

Detailed Report on
Two-Day Discussion Meeting -Cum-Workshop on Modeling and Simulation
Silent Valley Corporate Resort, Kalasa, Chickmagalur Dist.
August 14-15, 1999
Organised by
CASDE IIT Bombay and ADA, Bangalore

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Briefing Papers to Delegates
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Introduction to Modeling & Simulation

Model is an abstraction of **reality** where the essentials are captured while ignoring the inconsequential. What is relevant and what is not depends on what aspect of the **reality** is to be studied. A model could be physical, analogue or digital.

Simulation is the execution of the model to mimic the system behaviour. A simulation could be wholly executed on a digital computer or could have physical models of some of the components of the system. Often one may embed a component itself instead of its model; e.g. human operator. While model is the static characterisation of a system; simulation is its dynamic aspect. If the system level model has embedded within it physical components (humans included), simulation will need to be executed in real time.

Integration is the act of interfacing component level models into a system level model. While modeling a complex system, no single person has the expertise to model the entire system. Even if one person has the expertise in all disciplines he/she decomposes the problem to a level at which it becomes tractable. Thus a complex system is decomposed into sub-systems and models are generated for sub-systems separately. These sub-system models are then integrated into a system level model.

CASDE is expected to set up an Integrated Modeling and Simulation Laboratory (**IMSL**) at IIT Bombay. Broad plans for this have been formulated and have been approved by the Joint Policy Committee, CASDE and also critically examined by the Scientific Programmes Committee, CASDE.

The objective of the Two Day Discussion Meeting-Cum-Workshop is to sharpen the thinking on following points,

- Adequacy of the proposed laboratory facility at CASDE. Specific laboratory exercises that can be defined for the academic programme in Systems Engineering.
- View points on evolving integrated models for inter-disciplinary analysis/design.
- Importance of initiating formal Multi-Disciplinary Analysis/Design activity
- System level models for simulation – for aircraft, space systems, unmanned vehicles, missiles, ...

Discussion is expected to give rise to specific recommendations about the software & hardware that will constitute a meaningful facility in Integrated Modeling & Simulation and focus for activities that will be pursued.

Modeling & Simulation CASDE Course & Laboratory

Organisations are requested to communicate their views about case studies for course and experiments for laboratory for the M. Tech programme in Systems Engineering. These will be consolidated by CASDE and will form the basis for discussion.

Flight Simulator for CASDE

Systems Engineering Education requires a strong component of hands on experience on hardware, software as against just theory. Most complex systems have elements of measurement, feedback and control. Complex systems are often modeled with physical components embedded with in, requiring real time simulation.

An aircraft flight simulator offering a scope for incorporating all of the above is planned as a facility at IMSL, CASDE. This will have 3 networked computers - one each for Flight Dynamics Simulation, FCS Simulation and Display processing. The feedback for FCS will initially be tapped from Flight Dynamic simulation. A desktop motion platform and an aircraft model that will allow measurements is planned. These measured quantities will be used to feedback to the FCS. A human can actually be in the loop on a fixed base without any body cues. This will necessitate real time simulation.

Integrated Modeling & Analysis

Analysis and Design of complex systems is inter-disciplinary in nature. Capturing of knowledge in such an environment is a distributed activity; and takes place within each and every participating disciplinary group. Knowledge about the system is realised only by integrating this distributed knowledge. Capturing knowledge is here equated to development of digital models (that can be coded in any commonly used programming language); based either on heuristics or scientific principles. Disciplinary models have presently grown to be complex and computationally intensive. An environment that will enable creation of such digital models, ability to share such models with other disciplines or system level people, coupled with a means to integrate these disciplinary (or sub-system) models to system models is desired. Growing computer network seem to offer just such an opportunity.

Multi-disciplinary Design Optimisation/Analysis (MDO/A)

Arrival of fast computers have made disciplinary analysis which till recently was carried out during preliminary design to be used even during early conceptual studies. Integrating such complex analysis packages for performing integrated analysis or design requires formal approaches. Multi-disciplinary Design Optimisation/Analysis is thus an emerging area of research.

System level Simulation for Aircraft, Missile, Space Systems, ..

CASDE lacks clarity at the moment about *System Level Modeling & Simulation* requirements for Systems Engineering education. *What levels of abstraction are relevant and how these abstraction levels are identified needs to be part of the education.* Having formulated the models, hands on simulation sessions should be part of the education. Here too, one requires to impart *norms for arriving at what simulations are to be carried out.*

CASDE will immensely benefit if following is addressed,

1. Software/Hardware that IMSL, CASDE should have, to impart to students, the main concepts in system level simulation.
2. Is it possible to make available to CASDE such a facility? OR Point out sources from where such facilities can be procured OR offer help in developing such a facility.

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General Briefing for Discussion Groups

CASDE is keen on consolidated views of delegates on four issues,

1. Systems Engineering Academic Programme; to identify the Case Studies and Models for Simulation experiments.
2. Integrated Modeling & Simulation Laboratory – Facilities to be built, Focus for activities
3. Multidisciplinary Design Optimisation/Analysis – Perception of Organisations
4. Avionics Systems & Modeling

Four groups are formed as indicated below,

b) Academic Programme

1. Prof. Suryanarayan, (Coordinator)
2. Prof. Goshal, Jadavpur Univ.
3. Dr. N. Swamy, DRDL, (IISc)
4. Dr. S.Y. Bhave, IAT
5. Mr. M.P. Reddy, ADA
6. Prof. Sanjay Bhat, IITB
7. Prof. M.M. Kulkarni, ex-IITB

c) MDO

1. Prof. P.M. Mujumdar, IITB (Coordinator)
2. Dr. M. Krishnamurthy, NAL
3. Dr. S. Dasgupta, VSSC
4. Mr. R.K. Jolly, ADA
5. Prof. K. Sudhakar, IIT B

b) IMSL

1. Prof. Ashok Joshi, IITB (Coordinator)
2. Dr. S. Srinathkumar, NAL
3. Dr. N. Venkiteswaran ISAC
4. Dr. S.K. Chowdhury, RCI
5. Wg. Cdr. Mishra, ADA
6. Mr. G. Elangovan ADE

d) Avionics Systems & Modeling

1. Prof. J. Chandrasekhar, IITB (Coordinator)
2. Dr. B.N. Suresh, VSSC
3. Mr. S. Balakrishnan, ISRO
4. Dr. K. Soundara Rajan, ADE
5. Ms. Padmavathi, ADE

Specific tasks for each group will be explained by the coordinators to their respective group

Academic Programme

Specific tasks for each group will be explained by the coordinators to their respective group members on 13th August 1999. Members of each group are requested to formulate their observations based on deliberations over the two days and information from presentations. The two day deliberations have one slot (Session 8) for these groups to meet, discuss and consolidate their views. Members are requested to give their written observations to respective coordinators prior to this session. These consolidated views are to be presented during Session 9. Thereafter they will be recorded as final recommendations.

Discussion groups are requested to keep in mind the present working strength of CASDE while making recommendations. Tasks that are important but cannot be addressed immediately may also be identified for future attention.

Collaborative efforts are required – Kindly indicate areas where close working arrangements are possible. Formalising such a working arrangement will be taken up through a separate meeting between CASDE and the organisations.

In addition to the four groups, a fifth group coordinated by Prof. A. G. Marathe, Head, Aerospace Engineering, IITB is formed to discuss various issues related to support to the CASDE programme at the institutional level from DRDO, ISRO, HAL & IAT. This group is as follows,

1. Prof. A.G. Marathe, IITB, Coordinator
2. Dr. Kota Harinarayana, ADA
3. Dr. T. G. Pai, ADA
4. Dr. D. Narayanamoorthi, ISRO
5. Gen. V. J. Sundaram, DRDO
6. Prof. G.S. Mani, IAT
7. Mr. J. Jayaraman, ADE
8. Mr. N. Balasubramanian, HAL
9. Dr. B. S. Sarma, DRDL

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Summary of Written Comments

As part of the overall structure for interaction for the 2 day discussion meeting cum workshop it was decided to seek written comments from the delegates on various issues. These comments are summarised using following ground rules,

- a) Comments which are common to more than one delegate appear only once. These are restated to represent the overall viewpoints.
- b) Observations made by one delegate on the presentation of another delegate more in the form of clarification are not reproduced.
- c) Comments which reiterate some of the activities already reported or proposed by CASDE are not reproduced.
- d) Comments which are reflected in record of discussion of “Observer Group” are not reproduced.

Summary of comments follow,

1. Research component of CASDE should be carefully worked out after identifying where other institutions are already ahead and ensuring that core-competence at IITB gets strengthened.
2. Real time systems should find a place in overall IMSL facility to give exposure to students
3. Exposure to connectivity options, eg., 1553B, Ethernet, VME, SCRAM will be beneficial
4. Perception model, Human pilot dynamics model should be looked into; it should even find a place in student awareness creation. It can be used in the Research Flight Simulator.
5. Software Engineering as a subject will be a useful addition in the syllabus.
6. Case studies on avionics architecture on National aerospace systems will be of great use.
7. Visit to organisation for on the spot studies of simulation facility is essential.
8. Design study objective/cost to be formulated keeping environment in the picture.
9. Use of analog computers in the laboratory to be minimised.
10. R&D activities in MDO should be clearly defined through a separate CEP.
11. Distributed interactive simulation is a must.
12. “Project Management” will be useful for the students.
13. Suggestion for M.Tech topics in respective area should come from the organisation.

Observer Group on "Organisational Support to CASDE"

The following participants of the workshop were involved in the discussion of the observer group.

10. Prof. A.G. Marathe, IITB, Coordinator
11. Dr. T. G. Pai, ADA
12. Dr. D. Narayanamoorthi, ISRO
13. Gen. V. J. Sundaram, DRDO
14. Prof. G.S. Mani, IAT
15. Mr. J. Jayaraman, ADE
16. Mr. N. Balasubramanian, HAL
17. Dr. B. S. Sarma, DRDL

1. We should write a letter to DAERO i.e. Mr. Ajai Kumar stating that we need the help from scientists of various DRDO Labs. He should inform to various Labs in this connection. Also the number of candidates from each lab which will be deputed for the M.Tech course.
2. A copy of this should go to JPC/SPC members.
3. We can be in touch with Directors of various DRDO labs, Chairman HAL, PD-LCA, Chairman ISRO, Directors ISAC, VSSC and other SOS Units, DG-Civil Aviation and Various Services Heads (Prof. Mani of IAT Pune has given some information through FAX) for the support for various things like Visiting faculty, Setting up the facilities (Hardware and Software). Also we should get the number candidates from various labs and units in the first year for M.Tech course. Why not be in touch with other IITS, RECs, CSIR (NAL)?
4. IITB faculty should spend time with various organisations to have close rapport and to know the case studies, their requirements.
5. Regarding the service personals for the course to be started in July 2000, we have to start immediately. We should write the letter to proper authority to add this course in their M.Tech Information. So that in April/May we can have some participants.
6. We will send the admission procedure to all the organisations : course, information.
7. For running the M.Tech Program 2000-2001, what are the requirements needed from other organisations. This should be clear as early as possible.
8. FEES - for the sponsored candidates, Accommodation on campus. Duration he has to spend at IITB.
9. Regarding visiting faculty - terms and conditions, (e.g. travel, stay, Honorarium etc) should be clear.

Prof. A.G. Marathe
Coordinator

Observer Group on "Academic Programme"

The following participants of the workshop were involved in the discussion of the observer group.

8. Prof. Suryanarayan, (Coordinator)
9. Dr. S.Y. Bhawe, IAT
10. Mr. M.P. Reddy, ADA
11. Prof. Sanjay Bhat, IITB
12. Prof. M.M. Kulkarni, ex-IITB

1. The syllabus as indicated by Prof. Ashok Joshi (AJ) was considered to adequately cover the material needed, by most of the participants. A few participants suggested that some specific topics be considered/included. (These topics will be passed on to AJ.) It is noted that the emphasis and coverage of the various topics in the course will depend on the background of the students registering for the batch. The syllabus can only be indicative at this stage. The operation of the course will have to be left to the judgement of the course-instructor.

2. The support needed for the academic programme is mainly inputs and participation, for case studies, as lectures/discussions for the theory course and examples for demonstration and simulation for the Lab. course. A number of participants have offered, some in writing, to provide such support. Particular mention may be made of the offers from Dr B N Suresh of VSSC, Mr Elangovan of ADE, Prof. M M Kulkarni and Prof. Bhawe on behalf of IAT. (These inputs will be passed to AJ)

3. The CEP programme on Modelling and Simulation proposed to be organised by AJ/CASDE in Oct. 99 is expected to give concrete shape to the nature and extent of participation from various DRDO, ISRO, NAL, HAL and other organizations, on a regular basis, in the theory and lab. courses on System Modelling and Simulation.

4. There were many suggestions from participants on topics on "System Modelling and Simulation" for the M. Tech main project. Discussions on potential topics for the July 2000 batch need not wait till next year, for the batch to join the IIT. However, it is necessary to note that the number of M. Tech main projects on this topic to be taken up by each batch will depend on the background of the batch as well as the preferences of their sponsoring organizations. This will also have to take into account the availability of IIT faculty for providing project guidance. (Faculty members may like to restrict the number projects they offer/guide, to each batch.)

S. Suryanarayan
Co-ordinator

Observer group on “Integrated Modelling & Simulation Laboratory”

The following participants of the workshop were involved in the discussion of the observer group.

1. Dr. A.Joshi, IIT Bombay, Coordinator
2. Dr. S.Srinath Kumar, NAL Bangalore
3. Dr. B.N.Suresh, VSSC, Thiruvananthapuram
4. Mr. G.Elangovan, ADE Bangalore
5. Dr. S.K.Chaudhuri, RCI Hyderabad
6. Dr. N.Venkiteswaran, ISAC Bangalore

The observer group on Integrated Modelling & Simulation Laboratory (IMSL) set for itself the following agenda. Are the elaborated requirements complete? Are the planned activities compatible? What is the nature and extent of support for setting up of the IMSL?

At the outset, Dr. Joshi briefly outlined the charter of the CASDE, the total Systems Engg. Curriculum and the role of Modelling & Simulation that was envisaged by the CASDE. He also pointed out to the members that the curriculum was slated to start from July 2000 and therefore, there was an urgency in concretizing the Modelling & Simulation activity of the CASDE.

As the discussion progressed, there was a general agreement among the participants that requirements, as presented by the CASDE, were appropriate and only a few pertinent issues needed to be suitably emphasized. In this context Dr. Chaudhuri emphasized the need for including Numerical Integration & Filters in the curriculum, Mr. Elangovan & Dr. Srinath Kumar pointed out the need to have the Pilot Modelling Aspect to be included in the simulation loop and Mr. Elangovan brought out the need to have Helmet Mounted Displays as well as Effecters for Real-Time Simulation through Virtual Reality. Dr. B.N.Suresh was of the view that as a part of modelling & simulation course, students must be made aware about the gross nature of different types of Aerospace Systems and others also concurred with this. Similarly, Mr. Elangovan felt that simulated hardware could also be modelled using Software Based Options, in addition to the analogue computer. Finally, as general remark, all participants stressed the need to have a visit to all Aerospace Simulation Facilities available with DRDO & ISRO., as part of either the theory course or the lab. (The CASDE will examine inclusion of all these and will get back to participants if there are further points to be discussed.)

Next, the issue of supporting the educational programme and setting up of the IMSL was discussed. The discussion for educational programme was focused on (1) Lecture Support, (2) Case Studies, (3) Laboratory Examples, (4) Mini Project and (5) Main Project. All the external participants offered to contribute to all the five components of the educational aspects of the Modelling & Simulation. Dr. Joshi assured that whatever support that CASDE could offer for facilitating such an intense interaction, would be freely forthcoming. In addition, all participants confirmed that they would act as coordinators from their organization for this purpose and would any additional faculty from their organization, if needed. All were very keen that students should do their main project in their organization, with the scientist from the organizations acting as co-guides.

However, Dr. Venkiteswaran mentioned that ISAC would be able to offer only software based main project topics as their hardware facilities, which were quite massive and fairly busy, could not be offered to the students. Similarly, Dr. Chaudhuri said that students coming to the RCI for their main project would have to be necessarily from the DRDO system only, due to security reasons. (CASDE is grateful to receive above support and will keep in mind the constraints of each organization. Further, in cases where the organization is unable to provide the needed experimental support for the main project, CASDE will make suitable arrangements.)

In the context of the providing lectures, case studies and laboratory examples, all participants felt that a Continuing Education Programme (CEP) should be held now at IITB as a kind of dress rehearsal, in order to finalize the nature and content of lecture notes as well as streamline and formalize the process of actual delivery of these case studies in Oct. 2000. All participants were agreeable for a two day event in the first week of Oct. 1999 and Dr. Joshi agreed from the CASDE side to organize the event. (CASDE has already prepared the groundwork in this regard with tentative dates being Oct. 9-12.

Next, the observer group took up the discussion on the facilities to be created as part of the IMSL and there was general appreciation of the effort already put in by the CASDE in getting two activities namely; CASDE Research Flight Simulator (CRFS) and Free Flight Simulator (FFS). In particular, Dr. Srinath Kumar wanted such an activity to be a kind of continuing facility for the students to experiment with. All were of the opinion that software tools e.g. MATLAB, SIMULINK, MATRIXx, AVDS, ACEOM, RTOS etc. were all essential for the IMSL. Dr. Srinath Kumar and others were of the view that presently, a lot could be achieved using only the software modelling and simulation tools and the hardware part could be restricted to actuators and sensors. (CASDE will strive hard to create IMSL facility along these lines, latest by June 2000).

Lastly, the observer group discussed the software & hardware support that the participating organizations could give in setting up the IMSL. It was generally felt that support should lead to establishment of a good IMS Laboratory wherein students can carry out research projects relevant to aerospace vehicles. With regard to the software, Dr. B.N. Suresh offered to provide a basic core of the launch vehicle system simulation software, as tool for students to add more modules and learn software integration. Mr. Elangovan offered to give a suitable Flight Modelling Software package that he considered appropriate for the IMSL. Dr. Srinath Kumar offered to give the HQ Pack software that they have developed for Control System Modelling. Dr. Chaudhuri offered to give the Guidance System Simulation Software and Dr. Venkiteswaran offered the satellite system simulation software for the IMSL. It was also noted that most of these software were under MATLAB/SIMULINK/MATRIXx environment and no compatibility issues were envisaged. (CASDE is extremely thankful for the generous offer of modelling and simulation tools for the IMSL and it would be initiating the process of getting these packages once the computer platforms with relevant Operating Systems are finalized and put in place).

Prof. Ashok Joshi
Co-ordinator

Observer group on “Multi-disciplinary Design Optimisation”

The following participants of the workshop were involved in the discussion of the observer group.

1. Prof. P.M.Mujumdar, IITB, Coordinator
2. Dr. S. Dasgupta, VSSC
3. Dr. M. Krishnamurthy, NAL
4. Mr. R. K.Jolly ADA
5. Prof. K. Sudhakar, IITB

There were only two formal presentations on Multi-disciplinary Design Optimisation (MDO) at the Meeting. The first presentation was by Prof. Mujumdar of IITB who gave an overview of MDO covering its need, importance, definition, goals, sub-components, engineering aspects, the international status and work initiated at IITB. The second presentation was by Dr. B.S.Sarma on issues related to structure–control synthesis in missiles including issues of Aeroservoelastic optimization as an MDO problem.

Since Dr. Sarma could not attend the group meeting, Prof. Mujumdar met him separately and discussed DRDL’s views.

During the meeting it was noted that formal MDO practice has not yet been initiated in the country as far as aerospace systems are concerned. However, the need for adoption of MDO as a part of Systems Engineering approach has been stressed at a number of forums by Directors of Aerospace R&D Institutions. In this context, Prof. Mujumdar stated that a group of faculty at the IITB Aerospace Engg, Dept. has shown interest in taking up this activity under CASDE and some work has already been started. Prof. Mujumdar explained the preliminary work which has been initiated at the department (as per details in the workshop handout) and also the specific issues within the larger framework of MDO which the group would be looking at in the near future. However, to give a meaningful direction to the activity, direct and active interaction with as well as participation of the Aerospace R&D Institutions is required. Prof. Mujumdar and Prof. Sudhakar pointed out that IIT Bombay’s (IITB) role is envisaged as a facilitator to the Industry for (i) Providing information and awareness about MDO in general (ii) Formulating a given well stated design problem with sufficient disciplinary support as an MDO problem (iii) Optimization aspects of MDO. Since IITB faculty expertise and experience in disciplinary design and analysis, particularly of full scale complex aerospace systems, is limited, they are not envisaged to play a major role in this aspect. IITB will strive towards building up understanding and expertise in putting together the disciplinary design models in an MDO framework and working out optimized solutions. Industry is expected to come up with well-posed multi-disciplinary design problems with required disciplinary analysis/design support in the form of mathematical models/software codes/design information databases. Both Dr. Sarma on behalf of DRDL and Dr. Dasgupta on behalf of VSSC welcomed the ideas put forward by the IITB team and reiterated the pressing need that is felt in their respective organizations.

Dr. Sarma stated that DRDL would be eager to interact with IITB in MDO studies related to optimal structure-control synthesis in missiles, which they have already initiated. A well developed analysis methodology and software already exists with DRDL. Dr. Sarma agreed to take up the responsibility of initiating interaction between DRDL and CASDE in the MDO area. Initially, he would send the relevant literature describing the work done at DRDL to Prof. Mujumdar for familiarization with the problem. Dr. Sarma also agreed to work out the definition of a suitable simplified design problem, which could be the starting point for the MDO studies. Mr. Prahlada and Dr. Kadam from DRDL would also be associated with this work.

Dr. Dasgupta described some of the trajectory optimization related problems faced in Launch Vehicles at VSSC, which could benefit from an MDO approach. He described in some detail, how the problem can be looked at from three different levels with increasing disciplinary complexities. He inquired whether this could be taken up by CASDE. Reacting to the request, the IITB members stated that the kind of disciplinary analysis expertise and tools required to take up this problem is not available at IITB. However, CASDE would be willing to interact with VSSC and help on MDO architecture and optimization issues, if the design problem can be formalized mathematically with requisite disciplinary tools. Dr. Krishnamurthy suggested an interesting extension of the MDO studies in wing design currently ongoing at IITB, which could be taken up with his involvement after the ongoing work has matured. This relates to tailplane configuration and sizing optimization for minimizing drag.

Prof. Sudhakar added that CASDE was planning to hold a similar workshop devoted to MDO by mid 2000. However, this would be meaningful only if the Aerospace R&D Organizations in the country are committed to some level of preparedness in MDO and able to make presentations of any work done/ongoing at such a workshop. This could be even in the form of presentations of past non-formal MDO work/experiences or in the form of detailed presentations on formally posed multi-disciplinary design problems requiring an MDO approach.

During the final session of the IMSL workshop, Dr. Pai from ADA added that ADA is already interacting with CASDE on Transport Aircraft studies as a part of which it is committed towards MDO related to transport aircraft design. Prof. Mujumdar summarized the discussions and announced CASDE's intention to organize the workshop on MDO. He requested all the organizations represented to make available case studies on design optimization, which could be used as examples for the course on "Engineering Design Optimization" and its associated "Laboratory" under the M.Tech. program in Systems Engineering to be offered by CASDE.

P.M. Mujumdar
Coordinator

Observer group on “Avionics Systems & Modeling”

The following participants of the workshop were involved in the discussion of the observer group.

1. Prof. J. Chandrasekhar, Coordinator
2. Dr. BN Suresh, VSSC
3. Mr.Soundararajan, ADE
4. Dr. Venkiteshwaran, ISRO
5. Mr.MP Reddy, ADA
6. Ms.Padmavathi, ADA

Since Avionics is a new topic for Department of Aerospace, IIT; help was sought from specialists to participate in teaching. Following topics have been identified where help will be offered, in terms of visiting faculty support.

Introduction to Avionics

- “Control laws; Redundancy & failure survival; Digital implementation; Fly-by-light control system”. FCS groups from ADE and NAL have offered help. (Attn. Mr. Sunderarajan ADE)
- Inertial Navigation; GPS; Terrain reference navigation. Aids to approach and landing”, ISAC, VSSC have offered help (Attn. Dr. B.N Suresh, VSSC)
- “Radar & Communication. FMS. Avionics Systems integration. Data bus”, ISAC/VSSC (Attn. Dr. BN Suresh, VSSC)
- “Introduction to basic principles of navigation; Radio direction finding, Radio ranges, Hyperbolic system of navigation (LORAN, DECCA); DME and TACAN; Doppler navigation” Also, “Introduction to safety systems, EGDWS, SWS, These topics for civil aviation may be handled by AAI. (Attn. Prof. Chandrasekhar)

The experts have recommended following books as references for the course,

- “Digital Avionics - ?”, 2nd Edition, Spitzer
- “Introduction to Radar Systems”, Skolink.

Advanced Avionics Systems (Elective)

- “Avionics systems integration. Data bus systems”, ADE, ISRO
- “Telemetry Systems”, VSSC, ADA
- “Man-machine interface”, MP Reddy, ADA
- “Electronic warfare (anti-jamming)”, ADE, AESEIO
- “Multimode radar systems”, LRDE?

Special lectures on following topics are suggested,

- Electro Optic Systems
- AI in cockpit
- Advanced Avionics Architecture
- Low observables (stealth)

Following reference has been suggested

- “Avionics & Navigation”, Dayton and Freid, 2nd Edition

All the members were unanimous in opinion that the students should visit “Avionics/Simulation facilities of the organisations” as part of their course.

Prof. J. Chandrasekhar
Coordinator