F. ONGARO

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SMO FuegoTec Programme

The FUEGO 1st satellite

Final Presentation

TIDC-CR-8054

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The forest fire problem in the Mediterranean countries

Forest fires are one of the main causes of deforestation in the world. In the case of the Mediterranean countries fire incidence was (in thousand of hectares):

Country	1990	1991	1992	1993	1994	1995
Greece	34	23	20	47	63	-
Italy	196	99	106	203	123	42
France	73	10	18	12	25	-
Portugal	137	171	46	49	39	128
Spain	203	225	105	89	438	126

Average for Mediterranean Europe: 500,000 per year
Economical losses: about 400 MECU per year.

Origin of Mediterranean fires is peculiar

- climate
- humidity reductions
- orography
- accumulated dead fuels
- population focused in susceptible areas

A considerable effort in presuppresion has led to decrease in the burned surface per fire, although the number of outbreaks has moderately increased.

Wildfire problem in the Mediterranean countries means the conservation of an environment of great value to human development and welfare. A danger of non-conservation does exist.

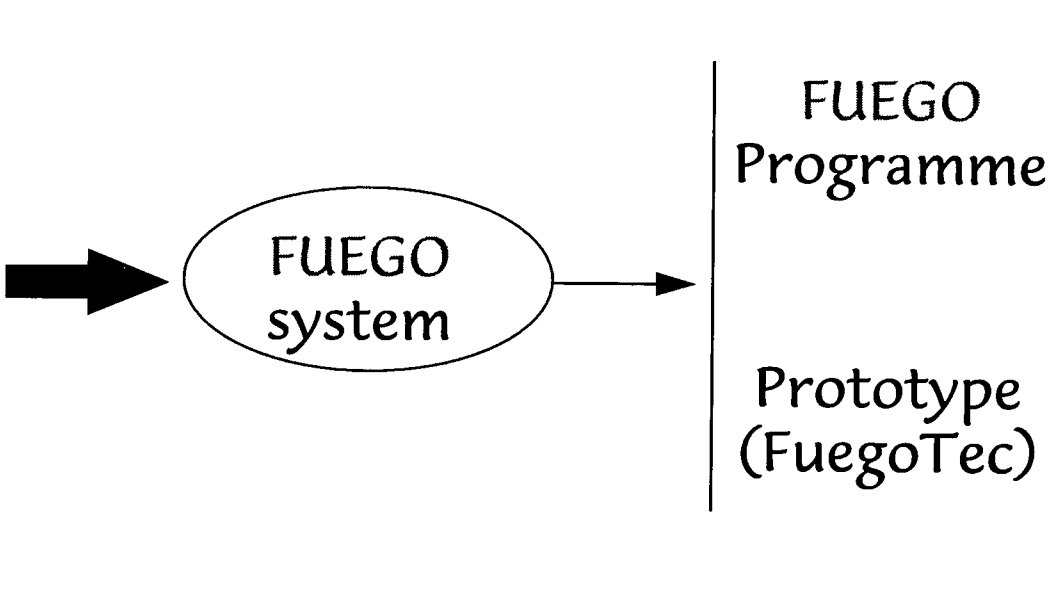
Forest fire fighting requirements

These aspects lead to the urgent establishment of a system specifically dedicated to enhance and provide useful information to forest fire fighting authorities in two ways:

- by providing effective fire detection
- by providing fire monitoring information

INSA, with internal funding, conducted a study and preliminary survey aimed to establish the requirements of the forest fire fighting responsible on that aspects:

- detection time not more than 30 min.
- day and night operation
- direct communication to supression crews
- accurate location and intensity of fires
- small false alarm rates
- focused to risky areas only
- a prototype of the system is needed to validate the service



The FUEGO Programme

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FUEGO is a project to develop a space system devoted to forest fire fighting. The FUEGO Programme feasibility and definition study started oficially in November 1996 funded by the European Comission (DG-XII). This study is being carried out by an European industrial team led by INSA and also integrated by Officine Galileo (Italy), SEMA Group (France), INTA (Spain) and two Spanish scientific advisors (INIA and CIF).

The aim is to develop an operational service available by the year 2001. FUEGO consists of a constellation of six small LEO satellites equipped with IR sensors and proper processors to detect and monitor forest fires and to assess the damage they cause.

Detection mode:

Resolution:	~10 m^2 fire
Re-visit:	~45 min

Monitoring mode:

Resolution:	~35 m (MIR)
Re-visit:	~95 min

Constellation: 6 satellites

Height:	600 km
Inclination:	47.5°
Mass:	<240 kg each
Lifetime:	7 years (goal)

including idle intervals

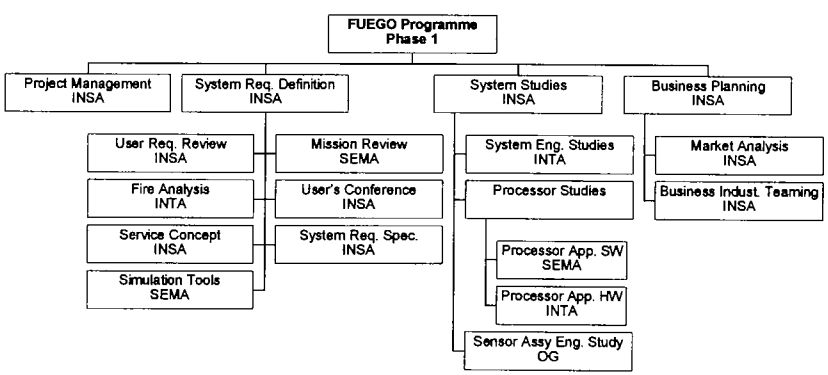
The FUEGO Programme structure

An iterative process will be used to achieve the propertrade off's to provide the optimum cost effectiveness.

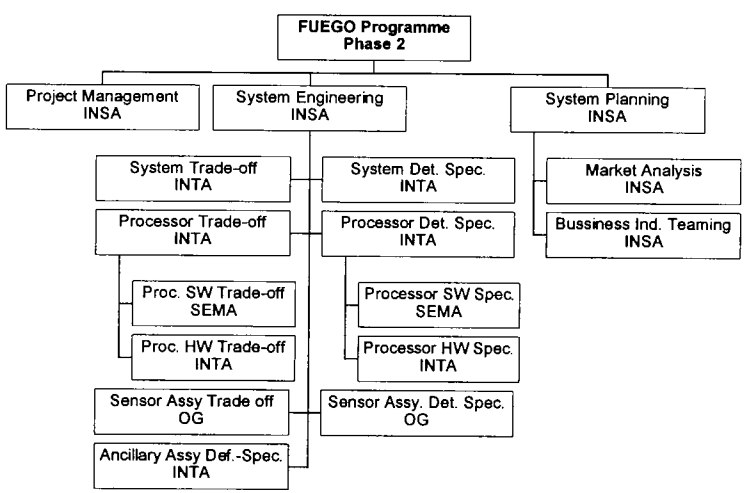
FUEGO is a user oriented programme:

- User Comittee
- User Group
- Two User Conferences

FUEGO Programme is a 20-months project structured in 2 phases:



Phase 1



Phase 2

INSA responsibilities in the FUEGO Programme

Management:
- Coordination reporting
- Cost-benefit analysis data gathering
- Liason with other programmes (competing and non competing) within the EC context
- Configuration control

Requirement Engineering:
- Req. analysis validation, allocation, and maintenance

System analysis studies:
- Continuos cost and key parameter assessment
- Environment impact assessment
- Functional analysis and architecture verification
- Req. allocation analysis
- Verification and validation approach
- System preliminary plan

Bussiness planning:
- Match of user expectation and system charact.
- Establish price, distribution and promotion
- Establish acquisition modes
- Establish competition structure
- Establish potential industry interest in the implementation phase

System Engineering:
- Manage the req. processing and trade-off
- Compile budgets
- Manage and compile the preliminary and final system spec.

System planning:
- Cooperate in User Conference 2
- Establish plans and budget estimate for development and deployment phases
- Establish candidate financing options

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Objectives of FuegoTec (or FUEGO 1st satellite)

- To provide first services to users by active fires monitoring and burned area measurement.
- To demonstrate the performance of FUEGO high technology elements.

Objectives of SMO FuegoTec Programme

- To produce a feasibility study of the FuegoTec payload so that ESA can consider an implementation phase under the SMO Initiative.
- To study the potential users real interest of FuegoTec and the finantial viability of the proposed services.

FuegoTec study logic

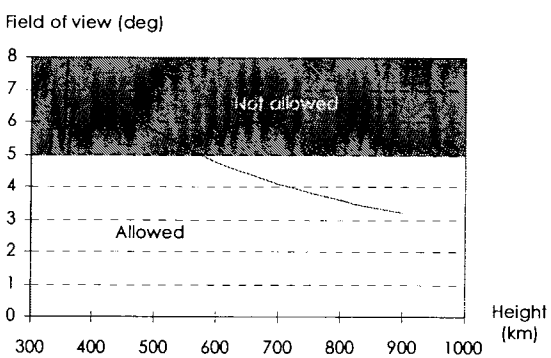
- Mission definition and SMO basic req. → Preliminary mission analysis and schedule; Payload preliminary description; Detector and optic definition
- SMO interfaces req.
- Market analysis and business plan

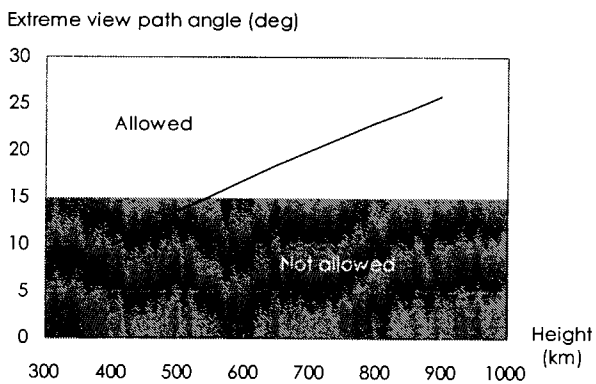
FuegoTec mission analysis (I)

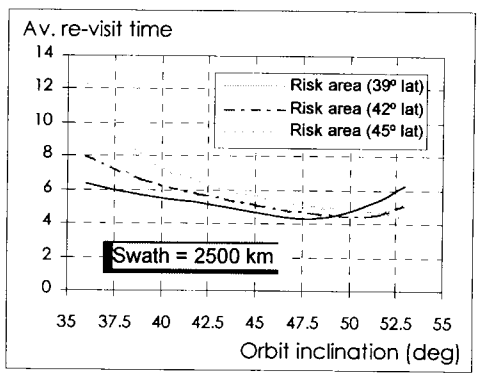
FuegoTec has to be as much similar as possible as FUEGO (mission and concept).

FUEGO mission analysis was based on:

- low orbit allow better resolutions
- optimal coverage of Europe has to be ensured
- infrared wave lenghts constraint the size of the optics, so lower orbit lighten the payload, even though higher orbits give larger coverage
- orbit inclination has to ensure required temporal resolution with the minimum number of satellites
- incidence angle between the line of view and the horizontal has to be larger then 15°
- sensor FOV has to be no more than 5° and IFOV no less than 0.04 mrad

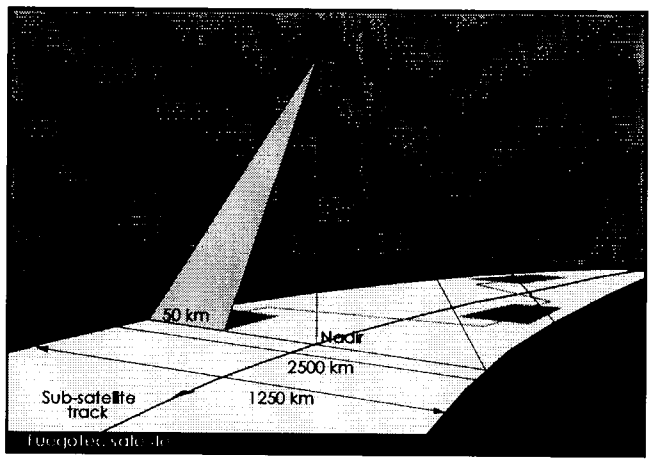


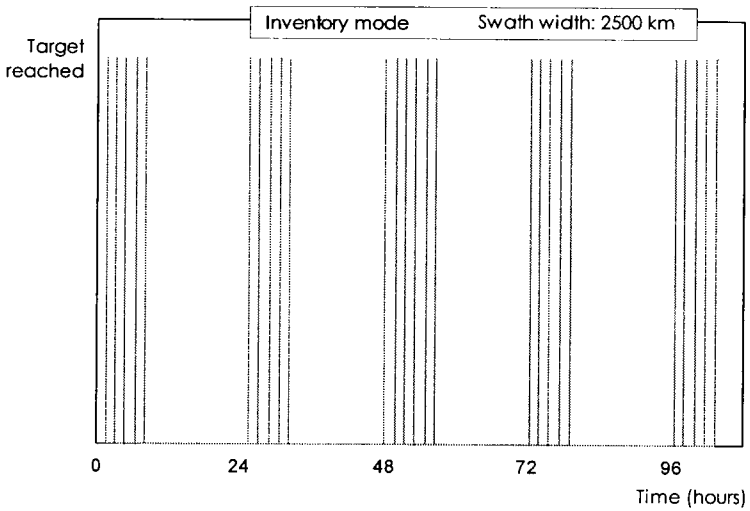


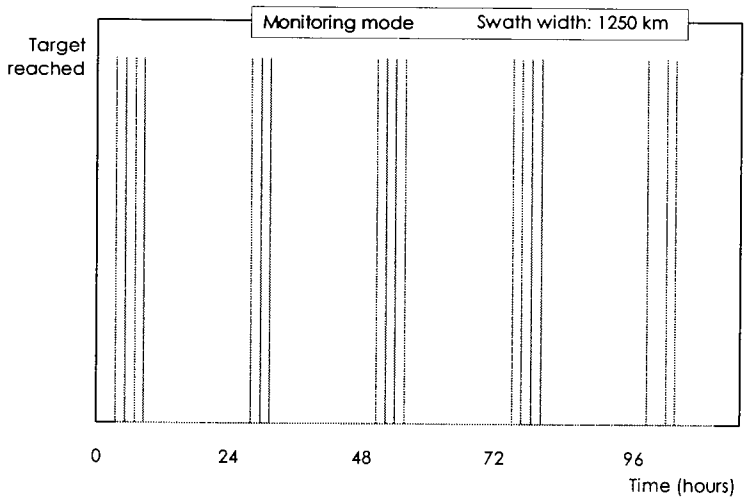


FuegoTec mission analysis (and II)

Altitude (km)	Inclination (deg)	Period (min)	Ascending node change (deg/day)
599	47.5	96.7	4.9





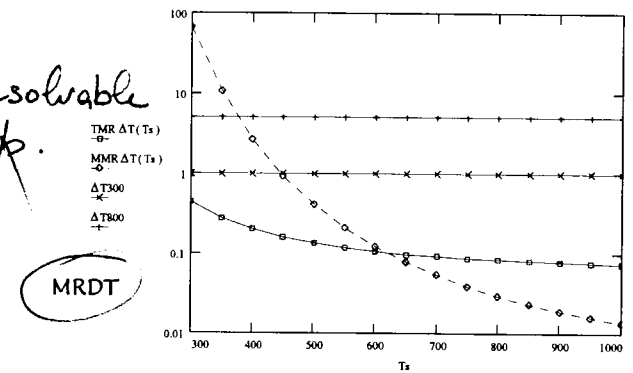


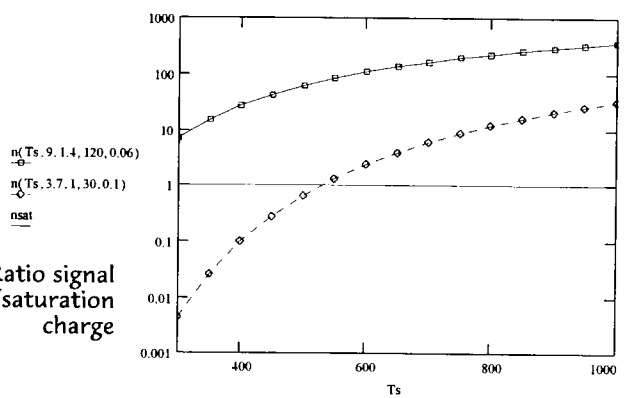
Inventory mode			Monitoring mode		
Swath (km)	Max. across pointing (deg)	Consecutive passes (min)	Swath (km)	Max. across pointing (deg)	Consecutive passes (min)
2500	±59	5 - 6	1250	±44	3 - 4

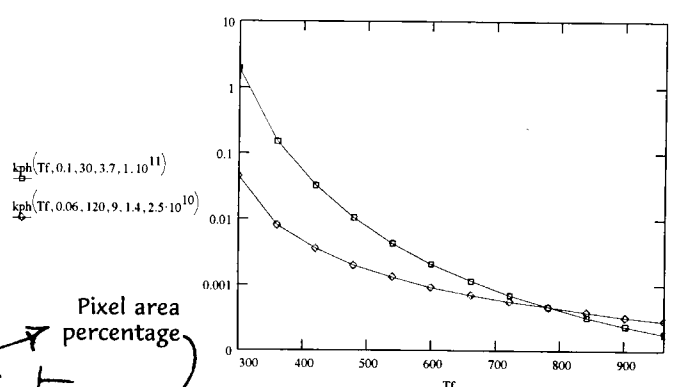
Payload radiometric analysis

Parameter	MIR	TIR	Remarks
Satellite			
Height	600 km	600 km	
Ground speed	6.91 km/s	6.91 km/s	
Scene			
Ground resolution	30 m	120 m	
Temperature	280-1000K	280-1000K	
Atmosphere transmittance	0.5	0.5	To be confirmed
Central wavelength	3.7 μm	9 μm	
Bandwidth	1 μm	1.4 μm	
Optics			
Aperture	100 mm	60 mm	
Transmittance	0.5	0.5	
Focal length	560 mm	140 mm	
Nyquist frequency	10 cy/mrad	2.5 cy/mrad	
Detector			
Pixel size	28 μm	28 μm	From Sofradir
Pixel number	1660	420	
Detectivity	$1*10^{11}$ cm*W^{-1}*t$^{0.5}$	$2.5*10^{10}$ cm*W^{-1}*t$^{0.5}$	From Sofradir
Saturation charge	3.4 pC	3.4 pC	From Sofradir
Max integration time	4.3 ms	17.4 ms	

min. resolvable Δ temp.





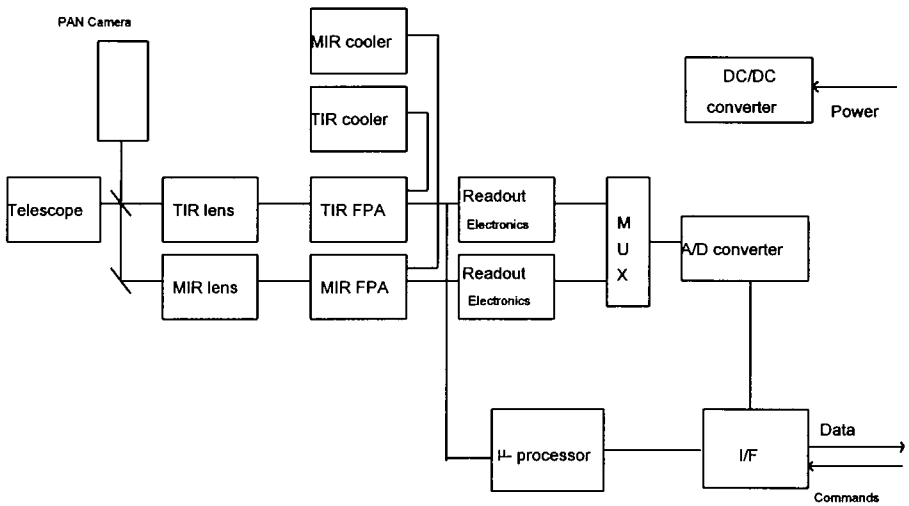


Are the two chan. justified from discrimination standpoint?

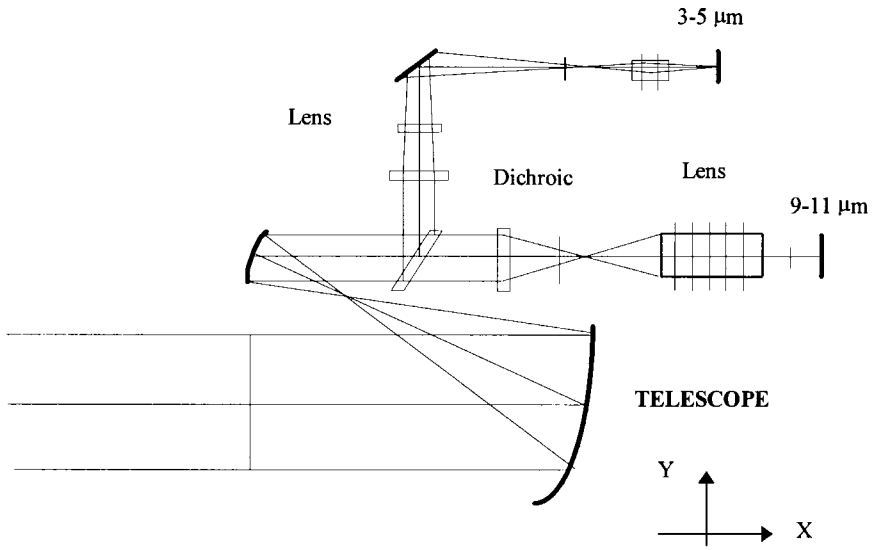
min. area of a pixel that can be detected

reference pixel = 30 m^2
objective → 10 m^2

Payload description (I)



Payload block diagram

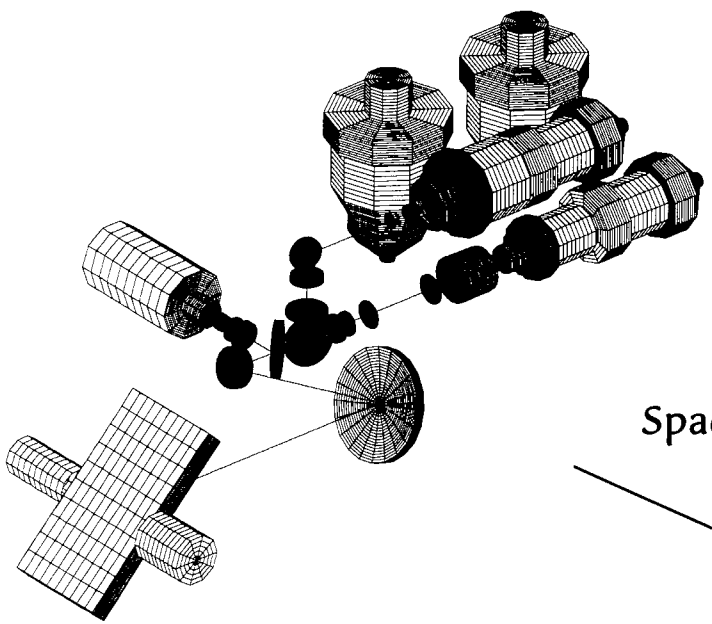


Overall layout

Channels	Wavelength	Spatial resolution	Number of pixels	Swath
VIS	0.6-0.9 µm	20 m	2500	50 km
MIR	centred at 3.7 µm	30 m	1660	
TIR	centred at 9 µm	90-120 m	555-420	

Summary of performances

Payload description (and II)



Mass breakdown

Scan mirror	8 kg
Telescope	6 kg
Lenses	4 kg
IR focal planes with dewars	3 kg
VIS camera	2 kg
Cryo-coolers	12 kg
Processor	10 kg
Electronics	8 kg
Structure	10 kg
Thermal hardware	2 kg
Others and margin	10 kg
Total	75 kg

The instrument shall be mounted withy clear view at nadir of:

- 5 deg along track
- 60 deg across track

Power requirement: 100 W

mainly due to cryocooler!

FuegoTec products (I)

Two kinds of products:

- engineering
- user (service)

Engineering products

The engineering products will be used to validate the technologies to be used in FUEGO:

- focal plane arrays (PAN, MIR, TIR)
- infrared acquisition technique (pushbroom)
- read-out electronics (saturation prevention and power dissipation)
- confocal off-axis parabolas telescope concept
- lightweight optics
- scan mirror
- active cooler performances
- on-board processor

FuegoTec products (and II)

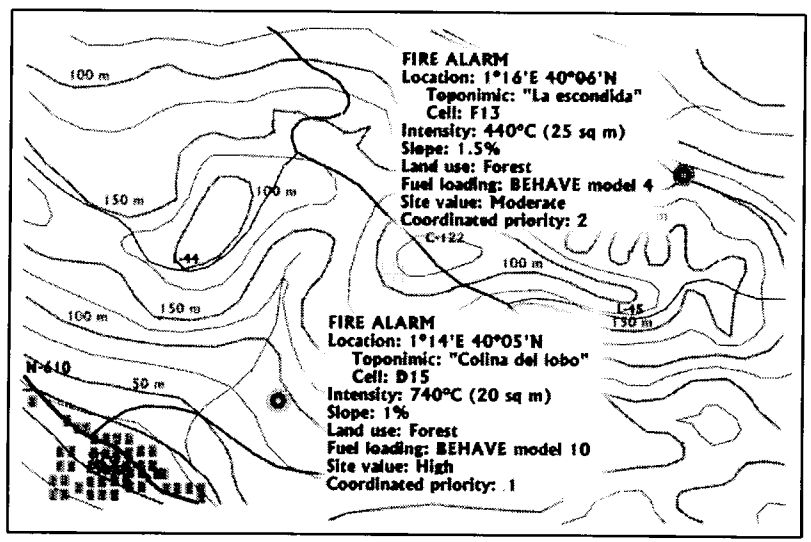
User products

FuegoTec user products are similar as the expected for FUEGO although, as a single-satellite system, some differences arise.

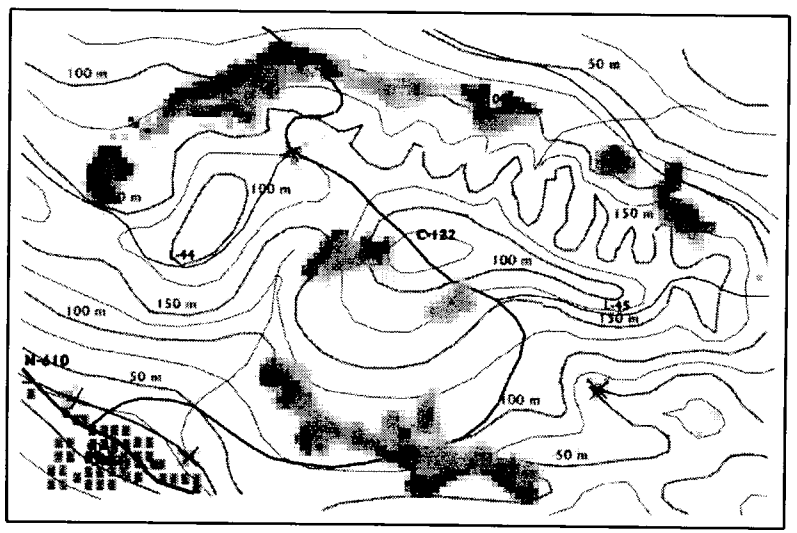
In the FUEGO concept users receive the data directly through a specific handheld terminal..

FuegoTec detection products will have inventory purposes only.

FuegoTec monitoring products will be synoptic callibrated images of 35 m ground resolution.



Inventory



Monitoring

FuegoTec operational concept (I)

FuegoTec data will be forwarded from the space segment to the users through a central ground station. Direct downloaded is not possible.

In Europe, forest fire fighting responsibility is delegated to the regions so FuegoTec data have to be disseminated at national, regional and local level.

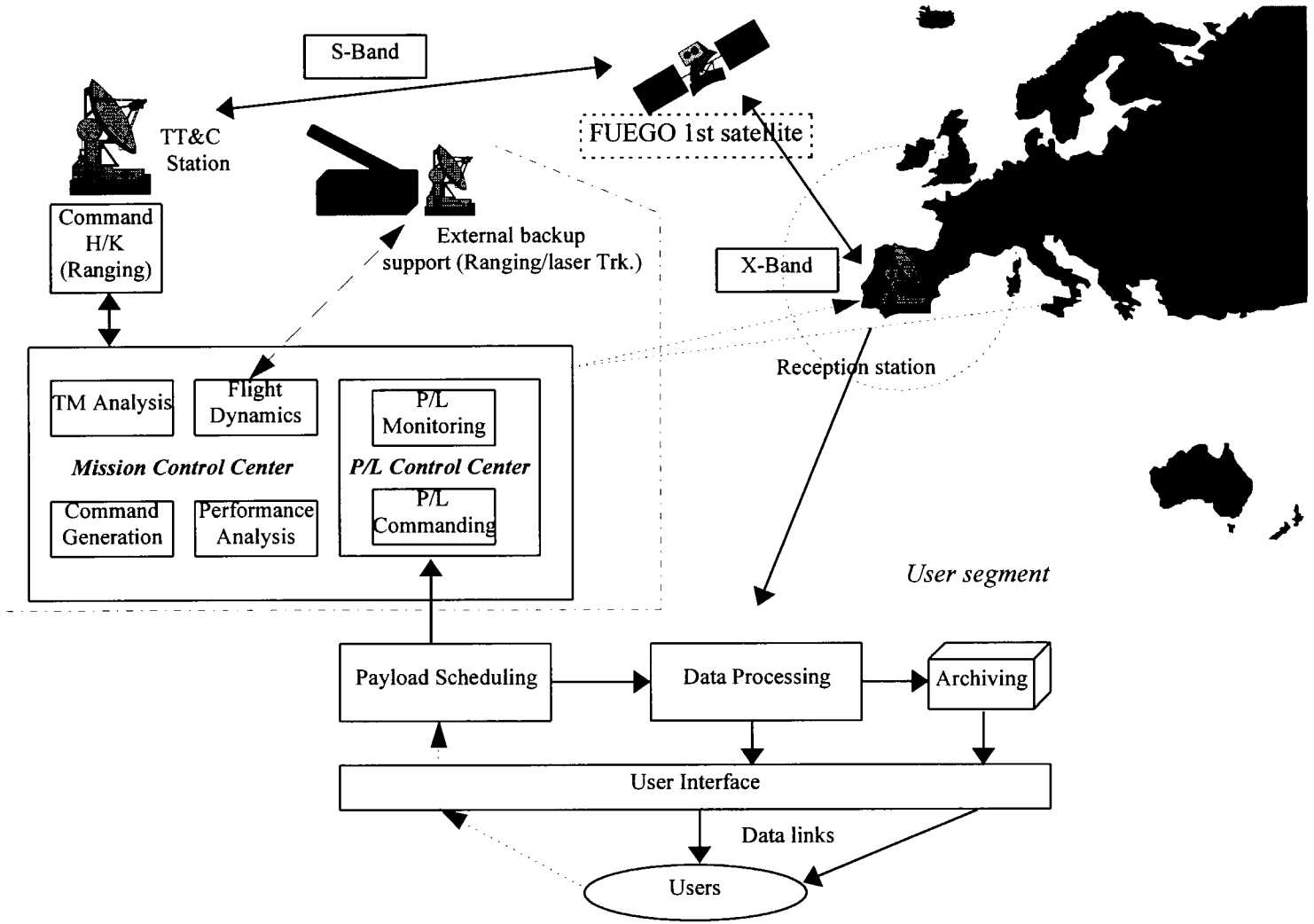
Special emphasis is put in providing the adequate interface with current Geographical Iformation Systems (GIS) and in ensuring the proper operational interface with high resolution simulators.

With the received information, the user will be able to work out:

- fire extension maps
- arrival time for the available extinction resources
- optimised trajectory for extinction resources
- foreseen actions for fire extinction
- optimum fire attack
- consequences of the defined actions

These capabilities are going to be developed under the FUEGO context.

FuegoTec operational concept (and II)



FuegoTec SMO requirements (I)

FuegoTec payload mass is 75 kg.

Estimated mass of spacecraft (payload + bus) is 250 kg.

Typicall dimmensions are:

800 mm in X direction

500 mm in Y direction

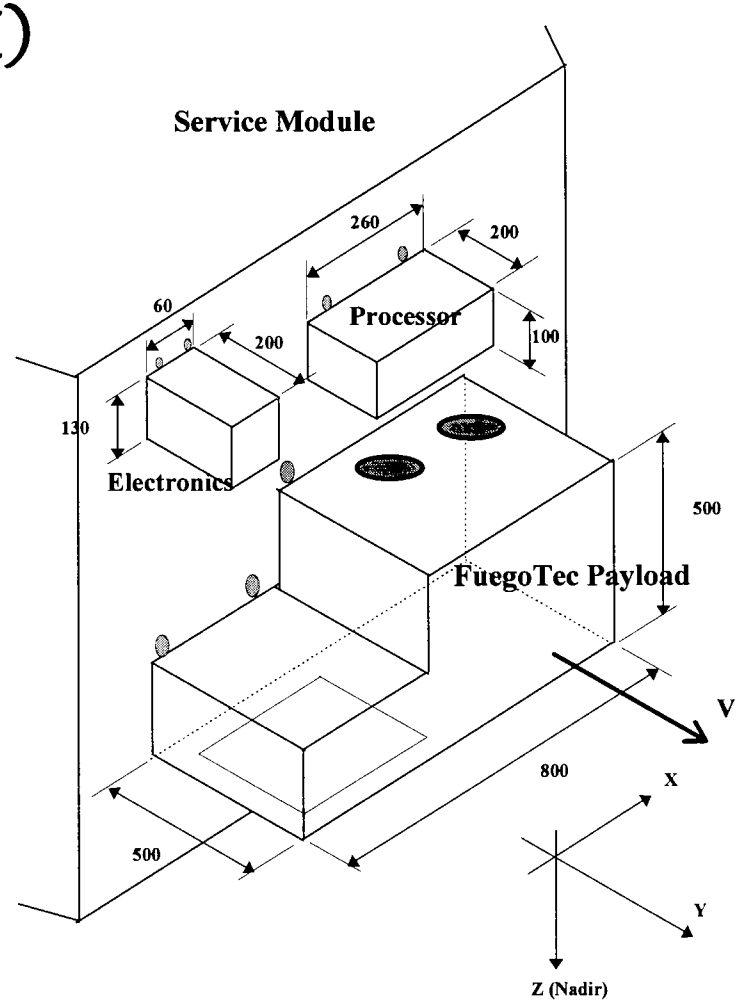
500 mm in Z direction

Processor preliminary dimmensions are:

260 x 200 x 100 mm

Electronic box preliminary dimmensions are:

130 x 200 x 60 mm



Interface with the Service Module

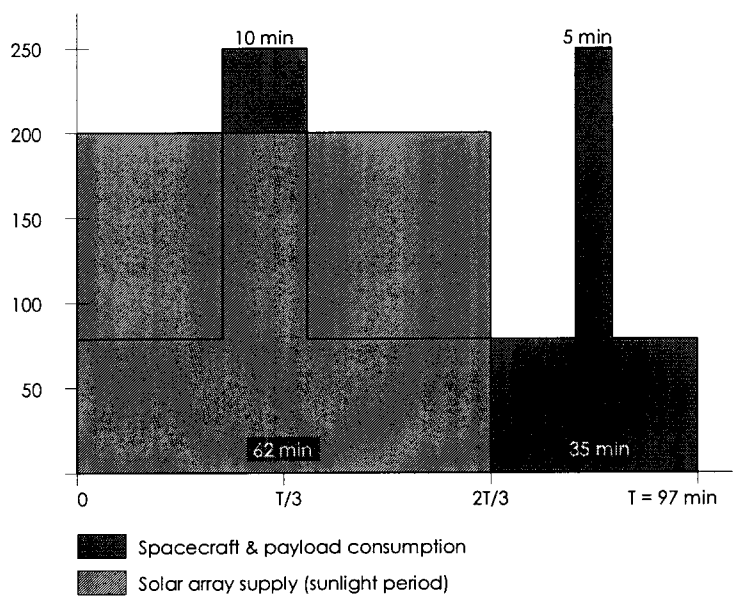
FuegoTec SMO requirements (II)

Power requirements

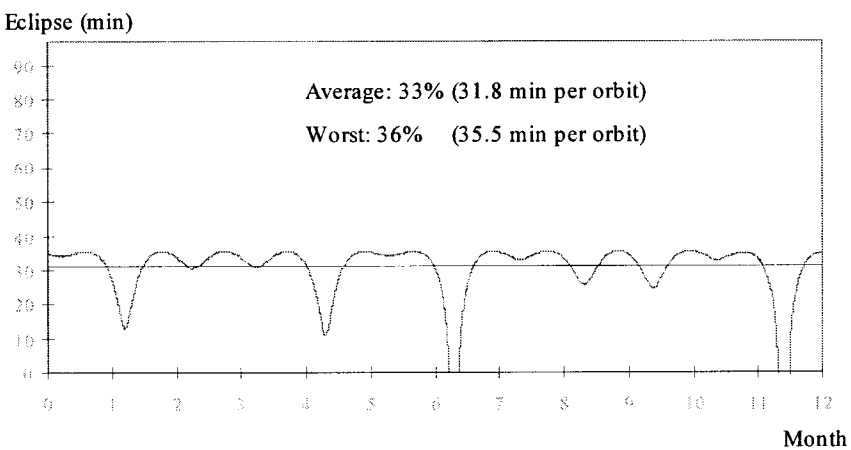
Total requested spacecraft power is 250 W (payload peak power is 40% of total spacecraft power)

Non-acquisition power is 75 W.

During operation 250 W are requested for 10 minutes sun-illuminated and 5 minutes eclipse.



	Sunlight	Eclipse
P_{min}	75 W	75 W
P_{nom}	103 W	100 W
P_{max}	250 W	250 W



Assuming NiCd batteries the requested capacity is 216 Wh

For a 28 V bus that yields 8 Ah

FuegoTec SMO requirements (and III)

Pointing requirements

- Control accuracy: 0.1 deg
- Attitude knowledge: 18 arc sec
- Stabilization: 0.01 deg/s
- No propulsion system is required

Link requirements

- Payload data download in X-band (15 Mbps)
- TTC link in S-band (2 kbps)
- Processing SW to be uploaded from ground

Mission lifetime is 2 years.

Mission orbit is 600 km altitude, 47.5ş inclination.

Launcher baseline is OSC Pegasus XL. (Fairing dia.1170mm h. 2100 mm)

Market analysis (I)

The business value of a system like FUEGO in the light of the SMO Initiative has been primarily directed towards obtaining the user feedback with respect to:

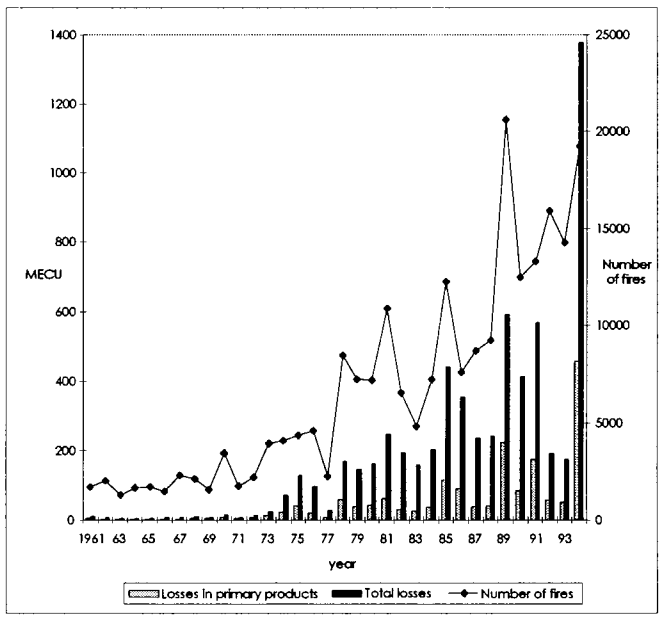
- present situation of the detection and monitoring services
- ratings that define the profile of value for the service in detection and monitoring
- ratings of present systems to identify basic areas of improvement as felt by potential customers
- understanding of the volume and accesibility of the market

Cost of forest fire management has increased substantially in recent years

Spain, 300 MECU in 1995

Italy, about 300 MECU in 1995

rationale for mission: proof of service and technology



Number of fire and its damage in Spain the last 20 years

Market analysis (II)

European fire fighting support is structured in:

Presupression	Prevention Detection Fire Attack Forces Fire aviation Ops. Fuel Management New Technologies Insertion	Suppresion	Fire Attack Forces Operation Fire Aviation on contract Fire Aviation Supplies Emergency Medical Support Planning and Management of Ops.

Deployment during high risk season

- fixed observers
- mobile observers
- aerial surveillance → IR or smoke?
- first attack (rapide mobile units)
- firefighting units
- fire fighting aircrafts
- coordination centres

Paramount criterion to reduce fire effects is to reach the fire early enough to allow its control (rapid reaction).

Rapid reaction relies on early and reliable detection, prepositioning of units and availability of access routes or aircrafts/helicopters.

Second strategic line is knowledge of fire evolution: knowledge of fire status, fireline position, atmospheric conditions and fuels in the area.

Market analysis (III)

Present status of fire detection means

Nowadays, look out towers are the dominating technique to spot forest fires, but their are based in seasonal and discontinous jobs placed to not well trained people.

Infrared detection systems are expensive and not very efficient.

Aircraft based sensors are extremly expensive, comparatively, and their use under bad weather conditions is limited.

Satellite sensors have not been affordable so far.

Current existing satellite based sensors (AVHRR) do not provide effective information for forest fire detection (insufficient revisit time, false alarms, coarse resolution, ...).

The interest and consequently the willingness to pay for services is structurally growing in the prevention and detection areas

Market analysis (IV)

Quantification of the incurred costs in forest fire fighting

There are no official stadistics on the cost dedicated to forest fire fighting in the Mediterranean countries.

An estimate of the total costs incurred in these countries was performed based on:

- number of persons engaged in observation tasks per region and country
- total number of persons in firefihghting per region and country
- total budget per region
- total number of aircrafts used for firefighting and information purposes

	SPAIN	ITALY	PORTUGAL	FRANCE	GREECE	Total
Total Budget (MECU)	243.	182.	37.	81.	54.	597.
Fixed/Mobile Surveillance Budget (MECU)	30.	22.	5.	7.5	4.5	69.
Fire Information from Air Budget (MECU)	1.44	1.13	---	0.81	---	3.38
People engaged	21000	14000	3000	3800	6000	47800
Aircraft engaged L	24	17	3	12	18	74
S	47	38	29	21	30	165
Budget Central or Fixed (MECU)	53.	44.	15.	44.	54.	

The forecast done on the growth of the budget dedicated to forest fire fighting in EU and US in information gathering is ~~3-6% per year.~~

Coordination efforts involve obtaining images of ongoing fires and after compression sending them to the district center or region.

currently used only after fire is [illegible] for [illegible]

Market analysis (V)

Changes in the demand

Availability of well trained personnel is becoming a problem.

Special emphasis will put in avoiding large fires (prevention and prepositioning in risky areas)

Severe criticism of new technology products and services is being made by the administration users because promises of the past were not fulfilled.

The trend is the regionalisation and europeisation of the fire fighting responsibility.

The current figure of merit is the average surface burned per outbreak, which highly depends on the early detection.

Changes in the supply

burning along with the fire?

Aircraft and helicopter costs are going to increase in the near future.

Large scale constellations and GSM full coverage will make easier the continuos command and information exchange between the different levels.

Satellite and launch costs are being reduced

On-Board processing of large amounts of information is presently possible.

IR towers do not satisfy user demand (cost, maintenance, lanscape intrusism)

Aircrafts are expensive and are considered only as supplement.

Market analysis (and VI)

Profile of a new service

The ideal profile of a new service has to provide:

- location of fire risk areas and risk index, allowing preposition of fire attack assets
- location of agricultural burning
- fire location and intensity and local wind status
- day and night service, independent of cloud coverage
- location of the fireline and structure
- location of hot spots
- perimeter of burned land and surface

FUEGO market

EU is the primary FUEGO market:

Spain Italy Greece

France Portugal

Other identified markets are:

- US/Mexico: 1/3 of the EU market
- Australia: 5% of EU market
- South America: 5% of EU market
- Others: Other Mediterranean countries, China, Pacific countries

Business plan (I)

FUEGO costbreakdown

System cost		Operations cost
Spacecrafts	90 MECU	1.5 MECU per year, including:
Launchs	30 MECU	• Operation of system ground segment
Ground segment	3 MECU	• Distribution and billing
User segment	2 MECU	• Help desk and user support
Operational reserve	15 MECU	• Management
		• 7 years lifetime
TOTAL system	140 MECU	TOTAL operations 10.5 MECU

Need for cheap launches and ~~off-the-shelf~~ platforms -

7 yrs → 40 Mecu x year.

Conclusions

Losses due to forest fires in the Mediterranean countries are in the range of 400 MECU per year.

Forest fire fighting responsible require a system which provides fire effective early detection and monitoring information of on-going forest fires.

INSA's proposal to these requirements is the FUEGO system. The definition of this system is being carried out by an European team led by INSA under a 20-months EU contract (the FUEGO Programme).

The studies made by INSA confirm the market and the cost-effectiveness of this system.

To validate the technologies of the FUEGO system, on one hand, and the proposed service (requirement mandatory for potential users), on the other hand, a prototype of the FUEGO system has to be developed.

This prototype, called FuegoTec or FUEGO 1st satellite, fully fits within ESA's SMO Initiative. The mission definition, SMO interfaces requirements and cost-benefit analysis for FuegoTec have been presented so far.

Conclusions

Losses due to forest fires in the Mediterranean countries are in the range of 400 to 900 MECU per year with the present firefighting system.

Forest fire fighting responsible require a system which provides fire effective early detection and monitoring information of on-going forest fires.

INSA's proposal to these requirements is the FUEGO system. The definition of this system is being carried out by an European team led by INSA under a 20-months EU contract (the FUEGO Programme).

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→ where?