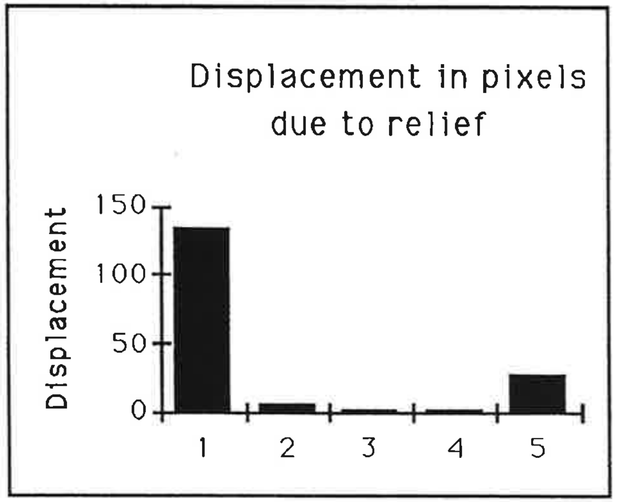


The magnitude of displacement due to relief is given by the expression: $$aa' = an \cdot \frac{h}{H}$$

- or in terms of a radial distance from the nadir points (r) : $$dr = r \cdot \frac{h}{H}$$

EFFECT OF RELIEF

Sensor	Altitude (km)	Half swath (km)	dr for h= 500m	Pixels
1. Aerial camera with f=150mmm	10	4	200	133 (15µm)
2. Metric camera on Spacelab f=300mm	250	90	180	5 (15µm)
3. Landsat	705	90	64	2
4. SPOT nadir	830	30	18	2
5. SPOT 27°	830	450	271	27



METHODS OF MAPPING

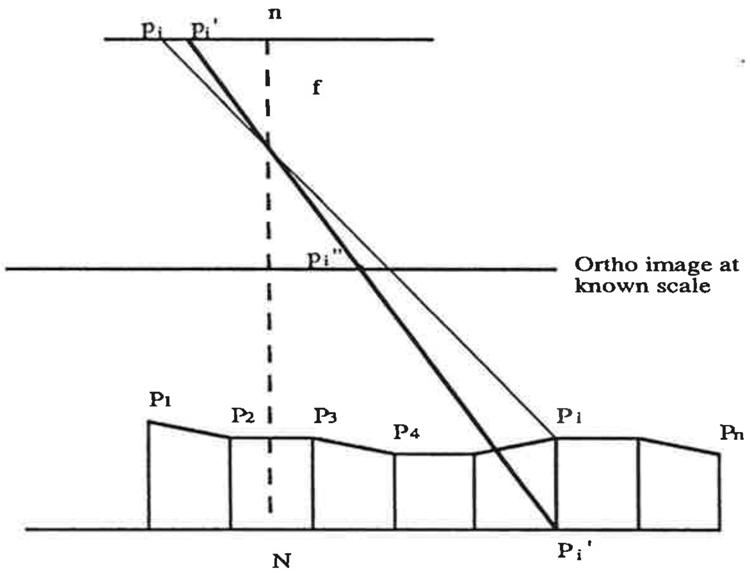
SINGLE IMAGES

Geometric correction with XY control points > georeferenced image
Geometric correction with XY control points and DEM > geocoded image
ortho image
Orthoimage plus other information > image map

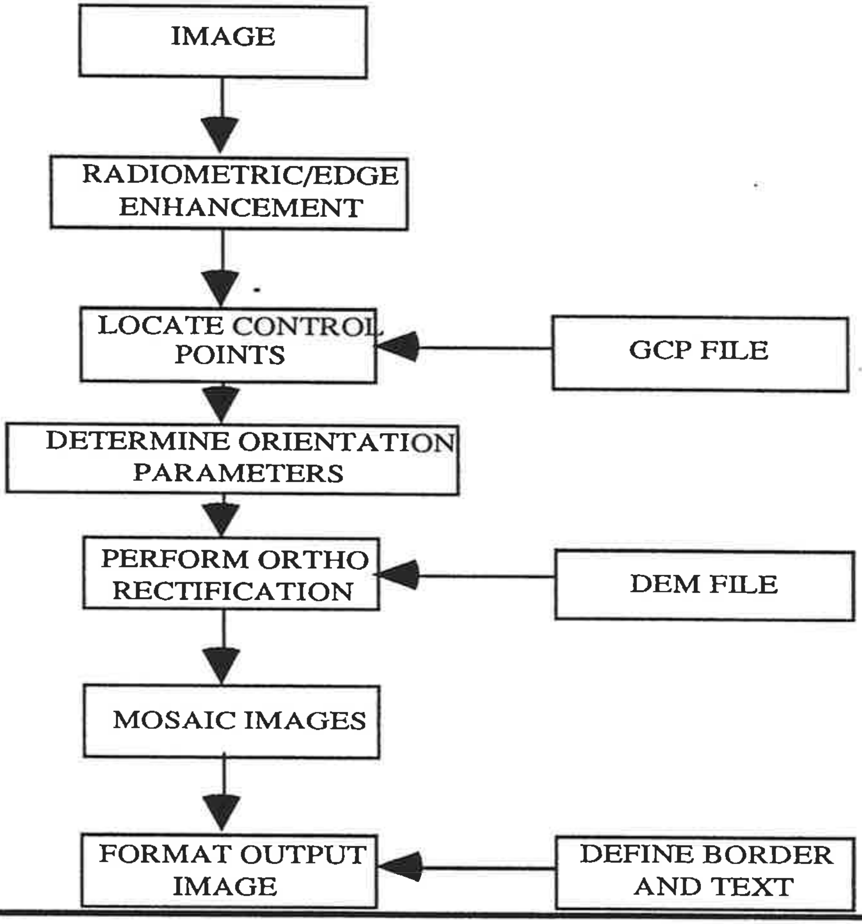
STEREO IMAGES

Stereo restitution on plotting instrument > topographic map
Digital image matching > DEM. contours

PRODUCTION OF ORTHOIMAGES



Flow chart of the orthoimage production system.



IMAGE

RADIOMETRIC/EDGE ENHANCEMENT

LOCATE CONTROL POINTS

GCP FILE

DETERMINE ORIENTATION PARAMETERS

PERFORM ORTHO RECTIFICATION

DEM FILE

MOSAIC IMAGES

FORMAT OUTPUT IMAGE

DEFINE BORDER AND TEXT

COMMENT ON DIFFERENT SENSOR SYSTEMS

AERIAL PHOTOGRAPHY

Well established formuale pased on perspective projection and determination of exterior orientation. Needs 3D correction with DEM except in very flat areas.

LANDSAT TM

Generally work well with warping but limit is pixel size.

SPOT

Warping works well in flat area on nadir images.
Oblique images, particularly in non flat areas requires 3D correction.

ERS-1

Ellipsoid geocoding in flat areas.
3D geocoding in hilly areas.
Limit is resolution of imagery
Can reduce control points because of good orbit

TYPES OF SYSTEM

standard image processing workstation with image processing software with photogrammetric application modules e.g. ERDAS Imagine + Orthomax + softcopy mapper

standard photogrammetric workstation with software for photogrammetric orientation. e.g. Zeiss Phodis, Leica

PC system with photogrammetric and/or image processing software e.g. RWel DMS, DVP

These systems are based on commercial-off-the-shelf (COTS) hardware and therefore depend on the software to perform the image processing tasks. Other systems use special hardware running image processing and photogrammetric software for example the Intergraph Image station.

SYSTEM	**COMMENT**	**ORIGIN**
ZEISS PHODIS	Fully functional photogrammetric work station.	Photogrammetric Company
HAI-750 HAI-500	Two full photogrammetric systems on Sun or PC platforms.	US military
Intergraph ImageStation	Photogrammetric data capture as part of digital mapping system.	Auto carto systems
I^2S PRI^2SM	Interface for orthophoto production.	Image processing
ERDAS Orthomax and softcopy station	Image processing system for remote sensing with added functionality from photogrammetric source	Image processing
R-Wel DMS	PC based system for DEM and feature extraction from images as input to and integration with a GIS.	University

PRODUCTION WORKSTATION

ZEISS PHODIS

Display and measuring modes

FI/MC Fixed Image/Moving Cursor
Needs epipolar geometry

MI/FC Moving Image/Fixed Cursor
Real time image rotation

Automation

Interior orientation
Exterior orientation

Viewing

Stereo viewing with liquid crystal shutter

Separate mono viewing screen

Integration

CADMAP standard
Link to GIS

ERDAS

- Designed for image processing with link to GIS
- Includes full photogrammetric orientation and plotting package
- DEM extraction
- Orthoimage generation
- Link with ARC/INFO for integrating data into GIS

ACCURACY OF PRODUCTS

Thematic mapper

Best result	USGS 1:24 000 specification
Average result	1:50 000 - 1:100 000 specification

SPOT

Best result	1:25 000 specification
Average results	1:50 000 specification

NOTE: Correction for relief is needed in when terrain is not flat

SUMMARY OF PROBLEMS

- Ground control points - accuracy, numbers and distribution
- Easy to use orientation software - including good diagnostics and presentation of results
- DEMs - availability and accuracy
- Scanning at low resolution on low cost scanner can cause problems.
  (Data volume > data compression)
  15μm suitable for aerial photography
- Evaluation of results: statistics and validation tools.

ACCURACY AND SPACING REQUIRED FOR DEMs

- Depends on relief and terrain type
- Proportional to relief and flying height
- Rule of thumb to give accuracy to 1 pixel:

(15μm pixel size) 1m

For 1:40 000 photography DEM vertical accuracy needs to be ~~0.5~~m
Spacing depends on on terrain.

AVAILABILITY OF DEMs

Global digital elevation models.

	DCW	ETOPO5	GLOBE	DTED
Spacing		5'	30"	3" (100m)
Accuracy	Heights from 1000' contours	Variable	Variable	25m
Comments	Global coverage derived from world navigation charts	Global coverage	Currently under development.	70% of earth covered but still classified.

DEMs IN EUROPE

(Information is indicative only - may be out of date)

Country	Spacing	Vert Acc.	Source/ comments
AUSTRIA	30-50m		Profiles for orthoimages
BELGIUM	100m	30m	From 1:50 000 mapping
FRANCE			High accuracy data being prepared
GERMANY	25 - 50m	0.5 - 3m	Varies with different Landes (aerial photos)
NETHERLANDS	0.5 x 1km	30m	
NORWAY	0.5 x 1km	30m	
SWEDEN	50m		Aerial photography
SWITZERLAND	250m		1:25 000 mapping
UNITED KINGDOM	50m Contours	2-3m 1m	1:50 000 mapping 1:10 000 mapping

SOURCE: A survey of the world's digital elevation data by UCL for DRA

SOURCES OF DEMs FROM SPACE SENSORS

	OPTICAL STEREO	SAR INTERFEROMETRY	DIFF SAR INTERFEROMETRY	SAR STEREO
SPATIAL RESOLUTION				
Footprint	10m pan; 20m XS	50m	50m	30m
Elevation (rmse)	5m	$7m\sqrt{n}$ n - no. of passes	2mm relative displ.	?50m
MAIN ADVANTAGES	• no speckle • operational technolgy • visual validation • small footprint	• global coverage • independent of weather • not dependent on contrast	• global coverage • independent of weather • not dependent on contrast	• global coverage • independent of weather
MAIN DISADVANTAGE *	• clouds • illumination dependent • contrast dependent	• overlay and shadow • orbit constraints • weather changes • new technology	• orbit constraints • weather changes • new technology	• difficult to find common points • speckle • limited coverage
AVAILABLE SYSTEMS	SPOT, OPS, MOMS-02, KFA1000, DD5	ERS1 JERS1	ERS1 JERS1	ERS1 JERS1
FUTURE MISSIONS	Landsat 7 SPOT 5	Radarsat? ERS2	Radarsat? ERS2	Radarsat ERS2
FUTURE WISHES	$\sigma_h = \pm 2.5m$		Global topo mission ERS1 // ERS2	ERS1/ERS2

AUTOMATION OF IMAGE REGISTRATION AND ORTHOIMAGE CREATION

- A major problem is the identification of ground control points
- Automatic image to image registration is possible
- Automatic image to map registration is still a research topic

EXAMPLE

Prototype Automated Image Registration System (PAIRS)
developed for WEU Satellite Centre

CONCLUSIONS

- High accuracy orthoimages can be produced from any data
- Requirements:
  - Accurate sensor model
  - Accurate DEM
  - Accurate ground control points
- Cost for this may be high
- Reliability can be introduced with good statistics and validation procedures
- Automation is possible

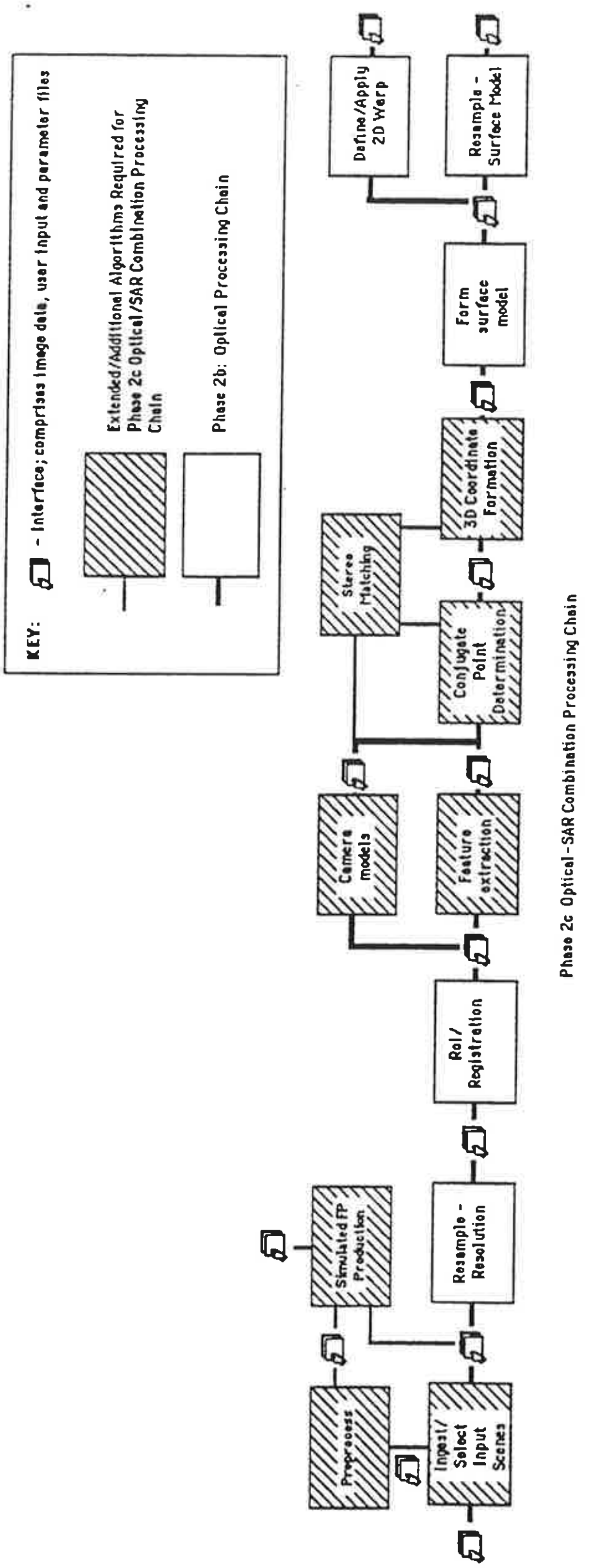


Figure 6
Phase 2c Optical-SAR Combination Processing Chain

Possibilities in the production of orthoimagery

Torbjörn Westin

SSC Satellitbild
Box 816
S-981 28 Kiruna, Sweden

ABSTRACT

Satellite sensor possibilities:

- Existing well proven: SPOT, Landsat TM
- New existing possibility: JERS-1 OPS
- New potential possibility: IRS-1C
- SAR possibilities: ERS-1/2, JERS-1 SAR, Radarsat

Production refinement possibilities:

- Radiometric corrections:
  - Quantization
  - Banding
  - Coherent noise
  - Calibration lamp

- Geometric correction:
  - Orbital model
  - Strip triangulation
  - Detector placement corrections
  - Scan gap/overlap resampling

Precision possibilities:

- Ground control requirements
- Stability and precision in long strips
- Need for DTM in orthoimage production

Suggested improved requirements on orthoimagery:

- Shorter time of delivery (>24h)
- Subpixels accuracy

SPOT

Launch: 1986, 1990, 1993
Archive: > 2 million scenes

Band	Spectrum	Pixelsize	Swath
Pan	510-730 nm	10 m	60 km
XS1	500-590 nm	20 m	60 km
XS2	610-690 nm	"	"
XS3	780-890 nm	"	"

Landsat TM

Launch: 1982, 1984
Archive:

Band	Spectrum	Pixelsize	Swath
B1	450-520 nm	30 m	185 km
B2	520-600 nm	"	"
B3	630-690 nm	"	"
B4	760-900 nm	"	"
B5	1550-1750 nm	"	"
B7	2080-2350 nm	"	"

JERS-1 OPS

Launch: February 1992
Archive: Limited

Band	Spectrum	Pixelsize	Swath
B1	520-600 nm	18x24 m	75 km
B2	630-690 nm	"	"
B3	760-860 nm	"	"
B4	760-860 nm	"	"

IRS-1C

Launch: 23 december 1995
Archive: --

Band	Spectrum	Pixelsize	Swath
Pan	500-750 nm	5.8 m	70 km
B2	520-590 nm	23.5 m	141 km
B3	620-680 nm	"	"
B4	770-860 nm	"	"
B5	1550-1700 nm	70.5 m	148 km

SAR

	Wavelength	Incidence
ERS-1/2	C-band	23°
JERS-1 SAR	L-band	35°
Radarsat	C-band	20°-50°

Need for DTM in ortho-rectification of different sensors

	1995 requirement RMS [m]	Nadir viewing ΔHeight [m]	Off-nadir vieving ΔHeight [m]
SPOT P	20	570	35
SPOT XS	30	860	50
Landsat TM	50	700	
JERS-1 OPS	(30)	450	
IRS-1C Pan	(20)	470	35
IRS-1C Liss-III	(30)	170	
ERS-1/2	50		20
JERS-1 SAR	(50)		35
Radarsat	(50)		20-60

PRODUCTION POSSIBILITIES

Timeliness:

- 24 h is technically possible!

- What is needed?

Accuracy:

- Subpixel accuracy is possible!

- Subpixel accuracy is needed:

    * efficient use of vector plot data
    * multi-temporal classification

THE USE OF ORTHORECTIFIED AND NON-ORTHORECTIFIED AERIAL PHOTOS IN CONTROL OPERATIONS

J Miguel Miranda

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The strategy of using remote sensing techniques to control the application of surface aids, has proved to be a cost effective way of handling, in a short delay, a large number of agricultural parcels. Being largely dependent on the processing of satellite imagery, the geometric and the agronomic accuracy have always been the subject of discussion, and, in the case of Portugal, the use of the technique has been confined to the southern areas, being the only region where cadastral data was available and the parcels are of a large enough size.

What moves us in the direction of using high altitude aerial photos for control operations? First of all, the possibility (in the technical and meteorological points of view) to make such a survey. Second, the need to extend to the northern areas (of Portugal) the use of remote sensing control. Third, the possibility to include new variables (quality of the crops, trees, etc...) in the control.

The use of a single BW aerial coverage constrains seriously the photo-interpretation work that can be done, if the identification of all the crops is really needed; hence the need for systematic field controls. This heterodox methodology, where the RS is confined to the parcel identification and delimitation, the preparation of the field control documents, and the area measurements, tries to incorporate the best of both worlds: the synoptic view that only RS can give with the reliability of a field control.

The major problem that must be faced when using aerial photos is the level of orthocorrection really needed in order to achieve the accuracy level required in the control operations. Is it possible already to make a good quality orthocorrection every year, or must we be able to process a mix of orthocorrected and non-orthocorrected aerial images? How can a continuous spatial database be constructed from such a dataset?

Two different techniques are here compared. The first one is based on affine corrections in areas of smooth topography and with a small altitude range; the second one is based on the joint processing of a (2 year) orthophoto base, and a 1995 non-corrected coverage. The results are very positive with respect to geometric accuracy and parcel identification, far better than can be made using the satellite image approach.

The development of the Parcel Project in Portugal will make available in the near future a coherent orthophotomap database. This can be used to organise future controls, but does not substitute the need for a yearly coverage. The choice between true orthocorrection techniques and mixed approaches, will be mainly a function of the comparative cost between the processing on non-orthocorrected photos and “quick” orthophotos, based upon archive DEMs and reference orthophoto datasets.

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

Where ?

⇒ Trás-os-Montes, North Portugal
⇒ nearly 1:15000 enlargements obtained from 1:43000 survey

Why ?

⇒ rough topography
⇒ high altitude range
⇒ low cost (compared with true orthophotomaps)

Auxiliary Data:

⇒ Analogic Orthophotomaps at 1:10000 scale of 1993

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

Methodology

1. Processing of the Auxiliary Data

   ⇒ Scanning of the orthophoto database 250 dpi
   ⇒ Warping of the raster files
   ⇒ Resampling
   ⇒ Archive in CD

2. Processing of the 1995 Survey

   ⇒ Scanning of the aerial photos (enlargements)
   ⇒ Warping of the raster files with the auxiliary data
   ⇒ Resampling
   ⇒ Archive in CD

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

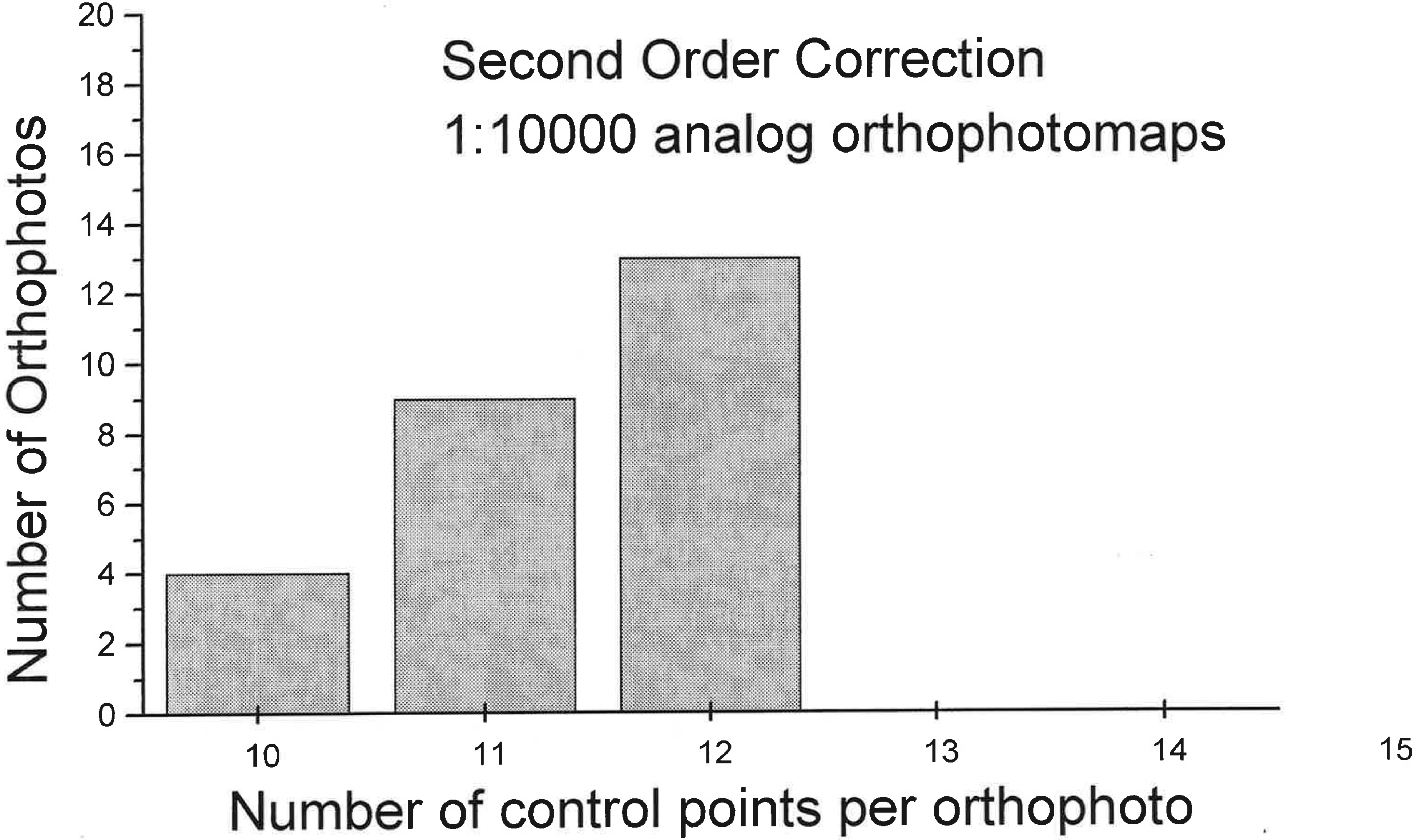
Methodology

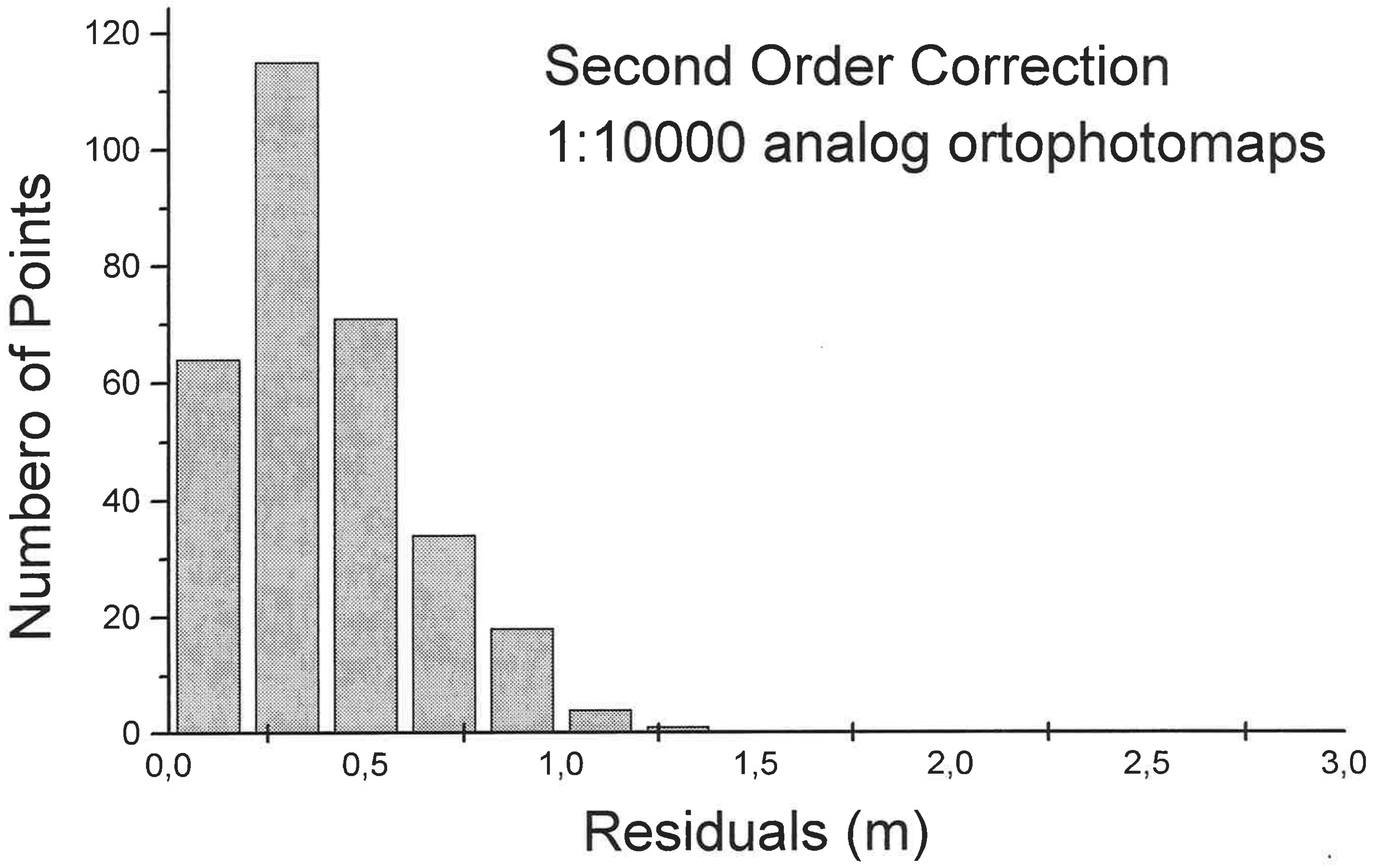
3. Parcel Delimitation

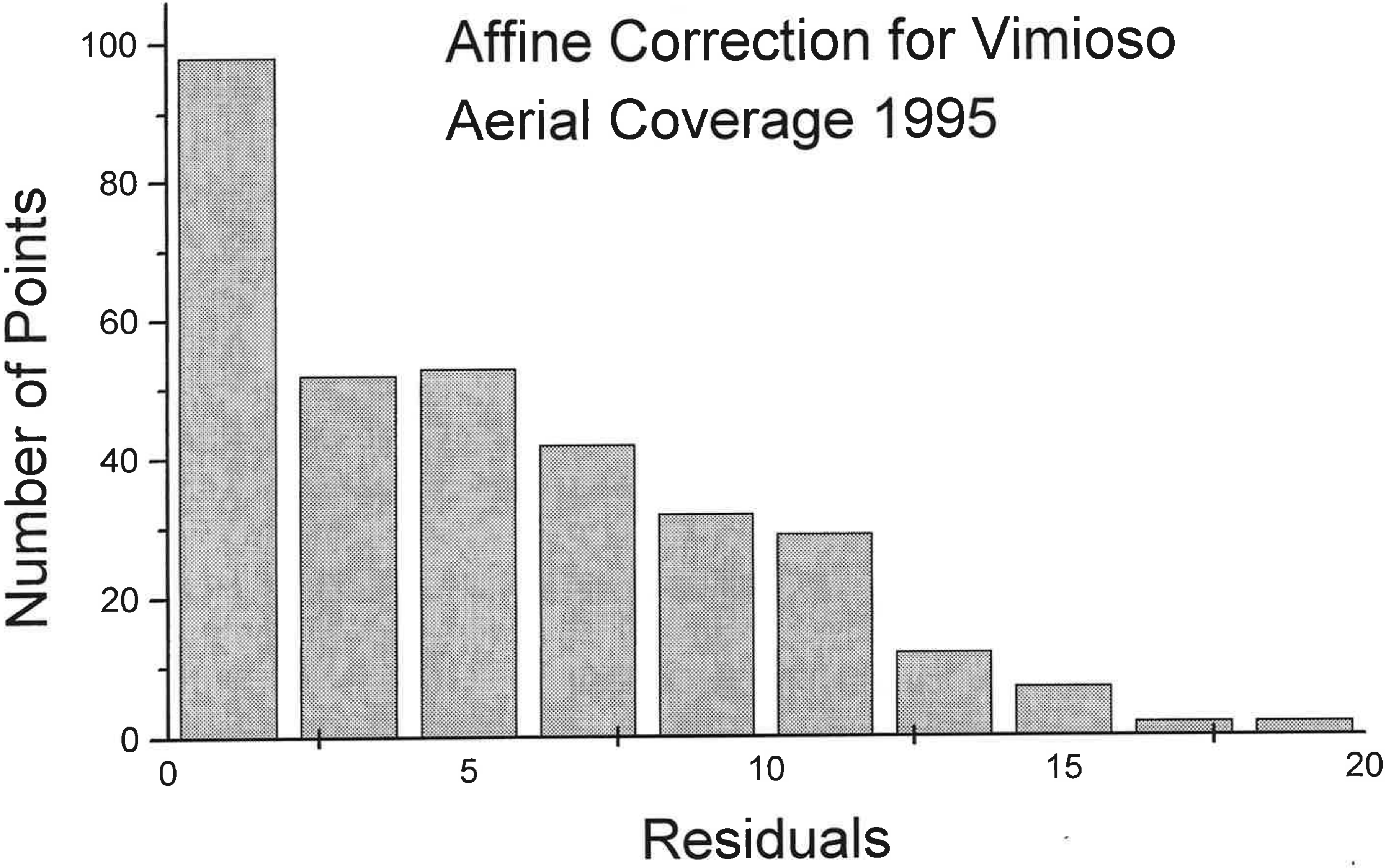
⇒ local affine correction
⇒ continuous database
⇒ two step parcel identification

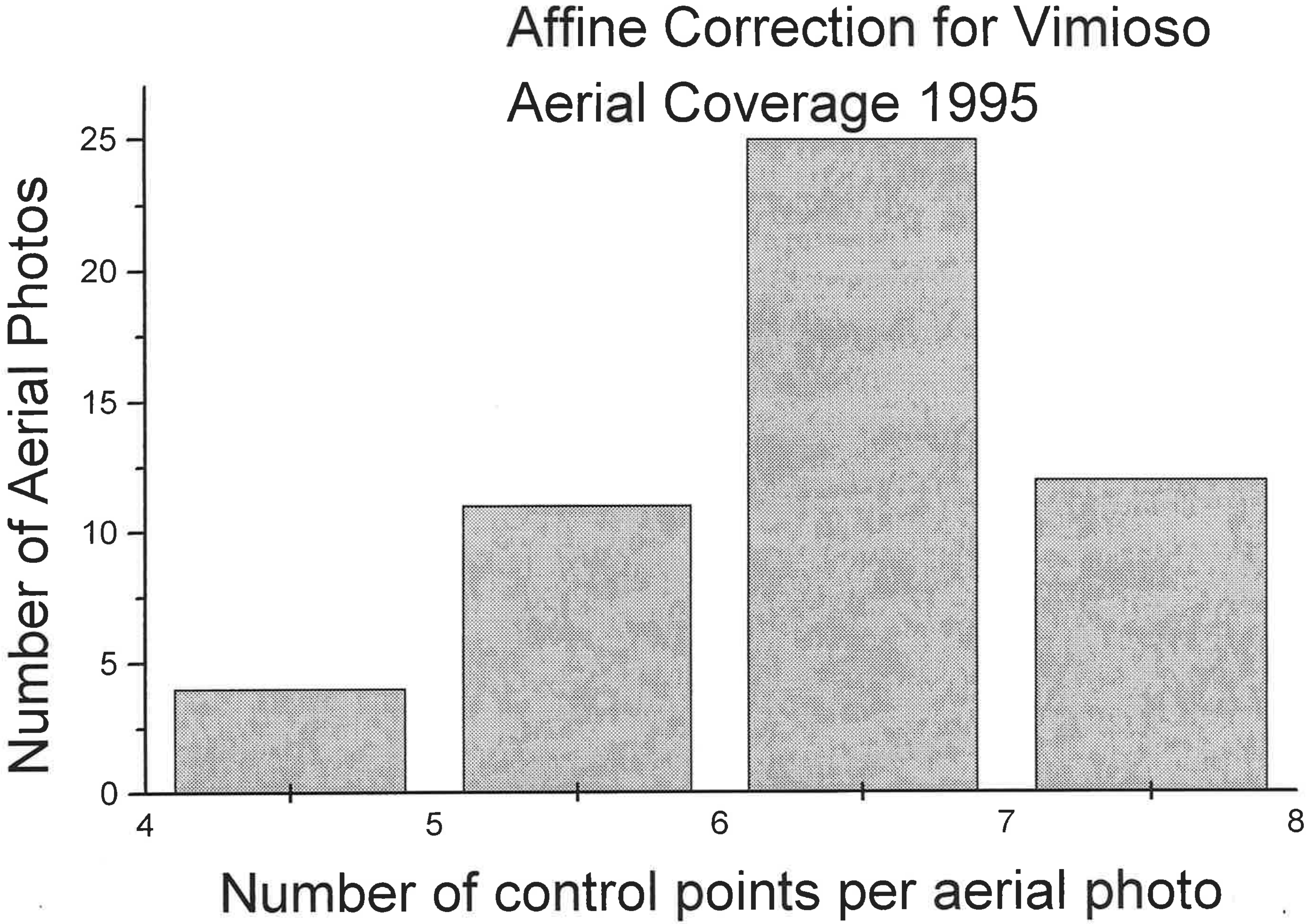
4. Area Computation

⇒ global


Second Order Correction
1:10000 analog orthophotomaps
Number of Orthophotos
0
2
4
6
8
10
12
14
16
18
20
10
11
12
13
14
15
Number of control points per orthophoto


Second Order Correction
1:10000 analog ortophotomaps
Numbero of Points
0
20
40
60
80
100
120
0,0
0,5
1,0
1,5
2,0
2,5
3,0
Residuals (m)


Affine Correction for Vimioso
Aerial Coverage 1995
Number of Points
100
80
60
40
20
0
0
5
10
15
20
Residuals


Affine Correction for Vimioso
Aerial Coverage 1995
Number of Aerial Photos
25
20
15
10
5
0
4
5
6
7
8
Number of control points per aerial photo

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

WITH AN ARCHIVE ORTHOPHOTOMAP BASE

When ?

⇒ All situations

Advantages:

⇒ quick and inexpensive if the orthophoto database already exists
⇒ easy to manipulate if the interpreted field enlargements are used
⇒ possibility to construct a continuous spatial database if the reference survey is not outdated

Problems:

⇒ The two step parcel delimitation
⇒ What is the real accuracy of the parcel area
⇒ The handling of big parcels

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

Where ?

⇒ Alentejo - South Portugal
⇒ nearly 1:10000 enlargements obtained from 1:43000 survey

Why ?

⇒ smooth topography
⇒ small altitude range
⇒ low cost (compared with true orthophotomaps)

Auxiliary Data:

⇒ Cadastral Maps at 1:5000 scale

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

Methodology

1. Processing of the Auxiliary Data

⇒ Preparation of the Mapsheets
⇒ Scanning of the cadastral mapsheet at 300 dpi
⇒ Warping of the raster files
⇒ Resampling
⇒ Archive in CD

2. Processing of the 1995 Survey

⇒ Scanning of the aerial photos (enlargements)
⇒ Warping of the raster files with the auxiliary data
⇒ Resampling
⇒ Archive in CD

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

Methodology

3. Parcel Delimitation

    ⇒ by enlargement
    ⇒ subdivision of big parcels

4. Area Computation

    ⇒ by enlargement

NON-ORTHOCORRECTED AERIAL PHOTOS PROCESSING

WITH A ORTHOCORRECTED RASTER CADASTRE DATABASE

When ?

⇒ smooth topography
⇒ small altitude range

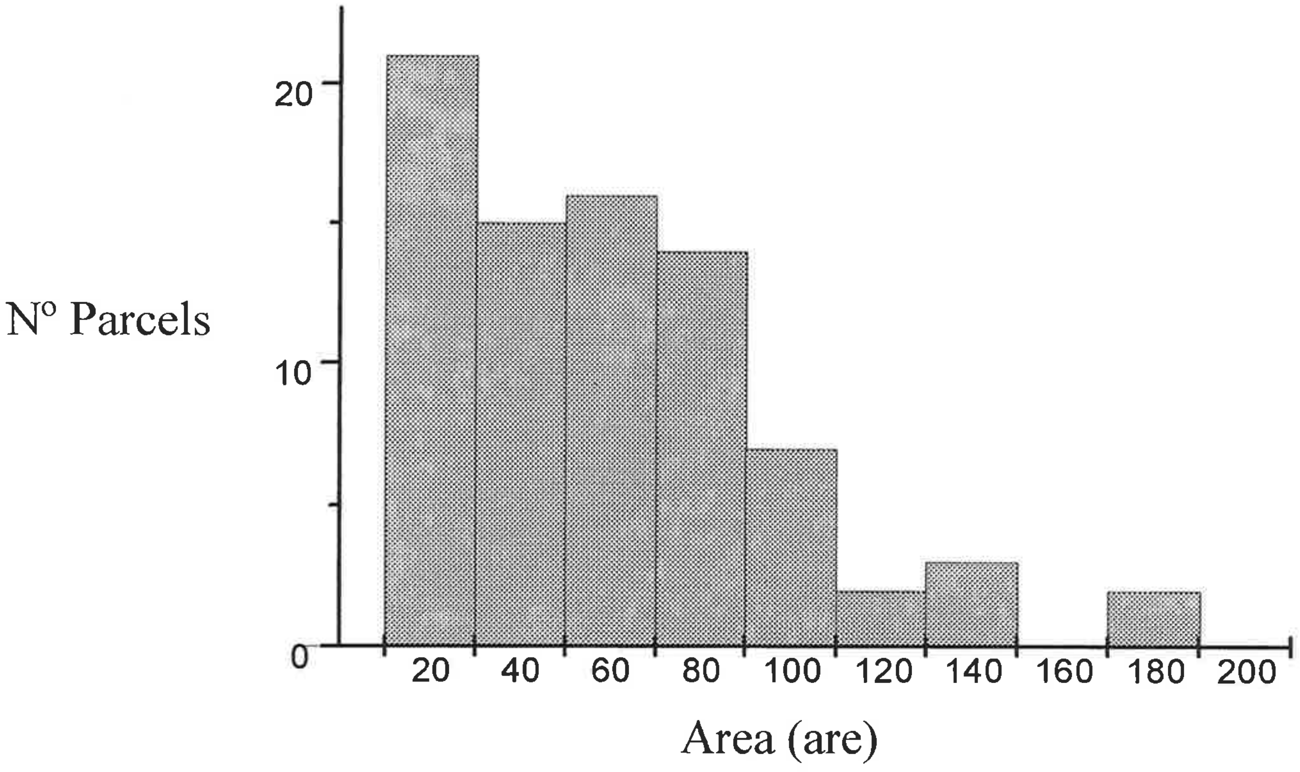
Advantages:

⇒ quick and inexpensive if the cadastre database already exists
⇒ easy to manipulate if the interpreted field enlargements are used

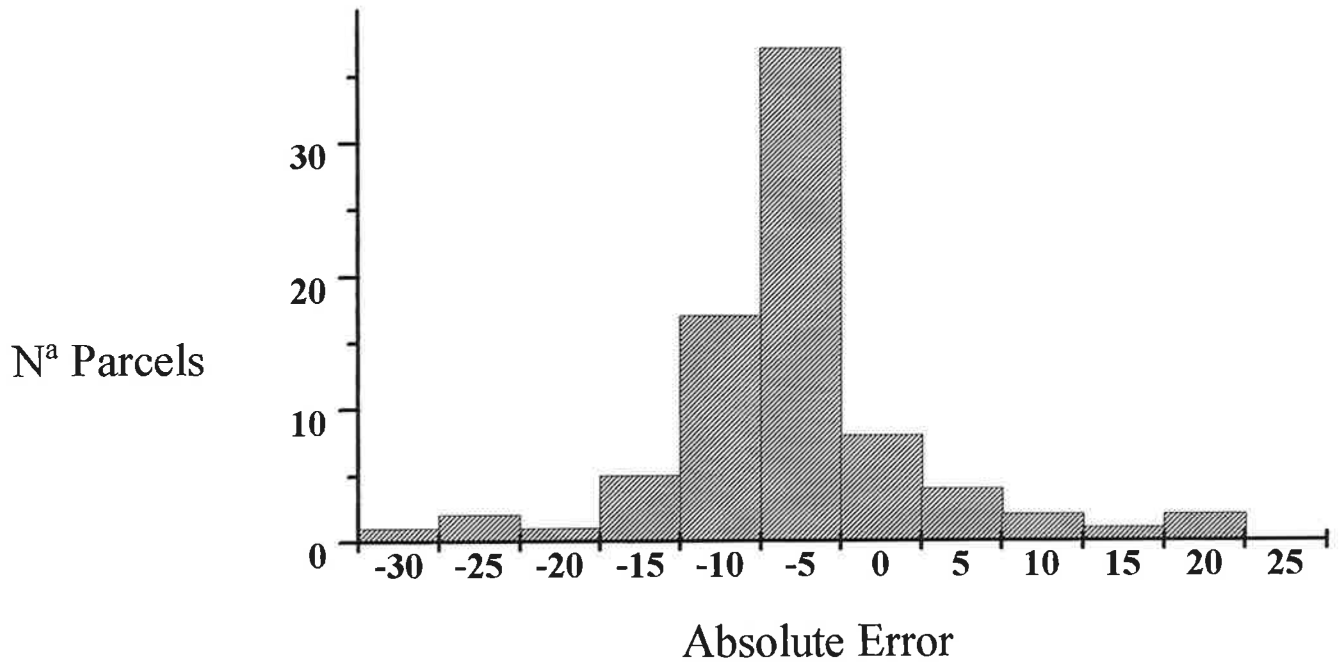
Problems:

⇒ Local Corrections vs global corrections
⇒ Must we prepare a continuous spatial database ? How ?
⇒ How to measure the area of each parcel ?
⇒ The handling of big parcels ?

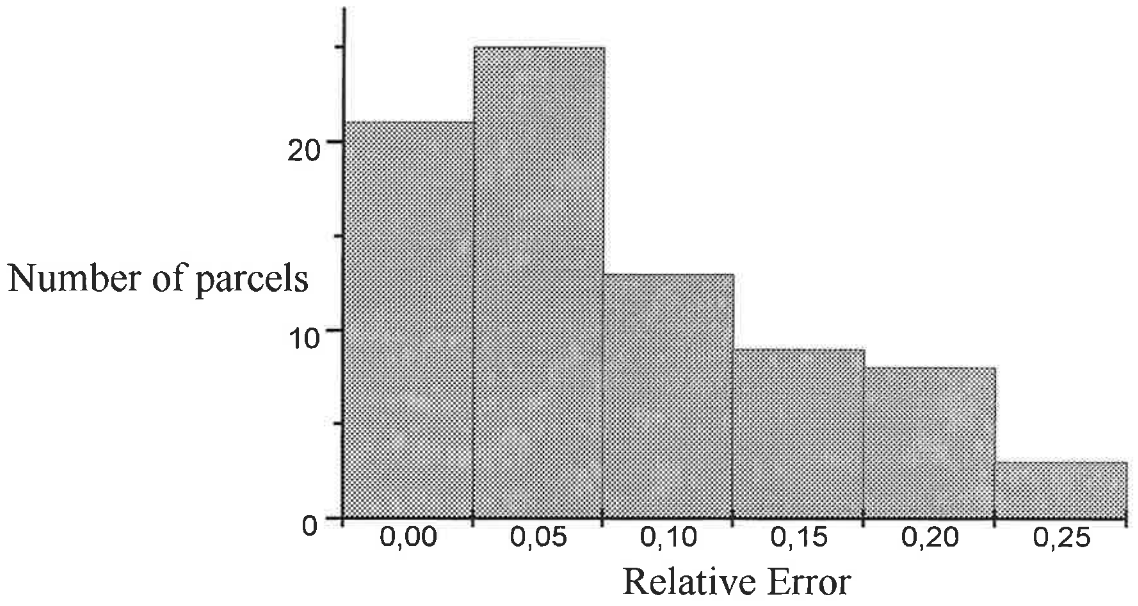
SAMPLE STRUCTURE
AERIAL PHOTO - MIX OF CORRECTED AND NON-CORRECTED AERIAL PHOTOS
SITE: MOGADOURO



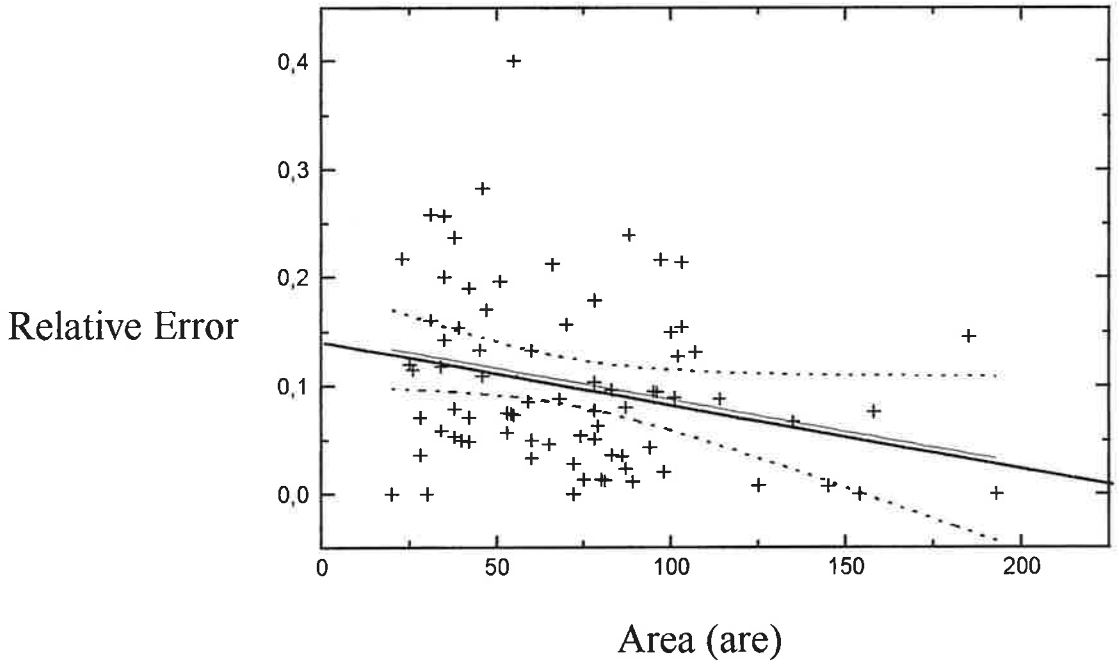
ABSOLUTE ERROR IN THE AREA COMPUTATION
AERIAL PHOTO - MIX OF CORRECTED AND NON-CORRECTED AERIAL PHOTOS
SITE: MOGADOURO



RELATIVE ERROR IN THE AREA COMPUTATION
AERIAL PHOTO - MIX OF CORRECTED AND NON-CORRECTED AERIAL PHOTOS
SITE: MOGADOURO



RELATIVE ERROR IN THE AREA COMPUTATION
AERIAL PHOTO - MIX OF CORRECTED AND NON-CORRECTED AERIAL PHOTOS
SITE: MOGADOURO



CONCLUSIONS

⇒ The use of Non-Orthocorrected Aerial Photos in smooth areas is possible but the construction of a continuous spatial database can give origin to large problems in the area computations

⇒ Some of these problems can be less important if an archive orthocorrected database is used, combined with local adjustements of the non-orthocorrected aerial images

⇒ The use of this kind of techniques is only interesting if the orthophoto production with archive MDTs and GCPs is much more expensive.

SESSION 2

The use of imaging RADAR

EUROPEAN COMMISSION
DIRECTORATE GENERAL VI-G-4
FEOGA

FEOGA SAR Requirements and Methodologies 1993-1995

Kate TEMPANY

Baveno 21-22/11/1995

SAR Satellite data available

	ERS-1	Radarsat
Angle of Incidence	23°	20-60°
Band	C (5.3 GHz or 5.6 cm)	C (5.3 GHz or 5.6 cm)
Swath width	100 km	100-500 km
Nominal resolution	30 m	10-100 m
Cycle	35 day (ascending-descending)	24 day (ascending-descending)
Polarisation	V-V	H-H
new developments	ERS-2, Interferometry	Launched 4 Nov 95 ?

Techniques Used

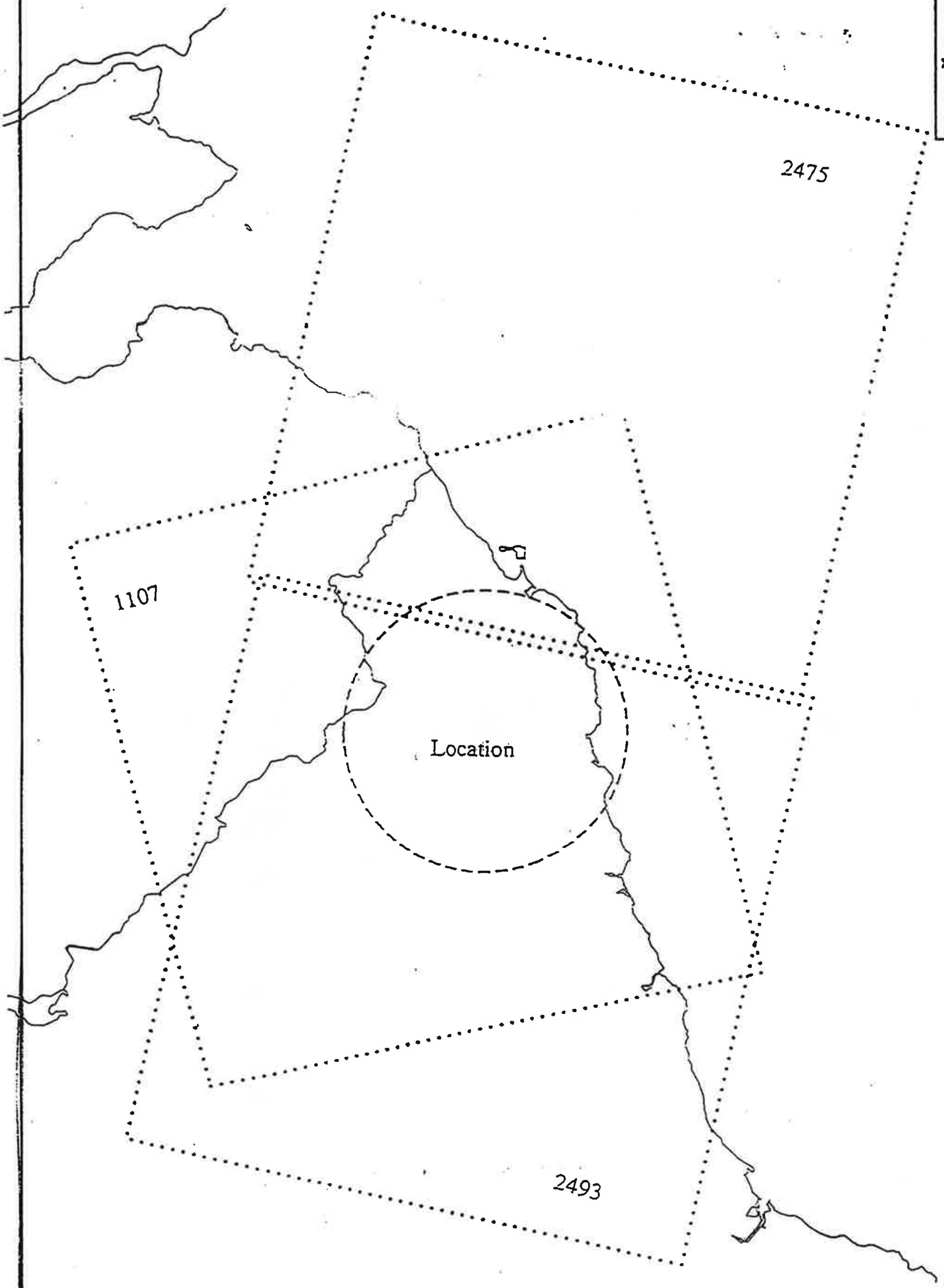
	ERA- Maptec 1993	ERA- Maptec 1994	NRSC 1995
Sensor	ERS-1	ERS-1	ERS-1
No of sites	1	2	1
No of Images	4	2+1	6
Geometric correction	3 rd Order Polynomial	Level 3	Terrain Corrected
Software	ERDAS (8.02)	DELTA (IGN)	TSAR (NRSC)
Classification	Maximum Likelihood	None	Maximum Likelihood
Other techniques	Colour Composite	1 XS and 2 ERS-1 merged	PCA

Geometric Correction

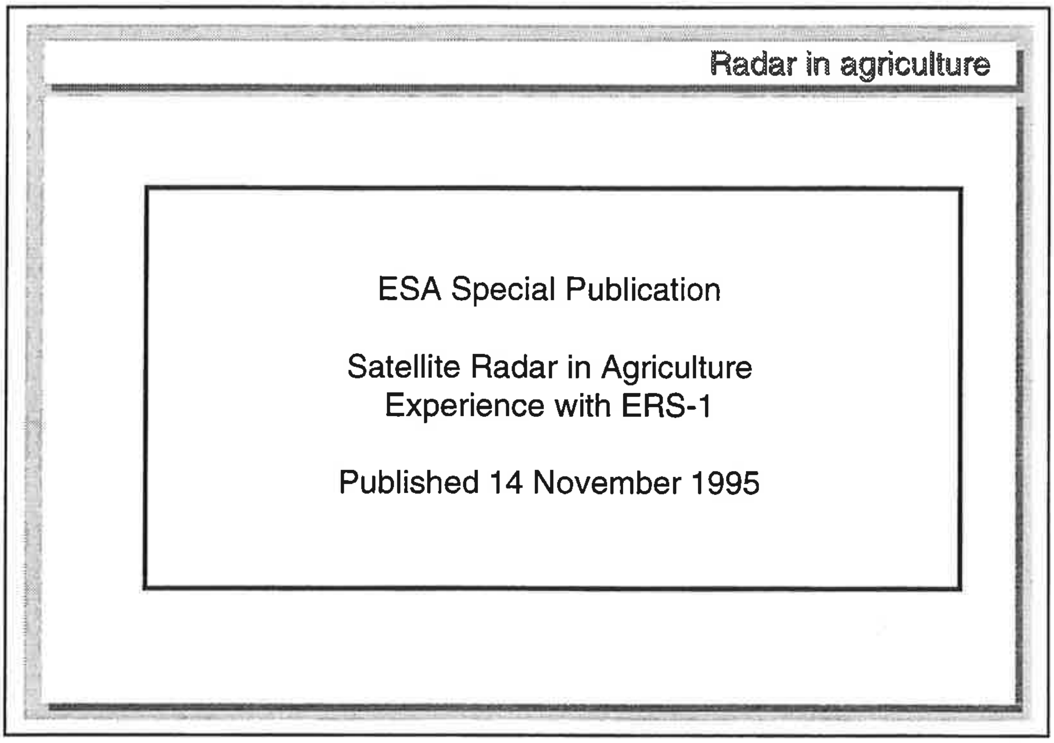
	1993 ERA- Maptec	1994 ERA- Maptec	1995 NRSC
Level	3 rd Order Polynomial	Level 3	Terrain Corrected
Number of GCP's	18	19	11
RMS (absolute)	100 m (rel)	31.9 m	21 m
Software	ERDAS (8.02)	DELTA (IGN)	TSAR (NRSC)

SAR CLASSIFICATION

	ERA- Maptec 1993	NRSC 1995
Pre-Classification	A despeckle (3 pass Sigma) filter was applied	The average pixel value for each field was calculated.
Supervised Classification (SAR)	ground truth data used	ground truth data used
	Maximum likelihood - 6 classes	Maximum likelihood - 6 classes
Accuracy assessment	74%	67.5%, (combining SAR with XS 78%)



The Position of the SAR Frames 1107, 2475 and 2493



Radar in agriculture

ESA Special Publication

Satellite Radar in Agriculture
Experience with ERS-1

Published 14 November 1995

Exactly one week ago ESA published a volume which summarizes the European activities related to the use of ERS SAR in agriculture.

Rather than try to outline the contents of that document in 15 minutes, I feel it would be more profitable for you to get the book from ESA and for me to give you enough elements to understand how a radar image differs from an optical one.

Radar in agriculture

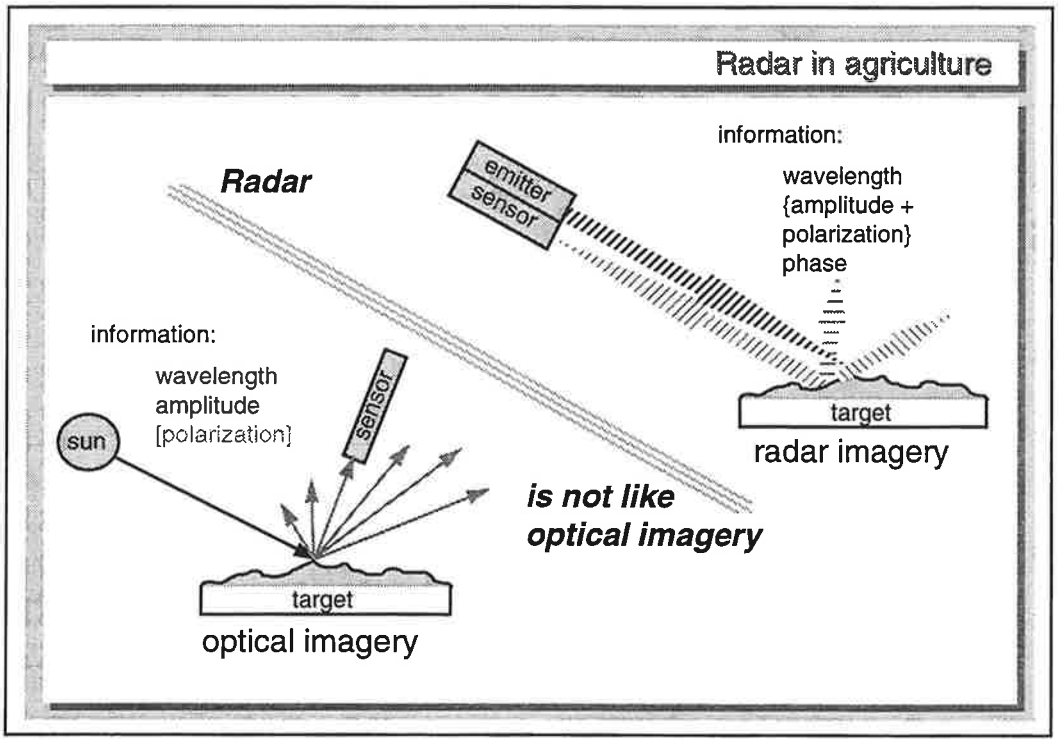
What is radar?

What does it tell us?

Operational perspectives

Radar is becoming increasingly used in agricultural applications. However, while the scientific community has had access to radar images of first quality from ERS-1 for the better part of a decade, it is clear that fully operational applications of radar in agriculture have been slow in emerging.

This talk is aimed at providing the necessary elementary understanding of radar Earth observation for the listener to understand just why radar is so unlike optical imagery, and what the challenges are in establishing an operational use of satellite-borne radar. It starts by explaining some of the elements of radar, briefly touches on the information content of the signal, and finishes with a glimpse of the operational perspectives.



Radar in agriculture

Radar

is not like
optical imagery

information:
wavelength
amplitude
[polarization]

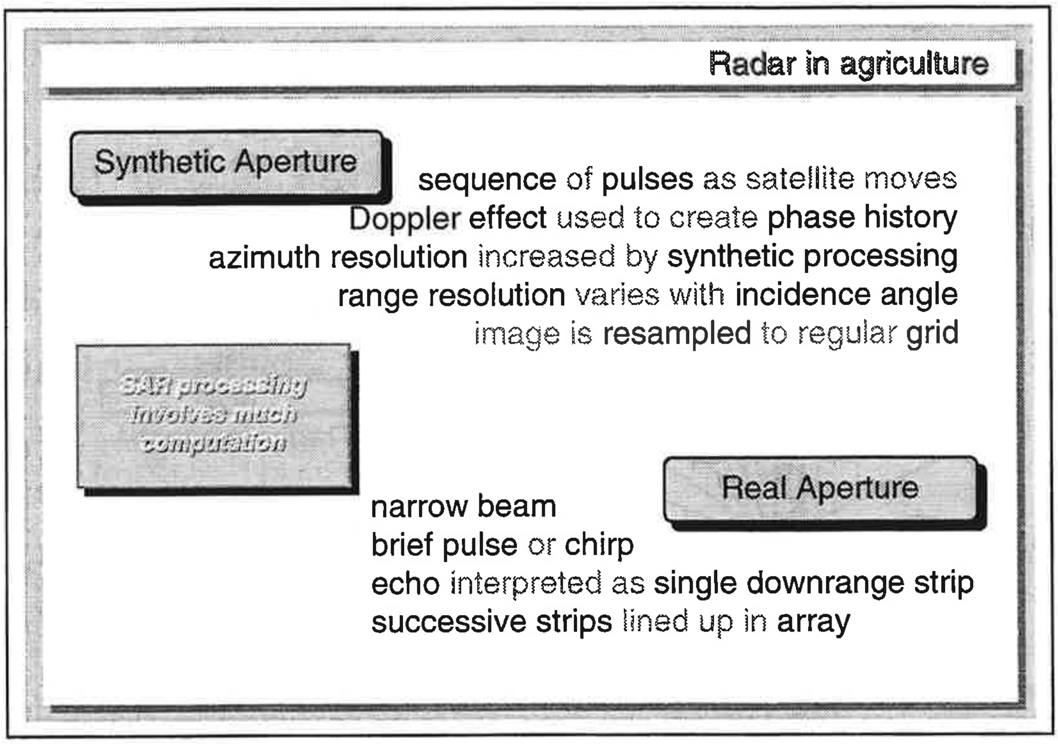
optical imagery

information:
wavelength
{amplitude +
polarization}
phase

radar imagery

When we see a radar image on the screen or on a poster, we are quite naturally tempted to interpret it in the same way that we would an image derived from an optical instrument. We see the same structures - less clearly, perhaps, but we can make them out - and we may notice systematic differences that we believe might be due to differences, for example, in crop types. We may be puzzled at the markedly speckled appearance of the image, and wonder if the image has somehow been badly processed or whether there is something inherently noisy in a radar image.

The main message of this presentation is that we cannot treat radar as another form of optical data. Radar and optical data are fundamentally different, and it is not only a matter of the illumination source.



Radar in agriculture

Synthetic Aperture

sequence of pulses as satellite moves
Doppler effect used to create phase history
azimuth resolution increased by synthetic processing
range resolution varies with incidence angle
image is resampled to regular grid

SAR processing involves much computation

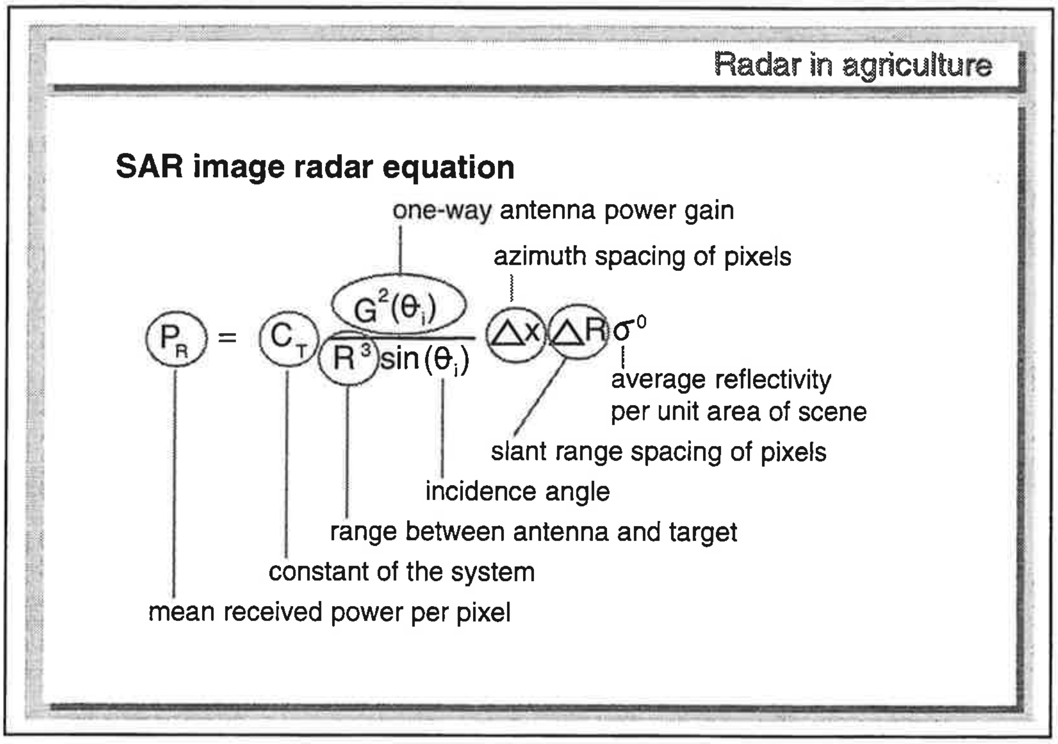
Real Aperture

narrow beam
brief pulse or chirp
echo interpreted as single downrange strip
successive strips lined up in array

The instrument on the ERS satellites that I shall be discussing is a Synthetic Aperture Radar, or SAR. The same sort of instrument will orbit on ENVISAT and is currently in its early commissioning phase on the Canadian RADARSAT.

Let us imagine an echo-locating bat flying low over the audience in this room. It emits a brief pulse of high-intensity sound in a very tight beam and listens to the echoes. Echoes from close objects reach it almost immediately; echoes from further objects arrive later. It unscrambles the return signal and can interpret what lies ahead in that narrow beam. A real aperture radar works on that principle, except that it looks out of the side of an aircraft and repeatedly emits brief pulses of tightly-beamed electromagnetic energy. The computer unscrambles the pulses from each pulse and assembles the pulses side by side to make a matrix, or along-track image.

A Synthetic Aperture Radar works rather differently. Its pulses are less tightly beamed. As the satellite moves along its track the leading edge of the pulse hits an object that is still downrange. The echo comes back distorted by a shift towards shorter wavelengths by the Doppler effect because the satellite is moving rapidly towards the object. A few seconds later the object is behind the satellite which is now moving rapidly away. The Doppler effect ensures that the returning echoes now have a longer wavelength than the emitted ones. The computer program that analyses the signal uses the phase history to determine the location of the object.



Radar in agriculture

SAR image radar equation

one-way antenna power gain

azimuth spacing of pixels

$$P_R = C_T \frac{G^2(\theta_i)}{R^3 \sin(\theta_i)} \Delta x \Delta R \sigma^0$$

average reflectivity per unit area of scene

slant range spacing of pixels

incidence angle

range between antenna and target

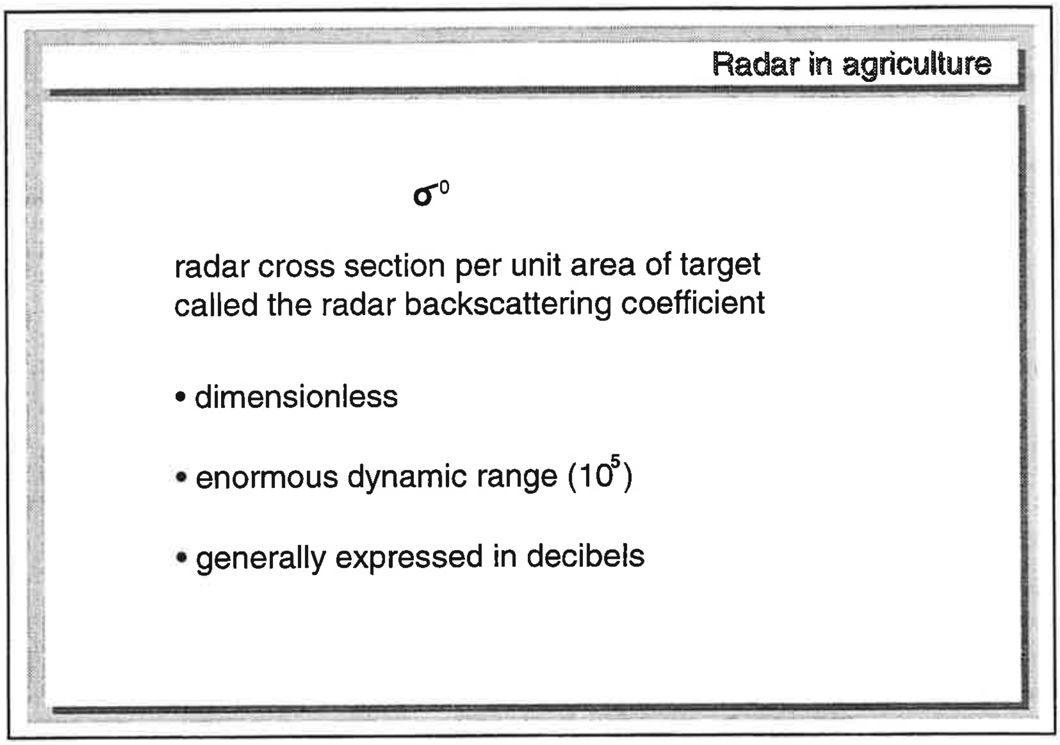
constant of the system

mean received power per pixel

The radar equation relates the power received at the sensors to the average reflectivity of the part of the scene illuminated. The terms of the equation concern mainly the distance from the radar to the target, or range, and the incidence angle at which the radiation hits the target. The slant range spacing of pixels is the distance parallel with the path of the satellite between pixel centres, while the azimuth spacing is the orthogonal distance. These two terms therefore define the area of the pixel. Two of the remaining terms are a function of the instrument; one is related to the sensitivity of the antenna while the other takes into account the remaining characteristics of the instrument such as the sensitivity of the internal circuitry. The final term is sigma nought, once called sigma zero, which is a function of the nature of the target.

This simple equation shows, among other relationships, the highly important dependency of the signal on the gain of the antenna, making it necessary to calibrate the system carefully.

The SAR on the ERS satellites has proved to be a highly reliable and stable instrument that makes the calculation of sigma nought particularly easy.



Radar in agriculture

σ^0

radar cross section per unit area of target
called the radar backscattering coefficient

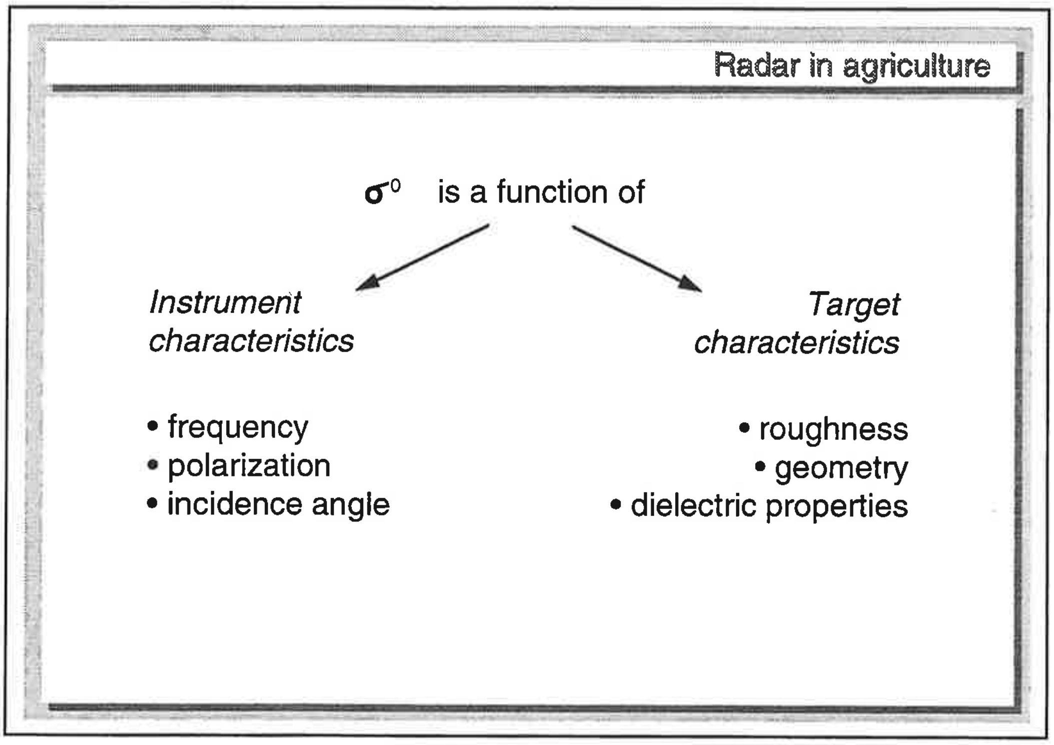
- dimensionless
- enormous dynamic range (10^5)
- generally expressed in decibels

Sigma nought, the backscattering coefficient, is a dimensionless quantity that describes the radar cross section of the target.

If we use an optical analogy - perhaps a dangerous thing - we might say that a mirror oriented to reflect a torch beam would have a high optical cross section. The person holding the torch would see it as a bright object. A piece of black glass in the same orientation would reflect very little and would seem dark, while a sheet of transparent glass that transmits the light might seem equally dark. Both these last objects have a small optical cross section.

Similarly, radiation from radar instruments may encounter objects that tend to reflect, absorb or transmit microwaves. The more reflective objects will tend to have larger radar cross sections, depending on their orientation.

Sigma nought ranges over about 5 orders of magnitude, and for this reason it is normally quoted in decibels.



Radar in agriculture

σ^0 is a function of

Instrument characteristics

- frequency
- polarization
- incidence angle

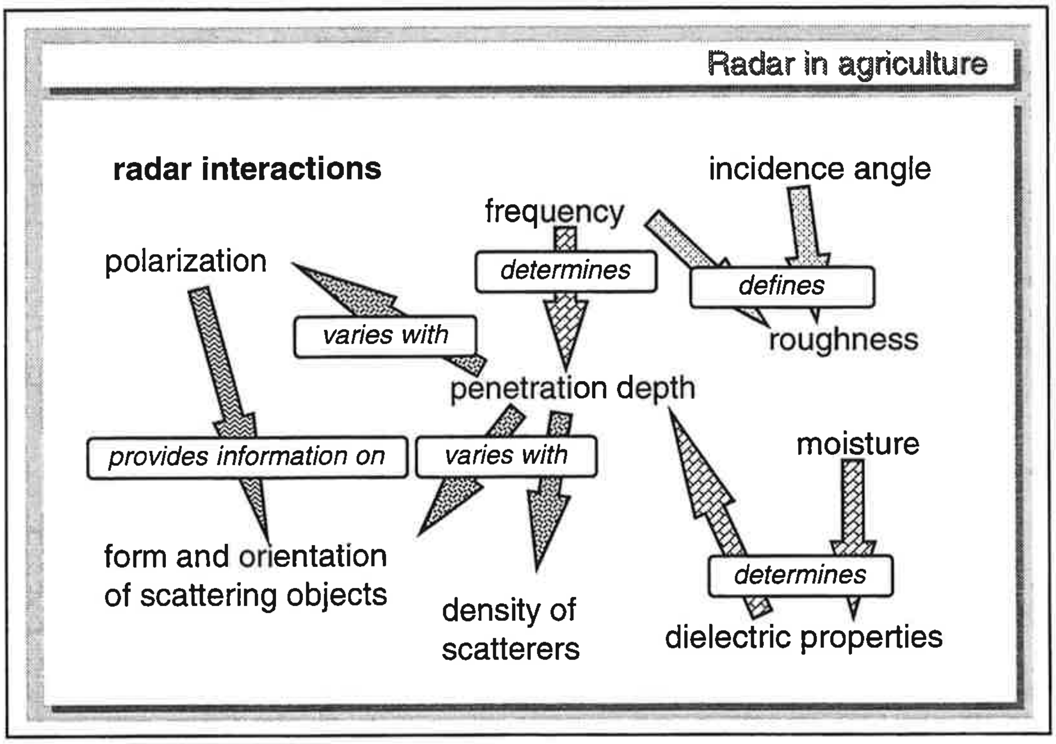
Target characteristics

- roughness
- geometry
- dielectric properties

The backscatter coefficient is partly a function of the characteristics of the radar instrument itself.

The backscatter coefficient of any given object depends on the frequency of the incident radiation. Typically, if the wavelength of the incoming radiation is longer than the dimension of the object in the path of the beam, the object will have a low backscatter coefficient. The backscatter coefficient also depends on the polarization of the incoming signal. A tall vertical object will typically have a large backscatter coefficient in vertically polarized radiation, and a much smaller coefficient in horizontally polarized radiation. The incidence angle also influences the backscatter coefficient. For example, the backscatter coefficient of a vertical object will generally decrease as the source of the incoming signal approaches the zenith.

A smooth object may act act as a mirror, reflecting the radar signal away from the receiver. If the object is covered with undulations whose dimensions are the same order of size as the wavelength of the radar radiation, it will tend to reflect some of the incident radiation back to the source, and will thus have a larger radar cross section. The geometry of the object has a strong influence on its radar cross section, a corner reflector being one extreme. The permittivity and conductivity of a material contribute to its dielectric constant, which has a strong influence on the backscatter coefficient.



Radar in agriculture

radar interactions

polarization

frequency

incidence angle

determines

defines

varies with

roughness

penetration depth

provides information on

varies with

moisture

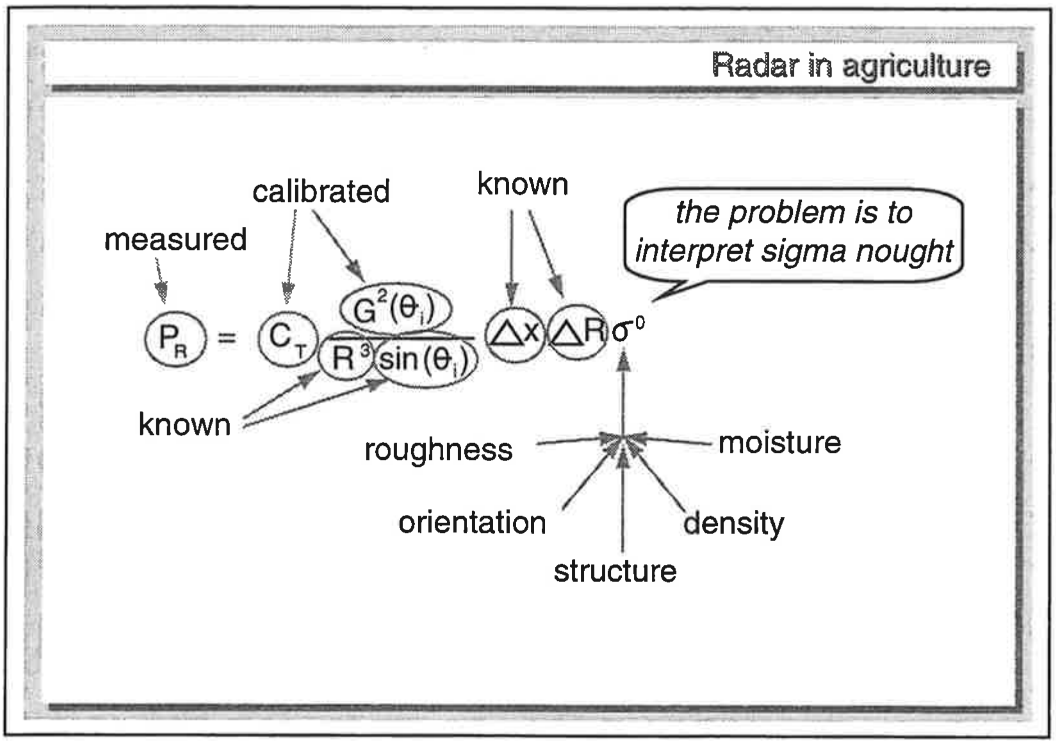
form and orientation of scattering objects

density of scatterers

determines

dielectric properties

The backscatter coefficient of an object bathed in microwave radiation depends on many factors, some of which interact. For example, the frequency and incidence angle of the incoming radiation define whether the object is rough, while the form and orientation of the object will determine whether a smooth object reflects back to the sensor, appearing bright, or in some other direction, appearing dark. Dielectric properties vary with the moisture content of the scatterers and determine how far the radiation penetrates. Increasing the water content of an object generally increases its radar reflectivity. A dry canopy will tend to be more transparent to radar than a humid one. Humid soils reflect more strongly than dry ones - quite opposite effect from that which occurs with optical wavelengths. Other interactions are shown on this figure.



Radar in agriculture

calibrated

known

measured

the problem is to interpret sigma nought

$$P_R = C_T \frac{G^2(\theta_i)}{R^3 \sin(\theta_i)} \Delta x \Delta R \sigma^0$$

known

roughness

moisture

orientation

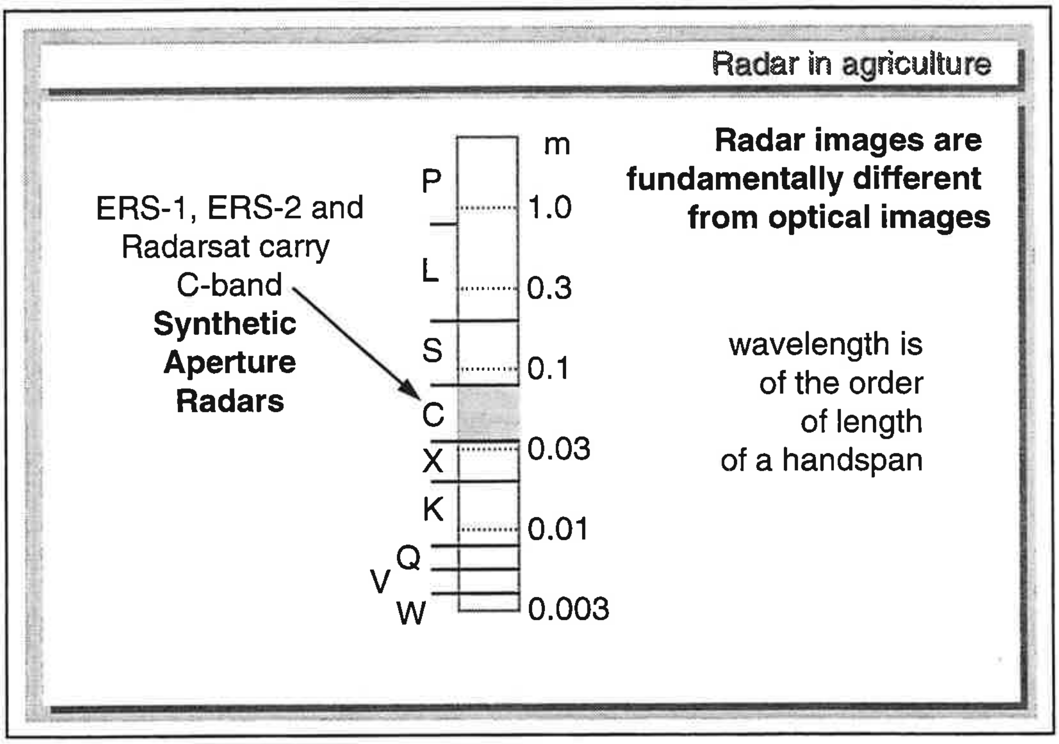
density

structure

We can measure the mean power received; we know , calibrate or can measure all but one of the other parameters.

From this it follows that we can derive sigma nought, which is a characteristic of the target. The problem therefore lies in the interpretation of sigma nought, the backscattering coefficient.

This coefficient depends on many characteristics of the target. If we are thinking about a vegetated surface, then sigma nought depends on the surface roughness and humidity; the canopy density and structure, the orientation of the leaves and stems, and in some cases the orientation of the rows of crops. This makes the interpretation of the backscatter coefficient of a vegetated canopy far from straightforward.



Radar in agriculture

ERS-1, ERS-2 and Radarsat carry C-band **Synthetic Aperture Radars**

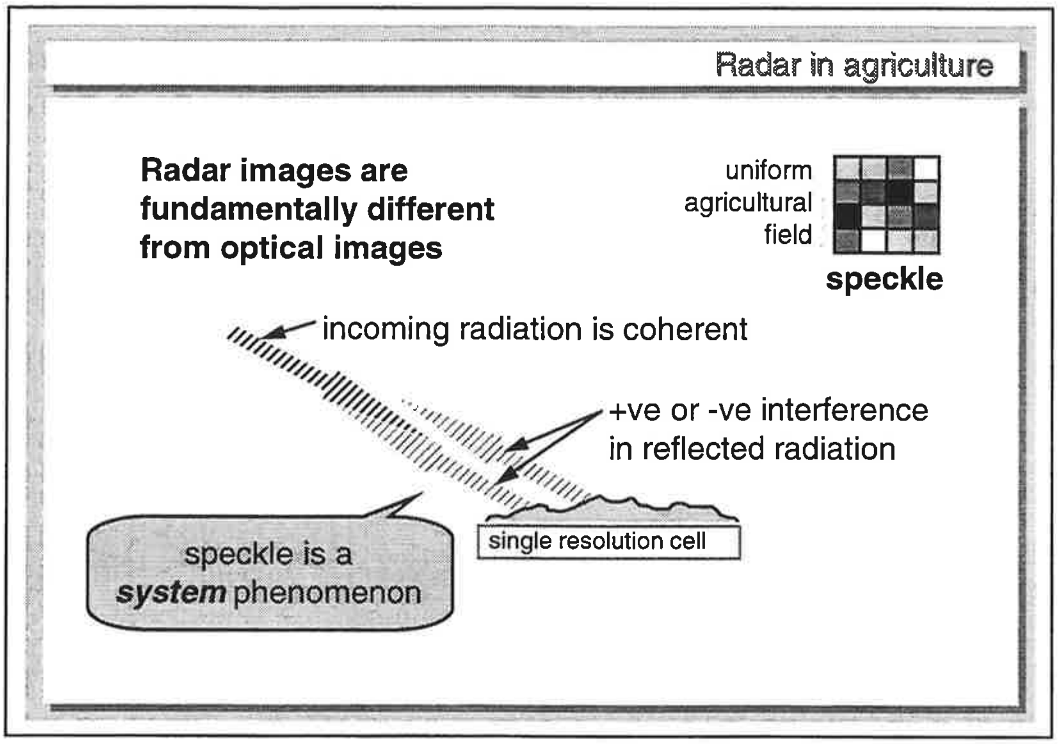
Radar images are fundamentally different from optical images

wavelength is of the order of length of a handspan

Radar depends on electromagnetic radiation, just as do our eyes. But the difference in scale is such that the quality of information contained in the signal is really significantly different. The radar spectrum runs from about 3 millimeters to about 1 meter, and is divided arbitrarily into bands that were given code letters during the second world war. These letters have stuck, making the task of remembering which is which un-necessarily difficult.

C-band radar operates in a region of wavelengths of about 3 centimeters, or roughly the width of the palm of a hand. We can try give an idea of the different world that this examines, relative to optical light, by thinking about what optical light interacts with. Inside a plant cell (and animal cells for that matter) are tiny organelles called mitochondria. They are far smaller than the cell itself. If we scaled optical wavelengths up to C-band wavelengths, then mitochondria would be the size of a fire extinguisher. If we scale optical wavelengths up to about a centimeter, then C-band would have wavelengths of about 100 meters. Whole buildings would be invisible to this radiation.

C-band radar interacts with things the size of leaves and twigs. It bounces around in the canopies of forests like optical light bounces around in the palisade cells of a leaf.



Radar in agriculture

Radar images are fundamentally different from optical images

uniform agricultural field

speckle

incoming radiation is coherent

+ve or -ve interference in reflected radiation

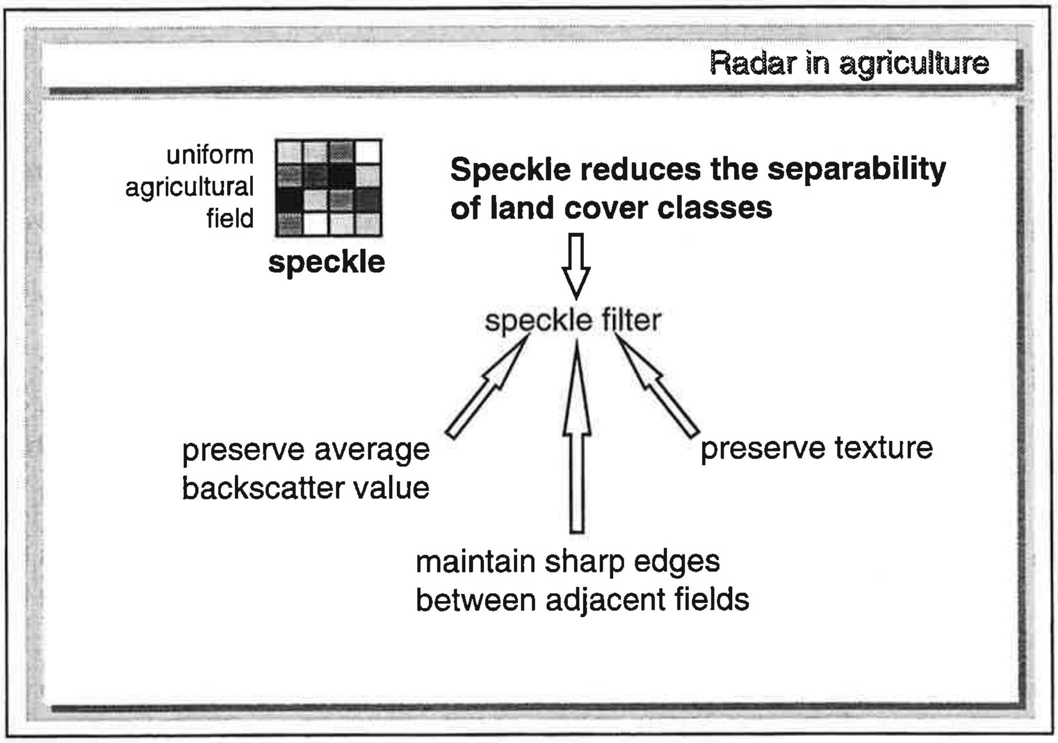
single resolution cell

speckle is a *system* phenomenon

Radar images are characterized by speckle. Neighbouring pixels representing a homogenous field of a single crop may have widely different grey tones, one dark, the next light. This is not the result of some strange error in the instrument; it is in fact the result of the highly pure radiation emitted by a radar. This radiation is necessarily emitted at a single, sharply defined frequency. It is emitted as a series of sharply defined pulses. In other words, the radiation is coherent; wave fronts are in phase.

When this coherent radiation interacts with an extended target (a single pixel in a homogenous field, for example), some parts of the wave front hit parts of the target and start their return journey an instant before the neighbouring part hits a different part of the target. The returning signal is therefore made up of a jumble of echoes with different phases. If the returning echoes are generally in phase, the target pixel will seem bright. If they are out of phase it will seem dark. This phenomenon gives rise to the characteristic speckle of a radar image, which is therefore a system characteristic.

Speckle interacts with texture when the spatial frequency of the texture is similar to the dimension of the pixel. In this case, speckle generally decreases our ability to differentiate textures in radar images. Where optical images may show similar mean grey tones for a forest or a field, the texture of the forest may give us a strong clue to the land cover. With radar, speckle may sometimes obliterate this information.



Radar in agriculture

uniform
agricultural
field

speckle

Speckle reduces the separability of land cover classes

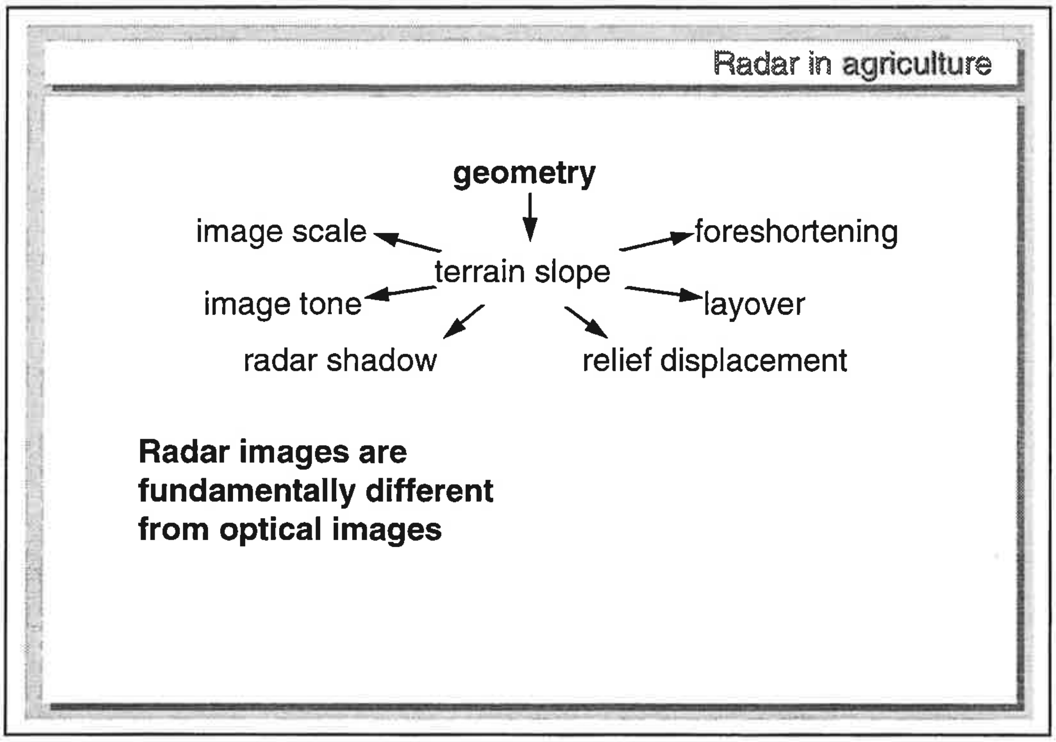
speckle filter

preserve average
backscatter value

maintain sharp edges
between adjacent fields

preserve texture

We therefore wish to reduce, and if possible eliminate speckle, without eliminating at the same time useful information in the image. To to this, we apply a speckle filter designed to smooth out the speckle and allow the average backscatter value to remain to characterize the target. At the same time the filter must preserve edges between objects, and the texture of the objects. This is clearly not an easy set of objectives to meet simultaneously, and many ingenious algorithms have been devised to satisfy this most demanding set of requirements.



Radar in agriculture

geometry

image scale

foreshortening

terrain slope

image tone

layover

radar shadow

relief displacement

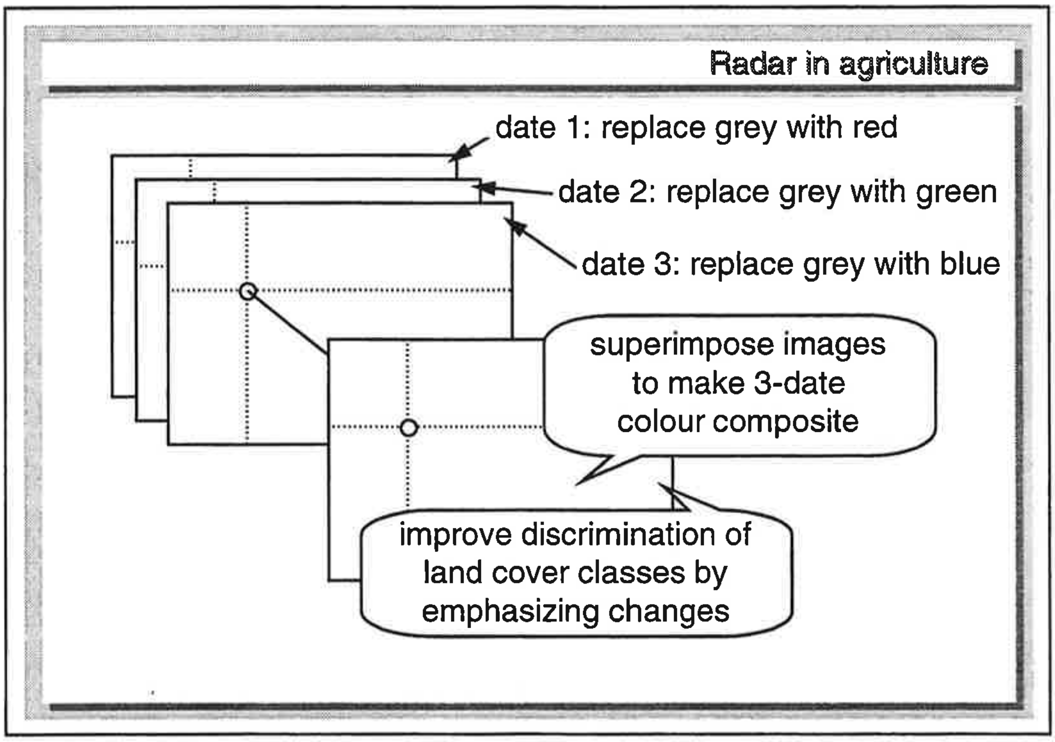
Radar images are fundamentally different from optical images

Radar images are also fundamentally different from optical images in the influence of terrain on the geometry of the image.

Radar is inherently a geometric probe - coherent wave fronts are emitted and the echoes are used to measure distances. Radar images are therefore (in part) an expression of the geometry of the target, and it is inevitable that the geometry of the target strongly influences the returning signal.

The slope of the land relative to the incident signal will alter the backscatter coefficient, with brighter returns typical of land sloping so that the incident radiation is more nearly normal to the surface. Since more of the surface is visible to the radar in this case, this slope will also occupy a larger part of the image than a slope away from the satellite, which will also seem darker. Extreme slopes away from the satellite may be invisible to the radar and give rise to a hole in the imagery, called a radar shadow. Slopes that rise so steeply towards the satellite that the summit of the slope is closer to the satellite than the foot will cause a curious echo which makes the slope seem to lay over towards the satellite, and in general steep slopes will seem to be displaced towards the satellite relative to a neighbouring flat area.

The correct interpretation and geo-referencing of a radar image requires the operator to take account of the relief of the area, and will normally involve the use of a digital terrain model.



Radar in agriculture

date 1: replace grey with red

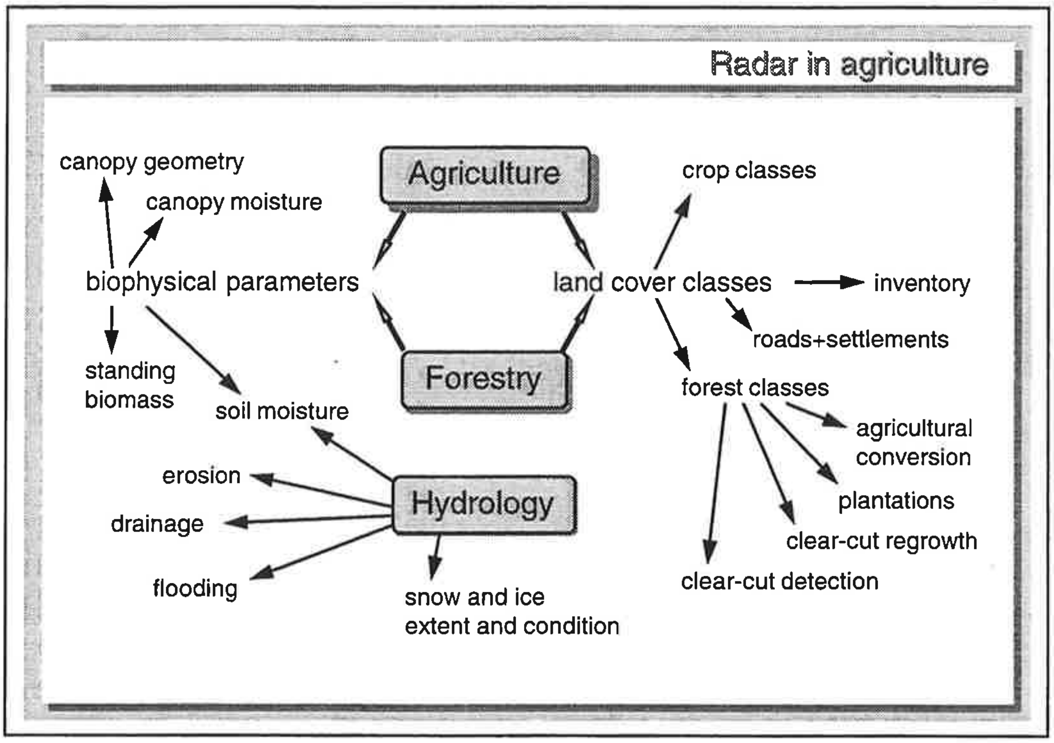
date 2: replace grey with green

date 3: replace grey with blue

superimpose images to make 3-date colour composite

improve discrimination of land cover classes by emphasizing changes

The preceding description will make is quite clear that single date radar images are difficult to interpret unambiguously. For agricultural applications, it is more useful to combine images acquired at different dates. The grey scale on each image is transformed into a red, green or blue image and the three images are overlaid to produce a final one. On this image, areas whose radar cross section or backscatter coefficient have remained stable will be represented in tones of grey. The backscatter coefficient of white areas have remained consistently high; that of black areas have remained low in all three dates. Where one colour dominates the backscatter coefficient was highest at that date, and this may give a strong clue to the identity of the land cover or crop in that area.



Radar in agriculture

Agriculture

Forestry

Hydrology

canopy geometry

canopy moisture

biophysical parameters

standing biomass

soil moisture

crop classes

land cover classes

inventory

roads+settlements

forest classes

agricultural conversion

plantations

clear-cut regrowth

clear-cut detection

erosion

drainage

flooding

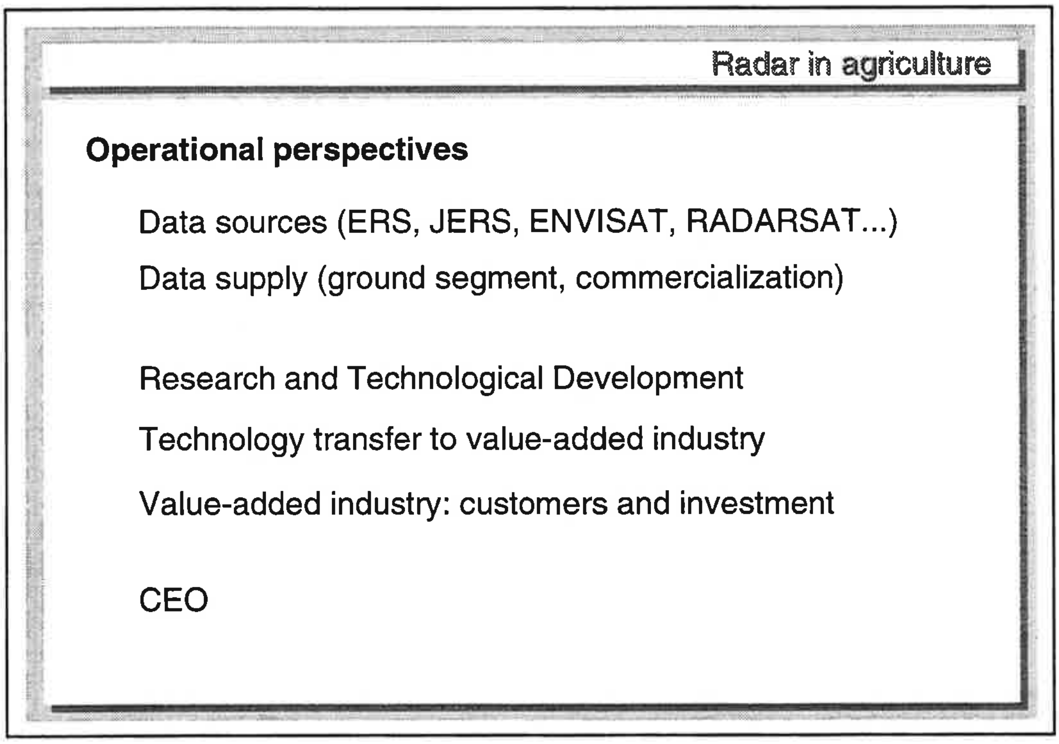
snow and ice extent and condition

We have now had access to excellent radar images from ERS-1 for several years. We have learned a great deal in those years and can see potential applications for the imagery in a wide range of topics. In agriculture, radar may be able to give us information that is simply unattainable with optical imagery, including soil moisture and, with radar instruments other than ERS SAR, estimates of biomass.

The great challenge is no longer so much to discover what interesting phenomena can be detected and sometimes measured using radar imagery. It is to translate these scientific gains into operational use.

By operational, I mean that a client, such as a Ministry of Agriculture or the DG VI, can reasonably expect a regular supply of the information they need, when they need it. This will allow them to build an information system that depends on the routine supply of that information.

We now know that at least some of the information is probably there in the data. What can we say about the other parts of this definition of operationality?



Radar in agriculture

Operational perspectives

Data sources (ERS, JERS, ENVISAT, RADARSAT...)

Data supply (ground segment, commercialization)

Research and Technological Development

Technology transfer to value-added industry

Value-added industry: customers and investment

CEO

We already have 2 ERS satellites in orbit. The SAR on ERS-1 has proven to be an excellent instrument, performing nominally to specification or better than specification with wonderful results. Initial indications are that the duplicate instrument on ERS-2 will perform equally well. ENVISAT will no doubt continue in this tradition of excellence. The Canadian RADARSAT was launched earlier this month.

The data supply seems therefore assured for some time to come, although some applications may find that there are not enough satellites to ensure an overpass when the data are needed. This will be a strong limitation on the expansion of the market in some sectors. Data supply has been a contentious issue in the past, partly because the power requirements of the SAR are so great that it is not always possible to switch the instrument on over a particular site, and partly because of difficulties with the distribution of data by the ground segment. We may hope that difficulties related to the ground segment will vanish as the system matures. It will be interesting to see the effect on data supply of the resolutely commercial attitude of RADARSAT.

The remaining issues of the movement towards are perhaps ones of technology transfer from the laboratories to the value added industry, and the limited possibilities for the value added industry to invest in locating and developing new customers. Here the 4th Framework Programme may be of help, and we intend that the CEO shall contribute significantly to this effort.

EUROPEAN COMMISSION
DIRECTORATE GENERAL XII - JRC
SCIENCE, RESEARCH AND DEVELOPMENT - JOINT RESEARCH CENTRE
Institute for Remote Sensing Applications

Spaceborne SAR Data in the MARS-STAT Project Uses and Prospects

JRC / IRSA
Agricultural Information Systems Unit

Image Material : © ESA / Eurimage
Contributions : [1] SYNOPTICS (NL)
contract 10653-94-12-F1ED-ISP-NL

H.De Groof
G.G.Lemoine [1]

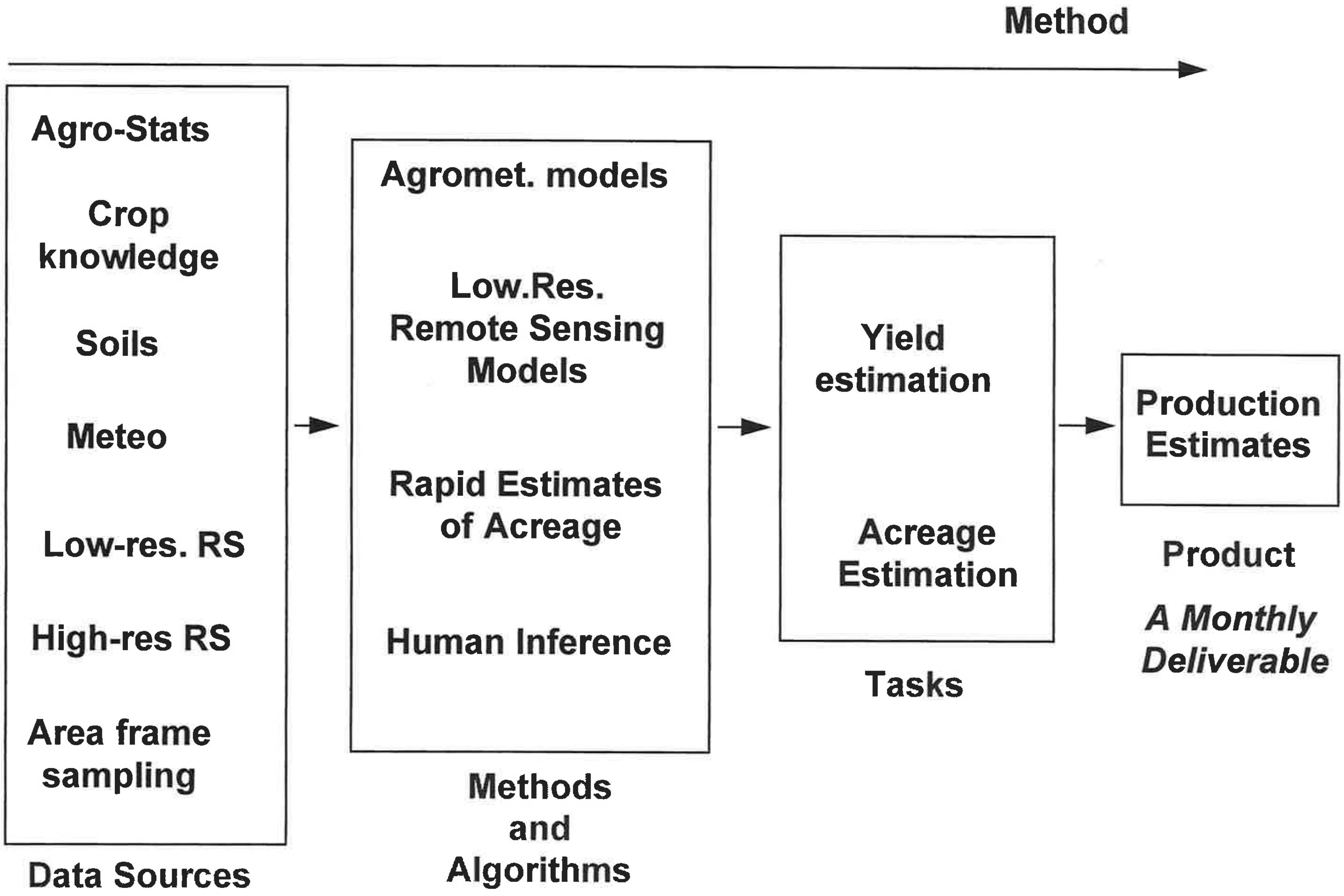
MARS - STAT Outline

Objective :

To timely estimate the agricultural production

- for a number of target crops
- for a given region of interest
  - European Union
  - PHARE, TACIS, MAGREB
  - Other non-E.U

MARS - STAT Outline



Method

Agro-Stats

Crop knowledge

Soils

Meteo

Low-res. RS

High-res RS

Area frame sampling

Data Sources

Agromet. models

Low.Res. Remote Sensing Models

Rapid Estimates of Acreage

Human Inference

Methods and Algorithms

Yield estimation

Acreage Estimation

Tasks

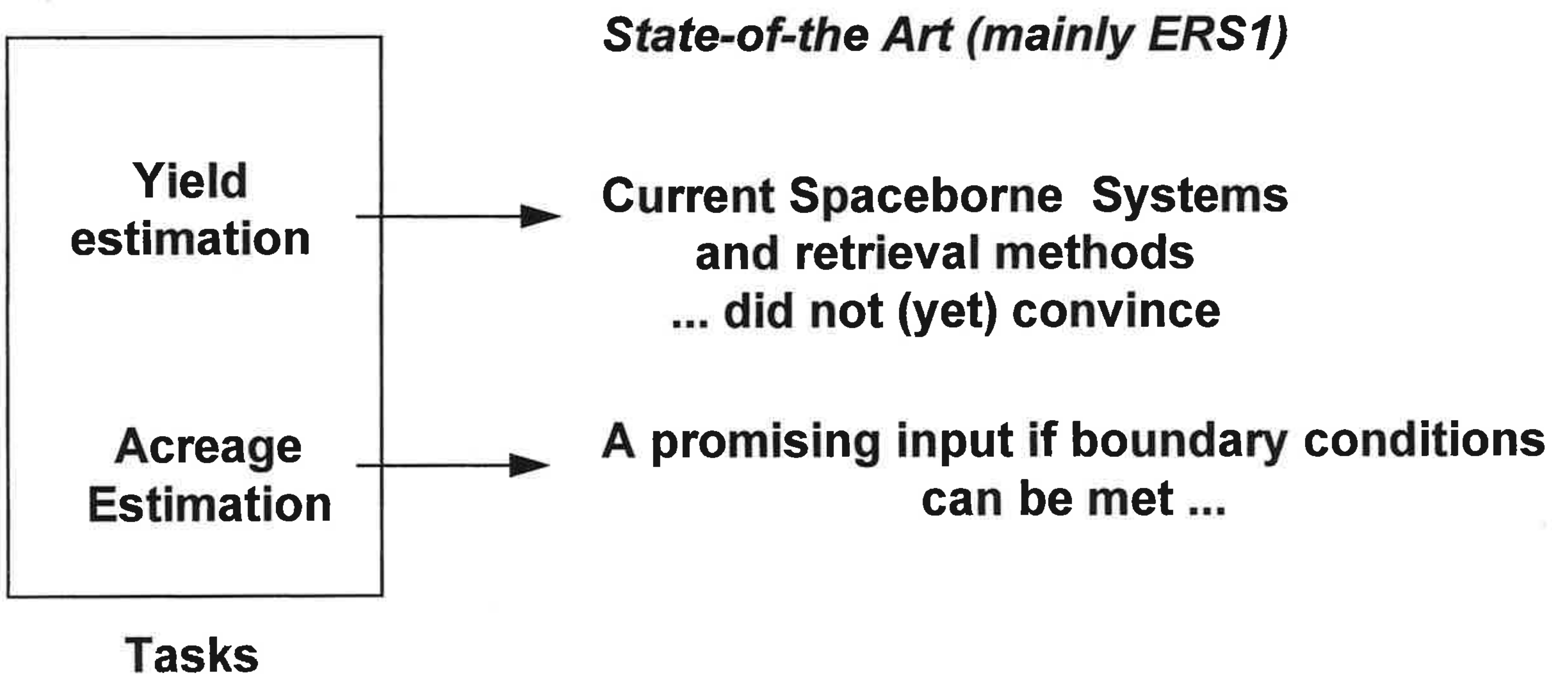
Production Estimates

Product

A Monthly Deliverable

Spaceborne SAR Data

A Source of Information ?



State-of-the Art (mainly ERS1)

Yield estimation → Current Spaceborne Systems and retrieval methods ... did not (yet) convince

Acreage Estimation → A promising input if boundary conditions can be met ...

Tasks

Spaceborne SAR in MARS-STAT

A Strategy

Pre-1994

Experiments on individual sites

throughout the growing season

January 1994

"Brainstorming meeting at JRC"

Recommendations for short, medium,
long term strategy

JRC Exploratory Research Project 1994

Preliminary Results

Throughout the growing season

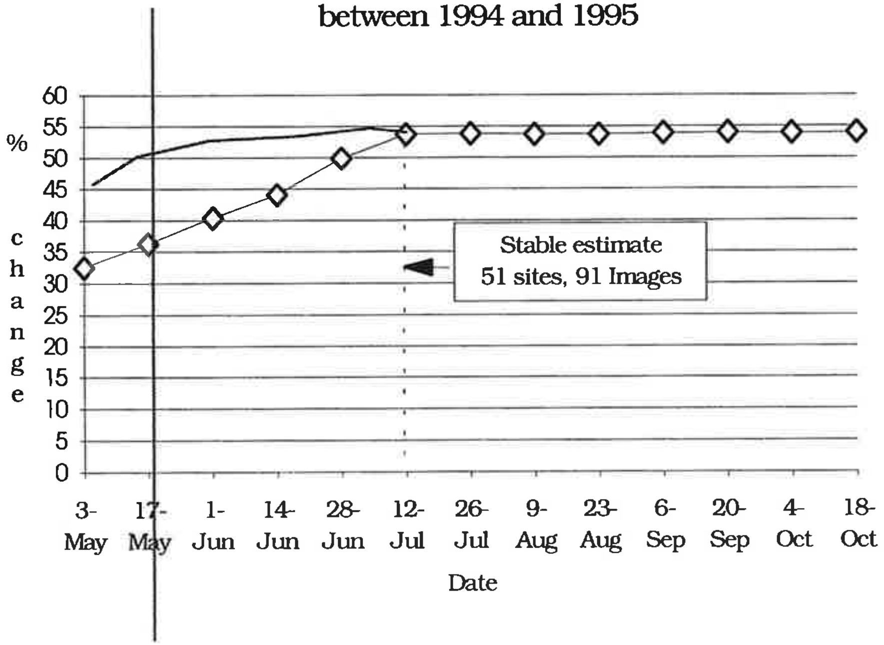
On different sites,

ERS1 data alone, combined with optical
an improved classification result.....

Cost / Benefit ?

A new Objective...

Relative Change of * Acreage
between 1994 and 1995



A new Objective...

More early season ,
more precise,
crop acreage estimation by incorporating of
ERS-1/2 imagery
of land preparation activities

Hypothesis...

- **SAR imagery can be used to distinguish bare soils which vary in surface structure and moisture content**
- **Land preparation is crop specific (tillage activities)**

calendar - meteo - soils

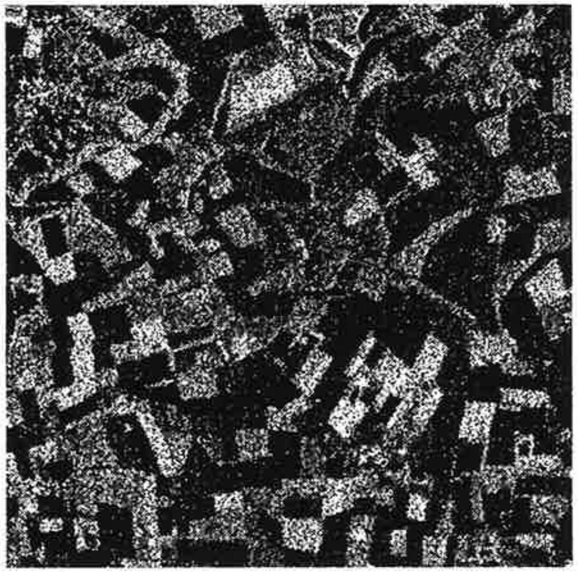
A case study on the Great-Driffield site.....

“SUMMER”

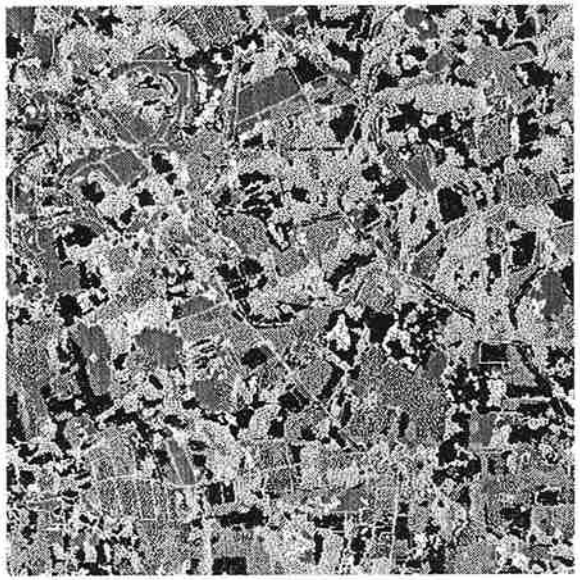
21/2/95

9/5/95

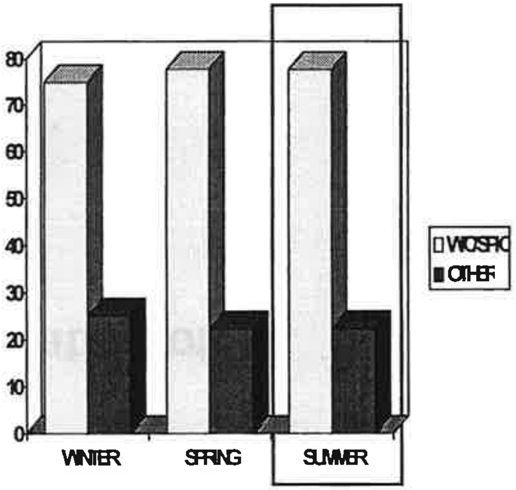
25/6/95



Classification result at field level



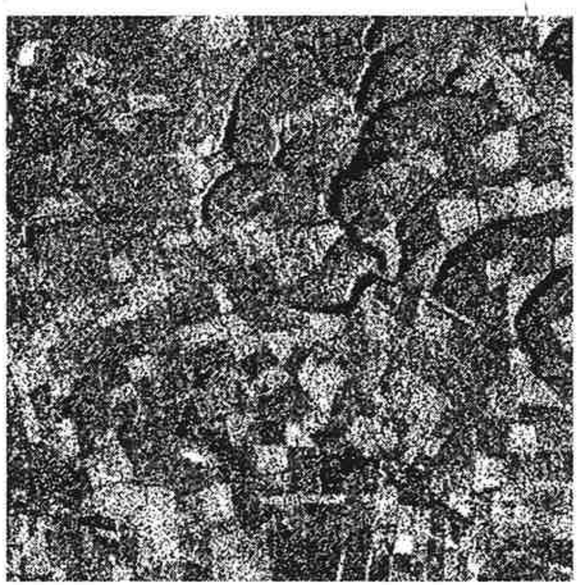
- ▨ Winter wheat
- ▨ Oil seed rape
- ▨ Peas / Sugarbeet
- ■ Potatoes
- ▨ SBT/POT/PEA/RAP
- ▨ Pasture
- ■ Winter barley
- □ Spring cereals / rape
- ▨ Other



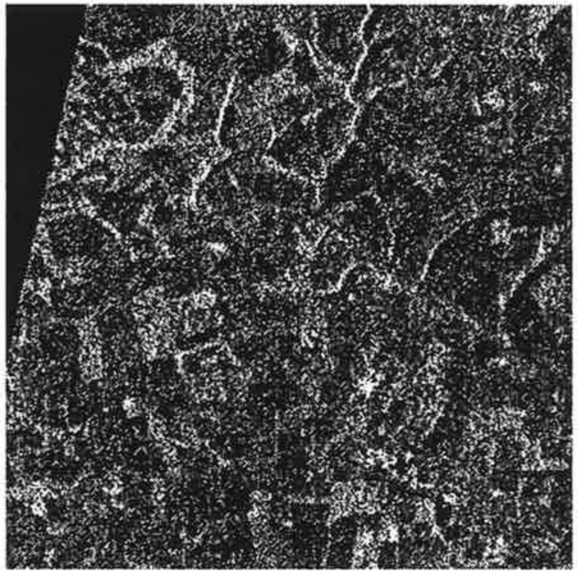
77.7 % **Winter & Spring Cereals against other crops**
146 out of 188 fields correctly classified

"SPRING"

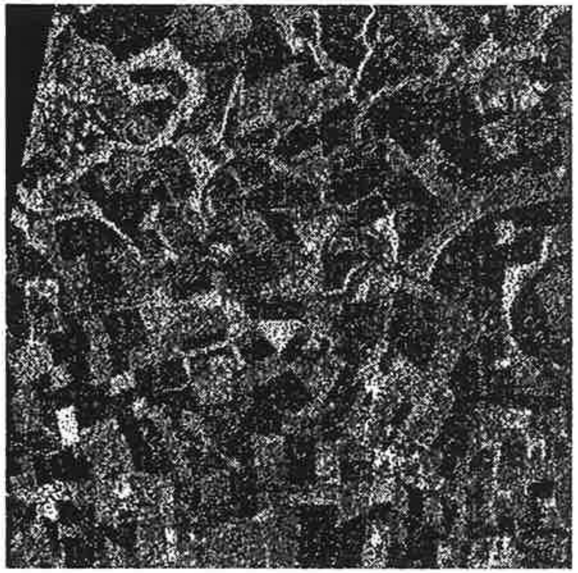
21/2/95



16/4/95

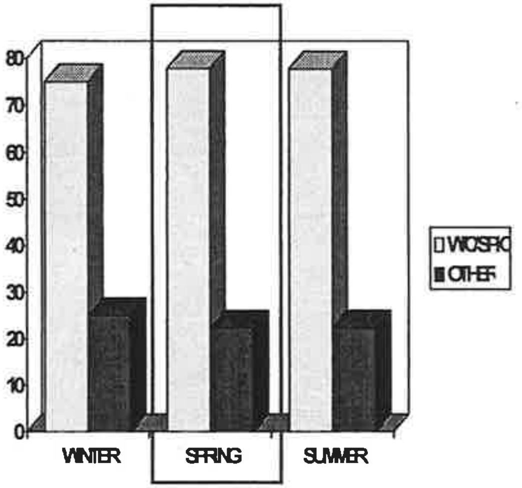


21/5/95



Classification result at field level

- ▨ Winter Cereals
- ▨ Oil Seed Rape
- ▨ Peas/Sugarbeet/SPC
- ■ Potatoes
- ▨ Pasture
- □ Spring Cereals / Spring rape
- ▨ Other

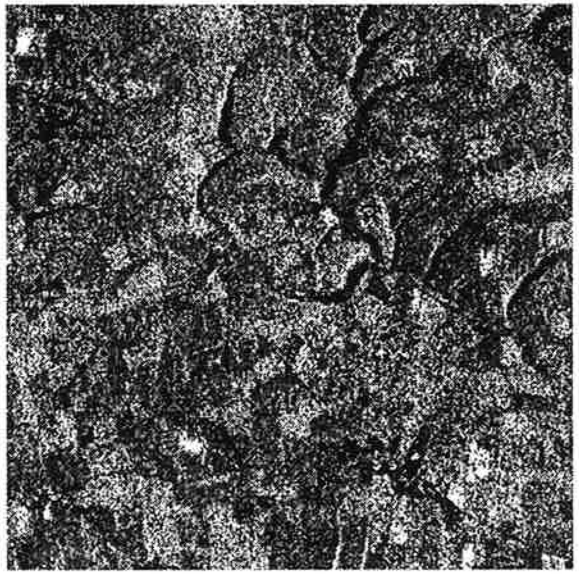


77.8 % **Winter & Spring Cereals against other crops**
147 out of 189 fields correctly classified

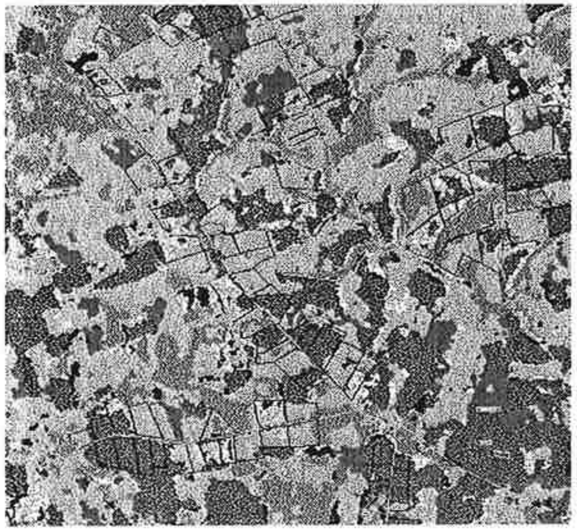
“WINTER”

26/12/94

9/12/94



21/2/94



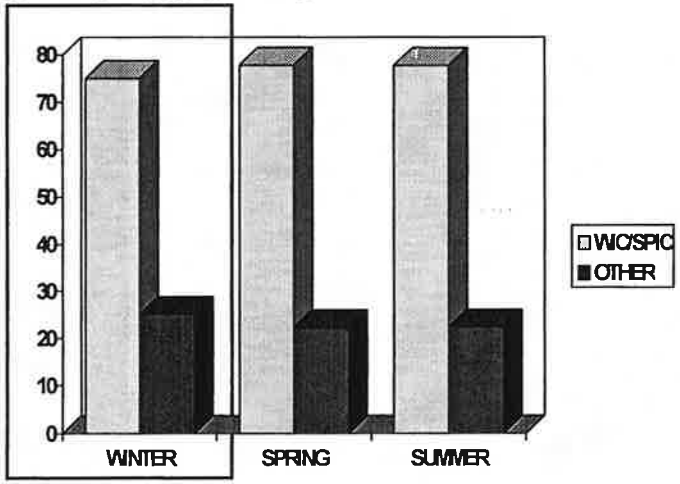
Classification result at field level

Winter Cereals
Oil Seed Rape

Summer Crops

Pasture

Spring Cereals
Other



75.0 % Winter & Spring Cereals against other crops
123 out of 164 fields correctly classified

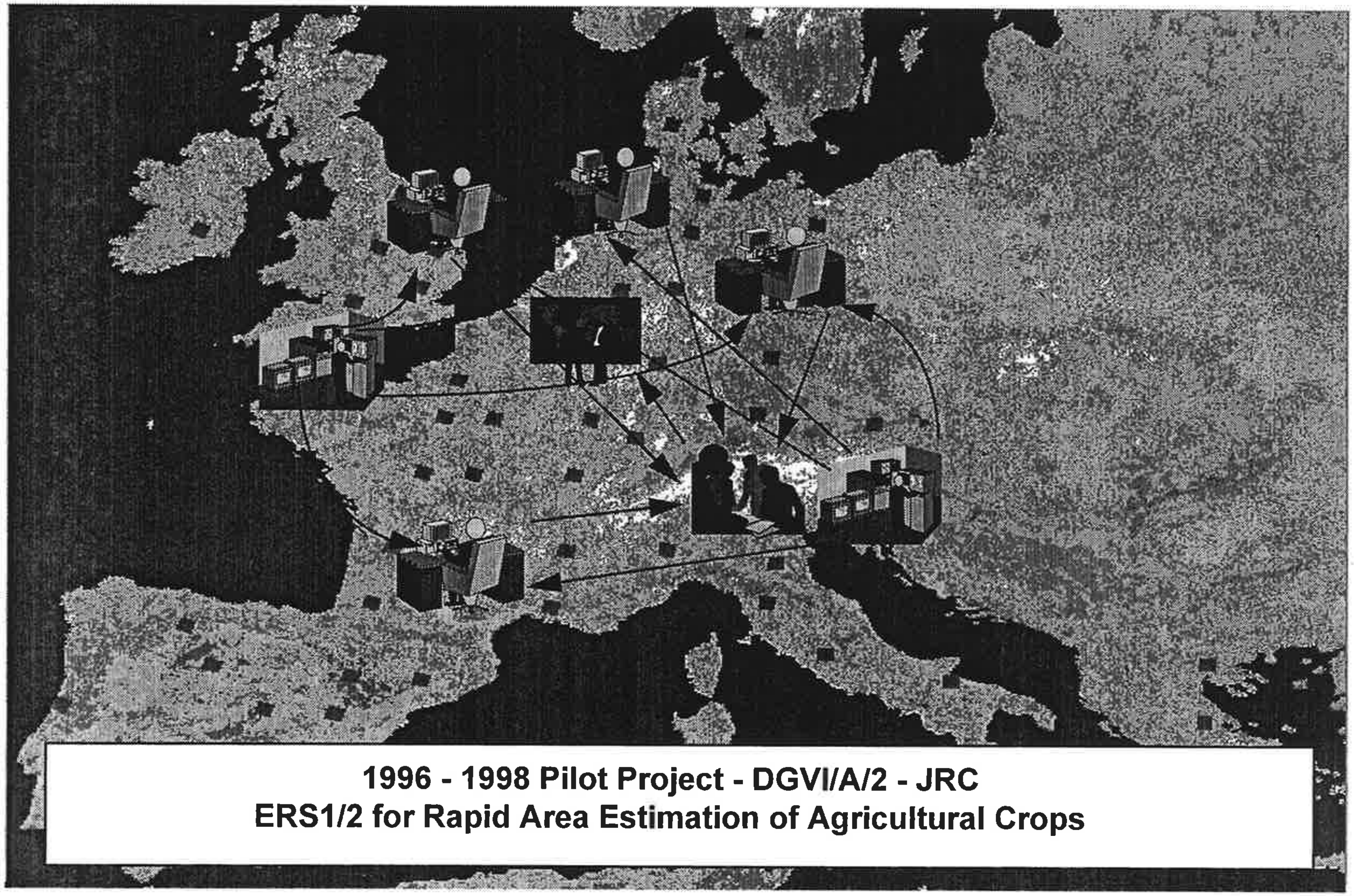
Conditions and Constraints..........and nice to have

- ERS image data availability and quality
- Acquisition frequency
- Acquisition geometry
- Land preparation calendars
- Crop calendars
- Meteo data.....................agromet. simulations
- Geocoding..... a clear asset
- Bare soil backscatter simulations
- Backscatter coefficient database

1996 - 1998 Pilot Project - DGVI/A/2 - JRC
ERS1/2 for Rapid Area Estimation of Agricultural Crops

NOAA14 - AVHRR MVC September 1995 - Processing MARS

Acquisition and Pre-processing → Centralised
Interpretation → Distributed
Integration → Centralised



1996 - 1998 Pilot Project - DGVI/A/2 - JRC
ERS1/2 for Rapid Area Estimation of Agricultural Crops

SESSION 3

Classification and automated Control

Cranfield
UNIVERSITY

Classification and Automated Control
Principles, Method and Validation

by

J. C. Taylor

Silsoe College

Main Points

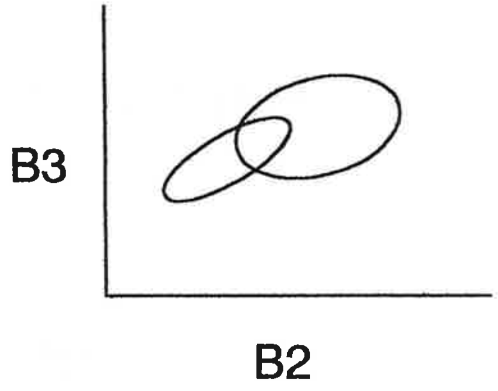
- "Standard" Methods
- Potential Enhancements
- Role of Ground Survey

"Standard" Method

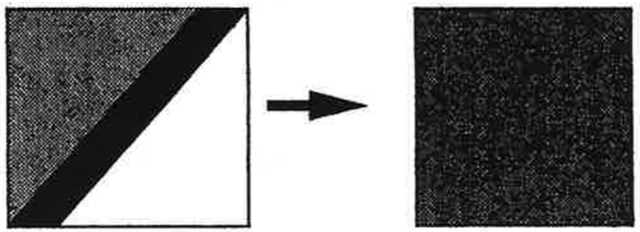
- Maximum likelihood decision rule
- Supervised training
- Per pixel
- Equal *a priori* probabilities
- Single image

Problems with "standard" method:

- spectral confusion



- mixed pixels



Enhancements to "Standard " Methods

- multi date images
- per parcel classification
- *a priori* information
- use of error matrix
- use of threshold probabilities

Accuracy improvements with a per parcel classifier:

Single Date ML	56%
+ transition probs	80%
+ another image	85%
+ another image	>90%

Survey Design

- samples proportional to crop areas
- representative sample ie random
- independent of farmer returns
- MARS or TER-UTI can be used
- at least 50 independent obs for main crops

Role of Ground Survey

- representative sample of training pixels
- produce unbiased error matrix
- public confidence

Effect of bias.

		Reference Data	x2									
		Woods	Inland Water	Urban	Wheat	Barley	Summer Crops	Grasses	OSR	Other	TOTAL	User Accuracy	
	Woods	16	1		1						18	89%	
	Inland Water		4	1	1						6	67%	
Image Data	Urban			35		1	22	~~6~~ 12		11	~~75~~ 81	~~47%~~	43
	Wheat	9	1	2	170	10	1	~~13~~ 26		2	~~208~~ 221	~~82%~~	77
	Barley			1	3	1					5	20%	
	Summer Crops		3	2		3	36	~~2~~ 4	1	3	~~50~~ 52	~~72%~~	69
	Grasses	2		10	6	22	6	~~63~~ 126	1	8	~~118~~ 181	~~53%~~	70
	OSR				1				29	1	31	94%	
	Other				2	1	4	~~3~~ 6		2	~~12~~ 15	~~17%~~	13
	TOTAL	27	9	51	184	38	69	~~87~~ 174	31	27	~~523~~ 610		
	Producer Accuracy	59%	44%	69%	92%	3%	52%	73%	94%	7%.	Overall Accuracy ~~68%~~ Kappa 60% Var(kappa)0.000589		69%

Classification et validation automatique

JM TERRES
Projet MARS

Pourquoi

Bilan 95

Méthode

Stratégie et Mise en oeuvre

Classification et validation automatique

Pourquoi

- Opération très contraignante avec délais très courts
  10-15j entre dernière image et fourniture résultats

- Photo-interprétation : auparavant goulot d'étranglement (en 95 ?)

- Classification automatique

. critères objectifs : paramètres de classification
. processus stable : temps (fatigue opérateur) et différences entre opérateurs

Classification et validation automatique

Bilan 95 : classification

. validation auto	De, Dk, El, F, Ir, It, NL, Po
. information élaborée	Es
. information simple	De, Fin, Sw, UK

	total parcelles	validation auto	%
Esp	220000		
F	83000	☑	31%
Ir	16000	☑	18%
NL	16000	☑	83%

⇨ Situation disparate

Classification et validation automatique

Bilan 95 : PIAO

	parcelles pour PIAO	PIAO
Esp	220000	100j
F	62000	33j
Dk	4600	10j
Po (PVA)	21000	21j

Charge PIAO dans le projet : 2% 10-15% 35-40%

Classification

Méthode générale

- Seuil 1 : Précision radiométrique

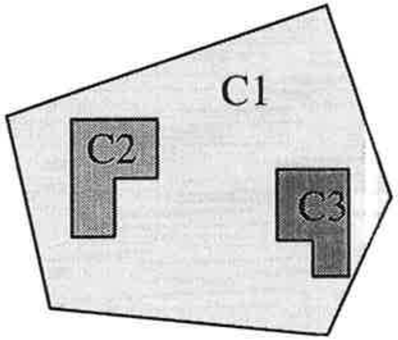
calculée sur matrice de confusion
données terrain indépendantes à entraînement

Si Seuil 80% : Classes C1 et C2 sélectionnées

classe terrain	C1	C2	C3	C4
blé	88	16	0	0
colza	12	84	0	0
tournesol	0	0	60	35
mais	0	0	40	65
Total	100	100	100	100
Précision	88	84	60	65

- Seuil 2 : Précision d'affectation parcellaire

$$\frac{S_{c1}}{S}$$



Si $S_{Cl} > 70\%$ et autres $S_C < 20\%$: parcelle classée validée

Classification

Mise en oeuvre

- Aide au photo-interprète information simple / élaborée
- Validation automatique cultures homogènes et fréquentes

Validation automatique	. classes retenues pour classification (seuil 1) . parcelles validées (classes retenues) (seuil 2)
Photo-interprétation	. classes non retenues . parcelles non validées . classification ≠ culture déclarée . occupation du sol hétérogène (ex : gel)

Classification et validation automatique

Stratégie

avantages	désavantages
. paramétrable (critères objectifs et stables : intègre variabilité du terrain dans des paramètres de classification) . quantification possible de la précision . allège charge de PIAO	. pas performant si culture hétérogène . temps de préparation . limites de parcelles doivent être ajustées préalablement ($Es \neq F$)

Session 3 : Classification et validation automatique

- GeoRas (NL) : Automated decision modelling in 1995 Dutch Remote Sensing Control - *Diminution charge PIAO*
- Tragsatec (Es) : Use of Classification in control of area based subsidies using Remote Sensing in Spain - *Fourniture information élaborée*
- Sotema (Fr) : Classification et méthode automatique : la méthode Sotema *Problème limites parcellaires : îlots*

Baveno Teledetection Contractors meeting
November 21 -22 1995

THE 1995 DUTCH TELEDETECTION APPROACH AND THE ROLE OF AUTOMATED DECISION MODELLING

Mahmoud Hassani
Franke van der Laan
Mark Honig
GeoRas, Hoofddorp, The Netherlands

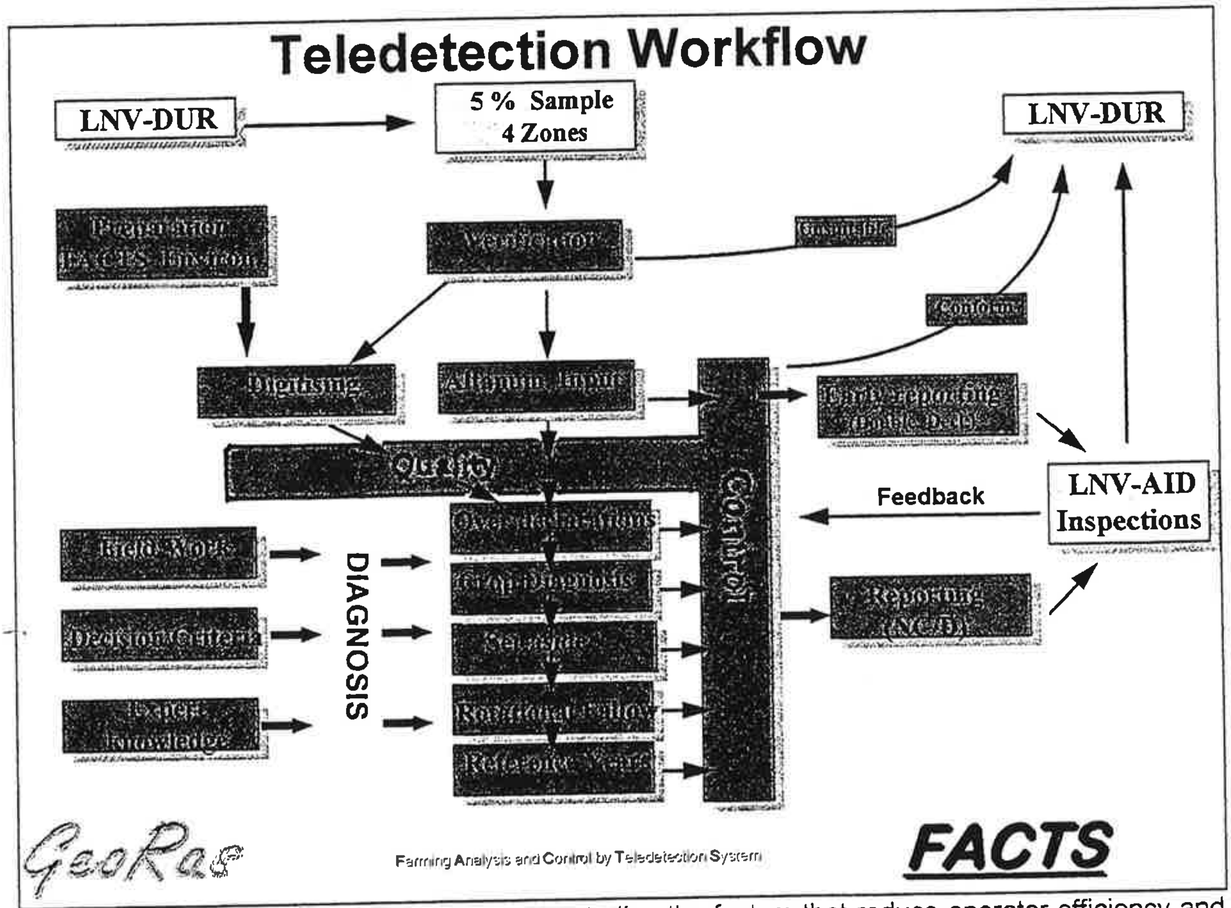
Summary

In this paper, presented at the Baveno meeting of the 1995 FEOGA Teledetection Control contractors an overview is given of the GeoRas Farming Analysis and Control by Teledetection System (FACTS). Due to the nature of the session on 'classification & automated control' the emphasis of the paper is on automated decision modelling approach for crop diagnosis. Thanks to the automation, the labour investment in classification and decision-modelling is reduced to 2% of the total labour requirements.

Introduction

The subject of this paper is the automation of the crop diagnosis process in the GeoRas **F**arming **A**nalysis and **C**ontrol by **T**eledetection **S**ystem (FACTS). An early version of this system was used in Greece during the 1994 campaign and the fully developed system was used in The Netherlands during the 1995 campaign.

The objective behind the development of the FACT-System is to reach a high degree of cost-effectiveness. Automation of the crop diagnosis is only one of the sections of the workflow chain to achieve this. An overview of the teledetection workflow is indicated graphically in Figure 1.



The key design principles of FACTS are to neutralise the factors that reduce operator efficiency and objectiveness. The nature of the Teledetection control work is that it is very repetitive. This leads to reduction of operator motivation and 'sharpness'. A high degree of automation and quality control during input, diagnosis and reporting and a strong emphasis on quality control are the result of two years FACTS development . For insiders, the labour distribution chart of the 1995 project in the last part of this paper is a good illustration of its effectiveness.

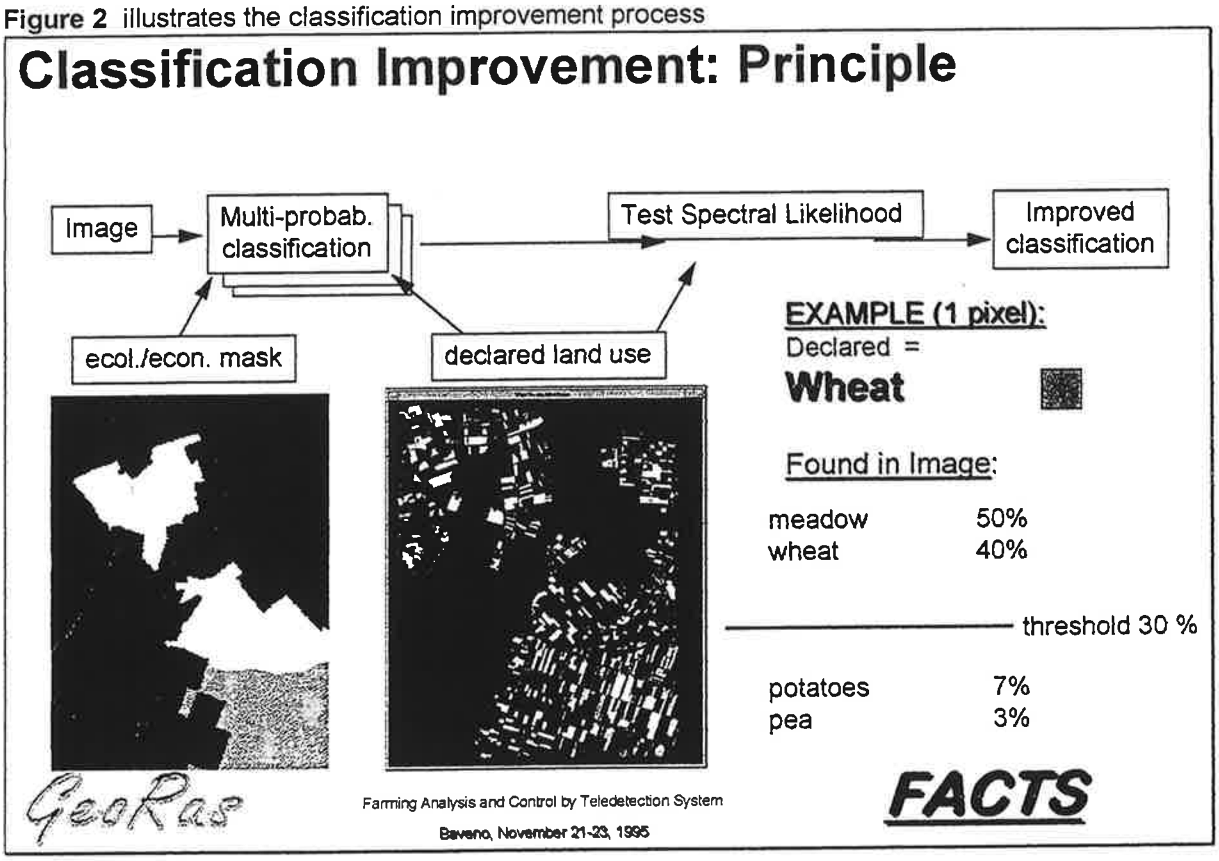
Principles of the automated decision modelling

The problem in all image analysis is the spectral overlap of the classes to be identified. The challenge in automated decision modelling, is to correctly separate the (majority of) conform declarations from the doubtful and non-conform ones, amongst tens of thousands of declared plots, with a minimum of operator involvement. A 100 % certainty threshold in the modelling is required on the one hand for legal considerations. This will make the 'yield' of the process very low, thus requiring a large amount of operator work, which is error prone.

The key elements, where the GeoRas approach stands apart from conventional image analysis are:

- extensive use of ecological masks that allow an optimum spectral separation of land cover types spatially
- a multi-probability classification approach that allows a considerable reduction of the number of (frustrating) iteration cycles during the training process and the use of expert judgement in the selection of the proper class from many classification results.
- In traditional image classification, the 'decision' on the land cover per pixel is left to the classification algorithm. In the FACTS approach the algorithm supplies the material for a proper expert judgement.
- At the parcel level, external expert judgement and existing GIS information is used in the final decision

Figure 2 illustrates the classification improvement process



Classification Improvement: Principle

EXAMPLE (1 pixel):
Declared =
Wheat

Found in Image:

meadow	50%
wheat	40%
threshold 30 %	
potatoes	7%
pea	3%

GeoRas
Farming Analysis and Control by Teledetection System
Baveno, November 21-23, 1995
FACTS

Observations with Figure 2:
A multi-probability classification is performed by ecological stratum and only for the image area under the declared plots. This results in several classification maps with their corresponding probabilities. For one (wheat) pixel the subsequent decision considerations are indicated that allow to pick out wheat as the correct class in spite of the fact that it spectrally has the second highest probability.

The logic of the multi-probability approach is illustrated in **Figure 3**.
It shows the spectral probabilities of four hierarchical classifications on the pixels under a transect. This figure visualised why any classification approach can pick out the 50-60 % of pixels where the spectral probability of the highest probability class is 80-30 % higher from the next probable one. Only with external information and the knowledge of the probability distribution per pixel something useful can be obtained from the cases where different probabilities are (virtually) equal.

Figure 3:Relations between multi-probability classifications

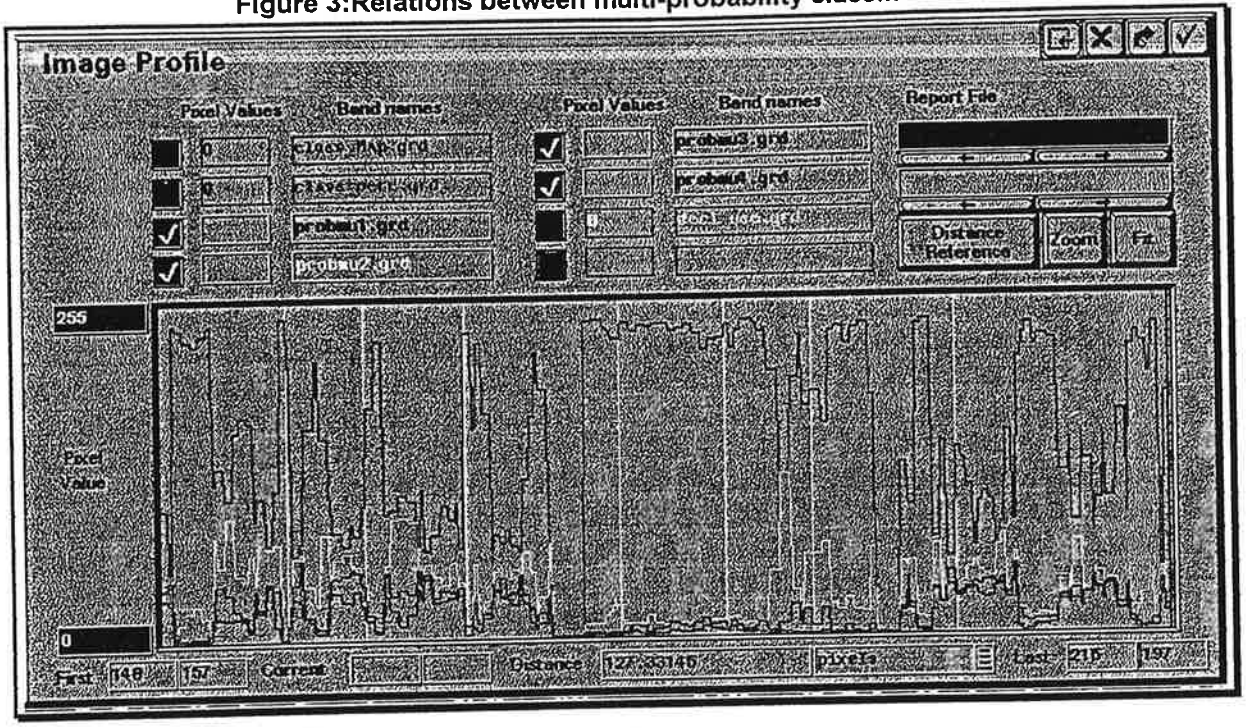
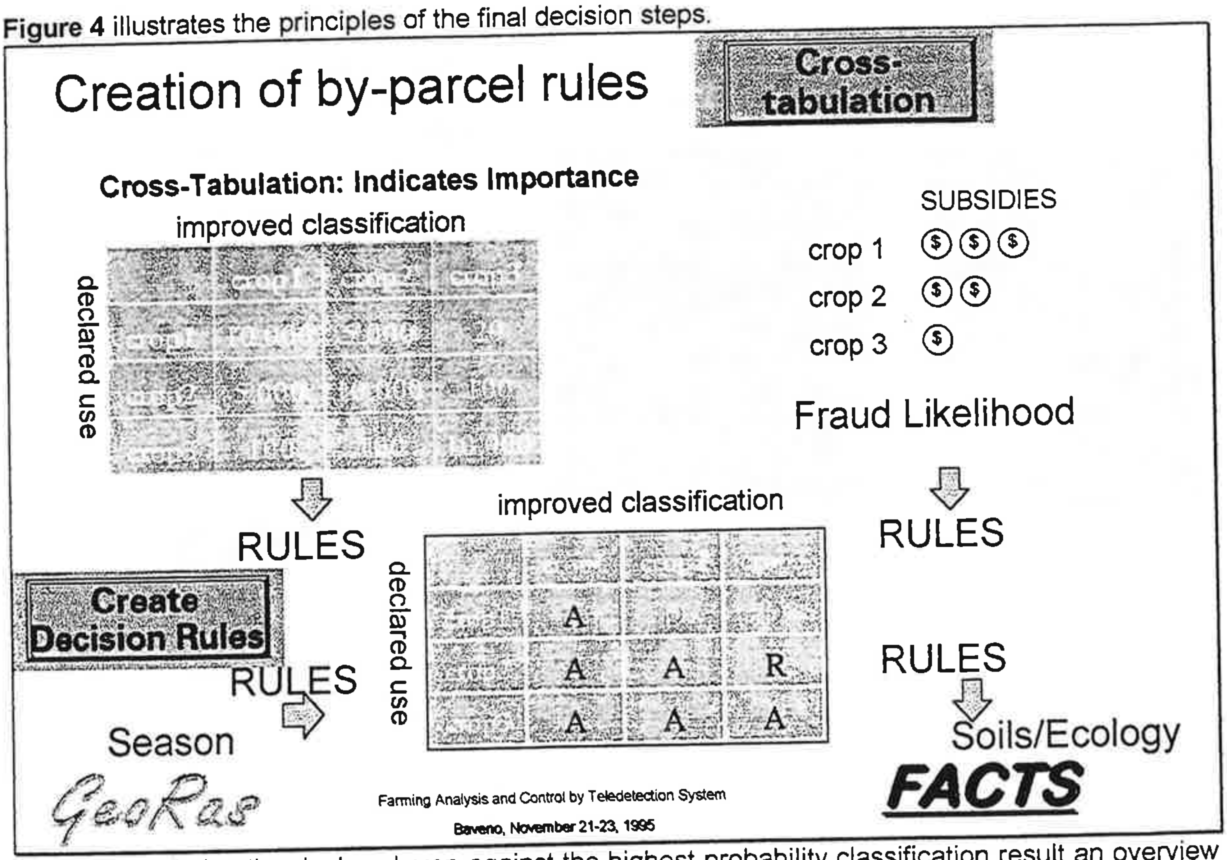


Figure 4 illustrates the principles of the final decision steps.


Creation of by-parcel rules

Cross-tabulation

Cross-Tabulation: Indicates Importance

improved classification

declared use

RULES

Create Decision Rules

RULES

Season

improved classification

declared use

SUBSIDIES

crop 1 $ $ $

crop 2 $ $

crop 3 $

Fraud Likelihood

RULES

RULES

Soils/Ecology

FACTS

GeoRas

Farming Analysis and Control by Teledetection System

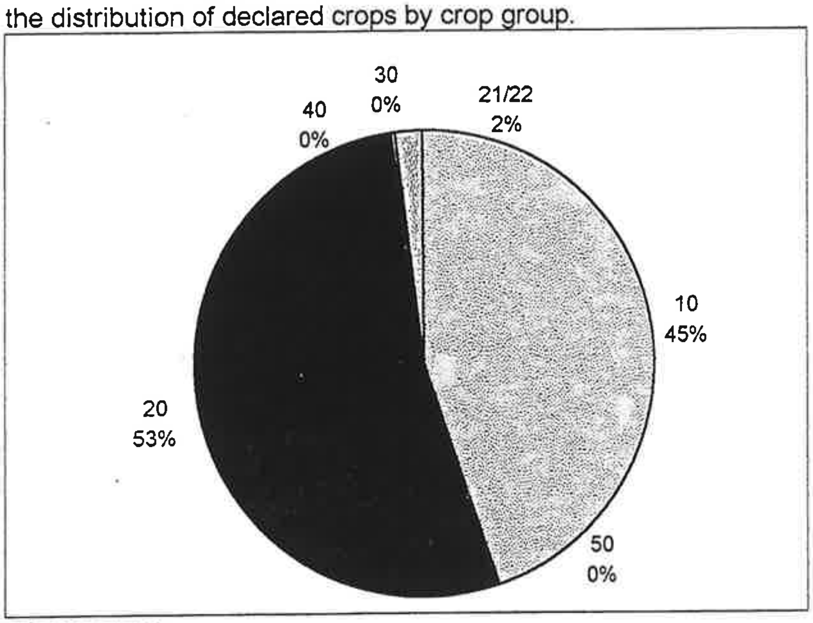
Baveno, November 21-23, 1995

By cross tabulating the declared crop against the highest probability classification result an overview is obtained of the importance of each combination. The aim is to reduce the amount of operator work. The cross-tabulation is a guideline to systematically look for an explanation for relevant problem classes. It is irrelevant for the method if the deviation is rooted in spectral, fraud, ecological or any other causes.

Practical use

The decision modelling can be used flexibly. The larger the number of plots are the more advantageous it is, with an optimum in the order of magnitude of fifty thousand or more.

Using the modelling for a few hundred or thousand plots is no useful because the time advantage against pure CAPI is lost in the extra preparation time required.
The approach followed in 1995 shows some of the flexibility:
Figure 5 shows the distribution of declared crops by crop group.



Problem cases and rare crops

The number of plots per crop type is very unevenly distributed. Three crops (grassland, winter wheat and maize) of 27 occurring, represented 90 % of the parcels. It makes no sense for the rare crops with one to 100 occurrences per zone to be subjected to a classification, let alone to automated modelling. All rare crops and in addition the problem cases that were marked during input were therefore documented on transparent overlays on the field inspection maps. As such a kind a rapid field visits could be made to the majority of these cases.

Common crops

Only the plots of the common crops were bulk-processed using the automated classification and decision modelling process as described above. The general crop characteristics of the three crops on the images available were:

The training and classification phase

A training-set on all three XS images combined per zone was found to result in the most significant spectral separation of the classes. The training set was generated fusing all 2052 plots documented during field work (i.e. including the rare crops and problem cases sampled). The field data on all crops were used for spectral tuning and training, but only the three bulk crops grass, maize and winter wheat were actually colour coded and used in the follow-up process. The spectral significance of 95 % for winter wheat and grass and 86 % for maize made the use of a multi-probability step irrelevant in this case.

Rule building

The declared plots on maize, grass and winter wheat were, using the images as a geographical template, transferred in raster form and cross-identified with the previously obtained classification results. The cross tabulation of the differences allowed the identification of reliable and unreliable conform, doubtful and non-conform cases, taking all spectral, ecological and fraud likelihood's on regulations into consideration. The rules defined per combination are applied to the declared use and classification statistics per plot.

Automated Decision Modelling

The classification results of the images with a significant differentiation for the crops were processed with the rules at a 70 % cut-off threshold for each plot.
Table 1 shows that from the 14754 plots processed, 2495 or 17 % were identified as doubtful or rejected. After CAPI checking on these cases 187 were identified as potential problem cases, for which the farmer dossier had to be lifted from the archive for final quality control. 60 % of these were resolved as obvious errors. The large number of obvious errors corrected and after CAPI can generally be linked to three causes:

- The quality of the soil. The better the soil conditions, the more prominent the spectral signature. The influence of the soil characteristics, in particular its moisture content, in 1995 was particularly strong, because of a severe drought period in the summer that lasted from late June to early August.

Table 1: Results of Automated Decision Modelling

		Zone1	Zone2	Zone3	Zone4	Total
GRASS	**Total plots**	**382**	**602**	**4608**	**981**	**6573**
	Automated Doubt	48	78	450	165	741
	Automated Reject	21	25	46	31	123
	Total Automated	**69**	**103**	**496**	**196**	**864**
	CAPI Reduction	**82%**	**83%**	**89%**	**80%**	**87%**
	Left after CAPI	9	4	20	21	54
WINTER WHEAT	**Total plots**	**1841**	**614**	**14**	**1588**	**4057**
	Automated Doubt	269	108	-	233	610
	Automated Reject	52	26	-	52	130
	Total Automated	**321**	**134**	**0**	**285**	**740**
	CAPI Reduction	**83%**	**78%**	**100%**	**82%**	**82%**
	Left after CAPI	9	8	0	28	45
MAIZE	**Total plots**	**215**	**209**	**1677**	**2023**	**4124**
	Automated Doubt	75	64	231	392	762
	Automated Reject	22	19	35	53	129
	Total Automated	**97**	**83**	**266**	**445**	**891**
	CAPI Reduction	**55%**	**60%**	**84%**	**78%**	**78%**
	Left after CAPI	3	2	45	38	88
TOTAL	**Total plots**	**2438**	**1425**	**6299**	**4592**	**14754**
	Automated Doubt	392	250	681	790	2113
	Automated Reject	95	70	81	136	382
	Total Automated	**487**	**320**	**762**	**926**	**2495**
	CAPI Reduction	**80%**	**78%**	**88%**	**80%**	**83%**
	Left after CAPI	21	14	65	87	187

The impact of automated decision modelling

Without a proper administration and reporting structure a Teledetection system is not complete. The structure of FACTS allows a high degree of early reporting and streamlining of the preparation of the field documents. **Figure 6** shows the reporting progress in the 1995 project. The initial reports were delivered as cases (mainly double declarations) were encountered. Once the final image, required for crop diagnosis was obtained, the automated processes were initiated, with the consequences shown in figure 6.

Figure 6: Progress

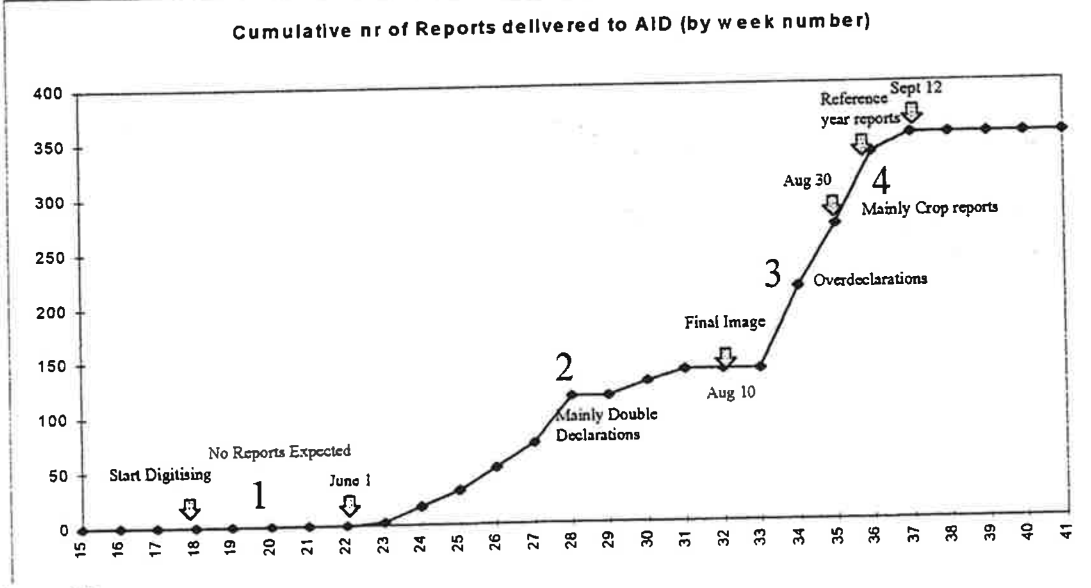
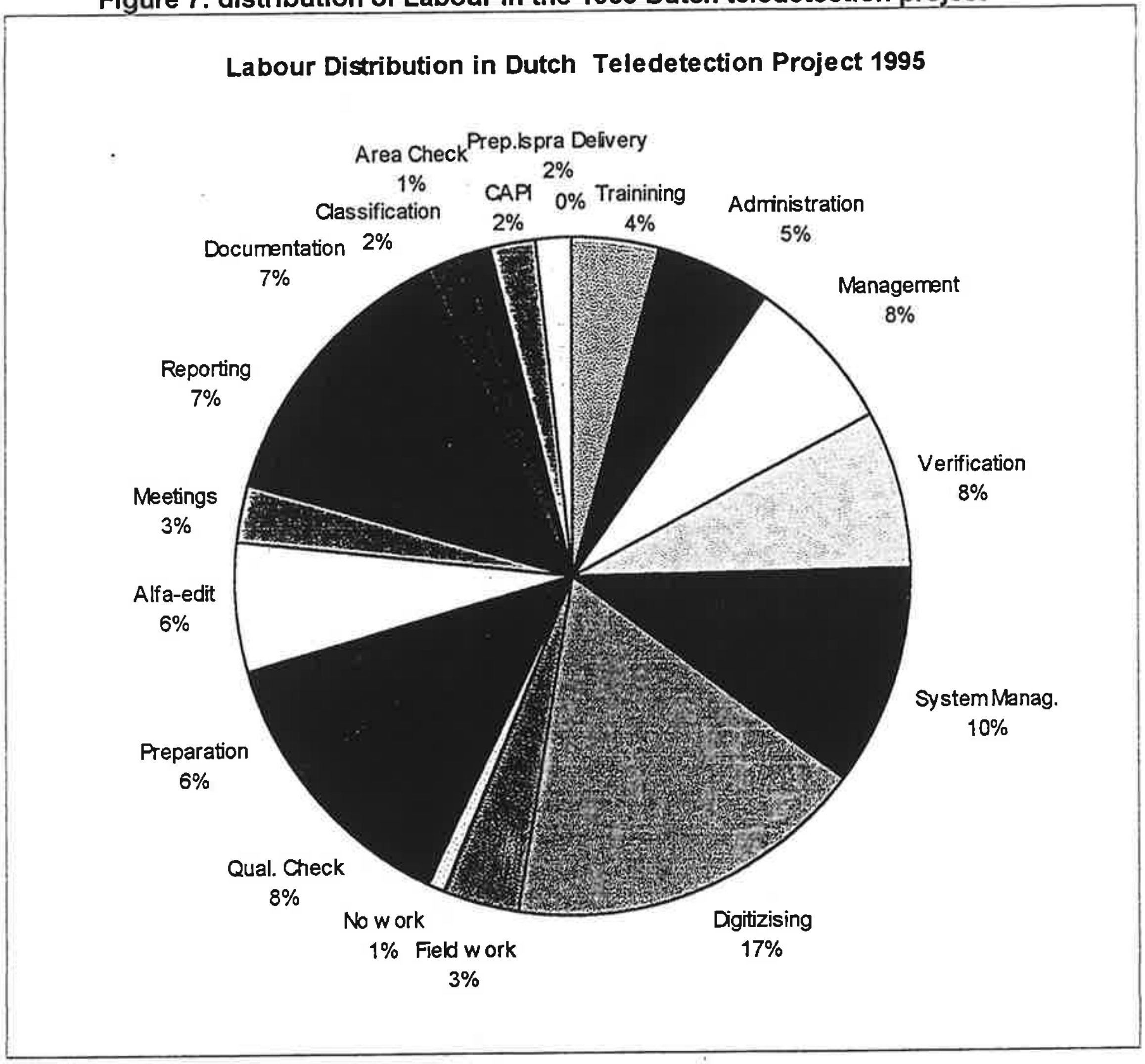


Figure 7: distribution of Labour in the 1995 Dutch teledetection project



Cost-effectiveness

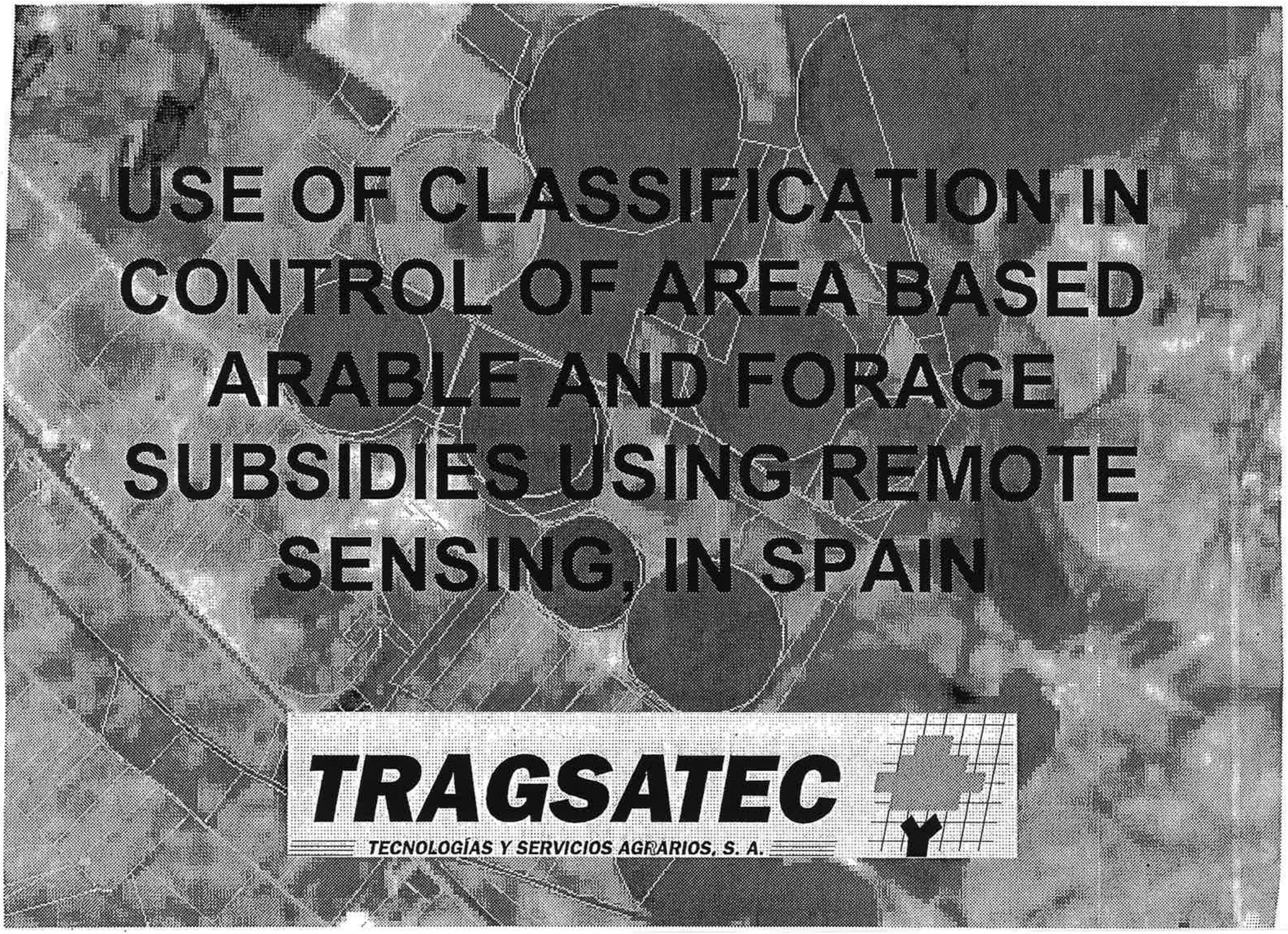
Figure 7 indicates the distribution of labour in the Dutch Teledetection project. Clockwise from the top, the following work categories may benefit from an explanation:

- Preparation for Ispra Delivery stands for the preparation of the Quality control data in Cachoo format;
- Training involves the training and familiarisation period of the temporary personnel for digitising;
- Verification includes the time spent on pre-input quality checks;
- System Manag. stands for System management, system tuning and support;
- 'No work' indicates the mismatch between processing capacity and dossier delivery by zone during the digitising phase;
- Preparation stands for Image pre-processing and the set-up of the FACTS GIS environment;
- Reporting stands for reporting to the administrations;
- Documentation stands for preparation of field reports and image map preparation.

As indicated in the introduction, the labour distribution gives a good indication of the efficiency automation process. While in 1995 the system was undergoing a fair amount of development and tuning its productivity was already considerable: All diagnosis activities including classification (and decision-modelling), area check and CAPI together took no more than 5 % of the project's labour resources. Also the digitising effort for all plots, with 17 % rates favourably.

Conclusions on the role of automated decision modelling in the FACTS Teledetection approach:

- Automated crop diagnosis is only one of the many optimisations that have been developed to improve cost-effectiveness and operator efficiency
- The automation allowed all tasks in the Dutch 1995 Teledetection project to be carried out by three permanent staff members with the assistance of temporary personnel during the input phase (four) and for alphanumeric input and field work.



USE OF CLASSIFICATION IN CONTROL OF AREA BASED ARABLE AND FORAGE SUBSIDIES USING REMOTE SENSING, IN SPAIN

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TECNOLOGÍAS Y SERVICIOS AGRARIOS, S. A.

USE OF CLASSIFICATION IN CONTROL OF AREA BASED ARABLE AND FORAGE SUBSIDIES USING REMOTE SENSING, IN SPAIN

USE OF CLASSIFICATION IN CONTROL OF AREA BASED ARABLE AND FORAGE SUBSIDIES USING REMOTE SENSING, IN SPAIN

1.- USING CLASSIFICATION AS A SUPPORT TO COMPUTER ASSISTED PHOTO - INTERPRETATION (CAPI). WHY?

2.- INFORMATION HANDLED BY THE PHOTOINTERPRETERS.

3.- CLASSIFICATION AND ITS USE.

4.- CLASSIFICATION RESULTS IN ‘95 CONTROL.

5.- CONCLUSIONS.

1.- USING CLASSIFICATION AS A SUPPORT TO COMPUTER ASSISTED PHOTO - INTERPRETATION (CAPI). WHY?

1.1. EXECUTION FRAMEWORK AT PLOT LEVEL EVALUATIONS

- 224,447 declared AGRICULTURAL PARCELS, in 12 control SITES, with 4 or 5 strata/site.
- Declaration basis: on cadastral maps over 133,655 CADASTRAL PLOTS, 184,302 PHOTOINTERPRETED SUB-PLOTS.
- 3 GROUPS OF 9 PHOTOINTERPRETERS during 20 WEEKS (approx.).
- SHORT plot level EVALUATION PERIOD from the last image reception (3-4 days per control site).

1.- USING CLASSIFICATION AS A SUPPORT TO COMPUTER ASSISTED PHOTO - INTERPRETATION (CAPI). WHY?

1.1. EXECUTION FRAMEWORK AT PLOT LEVEL EVALUATIONS

- 12 DIFFERENT GROUPS OF CROPS in post-classification key.
- 10 LAND USES to identify through CAPI:
  - dominant (2): cereals (1^{st} phase) and sunflower (2^{nd} phase)
  - marginal (4): flax, rape/soya bean, protein crops, pulses.
- 10,070 REFERENCE PLOTS (field survey) on 142 cadastral polygons.
- Average acreage per plot 3.64 ha, and less than 2 ha in 5 control sites.

1.2. PROBLEMS USING CAPI

- DIFFERENT PHOTOINTERPRETERS MAY SHOW DIFFERENT RESULTS
- PHOTOINTERPRETERS RESULTS MAY VARY IN TIME
- DIFFICULTY IN INTEGRATION AND USE OF FIELD SURVEY REFERENCES.
- DIFFICULTY IN ASSESSING CAPI QUALITY.

- STRONG SUPERVISION REQUIREMENTS TO ASSURE QUALITY

- USE OF CLASSIFICATION AS CAPI SUPPORT

1.3. ADVANTAGES AND LIMITATIONS OF USING CLASSIFICATION

ADVANTAGES

- SYNTHETIC, OBJECTIVE AND STATISTICALLY CONTROLLED images: good complement for raw images and NDVI
- EASY EVALUATION OF PRECISION in land use recognition.
- Implementation of AUTOMATIC INTERPRETATION RULES for Pattern Recognition Model using a “SEMI-SUPERVISED METHOD”: clustering + radiometric class identification based on field survey references.
- TIME REDUCTION FOR CAPI due to the use of semiautomatic diagnosis at plot level under certain circumstances.

1.3. ADVANTAGES AND LIMITATIONS OF USING CLASSIFICATION

LIMITATIONS

- **ONLY SPECTRAL INFORMATION** at pixel level. Raw and NDVI images also provide information about texture, structure and plot environment.
- Mainly used in **PLOTS OF EASY DIAGNOSIS**. Need of raw and NDVI images in difficult cases.
- **QUALIFIED PERSONNEL** required in image processing - less flexible and more expensive than photointerpreters.

1.4. TWO POSSIBLE WAYS OF USING CLASSIFICATION

AS CAPI SUPPORT

- ADVANTAGES
  - BETTER CONTROL of photointerpretation with the same time for image analysis
- DISADVANTAGES:
  - At plot level: no information is given about identification precision.

FOR AUTOMATIC PHOTOINTERPRETATION

- ADVANTAGES
  - LESS TIME (only for simple cases)
- DISADVANTAGES:
  - Longer preparation and analysis time

1.5.- CHOSEN METHOD: CLASSIFICATION AS SUPPORT FOR CAPI

- FACTS:
  - TIME is the LIMITING FACTOR for results delivery (3-4 days from last image reception)
  - Need for more CONTROL in plot diagnosis (all plots evaluated with the same criteria)

- USAGE CRITERIA: ONLY WHEN PRECISION IS GUARANTEED
  - Identification Precision (I.P.) ≥ 70%
  - Cartographic Precision (C.P.) ≥ 2%

2. INFORMATION HANDLED BY THE PHOTOINTERPRETERS

ON SCREEN

- CLASSIFIED IMAGE (only optimum land use classes are coloured)
- RAW IMAGES
- VEGETATION INDEX
- DECLARED LAND USE

between the
available are

2. INFORMATION HANDLED BY THE PHOTOINTERPRETERS

SYNTHESIS REPORT

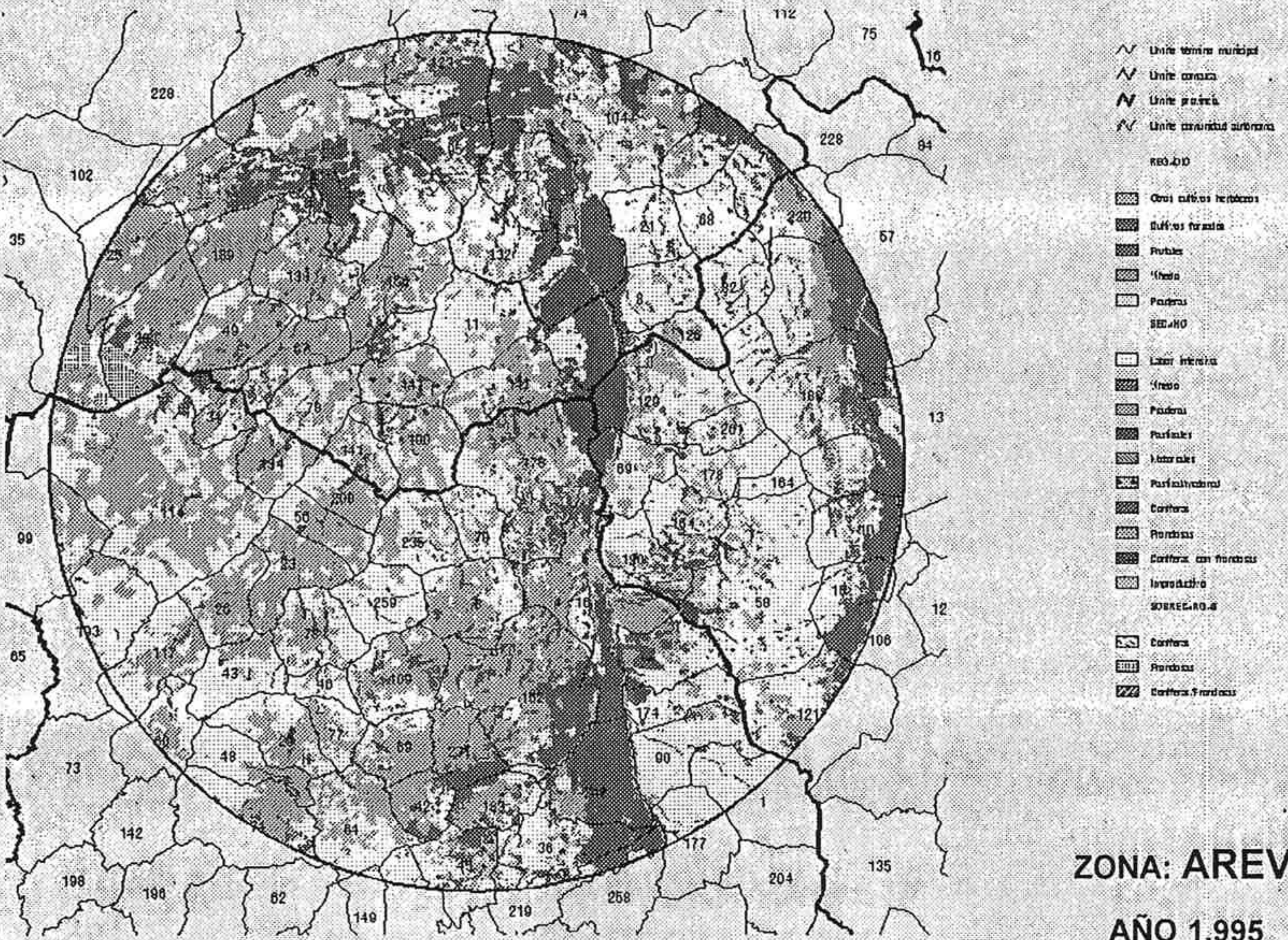
- PHOTOINTERPRETING RULES DOCUMENT (for each site and phase):
    - Land uses colours, I.P. and C.P.
    - Identification of land uses that are difficult to recognize or may look different in the images (ie. irrigable/dry land).
    - Comments about crop vegetative period, draught influence, ...
- FIELD SURVEY REPORT
- CROP CALENDAR
- LAND USE CARTOGRAPHY
- REGIONALIZATION CARTOGRAPHY (strata site in homogeneous regions for irrigation/dry land crop production)

CROP CALENDAR
CONTROL SITE: AREV (CASTILLA Y LEÓN)

CROP	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.
DRY BROAD BEAN	20	30	20			10	20				85	15
LENTIL VETCH	30	10				10	50			15	85	
LENTILS		30	10				40	20		10	90	
BARLEY 6C					30	45	25				70	30
WHEAT		50	35	5	5	5					30	70
BARLEY 2C					35	40	25				70	30
DRY PEAS	10	15				5	60	10		20	70	10
BEET (Summer harv.)												
BEET (Winter harv.)		5	30	35	20	10	45	50	5			
CHICK-PEA							10	90			45	55
SUNFLOWER	5	80	10					20	5	75		
SOYA BEAN		100								100		
DRY BEANS	35	65						10	90			
MAIZE		30	20	15	30	5		30	70			

▩ 10 **SOWING** (% SURFACE) ▨ 10 **HARVEST** (% SURFACE)

LAND USES ACCORDING TO CROP AND USE MAP Scale: 1:50.000



ZONA: AREV

AÑO 1.995

Escala: 1:325000

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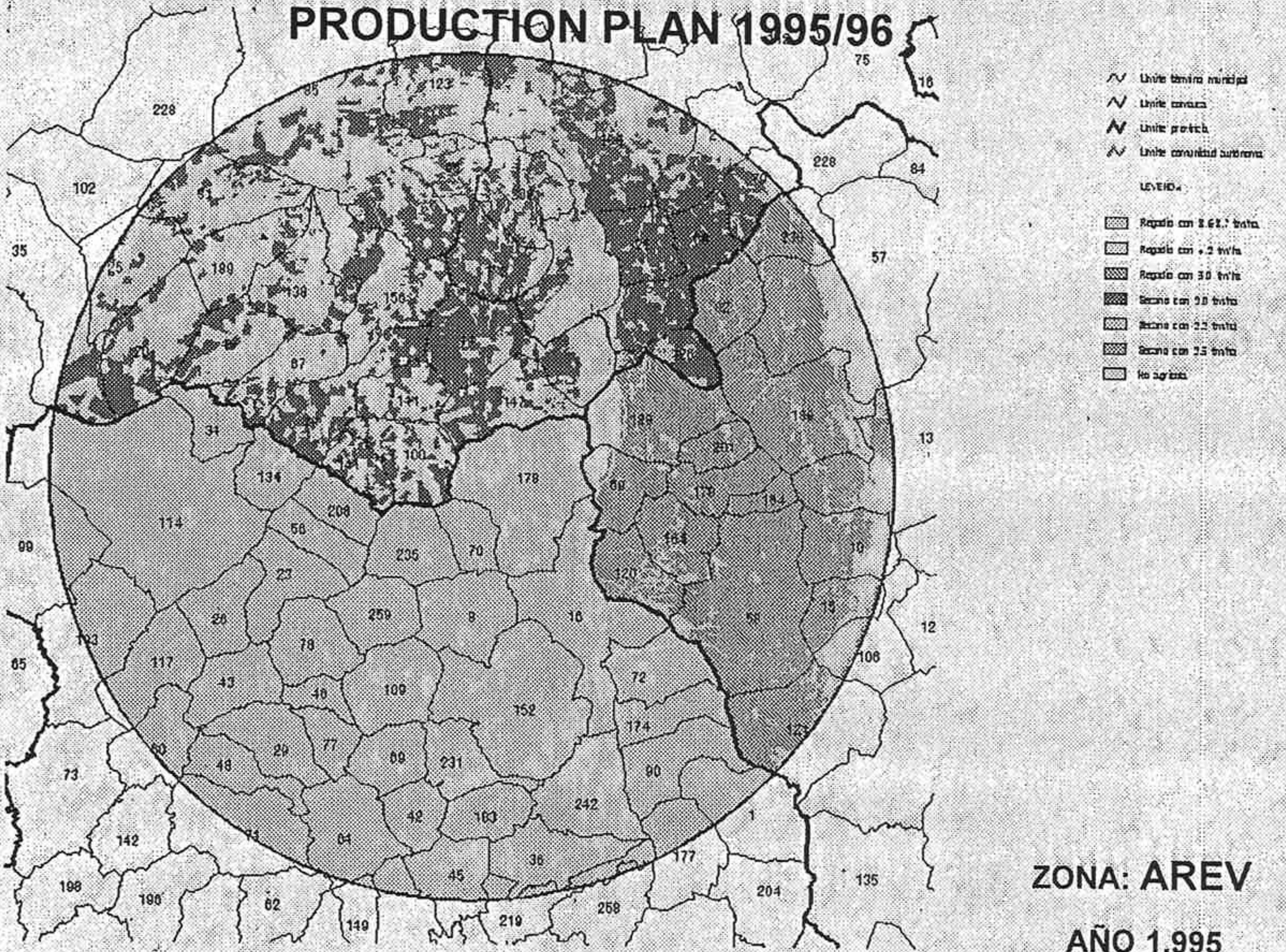
STRATIFICATION ACCORDING TO CROP MAP AND REGIONAL PRODUCTION PLAN 1995/96



ZONA: AREV

AÑO 1.995

Escala: 1:325000

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3. CLASSIFICATION AND ITS USE

3.1. KEYS FOR SUCCESS IN CLASSIFICATION

- ADEQUATE IMAGE DATE (requires good knowledge of crop calendars)
- FIELD SURVEY REPRESENTATIVE OF REALITY

3.2.- REPRESENTATIVE FIELD SURVEY DEFINITION

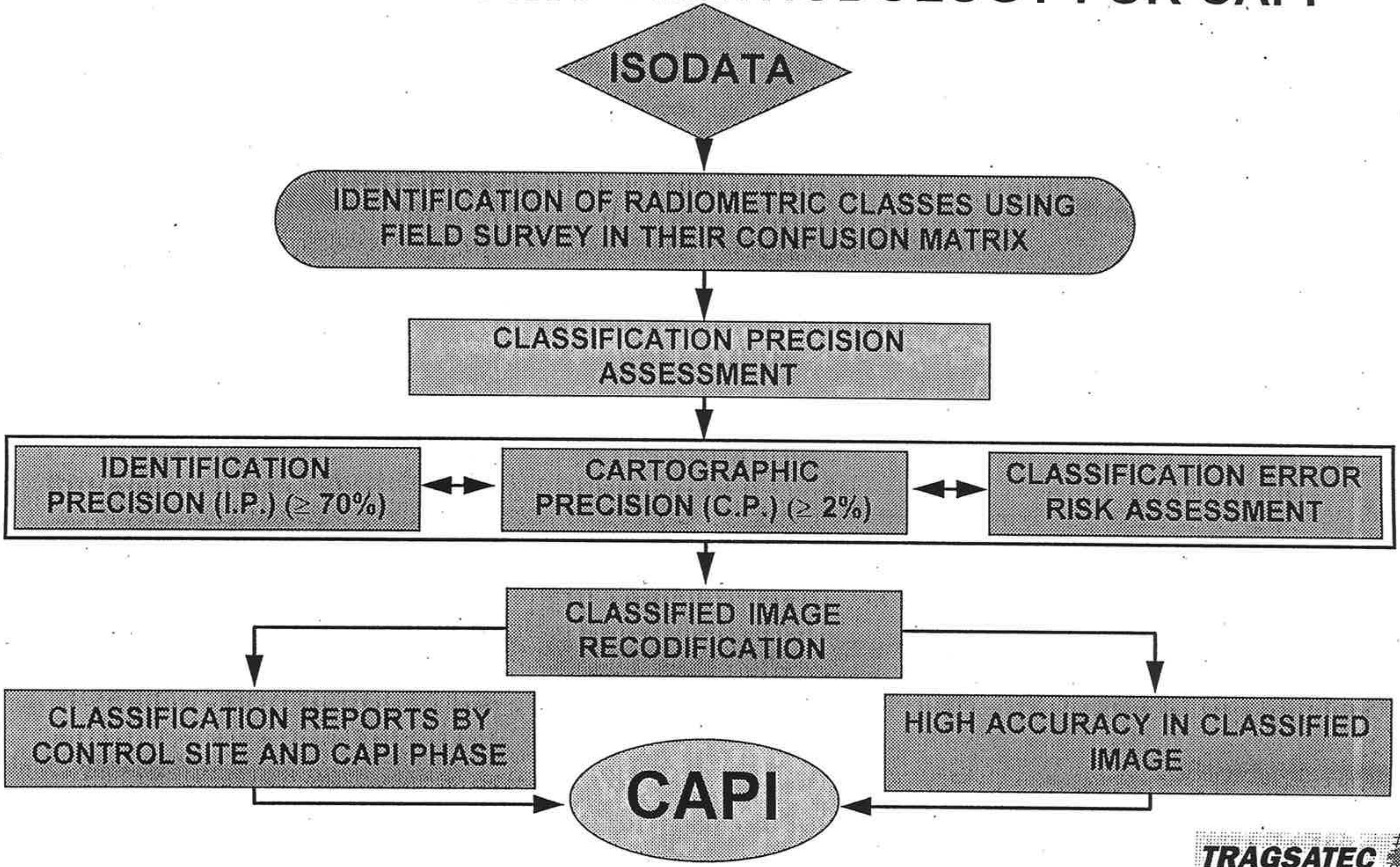
- BASIS: PREVIOUS YEAR DECLARATIONS
- CRITERIA: BALANCE OF DECLARED AND SURVEYED USES
- METHODOLOGY:
  - CADASTRAL POLYGON SELECTION BASED ON THE STRATIFICATION AND RELATED TO:
    - NUMBER of declared plots in the polygon.
    - DIVERSITY of declared land uses on the map.
    - ACCESSIBILITY to the polygon area.
  - PLOT SELECTION AIMING AT A MINIMUM NUMBER OF PLOTS PER LAND USE AND PER SITE (25 PLOTS/USE, EXCEPT FOR MARGINAL CROPS).

3.3.- FIELD SURVEY DATA IN ‘95 CONTROL

10,070 surveyed plots (4.5% of declared plots)

	'95 DECLARATIONS		'95 FIELD SURVEY	
	Number of plots	%	Number of plots	%
CEREALS	104.942	47	4.236	42
MAIZE	9.478	4	572	6
SUNFLOWER	14.775	7	621	6
OTHER OILSEEDS	1.034	1	37	1
PROTEIN CROPS	2.257	1	93	1
PULSE CROPS	2.898	1	91	1
SET ASIDE / FALLOW	61.000	27	2.027	20
FORAGE CROPS	15.726	7	1.007	10
OTHER	12.367	6	1.386	14
TOTAL	224.477	100	10.070	100

3.4. CLASSIFICATION METHODOLOGY FOR CAPI



ISODATA

IDENTIFICATION OF RADIOMETRIC CLASSES USING FIELD SURVEY IN THEIR CONFUSION MATRIX

CLASSIFICATION PRECISION ASSESSMENT

IDENTIFICATION PRECISION (I.P.) (≥ 70%)

CARTOGRAPHIC PRECISION (C.P.) (≥ 2%)

CLASSIFICATION ERROR RISK ASSESSMENT

CLASSIFIED IMAGE RECODIFICATION

CLASSIFICATION REPORTS BY CONTROL SITE AND CAPI PHASE

HIGH ACCURACY IN CLASSIFIED IMAGE

CAPI

3.5.- CLASSIFICATION EVALUATION EXAMPLE

CLASS FIELD	1	2	3	4	TOTAL	CP
CEREALS	130	-	10	5	145	90%
MAIZE	5	80	5	-	90	89%
PULSE CROPS	-	3	15	2	20	75%
FALLOW	18	15	7	20	60	33%
TOTAL	153	98	37	27	315	

	1/Cereals	2/~~Sunflower~~ Maize	3/Pulses	4/Fallow
IP	85%	82%	40%	74%

Identification of:
1 = Cereals
2 = Sunflower
3 = Fallow

4.- CLASSIFICATION RESULTS IN '95 CONTROL

PRECISION FOR CROP IDENTIFICATION USING CLASSIFICATION

SITES	ALBA		AREV		ARRO		BALE		BELC		CIUD		EJEA		EMPO		JERE		SALV		VALD		VILL	
CROPS	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP	CP	IP
CEREALS	58	82	92	90	87	95	28	76	53	81	61	82	41	77	18	74	31	83	83	87	45	82	81	88
FALLOW	36	70	28	83	-	-	4	72	31	76	2	80	-	-	-	-	-	-	14	74	-	-	81	80
FORAGE CROPS	71	98	-	-	-	-	13	86	-	-	29	94	59	82	9	91	-	-	-	-	-	-	-	-
PULSE CROPS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OIL SEEDS	56	86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUNFLOWER	-	-	50	84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34	75	19	68	37	77
MAIZE	54	78	-	-	16	80	-	-	-	-	-	-	51	76	2	97	-	-	-	-	-	-	90	88
NON ELIGIBLE	77	91	56	89	78	93	51	89	14	74	47	82	14	96	64	94	16	79	16	80	57	86	1	75

TRAGSATEC
TECNOLOGÍAS Y SERVICIOS AGRARIOS, S. A.

Classification is more synthetic than vegetation index.

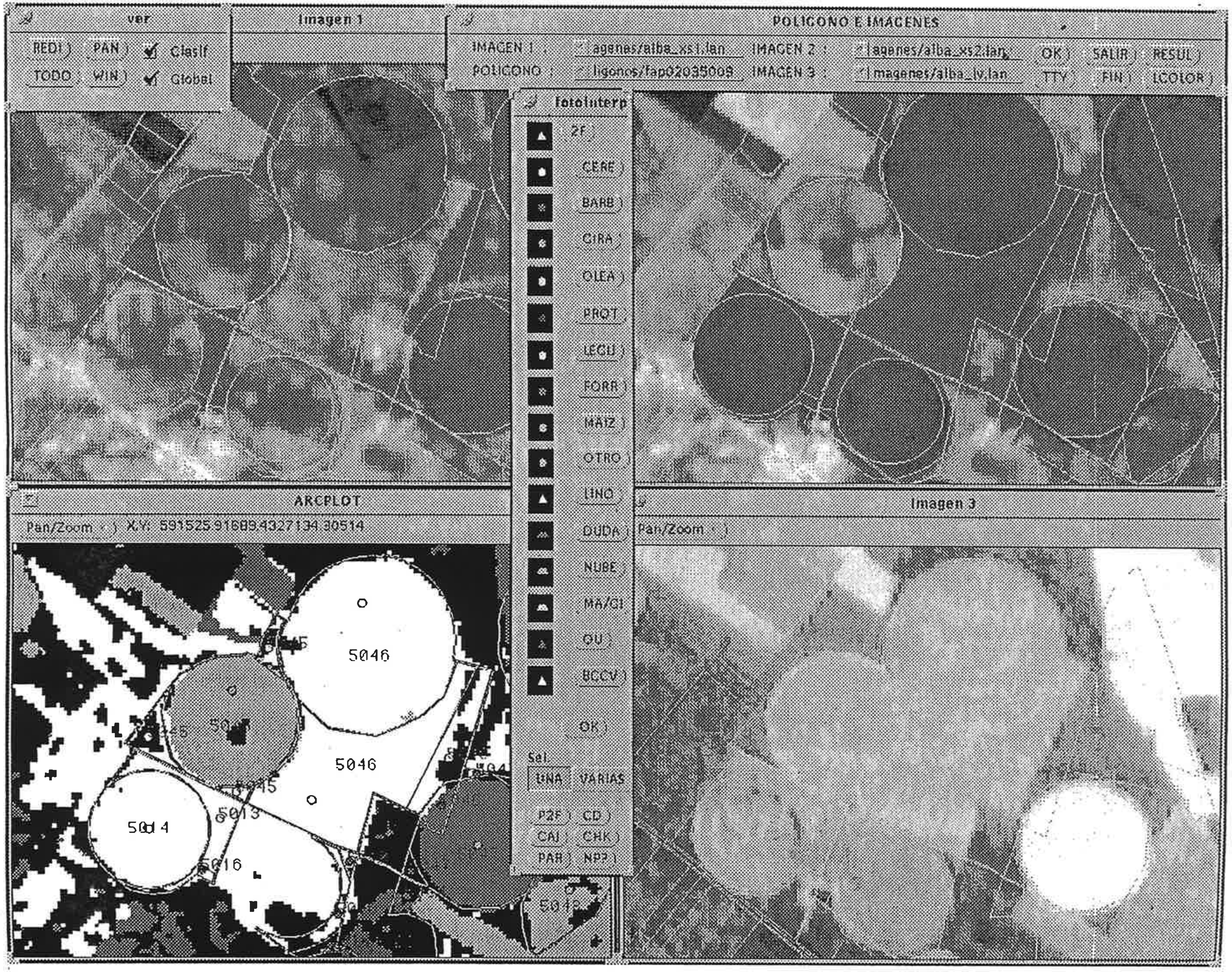


IMAGEN 1 : agenes/alba_xs1.lan

IMAGEN 2 : agenes/alba_xs2.lan

POLIGONO : ligonos/fap02035009

IMAGEN 3 : magenes/alba_iv.lan

X,Y: 591525.91689.4327134.30514

☑ Clasif

☑ Global

POLIGONO E IMAGENES

IMAGEN 1 : …agenes/vill_xs1.lan
POLIGONO : …ligonos/fap49051001
IMAGEN 2 : …agenes/vill_xs2.lan
IMAGEN 3 : …agenes/vill_iv1.lan

X,Y: 291565.87420,4639594.53106

Vegetation index is more homogeneous than classification.

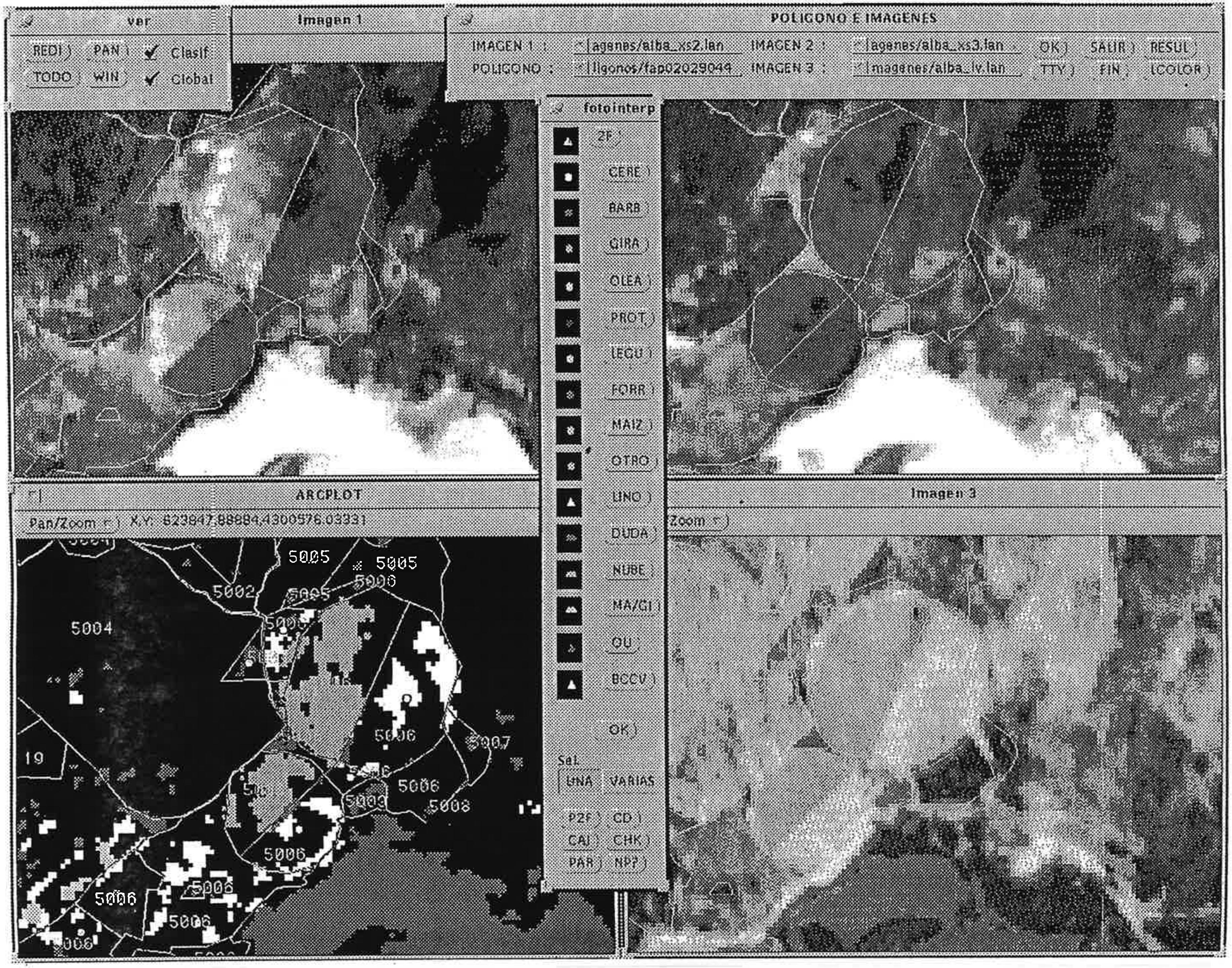


IMAGEN 1 : …lagenes/alba_xs2.lan

IMAGEN 2 : …lagenes/alba_xs3.lan

POLIGONO : …lligonos/fap02029044

IMAGEN 3 : …limagenes/alba_lv.lan

X,Y: 623847.88884,4300576.03331

5.- CONCLUSIONS
USING CLASSIFICATION AS CAPI SUPPORT

- MORE SYNTHETIC AND HOMOGENEOUS INFORMATION.
- ALLOWS AN EASY AND CONTROLLABLE EXTRAPOLATION OF FIELD SURVEY DATA TO ALL THE AREA UNDER EVALUATION.
- REDUCED PREPARATION TIME FOR IMAGE ANALYSIS.
- BETTER CONTROL DURING PHOTOINTERPRETING PROCESS, AND KEEPING DEADLINES.

ALLOWS **CAPI** IMPROVEMENT
WITHOUT INCREASING TIME REQUIRED
FOR IMAGE INTERPRETATION

CONTRÔLE PAR TÉLÉDÉTECTION - 1995

CLASSIFICATION ET CONTRÔLE AUTOMATIQUE

Réunion de clôture CONTRÔLE 95
Novembre 1995 - Baveno

Pierre-Noël PASCAUD

- ▼ Objectifs
- ▼ Méthodologie
- ▼ Résultats
- ▼ Conclusion

SOTEMA

OBJECTIFS

▼ **VALIDER**
le plus grand nombre possible de parcelles sans intervention humaine.

▼ **OBTENIR** un taux d'erreurs très bas.

▼ **RÉDUIRE** coûts et délais.

SOTEMA

MÉTHODOLOGIE

▼ Segmentation automatique

▼ Classification non supervisée des parcelles

▼ Reconnaissance des classes

▼ Contrôle qualité

▼ Validation des parcelles

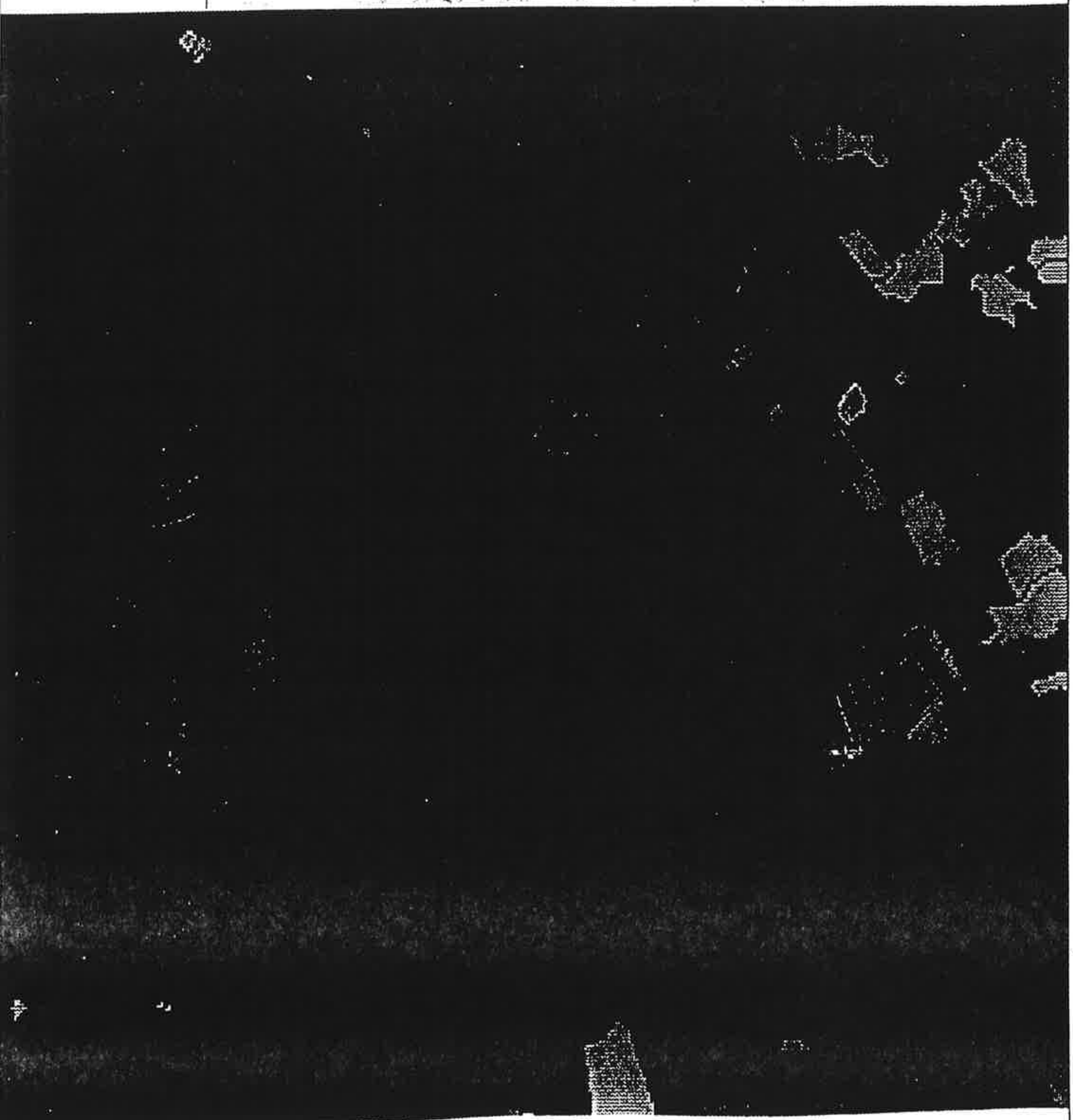
CONTROLE PAR
TELEDETECTION
DES AIDES AUX
SURFACES CULTIVEES
ET AU CHEPTEL

15

helle 1:30 000

N

CADASTRE DE
WARLOY-BAILLON
SUR CLASSIFICATION
32 CLASSES
DE L'IMAGE SPOT XS
DU 28/04/93



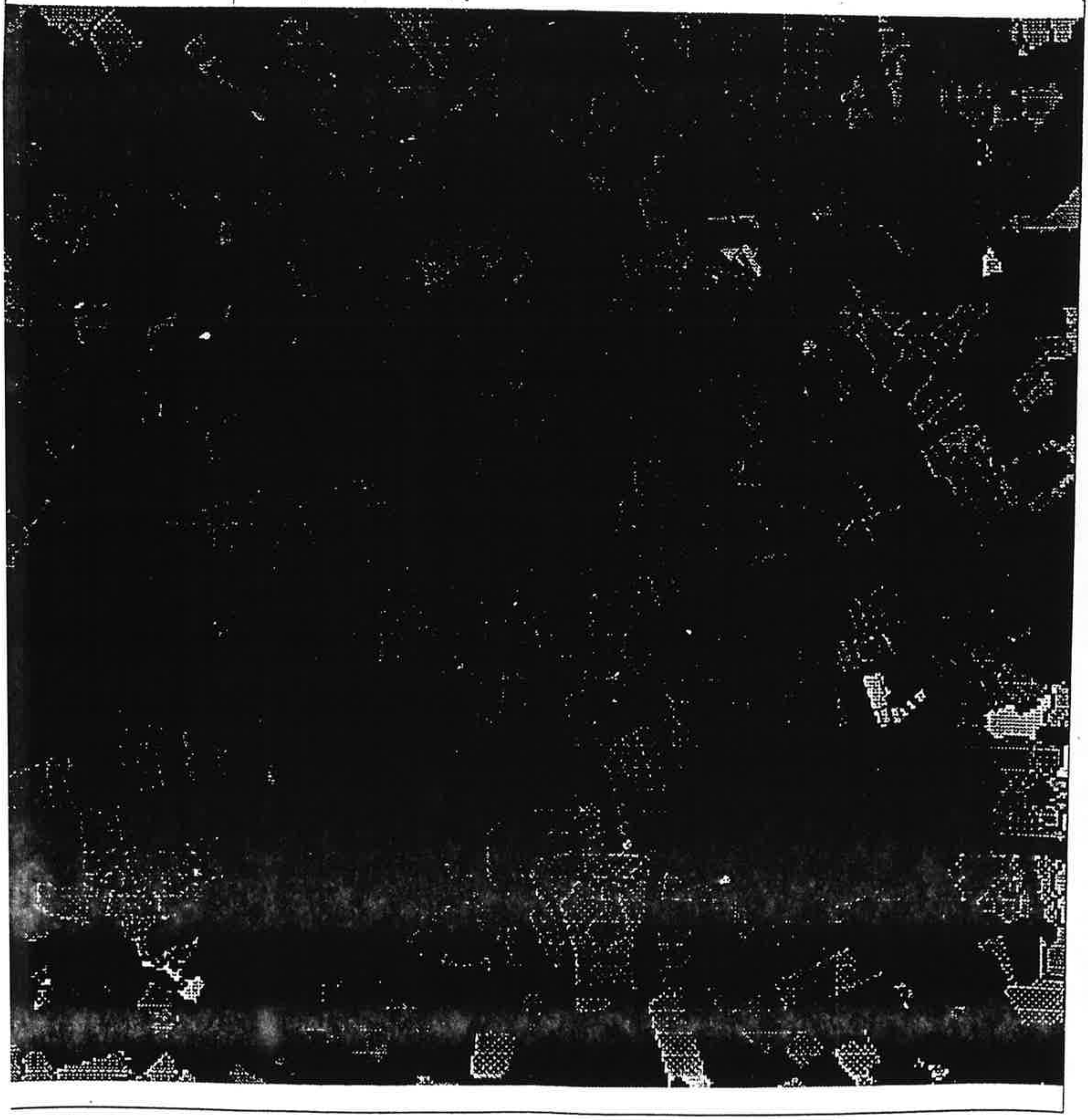
CONTROLE PAR TELEDETECTION DES AIDES AUX SURFACES CULTIVEES ET AU CHEPTEL

Echelle 1:30 000

CADASTRE DE WARLOY-BAILLON SUR CLASSIFICATION SEGMENTEE DES IMAGES DU 28/04/93 ET DU 07/08/93

Marron: jacheres + proteagineux
Jaune: cereales d'hiver
Rouge: cultures d'ete
Vert clair: prairies
Vert fonce: bois

Bleu sombre: sol nu urbain
Orange et beige: cultures de printemps
Blanc: non classe



SOTEMA

CONTRÔLE QUALITÉ

Site 3
Matrice de confusion

		LEGENDE OBSERVATIONS TERRAIN														
		Maïs sec	Colza d'hiver	Pois sec	Jachère	Blé tendre	Fourrages	Prairies temporaires	STH	Vigens et vergers	Autres utilisations	Orge	Avoine	Seigle		
LEGENDE CLASSIFICATION	CLASSE	1	5	9	10	12	14	15	16	19	20	21	22	25	TOTAL en points	Taux de reconnaissance
Colza	2	0,00	100,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	12	100
Classe hétérogène	3	7,81	1,56	0,00	10,94	35,94	0,00	3,13	20,31	0,00	0,00	17,19	3,13	0,00	64	
Pois	7	1,92	1,92	[illegible]	0,00	0,00	5,77	0,00	1,92	0,00	5,77	0,00	0,00	0,00	52	82,69
Céréales, prairies	10	0,00	0,00	0,00	17,65	2,94	0,00	2,94	61,76	0,00	2,94	11,76	0,00	0,00	34	
Cultures P. et autres	13	6,25	0,00	43,75	0,00	0,00	0,00	12,50	12,50	0,00	25,00	0,00	0,00	0,00	16	
Céréales	15	0,00	0,00	0,00	0,00	75,94	0,00	0,47	3,30	0,00	0,47	13,68	4,25	1,89	212	95,76
Prairies	16	0,00	0,47	0,00	0,47	3,77	0,00	3,30	88,21	0,47	0,00	2,83	0,47	0,00	212	91,51
Maïs	18	[illegible]	0,00	0,86	6,87	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00	0,00	233	89,27
Sols nus	19	57,50	0,00	0,00	42,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	40	
Non agr[illegible]	20	100,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1	
Classe hétérogène	21	40,00	0,00	0,00	20,00	0,00	0,00	0,00	0,00	0,00	40,00	0,00	0,00	0,00	5	
TOTAL en points enquêtés		241	15	52	48	193	3	13	231	1	18	50	12	4	881	
TOTAL en pourcentage		*27,36*	*1,70*	*5,90*	*5,45*	*21,91*	*0,34*	*1,48*	*26,22*	*0,11*	*2,04*	*5,68*	*1,36*	*0,45*	*100*	

Validation des parcelles

▼ **Croisement déclaration - classification**

▼ **Test**

Surface et occupation déclarées acceptées

si

Surface bien classée > 90% pour les parcelles > 7 ha

ou

Surface bien classée > 80% pour les parcelles < 7 ha

et si

la surface mal classée (maximum 10 ou 20%)
ne comporte aucune composante photo-interprétable

SOTEMA

RÉSULTATS

Efficacité du traitement automatique

Nombre de parcelles culturales par îlot ou parcelle cadastrale	Nombre de parcelles culturales	*Pourcentage*	Superficie	*Pourcentage*
1	19 519	*42,69*	36 841	*41,13*
2	1 357	*10,96*	4 833	*12,87*
3	167	*3,19*	630	*3,25*
4	31	*1,20*	177	*1,61*
5	4	*0,32*	12	*0,20*
6	10	*1,61*	30	*0,82*
TOTAL	21 088	*30,92*	42 523	*25,06*

CULTURE	*Pourcentage parcelles*
Prairies naturelles	46
Prairies temporaires	28
Fourrages	17
Céréales	45
Colza	53
Maïs grain	33

CONCLUSION

- ▼ Utilisation en France
  1993 : 200 dossiers
  1994 : 1 700 dossiers
  1995 : 3 700 dossiers
- ▼ Taux de reconnaissance
  30 - 40% des parcelles agricoles
- ▼ 5 fois plus rapide que la PIAO
- ▼ En 1994 : aucune erreur

SESSION 4

Satellite image and/or aerial photography

Baveno 01/11
21-22 Nov. 1995

IMAGES SATELLITES et/ou PHOTOS AERIENNES : *BILAN ET SYNTHESE 1995*

1. **Les critères d'évaluation**
2. **Les données de base**
3. **Les traitements d'image**
4. **Les méthodes de mise en oeuvre**
5. **Les choix techniques 1995**
6. **Les résultats 1995**

Baveno 02/11
21-22 Nov. 1995

IMAGES SATELLITES et/ou PHOTOS AERIENNES :

1. Les critères d'évaluation

1.1 Tamisage des dossiers :

- Minimisation des vérifications sur place

1.2 Fiabilité des décisions :

- Absence de faux positifs et de faux négatifs

1.3 Respect des délais :

- Adaptation au calendrier cultural
- remise des résultats avant récolte

1.4 Minimisation des coûts :

- prix par dossier,
- charges administratives

1.5 Opposition probante:

- possibilité d'archivage
- clarté des documents

1.6 Complexité technique :

- acquisition des données
- traitements et interprétations

IMAGES SATELLITES et/ou PHOTOS AERIENNES :

2. Les données de base

2.1 Acquisition:

- Contraintes de programmation
- Blocs/Bandes
- Répétitivité

2.2 Flexibilité :

- Analyse de risque: taille du site

2.3 Délais :

- 10 tentatives -> 20 à 30 jours
- photos de 95, 3 semaines

2. Les données de base

2.4 Géométrie

- satellite: numérique corrigé
- photo: analogique brut

2.5 Contenu d'information :

- satellite: 1, 3, 5 canaux utiles
- photo: 1 ou 3 couches, stéréoscopie

2.6 Volumes des fichiers :

- satellite spot : 10K/Km^2
- photo N/B : 1M/Km^2
- volume utile, recouvrement

2.7 A quel prix ?

- Spot: 1 ECU/Km^2
- B/N 1/40.000: 3 ECU/Km^2
- sur site de 500 km^2?

IMAGES SATELLITES et/ou
PHOTOS AERIENNES :

3. LES TRAITEMENTS

3.1 Scannage

- 30 min / photo
- géométrie : 2μ contre 25μ
- résolution : perte √2
- 64-256 niveaux de gris: réglages

3.2 Géométrie

- Agrandissement: Italie 85-94, PO 95
- Polynomes: photo 20.000 5-10 m
  satellite 30-40 m
- Ortho: photo 40.000 2-3 m
  Spot P 15-20 m

3.3 Fusion image / carte

- échelles : 1/2.000 à 1/10.000
- rater/vecteur
- codage sur 8 bit: It

3.4 Améliorations

- rééchantillonnage: scannage, corrections
- filtrage: fourier sur vignoble

IMAGES SATELLITES et/ou
PHOTOS AERIENNES :
BILAN ET SYNTHESE 1995

4. METHODES DE TRAVAIL 1995

4.1 Satellite multidate seul:

- D,DK,El,F,Ir,Nl,Po,SP,UK

4.2 Photo monodate et visite rapide :

- systématique 100%: It,Po,Andalousie
- partielle 30-40% : B,Sirs,Octopus

4.3 Photo monodate et satellite multidate:

- Suède, Finlande, Sirs

4.4 Fusion photo/image:

- abandonné

5. LES CHOIX TECHNIQUES 1995

B	**1/30.000**	**couleur**	**Agfa H100**
SP	**1/20.000**	**couleur -> N/B**	**Kodak Pan 2415**
F	**1/20.000**	**I.R.C.**	**Kodak IR 2443**
It	**1/40.000**	**N/B**	**Kodak Pan 2412**
Po	**1/40.000**	**N/B I.R.**	**Agfa Pan 50**
Fin	**1/55.000**	**N/B**	**Kodak Plus X**
Sv	**1/60.000**	**N/B**	**Kodak Double X**

IMAGES SATELLITES et/ou PHOTOS AERIENNES :
BILAN ET SYNTHESE 1995

6. RESULTATS 1995

Taux de tamisage

	Photo			Photo-Sat			Satellite	
	Ref	Inc		Ref	Inc		Ref	Inc
B	20	29	Fi	10	4	Dk	12	2
Sp	60	0	Sv	2	4	D	2	7
It	30	0	F	11	13	El	23	28
Po	28	25				Sp	27	4
Po	37	11				F	7	13
						Ir	3	5
						Nl	9	1
						Uk	1	.3
Mé	30	11		10	4		8	4.5

IMAGES SATELLITES et/ou PHOTOS AERIENNES :

BILAN ET SYNTHESE 1995

Les prix par dossier

Photo		**Photo-Sat**		***Satellite***	
B	**109**	**Fi**	**164**	**Dk**	**153**
Sp	**91**	**Sv**	**295**	**D**	**275**
It	**93**	**It**	**124**	**El**	**116**
Po	**116**	**F**	**663**	**Sp**	**114**
Po	**155**			**F**	**327**
				Ir	**111**
				Nl	**143**
				Po	**130**
				Uk*	**423**
Méd	**109**		**180**		**143**

Baveno 10/11
21-22 Nov. 1995

IMAGES SATELLITES et/ou PHOTOS AERIENNES :

BILAN ET SYNTHESE 1995

Délais de remise des dossiers

		min	max
photos	**début**	**15.07 Sp**	**15.11 Po**
	fin	**08.09 B**	**31.12 It**
photo-sat	**début**	**25.07 F**	**21.08 Fi**
	fin	**20.08 F**	**01.09 Sv**
satellite	**début**	**31.05 Sp**	**29.09 El**
	fin	**07.07 D**	**??.11 Po**

Baveno 11/11
21-22 Nov. 1995

IMAGES SATELLITES et/ou PHOTOS AERIENNES :
BILAN ET SYNTHESE 1995

?

Cop
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CONTRIBUTION TO THE JRC BAVENO MEETING
(Preliminary Copy)

By a very long time, aerial photography is massively used in agricultural projects and inventories and, in the last ten years, has overtaken remote sensing from space also for agricultural controls, for reasons that I shall briefly summarize:

1) The need to have high resolution information
2) The need to match the surveyed data with the existing geographical and cadastral data related to the property
3) The need to replace or substitute, at least partially, those documents that are lacking or insufficient
4) The need of obtaining unimpeacheable documentation, even from a legal viewpoint, that reduces possible contentiousness between the producers and the organizations charged with payments and controls
5) The need to have with certainty the imagery within the seasonal period of adequate crops' growth
6) The high innovation in methodology and technology of aerial photography and data treatment (high resolution, FMC, GPS) which reduces costs and time, and increases quality.

To fly higher and faster is the way to be sure to cover large areas in a very short time within a determined short seasonal period.
It is a problem for all the countries in the field of agricultural controls and registers, which involve satellite imagery, as well as aerial photography.
For example, to control herbaceous crops it is necessary not only that the land be in cultivation and the crop be identifiable during the aerial survey but also that the graphic products be available for field checking before harvesting and clearing of crops' residue. For trees, it is necessary not only that their foliage and ground vegetation permit the discrimination of the plants but, more, so it is necessary that the shadow from the trees' crowns or

from the rows does not cover nearby trees preventing their observation. Obviously, in any case the best meteorological condition is needed: no clouds, fog, haze, or smokes. This means that the available days during the year are few and the hours fewer yet.

For this reason the use of jet planes is strongly raccommanded for agricultural controls.

It is a particular type of aerial survey, at high altitude and for very large area, which permits flight plans with very long strips, conditions that use at the best the capability of the aircraft.

Recently, we have covered the Irish Republic within 17 calendar days using only one plane, a Lear Jet 25.

I believe that Irland's project is the largest one in Europe to have included principal point's calculation in WGS 84 system by the use of D-GPS. Our approach to GPS technologies does not emphasize its navigational aspect but, rather, is strongly involved in its aerial triangulation's potential.

We have used Leica's Ascot System on board and three ground stations, located in Dublin, Ennis and Sligo so, as to allow less than 200 Kms of distance between the ground receiver and the ASCOT.

We had good assistance by Leica and a perfect collaboration with the Ordnance Survey Office of Ireland, I believe from my experience, one of the best National Services in the world. This collaboration was particularly important cause we used new receivers and new software so, as you could imagine, problems were not simple.

One of the principal problems is the same in all aerial D - GPS surveys: to lose the signal or to have insufficient coverage by satellites. In Ireland this problem was dramatic, because the local weather conditions are so critical to carry out the aerial survey that the previous similar coverage had been executed in five (5) years. So, we decided together with the O.S.O. to take pictures, if the weather was good, even if we had no assureness of GPS recording.

That decision was very important and we used it at the maximum all the time that sun rays' inclination and meteorological conditions permitted us to fly. So, unbelievably, within 17 calendar days, of which 11 were operational, we finished the survey.

At the end, 12,598 Kms of flight divided in 78 strips and more than 5,000 photographs have been collected.

For what concerns post processing GPS data computation, only about 150 frames had been useless in order to be restored the results.

From our point of view, D-GPS on board is not a real advantage in navigation because our navigators have the same level of production (or better) without the system. However, the capability of determining the principal points with an accuracy of +/- 1 m is a real quality jump in the management of aerial photography survey projects. We strongly reccommand to give the entire responsability of ground points determination, aerial photography, and aerial triangulation to the same very specialized contractor, to save time and to have the highest level of assureness of good results.

The final result of the operation, in fact, is photographs' orientation data in national coordinates available only at the end with quality strictly depending on the accuracy obtained in the three phases above.

From the point of view of film's type, we have at our disposal two very good b/w emulsions, manufactured by Kodak and Agfa.

The papers furnished by the manufacturers present favourable characteristics for AGFA PAN 50.

Resolution power is nearly the same (KODAK PANATOMIC X 400 l/mm, AGFA PAN 50 410 l/mm) but AGFA FILM presents larger spectral sensitivity in the blue, in the red and near infrared spectrum's regions. For some special applications these characteristics are a real advantage, for example to discriminate water and land but, in the specific field of aerial flights for agricultural projects, I think that, in the final result, lenses, operators and processing are more important that the choice between these two films.

For what concerns aerial cameras, Wild RC 20 - 30 and Zeiss RMK - Top, from my experience, are both at the needed quality level.

We can consider three groups of cameras: the old ones, the high resolution and the state of the art. The best old cones, had an average resolution of 40 lp/mm and, at the best, mechanical solutions to compensate the forward motion effect.

High resolution cameras have a resolutive average power of about 70 lp/mm and Forward Motion Compensation Systems.

State of the art cameras have near 100 or more lp/mm and GPS standard interface (certainly FMC systems too).

Within the first group you can put Zeiss RMK.A, Zeiss Jena LMK, WILD RC10A; in the second WILD RC 20, Zeiss RMK TOP; state of art camera, in my opinion, is WILD RC 30.

Regarding other type of emulsion, we have 50 rolls of an excellent IRFC high resolution film, perfect to fly at very high altitudes. Unfortunately this film, Kodak SO131, is out of production and thus, it is not possible to forecast a general use of it, at the moment.

Colour higher resolution films, at the moment is Agfa H 100 PE 1 with a max. resolution power of 114 l/mm.

I want to remind you that colour film is a combination of 3 different emulsions so, the final grain of the image has not the same type of structure of b/w's one and that Colour film is more disturbed by haze and also by normal scattering than b/w one.

From my experience, acceptable conditions of atmosphere's scattering for b/w are critical for colour. In any case it is possible to use that type of films also at very high altitudes but I believe that it becomes disadvantageous if the final products are black and white photographic or digital documents, advantageous if it is photointerpretation.

I have a good dial of experience of flights at 12.000 meters or more because C.G.R. has carried out the coverage of the whole of Italy twice, in 88-89 and last year, at the scale of 1:75.000.

We used those pictures also for large scale orthophotos, for example 1:2.000, to video-update quickly cadastral maps and I can give you the state of the art situation from the digital orthophotomapping point of view. It is necessary to consider the problem in printing and in its video aspects. In video, we don't find large differences between 1:40.000 and 1:70.000 to produce orthophotos with 1 square meter pixels.

We start, in both the cases, with a 25µ scanning of the photos.

Obviously, the algorithms to produce the final imagery resample more in the case of 1:75.000 scale than in that of 1:40.000 but their quality on the screen is nearly the same.

I believe that there are no limits in the use of 1:75.000 photo scales for controls and also for olive tree registering but I have some dubts even of an 1:40.000 scale use for vineyards' registers.

The problems are in the field of radiometry and in resolution because, from the point of view of cartographic accuracy, I believe that the tolerances required for controls (4 meters on points and 6 meters on distances) are sufficient also for vineyard's registration. Vineyards are very difficult to photointerpret because of their structure and foliage and because, often, they are associated with trees and, at the ground level, herbaceous crops or grass result in a similar radiometry. In general, I think that the scale of the flights for controls and for olive trees' register must be determined, starting from 1:40.000, depending on the final subdivision of the maps. It must be adeguate to guarantee a good sidelap and the best ratio between map sheets and pictures.

I suggest higher altitude D-GPS flight when net points and DTM's are not available to simplify the Aerial Triangulation phase and because, in any case, the management of 4 times fewer pictures and the flying of 2 times less kilometers is a sizeable advantage.

Printing is the most difficult in the process, because of the quality and the costs of the products.

You can obtain good quality from both flights up to 1:5.000 orthophotomap scale. Larger scale print presents or too much lower level of quality or cost and time adequate for pilot projects and studies but not for an operational use for the control system.

Having a final digital orthophotomap's definition of 1 sqm/pixel implies that the volume of data in any case depends exclusively on the size of the final map.

A 25µ scanning of each aerial photograph needs nearly 100 MB of memory, independently of its scale.

This definition produces pixels with a regular dimension at the scannning scale but irregular at the terrain level.

So, each pixel need be resampled during the orthorectification.

Therefore, the final volume of data depends on the decision made about the rectified pixel's size. This means that, because computation is not the heaviest time consumer within the process, the main differences, using different scales could be in the scanning time of each picture and in the final quality of the resampling. Quality we have discussed before; about scanning time, also if you chose a 12,5µ scanning of the higher scale pictures, you will have near three times more scanning time but a quarter of pictures.

I wish to call to your attention another problem which is a main one, in my opinion, within the geographical data base used for controls and even more in registers. Each traditional cartographic product has a scale of reference which determines the accuracy and the content of the map. In digital cartography we have not a "scale" but one is always needed to define and to obtain general and local accuracy, also in raster form. This means that the user knows exactly which kind of data he is using throughout.

If there is a random lower accuracy the entire geographic data become unreliably.

If this happens, each unit of cost and time lose its logic because it is referred to another product which is not a digital orthophoto.

In this case we are speaking about digital enlargements with the same value in the end, as simple rectification.

This means that it is not worthwhile to produce DTMs because same simple operation based on knew points extracted from existing maps can produce a reasonable approximated merging of maps and pictures (Warping). The disadvantage of this type of approach concerns the multitemporal management of the data. Working under digital orthophoto standards, it is possible to repeat exactly the same digital map with a new aerial flight. I think that having a complete coverage of digital orthophotos and vectorial property's data base, will make it possible to operate for some years without orthophotos replacement.

Only colour or false colour aerial photography and traditional photointerpretation will be sufficient to carry out controls, producing paper documents only when in contention.

Only the vectorial data base will be updated each year resulting in a multitemporal documentation of properties and crops.

Also film's producers depend on the market as there are no technical problems to produce high resolution films in colour or false colour but only business ones. So, if there will be a reasonable request for this type of film Kodak and Agfa will surely produce it.

Controle Agricole par Télédétection en Belgique en 1995

Utilisation de photographies aériennes combinées à des visites rapides de terrain

présenté par
par Paul Counet
da Vinci Consulting s.a.

Baveno, le 21 novembre 1995

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Composants de la méthode proposée

Utilisation simultanée

- de photographies aériennes de l'année
- de visites rapides de terrain

Objectifs de la méthode

- être simple
- être facile à mettre en oeuvre (modulable)
- être plus efficace que les méthodes utilisées par le passé
- être peu coûteuse

Problématique

- Localiser
- Mesurer
- Identifier la culture

de petites parcelles agricoles situées en milieu agricole homogènement petit

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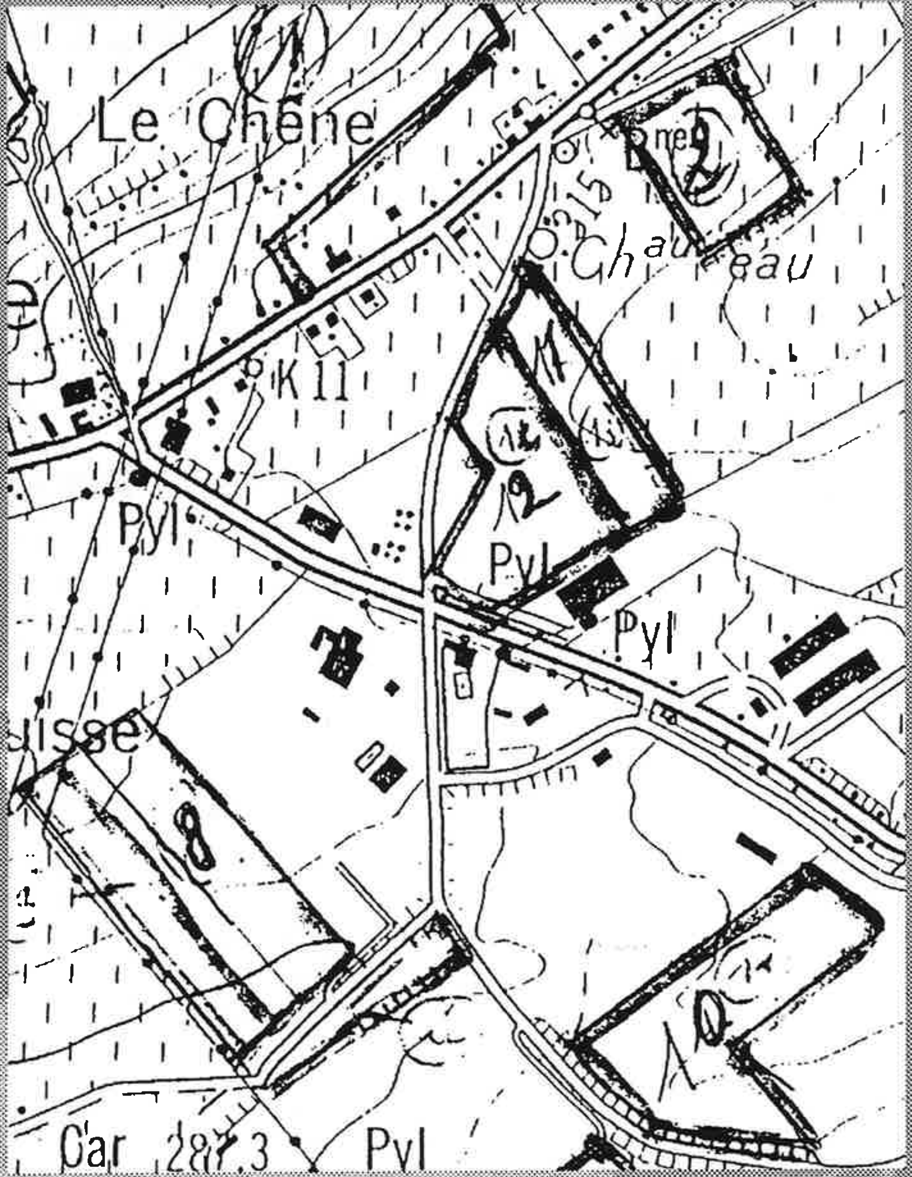
Caractéristiques belges

- Pas encore de système de référence pour la numérisation des parcelles
- Plan dessiné par l'agriculteur sur une carte au 1:10.000ème
- Prob.
  - localisation précise
  - mesurage
  - identification de la culture



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Sur base des chiffres 1992, 1993 et 1995

Zone A

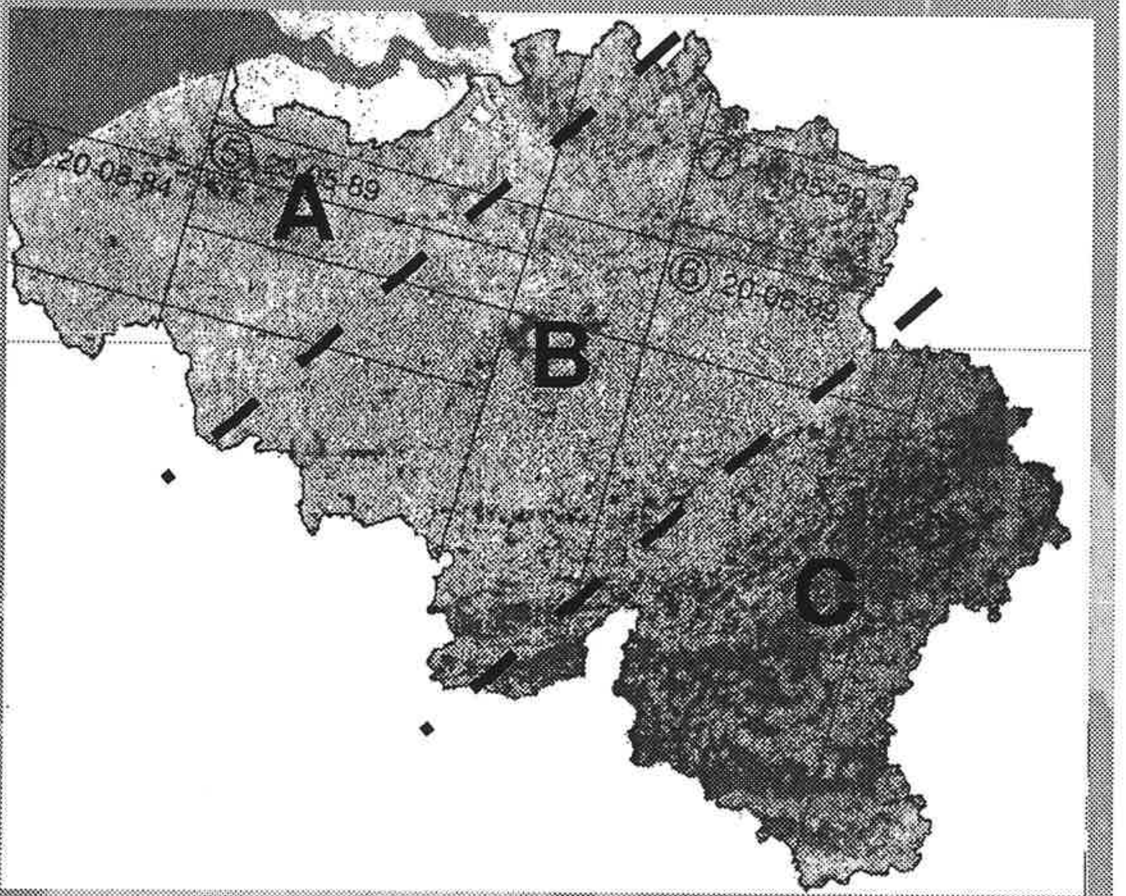
- Taille moyenne : 1. 2 Ha
- Mode : 0. 81 Ha
- Cultures : fourragères et maraîchères

Zone B

- Taille moyenne : 4 Ha
- Cultures : céréales, pdt, bs,...

Zone C

- Taille moyenne : 3.5 Ha
- Cultures : fourragères



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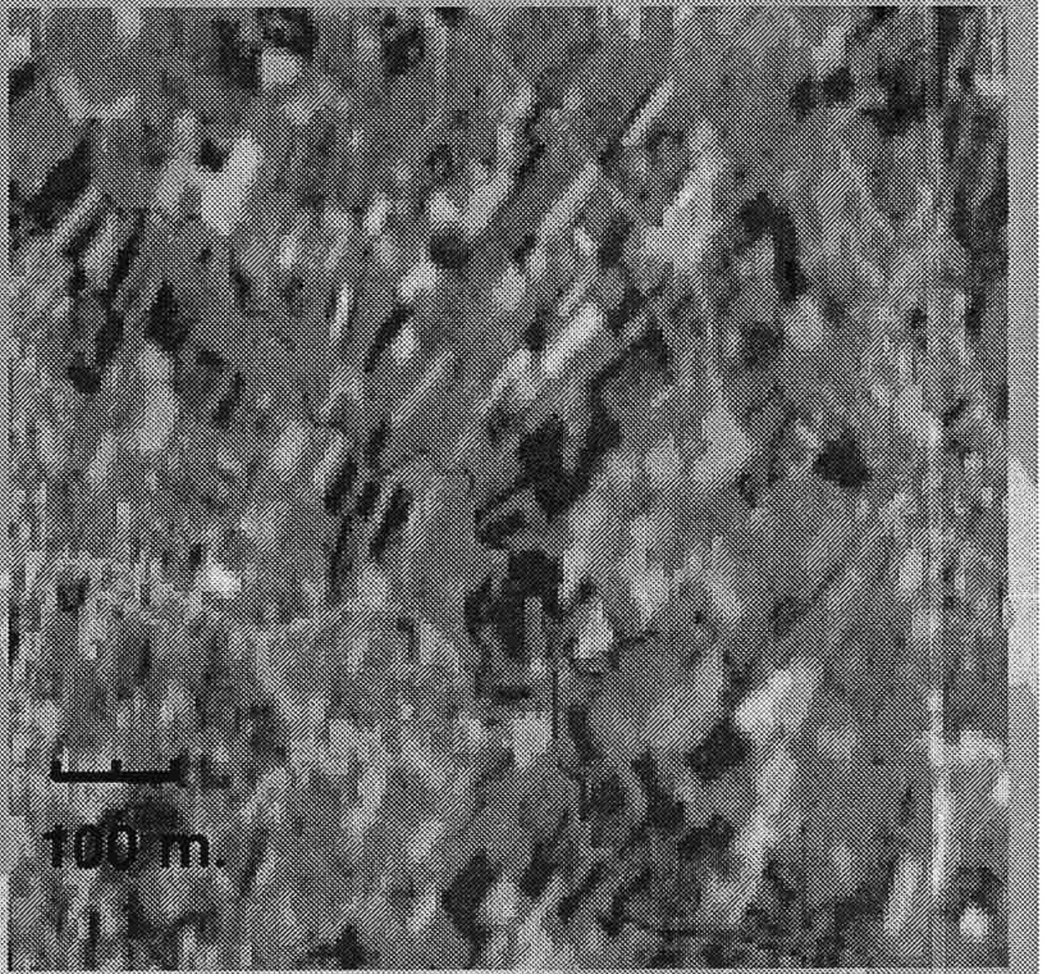
Zone de contrôle en Belgique en 1995

- Zone 1 totalement située dans la partie A
- Zone 2 totalement situé dans la partie B
- Zone 3 situé à cheval sur les paties B et C
- Zones rectangulaires de 1000 km² (40 x 25 Km)



Utilisation de photographies aériennes

Acquisition

- 3 mai 1995
- Altitude : 14.000 ft
- Echelle : 1:30.000 ème
-

Scanning

- 30 microns (80 cm)
- 24 bits
- 170 Mb / photo

Zone 1

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Utilisation de photographies aériennes

Correction Géométrique

- Modèles de correction classiques ne faisant pas appel à l'orthorectification
- Test : RMS max = 10 m. en conditions extrêmes
- Règles :
  - Exclusion des pourtours
  - Travail par quadrants
  - RMS max : 5 m.
  - Minimum de points par quadrant

Zone 2

Utilisation de photographies aériennes

<u>Numérisation - Photo-interprétation</u>

- **Numérisation directe à l'écran par comparaison entre la photographie et le plan de l'agriculteur**
- **Avantages :**
  - **Rapidité d'encodage**
  - **Précision d'encodage (on observe la réalité) - Localisaiton possible**
  - **Photo-interprétation <u>certaine</u> de toutes les cultures d'hiver (céréales, colza,..;) - des prairies - de certaines cultures de printemps (céréales), soit <u>60%</u> des parcelles**
- **Conclusions :**
  - **Excellents résultats de localisation**
  - **Excellents résultats de mesurage de parcelles**
  - **Photo-interprétation d'un grand nombre de parcelles**

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Caractéristiques des zones de contrôle

	Zone 1	Zone 2	Zone 3
Nombre de parcelles déclarées	8622	9147	8730
Nombre minimum déclaré	1	1	1
Nombre maximum déclaré	59	61	65
Surface moyenne déclarée	21.81	46.79	50.78
Surface minimum déclarée	0.6	0.7	0.95
Surface maximum déclarée	128.05	299.9	345.67
Surface moyenne par parcelle	1.83	3.16	3.72

Rapides visites de terrain

Objectif

- Détermination de l'occupation du sol des 40% de parcelles restantes, soit 12.000 parcelles

Méthode

- Préparation de documents de terrain - Fond photographique - Incrustation des parcelles - Echelle 1:10.000 ème

Conclusions

- Permettent l'identification des occupations de sol
- Permettent de résoudre de nombreux problèmes déclaratifs et donc de réduire les cas douteux

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Résultats obtenus

	Acceptés	Douteux	Refusés
Zone 1	59	19	22
Zone 2	53	29	18
Zone 3	55	30	15

Confrontation avec les résultats du Ministère - Retour terrain

- Identification précise des problèmes ---> Réduction du travail de contrôle administratif
- Mesure de superficies très précises (comparables aux mesures par théodolite) ---> Réduction du travail de contrôle sur le terrain

---> Gain d'efficacité très net dans le travail à faire par le Ministère

Calendrier de Travail

- 03/05/95 : Acquisition des PVA
- 22/05/95 : Réception des premiers dossiers
- 16/06/95 : Réception des derniers dossiers et de la base de données
- 27/07/95 : Remise des premiers dossiers
- 08/09/95 : remise des derners dossiers

Limites de la méthode

- Quantité de données à gérer (170 Mb x 120 - 5.5 Gb in fine)
- Temps de traitement lié à cette masse de données

Conclusions finales

- **Méthode efficace dans petit parcellaire**
- **Méthode spécifique à la Belgique ou parcellaires équivalents**
- **Gain substansiel en précision :**
    - **dans la <u>localisation</u>**
    - **dans le <u>mesurage</u> des parcelles**
    - **dans <u>l'identification</u> des cultures en place**
- **Réduction du travail de contrôle du Ministère**
- **Méthode de contrôle simple**
- **En combinaison avec d'autres techniques, méthode permettant une réduction drastique des coûts du contrôle (-30 % en Be en 1995)**

SESSION 5

Current technical and operational Constraints

Commission Européenne
Direction de la Recherche DG XII - CCR D' ISPRA
Direction de l'Agriculture DG VI - FEOGA

Conférence
"Contrôles par télédétection des aides à la Superficie"

21 - 22 Novembre 1995, BAVENO.

Session 5:
Les principales limitations actuelles

Olivier Léo

COMMISSION EUROPEENNE,
Direction Générale de la Recherche, D.G. XII,
CENTRE COMMUN DE RECHERCHE D'ISPRA.
Institut des Applications de la Télédétection,
Projet MARS.

Session 5: Les principales limitations actuelles

Objectifs et contexte général (1)

Pourquoi analyser les limitations?

→ *Identifier les points critiques,*

→ *Pour les corriger à court ou moyen -termes.*

Comment?

→ *En faisant évoluer la méthodologie et les techniques,*

→ *En utilisant mieux le contrôle par télédétection*

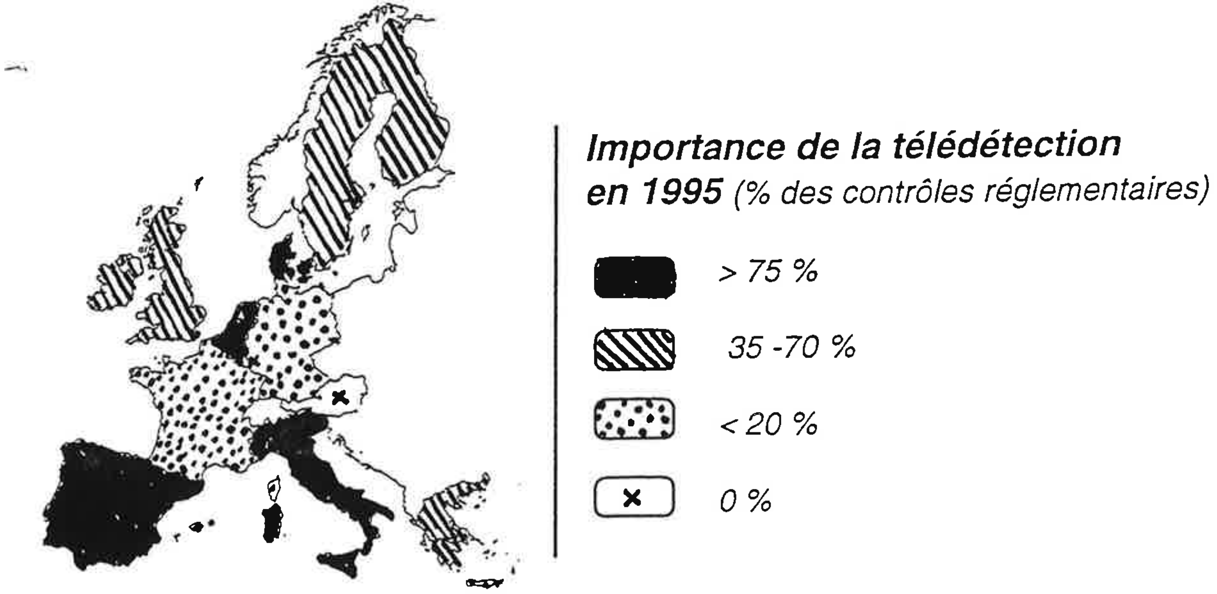
- *Adaptation aux contextes régionaux?*
- *Complémentarité d'autres types de contrôles?*

Le contexte général

→ *Le contrôle par télédétection est devenu opérationnel*

→ *1995 est une année charnière,*

- *Responsabilité accrue des Etats membres (cofinancement, suivi technique...)*
- *Importantes ouvertures méthodologiques (photographie aérienne, visites rapides...)*



***Importance de la télédétection en 1995** (% des contrôles réglementaires)*

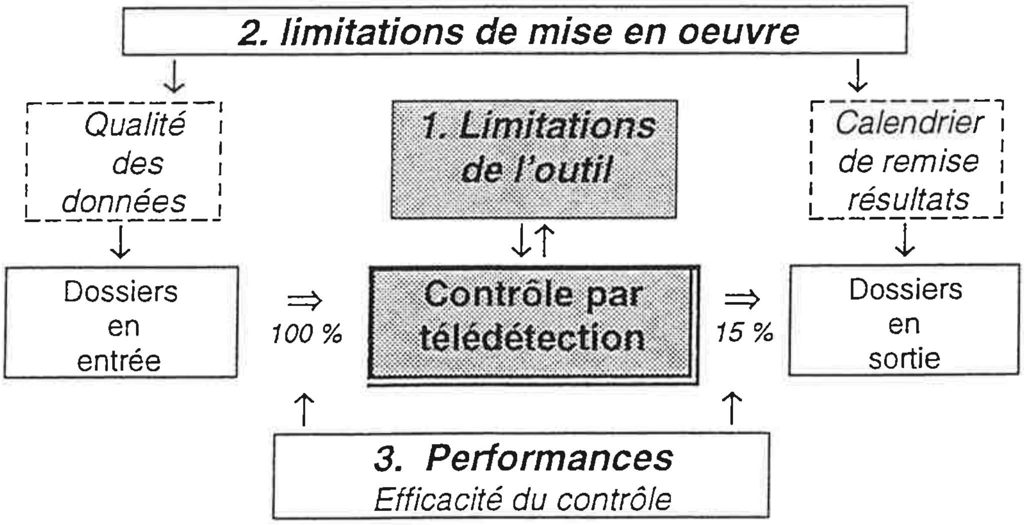
Session 5: Les principales limitations actuelles
Objectifs et contexte général (2)

3 types de limitations actuelles

- ***Limitations techniques de l'outil:*** *adaptation des outils aux parcellaires agricoles à contrôler?*
  - ***Contrôle des surfaces:*** *dimension du parcellaire / résolution - précision des données de télédétection*
  - ***Contrôle des occupation des sols :*** *discrimination et confusions possibles?*

- ***Limitations dans sa mise en oeuvre:***
  - *Calendrier?*
  - *Qualité des données d'entrée (déclarations, cartes de référence)...*

- ***Limitations dans les performances.***
  - *l'efficacité du tri effectué par le contrôle par télédétection: réduction des contrôles terrains, objectivité, etc.*



2. limitations de mise en oeuvre

Qualité des données

1. Limitations de l'outil

Calendrier de remise résultats

Dossiers en entrée

⇒ *100 %*

Contrôle par télédétection

⇒ *15 %*

Dossiers en sortie

3. Performances
Efficacité du contrôle

Session 5: Les principales limitations actuelles

***Les limitations de l'outil** (1)*

- ***Adaptation au parcellaire et précision de mesure des parcelles***

→ ***Des améliorations considérables grâce aux photographies aériennes*** *(pixel de 1m, soit résolution géographique 100 fois supérieure aux données SPOT).*

→ ***La perception de la parcelle et les imprécisions sont fonction de la forme de la parcelle*** *(allongement)*

Erreur maximum de surface en %
fonction de la Surface de la parcelle et de la résolution des données

Parcelle rectangulaire (b = 2a)	Photo aérienne scannée	Satellite à très haute résolution	Données SPOT Panchro	Données SPOT XS	Données Landsat T.M.
Surface ha	**Erreur ponctuelle sur le périmètre (mètres) ± 0.5 pixel**				
	0.5	**2.5**	**5.0**	**10.0**	**15.0**
0.5	3.0	15	30.0	60.0	90.0
1	2.1	11	21.2	42.4	63.6
2	1.5	7.5	15.0	30.0	45.0
5	0.9	4.8	9.5	19.0	28.5
10	0.7	3.4	6.7	13.4	20.1
20	0.5	2.4	4.7	9.5	14.2
50	0.3	1.5	3.0	6.0	9.0
100	0.2	1.0	2.1	4.2	6.4

░ *Situations ou la parcelle n'est plus toujours identifiable*
▒ *Situations ou la précision à la parcelle est meilleure que 2,5 %*

N.B.: *Les T.O.R. mentionnent 0.3 ha comme seuil de la télédétection satellite.*
→ En fait, ce seuil correspond à un seuil de perception de la parcelle (contrôle de l'occupation et non de la surface)...
→ En fonction des formes de parcelles et des occupations des parcelles environnantes, des problèmes peuvent être fréquents jusqu'à 0.7 ha....